POLITECNICO DI TORINO

Master's Degree in Automotive Engineering

Master's Degree Thesis

Development of a market strategy penetration for the Asian Region with application of the simulation software for flexible components IPS Cable Simulation by fleXstructures

Supervisors
Prof. Andrea Tonoli
Eng. Valerio Cibrario

Candidate
Francesco Carluccio

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Contents

List of Figures

Abstract

This Thesis was developed during a six-month internship at fleXstructures Italia in Turin, Italy, with the aim to develop new marketing material mainly addressed to the Asian market, and in particular to the countries of China, Japan and South Korea. Starting with the classical theory of strategic marketing and passing from an analysis of the market at macroscopic and microscopic level in Asia, many useful marketing materials have been developed for different sectors in which fleXstructures operates, in particular: automotive, motorcycle, railway, off-roads.
The first chapter has a theoretical function, the whole theory of strategic marketing is presented.
The second chapter deals with the product developed and sold directly by fleXstructures Italia and fleXstructures Germany, the head-quarter. This chapter discusses the advantages and features of the IPS Cable Simulation software and the integration with other IPS tools, such as: IPS IMMA (Intelligently Moving Manikin in Assembly) and IPS Robot Optimization.
Chapter three is entirely dedicated to the macroscopic analysis of the Asian countries. It deals with the various factors that influence the Chinese, Japanese and South Korean markets at a macroscopic level.
Chapter four deals with the microscopic analysis of the Asian area.
Finally, chapter five presents the deliverables achieved and developed according to the market requirements, i.e. the materials created during the internship that are useful for corporate marketing.

Introduction

fleXstructures regularly organizes annual meetings with their worldwide local distributors with the aim to collect feedback across the local markets on IPS product selling and to support and instruct the distributors on how to sell IPS products at best, highlighting the value proposition of IPS tools. In particular, fleXstructures Italia deals with the Asian market. During one of these meetings with the local distributors, it popped up clearly that further marketing material in integration of the existing one was needed, with special focus to off-road, motorcycle and railway, next to the well consolidated automotive fields. From this need was born my collaboration with fleXstructures Italia, with the aim to perform several researches about the Asian market and to develop IPS models useful to fleXstructures for local distributors and customers.

Chapter 1

Marketing

Today, customer relationships and value are especially important. Due to technological changes, economic, social and environmental challenges, customers are reevaluating their relationship with brands. Strong customer relationships based on continuing exchange of value.

1.1 What is Marketing?

The aim of **Marketing** is to make selling unnecessary (Peter Druker).
Marketing is a social and managerial process by which individuals and groups obtain what they need, and want, through creating and exchanging products and value with others.
Marketing is a process by which companies create value for customers and build strong relationships in order to capture value from customers in return (Kotler and Armstrong 2010).
The term marketing has historically been used to indicate the company's activity aimed at managing relations with the market and facilitating the marketing of goods and services. Marketing typically concerns decisions related to the product: characteristics and image, sales price, distribution channels, promotional and advertising actions, sales network. With the passage of time the word has changed meaning due to socio-economic changes, and an increasing customer orientation has been observed, which has generated a radical change of perspective. So, we have moved from the "production oriented" company, focused on production and the product, to the "marketing oriented" company, focused on the customer.

1.2 Customer Needs and Marketplace

One of the most important things that marketers have to do is to understand customers' needs, and to have a deep knowledge of the marketplace in which they operate. A serious mistake is focusing only on existing wants and losing sight of underlying consumer needs, so called marketing "*myopia*". *Need* occurs when the individual feels deprived of basic necessities (food, clothing, shelter). *Desire* is a need determined by the individual's learning, culture and personality.

1.2.1 Customer Value

To fulfill customer's needs and wants, market offerings are not limited to physical products but they also include services[1]. Infact, smart marketers offer, and create, a real brand experience, going beyond the attributes of the products and services they sell.
It is important to have satisfied customers for a company, because they buy again and make known their good experiences. Unlike, a dissatisfied customer change brand going to other competitors. So, it is essential to build and manage customer relationships to have customer for life.
A recent study divides consumer in bipolar tendencies: on one hand they seem to look for the "low cost", where the price variable nullifies much of the emotional investment; secondly there is the willingness to purchase "premium price". The market is not only complex situations and the multiplicity of actors involved, but it is also a network of "trends" in continuous evolution. New product and services, to maintain loyalty of old customers and reach new ones, have to follow the *Voice Of Customer*[2] (VOC).
The customer is the idol, the "totem pole" to understand and serve, with all the best techniques possible. The *Customer Relationship Management*[3] (CRM) should be practiced by all institutions of sale with a large customer base.

The Operational and Analytical Customer Relationship Management

To create a Customer Relationship Management (CRM) strategy, it is important to make a distinction between "Operational CRM" and "Analytical CRM". The operational and analytical CRM feed off each other, according to a logic of learning and adaptation. They represent an environment of interaction that has at its core customer needs, and is able to provide a unified vision, constantly updated.

The Operational CRM

The Operational CRM involves all areas where you have a contact with the customer, with the expectation of the visit and personal interview. It can interact in an integrated way through a variety of channels: call centers, telephone, e-mail, messaging, etc. The progressive acquisition of knowledge of the customer, the experiences, the needs, make possible the realization of customer lifetime management.

The Analytical CRM

The role of technology is to make available applications that allow to interact with customers and applications, capturing all relevant customer information to decide "how" to relate him. The analytical CRM includes the set of applications that allow to analyze and interpret data collected about customers, to gain knowledge of their needs and preferences.

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[1] A service is an activity by which a supplier delivers a service to a customer involving him in an exchangeof value rather than in a transfer ownership

[2] The *Voice Of Customer* identifies the process of collecting feedback and wishes from users (prospects, clients, employees) with the aim of providing the best possible user experience in relation to its products and services.

[3] "CRM is a business strategy to select and manage the most valuable customer relationships. Requires a customer-centric CRM business philosophy and culture to support effective marketing, sales, and service processes" (Thompson).

1.2.2 Markets

The concepts dealt with up to this point of exchange and relations with clients leads to the market concept. A market is the total sum of all sellers and buyers dealing for a good or service. Both sellers and buyers make their own researches, the firsts one to identify the needs of the second one, to set the prices for them and to promote them. The seconds one to obtain information from companies and make their purchase obtaining the best offer of the market. The next figure shows how marketing involves final consumers in the face of competitors. The consumer needs are at the center of the company's and competitors' interest to do research in the market and to interact with them. After that their market offerings are sent to consumers, directly or through marketing intermediaries. Obviously, the system is affected by major environmental forces (economic, demographic, natural, political, technological, and social/cultural).

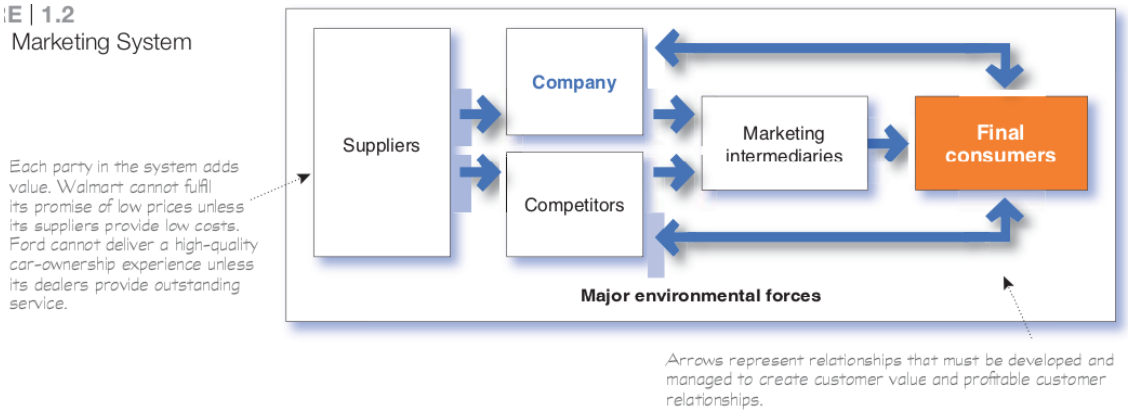


Figure 1.1: The main elements in a marketing system. Source: Kotler and Armstrong (2010)

Marketing management

To have a deep knowledge about consumers and marketplace is a must, the marketing management can design a customer-driven marketing strategy. *Marketing management* is the art and science of choosing target markets and building profitable relationships with them. A winning marketing strategy must answer two important questions: *What customer will we serve?* and *How can we serve these customers best?* So, it is important the selection of customers to serve because it is impossible to serve any customers well. The market is divided into segments of customers (*market segmentation*), and after that is selected which segments the company will go after (*target marketing*). In fact, the company will differentiate and position the customers in the marketplace. The aim of the marketing management is to design strategies that will build strong relationships with target consumers. This is done through five alternative concepts that carry out their marketing strategies:

- *Production concept*: consumers will favor available and very reliable products. Management should, therefore, focus on improving production and distribution efficiency.
- *Product concept*: consumers will favor products that offer the most in quality, performance, and innovative features. Thus, an organization should devote energy to making continuous product improvements.

- *Selling concept*: consumers will not buy anything of the firm's product unless it undertakes a large-scale selling and promotion effort.

- *Marketing concept*: to achieve organizational goals depends on knowing needs and wants of target markets and delivering satisfactions better than competitors do.

- *Societal marketing concept*: the organization should determine the needs, wants and interests of target markets. It should then deliver the desired satisfactions more effectively and efficiently than competitors in a way that maintains or improves both the consumer's and society's well-being. It should look at the long-run consumer welfare, and requires for *sustainable marketing*. This point is very important, especially in this period, because the companies have to meet the needs of the present without compromising the ability of future generation to meet their own need. Sustainable marketing counters today consumption against that of future consumers and future society.

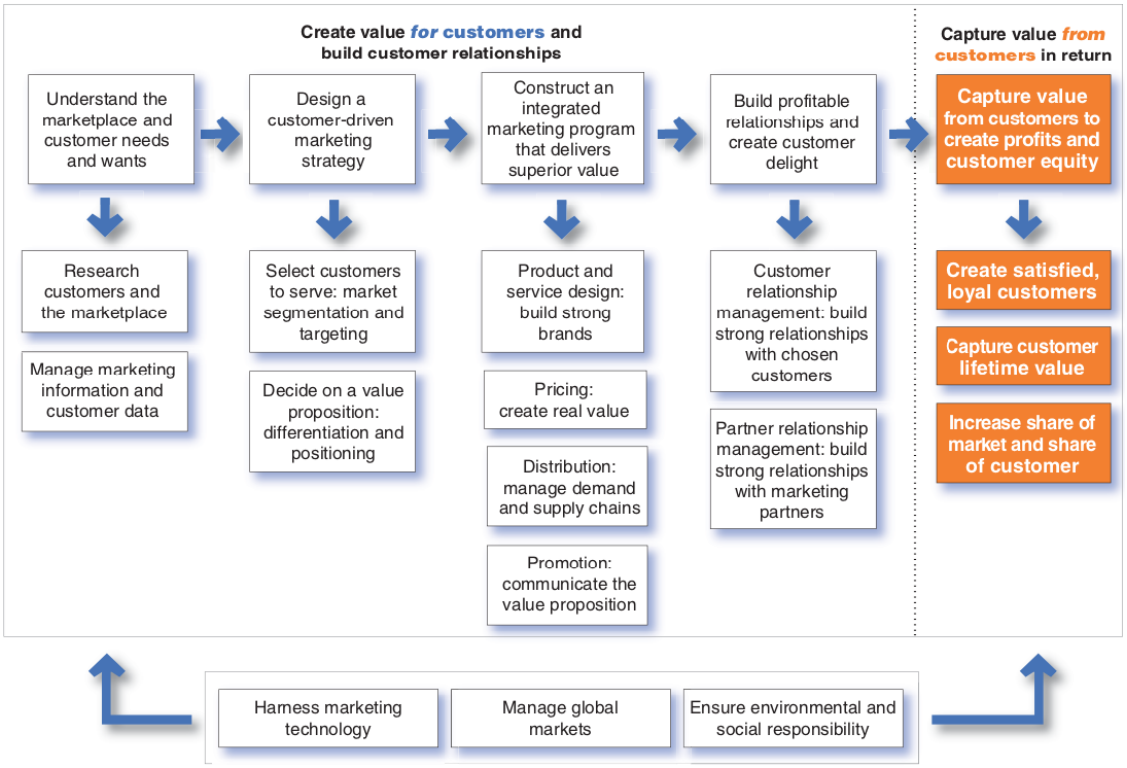


Figure 1.2: Expanded model of Marketing Process. Source: Kotler and Armstrong (2010)

Figure 1.2 presents the meaning of the question: What is marketing? The first four steps, of the marketing process, help on creating value for customers and build customer relationships. The last step is useful to capture value from customer in return.

Once the company has chosen the appropriate marketing strategy, it builds an integrated market program, which consists of a blend of the four marketing mix elements (the *the four Ps*) useful to transforms the marketing strategy into real value for customers.

1.3 Marketing strategy and Marketing mix

The aim of **strategic planning** for a company is find a long-run plan that allows the company's survival and growth, thereby maintaining a strategic fit between the organization's goals and capabilitiesand its changing marketing opportunities. Considering strategic planning, three types of plan can be analyzed:

- The *annual plan* is a short-term plan that describes the current situation, company objectives, the strategy for the year, the action program, budgets and controls.
- The *long-range plan* describes the primary factors and forces affecting the organization during the next several years, including the long-term objectives, the main marketing strategies used to attain them, and the resources required.
- The *strategic plan* describes how a firm will adapt to take advantage of opportunities in its constantly changing environment.

The strategic planning is divided in four steps, where the first three are done at corporate level, while the last one is done at business unit, product, and market level.

1. **Defining the company mission**. The mission statement is the purpose of the organization; what it wants to achieve in the wider environment. It should be market oriented, therefore defined in terms of satisfaction of clients' needs. A mission should be: realistic, specific, based on distinctive competencies and motivating.
2. **Setting company objectives and goals**. The mission chosen is translated in supporting objectives for each level of management. The marketing objectives are supported by marketing strategies and programs.
3. **Designing the business portfolio**. A business portfolio is the accumulation of strategic business units that together makes a company. The company has to analyze its current business portfolio and decide which business should receive more, less or no investment. Thus, it has to identify the *strategic business units* (SBUs), that can be a company division, a product line within a division, or a single product/brand. It develops growth strategies for adding new products or business to the portfolio, using its strengths by taking advantage of opportunities in the environment. The Boston Consulting Group (BCG) has created a

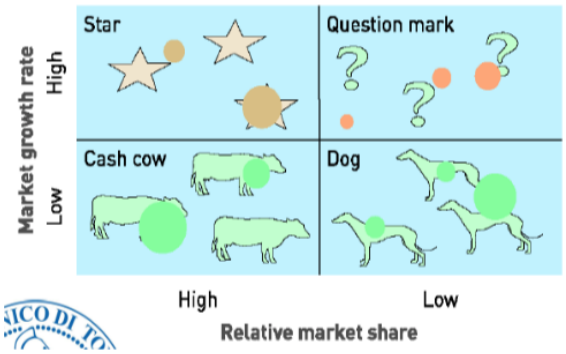


Figure 1.3: Growth-share matrix

useful method for companies to classify all their SBUs according to the growth-share matrix (Figure 1.3). On the vertical axis there is market growth rate, which provides a measure of market attractiveness; on the horizontal axis there is relative market share, which serves as a measure of company strength into the market. From the matrix is possible to see four types of SBUs:

- *Stars* are high growth and high market share businesses or products requiring investments to finance their rapid growth. They will eventually turn into *cash cows*;
- *Cash cows* are low market growth rate but high market share. These products or businesses require less investment to maintain market share.
- *Question marks* are low market share business units in high growth markets. These require a lot of cash to hold their share.
- *Dogs* are low growth and low share business and products.

4. **Planning marketing and other functional strategies**. For each business unit a more detailed planning takes place. In the company's planning strategy marketing is essential, because the marketing concept suggests to the company the strategy it should adopt to build profitable relationships with clients. Also because marketing provides inputs to identify attractive markets, and helps to design strategies to achieve the unit's objectives.

1.3.1 Marketing strategy

Marketing strategy is the way the company wants to create customer value and build profitable customer relationship. It is divided in:

- *Segmentation and targeting.* The company decides which customers it will serve.
- *Differentiation and positioning.* The company decides how it will serve the customers.

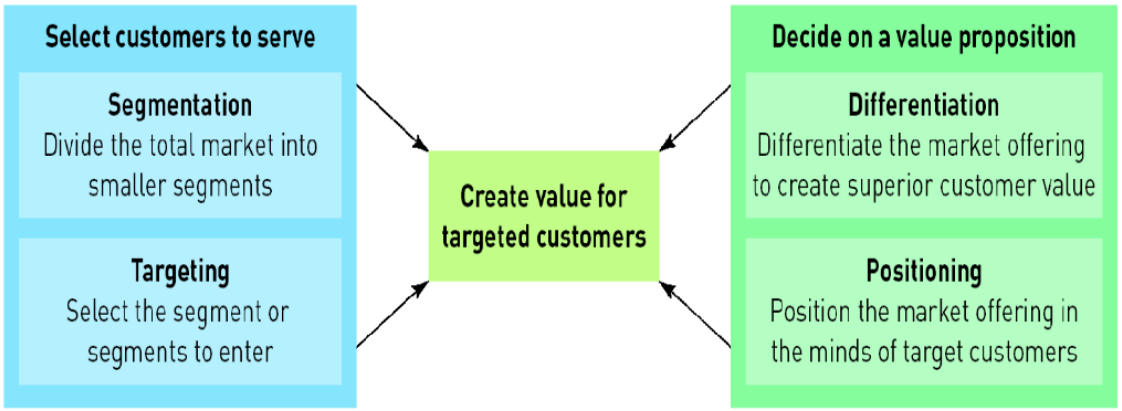


Figure 1.4: Customer-driven marketing strategy

Market Segmentation

As already mentioned, companies cannot serve all customers in a given market. Too many different types of customers with different needs. Therefore, each seller has to determine which segments offer the most opportunities for profit. Market segmentation involves dividing large and heterogeneous

markets into smaller market segments. In this way, these segments can be reached more effectively, and efficiently, with products and services that match their unique needs. The segmentation to be effective must be: measurable, accessible, substantial, differentiable, actionable. There is no single way to segment a market, but to find the best way to see the structure of the market the seller must take into account several variables including:

- *Geographic segmentation.* It divides the market into different geographical area (nations, regions, states, countries, cities, or neighborhoods).
- *Demographic segmentation.* It divides the market into different segments based on variables such as age, gender, occupation, religion, ethnicity, and generation. This segmentation is the most used.
- *Psychographic segmentation.* It divides the market into different segments based on social class, lifestyle, or personality characteristics.
- *Behavioral segmentation.* It divides the market into different segment based on consumer knowledge, attitudes, use of a product, or responses to a product.
- *Intermarket segmentation.* It divides the market into different segments of consumers who have similar needs and buying behaviors even though they are in different countries.

Market Targeting

After segmenting the market, the company must choose which segments to serve best. Obviously one or more segments can be chosen, based on those that can generate more customer values, and if they mesh with the company's long-term objectives. A target market consists of a number of buyers who share common needs, or characteristics, that the company wants to serve. There are, generally, four different types of targeting strategies, in which the company can target very broadly or very narrowly.

- **Undifferentiated Marketing**. It is a strategy with which the company decides to ignore different market segments and treat the market as one, single target. Basically, everyone is a possible client. If we imagined the market as a big cake, this kind of strategy would take it all without slicing it.
- **Differentiated Marketing**. This is one of the most used strategies. Once the objectives have been decided, different marketing strategies are developed for each one. In this way the customer is not homologated to the entire market but understands that he is receiving a personalized product. This strategy not only increases company sales but also increases costs, as developing different marketing campaigns for different segments requires extra marketing research, forecasting, sales analysis, promotion planning and so on.
- **Concentrated Marketing**. It is also called *niche marketing* strategy. If we take the cake metaphor, this strategy allows us to take only a slice of cake. Through concentrated marketing, small companies achieve a strong market position because it allows them to market their products more effectively and be totally ignored by large companies. But although this strategy is very profitable the risks are many, because if the business is based on one or a few segments, if this is no longer appreciated by the market the company may fail.
- **Micromarketing**. It is a strategy similar to concentrated marketing, because it targets a specific group within the niche market. Micromarketing includes local marketing and individual marketing. The first one involves tailoring brands and promotions for the needs

and wishes of local customer groups, the last involves tailoring products and marketing programs for a customer's needs.

Figure 1.5: Target marketing strategies. Source: Langford 2019

Market Differentiation and Positioning

Market differentiation allows a company to differentiate the market offerings for each targeted segment, while market positioning what position it wants to occupy in that segment. That is, the position it occupies in the consumer's mind in relation to competitive products. It is difficult for a customer to have a clear idea about all the products in circulation in the market every time he has to make a purchase. To simplify the process, the customer organizes the different products and services in different positions in their mind. Therefore, the position is nothing more than a series of impressions, and perceptions, that the client has of the product in comparison with the competitive ones. Obviously, in all this, marketers want to get the best position for their product in the minds of their customers.
In order to achieve an effective position it is necessary to start with a good differentiation of a company's market offer. There are three steps to follow to make differentiation and positioning task profitable:

1. Identifying possible value differences and competitive advantages. In order to gain a competitive advantage over competitors, it is necessary to have a deep knowledge of what customers' needs may be, and to present solid promises about the image that the company wants to give of its product.

2. Choosing the right competitive advantages. Concept of Unique Selling Proposition (USP), an attribute that makes a brand attractive to buyers, company should be the number one in that specific attribute.

3. Selecting an overall positioning strategy. There are different positioning strategies used by companies to place their product.

   - *More for more.* This market offers not only high quality, but also prestige to the buyer. The price is high to cover the high costs.
   - *More for the same.* This positioning allows companies to offer higher quality at the same price as the previous product, giving them an advantage over competitors offering more for more positioning.
   - *The same for less.* The company offers the same product as its competitors at a lower price
   - *Less for much less.* This positioning involves meeting consumers' lower performance or quality requirements at a much lower price.
   - *More for less.* Companies offer more performance or quality at lower prices than their competitors.

After that the company must communicate and deliver the chosen position to the market.

1.3.2 Marketing mix

Marketing mix is the combination of controllable marketing variables that companies use to achieve their objectives. So, it consists of everything a company can do to influence the demand for its product. The variables that traditionally make up the marketing mix are the so-called 4P (four Ps) theorized by Jerome McCarthy and later taken up by many others:

- *Product.* The product (Product) is the good or service that is offered (sold) in a market to meet certain consumer needs. The most important marketing decision making leverage concerning the product is the brand management policy. There are three types of product:

  – Essential product: it gives shape to the essential, central element;
  – Tangible product: is the set of elements through which the customer's expectations are met;
  – Expanded product or intangible product: it is the set of installations, after-sales services, delivery time, warranty and payment conditions.

  It should also be noted that in the intangible product there is also the brand of the product. It is generally composed of three elements: the logo, the pictogram and the payoff. The logo is the textual part of the brand, which represents the name of the company or the product itself. The pictogram is that emblem, that abstract or iconographic symbol that differentiates the product from others. The payoff does not appear often. It is the slogan of the product: the phrase that sums up the essence of the product or company. In other words, it is the verbal element that accompanies the logo and pictogram.

- *Price.* The price is the amount of money the consumer is willing to pay to receive a particular good or service. There are various pricing policies that a company can implement, depending on the objectives that the company sets itself:

  – Skimming pricing: sets high initial prices to *skim* revenue layers from the market. Product quality and image must support the price.

  - Penetration pricing considers the cost differences between products in the line, customer evaluations of their features, and competitors' price.
  - Segment pricing involves selling a product or service at two or more prices, where the difference in prices is not based on differences in costs.

  The price is the only marketing mix lever that, in addition to generating costs, is able to generate revenues and, therefore, it is increasingly essential to take care of its fixing.

- *Place.* Distribution (Place) is the set of activities necessary to get a certain product to the final consumer, or even to points of sale and shops, with the various intermediate steps. Distribution takes place through the management of distribution channels and warehouses, goods logistics, market coverage, being very connected to merchandising activities.
- *Promotion.* Promotion is the set of activities aimed at promoting, advertising and making a company or a specific product or service known to the market. Recently, marketing scholars have preferred to replace the term promotion with the term corporate commercial communication, defined as the set of activities through which a company presents itself to the market.

1.4 Marketing management

The management of marketing processes requires the help of four functions: *analysis, planning, implementation, and control.* it is important that the company first develops strategic business plans which are then translated into marketing plans. Through implementation, the company transforms the plans into actions. Finally, control consists of evaluating and measuring the results of marketing activities, and taking corrective action if necessary.

Marketing analysis

It is the first step for marketing management, it allows to understand the situation of the company through a complete internal analysis, in order to identify which opportunities make more sense to pursue. In order to identify the key issues, a common technique is the **SWOT analysis**, an approach that can be useful to identify the business critical factors by the exploration of four categories: strengths (S), weaknesses (W), opportunities (O), and threats (T).
Strengths and weaknesses describe the strength and weakness aspects that may arise within the organization itself about the considered business. In particular, the strengths are key positive issues for the value proposition, that is the internal leverages to base the initiative on and the areas form which highest returns are expected. Whereas, weaknesses are key internal weaknesses for the value proposition, due to possible inefficiencies or lack of competencies.
Opportunities and threats represent the positive and negative external factors that may have an impact on the business. In particular, the opportunities may increase the business revenues and require the definition of appropriate development strategies to be managed. Whereas, threats may negatively affect the business profitability and must be monitored both at the beginning and during the initiative development.
To do this, companies should analyze the markets and marketing environment to find opportunities and identify environmental threats. The main objective is to combine the company's strengths with opportunities, while eliminating weaknesses and minimizing threats.

Marketing planning

Market planning is a process that allows companies to decide what to do with each business unit. It involves the choice of marketing strategies that make it possible to draw up a marketing plan

for each product, or service. A solid marketing plan consists of a value proposition of the company, information about its market targets or customers, distribution channels, and a positioning of its competitors in the market. Good planning makes it possible to know how each strategy responds to threats and opportunities.

Marketing implementation

It is the process that turns marketing plans into effective actions, which ensure that marketing objectives are achieved.

Marketing control

To avoid the occurrence of various threats, it is essential that there is continuous monitoring in the evaluation of the results of the marketing strategies implemented. This process involves continuous checks on expected and current performance in the market, and helps companies to implement corrective actions if necessary.

1.5 Analysis of the marketing environment

For a marketing strategy to be effective, it must be based on a deep knowledge of the market environment in which the company operates. Marketers have the ability to control a company's internal factors, but sometimes they are forced to change marketing strategies due to external factors. The knowledge of the market environment allows the marketer to change and adopt new marketing strategies with simplicity, and above all to increase the company's profits. So, internal and external factors, and forces, can directly or indirectly affect the income of a company. The marketing environment is divided into two components: internal and external environment. The internal marketing environment is composed of all the different factors that make up a company such as women, men, human resources, money, products, machinery and so on. While the external marketing environment is in turn divided into two different factors: *microenvironment* and *macroenvironment*. The first consists simply of the actors close to the company who influence the service of clients through their activities. The second consists of the larger forces in the company that influence the microenvironment.

1.5.1 Microenvironment

As mentioned above, marketing management is based on customer relationships. In order, to be effective, it is important to build profitable relationships with other departments of the company, suppliers, competitors, marketing intermediaries, publics, which combined add value to the company's delivery channels.

The company

It is essential for marketing management that other departments, within the company, are taken into account in order to create customer value in each department.

Suppliers

Suppliers provide the materials and wips for the realization of products and services by the company. In addition, they form an important connection between the company and customers, being within the distribution channels. Through them the company can grow its profits, so they are an essential part of the microenvironment.

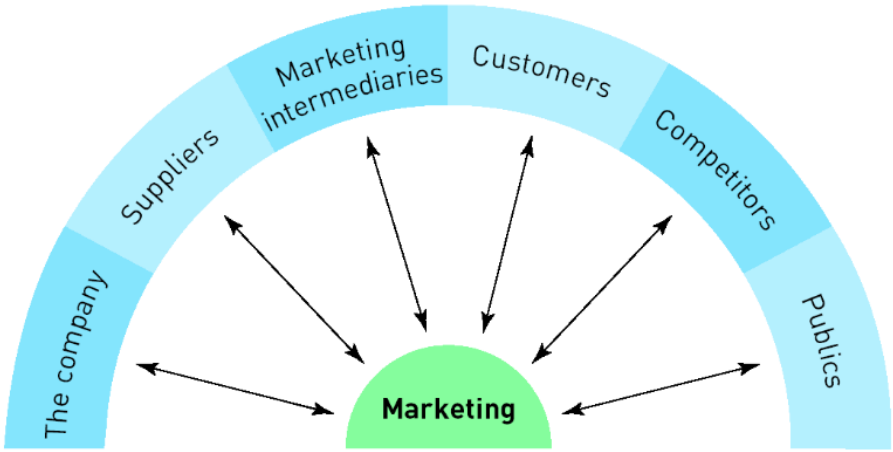


Figure 1.6: Actors in the Microenvironment. Source: Kotler and Armstrong 2010

Marketing intermediaries

Marketing intermediaries are useful because they make it possible to distribute a product to a company's customers. They can help directly the company to sell the product or service, or to promote it. This group is made up of resellers, physical distribution firms, marketing services agencies, and financial intermediaries.

- *Resellers* help companies to sell their products, or services. In this group are include wholesalers and retailers.
- *Physical distribution firms* help companies to transport and store the product.
- *Marketing services agencies* help companies to advertise and promote their products in the right marketplace.
- *Financial intermediaries* help companies with financial transactions or insure companies against the risks associated with buying and selling goods.

Customers

They are the most important part of the microenvironment, because without customers a company cannot survive. There are five different types of customers in the market.

- *Consumer markets.* Those who buy the product/service for personal use.
- *Business markets.* Buying products or services useful in other production processes.
- *Reseller markets.* Buying products or services and then resell them at higher prices.
- *Government markets.* Buying products or services to be used for public services.
- *International markets.* They are all those buyers located in other countries.

Competitors

Competitors are defined as all companies that produce a product, or a service, similar among their products that makes them competing to sell it. Benchmarking is very useful to reach in a more successful way the customers' satisfaction than its competitors do. There is not a single way to gain advantage from other companies, but it depends on company's size and position in the marketplace.

Publics

Public is defined as any group that may have a potential impact on the achievement of a company's objectives. There can be different types of publics, for example media publics, financial publics, government publics, etc.

1.5.2 Macroenvironment

In the world economy there are six forces that make up the macroenvironment. Some of these forces can be uncontrollable, while others can be predicted to be managed with the right strategies. Obviously, the more a company is dependent on the world economy, the more it is influenced by these forces. It is very useful, in these cases, to conduct a PEST (political, economic, socio-cultural, and technological) analysis to identify those factors that can influence, or may influence in the future, the company's business.

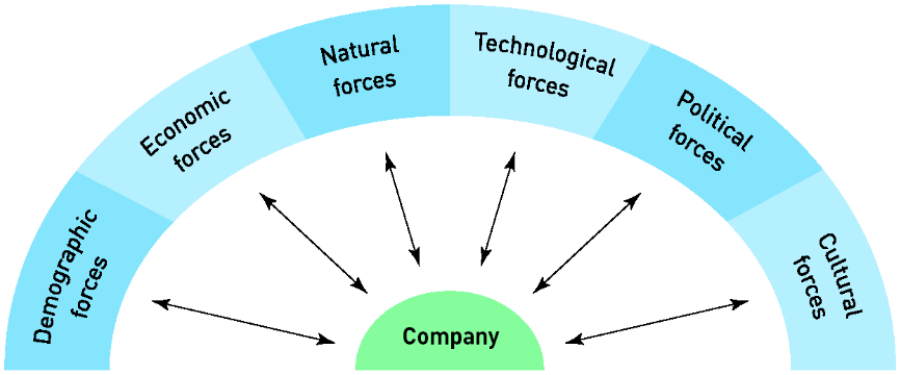


Figure 1.7: Forces in the Macroenvironment. Source: Kotler and Armstrong 2010

Demographic forces

The demographic factor is the study of the human population in terms of size, density, location, age, gender, ethnicity, employment, etc.. This factor is of great interest because people create the market, and having a deep knowledge of the market a company wants to enter allows them to grow their profits. Knowing the lifestyle of a population makes it easier to sell. As we live in times of rapid population growth, changing demographics and lifestyles, this factor becomes essential for entering a market. In addition to the growth of the world population other different factors are influencing the markets such as:

- Changing age structure, today's lifestyle allows people to live longer.
- Changing family structures, families made up of father, mother and son are no longer the majority.

- Geographic shifts in population, more and more people are migrating to a higher economic status.

Economic forces

This is important because it is influenced by people's purchasing power, which in turn depends on consumer income, debt, and credibility. Marketers must launch the product where people can afford it. In recent decades, the rich have become richer, the middle class has shrunk, and the poor have remained poor.

Natural forces

Natural forces, also called ecological forces, have become important in recent years due to increased pollution. Just look at the car world as it is moving into electrification. Many companies have been implementing corporate sustainability departments for some years now, and we are keen to let customers know how they are helping to support the environment.

Technological forces

Day after day technology is advancing, and it is influencing our lifestyle, making it easier and easier. Wireless communication techniques are creating and growing new business opportunities. Therefore, new markets are being created, but the companies always have to take into account that a new technology replaces an old one. So, companies that do not follow the evolution of technology are failing.

Political forces

Political forces limit every business. These forces include laws, government agencies and pressure groups. Marketing strategy choices are influenced by them, in fact before entering a new market in a foreign country, the company should know everything about the legal and political environment. But good regulation can encourage competition and ensure fairer markets. It is important that companies, clients and corporate interests are protected by government regulations.

Social-Cultural forces

Cultural forces deeply influence a company's business, and it is important to know the tastes, needs and wishes of targeted clients. The factors that influence multiple markets are:

- *The persistence of cultural values.* The beliefs and values of a population form more specifically attitudes and behavior in their everyday life;
- *Shifts in secondary cultural values.* Cultural fluctuations take place and people can begin to have a different consideration of themselves, others, society, and the universe.

1.6 Marketing channel

The marketing channels are all those people, organizations and activities that make it possible to transfer ownership of an asset from production to consumption. The members of the channels allow the consumer to get the product, and in this way they add value to the company. Obviously, members of the marketing channel have several tasks, including: obtaining and distributing information about customers, producers, and every forces within the market environment; developing persuasive communications about an offer; finding and communicating with potential customers;

shaping offers to meet consumer needs; and, finally, negotiating a deal for a possible transfer of ownership.
Each company can design distribution channels in different ways to make products, or services, available to consumers. But distribution channels are made up of a number of companies that interact with each other to achieve their objectives. Therefore two types of conflict can be created:

- *Vertical*, when it is on different levels as between manufacturer and retailer.
- *Horizontal*, when the conflict is between members of the same level as between two retailers.

It is important that a company analyses and evaluates different channels to get the product to the consumer.The marketing channel design helps to analyze consumer needs, set channel objectives, identify and evaluate different channel alternatives. All this starts with asking what the consumer wants from the channel. The faster the delivery, the larger the assortment, and the higher the level of service perceived by the customer. Obviously it is impossible for a company to have the same level of service for any channel, so it is important to decide which segments to serve and the best channels to use, with the main objective of minimizing channel costs. Once the channel has been selected, it must be continuously managed and motivated to give the best, because the product is sold not only through the various members of the channel but also to and with them. Often exclusive channels are developed by companies for their products, where retailers do not deal with competitors' products but only with the products of the company with which they have exclusive dealing. Having exclusive dealing often means having exclusive territorial agreements, so sellers are forced to sell only in a given territory.

Marketing logistics

Marketing logistics means all those actions aimed at involving the planning, implementation and control of physical flows of products, services and related information from the starting point to the consumer. In simple terms, it allows you to give the right product to the right customer, in the right place at the right time. The customer has become the center of logistics planning, starting with him and moving from retailers, the company and finally to suppliers.

1.7 Global marketplace

Global marketing refers to the communication, promotion and sales strategy that involves foreign markets different from that of the company. The main objective is to penetrate foreign markets and optimize its presence. More and more companies of all sizes, not only large corporations but also small and medium sized companies, are forced to enter the world market if they want to survive. However, by entering new foreign markets a company must first of all create value for consumers through various steps, including: improving its services, creating new forms of communication, and finding new distribution channels that allow the company to reduce the price of services and products. All this is possible thanks to the study and analysis of the internal and external environment in which the company wants to move, evaluating the pros and cons of those geographical areas. Then, it is important that the company assesses the chosen markets in which to enter with the right marketing strategy.

1.7.1 International marketing environment

It is important, for a company, to know the market it wants to enter, as governments may charge tariffs, taxes, on certain imported products to increase revenue or simply to protect domestic products. Some countries, such as the European Union, have formed a free trade zones, where it is

possible to have free trade in goods without paying taxes. Another important example is NAFTA (North American Free Trade Agreement) a free trade zone between the United States, Mexico, and Canada. Each country has its own characteristics, which must be understood before entering the market. The attractiveness of a nation's market hangs from three different environments:

- Economic environment. What makes a country's market attractive is its industrial structure and income distribution. The first factor shapes the products and services needs, the second factor made companies create products also for low and medium income families.
- Political-legal environment. Given a nation and a company that would like to open its headquarters in that country, it is important to consider government bureaucracy, political and economic stability. Some countries located in Asia are less accommodating than others, such as India, which imposes certain restrictions and limitations on foreign companies wishing to operate there, and Singapore and Thailand, on the other hand, which encourage and encourage companies to invest in their territories. Moreover, there are countries that have very volatile governments, caused by economic factors such as inflation, and others where monetary regulation is a problem.
- Cultural environment. The diversity of cultures has long been evaluated both in terms of relations between companies and markets and in terms of problems and organizational processes within the internationalized company. Culture is a complex mixture of patterns and perceptions of behavior inherited from our ancestors and which distinguishes our society from others. It determines the clothing we wear, the food we eat, the places we live, the car we drive and many other aspects of our daily lives. Cultural influences are not static but change over time, so it is the responsibility of the marketing manager to control these changes and to adapt marketing policy to them, as culture largely determines how, why and which products and services are purchased. The task of intercultural marketing is to understand cultural, social and cultural diversity, individual of the target market in order to develop a winning strategy and effective.

1.7.2 Entering a market

Companies should decide which markets to enter and define their international marketing objectives. It is not convenient for a company to enter different markets from the outset, so it is important to choose the type of country to enter based on: geographical factors, income and population, political climate, and many other considerations. After making a list of the various international markets, the company must carefully evaluate each one and choose the most profitable ones. Once it has chosen the foreign country in which to sell, it must enter the market in the best way. There are three different market entry strategies:

- **Exporting**. It can be direct or indirect and is the easiest way to enter a foreign market. In any case the product is made in the company's country and then exported.
- **Join venturing**. The union with foreign companies makes it easy to enter a foreign market. There are four types of unions:
  - *Licensing*. By accepting a license a company can easily enter a foreign market. With the payment of royalties, the license allows the use of the manufacturing processes of the company, trademark, patent and so on.
  - *Contract manufacturing*. In this type of contract, companies hire foreign manufacturing companies to produce their product in that country.
  - *Management contracting*. The domestic company provides know-how management to a foreign company that provides the capital.

  - *Joint ownership*. A company joins forces with foreign investors to create local businesses in which they share ownership and control.

- **Direct investment**. Development of manufacturing plants directly in the foreign country.

1.7.3 Global marketing organization

When companies decide to enter a foreign market they have to decide which marketing strategy to use between a standardized global marketing strategy or an adapted one. The former allows companies to use the same marketing strategy for different continents, so there is a cost saving, the latter allows for a larger market share and returns, thanks to the marketing strategy tailored to each country. The company must in any case respect local cultures and become part of them. Because the more comfortable the customer, the more he is willing to spend.
Five different strategies are used to adapt the product and marketing communication strategies to the global market.

- *Straight product extension* is the case where both product and communication do not change in a foreign market.
- *Product adaptation* involves, only, product change, so that it adapts to the uses and tastes of consumers, while communication remains unchanged.
- *Product invention* consists in creating the product from scratch to meet consumer demands, and therefore also communication.
- *Communication adaptation* is a strategy that leads to the adaptation of advertising messages to the markets in which they are targeted.
- *Dual adaptation* is when a company decides to adapt both the product and the communication to the foreign market.

Once the market entry strategy has been decided, the most suitable distribution channel is chosen. The distribution of the product, usually from the seller to the final buyer, takes place through several steps, which the company must be able to manage in the best way to compete at international level. By global value delivery network, we mean the channels to be managed so that the product starts from the international seller, passes through the channels between countries and those within countries, to reach the end user.

Chapter 2

The Product: IPS Cable Simulation from fleXstructures

IPS provides capabilities throughout the process, from concept and design through assembly and production planning until the After-Sales. The world's leading manufacturing companies use IPS for tasks ranging from flexible components design, assembly feasibility, robot optimization to simulation of complex flow and surface treatment processes. The product portfolio comprises the software tools IPS Cable Simulation, IPS Intelligently Moving Manikin in Assembly (IMMA), IPS Path Planner, IPS Virtual Paint Spray + Sealing, IPS Robot Optimization and others. Precision and computing speed are unique selling propositions of these tools.

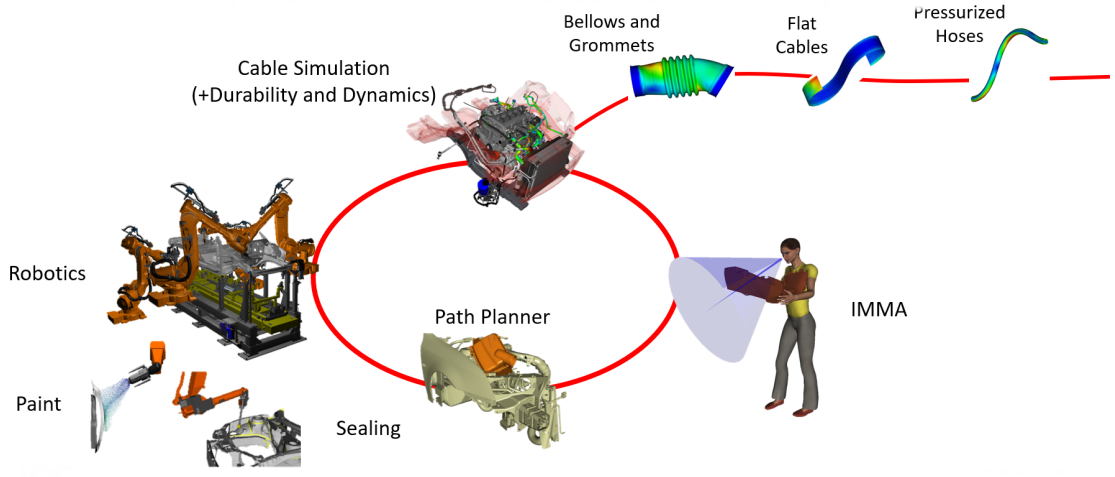


Figure 2.1: Smart industries 4.0: IPS Product Suite makes it easy.

2.1 The company

In 2012 Oliver Hermanns founded fleXstructures GmbH and started his journey of building a global leading software company in the field of flexible simulation. fleXstructures succeeded in expanding the business and distributing the new IPS software in several countries around the

world.
fleXstructures GmbH is a high-tech spin-off company of Fraunhofer Institute for Industrial Mathematics (Fraunhofer ITWM) in Kaiserslautern, Germany. The company's main areas of activity are worldwide distribution, engineering services and development of specific software solutions based on new advanced, efficient algorithms.
Leading OEM, suppliers and service providers of the automotive and commercial vehicles industry, as well as companies of other industrial domains like motorbikes, railways, defense vehicles, aerospace and electronics industries use the IPS software tools.
Due to the close cooperation between fleXstructures, Fraunhofer ITWM and the Swedish Fraunhofer-Chalmers Centre, the latest Fraunhofer research results are continuously incorporated into the software development processes.

Figure 2.2: fleXstructures GmbH, Kaiserslautern.

Whereas, fleXstructures Italia S.r.l. is a limited liability company established in 2018, controlled by fleXstructures GmbH, where the research thesis was done.
fleXstructures Italia S.r.l. has the distribution and sales rights for IPS Suite products in South Europe, Middle East, China and South Korea.
fleXstructures Italia S.r.l. also carries out research projects and develops and implements innovative modules of IPS Cable Simulation and IPS Robotics products.

2.2 The product

2.2.1 What is IPS Cable Simulation?

IPS Cable Simulation is the worldwide leading technology for the simulation of wires, wiring harnesses and hoses. Its accuracy is unique due to algorithms developed in Fraunhofer research considering physically correct material properties and gravity. In addition to realistic simulation, the program provides visualization in real time, which enables interactive working.
The software is very successful in benchmarking and it is already integrated into the product process of main leading automotive companies.

By using IPS Cable Simulation, validated results regarding flexibles and related parts are achieved early in the product process. This leads to great savings in terms of time and money due to less prototyping and iterations. All of this because IPS Cable Simulation allows companies to have one tool for complete product processes from design concept to prototype.
Applying the software in design, virtual assembly, DMU processes and for troubleshooting results in higher product quality and improved durability of flexible parts.

IPS Cable Simulation serves as a common fast decision platform bringing together different divisions of a company in all phases of the product process. This helps detecting flaws and assures product quality. Thanks to IPS in design processes, engineers find optimum routings, lengths and shapes for flexible components interactively by applying IPS Cable Simulation. It is either possible

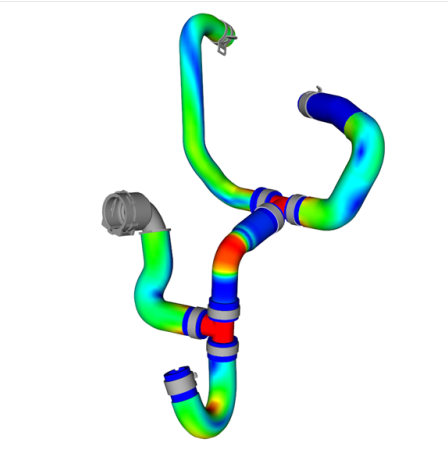


Figure 2.3: Simulation of a piping of cooling hoses with clips, using IPS Cable Simulation.

to route a cable or a hose from scratch or to make your CAD geometry flexible.
The software allows companies to design flexible parts with or without pre-deformation, through an interactive optimization of routings and lengths. Customized clips, kinematic clips and an entire database of various clips can be added to the project. In **Figure 2.3** it is possible to see an example of the flexible with the measurement and visualization of contacts, collisions, stresses and strains. For design engineers the required space for cables and hoses is a crucial challenge. In order to do a motion analysis of flexible components a real-time solution is needed. In addition IPS Cable Simulation provides capabilities such as:

- Envelopes of needed installation space for variations of length and fastening.
- Tolerance analysis.
- Swept volumes for flexibles and rigid bodies.
- Comparison of the designed space (envelopes)

By applying IPS Cable Simulation, risk factors such as tensions, small bending radius and points of collision can be identified. Additionally, various parameters such as material properties and cable lengths can be optimized interactively in real time. Several analysis features regarding bending radius, torsion, forces, tension and distances ensures a validated result.
IPS Cable Simulation does not use time-consuming finite element methods. Instead, a physically correct beam model is used. As a consequence, the computing time is considerably reduced while the maximum accuracy is achieved.
A brief example that explains how the software broadly works is the following:

1. **Define the wire**. The scene geometry can be imported from any CAD system, as a VRML- or JT-file. Before creating a wire, the material parameters need to be defined manually or loaded from a database. There are three possibilities of defining a wire: Creating an initial cable instantly, using the Automatic Routing feature or providing a pre-deformed shape by inserting a curve.

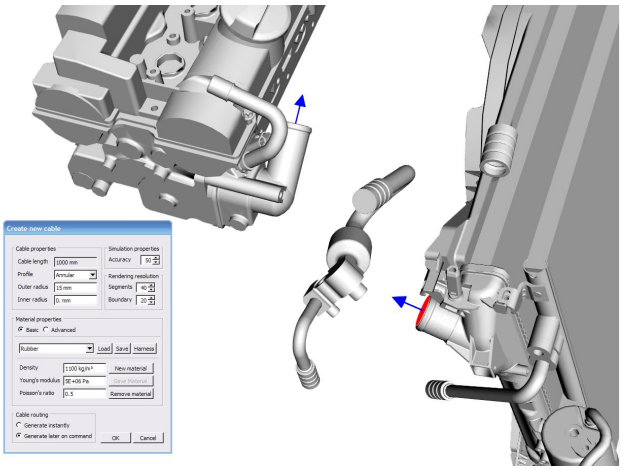


Figure 2.4: Definition of material parameters.

2. **Connect the wire**. The locations for fastening cable clips and clip connections need to be defined. After that the cable can be connected with any object and/or other cables.

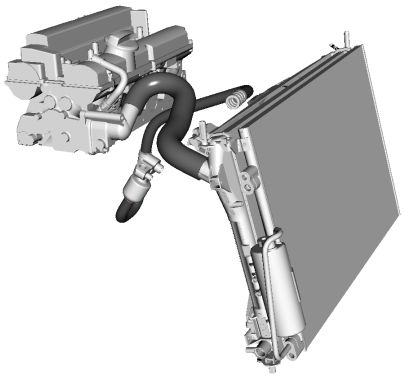


Figure 2.5: Connection of CAD objects.

3. **Visualize**. The stress and strain in the wire are visualized by color coding, and it is possible to set up and monitor critical distance and value measurements.

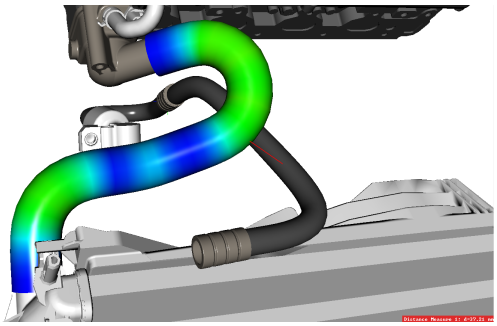


Figure 2.6: Visualization of color coding.

4. **Analyze motions**. The object motions can be imported from XMO or EngMo. They provide a basis for the analysis of the wire's motions with respect to the critical measurements. An envelope of the motion can also be created.

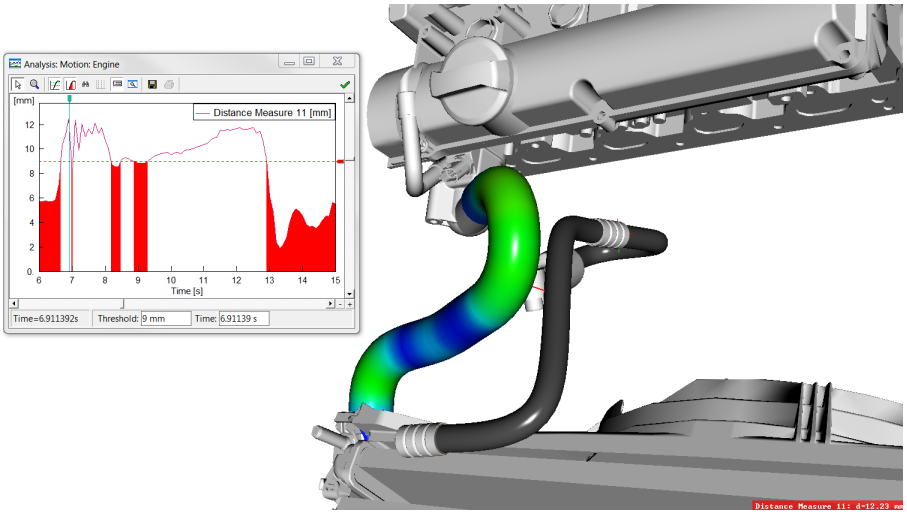


Figure 2.7: Analysis of stress.

2.2.2 Advantages of IPS Cable Simulation

IPS Cable Simulation is one tool for the complete product processes, meaning for that:

- Process optimization;
- Design optimization;
- Virtual assembly;
- Digital mock-up (DMU).

Process optimization

Today lot of manual work is still apllied in cable, hose, wiring and harness development. Process is even complicated through the application of the trial-error methodology, which leads to late modifications in the development stage, with high impact in terms of resources and costs, sometime even making impossible to industrialize the best solution in time for the production. Process optimization is the answer to the industry needs and IPS Cable Simulation is the solution to realize it, allowing:

- Reduction of cost and time: by using IPS Cable Simulation, validated results regarding flexibles and related parts are achieved early in the product process. This leads to great savings in terms of time and money due to less prototyping and iterations.
- Quality improvement and quality assurance, applying the software in design, virtual assembly, DMU processes and for troubleshooting results in higher product quality and improved durability of flexible parts.

- Interdisciplinary cooperation: IPS Cable Simulation serves as a common fast decision platform bringing together different divisions of a company in all phases of the product process. This helps detecting flaws and assures product quality.

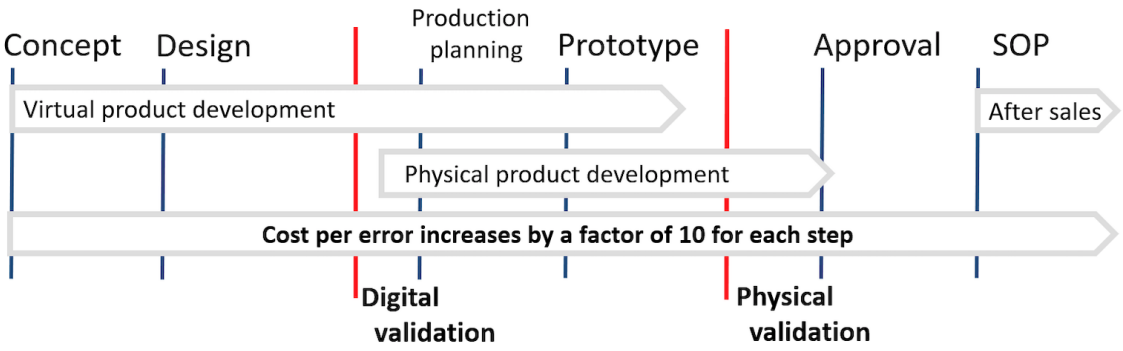


Figure 2.8: Typical product development process. Source: Association of German Engineers (VDI standard 2247 quality management).

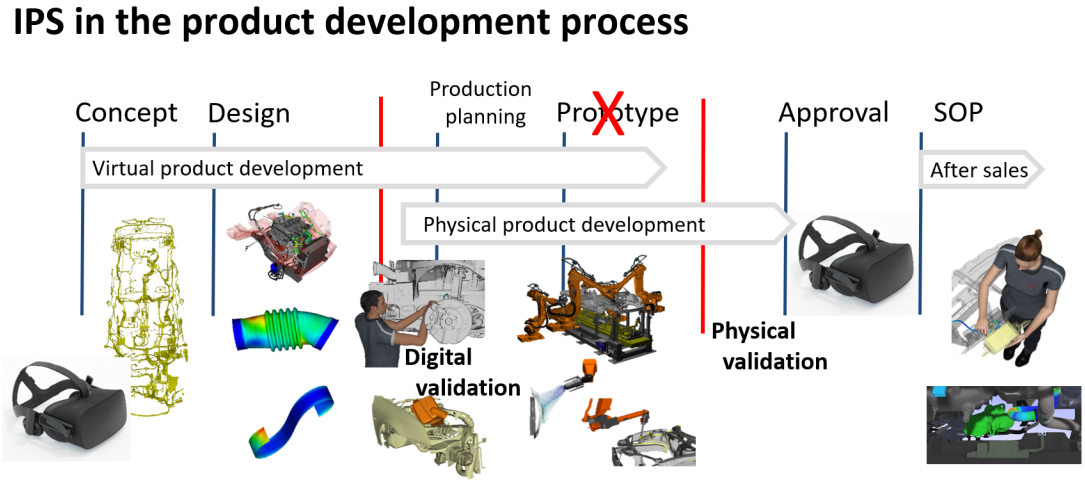


Figure 2.9: IPS in the product development process.

Design optimization

Until now, in the phase of vehicle and machine design, CAD-systems were used to arrange and lay electric cables and hoses. In this proceeding the course of the wires often was estimated and designed using experience values. The real material properties and the behavior of flexible wiring systems were only partially considered. Besides, changings in the surrounding geometry often led to a complete redesign of the wire's course. As a result, the expenses in terms of time and money were high. IPS Cable Simulation offers the following advantages:

- Automatic creation of the wire's course (autorouting).
- Interactive laying in real time.

- Consideration of the realistic material properties and the force of gravity.
- Early detection of critical constructions.
- Installation space analysis of moving parts.
- Tolerance, collision and movement analysis.
- Interactive optimization of the wire's course and length based on bending radius and other criteria

Virtual assembly

In assembly processes it is a great challenge to install flexible parts such as wires and hoses without causing inacceptable stresses or even damages. Although the installation space is often limited, it still has to provide enough space for the mounting process. Furthermore, the wires and hoses need to have optimum lengths in order to avoid damages during the installation or signs of wear in daily operations. When applying IPS Cable Simulation in virtual assembly processes the required installation space and optimized wire lengths may be determined in advance. Key features and benefits:

- Stress analysis of the flexible elements during the assembly process and after their installation.
- Risk analysis for incorrect assembly.
- Assembly-based construction validation.
- Interactive optimization (e.g. of material parameters or cable length).
- Adjustment of clips to the assembly process.
- Prevention of a repeated design process.

Digital Mock-Up

In the phase of Digital Mock-Up (DMU), a product validation is carried out to ensure the durability of flexible components, especially for moving parts, which often wear out early. The objective is to minimize loads during running operations and to reduce the number of prototype tests, which are expensive in terms of time and money. By applying IPS Cable Simulation, risk factors such as tensions, a small bending radius and points of collision can be identified. Additionally, various parameters such as material properties and cable lengths can be optimized interactively in real time. IPS Cable Simulation does not use time-consuming finite element methods. Instead, a physically correct beam model is used. As a consequence, the computing time is considerably reduced while the maximum accuracy is achieved. Advantages of IPS Cable Simulation:

- Physically correct simulation in real time.
- Design validation regarding bending radius, torsion, forces, tension etc.
- Various analysis features (normal stress, shear stress etc.).
- Tolerance analysis.
- Contact handling (wire to wire, wire to geometry, self-contact).
- Swept volumes for flexible and rigid bodies.

2.2.3 Features

MeSOMICS - Measurement System for the Optically Monitored Identification of Cable Stiffness

IPS Cable Simulation software allows a highly precise simulation of behavior of wires, hoses and even complete wiring harnesses. However, for achieving accurate results, it is essential to apply correct input parameters. In this context, Fraunhofer ITWM has developed a methodology and a patented measuring machine MeSOMICS allowing to capture and to measure single electric cables, wiring harnesses and hoses with respect to their material properties. As a result, the software users obtain the parameters that are necessary as input data for an exact simulation, including bending, extensional and torsional stiffness. In case the exact material properties of the relevant cables and hoses are not available, it is possible to stipulate the material properties.

In combination with the simulation software IPS Cable Simulation, a complete solution was created that makes it possible to optimally accommodate several kilometers of cables and hoses in the small installation spaces of modern vehicles. With MeSOMICS, the industry can measure the mechanical properties of cables and hoses and reproduce them realistically in the simulation. The innovative interaction of the measuring machine MeSOMICS and IPS Cable Simulation is a unique combination of correct stiffness values of cables and hoses and physically correct simulation in **real time**.

MeSOMICS allows to bend the cable in question, even with highly non-linear deformations, under optimal contour conditions without disturbing effects. Thanks to optical detection there is a robust evaluation and immediate feedback from the theoretical solution. It is possible also measure hoses with internal pressure and measure at specified temperature (integrated climatic chamber).

Figure 2.10: MeSOMICS

Bellows and Grommets

The inability to simulate bellows and grommets as a beam makes it difficult to calculate and study these elements. Simulate flexible, moving bellows and grommets with fine structures using a fast FEM-based approach. Flexible objects are defined by their physical dimensions in 2D, along with a thickness parameter for the third dimension, and material parameters. The dedicated software module for bellows and grommets is based on a FEM shell solver developed by the Fraunhofer-Chalmers Centre and delivers fast simulation times. The module offers possibility to create and import motions, analyze reaction forces, von Mises stress, and distance to surrounding geometries.

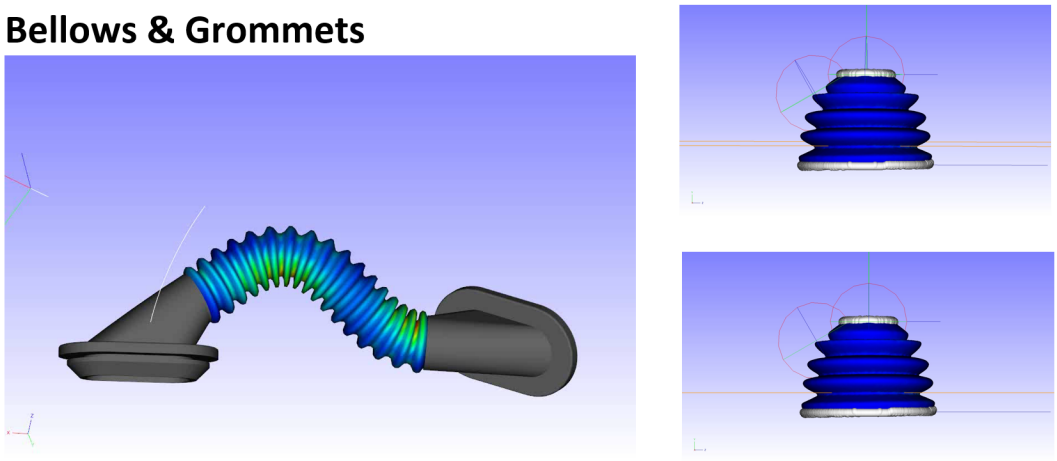


Figure 2.11

Flat cable

Flat cables are mainly used in the electronics field. A reliable simulation is essential to ensure that a flat cable continues to operate despite continuous stress. Flat Cables is a tool for fast and realistic simulations of flat cables.

Pressurized Hoses

Hose systems must have both superior strength, thermal and dimensional stability. The development of brake systems triggers the need for reliable brake hoses.

Dynamics and durability

The dynamic behaviour on cables and hoses can play a decisive role in the suspension (sensor cable or brake hose). Rapid changes in motion or high frequencies based on excitation during compression and rebound in the suspension can result in dynamic effects that can be simulated with the dynamic module after the quasi-static design in IPS. As a result, the user receives a virtual validation of dynamic influences on flexible components to examine the layout, design space and durability in order to reduce hardware prototypes. The Durability and Dynamics module offers the possibility of reducing the number of physical prototypes in the long term and thus optimizing your development process.

- **Durability**. Load data analyses can be performed on the basis of simulation results from quasi-statics or dynamics. This analysis forms the basis for the accumulated pseudo-damage calculation and thus enables the evaluation and optimization of the physical configuration of cables and hoses. Benefits:

  - Easy comparison of damage for various configurations.
  - Early optimization of lifetime already in design phase.
  - Significant reduction of hardware prototype testing.

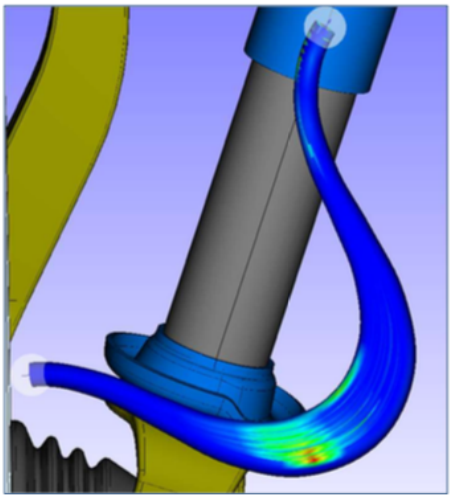


Figure 2.12: Brake hose of a suspension

- **Dynamics**. The basis for the dynamic simulation is a physical model with corresponding inertia and damping models. The implemented algorithm is easy to parameterize and thus enables a wide range of applications. The dynamic simulation of cables and hoses is a further investigation to be able to analyze the dynamic behavior after a quasi-static design. Benefits:

  - Physically correct results also for fast moving cables.
  - Additional solver for further analysis of fast excitations (e.g. engine vibration, suspension motion, road excitation, etc.).

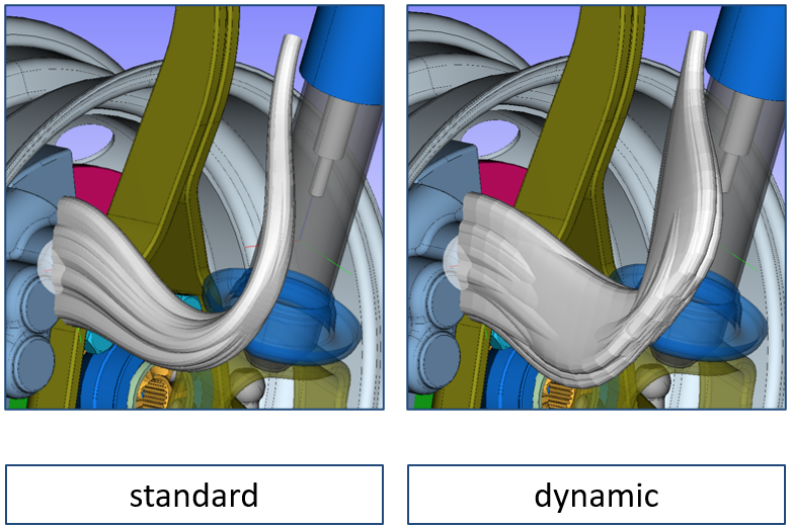


Figure 2.13: Comparison between standard (quasi-static) and (full) dynamic simulation

Integration with other IPS Tools

IPS IMMA - Intelligently Moving Manikin in Assembly

The human is the most valuable part in the production process and industrial applications, such as assembly tasks. Therefore, keeping them safe and healthy is essential. In order to reach hidden assemblies with poor accessibility and saving time in iterations and working steps a digital human modelling simulation is a great advantage for the manufacturing industry.
Moreover, the consideration of human factors is an indispensable part of modern design that leads to better products, shorter and more cost-effective development cycles. Inside IPS, the ergonomist is able to validate ergonomic criteria and visualize ergonomic differences in human anthropometrics directly in an analysis diagram.

After planning the path of objects with IPS Path Planner, IPS IMMA can use these paths and consider the human inside the assembly applications or ergonomic studies. IPS Path Planner is an integral part of the IPS IMMA tool.
Instead, in combination with IPS Cable Simulation, flexible components can be taken into account, either for assembly or disassembly tasks or for validations with respect to such parts in the product process.

Figure 2.14: IPS IMMA

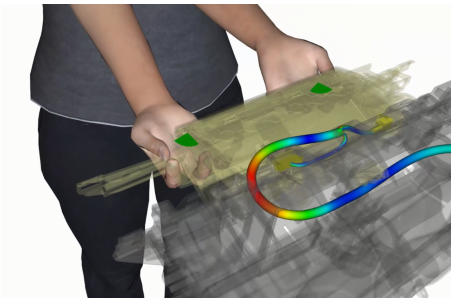


Figure 2.15: IPS Cable Simulation together with IPS IMMA

IPS Robot Optimization

Manually programming robots with correct paths for sealing curves and welding is a complex task without knowing the correct result. Although great parts of product developments in the automotive industry are already digitized today, a solid mathematical basis is still missing for a wide range of tasks. IPS Robot Optimization is an intuitive software application used for finding optimized and collision free robot paths for individual or multi-robot stations.
In combination with IPS Cable Simulation, the robot optimization process also considers the cables, not only for the optimal collision free path, while also for the optimal usage of the cable itself, which gives additional constrains to the robot movement maximizing the cable usage.

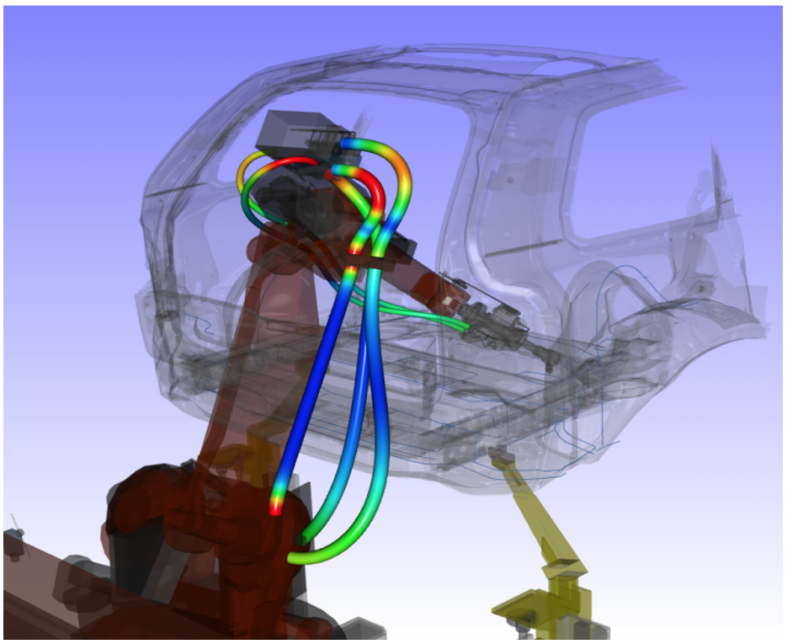


Figure 2.16: IPS Robot Optimization

2.2.4 Challenges in the Automotive Industry

The automotive industry is pushing more and more to electrification of the vehicle and is projected towards autonomous driving. Automated Driving System, or A.D.S., is "s a vehicle automation system that assumes all real-time driving functions necessary to drive a ground- based vehicle without real-time input from a human operator". The Automated Driving System is generally an integrated package of individual automated systems operating in concert to drive the vehicle without real-time input from a human driver. Automated driving implies that any human sitting in the driver's seat (or not) has transferred all real-time driving functions (i.e., all appropriate monitoring, agency, and action functions) to the vehicle automation system.

Aim of Electrification and Autonomous Driving is to solve many problems which effect constantly our life:

- Safety, to prevent accidents and save million of lives.
- Efficiency, to decrease the problem of the pollution and the environmental impact, especially in the megalopolis, which will represent the future of the cities.
- Convenience, because during travelling it will be possible to continue working, enjoying or relaxing.
- Extended mobility, allowing people with limited mobility to move again without any restriction.

The engineering challenges required to satisfy such requirements are:

- **Exponential growth of electronic control systems and functions**: cars are more and more mainly software enabled by hundreds of different electronic systems.

- **Exploding requirements and test cases**: to achieve full reliability, especially required for highly and fully automated levels, thousands of functional requirements and specifications are needed, next to millions of kilometers to drive.
- **Multiple variants and system architectures** are already in place and expected to increase with the electrification development.
- **Big Data**, useful for monitoring, analysis and optimization of the circulating connected cars, which today already generates 25 GB/hr data (increased to 500 GB/hr for AD).

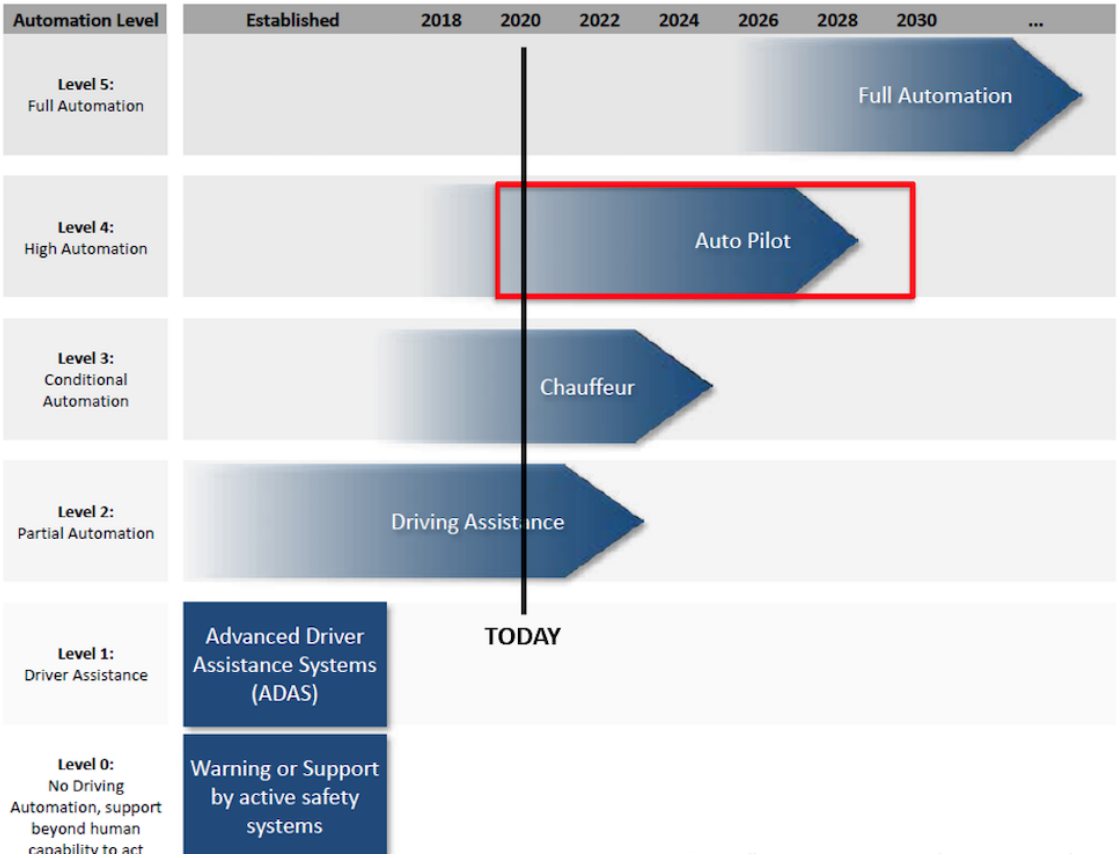


Figure 2.17: Roadmap to Autonomous Driving. Source: ERTRAC "Connectivity and Automated Driving" 2019

By 2030 it is expected EVs (Battery Electric Vehicles) and PHEVs (Plug-in Hybrid Electric Vehicles) to be over 40% of all European vehicles sold each year. Electrification and autonomous driving are also expected to double the automotive electric and electronic components market in Europe. More than 50 large, and established companies are working on autonomous vehicles or systems, some near unlimited balance sheets to invest.

IPS Cable Simulation is ready for answering the engineering challenges addressed to Electrification and Autonomou Driving, meaning for that:

- Electric components and complex cooling systems development, because of its ability to optimiza such subsystems;

- Functional Safety according to ISO 26262 definition ("absence of unreasonable risk due to hazards caused by malfunctioning behavior of electrical/electronic systems"), allowing Redundancy and Complex cable packaging;
- Reliability, achieved through Virtual Validation to realize millions of miles to test and dozens of variants to consider fully virtually.

2.2.5 IPS Cable Simulation summary

In summary, IPS Cable Simulation answers all industry needs in the product development, at each industry level:

- Management level requirements, through:
  - Immediate decisions across the entire product development phases: IPS Cable Simulation with the real-time functionality performs analytics and optimization in shorten time, allowing quick decisions at any level of technical and management responsibility.
  - High-performance execution: the physical modelization of flexibles with high fidelity of the results guarantees high-performance execution solution that is cost effective.
  - Improved performance through more productive collaboration: the IPS Product Suite platform enables collaboration across the different industrial processes and teams, sharing data and enhanced results, even considering real environment through point cloud data acquisition.
  - Virtual Reality integration: fully integrated in VR environment for an immersive understanding.
- Engineering level requirements, through:
  - a user-friendly interactive interface due to real time calculations;
  - exact space and tolerance analysis;
  - highly accurate and collision-free cable routing and calculation of large deformations between moving parts;
  - load data analysis, stress recovery and fatigue durability computation;
  - dynamics effect due to cable inertia and damping.

As a result of this, IPS Cable Simulation makes possible to:

- Save enormous amount of time in the industrial development process, because of frontloading early in the Stages;
- Reduce drastically the number of prototypes, which will be thus used for final verification only;
- Get tangible Return of investment,proven within several customer application cases.

Chapter 3

Macroscopic analysis of the Asian area

Asia is the largest continent in the world, in fact it occupies 8.7% of the earth, and it hosts close to 4.4 billion inhabitants, equivalent to 60% of the world population. It is classified as the continent with the highest population growth rate. This continent, being so populated, is characterized by different cultures, ethnic orientations, political systems, economic systems and physical environments.

Asia was the seat of the first most important and complex cultural evolutions; in western Asia (Middle East) the first methods of agriculture and breeding were probably implemented, metallurgy was invented and the first states were born. In the immense spaces of Asia, some of the greatest continental empires that history remembers arose and developed: from Persian to Arabic, Byzantine, Ottoman, Chinese and Russian.
A useful tool to analyse the Asian macro environment is the PESTEL, which stands for Political, Economic, Social, Technological, Environmental and Legal factors, i.e. the forces that can impact on it. Changes in the macro environment can impact not only the Asia Pacific Data Centre Group[1] but also the Porter Five Forces[2], that shape strategy and competitive landscape.

This chapter will only examine three states in more detail, as they are of interest to the company fleXstructures, being host to the largest car manufacturers in the Asian market. These states pf analysis are: China, Japan and South Korea.

3.1 China

China is the most populous country in the world with about 1.4 billion people living there. China is a People's Republic where power is exercised by the Chinese Communist Party alone. The government is based in the capital Beijing and exercises jurisdiction over twenty-two provinces, five autonomous regions, four directly controlled municipalities (Beijing, Tianjin, Shanghai and Chongqing) and two special administrative regions (Hong Kong and Macao) partially autonomous.

[1] A data centre is a physical facility used by organisations to host their critical applications and data. The design of a data centre is based on a network of processing and storage resources that enable the delivery of shared applications and data.

[2] The analysis of Porter's five forces is a tool that companies can use to assess their competitive position. The model aims to identify the forces (and to study their intensity and importance) that operate in the economic environment and that, through their action, erode the long-term profitability of companies.

China's surface area is 9.7 km^2, slightly less than the whole of Europe, making it the largest state in East Asia.

The Chinese market in the last thirty years has become a world economic power (the country's GDP has grown with an average of 10%), considering that it started from a backward agricultural economy. China has become the world's largest exporter, and the second largest importer, after the United States. The Chinese market is also considered to be one of the most stable, just see how the Chinese market rose from Covid-19 with a positive response of +4.9% in the third quarter.

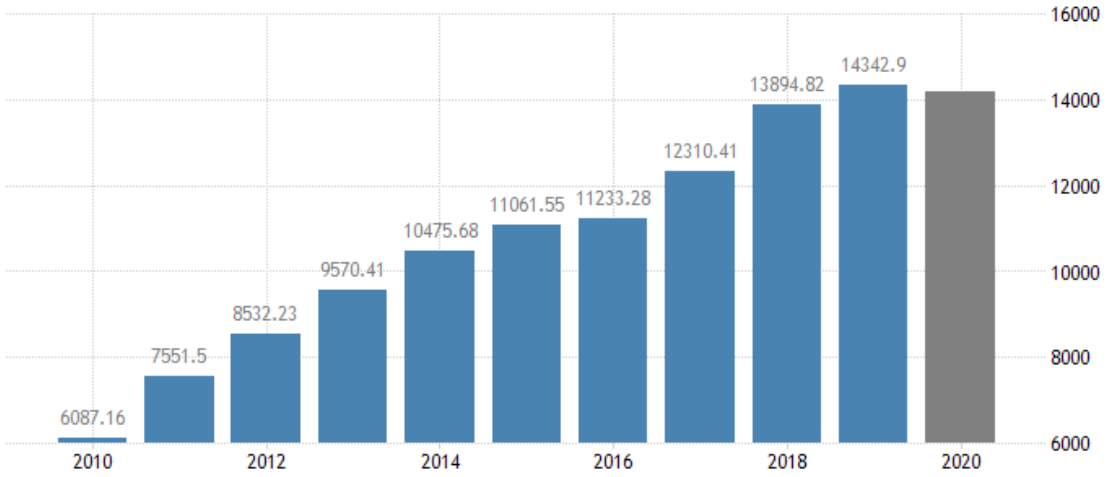


Figure 3.1: The Gross Domestic Product in China according to official data from the World Bank and projections from Trading Economics. Source: TradingEconomics.com | World Bank

The industrial sector that has led China to a leading position is manufacturing. This has led many foreign companies to invest in this sector, making it the largest manufacturing country in the world, surpassing the United States in 2010. The Chinese middle class has grown rapidly, thus also increasing strong domestic demand for products. As far as electronics manufacturing is concerned, the low costs and government support have allowed China to be the center of the electronics advancement, attracting a large number of manufacturers from all over the world. All this, however, over the years has led to an increase in labor costs and land prices. Considering also other difficulties such as language barriers, unstable working relationship with employees due to high staff turnover, incomplete legal system and high taxation problems, China is losing its competitive advantage over other countries.
But in 2015 China launched an ambitious plan to become one of the leading global technology superpowers by 2049. This plan defines ten crucial areas, visible in the figure below, in which China wants to achieve significant progress and develop competitive companies on a global scale. Investments in internet, supercomputers, artificial intelligence, robotics, industrial automation, new materials, and green development are just some of the cornerstones of Made in China 2025 to accelerate the transition from an industrial country to an industrial powerhouse.

Figure 3.2: Ten core industries. Source: Graphic Asia Briefing Ltd.

In this context it is necessary to carry out a PEST analysis, if a foreign company decides to start investing in the Chinese market. This analysis involves the study of the following factors:

- **Political** factors
- **Economic** factors
- **Social** factors
- **Technological** factors

But to have a wider view of the market it is useful to add other two factors, **Natural** and **Demographic**, that, together with the four mentioned above, allow to have a more detailed analysis of the market.

3.1.1 Demographic factors

As already mentioned, China is the most populous country in the world, but it has witnessed demographic changes of historical proportions in the last thirty years. It has moved from a transitional demographic society to a post traditional one, where life expectancy has reached new heights, fertility has declined below replacement level, and the rapid aging of the population is on the horizon. China has also witnessed processes of migration and urbanization, which has led the population to concentrate mainly in the eastern provinces and the great plains, while in the west, a harsher and drier area, there is a very low density. There are 56 different ethnic groups in China, including one main, the Han ethnic group, which includes 92% of the population, and another 55 ethnic minorities. The distribution of ethnic groups is actually very irregular, in fact there are areas where the Han ethnicity is the minority.

Demography in China is considered the real nightmare, as the Pulitzer Prize George Will writes in the Washington Post, the latest demographic surveys reveal that the population increase is about to end leaving room for a ruinous swoop. Looking at the segment of the population that most of all affects the trend of GDP, the "working age" between 15 and 64 years, in China, from

1975 to 2010, has doubled. In these thirty-five years, however, fertility has remained well below the so-called "replacement level". Nicholas Eberstadt, an economist in force at the American Enterprise Institute (AEI), predicts that there will be a decline in the population from 2027. In addition to a slowdown in population growth, it is doomed to grow old. Cai Fang, a scholar at the Chinese Academy of Social Sciences, said at a conference on the economy of the former Celestial Empire in 2012, "there is no doubt that China will become old before it becomes rich".

3.1.2 Natural factors

Pollution in China has always been a big problem, in fact 90% of 161 cities surveyed by the Ministry of Environmental Protection do not reach the air quality values set by the government. According to a Berkeley Earth study, air pollution in China is killing an average of 4000 people a day. Pollution levels were up to 30 times higher than those deemed safe by the World Health Organization in cities like Beijing and Shanghai in January 2013. However, although China is the largest consumer of coal, it is at the same time the largest promoter of renewable energy in the world. In fact, a striking example is the construction of the world's largest air purifier in the city of Xi'an in northern China in 2018. The tower is more than 100 meters high and produces over 10 million cubic meters of clean air per day. Another source of pollution in large cities is transportation, but China is also the largest buyer and manufacturer of electric vehicles and has come to play a leading role in electrification of mobility.

3.1.3 Political factors

China is a People's Republic in which power has been exercised by the Chinese Communist Party alone, since 1949 until today. Although it is a stable political environment, the lack of political freedom is a cause for concern. The CCP has also been charged with human rights violations for the mass treatment and detention of Uighurs in Xinjiang and the persecution of Falun Gong. However, with cheap labour and better infrastructure, China is positioned as a major destination for foreign direct investment (FDI).

3.1.4 Economic factors

The purchasing power of the Chinese population in the last four decades has increased, considering that in 1978 64% of the Chinese population lived below the poverty line of 1 dollar a day, in 2009 it was about 10%. China's entry into the World Trade Organisation (WTO) in December 2001 opened up new scenarios for the domestic market at the expense of the foreign market. In fact, from this date on, the incredible phenomenon of China's industrialization took off, and the beginning of the collapse of some Western companies that could not compete with the Chinese ones. However, this economic development has caused high inequality, rapid urbanization and environmental damage that China is forced to deal with if it wants to maintain its economic sustainability. For companies that have invested in the Chinese market, the constant growth in consumption driven by urbanisation has opened up retail opportunities in both low-cost and luxury sectors. The growth in the technological level of Chinese industrial production has required skills and knowledge in the short term, and has opened up important opportunities for mechanical components.

3.1.5 Social-cultural factors

The Chinese market is immense, and precisely for this reason cannot be considered a single entity with homogeneous needs. Following Mao Zedong's death, the social status of Chinese citizens has completely changed, in fact if before the relationship with power structures such as the Party, the

state or the army was fundamental, later the decisive factors became income, wealth, professional profile and level of education. This opened the way for a new social group, the middle class, which was strongly consumer-oriented. But as previously written, it is difficult to define the characteristics shared by the Chinese population who are part of this new social class, because there are several categories of people such as: professionals, state workers, baofabu (a derogatory term used to refer to those who became rich in the previous period and display wealth). Although individualism characterises consumer spending behaviour more and more, a distinctive feature of Chinese culture is the tendency towards collectivism and conformism. This is due to the heritage left by Maoist socialism where the individual and his needs were subordinate to the collective interest. In fact, while the Western consumer pursues uniqueness and originality through the products he buys, the Eastern consumer tends towards conformity because he considers it extremely important to be positively evaluated by others. Therefore, the purchase of the product is linked to the image that it gives itself to others. If the company attributes a high value to a product, and therefore guarantees a respectable social status to its owner, the ownership of many high value products is perceived as a fundamental act to improve own position within the community.

3.1.6 Technological factors

With the Made in China 2025 plan, China aims at world technological leadership, by forgetting low-cost production and implementing a 4.0 digital upgrading and transformation plan. This transition will lead it to be an advanced economy based on consumption, services and innovation. With Made in China 2025 and the Belt and Road Initiative it will change not only "what China produces" but also "to those who sell China" and "with those who produce China".

3.2 Japan

The capital of Japan is Tokyo and with its 126.5 million inhabitants it is the eleventh most populous state in the world. It extends for 372,824 km2 and is an archipelago formed by 6,852 islands, whose five largest are Hokkaidō, Honshū, Kyūshū, Shikoku and Okinawa. These alone account for about 97% of Japan's land surface.

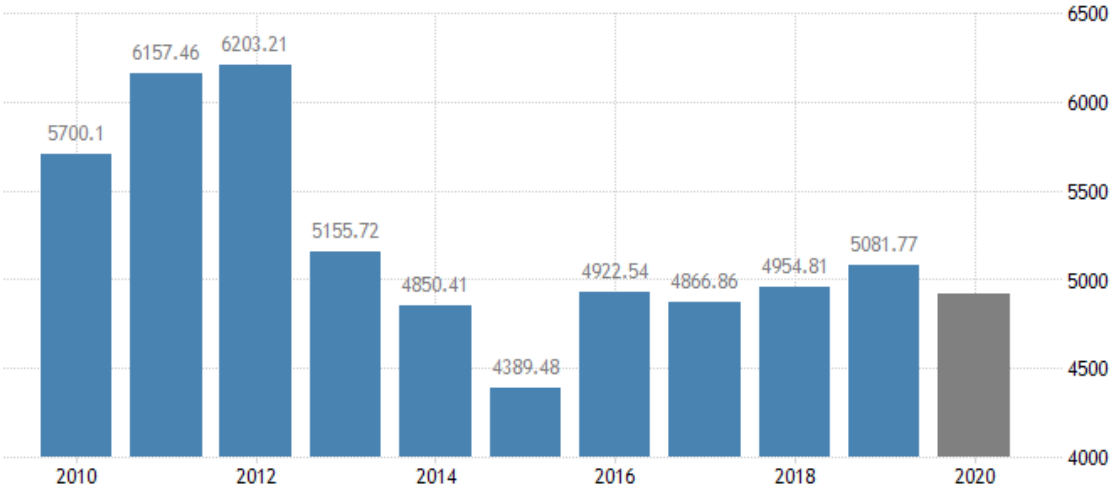


Figure 3.3: The Gross Domestic Product in Japan according to official data from the World Bank and projections from Trading Economics. Source: TradingEconomics.com | World Bank

It has the third largest economy by gross domestic product, preceded only by the United States and China, and the fourth largest by purchasing power; it is also the fourth largest exporter and the sixth largest importer in the world. The domestic market, in Japan, is driven by considerable consumption as a cutting-edge infrastructure and a strategic position that allows it to maintain various economic and commercial ties with China. The country's economic growth is also due to an important integration of innovative technologies in the various sectors. The Japanese legal system is favourable to foreign investment and is inclined to maintain stable and long-term commercial relations. And policies to encourage economic investment in Japan encourage economic growth and promote important future investments in the energy sector and environmental conservation. There are several factors in which it is beneficial to invest in Japan, among them: renewable energy sector; information and communication industry; electromedical equipment sector; E-health sector. It is not easy for foreign companies to enter in the Japanese market. In fact, Japanese people prefer to cultivate relationships with their own countrymen, or at least with partners who speak their own language and know Japanese culture well. Once started a business relationship with a Japanese company it is important to build a relationship of trust, showing 100% commitment to their business partners and customers.

Japanese culture makes its way into companies, and while Western companies are projected to annual profit, the main goal of Japanese companies is to survive in the long term, ensuring work for all employees. For the Japanese are considered virtues the control of their emotions and the continuous search to perfect their work. In fact in the company the organization becomes a pillar to achieve its objectives, the workplace is safe and efficient, thanks to the 5S system. This system, promoted by Japanese culture, has become a fundamental pillar for the lean production of companies worldwide. It is a five-principle (5S) implementation program that helps the company achieve operational excellence through workplace improvement.

Figure 3.4: Source: adizes.hr

1. **Seiri/Sorting**: Separating what is necessary from what is not (or no more) necessary in the workplace, eliminating everything that is not used.

2. **Seiton/Straitening**: Defining an arrangement of materials and tools inside the workplace so that they are immediately available when needed. Order and organize, efficiently and neatly arranging everything "a place for everything and everything in its place".
3. **Seiso/Shining**: Not only removing dirt from machines and equipment but above all checking the work stations, equipment and tools in order to detect any anomalies.
4. **Seiketzu/Standardizing**: Formalizing "cleaning" activities through standard procedures and improve the work procedures, organization and cleaning activities created.
5. **Shitsuke/Sustaining**: Making sure the achieved results are kept through periodic checks (audits). The continuous analysis of problems and the identification of the associated countermeasures, together with monitoring the achieved performance, allow setting new objectives according to the "continuous improvement" principle.

To have a more in-depth analysis of the Japanese market it is useful to make a Pest analysis also in this case, dealing with the various factors that influence it.

3.2.1 Demographic factors

Although Japan has been the eleventh largest country in terms of number of inhabitants for several years, its internal composition has changed over time, leading to a growth of the population over 65 years of age from 4.9% in the 50s to 28.1% in 2018. This continuous aging of the population, the vertiginous increase of families formed by one person, the constant decrease of the total fertility rate and the almost halving of marriages, it is leading to a radical decrease of the population that will fall to about 93 million people in 2050. The Country of the Rising Sun has been facing for several years now the problem of the aging population and the consequent abandonment of rural areas. All this together with the geography of the country has led to an increase in density especially in the three major metropolitan areas Kantō, Chūkyō, Kansai where 51.9% of the population lives.

3.2.2 Natural factors

As already mentioned, most of the population is concentrated in the three largest metropolitan areas of Japan. This urbanization, which in some cases has been forced due to the geography of the continent, has led to the production of large amounts of gas emissions into the atmosphere, which, by accumulating, contribute to the greenhouse effect. Despite the increase in air quality over the last thirty years, Japan has the highest level of tropospheric ozone among the OECD nations, leading to premature deaths of thousands of people every year. However, it is considered a world leader in the development of new climate-friendly and climate-friendly technologies, just see the electric and hybrid vehicles developed by Toyota and Honda which are the best in terms of fuel consumption performance and low greenhouse gas emissions.

3.2.3 Political factors

Formally Japan is a parliamentary monarchy, but the role of the emperor is exclusively symbolic, as established by the rigid Constitution in force since 1947. In fact, sovereignty belongs to Japanese citizens who elect their representatives in all powers. Japan's domestic policy is considered stable and holds a key role in the Asian and international context thanks to the Abe Government, which has always been in favor of greater trade openness and consolidation of the multilateral trade system. The economic and trade policy choices make Tokyo a strategic partner for both the major world economies and the emerging countries. It guarantees foreign investors an attractive and stable business, thanks to the stability and continuity of the Abe Executive.

3.2.4 Economic factors

Japan is the second largest economy in Asia. It is a member of G7, G20, APEC, and ASEAN. It has a very strong economy, and as shown by the life expectancy within the country (81 years for men and 87 for women) the standard and quality of life is high. The industry is among the most advanced in the world, it is dominated by two key sectors: automobile manufacturing and consumer electronics. Japan is world-renowned for the automotive industry and home to some of the largest vehicle manufacturing industries such as: Toyota, Honda, Suzuki, Mazda, Nissan, Mitsubishi, and Yamaha. Although the unemployment rate is at an all-time low, although due to Covid-19 it has risen to 3% (it was 2.9% in 2017), for the Japanese it is high and quite worrying.

3.2.5 Social-cultural factors

The biggest problem is the aging of the population also caused by a very high standard of living. Despite this, many studies indicate a low level of happiness and satisfaction with life among Japanese people compared to most of the world, in fact the suicide rate in Japan is the highest among the first world countries. Shintoism and Buddhism are two major religions while the major language is Japanese which is spoken by around 99% of the country's population. As previously mentioned, many people in Japan prefer Japanese companies to foreign ones. This makes trading difficult for foreign companies which often fail.

3.2.6 Technological factors

In addition to the United States and China, the third pole that could lead the fourth industrial revolution is Japan. It is one of the most technologically advanced states in the world, and this is mainly due to Prime Minister Shinzo Abe who is generating investment in innovation with his programs. The demographic decline, the increase in the average age of the population and the low unemployment rate give the government the possibility to implement new technologies easily. Japan is one of the most advanced countries in robotics and automation systems, particularly used in hospitals, airports, and restaurants. In addition, the lack of restrictive laws on personal data makes it possible to connect to WI-FI virtually anywhere in populated areas.

3.3 South Korea

South Korea, also known as the Republic of Korea, with its 51 million inhabitants is the 20th most densely populated country in the world, and its total area covers 100.221 km^2. South Korea is a semi-presidential multi-party democracy. The President of the Republic, elected directly by the citizens for five years and not eligible for re-election, appoints the Prime Minister and the ministers who will compose the executive cabinet; he is the Supreme Leader of the Korean Defence Army. South Korea is administratively divided into one special city, six metropolitan cities and nine provinces, one of which has a special statute. The capital is Seoul, with more than 10 million inhabitants in the metropolitan area is one of the most populated cities in the world, is the most important political, cultural, social and economic center of the state. In fact, the main multinationals are based here and therefore represents one of the strongest economies in the world. Due to its geographical position and the characteristics of its production system, South Korea is a logistic and technological hub of significant strategic importance. The main sectors that have made South Korea an economic power are mainly transport and digital media.

In order to have a more in-depth analysis of the macro environment it is necessary to see the factors that most impact the market, as done for China and Japan.

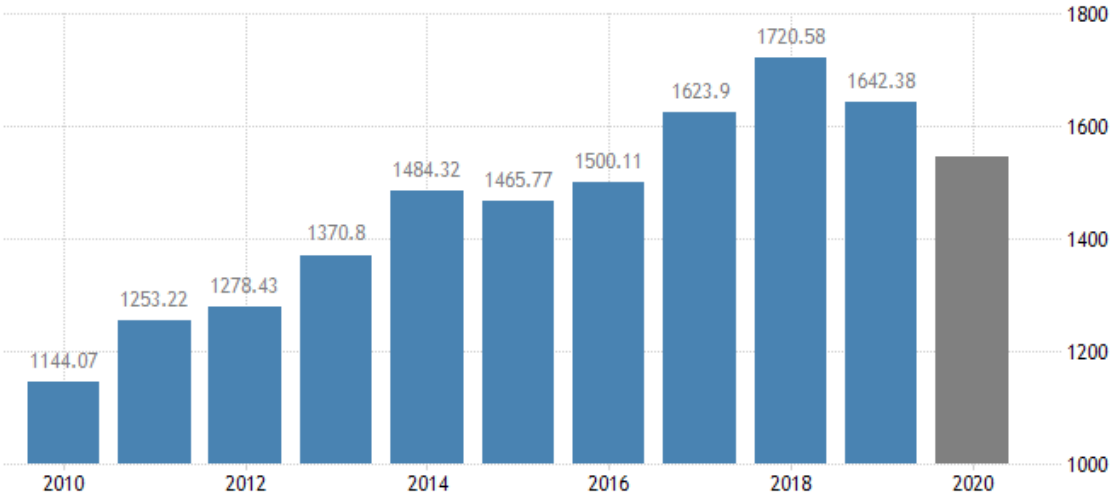


Figure 3.5: The Gross Domestic Product in South Korea according to official data from the World Bank and projections from Trading Economics. Source: TradingEconomics.com | World Bank

3.3.1 Demographic factors

The population density is one of the highest in the world, at about 513.6 people per square kilometer. More than 80% of South Korea's population lives in urban areas, such as Seoul and Busan, with a very high concentration in the capital area. This is a consequence of the rapid industrialization and urbanization of the nation in the 1960s and 1970s. The population is composed of 97.3% Koreans, the foreigners present are mainly Chinese (1.4%); 46% of the inhabitants do not profess any faith, 29% are Christian, 23% Buddhist. In recent years, a gradual aging of the population is underway, resulting from a chronically low birth rate, and the average age has risen to 42.1 years. In fact, fifty-year-olds represent the most numerous age group. The unemployment rate in October reached 4.2%, considering that the year before it had reached 3.5%.

3.3.2 Natural factors

The government has taken various control measures in urban areas and is promoting environmental education in schools and business communities. However, South Korea's high levels of emissions are a cause for concern. In fact, it is one of Asia's largest producers of SO2, which is the main substance that brings acid rain. In addition, South Korea is bordering China, so part of the climate is affected by China's pollution. During the period of industrialization, in the 70's, the main concern was to become an economic power. When the goal was reached, plans changed and in recent years the South Korean government has passed numerous environmental laws, of which include restrictions on both green belts and emission that have dramatically improved Seoul's air quality. Government policies and directives on environmental development have led to the formation of national ecological parks and environmentally friendly technologies.

3.3.3 Political factors

South Korean political past is quite turbulent. The order of the state went from the sovereignty of Japan (in 1910) to being later occupied by U.S. troops in 1945. Only in 1948 it became independent and in 1950 war broke out with North Korea. The election of Roh Tae-woo as president in 1987 marked the beginning of the process of democratization of the institutions. The Korean peninsula

remains one of the longest and most volatile conflict zones in the world. In 1988 Korea became a democracy, a change that gave the country a strong socio-political stability, so much so that in 1997 it became an OECD country. In South Korea, the president plays a key role in both the economy and politics of the country. The president is the head of state, head of government and head of the armed forces. Because of the centralization of power in the hands of the president, he must regulate and resolve all administrative matters. In 2017, President Moon Jae-in came to power. In recent years, his government is promoting support for small and medium-sized enterprises (SMEs) to bridge the gap between them and the big giants of the economy. In fact, he has tried to increase wages to the lower social classes, expand public spending and fight against the power of the chaebols (large industrial conglomerates) on which the South Korean economy has been based for decades. In fact, exports account for about 43% of GDP and the ten largest chaebols in the country alone account for 44.2% of GDP. Thanks to the results achieved over the last forty years in the economic and commercial field, South Korea has resolutely implemented an action aimed at giving the country a greater role on the international scene.

3.3.4 Economic factors

South Korea is named one of the "four Asian tigers" due to its rapid economic rise in the world market. Development and economic growth have been improving for years and it is also a leader in the electronics, biotechnology, renewable energy, robotics, ITC, automotive and semiconductor manufacturing industries. An important factor behind the development process has been the long-term planning process, a macroeconomic policy, but also an industrial policy that creates the optimal conditions for companies to introduce innovations. In fact, in the period between 2005 and 2010 research and development expenditure increased by 10% per year.

3.3.5 Social-cultural factors

In South Korea, compared to neighboring countries, salaries are higher and can claim a well-educated and technically highly qualified workforce. High salaries mean more people willing to enter the sector and therefore a continuous production together with a continuous demand. A rapid industrialization led a large number of people to move from the more rural to the more urbanized areas, this increase led to the concentration of economic activities especially in the metropolitan area of Seoul. A significant challenge facing South Korea is the low fertility ratio and the continuous aging of the population. The ageing is mainly due to the low fertility ratio and the high number of divorces. As far as the nation's social welfare is concerned, expenses continue to be low and about 14% of the population over sixty-five years old received a pension in 2004, compared to 60-70% in the advanced European countries.

3.3.6 Technological factors

South Korea is the most wired country in the world in terms of communications and internet facilities. Thanks to its highly educated workforce and well-equipped facilities, the country is a favored destination for R&D. The driving forces behind South Korea's economic growth are its world-leading industries that act as powerful attractors for foreign investors. South Korea is the sixth largest automobile manufacturer in the world and ranks first in DRAM semiconductor and LCD production. One of the problems of this country is that being mostly covered by mountains, there are few natural resources, and it becomes necessary to import useful materials for the industries. Rising salaries and the tightening of labor laws have increased the cost of maintaining R&D centers, paving the way for countries such as China and India that require fewer costs for the same productivity.

3.4 New scenarios

Despite the cultural differences and political tensions that began with the Second World War, especially between China and Japan, November 2020 opens up new scenarios for the Asian market. In fact, the trade agreement announced by the leaders of 15 Asian countries, led by China but pulling in giants like Japan and South Korea, will have the potential to add 186 billion dollars to the global economy and an effect of 0.2% of GDP on its members. Thanks to the Regional Comprehensive Economic Partnership (Rcep), the Asia-Pacific region could take global leadership in the post-Covid-19 recovery and reduce US hegemony in the region: agreement has been defined by Chinese Prime Minister Li Keqiang as "a victory for multilateralism and free trade".

Chapter 4

Microscopic analysis of the Asian area

The microenvironment consists of the actors close to the company that influence its ability to serve its customers. To have a successful marketing strategy it is useful to build strong relationships with other departments of the company, marketing intermediaries, customers, who combine to build the company's value delivery network. This chapter will deal in particular with the automotive market in the Asian area, as this sector represents an important business for fleXstructures.

4.1 The company

In designing marketing plans it is important that the marketing manager interacts between the different company departments. With the vision of marketing plans taking the lead in a transversal way between all departments, it is in fact possible to create customer value and understand the customer needs on multiple levels. In case of fleXstructures, the marketing manager is able to effectively interact with those who have industrial experience, with the whole structure of the vendors, with the developers of the software, useful when there is the launch of a new version of the product to promote and position it in the correct way highlighting its added value, and with the CEO of the company. Marketing is the glue for all departments. In this case the interaction of the marketing between all the different divisions is transversal, transforming the company organigram in a matrix, since vertically there are the different divisions.

Next to the core business of the company, represented by the software selling, the additional services that the company provides are all aimed at customer's satisfaction and care, based on engineering services and IPS software trainings.

- Engineering services: customer-oriented engineering projects are conducted in the field of design, optimization and virtual validation, using the extensive features of the IPS product portfolio and the specific expertise of company's staff to support the customer in developing solutions customized to its particular use case. Depending on the task the company simulates or reconstructs customer's case, carries out causal research and troubleshooting, and offers it an optimized solution.

- IPS software trainings: the company regularly offers training courses and workshops for the application of IPS products. The training courses are ideal for beginners (IPS Basic Seminar) and experts (IPS Advanced Training).

4.2 Marketing intermediaries

As already mentioned in the chapter regarding marketing, marketing intermediaries help the company to promote, sell and distribute its products to the final buyer. Due to the vastness of the Asian market, it is difficult for a company located outside the continent to reach customers and provide services that create customer value. In its quest to create satisfactory customer relationships, the company must do more than just optimize its performance. It must work effectively with marketing intermediaries to optimize the performance of the entire system.

fleXstructures does not use a single business strategy while applies the best-selling strategy depending on the market needs, including cultural factors, as they count significantly. The parent company and the various business units work with customers in a direct way, sharing the world market. However, in some cases, such as form most of the Asian territory, they use local distributors, while in some other cases they use a hybrid system.

- **Territorial exclusivity**: it is granted only if the local distributor is able to manage the market of the entire territory, bringing increasing profits from year to year. In this case the parent company grants the exclusive license to a partner for a country or macro-area with the commitment to find and serve customers by providing engineering and software training services.
- **Customer exclusivity**: once the local distributor acquires a customer, it cannot be moved to another distributor. Also in this case the local distributor provides the same services provided by those with territorial exclusivity.
- **Sales concession**: in this case the company that obtains this concession has the possibility to sell the product to the customers found, but once the sale is completed, the customer is put in contact directly with fleXstructures for the provision of services regarding the software.
- **No concessions**: agents are used who are only concerned with finding the customer. Once the customer proves to be interested in the product, he is put in contact directly with fleXstructures which takes care of both the commercial and the technical part.
- **Hybrid solution**: this solution consists on the combination of local fleXstructures sales in combination with pre-sales and technical teams covered by local distributors who work closely with the company office.

4.3 Customers

In the microenvironment of a company, customers are the most important players, because without them a company could not survive. Therefore, it is important that the company divides the market into different customers since each type of customer market has its main characteristics that a seller must study carefully. In the case of fleXstructures most clients fall into the types of business markets and international markets, in the case of buyers from other countries such as China, Japan and South Korea. In the business markets we find companies that buy the product and services for further processing or use in their production processes.

The software developed and sold by fleXstructures is used in various industries such as: automotive, trucks and buses, off-road vehicles, motorcycle, railway, aerospace, electronics. Automotive is the most important sectors on which fleXstructures can count, also thanks to the new scenarios that are leading to more and more advanced electrification and autonomous driving. Ernst and Young noted that the Chinese market has become the "most important pillar" of the German automotive industry, as well as the global auto industry. China is now the largest automotive

market in the world. In fact, with 28 million vehicles sold each year, China represents almost a third of the world's automobile market. This is due to the rise of the middle class, due to rapid urbanization leading to higher incomes, and continued government incentives. In this context, the demand for cars as a means of mobility and a symbol of economic growth, but also as an expression of the desire for individuality and independence, is constantly growing.

Japan is also considered a colossus as it is the third largest market in the world after China and the United States, and the second largest car manufacturer after China (and before Germany), even if due to the Covid-19 issue the market has slowed down. The country is home to a number of companies that produce cars, construction vehicles, motorcycles, off-road vehicles and engines. The most important Japanese car manufacturers include Toyota, Honda, Daihatsu, Nissan, Suzuki, Mazda, Mitsubishi, Subaru, Isuzu, Kawasaki, Yamaha and Mitsuoka. And six of these are among the top twenty carmakers in the world. The automotive industry is worth over 450 billion euros, about 11% of gross domestic product. The sector has a total of 5.39 million employees - 8.3% of active workers - and represents 18.2% of the entire manufacturing sector of the nation. Japan is among the first in the world for investment in automotive research and development. Among the main objectives, the reduction of CO2 emissions and autonomous driving, in fact Japanese carmakers maintain leadership in the development of low environmental impact technologies (electric and hybrid propulsion engines). In recent years there has been a redefinition of the national panorama of two and four wheels within the borders of Japan. Several Japanese car manufacturers have, in fact, concluded joint ventures and, in some cases, original equipment manufacturing (OEM) agreements, on the basis of which a company produces models or components that are purchased by the partner company and marketed by it under its own brand, saving on investment capital and expanding economies of scale. This dynamic is reshaping the automotive sector, which seems to be reorganizing into three major groups: Toyota (with Daihatsu and Fuji), Nissan (with Mitsubishi, Mazda and Suzuki) and Honda.

South Korea is slightly behind in the ranking of car manufacturing countries compared to China and Japan and is only in seventh place. Considering that 61% of cars are produced in Asia, the market is divided as follows: 33% in China, 12% in Japan, 6% in India, 5% in South Korea. Among the most important brands we find the South Korean giant Hyundai - Kia, which in the first quarter of 2020 reached almost 9% share on the world market, surpassed only by the leader Toyota, the Volkswagen group and the Alliance Renault-Nissan-Mitsubishi, SsangYong and Daewoo, which today belongs to the American General Motors.

4.4 Competitors

A good benchmarking is useful for a company that wants to obtain strategic advantages due to the positioning and pricing of the product. The concept of marketing requires that a company provides greater customer value and satisfaction than its competitors. Each company should also consider its size and the industry's position compared to those of its competitors. The strategies used by large companies cannot always be used by small and medium-sized companies. IPS Cable Simulation by fleXstructures distinguishes itself from its competitors' products in different ways already mentioned in the chapter on IPS Cable Simulation, such as:

- Value proposition. Already described in the chapter dealing with the IPS Cable Simulation product.

- Costs. The price of the product, which is not one of the lowest in the market, is justified by the result obtained by using the product. It allows an effective time saving in the product development process with a proven ROI.

- Unicity. The product has an easy-to-use interface and allows a simulation of the cables in real time, with a very high confidence of the results thanks to the MeSOMICS.

IPS Cable Simulation's main competitors are mainly:

- Commercial products similar in concept to IPS Cable, able to simulate the physical behaviour of the flexibles. The diffentiator in this case is the real-time easy-to-use functionality.
- CAD products. In this case there are a number of problems associated to the usage of CAD programs simulating flexible cables, such as:
  - Huge differences between CAD design and real cables;
  - Gravity not considered;
  - Cable not following motions;
  - Routing uses simple approach.

  All this can lead to:
  - Wrong installation, such as cables which cannot be installed inside the vehicle.
  - Contacts not included in CAD design which may lead to cable damage once installed.
  - Many iterations on physical prototype, which means additional costs and resources at each iteration.

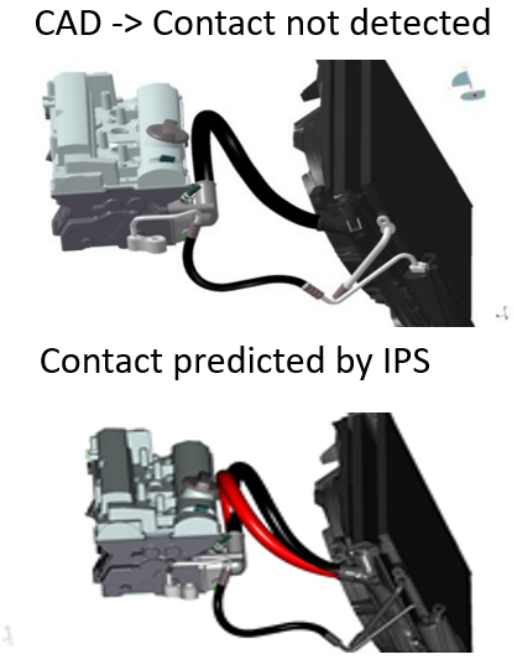


Figure 4.1: Changing processes by digital validation of flexible parts using IPS Cable Simulation instead of CAD

Chapter 5

Deliverables

This chapter will consider the creation of useful marketing materials for the Asian market. The tools that have been used are IPS Cable Simulation and Catia V5. From the organizational point of view, in the course of the work, periodic contacts were made with the Marketing Manager of fleXstructures Germany, the Managing Director and the Application Engineer of fleXstructures Italia. At the completion of the work, demo material was created and will be used by the company as IPS Cable Simulation software features presentations to customers.

5.1 Marketing materials

Every year fleXstructures holds several meetings with its local distributors. These meetings aim to find out how better penetrate the market where the distributor operates, and to analyse the IPS market and its potential and development year after year. After the last meeting between fleXstructures and the local Asian distributors, more precisely in China, Japan and South Korea, the need for demo material and show cases is emerged in the areas of:

- automotive;
- motorcycle;
- raillway;
- off-road.

The required material was prepared mainly using the IPS Cable Simulation software, while in some cases, such as for the off-road and motorcycle sectors, the Catia V5 program was used too, to create kinematics mechanism useful for the study of the cables.

5.2 Automotive

Car is progressively migrating its meaning and customer usage thinking of new paradigms of electrification and autonomous driving. These new concepts represent a real revolution in the automotive industry. These are also the most challenging trends which automotive engineers are facing today during all development phases, from designing to manufacturing, keeping constraints on green technology, and continuously compressing the required time-to-market.

5.2.1 Show cases

The automotive industry is among one of the most complicated in cable management. Typical mean length of the total wires and wiring harnesses cables mounted in a car is about 3.5 km (see Figure5.1), which gives an idea about the complexity and the difficulty in designing properly such fundamental components.
Between all possible subsystems, it has been decided to concentrate on the powertrain interface, as it includes all different types of cables, tubes, hoses and grommets, that must undergo pressures, high temperatures, vibrations, stress, etc.

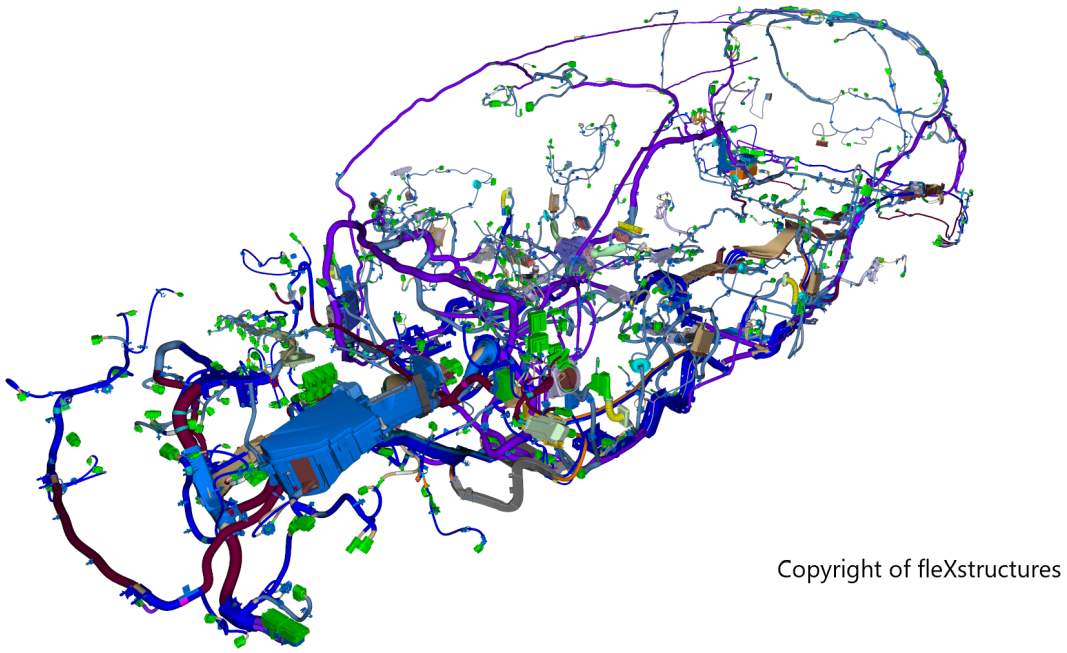


Figure 5.1: Flexibles Volvo XC-90-5

5.2.2 Demo material

Typical problems involving hose cables are several and can be summarized as follows:

- ideal cable length;
- minimal bending radius;
- collision-free to surrounding parts;
- enough designed space;
- different clamping or guiding clips which can affect the behavoiur of the hoses.

All these issues have been solved with efficient usage of IPS Cable Simulation from fleXstructures' customers.
These issues were conidered and solved during the internship as well. The result led to the creation of demo material explaining the effects in using any 3D CAD tools instead of an efficient usage of

IPS Cable Simulation.

Without IPS Cable Simulation:

- Huge differences between CAD design and real cables;
- Gravity not considered;
- Cable not following motions;
- Routing uses simple approach;
- Wrong installation –> cables can not be installed;
- Contact –> damage of cables;
- Many iterations on physical prototype.

With IPS Cable Simulation:

- Digital validation of flexible structures;
- Reduction of prototypes saving time and cost;
- First time realistic results in short time (interactive);
- Helps engineers to find best design;
- Cable configurations change in seconds;
- Analysis of motions (moving parts) and virtual assembly;
- Raises Product quality and reduces warranty cost.

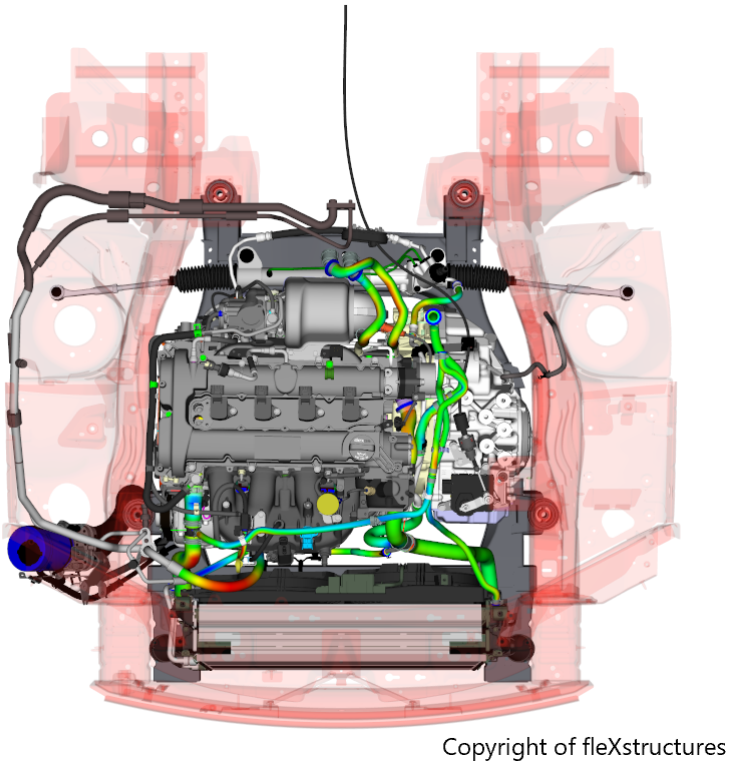


Figure 5.2: Engine.

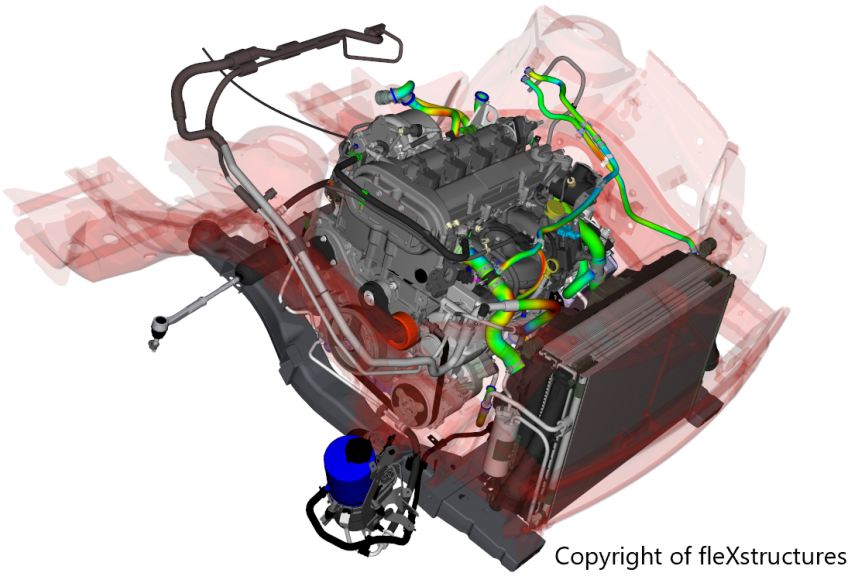


Figure 5.3: Engine from another point of view.

5.3 Motorcycle

Motorcycle stands for freedom of mobility and real driving pleasure. Motorcycle also means speed performance and engine sounds. Continuously increased performance and achievements of required level of safety are the challenges which motorcycle engineers are currently facing. Moreover, advanced driver assistance systems and electrification are topics which engineers have to consider these days during all development phases, from designing to manufacturing, to keeping the constraints on green technology and to continuously compressing time-to-market.

5.3.1 Show cases

Another interesting market to consider, as many fleXstructures' customers belongs to it, is the motorcycle. Motorcycle is progressively increasing its complexity and flexibles are increasing as well, even considering electrification starts to appear in this field, too.
Finding useful material for the motorcycle is not very easy due to the strictly confidential material with fleXstructures' client companies. It has been then decided to purchase from CGTrader site (https://www.cgtrader.com/) one of the available models, and in particular the 2018 Honda CBR500R. 3D model of the motorbike was then used to create marketing material to showcase the potential of IPS Cable Simulation for this industry as well.

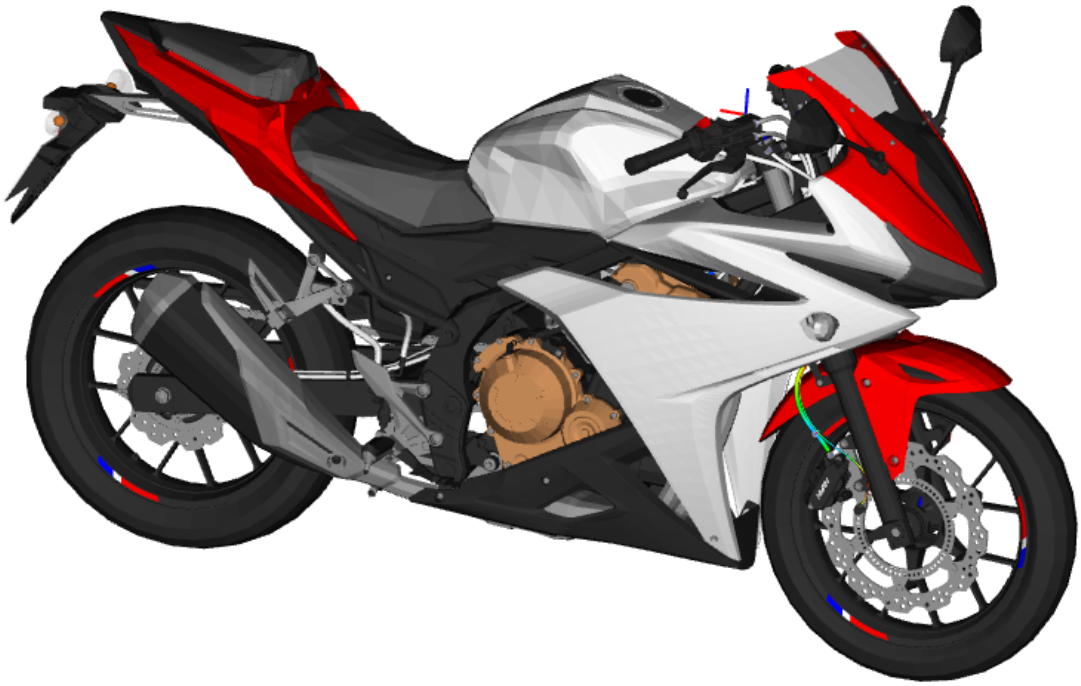


Figure 5.4: Honda CBR 500 R.

5.3.2 Demo material

Main challenges coming from the design of new models are due to:

- throttle cable;
- clutch cable/hose;
- brake cable/hose;
- fuel hoses;
- seat lock cable.

Among all these cases the brake cable was chosen to analyze in IPS Cable Simulation. Typical problems of such cable are frequent contacts and rubbing against other parts, and the continuous modification of positions and shapes to manage the angle and displacement of the suspension, which may bring to wear of the cable or concentrated high stresses in local parts of the cables.
Specifically, in the Honda CBR 500R model, the cable path issue has been solved as follows. As

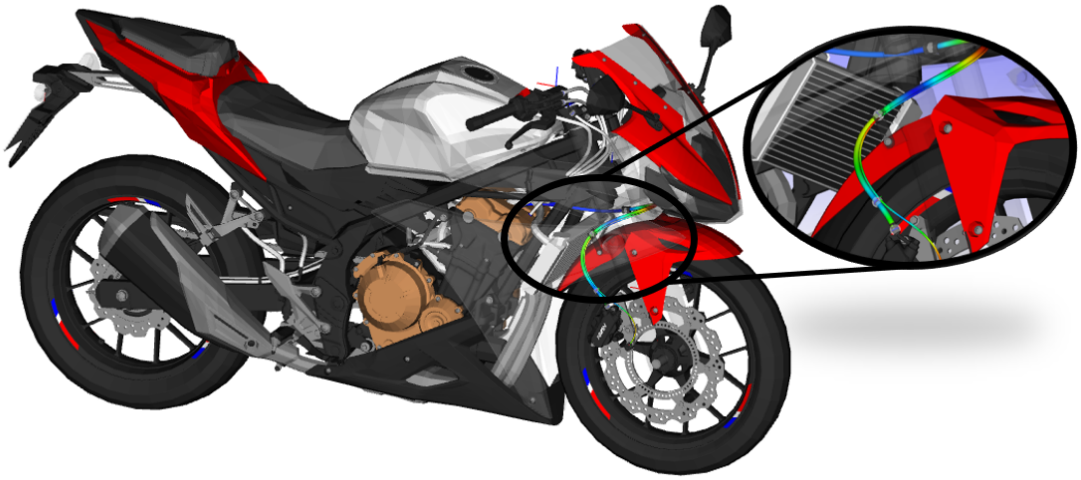


Figure 5.5: Zoom in on the brake cable.

you can see from the figs. 5.6 and 5.7 though, the cable takes on a U-shape that is accentuated during the displacement of the suspension. This is a problem due to the continuous bending of the cable.
A kinematic was created to study the dynamics of the cable. The kinematic was created with Catia following the steps summarized in Appendix A. The kinematics involves respectively the rotation of the handlebars simulating a cornering and the compression displacement of the suspension simulating the crossing of a bump-stop.

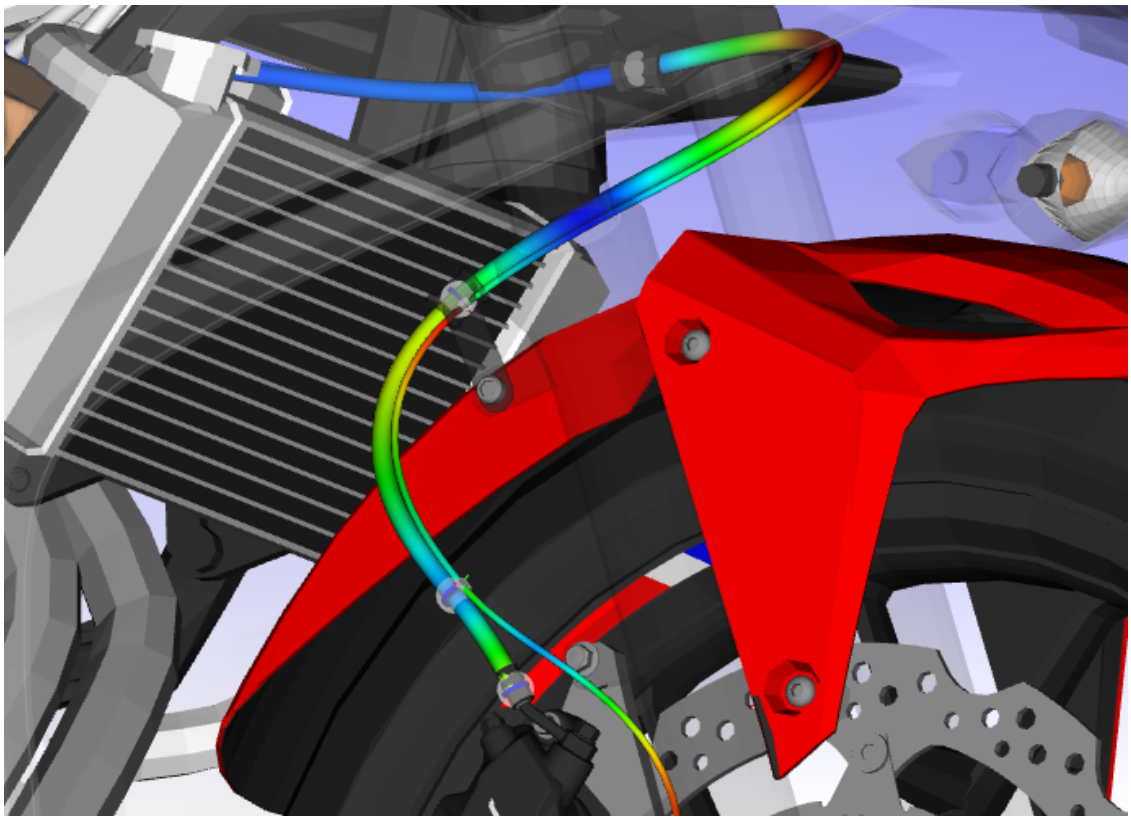


Figure 5.6: Brake hose.

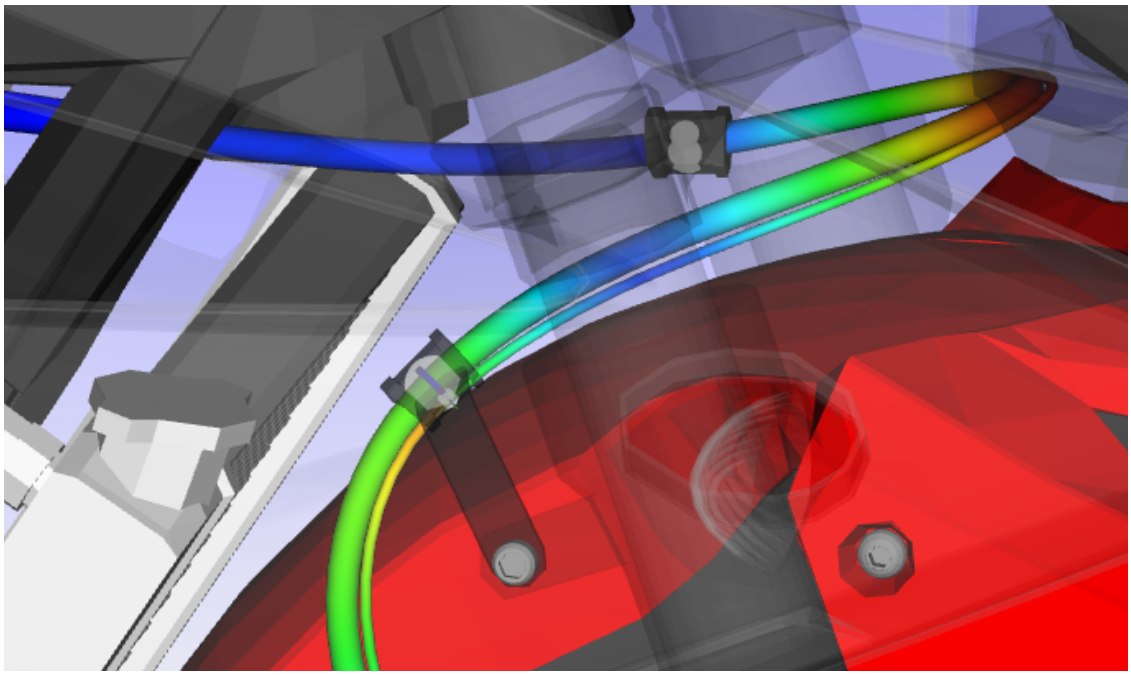


Figure 5.7: Brake hose.

Without IPS Cable Simulation:

- check the cable routings roughly by CAD system;
- actual shape is different from model shape;
- confirm the routings in detail at prototype stage –> physical validation;
- risk of significance costs due to late design changes.

With IPS Cable Simulation:

- the simulation can reproduct the actual behaviour;
- the simulation can reproduct hose deformation;
- optimization in real time of the cable shape and position;
- the time to examine wiring designis reduced to one third.

5.4 Railway

Passengers usually consider railway as mobility with enough time for relaxing or working, especially for long-distance travel. However, the revolution today is the long-distance travel in a short time. Producing trains for long distance travel within the shortest time with the highest safety is always the challenge of railway industry. Especially the next Maglev generation, the Hyperloop, which travels “under vacuum”. This means, the trains will travel with airplane’s speed due to a combination of magnets placed on the outside of the train and on the walls of the tunnel. The challenge is to continuously increase the transportation speed in full safety with very complex technologies and to extremely shorten return of investment time.

The customers' support in designing trains is important for fleXstructures, which match with the infrastructure (e.g. using all available space, matching with platform height or length, with safety equipment and with depot equipment). Besides that, the trains reach diverging requirements in different countries for different customers (e.g. national standards or specific service requirements). Early integrating the IPS product portfolio into the product development process allows to make quick and cost-effective modifications and optimizations.

5.4.1 Show cases

The model chosen for the railway sector is the one shown in the figure 5.8, purchased from the CGTrader website (https://www.cgtrader.com/). The technical challenges in railway are several and can be related to factors both external and internal to the railway company itself. For example, the iterative updating of industrial design simulation technology and the development of competition in the industry itself are among the external factors that most concern this sector. Users demand increasingly advanced design simulation reports as there are no flexible and reliable simulation tools for the pipeline. The high cost and long cycle times for physical verification are among the factors that most affect the railway industry.

Figure 5.8: Railway model

5.4.2 Demo material

Main technical issues identified by constructors are the following:

- **Bogie harness:** the problems are caused by minimum dynamic play, maximum traction force and minimum bending radius.

- **Vehicle and jumper cable:** the current design of the locomotive connecting cable focuses only on the structure and position of the joint, and there is no detailed and reliable design tool for the cable.

- **Brake hose:** as the brake lines of locomotives are connected by a rigid connector in the centre, the quality of the central connector cannot be taken into account in the design process, with the result that the brake line phenomenon is pulled and interferes in real vehicles.

- **Axle end ground wire:** the axle end ground wire is divided into two parts, which are attached to the subframe cable clamp, the bogie frame cable clamp and the axle end grounding device. Under complex conditions of line operation, relative movements occur between the three, resulting in very risky and unpredictable dynamic behaviour of the cable, which is usually verified in a physical bench by means of "experience + test".

The possibility of testing the dynamic and static behaviour of cables gives the railway sector a big advantage over the past. The introduction of IPS Cable Simulation provides a design basis for the static and dynamic design of connecting cables, with possibility to finally have a control on the risk caused by the dynamic of the system. Among the cases just mentioned, the case of vehicle and jumper cable was examined in detail. The model chosen, through a kinematic motion, allowed the creation and optimisation of cables connecting two wagons through a study of them both statically and dynamically. In comparison with the other models, the kinematic movement of the railway model was created entirely in IPS Cable Simulation, i.e. without the use of external software. In the following figures it is possible to see the positioning of the cables from different views.

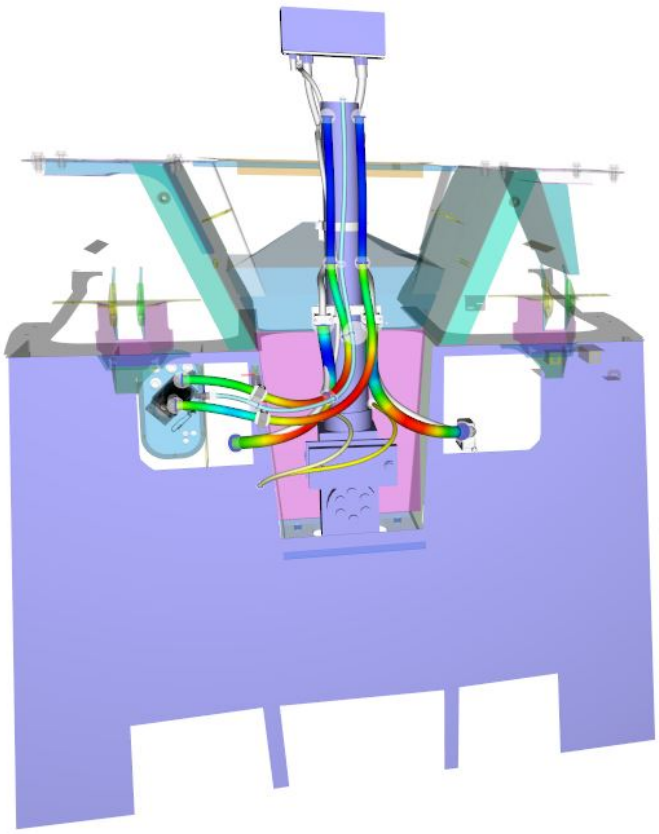


Figure 5.9: Railway model

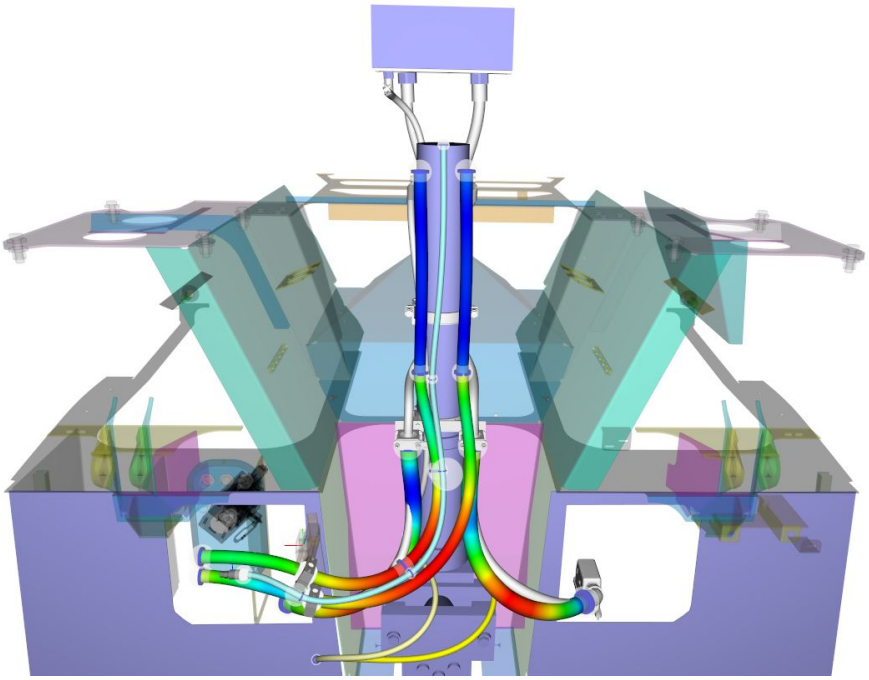


Figure 5.10: Railway model

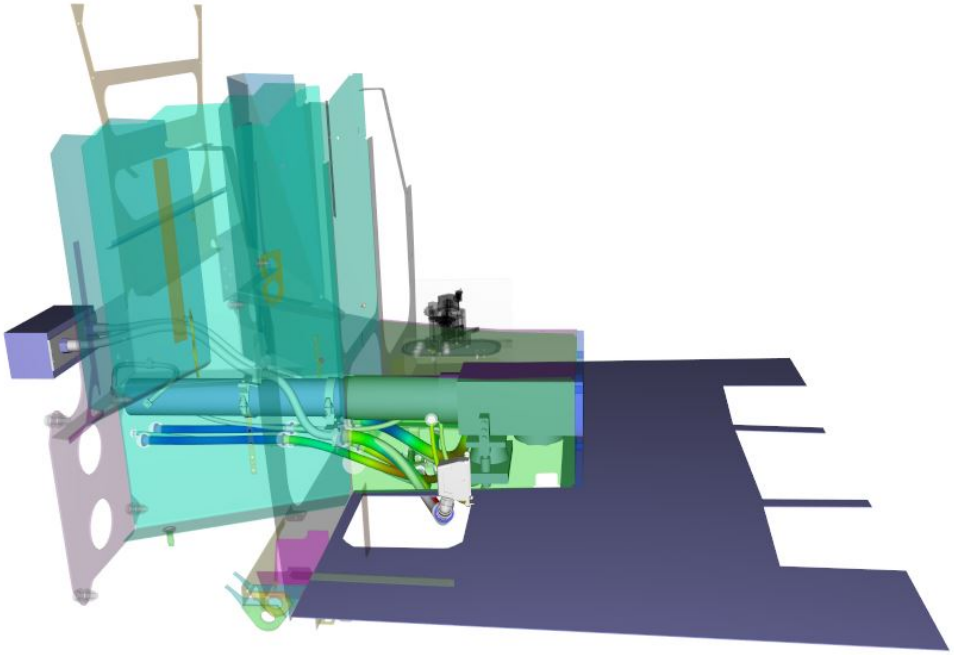


Figure 5.11: Railway model

Without IPS Cable Simulation:

- The pipe line are rigid bodies, and their flexible deformation cannot be simulated.
- It is impossible to consider the actual material characteristics and gravity of the pipe and line.
- No force analysis can be performed.

With IPS Cable Simulation:

- Pipes lines are flexible bodies, and their flexible deformation can be simulated in real time.
- The material characteristics of different pipes and lines are considered, even with the effect of the gravity, making them consistent with the real load shape.
- It can carry out the interference, bending and torsion and force and other parameters of the calculation.

5.5 Off-road

Tractors and excavators are heavy-duty vehicles with a high fuel consumption due to heavy loads. Drivers of these vehicles need to feel very comfortable to succeed in working continuously. Autonomously driving off-road vehicles with reducing CO2 emissions change completely the mission of off-road vehicles. The off-road vehicles shall be able to work around the clock 24/7, while the driver will be sitting in a separate control room. This is the assignment engineers are trying to achieve these days to fully satisfy the demands of off-road market. To meet the requests made by local distributors, three models were considered to best represent the Off-roads industry.

5.5.1 Show cases

The following models have been chosen for demonstration purposes and include:

- Hitachi ZX200;
- Hitachi ZW550.

These three models were purchased through CGTrader site (https://www.cgtrader.com/). By using the PTC CREO CAD program those files have been converted from .OBJ files into .PVZ files. Thanks to this conversion, it was possible starting working on IPS Cable Simulation. In this phase the joints were correctly positioned, the model was splitted into different rigid bodies, and finally the .CGR files was extracted from IPS Cable Simulation. Those files were useful to create the kinematics mechanism in Catia V5 programm, used to understand the volume occupied by each rigid body. In fact, the imported CGRs are seen by the program as "dead geometry", therefore a pure representation is not usable for geometry creation or joint definition. To create the entire kinematic mechanism, considering for example the model ZX200 and ZW550, it was useful to create the arm skeleton with the respective axes of rotation and cylindricity. Then, it was imported the CGR files, which were useful for space occupation as mentioned before, and finally created the kinematic motion. This motion was exported as an HTML file and then imported into IPS Cable Simulation. After the colouring phase of the model in all its parts, main cables have been made flexible to show the potential of the software. All these passages were done for the three models and this has led to the creation of three demonstration models useful for marketing purposes.

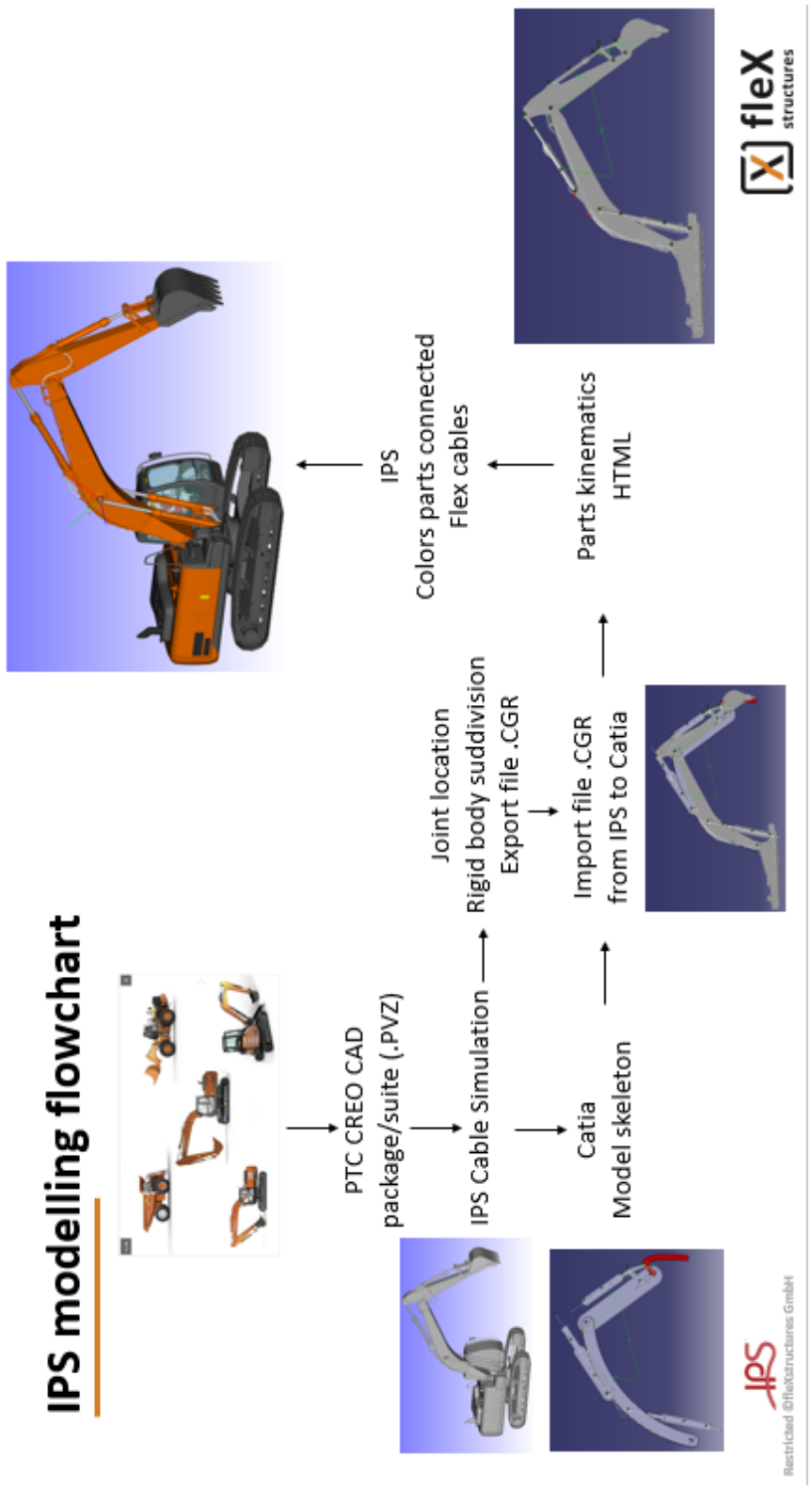


Figure 5.12: Modelling flowchart of Hitachi ZX200

Step by step explanation on how to create a kinematic motion in Catia V5 has been collected in Appendix A.

For each model, show cases were created considering the typical working maneuvers of the single off-road model, which have been defined through some research carried out between off-roads customers. Kinematic movements were then created for the ZX200 and ZW550 models that allowed the optimization of all the cables present. The main maneuvers of the hydraulic excavator consist of:

- Excavations below the floor level;
- Fixed section excavations;
- Stripping excavations.

Figure 5.13: Excavator maneuvers

With respect to the main maneuvers of the wheel loader, it is effective in moving and excavating sections of soil at or above the floor level. In the following image it is possible to see how far the arm can reach.

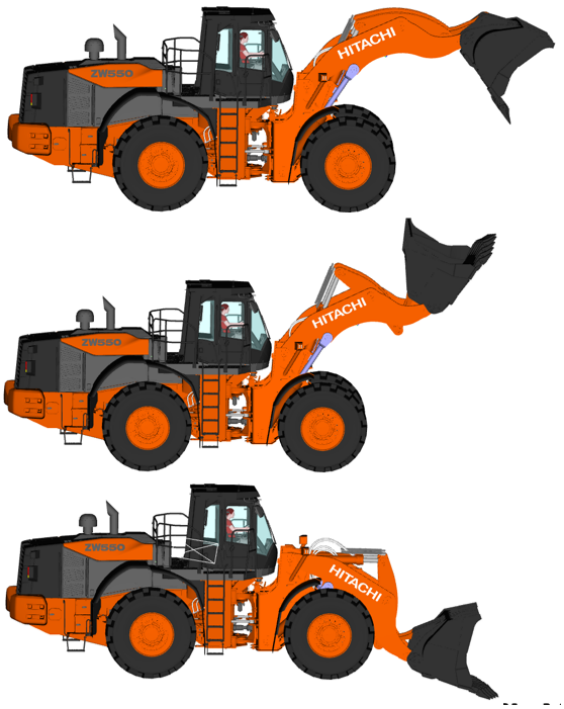


Figure 5.14: Wheel Loader maneuvers

5.5.2 Demo material

The creation of the kinematic motion of the two models ZX200 and ZW550 allowed to clearly observe some criticalities that can be solved thanks to the IPS Cable Simulation software. In fact, with usage of any 3D CAD model such criticalities cannot be found during the design phase, while they clearly pop up during the prototype development, such as cable handling without contact with vehicle parts. Having the possibility to predict potential issues still during the design phase represent a big advantage for the off-roads companies as it allows them to optimize the cable connections avoiding any troubleshooting problem in the prototype, which will then lead to enormous amount of time and costs to be solved. However, even in such last case, IPS Cable Simulation can be efficiently used to identify the best solution to solve the issue taking into account all the already-existing bounderies.

Hydraulic Excavator

With respect to the hydraulic excavator, several models have been analyzed and one of the most critical development areas is located at the base of the mechanical arm and pistons. In fact, there the cables undergo a greater flexion compared to other cables and are forced to move in narrow spaces with the possibility of interfering with other parts of the excavator. It is therefore very hard in these cases to design the best path for the cables without the support of a suitable software.

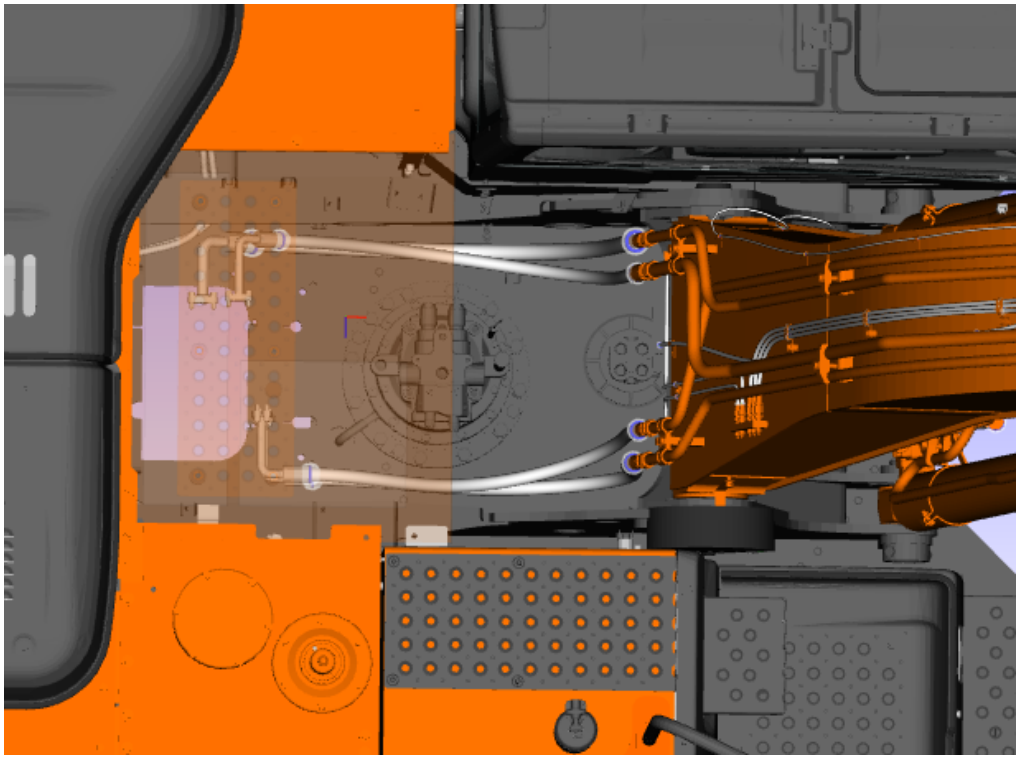


Figure 5.15: Cables at the arm's base of the Hitachi ZX200 model.

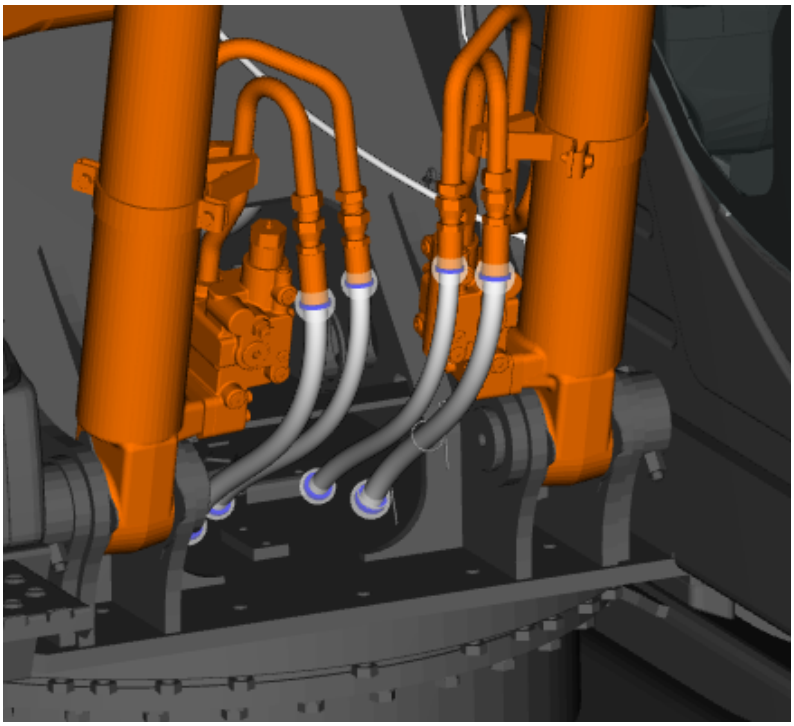


Figure 5.16: Cables at the pistons' base of the Hitachi ZX200 model.

Without IPS Cable Simulation:

- Path of actual vehicle and 3D CAD model are different;
- CAD-Based Virtual Design;
- Model shape is different from actual shape;
- Physical validation;
- Risk of significance costs due to late design changes.

With IPS Cable Simulation:

- The simulation can reproduct the actual behaviour;
- The simulation can reproduct hose deformation;
- Dynamic path simulation enables to check clearances or interferences;
- No dedicated hardware prototypes;
- First time correct routing with the influence of gravity and physical stiffness parameters;
- High-precision and collision-free cable design;
- First step before optimized hose.

Wheel loader

With respect to the wheel loader, a common problem detected is related to the hose which connects between rear frame side and front frame side. During the rotation of the front frame to the left side, the cables connectors assume a straight shape, and the problem appears during the rotation to the right because the hoses bend to a U-shape. Also, in this case the problem has been analyzed and optimized with usage of IPS Cable Simulation.

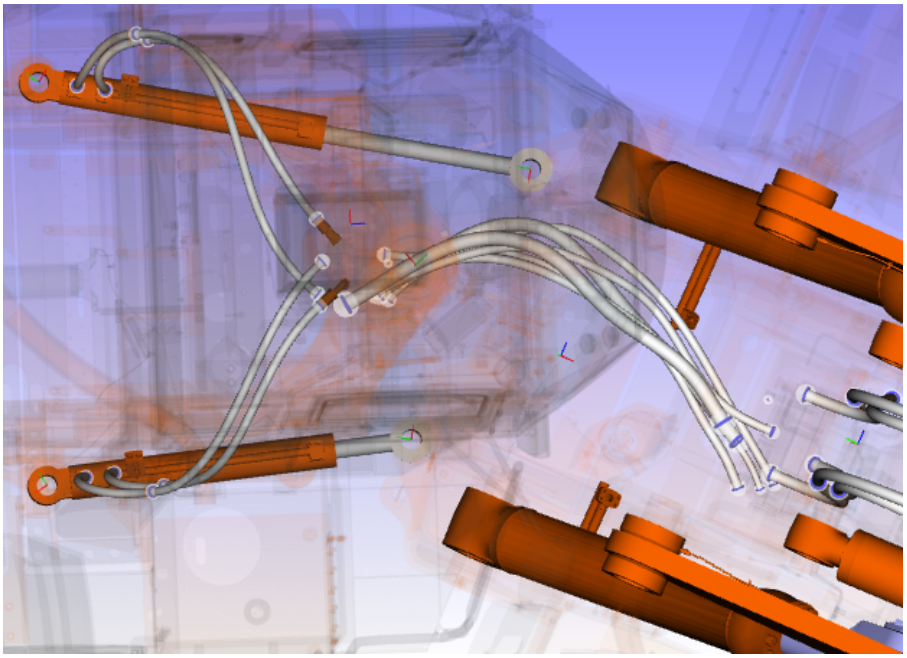


Figure 5.17: When the wheel loader turns to the right the hoses assume an U-shape.

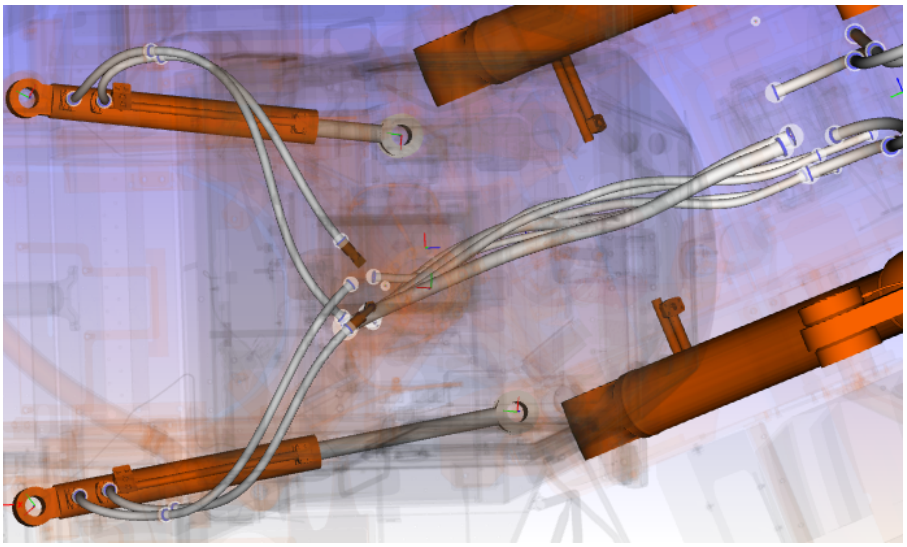


Figure 5.18: When the wheel loader turns to the left the hoses assume a straight shape.

Before IPS Cable Simulation:

- Difference between actual shape and simulation;
- Drop of the simulation hose is smaller than it of the actual hose
- CAD-Based Virtual Design;
- Model shape is different from actual shape;
- Physical validation;
- Simulation model doesn't down as much as the vehicle shapes so verification of simulation stiffness to match actual shapes is necessary;
- Risk of significant costs due to late design changes.

With IPS Cable Simulation:

- The simulation can reproduce the actual behaviour;
- The simulation can reproduce hose deformation;
- Dynamic path simulation enables to check clearances or interferences;
- No dedicated hardware prototypes;
- First time correct routing with the influence of gravity and physical stiffness parameters;
- High-precision and collision-free cable design;
- First step before optimized hose.

Conclusions

Chapter 5 highlighted the results of a study of the Asian market and its demands. The analysis of the marketing environment led to the discovery of several useful factors and trends to be taken into account for the business growth and market share of fleXstructures products into the Asian market.
For a marketing strategy, to be effective, it must be based on a deep knowledge of the market environment in which the company operates. The knowledge of the market environment allows the marketer to change and adopt new marketing strategies with simplicity, and above all to increase the company's profits. Hence, internal and external factors or forces which could directly or indirectly affect the income of a company.
In this context, a macro and a micro-analysis of the environment had been carried out in chapter 3 and 4 respectively. The first one allowed to better understand the strategies of fleXstructures within the Asian market, in order to recognize which economical, political, cultural and technological forces could be of impact. The second one allowed to better plan the marketing strategy that can be used to build profitable relationships with other departments of the company, suppliers, competitors, marketing intermediaries and publics. Which combined add value to the company's delivery channels.
The micro-analysis carried out on the Asian market and the strong exchange of information between fleXstructures and local distributors led to the development of demo materials and showcases useful for the expansion of the company in the Asian market. In fact, before the availability of such public marketing materials, unique available material came from customer application cases, which cannot be even show to other customers as strictly confidential. Moreover, main material available was in automotive field only, limiting a lot the marketing potential toward other market sectors, such as off-roads, motorcycle, railway.
The feedback received by the local Asian distributors for a better market penetration was internally checked and discussed in detail and as outcome it was decided what to concentrate and prioritize in order to further expand the market in the various countries of origin. In chapter five related deliverables have been made and provided, focusing on the automotive, motorcycle, railway and off-road markets. Over the period of this thesis all the IPS models required have been developed. The availability of such models allows fleXstructures not only to have access to showcases and demos without any confidentiality constraints, while even the possibility of their usage during training sessions to new customers.
As next step, all the models will be delivered also to the local Asian distributors during the next Distributor Meeting planned April 2021, to be finally used to enhance the expansion of IPS into the Asian market.

How to create a kinematic motion in Catia and import it into IPS

Introduction

Before reading the detailed instructions on using Catia V5, the following section is intended to give an idea of what it is possible to do with the product. It provides a detailed scenario and illustrates how to use the key functions. This manual is limited to providing the knowledge to create a kinematic motion in Catia V5 and export it correctly. It will be shown how to create a part in Catia V5, using the positions of the IPS Cable Simulation control frames for each rigid body for which a movement is to be created. And finally, how to create a product containing the individual parts, previously created, in order to assembly the entire body to move. This manual was born out of the need to create a movement of various CAD models purchased for marketing purposes. The following steps will be based on the Hitachi ZX200 CAD model, but can be extended to any CAD model.

IPS Cable Simulation

After dividing the CAD model into separated rigid bodies and positioning all control frames at the centres of rotation in IPS Cable Simulation, export of the rigid bodies in CGR format has been performed. These files are then used in Catia V5 to create the possible movement actions for the demo working model.

Catia V5

Create a part

Open Catia V5 and click on the **File button** –> **New... [Ctrl + N]**.

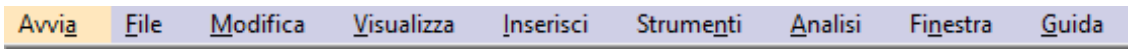


Figure 19

A window will open at the bottom right. Select in the **List of Types** –> **Part** and press **OK**.

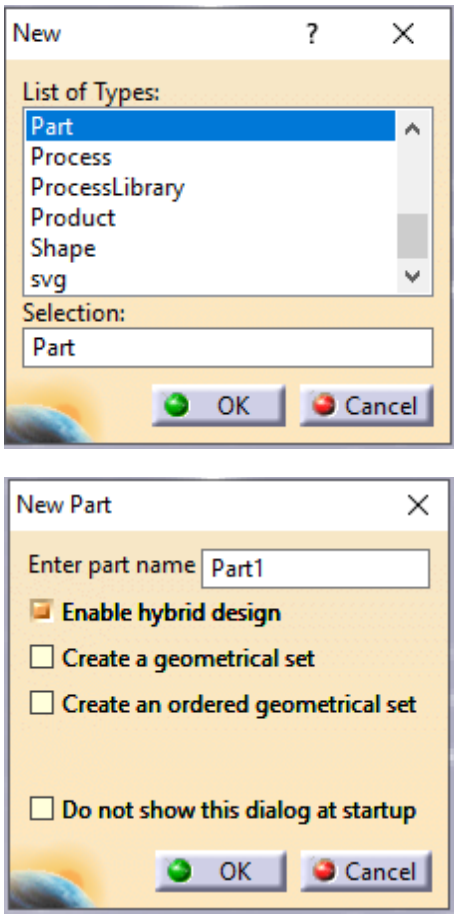


Figure 20

If the user wants to change the part name, he can change it in the **Enter part name** window and press **OK**. After the work window has opened, the work on the single parts can start. It is useful to work in Catia in the same plane as in IPS. Select the plane you want to work in at the top left on the scene tree.

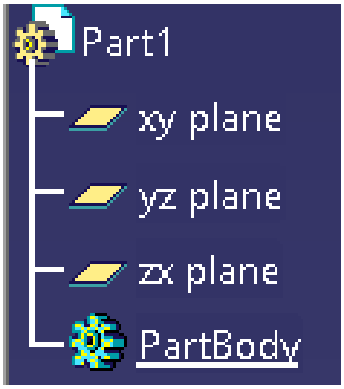


Figure 21

In the right bar, select the image with the pen on the sheet and click on the black arrow at the bottom right of the symbol and select **Positioned Sketch**.

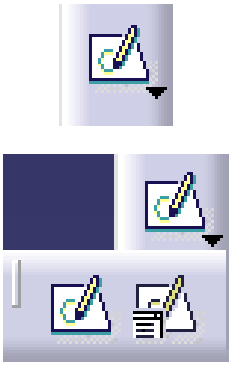


Figure 22

This path is useful because the H-axis has the opposite direction to the X-axis, so you can check the **Reverse H** box to position it in the same direction as X and press **OK**.

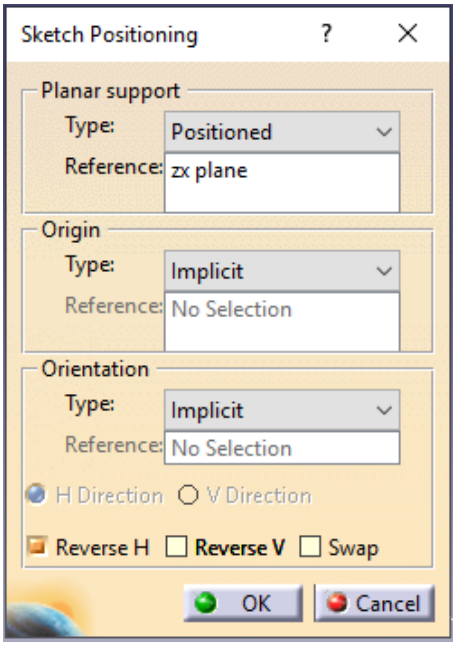
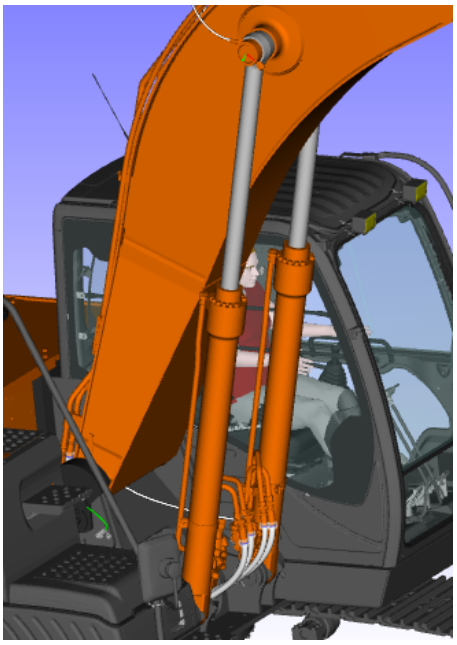


Figure 23

Taking into account the actuators at the base of the arm of the ZX200 model as an example, it can be seen there are two separate rigid bodies, connected by a kinematic motion of cylindricity to each other and a rotation at the base of the piston and at the end of the cylinder.



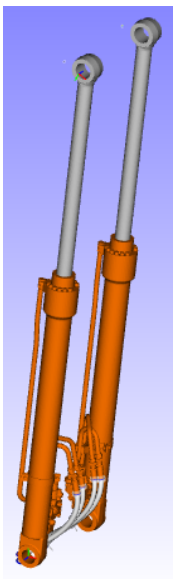


Figure 24

Obviously in Catia V5 it is necessary to create two different parts to create the whole piston system. To create the two parts of the piston it is useful to take the reference points that will then be used to create the kinematic mechanism; in this case the centre of rotation of the base and the point of contact between the outside of the piston and the incoming cylinder. After taking into account the coordinates of the two points in IPS, those can be drawn in Catia by selecting in the right toolbar the **Point by Clicking** button.

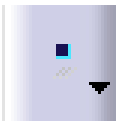


Figure 25

User can now click anywhere on the sheet to position the two points. Please note that the point must be positioned in line with the sign of the coordinates on IPS Cable Simulation. For example, if a point has a negative X-axis co-ordinate and a positive Z-axis co-ordinate, the point has to be located anywhere in the second quadrant, and so on.

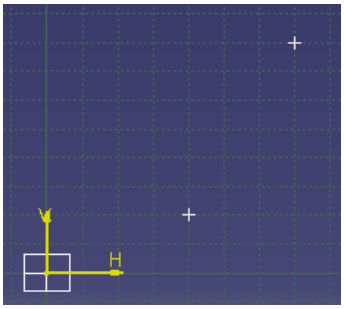


Figure 26

Select the **Constraint** button on the right-hand toolbar and select one of the two points, already positioned, and its axis on which you want to change the distance. Then double-click on the number that appears and change the co-ordinate to the correct one taken from IPS.

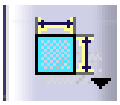


Figure 27

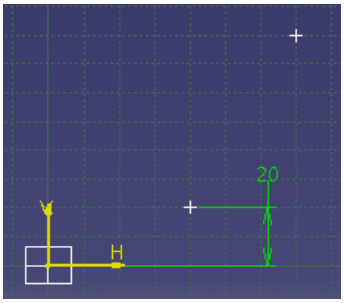


Figure 28

It is possible now to exit from the workbench by pressing the **Exit workbench** button.

Figure 29

If the kinematic mechanism for the piston has been constructed, next step is to create two axes, passing through the two points, for which there will be a rotation around the y-axis for the bottom one and a cylindricity, between the external piston and the incoming cylinder, for the top one. To construct the axis of rotation passing through the bottom point, select the **Line** button on the right toolbar.

Figure 30

The following window will then appear. Select on **Line type** the item **Point-Direction**, then select the relevant point (in this case the one at the bottom left), and finally under the item **Direction** click with the right button and select **Y Component**. To make the created axis visible, modify the length where the word **End** is written, activate **Mirrored extent** and give the **OK**. To create the axis that will allow the cylindricity of the two bodies, follow the same steps but select **Point-Point** under **Line type**, and select the two points on the worksheet.

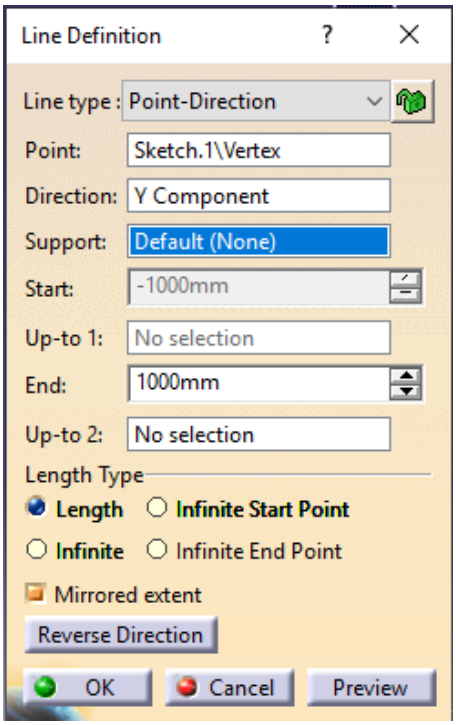


Figure 31

Save everything.

Create a product

Open a new worksheet, this time by choosing in the **List of Types** –> **Product**.

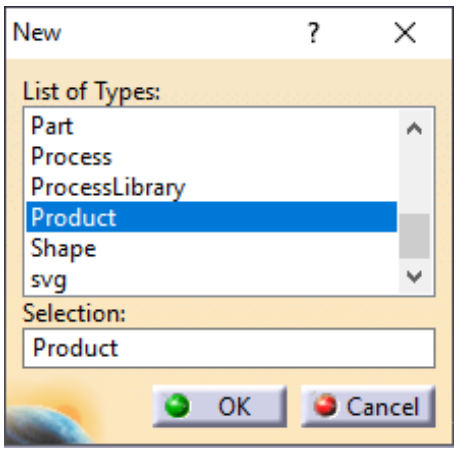


Figure 32

In the toolbar at the top left, select **Insert** –> **Existing Component...** . Import the previously saved created part and the CGR file exported from IPS Cable Simulation.

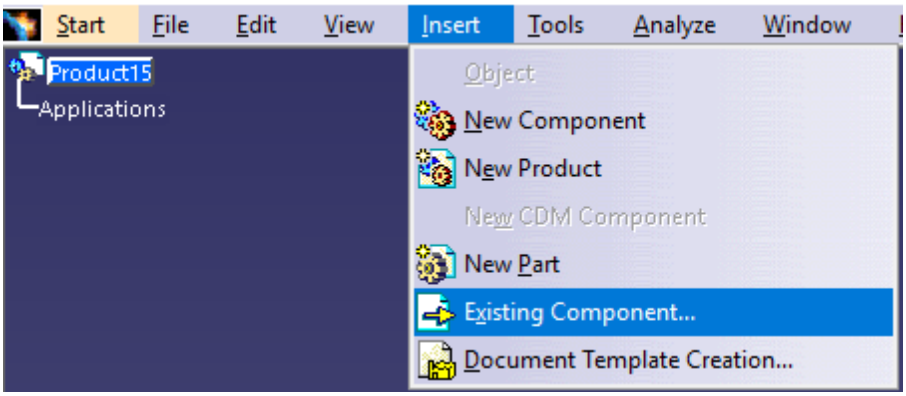


Figure 33

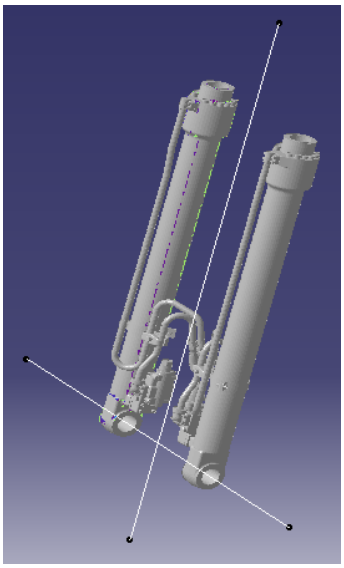


Figure 34

Save the product in the same folder as the part was created and proceed similarly for all existing rigid bodies.

When the axes for each rigid body have been created, import everything into a new Product file. It is now possible to create the kinematics for the whole body.

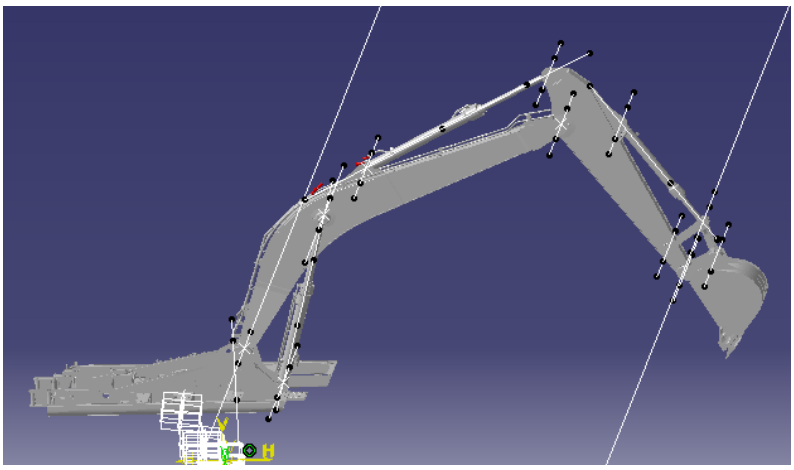


Figure 35

Create a kinematic motion

Select **Start** –> **Digital Mockup** –> **DMU Kinematics**.

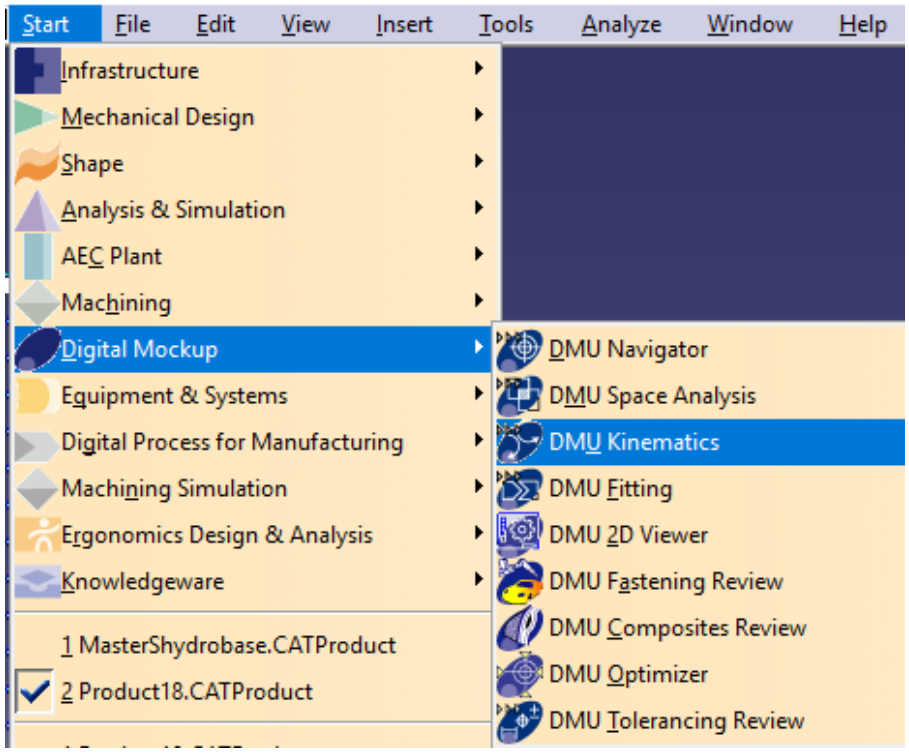


Figure 36

To create a revolute joint, click on the following image on the right-hand side of the worksheet.

Figure 37

To start it is necessary create a **New Mechanism**. Using the visible axes created before select:

- On **Line 1**: the axis around which the rigid body rotates.
- On **Line 2**: the axis that rotates.
- On **Plane 1**: the plane where the rotation inherent to the rigid body takes place (for example if the axis rotates around the Y axis, let choose the ZX plane), it must be taken in the same rigid body taken for **Line 1**.
- On **Plane 2**: the plane of the rigid body that rotates.

For all angles whose rotation is independent of the rotations of the other rigid bodies, select the **Angle driven** button.

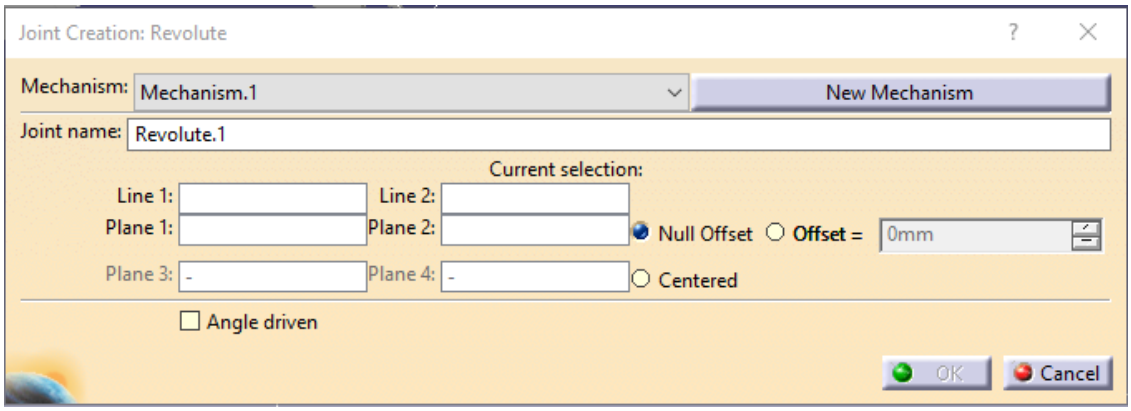


Figure 38

To create a **Cylindrical joint**, select the following button and then the axes of the two rigid bodies for which you want to create the movement.

Figure 39

Proceed in this way until all joints have been created. In order, to simulate the movement, it is still necessary to choose the fixed part of the rigid body. Select **Fixed Part** on the right-hand toolbar and select the body part that will remain fixed for the entire movement simulation.

Figure 40

A window should now appear saying *"It is possible to simulate the motion"*. Click on the following button to create a simulation, select the new mechanism created and click "OK".

Figure 41

It is now finally possible to create the simulation. The **Kinematics-Simulation** window allows the mechanisms to be moved using the different commands previously created. After setting the position for a rigid body, then moving the wheel between -360° +360°, it is possible to insert the position in the **Edit Simulation** window by clicking on **Insert**. Continue in this way until the entire movement has been created.

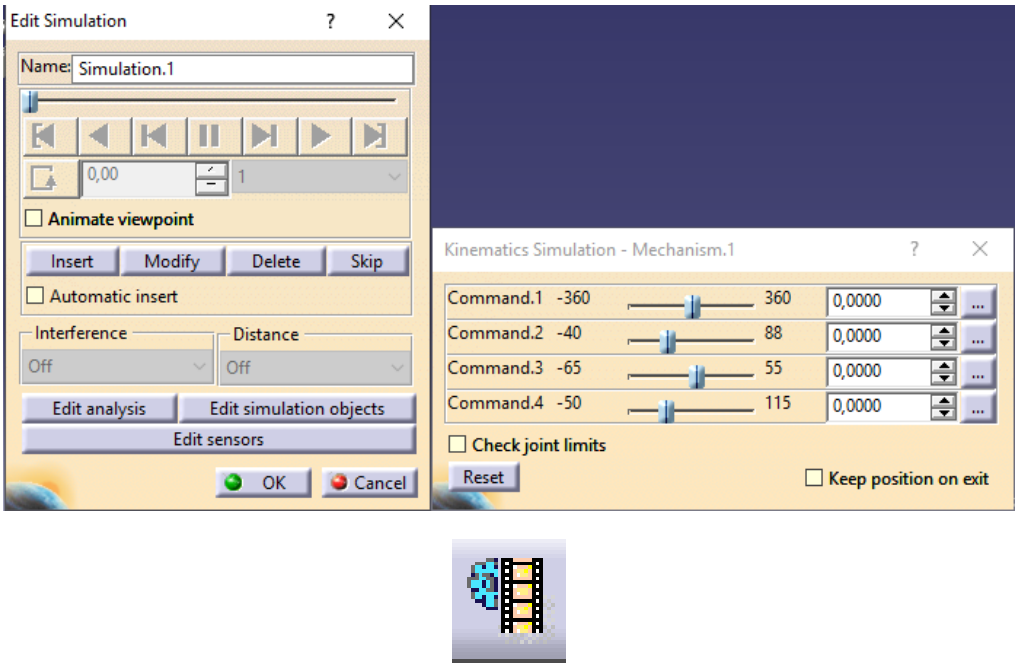


Figure 42

To record the entire movement, select the **Compile Simulation** button. Choose the simulation you have just created and in the **Time step** box select the smallest number (0.01) and click on "OK".

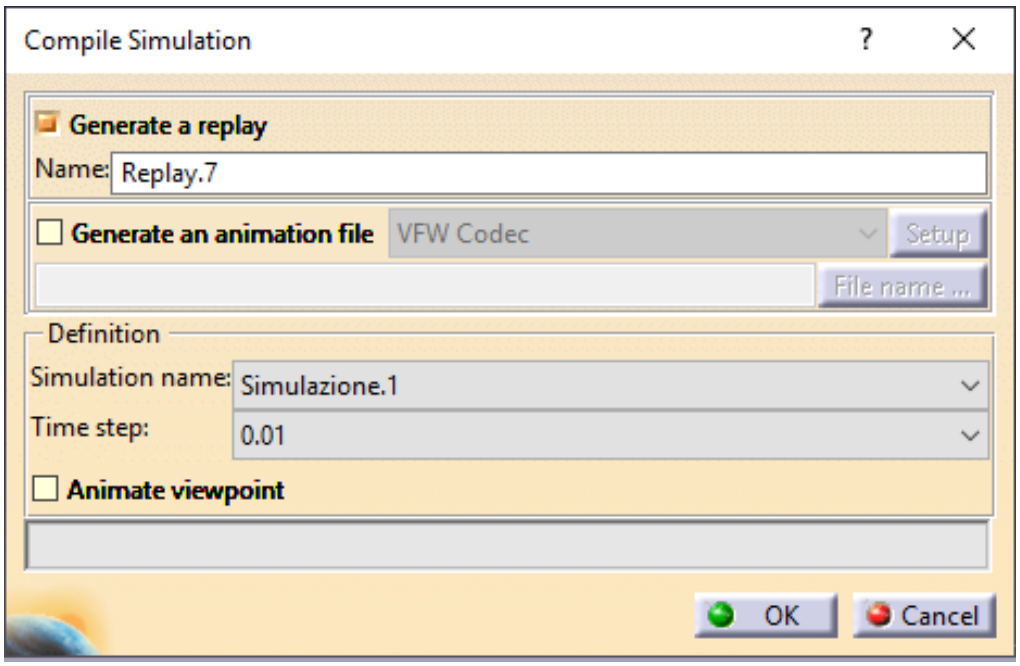


Figure 43

To save the simulation select **Tools** –> **Publish** –> **Start Publish**.

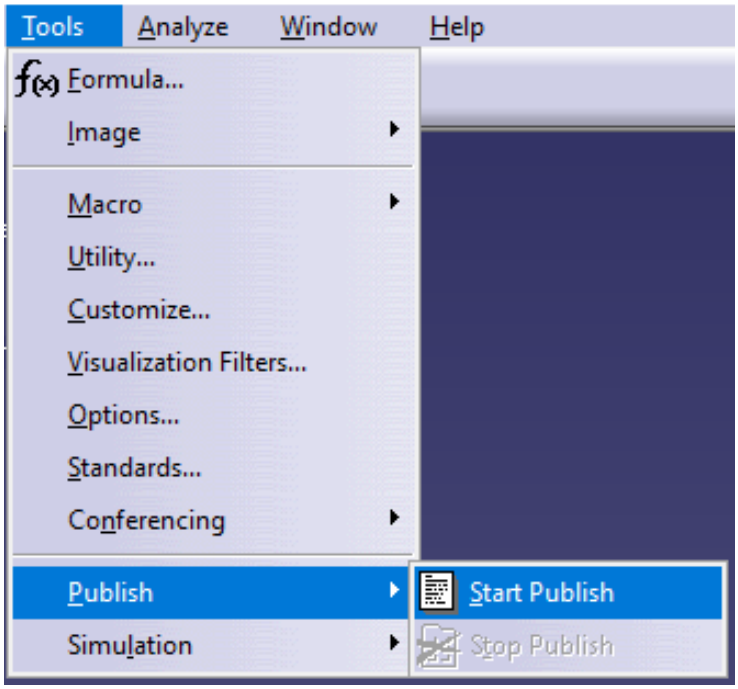


Figure 44

Select the **Feature Publish** button and click on the previously replay created visible on the scene tree.

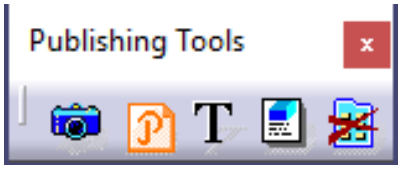


Figure 45

Figure 46

IPS Cable Simulation

Import motion

Import the newly saved movement into IPS Cable Simulation. By linking each rigid body to its movement, taking and releasing the rigid body on the chosen movement, the following window will open. Select **Motion start** and click ok. Proceed in the same way with the remaining rigid bodies.

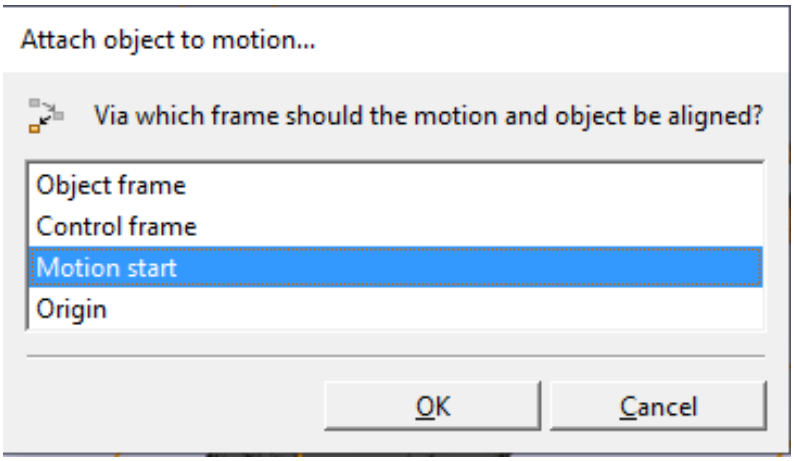


Figure 47

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