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Analysis and support of production planning processes: the case of Pirelli Industrie Pneumatici S.r.l.

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INTRODUCTION

This thesis focuses on the development of technical solutions with the aim of overcoming management problems that create disorder and obstacles in the production process. The activities, later exhibited, were carried out during an internship curricular between July and September 2019 at the headquarters of Pirelli in Settimo Torinese (TO), in the Production department. With the help of the whole team, two macro problems were faced that made the work process difficult: the structuring of a database inside the department and the analysis of materials out of production. During the first month, the attention was focused on building such a database called Planet Production. The need arose because of the introduction by the company of a management software with the aim of unifying the codes of materials, components and products of all plants and, because this structure for the production department is verbose. Hence the creation of a smaller database containing the essential information for the continuation of factory operations. Subsequently, it was considered appropriate to study and analyse the problems of management of the materials inside of the production and in warehouse as the stocks reported from the database did not coincide to the quantities verified manually. From here, the analysis of data has shown deficiencies in terms of completion of certain tasks by staff, suggesting a different approach in order to improve industrial production.

The draft has been structured in three chapters, each of which has particular objectives: the first, is mainly concerned with introducing and explaining the Pirelli context, therefore, the work structures with which it has been dealing (office, warehouse, factory) and, finally, the human relationship with employees and workers; the second chapter, instead, after introducing the tyre, it illustrates the macro problems connected to the realization of an internal database to the department of

Production and analyses the concept of management of the inventory of warehouse, with the relative implications; in the third and last chapter, have been formulated and inserted the possible solutions of the aforementioned problems, analysing the database developed by the team, highlighting the errors in the management of the materials and proposing some guidelines to adopt.

1 PIRELLI

1.1 About Pirelli

1.1.1 The History of the Group

Founded in Milan, Pirelli is a global brand known around the world for its technology, high-end production excellence and passion for innovation that draws heavily on its Italian roots in tyre market. In 1872 Giovanni Battista Pirelli founded a partnership, "G.B. Pirelli & C.", to produce elastic rubber items. G.B. Pirelli & C. was liquidated and Pirelli & C., a limited shares partnership was established. In 1873, the first plant for the production of rubber items was built in Milano. After a few years, in 1894 the first tyre for velocipedes was launched, results of a series of innovations in the preparation of materials and manufacture of tyres. The production of car tyres started in 1901, date from which began a relevant growth thanks to two major factors: attention for technological development of processes and products and a strong geographic expansion., Pirelli's geographic expansion, during the first years of '900, took start with the opening of their plants in Barcelona, Southampton, Buenos Aires, Manresa and Burton on Trent and, first of all, engaged in sports sector: the first Grand Prix of the Automobile Club of France was won by a car fitted with Pirelli tyres in 1907. During the 1920s, Società Italiana Pirelli (the outcome of a reorganization of Pirelli & C.) was listed at the New York Stock Exchange, allowing the Pirelli Group to become the first Italian Group with shares traded on the US market. In 1929, Pirelli built the first Brazilian plant, contributing to expansion throughout the country. After the war, the Superflex Stella Bianca, the first and innovative sport tyre, was developed and launched in the market with excellent

business results. The tyre, that became very popular in Italy during the 1930s, was fitted with a reinforced tread to avoid damages at high speeds. Alongside, Pirelli was going to open other plants for instance in Santo André, in the Merlo factory in Argentina, in order to intensify its presence in South America and this strategy also continued during the 1960s and the 1970s but focusing more intensively on the technological innovation. In this sense, low tyre born: a specific product which thanks to the know-how acquired in racing, met the power requirements for cars produced by big international car makers. This item was continuously developed until the production of super-low tyres, a stronghold of the Group in both the sporting and industrial markets.

With the new millennium, geographic expansion is accompanied by a vigorous business strategies: Pirelli sold to Cisco, a worldwide leader in networking, their terrestrial systems and to Corning, a multinational company specialized in technologies like advanced optics, their optical component business, for 5 billion euro; Pirelli acquired a share in Telecom Italia S.p.A. and signed a joint venture agreement with Continental AG to produce steel cords in Romania: through this joint venture, Pirelli acquired an 80% control share over it and a plant in Slatina was also built; Pirelli sold its *"Cavi e Sistemi Energia e Telecomunicazioni"* business to Goldman Sachs, was named Prysmian S.p.A. In the same years, Pirelli opened their first Chinese tyre plant, in the area that would become the Group's production core in this country. Meanwhile in Italy, the industrial plant of Settimo Torinese was born: the plant was the result of the integration of two factories and became the most technologically advanced cluster in the entire Group. Research to develop technologies on tyre energy efficiency also gained momentum, and in 2009 Cinturato P7 was introduced, the first high-performance tyre based on a "green philosophy". In 2010, Pirelli completed its transformation into a "pure tyre company" and became the exclusive tyre supplier of Formula 1 since 2011. In 2015, the Camfin, LTI and Coinv shareholders signed with ChemChina and its controlled company CNRC (China National Tire & Rubber Corporation, Ltd.) a long-

term industrial partnership agreement involving Pirelli and with the purpose of making Pirelli's development plans stronger, be in strategically important geographic areas and achieve the integration of their tyre business into CNRC and Pirelli industrial market. Between 2015 and 2017, Pirelli's focus was to accomplish all the objectives set forth in the partnership agreement. More specifically, to improve the level of independence to its Industrial Tyre business, also with due consideration to the integration with CNRC projects and actions in this segment.

1.1.2 Innovation and R&D

With around 30.000 employees and turnover of more than 5,3 billion of euro, Pirelli is one of the most important global tyres makers and the only dedicated entirely to Consumer market. Pirelli is a Pure Consumer Tyre Company focused on High Value tyres market and continuously engaged in the development of innovation products with the objective to satisfy specific requirements.

To produce the highest-quality products, Pirelli stresses on operational excellence along its entire value chain, starting with high-tech plants culminating in the engagement of end customers. With 18 plants in 12 countries, Pirelli had a production capacity of 76 million car tyres in 2017, and over 14,600 points of sale in over 160 countries – a growing sales network that puts Pirelli ever closer to its customers.

In this sector, Pirelli competes with Nokian; Bridgestone, Michelin, Continental and Goodyear, characterized by higher prices than average and by a large product range. In the context of High Value tyres, today Pirelli covers a leadership position in several markets, with more than 33% of global market in terms of volume. The full focalization on Consumer business began after the separation of functions related to Industrial tyres, at the end of a transition process finished with the return on the Milan Stock Exchange.

The Prestige range is a tyre developed individually to improve the characteristics of each car model, ensuring the highest levels of safety and performance in any

condition. Focusing on a precise market segment, Prestige is the result of a strong collaboration between Pirelli and the best manufacturers of supercar houses (Houston Martin, Lamborghini, Bentley, Ferrari, Porsche and so on) which makes it possible to be the global leader. In the motorcycle sector, the Pirelli brand, always recognized and appreciated for its strong sports DNA, is an undisputed leader offering a complete range of racing both for track racing and for those in off-road vehicles, respectively with the Diablo line, ideal for asphalt and Scorpion lines, for off-road driving. Lastly, for some years now Pirelli has decided to use all the know-how gained in the world of motors also for the realization of bicycle tyres, first exclusively by road and, recently, also by Mountain Bike.

The Pirelli P Zero Velo, as shown in Figure 1, is the result of Pirelli's experience and know-how, applied to bicycle tyres. It is ideal for competition, but given its versatility can be considered an excellent rubber to be used even in training and under any climatic conditions.

Figure 1. Pirelli P Zero in action

His high-quality products are possible thanks to a constantly engagement in Research & Development that operates through a "Open Innovation" model. This is a new strategic approach whereby companies, in order to create more value and compete better in the market, choose to use not only internal ideas and resources but also ideas, solutions, Technological tools and skills that come from outside, in particular

from start-ups, universities, research institutes, suppliers, inventors, programmers and consultants. In this sense, Pirelli cooperates with 28 universities and it has outsourced more than 150 projects in materials, processes, software and electronics. In 2017, it invested, in R&D programs, 6,5% of its own revenues from High Value products and more than 90% of the total expenses, one of the highest ratio among the world's major tyre producers. Pirelli has 1,800 people engaged in R&D located at its Milan headquarters and 12 local technology centres and a portfolio of 6,100 patents.

1.1.3 Racing

The attention of the consumer starts already in the phase of product development: so having consolidated partnership with the most prestigious car and moto makers is essential. The company currently works in more than 460 car and motorcycle sport events and has been the exclusive tyre supplier to the Formula One™ World Championship since 2011. Such a strong presence in motorsport enables Pirelli to transfer a series of avant-garde solutions to its day-to-day operations providing the final consumer with the maximum levels of performance and safety.

From 2011, Pirelli, as shown in Figure 2, is the exclusive supplier of the tyres in use during the Formula 1 World Championship and will continue to be so until the end of the 2019 season. The most popular races in the world, those of the Formula Championship 1™, are the best showcase worldwide with an audience that every year is equal to 1.6 billion spectators. Pirelli supplies around 1,700 race tyres and a total of 45,000 tyres a year, including those used for testing purposes, during the Formula 1 races. The tyres are supplied in seven varieties of compounds (five slicks, one wet and one intermediate). Each compound is identified by the colour in order to enable the public to know what the mixture used in a specific competition is. All this led to the launch in 2017 of the Pirelli Color Edition, a line of tyres available not only in the seven Formula 1 colours, but in as many as 3,000 shades of pantone colour. In the

motorcycle industry, Pirelli has been the official supplier of the FIM Superbike Championship (WSBK) since 2004.

Figure 2. During a race of the Formula Championship 1™

1.1.4 People

As mentioned in Chapter 1.1.2, Pirelli employs around 30,000 people from different countries, who share a strong sense of belonging and a common goal. Internationality makes it possible to enhance teamwork and provides a cross-cultural and intercultural mentality. These are particularly interesting elements to attract and enhance young talent.

The learning model adopted allows people to develop the skills needed to implement the strategy and on the basis of this experience, Pirelli has been engaged for years in the training of its employees and management through multiple initiatives. Over the last few years, Pirelli's investment has continued with a positive trend, involving more than 96 % of the employees, with at least one training day. It is important to note that, for 6 consecutive years, the overall investment in training exceeded the target set in 7 training days per employee per year. To strengthen and support this

strategy, Pirelli has established the School of Management– dedicated to the development of the managerial culture within Pirelli, aimed at management, young talents and recent graduates employed by the Company. In addition, there are ten Professional Academies that have the objective of providing continuing training, spur collaboration, to ensure the exchange of skills and know-how between countries and develop tools and procedures within the organization.

1.1.5 Brand

The brand Pirelli is synonymous, all over the world, of excellence and technology with his "P" that, from over one century, it marks the style, the creativity, the quality but also its dominant position of supplier of tyres to the producers of auto of luxury (Figure 3).

Figure 3. The brand

The brand Pirelli is considered an icon of the technology, of the taste and of the Italian excellence. With a record of 110-year-old presence in the sporting competitions, Pirelli is sponsor of Inter, winning of the American's Cup with the team Emirates New Zealand over, for instance, to the recent sponsorship of the team of baseball L.A. Dodgers in California. Pirelli, promotes besides the appointment in the art and in the culture both with the Calendar Pirelli, both with the support to the Foundation and of Pirelli Hangar Bicocca, one of the display spaces for the art greatest of Europe.

With the sponsorships the brand is defined and gets involved the public. In the kick, the historical sponsorship of Pirelli for FC Internazionale Milan, internationally known as Inter, as shown in Figure 3, is an element that consolidates the brand awareness, with particular resonance in Asia. The sponsorship of the team of baseball of the Dodgers is another important element to maintain and to improve the prominence of the brand to international level.

The sponsorship of the World Championship of Alpine Ski FIS and of the World Championship of IIHF Hockey on Ice IIHFs are support to the image of the tyre Winter. The sponsorship of the team New Emirates Team Zealand, which has been awarded the edition 2017 of the America's Cup, turns him, instead, to the products Prestige market, particularly sensitive to the innovation and the high performance.

Figure 4. Historical sponsorship for FC Internazionale Milan

Pirelli created, in 1964, the Calendar with the objective to create a tool of promotional value from the artistic and cultural content.

From over a fifty years, The Calendar marks the to spend some time with the images of the most famous photographers of the moment, able to capture and to interpret the contemporary culture, often underlining new tendencies. Today, The Cal. contributes to the image and the positioning of the brand Pirelli, a brand that goes over the auto industry and that it embodies lifestyle, innovation, art and culture.

Pirelli Design is the incubator of projects Prestige that contributes to the exploitation of the brand, of the innovation, of the performance level and of the glamour, through the development of products for a unique lifestyle. The know-how of Pirelli is able, through the collaboration with a selected number of partners that they represent the excellence in the respective areas of business in which they are active to serve from springboard for the creation of projects of different nature. Pirelli, for instance, has a partnership with Roger Dubuis for the products of clock making, with Blossom for the creation of skis and with Tecnorib for the creation of a line of boats, the "P Zero speedboats".

One of the numerous activities of the Foundation Pirelli is the maintenance of all of this that, historically and culturally, characterized and characterizes Pirelli, as also the promotion of the business culture, through local projects and shows. The Foundation also entertains relationships with other corporate body and cultural foundations in the world.

Pirelli, through social media, has reached, in the 2017 first quarter, 88,3 million people, the triple one, in comparison to the same period of the 2016. It increases, in proportionally, also the number of the fans: they are 2,1 million on Facebook 288.000 followers on Instagram 221.000 followers on Twitter 233.000 followers on LinkedIn and 11.300 visitors on YouTube.

Particularly, the social media have brought traffic on the site pirelli.com, the base of digital communication of Pirelli launched at the end of 2015, on which a high number of articles and video appear on the products, motorsport, business, culture and sustainability.

The site has had over 3,3 million of visits in 2016 and around 2.5 million unique visitors of which over the half through the social networks, an increase of the rate of conversion tenfold in the 2017. Besides, the application Super Pirelli's Diablo Biker has been unloaded more than 630.000 times. Furthermore, Pirelli publishes the Magazine World.

1.1.6 Sustainability

Pirelli, thanks to actions already aimed at the sustainable management of the entire value chain, was named the 2018 Sustainability Leader in the Automobiles & Components sector of the Dow Jones World and Europe indices, which are among the most relevant in the world and took into consideration several topics: capacity for dialogue and creation of lasting value for stakeholders, sustainability of the supply chain, development of human capital, health and safety at work, risk management and respect for the environment. And again, emissions reduction and environmental consumption capacity, responsible product management, innovation management and corporate governance. In January 2019, Pirelli became the only company in the Auto Components sector in the world to obtain "Gold Class Company" status in RobecoSAM's 2019 Sustainability Yearbook.

The analysis involved more than 2,200 companies from 61 industrial sectors through an integrated assessment of economic, environmental and social elements. Only 10% of the companies analysed reached a score that allows inclusion in the indices. With Pirelli, there are altogether 5 Italian excellences that have distinguished themselves in the world for sustainability in their own sector: Leonardo in Aerospace & Defence, Terna in Electric Utilities, Saipem in Energy Equipment & Services, Moncler in textile, Apparel & Luxury Goods.

1.2 The industrial pole Pirelli of Settimo Torinese

Projected to become its 'factory of the future', the industrial pole Pirelli of Settimo Torinese is the most technologically advanced and efficient of the group.

Born by the integration of two historical establishments Pirelli, operational from more than 60 years in the Municipality of Settimo, the Pole extends it on an area of over 250.000 square meters and it almost produces 4 million tyres a year.

The plant of Settimo represents the excellence in the world of the Industry 4.0, the based new paradigm of industrial production on the most complete digitization. As shown in Figure 5, heart of the Torinese site is, in fact, the "Next Mirs": an innovative technology owner of Pirelli, completely robotized, for the production of High Ultra tyres Performance from the 19 thumbs to the 23 thumbs. The Next Mirs is able to also reach an applicable productive flexibility to the smallest lotteries of tyres and that it satisfies the objective to employ an industrial model that not only assures a quality "high performance", but that is effective, fast and flexible, and that is able to quickly suit for the numerous ones produced by to develop and by to produce. In the site, in fact, produced the tyres more effective than the range Pirelli.

Figure 5. The Next Mirs

The establishment, as shown in Figure 6, the most innovative in terms of products and productive trials of Pirelli, has been projected at the known architect Renzo Piano beginning from the central body: its "Spina", centre of the activities and the tortures for the employees, Car Nord, the department at north of Spina in which materials are processed and products are produced, and Car Sud, at south of Spina (with the same activities of Car Nord). The idea of the retraining of the industrial site of Settimo is born in 2007 and takes life in 2008 when Piedmont Region, Turin Province, Municipality of Settimo Torinese, University di Turin and Pirelli signed a protocol for the realization of a technological and industrial pole for the production of tyres car. Already in May 2010 Pirelli started the production of tyres auto and in July of the same year it added the production of compounds, inclusive those for the Formula 1.
The Pole is the centre of excellence in which the technological innovation of the R&D meets the production. The tyres developed here, all of high technological content, splits in two ranges: Summer/Winter and All Season. It goes from Ultra High Performance tyres, like P Zero and P Zero Corsa, for sporting and sure guide, to High performance, like for instance P7 Blue. An important part of production is dedicated to Winter and Suv tyres.

Figure 6. The structure of the pole

How does the productive trial work?

The raw materials warehouse receives the materials in entry. Inside the mixing room, all the compounds are realized for the production, with the online control performed from the inside laboratory. From here, a part of the materials is brought to Car Sud and another part to Cell Production in Car Nord. In these areas seven different typologies of semi-finished are produced for the production of the tyres.

The department of semi-processed products feeds the process of building, the trial where all the semi-processed products are assembled for creating the green tyre. The following step is the vulcanisation. Vulcanised tyres are enlivened in automatic way to the finishing and checked with special tools. They finally pass to the store produced ended and, from here they are ready to be delivered to the customers.

The innovation is not only technology: it is sustainability, respect for the environment, the people's care. The industrial hub of Settimo Torinese represents the synthesis of all this.

2 MATERIALS MANAGEMENT

Throughout the tyre production chain, but in general for any product, material management is essential: monitoring the warehouse, structuring a database, optimising production processes, highlight and avoid unsuitable materials, are part of the problems that the Production department of a company constantly examines.
In this case, the pole of Settimo Torinese, which, as highlighted in the previous chapter, is the flagship of Pirelli in Italy, boasts a heterogeneous and compact production department, composed of highly qualified employees, with strong communication skills, with the task, precisely, to shape and manage production according to the objectives set by the company.
In order to better understand the following paragraphs, the structure of the tyre should be explained in detail and thus its components should be known.

2.1 The tyre

As for the types of the tyre currently available on the market, there are two types: with air chamber, from English *"tube type"*, and without air chamber, *"tubeless"* (Figure 7). The first type of tyre has an air chamber containing compressed air inside, which is then protected by a more rigid structure of rubber and fibreboard or metal. Despite the same substantial operation, namely the maintenance of a certain structure and consistency due to the compressed air inside, the second type does not include the presence of an air chamber: The air is in fact contained between the structure and the rim, welded so as to seal it between them. As mentioned above, the first type is almost no longer used in the automotive and motorcycling world, except for those purely off-road vehicles: the pneumatic tube type, in fact, it has a higher impact

resistance and in the case of drilling it is sufficient to replace the air chamber without having to replace the whole tyre. Because during drilling the air escapes very quickly from the air chamber, which does not happen in the tubeless type, in road use it is strongly advised against the tube type tyre because the sudden loss of pressure entails a real risk for the safety of the driver.

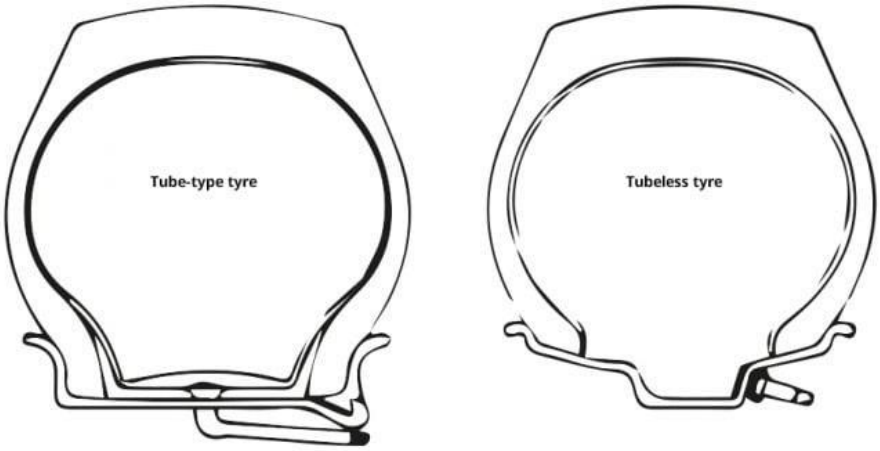


Figure 7. Illustration of the typologies of tyre

In order to know the structure of the tyre, the main components should be considered. The tyre, as shown in Figure 8, is composed, first of all by the *"tread"*, key component to ensure the adherence of the vehicle to the road, is the first element of protection from the road: very resistant to wear, is a layer of rubber more or less thick, with the presence in most cases of grooves to ensure the flow of water between them, to maintain an optimal adhesion even in the wet. Below the tread there is a weave of steel, nylon and polyester wires with the aim of ensuring resistance, stability to the tire and protection against impact, cuts and punctures and takes the name of *"belt"*. The underlying layer, called *"carcass"* o *"tyre casing"*, is nothing more than the tire skeleton and establishes its shape. The carcass is composed of one or more overlapping canvas which are intended to provide flexibility to absorb all the forces involved whether they are related to the movement, braking or tyre pressure. The *sidewall* of the tyre or *"shoulder"* instead, it is used to protect the tyre from

atmospheric agents and side impacts; it can be more or less rigid depending on the use. The part at the base is called *"bead"* which still hermetically the rubber at the rim, prevents wear and ensures the necessary friction so that the rubber does not slip on the rim. Finally, the two metal cores passing through the *"bead circles"* serve to give additional strength, so as to keep the tyre in place.

Figure 8. The structure of the tyre

2.2 Database monitoring

2.2.1 From Planet to Planet Production

In recent years, Pirelli has focused on the introduction of a general database, able to unify the material codes of all the plants of the company into one: it is certain that the creation of a database requires considerable resources such as staff competence in the areas of soft skills, time, large investments but above all a high level of cooperation between the R&D units of the various plants; on the other hand helps to simplify communication between departments, optimizes and speeds up tasks. Also the department of Production is active part of the evolution of the database in how much taking care of the production has the task to monitor eventual anomalies in the codes of the members and to report them timely. The Figure 9 shows only in part, for reasons of space, the structure of the database called Planet: in fact, it is composed of a considerable number of columns, each of which provides precise information about the tire of i-th line as for example:

- *IP_Code*: The first column describes the code assigned to the tyre. This code is usually used when different departments come into contact.
- *Short_Code*: the second column assumes the same meaning of the previous one but the use of different: usually it is used to the inside of the department (much diffused in Production).
- *STATUS*: allows to understand the current situation of the tyre and, therefore, to know if it is out of operation (FG), if it is in production (PR), if it is a prototype (PT), etc.

PLANET - Luigi's configuration

##

Identification					Components		Sizing		
IP_Code	Short_Code	SAV_Code	STATUS	BOMDI_Spec_Notes	SAV_DDI_Foam	SAV_DDI_SAB	Description	Diameter	Tread_Pattern
18132	1132	AV5659A2ST0	FG			SAG1560CJST0	205/55R16 91H V210s2	16	V210s2 [SOTTOZERO]
18132	1132	AV5659A2ST0	FG			SAG1560CJST0	205/55R16 91H V210s2	16	V210s2 [SOTTOZERO]
18132	1132	AV5659A2ST0	FG			SAG1560CYST0	205/55R16 91H V210s2	16	V210s2 [SOTTOZERO]
18133	1133	AV5871A1ST0	FG			SAG1480AOST0	215/45R17 91H XL V210s2	17	V210s2 [SOTTOZERO]
18133	1133	AV5871A1ST0	FG			SAG1480AQST0	215/45R17 91H XL V210s2	17	V210s2 [SOTTOZERO]
18133	1133	AV5871A1ST0	PR			SAG1480ATST0	215/45R17 91H XL V210s2	17	V210s2 [SOTTOZERO]
18134	1134	AV5867A2ST0	FG			SAG1480APST0	215/45R17 91V XL V240s2	17	V240s2 [SOTTOZERO]
18134	1134	AV5867A2ST0	FG			SAG1480ARST0	215/45R17 91V XL V240s2	17	V240s2 [SOTTOZERO]
18134	1134	AV5867A2ST0	PR			SAG1480ASST0	215/45R17 91V XL V240s2	17	V240s2 [SOTTOZERO]
18135	1135	AV5723A1ST0	FG			SAG5330A0ST0	215/55R16 97H XL V210s2	16	V210s2 [SOTTOZERO]
18135	1135	AV5723A1ST0	FG			SAG5330A2ST0	215/55R16 97H XL V210s2	16	V210s2 [SOTTOZERO]
18135	1135	AV5723A1ST0	FG			SAG5330A4ST0	215/55R16 97H XL V210s2	16	V210s2 [SOTTOZERO]
18135	1135	AV5723A1ST0	FG			SAG3386A8ST0	215/55R16 97H XL V210s2	16	V210s2 [SOTTOZERO]
18135	1135	AV5723A1ST0	PR			SAG3386ABST0	215/55R16 97H XL V210s2	16	V210s2 [SOTTOZERO]
18136	1136	AV5817A1ST0	FG			SAG5330A1ST0	215/55R16 93H V210s2	16	V210s2 [SOTTOZERO]

Figure 9. Planet illustration

Despite this, this tool is not used in Production because much of the information contained is considered unnecessary and further clutter and waste of time. To overcome this problem, a second database called Planet Production has been developed, which automatically draws from Planet and contains the essential contents for the production processes. Therefore, its realization is not to be attributed to a single employee but rather to the entire Production Department that meticulously first studied the structure and meaning of the information of Planet and, subsequently, created Planet Production as if it were a sort of summary of the previous.

2.2.2 Database problems

The structure and characteristics of Planet Production, as reported in the previous paragraph, is different (34 columns and 335 rows while PLANET contains 578 columns and 1906 rows) even if it takes data from the general database. The difficulty of its realization is to understand how to organize the data and which are the most appropriate ones to insert in the special column. Among the various

problems encountered in its development it is appropriate to highlight the most important critical points:

- Choice of tyres;
- Reorganization of bead level;
- Choice of vulcanization rooms;
- Extraction of partial information.

Choice of tyres

The first obstacle to be solved is the choice of tyre. In the Production department, only the measures in real-time production are concerned and, therefore, it is superfluous to know that a measure has already been processed. As illustrated in Figure 10, we can notice how the measure 18134 or better 1134 presents both two tuples with *Status* "FG" and a tuple with *Status* "PR". This indicates that the same measure has been processed several times during the year and is currently in production.

Figure 10. IP_Code 18134

Considering the above example only tuple 1134 with *Status* "PR" is useful.

Reorganization of bead level

As shown in paragraph 2.1, the tyre is composed inside by beads and depending on the number of bead levels, it will present different codes:

- Bead Level 1: in this case the tyre contains only the monofilament or naked headband;
- Bead Level 2: the headband is also the bead;
- Bead Level 3: and finally it is also trimmed.

However, in the Planet database, the above information is structured differently (as shown in Figure 11). It is not said that the entry *Bead_1st_Level* always contains the code of the monofilament headband; indeed, it can also express the code of the bead or the code of the trimmed headband.

Identification					Components		Bead_1st_Level	Bead_2nd_Level	Bead_3rd_Level
IP_Code	Short_Code	SAV_Code	STATUS	BOMOI_Spec_Notes	SAV_001_Foam	SAV_002_SAG	CELV1_Bead_FAC_Code	CELV2_Bead_FAC_Code	CELV3_Bead_Topping_M
12809	1809	SAV3030A3ST05	FG			SAG4193A6ST04	17B1	M1380B	
12809	1809	SAV3030A3ST02	FG			SAG5146A0ST01	172	MO1380A	
12809	1809	SAV3030A3ST03	FG			SAG5146A0ST08	172	M1380A	
12809	1809	SAV3030A3ST04	FG			SAG5146A0ST09	172	M1380A	
12809	1809	SAV3030A3ST06	PR			SAG4193A6ST05	723A20	D1382B	

Figure 11. Bead Level

In the event that the size shows the trimmed headband, the code of this last one will be in *Bead_1st_Level*. Consequently, *Bead_2nd_Level* will indicate the code of bead and the *Bead_3rd_Level* instead the code of monofilament headband. Examining a measure with a beaded circle, it will present the code of bead in *Bead_1st_Level* and the code of monofilament circle in *Bead_2nd_Level*. The last case is that relative to a measure containing only the monofilament circle: its code will be *in Bead_1st_Level*.

To remember that in Planet, in correspondence of the *Bead_3rd_Level* entry, the cells are totally empty because the database is being developed and, therefore, lacks some information. The Table 1 below presents the three possible situations.

Bead level/Tyre	Trimmed tyre	Beaded tyre	Naked tyre
Bead_1st_Level	Code of trimmed headband	Code of bead	Code of naked headband
Bead_2nd_Level	Code of bead	Code of naked headband	
Bead_3rd_Level	Code of naked headband		

Table 1. Organization of bead codes

Choice of vulcanization rooms

The vulcanization chambers are structures in which the rubber undergoes a process, called vulcanization, in which the rubber is chemically bonded to the sulphur by heating to obtain an elastic material which is not very swollen when kept in contact with organic solvents. The effect of this chemical process is to modify the molecular shape of the polymer in order to increase its rigidity and tensile strength and to suppress certain undesirable properties such as abrasiveness.

In the Planet database (as shown in Figure 12), both types of rooms are stored respectively in *HF46 DESCR_CAM_VULC* and *HF48 DESCR_CAM_VULC*, while in Planet Production the situation is different. In fact, the objective of the team is to have a single column referring to the vulcanization chambers in which for each measure is inserted the code reported in *HF48 DESCR_CAM_VULC* and in case it is not there, the code in *HF46 DESCR_CAM_VULC* is inserted.

PLANET - Luigi's configuration

##

Identification					Components		Curing				
IP_Code	Short_Code	SAV_Code	STATUS	BOM01_Spec_Notes	SAV_001_Foam	SAV_002_SAG	Curing_Cycle_Time_mi	Curing_Cycle_Time_se	Curing_Blader	HF46 DESCR_CAM_VULC	HF48 DESCR_CAM_VULC
12809	1809	SAV3030A3ST05	FG			SAG4193A6ST04	13	0	B09183600	270-290X370X515	270-290X370X515
12809	1809	SAV3030A3ST02	FG			SAG5146A0ST01	13	30	B09140000	270-290X330X540	
12809	1809	SAV3030A3ST03	FG			SAG5146A0ST08	13	30	B09140000	270-290X330X540	
12809	1809	SAV3030A3ST04	FG			SAG5146A0ST09	13	30	B09140000	270-290X330X540	
12809	1809	SAV3030A3ST06	PR			SAG4193A6ST05	13	0	B09183600	270-290X370X515	270-290X370X515
13107	1107	SAV3789A3ST01	FG			SAG4026A4ST01	13	0	B09183600	270-290X370X515	270-290X370X515
13107	1107	SAV3789A3ST03	FG			SAG4026A4ST02	13	0	B09183600	270-290X370X515	270-290X370X515
13107	1107	SAV3789A3ST02	FG			SAG4026A4ST03	13	0	B09183600	270-290X370X515	270-290X370X515
13107	1107	SAV3789A3ST04	PR			SAG4026A4ST05	13	0	B09183600	270-290X370X515	270-290X370X515

Figure 12. Curing

Extraction of partial information

At times the information contained in the cells tend to be too verbose and little concise and therefore, according to the dictates of the Production department, some types of they have been trimmed in order to be more effective and immediate.

In Figure 12 below, the columns in question are shown from the first named *Sidewall_Material_SAP_Code* to the last named *CELV3_Bead_Topping_Material*. As is easy to note, the columns above indicate the materials with which those particular components are produced and, usually, the characters taken into consideration are from the second to the fifth. For example, taking into consideration the first measure in the Figure 13, 12384, in correspondence of the column *Antiabrasive_Material_SAP_Code*, the cell contains the code "CTURN001C" and therefore is sufficient the code "TURN".

PLANET - Luigi's configuration

##

Identification				Sidewall		Tread			Bead_1st_Level	Bead_2nd_Level	Bead_3rd_Level
IP_Code	Short_Code	SAV_Code	STATUS	Sidewall_Material_SAP_Code	Antiabrasive_Material_SAP_Code	TFA_Tread_Material_SAP_Code	TFA_UnderTread_Material_SAP_Code	UnderLayer_Material_SAP_Code	CELV1_Bead_Topping_Material	CELV2_Bead_Topping_Material	CELV3_Bead_Topping_Material
15696	1696	SAV3880A1ST03	FG	CEST_001C	CTURN001C	CDBV_001C	CUNIT001C	CUNIT001C	CARCI001C	CARCI001C	CARCI001C
16388	61388	SAV4841A1ST01	FG	CELBA001C	CTASK001C	CDBV_001C	CUNIT001C	CUNUM001C	CALDO001C	CALDO001C	CALDO001C
16388	1388	SAV4841A2ST01	FG	CELBA001C	CTASK001C	CDBV_001C	CUNIT001C	CUNUM001C	CALDO001C	CALDO001C	CALDO001C
16388	1388	SAV4841A2ST02	PR	CELBA001C	CTASK001C	CDBV_001C	CUNIT001C	CUBER001C	CALDO001C	CALDO001C	CALDO001C
16388	61388	SAV4841A1ST05	PT	CELBA001C	CTASK001C	CDBV_001C	CUNIT001C	CUBER001C	CALDO001C	CALDO001C	CALDO001C
16388	61388	SAV4841A1ST02	PT	CELBA001C	CTASK001C	CDBV_001C	CUNIT001C	CUBER001C	CALDO001C	CALDO001C	CALDO001C

Figure 13. Extraction of partial information

2.3 Warehouse management

Always with greater frequency we speak of business digitalization, forgetting that to the base of an effective optimization of the operations and the resources, there is a correct management of the warehouse and of the entire logistic chain. With the flow of goods, their rotation and their provision it is possible to guarantee linear processes, efficient production cycles and customer satisfaction. Although firmly anchored to the material world, warehouse management can take many advantages from digital solutions. This applies to each phase and responsibility that alternate along the production chain.

2.3.1 The fundamental aspects

The warehouse is a logistic structure that regulates the differences between the flow of income and flow of exit of the goods with the aid of the storage equipment and handling, to the human and managerial resources. In other words, the warehouse allows the companies to receive, conserve and distribute these flows that usually are coordinated and this is one of the reasons why the storage is used. Inside are articulated operations and processes, some even very complex as:

- Reception of goods: these are essential activities involving a phase of registration and control, verifying the parcels in real time through the use of WBS software.
- Inland transport activities: this can be done in a traditional way, that is using lifting equipment, or you can opt for a more efficient automatic handling of the load.

- Selection of storage and storage areas: first store the goods to be moved to the area of preparation of the order. Here there will be the consolidation of the loads and finally the shipment of the goods.
- Update of information on stocks and stocks, re-checking of new flows according to demand or forecasts.

Efficiency, as you know, is the fundamental principle of supply and warehouse management. Every element, every resource, every gesture needs a coordination studied according to precise objectives of KPI and business. Therefore, it is necessary to focus in order to be more performing on the dynamics internal of the warehouse that favor a wider picture regarding the logistics or other strategic functions. This means that to every action completed in warehouse must correspond a precise trace to correlate to the register of the documentation of the goods. Only in this way it becomes possible to analyse the movements to the inside of the warehouse in order to optimize the levels of efficiency that regard the entire organization. As in any other business process, employees are at the heart of management activities. It's their decisions, their ability to assess situations, the same knowledge of spaces, the experience acquired in the control of the inventory to be the fulcrum of any project of optimization of the reception and storage of the goods. All this presupposes a precise division of tasks: it is essential to organise tasks properly when it comes to demanding maximum precision.

In this case, therefore, the tasks are different and multiple, but all extremely delicate: be careful to receive the goods in arrival, check compliance with the accompanying documentation and verify that it is integrity; move the goods to the storage area according to pre-established management criteria; update the inventory and based on it establish minimum stock limits whenever there is a need; lastly, structure the shipment of products and ensure that they are handled by partners. For this reason, every role and gesture must be planned with the utmost attention and precision. On the other hand, when it comes to logistics, precision is synonymous with safety. the

possibility to verify in detail the handling and to keep track of the type of goods entering and leaving, as well as the process along the entire logistics chain is essential to understand which devices and plans to activate to preserve the safety of people, things and machinery inside the warehouse. To remember that the threats and the risks evolve with the logistic systems, the software of management of the documentation and with the same physiognomy of the warehouse. It is therefore necessary to organise regular training courses to update staff both with regard to safety standards and the proper functioning, as new elements and procedures are being introduced.

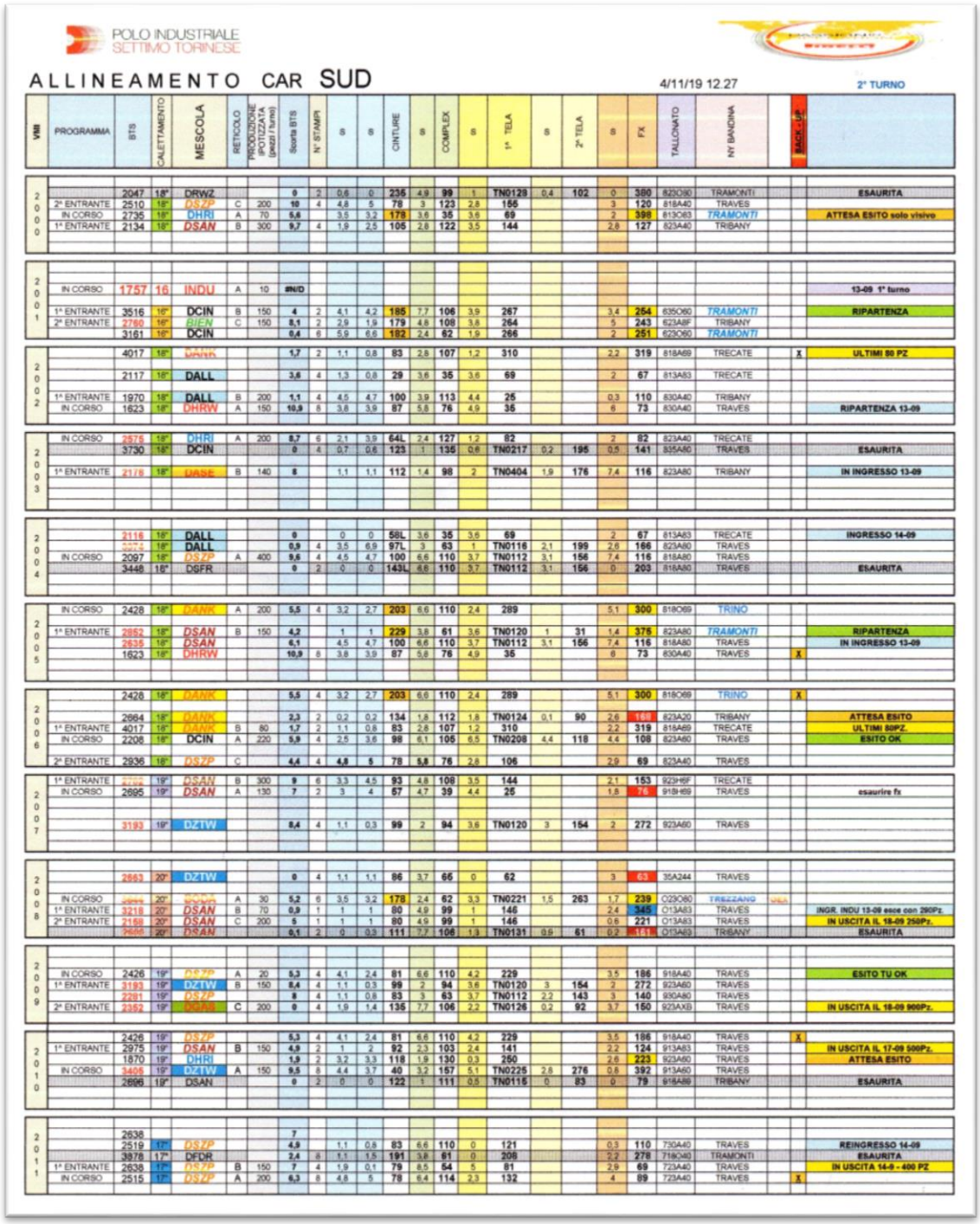
2.3.2 The role of technology for warehouse management

The use of digital technologies and software is the engine to make for more effective management operations outside or inside the warehouse. Just think that only the introduction of management software that digitize most data acquisition operations and practices allows any organization to make a huge leap in quality. From the data entry activities related to DDT and inventory, up to the real-time reports on the handling of the goods passing for the control of the performances regarding the productivity objectives, the software for the management of the warehouse offer an always updated vision on the available stocks of goods and their position in the warehouse, and from the other one an estimate on the exhaustion of the supplies planning in automatic the reorders. In reference to the managerial software for the warehouse, Gartner has defined the ERP like a technological means that automates and connects the functionalities of administrative business and those operating ones as for example area finance, human resources, purchases, applying different levels of integration. In this way they increase the advantages thanks to the adoption of the ERP beyond the administrative functions, integrating it with the operating areas, like the management of the orders, the production, the logistics and the supply chain, in order to optimise operational efficiency.

2.3.3 Materials monitoring

The tools available give the possibility to understand the levels of the stocks of the materials and to plan in coherent way the production. During this process, in Production but also in other departments, the employees use a particular instrument that reports the number of units in stock for each specific material, component and semi-finished. Developed on Microsoft Excel, it is structured in two files in order to focus separately the attention on the departments Car Sud and Car Nord. As shown in Figure 14 and Figure 15, both alignments are very similar to each other with the exception of the number of VMIs: in fact, in Car Nord alignment, there are only 4 types of VMI along the *VMI*, while in the other there are 12 VMI: it is evident that the latter is considerably larger than the other. The Car Sud also houses most of the stocks of semi-finished products and components, a detail not to be overlooked when they are transported by Car Nord and processed at the VMI 1200, 1300, 1400, 1500. Continuing the second column called *PROGRAMMA*, indicates the sequence by which the VMI will process the measurements (reported in the *BTS* column). The most important columns, for the analysis of the materials, are the columns called *S*: they indicate the units of that determined semi-finished one in warehouse, each of which makes reference to the column that anticipates the same thematic colour. However, their content is not entirely reliable: every time a material is used along the production chain, the workers have the task of entering such data in the database. All this is possible thanks to the identification plates of the materials, whose barcode contains the essential information such as the quantity of material, the production date, the expiration date, etc. At this point, the workers use a tool capable of reading the bar code and automatically entering such data in the database. The realization of this task is essential and strategic because it promotes greater efficiency and less waste of materials. Unfortunately, this task is not always completed, causing a mismatch between the stocks reported in the database (see Figures 14 and 15) and the actual stocks. Consequently, the Production department has opted, for a determined period, the physical monitoring of the supplies, in order to evidence better, the

discrepancies of the data, understand their impact on production and extrapolate new information to optimize processes.



POLO INDUSTRIALE
SETTIMO TORINESE

ALLINEAMENTO CAR SUD

4/11/19 12.27

2° TURNO

VAR	PROGRAMMA	BTS	CALETTAMENTO	MESCOLA	RETICOLO	PRODUZIONE (POTIZZATA (pezzi / turno)	Scorta BTS	N° STAMPI	ø	ø	CINTURE	ø	COMPLEX	ø	1° TELA	ø	2° TELA	ø	FX	TALLONATO	N° BANDINA		BACK CAP	
2000		2047	18"	DRWZ			0	2	0,6	0	235	4,9	99	1	TN0128	0,4	102	0	380	823O80	TRAMONTI			ESAURITA
	2° ENTRANTE	2510	16"	DSZP	C	200	10	4	4,8	5	78	3	123	2,8	155			3	120	818A40	TRAVES			
	IN CORSO	2735	16"	DHRI	A	70	5,6		3,5	3,2	178	3,6	35	3,6	69			2	398	813O83	TRAMONTI			ATTESA ESITO solo visivo
	1° ENTRANTE	2134	16"	DSAN	B	300	9,7	4	1,9	2,5	105	2,8	122	3,5	144			2,8	127	823A40	TRIBANY			
2001	IN CORSO	1757	16	INDU	A	10	#N/D																	13-09 1° turno
	1° ENTRANTE	3516	16"	DCIN	B	150	4	2	4,1	4,2	185	7,7	106	3,9	267			3,4	264	635O60	TRAMONTI			RIPARTENZA
	2° ENTRANTE	2760	16"	BIEN	C	150	8,1	2	2,9	1,9	179	4,8	108	3,8	264			5	243	623A8F	TRIBANY			
		3161	16"	DCIN			0,4	6	5,9	6,6	182	2,4	62	1,9	266			2	251	623O60	TRAMONTI			
2002		4017	18"	DANK			1,7	2	1,1	0,8	83	2,8	107	1,2	310			2,2	319	818A69	TRECATE		X	ULTIMI 80 PZ
		2117	16"	DALL			3,6	4	1,3	0,8	29	3,6	35	3,6	69			2	67	813A83	TRECATE			
	1° ENTRANTE	1970	16"	DALL	B	200	1,1	4	4,5	4,7	100	3,9	113	4,4	25			0,3	110	830A40	TRIBANY			
	IN CORSO	1623	16"	DHRW	A	150	10,9	8	3,8	3,9	87	5,8	76	4,9	35			6	73	830A40	TRAVES			RIPARTENZA 13-09
2003	IN CORSO	2575	16"	DHRI	A	200	8,7	6	2,1	3,9	64L	2,4	127	1,2	82			2	82	823A40	TRECATE			
		3730	16"	DCIN			0	4	0,7	0,6	123	1	136	0,6	TN0217	0,2	195	0,5	141	835A80	TRAVES			ESAURITA
	1° ENTRANTE	2178	16"	DASC	B	140	8		1,1	1,1	112	1,4	98	2	TN0404	1,9	176	7,4	116	823A80	TRIBANY			IN INGRESSO 13-09
2004		2116	16"	DALL			0		0	0	58L	3,6	35	3,6	69			2	67	813A83	TRECATE			INGRESSO 14-09
		2442	16"	DALL			0,9	4	3,5	6,9	97L	3	63	1	TN0116	2,1	199	2,6	166	823A80	TRAVES			
	IN CORSO	2097	16"	DSZP	A	400	9,6	4	4,5	4,7	100	6,6	110	3,7	TN0112	3,1	156	7,4	116	818A80	TRAVES			
		3448	16"	DSFR			0	2	0	0	143L	4,6	110	3,7	TN0112	3,1	156	0	203	818A80	TRAVES			ESAURITA
2005	IN CORSO	2428	18"	DANK	A	200	5,5	4	3,2	2,7	203	6,6	110	2,4	289			5,1	300	818O69	TRINO			
	1° ENTRANTE	2852	16"	DSAN	B	150	4,2		1	1	229	3,8	61	3,6	TN0120	1	31	1,4	375	823A80	TRAMONTI			RIPARTENZA
		2635	16"	DSAN			6,1		4,5	4,7	100	6,6	110	3,7	TN0112	3,1	156	7,4	116	818A80	TRAVES			IN INGRESSO 13-09
		1623	16"	DHRW			10,9	8	3,8	3,9	87	5,8	76	4,9	35			8	73	830A40	TRAVES		X	
2006		2428	18"	DANK			5,5	4	3,2	2,7	203	6,6	110	2,4	289			5,1	300	818O69	TRINO		X	
		2984	16"	DANK			2,3	2	0,2	0,2	134	1,8	112	1,8	TN0124	0,1	90	2,6	168	823A20	TRIBANY			ATTESA ESITO
	1° ENTRANTE	4017	16"	DANK	B	80	1,7	2	1,1	0,8	83	2,8	107	1,2	310			2,2	319	818A69	TRECATE			ULTIMI 80PZ.
	IN CORSO	2208	16"	DCIN	A	220	5,9	4	2,5	3,6	98	6,1	105	6,5	TN0208	4,4	118	4,4	108	823A60	TRAVES			ESITO OK
	2° ENTRANTE	2836	16"	DSZP	C		4,4	4	4,8	5	78	5,8	76	2,8	106			2,9	69	823A40	TRAVES			
2007	1° ENTRANTE	2702	19"	DSAN	B	300	9	6	3,3	4,5	93	4,8	108	3,5	144			2,1	153	923H6F	TRECATE			
	IN CORSO	2695	19"	DSAN	A	130	7	2	3	4	87	4,7	39	4,4	25			1,8	76	919H69	TRAVES			esaurire fx
		3193	19"	DZTW			8,4	4	1,1	0,3	99	2	94	3,6	TN0120	3	154	2	272	923A60	TRAVES			
2008		2663	20"	DZTW			0	4	1,1	1,1	86	3,7	65	0	62			3	63	35A244	TRAVES			
	IN CORSO	2944	20"	DANK	A	30	5,2	6	3,5	3,2	178	2,4	62	3,3	TN0221	1,5	263	1,7	239	O23O80	TREZZANO	USA		
	1° ENTRANTE	3218	20"	DSAN	B	70	0,9	1	1	1	80	4,9	99	1	146			2,4	345	O13A83	TRAVES			INGR. INDU 13-09 esce con 290Pz.
	2° ENTRANTE	2158	20"	DSAN	C	200	5	1	1	1	80	4,9	99	1	146			0,6	221	O13A83	TRAVES			IN USCITA IL 18-09 250Pz.
		2666	20"	DSAN			0,1	2	0	0,3	111	7,7	108	1,3	TN0131	0,6	61	0,2	141	O13A83	TRIBANY			ESAURITA
2009	IN CORSO	2426	19"	DSZP	A	20	5,3	4	4,1	2,4	81	6,6	110	4,2	229			3,5	186	918A40	TRAVES			ESITO TU OK
	1° ENTRANTE	3193	19"	DZTW	B	150	8,4	4	1,1	0,3	99	2	94	3,6	TN0120	3	154	2	272	923A60	TRAVES			
		2281	19"	DSZP			8	4	1,1	0,8	83	3	63	3,7	TN0112	2,2	143	3	140	930A60	TRAVES			
	2° ENTRANTE	2392	19"	DSAN	C	200	0	4	1,9	1,4	135	7,7	106	2,2	TN0126	0,2	92	3,7	150	923AXB	TRAVES			IN USCITA IL 18-09 900Pz.
2010		2426	19"	DSZP			5,3	4	4,1	2,4	81	6,6	110	4,2	229			3,5	186	918A40	TRAVES		X	
	1° ENTRANTE	2975	19"	DSAN	B	150	4,9	2	1	2	92	2,3	103	2,4	141			2,2	124	913A83	TRAVES			IN USCITA IL 17-09 500Pz.
		1870	19"	DHRI			1,9	2	3,2	3,3	118	1,9	130	0,3	260			2,6	223	923A60	TRAVES			ATTESA ESITO
	IN CORSO	3405	19"	DZTW	A	150	9,5	8	4,4	3,7	40	3,2	157	5,1	TN0225	2,8	276	0,8	392	913A60	TRAVES			
		2666	19"	DSAN			0	2	0	0	122	1	111	0,5	TN0116	0	83	0	79	918A69	TRIBANY			ESAURITA
2011		2638					7																	
		2519	17"	DSZP			4,9		1,1	0,8	83	6,6	110	0	121			0,3	110	730A40	TRAVES			REINGRESSO 14-09
		3878	17"	DFDR			2,4	8	1,5	1,5	191	3,8	61	0	208			2,2	278	718O40	TRAMONTI			ESAURITA
	1° ENTRANTE	2638	17"	DSZP	B	150	7	4	1,9	0,1	79	8,5	54	5	81			2,9	69	723A40	TRAVES			IN USCITA 14-9 - 400 PZ
	IN CORSO	2515	17"	DSZP	A	200	6,3	8	4,8	5	79	6,4	114	2,3	132			4	89	723A40	TRAVES		X	

Figure 14. Alignment Car Sud

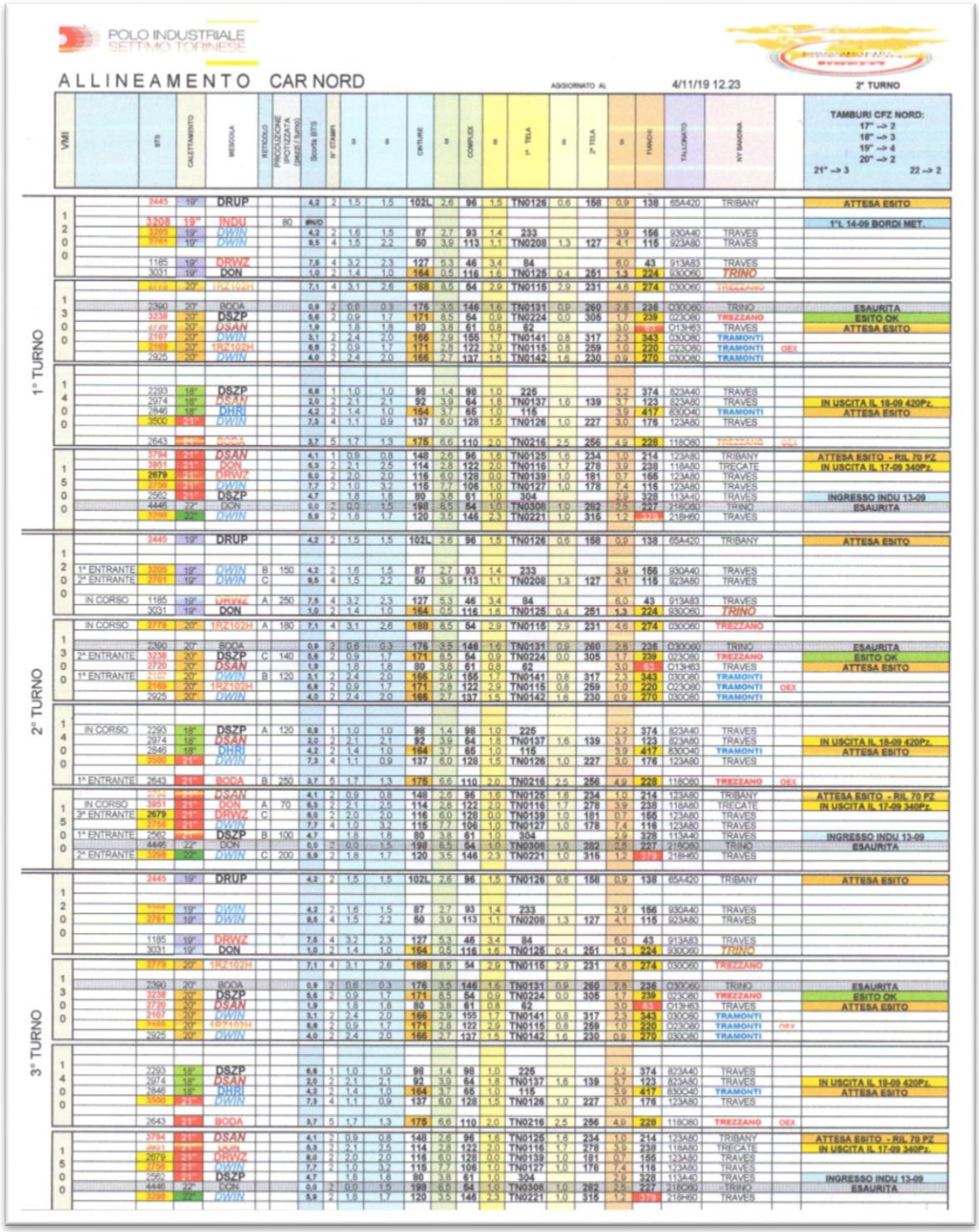


Figure 15. Alignment Car Nord

3 PROBLEM SOLVING

With the term *problem solving* (English word that can be translated into Italian as problem solving), intellectual activity of thought is indicated in order to achieve a desired condition starting from a given condition. It should be noted that problem solving is only part of the problem solving process: the procedure includes two other previous steps: *problem finding*, including the identification and definition of a problem situation, and *problem shaping*, with the objective of delineating and better defining a problem, it has been formulated in terms that are too vague for it to be effectively addressed and resolved.

To be kept in mind that the solutions formulated and adopted do not have to be considered the best one since, facing every day multiple problems, the prerogative of the staff of the department of Production is, therefore, the identification of a solution that is immediately accessible and easy to understand.

3.1 Database construction

As introduced in section 2.2.2, the composition of the Planet Production database turns out to be very functional and little redundant, offering the main information for the production process of the tire (see Figure 16). The selection of the information to be entered in the database has been thought thanks to a careful study of the data finalized to the satisfaction of all the possible necessities along the production process. The file, made using the Microsoft Excel tool, is composed of the following columns that attribute specific information to a particular measure:

- *IPS*: together with the columns Fact Code and Status, they have been introduced in the previous chapter. It indicates the tyre code.

- *FACT CODE*: also called with the name of Short Code, the code indicates, like the previous attribute, the measure and is used daily in Production.
- *STATUS*: provides information about the current state of the measure and can take the following values: PR (production), FG (out of operation), PT (prototype), AV (start-up), SD and DR.
- *Cured Description*: full description of the product, includes features such as line and heat-shrinking**.**
- *CLIENTE*: indicates whether the measure is produced for a specific customer such as Jeep and Volvo.
- *Cappiato*: boolean information on the presence of the capped headband. Although the content may seem rather meagre, it is useful to understand the nature of the measure immediately. In any case, the team has inserted another special column for the code capped.
- *Bitela*: the following attribute behaves like the previous. In this way, it is easy to know if the measure also presents the second canvas.
- *BTS*: provides information about the material used to make the tread.
- *trafilatura 1 e trafilatura alternativa*: forming process that induces a change in the shape of the starting raw material through forces imprinted by equipment and matrices. In the present case, they indicate the type of machinery used for this process.
- *CT Vulca*: the following column indicates the cycle time that the vulcanization room takes to heat the rubber and get an elastic material.
- *Sottostrato 1* e *Sottostrato 2*: provide information about the materials of which the tread is composed, respectively under tread material and under layer material.
- *Bocchettone*: threaded metal element of connection between two pipes.
- *Mescola FX*: shows the material of the mixture with which the side of that particular measure was made.
- *Cod FX*: indicates the shoulder code.

- *Cod CX*: provides the complex code, tire component.
- *Tessuto 1 TELA*: information of the material of which the first canvas is composed.
- *Cod 1 TELA*: contains the code of the first cloth used for that measure.
- *Tessuto 2 TELA*: the column Bitela indicates whether the tyre is composed of two canvases or not. If so, the following attribute indicates the material of the second canvas.
- *Codice cerchietto monofilo*: delicate information to be extrapolated for the different organization of the Planet database be from which Planet Production draws.
- *Cerchietti da Ext*: sometimes some measures need special circles that are imported from foreign plants. In such a case, the presence of this information in the database means that in the cells related to the monofilament circle, beaded and capped, there is no information.
- *Tallonato*: the same goes for the code of the beaded headband.
- *Tessuto per cappio*: the column indicates the material with which the capped headband is made.
- *Cappio*: as for the bead level 1 and the bead level 2, also for the code of capped headband Planet Production has reserved a column.
- *Tex metallico*: focusing on the belts, this column indicates the metallic material with which they are made.
- *COD cintura 1* e *COD cintura 2*: belts are an essential component of the tyre: they ensure resistance, stability and protection against impacts. Therefore, the codes of both are needed.
- *Larghezza cintura*: as the name suggests, it indicates the width of the belt. This information is extremely useful because in some cases the belt can be resized and used on other tyres.

- *Camere*: thanks to the preceding paragraphs, it is easy to understand the importance of the vulcanization rooms and, consequently, it is logical to insert their codes in the database.
- *SAP Code*: with the term SAP (Systems, applications and Products in data processing) means a multinational software house for the management of all the company's processes such as sales, purchases, warehouse management, accounting etc. Its presence is useful in case we want to have more information about the tyre: in this sense it is possible to investigate the software through the use of the SAP code.
- *Linea*: presents the range of which that specific measure forms part.
- *Calettamento*: the following attribute indicates the minimum inner diameter of a tyre, expressed in inches or millimetres and normally represented by the second of the two numbers on the tyre sidewall.
- *VMI*: It is important to know on which VMI the measure is planned to be processed as this makes it easier to identify any problems in the transport of components.

Figure 16. Overview of Planet Production

Choice of tyres

The choice of tyre was the first major problem addressed and promptly resolved. As mentioned above, this choice is based on the Status of the tyre and around it rotates the whole selection of measures to be inserted in the database. To begin with, for occasional needs, the team has chosen to include in Planet Production, not only the measures that present a Status "PR", but also those with Status "SD" and "DR". The solution of this problem has been generated by inserting in the indicated cells, the appropriate formulas used in Microsoft Excel and, therefore, avoiding to create a macro through the use of the programming language VBA. The first step in resolving the problem is the creation of a Boolean table: the code provided for the verification of the Status of each measure by accepting only the above criteria. As shown in Figure 17, the table also contains a column counting cumulatively the number of tyres meeting these conditions: Thanks to it is possible to undo the exact line in the Planet database of the selected measures.

PR	SD	DR	TOT
FALSO	FALSO	FALSO	0
FALSO	FALSO	FALSO	0
VERO	FALSO	FALSO	1
FALSO	FALSO	FALSO	1
VERO	FALSO	FALSO	2
FALSO	FALSO	FALSO	2
FALSO	FALSO	FALSO	2
FALSO	FALSO	FALSO	2
VERO	FALSO	FALSO	3
FALSO	FALSO	FALSO	3
FALSO	FALSO	FALSO	3
VERO	FALSO	FALSO	4
FALSO	FALSO	FALSO	4
FALSO	FALSO	FALSO	4
FALSO	FALSO	FALSO	4
VERO	FALSO	FALSO	5
FALSO	FALSO	FALSO	5
VERO	FALSO	FALSO	6
FALSO	FALSO	FALSO	6
FALSO	FALSO	FALSO	6
FALSO	FALSO	FALSO	6
VERO	FALSO	FALSO	7
FALSO	FALSO	FALSO	7
FALSO	FALSO	FALSO	7
VERO	FALSO	FALSO	8

Figure 17. Table

Looking at the table it is easy to notice that some numbers have been repeated and could be misleading: this because as already said the last column is referred to the cumulate and, therefore, the lines that repeat the number, are those which add nothing to the sum and do not meet the criteria. Here is the code of the first column:

=SE(E('[Planet.xlsx]Planet'!$A5='[Planet.xlsx]Planet'!$A4;'[Planet.xlsx]Planet'!$D5='[Planet.xlsx]Planet'!$D4);0;VAL.NUMERO(RICERCA("PR";'[Planet.xlsx]Planet'!$D5)))

The instruction has several functions, nested between them: if the tyre size of the i-th row is the same as the previous one, and the two statuses are the same, it returns the value 0, otherwise it returns 1 if the measurement status is “PR”.
The following two columns show similar formulas, changing only the Status “PR” in the SEARCH function. The fourth column instead presents the following formula:

=SOMMA(E4;A5+B5+C5)

Thanks to the SOMMA function set up in this way you can generate the cumulative sum, essential for choosing the right tuples. Finally, the nested use of the functions INDICE and CONFRONTA, allow to return values both on the left and right of the column within which a value was searched:

=SE.ERRORE(INDICE('[Planet.xlsx]Planet'!$D$5:$D$2776;CONFRONTA(RIGHE(C$5:C5);Table[TOT];0));"NO SPEC")

The function SE.ERRORE has the task to intercept and manage the errors in a formula: it returns a specified value if a formula returns an error and, if not, returns the result of the formula.
By means of the following instructions, it is possible to select the values of the cells of the measurements that meet the three criteria and have thus greatly reduced the

number of lines: in fact, in every column there is the same structure-base of the code, each of which is linked to a different column of the original database.

Reorganization of bead level

The second macro problem solved is the arrangement of data related to the tyre bead levels: the case, examined in the previous chapter and illustrated in Table 1, suggested to the team a solution evidently not stylistic but effective for the continuation of the activities, starting from the bead Level 1, that is the monofilament headband:

=SE.ERRORE(SE(A5="NO SPEC"; "NO SPEC";SE(AC5="-";
SE(INDICE('[Planet.xlsx]Planet'!$AU$5:$AU$2776;CONFRONTA(RIGHE(AB$5:AB5);Table[TOT];0))<>0;INDICE('Planet.xlsx]Planet'!$AU$5:$AU$2776;CONFRONTA(RIGHE(AB$5:AB5);Table[TOT];0));
SE(INDICE('[Planet.xlsx]Planet'!$AR5:$AR$2776;CONFRONTA(RIGHE(AB$5:AB5);Table[TOT];0))<>0;INDICE('[Planet.xlsx]Planet'!$AR$5:$AR$2776;CONFRONTA(RIGHE(AB$5:AB5);Table[TOT];0));INDICE('[Planet.xlsx]Planet'!$AN$5:$AN$2776;CONFRONTA(RIGHE(AA$5:AA5);Tabl[TOT];0)))));"-"));"NO SPEC")

Analyzing the formula, composed of functions already introduced in precedence, indicates that if:

• the measurement shows a capped headband; the content is in the column *Bead_1st_Level* of Planet;

• the product is composed by a beaded circle; the information is contained in *Bead_2nd_Level*;

• if the tyre has only the monofilament headband, the information is contained in *Bead_3rd_Level*.

The core of the programming code develops three nested SE functions and all of them present to them the usual combo INDICE and CONFRONTA. Going more and more externally, emerges another SE command with the scope to change the content of the cell if the measure needs a circle coming from foreign plants. And finally, as in the previous formulas, the function SE.ERRORE has been inserted in default.
The implementation of the instructions for the code capped and the code beaded follow the same process, taking advantage of the above functions to search for the specific data and to consider the different situations that affect the position of the latter: therefore, it is repetitive to insert their respective formulas.

Choice of vulcanization rooms

At this point, after having managed enough with the main functions in Microsoft Excel, the formulation of the code is transparent and immediate. As shown below, the command is internally structured by the SE function, which returns the i-th measurement data from the column HF48 DESCR_CAM_VULC if it is not empty, otherwise fishing from the column HF46 DESCR_CAM_VULC, while the most external part of the code is reserved to the SE.ERRORE command to report any errors:

=SE.ERRORE(SE(A5="NO SPEC"; "NOSPEC";
SE(INDICE('[Planet.xlsx]Planet'!$O$5:$O$2776;CONFRONTA(RIGHE(AN$5:AN5);Table[TOT];0))="";INDICE('[Planet.xlsx]Planet'!$N$5:$N$2776;CONFRONTA(RIGHE(AN$5:AN5);Table[TOT];0));INDICE('[Planet.xlsx]Planet'!$O$5:$O$2776;CONFRONTA(RIGHE(AN$5:AN5);Table[TOT];0))));"NO SPEC")

Not having been visible, here, in Figure 18, the position of the following data in the Planet Production database.

IPS	FACT CODE	STATUS	CAMERE	SAP_Code	Linea	Calettamento	VMI
27488	2488	PR	270-290X400X515	SAG7149A2ST02	WSZer3 [SOTTOZERO]	18"	VMI_ALL
27528	3528	PR	410-430X410X600	SAG8455A1ST01	SZROAS [SCORPION]	21"	VMI_249
27529	2529	PR	320-340X490X560	SAG7595A2ST01	SZROAS [SCORPION]	20"	VMI_249
27610	2610	PR	320-340X490X560	SAG8017A0ST02	P-ZERO [P ZERO]	21"	VMI_249
27611	2611	PR	320-340X470X560	SAG8018A0ST02	P-ZERO [P ZERO]	21"	VMI_249
27614	2614	PR	320-340X470X560	SAG8069A0ST02	P-ZERO [P ZERO]	20"	VMI_ALL
27615	2615	PR	320-340X440X560	SAG8204A0ST03	P-ZERO [P ZERO]	20"	VMI_ALL
27637	3637	PR	320-340X440X560	SAG9271A0ST01	WSZer3 [SOTTOZERO]	19"	VMI_ALL
27643	2643	SD	320-340X470X560 NCY	SAG8432A1ST01	P-ZERO [P ZERO]	21"	VMI_249
27644	3644	PR	320-340X470X560 NCY	SAG8489A1ST01	P-ZERO [P ZERO]	20"	VMI_248
27753	3753	SD	270-290X400X515	SAG7979A3ST01	P-ZERO [P ZERO]	18"	VMI_ALL

Figure 18. Camere

Extraction of partial information

The resolution of such problem passes through the use of a particular function known as STRINGA.ESTRAI that returns a specific number of characters of a text string from the specified location, depending on the number of characters. Syntactically, the command consists of three fields: *testo*, contains the text string that is extracted; *inizio*, indicates the position of the first character you want to extract from the text; finally, *num_caratt*, specifies the number of characters that the STRINGA.ESTRAI function must return from the text. Its application has served to lighten the contents of some columns such as *BTS*, *Sottostrato 1*, *Sottostrato 2* e *Mescole FX*. In our case, the formula is as follows:

=SE.ERRORE(SE(A60="NO SPEC"; "NO SPEC";
SE(STRINGA.ESTRAI(INDICE('[Planet.xlsx]Planet'!$S$5:$S$2776;CONFRONTA(RIGHE(R$5:R60);Table[TOT];0));5;1)<>"_";STRINGA.ESTRAI(INDICE('[Planet.xlsx]Planet'!$S$5:$S$2776;CONFRONTA(RIGHE(R$5:R60);Table[TOT];0));2;4);
STRINGA.ESTRAI(INDICE('[Planet.xlsx]Planet'!$S$5:$S$2776;CONFRONTA(RIGHE(R$5:R60);Table[TOT];0));2;3)));"NO SPEC")

In the present case, the above code, developed and inserted in the column *Mescola FX*, is near the commands inserted in the columns above, highlighting, as in the previous formulas, the same structure with INDEX, COMPARISON, SE and SE.ERRORE while the new function says that if the fifth character does not have the low hyphen, returns from second to fifth character, otherwise fishing from second to fourth character. The need for this process arises from the fact that sometimes the fifth character of these columns presents the low dash and, functionally and graphically, could cause problems in particular soft tasks in stock: as illustrated in Figure 19, in *Mescola FX* there are no such errors.

IPS	FACT CODE	STATUS	Mescola FX	Cod FX	Cod CX	Tessuto 1 TELA	Cod 1 TELA
22884	2884	PR	EST	45	48	BALME	TN0112
22896	2896	PR	ELIK	189	51	BUBBIO	47
22898	2898	PR	ELBA	118	102	PESIO	16
22899	2899	PR	ELIK	187	20	BUBBIO	60
22901	2901	PR	ELBA	110	105	BUBBIO	175
22902	2902	PR	ELBA	96	88	FINALE	65
22904	2904	PR	EST	77	63	PESIO	59
23069	2069	PR	ELBA	119	115	PESIO	TN0211
23097	2097	PR	ELBA	116	110	BALME	TN0112
23200	2200	PR	ELBA	152	103	BUBBIO	175
23208	2208	PR	EST	108	105	PESIO	TN0208
23247	2247	PR	ELBA	113	119	BALME	TN0136
23291	2291	PR	ELBA	125	121	PESIO	16
23299	2299	DR	ELBA	146	100	PESIO	4
23300	2300	PR	ELBA	146	100	PESIO	4
23301	9991	PR	EST	49	15	FINALE	54
23303	2303	PR	EST	61	85	FINALE	53

Figure 19. Mescola FX

3.2 Data analysis of stock

Data analysis in data science is a process of inspection, cleaning, transformation and modelling of data in order to highlight information that suggests conclusions and supports strategic business decisions. Data analysis has many approaches and facets, which includes very different techniques that are recognized with a variety of definitions in commerce, the natural and social sciences. In the highlighted case, the Production team has monitored the warehouse during the period of August and September 2018, accumulating the specific data inherent to the materials out of management. To begin with, the analysis drawn up is not based on any economic element within the company because they are considered sensitive data and more important to remember that the following elaboration takes into consideration only a short period of time: Therefore, the project should be further developed, thus gathering more information to have an evaluation based on an optimized solution.

3.2.1 Data gathering

To collect the information, the team has developed another file through Microsoft Excel, structured in three pages: PCS_SISTEMA in which the data provided by the system are inserted, relative to the materials out of management per day; ACTUAL_FISICA, composed from the data instead verified manually; and finally, DATA_SET, page where evidenced the differences, in terms of quantity of out of production, between the supplies of the database and those effective.
As illustrated in Figures 20 and 21, both structures are based on the information reported on the respective delivery notes therefore release date, production date, expiry date, material code, quantity and so on but ACTUAL_FISICA contains, in addition, a special section on the provisions to be made for that particular out-of-

management component. This attribute is very useful to understand which materials are to be recycled, which are not and which are to be reused.

DATA_SET, illustrated in Figure 22, made using the information on the previous pages, side by side to every component of that relative measure the two different quantities of supplies and their difference in terms of unit of containment. To highlight the meaning of the value "C" along the columns denominated *IN COMUNE*: when a component is still used for the same tyre but on another VMI, or is also a component of another measure, it is considered as a common measure and therefore no longer as a material to be discarded or recycled.

MISURA	DATA USCITA	COMPONENTE	COD. MATERIALE	CODICE BOBINA	QUANTITA'	DATA PRODUZIONE	DATA SCADENZA	LOCAZIONE	TOVATA IL
2820	05/09/2018	TELA 1	TN0304	00ZD1124KM	0,8	04/09/2018	09/09/2018	1500	05/09/2018
2140	05/09/2018	TELA 1	TN0129	00ZD1124IQ	1	02/09/2018	07/09/2018	?????	?????
2140	05/09/2018	TELA 1	TN0129	00ZD1124IU	0,5	02/09/2018	07/09/2018	2007	05/09/2018
2541	05/09/2018	TELA 1	TN0130	00Z7009P0D	1	02/09/2018	07/09/2018	MAC. TELE SUD	05/09/2018
2541	05/09/2018	TELA 2	108	00Z7009P65	0,4	04/09/2018	09/09/2018	2006	05/09/2018
2541	05/09/2018	TELA 2	108	00Z7009P66	1	04/09/2018	09/09/2018	2006	05/09/2018
2123	05/09/2018	TELA 2	188	00ZD1124K4	1	03/09/2018	08/09/2018	MAC. TELE NORD	05/09/2018
2820	05/09/2018	TELA 2	255	00ZD1124KP	0,6	04/09/2018	09/09/2018	1500	05/09/2018
2123	05/09/2018	FX	101	00Z2006X69	1	03/09/2018	08/09/2018	DUPLEX	05/09/2018
2123	05/09/2018	FX	101	00Z2006X6A	0,9	03/09/2018	08/09/2018	DUPLEX	05/09/2018

Figura 20. PCS_SISTEMA

MISURA	DATA USCITA	COMPONENTE	COD. MATERIALE	CODICE BOBINA	QUANTITA'	DATA PRODUZIONE	DATA SCADENZA	LOCAZIONE	TOVATA IL	DISPOSIZIONE
3176	26/07/2018	TELA 1	TN0128	00ZD 11239N	0,8	25/07/2018	30/07/2018	2005	26/07/2018	RECUPERABILE
3176	26/07/2018	CINTURA 1	103,1	00Z1 00BXEI	0,4	24/07/2018	29/07/2018	2005	26/07/2018	RECUPERABILE
3267	26/07/2018	TELA 1	TN0125	00Z7 009LGT	0,4	23/07/2018	28/07/2018	2007	26/07/2018	NORD IN CARTUCCIA
3267	26/07/2018	COMPLEX	51	00Z4 006FGM	0,3	19/07/2018	24/07/2018	2007	26/07/2018	RECUPERABILE
3267	26/07/2018	CINTURA 1	168,1	00Z1 00BX91	0,6	23/07/2018	28/07/2018	2007	26/07/2018	RECUPERABILE
3267	26/07/2018	CINTURA 2	168,2	00Z1 00BX90	0,4	23/07/2018	28/07/2018	2007	26/07/2018	RECUPERABILE
3267	26/07/2018	CINTURA 2	168,2	00Z1 00BX94	0,8	23/07/2018	28/07/2018	FISHER SUD	26/07/2018	RECUPERABILE
3267	26/07/2018	BTS	3267	00Z3 00CDL3	0,3	24/07/2018	29/07/2018	2007	26/07/2018	RICICLO
3267	26/07/2018	CERCHETTO	913H63	00S1 00ZKU4	120	25/07/2018	01/08/2018	2007	26/07/2018	SCARTO
1390	26/07/2018	FX	135	00Z2 006TS8	0,3	22/07/2018	27/07/2018	1300	26/07/2018	RICICLO

Figure 21. ACTUAL_FISICA

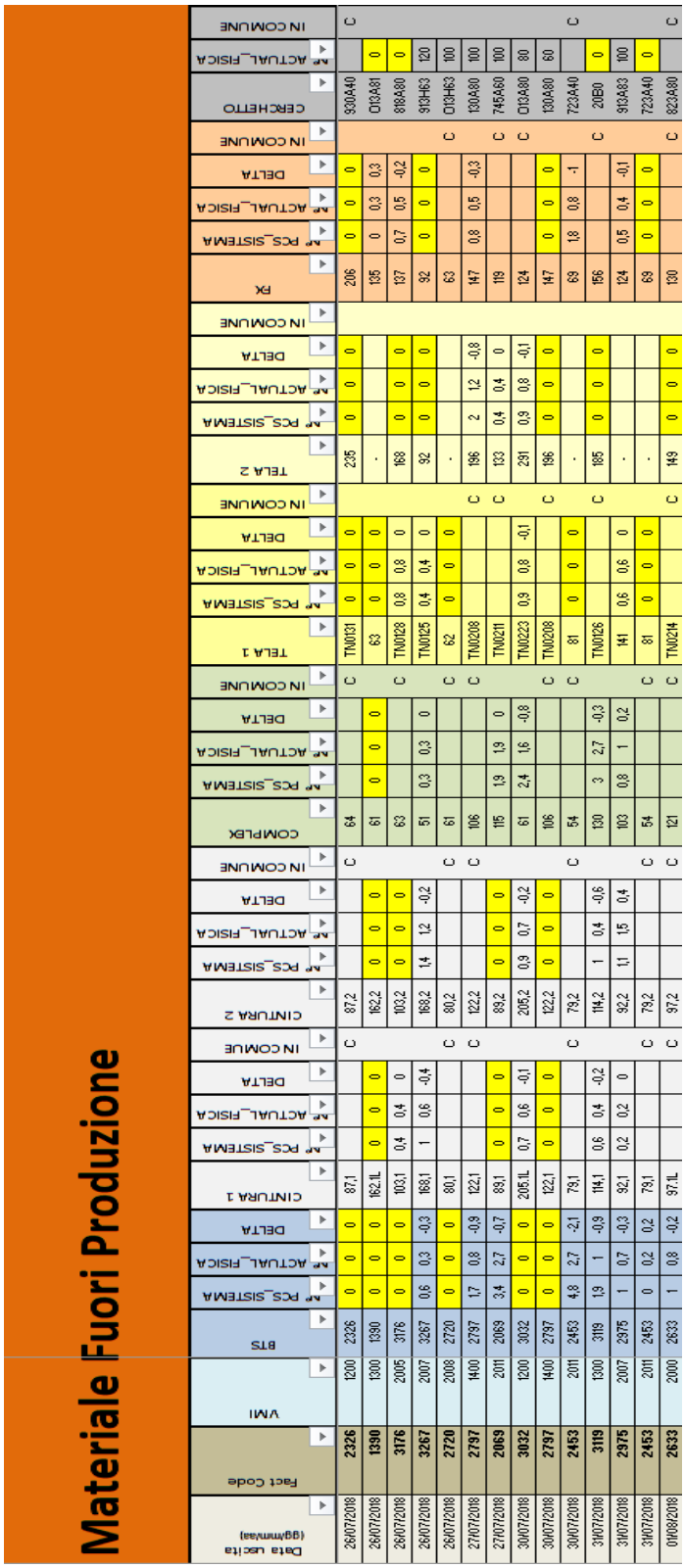


Figure 22. DATA_SET

3.2.2 Analysis and possible solutions

From the following data, it is evident that there is a substantial discrepancy between the data reported in the system and the manually verified data: in the period considered, the units of components, excluding headbands, are 118.5 but in reality are 98.5. This means that 16,88 % of these materials have not been recorded and, for the production process, they do not exist. Focusing more closely on the individual transmitter of the measure, BTS estimates a loss of 31,74 %, complex counts 16,67 %, while the shoulders accumulate a discrepancy of 13,41 %. Metal materials, however, suffer less from this problem, as DATA_SET shows a difference of 10 for the first and second belts respectively,52 % and 12,18 %, and for the first and second loops a misalignment of 9,09 % and 6,12 %.

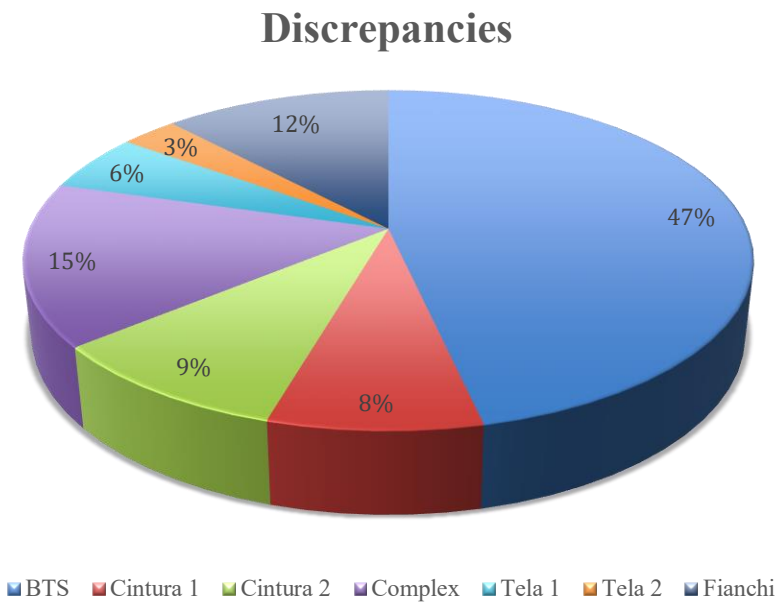


Table 2. Discrepancies

Table 2 shows the specific weight of any misalignment with the total: as you can well understand the BTS is the component that most affects these problems, followed by Complex and hips. Their behaviour is explained by the fact that all three components

can be recovered, unlike belts and cloth, through a rubber recycling process, giving the possibility to reuse 50 % of the material. The other two components differ: it is true that belts and canvas have a smaller loss but they do not have the possibility of being recycled. In fact, only in sporadic cases, they can be resized and applied to other tyres. The lowest percentage is for the second canvas because not all the measurements are equipped with double canvas or *bitela* and, consequently, also the amount of pieces in circulation is smaller.

The cause of all this is to be related to figures such as VMI workers and transporters. Both figures are in direct contact with the products both in the Production department and in the warehouse: the VMI workers are also called line workers, working in symbiosis with the machine and managing it should promptly enter such data in the database with the help of suitable tools, able to read the barcode present on the delivery notes of the units of materials, and the workers delegated to the transport of the supplies would have to carry out also such task in order to update the system on the effective position of the members. The solution, with the objective of optimizing the processes, is based on:

- *static subdivision of the production workers' teams*, in order to create cohesive and varied groups, always composed of the same employees with different profiles also from the point of view of character;
- *the introduction of a supervisor*, external to the team with the task of monitoring the actual performance of the team's tasks and the realization of the tasks of transporters;
- *weekly economic incentives* to encourage employees to give their best;
- *group penalty*, so that workers driven and stimulated by their teammates avoid heavy penalties;
- *training courses* aimed at the correct use of the tools needed to complete these tasks.

In this respect, there should also be better management of material storage areas, avoiding that the components occupy erroneously zones and in this way these last ones can be occupied by other material and increasing the production decreasing the warehouse costs.

Another problem, highlighted by ACTUAL_FISICA, concerns the location of the headbands. As a rule, the different types of circles are allocated along each VMI depending on the size processed: moreover, unlike all other components having a life of 5 days, their duration is 7 working days which allows them to be managed differently. Therefore, the areas used for their positioning are not only around the machines, but they have been allocated along the perimeter of the production department in order not to occupy excessive space close to the VMI, optimizing the entire warehouse and remaining always ready for use. Therefore, for materials located around the VMI the situation with the barcodes appears significant, the problem for the circles is softened by their economic impact because even if occasionally quantities fall into the situation of out of management, it is not to be considered a serious waste.

CONCLUSION

The thesis presents the study of business problems and the development of practical solutions of managerial type in order to facilitate, therefore, the working activities of all the department is not only. Thanks to the database structuring, it was possible to learn in an advanced way the use of the Microsoft package, in particular the use of the instructions inside the cells of Microsoft Excel VBA programming codes, even if the latter, because, the developed one had to be accessible to the whole team, were not included in the solution provided and illustrated in this thesis. During the internship period, it was possible to get to know the R programming environment and apply the SQL language manually.

The second macro problem faced assumed a continuous supervision of the database containing the levels of supplies and a manual verification of the units of the materials: as a result, it has been possible to get in touch with multiple work figures, increasing verbal communication skills, including in English, thanks to the help of the Production team, always available and prepared. However, the analysis of off-site materials has been carried out over a period of three months, too little time to bring out more complex information (by means of statistical analysis of R) mostly in an annual period when summer holidays have softened and slowed the production of tyres. That said, the experience gained with the help of the team suggests that problems of this kind require a longer data collection period, preferably 12 months, and 3 more for the functional study of them. In addition, other small problems, such as giving instructions to workers and conveyors on what they should do, have been dealt with by hand, thus being able to observe the environment from different points of view.

INDEX OF FIGURES

TABLE INDEX

LIST ACRONYMS

CNRC	China National Tire & Rubber Corporation
FIM	Fédération Internationale de Motocyclisme
WSBK	World Superbike
FIS	Fédération Internationale de Ski
IIHF	International Ice Hockey Federation
FG	Fuori Gestione
PR	Produzione
PT	Prototipo
WMS	Warehouse Management System
KPI	Key Performance Indicator
ERP	Enterprise Resource Planning
VMI	Vendita Macchine Industriali
BTS	Battistrada
SAP	Systems, Applications and Products in data processing
VBA	Visual Basic for Applications

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