



**AVEVAWORLD**  
PARIS

OCTOBER 2024

---

# Novartis Manufacturing Cockpit

Using AVEVA PI System

Andre Muller, Principal Automation Engineer

Uros Pudgar, Principal Automation Engineer

# Novartis Manufacturing Cockpit

Using AVEVA PI System

# Reimagining medicine

**Andre Muller**

Principal Automation Engineer  
Novartis Global ITOT

October 15, 2024

 **NOVARTIS** | Reimagining Medicine



# Disclaimer

- These slides are intended for educational purposes only and for the personal use of the audience.
- These slides are not intended for wider distribution outside the intended purpose without presenter approval.
- The content of this slide deck is accurate to the best of the presenter's knowledge at the time of production.
- No statement as part of this presentation shall be construed as a warranty or representation on the part of the presenter or Novartis

# About the presenter

## Andre Muller



André is part of the Global Novartis ITOT organization working in Automation and collaborating with all sites to enable relevant use cases to best benefit in the production of medicines.

André joined Novartis in 2002 at a manufacturing site and joined the Global Novartis Organization in 2006.

# Novartis is an innovative medicines company

Novartis consistently ranks among the world's top companies investing in R&D.<sup>1</sup>

**USD 8.6 bn**  
Core R&D spend in 2023 <sup>2</sup>



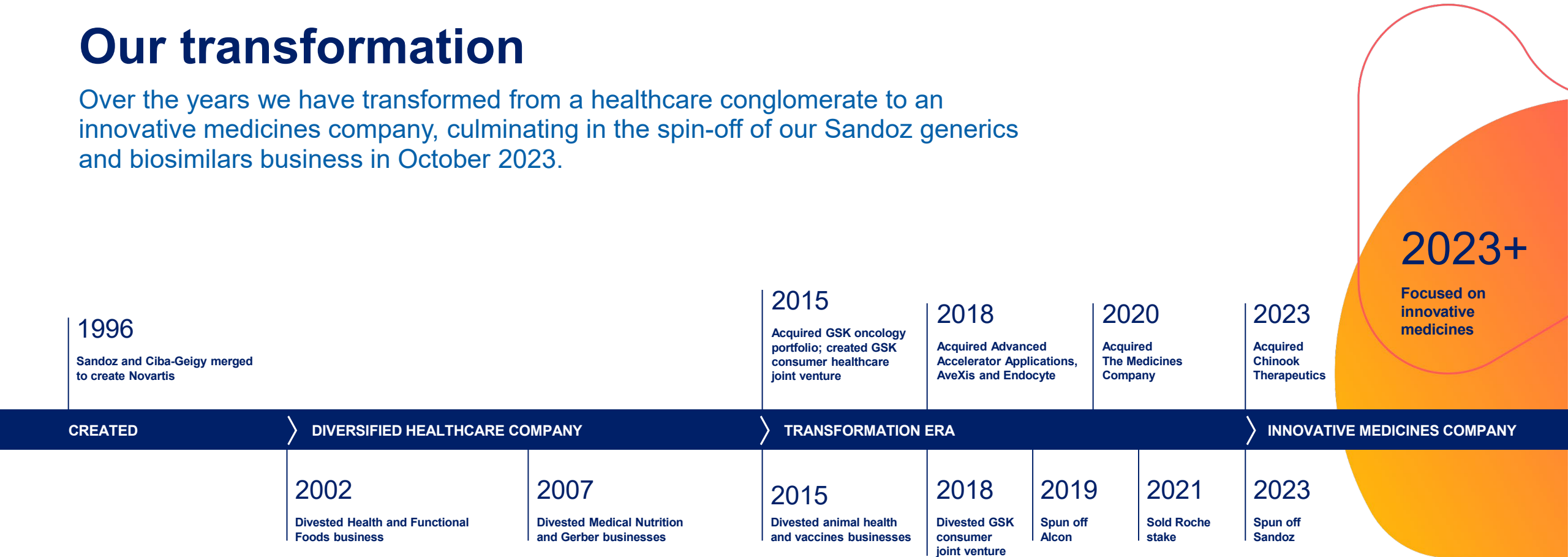
**USD 45.4 bn**  
Net sales in 2023

<sup>1</sup> All figures refer to continuing operations (i.e. excluding Sandoz).

<sup>2</sup> This presentation includes non-IFRS financial measures such as constant currencies and core R&D spend. A definition of non-IFRS measures used by Novartis, and further details, including reconciliation tables, can be found in "Item 5. Operating and Financial Review and Prospects" of the Novartis Annual Report 2023.

# Our transformation

Over the years we have transformed from a healthcare conglomerate to an innovative medicines company, culminating in the spin-off of our Sandoz generics and biosimilars business in October 2023.





# Our purpose and vision are supported by a strong culture with clear values



## Purpose

Reimagine medicine to improve and extend people's lives



## Vision

To become the most valued and trusted medicines company in the world



## Values and behaviors

Inspired. Curious. Unbossed. Integrity



# Millions of people worldwide benefit from our medicines

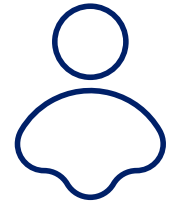
130



**Countries**

where Novartis medicines are distributed<sup>1</sup>

284 m



**Patients reached**

with our medicines

All figures refer to continuing operations (i.e. excluding Sandoz).

# Embed operational excellence

We aim to drive efficiency and free up resources to invest in innovation for patients. In everything we do, we maintain high standards of patient safety, while also working to reduce our environmental footprint

## Highlights | 2023

**19.8 bn**

treatments sold to third parties



**63%**

reduction in greenhouse gas emissions in our own operations since 2016



**50%**

reduction in water consumption in our own operations since 2016



All figures the refer to continuing operations (i.e. excluding Sandoz).

# Our achievements are gaining recognition

## Access to Medicine Index

Novartis has ranked in the leadership group for more than 10 years

## CDP

Novartis achieved Double A List status in Climate Change and Water Security (based on latest available results from 2022)

## Bloomberg Gender Equality Index

Novartis was included in 2023 for the fourth year in a row

## MSCI

Novartis maintained its AA rating in the 2023 MSCI ESG Ratings assessment.

1. All information based on 2023 data.

# MANUFACTURING COCKPIT 2

**Pudgar, Uros**

Principal Automation Engineer  
Novartis Global ITOT

October 15, 2024

 **NOVARTIS** | Reimagining Medicine

# About the presenter

## Uros Pudgar



Uros is part of Global Novartis ITOT Organization working on different use cases across several manufacturing sites.

He joined Novartis in 2017 at a manufacturing site and transitioned to the global Novartis organization in 2020.

He holds a Bachelor's degree in Computer Science and Electrical Engineering from University of Maribor, Slovenia.

# Novartis lays a foundation to help improve equipment efficiency by at least 5%

## Challenge

- **Standardization:** adopt global standards across all sites
- **Transparency:** siloed and locally managed data

## Solution

- **Use AVEVA™ PI System™** to centralize data and apply global standard guidelines for analytical calculations

## Results

- End to end link between shopfloor and Business Intelligence platform
- Strong foundation for improvement actions / continuously improving knowledge database
- Expected outcome to improve equipment efficiency by at least 5 %

# Agenda



## 1. About Manufacturing Cockpit

MACO in a nutshell



## 2. How it was done

Architecture design



## 3. How it looks like

MACO OT & BI



## 4. Benefits

What are the expected benefits





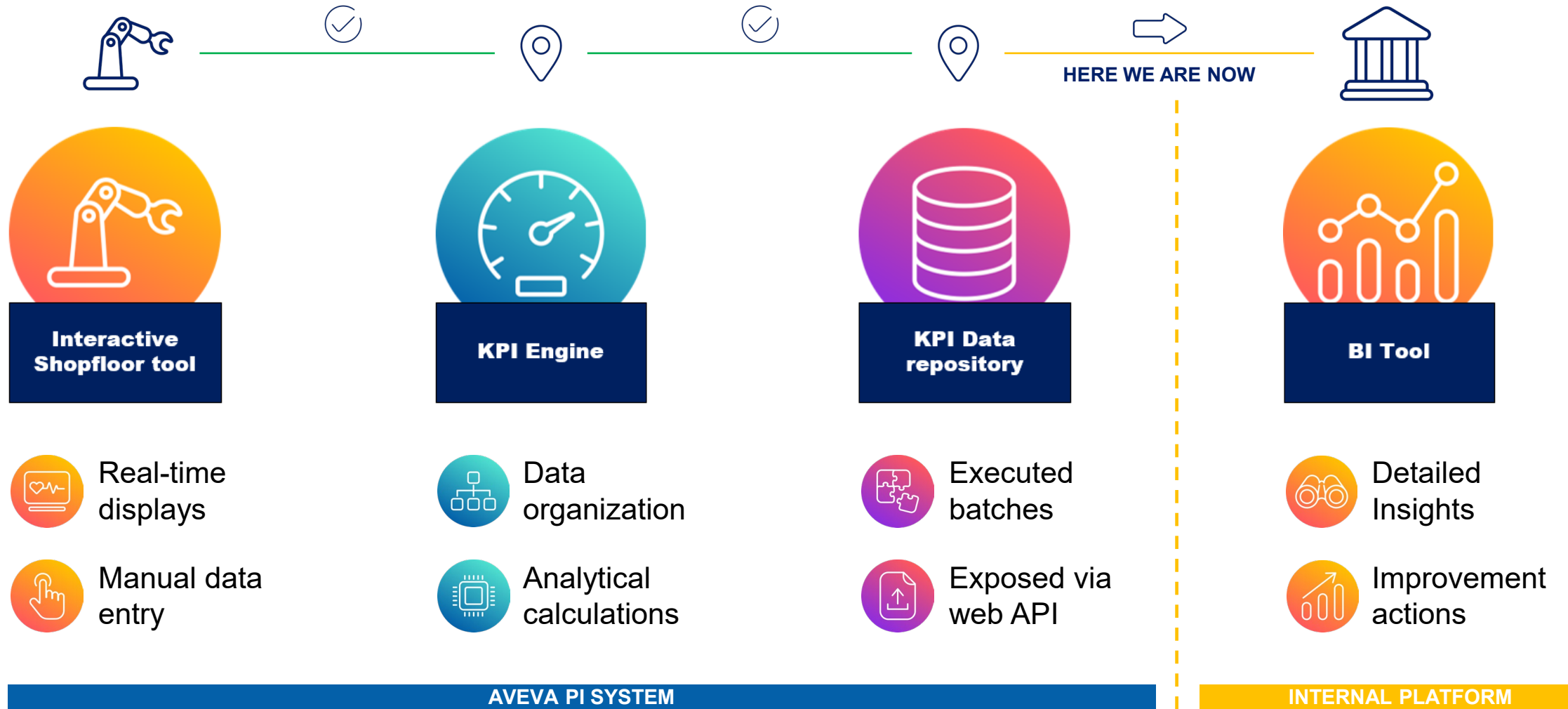
1

# About Manufacturing Cockpit

MACO in a nutshell

# About MACO

## FROM THE SHOP FLOOR TO THE TOP FLOOR



# 2.1

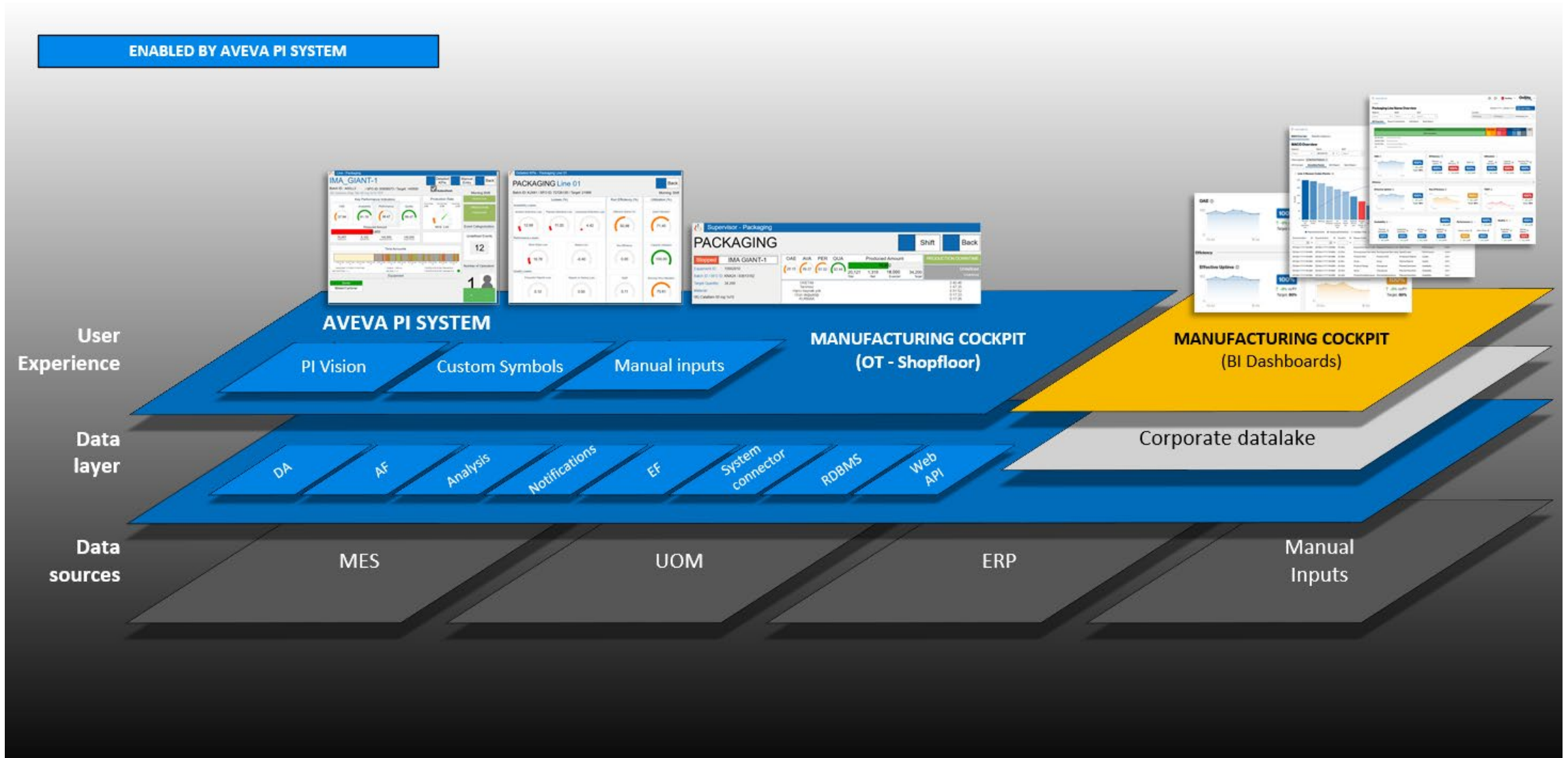
## Architecture Design

### 2.1 Datasources and PI Components

2.2 Interfaces / gathering data

2.3 Organizing and using the data

# Datasources & PI Components



# 2.2

## Architecture Design

2.1 Datasources and PI Components

**2.2 Interfaces / gathering data**

2.3 Organizing and using the data

# Interface 1 of 5: MES System

## MES

- Interface type: **RDBMS**
- Direction: One way
- Type of data:
  - SFO logbook
  - Equipment logbook

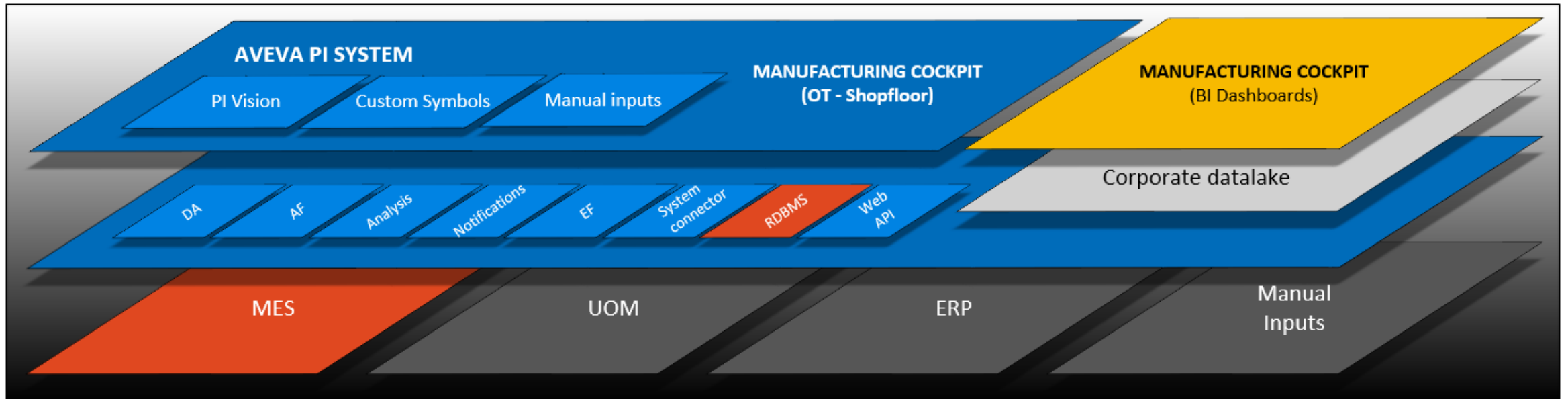
General	Archive	Classic	Security	System	
Location1:	<input type="text" value="1"/>	Conversion Factor:	<input type="text" value="1"/>	UserInt1:	<input type="text" value="0"/>
Location2:	<input type="text" value="0"/>	Filter Code:	<input type="text" value="0"/>	UserInt2:	<input type="text" value="0"/>
Location3:	<input type="text" value="1"/>	Square Root Code:	<input type="text" value="0"/>	UserReal1:	<input type="text" value="0"/>
Location4:	<input type="text" value="1"/>	Total Code:	<input type="text" value="0"/>	UserReal2:	<input type="text" value="0"/>
Location5:	<input type="text" value="0"/>				
Instrument Tag:	<input type="text" value="MACO_ED1_EQMLOG-MO-ACTUALAMOUNT_IMAG1.sql"/>				

General	Archive	Classic	Security	System
Name:	<input type="text" value="TR10.PCK.Ambalaj.IMAG1.MACO.MES.ActualAmount"/>			
Descriptor:	<input type="text"/>			
Stored Values:	<input type="text" value="Real-time data"/>	Point Source:	<input type="text" value="RDBMS_MACO-TRKU1"/>	
Point Type:	<input type="text" value="Int32"/>	Digital Set:	<input type="text"/>	
Eng Units:	<input type="text"/>			
Exdesc:	<input 10002810"="" p2='TS"/' type="text" value="P1="/>			
Source Tag:	<input type="text"/>			

```
SELECT MO.ACTUALAMOUNT AS ACTUALAMOUNT, 0 FROM EDI_EQM_EQMLOG LOG  
LEFT JOIN EDI_EBR_MO MO ON LOG.MANUFACTURINGORDERCUSTOMID=MO.CUSTOMID  
WHERE LOG.EQUIPMENTCUSTOMID=? AND ((LOG.DATE_) > ?) ORDER BY (LOG.DATE_) DESC;
```

P1

P2

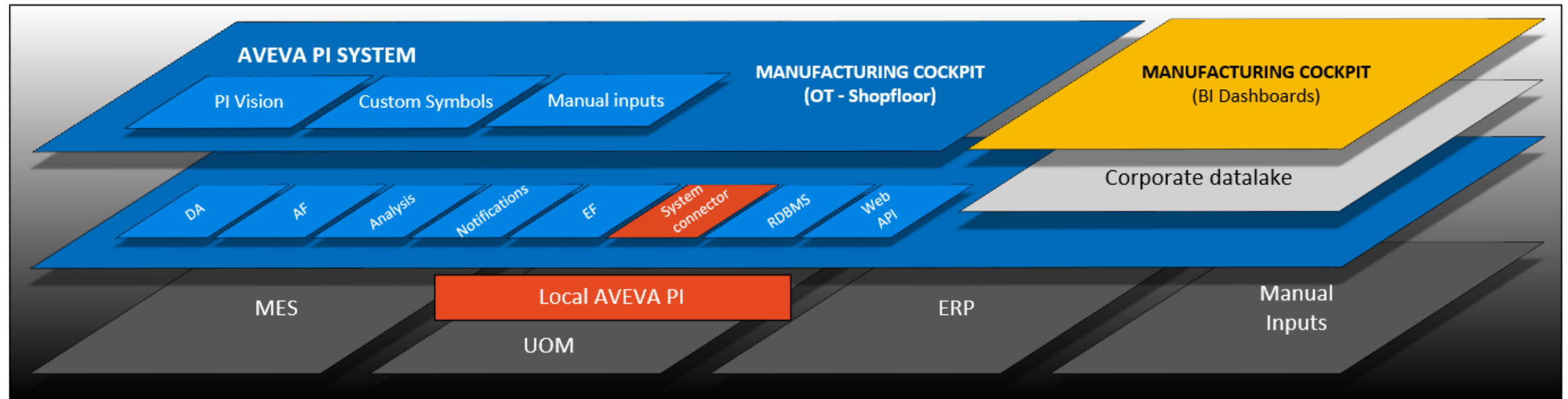


# Interface 2 of 5: Local PI System

## Local to Global PI

- Interface type: **Sys Connector**
- Direction: One Way, to global
- Type of data:
  - Real-time machine signals

The top-left screenshot shows the 'PI Data Collector Manager' interface with a routing diagram. A red box highlights the 'MACO 2.0' data source and its connection to 'C015 PI System Connector', which then routes through 'TRRU' and 'TRRU' to 'C015'. The top-right screenshot shows a 'MACO' data source configuration window with a table of data points. A red box highlights the 'Parsing Alarms' category, showing a specific alarm event: '1779478:0:[MAD] 032 HEATING UNITS WARMING UP; 10.08.2024 08:24:43'. The bottom-right screenshot shows the 'Settings' for the 'Parsing Alarms' data source, with a red box highlighting the 'Settings' field containing the path '1\PH085-ST320557\C015.TR.10.FCK.Ambale\IMAG.L-Parsing.Alarms'.



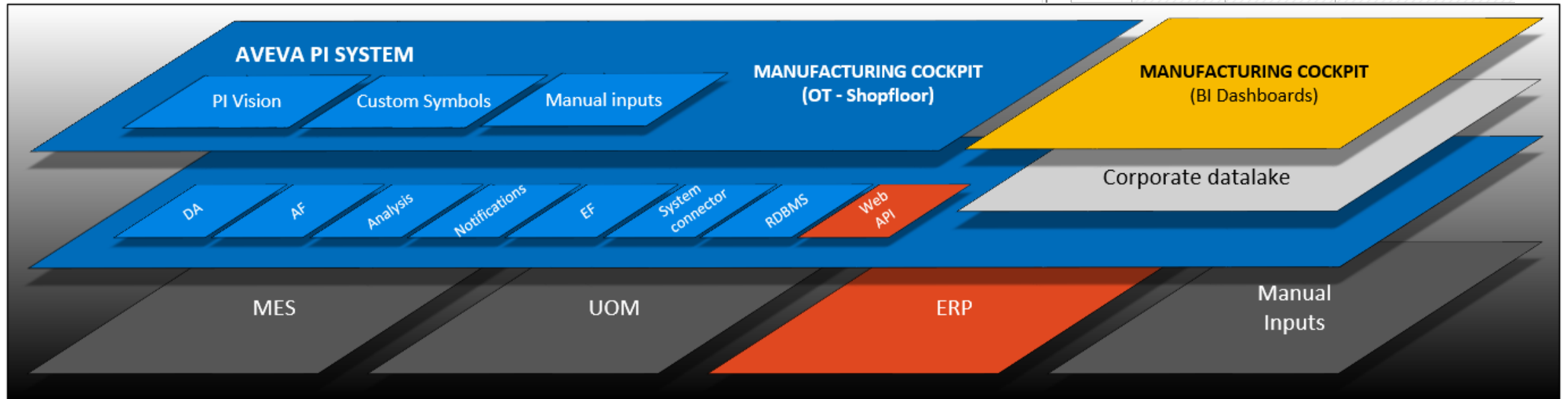
# Interface 3 of 5: ERP System / inbound

## ERP

- Interface type: **WEB API**
- Direction: Bi directional
- Type of data:
  - Process Orders
  - Material Master

The screenshot displays the AVEVA PI System interface. On the left, the 'Time Series Data' window shows a 'Data Pipe' configuration with a table of data points. On the right, a 'PI Buffer' table is visible, showing a list of data points with columns for 'Id', 'Buffer', and 'Value'.

Id	Buffer	Value
1	ewoJIKxPSVBSTzAyX01BQ08IOB7CgkJKLxQUZLT0wiOIB7CgkJCSJBVUZOUiI6ICI3MDAwM	
2	eyJMT0lQUk8wMj9NQUVpYXZlL0wvOnsiQVYVGTB0I3MDAwMDA1ZnZglCJnQVR0I	

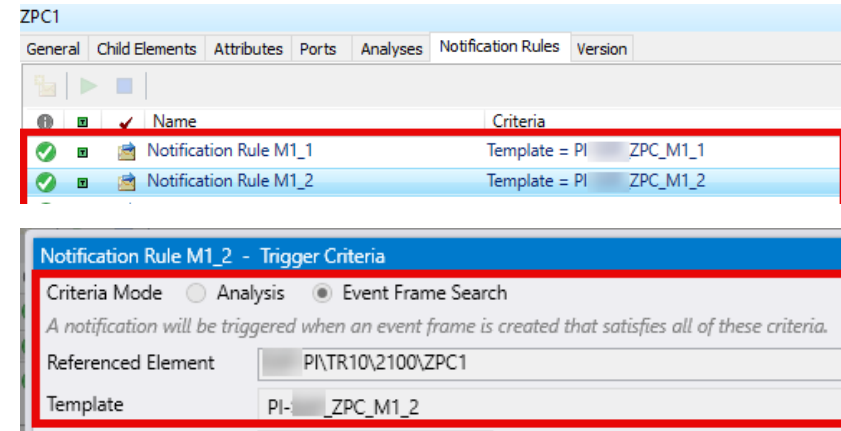




# Interface 3 of 5 ERP System / outbound

## ERP

- Interface type: **WEB API**
- Direction: Bi directional
- Type of data:
  - Operational times



The screenshot shows the ZPC1 Notification Rules configuration interface. It features a table with two rows, both highlighted with a red border. The first row is 'Notification Rule M1\_1' with 'Template = PI\_ZPC\_M1\_1'. The second row is 'Notification Rule M1\_2' with 'Template = PI\_ZPC\_M1\_2'. Below the table, the 'Notification Rule M1\_2 - Trigger Criteria' section is also highlighted with a red border. It shows 'Criteria Mode' set to 'Event Frame Search', a description 'A notification will be triggered when an event frame is created that satisfies all of these criteria.', 'Referenced Element' as 'PI\TR10\2100\ZPC1', and 'Template' as 'PI-\_ZPC\_M1\_2'.

Name	Criteria
Notification Rule M1_1	Template = PI_ZPC_M1_1
Notification Rule M1_2	Template = PI_ZPC_M1_2

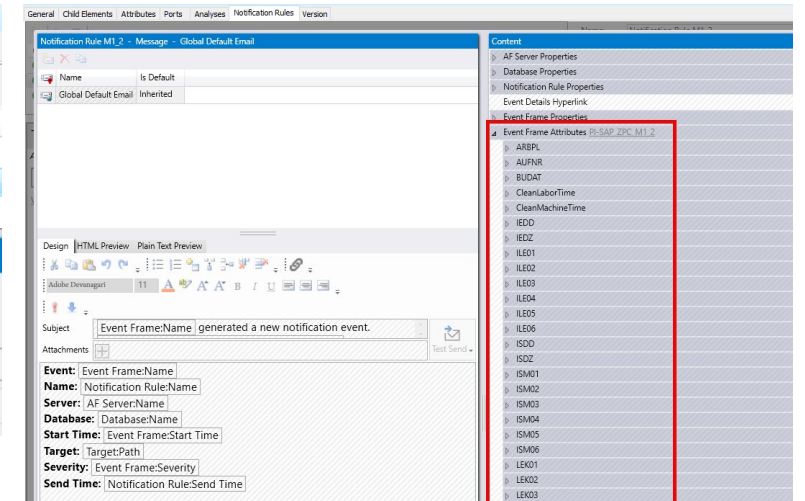
**Notification Rule M1\_2 - Trigger Criteria**

Criteria Mode:  Analysis  Event Frame Search

A notification will be triggered when an event frame is created that satisfies all of these criteria.

Referenced Element: PI\TR10\2100\ZPC1

Template: PI-\_ZPC\_M1\_2



The screenshot shows the configuration details for 'Notification Rule M1\_2'. The 'Attachments' section is highlighted with a red border and lists various event frame attributes: Event Frame:Name, Name: Notification Rule:Name, Server: AF Server:Name, Database: Database:Name, Start Time: Event Frame:Start Time, Target: Target:Path, Severity: Event Frame:Severity, and Send Time: Notification Rule:Send Time. The 'Content' pane on the right also shows a list of event frame properties, with 'Event Frame Attributes PI-SAP\_ZPC\_M1\_2' highlighted in red.

Attachments:

- Event: Event Frame:Name
- Name: Notification Rule:Name
- Server: AF Server:Name
- Database: Database:Name
- Start Time: Event Frame:Start Time
- Target: Target:Path
- Severity: Event Frame:Severity
- Send Time: Notification Rule:Send Time

Content:

- AF Server Properties
- Database Properties
- Notification Rule Properties
- Event Details Hyperlink
- Event Frame Properties
- Event Frame Attributes PI-SAP\_ZPC\_M1\_2
- ARBPL
- AUFNR
- BUDAT
- CleanLaborTime
- CleanMachineTime
- IEDD
- IEDZ
- ILED01
- ILED02
- ILED03
- ILED04
- ILED05
- ILED06
- ISDD
- ISOZ
- ISM01
- ISM02
- ISM03
- ISM04
- ISM05
- ISM06
- LEK01
- LEK02
- LEK03

# Interface 4 of 5: Manual inputs

## Global PI to datalake

- Interface type: **WEB API**
- Direction: One Way, to datalake
- Type of data:
  - Event frames of executed batches

Event Categorization

Select Root Cause Machine

Undefined Blister/Carton

LEVEL 1: Select Loss Category

Ancillary Time Unplanned Downtime Planned Downtime

LEVEL 2: Select Downtime Category

Logical Stoppages Technical Stoppages Equipment Breakdown

Modify Status

Clean Start

3

1 2 3 4 5 6 7 8 9

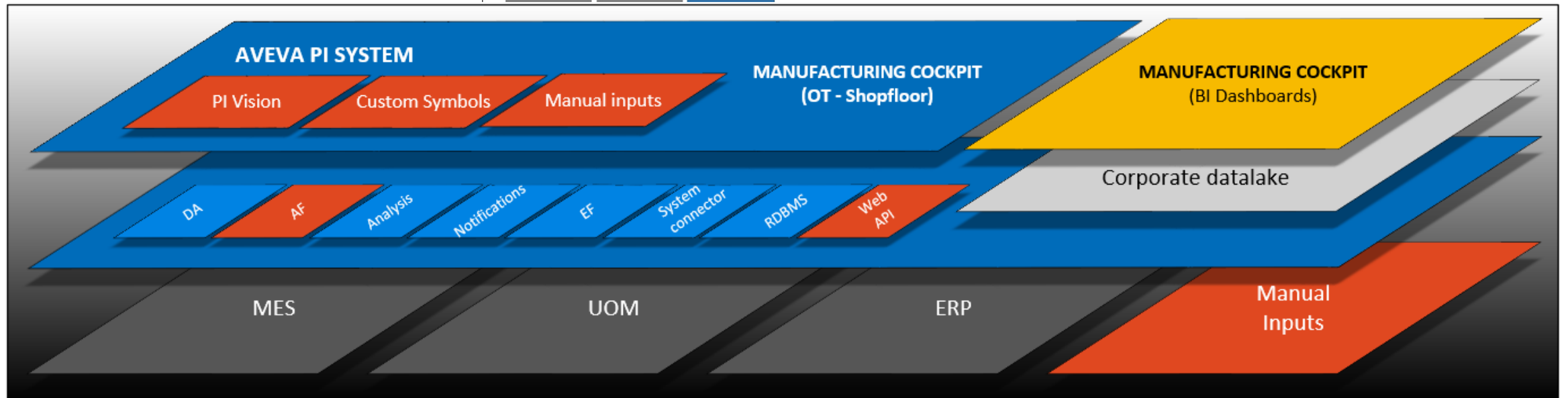
Save Cancel

Start Time 1 9/18/2024 12:40:28 AM End Time 1 9/18/2024 13:10:28

Start Time 2 9/18/2024 13:10:28 End Time 2 9/18/2024 13:20:28

Start Time 3 9/18/2024 13:20:28 End Time 3 9/18/2024 1:48:17 AM

Save Cancel



# Interface 5 of 5: Corporate datalake

## Global PI to datalake

- Interface type: **WEB API**
- Direction: One Way, to datalake
- Type of data:
  - Event frames of executed batches

MACO_BATCH_Template	
General Attribute Templates	
Filter	
<input type="checkbox"/> Name	<input type="checkbox"/> Description
<ul style="list-style-type: none"> <li>Category: Alarms                             <ul style="list-style-type: none"> <li>Error ID</li> </ul> </li> <li>Category: Availability Losses                             <ul style="list-style-type: none"> <li>Ancillary Downtime Loss</li> <li>Planned Downtime Loss</li> <li>Undefined Loss</li> <li>Unplanned Downtime Loss</li> </ul> </li> <li>Category: Event Categorization                             <ul style="list-style-type: none"> <li>Event Category L1</li> <li>Event Category L2</li> <li>Event Category L3</li> <li>Event Comment</li> <li>Event Source Equipment</li> </ul> </li> <li>Category: Event Frame</li> </ul>	

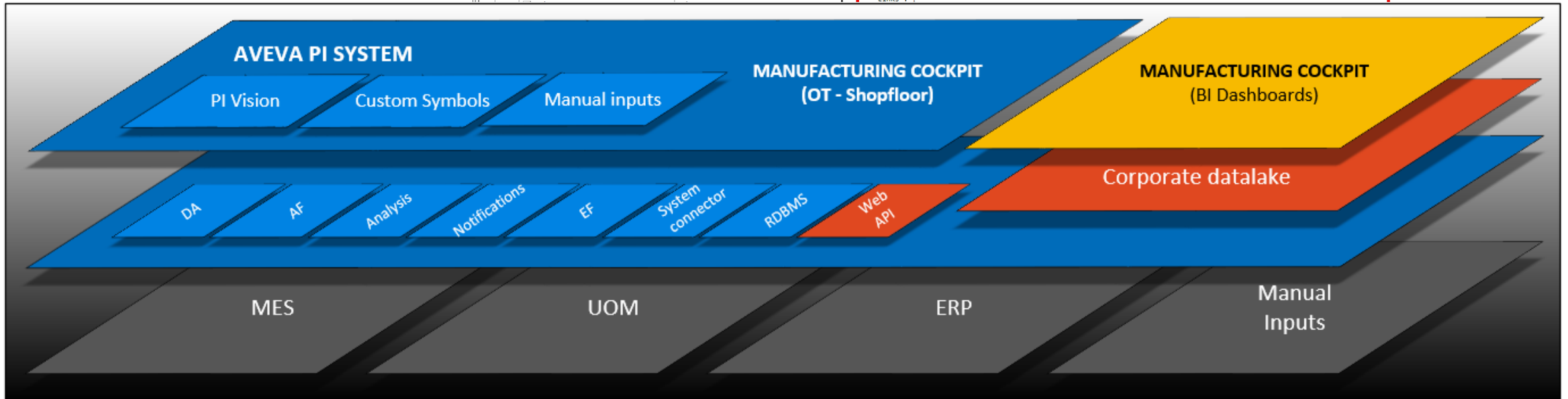
```

Help pages: PI_Web_API_Help > AssetDatabase > GetEventFrames

{
  "Links": {
    "First": "https://pivis-chgh-n.eu.novartis.net/piwebapi/assetdatabases/F1B00E015p0I8UIdGzas5GQDF0uZ100V3hyE53_08gomfaTe00HHSF9QSV98R19RXE18008/eventframes?startTime=9272024-07-25T00:30:00.0000000Z",
    "Last": "https://pivis-chgh-n.eu.novartis.net/piwebapi/assetdatabases/F1B00E015p0I8UIdGzas5GQDF0uZ100V3hyE53_08gomfaTe00HHSF9QSV98R19RXE18008/eventframes?startTime=9272024-07-25T00:30:00.0000000Z"
  },
  "Items": [
    {
      "WebId": "F1AbFQE015p0I8UIdGzas5GQDF0uZ100V3hyE53_08gomfaTe00HHSF9QSV98R19RXE18009",
      "Name": "MACO - TRKU.MA1.1 - 2024-07-23T16:47:55.0000000Z",
      "Description": "Template for MACO Batch Information",
      "Path": "\\CHGH_PI_AF_Q\\MACO\\EventFrames[MACO - TRKU.MA1.1 - 2024-07-23T16:47:55.0000000Z]",
      "TemplateTime": "MACO_BATCH_Template",
      "HasChildren": false,
      "CategoryNames": [
        "MACO"
      ],
      "ExtendedProperties": {},
      "StartTime": "2024-07-23T16:47:55Z",
      "EndTime": "2024-07-25T04:13:03Z",
      "Severity": "Information"
    }
  ]
}

Help pages: PI_Web_API_Help > StreamSet > GetValues

{
  "Links": {},
  "Items": [
    {
      "WebId": "F1AbFQE015p0I8UIdGzas5GQDF0uZ100V3hyE53_08gomfaTe00HHSF9QSV98R19RXE18009",
      "Name": "Plant Code",
      "Path": "\\CHGH_PI_AF_Q\\MACO\\EventFrames[MACO - TRKU.MA1.1 - 2024-07-23T16:47:55.0000000Z][Plant Code]",
      "Links": {}
    }
  ]
}
    
```



# 2.3

## Architecture Design

2.1 Datasources and PI Components

2.2 Interfaces / gathering data

**2.3 Organizing and using the data**

# MACO Hierarchy in Asset Framework

## Organizing the data & contextualizing

### ISA-88: Physical model

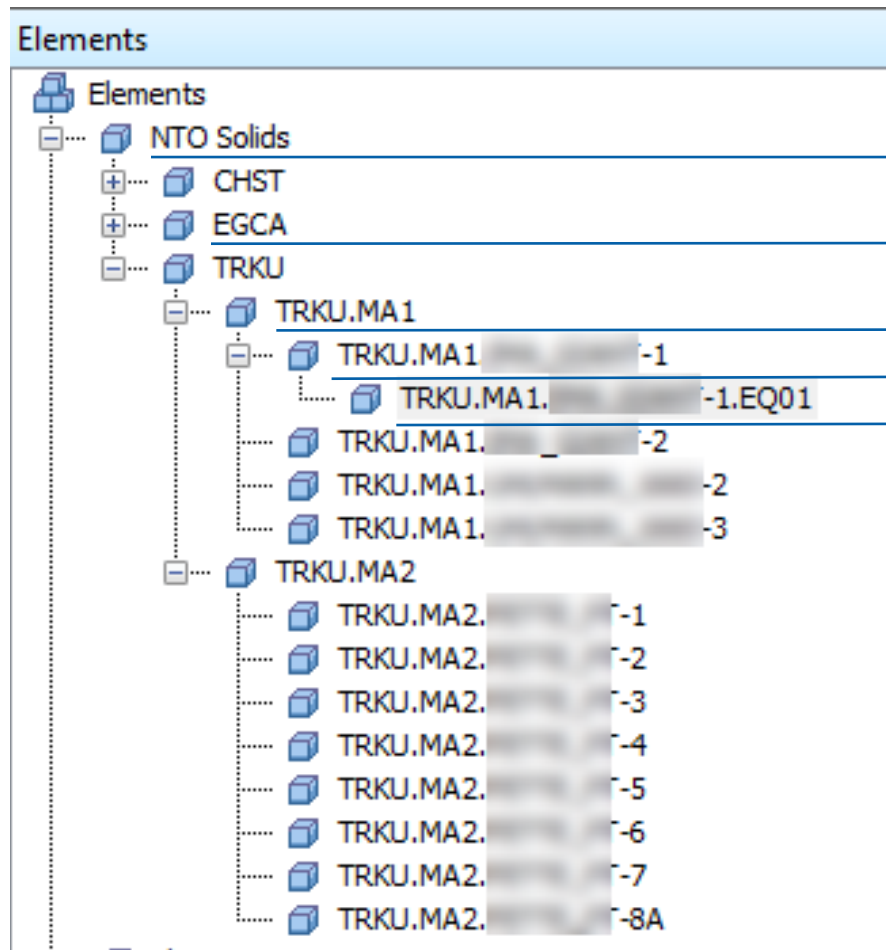
**Level 1:** Platform

**Level 2:** Site

**Level 3:** Manufacturing Area

**Level 4:** Manufacturing Line

**Level 5:** Manufacturing Unit



### Set of attributes

TRKU.MA1. -1.EQ01

General Child Elements Attributes Ports Analyses Notification Rules Version

Filter

Name	Value	Time Stamp	Description
Category: Equipment Data			
EQ Bad counter	0	10. 08. 2024 10:34:34.379	Bad Items for Equipment
EQ Batch ID		10. 08. 2024 10:34:34.676	Equipment Batch ID
EQ Error ID	1779478;0;[MAIN] 032 HEATING U...	10. 08. 2024 10:24:43	Equipment Error ID
EQ Good counter	0	10. 08. 2024 10:34:34.379	Good Items
EQ Machine in Operation	False	26. 07. 2024 05:51:25.514	True when machine is produc
EQ Machine Not in Operation	1	28. 08. 2024 17:07:00	1 when machine is producing
EQ Machine Running	Stopped	28. 08. 2024 17:07:00	Equipment Machine Running
EQ Machine Speed	180	10. 08. 2024 10:34:34.629	Equipment Machine Speed
EQ Product Name		10. 08. 2024 10:34:34.879	Material or product name
EQ SC FAULT	-1	10. 08. 2024 10:14:25.045	Equipment SC FAULT
EQ SC RUN	0	10. 08. 2024 10:14:25.077	Equipment SC RUN
EQ Start-up rejections	0	19. 08. 2024 19:54:07.224	Equipment Start-up rejections
Error ID	1779478;0;[MAIN] 032 HEATING U...	10. 08. 2024 10:24:43	Equipment Error ID

# MACO KPI Calculations

## Calculation Example

**Step 1:** Take real-time input values / machine or MES signals / from PI Point

Name	Value	Time Stamp	Description
EQ Good Counter	0	10. 08. 2024 10:34:34.379	Good Counter Items (blisters)
EQ Good Counter Available	True	1. 01. 1970 00:00:00	Set True If EQ Good Counter is coming from Production Unit

**Step 2:** Pass the signal as input and calculate next level of information, e.g. „Quality“.

Name	Expression	Output Attribute
Quality	<pre>                     If                     Then                         Not(BadVal('Current Produced Quantity')) And Not(BadVal('SFO Good Production Counter')) And Not(BadVal('SFO Status'))                     Then                         If                         Then                             'Current Produced Quantity' = 0 Or Compare('SFO Status', 'SFO Status No Workorder')                         Then                             0                         Else                             ('SFO Good Production Counter' / 'Current Produced Quantity') * 100                         Else                             NoOutput()                     </pre>	Quality

**Step 3:** Keep building up dependency chain until final calc., e.g. „OAE“

Name	Backfilling
OAE	✓
OAE Day	✓
OAE Shift	✓
Performance	✓

Name	Expression
OAE	<pre>                     If                     Then                         Not(BadVal('SFO Status'))                     Then                         If                         Then                             Not(Compare('SFO Status', 'SFO Status No Workorder'))                         Then                             If                             Then                                 Not(BadVal('Availability')) And Not(BadVal('Performance')) And Not(BadVal('Quality'))                             Then                                 (('Availability' / 100) * ('Performance' / 100) * ('Quality' / 100)) * 100                             Else                                 NoOutput()                         Else                             0                     Else                         NoOutput()                     </pre>

**Step 4:** Bring final value to the visualization layer.

**Real time**

**Total number of analysis rules**

**93**

# 3.1

## MACO OT & BI

**3.1 How it looks like on the shopfloor (OT)**

3.2 How it looks like on the top floor (BI)

# MACO Landing page (AVEVA PI Vision)

## Landing Page

The screenshot shows the MACO 2 Manufacturing Cockpit 2 landing page. The top navigation bar includes the OSisoft PI Vision logo and a 'New' button. The main header features a world map with 'Small Molecules' text, the title 'MACO 2 Manufacturing Cockpit 2', and the Novartis logo. A blue banner displays 'GSDA Central Sharepoint Page' and the timestamp '9/18/2024 3:59:30 PM'. Below this is a 'KPI and Phase Confirmation' section with four columns: Operators, Supervisors, Viewers, and Business Intelligence. Each column contains cards for 'Packaging' and 'Bulk' with 'Click Here' buttons.

OSisoft PI Vision + New

Small Molecules

# MACO 2

Manufacturing Cockpit 2

**NOVARTIS**

GSDA Central Sharepoint Page 9/18/2024 3:59:30 PM

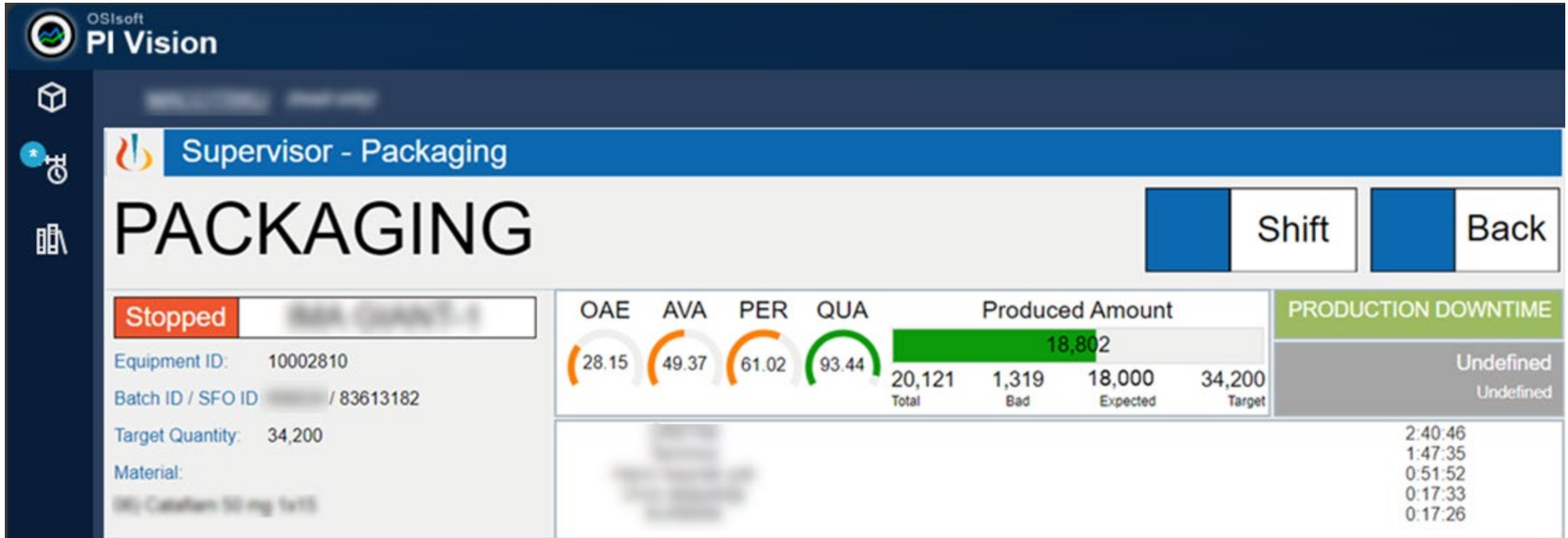
### KPI and Phase Confirmation Module 1

Operators	Supervisors	Viewers	Business Intelligence
<p>Packaging</p> <p><a href="#">Click Here</a></p>	<p>Packaging</p> <p><a href="#">Click Here</a></p>	<p>Viewers</p> <p><a href="#">Click Here</a></p>	<p>MACO v1 BI</p> <p><a href="#">Click Here</a></p>
<p>Bulk</p> <p><a href="#">Click Here</a></p>	<p>Bulk</p> <p><a href="#">Click Here</a></p>		<p>MACO KPI BI</p> <p><a href="#">Click Here</a></p>



# MACO Lines overview (AVEVA PI Vision)

List of lines in selected manufacturing area



# MACO Main line display (AVEVA PI Vision)

Main line display as seen by the operator



# MACO Main line display (AVEVA PI Vision)

Splitting one large event into multiple smaller chunks

The image shows a composite screenshot of the AVEVA PI Vision interface. On the left, the 'Line - Packaging' dashboard displays various KPIs: OAE (27.94), Availability (81.18), Performance (38.47), and Quality (89.47). The 'Produced Amount' section shows a total of 76,957, with 8,102 bad amounts and 145,500 expected amounts. A red box highlights the 'Undefined Events' count of 12. A red arrow points from this box to a 'Split' button in the event table on the right. The event table has columns for Event Timeframe, Root Cause Machine, Loss Category, Downtime Category, Event Reason Code, and Comment. A modal window titled 'Modify Status' is open, showing a date picker for 9/18/2024 and a 'Number of Operations' field set to 3. Below this, three event rows are defined with their respective start and end times.

Event Timeframe	Root Cause Machine	Loss Category	Downtime Category	Event Reason Code	Comment
9/18/2024 12:40:28 AM	undefined	undefined	undefined	undefined	N/A

Start Time	End Time
9/18/2024 12:40:28 AM	9/18/2024 13:10:28
9/18/2024 13:10:28	9/18/2024 13:20:28
9/18/2024 13:20:28	9/18/2024 1:48:17 AM

# MACO Main line display (AVEVA PI Vision)

## Categorizing downtime using 3 levels

OSsoft  
PI Vision

Line - Packaging

Batch ID: / SFO ID: 83958573 / Target: 145500

Autorefresh

Morning Shift

Key Performance Indicators

- OAE: 27.94
- Availability: 81.18
- Performance: 38.47
- Quality: 89.47

Production Rate

Current Rate: 3.80, Average Rate: 0.88, Target Rate: 2.83

MVS: 2.83

Produced Amount: 88,855

Time Accounts

Equipment: Durdu, Blister/Cartoner

Number of Operators: 1

Undefined Events: 12

Event Categorization

Select Root Cause Machine

- Undefined
- Blister/Cartoner

LEVEL 1: Select Loss Category

- Ancillary Time
- Unplanned Downtime
- Planned Downtime

LEVEL 2: Select Downtime Category

- Logical Stoppages
- Technical Stoppages
- Equipment Breakdown

LEVEL 3: Select Downtime Reason Code

- Temp. sensor malfunction
- Camera malfunction

Insert Comment (Optional)

N/A

Save

# 3.2

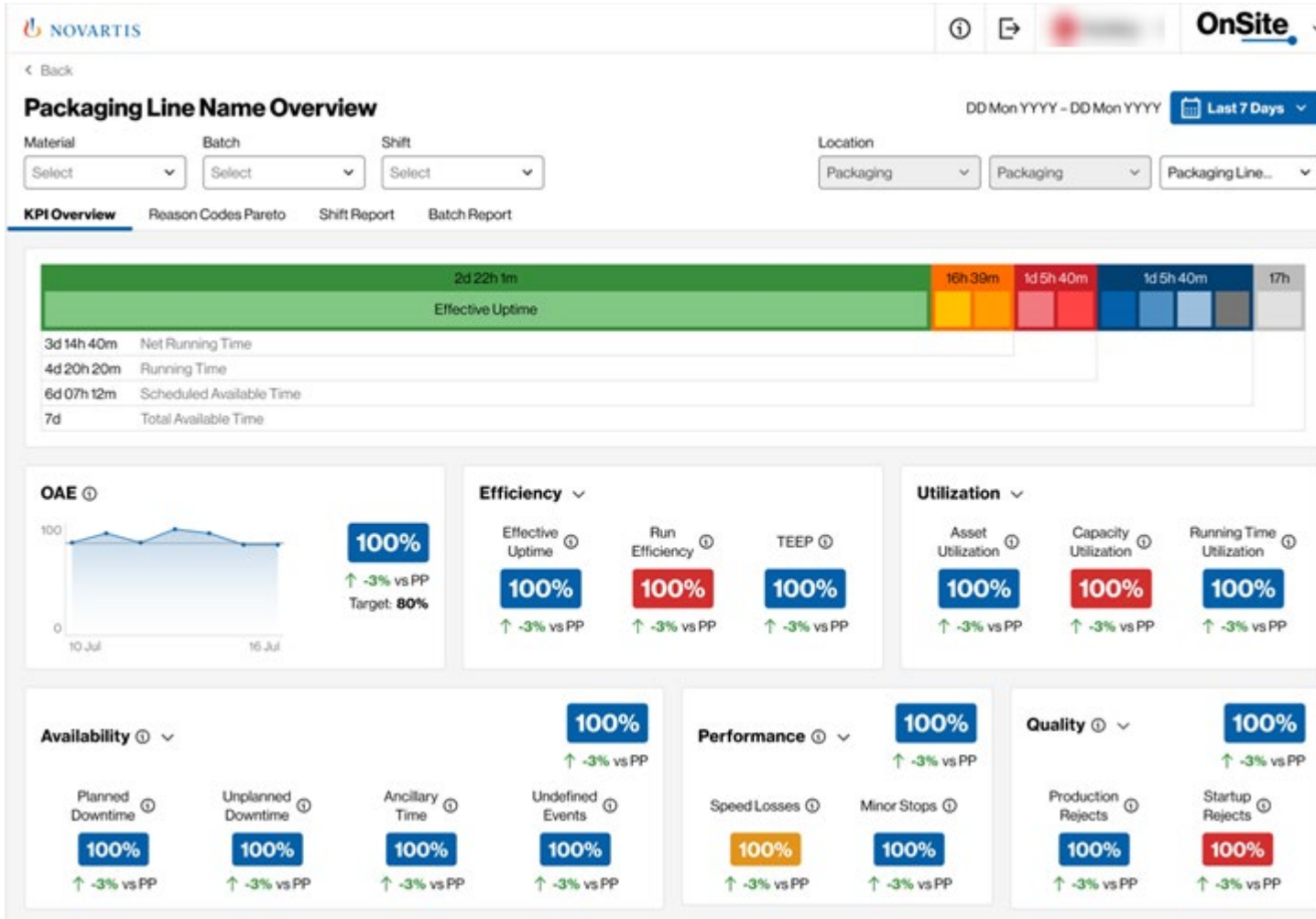
## MACO OT & BI

3.1 How it looks like on the shopfloor (OT)

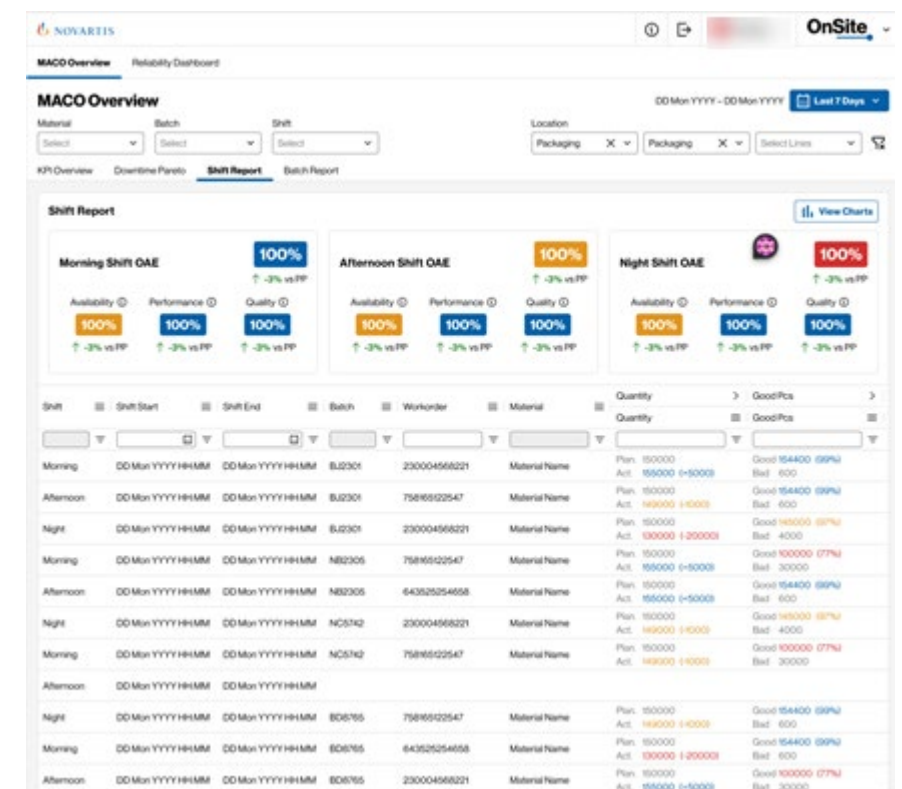
**3.2 How it looks like on the top floor (BI)**

# MACO BI (Test data)

## KPI Dashboard / Line performance

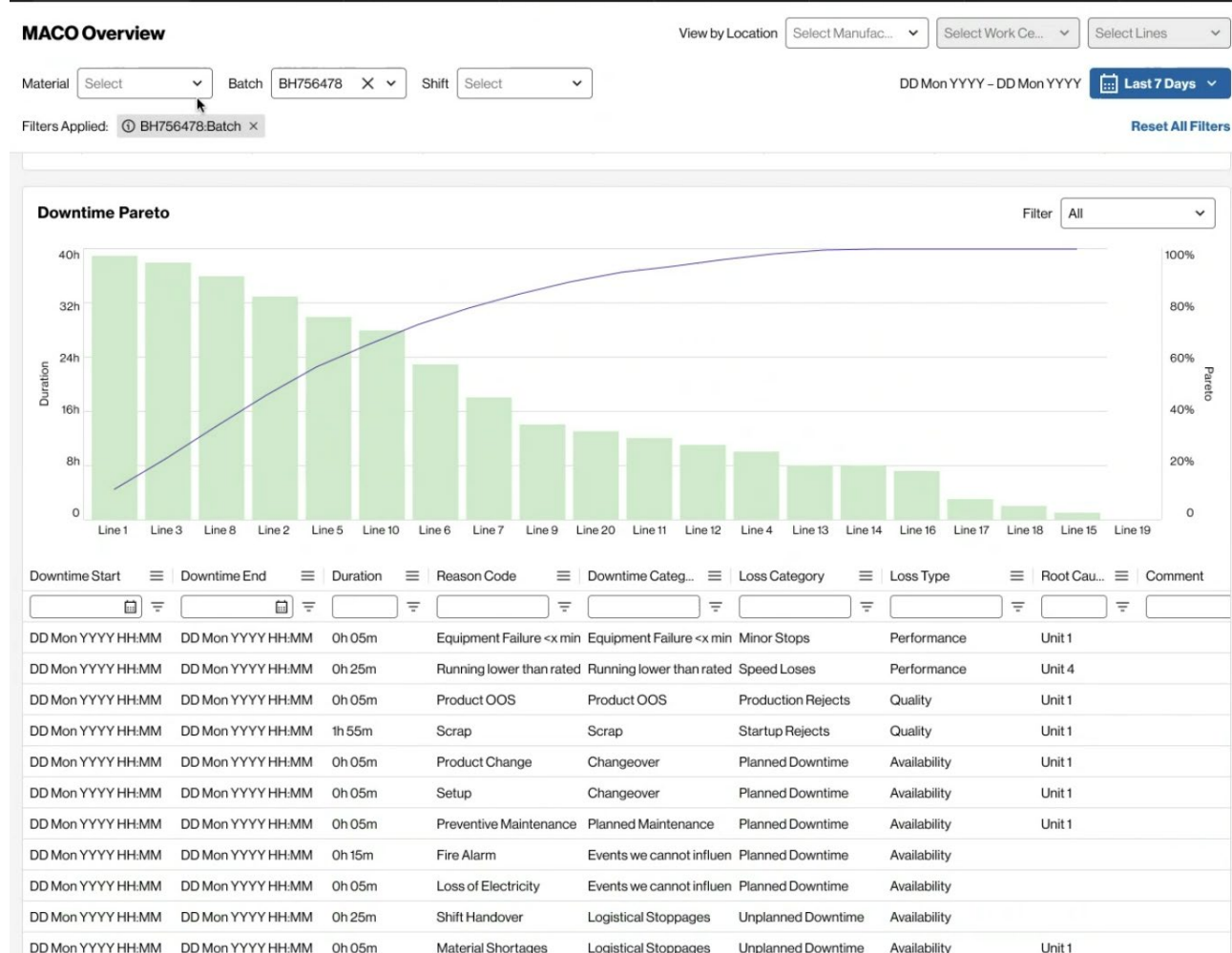


## KPI Dashboard / Shift performance

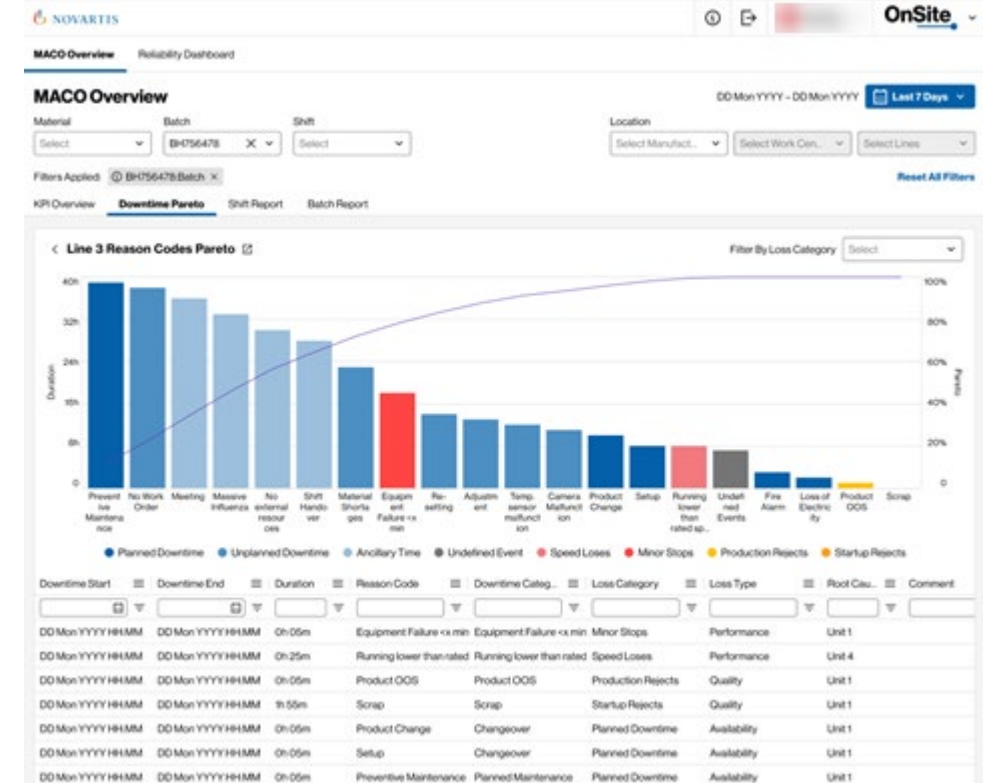


# MACO BI (Test data)

## Pareto / Top & worst performers



## Pareto / Top reason codes for low performance

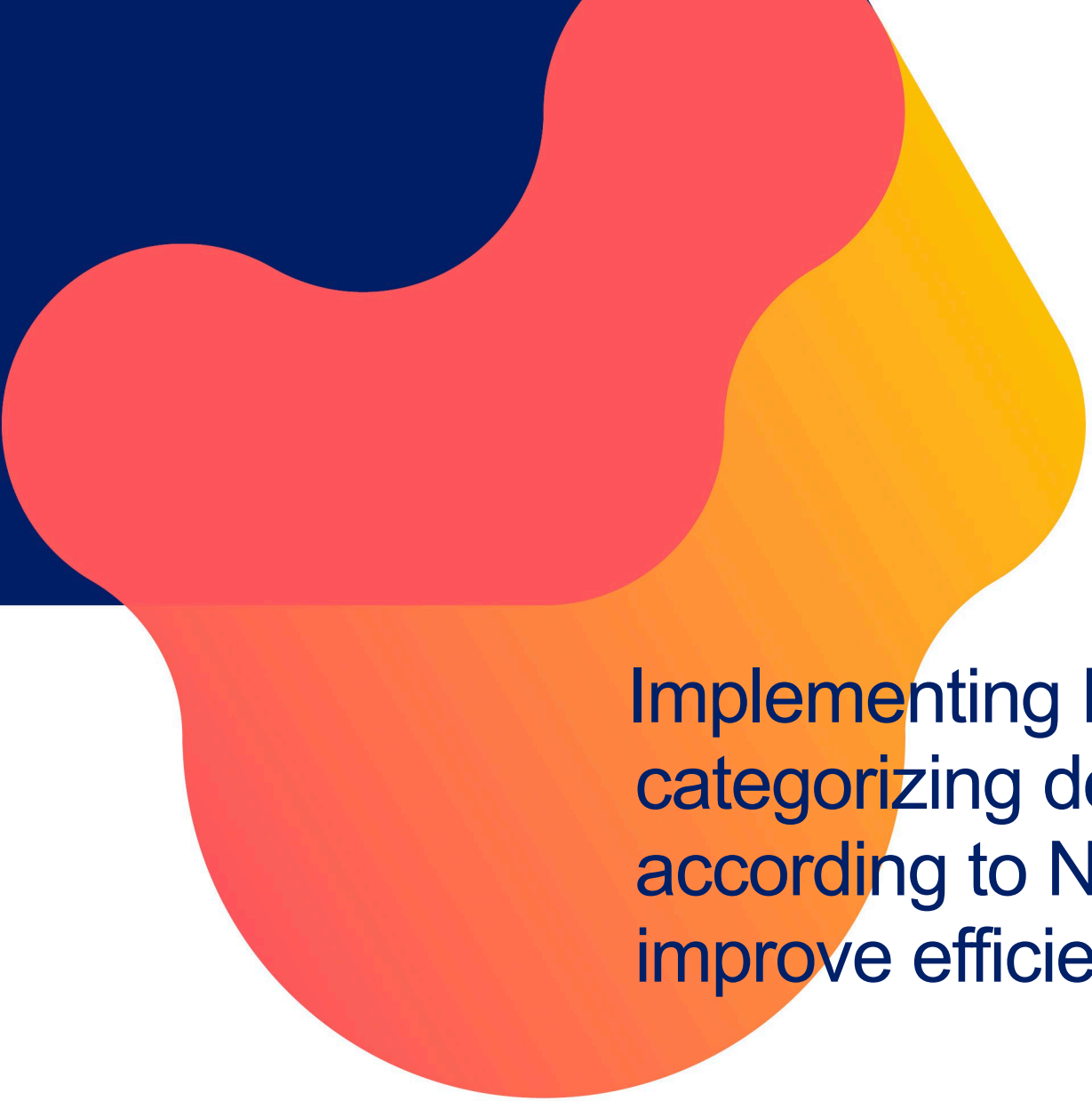


# 3.2

## Benefits

What are the expected benefits?





Implementing MACO for capturing process data, categorizing downtimes and measuring KPI's according to Novartis time model, will enable us to improve efficiency by at least 5%.

**Pudgar, Uros**

uros.pudgar@novartis.com

**Thank you**

# Questions?

Please wait for the microphone.  
State your name and company.



# Please remember to...

Navigate to this session in the mobile app to complete the survey.



# Thank you!