POLITECNICO DI TORINO

Master of Science - level

Engineering and Management

Master of Science Thesis

Analysis of the critical supply of carbon fiber components

in a luxury firm of the automotive industry

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Summary

1. Introduction

The following thesis is based on the work performed during an internship in Ferrari S.p.A., in Maranello, which started in March 2020 and finished in September 2020.

The internship was conducted in the Supply Chain and Logistics department in the Gran Turismo division, in particular in the Product Definition functional area, which deals with the starting models, car models that are not yet produced in series.

The objective and the scope of the internship was to support the Supply Chain Management (SCM) activities and to implement a new management and monitoring system for the critical supply of composite materials, in particular carbon fiber components.

Indeed, in recent years the production output of Ferrari has sensitively increased: in 15 years, from 2004 to 2019, the units shipped doubled. Accordingly, the employment of carbon fiber components has widened, thanks to higher economic feasibility and greater manufacturability.

This led to a new need for an approach specifically designed for the Supply Chain Management of carbon fiber components, in order to spot criticalities in advance and take corrective or preventive measures to avoid missing items in the production line.

The work performed during the internship consists in an analysis of the critical supply of carbon fiber components, starting from the collection of data about internal production needs, detection of carbon fiber components from the Bill of Materials (BOM) of the car models, car options involved, forecasts of percentage of adoption of carbon fiber options etc.

Subsequently, suppliers' production capacity values are collected as well, in order to compare the Ferrari production needs with the suppliers' production capacity and verify if potential insufficient production capacity is detected.

The material planners who work in the Supply Chain and Logistics department already do this work, but partially. For each project (i.e. car model), a team of material planners is assigned and each of them has the responsibility of the procurement of a group of components and sub-systems according to a functional division, for instance: engine, hybrid system, external or internal components etc.

Although the Supply Chain Management of all the components, including the carbon fiber ones, are assigned to the material planners, a dedicated and focused management of the carbon fiber parts is not already in place. The analysis explained in the following thesis is positioned transversally

among the various material planners and gives the opportunity to have a holistic view of the procurement and the supply capacity of carbon fiber components.
During the internship, the dedicated management system designed to analyze the critical supply of carbon fiber components have been applied to three car models, with their variants, if present:

- F8 Tributo and F8 Spider;
- SF90 Stradale and SF90 Stradale Spider;
- Roma.

However, the methodology and the approach are the same, hence, in order to avoid repetitions and redundancies, only the analysis of the F8 Tributo and F8 Spider is presented and explained in this work.
It passes through four macro steps:

- Internal data collection;
- External data collection;
- Data processing;
- Suggestion of corrective and preventive measures to take.

Because of high confidentiality of some data and information, supplier companies are mentioned not with their real business names, but through pseudonyms; for the same reason, production ramp-up of Ferrari car models is not expressed through the actual values but through percentage values computed as follows:

- the “100” value is attributed to the peak of the production ramp-up of the F8 Tributo and F8 Spider (expressed in daily production rate), which is observed in November 2020;
- all the remaining values are derived by computing a proportion with respect to the “100” value.

All the data mentioned in this work are obtained with this method, hence not only production values of the F8 Tributo and F8 Spider, but also production rate of the other discussed car models, as well as production capacity values of suppliers etc.
Clearly, the “100” value is not the maximum observable value in the thesis, it is just a point of reference to compute the remaining data.
The thesis is divided into seven chapters and it is structured as follows:

- chapter 1: introduction of the work and of the topics that will be discussed;
- chapter 2: presentation of the company with its products and the functional area where the internship was conducted;
- chapter 3: introduction to properties and characteristics of composite materials and, specifically, carbon fiber components;
- chapter 4: detailed explanation of the scope and the objective of the analysis;
- chapter 5: it is the heart of the thesis, firstly the methodology and the approach are presented, then it is applied practically to the Ferrari F8 Tributo and Ferrari F8 Spider models;
- chapter 6: after the presentation of the results of the analysis, it is given a quick view of how the crisis caused by the Corona Virus was managed from a SCM perspective. In this case, the car model taken into consideration is the SF90 Stradale, because during the months of April, May, June and July 2020, it should have started to be produced in series, hence the outbreak of the pandemic coincided with a delicate phase of development synchronized with suppliers, some of them established in other countries;
- chapter 7: conclusions of the work are presented and explained.

2. The company

Ferrari S.p.A. is an Italian car manufacturer positioned among the world's leading luxury brands, focused on design, engineering, production and sale of the world's most recognizable luxury performance sports cars. The Ferrari brand is a symbol of exclusivity, innovation, state-of-the-art sporting performance and Italian design and engineering heritage. Its name, history and reputation are closely associated to the Formula 1 racing team, Scuderia Ferrari, the most successful team in Formula 1 history. From 1950, the inaugural year of Formula 1, through the end of 2019, Scuderia Ferrari has won 238 Grand Prix races, 16 Constructor World titles and 15 Drivers' World titles.

Figure 1: Ferrari logo.

Figure 2: Scuderia Ferrari logo.

In addition, Ferrari is one of the most successful racing teams in Sportscar, Prototypes and Gran Turismo Championships, such as the World Sportscar Championship and the Endurance FIA. It boasts several victories in the classic endurance races, as the 24 hours of Le Mans, the 12 hours of Sebring, the 24 hours of Daytona etc.

Ferrari designs, engineers and produces its cars in Maranello, Italy, and sells them in over 60 markets worldwide through a network of 166 authorized dealers operating 187 points of sale.

At the end of 2019, Ferrari counted 4,285 employees, of these 4,043 were based in Maranello, € 3,766 million of net revenues and € 699 million of net profit.

2.1 History

Figure 3: historic entrance in Via Abetone Inferiore of the Ferrari plant in Maranello, Modena.

Ferrari was founded in 1947, when, through the historic gate of Via Abetone Inferiore in Maranello, the first Ferrari branded car came out, the Ferrari 125 S.

However, the origins of the company are indissolubly linked to the founder's life,

Enzo Ferrari. He dedicated his entire life to car racing. Pilot of Alfa Romeo in 1924, five years later he founded the Scuderia Ferrari, with the aim of allowing his partners to participate in the races. After the interruption of all racing activities during the World War II, the first Ferrari began to be designed and constructed.

During the 50s important changes occurred: at the end of the decade, Ferrari was known worldwide. From a sporting point of view the first achievements were reached: it won the first Gran Prix in 1951 while in 1952 and 1953 Alberto Ascari won the World Championship.

Between 1950 and 1960, sales tripled.

Enzo Ferrari transformed the firm in a public corporation in 1960 and in 1969 signed an agreement with FIAT for the sale of 50% of stock. In the second half of the decade, Scuderia Ferrari triumphed several times in both the Pilot and the Constructor World Championships.

During the 80s, the company faced a sensitive moment. Enzo Ferrari died in 1988 and FIAT increased its stake in the company up to the 90%, while the remaining 10% remained in the hands of Enzo's son, Piero Lardi Ferrari.

The new millennium brought many significant achievements: in Formula 1 from 2000 to 2008, Scuderia Ferrari wins thirteen World Championships (six Pilots World Championships and seven Constructors World Championships).

Figure 4: Michael Schumacher driving the Ferrari F2002, formula one car with which he won the 2002 World Championship.

Meanwhile several successful car models came to market and, most of all, new branding policies were implemented. After the first Ferrari Store inauguration in Maranello in 2002, new several openings took place worldwide in cities such as St. Petersburg, Dubai, Abu Dhabi, New York, Singapore.

The results of such successful policy are clear in the recent years: Ferrari has been awarded the title of the world's strongest brand for two consecutive years, in 2019 and 2020, by Brand Finance, the leading international independent brand valuation and strategy consultancy.

Indeed, the past decade has seen a period of strong expansion.

The company has broadened its presence in emerging markets such as Middle East, China, Japan and the rest of East Asia, while strengthening its position in the USA, United Kingdom and Germany.

In 2015, FCA sold 10% of its Ferrari shares with the aim of an IPO (Initial Public Offering) and on October 21th Ferrari was listed in the New York Stock Exchange.

Ferrari became an independent, publicly traded company following its separation from FCA, which was completed on January 3rd, 2016.

2.2 Business overview

Ferrari divides the regional markets into EMEA, Americas, Mainland China, Hong Kong and Taiwan, and Rest of APAC, representing respectively 48.3 percent, 28.6 percent, 8.3 percent and 14.8 percent of units shipped in 2019.

More specifically, at the end of 2019 the 10,131 unit shipments were distributed as follows:

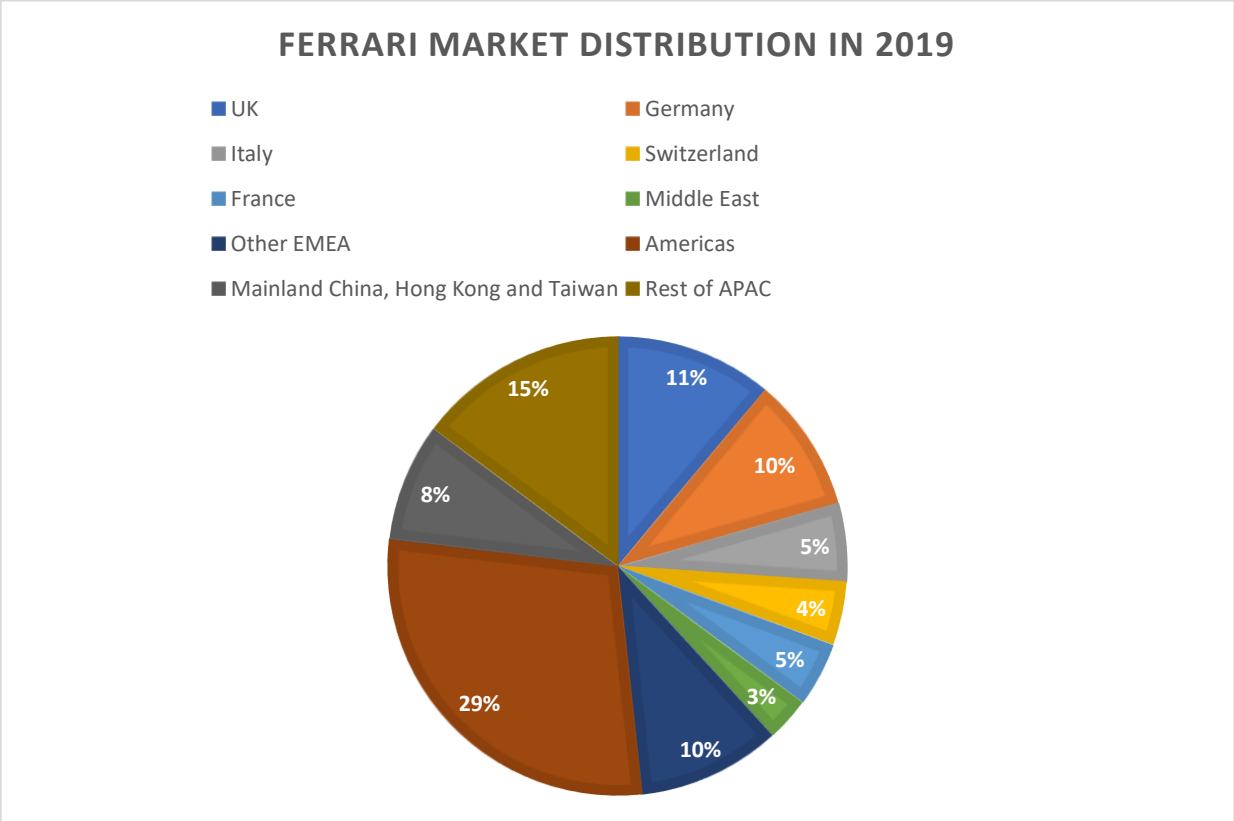


Figure 5: Ferrari market distribution in 2019.

In Figure 5:

- Middle East includes the United Arab Emirates, Saudi Arabia, Bahrain, Lebanon, Qatar, Oman and Kuwait;
- Rest of EMEA includes Africa and the other European markets not separately identified;

- Americas includes the United States of America, Canada, Mexico, the Caribbean and Central and South America;
- Rest of APAC mainly includes Japan, Australia, Singapore, Indonesia, South Korea, Thailand and Malaysia

2.3 Car models

The product offering includes four main strategic pillars: the sports range, the GT range, special series and Icona. The product range at the end of 2019 comprises five sports cars, four GT cars and two special series cars, as well as the Icona cars, introduced in 2018 with the Ferrari Monza SP1 and SP2.

Currently, Ferrari offers the broadest ever model range, which is able to offer a highly differentiated product line-up that can meet the various needs of new customer segments (in terms of sportiness, comfort, on-board space, design) and that meets also the existing clients' needs.

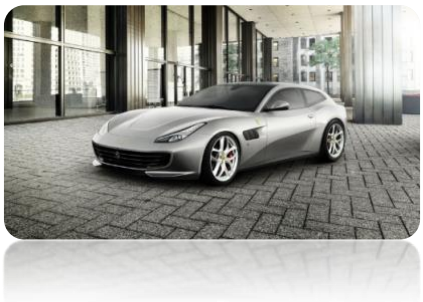
The diversified product offering includes different architectures (such as front-engine and mid-rear engine), engine sizes (V8 and V12), technologies (atmospheric, turbo-charged, hybrid, electric), body styles (such as coupes and spiders), and seats (2 seaters, 2+2 seaters and 4 seaters).

2.3.1 Sports models

	**812 SUPERFAST** With its 800 PS and 6,496 cc, it's the most powerful naturally aspirated engine ever for a vehicle produced in series. It merges innovative contents and a hidden special meaning, as the V12 was the first engine designed and produced by the "Prancing horse". It accelerates from 0 to 100 km/h in 2.9 seconds and it has a top speed of 340 km/h.

	**812 GTS** It is the open top version of the 812 Superfast.
	**F8 Tributo** This model climbs on a central-rear, 3.9 L twin-turbocharged V8 engine. With 720 PS and a specific power of 185 PS/l, this is the most powerful V8 Ferrari ever. It is based on the same unit that has been used for other models and has been awarded for three years in a row “International Engine of the Year”. It accelerates from 0 to 100 km/h in 2.9 seconds and its top speed is above 340 km/h.
	**F8 Spider** It takes inspiration from the F8 Tributo and adds some features such as the Retractable Hard Top (RHT).
	**SF90 Stradale** The beginning of a new era in Ferrari history with the introduction of the first PHEV (Plug-in Hybrid Electric Vehicle) produced in series. It is the most powerful Ferrari road car ever made with a total of 1000 PS (220 PS supplied by three electric motors in addition to 780 PS supplied by the V8 internal combustion engine). It accelerates from 0 to 100 km/h in 2.5 sec and from 0 to 200 km/h in 6.7 sec.

2.3.2 Gran Turismo models

	**Roma** Characterized by timeless design and unique refinement, this model is powered by a V8 turbo engine, which unleashes 620 PS with a weight/power ratio of 2,37 kg/PS. It accelerates from 0 to 100 km/h in 3.4 seconds, from 0 to 200 km/h in 9.3 seconds and a top speed of 320 km/h.
	**Portofino** Lighter than its predecessor, the California T, with its 600 PS it goes from 0 to 100 km/h in 3,5 sec. The Retractable Hard Top, the capacious trunk, and great habitability allow having sportiness, elegance and comfort merged together.
	**GTC4Lusso** With four seats, steering rear wheels, four-wheel drive and great habitability, this model targets those customers who demand comfort. 690 PS and a record-breaking weight/power ratio for the category are the distinctive features of this 6,262 cc front-mid mounted V12 engine. It accelerates from 0 to 100 km/h in 3.4 seconds and it has a top speed of 335 km/h.
	**GTC4Lusso T** It is the first Ferrari model with four seats and a rear wheel drive which climbs on a 3,855 cc twin-turbocharged V8 engine. It is dedicated to those customers who search for sportiness together with versatility and high frequency of use. It accelerates from 0 to 100 km/h in 3.5 seconds and it can reach 320 km/h of top speed.

2.3.3 Special series models

	**488 Pista** Its development has its roots in the racing environment after five Constructors titles of FIA WEC from 2012, through several solutions in engine, dynamics and aerodynamics of the vehicle. The V8 engine unleashes 720 PS and a specific power of 185 PS/l as for the F8 Tributo and F8 Spider.
	**488 Pista Spider** It is the Ferrari spider with the best performance ever, with a remarkable weight/power ratio (1,92 kg/PS).

2.3.4 Icona series models

The Icona series car models take inspiration from the iconic cars of the past and interpret them in a modern way with innovative technology and materials.

 	**Monza SP1 and Monza SP2** These models revive the concept of the 50s “barchette” which became famous thanks to the victories of Scuderia Ferrari and the gentlemen who drove them. They are specifically designed for collectors. Both of them are powered by a naturally aspirated 6,496 cc V12 engine, which unleashes 810 PS. As for the racing cars, carbon fiber components have been largely employed. The only difference between them is that the Monza SP1 has just one seat, while the Monza SP2 has two.

2.4 Supply Chain and Logistics department

The main function of the Supply Chain and Logistics department is the management of the flow of goods in inbound and outbound as well as inside and between the company infrastructures (Supply Chain Management or SCM). It involves the movement and storage of raw materials, of work-in-process inventory and of finished goods as well as end-to-end order fulfilment from point of origin to point of consumption.

This work will focus on supply chain activities in inbound, hence procurement of raw materials and assembled goods in order to fulfil the internal production needs. It consists in a cross-functional approach because, in order to implement planning methodologies and to ensure harmonization between procurement and production, the Supply Chain department needs to keep a constant information and communication flow not only with the Production department but also with the Technological, Quality, Purchasing and Marketing departments:

- Technological dept. is necessary in order to understand the function and the application of the components;
- Quality dept. informs if the incoming parts are satisfactory according to the company quality standards;
- Purchasing dept. is responsible for the agreements with suppliers, including deals on equipment, investments and costs;
- Commercial dept. provides relevant data about sales forecasting, adoption percentages of option etc.

Figure 6: Information and communication flow of Supply Chain and Logistics department.

In the automotive industry, the Supply Chain & Logistics function has a crucial role, as companies like Ferrari are Original Equipment Manufacturers (OEMs). This type of firms assembles and sells

material and components that are partly manufactured by other companies in the supply chain, under their own brand name. The OEM supply chain can be depicted also as a supply pyramid in which at the top there is the OEM, in this case Ferrari, while in the lower levels suppliers of modules, components and parts, called also tier 1, tier 2 and tier 3 suppliers, respectively. Naturally, there is no limit in the structure of sub-suppliers, hence, depending on the complexity of a supply chain and on the distance from the OEM, there will be n-tier suppliers.

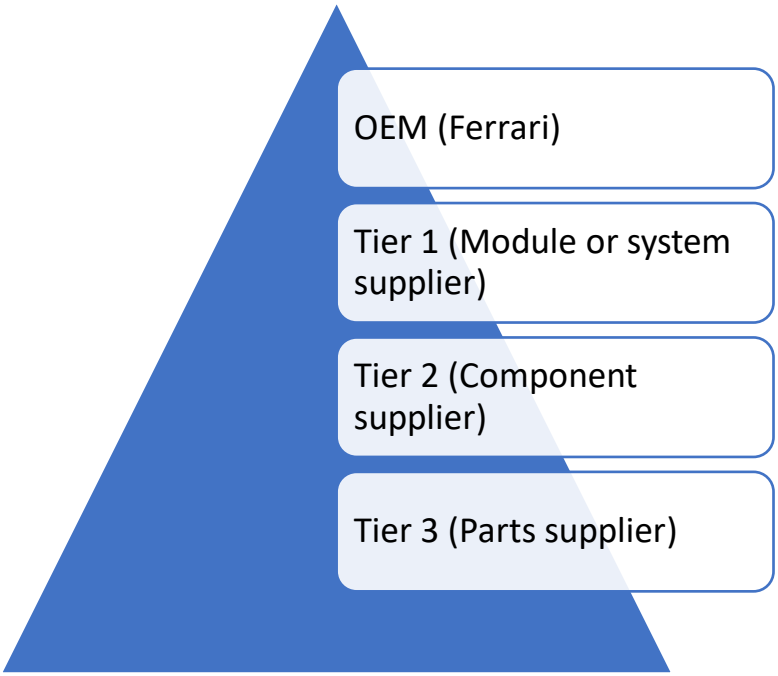


Figure 7: pyramidal structure of the supply chain in case of an Original Equipment Manufacturer (OEM).

2.4.1 Product definition – SCM of starting models

Each car model passes through different technological and organizational phases before being produced in series (Start of Production or SOP). The path that needs to be crossed depends on particular issues related to global performance, manufacturability, good aesthetic result, compatibility, synergy among components and so forth.

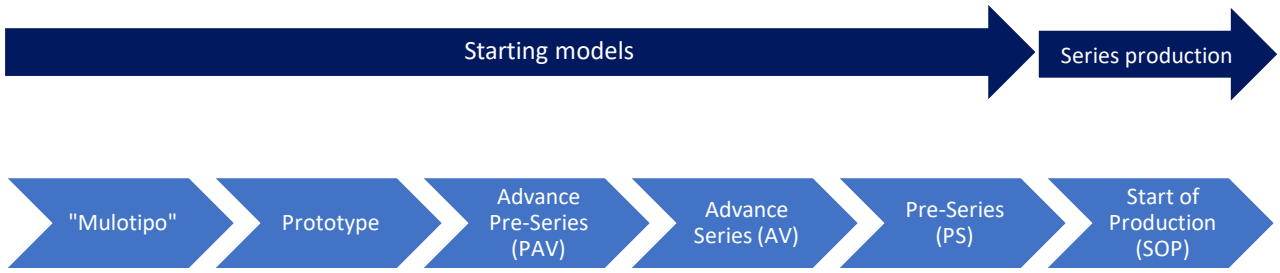


Figure 8: phases of a new car model

All those car models that are currently in the phases before series production are referred to as *starting models.* The latter require high effort and attention from a Supply Chain Management perspective, because of the numerous changes that involve components.

Passing through all these stages, vehicle meaningfulness continuously increases. Meaningfulness refers to the level of definition of employed components and adopted manufacturing processes.

In the initial phases (e.g. “mulotipo”, prototype) most of the components are not defined, as well as the assembly process. Moving forward Advance Pre-Series, Advance Series and Pre-Series cars, the level of definition of components and processes (that is to say meaningfulness) improves, until the 100% is reached, hence allowing the Start of Production.

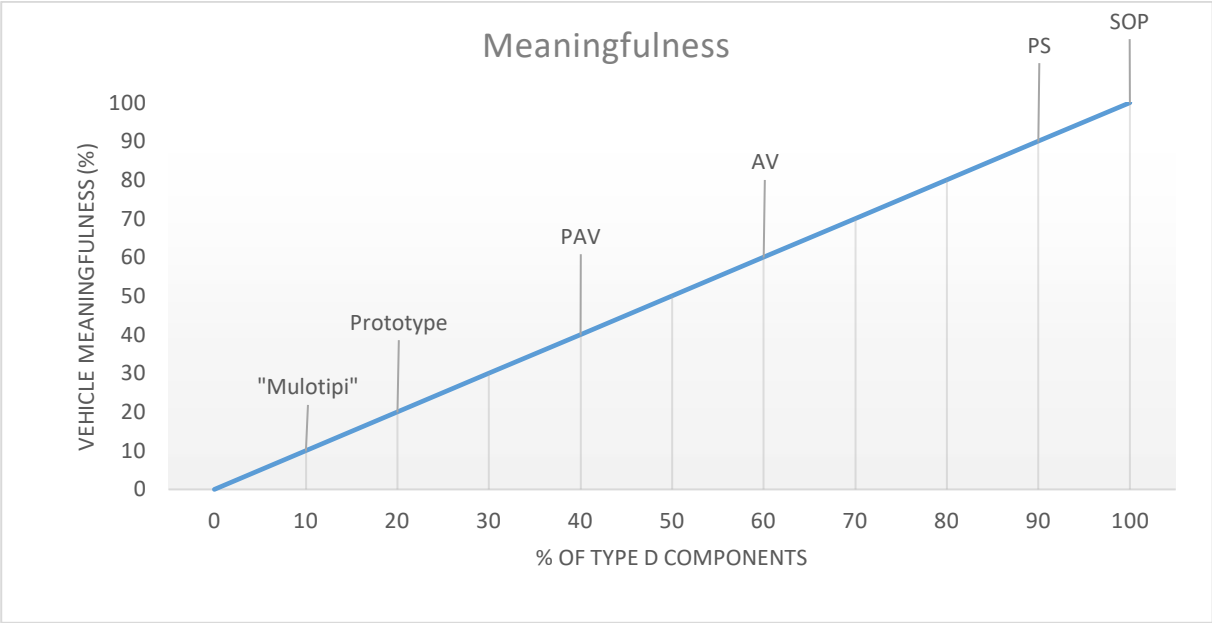
Components employed in the early stages of the development of a car model, for instance in the prototypal stage, are likely to be modified because of their low meaningfulness.

Specifically:

- “Mulotipo”: in this phase frame, suspension, steering, brakes, electrical systems, cooling system are tested;
- Prototype: here the car begins to take shape and both internally and externally it is more similar to the final version; in this phase aerodynamics and interior quality are tested;
- Advance Pre-Series (PAV): it serves as an intermediate step between Prototype and Advance Series, few changes may be made;
- Advance Series (AV): production tolerances and supply chain are verified; what is called *project debug* is performed;
- Pre-series (PS): cars are realized in the production line with the aim of testing the process; indeed, what is called *process debug* is performed.

After the Pre-Series cars, a new phase is approached: Off Tool Off Process (OTOP). In the automotive industry, this expression is used when all the components, tools, equipment and processes have

been tested, verified, defined and confirmed. Once a project enters in the OTOP phase, the series production can officially begin.



Graph 1: qualitative representation of meaningfulness of a car model in function of the percentage of type D components

In order to distinguish among components of different nature basing on their meaningfulness, the following classification is considered:

- type C components: prototypal components and processes;
- type D components: highly meaningful components and processes, almost final;
- type E components: final components and processes, quality control is passed.

Focusing only on the distinction between type C and type D components, the higher the number of type D components, the lower the number of type C ones. Hence, the x-axis of Graph 1 can be interpreted as increasing percentage of type D components or decreasing percentage of type C components.

As explained previously, once the OTOP phase is reached, the series production begins, but not all the components cease to be critical from a procurement point of view. Indeed, after the Start of Production, most of the car parts continues to be managed by the Supply Chain & Logistics branch which deals with starting models: the Product Definition area. Then, the Supply Chain Management will progressively shift to the Supply Chain and Logistics area, which deals with series production models.

3. Composite materials

A composite material is a combination of two macroscopically identifiable materials with different physical and chemical properties. When they are combined, they create a material which is specialized to do a certain job, for instance to become stronger, lighter or resistant to electricity. The reason for their use over traditional materials is that they improve the properties of their base materials and are applicable in many situations.

3.1 Carbon fiber materials

Carbon fibers are fibers about 5–10 micrometres in diameter and composed mostly of carbon atoms. They present several physical and mechanical advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports. However, they are relatively expensive.

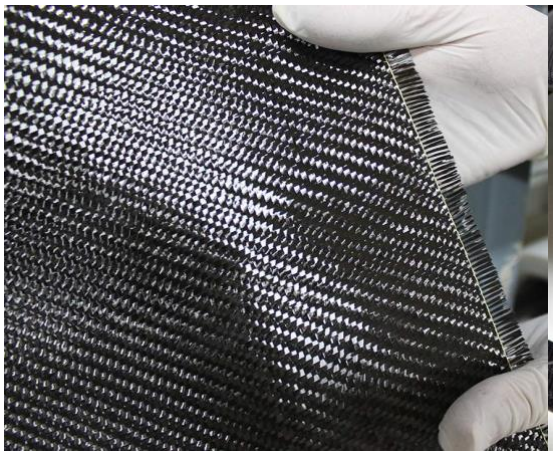


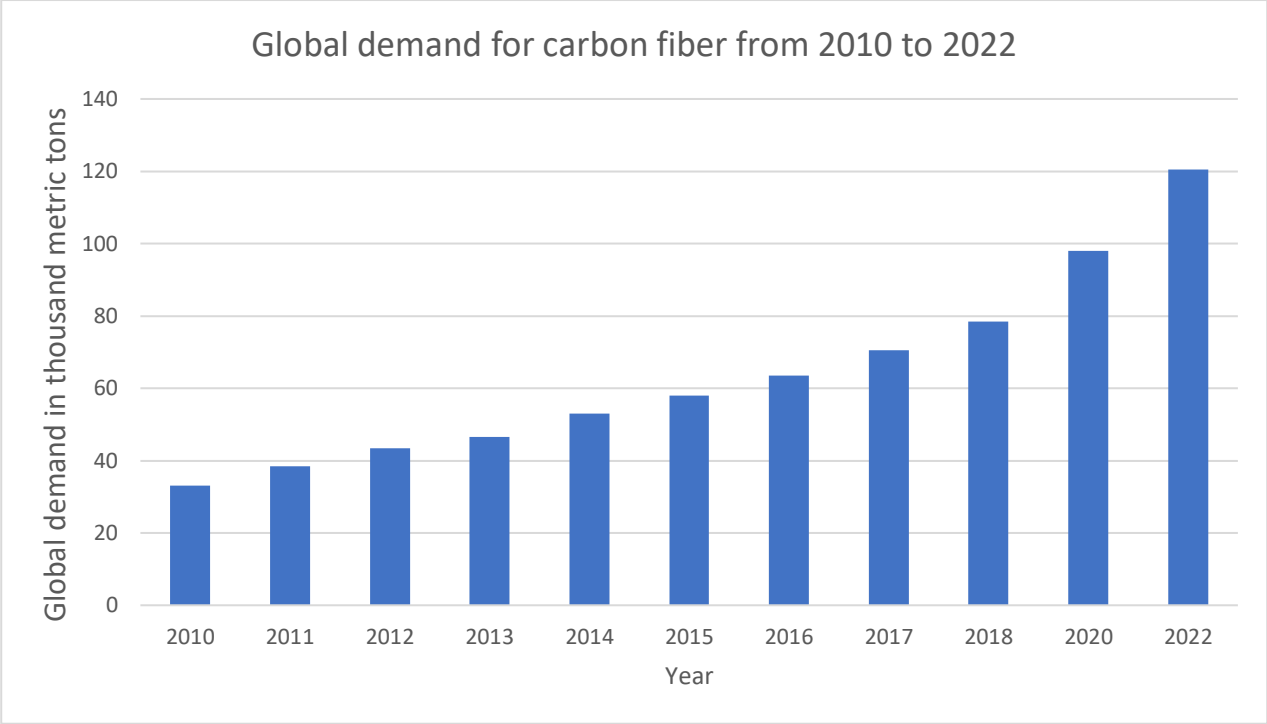
Figure 9: carbon fiber sheet ready for lamination

Figure 10: finished carbon fiber rear diffuser

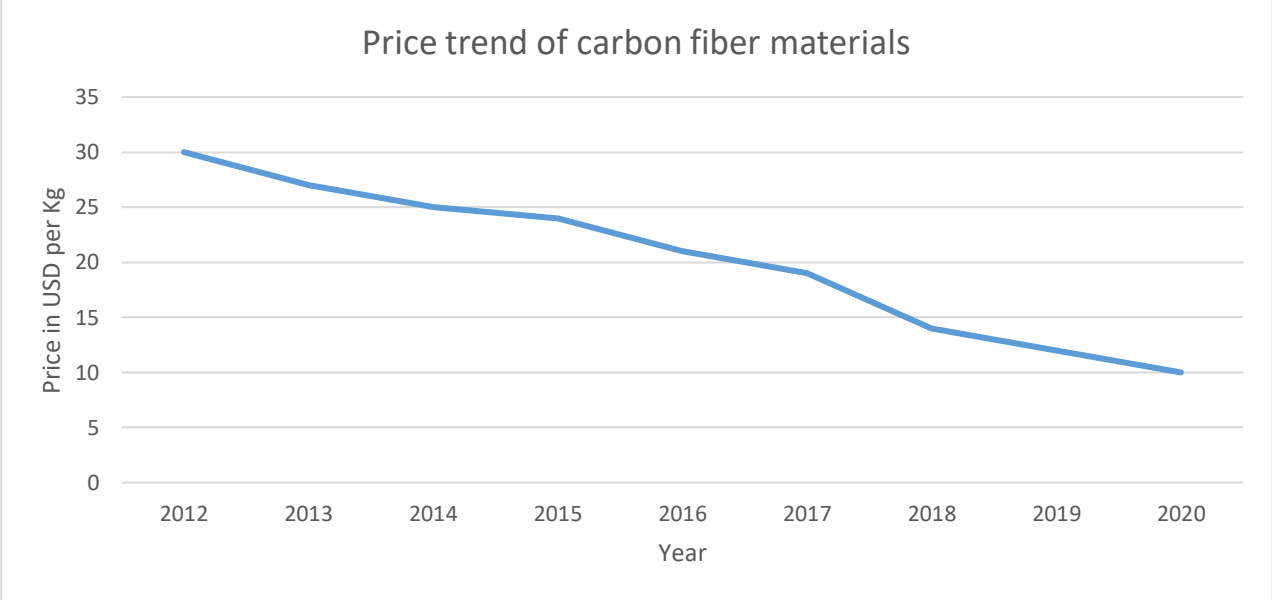
In industrial application, carbon fibers are usually combined with other materials to form a composite. When impregnated with a plastic resin and baked, it forms carbon-fiber-reinforced polymer (it is referred simply to as carbon fiber) which has a very high strength-to-weight ratio and

is extremely rigid. Carbon fibers are also combined with other materials, such as graphite, to form reinforced carbon-carbon composites, which have a very high heat tolerance.

The excellent properties of carbon fiber materials have boosted its application in the past years (Graph 2) and have sensitively decreased its unit price (Graph 3).



Graph 2: worldwide carbon fiber demand through years; values in 2018, 2020 and 2022 are forecasted values; results of a study published on Statista.com by M. Garside.



Graph 3: price trend of carbon fiber materials in the past 8 years; Infosys paper "Carbon composites are becoming competitive and cost effective" by Shama Rao, Simha, Rao, and Ravi Kumar.

Although carbon fiber employment is spreading and widening, allowing lower prices, better manufacturing techniques and higher feasibility, it is still a critical material due to long production lead time and delicate process steps. These aspects are problematic in several application fields such as, military, medical, aerospace. On top of that, high quality standards and stringent aesthetics requirements that characterize a luxury company like Ferrari make the production and supply of carbon fiber components even more critical.

From a Supply Chain Management perspective, carbon fiber components require higher attention.

4. Scope and objectives of the analysis

Ferrari has been increasing production volumes year by year, reaching 10,131 car shipments in 2019, a new record. Accordingly, carbon fiber application has been widening, as it was shown from a macro perspective in the previous chapter. These phenomena lead to a substantial rise of Ferrari demand for carbon fiber components.

From these assumptions a new internal and organizational need is born: **to analyse in the medium and the long term the suppliers' production capacity of carbon fiber components in order to verify if they are able to satisfy production needs.**

This approach aims to detect potential criticalities in advance, before delays in components delivery occur and in order to avoid missing items in the production line.

The medium and long-time horizons are crucial in this type of study because, when criticalities are detected, the possible actions to take may require time and money.

It is fundamental to remember that this type of study has the aim of spotting *potential* criticalities. It means that there is no certainty in whatever conclusion or statement that can be expressed during the analysis, both in positive and negative aspects:

- in case a particular car option or item is considered potentially non critical, it doesn't erase any chance of missing items in the production line or other supply issues that could be related to several causes (quality issues, specific issues of the supplier's production line, wearing of tools, unexpected peak from customers for some car options etc.);
- on the opposite, if a car option is recognized as critical from a production capacity perspective, it does not mean that issues will necessarily come up if preventive and corrective actions are not undertaken.

All the quantitative and semi-qualitative results of the following study need to be accompanied by other instruments, in order to implement an optimal decision-making process.

5. Analysis of critical supply of carbon fiber components

5.1 Approach and methodology

Before going into details analysing suppliers' production capacity of carbon fiber components for a specific car model, the adopted methodology is explained in the following paragraphs.

5.1.1 Internal data mining

Before collecting data about production capacity from suppliers, it is necessary to begin the study from the car model that will be the object of the analysis, in particular:

- to identify the car model parts that are made of carbon fiber in their standard version (100% of the produced cars will be assembled with that component in carbon fiber);
- to identify and list all the car options that involve carbon fiber components;
- to identify the car model parts that are made of carbon fiber depending on the option that is chosen by the client (absorption rate of that component in carbon fiber lower than 100%); in this case if the car option that impacts a particular component is not chosen, that car part will not be in carbon fiber;
- to collect absorption rates of car options based on forecasts performed by the Commercial dept.;
- to identify and link all the part numbers (items with an identification code attached) to each option of interest;
- to identify destination markets for each component (depending on different regulations and rules, some parts may be different according to the market, for instance right-hand and left-hand drive countries);
- to identify the suppliers of each item of interest;
- to derive the production ramp-up curve for the car model of interest, in order to consider the production needs through the months.

Theoretical or **Forecasted Absorption Rates (FAR)** of an option refer to the percentage of the produced cars that are expected to be assembled with the particular component/s associated to the relative option. In other words, it is the expected percentage of cars that will be requested by customers with that option.

They are forecasted by the Commercial dept. in the initial phases of the project and represent a significant parameter in the decision-making process about how much the suppliers need to be equipped. High absorption rates require a higher amount of installed lamination tools for the production of carbon fiber components, in order to ensure a satisfactory material flow towards the Ferrari manufacturing plant. Moreover, these decisions need to be taken precisely and early, because the tooling and set-up procedures may require several weeks, up to 8-10 weeks.

On the other side, also **Real Absorption Rates (RAR)** can be derived by extracting orders placed in the Enterprise Resource Planning (ERP) system. This is surely a reliable value because it is computed by looking to the cars that will be actually produced, but, in contrast, it refers to a short time horizon.

In the following analysis, **Key Performance Indicators (KPIs)** will be computed considering the Forecasted Absorption Rates, but, at the same time, Real Absorption Rates will be taken into account as an auxiliary element to evaluate some criticalities, mostly in the short term.

After the collection of the data previously mentioned, the production need through months of each component is computed.

It is affected by:

- Forecasted Absorption Rate of associated option;
- destination market;
- production ramp-up curve of the car model.

By combining all these data and information together, it is possible to derive the specific production need for each item over time.

5.1.2 External data mining

Once the internal data mining phase is concluded, it is necessary to collect the production capacity of the suppliers for each component. These data will be determined by:

- total number of equipped lamination tools agreed with Ferrari;

- time required to progressively install lamination tools;
- production time for each piece;
- maintenance and useful life of equipment and tools;
- work shifts (managed by supplier);
- work force employed.

The data mining phase is now concluded. Both production needs and suppliers' production capacity have been collected and can be compared, in order to spot potential criticalities.

5.1.3 Evaluation and interpretation

During the evaluation process, it is crucial to remember that the data involved in the analysis deal with maximum production capacity, not with actual production plan and delivery of items.
Number of delivered parts can be:

- lower, in the case Ferrari orders (which depend on production on a day-by-day basis) are simply lower than the maximum production capacity of the supplier;
- higher, in the case a supplier cumulates stock during low demand periods and begins to deliver just-produced parts together with in-stock ones in high demand periods.

In this stage, the performance evaluation process is simple and immediate:

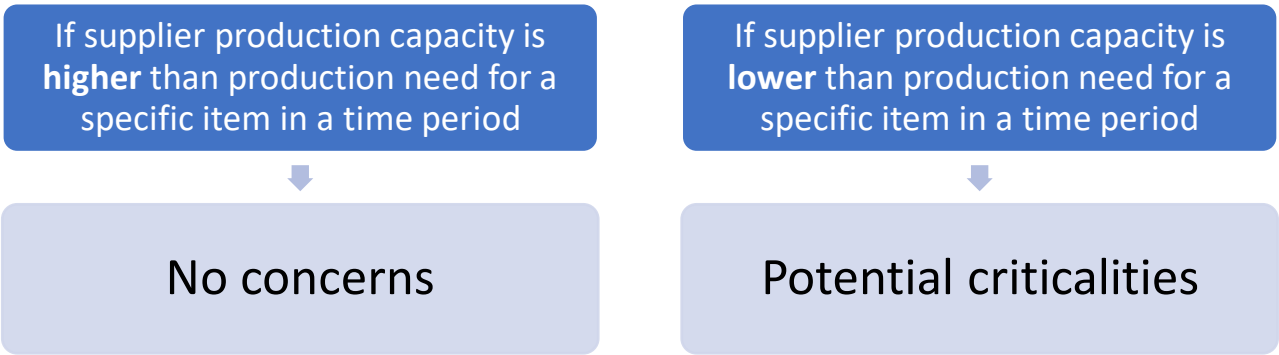


Figure 11: first evaluation of suppliers based on their production capacity.

In case of low production capacity, a generalization of the approach can be tricky, because the gravity of the criticality depends on several factors such as total duration of insufficient production capacity, severity of insufficiency and so forth.

If an intervention is necessary, two possible actions can be taken:

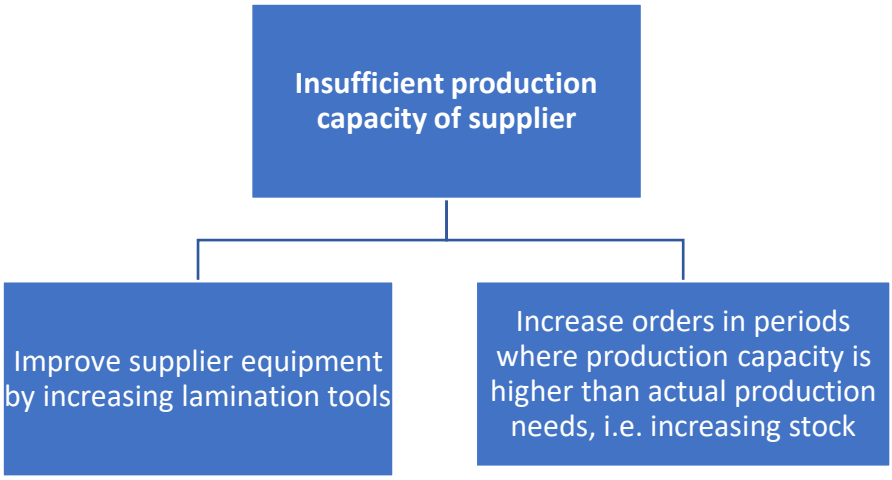


Figure 12: possible actions to undertake in case of detection of insufficient production capacity of a supplier.

Clearly, improving supplier equipment is costly and require more effort, as other departments need to be involved. It is advisable to act in this way when big differences between supplier production capacity and production needs are observed.

5.2 Analysis of critical supply of carbon fiber components of F8 Tributo and F8 Spider

Ferrari F8 Tributo is produced in two versions:

- Ferrari F8 Tributo, coupé (from now on it will be referred to as simply F8 Tributo);

Figure 13: front and back view of F8 Tributo.

Figure 14: internal view of F8 Tributo.

- Ferrari F8 Spider.

Figure 15: front and back view of F8 Spider.

Figure 16: Internal view of F8 Spider.

5.2.1 F8 Tributo and F8 Spider internal data mining

In this paragraph, all the relevant data useful for the analysis are collected within the company, thanks to the Enterprise Resource Planning system and communication links with colleagues who work internally and externally to the Supply Chain and Logistics function.

Most of the components are in common between the two versions but in some cases, a distinction needs to be made because of specificity of parts.

Regarding this model, there are not parts in carbon fiber in the standard version.

5.2.1.1 Options and absorption rates

Therefore, the next step can be performed: identification of all the options that involve carbon fiber items associated to Forecasted Absorption Rates (FAR) computed by the Commercial dept.:

F8 Tributo and F8 Spider			
Functional group	**Option**	**FAR**	**Option description**
INTERNAL	**LEDS**	**90%**	VOLANTE IN CARBONIO CON LEDS
EXTERNAL	**CEAI**	**55%**	S-DUCT SU COFANO IN CARBONIO
EXTERNAL	**CEXG**	**55%**	BAFFI SU PARAURTI ANTERIORE IN CARBONIO
EXTERNAL	**FCWS**	**55%**	SPLITTER SU PARAURTI ANTERIORE IN CARBONIO
EXTERNAL	**CEXF**	**55%**	MOSTRINA PROIETTORE IN FIBRA DI CARBONIO
EXTERNAL	**CEIS**	**55%**	MOSTRINA PRESE ARIA LATERALI IN FIBRA DI CARBONIO
EXTERNAL	**CEXS**	**55%**	COPRIBRANCARDO ESTERNO IN FIBRA DI CARBONIO
EXTERNAL	**CEXD**	**55%**	ESTRATTORE POSTERIORE IN FIBRA DI CARBONIO
INTERNAL	**CIDL**	**31%**	ALLESTIMENTO ZONA GUIDA IN FIBRA DI CARBONIO + VOLANTE CON LEDS
INTERNAL	**CILR**	**46%**	BRIDGE TUNNEL IN FIBRA DI CARBONIO
INTERNAL	**CIDH**	**46%**	MANIGLIE PORTA IN FIBRA DI CARBONIO
INTERNAL	**CFPA**	**24%**	PALETTE IN CARBONIO RACING
INTERNAL	**DATR**	**44%**	INSERTI PLANCIA IN FIBRA DI CARBONIO
INTERNAL	**CIIP**	**44%**	VELE COPRISTRUMENTO IN CARBONIO
INTERNAL	**CITZ**	**44%**	PARTE SUPERIORE TUNNEL IN FIBRA DI CARBONIO
INTERNAL	**CIPZ**	**44%**	PANNELLI PORTA IN FIBRA DI CARBONIO
INTERNAL	**CIMP**	**44%**	CARBONI INTERNI OPACHI
INTERNAL	**CISK**	**44%**	BATTITACCO ESTERNO IN FIBRA DI CARBONIO
EXTERNAL	**MNFC**	**33%**	ENGINE COVERS IN FIBRA DI CARBONIO
EXTERNAL	**CEL2**	**33%**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO
INTERNAL	**RSCH**	**33%**	SEDILE RACING IN CARBONIO CORSA
INTERNAL	**CIZB**	**33%**	ZONA BAULE IN CARBONIO
EXTERNAL	**CUPC**	**12%**	COPPETTE RUOTA IN FIBRA DI CARBONIO
INTERNAL	**RSCD**	**11%**	SEDILE RACING IN CARBONIO DAYTONA
EXTERNAL	**RMCF**	**10%**	CERCHI RUOTA IN CARBONIO

Table 1: list of options that involve carbon fiber components for F8 Tributo and F8 Spider.

Then, options that are associated to specific parts of only one of the two versions are identified and listed:

F8 Tributo			
Functional group	**Option**	**FAR**	**Option description**
EXTERNAL	**CERB**	**55%**	TERMINALE COFANO POST IN CARBONIO
EXTERNAL	**CEL2**	**33%**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO
EXTERNAL	**BONF**	**15%**	TELAIETTO COFANO MOTORE IN CARBONIO

Table 2: list of options that involve carbon fiber components for F8 Tributo.

F8 Spider			
Functional group	**Option**	**FAR**	**Option description**
EXTERNAL	**CERB**	**55%**	TERMINALE COFANO POST IN CARB E GRIGLIA MOTORE
EXTERNAL	**CERF**	**50%**	INSERTO MONTANTE B IN CARBONIO SPIDER
EXTERNAL	**CEL2**	**33%**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO

Table 3: list of options that involve carbon fiber components for F8 Spider.

The option CEL2 is listed in all the three tables. This means that some of the items associated to CEL2 are in common between coupé and spider versions, while other parts are specific for each one of the two versions.

5.2.1.2 Items identification

Once all the options involving carbon fiber have been listed, it is necessary to derive the components that are assembled when the above mentioned options are activated.

This procedure can be implemented by looking to the constraints attached to the items in the ERP system, in particular in the Bill of Materials (BOMs). If a part number shows a “validate” type constraint together with an OPT (option) code, it means that the particular component is assembled only if that OPT is activated.

Through many iterations, all the part numbers linked to the above listed options are obtained.

Similarly, by interpreting the BOMs of each component, the destination market can be found.

Indeed, from the code, several pieces of information can be extracted such as car model, model year, market destination.

At end of the research, the following table is derived:

F8 Tributo + F8 Spider							
Functional group	**Option**	**Option description**	**Item code**	**Item description**	**Market**	**FAR**	**RAR**
INTERNAL	**LEDS**	VOLANTE IN CARBONIO CON LEDS	73520444	VOLANTE CPL F142MFL CARB+LED	ALL	**90%**	**95%**
EXTERNAL	**CEAI**	S-DUCT SU COFANO IN CARBONIO	914076	COPER.EST.CENT.PROLUNGA CARB.C	ALL	**55%**	**13%**
			904557	IMBOCCO S-DUCT CARB. COFANO AN	ALL	**55%**	
EXTERNAL	**CEXG**	BAFFI SU PARAURTI ANTERIORE IN CARBONIO	73530344	PARAURTO ANT.CS FLICK INF.LAT	NO USA, CAN	**44%**	**20%**
			73574244	PARAURTO ANT.CS FLICK LAT. CA	USA, USL, CAN	**22%**	
EXTERNAL	**FCWS**	SPLITTER SU PARAURTI ANTERIORE IN CARBONIO	73530744	PARAURTO ANT.CS.MOSTRINA CENTR	NO USA, CAN	**44%**	**25%**
			73574144	PARAURTO ANT. CS MOSTR.CENTR.C	USA, USL, CAN	**22%**	
EXTERNAL	**CEXF**	MOSTRINA PROIETTORE IN FIBRA DI CARBONIO	881792	PRESA ARIA FRENI DX CPL CARB.	ALL	**55%**	**11%**
			881787	PRESA ARIA FRENI SX CPL CARB.	ALL	**55%**	
EXTERNAL	**CEIS**	MOSTRINA PRESE ARIA LATERALI IN FIBRA DI CARBONIO	891184	ALA LATERALE CARBONIO DX CPL	ALL	**55%**	**61%**
			891163	ALA LATERALE CARBONIO SX CPL	ALL	**55%**	
EXTERNAL	**CEXS**	COPRIBRANCARDO EXTERNAL IN FIBRA DI CARBONIO	73527944	RIVESTIM. SOTTOPORTA DX CPL CA	ALL	**55%**	**16%**
			73528044	RIVESTIM. SOTTOPORTA SX CPL CA	ALL	**55%**	
EXTERNAL	**CEXD**	ESTRATTORE POSTERIORE IN FIBRA DI CARBONIO	906929	SCIVOLO ESTRATTORE CPL BASE CA	ALL	**55%**	**21%**
			899283	PORTELLA CENTRALE IN CARBONIO	ALL	**55%**	
			786906	PORTELLA LATERALE DX CARBONIO	ALL	**55%**	
			786905	PORTELLA LATERALE SX CARBONIO	ALL	**55%**	
INTERNAL	**CIDL**	ALLESTIMENTO ZONA GUIDA IN FIBRA DI CARBONIO + VOLANTE CON LEDS	863731	NQS ECE OPT NERO CARB	NO USA	**55%**	**61%**
			863752	NQS USA OPT NERO CARB	SOLO USA	**22%**	
			327251	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	
			892382	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	
INTERNAL	**CILR**	BRIDGE TUNNEL IN FIBRA DI CARBONIO	881252	BRIDGE COMANDI F1 CARBONIO CPL	NO USA, USL, CAN	**28%**	**60%**
			896471	BRIDGE COMANDI F1 CARB LUCI US	USA, USL, CAN	**18%**	
INTERNAL	**CIDH**	MANIGLIE PORTA IN FIBRA DI CARBONIO	912466	MANIG TIRAPO CARBON LUCIDO SX	ALL	**46%**	**24%**
			918560	MANIG TIRAP CARBON LUCIDO DX C	ALL	**46%**	
INTERNAL	**CFPA**	PALETTE IN CARBONIO RACING	881217	GRUPPO COM.CAMBIO F1 RACING KE	ALL	**24%**	**13%**
			890896	GRUPPO COM.CAMBIO F1 RACING CA	ALL	**24%**	

INTERNAL	DATR	INSERTI PLANCIA IN FIBRA DI CARBONIO	922005	SATELLITE DX PASS. CARB. CPL	NO AUS, UK	33%	41%
			891898	SATELLITE SX GUIDATORE CARB CP	ALL	44%	
			892196	SATELLITE DX GUID CARB CPL	ALL	44%	
	DATR GDX	INSERTI PLANCIA IN FIBRA DI CARBONIO	899428	SATELLITE SX PASSEG CAR LUC GD	UK, AUS	11%	
INTERNAL	CIIP	VELE COPRISTRUMENTO IN CARBONIO	892176	VELA SUP SX CARB OP CPL	NO AUS, UK	33%	5%
			892178	FUSIONE SUP SX GUID CARB OP CP	NO AUS, UK	33%	
			892181	SATELLITE SX GUIDATORE CARB OP	ALL	44%	
			892599	VELA SUP DX CARB OP CPL	NO AUS, UK	33%	
			892596	FUSIONE SUP DX GUID CARB OP CP	NO AUS, UK	33%	
			892598	SATELLITE DX GUID CARB OP CPL	ALL	44%	
	CIIP GDX	VELE COPRISTRUMENTO IN CARBONIO	899359	VELA SUPER SX CARB OPACO GDX C	UK, AUS	11%	
			899305	VELA SUPERIORE DX CARB OPACO G	UK, AUS	11%	
			936682	FUSIONE SUP DX GUID CARB GDX	UK, AUS	11%	
			899358	FUSIONE FINIZ SUP SX CARB OPA	UK, AUS	11%	
INTERNAL	CITZ	PARTE SUPERIORE TUNNEL IN FIBRA DI CARBONIO	891932	CORNICE MOBILE CARBONIO LUCIDO	ALL	44%	12%
INTERNAL	CIPZ	PANNELLI PORTA IN FIBRA DI CARBONIO	908592	COMP PAN+TASC PORTA SX CAR LUC	NO AUS, UK	33%	3%
			908597	COMP PAN+TASC PORTA DX CAR LUC	NO AUS, UK	33%	
	CIPZ GDX	PANNELLI PORTA IN FIBRA DI CARBONIO	909716	COMP PAN+TASCA PORTA CARB LUC	UK, AUS	11%	
			909714	COMP PAN+TAS PORT CARB LUC DX	UK, AUS	11%	
INTERNAL	CISK	BATTITACCO EXTERNAL IN FIBRA DI CARBONIO	86538300	BATTICALCAGNO EST.DX CARBONIO	ALL	44%	17%
			86538200	BATTICALCAGNO EST.SX CARBONIO	ALL	44%	
			915177	BATTICALCAGNO EST.DX CARBONIO	ALL	44%	
			915176	BATTICALCAGNO EST.SX CARBONIO	ALL	44%	
EXTERNAL	MNFC	ENGINE COVERS IN FIBRA DI CARBONIO	902970	Polmone aspirazione DX CPL	ALL	33%	3%
			902971	Polmone aspirazione SX CPL	ALL	33%	
EXTERNAL	CEL2	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	86935100	PARATIA EST.CENT.VANO MOT.CPL	ALL	33%	11%
INTERNAL	RSCH	SEDILE RACING IN CARBONIO CORSA	-	-	-	33%	20%
INTERNAL	CIZB	ZONA BAULE IN CARBONIO	881765	COPERTURA ESTETICA DX CPL CARB	ALL	33%	1%
			881763	COPERTURA ESTETICA SX CPL CARB	ALL	33%	
			881773	MOSTRINA SOTTOPARABREZZA DX CP	NO AUS, UK	25%	
			881771	MOSTRINA SOTTOPARABREZZA SX CP	NO AUS, UK	25%	
			881769	COPERTURA ESTETICA CENTRALE CP	ALL	33%	
	CIZB GDX	ZONA BAULE IN CARBONIO	895812	MOSTRINA SOTTOP DX CPL GDX CAR	UK, AUS	8%	
			895839	MOSTRINA SOTTOP. SX CPL GDX CA	UK, AUS	8%	

EXTERNAL	**CUPC**	COPPETTE RUOTA IN FIBRA DI CARBONIO	281089	COPPETTA COMPLETA PER CERCHI	ALL	**12%**	**6%**
INTERNAL	**RSCD**	SEDILI RACING DAYTONA	-	-	-	**11%**	**9%**
EXTERNAL	**RMCF**	CERCHI RUOTA IN CARBONIO	866268	CERCHIO POST 11J X 20 CARBONI	ALL	**10%**	**2%**
			866267	CERCHIO ANT 9J X 20 CARBONIO	ALL		

Table 4: carbon fiber items associated to the relative options for F8 Tributo and F8 Spider.

Regarding option RSCH and RSCD, associated items have been not considered because they are Carry Over (CO) items. This term precisely refers to an extension of the original area of application. In other words, they are items that were or are assembled also for other car models. They are not part of the study because criticalities should be lower, because of the absence of tooling cost and time and because production ramp-up curve of supplier is determined and stable.

F8 Tributo							
Functional group	**Option**	**Option description**	**Item code**	**Item description**	**Markets**	**FAR**	**RAR**
EXTERNAL	**CERB**	TERMINALE COFANO POST IN CARBONIO	890807	PARETE INF.COND.SPOILER POST.C	ALL	**55%**	**9%**
EXTERNAL	**CEL2**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	826052	PARATIA EST.SOTTOL.VANO MOT.CA	ALL	**33%**	**15%**
			813260	PAR EST SX CPL VA MOT CAR ASTA	ALL	**33%**	
			880045	PARATIA EST.DX MOTORE CARB.AST	ALL	**33%**	
			911776	PARATIA EST.DX CARB.MOT.STABIL	ALL	**33%**	
			880045	PARATIA EST.DX MOTORE CARB.AST	ALL	**33%**	
			782017	PARATIA ESTET.SX VANO MOTORE C	ALL	**33%**	
EXTERNAL	**BONF**	TELAIETTO COFANO MOTORE IN CARBONIO	855145	COFANO POSTERIORE IN CARBONIO	ALL	**15%**	**0%**

Table 5: carbon fiber items associated to the relative options for F8 Tributo.

F8 Spider							
Functional group	**Option**	**Option description**	**Item code**	**Item description**	**Markets**	**FAR**	**RAR**
EXTERNAL	**CERB**	TERMINALE COFANO POST IN CARB E GRIGLIA MOTORE	73730844	CONDOTTO SPOILER POST.CPL CARB	ALL	**55%**	**30%**
			958397	GRIGL.USC.ARIA COF.MOT.DX CPL	ALL	**55%**	
			958423	GRIGL.USC.ARIA COF.MOT.SX CPL	ALL	**55%**	
EXTERNAL	**CERF**	INSERTO MONTANTE B IN CARBONIO SPIDER	87586400	MOSTRINA ESTETICA SX MONT.B CS	ALL	**50%**	**24%**
			87586000	MOSTRINA ESTETICA DX MONT.B CS	ALL	**50%**	
EXTERNAL	**CEL2**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	938571	PARATIA EST.DX CPL VANO MOT.CA	ALL	**33%**	**4%**
			938572	PARATIA EST.SX CPL VANO MOT.CA	ALL	**33%**	

Table 6: carbon fiber items associated to the relative options for F8 Spider.

Subsequently, a further inspection of the selected item codes has been performed and the following Carry Over options, together with the previously mentioned, have been identified:

- RSCH
- RSCD
- RMCF
- CUPC
- CERF

They will not be object of the analysis anymore because of their Carry Over nature: from a production capacity perspective, criticalities should not emerge.

For each option, both the Forecasted Absorption Rate and the Real Absorption Rate are associated. Specifically for the Forecasted Absorption Rate, the values shown in the tables above take already into account the influence of the destination market.

In general, the market is distributed as follows:

- USA, USL and CAN stand for United States of America, USA light (which refers to those countries that have similar regulations and rules as USA with few differences) and Canada, respectively; to them a 40% of total distribution is attributed;
- GDX markets, which are those countries with right-handed drive cars, such as United Kingdom, Australia, Japan; 25% of the total distribution is dedicated to them;

- Rest of the GSX market, i.e. countries with left-handed drive excluding areas of USA, USL and CAN markets; it refers to countries in Europe (excluding UK), Middle East and others. 35% of the total distribution is attributed to these markets.

The previous distribution percentages have been taken into account together to the absorption rates in order to compute the final value of Forecasted Absorption Rates for each item.
Hence, given an absorption rate AR:

Case	**Item Forecasted Absorption Rate**
Item can be mounted in cars with any destination market	AR
Item can be mounted only in USA, USL and CAN cars	AR * 40%
Item can be mounted only in cars with any destination market excluding USA, USL and CAN	AR * 60%
Item can be mounted only in GDX cars	AR * 25%
Item can be mounted only in GSX cars	AR * (40%+35%)

Table 7: how to compute the specific absorption rate of an item according to its market destinations.

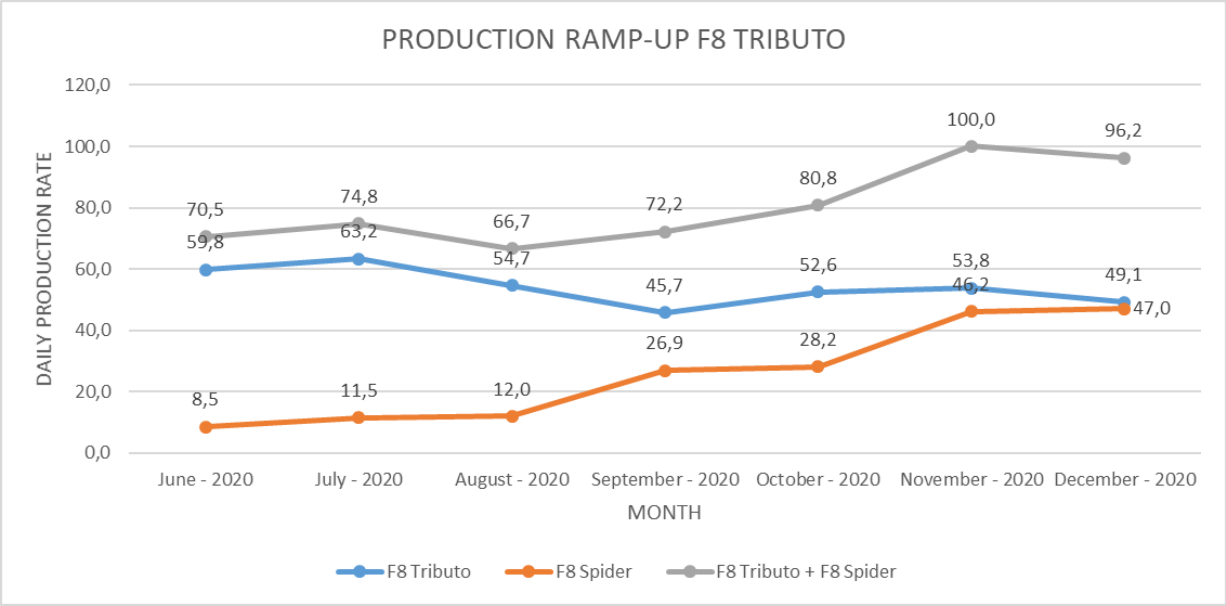
In case of destination markets not categorized as in the table above, approximations have been made. For instance, in the case of USA + CAN markets, the same percentage of USA + USL + CAN have been used.
Most of the above listed components are actually sub-assembled products, which are composed by carbon fiber parts but also by other materials that should not be critical. In order to isolate the analysis only to the carbon fiber components, it is necessary to investigate which are the particular parts that are made of carbon fiber and the relative supplier. In some cases, tier 2 suppliers need to be involved as they supply tier 1 companies of the carbon fiber parts and then the latter assemble the component to be delivered to Ferrari.

5.2.1.3 F8 Tributo and F8 Spider production ramp-up

Now that all the items in carbon fiber have been identified and listed, associated with their specific Forecasted Absorption Rate, it is necessary to collect data about the production ramp-up of the F8 Tributo and F8 Spider.

	F8 Tributo	F8 Spider	F8 Tributo + F8 Spider
Month	**Daily production rate**		
June - 2020	**59,8**	**8,5**	**70,5**
July - 2020	**63,2**	**11,5**	**74,8**
August - 2020	**54,7**	**12,0**	**66,7**
September - 2020	**45,7**	**26,9**	**72,2**
October - 2020	**52,6**	**28,2**	**80,8**
November - 2020	**53,8**	**46,2**	**100,0**
December - 2020	**49,1**	**47,0**	**96,2**

Table 8: production ramp-up on a daily basis, month by month, of F8 Tributo and F8 Spider from June to December 2020.



Graph 4: production ramp-up on a daily basis, month by month, of F8 Tributo and F8 Spider from June to December 2020.

5.2.1.4 Items production need

By multiplying daily production rate month by month with Forecasted Absorption Rates of each item, the specific production need related to each component is obtained.

F8 Tributo + F8 Spider						Month						
						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily car production rate						
Option	**Item code**	**Item description**	**Markets**	**FAR**	**RAR**	**70,5**	**74,8**	**66,7**	**72,2**	**80,8**	**100,0**	**96,2**
						Specific production need						
LEDS	73520444	VOLANTE CPL F142MFL CARB+LED	ALL	**90%**	**95%**	63,7	67,5	59,8	65,0	72,6	90,2	86,8
CEAI	914076	COPER.EST.CENT.PROLUNGA CARB.C	ALL	**55%**	**13%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	904557	IMBOCCO S-DUCT CARB. COFANO AN	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
CEXG	73530344	PARAURTO ANT.CS FLICK INF.LAT	NO USA, CAN	**44%**	**20%**	31,2	32,9	29,5	31,6	35,5	44,0	42,3
	73574244	PARAURTO ANT.CS FLICK LAT. CA	USA, USL, CAN	**22%**		15,4	16,7	14,5	15,8	17,9	21,8	21,4
FCWS	73530744	PARAURTO ANT.CS.MOSTRINA CENTR	NO USA, CAN	**44%**	**25%**	31,2	32,9	29,5	31,6	35,5	44,0	42,3
	73574144	PARAURTO ANT. CS MOSTR.CENTR.C	USA, USL, CAN	**22%**		15,4	16,7	14,5	15,8	17,9	21,8	21,4
CEXF	881792	PRESA ARIA FRENI DX CPL CARB.	ALL	**55%**	**11%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	881787	PRESA ARIA FRENI SX CPL CARB.	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
CEIS	891184	ALA LATERALE CARBONIO DX CPL	ALL	**55%**	**61%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	891163	ALA LATERALE CARBONIO SX CPL	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
CEXS	73527944	RIVESTIM. SOTTOPORTA DX CPL CA	ALL	**55%**	**16%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	73528044	RIVESTIM. SOTTOPORTA SX CPL CA	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0

CEXD	906929	SCIVOLO ESTRATTORE CPL BASE CA	ALL	**55%**	**21%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	899283	PORTELLA CENTRALE IN CARBONIO	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
	786906	PORTELLA LATERALE DX CARBONIO	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
	786905	PORTELLA LATERALE SX CARBONIO	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
CIDL	863731	NQS ECE OPT NERO CARB	NO USA	**55%**	**61%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
	863752	NQS USA OPT NERO CARB	SOLO USA	**22%**		15,4	16,7	14,5	15,8	17,9	21,8	21,4
	327251	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
	892382	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**		38,9	41,0	36,8	39,7	44,4	55,1	53,0
CILR	881252	BRIDGE COMANDI F1 CARBONIO CPL	NO USA, USL, CAN	**28%**	**60%**	19,7	20,9	18,8	20,1	22,6	28,2	26,9
	896471	BRIDGE COMANDI F1 CARB LUCI US	USA, USL, CAN	**18%**		12,8	13,7	12,0	12,8	14,5	17,9	17,5
CIDH	912466	MANIG TIRAPO CARBON LUCIDO SX	ALL	**46%**	**24%**	32,5	34,6	30,8	33,3	37,2	46,2	44,4
	918560	MANIG TIRAP CARBON LUCIDO DX C	ALL	**46%**		32,5	34,6	30,8	33,3	37,2	46,2	44,4
CFPA	881217	GRUPPO COM.CAMBIO F1 RACING KE	ALL	**24%**	**13%**	17,1	17,9	15,8	17,5	19,2	23,9	23,1
	890896	GRUPPO COM.CAMBIO F1 RACING CA	ALL	**24%**		17,1	17,9	15,8	17,5	19,2	23,9	23,1

DATR	922005	SATELLITE DX PASS. CARB. CPL	NO AUS, UK	**33%**	**41%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
	891898	SATELLITE SX GUIDATORE CARB CP	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
	892196	SATELLITE DX GUID CARB CPL	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
DATR GDX	899428	SATELLITE SX PASSEG CAR LUC GD	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
CIIP	892176	VELA SUP SX CARB OP CPL	NO AUS, UK	**33%**	**5%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
	892178	FUSIONE SUP SX GUID CARB OP CP	NO AUS, UK	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	892181	SATELLITE SX GUIDATORE CARB OP	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
	892599	VELA SUP DX CARB OP CPL	NO AUS, UK	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	892596	FUSIONE SUP DX GUID CARB OP CP	NO AUS, UK	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	892598	SATELLITE DX GUID CARB OP CPL	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
CIIP GDX	899359	VELA SUPER SX CARB OPACO GDX C	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
	899305	VELA SUPERIORE DX CARB OPACO G	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
	936682	FUSIONE SUP DX GUID CARB GDX	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
	899358	FUSIONE FINIZ SUP SX CARB OPA	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
CITZ	891932	CORNICE MOBILE CARBONIO LUCIDO	ALL	**44%**	**12%**	31,2	32,9	29,5	31,6	35,5	44,0	42,3

CIPZ	908592	COMP PAN+TASC PORTA SX CAR LUC	NO AUS, UK	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	908597	COMP PAN+TASC PORTA DX CAR LUC	NO AUS, UK	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
CIPZ GDX	909716	COMP PAN+TASCA PORTA CARB LUC	UK, AUS	**11%**	**3%**	7,7	8,1	7,3	8,1	9,0	11,1	10,7
	909714	COMP PAN+TAS PORT CARB LUC DX	UK, AUS	**11%**		7,7	8,1	7,3	8,1	9,0	11,1	10,7
CISK	86538300	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
	86538200	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
	915177	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**	**17%**	31,2	32,9	29,5	31,6	35,5	44,0	42,3
	915176	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**		31,2	32,9	29,5	31,6	35,5	44,0	42,3
MNFC	902970	Polmone aspirazione DX CPL	ALL	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	902971	Polmone aspirazione SX CPL	ALL	**33%**	**3%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
CEL2	86935100	PARATIA EST.CENT.VANO MOT.CPL	ALL	**33%**	**11%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
CIZB	881765	COPERTURA ESTETICA DX CPL CARB	ALL	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	881763	COPERTURA ESTETICA SX CPL CARB	ALL	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6
	881773	MOSTRINA SOTTOPARABREZZA DX CP	NO AUS, UK	**25%**	**1%**	17,5	18,8	16,7	17,9	20,1	25,2	23,9
	881771	MOSTRINA SOTTOPARABREZZA SX CP	NO AUS, UK	**25%**		17,5	18,8	16,7	17,9	20,1	25,2	23,9
	881769	COPERTURA ESTETICA CENTRALE CP	ALL	**33%**		23,1	24,8	21,8	23,9	26,5	32,9	31,6

CIZB GDX	895812	MOSTRINA SOTTOP DX CPL GDX CAR	UK, AUS	**8%**		5,6	6,0	5,1	6,0	6,4	8,1	7,7
	895839	MOSTRINA SOTTOP. SX CPL GDX CA	UK, AUS	**8%**		5,6	6,0	5,1	6,0	6,4	8,1	7,7

Table 9: specific production need for each item on a daily basis, month by month, for F8 Tributo and F8 Spider.

F8 Tributo						**Month**						
						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily car production rate						
Option	**Item code**	**Item description**	**Markets**	**FAR**	**RAR**	**59,8**	**63,2**	**54,7**	**45,7**	**52,6**	**53,8**	**49,1**
						Specific production need						
CERB	890807	PARETE INF.COND.SPOILER POST.C	ALL	**55%**	**9%**	32,9	34,6	29,9	25,2	29,1	29,5	26,9
CEL2	826052	PARATIA EST.SOTTOL.VANO MOT.CA	ALL	**33%**	**15%**	19,7	20,9	17,9	15,0	17,5	17,9	16,2
	813260	PAR EST SX CPL VA MOT CAR ASTA	ALL	**33%**		19,7	20,9	17,9	15,0	17,5	17,9	16,2
	880045	PARATIA EST.DX MOTORE CARB.AST	ALL	**33%**		19,7	20,9	17,9	15,0	17,5	17,9	16,2
	911776	PARATIA EST.DX CARB.MOT.STABIL	ALL	**33%**		19,7	20,9	17,9	15,0	17,5	17,9	16,2
	782017	PARATIA ESTET.SX VANO MOTORE C	ALL	**33%**		19,7	20,9	17,9	15,0	17,5	17,9	16,2
BONF	855145	COFANO POSTERIORE IN CARBONIO	ALL	**15%**	**0%**	9,0	9,4	8,1	6,8	7,7	8,1	7,3

Table 10: specific production need for each item on a daily basis, month by month, for F8 Tributo.

F8 Spider						Month						
						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily car production rate						
Option	**Item code**	**Item description**	**Markets**	**FAR**	**RAR**	**8,5**	**11,5**	**12,0**	**26,9**	**28,2**	**46,2**	**47,0**
						Specific production need						
CERB	73730844	CONDOTTO SPOILER POST.CPL CARB	ALL	**55%**	**30%**	4,7	6,4	6,4	15,0	15,4	25,2	26,1
	958397	GRIGL.USC.ARIA COF.MOT.DX CPL	ALL	**55%**		4,7	6,4	6,4	15,0	15,4	25,2	26,1
	958423	GRIGL.USC.ARIA COF.MOT.SX CPL	ALL	**55%**		4,7	6,4	6,4	15,0	15,4	25,2	26,1
CEL2	938571	PARATIA EST.DX CPL VANO MOT.CA	ALL	**33%**	**4%**	3,0	3,8	3,8	9,0	9,4	15,4	15,4
	938572	PARATIA EST.SX CPL VANO MOT.CA	ALL	**33%**		3,0	3,8	3,8	9,0	9,4	15,4	15,4

Table 11: specific production need for each item on a daily basis, month by month, for F8 Spider.

In the matrixes above, many of the collected information are synthetized into a unique representation mean, also adding data about production need specific to each item. The latter has been computed by multiplying the daily production rate of the car model in its version in the month of interest (in the blue boxes) with the specific Forecasted Absorption Rate of each item.

Now, the expected quantities of each item that will be demanded by Ferrari on a daily basis are known.

5.2.2 F8 Tributo and F8 Spider external data mining

A further step can now be performed: collecting relevant data and information directly from suppliers, in order to derive their production capacity over time.

Theoretically, maximum production capacity refers to how many parts can be produced according to equipment (i.e. lamination tools) and work force. The data that will be collected should be called "Maximum delivery capacity", which is of interest for Ferrari, because it considers process scraps as well as subsequent production steps, such as coating and finishing, which are non-negligible in terms of lead time and criticalities. For simplicity, it is called just production capacity.

Therefore, the number of equipped lamination tools or the equipment plan of the lamination tools is surely a fundamental input in the computation of production capacity. Indeed, by considering number of currently equipped lamination tools and process time, a quantity of daily average processed parts can be derived, but it is not sufficient. In addition to that, supplier considers the overall process scrap rate and the overall processing time (including subsequent production steps such as coating and finishing).

Production capacity values computed considering all the above-mentioned aspects can be interpreted as reliable.

For the Product Definition area is fundamental to be aware of all these aspects and contributions, because, thanks to the deep understanding of the process steps, decisions about supplier equipment can be made.

Moreover, Ferrari is deeply involved in such decisions and directly invests for equipment and tooling in order to reduce dependency on suppliers, which can be strategically dangerous, and because of:

- high components specificity,
- high quality standards,
- process complexity,
- expensiveness of parts.

Through this modus operandi, suppliers are very transparent and Ferrari can leverage on more flexibility, because, by enabling a strong co-development strategy, it can operate and make changes more freely.

From the perspective of the suppliers it is convenient as well, in order to reduce the occurrence of hold-up problems: they are situations where two parties refrain from cooperating thus increasing the bargaining power of one of them reducing profits and leading to severe economic cost for the other party.

5.2.2.1 Suppliers' production capacity

In the following matrix, the specific production capacity for each item is listed, as daily production capacity, in each month from June 2020 to December 2020.

F8 Tributo + Spider						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
Option	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Daily production capacity**						
LEDS	73520444	VOLANTE CPL F142MFL CARB+LED	ALL	**90%**	ALPHA SPA	66,2	66,2	70,5	72,6	81,2	89,7	89,7
CEAI	914076	COPER.EST.CENT.PROLUNGA CARB.C	ALL	**55%**	BETA SPA	17,1	32,1	42,7	42,7	51,3	51,3	51,3
	904557	IMBOCCO S-DUCT CARB. COFANO AN	ALL	**55%**	BETA SPA	17,1	32,1	42,7	42,7	51,3	51,3	51,3
CEXG	890505	FLICK AERO INF. LAT. SX CARBON	ALL	**55%**	GAMMA SPA (tier 2)	54,7	54,7	54,7	54,7	54,7	54,7	54,7
	890502	FLICK AERO INF. LAT. DX CARBON	ALL	**55%**	GAMMA SPA (tier 2)	54,7	54,7	54,7	54,7	54,7	54,7	54,7
FCWS	890546	MOSTRINA CENTR.CARBONIO	ALL	**55%**	GAMMA SPA (tier 2)	54,7	54,7	54,7	54,7	54,7	54,7	54,7
CEXF	881792	PRESA ARIA FRENI DX CPL CARB.	ALL	**55%**	KAPPA SRL	42,7	47,0	47,0	47,0	47,0	47,0	47,0
	881787	PRESA ARIA FRENI SX CPL CARB.	ALL	**55%**	KAPPA SRL	42,7	47,0	47,0	47,0	47,0	47,0	47,0
CEIS	891184	ALA LATERALE CARBONIO DX CPL	ALL	**55%**	EPSILON SRL	42,7	46,2	51,3	76,9	76,9	76,9	76,9
	891163	ALA LATERALE CARBONIO SX CPL	ALL	**55%**	EPSILON SRL	42,7	48,7	51,3	76,9	76,9	76,9	76,9

CEXS	73527944	RIVESTIM. SOTTOPORTA DX CPL CA	ALL	**55%**	KAPPA SRL	49,1	49,1	49,1	49,1	49,1	49,1	49,1
	73528044	RIVESTIM. SOTTOPORTA SX CPL CA	ALL	**55%**	KAPPA SRL	49,1	49,1	49,1	49,1	49,1	49,1	49,1
CEXD	906929	SCIVOLO ESTRATTORE CPL BASE CA	ALL	**55%**	KAPPA SRL	21,4	25,6	25,6	34,2	38,5	42,7	49,1
	899283	PORTELLA CENTRALE IN CARBONIO	ALL	**55%**	KAPPA SRL	21,4	25,6	25,6	34,2	38,5	42,7	49,1
	786906	PORTELLA LATERALE DX CARBONIO	ALL	**55%**	EPSILON SRL	34,2	34,2	34,2	64,1	64,1	64,1	64,1
	786905	PORTELLA LATERALE SX CARBONIO	ALL	**55%**	EPSILON SRL	34,2	34,2	34,2	64,1	64,1	64,1	64,1
CIDL	863731	NQS ECE OPT NERO CARB	NO USA	**55%**	ZETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
	863752	NQS USA OPT NERO CARB	SOLO USA	**22%**	ZETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
	327251	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	ALPHA SPA (tier 2)	170,9	170,9	170,9	170,9	170,9	170,9	170,9
	892382	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	ALPHA SPA (tier 2)							
CILR	881252	BRIDGE COMANDI F1 CARBONIO CPL	NO USA, USL, CAN	**28%**	TETA SPA	61,5	61,5	61,5	61,5	61,5	61,5	61,5
	896471	BRIDGE COMANDI F1 CARB LUCI US	USA, USL, CAN	**18%**	TETA SPA	61,5	61,5	61,5	61,5	61,5	61,5	61,5
CIDH	912466	MANIG TIRAPO CARBON LUCIDO SX	ALL	**46%**	KAPPA SRL	34,2	40,6	40,6	42,7	42,7	42,7	42,7
	918560	MANIG TIRAP CARBON LUCIDO DX C	ALL	**46%**	KAPPA SRL	34,2	40,6	40,6	42,7	42,7	42,7	42,7
CFPA	881217	GRUPPO COM.CAMBIO F1 RACING KE	ALL	**44%**	ALPHA SPA (tier 2)	170,9	170,9	170,9	170,9	170,9	170,9	170,9

	890896	GRUPPO COM.CAMBIO F1 RACING CA	ALL	**44%**	ALPHA SPA (tier 2)							
DATR	922005	SATELLITE DX PASS. CARB. CPL	NO AUS, UK	**33%**	TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
	891898	SATELLITE SX GUIDATORE CARB CP	ALL	**44%**	TETA SPA	46,2	46,2	46,2	46,2	46,2	46,2	46,2
	892196	SATELLITE DX GUID CARB CPL	ALL	**44%**	TETA SPA	46,2	46,2	46,2	46,2	46,2	46,2	46,2
DATR GDX	899428	SATELLITE SX PASSEG CAR LUC GD	UK, AUS	**11%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4
CIIP	892176	VELA SUP SX CARB OP CPL	NO AUS, UK	**33%**	TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
	892178	FUSIONE SUP SX GUID CARB OP CP	NO AUS, UK	**33%**	TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
	892181	SATELLITE SX GUIDATORE CARB OP	ALL	**44%**	TETA SPA	46,2	46,2	46,2	46,2	46,2	46,2	46,2
	892599	VELA SUP DX CARB OP CPL	NO AUS, UK	**33%**	TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
	892596	FUSIONE SUP DX GUID CARB OP CP	NO AUS, UK	**33%**	TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
	892598	SATELLITE DX GUID CARB OP CPL	ALL	**44%**	TETA SPA	46,2	46,2	46,2	46,2	46,2	46,2	46,2
	892618	FUSIONE SUP DX GUID CARB OP RU	EU (RUS)		TETA SPA	38,5	38,5	38,5	38,5	38,5	38,5	38,5
CIIP GDX	899359	VELA SUPER SX CARB OPACO GDX C	UK, AUS	**11%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4
	899305	VELA SUPERIORE DX CARB OPACO G	UK, AUS	**11%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4
	936682	FUSIONE SUP DX GUID CARB GDX	UK, AUS	**11%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4

CIIP GDX	899358	FUSIONE FINIZ SUP SX CARB OPA	UK, AUS	**11%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4
CITZ	891932	CORNICE MOBILE CARBONIO LUCIDO	ALL	**44%**	TETA SPA	50,0	50,0	50,0	50,0	50,0	50,0	50,0
CIPZ	908592	COMP PAN+TASC PORTA SX CAR LUC	NO AUS, UK	**33%**	KAPPA SRL	25,6	25,6	29,9	34,2	38,5	38,5	38,5
	908597	COMP PAN+TASC PORTA DX CAR LUC	NO AUS, UK	**33%**	KAPPA SRL	25,6	25,6	29,9	34,2	38,5	38,5	38,5
CIPZ GDX	909716	COMP PAN+TASCA PORTA CARB LUC	UK, AUS	**11%**	KAPPA SRL	25,6	25,6	29,9	34,2	38,5	38,5	38,5
	909714	COMP PAN+TAS PORT CARB LUC DX	UK, AUS	**11%**	KAPPA SRL	25,6	25,6	29,9	34,2	38,5	38,5	38,5
CISK	86538300	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**	TETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
	86538200	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**	TETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
	915177	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**	TETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
	915176	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**	TETA SPA	76,9	76,9	76,9	76,9	76,9	76,9	76,9
MNFC	902970	Polmone aspirazione DX CPL	ALL	**33%**	KAPPA SRL	21,4	25,6	25,6	29,9	29,9	29,9	29,9
	902971	Polmone aspirazione SX CPL	ALL	**33%**	KAPPA SRL	21,4	25,6	25,6	29,9	29,9	29,9	29,9
CEL2	86935100	PARATIA EST.CENT.VANO MOT.CPL	ALL	**33%**	TETA SPA	65,4	65,4	65,4	65,4	65,4	65,4	65,4

CIZB	881765	COPERTURA ESTETICA DX CPL CARB	ALL	**33%**	TETA SPA	32,5	32,5	32,5	32,5	32,5	32,5	32,5
	881763	COPERTURA ESTETICA SX CPL CARB	ALL	**33%**	TETA SPA	32,5	32,5	32,5	32,5	32,5	32,5	32,5
	881773	MOSTRINA SOTTOPARABREZZA DX CP	NO AUS, UK	**25%**	TETA SPA	26,9	26,9	26,9	26,9	26,9	26,9	26,9
	881771	MOSTRINA SOTTOPARABREZZA SX CP	NO AUS, UK	**25%**	TETA SPA	26,9	26,9	26,9	26,9	26,9	26,9	26,9
	881769	COPERTURA ESTETICA CENTRALE CP	ALL	**33%**	TETA SPA	32,5	32,5	32,5	32,5	32,5	32,5	32,5
CIZB GDX	895812	MOSTRINA SOTTOP DX CPL GDX CAR	UK, AUS	**8%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4
	895839	MOSTRINA SOTTOP. SX CPL GDX CA	UK, AUS	**8%**	TETA SPA	15,4	15,4	15,4	15,4	15,4	15,4	15,4

Table 12: suppliers' production capacity specific for each item for F8 Tributo and F8 Spider.

In some cases, the production capacity is associated to a group of item codes, as it is for option CIDL and CFPA, in particular 327251 together with 892382 and 881217 coupled with 890896, respectively. These components present a unified production capacity because they are similar parts, produced with a similar process, exactly in the same lamination tools. They differ just for the coating phase: the result may be a carbon look component or an opaque black one.

Figure 17: example of a carbon look component, specifically the internal central tunnel of the Ferrari 488 GTB

F8 Tributo						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
Option	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Daily production capacity**						
CERB	890807	PARETE INF.COND.SPOILER POST.C	ALL	**55%**	EPSILON SRL	34,2	34,2	34,2	34,2	34,2	34,2	34,2
CEL2	826052	PARATIA EST.SOTTOL.VANO MOT.CA	ALL	**33%**	TETA SPA	46,2	46,2	46,2	46,2	46,2	46,2	46,2
	813260	PAR EST SX CPL VA MOT CAR ASTA	ALL	**33%**	TETA SPA	17,1	17,1	17,1	17,1	17,1	17,1	17,1
	880045	PARATIA EST.DX MOTORE CARB.AST	ALL	**33%**	TETA SPA	17,1	17,1	17,1	17,1	17,1	17,1	17,1
	911776	PARATIA EST.DX CARB.MOT.STABIL	ALL	**33%**	TETA SPA	17,1	17,1	17,1	17,1	17,1	17,1	17,1
	782017	PARATIA ESTET.SX VANO MOTORE C	ALL	**33%**	TETA SPA	17,1	17,1	17,1	17,1	17,1	17,1	17,1
BONF	855145	COFANO POSTERIORE IN CARBONIO	ALL	**15%**	TETA SPA	7,7	7,7	7,7	7,7	7,7	7,7	7,7

Table 13: suppliers' production capacity specific for each item for F8 Tributo.

F8 Spider						jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
Option	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Daily production capacity**						
CERB	73730844	CONDOTTO SPOILER POST.CPL CARB	ALL	**55%**	BETA SPA (tier 2)	4,3	6,8	8,5	19,2	25,6	25,6	25,6
	958397	GRIGL.USC.ARIA COF.MOT.DX CPL	ALL	**55%**	BETA SPA	4,3	6,8	8,5	19,2	25,6	25,6	25,6
	958423	GRIGL.USC.ARIA COF.MOT.SX CPL	ALL	**55%**	BETA SPA	4,3	6,8	8,5	19,2	25,6	25,6	25,6
CEL2	938571	PARATIA EST.DX CPL VANO MOT.CA	ALL	**33%**	TETA SPA	21,4	21,4	21,4	21,4	21,4	21,4	21,4
	938572	PARATIA EST.SX CPL VANO MOT.CA	ALL	**33%**	TETA SPA	21,4	21,4	21,4	21,4	21,4	21,4	21,4

Table 14: suppliers' production capacity specific for each item for F8 Spider.

For each part, the related supplier is associated. The information in brackets "tier 2" is explicated when such supplier does not delivery the component to Ferrari but it produces particular parts in carbon fiber that are supplied to a tier 1 producer. Then, the latter assembles carbon fiber and other materials together in order to deliver to Ferrari the sub-assembled product that can be assembled in the production line.

As can be easily seen, some options are associated to items that are produced by different suppliers, hence, with slightly different production capacity. For this reason, it is not possible to perform the analysis on an option basis rather on a specific item basis.

The above tables show two different type of situations:

- some suppliers, such as TETA S.p.A., have completed the equipment phase, as the maximum production capacity is stable over time;
- other suppliers, such as BETA SPA, present an increasing production capacity, meaning that they are currently in the equipment and tooling phase.

The latter situation may require more attention because both Ferrari car production rate and supplier production capacity are increasing. Therefore, it is necessary to check and monitor that the supplier's ramp-up curve is constantly higher than the F8 Tributo one.
Now that all the necessary data have been collected from suppliers, the core activity of the analysis can be performed: **comparing internal production needs with suppliers' production capacity and verify if criticalities emerge.**

5.2.3 Evaluation and interpretation

In the following paragraph the production needs, computed by taking into account Forecasted Absorption Rate of the associated options and market destinations, are compared to the maximum production capacity declared by suppliers, both related to each specific item.
The values shown are average values per day related to the correspondent month.
All the options (linked to the relative items) are grouped according to their Forecasted Absorption Rate (FAR). For each group of options with the same FAR, the specific production need month by month is computed and inserted in the grey boxes.
Below each grey line the item codes are listed with the corresponding production capacity values declared by suppliers. The production capacity values are shown in green or red:

- green if the production capacity for that month is higher than the relative production need (shown above in the grey box in the corresponding column);
- red if the production capacity for that month is lower than the relative production need (shown above in the grey box in the corresponding column).

F8 Tributo + F8 Spider				Daily production rate ->		70,5	74,8	66,7	72,2	80,8	100	96,2
OPT	Item code	Markets	FAR	Supplier	Specific abs. Rate ↓	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily production capacity						
				Abs./day (ALL MKT)	90%	63,7	67,5	59,8	65,0	72,6	90,2	86,8
LEDS	73520444	ALL	90%	ALPHA SPA		66,2	66,2	70,5	72,6	81,2	89,7	89,7
				Abs./day (ALL MKT)	55%	38,9	41,0	36,8	39,7	44,4	55,1	53,0
CEAI	914076	ALL	55%	BETA SPA		17,1	32,1	42,7	42,7	51,3	51,3	51,3
	904557	ALL	55%	BETA SPA		17,1	32,1	42,7	42,7	51,3	51,3	51,3
CEXG	890505	ALL	55%	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
	890502	ALL	55%	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
FCWS	890546	ALL	55%	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
CEXF	881792	ALL	55%	KAPPA SRL		42,7	47,0	47,0	47,0	47,0	47,0	47,0
	881787	ALL	55%	KAPPA SRL		42,7	47,0	47,0	47,0	47,0	47,0	47,0
CEIS	891184	ALL	55%	EPSILON SRL		42,7	45,9	51,3	76,9	76,9	76,9	76,9
	891163	ALL	55%	EPSILON SRL		42,7	48,5	51,3	76,9	76,9	76,9	76,9
CEXS	73527944	ALL	55%	KAPPA SRL		49,1	49,1	49,1	49,1	49,1	49,1	49,1
	73528044	ALL	55%	KAPPA SRL		49,1	49,1	49,1	49,1	49,1	49,1	49,1
CEXD	906929	ALL	55%	KAPPA SRL		21,4	25,6	25,6	34,2	38,5	42,7	49,1
	899283	ALL	55%	KAPPA SRL		21,4	25,6	25,6	34,2	38,5	42,7	49,1
	786906	ALL	55%	EPSILON SRL		34,2	34,2	34,2	64,1	64,1	64,1	64,1
	786905	ALL	55%	EPSILON SRL		34,2	34,2	34,2	64,1	64,1	64,1	64,1
				Abs./day (CIDL)	31%	21,8	23,1	20,5	22,2	24,8	30,8	29,5
CIDL	863731	NO USA	55%	ZETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
	863752	SOLO USA	22%	ZETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
	327251	ALL	55%	ALPHA SPA (tier 2)		170,9	170,9	170,9	170,9	170,9	170,9	170,9
	892382	ALL	55%	ALPHA SPA (tier 2)								
				Abs./day (ALL MKT)	46%	32,5	34,6	30,8	33,3	37,2	46,2	44,4
				Abs./day (NO USA,USL, CAN)	28%	19,7	20,5	18,4	20,1	22,2	27,8	26,5
				Abs./day (USA,USL,CAN)	18%	12,8	13,7	12,4	13,2	15,0	18,4	17,5
CILR	881252	NO USA, USL, CAN	28%	TETA SPA		61,5	61,5	61,5	61,5	61,5	61,5	61,5
	896471	USA, USL, CAN	18%	TETA SPA		61,5	61,5	61,5	61,5	61,5	61,5	61,5
CIDH	912466	ALL	46%	KAPPA SRL		34,2	40,6	40,6	42,7	42,7	42,7	42,7
	918560	ALL	46%	KAPPA SRL		34,2	40,6	40,6	42,7	42,7	42,7	42,7

				Abs./day (CFPA)	**24%**	**17,1**	**17,9**	**16,2**	**17,5**	**19,7**	**24,4**	**23,1**
				Abs./day (ALL MKT)	**44%**	**31,2**	**32,9**	**29,5**	**31,6**	**35,5**	**44,0**	**42,3**
				Abs./day (GDX MKT)	**11%**	**7,7**	**8,1**	**7,3**	**8,1**	**9,0**	**11,1**	**10,7**
				Abs./day (NO AUS, UK)	**33%**	**23,1**	**24,8**	**21,8**	**23,9**	**26,5**	**32,9**	**31,6**
CFPA	881217	ALL	**44%**	ALPHA SPA (tier 2)		**170,9**	**170,9**	**170,9**	**170,9**	**170,9**	**170,9**	**170,9**
	890896	ALL	**44%**	ALPHA SPA (tier 2)								
DATR	922005	NO AUS, UK	**33%**	TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
	891898	ALL	**44%**	TETA SPA		**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**
	892196	ALL	**44%**	TETA SPA		**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**
DATR GDX	899428	UK, AUS	**11%**	TETA SPA		**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**
CIIP	892176	NO AUS, UK	**33%**	TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
	892178	NO AUS, UK	**33%**	TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
	892181	ALL	**44%**	TETA SPA		**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**
	892599	NO AUS, UK	**33%**	TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
	892596	NO AUS, UK	**33%**	TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
	892598	ALL	**44%**	TETA SPA		**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**	**46,2**
	892618	EU (RUS)		TETA SPA		**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**	**38,5**
CIIP GDX	899359	UK, AUS	**11%**	TETA SPA		**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**
	899305	UK, AUS	**11%**	TETA SPA		**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**
	936682	UK, AUS	**11%**	TETA SPA		**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**
	899358	UK, AUS	**11%**	TETA SPA		**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**	**15,4**
CITZ	891932	ALL	**44%**	TETA SPA		**50,0**	**50,0**	**50,0**	**50,0**	**50,0**	**50,0**	**50,0**
CIPZ	908592	NO AUS, UK	**33%**	KAPPA SRL		**25,6**	**25,6**	**29,9**	**34,2**	**38,5**	**38,5**	**38,5**
	908597	NO AUS, UK	**33%**	KAPPA SRL		**25,6**	**25,6**	**29,9**	**34,2**	**38,5**	**38,5**	**38,5**
CIPZ GDX	909716	UK, AUS	**11%**	KAPPA SRL		**25,6**	**25,6**	**29,9**	**34,2**	**38,5**	**38,5**	**38,5**
	909714	UK, AUS	**11%**	KAPPA SRL		**25,6**	**25,6**	**29,9**	**34,2**	**38,5**	**38,5**	**38,5**
CISK	86538300	ALL	**44%**	TETA SPA		**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**
	86538200	ALL	**44%**	TETA SPA		**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**
	915177	ALL	**44%**	TETA SPA		**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**
	915176	ALL	**44%**	TETA SPA		**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**	**76,9**

				Abs./day (ALL MKT)	33%	23,1	24,8	21,8	23,9	26,5	32,9	31,6
				Abs./day (GDX MKT)	8%	6,0	6,0	5,6	6,0	6,8	8,1	8,1
				Abs./day (NO AUS, UK)	25%	17,5	18,4	16,7	17,9	20,1	24,8	23,9
MNFC	902970	ALL	33%	KAPPA SRL		21,4	25,6	25,6	29,9	29,9	29,9	29,9
	902971	ALL	33%	KAPPA SRL		21,4	25,6	25,6	29,9	29,9	29,9	29,9
CEL2	86935100	ALL	33%	TETA SPA		65,4	65,4	65,4	65,4	65,4	65,4	65,4
CIZB	881765	ALL	33%	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
	881763	ALL	33%	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
	881773	NO AUS, UK	25%	TETA SPA		26,9	26,9	26,9	26,9	26,9	26,9	26,9
	881771	NO AUS, UK	25%	TETA SPA		26,9	26,9	26,9	26,9	26,9	26,9	26,9
	881769	ALL	33%	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
CIZB GDX	895812	UK, AUS	8%	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
	895839	UK, AUS	8%	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4

Table 15: comparison between suppliers' production capacity and Ferrari production needs for F8 Tributo and F8 Spider.

F8 Tributo				Daily production rate ->		59,8	63,2	54,7	45,7	52,6	53,8	49,1
OPT	Item code	Markets	FAR	Supplier	Specific abs. rate ↓	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily production capacity						
				Abs./day (ALL MKT)	55%	32,9	34,6	29,9	25,2	29,1	29,5	26,9
CERB	890807	ALL	55%	EPSILON SRL		34,2	34,2	34,2	34,2	34,2	34,2	34,2
				Abs./day (ALL MKT)	33%	19,7	20,9	17,9	15,0	17,5	17,9	16,2
CEL2	826052	ALL	33%	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
	813260	ALL	33%	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
	880045	ALL	33%	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
	911776	ALL	33%	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
	782017	ALL	33%	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
				Abs./day (ALL MKT)	15%	9,0	9,4	8,1	6,8	7,7	8,1	7,3
BONF	855145	ALL	15%	TETA SPA		7,7	7,7	7,7	7,7	7,7	7,7	7,7

Table 16: comparison between suppliers' production capacity and Ferrari production needs for F8 Tributo.

F8 Spider				Daily production rate ->		8,5	11,5	12	26,9	28,2	46,2	47
OPT	Item code	Markets	FAR	Supplier	Specific abs. rate ↓	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
						Daily production capacity						
				Abs./day (ALL MKT)	55%	6,0	6,4	6,4	15,0	15,4	25,2	26,1
CERB	73730844	ALL	55%	BETA SPA (tier 2)		4,3	6,8	8,5	19,2	25,6	25,6	25,6
	958397	ALL	55%	BETA SPA		4,3	6,8	8,5	19,2	25,6	25,6	25,6
	958423	ALL	55%	BETA SPA		4,3	6,8	8,5	19,2	25,6	25,6	25,6
				Abs./day (ALL MKT)	33%	3,4	3,8	3,8	9,0	9,4	15,4	15,4
CEL2	938571	ALL	33%	TETA SPA		21,4	21,4	21,4	21,4	21,4	21,4	21,4
	938572	ALL	33%	TETA SPA		21,4	21,4	21,4	21,4	21,4	21,4	21,4

Table 17: comparison between suppliers' production capacity and Ferrari production needs for F8 Spider.

The above matrixes allow elaborating a quick interpretation of the general picture. However, some of the already mentioned data was omitted for layout reasons, such as options description, items description etc. The complete and extended matrixes can be found in the Appendix.

Some of the considered options are clearly noncritical from a production capacity perspective.

In other cases, options show a number of criticalities that cannot be neglected.

Starting from these data, it is possible to compute summary tables that give immediate information about most critical periods and suppliers.

F8 TRIBUTO + F8 SPIDER	
Period	**% of potentially critical items**
June-2020	23%
July-2020	23%
August-2020	14%
September-2020	3%
October-2020	11%
November-2020	34%
December-20	21%

Table 18: months criticalities basing on suppliers' insufficient production capacity.

F8 TRIBUTO + F8 TRIBUTO SPIDER	
Supplier	**% of sufficient supply capacity**
KAPPA SRL	70%
EPSILON SRL	81%
ALPHA SPA	79%
TETA SPA	89%
BETA SPA	56%
ALPHA SPA (tier 2)	100%
GAMMA SPA (tier 2)	86%
Total	84%

Table 19: suppliers' evaluation based on their sufficient production capacity.

When the same firm is a tier 1 supplier for some components and a tier 2 supplier for others, the two cases have been distinguished, because when a supplier is tier 2 for Ferrari, the responsibility and Supply Chain Management fall on the corresponding tier 1 supplier.

The most critical month is November, as expected, because the production ramp-up for the F8 Tributo has its peak in that period.

In September, very low percentage of potentially critical items is observed. This can be the result of a still stable car production rate, with respect to previous months, in concordance with a tooling and equipment phase for suppliers that is consolidating in the same period.

Among suppliers, BETA SPA S.p.A. is the most critical in relative terms, but in absolute terms it is not, as it produces a very low number of components.

TETA S.p.A. shows good results with almost 90% of sufficient supply capacity. It is a very significant datum, because it produces many components destined to the F8 Tributo and F8 Spider.

There are a lot of collected data and results, hence, it could be complex to give a quick and intuitive interpretation. For this reason, a synthetic view of the above listed data is given below.

Option	FAR	RAR	OK / KO	KO starting from
F8 TRIBUTO + F8 SPIDER				
LEDS	90%	95%	KO	July-20
CEAI	55%	13%	KO	June-20
CEXG	55%	20%	KO	November-20
FCWS	55%	25%	KO	November-20
CEXF	55%	11%	KO	November-20
CEIS	55%	61%	OK	-
CEXS	55%	16%	KO	November-20
CEXD	55%	21%	KO	June-20
CIDL	55%	61%	OK	-
CILR	46%	60%	OK	-
CIDH	46%	24%	KO	November-20
CFPA	44%	13%	OK	-
DATR	44%	41%	OK	-
CIIP	44%	5%	OK	-
CITZ	44%	12%	OK	-
CIPZ	44%	3%	OK	-
CISK	44%	17%	OK	-
MNFC	33%	3%	KO	June-20
CEL2	33%	11%	OK	-
CIZB	33%	1%	KO	November-20
F8 TRIBUTO				
CERB	55%	9%	KO	July-20
CEL2	33%	15%	KO	June-20
BONF	15%	#N/D	KO	June-20
F8 SPIDER				
CERB	55%	30%	KO	June-20
CEL2	33%	4%	OK	-

Table 20: synthetic view of the criticalities linked to option involving carbon fiber component for F8 Tributo and F8 Spider.

In Table 20, each option object of the analysis is associated to the relative Forecasted and Real Absorption Rates. In addition, two more pieces of information are provided:

- OK: if all the items associated to the option OPT_i show supplier production capacity higher than production need for each time period, that OPT_i is considered as non-critical;

- KO: if at least one item associated to the option OPT_i shows at least in one time period an insufficient production capacity, it is considered as critical;
- in the case an OPT is considered critical, the first month in which such criticality is observed is provided.

However, this is a useful table in order to quickly determine critical and non-critical option, but gravity and duration of criticalities are not explicated.

In Tables 21 and 22, it is possible to observe each item in which months is critical and the gravity of such criticalities, thanks to the employment of a Key Performance Indicator (KPI), called "Delta". It is simply:

$$Delta = \frac{Supplier\ maximum\ capacity}{day} - \frac{Production\ need}{day}$$

Each Delta value is referred to a specific item in a determined period.

If it is negative the supplier production capacity in the relative period is insufficient and, depending on the absolute value of Delta, the criticality can be worrying or under control.

In the same tables, daily production rates of F8 Tributo and F8 Spider are reported in order to provide a better interpretation of the Delta values.

Option	Forecasted absorption rate	Item code	Coupé/ Spider	Supplier	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
					Avg daily prod. rate per month F8 Tributo + F8 Tributo Spider						
					70,5	74,8	66,7	72,2	80,8	100,0	96,2
					Avg daily production rate per month F8 Tributo						
					59,8	63,2	54,7	45,7	52,6	53,8	49,1
					Avg daily production rate per month F8 Tributo Spider						
					10,7	11,5	12,0	26,9	28,2	46,2	47,0
					Delta [(Supplier max cap./day) - (Prod. need/day)]						
CRITICAL DELTAS											
CEXD	55%	906929	C + S	KAPPA SRL	-17,5	-15,4	-11,1	-5,6	-6,0	-12,4	-3,8
		899283	C + S	KAPPA SRL	-17,5	-15,4	-11,1	-5,6	-6,0	-12,4	-3,8
		786906	C + S	EPSILON SRL	-4,7	-6,8	-2,6	24,4	19,7	9,0	11,1
		786905	C + S	EPSILON SRL	-4,7	-6,8	-2,6	24,4	19,7	9,0	11,1
CEXF	55%	881792	C + S	KAPPA SRL	3,8	6,0	10,3	7,3	2,6	-8,1	-6,0
		881787	C + S	KAPPA SRL	3,8	6,0	10,3	7,3	2,6	-8,1	-6,0
CEXS	55%	73527944	C + S	KAPPA SRL	10,3	8,1	12,4	9,4	4,7	-6,0	-3,8
		73528044	C + S	KAPPA SRL	10,3	8,1	12,4	9,4	4,7	-6,0	-3,8
CEAI	55%	914076	C + S	BETA SPA	-21,8	-9,0	6,0	3,0	6,8	-3,8	-1,7
		904557	C + S	BETA SPA	-21,8	-9,0	6,0	3,0	6,8	-3,8	-1,7

CIDH	**46%**	912466	C + S	KAPPA SRL	**1,7**	**6,0**	**9,8**	**9,4**	**5,6**	**-3,4**	**-1,7**
		918560	C + S	KAPPA SRL	**1,7**	**6,0**	**9,8**	**9,4**	**5,6**	**-3,4**	**-1,7**
MNFC	**33%**	902970	C + S	KAPPA SRL	**-1,7**	**0,9**	**3,8**	**6,0**	**3,4**	**-3,0**	**-1,7**
		902971	C + S	KAPPA SRL	**-1,7**	**0,9**	**3,8**	**6,0**	**3,4**	**-3,0**	**-1,7**
CERB	**55%**	890807	C	EPSILON SRL	**1,3**	**-0,4**	**4,3**	**9,0**	**5,1**	**4,7**	**7,3**
		73730844	S	BETA SPA (tier 2)	**-1,7**	**0,4**	**2,1**	**4,3**	**10,3**	**0,4**	**-0,4**
		958397	S	BETA SPA	**-1,7**	**0,4**	**2,1**	**4,3**	**10,3**	**0,4**	**-0,4**
		958423	S	BETA SPA	**-1,7**	**0,4**	**2,1**	**4,3**	**10,3**	**0,4**	**-0,4**
LEDS	**90%**	73520444	C + S	ALPHA SPA	**2,6**	**-1,3**	**10,7**	**7,7**	**8,5**	**-0,4**	**3,0**
BONF	**15%**	855145	C	TETA SPA	**-1,3**	**-1,7**	**-0,4**	**0,9**	**0,0**	**-0,4**	**0,4**
CEL2	**33%**	813260	C	TETA SPA	**-2,6**	**-3,8**	**-0,9**	**2,1**	**-0,4**	**-0,9**	**0,9**
		880045	C	TETA SPA	**-2,6**	**-3,8**	**-0,9**	**2,1**	**-0,4**	**-0,9**	**0,9**
		911776	C	TETA SPA	**-2,6**	**-3,8**	**-0,9**	**2,1**	**-0,4**	**-0,9**	**0,9**
		782017	C	TETA SPA	**-2,6**	**-3,8**	**-0,9**	**2,1**	**-0,4**	**-0,9**	**0,9**

Table 21: items with critical Delta values.

Option	**Forecasted absorption rate**	**Item code**	**Coupé/ Spider**	**Supplier**	**jun-20**	**jul-20**	**aug-20**	**sep-20**	**oct-20**	**nov-20**	**dec-20**
					Avg daily prod. rate per month F8 Tributo + F8 Tributo Spider						
					70,5	74,8	66,7	72,2	80,8	100,0	96,2
					Avg daily production rate per month F8 Tributo						
					59,8	63,2	54,7	45,7	52,6	53,8	49,1
					Avg daily production rate per month F8 Tributo Spider						
					10,7	11,5	12,0	26,9	28,2	46,2	47,0
					Delta [(Supplier max cap./day) - (Prod. need/day)]						
DELTAS CLOSE TO 0											
CEXG	**55%**	890505	C + S	GAMMA SPA (tier 2)	**15,8**	**13,7**	**17,9**	**15,0**	**10,3**	**-0,4**	**1,7**
		890502	C + S	GAMMA SPA (tier 2)	**15,8**	**13,7**	**17,9**	**15,0**	**10,3**	**-0,4**	**1,7**
CIZB	**33%**	881765	C + S	TETA SPA	**9,4**	**7,7**	**10,7**	**8,5**	**6,0**	**-0,4**	**0,9**
		881763	C + S	TETA SPA	**9,4**	**7,7**	**10,7**	**8,5**	**6,0**	**-0,4**	**0,9**
		881769	C + S	TETA SPA	**9,4**	**7,7**	**10,7**	**8,5**	**6,0**	**-0,4**	**0,9**
FCWS	**55%**	890546	C + S	GAMMA SPA (tier 2)	**15,8**	**13,7**	**17,9**	**15,0**	**10,3**	**-0,4**	**1,7**

Table 22: items with Delta values close to 0.

In Table 21 are listed all those options that show a critical difference between supplier maximum capacity per day and production need per day, in particular if Delta values lower than -0,5 are observed.

What does "-0,5" mean exactly? In an extreme situation, in which stock for a particular component is equal to 0 and the Forecasted Absorption Rate for the relative option corresponds to the one

observed, then in one car every two days it will not be possible to assemble that particular component.

This value has been chosen as threshold to determine critical situations and non-critical situations that need to be monitored.

Indeed, in Table 22, the general situation is under control, not only because the Delta is close to 0, but also because it is observed only in November, when production peak is reached, and because all the previous months are characterized by positive values, sensitively higher than 0. The best solution for such situation is to increase orders to suppliers in September and October, demanding more parts than what is actually needed by production, in order to increase stock with sufficient advance, according to supplier capacity, and to be prepared in November, when supplier may not satisfy all the Ferrari orders.

On the opposite, in Table 21, the situation is less homogeneous and non-negligible criticalities are spotted.

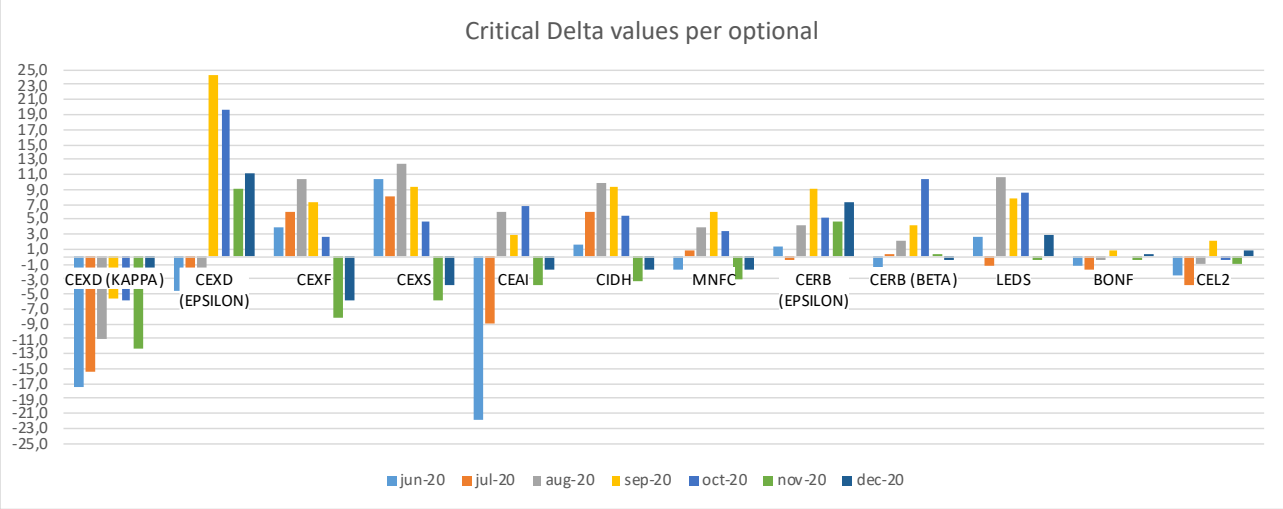
5.2.3.1 Critical option and periods

In Graph 5, the delta values listed in Table 21 are depicted month by month and grouped by option. CEXD, in particular regarding items produced by KAPPA SRL, is the most critical option, as it shows negative Delta values in all periods and with absolute values significantly high.

Similarly, also items produced by EPSILON SRL associated to option CEXD has negative values for the period from June to August, but then, differently from KAPPA SRL, they begin to show positive values.

The reason behind such difference in the trend of Delta regarding the two suppliers resides in the speed and adequacy of tooling and equipment.

KAPPA SRL has implemented a tooling and equipment plan that is too slow and inappropriate if compared to Ferrari production needs, while EPSILON SRL, even if at the beginning shows insufficient capacity, boosts its equipment in order to meet as soon as possible the F8 Tributo and F8 Spider production ramp-ups.



Graph 5: critical Delta values month by month grouped by option.

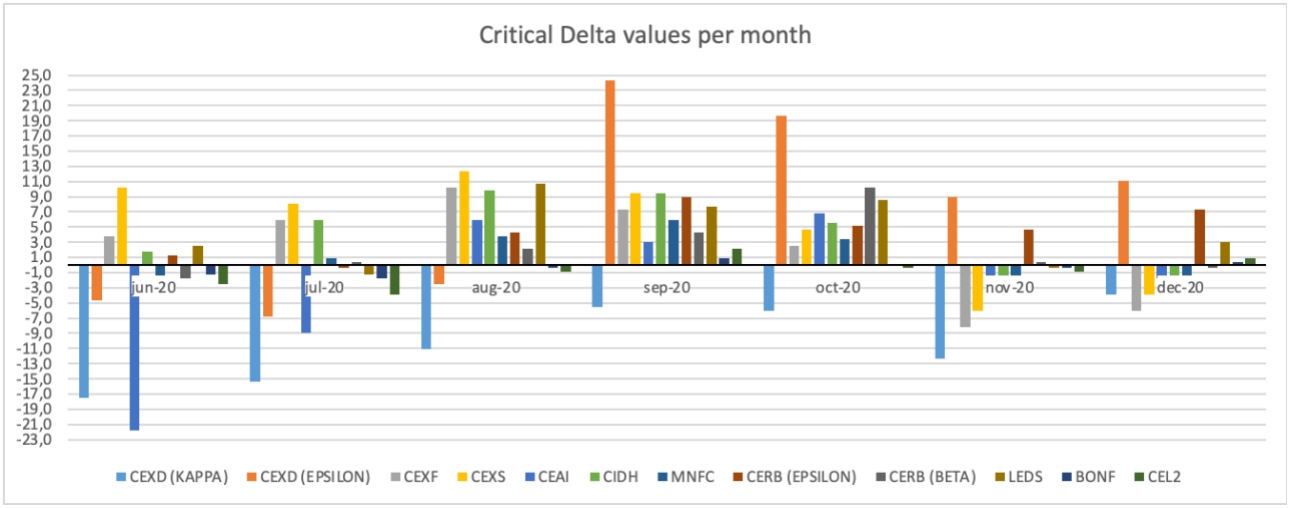
The following options present positive Delta values (or very close to 0) for the first months and then negative values approaching the end of 2020: CEXF, CEXS, CIDH, MNFC. In those cases, there is enough time for preventive actions (increase stock in advance) or corrective ones (improve supplier equipment).

Among other options, CEAI requires special attention: in June and July, the Delta values are worryingly low, meaning that supplier has not already equipped its production line to satisfy Ferrari production needs according to the Forecasted Absorption Rate.

Fortunately, in this case the Real Absorption Rate comes to help because the time horizon in object is very close.

As can be seen in Table 4, the option CEAI is associated to a Real Absorption Rate of 13%, hence in the near future this OPT should not be critical.

It is important to remember that the Real Absorption Rates have been determined by observing the orders collected in the system that includes the different options of interest. Usually the time horizon covered by these orders that can be read in the ERP system is about one month or one month and a half.



Graph 6: critical Delta values grouped by month.

In Graph 6, the various Delta values are grouped by month in order to spot the most critical periods. Leaving aside CEXD (KAPPA SRL), which was mentioned previously and which will be discussed more deeply in the next paragraph, the following breakdown can be done:

- June and July: the overall situation is not very good, mainly because suppliers' equipment and tooling phase is still in an intermediate phase;
- August, September, October: optimal situation in which most of the options shows positive Delta values, due to suppliers' advanced equipment phase which leads to a production capacity that overcomes Ferrari demand;
- November and December: although the equipment phase for most of the suppliers has reached a good level, in these two months the daily production rate of F8 Tributo and F8 Spider increases substantially, hence some of the Delta values approach slightly negative values.

5.2.3.2 Suggested preventive and corrective actions

Regarding option listed in Table 21, where a more complex situation is shown, a different approach needs to be implemented and option specific actions may be undertaken.

Option	Spotted criticalities	Suggested actions
CEXD (KAPPA SRL)	Delta values are negative during the whole observation period, hence, in 2020, production capacity is constantly insufficient.	The real absorption rate is 21% (Table 4), sensitively lower than the forecasted 55%. However, it is expected that the former will increase in order to meet forecasted values in the long term, hence, it is advisable to improve supplier equipment in order to raise production capacity.
CEXD (EPSILON SRL)	In June and July, a non-negligible insufficiency in production capacity is observed, while, in August, the criticality starts to flatten. From September onwards, only positive values are shown.	Although negative values characterize the period from June to August, the real absorption rate of 21% reduces the urgency for a corrective action in immediate future. After that period, when the Real Absorption Rate may increase, the production capacity of EPSILON SRL will increase accordingly, hence no actions need to be taken, just place orders according to the maximum current production capacity.
CEXF CEXS CIDH	Delta values for these three options behave similarly overtime. From June to October only positive values are recorded. In November and December, they become negative, because of the increase in car production rate.	In this situation, it is not necessary to invest more money to improve suppliers' equipment. Because of the long period of positive Delta values, the best strategy to implement in order to avoid the possibility of missing items in the production line is to increase stock for the relative components in order to be "covered" during the months in which suppliers' production capacity may be insufficient.

CEAI	In June the production capacity is strongly insufficient (-21,8), then the criticality is reduced in July (-9) and finally from August to October Delta values become positive. However, in November and December negative values are again observed.	The Real Absorption Rate is 13%, meaning that in the month of June and July big problems should not emerge. Then, in August, September and October, it is advisable to increase stock for all the involved items in order to be prepared to the possibility of insufficient production capacity in November and December, as it was already explained for option CEXF, CEXS and CIDH.
MNFC	In June, the supplier's production capacity is slightly insufficient. Then, from July to October, positive Delta values are recorder. Instead, in November and December negative Delta values are again observed.	This option is not particularly critical. The current Real Absorption Rate is about 3%, hence no problems will arise in the immediate future. In order to face the possibility of supplier's insufficient production capacity, stock can be increase during the months before November.
CERB (EPSILON SRL)	Only positive Delta values characterize components produced by EPSILON SRL associated to the option CERB, except for July, when a slightly negative value is shown (-0,4).	No particular actions need to be undertaken in this case.
CERB (BETA SPA)	In June (-1,7) and in December (-0,4) there are the only negative Delta values that characterize the items produced by BETA SPA for the option CERB.	In June, problems should not arise because the Real Absorption Rate is 30%, against the forecasted 55%. In the following months, stock can be increased in order to be prepared to a possible insufficiency in capacity in the end of 2020.

LEDS	In July (-1,3) and November (-0,4) slightly negative Delta values are spotted.	The Real Absorption Rate is 95% against the forecasted 90%. This means that the insufficient production capacity in July may represent an issue. The possible action to undertake is to communicate to the supplier to produce at full capacity in June and July, in order to increase stock in June, if possible, and to reduce the probability of missing items in the production line in July.
BONF	The only positive Delta values are observed in September and December. In the remaining months, slightly negative or zero values are recorded.	It is not a critical option because it was closed until now, i.e. it was not available for customers, due to technical and quality issues. Indeed, the Real Absorption Rate is not provided, because no order can include BONF as option.
CEL2	Several negative Delta values are reported. Only in September and December, positive values are observed.	Even if the current Real Absorption Rate is 15% against the forecasted 33%, most of the considered periods show the possibility of insufficient production capacity. In order to be more far-sighted, an improvement in supplier's equipment could be the best choice.

Table 23: suggested actions for each option that shows critical Delta values.

At this point, all the criticalities have been spotted and the relative considerations have been made. Then, as it is shown in Table 23, the optimal actions to correct or prevent a criticality have been explained.

It is fundamental to remember that the whole work is an analysis of the critical supply of carbon fiber components, then, because of its analytical nature, it is in parallel with the other company and functional area processes.

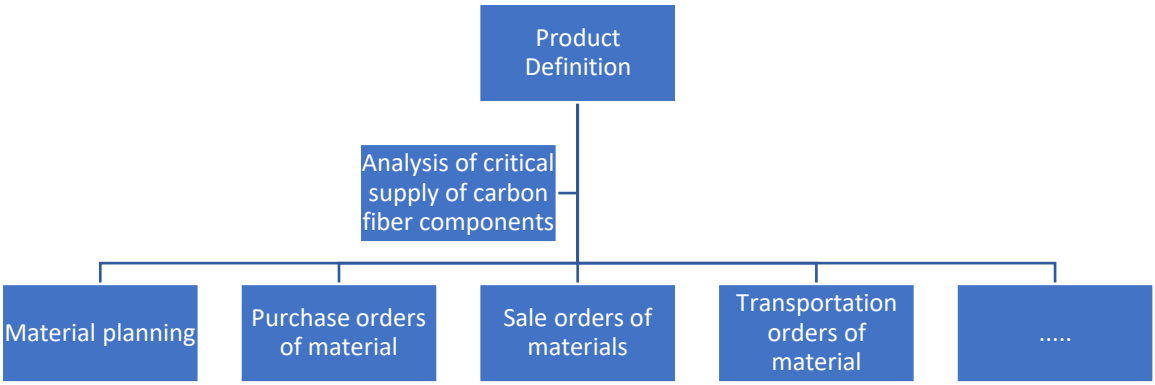


Figure 18: role and positioning of the analysis with respect to the other activities of the Product Definition area.

Therefore, once the results of the analysis have been achieved, the interested material planners and logistics managers have been informed of the criticalities in order to discuss together whether to intervene or not and what actions to undertake.

5.3 Cross-check with other car models

Up to now, the analysis had its focus on suppliers' production capacity of carbon fiber components limited on F8 Tributo and F8 Spider models.

However, even if most of the components object of the analysis are specific for these models, there are some of them that are in common with others car models currently in production.

This introduces new issues: the production capacity declared by suppliers of components in common with other car models may refer only to the F8 Tributo and F8 Spider or may be intended as the total production capacity of their production line that needs to be split into the different Ferrari car models.

In the case the provided production capacity refers only to the F8 Tributo and F8 Spider, additional issues should not arise, because the supplier, basing on the production plan provided previously by Ferrari, has already split its overall production into the different car models involved.

If the supplier did not do this job autonomously, the data provided refer to the overall quantity of material that it is capable to deliver in a period. Starting from this point, it is necessary to sum the Ferrari production needs of the different car models currently in production and verify if the supplier's production capacity is sufficient.

5.3.1 F8 Tributo and 488 Pista

In the following paragraph it is going to be analysed the cross-model demand and supplier's production capacity regarding codes 786905 and 786906, with description "Portella laterale sx" and "Portella laterale dx", respectively. They are associated to the option CEXD, "Estrattore posteriore in fibra di carbonio", the rear diffuser in carbon fiber.

Figure 19: rear diffuser in carbon fiber of the Ferrari F8 Tributo.

The two above mentioned items are in common with the following models:

- F8 Tributo
- F8 Spider
- 488 Pista
- 488 Pista Spider

It is necessary to verify that the overall production need associated to those models with the relative absorption rates is satisfied by the supplier's production capacity over time.
It is not immediate nor trivial, because the two aggregated models (i.e. F8 Tributo + F8 Spider and 488 Pista + 488 Pista Spider) have different production ramp-up overtime, Forecasted Absorption Rates and Real Absorption Rate.

The variables to take into considerations, which may change month by month, are several, therefore a best case and worst case scenario analysis seems to be the best approach.

CAR MODEL	JUL	AUG	SEP	OCT	NOV	DEC
F8 TRIBUTO + F8 SPIDER	74,8	66,7	72,2	80,8	100,0	96,2
488 PISTA + 488 PISTA SPIDER	31,2	35,0	34,6	32,1	17,1	0,0

Table 24: production ramp-up of the F8 Tributo + F8 Spider and 488 Pista + 488 Pista Spider expressed in average number of cars per day produced.

Basing on the production rump up of the two (aggregated) models, a deeper study of the production needs in best and worst scenarios can be performed.

In both of them, the daily production need is computed considering for the 488 Pista and 488 Pista Spider the 99% of absorption rate, as this option is selected for almost all the orders, while for the F8 Tributo and F8 Spider two different values are used for the evaluation:

- 21% in the best case scenario, as it is the Real Absorption Rate and it's lower than the Forecasted Absorption Rate, meaning a reduced production need in comparison to the forecasting;
- 55% in the worst case, which coincides with the Forecasted Absorption Rate; in July and August it seems to be far from such value, but it's necessary to take it into consideration, as the Real Absorption Rate may suddenly get close to the theoretical one.

Car model	Absorption rate		JUL	AUG	SEP	OCT	NOV	DEC
BEST CASE								
F8 TRIBUTO + F8 SPIDER	**21%**	Daily production need	15,7	14,0	15,2	17,0	21,0	20,2
488 PISTA + 488 PISTA SPIDER	**99%**		30,8	34,6	34,2	31,6	17,1	0,0
Total daily production need **(A)**			46,6	48,7	49,6	48,7	38,0	20,1
Production capacity supplier **(B)**			76,9	76,9	76,9	76,9	76,9	76,9
Delta **(B-A)**			30,3	28,2	27,4	28,2	38,9	56,8
WORST CASE								
F8 TRIBUTO + F8 SPIDER	**55%**	Daily production need	41,0	36,8	39,7	44,4	55,1	53,0
488 PISTA + 488 PISTA SPIDER	**99%**		30,8	34,6	34,2	31,6	17,1	0,0
Total daily production need **(A)**			72,2	71,4	73,9	76,1	71,8	53,0
Production capacity supplier **(B)**			76,9	76,9	76,9	76,9	76,9	76,9
Delta **(B-A)**			4,7	5,6	3,0	0,9	5,1	23,9

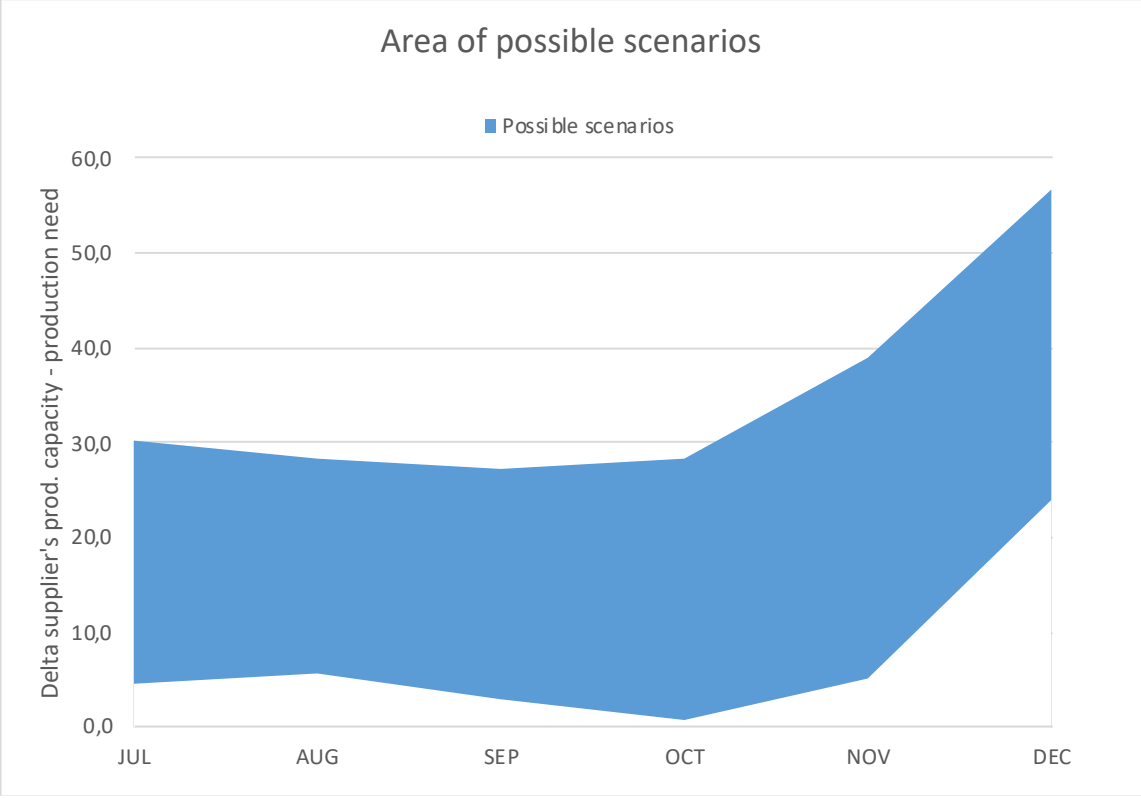
Table 25: best and worst case scenario analysis of the supply of part numbers 786905 and 786906 for both the F8 and 488 versions.

Then, the total daily production need (A) is computed by simply summing the daily production need of F8 Tributo, F8 Spider, 488 Pista and 488 Pista Spider and compared to the total production capacity declared by the supplier relative to the item codes 786905 and 786906.

Finally, the Delta (B-A) is computed in order to verify if the supplier's production capacity is sufficient in order to satisfy all the Ferrari orders for the different car models.

From the results of this short analysis, no particular issue should arise, as no negative Delta values are shown.

However, in September and October the Real Absorption Rate of the option CEXD should be monitored, because if for the F8 Tributo and F8 Spider the orders including CEXD raise substantially, exceeding the forecasted 55%, an insufficient production capacity may emerge.



Graph 7: representation of all the possible Delta values that may occur according to the best and worst case scenario analysis for the supply of part numbers 786905 and 786906 for the F8 Tributo, F8 Spider, 488 Pista and 488 Pista Spider.

In Graph 7, the different possible scenarios are depicted: the upper bound of the blue area is best case scenario through months, while the lower bound corresponds to the worst case scenario. Obviously, they are just the limit cases considered in the analysis, therefore all the intermediate situations are the possible scenarios that may occur.

From the results of this cross-analysis between F8 Tributo versions and 488 Pista versions, it is clear that no critical issues emerge.

The interval of possible Delta values is always positive. The most critical situation is observed in October 2020, when the worst case scenario approaches the 0 value. However, it is an extreme situation, hence no particular actions need to be taken.

5.4 Alignment between planned orders and production capacity

Communication and information flows between Ferrari and its suppliers are cyclical and constant, starting from the early development of a car model to the final weeks of production.

Generally, there is a high level of transparency in the information shared in order to ensure good coordination, efficiency and respect of the deliveries over time.

Although Ferrari provides crucial guidelines about forecasted production needs and necessary tools and equipment with several months in advance to the suppliers, it is fundamental to monitor and manage the behaviour of suppliers.

With this aim, another useful application of the analysis of the critical supply presented in this work can be performed: to verify if the planned orders by Ferrari towards suppliers are sustainable if compared with the maximum production capacity declared by them.

As this kind of analysis is based on the planned orders that are reported in the system, the time horizon cannot be too long.

OPT	ITEM CODE	ITEM DESCRIPTION		
CEL2	911776	PARATIA EST.DX CARB.MOT.STABIL		
Week	Day	Ordered quantity	Average daily ordered quantity	Supplier's production capacity
29	15/07/2020	8,5	12,8	17,1
29	17/07/2020	55,6		
30	22/07/2020	21,4	13,7	17,1
30	24/07/2020	47,0		
31	29/07/2020	34,2	11,1	17,1
31	31/07/2020	21,4		
35	26/08/2020	21,4	10,3	17,1
35	28/08/2020	29,9		
36	02/09/2020	38,5	12,8	17,1
36	04/09/2020	25,6		
37	07/09/2020	4,3	10,3	17,1
37	09/09/2020	21,4		
37	11/09/2020	25,6		
38	16/09/2020	34,2	6,8	17,1

Table 26: comparison between planned orders and supplier's production capacity for the item 911776

In Table 26 an analysis of the alignment of the planned orders with the supplier's production capacity of the item 911776 associated to the option CEL2 (specific for F8 Tributo) is performed.

Firstly, the planned orders inserted in the ERP system have been extracted. Many times, the reported day for the order may receive some variations, hence, the ordered quantity is considered as a daily average for the relative week.

For example, in week 29, there are two days in which orders will be sent. As we are not interested in the exact quantity delivered in a specific day, the total ordered quantity in week 29 is summed and divided by 5 working days, in order to compute a daily average.

In the case of the item 911776, no issues arise from the analysis, as the average daily ordered quantity relative to each week is always lower than the maximum production capacity, for the time horizon considered.

OPT	ITEM CODE	ITEM DESCRIPTION			OPT	ITEM CODE	ITEM DESCRIPTION		
CERB	958397	GRIGL.USC.ARIA COF.MOT.DX CPL			CERB	958423	GRIGL.USC.ARIA COF.MOT.SX CPL		
Week	Day	Ordered quantity	Average daily ordered quantity	Supplier's production capacity	Week	Day	Ordered quantity	Average daily ordered quantity	Supplier's production capacity
29	17/07/2020	47,0	9,4	6,8	29	17/07/2020	47,0	9,4	6,8
30	24/07/2020	42,7	8,5	6,8	30	24/07/2020	42,7	8,5	6,8
31	31/07/2020	42,7	8,5	6,8	31	31/07/2020	42,7	8,5	6,8
35	28/08/2020	38,5	7,7	8,5	35	28/08/2020	38,5	7,7	8,5
36	04/09/2020	34,2	6,8	19,2	36	04/09/2020	34,2	6,8	19,2
37	11/09/2020	38,5	7,7	19,2	37	11/09/2020	38,5	7,7	19,2
38	18/09/2020	17,1	3,4	19,2	38	18/09/2020	17,1	3,4	19,2
39	25/09/2020	21,4	4,3	19,2	39	25/09/2020	21,4	4,3	19,2

Table 27: comparison between planned orders and supplier's production capacity for items 958397 and 958423

In Table 27, a different situation is shown. The two considered items have codes 958397 and 958423 and they are both associated to the option CERB (specific for F8 Spider).

The steps performed are the same as for the item 911776: after having extracted the planned orders from the ERP system, the average daily ordered quantity is computed and compared to the supplier's production capacity.

In weeks 29, 30 and 31 a critical issue emerges: the quantity ordered to the supplier exceeds its maximum production capacity. What does it mean exactly? The excessive ordered quantity may cause delay in the deliveries or lower delivered quantity that, in case of low in-stock quantities, could lead to issues on the production line.

On the other side, it could be possible that the supplier has previously cumulated materials in the warehouse and starts reducing the in-stock quantity by delivering some of the stocked items together with the just produced components.

In any case, a criticality is spotted, hence some verifications need to be done, both internally (with material planners) and externally (directly with suppliers).

6. Suppliers management during Covid-19 emergency

The outbreak of the Corona Virus (Covid-19) pandemic has caused strong and devastating consequences on the economy at a global level. Almost all the economic fields and businesses stalled for several weeks worldwide, in different moments and with various durations, depending on the countries and the measures adopted by governments.

In Italy and part of Europe, the lockdown started in the middle of March 2020 ending approximately after 2 months.

In those weeks everything stopped.

Incredible effort was required in order to reduce the possible economic losses and to ensure an efficient and smooth recovery.

From a Supply Chain Management perspective, the recovery phase is particularly critical because Ferrari is strictly dependent on its suppliers and sub-suppliers. In case the suppliers' re-opening and recovery phase is not aligned with the Ferrari one, several issues may arise.

For this reason, knowing exactly the conditions and the plans of suppliers becomes fundamental, in order to have a clear big picture and to make semi qualitative evaluations of suppliers, spot critical issues and take the necessary measures.

Figure 20: the Ferrari SF90 Stradale.

The car model object of such analysis is the SF90 Stradale which was still partially under the Product Definition area during and after the lockdown period, therefore it was in a delicate phase and it required more attention.

6.1 The questionnaire

The first step consists in the distribution of a questionnaire to the suppliers, in this case not just suppliers of carbon fiber components, but also supplier of parts and sub-assemblies of other nature. More in general, companies that supply components that are not Carry Over, hence, those parts

that may represent a higher threat to the regular conduct of the development and production of the SF90 Stradale.

The questions touch various aspects about the suppliers' situation, from alignment with Ferrari production needs to the status of development of components and quality issues.

Below some examples of the asked questions:

- Did you define your production ramp-up curve based on Ferrari forecast?
- Are you in an Off Tool Off Process phase?
- Which is your current production capacity?
- Which is the current scrap rate on your products?
- Do you have any critical issues with your sub-suppliers that need to be mentioned?

After some weeks, the greatest part of the answers has been collected, hence the next step of interpretation and evaluation is performed.

6.2 Suppliers' readiness evaluation

Because most of the answers were semi-qualitative, discursive and with different formats, pre-cleaning and rearrangement of answers was a necessary step.

After the "cleaning phase" a first categorization of the respondents can be done, based on the answers to the questionnaire:

- twenty-five suppliers are considered non-critical;
- thirty-four suppliers show some critical issues.

Among the critical suppliers, a further classification needs to be made. With this aim, a list of different types of critical issues is prepared, with the associated weights according to their severity and the identification type number.

Critical issues weights (1-3)	Types of critical issues	Type number
1	Scrap rate not given or non-available	Type 1
2	Lead time tier 2 / Sub-supplier issues	Type 2
1	OT-OP phase characteristics not clear	Type 3
3	No OT-OP phase	Type 4
1	It asks for SF90 Stradale ramp-up	Type 5
3	Quality issues	Type 6
1	It uses the online portal for orders	Type 7
1	Production capacity not clear	Type 8
2	Production not based on Ferrari forecast	Type 9
2	Tools under installation/modification	Type 10
3	Insufficient production capacity	Type 11
3	No necessary tools	Type 12
2	No skilled manpower	Type 13
3	Necessary checks after lockdown	Type 14
3	Partial answers	Type 15

Table 28: types of critical issues with the associated weights and identification type number.

After the selection of the different types of criticalities, it is possible to quickly determine how many and which of them are characterizing the various critical suppliers.

The matrix shown in Table 29 put together the thirty-four critical suppliers, named with pseudonyms, with the types of critical issues listed in Table 28.

If a supplier, through its answers, expressed the presence of one of the criticalities, a “1” is shown in the corresponding box.

Once the associations suppliers-criticalities are completed, two KPIs are computed:

- KPI 1 is the supplier's overall criticality with unit weights regarding the critical issues; in other words, for each supplier it is counted how many critical issues are associated, ignoring the corresponding weights;
- KPI 2 is the supplier's overall criticality with weighted critical issues, hence, for each supplier it is the weighted sum of all the criticalities associated to it.

		Types of critical issues with weights															KPI 1	KPI 2
		1	2	1	3	1	3	1	1	2	2	3	3	2	3	3		
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8	Type 9	Type 10	Type 11	Type 12	Type 13	Type 14	Type 15		
Critical suppliers	AG	1															1	1
	AA	1															1	1
	AH	1															1	1
	AAG	1	1					1									3	4
	AB	1					1										2	4
	AE		1														1	2
	AN		1														1	2
	AF		1														1	2
	AAE		1														1	2
	AI			1													1	1
	AS			1													1	1
	AZ					1											1	1
	AAC	1				1	1										3	5
	AAF	1				1			1								3	3
	AL				1												1	3
	AR				1	1											2	4
	AK	1			1												2	4
	AU	1			1					1							3	6
	AAA				1						1				1		3	8
	AD				1		1										2	6
	AY		1		1												2	5
	AJ	1			1		1										3	7
	AT		1		1	1											3	6
	AAD							1				1	1				3	7
	AX	1					1					1	1				4	10
	AM	1	1		1		1	1				1					6	13
	AC		1									1					2	5
	Z							1									1	1
	AP														1		1	3
	AV														1		1	3
	AAB	1									1				1		3	6
	AO															1	1	3
	AQ															1	1	3
	AW															1	1	3

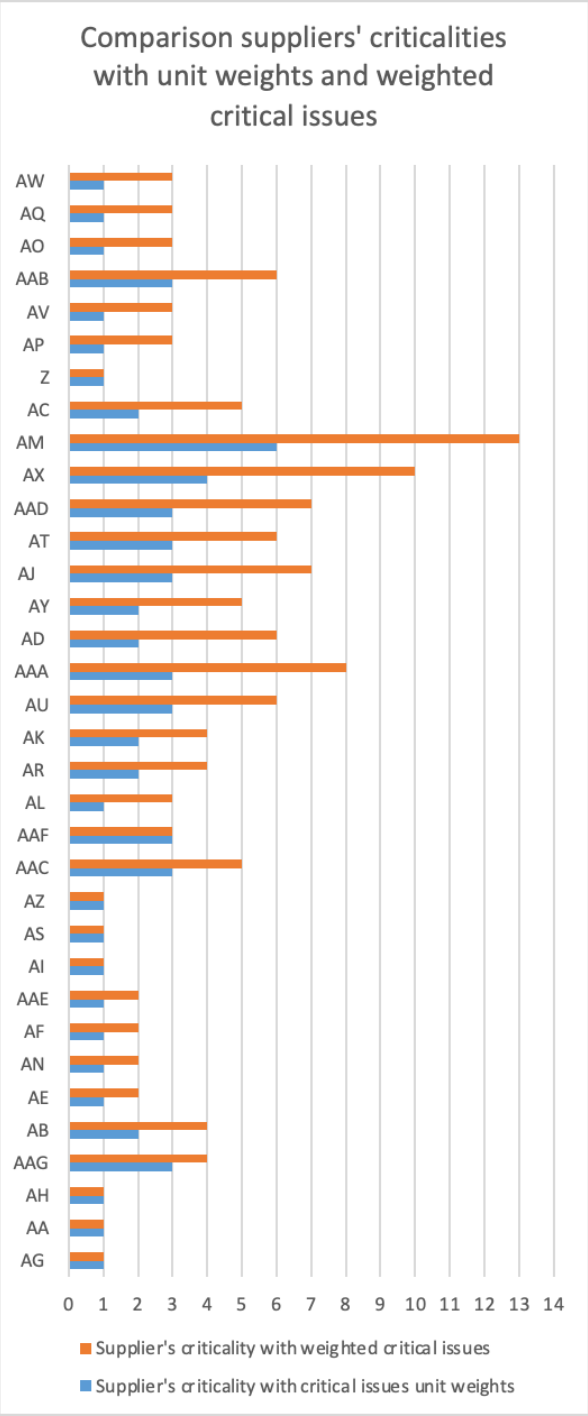
Table 29: matrix of critical suppliers associated to the different types of critical issues.

The KPIs values are useful to subdivide the critical suppliers in three categories, basing on the seriousness of the associated critical issues.

Critical issues seriousness of suppliers		
Seriousness	**Seriousness description**	**N. of suppliers**
Low	Weighted overall criticality between 1 and 2	11
Medium	Weighted overall criticality between 3 and 6	18
High	Weighted overall criticality > 6	5

Table 30: grouping of critical suppliers basing on their KPI 2 values.

The grouping performed in Table 30 depends only on KPI 2, in which critical issues weights are considered.



Graph 8: comparison between KPI 1 and KPI 2 for each supplier.

Therefore, why KPI 1 is computed?

In Graph 8, both KPI 1 and KPI 2 values are depicted for each supplier.

The two values (or bars, from a graphical point of view) put together give more information than just one of them without the other one.

The blue bar tells how many critical issues have been reported for a supplier, while the orange bar tells how much those critical issues are severe.

For instance, for suppliers AV and AP only one criticality has been found, but it is very serious.

It means that high priority is characterizing them, because if insufficient production capacity or important quality issues define their criticalities, actions need to be undertaken very soon.

On the contrary, supplier AAF counts three critical issues, but the severity of all of them is the minimum. It means that such criticalities may refer to some marginal pieces of information that needs to be cleared.

In other cases, such as suppliers AZ, AS, AI, only one critical issue is observed, with the lowest severity, hence the priority in solving this criticality is very low.

The approach and methodology explained so far shows the advantages of converting qualitative and semi-qualitative information into data, even more when the information at disposition is a lot and, by leaving it as qualitative, the risk of bad evaluation and lacking big picture view is very high.

Now it is possible to prioritize the different situations characterizing critical suppliers, in order to take measures to ensure a more efficient recovery after the lockdown caused by the Covid-19 pandemic in spring.

7. Conclusions

The system that has been designed for studying the critical supply of carbon fiber components for the F8 Tributo and F8 Spider can be applied for any car model. Indeed, as it was explained at the beginning of this work, during the internship the study was expanded to other car models, that are the Ferrari SF90 Stradale, the Ferrari SF90 Stradale Spider and the Ferrari Roma.
The importance of a dedicated approach for such critical parts, as the carbon fiber components, can be summarized in four aspects:

- forecast of criticalities;
- optimization of material flows towards production lines of different car models;
- evaluation of suppliers;
- production constraints.

The methodology exposed in the previous chapters allows forecasting with several months in advance the emergence of a criticality. It is crucial to spot problems with great advance because, in case it is necessary to improve supplier's equipment, the lead time until the new lamination tool is ready for production may be more than 12 weeks, considering the time required to:

- issue an order for the additional lamination tools,
- make the order internally approved by the different interested managers,
- let the supplier duplicate the lamination tools,
- get the lamination tools ready for production,
- let the supplier schedule new workforce and additional incoming raw materials.

The big picture view that such study provides, gives the opportunity to optimize the material flows that involve different car models. As it was explained in paragraph 5.3, suppliers may produce some items in order to be assembled in multiple Ferrari car models that are simultaneously produced in series. In case of lack of coordination between the multiple involved teams, the production need of one of the car models may cannibalize the other ones.

With the results of this short analysis, it is possible to reschedule the production of some units in order to keep the overall production need sustainable for suppliers, reducing the risk of insufficient production capacity or missing items in the production line.

An additional outcome of the analysis of the critical supply of carbon fiber components is an evaluation scheme for suppliers. In Table 19, all the involved suppliers have been evaluated basing on their ability to satisfy the Ferrari production needs through their production capacity overtime. By implementing the methodology to all car models, it is possible to assess if a given supplier results critical for many projects.
This information may be a great support for the top management in order to evaluate if switching from one supplier to another because of its malpractice.

The last contribution of the analysis regards production constraints.
Communication flow and coordination with the Production Planning area is bidirectional:

- in one direction, the Production Planning provides data about the production ramp-up of the car models and the daily production rate;
- in the opposite direction, the Supply Chain and Management dept. provides production constraints in terms of maximum number of cars in a period that can be assembled with certain components, depending on the limits of the suppliers' production capacity.

Thanks to production constraints associated to car options, the Production Planning area will schedule the cars entering the production line ensuring a harmonious distribution overtime, avoiding a huge concentration of orders with same attached options that would cause congestion to the material flow in inbound.

Appendix

F8 Tributo + Spider							Daily production rate ->		70,5	74,8	66,7	72,2	80,8	100	96,2
Functional group	**Option**	**Option Description**	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Specific absorption rate**	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
									Daily production capacity						
							Abs./day (ALL MKT)	**90%**	63,7	67,5	59,8	65,0	72,6	90,2	86,8
INTERNAL	**LEDS**	VOLANTE IN CARBONIO CON LEDS	73520444	VOLANTE CPL F142MFL CARB+LED	ALL	**90%**	ALPHA SPA		66,2	66,2	70,5	72,6	81,2	89,7	89,7
							Abs./day (ALL MKT)	**55%**	38,9	41,0	36,8	39,7	44,4	55,1	53,0
EXTERNAL	**CEAI**	S-DUCT SU COFANO IN CARBONIO	914076	COPER.EST.CENT.PROLUNGA CARB.C	ALL	**55%**	BETA SPA		17,1	32,1	42,7	42,7	51,3	51,3	51,3
			904557	IMBOCCO S-DUCT CARB. COFANO AN	ALL	**55%**	BETA SPA		17,1	32,1	42,7	42,7	51,3	51,3	51,3
EXTERNAL	**CEXG**	BAFFI SU PARAURTI ANTERIORE IN CARBONIO	890505	FLICK AERO INF. LAT. SX CARBON	ALL	**55%**	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
			890502	FLICK AERO INF. LAT. DX CARBON	ALL	**55%**	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
EXTERNAL	**FCWS**	SPLITTER SU PARAURTI ANTERIORE IN CARBONIO	890546	MOSTRINA CENTR.CARBONIO	ALL	**55%**	GAMMA SPA (tier 2)		54,7	54,7	54,7	54,7	54,7	54,7	54,7
EXTERNAL	**CEXF**	MOSTRINA PROIETTORE IN FIBRA DI CARBONIO	881792	PRESA ARIA FRENI DX CPL CARB.	ALL	**55%**	KAPPA SRL		42,7	47,0	47,0	47,0	47,0	47,0	47,0
			881787	PRESA ARIA FRENI SX CPL CARB.	ALL	**55%**	KAPPA SRL		42,7	47,0	47,0	47,0	47,0	47,0	47,0
EXTERNAL	**CEIS**	MOSTRINA PRESE ARIA LATERALI IN FIBRA DI CARBONIO	891184	ALA LATERALE CARBONIO DX CPL	ALL	**55%**	EPSILON SRL		42,7	45,9	51,3	76,9	76,9	76,9	76,9
			891163	ALA LATERALE CARBONIO SX CPL	ALL	**55%**	EPSILON SRL		42,7	48,5	51,3	76,9	76,9	76,9	76,9
EXTERNAL	**CEXS**	COPRIBRANCARDO EXTERNAL IN FIBRA DI CARBONIO	73527944	RIVESTIM. SOTTOPORTA DX CPL CA	ALL	**55%**	KAPPA SRL		49,1	49,1	49,1	49,1	49,1	49,1	49,1
			73528044	RIVESTIM. SOTTOPORTA SX CPL CA	ALL	**55%**	KAPPA SRL		49,1	49,1	49,1	49,1	49,1	49,1	49,1
EXTERNAL	**CEXD**	ESTRATTORE POSTERIORE IN FIBRA DI CARBONIO	906929	SCIVOLO ESTRATTORE CPL BASE CA	ALL	**55%**	KAPPA SRL		21,4	25,6	25,6	34,2	38,5	42,7	49,1
			899283	PORTELLA CENTRALE IN CARBONIO	ALL	**55%**	KAPPA SRL		21,4	25,6	25,6	34,2	38,5	42,7	49,1
			786906	PORTELLA LATERALE DX CARBONIO	ALL	**55%**	EPSILON SRL		34,2	34,2	34,2	64,1	64,1	64,1	64,1
			786905	PORTELLA LATERALE SX CARBONIO	ALL	**55%**	EPSILON SRL		34,2	34,2	34,2	64,1	64,1	64,1	64,1

							Abs./day (CIDL)	**31%**	21,8	23,1	20,5	22,2	24,8	30,8	29,5
INTERNAL	**CIDL**	ALLESTIMENTO ZONA GUIDA IN FIBRA DI CARBONIO + VOLANTE CON LEDS	863731	NQS ECE OPT NERO CARB	NO USA	**55%**	ZETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
			863752	NQS USA OPT NERO CARB	SOLO USA	**22%**	ZETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
			327251	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	ALPHA SPA (tier 2)		170,9	170,9	170,9	170,9	170,9	170,9	170,9
			892382	GRUPPO COMANDI F1 KEYLESS CA	ALL	**55%**	ALPHA SPA (tier 2)								
							Abs./day (ALL MKT)	**46%**	32,5	34,6	30,8	33,3	37,2	46,2	44,4
							Abs./day (NO USA,USL, CAN)	**28%**	19,7	20,5	18,4	20,1	22,2	27,8	26,5
							Abs./day (USA,USL,CAN)	**18%**	12,8	13,7	12,4	13,2	15,0	18,4	17,5
INTERNAL	**CILR**	BRIDGE TUNNEL IN FIBRA DI CARBONIO	881252	BRIDGE COMANDI F1 CARBONIO CPL	NO USA, USL, CAN	**28%**	TETA SPA		61,5	61,5	61,5	61,5	61,5	61,5	61,5
			896471	BRIDGE COMANDI F1 CARB LUCI US	USA, USL, CAN	**18%**	TETA SPA		61,5	61,5	61,5	61,5	61,5	61,5	61,5
INTERNAL	**CIDH**	MANIGLIE PORTA IN FIBRA DI CARBONIO	912466	MANIG TIRAPO CARBON LUCIDO SX	ALL	**46%**	KAPPA SRL		34,2	40,6	40,6	42,7	42,7	42,7	42,7
			918560	MANIG TIRAP CARBON LUCIDO DX C	ALL	**46%**	KAPPA SRL		34,2	40,6	40,6	42,7	42,7	42,7	42,7
							Abs./day (CFPA)	**24%**	17,1	17,9	16,2	17,5	19,7	24,4	23,1
							Abs./day (ALL MKT)	**44%**	31,2	32,9	29,5	31,6	35,5	44,0	42,3
							Abs./day (GDX MKT)	**11%**	7,7	8,1	7,3	8,1	9,0	11,1	10,7
							Abs./day (NO AUS, UK)	**33%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
INTERNAL	**CFPA**	PALETTE IN CARBONIO RACING	881217	GRUPPO COM.CAMBIO F1 RACING KE	ALL	**44%**	ALPHA SPA (tier 2)		170,9	170,9	170,9	170,9	170,9	170,9	170,9
			890896	GRUPPO COM.CAMBIO F1 RACING CA	ALL	**44%**	ALPHA SPA (tier 2)								
INTERNAL	**DATR**	INSERTI PLANCIA IN FIBRA DI CARBONIO	922005	SATELLITE DX PASS. CARB. CPL	NO AUS, UK	**33%**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5
			891898	SATELLITE SX GUIDATORE CARB CP	ALL	**44%**	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
			892196	SATELLITE DX GUID CARB CPL	ALL	**44%**	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
	DATR GDX	INSERTI PLANCIA IN FIBRA DI CARBONIO	899428	SATELLITE SX PASSEG CAR LUC GD	UK, AUS	**11%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
INTERNAL	**CIIP**	VELE COPRISTRUMENTO IN CARBONIO	892176	VELA SUP SX CARB OP CPL	NO AUS, UK	**33%**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5
			892178	FUSIONE SUP SX GUID CARB OP CP	NO AUS, UK	**33%**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5
			892181	SATELLITE SX GUIDATORE CARB OP	ALL	**44%**	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
			892599	VELA SUP DX CARB OP CPL	NO AUS, UK	**33%**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5
			892596	FUSIONE SUP DX GUID CARB OP CP	NO AUS, UK	**33%**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5
			892598	SATELLITE DX GUID CARB OP CPL	ALL	**44%**	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
			892618	FUSIONE SUP DX GUID CARB OP RU	EU (RUS)	**/**	TETA SPA		38,5	38,5	38,5	38,5	38,5	38,5	38,5

	CIIP GDX	VELE COPRISTRUMENTO IN CARBONIO	899359	VELA SUPER SX CARB OPACO GDX C	UK, AUS	**11%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
			899305	VELA SUPERIORE DX CARB OPACO G	UK, AUS	**11%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
			936682	FUSIONE SUP DX GUID CARB GDX	UK, AUS	**11%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
			899358	FUSIONE FINIZ SUP SX CARB OPA	UK, AUS	**11%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
INTERNAL	**CITZ**	PARTE SUPERIORE TUNNEL IN FIBRA DI CARBONIO	891932	CORNICE MOBILE CARBONIO LUCIDO	ALL	**44%**	TETA SPA		50,0	50,0	50,0	50,0	50,0	50,0	50,0
INTERNAL	**CIPZ**	PANNELLI PORTA IN FIBRA DI CARBONIO	908592	COMP PAN+TASC PORTA SX CAR LUC	NO AUS, UK	**33%**	KAPPA SRL		25,6	25,6	29,9	34,2	38,5	38,5	38,5
			908597	COMP PAN+TASC PORTA DX CAR LUC	NO AUS, UK	**33%**	KAPPA SRL		25,6	25,6	29,9	34,2	38,5	38,5	38,5
	CIPZ GDX	PANNELLI PORTA IN FIBRA DI CARBONIO	909716	COMP PAN+TASCA PORTA CARB LUC	UK, AUS	**11%**	KAPPA SRL		25,6	25,6	29,9	34,2	38,5	38,5	38,5
			909714	COMP PAN+TAS PORT CARB LUC DX	UK, AUS	**11%**	KAPPA SRL		25,6	25,6	29,9	34,2	38,5	38,5	38,5
INTERNAL	**CISK**	BATTITACCO EXTERNAL IN FIBRA DI CARBONIO	86538300	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**	TETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
			86538200	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**	TETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
			915177	BATTICALCAGNO EST.DX CARBONIO	ALL	**44%**	TETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
			915176	BATTICALCAGNO EST.SX CARBONIO	ALL	**44%**	TETA SPA		76,9	76,9	76,9	76,9	76,9	76,9	76,9
							Abs./day (ALL MKT)	**33%**	23,1	24,8	21,8	23,9	26,5	32,9	31,6
							Abs./day (GDX MKT)	**8%**	6,0	6,0	5,6	6,0	6,8	8,1	8,1
							Abs./day (NO AUS, UK)	**25%**	17,5	18,4	16,7	17,9	20,1	24,8	23,9
EXTERNAL	**MNFC**	ENGINE COVERS IN FIBRA DI CARBONIO	902970	Polmone aspirazione DX CPL	ALL	**33%**	KAPPA SRL		21,4	25,6	25,6	29,9	29,9	29,9	29,9
			902971	Polmone aspirazione SX CPL	ALL	**33%**	KAPPA SRL		21,4	25,6	25,6	29,9	29,9	29,9	29,9
EXTERNAL	**CEL2**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	86935100	PARATIA EST.CENT.VANO MOT.CPL	ALL	**33%**	TETA SPA		65,4	65,4	65,4	65,4	65,4	65,4	65,4
INTERNAL	**CIZB**	ZONA BAULE IN CARBONIO	881765	COPERTURA ESTETICA DX CPL CARB	ALL	**33%**	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
			881763	COPERTURA ESTETICA SX CPL CARB	ALL	**33%**	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
			881773	MOSTRINA SOTTOPARABREZZA DX CP	NO AUS, UK	**25%**	TETA SPA		26,9	26,9	26,9	26,9	26,9	26,9	26,9
			881771	MOSTRINA SOTTOPARABREZZA SX CP	NO AUS, UK	**25%**	TETA SPA		26,9	26,9	26,9	26,9	26,9	26,9	26,9
			881769	COPERTURA ESTETICA CENTRALE CP	ALL	**33%**	TETA SPA		32,5	32,5	32,5	32,5	32,5	32,5	32,5
	CIZB GDX	ZONA BAULE IN CARBONIO	895812	MOSTRINA SOTTOP DX CPL GDX CAR	UK, AUS	**8%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4
			895839	MOSTRINA SOTTOP. SX CPL GDX CA	UK, AUS	**8%**	TETA SPA		15,4	15,4	15,4	15,4	15,4	15,4	15,4

Table 31: extended matrix of the comparison between suppliers' daily production capacity and F8 Tributo + F8 Spider production need.

F8 Tributo							Daily production rate ->		59,8	63,2	54,7	45,7	52,6	53,8	49,1
Functional group	**OPT**	**OPT Description**	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Specific absorption rate**	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
									Daily production capacity						
							Abs./day (ALL MKT)	**55%**	32,9	34,6	29,9	25,2	29,1	29,5	26,9
EXTERNAL	**CERB**	TERMINALE COFANO POST IN CARBONIO	890807	PARETE INF.COND.SPOILER POST.C	ALL	**55%**	EPSILON SRL		34,2	34,2	34,2	34,2	34,2	34,2	34,2
							Abs./day (ALL MKT)	**33%**	19,7	20,9	17,9	15,0	17,5	17,9	16,2
EXTERNAL	**CEL2**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	826052	PARATIA EST.SOTTOL.VANO MOT.CA	ALL	**33%**	TETA SPA		46,2	46,2	46,2	46,2	46,2	46,2	46,2
			813260	PAR EST SX CPL VA MOT CAR ASTA	ALL	**33%**	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
			911776	PARATIA EST.DX CARB.MOT.STABIL	ALL	**33%**	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
			880045	PARATIA EST.DX MOTORE CARB.AST	ALL	**33%**	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
			782017	PARATIA ESTET.SX VANO MOTORE C	ALL	**33%**	TETA SPA		17,1	17,1	17,1	17,1	17,1	17,1	17,1
							Abs./day (ALL MKT)	**15%**	9,0	9,4	8,1	6,8	7,7	8,1	7,3
EXTERNAL	**BONF**	TELAIETTO COFANO MOTORE IN CARBONIO	855145	COFANO POSTERIORE IN CARBONIO	ALL	**15%**	TETA SPA		7,7	7,7	7,7	7,7	7,7	7,7	7,7

Table 32: extended matrix of the comparison between suppliers' daily production capacity and F8 Tributo production need.

F8 Spider							Daily production rate ->		10,7	11,5	12,0	26,9	28,2	46,2	47,0
Functional group	**OPT**	**OPT Description**	**Item code**	**Item description**	**Markets**	**FAR**	**Supplier**	**Specific absorption rate**	jun-20	jul-20	aug-20	sep-20	oct-20	nov-20	dec-20
									Daily production capacity						
							Abs./day (ALL MKT)	**55%**	6,0	6,4	6,4	15,0	15,4	25,2	26,1
EXTERNAL	**CERB**	TERMINALE COFANO POST IN CARB E GRIGLIA MOTORE	73730844	CONDOTTO SPOILER POST.CPL CARB	ALL	**55%**	BETA SPA (tier 2)		4,3	6,8	8,5	19,2	25,6	25,6	25,6
			958397	GRIGL.USC.ARIA COF.MOT.DX CPL	ALL	**55%**	BETA SPA		4,3	6,8	8,5	19,2	25,6	25,6	25,6
			958423	GRIGL.USC.ARIA COF.MOT.SX CPL	ALL	**55%**	BETA SPA		4,3	6,8	8,5	19,2	25,6	25,6	25,6
							Abs./day (ALL MKT)	**33%**	3,4	3,8	3,8	9,0	9,4	15,4	15,4
EXTERNAL	**CEL2**	PARATIE VANO MOTORE IN FIBRA DI CARBONIO	938571	PARATIA EST.DX CPL VANO MOT.CA	ALL	**33%**	TETA SPA		21,4	21,4	21,4	21,4	21,4	21,4	21,4
			938572	PARATIA EST.SX CPL VANO MOT.CA	ALL	**33%**	TETA SPA		21,4	21,4	21,4	21,4	21,4	21,4	21,4

Table 33: extended matrix of the comparison between suppliers' daily production capacity and F8 Spider production need.

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