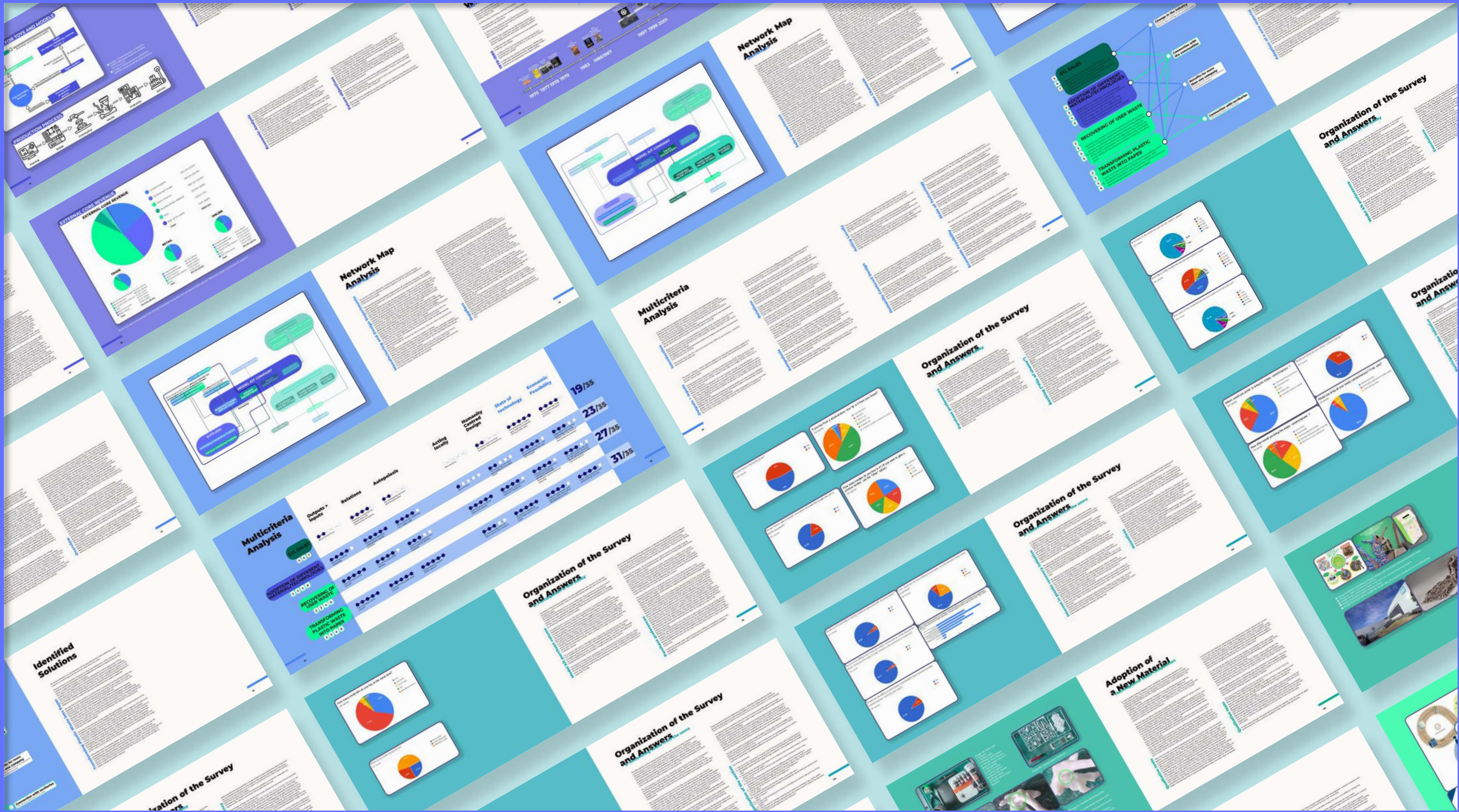

Model kits & Systemic Design

Analysis of the model kit industry and development of Systemic Design solutions

Politecnico di Torino

Master degree in **Systemic Design**
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Systemic Design course

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Thesis Co-supervisor: Mariapaola Puglielli

Thanks

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Abstract

The objective of this thesis is the study and analysis of the model kit industry in order to find issues that can be resolved by applying Systemic Design solutions.
By focusing on production processes and using two world renown companies, this thesis will try to define the system network of this industry, from the Business to Business aspects to the Business to Customer ones. In addition to that, the thesis will also try and analyse the consumers of this industry products, the model builders. Using a survey, the thesis will explore their interaction with the hobby, their interest towards eco-friendly solutions and other elements, in order to understand how a systemic approach to the existing industry network may affect the consumer base.
In order to develop an effective system, case studies geared towards making plastic products more eco-friendly will be analysed, in order to understand how to implement them in the network.
A test nation will be found in Germany, which will be studied in order to understand the country interest towards both the model kit industry and the recovery and recycling of plastic.

This thesis will then focus on the effects that opening the model kit industry system will cause, as well as how they will affect the existing actors. In particular, the introduction of a new material in the system and the launch of a user waste recovery system may allow the opening of the model kit industry towards the paper industry and an increase in Polystyrene recycling on the whole German territory.

Index

Introduction

The model kit industry has always been an niche sector in the plastic and resin industry. Covering many different types of products, these mainly figure vehicles, from historical ones, like tanks and ships, to science fiction and fantasy ones, like mechas and dragons. This industry has a long history, especially when considering the use of plastic. In its history, the main goal of all the companies producing model kits was to find a way to replicate all the details from the concepts and the real-life counterparts.
But how can a niche industry focused on creating detailed and realistic model kits adopt Systemic Design solutions? Which issues in the industry can be resolved or, at least, minimized? Which branch of this sector is more susceptible to change, and how?

The objective of this thesis is to analyse the model kit industry, by finding two case studies and analysing their product line, the innovations that were developed and which issues were covered. This thesis will also analyse the most common production methods in the sector, which material is used and how and which issues the production methods present.
After this initial analysis, the sector network map will be defined via research and, from that, there will be an application of the findings from the previous analysis, in order to define the potential challenges and opportunities that may present. From these, solutions will be identified and analysed via multicriteria analysis, in order to understand which solution would be more effective in introducing Systemic Design tenets in the sector.
Given the niche nature of the model kit industry, it was necessary to understand the final users of the products: the model makers and builders. In order to have a solid feedback about potential changes in the industry, a survey was developed with the objective to connect with the model making community and understand how they would react towards changes and initiatives.

Once these analysis are completed, the systemic project will be developed. Starting with changing the sector network, the identified solutions will be inserted, in order to visualize the initial changes and the effect that they would have. After, each solution will be defined in detail, through research on each topic. By finding case studies, it will be possible to develop a solid understanding of each solution and how to make them interact with each other and with the system.
The systemic project will be developed starting with the analysis of Germany as test nation, in order to define the effectiveness of the project strategies on this territory. Then, a new system for the model kit industry will be defined and analysed in its entirety and divided in material, commercial and information flows and its definition on a micro, meso and macro territorial scale. In addition to that, the effects of the system will be also analysed on those scales and in three time periods: a short one (0-3 years), a medium one (3-6 years) and a long one (6+ years), with the definition of a goal towards the first decade.
Finally, the potential outputs and outcomes of the new system will be presented starting from data related to model kit production and plastic waste, continuing with an analysis over the outcomes on the three territory scales and during the time periods.

1. Model Kit Industry Analysis


INJECTION MOULDING
1- MOULD MAKING
2- INJECTION MOULDING CYCLE
DEFECTS
UNAVOIDABLE
AVOIDABLE
VACUUM FORMING
1- MOULD MAKING
2- VACUUM FORMING PROCESS
3- FINISHING METHODS
DEFECTS
RESIN CASTING
3D PRINTING
Two-part moulds
No moulds
FINISHING TOUCHES

BANDAI SPIRITS

CASE STUDY

BANDAI SPIRITS CO - MAIN IPS

TOYS AND HOBBY

Anpanman

Mobile Suit Gundam

PRETTY CURE!

DRAGON BALL

ONE PIECE

KAMEN RIDER

ULTRAMAN SERIES 45th ANNIVERSARY

Ultraman

Super Sentai

G-BASE TAMACHI

BANDAI NAMCO TRADING (HK) LIMITED

General presentation

Based in Japan, the company BANDAI SPIRITS is part of the Bandai Namco Holdings Inc. Established in 2018, BANDAI SPIRITS is part of the "Entertainment Unit" of Bandai Namco, covering the "Toy and Hobby Business", together with Bandai Co.. It "was established in 2018 with the goal of continuously accelerating business growth in global markets for products geared toward a mature fan base." (Nao Udagawa, President and Chief Executive Officer, BANDAI SPIRITS CO, LTD Corporate Profile 2022) [1].
Focusing on plastic model kits and collectible items, BANDAI SPIRITS is a Kabushiki-gaisha type of company, literally translate as "stock company". It has a main site in the G-Base Tamachi, located in Tokyo and a secondary site in Hong Kong: the Bandai Namco Trading (HK) Limited.
BANDAI SPIRITS is divided in various departments, the majority of which are on-site in the Tokyo G-Base.
In the city of Shizuoka is located the "Creation Department, Hobby Products Division". This department is based in the BANDAI HOBBY CENTER and is responsible for product planning and development of plastic model kits, focusing on the Gunpla series. Other than the development, on-site are present the facilities needed for the production of said model kits.
Also linked to model kits is the "Global Business Department, Hobby Products Division", which is responsible for global marketing (sales, promotion, etc.) of plastic model kits.
Under these two departments are located all the model kit brands linked to the Mobile Suit Gundam series, together with other IPs that BANDAI SPIRITS produces, usually still linked to the Mecha genre of animation.
The rest of departments are focused on collector toys, character lottery and amusement prizes. Each department covers various IPs, usually all collected under one singular brand.
In the "Collector Toys Department", all the IPs are collected under the brand "Tamashii Nations", which presents high quality products, which usually retail for high prices. The reason is the high quality materials used, often presenting internal components made of metal to ensure stability and guarantee solidity in the joints. These products are highly regarded for the quality of the details and the colours used on the toy, which faithfully represent what was shown on screen.
The "Lot & Innovation Department" focuses on lottery characters. These statues, often representing characters from animated series, fall under the brand "Ichibankuji".
Finally, the "BANPRESTO Department" plans, develops, and sells prizes that are exclusive to amusement facilities and can be won at crane games and other machines. In this case, the BANPRESTO brand covers products that can vary from statues of characters, to plushes, to branded objects.
In total, BANDAI SPIRITS counts 665 employees, divided in the various departments.
For this thesis, the products and the department that will be analysed are plastic model kits, the IPs and the production methods of the "Creation Department, Hobby Products Division" [11].

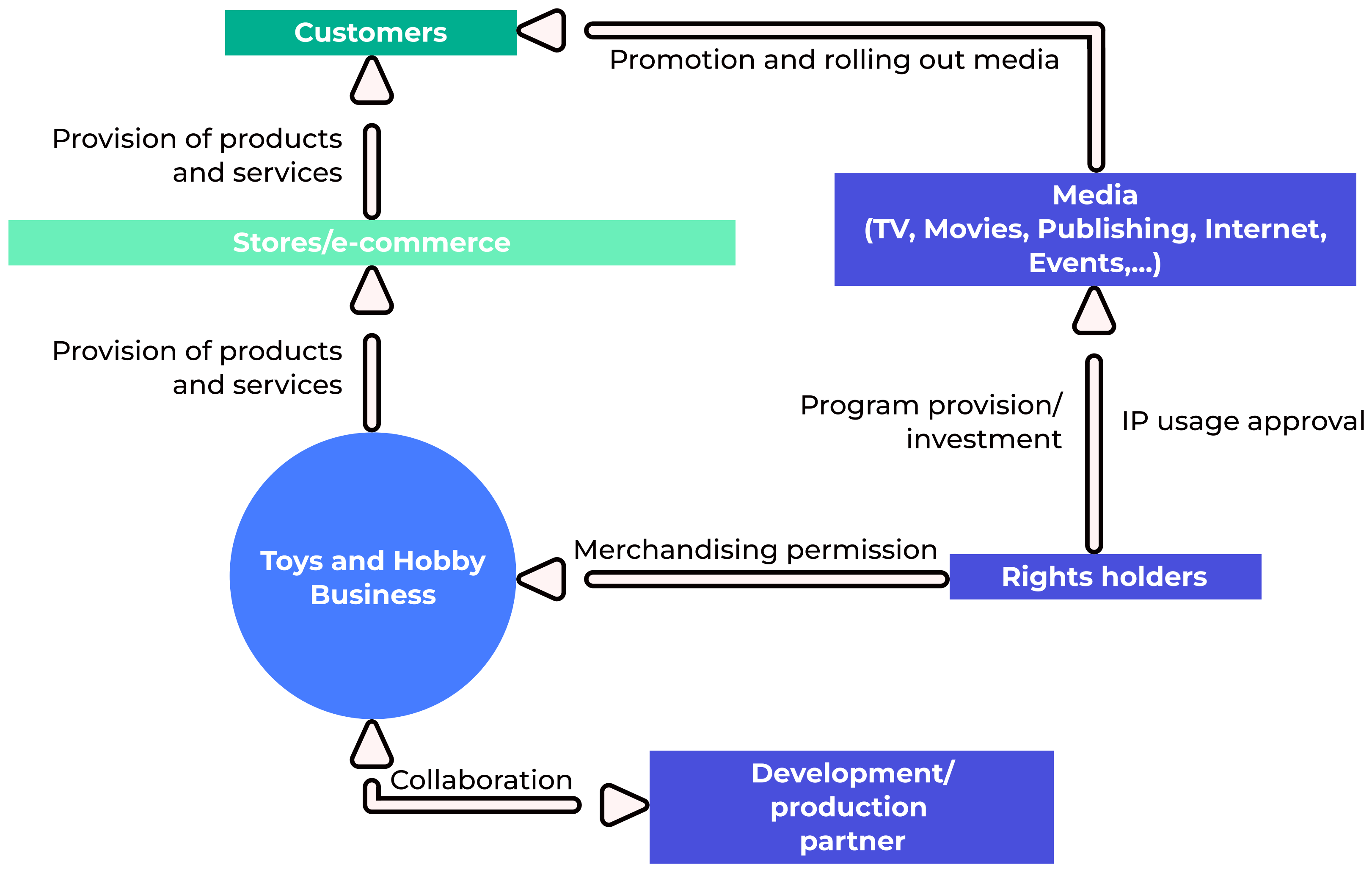
The reason why BANDAI SPIRITS was chosen as a case study is because it managed to develop a very streamlined production process that utilizes methods that are very common in the model kit industry while also innovating and improving in every way that may allow for better products. The innovations that will be described later also show an effort to try and make the production process less wasteful as possible.

IPs and products

As previously mentioned, the Hobby Products Division presents a large catalogue of model kits, each divided in lines and between the various IPs. As shown in the previous page, BANDAI SPIRITS presents eight main IPS. Of these, five are the main IPs for the production and sales of toys and model kits. The majority of these IPs (Anpanman, PRETTY CURE!, DRAGON BALL and One Piece) have their products part of the Figure-rise Standard and Figure-rise Standard Amplified lines, which focus on action figures with a variety of accessories.
The IP "Mobile Suit Gundam", which consists of a long-standing series both animated and in manga form, has its products part of the vast majority of lines produced by the Hobby Products Division.
These lines, which are all commonly known as "Gunpla" (from the union of Gundam and plastic) are differentiated by various factors: the scale, which goes from 1:144 to 1:48, the level of details, which start from the simplest to build, the High Grade line, to the most complex (with a higher number of components and thus, higher prices), the Perfect Grade line.
Thanks to this, the Gunpla products manage to be open to almost anyone, independently of age and economic status.
All of these plastic model kits are produced mainly using Polystyrene, which is used for the majority of the components of the model kit. Some parts, though, can be manufactured in different plastics, depending on the function in the model kit. An example are the polycaps, which are components that are used in the joints in order to guarantee the correct friction to allow movement, without being too loose. These polycaps usually are made of Polyethylene.
In some cases, usually when manufacturing components that need to be made in a flexible material, thermoplastic elastomers (TPE) are used.
In the case of Real Grade model kits, some small components are manufactured already assembled together, in order to facilitate the overall assembly of the model kit. Usually these components are manufactured in both ABS (Acrylonitrile Butadiene Styrene) and Polypropylene.

Thanks to the popularity of the Gunpla line, Bandai Namco saw the opportunity to develop sustainable activities using these products. Other than a recycling initiative that will be explored in detail later and the environmentally driven innovations in model kit planning and design, Bandai Namco developed the "Gunpla Academia", a teaching resource based on the subject of Gunpla.
The objective of this Academia is to encourage kids to think about manufacturing and the global environment at elementary schools throughout Japan.
Through the experience of assembling Gunpla and watching videos that showcase the facilities and production processes of the BANDAI HOBBY CENTER, where BANDAI SPIRITS plastic models are produced, as well as the work of the people involved in production, this initiative allows students to learn about manufacturing and about recycling and other sustainable approaches to global environmental issues with the aim of raising interest in advanced technology and innovations for sustainable manufacturing.
This interest in environmental issues and in encouraging the final users to participate in similar initiative will come back later.

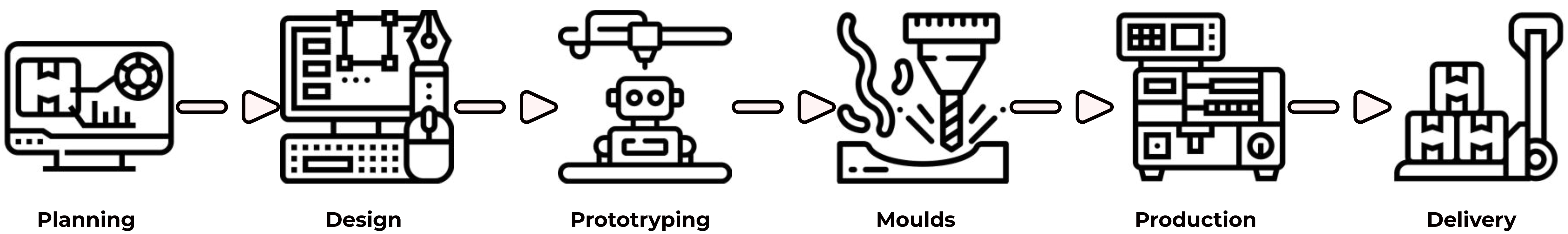
BUSINESS MODEL FOR TOYS AND MODELS



◀ Image 1. Schematization of BANDAI SPIRITS Business Model for another Company's IP

▼ Image 2. Schematization of BANDAI SPIRITS model kit production process

PRODUCTION PROCESS



Business Model

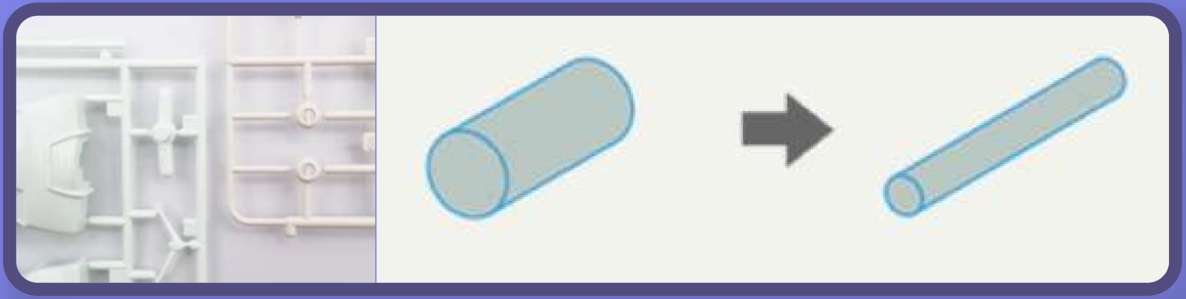
Being part of a larger company, BANDAI SPIRITS has access to a large number of IPs to work with to produce various toys and model kits, as stated previously. This also means that outside of the planning and developing of such products, there aren't many steps before the launch of a new line of products. This is possible thanks to the fact that the Bandai Namco Group has bought various animation studios and the rights to the merchandise of the animes aired by those studios. This way, the company has the ability to develop products both for existing characters and for new animations during the development of such media. An example would be the newest animated series of "Mobile Suit Gundam", titled "The Witch from Mercury". In this case, the anime was launched in 2022 and the model kits that reproduce the mechas are being launched together with their appearance in the anime.

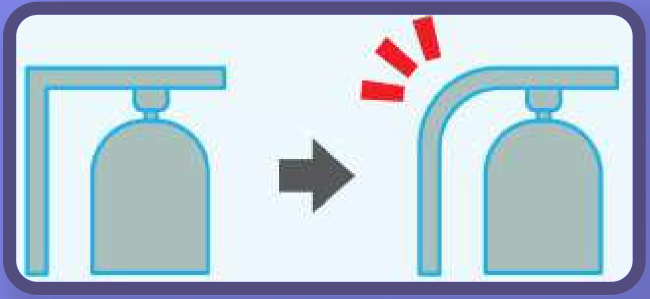
Bandai Namco and BANDAI SPIRITS follow a different business model when it comes to developing and launching products for another company's IP. The rights holders have the main say when it comes to merchandising and IP usage. As such, the merchandise must be developed in a way that faithfully represents the characters and the elements from the IP itself. The same goes for the development of media: in this case, whether it is a television production, a movie, publishing or even marketing through internet ads or events, the IP must be used in a way that the rights holders approve. This could mean avoiding showing characters or events that appear later in the IP (in this case, usually comics or light novels), in order to avoid spoilers. The same precautions must be taken during the promotion period, which has the objective to interest the customers in consuming the media presented.
When it comes to the development of the merchandise, the Toys and Hobby Department may work together with a development or production partner. This usually happens when the merchandise can not be produced by the facilities that the Bandai Namco Group owns.
Once the merchandise production has started and the finished products can be shipped, the distribution is divided between physical stores and e-commerce ones. These stores can be both first-party (owned by the Bandai Namco Group) and third-party, owned by private owners or other companies. An example is the Cosmic Group, a chain that serves as official distributors in Italy, France and United Kingdom for the brand Bandai Tamashii.
From the stores, then, the customers can buy the finished products that were advertised [2, 4]. (Image. 1)

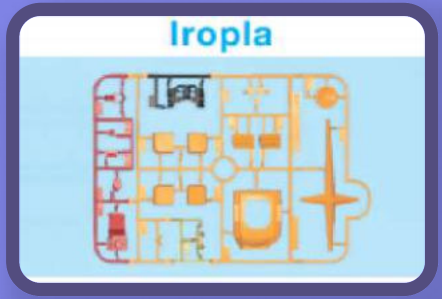
Production Process

The production process of the model kits is a streamlined process thanks to all the years of experience that the BANDAI SPIRITS manufacturing team has in designing the kits. Each model has a number of parts varying from 50 to 500, depending on the line the model kit is part of, the complexity of the inner frame of the model kit and the details and colour separation needed to provide a faithful recreation of the mecha.
The first step in the process is planning. This step sees the decision of which product will be developed. It could be a new sub-line of Gunplas (an example is the series "Master Grade Ver.Ka", solely developed by the designer Hajime Katoki who redesigned the model kits, both already released or without a physical counterpart, focusing on improving its visuals and proportions) or a series of Gunpla linked to an airing anime, like the aforementioned "The Witch from Mercury", recently aired.
After planning the model kit, the design phase sees the creation of a 3D CAD model, using images and videos from the show, of both the main mecha and its accessories. Developing the 3D model allow the designers to better understand the details of the robot, and to test the freedom of movement the model kit should have in order to replicate particularly iconic movements and poses from the media. This step is crucial, since the following steps and the finished products depend on the digital model: each component of the final model kit is modelled, so that it is possible to both plan the interlocks and to prototype it before launching production.
Once the 3D model has been developed, the prototyping phase starts. This phase sees the digital model produced via 3D printing. This allows for fast prototyping that allow to maintain the details designed digitally and testing the durability of each component. This phase also allows to test the solidity of the interlocks of the model kit and the tightness of the joints. Once the prototype gets tested, the digital model is modified accordingly and this process gets repeated until the final result reaches the standards needed for launching production.

Since the production method that BANDAI SPIRITS employs for model kits is injection moulding, before the production can start it is necessary to make metal moulds. These moulds are initially machined in order to speed up the process, cutting in the metal the main shapes and larger details of the model kit. After the initial machining, the minute details are carved by hand. This is uniquely possible thanks to the fact that the mould making facility is owned by the Bandai Namco Group. This allows for lower production costs for the moulds, which often reach prices well over 80'000 $ thanks to the complexity of the details of the model kits.
Once the moulds are ready, the production phase starts. The model kit are produced using a injection moulding method, which injects the melted plastic in the moulds, making so that it takes the shape needed. Over the years Bandai developed various technologies in order to reduce plastic waste and to speed up production. One of these is the Iropla technology. This technology allows the production of a multi-coloured runner, and will be described in more detail later.
Once the plastic is injected, the mould gets cooled down, completing the production in around 20 seconds. This production method allows for industrial mass production.
Finally, once all the runners that hold the model kit components are produced, they get packaged first in transparent plastic bags, which are sealed shut, and then placed in a cardboard box together with an instruction manual. Both the box and the manual present various images of the assembled model kit, with iconic poses that show the ample range of movements of the model kit. The box also present a dedicated artwork on it, in order to entice the potential customers. (Image. 2)

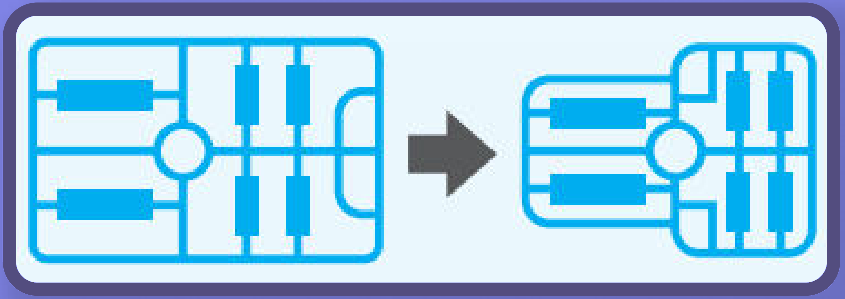


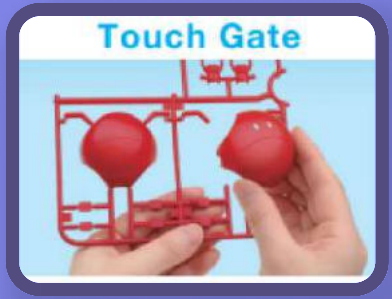


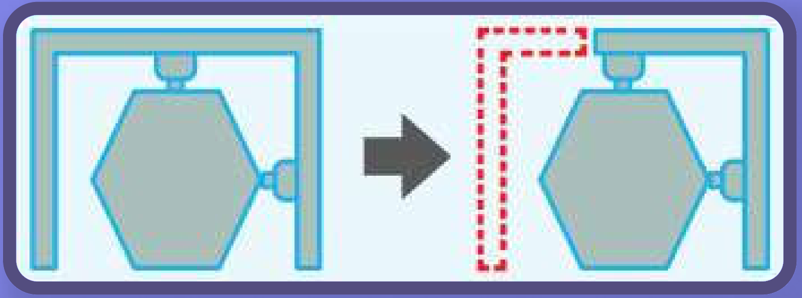


▲Image 3. Reduction of runners diameter
▲Image 4. Rounding of runners corners
◀Image 5. Tightly laid out product parts
▼Image 6. Removal of the outer frame of the runner

▲Image 7. Example of Iropla-produced runner
◀Image 8. Example of Snap-fit technology
▼Image 9. Example of Touch Gate design
▼Image 10. Example of Undergate design







Production Innovations

BANDAI SPIRITS has recently developed some innovations in producing their model kits in order ot reduce usage of plastic, while still maintaining high quality. In order to do so, four different solutions were adopted from the fiscal year of 2019.

The first is the reduction of the diameter of the runner, while maintaining both the molten plastic flow and the quality of the details. This was possible thanks to deeper mould engravings, which helped maintaining high quality in the details of the model kit. The difference is quite noticeable, with a reduction of the diameter of about half. This reduction, though, is mainly reserved for the external part of the runner. While it would probably be possible to reduce the diameter of also the internal branches of the runner, the connection points with the model may become too brittle and not stable enough to provide a safe distribution of the finished product. (Image. 3)
Another solution is the rounding of the external corners of the runner. This very simple change in shape helped reducing the material usage, without compromising either the solidity of the runner or the detail quality of the model kit. (Image. 4)
The third solution was to organize all the model kit components closer together on the runner. This was not designed in order to fit more parts on a single runner frame, but to reduce the dimension of the runner. This solution, combined with the previous two, allows for an exceptional reduction of material needed. (Image. 5)
The final solution is the removal of part of the outer frame of the runner. This is not very common and is reserved only for some products. Usually these products belong to the "Super Deformed" line, which presents model kits that have exaggerated proportions, usually with a big head and smaller torso and limbs. This is also known as "Chibi style" and the products part of the "SD" line are usually made with less parts (around 50), which don't usually include smaller and more frail components. (Image. 6)

All in all, these four solutions have amounted to a reduction of annual consumption of plastic by approximately 70 tons.

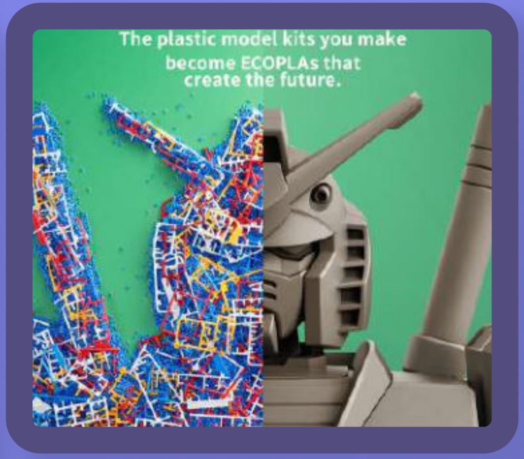
With more than 40 years of life, the Gunpla line of products saw an humble start in 1980. When first produced, the model kits were monochromatic, each mecha made in a coloured plastic that reproduced the main colour the mecha was painted with in the animated series. The mecha representative of the series, the RX-78-2 Gundam, for example, was produced in a completely white plastic. That meant that the model builders had to paint the model kits once assembled. In order to help in this regard, the instruction booklet included a colour guide, so that the model builders would have been able to reproduce faithfully the colours by themselves.

Three years later, in 1983, the Iropla technology was developed. This technology had the main objective of providing the model builders with a more faithful representation of the mechas as seen in the anime, without requiring further work other than assembling the model kit. In order to do this, the Iropla technology allows for injecting plastic of different colours for the production of the runners. While it is not implemented for each runner of a model kit (usually the inner frame is made out of dark grey plastic), the Iropla technology is useful in order to reduce plastic waste both during production and after assembly of the model kit. By allowing for multicoloured runners, there is no need for separate runners divided by colour, thus reducing the quantity of plastic needed. (Image. 7)
Also, this technology is particularly well used in the lines called "Real Grade", "Master Grade" and "Perfect Grade". All of them deliver highly detailed model kits that present almost no stickers used for colour correction, as opposed to the "High Grade" line, which often need coloured stickers for certain parts. In all three of these lines, the colour division is of the highest level, so much so that the stickers given with the model kits usually only consist of the colour for the "eyes" of the mecha, metallic coloured details and decals, like codes and hazard warnings.

In 1987, four years later, the Snap-fit technology was developed. Before it, Gunpla model kits required glue to assemble. The idea behind Snap-fit was to allow assembly not only without the use of glue, but exclusively using interlocks. This technology was subsequently developed in the "Multi-Insert Casting", a modelling technology that prepares the components in order to allow perfect fitting between parts, easy assembly and difficult accidental disassembly. (Image. 8)

Design Innovations

The technology behind the design of model kits kept evolving, developing the Touchgate and Undergate design in positioning of the model kit components on the runners. Both design ideas were developed together with mould making technologies.
The Undergate design was developed with the idea of connecting the components and the runners in positions hidden after the model kit assembly: this way, less cleaning was required by the model builder after detaching the component from the runner. (Image. 9)
The Touchgate design, instead, was developed with the idea of connecting the component to the runner using only a smaller contact point between the two. In this case, the objective was to reduce the need of clippers to cut the component away from the runner. (Image. 10)
The Touchgate design is usually reserved for larger external components, like torsos. These components are usually sturdy enough to avoid needing a solid connection point with the runner and, being external, are often checked more thoroughly. Thus, the potential presence of visible contact points is not a huge issue, since they would get cleaned.
The Undergate technology, instead, is usually used for smaller pieces, that need to be well connected to the runner in order to be completely filled with plastic. These components usually have small and precise details, so they must be secured to the runner and positioning the contact point in a zone with no detail (usually the back of the part) allows for a larger and more stable connection without loosing details.



▲ Image 11. From left to right: Gunpla Recycling Project scheme description, Gunpla Recycling Project marketing showing how runners can become ECOPLA, runners made in recycled plastic
▼ Image 12. SDGs adopted by Bandai Namco Group

Problems and Solutions

During the production of the model kits, a certain amount of plastic becomes waste.
The waste from production can be divided in two categories: one is the sprue, which is the plastic that goes from the extrusion funnel (in injection moulding) to the runner and the components machined in the mould. This material is cut off from the cooled runner when it gets extracted from the mould and often is reintegrated in the production cycle.
The second type of production waste are failed products. These range from failed prints, to broken parts, to flashes caused by an excessive injection of plastic.
All of these issues are resolved thanks to the intrinsic property of plastic that allows it to be recycled and reused without problems. This makes so that it is possible to input back into the production process what was previously an output.
Another issue is obviously the use of great quantities of plastic. Now, BANDAI SPIRITS has gone great lengths in order to reduce the use of said material, but the main issue is that the plastic used is “virgin”. This means that it is material appositely produced and since it is oil based, the plastic used, Polystyrene, is not product of recycling and needed raw monomers to be polymerized and then coloured as needed. This means that the resources needed to produce the plastic are not particularly environmentally friendly. Because of this, BANDAI SPIRITS has started working towards reducing the usage of virgin plastic materials and introducing products made out of recycled plastic.
BANDAI SPIRITS has developed the KPS plastic. This material is a Polystyrene (PS) reinforced (“Kyouka”, Japanese word for reinforced), completely recyclable with other Polystyrene and mainly used for plastic model kits.
Other than this, BANDAI SPIRITS also started the initiative Gunpla Recycling Project. This initiative, which will be analysed mode in depth later in the thesis, has the objective of recovering the empty runners from the customers and recycling them in three different ways: either recycling the plastic mechanically, manufacturing a dark grey material called “ECOPLA”, recycling the recovered runners chemically or using them in order to generate thermal energy to power the facilities used to produce Gunplas. (Image. 11)
On the topic of energy, another development in the production process that the company has worked on is a multi-coloured moulding machine that allows for the Iropla production of model kits. This machine allows for reduction of both power consumption and material usage, thanks to the applications of the solutions mentioned beforehand.

As many other companies, BANDAI SPIRITS has also adopted various SDGs in order to improve its sustainability. The Sustainable Development Goals that BANDAI SPIRITS has adopted include, but are not limited at, the solution described beforehand. (Image. 12)
The goals that the developed solutions try to reach are the ninth, “Industry, Innovation and Infrastructure”, which is tackled by the development of KPS and the multi-coloured moulding machine; the machine is also an effort to work towards the seventh goal, “Affordable and Clean Energy”. Finally, the solutions to reduce material used in the production of model kits try to reach the twelfth goal, “Rensponsible Consumption and Production”.
BANDAI SPIRITS has also developed efforts to work towards various other goals.
As an effort to work towards the fourth goal, “Quality Education”, BANDAI SPIRITS hosts factory tours, mainly aimed towards children from local elementary, junior high, and high schools.
As well as the production process for plastic models, the visitors can also learn about the environmental initiatives BANDAI SPIRITS is taking to become a green factory.
In addition, BANDAI SPIRITS is part of the project “Hobby City Shizuoka”, which promotes creative education. Thus, the facility offers on-site classes at elementary schools in Shizuoka prefecture, as part of the “Gunpla Academia” described beforehand. The employees explain the processes involved in the planning, development and production of plastic models, and then assemble plastic models with the students, in order to familiarize them with the manufacturing in the facilities, thus increasing the student’s interest in local industries.
Other than the multi-coloured moulding machine, BANDAI SPIRITS is working towards the seventh goal by also putting efforts towards a better management of environmental resources.
The first effort was the installation of large solar panels on the outer walls of the BANDAI HOBBY CENTER. These panels generate around 56’000 kWh of solar energy annually, thus contributing to about 5% of the power used in the factory.
The second effort is the storing of rainwater, which gets filtered through purification equipment. This equipment is in a storage facility in the factory basement and it is able to store around two tons of water. This water is then recycled for flushing toilets in the factory itself. With this system, approximately 2,000 tons of water are recycled annually.
There are various efforts from BANDAI SPIRITS to work towards the eight goal, “Decent Work and Economic Growth”.
The first was the introduction of the “Meister System” at the BANDAI HOBBY CENTER. The objective of this system is to “ensure that future generations inherit the skills of our expert craftsmen who have valuable techniques for plastic model production.” (Excerpt from the SDGs online page from the official BANDAI SPIRITS site, https://www.bandaispirits.co.jp/about/sdgs_en/?l=en). The title of Meister is given to employees with “undisputedly outstanding techniques who are eager to improve their own expert knowledge and skills, and are also willing to train and mentor their successors.” (Excerpt from the SDGs online page from the official BANDAI SPIRITS site, https://www.bandaispirits.co.jp/about/sdgs_en/?l=en).
This is to motivate the employees to improve together, as well as to continue to offer high quality products.
Another effort was to implement various systems in order to create a work environment that would allow the employees to achieve a good work-life balance.
Some examples include more flexible working schedules and styles, especially geared towards helping with parenting, like childcare leave, flextime and shorter working hours. It was also introduced a maternity payment system to support childbearing and parenting.
Similar systems were introduced in order to allow employees to take leave, work shorter hours or flextime when necessary, like in the occurrence of family emergencies.

In order to work towards the tenth goal, “Reduced Inequalities”, all the final packing factories that produce BANDAI SPIRITS products undergo audits at least once a year. The audits are used both to verify the manufacturing system and the compliance with laws and regulations, and to ensure that workers’ rights set by the international labour organizations of the country are protected. Other than that, all the workplace safety measures are inspected.
Other than the innovations in reducing material usage, BANDAI SPIRITS took more efforts towards the twelfth goal, efforts that help the company work also towards the 15th goal, “Life on Land”. Both of these efforts have the objective to reduce the paper usage in packaging.
The first effort is to print instruction manuals for some figures directly on the packaging, instead of using separate booklet, thus reducing the paper usage. In a similar fashion, the company started printing the background design for the figure directly inside the package, instead of on cardboard that has previously been used.
These efforts have led to a reduction of 2.4 tons of paper per year.
BANDAI SPIRITS is also reviewing the use of blister packaging, a cushioning material made of transparent plastic (PET) and making efforts to switch to cardboard cushioning [12].

SDGs

TOYS AND HOBBIES MAIN IPS REVENUE

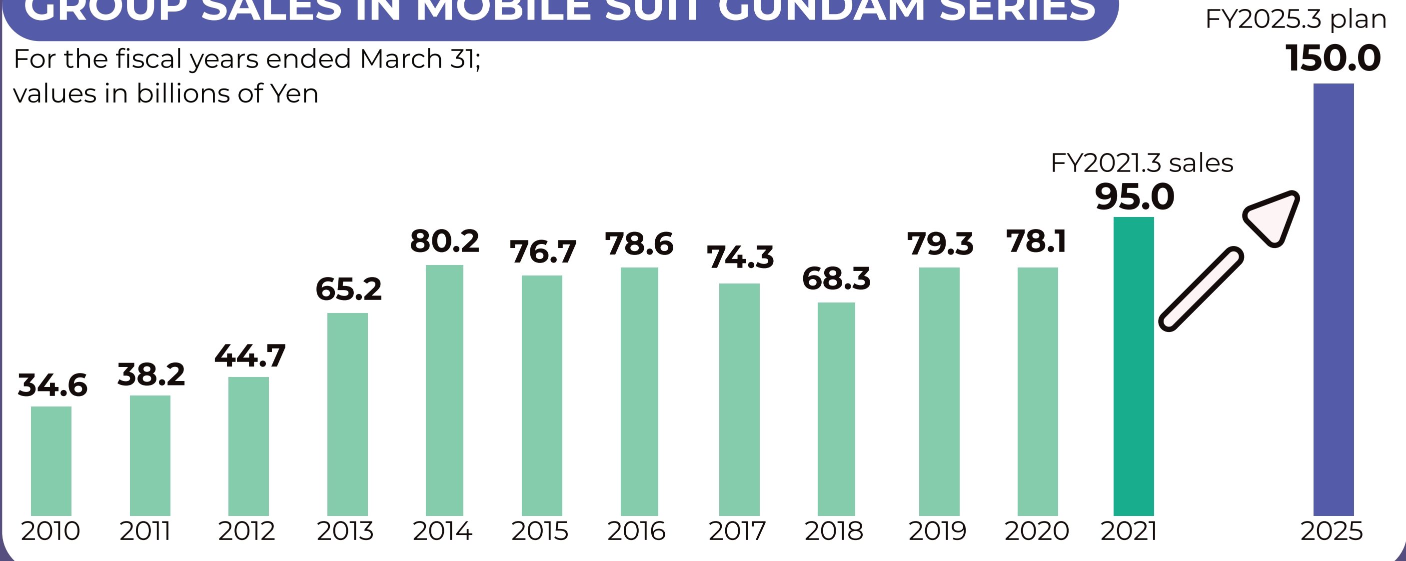
Main IPs	Revenue 2020	Revenue 2021	Revenue 2022
Anpanman	9,4*	8,3*	8,7*
Mobile Suit Gundam	35,7*	41*	44,2*
PRETTY CURE! series	8,3*	6,6*	5,7*
KAMEN RIDER series	28,5*	24,3*	22,8*
DRAGON BALL series	20,7*	15,4*	19,7*
ONE PIECE	7,9*	7,1*	10*
Total	110,5*	102,7*	111,1*

*values in billions of Yen

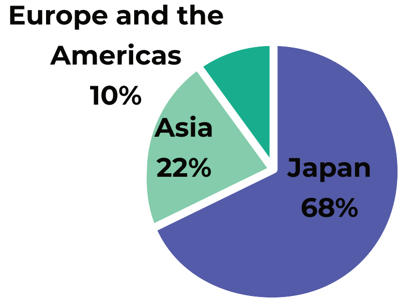
VALUES CALCULATED ON THE SALES OF TOYS AND HOBBY PRODUCTS (MODEL KITS, COLLECTABLES,...)

GROUP SALES IN MOBILE SUIT GUNDAM SERIES

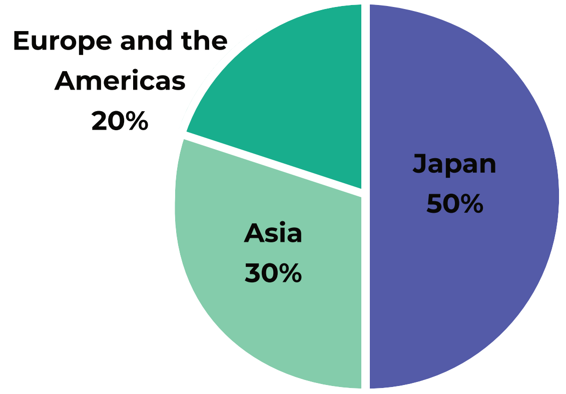
For the fiscal years ended March 31; values in billions of Yen



MOBILE SUIT GUNDAM SERIES: REGIONAL SALES RATIO



Current Sales Ratio (FY2021.3)



Vision: Doubling the sales in Europe and the Americas, increasing to 30% the sales in Asia, while maintaining 50% of the total sales in Japan

Data extrapolated from the Bandai Namco Group Integrated Report of 2021

Economic Analysis

In 2021 the revenue of the toys and hobby products saw a slight reduction from 2020, but interestingly, saw a favourable performance of products geared towards mature fan base (model kits and collectables).
In 2021 the Mobiel Suit Gundam franchise overcame as biggest earner the DRAGON BALL franchise, which is still the greatest earner outside of the Toys and Hobby sector. As a matter of fact, the Mobile Suit Gundam is the only franchise that registered a growth in revenue between 2020 and 2021.
Comparing these data with the third quarter of 2022, it is possible to notice a constant growth of the Mobile Suit Gundam franchise, together with the growth of the DRAGON BALL and ONE PIECE franchises, which both launched an animated movie in that year.

Analysing the data relative to the shipment of model kits, it is possible to notice that from the initial production in July 1980 to March 2021, 538,24 million units were shipped of the "real" series of Gunplas (the term is used to agglomerate all the Grade lines together), while the Super Deformed line of Gunpla shipped 176,6 million units from July 1987 to March 2021. This marks a total of 714,84 million cumulative units of Gunpla plastic model kits shipped from the launch of the product line until March 2021.
Comparing these data to March 2022, the number raised to 555,26 million units of the "reals" series of Gunplas and to 180,44 million units for the Super Deformed line, for a total of 735,70 million cumulative units [2, 4].

Vision

As shown in the data, the sales for the Mobile Suit Gundam series are projected to reach around 150 billion Yen by the third fiscal quarter of 2025. While this is plausible thanks to the constant growth of the sales and the revenue that the franchise is managing to produce, an interesting factor is the vision for the regional sales ratio. At the time of the third fiscal quarter of 2021, the sales in Japan alone covered 68% of the total series sales, while the sales in the rest of Asia amounted to 22% and the remaining 10% was covered by Europe and the Americas.
The Bandai Namco Group has a goal to increase the total ratio of overseas sales to 50%, focusing its efforts towards China and North America. This is shown as in April 2021 a lifesize Gundam exhibit was opened in China, near a large-scale commercial facility.
In North America the previous Mid-term Plan registered an increase in demand as a full-scale rollout of an in-house e-commerce site was implemented, expanding the sales network to large-scale retailers.
Other than these actions, a live-action movie is currently in production in Hollywood and further growth is anticipated when it launches [3, 5].

BANDAI SPIRITS

HISTORICAL OVERVIEW

Bandai's history shows the development of various mode kits and toys based on Japanese media, especially animes taking place in sci-fi universes [13].

1950-1960

In 1950, BANDAI-YA was established in Asakusa-Kikuyabashi, Taito-ku, Tokyo.

In 1955 the industry pioneering quality control system was established and BANDAI's first toy with product warranty was released.

In 1961 the company name changed from BANDAI-YA to BANDAI.

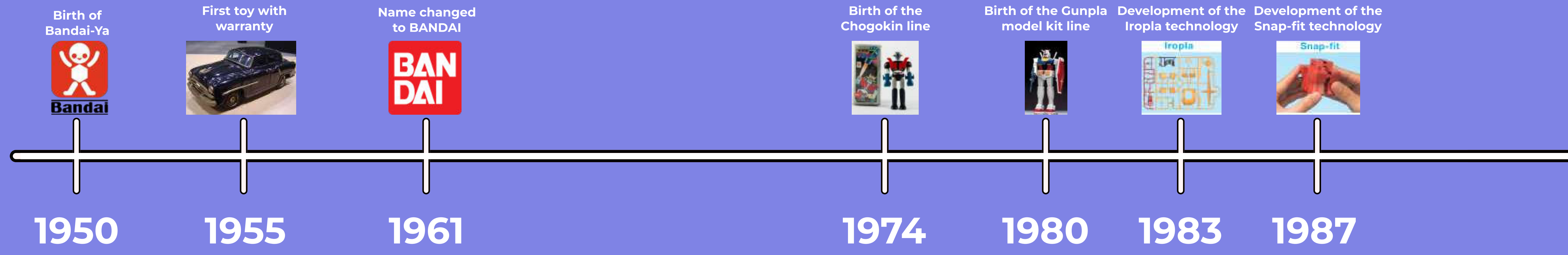
1970-1980

In 1974 the first product of the Chogokin line was launched, the Chogokin Mazinger. This line would pioneer the production of mecha toys with parts in metal.

In 1980, to promote the anime Mobile Suit Gundam, the Gunpla line was launched, kickstarting a franchise that became loved globally.

In 1983 the Iropla technology was developed, which first introduces multi-colour moulding technology to mould parts in four different colours on a runner sheet for plastic model kits.

In 1987 the Snap-fit technology was developed, which enables construction of model kits without adhesive.



1990-2000

In 1990 the High Grade (HG) line was launched, a 1/144 scale standard Gunpla brand.

In 1995 the Master Grade (MG) line was launched, a 1/100 scale advanced Gunpla brand. The name was used to indicate the advanced complexity of the model kits and their details.

In 1998 the Perfect Grade (PG) line was launched, the highest-grade brand Gunpla on a scale of 1/60. This line was designed to perfectly replicate the mechas as seen on screen, with plenty of gimmicks and minute details that even the Master Grade line was unable to present.

In 2006 the BANDAI HOBBY CENTER plastic model kits production plant (Shizuoka Prefecture) opened.

In 2008 an exclusive Premium Bandai online store was launched. On this site is possible to buy exclusive model kits, unreleased outside of events and this online store. Also, An 18-meter-high, Life-Sized Gundam Statue appears at the Odaiba Shiokaze Park in commemoration of the 30th anniversary of the airing of Mobile Suit Gundam on TV. During 52 days of exhibition, around 4.15 million people visit the park to see the statue.

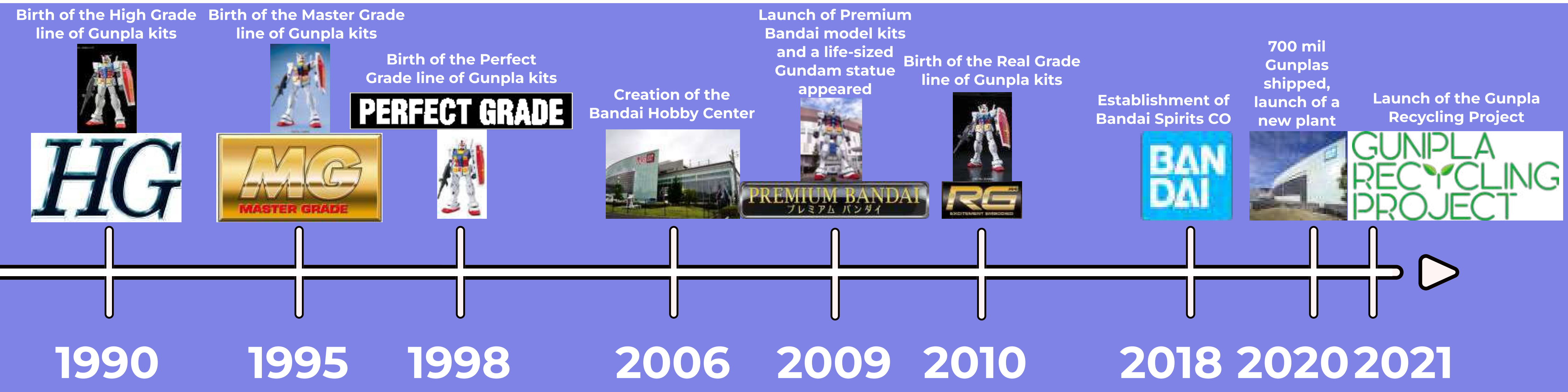
2010-2020

In 2010 the Real Grade (RG) Gunpla line was released, a line that wanted to combine the 1/144 scale of High Grade with the realistic looks and details of Master Grade.

In 2018 BANDAI SPIRITS Co, Ltd was established.

In 2020 the goal of over 700 million Gunpla units shipped was reached and a new plant at the Bandai Hobby Center was built, with the aim of bolstering plastic model production capabilities, including Gunpla.

In 2021 the Gunpla Recycling Project was launched. In this project, Gunpla runners are collected with the aim of producing plastic model kits through chemical recycling in a joint initiative with the customers.



Games Workshop

CASE STUDY

GAMES WORKSHOP - MAIN IPS

WARGAMES

- Warhammer 40'000
- Middle Earth
- Warhammer Age of Sigmar
- Warhammer The Horus Heresy

SUPPLIES

- Citadel

PUBLISHING

- Black Library

BOX GAMES

- KILL TEAM
- Necromunda
- BloodBowl
- Warhammer Underworlds
- Warcry
- Warhammer Quest

NOTTINGHAM

General presentation

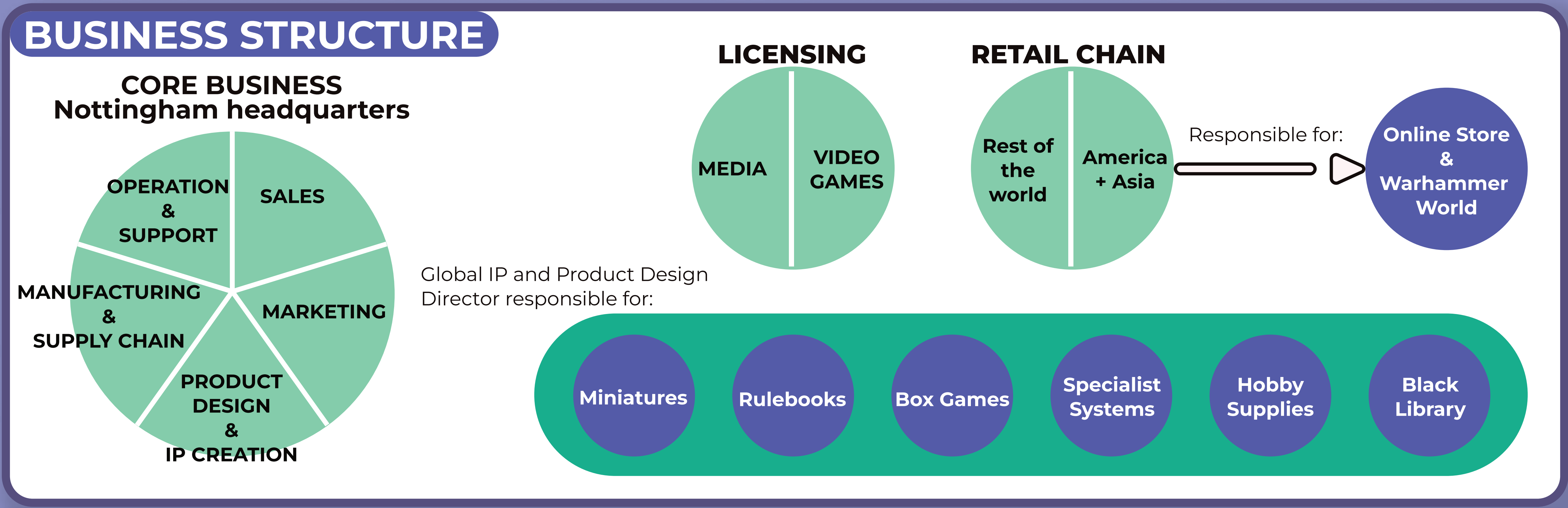
The british company Games Workshop is a model kit company that started in 1975 as a miniature retailer, created by the three friends John Peake, Ian Livingstone and Steve Jackson in London.
Games Workshop is a "Publicly-Owned Company" (a company whose ownership is organized via shares of stock which are intended to be freely traded on a stock exchange or in over-the counter markets) that produces both miniatures and model kits for its brands, which are divided mainly in wargames and box games. It works with the company Citadel Miniatures, initially a separate entity, for the production of its plastic miniatures and model kits.
Games Workshop has a subsidiary company in Forge World, which produces highly detailed, expensive and exclusive miniatures and model kits in resin.
Soon after the birth of Games Workshop, the company started producing and publishing the magazine "White Dwarf". This magazine was focused on roleplaying games and wargames, talking about the most important brands and news. With time and with the growth of Games Workshop, White Dwarf became completely a "house organ", publishing exclusively news and articles on the new Games Workshop products.
While originally born in London, the company relocated to Lenton, Nottingham, where Citadel Miniatures had its site. Here are present the headquarters, the White Dwarf newsroom, manufacturing facilities and mail-order and shipping offices for Europe, and the offices of the creative groups that design miniatures and games.
The company is divided in various departments.
The Development Department and the Production Department are responsible for Wargames and Box Games.
The Publishing Department covers both the publishing of White Dwarf and of the Black Library books. The Black Library is the division of Games Workshop that publishes various stories taking place in the Fantasy and Sci-fi universes where the Games Workshop games are set.
Finally, the Painting and Hobby Supplies department works on all of the tools needed to participate in the hobby. These tools are all produced under the Citadel brand.
In total, Games Workshop counts 2'436 employees, divided in the various departments.

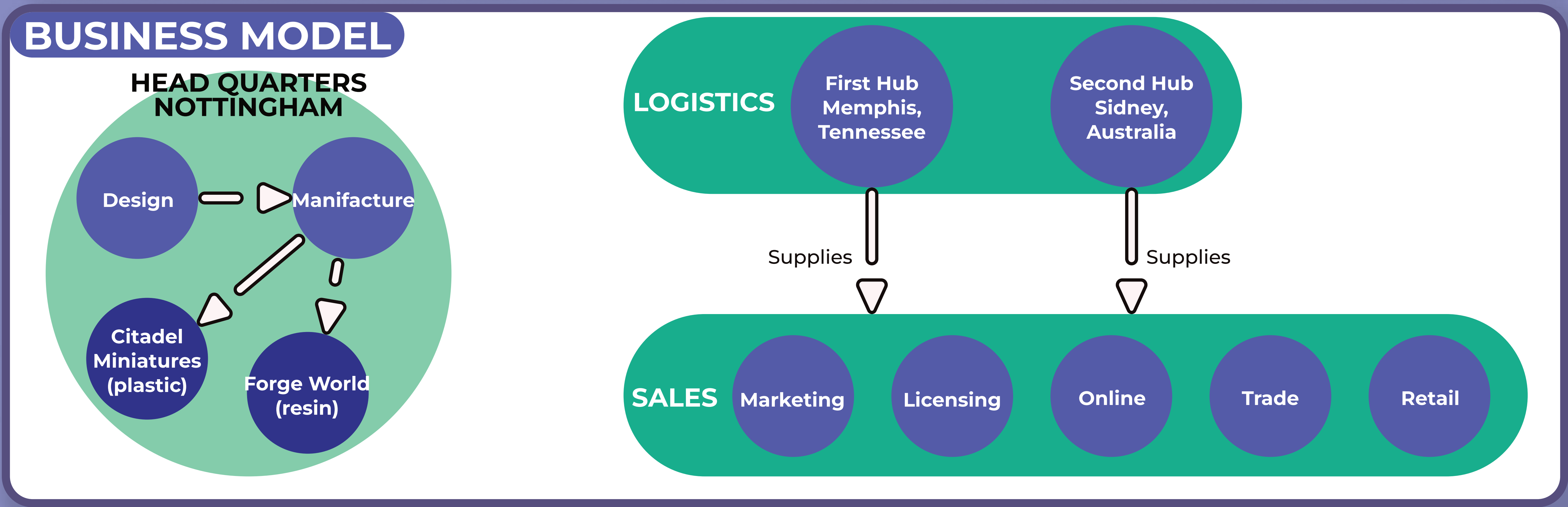
Games Workshop takes great pride in the hobby, so much so that presents a "Games Workshop Hobby" guide on its official site. This guide is divided in four steps: collecting the miniatures/models, assembling them, painting the miniatures and starting playing. These steps also focus on the customizing aspect of things: the customers are pushed to customize their miniatures, whether by kitbashing them (combining various miniatures/models together) or by painting them without following official colour guides.

The reason why Games Workshop was chosen as a case study is because it managed to develop a very streamlined production process that utilizes different methods for different materials. During the years since the start of producing proprietary miniatures, Games Workshop has changed material a number of times, from pewter to resin, to Polystyrene. This evolution in material used went hand in hand with an evolution in products, that managed to become more detailed and bigger.

IPs and products

The Intellectual Properties that Games Workshop owns are mainly linked to tabletop gaming. The most known franchises are Warhammer 40'000, which launched in 1987, Warhammer (also known as Warhammer Fantasy in order to distinguish it from the Sci-fi cousin), launched in 1983 and then rebooted in 2015 as Warhammer Age of Sigmar, and Warhammer Horus Heresy, launched in 2013, which brought the model makers and wargame players in a prequel to Warhammer 40'000.
In 2001, thanks to the immense popularity of the Lord of the Rings movie trilogy produced by Peter Jackson, the wargame Middle Earth was launched.
All of these games saw the evolution of materials used in the production of miniatures. Warhammer 40'000 and Warhammer Fantasy both started with pewter miniatures, then were produced in resin and finally in Polystyrene.
When it comes to the other wargames, all of them have both plastic and resin miniatures, but the Warhammer Horus Heresy ones started as resin products, exclusive to Forge World.
On this topic, Forge World produces miniatures for both the wargames and the box games. All of its products are made in resin and are known to be very detailed, but often present minor issues, like warping, that can easily be corrected by the model builder before assembly. The models and miniatures are exclusive to the online shop and have high detail and high retail price, with special rules dedicated to the "Apocalypse" version of the wargames. This version sees huge armies of models fighting, which often causes the games to be divided in multiple days. Interestingly enough, the models and their rules can be used in normal games of Warhammer 40'000 and Age of Sigmar.
When it comes to box games, the various IPS can be generally divided between the Age of Sigmar universe (Warhammer Underworlds, Warcry and Warhammer Quest) and the Warhammer 40'000 universe (Kill Team, Necromunda). These games usually offer quicker gaming sessions, whether it is an encounter between smaller armies (Underworld, Warcry, Kill Team and Necromunda) or role playing games (Warhammer Quest). All of these games are sold in boxes, with Underworld, Warcry, Kill Team and Necromunda that offer expansions in the form of miniatures bundles, which often are enough to build and paint a squad of characters to play games with.
In an interesting fashion, the game Blood Bowl is a game where a team of fantasy creatures face one against the other in a violent version of American football. Similar to the other games, each team represents a fantasy race, like elves or dwarves and possesses different rules and abilities.
Games Workshop also offers books that narrate the events happening in the universes where all the games take place, thanks to the Black Library publishing company. The books allow the readers to immerse themselves in the lore of each universe and many stories span a number of volumes. One of the most famous and beloved series is the "Horus Heresy", taking place in a version of Warhammer 40'000, 10'000 years before the age where the games happen. This series of books, which reached a total of 62 volumes, has inspired the Warhammer Horus Heresy wargame.
Finally, Games Workshop offers its customers a number of tools for assembling and painting its miniatures and models under the Citadel brand. These tools range from brushes of various measures, to miniature holders, to cutting knives, to glues and colour palettes. There is also a very ample range of paints, each with a different name based on either characters, races or places in the universes. There are various types of paints, from more simple base colours to "shades" a variety of paints that are more fluid and don't require thinning with water, which set in the recesses of the models and allow for the development of natural shades.





Business structure and model schemes extrapolated from Games Workshop Group PLC Annual Report 2022, section “Business model and structure”, page 5-6

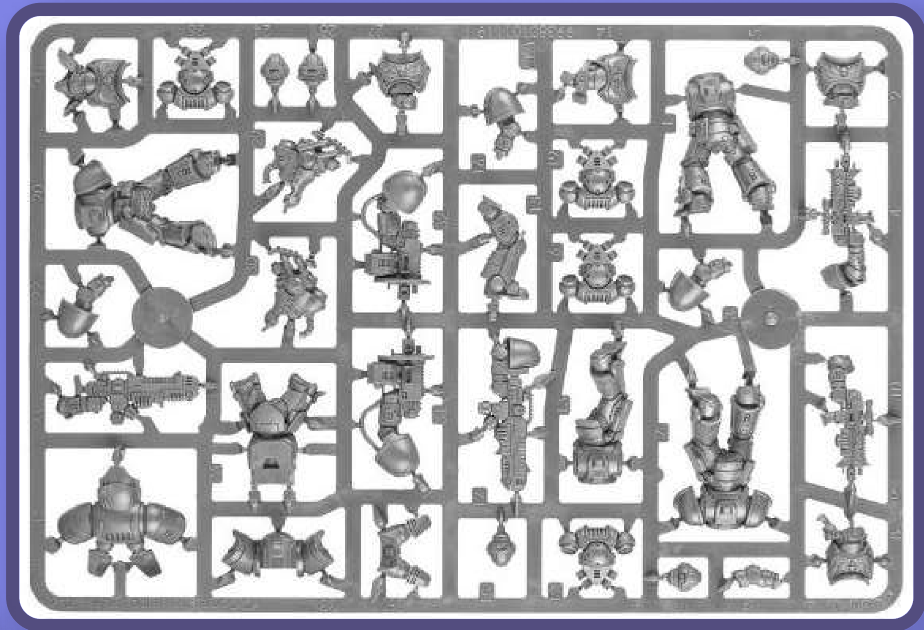
Business Structure & Business Model

The business is controlled centrally from the Headquarters in Nottingham.
As it is possible to notice from the scheme in the previous page, the business model is divided in a few main areas.
The core business is split in five departments: Product Design and IP Creation, Manufacturing and Supply Chain, Sales, Marketing and Operations and Support.
The licensing sector has been recently split into two main areas: Media and Video Games.
A Global IP and Product Design Director is responsible for all of the design studios: miniatures, books, box games, specialist systems, hobby supplies and the Black Library publishing business.
All of these studios work together with a Creative Director who manages the licensing team, in order to ensure any content produced, whether physical or virtual, represents the company's IPs.
The responsibility for the retail chain is split between two retail territory heads, one for North America and Asia and one for the rest of the world, while the trade sales are the responsibility of a single Head of Trade Sales.
The online store (the biggest store of the company) is the responsibility of the Rest of the World Retail Manager, who also manages Warhammer World, the company's biggest physical store. These sales channels are supported by a merchandising team, managed by the Global Manufacturing and Supply Chain Director, and by the marketing team under the company Marketing Manager. The Global Manufacturing and Supply Chain Director also manages the factories and the four main warehouse facilities in Nottingham, Memphis and Sydney.

Games Workshop is an international business centrally run from Nottingham, with 78% of the sales coming from outside the United Kingdom. The headquarters consist in two main factories, two warehouse facilities, design studios and back office all based in or near the city.
All the products are designed in the headquarters, employing 284 people. The designs include all the IP and all the associated miniatures, artwork, games and publications. Annually, these specialist staff produce hundreds of new sculpts, illustrations, rules, stories,... delivering new products every week, in order to keep the customers engaged and excited for new releases. In 2021/22 Games Workshop invested £16.7 million in the studio, with a further £5.7 million spent on tooling for new plastic miniatures.
The products are distributed from the main warehouse at the headquarters HQ or from a rented warehouse facility approximately 25 minutes away. These facilities supply two hubs; one in Memphis, Tennessee and one in Sydney, Australia. Between these four facilities, is possible to directly supply the independent retailers, the company retail stores and fulfil online orders.
On this topic, the core revenue of the company is generated via three sales channels: first-party retail stores ("Retail" in the scheme), third-party independent retailers ("Trade" in the scheme) and the company online store ("Online" in the scheme). Games Workshop products are also sold via licensing partners.
All these channels and activities are supported by the company digital and marketing team.
The first-party retail store provide Games Workshop products in their geographical area. They exclusively stock the company products and are estimated the reason why the majority of new customers enter the hobby. In order to do so, the stores don't offer the full range of products, but focus on starter sets, newly released products, and the appropriate extended range. Also, these stores offer various Citadel-branded hobby tools, like paints, brushes and holders, in order to facilitate the participation in the hobby.
At the end of 2022, 518 retail stores in 23 countries were counted and contributed to around 23% of the year's sales [7].

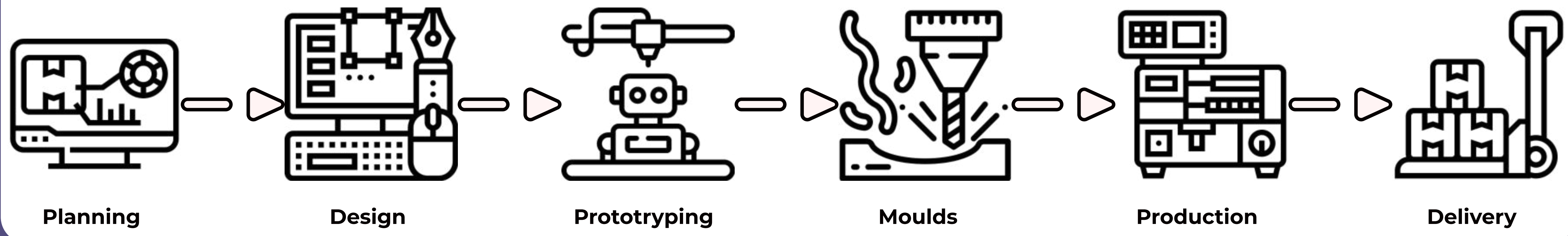
Business Structure & Business Model

Out of the retail stores, 400 are single staff stores: small sites, each operated by only one store manager. The remaining 118 stores are multi-staff. All stores are constantly reviewed in order to ensure profitability. If a multi-staff store can't remain profitable, it may be converted in a single staff store.
The third-party retailers buy Games Workshop products under closely controlled terms and conditions. These retailers are seen as an integral part of the company business model, since they help to sell the products around the world, especially in areas where first-party store aren't located. The bulk of the sales to these retailers is handled by the telesales teams in Memphis and Nottingham. There are also small telesales teams in Sydney, Tokyo, Shanghai, Singapore, Hong Kong and Kuala Lumpur.
In 2021/22 the company worked with 6,200 independent retailers (from 5'400 in 2021) in 72 countries. 55% of the core revenue came from sales to independent retailers in the period reported. These sales are from physical stores as well as online web stores
Sales via our the Games Workshop web stores accounted for 22% of total core revenue in 2021/22. All of the first-party retail stores also have a web store terminal that allows the customers to access the full range of products from within the store. The web stores are run centrally from the Nottingham headquarters.
Licenses are granted only to a number of carefully selected partners. This allows Games Workshop to leverage its IPs to broaden the presence and brand exposure of Warhammer around the world, often entering new markets such as board games, apparel or accessories and media and entertainment, generating additional income. Currently, the majority of this income is generated by video games sales in North America, the United Kingdom and Continental Europe.
Finally, the marketing team acts as a bridge between the various business areas, ensuring a jointed approach between products (from design to manufacturing) and sales.
Also, the marketing team spends a lot of time interacting with the customer base, in order to keep their needs at the forefront [7].



- Image 13. Example of a Blood Bowl pewter miniature
- Image 14. Centrifugal machine used to produce pewter miniatures
- Image 15. Example of resin runner of a Games Workshop miniature
- Image 16. Comparison between a pewter miniature and a resin recast
- Image 17. Example of plastic runner of a Games Workshop miniature
- Image 18. Schematization of the modern Games Workshop model kit production process

PRODUCTION PROCESS



Production Methods and Process

The production methods that Games Workshop adopted during the years were always a variation of casting a mould to produce the models. The main changes were linked with the material of the mould and the material for the cast. Initially, the moulds were made in silicone. This material was used together with the first sculpt of the product, which was initially made by hand. The silicone is then vulcanized, so that becomes rigid and maintains the shape of the sculpt. Once the mould is ready, molten pewter is cast in. This was called “Diecast” method.
With the development of moulding technology, the material switched to resin. This material allowed to produce miniatures and models with sharper and cleaner details compared to pewter. The resin is Polyurethane, mixed with a curing agent and injected in the moulds. This method was dubbed “Finecast” and is still used for Forge World models.
With the increase in popularity and demand the moulds in silicone were not able to produce the volume of miniature and models required. Thus, metal moulds were adopted. While more expensive, these moulds were able to mantian the details for much longer than the silicone ones, allowing for higher production volumes.
Nowadays the majority of Games Workshop miniatures are made in Polystyrene, using an injection moulding technique. This allows for quicker production and the moulds are not damaged by the material used.
All the miniatures are now produced on “gates” or runners, where the models are divided in a number of parts, connected with a structure, similar to the runners that BANDAI SPIRITS uses for its model kits. Initially, the miniatures were produced as almost complete sculpts, with only a few parts disconnected. This was possible thanks to simpler designs and less details. Also, pewter could only be glued with cyanoacrylate glue, which would become brittle once dry. Polystyrene can be glued using particular solvents, which fuse the material together, creating a stronger bond. (Image. 13, 14, 15, 16, 17)

The production process that the manufacturing team of Games Workshop follows starts from the design process.
The miniature is planned, deciding which faction of which IP the product will be part of. There are various base size which will influence various aspects of both the role the miniature will have to play and the “type” that will be. For examples, bigger base sizes are usually used for vehicles, while 32 mm bases are used for smaller characters and troop units.
Once the miniature has been planned and designed, it gets prototyped. In the earlier years of production, these prototypes were hand sculpted, usually using two-part putty, which hardened after a certain time being mixed. The prototypes nowadays are sculpted using digital softwares, but trying to capture a cohesive style, in order to blend in with the rest of the faction line. For example, elven characters will have sleeker designs, with delicate details, while ork characters will have a more brutal look, often with armor made out of scraps and crudely worked metal plates.
The prototypes are also used to plan the contact points for each component of the miniature or model: this step is crucial, since the prototype will be used as a master for the moulds and the positioning of the components is done automatically by a machine.
The moulds are then machined and these can cost up to 100’000 £. This is the reason why, with time, Games Workshop absorbed the Citadel Miniature company. Initially, Games Workshop did not produce directly its products, but outsourced them to Citadel. Once Games Workshop managed to acquire the company, the production costs plummeted. Also, thanks to the in-house production of the CAD files used to machine the moulds, it is possible for them to produce independently the moulds. This also reduced extremely the costs of production [14].

Production Process

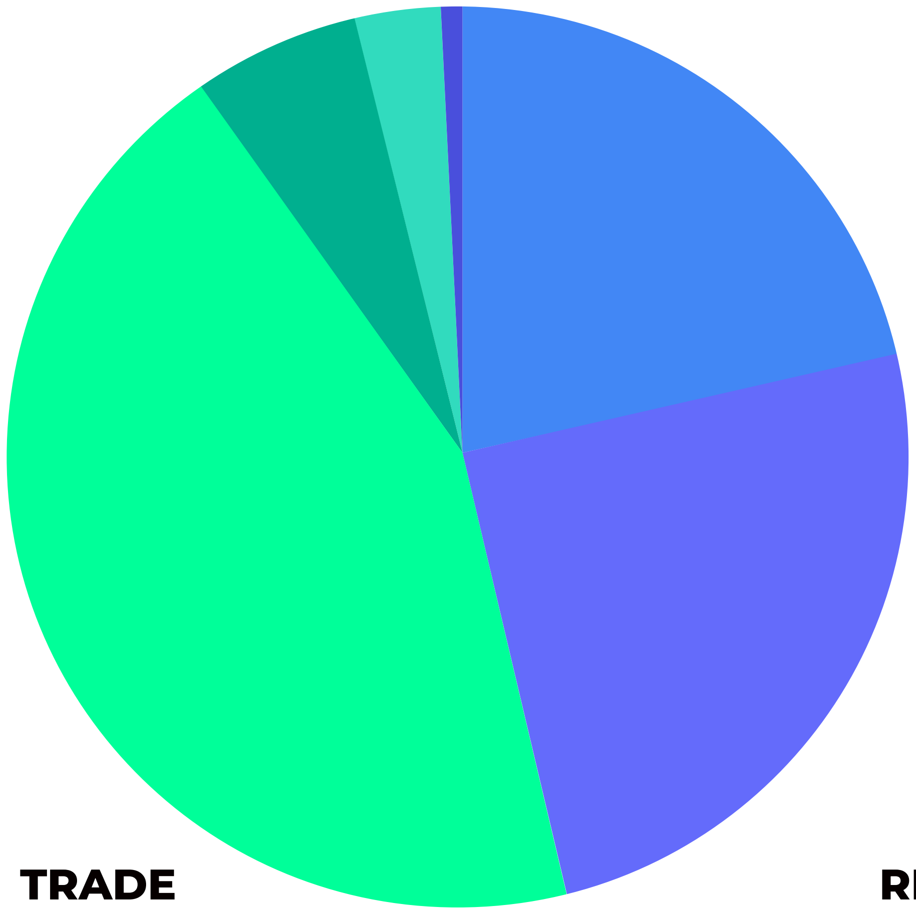
Once all the previous steps are completed, the production starts. Depending on the IP, the faction and the exclusivity of the model, it will be produced under the Forge World or the Citadel brand, either in resin or in plastic.
Games Workshop employs an injection moulding process to produce its plastic miniatures and, in order to incentivize both the painting and the customization of its products, uses a monochromatic grey plastic.
To facilitate assembly, each model comes with an instruction manual, while the cardboard box is used to show various options. On the front the product is shown assembled, painted and placed in front of a background. On the back are shown the optional ways to assemble the model itself. In some cases, especially with models of a faction divided in different subfactions, on the back is possible to see various different ways to paint the miniatures, in order to reproduce the colour palettes of said subfactions. (Image. 18)

Problems and Solutions

The long manufacturing history of Games Workshop has as a focal point the change of materials used in production. While the previously mentioned change in mould material was needed to maintain the quality of products for higher production volumes, it was also necessary because of the erosion of the silicon moulds caused by the materials adopted. The molten pewter damages the moulds with time because of its initial high temperature. The resin, instead, produces heat while curing. This causes the moulds to last only around 30 production cycles, then new ones were needed. This issue was not limited to the silicon moulds, but also affects the metal ones. This is why the resin products, even if with sharper details, are limited to the Forge World brand. Thanks to the high prices and exclusivity, these products are not in a high demand similarly to the plastic models. The Polystyrene model, as an added bonus, have a much faster production cycle, since are produced via injection moulding, which includes a cooling phase, which is not available for the productions with resin.
Another issue that is limited to resin products are the deformations and damages that may occur to the model during shipping. The resin is much more brittle than plastic and often softens during long travels. This may cause warping during transportation and often extra work is needed by the model builder to straighten back the components. Luckily, this can easily be done by warming up the resin. In order to help the model builders with its resin products, Games Workshop has a free online document called “Working with Resin Miniatures” [15] that details all the steps and the tools needed to clean up any defect that occurred in the model.
One step that is particularly necessary for resin models, independently to warping or other possible issues, is the washing of the components of the model. This step is needed because the models have a slight glossy sheen on them, caused by the release agent used to remove the parts from the moulds. To clean them is enough to soak them in warm soapy water for a few minutes, followed by a thorough scrub with an old toothbrush or similarly soft bristled tool.

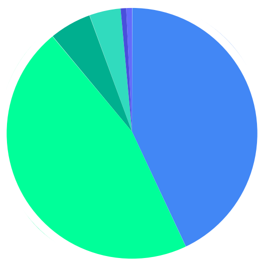
EXTERNAL CORE REVENUE

EXTERNAL CORE REVENUE



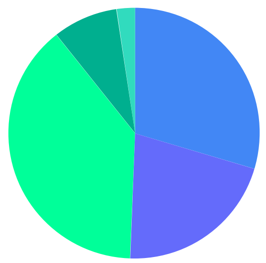
United Kingdom	83,4 £m (21,6%)
Continental Europe	95,6 £m (24,7%)
North America	169,7 £m (43,9%)
Australia & New Zealand	23,3 £m (6,6%)
Asia	11,8 £m (3%)
Rest of the world	3 £m (0,8%)
Total	**368,8 £m**

TRADE



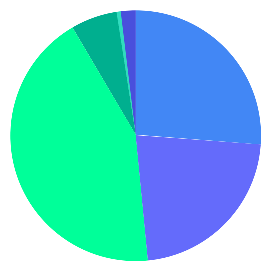
UK & Continental Europe	90,4 £m (43,0%)
North America	96,5 £m (46,0%)
Australia & New Zealand	11,4 £m (5,4%)
Asia	8,5 £m (4,0%)
Rest of the world	1,6 £m (0,8%)
Black Library	1,6 £m (0,8%)
Total	**214,3 £m (55,4%)**

RETAIL



United Kingdom	25,7 £m (29,5%)
Continental Europe	18,5 £m (21,2%)
North America	33,6 £m (38,5%)
Australia & New Zealand	7,3 £m (8,4%)
Asia	2,1 £m (2,4%)
Total	**87,2 £m (22,5%)**

ONLINE



United Kingdom	19 £m (26,1%)
Continental Europe	16,3 £m (22,4%)
North America	31,4 £m (43,1%)
Australia & New Zealand	4,4 £m (6,0%)
Asia	0,4 £m (0,5%)
Rest of the world	1,4 £m (1,9%)
Total	**85,3 £m (22,1%)**

Economic data extrapolated from Games Workshop Group PLC Annual Report 2022, section “Business model and structure”, page 67

Economic Analysis

Analysing the revenue of Games Workshop in the year 2022, it is possible to notice how the main external core revenue comes from the sales in the North America region. Followed by Continental Europe and by the United Kingdom, these three regions together cover almost 90% of the total external core revenue of the company.
Analysing the revenue for Trade (the sales through third-party retailers), this trend remains constant, with the United Kingdom and Continental Europe market covering43% of the trade revenue (£90,4 million), while the North America region accounts for 46% of the revenue (£96,5 million). In the Trade revenue the Black Library sales account for 0,8% of the total, around £1,6 million.
In the Retail revenue, is possible to notice that the United Kingdom region and the North America region are closer in percentage, 29,5% and 38,5% respectively, when compared with the previous data-
Finally, the online sales revenue keeps the difference constant, with the three previously mentioned regions still accounting for more than 90% of the revenue.
In all the revenue areas, the regions where there is less demand of Games Workshop products are the Asia region and the “Rest of the World”, which accounts zones where there are no first-party Games Workshop retailers [7].

Future objectives

Games Workshop has a few objectives for the future.
The first is to mitigate a decline in the gross earning of around 2% (£8 million). For this, they are foreseeing an increase in product prices on the existing range of around 5%. Even if they will absorb part of the cost pressure internally, and only increase prices for the newly released products, it is foreseen that increasing the prices on a larger scale will be needed.
Other than that, the company will also complete a project that will develop a new finished goods warehouse near Nottingham and a new ERP (Enterprise Resource Planning, a management software that integrates all business processes and all relevant business functions, such as sales, purchasing, warehouse management, finance or accounting) system.

In order to grow in terms of retail stores, Games Workshop is planning to open 21 additional stores: 15 in North America and 5 in Europe, in France, where the sales registered a successful year.
In addition to that, Games Workshop is planning to open their first large store in Japan, the Warhammer café in Tokyo [7].

Recently, Games Workshop has also announced an initiative that offers to recover the empty runners from the model makers, in selected stores all around the United Kingdom.

Games Workshop

HISTORICAL OVERVIEW

1970-1980

Games Workshop history is very interesting, since it follows the growth of a company born of three friends and the evolution in materials used in the miniature and models industry [16].

In 1975 Games Workshop was born in London.

Two years later, in 1977, the first number of the magazine White Dwarf was published.

In 1978 the first physical Games Workshop store was open. At the time, they were selling traditional board games, like Backgammon.

In 1979 the first original Games Workshop miniatures was produced. They were nameless characters made in pewter, designed to be used other roleplaying games.

In 1983 the first edition of Warhammer was published, creating a new hobby.

In 1986 the first Sci-fi miniatures were produced and amongst them, the Space Marine, to this day the face of Warhammer 40'000.

In 1987 the first edition of Warhammer 40'000 was published, called Warhammer 40'000 Rogue Trader, thanks to the popularity of the Space Marine.

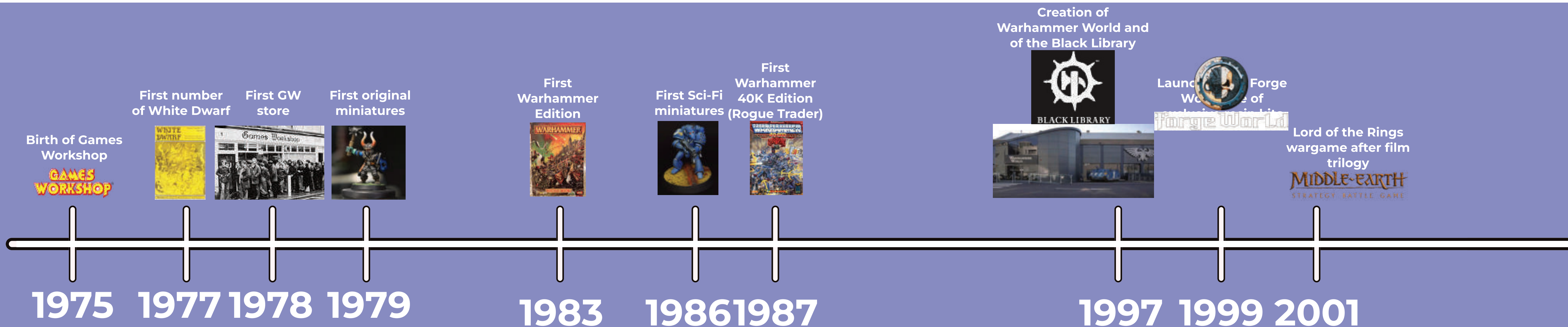
1990-2000

In 1997, Games Workshop's head office relocated to the Nottingham, in search for room to grow. Together with the new offices, the Warhammer World visitor centre was created in the process.
In the same year, the Black Library publishing company was created, to produce fiction set in the universes of Warhammer.

In 2001 a wargame based on the movie trilogy of Lord of the Rings was published, Middle Earth.

In 2004 the computer game Dawn of War, developed by the studio Relic managed to bring to life the tactical wargames set in the Warhammer 40'000 universe.

In 2007, thanks to the advances in mould making and design technology, Games Workshop was able to start producing new bigger and more complex models, like the "Baneblade" tank, previously present only in the books.



2010-2020

In 2013, based on the popularity of the Horus Heresy novel series, Forge World brought the battles from the dawn of the Warhammer 40,000 setting to tabletops for the first time.

In 2015, the Warhammer Fantasy universe was rebooted into Warhammer Age of Sigmar.

In 2016 the online Warhammer Community site was published, which provided a central hub for news and articles on every aspect of the Warhammer hobby.

In 2017 the 8th edition of Warhammer 40'000 was launched, which brought a large number of new and more complex and detailed miniatures

In 2020 the 9th and latest edition of Warhammer 40'000 was launched.

Production Processes

INJECTION MOULDING

Introduction

Injection moulding has a very long history. Being the most used technology for mass production of plastic products, injection moulding has been developed for a very long time.
The first injection moulding machine was developed in 1872 by the brothers John and Isaiah Wesley Hyatt. This machine was relatively crude in comparison to machines in use today, working like a large hypodermic needle. It used a plunger to inject melted plastic through a heated cylinder into a two part mould. The industry progressed slowly over the years, developing more and more complex products, which required more and more complex moulds and injection technologies.

More than 70 years later, in 1946, American inventor James Watson Hendry built the first extrusion screw injection machine. This machine worked thanks to a rotating screw, which gave much better control over and injection speed and therefore better quality of the articles produced. While the plastic pellets have always been melted during the process, the rotating screw helped the heater bands in the heating of the plastic due to the friction, thus reducing energy usage.

In 1956, W. H. Willet patented the reciprocating screw plasticator. This was the next development of the extrusion system. In this system, the screw moves backwards and forward during the mould cycle. After mixing, the screw stops turning and pushes forward, acting like a plunger. This helps injecting the material in the mould. During plastication, the screw moves backwards against the hydraulic back pressure [18].

Screw machines nowadays make up approximately 95% of all injection moulding machines. This production method allows for quick and efficient production processes and is ideal for large production volumes.

Process

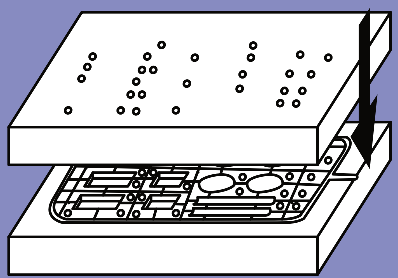
Before starting the production process a mould is needed. The moulds are made in metal (from 1990 Aluminum is widely used). These moulds are machined following the designs sent by the customers of mould making companies. This step is usually the biggest investment in the production process. The moulds can cost tens to hundreds of thousands of dollars, and the more details are required, the higher the cost. An important element that all moulds have are dedicated cooling channels, which are drilled in a way to avoid damaging the details carved in them.
In this step the waste produced are metal shavings, which can easily be recycled.

Once the moulds are ready, they get placed in the injection moulding machine. The moulds are clamped shut, in order to avoid as much as possible material leak out when still molten. The clamp has also the function to release the hardened plastic from inside the mould in the opening step.

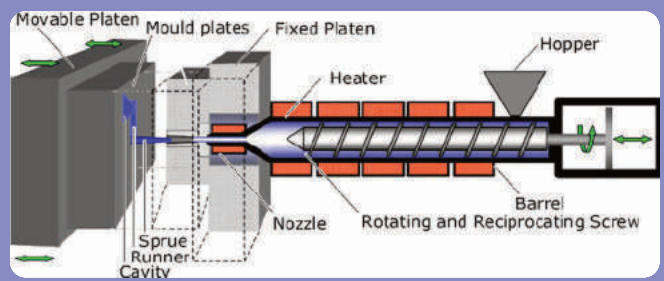
Once the mould is secure and closed, the injection moulding process can start. The plastic pellets are fed using a hopper into a heated barrel with a reciprocating screw. The screw turns, feeding the next shot to the front screw. The importance of the reciprocating screw is enormous: in the first examples of injection moulding there were issues of uneven temperature in the plastic. At the center it often remained too cold, and not completely melted, causing issues in the finished products and difficulties in obtaining constant quality. The introduction of the screw allowed the material to be pushed towards the heater bands around the barrel, ensuring a constant heating of the material.
Initially, the mould cavities were fully packed, keeping constant pressure. This, though, caused large variations of dimension between cycles, since it was difficult to maintain an identical pressure between cycles.
In the '90s, the company RJG Inc developed decoupled moulding. This system consists of filling 98% of the cavities at full speed controll, with little to no pressure limitations. Then the process switches to pressure control, filling the mould (packed out mould) at a constant pressure. This reduced the dimensions variations to thousands of an inch [19].

Once the cavities of the mould are completely filled, the mould is cooled using a coolant fluid passing through the cooling channels mentioned before. These channels often have a complex shape, in order to cool the whole mould evenly.

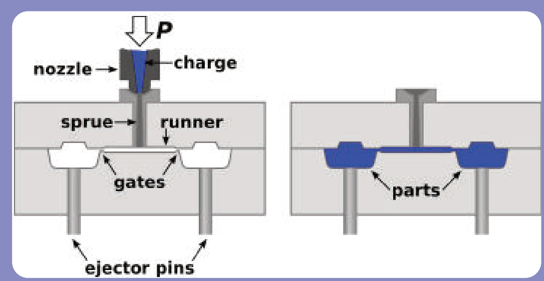
Closing of the moulds



Injection of the polymer



Mould filling



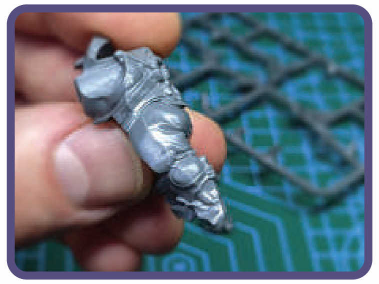
Once the mould and the plastic are cooled, it is time to remove the product. This is a very delicate passage. As the mould opens, the volume increases without introducing air. This creates a strong suction that holds the mould together. This is why the clamp has also the function of opening the mould. Initially, the two parts of the mould are distanced by a few millimeters, in order to allow the air to enter the gap, eliminating the vacuum. Then, the mould quickly opens the rest of the way, allowing the plastic to be removed. The slow opening is required to avoid any damage to the mould, since it has very high costs.
Removing the plastic can be difficult. When the material cools down, it shrinks and become tightly stuck to the mould. To push the part off the mould, ejector pins are built in the mould. These are contact points with the plastic that are flush with the half of the mould that the clamp moves, but are not perfectly aligned: sometimes are protruding, sometimes are slightly dented. In order to avoid leaving marks on the model kit parts, each runner has dedicated places where the plastic comes in contact with the ejector pins.
Finally, the “sprue” is removed from the runner. A sprue is the section of plastic that connects the injection unit to the mould. This is the only post-processing needed and it can be done by hand or by machine, but is generally very quick and cheap [8, 9, 20].

Process

Being a very precise production process, the production waste that comes from it is mainly caused by human mistakes. Usually it consists of the sprues, but also defective products, especially when the plastic is not injected or heated properly.
In total, the production waste from start to finish counts the metal shavings from the mould production, plastic scraps, cutoff sprues and defective products. All of the production waste is recyclable [21].
In terms of user waste, it will consist of empty runners once the model kit is assembled and the packaging the product came in. This can consist of cardboard boxes and there could be plastic bags, depending on the producing company. For examples, BANDAI SPIRITS bags the runners before putting them in the box, while Games Workshop does not.
This production process requires very high investments, both in terms of moulds and in terms of machinery. Because of this, it is nearly impossible for a private owner to adopt.

Defects

The defects of the injection moulding production process can be divided in unavoidable and avoidable.
The only unavoidable defects are mould lines. These thin lines are present on the surface of the model kit and depend on the positioning of the part on the runner. If the parts are placed in a certain way, the lines are almost invisible or are a non-issue. For example, if a thin panel can be placed parallel to the mould connecting point, the mould lines will be on the thin sides. If it is placed perpendicularly, the mould lines will appear on the larger surface, often on top of some details. Mould lines can generally be removed by sanding or scraping with a hobby knife, therefore it is important to plan carefully the placement of the parts of the model on the runner correctly, in order to reduce the impact of mould lines to a minimum. (Image. 19)
The avoidable defects can happen because of mistakes before and during the process. Examples of mistakes before the injection would be designing the runner without considering properly the flow of the material, like making the channels too thin, or errors during the machining of the moulds or even bad positioning of the components on the runners and of the sprue channel.
During the process, heating too much or too little the material, injecting the plastic too quickly or too slowly, using too little o too much material can cause defects like flashes, burn spots, sink marks,... Another issue could be the presence of foreign materials, which would ruin the process completely. (Image. 20)



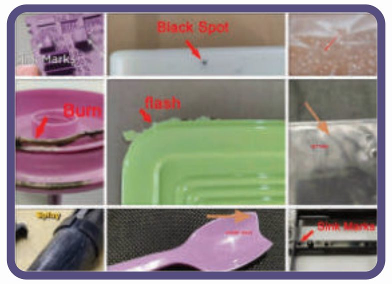
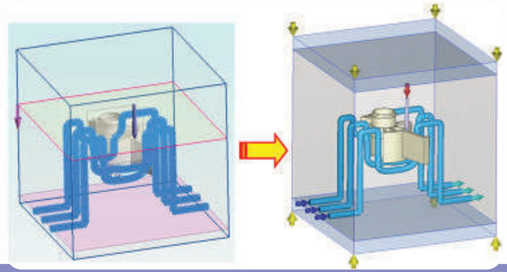
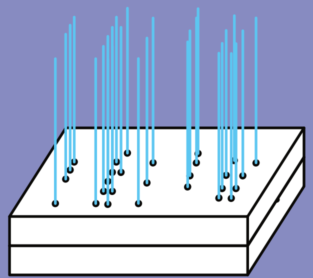


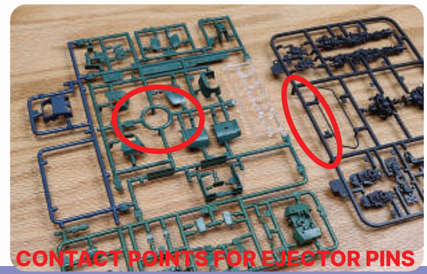
Image 19. Example of mould lines
Image 20. Examples of various defects during production

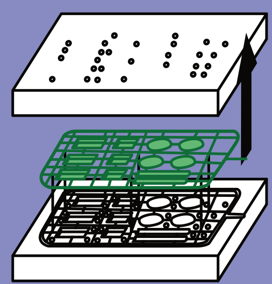
Cooling of the mould



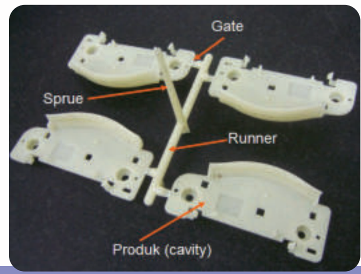


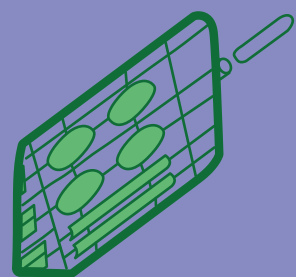
Opening of the mould and release of the runner





Removal of the sprue





Production Processes

VACUUM FORMING

Introduction

Vacuum forming has been developed since the 1950s, when a “machine for making articles, such as display covers from thin plastic sheet material” was patented. This was followed by a series of vacuum moulding machines, until a “plastic sheet vacuum forming machine” was finally perfected and patented in 1964.
All these thermoplastic and vacuum forming machines started from an older concept of using vacuums in any kind of casting or moulding process to remove excess air. Trapped air creates weak spots in mouldings which can quickly break; applying a vacuum completely took the air out and ensured a perfect result every time.
In the 1970s the technology was being developed into machines very similar to the current methods, with a patent in 1974 for “An improved vacuum moulding apparatus for forming plastic signs, with a heater which can be pulled over a sheet of plastic held in a frame to soften it, a forming bed on which moulds are placed including an upwardly extending edge, a vacuum system for removing air from the space between the bed and a softened sheet and means for raising and lowering the frame and sheet with channels for guiding air flow out of the system so that the sheet is quickly pulled onto the mould."
Since then the deveolpments of the technology have been focused towards perfecting the methods and equipments, especially for higher outputs and uniformity, with a large range of plastics and thermoplastics [22}.

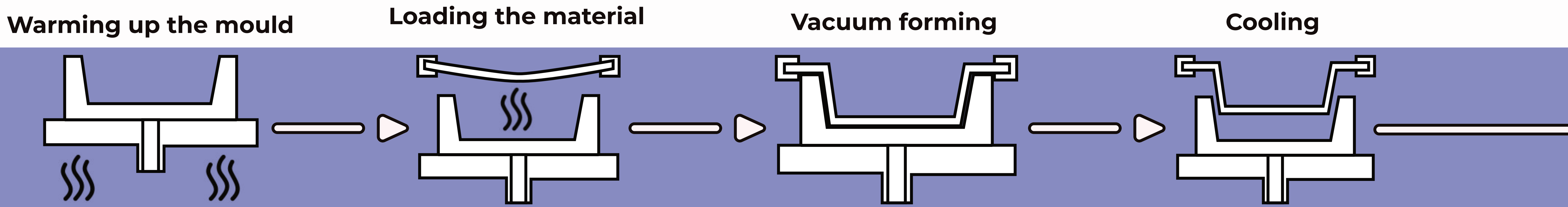
Similarly to injection moulding, vacuum forming is mainly used in the industrial sector and the technology has been updated in order to guarantee a large production volume.

Process

Similarly to injection moulding, vacuum forming is a production process that involves the use of a mould. In this case, though, it is not a two-part mould, but is enough to use a male or female mould. Thanks to the vacuum that is used to adhere the material to the mould, it will take the shape needed without requiring a secondary part of the mould to contain the material.
While the design is essential, the production of the mould can happen in three different ways.
The moulds made by casting aluminum are made in foundries, with temperature control lines, have many applications and are generally expensive.
Moulds made with machined aluminum have the same properties of the cast aluminum ones, but are made with CNC machines and are usually used to produce shallow parts, made out of thin sheets of material. These moulds are very expensive too. The process to produce these moulds has waste in the form of metal shavings, very easy to recycle.
Finally, composite moulds are made out of filled resin, which starts as a liquid, then hardens with time. Depending on the use, they can last very long and can produce high quality components. These moulds are usually cheaper than aluminum ones.

Once the mould is ready, the production process is very simple and straightforward.
The first step is the heating of the mould. Then the material, in roll or sheet form, is loaded on to the vacuum forming machines material carrier.
Heaters, located above the sheet, warm up the material until it softens. Thanks to a levelling device, the material is supported with air.
The mould is raised to meet the bottom surface of the sheet of material and a vacuum of air is applied. This draws the sheet over the shape of the vacuum forming mould.
The plastic is cooled with air to set hard. The vacuum forming can be removed by hand or with the use of air to carry out any necessary secondary operations [23].

There are five different finishing methods that can be used to complete the production of a vacuum formed component [24].
The first one is called guillotining. This methods is the simple cutting away unnecessary material. It does not require a special cutting tool to be made for an individual product and is therefore suitable for low volumes of parts where straight lines are no problem. This approach, though, is too slow for projects with larger quantities.



Process

The second method is drilling. This method consists in drilling simple round holes and is particularly indicated for smaller production volumes, especially if done by hand. Guides can be used to ensure holes in the right positions
Another method is roller cutting. This uses a custom made cutter that detaches the items made from the sheet. It can even punch holes. Roller cutting is suitable for fairly large items, where precision alignment is not required. As the vacuum formings and the cutter are rolled sideways through the roller cutter machine, some misalignment can occur. Roller cutting can't be used for making holes or features in the sides of vacuum formings, as the cutter tool always cuts vertically from the bottom.
The fourth finishing method is called press cutting. This is a very precise method of cutting which uses a press and a custom precision made cutting tool. This method is very suitable for items where the roller cutting process wouldn't achieve the precision required. It is often used for punching very small finished items out of a plastic sheet, rather than punching features into a product. Press cutting can't be used to make features in the sides of vacuum formings.
The final finishing method is CNC cutting. This process is a very precise method of creating holes & features. The real advantage is that it can be used to create features in the sides of vacuum forming, like guide rails. It can also cut sidewalls of a different depth than the pockets, which is something that cannot be done with roller or press cutting.
Not all the finishing methods are applied to a single product and only the necessary ones are chosen. For example, the ability of CNC cutting of working on the sides of a finished piece can be combined with the precision of press cutting if necessary.
Similarly to injection moulding, the production waste amount to metal shavings from the production of the moulds and the plastic scraps from the post-production of the products. Again, all the waste is recyclable.
Also the user waste is similar: again the packaging and the scraps that come once the components are cut away.
This production process is more adoptable by private owners, but the vacuum forming machines open to the public have limited dimensions and suction power. Generally, the bigger and more powerful the machine, the more expensive it is.

Defects

There are a few defects that can emerge from vacuum forming.
Bubbles, for example, are present if the material absorbed any moisture. That moisture can expand from heating, forming bubbles in the plastic inner layers, thus weakening it. It is solvable by drying the material at high but sub-melting temperatures. (Image. 21)
Another defect can be webbing. This appears on the formed plastic when it is overheated, if the mould used is too large or if the parts to be produced are placed too close to each other. (Image. 22)
A final issue are the formed object sticking to the mould. This usually happens if the shape of the parts on the mould does not have a slight draft. It is easily avoided, though, since the moulds are often designed with a draft angle of 3° or more. (Image. 23)

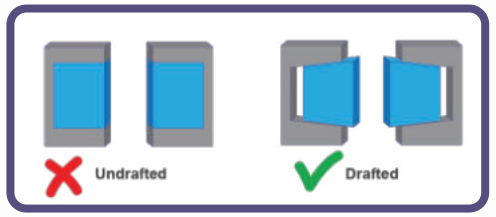
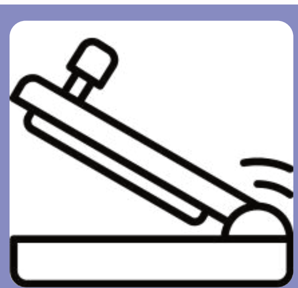


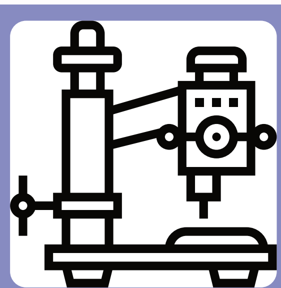
Image 21. Example of bubbles
Image 22. Example of webbing
Image 23. Difference between drafted and undrafted parts

One of five finishing methods

Guillotining

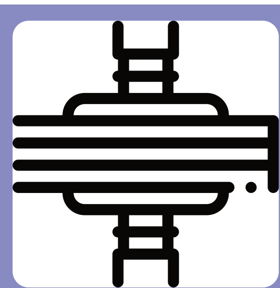


Drilling

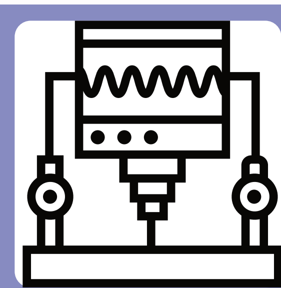


Roller cutting

Press cutting



CNC cutting



Production Processes

RESIN CASTING

Introduction

Resin casting is a technology that has seen many applications, both in and outside the model making industry. This process allows for the production of highly detailed components, but the long curing times needed do not allow for industrial production volumes comparable to injection moulding or vacuum forming. This process is the most available of the four to be adopted by privates: the moulds can be made out of silicone and the majority of the costs come from the resin itself.
One of the issues that come from resin casting are the curing fumes that are generated during the curing process. These are toxic, so it is always suggested to use a respirator while casting and doing so in a well ventilated area. For the same reason, it is advised to use a respirator when working with cured resin, since the dust is toxic as well.
This process is often used by model makers to avoid buying more copies of the same product more than once. This is also used by unauthorized resellers to cast multiple copies of model kits and selling them online.
Thanks to the low costs of the silicone and the ease to find of the resin, this production process is very feasible for almost anyone.

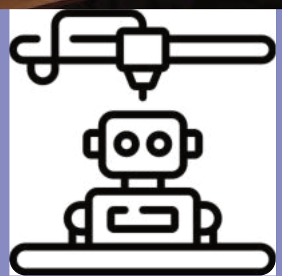
Process

The first step in the resin casting process is the creation of a prototype. This can be made in various ways, like using two-part epoxy to sculpt it. This prototype is then used to make a two part mould. Using materials like silicone, the mould is made taking care to include a channel to pour the resin. An important step is to check that the mould took in all the details of the prototype and to check if any residual material is present. The moulds can be completely closed, open at the top, rigid or flexible. Moulds made with silicone or other vulcanized rubbers will have a low production cost, but will last a limited number of cycles.

The next step is the resin mixing. The resins usually used in this process are Epoxy resin, general-purpose Polyesters, Polyurethanes, Phenilic resins and Allylic ester resins.
Epoxy resins are the most popular, thanks to their properties: they are versatile, have low cure shrinkage, excellent adhesion, are compatible with many materials, are resistant to weather and chemicals and are able to cure under adverse conditions.
General-purpose Polyesters, when blended with other monomers, like Polystyrene, will produce rigid, rapidly curing transparent castings.
Polyurethanes are influenced by the curing agents, which affects the curing characteristics and final properties.
Phenolic resins are available as syrupy liquids. When blended with a chemical active hardener, can be cast and cured in moulds made from various materials.
Finally, Allylic resins possess excellent clarity, hardness and colour stability and are often used to cast optical parts. They do present some issues, though. Their curing phase causes monomer shrinkage and the exothermic control is hard to keep in check.
The curing agents used normally in resin casting are Amines, Anhydrides, Phenols and Thiols [10].

The most common and simplest method to cast the resin in the mould is called gravity casting, where the liquid resin is poured in the mould and pulled in all the details and parts by gravity.
One thing to keep in mind is the presence of bubbles in the mixed resin. When the resin and the curing agent are mixed together, bubbles tend to form. These can be removed in a variety of ways, like using a vacuum chamber or in a pressure pot. In the first case the bubbles are extracted, while in the second they are reduced in size, to the point that they are not visible. Specialist equipment can enable closed moulds to be filled whilst under vacuum, a process known as resin vacuum casting, where air and gas bubbles are completely removed from the cast part. Pressure and/or centrifugal force can be used to help push the liquid resin into all details of the mould. The mould can also be vibrated to expel bubbles.

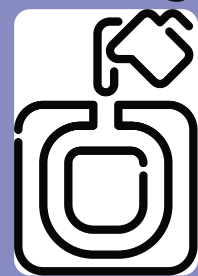
Prototyping



Moulds

Resin mixing

Pouring



Process

Once the resin completes the curing process, it can be removed from the mould. Even if all the precautions possible were taken, some finishing touches are always needed. This is particularly necessary with flexible moulds, since in many cases they are not perfectly air-tight and defects, like flashes and blisters can happen. One defect that is almost always present are mould lines, which can be much more apparent than in injection moulding. Comparing the two production processes it is possible to notice that they are at the opposite ends of the spectrum when it comes to initial investments and post-production processing: resin casting is very cheap, while injection moulding requires high initial investments. When it comes to post-production, resin casting requires much longer times and, therefore, higher costs (especially since it will mostly be done by hand), while injection moulding requires almost no post-processing and is ideal for industrial production volumes.
Resin casting is a process that holds a few production waste, most of which are not recyclable. Any uncured resin that may be still in the mould would be reusable, while cured resin either from the post-production finishes or from defective products, is not. This is because the curing cycle is not reversable, keeping the resin in solid form.
The user waste is similar: the packaging the product came in will be most likely recyclable, while the water used to clean the model and the empty runner will not.

Defects

As stated before, resin casts can present various defects. Mould lines are very common, while things like flashes and bubbles are caused by human errors, usually during the mixing of the resin. These defects often cause loss of details.
On some productions of larger pieces the gates are still attached to the part. This is an issue, since the material needs to be removed using a hobby saw, creating dust and more work for the final user. Also, as stated previously, resin dust is toxic, therefore the user will need additional equipment in order to better deal with the gates [15].
(Image. 24, 25, 26)

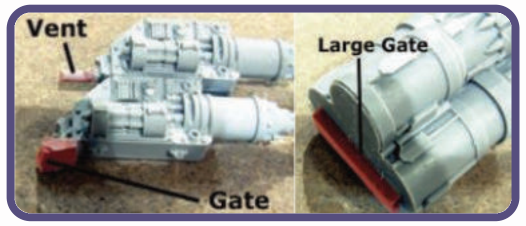
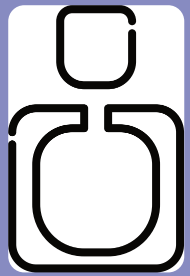


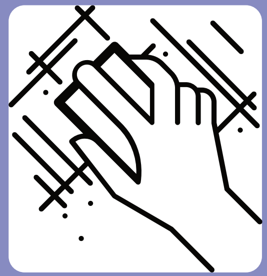
Image 24. Example of mould lines
Image 25. Example of a flash
Image 26. Examples of gates

Bubble removal

Extraction



Sanding



Finishing touches

Production Processes

3D PRINTING

Introduction

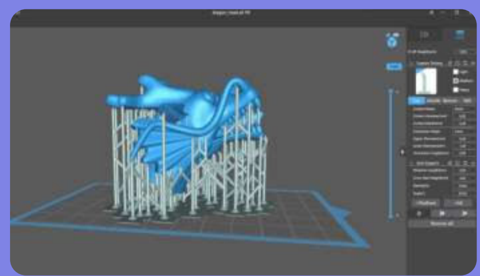
3D printing is an excellent example of additive manufacturing and has a very long story of development of the technology. Born in the ‘80s as a form of rapid prototyping the technology has evolved to the point that is used also to produce finished products [25]. While its long printing times are still a limitation that stops it to become more utilized as an industrial production process, 3D printing still has a very important place in various industries as a prototyping technology. In the model kit industry it is starting to cover both functions. As of now its printing times make it a technology more apt to low production volumes, the level of detail of the machines is rapidly reaching the quality of injection moulding and resin casting.
It is also available to private owners, especially since plug-and-play machines are becoming more and more common. Interestingly enough, resin 3D printers are the most common plug-and-play machines, since often the FDM (filament deposit technology) come unassembled, with detailed instructions.

Process

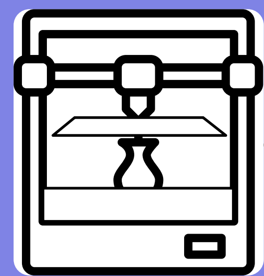
The process to prepare a 3D print starts from the digital development of the model to print. The model will have to be already divided in its components, in order to facilitate the printing process. Another important precaution would be to give each part a flat surface. This surface will be in contact with the printing bed, so that the component will have a solid contact point with it.
Once the file has been modelled, it will be exported as a STL (Standard Tassellation Language) file. This type of file is a CAD file format for additive manufacturing that stores data based on triangulations of the surface of CAD models.
The STL file is then loaded in a “slicer” software, which allows the user to define various settings for the printer to follow. Some of these settings are the layer height, the thickness of the walls, the percentile of filling and the preparation of the supports that hold the model parts. Once all of the parameters have been set, the file is saved as a G-code format file and can be loaded in the printer.
The printer is prepared before starting the print itself. The majority of industrial model kit printers work with a photopolymer resin, which is cured layer by layer with UV light.
The key preparations for the printer are the levelling of the build plate, crucial in order to obtain correct prints, the cleaning of the build plate and filling the printer vat with resin.
The 3D printers that use UV light and that are most common (especially the versions that are available to private owners) work with a printing bed that gets submerged in the resin vat, then slowly rises. This technology is called Stereolithography. The process makes so that the print will be “upside down”, with the UV light source that draws the pattern of each layer. These layers are codified during the slicing of the digital file: the slicer software “cuts” the 3D model in order to give the data to the printer for each layer. The UV light cures in real time the resin and solidifies it. Thanks to the moving build plate, the uncured resin covers the previous layer, allowing the UV light to cure the next one. This process continues until the print is completed.
Once the print is complete, the model can be removed from the build plate. It will need two forms of cleaning: the first, and most immediate one, is the removal of the supports that helped the construction of the components. The second type of cleaning is needed to remove excess uncured resin that stuck on the model. This type of cleaning can be done by hand, in a tub with warm soapy water, or using a cleaning station, which will use vibration to detach the uncured resin.
The last step is another curing phase. This is needed to strengthen the model and completely solidifies the resin. Usually this phase is done with an external curing station, which exposes the model to UV light, but can be done by exposing the model to the sun for a few hours [26].
All in all, the process is very straightforward, especially if the digital model used has been bought or in general obtained without needing to model it.
When it come to both user and production waste, the situation is very similar to resin casting: any uncured resin can go back in the production cycle, while cured resin is not recyclable. Any liquid used to clean rinted parts does not become recyclable waste and, while it is not necessary to replace it with every washing cycle, it is necessary to bring the water to a water filtering center, rather than throwing id down the sink [27].

Design

Slicing



Loading



Defects

The majority of defects that the model can have are usually caused by the resin not curing properly, bad preparation of the printer, like unlevel build plate, incorrect slicing, insufficient resin in the vat...
The resin not curing can cause holes in the print and defects that can spiral out of control, since there is the risk of the subsequent layer lacking a solid support.
An unlevel build plate can have similar effects, other than obtaining prints that are skewed and crooked. Similar effects can be had with the presence of foreign objects on the build plate, since they would not allow the printed layers to be flush on the plate.
Incorrect slicing and issues in the digital model can cause any sort of problems: walls too thin will mean that they can’t support themselves or elements that stand on that component; the lack of a flat surface in contact with the build plate may mean difficulties for the printer to develop the piece entirely, since the model would risk not being able to stick to the build plate. Incorrect slicing can also cause a webbing effect similar to the one seen in vacuum forming, especially with 90° angles [28].
(Image. 27, 28, 29)

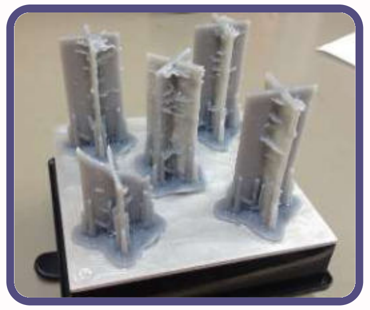
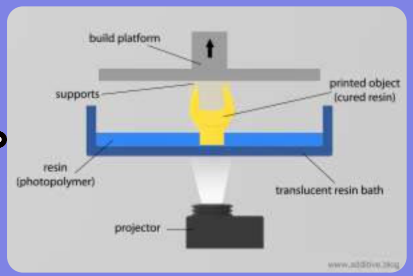


Image 27. Examples of webbing on the model
Image 28. Example of parts of the model not printed
Image 29. Example of hole caused by uncured resin/thin walls

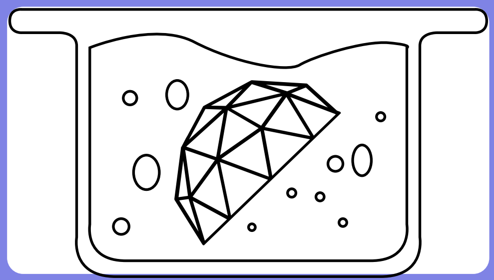
Issues

3D printing presents a few issues. As stated before, there is mandatory post-processing, but in general it takes a relatively long time to complete the print. It obviously depends on the size of the model, but the slicing parameters can heavily influence the print times. The quality is not always constant and, similarly to resin casting, it is impossible to check the results before the process is finished.
In addition to that, 3D printing presents a few health hazards, since the resin used releases toxic fumes during curing. While all resin 3D printers present a transparent lid that helps reducing the exposure of the user to the fumes, it is always suggested to use a respirator and print in ventilated areas.
Finally, resin is not easily disposable, especially when cured. Also, still liquid resin may not be filtered constantly, reacing an end point, which signifies the end life of that batch [29].

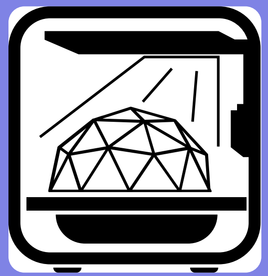
Printing



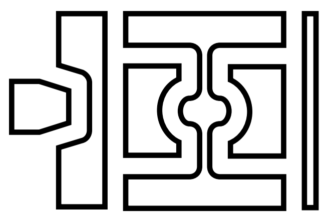
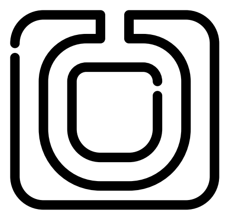
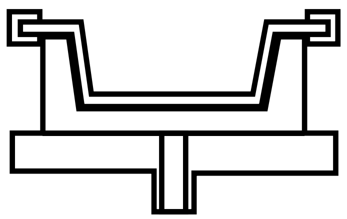
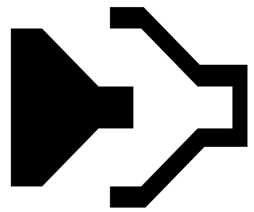
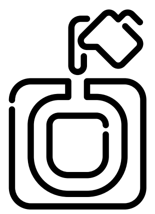
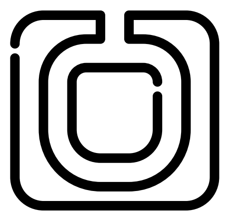
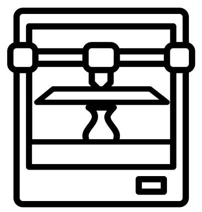
Washing



Curing



Production Processes Comparison

	MOULDS	PRE-PRODUCTION COSTS	POST-PRODUCTION WASTE	AVAILABILITY
INJECTION MOULDING 	 Two-part moulds	Highly costing moulds (which increases with details), highly costing machinery	Removal of sprues	Nearly impossible to do outside an industrial setting, this process is designed to produce a large number of products in a short time and both the machines and the moulds are enormous investments
VACUUM FORMING 	 Male or female mould	Highly costing moulds, depending on the material	Excess plastic trimming, using various tools, by hand	The material is easy to find, but the machine dimension is limited to its cost: the bigger, the more expensive it is
RESIN CASTING 	 Two-part moulds	Low cost for moulds (if silicone), material (like 3D pronting), prototype (like 3D printing)	Removal by hand of sprues and defects, sanding seams	Silicone and rubber moulds easy to make, relatively easy to mix resin. But requires more attention than 3D printing, especially to the fumes
3D PRINTING 	No moulds	Printer (cost fluctuates depending on the printer specifications), material (resin more expensive than plastic), prototype (even if digital, the cost increases with the details)	Washing, curing, removal of supports, mould lines and defects, all by hand	Great number of plug-and-play 3D printers, easy to access material and easy to access free 3D models. The post-production processes require additional equipment, but some, like the final curing, can be done with sunlight and patience

This chart puts the main points of each production process in comparison, in order to better analyse the differences between each process and the pros and cons of each one when comapred with the others.

	HEALTH HAZARDS	PRODUCTION WASTE	USER WASTE	TYPE OF PRODUCTION
INJECTION MOULDING	No health hazards caused by chemical reactions	• Metal shavings • Plastic scraps • Defective products (plastic sprues, badly printed runners)	• Empty runners • Empty packaging (plastic bags and cardboard boxes)	**Industrial production** • High initial costs, but low costs per finished product • Short production times per piece • Optimal ofr any size of production volume
VACUUM FORMING	No health hazards caused by chemical reactions	• Metal shavings • Plastic scraps	• Plastic scraps • Empty packaging (plastic bags and cardboard boxes)	**Industrial production** • Relatively high initial costs and higher costs post-production than injection moulding • Longer production times, mainly thanks to longer finishing touches • Higher costs per finished products
RESIN CASTING	Toxic polymerization fumes require good air flow and respirator	• Uncured resin • Defective products (badly printed cured resin parts)	• Dirty water from washing resin products • Empty packaging (plastic bags and cardboard boxes)	**Low volume production** • Easy preparation, but longer and more careful post-production processes • Long curing periods • Moulds last only a few casting cycles • More apt ofr made-to-order than mass production
3D PRINTING	Toxic polymerization fumes require good air flow and respirator	• Uncured resin • Defective products (badly printed cured resin parts)	• Empty runners • Dirty water from washing resin products	**Low volume production** • Longer preparation times, especially when 3D model is made from scratch • Long printing times, depending from size and resolution neede • Longest post-processing times • Production volume limited only by time and material available

▲
Image 30. Example of model kits. From left to right: T. Rex model kit in Limex, High Grade L-Gaim, Real Grade RX-78-2 Gundam, High Grade Aug
Image 31. Runners on which the model kits are sold. The 4 model kits components were placed on a total of 33 runners, 3 of which were for the Limex T. Rex

▼

Critical issues

Material Usage and Waste

As it was shown in this chapter, the model kit industry is variegated, both in terms of products and in terms of production processes.
There is, though, an issue common to all of them: the presence of excess material in the finished product. Whether this excess is from the supports of a 3D print or the runner of a injection moulded model kit, these components have their use more in the production process than for the customer.

While this issue is common in the industry, it would be more effective to focus on the plastic material and less on the resins. The reason for this is very simple: as stated before, injection moulding is the most common production process used in the model kit industry, since it allows for high production volumes and low production costs per unit, even considering the high initial investments. Since this process uses plastics and the most used is Polystyrene, analysing the issue of excess material becomes more effective when centred around this one.
Other than that, the fact that the resin dependent processes are much less adopted than the plastic dependent ones means that the overall quantity of excess material is minuscule in comparison.
Another reason for focusing on Polystyrene, and plastics in general, is the intrinsic issue of resin of not being recyclable once cured. This makes so that any effort should be focused on the development of solutions regarding a change in material or in production process and, as it will be explored in the next chapter, this presents quite a few issues for the smaller companies that employ resin casting or 3D printing.

The large usage of Polystyrene and the large quantity of material wasted in the runners is well known in the industry. The main challenge for dealing with the runners is the fact that not only they are produced together with the model kit components, but also that they are a necessity, since they correspond to the channels that the plastic flows into to reach each component. This makes so that the quantity of material wasted during the production is very difficult to reduce. Also, not many companies particularly care about this issue, since the material is cheap enough that the production costs do not increase excessively. At the moment, the only known company that is taking steps to both reduce the quantity of waste material in the runners and to recover and reuse said material is BANDAI SPIRITS. In addition to the innovations listed previously in this chapter, the Japanese company has noticed that around 2'000 tons out of the 7'000 tons used to produce Gunpla model kits are wasted runners [30, 31], around 29%. Considering an average weight for a Gunpla model kit to be 500 grams (still on the runners) and considering that in 2021 the company reached 700 million units shipped, it can be calculated that at least 350 million tons of plastic have been used from 1980 to 2021 to produce Gunpla model kits. If the 2'000 tons data has been calculated in average, it can be deduced that from 1980 to 2021 at least 98 million tons of the plastic used to produce Gunpla model kits was in the form of runners.

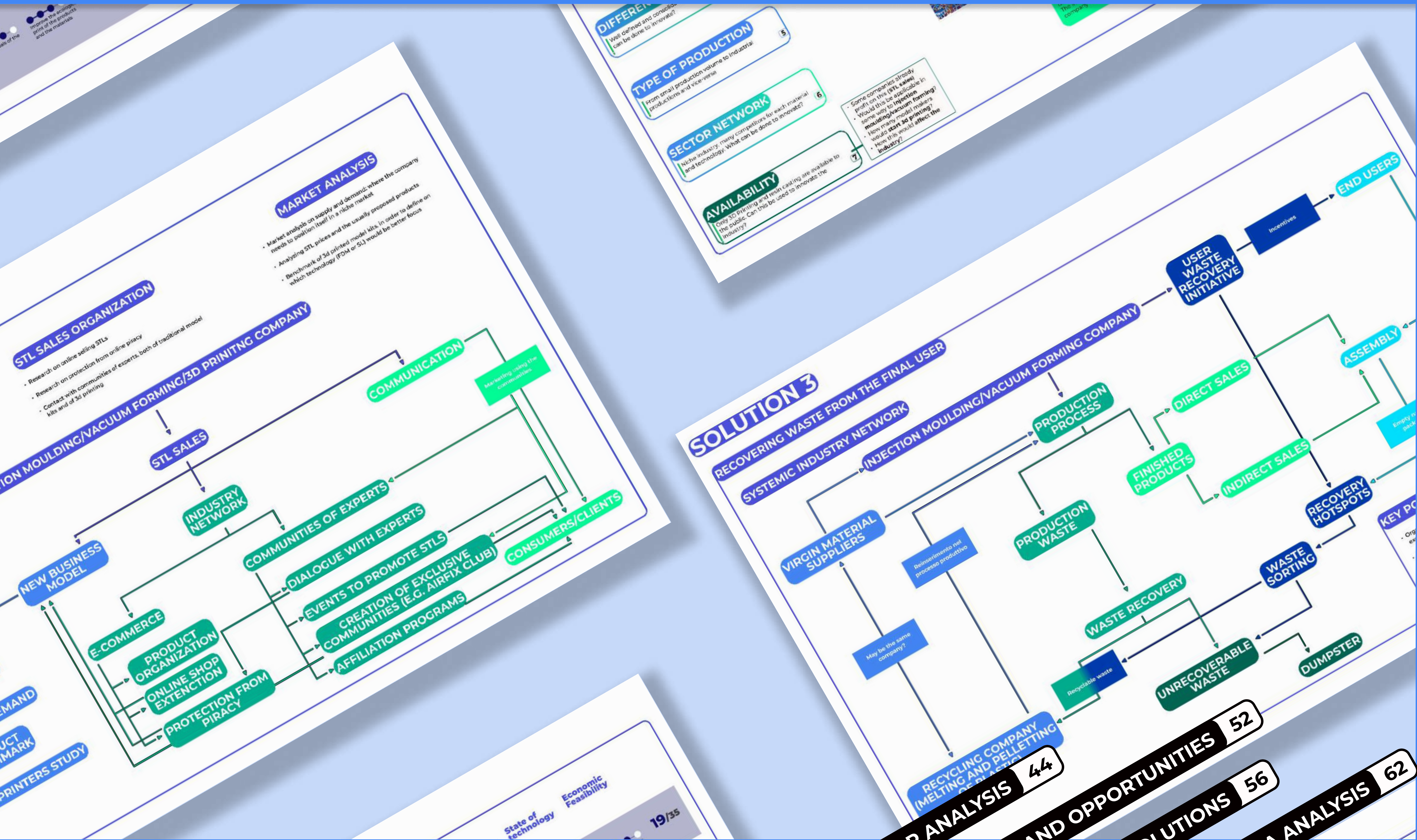
While this data was calculated on average, the weight of each model kit varies greatly between grades, even if on similar scales. For example, a High Grade model kit will be generally lighter than a Real Grade. This is because, even if they are both in the 1/144 scale, the number of components and runners is much different: a High Grade box will contain 6 to 8 runners, for a total of around 150 components. A Real Grade box, instead, will contain 9 to 10 runners, a difference between 2 and four runners, for a total of around 250 parts. An even bigger difference is present when considering the Master Grade, the Perfect Grade and the Mega Size. These grades correspond to the scales 1/100, 1/60 and 1/48 respectively. A Master Grade box contains between 15 and 17 runners, almost double the number in a Real Grade box, with 260 components. A Perfect Grade box contains 22 to 24 runners, up to three times the runners in a High Grade box, with 510 components. Finally, a Mega Size box contains the same number of runners of a Perfect Grade Box, but with fewer components than a Real Grade "only" 220. This shows the large difference in wasted plastic in the runners [6, 32].
In addition to this information, on the page on the left there are a few photos portraying some model kits built by the thesis student, each one with the runners that it came in side by side. In terms of weight comparison, the Real Grade RX-78-2 Gundam, scale 1/144, weights 54g, while the runners weight 162g. The two High Grade model kits weight 82 and 67g each, while their runners weight 123 and 155g. The T. Rex model kit, made in Limex, a material that will be analysed in depth in a following chapter, shows the lowest weight difference: the model weights 42g, while the runners 53g (Image 30, 31).
This comparison seems contradictory from the statement of BANDAI SPIRITS towards the amount of plastic in runner form, but there are a few factors to keep in mind. First of all, all of these model kits are in the smallest scale produced by the company. Second of all, all of the runners, independently of the grade and scale of the model kit, have the same diameter. This means that for bigger model kits, with mode and bigger components, the weight difference shifts in favour of the model kit very quickly, starting from the Master Grade series.

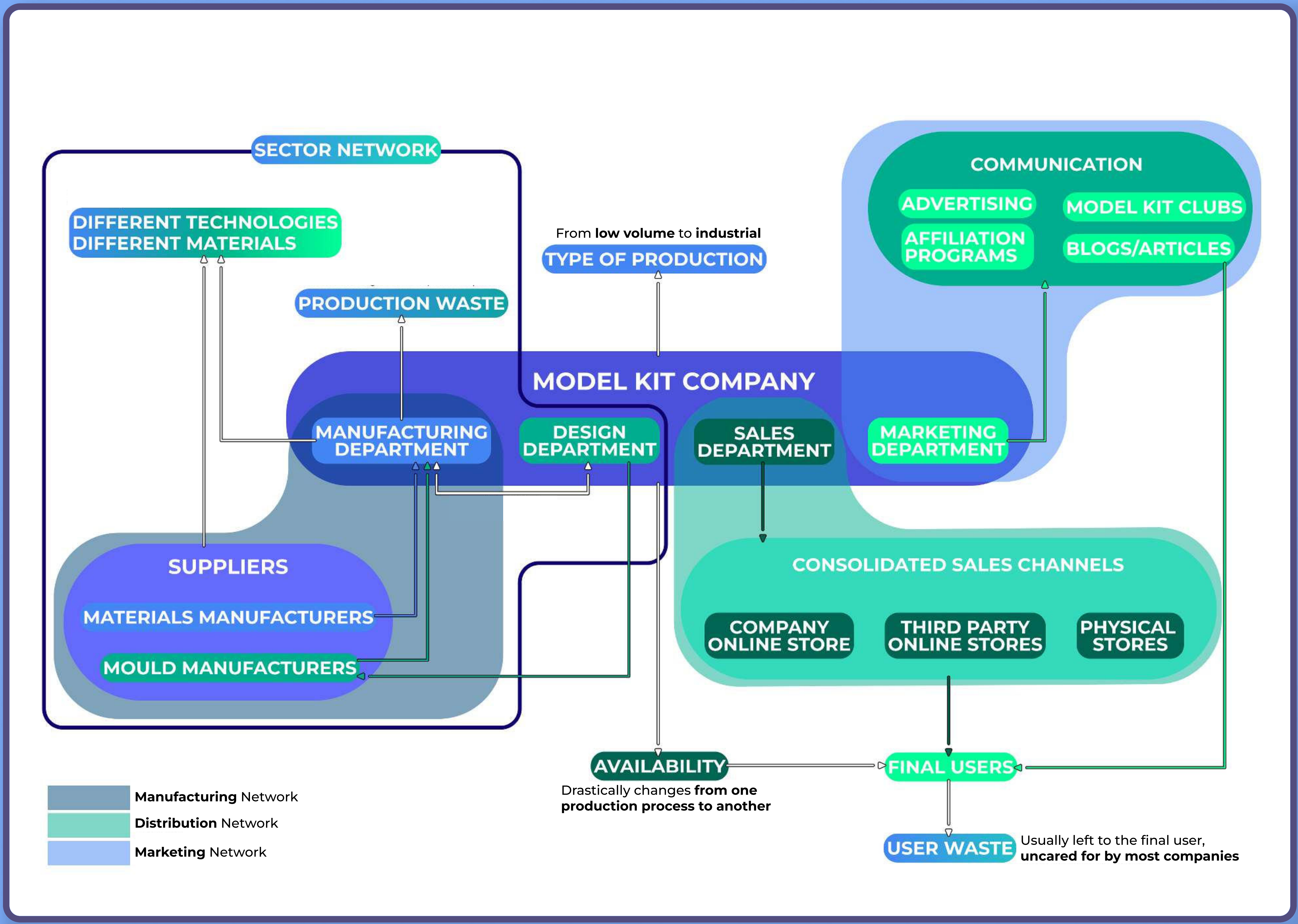
Material Usage and Waste

There are other factors, though, that make this excess material an issue that needs to be addressed quickly.
First of all, is the recycling aspect of Polystyrene. This material is used in injection moulding and in vacuum forming. Thanks to its properties as plastic, it can be reintroduced in the production process as a recycling method, but plastic companies use many different additives during its manufacturing process, so it can be difficult to create an efficient process to work the recovered plastic and recycle it. This translates to high investments for the model kit companies, since the recycling process that plastic recovered from the users need would comprise all the passages, from crushing, to cleaning, to reforming in pellets. As an added issue, many companies colour their plastic, which automatically makes it harder to reintroduce in a production process, since mechanical recycling does not eliminate the pigments present in the material [33].

Another issue is shown in the research report "Model Kits for Hobbyists Market Growth, Size, Trends, Analysis Report by Type, Application, Region and Segment Forecast 2022-2026" [34], published in 2022 by Technavio.
This report talks about a fractured industry, where each company is competing to cover a niche section of the market.
In addition to that, the report forecasts a composite annual growth rate (CAGR) of 3.48%, reaching 195,09 $ millions in 2026, with an estimation of year-over-year growth of 2.79% in 2022.
This growth will mean more and more model kits will be produced and the necessity of developing a solution to either reuse the empty runners or changing the most used material to a more eco-friendly one becomes more and more imperative.

2. Challenges and Opportunities


MARKET ANALYSIS
STL SALES ORGANIZATION
INJECTION MOULDING/VACUUM FORMING/3D PRINITNG COMPANY
STL SALES
COMMUNICATION
INDUSTRY NETWORK
NEW BUSINESS MODEL
COMMUNITIES OF EXPERTS
DIALOGUE WITH EXPERTS
EVENTS TO PROMOTE STLS
CREATION OF EXCLUSIVE COMMUNITIES (E.G. AIRFIX CLUB)
AFFILIATION PROGRAMS
CONSUMERS/CLIENTS
E-COMMERCE
PRODUCT ORGANIZATION
ONLINE SHOP EXTENCTION
PROTECTION FROM PIRACY
TYPE OF PRODUCTION
SECTOR NETWORK
AVAILABILITY
SOLUTION 3
RECOVERING WASTE FROM THE FINAL USER
SYSTEMIC INDUSTRY NETWORK
INJECTION MOULDING/VACUUM FORMING COMPANY
USER WASTE RECOVERY INITIATIVE
Incentives
END USERS
PRODUCTION PROCESS
DIRECT SALES
ASSEMBLY
FINISHED PRODUCTS
INDIRECT SALES
RECOVERY HOTSPOTS
VIRGIN MATERIAL SUPPLIERS
PRODUCTION WASTE
WASTE SORTING
WASTE RECOVERY
UNRECOVERABLE WASTE
DUMPSTER
Recyclable waste
May be the same company?
RECYCLING COMPANY (MELTING AND PELLETTING
State of technology
Economic Feasibility
19/35


SECTOR NETWORK
DIFFERENT TECHNOLOGIES
DIFFERENT MATERIALS
PRODUCTION WASTE
From low volume to industrial
TYPE OF PRODUCTION
COMMUNICATION
ADVERTISING
MODEL KIT CLUBS
AFFILIATION PROGRAMS
BLOGS/ARTICLES
MODEL KIT COMPANY
MANUFACTURING DEPARTMENT
DESIGN DEPARTMENT
SALES DEPARTMENT
MARKETING DEPARTMENT
SUPPLIERS
MATERIALS MANUFACTURERS
MOULD MANUFACTURERS
CONSOLIDATED SALES CHANNELS
COMPANY ONLINE STORE
THIRD PARTY ONLINE STORES
PHYSICAL STORES
AVAILABILITY
Drastically changes from one production process to another
FINAL USERS
USER WASTE
Usually left to the final user, uncared for by most companies
Manufacturing Network
Distribution Network
Marketing Network

Network Map Analysis

General Overview

Introduction

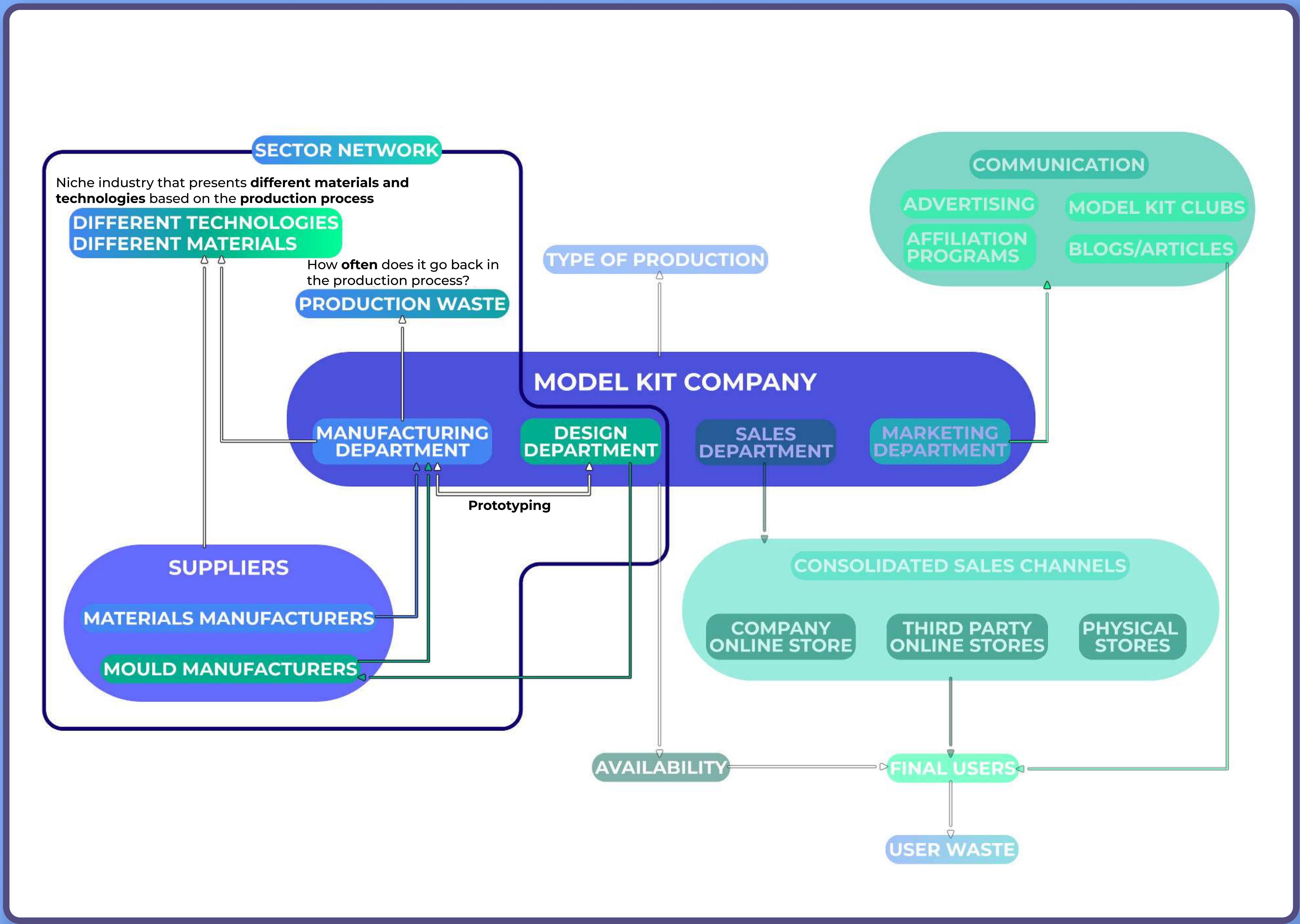
This chapter is going to focus on analysing the model kit industry network map, first as a general overview, then divided in the various sectors: manufacturing, marketing/communication and sales. This analysis will be used to find challenges and opportunities within the network and to define potential solutions. These solutions will be analysed using a multicriteria analysis in order to find the most effective ones.
After researching the industry sector and the most common production processes, it was possible to design a plausible general industry network. This network is mainly focused on production processes that require moulds, in particular injection moulding. There are a few reasons for this: the first and most important one is the fact that injection moulding not only is the most common method of production for model kits, but it is also the one that guarantees the highest production volume. This, in turn, translates to a higher quantity of production waste and of user waste. Another important reason is that the injection moulding sector network is much more common in various industries outside model making when compared to resin casting and 3D printing. This means that it was possible to analyse it more in depth, since the general organization of the network is very similar between industries. Since vacuum forming, resin casting and 3D printing are more niche and have other application much more different from the model kit industry, it was not possible to hypothesize an industry network that could be proven in a significant way.
One final reason is the material used in the process. The plastic used by the vast majority of model kit companies is Polystyrene, while the resin used in both resin casting and 3D printing has many different options. The fact that a single type of plastic is used in the industry makes much more feasible to develop solutions that can be applied to the industry as a whole: an example would be the transition to a different plastic material that can be used with existing technologies, which could be adopted on a larger scale, instead of needing a different solution from company to company.

Overview

Analysing the network map as a whole, it is possible to notice a few things.
The first interesting aspect is the fact that there is no contact between the final users and the sector network. Particularly, the manufacturing system does not have a direct connection with the customer. While this is not necessarily an issue in and on itself, since the interest that the customer has in the company model kits is usually not correlated with the production process, it does leave the customers in the dark for quite a few details. Raises in price, for example, can be met with suspect if the final users do not have any clear idea about production costs and eventual changes. If a company were to adopt a new material, the users may not be able to understand how much will change in terms of tools needed, especially if there already is a lack of understanding of the production process.
In terms of connections between sectors, manufacturing, communication and sales are interconnected inside the company itself. As described in the Games Workshop case study, the departments need to work together in order to market the finished products to the customers and to offer them the highest quality model kit possible. This can be avoided by creating a channel for the costumers to better understand the production process behind the company products. While it does not need to be particularly detailed (e.g. suppliers, the technical working of the machines,...), allowing a more complete understanding of the production process can help accepting news regarding costs and prices issues and potential changes in material. One important detail about materials are the tools needed to assemble the models. While some, like the BANDAI SPIRITS ones, can be assembled without glue, others require to be glued, especially models like the Games Workshop miniatures. A clear communication regarding the most effective and safest glue options could be very useful, especially in case changes to the material used in production happen. While often community of enthusiasts can help newcomers to understand which tools are effective, receiving information from the manufacturers may help the model makers as a whole.

Overview

There are three more focus points on the diagram on the previous page.
The type of production, which can go from low volume to industrial production volume is indicative of the difference between the four production processes analysed previously. As seen at the end of the chapter, the processes that utilize plastic are more indicated for industrial production volumes. While analysing the network and the possible solutions, it appeared more feasible for companies that already invested in more expensive production process to adopt systemic solutions. In the case of companies that utilize resin casting and 3D printing, the investments needed to adopt new technologies and/or new materials may be too much to bear. Also, in those cases, it would be more akin to an expansion of the product catalogue.
In similar fashion, the availability point is more an analysis of private owners to start using the production processes: resin casting and 3D printing already are feasible by almost anyone, while injection moulding and vacuum forming are limited to a factory context.
The final focus point is the user waste. This is mainly composed by empty runners, the cardboard box that contained the model kit and other packaging. As seen previously, each production process presents different waste for the user, with plastic being recyclable, while resin is not. As a matter of fact, the many available ways to recycle plastic make the user waste a valuable resource, which at the moment is left to the final user, uncared for by most companies.



SECTOR NETWORK
Niche industry that presents **different materials and technologies** based on the **production process**
DIFFERENT TECHNOLOGIES
DIFFERENT MATERIALS
How **often** does it go back in the production process?
PRODUCTION WASTE
TYPE OF PRODUCTION
COMMUNICATION
ADVERTISING
MODEL KIT CLUBS
AFFILIATION PROGRAMS
BLOGS/ARTICLES
MODEL KIT COMPANY
MANUFACTURING DEPARTMENT
DESIGN DEPARTMENT
SALES DEPARTMENT
MARKETING DEPARTMENT
Prototyping
SUPPLIERS
MATERIALS MANUFACTURERS
MOULD MANUFACTURERS
CONSOLIDATED SALES CHANNELS
COMPANY ONLINE STORE
THIRD PARTY ONLINE STORES
PHYSICAL STORES
AVAILABILITY
FINAL USERS
USER WASTE

Network Map Analysis

Sector Network

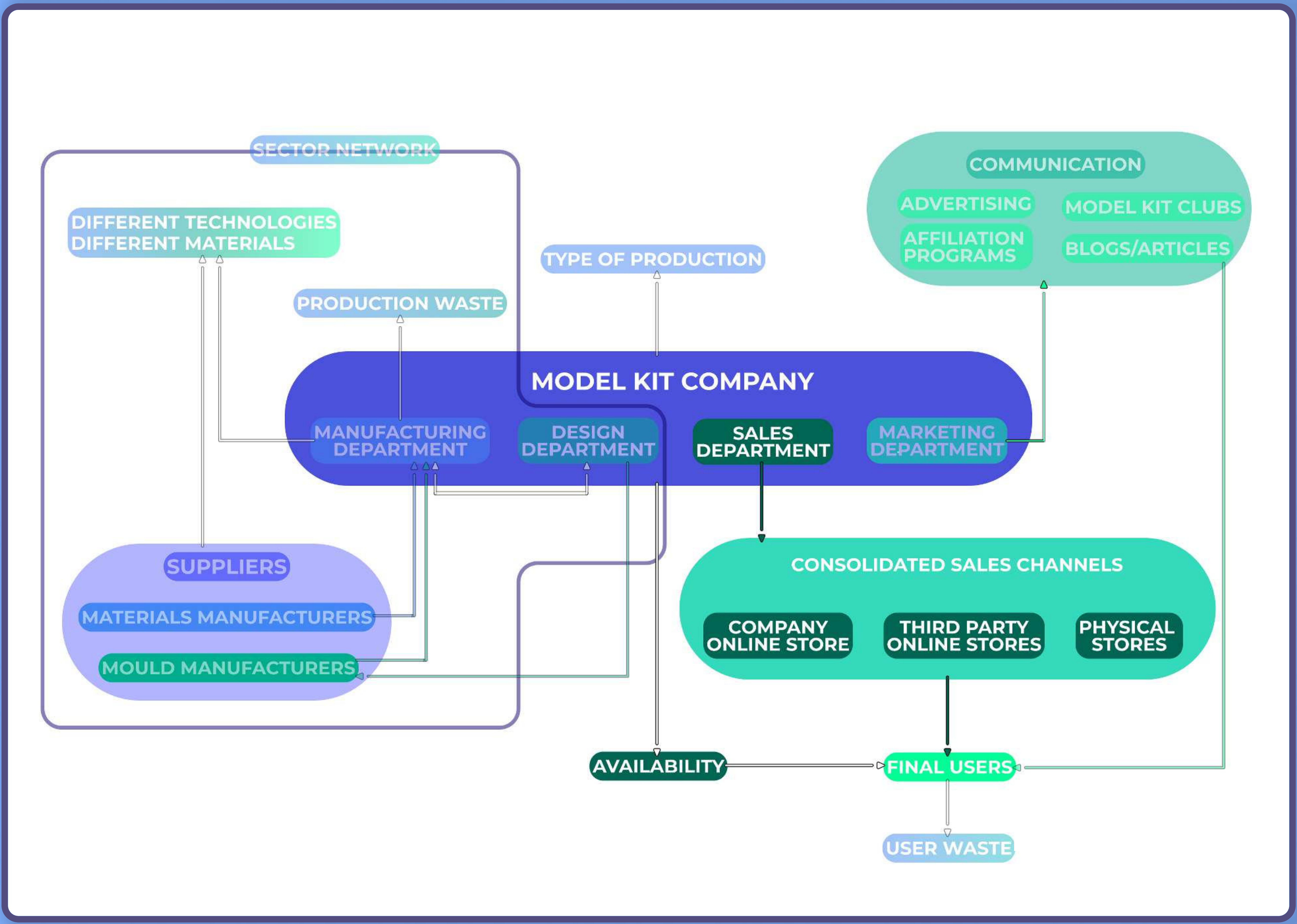
Manufacturing and Design Departments

The sector network identified comprises the manufacturing and design department of a model kit company, together with the external suppliers of materials and moulds.

The manufacturing and design departments of a model kit company work closely together to develop each new product and to develop all the elements needed for the production.
The design department starts by designing the model kit in all of its details, from the overall size to the shape of each component. It also works on the contact points that allow the assembly of the model kit: in the case of interlocks, the design will comprise all the locking points on each component. In the case of models that need to be glued together, the contact points between each component are studied so that the surface of contact will be large enough to give solidity to the connection, independently of the glue used. This is critical especially for smaller components, which may have trouble sticking to larger ones.
Once a first version of the design has been developed, the manufacturing department prototypes it. This allows to check all the key points of a model kits: from the overall assembly, to how flush the various components fit together. After these first tests, the prototype and the results are sent back in the design departments, so that the model kit can be modified and adjusted. This process gets repeated until the final version of the model kit is reached.
At this point the components of the model can be separated one last time and placed on the runner digitally. Then, the file will be sent to the mould manufacturer, which will produce the mould based on both the design and the required parameters.
Once the moulds are received by the company, these are used in the production process.
To produce the model kits, a material supplier is needed.
From the material manufacturers, the company will buy the materials necessary. These vary in base a few factors, like the colour and, most importantly, the demand from the company customers. This data is given by the sales department, which will be analysed later in the chapter.
Once the company manufacturing department has at its disposition all the materials and the moulds needed, the production process can start.
From the production process and the manufacturing department come the production waste, which can be recycled.

Suppliers

Analysing the suppliers for the model kit industry, these can be mainly differentiated between mould manufacturers and material manufacturers.
The former work together with the company more closely than the latter. This is because the mould making process is directly linked to the design department of the company.
The mould making process usually sees the metal machined, since it is the most precise way to cut and drill all the details on the material without the need of a physical master. The CNC (Computer Numerical Control) machines process the metal by following coded programmed instructions. These instructions are the data in the digital file that the model kit company send to the mould manufacturer.
Before the actual production of the mould, though, there is a communication between the two companies in order to preventively modify the digital file if any issue is noticed by the mould manufacturer. These issue may be errors in the digital model that not allow the machine to cut a certain section in a certain way.
This back and forth is also important in defining an estimate of the cost of the mould. The final price will be defined at the end of the production of the mould and, based on various parameters (e.g. complexity, size,...) it can range from tens to hundreds of thousands of dollars.
When it comes to material manufacturers, they will be in contact with the company in a less communicative way. Generally speaking, outside of situations where the model kit company need a specific colour outside of the standard ones that the material suppliers has at hand, the interaction needs less details.
In this case, the plastic material used in the industry is mainly Polystyrene, which is widely produced and has a relatively low cost, 1'587 $/ton (data at 2022 from Statista.com). This helps lowering the production costs, and, since the majority of model kits are quite light, usually well under 1 kg, the material cost per unit produced is low.
Depending on the company, the Polystyrene bought will be of various colours. Companies that offer multicoloured kits from the box will need to buy multiple batches of various colours, giving precise requests on the colour codes. In this case, the communication between the two companies may be more in depth, mainly in order to guarantee the correct colour needed.
Companies that, instead, sell model kits that need to be painted will buy only a single colour batch. This will differentiate the overall costs of the material, since custom-coloured material will have a higher price compared to a standard colour one.


SECTOR NETWORK
DIFFERENT TECHNOLOGIES
DIFFERENT MATERIALS
PRODUCTION WASTE
TYPE OF PRODUCTION
COMMUNICATION
ADVERTISING
MODEL KIT CLUBS
AFFILIATION PROGRAMS
BLOGS/ARTICLES
MODEL KIT COMPANY
MANUFACTURING DEPARTMENT
DESIGN DEPARTMENT
SALES DEPARTMENT
MARKETING DEPARTMENT
SUPPLIERS
MATERIALS MANUFACTURERS
MOULD MANUFACTURERS
CONSOLIDATED SALES CHANNELS
COMPANY ONLINE STORE
THIRD PARTY ONLINE STORES
PHYSICAL STORES
AVAILABILITY
FINAL USERS
USER WASTE

Network Map Analysis

Distribution

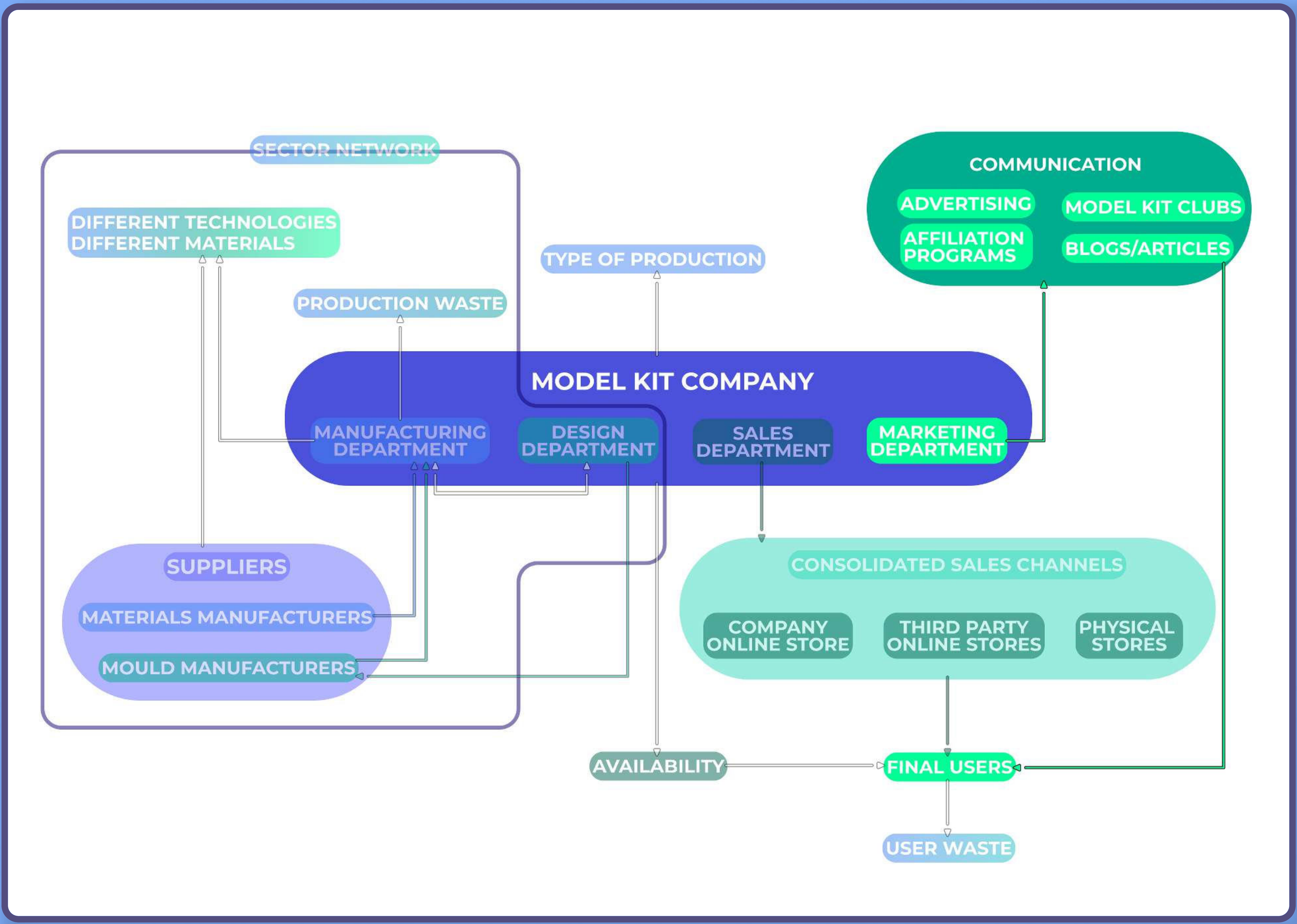
Sales Department

The sales department works in tandem with the other three departments in order to organize the sales of the new products developed.
Together with the manufacturing and the marketing departments they analyse the potential demand for the announced products, in order to define the quantity of material necessary to fulfil the requests. This is generally done in two phases. First, the departments research the sales volume of similar items. For example, when BANDAI SPIRITS releases a new model kit in the Real Grade line, the sales of other kits in the same line in a similar release period will be compared, in order to plan the first production batch.
Another way to check the potential demand of a new product can be the reaction to the announcements. For example, Games Workshop usually announces new models using the site Warhammer Community. The articles give the option to the reader to like them and/or share them. The numbers of likes and shares will be compared to sales of similar products and from that it is possible to have a relatively clear picture of the sales at launch of new model kits.
This allows the manufacturing department to order the material needed in batches, in order to distribute the material costs on a certain time frame, avoiding excessive buying compared to the potential demand. This method, though, can be risky. For example, at the launch at the end of 2021 of the box game "Warhammer: Cursed City", the perceived demand was too low compared to the actual one [35]. Many people had issues buying it from the online store, thanks to it quickly selling out. Also, many copies were sent directly to retail stores, which often require these games based on the interest shown by the customers. Later, during 2022, the game was reprinted, first in a two week long made-to order system (a system in which customers could order a copy and it was guaranteed to receive) and then a full reprint. Nowadays the game is available online.
Another element of the model kit decided by the sales department is the final price. The price of a model kit is linked to various factors. The first and most important one, are the production costs. These must be covered by the price and often make up the baseline from which the final value is set. They are the sum of all the costs the company incurred during the production divided by the number of units produced. The costs include: the manufacturing of the moulds, the material to produce the model, the manpower needed both in the manufacturing phase and in the design phase and, in general, the cost of the employees, etc. From this value, the price is decided using the markup method, which adds a percentage of the costs to them. For example, if the overall costs per unit are 100€ and the markup is 20%, the final price of the model kit will be 120€. This calculation, though, must be made taking care in placing the model kit price in a certain range depending on the model itself. For example, the High Grade model kits will cost between 10 and 20€, unless they are limited editions/exclusive products. Master Grade model kits, instead, will range between 50 to more than 200€, depending on the model and the level of detail.

Sales Channels

Online stores generally function in a very similar way. First-party ones are focused exclusively on the products from that specific company and can act as a marketing tool, while third-party ones are usually more diversified.
The products presented on the home page of first-party stores are generally divided between various categories. The most prominent are new products. These are presented in colourful graphics and, especially if the models need to be painted, there are high definition pictures of the assembled and painted model to entice the customer. There are also featured products, which often consist of models that are often bought. In this case too, though, the focus is put on newer products and on more expensive ones. Another important information often present on the homepage of an online store is relative to shipping and shipping fees. Generally these information are linked to a minimum order price needed to void the shipping fees and, if the company has physical store, if there is the option to receive the order directly in the store and what that entails. Another important sections of the homepage are a search bar, which helps customers to find the products that they are interested in, and a header, which is particularly useful to allow the customers to look for a certain type of product. The products are, in fact, generally divided in categories by tags. A header will usually show more general tags, especially when a company has more than one IP. Some sites headers function with a hover feature, where by hovering the cursor on a tag a scroll down window will appear, allowing for a more precise selection of products.
When it comes to a product page, usually there are a few key things that help the customer in purchasing the item. First of all, a section with name, price and availability. Generally a button that allows to put the product in the shopping cart is present. A shopping cart is another function that entices the customer in buying more products: giving them the option to select which items they are interested in, without forcing them to buy the products immediately one by one, the customers are more interested in continuing browsing and may end up buying more products than originally intended. Other than these functions, pictures of the assembled and posed model kit are always present, since the customer needs to be able to see clearly what they are about to buy. Then, some more general information may be present, with more detailed ones placed lower in the page. This makes the customer scroll down and, often, before the detailed information, a section that suggests interesting items for the customer is present. This section is often curated by an algorithm, which analyses the order of other customers that include the item browsed at the moment.
Going quickly back on the availability of certain items, there are two main scenarios: if a product is yet to be released, it may be possible to pre-order it. This guarantees the customer to receive a copy once the model kit is launched. In the case that an item is not available online, there may be the option to request a notification when it will be again available.

When it comes to physical stores, the main difference (other than the fact that third-party stores offer more than just one company products) is the availability of products and how often new products will be shipped. In a first-party physical store, the line between company and store is direct and thus, the products are relatively easy to obtain. Third party retailers, instead, may have an harder time receiving new products and restocking. If a physical store is part of a retail chain, the items sold by the model kit company will be redistributed in the stores part of the chain.
This makes harder for a customer to easily find certain items, while in first-party physical stores is easier to order the wanted product, thanks to the help from the store employees.


SECTOR NETWORK
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Network Map Analysis

Communication

Marketing Department

The marketing department has the arduous job of creating interest in new products in the customers.
Having the task of publicizing a new product, this department is the ones that has the most contacts outside the company in order to reach with the most potential customers. It also has the job of developing a marketing language tailored to the IP and to the product itself.
Working together with the sales and design departments, the marketing one can communicate to the customers details in regard of new products to be launches, but only in the quantity and with the timing allowed by the company. Regarding new products, the marketing team job is to create and build interest in the customer by giving only small bits of information. An example is the “Rumor Engine” system developed by Games Workshop. This system releases a new article on the Warhammer Community site releasing a single picture, in black and white, of a detail of a new model. This creates curiosity in the community of enthusiasts, who try and guess what the new model could be.
In general, the marketing department will also work on the company online store and site. In the store, they will mainly work on the various graphics of the front page. For example, all the images and photos used in the products page and on the homepage are selected by the marketing teams and the design team. If a model has a particularly innovative mechanic or interesting details, the job of the marketing department is to focus on those key elements.
Another aspect that the marketing department has the duty to communicate to the public are launch dates for new products. These dates are usually set based on the state of production of a model and the anticipated period in which the company will have produced enough copies to send to first and third party stores, both physical and online.
Also, the marketing team has to publicize various events organized by the company. Whether the events are linked a collaboration with other IPs or are celebratory of an anniversary it is not important. The main objective is to help the community of enthusiasts know about the events and participating.
Also, the marketing department works in organizing said events, especially when it comes to get in contact with figures outside the company which could bring more participants. For example, an event centred around assembling model kits may end up with the company inviting influencers to participate.
Finally, the marketing team will supervise the company participation to externally-organized events, like conventions. In these events, the company may organize a stand to sell its products, but also organize activities that may introduce new people to the hobby.

Communicaiton Channels

The marketing department uses various communication channels to spread information to the potential customers. Some of these channels are part of the company assets, while others are either “third-party” or external and contacted by the company in various occasions.
Generally, the marketing department will work on the various articles that are published on the main company site available to the public. These articles are usually used to communicate about new products, changes in practices and prices and even about new physical stores that the company will open. Similarly to the online store, these articles are used to create interest in new products and inform the customers on the detail the company intends to share. For example, when a company starts a new initiative, of any kind, an apposite article will be written and published in order to inform the public. This kind of article, though, don’t always contain all the details to paint a full picture and, instead, are used to slowly fill all the gaps. This way, the users are more invested in following the news from the company.
When it comes to advertising, generally model making companies do not use mainstream channels like television advertisements, but prefer to occupy spaces where there is already an interest towards the hobby. This means that they prefer working with hobby sites, giving material to write and publish articles about new products. Also, many companies present a dedicated page on their websites, where industry journalists can find material like high definition pictures and have a channel to contact directly the company.
These journalists are then able to write articles based on the information that the company gives them.
Another way model kit company have to market new products is the use of affiliation programs and collaborations with influencers. These programs vary from company to company, but generally have to do with publicizing a company product using means like a private site or a YouTube channel. Another thing these programs have in common is the opportunity for the participants to earn a percentage of the purchase done by their followers without any additional costs for the buyer. An example is the Airfix affiliate program [36], which will earn a commission between 3 and 5% on the purchase based on whether a customer is recurring or new. In some cases, the companies will send in advance new products to affiliated influencers, in order to more directly publicize it. This usually happens with YouTube influencers, since they can give information and feedback on the product in a more “hands-on” way, since they will usually assemble and work with the model on video.
Another way the marketing department can directly contact the customers is through a hobby club. These club usually are an exclusive system that allows interested customers to have a few benefits. Using the company Airfix as an example again, the Airfix Club [37] can be joined by anyone, provided the payment of a fee and can be renewed annually. Joining will guarantee to receive exclusive models one of which is given upon signing, 10% discount on all purchases and magazines, in addition to other benefits.

PRODUCTION WASTE

1

Sprue and defective products. How many companies recover and reuse theirs? How?

- **Standard** in many companies
- The recovered material is **immediately input** in the production process
- Costs depend if the company can recycle the material **independently**

USER WASTE

2

Empty runners and boxes. Do they get used by the model makers? How? How often?

Potential benefits

- Connection with **userbase**
- Potential recover of **great quantities** of plastic
- Plastic recycling can be done by the **original company or by specialized ones**

DIFFERENT MATERIALS

3

Well defined and consolidated materials. What can be done to innovate?

DIFFERENT TECHNOLOGIES

4

Well defined and consolidated technologies. What can be done to innovate?

- Polistyrene, ABS,... many plastic materials are the **standard and consolidated**
- Injection moulding is the main production process, used by the **vast majority of companies**
- Would **recycled plastic** be useable to build plastic model kits?
- What **alternatives** are there to **standard** technologies and materials?

TYPE OF PRODUCTION

5

From small production volume to industrial productions and vice-versa

SECTOR NETWORK

6

Niche industry, many competitors for each material and technology. What can be done to innovate?

Existing example

- **Gunpla Recycling Project**: waste from production and from gates recovered from end users are recycled in Eco-Pla. These wastes are also fed back in the model kit cycle or used to produce energy.
- At the end of 2022 (first year of the initiative) Bandai managed to recover more than 11 tons of empty runners, exceeding the target of 10 tons.

AVAILABILITY

7

Only 3D Printing and resin casting are available to the public. Can this be used to innovate the industry?

- Some companies already profit on this (**STL sales**)
- Would this be applicable in some way to **Injection moulding/ vacuum forming**?
- How many model makers would **start 3d printing**?
- How this would **affect the industry**?

Challenges and Opportunities

1. Production Waste

Production waste is an element particularly present in every type of production process analysed. Each process has its variety of waste, but the main issue for all of them is the feasibility in reintroduction in the production process.

While cured resin is not recyclable because of the nature of the curing process, the thermoplastic used in model kit production is completely recyclable.
But while it can be recycled, the machinery needed to do so is not always within economic reach of a company, especially if on the smaller side.
While bigger companies may have the ability to acquire both the machines and the competences needed to operate them, smaller companies do not have even the space to install a recycling plant. In both cases, though, it would be necessary to make an in depth analysis related to the quantity of production waste is the output of the production process. Smaller quantities may not be impactful enough to require any investment to recycle, while bigger volumes may be too expensive for the company to recycle autonomously.

In both cases it would be more economically positive for the company to work with an external recycling company, especially since the plastic would need to be brought back in pellet form in order to avoid risks during production. Feeding bigger pieces of plastic in the injection moulding machine, without any prior processing (like cleaning the material, crushing it or cutting it), may ruin a production batch. There could be various issues, like the plastic may not melt completely or larger pieces may damage the rotating screw. Therefore, production process is both a challenge and an opportunity for a model making company.

2. User Waste

In a similar fashion to production waste, the empty runners left to the user are an enormous opportunity for companies that are interested in becoming more eco-friendly. Recovering the waste left to the model builders would allow the companies to start producing model kit with a percentage of recycled plastic. Or, taking for example the Gunpla Recycling Project, producing model kits completely out of recycled plastic. Similarly to the previous point, though, this would be feasible varying on the ability of a company to recycle autonomously plastic.

There would be the need for a serious cost-benefit analysis before starting to commit to such a resource-heavy project. There would be the need for a well organized network of hubs where the waste can be easily recovered by the company, together with investments in manpower to recover the waste from the hubs.

Another interesting point to consider is the interest of the users in participating. Model makers can see the empty runners as a resource itself, using them in their projects. Thus, it would be interesting to see how the model builders community would react to such a project.

Challenges and Opportunities

3. Different Materials

The model kit industry has a variety of different materials, each one needing specific tools to be worked with.
Thus, many model builders are used to work with various materials and possess the necessary tools and glues.
This makes so that introducing a new material in the industry may be possible, but it would have a few challenges to overcome.

First of all, the material would need to be compatible with the production process commonly used by the companies. Whether it can be formed using injection moulding or vacuum forming if it has plastic-like properties, or is more akin to a resin, that needs to be cured, this material will be able to conform to at least one of the processes described previously.
In addition to this, it would be optimal if it were compatible also with the usual tools available to the model builders. This would mean that it can be cut with a hobby knife, can be glued either with a cyanoacrylate glue or with a solvent glue, for example. On this topic, the material should also be thoroughly tested in order to ascertain that no dangerous reactions may happen when in contact with common hobby glues and with the paints used by hobbyists.

If this new material can not satisfy these requirements, it would at least be easy to adapt to. This means that the investments for the companies should not be too high, while the tools needed by the model builders to work with it should be easy to acquire.
Finally, the adoption of a new material should not come with an unforeseen increase in costs for either the companies and the users, while not guaranteeing good returns.

4. Different Technologies

Similarly to the materials, the technology used in the model kit industry has been developed and adopted for a long time and, particularly in the case of injection moulding and vacuum forming, has reached the point where it is the best solution when it comes to industrial production.

Each technology fills a certain niche, with injection moulding and vacuum forming guaranteeing high quality products on an industrial scale, while resin casting and 3D printing give excellent quality on a much lower production volume.
This situation makes it difficult to introduce an innovative technology, much more than trying to find a new material. In that case the requirements of the material are clear and measurable, since they are based on existing technology.

When trying to develop a new innovative technology there are no parameters, outside maybe which materials to use. The issue is that the existing materials are already used in technologies that can employ them perfectly. Injection moulding and vacuum forming work with any thermoplastic resin, which makes them inherently flexible in terms of materials. Resin casting can also employ a vast array of resins, while 3D printing is still being developed more and more, but in general works with photopolymers, which again make the technology flexible when it comes to materials.

Outside of these issues, a high hurdle for developing an innovative technology are the development times and investments needed to bring it to the level of existing machines. While a material can be tested on already adopted technology, since it will be used by those machines, a new technology would require a long experimental phase.

As a final point, new, developing technology usually corresponds to high investments for results that may not yet be at the level of the standard set by the industry.
All in all, developing a new technology is a very risky and challenging approach.

5. Type of Production

With each analysed technology being more indicated towards either an industrial production volume or a low production volume, a passage of type of production could be an interesting opportunity for some companies.
This, however, does have a few issues that make changes in type of production very risky.

The first and major issue are the limits of production that each technology presents. Resin casting and 3D printing both require long production times, making so that, if a company was willing to increase the production volume, it would be necessary to either increase the machines at its disposition, or invest in another type of technology. In these situations, when the demand of a company products increases, the company will have to find solutions in order to satisfy its customers, which can be very difficult without buying new machines or adopting a new technology.
However, as stated during the analysis of the various production processes, both injection moulding and vacuum forming require high investments, both for the machinery and the moulds necessary for production.

There is, though, another potential obstacle to a change of production volume, not linked to machines or technologies: the reaction of the customers.
A change in production process usually would mean a change in material but, more than that, it could mean changes in how the hobbyists will have to work with the new products. This can be very risky, especially if the model making company was working in a niche area (e.g. roleplaying games miniatures). Long term customers may have questions that the company will have to answer to in a clear and precise manner, in order to dispel all doubts. Many customers will fear a price hike followed by lower quality products (since often mass production and low quality have come hand in hand).
So changing production type and increasing production volume may create general distrust and risk of losing customers in the short term.

6. Sector Network

Analysing the sector network it appeared that, similarly to the technologies and the materials used in the model kit industry, is very difficult to innovate.

The analysed network shows that each company has its own preferred suppliers, independently of whether they supply materials or moulds. This already makes difficult the introduction of innovations in the network. Companies that have worked together for a long time have some level of trust in each other, which is often noticeable in their trade agreements. Trying to insert something external from the companies in the network may be met with distrust and have an hard time find a market niche where it can position itself.
If, instead, the innovation were to come from a company, it could be possible to find its place in the network more easily, thanks to the reputation of the company.

Generally, then, the sector network is closed on itself and it is difficult to open to external projects. The opportunities to open it are most likely linked to recycling, but the niche nature of the sector and the variety of materials limit the options.

7. Availability

The availability of each production process varies enormously.
As seen in the analysis of the processes, injection moulding and vacuum forming are not particularly easy for private owners to use, while resin casting and 3D printing are much more within reach of almost anyone, especially when 3D printers become more and more cheap.

An opportunity to make model kits and their production more available to private owners would be the distribution of the STL and CAD files used by the company for the production of the moulds. These files would need to be protected from illegal distribution, but this is a practice already adopted by some 3D printing model kit companies. These companies give the customers various options of products, one of which are the digital files ready to be sliced and printed. The files are not open to modifications by the customer, since they are already STL and not the original type used for 3D modelling.

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STL SALES

Selling 3d files to the communities would deepen the connection between company and customers. Also, this solution has lower investments, but with revenues linked mainly to the interest of the communities

2
3
4
6

ADOPTION OF DIFFERENT MATERIAL/TECHNOLOGIES

Adopting a new material or new technologies would heavily increase the investments, while the revenue would be more linked to the communication of such changes with the communities. Also, the new materials and technologies should be focused towards improving the ecological print of the company

2
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4
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RECOVERING OF USER WASTE

Developing a network to recover model kit waste (e.g. empty runners or boxes) to recycle and input back in the production process may deepen the connection between companies and final users. This network will depend on the willingness of the users to participate. The investments may vary based on the ability of the company to adopt an internal recycling plant

2
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TRANSFORMING PLASTIC WASTE INTO PAPER

Limex is a material made out of limestone and plastic, which can be either a substitute of plastic or of papaer. After transformming plastic waste into pellets, it can be combined with limestone to become “limestone paper”

Change in the industry
(Customers can create the demand and then the offer of 3D files and recyclable plastic)

Connection with the communities

Benefits for more than one company
(Change in the industry and expansion of the sector network)

Connection with territories
(The recovery depends on the area)

Identified Solutions

Objectives

Before identifying the solutions, there was the definition of objectives that said solutions should strive to reach and satisfy.

The first objective is the reduction of waste during production. This objective is particularly hard to achieve, considering the development of the technologies that the companies use. However, there are various ways to reach it. For example, offering a product that does not produce waste during its production phase, while slightly reducing the production volume of items made using traditional technologies. These items would still be produced, since they would still be the products with more demand, but incentivizing the customers towards innovative products may help in this regard.

Another objective focused on the production waste would be the introduction of innovative solutions of recovering and reusing said waste. This objective is much more feasible to reach than the first one, considering that all model kit companies have some sort of production waste. That said, the majority of companies may be more interested in reusing the waste in the production process, but there could be solutions that incentivize the upcycling of the waste material in other sectors.

Another objective is the development of a network based on the recover and reuse of waste, both from the company and the customers. Developing a network my mean that the waste does not go back as an input in the model kit industry, but becomes one in a different sector.

Finally, the main objective of each solution should be the development of new ways to educate the userbase on the waste, the correct way to dispose it and of any initiative that may help them in reusing it in an eco-friendly way.

STL Sales

The first solution that can be developed has already been hinted at previously. The sales of STL and CAD files.
This solution immediately has a few needs that will have to fulfil external to the objectives listed previously.
First of all, the digital model will have to be as detailed as possible, in order to provide to the customers model kits of similar quality of the ones produced traditionally. Another need to be fulfilled is the compatibility of said digital model with a 3D printer. This means that each model will have to be modified in order to guarantee key points common to all the digital models sold, like a flat surface as a wide contact point with the print bed.
Finally, the files will have to be protected from piracy, either using a license or other similar warranties.

When compared to the objectives that the solutions need to reach, STL sales would not be the best option. While it could help in the reduction of production waste, especially if a company manages to avoid increasing production too much after an increase in demand, it does not touch reuse of waste in any form, and it would not be particularly effective in educating the userbase on waste.

Other than this issue, though, STL sales would need an intensive research and planning by the company in order to make this option work.
First of all, the market of STL sales is still very niche, much more than the model kit market. This means that companies that focused on producing physical models will have to enter a market completely outside their skill set and would require help from experts, especially when it comes to protection from piracy. Also, this would mean that any company that is interested in entering the STL sales market would need to do an in-depth analysis of the market, from supply and demand to usually proposed prices, to benchmarks of 3D printed model, in order to define which technology would be better for those products.
This, though, is an excellent opportunity for model kit companies to enter more in contact with the userbase and obtaining new customers. With 3D printing being a relatively accessible technology, many hobbyists have taken interest in tinkering with it to enhance their experience with the hobby, with some of them becoming enthusiasts and experts.
From this contact with the userbase, a company may start developing events to promote the STLs and organize affiliation programs to incentivise the sales. Also, companies that already have hobby clubs can use those platforms to advertise these new products, while offering exclusive files to customers subscribed to the club.
In addition to that, companies that already have an online store will have to expand it in order to give STL files their own category, while companies that up then only used retailers to sell their products may use this opportunity to develop an online store.

All in all, this solution is more targeted towards a diversification of the sales of model kit companies and less towards making them more eco-friendly.

STL SALES

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Selling 3d files to the communities would deepen the connection between company and customers. Also, this solution has lower investments, but with revenues linked mainly to the interest of the communities

ADOPTION OF DIFFERENT MATERIAL/TECHNOLOGIES

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Adopting a new material or new technologies would heavily increase the investments, while the revenue would be more linked to the communication of such changes with the communities. Also, the new materials and technologies should be focused towards improving the ecological print of the company

RECOVERING OF USER WASTE

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Developing a network to recover model kit waste (e.g. empty runners or boxes) to recycle and input back in the production process may deepen the connection between companies and final users. This network will depend on the willingness of the users to participate. The investments may vary based on the ability of the company to adopt an internal recycling plant

TRANSFORMING PLASTIC WASTE INTO PAPER

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Limex is a material made out of limestone and plastic, which can be either a substitute of plastic or of papaer. After transformming plastic waste into pellets, it can be combined with limestone to become "limestone paper"

Change in the industry
(Customers can create the demand and then the offer of 3D files and recyclable plastic)

Connection with the communities

Benefits for more than one company
(Change in the industry and expansion of the sector network)

Connection with territories
(The recovery depends on the area)

Identified Solutions

Adoption of different Material/Technology

The second identified solution is the actual adoption of different materials or technologies. Initially this solution was mainly aimed towards resin casting and 3D printing, especially with the forecast of increases in demand. Therefore, the needs individuated that this solution had to fulfil were focused on guaranteeing the same quality of products and increasing production volumes.
Slowly, though, the focus shifted towards utilising eco-friendly materials (recyclable or reusable or upcyclable) and sustainable initial investments during the transition phase. With the analysis of the industry centring more on the plastic side of the model kit industry, the needs changed.

Mantaining the focus on eco-friendly materials, this meant switching the research outside the model kit industry and trying to open the industry, changing it for the better. By trying to find interesting solutions keeping a plastic-like material as the focus of the research, it would be possible to bring benefit to more than one company and to expand the network. As it will be analysed more in depth, there is a plastic material made from limestone that could help the network to depend less on oil-based plastics.

That said, the identified solution, whether it will be just a material or also a new technology, will need to possess a few key points.
Ideally, either technology or material would need to be out of the experimental phase and have already an actual application, especially in sector comparable to the model kit industry. While it does not mean that the solution needs to be immediately insertable in the industry, it does need to be easy to add without a prolonged test period. In the case of the material, though, it would be better if it is already used in an number of applications, preferably in more than one sector. This flexibility would help the experts in the model kit industry to develop the best way to use it.
All in all, then, either technologies and materials need to be developed enough to allow an easy transition from the ones already in use.

An important step for any company that starts adopting a new material or a new technology is a clear communication with the communities of enthusiasts that buy and build their products about the changes adopted.
This is crucial for various reasons. The first one is because changes in material will require clear information regarding the tools normally used. This is important even if the new material does not require new tools: the customers do not know all the qualities of said material, so the experts that brought it in the industry will need to clarify any doubt. If, instead, the adopted material is not compatible with the traditional tools and glues, the company will have to inform clearly the model makers and provide some type of advice.
All of these communications will have to be done using the marketing department, which could employ various methods, such as events and installations where the customers can try first-hand the new material, and digital communication.

Recovering User Waste

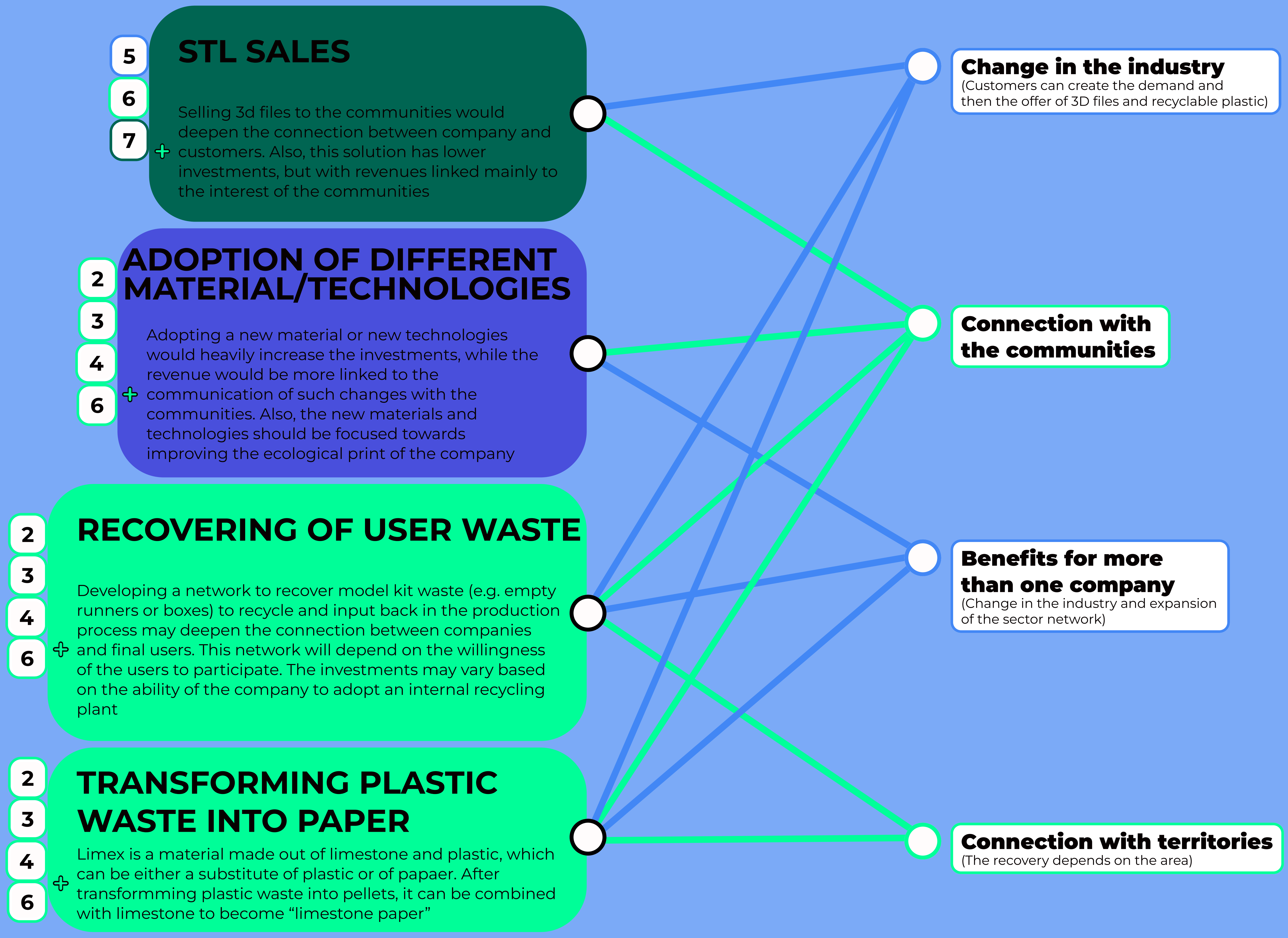
User waste is an enormous potential source of recyclable material that many companies could recover and input back in the production process. This is an approach that is starting to slowly take place, with only BANDAI SPIRITS participating, thanks to the launch in 2021 of the “Gunpla Recycling Project”.
The objective of this solution is not only to recover useless waste from the model makers and recycle it back in the production process, but also connect the community with the company, creating a substantial change in the industry, making the customers become a supplier of sorts.
This solution, also, helps a company to connect with the territories where they sell using physical stores (first and third party ones), while acting locally to gather the user waste.

A key point of this solution is the actual processing of the user waste.
This initiative would mainly collect plastic runners, since resin can not be recycled once cured, thus a recycling plant will be needed to process the material in a form that can be fed back in the processes. This plant may be external to the model kit company or internal. This depends on various factors, like the ability of the model kit company to invest in a recycling plant, the actual volume of plastic collected and the difference in costs between an in-house recycling plant and working with an external company.

Another important point is how to organize and incentivize the participation of model builders with the initiative.
A relatively easy way to gather the waste is using Hubs. These can be collocated in hobby stores where a company sells its products. In case of first-party stores, there would be no issues, while with retailers, they would need to be interested in participating. The use of hubs would give the users an easy to reach way to dispose of their waste.
Another way to spur the participation is the organization of incentives for the users. These can vary widely from company to company, but they could be generally devised to offer discounts and rewards.
These incentives, though, will need to be developed deeply, especially in order to make the offer tempting for the model builders. Also, a system to avoid exploitation will have to be developed.

Finally, companies that offer affiliation programs and hobby clubs can use those platforms to both market the initiative and give additional incentives for the subscribers.

This solution could also be easily connected with the adoption of a new material, since the recycled plastic could count as such. In addition to that, this solution would help opening the network either towards plastic recycling companies or the production of other items that may use the recovered plastic in a more eco-friendly way than just inputting it back in the production process.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STL SALES
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Identified Solutions

The fourth solution is a combination of the second and the third: adopting a new material or technology and recovering waste from the users.

Researching an innovative material to substitute Polystyrene, Limex came up. This material combines limestone and thermoplastics to make a material that can be either a substitute of plastic or of paper.
This opens many possibilities in both the development of the application of the material in the industry and in the opening of the network towards other markets.
The objective of this solution is to develop a new waste management system in the sector network, which would allow to recover the user waste and transform it in an eco-friendly material, helping the industry to depend less from oil-based plastics. In addition to that, the waste will also be transformed into a paper substitute.

The key point of this solution is the fact that it comprises the key points of both the adoption of new material and the recovery and reuse of user waste. This means that this solution will need to develop thoroughly both the recovery of waste, the processing of it and the material in which is transformed.
The material will need to be tested carefully in order to respect the industry standard, both in the case of the plastic substitute and the paper substitute.
The processing will be similar to the ones that will be described in the following chapters, but in general it will have the waste processed until it is transformed back into pellets, which will be mixed with limestone to produce Limex. This material can easily be worked with using common techniques, like injection moulding and cutting it into paper sheets.

Similarly to the recovery of user waste, the participation and incentivization of the model kit users is vital to the adoption of this solution.
In this case, though, the communication and incentivization aspects will have to be particularly effective. While the user waste recovery solution sees the plastic material completely go back in the model kit production process, in this solution it will see a sizeable part of said waste turned into paper. While the paper may be used in a variety of ways (e.g. thicker, cardboard-like paper may be used for the packaging of the model kits), the fact that the runners will not be completely reused in the model kit industry may not be a particularly interesting idea for the model builders. Thus, there is the need to effectively communicate both the usage of the waste and the effects in the industry.

One particularly interesting aspect of this solution is the fact that Limex can be produced with any thermoplastic. At the moment, the most used ones are Polypropylene, Polyethylene and Polystyrene, but any plastic which presents similar production processes may be used. While it needs more experimenting, this option may help a startup company producing Limex to use a large variety of plastic waste if the waste recovered from the model kit users is not enough to satisfy a large production volume.

Multicriteria Analysis

	Outputs > inputs	Relations	Autopoiesis
STL SALES 5 6 7	●●○○○ Not the main focus	●●●●○ Necessity in creating new relationships with community and experts	●●○○○ Less autopoiesis and more sales diversification
ADOPTION OF DIFFERENT MATERIAL/TECHNOLOGIES 2 3 4 6	●●●●○ Recycling could be interesting	●●●●● Collaborations between companies for specific solutions	●●●●○ More sectors can collaborate on a larger scale
RECOVERING OF USER WASTE 2 3 4 6	●●●●● The main focus of the solution	●●●●○ One of the goals of the solution	●●●○○ Improve the ecological print of the products and the materials
TRANSFORMING PLASTIC WASTE INTO PAPER 2 3 4 6	●●●●● The main focus of the solution	●●●●● One of the main goals of the solution	●●●●● Various sectors become linked together

Acting locally	Humanity Centred Design	State of technology	Economic Feasibility	
Not the focus	The focus might be more economic than needs driven	The technology is largely used, both by companies and by private users	There will be less costs compared to physical products	19/35
Not the focus	The focus might be more technological than needs driven	New materials may be more easily developed than new technologies	Depends on the material/ technology and on the impact that may have on the production process	23/35
Local presence would be vital to the solution	Collaboration between end users and companies	The technology used in the mechanical recycling process is extensively developed. Less so chemical recycling	The initial investments will be high and the economic return will be based on the user participation	27/35
Recovering waste from the users requires local presence	The goal is to transform man-made waste in a new input	Limex is in production and use from 2013, with further development in mind	High initial investment but solid potential revenue	31/35

Multicriteria Analysis

Introduction

In the Multicriteria Analysis each solution has been evaluated based on seven different factors: the ability to transform an output in an input, the relations that the solution would create, the influence on the autopoiesis of the system, the ability of the solution to act locally, how much that solutions follows the tenets of “Humanity Centered Design”, the state of technology that said solution proposes and the economic feasibility of the solution.
The solutions were graded from 0 to 5 for each factor and a solution was considered particularly effective if it scored more than 20 points out of 35.

Based on this evaluation, it was possible to identify which solutions would be more effective towards the challenges and opportunities in the network, while also considering how each solution has a more systemic design approach to said issues compared to the others.
In addition to that, using these seven factors to analyse each solution has allowed a more defined view of them.

The results show that STL sales is not particularly effective as a solution, while the other three solutions are.

Outputs > Inputs

The factor “Output > Input” had the objective to evaluate each solution based on if and how said solution was able to transform an output, like production waste or similar, into an input.

Analysing the four solutions, it was shown that the sales of STL files would not have the transformation of an output in an input as objective of the solution, while it is the case for the recovery of user waste. In that case, as a matter of fact, this factor is the core objective.
When it comes to the adoption of a new material, though, it was decided to evaluate it fairly high on the scale, 4 out of 5. The reason behind this decision is the fact that using recycled plastic as a material for the production of model kit can be seen as the adoption of a new material. The plastic is not a virgin material and it is not freshly made by the polymerization of oils, but it comes from the mechanical recycling process.
There is, also, an example of treating recycled plastic as a new material: BANDAI SPIRITS has recently launched a line of Gunplas made in mechanically recycled plastic, and the material is called Ecopla.
Finally, both recovering user waste and transforming plastic into paper have this factor as the main objective of the solution, thus the 5 out of 5 evaluation.

Relations

While for the previous factor there are differences between the solutions when it comes to the evaluation, in the case of building relationships either outside or inside the system, all three scored between 4 and 5 out of 5.

For the sales of STL files the relations are built based on the need to create new relationships with the community and with experts in the online files sales. As stated before, there are various issues to overcome, first of all the dangers of piracy.

The recover of user waste has the necessity to create new relations with the community as the collaboration with the customers is essential to actually have a functioning network that recovers an amount of material which can justify the investments behind said project.

Finally, the reason why both adopting new material or technology and transforming plastic into paper are rated 5 out of 5 is the fact that these solutions are the only ones that reache outside the model kit industry. The research for new technology or material inherently requires leaving behind the traditional tools, in order to find new applications for solutions found in other sectors.

Autopoiesis

Considering that the concept of Autopoiesis in Systemic Design is centred around the idea that a system influences itself in all of its components and influences them not as singular entities, but by creating an autopoietic net of relations between all of its parts, each solution had a largely different evaluation, for different reasons.

In the case of sales of STL files, there is not any major influence in the system itself, since the biggest impact it may have in the short term is the diversification of sales. In this case, then the only elements of the system that influence each other are the company as a supplier of goods and the customers. All the relations that are built around the sales of files are not created in order to better the system itself, rather to better implement a new product.

Conversely, the adoption of new materials or technologies will influence the system as a whole, in all of its areas. The material flow will change, either to allow the implementation of the new material or as result of the total adoption of said material, which could destroy the previous flow. The information flow will be modified with all the information needed on the change, so that the final users can adopt it better. The system as a whole will change, in order to open itself.

The recover of user waste is another example of incomplete autopoiesis, since the system itself will only marginally change, and only regarding the material flow. That said, the change would be for the best, as it would improve the ecological print of the products and the materials.

Finally, transforming plastic into paper influences the system as a whole, while also linking it together with the paper industry. This makes so that the material, information and commercial flows are affected.

Acting Locally

The concept behind the “Acting locally” evaluation factor is how much is the solution applicable to a local context. In this case, both the STL sale and the adoption of new material or technology do not operate at a local level, and it is not the focus of these solutions.

On the contrary, the recover of user waste and the transformation of plastic waste into paper see a local presence of hubs vital to the processes: giving the participants an easy way to leave their waste would help them participating and, most of all would incentivise them.
One of the obstacles that these solutions have to overcome is the organization of how can the participants dump their waste without any excessive effort.
One of the potential solution would be the placement of hotspots inside or near hobby stores, or the creation of clearly marked and easily reachable hubs.

Humanity Centered Design

Similarly to the previous evaluation factor, “Humanity Centered Design” is not the focus of either STL sales or adoption of new technology or material. The definition of “Humanity Centered Design” is a focus on people’s needs not as individuals but as societies with complex, deep-rooted problems. This, paired with the fact that both solutions are more technologic or economic driven rather than needs driven causes a low evaluation of them.

Again, the recover of user waste is much more in line with the evaluation factor, thanks to the needed collaboration between the user communities and the companies. The effect that this project may have on the users will be more clear with the analysis of the results of a survey run in the model building communities, particularly by observing how much waste from model kits each hobbyist has and how much of that gets recycled or thrown away.

The transformation of plastic waste into paper is also a solution that follows this evalaution factor closely. Transforming human waste in a new material, which, as it will defined in later chapters, is planned to be upcyclable, makes so that this solution follows a humanity centered design, thanks to the fact that human waste becomes a new input.

State of Technology

Evaluating each solution on the “State of technology” meant analysing them considering how developed is the technology that the solution would implement.

Starting with the sales of STL, the technology is already widely used, both by 3D printing companies and by private user that model and sell their designs. Therefore, the technology would not require any experimental development.

When it comes to the adoption of new materials or technologies, the evaluation is slightly lower than the previous one, simply because there are no technologies that can easily substitute the ones already in use. There is, though, a material that has been developed for a few years that will be analysed in detail later in the thesis.

Recovering user waste has a high evaluation thanks to the fact that mechanical recycling for plastic is extensively developed. There is also another type of technology that is getting more and more developed, chemical recycling.

Finally, the Limex is a material in production and in use from 2013, giving it a high evaluation thanks to its state of technology. While there are still experiments being done, like the possibility of producing Limex paper using bioplastics, the core technology is fully developed.

Economic Feasibility

The last evaluation factor analysed the economic feasibility of each solution.

While the sale of STL has a high score thanks to its nature of adding a new product without requiring particularly high investments, both the adoption of new materials or technologies and the recovery of user waste have scores that reflect the experimental nature of the two solutions.

In the case of adopting new material or technologies, the economic feasibility depends on the impact that the new element introduces in the system. If a new material requires particular machinery to be processed, the investments required would be quite high. Similarly, if the technology is not perfectly developed, it would require funds to be perfected.

Recovering user waste would require a high initial investment, even if the technology adopted is well developed and the organization is as streamlined as possible. This is the result of acting locally on the territory in order to reach as many potential participants as possible. In addition to this, the economic return will be based on the user participation.

Similarly to the previous two solution, transforming plastic into paper requires high initial investments. This solutions presents a large variety of machinery needed to both recycle plastic waste in pellets and combining it with limestone powder to produce Limex.

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STL SALES

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Change in the industry
(Customers can create the demand and then the offer of 3D files and recyclable plastic)

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(Change in the industry and expansion of the sector network)

Connection with territories
(The recovery depends on the area)

Multicriteria Analysis Results

In this chapter the challenges and the opportunities present in the model kit industry have been evaluated based on an analysis of the industry network. Based on that, a few solutions have been identified and evaluated in order to understand which would be more effective, with the results showing that the ideal route to overcome the challenges in the industry is to open the network and invite innovation.

Adoption of a new material

By adopting a new material or technology, the industry would be able to avoid stagnating in the niche market that it has occupied. While the companies are able to offer different designs to the model makers, there is a lack of innovation when it comes to the production processes.

All of the technologies analysed in the previous chapter have a more or less long history of development, which slowly stopped as soon as a particularly stable innovation became the norm. For example, in the case of injection moulding, once the reciprocating screw was developed in 1956, there was little innovation in the technology, with only advances in how the system behaves in order to produce more precise details on more complex designs.
Similarly, the materials adopted in the processes, especially when considering plastics, do not present particular innovation after the adoption of Polystyrene, now the most used plastic in the industry.
As a matter of fact, though, researching about innovative production processes in the plastic industry, it was very difficult to identify a potential innovation towards production processes. As of now, the main focus is not to find less wasteful processes, but to develop new materials that not only maintain similar properties to plastic, but that can be processed with the current methods.

Thus, by opening the technological and material departments of the industry to innovations developed for other uses would help model kits to become more eco-friendly without affecting quality and without compromising the userbase.
As it will be analysed later, the Limex, a plastic made from limestone, is a very interesting first step in the right direction. And it can easily be worked with traditional tools.

Recovering User Waste

Together with the adoption of a new material, recovering user waste is one of the few solutions effective enough to impact the model kit industry.

While this solution may not open the industry as much as the previous one, recovering user waste would bring more focus towards how much plastic waste is built-in model kits. With the majority of plastic model kits being produced on runners, these become empty once all the components have been detached and assembled to form the model kit. This means that a good portion of the plastic used in the production process goes to waste, either left in the packaging by the model builder or thrown away. Rarely the runners get used in some project by the hobbyists, but this does not happen in the majority of cases. This is another topic in the survey run in the hobby communities, since learning how much empty runners model builders have, how much of those runners are reused and how could be eye-opening.

Recovering the waste is not enough, though. It will have to be processed in order to be input back in a production process. This is how the system opens up in this solution. While turning the runners back into model kits is definitely poetic, it could cause the system to remain closed in and on itself. Therefore, the correct way to develop a network based on the recovering of user waste will have to present a connection with a completely different sector, which will use the plastic in another way completely.
This development also offers a way to connect the two identified solutions. By finding a way to process empty runners and a new innovative material already adopted in other industries, it would be possible to open the network to at least one of the other sectors. More importantly, if there are predictions of implementing an innovative material in another industry, that can be done together with the user waste from the model kit industry.

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Multicriteria Analysis Results

Transforming Plastic Waste into Paper

The last solution to have been found effective is the transformation of plastic into paper. In addition to that, this solution is also the one that scored the highest in the multicriteria analysis, thanks to it being a combination of the previous two.

This solution manages to propose all the pros of adopting a new material and of recovering user waste, while also covering part of the weaknesses of the two.
First of all, this solution manages to open the network similarly to adopting a new material, since the same Limex that can be introduced in the model kit industry is the one that will be produced as a paper alternative. In addition to this, the system would not only see a new material input, but also an output, since the paper made out of recycled plastic will be fed in the paper industry.

By focusing the production of Limex on the empty runners that make up the majority of user waste, the positive aspects of the third solution are maintained. This, though, makes so that the obstacles that come up for recovering user waste are present also for this solution. As stated previously, not only it will be necessary to develop a solid network to recover user waste, but the communication aspect will have to be particularly effective in convincing the model builders in participating.

This solution comes with its own challenges, though. Having defined a potential new industry towards where open the model kit industry, it will be necessary to understand it. This means that developing a market analysis to understand demand and offer will be particularly necessary for a variety of reasons.
The first one is to understand the material output needed to enter competitively and avoiding a shortage of raw materials. Another reason is to understand the overall pricing for the various weights of paper and the quality expected by the customers. Also, the variety of types of paper is a challenge in and on itself: as it will be better detailed in its analysis, Limex paper at the moment is produced on some precise weights and for each there are suggested uses.
Generally, entering a different industry requires an in-depth study of said industry, in order to avoid not being able to find a solid foothold.

All in all, though, this solution has the highest potential to help the model kit industry to embrace innovations following a Systemic Design philosophy, especially when compared to the previous two.

your opinion of that company?
Yes
No
14,8%
85,2%
Do the company efforts to be more eco-friendly influence you buying their model kits?
230 risposte
Yes
No
61,3%
38,7%
Did you enjoy the change of pace in building them?
230 risposte
150
100
50
0
54 (23,5%)
14 (6,1%)
121 (52,6%)
1
2
models do you have in it? (If you want to give a
number, use the "Other" option)
Less than 5
5-10
11-20
21-40
More than 40
None
How much plastic do you think you have in runners/sprues ?
230 risposte
Less than 1 kg
1-3 kg
3-6 kg
6-10 kg
More than 10 kg
28,3%
57,4%
How much of the empty runners/sprues do you manag
230 risposte
15,2%
9,6%
66,5%
hat be a positive change or
would that be a positive change or
short text.

3. Survey

Copia
26 (11,3%)
15 (6,5%)
3
4
5
Have you ever built model kits not in plastic or resin (e.g. pewter)?
230 risposte
Yes
No
54,3%
45,7%
Do you have a favourite store?
230 risposte
Yes
No
47%
53%
Less than 10%
10-30%
30-50%
50-70%
70-100%
How often do you build model kits?
230 risposte
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Occasionally/take a long time to finish building
How often do you buy model kits?
230 risposte
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Rarely/on occasion/when I can afford one

Objectives of the Survey

Introduction

This chapter is dedicated to the survey developed to ask the users of model kits various questions about both the hobby, the industry and the solutions introduced in the previous chapter.
The objective of this survey was to learn how the model builders participate in the hobby from a point of view of what they consider waste, how they see the companies that produce model kits and if they are interested in any eco-friendly effort these companies may take. In addition to these information, the survey asked the hobbyists if the identified solutions may be of interest and if these solutions may affect some aspects of the hobby.

The survey was conducted in online communities of hobbyists. In these communities, model builders share their latest model built and painted and often there is a healthy share of suggestions. The survey was sent from the beginning of March 2023 to the end of the first half of April of the same year. It managed to gather a total of 230 answers.
The online communities were part of the social network “Reddit”, which is divided in various “subreddits”. The major ones in which the survey was sent were “r/Warhammer40K”, “r/Gunpla”, “r/modelmaking” and “r/minipainting”. These communities were the most active ones and this influenced the answers of some of the questions, mainly the ones dedicated to discovering the preferred companies of the model builders. This, though, was expected, since the communities of the products of Games Workshop and BANDAI SPIRITS are more mainstream than the ones dedicated to historical model building. In addition to that, both companies are linked to various IPs and media, which eased a larger public into the model kit hobby.
In addition to that, the Games Workshop communities are also spread in the various factions of the company wargames and IPs, making much easier to enter in contact with the Warhammer community than other ones.
Also, generally the r/modelmaking community is less active than the other ones, while r/minipainting, the biggest one in which the survey was run, has a high concentration of beautifully painted Games Workshop model kits.

1. Hobby and user waste

The first objective of the survey was to understand how the userbase interacts with the hobby, mainly regarding topics like the preferred material for the model kits, the preferred purchasing location and other information that would help define how to implement the identified solutions.
In addition to that, this objective is particularly important since it will be directly linked to the perception that the model builders have of the companies producing model kits and to the interest that the userbase may have towards the identified solutions. Using the information related to the hobby and the materials more commonly used by the community. It would be possible to add another analysis layer to the multicriteria analysis that allowed the definition of the more effective solutions.

Another key point of this objective is what does the model building community see as waste from the model kit. Considering what has transpired previously by the analysis of the various production processes, it is already possibly to determine that the empty runners are a common waste present in the model kits. It would be very insightful to be able to see how the userbase sees this type of waste and, more importantly, if the model builders themselves already try to reuse the empty runners. In addition to that, it would be interesting to understand how the runners are reused. Presumably it will happen inside the hobby itself, but the ways in which it happens may allow to better understand the importance given to the waste.
Finally, an important information to gather is the amount of empty runners that the community has on average, how much of it is used and, most importantly, if the general sentiment is a willingness to use more of it.

2. Companies perception

The second objective of the survey was to understand the perception of the model making companies. The key point of this objective was to determine if the community perception of the model making companies would change together with the companies' effort to become more eco-friendly, and how it would change. While this objective is perhaps less indicative than the previous one, since the perception of the companies would change exclusively if and when a solution is adopted, making the objective less linked to other segments of the survey, it can still provide useful information about the model building community.

First of all, it allows a better understanding of why model builders may be inclined to buy products from certain companies. Model builders may have various reasons outside the model kits designs and IPs to purchase new ones, so it could be interesting if a change in production processes or efforts to become more eco-friendly may be incentives to buy products from multiple companies.

Another interesting element would be how the perception of the model making companies would change, if in positive or in negative and, in more detail, why it would change. By understanding the reason the perception changes, it would be easier to develop a strategy that focuses on reaching the most common reasons that bring a positive change in opinion and avoid the ones that result in a negative change.

All in all, this objective is more interesting from a "public relation" point of view, rather than from a more technical one.

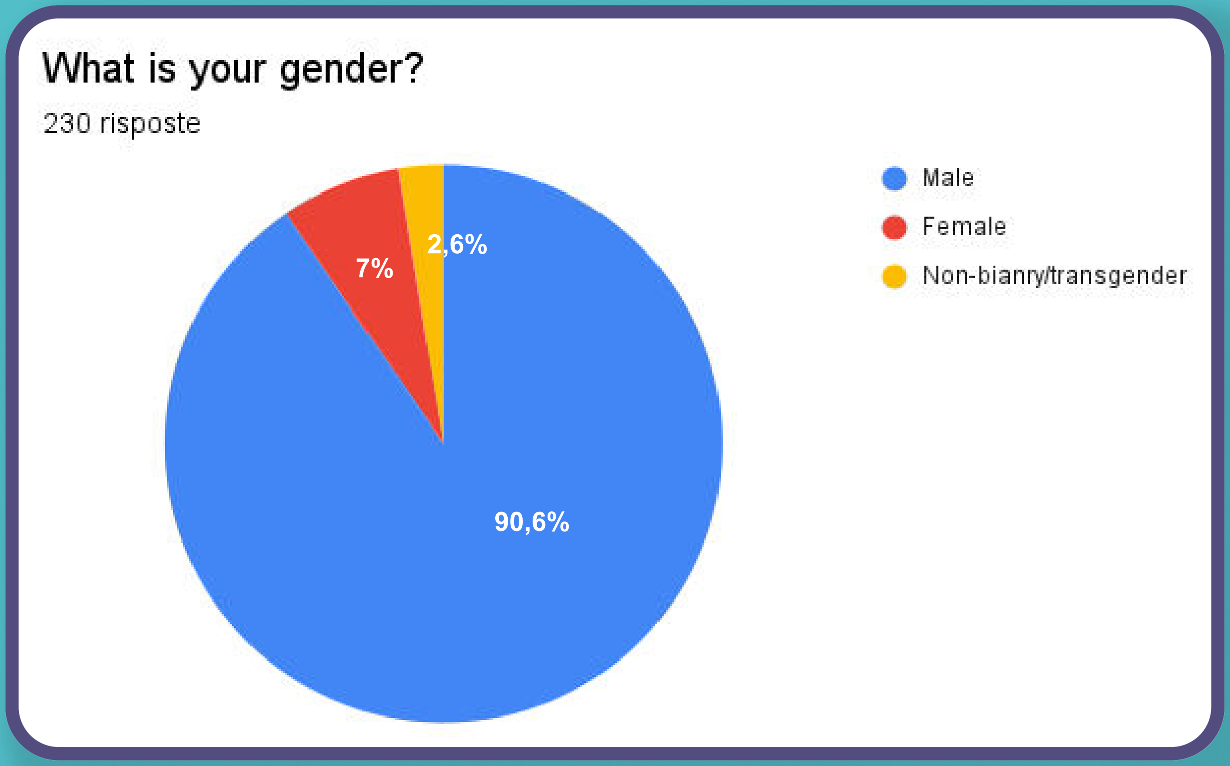
3. Interest in the solutions

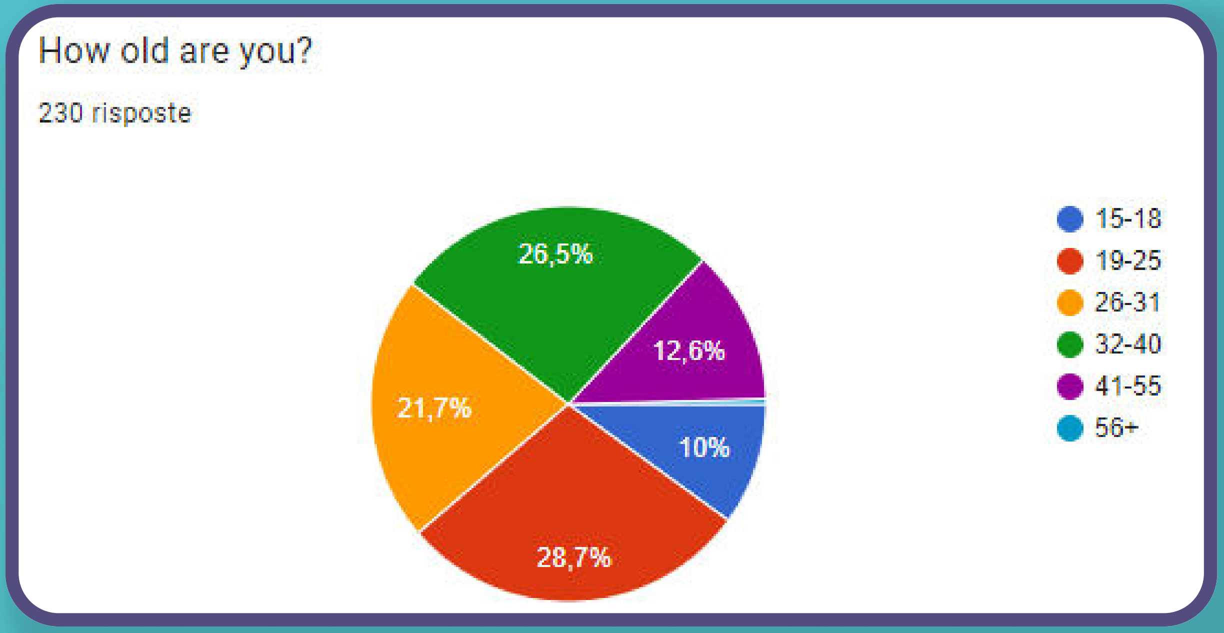
The third and main objective of the survey was to understand the interest of the users in the identified solutions. This, together with the first objective, is particularly important, since it would work similarly to a multicriteria analysis developed from the feedback from the userbase.

The key point of this objective was to gather and analyse how the model building community feels towards the identified solutions and in there was particular interest towards one or more of them. In order to not only obtain the opinion of the community, but also to understand how used is the community to similar possibilities, the information about different materials and the use of digital files include also potential previous experiences that the model builders may have. This way it would be possible to speculate how much the community is already used to less traditional options that may become part of the hobby.

In addition to that, this objective also intends to understand the willingness of model builders to participate in initiatives where the waste from the model kits are recovered. In this case, the main points that the objective tries to understand go from the simple interest in participating, to how often the community would participate, to which issues may come up that would make the model builders less interested in participating.
This point of the objective is particularly interesting towards understanding the community because it is directly linked with the first objective, the participation of the model builders in the hobby. By cross-examining the results from the questions in the relative sections, it will be possible to gather interesting data regarding both the issues regarding the preferred location of purchases, the quantity of purchased model kits, the amount of backlog and how all of these points may be influenced by participating in a similar initiative.

As a final note, this objective will be particularly effective towards the development of the project, especially when the data gathered is analysed together with the data from the previous objectives. It will be possible to understand how to develop a communication strategy, a new network and how to open the model kit industry with the collaboration of the userbase.


What is your gender?
230 risposte
Male
Female
Non-bianry/transgender
90,6%
7%
2,6%


How old are you?
230 risposte
15-18
19-25
26-31
32-40
41-55
56+
26,5%
12,6%
21,7%
10%
28,7%

Organization of the Survey and Answers

1. Profiling

Introduction

The survey was divided in eight different sections, each one consisting of various questions. Each section covered a different topic, covering all the objectives described previously. Thanks to the diversity of key points in each objective, each section covered one of the key points.
The survey consisted in both open questions, where the participants had to write a short text, and multiple chioce questions. In the majority of the multiple choice questions the participant could only choose one answer, but in some there was the option to add an additional answer if the participant decided to. There were also some questions where the participants could choose multiple options.

The survey was completely anonymous, but an initial profiling section was added, in order to paint a generic picture about the model kit community.
The survey was to be answered in English and was developed using the free online survey maker from Google, Google Form.

Organization of the section

The first section of the survey covered the general profiling of the model making community.
This section was quite short and quick to compile, requiring the participants to answer only four questions.
The first question regarded the gender of the participants. In order to ease answering and compiling the data, this was a multiple choice question. The available answers were “Male”, “Female” and an open one, where participants not identifying with one of the two previous answers (or unwilling to choose one of them) were able to write the preferred gender identity.
The second question regarded the age. This one was again a multiple choice question, dividing the ages in various ranges. The ranges went from “15-18” years old as the youngest age group, to “56+” as the oldest. This choice allowed for data easily compilable.
The third question was about the country of origin. In this case, the question was formatted using a dropdown list, in which all the countries on Earth were inserted. This is a common format for similar questions, allowing to compile the answers in a simple pie chart.
The fourth and final question asked the participants their occupation. In this case the participants were required to answer by writing a short text. While it would have been possible to propose a multiple choice question, giving the options between “student”, “worker” and a final open one, similarly to the gender question, the results that could come from asking the participants to define their main occupation may be particularly interesting, especially if a particular occupation were to be more prominent than others.

List of the questions:

1. What gender are you?
2. How old are you?
3. From which country are you from?
4. What is your occupation?

Gender

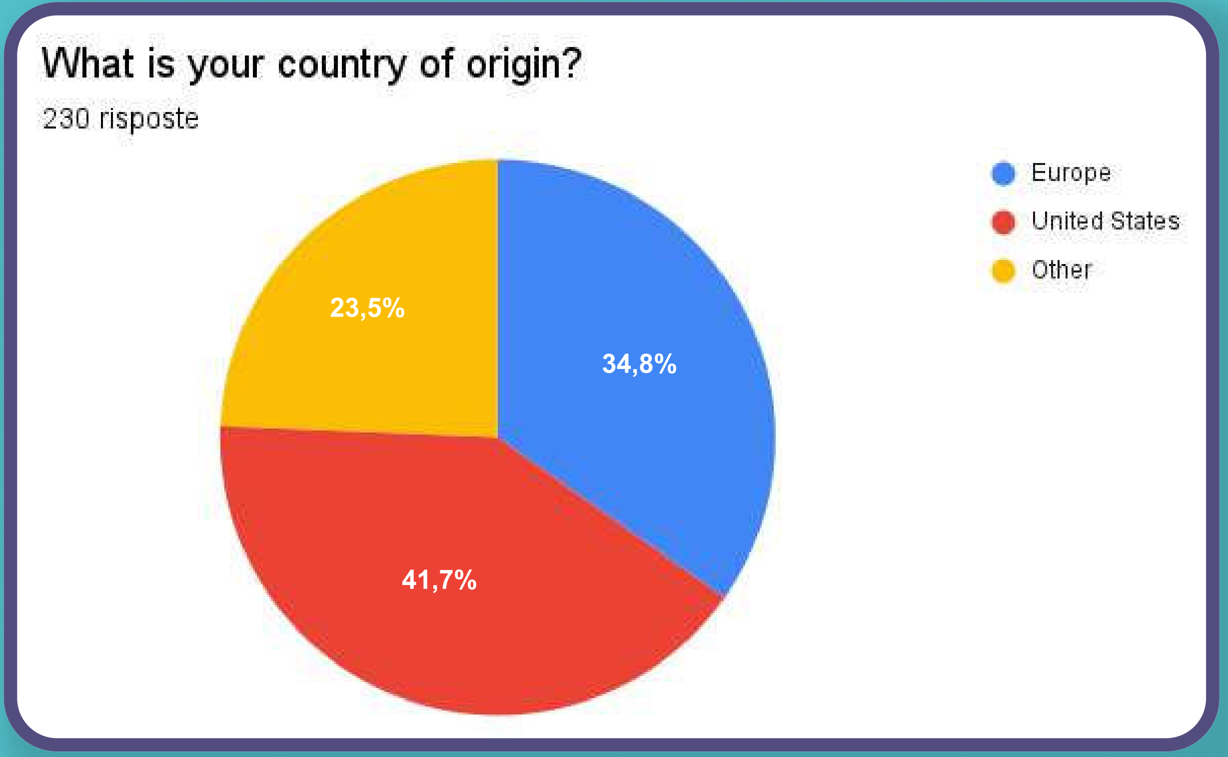
The first profiling element was the determination the gender distribution in the model building hobby. In order to do this, the simple question “What gender are you” was presented first to the participants to the survey.
There were some predictions, mainly towards a predominantly presence of male hobbyists, but it was still expected the presence of female model builders, as well as non-binary or transgender individuals.

The results confirmed said predictions: the percentage of male model builders amounted to 90.6%, while female model builders made up 7% of the total answers. Finally, non-binary and transgender hobbyists amounted to 2.6%.
While this may seem that there is some sort of discrimination in the community or general closing of the hobby towards the less represented genders, it is important to remember that the hobby was always mainly targeted towards a male audience, particularly towards men and teenagers interested in fantasy or sci-fi settings. Therefore, it should not be surprising that the hobby has a predominant male presence.

Age

Another factor in profiling the model building community was to determine the average age, mainly dividing it in ranges.
While in the gender profiling there was some level of predicting the results, thanks to the known target of the hobby, in the case of age profiling there is no real indicator, outside the recommended age for the model kits and outside the fact that the survey was run on Reddit, a social network more common between young adults.
The recommended age, though, changes from model kit to model kit, especially when comparing two different IPs. For example, BANDAI SPIRITS model kits are not recommended for kids under three years old, thanks to the presence of small parts, which can be a chocking hazard. Games Workshop model kit, instead, indicate a minimum age of twelve years old, because of the need of glues to keep the kits assembled and the necessity of painting them.
In addition to that, the survey was launched on a social network, therefore the minimum age was set at 15 years old.

The results were interesting: the most common age range selected was between 19 and 25 years old, corresponding to a percentage of 28.7%. While this result was in line with the age prediction, the real surprise came from the second most indicated age range: 32-40 years old, covering 26.5% of the participants. In addition to this, the age range between 26 and 31 years old was the third most selected option, reaching 21.7% of the answers. Then the fourth most selected option was the range 41-55 years old, at 12.6% of answers. Finally, the range 15-18 corresponded to 10% of the answers, while the option 56+ only registered one answer, 0.4% of the total.
These results show that the passion for a hobby can help people from all ages to come together and share that passion. In addition to that, the results indicate that the potential targets for a collaboration with the hobbyists does not necessarily need to be focused only on a small age group.


What is your country of origin?
230 risposte
Europe
United States
Other
23,5%
34,8%
41,7%


What is your occupation?
230 risposte
Student
Working
Unemployed
7,4%
21,7%
70,9%

Organization of the Survey and Answers

1. Profiling

Country of origin

After analysing the gender and the age of the model building community, the following step was to analyse the country of origin of the community.
This type of data could be interesting in order to determine a country where the user waste recovery could be particularly effective.
Similarly to the gender results, there were predictions on the country of origin. In this case, though, it was caused from the social network used to run the survey and the general distribution of the hobby. Reddit, as a matter of fact, is a social network born in the United States of America and, while it is open to users all over the world, the expected answers were of a majority American and/or European. This would also be in line with where the model building hobby is more diffused in western countries and countries in the Asia area.

The predictions were proven right, with the majority of the participants coming from the United States, equating to 41.7%, while the European participants covered 34.8%. The European participants came mainly from the United Kingdom (34, 14.8% of the total), followed by Italy and Germany (6 answers for each country, 2.6%).
The remaining participants were from various countries from all over the world.

These results illustrate a higher potential for participating in a user waste recovery initiative in western countries. That said, the correct country will be defined in the following chapters, especially since there will be different factors which will influence the final decision. For example, organizing a recovery network around the United States of America could be nearly impossible, thanks to the large amount of territory that the network would have to cover.

Occupation

Finally, the last element needed to profile the community was to understand the general occupation of the model builders.
This information would be useful in defining in a more clear way “personas”, fictional model building hobbyists that could be used to better develop the user section of the new industry sector.
Contrary to the previous questions, for this one there were no predictions regarding the occupation: by giving the option to the participants in the survey to indicate their occupation, without confining them in a closed category, the results may be surprising and give interesting ideas.

The first step in analysing the answers was to cluster them in three main categories, which could be expanded if needed.
The first one was “Students”. In this category was classified any answer in which the participant defined themselves as a student, without necessarily discriminating between high school or university or other type of education. This category counted 50 answers, equating to 21.7% of the total. It was not possible to gain particular insight in the different types of students that answered, since the majority simply answered “Student”.
In the second category were collected all the answers that corresponded to any type of job. This category ended up collecting the most answers, numbering 163, equating to 70.9% of the total. Anlaysing the answers, the most common ones were Engineers and IT positions, but there were working positions in both white and blue collar work environments. The jobs went from designer (both systemic and web designer) to artists, to freelancers, to butchers and warehouse workers.
The final category was “Unemployed”. This category numbered the lowest number of answers, only 17, 7.4% of the total.
These results showed that the hobby is enjoyed by people from many different backgrounds, making the occupation less defining for a personas than age, gender or country of origin.

Personas

From the answers gained in this first section of the survey, a potential personas with which develop the project would be a western male person, employed, either in a blue or white collar job, of an age between 25 and 40. These superficial traits will not be enough to define a personas completely, since the data gained in the following sections will be necessary in order to identified needs and wants of the model builders, as well as any identified issues.

Organization of the Survey and Answers

2. Participation in the Hobby

Organization of the section

The second section of the survey focuses on the first key point of the objective "Hobby and user waste".
In this section, the survey asks the participants questions related to their participation in the hobby, ranging from how often they purchase model kits, to how many they buy at the same time, to the distance to their preferred store, to their backlog, to the material of the model kits.
This section is divided between thirteen questions, the majority of which are multiple choice questions.

The first question asked about the frequency of purchasing model kits. The answers were organized in temporal ranges. The shortest one was "more than one a week", while the longest one was "less than once a year".
The second question asked about the frequency of building the purchased model kits and presented the same temporal ranges as the previous one.
The third question focused instead on the quantity of model kits purchased at the same time. In this case, the answers were divided in ranges, with the smallest one sitting at only one model kit bought, while the largest range indicated "more than 10 at once".
These three questions had the objective of measuring the average frequency in which the community participates in the hobby. This data, together with other following questions, will allow to measure both the time spent and the quantity of material consumed on average by the model builders community.

The following five questions were then focused on the stores where model builders purchase model kits.
The fourth question asked which type of store the participants preferred purchasing model kits from: online stores, physical stores or both.
The fifth asked, requiring a short text, the reason behind the preference. These two questions had the objective to understand more clearly where and why the model builders prefer to buy, in order to better define how effective a user waste recovery initiative could be. This is the general objective of the various quesitons about the stores.
The sixth and seventh questions referred to a preferred store for the participants. While this question does not seem to have particular importance towards the overall objectives described previously, the data recovered may be useful if the majority of the stores indicated by the participants were either first-party stores or third-party ones.
The final question regarding the stores referred to the distance between the participant house and the store itself. Again, the answers were divided in ranges, with the shortest distance being "less than 300 metres", while the longest distance was "in another city". Similarly to the previous questions, this one helps in estimating the effectiveness of a user waste recovery initiative.

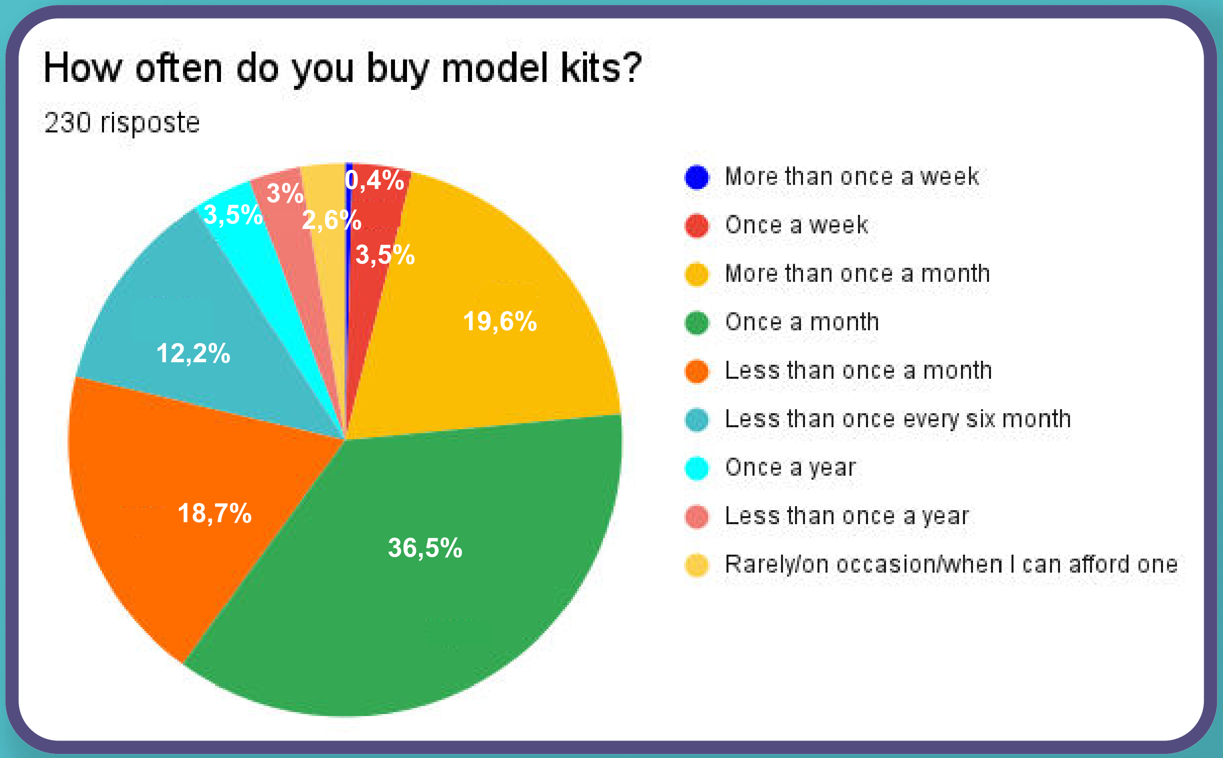
Organization of the section

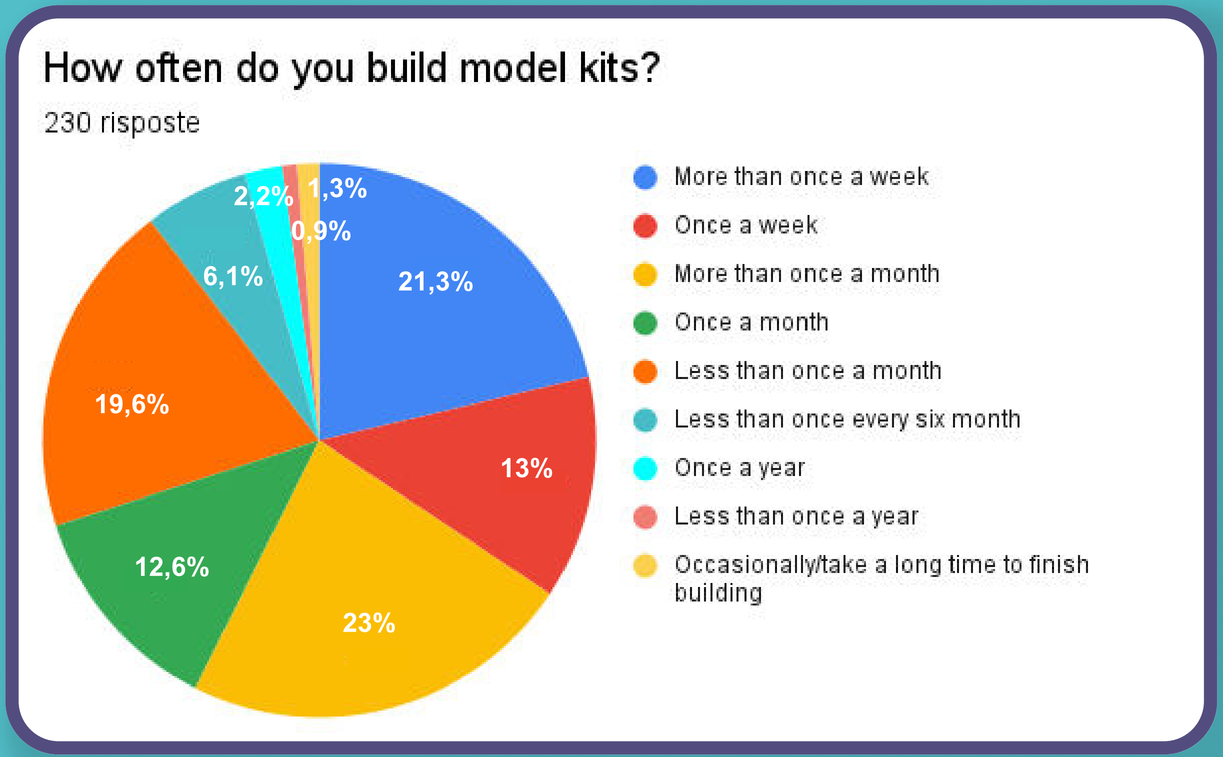
The ninth and tenth questions were related to the presence of a backlog for the participants. Often referred as a "pile of shame", a backlog can be present for a variety of reasons, which can range from lack of time to build the models, to impulse buying. These two questions were useful to estimate an average number of model builders that have a backlog and an average of how many model kits compose it. This question and the data that gathered will be more useful with the questions present later in the survey. In the case of the quantity of model kits present in the backlog, the answers were organized in ranges, with the smallest being "less than 5" and the largest being "more than 40". In this case, an open option was present, in order to allow the participants to indicate a more precise number.

The final three questions are related to the material of the model kits and the distribution of the components on runners.
The eleventh and twelfth questions are about the material, asking the participants the percentage of model kits that they have assembled that are either in plastic or in resin. The answers were in ranges, ranging from "0%" to "75-100%". These questions had the simple objective to scout the material preferred in average by model builders.
The thirteen and final question of the section was about the use of runners for the packaging of the model kits. The answers were divided in ranges like the previous two questions, and the objective of this one was to try and identify a possible quantity of material recoverable from the users.

List of the questions:

1. How often do you buy model kits?
2. How often do you build model kits?
3. How many model kits do you buy at the same time?
4. Where do you prefer buying the kits?
5. Why do you prefer physical/online store? Please explain with a short text.
6. Do you have a favourite store?
7. What is the name of the store?
8. If you buy from a physical store, how far is it from your house?
9. Do you have a "pile of shame" (a number of model kits bought but yet to build/ unopened)?
10. How many models do you have in it? (If you want to give a precise number, use the "Other" option)
11. How many of the model kits you buy are made in plastic?
12. How many of the model kits you buy are made in resin?
13. How many of the model kits you buy are made on runners/sprues?


How often do you buy model kits?
230 risposte
0,4%
3,5%
19,6%
36,5%
18,7%
12,2%
3,5%
3%
2,6%
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Rarely/on occasion/when I can afford one


How often do you build model kits?
230 risposte
21,3%
13%
23%
12,6%
19,6%
6,1%
2,2%
0,9%
1,3%
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Occasionally/take a long time to finish building

Organization of the Survey and Answers

2. Participation in the Hobby

Model kit purchase freqeuncy

As stated previously, the objective of this section of the survey was to analyse the participation in the model building hobby of the model builders. This meant understanding the purchasing habits of the hobbyists, as well as how often they consume the products. In addition to this information, studying their preferences in terms of stores could prove useful.

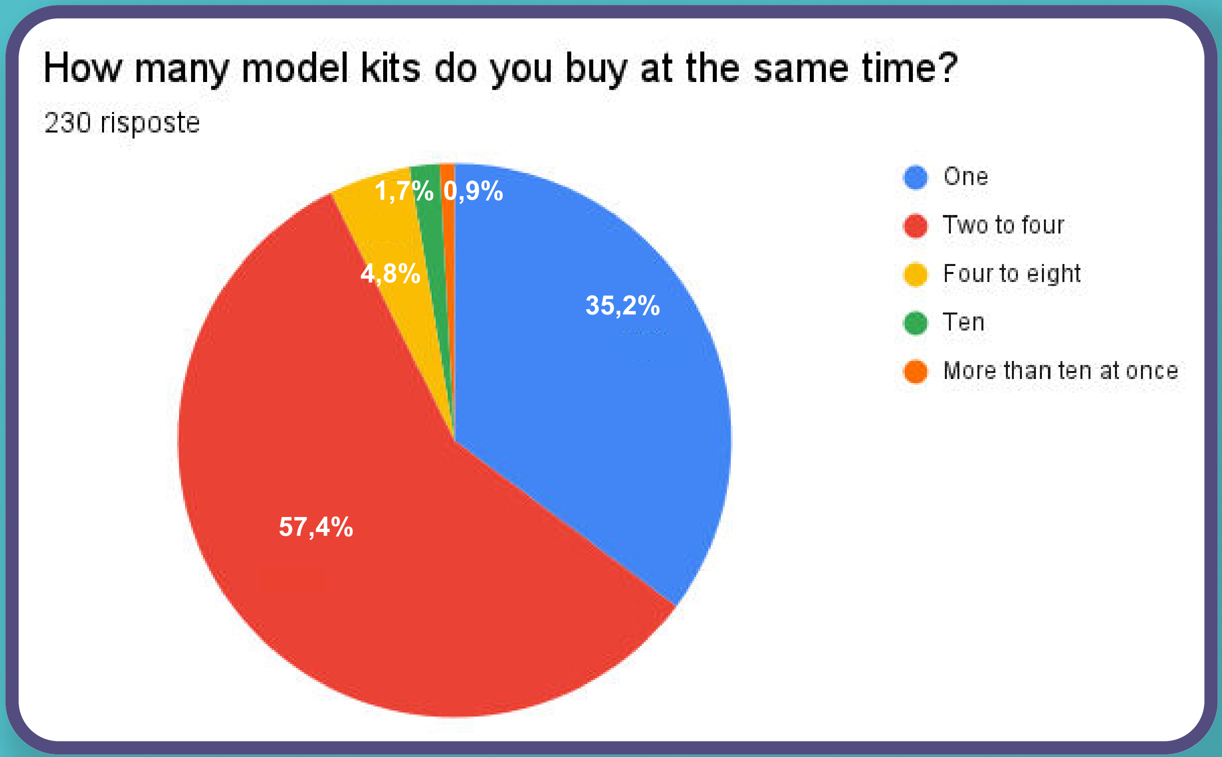
The first question asked how often the model builders purchase model kits, giving a variety of options. In this case, understanding the average period in which the model building community usually purchases new products could become useful in planning both the frequency in which they could be interested in bringing user waste to recovery hotspots and the frequency in which said hotspots could be emptied.
Considering the answers in the previous section of the survey, which depicted an adult between 25 and 40 years old, most likely with a job, it could be predicted that the frequency in which model builders purchase new model kits may be closer to a monthly one, rather than a weekly one.

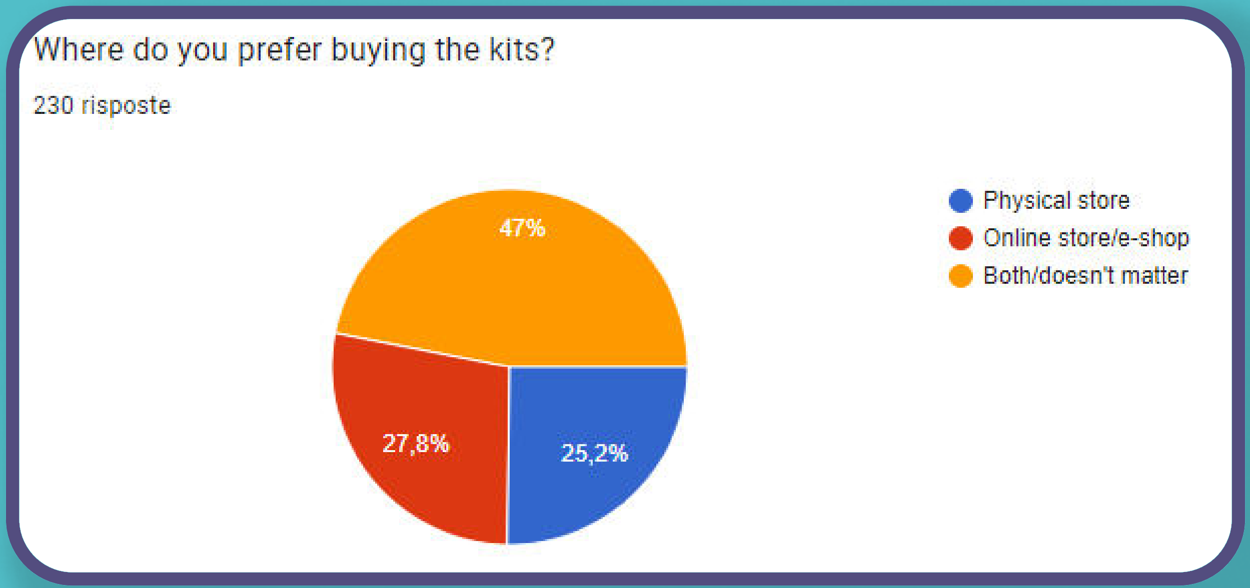
The results confirmed that prediction. The majority of the answers indicated the purchase of new model kits “once a month”, which was selected 36.5% of the time. Interestingly, the other two options linked to a monthly frequency were the second and third most selected ones, “more than once a month” and “less than once a month”, selected 19.6% and 18.7% of the time respectively.
Interestingly enough, the fourth most selected option was “less than once every six months”.
Finally, the remaining percentages were more or less equally distributed between the various options, except for “more than once a week”, which was selected only by one participant.
In addition to these results, a few participants indicated that they purchase model kits only on particular occasions, like Comicons and other similar events. Other participants, instead, affirmed that they only purchase model kits when they are sure that they can afford the products that they want.
These results show that the model building community has a relatively low purchasing frequency per person, but at the same time it presents enough model builders so that a low personal purchasing frequency does not hinder the economic growth of the industry. In addition to that, the reason for such a low frequency may simply be linked to the private life of the model builders, which can influence both the rate at which they are able to purchase model kits and the rate at which model builders assemble the kits. Also, it is important to understand the quantity of model kit bought at the same time on average.

Model kit building frequency

Following the previous question, the participants were asked how often they built the purchased model kits. In this question the options available gave the same frequency as the previous one, in order to understand how often model builders take time to enjoy their hobby.
Considering the results from the previous question, it would be reasonable to expect similar data to come from the answers for this one.

Interestingly enough, the results show a less cohesive picture than the one painted by the answers in the previous one.
While the most selected option was still “more than once a month”, this time it was chosen only 23% of the time. The second most selected option was “more than once a week”, reaching 21.3% of the total answers. This discrepancy between the two questions shows that a good portion of hobbyists manage to find the time to work on their model kits more often than they are able to go purchase new ones.
That said, the other most chosen options were “less than once a month” (19.6%), “once a week” (13%) and “once a month (12.6%), solidifying this initial analysis
In addition to that, the remaining options, which indicated building model kits less than once every six months, once a year or less than that have been chosen only in small percentages.
An interesting insight is what some participants (1.3% of the total) have indicated in the open option: in this case, the main reasons for which they could not indicate a precise frequency is because they either take a long time finishing working on the model kit or because they only occasionally purchase and build one.
The data recovered from these answers contrasts with the observed purchasing rate. With the frequency of assembly of model kits leaning more towards at least once per week, while the purchasing rate observed leans more towards once a month, it would suggest that the hobbyists purchase multiple model kits, especially if they buy something only once every month or less. The next question and its answers will allow understanding better the correlation between purchasing rate and assembly rate.


How many model kits do you buy at the same time?
230 risposte
1,7%
0,9%
4,8%
35,2%
57,4%
One
Two to four
Four to eight
Ten
More than ten at once


Where do you prefer buying the kits?
230 risposte
47%
27,8%
25,2%
Physical store
Online store/e-shop
Both/doesn't matter

Organization of the Survey and Answers

2. Participation in the Hobby

Model kit purchase volume

As stated in the previous question, the data gained from the answers to this one allowed for a more complete vision of the purchasing-assembly part of the model building hobby.
By asking the participants how many model kits they purchase at the same time it is possible to ascertain both an average number of model kits purchased per person and, once compared with the results of the previous questions, an average of how many model kits a hobbyist assembles per month (considering an average purchasing frequency of once a month).

Considering the answers to the previous questions, it would be plausible to hypothesize an outcome where the majority of model builders would purchase multiple model kits at the same time, for two main reasons. The first reason, linked to the occupation of the general audience, suggests that it may be possible that, considered the majority of working participants to the survey, hobbyists may generally be able to purchase multiple model kits, thanks to having funds for them.
The second reason, linked mainly to the previous two questions, may suggest that purchasing multiple model kits at once would reduce the number of times that would be required to go to the preferred store, whether online or physical. This would reduce the frequency in which a model builder would purchase model kits, while also maintaining a number of kits worked on at least one each week or multiple a month.

The answers did confirm the hypothesis, especially considering that the option “2-4” model kits at once was the most selected, reaching 57.4% of the total. Considering that the second most chosen answer was “1”, at 35.2%, then followed by “4-8” model kits at once, at 4.8%, it is safe to assume that the vast majority of model builders prefer to purchase multiple items at the same time.

The results of these three questions, when compared to the previous section, allow identifying as a personas an European or American male hobbyist, aged between 25 and 40 years old, working, which prefers to purchase multiple (2-4) model kits at once, but limits himself to only purchasing once a month, in order to have time to assemble the kits.

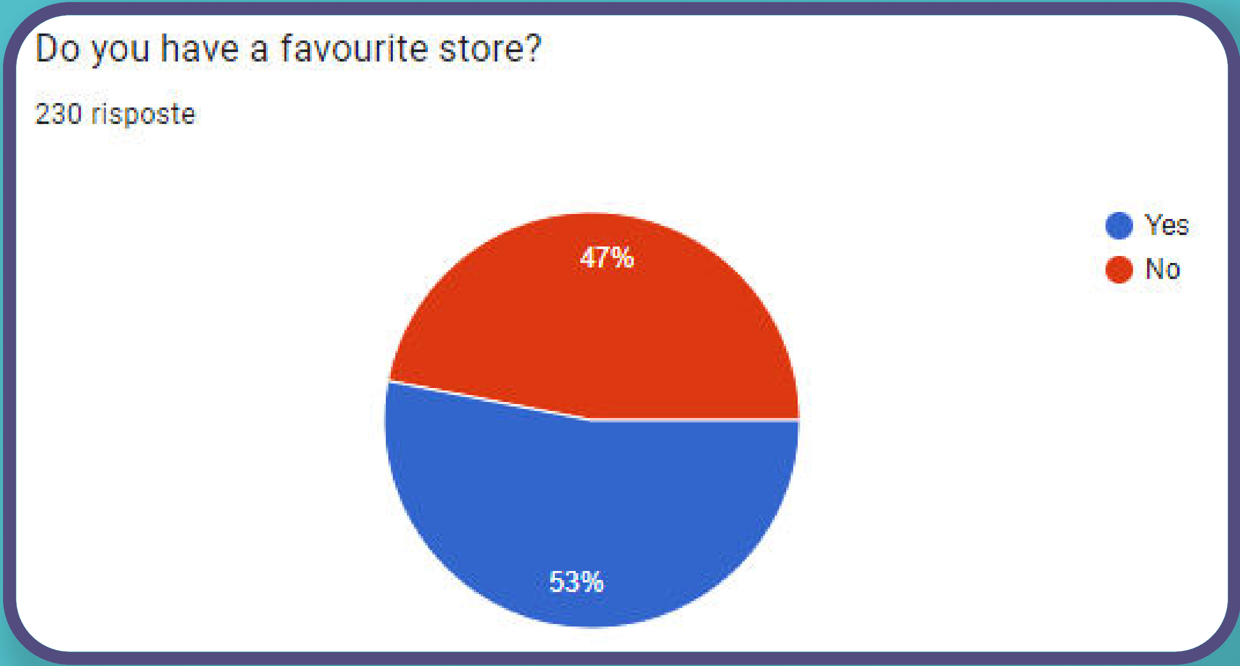
Purchase preferences

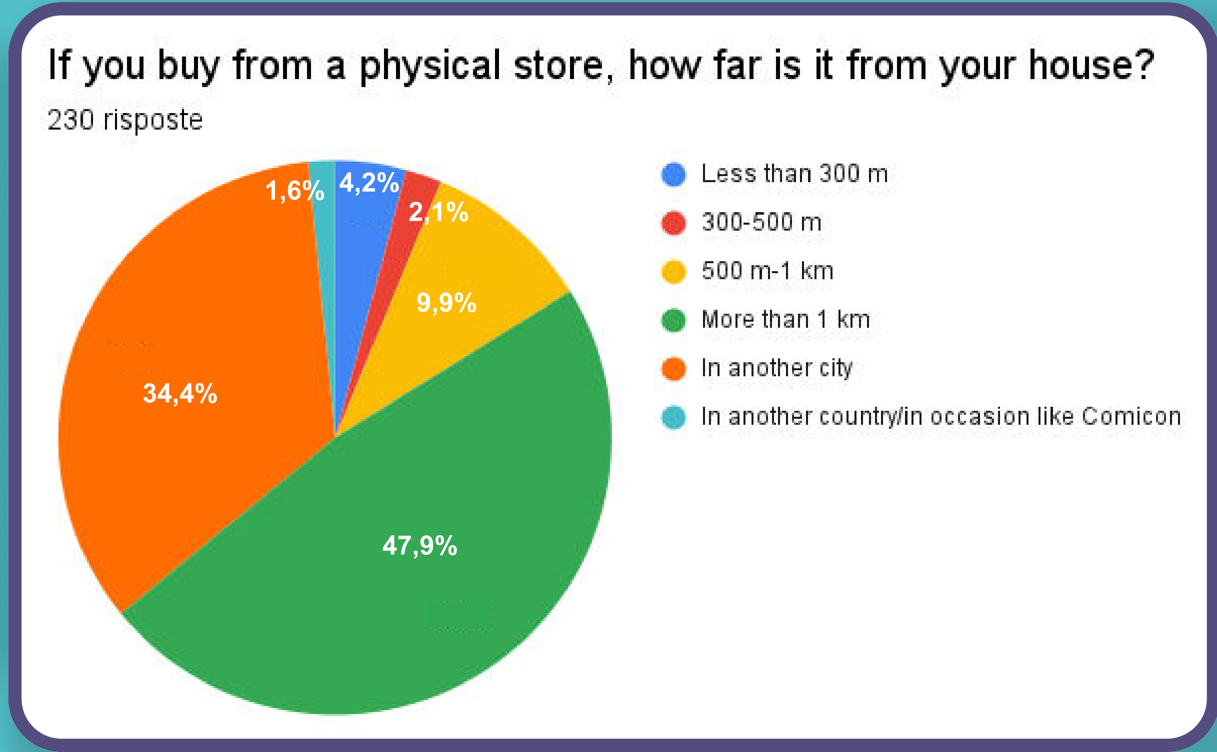
Once having established the participation in the purchasing aspect of the hobby in a vacuum, asking exclusively the purchasing frequency and the amount of model kits bought at the same time, it was necessary to understand the purchasing preferences of the model builders. In particular, the preferences when it comes to the type of store where they purchase model kits, the reason why and other details.

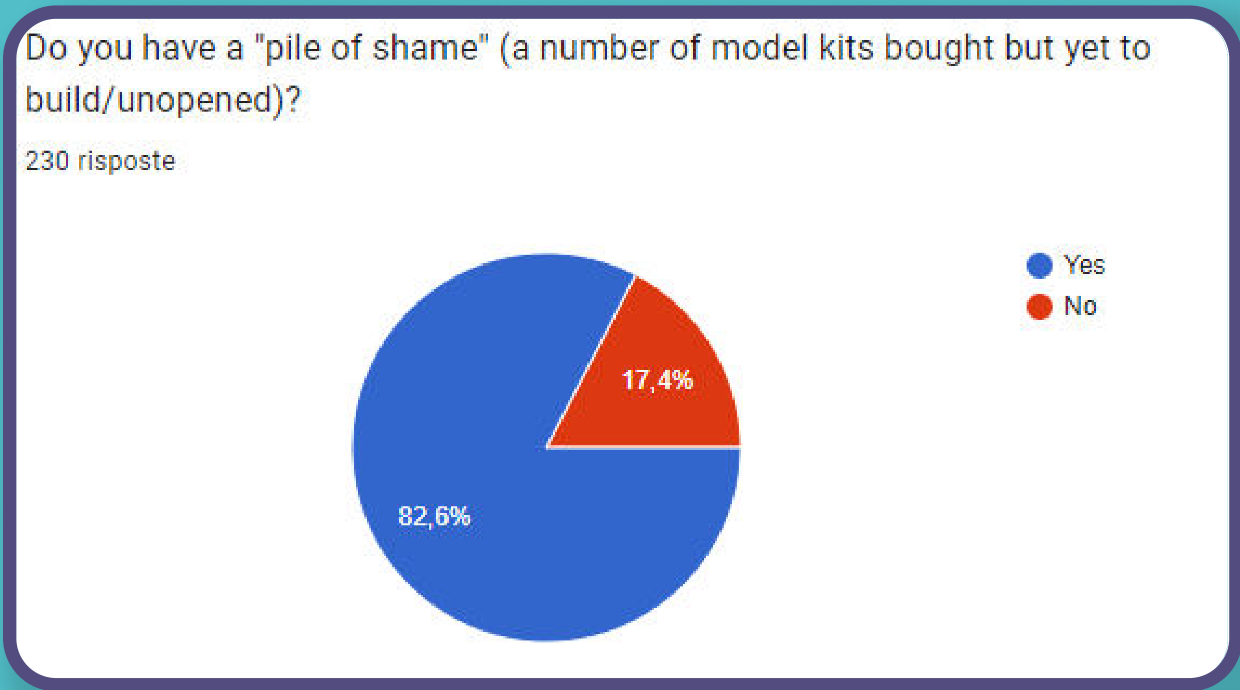
Starting this analysis, the participants were asked where do they prefer buying model kits, whether it was physical stores, online stores or if they prefer both or the type of store did not matter.
The results of this question would have been interesting no matter what option was chosen the most. The reason for this is the fact that both physical stores and online stores have strong and weak points. Physical store, for example, allow hobbyists to get in contact together and chat, but the limited space could mean that a model builder may not be able to find the product that they are looking for. Online stores behave exactly the opposite way. It is much easier to find a precise model kits, but there is a total lack of human contact.

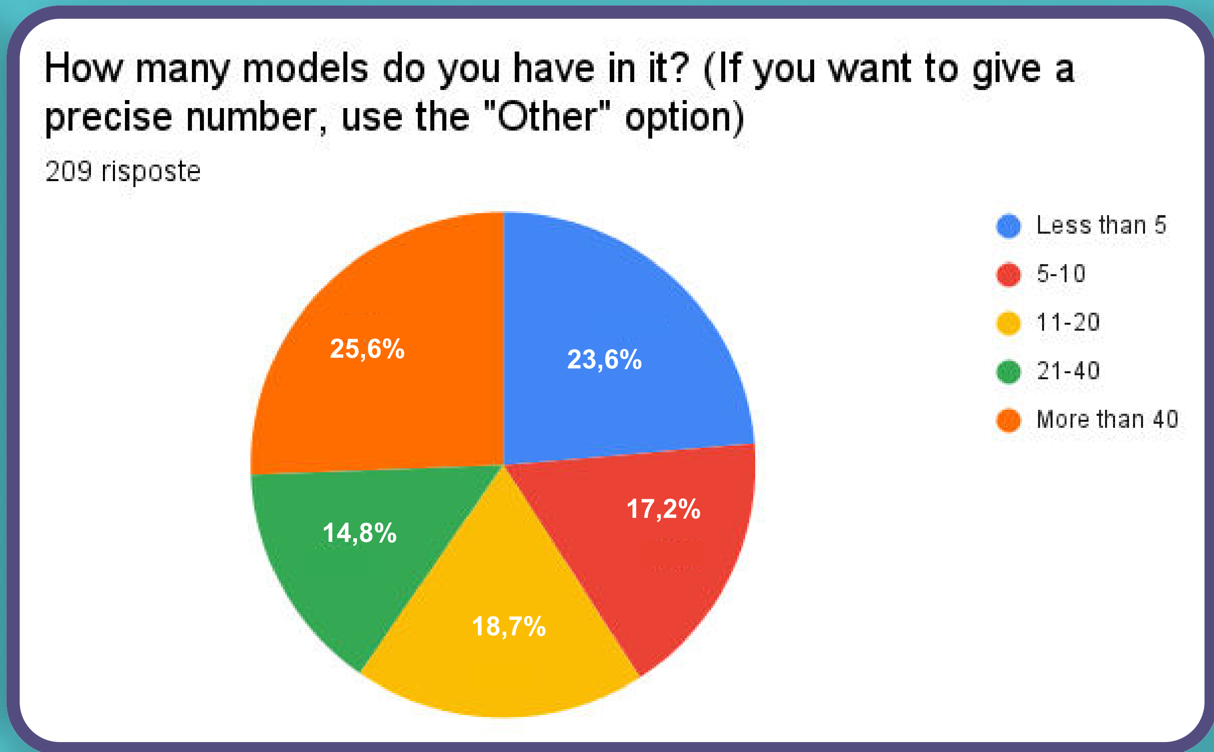
The results showed that a large part of the community does not have a real preference between the two type of stores, since 47% of the participants selected the “both/doesn’t matter” option. When compared the two types of stores, though, online store were slightly more preferred, registering 27.8% of selections against 25.2% for physical stores.
When asked for a reason for their preferences, the participants that choose physical stores mainly indicated that they prefer supporting local stores, indicating that they often buy from a singular one and that they have some level of connection with it. Another reason is the human interaction that can be had with the staff and other patrons of the store. A final reason is the immediate availability of the model kits.
The model builders that preferred online stores gave various reasons as well. The most common was the ease of access. Many explained that being able to browse freely online stores, while looking for a specific model kits allowed for a larger catalogue from which to choose. In addition to that, various participants listed that often online stores offer better prices than physical stores, both in terms of regional pricing and in terms of sales. Finally, a few model builders stated that they do not have a store near them, thus needing online stores to buy kits. In addition to these reasons, some participants explained that often the shipping times are not particularly long.
Finally, the model builders that indicated no particular preferences generally stated that they use physical stores and online ones for different model kits and different reasons. The main difference between the use of online and physical stores is that online stores are used to either find and purchase second-hand models or to buy precise products that may not be available in stores, while physical stores are often used to browse and chat with the staff, while also allowing for a closer look to the model kits.

In general, though, each type of store covers different necessities, thus, in the development of a personas, it would be more useful to avoid an exclusive preference.


Do you have a favourite store?
230 risposte
Yes
No
47%
53%


If you buy from a physical store, how far is it from your house?
230 risposte
Less than 300 m
300-500 m
500 m-1 km
More than 1 km
In another city
In another country/in occasion like Comicon
1,6%
4,2%
2,1%
9,9%
34,4%
47,9%


Do you have a "pile of shame" (a number of model kits bought but yet to build/unopened)?
230 risposte
Yes
No
17,4%
82,6%


How many models do you have in it? (If you want to give a precise number, use the "Other" option)
209 risposte
Less than 5
5-10
11-20
21-40
More than 40
25,6%
23,6%
17,2%
14,8%
18,7%

2. Participation in the Hobby

Purchase preferences

Another point of interest in analysing the preferences of the model builders towards hobby stores was understanding if they had a favourite store. The results gave a slightly more positive result, with “yes” being selected 57% of the time, while “no” was selected 43% of the time. A subsequent question asked the name of the store, in order to understand if the majority of model builders preferred shopping in first or third party stores. The question was not mandatory, since the participants may not have a favourite store. As a result, though, the various answers received listed mainly third party stores, so much so that almost each participant with a favourite store gave a different answer, making useless drawing a pie chart with the names.

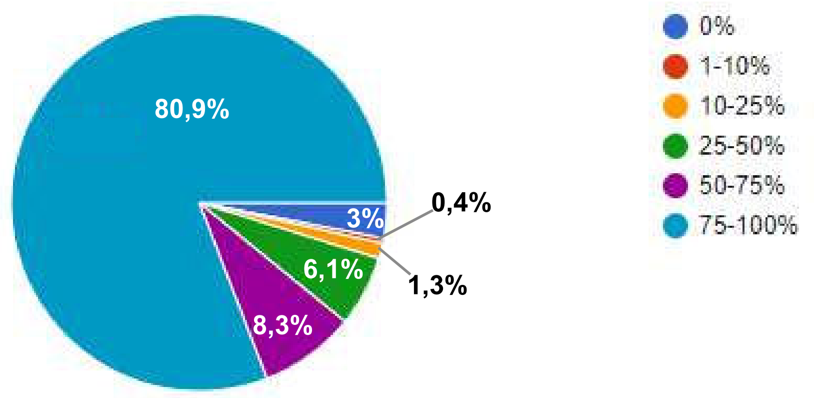
The final question regarding the stores asked the participants to broadly indicate the distance between their house and the physical store from which they buy model kits. The results of this question may be particularly useful when defining a user waste recovery network.
The results were very interesting. First of all, the most selected answer was “more than 1 km”, which reached 47.9% of the total. In addition to that, the second most chosen answer was “in another city”, selected 34.4% of the time. This shows an interesting element in the development of a user waste recovery network: model builders are willing to travel more than 1 km (most likely by vehicle) in order to purchase model kits. This could mean that a waste recovery network may be quite effective even in areas where hobby stores are not present in every city or in all the districts of a city.

Backlog (“Pile of shame”)

Another aspect of the hobby is the presence of a backlog in the collection of a model builder. In some cases there is none, but in others it may be made of tens of model kits.
In order to continue understanding the model builders community and to develop a personas, it would be useful to determine how common is the presence of a backlog and how many model kits compose it on average.
The first step was asking about the presence of a backlog, commonly called “pile of shame”. This nickname is generally used to help the model builder in avoiding purchasing other model kits when they already have a large amount of models still in the boxes and unopened.
The presence of a pile of shame is quite common, therefore there was no particular surprise in seeing that the vast majority of participants in the survey answered yes (82.6%).
What is interesting are the answers to the follow-up question, which asked the amount of model kits in the backlog.
First of all, while this question was not mandatory, since in the previous one there was the possibility to answer that the model builder did not have a pile of shame, the total answers were 209, which contrasted with the difference between 190 “yes” and 40 “no”. This means that some model builders do not see their backlog as a shameful pile of unopened model kits.
The other interesting aspect of the answers, is that they are relatively well distributed between all five of the available options. While the most selected answer was “more than 40”, which gathered 25.6% of the total, the least chosen option was less than ten percentage points lower: “21-40” model kits was selected 14.8% of the time.
That said, the two most chosen option are very contrasting: while the most chosen option indicates more than 40 model kits in the backlog, the second most selected is the lowest amount: “less than 5” covered 23.6% of the total answers.
The other options, £5-10” and “11-20” were selected 17.2% and 18.7% of the time, respectively.
An interesting observation is related to the open answer. In this case, some participants stated that they have an enormous backlog, reaching over a thousand model kits. Since this data was much higher than the rest of the options and only a few participants gave it, it will not be used to define a personas.

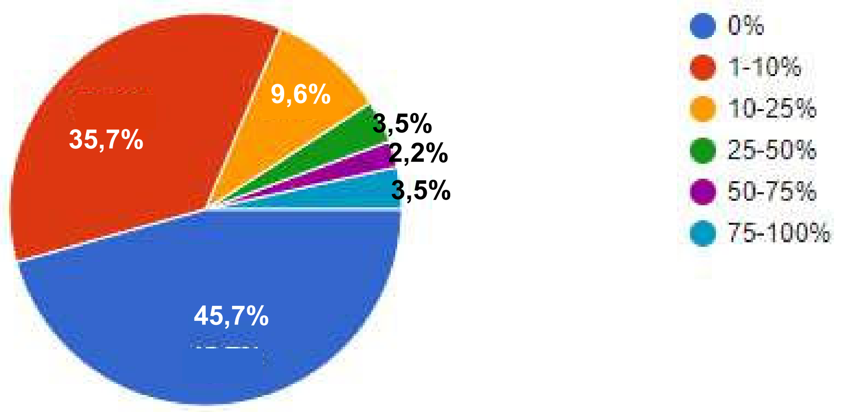
How many of the model kits you buy are made in plastic?

230 risposte



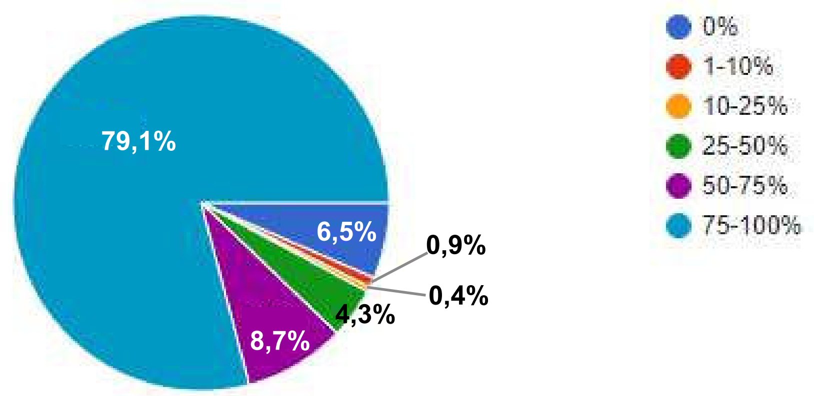
How many of the model kits you buy are made in resin?

230 risposte



How many of the model kits you buy are made on runners/sprues?

230 risposte



Organization of the Survey and Answers

2. Participation in the Hobby

Model kit preferences

The last element needed in order to better define the participation in the hobby by the model building community was understanding the material in which the majority of the purchased model kits are made out of.
In order to do so, or at least in order to try and define the most common material used by the hobbyists was asking the community how many model kits that they own were made out of plastic or resin. While these two materials are not the only ones used in the industry, they are the most common, as the four production processes analysed in the first chapter demonstrated, since all four use one of the two.
In the question about plastic model kits, the vast majority (80.9%) stated that 75-100% of the kits that they own are made out of plastic. Lowering the suggested percentage range (50-75%, 25-50%,...) the percentage of selection lowered. Interestingly enough, though, the lowest option, 0%, registered 3% of the total answers, while 1-10% only registered 1 answer.
Comparing these answers with the ones for the same question about resin, the numbers seem to match, more or less. The 0% option was the most selected one, reaching 45.7% of the total. This allows to hypothesize that almost half of the model building community purchases exclusively plastic model kits. This is also in line with the analysis of the production processes: both injection moulding and vacuum forming, two industrial level processes, use plastic and are very common in the industry. The next most chosen answer was 1-10%, which reached 35.7% of the total answers. Again, it showed a general preference towards plastic. One last element about this question, the 75-100% option was selected 3.5% of the time, more or less in line with the opposite answer from the previous question.

One final question on this section is the amount of model kits that come on runners. The reason for this question is to try and understand how many runners the model builders will end up still having once the model is assembled.
The results were very much in line with what transpired from the previous two questions: the vast majority (79.1%) of the model kits purchased by the participants come on runners. Again, as seen in the analysis of the production processes, plastic model kits are produced on runners, especially when produced with injection moulding. The remaining answers were again in line with the previous answers, especially considering that some resin model kits may not come on runners and instead are divided in various parts.

Conclusions

The results from the questions in this section were very useful both in developing the personas that will be used to define the userbase for a new industry network. Thanks to the data regarding how the community interacts with some aspects of the hobby, it will be possible to define how they will interact with changes in the network, from initiatives to new materials.
In addition to that, the information that resulted from preferences in type of stores and in materials will be particularly needed to better understand the answers to the following sections. Not only that, but the addition to the general distance between the hobbyists and the stores may prove useful if the need to define a recovery network on a map is needed.
Regarding the development of the personas, it could be added that they would purchase model kits both from physical stores and online ones, searching for precise items online and browsing a local hobby store while chatting with other hobbyists and the staff. The physical store would be more than 1 km away from their house, and they would be used buying more than 2 kits at once. That said, the personas would have a backlog, which thanks to the large difference between the most selected answers would require the development of at least two different personas, one that has a smaller backlog (which can be explained by them being able to assemble their purchases more often) and one that has a much larger one (possibly explained by less time to assemble the kits and collecting urges that cause impulse buying). The personas would prefer plastic model kits, sold on runners.

Organization of the Survey and Answers

3. Waste from the model kit

Organization of the section

The third section of the survey covers the remaining key point of the objective “Hobby and user waste”, focusing on the user waste.
The nine questions range from what do the model builders see as waste from after assembling the model kit, to what do they do to the empty runners, the amount of plastic still in their possession and interest in changing that.

The first question asked the participants what constituted waste after the assembly of the model kit. In this case various options were listed. Other than the empty runners, the options comprised the shavings from cleaning the model kit components, the packaging and two additional options: “none of the above”, “all of the above”.

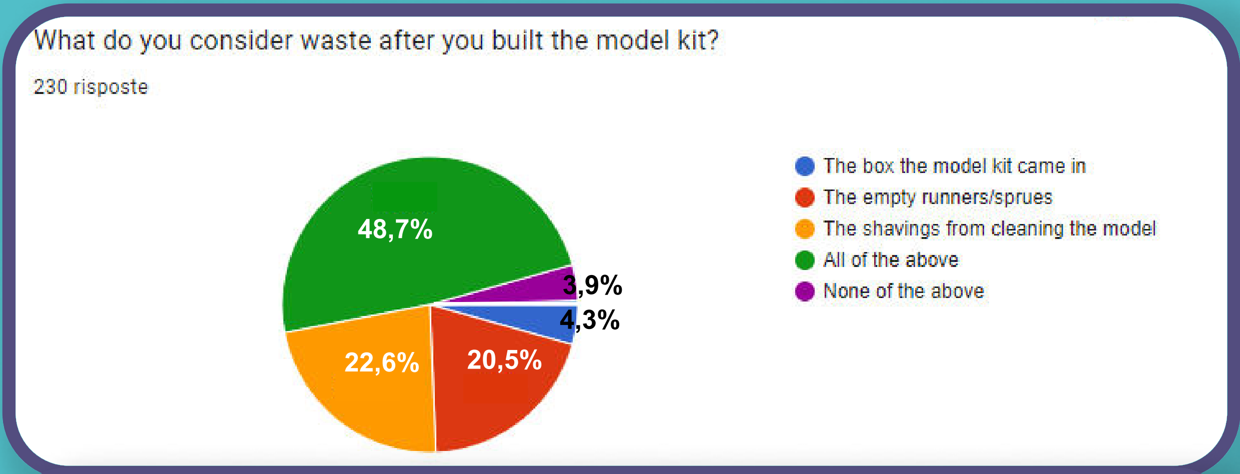
The second and third questions were aimed towards the packaging, mainly the boxes the model kits came in. These questions simply asked if the participants threw away the boxes and why.

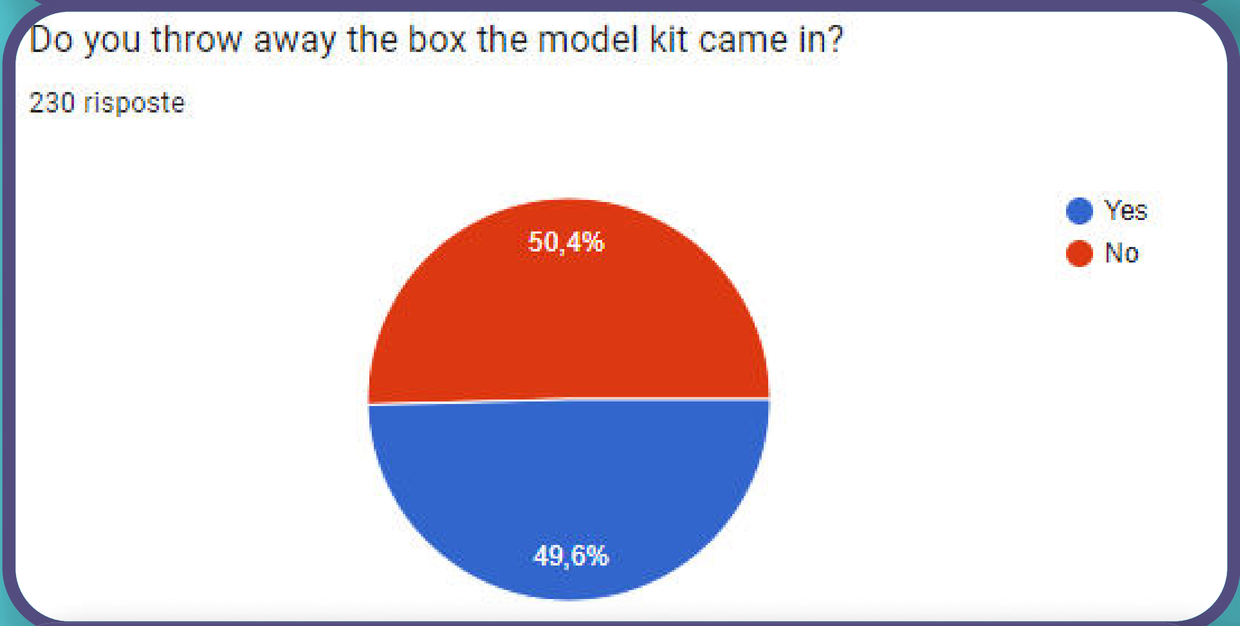
The remaining six questions were focused exclusively on the empty runners.
The fourth question asked the participants if they threw away or not the empty runners, using a simple yes or no question. Similarly, the fifth question asked if the participants reused the runners, using the same type of question.
The sixth question asked how much plastic do the participant think they have. In this case the answers were divided in ranges, going from “less than 1 kg” to “more than 10 kg”. Like similar questions in the previous section, this one had the objective to find an average quantity of material recoverable from the users.
The seventh question asked the participants how much of the runners they managed to reuse, using ranges going from “less than 10%” to “70-100%”. This question worked together with the previous one to try and understand the potential quantity of material that the model builders would be willing to part with.
The eight question asked how the model builders prefer to reuse the runners. The answers proposed various options, adding an open one to allow for a more precise answer.
This question had the objective to better understand both how the participants still see use in the runners, but also to try and understand how many runners the model builders would still want to keep. For example, one of the possible answers was “gap filler after melting”. This answer meant that the participants melt the runners using solvents, usually acetone based, that transform the plastic in a dense “slime” that can be used to fill gaps in the model kit. This type of use usually does not require huge amounts of material, while other options, like “kitbashing/ scratchbuilding material” could require more material. Kitbashing is an activity in which various parts of model kits (and runners) to assemble a completely original one. Scratchbuilding, instead, is an activity in which any type of components, even parts of everyday objects. Both activities may require a different quantity of material, depending on the parts necessary.
The final question asked if the participants would be interested in reusing the runners more, suing a simple yes or no question.

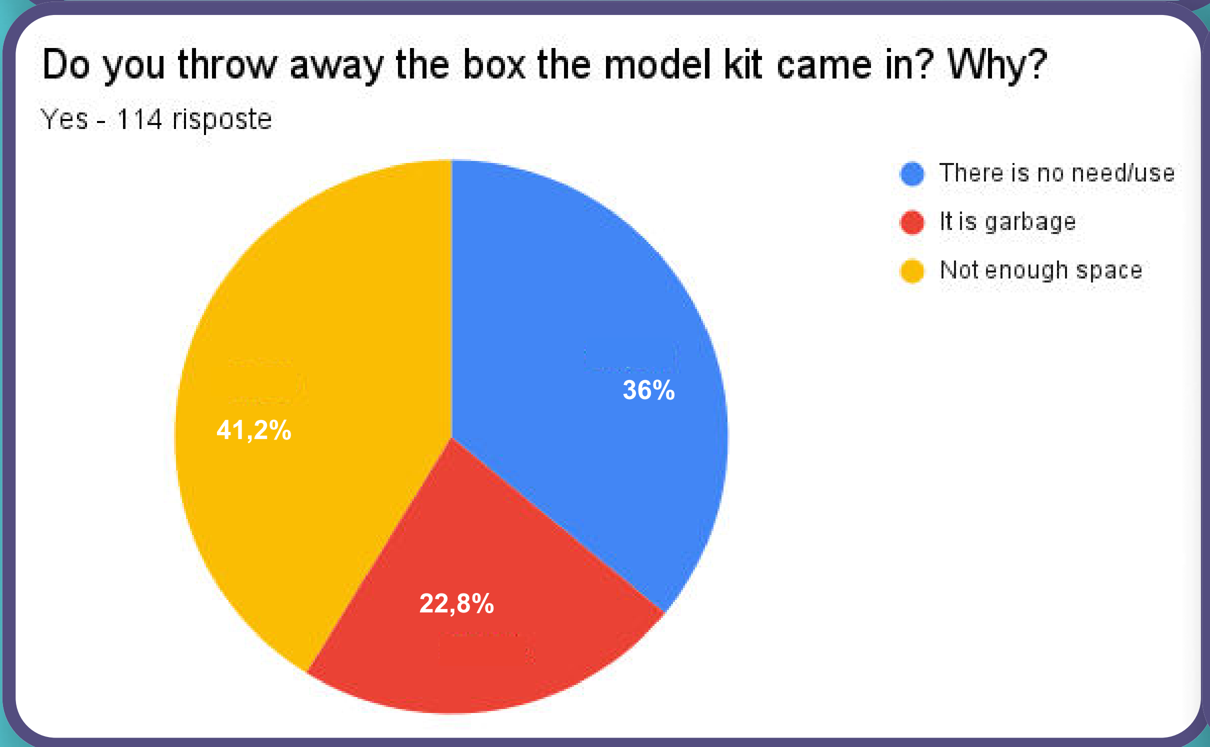
Organization of the section

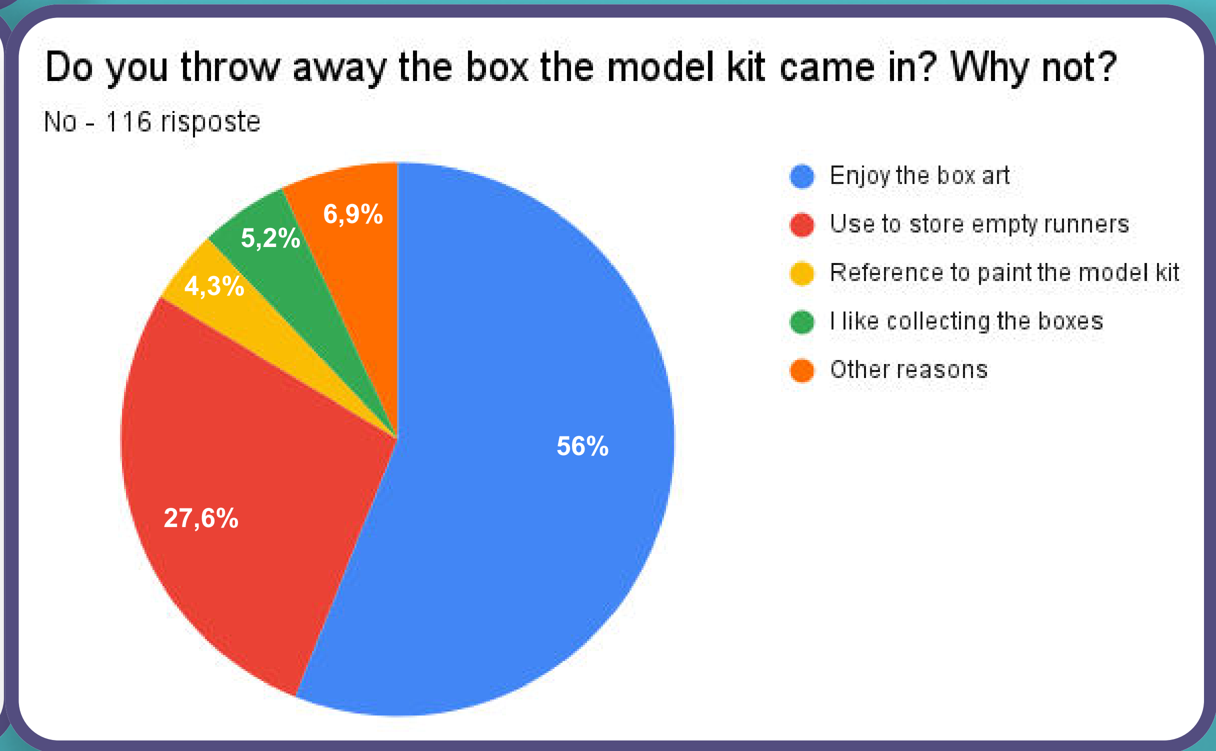
List of the questions:

1. What do you consider waste after you built the model kit?
2. Do you throw away the box the model kit came in?
3. Why/ why not?
4. Do you throw away the empty runners/sprues ?
5. If not, do you reuse the runners/sprues ?
6. How much plastic do you think you have in runners/sprues ?
7. How much of the empty runners/sprues do you manage to reuse?
8. How do you usually reuse the runners/sprues ?
9. Would you like to reuse the runners/sprues more?


What do you consider waste after you built the model kit?
230 risposte
The box the model kit came in
The empty runners/sprues
The shavings from cleaning the model
All of the above
None of the above
48,7%
3,9%
4,3%
22,6%
20,5%


Do you throw away the box the model kit came in?
230 risposte
Yes
No
50,4%
49,6%


Do you throw away the box the model kit came in? Why?
Yes - 114 risposte
There is no need/use
It is garbage
Not enough space
36%
41,2%
22,8%


Do you throw away the box the model kit came in? Why not?
No - 116 risposte
Enjoy the box art
Use to store empty runners
Reference to paint the model kit
I like collecting the boxes
Other reasons
6,9%
5,2%
4,3%
56%
27,6%

Organization of the Survey and Answers

3. Waste from the model kit

What constitutes waste

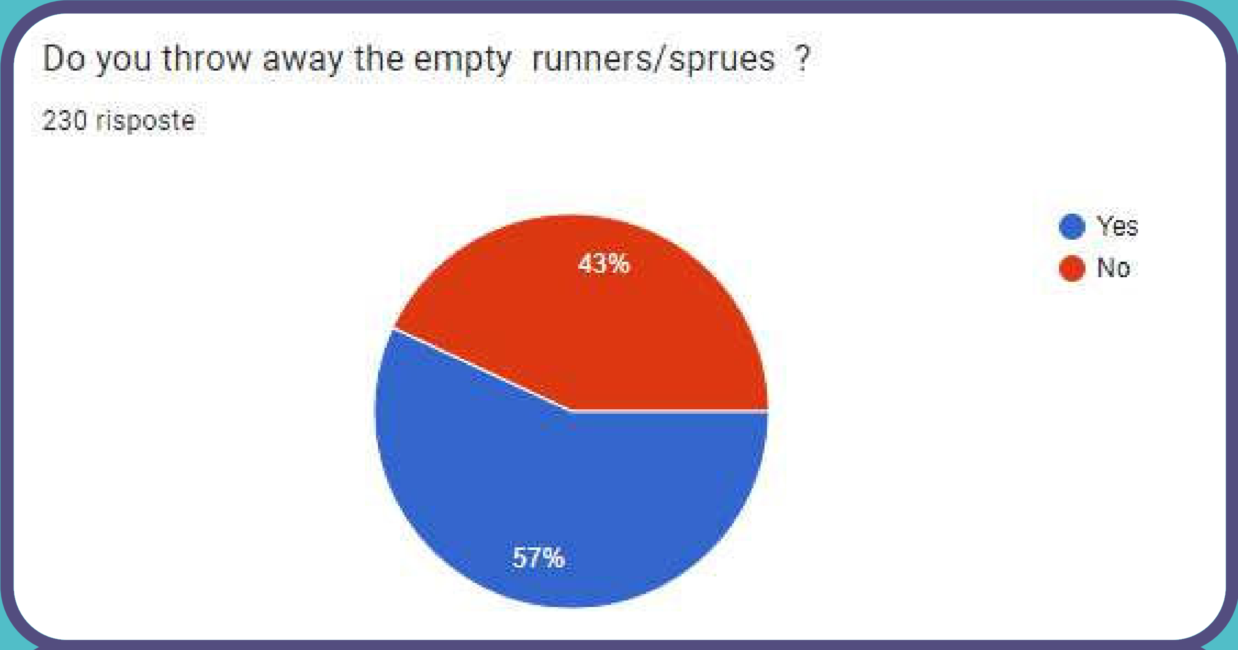
The step following understanding the interaction with the hobby was to understand what constitutes waste for the model builders and if there are any ways in which they try to reuse said waste.
In order to do so the survey dedicated a section to pose questions which will allow to better define what is defined as waste and what instead is still considered useable material.

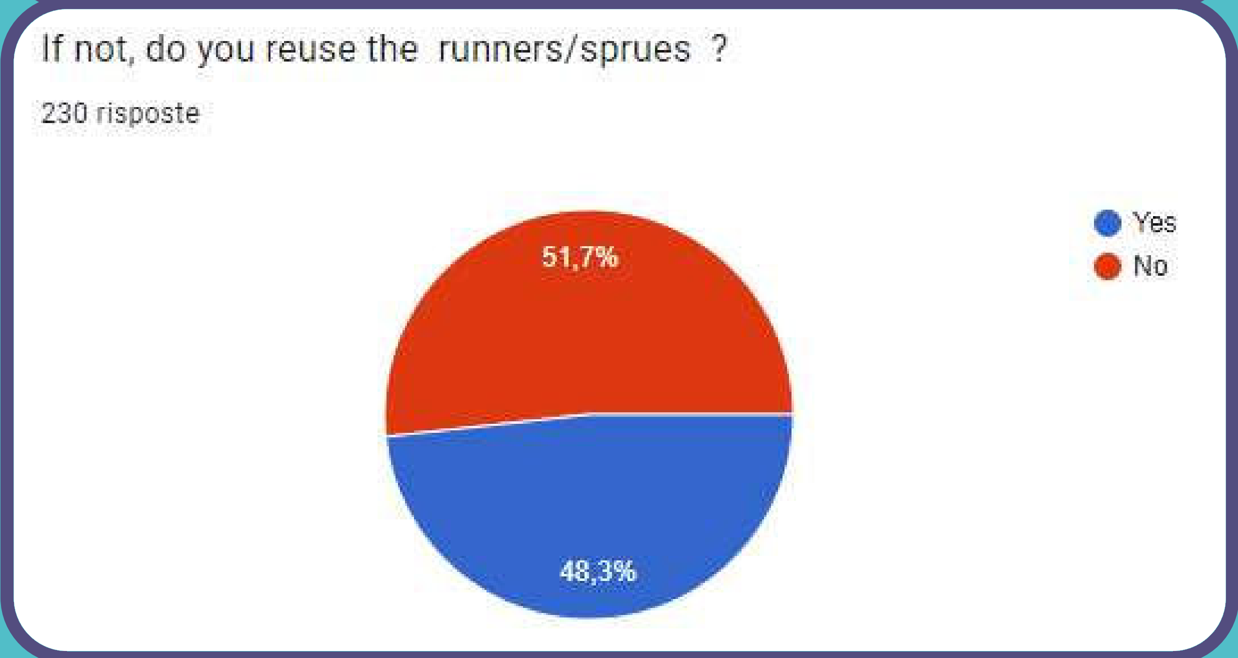
The first question asked regarded a general definition of what is considered waste. In this question the available options covered both the packaging, the empty runners and the shavings that may come from cleaning a model kit from mould lines. In addition to that the option “all of the above” gave the opportunity to define all the other answers as waste. Similarly, if a participant did not see any option as waste, they could select “none of the above”.
The results were very interesting: the “all of the above” option was selected the most, being chosen 48.7% of the time, while the second, the shavings, only reached 22.6%. The runners and the box were chosen respectively 20.5% and 4.3% of the time, showing that singularly the runners are regarded as waste more than the packaging boxes.
Finally, the “none of the above” option was selected only 3.9% of the time.

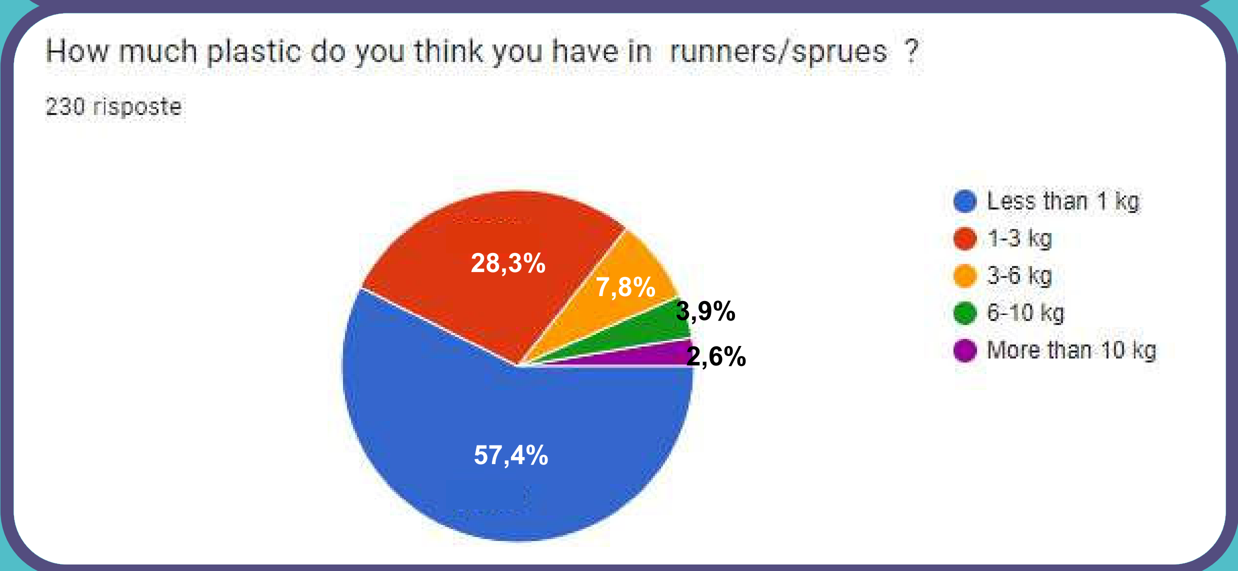
These results are very interesting. The vast majority of the participants saw at least one of the option proposed as waste, with almost half defining all of them as such. That said, the reuse of some of these types of waste is pretty common in the community, therefore these results beg the question: if both boxes and empty runners are commonly seen as waste, why some hobbyists still see value to them? And how do they use these elements?

The model kit box

After gaining a first understanding on the general view of waste, it could prove useful to observe the community view of both boxes and empty runners separately. Starting with the boxes, the participants were asked whether they threw away the packaging the model kit came in. Interestingly enough, the answers were almost split in half between yes and no, which registered 49.6% and 50.4% respectively. This result is very curious, especially considering that the boxes were considered waste most of the time.
In order to better understand the reason behind the answers to this question, a following one that asked the reason was prepared. In order to better distribute the results between the reasons why the participants answered yes or no, the motivations were divided between the two.
Starting with the reasons behind the “yes” answer, which collected 114 selections, the results showed very simple and understandable motivations. First of all, the most common was the lack of space to store the boxes, which was indicated 41.2% of the time. The participants then also indicated the lack of use for the boxes once the model kit was assembled, giving this reason 36% of the time. Finally, given as a reason 22.8% of the time, was that the box becomes simply garbage once it exhausted its use as packaging. In addition to that, various users state that it would be better if the boxes get recycled as paper waste rather than accumulate dust on a shelf.
As for why a slight majority of the participants answered that they do not throw away the boxes, various reasons were given.
The most common was that the participants simply liked the box art. This reason was stated 56% of the time, showing great interest towards the presentation of the packaging. The second most common reason was using the boxes as storage, which was indicated 27.6% of the time. This is very interesting, since this practical use of the boxes was often combined with the preservation of the empty runners. This data will be compared later with the analysis towards the behaviour of model builders towards the empty runners.
The other most common reasons given were stated less, like collecting the boxes (5.2%) and using them as references (4.3%). The remaining 6.9% of the answers were miscellaneous, going from using the boxes as basing material or as painting trays.
The results from these questions showed that not only a good part of the community still sees value in the boxes, but also that the uses are quite varied, at least outside simply enjoying the box art.


Do you throw away the empty runners/sprues ?
230 risposte
Yes
No
43%
57%


If not, do you reuse the runners/sprues ?
230 risposte
Yes
No
51,7%
48,3%


How much plastic do you think you have in runners/sprues ?
230 risposte
Less than 1 kg
1-3 kg
3-6 kg
6-10 kg
More than 10 kg
28,3%
7,8%
3,9%
2,6%
57,4%

Organization of the Survey and Answers

3. Waste from the model kit

The empty runners

When it came to understanding the relationship between model builders and the empty runners, it appeared that multiple questions were needed, asking more or less details depending on the focus and the objective of the questions.
That said, the questions as a whole needed to communicate and to allow to define both how runners are seen by the community and, if the model builders saw use in the runners, how they get reused.

The first step in developing this understanding was to ask the participants if they threw away the empty runners. Considering that a sizeable portion of the answers in previous questions defined runners as waste, it would be plausible to foresee a majority of “yes” as an answer. As a matter of fact, those were the results, with “yes” being selected 57% of the time, while “no” the remaining 43%. Interestingly, the difference between the two selection is not particularly large, thus showing that there is some worth in the runners themselves.

Subsequently, the participants were asked if they reused the runners. In this case, a slight majority (51.7%) answered “yes”, contrasting the previous results. This may indicate that even part of the community that throws away empty runners still tries to make some use of them before disposing of them.

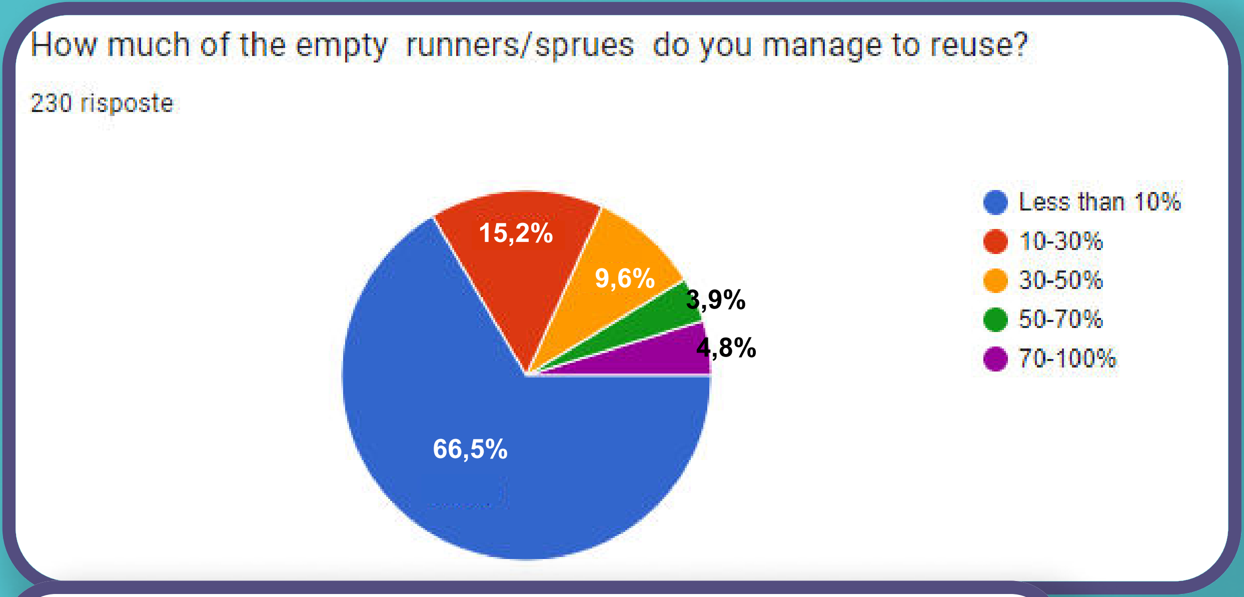
These first results can be telling on what to expect from the following questions. Considering that a majority of the model builders throws away the empty runners, for example, it could be possible to predict that there is a low average regarding the weight in plastic that the average hobbyist may still have as empty runners.
The results regarding the amount of model builders reusing the runners could indicate that there is a variety of methods with which reuse them.
Finally, considering both questions, it could be interesting to analyse the results regarding the actual amount of runners that the model builders manage to reuse.

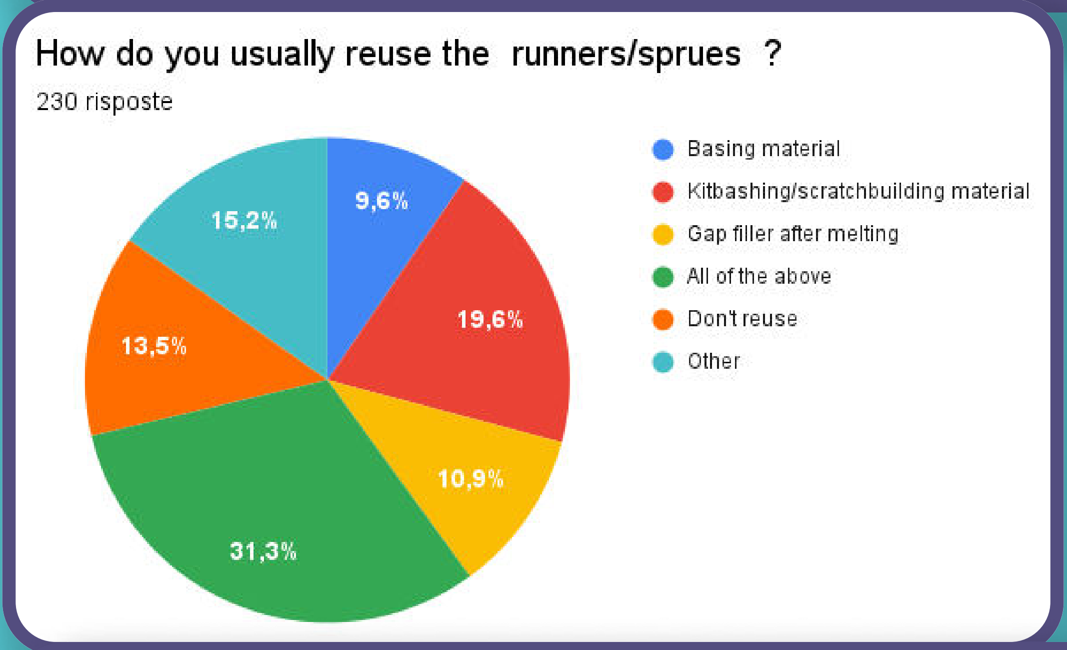
Plastic waste weight

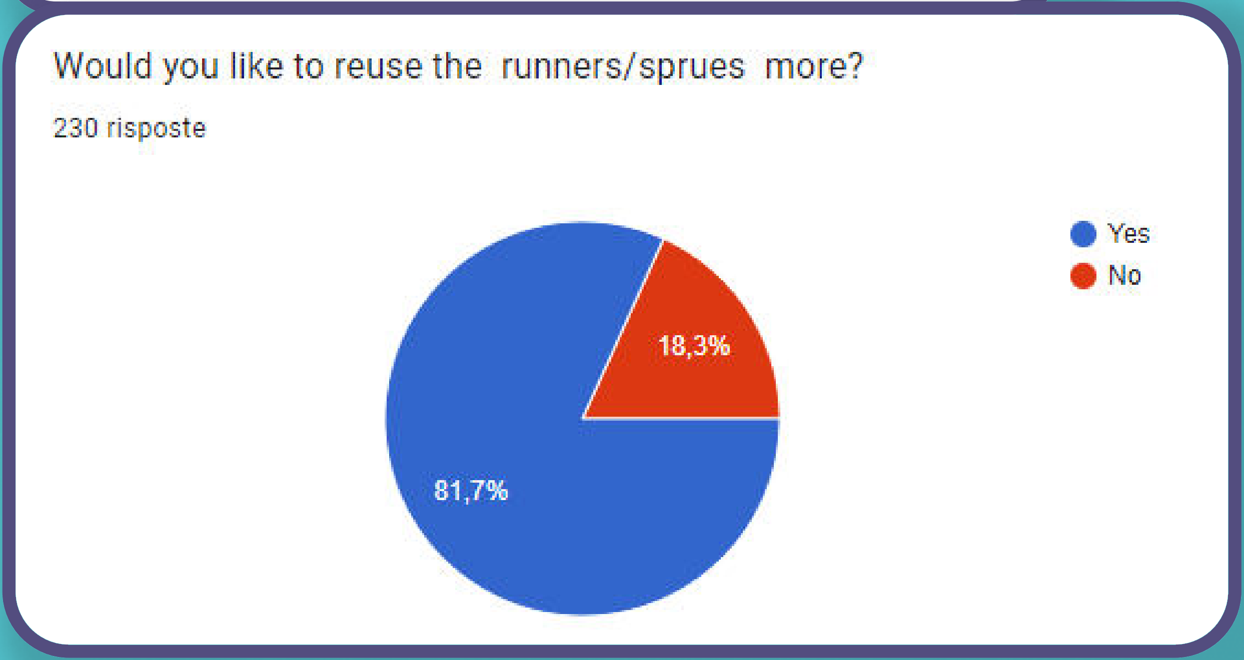
After gathering some elements to analyse the behaviour of the model builders towards the empty runners, trying to understand an average weight in plastic still present in their houses may prove useful when ascertaining the amount of material actually used by the hobbyists.
This question asked specifically for the amount of plastic in runners because the Polystyrene used to produce model kits can be reused even by a singular person, while resin runners or other elements can not be recycled by a single person in ways similar to plastic, especially, as it will be defined better later, as a gap filler after melting the runners.

As stated previously, by analysing the results from the other questions it could be possible that the average amount of plastic in runners may be low.
The answer to this question prove that: the average seems to be around 2 kg, with the two most chosen options being “less than 1 kg” (57.4%) and “1-3 kg” (28.3%). Comparing the two, an amount around 1 to 2 kg could be considered the mathematical average in the model building community, since the other options (“3-6 kg”, “6-10 kg” and “more than 10 kg”) all have been selected less than 10% of the time, thus lowering the impact that they may have on the average.

With the answers in this question following the hypothesis matured from the answers to the previous ones it seems that the community of model builders not only does keep only a small quantity of runners from the model kit boxes, but also seems to keep only runners (or part of runners) that could be reused, thus reducing the actual amount of material kept.
The next steps will be to understand how these runners are reused and how much of them is actually used up.


How much of the empty runners/sprues do you manage to reuse?
230 risposte
15,2%
9,6%
3,9%
4,8%
66,5%
Less than 10%
10-30%
30-50%
50-70%
70-100%


How do you usually reuse the runners/sprues ?
230 risposte
9,6%
15,2%
19,6%
13,5%
10,9%
31,3%
Basing material
Kitbashing/scratchbuilding material
Gap filler after melting
All of the above
Don't reuse
Other


Would you like to reuse the runners/sprues more?
230 risposte
18,3%
81,7%
Yes
No

Organization of the Survey and Answers

5. Waste from the model kit

The final part of this section of the survey functioned as a way to complete the understanding of the relationship between hobbyists and the empty runners that compose the plastic waste from the hobby.
While with the previous questions it was possible to develop a general idea of the amount of plastic waste in runners that the model builders keep, the objective of the following questions is to understand how much of that waste gets reused by the model builders, how and, finally, if they are content with the amount reused.

The community answered in an interesting way to the question about the amount of empty runners that they manage to reuse. The vast majority answered “less than 10%”, which was selected 66.5% of the time. The other options were selected less and less as the proposed percentage increased, with the second most chosen, “10-30%” reaching only 15.2% of the total answers.
This trend shows that while there is interest in reusing the runners, the majority of the model building community either does not do that much. This could be based on various factors, like the difficulty in adapting the pieces of runners to the projects or a lack of knowledge of how to reuse them. In addition to that, there is another obstacle to a more thorough use of the runners: their shape and size. The runners are often shaped in a way that both allows a fluid flow of molten plastic in each component of the model kit, while also avoiding an excessive diameter for the sections of the runner. This makes so that, in some cases (e.g. Games Workshop model kits), the runners’ shape and diameter could differ from a model kit to another, making more difficult their use on projects, especially if the sections of the runners need to be used in a specific way.

The reuse of runners

After these speculations it is necessary to understand how the runners are used. In the question there were various options for the participants to choose. Each option is a common way as seen in the communities on social networks. “Basing material” meant that the runners are used to decorate the bases of some model kits, like Games Workshop ones, which usually come on various sized bases. “Kitbashing/scratchbuilding material” meant that the runners are used as part of kitbashing projects. “Gap filler after melting” meant the transformation of solid plastic runners into a slime-like liquid after they are dissolved in acetone. This material is then used to close possible gaps in the model kits. Finally, “all of the above” was the option for participants that use the runners in all of the previously mentioned methods. In addition to these options, an open one was left for the model builders to add their own usage.
The most selected option was “all of the above”, registering a total of 31.3% of the total. The second was “kitbashing/scratchbuilding material”, which was selected 19.6% of the time. These two options show that the community does seem to manage to use in a variety of ways the runners, thus slightly contrasting with the previous results. It could mean, though, that since one of the most common uses is kitbashing, the limited amount used is caused by the necessity of precise shapes, that can be difficult to obtain simply by bending the runners.

The reuse of runners

Comparing these two answers with the other ones, it seems that less complex uses, like gap filling and basing material do not interest the community as much. This does make sense, since it is possible to find other products that can cover those needs. In particular, basing material is a market with a large variety of options, from sand of various grain to fake grass tufts and fake flowers and plants.
While analysing the other methods that some participants listed, it appeared that rarely runners are also used in the painting stage of the hobby, usually either to test paints or to hold smaller components.

The final question about the reuse of runners was a simple yes or no one, asking the participants if they were interested in reusing a larger quantity of runners. Interestingly enough, the answers were mostly positive, reaching 81.7% of the total. This shows that while the community is interested in reusing the runners, there are not enough methods that allow an easy reuse. This could be an indication that providing an alternative to throwing away runners and reusing them in another way could interest model makers, especially the ones that do not reuse the runners but also do not throw them away.

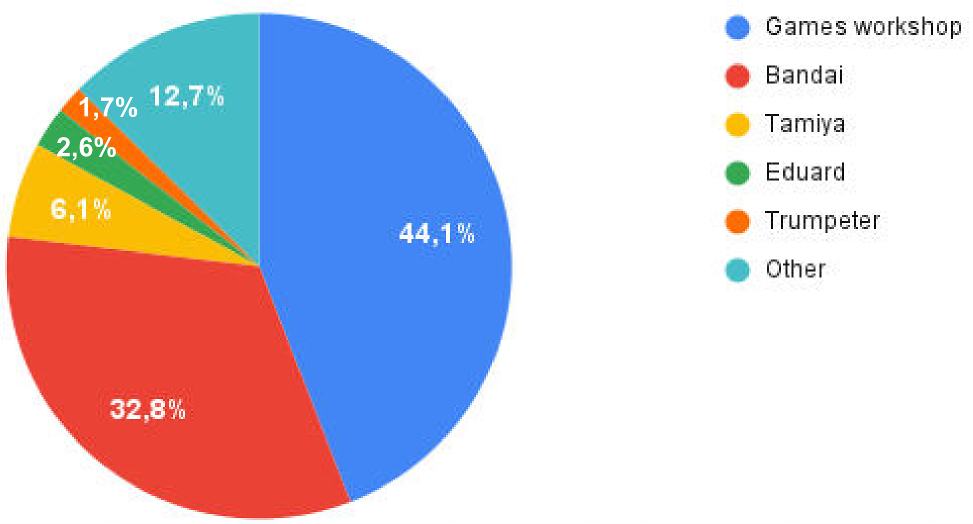
Conclusions

The results of this section of the survey managed to develop further the personas, by allowing to establish their connection with the waste from the model kits.
The personas will be someone that sometimes throws away the box the model kit came in, thanks to a lack of space, keeping instead only the ones with a particularly captivating box art. They are also keeping part of the runners, limiting themselves to ones or parts of ones, that can be useful in their projects. Even so, they are not always able to reuse large amounts of runners and would like to do so more often.

In addition to the contribution to the personas, this section of the survey managed to help define the model building community as one that does seem to be interested in reducing waste, at least partially, by reusing part of the packaging model kits come in. That said, it is still an effort made by private members of society, which reduces the effectiveness that it may have. In the later sections of the survey it will be very interesting to analyse how the community felt towards eco-friendly efforts from the model making companies and if the model builders would be willing to participate in eco-friendly initiatives.

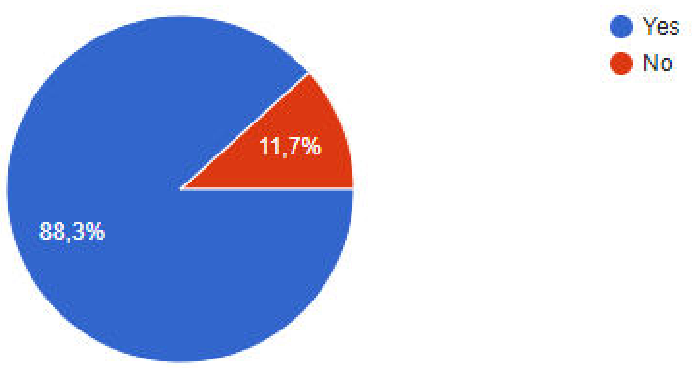
Which company model kits do you buy the most? Please name only one.

230 risposte



If the company is making any efforts to become more eco-friendly, would you care?

230 risposte



Organization of the Survey and Answers

4. Perception of the company

Organization of the section

The fourth section covered the perception that model builders have of the companies producing the model kits. This section had the main objective to understand how this perception would change if companies were to adopt eco-friendly options.

The first question asked the participants to indicate the company from which they bought the majority of their model kits. This data could be interesting, since some of the companies indicated may already have started making eco-friendly efforts.

The following questions were linked to the effects eco-friendly efforts would have on the perception of the companies by the userbase.
The second question, a yes or no one, asked whether participants in the survey would care about eco-friendly efforts.
The third question, again a yes or no one, asked whether eco-friendly efforts of a model kit company would influence participants in buying model kits from that company.

The fourth and fifth questions are focused on how the perception of a company would after eco-friendly efforts.
In particular, the fifth and last question is an open one, asking more in detail how the perception would change, if in positive or negative and why.

Overall, like indicated in the objective chapter, these questions and this objective is more interesting on a public relation point of view. The way the perception that model builders have on companies could change based on eco-friendly efforts could help develop the solutions in a new system.

List of the questions:

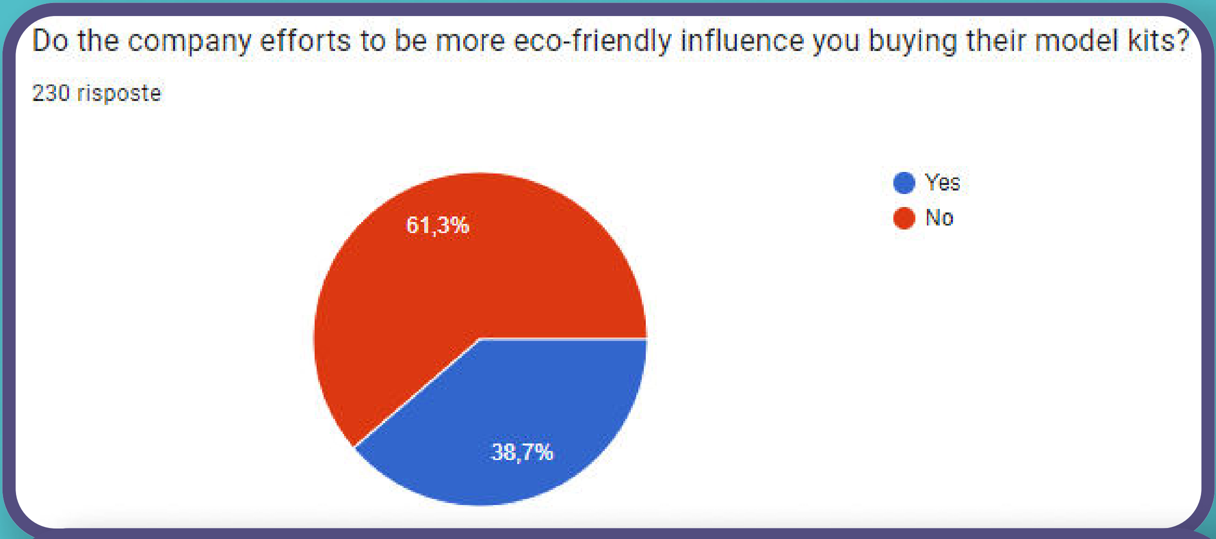
1. Which company model kits do you buy the most? Please name only one.
2. If the company is making any efforts to become more eco-friendly, would you care?
3. Do the company efforts to be more eco-friendly influence you buying their model kits?
4. If the company started making changes to become more eco-friendly, would that influence your opinion of that company?
5. If your opinion would change, would that be a positive change or negative? Please explain with a short text.

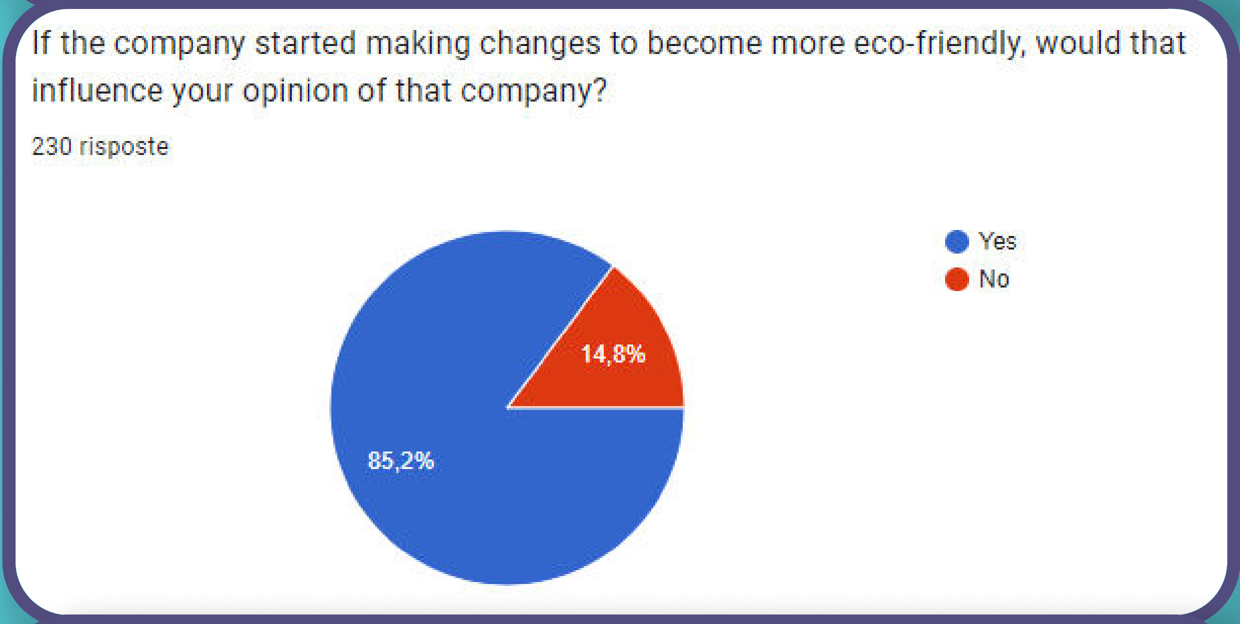
Company preference

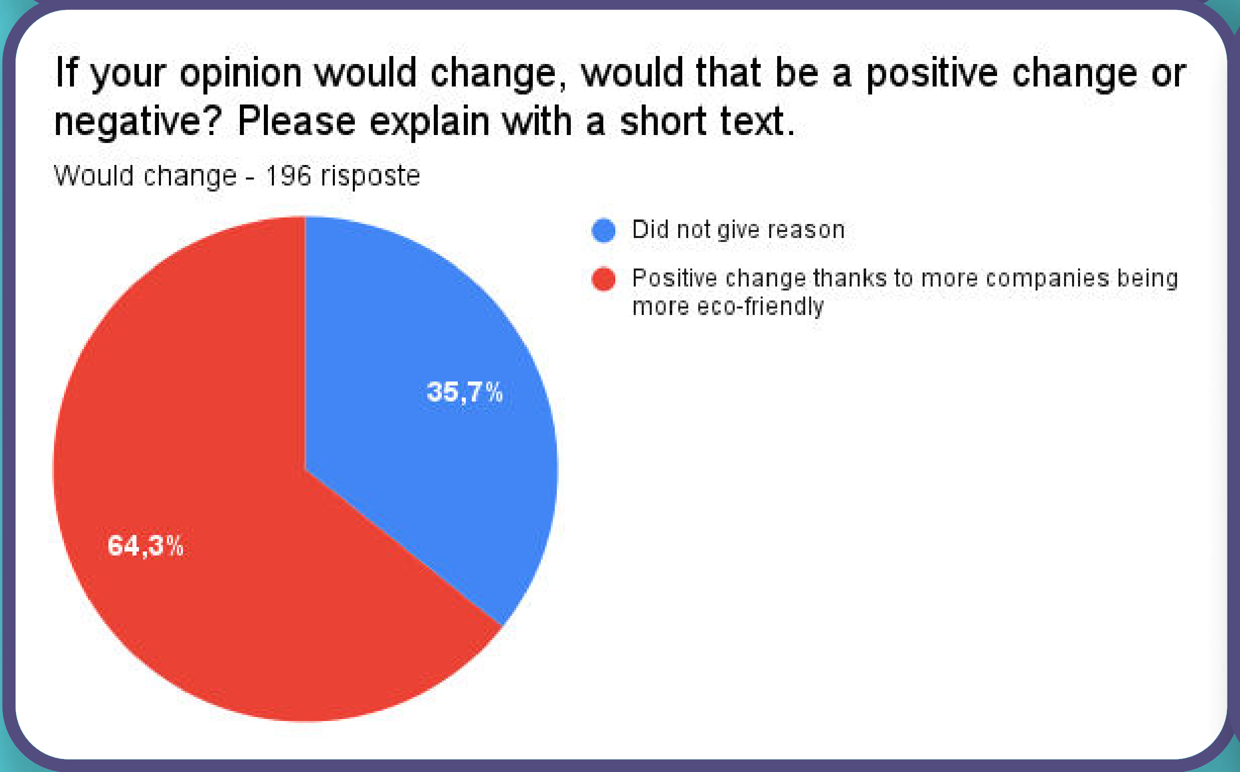
After having obtained a clearer view of the way model builders see waste and the relationship between the two, the following step was to understand if the perception of the model making companies that they have would change in any way if said companies were to implement efforts to become more eco-friendly.

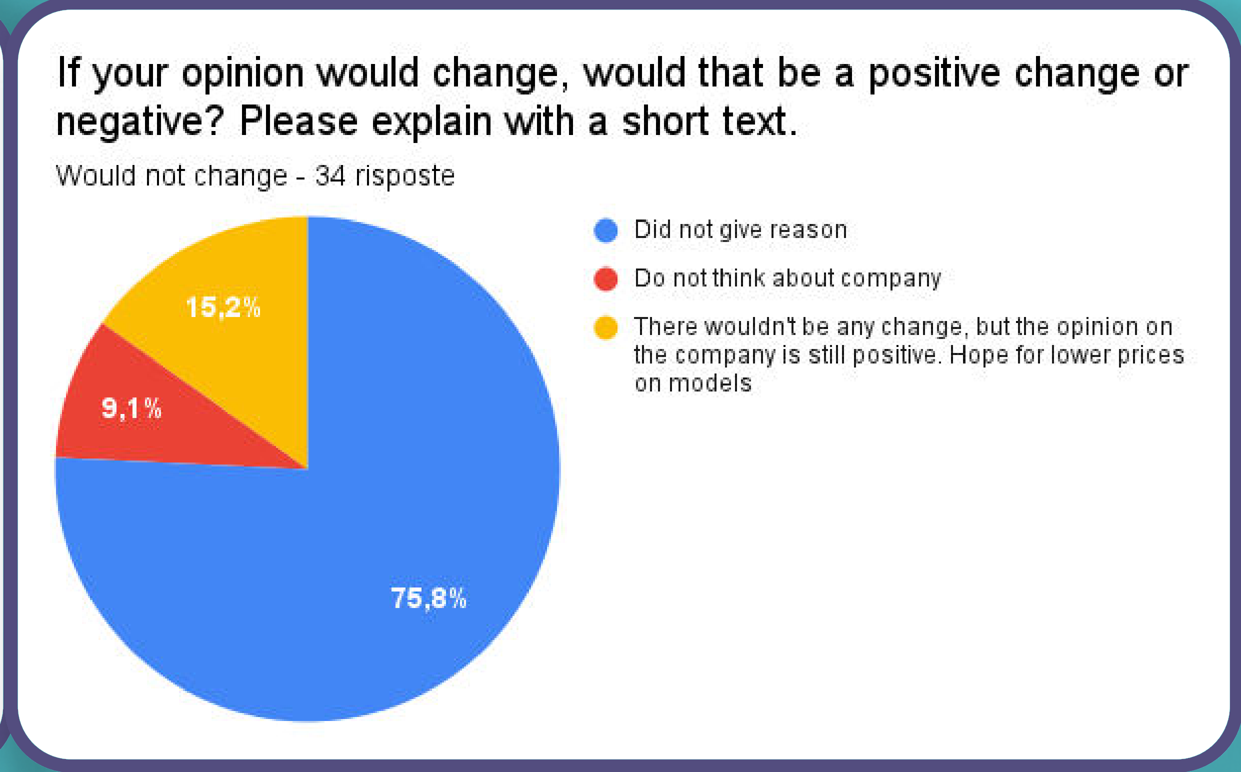
The questions in this section will focus on defining not just how the opinion of model making companies would change, but also which aspects would be affected. Do model builders care about eco-friendly efforts? Would those efforts influence their purchasing habits?

The first element was to investigate which companies the model builders preferred purchasing from. As stated previously, the results of this question were heavily influenced by the online communities where the survey was run. Considering the amount of activity in Warhammer and Gundam subreddits, it was not surprising that the companies Games Workshop and Bandai were the most indicated, covering respectively 44.1% and 32.8% of the total.
Outside of these two companies, though, a relatively large amount of different names were stated. Other than Tamiya (6.1%), Eduard (2.6%) and Trumpeter (1.7%), 21 different companies were indicated by one or more participants. These results showed that there is a large variety available to the model builders, especially when it comes to historical model kits. For example, some of the companies were Italeri, an italian model kit companies that focuses on both World Wars troops and armaments, as well as historical dioramas, and Airfix, a company that mainly produces model kits of planes. Both Airfix and Italeri are model making companies with a long history.


Do the company efforts to be more eco-friendly influence you buying their model kits?
230 risposte
Yes
No
61,3%
38,7%


If the company started making changes to become more eco-friendly, would that influence your opinion of that company?
230 risposte
Yes
No
14,8%
85,2%


If your opinion would change, would that be a positive change or negative? Please explain with a short text.
Would change - 196 risposte
Did not give reason
Positive change thanks to more companies being more eco-friendly
35,7%
64,3%


If your opinion would change, would that be a positive change or negative? Please explain with a short text.
Would not change - 34 risposte
Did not give reason
Do not think about company
There wouldn't be any change, but the opinion on the company is still positive. Hope for lower prices on models
15,2%
9,1%
75,8%

Organization of the Survey and Answers

4. Perception of the company

Effects of eco-friendly efforts

After delving in the company preferences of the participants, it was necessary to understand the stance of model builders on eco-friendly efforts from the companies. The reason why the previous question was asked was because it seems that model making companies may start developing said efforts. Bandai is the perfect example, thanks to their Gunpla Recycling Project.
Thus, it would be interesting to understand how these efforts may influence the community.

The first question on this topic was about whether the participants would care if model making companies started to implement eco-friendly efforts. Considering that the previous section concluded that model builders seem at least interested in reducing waste in a proactive way, the expected results were that they would indeed care about said efforts.
The results confirmed these suspicions, showing that 88.3% of the participants would care about these efforts, while only 11.7% would not.

The second question on the topic of the effects that eco-friendly efforts would have on the perception of the companies asked the participants if said efforts would influence them in purchasing model kits from that company. The results were very interesting: in this case, the majority of participants indicated that they would not be influenced, selecting “no” 61.3% of the time, while 38.7% of the model builders instead selected “yes”. While the results did switch, the difference between the two answers was not as extreme. This may indicate that the adoption of eco-friendly efforts may have a positive effect on sales, though the products and the designs would still need to be high quality in order to interest the majority of model builders.

The final element to understand the effects of eco-friendly efforts was the changes in opinion of a company.
This question was divided in two separate questions, one asking if the opinion would be influenced and the other if the change would be positive or negative.
The first answer showed a large amount of participants stating that their opinion would change, with 85.2% of them selecting “yes” against 14.8% selecting “no”.

Effects of eco-friendly efforts

The second question posed interesting results. First of all, both the participants that selected “yes” and the ones that selected “no” answered it, even if only the ones whose opinion would change were requested to answer.
Second of all, many decided to not give a reason.
That said, who indicated that their opinion would change generally stated that it would be a positive change, giving as a reason that it simply would be positive to see more companies trying to become more eco-friendly (64.3%).
In the case of whose opinion would not change, the majority did not give a reason (75.8%), but the ones who did, stated that either they do not particularly care about the companies (9.1%) or that the opinion would remain positive, mainly hoping for a reduction of the model kit prices.

The results showed that, in line with the previous questions, the opinion of model builders would generally be more positive towards the companies, but the reasons are not particularly defined, other than a general positive view of said efforts.

Conclusions

This short section of the survey gave some interesting data regarding the effects of eco-friendly efforts.
While these results do not illustrate a particularly defined reason as of why, adopting efforts to become more eco-friendly would garner sympathy towards model making companies.

In addition to that, the influence on the personas makes so that they would be interested towards said efforts, but that they would not necessarily push them to purchase model kits from a company exclusively because of the efforts.

Organization of the Survey and Answers

5. Recovering waste from the users

Organization of the section

The fifth section of the survey focused on the user waste recovery initiative and covered one of the key points of the "Interest in the solutions" objective.
The questions in this section were used to understand the interest that model builders would have in participating in an initiative in which empty runners were recovered from the users. The questions ranged from asking whether the model builders would participate in the initiative, to asking whether incentives would interest them more in said initiative, to how often they would participate, to where they would prefer bring the empty runners and why.

The first question, a yes or no one, asked the participants if they were interested in purchasing model kits made with recycled plastic. While this question is not perfectly in line with the following ones, it is linked to the initiative, since in the Gunpla Recycling Project case study that will be analysed more in depth in the next chapter, the recovered runners will be reused by producing model kits in recycled Polystyrene.

The questions from the second to the fifth one are focused on the initiative.
The second question, a yes or no one, like the following two, asked the model builders if they were willing to give away empty runners if that reduced the plastic waste and the usage of virgin material in the production of model kits. The third question, then, asked the model builders if they were interested in participating in a user waste recovery initiative. Then, the fourth question asked if the presence of incentives would convince the model builders in participating in the initiative. In this questions, the available answers were "yes", "no" and "maybe".
The fifth question was again related to the incentives, giving a few examples and allowing the participants to both choose multiple options and adding one of their own, with an open space.
These questions had the goal of scouting the general interest of the model builders towards a similar initiative, together with gaining an understanding of which incentives could be more effective in increase the willingness in participating.

The sixth question was related to a location preference. By giving the options of bringing the runners either to a dedicated hub or to their preferred hobby store, it was possible to have a basis on which develop a recovery network.

The seventh question and the following two were related to how many runners the model builders would bring to the recovery points and how often. The seventh question asked very generally if the model builders would bring all of the empty runners to the recovery points, while the eight question was open, asking for the reason why not. The answer was required to be a short text, allowing the participants in the survey to better communicate the reason.
The ninth question asked the model builders how often they would bring the empty runners. In this case, the answers gave examples, like "once a week" or "only when going buying other model kits". In addition to these options, an open answer was available, in order to allow the participants to indicate a more precise occasion when they would bring the runners.

Organization of the section

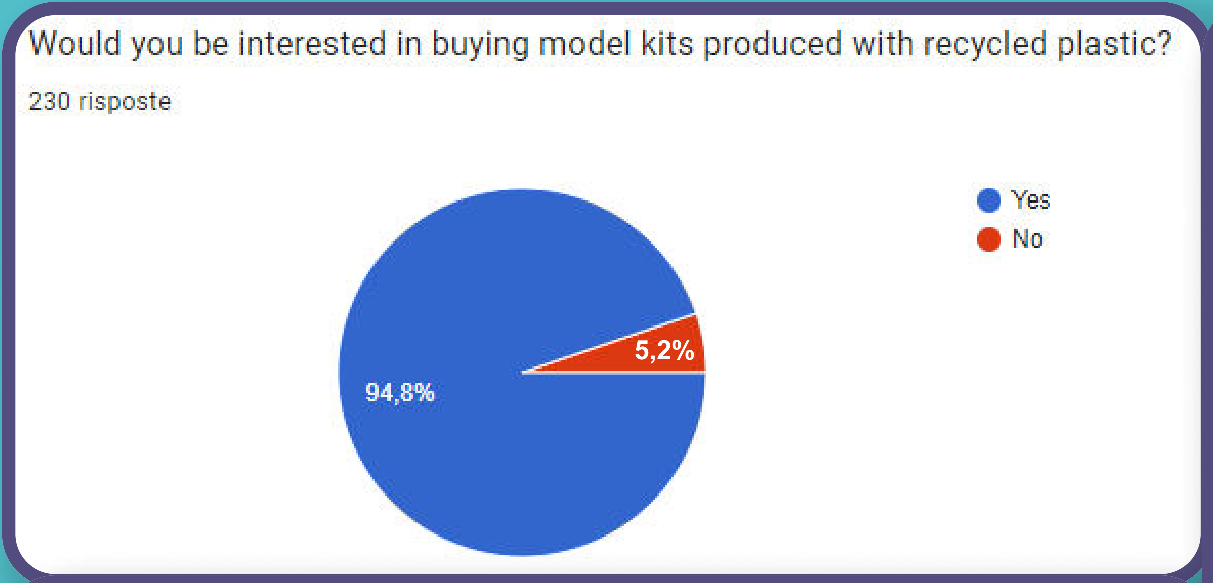
These questions had the objective to paint a relatively precise picture of the potential participation of the model builders in a user waste recovery initiative, which would allow to define the timing for the various elements in a new network.

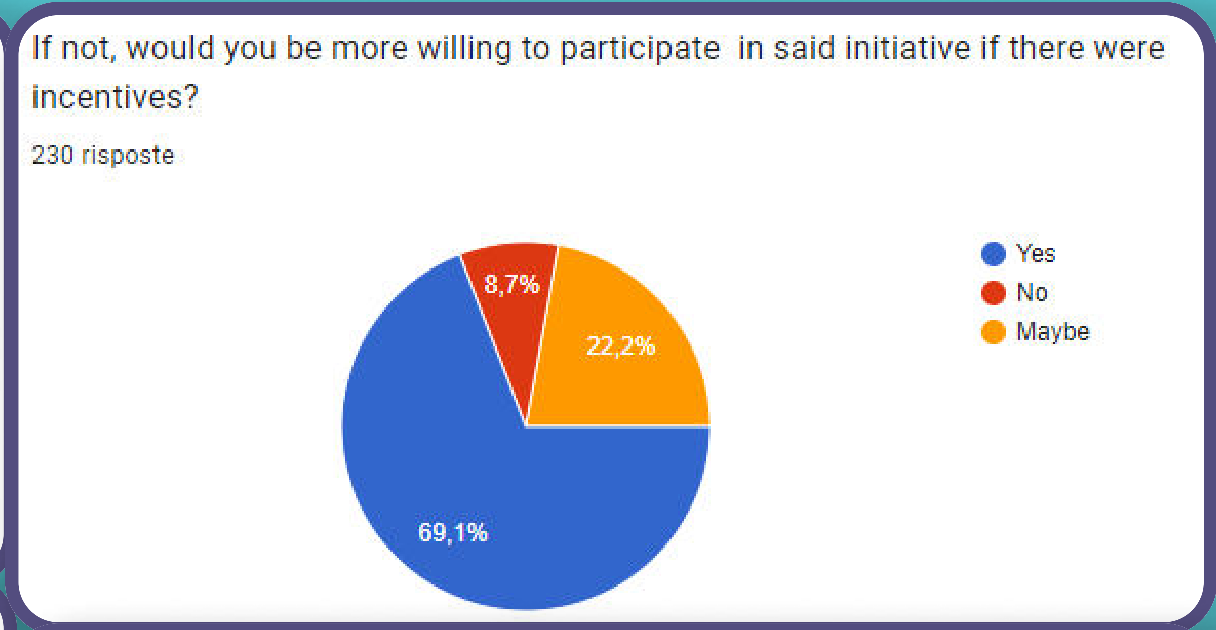
The following four question (from the tenth to the thirteenth) asked the model builders if and why participating in a user waste recovery initiative would influence their participation in the hobby.
The tenth and eleventh questions asked the model builders if participating in the initiative would help them reduce their backlog, while the twelfth and thirteenth questions asked the same about the model builders purchasing more model kits.
In both cases the tenth and twelfth questions were simple yes or no ones, while the eleventh and thirteenth questions required a short text as an answer, asking why or why not the initiative would influence the previously mentioned points.

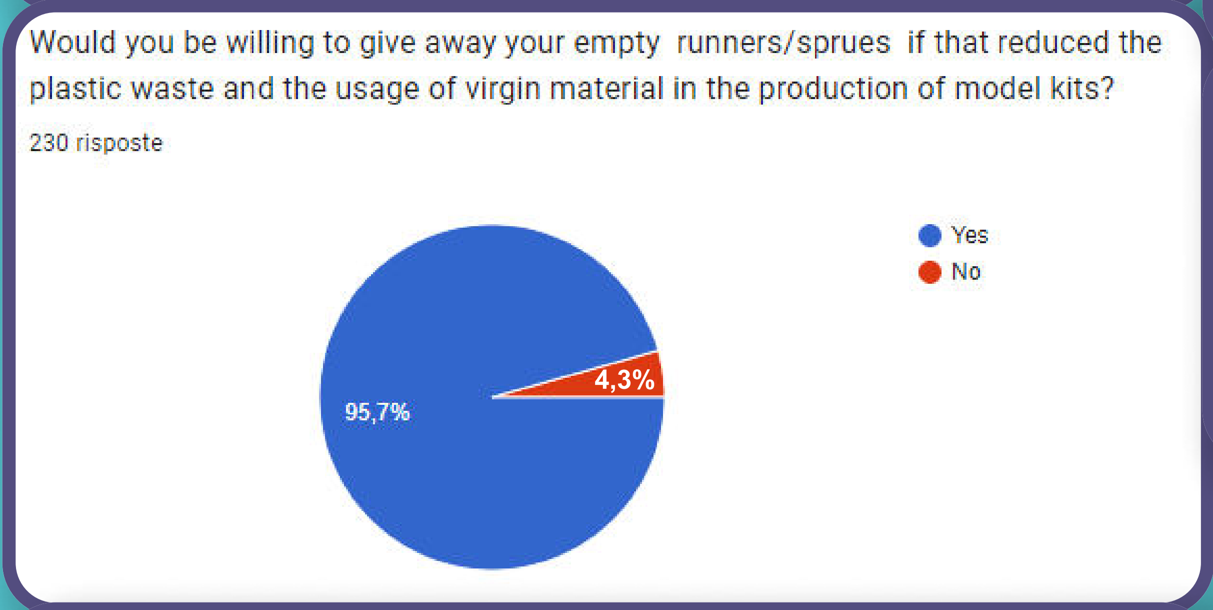
The last two questions asked the model builders if they were part of a hobby club and if the presence of additional incentives in participating in the initiative would influence them in entering in one.
These questions and their answers were simple yes or on questions and the results could be interesting in identifying effective communication methods.

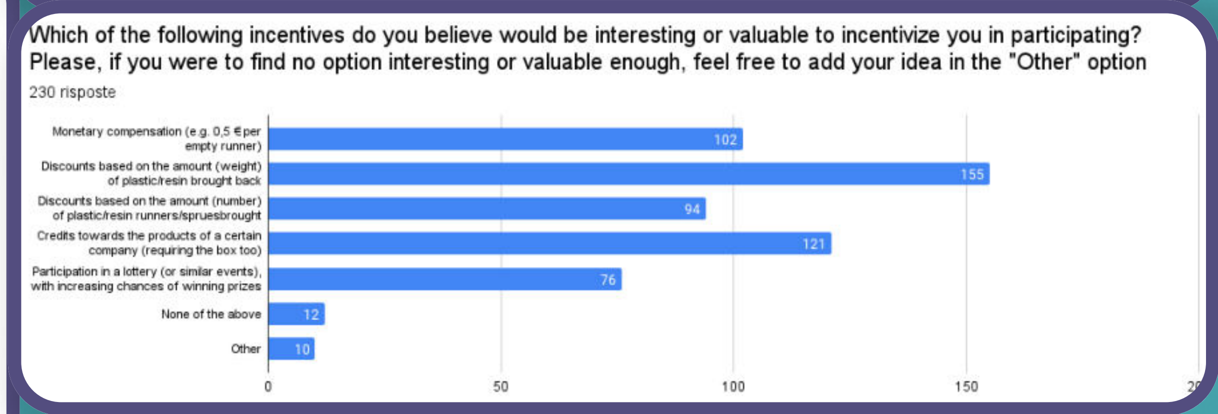
List of the questions:

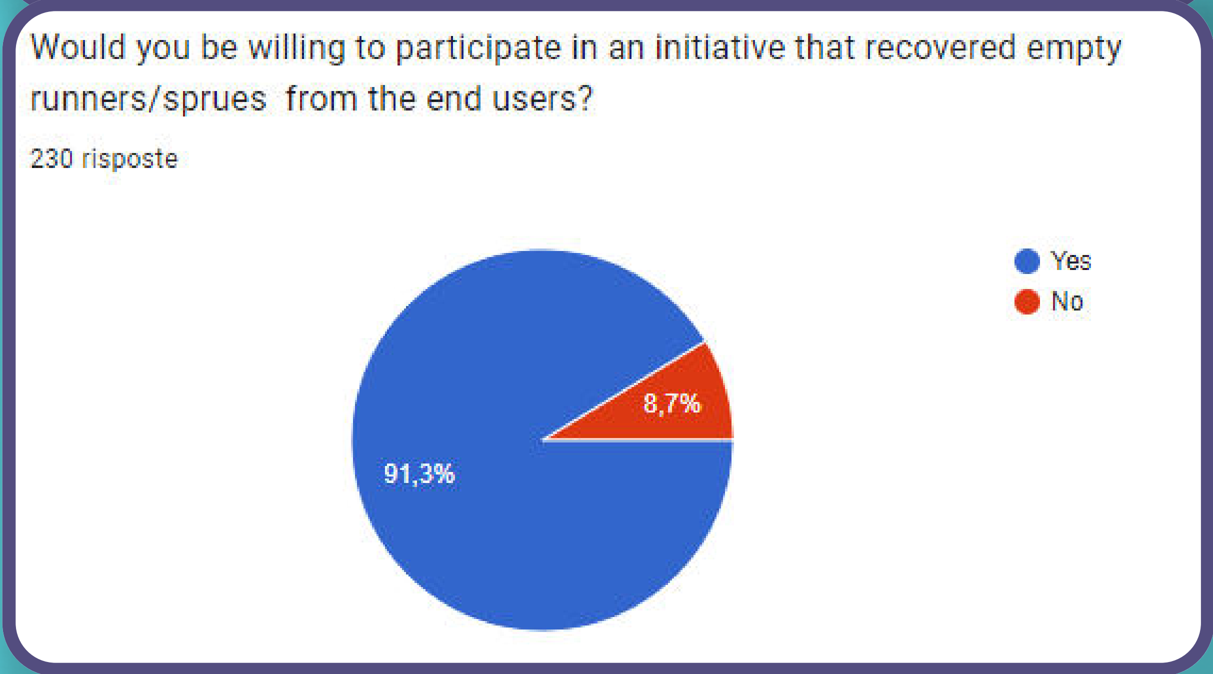
1. Would you be interested in buying model kits produced with recycled plastic?
2. Would you be willing to give away your empty runners/sprues if that reduced the plastic waste and the usage of virgin material in the production of model kits?
3. Would you be willing to participate in an initiative that recovered empty runners/ sprues from the end users?
4. If not, would you be more willing to participate in said initiative if there were incentives?
5. Which of the following incentives do you believe would be interesting or valuable to incentivize you in participating? Please, if you were to find no option interesting or valuable enough, feel free to add your idea in the "Other" option
6. Where would you prefer to bring the empty runners/sprues ?
7. Would you bring all your empty runners/sprues ?
8. If not, why?
9. How often would you bring the empty runners/sprues ?
10. Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"?
11. Why?
12. Do you think bringing your empty runners/sprues would make you buy more model kits?
13. Why?
14. Are you part of a model making club linked to a company (e.g. Airfix club)?
15. Would you be willing to become part of a similar club if it meant having extra rewards for participating in the initiative?


Would you be interested in buying model kits produced with recycled plastic?
230 risposte
Yes
No
5,2%
94,8%


If not, would you be more willing to participate in said initiative if there were incentives?
230 risposte
Yes
No
Maybe
8,7%
22,2%
69,1%


Would you be willing to give away your empty runners/sprues if that reduced the plastic waste and the usage of virgin material in the production of model kits?
230 risposte
Yes
No
4,3%
95,7%


Which of the following incentives do you believe would be interesting or valuable to incentivize you in participating? Please, if you were to find no option interesting or valuable enough, feel free to add your idea in the "Other" option
230 risposte
Monetary compensation (e.g. 0,5 € per empty runner)
102
Discounts based on the amount (weight) of plastic/resin brought back
155
Discounts based on the amount (number) of plastic/resin runners/spruesbrought
94
Credits towards the products of a certain company (requiring the box too)
121
Participation in a lottery (or similar events), with increasing chances of winning prizes
76
None of the above
12
Other
10
0
50
100
150


Would you be willing to participate in an initiative that recovered empty runners/sprues from the end users?
230 risposte
Yes
No
8,7%
91,3%

Organization of the Survey and Answers

5. Recovering waste from the users

Interest in plastic recovery initiative

In the previous sections of the survey the objective was to define how model builders interact with various elements of the hobby, from the participation in the hobby to what they consider waste, to how they would react towards eco-friendly efforts from model making companies.
In this and in the following sections the objective was to propose to the participants in the survey the various solutions developed in the previous chapter. As it will be clear, the solution "Transforming Plastic Waste into Paper" was not proposed to the model builders to comment on, since it was developed as the adoption of multiple solutions at the same time. In the survey the three solutions, "Recovering of User Waste", "Adoption of Different Material/Technologies" and "STL Sales" were presented in three different sections.

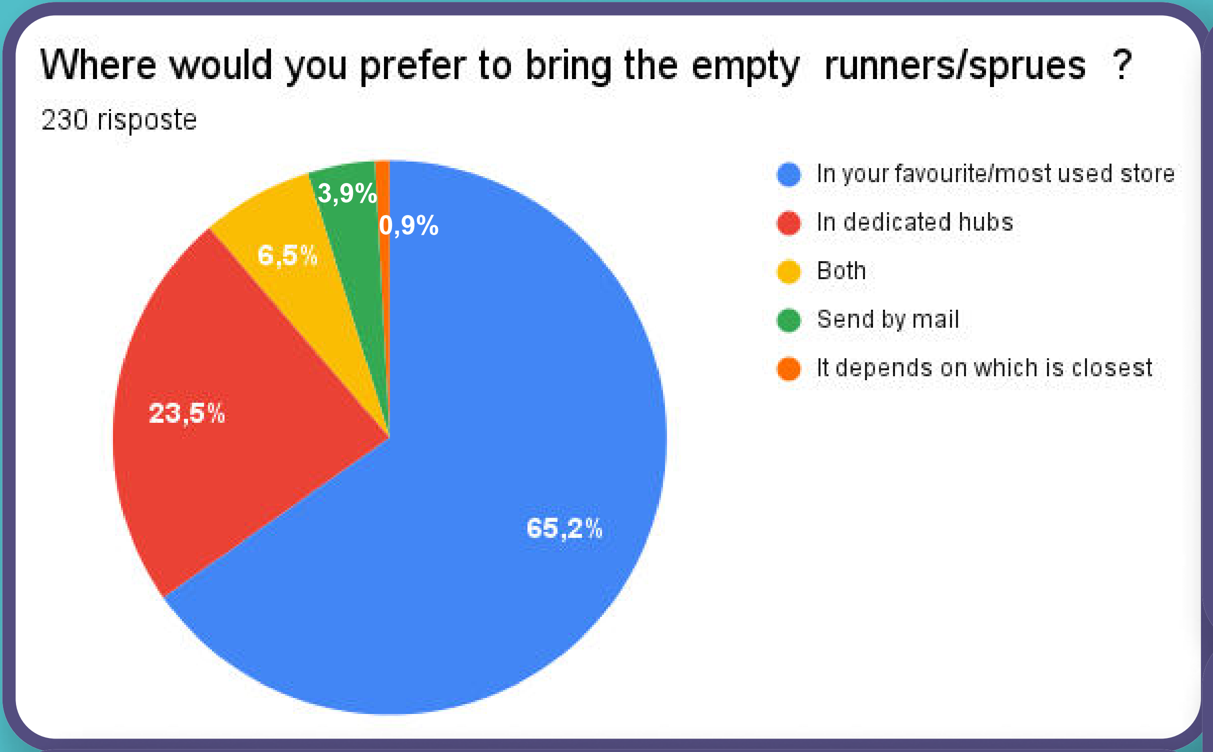
The first one covered an initiative to recover user waste from the user, understanding the interest towards recycled plastic being used to produce model kits, the influence of incentives towards participating in a similar initiative, how often the model builders would participate, the influence that recycling plastic may have on the hobby for the model builders and potential interest towards a hobby club.

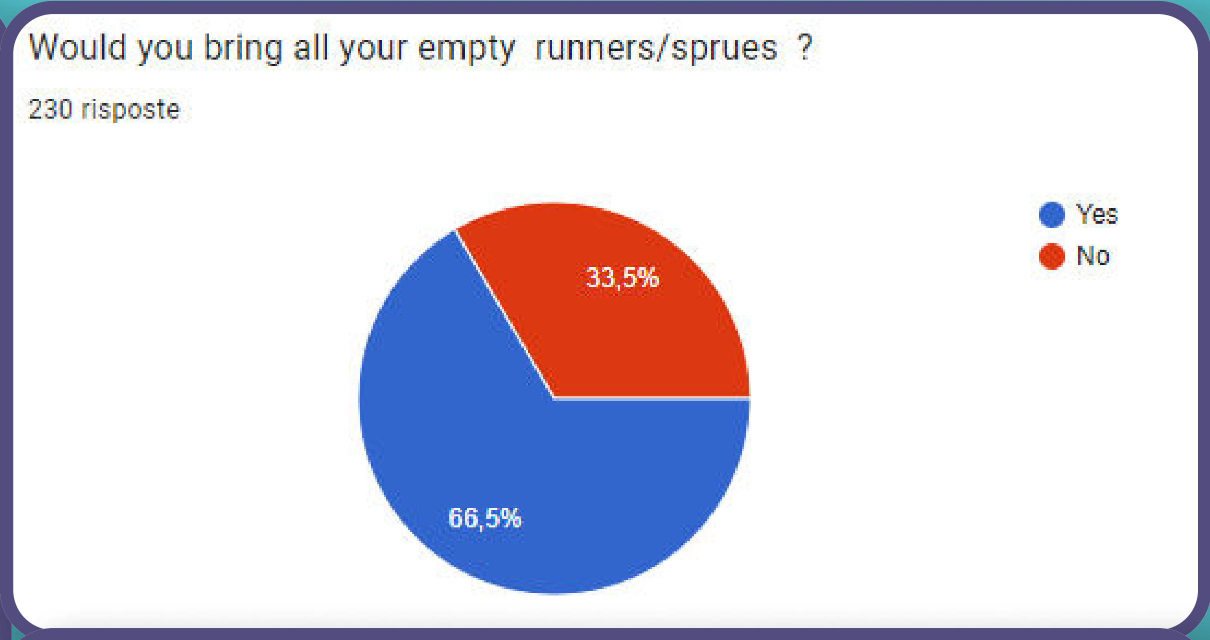
By asking the model builders if they were interested in purchasing model kits produced with recycled plastic it was possible to have a first look in how effective an initiative that brings material back to the production plant may be.
The results from this first question were very positive, registering 94.8% "yes" as an answer. This display of interest is already in line with the conclusions reached with the answers of the previous sections.
The positive results continue with the following question, which asked the participants if they were willing to give away their empty runners if that could reduce both plastic waste and usage of virgin material in the production processes. 95.7% of the participants answered yes, further demonstrating interest in participating actively in a similar scenario.
As a final confirmation, the third question asked directly to the model builders if they were willing to participate in an initiative that recovered empty runners from the end users. Again, the model builders answered "yes", which reached 91.3% of the total.
These initial questions allowed understanding, at least on surface level, that the community seems interested in becoming more eco-friendly. The following questions in this section of the survey will try to analyse more in depth how much the model builders are actually willing to do.

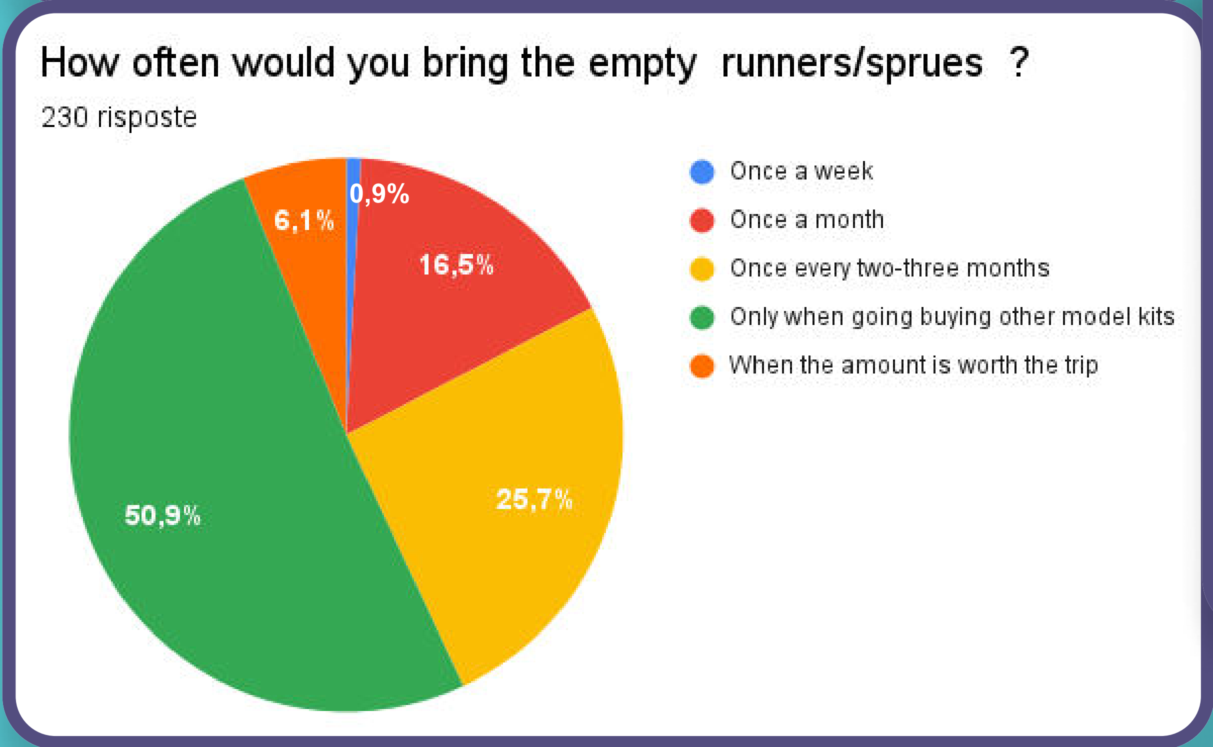
Incentives

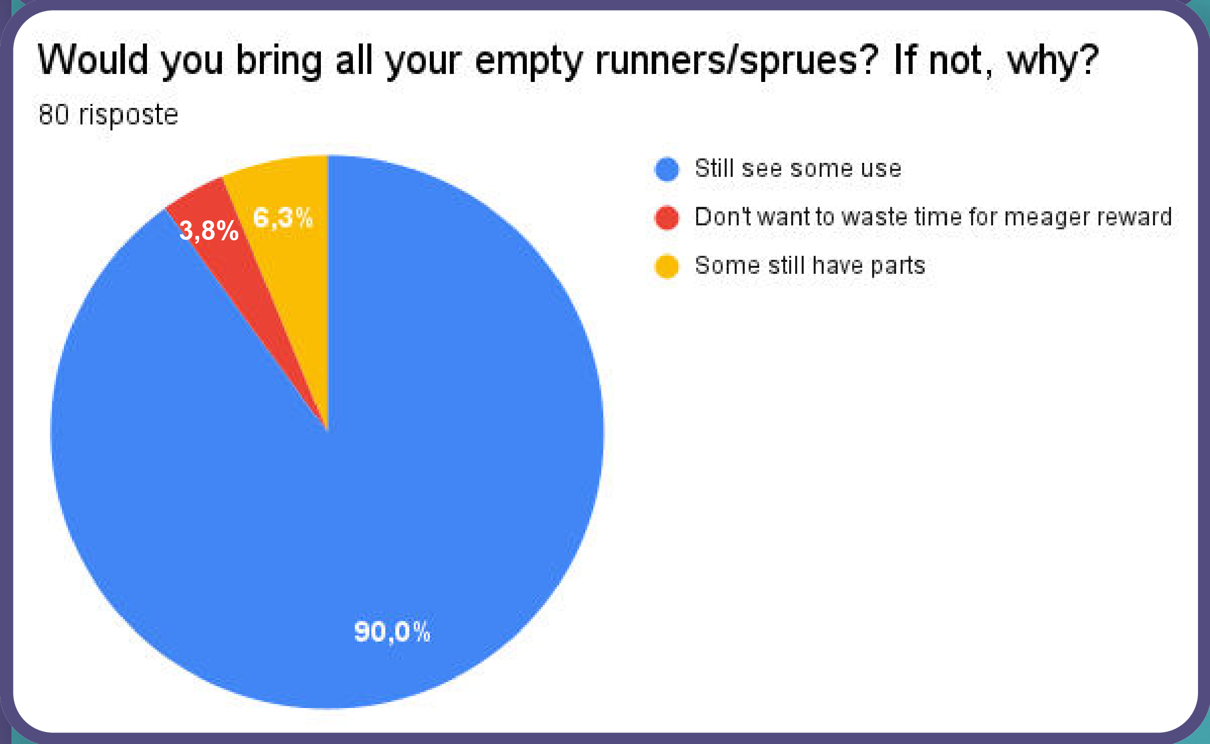
Following the previous questions, the participants were asked if the presence of incentives would make them more willing to participate in a waste recovery initiative.
The results were interesting: the number of people indicating "no" remained the same (8.7%), while there was a reduction of "yes" (69.1%), thanks to the presence of the option "maybe", which was selected 22.2% of the time. This shows that interest is still there, but that the presence of incentives may influence the participation. This may indicate that the incentives will have to be at least somewhat enticing for the majority of model builders to participate.

In order to understand which incentives would be more effective, a question with a variety of options was presented. This question allowed each model builder to select more than one incentive and, by selecting the open option, to add their own.
The results showed that receiving discounts based on the amount in weight of the material was by far the most appreciated option, being selected 155 times.
Following that, the option to receive store credit for other products for a determined company (which would require also the box of the model kits, in order to guarantee the company) was chosen 121 times.
Another option that interested the model builders particularly was the potential to receive a monetary compensation, based again on the weight of the material brought. This option was selected 102 times.
Only a handful of participants was not interested in the incentives proposed and, while still a small number, some participants indicated that incentives were not necessary for them to participate. Another few added that the most important part for them was that the initiative guaranteed ease of delivery, since a lack of it would discourage model builders from participating, regardless of the incentives.


Where would you prefer to bring the empty runners/sprues ?
230 risposte
In your favourite/most used store
In dedicated hubs
Both
Send by mail
It depends on which is closest
65,2%
23,5%
6,5%
3,9%
0,9%


Would you bring all your empty runners/sprues ?
230 risposte
Yes
No
66,5%
33,5%


How often would you bring the empty runners/sprues ?
230 risposte
Once a week
Once a month
Once every two-three months
Only when going buying other model kits
When the amount is worth the trip
0,9%
16,5%
25,7%
50,9%
6,1%


Would you bring all your empty runners/sprues? If not, why?
80 risposte
Still see some use
Don't want to waste time for meager reward
Some still have parts
90,0%
3,8%
6,3%

5. Recovering waste from the users

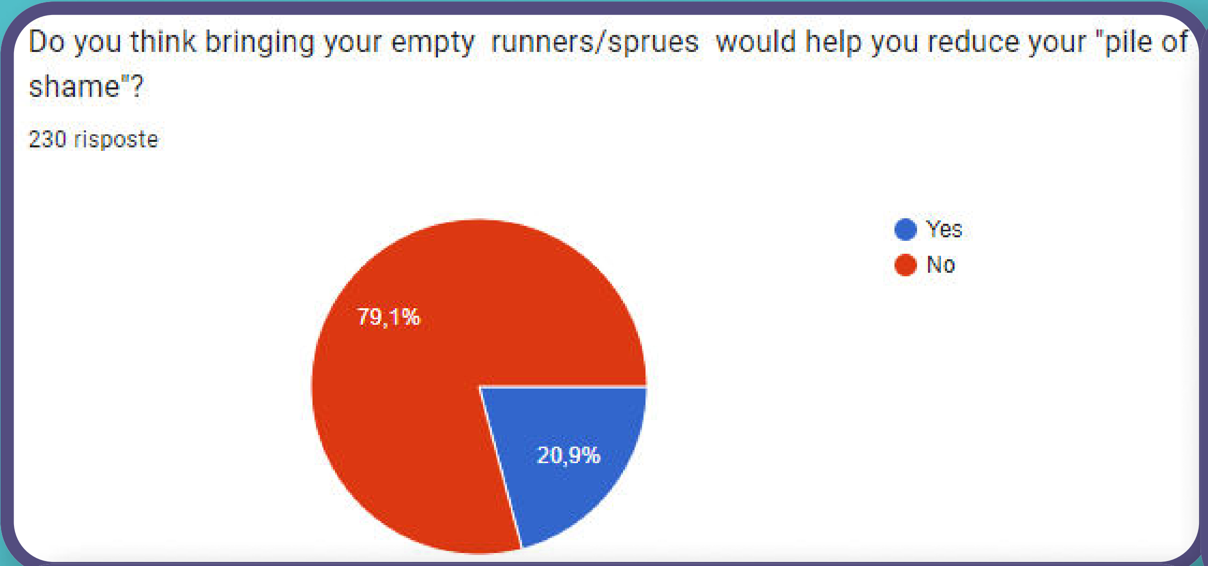
Participation in the initiative

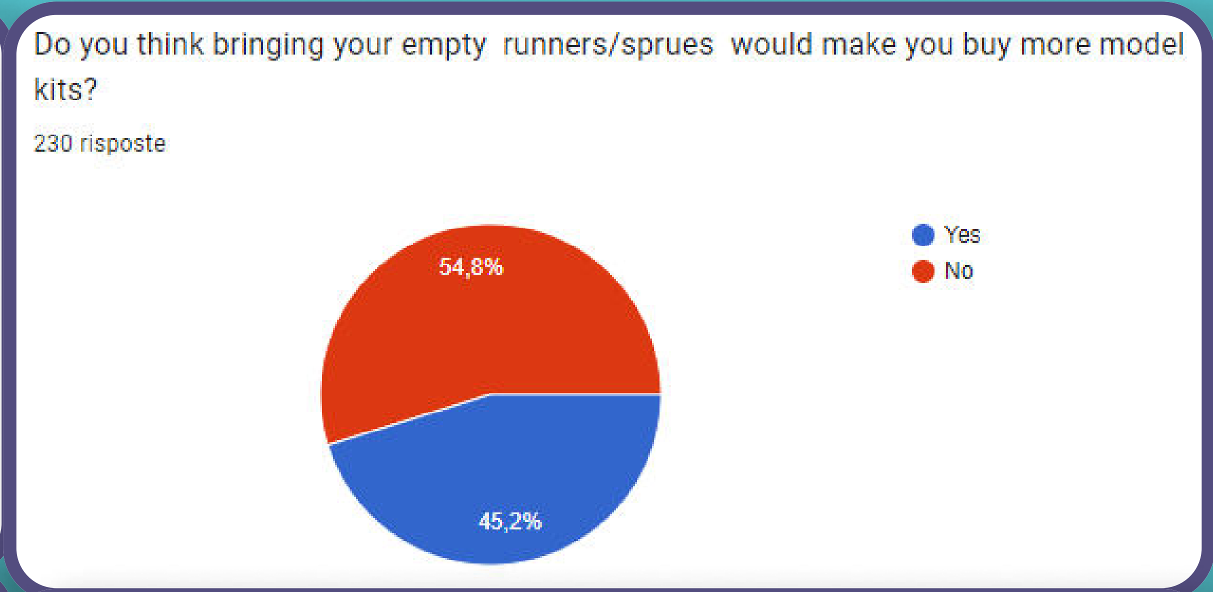
Following the previous questions, analysing the participation in the initiative was the following step.
In order to do so, the participants were asked where they would prefer bring the empty runners, as well as if they would bring all of the runners and how often.

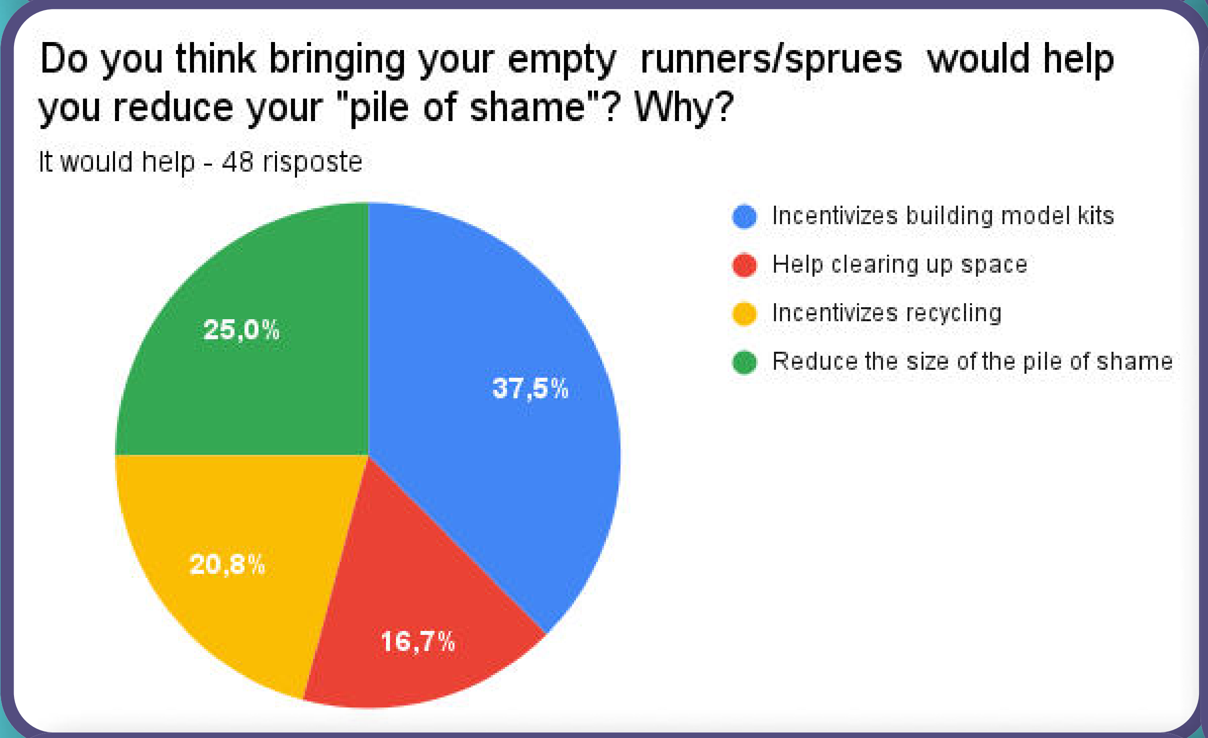
The options for the location where to bring the runners were the hobby store most used, dedicated hubs or both, while also giving an open space. The vast majority of participants selected the store option, which was chosen 65.2% of the time, while the dedicated hubs were selected 23.5% of the time. From the open option a very interesting feedback came back: the possibility of sending the runners using mail or shipping. The participants that indicated that often added that they live in rural areas or areas where there are no hobby stores, therefore they shop online. In order to participate they would need this option available.
These results help definine a recovery network, while also reminding that the option to shop in physical stores is not necessarily available to everyone. Thus, considering a mail or shipping option could not only help willing model builders participate in the initiative, but also improve the overall volume of material recovered.

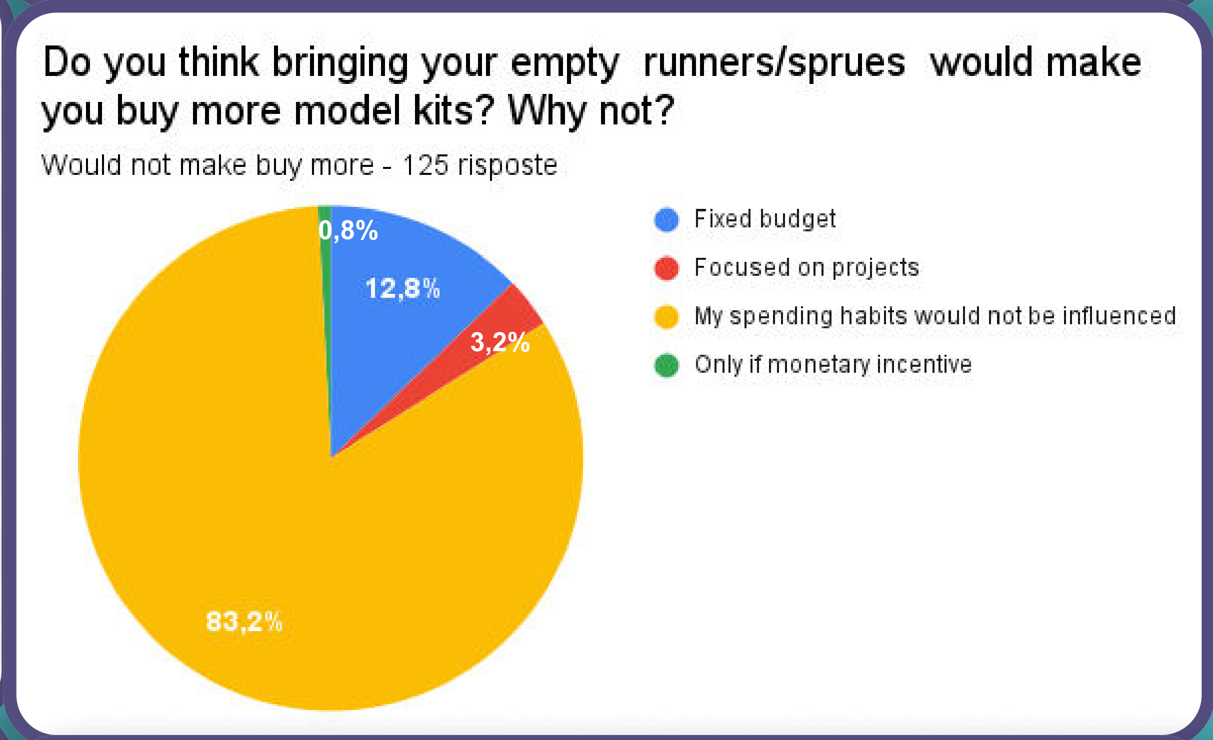
The participants were then asked if they would bring all the empty runners. Considering that in a previous question the model builders stated that they still see some use in the runners this question would result in an overwhelming negative answer, but the results showed that a sizeable part of the community would actually bring all of the runners. This is to be expected, since the amount of people that reuse the runners is much smaller than who does not. When asked why they would not bring all of the runners, only 80 of the 153 “no” answers responded. The majority, though, stated that they still see some use out of the runners, in line with what was expected. A much smaller amount (3.8%) stated that they would not want to waste time for meager rewards, indicating that they would still not participate in the initiative.

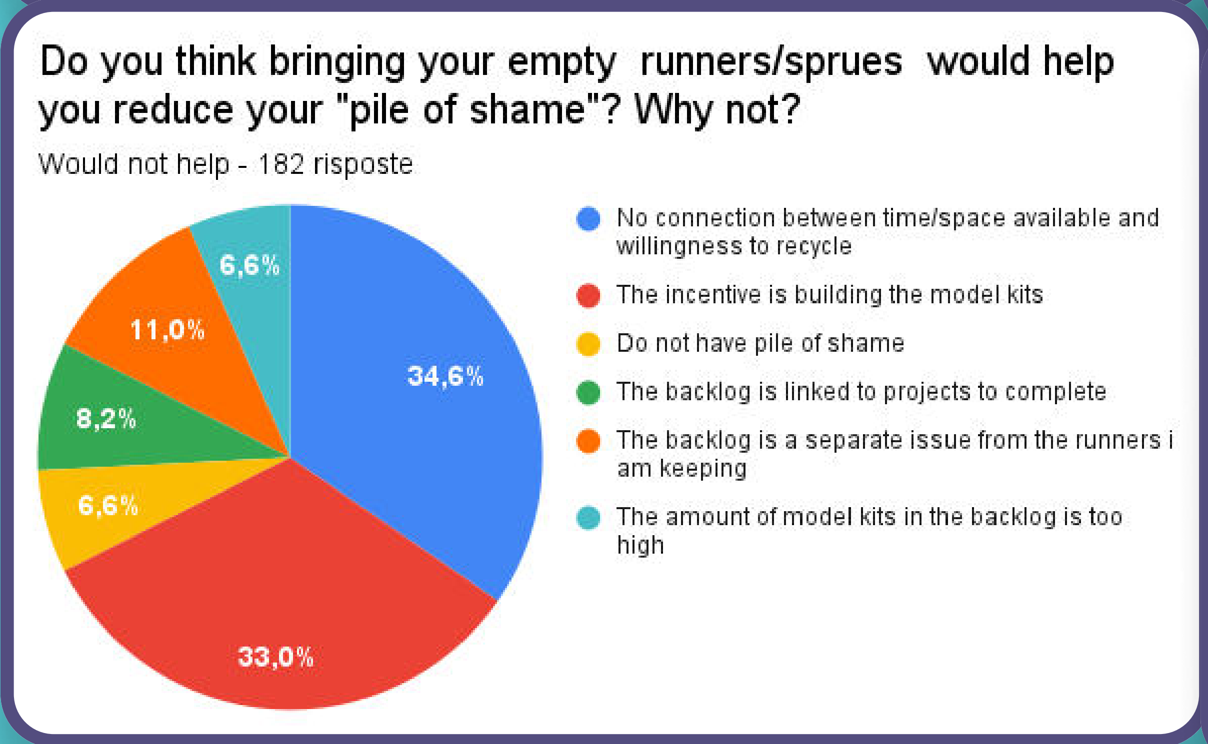
When asked how often the participants would bring their empty runners, the results were very interesting. First of all, the frequency showed seemed to be even lower than how often the model builders would purchase model kits. In particular, the most selected answers were “only when going buying more model kits” (50.9%) and “once every two-three months” (25.7%).
When compared with the previously mentioned question, which had the most selected option as “once every month”, in this question the answers was chosen only 16.5% of the time. Interestingly enough, some participants (6.1%) stated that they would only go after accumulating an amount worth the trip.
These results show that the participation would happen, but that the frequency would not necessarily be constant, but instead would vary depending on the shopping habits of the individuals.

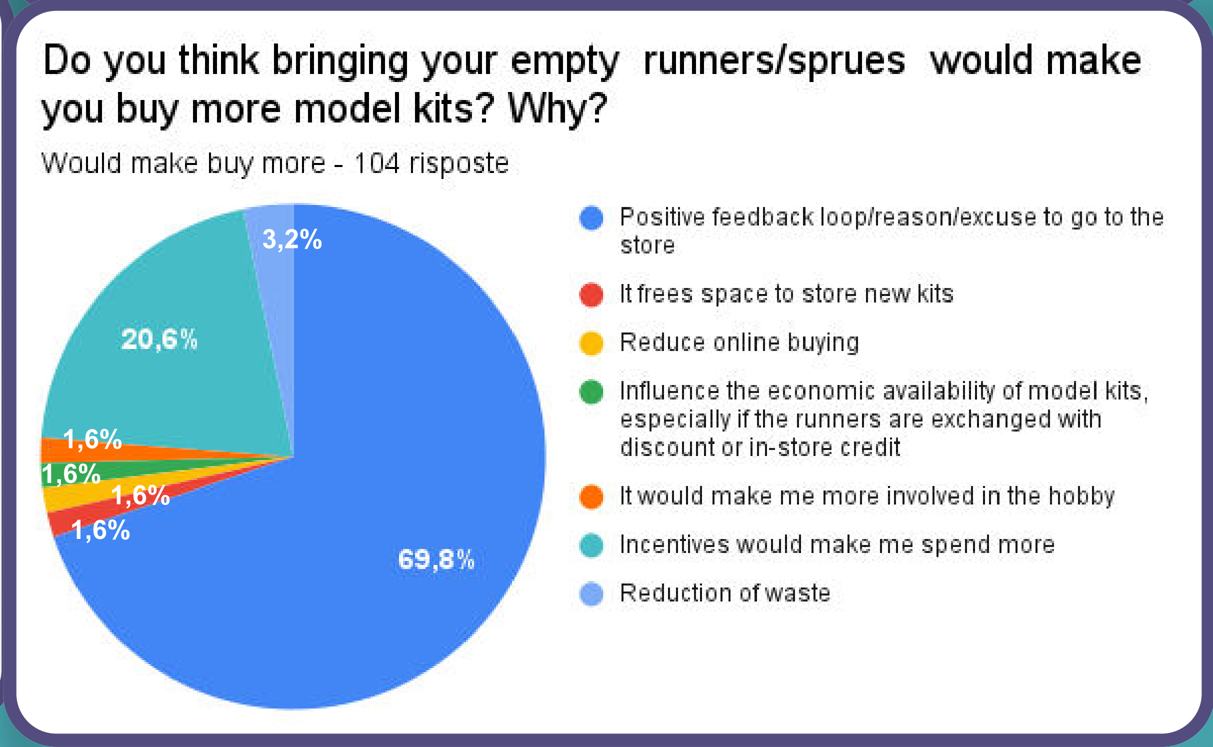

Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"?
230 risposte
Yes
No
79,1%
20,9%


Do you think bringing your empty runners/sprues would make you buy more model kits?
230 risposte
Yes
No
54,8%
45,2%


Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"? Why?
It would help - 48 risposte
Incentivizes building model kits
Help clearing up space
Incentivizes recycling
Reduce the size of the pile of shame
25,0%
37,5%
20,8%
16,7%


Do you think bringing your empty runners/sprues would make you buy more model kits? Why not?
Would not make buy more - 125 risposte
Fixed budget
Focused on projects
My spending habits would not be influenced
Only if monetary incentive
0,8%
12,8%
3,2%
83,2%


Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"? Why not?
Would not help - 182 risposte
No connection between time/space available and willingness to recycle
The incentive is building the model kits
Do not have pile of shame
The backlog is linked to projects to complete
The backlog is a separate issue from the runners i am keeping
The amount of model kits in the backlog is too high
6,6%
11,0%
34,6%
8,2%
6,6%
33,0%


Do you think bringing your empty runners/sprues would make you buy more model kits? Why?
Would make buy more - 104 risposte
Positive feedback loop/reason/excuse to go to the store
It frees space to store new kits
Reduce online buying
Influence the economic availability of model kits, especially if the runners are exchanged with discount or in-store credit
It would make me more involved in the hobby
Incentives would make me spend more
Reduction of waste
3,2%
20,6%
1,6%
1,6%
1,6%
1,6%
69,8%

Organization of the Survey and Answers

5. Recovering waste from the users

After analysing the interest of the participants in a waste recovery initiative, the following step was to determine how said initiative could influence some of the elements analysed previously.
The two main topic of interest was the effect on the backlog and on the purchasing habits of model builders.

Influence on backlog

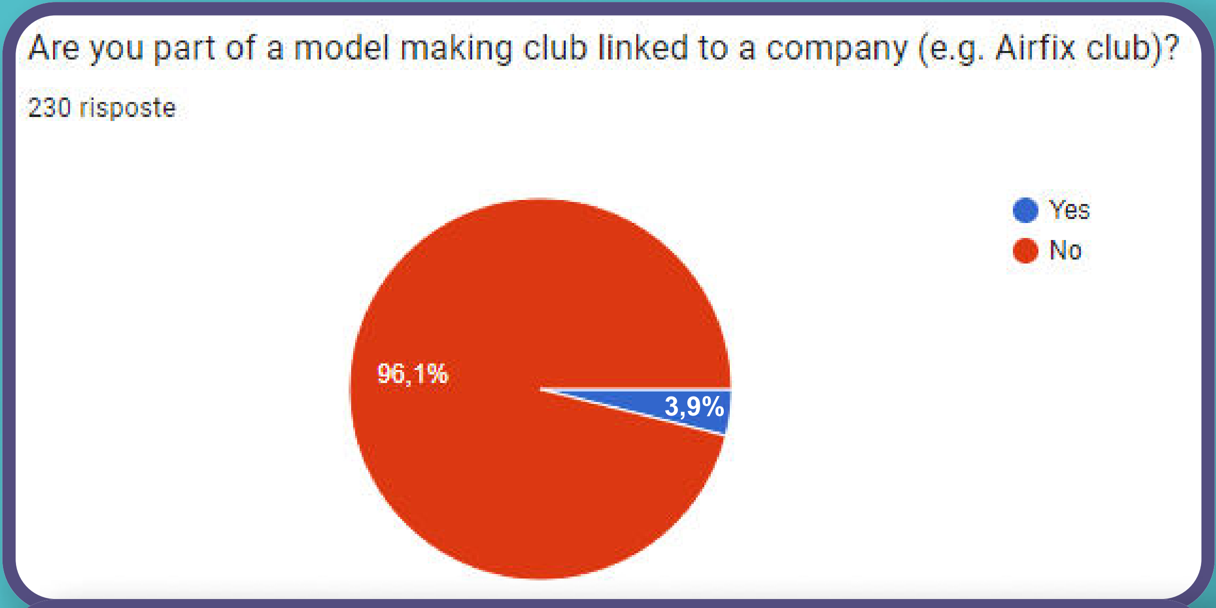
When it comes to the influence on the backlog, the question asked if a waste recovery initiative would help reduce it. The majority of participants answered that it would not have an influence (79.1%), while only 20.9% indicated it would.
When asked a reason, the participants that stated that the waste recovery initiative would help reducing the backlog indicated as main reasons that it would incentivize them in building the model kits (37.5%), it would reduce the size of the pile, especially when it comprises both model kits and empty runners (25%), that by incentivizing recycling it would help them have the model kit built, and the runners deposited (20.8%) and that it would help them clean up space, which was cluttered by the runners (16.7%).
Conversely, the participants that did not consider the initiative helpful towards reducing the backlog stated that there is no connection between the time and space needed to build model kits and the willingness to recycle (34.6%), that the incentive in reducing the backlog is building the kits themselves (33%) and, in general, there is no connection between the two, considering them separate issues.

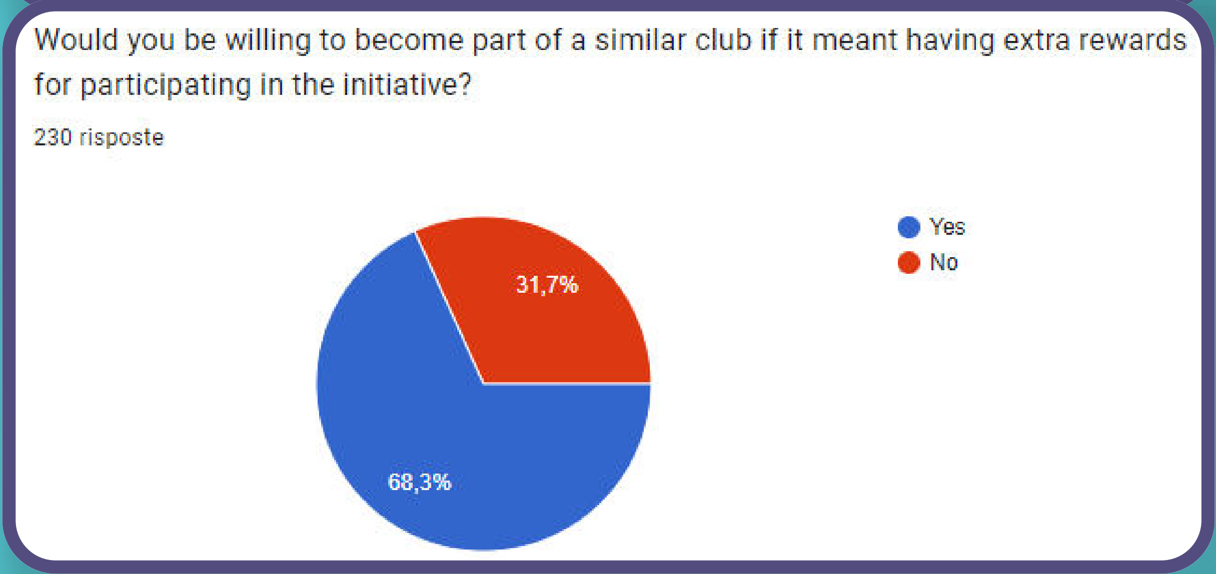
These results show that the model builders are aware of the issues behind a backlog, but the majority does not believe that participating in a waste recovery initiative would be helpful in reducing it, since too many different factors (like impulse buying or the lack of time to assemble the kits) cause the development of a “pile of shame”.

Influence on purchases

Following the previous question, the participants were asked whether the initiative would influence their purchasing habits. In this case the difference was not as stark, though the answers were still mostly negative (54.8%).

In the cases where the initiative would influence purchasing habits, the model builders stated that the positive feedback loop from the incentives and the overall initiative would actually influence in purchasing more, as well as giving them another excuse to go to the hobby store (69.8%). Another reason was that the simple implementation of incentives would push them to purchase more, especially when the incentives are monetary in nature (20.6%).
Regarding a lack of change in the purchases, the majority simply stated that their spending would not be influenced (83.2%), while 12.8% stated that they operate on a fixed budget, therefore the initiative would not make them spend more than usual.


Are you part of a model making club linked to a company (e.g. Airfix club)?
230 risposte
Yes
No
96,1%
3,9%


Would you be willing to become part of a similar club if it meant having extra rewards for participating in the initiative?
230 risposte
Yes
No
31,7%
68,3%

5. Recovering waste from the users

Hobby Clubs

A final note in this section of the survey was the interest of model builders towards hobby clubs. While this type of association is not directly linked to a waste recovery initiative, these type of clubs often offer various benefits, as described in a previous chapter. They could be helpful in enticing model builders in participating in the initiative, especially if there were exclusive incentives for members of said clubs.

In order to test the interest of the participants, it was asked to them if they were part of a hobby club, a question which was anwered negatively by the majority of the participants (96.1%).
As a follow-up, the model builders were asked if the presence of additional incentives and bonuses for hobby club members would entice them in becoming part of one showed a more positive attitude, with 68.3% of the participants answering “yes”.

The results from these two questions showed that the incentives may be applied on multiple sides, with some differences, in order to obtain the best results.

Conclusions

This section of the survey managed to help define in a more clear way the efforts that the model building community would take in participating a waste recovery initiative. The community seems open to similar projects, albeit the amount of material recovered may not be consistent during the time period. Also, it appears that, if incentives are offered to the model builders, they should focus on compensations of some kind, especially discounts. Another factor to develop extensively would be the organization of the network, with particular attention towards options of mailing the runners.

Considering the personas, they would be open to participate, but also unwilling to bring all the runners, since parts of them would be used in various ways still. Also, the personas could be interested in becoming part of a hobby club if additional incentives were proposed.

Organization of the Survey and Answers

6. New technologies and new materials

Organization of the section

The sixth section of the survey focused on the interest that model builders may have towards new materials and new technologies used to produce model kits. Together with the previous section and the following one, they cover the key points of the objective "Interest in the solutions".
This section is divided in six questions, which range from understanding the previous experiences of the model kit userbase with materials different from plastic or resin, to observing the interest towards new materials used in the production processes and, finally, to understand which doubts may rise from changes in said processes.

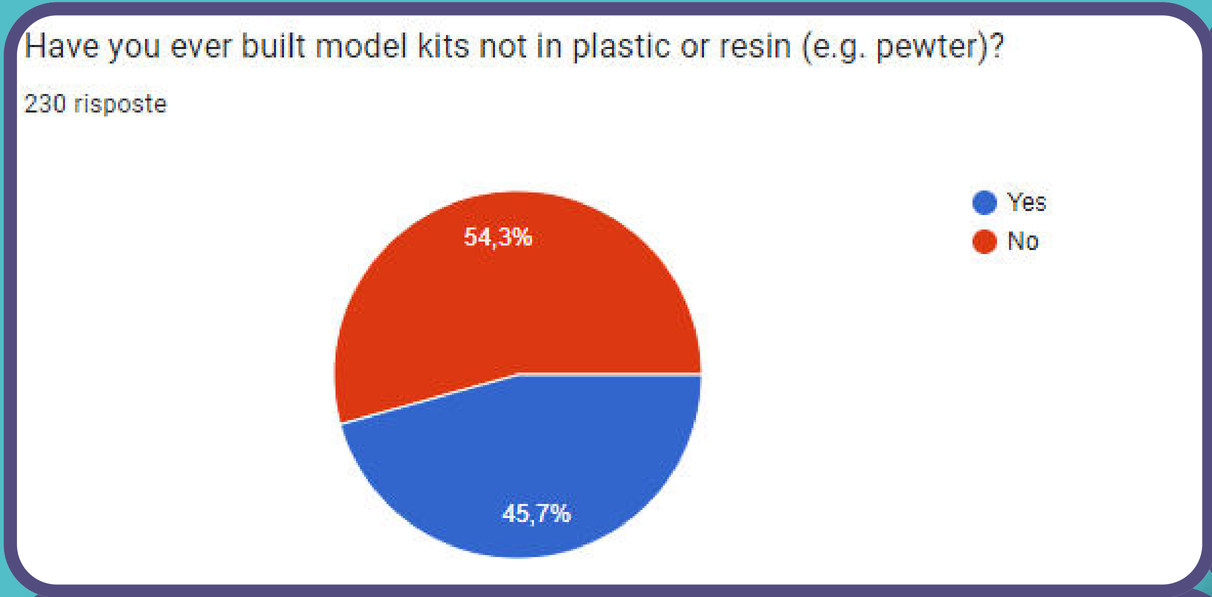
The first three questions focused on the experiences of the model builders with materials different from plastic and resin.
The first question asked the participants if they ever built a model kit made out of a material different from plastic or resin, giving pewter as an example. This material was common in the production of model kits and miniatures, especially when it came to wargaming miniatures. The following question then asked their enjoyment in working with said material, using a linear scale with values from 1 to 5, 1 corresponding to a complete lack of enjoyment and 5 to an enjoyable experience.
The third question asked simply whether model builders would be interested in buying more model kits made in different materials than the usual plastic or resin.
Both the first and the third questions were yes or no questions.

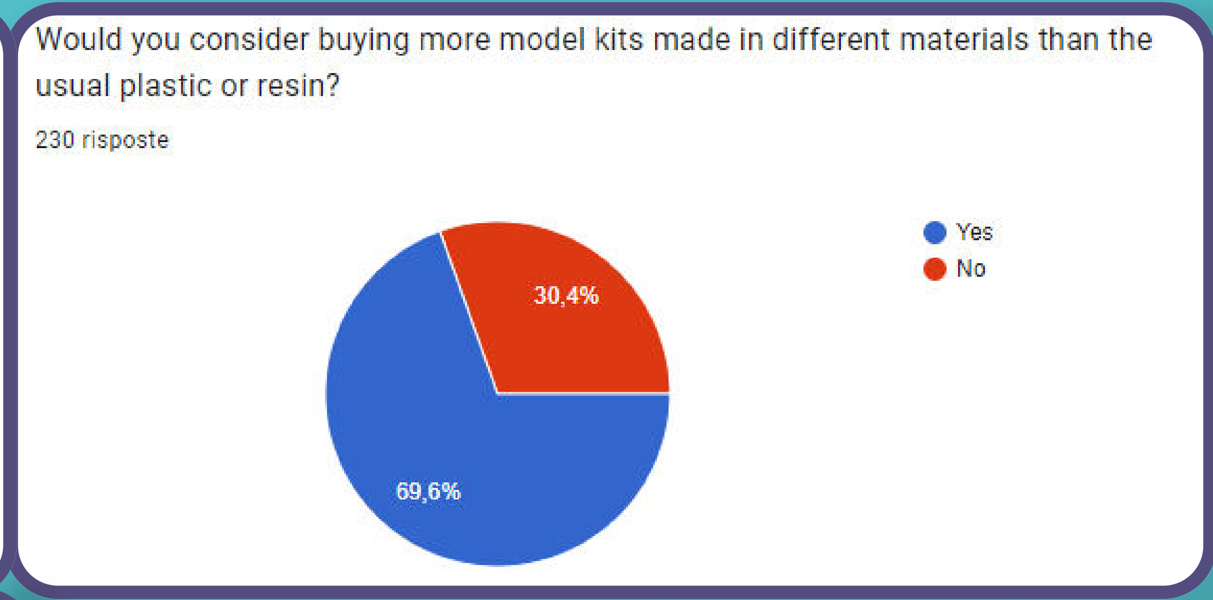
The last three questions focused again on the effect that changes in the companies could have on the model builders. The fourth question asked the participants whether they would trust model kit companies if a new material was advertised as having similar properties and being useable with the usual glues and adhesives.
This question needed a short text as an answer, mainly in order to better understand how model builders would feel when confronted with similar news. In particular, it would be interesting depending on the reason why they would or would not trust the model making companies.
The fifth question asked the participants if they would care if the model making companies were to change production processes or technologies to manufacture model kits.
The final question of this section asked the participants what would be their doubts about similar changes. In this case the question allowed for the selection of multiple options, which included higher prices, lower quality and difficulty in using the usual tools to build the kits. In addition to these options, an open one was present, allowing the model builders to add their own possible doubt.

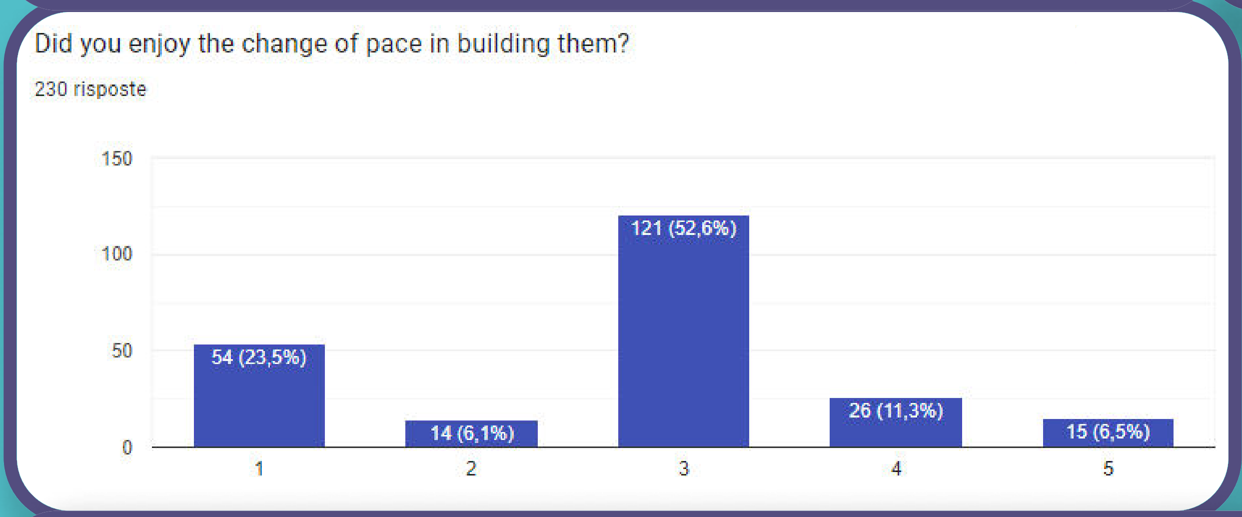
Organization of the section

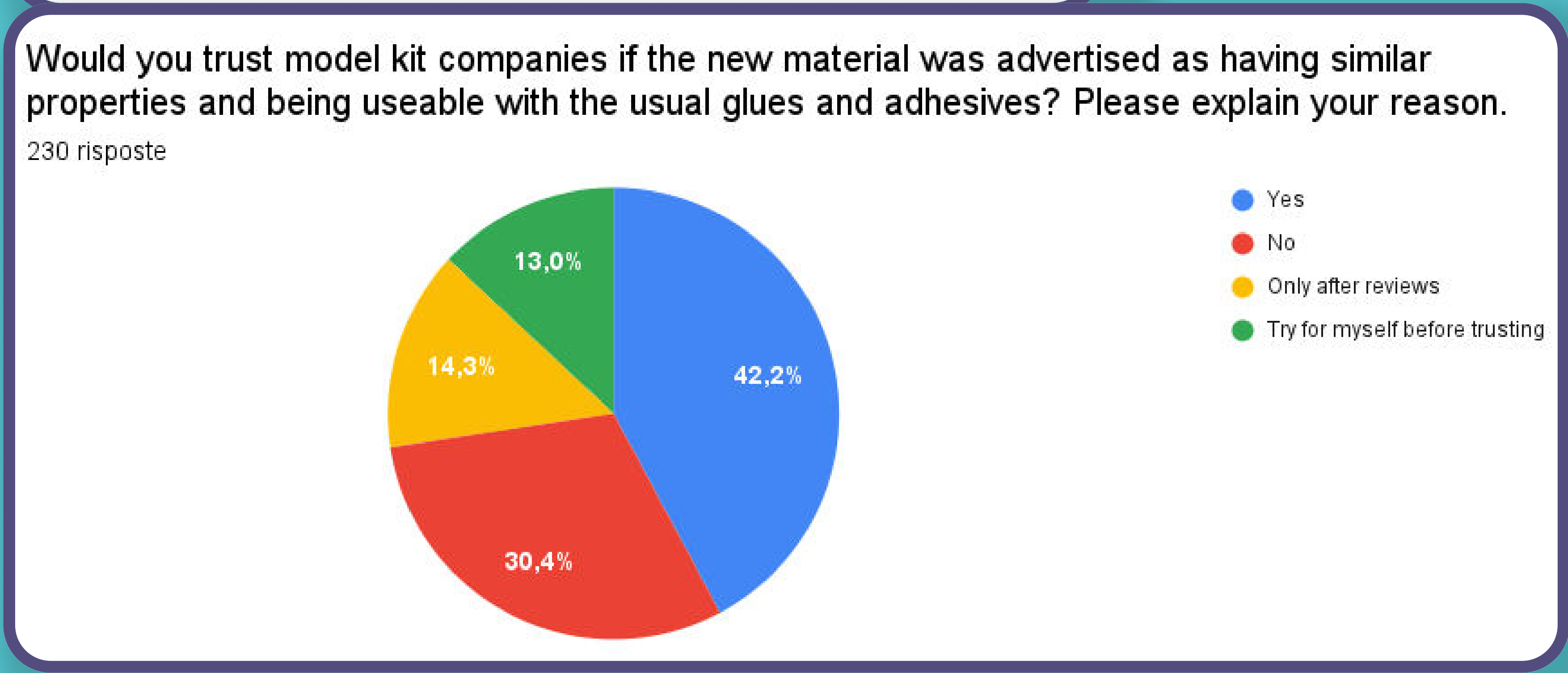
List of the questions:

1. Have you ever built model kits not in plastic or resin (e.g. pewter)?
2. Did you enjoy the change of pace in building them?
3. Would you consider buying more model kits made in different materials than the usual plastic or resin?
4. Would you trust model kit companies if the new material was advertised as having similar properties and being useable with the usual glues and adhesives? Please explain your reason.
5. Would you care if model making companies changed production processes/ technologies to make the model kits?
6. What would be your doubts about similar changes?


Have you ever built model kits not in plastic or resin (e.g. pewter)?
230 risposte
54,3%
45,7%
Yes
No


Would you consider buying more model kits made in different materials than the usual plastic or resin?
230 risposte
30,4%
69,6%
Yes
No


Did you enjoy the change of pace in building them?
230 risposte
150
100
50
0
54 (23,5%)
14 (6,1%)
121 (52,6%)
26 (11,3%)
15 (6,5%)
1
2
3
4
5


Would you trust model kit companies if the new material was advertised as having similar properties and being useable with the usual glues and adhesives? Please explain your reason.
230 risposte
13,0%
14,3%
42,2%
30,4%
Yes
No
Only after reviews
Try for myself before trusting

6. New technologies and new materials

Experience with other materials

When asking the participants in the survey about their interest in new technologies and, more importantly, new materials, it seemed appropriate to ask them if they have prior experience with materials outside resin and plastic, nowadays the main materials used in model kits and miniatures production. The objective of the question in this section was to gauge the interest of the community towards new material and new technologies.

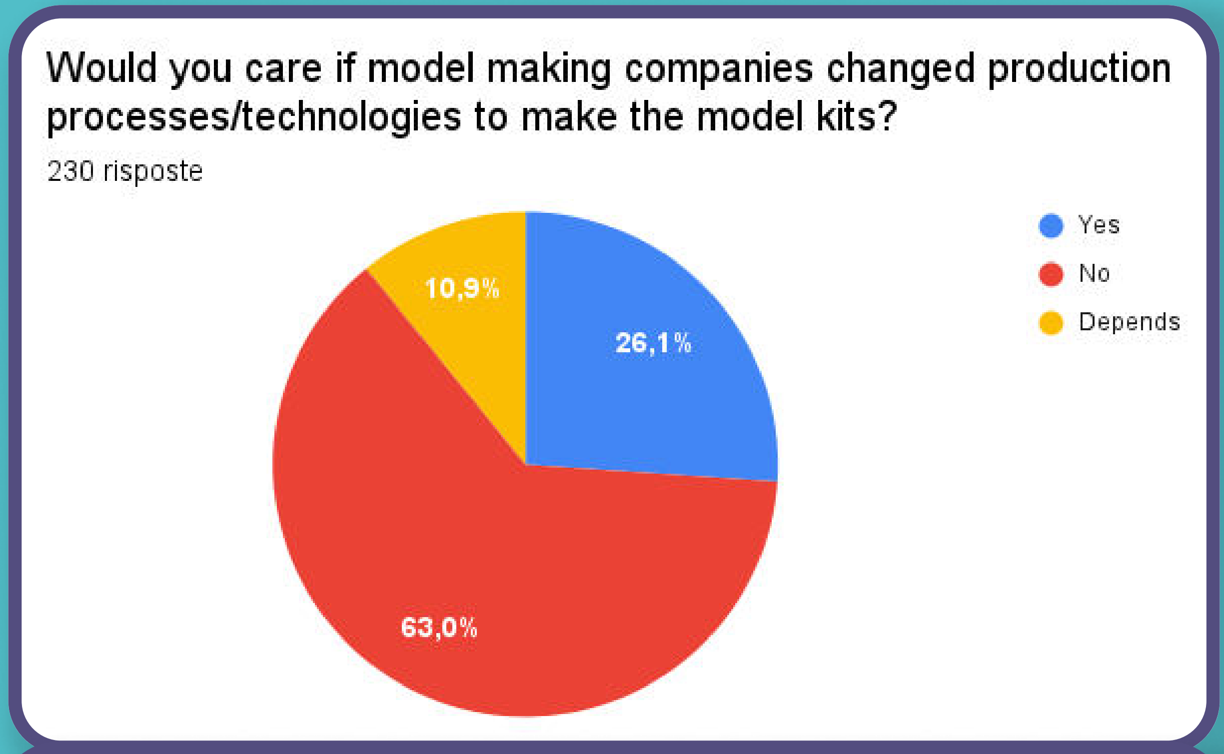
Asked about their experience with model kits made in materials not in plastic or resin, the majority of the community answered “no” (54.3%), but a still sizeable portion of the participants answered positively (45.7%). As a follow-up, the model builders were asked to rate from 1 to 5 their enjoyment of the assembly process. The results were interesting. While the majority of the participants answered with an average value (52.6%), most of the remaining answers were negative: 1 (Not enjoyable) was selected 23.5% of the time, 2 was selected 6.1% of the time, contrasting with 5 (very enjoyable), which was selected 6.5% of the time, and 4, selected 11.3% of the time. So, overall, the experience was not particularly enjoyable. This result may have been influenced by the example of pewter given in the previous question. Being a metal, it required an extra step for assembly model kits, pinning. This step required drilling, using a hobby drill, a few millimetres deep hole in two sections that would be glued together, then inserting a thin metal wire in the holes gluing it with cyanacrylic glue. This technique helped securing the connection between the components. In addition to that, pewter is a very soft metal, which meant that it was easy to damage, especially if dropped by accident, bending elements of the model kit.

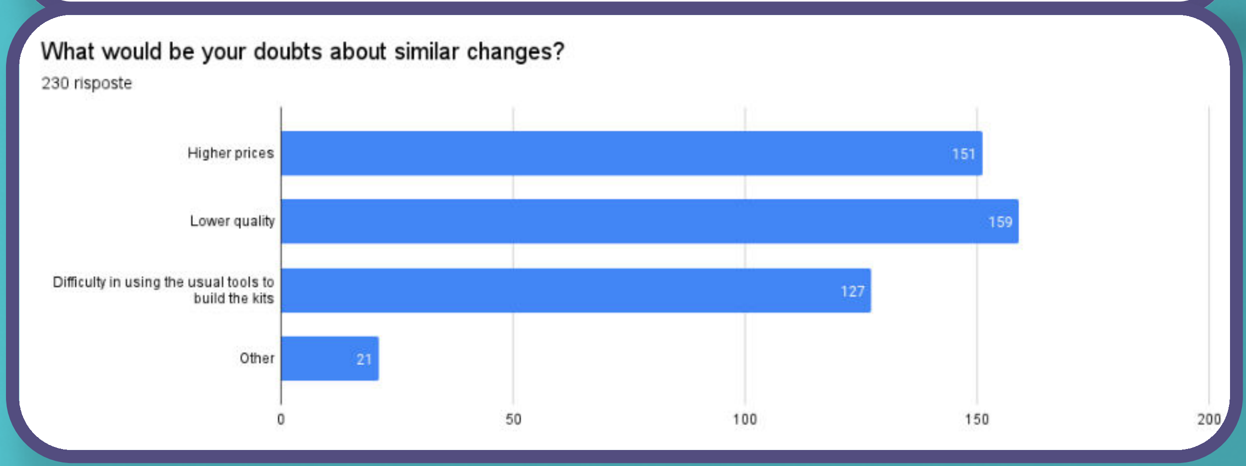
After these initial questions, the participants were asked if they would be interested in purchasing model kits made in a different material from plastic or resin. The answers contrasted with the results of the first question of this section, showing that the community is interested in alternatives: 69.6% of the model builders selected “yes”, while 30.4% chose “no”.
These results show that there seem to be some interest towards new materials, therefore the next step was to understand how this possibility is seen by the individuals.

Interest and trust

A very important element for companies to promote a new material to their customers is the trust that said customer have to put in the new material. Therefore, this was the objective of the open question where participants had to also explain their reason.
The answers were very interesting. While the majority of participants answered positively (42.2%), giving various explanations, like that the companies would have no need to lie or that as long as the quality standards remained high and maintained similar properties they would trust the word of the manufacturers, the most sceptical participants stated that they would look for reviews of the new products before trying themselves (14.3%). Similarly, some participants stated that before trusting completely the companies they would prefer purchase a product and test it. But a sizeable (30.4%) portion of the participants stated that they would not trust the companies at all. The examples given were Games Workshop finecast, which has a history of flashes, bubbles and other very disappointing defects, paired with fragility and difficulty to assemble the model kits, and an issue in 2017 caused by the company Battlefront Miniatures, which released new plastic miniatures, substituting metal ones, but using low quality materials.

The results show that the community is willing to trust a new material, but would probably still wait reviews and personal tests before doing so blindly.


Would you care if model making companies changed production processes/technologies to make the model kits?
230 risposte
Yes
No
Depends
26,1%
63,0%
10,9%


What would be your doubts about similar changes?
230 risposte
Higher prices
151
Lower quality
159
Difficulty in using the usual tools to build the kits
127
Other
21
0
50
100
150
200

Organization of the Survey and Answers

6. New technologies and new materials

Interest and doubts in new technologies

After having assessed the interest and the trust that model builders may have towards a new material, the same process was to be done towards new production process technologies that companies may adopt.

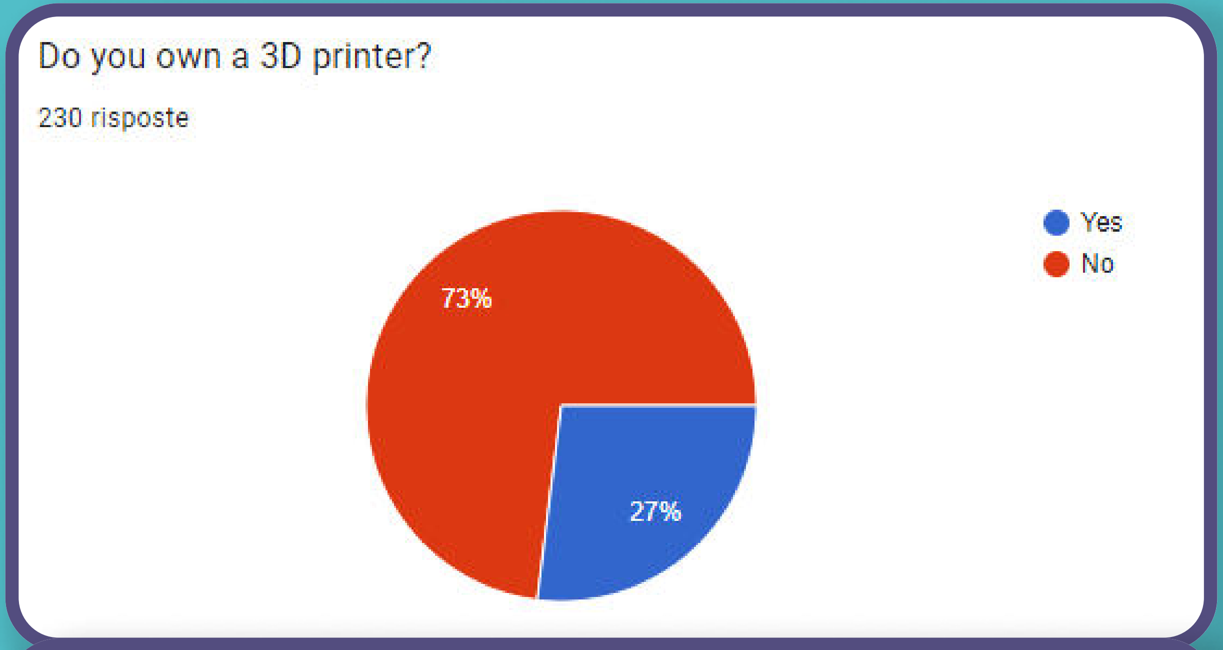
The first step was asking if the model builders would care about the adoption of said technologies, in a similar fashion to what was asked them in the section regarding the perception of model making companies.
Interestingly enough, the results from this question contrasted with the ones from the mentioned question. In this case, the majority stated that they would not care (63%), while around 10% answered that it would depend on various factors, mainly from what those changes would entail.
Changes that were to improve the environmental impact, reduce prices or improve production quality would be obviously seen in a positive light, but if either quality or prices were affected negatively, the opposite would happen. Generally, though, if the product quality was not affected, the potential changes were met with apathy and indifference.

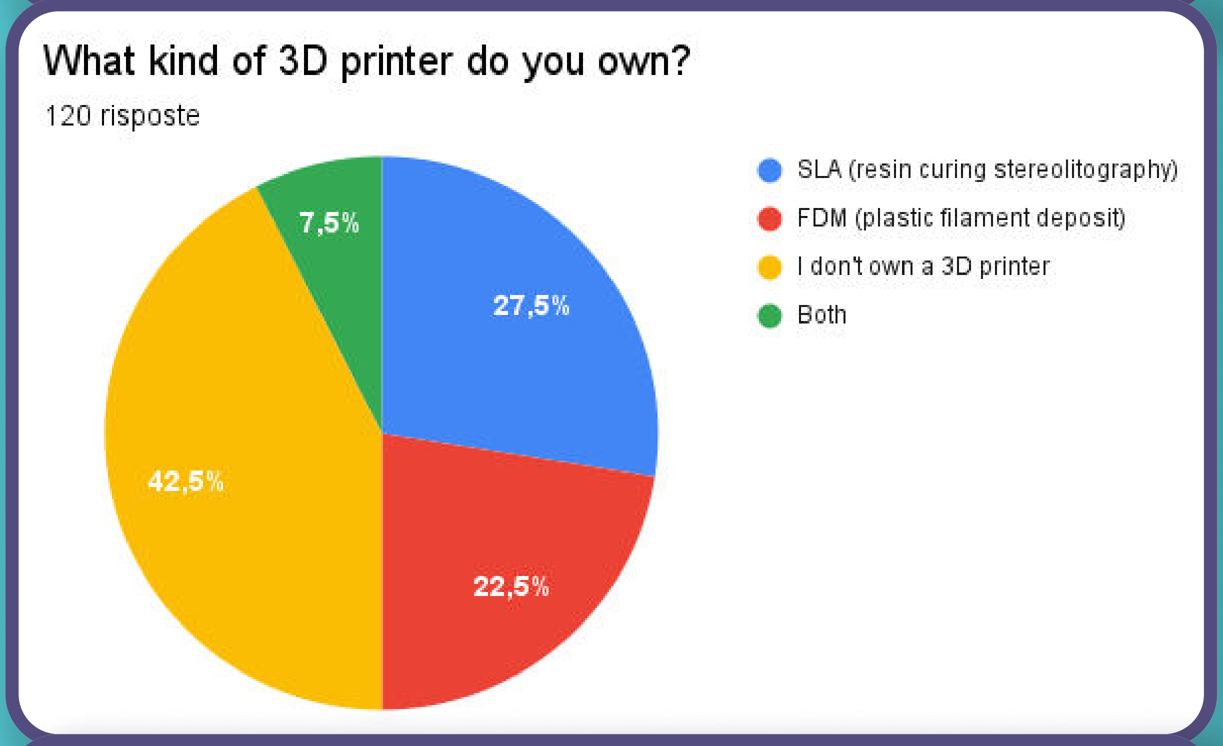
The participants were also asked to indicate which were the main doubts towards similar changes, giving them the possibility to choose multiple options and to add their own reason.
The results showed that all the three available options were considered almost equally concerning, with “lower quality” of the products being selected the most (159 times), followed by “higher prices” (151 times) and “difficulty in using the usual tools to build the model kits” sitting ad 127 votes.
21 participants also added their own reasons, which ranged from risk of incrementing pollution, to “Change in the plasticity of the surface - some types of resins and plastics, for example, have great tendency to deform or be difficult to trim, or are difficult to use in play due to them being too soft”; other doubts regarded efficiency, less shelf life of the models, linked to loss of sturdiness and longevity of the material, immaturity of some technologies (e.g. 3D printing) and, finally, issues with some materials, like the toxicity of resins and lead and the issues with metal already explained with pewter.

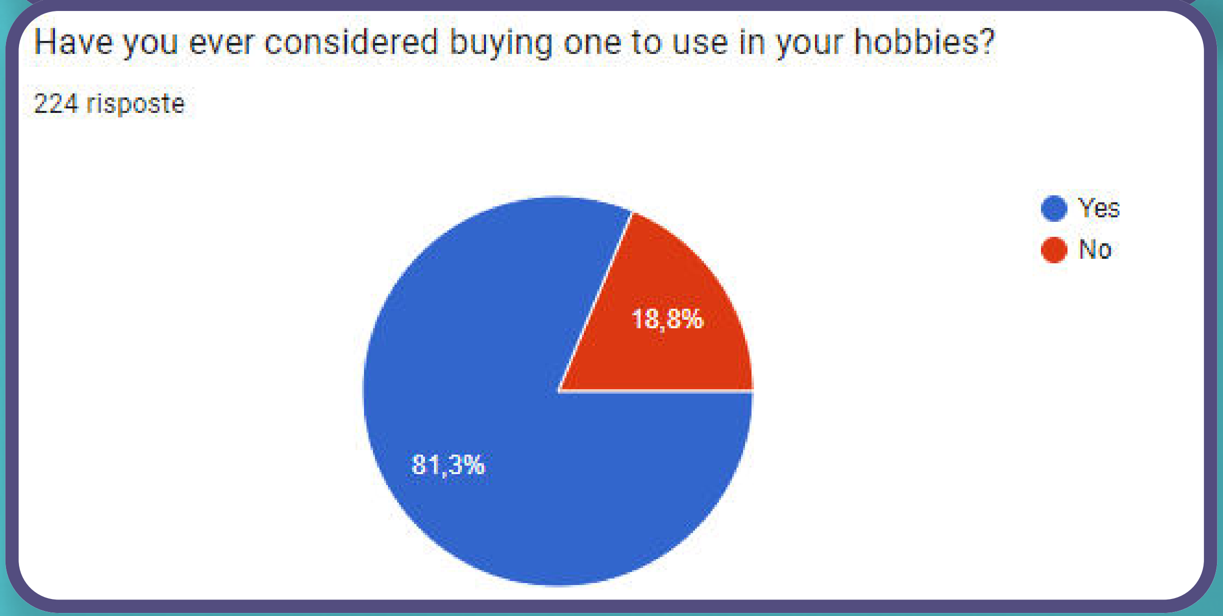
Conclusions

This section allowed to understand the issues that model builders may have with changes in technology and materials.
The community does seem to be open towards said changes, but would require a lot of work from the companies to prove the positive effects that said changes must have, in order to be supported and accepted by their customers.

Considering the personas, this section simply added the same conclusions already stated: they would be open to changes, but still requiring some level of proof before accepting them.


Do you own a 3D printer?
230 risposte
Yes
No
73%
27%


What kind of 3D printer do you own?
120 risposte
SLA (resin curing stereolitography)
FDM (plastic filament deposit)
I don't own a 3D printer
Both
7,5%
27,5%
42,5%
22,5%


Have you ever considered buying one to use in your hobbies?
224 risposte
Yes
No
18,8%
81,3%

Organization of the Survey and Answers

7. STL Sales

Organization of the section

The seventh section is the last one covering one of the key points of the objective "Interest in the solutions". In this case, the objective was to understand how much, on average, the model building community would be interested in STL sales, analysing both the percentage of adoption of 3D printers, their use and the issues that the community may fear when considering purchasing official 3D models.
It is important to notice that the survey was developed together with the solutions analysed and identified in the previous chapter, thus comprising the "STL Sales" solution, which was not ultimately found effective in the multicriteria analysis.

The first three questions regarded mainly on the possession of a 3D printer and the interest in purchasing one to use for the model making hobby.
The first question, a yes or no one, asked if the participants own a 3D printer. The second question asked about the type of printer, listing as answer options "FDM printer" and "STL printer". It also had an open space if any participants owned a different kind of machine.
The third question asked the community about whether they ever thought about purchasing one to use for the model making hobby.
By asking these questions it would be possible to determine a general interest of the community towards private additive manufacturing, further helping the development of a new industry network.

The following three questions concluded the section asking the participants their potential interest towards purchasing official STL files from the model making companies.
The fourth question asked the participants if they were interested in purchasing the digital files from model making companies, while subsequently, in the fifth question asking the reason for which they may have answered "no". In this question, the answer could be chosen from the available options, giving also the possibility to the participants to add their motivation, thanks to an open answer. The answers listed various issues and post-processing common in the 3D printing production process, which was analysed in the first chapter.
Finally, in the sixth question, the participants were asked to choose which type of models they would be more interested in purchasing. While this question seems inconsequential at first, it has the precise objective to define which type of model kit would be more effective to be sold as STL files.

List of the questions:

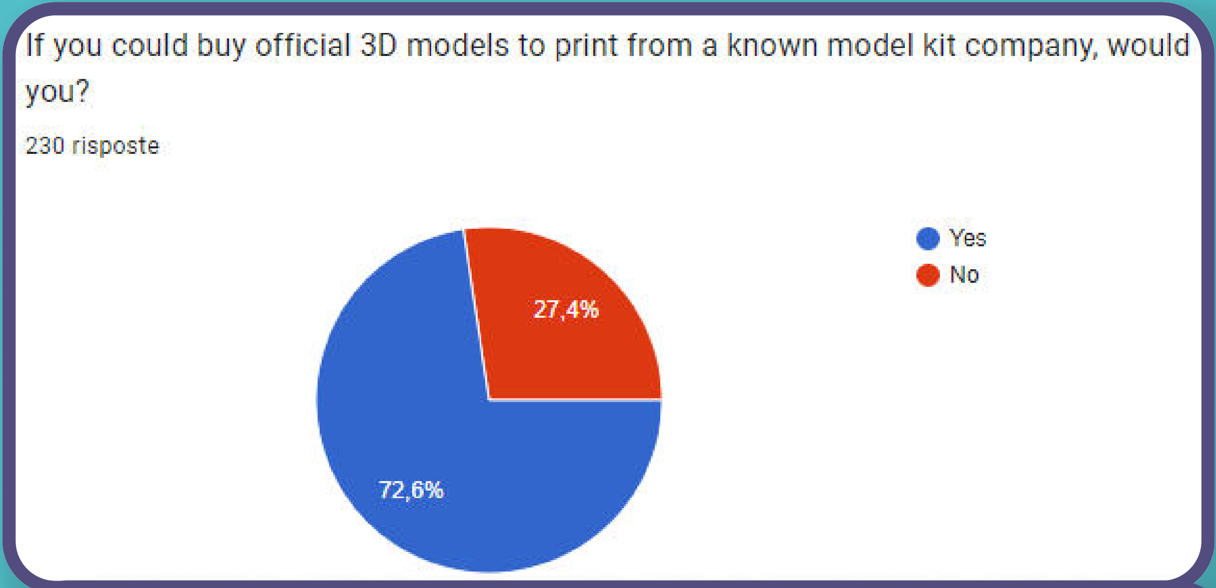
1. Do you own a 3D printer?
2. What kind of 3D printer do you own?
3. Have you ever considered buying one to use in your hobbies?
4. If you could buy official 3D models to print from a known model kit company, would you?
5. If not, why?
6. If you were to buy 3D files of model kits, which would interest you more?

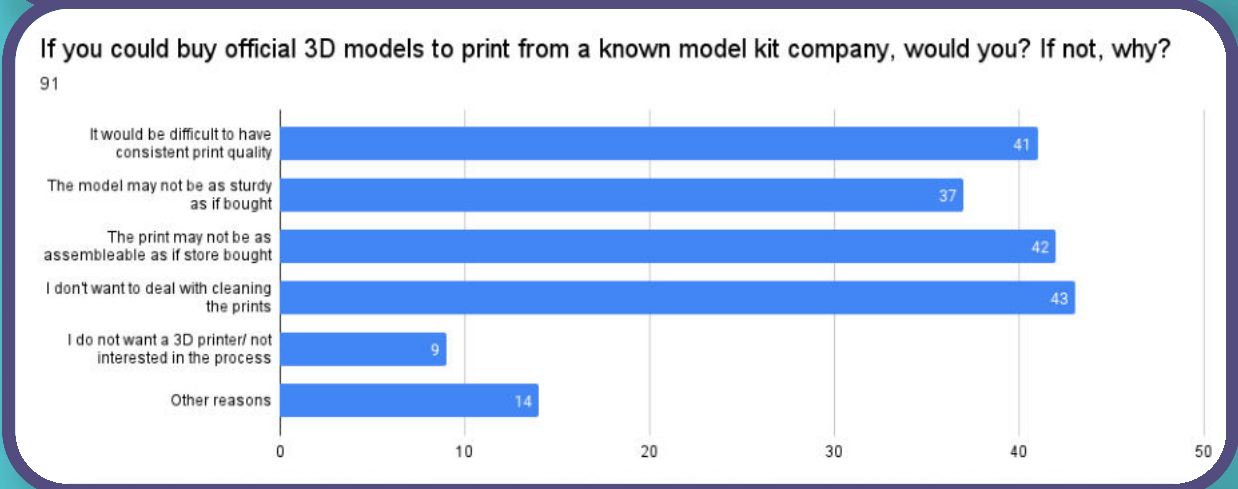
Presence of a 3D printer

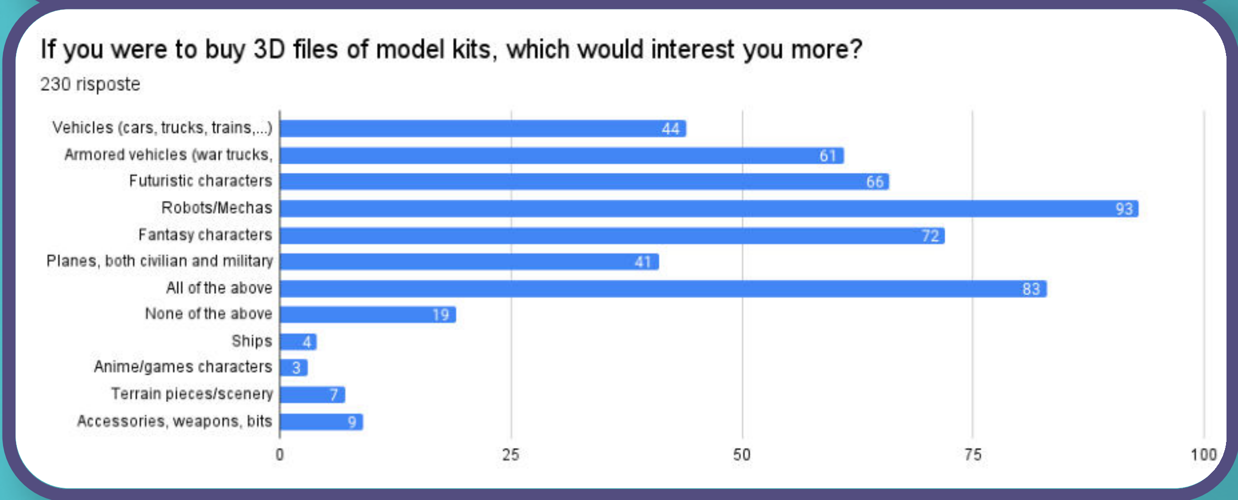
The final section dedicated to the identified solutions focused on the STL Sales. In this section the community was asked topics regarding the adoption of 3D printers, the interest towards official 3D models and generally what would be the types of model most requested.

Being asked if they owned a 3D printer, the vast majority of the participants answered "no" (73%). Following this question, one asking the type of printer they owned received 120 answers, where 42.5% of them stated that they do not own one. The most popular printer was an SLA printer, which uses resin curing stereolithography to harden the resin and produce the model components. That said, the difference is not particularly large: SLA printer was selected 27.5% of the time, while FDM printer, which deposits plastic filament layer by layer, was chosen 22.5% of the time. Interestingly, 7.5% of the participants who answered stated that they own both types.
The reason behind this difference is based on the use of the printer: SLA printers are more precise, with layers that can be lower than 0.05 mm, thus are preferred for model kits with many small details. FDM printers work on a lower resolution (minimum around 0.05 mm, but that is available only on the best, and often more expensive, machines), therefore are usually used for larger pieces, especially if also the details remain large and simple.

Then, the participants were asked if they ever considered purchasing a 3D printer to use in the hobby. The results showed interest towards these machine, since 81.3% of model builders answered "yes".


If you could buy official 3D models to print from a known model kit company, would you?
230 risposte
Yes
No
27,4%
72,6%


If you could buy official 3D models to print from a known model kit company, would you? If not, why?
91
It would be difficult to have consistent print quality
41
The model may not be as sturdy as if bought
37
The print may not be as assembleable as if store bought
42
I don't want to deal with cleaning the prints
43
I do not want a 3D printer/ not interested in the process
9
Other reasons
14
0
10
20
30
40
50


If you were to buy 3D files of model kits, which would interest you more?
230 risposte
Vehicles (cars, trucks, trains,...)
44
Armored vehicles (war trucks,
61
Futuristic characters
66
Robots/Mechas
93
Fantasy characters
72
Planes, both civilian and military
41
All of the above
83
None of the above
19
Ships
4
Anime/games characters
3
Terrain pieces/scenery
7
Accessories, weapons, bits
9
0
25
50
75
100

Organization of the Survey and Answers

7. STL Sales

Interest in official 3D models

Regarding the adoption of the solution, the participants were asked if they were interested in purchasing eventual official 3D models from the model making companies. The general consensus was positive, with 72.6% of model builders answering “yes”. This result was in line with the previous question.

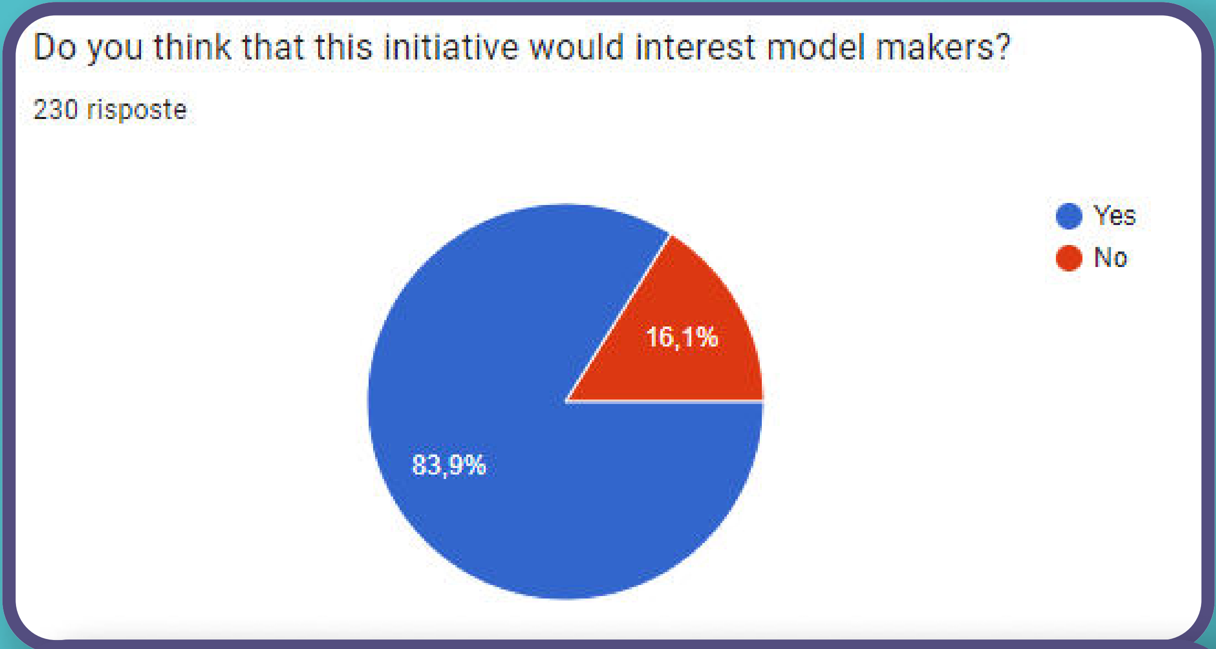
Then, the participants were asked why they would not be interested in purchasing said STL files. Interestingly, the total of “no” answers in the previous question was 63 (27.4% of the total), while the total answers for this one were 91. This means that 28 participants interested in purchasing official 3D models wanted to give their feedback on why they would not.
The question allowed each participant to select multiple options, as well as adding their own. The results showed that the four original options were all almost equally valid: “It would be difficult to have consistent print quality” was selected 41 times, “The model may not be as sturdy as if bought” 37 times, “The print may not be as assembleable as if store bought” 42 and “I don't want to deal with cleaning the prints” 43. In addition to that, 9 participants added that they are not interested in 3D printing and do not want the machines, preferring the assembly and painting stages of the hobby. 14 other participants gave more different reasons, going from the starting costs (especially for resin printing), wanting to avoid a markup on digital files, health and safety concerns and the fact that they are already able to find free STL files online, thus not needing to purchase official ones.

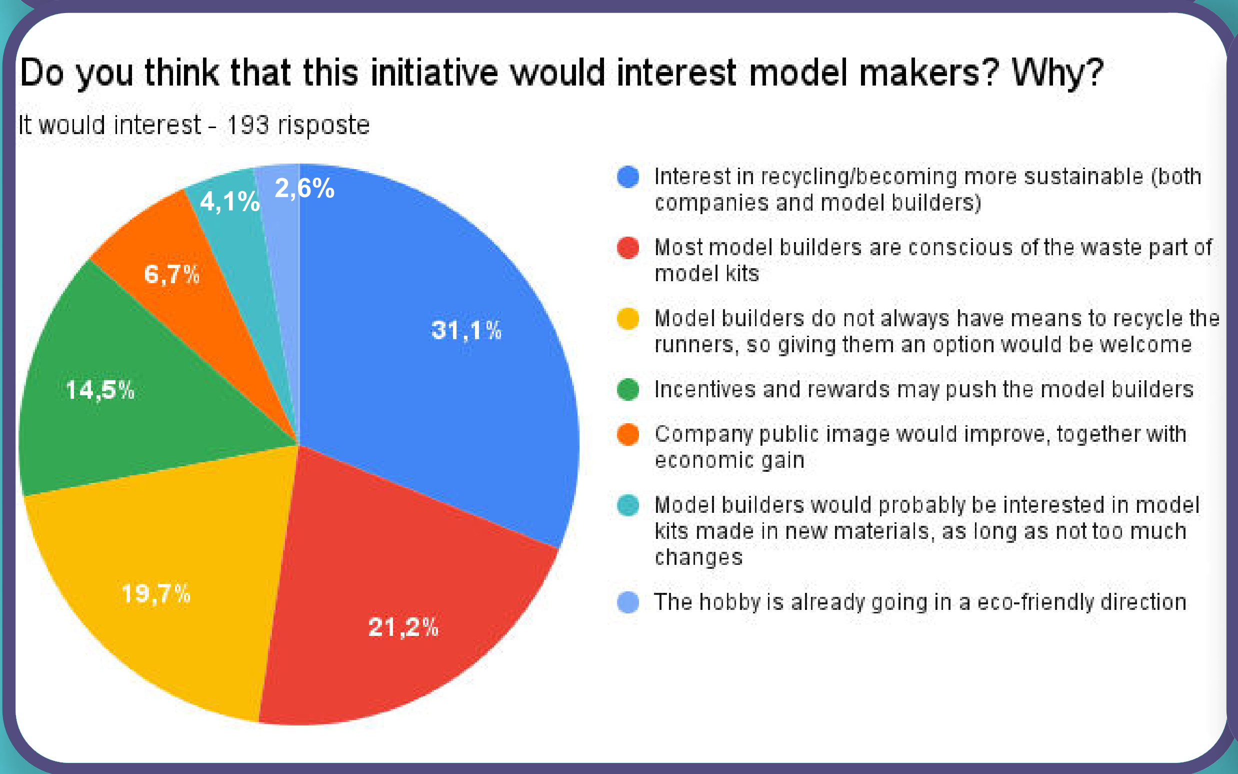
A final question regarded the type of models the participants would be more interested in.
The results were interesting. This question was organized like the previous one and the most selected option was “Robots/Mechas”, with 93 votes. Also, “All of the above” was very liked, with 83 votes. Other notable selections were “Fantasy characters” (72 votes), “Futuristic characters” (66 votes) and “Armoured vehicles (war trucks, tanks, army vehicles in general)” (61 votes).
The options added by the participants regarded mainly accessories, weapons and “bits” (small details and additions to models), as well as terrain pieces and scenery.

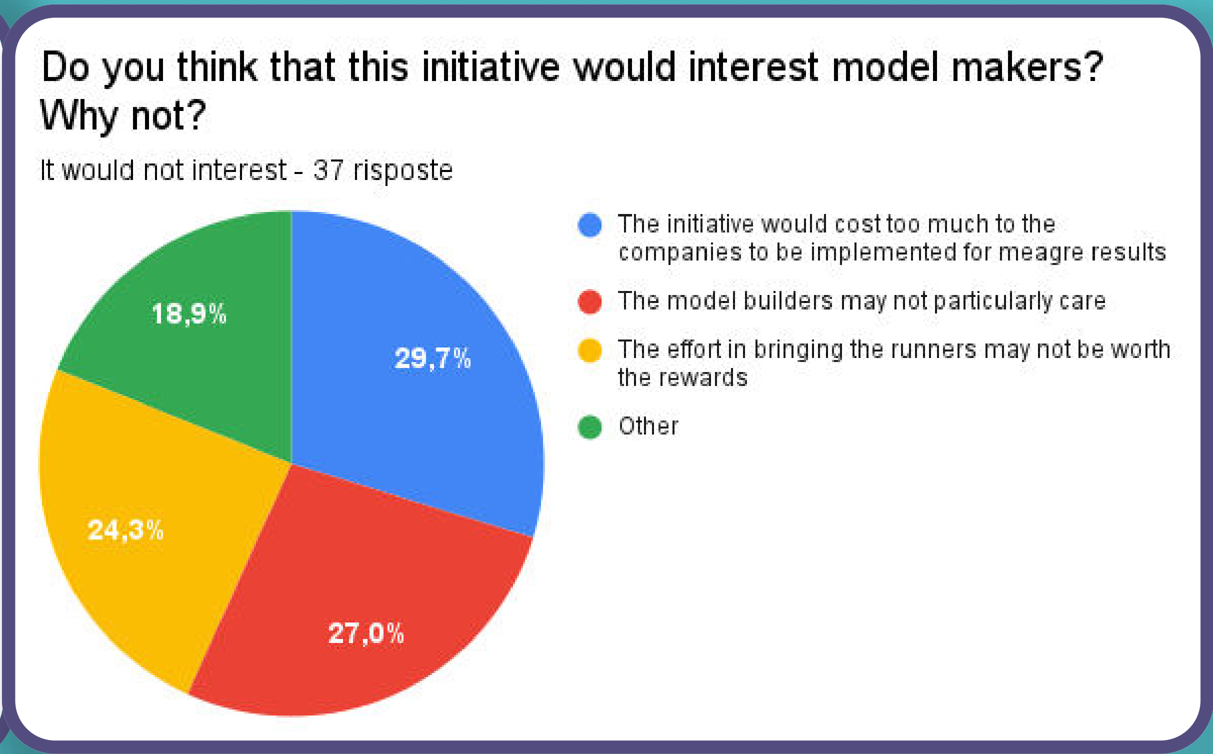
Conclusions

The results from this section showed a tentative interest towards this solution, but with some very interesting reasons as for why there may still be lack of interest. That said, the community is still not large enough part of the 3D printing sector to completely justify the organization of STL sales, especially since they would most likely be one-time purchase.

Regarding the personas, they would probably be developed more towards being interested in purchasing a 3D printer and certain types of models, but with only a small percentage of them actually owning one.


Do you think that this initiative would interest model makers?
230 risposte
Yes
No
16,1%
83,9%


Do you think that this initiative would interest model makers? Why?
It would interest - 193 risposte
Interest in recycling/becoming more sustainable (both companies and model builders)
Most model builders are conscious of the waste part of model kits
Model builders do not always have means to recycle the runners, so giving them an option would be welcome
Incentives and rewards may push the model builders
Company public image would improve, together with economic gain
Model builders would probably be interested in model kits made in new materials, as long as not too much changes
The hobby is already going in a eco-friendly direction
31,1%
21,2%
19,7%
14,5%
6,7%
4,1%
2,6%


Do you think that this initiative would interest model makers? Why not?
It would not interest - 37 risposte
The initiative would cost too much to the companies to be implemented for meagre results
The model builders may not particularly care
The effort in bringing the runners may not be worth the rewards
Other
29,7%
27,0%
24,3%
18,9%

Organization of the Survey and Answers

8. Comments on the user waste recovery initiative

Organization of the section

The eight and final section of the survey was focused on asking the participants their personal opinion on the user waste recovery initiative.
The questions had the objective to obtain feedback from the community on the potential interest that may come from other model builders, while also trying to obtain a more clear picture of the reason.
Therefore, the first two questions asked the participant if, in their opinion, a user waste recovery initiative would interest model builders and why.

The third question, instead, asked the participants their personal opinion on the initiative, more precisely if they thought that it could help reduce the usage of virgin plastic material. The reason as for why asking an opinion on such a technical topic was to try and garner as many points of view as possible from the community. With one of the overall objectives of the project being opening the system and incentivize recycling plastic, the feedback of the community, which could be partially a supplier of recyclable material, is important.

List of the questions:

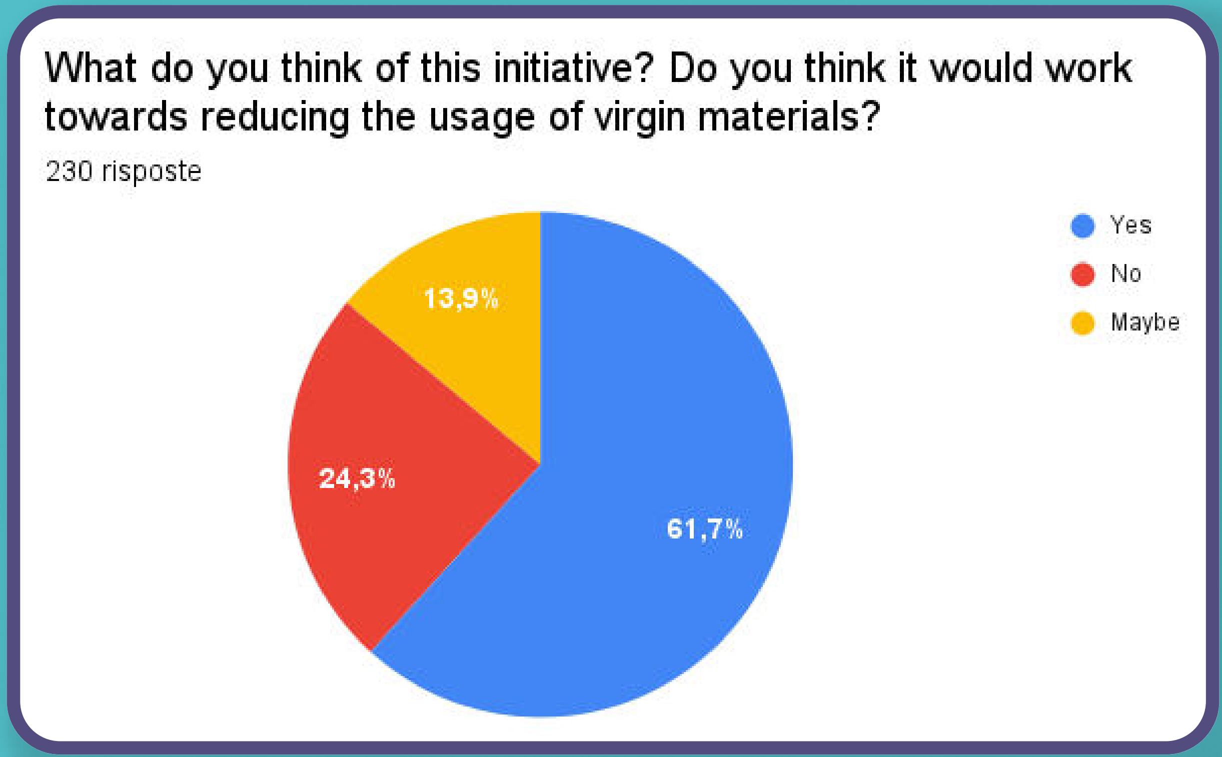
1. Do you think that this initiative would interest model makers?
2. Why?
3. What do you think of this initiative? Do you think it would work towards reducing the usage of virgin materials?

Opinions on interest

The final section of the survey asked the participants to leave some comments regarding their opinions on the interest of model builders towards a waste recovering initiative and on the initiative itself.

Asking the participants if, in their opinion, model builders would be interested in the initiative, the majority (83.9%) answered "yes". Then, when asked about their reason, they stated that it would be because of a general interest in recycling and/or becoming more eco-friendly, both the companies and the model builders (31.1%). Another reason was that most model builders were already conscious about the waste part of model kits, so offering a solution would probably interest them (21.2%). Also, around 19.7% of the participants indicated that some model builders do not have the means to recycle said waste, either because of limitations in their country, or for personal reasons, so, again, proposing a waste recovery service would be welcomed. Also, incentives and rewards would help push model builders in participating (14.5%). Other reasons listed were that the public image of the company would improve, as well as its economic gains (6.7%) and that the model builders would welcome eco-friendly changes, as long as not too much changes in the model kits, like the tools or the glues needed (4.1%). Finally, a small portion of the participants stated that the hobby is already going in an eco-friendly direction, taking as example the Gunpla Recycling Project (2.6%).
On the other hand, 16.1% of the participants stated that the model builders would not be interested, explaining that the initiative would cost too much for the companies to implement for meagre results (29.7%), that model builders may not particularly care (27%) and that the efforts needed to bring the runners may not be worth the rewards (24.3%). In addition to that, other reasons given were laziness from the model builders, insufficient incentives and general lack of care in the industry towards similar initiatives.

When comparing these results with what emerged from the previous sections, it seems that the more negative participants are much harder to convince than the ones that view the initiative positively. While in various questions along the survey many participants gave interesting feedback, more often than not it was positive, especially when suggesting additional elements, like the possibility of a mail or shipping solution to recover waste from model builders living in rural areas. Negative feedback was usually limited to lack of faith towards the community, often stating that there is no interest towards recycling. This difference in view is very interesting, and is something to keep in mind when developing a new industry network.

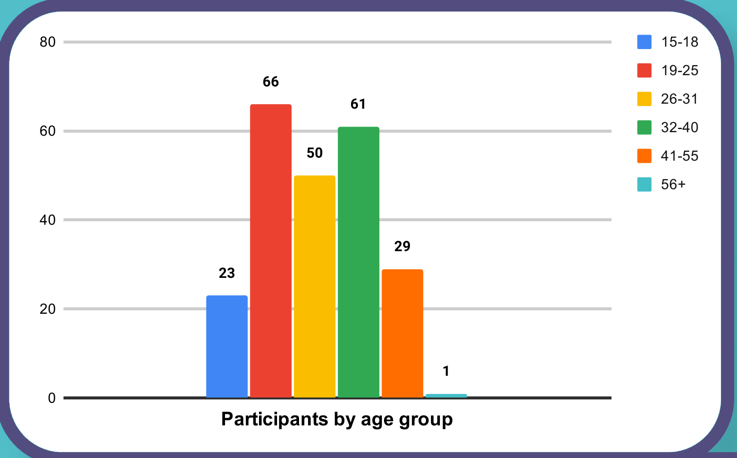

What do you think of this initiative? Do you think it would work towards reducing the usage of virgin materials?
230 risposte
Yes
No
Maybe
13,9%
24,3%
61,7%

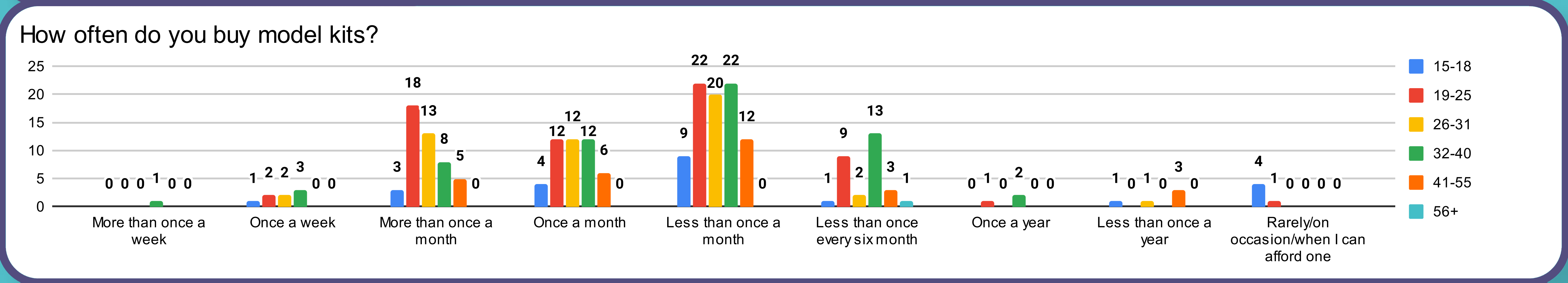
8. Comments on the user waste recovery initiative

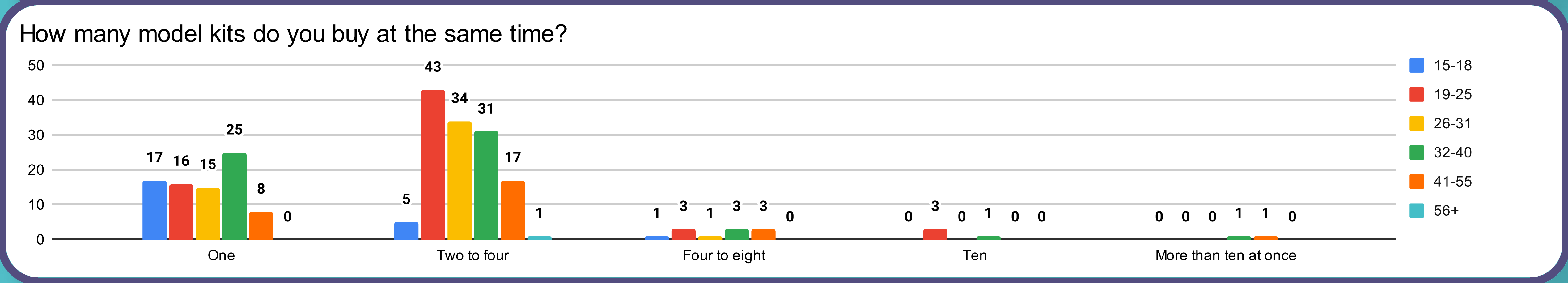
Opinions on the initiative

The final question in the survey asked the participants if the waste recovery initiative would work towards reducing the usage of virgin materials in the production processes of model kits.
While the question was open, the answers were clusterized in “yes”, “no” and “maybe”. The reason for this was both the high amount of answers that were simply affirmative (61.7%), negative (24.3%) and undecided (13.9%).
That said, when reading the 230 answers, these were in line with the results from previous questions when positive, down to the same doubts reported in the section regarding new materials and technologies.

The negative responses, instead, stated generally that their reasons for not believing the helpfulness of this initiative rested in the fact that model making is still a niche market, with a relatively small customer base, especially when compared with plastic industry market that cover everyday needs. This would make the recoverable amount of plastic meagre, especially when considering that not all model builders purchase the model kits with high frequency. Another issue that is brought forward is the fact that the initiative requires the participation of model builders, making so that any prediction regarding the actual amount of recovered material uncertain at best.


80
60
40
20
0
15-18
19-25
26-31
32-40
41-55
56+
23
66
50
61
29
1
Participants by age group


How often do you buy model kits?
25
20
15
10
5
0
15-18
19-25
26-31
32-40
41-55
56+
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Rarely/on occasion/when I can afford one


How many model kits do you buy at the same time?
50
40
30
20
10
0
15-18
19-25
26-31
32-40
41-55
56+
One
Two to four
Four to eight
Ten
More than ten at once

Cross Analysis of the Answers

Introduction

After analysing the results for each question separately, a cross analysis of the answers was done in order to define better the community based on the data recovered from the profiling.
This cross analysis was initially distributed on the age groups, the occupation and the origin of each participant. The gender was not considered, since the vast majority (90.4%) of the participants were male, thus not being a diverse enough pool of participants to obtain interesting results.
During the cross analysis, though, it appeared that both the use of occupation and origin would not bring forth interesting results.
First of all, the results of the occupation question showed that the participants were mainly working, but, most importantly, during the cross analysis of each section of the survey and of the most interesting questions, it appeared that the various answers were mostly equally split between the options “Working”, “Student” and “Unemployed”. Even if each option varied in number of selection (as a reminder: 70.9% of the participants chose “Working”, 21.7% chose “Student” and only 7.4% chose “Unemployed”), the answers for each question did not vary much in percentage, even if, for the smaller categories, the difference seemed more drastic. In addition to that, the large difference between choices muddled the results: the 17 participants that chose “Unemployed”, when compared to the 163 that chose “Working”, would not show useful data, since the pool is too small.
When it comes to the origin, as it will be shown later regarding the preferences where purchasing model kits, it seemed that the similar pool size of answers gave another result: the answers were relatively equally divided between the three options “United States”, “Europe” and “Other”. This division would not really allow gaining insight in the community, especially when considering that the pool of participants counted 230 ones.
More interesting results related to occupation and origin could be obtained from a survey that gained a larger pool of participants, especially considering that the “Other” category ended up covering South America, Asia and Australia/New Zealand.
Instead, the results that emerged from cross analysing the questions with the age groups showed interesting results, even when taking in consideration the difference in numbers between options. As noticed in the section of the chapter dedicated to profiling, the two groups “15-18” and “41-55” had similarly sized pools, allowing for a comparison between two extreme age groups. The smallest group “56+”, only counted one participant. This group was still counted in the cross analysis, but the results obviously do not hold any weight. Finally, the three largest age groups, “19-25”, “26-31” and “32-40”, which counted 65, 50 and 61 participants respectively, allowed for an interesting comparison, related mainly to a gradual ageing in the community. Still, each cross analysis has been conducted maintaining the other categories, in order to avoid losing potential interesting results. For example, the cross analysis of the questions about the timing and amount of model kit purchasing was conducted with both age groups and occupation categories.

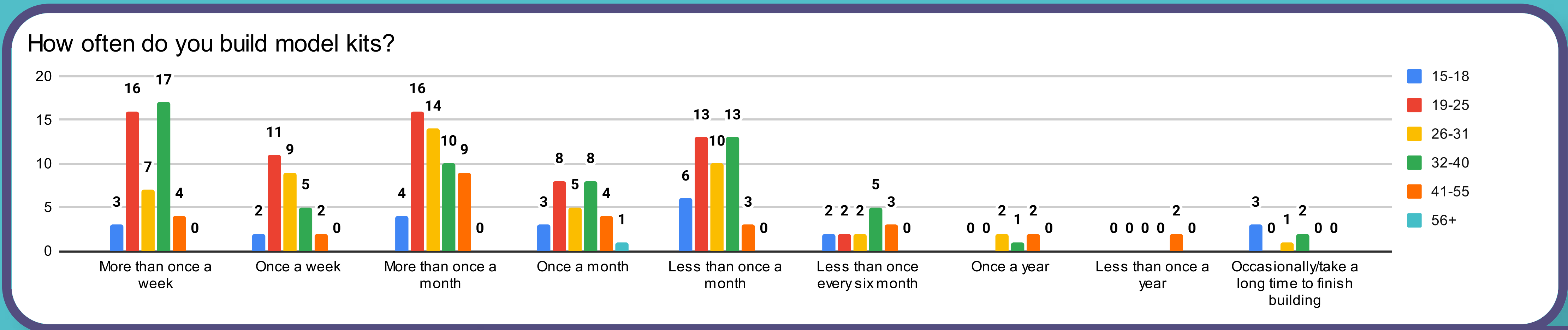
On a final note, outside the results from cross analysing questions with multiple selections, the percentages presented in the text describe the total of participants in a certain age group. On the previous page, together with the graphs about the hobby, one with the total numbers of participants for each age range is present.

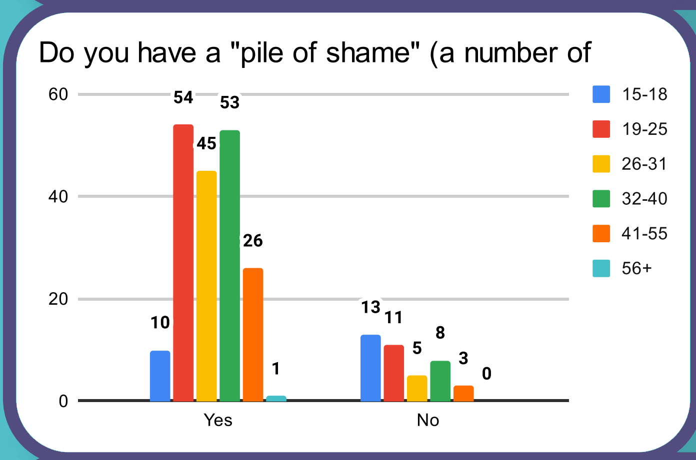
Participation in the hobby

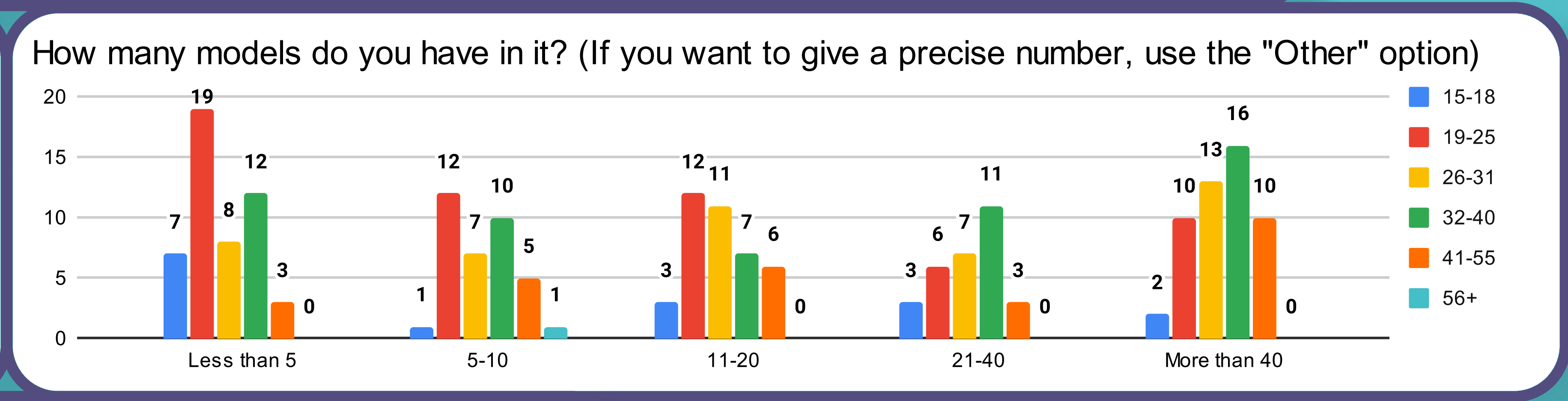
The cross analysis started from the results from the questions about how the community participates in the hobby.
The elements that were analysed were related to the purchasing preferences (timing, amount, location), assembly (timing) and backlog. In order to maintain a similar information flow as the one used in the previous section of the chapter, the results from the analysis will be presented in the same order.

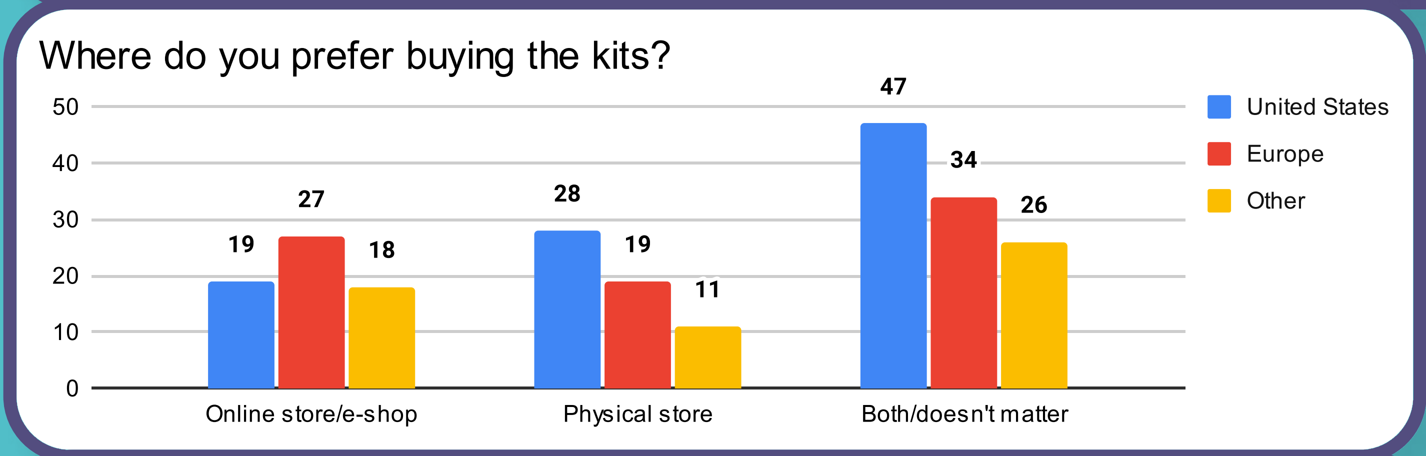
Comparing the results from the question “How often do you buy model kits” with the age groups, it is possible to notice that the majority of the participants for each group has a preference towards the “monthly” options. In particular, in line with the results of that question, All the age groups (outside “56+”), has a preference towards the option “Less than once a month”, which was selected between 33.8% and 41.4% of the time. In addition to this, the other “monthly” options average around 20% of the choices for each age group when it comes to “Once a moth”, with the age group “15-18” selecting it 17.5% of the time and being the one that chose this option the least. The group that chose this option the most was “26-31”, 24%. For the option “More than once a moth”, the percentage of participants that selected it averaged around 19.4% for each group, with “15-18” choosing it 13% of the time.
Interestingly enough, this same age group is one of the two that indicated that they purchase model kits “Rarely/on occasion/when I can afford one”. This is one of the few times a selection could be motivated by the occupation, since this age group was composed mainly by students. That said, this option was only chosen 17.5% of the time by the participants between 15 and 18 years old, indicating that the actual occupation may not have such a strong impact.

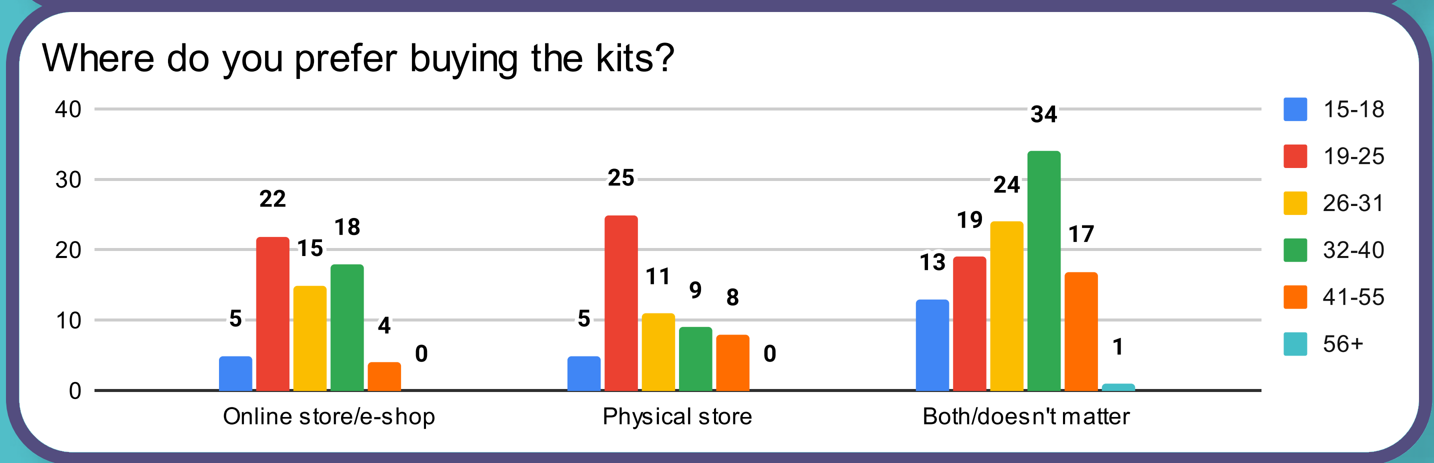
The following question, “How many model kits do you buy at the same time?”, showed another example of general symmetry between age groups. Interestingly enough, all age groups bar one indicated the purchase of “2-4” model kits at the same time. The only group that mainly selected “1” was the “15-18” group. This again could be linked with the difference in occupation, since the remaining groups presented a vast majority of working participants. That said, the age group “32-40” showed a very slight difference between the two options, choosing “1” 40.9% of the time and “2-4” 50.8% of the time. In addition to that, while “2-4” averaged 53.1% of the choices in the various age groups, the option “1” averaged 39.4%. This shows that these two options were the most common, despite any difference between age groups, occupation and origin.
The difference between the amount of participants that choose “1” (74%) and “2-4” (21.7%) in the age group “15-18” may not be necessarily linked to the money available to them. Since this is the age group that counts the youngest participants, it is plausible that they are not as experienced as participants in older age groups. Thus, these model builders may prefer purchase a smaller amount of model kits in order to start their collection and to slowly build up their skills, before starting to work on more advanced projects. Another element to consider is the fact that each model kit IP covers price ranges that may be very large, depending on the products. This may influence the amount of kits purchased at once: sometimes one large and expensive, other times multiple smaller and cheaper ones.


How often do you build model kits?
15-18
19-25
26-31
32-40
41-55
56+
More than once a week
Once a week
More than once a month
Once a month
Less than once a month
Less than once every six month
Once a year
Less than once a year
Occasionally/take a long time to finish building


Do you have a "pile of shame" (a number of
15-18
19-25
26-31
32-40
41-55
56+
Yes
No


How many models do you have in it? (If you want to give a precise number, use the "Other" option)
15-18
19-25
26-31
32-40
41-55
56+
Less than 5
5-10
11-20
21-40
More than 40


Where do you prefer buying the kits?
United States
Europe
Other
Online store/e-shop
Physical store
Both/doesn't matter


Where do you prefer buying the kits?
15-18
19-25
26-31
32-40
41-55
56+
Online store/e-shop
Physical store
Both/doesn't matter

Cross Analysis of the Answers

Participation in the hobby

Subsequently, analysing the question “How often do you build model kits”, it was possible to notice how the results for each age group show that the answers were more or less distributed between the options “More than once a week”, “Once a week”, “More than once a month”, “Once a month”, “Less than once a month”, with the third and fifth one being preferred slightly more.
This information, paired with what emerged from the previous analysis, start to paint a very interesting picture of the model kit community. While some differences are visible, and will become more apparent in following questions, the community seems to be relatively stable, without major contrasts between age groups. This may be linked to the inherently communitary nature of the model building hobby. This is a hobby that has a heavy focus not only on the model kits, but also on talking with other model builders, either to ask for guidance or to compare projects and find new ways to build the model kits or how to paint them. The online communities where the survey was run show this nature often. From new model builders asking how to achieve a certain colour shade, to veterans of the hobby that present their latest project, each post has various comments that provide a sense of community. This is not limited to online forums: as gathered from the previous section of this chapter, one of the reasons why model builders may prefer physical stores is for the human contact and opportunity to chat either with other model builders and the store staff.
This nature of the hobby ends up making so that the community influences itself, creating a “loop”, where new model builders start behaving similarly to people collecting for years. This can be often times seen when it comes to more technical aspects of the hobby, assembling a model kit and painting it, but it seems to also influence other aspects, which may not be obvious. While purchasing preferences may be influenced by various elements (self-control, time available, money available, …), they may also be affected by suggestions from other builders. A very simple example are newer model builders purchasing a small number of kits, upon suggestion from older builders, in order to avoid spending a large amount of money immediately when starting.
Similarly, the time available to actually assemble a model kit varies between model builders, but it also may be linked to suggestions from the community, as well as how much time a model builder wants to dedicate to a single project.

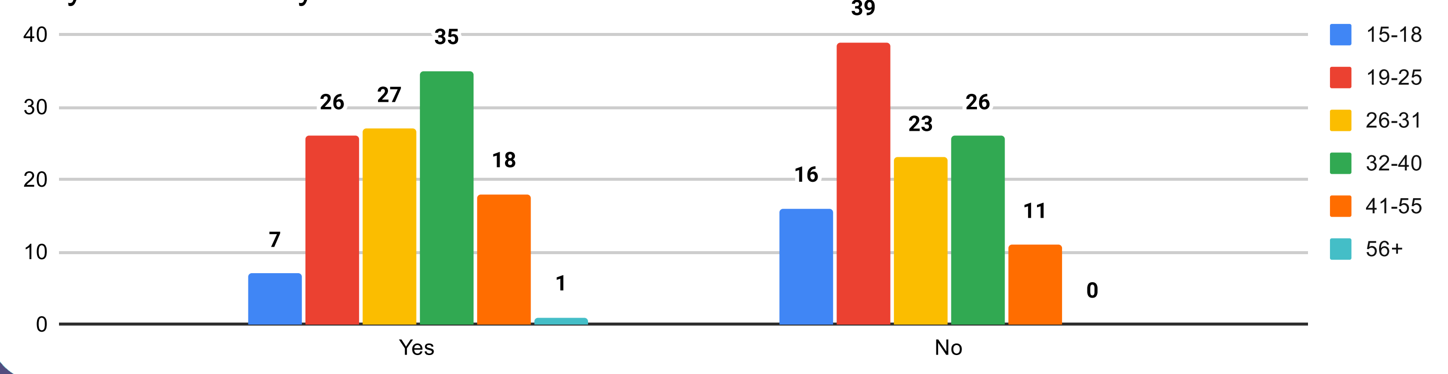
On a final analytical note, it is possible to notice that for this question it seems that personal preference is still more indicative than influences from the community: the age group “15-18” selected the option “Less than once a moth” the most (26.2% of the time), while both the groups “19-25” and “26-31” chose the most the option “More than once a month” (24.6% and 28% of the time respectively). Finally, the group “32-40” showed preference towards the option “More than once a week” (27.9% of the time), while the group “41-55” selected the most “More than once a month” (31.1% of the time), similarly to the groups previously mentioned.

Participation in the hobby

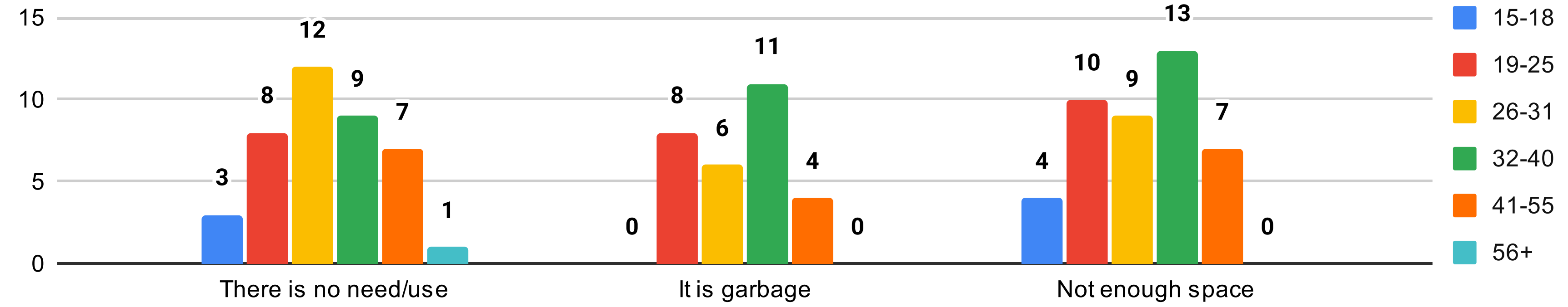
Regarding the backlog, when asked “Do you have a “pile of shame” Do you have a "pile of shame" (a number of model kits bought but yet to build/unopened)?” the majority of almost all age groups answered yes, in line with the results from the question. Outside of the group “15-18”, though, each age group indicated “yes” between 83.1% of the time (group “19-25”) and 90% of the time (group 26-31). The group “15-18” was the only outlier, since the majority chose “no” (56.5%). That said, it was still around half of the participants in that age range. This can be expected, since the participants around that age would not have, on average, the same economic availability of working adults. Building up a backlog would require both a relatively constant purchasing of model kits and a lack of time to assemble each one as soon as purchased. Therefore, work life would limit at least the second factor much more than an average school life.
In addition to these results, the answers for “How many models do you have in it? (If you want to give a precise number, use the "Other" option)”, the follow-up question to the previous one, showed that the majority of the participants between 15 and 18 years of age have a smaller amount of model kits in their backlog than the other age ranges: the option “Less than 5” was chosen 43.7% of the time.
The only other age group that ended up choosing the most the first option was “19-25”, but the total answers from those participants were distributed much more equally on all the options.
The proof about the effects of age and time spent in the hobby can be seen in the results from the other age groups: all “26-31”, “32-40” and “41-55” selected the last option “More than 40” 28.3%, 28.6% and 37.1% of the time, respectively. Another information came from this analysis: all the three age groups with the most participants had their answers relatively distributed around the available answers, while both the “15-28” and “41-55” age groups ended up with a more polarized results on the two extremes. This, again, is an example of how much the participants pools effect the outcomes, but also how many decades spent collecting would affect the participants.

The last element to be cross-analysed from this section of the survey was the preference between types of stores. This cross analysis was initially conducted using the data from the origin question of the survey, but, as it is possible to notice from the graph, the results show that, regardless of the origin, the majority of participants do not have a strong preference between the two store, using them interchangeability. The only slightly interesting data comes from the participants from the United States, who chose “Online store/e-shop” more than “Physical stores”, contrasting with the other two categories. That said, between 42.4% and 50% of the participants of each category still chose the “Both/Doesn’t matter option”.
Compared with these results, the ones from cross analysing age groups with the preferences in type of stores give more details. First of all, similarly to the results from the previous cross analyses, both the “15-18” and “41-55” age groups show more polarized results, with a higher majority of participants choosing “Both/doesn’t matter” (56.5% and 43% of the time respectively). In this case, though, the younger age range has selected the other options equally, while the older range leaned towards online stores. Considering, instead, the three middle ranges, the older ones, even if choosing the most “Both/doesn’t matter”, showed more interest towards physical stores: the group “26-31” selected the options “Physical stores” and “Online stores/e-shops” 30% and 22% of the time, respectively, while the group “32-40” selected the two options 29.5% and 14.7% of the time, respectively.
Interestingly enough, the remaining age group “19-25” showed a more balanced selection of the three options. It was the only age range no selecting “Both/doesn’t matter” the most (29.2%), while also selecting “Physical stores” 33.8% of the time, with “Online stores/e-shop” being chosen 37% of the time.
This analysis showed that, while there is a common indifference towards which type of stores is preferred, the community seems to be almost equally split between physical and online stores.

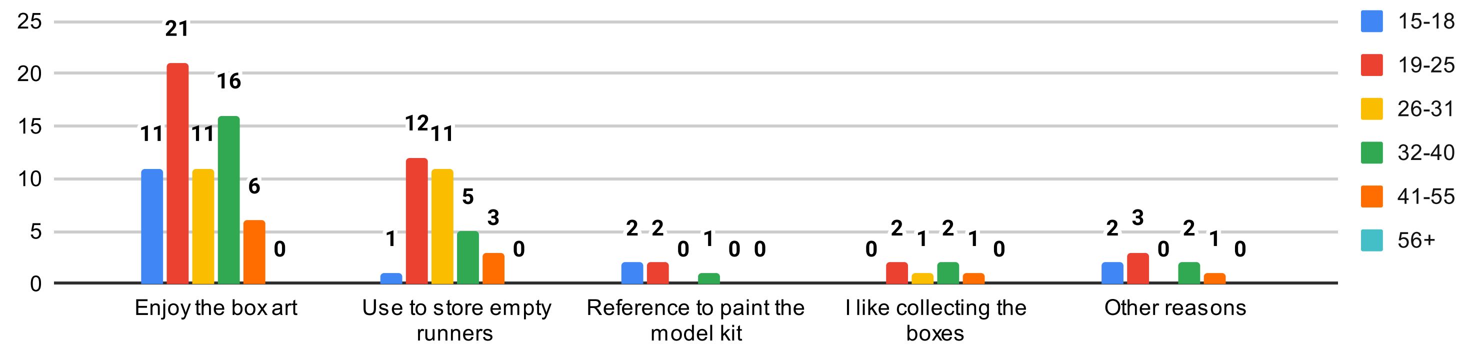
Do you throw away the box the model kit came in?



Do you throw away the box the model kit came in? Why?



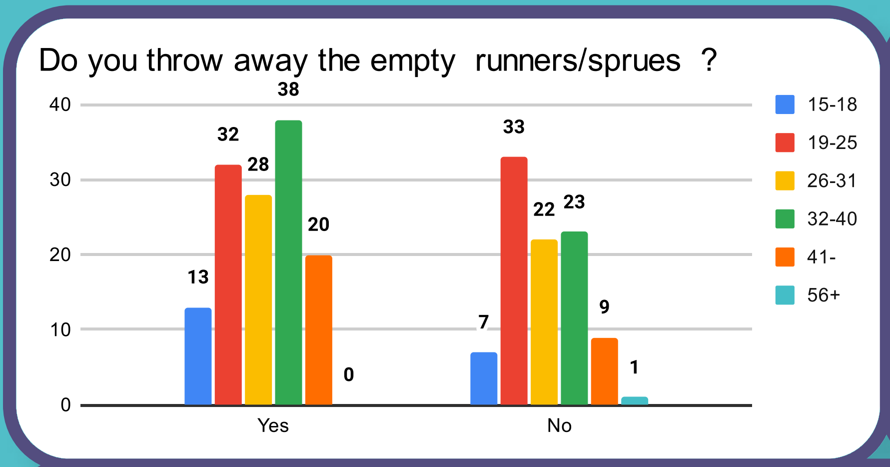
Do you throw away the box the model kit came in? Why not?

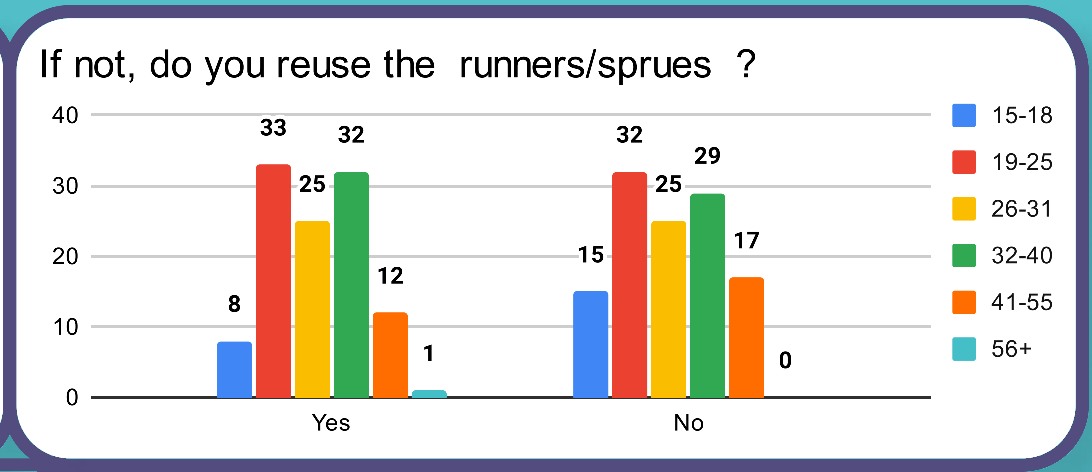


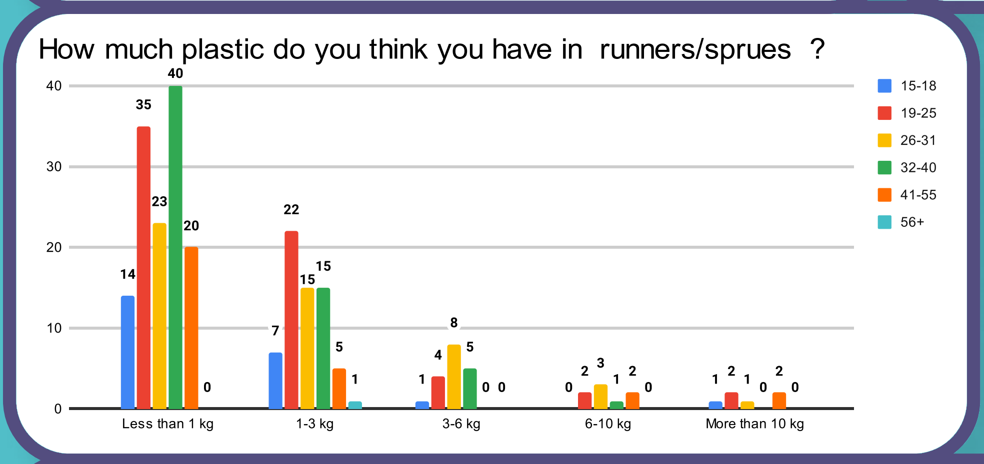
Cross Analysis of the Answers

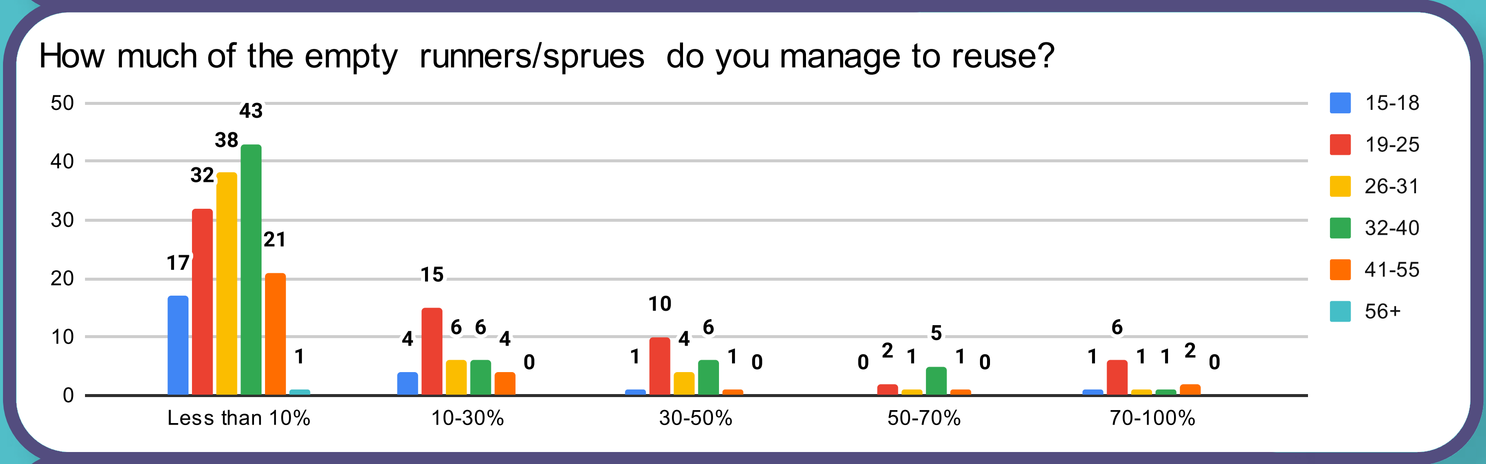
The cross analysis proceeded with the second section of the survey, which covered the waste from model kits. In this case, the focal points of this cross analysis were the behaviour of the participants towards the packaging of the model kits and the runners.

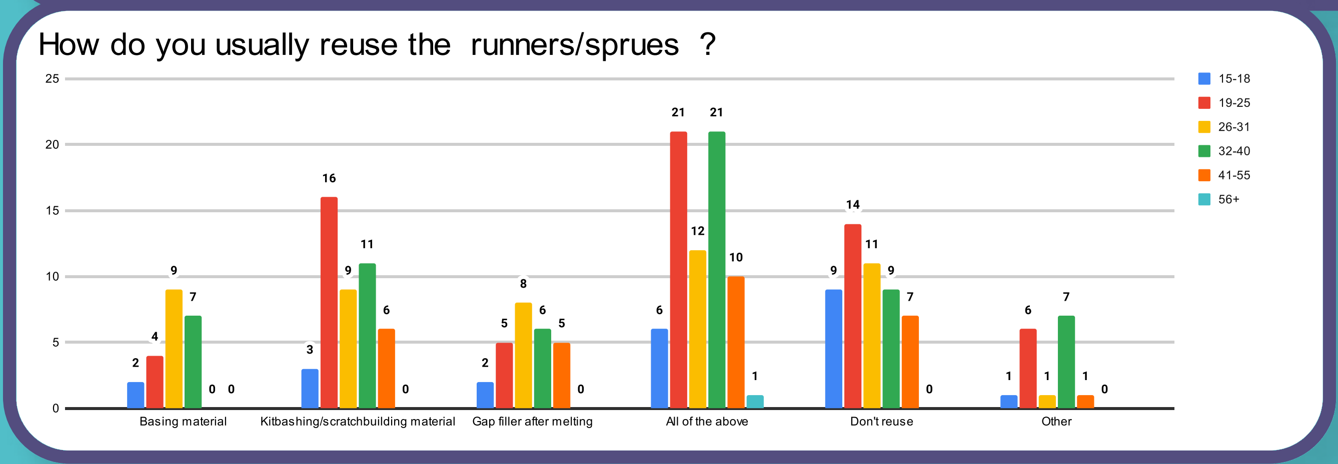
The first question to be analysed asked the participants if they threw away the boxes. The results showed a clear difference between the younger and older age groups: both the groups “15-18” and “19-25” had a majority of “No” (69.6% and 60% respectively), while the remaining groups chose mostly “Yes” (“26-31” registered 54% “Yes”, “32-40” 57.4% and “41-55” 62.1%). These results seem linked again with the time spent on the hobby. Considering some of the reasons as for why boxes may not be thrown away, such as being used as storage, it would be quite likely that participants in the survey that spent years in the hobby would have an amount of boxes used for storage, not requiring any more. In addition to that, a larger collection would equate to less space available for empty or unused boxes.
Before analysing the results from the reasons why participants would or would not throw away the boxes, it is important to notice that the question asking for them was only one, where the participants could give their reason. In order to obtain a clearer result, the answers were split in two graphs, one analysing the reasons why the participants would throw away the boxes and one analysing why not. The percentages that will be used regarding these results are not linked to the total participant for each age group, but to the participants that answered positively or negatively to the previous question. For example, in the age group “26-31”, which counted 50 participants, 54% chose “Yes”. Thus, 27 participants from the group “26-31” were counted for the percentages of the answers, while the remaining 23 made up the total for the percentages of the participants that would not throw away the boxes.
When asked for the reason, the participants that answered “Yes” were relatively equally split on the three most common listed reasons. The only age group that did not covered all three was “15-18”, from which only 7 participants answered “Yes”. These 7 were split 3 to 4 between “There is no need/use” and “Not enough space”. The only other (albeit slight) outlier was the group “26-31”, which selected the option “There is no need/use” 44.5% of the time, a higher percentage than the other age ranges, which selected it between 25.8 and 38.9% of the time.
Analysing, instead, the reasons as for why the boxes are not thrown away, all groups indicated mainly that they “Enjoy the box art” followed by “Use to store empty runners”, as the second most pointed out reason. The percentage of participants from each age group varied, going from 47.9% of “26-31” to 68.8% of “15-18” for the first given reason. That said, the most interesting result come from the differences regarding the second reason: the age range “15-18” pointed it out only once (6.2% of the answers), while the others ranged from 19.2% (group “32-40”) to 47.8% (group “26-31”).
As a final note on these results, it is possible to notice how the smaller pools for the group “15-18” polarized the results towards the first reason, with very few participants pointing out the other ones. The group “41-55” had a similar result, with the main difference being a higher interest in using the boxes as storage.


Do you throw away the empty runners/sprues ?
40
30
20
10
0
13 32 28 38 20 0
7 33 22 23 9 1
Yes
No
15-18
19-25
26-31
32-40
41-
56+


If not, do you reuse the runners/sprues ?
40
30
20
10
0
8 33 25 32 12 1
15 32 25 29 17 0
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


How much plastic do you think you have in runners/sprues ?
40
30
20
10
0
14 35 23 40 20 0
7 22 15 15 5 1
1 4 8 5 0 0
0 2 3 1 2 0
1 2 1 0 2 0
Less than 1 kg
1-3 kg
3-6 kg
6-10 kg
More than 10 kg
15-18
19-25
26-31
32-40
41-55
56+


How much of the empty runners/sprues do you manage to reuse?
50
40
30
20
10
0
17 32 38 43 21 1
4 15 6 6 4 0
1 10 4 6 1 0
0 2 1 5 1 0
1 6 1 1 2 0
Less than 10%
10-30%
30-50%
50-70%
70-100%
15-18
19-25
26-31
32-40
41-55
56+


How do you usually reuse the runners/sprues ?
25
20
15
10
5
0
2 4 9 7 0 0
3 16 9 11 6 0
2 5 8 6 5 0
6 21 12 21 10 1
9 14 11 9 7 0
1 6 1 7 1 0
Basing material
Kitbashing/scratchbuilding material
Gap filler after melting
All of the above
Don't reuse
Other
15-18
19-25
26-31
32-40
41-55
56+

Cross Analysis of the Answers

Following the matter of the boxes, the questions about the behaviour of the participants towards the empty runners were cross analysed.
The first question asked whether the participants threw away the empty runners. As seen in the results of the question, there is a slight preference towards throwing the runners away. This result, though, is not common in all the age groups: the group "19-25" had a slight preference (50.8%) towards not throwing the runners away. In addition to that, while the other groups do still prefer throwing them away, the difference between "Yes" and "No" is smaller in the groups "15-18" (56.5% "Yes", 43.5% "No") and "26-31" (56% "Yes", 44% "No"), than in the older groups ("32-40": 62.3% "Yes", 37.7% "No"; "41-55": 69% "Yes", 31% "No"). This difference may be caused by the experience in reusing runners between age groups, as well as the amount of material that the runners are: after a long time participating in the hobby, the amount of plastic in empty runners may be so much that keeping newer ones would just be a waste of space.

As a follow-up to that question, the next one to be cross analysed was the one asking the participants if they reused the empty runners. The results confirmed the reason behind the difference noticed in the previous analysis: outside of the two smaller groups, all of the age groups indicated that reusing the runners was relatively common, enough to amount to around half of the answers. Interestingly, the results from the age group "15-18" showed a difference between "Yes" and "No" of around 30% (34.8% selected "Yes", 65.2 "No"), while for the age group "41-55" the difference was much smaller: 41.4% of the participants in that group answered "Yes", while 58.6% "No". This difference is much more in line with the one from the remaining age groups, indicating that, maybe with a larger pool of participants aged between 41 and 55 years old, the results may change.

In the survey, the subsequent question to the one just analysed asked the participants the amount of plastic that they have in empty runners. Considering the previous questions and the results from the answers on this one, as seen in the previous section of this chapter, it was already known that the majority of participants, independently of the age group, would indicate that they have a relatively low amount of plastic in the form of runners. While the results from this cross analysis confirmed this, it is interesting to notice the distribution difference of the answers between age groups.
While all the groups had the first option, "Less than 1 kg", as the most selected one, the percentage for each group varies between 46% ("26-31") and 69% (41-55). In addition to that, both the age groups "19-25" and "26-31" were the only ones to present at least one selection for each option available. While this does not seem particularly important, it is interesting when noticing a peculiar trend: the percentage of material in empty runners grows with the age, at least until "26-31", after which it decreases gradually. As proof, the age group with the highest percentage of participants selecting "Less than 1 kg" is "41-55" (69%).

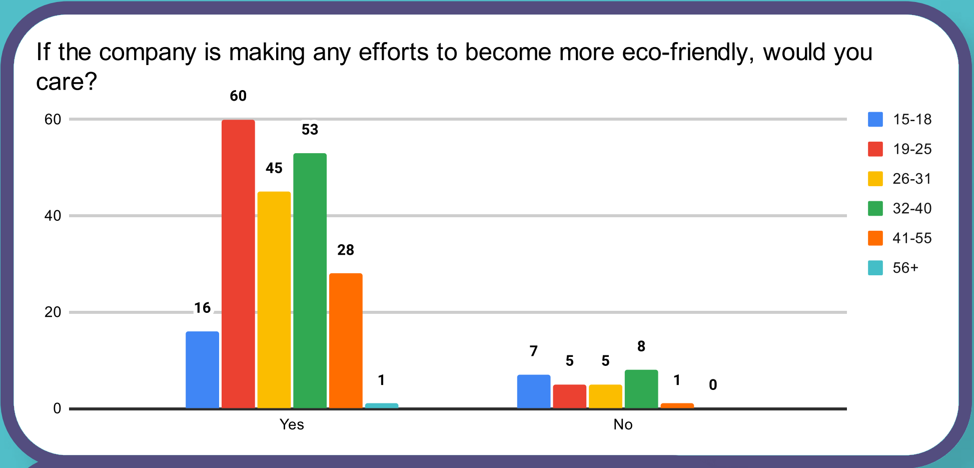
Waste from the model kit

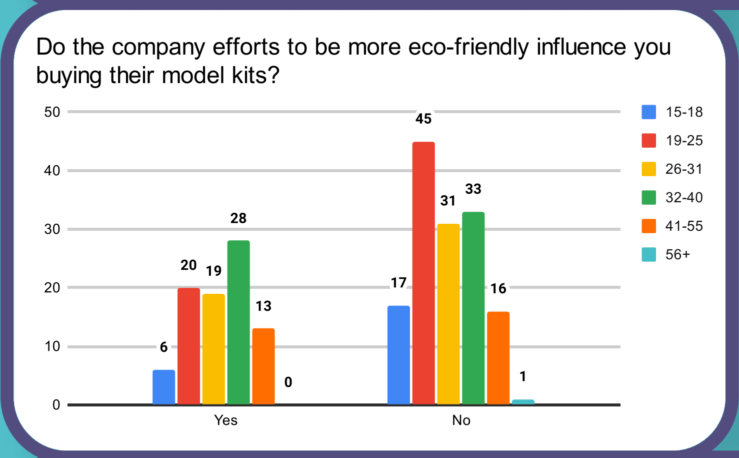
This progression does seem to slightly contrast with the results from the previous cross analysis, but it could also be proof of the actual amount of material reused by each age group, as well as the amount of empty runners that older hobbyists are willing to keep, which could be affected by factors like space available, similarly to them choosing whether or not keeping boxes.

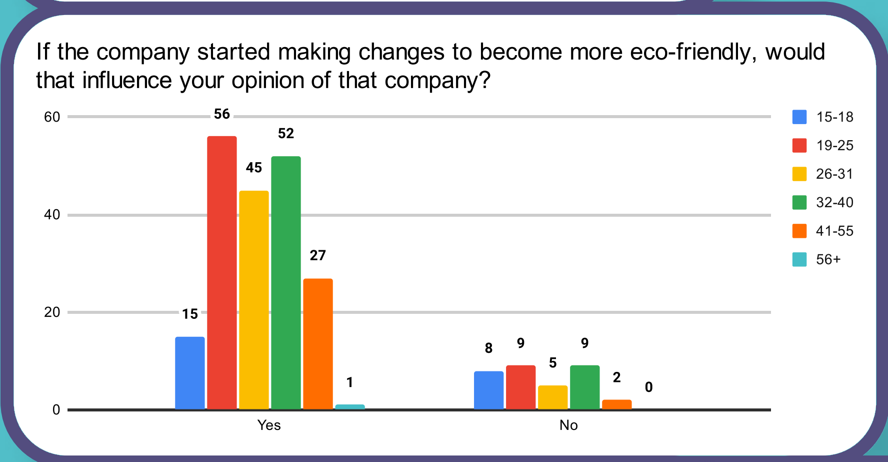
The next question to be cross analysed was asking the participants how much plastic they manage to reuse. The results from the question originally portrayed the vast majority of the community answering "Less than 10%", which was still confirmed by this analysis. There were a few key differences, again highlighted by the age groups. While most of the age groups indicated that option between 70.6% of the time ("32-40") and 84% of the time ("26-31"), the only group that showed a more balanced distribution between the various options was "19-25". While these participants still chose "Less than 10%" the most (49.2% of the time), the remaining distribution contrasted heavily with the other age groups. While the second option, "10-30%", was still the second most selected for all groups, only "19-25" chose it more than 20% of the time, followed by "15-18", which chose it 17.4% of the time. In addition to that, the distribution of the remaining participants in this age group was lower than the other groups only for the fourth option, "50-70%", for which only the "32-40" age group chose it more. That said, these results do follow the ones from the question about throwing away the runners: the group "19-25" was the only one that was almost equally split between the two options (32 participants selected "Yes", 33 "No"), while the other groups showed larger differences. In addition to that, this scenario repeated itself with the following question, about reusing the runners, and the distribution about the amount of plastic in runners showed again this age group as one of the most well distributed, covering all options.

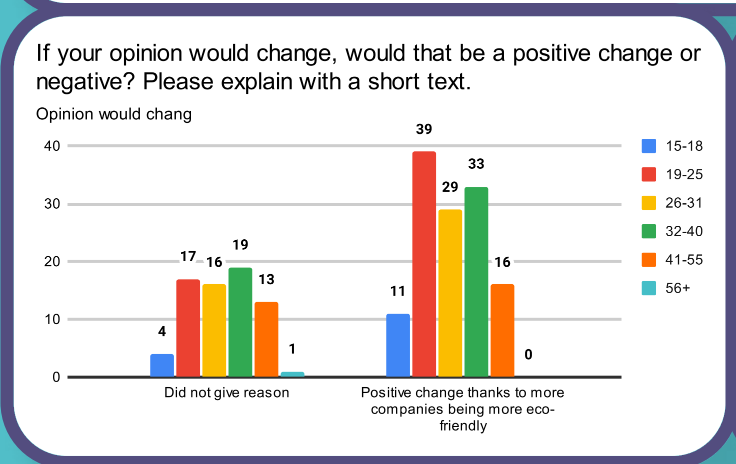
The last element to be cross analysed about the topic of waste from the model kits is how the participants reuse the runners. The results for this question were very interesting, showing that the majority of the community reuses the runners in all of the mentioned methods, since the most selected option was "All of the above". During the cross analysis, this was confirmed, since all the age groups had that as the most selected option, except for the group "15-18", which selected more "Don't reuse" (39.2%). That said, the "All of the above" option was still the second most chosen (26.1%). Comparing the results of the cross analysis with the ones from the original question, it is possible to notice some interesting details. First of all, the age group with a more balanced distribution of answers was "26-31", where the "All of the above" option was selected 24% of the time, making it the smallest percentage between the age groups. In addition to that, the other options, outside of "Other", all were selected between 16% of the time ("Gap filler after melting") and 22% of the time ("Don't reuse"). Another example of interesting distribution of the answers was the age group "32-40", which distributed the answers outside "All of the above" (34.5%) between all the remaining options, the percentages of which ranged between 9.8% and 18%.
A final comparison can be made between the age groups "15-18" and "41-55". The first group showed a more extreme distribution of the answers, since outside of the two mentioned previously, the remaining options were selected between 4.3% and 13% of the time. The second group, instead, was the only one that never selected the option "Basing material", distributing instead the answers between the remaining options and thus selecting most of them between 17.2% of the time ("Gap filler after melting") and 34.6% ("All of the above"). Interestingly, both groups gave an open answer (classified as "Other") only once.

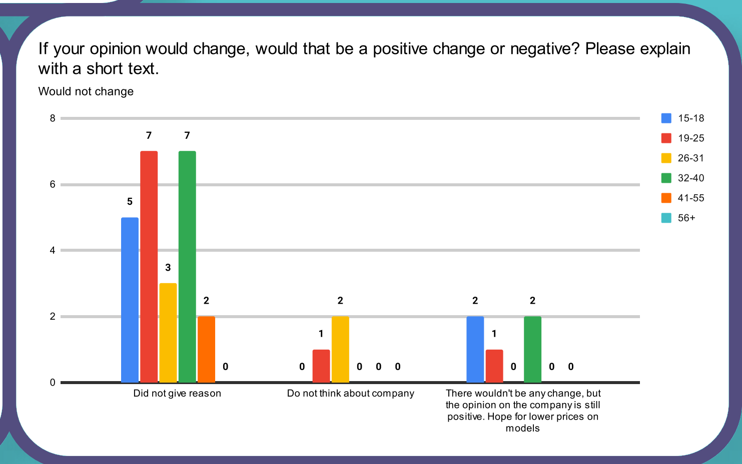
As a final note, the cross analysis of the behaviour towards waste from the model kits seems to follow a similar conclusion to the one derived from the participation in the hobby, but with differences that seem based more on the time spent on the hobby and the experiences that come from it.


If the company is making any efforts to become more eco-friendly, would you care?
15-18
19-25
26-31
32-40
41-55
56+
Yes
No
16
60
45
53
28
1
7
5
5
8
1
0


Do the company efforts to be more eco-friendly influence you buying their model kits?
15-18
19-25
26-31
32-40
41-55
56+
Yes
No
6
20
19
28
13
0
17
45
31
33
16
1


If the company started making changes to become more eco-friendly, would that influence your opinion of that company?
15-18
19-25
26-31
32-40
41-55
56+
Yes
No
15
56
45
52
27
1
8
9
5
9
2
0


If your opinion would change, would that be a positive change or negative? Please explain with a short text.
Opinion would chang
15-18
19-25
26-31
32-40
41-55
56+
Did not give reason
Positive change thanks to more companies being more eco-friendly
4
17
16
19
13
1
11
39
29
33
16
0


If your opinion would change, would that be a positive change or negative? Please explain with a short text.
Would not change
15-18
19-25
26-31
32-40
41-55
56+
Did not give reason
Do not think about company
There wouldn't be any change, but the opinion on the company is still positive. Hope for lower prices on models

Cross Analysis of the Answers

Perception of the companies

The next section of the survey to be cross analysed was the third one, focusing on the perception of the companies by the community. For this section of the survey, which was composed of only few questions, all of them were cross analysed.

The first question asked the participants if they would care if model kit companies were to start making more efforts to become more eco-friendly. As noticed in the results of the question, all the age groups answered positively. However, the "15-18" age groups, while still answering mostly positively, did show less care towards these efforts, since 30.4% of the participants in that group answered "No".

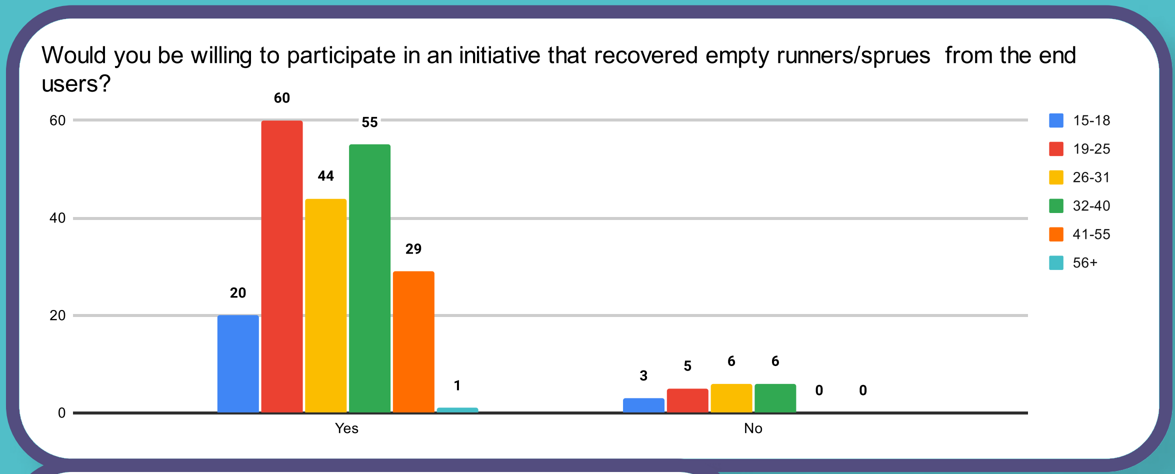
Subsequently, the participants were asked if the aforementioned efforts would influence them into purchasing products from companies making them. Again, the results from the question were reflected in the cross analysis, with the majority of the participants for each age group answering negatively. Interestingly, though, the percentage of participants that answered positively increased with the ageing: the "15-18" group answered "Yes" 26% of the time, the group "19-25" 30.8% of the time, the group "26-31" 38%, the group "32-40" 46% and, finally, the group "41-55" answered "Yes" 44.8% of the time, a slight decrease from the previous one. In the case of the last age group, it could be possible that with a larger pool the result may change: the difference between participants that answered "Yes" and the ones that answered "No" was only 3. A larger pool could balance this difference out. These result show that companies choosing eco-friendly solutions may be generally seen not only as positive by the majority of the community, but could influence the purchasing preferences of older hobbyists, much more than the preferences of newer ones.

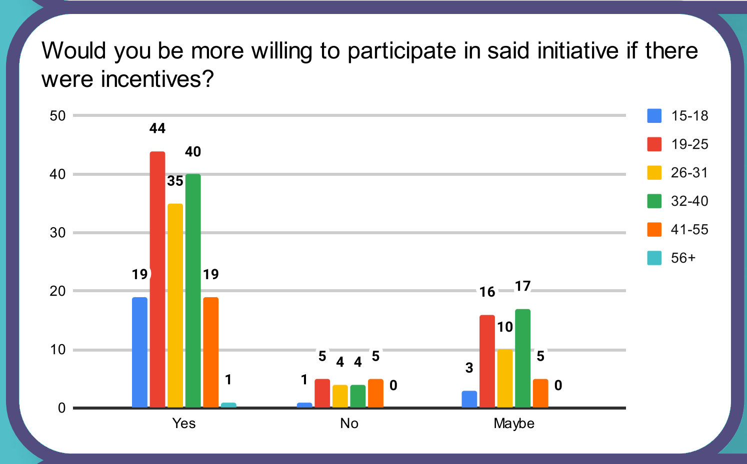
The questions following the ones just cross analysed focused on understanding if the opinion of the community towards the companies would change, and how. The first step was to investigate how many participants for each age group would have their opinion on companies influenced by eco-friendly efforts. The results showed that, while all age groups would have a vast majority of participants being influenced (up to 93.1% for the group "41-55"), the youngest one, "15-18" would still have more participants sceptical, since 34.8% of them would not be influenced. This is quite in line with the result of the analysis of the first question, and it shows that younger generations seem less willing to trust companies in changes in productions and eco-friendly promises.
Following this first analysis of the influence on opinions, the next step was to compare how each age group answered. In order to organize the results more clearly and avoid confusion, the results from the original answer were divided in two main categories: one containing how the opinion of the participant would be changed, and the other containing the reason why it would not be changed. This step was necessary, since not only the community did not express a negative change in opinion, but also because this question needed the participants to write their reason.

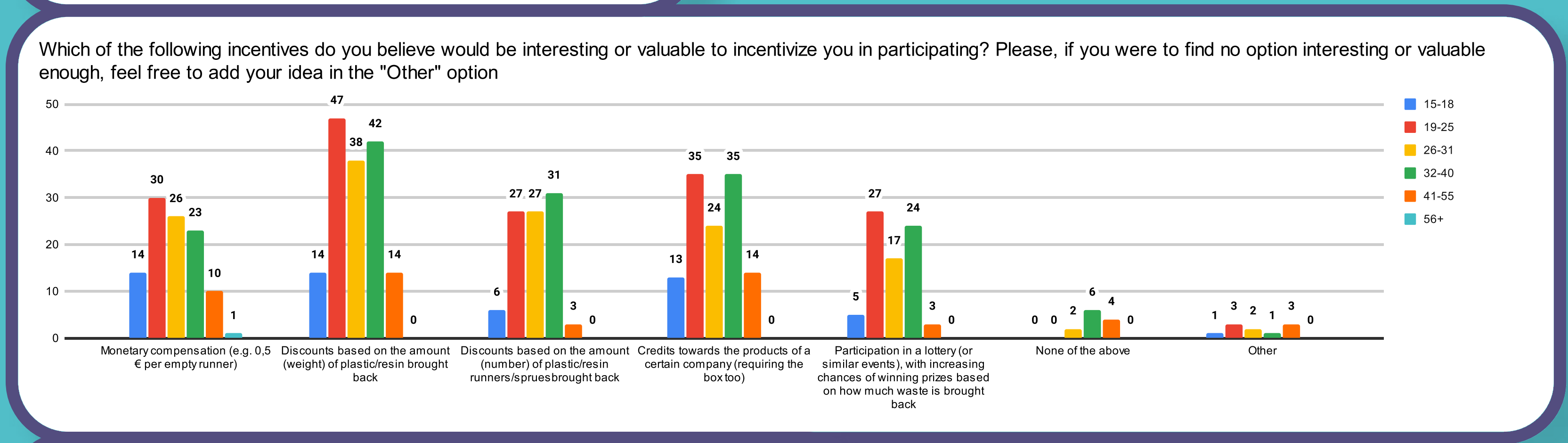
Perception of the companies

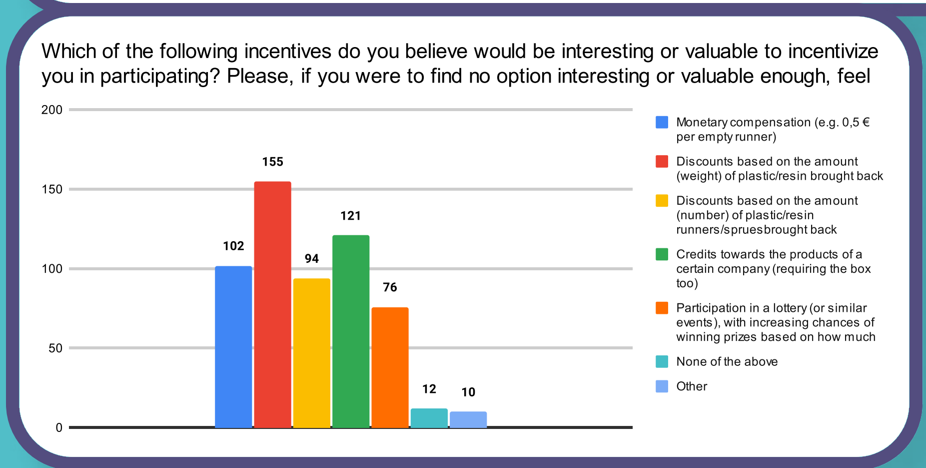
In addition to that, various participants did not give an exact reason, and only answered "Positive" or other similarly vague answers. In order to better divide the results, the number of participants for each age group was divided using their answer to the previous question. This way it was possible to distinguish between participants whose opinion would change and ones whose opinion would not, regardless of the level of detail, or lack thereof, present in the written answer.

Starting from the reasons why their opinion would change, the majority of participants in the survey gave a reason why, but it was still relatively generic. All of them wrote that their opinion would become more positive of the company, since the model kit companies would become more eco-friendly. This reason, while welcoming said changes, seem to be very non-committal, which could have been caused by a lack of examples of possible changes in the previous questions.
Regarding the participants that answered positively to the previous question, but did not give a reason, they amounted between 26.6% and 36.5% for the age groups from "15-18" to "32-40", with the participants from the "41-55" group did not give a reason 48.1% of the time.
When analysing the reasons why the opinion of the participants would not change, the results were much less useful than the previous ones. In this case, the vast majority of the participants who answered negatively on whether their opinion of model kit companies would be influenced by eco-friendly efforts did not give a reason. This result hinders this cross analysis, even if part of the community did give some reasons, particularly stating that, while the opinion would not change, it would still be positive. This, at least, shows that, in line with previous results, the model kit companies are seen in a general positive light even prior any eco-friendly efforts. A few participants, 1 from the group "19-25" and 2 from "26-31" stated that they do not think about the company.


Would you be willing to participate in an initiative that recovered empty runners/sprues from the end users?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


Would you be more willing to participate in said initiative if there were incentives?
Yes
No
Maybe
15-18
19-25
26-31
32-40
41-55
56+


Which of the following incentives do you believe would be interesting or valuable to incentivize you in participating? Please, if you were to find no option interesting or valuable enough, feel free to add your idea in the "Other" option
Monetary compensation (e.g. 0,5 € per empty runner)
Discounts based on the amount (weight) of plastic/resin brought back
Discounts based on the amount (number) of plastic/resin runners/spruesbrought back
Credits towards the products of a certain company (requiring the box too)
Participation in a lottery (or similar events), with increasing chances of winning prizes based on how much waste is brought back
None of the above
Other
15-18
19-25
26-31
32-40
41-55
56+


Which of the following incentives do you believe would be interesting or valuable to incentivize you in participating? Please, if you were to find no option interesting or valuable enough, feel
Monetary compensation (e.g. 0,5 € per empty runner)
Discounts based on the amount (weight) of plastic/resin brought back
Discounts based on the amount (number) of plastic/resin runners/spruesbrought back
Credits towards the products of a certain company (requiring the box too)
Participation in a lottery (or similar events), with increasing chances of winning prizes based on how much
None of the above
Other

Cross Analysis of the Answers

Recovering waste from the users

The next section of the survey to be cross analysed covered the first of the three solutions presented in the survey, a user waste recovery initiative. The questions that were analysed focused on the interest towards a similar initiative, the influence of incentives, the effects that this initiative could have on some aspects of the hobby and how would the community participate.

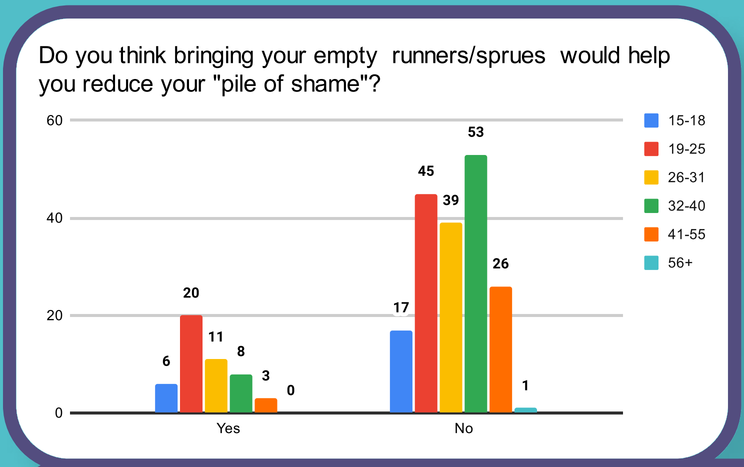
The first question asked the community if they were interested in participating in said initiative. The answers from the question were mainly positive, but the distribution of those answers in the various age ranges showed a very interesting picture. While all the groups responded overwhelmingly positively, only the “41-55” one showed a complete interest in participating, selecting the “Yes” option 100% of the time. The closest group to that result was the “19-25” one, which selected “Yes” 92.3% of the time.

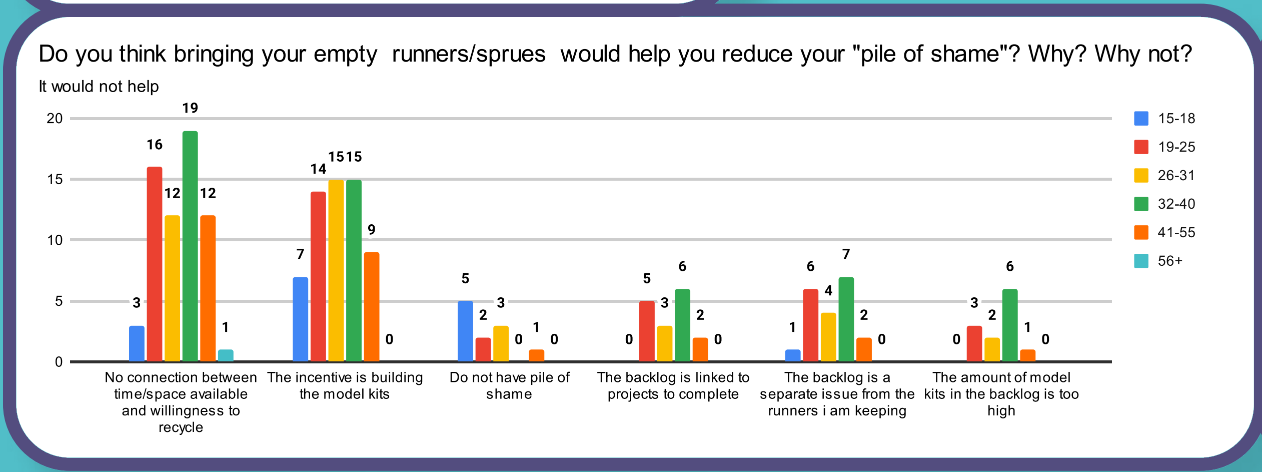
When confronting these results with the ones from the cross analysis of the following question, which asked the participants if the presence of incentives would convince them to participate, three age groups saw a reduction of participants who selected “No”: the “15-18” group, the “26-31” one and the “32-40” one. On the other hand, the “41-55” group saw 5 participants answering “No”. This is not necessarily a negative result, but it could actually be positive, since it could mean that these participants would not need any incentives to participate in a similar initiative. Interestingly, the only age group that saw a growth on the “No” selection was the “19-25” one, where the “No” went from 5 to 6.
In addition to that, in all cases except one, the participants that selected “Maybe” were more than the ones that selected “No”. The only exception was the group “41-55”, where the amount of selection of “No” and “Maybe” was the same: 5 participants, equating to 17.2% of the ones in this age group.

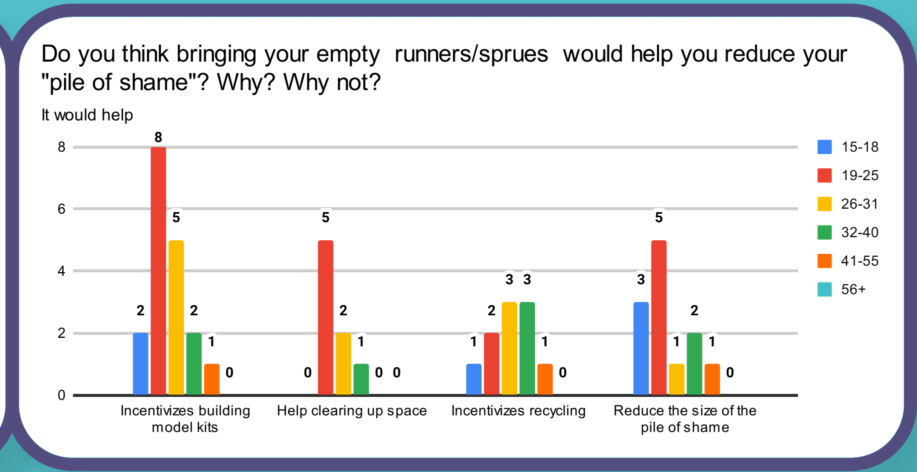
Following this question, the participants were asked to select which incentives would be more effective in spurring them in participating in the initiative.
This question allowed the participants to select multiple option for their answers, therefore it needed a different approach in cross analysing it. The first step was to avoid using the total number of participants in the age groups, since it would not reflect the actual amount of selections chosen by each of the participants. Instead, the data used to analyse them was comparing the amount of times each option was chosen in each age group. This way it was possible to notice both which were the most appealing options for each group, while also analysing the influence that each age group had on the final results of this question. This method will be utilised for all the other cases of multiple selection questions. In order to allow a more clear picture of the results, under the graph detailing the choices of each age group another graph is present, showing the total selections for each option.

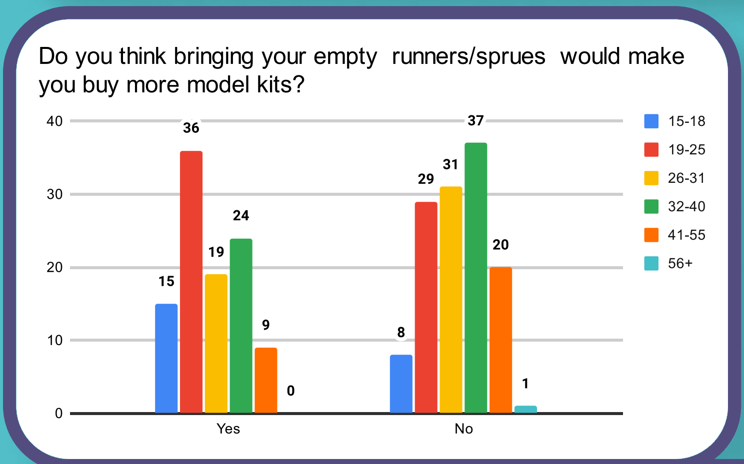
Recovering waste from the users

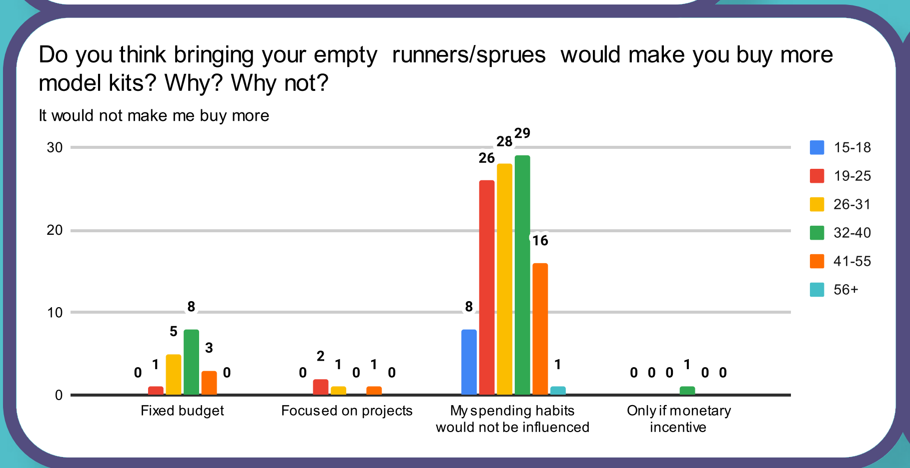
Starting from the age group “15-18”, the options chosen the most by the participants in this age range were “Monetary compensation (e.g. 0,5 € per empty runner)” (14 times, equating to 13.7% of its total selections), “Discounts based on the amount (weight) of plastic/resin brought back” (14 times, equating to 9% of its total selections of this option) and “Credits towards the products of a certain company (requiring the box too)” (13 times, 10.8% of its total selections of this option).
The second age group, “19-25”, together with the next two, thanks to its larger pool of participants, covered a large amount of the total selections for all of the options, except for “None of the above”. The participants in this age range showed interest towards the first five options, ranging in each of them between 27 and 47 selections. In particular, the first option was selected 30 times (27.6% of its total selections), the second 47 times (30.4% of its selections) and the fourth 35 times (28.9% of its total selections). In addition to that, in all three this age group covered the highest percentage of selections, being equalled only for the fourth option by the age group “32-40”. The age group “19-25” covered the highest percentage of selections also for the fifth option, where having selected it 27 times equated to 35.5% of its total selections.
Similarly to the previous age group, the one ranging from 26 to 31 years old showed interest towards the first five options, though in this case the participants focused more towards the first three. That said, this is one of the three age groups that pointed out that none of the available options were particularly interesting, doing so 2 times.
The age group “32-40” followed a similar trend to the previous two, with more focus towards the second, third and fourth option. In this case, this age group covered the highest percentage of the selections of the third option, 31, which equated to 33% of its total selections. In addition to that, this age group also covered the highest percentage of the “None of the above” option, with 6 selections, equal to 50% of its total selections.
The group “41-55” was in a similar position as the “15-18” one, considering that both had small participant pools. That said, it had lower impact on the total selections for the first five options, even though its participants focused on the first, second and fifth one. This age group covered a sizeable percentage of the “None of the above” option, 33.3%, and, together with the “19-25” group, covered 60% (30% of the total selections each) of the seventh “option”, which was the open space where participants could suggest an incentive.

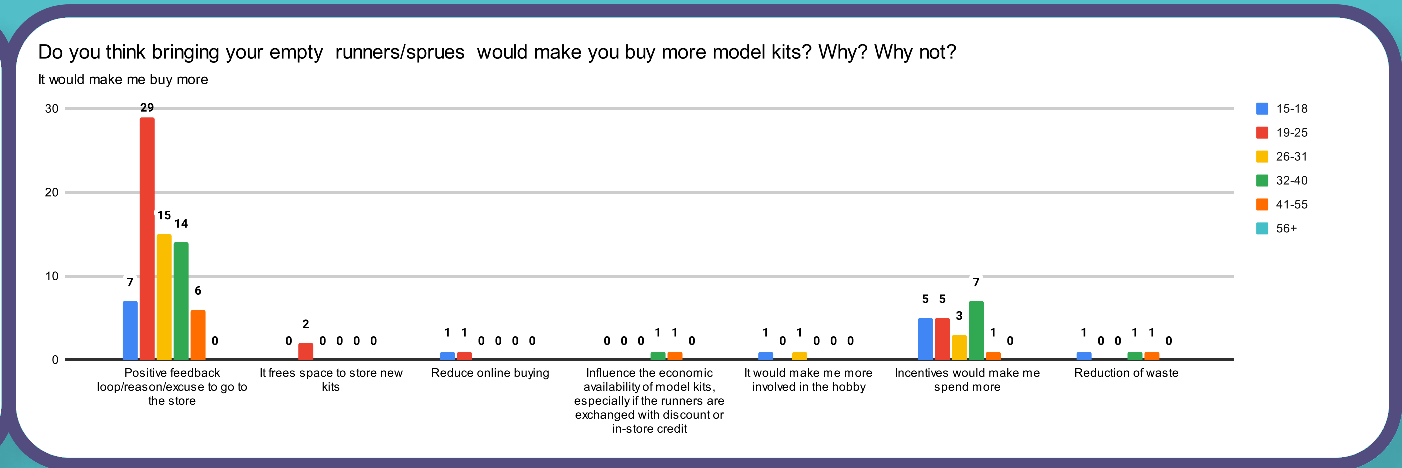

Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"? Why? Why not?
It would not help
No connection between time/space available and willingness to recycle
The incentive is building the model kits
Do not have pile of shame
The backlog is linked to projects to complete
The backlog is a separate issue from the runners i am keeping
The amount of model kits in the backlog is too high
15-18
19-25
26-31
32-40
41-55
56+


Do you think bringing your empty runners/sprues would help you reduce your "pile of shame"? Why? Why not?
It would help
Incentivizes building model kits
Help clearing up space
Incentivizes recycling
Reduce the size of the pile of shame
15-18
19-25
26-31
32-40
41-55
56+


Do you think bringing your empty runners/sprues would make you buy more model kits?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


Do you think bringing your empty runners/sprues would make you buy more model kits? Why? Why not?
It would not make me buy more
Fixed budget
Focused on projects
My spending habits would not be influenced
Only if monetary incentive
15-18
19-25
26-31
32-40
41-55
56+


Do you think bringing your empty runners/sprues would make you buy more model kits? Why? Why not?
It would make me buy more
Positive feedback loop/reason/excuse to go to the store
It frees space to store new kits
Reduce online buying
Influence the economic availability of model kits, especially if the runners are exchanged with discount or in-store credit
It would make me more involved in the hobby
Incentives would make me spend more
Reduction of waste
15-18
19-25
26-31
32-40
41-55
56+

Cross Analysis of the Answers

Recovering waste from the users

Following those questions, the participants were asked about how the participation in a user waste recovery initiative would influence some aspects of the hobby: the backlog and the purchasing habits.

Regarding the backlog, the original question showed, with its results, that the vast majority of the community did not believe that participating would help reducing it. This was reflected in the cross analysis, in particular when comparing the positive and negative answers of the older age groups. While the groups between "15-18" and "26-31" averaged positive answers around 26.3% of the time and negative ones around 73.7% of the time, the "32-40" and "41-55" age groups had a larger difference: the average amount of positive answers was 11.7%, while the average of negative ones amounted to 88.3%.

Analysing the reasons why the participants answered positively or negatively, these were divided between the two, using the previous results. This way it was possible to better identify the most common reasons both in the community and in each age group. The percentages that will be used will refer to those amounts.

Regarding the positive answers, the majority of the participants in the first age group tended to point out that it would incentivize building model kits (33.3% of the participants stated so) or that it would generally reduce the size of the "pile of shame" (50% of the positive answers for this group).
The group "19-25" showed similar reasons as the previous one, with the participants that gave the first reason amounting to 40% and the ones talking about the reduction of the backlog reaching 25%.
The third age group still focused on the first reason (45.4%), but, instead of the reduction of the backlog, stated that the initiative would "Incentivize recycling" (27.3%).
The group "32-40" stated the same.
Finally, the age group "41-55", which registered only three participants positive towards the effects of the initiative, was equally divided between the first, third and fourth reason, as seen on the graph on the previous page.

Regarding the negative answers, the first age group focused more on the fact that the incentive to reduce the backlog was to build more model kits (47.1%) or that they do not have a backlog (29.4%).
All of the other age groups, instead, stated mainly that there is no connection between time and/or space available to build more model kits and their willingness to recycle (average around 36.4%) or that their incentive should be to build more kits, not recycling (average around 33.1%), similarly to the "15-18" age group.

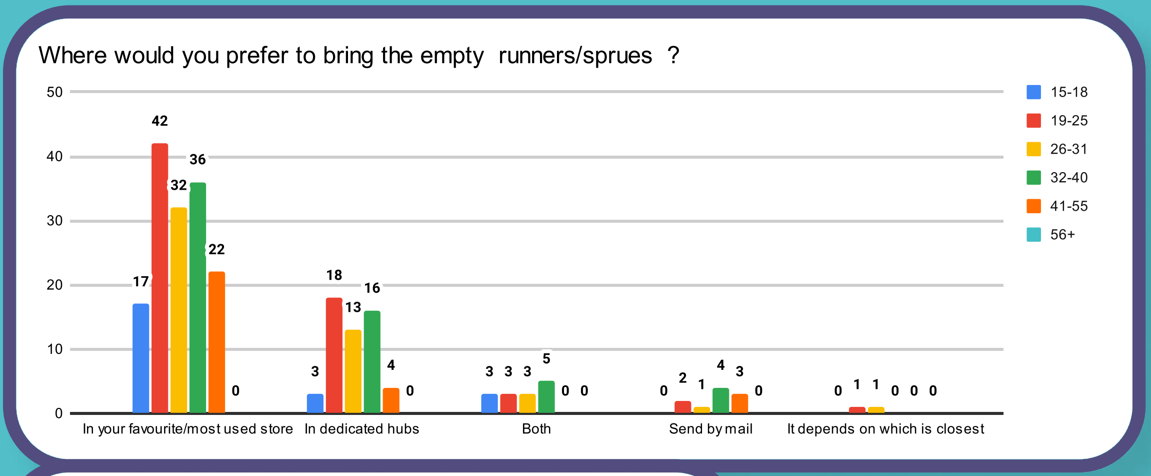
Recovering waste from the users

Following these results, the participants were asked if taking part in this initiative were asked if and how it would influence their purchases.
The results were very interesting. While the ones from the original question showed the negative answers slightly more than the positive ones, when divided in the various age groups, some groups showed the opposite. Both the "15-18" and "19-25" groups indicated that their participation in the initiative would make them purchase more model kits (65.2% and 55.4% respectively). Contrasting that, the remaining three groups were more in line with the results of the original question, averaging 63.9% of participants choosing the negative option.

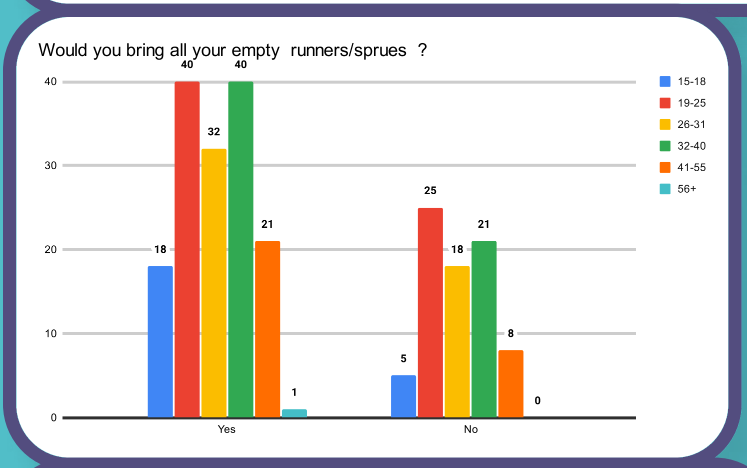
Similarly to the previous analysis, the reasons as for why or why not the purchasing habits would be influenced were divided between the positive and negative answers.

Regarding the reasons for the positive answers, the majority of participants in each age group stated that they would be inclined to purchase more thanks to the positive feedback loop coming from participating in this initiative, which would also make them feel less guilty about purchasing more model kits. In addition to that, bringing the empty runners to a hotspot, especially if located near a hobby store, would give them an excuse to enter and browse the products, which would likely bring them to purchase something. This reason was given on average 66.5% of the time, with the age groups "19-25" and "25-31" pointing it out 77.7% and 78.9% of the time, respectively.
Another reason given often was that the incentives would make the participants spend more. This reason was pointed out mainly by the age groups "15-18" and "32-40", 33.3% and 29.2% of the time, respectively.

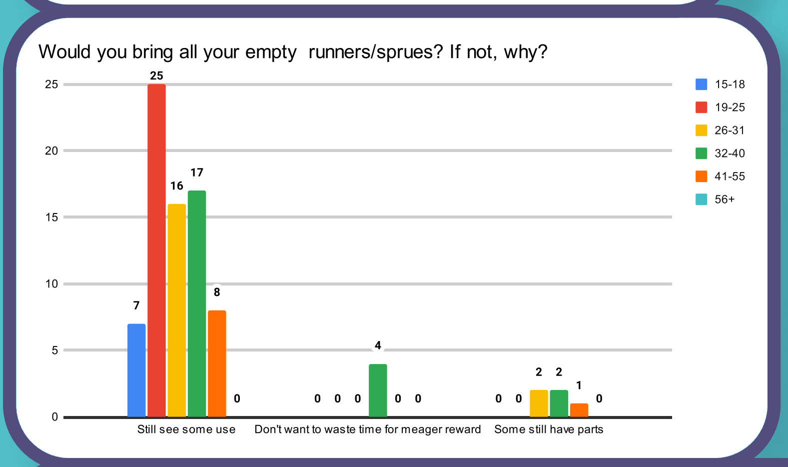
Regarding, instead, the reasons behind the negative answers, the most pointed out by all age groups was that their spending habits would not be influenced. This reason was stated on average 85.2% of the time. The group "15-18" stated it 100% of the time, while the group "32-40" also stated that they have a fixed budget to spend on the hobby the most (21.6% of the time).



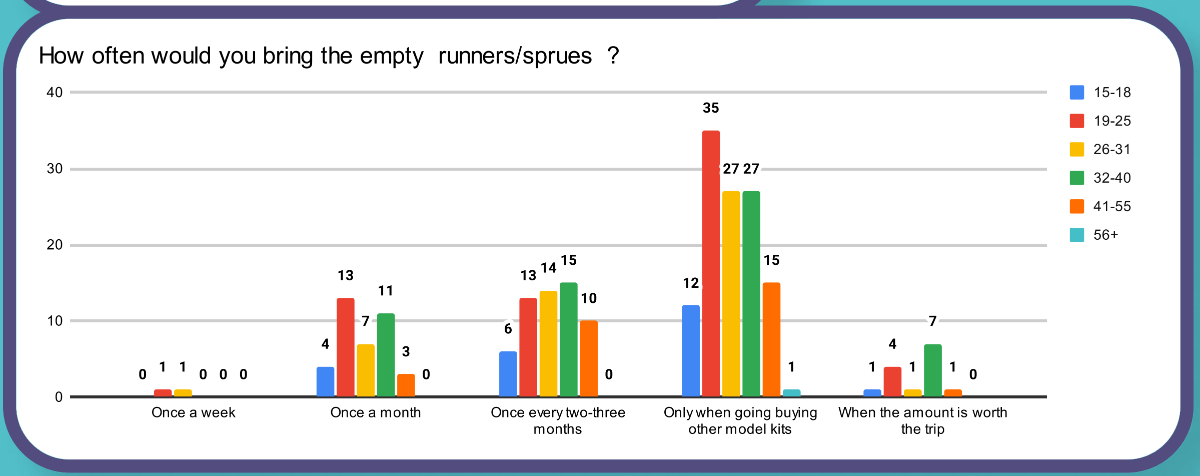
Where would you prefer to bring the empty runners/sprues ?
15-18
19-25
26-31
32-40
41-55
56+
In your favourite/most used store
In dedicated hubs
Both
Send by mail
It depends on which is closest



Would you bring all your empty runners/sprues ?
15-18
19-25
26-31
32-40
41-55
56+
Yes
No



Would you bring all your empty runners/sprues? If not, why?
15-18
19-25
26-31
32-40
41-55
56+
Still see some use
Don't want to waste time for meager reward
Some still have parts



How often would you bring the empty runners/sprues ?
15-18
19-25
26-31
32-40
41-55
56+
Once a week
Once a month
Once every two-three months
Only when going buying other model kits
When the amount is worth the trip

Cross Analysis of the Answers

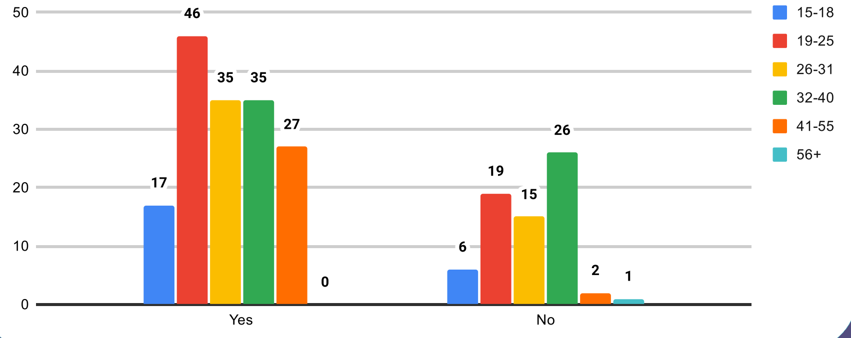
The last element from this section to be cross analysed was the participation in the initiative. The key points were the location where the model builders prefer bringing the runners, how much and how often.

Similarly to the results from the original question, the majority of participants from each age group preferred bringing the runners to hobby stores, rather than in dedicated hubs. In the cases of the largest three age groups, the options of dedicated hubs was chosen around 26.6% of the time.
Another element that emerged from the original answer was the possibility to send the runners by mail. The age groups that pointed out this possibility were “19-25”, “26-31”, “32-40” and “41-55”.

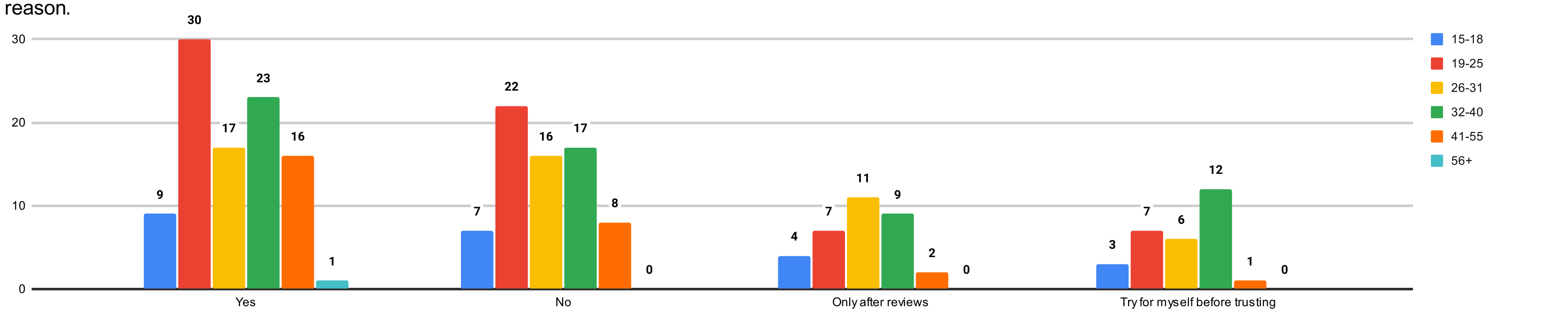
Following this analysis, the question asking whether the participants would bring all the runners showed interesting results. As seen in the original question, the majority of participants would do so, but the three largest groups do not show the same difference. When confronting the answers, it is possible to notice that both the “15-18” and “41-55” groups were more inclined towards bringing all the empty runners (average of 75.4%) than the remaining groups, which stated that they would not bring all the runners 36.3% of the time on average.
When asked why not, the vast majority of participants that did not want to bring all the runners stated that there was still some use to the runners and that they wanted to keep some in order to reuse them. This is in line with the results from the cross analysis on the waste from the model kit: these age groups were the ones that stated that they reused the runners the most.

The final question regarding this section to be cross analysed asked the participants how often they would bring the runners. The results from this analysis showed the biggest flaw of this initiative: the majority of participants of all age groups stated that they would bring the runners “Only when going buying other model kits”. This, paired with the fact that the participants showed that their frequency of purchase is not particularly high, indicates that the recovery network could need a very thorough development in order to face this issue.
That said, many participants from the age groups “15-18”, “26-31”, “32-40” and “41-55” stated that they would bring the runners “Once every two-three months”, giving a more precise time frame. In addition to that, participants in the “19-25” group stated that their frequency could be “Once a month”, again giving a plausible time frame. This is also the largest age group, slightly more representative of the community than the other ones.

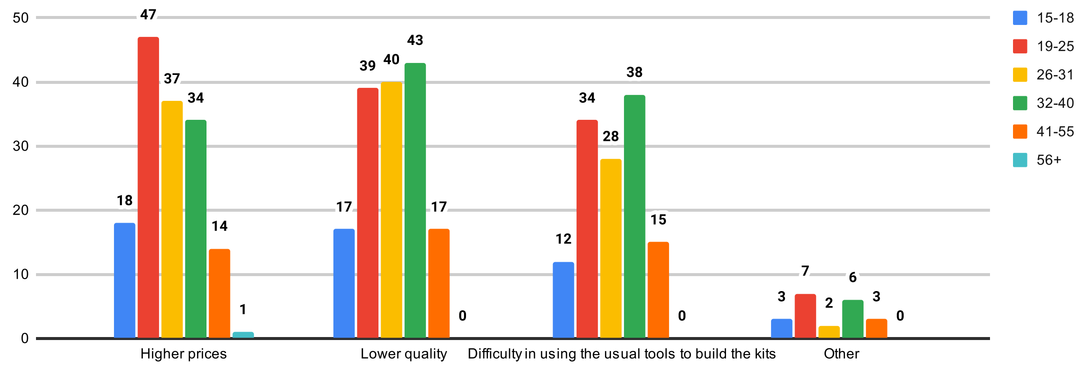
Would you consider buying more model kits made in different materials than the usual plastic or resin?



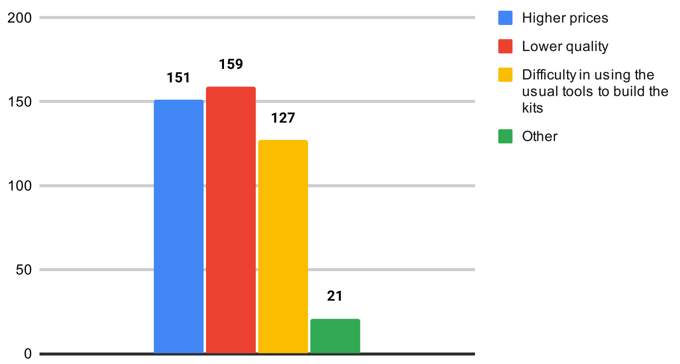
Would you trust model kit companies if the new material was advertised as having similar properties and being useable with the usual glues and adhesives? Please explain your reason.



What would be your doubts about similar changes?



What would be your doubts about similar changes?



Cross Analysis of the Answers

The next section of the survey that was cross analysed was the one regarding the second solution: the adoption of new technologies or materials in the production processes by the companies and how the community would react.
The questions that were cross analysed in this section focused on the community reaction towards new materials and the doubts that can come from them.

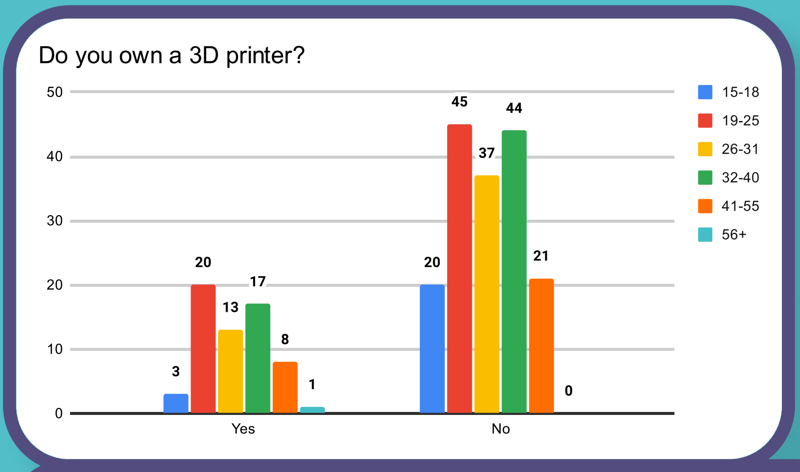
The first step was to understand how much each age group was interested in purchasing a model kit produced in a different material from plastic or resin. As seen in the analysis of this question, the community seemed mostly interested in this option, and this was confirmed from the results of this first analysis. In particular, it is possible to notice that, while the age groups between “15-18” and “32-40”, while interested, still presented an amount of sceptical participants (which amounted between 26.1% to 42.6%), the group “41-55” responded almost completely “Yes”, with only 2 participants (6.8%) not being interested.

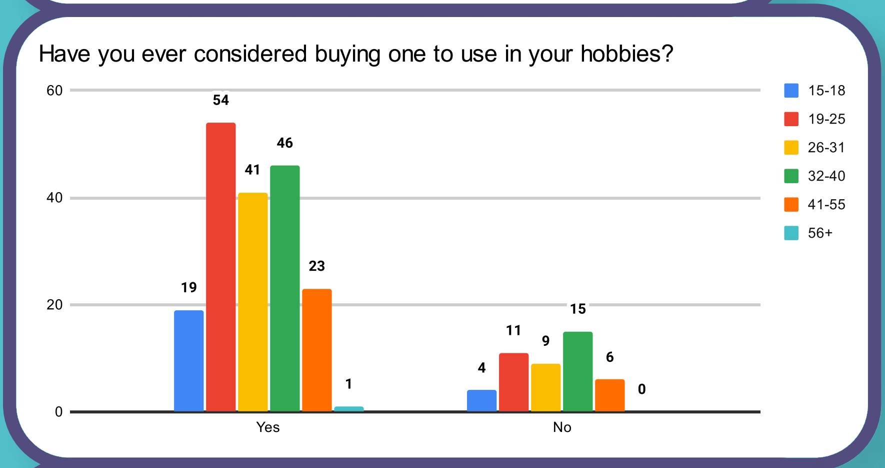
Subsequently, the next question to be cross analysed asked the participants whether they would trust said changes. This question was open, allowing the participants to elaborate. As stated in the previous section of the chapter, the answer could be mainly summarised in four main categories: “Yes”, “No”, “Only after reviews” and “Try for myself before trusting”.
The results from this analysis showed some interesting information. All the age groups had as most indicated category the first one, “Yes”, but the distribution between the remaining three was consistent between groups. With the majority of age groups selecting it between 34% and 44.6% of the time, the only group that chose this category more was “42-55”, which opted for “Yes” 62.1% of the time, showing more trust than any other group of participants.
The category “No” was consistently pointed out around 30% of the time, with the group that chose it the least (“42-55”) selecting it 27.6% of the time, while the group that opted for it the most (“19-25”), did so 33.8% of the time. When it came to the other two categories of answers, the distribution was relatively balanced inside each age group. The group “15-18” showed more trust in reviews (17.4%) and less interest in trying the new material for themselves (13%), while the group “19-25” was balanced, opting for each category 10.8% of the time.
The age group “26-31” was the one with the largest gap between the two categories, choosing to trust reviews 22% of the time, while trying the new material only 12% of the time.
The only group that was more interested in experimenting with the material rather than waiting for reviews was “32-40”, pointing the two categories 19.7% and 14.7% of the time respectively.
Finally, the group “41-55” was very close in balancing the two, since “Only after reviews” was pointed out twice (6.9%), while “Try for myself before trusting” was indicated only once (3.4%).
As expected, the community seem to be willing to trust companies about new materials, but not without a certain amount of scepticism.

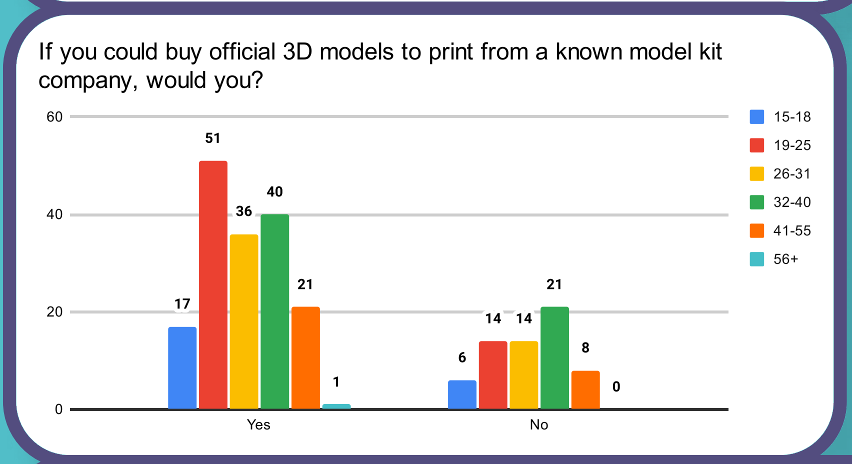
The last question to be cross analysed the doubts expressed by the community. The question concerning said doubts was a multiple selection one and the analysis was conducted in the same way as for the question regarding which incentives the participants would prefer. In this case as well, the total amount of selection for each option is reported with a graph next to the one dividing the answers between age ranges.

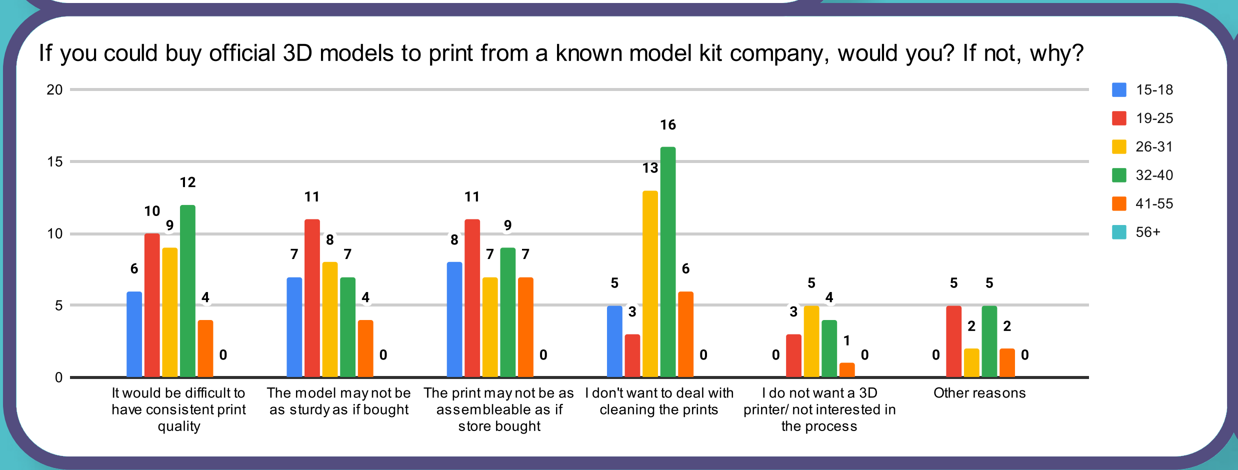
Comparing the amounts of selections for each option by each age group it is possible to notice an interesting trend: all of the age groups are concerned with an increase in prices and a decrease in quality, which is understandable, considering that the model building hobby could become quite expensive, depending on the complexity of the model kit itself. That said, it is very interesting how the selections for each age group are distributed between the options.
All age groups have a minor number of participants that expressed concerns not present in the available options, with the two largest groups, “19-25” and “31-40”, having the highest amount.
On the other hand, all groups covered each option relatively equally. For example, the group “15-18” consistently covered between 9.4% and 10.8% of the total selections for the three available options, similarly to the group “41-55”, which covered between 9.3% and 11.8% of those totals. The remaining three groups behaved similarly, with the exception of the group “19-25” for the first option “Higher prices”. In this case, this group covered 32.4% of the total selections. Similarly, the group “32-40” covered 29.9% of the total selections for the third available option, “Difficulty in using the usual tools to build the kits”.
Otherwise, the three groups “19-25”, “26-31” and “32-40” all covered between 22% and 26.9% of the selections for the various options.

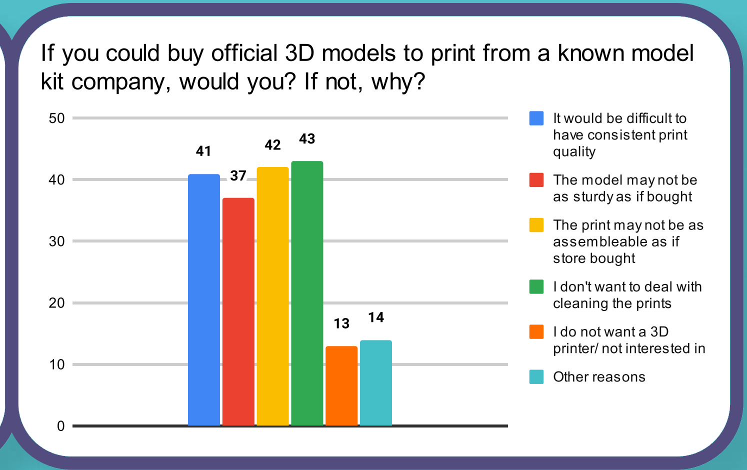
As a final note, the community continues to demonstrate common doubts and interests towards the solutions presented to them, again seemingly confirming the hypothesis of a self-influencing community.


Do you own a 3D printer?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


Have you ever considered buying one to use in your hobbies?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


If you could buy official 3D models to print from a known model kit company, would you?
Yes
No
15-18
19-25
26-31
32-40
41-55
56+


If you could buy official 3D models to print from a known model kit company, would you? If not, why?
It would be difficult to have consistent print quality
The model may not be as sturdy as if bought
The print may not be as assembleable as if store bought
I don't want to deal with cleaning the prints
I do not want a 3D printer/ not interested in the process
Other reasons
15-18
19-25
26-31
32-40
41-55
56+


If you could buy official 3D models to print from a known model kit company, would you? If not, why?
It would be difficult to have consistent print quality
The model may not be as sturdy as if bought
The print may not be as assembleable as if store bought
I don't want to deal with cleaning the prints
I do not want a 3D printer/ not interested in
Other reasons

Cross Analysis of the Answers

STL Sales

The last section about the solutions to be cross analysed was the one about STL sales and 3D printing.
This cross analysis focused on the interest towards 3D printing and the purchasing of official STL files from model kit companies.

The first question to be analysed asked the participants if they owned a 3D printer. While the overall results were easily predictable, since the majority of answers for the original question were negative, the differences between each age group will help define better the results that will come from the next questions.
While all age groups did answer mostly negative, the “15-18” one showed the largest difference between positive and negative answers, with 87% of them being negative. The other age groups had a much lower difference, averaging around 72% negative answers against an average 28% positive ones.
This may be another indication of the rare differences between occupation, since students would have a lower available income to purchase machines like 3D printers, whose prices can vary. That said, considering the fact that the participants did mostly answer negatively, it is possible that there are different factors influencing this type of purchase, other than monetary ones.

Subsequently, the participants were asked if they ever considered purchasing one to use in the hobby. Again, like the previous question, the results were predictable: the majority of the participants in each age group answered positively. Compared to the results from the previous analysis, it was possible to notice that the age groups were all relatively similar in the answers, with the three “15-18”, “19-25” and “26-31” that answered positively averaging 82.5% of the time, while the two “32-40” and “41-55” averaged 77.4% positive answers.

Then, the participants were asked about their interest towards purchasing official STL files from model kit companies, if the occasion ever arose.
Again, the initial results from the question indicated a generally positive attitude from the community, with a majority of positive answers. This was reflected in the cross analysis, where every age group was interested. Similarly to the previous analysis, the results were relatively equal, with the only exceptions being the groups “19-25” and “32-40”. These two cases showed a higher and lower interest towards this possibility: the group “19-25” selected “Yes” 78.5% of the time, slightly higher than the other groups, who averaged a positive response of 72.7%. The group “32-40”, instead, selected “Yes” much less, reaching 65.6%.
These results were in line with the ones analysed previously for the group “19-25”, which showed more interest than the rest towards adopting 3D printing in the hobby. The results also slightly contrasted the ones regarding the group “32-40”, which initially showed interest towards the adoption of said technology.

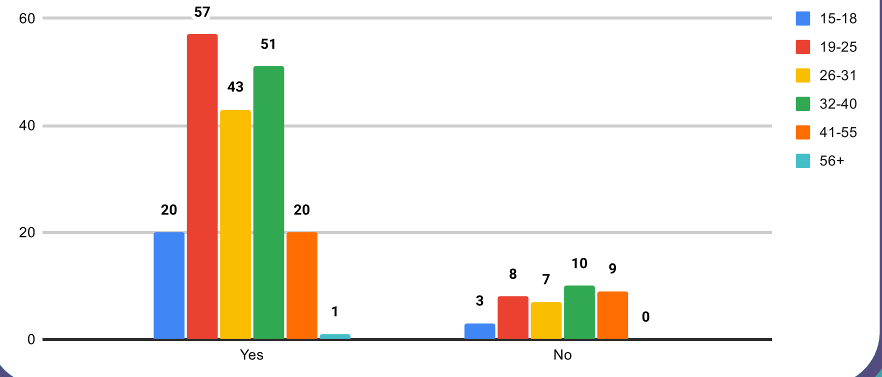
STL Sales

The final question cross analysed in this section covered the reasons why participants would not be interested in purchasing official STL files from model kit companies. In order to analyse the results from the initial question using the age groups, the same method described previously was adopted for this one, since it was again a multiple selection question. Again, the percentages that will be used are linked to the total amount of selections that each options got, not to the number of participants in the age groups. In addition to that, the question addressed the participants that answered negatively to the previous question, but also participants that answered positively decided to share their reason as for why they would avoid purchasing STL files. This resulted in a lower amount of participants for this question, together with lower total selections for each option. The total selections are displayed in a graph next to the one dividing the answers between age ranges.

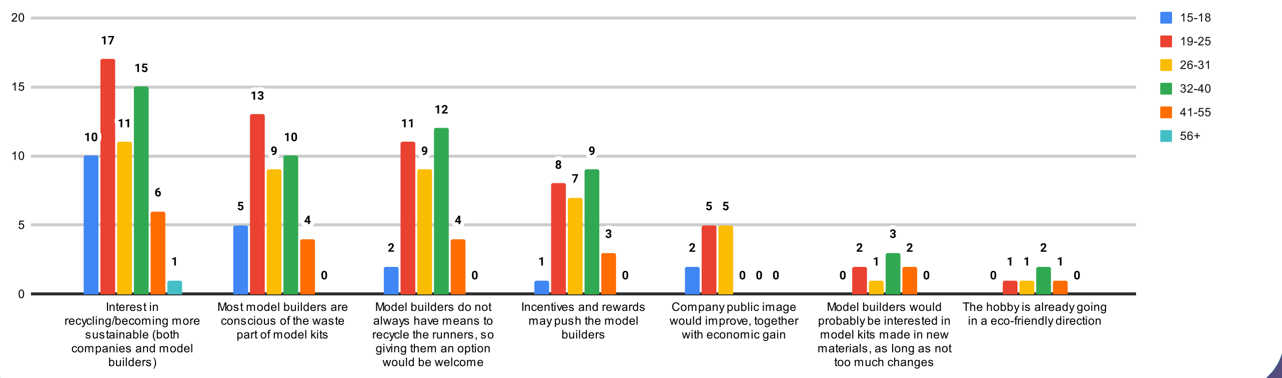
As observed in the previous instances of this type of cross analysis, the smaller pools of participants (the age groups “15-18” and “41-55”) covered smaller percentages of the options they selected. In this case, though, the participants in the younger age group did not choose the last two options, “I do not want a 3D printer/ not interested in the process” and “Other reasons” (reasons inserted in the open space that did not find similarities with other reasons, such as the disinterest towards 3D printing). All the remaining age groups did have at least one participant that gave one reason similar that could enter in one of the two categories.
Comparing the various age groups, it appeared that different groups had similar doubts towards the idea of purchasing STL files.
The two youngest age groups both focused more on issues with the model, both in terms of sturdiness and assembleability.
With the ageing of the participants, the most concerning issue appeared to be the interest towards 3D printing, which was selected the most by the groups “26-31”, “32-40” and “41-55”. The first two groups of these three also focused on the consistency in print quality, though still less concerning than the interest towards the technology.
Interestingly, the age group “42-55” showed concern towards the assembleability of the printed model kit, similarly to the two youngest age groups.
On a final note about this cross analysis, it can be easily seen that the available options given to the participants did seem to centre the most common distrusts towards 3D printing in the community.

Regarding the topic of the sales of STL files, it seems that, as noticed by analysing the answers given, the model building community is still unsure about them, with also a clear lack of interest when considering the older hobbyists.

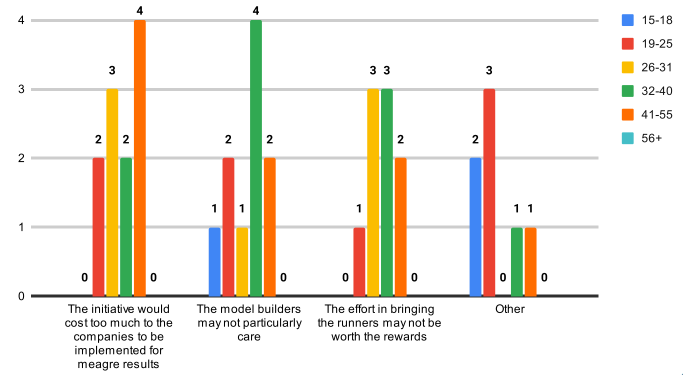
Do you think that this initiative would interest model makers?



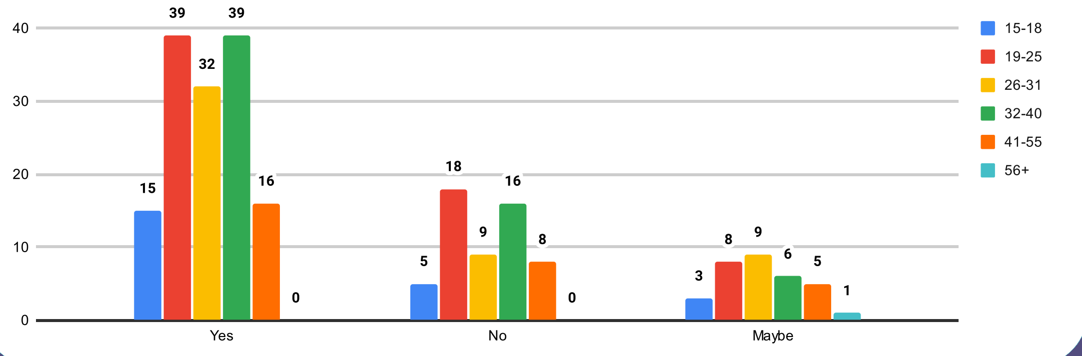
Do you think that this initiative would interest model makers? Why?



Do you think that this initiative would interest model makers? Why not?



What do you think of this initiative? Do you think it would work towards reducing the usage of virgin materials?



Cross Analysis of the Answers

Comments on the initiative

The final section of the survey to be cross analysed was the one regarding the comments from the participants on the waste recovery initiative.

Starting with asking the participants if, in their opinion, model builders would be interested in participating, the results of the analysis reflected the ones from the question: all age groups were strongly convinced that the community would be interested, except for the "41-55" age group, which had around a third of its participants being more sceptical about it.

Following that analysis, the focus shifted towards the reasons behind their answer. Similarly to how previous open questions were handled, the positive and negative reasons were separated, then divided between age groups using the profiling information. As a reminder, the percentages that will be listed will reflect this separation between positive and negative answers, working on those amounts and not on the total participants for each age group.
All the age groups seemed to choose similar reasons the most when justifying their answers, even if the distribution varies from one group to the other.
As it is possible to notice from the graph, the first three reasons were listed the most for all age groups, especially "Interest in recycling/becoming more sustainable (both companies and model builders)", which was pointed out 50% of the time by the "15-18" age group, and an average of 28.8% of the times by the other four groups. The small pool of participants in the "15-18" group caused its reasons to be more focused on the first two, while the other groups, thanks to their larger pools, pointed out different reasons more.
This can be easily seen in the amount of answers for the second reason, "Most model builders are conscious of the waste part of model kits", where the "15-18" group shared it 25% of the time, much more often than the other four, which averaged around 20.8%.
Another example of this is apparent when comparing the percentages of participants for each age group that gave as a reason "Model builders do not always have means to recycle the runners, so giving them an option would be welcome". The "15-18" group gave that reason 10% of the time, the "19-25" did so 19.3% of the time, while the other three pointed it out more than 20% of the time, averaging 21.5%.
In addition to that, all the groups outside "15-18" saw them give the remaining four reasons fewer times more gradually, even though both the groups "32-40" and "41-55" did not have participants pointing out the fifth one, "Company public image would improve, together with economic gain".

Regarding, instead, the reasons why model builders may not be interested, the reasons listed were more or less shared by most of the age groups, with only the "15-18" one not indicating either "The initiative would cost too much to the companies to be implemented for meagre results" or "The effort in bringing the runners may not be worth the rewards". This, though, could be linked to the fact that this age group had a smaller pool of participants than the rest.

Comments on the initiative

The final question to be cross analysed asked the participants if, in their opinion, a waste recovery initiative would be helpful in lowering the usage of virgin plastic material in the model kit industry.
As a reminder, the answers given by the participants in this question were relatively in line with the ones given for previous ones, while the negative answers were rooted in scepticism towards the effectiveness that a niche market, with doubts on the frequency of the actual recovery and the participation of the community.

The results from this analysis were generally in line with the ones seen in the question, with each age group leaning towards a positive outlook. Four age groups ("15-18", "19-25", "26-31" and "32-40") were more optimistic, averaging 63.2% "Yes". The group "41-55", instead, was less positive, giving a positive answer 55.2% of the time.
When comparing the negative and undecided answers, the four groups were more or less in line with each other, though the ranges were relatively large, with a difference of around 9 percentage points in both cases.
The negative answers ranged between 18% (group "26-31") and 27.7% (group "19-25"), while the undecided answers ranged between 9.8% (group "32-40") and 18% (group "26-31").

Results of the Survey

General results

Concluding this chapter on the survey, it is possible to analyse the overall results from the community participation and the cross analysis of the answers.

The model building community seems to be one that is well aware of the remaining waste from the packaged products. Whether they consider only the runners, the boxes, or everything as waste, they know that their hobby has an issue of leaving them not only with a beautiful result of assembling it, but also with an output that has no direct use and risks ending up in a landfill, especially the plastic portions of it.
The community seems also to be interested in trying to avoid this material to end up unused and treated simply as waste. This would be especially true considering that Polystyrene, as it will be seen later, is a plastic that poses some issues in recycling, thus making it less appealing to plastic recycling companies. This thermoplastic resin, then, is often left in landfills, creating a huge environmental issue.

The model builders seem, in average, interested in participating in solutions that may either help recycling the plastic, or reduce its use in the production processes. They appear to be relatively welcoming towards alternative materials, even though the community would not trust blindly the companies advertising said materials just as good as the previously used ones.
There are still some doubts and negativity towards the proposed solutions, especially when considering digital models and anything that may cost more to the model builders to adopt or that may cause a decrease in quality of the model kits.

Overall, the various profiling elements, outside the age groups did not seem to influence the answers from the participants, outside of a few examples, which could still be explained by other factors outside monetary ones, like lack of experience. The community seems to influence itself, with older generations helping younger ones to start developing both skills needed to progress as model builders and points of view on various aspects of the hobby.
The age groups, though, still present differences on various themes, mainly when it comes to trust towards companies and innovations. Interestingly, younger generations appear more sceptical towards changes in the hobby, though they also seem more easily influenced by active initiative. In contrast, older generations seem to be more influenced by internal efforts made by the model kit companies.

Therefore, when trying to develop a new industry network, it would be wise to define a strong communication system, which would help model builders understand both the changes and what they would entail, in order to dispel any doubts. Also, incentives will be very useful in pushing the community in participating in waste recovery initiatives, which would also require careful planning in order to allow as many people as possible to participate.

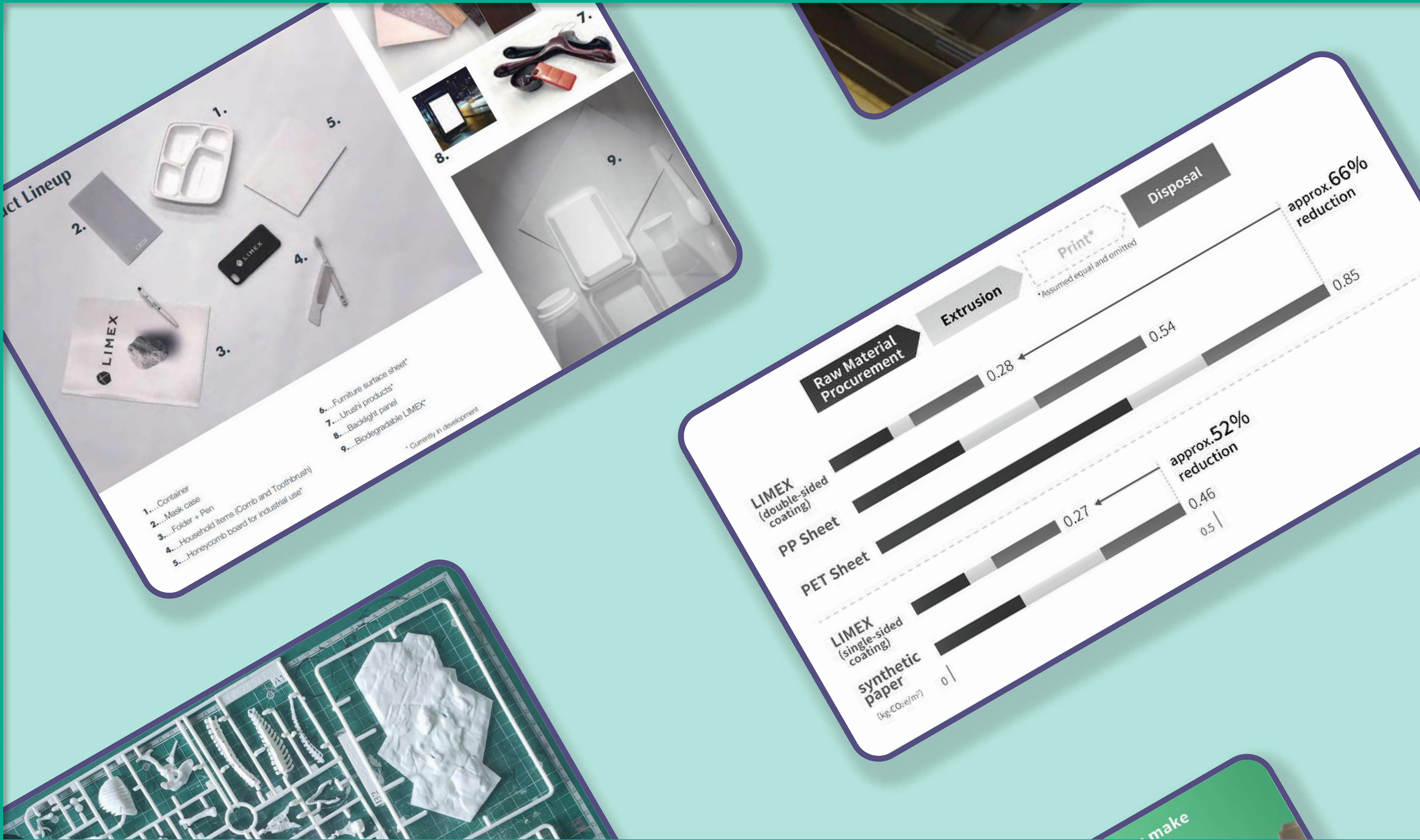
Personas

During the analysis of the results of the sections of the survey, there was an attempt to define the personas that would help create an artificial userbase feedback towards a new industry system.

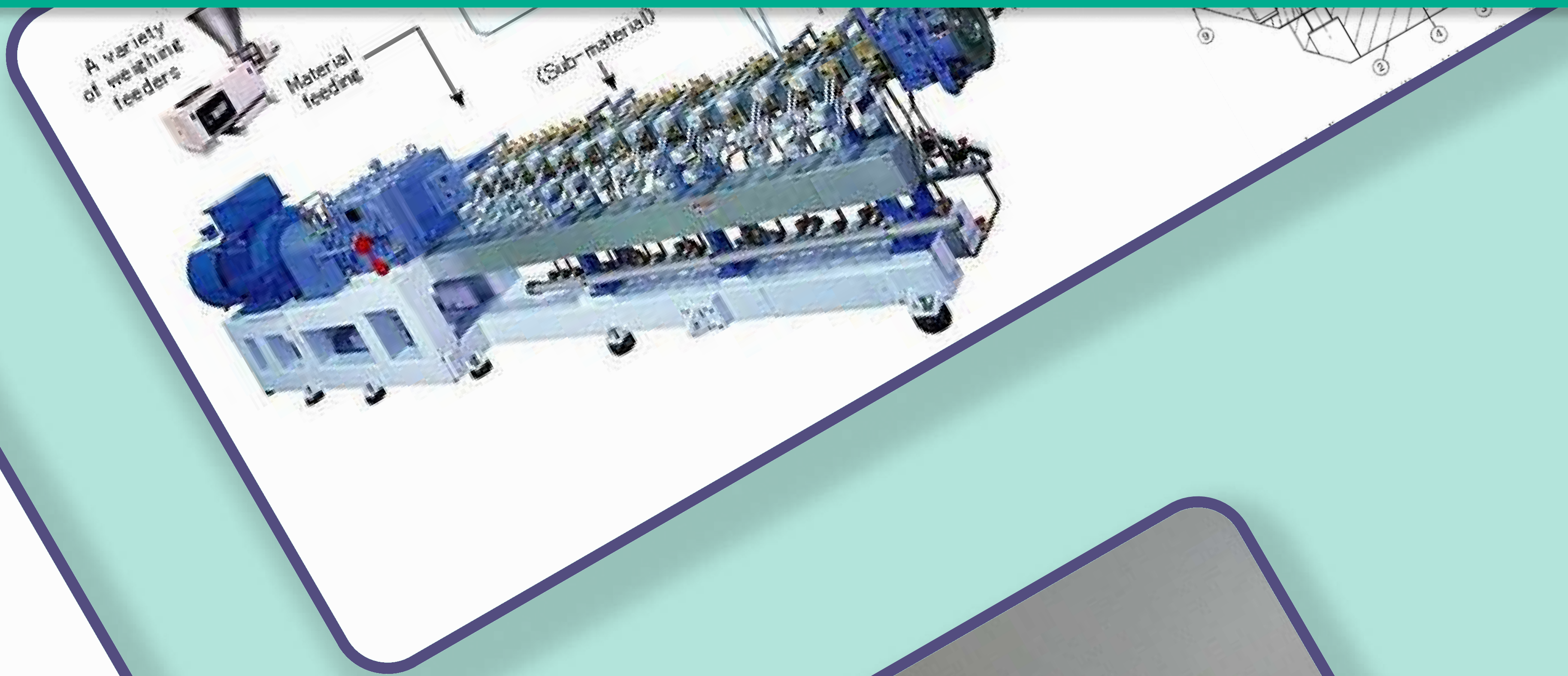
As a final note in this chapter, the final result of the general idea of the personas (which will be fleshed into multiple ones, each with their different needs, in a following chapter) is an European or American male, between 25 and 40 years old. The personas would either be a worker, white or blue collar, or a university student. They would most likely prefer plastic kits, usually purchasing them monthly, and from both physical and online stores, depending on what they want to buy.
The personas would keep the boxes when a box art catches their eye, and the runners. Only some of the personas would manage to reuse the runners, and even then, only a small amount, usually depending on the actual use.
When considering the solutions, most of the personas would be interested in participating in a waste recovery initiative and would be interested in trying out model kits produced in a different material, though still being wary of the promises of the companies. Only a small portion of them would own a 3D printer and would purchase digital files, each searching for different type of models.

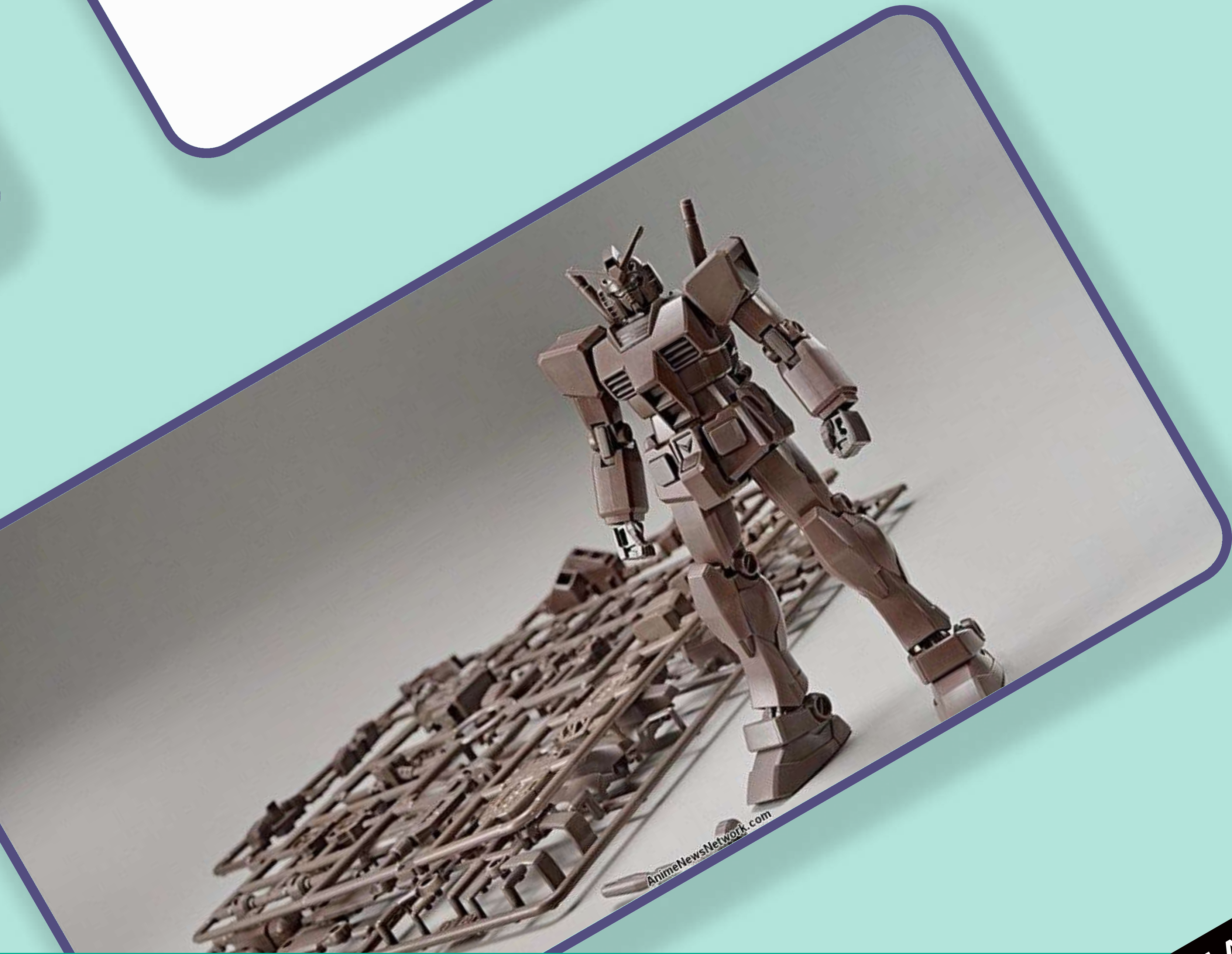
Thanks to the cross analysis, the personas could be more fleshed out, in order to highlight the differences between the generations of hobbyists, particularly thanks to the youngest and oldest generations that took part in the survey

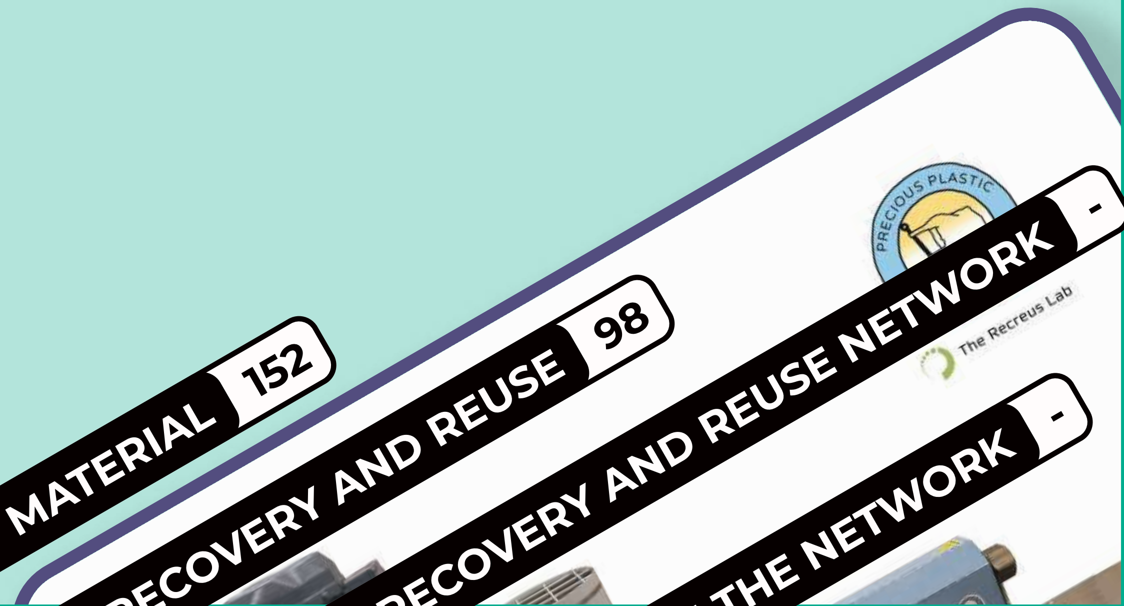
Most of the personas would see the waste from the model kits as an issue for which would welcome a solution that could avoid the plastic ending up in a landfill, but would still need some incentives to participate. Also, their participation would be mainly linked to the amount of runners accumulated over time, making their contribution not particularly constant.



4. Systemic Project - Case Studies







ADOPTION OF A NEW MATERIAL 152

USER WASTE RECOVERY AND REUSE 98

THIRD PARTY RECOVERY AND REUSE NETWORK -

SOLUTIONS IN THE NETWORK -

Image 32. Example of Polypropylene pellets
Image 33. Example of limestone

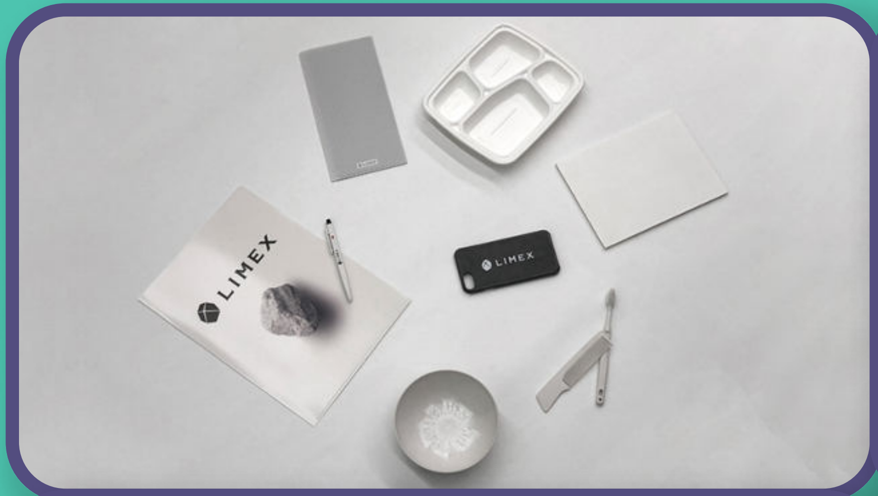


Image 34. Examples of articles produced with Limex plastic
Image 35. Examples of articles produced with Limex sheets
Image 36. Bandai model kits produces in Limex

Adoption of a New Material

Thermoplastic Resin Composition

Introduction

This chapter will focus on the case studies identified and analysed in order to understand and develop the solutions described previously. These case studies were researched during the development of said solutions and helped understand the key point for each one of them. In particular, the case studies that will be described are the ones that helped develop the three solutions that the multicriteria analysis found most effective: the adoption of a new material or technology, the recovery and reuse of the waste from the users and the development of a third party recovery network that would transform the plastic in a new material.

The first case study is related to the adoption of new materials or technologies. Researching the topic of the technologies used to produce model kits in plastic, it appeared that there was no interest in trying to innovate. The main reason is that the technologies in use today (injection moulding and vacuum forming) already allow for industrial volume of production, lowering the prices of the model kits and maintaining constant quality.
There is, however, interest towards developing alternative materials to plastic that could be used in the same production cycles already in use.

The material studied is defined as “Thermoplastic Resin Composition”, a new thermoplastic resin composed of a blend of polymer and an inorganic filler. The commercial name of this material is “Limex”, and it will be used to reference it in this thesis. Limex is produced by the Japanese company TBM Co, Ltd [38].
This material is produced by blending together a thermoplastic resin (Polypropylene) with an inorganic filler, Calcium Carbonate ($CaCO_3$), in a blend ratio that can vary between 50:50 and 10:90 by % of mass. The lower amount is the thermoplastic resin, while the higher amount is the filler.
The company producing Limex claims that it can be used both as a substitute of plastic, using the common production methods, and of paper, by producing sheets. In addition to that, this material has a lower greenhouse gasses emission rate from procurement to disposal of both already in use thermoplastic resins and paper. TBM also claims that Limex can be upcycled.

Limex has been patented in a variety of countries, like Japan, United States, various European countries (e.g. Italy, Belgium, Germany and the United Kingdom) [39].
It is already in use in a variety of products, both as a plastic substitute (Image 34) and a paper substitute (Image 35). Recently, the company BANDAI SPRITS released a few model kits in Limex, depicting, between the others, the skeletons of a Tyrannosaurus Rex and the skeleton of a Triceratops.

Material production

Limex is produced by blending together a thermoplastic resin, an inorganic filler and, if necessary, additives to give the resulting blend particular additional properties.
Both the resin and the filler must follow some guidelines in order to provide a satisfactory result.

The thermoplastic resin is itself a blend of two polymers. The ones used by TBM are Propylene -based polymers, one with no long chain branching and one with long chain branching, in a blend ratio that can go between 80:20 and 98:2 % of mass, respectively.
While the Limex produced and sold by TBM is Propylene-based, in the patents the company stated that other thermoplastic resins may be used, either as a substitute, or added to the blend. These resins, though, must fullfill some prerequisites.
First of all, the resin blended together with the Propylene-based ones must not impair the effects provided by those. This requisite is particularly important, since the blend of resins must allow for consistent properties, especially when considering that blending this resulting resin will have to give plastic properties to the inorganic filler. Since the filler will comprise at least half of the mass of Limex, the resin blend will have to be consistent in key elements like the internal structure (consistent amounts of amorphous and crystalline structure), reaction to heat and mechanical and physical resistances.
In the patent, TBM also provided a list of acceptable resins: Polyolefin resins, biodegradable resins, Polybutylene Terephthalate (PBT) and Polyethylene Terephthalate (PET). Since the Propylene-based polymers used are Polyolefin resins, the company stated that resins from the same family could be compatible. When considering the biodegradable resins, the company gave a short list of specific examples: Polylactic Acid (PLA), Polycaprolactone(PCL), Polybutylene Succinate (PBS), Polybutylene Adipate (PBA), Polyethylene Succinate (PES), and Cellulose Ester.
Another key information given by TBM in this section of the patent is the fact that resins with a crystalline structure are preferred. The wording of this statement is very important, since it highlights that crystalline structures in the resins used are not a necessity. Considering that the type of structure gives the polymer different properties, it could be possible that using a polymer with an amorphous structure rather than a crystalline one could be beneficial in some applications. The main differences are the elasticity of the material (polymers with crystalline structures tend to be more rigid), the fusion temperature (amorphous polymers tend to melt at lower temperatures over a larger range of temperatures), the chemical resistance (higher in crystalline polymers) and the hardness (amorphous polymers are soft, crystalline ones are hard).
TBM also gave examples of crystalline macromolecules in Polypropylene and Polyethylene.
A final note given on the topic of different resins is the statement that these alternative thermoplastics may be copolymers with other monomers.

Image 37. Example of twin-screw kneader
Image 38. Example of extrusion forming machine

Image 39. Example of injection forming machine
Image 40. Example of vacuum forming machine

Adoption of a New Material

Thermoplastic Resin Composition

Material produciton

The inorganic filler that gets blended together with the resin can be classified as either “light” or “heavy”.
A light filler is produced artificially using synthesis methods, which produce perfectly spherical particles.
A heavy filler, instead, is produced by mechanically grinding and classifying natural materials which include Calcium Carbonate, like limestone. This process produces irregularly shaped particles, but it is preferred from economic viewpoint. In addition to that, the mechanical grinding can be done using a dry or a wet method, the former being less expensive.
The preferred filler is Calcium Carbonate, but in the patent, the company listed some alternatives: Magnesium Carbonate, Zinc Oxide, Titanium Oxide, Silica, Alumina, Clay and Talc. The reason why Calcium Carbonate is preferred is the amount of limestone deposits present around the world, making it a very cheap raw material from which extract the filler. One of the objectives that TBM has for Limex is to develop a material cheap to produce, but that does not impact the environment. The use of limestone as raw material helps in that regard.
Developing Limex, TBM has defined the correct dimensions for the filler particles. This is important, since the particles produced using mechanical grinding can be in various shapes: spherical, flakes, granules and fibres. The company stated in the patent that the lowest useable diameter for the particles is 0,5 nm, since smaller particles may significantly increase viscosity when kneaded with the resin. In general, though, the diameter for the particles is acceptable up to 50 nm, while fibres can have an aspect ratio between 10 and 30 between length and diameter, for which the maximum is set at 1,5 nm.

As stated previously, in the patent TBM included the possibility to add additives to the blend. These can be added in quantities between 0 and 5% of the mass, preferably 2% or less.
These additives can be:

- Colourants
- Lubricant agents
- Antioxidants
- Phosphate esters
- Phenol-based antioxidants
- Flame retardants
- Foaming agents

For each type of additive the company listed a variety of acceptable substances.

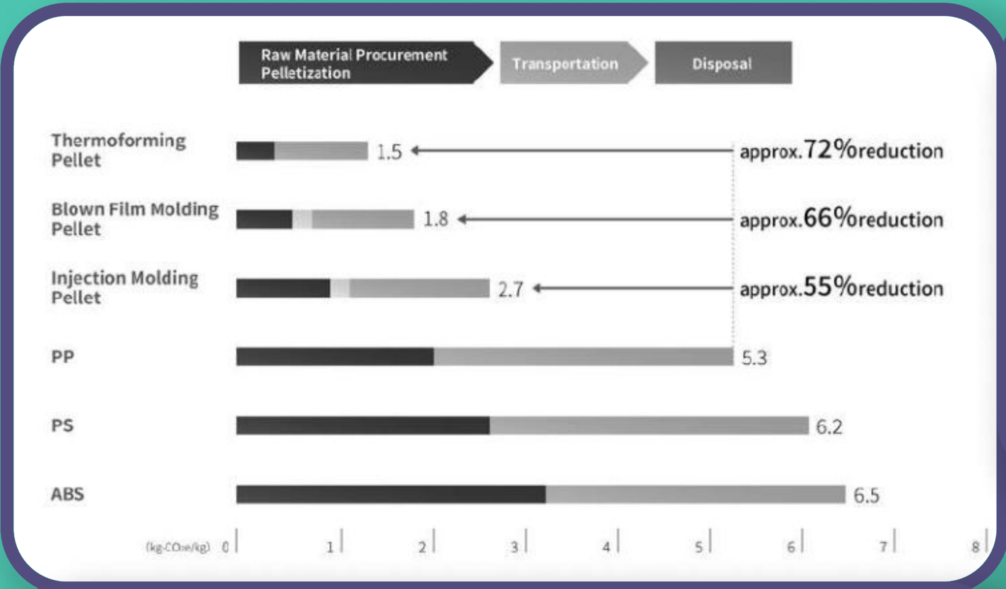
Material produciton

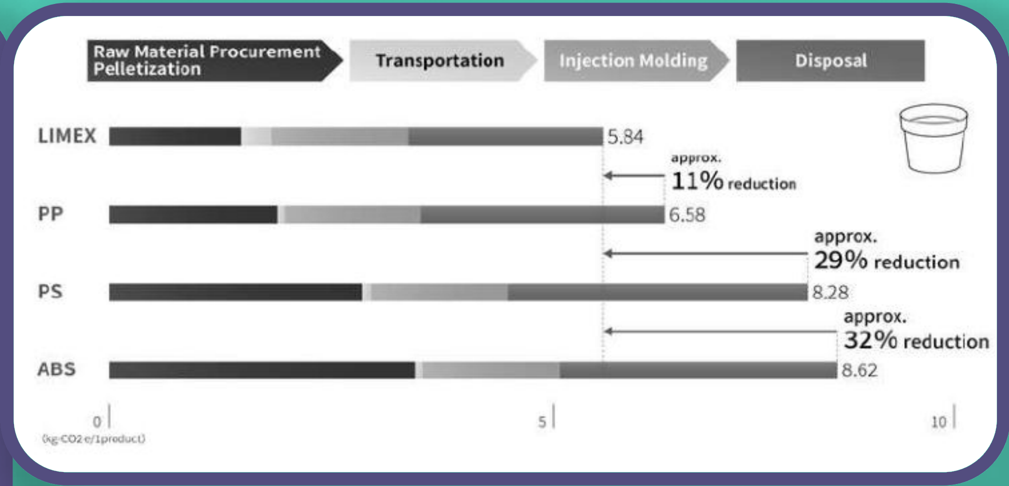
The production of Limex, as stated previously, can be done using common methods already largely available. In the patent, the company TBM stated that the appropriate method can be determined based on the forming technology that will be used to produce the final articles. In addition to that, some examples were given, listing extrusion forming, injection forming and vacuum forming as methods that can be used to produce articles using Limex.

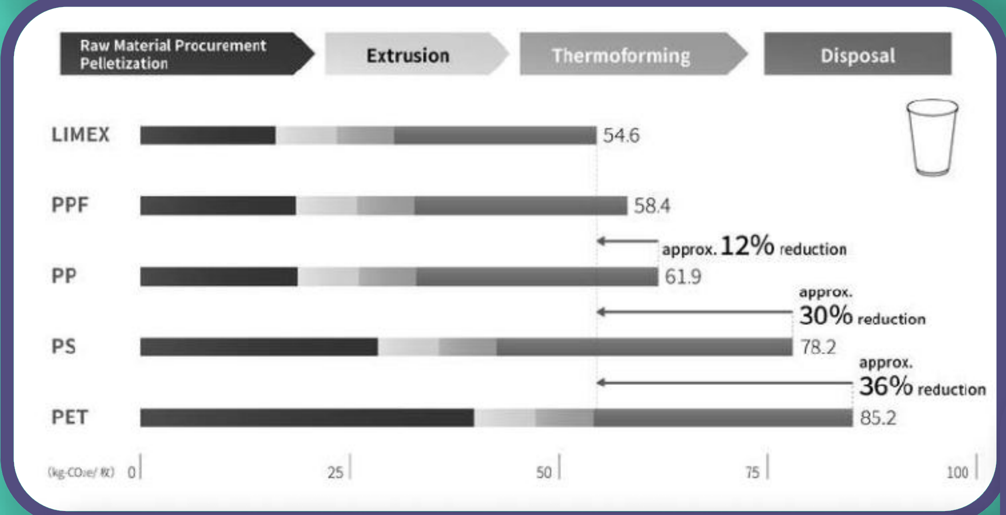
As the thermoplastic resin and the inorganic filler are blended, TBM stated some key details regarding the ratio of the two.
While the blend ratio is described as not particularly limited, as long as it is between 50:50 and 10:90, the preferable ratio should be between 40:60 and 25:75. The reason for this is that the final texture and the physical properties (e.g. impact resistance) of the Limex can not be obtained if the ratio of the inorganic filler is less than 50% of the total mass, while a ratio of over 90% of the total mass would make forming processes (e.g. extrusion forming) difficult.

One of the methods described stated that the components that would be blended together can be kneaded and melted before being fed in the hopper of a forming machine.
The other method, instead, stated that the components could be integrally and simultaneously kneaded and melted in the forming machine.
In both cases, the kneading method described would be carried out by applying high shear stress to the materials. By using a twin-screw kneader (Image 37), the inorganic filler is uniformly dispersed in the thermoplastic resin.

Once the components have been blended together, it is possible to form them either in a finished product or in pellets.
In the case of pellets, the final shape is irrelevant to their performance as forming material, with the company stating that they could have any shape, like cylindrical, spherical or elliptical.







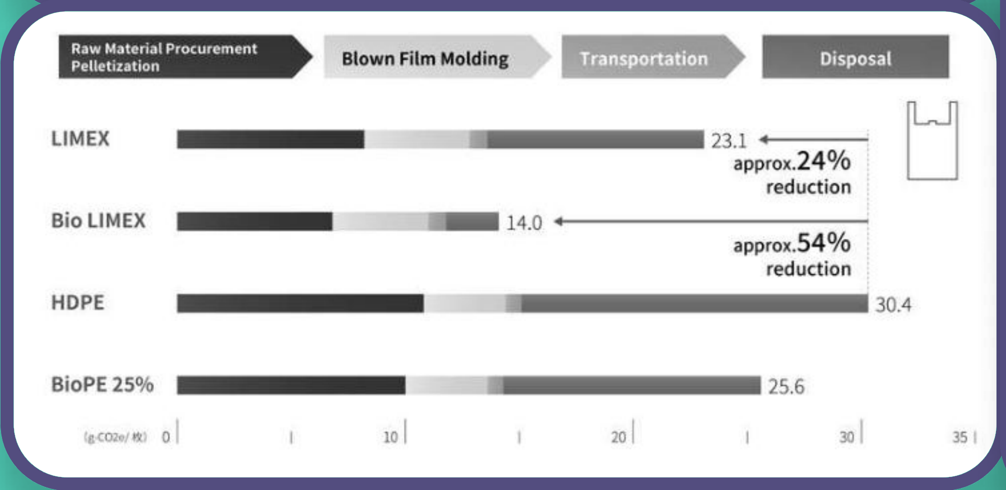


Image 41. General comparison of Greenhouse Gasses emissions between materials
Image 42. Comparison of Greenhouse Gasses emissions in thermoformed products
Image 43. Comparison of Greenhouse Gasses emissions in inflation moulded products
Image 44. Comparison of Greenhouse Gasses emissions in injection moulded products
Image 45. Product lineup presented on the TBM site

Thermoplastic Resin Composition

Article production

The production of articles in Limex is described in the patent as not particularly limited, since the methods that can be employed are already known and common. A list of examples was given. The methods with which Limex can be formed in finished products include: extrusion forming, injection forming, vacuum forming blow forming and calendar forming. This is possible thanks to the fact that, once the components of Limex are blended together, the material is then processed either directly in a finished article, or in pellets, which can be easily fed in a forming machine through its hopper.
Furthermore, details related to foam forming were given. In particular, the company stated that common foaming methods may be used: extrusion foaming, blow foaming, solid phase foaming such as bead foaming, batch foaming, press foaming, and secondary foaming under normal pressure.

In the patent, TBM stated that an optimal forming temperature can not be easily determined, since the temperature varies to a certain extent depending on the forming method.
For example, a finished product formed at a temperature between 190 and 230° C would have excellent drawdown and extension properties, with the shape being formed without local degenerations. This effect is linked to the internal structure of the resin composition, since the temperature and its cooling times influence the internal structure.

Thanks to the possibility of using Limex in the most common plastic forming processes, the products that can be manufactured using this material is variegated. A product lineup (Image 45) was presented by TBM, which includes: containers, mask cases, office supplies (e.g. folders and pens), household items (e.g. combs and toothbrushes, which also show that the material can come in contact with human skin) and backlight panes for marketing. In addition to those products, others are in development, such as honeycomb boards for industrial use and furniture surface sheets. A biodegradable version of Limex is also in development [40].

Thanks to the particular composition of Limex, it is possible to compare it with other thermoplastic materials in order to understand the differences in greenhouse gasses emissions. The company TBM, on their site, reports the effective differences in emissions from the raw material procurement to the disposal between Limex and other thermoplastics [41].
This comparison could be made measuring the amount (in kilograms) of CO_2 produced for various factors, depending on the comparison: for a general one between materials, the factor indicated was 1 kilogram of resin. For the production of articles, the amount of CO_2 compared was per item produced.

Article production

The first comparison is between various types of pellet of Limex with Polypropylene, Polystyrene and ABS. The pellets analysed were: general thermoforming pellets, blown film moulding pellets and injection moulding pellets. All three types scored a much lower amount of CO_2 produced per 1 kilograms, reaching respectively 1.5 kg, 1.8 kg and 2.7 kg. Compared with Polypropylene, which had the lowest amount of CO_2 produced between the three thermoplastics at 5.3 kg, the three types of pellets showed a reduction of CO_2 produced of 72% for thermoforming pellets, a reduction of 66% for blown film pellets and a reduction of 55% for injection pellets (Image 41).

When comparing the greenhouse gasses produced from thermoformed products, Limex scored 54.6 kg per kilogram of thermoplastic composition, showing a reduction of around 12% from Polypropylene (61.9 kg) thermoformed products, a reduction of 30% from Polystyrene (79.2 kg) products and a reduction of 36% from PET (85.2 kg) products (Image 42).

Another comparison was made on blown film products, still based on kilograms of CO_2 produced per kilogram. In this case, though, the materials compared also included Biodegradable Limex, which saw its first development for the production of shopping bags.
In this case, the Biodegradable Limex showed a larger difference in CO_2 produced when compared to HDPE (High Density Polyethylene), equal to 54%, than the difference between Limex and HDPE (24%) (Image 43).

The final comparison shows the difference between injection moulded products. As for the previous cases, a product made out of Limex produces less CO_2 than the materials already in use (5.84 kg). In this case, the difference is less stark when compared to Polypropylene (11%) than when compared with Polystyrene (29%) and ABS (32%). Also, in this case, the amount of CO_2 is analysed based on unit produced.

These comparisons show that the claims about the reduction of greenhouse gasses seem to be proven right, but, in the cases where the difference is relatively small (mainly when it comes to product made out of Polypropylene), it could be difficult to integrate Limex in the production processes, since the production costs of this thermoplastic composition may not be outweigh by the ecological effects. On the other hand, when it comes to larger differences, the adoption of this new material may be much more beneficial to a plastic manufacturing company, at least from a public image perspective [42].

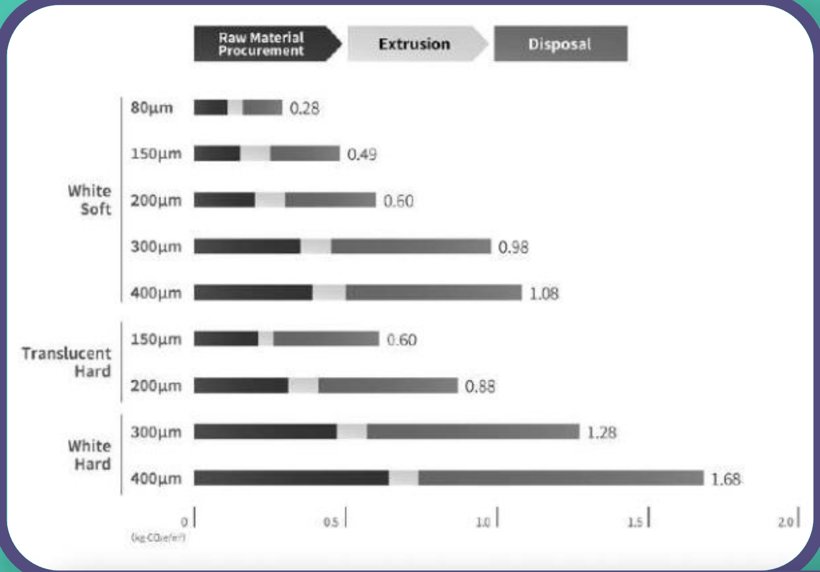


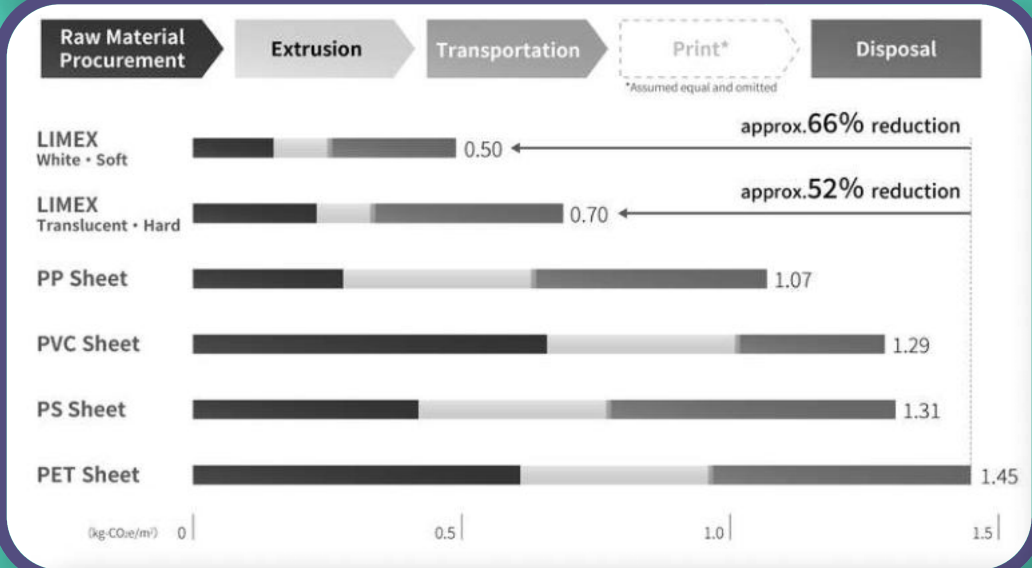
Image 46. General comparison of Greenhouse Gasses emissions between grammages

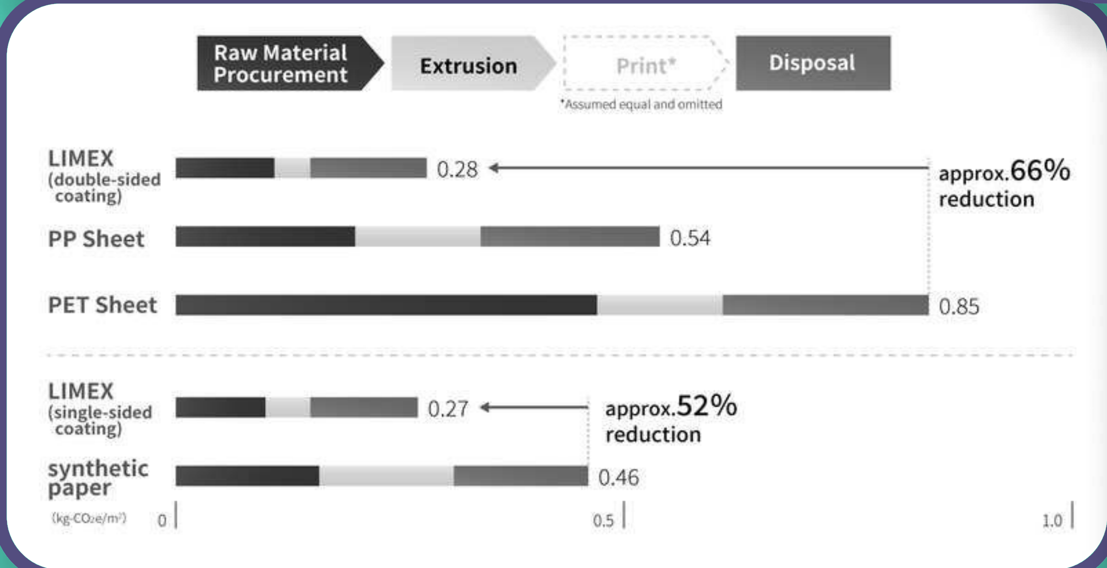
Image 47. Comparison of Greenhouse Gasses emissions between 150 nm sheets

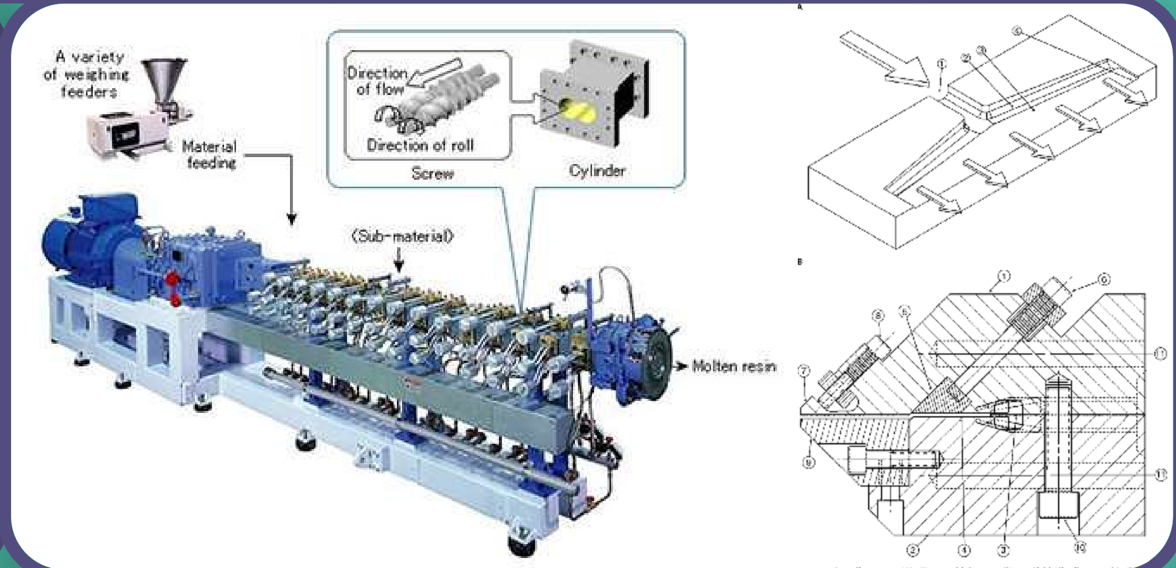
Image 48. Comparison of Greenhouse Gasses emissions between 80 nm sheets

Image 49. Product lineup presented on the TBM site

Image 50. Example of a twin-screw extrusion forming machine and diagram of a sheet extrusion die







Sheet production

Sheet production using Limex has been developed in order to substitute paper. In order to allow for the production of sheets of various thicknesses, the material has been developed in order to allow using production methods that have as output a result that can be fed in a sheet making machine, which will draw and thin out the material until at the desired thickness.

While conventional sheet production methods, already in use for plastic sheets can be used, the preferred method is extrusion forming, thanks to the smoothness of the material surface.
In addition to that, a direct production method, in which the components of the thermoplastic composition are kneaded and formed simultaneously, is preferred. In particular, in order to immediately obtain a sheet-like result, a twin-screw extrusion forming machine, with a T-die system is used (Image 50).
Then, this first result can be stretched in a unidirectional, bidirectional or multi-axial direction (e.g. tubular method), either during or after forming. If the stretching is biaxial, it may be sequential or simultaneous.
If the stretching is applied after the initial forming (e.g. longitudinal and/or transverse stretching), it decreases the density of the sheet, making it lighter. This happens because during the stretching, microscopic gaps open on the surface of the sheet, making it thinner, lighter and more flexible.
In addition to that, this stretching process, together with the inorganic filler, improves the whiteness of the sheet.

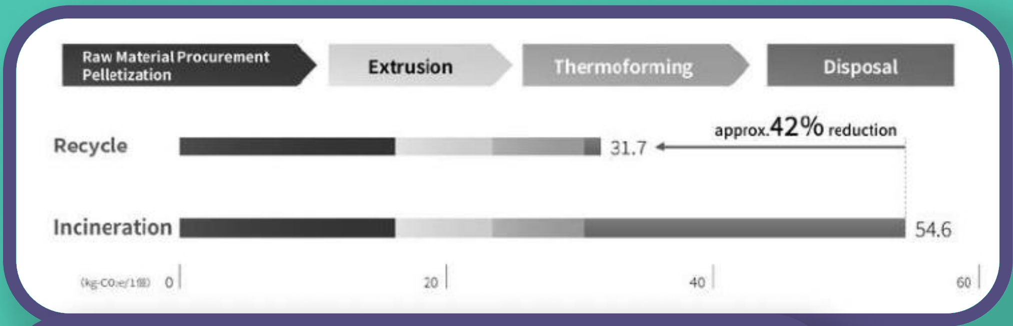
The Limex sheets can be divided in three categories.
The first is called “White/soft Limex”, and it is a supple type with high whiteness and low specific gravity. It is produced in the largest variation of thicknesses: 80,150, 200, 300 and 400 nm. It is produced either in sheets or rolls (for rolls, only thicknesses of 150, 200 and 300 nm). At the moment, this type of Limex is mainly used for booklets, flyers, posters, business cards, menu tables, folding boxes, tapestries and POPs.
The second type of Limex is called “Translucent/hard Limex”. This material is produced in a much smaller amount of thicknesses: 150, 200 and 300 nm, and it is used mainly for files, mask cases, illumination films and folding boxes (assembled boxes).
Finally, “White/hard Limex” is a version with high whiteness and firmness, is produced in the thicknesses of 300 and 400 nm, and it is used for table menus, packages, door tags, store POPs, hand fans and calendars.
The product lineup (Image 49) illustrates the variety of products that can be made with Limex sheets.
It is not possible to produce transparent Limex sheets, since the inorganic filler makes so that the default colour of the material is white. The translucent version of the material, though, is optimal for backlight panels.

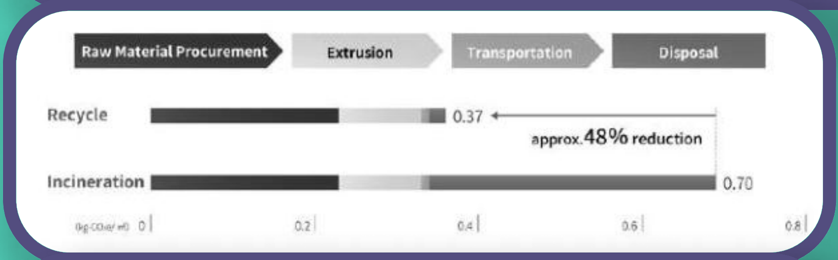
Sheet production

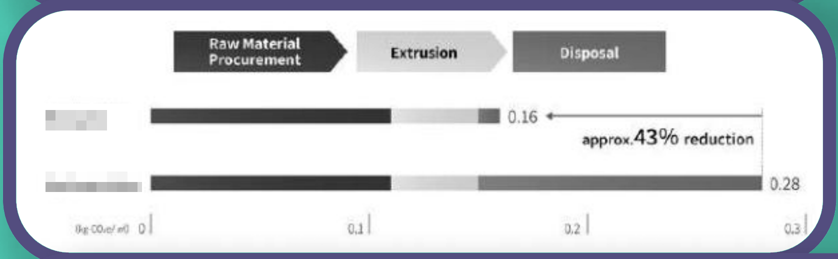
When compared to traditional paper, Limex sheets do not require the use of trees or water, significantly reducing the impact that this material would have on the environment. That said, since it is a thermoplastic material, it will still have an impact, caused by the production of greenhouse gasses from raw material procurement to disposal [43].
In the case of thermoplastic sheets, TBM showed the differences between the types of Limex, the difference between Limex sheets and other thermoplastic sheets, and the differences between coated Limex paper with thermoplastic sheets and synthetic paper. In all cases, the amounts of kilograms of CO_2 produced were compared per square metre of sheets.
When comparing the various types of Limex sheet, it is possible to notice that the same thickness of 150 nm, “White soft” has a slightly lower emission of gasses than “Translucent hard” (0.49 kg and 0.6 kg respectively). The same results can be seen for the thickness of 200 nm (0.6 kg and 0.88 kg) and when comparing “White soft” with “White hard” for the thicknesses of 300 and 400 nm. These result indicate that the use of each material (and, therefore, the physical properties required), influence the environmental impact of the types of sheets (Image 46).

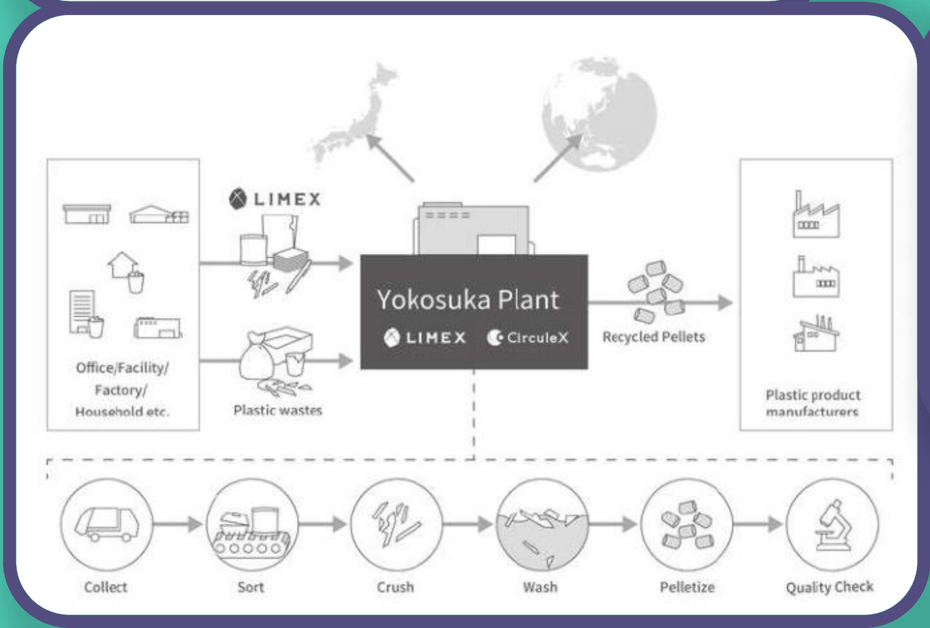
Comparing, instead, the “White soft” and “Translucent hard” types of Limex with other thermoplastic sheets, it is shown that the Limex sheets produce less greenhouse gasses than all the other thermoplastic sheets.
In addition to that, when compared to the most impactful one (PET sheets, 1.45 kg of CO_2 produced), the “White soft” registers a reduction of greenhouse gasses equal to 66% (0.5 kg), while “translucent hard” sees a difference of 52% (0.7 kg) (Image 47). This comparison was done with sheet 150 nm thick.

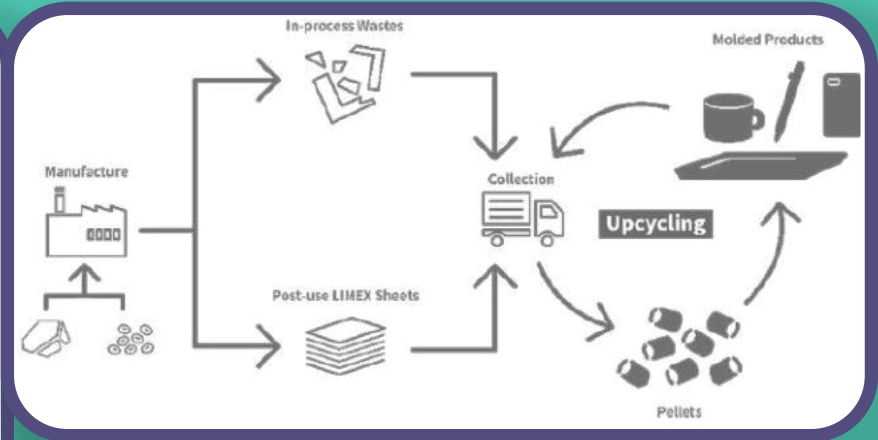
Comparing 80 nm coated sheets, the double-sided coated Limex ones register a reduction of gasses production of 66% (0.28 kg) when compared to PET sheets. Single-side coated Limex sheets see a reduction of greenhouse gasses production of 52% (0.27 kg) when compared to synthetic paper (Image 48) [44].











◀Image 54. Reduction of greenhouse gasses emissions by recycling products in Limex
▶Image 55. Reduction of greenhouse gasses emissions by recycling Limex sheet 150 nm thick
▶Image 56. Reduction of greenhouse gasses emissions by recycling Limex sheet 80 nm thick
▶Image 57. Yokosuka plant recycling cycle
▼Image 58. Recycling cycle of Limex

Adoption of a New Material

Thermoplastic Resin Composition

Sustainability

As a material Limex has a base of thermoplastic resin, which can mean that, as the majority of them, it can be recycled. The company TBM does indeed claim that in can be recycled and even upcycled.
Together with the comparisons related to greenhouse gasses present on its site, TBM included the reduction of emissions if, at the disposal step of the life cycle of the material, it gets recycled instead of getting incinerated.
In the case of Limex formed articles (Image 54), the reduction equates to 42%, with the recycling making the final total emissions of formed plastic articles amount to 31.7 kg of CO_2 per product, while incinerated articles produce a total of 54.6 kg of CO_2.
In the case of Limex sheets, the comparison was made for sheets 150 nm thick (Image 55) and 80 nm thick (Image 56). While in both cases there was a large difference, interestingly the thicker sheets show a slightly larger difference: the reduction amounted to 48% (0.37 kg when recycling, 0.7 kg when incinerating). When recycling 80 nm sheets, the reduction amounted to 43% (0.16 kg of CO_2 emitted when recycling, 0.28 kg when incinerating) [45].

In order to process Limex waste, TBM opened a recycling plant in Yokosuka City, in the Kanagawa Prefecture [46].
In this plant, they are able to sort the plastic waste using infrared technology and recycle it in pellets. The waste recycled is not limited to Limex, though. Instead, TBM works with a variety of plastic waste, including Polypropylene, Low Density Polyethylene, High Density Polyethylene and Polystyrene. They process around 40’000 tons of material each year, with an output of around 24’000 tons.
The material output is called “Circulex” and is a recycled material made from used plastics and Limex. The products made using Circulex include garbage bags and umbrellas.

The recycling method used by TBM is known as mechanical recycling, where the recovered waste is sorted, crushed in smaller pieces, washed to remove impurities, then pelletized. A final quality check looks for defects and other potential issues. The produced pellets are then sent to the manufacturing plants, the Shiroishi factory and the Tagajo factory.
The Shiroishi factory is the base for research and development, as well as human resources development, and is the foundation for the business expansion of TBM. It has the lowest production volume of the TBM plants, at 6’000 tons each year.
The Tagajo factory is a mass production plant, where the bulk of productions takes place. This facility also promotes technology exports around the world, mainly in areas where water resources are scarce. The production volume amounts to around 23’000 tons per year.

Sustainability

As a final note, the upcycling that TBM references when depicting it in Image 58 has the meaning of creating a new material starting from a waste. As it can be seen in the scheme, the upcycling step happens after the collection of post-use Limex sheets and in-process waste, which are collected and recycled in pellets. These pellets enter again in the production cycle, feeding the whole upcycling process with new in-process waste and, with time, either moulded products that become waste, or other post-use sheets.
This is a more industrial approach to upcycling, contrasting with the more common meaning of the term. As a matter of fact, it is much more similar to downcyling, though there is no loss of quality in the resulting material. Instead, the output of this cycle is again Limex, going back to its original state as pellets.

Image 59. Tools used
1- Nippers
2- Hobby knife
3- 400-grit sand paper
4- Tamiya Thin Cement (Acetone-based solvent)
5- Wet palette
6- Paint brushes
7- Variuos paints
8- Primer for model making (black)
9- Water pot to clean brushes

Image 60. Disassembled model kit

▼Image 61. Disassembled leg-pelvis joint
▼Image 62. Assembled leg-pelvis joint (not glued)
▲ Image 63. Assembled leg-pelvis joint (glued)
◀ Image 64. Comparison between Polystyrene runner (left) and Limex runner (right)
◀ Image 65. Comparison between primed (below) and not primed (above) painted Limex runner

Adoption of a New Material

Thermoplastic Resin Composition

Qualitative tests

It was possible to test a Bandai Limex model kit, depicting the skeleton of a Tyrannosaurus Rex. The tests conducted were linked to three aspects of model building: assembling the model, glueing it and painting it. These qualitative tests allowed understanding how this material would function when adopted in the model kit industry.
In addition, a quick comparison between Limex and Polystyrene as made by cutting a section of runner using nippers, in order to see the difference.
The tools used (Image 59) were mainly nippers, which were used to detach the model kit components from the runner, a hobby knife, to clean the mould lines and the stress marks from detaching the parts from the runner, the acetone based solvent, a primer, brushes and colours.

The first test was about the ease of assembly and the possibility of using a solvent glue to connect the components and bound them together.
Before starting assembling the model kit, the components were detached from the runner using the nippers. The runner was designed by BANDAI SPIRITS using the innovations described previously. Thanks to those innovations, the detachment of the components was relatively easy, with only a few connection points between runners and components. That said, using the nippers caused some stress marks, which were then removed using the hobby knife.
The model kit was then assembled. AN important element were the interlocking joints present for various elements of the kit, like the connection between the pelvis and the spine.
The assembly using the interlocks worked relatively well for bigger joints, like the one between the legs and the pelvis (Images 61 and 62). Other joints, like the tail one, were very weak and did not hold the parts properly. In particular, the tail joint was the weakest one, with the tail constantly falling off. Another issue was given by the interlock between the pelvis components and the spine, since the connection points were small, making it difficult to connect the parts.

After this first test, an acetone-based solvent glue was used to glue the connection points. The glue used was “Tamiya Thin Cement”, one of the most commonly used acetone-based solvent glues. This type of glue does not harden creating a rigid connection between two parts of a model kit, but fuses together the two parts. This effect is caused by the acetone in the solution, which affects thermoplastic resins like Polystyrene. The Thin Cement was applied to both the leg joint with the pelvis (Image 63) and the tail joint. The glue not only bonded together the components without an issue, but the strength of the bond allowed for a very solid structure that held the tail in the wanted position without issues. This first test allowed immediately to understand that the tools used for the first steps of model building are well suited to be used with Limex. This result, especially the fact that a very common glue worked without any issue, confirms that Limex may be adoptable by the model kit industry. As a final note, the issues related to the assembly may be caused by the size of the connection points. On a different model kit, either with larger interlocking joints or a generally different shape, this issue may not appear.

Qualitative tests

A quick test was made by cutting part of a Polystyrene runner and part of a Limex runner. As it can be seen in the Image 64, both present stress marks and got “crushed” where the nippers cut. The main difference is that Limex is slightly softer that Polystyrene, thus getting more compressed than the other material. It also felt easier to cut that Polystyrene. This difference also caused stress marks to appear more easily on the parts that were cut from the runner, though it was possible to remove them by lightly scratching them using a hobby knife.

In order to test the ability of Limex to be painted, two separate tests were made. One runner of the model kit was partially painted using only an acrylic model paint, while another runner was first primed using a model building apposite black primer, then painted using the same colour.
The acrylic paint chosen was “Orange Fire” from Vallejo, colour code 72.008. The reason for this choice was the fact that this paint is very pigmented and bright, which helped show on the runner. The company Vallejo is well known in the hobby, with high quality hobby paints, which are used on both resin and plastic model kits.

Before applying the colour, a few drops of it were placed on a wet palette. This kind of palette works by using a wetted sponge as the base for a thin hydration paper. This helps maintaining the paint wet during long paint sessions, as well as lightly diluting the paint, making it easier to apply on models.

The colour was first applied to the non-primed runner, then on the primed one. Immediately a few observations could be done.
First of all, in both cases multiple passages and layers of paint were needed. In the case of the primed runner, though, this was needed in order to cover the dark primer underneath. Even after the test, additional layers may be needed to guarantee a consistent coverage.
Regarding the non-primed runner, instead, multiple layers were needed to help the paint adhere to the plastic. This is common when painting plastic model kits, since the smooth surface does not allow for an easy adhesion of the paint.
Demonstrating this, the paint applied to the primed runner adhered much better than the application on the non-primed runner. The paint used on the non-primed runner, as a matter of fact, was easily removable, even just by scraping it with a fingernail. In contrast, the paint applied to the primed runner was not easily removable.

In both cases, though, the paint did not cause any reaction with the material, again confirming that Limex could be adopted in the model making industry.

Image 66. Poster explaining in broad strokes how the Gunpla Recycling Project works
Image 67. Poster marketing ECOPLAs
Image 68. Box collecting empty runners for the Gunpla Recycling Project
Image 69. BANDAI SPIRIT Shizuoka Plant
Image 70. First ECOPLA model kit, the RX-78-2, the original Gundam from the 1979 anime

User Waste Recovery and Reuse

Gunpla Recycling Project

Introduction

The second case study analysed covered the recovery and reuse of user waste. Researching initiatives aimed to recovering plastic, the majority focused on reusing the plastic deposited in landfills or, in general, polluting the environment, like the plastic present in the seas. These projects, while very impactful on the effects that they have on the environment, work towards plastic waste that was not properly disposed of. The research, instead, was focused on analysing projects with the aim to work together with the customers avoiding improper disposal and guaranteeing the correct reuse of the waste.

The Gunpla Recycling Project [47] was launched by Bandai Namco in April 2021 with the objective of recovering empty runners from the customers, then recycling using thermal, mechanical and chemical methods.
For the first year of its implementation, this project had the objective of collect 10 tons of plastic, with the intent of further increasing the amount in the future.
The objective of this project, other than the one mentioned above, was to reflect the eco-friendly efforts that Bandai Namco, as a company, is adopting to reduce its carbon footprint. Thanks to the Gunpla Recycling Project, the company aims to demonstrate said efforts using the Gundam IP.

Organization

The Gunpla Recycling Project organization takes advantage of the various businesses that compose Bandai Namco.
Thanks to the various amusement facilities owned by the company, it was possible to organize the waste recovery hotspots in the stores that sell, among other products, also Gunpla Model kits. Focusing on the stores owned by the company, it was possible to organize a solid network which did not require collaboration with third party stores.
The stores where the collection boxes (Image 68) were located were part of the BANDAI NAMCO Amusement line. 190 stores were selected all over Japan in order to give the possibility to a large amount of customers to participate, while still containing the investments needed.

The collected runners were then recycled using three methods (Image 66). The first one was mechanically recycling part of the runners, combined with plastic leftovers from the production processes in order to manufacture new model kits.
Another portion of the runners was used as a material for verification testing targeting the realization of chemical recycling and the rest was reused via thermal recycling.

Mechanical Recycling

The mechanical recycling of the recovered plastic waste is operated at the Bandai Hobby Center. In this facility, which also produces the Gunpla model kit lines, the waste follows the usual steps for mechanical recycling.
First, the runners are sorted by type of material. This sorting is necessary, since, while the majority of the model kits are produced using Polystyrene, some components use other thermoplastic resins. For example, smaller components are manufactured in both ABS (Acrylonitrile Butadiene Styrene) and Polypropylene. The sorting happens in order to avoid contamination between materials, which could render useless entire recycled batches.
Then, the runners are ground in finer pieces before being fed to a pelletization machine. This type of extrusion forming machine heats up and melts the material, thus grinding the runners before this passage helps the melting and, consequently, the extrusion and pelletization.
The pelletization happens using a method called granulation, in which the melted material is extruded and cut into pellets. The pellets are then cooled quickly, in order to avoid them sticking together due to their heat, and instead maintaining their shape.
Once the runners are processed in pellets, they can be input back in the production process. The material obtained through the mechanical recycling is called "ECOPLA". The name comes from the fact that is composed exclusively of recycled plastic and, since there is no colour sorting, the material has a dark brown colour (Image 67) [48].
This material is already in use, but the amounts of runners recovered and then reused this way is still much lower than the plastic used to produce the normal model kits. The first model kit produced using ECOPLA that was unveiled was a Gundam RX-78-2, the original mecha from the first animated series, in a 1/144 scale (Image 70).

User Waste Recovery and Reuse

Gunpla Recycling Project

Chemical Recycling

Chemical recycling plastic is a method which uses chemical reactions to transform the plastic in a new material.
In the case of Polystyrene, the recycling focuses on thermally decomposing the material and returning it in a Styrene monomer, its raw material. The monomer would then be polymerized back into Polystyrene, to be input back in the production process.
This method seem to be particularly compatible with Polystyrene, thanks to its low thermal decomposition energy. This makes it very suitable for chemical recycling, and, since raw materials obtained by chemical recycling contain few impurities, the polymerization of the monomer would be of high quality [50].

The pyrolysis cycle works by applying very high heat to the material in complete absence of oxigen. This results in a melting and coating of the particles of the material, which slowly depolymerises.
From that, the Polystyrene becomes an oligomer, which by cracking (the moment in which the polymer completely fragments) completely reverts to the Styrene monomer.
Secondary reactions produce aromatics and polycyclic aromatic hydrocarbons. Each step is influenced by the application of heat, which can hinder or enhance the effects of pyrolysis. For example, the final cracking step is greatly enhanced by the application of heat.

As a result, the styrene monomer yield is strongly influenced by both temperature and gas flow rate, with the maximum yield being 70.6 wt% at 500 °C and a gas velocity twice the minimum one (1 mL/min)
(Image 71).

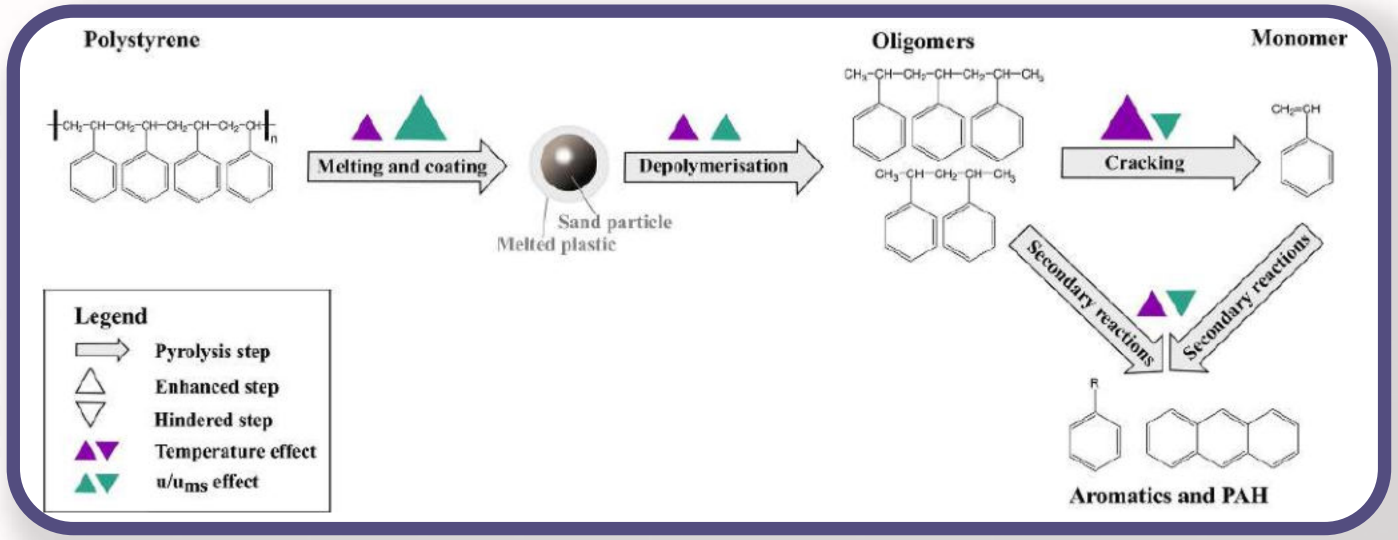


Image 71. Pyrolysis cycle of Polystyrene

Chemical Recycling

Once the styrene monomer is collected from the pyrolysis cycle, it is free from any additives that were added during the previous polyimerization cycle. This means that, if the monomer were to be polymerized without adding anything, it would form Polystyrene in its base form, a colourless solid.

To polymerize the monomer, it is first pumped in a “feed dissolver”, where is mixed with the additives necessary to produce the wanted type of Polystyrene.
Then, this mixture is further agitated in order to blend everything together. Then the mixture is heated in order to reach the reaction temperature which will initiate the polymerization. Then, once this process is concluded, the residual monomer and other substances are removed. Molten Polystyrene is extruded using a stranding die plate, then cooled using a water bath. The final steps see the material pelletized and sent to storage.

Thermal Recycling

The final recycling method employed by Bandai Namco transforms the waste into energy generated during incineration. While this type of recycling is not universally recognized, since the reuse of the material sees it become a form of energy via a method that can pollute the environment further, the company employs partners to incinerate the waste to produce the energy needed to power its facilities.

The recycling is not operated by Bandai Namco, but they partnered with J&T Environmental Co, Ltd, who will carry out the thermal recycling. The electricity generated will then be purchased by Urban Energy Co, Ltd, a group company of J&T. This company provides a system for its clients where the amount of power generated by its customers is discounted on the customer's electricity bill. This system is called "Soden Wari R", and the discount is calculated accordingly to the amount of waste when Urban Energy Co., Ltd. purchases electricity generated from waste and supplies it to the facility where the waste is generated. The service started in 2017.

Results

The results of the Gunpla Recycling Project were described in the Bandai Integrated Reoprt of 2022. The results up to the third quarter of 2022 registered a total collection of 11 tons of empty runners, exceeding the original goal of 10 tons. This positive result confirmed the interest that the model building community has towards making their hobby more eco-friendly. An interesting point is the fact that this initiative did not present any incentives to the participants and still reached and overcame the initial goal.

In light of this project and its success, another company started a similar initiative in 2023.
Games Workshop announced at the beginning of March 2023 that an initiative called "Warhammer Recycling Programme" [51], which started at the end of the month. In 28 stores around the United Kingdom, the model builders would be able to deposit old Warhammer runners, together with empty Citadel paint pots. These will be recycled in new materials and products. The plastic used for the model kits and the runners is high quality, so the recycling possibilities are variegated, including garden planters and playground equipment. Despite the quality, the standard for the Games Workshop model kits do not allow for the input of the recycled material back into the production process, though the company stated that they are investigating such use for the future.

Image 72. “Lapis” plastic panel, produced using HDPE industrial waste and waste sorting. The “Lapis” panel is part of a line designed in a way to resemble marble

Image 73. “Maria Antonietta” kitchen, with top and doors made with “Milk” plastic panels, produced in HDPE from waste sorting

Third Party Recover and Reuse Network

Plastiz & Precious Plastic

Introduction

The third case study researched was related to the analysis of examples of waste recovery networks organized not by proprietary companies, but by third party ones. This research focused on projects that worked towards recovering plastic waste from any source and reusing them to create something new. The examples found were Plastiz, an Italian company based in Turin, and Precious Plastic, the network of which Plastiz is part of. Both the Italian company and the project focus on transforming plastic waste in something with more value, “upcycling” it [52].

Plastiz is a startup born from the Social enterprise SRL Izmade, a design and architecture study which designs and produces furnishings and fittings promoting social impact and environmental sustainability.
As a company, Plastiz focuses on producing high quality panels and bars made in compressed plastic waste, using methods that give the material new beauty.
The products are produced by compressing plastic shards, after designing the texture and the patterns that should appear on the panels.
An example of this is the panel “Lapis” (Image 72) [53], produced using exclusively recovered HDPE waste from industrial waste and waste sorting. This panel is part of the “marble” line, the designs of which are developed in order to resemble the textures and the details of marble, but lighter and cheaper. The panels are waterproof and resistant to wear, and the colours are selected in order to maintain a look similar to marble slabs, though the panels are available both in black and white and in coloured versions.
All the panels produced by Plastiz are monopolymeric, without additives or paints (avoiding adding potentially harmful substances or pollutants), completely recyclable, resistant to water and chemical agents and easy to clean and maintain.
The company also stated that their panels can be worked with, giving a list of potential processes that can be used: cut (even with CNC machines), grinding and planing, drilling and engraving, edging, bending and thermoforming, smoothing and polishing.
Considering that each polymer has different properties, Plastiz presents a guide to the possible processing that can be done to each material.

In addition to panels and bars, Plastiz also produces various furnishing using the plastic waste. AN example of this is the kitchen “Maria Antonietta” (Image 73) [54], which presents top and doors made with coloured “Milk” panels. Like the Lapis panel, Milk panels are produced using HDPE.

Plastiz

Plastiz has the objective to sensibilize and create awareness on the problem of plastic waste, on circular economy and on sustainable entrepreneurship. The company does this using its products, the processes used to manufacture them and the raw materials used.
Thanks to this, Plastiz states that they are a company that does not have an impact on the environmental resources of the planet, since by regenerating plastic waste they avoid it polluting nature, ending up in a landfill or incinerated.

Image 74. Extruder machine developed by Precious Plastic India (Industrial Safety Standard)

Image 75. “Pearl” table. The tabletop is made in 100% recycled post-consumer Polystyrene, while the tubular legs are produced by a Czech company

Third Party Recover and Reuse Network

Plastiz & Precious Plastic

Precious Plastic

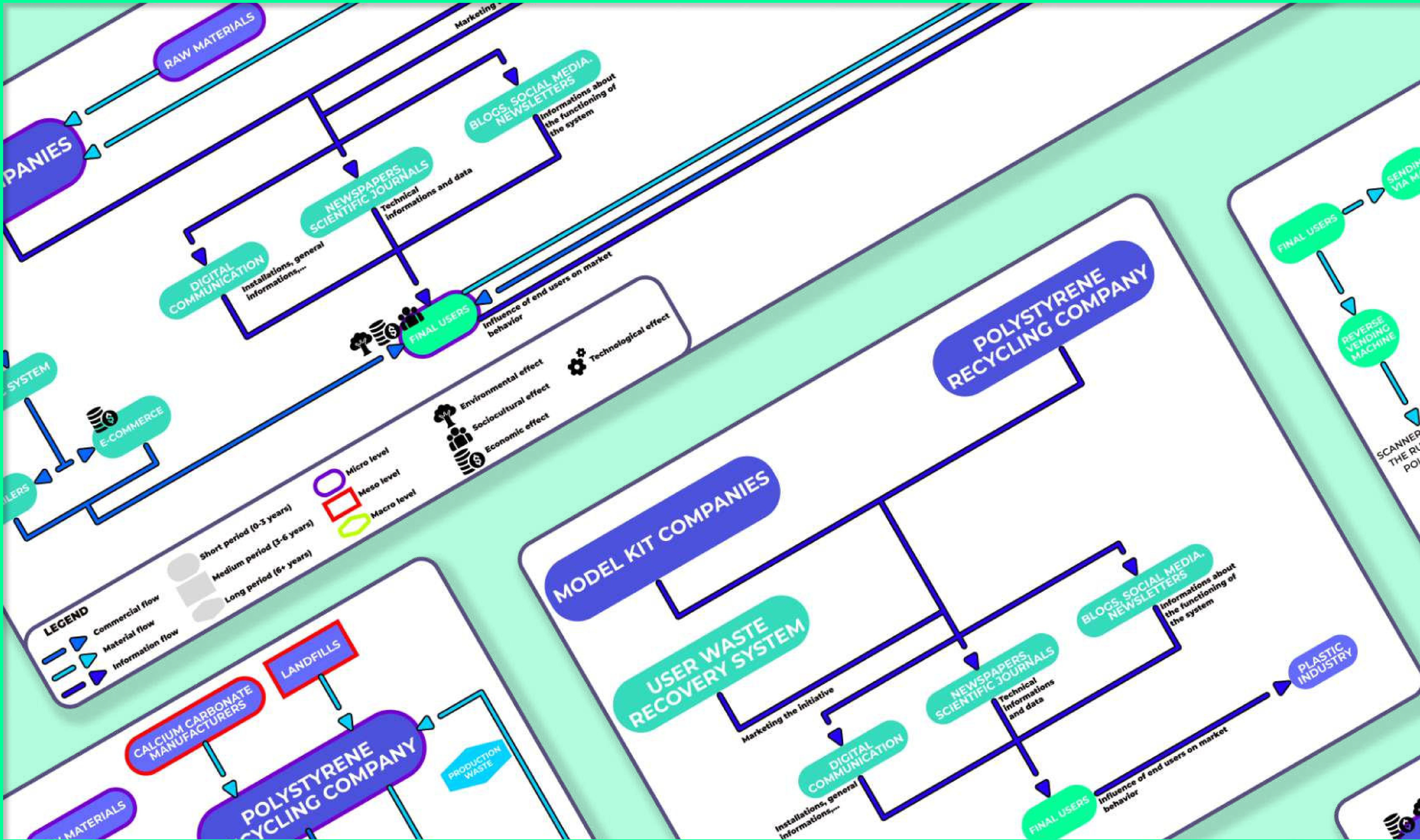
Precious Plastic is a network of individuals that came together in order to fight the improper disposal of plastic and the issue of plastic pollution by helping anyone interested in participating in a recycling network geared towards resolving those issues [55].

In order to create this network, Precious Plastic was initially launched in 2013 by Dave Hakkens, a student of Design Academy in Eindhoven. In 2013, during his graduation show, he released Precious Plastic Version 1, a machine that allowed anybody to recycle plastic in pellets. In 2014, thanks to the Creative Commons license of his project, three more people replicated Hakkens' machine, kickstarting the project itself. Precious Plastic grew as a community and, by 2018, it became a global network. In 2020 the platform "Precious Plastic Universe" was released with the aim to become the global alternative recycling system.

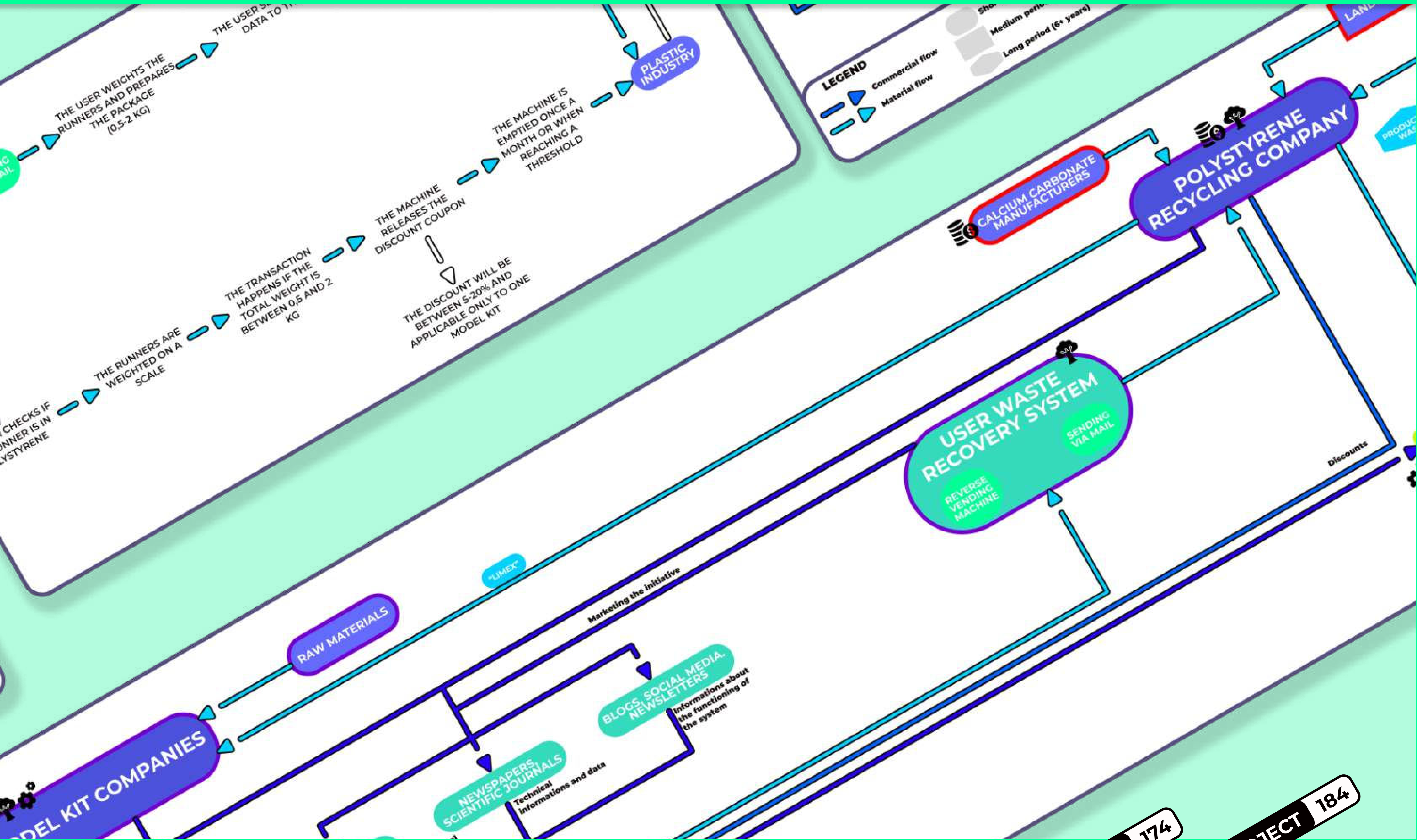
In the Precious Plastic Universe, each participant chooses their Space [56], in which they have their own mission and focus on their task, while still being part of a whole and working together. Each Space is distinct with an icon.
Participants in the "Members" Space provide the initial plastic waste and buy Precious Plastic recycled products.
"Workspaces" are where plastic gets transformed from waste into valuable materials or products. There are five different workspaces: Shredder, Extrusion, Sheetpress, Injection and Mix.
"Machine shops" produce and build parts, moulds and entire machines for other workspaces and projects in the local recycling network.
"Community Points" connect and grow the network locally. Strengthening the existing local community while bringing in more & more people.
"Collection Points" gather plastic from neighbours, organisations and businesses to be used by local Shredder Workspaces.
This distinction allows for an organic organisation of the tasks and each participant can be part of the community based on their own skills, the local needs and their budget.
The focus of Precious Plastic is to help each participant to act locally, in order to expand their phylosophy to as many people as possible and to act in as many local realities as possible.

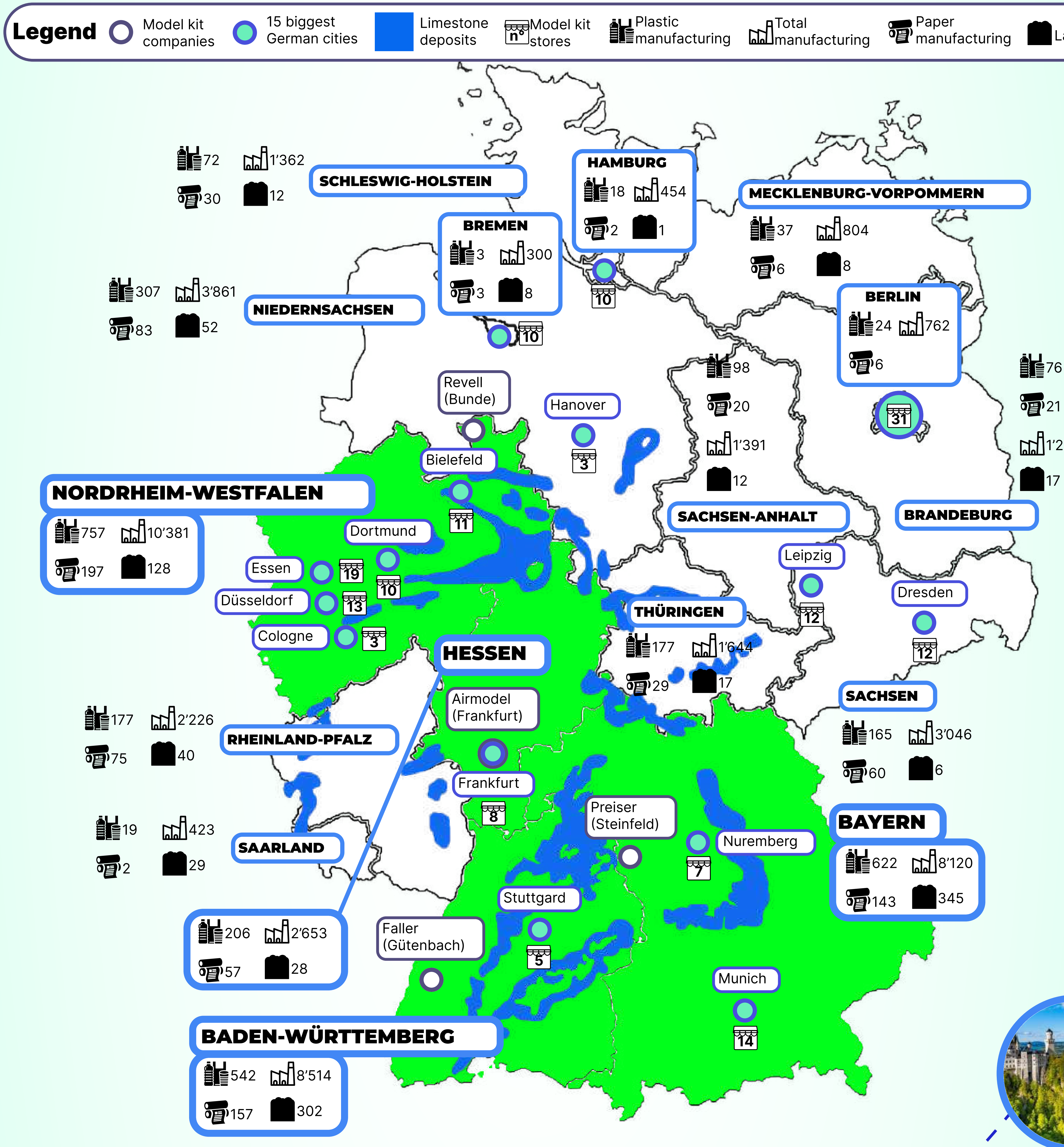
Precious Plastic

In addition to the Precious Plastic Universe, the network presents also a "Bazaar" [57].
The Precious Plastic Bazaar is a marketplace that connects all the Spaces, allowing the sales and purchasing of Precious Plastic machines (e.g. extruders, Image 74), moulds, raw materials and products manufactured by the community (Image 75). All the items listed are created by Precious Plastic Workspaces from all around the world
The Bazaar is also a way for this network to fund itself: each transaction presents a 5% fee when items are purchased, covering the costs of running the platform.
For this reason, there are a few requirements and rules in place. For example, when starting a transaction, the user agrees to finish it on the Bazaar. This rule is in place in order to avoid users trying to not cover the transaction fee.
Another requirement is a check-out per seller, since the as the payment goes directly to them. Similarly, any dispute between sellers and customers need to be resolved between them. The Bazaar does not take any responsibility towards disputes.



5. Systemic Project


THE USER WEIGHTS THE RUNNERS AND PREPARES THE PACKAGE (0,5-2 KG)
PLASTIC INDUSTRY
THE MACHINE IS EMPTIED ONCE A MONTH OR WHEN REACHING A THRESHOLD
THE MACHINE RELEASES THE DISCOUNT COUPON
THE DISCOUNT WILL BE BETWEEN 5-20% AND APPLICABLE ONLY TO ONE MODEL KIT
THE TRANSACTION HAPPENS IF THE TOTAL WEIGHT IS BETWEEN 0,5 AND 2 KG
THE RUNNERS ARE WEIGHTED ON A SCALE
LEGEND
Commercial flow
Material flow
Medium period
Long period (6+ years)
CALCIUM CARBONATE MANUFACTURERS
POLYSTYRENE RECYCLING COMPANY
USER WASTE RECOVERY SYSTEM
SENDING VIA MAIL
REVERSE VENDING MACHINE
Discounts
"LIMEX"
Marketing the initiative
RAW MATERIALS
BLOGS, SOCIAL MEDIA, NEWSLETTERS
Informations about the functioning of the system
NEWSPAPERS, SCIENTIFIC JOURNALS
Technical informations and data
MODEL KIT COMPANIES



NORDRHEIM-WESTFALEN

Main manufacturing industries:
1. Metal products
2. Machinery and equipment
3. Food
4. Rubber and plastic products

11.1 mn inhabitants
GRP: **793,790 billion US$**

HESSEN

Main manufacturing industries:
1. Machinery and equipment
2. Metal products
3. Food
4. Rubber and plastic products

11.1 mn inhabitants
GRP: **793,790 billion US$**

BADEN-WÜRTTEMBERG

Main manufacturing industries:
1. Metal products
2. Machinery and equipment
3. Food
4. Rubber and plastic products

11.1 mn inhabitants
GRP: **793,790 billion US$**

BAYERN

Main manufacturing industries:
1. Food
2. Machinery and equipment
3. Other non-metallic products
4. Rubber and plastic products

11.1 mn inhabitants
GRP: **793,790 billion US$**

Territory size

Germany	357.588 km^2

Population

Total population	84.3 mn
Urban population	73%
Foreigners	11.4 mn

Economics

GDP	5.5 trillion US$
GDP per capita	66'132 US$
Inflation	10%

Three sectors GDP

Agriculture	0.7% (0.0385 trillion US$)
Industry	30.7% (1.6885 trillion US$)
Services	68.6%% (3.773 trillion US$)

Major cities

Germany	15
4 Lander	9

Landfills

Total (2021)	1005
Plastic input (2021)	509'800 tons

Pfand System

Plastic packaging recovered	97%
Machines in Germany	300'000

ERDE System

Plastic recovered	38'476 tons
CO_2 saved	42'748 tons

Plastic and paper industries

Total plastic production	36.3 billion €
Total paper production	4.7 billion €

Model kit stores

Total in 15 cities	168
Total in 4 Lander	90

Total inhabitants 84.3 mn

Total Men	41.5 mn
Total Women	42.8 mn
Urban population	73% (63.9 mn)
Median age	45.7
Life expectancy	81.9
Life expectancy (Men)	79.6
Life expectancy (Women)	84.1

Total foreigners 11.4 mn

Foreign men	5.9 mn
Foreign women	5.5 mn

Citizenship

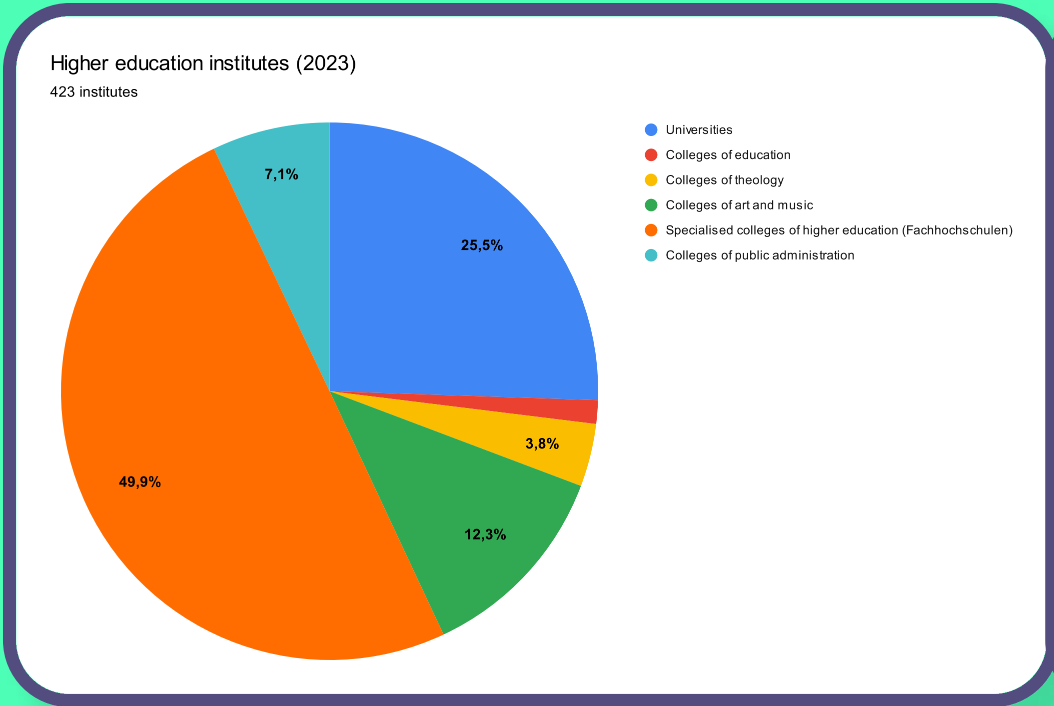
German	72.3 mn
Foreign	10.9 mn

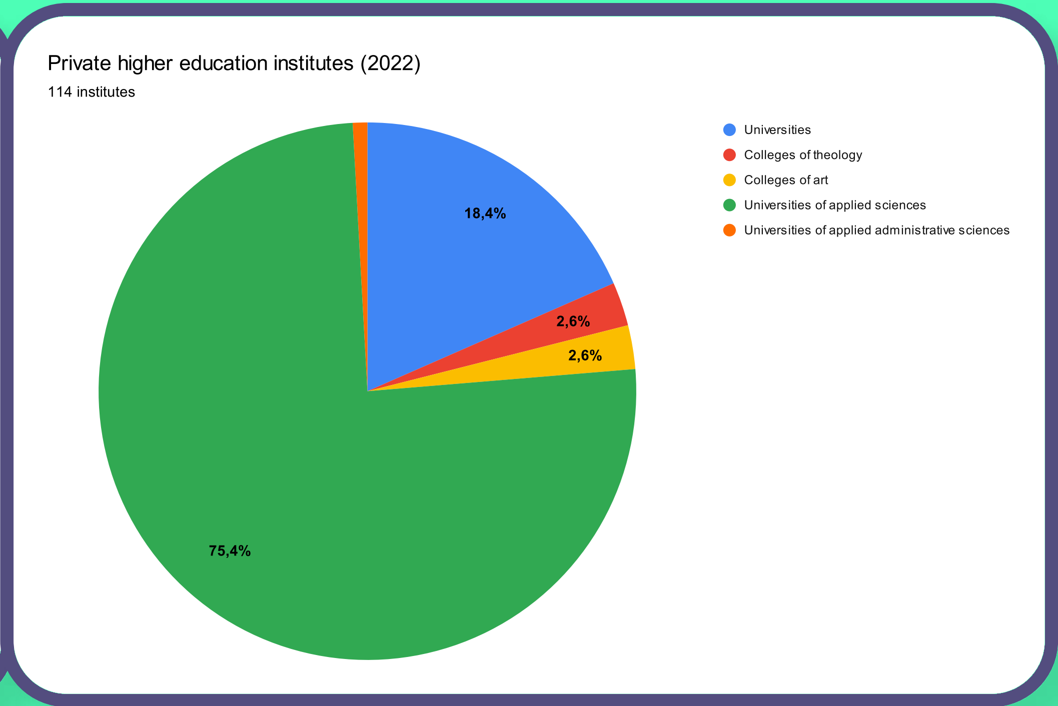
Country of Birth (C 2011)

Germany	68.4 mn
EU 27	4.2 mn
Europe (Other)	3.3 mn
Other country	2.9 mn
Unknown	1.4 mn

Religion

Roman Catholic	24 mn
Protestant	23.4 mn
Other/No/Unknown	32.8 mn





Territory size

Germany	357.588 km^2
Baden-Württemberg	35.751 km^2
Bayern	70.550 km^2
Hessen	21.115 km^2
Nordrheim-Westfalen	34.098 km^2

Model kit stores

15 major cities	168
Major cities in the Lander (9)	90

Test Nation

Germany

Introduction

This chapter will focus on the analysis of a test nation in which the systemic project will be applied, the analysis of the Polystyrene as a material and how the new model kit industry system will work in the framework of the country.
In order to do so, it was necessary to define which country the system would be more effective, considering various factors, such as: the plastic industry of the nation, its economy, the presence of recycling initiatives and how they work and, if possible, additional key points that would make it particularly interesting.

The chosen country was Germany, thanks to its strong economy, its high rate of recovering and recycling plastic and the various systems adopted in order to reduce the pollution caused by its industries. In addition to that, the market analysis described in the first chapter indicated Germany as one of the key consumer countries for the model kit industry, together with the United Kingdom, the United States, China and Japan [34]. While all five countries were potential candidates for the test nation of the systemic project, both China and the United States were avoided due to their size, while both Japan and the United Kingdom have a user waste recovering system launched by model kit companies.
In addition to that, out of all the 15 most important cities in Germany presented model kit stores.
The country also houses four different model kit companies: Airmodel in Frankfurt, Preiser in Steinfeld, Faller in Gütenbach and Revell in Bünde. All four are companies with a long history, launching between the late 1940s and early 1970s. These companies work with plastic, with only Airmodel using vacuum forming instead of injection moulding.

Demography

The territory of Germany covers 357'588 km², with a total number of inhabitants around 84.3 millions. The country has an urban population of around 63.9 millions, meaning that around 73% of its inhabitants live in cities.
The average age of the country is around 45.7 years old, with a life expectancy of 81.9. This is slghtly higer of both the European age average (44 years old) and life expectancy (80.1 years).
The country houses around 11.4 million foreigners, 10.9 of which are not German citizens.
The country is relatively religious, with 24 million inhabitants following the Roman Catholic doctrine and 23.4 million following the Protestant doctrine.

Germany is a well-educated country, with 33.5% of the population having reached University or Fachhochschule (University of Applied Sciences) [59] and 12.9% having obtained a vocational Diploma [60].
The country counts a total of 423 public higher education institutes and 114 private higher education institutes [61].

Demography

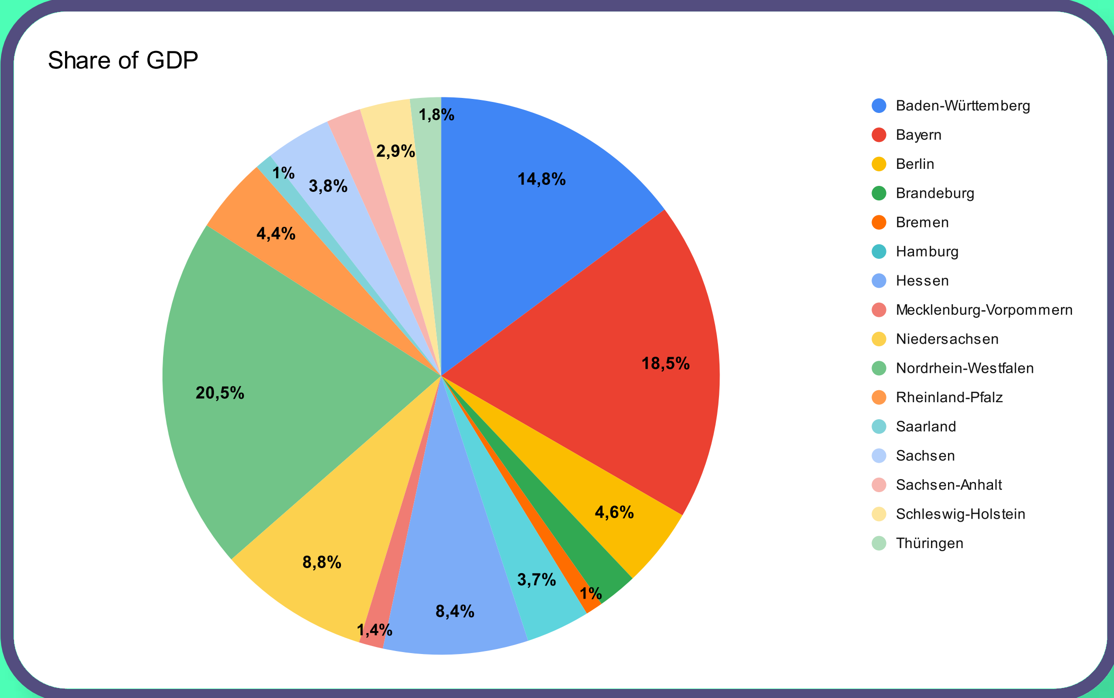
While it was not possible to obtains sufficient data regarding the education of model hobbyists, it is possible to compare the education data of Germany with the education data of professional model builders. According to the american website "Zippia" [62], 66% of model builders present a Bachelor's degree, 14% have an Associate degree and the remaining 20% is divided between High School diploma, Master's degree and other degrees.
In Germany, model builders would probably come mainly from Art and Music colleges, both private and public. Another option could be technical schools, especially from ones that offer woodworking and small details work. In addition to that, Architectural schools may launch scale model builders, in particular by offering a Curriculum centered around scale models of buildings and dioramas.

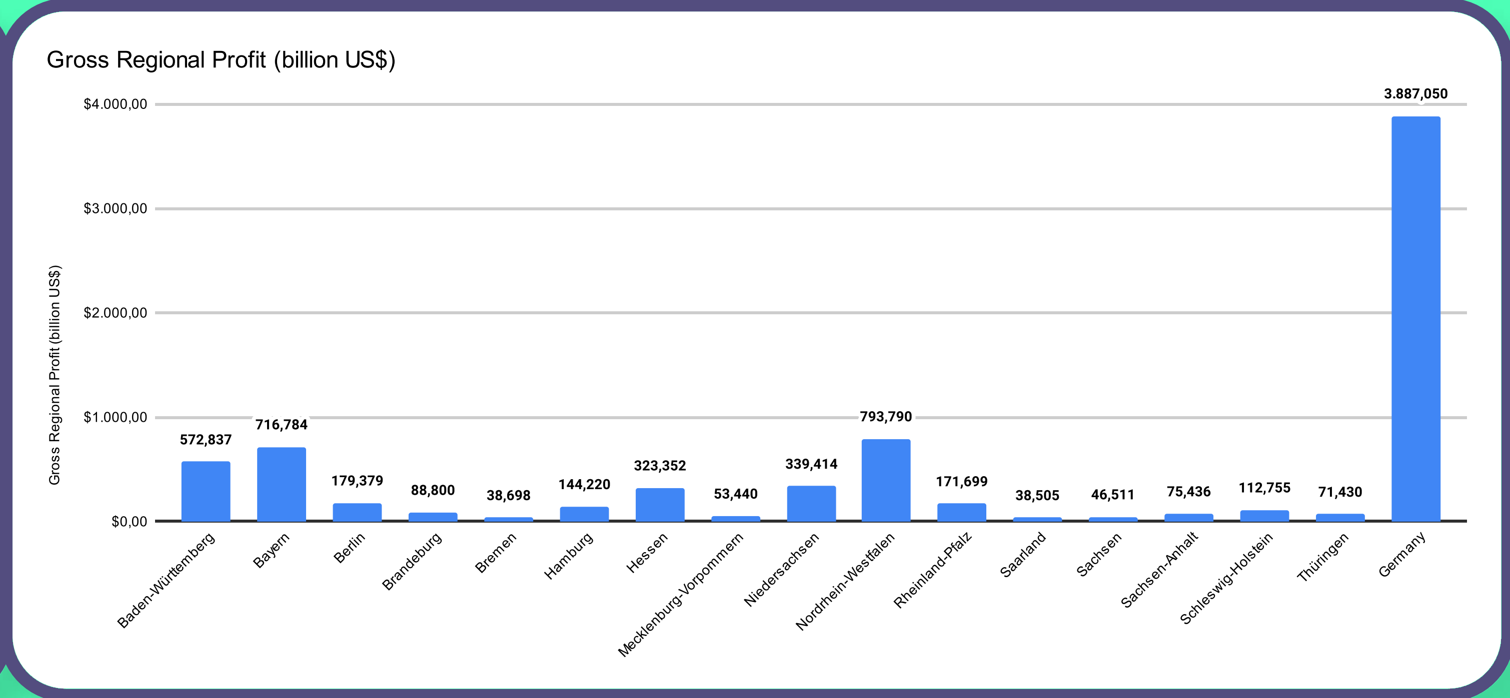
Territory

The country is divided in 16 Federal States, called "Länder". The capital, Berlin covers one itself, like the cities of Bremen and Hamburg. All three are part of the 15 most important cities of the country.
As it is possible to notice from the map, the four highlighted Länder Hessen, Nordrheim-Westfalen, Bayern and Baden-Württemberg have a few elements in common which make them very interesting considering the elements for which Germany was chosen as test nation.
The first and most noticeable element is that all four of the model kit companies are located in one of these Länder: Revell is in Nordrheim-Westfalen, Airmodel is in Hessen, Preiser in Bayern and Faller in Baden-Württemberg.
Another important element is that all four Länder contain at least one of the 15 most important cities of the country. In particular, Nordrheim-Westfalen hosts a third of all of 15 cities (Bielefeld, Dortmund, Essen, Düsseldorf and Cologne).
In addition to that, as it will be described more in detail further in this chapter, these four Länder are the richest of the country.

Germany presents a large amount of limestone deposits between the Länder of Niedersachen, Hessen, Nordrheim-Westfalen, Rheinland-Pfalz, Baden-Württemberg, Bayern and Thuringen. As it is possible to notice from the map, the largest deposits appear to be situated in Baden-Württemberg and Nordrheim-Westfalen. This information is particularly useful in the definition of a potential location for the initial development of the new system. Developing a new material based on Limex, using Polystyrene as thermoplastic resin, would require the purchase of the inorganic filler. If a company were to locate itself in a territory rich of the raw materials needed to produce said filler, it would allow it to reduce costs and shipping pollution.

As stated previously, the analysis of the territory included observing the amount of model kit stores present in the 15 most important cities of the country. The numbers varied largely from a city to another, with Cologne counting only three stores, while Berlin, the city with the largest amount, hosted 31 model kit stores. In order to focus on stores that focus on model kits, only the ones that were marketed as either "Hobby stores", "Model stores", "Model train stores" and "Miniature stores" were counted. Shops marketed as "Toy stores" and "Game stores" were avoided, since often sold only toys or videogames.
The results were in line with what noticed about the Länder previously: in the four highlighted Länder were located 90 out of 168 model kit stores, an average of 10 stores per 9 cities out of 15.





GDP **4.5 trillion US$** (nominal, 2023 est.)
5.5 trillion US$ (PPP, 2023 est.)

Agricultural sector **0.7% (0.0315/0.0385 trillion US$)**
Industrial sector **30.7% (1.3815/1.6885 trillion US$)**
Service sector **68.6% (3.087/3.773 trillion US$)**

GDP per capita **51'383 US$** (nominal, 2023 est.)
66'132 US$ (PPP, 2023 est.)

Inflation **10%** (September 2022)

Labour force by sector

Agricultural sector **1.4%**
Industrial sector **24.2%**
Service sector **74.3%**

Unemployment **2.99%** (2022)

Population below the poverty line **17%** (2020)

Persons employed and turnover of local units in manufacturing		Local units	Persons employed	Gross wages and salaries (Tsd. €)	Turnover (Tsd. €)
Manufacture of rubber and plastic products	2020	3'370	115'519	16'037'693	75'250'803
	2021	3'319	121'245	16'685'917	84'908'349
	2022	3'300	123'475	17'205'252	93'550'472
Manufacture of paper and paper products	2020	900	129'914	5'813'172	36'866'400
	2021	892	128'677	5'882'308	41'676'991
	2022	891	128'511	6'067'391	50'979'102

Key data of enterprises in manufacturing (2020)	Total turnover (mn€)	Material expenditure*	Staff expenditure*	Expenditure on services received*
Manufacture of rubber and plastic products	75'251	49,8%	25%	17,1%
Manufacture of paper and paper products	36'866	55,3%	18,9%	16,6%
Total manufacturing data (all industries)	2'096'575	54,7%	20,8%	16,6%

*share at total turnover

Test Nation

Germany

GDP and GRP

When analysing the economic data about Germany, it is possible to notice that is a very rich country, having the fourth highest nominal GDP (Gross Domestic Product) worldwide, at 4.5 trillion US$ and the fifth highest Purchase Power Parity GDP, at 5.5 trillion US$ [64].
When considering the Länder, the four highlighted on the map cover the largest shares of the GDP: Nordrheim-Westfalen covers 20.5%, Bayern 18.5%, Baden-Württemberg 14.8% and Hessen 8.4%.
Germany has a GDP more centered towards services and industries than towards agriculture. While the services sector commonly covers a larger share of GDP for the vast majority of countries (the world average is 63.6%, while the Germany GDP share amounts to 68.6%), the weight that the agricultural sector has on the German GDP is much smaller than average. Amounting to only 0.7%, compared to the world average of 5.9%, it shows that Germany may depend on its imports of agricultural products and goods. This is a stark contrast with the other two sectors, especially considering that the industry one covers the remaining 30.7% of the country GDP.
When considering the Gross Domestic Product per capita, Germany is on a lower position in ranking, compared to the country GDP. In particular, the nominal GDP per capita equals to 51'383 US$, placing the country at the 20th place, while the PPP GDP per capita amounts to 66'132 US$, placing Germany at the 18th place on the world ranking.

Regarding the GRP, or Gross Regional Profit, Germany as a country registered a total of 3'887.05 billion US$, and the four highlighted Länder participate the most in this total, as seen on the diagram on the left. In particular, Nordrheim-Westfalen showed being a particularly rich Länder, reaching 793'790 billion US$ of GRP, followed by Bayern with a GRP of 716'784 billion US$ [65]

Considering the labour force by sector, Germany maintains similar percentages for the services sector (74.3% of the working population is employed in the service industry), while registering a smaller percentage for the industry employment, which covers 24.2% of the working population. Finally, the agricultural sector sees a labour force equal to 1.4% of the country's.
Following this information, the unemployment rate of Germany, as of 2020, is equal to 2.99%, showing a steady decrease from 2005, when it reached 11.7% [66].
Despite this positive result, the population below the poverty line reached 17% in 2020, with some researches indicating that it could grow to more than 20% in the following years.

On a final note, Germany reached an inflation rate of 10% on September 2022.

Manufacturing

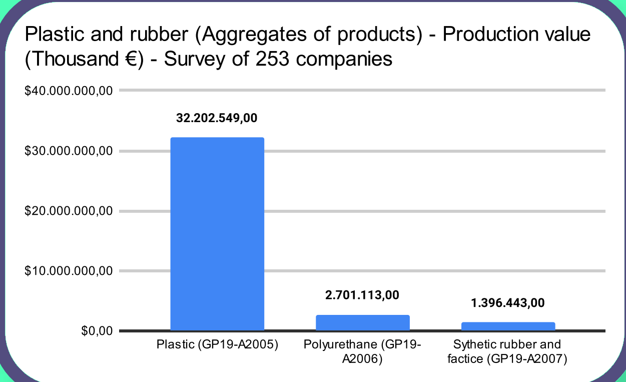
An important element in the economics of Germany were the plastic and paper industries. These industries will be key in the systemic project, therefore it was necessary to understand the state of them in this country.
The first analysis was linked to the number of companies in each sector, together with the amount of people employed and an estimate of monetary data. This information will allow understanding the impact that these industries may have on the territory, especially when comparing production, import and export and the recovery rate of plastic and paper waste.

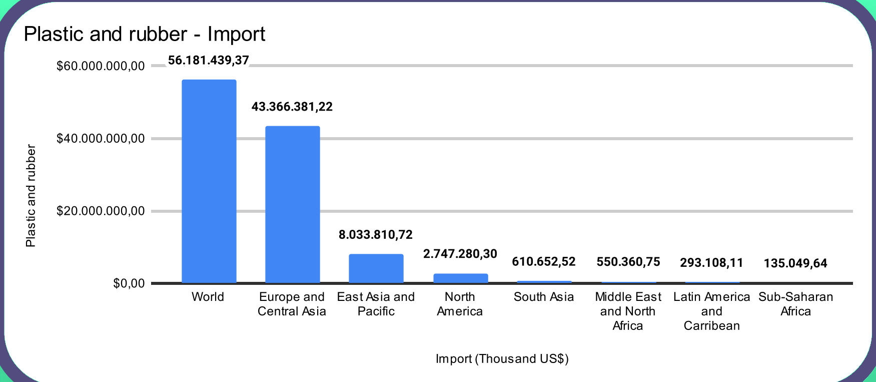
As it is possible to see from the table on the left, "Persons employed and turnover of local units in manufacturing", which was found on the Bundesamt statistics database Destatis [67], the amount of rubber and plastic products manufacture companies steadily decreases between 2020 and 2022, while both the amount of persons employed and gross salaries and wages increased. This follows the registered turnover data: the increase in value of the turnover shows an increase in sales and gross revenue in general. This, combined with the reduction of companies, shows that the plastic industry in Germany is slowly becoming more and more specialised, with high quality products and smaller companies get absorbed by larger ones, which can afford to employ more people each year.

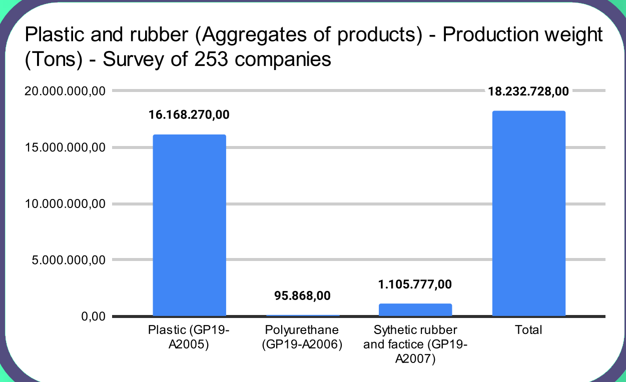
A similar, yet different situation can be noticed in the paper industry. In this case, like the plastic industry, the number of companies slowly decreased between 2020 and 2022, together with the number of employed people. In contrast, both gross wages and salaries and turnover increased in the three years. This situation seems to indicate that the paper industry, while still registering a positive turnover growth, is not able to sustain an increase in employees, forcing the ones still working in it to become more specialised, requiring higher salaries.

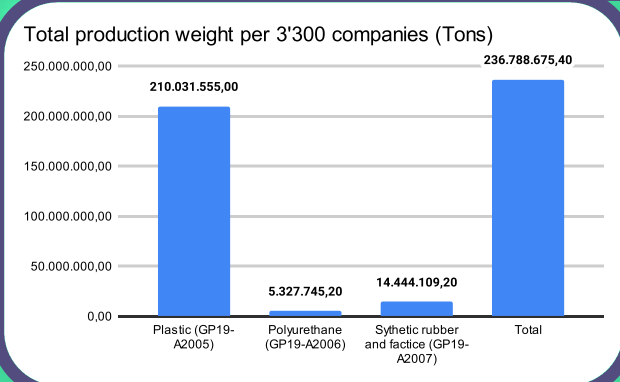
When comparing these data with the key data of enterprises in manufacturing (2020) [68], it is possible to gauge the amount of investments that each industry spends on various macrocategories. The percentages shown on the table are values related to the total turnover of each industry, showing the impact that these costs have on the gross revenue. Comparing the two industries, the plastic one has higher staff expenditure (25%), being also higher than the percentage of the total manufacturing turnover, while the paper industry has lower staff expenditure, in line with what shown in the previous table. Interestingly enough, though, the paper industry shows higher expenditure on the materials and has the same share of expenditure on services received as the total manufacturing data. Regarding said services, the plastic industry has higher expenditure than the other two.

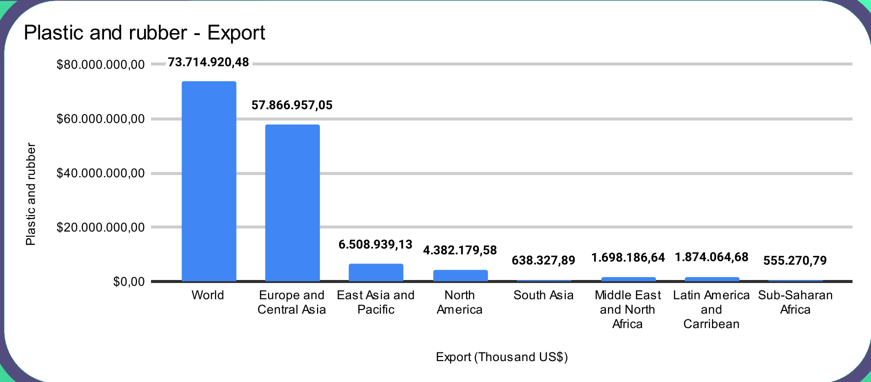
On the map presented on page 174 it is possible to notice that for each Länder were indicated the total amounts of industries, of plastic industries and of paper industries. In addition to that, the four highlighted Länder had the four main industries for number of companies indicated. Interestingly enough, all four Länder showed that rubber and plastic products manufacturing is one of the main industries, further cementing the hypothesis that it would be particularly effective focusing on those territories. When comparing the total number of companies in the plastic industry with the total of companies in those four Länder, it appears that around 64.4% of plastic manufacturing companies is located in those territories. Similarly, 62.2% of paper manufacturing companies is housed between the highlighted Länder.

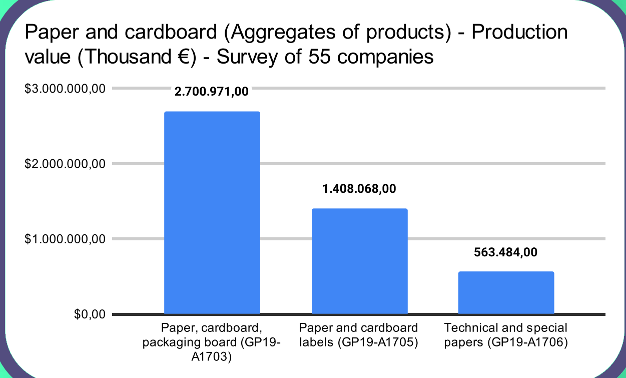


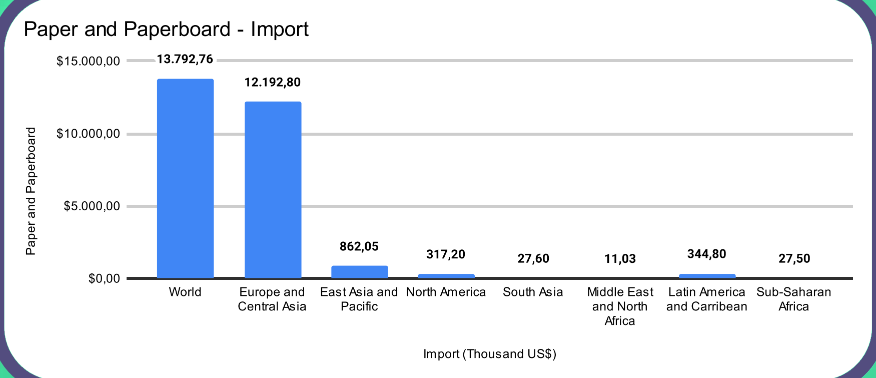


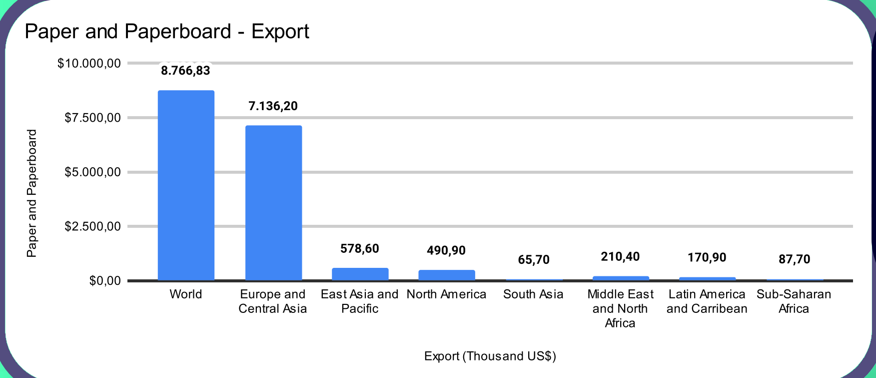












Goods and services for environmental protection overview by economic activities and types of services (2018)	Units with environmental turnover	Turnover of goods, construction work and services for environmental protection	Employees for the environmental protection
Manufacture of rubber and plastic products	394	4'942 mn€	20'672
Total	7'319	71'408 mn€	289'280

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Production

The paper and plastic industries were further analysed by researching the production volumes and the value of said production.
The data was obtained on the Bundesamt database Destatis [69], where the production of the manufacturing sector was divided in aggregates of goods. In addition to that, the database included both the production value in thousands of € and the production weight in thousands of tons. The data available on the Destatis database was obtained using surveys. On an additional note, not all the aggregates of goods presented data related to the produciton weight. In the case of the categories of plastic and paper products, only the paper ones lacked such data. Each aggregate was defined by a name and a code.

The aggregates of goods for rubber and plastic products were divided in the "Plastic" (GP19-A2005), "Polyurethane" (GP19-A2006) and "Synthetic rubber and factice" (GP19-A2007). As it can be noticed from the graph on the top left (Production value) and from the graph right under it (Production weight), the vast majority of the plastic industry manufactures products aggregated in the more generic "Plastic" category, which reached a value of 32'202'549 thousand € and a total weight of 16'168'270 tons in 2022. These results were obtained from a survey of 253 plastic manufacturing companies, equal to 7.7% of the total amount of companies in the plastic industry. If the sum of the three aggregates data were to be scaled to the actual amount of companies in the industry, an estimate of production weight would amount to approximately 236'788'675.4 tons. This result will be used later when comparing the amounts of plastic sold in Germany in 2022 with the amounts of plastic recovered using systems like the Pfand System.
Regarding the paper industry, the aggregates were divided between "Paper, cardboard, packaging board" (GP19-A1703), "Paper and cardboard labels" (GP19-A1705) and "Technical and special paper" (GP19-A1706). Between these aggregates, the production of "Paper, cardboard, packaging board" amounted to 2'700'971 thousand € in 2022. The survey covered 55 companies, equal to 6.2% of the total companies in the paper industry. If scaled, the production value of this aggregate would amount to an estimate of 45'016'183.3 thousand €. The overall total production value would amount to 74'927'790,3 thousand €.
As stated previously, it was not possible to obtain the production weight for the aggregates of "Paper, cardboard, packaging board" and "Paper and cardboard labels". This impedes both an accurate measurement of the amount of paper material in tons in the survey and in scaling these data to the total number of companies in the industry.

An interesting data that emerged while researching the manufacturing industries were the manufacturers of certain products that developed goods and services for environmental protection [70]. The macrocategory of rubber and plastic products was one of the industries counted, with 394 companies (5.4% of the total), with a total turnover of 4'942 million € (6.9% of the total turnover) and counting 20'672 employees (7.1% of the total amount). There were no companies from the paper industry in this database.

Import and export

A final analysis of the paper and plastic industries was related to the import and export of their products in and from Germany. The data was recovered using the website World Integrated Trading Solutions", which catalogued the import and exports if a country in macrogroups and organized the foreign trade data either for single countries, for world regions or towards the world as a whole. In particular, for more precise products, the data is either shown divided between single countries or the whole world, while the macrocategories data can be obtained also divided between world regions (e.g. Europe and Central Asia). In the case of the plastic industry, it is considered a macrocategory, thus it was possible to recover the data divided between world regions, while the paper industry is part of the "wood" macrocategory, which covered the IX and X sections of the Harmonized System (International Standard system for nomenclature) Nomenclature of 2022. In particular, the X section covers paper and paperboard products. In order to obtain the values for the paper industry, it was necessary to compare the import and export with the whole world of this industry with the ones of the Wood macrocategory.

Regarding the plastic industry [71], Germany shows much higher exports (73'714'920.48 thousand US$) than imports (56'181'439.37 thousand US$). In addition to that, both type of foreign trade are mostly focused on the European and Central Asia territories, which cover 78.5% of the total exports and 77.2% of the total imports. As a matter of facts, the exports towards Europe and Central Asia alone higher than the imports worldwide. This shows that Germany has, at least concerning this industry, the vast majority of business exchanges limited on these territories.

Concerning the paper industry, as stated previously, it was necessary to estimate the imports and exports amounts based on the ratio between worldwide paper imports and exports [72, 73], and the Wood macrocategory [74]. Comparing these data, Paper and paperboard imports (13'792.76 thousand US$) amounted to around 0.05% of the worldwide Wood imports (28'770'858.32 thousand US$), while the exports of the paper industry (8'766.83 thousand US$) amounted to 0.02% of the worldwide Wood exports (35'883'418.53 thousand US$).
The remaining data related to the various world region was estimated by applying the calculated ratios to the amounts of imports and exports for the Wood macrocategory. Similarly to the plastic industry, the majority of business exchanges for the paper industry are related to the European and Central Asia territories, with the imports amounting to 88.4% of the worldwide imports and the exports being equal to 81.4% of the worldwide total.
Contrary to the plastic industry, though, the paper industry sees imports than exports, with the European and Central Asia imports being higher than the worldwide exports.

Transport and secondary packaging (2020)	Total quantity collected (1'000 tons)	Destination: Sorting facilities (in-house and external) (1'000 tons)	Destination: Recovery operations (including scrap merchants) (1'000 tons)
Plastic	329,9	135	195
Paper and board	2'946,1	1'234	1'712
Total (Amounts corresponding to the total sum of all materials, not limited to plastic and paper)	4'731,8	2'218,3	2'513,6

Sales packaging: quantities collected from private final consumers (2020)	Total quantity collected (1'000 tons)	Collected by industry solutions (1'000 tons)	Collected by system operators (1'000 tons)
Separately collected plastic	13,7	0,9	12,8
Paper and board	1'679,7	19,6	1'660,1
Total (Amounts corresponding to the total sum of all materials, not limited to plastic and paper)	6'503	25,3	6'477,7

	Quantity delivered after sorting, including separately collected materials		Delivered for/to		
Sales packaging: quantities collected from private final consumers (2020)	Total (1'000 tons)	Including quantities delivered abroad (1'000 tons)	Mechanical recycling (1'000 tons)	Other forms of recycling (1'000 tons)	Energy reovery (1'000 tons)
Separately collected plastic	1'302,9	278,2	752,3	20,9	529,8
Paper and board	1'872,3	214,3	1'816	-	-
Total (Amounts corresponding to the total sum of all materials, not limited to plastic and paper)	6'436	568,5	5'098,1	95,2	780,7

Waste disposal: Germany, years, types of waste (2021)	Input in waste disposal facilities (1'000 tons)	Total plastic waste input 2019 (1'000 tons)	Total plastic waste input 2020 (1'000 tons)	Total plastic waste input 2021 (1'000 tons)
EAV-020104-U: Agriculture etc: Waste plastics (except packaging)	30	489,8	689,6	509,8
EAV-070213-U: Waste plastic	424,5			
EAV-070299-U: Plastics, synthetic rubber, fibres: Wastes n.o.s.	55,3			
EAV-030301-U: Pulp, paper cardboard prod.: Waste bark and wood	265.5			
EAV-030399-U: Pulp, paper, cardboard production: Wastes n.o.s.	29.1			

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Following the production of plastic and paper products, a research was conducted relatively to waste management, maintaining the focus on those products. The data retrieved from the Destatis database focused mainly on packaging, with an additional data related on the general waste treatment of types of waste, divided in macrocategories. The data related to packaging goes back to 2020, while the data on general waste management were dated to 2021.

The first data retrieved described the amount of transport and secondary packaging recovered and the destination of the waste [75]. Transport packaging, also known as “tertiary packaging”, includes all forms of packaging whose objective is to protect the products during transport, like containers, pallets, liquid tanks and drums. Secondary packaging, instead, indicates groups and bindings that contain more than one product. An example of secondary packaging is the film surrounding bottles of water, which also reports information on the products.
The total quantity collected for transport and secondary packaging made out of plastic amounted to 329.9 thousand tons in 2020, while the amount of the same products in paper amounted to 2’946.1 thousand tons. When compared to the total amount of these types of packaging recovered, the plastic ones were equal to 7%, while paper packaging amounted to 39.6%, almost six times as much.
The waste is redistributed between sorting facilities (both in-house and external) and recovery operations, which included scrap merchants. In both cases for plastic and paper, this redistribution leans slightly more towards recovery operations. This seems to be the norm, since this trend appears even for the total amount of recovered transport and secondary packaging.

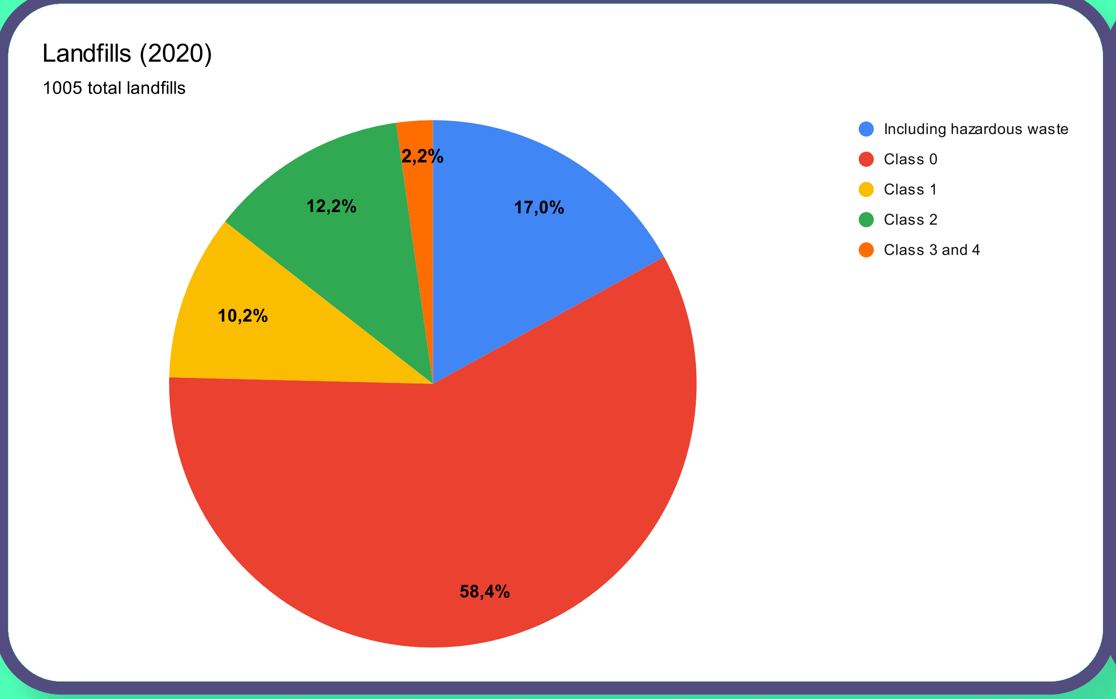
The other data collected related to packaging covered sales packaging. Also known as primary packaging, it protects and identifies the product. A perfect example are water bottles.
The second table, under the one related to transport and secondary packaging, covers the quantities collected from private consumers and the amounts collected by industry solutions and system operators [76]. As is shown in the table, the amount of plastic packaging is much less than the amount of paper and board packaging. This could be caused by a variety of reasons. For example, many food companies are slowly pivoting towards more green packaging, which often results in substituting plastic with paper. In addition to that, often paper packaging is used to ship electrodomestics and house appliances and paperboard ends up being much heavier than the foam plastic used to protect the products in these boxes. An interesting data related to the collection of sales packaging is the fact that the amount collected by industry solutions is much lower than the amount collected by system operators. As it will be explained further in this chapter, this is the result of various waste collection initiatives launched from the 1990s in Germany.
The other data related to sales packaging analysed the amount of collected waste sorted and delivered in order to be used in a variety of ways [77].
As it can be seen by the third table, the amounts differ greatly from the ones described previously. The reason for this is the fact that the amounts analysed focus on the waste sorted.

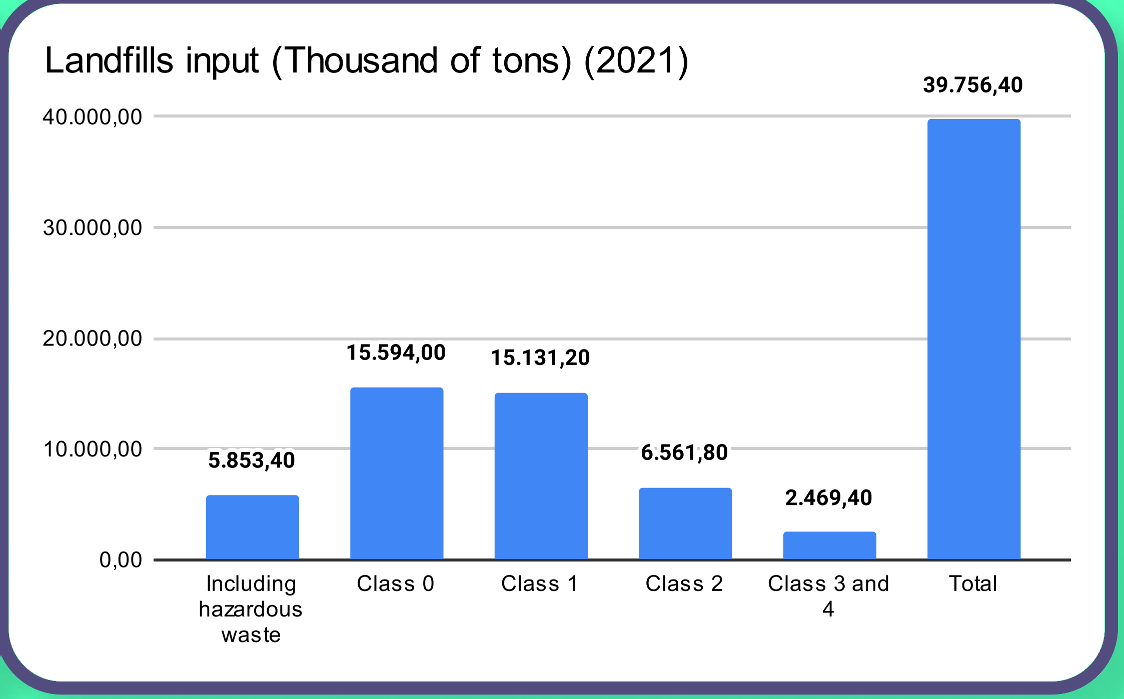
This means that the waste collected from private consumers does is not immediately delivered towards recycling solutions and first must be sorted in order to avoid contamination. This sorting causes the amount to pile up, resulting in higher amounts of waste redistributed.
Interesting information that can be extrapolated from this data is the fact that paper seems to be completely recycled, while plastic is not. As seen in the table, plastic sees small amounts of its waste being recycled using other forms rather than mechanical, like chemical or thermal recycling and around 40.6% is used for energy recovery, most likely being incinerated. This difference is very interesting, since it shows that paper there is much more effort and success in recycling paper than plastic, so much so that a large amount of plastic waste sees it life-cycle end, instead of being recycled.
When comparing this with the total amount of sales packaging redistributed, it can be seen that plastic waste covers the majority of the amount of waste used for energy recovery (67.9%), so it seems that such an issue may be unique to plastic. As additional proof of that, the sum of paper and plastic waste recovered from private consumers and redistributed amounts to 49.3%, less than half. In comparison, glass waste covers alone 31.7% of the total.

The final data regarding waste management covers the amount of plastic and paper waste input in waste disposal facilities in 2021 [78].
The types of waste are divided by macrocategoris, with plastic being divided between agricultural waste (EAV-020104-U), generic waste plastic (EAV-070213-U) and plastics, synthetic rubber, fibres and waste not otherwise specified (EAV-070299-U). Paper waste was divided between pulp, paper cardboard production (EAV-030301-U) and pulp, paper, cardboard production and waste not otherwise specified (EAV-030399-U).
The data shown on the table paints a different image than the one coming from packaging waste: in this case the total amount of plastic waste is much higher than the total of paper waste, with the generic “waste plastic” nomenclature alone covering the total of paper waste.
This shows that the amount of plastic that was not considered recyclable or reusable was quite high in 2021, totalling 509.8 thousand tons. It shows, though, a positive change when compared to the amount of user plastic packaging waste destined to energy recovery in 2020: the amount is 20 thousand tons lower.
Considering that the data from 2021 was presented as including any type of waste (the only category openly excluding packaging was the agricultural plastic waste), it could be speculated that the amounts of generic plastic waste was reduced greatly. As proof of that, when selecting as year 2020 instead of 2021, the total amount of plastic waste input in waste disposal facilities was equal to 689.6 thousand tons, 179.8 thousand tons higher. When compared to 2019, the input of that year amounted to 489.8 thousand tons. It is possible that one effect that the COVID-19 virus had on Germany waste disposal caused an increase of not easily recyclable plastic, like an increase of online purchases, which often contain Polystyrene foam to protect the shipped products. As it will be analysed later, foam Polystyrene is one of the issues that make recycling this thermoplastic challenging.

Waste management

Comparison between amounts of produced plastics and recovered plastics	Amount (1'000 tons)
Produced plastic weight (3'300 companies, 2022)	236'788,7
Plastic sold in Germany (production minus export)	163'073,7
Recovered plastic secondary packaging	329,9
Recovered sales packaging (separately collected plastics)	13,7
Sales packaging (separately collected plastics) - quantity delivered after sorting	1'302,9
Total plastic waste input in landfills in 2021 (1'000 tons)	509,8





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Comparison

After having obtained the data related to the production amounts of plastic and the amounts recovered through waste management programs, it was possible to compare the two data. In order to do so, from the estimated amount of plastic produced by 3'300 companies in the industry, the amount of plastic exported from the country was subtracted. The remaining amount, defined as "Plastic sold in Germany" was then compared to the amounts described in the previous page. While the amounts of recovered plastic packaging and the total plastic inputs in landfills are very small amounts when compared with the total plastic weight produced and sold in Germany, it is possible to notice that the total amount of plastic input in landfills is much lower than the amount recovered and recycled, even if that data is related exclusively to packaging.

As it will be explained in the following page, Germany is home of a variety of initiatives and acts focused on either recovering and recycling plastic waste, particularly packaging, or on reducing waste all together. Considering the fact that the systemic project will focus on recovering Polystyrene waste, which is a material often not considered worth the effort of recycling, there is a very real possibility that would see success, especially if working together with private citizens and offering incentives.

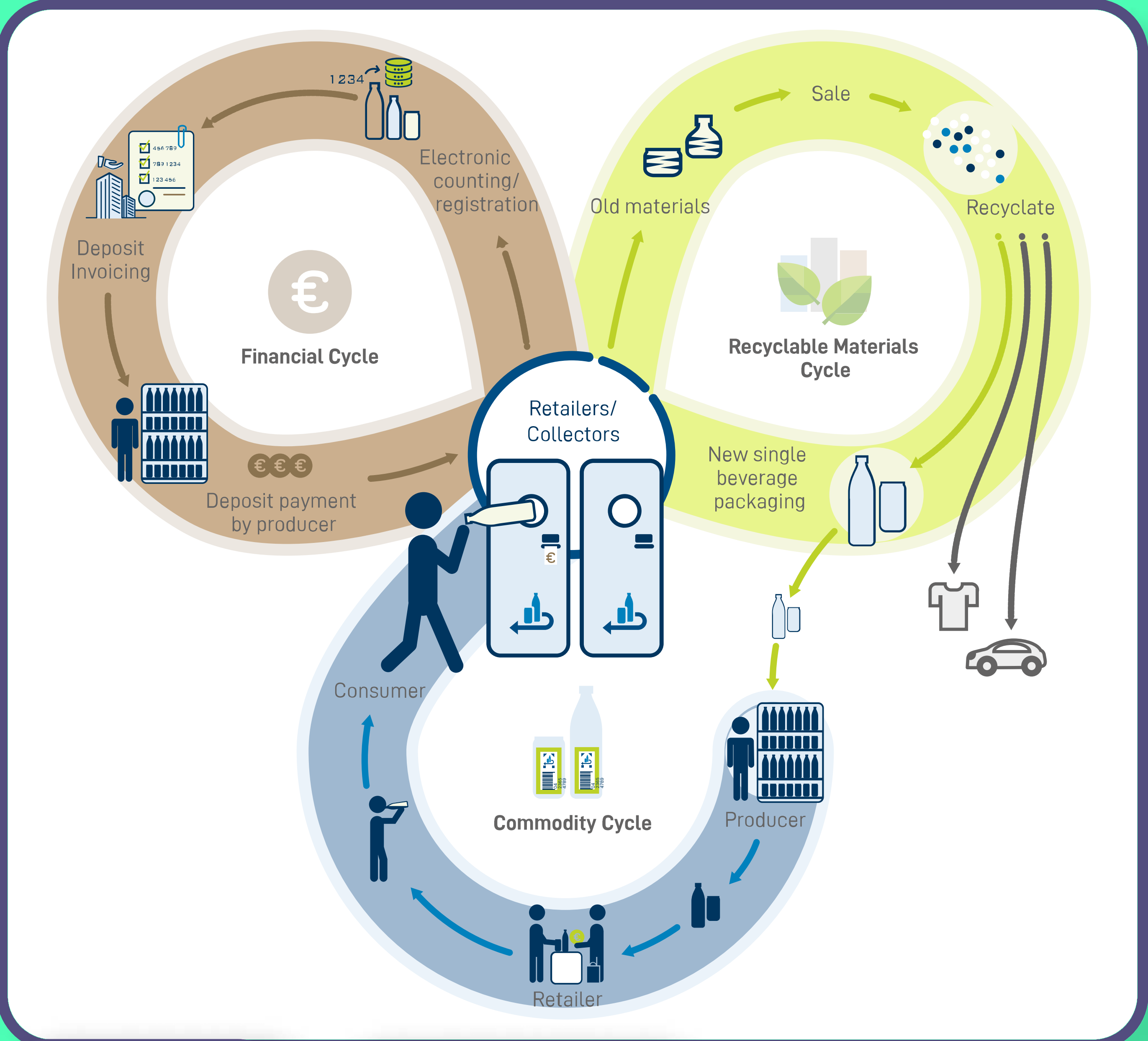
Landfills

Concluding the data analysis regarding waste management, research related to the landfills present on the German territory was conducted.

The German classification of landfills divides the sites in five different categories [79].
Class 0 landfills are above ground sites used exclusively for inert waste.
Class 1 landfills are above ground and used for waste which has low organic content and low pollutant releases in leaching tests.
Class 2 landfills are above ground and are used for waste with higher organic content and releases in leaching tests than the waste acceptable in Class 1 landfills.
Class 3 landfills is the last above ground class of sites and are used for both non-hazardous and hazardous waste with higher contamination rates and stronger releases in leaching tests than waste acceptable in Class 2 sites.
Finally, Class 4 landfills are underground storage sites.
Leaching tests are used in order to assess the risk of a waste to release organic and inorganic pollutants. There are a variety of tests, used in order to verify the potential release of pollutants under different circumstances, like the exposure to environmental conditions. These are particularly necessary when considering that the majority of classes of landfills in Germany are above ground, thus increasing the risk of polluting the land around them.

The data related to landfills found in the Bundesamt database Destatis [80] show a total of 1005 (as of 2020) landfills distributed on the German territory.
The most common class is Class 0, with 707 sites, followed by Class 2 (148 sites), Class 1 (123 sites), then Class 3 and 4 (27 sites all together). Interestingly, in the total landfills are counted 206 hazardous waste collection sites.
When analysing the distribution of landfills on the territory, it appears that, out of the four highlighted Länder, both Bayern and Baden-Württemberg have more than 300 landfills each, while Nordrheim-Westfalen counts 128 sites and Hessen only 28. As a matter of fact, Hessen counts fewer landfills than 3 other Länder, as it can be seen on the map on page 176. This seems to show that the territories of Bayern and Baden-Württemberg are particularly favourable for the installation of landfills, especially considering that only Nordrheim-Westfalen is the other Länder counting a three digit amount of landfill sites.

A final data regarding landfills is the amount of input registered in 2021 [80]. As it can be seen on the graph, the total amount of waste input in landfills in that year reached 39'756.4 thousand of tons. The vast majority of it was divided between Class 0 (15'594 thousand of tons) and Class 1 (15'131.2 thousand of tons) landfills, while Class 3 and 4 registered 2'469.4 thousand of tons. These results highlight that the majority of waste produced in Germany is either inert or not particularly hazardous, though hazardous waste reached 5'853.4 thousand of tons. When comparing the amounts of plastic waste recovered with the amount of waste input in landfills, the former is equal to around 4.14% of the latter.



▶Image 76. Scheme explaining the organization of the Pfand System
◀Image 77. Logo on single use containers
◀Image 78. Logo on reusable containers
▲Image 79. Logo of the ERDE recycling system
▲Image 80. The Green Dot scheme logo
▲Image 81. TOMRA Revolution machine

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Germany

Germany presents a variety of systems and initiatives operating towards the recovery of waste from consumers. Regarding plastic, the most well known is the Pfand System [81], which focuses on recovering single beverage containers using reverse vending machines. This system is not limited to plastic bottles, but also to glass and metal containers.
The Pfand System was in the works since 1991, but the reverse vending machines were installed only in 2003.
The system works thanks to the addition of a deposit to the price of a container: the price is variable for reusable containers (like plastic bottles), adding between 0.08 and 0.15 €, while is fixed for single use containers (e.g. glass bottles and cans), amounting to 0.25 €.
This deposit is then given back to the consumer when they deposit the empty beverage containers in the machines.
The system allows for the deposit of drinking containers of volumes between 100 ml and 3 l, allowing for a wide range of acceptable products. The containers that can be deposited in the machines can be recognised by a logo on either the label or on the container itself. The logos also indicate if the container is reusable or single use, with the reusable logo presenting the words "Für die umwelt" (for the environment) and "Mehrweg" (multiuse). The logo on single use containers simply presents the stylized picture of a bottle and of a can.
As it is explained by the scheme of the Pfand System, the machines are located near retailers and collector sites, allowing for the consumers to deposit the empty containers and then obtain the financial return of the system. The system in itself is designed in a way to not influence the usual routine of the consumers participating: the only step added is the deposit of the containers, while any other step, from purchasing to consuming the beverage remains unaffected (Commodity Cycle). Another interesting aspect of the system is the so-called "Financial Cycle": the machine counts and registers the containers deposited, dividing them in the various categories. Then, it calculates the amount of money equal to the number and type of containers deposited, which is then given to the participant using an invoice. The deposit is paid by the producers of the containers, since the original deposit added to the prices of the beverages is part of the revenue gained from the sales.
The recovered containers are then considered "old materials", as it can be seen in the "Recyclable Materials Cycle", and are sold and recycled. They can either re-enter in the beverage packaging line or can be used to produce other products, like clothes or automotive parts.
The Pfand System saw great results in the years it was implemented: in 2018, the system registered a 97% redemption rate of the estimated sold plastic beverage containers [82]. Considering the amounts of recovered plastic packaging, it can be surmised that, in 2022, a total of 1'680 thousand tons of plastic packaging was produced.
The system uses reverse vending machines produced by the Norwegian company TOMRA [83]. There are around 30'000 machines on the German territory, scanning the logos on the packaging.
Recently, TOMRA developed the Revolution line [84], which is able to receive up to 100 between PET bottles and cans at once, reducing the times and simplifying the deposit process. Instead of the normal mechanical sorting, it uses compressed air.

Initiatives and acts

The Pfand System is not the only plastic recovery initiative active in Germany. Another example is the ERDE system (Erntekunststoffe Recycling Deutschland) [85], which is focused on recovering plastic films, bale twine, nets and other products used in agriculture and reintroducing them in the material cycle through recycling. In 2022 they managed to recover 38'476 tons of agricultural plastic and have an average of 42'748 tons of CO_2 saved per year. According to the calculations of the Frauenhofer Institut Umsicht, this amount is equal to the amount of CO_2 bound by 3.080.902 trees.

Another historical initiative was "Der Grüne Punkt" (The Green Dot) [86]. Precursor of the European scheme by the same name, this system was launched in 1990 by the Duales System Deutschland. This system aimed to make companies contributing to the cost of recovery and recycling of their products, and signalling so to the consumers with a logo which manufacturers participated.
The recovery could happen both with household waste collected by authorities (e.g. in special bags) or with containers in public spaces.
To participate, companies have to pay a license fee to Duales System Deutschland in order to place the Green Dot logo on their products, while the company organizes the recovery of waste. The collection, transport and disposal of waste is not carried out by the DSD, but by commissioned disposal companies. In order to assign precise areas, the country is divided in "DSD contracted areas", which usually correspond to borders of cities and districts.
Following the Germany Waste Management Act, all companies must recover their packaging themselves, if they are not participating in the Green Dot scheme. This is only feasible for low-volume producers.

In 1991 the ordinance "Verpackungsverordnung" (Packaging Ordinance) [87] was launched, with the objective of recovering packaging and recycling it. A system was created in order to recover packaging from private citizens, avoiding returning contaminated packaging to stores, which could cause issues related to hygiene and space. In order to facilitate recovering waste from the citizens, similar solutions as the ones used in the Green Dot scheme were used, like yellow bags and bin containers. This allowed for an increase in the collection rates.

In September 1996 the Closed Substance Cycle and Waste Management Act [88] was launched. This act integrated product responsibility in the economic decision-making of manufacturing companies, with the aim to promote a life-cycle economy which avoided generating waste.
In order to do so, the act states that whoever consumes or produces goods is responsible for either avoid disposing, recycling, reusing or properly disposing the resulting waste.
The act defined a hierarchy of avoidance, recovery and disposal which set as primary obligation avoiding waste in the production processes, while also promoting low-waste products. If not possible, the waste should be recovered and either recycled or used as source of energy. If that is also not possible, then the waste must be disposed in an eco-friendly way.

Initiatives and acts

Test Nation

Germany

The result of the analysis of Germany as a test nation allows to highlight the reasons why it would be particularly effective to develop a system centreed around the recovery of plastic waste from both the users and landfills, as well as the input of said waste in a new industry after transforming it in a new material.

The nation presents a rich history of efforts towards the reduction of pollution coming from a variety of industries, as well as strong interest of the population in participating in initiatives that see them as the main supplier of recoverable waste, if given the correct incentives. In addition to that, the effort to reduce the amount of waste left in landfills can be noticed by the gradual decrease of quantity year after year, as well as the attention towards sorting the recovered waste in macrocategories, which will make the sorting step of the recycling process less stressful on the materials.

The German territory is rich in mineral resources, like limestone. When considering the adoption of a thermoplastic resin composition with Calcium Carbonate as inorganic filler, the German territory would be optimal, considering that limestone can be processed in order to obtain Calcium Carbonate relatively cheap.

When comparing industries, the paper one would gin valuable resources by starting to adopt alternative raw materials to wood pulp. In particular, the reduction of water usage caused by the substitution of paper with stone paper or materials similar to Limex could be impactful. There would, though, be the need to not require new technologies to work these materials in paper-like sheets.

Considering the effectiveness of the Pfand System, it is possible to expect an active collaboration between German model builders and a user waste recovery system. In addition to that, the large amount of model kit stores, even when only considering the 15 major cities in the country (168), presents a optimal opportunity to organize an effective recovery network which allows model builders to participate freely during their model kit purchasing trips.

Concluding the analysis of the territory, Germany is an excellent nation to use as a test for user waste recovering initiatives, both thanks to the experience that the consumers already have in that regard, and to the efforts that the country itself took in its history in order to reduce waste and pollution in its territory. The territory itself would help towards obtaining the resources needed to produce new materials starting from waste and the industries of the region could benefit from the adoption of new, more eco-friendly, materials.

Systemic Project

Analysis of Polystyrene

Introduction

Polystyrene is the thermoplastic resin most used when producing model kits in plastic. The cheap and light nature of the resin, combined with its formability in a large variety of production processes, allow for high volume productions. In addition to that, it adheres and fills well the moulds used, allowing even the smaller details designed to appear clearly on the final product.
Polystyrene, while used in a variety of applications, is still mostly known in foam form, since it is particularly common to use as packaging material, both as protection for shipped goods and for food packaging. Because of its ample range of applications, Polystyrene presents various issues that impede an easy input in any recycling process, particularly mechanical recycling.
In this section the issues and the recycling methods will be analysed, together with how Polystyrene could be an alternative to Polypropylene in the production of the thermoplastic resin composition known as Limex.

Issues

Polystyrene sees a large part of its use when foamed. In order to produce this type of material, foaming agents are injected in the resin during the production process. Foam Polystyrene, also known as Expanded Polystyrene, presents a variety of issues caused by its foam status.
One example is the fact that its "expanded". By adding foaming agents, the material ends up being distributed on a larger volume, causing issues in transporting and storing it: its bulk occupies large spaces, making it difficult to store and very expensive to transport. It also yelds small amounts of Polystyrene, it being only 2% of the total volume [89]. This is one of the reasons why Polystyrene is not recycled at the same rates of other thermoplastic resins: a large amount of Polystyrene waste is composed of expanded material, and the logistic issues hinder the recycling of the material as a whole.
Another very critical issue of foam Polystyrene, which make it much more dangerous for the environment than the other forms of Polystyrene is how much it is susceptible to photo-oxidation [90]. In this process, the surface of the material is degraded by the combined action of light and oxygen, heavily contributing to microplastics. Given its particular structure, the thermoplastic is surrounded by empty space, allowing both light and air to penetrate easily. Because of this, the photo-oxidation process affects the material as a whole, degrading it much faster than extruded plastics.

Considering the issues caused by the addition of foaming agents to Polystyrene, recycling problems surface with any type of additive used during the production processes. Due to its large amount of applications, additives are used in order to give Polystyrene the properties needed based on the final products [91]. Once the additives are mixed with the polymer, it is impossible to mechanically remove them in order to reuse the material outside sorting it by additive. The reason for this is that any chemical modification to the polymer may end up ruining an entire batch of recycled Polystyrene, which often consists of multiple tons of material.
This is also the reason as for why sorting thermoplastics is crucial before starting the recycling process. The sorting process usually is a combination of machine and manual work.

A final issue regarding recycling comes from the fact that Polystyrene is often used to produce food containers. These containers need to be thoroughly washed before recycling, in order to remove traces of food. The methods commonly used require wet washing, usually with detergents and caustic agents. These risks water pollution, therefore, together with dedicated washing equipment and a drying step, a wastewater treatment facility is necessary.

Recycling

When it comes to recycling Polystyrene is primarily downcycled into disposable cutlery and products, but by the tenth reprocessing cycle, the molecular weight of the plastic decreases by nearly 50% [92]. This is caused by Polystyrene sensibility to the shear stress applied to it in the extruder and, with increasing extruding speed, the thermo-mechanical degradation significantly increases. This causes a molecular mass decrease in the final product.
During extrusion, this degradation produces small amounts of very low molecular mass hydrocarbons, such as monomers and dimers.
This makes Polystyrene not particularly well suited for mechanical recycling, but is not the only issue that makes it so. The biggest one, already explained, is sorting. This process is both time and resource consuming, therefore various techniques to reduce stress during sorting are in development.
An example of automated sorting is "Near Infrared". This technology is used to determine the polymer type, using optical colour recognition. This sorts plastic into clear and coloured fractions.
There are various complementary technologies, like X-rays, analysis of density, melting point, hydrocyclons and selective dissolution.

Polystyrene was found to be particularly suited to chemical recycling. Since it is very sensible to degradation, techniques that have the objective of separating the polymer from other substances present in the plastic are quite effective. There are three main categories of chemical recycling.
The first one is "Solvent purification". This technique dissolves the Polystyrene in dichloromethane, toluene and limonene solvents, and subsequently precipitates it out by mixing methanol, water or hexane.
The second chemical recycling category is "Chemical depolymerization". This technique degrades Polystyrene in various supercritical solvents, like benzene, toluene or ethylbenzene, between 310 and 379 °C and at a pressure of 6.0 MPa. Out of these solvents, toluene is more effective for the recovery of Styrene monomer from Polystyrene. In addition to that, the highest yield of Styrene monomer from chemically degrading Polystyrene was obtained by dissolving it in toluene solvent at 360 °C for 20 minutes.
The third category is "Thermal depolymerization". Already introduced while talking about the Gunpla Recycling Project, thermal pyrolysis of Polystyrene yelds high percentage of styrene monomer. As of now, a 63% yield of Styrene was obtained ad 477 °C. Product oil containing 83% (yield at weight) of monomer was generated by pyrolysis at 520 °C using a fluidized bed reactor. These yields can be enhanced by adding organic additives, such as naphthalene, to the pyrolysis process.

Alternative to Polypropylene

When considering Polystyrene as a substitute to Polypropylene to produce the thermoplastic resin composition with inorganic filler commercially known as Limex, it is necessary to analyse which properties of the material would help in this regard and which could become issues and how to solve them.

The thermoplastic resin used to produce Limex is a blend of Polypropylene with long chain branching and without long chain branching. This is possible to achieve with Polystyrene as well, since its structure can be with and without said branching. Polystyrene is part of the family of polyolefins, having ethylene as the main chain which composes the polymer. This is very important, since the polyolefin family is one of the few thermoplastic resin categories listed as possible substitutes in the Limex patent.

While Polystyrene satisfies quite a few key points to be a substitute to Polypropylene, the first and main issue that comes from the Limex patent is related to the internal structure of the thermoplastic resin.
In order to produce the composition, the patent states that a crystalline structure is preferable. The structure of Polystyrene is completely amorphous, thus not making it the most desirable thermoplastic resin to substitute Polypropylene.
That said, Polystyrene is used in a varied array of products, one of which are model kits. Considering that Limex has been tested with Bandai model kits, as mentioned in the previous chapter, and that Polystyrene is the most used plastic in that industry, it could be possible to adopt it as a substitute to manufacture a new material, similar to Limex, but for types of products that may not need to benefit from a particularly crystalline structure. For example, paper and model kits, especially considering that a crystalline or amorphous structure, among other things, influences the resistance to heat of the plastic. Both applications would not necessarily require said resistance.

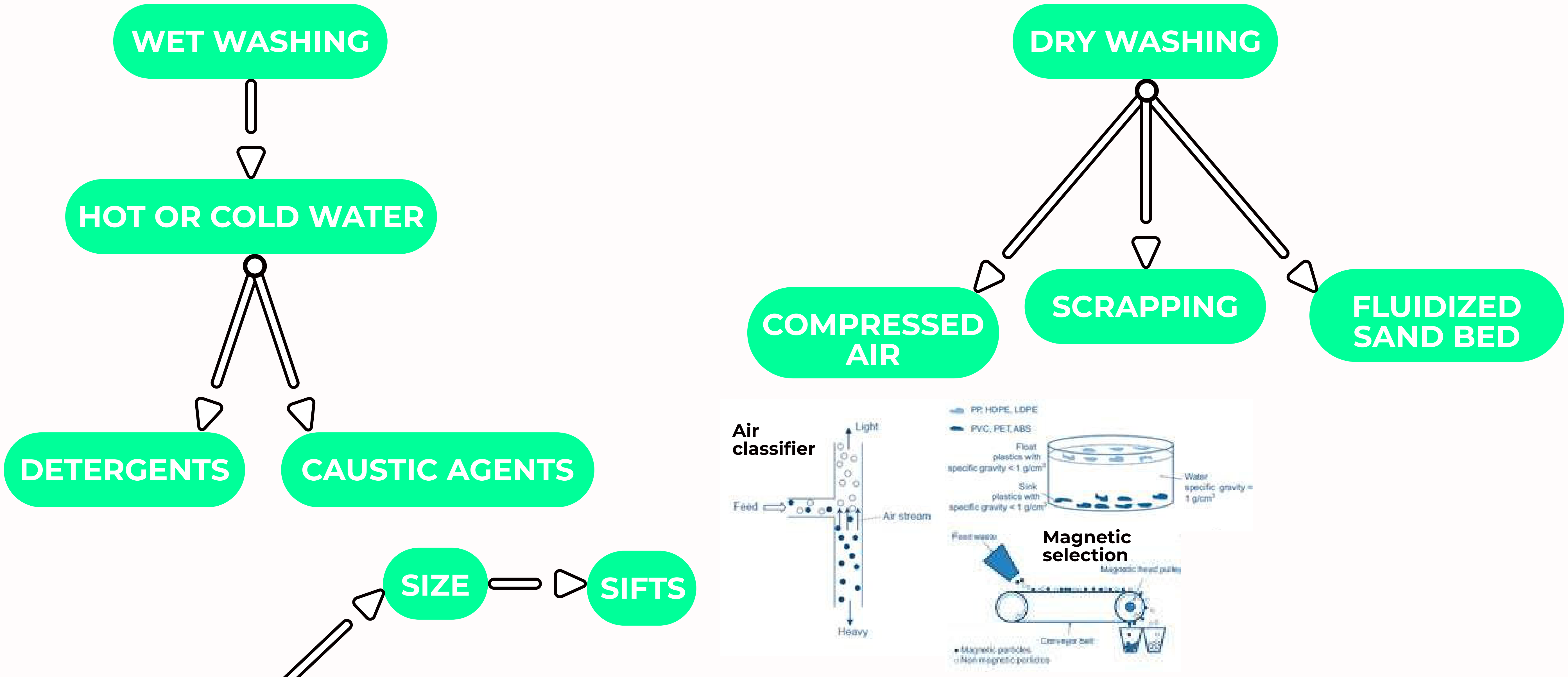
In addition to that, there are methods to polymerize Polystyrene in a way to give it a crystalline structure. In particular, the Ziegler-Natta method, which produces an ordered "syndiotactic polystyrene", which is highly crystalline [93].
This type of Polystyrene is already present on the market, produced by the Idemitsu Corporation, under the commercial name of "XAREC" [94].

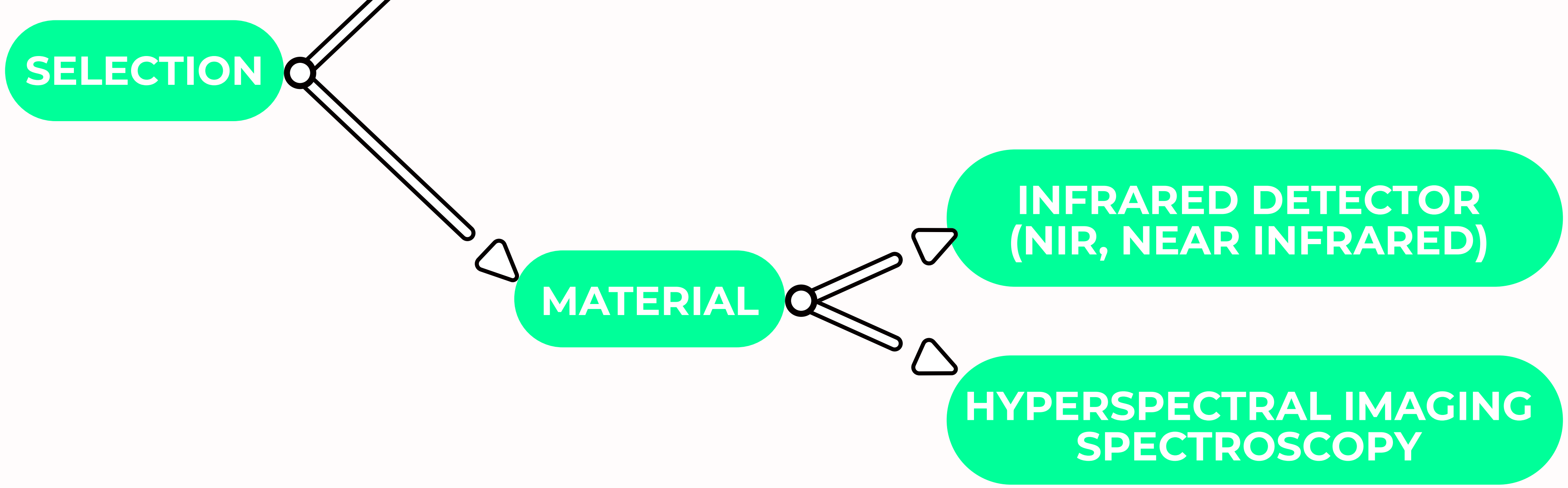
In conclusion, Polystyrene is a material that has a fair share of issues regarding its recyclability, though, just like the majority of thermoplastics, it is possible to recover it and input it back in a production cycle. Thanks to its versatility, it could be used as a substitute to Polypropylene to produce a thermoplastic resin composition, though it would require some experimenting in order to find the correct methodology to do so and the material ratios.
By developing a company focused on recovering and recycling Polystyrene it should be possible to improve the environmental footprint of the material, especially if the steps taken in order to do so can be scaled up based on the territory and the industry where the company inserts itself.

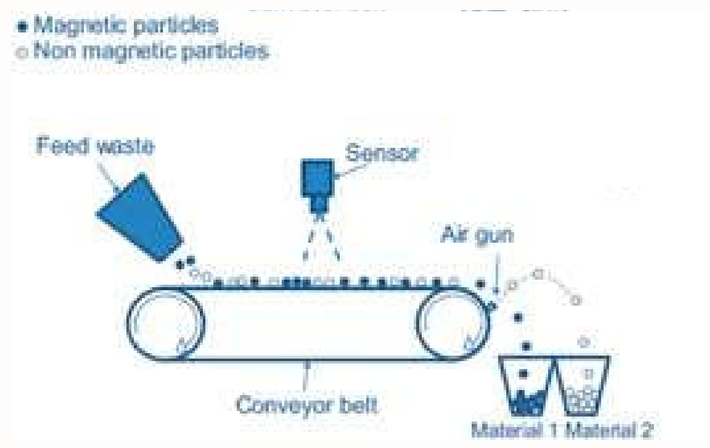
Systemic Project

Analysis of Polystyrene

	POLYSTYRENE	RECYCLING	SOLUTIONS
PROCESS ISSUES	Polystyrene is used in a variety of products, each requiring different properties • To achieve said properties, additives must be used • The additives are mixed in the polymer and must be removed in order to allow reusing the material • Foam Polystyrene requires foaming agents	• In mechanical recycling it is necessary to separate the Polystyrene from other plastics • Polystyrene is sensitive to shear stress in the extruder, with increasing extruder speed thermo-mechanical degradation will increase • By the tenth reprocessing cycle the molecular weight of PS decreased by nearly 50%	• Various techniques to reduce stress while sorting are in development (near-infrared, to determine type of plastic, and other complementary technologies) • Chemical recycling instead of mechanical (e.g. Pyrolysis to decompose Polystyrene in Styrene monomer)
ENVIRONMENTAL ISSUES	Foam Polystyrene is particularly susceptible to photo-oxidation, a process where the surface of the material is degraded by the combined action of light and oxigen. This also heavily contributes to microplastics	Polystyrene is often used to produce food containers • Before recycling the container, it needs to be cleaned in order to remove reaces of food • High use of water (most common technology), risking water pollution if not properly disposed of	• Increase Polystyrene recovery, avoiding leaving products in landfills, educate on the material issues, reduce its use to produce food containers,...
LOGISTIC ISSUES	Foam Polystyrene is hard to transport and store: its bulk occupies large spaces, making it very expensive to transport It also yelds small amounts of PS for reuse (around 2% of volume). Being one of the most common forms of Polystyrene, it hinders recycling the material	Separating Polystyrene from other thermoplastics is both time consuming and expensive, since it is a combination of machine working and manual sorting Using wet washing, it is necessary to have: • dedicated washing equipment • a drying step • a wastewater treatment facility	• If compressed (from 30 kg/m3 to 300 kg/m3, for example), foam Polystyrene becomes a recyclable commodity for pellets • Dry washing is in development, with initial results on par with washing using caustic agents







Allows challenging sorting, e.g., HDPE/LDPE, PET/PLA, or black products that cannot be identified with conventional NIR detectors

Systemic Project

The new system

Thanks to the data recovered during the survey on the model builders' community, the information and data related to the territory of Germany, on the model kit industry and its production cycles and the information related to Polystyrene, it emerged that a system employing all the solutions analysed using case studies, rather than a single one, would have stronger effects on each actor.
The new system would see at its centre the initial recovery of model kit runners from the final consumers, which would scale up in time, until reaching the recovery of Polystyrene from the 1'005 landfills in the German territory. The plastic material will not be simply recycled and input back in the production system, but it will be used in order to produce a thermoplastic resin composition using Calcium Carbonate as inorganic filler. This way it will be possible to maintain the physical and mechanical properties of Polystyrene, reducing the amount needed to produce the equivalent amount recovered and reducing its carbon footprint.
The properties gained from the inorganig filler will allow to employ the newly produced material not only in the model kit industry, where it will be initially input back in order to create a circular system. This new material, which will be defined as "Limex" (with the quotation marks, since it does not have the same composition as the original Limex discussed previously), will be implemented in the long term also in the paper industry and, on a much smaller scale, also in the general plastic industry. This will allow for a reduction of raw material and water usage, though the foreseen effects will be initially very weak, considering that the paper industry analysed spans the whole German territory.
This application of the new material is not completely new for the Limex manufacturer TBM Co. Ltd., since the material is already in use as both paper and plastic alternative. The main difference between the Limex and the "Limex" of this system is the thermoplastic material and the objective to produce it using exclusively waste Polystyrene, while opening the model kit industry and avoiding maintaining the closeness of the system as seen in the second chapter.

The new system

In order to better analyse and discuss the system, the actors will be defined and the benefits that they could gain from the system itself. These benefits can be divided between four main categories: economic benefits, environmental benefits, technological benefits and socio-cultural benefits.
Economic benefits define any positive effect regarding the purchase and sale of goods, as well as any other benefit that an actor can gain from participating, including incentives and reductions of production costs.
Environmental benefits describe positive effects on the environment caused by the participation in the system, like the reduction of plastic waste sent in landfills and production waste.
Technological benefits will focus on the technology needed to participate in the system and if and how it will impact the production processes of the industries in it.
Finally, socio-cultural benefits will describe how actors may be influenced during the participation in the system itself, and how the actors may influence each other.
The system will be analysed by dividing it in three time periods (short, medium and long period) and in three territory levels (micro, meso and macro level).

The three time periods will be particularly helpful in defining how the effects of the new system will affect the actors, as well as the intensity of said effects. By using a time period of 10 years, it is possible to set a bigger and more effective objective that maintains plausibility, especially when considering that the system will try to open up the model kit industry to other industries in the country.

Similarly, the three micro, meso and macro level will help distribute the actors on the territory. The micro and meso scale will cover territories included in the four Länder described previously, while the macro scale will touch the entire German nation.
On a micro scale, the main actors will be the ones present in the original system, with the addition of the waste recovery system and the Polystyrene recycling company. The reason for this is the fact that these actors will be the starting ones for the whole system.
The actors on a meso scale will be the ones that start influencing the system by interacting with the Polystyrene recycling company: Calcium Carbonate manufacturers and landfills. Regarding the landfills, while still mainly on a meso scale, with time will be also included on a macro scale, with the system reaching outside the four Länder.
For the macro scale, the main actors will be the industries towards which the system will open up. The reason for this is the fact that the system would not be immediately able to open up during the short and medium period, as it will be defined in the next chapter. Thus, the influence of outside industries will be corresponding on the opening towards a macro scale in the long period.

The system can be also divided in three main "flows", which describe the relations between actors.

The new system

The material flow focuses on the movement of Polystyrene and other materials in the system, defining when it becomes an output (waste) or an input (raw material). This is crucial in order to understand the impact that the system will have on each actor, especially on the environmental side of things.

The commercial flow is intertwined with the material flow. It shows the economic movements in the system, covering both purchases of goods, materials and incentives in the system. Since various material movements correspond to economic exchanges, the scheme on the next page will depict them as part of the material flow, since, in that case, the material movement has a higher priority than the economic one.

The information flow depicts both which information is shared and how. As it will be explained further later in this chapter, the information flow influences the participation in the waste recovery initiative and promotes it, using both scientific channels and other news sharing services, such as social media and newsletters.

The actors

In order to better understand how the new system affects the previous one, it is necessary to define the actors present and how they interact with each other.

The first actor(s) are the model kit companies present on the territory and the ones that sell their products using retailers and e-commerce solutions in Germany. These companies play a very important role in the system, just like in the original one. Being the providers of the material that will be recovered from the consumers, these actors affect the system from the start. Initially, though, the only other effect that they will have is going to be mostly marketing related. The system is not focused on a singular company, but the runners recovered from the users will come from the products of any model kit company that sells in Germany and that uses Polystyrene as production material. This makes it much more difficult to develop a direct collaboration system between the recovery of runners and the companies, which will influence how the model builders participating in the system will receive the incentives.

Another actor will be a Polystyrene recycling company. This company will be the second fundamental element that allows for the launch of the user waste recovery system, from which the runners will be gathered from the final users. This company will have the objective of both recovering the material and developing it in the "Limex" described previously. From the production of the new material the company will be able to grow and scale up the system itself, up until starting to gather Polystyrene waste from the German landfills. This company will also have the duty of granting the incentives to the model builders participating.

The third actor in the system is the user waste recovery system itself. This system, which will be defined more in depth later in this chapter, will be divided between allowing the model builders to leave the runners in apposite reverse vending machines near model kit stores, similarly to the Pfand System, or to send them via mail. This way it will be much easier for the participants to organize their participation, without additional effort and without requiring the development of a house-to-house recovery network. As it will be defined later, the incentives gained by participating will grant discounts to the model builders based on the weight of the plastic sent. There will be limitations on the minimum allowed as well as the maximum amount allowed.

The fourth actor(s) are the retail and online (e-commerce) stores that sell the model kits to the model builders. These actors are very important to the system because play a role in both the commercial and material flows.

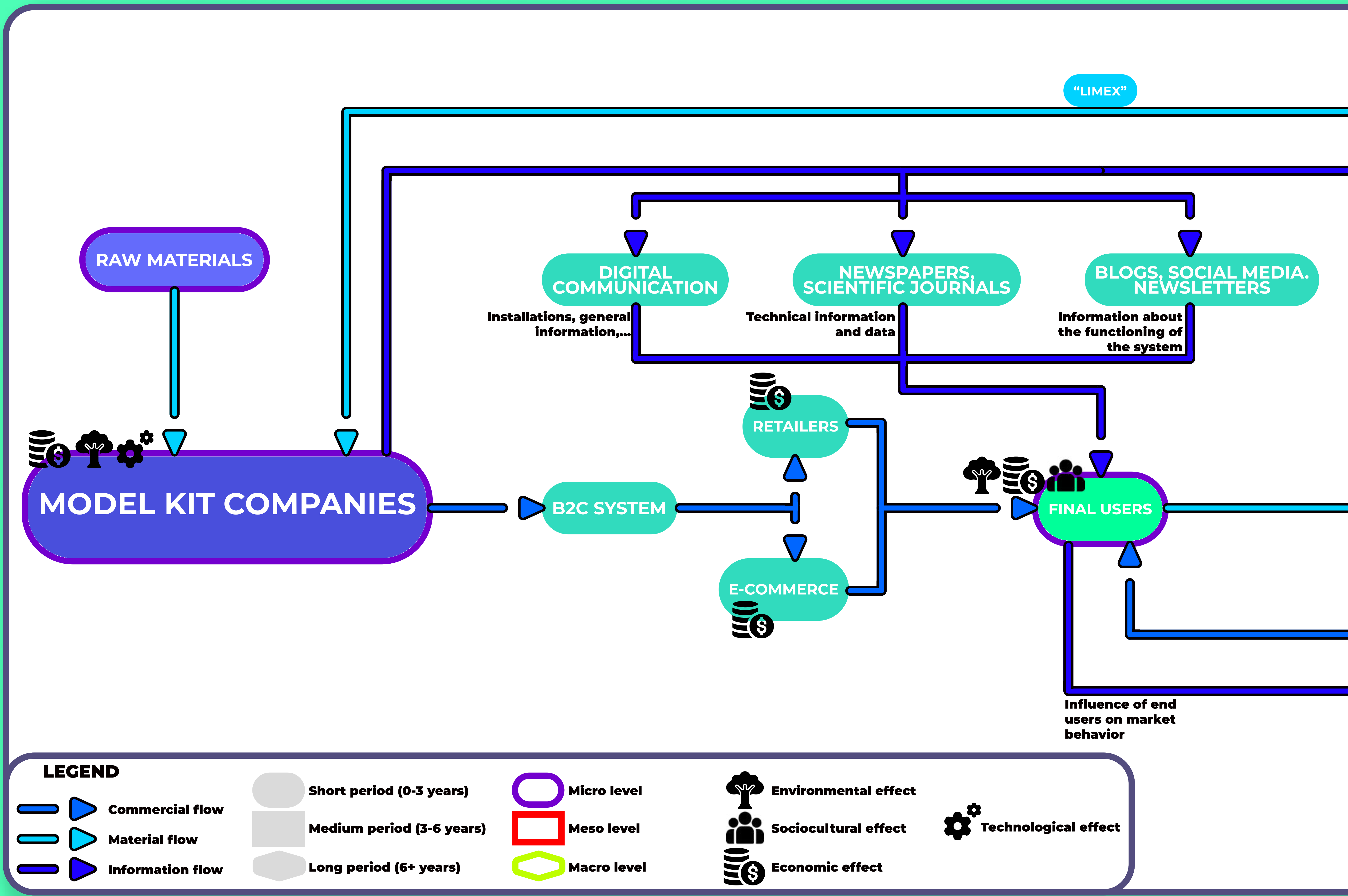
The actors

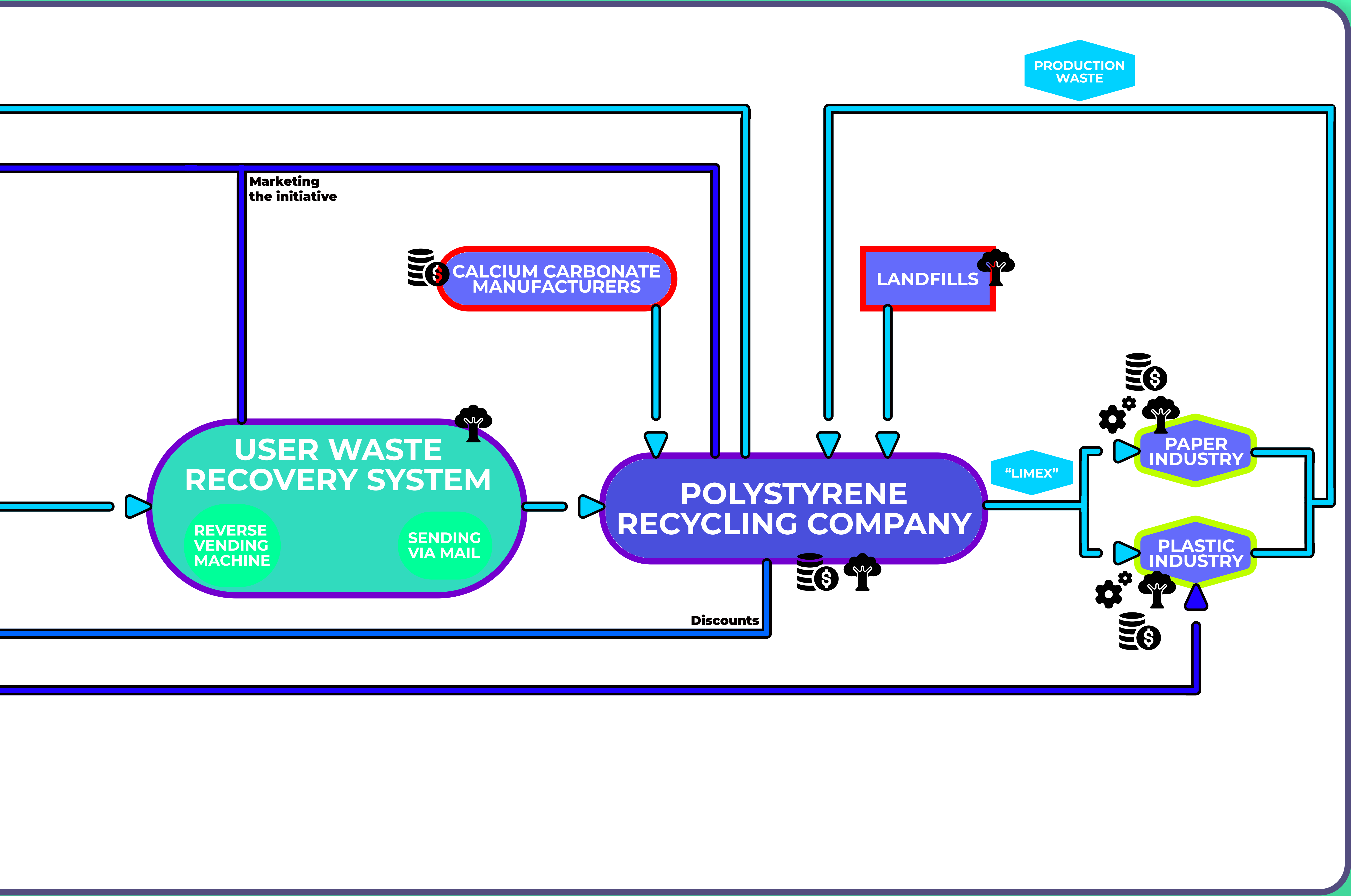
Stores, both physical and online, will receive incentives to participate in the waste recovery system. In both cases, the stores may not see a direct economic gain by participating, especially when considering that the results from the survey showed model builders not keen in purchasing model kits particularly often (around once a month). That said, as it will be explored in the next chapter, with time the participation of model builders in the waste recovery system will help the growth of sales for the stores participating.

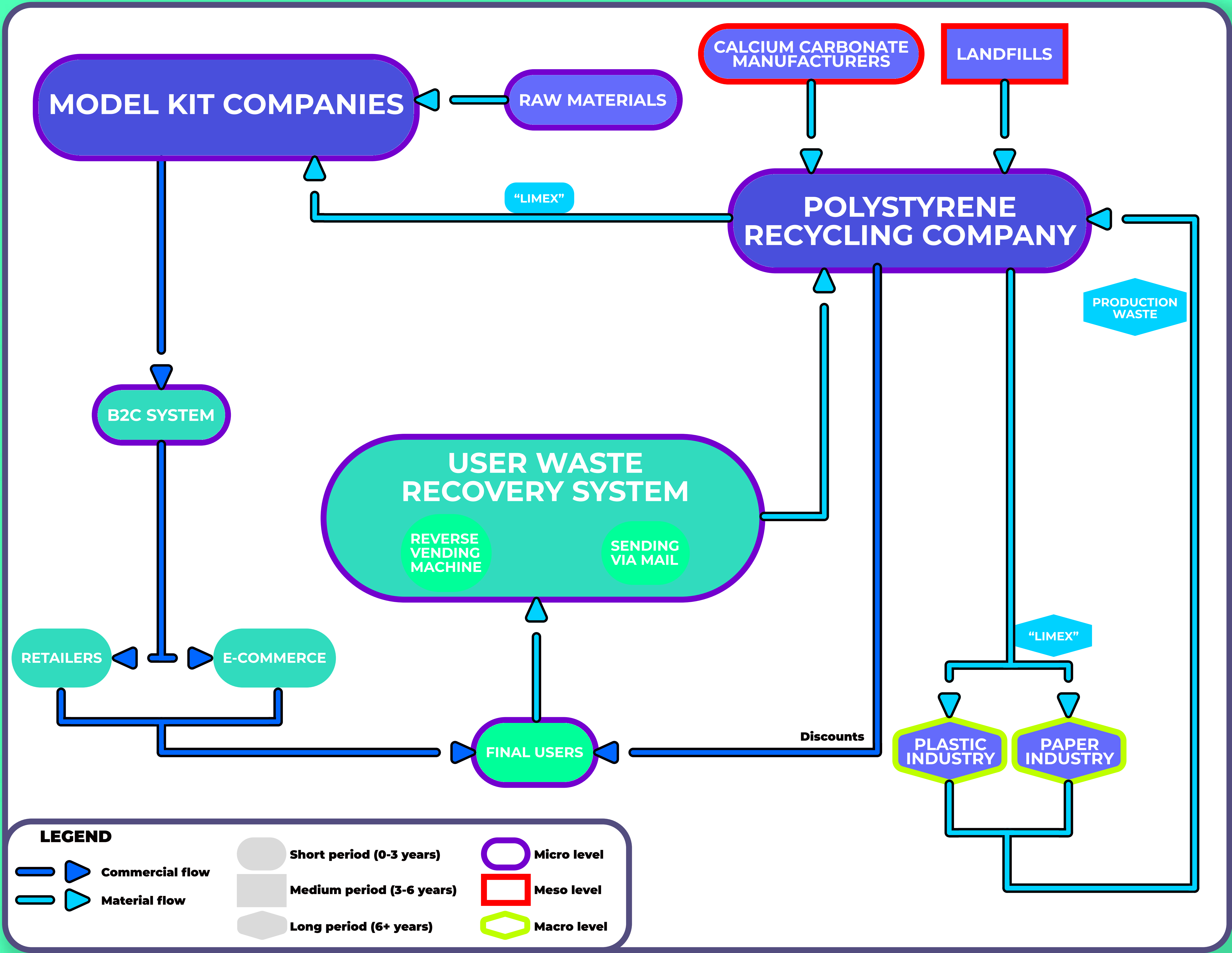
Another actor(s) added to the system are Calcium Carbonate manufacturers. These actors are necessary for the purchase of the inorganic filler used to produce "Limex". The manufacturers do not participate directly in the system itself and only interact with the Polystyrene recycling company. This is caused by the fact that the introduction of Calcium Carbonate in the system only affects other actors if implemented as part of the new material.

The next actor(s) are the German landfills. These sites will see initial effects of the system from the short period (0-3 years), but will start participating more actively in the system from the medium period (3-6 years). The reason for this is the necessity to allow for the system to stabilise itself using the user waste recovery system, as well as allowing the Polystyrene recycling company to become more economically stable. This will allow the company to purchase Polystyrene waste from the landfills, reducing gradually the quantity present. This is the long term objective of the system: reducing the amount of Polystyrene left in landfills.

The final actors in the system are the plastic industry and the paper industry. Both will enter the system in the long period and will not have an immediate active role in it. In both cases, their function is to open the system, by using "Limex" produced form waste Polystyrene, recovered from both the user waste recovery system and from landfills.
This is also one of the reasons why the system will need to be scaled up by recovering Polystyrene from landfills: as seen previously in this chapter, these industries see a product volume amounting to millions of €, which would make the amounts of "Limex" produced using recovered runners too small to affect the production significantly. In particular, the plastic industry saw an estimated yearly production of plastic of hundreds millions of tons of material. That said, an estimate of 6.1% of the total plastic production is covered by Polystyrene [95], reducing the necessary amount of "Limex" that needs to be produces in order to affect the Polystyrene industry.


"LIMEX"
RAW MATERIALS
DIGITAL COMMUNICATION
NEWSPAPERS, SCIENTIFIC JOURNALS
BLOGS, SOCIAL MEDIA. NEWSLETTERS
Installations, general information,...
Technical information and data
Information about the functioning of the system
RETAILERS
MODEL KIT COMPANIES
B2C SYSTEM
FINAL USERS
E-COMMERCE
Influence of end users on market behavior
LEGEND
Commercial flow
Material flow
Information flow
Short period (0-3 years)
Medium period (3-6 years)
Long period (6+ years)
Micro level
Meso level
Macro level
Environmental effect
Sociocultural effect
Economic effect
Technological effect


PRODUCTION WASTE
Marketing the initiative
CALCIUM CARBONATE MANUFACTURERS
LANDFILLS
USER WASTE RECOVERY SYSTEM
REVERSE VENDING MACHINE
SENDING VIA MAIL
POLYSTYRENE RECYCLING COMPANY
"LIMEX"
PAPER INDUSTRY
PLASTIC INDUSTRY
Discounts


MODEL KIT COMPANIES
RAW MATERIALS
CALCIUM CARBONATE MANUFACTURERS
LANDFILLS
"LIMEX"
POLYSTYRENE RECYCLING COMPANY
PRODUCTION WASTE
B2C SYSTEM
USER WASTE RECOVERY SYSTEM
REVERSE VENDING MACHINE
SENDING VIA MAIL
"LIMEX"
RETAILERS
E-COMMERCE
FINAL USERS
Discounts
PLASTIC INDUSTRY
PAPER INDUSTRY
LEGEND
Commercial flow
Material flow
Short period (0-3 years)
Medium period (3-6 years)
Long period (6+ years)
Micro level
Meso level
Macro level

Systemic Project

The new system

The material flow

The material flow of the new system manages to show how it is intertwined with the commercial flow. As it is possible to notice, the central actor of this flow is the user waste recovery system. It functions as a connection between the actual recycling company and the model builders that participate. By allowing the builders to deposit or send their empty runners, it functions as a way to transform their outputs in the Polystyrene recycling company inputs. Furthermore, the empty runners may be considered indirect outputs of the model kit companies themselves: being a key factor of the model kit production process, the runners end up as waste and their function ends once the model kit is in the hands of the builders.

Once the runners become input in the recycling company, they pass through various operations that have the objective of transforming them back into styrene monomer and, subsequently, back into Polystyrene. Then, the thermoplastic is combined with Calcium Carbonate, purchased from its manufacturers, to become "Limex".
This new material will be, in the short period, input almost exclusively back in the model kit industry, being sold to the German companies willing to participate and purchase it. This will help to transform the previous, linear system in a more circular one. That said, the system is still very close in itself and the amounts of runners recovered from the users would not be able to sustain the recycling company.

This is why, in the medium period, the company will start opening the system more by purchasing waste Polystyrene from landfills. This will increase the production volume of "Limex", allowing its sale to a larger audience. In this period, though, the system will have to remain closed to the model kit industry, since it would still in the midst of stabilising itself. The main objective would be to create a solid network focused on recovering Polystyrene from multiple sources, while also maintaining a constant production of "Limex".

In the long period, finally the system will open up to the paper industry and, on a smaller scale, to the Polystyrene industry. While the plastic industry is very strong in Germany, especially when compared to the paper one, the Polystyrene demand is only equal to 6.1% of the total plastic demand. Considering the issues of this material explored previously, the introduction of an eco-friendly alternative to this industry should help develop other alternatives. This would have a very positive impact on the industry, especially considering that the negative connotations of Polystyrene would help push a material that can satisfy the same requirements, but using between 60 to 90% less thermoplastic resin.

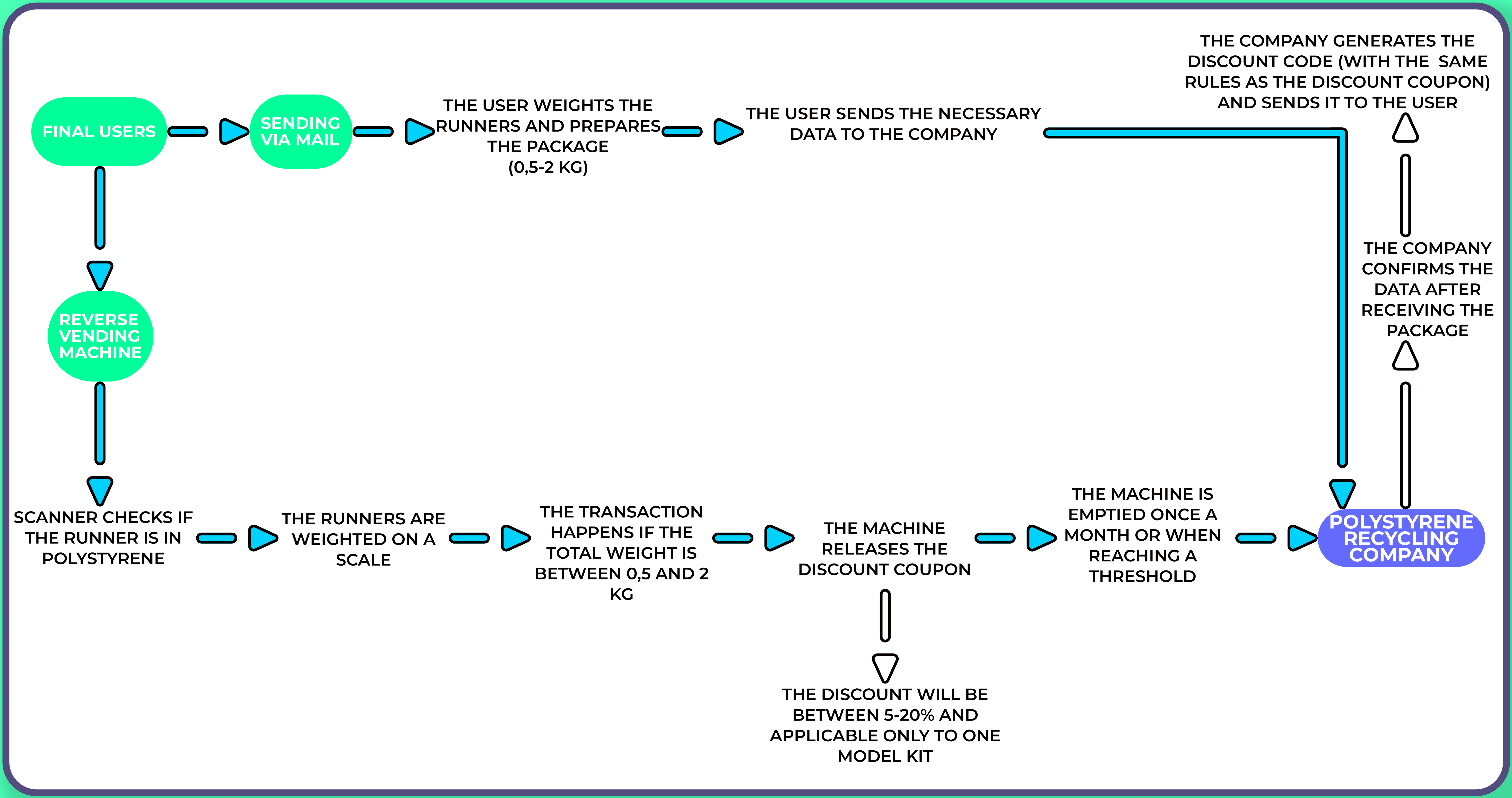
The stronger impact that "Limex" will have once the system completely opens up will be on the paper industry. As seen previously in this chapter, the paper industry is not particularly strong in Germany, with a greater import than export of products. The introduction of an alternative which manages to reduce the amount of water needed for 1 ton by around 97% and does not require wooden fibres to produce would help to improve the amount of paper produced in Germany. In addition to the reduction of waster usage and the total lack of need for fibres, the material will be produced starting from plastic waste, of which Germany has a large amount deposited in landfills each year.

The commercial flow

As stated previously, the commercial flow in the new system is partly connected with the material flow. This is caused by the material exchanges that happen in the system. Outside of said exchanges, already explored in the material flow, the commercial flow affects mainly the model builders and their connection with both the model kit companies and the Polystyrene recycling company.

The main connection between model kit companies and final users is the B2C system globally used in order to sell products to clients. In the case of model kits, as seen previously, the B2C system consists of retailers and e-commerce. In both cases, the model builders are free to purchase the model kits that they prefer, based on the availability in stock. This relationship between customers and sellers does not need to change in any way in order to make the overall system work. On the contrary, changing it may be harmful to the system.
The proof for this can be easily seen in the Pfand System: by not influencing the "Commodity Cycle", in which the consumers purchase beverages, the consumers do not feel any additional burden or additional responsibility towards the purchased product, and are free to organise themselves on when participating in the Pfand System. A similar philosophy must be applied in this new system: the model builders should not feel obliged in participating every time they visit a store, but should be encouraged without pressure. This will avoid negative feelings towards the recovery initiative and, combined with incentives, will instead make the model builders more willing to participate.

When it comes to the incentives, which will be described mode in depth, together with the recovery system, in the next page, these will need to be easy to understand and easy to acces by the model builders, as well as easy to implement in the system. By using discounts, the benefit for the builders will be obvious, while a simple system to calculate them will be easy to develop. The main issue with discounts will be related to the sellers: discounts will affect their revenue, thus it will be necessary to implement incentives for the sellers in order to cushion this effect. Renting space near the stores could be a valid option, as well as the added marketing, since each reverse vending machine will be kept track of in order to direct the interested participants. Having a machine near a store should improve, with time, the overall sales.
Online stores may be harder to convince, since they would not perceive any direct benefit by participating. Because of this, a direct marketing on their part would be the most effective solution, as well as added indirect marketing when model builders participate in the system by sending runners via mail, as it will be described in the functioning of the recovery system.



FINAL USERS
SENDING VIA MAIL
THE USER WEIGHTS THE RUNNERS AND PREPARES THE PACKAGE (0,5-2 KG)
THE USER SENDS THE NECESSARY DATA TO THE COMPANY
THE COMPANY GENERATES THE DISCOUNT CODE (WITH THE SAME RULES AS THE DISCOUNT COUPON) AND SENDS IT TO THE USER
THE COMPANY CONFIRMS THE DATA AFTER RECEIVING THE PACKAGE
REVERSE VENDING MACHINE
SCANNER CHECKS IF THE RUNNER IS IN POLYSTYRENE
THE RUNNERS ARE WEIGHTED ON A SCALE
THE TRANSACTION HAPPENS IF THE TOTAL WEIGHT IS BETWEEN 0,5 AND 2 KG
THE MACHINE RELEASES THE DISCOUNT COUPON
THE MACHINE IS EMPTIED ONCE A MONTH OR WHEN REACHING A THRESHOLD
POLYSTYRENE RECYCLING COMPANY
THE DISCOUNT WILL BE BETWEEN 5-20% AND APPLICABLE ONLY TO ONE MODEL KIT

Systemic Project

The new system

Reverse vending machines

The user waste recovery system presents two ways for the model builders to ship their empty runners to the Polystyrene recycling company.

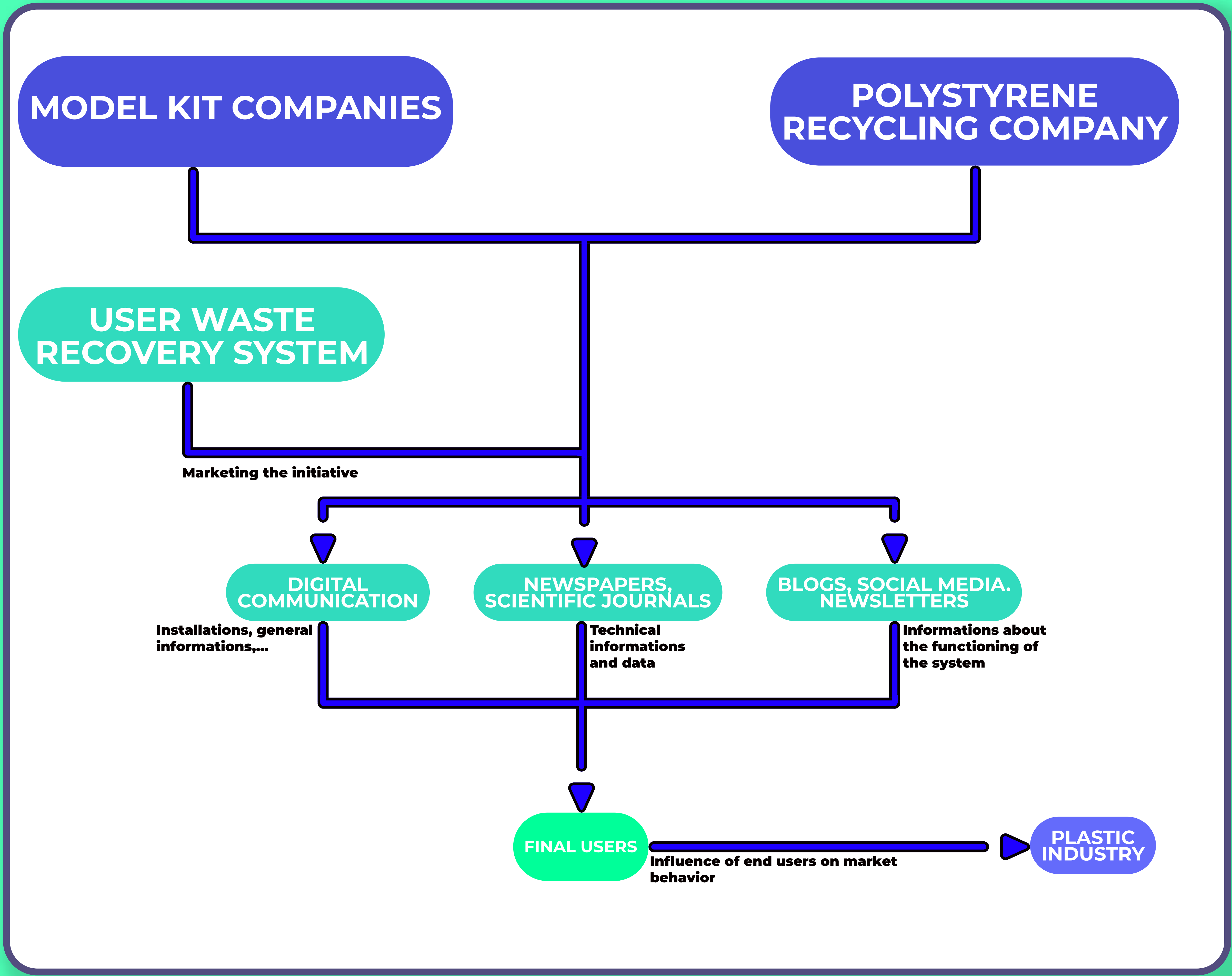
The first method uses a so-called “reverse vending machine”. These machines are similar to the ones used for the Pfand System, collecting the runners and calculating the discount gained by the model builder.

The machine will present a vertical slot, large enough to allow the insertion of one runner at a time and still leave some space. This will avoid the runners getting stuck because of their protrusions.
Once the runner is inserted, before weighting it, a scanner uses near-infrared technology to identify the material. If the runner is in Polystyrene, it will proceed to the weighting section. If not, it will be returned to the participant using an opening below. This selection is necessary in order to avoid contamination by adding other thermoplastic outside Polystyrene.
The runner is then dropped on a scale, which weights it before calculating the discount. The participant will be able to insert all the runners before the calculation and will be able to see the amount of runners dropped.
The minimum amount allowed is 0.5 kg, with the maximum being 2 kg. This restriction is also linked to the discount, which will range between 5 and 20%. In addition to that, the discount will be applicable to only one model kit and not to an entire purchase of multiple kits, though a participant will be able to obtain multiple discounts on a single trip by depositing various amounts each time. In order to allow this, each deposit will need a confirmation from the participant once they finished inserting the runners. While this solution may be bothersome to the participants, it was developed in order to reduce the weight of the initiative on the revenue of retailers.
The discount system was the most popular in the survey, in particular when considering weight instead of number of runners. A percentage system based on weight became much easier to implement, since the internal structure of the reverse vending machines would be simpler, only requiring a scanner, a scale and a screen, together with an internal deposit. All of these systems, outside of the scale, are already present in TOMRA machines. In addition to that, by only recovering Polystyrene it is not necessary to include an internal sorting system to divide the recovered runners.

Sending by mail

When considering a system to collect runners sent via mail, it was necessary to account for the material itself. In order to avoid contamination, it is required to the participant to send exclusively Polystyrene runners. In order to do so, the participants will need to check the material by themselves. This could be particularly difficult in cases in which the manufacturer does not indicate in a clear way the material of the model kit. While it is fairly easy to differentiate between plastic and resin, it is much harder to do the same between plastics. In some cases, like BANDAI SPIRITS model kits, the material for each runner is indicated on the first page of the instruction booklet. This page contains various information, like the potential dangers, and a representation of each runner, which is accompanied by the numeration (e.g. runner A1, B, C1,...) and by the material (e.g. ABS, PS,...). For manufacturers that do not do the same, like Games Workshop, a list of manufacturers that use Polystyrene will be available on the website of the Polystyrene recycling company.
This list will be part of the process which participants will use in order to send runners directly to the company via mail.

This type of deposit will put the participant in direct contact with the company, starting with the data required by the company in order to properly receive the runners and send the appropriate discount to the model builder.
The first data required from the participant will be personal, mainly name and surname, as well as address and e-mail. The participant will not be required to add phone number or other details if they desire so, but additional contacts would ease the contact from the company in case issues arise.
From that, the participant will have to share data related to the runners and to the package. The total weight, which will still have to be restricted between 0.5 and 2 kg, the tracking number of the package, which the company will use to monitor the travel of the package and, if available, the estimated date of arrival. In addition to that, in order to incentivise model builders unable to deposit runners in a reverse vending machine, the participants will be able to request a reimbursement for the shipping, by providing a receipt. Before concluding the process, the participant will have to indicate, using the aforementioned company list, the manufacturer of the runners. This is required since some manufacturers will use other plastics to produce particular elements of the model kits, thus it would be necessary to check the correct material once the runners arrive to the company, in case the participant was unable to do so. The final step for the participant will be to indicate an online store between the ones adhering to the waste recovery initiative, in order to allow the Polystyrene recycling company to generate a custom discount code valid exclusively or that store. The participant may also prefer to not select an online store, requesting instead a coupon valid for retailers. This could be particularly interesting for participants able to purchase their model kits from retailers but preferring to send the runners via mail.
On a final note, the discount codes used for online stores will follow the same restrictions as the coupon discounts generated by the reverse vending machines, in order to maintain fairness between sales channels that willingly participate in the user waste recovery initiative.


MODEL KIT COMPANIES
POLYSTYRENE RECYCLING COMPANY
USER WASTE RECOVERY SYSTEM
Marketing the initiative
DIGITAL COMMUNICATION
NEWSPAPERS, SCIENTIFIC JOURNALS
BLOGS, SOCIAL MEDIA. NEWSLETTERS
Installations, general informations,...
Technical informations and data
Informations about the functioning of the system
FINAL USERS
Influence of end users on market behavior
PLASTIC INDUSTRY

Systemic Project

The new system

The information flow

The information flow follows the information feed towards the public related to technical data on the system, general information regarding the installations, and broad discussions related to the functioning of the system.
The information flow will generate from the model kit companies and the Polystyrene recycling company, as well as the user waste recovery system itself.

The system will mainly use installations and general marketing to make the reverse vending machines recognisable, which will also present graphics and designs in order to easily differentiate from the ones used in the Pfand System. In addition to that, the marketing of the initiative will be both online and offline, using banners on e-commerce model kit websites, as well as posters and leaflets available in the retailers. The actual sharing of technical information, as well as the location of the machines, will be done by model kit companies and the Polystyrene recycling company.

Digital communication will help in sharing information regarding the installation location of the reverse vending machines, using maps that will pinpoint both the machines and the stores near which they are installed. This type of information if often seen used by model kit companies to indicate customers the location of either first party stores or affiliated retailers. Using a similar method, to which model builders are accustomed to, should help increase the amount of plastic recovered.

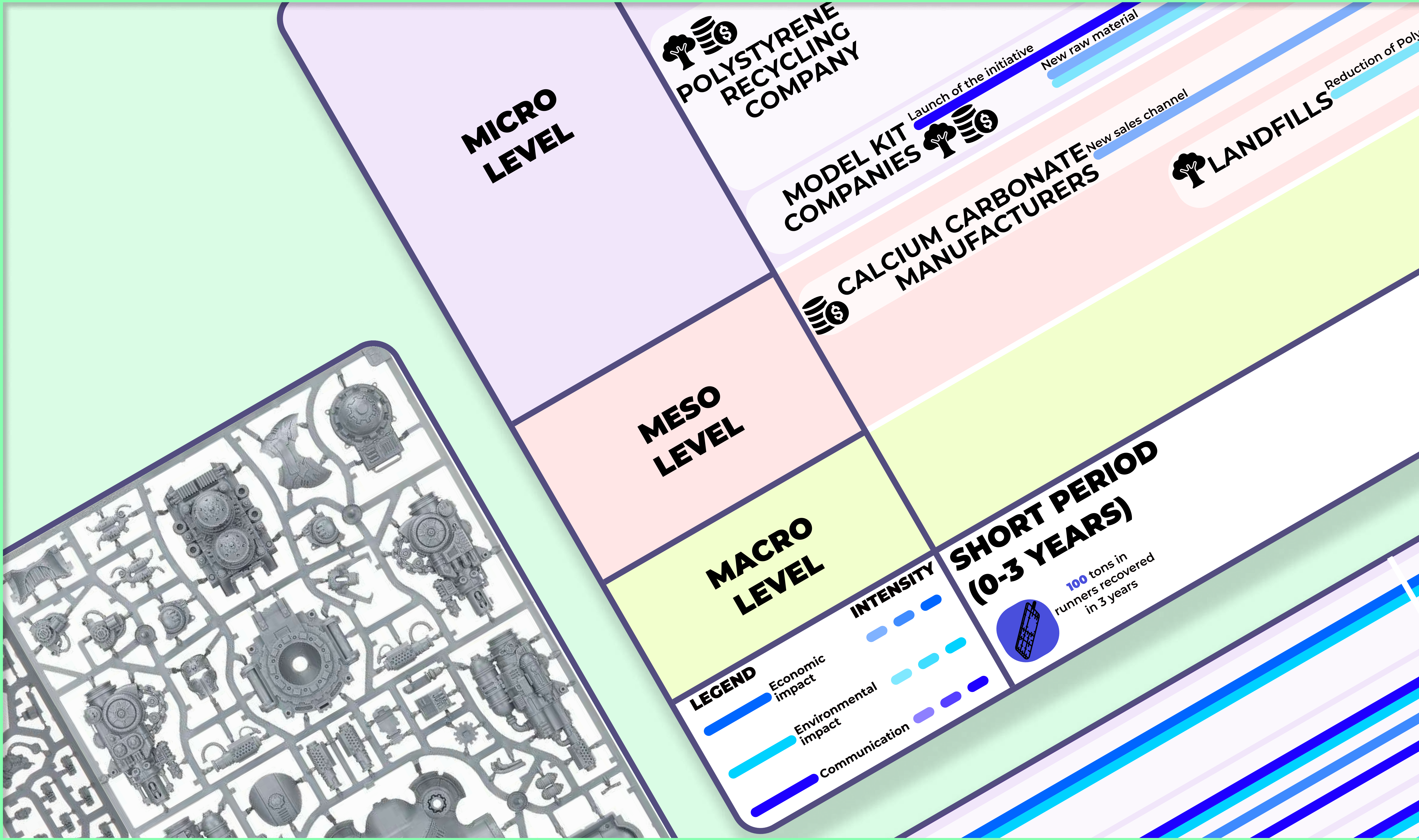
Using scientific journals and newspapers would allow a more "official" diffusion of the technical aspects, information and data of the system. This type of media, renown for spreading well documented information, will allow for a more serious and in-depth conversation regarding the benefits of the system for participants and companies, as well as the positive environmental effects that the system will develop. Using these platforms will spread more easily information to other industries, especially since it will be backed up by official data.
Both this type of information sharing and the display of the machines on a map will be mainly handled by the Polystyrene recycling company, since it will be the actor in the system mainly focused on receiving the material.

The final method of communication, the use of newsletters, blogs and social media will be mainly used by the model kit companies. This is a common method used by model kit companies to share news regarding events, new products and other similar situations, so it would be particularly effective employing this method to make known to more model builders the user waste recovery system.
With this type of sharing, model kit companies would inform the newsletters subscribers about the general functioning of the system. This means that the model builders would end up being constantly notified about new goals of the system, as well as the achievement of said goals. Other information shared would cover how the material is used, details regarding the recovery step after the reverse vending machines reach their threshold and other aspects that could be shared without risking data breaches.

The information flow

Some companies, like Games Workshop, also employ community sites, used to share information about new model kits and initiatives using blogs instead of newsletters. This method allows for a larger amount of people to come to know this type of news, but the trade-off is that they do not receive a direct notification, while it is usually the case with newsletters. Another similar method would be sharing information using clubs, like the Airfix club.

Another aspect of the information flow, which comes into play in the long period and helps connect the previous system with new industries, is the effect that the final users can have on the plastic industry. This effect is expected to appear later in time and it probably will not have a strong impact on the industry as a whole, but it could influence the Polystyrene industry.
The hoped result of introducing part of the "Limex" production back in the model kit company is positive feedback from the model builders. This could influence part of the modern German plastic industry in searching more eco-friendly alternatives to plastic produced exclusively using thermoplastic resins originated from oils.
Hopefully, the industry may open up to investing in materials that manage to maintain mechanical and physical properties of plastic, while reducing the amount of oils used.
In addition to that, considering that "Limex" will be produced using exclusively waste Polystyrene, the plastic industry may start investing more heavily in recovering waste material from landfills and in finding new ways to repurpose it and inputting it back in the production process.



6. Systemic Project Results

...styrene in...

MEDIUM PERIOD (3-6 YEARS)

400 tons in runners recovered
Objective: **10'000** tons of PS recovered from landfills (1/3 of yearly amount)

250-1'000 tons of Limex produced

Influence on the plastic industry

...on of Limex in other industries

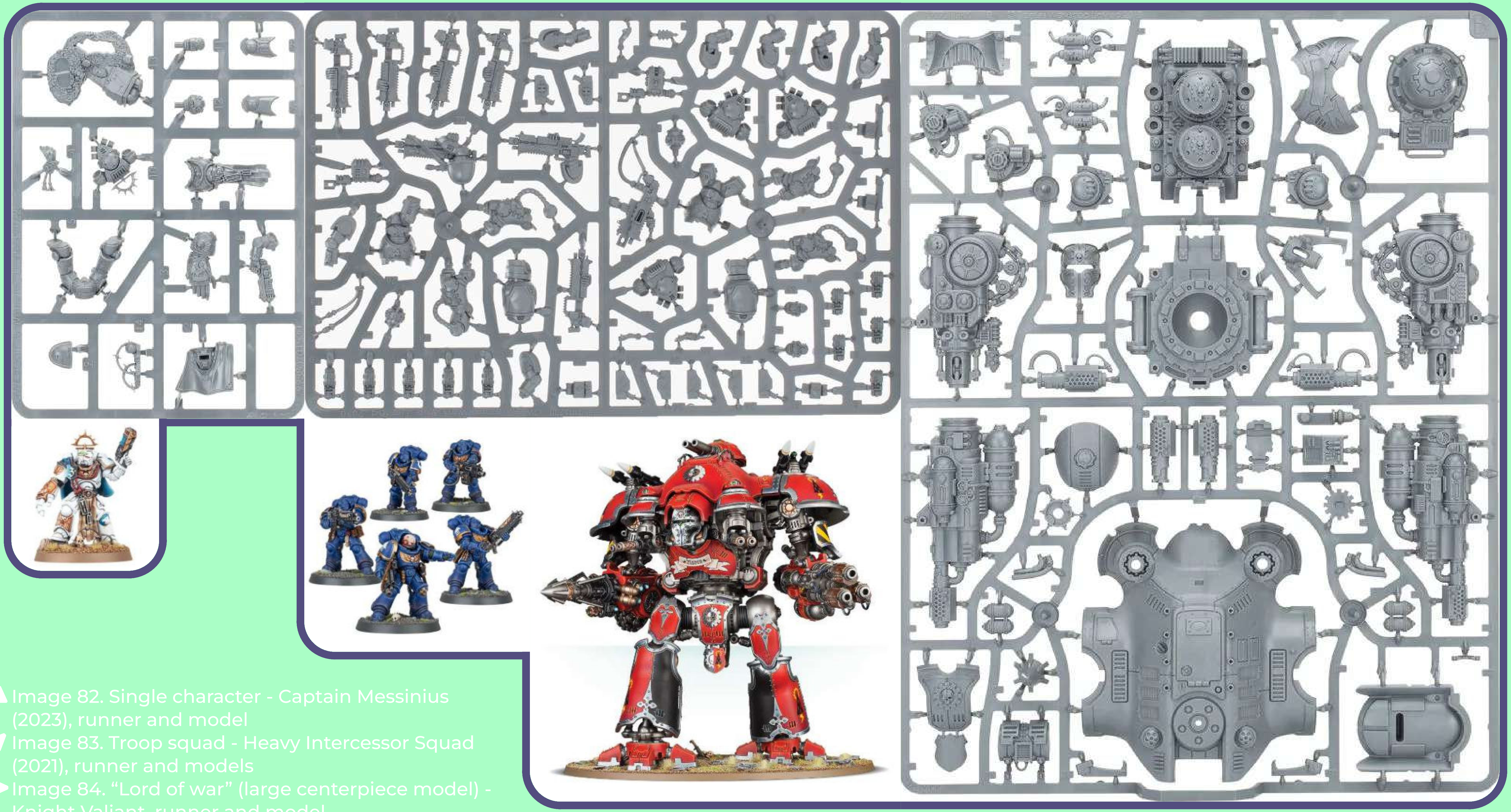


Image 82. Single character - Captain Messinius (2023), runner and model
Image 83. Troop squad - Heavy Intercessor Squad (2021), runner and models
Image 84. “Lord of war” (large centerpiece model) - Knight Valiant, runner and model

Systemic Project Results

Methodology

The results expected from the adoption of the new system are based on the data recovered from the Bundesamt database, as well as the information gathered regarding Polystyrene. These data, though, concern the Polystyrene waste found in landfills, lacking a clear image of the amount of plastic consumed by model kit builders, as well as the actual amount of plastic left as runners once all the components of the kits have been detached from it.
This typer of information is particularly hard to gather even for model kit companies, which often give an estimate regarding the total production. As stated in the first chapter, for example, Bandai estimated that around 2'000 tons of the 7'000 tons total of model kits are wasted in runners, around 28.6%. Other companies may report a different percentage.

In order to estimate a possible amount of runners recoverable during the time period chosen, it was necessary to find data related to the raw materials used by model kit companies and determine how much of that material was sold on the German territory.
The company takes as example was Games Workshop. During the analysis of model kit stores found in the 15 most important cities of the country, Warhammer stores appeared quite often, with the major cities (e.g. Berlin, Essen, Frankfurt, Munich,...) presenting often more than one. This demonstrated the interest of the German population towards Games Workshop products, making their data particularly useful. Another reason for choosing Games Workshop data was related to their analysis of revenue: they presented the data by dividing the world in regions, one of which is called "Continental Europe". In addition to that, for some elements, to this region is also added the United Kingdom territory, which is usually considered separate, since it is the motherland of the company, and they may have particular interest in analysing the revenue from it with more attention.
Finally, in order to estimate a possible amount of runner material present in Germany, the data related to the country of origin of the participants of the survey was used.
In the Integrated Report of 2022 released by Games Workshop, it was possible to gather that the amount of raw material used to produce model kits during that year was equal to 4.3 million £, which amounts to 5.4 million US$. Comparing this result with the price of Polystyrene pellets, which reached 1462 US$ per metric ton in 2022 [96], the total quantity of raw material purchased was around 3693 tons.

Methodology adn results

The revenue coming from the territories of the United Kingdom and Continental Europe amounted to 46.3% of the total, while the amount of German participants of the survey amounted to 7.7% of the model builders answering from a country in these territories.
By using these percentages to estimate the amount of plastic potentially sold in Germany, the final result amounts to 141.3 tons of plastic sold in 2022, equal to 206'580.6 US$.
This result, though, comprises the whole amount of material used in the production of model kits, and is not equal to the actual amount of the material needed exclusively for the runners.
In order to estimate a possible percentage, various products of Games Workshop were analysed. In particular, three types of model kits were very effective in helping define a possible average amount. First of all, the runners of the model kits are all standardized. As it is possible to notice from the Images 82, 83 and 84, which depict three different products, single character boxes contain smaller runners, while boxes that sell multiple miniatures, like troops, present runners twice as big as the character ones. Bigger model kits, especially vehicles and centrepieces, have bigger runners, again twice the size of troop runners. This allows the company to reduce mould planning and manufacturing costs. Another element of the runners that remains unchanged between kits is the thickness of the runners: at the largest point they measure 0.4 cm and 0.2 cm in height. This standardization allows for a more precise estimate of the amount of material. The main difference between products is the density with which the runners are packed with components, which is easily noticeable when comparing the three examples.
From these considerations, an estimate of 45% in weight can be used to calculate the actual amount of runner plastic sold in Germany. This percentage also takes in consideration the fact that, while the runners maintain constant size and thickness, the components of the kits do not, with larger but thinner elements (e.g. armour panels for vehicles) and smaller but thicker ones (e.g. troop weapons, often produced in a single piece).
The result indicates a possible amount of plastic in runners recoverable each year of up to 63.6 tons, 45% of the amount sold in Germany.

On a final note regarding the amounts of material estimated, these results allow for the calculation of both the amount of Calcium Carbonate needed to completely transform the Polystyrene in "Limex", and to calculate the price per metric ton of the new material. Considering that the ratio of thermoplastic resin can span between 10 and 40%, and that the amount of inorganic filler covers 60-90% of a metric ton of material, the necessary quantity of Calcium Carbonate will be between 95.4 and 572.4 metric tons. Considering that the price per metric ton of Calcium Carbonate reached 445 US$ per metric ton in 2022 [97], the cost of the filler necessary will be between 42'453 and 254'718 US$. The final amount of "Limex" that can be manufactured from the estimated amount of runners will be between 159 and 636 metric tons. A singular ton of "Limex" could be priced, based exclusively on the materials, between 851.8 US$ (60-40% ratio) and 546.7 US$ (90-10% ratio).

Systemic Project Results

Outcomes and impacts

Expected results

The expected results will be analysed over the three time periods. In each period, the system will be implemented further, and its effects will influence each actor with different intensity.

The timeline will span across 10 years, at the end of which the objective is to have managed to recover 50'000 tons of Polystyrene between landfills and user waste recovery system. The amount of material is quite high, but it is important to remember that the objective is to scale up the system on the whole German territory, and not limiting it to the 15 major cities of the country or the 4 Länder identified in the previous chapter. In addition to that, this amount is the cumulative objective to be reached during the whole 10 years and not to be reached in a singular year.
To put it into perspective, the Limex production company, TMB Co. Ltd., has recently launched a recycling plant in Yokosuka City, with a yearly input of 40'000 tons of plastic[46]. Considering that, a total amount of Polystyrene recovered in 10 years of 50'000 tons does seem feasible, though it will require efficient planning. In addition to that, TBM aims to circulate 1 million tons of Limex in 50 countries by 2030 [98]. According to the ratios defined by the company itself in the patent for the material, the amount of thermoplastic resin needed to manufacture a similar amount will be between 100'000 and 400'000 metric tons. This objective could not be easily reached in 10 years focusing exclusively on a singular country, though with time it could be possible, especially considering the interest that Germany demonstrated towards reducing plastic waste in landfills.
Regarding the landfills, an estimate of the amount of Polystyrene waste could be surmised comparing the total quantity of plastic deposited in them each year with the demand for Polystyrene described in the previous chapter, 6.1%. This results in a possible amount of Polystyrene waste left in landfills in 2021 equal to around 31.1 thousand tons. This amount shows that the quantity of material either still present or potentially dumped in landfills would be very much enough to help the system reach the 50'000 tons recovered goal in 10 years.

On a final note, considering that the recovered plastic waste will be transformed in "Limex", even with the ratios of 60-40% and 90-10% in favour of the inorganic filler, a large amount of raw material is necessary to produce enough "Limex" to make it a valid option to impact the other industries.

Short period (0-3 years)

In the short period, the effects of the system will be mainly felt in the micro scale.

During the first year of this period, the recovery system will be launched with the effort of both model kit companies and the Polystyrene recycling company. During this year, the reverse vending machines will be developed and the retailers and e-commerce sites will be contacted in order to offer them to participate in the recovery system. Also, the marketing and diffusion of information on the recovery system will start, making so that potential participants may learn about it and become interested in it by researching about it.

The effects in participating in the initiative will not be felt before the second year of this period, during which the model builders will start participating. In addition to that, the Polystyrene recycling company will also start purchasing Calcium Carbonate from its manufacturers. The amount of runners recovered in the second year will probably be around 30% of the estimated amount described previously, especially considering that the majority of participants in the survey stated that they would participate mainly when purchasing model kits and the majority stated that they purchase them around once a month. During this year, the effects of the system will start being felt also in the meso level, thanks to the purchase of Calcium Carbonate. In this case, the manufacturers of this material will gain a new sales channel, that with time will grow in value and revenue.

In the third and final year of the short period, the effects on the micro level will see the addition of an increase of sales for retailers and online stores, as well as an increase in participation from the model builders. The objective of this short period is to collect around 100 tons of plastic in runners. During this third year, the model kit companies will start purchasing "Limex" and introducing it in the production process. In order to reduce the costs from using a new material, the companies will start by releasing some of their best selling products in that material, making the most of their popularity. This will be possible thanks to the fact that the new thermoplastic resin composition will share the same properties as Polystyrene, adapting to the production processes used by the model kit manufacturers.
The final effect that will be noticed will touch the landfills: the recovery of runners will start reducing the amount of Polystyrene waste that end up in those sites. The amount, though, will not be particularly noticeable, since the estimated percentage would be around 0.5-1%. This impact will probably remain around this level during the remainder of the time period, given the niche nature of the hobby.

Medium period (3-6 years)

During the medium period the effects of the system will become gradually more intense. In addition to that, it will start affecting the meso level more, in particular landfills.

The first effect expected is an increase of the participation by model builders, which would allow setting to 400 tons the goal of amount of plastic recovered exclusively from users by the sixth year. The participants would also influence more the retailers and online stores, thanks to an increase in purchases, which are pushed forward by the incentives received and an increase in frequency for when the model builders go to stores. The system will also influence the model builders on a socio-cultural aspect: not only they will interact more with the staff of the stores and other enthusiasts of the hobby, but the participation in the waste recovery will influence them in paying attention towards other Polystyrene waste that they may produce (e.g. empty food containers).
This will be pushed also by the communication around the system, especially when the Polystyrene recycling company will start purchasing Polystyrene waste from landfills. This will start at the beginning of this time period, thanks to the system economically stabilising itself during the previous one. By creating a solid sales channel of “Limex” towards model kit companies, the recycling company will be able to purchase more raw materials to both increase their production volume and meet the demand from the model kit industry.

Both Calcium Carbonate manufacturers and landfills will perceive an increase in impact of the system: the former will notice an increase in revenue coming from the Polystyrene recycling company, while the latter will start seeing a reduction of Polystyrene waste in the deposits. The objective for this time period is to recover up to 10’000 tons of waste Polystyrene from landfills, which amounts to around 30% of the total amount deposited each year.
The model kit companies will be able to launch lines of products made out of “Limex”, making an effort to become more eco-friendly. This should help them with their image and, in the long run, increase their sales, if the model builders start appreciating their efforts.

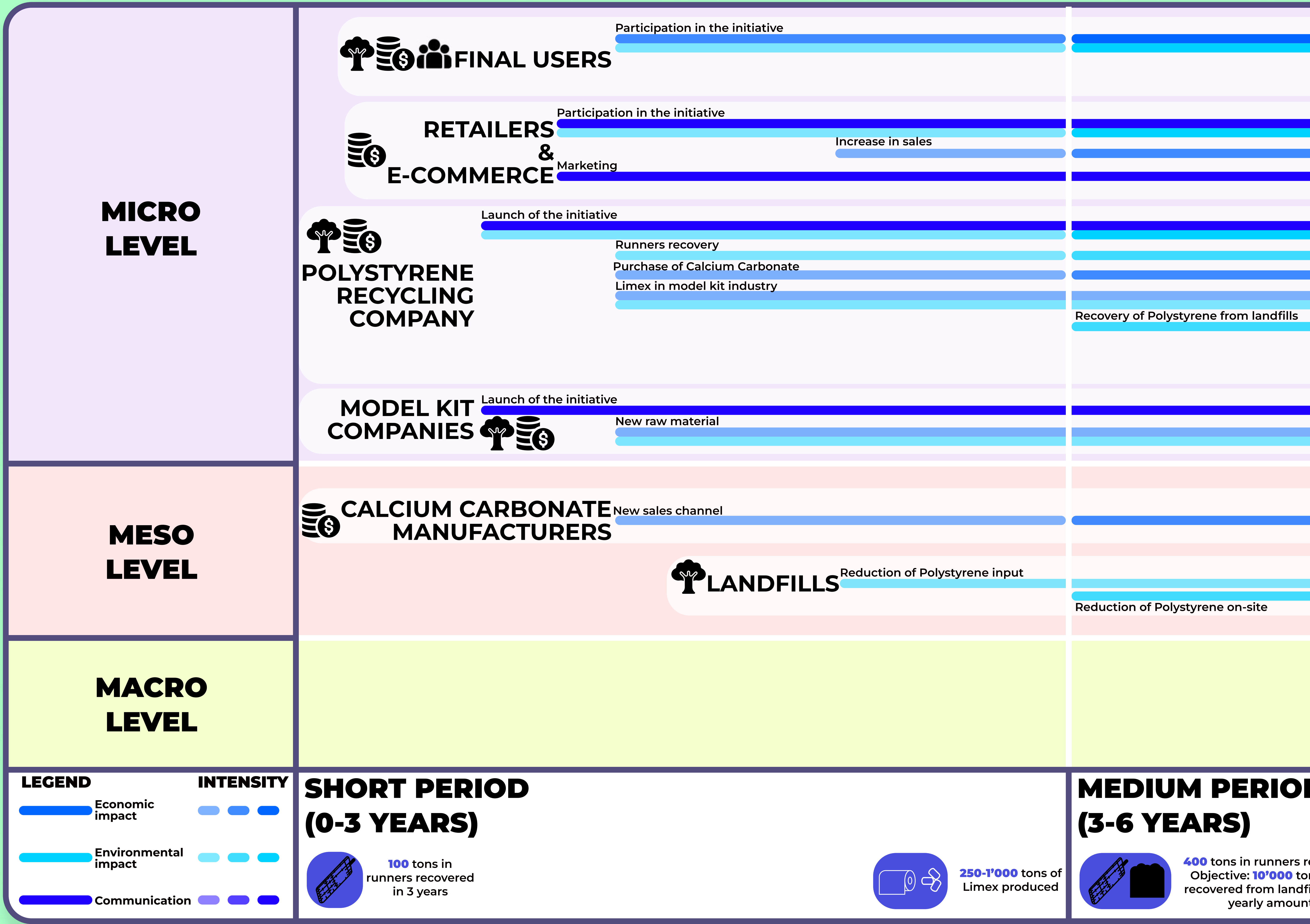
Long period (6-10 years)

The third and last period will have more effects on the macro level, while the already established ones will mostly increase in intensity.

The participation of model builders in the user waste recovery system will have increased even more, together with the increase in revenue for retailers and online stores.
Similarly, the purchase of Calcium Carbonate by the Polystyrene recycling company will increase, as well as the revenue from the manufacturers. The reason for this is also the increase of Polystyrene waste purchase from landfills: between the user waste recovery system and the landfills, the objective to reach in the tenth year is a total of 50’000 tons of Polystyrene recovered. This amount could equate to 125’000 and 500’000 tons of “Limex” produced in 10 years. Considering the previous objective, the amount of “Limex” produced in the final period may be between 75’000 and 400’000 tons.

Reaching said amount will allow the Polystyrene recycling company to open up the system to other industries, particularly towards the paper one. The total use of the produced “Limex” in the paper industry would result in a reduction of the total industry usage of water between 1.3 and 7 million tons or m3, which is an important result for a single company. This is an estimate based on the amount that water efficient plants in Europe and North America use to produce 1 ton of paper, which is between 10 and 25 tons or m3 of water [99]. The estimate was calculate by multiplying the range amount of “Limex” produced with the average between 10 and 25, which us equal to 17.5 tons.
If the system were to be scaled up to include multiple Polystyrene recycling companies, located in various regions of the German territory, it would be feasible to recover the majority of Polystyrene waste left in landfills each year (around 30’000 tons). This would become “Limex”, and, based on the ratios needed for its usage in the paper industry, it could reduce its water usage considerably. While, at the moment, it is not possible to estimate the actual impact, it is important to remember that the production of the normal Limex as paper substitute shows a reduction of 97% of water usage for a ton of material. Therefore, the paper industry would become less dependent on water.

An effect hoped for during this time period would be the influence of the model builders on the plastic industry, particularly towards the Polystyrene usage. Positive feedback towards “Limex” model kits could influence consumers to try and purchase plastic products that may present alternatives to normal oil-based thermoplastic resins. This could also affect the plastic industry as a whole, hopefully kickstarting investments and research towards greener alternatives.



FINAL USERS
Participation in the initiative
RETAILERS & E-COMMERCE
Participation in the initiative
Increase in sales
Marketing
POLYSTYRENE RECYCLING COMPANY
Launch of the initiative
Runners recovery
Purchase of Calcium Carbonate
Limex in model kit industry
Recovery of Polystyrene from landfills
MODEL KIT COMPANIES
Launch of the initiative
New raw material
MICRO LEVEL
CALCIUM CARBONATE MANUFACTURERS
New sales channel
LANDFILLS
Reduction of Polystyrene input
Reduction of Polystyrene on-site
MESO LEVEL
MACRO LEVEL
LEGEND
INTENSITY
Economic impact
Environmental impact
Communication
SHORT PERIOD (0-3 YEARS)
100 tons in runners recovered in 3 years
250-1'000 tons of Limex produced
MEDIUM PERIO
(3-6 YEARS)
400 tons in runners r
Objective: 10'000 to
recovered from landfi
yearly amoun

Influence on the plastic industry

Diffusion of Limex in other industries

PLASTIC INDUSTRY

Adoption of Limex

PAPER INDUSTRY

Adoption of Limex

D

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ills (1/3 of
t)

25’000-140’000 tons of
Limex produced
Stable use of Limex in
model kit industry

LONG PERIOD (6-10 YEARS)

Objective: **50’000** tons of PS
recovered in total in 10 years

Introduction of Limex in **paper and plastic industries**, reduction of use of water between 1.3 and 7 million tons for paper industry

Conclusions

This thesis had the objective of studying the model kit industry, finding issues present in it, investigate its community and develop systemic solutions based on what observed. The results show that it could be possible to apply solutions already in use in other contexts, as well as in similar ones, though limited to the products of a singular company.

The results of this thesis demonstrated that the model building community is interested in seeing their favourite hobby become more eco-friendly, but, at the same time, questions would rise when considering the quality of the materials used in order to do so.
The key towards the application of systemic solutions in the industry becomes the development of a new network between the manufacturing, the resource gathering and the consumers themselves. By giving them the opportunity to directly affect the system, the results would allow this new network to expand towards the reduction of Polystyrene waste present on the German territory, and the opening of the system towards the paper industry.

This change, though, leans on the uncertainty of the participation and collaboration of both customers and stores. In addition to that, the material implemented would still require some level of testing and experimenting, in order to assure good quality using waste to produce something new.

That said, if the model builders and the stores work together with the new system, and the new material reveals itself being of high quality despite originating from waste, the environmental and economic potential of this project skyrocket. The amounts of plastic waste present in German landfills would allow for low-cost raw materials, especially if compared to newly produced Polystyrene pellets. In addition to that, thanks to the fact that the thermoplastic resin composition maintains the mechanical and physical properties of the resin used, it will not be necessary for companies to invest in new technologies to manufacture products using this material.

The benefits that this system would bring to the industries taking part in it and the country in which takes place will be in line with what Germany has accomplished up until now and still tries to accomplish. The reduction of not recycled waste, especially plastic, has been a very difficult task to tackle, and in particular the recycling of Polystyrene has been a challenge. Even with the development of new techniques to do so, the logistics of recovering the material and transporting it have always been the biggest obstacle in its recycling. The introduction of a company focused on working on this material could help ease the burden that Polystyrene brings to the plastic recycling industry.
By scaling up the system to a national size, multiple supporting companies could be launched, in order to slowly reduce the amount of material sent to landfills and left there.

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