NOVA IMS Information Management School

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Mestrado em Gestão de Informação
Master Program in Information Management

SAP Analytics Cloud implementation - Step by step deployment

Raquel Toste Codorniz

Project Work report presented as partial requirement for obtaining the Master's degree in Information Management

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by

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Supervisor: Professor Dr. Vítor Manuel Pereira Duarte dos Santos

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ABSTRACT

The main purpose of this project was to develop a step-by-step guide for implementing SAP Analytics Cloud solutions. This project aimed to rectify prevalent inefficiencies within the Analytics department, consequently enhancing the overall customer experience at INETUM Holding Business, Portugal.

The project's usability was exemplified through its application in a real-world scenario involving a fictional client. Furthermore, the project contributes to academic enrichment by providing a fundamental, conceptual understanding of Business Intelligence, Planning and Predictive service providers like SAP Analytics Cloud. This not only paves the way for novel research prospects associated with SAP Analytics Cloud but also bolsters the foundation of understanding surrounding it. Practical value is added for system users to comprehend SAP Analytics Cloud on the deepest level. For system providers, the project offers a vantage point to discern vital system enhancements imperative for sustaining competitiveness within the industry.

RESUMO

O principal objetivo deste projeto foi desenvolver um guia com o passo-a-passo a seguir na implementação de soluções usando SAP Analytics Cloud. Este projeto visou corrigir ineficiências prevalecentes no departamento de Analytics, melhorando consequentemente a experiência global do cliente na empresa INETUM Holding Business, Portugal.

A usabilidade do projeto foi exemplificada através da sua aplicação num cenário real envolvendo um cliente fictício. Além disso, o projeto contribui para o enriquecimento académico ao fornecer uma compreensão fundamental e concetual dos fornecedores de serviços de Business Intelligence, Planeamento e Previsão, como o SAP Analytics Cloud. Isto não só abre caminho a novas perspetivas de investigação associadas ao SAP Analytics Cloud, como também reforça a base de compreensão que o rodeia. O valor prático é acrescentado para que os utilizadores do sistema compreendam o SAP Analytics Cloud a um nível mais profundo. Para os fornecedores de sistemas, o projeto fornece um ponto de vantagem para discernir as melhorias vitais do sistema, imperativas para sustentar a competitividade dentro da indústria.

Keywords: ERP; i-ERP; SAP Analytics Cloud; Decision support; Business Intelligence; Planning; Predictive

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LIST OF ABBREVIATIONS AND ACRONYMS

ABAP – Advanced Business Application Programming

AI - Artificial Intelligence

BI – Business Intelligence

CDS – Core Data Service

CRM - Customer Relationship Management

ERP – Enterprise Resource Planning

ETL – Extract, Transform, Load

HR - Human Resources

i-ERP – Intelligent Enterprise Resource Planning

IT – Information Technology

KPI – Key Performance Indicators

ML – Machine Learning

MRP – Material Requirements Planning

NLP – Natural Language Processing

RMSE- Root Mean Square Error

SaaS – Software as a Service

SAC – SAP Analytics Cloud

SCM – Supply Chain Management

1 Introduction

1.1 Background and Problem Identification

Nowadays, many companies look for Business Intelligence solutions that help in the decision-making process. This stems from the fact of the accelerated pace of change in business life and the complex situations that accompany these changes, requiring this way, companies to make fast and accurate decisions. Business Intelligence solutions allow decision makers to adopt approaches based on facts to have a competitive advantage instead of depending on their personal predictions and intuition (BİROĞUL & GÜLTEKİN, 2016). SAP Analytics Cloud (SAC) solutions are an effective information visualization instrument that helps to make better fact-based decisions (Gole & Shiralkar, 2020). SAC can connect to various on-premises and cloud data sources, such as SAP HANA, SAP S/4HANA, SAP BW/4HANA, SAP BusinessObjects solutions, SQL, OData, Google BigQuery and many others (SAP SE, 2022a). We should qualify this here by pointing out that Business Intelligence is only one aspect of the services that SAP Analytics Cloud seeks to provide; it incorporates also, Planning, Predictive and Application design services on a single platform to maximize data-driven decision making (Ren, 2009). Despite being an essential tool to monitor business performance in real-time, currently it is not clear what the protocol is when implementing SAC for different business SAP modules and strategies (Gole & Shiralkar, 2020).

A report attempting to forecast the global cloud analytics industry over the next five years has demonstrated that the market size is likely to expand from 21.82 billion euros (2020) to 61.52 billion euros by 2025 with a compound annual growth rate of 23%. (Ltd, 2020). That is the consequence of the *"increasing demand for the dashboards provided by various vendors, which helps businesses retain customers and identify new opportunities for future growth….To handle huge data volumes from heterogeneous data sources, and to extract useful informational insights from the data corpus, businesses need to set up more servers and other hardware equipment, along with highly skilled IT personnel."* (Angus, 2020). The SAP Analytics Cloud product holds only 0.15% of the business analytics market, despite some very large customers such as Brighthouse Financial Inc. in the United States and names such as Tate and Lyle in the United Kingdom. SAP is seen as a "visionary" with a "complete vision" rather than a "leader" with the "ability to execute". SAP Analytics Cloud suffers from its application being too nebulous and universal, making it difficult for the public to distinguish it from its competitors and to see the clear benefits that early adopters have discovered. As the cloud analytics market expands over the next five years, it is expected significant growth in SAP offerings within this ecosystem, in line with the rapid growth in customer experience. The current shrinkage and consolidation of SAP Analytics Cloud will be matched by the growth of the external market (Ltd, 2020).

INETUM Holding Business Solutions Portugal S.A is specialized in consulting management software solutions for the German company SAP. It was the first company in Portugal to specialize in consulting

for the integrated business management system SAP ERP and is the largest partner of SAP. INETUM, the market leader in implementing SAP solutions, was recognized by SAP Portugal in the categories of "Top SAP Reseller" and "Top SAP Cloud Reseller" at its annual Partner Kick-Off Meeting 2022 event. The distinction in the “Top SAP Cloud Reseller” category recognizes the achievement of performance and sales goals, as well as the consultancy's sustained growth in the Cloud solutions business area over the last few years. (Inetum, 2022). The purpose of this project is to emphasize the effect of SAC solutions on INETUM’s customer’s strategies and explain their advantages for the companies.

1.2 Objectives

The objective of this project is to develop an intern use case at INETUM Holding Business Solutions Portugal S.A that will serve as a reference for future customer implementations. The goal is to implement an SAP Analytics Cloud solution for a fictitious customer, providing a comprehensive guide that can be applied to real-time implementations across different SAP modules.
In this way, a set of steps to be followed is obtained in an integrated way that will allow various business needs to be adequately answered.

By following this guide, various business needs can be effectively addressed, ensuring the successful implementation of SAC solutions. To achieve this goal, the following intermediate objectives were defined:

1. Researching SAP Modules: Conduct thorough research on the different modules available in SAP, understanding their characteristics, functionalities and how they can integrate with SAC.
2. Influence of Business Strategies: Explore how different business strategies can impact SAC implementations and identify potential constraints that may arise during the implementation process.
3. Current and Future State Analysis: Analyze the current state of the company and define the desired future state. Identify the gaps between these states and develop actionable steps to bridge those gaps effectively.
4. Data Modeling: Establish a robust data modeling strategy, including data source identification, data preparation and transformation techniques within SAC.
5. Data Analysis and Visualization: Utilize SAC’s data analysis and visualization capabilities to derive meaningful insights from the data. Showcase various visualization techniques to effectively communicate the findings.
6. Planning: Explore SAC’s planning capabilities and guide the implementation of planning models. Define scenarios for comprehensive planning within the organization.
7. Predict Forecasting: Utilize SAC’s Predict functionality to predict future outcomes based on historical data, enabling organizations to make informed decisions and plan for future scenarios.
8. Application Design and Integration: Design the SAC application interface to align with the specific needs of the costumer use case.

By accomplishing these intermediate objectives, the project will provide a comprehensive and transversal guide for future SAC implementations, enabling successful deployments across different SAP modules and addressing various business requirements effectively.

1.3 Importance and Relevance

This project aims to make a significant positive contribution to future SAC implementations by optimizing performance and streamlining deployments. It is intended to help speed up the SAC deployments and avoid common errors by having a generic guide that can be useful and easily consulted for different business contexts. In this way the company will be prepared in a unique and personalized way to deliver an end-to-end solution view that allows its customers to make better decisions. Also, this project intends to highlight the impact of SAC solutions on INETUM customer's strategies and explain their benefits to businesses.

As mentioned in Chapter 1.1, the global market size of cloud analytics is projected to expand significantly over the next five years. Consequently, a growing number of companies are anticipated to offer SAC solutions. This project plays a crucial role in analyzing SAC implementations across various business contexts, enabling INETUM to proactively prepare for future demands and gain a distinct competitive advantage. By thoroughly understanding and optimizing SAC solutions, INETUM can position itself as a leading provider in the market, meeting the evolving needs of clients and delivering innovative and effective analytics solutions. This proactive approach ensures that INETUM remains at the forefront of the industry, capturing opportunities arising from the projected growth in the global cloud analytics market.

Upon completion, the project will culminate in the deployment of a SAC solution. This solution, developed through a case study approach, will play a vital role in guiding future SAC implementations by providing a comprehensive step-by-step guide.

The development process will offer valuable insights into the inner workings of the company, identifying areas for improvement and ensuring that the organization effectively fulfills its customer's mission. By understanding the daily activities that contribute to an efficient business solution, the project contributes to enhancing the performance of the studied organization through analysis of SAC development processes.

Additionally, this study is expected to provide valuable insights and contribute to the field of cloud analytics, extending beyond the immediate impact on the organization under study.

2 Work Plan

2.1 Project Phases

The methodological approach involves five steps as shown in Figure 1. (Peffers et al., 2007).

Figure 1 – Project phases (adapted from (Peffers et al., 2007))

2.1.1 Phase 1: Problem identification and motivation

In this initial phase, the project scope is defined, which includes the process of writing the proposal, providing an introduction, establishing the background, and clearly defining the problem.

2.1.2 Phase 2: Objectives of the project

During this phase, the project objectives are established and the methodology for achieving those objectives is developed.

2.1.3 Phase 3: Design and development

This is the most extensive phase of the project and encompasses several key activities, including developing the Theoretical Framework, Data Modeling, Planning, Forecasting, Data Analysis and Visualization and the Design of the application.

2.1.4 Phase 4: Demonstration and Evaluation

Considered one of the most critical phases, this stage involves analyzing the results of the implemented solution and evaluating its effectiveness.

2.1.5 Phase 5: Communication

The final phase focuses on effective communication and includes writing the conclusion, revising the project document undergoing supervisor revision and ultimately delivering the completed thesis project.

2.2 Tools & Technologies

During the development of this project, it will be used SAC, it is a cloud offering that combines planning, predictive analytics, and business intelligence in a single solution. SAC provides businesses with a comprehensive set of tools and technologies for connecting, visualizing, and analyzing data from multiple sources. This chapter will provide an overview of the key tools and technologies of SAC and explore their functionality, use cases, and benefits. Figure 2 demonstrates the core capabilities and analytic capabilities.

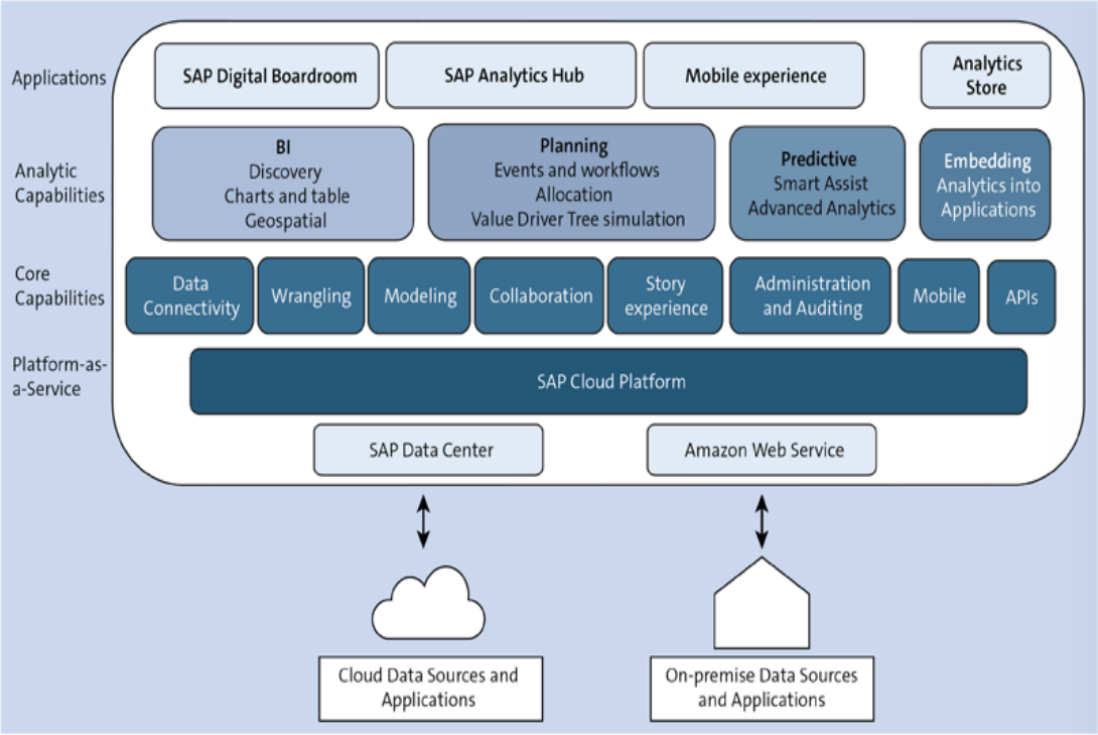


Figure 2 - Core Capabilities and Analytic Capabilities of SAP Analytics Cloud (Datar, 2019)

Analytic Capabilities

Business Intelligence (BI) encompasses visualizations and reports that complement the planning process by providing a comprehensive view of plan data. SAC offers a range of rich chart types and grids, facilitating data analysis and decision-making (SAP SE, 2021b).

Planning consists in creating events and integrating them into workflows to drive core planning activities or perform advanced planning functions. Users can create and modify plans and forecasts using various methods, including driver-based planning, top-down planning, and bottom-up planning. Additionally, the platform provides what-if analysis capabilities, enabling users to simulate different scenarios and assess the potential impact of changes (Chandra, 2023).

Predictive Analytics in SAC empowers users to leverage machine learning algorithms, allowing them to create predictive models and gain valuable insights into future trends and outcomes.

To enhance integration, SAC provides APIs that enable the embedding of SAC into other SAP and non-SAP applications, facilitating seamless data exchange and collaboration (Chandra, 2023).

Core Capabilities

SAP Analytics Cloud offers extensive connectivity options to a diverse range of data sources. These sources include both SAP and non-SAP systems, on-premises, and cloud-based systems. SAC supports integration within databases and applications, providing users with flexibility in accessing and blending data from multiple sources. SAC also offers real-time and batch data integration capabilities, ensuring that users can import and consolidate data from various sources into a unified view. Moreover, SAC features native integration with SAP systems, including SAP S/4HANA, SAP SuccessFactors and SAP BW/4HANA, further expanding its capabilities and compatibility (Datar, 2019).

During the development phase of the project solution, data modeling plays a crucial role organizing and structuring the data provided by the company in study. Figure 3 illustrates the process of accessing the data modeler in SAC.

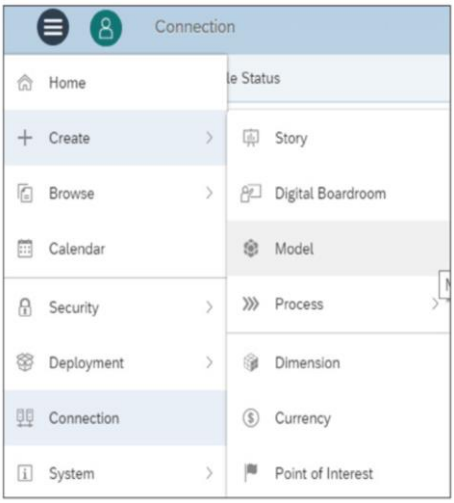


Figure 3 - Data modeler in SAC (Datar, 2019)

SAC offers a user-friendly data modeling and preparation tool that allows users to create and transform data models effortlessly. With this tool, users can add calculated fields, establish hierarchies, and apply filters to data sets. Additionally, SAC provides an AI-powered data profiling feature, enabling users to identify and address data quality issues before proceeding with analysis (Datar, 2019).

The data profiling feature in SAC enables users to explore data sets and detect common data quality issues like missing values, duplicates, and outliers. The platform provides comprehensive statistics and visualizations to help users understand the distribution of data. Built-in functions and tools allow users to handle duplicates, fill in missing values, correct data formatting problems, and perform calculations. Furthermore, SAC supports complex data transformations using scripting languages like R and Python (Datar, 2019).

SAC provides collaboration and sharing features that enable users to share insights with colleagues and stakeholders. Users can collaborate in real-time, share insights via email, and create storyboards that showcase their findings. SAC also includes a mobile app that allows users to access and share insights on-the-go (Datar, 2019).

To meet organizational requirements and ensure compliance with regulatory standards, SAC includes a range of administration and auditing capabilities. Robust security and access control features, content management capabilities, and monitoring and auditing functionalities empower administrators to effectively manage the platform and align it with their organization's needs (Datar, 2019).

SAC provides the flexibility to create both fully featured planning models and flexible analytics models. In a planning model, data is generated, edited, and inputted within the application, while an analytics model allows data to be accessed in read-only mode (Datar, 2019). Figure 4 demonstrates how to configure these two distinct model types.

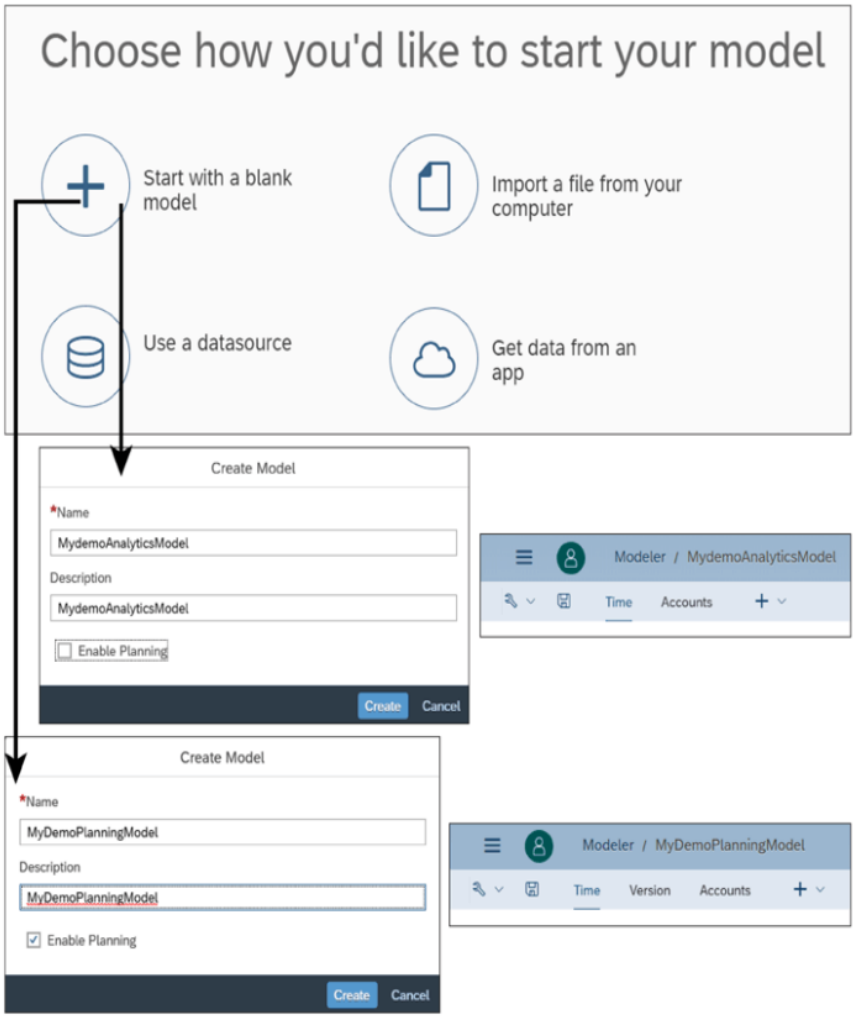


Figure 4 - Planning model vs Analytic model (Datar, 2019)

SAP analytics cloud allows to acquire data from many SAP and non-SAP applications as shown in Figure 5.

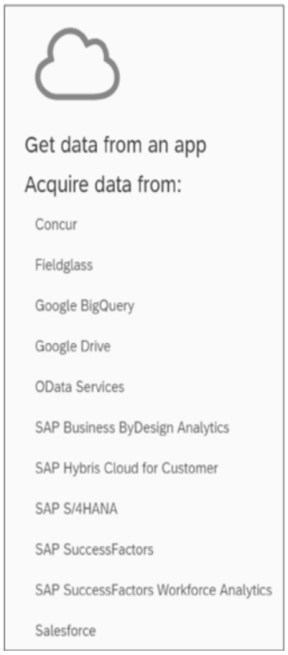


Figure 5 - Acquiring data from applications (Datar, 2019)

In addition, SAC allows to acquire data from other data sources as shown in Figure 6.

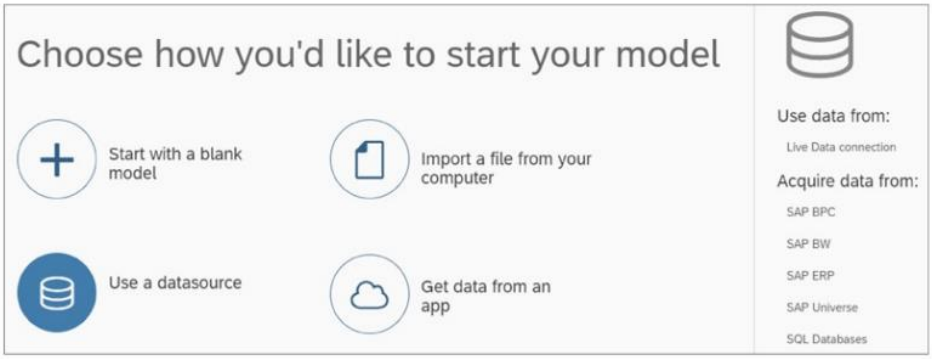


Figure 6 - Acquiring data from data sources (Datar, 2019)

There are five types of dimensions in SAC, Account, Organization, Time, Category and Generic. Every model must have at least one account type dimension (Datar, 2019). Figure 7 shows the two options of how to create a dimension.

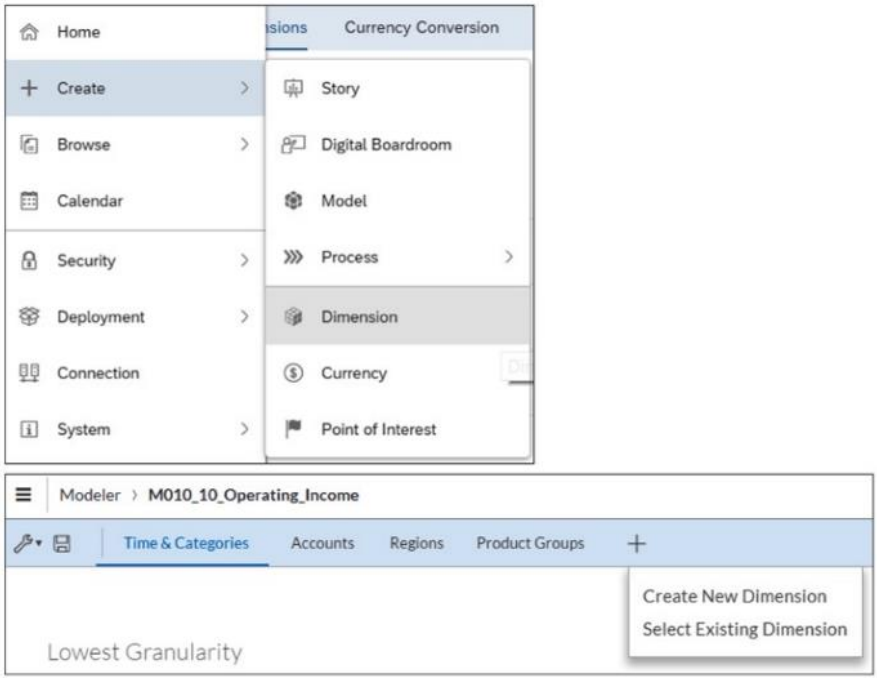


Figure 7 - Creation a new dimension (Datar, 2019)

The data modeler supports simple operations for quick calculations as well as full-feature advanced formula editor as shown in Figure 8.

Figure 8 - Advanced formula editor (Datar, 2019)

In SAC, a presentation-style document using charts, texts, images, pictograms, tables, etc. is called a story. The Figure 9 shows how we can create a new story.

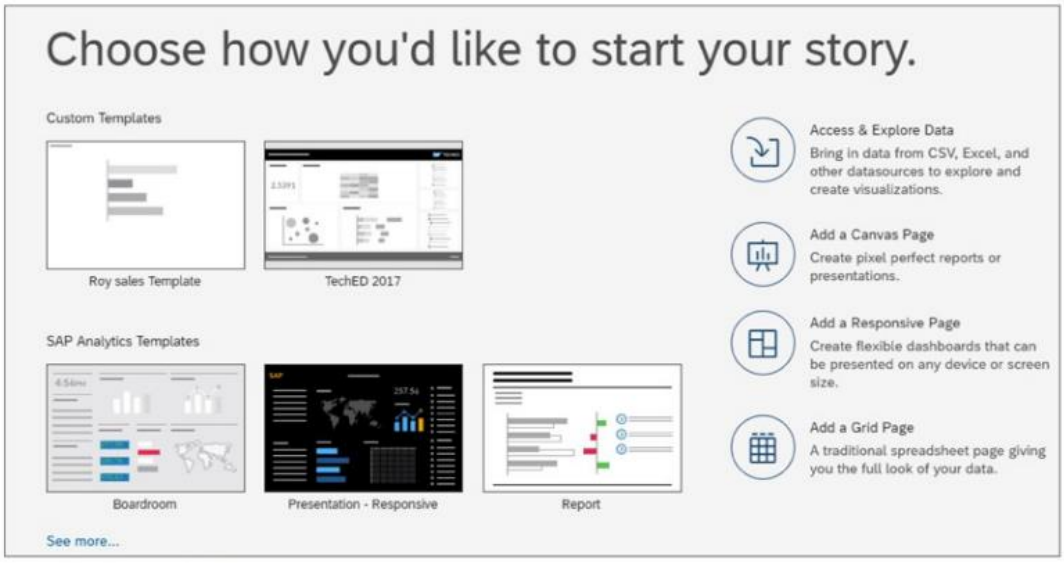


Figure 9 - Creation a new story (Datar, 2019)

Figure 10 showcases the Preview Predictive Forecast screen, which displays a preview of the forecasted result. This function employs a time series algorithm that leverages historical data. The preview also includes a confidence interval represented by three lines: optimistic forecast, pessimistic forecast, and most likely forecast for the selected time period (Datar, 2019).

Figure 10 - Preview of the Predictive Forecast (Datar, 2019)

By leveraging these tools and technologies, businesses can gain valuable insights from their data, enabling them to make informed, data-driven decisions and enhance their overall performance and competitiveness. SAP Analytics Cloud is a robust analytics platform that offers a comprehensive range of capabilities to support these endeavors.

2.3 Chronogram

The table below describes the planned chronogram associated with the project composed of five phases.

Table 1 - Project Chronogram

Stage	Activity	2022	2023									
		Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
1.Problem identification and motivation	Proposal Writing											
	Introduction Writing											
	Background Writing											
	Problem Definition											
2.Objectives of the project	Methodology Development											
3.Design and development	Theoretical Framework											
	Data modeling											
	Planning											
	Data analysis and visualization											
	Predictive Forecast											
	Design of the application											
4.Demonstration and Evaluation	Results analysis											
5.Communication	Conclusions Writing											
	Document Revision											
	Supervisor Revision											
	Thesis Delivery											

3 Theoretical Framework

In this chapter the Theoretical Framework is presented. It is divided into three sections containing the fundamental concepts for the development of this project. This entire chapter was consistently edited and improved throughout the period of September 2022 to October 2023, to include any newly discovered and relevant information.

Section 3.1 is focused on the concept of ERP, highlighting the main modules of ERP with particular emphasis on SAP modules. It also explores the definition of an intelligent ERP and discusses the associated challenges and opportunities.

In Section 3.2 the definition of SaaS is presented, along with the role of cloud computing in enabling SaaS solutions such as SAC.

SAP Analytics Cloud concepts are presented in section 3.3. In this section are presented important topics that will be used during the development of the project such as data modeling, data analysis and visualization, planning and predictive forecasting. These topics are integral to achieving the project's objectives.

3.1 Enterprise Resource Planning (ERP)

3.1.1 Concept

Enterprise Resource Planning (ERP) comes from Material Requirements Planning (MRP) software, which was created in the 1960s to assist large companies who needed to manage complex manufacturing operations. With advancing technology, ERP vendors expanded the software's capabilities to include both back-office functions (such as accounting and HR) and front-office functions (such as sales and CRM). (Goldston, 2020). The table below consists of a graphical representation of the evolution of business applications.

Table 2 - The Evolution of Business Applications (adapted from (Goldston, 2020))

Decade	Description
1960s	Early computers, Reorder point systems, and early Materials Requirements Planning (MRP)
1970s	Materials Requirements Planning (MRP)
1980s	MRP II and early Enterprise Resource Planning
1990s	ERP
2000s	Introduction to ERP cloud computing, early ERP vendor consolidations, mergers, and acquisitions

ERP software empowers an organization to coordinate all the primary business processes to improve proficiency and keep up a competitive position. It can be defined as an information system made up of different modules, where each module represents an organization's business process (Addo-Tenkorang & Helo, 2011).

One distinguishing feature of ERP software is its centralized database, which consolidates data from various business transactions and activities across different modules. This integration allows seamless communication between modules and ensures that all information is accurate and up to date. The central database serves as a "single source of truth," a concept well-known in IT (Ullah et al., 2018).

Generally, the architecture of the ERP systems can be defined in two types: logical architecture and physical (or tiered) architecture. The logical architecture (Fig. 11) demonstrates how the system is

organized to support the functional business requirements and related end users. The hardware infrastructure and database systems are located at the lowest layers followed by the core business logic which encodes the real-world business rules and constraints in the next layer. The fourth layer provides the details of functional business applications that are built into the ERP system. Between the end users and business applications lies the client user interface. It is responsible for all user interactions with the system.

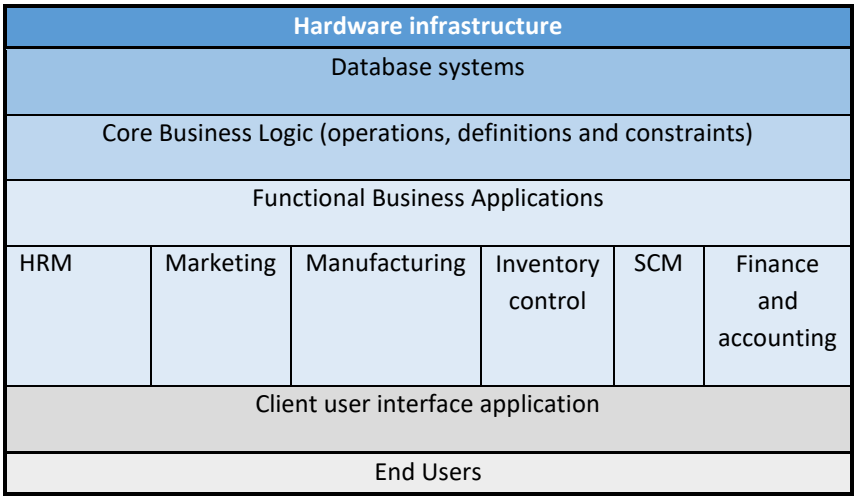


Figure 11 - ERP logical architecture (adapted from (Valashani & Abukari, 2020))

Therefore, the implementation of other layers is hidden from the end user. On the other hand, the physical architecture (Fig. 12) represents the composition of different physical components within the system in a way that the whole system can deliver the best performance and reduce costs (Valashani & Abukari, 2020).

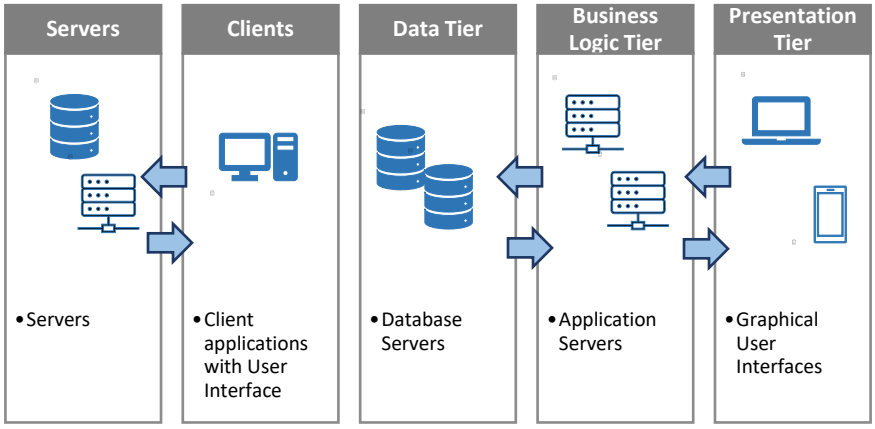


Figure 12 - The physical architecture of ERP systems: Two-tier ERP architecture and Three-tier ERP architecture (adapted from (Valashani & Abukari, 2020))

By opting for a cloud-based ERP service (Fig. 13), companies can save costs by eliminating expenses related to software ownership, licensing, installation, and maintenance associated with on-premises ERP systems. Cloud-based ERP solutions provide organizations with benefits such as high resource

availability, scalability, reliability, fault tolerance, security, and user-friendly interfaces. These advantages contribute to streamlined operations and improved user experience for customer organizations (Valashani & Abukari, 2020). The subject of cloud computing, specifically SaaS, will be covered in more depth in chapter 3.2.

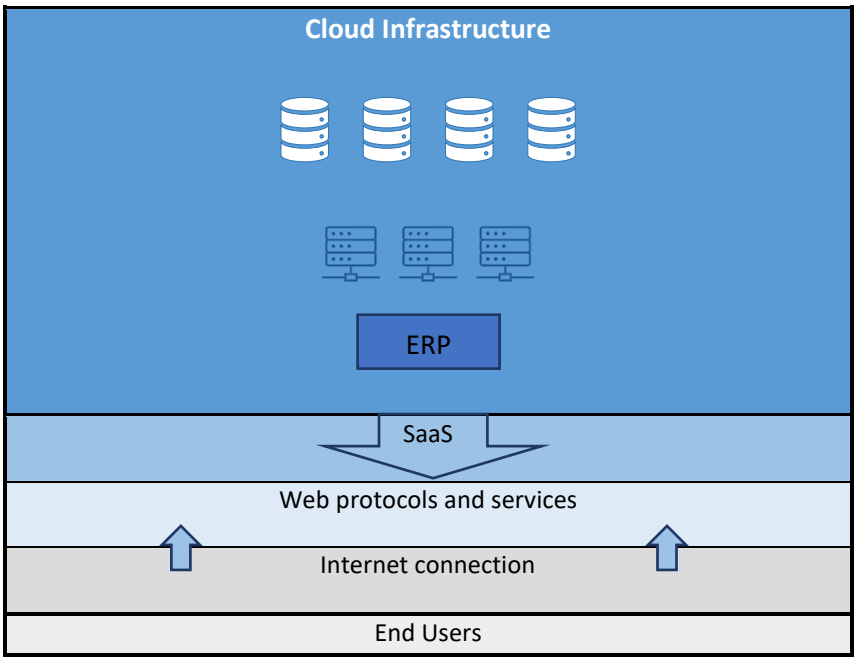


Figure 13 - Cloud based ERP architecture (adapted from (Valashani & Abukari, 2020))

3.1.2 Main Modules

The core business applications offered by SAP are the same as those offered (individually, in most cases) by traditional package software vendors: Financial Accounting, Controlling, Sales and Distribution, Materials Management, Production Planning and Human Capital Management (Doane, 2010). SAP Analytics Cloud (SAC) is a cloud-based analytics solution that can integrate with different SAP modules data to provide comprehensive insights and reporting capabilities. Following there are several SAP modules presented and their integration with SAP Analytics Cloud:

Table 3 - SAP Modules (adapted from (Hayes, 2022; Laudon & Laudon, 2019; Rashid et al., 2002))

SAP Module	Description	Activities	Integration with SAC
SAP Financial Accounting (FI)	Enables organizations to track financial flows and integrate financial information for decision-making.	Define organizational structure: company codes, business areas, functional areas, credit control. Maintain financial accounting global settings: fiscal year, posting periods. Set up number ranges for documents.	Real-time access to financial data stored in SAP FI. SAC can extract data from SAP FI to perform advanced financial analysis, create financial dashboards, track KPIs and generate interactive reports for financial reporting.
SAP Controlling (CO)	Supports planning, coordination, reporting, monitoring, and optimization of processes in an organization.	Plan and manage costs and revenues. Perform cost center accounting. Analyze cross-departmental business procedures. Manage internal orders. Calculate and monitor manufacturing costs.	SAC can integrate with SAP CO to access cost and profitability data. Enables business to perform in-depth cost analysis, monitor profitability, supports variance analysis and aids in decision-making related to cost management.
SAP Human Resources (HR) SAP HCM	Administers employee-related data for administrative, time-recording, and payroll purposes.	Manage business trip management. Conduct recruitment activities. Facilitate personal development. Handle organizational management. Manage time management.	Enables organizations to analyze HR data, track employee performance, identify skill gaps and optimize workforce planning. SAC's workforce analytics capabilities provide insights to support effective HR management

SAP Module	Description	Activities	Integration with SAC
SAP Customer Relationship Management (CRM)	Handles end-to-end customer-related processes and consolidates customer data.	Capture and manage customer relationships. Improve sales, services, and marketing strategies. Analyze customer data to gain consumer insights.	SAC can provide visualizations, dashboards, and predictive analytics based on CRM data to support data-driven decision-making.
SAP Material Management (MM)	Manages materials through logistics, supply chain management, sales and delivery, and warehouse processes	Handle procurement processes.	Allows analysis of procurement and inventory data. SAC can extract data from SAP MM to create visualizations, reports and dashboards for analyzing purchasing trends, inventory levels, vendor performance and optimizing procurement processes.
SAP Production Planning (PP)	Focuses on production planning and management	Collaborate with master data, sales and operations planning, distribution resource planning, material requirements planning, and product cost planning.	Provide insights into production planning and performance. Enables users to analyze production data, track production efficiency, monitor production costs and optimize production processes through interactive visualizations and reports in SAC.

3.1.3 Intelligent ERP

Nowadays intelligent technology can be used in many kinds of company operations systems, such as CRM, to establish high performance operations. This allows firms to record more useful information with autonomic and predictive intelligent assets. This improved ERP is called “intelligent ERP” or “I-ERP”, it is intended to help the companies make better business decisions and generate innovation (Jenab et al., 2019).

I-ERP takes advantage of machine learning on massive data sets to obtain innovative products and services and higher employee productivity. Consequently, the information available on the company is returned in a maximized way (Jenab et al., 2019). Intelligent ERP is an advanced type of ERP system that leverages emerging technologies such as ML, AI, and predictive analytics to enhance traditional ERP capabilities (Bertram, 2022).

It is expected that I-ERP will utilize cloud deployment because of the demanding infrastructure requirements to manage massive, heterogeneous data sets accessible in time to support tight decision windows. From a process perspective, I-ERP systems, via machine learning and predictive analytics, will be capable of learning from exceptions and adapting business rules, allowing users to discover insights, better predict and plan for outcomes, recommend next best steps, and automate processes. Users will see the difference in this new generation of applications as the user experience (UX) begins to incorporate assistive, collaborative conversational styles (with a mobile-first design) driven by advances in natural language processing (NLP) and machine learning (Bertram, 2022).

Figure 12 shows the four technologies that are the basis and foundations for the seven i-ERP capabilities identified.

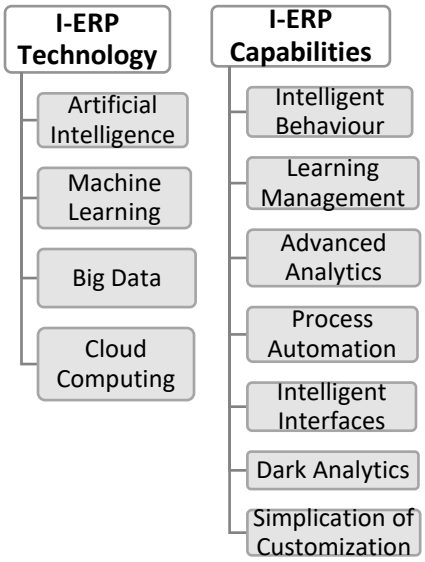


Figure 12 - i-ERP technologies and capabilities (adapted from (Sousa, 2022))

When integrated with SAC, I-ERP systems can benefit from platform’s advanced analytics capabilities, including real-time data analysis, predictive analytics, data visualization and collaboration features. This

can help organizations to gain deeper insights into their operations, optimize business processes and improve decision-making (Denecken, 2019).

SAP S/4HANA Cloud is SAP's intelligent ERP system, allows organizations to be more productive and efficient by streamlining and automating processes. Users can gain deeper actionable insights to connect and access to data streams in real time so the business can act quickly. SAP S/4HANA Cloud also provides organizations with more visibility to ensure policy and regulatory compliance, enable more accurate planning, and reduce fraud. SAP's intelligent ERP helps connect, analyze, and leverage data across the business (Rizza & Lava, 2021).

In addition to integrated operational processes, for an enterprise to be considered intelligent, it is necessary to have robust analytics capabilities. With the deep integration of SAP Analytics Cloud into the solution of SAP S/4HANA Cloud it is provided pre-defined reporting, personalized access to data and ad-hoc analytical capabilities. In this way, it is possible to get as much value out of the enterprise data as possible (Sieberg, 2022). For each SAP S/4HANA Cloud tenant, a new SAP Analytics Cloud tenant is provided. The SAP Analytics Cloud accesses the ABAP CDS views live, using the transient analytical queries generated automatically for the CDS views (Sieberg, 2022). Figure 13 shows the architecture.

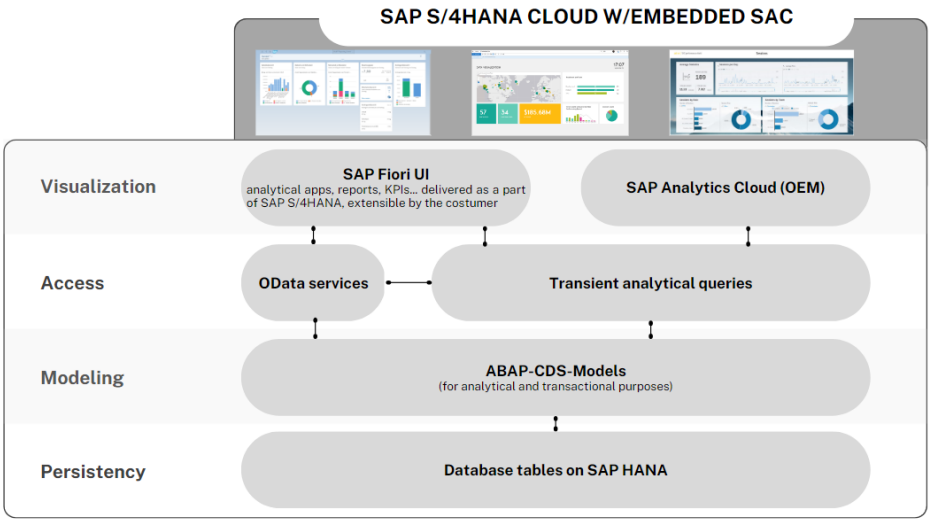


Figure 13 – SAP S/4HANA Embedded Analytics - High Level Architecture (adapted from (Sieberg, 2022))

3.1.4 Challenges and Opportunities

Despite their wide range of advantages, ERP systems face difficulties during the implementation of projects. That necessitates severe structure modifications, and businesses are typically encouraged to adopt a departmental hierarchy view. The transition from a functional to a process-based view is a great challenge. It is feasible to boost the number of successful cases with the right execution and strategy, which takes organizational culture factors into account (Shi and Wang, 2017). Because of technological advancements, businesses can now leverage enterprise resources without incurring significant

infrastructure costs. The fact that cloud ERP is online and stores corporate data in the cloud gives it an added advantage. With this step, the system is accessible from anywhere and information security is guaranteed. The following Table 4 summarizes predominant ERP advantages according to the authors consulted.

Table 4 - ERP Advantages

ERP Advantage	Description	Authors
Quality improvement	Improve the quality of the processes and customer service.	(Meiryani et al., 2021)
Reduced costs	Since they are more efficient, the costs of running the business go down.	(Jenab et al., 2019)
Information Centralization	The management of everything through the use of a single database, which allows different business sectors to access relevant and up-to-date data.	(Šimović et al., 2020)

Table 5 contains three ERP disadvantages according to the authors consulted.

Table 5 - ERP Disadvantage

ERP Disadvantage	Description	Authors
Initial investments	The initial investment costs are very high.	(Šimović et al., 2020)
Inflexibility	Processes are designed in a standard form.	(Azevedo et al., 2013)
Long implementation period	One of the major difficulties in the implementation of ERP Systems is the long implementation period that such systems require.	(Azevedo et al., 2013)

Table 6 summarizes i-ERP advantages according to the authors consulted.

Table 6 - i-ERP Advantages

i-ERP Advantage	Description	Authors
Improved decisions	The intelligent ERP system is the digital core that ties the data sets to analytics, turning the data into actionable insight	(Rizza & Lava, 2021)
Increased flexibility	Systems can run in the cloud, enabling them to grow and contract based on the business requirements.	(Rizza, 2020)
Improved communication	Resources and data are connected and centralized improving internal and external communication.	(Rizza & Lava, 2021)

The following Table 7 summarizes i-ERP disadvantages according to the authors consulted.

Table 7 - i-ERP Disadvantages

i-ERP Disadvantage	Description	Authors
Ethical issues	Internal policies, legal, and ethical aspects must be considered.	(Rizza, 2020)
Additional training	Understanding end-to-end business processes is critical as algorithms, data, analytics, and learning are applied.	(Rizza, 2020)
Data distortion	The data being consumed by i-ERP is subject to potential distortion and incomplete or erroneous information.	(Rizza, 2020)

3.2 Cloud Computing

During the 2000s, the field of computing witnessed the introduction of cloud computing (Katuu, 2020). Cloud computing has emerged as a powerful solution to satisfy the growing demands of many organizations that are not able or willing to purchase and maintain full software systems for their business environments. It's a well-established technology built upon advanced virtualization solutions, facilitating the access to computing and storage resources for any business processes. Customers can access virtualized resources whenever they want and wherever they are using a simple browser without worrying about any other technical problems (Valashani & Abukari, 2020). Cloud computing initially identified three forms of virtualized resources as services (Katuu, 2020):

1. Software as a Service (SaaS): In this model, software applications are offered as services on the Internet rather than as software packages to be purchased by individual customers (Pareek, 2014).

2. Platform as a Service (PaaS): This refers to providing facilities to support the entire application development lifecycle including design, implementation, debugging, testing, deployment, operation and support of rich Web applications and services on the Internet. Most often Internet browsers are used as the development environment (Pareek, 2014).

3. Infrastructure as a Service (IaaS): Deals with raw computing capacity by providing a server in the cloud along with storage. The goal is to have access to the computing capacity, without the responsibilities of installation or maintenance (Sousa, 2022).

Cloud-based ERPs emerged by the mid-2000s as a result of the recognized advantages of shifting away from the management of on-premises ERPs, particularly concerning the handling upgrades and maintenance procedures (Katuu, 2020). Cloud based ERP system architecture provides solutions to all

the difficulties encountered by conventional ERP system. It provides flexibility to the existing ERP systems and improves overall efficiency (Pareek, 2014).

ERP systems with cloud architecture can be categorized in the SaaS type of cloud computing services. The ERP software and database are hosted on the vendor's servers or third party-infrastructure. This setup enables users to access the ERP system remotely through a desktop connection or even a web browser on a tablet or mobile device with an internet connection. By opting for cloud-based ERP services, companies can reduce costs by eliminating the expenses associated with software ownership, licensing, installation, and maintenance typically seen in on-premises ERP systems (Valashani & Abukari, 2020). Table 8 summarizes the main differences between ERP and Cloud ERP.

Table 8 - ERP vs. CLOUD ERP (adapted from (Pareek, 2014))

Factor	ERP	Cloud ERP
Deployment	Local Server	Cloud Server
Reduced server cost	Low costs	High costs
Defining business flow	Defined by ERP developer and business organization specific.	Define by both, ERP developer and Business organization.
Implementation costs	High	Low
Ongoing costs	Relatively high	Low
Integration	Depend on vendor	Can be supported centrally
Licensing costs	High	Low
ERP module update	Costly	Low cost
Internet needed	No	Yes
Version controlling	Complex	Easy

3.2.1 Software as a Service (SaaS)

Software as a Service, also known as cloud application services, represents the most commonly utilized option for businesses in the cloud market. SaaS utilizes the internet to deliver applications, which are managed by a third-party vendor, to its users. Most SaaS applications run directly through web browser, which means they do not require any downloads or installations on the client side (Watts & Raza, 2019).

To paraphrase Marc Andreessen's famous quote "Software is eating the world", a more recent adaptation might be "The cloud is eating the world". At the time that the data was collected (May 2020),

23% of organizations or businesses had replaced their traditional on-premises marketing automation software with SaaS-based solutions. Similarly, 12% of organizations had migrated from on-premises BI software to SaaS-based BI solutions. “Planned replacements within the next two years outpace the levels of actual replacements”, this means that more organizations are intended to replace their existing on-premises applications with SaaS soon (SAP SE, 2019).

SAP ERP is not a SaaS solution by default, but it can be deployed as a SaaS solution through SAP’s cloud offering such as SAP S/4HANA Cloud. Traditionally, SAP ERP has been an on-premises solution, meaning it is installed and runs on a company’s own hardware and infrastructure. However, with the growth of cloud computing, SAP has developed cloud-based versions of its ERP solution that are hosted and managed by SAP and delivered to customers via the internet as a service (Keijzer, 2021).

According to Gartner, Inc.’s latest forecast, global SaaS dominates cloud services delivery models (Table 9). This surge is being driven by cloud computing, which is propelling the next wave of digital business. Gartner’s Vice President’s Analyst, Sid Nag, noted that hyperscale cloud providers are at the forefront of shaping the cloud landscape (Gartner, 2023).

Table 9 -Worldwide Public Cloud Services End-User Spending Forecast (Millions of U.S. Dollars)

	2022	2023	2024
Cloud Application Infrastructure (PaaS)	111,976	138,962	170,355
Cloud Application Services (SaaS)	**167,342**	**197,288**	**232,296**
Cloud Business Process Services (BPaaS)	59,861	65,240	71,063
Cloud Desktop-as-a-Service (DaaS)	2,525	3,122	3,535
Cloud Management and Security Services	34,487	42,401	51,871
Cloud System Infrastructure Services (IaaS)	114,786	150,310	195,446
Total Market	**490,977**	**597,325**	**724,566**

3.3 ERP Analytics

As a result of the big new data era ERP systems have gradually been exposed to a large volume and variety of data in a short period of time. The connection between ERP and big data analytics has made possible to faster decision making by providing near real-time statistical data and consistent dashboards of the organization's current scenario as well as reporting historical events (Cadersaib et al., 2018).

Because of the constant generation of massive amounts of structured and unstructured data due to cloud ERP, it has become necessary to integrate big data predictive analytics into this process in order to analyze these complex data sets. Enterprise Analytics, in the general sense, implies the process of making data and analytical solutions available all over the organization. Additionally, they can help senior level management discover common business opportunities and create intelligent enterprises (Shi & Wang, 2018).

In conclusion, ERP Analytics is, thus, a beneficial tool for organizations that aim towards providing customer satisfaction and continuously strive to survive and succeed in the competitive market (Pfutzenreuter & De Lima, 2022).

3.3.1 SAC Capabilities

SAP has created a cloud-based analytical platform with SAP Analytics Cloud, offering customers a comprehensive range of capabilities, from basic reporting to predictive and augmented use cases, all within a single platform. SAP Analytics Cloud combines classic business intelligence (BI) capabilities, with typical platform features, such as scheduling, and product capabilities such as planning and predictive (Ingo, 2020).

With SAP Analytics Cloud customers have the option to consolidate all their analytic needs and requirements into a single cloud-based solution that covers analytics, planning, application building, and predictive scenarios (Ingo, 2020).

The following sections aim to provide an in-depth understanding of SAC's capabilities, which will be fundamental to the development of the project.

3.3.1.1 Data Preparation and Wrangling

Data preparation can be carried out utilizing either a dataset or a model with SAC wrangling. Datasets store data in a single table, and the semantic structure is defined by the metadata. Models store data as a star schema, and the structure of the model is reflected in the database (Ingo, 2020).

Depending on the business case, it is possible to choose between preparing your data using a model or a dataset. The primary distinctions between a model and a dataset are shown in Figure 14 below.

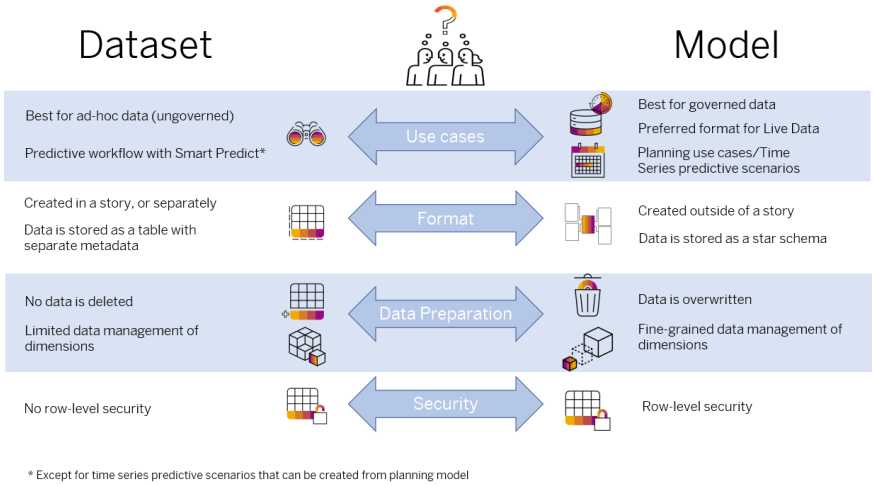


Figure 14 - Main differences between a model and a dataset (retrieved from SAP Help Portal)

Data Modeling is the process of enhancing available data by cleansing, transforming, and wrangling it to build a dataset that can be used in self-service analytics, stories, and dashboards (Gole & Shiralkar, 2020).

A model is a structured representation of any given quantifiable dataset. Models are made of Ordinal data (dimensions); Cardinal data (measures and accounts) and Data transformations (Datar, 2019).

Groups of related ordinal data values are called **dimensions**, and the individual values are called **dimension members**. In a data table, dimensions are often grouped together in a column with the dimension name as the column name and the individual row values as members. In Figure 15 it is possible to see an example of a Date dimension.

Date
2020.6.15
2020.5.7
2020.5.21

Dimension: Date
Members: Individual Dates

Figure 15 - Date Dimension example (Datar, 2019)

SAP Analytics Cloud has four categories of dimensions:

1. Accounts: special dimension for handling cardinal data in some planning models.
2. Dates: very common in business-related data; require quite a bit of special logic and handling.
3. Geographic: very common in business-related data; require quite a bit of special logic and handling.
4. Generic: anything else.

In SAP Analytics Cloud, dimensions can be public or private. Public dimensions are reusable in many data models, they are used for very complex dimensions or widely used dimensions. Private Dimensions are unique to a given model and they are maintained within the context of that model (Datar, 2019).

Cardinal values are values where mathematical operations give meaningful results. These operations can be performed on aggregates. For example, the daily sales of ice cream can be averaged or summed up over a Week; Month (Fig. 16); Quarter (Fig. 17) or Year (Fig. 18).

Date	Cones Sold
2001.5	50
2001.6	200
2001.7	500
2001.8	600
2001.9	250
2001.10	40

Figure 16 - Cones sold by month (Datar, 2019)

Date	Cones Sold
2001.Q2	250
2001.Q3	1350
2001.Q4	40

Figure 18 - Cones sold by quarter (Datar, 2019)

Date	Cones Sold
2001	1640

Figure 17 - Cones sold by year (Datar, 2019)

Groups of related cardinal data values can be lumped into measures or accounts. A measure groups these values into a single, cohesive group, normally into its own column in a table (Fig. 19). An account uses a dimension to group the values (Fig. 20).

	Count	Distance
Measures	10	50
	8	47
	5	134

Figure 19 - Measure example (Datar, 2019)

	Account	Value
Accounts	Count	10
	Distance	50
	Count	8
	Distance	47
	Count	5
	Distance	134

Figure 20 - Account example (Datar, 2019)

Many data models use a so-called star schema structure. There is a central fact table, called a data foundation in SAP Analytics Cloud. Measures are stored in the fact table, the data in the fact table is not normal (in SQL speak) (Datar, 2019). Dimensions are stored in their own tables; the Dimension data is normalized. There is a primary key, foreign key relationship between fact table dimension columns and the dimension tables (Gole & Shiralkar, 2020).

Unstructured data needs to have structure added to use it in a model. Structured data may be compatible as is or may need to be tweaked or modified. The process of transforming raw data into the desired structure is called data wrangling. In SAP Analytics Cloud, any given combination of a raw data source and a wrangled transformation is known as an import job (Datar, 2019).

There are two strategies in SAP Analytics Cloud for loading and consuming raw data (Fig. 21):

1. Extract, Transform, Load (ETL)
    a. Raw data is transformed and then stored in the transformed format.
    b. Used where repeatable, consistent data structures are needed (such as in planning, operational analytics).
    c. Star schema-based models use ETL for acquiring data.
    d. Data from disparate sources can be transformed and loaded into the same data model with ease.
    e. Data is transformed once, when initially loaded.
2. Extract, Load, Transform (ELT)
    a. Data is stored in its raw format.
    b. Transformed with each use.
    c. Fixed to a single data source.
    d. Used where analytic and design flexibility is prized over enterprise.

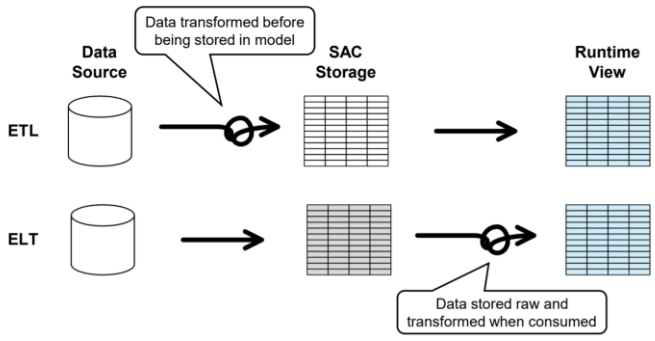


Figure 21 - ETL vs ELT (Datar, 2019)

There are two broad approaches to creating data models:

1. Structure First: star schema is built first, and the data is loaded later. It uses an ETL transformation strategy. The structure of the model can be custom built for its use case. It is used in planning and operational analytics.

2. Data First: model is built to work with specific data. The model structure is created via wrangling, and it can use either ETL or ELT transformation strategies. It is used for quick, ad-hoc analytics, it can sometimes be used for planning and operational analytics.

There are three types of models in SAP Analytics Cloud:

1. New Model: structure first or data first; it uses ETL import workflow and supports both accounts and measures. Primarily planning-centric
2. Dataset: data first only; it uses ELT import workflow; supports measures only. Primarily used for ad-hoc analytics
3. Classic Account Model: structure first or data first; it uses ETL import workflow. Accounts only

Data modeling provides structure for the data used in an information system. In SAC there's the possibility to create a fully featured Planning Model or a much simpler and flexible Analytics Model. The basic difference between planning and analytics models is that a planning model is the one where it's possible to generate, edit and input data within the application, whereas in an analytic model the data is used in read-only mode. Within the creation of a planning model, it is preconfigured dimensions for time and categories. For example, to analyze actual revenue or cost numbers the analytics model can be used but for creation of budget or forecast the planning model is the suitable since the forecast numbers are generated with SAC or are manually entered instead of just being loaded from an external source. Analytic models do not support categories or require time dimensions (Datar, 2019).

3.3.1.2 Data Analysis and Visualization

Data visualization is another key component of SAP Analytics Cloud. The platform provides a variety of data visualization tools that allow users to create interactive dashboards, charts, and reports. These visualizations can be customized to meet the specific needs of different stakeholders and can be shared with others for collaboration and decision-making (Datar, 2019).

SAC utilizes several features to analyze and visualize data, in this section these features will be presented as well as the techniques to employ to make productive analysis and informative visualizations.

An SAP Analytics Cloud story is a presentation-style document that uses charts, visualizations, text, images, and pictograms to describe data. It helps to analyze data and to make confident decisions faster with AI-driven insights.

To start the creation of a story it is added new page. The type of pages available are shown on Table 10:

Table 10 - Type of pages - Story

Type of pages	Characteristics
Responsive page	Responsive pages allow to create layouts that automatically resize and reflow when viewed on different sized screens.
Canvas page	Canvas pages allow to create a dashboard in a personalized format. They also give the option to overlap different objects.
Grid page	Grid pages allow to add data to an empty grid, or add a table based on an existing model.

When designing stories there are several widgets that can be added. Charts, tables, input controls, geo maps, images, shapes, and text are examples of some commonly used widgets.

Various visualizations are supported by SAC, in order to analyze the data. Some commonly used charts are Bar/Column Chart; Stacked Bar/Column Chart; Waterfall Chart; Line Chart; Numeric Point Chart; Time Series Chart; Pie/Donut Chart and Scatterplot. Story designers can also add custom charts supported with R library by choosing R Visualization from the Insert tab.

Tables in SAP Analytics Cloud are cross tables and can be used in stories to view and analyze data. The table's features and options depend on the table's data model type (for example, planning, analytic, or other model types). It can be added multiple measures and multiple dimensions to the tables by using the different axes (rows axis and columns axis). Also, it is possible to create local filters on the tables and create custom calculations (for example aggregations).

A report in SAP Analytics Cloud is a paginated-style document that uses tables, charts, visualizations, text, images, and pictograms to describe data. Tables in reports can span multiple pages.

There are a few things to keep in mind when creating stories that will help SAP Analytics Cloud work at its best. Here are a few examples:

- Use responsive pages.
- Choose the right template.
- Design using styling preferences.
- Leverage dynamic input controls.
- Use dynamic text tokens.
- Check device preview.

Analyzing across models is when with linked analysis, story, and page filters it is made a filtering across multiple models. The first step in enabling analysis across models is to create links between the model dimensions. These are called linked dimensions and are used when filtering and blending. Dimension

that exists in both data models and have the same data type and values can be linked. In Figure 22 it is possible to understand the concept of linking different dimensions together.

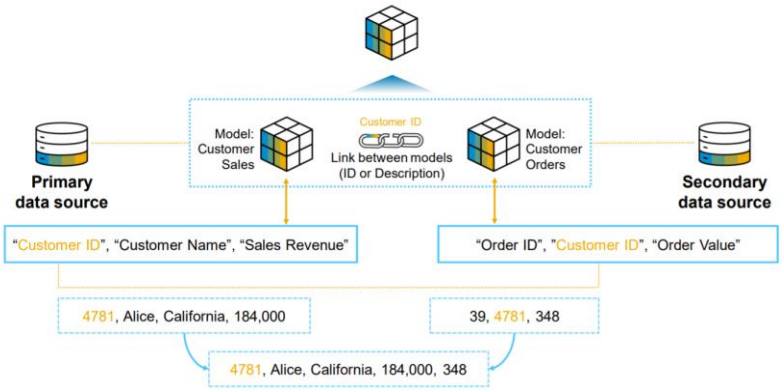


Figure 22 - Linked dimensions example

Once the models are linked it is possible to filter and blend across the linked models. Filter data models based on the filtered values of another model is called Filtering across models. When filtering across models it is possible to either filter on linked dimensions (direct filter) or filter on unlinked dimensions (indirect filter).

3.3.1.3 Planning

Before heading to the content of this chapter I would like to point out that the information regarding Planning section and the following subsections was mainly consulted on the SAP Help Portal, and in the books by the authors Datar, 2019; SAP SE, 2019; Irick at al., 2019.

In section 3.3.1.1, the discussion revolved around data modeling in SAC, highlighting two types of models in SAC: planning and analytical. While data analysis and visualization in the last section applied to both planning and analytical models, this section exclusively delves into planning models, offering insights into their functionalities.

With SAP Analytics Cloud, a range of planning operations can be executed, including scheduling tasks, initiate forecasts using predictive features, building custom planning applications, carrying out data entry and version management, and writing powerful scripted calculations.

As an application is developed, collaborate efforts within the team are facilitated, and advanced analytics are applied to planning data. This approach ensures alignment among team members towards a common goal and enhances the value derived from the plan. While reporting and analysis focus on historical data (known as actuals), it's crucial for businesses to have a clear vision of the future.

Planning is all about setting strategic goals and then determining how to meet those goals by creating annual budgets, tracking progress in forecasts, and simulating scenarios to find new opportunities. These plans are formed by projecting actuals into the future, by gathering input from different departments, and by considering trends, risks, and opportunities in the market.

Executive boards and finance departments play a big role in planning. But an effective plan needs input and support from the whole organization. Maintaining close integration between departmental plans and the overall strategic goals and financial plans is known as collaborative enterprise planning.

3.3.1.3.1 Versioning

Versioning is the most important function for planning with SAC Planning. This function includes Actual, Budget, Planning and Forecasts as predefined categories. It allows the division of the data into these versions. You can load data into any of these categories, the actual category typically gets data from the transactional system regarding the actual values such as actual revenue generated, or units sold.

Private versioning facilitates the analysis of in-plan scenarios during plan creation, users can copy the actual version to a private version to perform simulations without affecting the original version. Users can also create and share private simulations prior to publishing.

Variance is the difference between Plan and Actual. The difference between time intervals is an example of a variance typically used to compare time-based values, as in when comparing one year to the next.

3.3.1.3.2 Allocations

Allocation allows the disaggregation of data based on other drivers and rules. By using the allocation function it is possible to divide, define or copy values between dimensions. This can be done within the report or by defining allocation processes. Most competitors provide capabilities relating to allocations, but these are not easily configured or usable. SAP Analytics Cloud provides a straightforward editor to construct and execute complex allocations. One of the key use cases for using a planning tool is allocation. A second important component is the allocation-driver. The driver is a definition/rule that applies to an allocation or group of allocations.

There are different types of Allocations techniques: Spreading, Distributing and Assigning. Spreading uses weights to move data from a parent to the children, it is the process of taking different values from a higher level to a lower Level of a hierarchy. The top value stays the same, but the values of the lower levels are changed. For example, values at the level of year can be spread to quarters.

On Figure 23 it is possible to see as an example, the weights that were entered and the corresponding percentage in order to spread the value between United States and Overseas.

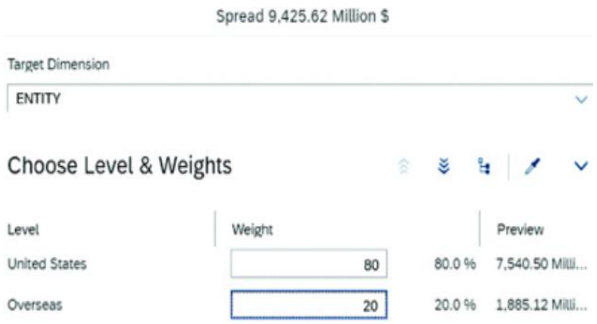


Figure 23 - Disaggregation by Spreading (Datar, 2019)

Unlike Spreading, Distribution uses actual values rather than weights. Distributing moves values from one cell to another, or to cells at the same hierarchical level. It is easy to allocate resources to different areas of the business. In this way it is possible to decide what resources a single department, product group, or product will get.

Assigning permits to put a Total directly on dimension values. The Total assigned is not based on any existing cell, but by adding or reducing the value of some cells. To reduce a value, a minus symbol (-) needs to be included before the value. Assigning helps in adding or replacing values at different points. For example, it enables an increase or decrease in the budget for different quarters of a year.

3.3.1.3.3 Validation Rules

In planning models, valid data entry and planning operations can be specified. Validation rules enable the definition of permissible member combinations across multiple dimensions to prevent inappropriate data entry and planning activities within stories and analytical applications built upon this model. For dimensions included in a validation rule, only the member combinations explicitly identified as permissible can successfully pass the validation process.

For instance, consider a scenario where specific products are only permitted for sale in certain locations. A validation rule can be established between product dimension and location dimension members, restricting planning users to only engage in planning activities for the allowed combinations of products and locations.

3.3.1.3.4 Data Locking

Data Locking provides control over the data entry access within a planning model. Without data locking it is easy to insert data in any cell in a table which contains a planning model. Data locking can lock

specified areas of the model or the entry modes, it provides granular control over data updates against multi-dimensional slices of the model.

Locking and unlocking data can be applied to any number of dimensions, such as Version, Time, or Cost Center, and provide visual cues within the grid for slices that are editable and those that are locked. The owner or administrator have the ability to put the node into Restricted edit mode so that only authorized users proceed with data editing.

3.3.1.3.5 Data Actions

The Data Actions function of SAP Analytics Cloud enables the creation of any necessary action on top of the planning data. Data Actions can be used to create and populate a new planning or forecast version, copy data between sections of the model, or create a more complex transformation. Data Actions is an orchestration and execution engine for sequential batch operations. Multi-step operations can be executed automatically, meaning that as many sequential steps as needed can be created as in a classical planning sequence. Two types of steps are provided, Data Copy and Advanced Formula Logic. The Data Action is executed based on a trigger button inserted on the story canvas.

The main function of Data Actions is to create, orchestrate, and execute complex multi-step planning operations:

1. Use multi-step process management and execution engine.
2. Chain as many steps together as necessary to achieve your objective.
3. Use capabilities including creation and execution of Batch data copy and Advanced Formula logic.
4. Execute processes based on action button included in a story.

Advanced Formulas are a specific type of Data Action step. These utilize a syntax very similar to that used for account formulas within the model, but allow for more robust looping, filtering, and multi-dimensional calculations and storage. The results from these Advanced Formulas are persisted and are recalculated on demand via a Data Action Trigger. This significantly supports and expands the native calculation capabilities within the SAP Analytics Cloud Modelling engine to substantially expand the types of calculations and use-cases.

3.3.1.4 Predictive Forecasting

Predictive Planning was delivered in SAP Analytics Cloud to support customers and partners that want to use time series forecasting in context of financial, HR or sales planning. Predictive Planning makes it possible to create predictive forecasts at scale, directly using planning-enabled models as the data foundation for predictive activities.

Time series forecasting scenarios can be created using two types of data sources, which are Planning-enabled models and Datasets (either acquired or live on SAP HANA on-premises systems). The major differences are listed in Table 11 below.

Table 11 - Planning models vs Datasets

Planning models	Datasets
Creating a planning model requires a Planning Professional license.	Creating a dataset can be done using any BI or Planning license.
Planning models are semantically rich. Metadata can help improve forecasting, for instance to predict at a higher-level of aggregation.	Datasets are simple collections of data. The data is always handled at the level provided in the dataset and cannot be aggregated.
It's possible to write the predictive forecasts directly into the planning models (in private versions).	Separate datasets containing the predictive forecasts are created. They need to be integrated with models and stories.
Data preparation can be automated (data refresh schedules, data actions, multi-actions).	Lightweight data preparation is offered, and data refreshes should be handled manually.

On Figure 24 it is possible to see that the main differences in forecasting using planning models and forecasting with datasets are the version on the time series data source and the filtering entities.

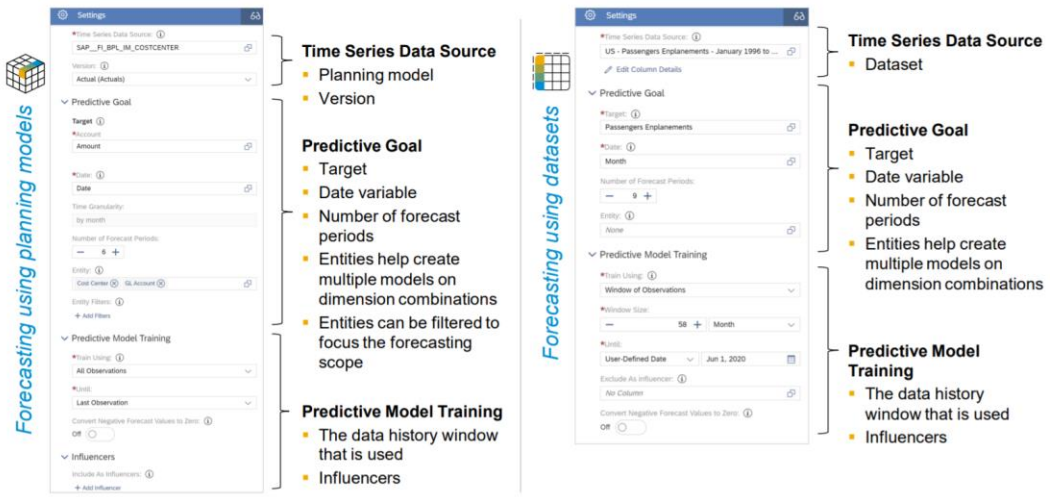


Figure 24 - Planning models vs Datasets

A predictive scenario answers a dedicated question and can contain multiple predictive models (experiments).

The expected MAPE (Mean Absolute Percentage Error) indicates how accurate a predictive model is. When creating the predictive model, an estimation of the expected MAPE is done. The expected MAPE is averaged across all entities. It is also possible to get an expected MAPE per entity. Finally, it is also possible to obtain the record count per entity.

The Forecast report includes the actuals, the predictive forecasts, the outliers, and the confidence intervals (error min/max). It helps to compare the model and the actuals for the past periods.

A classification model helps to classify observations based on historical data. Using classification, it is possible to predict the probability that a specific event will happen. Datasets contain the information required to create classification and regression scenarios and deliver predictions. Predictive scenarios deliver predictions into datasets, and datasets can in turn be used in stories (Fig. 25).

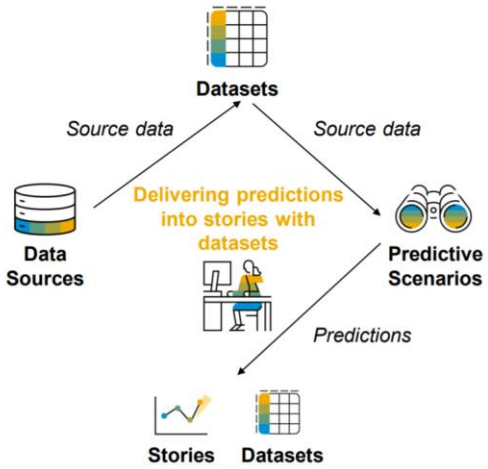


Figure 25 - Predictions using datasets process

Two indicators help evaluate the model:

1. The predictive power: evaluates the accuracy of the classification model (model quality). It primarily depends on input variables.
2. The prediction confidence measures the ability of the classification model to predict with the same reliability on new cases (model robustness). It primarily depends on observations.

Influencers contributions show the relative importance of each variable in the model. The confusion matrix shows the performance of the classification model by comparing predicted values with actual values, based on the contacted population. The profit simulation associates profit/cost with the positive categories.

A regression model is used to estimate the value of a measure. By using a regression model, it is possible to predict the most likely value for a given observation.

Two indicators help evaluate the model:

1. The root mean square error (RMSE) measures the quality of the regression model. The smaller the RMSE, the more accurate the model. It primarily depends on input variables.
2. Prediction confidence measures the ability of the regression model to predict with the same reliability on new cases (model robustness). It primarily depends on observations.

The regression model relies on a gradient boosting technique, similar to the classification model.

4 Project

This chapter explores the implementation of SAC in an intern use case at a construction supply company, with the objective of analyzing the company performance and identifying opportunities for growth. This project involves integrating data from data sources, preparing data for analysis, and visualizing the insights using SAC's analytical and predictive tools. It is intended to provide insights into the benefits and challenges of implementing SAC in a real-world user case and contributes to the understanding of how cloud-based analytics solutions can be used to drive business value.

4.1 Survey: Importance of Guide Documents in SAC implementations

A survey was created so that the project meets the current needs. The following questions were made to the INETUM's SAP Analytics Cloud team. They will help to get a sense of how important IINETUM's consultants consider guide documents to be in SAP Analytics Cloud implementation projects, how helpful they have found them in the past and what specific types of guide documents are most valuable to them.

The first question, "What is your level of experience in SAP Analytics Cloud?", was made to provide context by knowing the seniority level of the inquired participants. By knowing that 40% of the participants considered themselves as Intermediates in SAC and the others are divided into Beginners (30 %) and Experts (30 %) means that the insights regarding this survey are majority provided by persons with an intermediate level of seniority (Fig. 26).

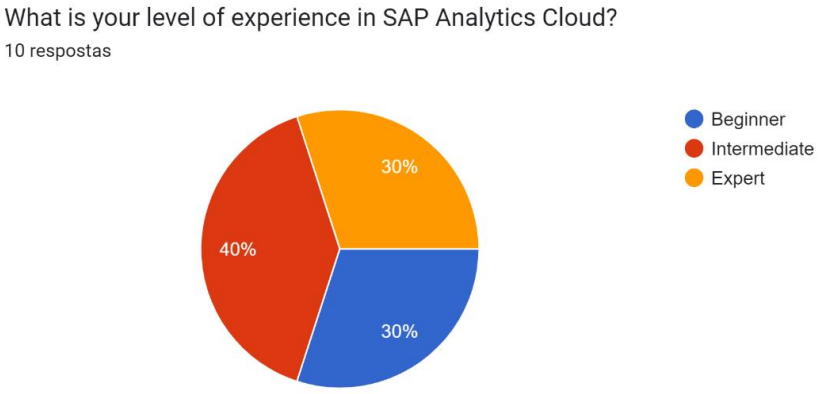


Figure 26- Distribution of Q1 answer

The question, "What are the main data sources used by you in implementations of SAC solutions?", is essential for identifying the predominant data sources and subsequently determining which ones will be most valuable to explore during the project (Fig. 27).

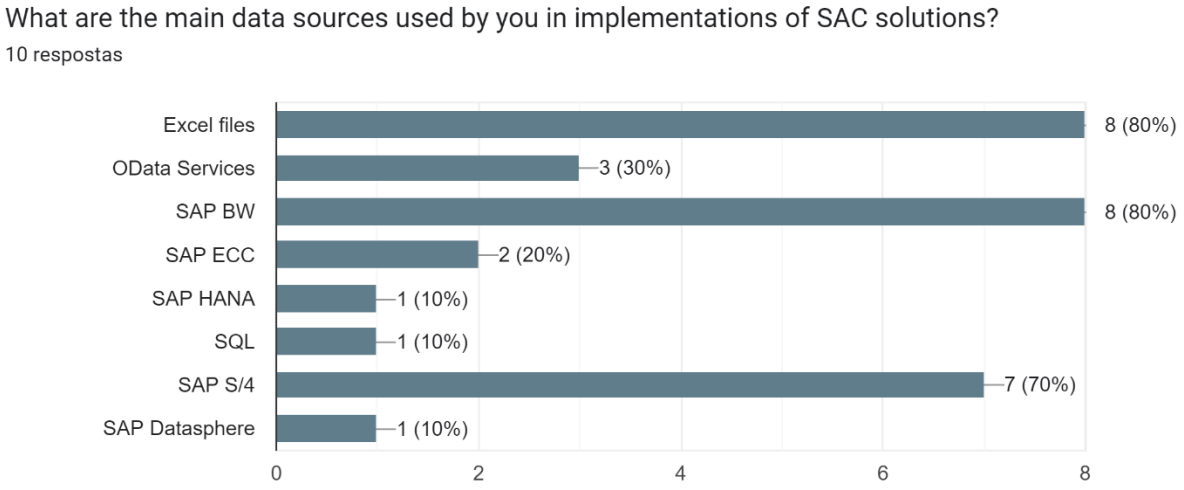


Figure 27 - Distribution of Q2 answer

The third question, "What are the most common constraints you face when implementing SAP Analytics Cloud projects?", allows to identify the main constraints. By identifying the most common constraints, we can anticipate and proactively address potential challenges and limitations that organizations typically face when implementing SAC solutions (Fig. 28).

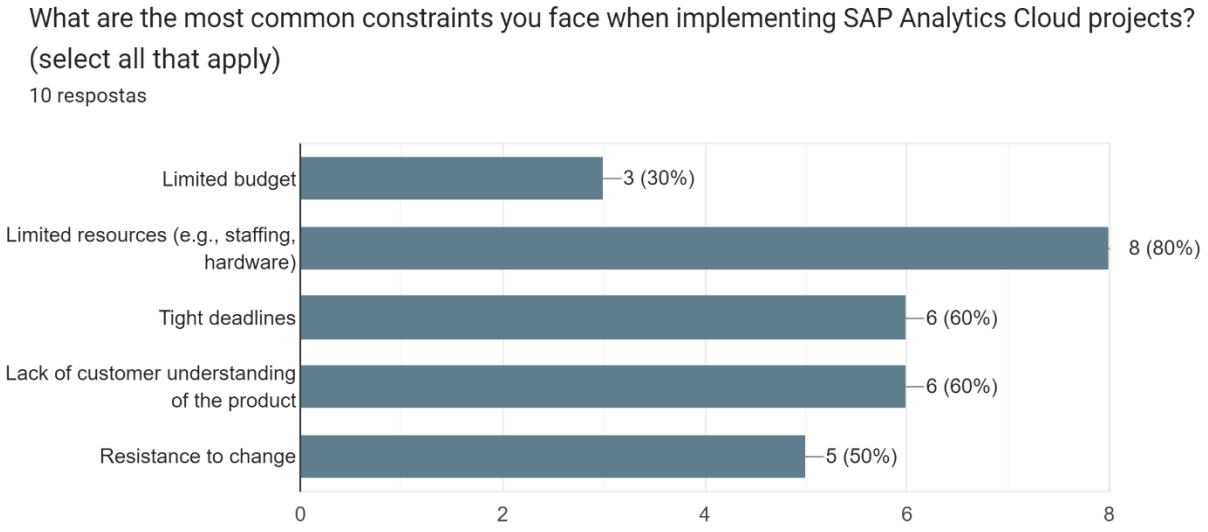


Figure 28 - Distribution of Q3 answer

The responses to the question, "In your opinion, what could be done to reduce or eliminate the constraints you face when implementing SAP Analytics Cloud projects?", help to understand what

should be done to mitigate or eliminate the constraints faced in the implementation of SAC solutions. By incorporating the insights and suggestions provided in response to this question, it is possible to develop targeted initiatives and action plans to reduce or eliminate the constraints encountered during SAC projects. This iterative approach ensures continuous improvement and enhances the overall success and effectiveness of SAC implementations (Fig. 29).

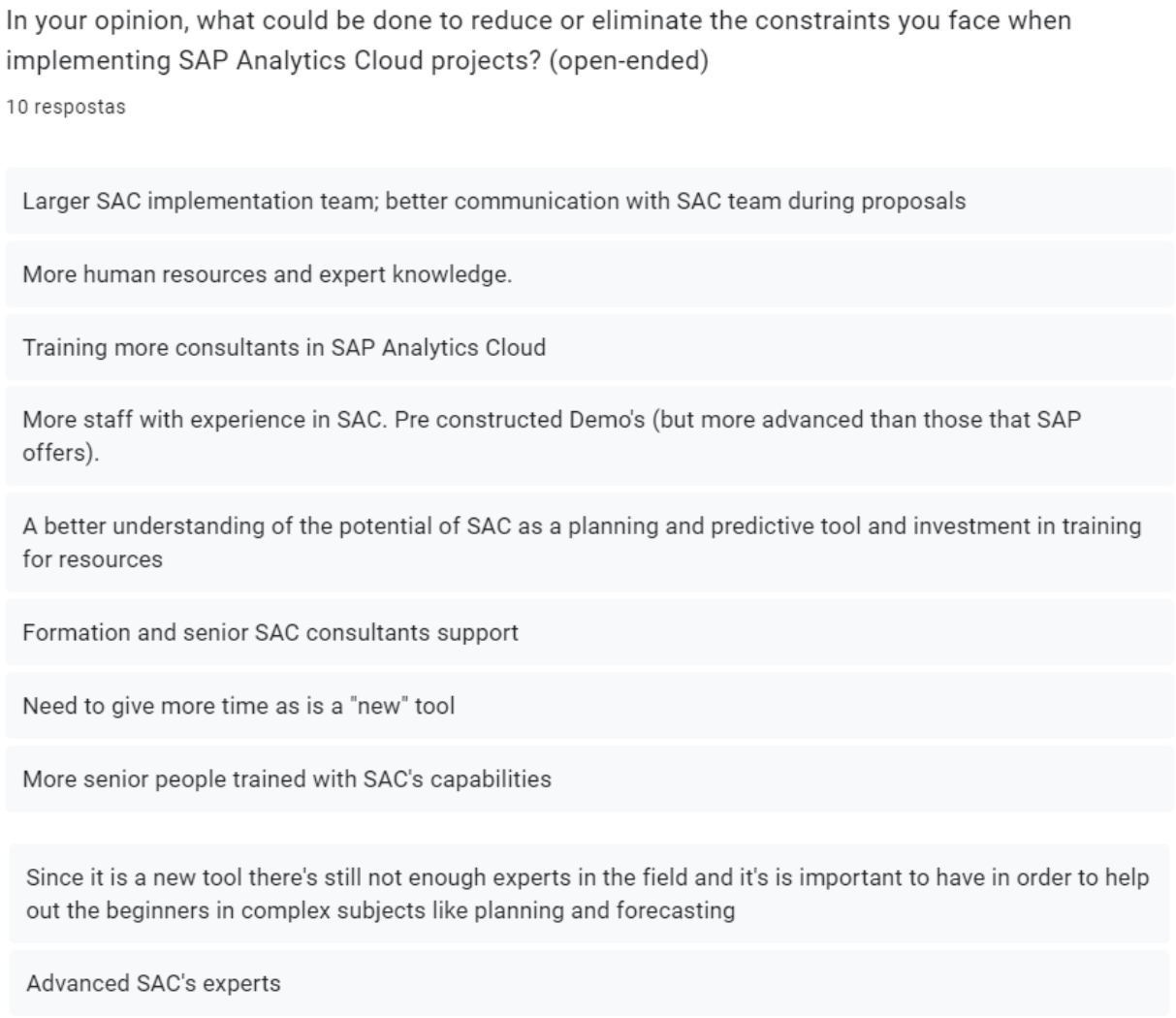


Figure 29 - Distribution of Q4 answer

Knowing that all respondents inquired have utilized guide documents in their SAC implementation projects indicates the significant importance of these documents to the consultants working with SAC. The unanimous adoption of guide documents by the consultants inquired underscores their importance and effectiveness in SAC implementation projects (Fig. 30).

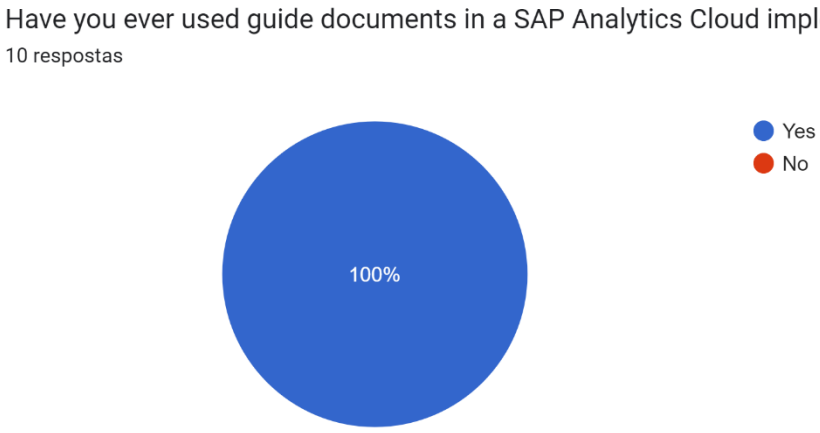


Figure 30 - Distribution of Q5 answer

For measure the relevance of guide documents, the question “If you answered, ‘yes’ to the previous question, how helpful were the guide documents in the implementation project?” was made. The results revealed varying levels of perceived helpfulness among the respondents: 50% considered the guide documents to be Very Helpful; 40% found them to be Moderately Helpful and 10% considered them as Somewhat Helpful. The results demonstrate that the guide documents played a positive and valuable role in SAC implementation projects, as they were perceived as helpful by the majority of respondents (Fig. 31).

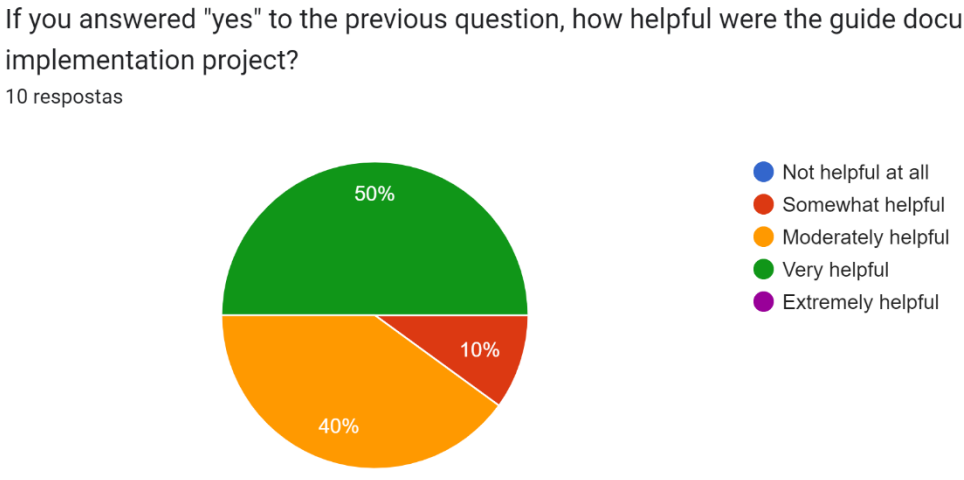


Figure 31 - Distribution of Q6 answer

For the question “Which types of guide documents have you used in an SAP Analytics Cloud implementation project?”, the inquired affirmed that User, Best Practices and Troubleshooting guides are the most used guide documents. The prevalence of User guides as the most used type of document signifies their importance in providing comprehensive instructions and insights into the functionalities and usage of SAC. These guides are specifically designed to assist users in understanding the platform, navigating its features, and effectively utilizing its capabilities during the implementation project. Additionally, troubleshooting guides were identified as a crucial resource during SAC implementation projects (Fig. 32).

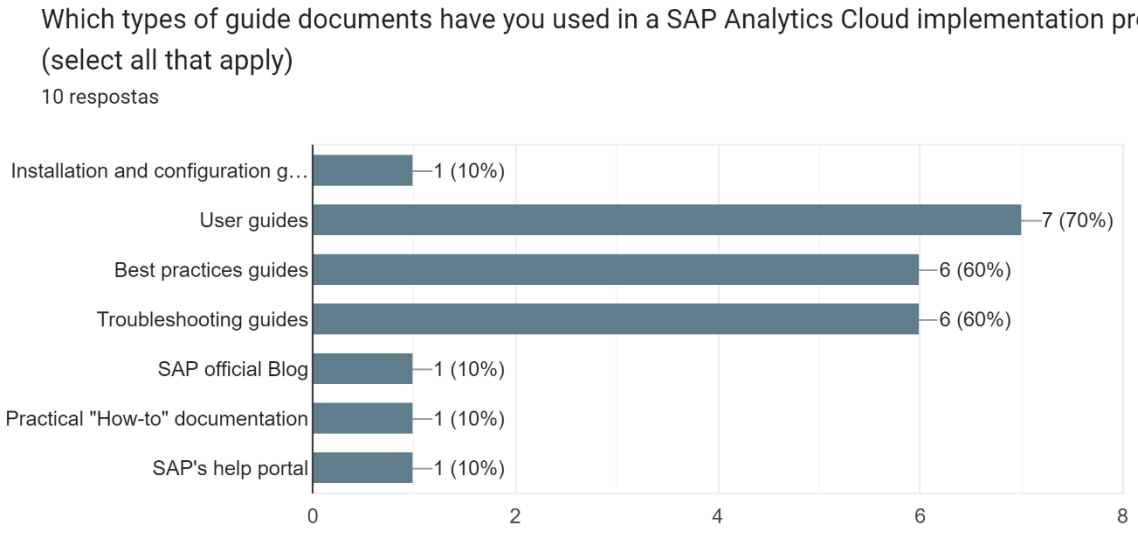


Figure 32 - Distribution of Q7 answer

The responses to the question “How frequently do you refer to guide documents during an SAP Analytics Cloud implementation project?” are divided into Occasionally (50%) and Frequently (50%), meaning that these documents have a moderated to important level of usefulness to the inquired participants during SAC implementation solutions (Fig. 33).

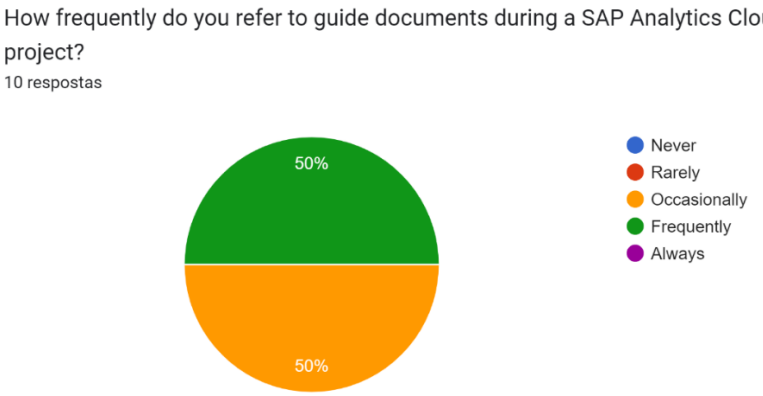


Figure 33 - Distribution of Q8 answer

A relevant percentage (70%) of the inquired considered that guide documents are Very Important in SAP Analytics Cloud implementation projects (Fig. 34).

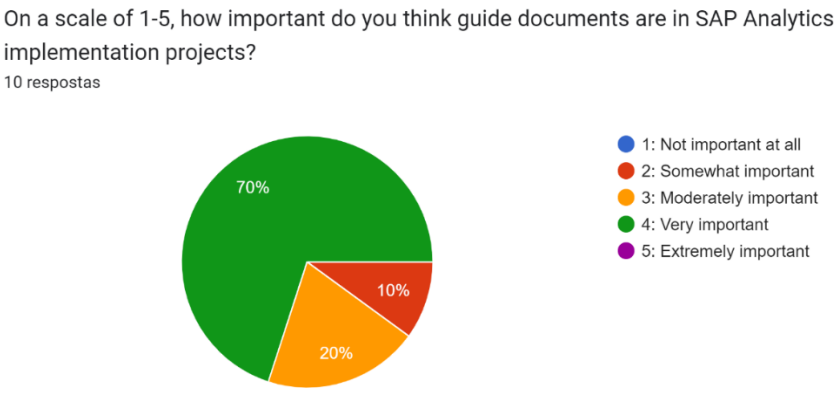


Figure 34 - Distribution of Q9 answer

To get a sense of what topics should be covered during the development of this project the question "In your opinion, what specific areas should be covered in guide documents for SAP Analytics Cloud implementation projects?" was made to the participants (Fig. 35).

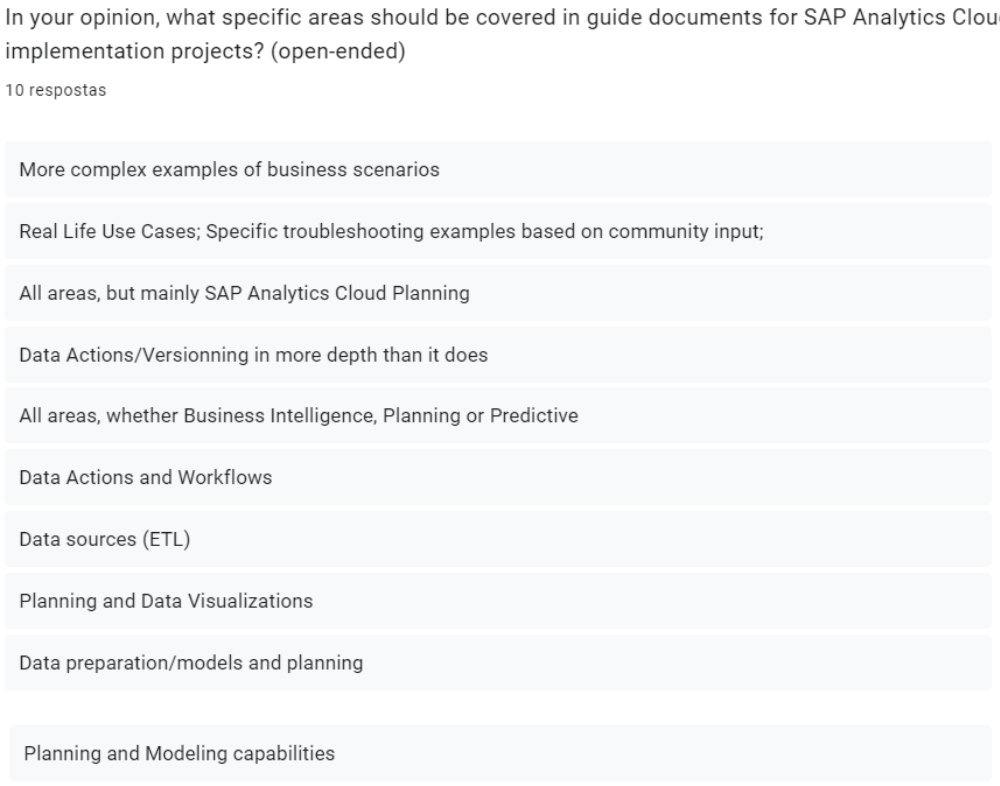


Figure 35 - Distribution of Q10 answer

With the previous responses it is possible to get a context of the INETUM'S SAC team. The next phase of this project will take that survey into consideration in order to provide the most helpful and useful insights.

4.2 Discovery Phase

This phase is for identifying the business requirements, objectives, and key performance indicators (KPIs) for the project.

Despite SAP having multiple modules with unique datasets, the analysis effort will be directed toward evaluating and understanding a specific business scenario, the Sales Performance.

The construction supply company XY is using SAC to analyze their sales data from different regions and products. The data is imported from an Excel source. The company wants to analyze the sales data to find out which products are selling well in which regions and which products need improvement. They also want to analyze the trend of sales over time.

Business Requirements regarding this scenario:

- Sales and Profitability Analysis: Understand and analyze historical sales and profitability across various dimensions.
- Forecasting: Predict future sales trends and profitability based on historical data and other relevant factors
- Planning: enable users to enter, manage and analyze planning data for sales and profitability targets.
- Scenario Analysis: Perform "what-if" scenario analysis to assess the impact of different planning scenarios on sales and profitability
- Data Visualization: Create interactive dashboards and reports to visualize sales and profitability data effectively.

Objectives:

- Data integration and Modeling: Integrate the Excel data into SAC, create a robust data model, and establish relationships between tables for seamless analysis.
- Historical Analysis: Analyze historical sales and profitability trends to identify patterns and insights.
- Predictive Analysis: Develop predictive models to forecast future sales and profitability accurately.
- Planning: Implement a planning solution to facilitate the input and management of sales and profitability targets.
- Scenario Planning: Enable users to create and evaluate different planning scenarios to support decision making.

Key performance indicators (KPIs):

- Total Sales: The overall revenue generated from the sale of products.
- Profit Margin Percentage: Assess the profitability of individual products to identify which are the most and least profitable.
- Total CMVMC: Comparing CMVMC values to assess the cost efficiency of the products.

By addressing these requirements, objectives and KPIs using SAP Analytics Cloud's data modeling, planning and predictive analytics capabilities, it is possible to deliver a comprehensive solution that supports historical analysis, future forecasting, planning and decision-making related to sales and profitability.

4.3 Data Modeling

For the business scenario in study on this project we will be using Modeling for data preparation. A model is preferred when it comes to govern the data processing, like in the case of planning. Models guarantee that the data they hold follows a series of business rules that certify that workflows such as planning can be run. Models also support row-level security, fine-grained data management of dimensions, and fact tables.

For analyzing the sales performance, firstly it is needed to import and model the data. The sales data that are going to be used in this project is provided by an INETUM's client and is saved in a csv format file.

In the next figures 36 and 37 are presented the first steps that are necessary for data preparation using the SAC's Modeler.

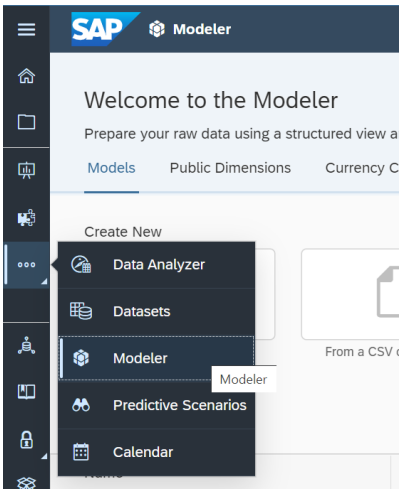


Figure 36 – Modeler

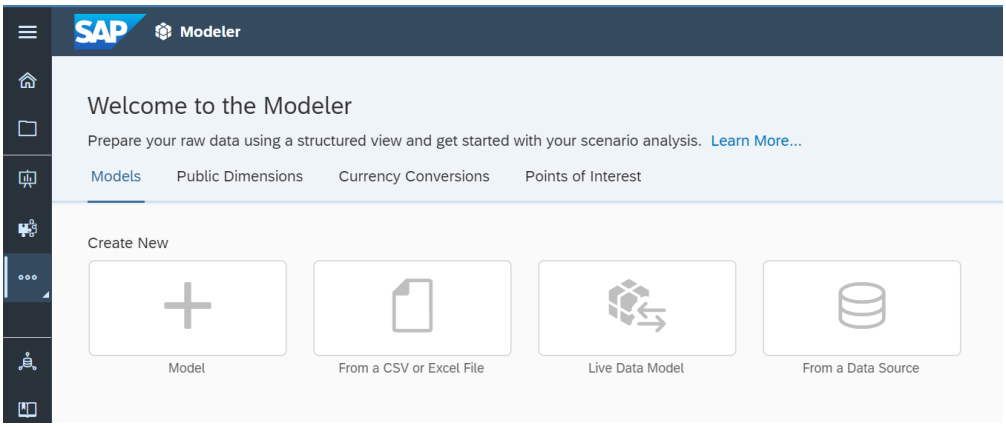


Figure 37 - Upload of the CSV file

There are three areas in the Modeler: Model Structure, Calculations and Data Management. To begin, the initial focus will be on the Data Management area, which is dedicated to the organization and manipulation of the data (Fig. 38).

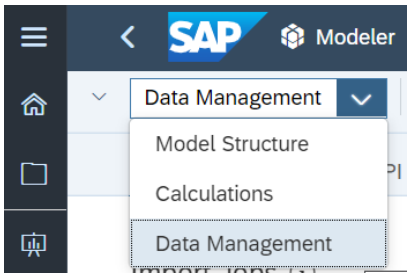


Figure 38 - Modeler main areas

Once the data is uploaded it is possible to see all the different columns. The columns presented in our dataset are presented in Figure 39:

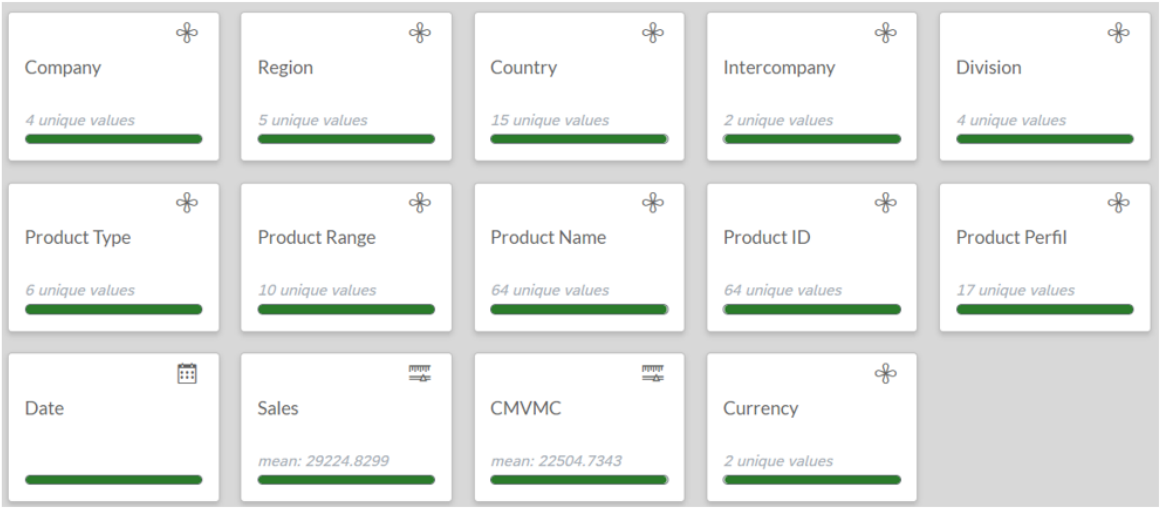


Figure 39 - Dataset columns

Company: Code that identifies the company.

Region: Region of the company where the product was sold.

Country: Country of the company where the product was sold.

Intercompany: When the value is “yes”, it signifies that the data entry or transaction is related to internal dealings within the company. These transactions may include transfers of goods or services between different entities or divisions within the organization. Conversely, when the value is “no” it represents external transactions with entities outside of the company.

Division: Categorize data by different product lines.

Product Type: Categorical attribute that classifies products into distinct groups based on common characteristics.

Product Range: Subset of products within a specific category.

Product Name: Descriptive label that uniquely identifies the products.

Product ID: Unique identifier that distinguishes the individual products.

Product Perfil: Characterization of a product’s unique specifications.

Date: Represents the specific calendar date to record when the transaction occurred.

Sales: Represents the revenue or income generated from the sale of products.

CMVMC: Cost, Margin, Value, Margin, Cost, which indicates metrics related to profitability.

Currency: Specifies the currency unit in which sales and CMVMC are denominated.

4.3.1 Measures

Measures hold numeric values that provide meaning to the data. The measures present in our data were automatically identified by the system when the data was imported. These measures are distinguished by the icon  as it is possible to see in Figure 39. The columns Sales and CMVMC are the two measures that were automatically identified as measures.

In a classic account model, measure values are stored in a single default measure, and the account structure is used to add calculations, specify units, and set aggregation types for all the data.

In the new model type, measures are exposed as single entities, multiple measures can be added and configured with aggregation and units to fit the data.

4.3.2 Dimensions

Because we have created a model by importing data, dimensions have been created from the imported data. The system automatically considered dimensions by identifying the columns with as it is possible to see in Figure 39 above.

Regarding our case study, the dimensions presented are based on company, products, and store's locations.

4.3.3 Proprieties

To specify dimensions, it is possible to create attributes, properties, and custom properties. Every dimension has at least the properties ID and Description.

To ensure the accurate presentation of data values in subsequent visualizations, it is crucial to correctly define the date format within the Date dimension (Fig. 40). This customization allows to align the date format with the dates provided in the dataset, ensuring precise and meaningful data representations.

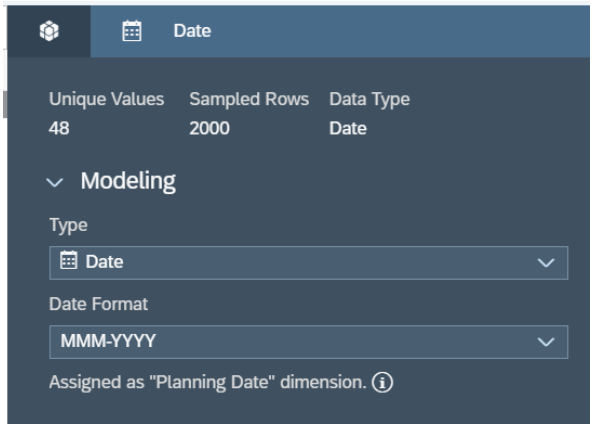


Figure 40 - Date format

4.3.4 Hierarchies

With hierarchies it is possible to structure the data. Hierarchies can be created during the data preparation stage, or within the modeler after the model is created. Creating hierarchies during the data preparation stage instead of in the Modeler is faster and more automated. However, to adjust, or to add or delete members from the hierarchy, it is needed to use the Modeler.

A level-based hierarchy organizes the members of a dimension into levels, such as Region and Country (Fig. 41) or Division, Product Type, Product Range, Product Perfil, Product Name and Product ID (Fig. 42). When the data is displayed in a story, hierarchies can be expanded or collapsed.

For the project data, the creation of the hierarchies was done according to the following steps:

1. The Level Based Hierarchy presented in the toolbar was selected.
2. Defined the name for the hierarchy in the Hierarchy Builder.
3. Selection of the dimensions to build in the hierarchy.

Note: In order to change the order of the levels the columns can be moved.

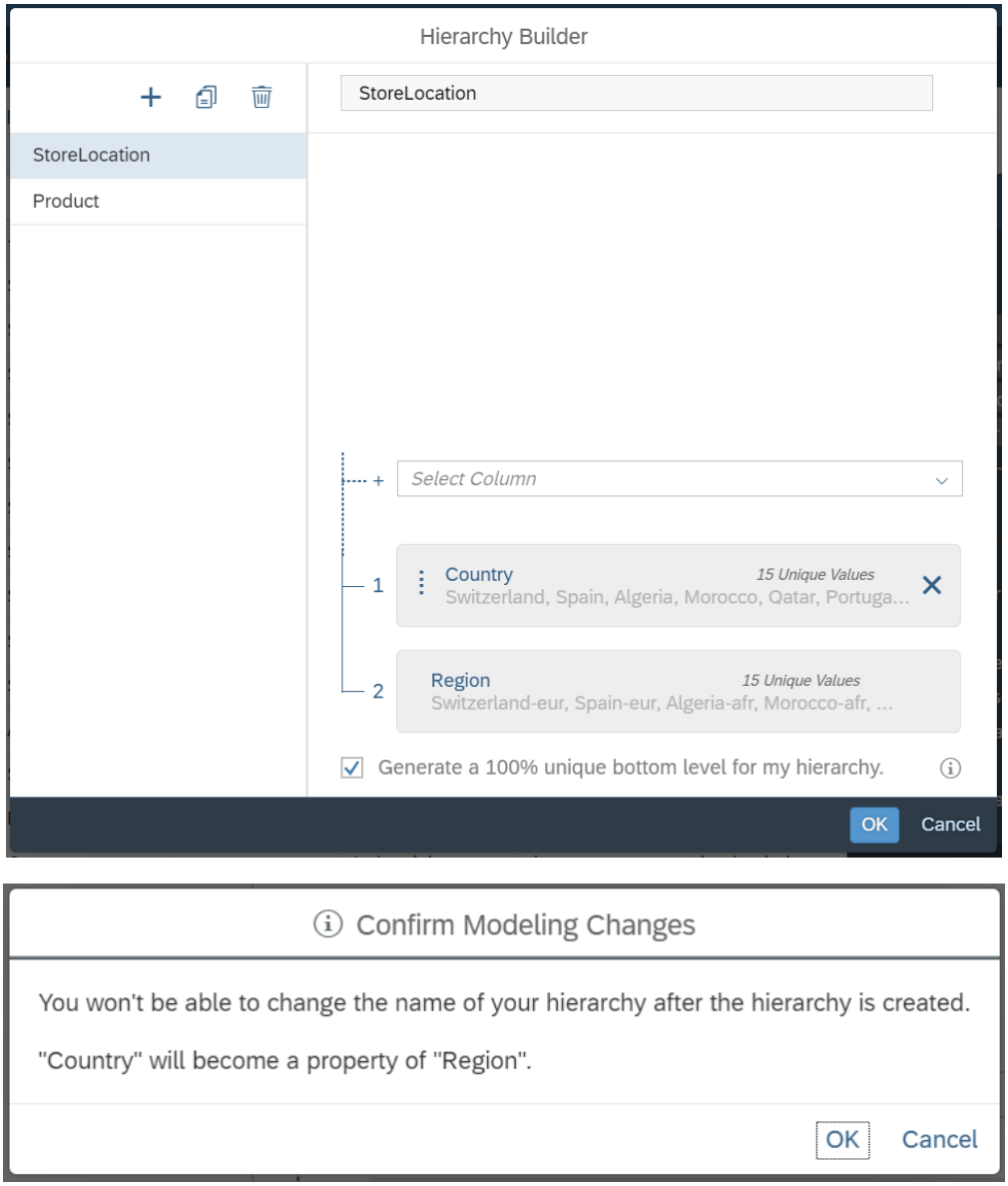


Figure 41 - Location hierarchy

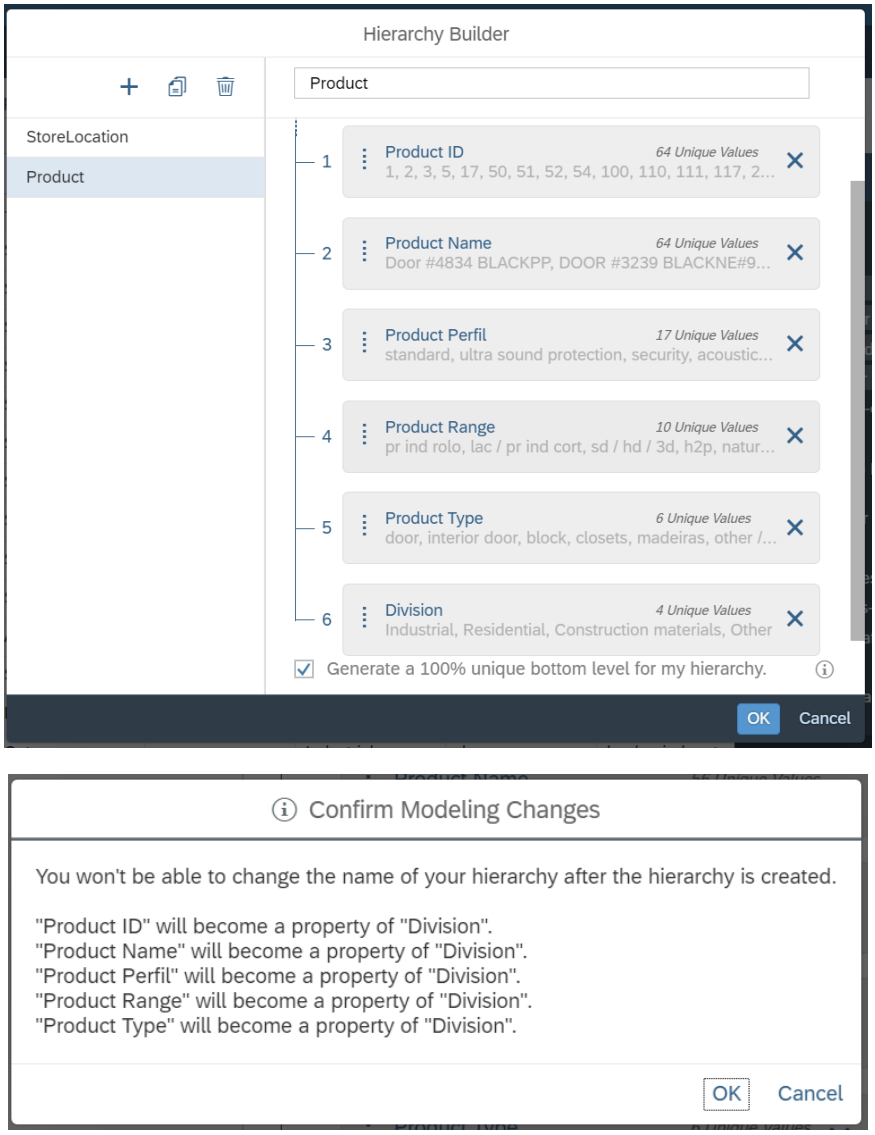


Figure 42 - Product hierarchy

At the top of the Product hierarchy, “Division” categorizes data by different product lines. Each product line represents a broad category of products, such as “Residential”.

The second level, “Product Type”, classifies products within a specific “Division”. Under “Residential” division there is “Interior Door”, “Closets”, “Panels” and “Pavements” as product types.

“Product Range” is the third level and represents a subset of products within a specific “Product Type”. For example, “Closets” product type has product ranges like “Walk-in Closets” and “Wardrobe Closets”.

The fourth level, “Product Perfil”, under “Walk-in Closets” product range there’s “Walk-in Closet with Drawers” and “Walk-in Closet with Shelves” as product perfil.

“Product Name” and “Product ID” are the last ones since they uniquely identify individual products.

When the hierarchy is created, a new column is generated, with unique values that serve as the dimension member IDs.

4.3.5 Geographic dimensions

To be possible to perform geospatial analysis in stories it is needed to first import coordinate data or area data and enrich it in the Modeler. This process creates a new column in the data view with an enriched format of latitude and longitude coordinates or by area using country, region, and subregion data.

For that, the data must contain a location ID column with unique data, as well as either latitude and longitude columns, or country column.

Because our dataset doesn't provide latitude and longitude columns we will stick with the option of enriching area while creating a model from a file. For that,

1. The Geo Enrichment in the toolbar was selected and then the option Area Name was chosen.
2. To specify the country data, the column containing the country data was selected (Fig. 43).

A new column is created for the Area dimension. Any data quality issues are displayed in the Details panel.

Note: for the system correctly identify the country it can be imported as ISO3 and ISO2 codes, or the country names in English. In the case of our dataset the system couldn't correctly identify the country "Côte d'Ivoire" because it was written with hyphen consequently it was identified as invalid geolocation (Fig. 44). In order to correct this issue, the system suggested two options, "Delete Value" or "Replace". On the Transformation section it is possible to see how this issue was corrected.

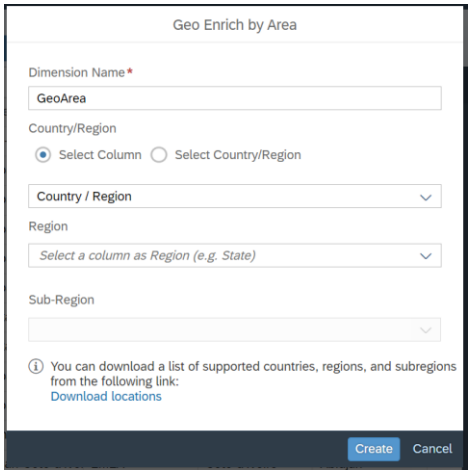


Figure 43 - Geo Enrich by Area

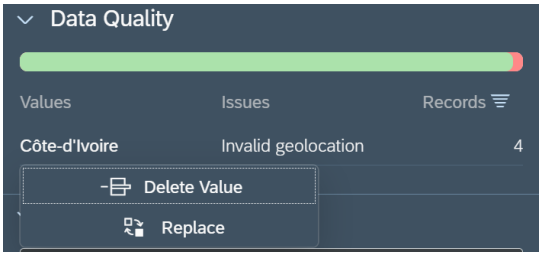


Figure 44 - Data Quality

4.3.6 Transformations

With the use of the formula bar, it is possible to transform the data and remove any inaccuracies.

By clicking on Create Transform there are five options available, which are, Concatenate, Split, Extract, Replace and Change.

To correct the issue mentioned above, the option Replace was selected, in this way, the country name "Côte-d'Ivoire" was replaced with "Côte d'Ivoire", so then the system was able to recognize it as a valid country name. The transformation formula used is presented in Figure 45.

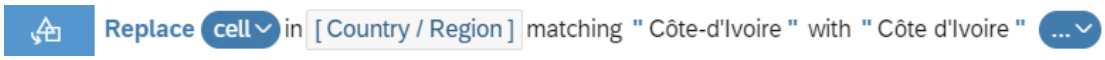


Figure 45 - Transformation formula

Once the data has been prepared, it is possible to validate the dataset's integrity by simply clicking on the "Validate Data" button. If no issues are detected during the validation, the process proceeds to create the model by clicking on the "Create Model" button. Any work done on the sample will be applied to the full data during the model creation.

4.3.7 Model structure

This model is based on a single Account dimension. Each column that is a measure will appear as members in the Account dimension. The account dimension is mandatory in a classic account model, but optional in the new model type.

The Structure view shows a star schema diagram that represents the contents of the model (Fig. 46). It helps visualize how fact data, attributes, and properties all relate to each other.

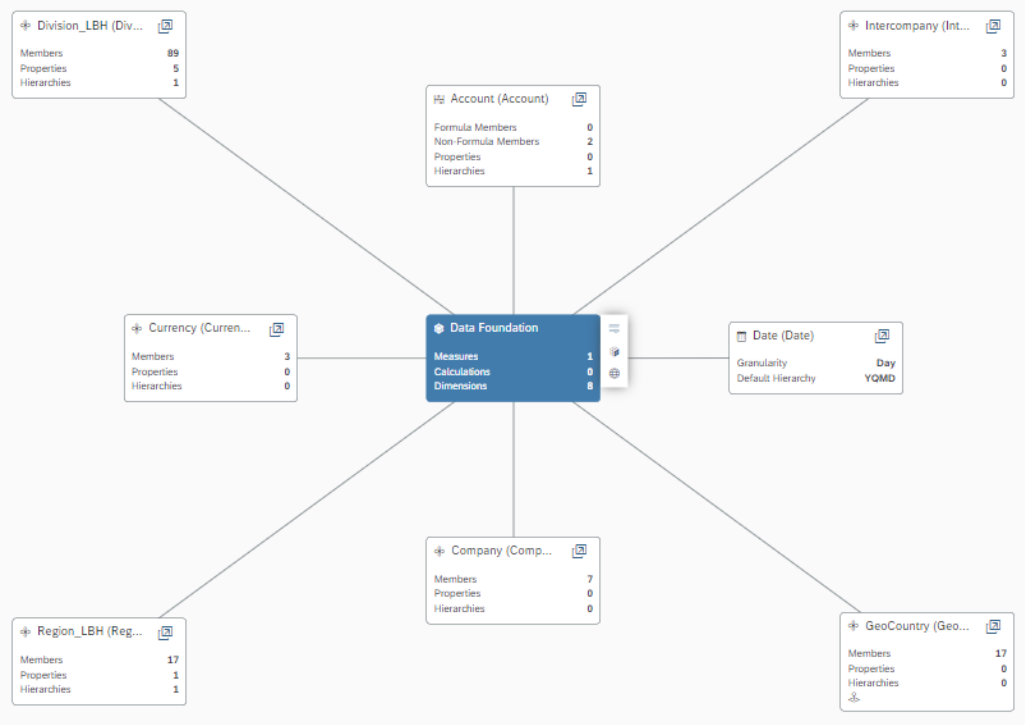


Figure 46 - Star Schema diagram

The two measures represent quantities such as Sales and CMVMC that provide meaning to the data. The eight dimensions represent categories that provide perspective on the data.

4.3.8 Calculations

The Calculations area is exclusively designed for generating additional calculations within the model, comprising the objects list, formula editor, preview pane and properties pane.

The objects list is adaptable and varies depending on the model type. In order to harness the full potential of these functionalities, the conversion of the classic model to the new model was made (Fig. 47). The model structure remains the same, however this migration opens a valuable new capability: the ability to create calculated measures using the existing ones.

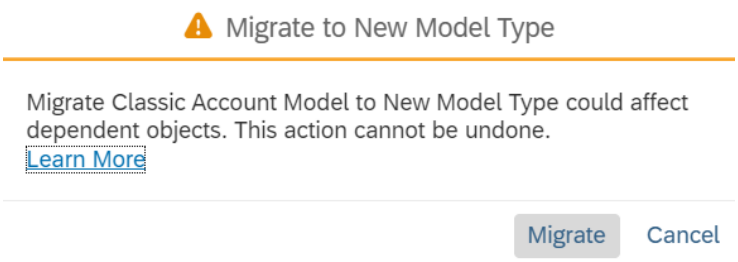


Figure 47 - Migrate to New Model

In the case of this project, since it is a new model type, it displays both dimensions and measures, as well as account members and calculated measures.

To create a new measure (profit margin) using the existing ones, the following formula was created (Fig. 48):

Figure 48 - Profit margin formula

As it is possible to see in Figure 49, the calculations preview pane offers a sneak peek of the aggregated and calculated data within the Modeler before moving on to a story. It is also possible to filter the data, in the example, it was filtered by GeoCountry.

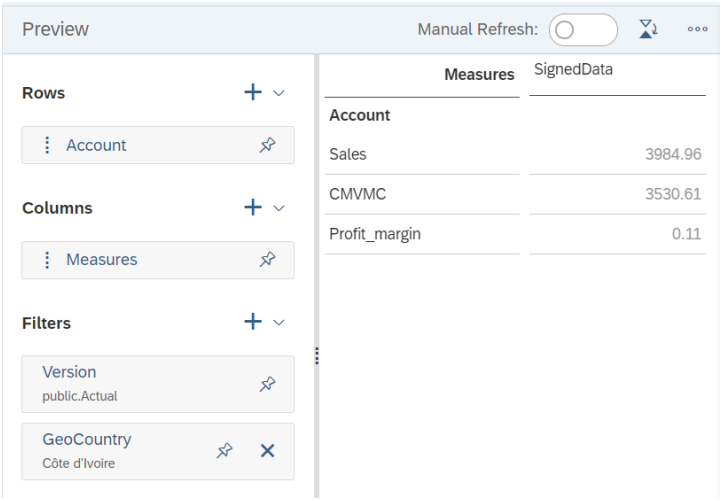


Figure 49 - Calculations preview

This new calculated measure will be part of the data model and can be utilized for data analysis and visualization within this project.

4.4 Planning

In this section of the project will explore the different SAP Analytics Cloud planning capabilities, outlining the specific steps and actions involved in executing planning within SAC platform.

4.4.1 Planning model

For planning in SAP Analytics Cloud it is necessary to work with data from a planning model as the analytic models lack the capability for planning operations such as data entry and version management. To support these features, planning models have more structure including a planning date dimension and a version dimension. A planning model extends the capabilities of an Analytic model by allowing planning, budgeting, and forecasting using the same historical data.

The steps that were taken for creating a planning model were the same as implemented in the analytical model. However, additional steps were added in order to configure it into a planning model.

1. On the data management area, the option “Enable Planning” was enabled, and Date column was added as Planning Date Dimension (Fig. 50).

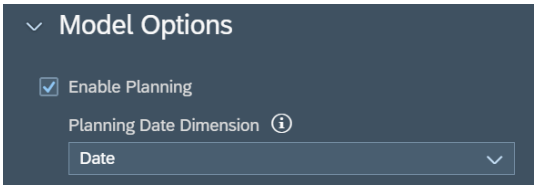


Figure 50 - Enable Planning

2. On the modeler settings, Planning was defined as Model Type (Fig. 51).

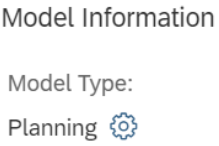


Figure 51 - Model Type definition

3. The Figure 52 below shows the structure of the planning model and it is possible to see that there’s an additional dimension compared to the analytical model – the Version dimension.

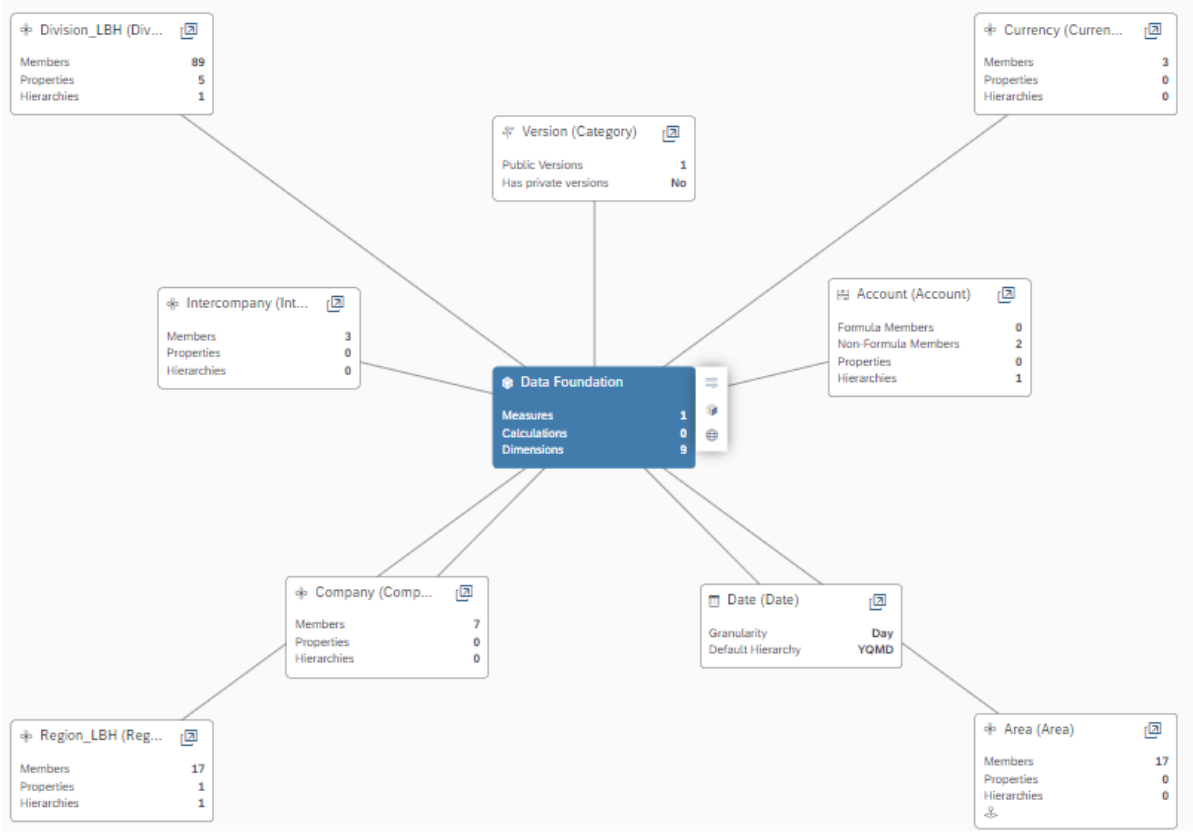


Figure 52 - Planning model structure

4.4.2 Validation rules

In order to establish validation rules, specific configurations are required. The following Figure 53 illustrates the configuration undertaken to enable the creation of these validation rules.

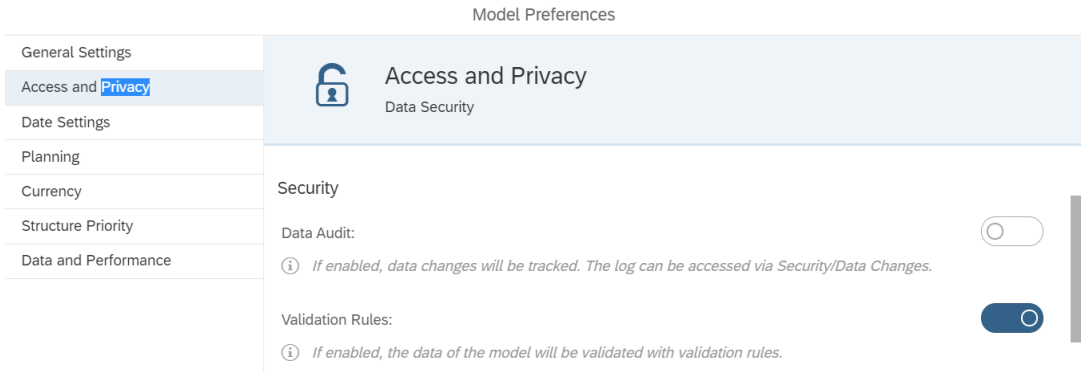


Figure 53 - Enable the validation rules.

SAC has the capability to enable validation rules in the models to restrict users from entering data for specific combinations of dimensions members. For instance, it can ensure that the currency EUR is available for specific countries but not for others, and the same applies to GBP.

These validation rules are established by directly specifying the dimension members that allow data entry. Dimension combinations other than the ones defined in the rule are invalid and won't allow data entry or planning operations.

To craft a validation rule successfully, the following steps were executed:

1. Navigated to the Validation Rules workspace within the model maintenance page.

2. Within the Validation Rules panel on the right, selected + Create New Rule opted for Create With Members.

3. Provided a name and description for the rule:

    a. Name: CurrencyRule.

    b. Description: Checks the valid currency for each region.

4. In the properties section, specified the Member Separator – ',' . The dimension members added to the grid are separated by comma, the member separator defined here (Fig. 54).

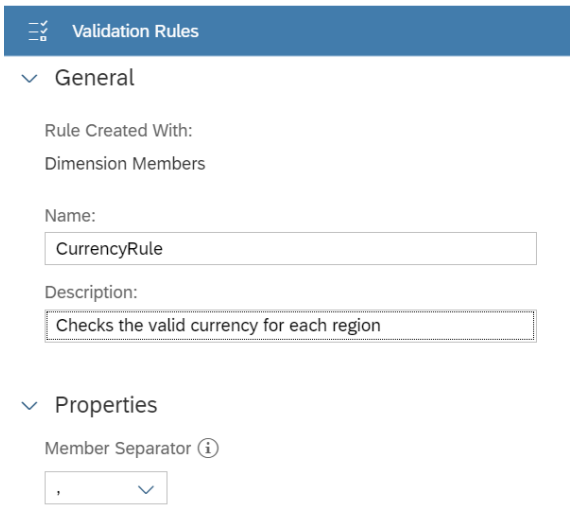


Figure 54 - Validation rule properties

5. In the grid, added dimensions and the corresponding dimension members that allow data entry (Fig. 55).

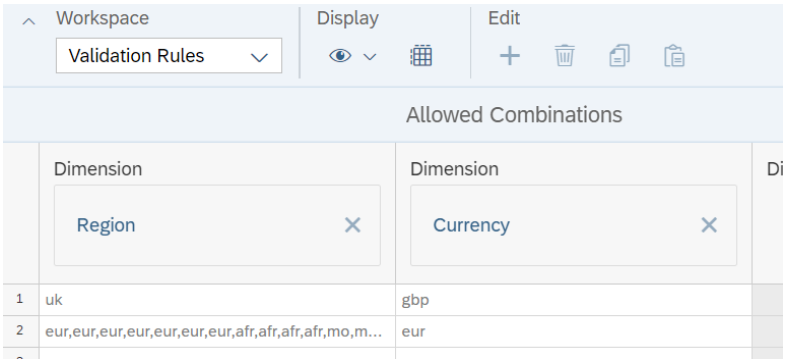
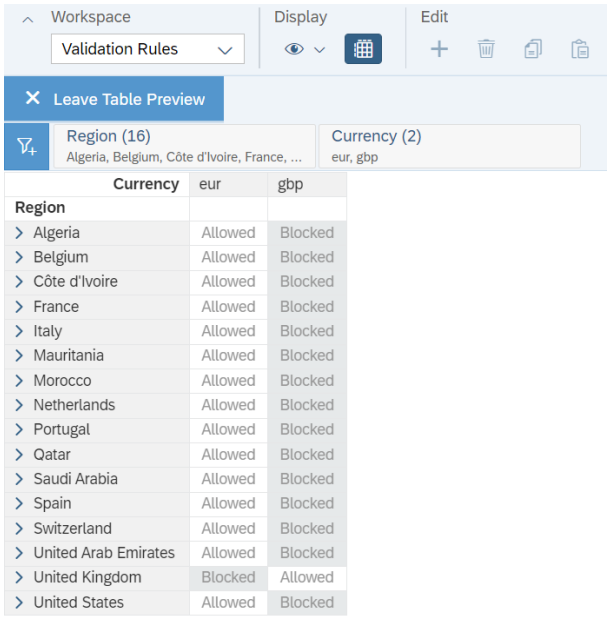


Figure 55 - Validation rule creation

6. In the Validation Rules panel on the right, clicked Save.
7. Once the rule is created, the Table Preview was opened to see which dimension member combinations are permitted and which are blocked (Fig. 56).



Currency	eur	gbp
Region		
Algeria	Allowed	Blocked
Belgium	Allowed	Blocked
Côte d'Ivoire	Allowed	Blocked
France	Allowed	Blocked
Italy	Allowed	Blocked
Mauritania	Allowed	Blocked
Morocco	Allowed	Blocked
Netherlands	Allowed	Blocked
Portugal	Allowed	Blocked
Qatar	Allowed	Blocked
Saudi Arabia	Allowed	Blocked
Spain	Allowed	Blocked
Switzerland	Allowed	Blocked
United Arab Emirates	Allowed	Blocked
United Kingdom	Blocked	Allowed
United States	Allowed	Blocked

Figure 56 - Table preview of the validation rule

4.4.3 Data locking

As was the case with validation rules, to apply data locking it is necessary to enable the option in the preferences for the underlying planning models (Fig. 57). The default lock state for all cells selected is "Open".

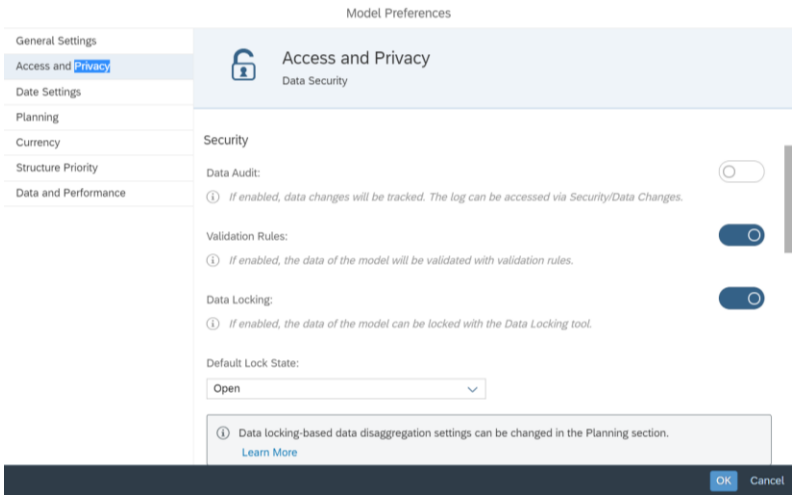


Figure 57- Enable the data locking.

Data locking enables the prevention of unwanted changes to data at certain stages of the planning processes. It prevents editing data for specific combinations of dimensions members and to re-enable editing when necessary. The following steps were taken to restrict changes to the products for a certain period of time.

1. Selected (Configure Data Locks).

2. The driving dimensions were chosen. Category and Date are set as driving dimensions automatically, the dimension Division was additionally added by clicking on +Add a new Driving Dimension (Fig. 58).

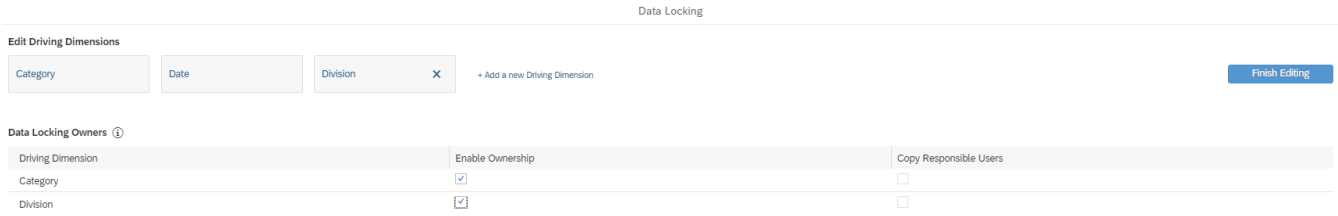


Figure 58 - Data locking

3. In the Data Locking Owners area, clicking on Enable Ownership enabled ownership for the data locking for the specific dimensions.
4. The intersection of cells to lock was chosen, all products were locked for Q1 period (Fig. 59 and Fig. 60).

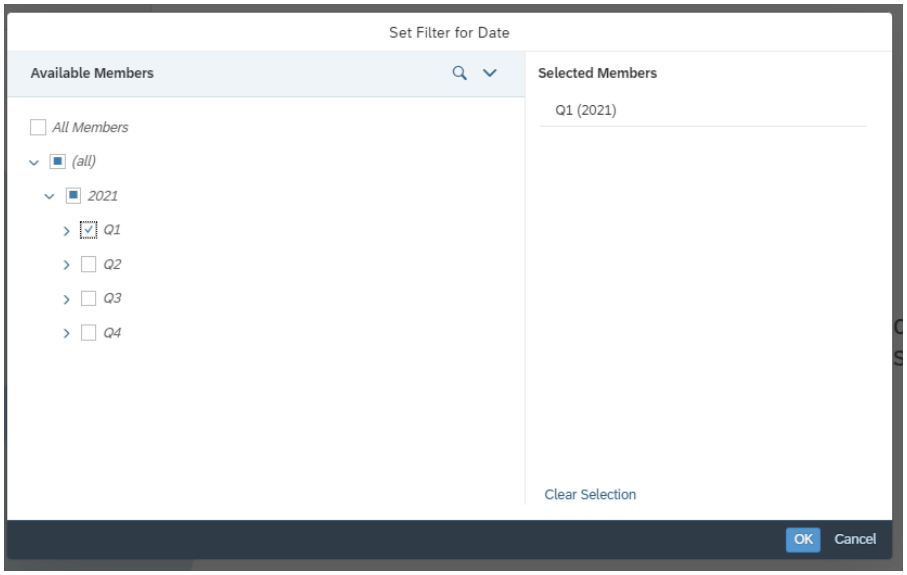


Figure 59 - Filter for Date

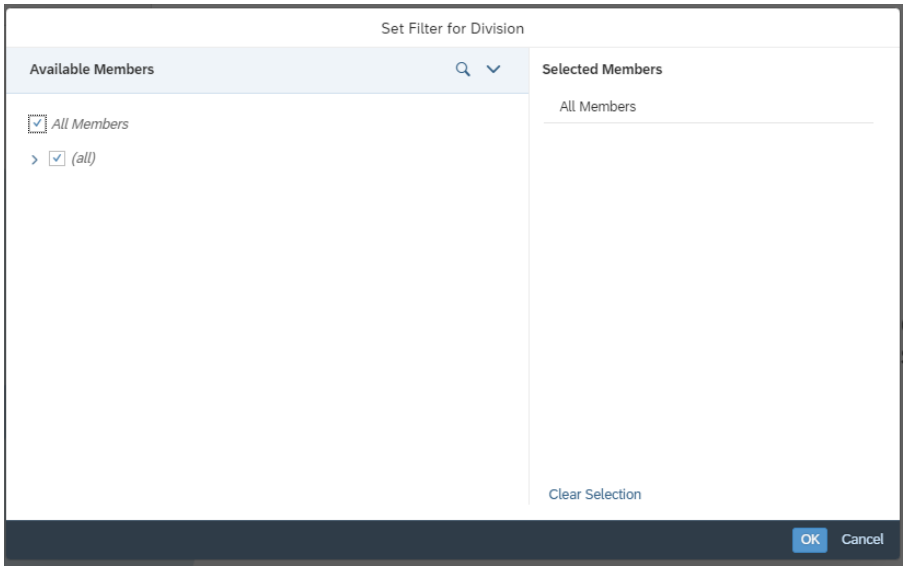


Figure 60 - Filter for Division

5. The values for all cells are “Open” by default, based on the settings applied in the model preferences. The values were changed to “Locked” since it prevents any changes until the dimension is unlocked and gives only the data locking owner permission to change the lock status (Fig. 61).

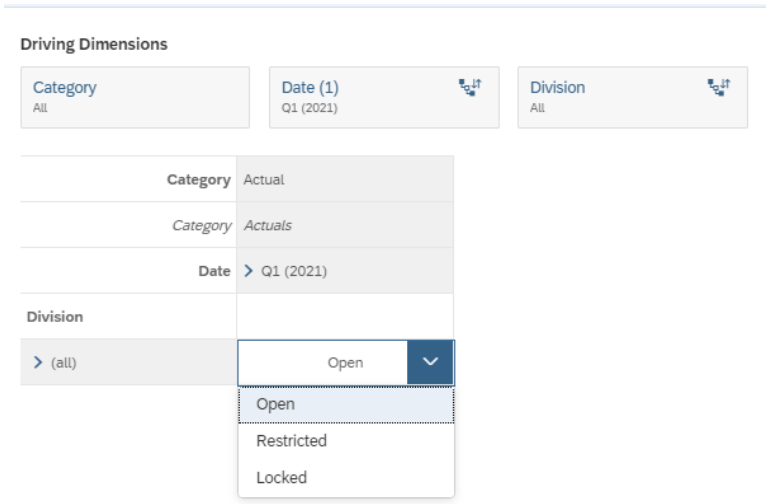


Figure 61 - Lock values

4.4.4 Data Actions

Data actions enable automation, data manipulation and the execution of predefined actions based on specific conditions. This section will showcase the creation of data actions for copying and subsequently transforming data from one version to another, by copying the total data sales from 2021 and allocating the monthly average to the planning version. To accomplish that the following steps were taken:

1. Selected data actions from the menu bar.
2. Created a new data action, named “Update Planning Data”.
3. Selected the planning model previously created.
4. Added parameters. All data actions have the parameter Target Version (this is the version that the data is being written to), additionally was added the parameter for source version (Fig. 62 and Fig. 63).

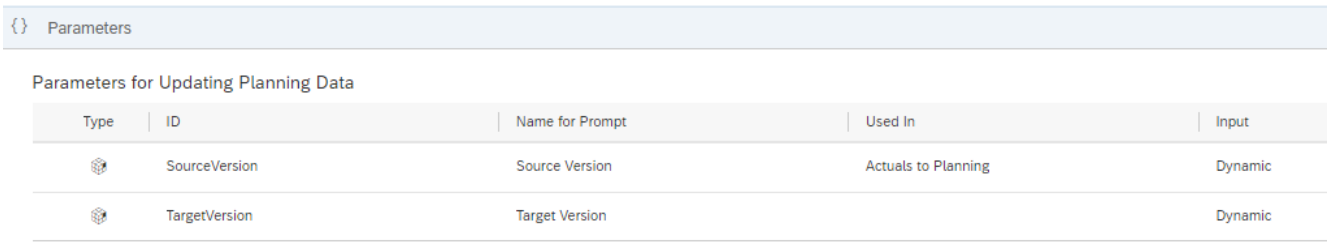


Figure 62 - Data action parameters

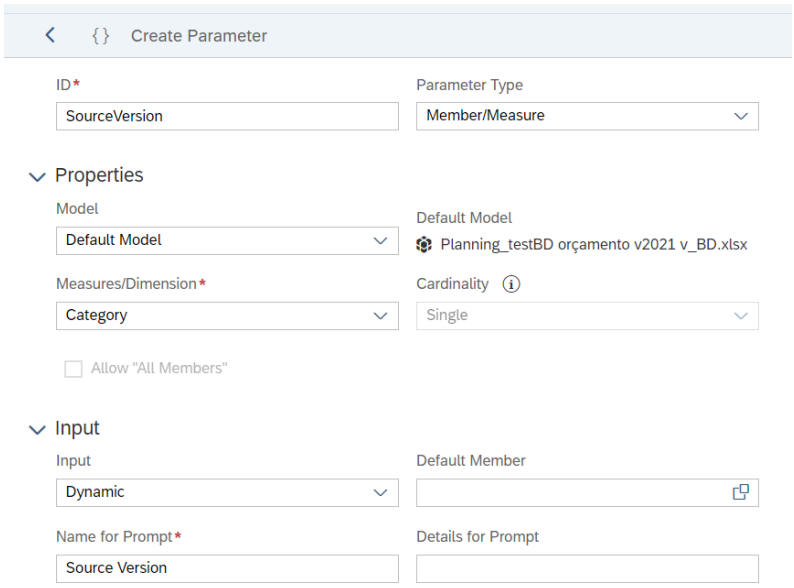


Figure 63 – Creation of parameter

5. Under add steps selected add copy, named it “Actuals to Planning” (Fig. 64).

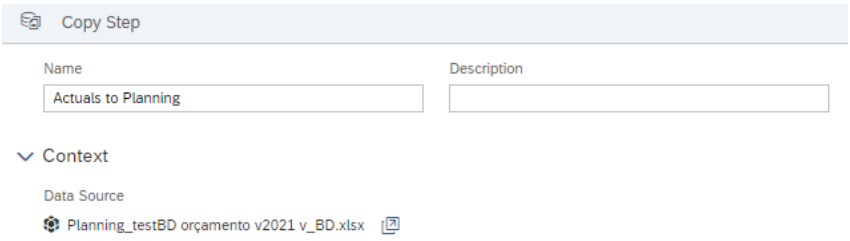


Figure 64 - Copy step

6. Under filters, selected version and changed the filter to the source version (Fig. 65).

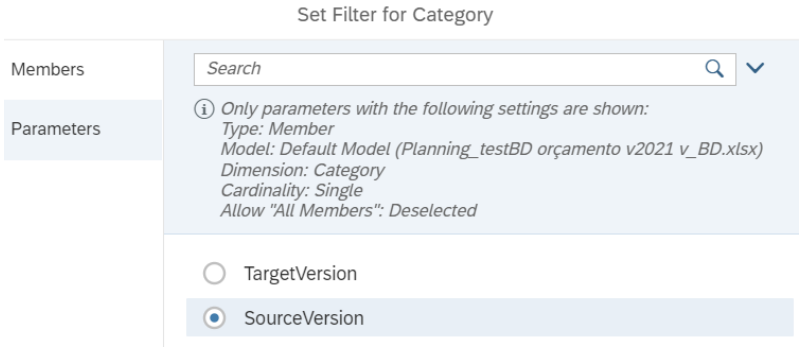


Figure 65 - Filter for Category

7. Clicked add filter and selected Account (Fig. 66).

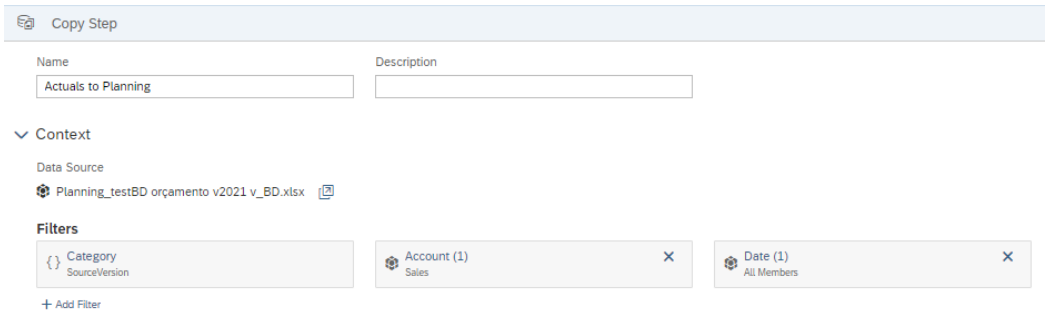


Figure 66 - Copy step filters

8. Checked the Sales (Fig. 67).

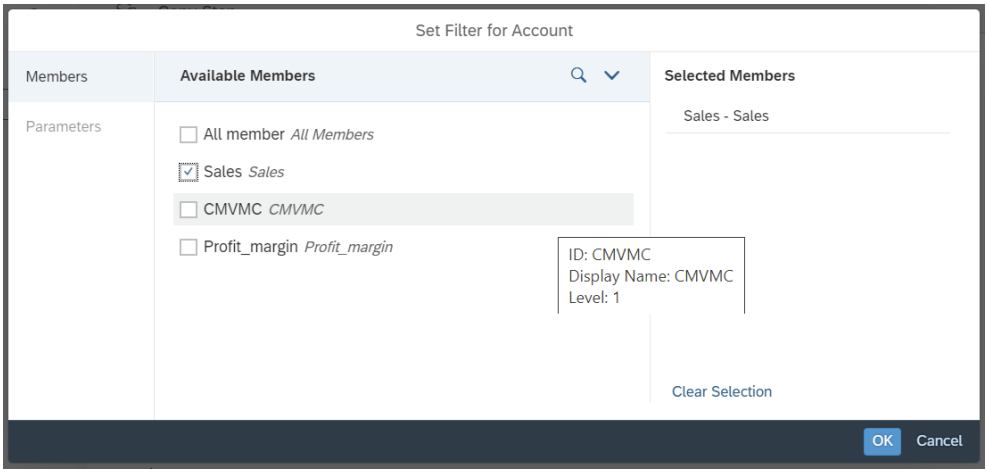


Figure 67 - Filter for Account

9. Clicked add filter and selected Date – checked 2021 (Fig. 68).

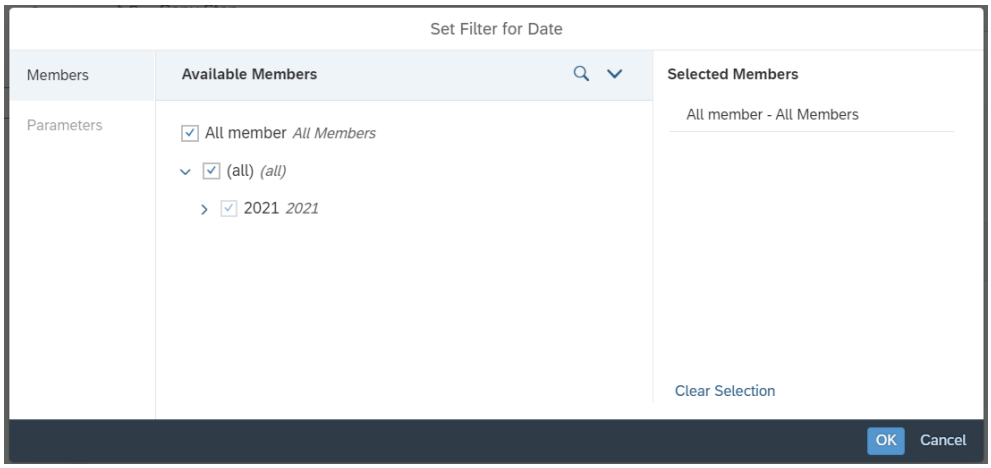


Figure 68 - Filter for Date

This step will now copy all the data including its disaggregation to the Target version instead we want the total sales for each product type to be aggregated to December 2022 in the planning version:

10. Under aggregate To, clicked add Dimension and selected date and then selected December 2022.

4.5 Data visualization (Stories)

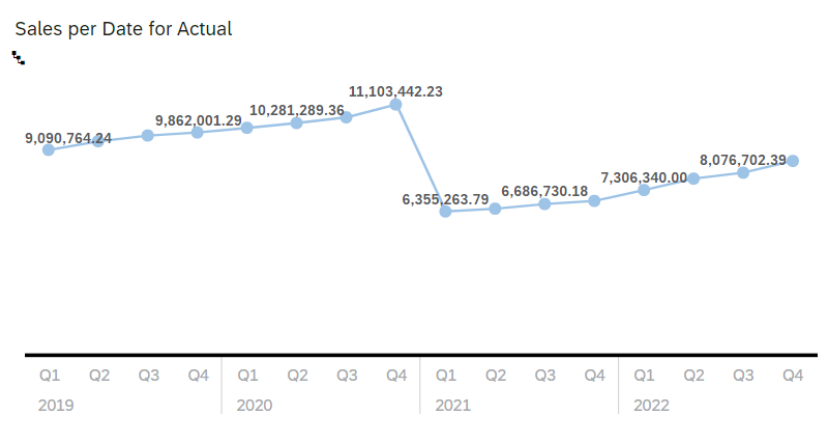
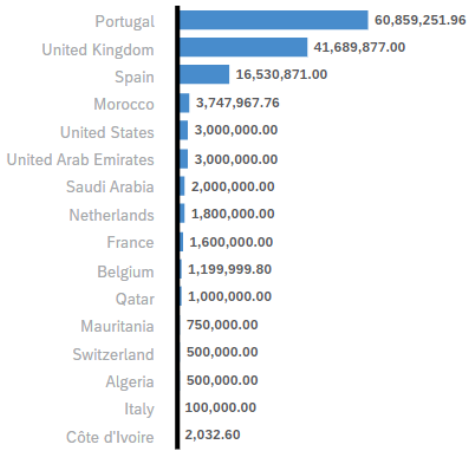
4.5.1 Analytical

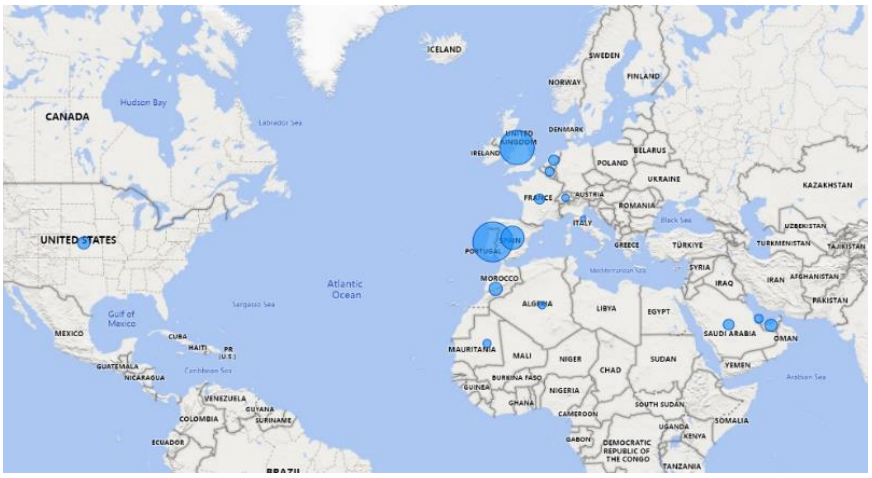
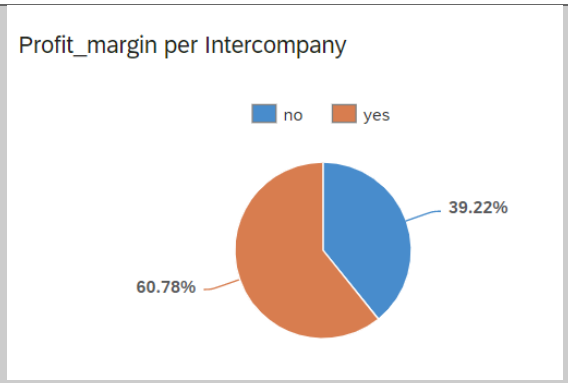
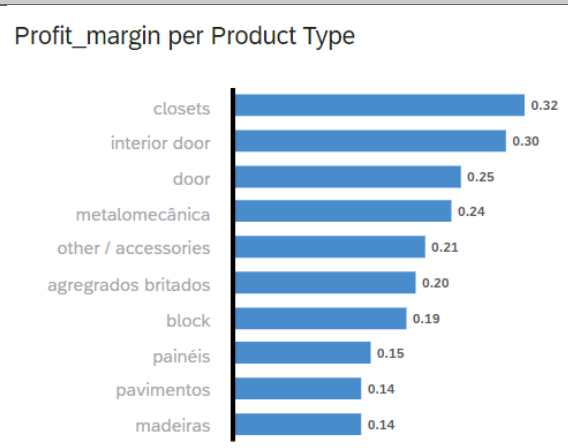
Once the model is created, it's time to visualize the data that has been prepared, structured and is ready for exploration. The creation of the Story was done according to the following steps:

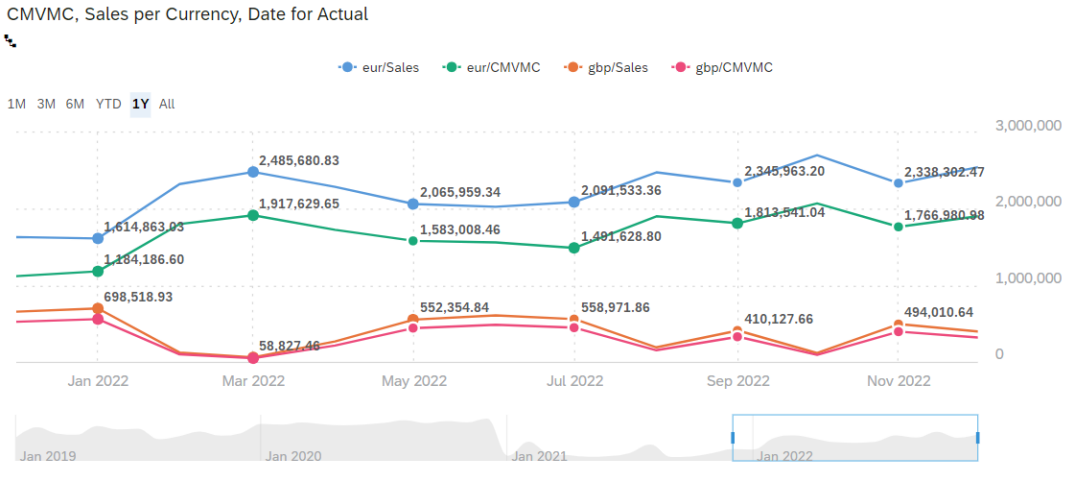
1. From the side navigation,  Stories was selected.
2. The option "Add a Canvas page" was selected, it is a versatile choice that empowers the creation of a data story by freely arranging and presenting a wide range of objects and visualizations on canvas.
3. Selection of the classic design experience over the optimized one, which offers a familiar and flexible design environment.
4. Clicked on the "Add Data" button to import data into the canvas page.
5. "Data from an existing dataset or model" option was chosen, and the analytical model previously created was selected.
6. The Designer panel was used to format and manipulate the data in the canvas elements.

The choice of visualization depends on the specific KPIs that are intended to be represented. The following table shows some examples of data visualizations along with the corresponding KPIs that they represent:

Table 12 - Data Visualization

KPIs	Data Visualizations
Total Sales over Time	 **Type**: Line chart Line charts are used to show trends over time – time series trends. Accounts: - Left Y-Axi : Sales Measures: - SignedData Dimensions: - Date
Sales per Country	 **Type**: Bar Chart Bar charts are excellent for comparing data across categories.

	 **Type**: Geo map Geo maps are used to represent KPIs related to geographic distribution.
Intercompany Analysis: Analyze the proportion of intercompany sales and profitability within the organization.	 **Type**: Pie chart Pie charts display the composition of a whole.
Profit margin per Product Type	 **Type**: Bar chart

Sales and CMVMC currency analysis over Date (month – year)	 **Type**: Time series Time series trends are represented by visualizations such as line charts. Display data points over a continuous time period. Accounts: - Sales - CMVMC Measures: - SignedData Time: - Date Colour: - Currency

4.5.2 Planning

This section will focus on the data visualization for the planning model previously created. Unlike the analytical model, where historical data was analyzed, here the focus will be on forecasts and planning scenarios by creating visualization using the configuration settings established on chapter 4.4.

4.5.2.1 Version Management

Version management is used to organize, compare, and maintain different versions of the data. In this section, the steps in order to create Planning and Forecast versions will be presented:

1. From the toolbar, selected (Version Management). The version management panel is displayed.

2. Selected (New) for creation a new Private Version.

3. In the Create Blank Private Version dialog, the name for the versions was entered (Fig. 69).

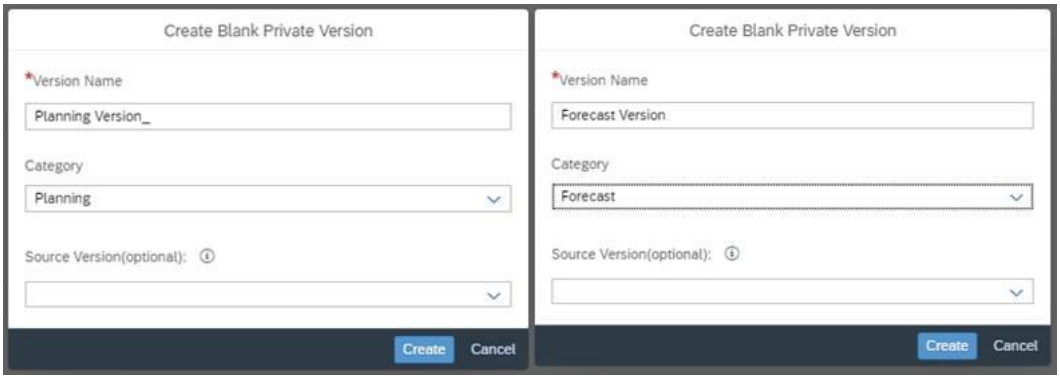


Figure 69 - Planning and Forecast Versions

4. The corresponding categories were chosen.

By having these versions, it is possible to create multiple scenarios which leads to the evaluation of potential outcomes. The next phases of the project are going to use these versions to preserve the original version of the historical data. By using separate versions for scenario planning, business can adjust and explore hypothetical changes without affecting the integrity of the actual data.

This allows users to experiment with changes in data, assess their impact on key performance indicators, and refine their strategies accordingly. It streamlines the process of testing different scenarios and reduces the risk of unintentional modifications to historical data.

4.5.2.2 Validation Rules

In a table based on the model, data entry is restricted for a blocked member combination. Figure 70 shows the list of countries in which GBP is blocked, meaning that users cannot input data for these combinations in the table. This restriction helps maintain data integrity and ensures that certain scenarios, like data entry in GBP for these countries are not allowed.

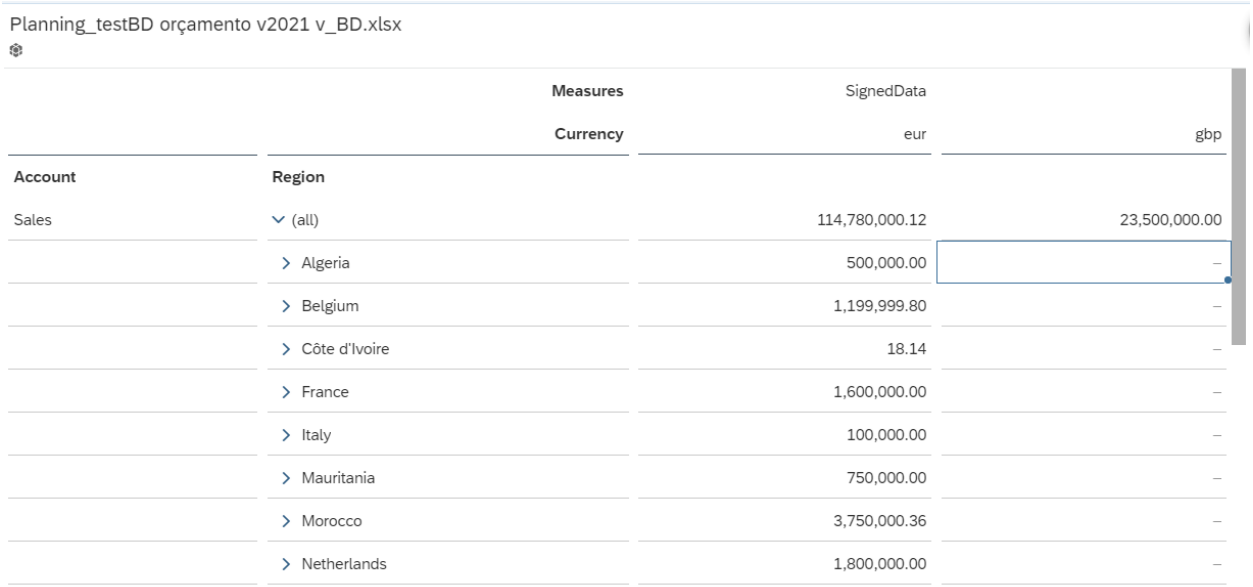


Figure 70 - Validation rule

It is possible to enable the option to understand the cause by selecting “Reason for unplannable data” (Fig. 71).

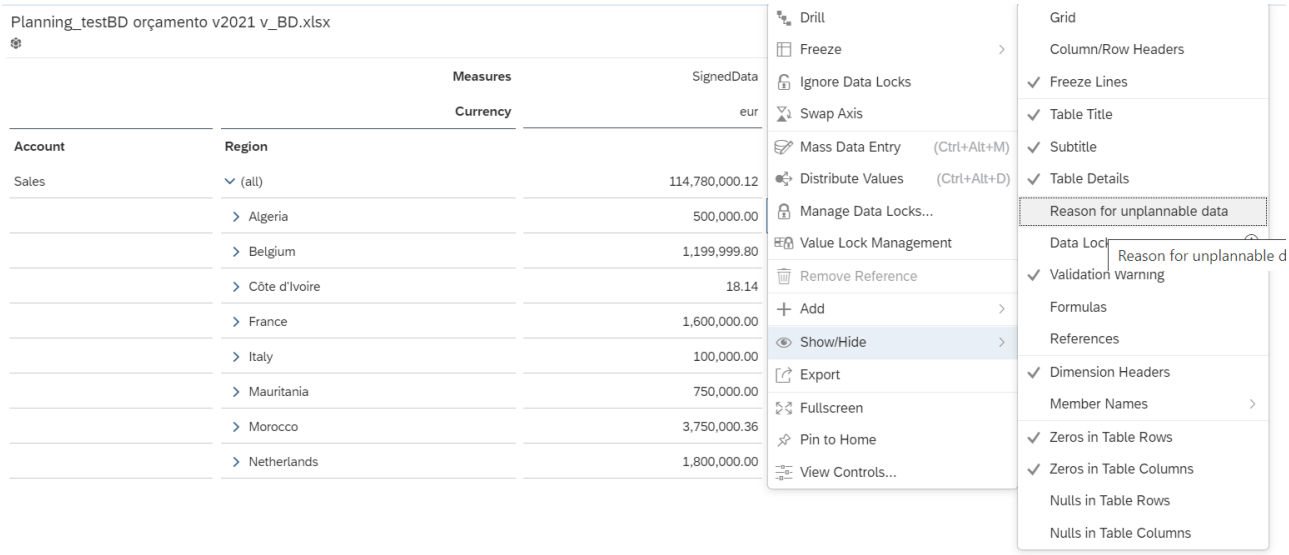


Figure 71 - Reasons for unplannable data

The message explaining the reason why the data is unplannable is in Figure 72 below.

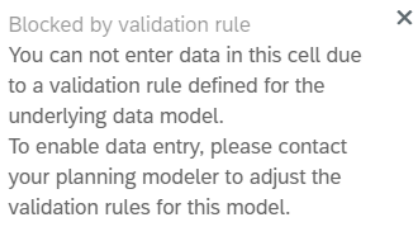


Figure 72 - Validation rule message

4.5.2.3 Data Locking

With the locks applied, any user who views the data will see the locked values in grey, indicating that they cannot be modified (Fig. 73).

Planning_testBD orçamento v2021 v_BD.xlsx

1 Filter

	Measures	SignedData
Division	**Account**	
(all)	Sales	35,911,722.76
1	Sales	5,741.43
100	Sales	809.85
1013	Sales	35,241.46
1025	Sales	31,300.33
110	Sales	1,173.60
111	Sales	2,715.09
1144	Sales	49,312.63

Figure 73 - Data locking

The message explaining the reason why the data is locked is in Figure 74 below.

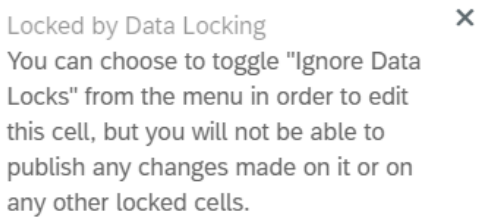


Figure 74 - Data locking message

Note that the locking owner can manage the data locks and change their status.

4.6 Forecasting

4.6.1 Time-series chart

SAC predictive forecast feature uses a time-series algorithm to predict future trends based on past data. It is possible to create a predictive forecast in Stories based on a planning model using time-series charts.

To create a predictive forecast from a chart, your chart must include a date dimension and at least one measure. The following steps were taken in order to create a predictive forecast for the measure Sales for the next nine months:

1. From Builder Chart Structure, selected Trend > Time Series.
2. Added the Sales measure.
3. Added the Date dimension.
4. From the chart action menu (⋯) was chosen Add > Forecast, and then selected Automatic Forecast:
    a. Automatic forecasts use machine learning to determine the best prediction approach while manual forecasts enable you to select the algorithm to be used. The solid line represents historical data, and the dashed line indicates the predicted trend, with the shaded region as the confidence interval (Fig. 75).

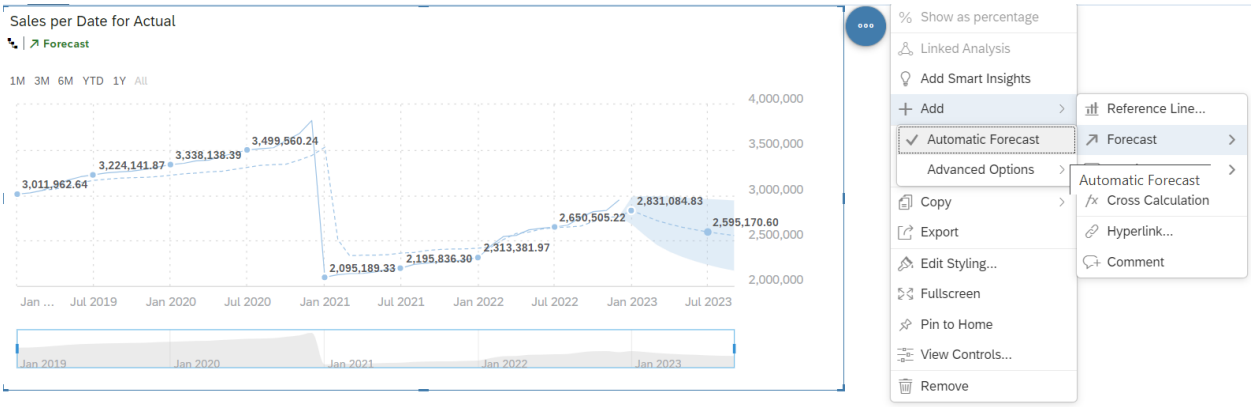


Figure 75 - Sales Forecast

b. Once the forecast is performed, a color-coded ↗ Forecast link is displayed above the chart. The link is green meaning that the forecast was performed successfully with no data issues.

c. Selected the link to display a Forecast Periods slider for the number of displayed periods and the Forecast Quality for the configured data (Fig. 76).

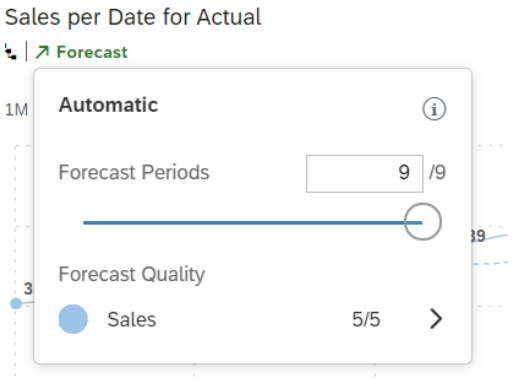


Figure 76 - Forecast Periods

d. Predicted periods can also be examined for information about upper and lower limits (Fig. 77).

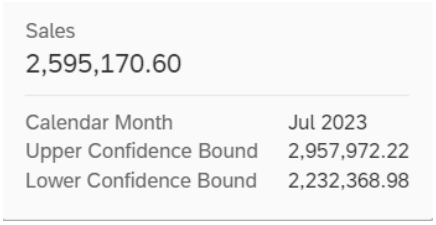


Figure 77 - Upper and lower info.

5 Results

The results and insights from the implementation of the project will be presented in this chapter. This project was meticulously executed, drawing from the invaluable input provided by INETUM's consultants through the survey mentioned in chapter 4.1. The foundation for the execution of the project was provided by the Theoretical Framework.

The focus of this chapter is on the utility and validity of the project. The aim is to evaluate what has been done and to highlight its contribution. The literature review has provided a deep understanding, fundamental to the project execution.

The following Table 13 covers the topics pointed out by the survey participants, the steps taken, and the outcomes achieved.

Table 13 - Results

Survey input	Steps	Results
- Real life use cases - Complex examples of business scenarios - Specific troubleshooting examples based on community input	Project based on historical data from a real construction company. Evaluation and understanding of a specific business scenario, the Sales Performance.	Comprehensive analysis of historical data from a real construction company, which provided valuable insights for future planning and decision-making.
- SAC Planning - Data Actions - Versioning;	Validation rule implementation: - Ensured that the currencies EUR and GBP are available for specific countries but not for others. Data Locking: - Restricted changes to the products for the Q1 period of 2021 Data Actions: - Copied the total data sales from 2021 and allocated the monthly average to the planned version. Version Management: - Created Planning and Forecast versions.	The successful implementation of a validation rule ensured accurate data entry by allowing specific currencies for particular countries, preventing errors in financial reporting. Data locking capabilities restricted changes to product data for a specific period, enhancing data integrity and planning accuracy. Data actions enabled the efficient copying of sales data from 2021 and its allocation to the planned version, streamlining forecasting processes. Version management facilitated the creation of distinct planning and forecast versions, enhancing scenario planning and performance evaluation.

- Data Visualizations	Created different types of visualizations	Various types of visualizations enhanced data presentation and understanding, making it easier for stakeholders to grasp key insights
- Modeling capabilities	Star schema for planning and analytical model implementation	Implementing a star schema for planning and analytical models streamlined data modeling and reporting, improving data consistency and accuracy.

The initial step involved integrating data from excel source into SAC. This integration facilitated a unified view of the financial and operational data, leading to improved data accessibility and the establishment of a consolidated data repository for analysis.

We leveraged SAC's predictive analytics capabilities to project future financial scenarios. This utilization resulted in enhanced forecasting accuracy and empowered decision-making.

Data locking was applied to restrict unauthorized changes to specific data elements, ensuring data integrity. Thid implementation led to enhanced data governance and increased data accuracy.

Various data visualization techniques were employed to present insights. This approach improved data communication and understanding of historical data.

The performance of our project was evaluated through key performance indicators, providing better insights into the construction company’s effectiveness and areas for improvement.

The project's successful implementation resulted in improved data-driven decision-making, streamlined planning processes, and enhanced data governance. Moving forward, it is imperative to continuously monitor the dynamic landscape of ERP, I-ERP, ERP Analytics, and SAC capabilities to remain at the forefront of data-driven innovation.

In conclusion, to summarize and structure the topics that were covered throughout the project, the following mind map was created (Fig. 78), since it is a tool that helps the audience to remember the information that matters the most. The central theme is SAP Analytics Cloud related topics are Planning, Forecast, Data Preparation and Data analysis and visualization.

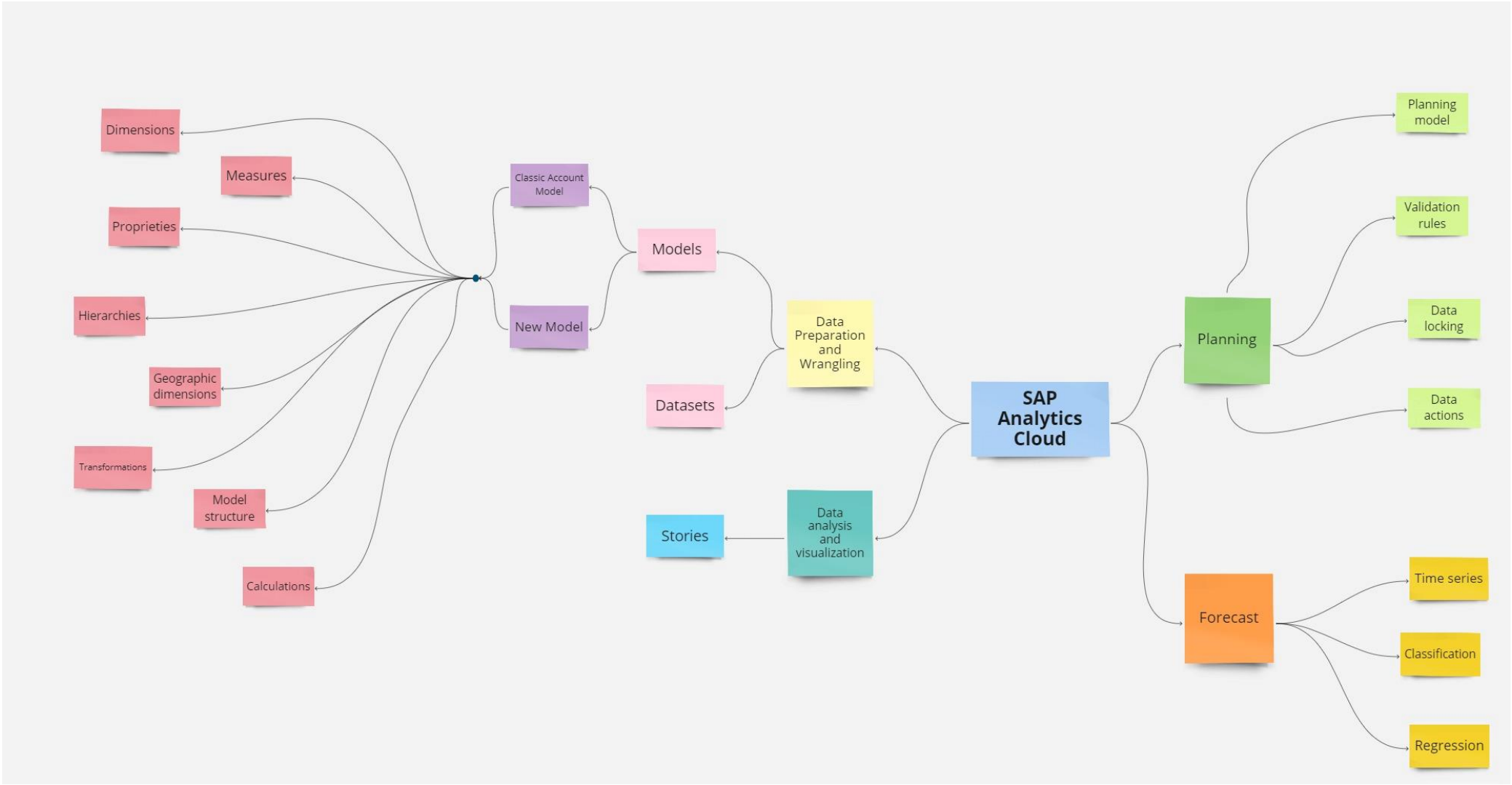


Figure 78 - Mind map (project summary)

6 Conclusions

6.1 Summary of the developed work

This project initiated with the purpose of implementing an SAP Analytics Cloud solution with the intention to contribute to the improvement of future SAC's projects implementations. This project intends to impact not only the INETUM's team that works daily with SAC but also everyone with every kind of level of experience in the field of analytics that wants to explore the capabilities of the service in study. The step-by-step guide presentation developed can be found in the appendix of this work.

To ensure this project followed the best practices in the field, it was necessary to research the existent literature about the technologies, methodologies and approaches involved in the development. Hence, it was understood that the topics Data Modeling, Data Visualization, Planning and Forecasting were necessary to be covered in the development of the project.

This project was built on Business Intelligence concepts but also covered Knowledge Management topics such as the mind map that summarized the work. Since both topics are part of the specialization of the master's degree in Information Management, they were central to the realization and achievement of the project.

6.2 Limitations

In order to accurately represent a real-life use case, this project relied on obtaining data from one of INETUM's clients. However, this dependency on external data introduced limitations in terms of timing and the planning of project phases that relied on this data. As a result, there were challenges in aligning the project timeline with the availability of data.

Due to the client's request for anonymity and data privacy, it was necessary to make slight alterations to the data used in the project. As a result, the use of live data was not feasible, which led to the project being limited to utilizing on-premises data sources in the form of local Excel files. This approach ensured the confidentiality and protection of the client's sensitive information.

Additionally, due to the comprehensive nature of the SAC platform, which encompasses a wide range of topics, it was challenging to determine which specific topics to prioritize and focus on. The abundance of options made the selection process difficult, requiring careful consideration and decision-making.

6.3 Future Work

SAP Analytics Cloud follows a quarterly release schedule, in line with SAP's global strategy for cloud application releases. This means that a new major version is released approximately every quarter. It's important to note that regular maintenance and updates are necessary to ensure the smooth operation and availability of the platform over time. These updates may include bug fixes, performance improvements, and the introduction of new features and functionalities. By keeping up with these releases and performing timely maintenance, users can take advantage of the latest enhancements and ensure the optimal performance of SAP Analytics Cloud.

Due to the frequent releases of SAP Analytics Cloud, it is crucial to maintain up to date the document guide provided by this project, in order to update the step-by-step instructions that enable the use of the platform effectively. As new versions are introduced on a quarterly basis, this guide needs to be regularly reviewed and updated to reflect any changes or enhancements in the software. By ensuring the document guide remains current, users can rely on accurate and relevant information to maximize their usage of SAP Analytics Cloud and stay informed about the latest features and functionalities. Keeping this guide up to date will help users navigate the platform seamlessly and make the most of its capabilities.

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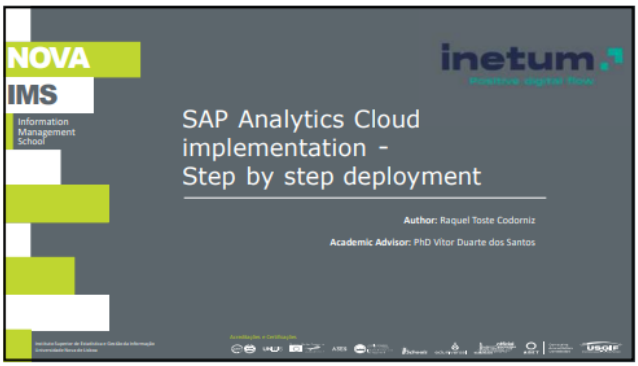
Appendix

SAP ANALYTICS CLOUD IMPLEMENTATION - STEP BY STEP DEPLOYMENT



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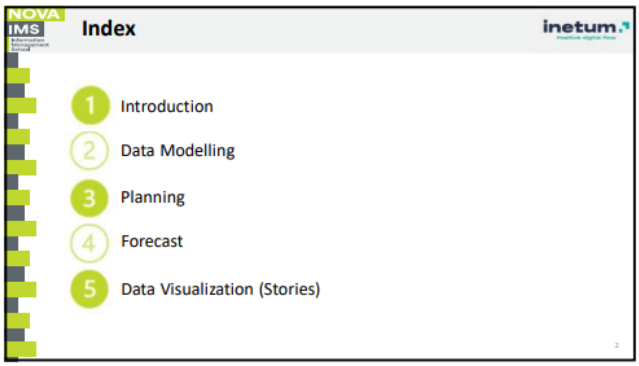

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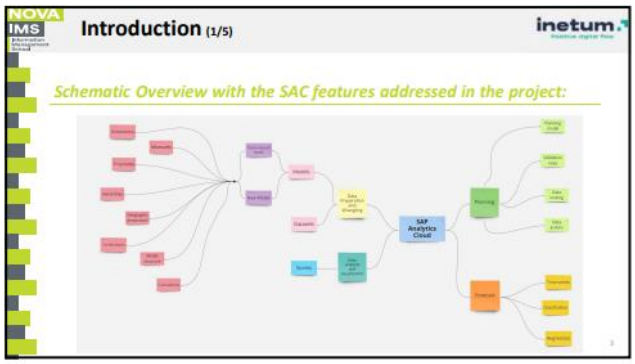

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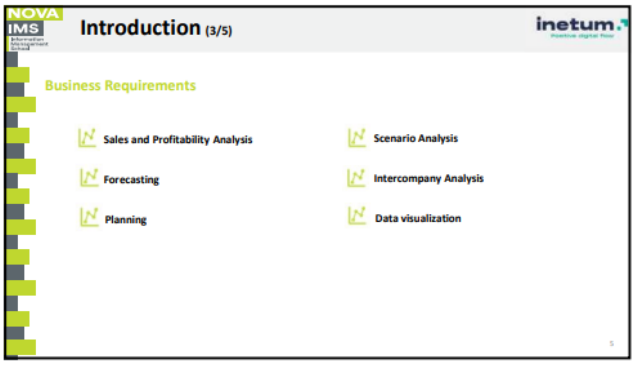

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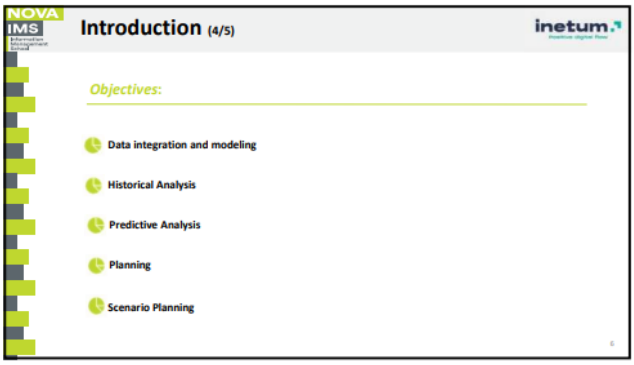

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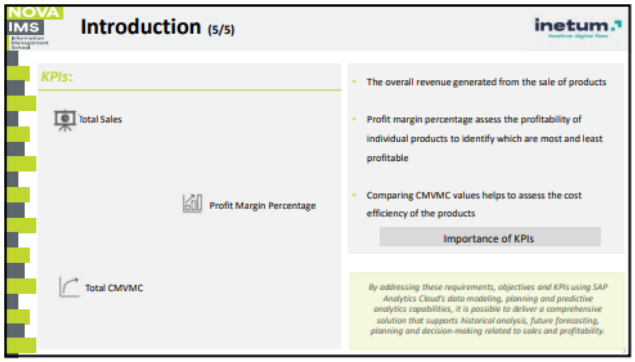
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KPIs:
Total Sales
Profit Margin Percentage
Total CMVMC
The overall revenue generated from the sale of products
Profit margin percentage assess the profitability of individual products to identify which are most and least profitable
Comparing CMVMC values helps to assess the cost efficiency of the products
Importance of KPIs
By addressing these requirements, objectives and KPIs using SAP Analytics Cloud's data modeling, planning and predictive analytics capabilities, it is possible to deliver a comprehensive solution that supports historical analysis, future forecasting, planning and decision-making related to sales and profitability.

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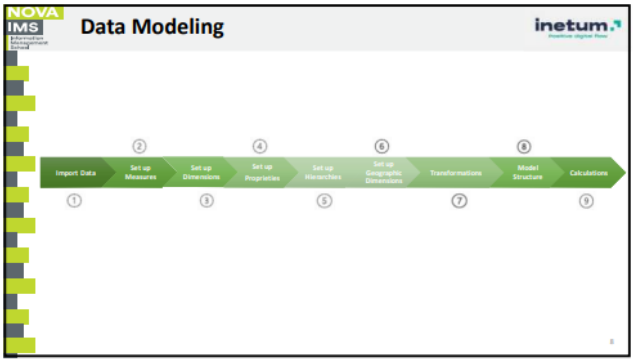
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Model Structure
Calculations

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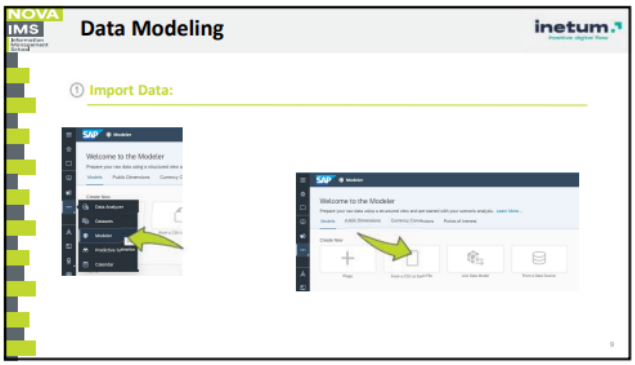
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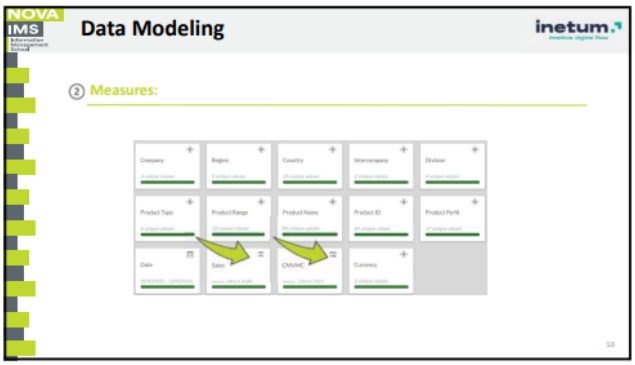
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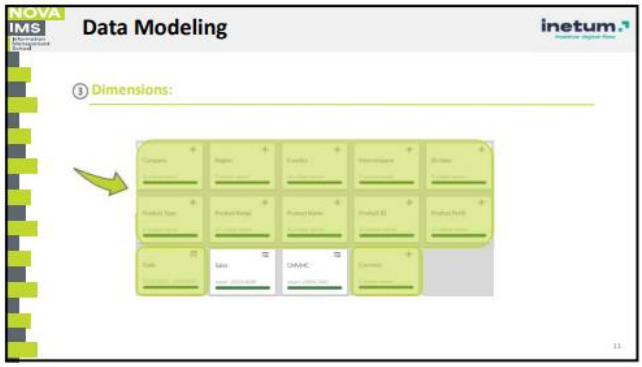
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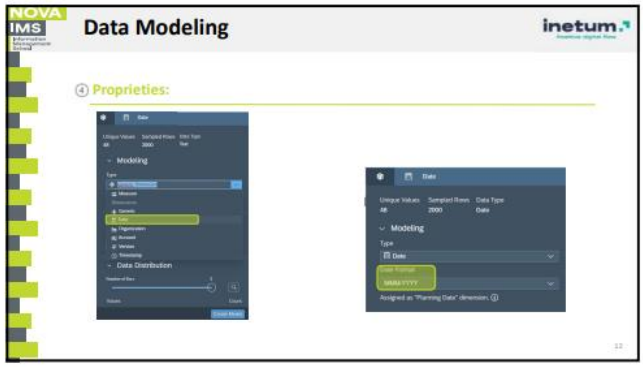
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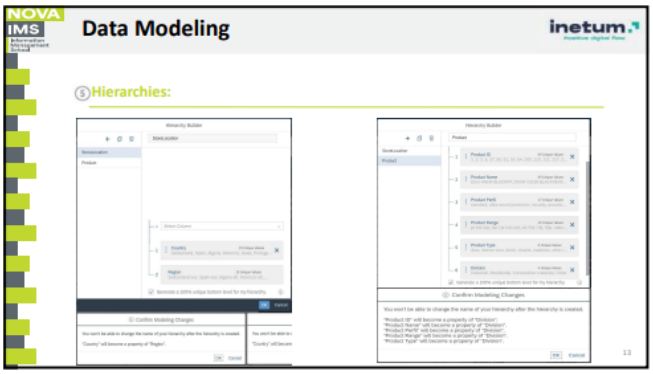

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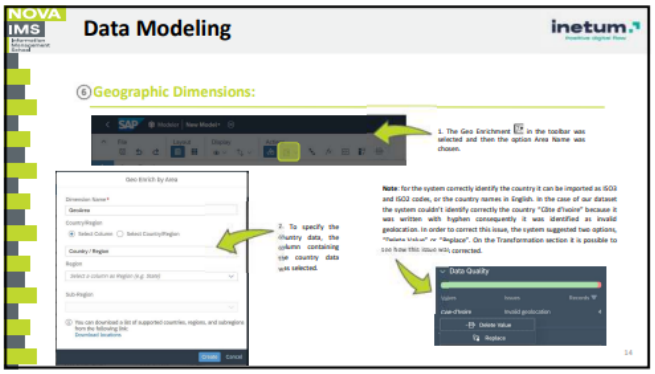

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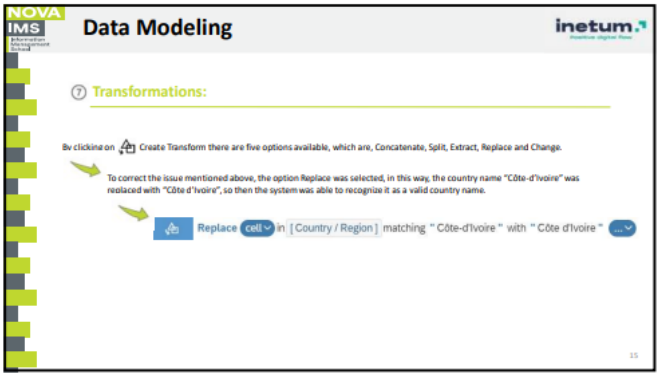

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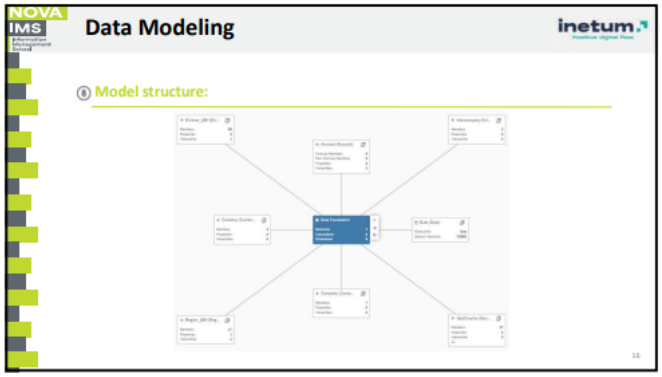

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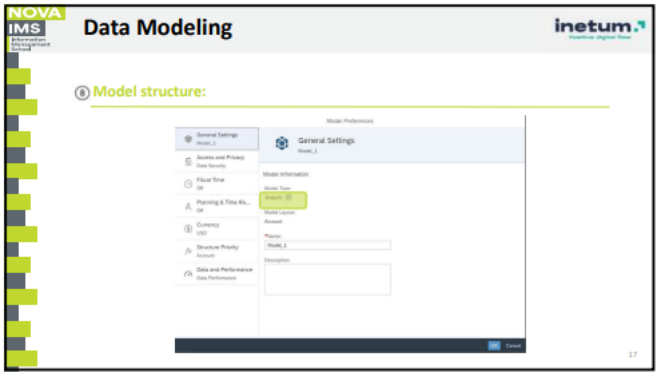

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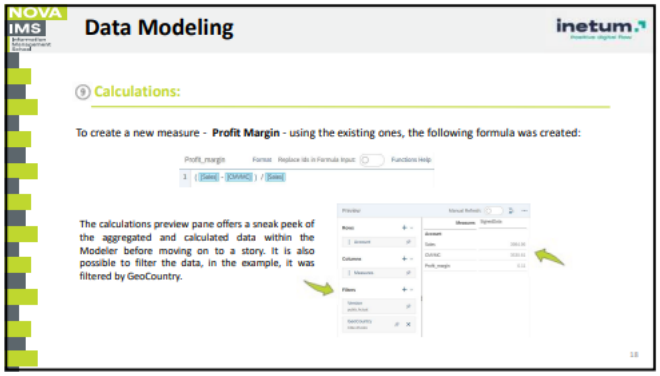

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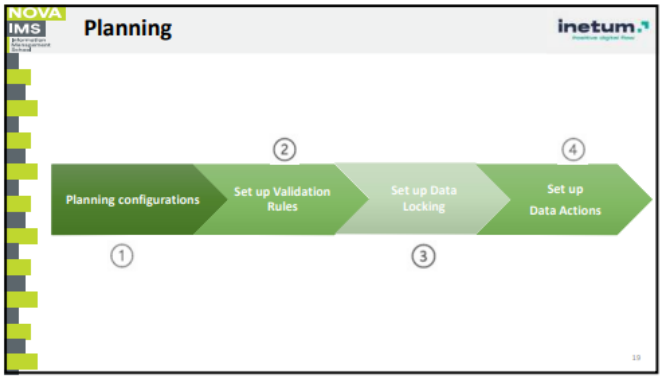

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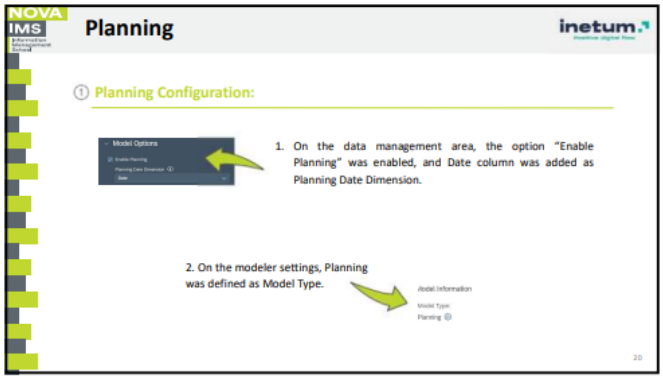

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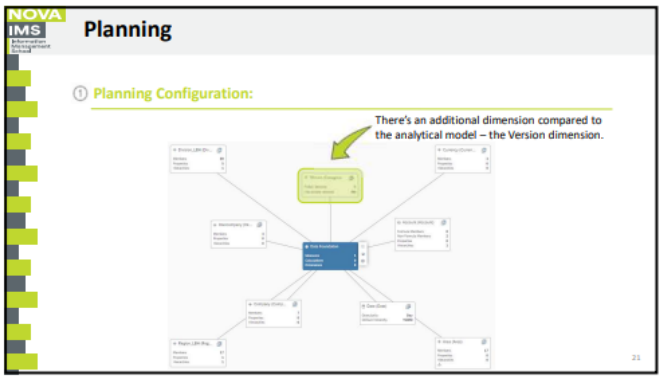

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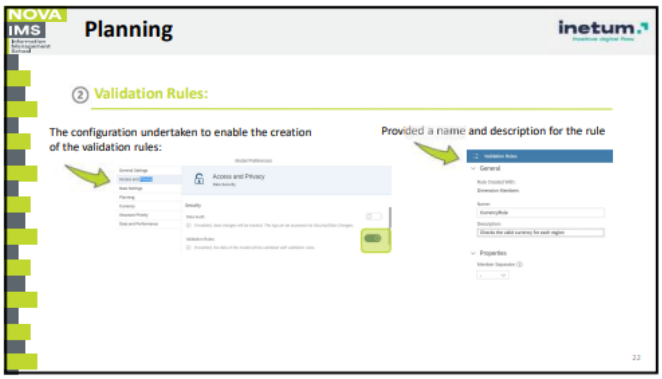

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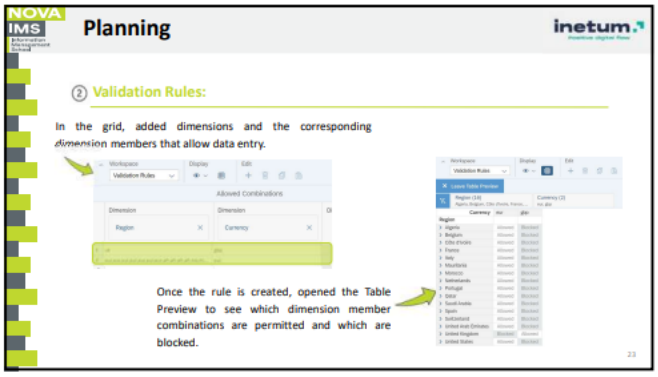

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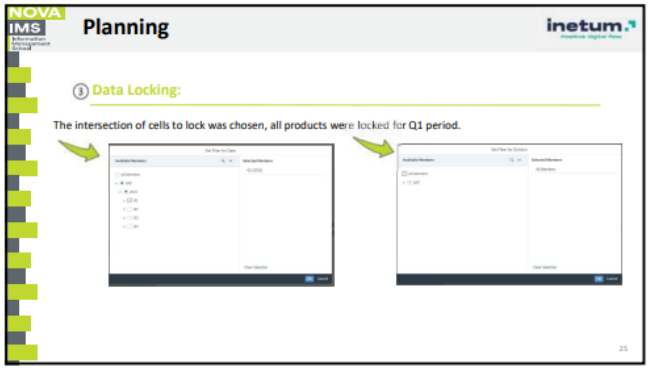

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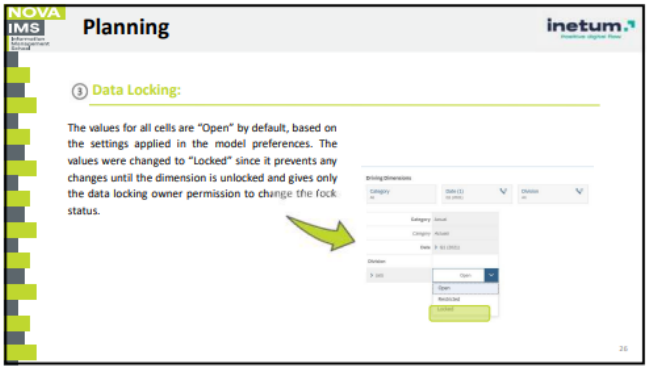

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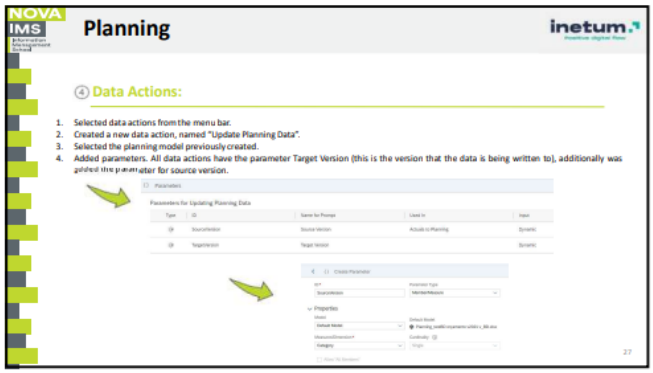

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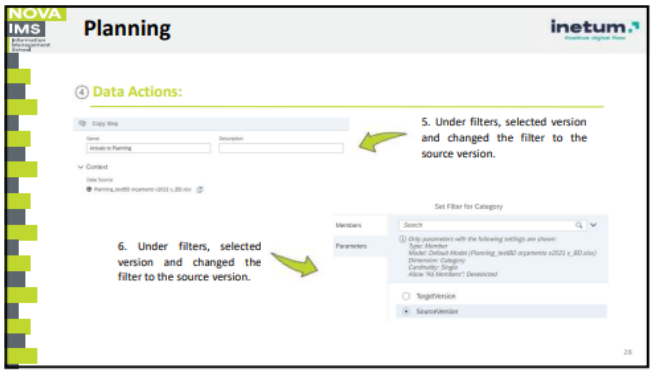

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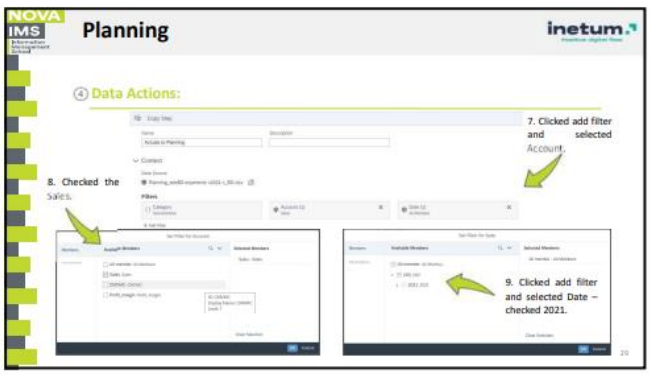

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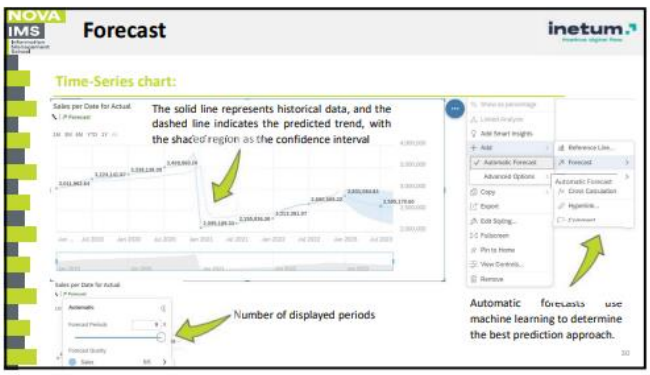

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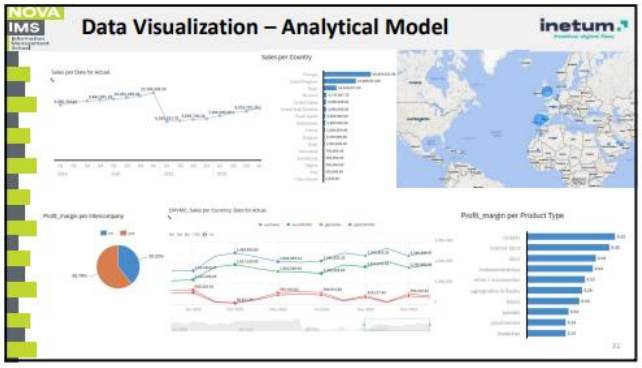

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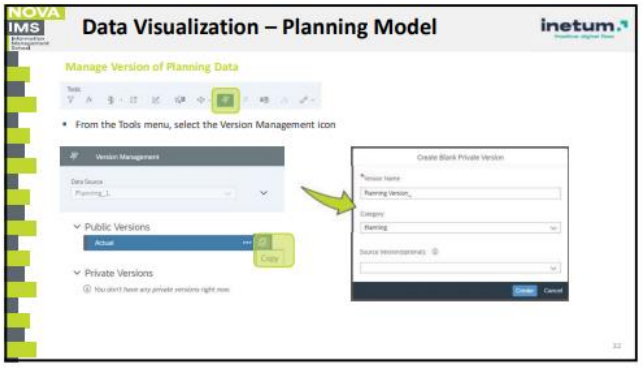

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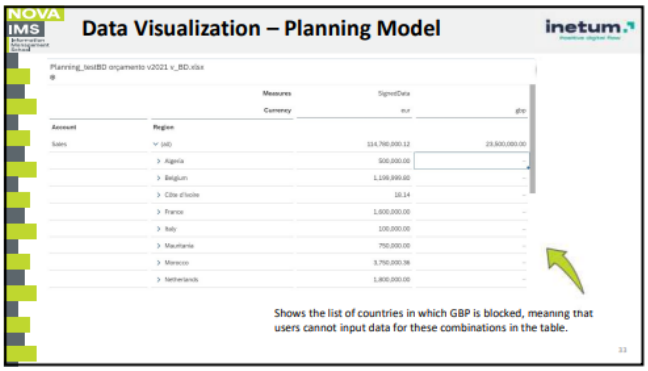

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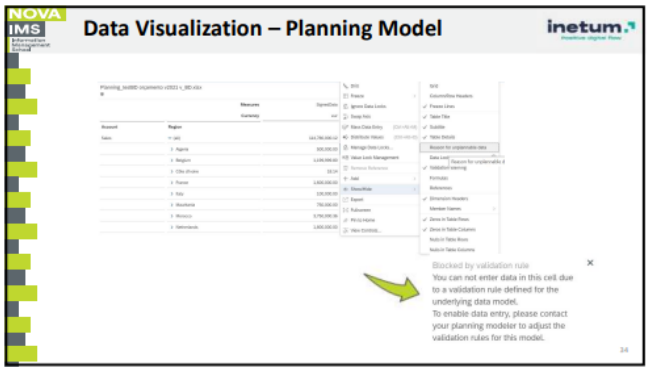

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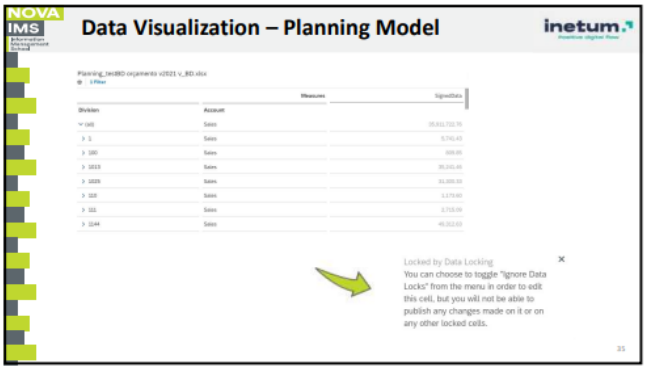

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