# Finance simulation and planning
# with Machine Learning in SAP Datasphere

Andreas Forster
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Public

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# Agenda

## 01

**Extending SAC Planning**

Use case and architecture

## 02

**Demo**

Risk assessment and mitigation

## 03

**Machine Learning in SAP Datasphere**

Details and how to start

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# SAP Extended Planning and Analysis

## PLAN TO WIN

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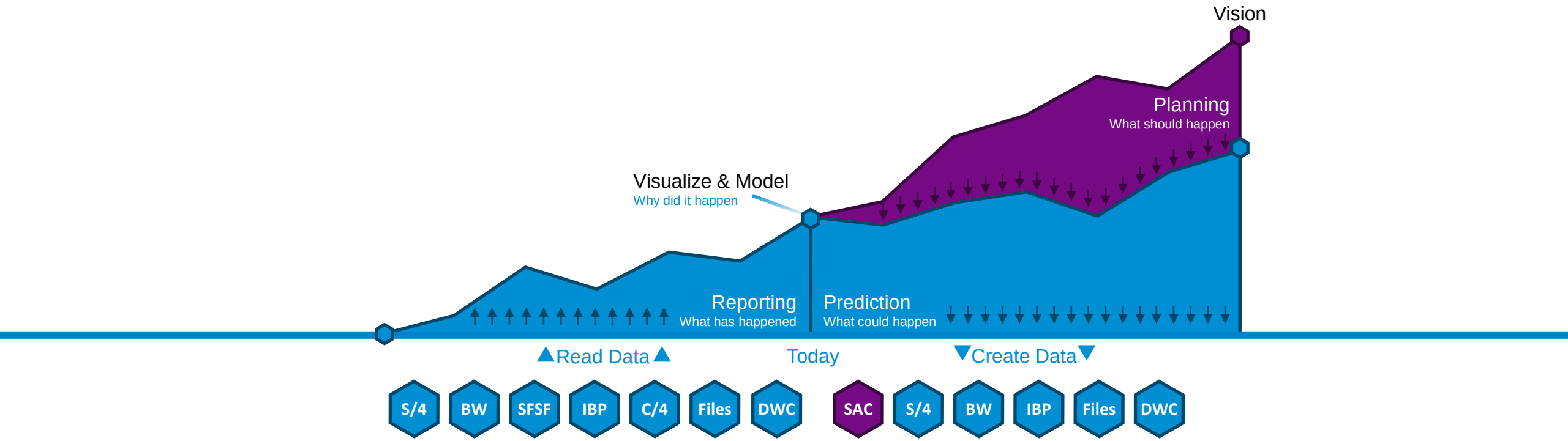
# Automate for Efficiency and Accuracy with Predictive Planning




- Long term driver based Financial forecasts generated in SAC by non statisticians – **Forecasting owned by FP&A to automate and improve accuracy with added influencer drivers**
- Native platform capabilities – **Embedded intelligence at a lower TCO**

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# Pro-active Business Steering with Flexible Simulations

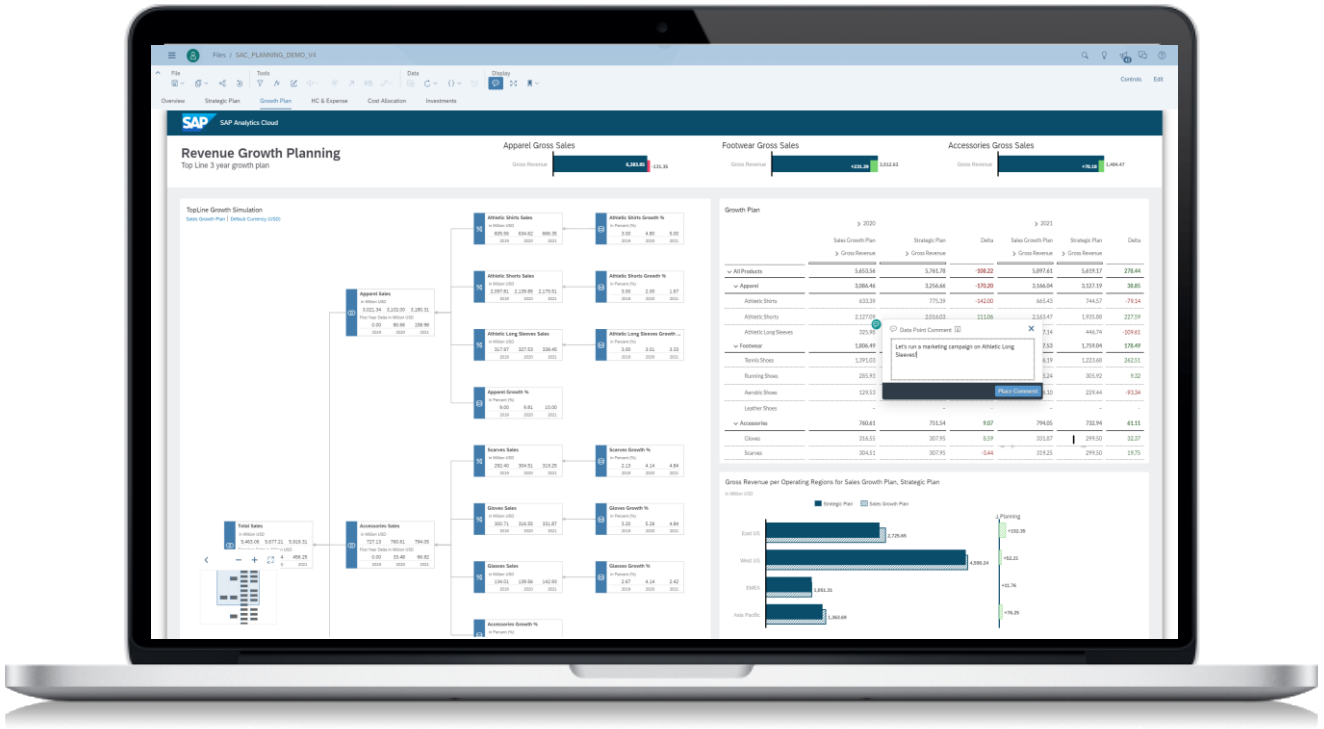
Driver based planning –
**Efficient and accurate steering**

Visual impact analysis –
**Quick problem resolution**

Sophisticated business logic
in SAP finance portfolio

- Top down/bottom-up alignment
- Fx effects
- Allocations

Multiple scenarios easily
prepared and shared

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# Pro-active Business Steering with Flexible Simulations

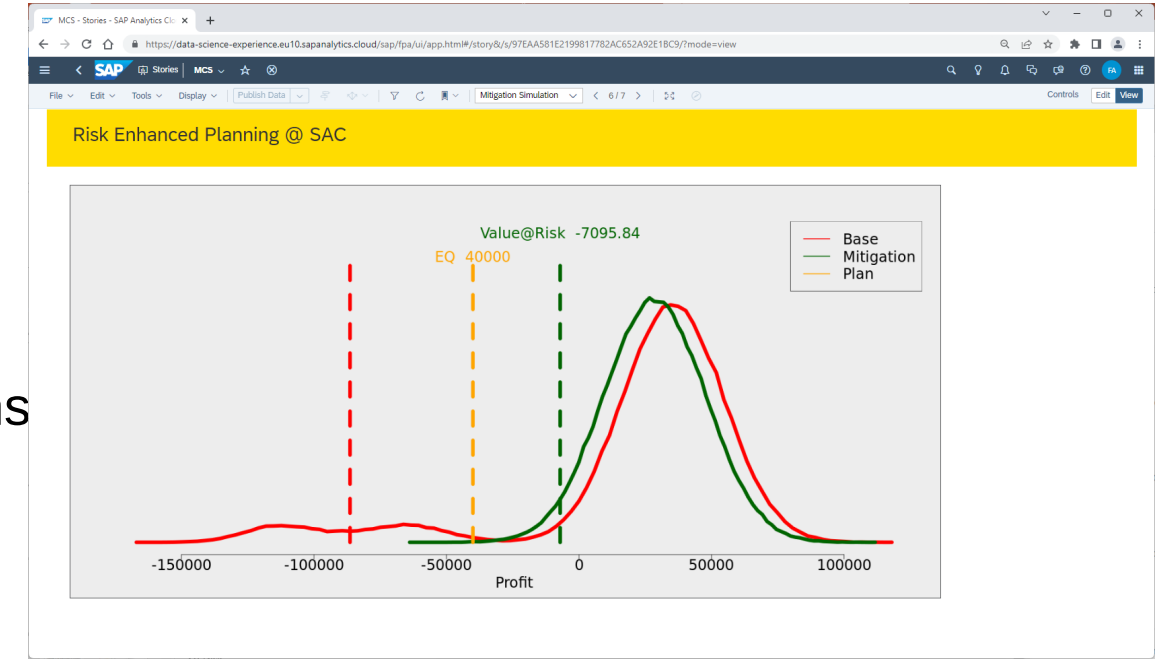
## and the ability to leverage additional calculations (ML, Monte Carlo, …) and data

Extend SAC Planning calculations capabilities with **native SAP HANA Cloud capabilities**

Address additional requirements like

- **Risk Simulations** (Monte Carlo) with Mitigations
- Specific Machine Learning algorithms
- Integrate price elasticity
- …

The planning user remains in the existing **SAC Planning** interface




MCS

2 Filters

| | Insolvency of big customers | Production stop | Decline Asia Market |
|---|---|---|---|
| Quantity | -1,000.00 | -2,000.00 | -500.00 |
| Price | – | – | – |
| Var. Costs p.P. | – | – | – |
| Revenue | – | – | – |
| Var. Costs | – | – | – |
| Fix Costs | – | – | – |
| Misc. Costs | – | -30,000.00 | – |
| **Operating Profit** | – | -30,000.00 | – |
| Probability | 0.05 | 0.10 | 0.03 |
| Assessment | It is quite likely that..... | | |

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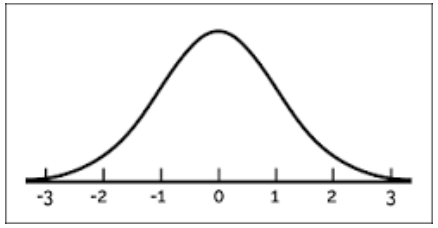
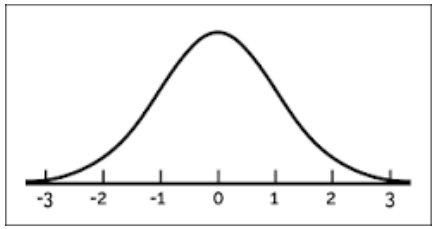
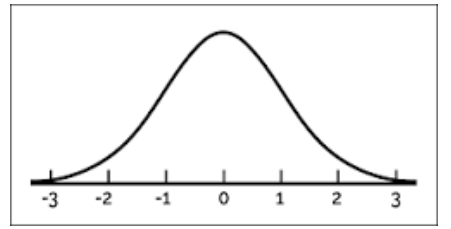
# Profit estimates under multiple uncertainties

Monte Carlo simulation to understand risks, ie of profit, loss and negative equity

**Basic example for revenue**

Revenue = 5’000 * 35 CHF = 175’000 CHF

**A little more realistically**

Revenue =  *  = 


**Similarly, uncertainties on costs and risks, but also ability to mitigate**
**How to assess, whether the risk to fall into negative equity is acceptable?**

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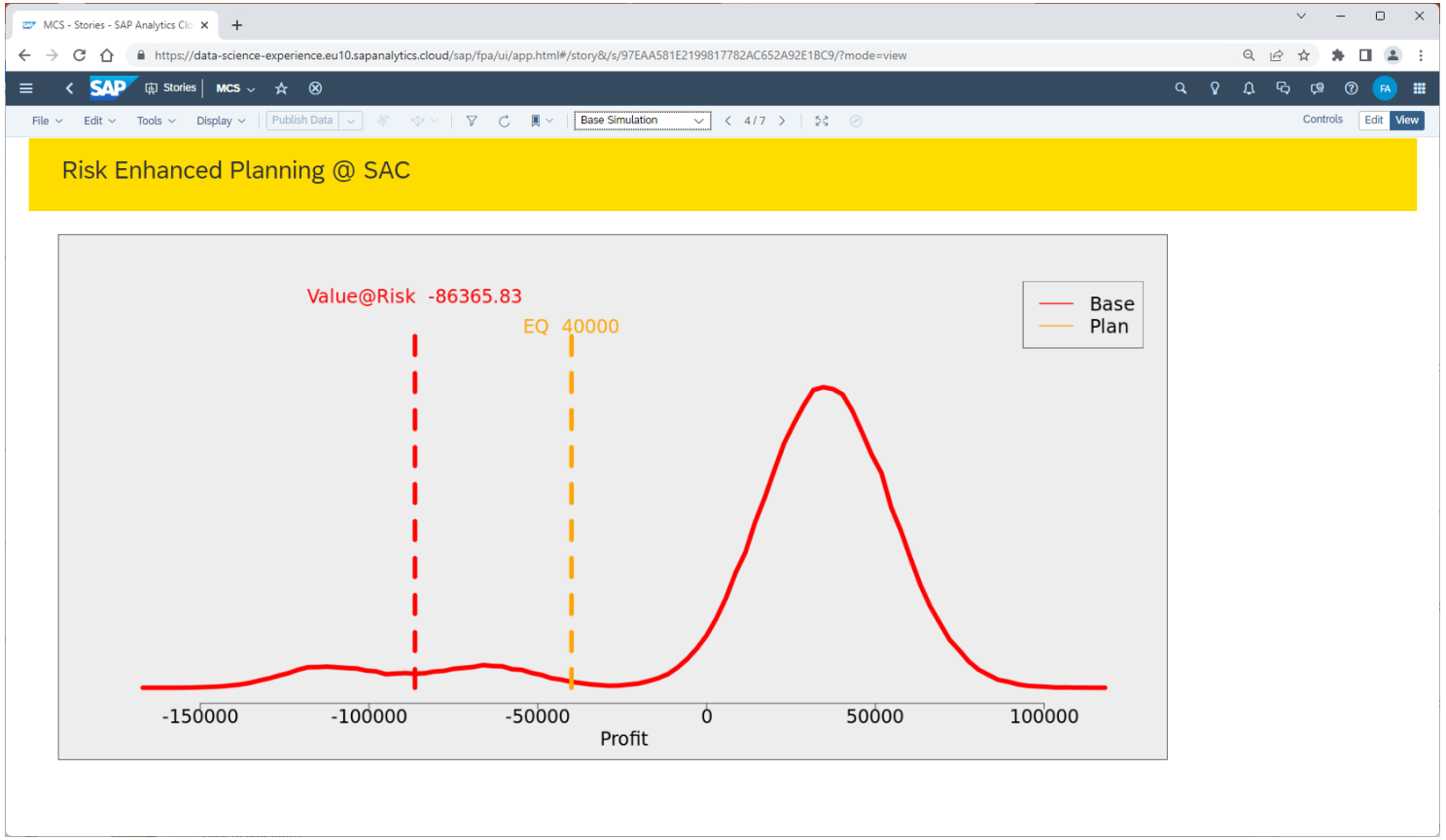
# Profit estimates under multiple uncertainties

## Monte Carlo simulation to understand risks, ie of profit, loss and negative equity

**How to assess, whether the risk to fall into negative equity is acceptable?**

Example:

- **Calculate a very high number of scenarios**
  (maybe 100.000 or more)
- Determine the **threshold** of the worst 5% outcomes

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# Profit estimates under multiple uncertainties

## Monte Carlo simulation to understand risks, ie of profit, loss and negative equity

### How to mitigate the risks?

Example:

- **Add insurance options** to the logic, to replace risk with a cost
- Calculate a very high number of scenarios (maybe 100.000 or more)
- Determine the threshold of the worst 5% outcomes

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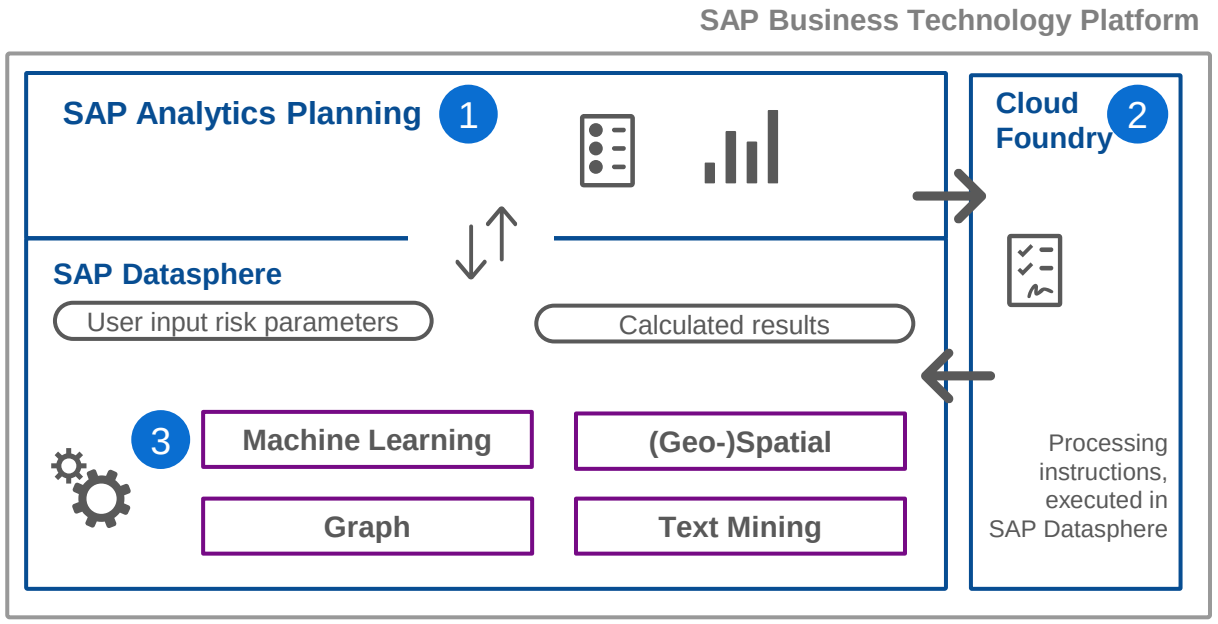
# Extending SAP Analytics Planning with custom logic

## SAP BTP Architecture




1
- Planning user enters details into SAC Planning grid
- The data entered by the user is accessible in SAP Datasphere as remote table
- Clicking a button on the SAC Planning interface triggers the processing

2
- A SAC multi action is triggered by the button
- A REST-API on Cloud Foundry gets called, which triggers the calculations in SAP Datasphere

3
- SAP Datasphere simulates 100.000+ scenarios and determines the percentiles, which are written to a staging table
- The Planning user sees the results in SAC Planning

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**Machine Learning in SAP Datasphere**

Details and how to start

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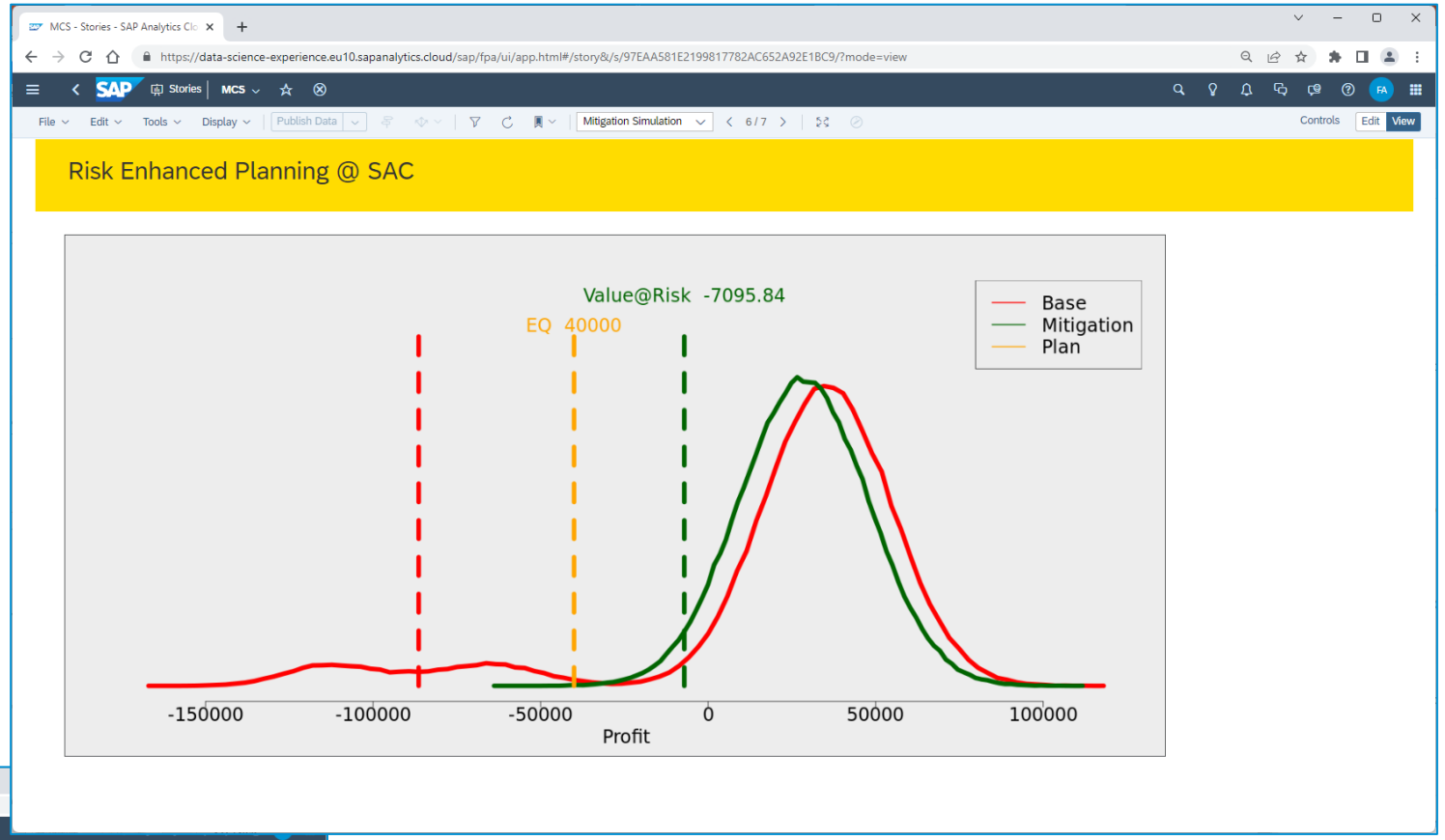


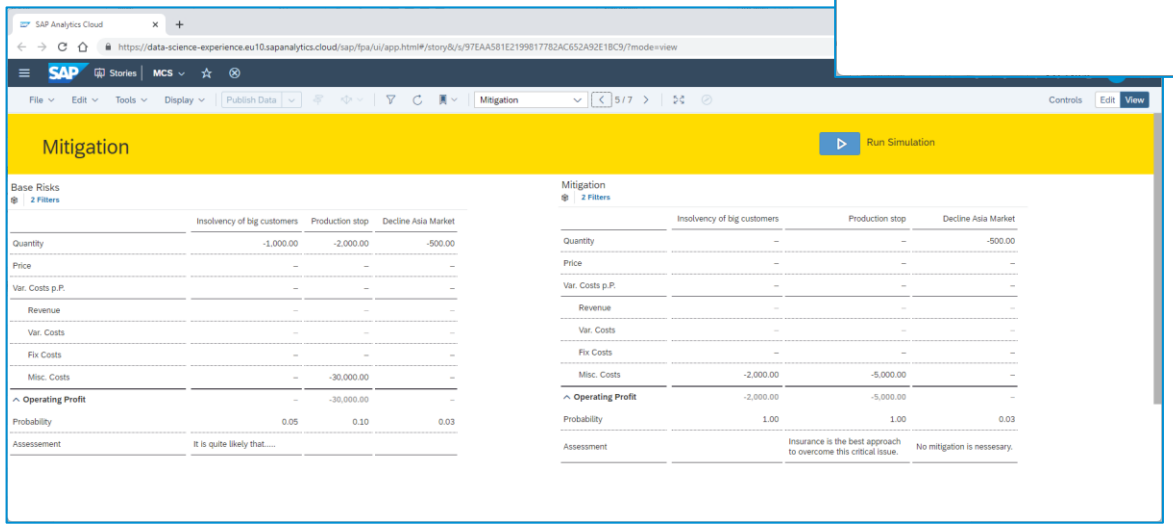


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MCS - Stories - SAP Analytics Clo

https://data-science-experience.eu10.sapanalytics.cloud/sap/fpa/ui/app.html#/story&/s/97EAA581E2199817782AC652A92E1BC9/?mode=view

Stories | MCS

File | Edit | Tools | Display | Publish Data | Entry | 1 / 7 | Controls | Edit | View

# Risk Enhanced Planning @ SAC

Operating Profit for Plan

3 Filters

**37,000.00**

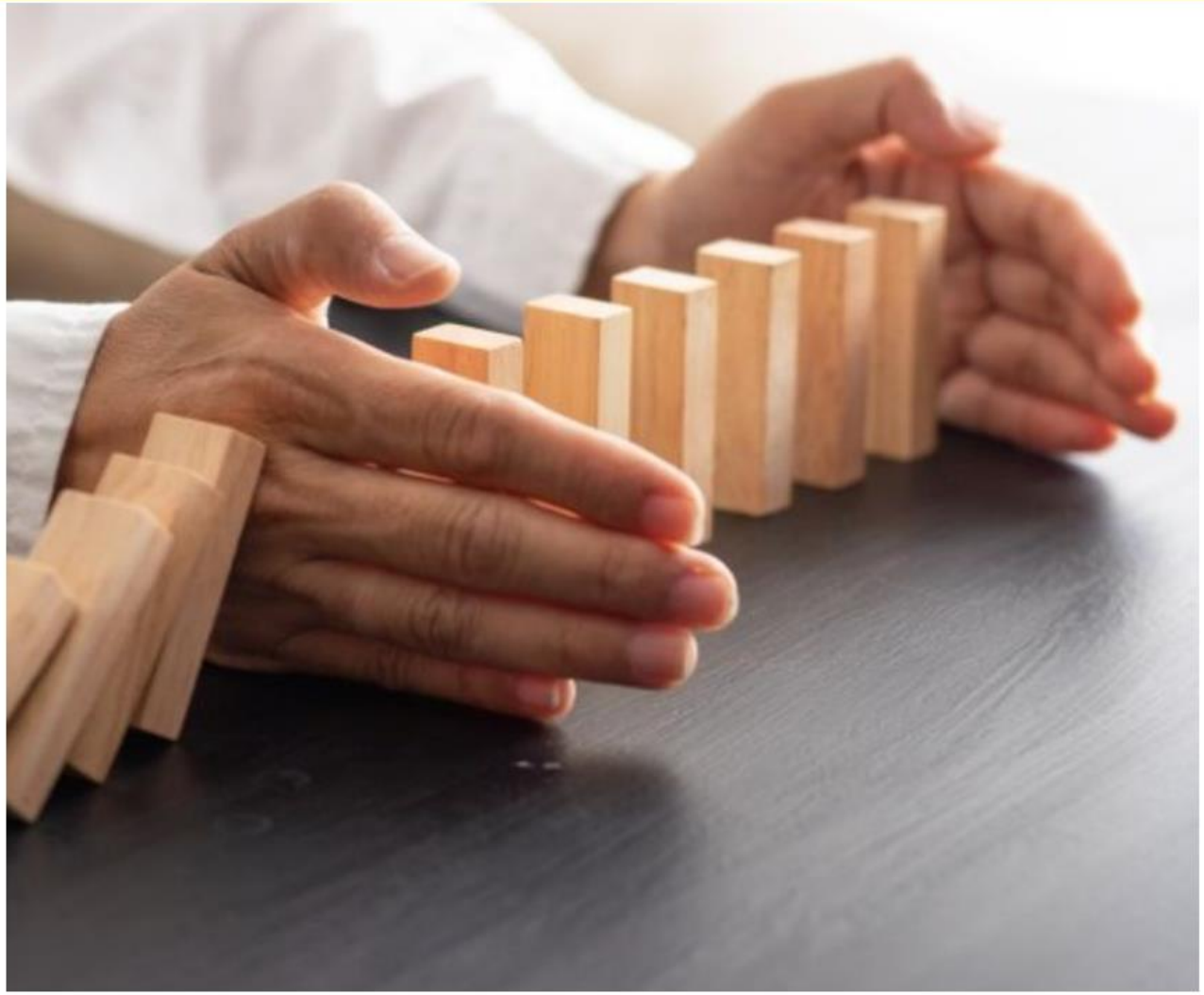
Operating Profit

Revenue for Plan

3 Filters

**175,000.00**

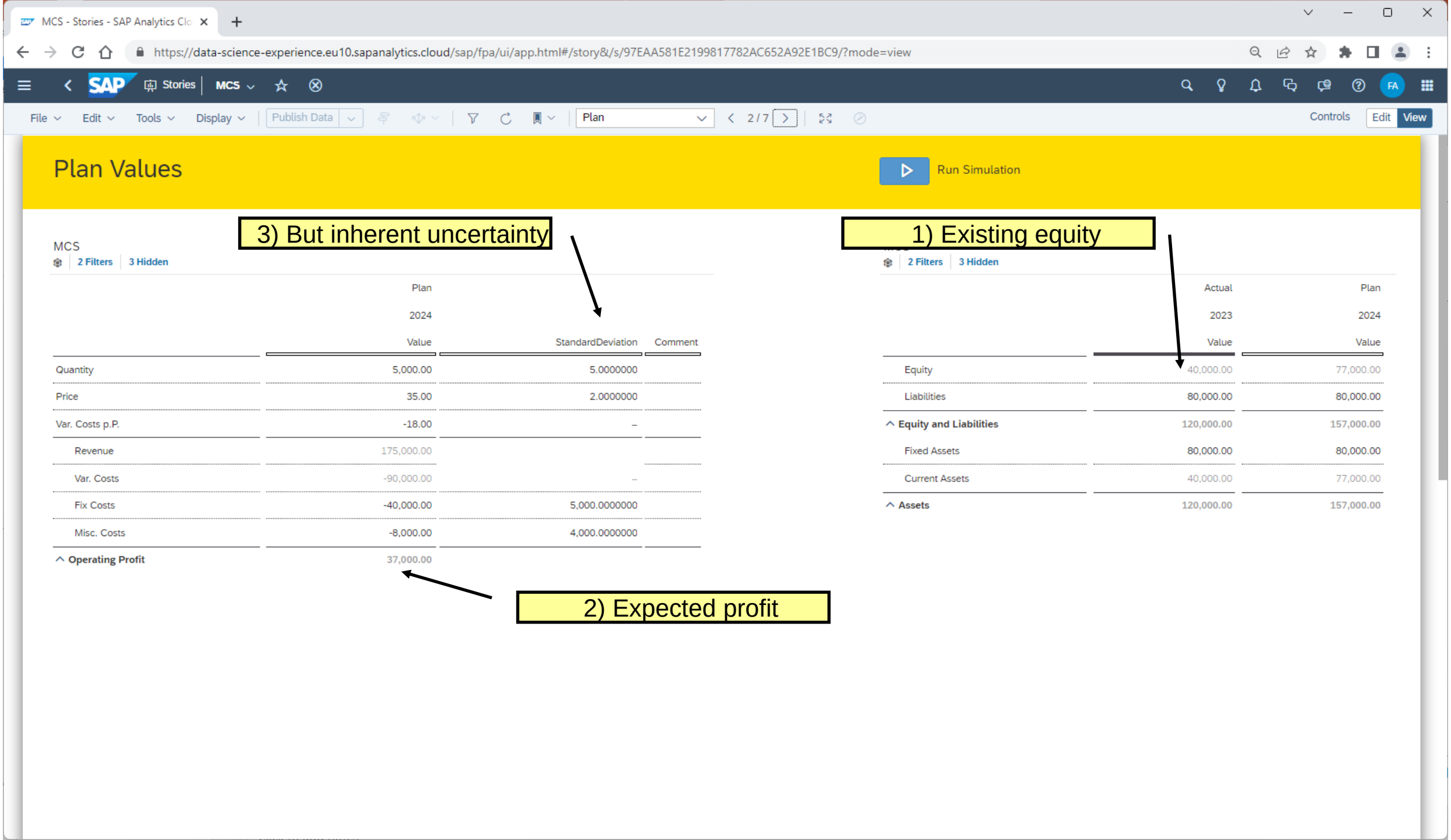
Revenue

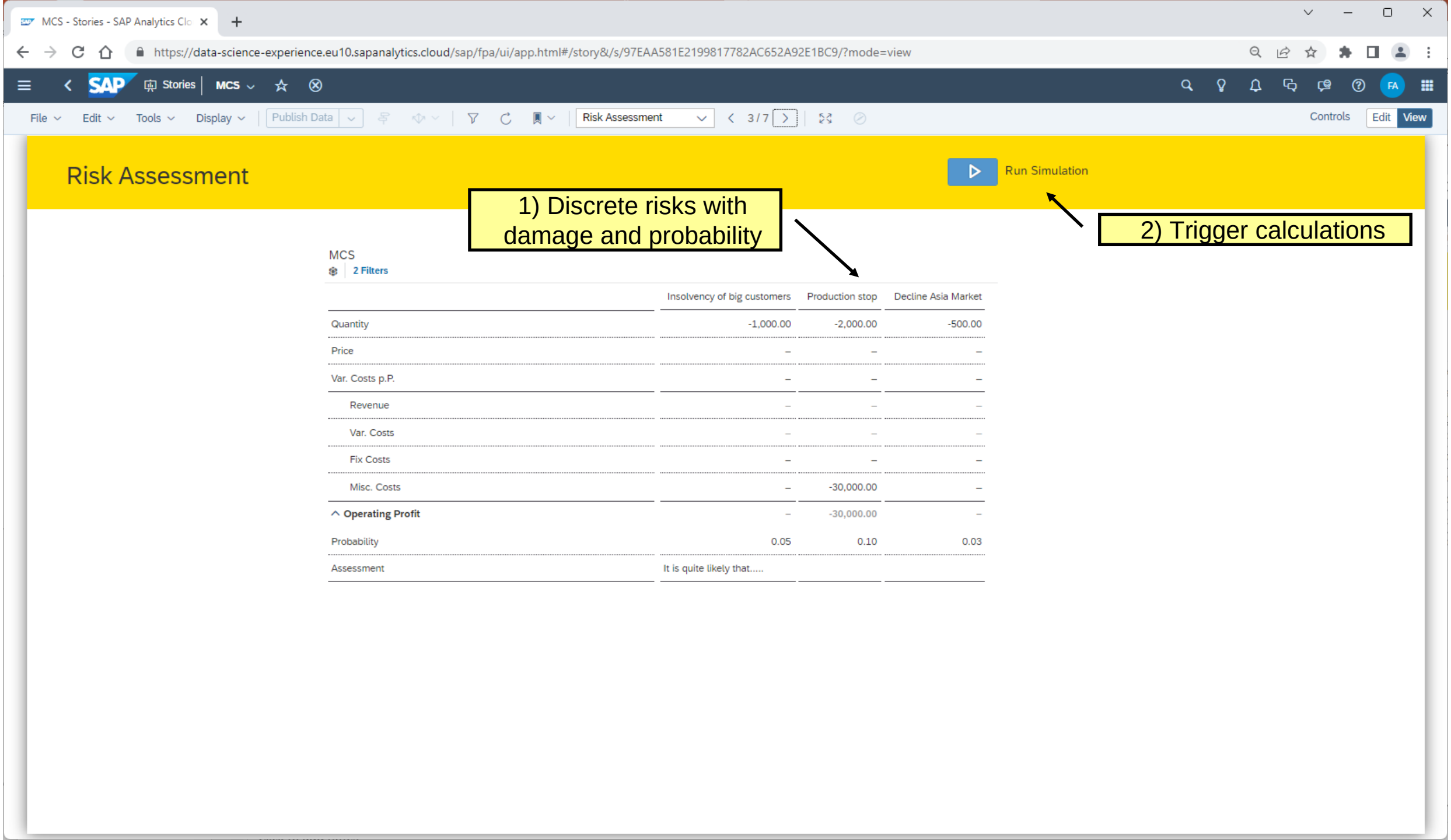


Planning

Risks

Mitigation


MCS - Stories - SAP Analytics Clo
https://data-science-experience.eu10.sapanalytics.cloud/sap/fpa/ui/app.html#/story&/s/97EAA581E2199817782AC652A92E1BC9/?mode=view
Stories
MCS
File
Edit
Tools
Display
Publish Data
Plan
2 / 7
Controls
Edit
View
Plan Values
Run Simulation
3) But inherent uncertainty
1) Existing equity
2) Expected profit
MCS
2 Filters
3 Hidden
Plan
2024
Value
StandardDeviation
Comment
Quantity 5,000.00 5.0000000
Price 35.00 2.0000000
Var. Costs p.P. -18.00 –
Revenue 175,000.00
Var. Costs -90,000.00 –
Fix Costs -40,000.00 5,000.0000000
Misc. Costs -8,000.00 4,000.0000000
Operating Profit 37,000.00
2 Filters
3 Hidden
Actual
2023
Value
Plan
2024
Value
Equity 40,000.00 77,000.00
Liabilities 80,000.00 80,000.00
Equity and Liabilities 120,000.00 157,000.00
Fixed Assets 80,000.00 80,000.00
Current Assets 40,000.00 77,000.00
Assets 120,000.00 157,000.00


MCS - Stories - SAP Analytics Clo
https://data-science-experience.eu10.sapanalytics.cloud/sap/fpa/ui/app.html#/story&/s/97EAA581E2199817782AC652A92E1BC9/?mode=view
Stories
MCS
File
Edit
Tools
Display
Publish Data
Risk Assessment
3 / 7
Controls
Edit
View
Risk Assessment
Run Simulation
1) Discrete risks with damage and probability
2) Trigger calculations
MCS
2 Filters
Insolvency of big customers
Production stop
Decline Asia Market
Quantity -1,000.00 -2,000.00 -500.00
Price – – –
Var. Costs p.P. – – –
Revenue – – –
Var. Costs – – –
Fix Costs – – –
Misc. Costs – -30,000.00 –
Operating Profit – -30,000.00 –
Probability 0.05 0.10 0.03
Assessment It is quite likely that.....

MCS - Stories - SAP Analytics Clo

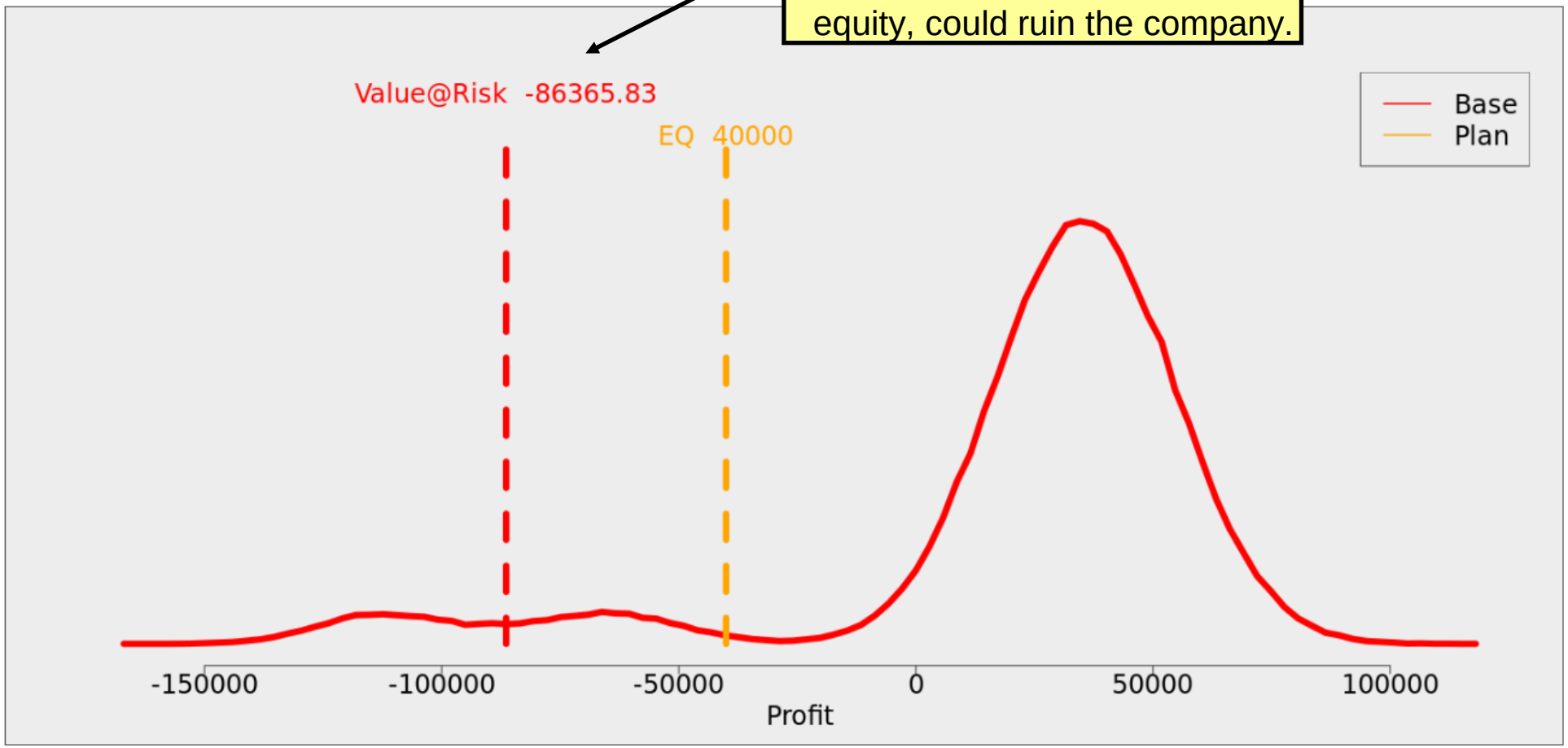
https://data-science-experience.eu10.sapanalytics.cloud/sap/fpa/ui/app.html#/story&/s/97EAA581E2199817782AC652A92E1BC9/?mode=view

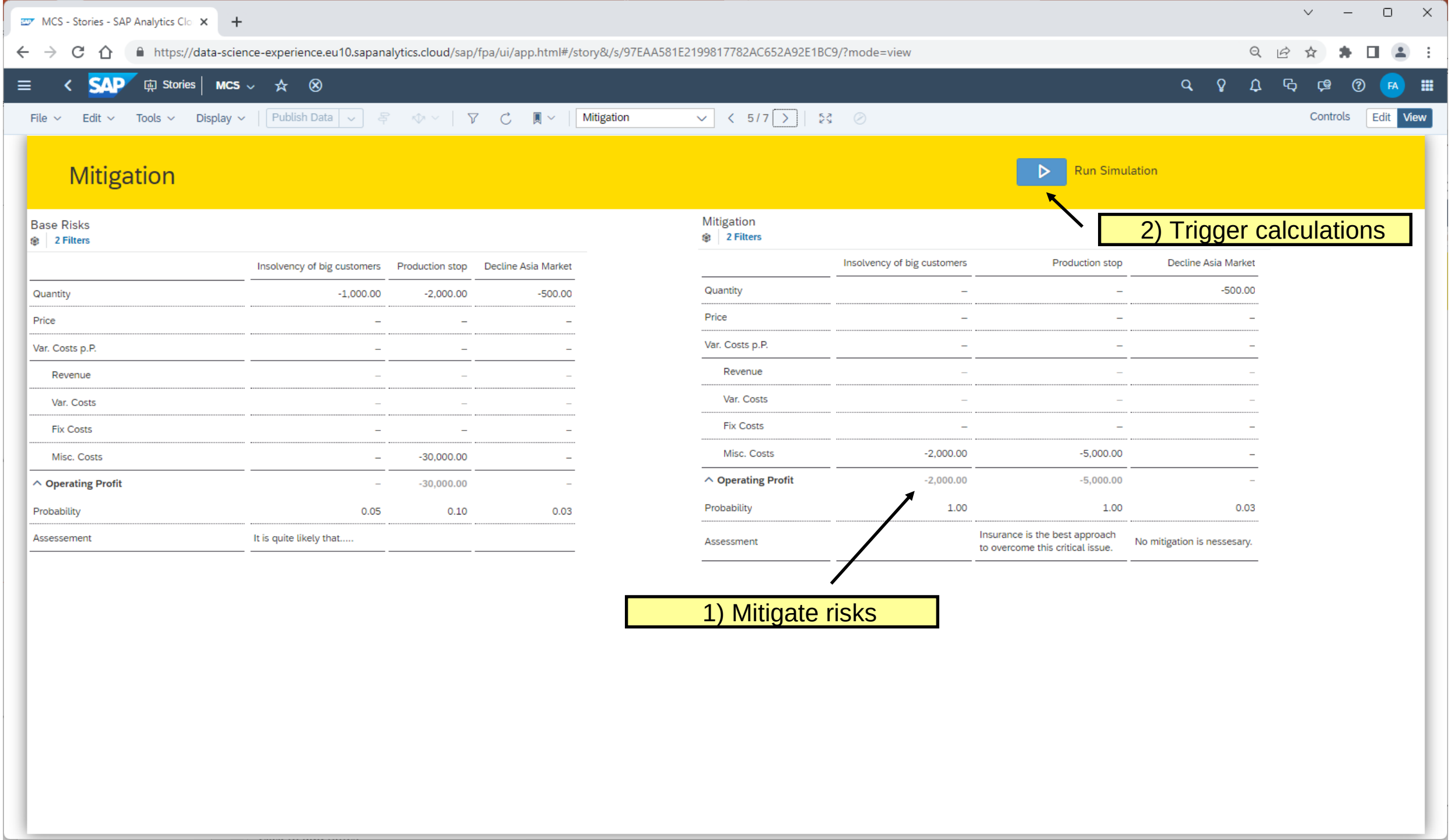
Stories | MCS

File | Edit | Tools | Display | Publish Data | Base Simulation | 4 / 7 | Controls | Edit | View

# Risk Enhanced Planning @ SAC

1) Value at risk larger than equity, could ruin the company.






| | Insolvency of big customers | Production stop | Decline Asia Market |
|---|---|---|---|
| Quantity | -1,000.00 | -2,000.00 | -500.00 |
| Price | – | – | – |
| Var. Costs p.P. | – | – | – |
| Revenue | – | – | – |
| Var. Costs | – | – | – |
| Fix Costs | – | – | – |
| Misc. Costs | – | -30,000.00 | – |
| **Operating Profit** | – | -30,000.00 | – |
| Probability | 0.05 | 0.10 | 0.03 |
| Assessement | It is quite likely that..... | | |

| | Insolvency of big customers | Production stop | Decline Asia Market |
|---|---|---|---|
| Quantity | – | – | -500.00 |
| Price | – | – | – |
| Var. Costs p.P. | – | – | – |
| Revenue | – | – | – |
| Var. Costs | – | – | – |
| Fix Costs | – | – | – |
| Misc. Costs | -2,000.00 | -5,000.00 | – |
| **Operating Profit** | -2,000.00 | -5,000.00 | – |
| Probability | 1.00 | 1.00 | 0.03 |
| Assessment | | Insurance is the best approach to overcome this critical issue. | No mitigation is nessesary. |

MCS - Stories - SAP Analytics Clo

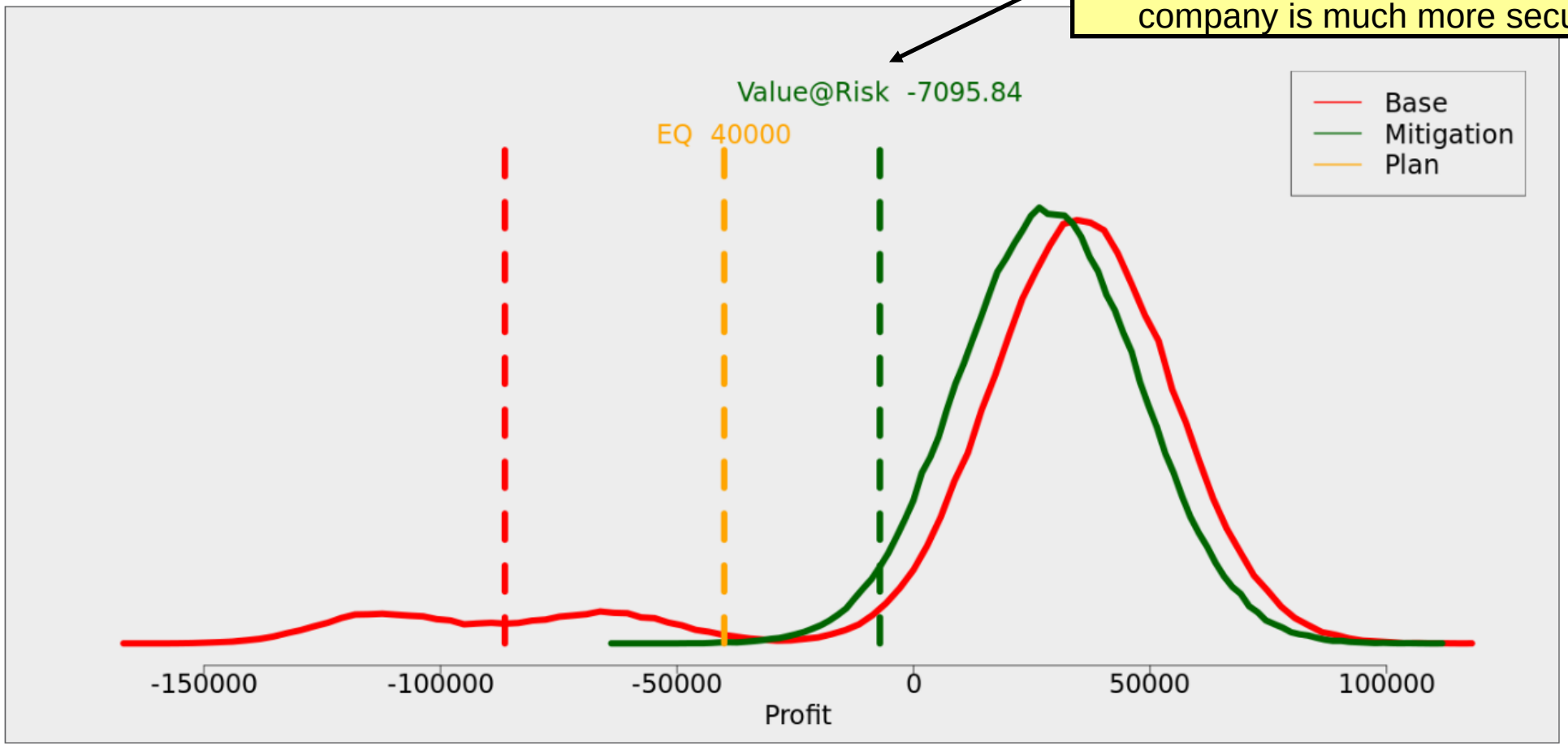
https://data-science-experience.eu10.sapanalytics.cloud/sap/fpa/ui/app.html#/story&/s/97EAA581E2199817782AC652A92E1BC9/?mode=view

Stories | MCS

File | Edit | Tools | Display | Publish Data | Mitigation Simulation | 6 / 7 | Controls | Edit | View

# Risk Enhanced Planning @ SAC

1) Value at risk is less than equity, company is much more secure



# Pro-active Business Steering with Flexible Simulations + Extensions

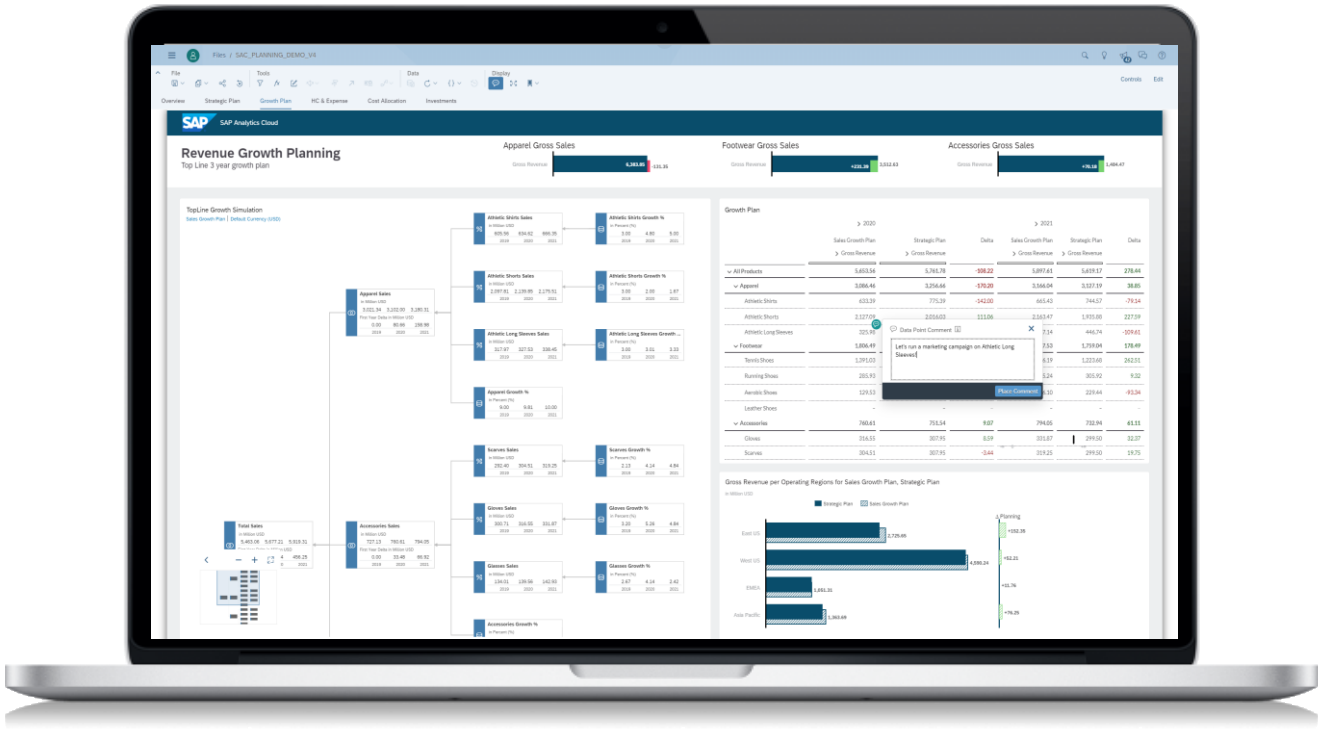
Driver based planning –
**Efficient and accurate steering**

Visual impact analysis –
**Quick problem resolution**

Sophisticated business logic
in SAP finance portfolio

- Top down/bottom-up alignment
- Fx effects
- Allocations

Multiple scenarios easily
prepared and shared

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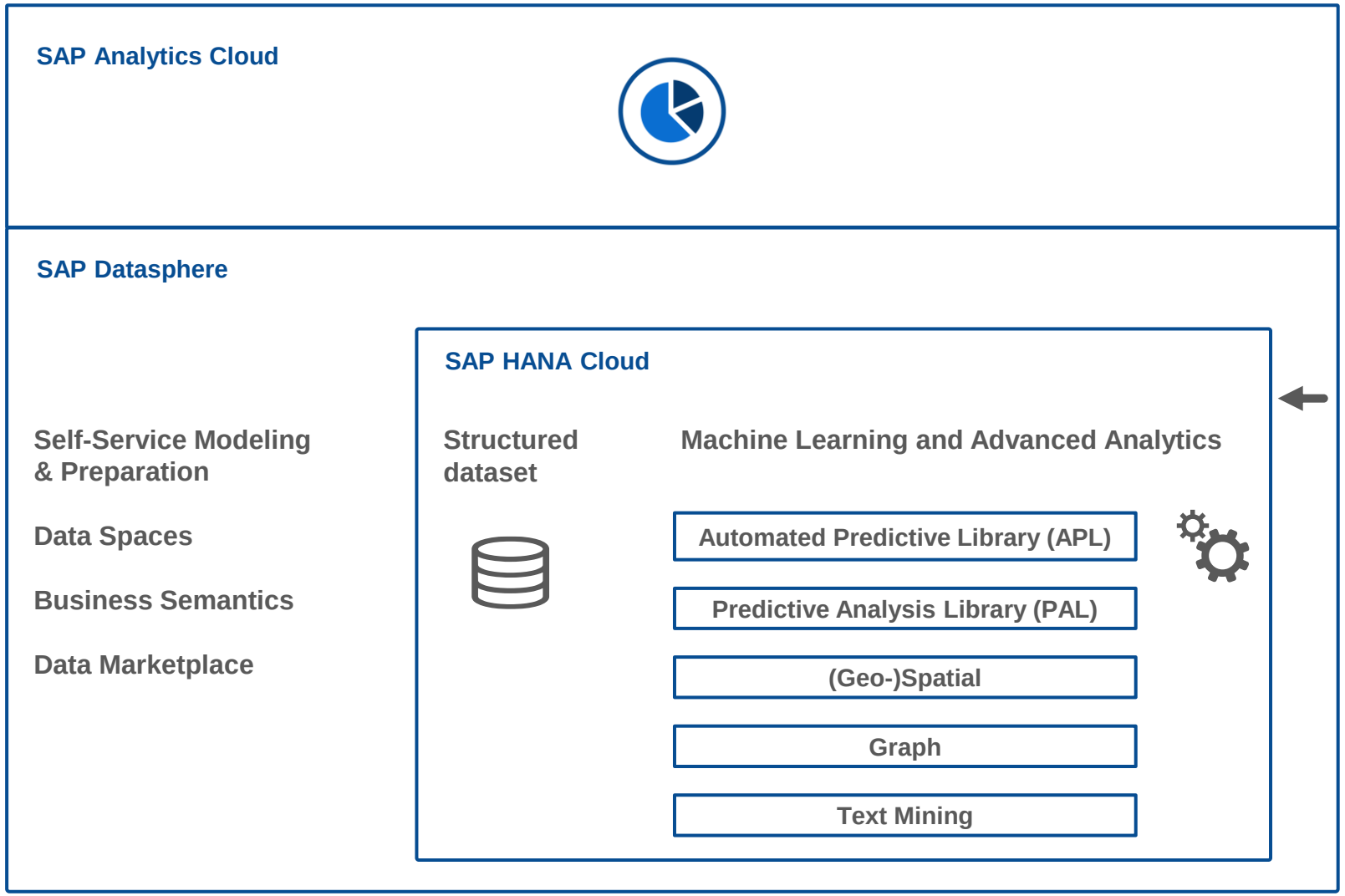
# SAP Datasphere / SAP HANA Cloud

## Embedded Machine Learning and Advanced Analytics




Data Science enrichment in SAP Datasphere, without data extraction

jupyterlab

DBeaver

SAP Business Technology Platform

.. and many others…

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# SAP Datasphere / SAP HANA Cloud

## Typical Scenarios Addressed with embedded Machine Learning

### Machine Learning Categories

Predicting customer behavior like churn, fraud or buying behavior (**classification**)

Predicting car prices, based on model characteristics and market trends (**regression**)

Enabling marketers to develop targeted marketing programs by grouping customers (**clustering**)

Provide personalized product recommendations by analyzing product associations, individual purchase history and external factors (**recommender system**)

Forecasting future sales, demand, cost, etc. based on historic time related data (**time series forecasting**)

Analyzing shopping baskets to suggest product placements or additional purchases to a customer (association analysis)

Detecting anomalies in financial transactions for fraud analysis, or in machine sensor data for predictive maintenance (**outlier detection**)

In a given social network, you seek to infer which new interactions among its members are likely to occur in the near future (link analysis / prediction)

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# SAP Datasphere / SAP HANA Cloud

Automated or hand-crafted Machine Learning

## Automated Predictive Library (APL)

- Framework that scales the use of Machine Learning
- Covers steps from variable selection, data preparation,  variable encoding, missing value handling, outlier handling, binning and banding, model testing and best model selection
- **Proprietary framework**, with global and local explainability

**Classification**

**Regression**

**Time series forecasting**

**Cluster analysis**

**Association analysis**

**Outlier detection**

**Recommender System**

**Link prediction**

## Predictive Analysis Library (PAL)

- Expert algorithm library, with over **100 classic and trending machine learning algorithms**
- Individual algorithms with full control for Data Scientists
- Requires manual insight, ie for parameterization
- Highly reproducible
- AutoML based on PAL in development (currently in beta)

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# SAP Datasphere / SAP HANA Cloud

## Predictive Analysis Library (PAL)

### Classification Analysis

- Decision Tree Analysis (CART, C4.5, CHAID) , Logistic Regression, Support Vector Machine, K-Nearest Neighbor, Naïve Bayes, Confusion Matrix, AUC, **Online multi-class Logistic Regression***
- Multilayer Perception (back propagation Neural Network)
- Random Decision Trees, Hybrid Gradient Boosting Tree (HGBT)[#,], **Continuous HGBT***
- Unified Classification[#] incl. explainability, **segmented (massive) classification**

### Regression

- Multiple Linear Regression, **Online Linear Regression***
- Polynomial-, Exponential-, Bi-Variate Geometric-, Bi-Variate Natural Logarithmic-Regression
- Generalized Linear Model (GLM)
- Cox Proportional Hazards Model
- Random Decision Trees, Hybrid Gradient Boosting Tree (HGBT) [#], **Continuous HGBT***
- **Unified Regression* incl. explainability, segmented (massive) regression**

### Pipeline and AutoML

- **Pipeline-models, -fit and -predict**
- **AutoML incl. data preprocessing, classi-fication, regression, time series forecasting**

### Cluster Analysis

- K-Means, Accelerated K-Means, K-Medoids, K-Medians, Geo- / DBSCAN, Agglomerate Hierarchical Clustering*****, Slight Silhouette, Cluster Assignment
- Kohonen Self-Organizing Maps, Affinity Propagation, Gaussian Mixture Model
- **segmented (massive)** Unified Clustering[#], **Spectral clustering***

### Time Series Analysis

- Single-, Double-, Triple-, Brown-, Auto Exponential Smoothing, **Unified Exponential Smoothing (incl. massive segmentation)***
- Auto-ARIMA, **Online ARIMA*, Vector-ARIMA*, ARIMA_EXPLAIN***
- Additive Model Analysis[#], **GARCH*, BSTS***
- Croston, **Croston TSB***, Linear Regression with damped trend and seasonal adjust, **Intermittent Time Series Forecast***
- Fast Dynamic Time Warping[#] , **DTW***, Hierarchical Forecasting
- FFT, **Discrete Wavelet/ Wavelet Packet Transform*, Periodogram***
- White Noise-, Trend-, **Stationary-***, Seasonality-Test, Change Point Detection, **Bayesian Change Point Detection***, **Outlier Detection*, TS Imputation***, Forecast Accuracy Measures
- **LSTM*, Attention*, LTSF***
- **Segmented (massive) Forecasting***

### Association Analysis

- Apriori, Apriori Lite, FP-Growth
- K-Optimal Rule Discovery (KORD) Discovery, Sequential Pattern Mining

### Link Prediction

- Link Prediction (Common Neighbors, Jaccard's Coefficient, Adamic/Adar, Katzβ), PageRank

### Recommender Systems

- Factorized Polynomial Regression Models, Alternating least squares, Field-aware Factorization Machines (FFM)

### Text Processing

- Conditional Random Field, Latent Dirichlet Allocation
- **TF-IDF*, term analysis*, text classification*, get related terms / documents*, get relevant terms / documents*, get suggested terms***

### Data Preprocessing

- Sampling, Partitioning, SMOTE, TomekLink, SMOTETomek[#]
- Binning / Discretize, Missing Value Handling, Scaling, **Feature Selection***
- **Isolation Forest***

### Statistical & Multivariate Analysis

- Univariate Analysis (Data Summary, Mean, Median, Variance, Stand. Deviation, Kurtosis, Skewness, ..)
- Kernel Density Estimation, Entropy
- Correlation Function (**with confidence**)
- Multivariate Analysis (Covariance Matrix, Pearson Correlations Matrix), Condition Index
- Principal Component Analysis (PCA)/PCA Projection, TSNE**, Categorial PCA**
- Linear Discriminant Analysis
- Multidimensional scaling, Factor Analysis
- Chi-squared Tests: Quality of Fit, Test of Independence, ANOVA, F-test (equal variance test)
- One-sample Median Test, T Test, Wilcox Signed Rank Test, **Kolmogorov-Smirnov Test***
- Inter-Quartile Range, Variance Test, Grubbs Outlier Test , Anomaly Detection (KMeans)
- Random Distribution Sampling, Markov Chain Monte Carlo (MCMC)[#]
- Distribution Fitting, Cumulative Distribution Function, Distribution Quantile

Misc. Functions

- Kaplan-Meier Survival Analysis, Weighted Scores Table, ABC Analysis, Tree model visualization[#]

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SAP HANA Predictive Analysis Library documentation 

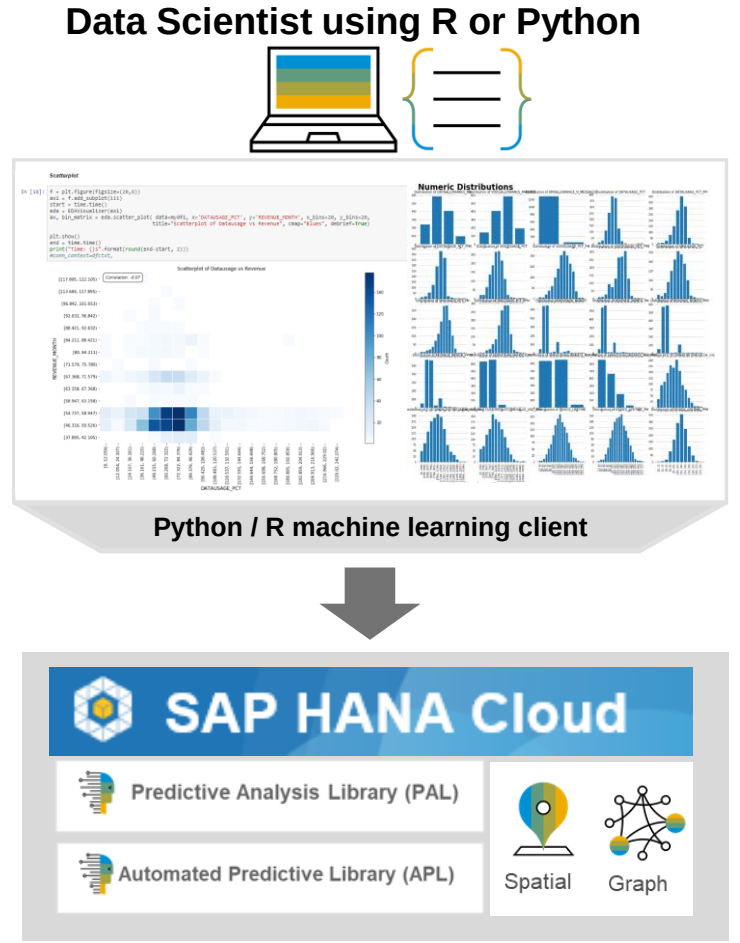
[#]SAP HANA 2 SPS05 & HANA Cloud | *SAP HANA 2 SPS06 & HANA Cloud | *New in SAP HANA Cloud | As of SAP HANA Cloud 2022 Q3 (CE2022.30))

# SAP HANA – Machine Learning

Python/R Machine Learning interfaces for Data Scientists

## Leveraging SAP HANA's data science capabilities

- Allow **scripting in Python or R**, while instructing remote processing of data and advanced analytics in SAP HANA Cloud
- Use the **HANA dataframe** object as virtual data reference for data preprocessing, transformation and analysis, including exploratory data analysis (EDA) visualizations
- Leverage the **Predictive Analyis Library (PAL)** in **Python / R**, allowing the expert Data Scientists a simple conversion from standard Python-packages to HANA embedded ML models and their operationalization
- **Automated Predictive Library (APL)** functions exposing SAP HANA's AutoML and non-expert predictive functions in **Python**
- Model storage and ML model performance reports
- Leverage SAP HANA **Spatial** and **Graph** capabilities in **Python**




Learn how to get started with PAL and SAP HANA Cloud, APL and SAP HANA Cloud see Python samples.

Python machine learning client documentation here
R machine learning client documentation here

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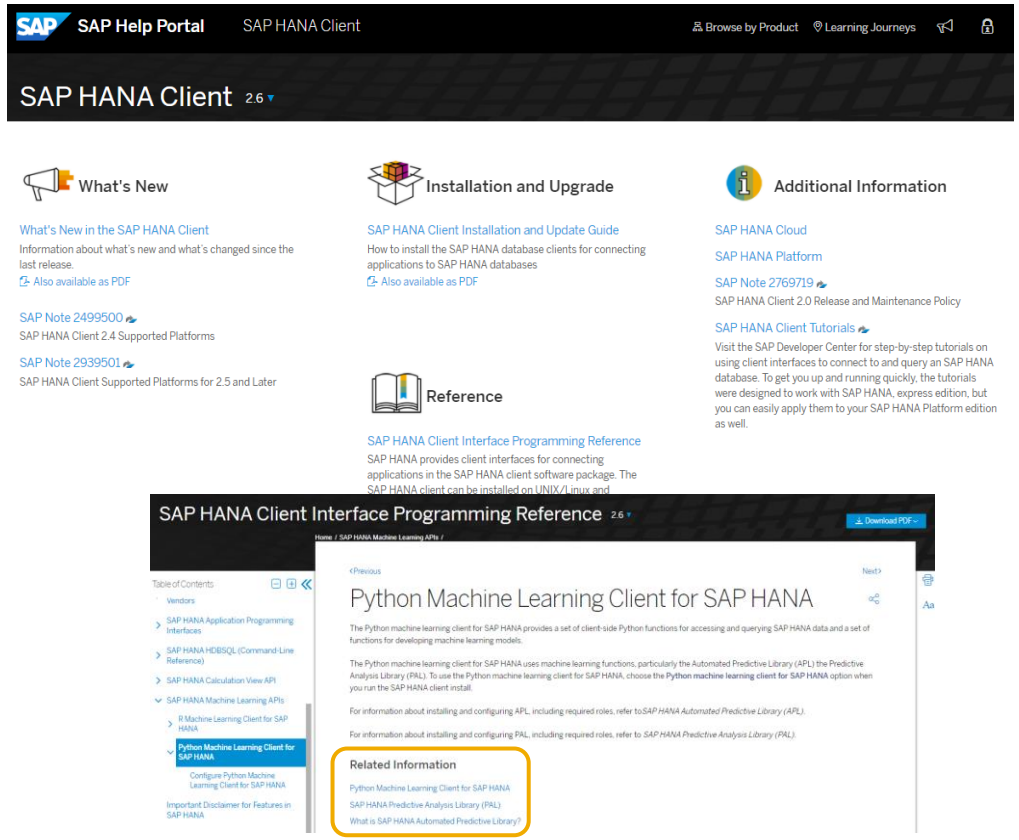
# SAP HANA – Machine Learning

## Python/R Machine Learning interfaces for Data Scientists

- Native SAP HANA database client* for ODBC / JDBC / Python / … see SAP Note 2939501
  - Documentation https://help.sap.com/viewer/product/SAP_HANA_CLIENT/latest
  - Available for developers and data scientists from tools.hana.ondemand.com/#hanatools
  - Expanded client distribution channels for Python client https://pypi.org/project/hdbcli/

```
hdbcli 2.11.14
pip install hdbcli
```




- Native Python machine learning client for SAP HANA Cloud
  - Exposing SAP HANA data as HANA dataframe in Python
  - Remote use of SAP HANA's machine learning-, spatial- and graph functions in Python
  - Available with SAP HANA Client download + expanded distribution via PyPi https://pypi.org/project/hana-ml/

```
hana-ml 2.11.22010700
pip install hana-ml
```

*support for SAP HANA Cloud and SAP HANA Platform

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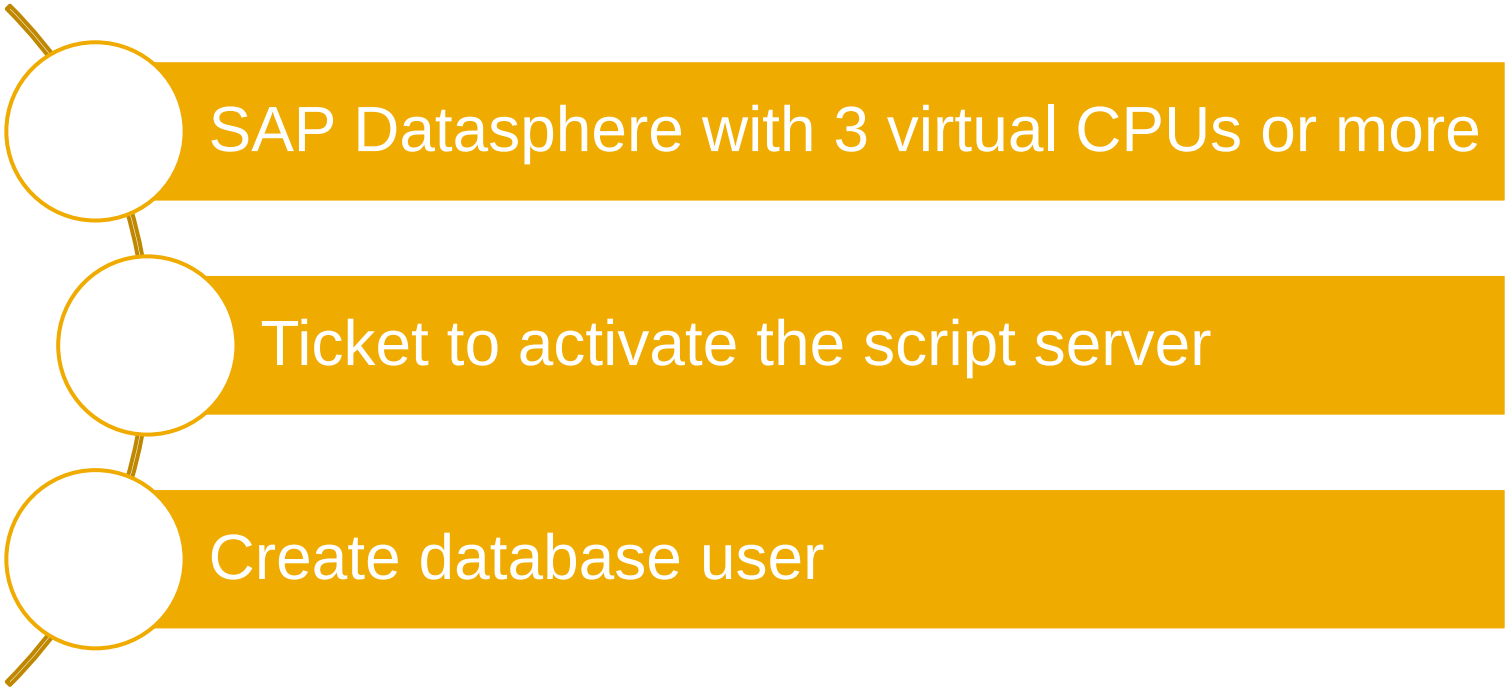
# Setup

Machine Learning in SAP Datasphere

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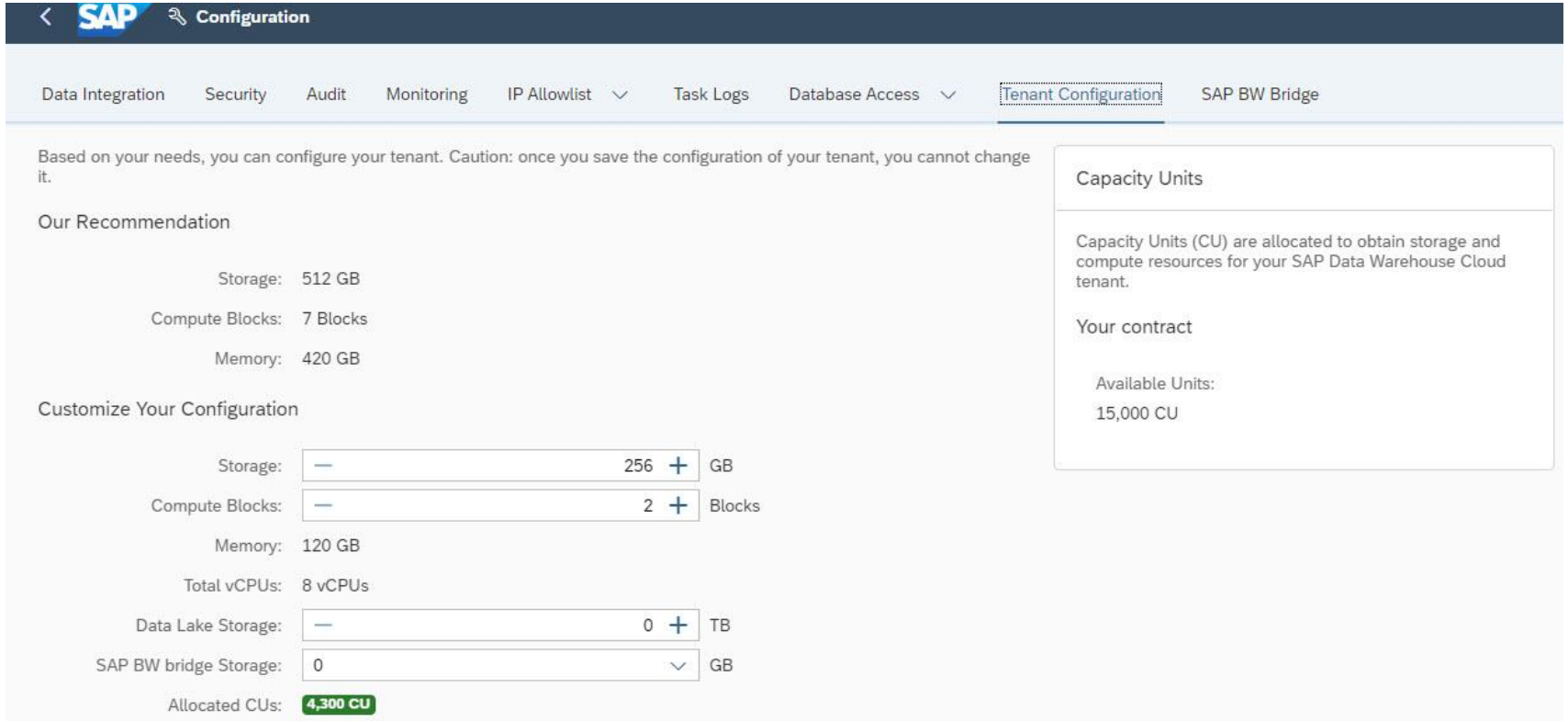
# 3 virtual CPUs or more

## Cloud setup 1 / 3




**Blog:** Configure the Size of Your SAP Data Warehouse Cloud Tenant
https://blogs.sap.com/2022/02/18/configure-the-size-of-your-sap-data-warehouse-cloud-tenant/

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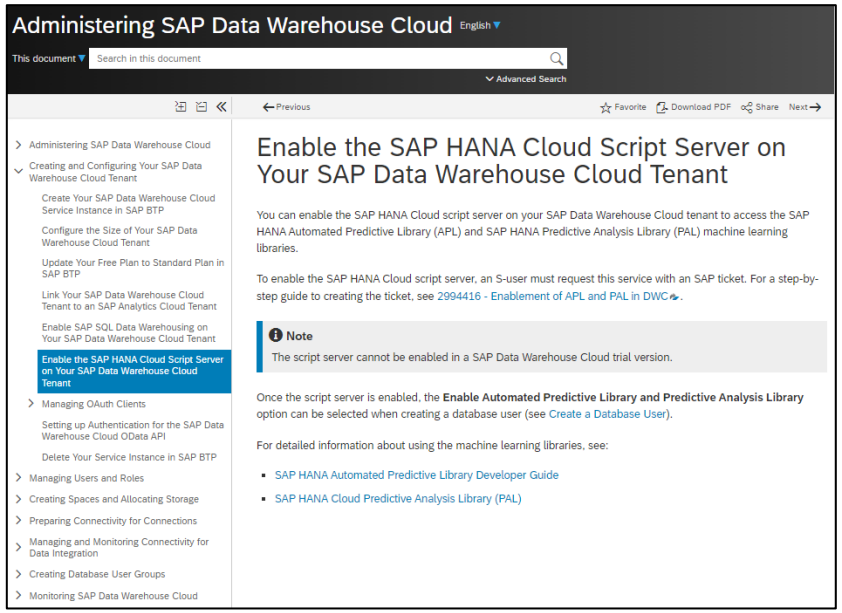
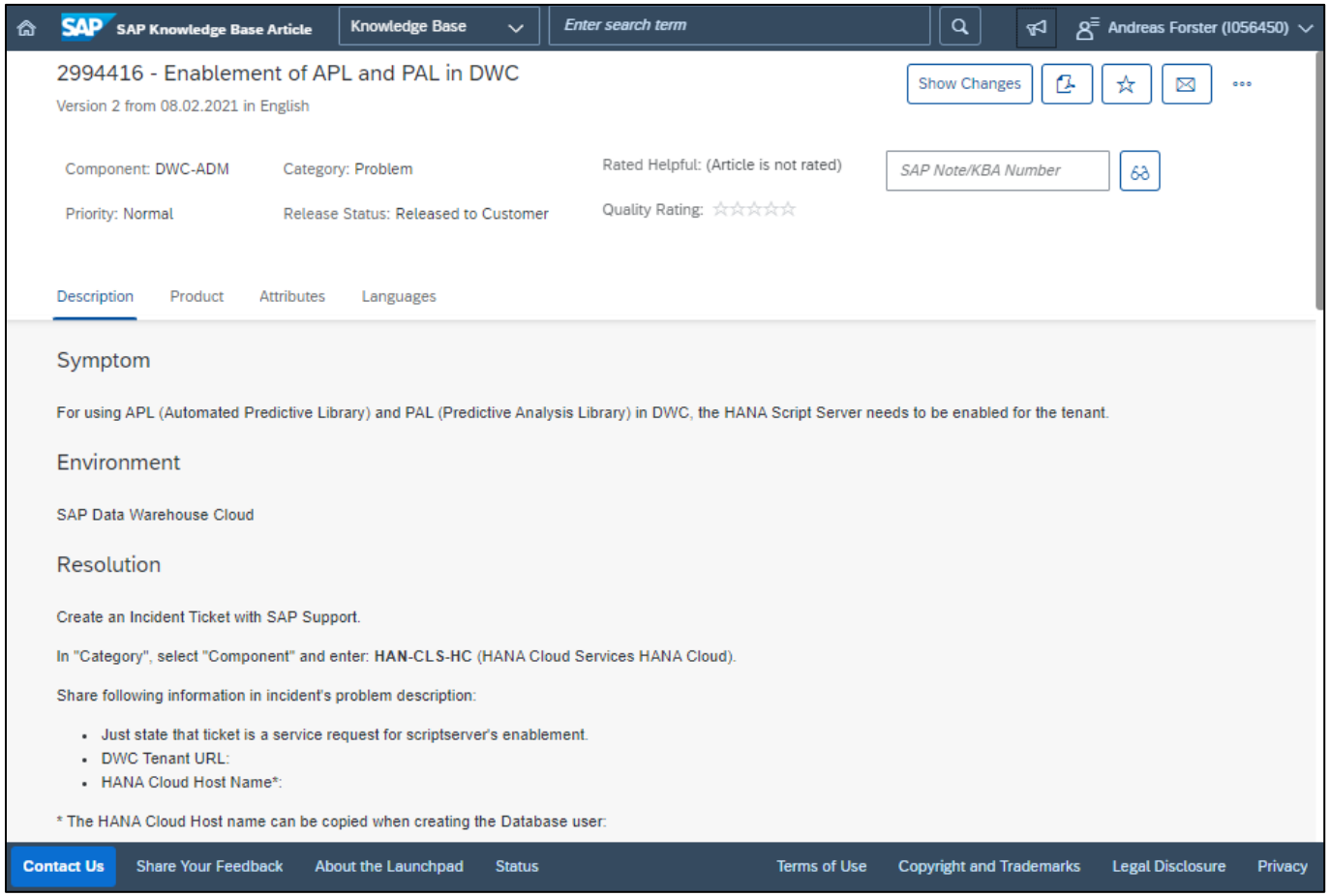
# Ticket to activate the script server

Cloud setup 2 / 3




No additional APL/PAL installation required




**SAP Note 2994416: Enablement of APL and PAL in DWC**

https://launchpad.support.sap.com/#/notes/2994416

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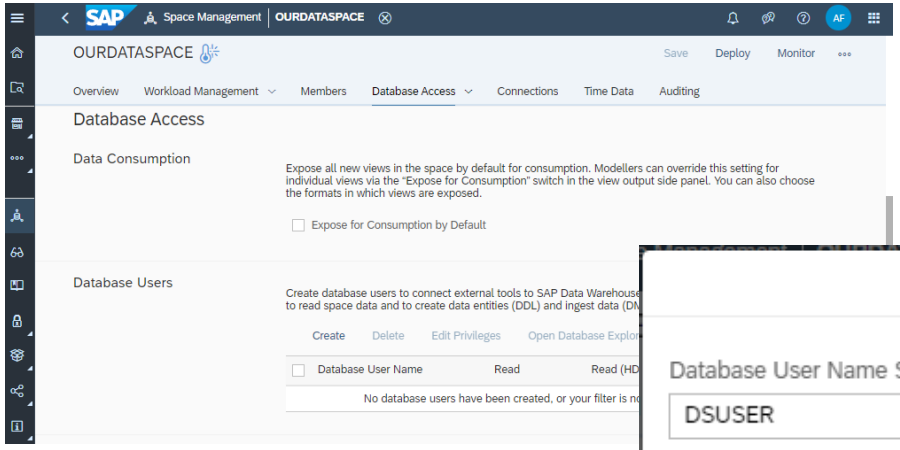
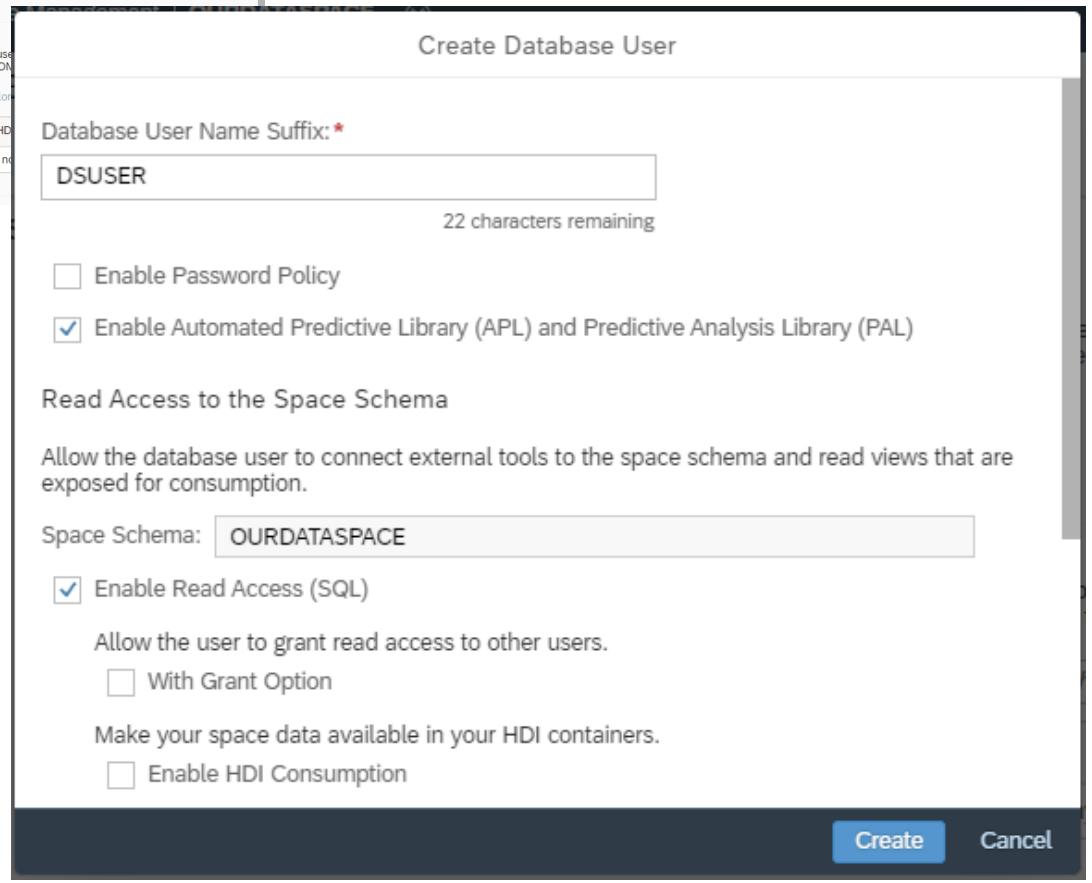
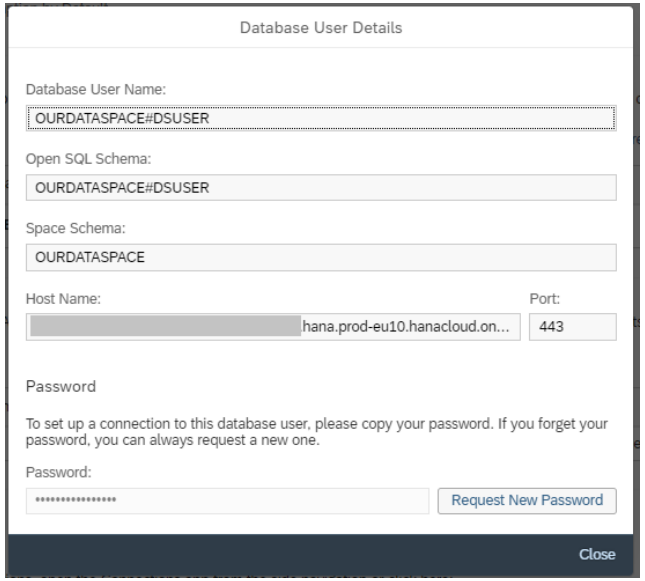
# Create database user

## Cloud setup 3 / 3

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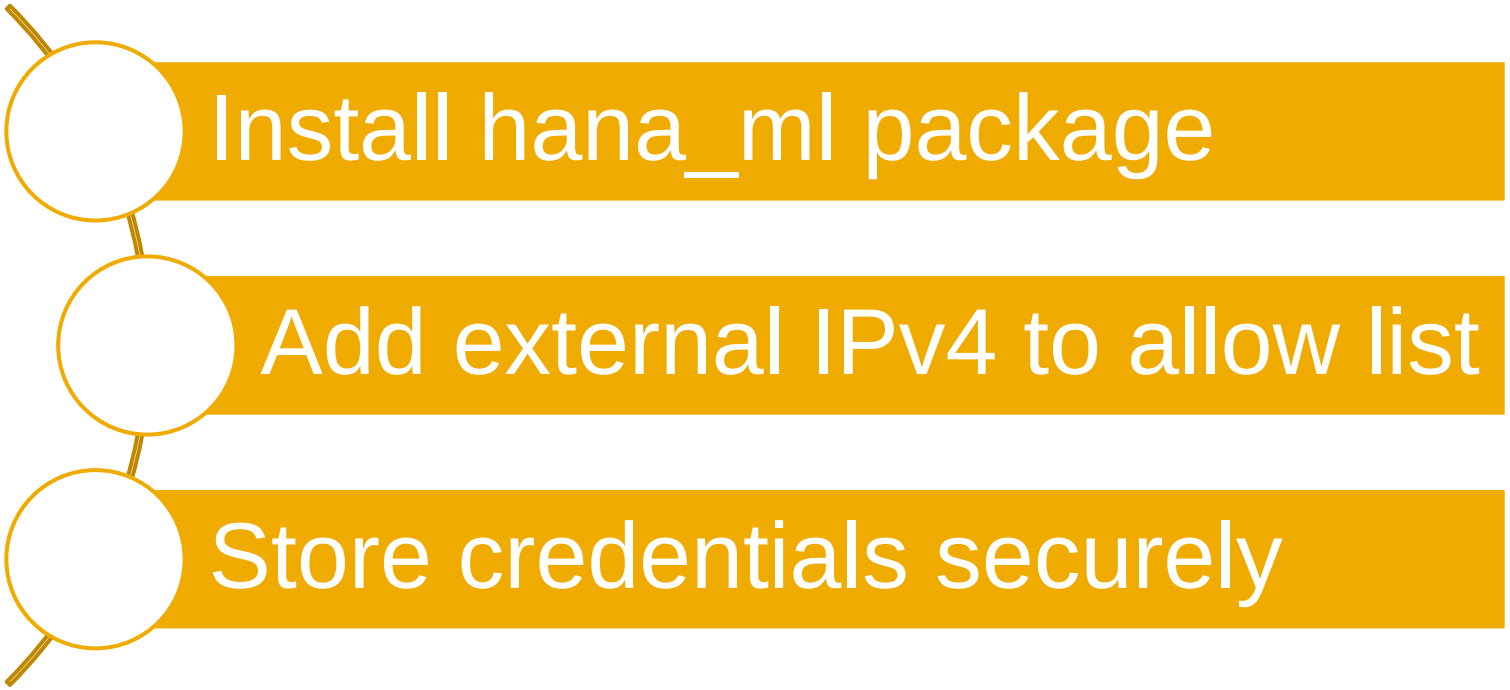
# Client Setup (Python)

Machine Learning in SAP Datasphere

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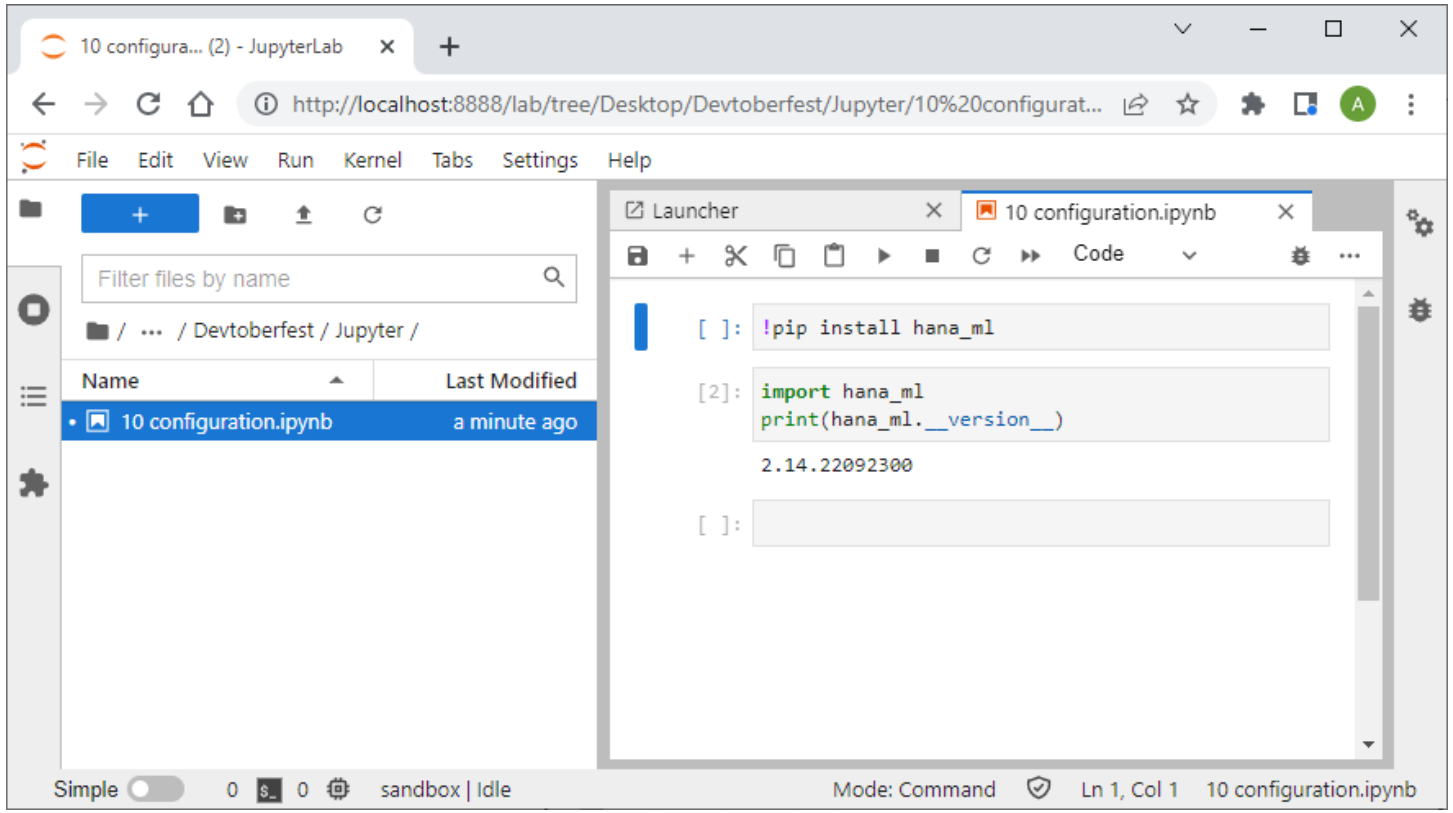
# Install Python Machine Learning Client for SAP HANA (hana_ml package)

Client setup 1 / 3




**The Python Package Index (PyPI):**
https://pypi.org/project/hana-ml/

**Documentation:**
https://help.sap.com/doc/1d0ebfe5e8dd44d09606814d83308d4b/latest/en-US/index.html

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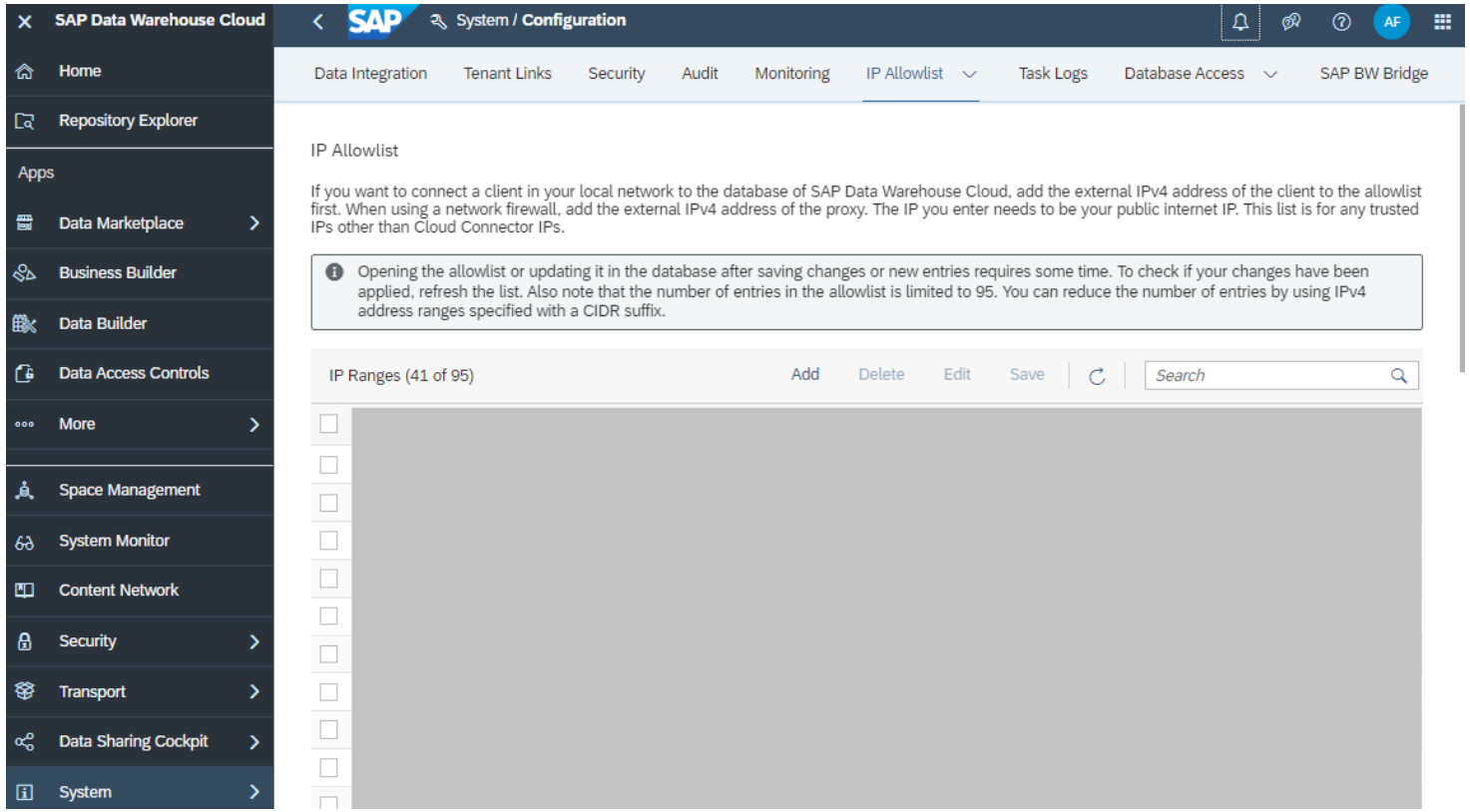
# Add external IPv4 address to allow list

Client setup 2 / 3

- Get your **external** IPv4 address, ie from a site like https://www.showmyip.com/
- 192.168.0.0 to 192.168.255.255 is **not** an external IP address
- Add the address to the allow list in SAP Datasphere in System → Configuration

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# Store credentials securely

Client setup 3 / 3 (optional, but recommended)

## 1) Test connection from Python to SAP Datasphere with hardcoded credentials

```
import hana_ml.dataframe as dataframe
conn =dataframe.ConnectionContext(address='                                    .hana.prod-eu10.hanacloud.ondemand.com',
                                  port=443,
                                  user='OURDATASPACE#DSUSER',
                                  password='                                   ')
conn.connection.isconnected()
```

```
True
```

## 2) Store credentials securely in the Secure User Store from the SAP HANA Client

## 3) Logon with these securely stored credentials

```
conn = dataframe.ConnectionContext(userkey='MYDWC')
conn.connection.isconnected()
```

```
True
```

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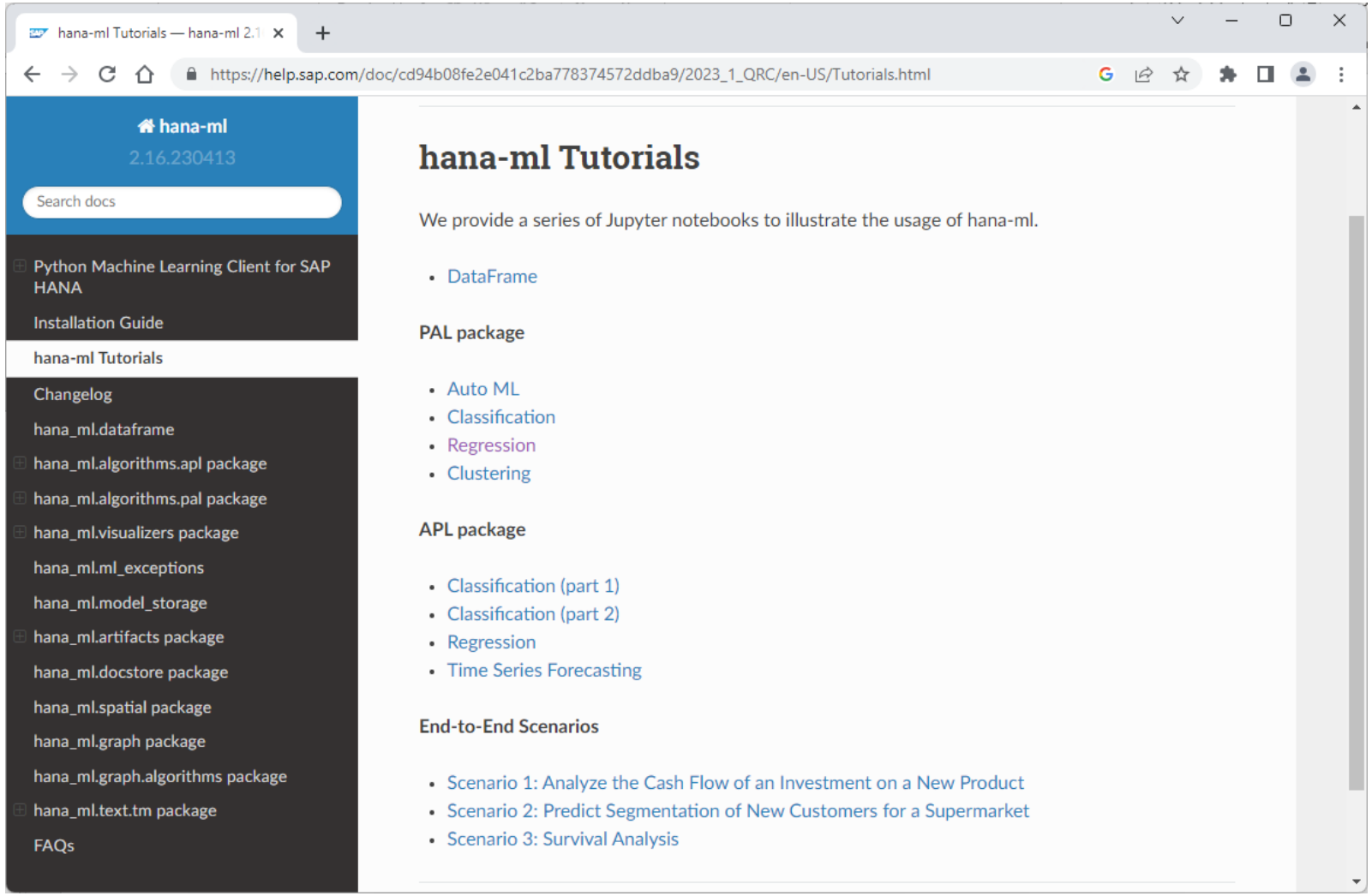
# Get Started

## Tutorials




https://help.sap.com/doc/cd94b08fe2e041c2ba778374572ddba9/latest/en-US/hana_ml.html

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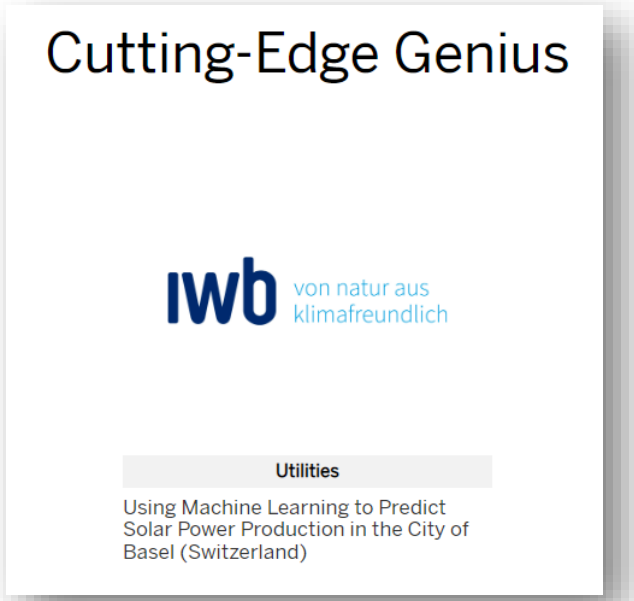
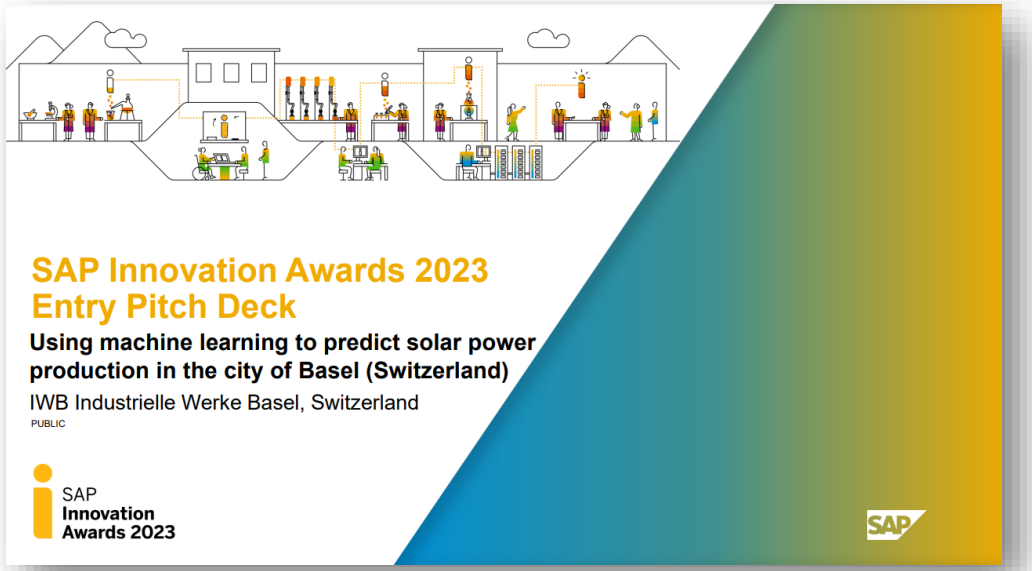
SAP Innovation Awards 2023

10th Anniversary




https://www.sap.com/idea-place/sap-innovation-awards/entries/2023-award.html

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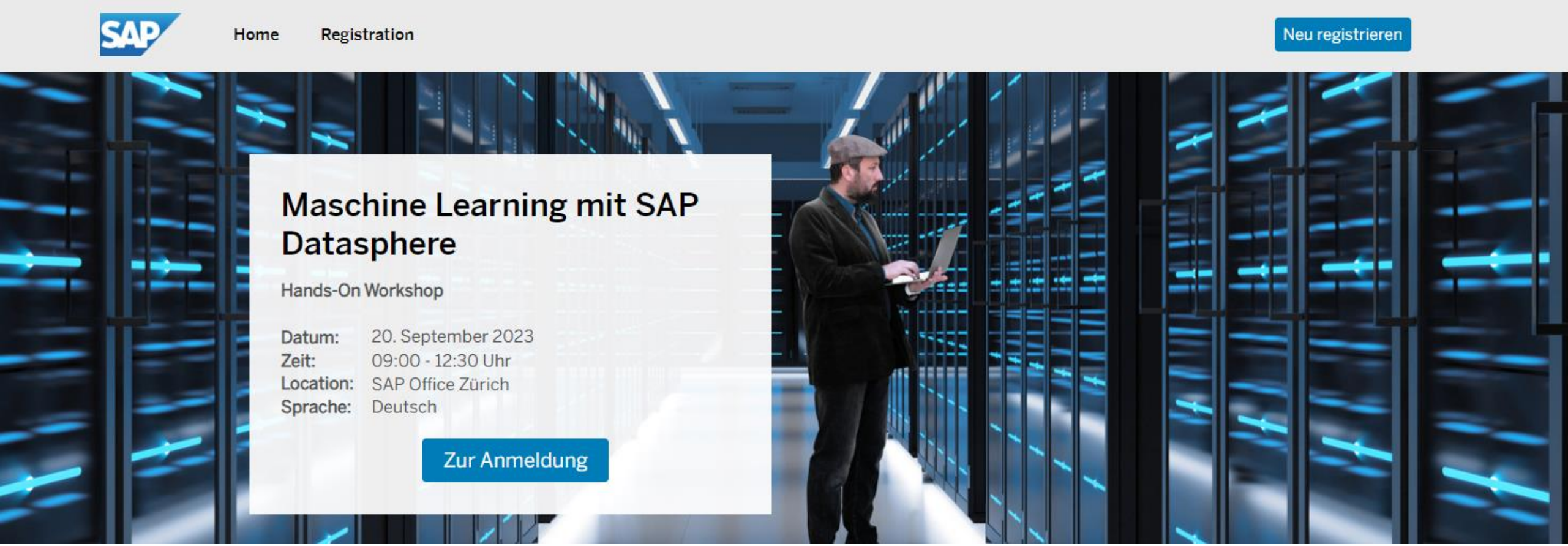


https://events.sap.com/ch/ml-sap-datasphere-workshop/de/home

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# Thank you.

**Andreas Forster**
andreas.forster@sap.com

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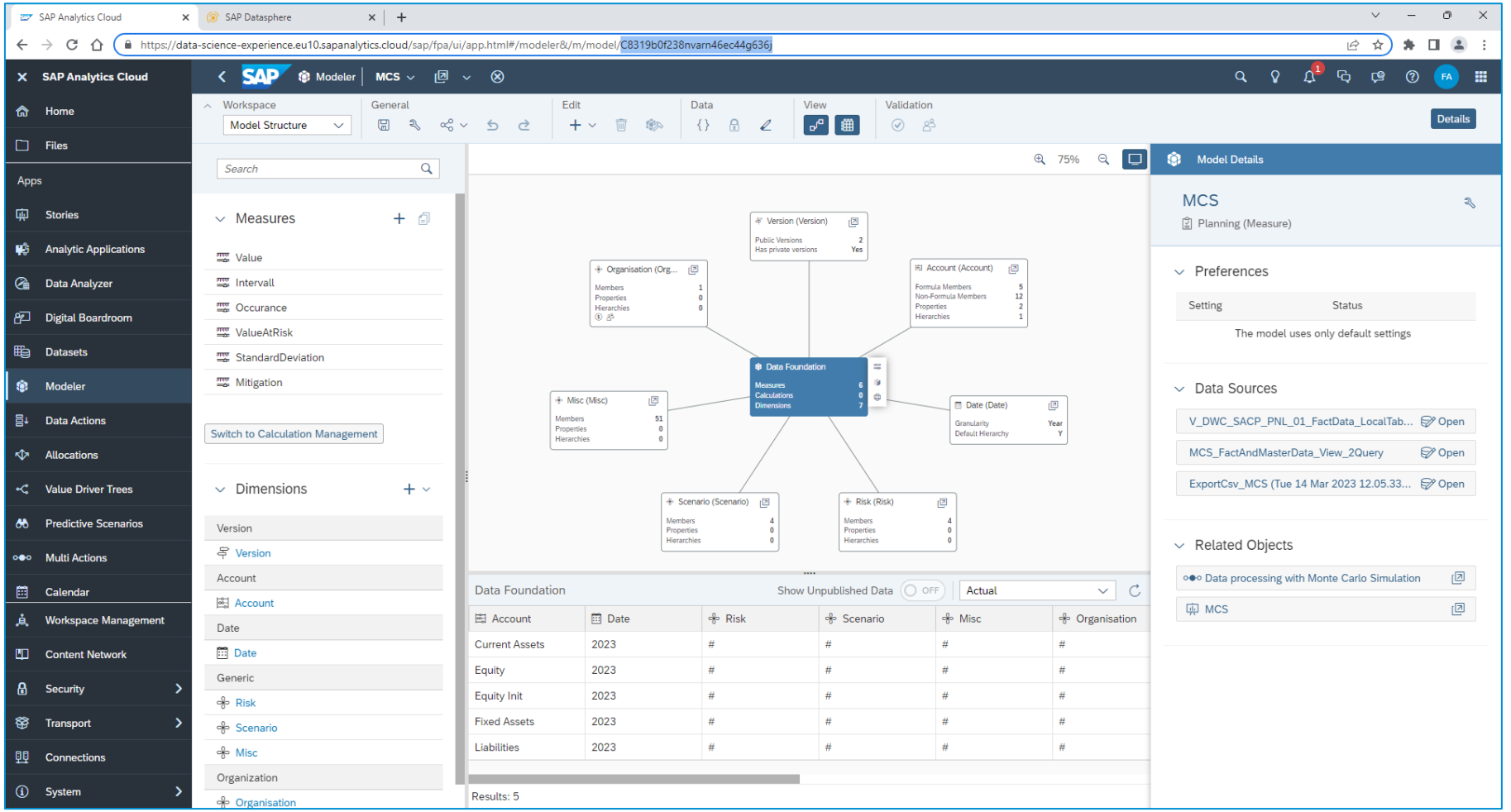
# Exposing SAC Planning input to SAP Datasphere

## SAC Planning model

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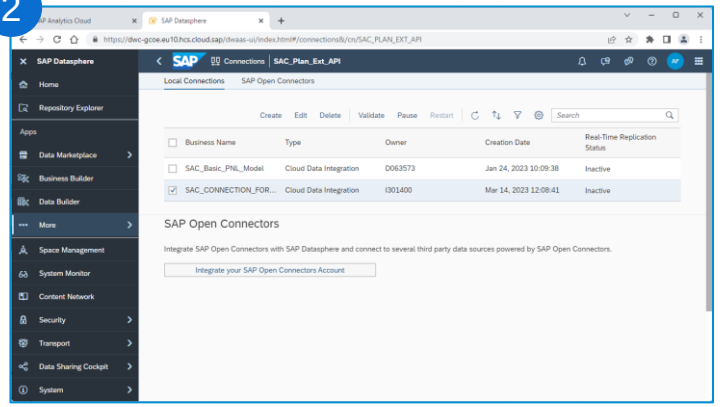
# Exposing SAC Planning input to SAP Datasphere

## SAP Datasphere connection

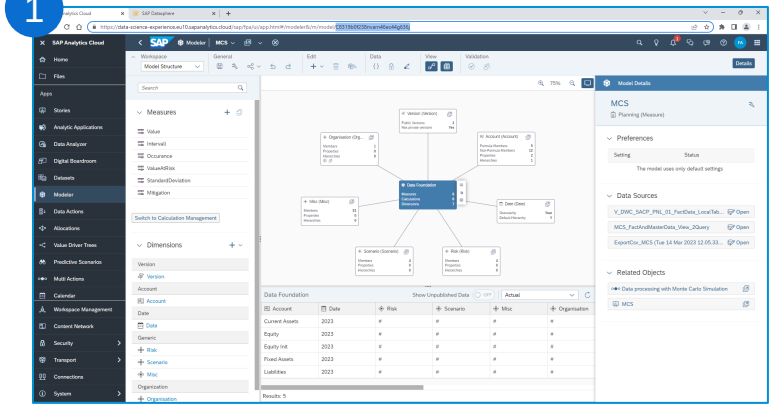
2




SAP Datasphere Connection

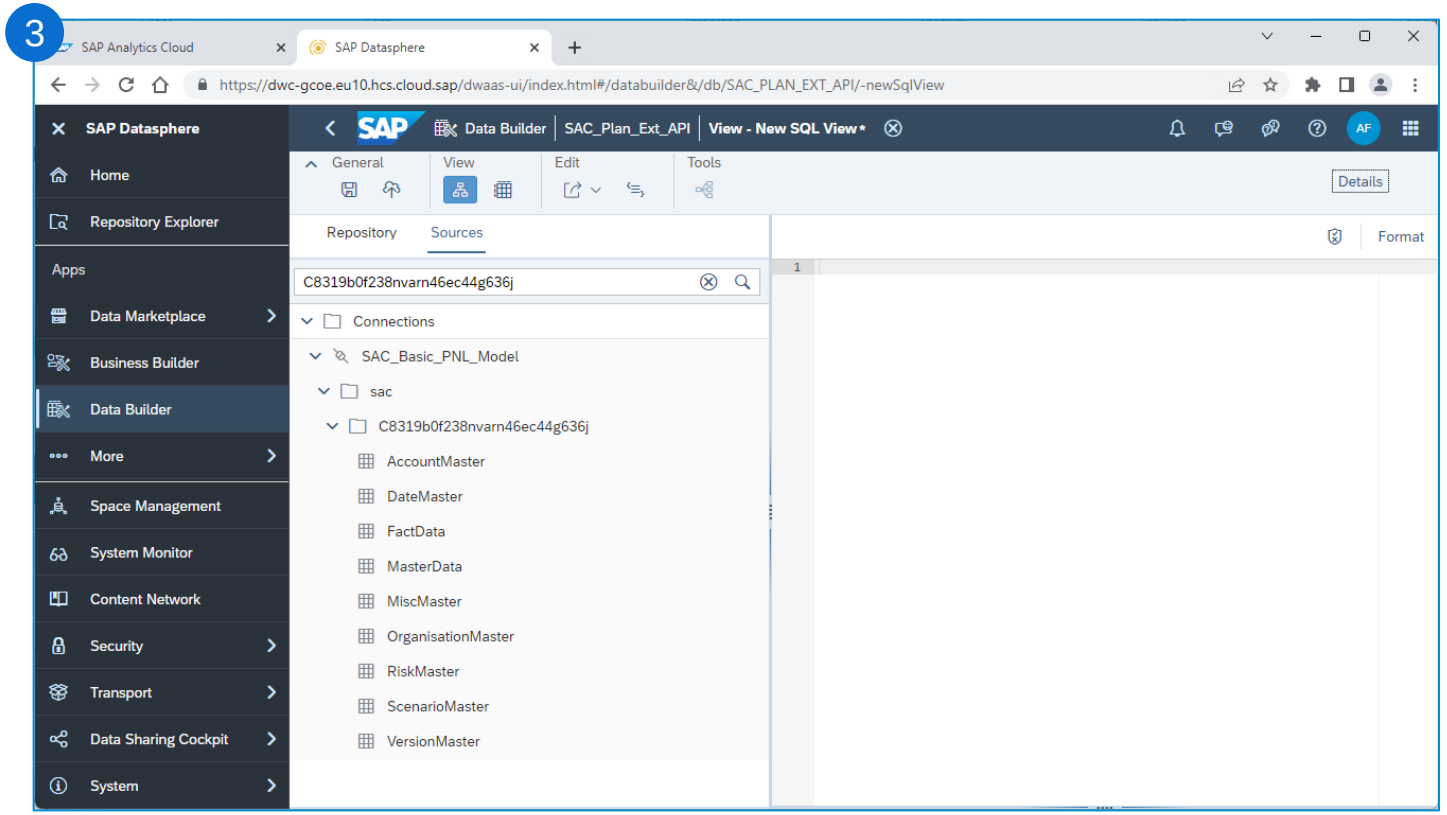
CDI / DPA

1



SAC Planning model

3




SAP Datasphere View to import a remote table

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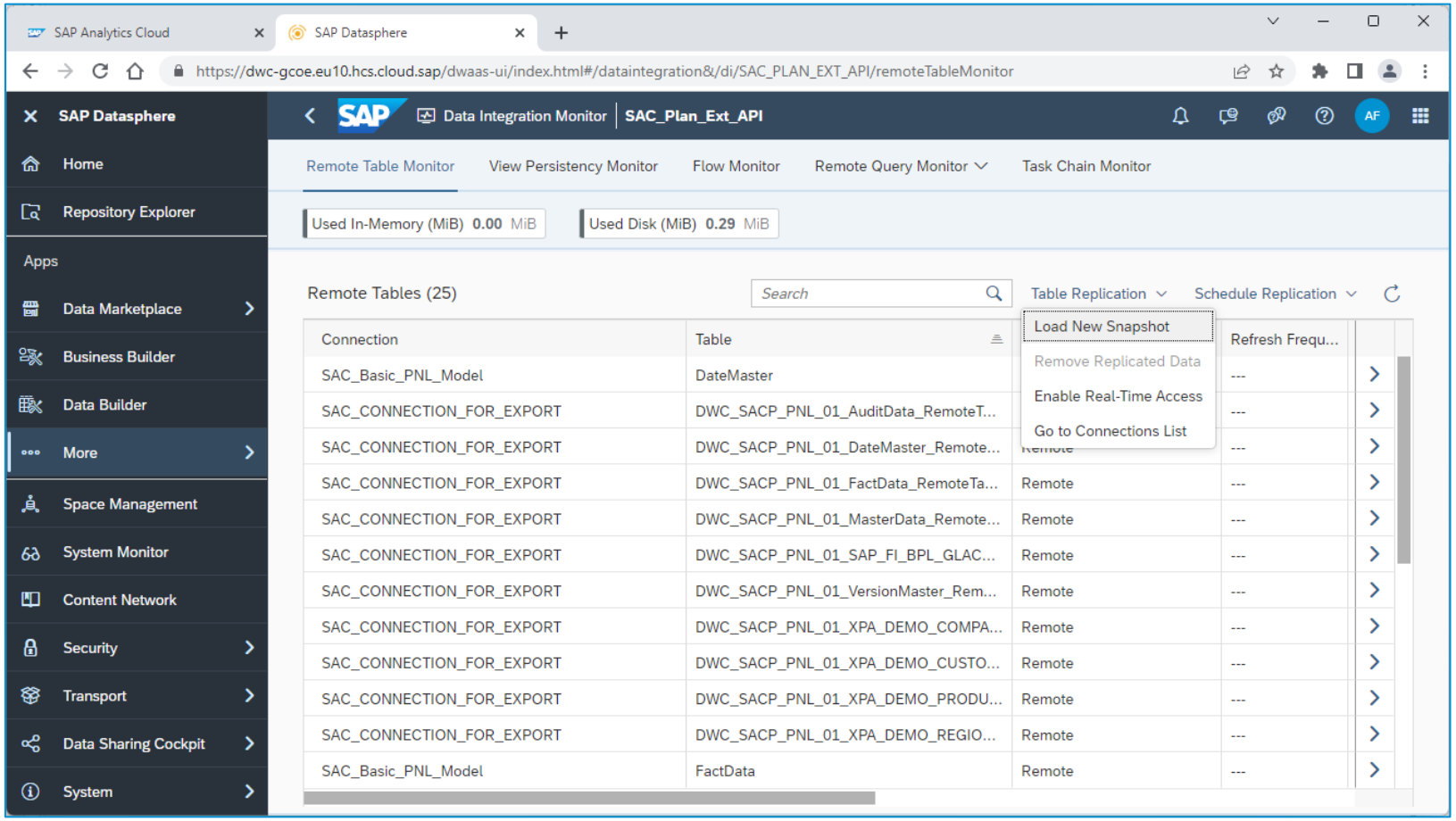
# Exposing SAC Planning input to SAP Datasphere

## Remote or replicated table




SAP Datasphere Data Integration Monitor

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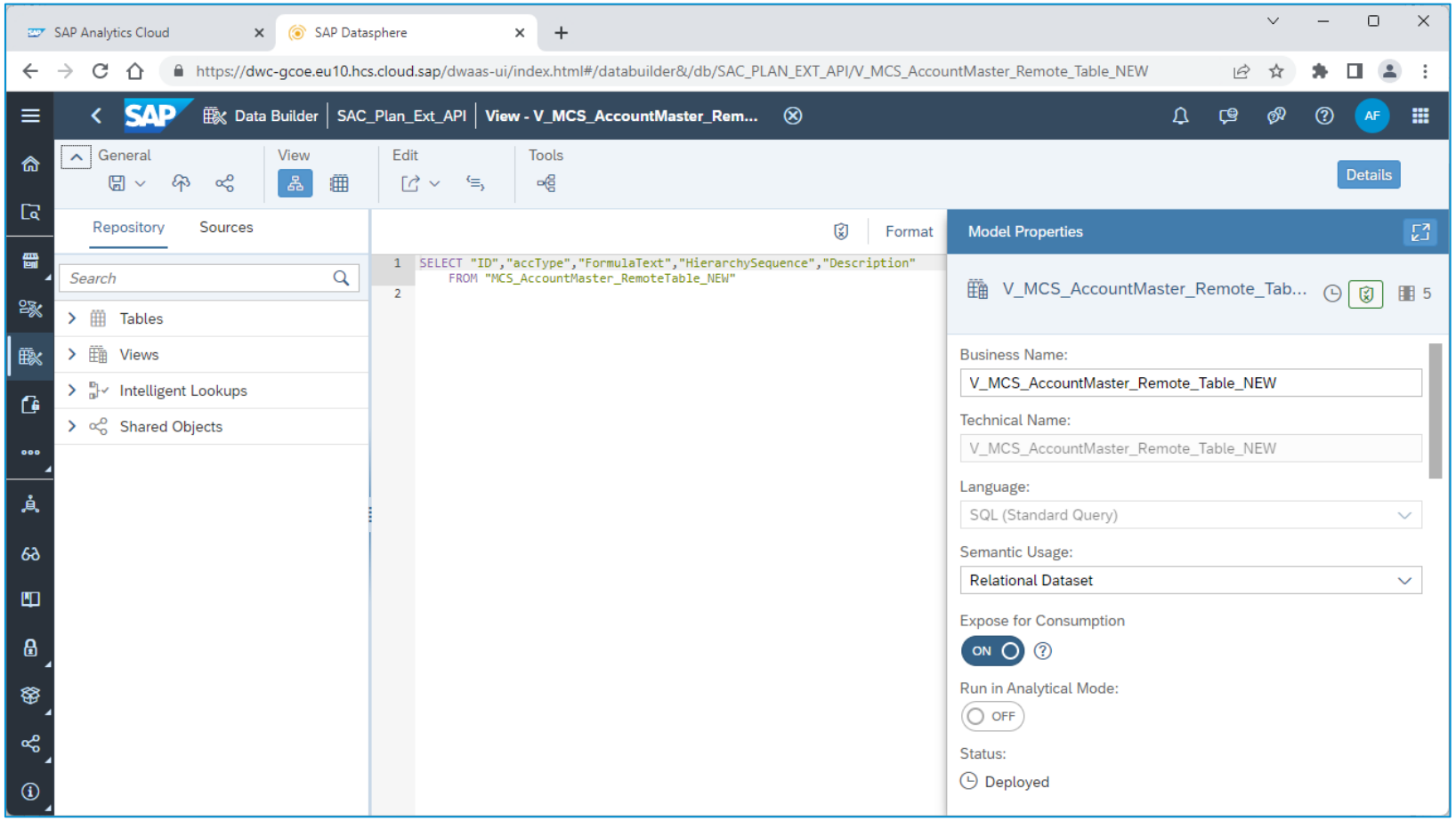
# Exposing SAC Planning input to SAP Datasphere

## Expose for consumption




SAP Datasphere Data Builder

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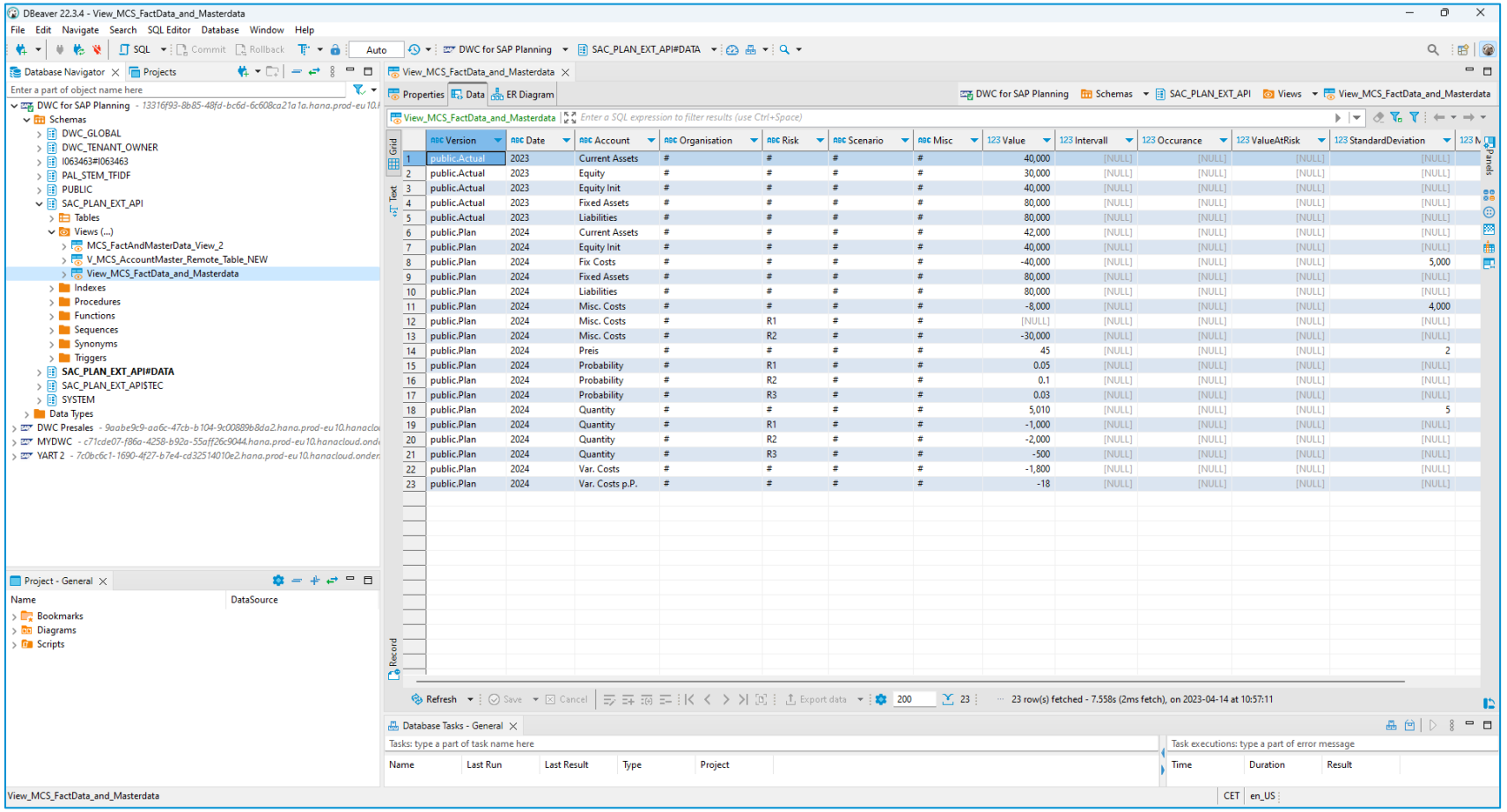
# Exposing SAC Planning input to SAP Datasphere

## Expose for consumption




Data is accessible from SAP HANA Database Explorer, DBeaver, SQL, etc…

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