Master Thesis

Master Industrial Engineering

Design of a tool to drive improved Supply Chain Planning decisions within the semiconductor Industry.

MEMÒRIA

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Content

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Summary

This is the Final Thesis wrote by Pol Aguirre Antonell within Infineon Technologies during the spring semester of 2023. The title of the Thesis is the Design of a tool to drive improved Supply Chain Planning decisions within the semiconductor Industry.

We start of explaining the context to understand the necessity of agile planning tools and data analysis within the team. How the Supply Chain and the production of semiconductor products is key for a prosperous European semiconductor segment. To have a good understanding of the needs of the team and company, we study and present the Supply Chain Planning process of Infineon.

Having this knowledge, we can start the process of creating the right and best tool to solve the knowledge gap between planning allocation and revenue impacts. To do so we benchmark the existing Data tools and solutions within Infineon Technologies, and we choose to create a Tableau Dashboard. This Dashboard will be connected to an automated data-source. Managed by a Tableau prep flow connected to the Data-lake through Cloudera Hadoop.

Coding the Dashboard, it has also been an important practical part of this Thesis and it is presented in Chapter 6. Effective coding, seems simple, light, and easier to explain. Maybe you can explain that most complexity comes from the Waterfall chart whereas the rest requires less workarounds. Overall, we present the use of Tableau workarounds towards a lean dashboarding, and a one-stop dashboard.

Lean Dashboarding is as important as having accurate data , and in Chapter 7 there is explanations on how and why the dashboard meets the design and interactivity requirements set by the different stakeholders and key users.

To finalize, we study some business analysis that derives uniquely thanks to the report. In this las part we address how the team can integrate the findings from this analysis into their process.

Overall, the thesis includes all steps of creating a Data Analysis tool and Dashboard. From idea to results.

1. Abbreviations

Abbreviation	Name	Explanation	Example
DIV	Division	Infineon Division	ATV, IPC
BL	Business Line	Infineon Business Line	HP, DCDC
PL	Product Line	Infineon Product Line	31, 34
HFG	Hauptfrabrikattegruppe	Main Fabrication Group	42_S
RFP	Rhythm Forecast Planner	Demand Planning Product identifier	1EBN1002AE
PPOS	Planning Item	SCM Product Identifier	1EBN1001AE
Prod Maturity	Product Maturity	Marketing Attribute	Growth, Decline
Main Family	Main Family	Marketing Attribute	CIPOS Maxi
Prod Family	Product Family	Marketing Attribute	128K
FE Line Concept	Line Concept FE	Marketing Attribute	B11
Pk Class Agg	Package Class Aggregation	Grouping of packages	TO220
Pk Class	Package Class	Grouping of packages	BGA
FE	Front End	Part of the Supply Chain	
BE	Back End	Part of the Supply Chain	
ATV	Automotive	Business Division	
LCM	Life Cycle Management	Team in charge of LCM	
TS	Tactical Strategic	Team that coordinates TS planning	
CAGR	Cumulated Annual Growth Rate	Growth KPI	
OEM	Original Equipment Manufacturer	Company that sells their own products B2C	Volkswagen
VRFC	Volume Rolling Forecast	Mid-term planning process	
FRFC	Finance Rolling Forecast	Financial planning	
BS	Business Scenario	Tactical planning time window	
PP	Production Planning	Operational planning time window	
RBA	Revenue Bridge Analysis	Analysis derived from Price Volume Mix	
UoM	Units of Measure	Explicit	
LOD	Level of Detail	Explicit	

2. Abstract

2.1. Motivation

With around 56,200 employees worldwide, Infineon is one of the leading companies of semiconductors. Semiconductors today have two crucial roles: connecting the real world with the digital world and helping to achieve a global net zero emissions target. As a global leader in semiconductor solutions, Infineon operates in a rapidly changing and highly competitive market, where customer demands, technological advancements, and global supply chain disruptions can significantly impact its business operations. Therefore, a strong motivation to manage the supply chain effectively can help Infineon to maintain its competitive edge, drive customer satisfaction, and ensure business sustainability.

The motivation after this project comes directly from the entrepreneurial spirit of the Project Owner. Amaury Chapelle is responsible for the reporting and analysis of the Tactical and Strategical team and while talking with colleagues from Finance and Marketing he realised there was this opportunity to drive a project to bring this kind of analysis to the Teams data. An opportunity to bridge a knowledge/analysis gap initiating this master thesis project.

2.2. Prerequisites

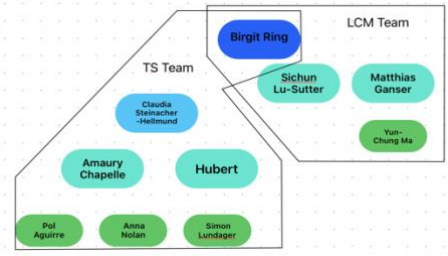


Figure 1 Digitalisation LCM TS Team

The project is driven by the SPM LCM TS team, therefore some of the prerequisites where set by the team. In a field where pricing strategies are a key success factor of the industry and critically confidential, the access and manipulation only to the team's Supply Chain based data. So, it was clear that we would not be using customer information due to the sensitivity of the subject but also to the scope of the planning since the planning is not maintained on such low granularity.

Within the SPM LCM TS Team, there has been a smaller team of contributed that have been involved in the development of this project.

Weekly meetings were scheduled to present the weekly progress, learnings, and future steps. A prerequisite that is worth mentioning is the Digitalisation round team, because it has been key to the development of the project. When stuck, the team has helped and guided me into the right direction. It has also pushed me to give my best and has enabled checking in other projects from the other teammates and learn from and with them.

3. Introduction

It is also important to understand the context. We are inside the Semiconductor industry and within Infineon automotive division. In this chapter a full overview of the context is given.

3.1. Semiconductor industry Context

The semiconductor industry was thrust into an unexpected spotlight in 2021 when chip shortages initially forced the shutdown of vehicle production lines. Suddenly, everyone was discussing the tiny chips that enabled numerous automotive features, like blind-spot recognition, seat control, battery management or interior lighting.

In 2020, semiconductor companies experienced a surge in demand from both consumer and business customers, leading to significant double-digit returns for shareholders. This positive outcome occurred despite supply-chain challenges and increasing disparities in global trade. The high demand created shortages throughout the value chain, prompting chip makers to pursue consolidation as a means to capitalize on the advantages of scale.

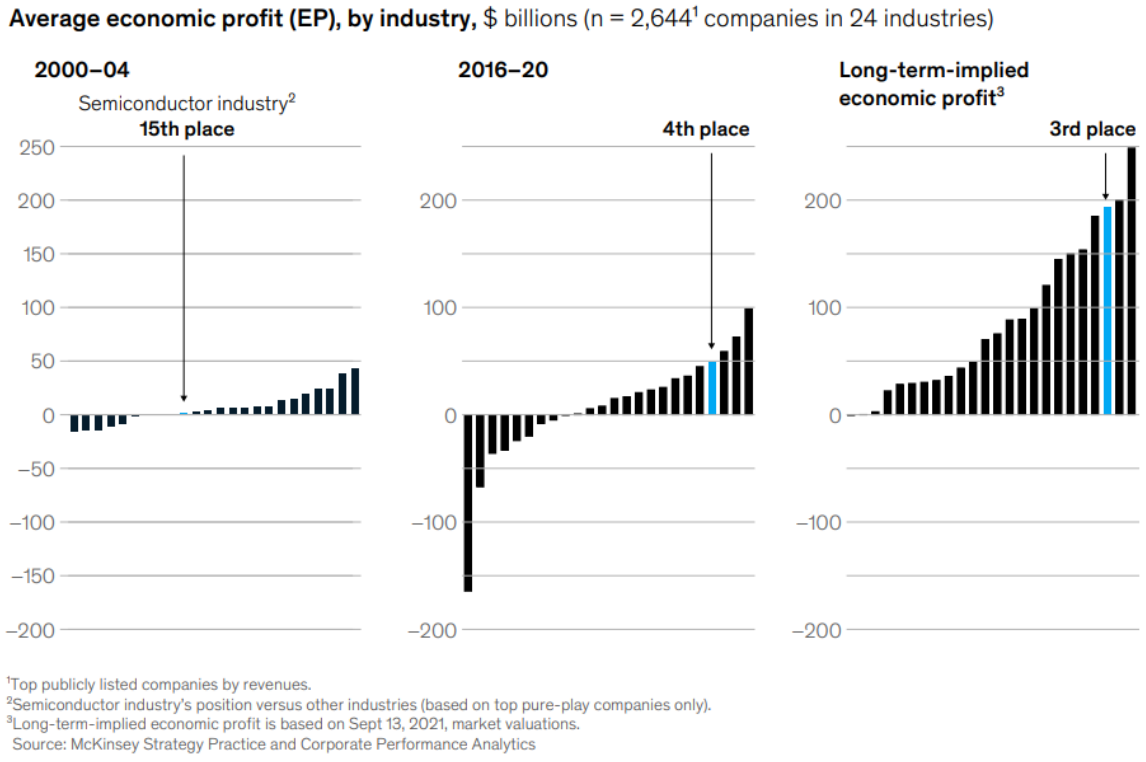


Figure 3 Semiconductor industry's economic profitability has improved relative to others, and this trend is expected to continue.

In the figure above we observe the consequences of this semiconductor industry's growth. In

the recent context, profitability on the industry has been growing and the strong players have become stronger. Infineon Technologies as one of the industry's leaders has enlarged its market share over the years and faces now the challenge to increase its profitability.

At Infineon, the bottleneck for most of the business is still the capacity and the Supply Chain. Therefore, is crucial to have tools to visualise the data and explain it. This project is promoted by the automotive division in charge of supply production planning and life cycle management. As a part of the digitalization of the team, to further drive data driven decisions.

3.2. Semiconductors in vehicles evolution

While it is anticipated that sales of passenger cars and light commercial vehicles will grow only modestly, from 89 million vehicles in 2019 to 102 million in 2030, representing a CAGR of just over 1%, the automotive software and electronics sector is anticipated to experience much more significant growth during the same time period. Sales of electronic control units (ECU) and domain control units (DCU), the market's largest category, are anticipated to generate $144 billion in total revenue by 2030. The software development industry, which includes integration, verification, and validation, is not far behind and has the potential to bring in $83 billion by 2030. Notably, the market for power electronics is the one that is expected to grow the fastest through 2030, with a stunning CAGR of 23% due to the rising popularity of electric vehicles (EVs). Additionally, it is anticipated that the market for sensors would expand at a compound annual rate of 6%, driven mostly by the need for sensors for advanced driver assistance systems (AD/ADAS). [1]

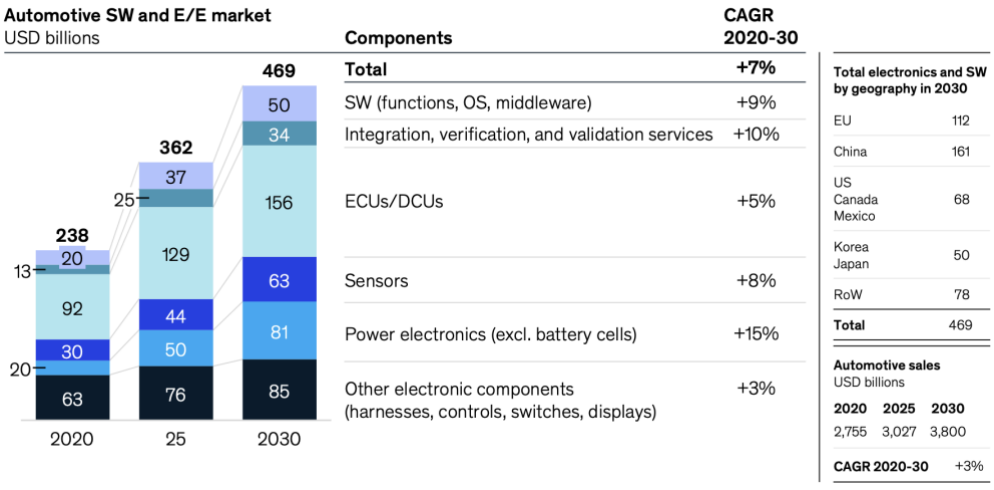


Figure 4 Automotive Semiconductors Revenue Forecast. Source: McKinsey analysis.

[1] McKinsey & Company on Future Electronics Architecture and Software. (2018, May). The Hansen

We observe a 7% CAGR from 2020 to 2030, outstanding growth parameters. Moreover, the allocation of this revenue will still put Europe as a strong geographical player within the industry. Main player is China but second comes from Europe.

Another report from McKinsey indicates how important is the business demand planning and the need for solutions in long term planning to increase the allocation.

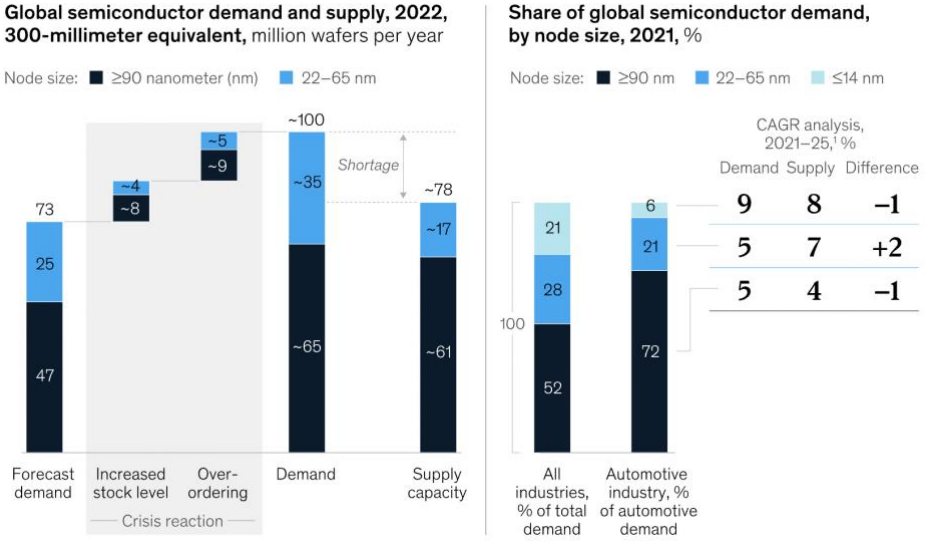


Figure 5 Industries Global Demand and Supply. Shortage view.

In the McKinsey report it is mentioned the importance to the Long-Term planning to reduce and avoid the shortage. For demand planning the challenge is the difficulty that OEMs must determine their custom orders for specific semiconductors. They even frequently make changes that affect the demand, even after beginning the production of the order. For suppliers such as Infineon, they require commitment on the structure of the demand allowing little flexibility, moreover the challenge is to decide on long-term capacity investments.

Report on Automotive Electronics, 31(4), 5–7

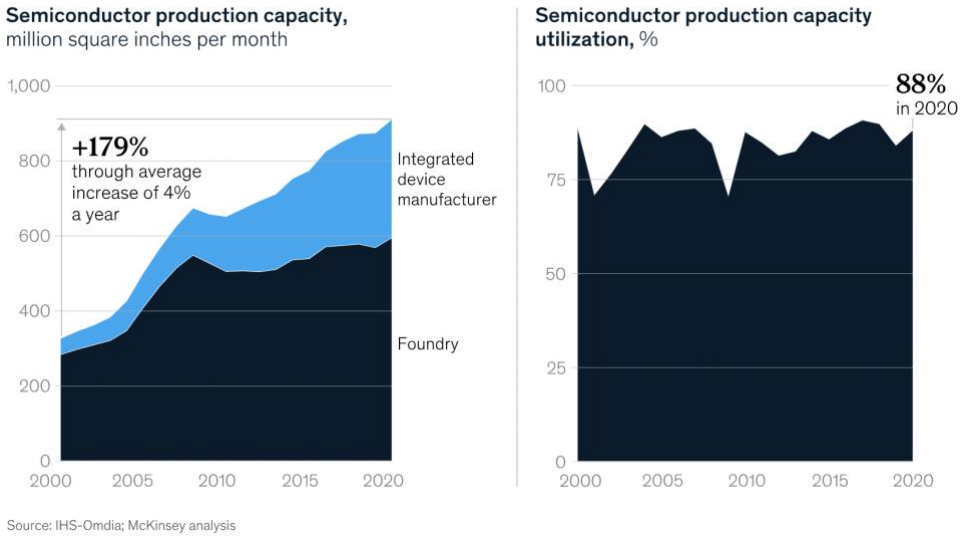


Figure 6 Production development and allocation.

To tackle this type of problems it is of major importance to share information on demand and supply through the full value chain, increase the accuracy of the planning through data-driven forecast algorithms. For better strategic outlook they extended the demand planning to 3-5 years.

3.3. Infineon Technologies context

Infineon Technologies AG is one of the world's leading semiconductor manufacturers. They are a German company, with headquarters in Munich, in Bavaria in the south of Germany. Infineon was founded in 1999 by splitting from Siemens. The slogan of the organization is to "Drive decarbonization and digitalization. Together", putting sustainability and innovation at the heart of their production. The organization consists of several divisions, many of them leaders in their respective markets. These consist of Automotive (ATV), on the cutting edge of trends like electromobility and autonomous vehicles; Green Industrial Power (GIP), working to increase efficiency across supply chains; Power & Sensor Systems (PSS), working with mobile devices to increase power efficiency and sensor capability; and Connected Secure Systems (CSS), which involves the internet of things (Infineon AG, 2023).

The company has 56,200 employees worldwide (as of September 2022) (Infineon AG, 2023), and take in over €10 billion in revenue yearly.

Infineon evolved from Siemens; another German corporation involved in engineering. Set up after World War II, Siemens AG is still a major player in mechanical and electrical engineering. In 1999, the semiconductor portion of the business spun off under the name Infineon Technologies, and shortly after that, in 2006, Siemens sold its remaining shares in the

company.

Since its founding, Infineon has continually grown, by acquiring other semiconductor companies, building fabrication sites and offices, and aiming towards digitalization in all areas of production.

Its most recent acquisition, Cypress was an American semiconductor business which Infineon bought in 2019 for €9.4 billion (Riley, 2019).The company had operations in the US, Ireland, India, and the Philippines. The deal made Infineon one of the ten largest semiconductor companies globally.

In recent years, especially as the global economy has recovered after the pandemic, Infineon's revenue, investments, and productions have grown massively. Revenue has almost doubled in the last five years (Figure 7). This is largely due to the growing market for semiconductors, as personal devices, automotive vehicles, and industrial machinery become increasingly complex. As well as this increase in revenue, it is clear from the diagram that the segment result margin, or proportion of revenue which attributes profit has increased in recent years.

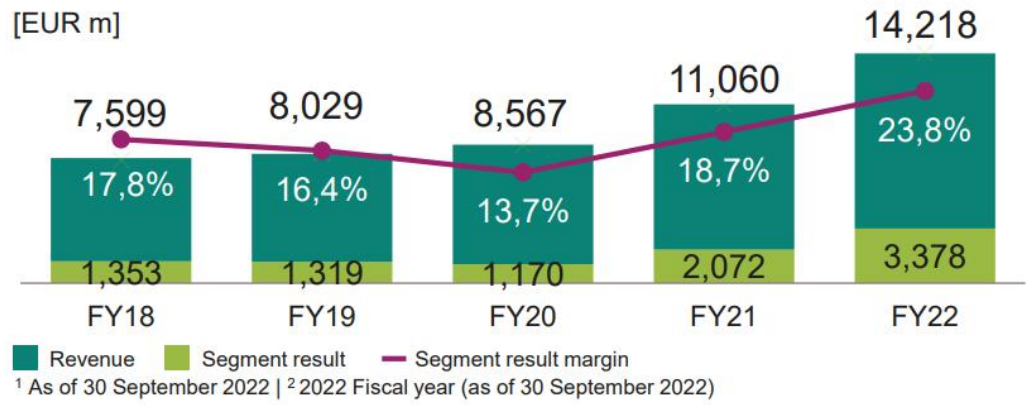


Figure 7 Revenue growth over 5 years

In terms of global presence, Infineon has grown massively since it was first set up in Germany. Today, R&D, and main headquarters are located outside München in Germany, and the sales headquarters are located in Milano in Italy. The company is present at 153 locations worldwide. Production facilities are spread across Asia, Europe, and North America. Research and development also occur worldwide but is centred in Europe.

In Figure 8, the manufacturing facilities are indicated. Front end manufacturing is the process of doping and masking the silicon wafers before being transported to the die banks. Back-end production is when the wafers are cut into chips, connectors are applied, and the products are packaged. As is evident in the map, most fabrication sites only conduct one type of production.

This makes the semiconductor supply chain very complex, requiring transportation across the globe several times over the course of productions. For this reason, lead times for microchips can be long, up to several months, meaning customers and Infineon itself need to be diligent in their planning to avoid supply-chain disruption and breakdown.

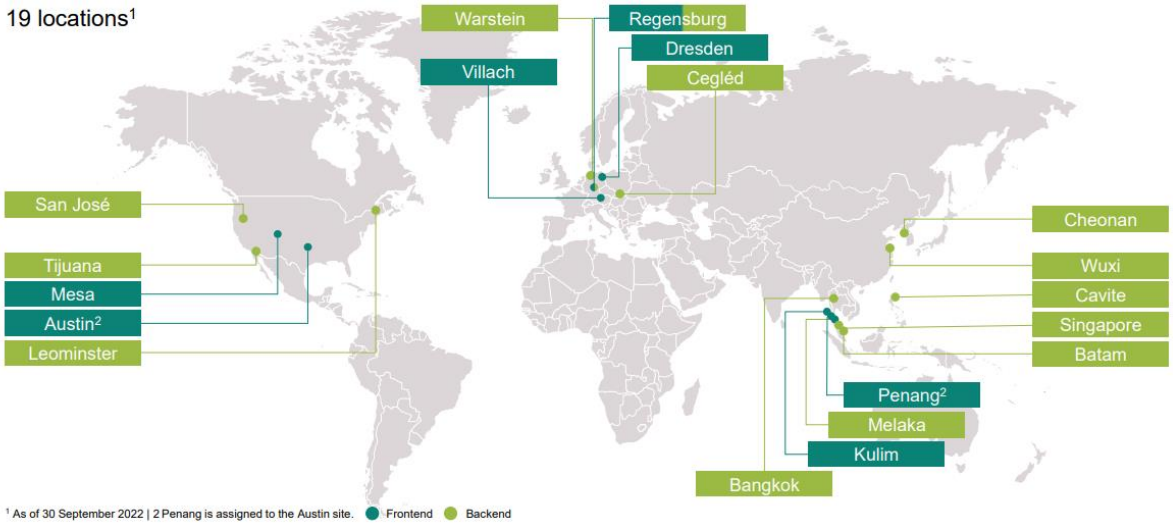


Figure 8 Fabrication sites globally

The most recent, and largest, investment was the construction of a fabrication site in Villach, Austria. Additionally, construction is ongoing for another module at the fabrication site in Dresden, Austria. Both large investments enhanced the economies in these towns, as well as bringing Infineon to the forefront in semiconductor fabrication in Europe. As well as having locations worldwide, Infineon has markets globally. Mainland China and Hong Kong contribute to a high proportion of the company's revenue (Figure 9), because of the high volume of electronics, automotive and industrial production there.

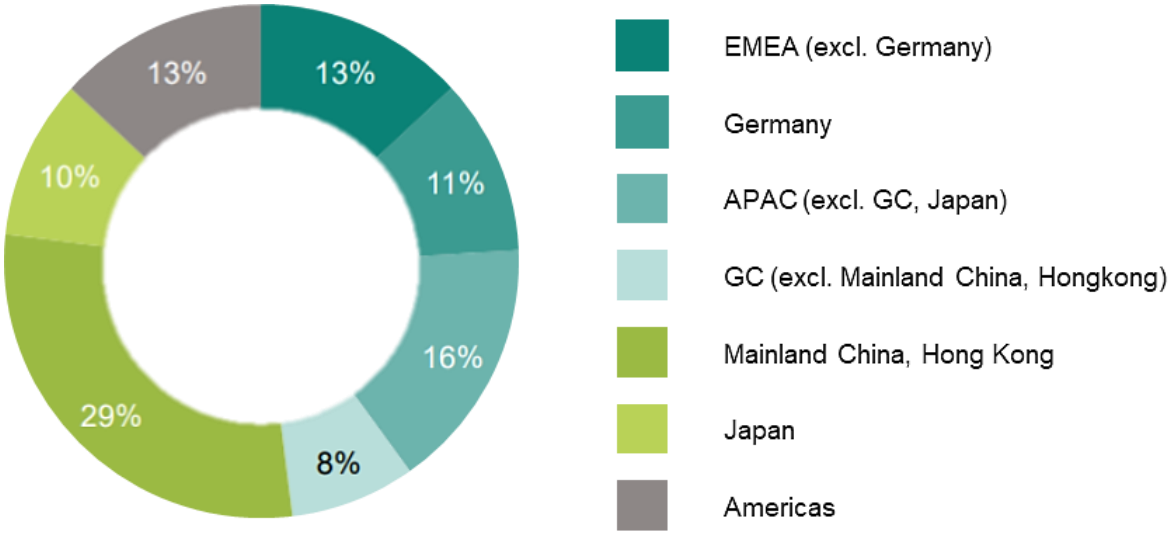


Figure 9 Infineon's revenue intake split by region. (EMEA = Europe, Middle East, and Africa; APAC = Asia-Pacific; GC = Greater China)

Like any other company, it is necessary for Infineon to look forwards. Planning and forecasting is a large part of any decision-making process. In this year's report, Infineon predicts a fall in the semiconductor market, but a recovery next year, in 2024 (Figure 10). The reason for this depression in demand is the macroeconomic instability currently affecting the whole world (Jochen Hanebeck - CEO of Infineon AG, 2023). The war in Ukraine, the coronavirus pandemic and the climate emergency are all causing untold human suffering. In addition to this, inflation is driving demand downwards, and prompting financial institutions to adopt more conservative investment strategies. The pandemic restrictions are ongoing in some part of the world, slowing and blocking the supply chain. Extreme weather events attributed to the climate emergency create instability in the sourcing of raw material and in production in affected areas. However, demand remains high as innovation continues in the technological industries.

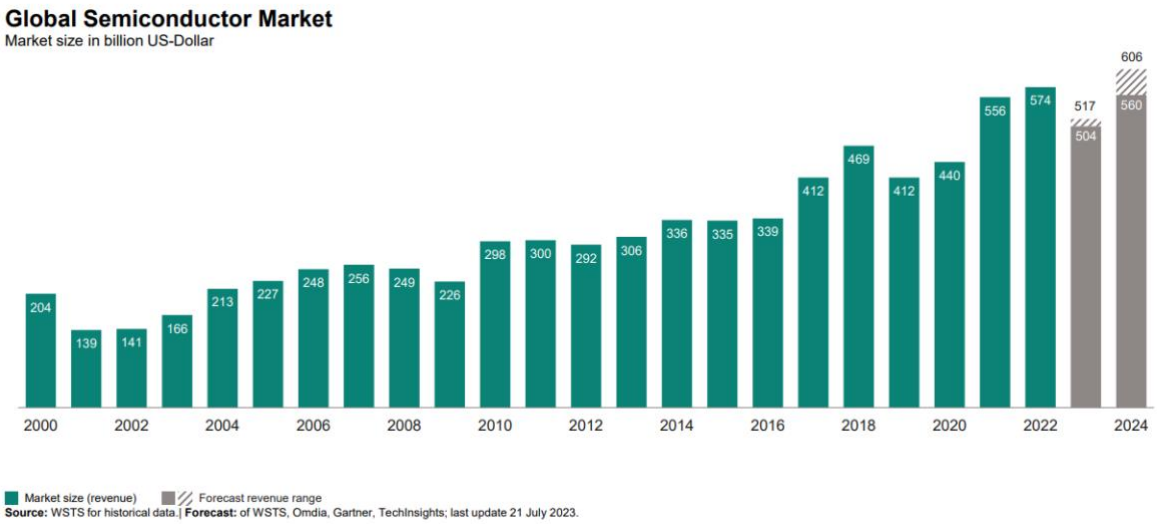


Figure 10 Actuals and forecast for global semiconductor market ($B Revenue)

Infineon's productions are divided across several divisions: Automotive, Green Industrial Power, Power and Sensor Systems, and Connected Secure Systems. Of these, the automotive division takes in the largest portion of revenue annually (Figure 11) and is the number one company in the automotive semiconductor industry. However, Infineon is a top player across all its target industries, taking first place with almost 20% of the power discrete and modules, market and fifth place with 12% of the microcontroller market (Infineon AG, 2023).

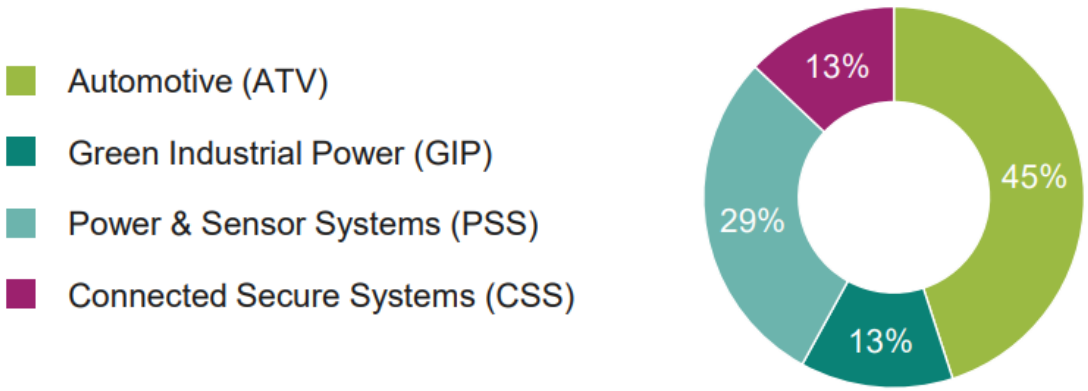


Figure 11 Revenue by business segments (2022/23 fiscal Year – as of September 2022)

3.3.1. Automotive (ATV)

The ATV division enables innovations in automotive mobility by creating microchips which can be used as sensors, microcontrollers, memory devices, power conductors and components for human-machine interaction and inter-vehicle connectivity. Silicon is obviously used in these semiconductors, but increasingly a new material, Silicon Carbide (SiC) has been integrated to the portfolio. One area of research in which Infineon has been investing is the necessity for highly efficient battery use and recharging for fully electric and hybrid vehicles. With increasing innovation in assistive driving solutions, Infineon is at the forefront of an emerging industry.

Even in cars which are constructed in a more traditional way, without assistive driving and electrification, convenience and comfort are of supreme importance to the user. For this reason, Infineon's portfolio includes chips for interior and exterior lighting, air conditioning, seat heating/cooling, windscreen wiper and cleaner, sunroof and window lift and more. Every new car produced today has most of these features, and the majority are powered by semiconductors.

The revenue taken in by the automotive division has risen steadily over the last five quarters (Figure 12), and it remains the division with the highest proportion of revenue intake. In addition to this, the profit margin has also increased, allowing for further investment into the previously discussed innovations.

Note: The fiscal year for Infineon runs from the 1st of October to the 31st of September annually.

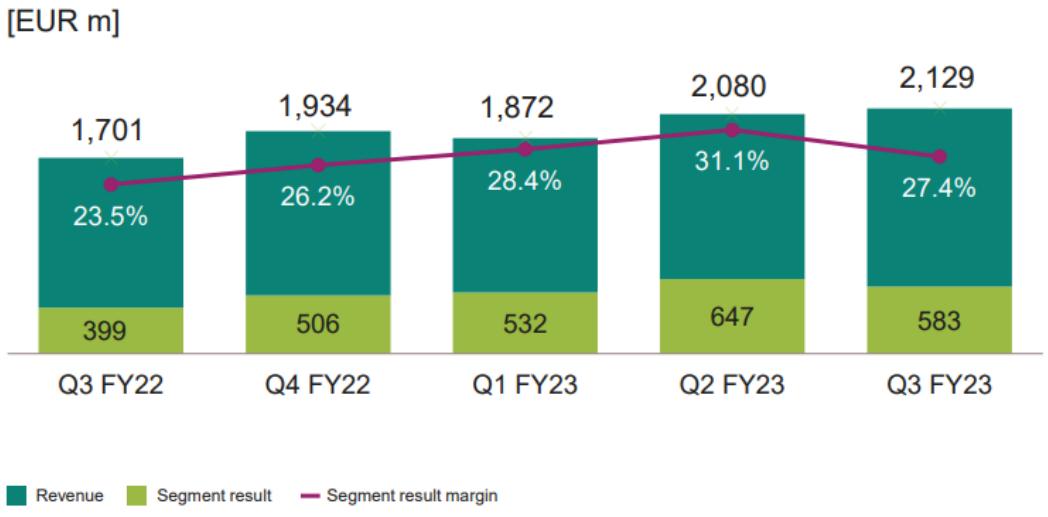


Figure 12 Automotive revenue and segment result between the end of FY22 and the mid-FY23

All the images in this section came from the Infineon company presentation released in August 2023 (Infineon AG, 2023). They are publicly available charts.

3.3.2. Green Industrial Power (GIP)

Green industrial power covers a wide range of use cases, delivering semiconductors which cover the entire supply chain of electricity, from generation, transport, storage to consumption. The consumption portion of this chain, as it applies to GIP consists of industrial power supplies, electrical vehicle charging, train systems and home appliances.

This division focuses on renewable energy solutions like solar and wind energy systems, sustainable energy consumption like electric light vehicles and public transit systems, and intelligent energy handling for transport and storage; “driving decarbonization for a better tomorrow”.

Despite a slightly more erratic gross revenue acquisition than ATV, the segment result has grown steadily in recent years. The lowering of cost price contributes to this misalignment of revenue and profit, indicating the importance of analysing both.

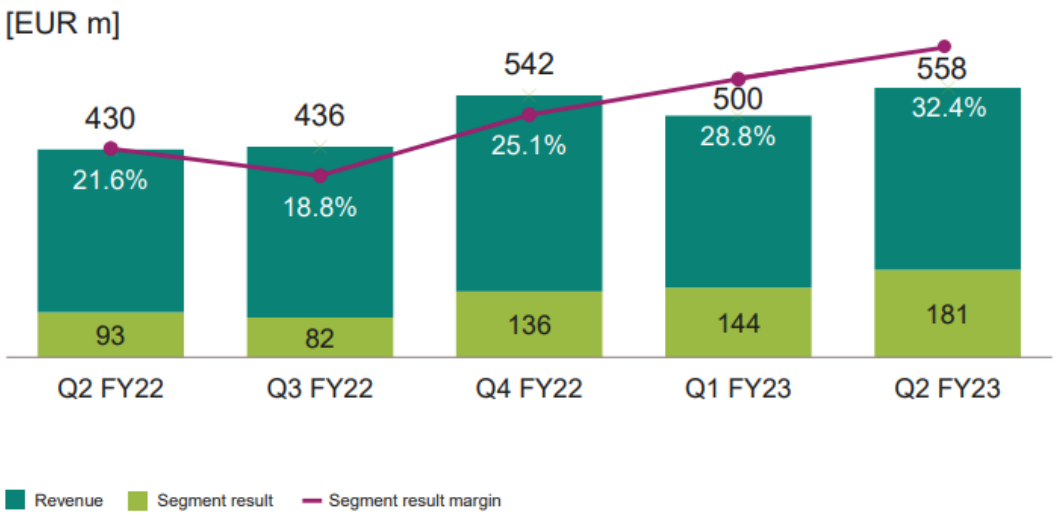


Figure 13 Green Industrial Power revenue and segment result over the 2022-2023 fiscal year.

3.3.3. Power & Sensor Systems (PSS)

This division creates sensors and power management devices, and boasts a portfolio consisting of power, sensor, and connectivity components. These allow their target products to become smaller, lighter, smarter, and more efficient. These semiconductors are used in personal devices, “smart home” devices, robotic technologies, power tools, charging devices and more.

In Figure 14 the PSS division is experiencing a downturn this quarter. However, analysing on such a narrow time horizon can cause downturns to appear more dramatic. The revenue intake is much higher than it was in 2021, at €787 million and the segment result has also increased, though by a noticeably smaller amount, from €184 million. Since PSS had an almost 30% share in the revenue intake at Infineon, this slower growth is noticeable; however, the revenue and profit are still increasing, albeit at a less rapid pace than ATV.

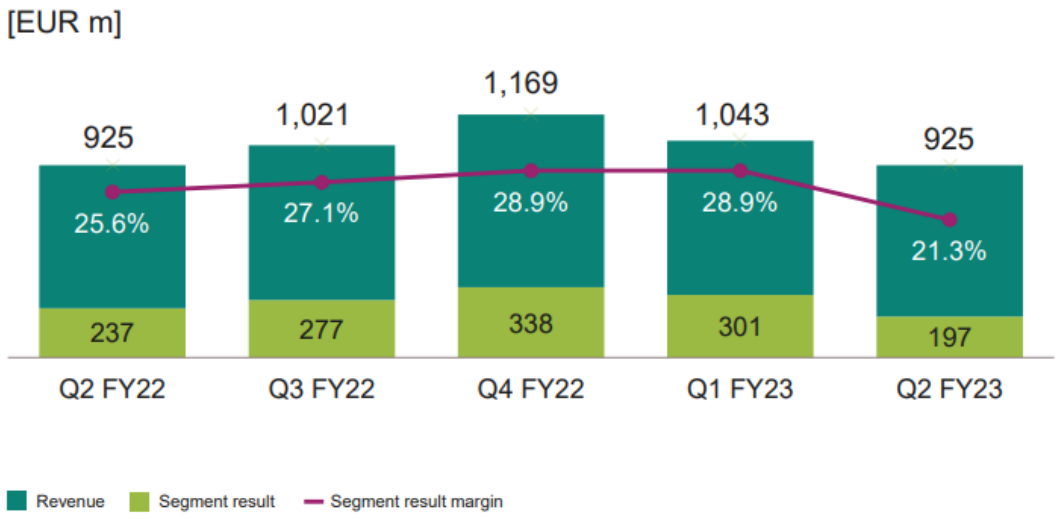


Figure 14 Power & Sensor systems revenue and segment result over the 2022-2023 fiscal year.

3.3.4. Connected Secure Systems (CSS)

CSS is involved in internet of things, allowing consumer electronics, home appliances, electronic passwords, credit and debit cards, and connected vehicles to be more efficient and secure than ever. Both hardware and software solutions are targeted, and the products make use of Wi-Fi, Bluetooth, and other technologies to ensure the highest security and convenience.

As illustrated, many of the divisions have overlap in the industries they target, allowing for a lot of collaboration between teams. Many people interact with Infineon products every day—at work, at home, in transit, and even when purchasing a coffee—showing their broad reach and robust business model.

As see in Figure 15, after a slow start to the fiscal year the CSS division has continued to grow steadily.

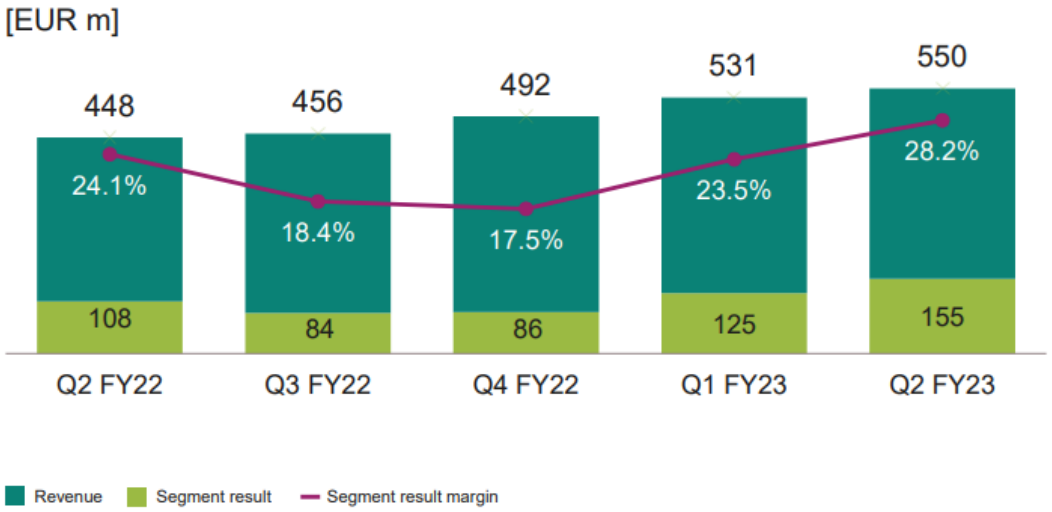


Figure 15 Connected secure systems revenue and segment result over the 2022-2023 fiscal year.

Overall, there has been steady financial growth in each of the four divisions, and the forecast is certainly positive for Infineon.

3.4. Objectives

The objective of this project is to bridge the gap in knowledge from planned capacities to the impact in revenue. Very little people within the company have the knowledge of which products are more expensive than others, how much revenue derives from the planning made etc. As hard to imagine as it seems, even the Business Demand Planners do not pay attention to the prices of the planned technologies.

Those little few that have this knowledge is through years of experience. They have developed a gut feeling or intuition, but there is no real tool to quantify what is driving these Revenue changes. Nevertheless, with today's technologies and following Infineon's strategy to digitalize and automate processes the team set up the project to create a solution for this gap of knowledge and reporting. Therefore, the result of the thesis will be a tool that enables interested stakeholders to visualize, understand and quantify revenue related to their project.

In other words, the objective of the project is to enable more transparent and precise analysis of the revenue deriving from the Supply Chain. To do so it is important to have some background on the team's function within Infineon Technologies.

3.5. Scope of the project

Since the project is a new topic and is time and resources limited the scope of this project will be limited to Supply Chain and Marketing Revenue measures. Also, it will be focused on the planning and therefore, most of the analysis will be made either from the Actuals or the Forecasted measures. Further development of these forecasted measures and where they come from will be explained in the upcoming chapters.

As mentioned above, the focus is on Supply Chain and Marketing measures, nonetheless we have not mentioned the Profit. Profitability is very important within Infineon and there are other initiatives within the company to drive more Profit driven solutions. Due to the complexity of the subject, and its sensitivity for competitiveness and ensuring fair competition profit margins and costs will be out of scope for this project.

It is also worth to mention that from the Global Finance department at Infineon there has been an initiative to adopt a similar solution, to create an IT solution where profits, price effects, quantity, and mix effects. The organization of such a project takes longer since there are many more stakeholders and decisions to agree to.

The automotive division was in the lead position to define the requirements for this solution thanks to this project. Further alignment with the Finance department has been held to share results and lessons learned.

4. Learnings, research, and processes

4.1. Supply Chain Processes

To create a reporting tool, we need to fully understand the processes we are reporting about. Thus, in this chapter we will give an overview of all the processes involved in the Supply Chain Planning process.

4.1.1. SCOR Model

The SCOR model, created by the Supply Chain Council, aids industries in enhancing their supply chain operations. It was established in 1996 and is currently available in Version 10, supporting English and Japanese languages.

Utilizing standardized process models facilitates effective communication within the supply chain, simplifies the integration of standard IT applications like SAP, and enables software providers to develop customer-centric IT solutions that are easier to implement.

Infineon successfully utilized the SCOR model to revamp their Demand to Cash processes in 2003 and Sourcing processes in 2004. Their efforts were recognized in 2010 when they received the SCC award for excellence.

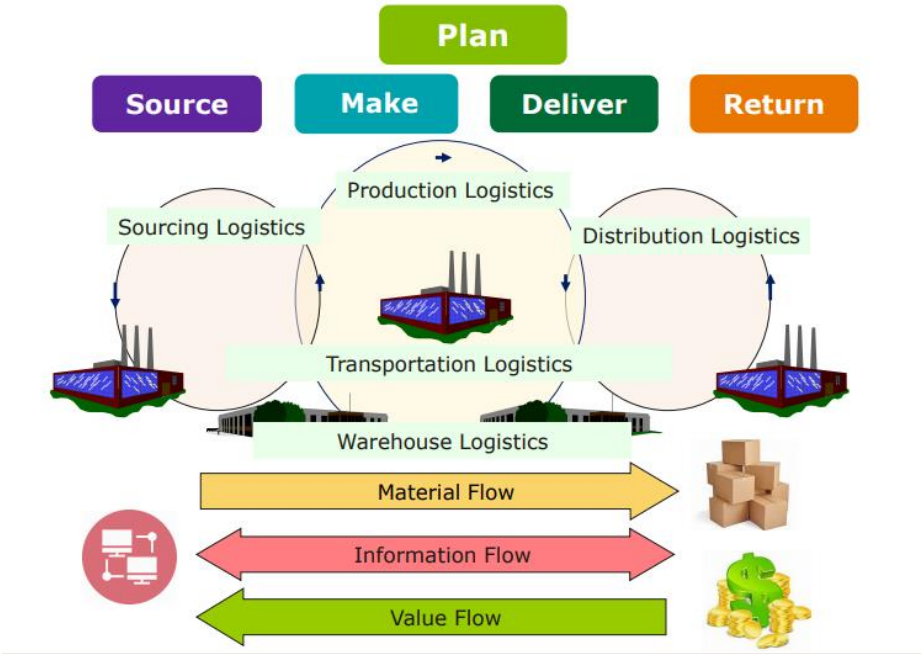


Figure 16 Five Major Supply Chain Processes according to SCOR®

In the image above, we observe the major processes of the Supply Chain according to the SCOR model. For the purposes of this Project, we will focus on the Planning process.

4.1.2. Planning

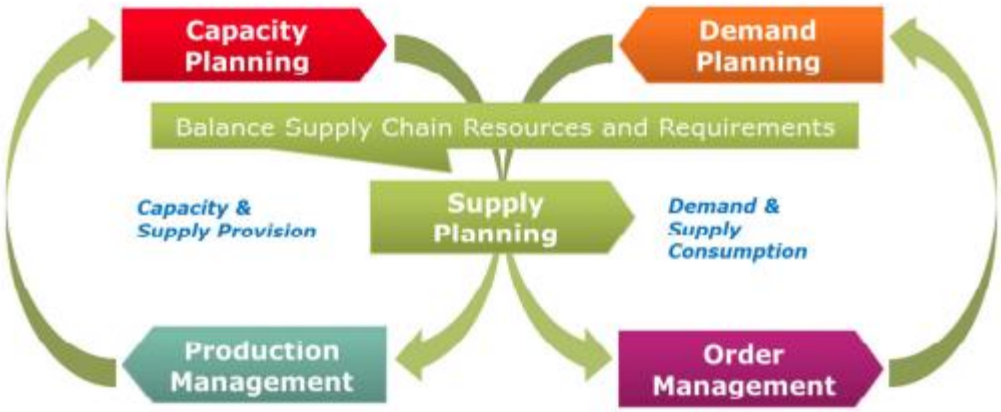


Figure 17 Plan processes. By SCOR Model.

Infineon uses the SCOR model to describe its Supply Chain. The main 5 processes are Plan, Source, Make, Deliver & Return. The Planning Process is divided into 5 sub-processes, which are Demand Planning, Capacity Planning, Supply Planning, Production Management and Order Management.

It will also be critical to well understand the time horizon of this processes. Since they are all rolling processes with different horizons, its understanding is very important for the calculation of KPI's and revenue calculation.

In the figure below we observe the timeline of the Volume Rolling Forecast, VRFC for short, that is the quarterly tactical process to match demand and production capacity at Infineon.

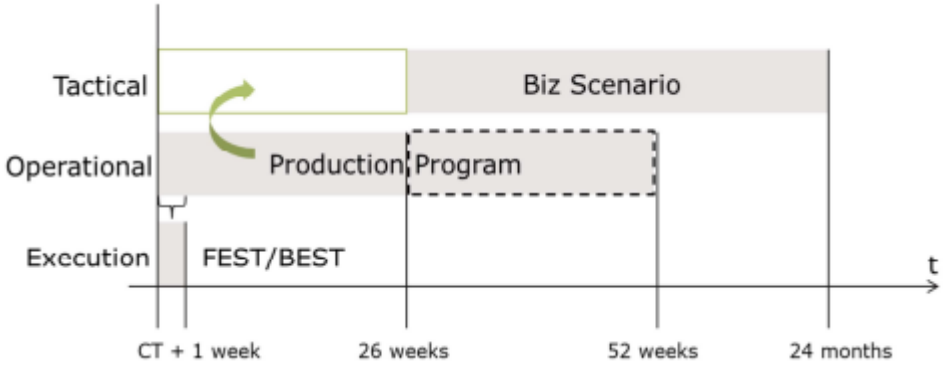


Figure 18 Infineon Plan Processes

Overall, the Production Program covers the initial 52-week period, followed by the Business Scenario from month 6 to month 24. The VRFC process, conducted quarterly, integrates the results of both the Production Program and the Business Scenario to provide updated volume forecasts.

4.1.3. Mid- and Long-term planning

The ATV LCM TS team engages with both tactical (mid-term – 24-month horizon) and strategic (long-term – 5-year horizon) planning, at various intervals throughout the year. These processes consist of quarterly Volume Rolling Forecast (VRFC) and annual MinMax planning. VRFC plans the following 24 months, whereas MinMax is concerned with up to 5 years in the future.

The VRFC process uses market data (worldwide light vehicle sales), as well as open orders and the sales forecast to “refresh” the planned manufacturing in the fabs. The team consolidates demand planning for each of the Product Lines (PLs), and considers inventory levels, transfer projects, ramp up and ramp down as well as strategic adjustments. Transfer projects refer to the process of transferring the manufacture of a certain product from one fab to another. Ramp-up occurs when a product is being given further investment, and its manufacture rate is projected to increase. Ramp-down is when a product is going out of production and will eventually be discontinued. It generally happens over time, giving customers enough time to purchase adequate inventory or to find an alternative.

VRFC consists of several planning stages: marketing, uncapped, pre-capped, capped, and post-processing.

The marketing stage involves market analysis and determines the state of the market. The marketing team (not ATV LCM TS) investigates the demand for various products and assesses their current and future customers. The idea is to plan potential sales as if the capacity of production was unlimited.

Next, uncapped planning consolidates information from the marketing stage from all divisions. Each division reports their projected demand, and the quantities they could sell if they had unlimited production capacity. All this information is consolidated, and some decisions can be made about allocation, based on projected revenue, cost, and other factors like inventory.

The next planning stage is the pre-capped one; it is the start of the allocation of load to various sites. At this stage, the demand corridor is consolidated with the capacity of sites. Here the new Bottleneck Capacities are given by the FE OPC team. The ones taking care of the FE sites on an operational level. Sometimes the demand does not fill the capacity. In this case, capacity is traded with other divisions outside of the automotive one, during JACC negotiations. Bottlenecks are filled and the resources are divided between the various product lines within

the automotive division.

Finally, the capped stage is when sites can use the information given at the pre-capped stage and determine whether they can fulfil the plans. Final adjustments are made to the plans. Figure 19 depicts an illustration of the entire VRFC process from beginning to end. The primary questions at the bottom of the image indicate the motivation behind each process: Marketing asks, “what could I sell if I had an unlimited supply of products?”, Uncapped asks “what would I want to produce if I had unlimited production capacity?”, Precapped asks “what am I able to produce with the capacity I have?” Finally, the capped stage answers the crucial question: “what will be produced & sold, given all the information I have compiled?”. The capped stage consolidates information from marketing about demand, as well as information from the sites about capacity. It is the basis for production planning at an operational level.

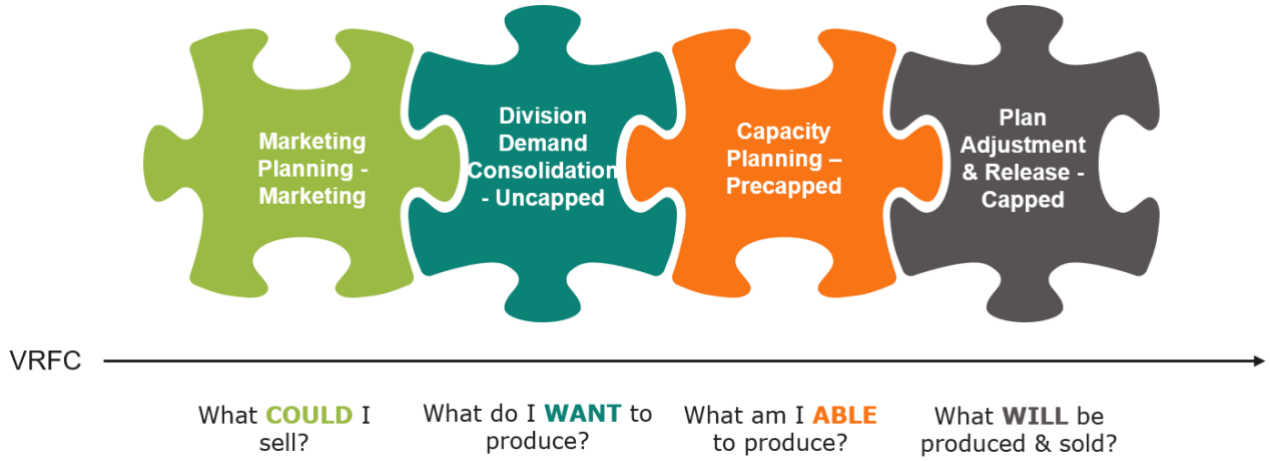


Figure 19 Illustration of the VRFC process from (Infineon Technologies AG) internal training material

After this intensive planning process, post-processing is completed. Feedback is given to the product managers in each business line (BDPs). Decisions are made about future investments, fabrication site construction, and discontinuation of obsolete products. Data from the VRFC and MinMax planning stages are used in this decision process.

4.2. Data tools at Infineon Technologies

In this chapter we will explain how the data is treated at Infineon Technologies. What tools are there and where is the data stored.

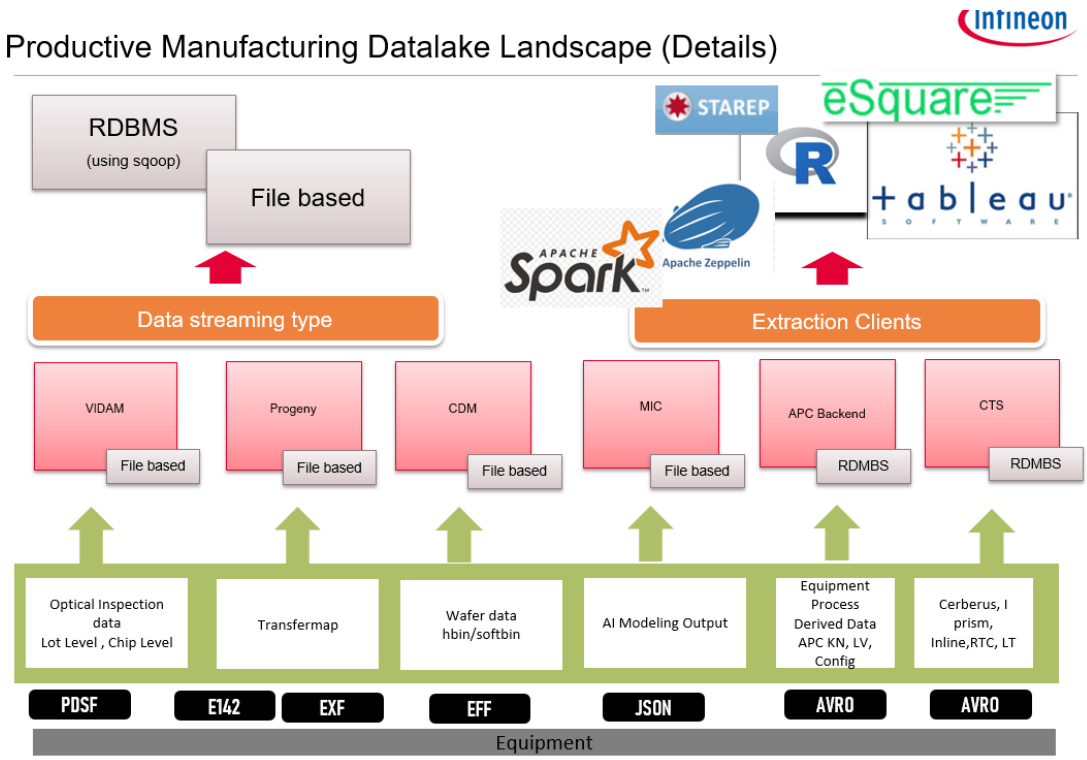
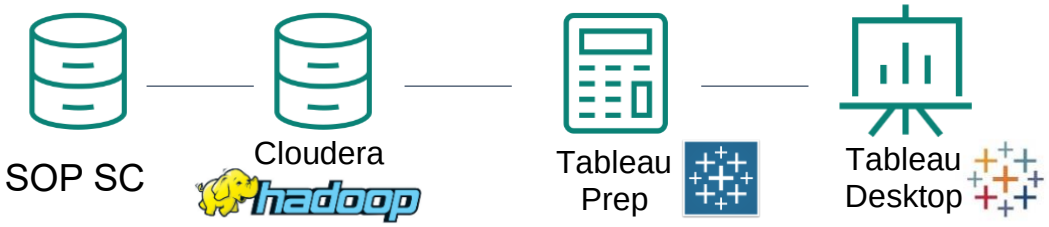


Figure 20 Datalake Landscape of Infineon

4.2.1. Chosen Set Up for our Solution.

A clear overview of the data structure of Infineon Technologies is needed to do any kind of reporting or analysis. From the generation of the data to the storage to the analysis and reporting.

In this chapter we will get an overview of the main tools used for data usage at the ATV LCM TS team. Starting by the tool where we manually enter the numbers for the planning, going through the different data bases where it is stored and finally getting to tableau.



4.2.2. S&OP Supply Chain

A BlueYonder (formerly JDA) application that supports the process by which the Capped Forecast is created together by Division Supply Chain Planning and Volume Planning organization. Balancing against Front End (FE) and Back End (BE) constraints, adjusted based on given corridor and provided to Finance as FRFC (Finance Rolling Forecast) input.

It is excel based and it is where all the Business Demand Planners put their planned capacities at the right granularity. It helps distributing load into the lowest granularity, helps overwriting planned capacities and it enables transfers, ramp ups and ramp down strategies.

It is used during all the phases of the planning explained in the chapter before.

4.2.3. Data Storage

Different storage options are available at Infineon for S&OP data that is derived from JDA software. The Online Analytical Processing (OLAP) cube in Excel is the most often utilized, while similar data is also available on the Corporate Big Data Platform (CBDP). The CBDP is a platform for Big Data analytics that runs on Hadoop and stores business data from many sources. Using clusters of affordable hardware, Hadoop is a "open-source software framework for storing data and executing applications. It offers huge processing power, massive storage for all types of data, and the capacity to manage almost infinite concurrent processes or jobs. Hadoop's key benefits include being affordable, effective, and open source while also supporting a variety of data sources.

We link to a 480-core CPU, 3TB of RAM, and 435TB of storage data lake that holds S&OP data. It is built on the HDFS (Hadoop Distributed File System), which is scalable, stable, and distributed (different nodes can store different sections of the same file). Because it is an affordable data storage option, Infineon uses it to store archive material. Its primary drawback is that since the archived data isn't updated later, there are discrepancies between it and the actual master data that S&OP users may view in the JDA application or OLAP cube. The primary limiting aspect is the possibility that the data lake contains typos or master data that is no longer valid.

4.2.4. Data access and query

The data contained in the data lake is accessible from SAP Business Objects universes. To display the properties and measurements of the several tables and columns of the data warehouse and to produce reports, a streamlined user interface is used. It functions as a semantic layer, translating tables and columns into business words so that users do not need

to be familiar with any query languages12. It even features a feature that allows users to create SQL (Structured Query Language) queries using a drag and drop user interface.

Once copied from the user interface, the resulting queries can then be modified on another SQL platform. Hue is Infineon's chosen SQL platform for CBDP data access. It is an open-source SQL Assistant for collaborating and accessing databases and data warehouses13. Each user must register for a Unix account at the Infineon IT Shop and seek access to the various Business Object Universes to use Hue and the data lake. Each user is then given access to a personal database where he or she may design customized views of the other databases. Once copied from the user interface, the resulting queries can then be modified on another SQL platform.

Since Business Object does not permit selecting data from several tables in the data lake, more complicated queries must be coded in SQL, which requires understanding of the language. To create sophisticated Business Intelligence reports, it is essential to understand how to combine or link data. The IT staff at Infineon is unable to provide or maintain the code and does not support business demands. Instead, if there are any particular inquiries or technical issues, IT specialists can be contacted. Below is a reminder of the normal SQL Query format that was applied in this project before we examine the data selection:

1. The SELECT statement is used to select data from a database.
2. The FROM command is used to specify which table to select from.
3. The WHERE clause is used to filter records.
4. The GROUP BY statement is used to group the result of the aggregate function (the Sum) by the selected columns.

In addition to these four main keywords of SQL, two others were used to create and drop views from the personal database. Those statements are respectively CREATE VIEW and DROP VIEW. The "CREATE VIEW" statement is used to create a virtual table, known as a view, within the database. The "DROP VIEW" statement is used to delete a view from the database. With this syntax we were able to create two queries to retrieve the data needed for the Dashboard. For performance reasons we divided the query in two tables. One with all the historical freezes and one with the current planning freeze; plan 0.

Table 1: For all the historical data, *vrfc_frfc_hist_tmp.*
This table contains all archived freezes, it refreshes every quarter once the planning cycle is finished through a Zeppelin script.

Table 2: For the current planning data, *sc_cube_vrfc_frfc_plan0*
This table is directly connected to the flow. Therefore, every time we run the flow the query runs and gets the most up to date data. The flow is run daily and so is this table.

The join for these two tables is made through the flow explained in the next chapter.

5. Tableau Prep

In the figure below we can observe the flow runed every morning to update the data in the Dashboard.

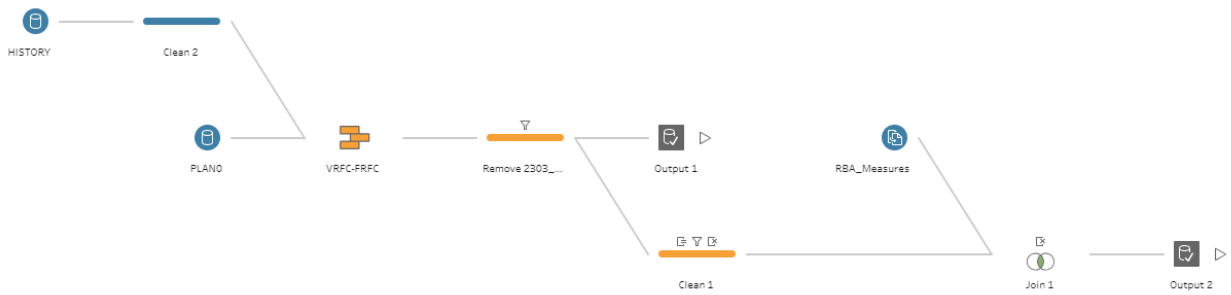


Figure 21 Tableau Prep Flow to enable Waterfall Chart and PVM Analysis

Step by step the flow works as follows.

- *Connection:* History and Plan0: Step that connects the flow to the data through Cloudera Hadoop. We connect to the two tables, vrfc_frfc_history_tmp and vrfc_frfc_plan0.
- *Union:* VRFC-FRFC: In this step we union the two tables with the same structure but that one is updated daily and the other one on a quarterly basis.
- *Cleaning steps:* Used to modify the dataset.
    - Clean 1: Selecting the set of relevant plans and most important of all creating a Calculated Field called ID and that is 1 for all rows.
- *Packaged File Connection:* RBA_Measures: This step is to retrieve the table with the structure to add a dimension to the dataset. We can observe the table below.

ID	RBA Measure
1	BAR_1
1	BAR_2
1	BAR_3
1	BAR_4
1	BAR_5
1	BAR_6
1	BAR_7
1	BAR_8
1	BAR_9
1	BAR_10
1	BAR_11

Table 1 RBA Measure structure. Excel table to enable Waterfall Chart.

By having created the ID on the Clean1 step, and now joining the tables we get the final data

structure.

Inner Join: Join 1: In this step we are doing an inner join of our dataset plus the table presented above. As mentioned, the resulting dataset is 11 times bigger and with a new dimension and granularity, RBA_Measure .

Published Data Source: Output 2: Finally, we must set the Output of our flow as a Published Data Source in order to be able to periodically run the flow every morning.

Scheduled task: To Refresh the data source we create a task that runs Daily at 04:00 UTC all days of the week.

Below we can observe the running history of it.

Output step	Run type	Parameters	↓ Run start	Run end	Duration	Status	Rows generated	Errors
Output 2	Full refresh		Aug 30, 2023, 7:17 AM	Aug 30, 2023, 7:33 AM	00:15:20	Succeeded	74,362,596	
Output 2	Full refresh		Aug 29, 2023, 7:41 AM	Aug 29, 2023, 8:19 AM	00:37:52	Succeeded	74,361,672	
Output 2	Full refresh		Aug 28, 2023, 6:46 AM	Aug 28, 2023, 6:58 AM	00:11:40	Succeeded	74,358,900	
Output 2	Full refresh		Aug 27, 2023, 6:49 AM	Aug 27, 2023, 7:05 AM	00:15:18	Succeeded	74,363,520	
Output 2	Full refresh		Aug 26, 2023, 6:56 AM	Aug 26, 2023, 7:13 AM	00:17:36	Succeeded	74,363,520	

Figure 22 Running history. Data source.

6. Data Analysis

In this chapter, the logic behind the dashboard will be developed. It is of the upmost importance to have a rigorous analysis. Trustworthy reports are the only ones that will be used during the day to day. And that is why this documentation will be also used within Infineon to further develop the tool.

6.1. Tableau Level of Detail Calculation

LOD calculations, in other words, provide us the ability to do and display computations at a different degree of detail than the information shown in our visualization. In Tableau, computations may be made at the row level (row level), for instance, [sales] / [orders]. The second choice is to sum ([sales]) / sum ([orders]), which aggregates the metrics. Tableau would return the error if we wished to determine the difference between a measure and its average, for instance, [sales] - avg([sales]). This function does not allow the mixing of aggregate and non-aggregate parameters. LOD makes it feasible to do these computations, giving us more options when performing their calculations.

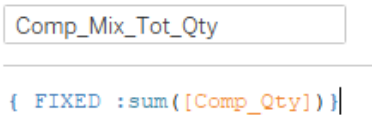


Figure 23 LOD Calculation Example

6.2. Tableau Order of Operations

Every analysis software has its own hierarchy when it comes to which operations you want to execute and in which order.

Sometimes, despite your expectations, Tableau may execute filters in a different sequence than what is required by the order of operations, producing surprising results. When this occurs, you may occasionally be able to alter the pipeline's execution order.

From top to bottom, this is the Tableau order of operations.

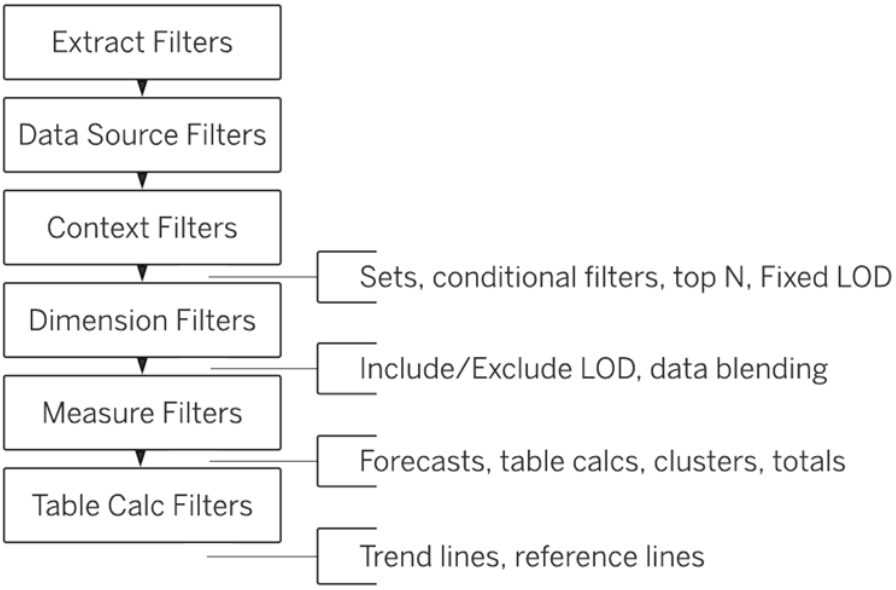


Figure 24 Order of Operations. Tableau Hierarchy.

And if we want to alternate the order of operations, we will use the functions or operations on the left. One example would be the Fixed LOD explained in the chapter above.

If we want a measure to be the SUM of what is filtered and not the sum of the leaf level, then you will use the fixed calculation and a context filter for that. The Fixed calculation will jump over any other type of filter, consequently it will always display the same level of the total of the context filtered data.

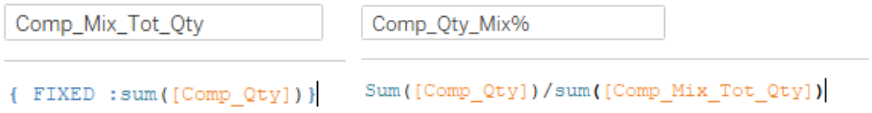


Figure 25 Calculation of the Mix percentage of product.

In the figure above, we observe how we calculate the percentage of the portfolio for each of the products. To get the total, on leaf level (RFP) we use the above-mentioned level of detail (LOD) calculation FIXED.

This will be key to later be able to do calculation on leaf level with totals from the portfolio to compare for the Price Volume Mix analysis.

6.3. Formulation and Analysis

When analysing revenue variance, you should have a thorough understanding of what's causing the fluctuations you're observing. You're undoubtedly wondering, "Is the price of my

products increasing", "What are the most profitable products in my portfolio?" and "How is my product mix affecting my revenue?" We'll look at the Price Volume Mix analysis as a tool that can answer all these questions.

Price - This is the easiest notion to grasp. Price merely reflects the cost of your product as it is sold. It is the primary contributor to the expansion of your company's margins.

Volume - The number of products that you sell. More money comes from selling more things at the same price. However, volume has little impact on profit margins. If your cost of goods remains constant, selling more products at lower prices diminishes your profitability.

Mix - Reflects the notion that not all products are created equal. Because some goods have higher prices than others, changes in your product mix will affect your revenue. Selling more products with higher prices increases revenue, and vice versa.

This has been a challenge within the team since expertise on the Price Volume Mix has had to be acquired, and due to the quantity of data and the diversity of products and thus different revenue developments, with negative values due to Ship and Debit, null quantities due to not Supply Chain relevant products.

Since Infineon has a huge portfolio, it has very distinct products. The vast majority have the pieces granularity, saved under the name qty for each different measure, and for each piece, one physical product is represented. On the other hand, there are some other products that the pieces granularity won't be equivalent to a physical product. Some of the examples that we see in this category are the ones coming from sales of non-tangible or manufactured products, such as Software and Licences. Moreover, due to Infineon's complex supply chain there are Ship and Debit products, where the client is charged only after using the chips, resulting in some negative values when products are returned or not sold in the quantity planned in the beginning.

With a set of data of almost 7 million rows, it has been critical to cluster different cases, to be sure that the analysis is made to the right products. Also, it is important to understand all the different types of outliers in the product side to have a neat analysis.

Therefore, we will do the Price Volume Mix analysis on the products that are considered quantity relevant. Consequently, we need to discard from the calculation, on leaf level, all products that are considered ramps, the ones that are considered Non-Manufactured and the Ship and Debit or with negative Revenues or Quantities.

6.3.1. Ramps and the Quantity Restriction Factor

Aside from the Effects explained above we want to differentiate ramping products. These

products will not be considered in the calculations of the PVM analysis. To determine which products will be considered Ramps we have used the established QRF from the TCM Bridge from finance.

The meaning of QRF is, that there is a huge difference in the quantity sold of one product within the two compared reporting periods. For example, there is a new product in the basic period which was just sold 100 times for a price of 200 Euro and now in the reporting period the same product is sold 100.000 times for a price of 50 Euro. On the other side there could be the situation that in the basic period a product was sold 1.000.000 times and because it is now not anymore in the product portfolio it's just sold 1.000 times.

This factor can have different factors depending on the structure in the Product Lines, nevertheless Infineon's QRF is stablished as to be 10.

Taking into consideration this QRF the formulation for the Ramp Up Flag and products will remain:

```
sum({ FIXED [rfp]: IF SUM([End_Rev])>sum([Start_Rev])*[QRF] AND sum([Start_Rev])>=0 AND sum([End_Rev])>=0
THEN
sum([End_Rev])-sum([Start_Rev])
ELSE 0
END})
```

Figure 26 Ramp Up Flag

Same for the Ramp Down:

```
sum({ FIXED [rfp]:IF max([flag ramp down])="Y" AND max([flag ramp up])="N" AND max([flag S&D])="N" AND max([manufactured])="
THEN
-(sum([Ref_Rev])-sum([Comp_Rev]))
ELSE 0
END })
```

Figure 27 Ramp Down

6.3.2. Ship and Debit

Ship and Debit is a type of agreement where a manufacturer offers incentives to its distributors in exchange for variable pricing of their products to help grow sales. The manufacturer agrees to provide a rebate to the distributor, which is usually a percentage of the difference between the distributor cost and the end purchaser cost of a product. This rebate helps ensure that the product can be sold at a competitive price.

At Infineon, this type of agreement is frequent, and it is one of the most problematic subjects for how it is reflected in the data. Ship and Debit is not flagged in the data source and is hard to cluster the products that have it. In our project, we have taken a simplified approach by clustering all products with negative figures, see formulation below.

```
FIXED [rfp]: IF sum([Ref_Rev])<0 OR sum([Ref_Qty])<0 OR sum([Comp_Rev])<0 OR sum([Comp_Qty])<0 THEN "Y" ELSE "N" END}
```

Figure 28 Ship and Debit Flag.

6.3.3. Non-Manufactured Products

This is the only flag that is within the data, so no further formulation is need it. We just had to add it to the Query and use it. It flags all products with manufacturing routes attributed.

6.3.4. Non-Quantity relevant products treatment logic

This leaves us with the treatment of non-quantity relevant products. Consequently, we need to discard from the calculation, on leaf level, all products that are considered ramps, the ones that are considered Non-Manufactured and the Ship and Debit (with negative Revenues or Quantities). Since there's the possibility that one RFP falls onto more than one of the categories the logic behind is quite complex and therefore below you can see a logic table with all the possible combinations and how we consider the RFP.

Non Manufactured	Ship and Debit	Ramp Up	Ramp Down	Output	Logic
0	0	0	0	PVM Analysis	IF MAX([ramp up])="N" AND MAX([ramp down])="N" AND MAX([S&D])="N" AND MAX([manufactured])="Y"
0	0	0	1	Ramp Down	IF max([ramp down])="Y" AND max([ramp up])="N" AND max([S&D])="N" AND max([manufactured])="Y"
0	0	1	0	Ramp Up	IF max([ramp up])="Y" AND max([S&D])="N" AND max([manufactured])="Y"
0	0	1	1	Ramp Up	IF max([ramp up])="Y" AND max([S&D])="N" AND max([manufactured])="Y"
0	1	0	0	Ship and Debit	IF MAX([manufactured])="Y" AND MAX([S&D])="Y"
0	1	0	1	Ship and Debit	IF MAX([manufactured])="Y" AND MAX([S&D])="Y"
0	1	1	0	Ship and Debit	IF MAX([manufactured])="Y" AND MAX([S&D])="Y"
0	1	1	1	Ship and Debit	IF MAX([manufactured])="Y" AND MAX([S&D])="Y"
1	0	0	0	Non Manufactured	IF MAX([manufactured])="N"
1	0	0	1	Non Manufactured	IF MAX([manufactured])="N"
1	0	1	0	Non Manufactured	IF MAX([manufactured])="N"
1	0	1	1	Non Manufactured	IF MAX([manufactured])="N"
1	1	0	0	Non Manufactured	IF MAX([manufactured])="N"
1	1	0	1	Non Manufactured	IF MAX([manufactured])="N"
1	1	1	0	Non Manufactured	IF MAX([manufactured])="N"
1	1	1	1	Non Manufactured	IF MAX([manufactured])="N"

Figure 29 How we treat all non-quantity related RFPs.

As we can observe we give priority to the non-Manufactured, since it's derived directly from

the data. Then, we give priority to the negative products since they should not be shown as Ramps and finally ramps. Arbitrarily, we have considered Ramp Ups with higher priority than Ramp Down.

6.3.5. Formulation for the Price Volume Mix

We want to present the formulation of the analysis. Moreover, we give some graphic representations to have a better understanding and intuition on the analysis.

It is very important to understand that all calculations are made on the lowest granularity.

Formulas

$$Price_{effect} = (ASP_{end} - ASP_{start}) * Qty_{end}$$

$$Volume_{effect} = (Tot\_Qty_{end} * Mix\%_{start} - Qty_{start}) * ASP_{start}$$

$$Mix_{effect} = (Qty_{end} - Tot\_Qty_{end} * Mix\%_{start}) * ASP_{start}$$

Figure 30 Formulation

Even though it's true that we do the calculations on RFP level we need to determine a portfolio to have a MIX effect. But let's at first have a look at a graphic example considering only one RFP.

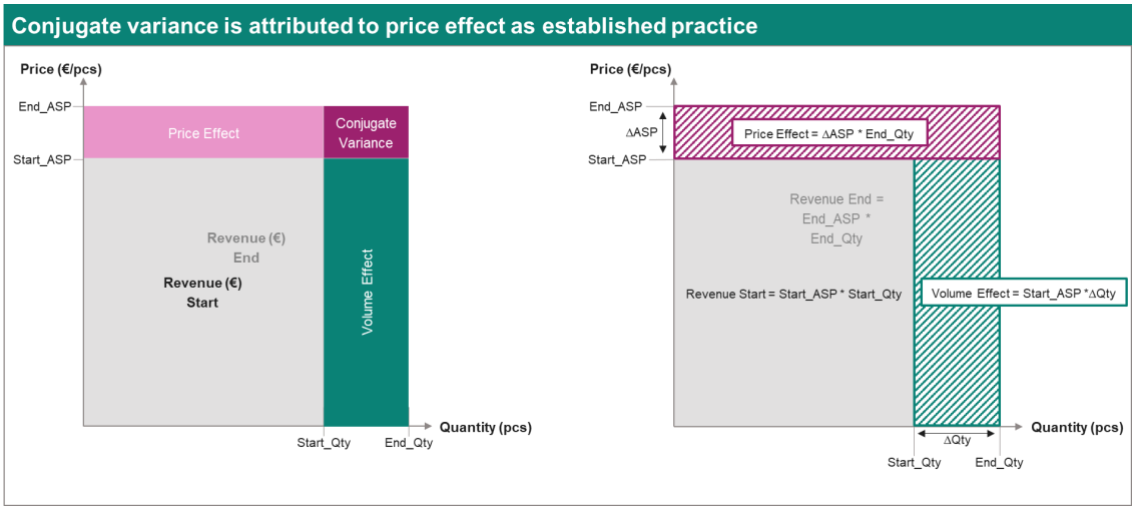
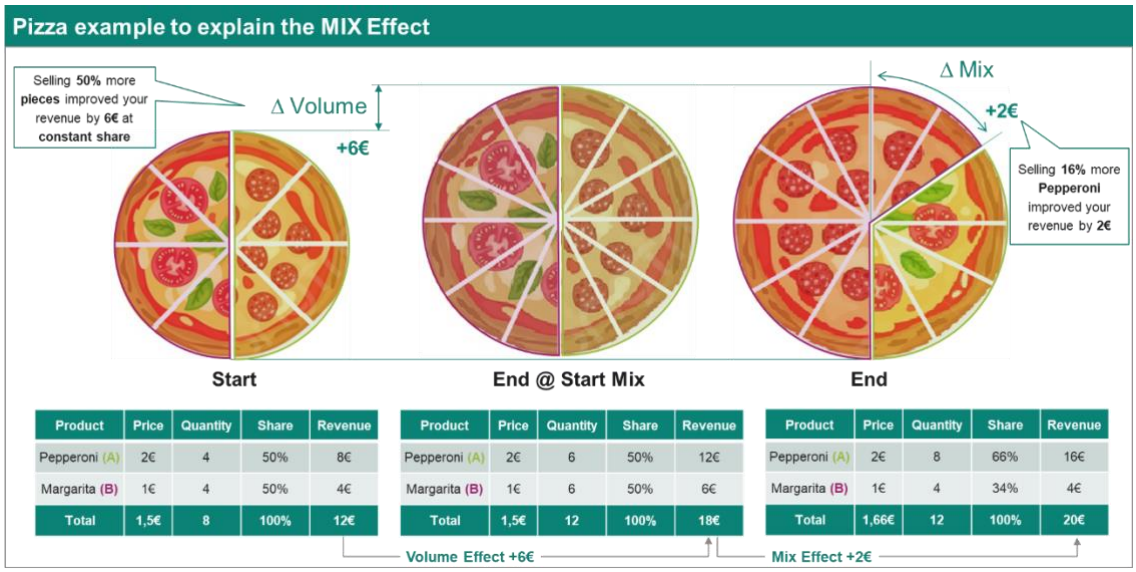


Figure 31 One product Price and Volume analysis

From the example above, we observe what is a Price Effect and what Volume Effect. We observe that there is some Revenue generated by the conjugate deltas of Price and Volume. It is important to note that this conjugate variance is attributed to Price Effect as Established Practice.

Now let's look at the Pizza example to understand the MIX effect. In this example, instead of RFP we have pizza slices, and we have Pepperoni (2€/piece) and Margarita (1€/piece) to represent RFPs with different prices.



Product	Price	Quantity	Share	Revenue
Pepperoni (A)	2€	4	50%	8€
Margarita (B)	1€	4	50%	4€
Total	1,5€	8	100%	12€

Product	Price	Quantity	Share	Revenue
Pepperoni (A)	2€	6	50%	12€
Margarita (B)	1€	6	50%	6€
Total	1,5€	12	100%	18€

Product	Price	Quantity	Share	Revenue
Pepperoni (A)	2€	8	66%	16€
Margarita (B)	1€	4	34%	4€
Total	1,66€	12	100%	20€

Figure 32 Pizza Example for the Price Volume Mix Analysis

At the start or reference point, we are selling a total of 8 slices and with a 50% "Portfolio" distribution. The Volume Variance is divided by two effects. Volume effect has impacted +6€ at constant share. The change in the portfolio distribution to two thirds Pepperoni has had a MIX effect of +2€.

6.4. Data Analysis in Tableau Desktop

6.4.1. Tableau Prep to enable Waterfall Charts

In this chapter we will go through all formulation needed behind the Dashboard. Since the visualization chosen has been the Waterfall Chart, we have had to modify a bit the Data to fit the calculations in one field for each leaf level.

So, in short terms, since we needed to store the result of each one of the effects, we have had to multiply the data per enough to store the results of these calculations there.

This process is made with Tableau Prep and the following flow structure.

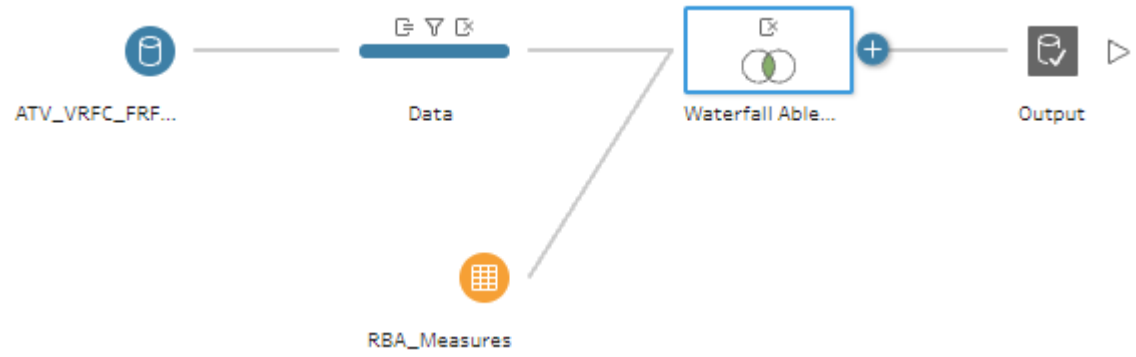


Figure 33 Flow to enable Waterfall Graphs

As we can observe we have two sources of data that we are joining. On one hand the ATV_VRFC_FRFC that is the result of the Query explained in the Chapter 5. On the other hand, we have an excel based file with the following structure.

ID	RBA Measure
1	BAR_1
1	BAR_2
1	BAR_3
1	BAR_4
1	BAR_5
1	BAR_6
1	BAR_7
1	BAR_8
1	BAR_9
1	BAR_10
1	BAR_11

There's an index that is continuously 1 and then a dimension called RBA Measure (for Revenue Bridge Analysis). Once we have these two data sources, we join them. Not before having created another ID=1 field in the ATV_VRFC_FRFC data. By creating this and then joining it together we eventually have a resulting data 11 times greater in size, with the same values repeated and changing only in the RBA_Measure dimension.

Figure 34 RBA Measures Excel

The consequence of such structure modifies the granularity of our data source. If before our leaf level was by [RFP] and [Cal Month] now it also must be by [RFP] , [Cal Month] and [RBA Measure].

6.4.2. Tableau Desktop Measures

In this chapter I will explain the logic under all the measures that we use for the Analysis, how to enable the analysis only on the chosen by the user. Most of the choosing comes from

parameters.

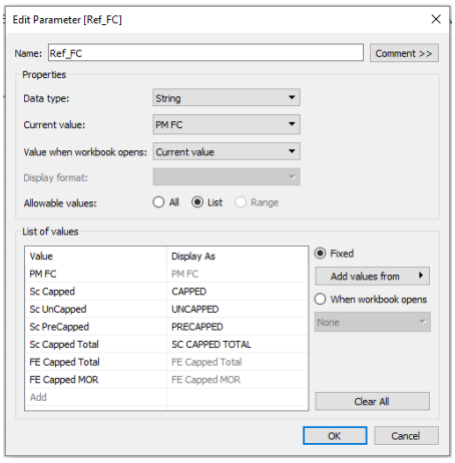
For computations, filters, and reference lines in Tableau, parameters can be used in place of constant values. By allowing users to alter certain features of the visualization without changing the underlying data or calculations, they let you develop more dynamic and adaptable visualizations. When you want to provide consumers the flexibility to explore numerous situations or compare distinct data points, parameters might be especially helpful.

The creation of interactive dashboards is one of the parameters' most effective uses. You may enable users to examine the data in numerous ways without having to build many iterations of the same graphic by utilizing parameters to modify various components of your dashboard.

6.4.2.1. Revenue and Quantity Measures

That is why we have used parameters in the following manner. We have the reference revenue and the comparison one. To choose and change this, we have created 4 parameters for each. Comp_X and Ref_X, having X as FY (for Year), Qtr. (for quarter), FC (Forecast Measure) and Plan (for Plan freeze).

Then the user needs to choose the year he wants to compare, the measure and the freeze. Moreover, there is the option to choose for a quarter comparison.



Here we can observe the set up and settings that we have used for our parameters used for the selection of the measures.

In this one we can observe that the values from the parameter are the measures that the user has the availability to choose from.

Other parameters would have as options, the years, the quarters, or the plan freezes.

Figure 35 Parameter creation and set up.

Once we have the parameters set up, we can already create the calculated fields that will store the measures that we want to compare in our Revenue Bridge.

Here is the code for this calculated field.

```
IF [plan_name]=[Ref_Plan] THEN
  IF  [Ref_Comp_Year] = [Ref_Y]THEN
    IF [Reference Qtr]="All" THEN
      CASE [Ref_FC]
       WHEN "PM FC"  THEN [pm_fc_vist_eur]/[RBA Length]
                  ...
      END
    ELSEIF [Ref_Comp_Qtr]=[Ref_Y]+[Reference Qtr] THEN
      CASE [Ref_FC]
       WHEN "PM FC"  THEN [pm_fc_vist_eur]/[RBA Length]
       ...
      END
    END
  ELSEIF [Ref_Y]="VRFC" THEN
     IF [month]>=[Plan_date_0] AND [month]<[Plan_date_+17] THEN
      CASE [Ref_FC]
       WHEN "PM FC"  THEN [pm_fc_vist_eur]/[RBA Length]
       ...
      END
    END
  END
END
```

We can observe that the logic is quite simple, combining IF statements and CASE statements we determine sequentially, the plan freeze we want to select, then the timeframe. That can be on a yearly basis if the Qtr. parameter is set to “All” quarterly. Alternatively, if the year parameter is set to “VRFC” then we will compare to a set of months that the planning is made. Finally with the CASE statement the forecast measures are chosen.

We can also observe that the measures, here in the example [pm_fc_vist_eur], are divided by [RBA Length] being RBA length the number of bars that we have multiplied the data for. In this case 11.

It is important to point out that there is a small tweak to these two measures when we are using the measures FE Capped Total and FE Capped MOR there will be two bars for the revenue. One of them will be the SC CAPPED TOTAL and the other will include the adder measures, this adder measures is extra revenue coming from planned contingencies.

6.4.2.2. Price Volume Mix and other effects

The analysis is done on a leaf level, product name or [RFP]. That is why we will used FIXED level of detail calculations on RFP level. And then aggregate with the sum() function.

PRICE EFFECT

```
sum({ FIXED  [rfp]: IF max([flag ramp down])="Y" OR max([flag ramp up])="Y" OR max([manufactured])="N"
OR max([flag S&D])="Y"
THEN 0
ELSE(IFNULL([Comp_ASP],0)-IFNULL([Ref_ASP],0))*IFNULL(sum([Comp_Qty]),0)
END})
```

We use the function ISNULL() for those products that don't have data in. This was after doing some bug fixing and realising that from plan to plan, [rfp] references change, new products appear, and old products disappear.

Also, we observe that we only calculate the effect following the logic explained in chapter 6.3.

MIX EFFECT

```
sum({ FIXED [rfp]:IF MAX([flag ramp up])="Y" OR  MAX([flag ramp down])="Y" OR  MAX([flag S&D])="Y"
AND MAX([manufactured])="N"
THEN 0
ELSE (IFNULL(sum([Comp_Qty]),0)-
IFNULL(sum([Comp_Mix_Tot_Qty]),0)*IFNULL([Ref_Qty_Mix%],0))*IFNULL([Ref_ASP],0) END
END })
```

Same for the MIX effect. For this one we have created some middle fields such as [Comp_Mix_Tot_Qty] that are fixed on other granularity. In this case, it aggregates the total quantity of the filtered portfolio.

VOLUME EFFECT

```
sum({ FIXED [rfp]:IF MAX([flag ramp up])="Y" OR  MAX([flag ramp down])="Y" OR  MAX([flag S&D])="Y"
AND MAX([manufactured])="N"
THEN 0
ELSE (IFNULL(SUM([Comp_Qty]),0)-IFNULL(sum([Ref_Qty]),0))*IFNULL([Ref_ASP],0)END
END})-[MIX]
```

Similar formulation for the Volume effect that we can observe here above.

Then for the others, we change the IF statement to determine which we want to display and as the result of it we just put the difference from one revenue to the other.

Having this formulated, we have the basis for the waterfall chart. We just need to create it with the right structure to display it as a waterfall chart.

6.4.2.3. Waterfall chart in Tableau

There is no specific chart type called Waterfall in Tableau Desktop. Nevertheless, by doing some workarounds we can manage to display information as waterfall chart.

Below we observe the structure to create the waterfall chart. We just need two measures and a dimension.

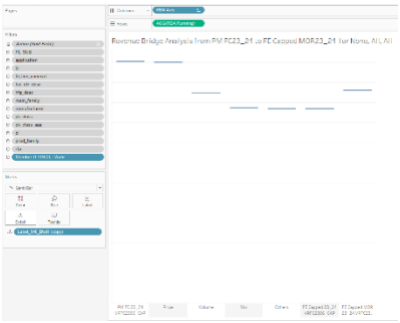


Figure 36 Gantt Chart of Running Sum

In this case we use the *RBA Axis* as dimension and *RBA Running* in the rows displayed as a Gantt Bar graph. *RBA Running* is the running sum of each one of the effects from the reference revenue to the comparison one. With this we manage to have the graph in the left. To finish the waterfall chart, we need to display the dimensions of the bars. We use the *RBA Calculation* as size of the Gantt Chart to generate the bars all the way to the bottom. Since the direction of these bars is down, we need to use the measure in the negative value.

The three fields are calculated fields, they are all based in the same logic. They are the final step of the whole formulation that is behind the waterfall chart.

Since we want the chart to change the set-up from grouping the others to not group them and display two new effects, we need a case that choses depending on the parameter. This are the *RBA Calculation*, *RBA Axis* and *RBA Running*.

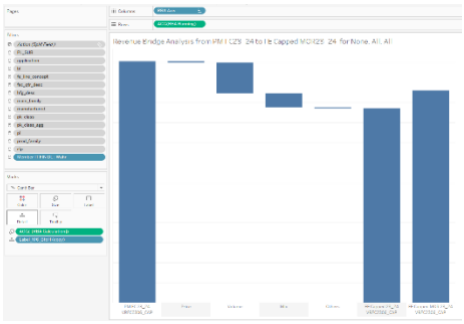


Figure 37 Waterfall chart adding size to the Gantt.

Here is the logic behind the formulation of each one of the fields. Specifically, RBA Axis.

```
CASE [Others Grouped]
WHEN TRUE THEN [RBA Others]
ELSE [RBA Ramps]
END
```

To continue with the explanation, we will focus on the others formulation.

RBA Axis:

```
CASE [RBA Measure]
WHEN "BAR_1" THEN [Ref_FC]+" "+[Ref_Y]+IIF([Reference Qtr]<>"All",[Reference Qtr],"")+" "+
[Ref_Plan]
WHEN "BAR_2" THEN IF[Ref_FC]="FE Capped MOR" OR [Ref_FC]="FE Capped Total" THEN "FE
Capped"+" "+[Ref_Y]+" "+[Ref_Plan]ELSE[Ref_FC]+" "+[Ref_Y]+IIF([Reference Qtr]<>"All",[Reference
Qtr],"")+" "+[Ref_Plan] END
WHEN "BAR_3" THEN "Price"
WHEN "BAR_4" THEN "Volume"
WHEN "BAR_5" THEN "Mix"
WHEN "BAR_6" THEN "Others"
WHEN "BAR_10" THEN IF[Comp_FC]="FE Capped MOR" OR [Comp_FC]="FE Capped Total" THEN "FE
Capped"+" "+[Comp_FY]+" "+[Comp_Plan] ELSE [Comp_FC]+" "+[Comp_FY]+IIF([Comp
Qtr]<>"All",[Comp Qtr],"")+" "+[Comp_Plan]END
WHEN "BAR_11" THEN [Comp_FC]+" "+[Comp_FY]+IIF([Comp Qtr]<>"All",[Comp Qtr],"")+"
"+[Comp_Plan]
END
```

RBA Calculation Others, the key to this is the Level of detail Calculation excluding [*plan name*] dimension from the calculation. This enables comparison plan to plan with exact calculation and displaying in the waterfall chart.

If we did not exclude the *plan name*, there would be a calculation behind for each different plan, and the result to it would be to have different charts for each one of the plans. On the other hand, if we exclude the *plan name* dimension the calculation does not consider that granularity and is done on a higher level to get optimal results.

```
CASE ATTR([RBA Measure])
WHEN "BAR_1" THEN sum({ EXCLUDE [plan_name]: sum([Ref_Rev_Adder])/[Divisor]})*[RBA Length]
WHEN "BAR_2" THEN sum({ EXCLUDE [plan_name]: [Start]/[Divisor]})
WHEN "BAR_3" THEN sum({ EXCLUDE [plan_name]: [PRICE]/[Divisor]})
WHEN "BAR_4" THEN sum({ EXCLUDE [plan_name]: [VOLUME]/[Divisor]})
WHEN "BAR_5" THEN sum({ EXCLUDE [plan_name]: [MIX]/[Divisor]})
WHEN "BAR_6" THEN sum({ EXCLUDE [plan_name]: [Others]/[Divisor]})
WHEN "BAR_10" THEN sum({ EXCLUDE [plan_name]:[End]/[Divisor]})
WHEN "BAR_11" THEN sum({ EXCLUDE [plan_name]: sum([Comp_Rev_Adder])/[Divisor]})*[RBA
Length]
END
```

Then for the Running Calculation the same logic is applied but doing a running sum of the measure above. Please see the annex for further formulas.

Once the formulation for the numbers behind is correctly displayed as a waterfall chart, we need to add the features such as Label, Tooltip and Colour.

In the following figure you can observe how many new fields take part in this graph. We will explain the most relevant ones.

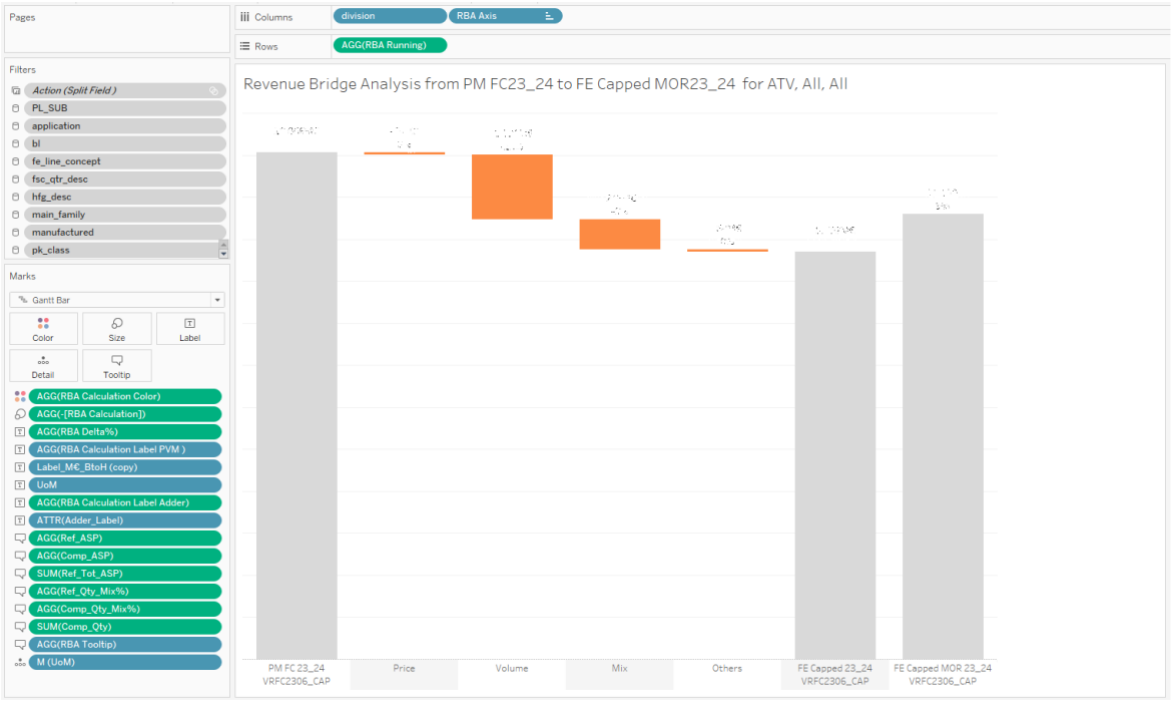


Figure 38 Waterfall Chart

Explanatory Tooltip

After doing the first rounds, we got the input to have the explanation of the analysis in words rather than in numbers. To do so, we have used the Tooltip capability. Every time you hover over one of the effect bars there is an explanation of the impact to the revenue.

This is formulated following this logic:

```
CASE ATTR([RBA COO Order])
WHEN "A" THEN [Ref_FC]+" is "+[Start_adder_str]+[UoM]+" in "+[Ref_Y]
WHEN "B" THEN [Ref_FC_Str]+" is "+[Start_str]+[UoM]+" in "+[Ref_Y]
WHEN "C" THEN IIF([PRICE]>0,"Average Sales Price increases resulting in an increase in Revenue of
"+[Price_str]+[M (UoM)]+"€.","Average Sales Prices decreases resulting in an decrease in Revenue of
"+[Price_str]+[UoM])
WHEN "D" THEN IIF([VOLUME]>0,"Quantity decreases resulting in an increase in Revenue of
"+[Volume_Str]+[UoM],"Quantity of units sold decreases resulting in an decrease in Revenue of
"+[Volume_Str]+[UoM])
WHEN "E" THEN  IIF([MIX]>0,"The portfolio its optimized to higher valued products. Resulting in an
increase in Revenue of "+[Mix_str]+[UoM],"The portfolio redistribution has been inneficient resulting
in an decrease in Revenue of "+[Mix_str]+[UoM])
WHEN "F" THEN "Other products have impacted a total of "+[Others_str]+[UoM]+". (Considering a
QRF* of "+STR([QRF])+")"
WHEN "J" THEN [Comp_FC_str]+" is "+[End_Str]+[UoM]+" in "+[Comp_FY]
WHEN "K" THEN [Comp_FC]+" is "+[End_adder_str]+[UoM]+" in "+[Comp_FY]
END
```

We observe that depending on the value of each of the effects we will get a different explanation. This helps understand the analysis and gives the user a reassurance of what he

can be analysing looking at the numbers.

As an example, we have the following figure. Hovering over the Mix Effect bar we observe that the impact has been of 500 M€ and negative. Due to an unfavourable redistribution of the portfolio.

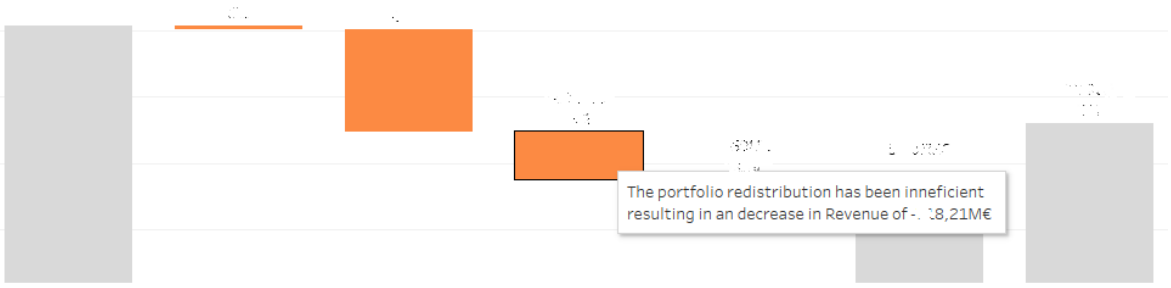


Figure 39 Tooltip Example

Colour coding

To differentiate more the Revenues from the effects we have to neutralize the colours. Below you can see the formulation of the field used for it and the colour settings on Tableau Desktop.

```
CASE ATTR([RBA Measure])
WHEN "BAR_1" THEN 0
WHEN "BAR_2" THEN 0
WHEN "BAR_10" THEN 0
WHEN "BAR_11" THEN 0
ELSE [RBA Calculation Others]
END
```

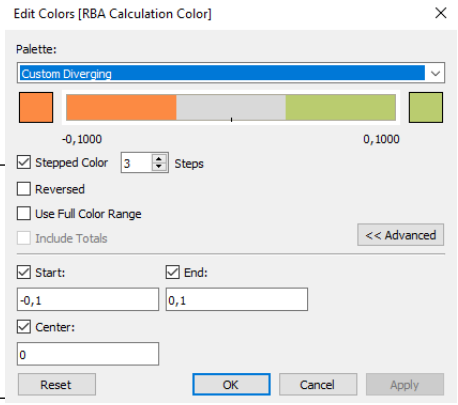


Figure 40 Color Coding

Labelling

Finally for the labels, we needed similar logic. We displayed the deltas only in the effects; therefore, we needed a specific field for that. Also, we displayed different labels for the Adder etc. No further explanations are needed since the logic behind is quite like the ones explained so far. Using CASE statements and displaying everything we would want in the label.

6.4.2.4. Complementary Charts

In order to explain the reason of the different effects, for example why is the Mix Effect negative it is important to determine which products are bringing more or less revenue and be able to

dig deep in the causes of the shape of the waterfall chart.

To do so there have been set up a series of complementary graphs that enable thorough analysis. These are, the detailed waterfall charts for Price, Volume and Mix, the revenue, quantity, or average sales price (ASP) bar charts with Split by and the Table clustering the Top RFPs considered as others and their categories.

Waterfall Details

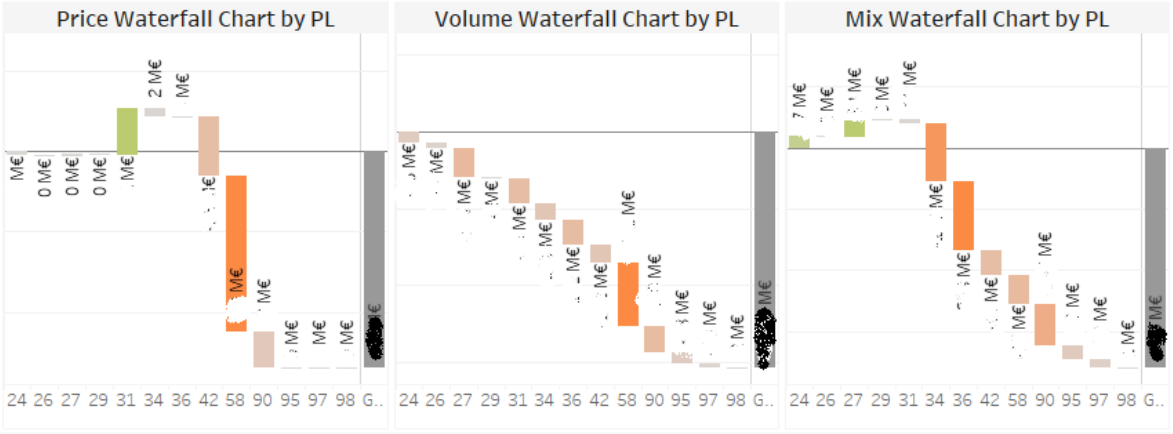
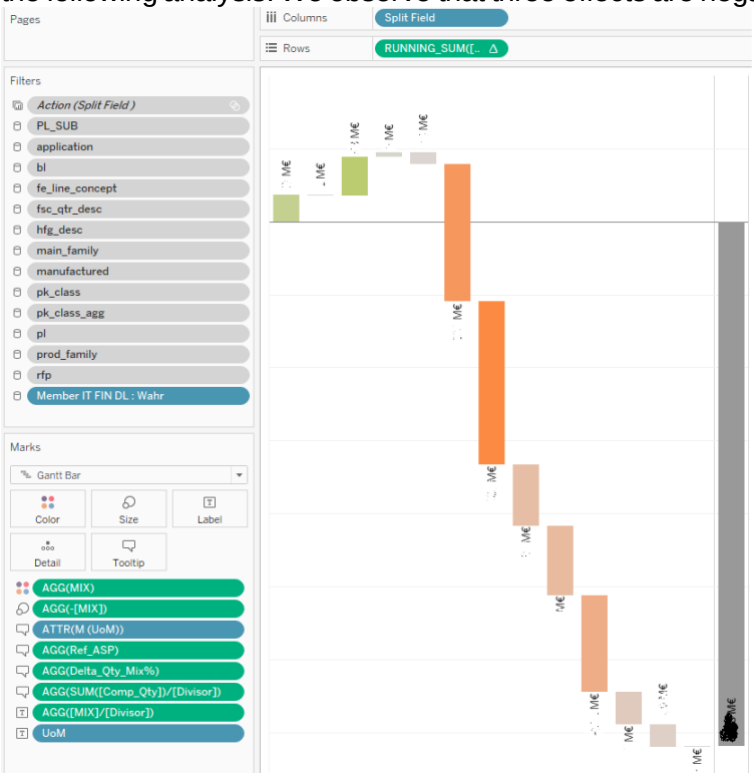


Figure 41 Detailed Price, Volume and Mix waterfall charts by PL

This is the result and how the three graphs are displayed in the Dashboard. Here we can derive the following analysis. We observe that three effects are negative overall. This, for ones means that the Price has had an overall decrease and we observe that is mainly coming from PL 42, 58 and 90 with a small increase from 31 and 34. The volume decreases overall, and we observe that the products with the biggest shares are 27, 58 and 90.



The Mix effect we also observe negative impact, this time coming mainly from PL 34 and 36 meaning this are the products that reducing its share are contributing more to a decrease on the Revenue. We

observe that from PL24 to 29 are the only ones increasing the share in the portfolio, but this is having minor impact on the revenue. On the other side the other PLs are decreasing their shares, and this brings overall a less valuable portfolio.

On the technical / formulation side, these graphs follow the same logic of the previous Waterfall Chart, a running sum of (Price, Volume or Mix) in the rows, the field we want to do the waterfall through and the negative of the field (Price, Volume or Mix) on the size mark.

Interesting to mark that the Split Field is a calculated field that is modified by the user when choosing the Split By parameter following this formulation:

```
CASE [Split By]
WHEN "BL" THEN [bl]
WHEN "DIV" THEN [division]
WHEN "PL" Then [pl]
WHEN "Application" THEN [application]
WHEN "RFP" THEN [rfp]
WHEN "Prod Maturity" THEN [prod_maturity]
WHEN "HFG" THEN [hfg_desc]
WHEN "Main Family" THEN [main_family]
WHEN "Prod Family" THEN [prod_family]
WHEN "FE Line Concept" THEN [fe_line_concept]
WHEN "PKC" THEN [pk_class]
WHEN "PKC_AGG" THEN [pk_class_agg]
WHEN "PL_SUB" THEN [PL_SUB]
END
```

Bar Charts for Revenue, Quantity and ASP

This detailed view helps us understand in a more classical view what is happening with our portfolio. We can observe the changes in Revenue, Quantity and Price from the Reference to the Comparison.

Similar analysis derives from this chart, but we will need to check on the overall deltas and the deltas for each split field.

For example, if the quantity delta for one specific BL is higher than the delta for the overall this means that this Business Line is increasing its

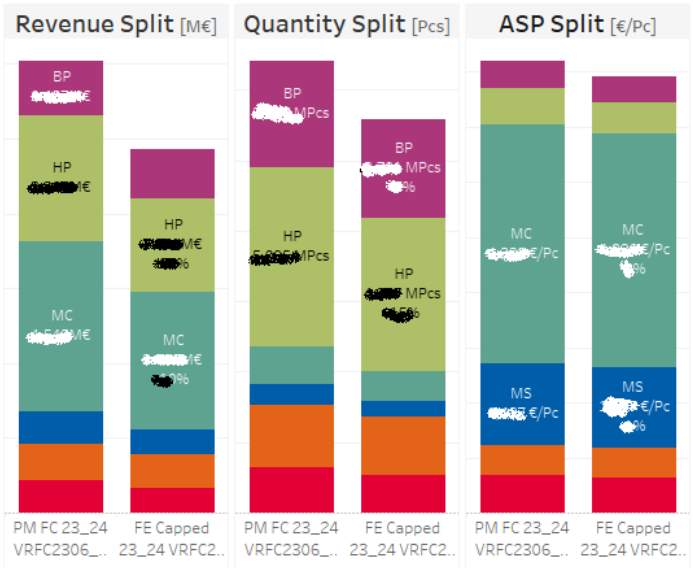


Figure 42 Split Bar Charts

share in the portfolio and has a positive Mix Effect. Also, we will observe the deltas on Price indicating the Price Effect, but in this case it may not 100% be valuable since these bar charts contain also products clustered as Others.

Others Table

This brings us to the others table, this is where we want to display the most significant RFPs that are not included in the Price, Volume and Mix Effect.

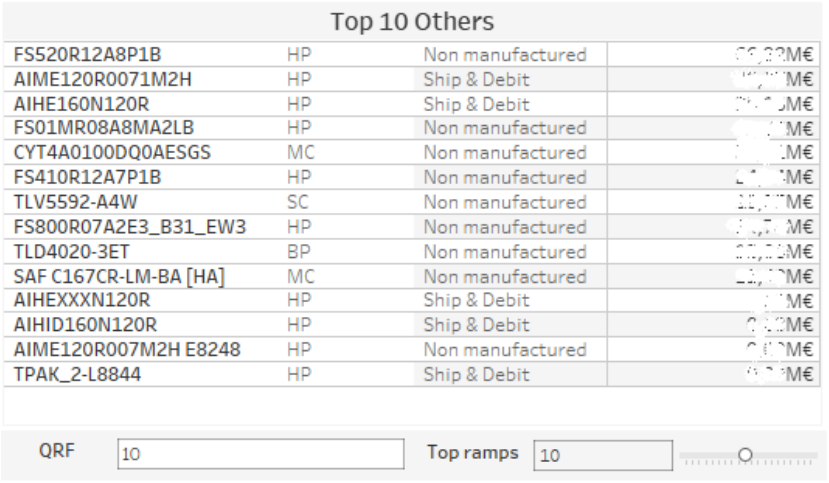


Figure 43 Top 10 Others Table

This table displays the Top X (X being a value entered by the user but set as 10 by default) RFPs with higher impact on the others.

They are sorted in descending order and display, RFP number, Split By, the category of Others and the delta on revenue of each of the RFPs.

The top others category follows this calculation:

```
IF [manufactured]="Y" THEN "Non manufactured"
   ELSEIF  [flag S&D]="N" THEN "Ship & Debit"
   ELSEIF [flag ramp up]="Y" THEN "Ramp Up"
   ELSEIF [flag ramp down]="Y" THEN "Ramp Down"
END
```

Adders Detail

When displaying the FE Capped Measures, both MOR and TOTAL, instead of the table above we display a tree map with the value of the Adder Revenue Measures.

Figure 44 Adders Detail Treemap

With this we have explained all the sheets used to do the Dashboard. We now just need to display the sheets following the lean Dashboarding principles.

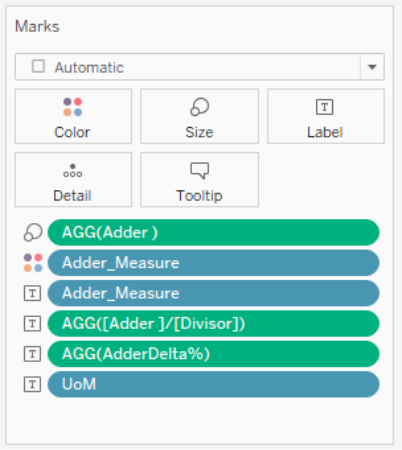


Figure 45 Marks set up for the Adders Treemap

7. Dashboarding

In this chapter the thinking process of generating the final product, the Dashboard is explained and exposed.

Organizations are overrun with large volumes of information from several sources in today's data-driven business environment. Businesses rely on Business Intelligence (BI) technologies, which provide insights through data visualization, to make wise decisions. "Lean Dashboarding," a methodology that puts efficiency and clarity first when designing effective dashboards, is one of the most popular methods to BI.

Understanding the objectives and key performance indicators (KPIs) of the company is the first step in the lean dashboarding process. The dashboard's design is built on these KPIs. Lean Dashboards prioritize giving the most pertinent data, making sure that each component directly influences decision-making rather than overloading consumers with a profusion of data points.

There are several essential steps to creating a successful Lean Dashboard:

Data Collection and Integration: Gather data from various sources, such as databases, spreadsheets, and APIs. To guarantee quality and consistency, this data has to be cleansed, processed, and merged.

Identify Key Metrics: Work with stakeholders to identify the crucial metrics that support the goals of the company. Do not add extraneous data that will clog the dashboard.

Design for Clarity: The priority in the design of Lean Dashboards is simplicity and clarity. To successfully communicate information, use simple visuals like charts, graphs, and tables. Make sure the dashboard is simple to use and easy to comprehend, especially for non-technical people.

Real-time Updates: The capacity to give real-time or almost real-time updates is a crucial component of Lean Dashboards. This guarantees that decision-makers have access to the most recent information at all times.

Interactivity: Implement interactive elements that allow users to drill down into specific data points or adjust parameters to gain deeper insights.

Regular Maintenance: BI technologies need ongoing maintenance to keep data sources current, address problems, and adjust to shifting business requirements.

In conclusion, Lean Dashboarding is an approach that focuses on simplicity, clarity, and relevance to speed the development of Business Intelligence solutions. Organizations may

harness the power of data to make wise decisions by adhering to the principles of Lean Dashboarding and utilizing cutting-edge BI technology. This will eventually increase productivity and competitiveness in today's fast-paced business climate.

Until this chapter we have covered all steps excluding the Design and the Interactivity.

7.1. Design

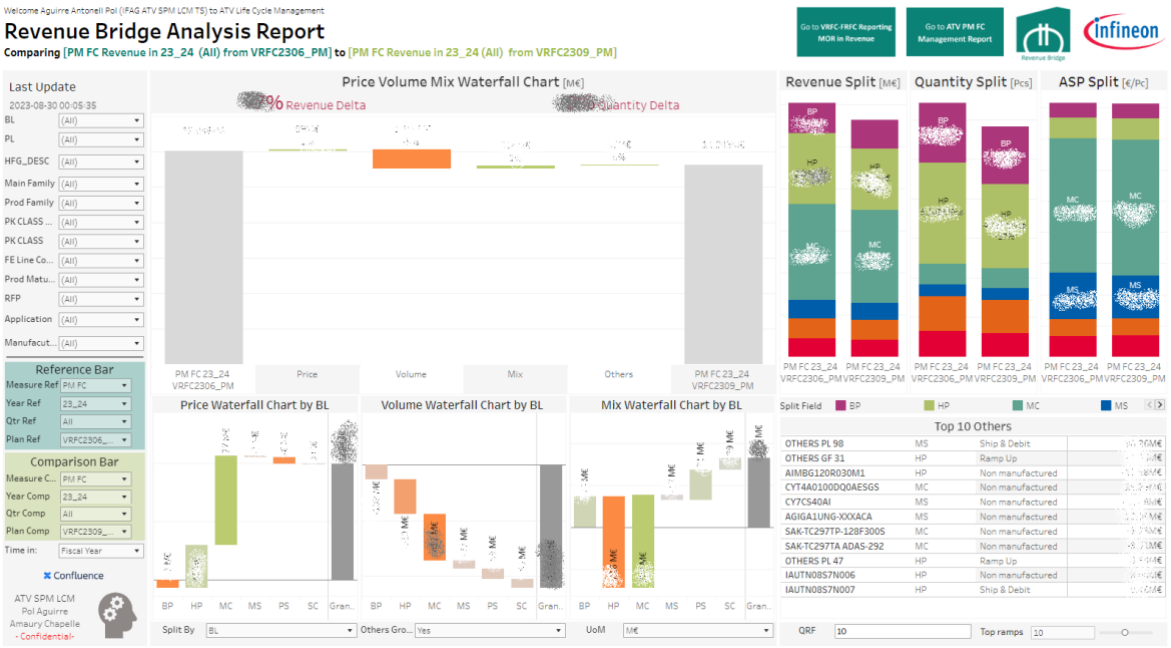


Figure 46 Design for clarity.

In the above Figure we observe the final dashboard in its default view after the Capping week. We will divide this chapter into sections of the Dashboard to explain why of the design and layout. The sections will be 4, the Title on the Top, Filters on the Left, the Main graph (Waterfall Chart) and the secondary charts.

7.1.1. Design: Title

The natural motion of the eyes in occident it's from top to bottom and from left to right. Having said that, we designed the Title following this principle. The most recognisable part of this section needs to be the Name of the Dashboard. Therefore, we used a Bold and Bigger font size. Just below, and in two different colours we have a dynamic subtitle that brings very relevant information. In this case, it displays as "Comparing [PM FC Revenue in 23_24 (All) from VRFC2306_PM] to [PM FC Revenue in 23_24 (All) from VRFC2309_PM]", explicitly giving the information of which two revenues we are doing the analysis in. By default, here we are comparing the PM measure for fiscal year 23_24 from last planning freeze to the latest

one, VRFC2309_PM.

Moreover, in this section we are also displaying two buttons that link to other Revenue related Dashboards, plus the Revenue Bridge analysis and Infineon logos.

Finally, there's a smaller text welcoming the user to the dashboard and to the ATV Life Cycle Management Team.

7.1.2. Design: Filters

On the left and inside a grey shaded box we have all filters and parameters that the user can change and interact with. Design wise, it is important to mention the colours for matching the subtitle.

For extra clarity, all parameters that refer to the Reference revenue Bar are in a box shaded in the same colour as the text in the subtitle regarding this bar, and the same with the comparison bar. Both colours are following corporate branding and have been maintained during the internship due to changes in the corporate image of Infineon.

Finally, there's the two help buttons, from one side the Confluence logo that it redirects you directly to the Confluence Page and the head that brings you to the following view.

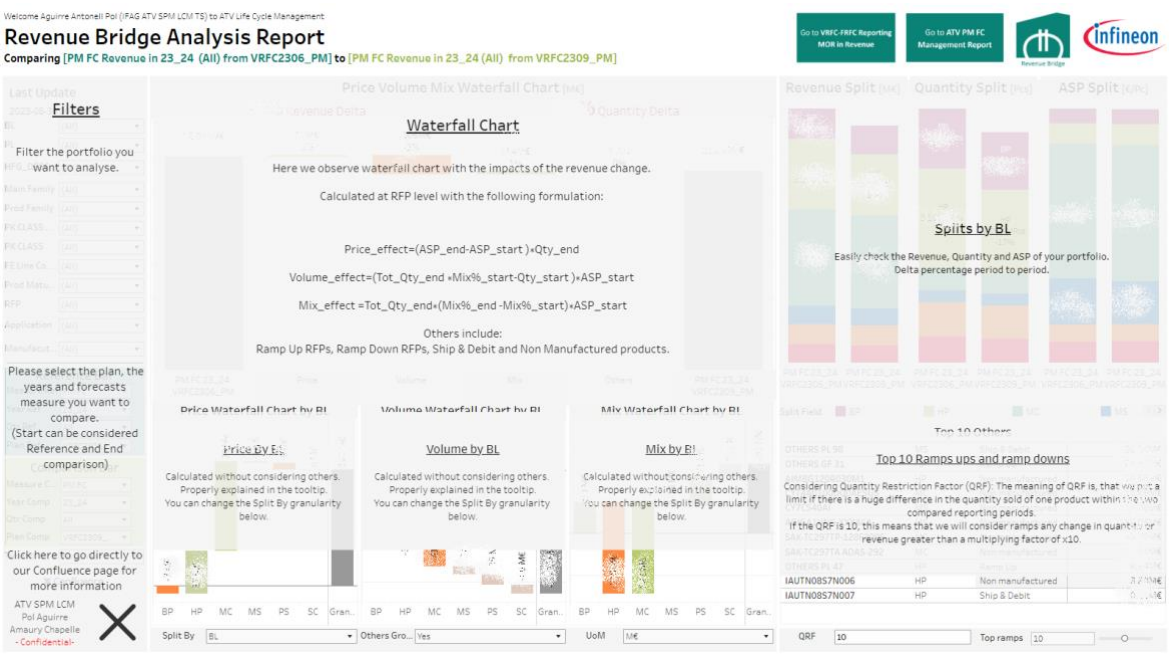


Figure 47 User help view.

7.1.3. Design: Waterfall PVM Chart

The part of the Dashboard that brings more value to the user. It needed to be as big as possible. Moreover, is displayed with the rectangular ratio of a Power Point Slide to be able to Snip it and paste it.

On top it has the two most relevant KPIs, the percentages of revenue and quantity change from reference to comparison bar. Additionally for more clarity, negative values are displayed in corporate orange and the positive effects in corporate green. For some extra clarity, the axis displays the two revenues that are being compared.

7.1.4. Design: Detail Charts

These graphs are thought to help further analyse where the effects come from. On the top right side, we have placed the Split Bar charts for Revenue, Quantity and ASP. Below the waterfall chart we observe the three detailed waterfall charts. These waterfall charts will give insights to the user, on a lower granularity.

Another important point of the detailed charts is the bottom left where depending on the measures the user chooses it displays a table with the most relevant others or a pie chart with the distribution of the Adder revenue.

7.2. Interactivity

Tableau Dashboards have two main usages. The analysis that is made through them, the user can consume in two different ways. We have been discussing the design is thought for snipping and pasting it to a Power Point, the first way of consuming the information given.

Another very interesting way is directly connecting o Tableau server and doing the analysis interactively. And here is where the interactivity plays a fundamental role. Tooltips are automated to give you extra insights.

7.2.1. Interactivity: Tooltips

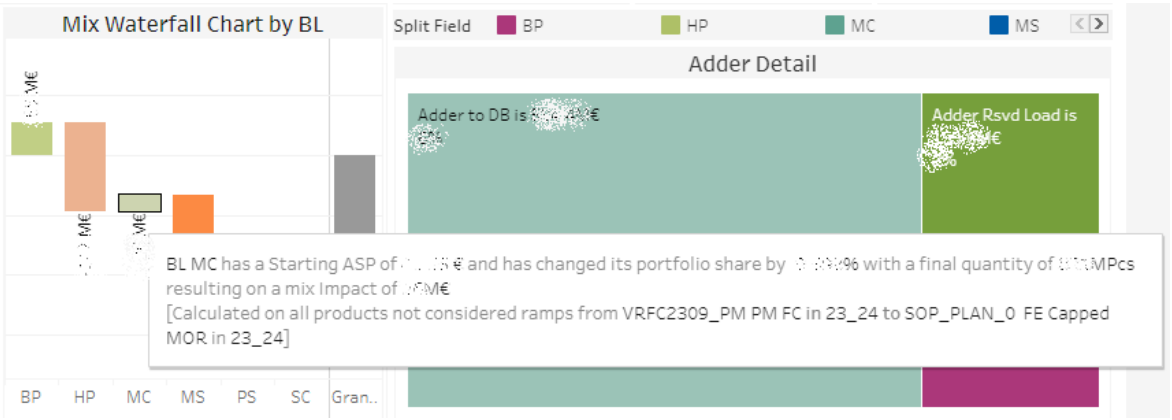


Figure 48 Mix Waterfall Chart Tooltip.

In the Mix Waterfall Chart for example, we get a lot of information from the Split field in particular. By hovering over the bar for MC (Microcontroller) we get the Starting ASP (Average Sales Price), plus its share change and the quantity, all the measures that impact the MIX effect. It also specifies with which products and revenue measure the calculation has been made, in this case only products considered quantity relevant. On the other hand, in the Split Bar charts the Revenue from all products is displayed.

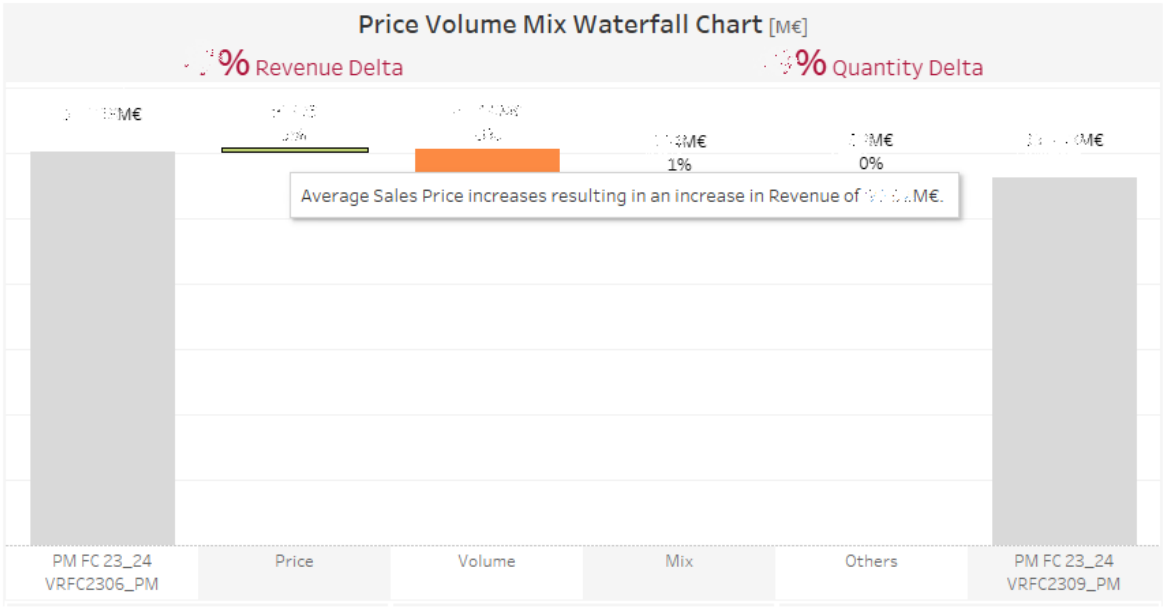


Figure 49 Price Volume Mix Waterfall Chart

In the figure above we observe an example of the tooltip when hovering over the price effect. It explicitly says if the ASP has increased or decreased and how much that has impacted the revenue.

7.2.2. Interactivity: Actions

Actions in Tableau, particularly filtering and drilling down, are pivotal in creating interactive and insightful data dashboards. These functionalities enable users to delve deeper into data, extract relevant insights, and customize their analytical experience.

In the Dashboard we have enabled actions in the Bar Charts and in the detailed waterfall charts and here is an example on how to use the actions.

Figure 50 Filtering action.

In the figure above we can observe the action of filtering. The example shows a default view where we observe a high positive contribution of the Mix by MC. To further investigate on that we can filter by just clicking the MC bar in one of the detail graphs. Once it's done, we can see the numbers for the filtered MC and observe that the reduction in quantity has been less than and therefore it has gained portfolio share, impacting positively on the revenue through what we call Mix Effect. Finally, to go back to the Default view we have to click again.

7.2.3. Interactivity: Parameters

Parameters are an essential part of interactive data dashboards. They encourage interaction, customisation, and deeper data exploration by allowing users to manage and modify many

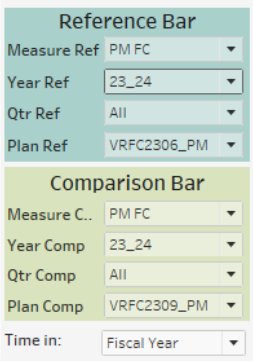


Figure 51 Parameters for Reference a Comparison Revenue Bars.

parts of the dashboard's functionality. Parameters substantially improve the usability of data-driven apps and the user experience by enabling users to interact interactively with data.

In this Dashboard parameters take a crucial role. First of all, we have the parameters that let select the Reference and Comparison Bars. In the Measure we can choose the measure in year, the year but also enable the window of comparing a whole plan window (18 months in the future from the plan date). Quarter lets you select 3 months of each of the years instead of a whole year. And finally Plan lets you control the freeze you want to do the analysis with.

On particularity is that by selecting one of the measures FE Capped the detailed table of Others is no longer displayed and instead we display the Adder view.

Another parameter that changes the view of the Dashboard is the one that enables ungrouping the Others Category.

In the figure on the left we can observe how the waterfall chart expands.

Ungrouping it we have, Ramp Up, Ramp Down, S&D and Non-Manufactured instead of all grouped as Others.

Then there's parameters such as the Quantity Restriction Factor (QRF), that will only modify the calculations behind but are also modifiable by the user depending on the needed value.

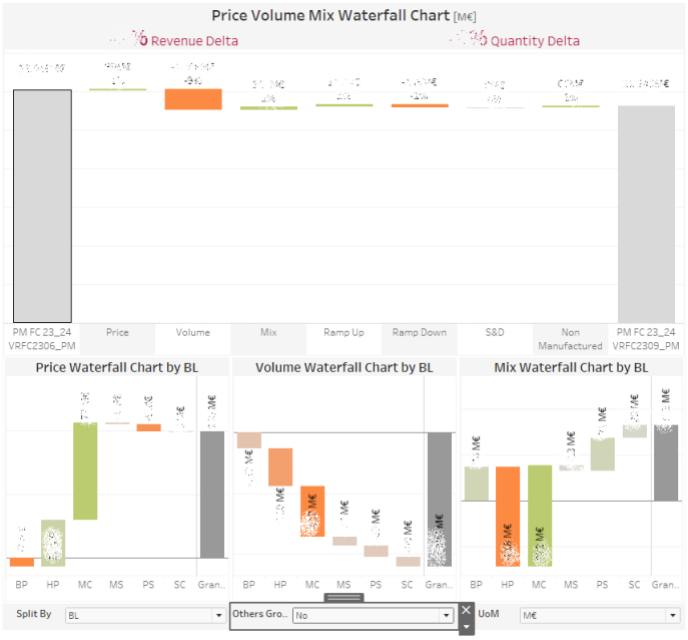


Figure 52 Parameter Others Ungrouped.

8. Budgeting of the project

In this chapter an overview of the expenses to realise this project we will make some assumptions on wages and hours spent on the project. We will only charge the manpower expenditures, even though we have used resources such as Software licences, hardware such as computers etc. we will consider them as negligible and not relevant for the cost of this project.

As we have previously mentioned in the prerequisites, this project has been developed by an intern developing the Dashboard full time plus the project owner and manager that has guided me through the process.

The contract for the intern it has been a 35h/week contract and it took approximately 12 weeks to develop the final version of the Dashboard. We consider that from those 35h, only 28 were dedicated to the Dashboard and the others to support to the team and administrative stuff. Moreover, we must add to training received and done to understand the Supply Chain, the data management tools of the team and gain expertise on Tableau.

For the Supervisor, evidently it has required less time. The more intense part has been the training and at the beginning of the project where all the expertise had to be shared this accounts for a total of 15 hours. Also, we consider that he has been reached out to twice a week, plus an hour of own work to organize with all stakeholders and communicate the progress to them. Also, he has been keying in presenting the Dashboard to the ATV division this has also been time consuming and it accounts for 20 hours more. To reach a total of 65 hours.

Having made these assumptions, the costs for this project turn out as follows.

	HOURLY WAGE	HOURS	
INTERN	15 €/h	416 h	6.240 €
SENIOR BUSINESS ANALYIST	35 €/h	65 h	2.275 €
TOTAL COST			8.515 €

Table 2 Project Costs

Approximately 8.500 € for the totality of the project is the estimated amount considering the hours invested solely in developing the Dashboard, presenting it to the different Stakeholders for inputs and change and add feature until the final product.

9. User guide and Use Cases

After developing the Dashboard, a big part of a Business Intelligence tool success is determined by how used it is. In order to be used we need to understand the business, have exchanges, and determine the use cases. Additionally, we need to proper document how to use the Dashboard to its full extend.

In order to do so, while developing the tool, in parallel we have had meetings with the 5 different BLs in the ATV division of Infineon. We have had inputs from Marketing colleagues, Finance, and Supply Chain planners.

In this chapter we will present the results of this round and the use cases. At the moment, it is already in use for some processes in the Marketing community and in the next planning cycle, we will adopt it further in the SC Community.

9.1. User Guide

We have not displayed any number since all the Data regarding the Revenue, Quantity and Price displayed in the Dashboard is Highly confidential.

9.1.1. Controls and Filter selection

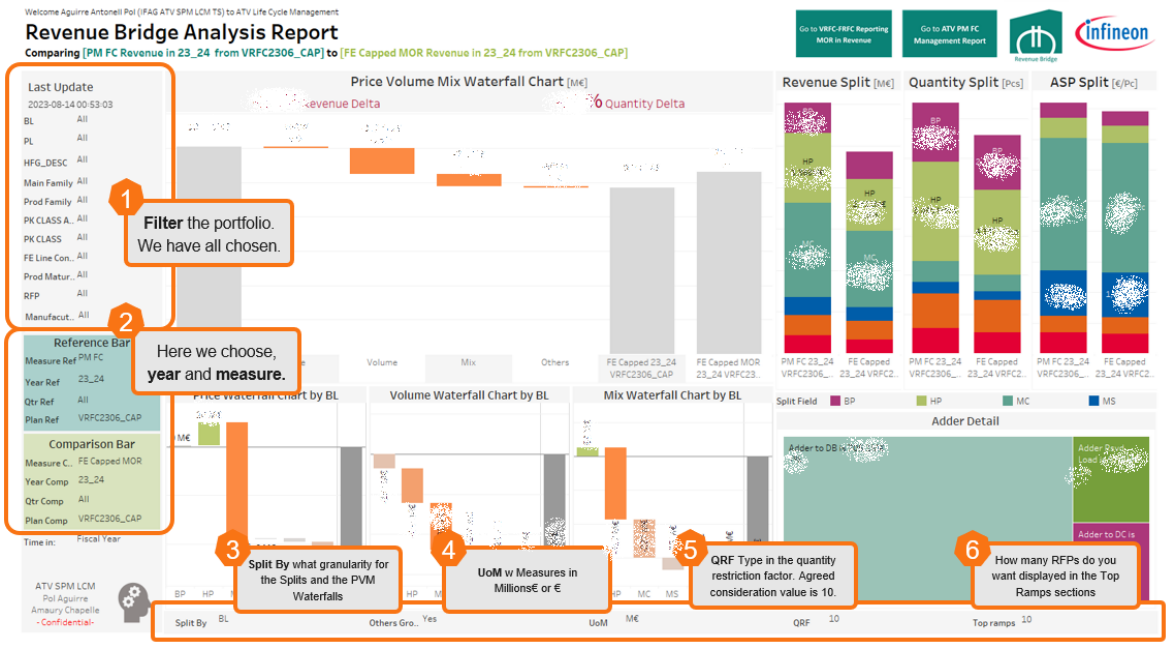


Figure 53 Controls and filter selection

1. Filter the portfolio: In this section the user must choose the portfolio he will analyse. It

is sorted from higher level of granularity to the lowest, RFP.

2. Here we choose the Reference Revenue, and the Comparison Revenue. For each we can decide on:
    a. Measure: [€]
        i. PM FC: Marketing forecast measure
        ii. UNCAPPED: Supply Chain forecast measure from the Uncap week.
        iii. PRECAPPED: Supply Chain forecast measure from the Precap week.
        iv. CAPPED: Supply Chain forecast measure from the Precap week.
        v. SC CAPPED TOTAL: Combination of measures includes actuals for past and CAPPED for Forecasted measures.
        vi. FE CAPPED TOTAL: SC CAPPED TOTAL plus the planned contingencies of revenue coming from inventories, Die Bank or Die Cast.
        vii. FE CAPPED MOR: (Monthly Operation Review) SC CAPPED TOTAL plus adder measures of contingencies planned to inventory or to reserved load.
    b. Year:
        i. Fiscal Years: To be chosen when we want to compare fiscal.
        ii. Calendar Years: To be chosen when we want to compare natural years.
        iii. VRFC: To be chosen when we want to compare the window of each VRFC, 18 months.
    c. Quarter:
        i. All: By default, to compare years and not quarters
        ii. Quarters: When we want to compare from quarter to quarter.
    d. Plan:
        i. Plan freezes
        ii. SOP Plan 0: To be chosen during the planning phase. Daily refreshed with the latest planned figures.
3. Here we can determine the Split By, how much granularity would we want to display the detailed waterfall charts and the Bar Charts.
4. 5. and 6. Minor default settings, Units, QRF, and number of TOP.

Moreover, there is the possibility to temporarily display filtered values by selecting a field.

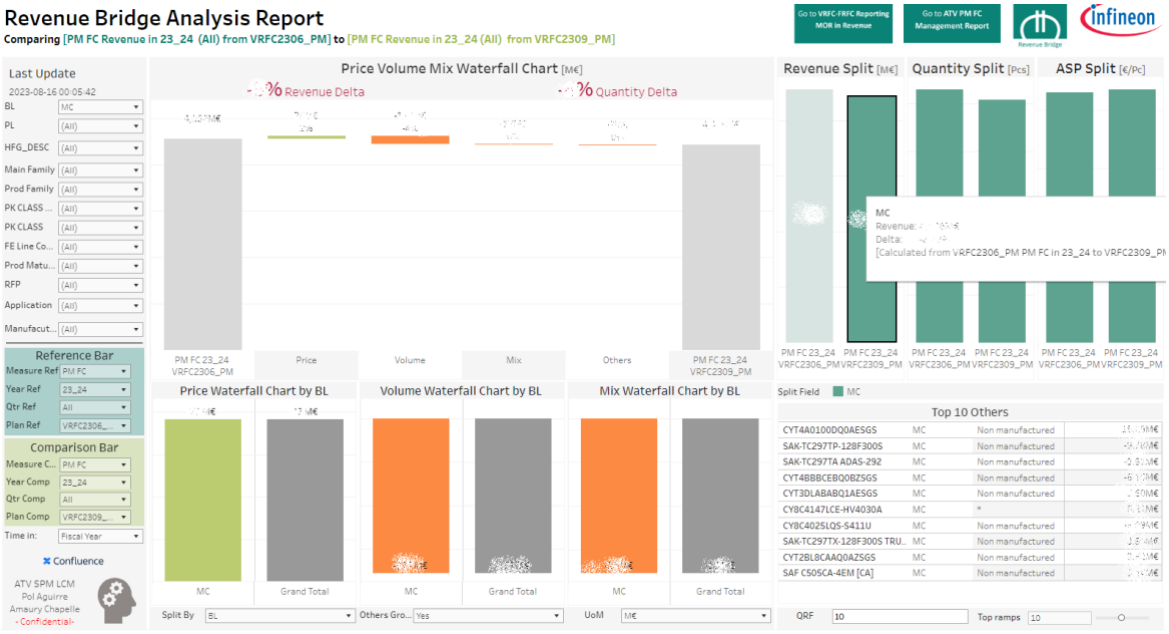


Figure 54 Action: Filtering.

We observe that after clicking on the MC slice of the Bar Chart we see the filtered view for Microcontroller. To undo this filtering, you need to click again in the MC Bar.

9.1.2. How to read the Dashboard

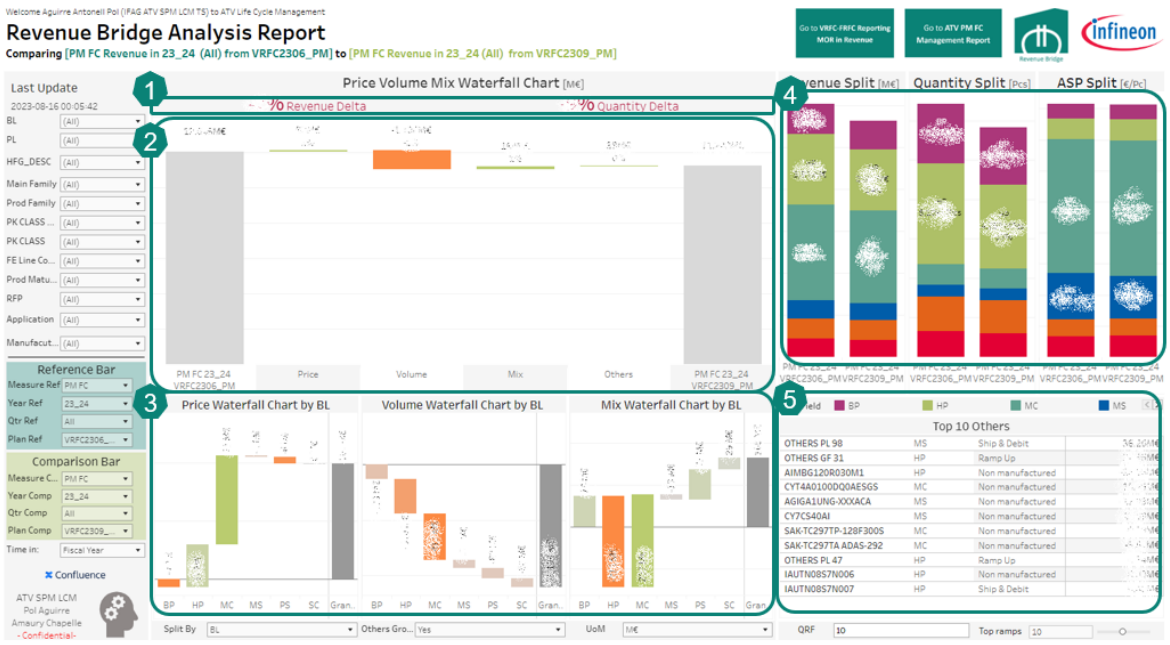


Figure 55 How to read the Dashboard.

You are probably already familiar with the Dashboard at this point, but here is the chapter on

how to read the information and analyse the results of the analysis.

1. **KPIs:** At first sight we have the two most important KPIs. The delta in quantity and revenue. The difference between these two values is exactly what we can explain with this analysis. So, let's illustrate a hypothetical example. In this first step we observe that there's an 8% quantity delta but only 5% Revenue delta.

2. **Price Volume Mix Waterfall Chart:** Next step we look at the Waterfall chart, and there from left to right we can go from the reference Revenue bar through the effects to end up in the Comparison Revenue bar. Let's imagine now we need to explain the delta in Revenue being 5% when quantity wise, we observe an 8%.
   First, the price effect has a 1% positive development, then the quantity effect / volume is -8% as it was already displayed in the quantity delta. To arrive to the 5% is explained with an extra 2% of Mix effect. To understand which products, cause the price development and the Mix effect we can go either to the 3rd or 4th step.

3. **Detailed Waterfall Charts:** We can focus on the Price and Mix effect charts. For the Price we observe that the positive development comes from HP and MC while the other Business Lines have negative impacts. In the Mix effect we observe that the two bigger players are again HP and MC but that they cancel each other out and then BP and PS also are growing in their share of the portfolio bringing a positive impact overall.

4. **Split Bar Charts:** Here we can see it in a more classical way, and we have to make some logical abstraction. The price graph is a bit biased since it is not extracting the mix effect, nevertheless if we observe the quantity split HP is having greater decrease of quantity than the overall portfolio explaining the negative mix effect and on the other hand, we have BP that has a -2% decrease versus the 8% overall meaning it's having a positive MIX effect.

5. **Top Others or Adders Detail:** In this part of the graph, we have final and quite specific information about the most important Others and their revenue delta from reference to comparison revenue.

   On the other hand, if the comparison revenue is a FE Total measure, we will have the Adder to/from Die Bank, to/from Die Cast or Reserved loading revenues. These being the contingency measures planned in certain cases for the Business Demand Planners.

9.2. Use cases for the Revenue Bridge Analysis Dashboard

In the following chapter the Use Cases used up to now will be presented. If developing the technical side of the Dashboard has probably been a 50% of the work behind this project, another 50% has been finding where in the planning process should the Dashboard be used. We have presented the Dashboard and its capabilities to different stakeholders within the Automotive division. During the last steps of developing the Dashboard we have had the opportunity to simultaneously develop the Use Cases for this analysis within the planning and here are some of the examples already in use in the team.

9.2.1. Demand Development Review

The first and most obvious use case there is to this Dashboard is to use it chronologically. In this section we see how to interpret the yearly development from FY23 to FY24 of the Marketing planning of June.

We observe a great increase from one fiscal year to the other, justified by the increasing market of semiconductors in the Automobile industry.

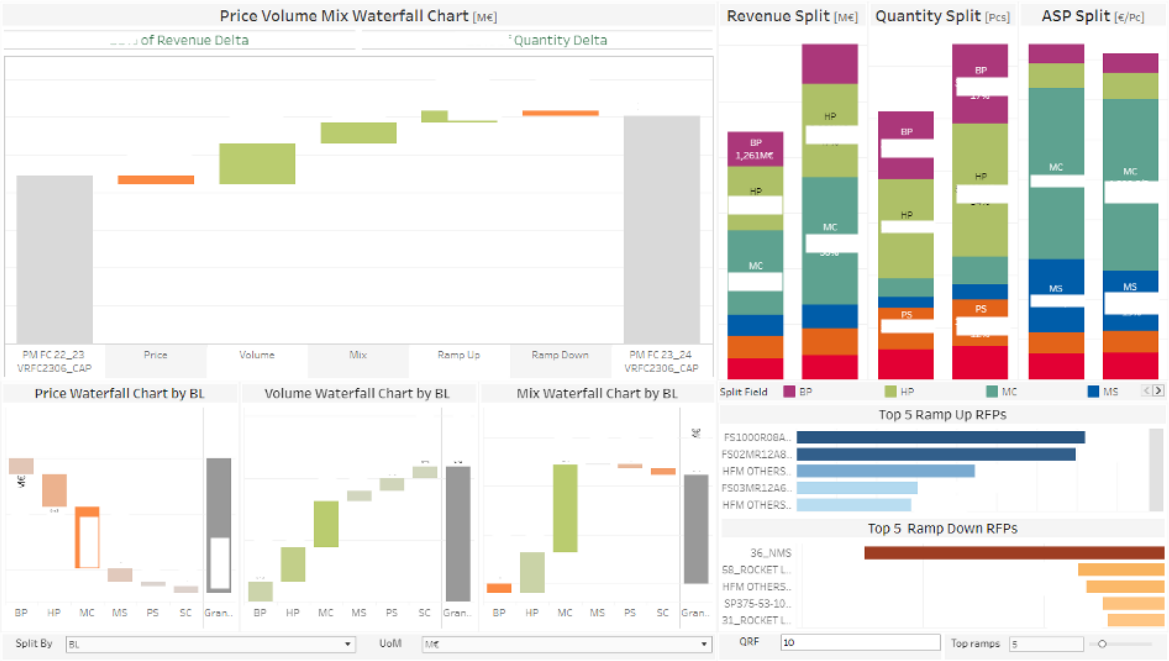


Figure 56 Use Case 1. PM FC Development.

We can also conclude that the Price development is negative, also justified by the nature of technological products, that loose value over time since they are every year less innovative. We sell overall more quantity, and the structure brings a positive Mix Effect.

9.2.2. Marketing Planning Review (PM FC)

In the figure below we observe the first snip from the Dashboard that has already been used during the COO Review of the VRFC process. Once the planning process is finalized the team must justify the revenue to the COO and which where the major Revenue driver effects.

As a pilot we have used the Dashboard to have a high-level view of what has happened with our planning. Here are some examples of the analyses deriving from the Dashboard.

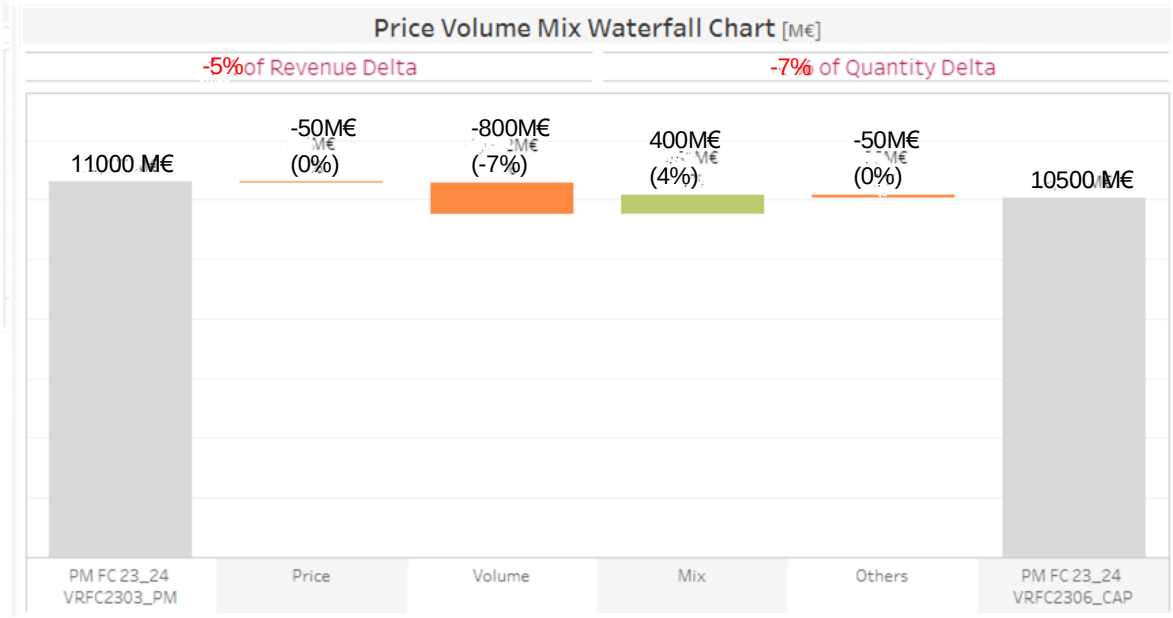


Figure 57 Use Case 2. VRFC Review. Plan to plan Marketing.

In the figure above we are comparing two Marketing forecasts for fiscal year 24, the one made in March and the one from June. From the Dashboard the following conclusions derive. Numbers are set as example for confidentiality reasons and to better understand the analysis.

The demand for FY24 from march to June has decreased. A total decrease of 7% in pieces but this has only impacted a negative -5% the revenue forecast. This is thanks to the Mix effect, that is bringing a +4% to the total revenue. If we analyse further in detail the other graphs this is the final comments of the presentation that was given as a pilot to present to the COO.

→ 2306 Revenue drivers on total ATV :

Price: -0% No impact

Volume: -7% reduced planned quantity (order reduction, market downside, push out)

Mix: +4% portfolio redistribution to BP, HP & MC having higher sales price.

9.2.3. Operations Planning Review (VRFC)

After reviewing the demand measures coming from Marketing, we must review the measures coming from the next step of the planning process. This one is the one that we are reviewing and responsible for as a team.

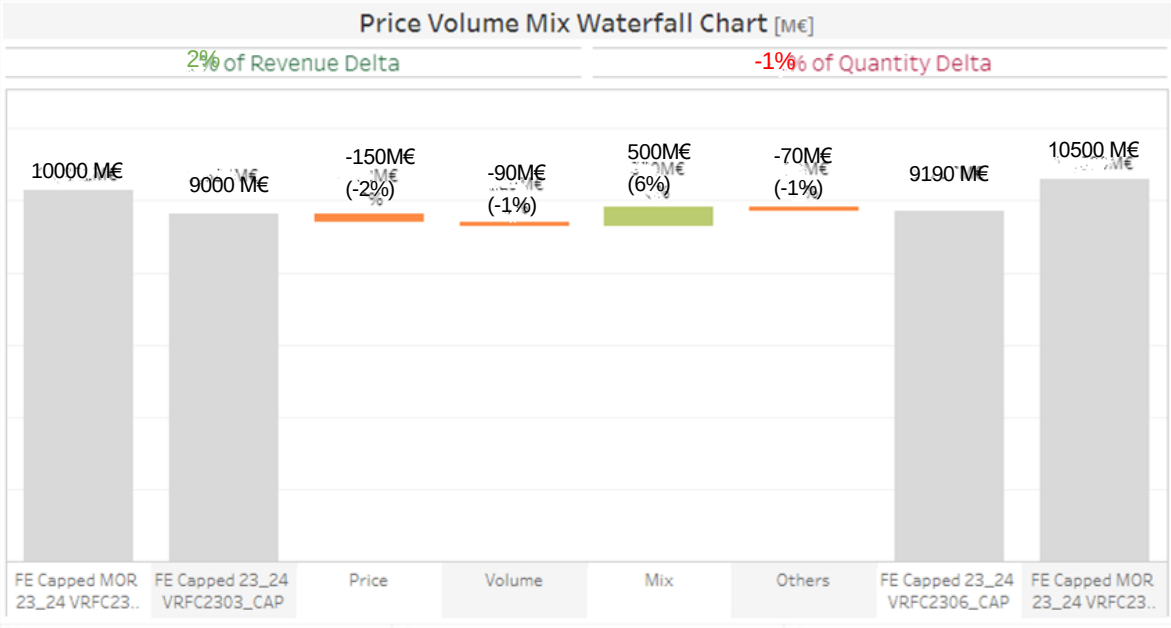


Figure 58 Use Case 3. VRFC Review. SC Plan to plan.

And we are comparing with the same plan to plan logic as before but instead of comparing the PM FC we are comparing the FE Capped Measures. Meaning the revenue derived from the capacity production of Infineon's Fabs. This measure is not only influenced by the Demand, but it is also taking into consideration the structure of the multiple technologies and resources that enable the production of the RFPs.

Having said this, what is the analysis that we can derive from this waterfall chart? First, there is only a -1% quantity delta and the Revenue increases from one plan to the other. "Price: -2% Price development. Volume: -1% Quantity reduction. Mix: +6% portfolio redistributed from PM FC.

From one plan to the next, we are still in full allocation. Meaning that all the production capacity is filled by demand. Therefore, the decrease in demand does not negatively impact our revenue. Nevertheless, the structure change of such demand does have an impact. We observe that the 4% of Mix Effect from the marketing forecast is amplified here as a 6% impact.

9.2.4. Capping Review

As of now we have only presented comparing same measure chronologically, but if we go a little bit further and compare the input measure of the process; the PM FC (Marketing forecast) with the result of the process FE Capped MOR we can have an overview of the capping that the Business Demand Planners have made. Here is an example.

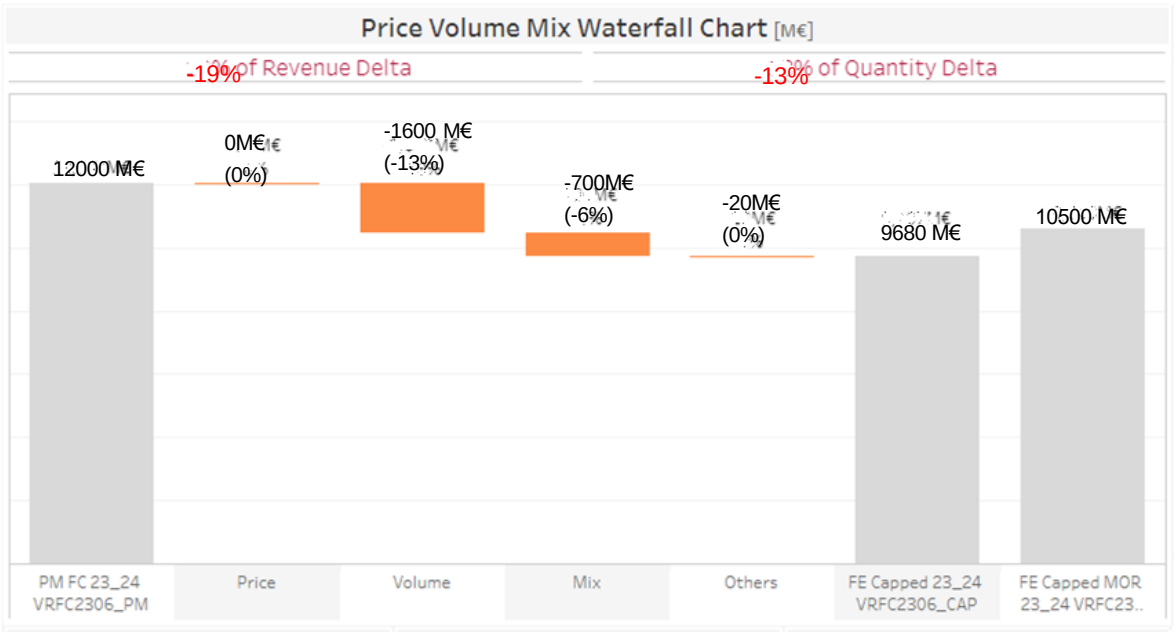


Figure 59 Use Case 4. Capping Review.

Let's have a reminder of the process, here we have the overview of the VRFC Process. A 4-week process where the BDPs go from the market demand forecast of each one of the products, also known as marketing, forecast to the capped revenue from the production capacity line.

They take into consideration the available production capacity but also the investments made on specific technologies to increment the production, the quantity of outsource to the Silicon Foundries of the selected technologies (normally more mature products and not critical technologies) and give a result of the realistic capacity of revenue fulfilment from the Supply Chain parameter.

So, let's see what the results from this process are. On the left we have 12 million euros that the marketing colleagues forecast as the demand for next fiscal year, and on the left we observe the 10,5 million Supply Chain forecasts to be able to produce.

There are only two effects, Volume and Mix. There is a 13% cut of quantity, meaning we are only allocating production for the 87% of the Marketing Demand. The remaining -6% of the

Revenue loss that we are not being able to allocate is due to the structure of this allocation. We are planning with technology limitations, and this translates as less revenue, meaning the products we can give full allocation are products that have lower price.

This use case has a lot of potential during the planning phase, if we can quickly run scenarios and review them, we will easily see the revenue impact. Furthermore, we will have the possibility to dig into where the mix effect is coming from and get a feeling of how to pivot our scenario into a more profitable use of our supply chain.

Right now, the limiting point of this approach is no longer the Dashboard, since we can bring the measures and refreshing it would cost 30 minutes approximately. The limiting point is the complexity of such planning. Business Demand Planners have merely time to finish their plan following all the limitations so the agility to redo different scenarios cannot be at such high level.

Nevertheless, the tool can also be used filtering into a lower level, giving the same information but let's just say at HFG level, giving the possibility to optimize the revenue for a particular set of technologies. And this could be used for the responsible of a narrower set of products.

Overall, capping review can be done once the planning is complete, to justify our Revenue numbers but also it can be used during the planning phases to run scenarios and analyse our product mix structure and the cutting structure.

10. Further prospects and conclusions

The prospect for the future of this work is to be introduced inside our process and to be our way of quantifying revenue driven decisions. Prove that it has been a successful project is how many more petitions have derived as future developments for the tool. For example, the possibility to enable comparing data from the strategic long-term planning. That will include fully understanding the structure of the data set, but also the planning process outliers to get consistent analysis.

Another idea would be to bring another level of granularity combining product with customer as leaf level. This would be helpful for the Marketing community that have to report their price accuracy forecasting. Other upgrades that are on the pipeline would be to add x-rate effect for the finance community or to derive the Dashboard to other Divisions.

In chapter 3, and at the beginning of the investigation and development of this project we set ourselves the objective creating a "*tool that enables interested stakeholders to visualize, understand and quantify revenue related to their project."* And we have achieved our goals and gone beyond expectations. By running this project both in the technical and the business analyst oriented.

On the one hand, we have put to practice advanced data preparation and analysis. Just to mention some of these; the union of the table to "multiply" and create another granularity dimension to enable the waterfall chart it is one of many work arounds that can be applicable to many other data analysis solutions.

On the other hand, it has also been a big part the design of the Dashboard and business analysis that have derived from the Dashboard once it has been set. We have created the steps to follow to develop a Dashboard following Lean principles of not overloading the customer with information. And we have set ground use cases that are already been in use by the team.

Overall, we successfully conclude the Thesis, but the project is far from over since as mentioned we will develop further in the future. Nevertheless, we are satisfied and proud with the project and the Dashboard as the final product.

11. Acknowledgements

My greatest appreciation goes out to my supervisor, Amaury Chapelle, for his advice and assistance. Without his knowledge sharing and training nothing would have been possible. I feel deeply fortunate that he gave me the opportunity to develop this Project with him. He has been a true inspiration and a role model to look up to.

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Finally, I want to sincerely thank my family for their constant support and inspiration during my whole academic career. My desire to learn new things and advance professionally has been motivated by their love, faith in my ability, and consistent encouragement.

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13. Figures and tables