Wastewater Treatment Digital Twins:
Data Quality, Real-Time Simulation & Operational Decision-Support

Primodal
Earth Essential Technologies
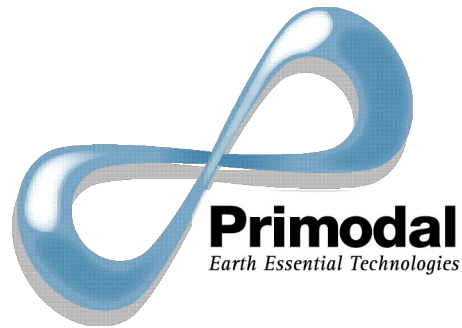
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Primodal

Primodal

- ➢ Based in Hamilton, ON. (est. 2005)

- ➢ Data-Driven Solutions
  - Mechanistic Process Modelling Specialists
  - Process Engineering & Modelling, Design, Control, Uncertainty Analysis, and Data Analytics

- ➢ COMMON THEME → <u>Data Evaluation</u>
  - the need for accurate and representative data
  - data analytics (quality, analysis, open data, …)

- ➢ *PrecisionNow*© software suite
  - data analysis, process modelling integration
  - dDesk, dDock & dDockDT

Towards A Digital Solution

➢ How?

- Staged Approach
- Realise Benefits Each Step

Automated Process Control
- link DT to plant actuators
- adoption of DT by all disciplines

Real-Time Process Optimisation
- real-time calculation of process/operational variables

On-Site Automated Data Analysis & Model-Based KPIs
- real-time data evaluation & real-time model operation
- simplified data-driven models for real-time KPI and process understanding

Process Insights, Data Understanding & Model Development
- model of process under study
- data analysis / quality assessment
- modelled control / operational procedures
- detailed system understanding

Towards A Digital Solution

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➤ Today's Presentation

- Data Assets
- Process Insights
- Real-Time Model-Based Process KPIs
- Performance & Digital Twins

Automated Process Control
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PrecisionNow Digital Solution ➔ *Why?*

Data ➔ KPIs / Actionable Outcome

➢ **Numerous Unrealised Benefits**

- Risk assessments; Process insights
- Day-to-day operations; Future operations; Situational awareness

➢ **Effort**
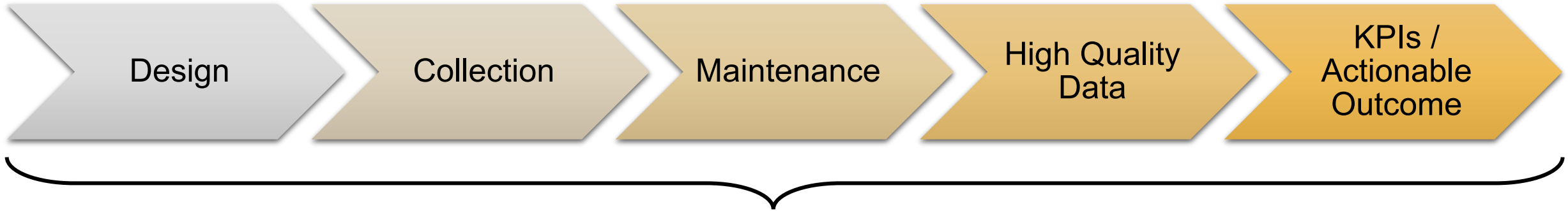
- Already collecting the data
- Can be automated

PrecisionNow Digital Solution ➔ *Why?*

Data ➔ **KPIs / Actionable Outcome**

➢ **Goal** (<u>irrespective of data user</u>)

- Improved Data Quality
- Practical Process Understanding & Improved Operation
- Better Decision-Making

PrecisionNow Data Analytics ➔ *How?*
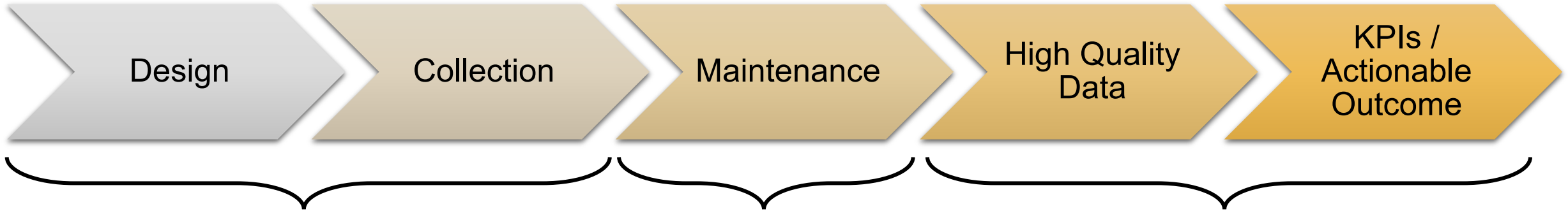
Data ➔ KPIs / Actionable Outcome

➤ Treat <u>Data as an Asset</u>

- Systematic approach to the care of that data
- Realise the value contained within that data
- Develop, maintain, and update that data & its collection cost effectively
- Maximise the economic and capital value of that data over time

PrecisionNow Data Analytics ➔ *How?*

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| Design | ➔ | Collection | ➔ | Maintenance | ➔ | High Quality Data | ➔ | KPIs / Actionable Outcome |

➢ Manage Entire Data Life-Cycle

- Design,
- Commissioning, Collection,
- Maintaining, Repairing,
- Modifying, Replacing

- ➔ What data and why is it needed?
- ➔ Resource allocation, departments?
- ➔ How will the data quality be assured?
- ➔ Criteria for replacement?

PrecisionNow Data Analytics → *Solution*

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Design → Collection → Maintenance → High Quality Data → KPIs / Actionable Outcome

➢ **Model-Based Design**
- Information maximisation
- Controller design
- Sensor / sampling
  - Frequency
  - Time
  - Locations

➢ **Real-Time Evaluation**
- Data quality assessment
- Maintenance / quality alerts
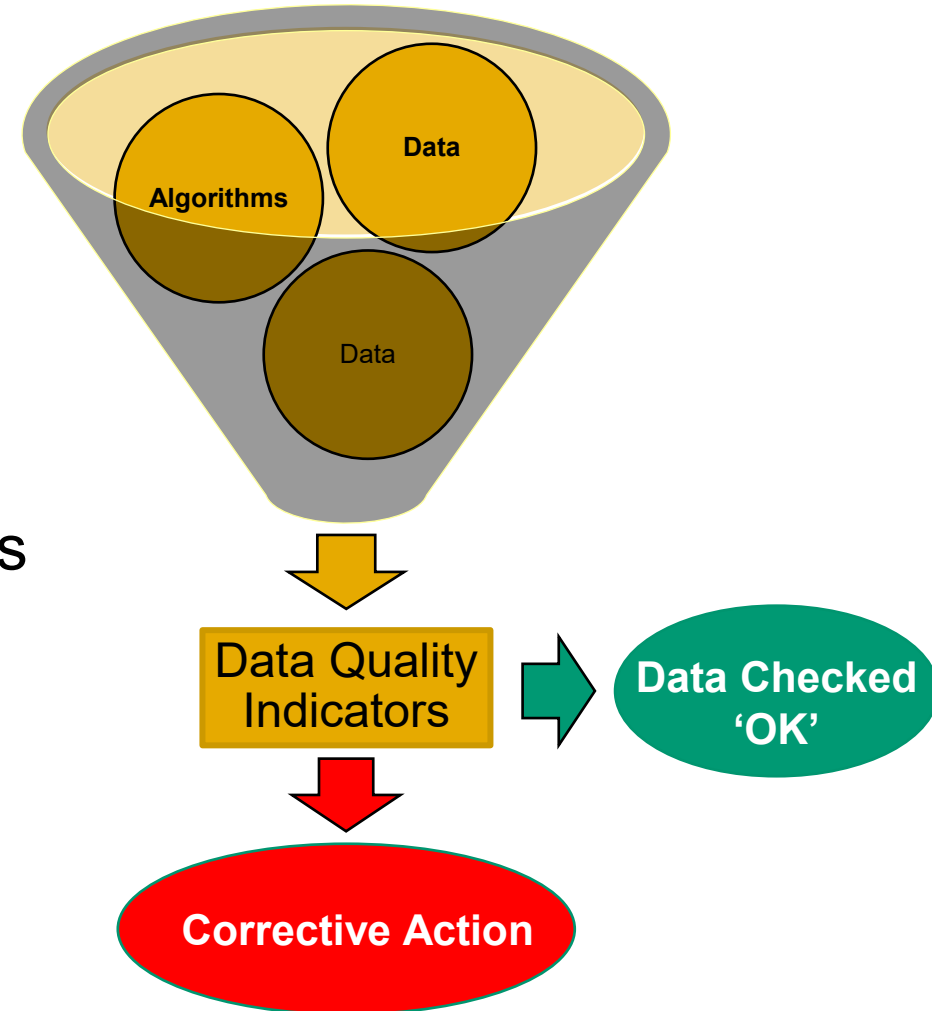
➢ **Data-Derived Outcome**
- Digital twin
- Data-driven KPIs
- Process insights
- Operational parameters

PrecisionNow Data Analytics → *Solution*

Design > **Collection**

➤ Model-Based Design

- Model development acts as knowledge repository
- Identification of previously unknown connections
- Process insights
- Identification of critical data gaps
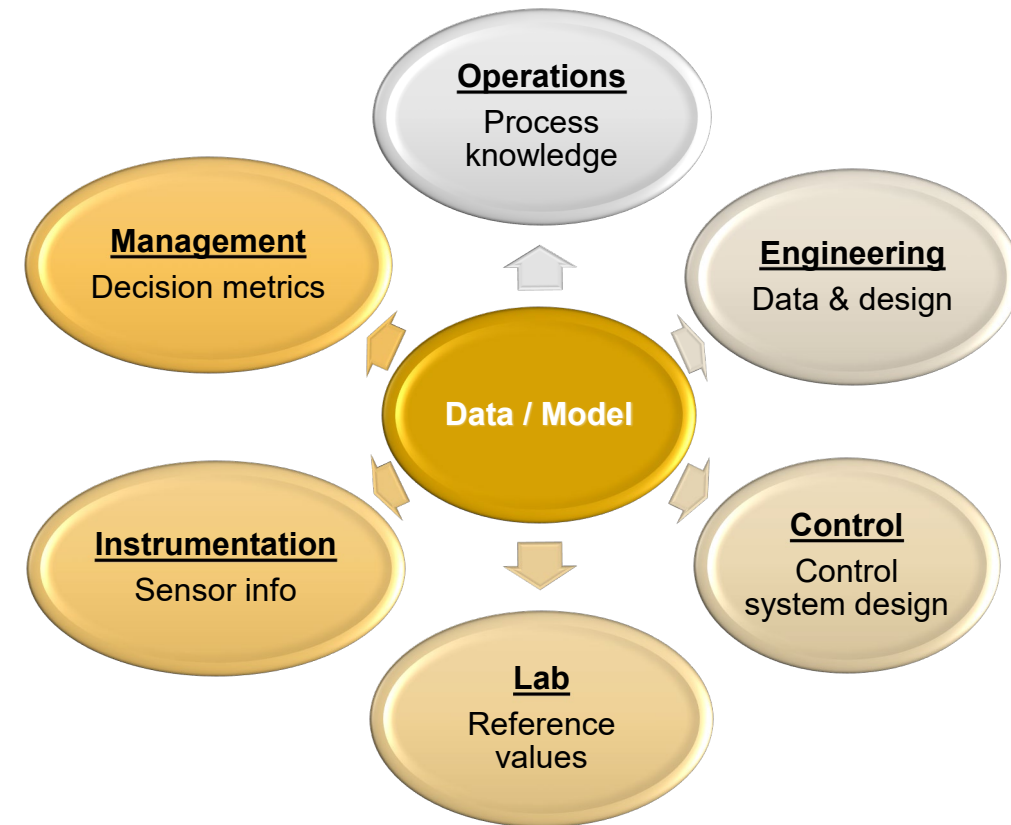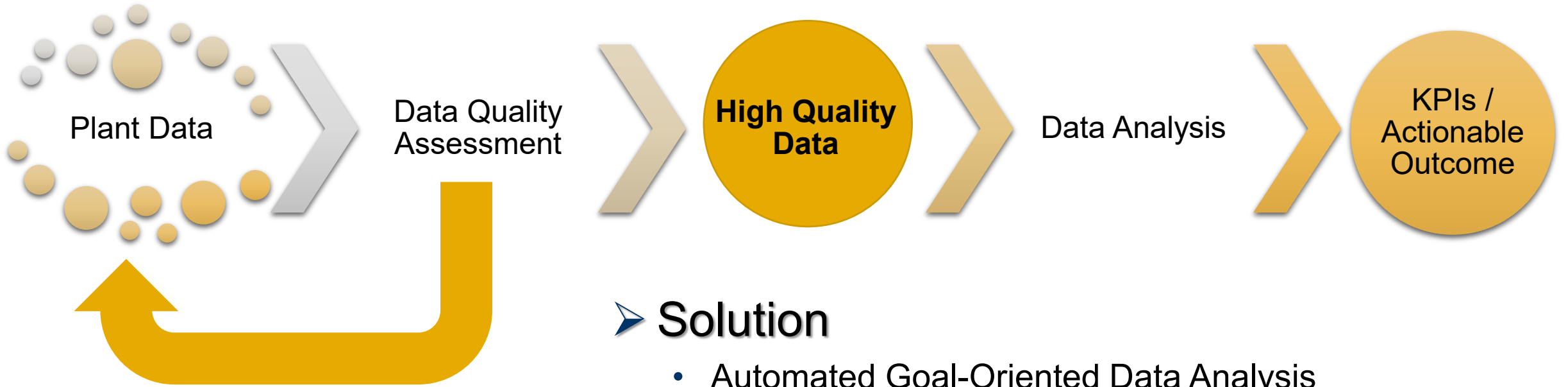- Determination of process indicators

Operations
Process knowledge

Management
Decision metrics

Engineering
Data & design

Model Development

Control
Control system design

Instrumentation
Sensor info

Lab
Reference values

PrecisionNow Data Analytics → *Solution*

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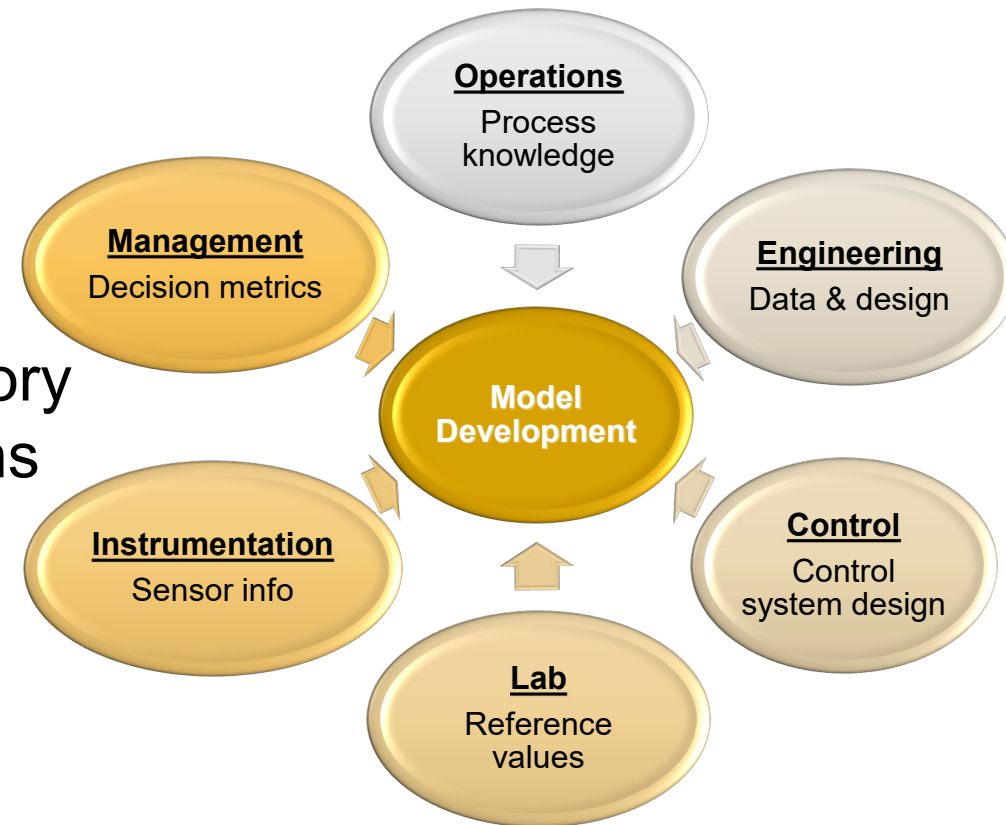
[Maintenance]

➤ Real-Time Evaluation

- Near real-time calculation of data quality indicators
- Immediate data quality feedback
- Data quality alerts and maintenance signaling
- Simple and complex quality algorithms
  - Comparison/combination of data sources

Algorithms

Data

Data

Data Quality Indicators → **Data Checked 'OK'**

Corrective Action

PrecisionNow Data Analytics → *Solution*

High Quality Data ➤ KPIs / Actionable Outcome

➤ **Data-Derived Outcomes**

- Real-time process KPIs
- Digital twin output
- Operational parameters
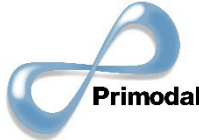- Risk assessment
- Situational awareness

Operations
Process knowledge

Engineering
Data & design

Management
Decision metrics

Data / Model

Control
Control system design

Instrumentation
Sensor info

Lab
Reference values

PrecisionNow Data Analytics ➔ *Solution*

Plant Data ➔ Data Quality Assessment ➔ **High Quality Data** ➔ Data Analysis ➔ KPIs / Actionable Outcome

➢ Solution

- <u>Automated</u> Goal-Oriented Data Analysis
- User-Configurable Data Algorithms
- Standardised Data Analysis Approaches
- Integrated Model (data, process) Analysis
- Verifiable QA/QC

Precision*Now*: *dDockDT*

Facility IT Network

Plant

On-Site Data

SQL SQL

iHistorian LIMs

Automated Real-Time Data Acquisition OPC-UA or Other Querying Method

dDockDT

Visualization

Process Information
- SRT = ?
- Mass Balance = ?

Acquisition & Storage

SQL

Active Analysis (Real-Time)

Data Quality

Control Room PC

Simulation Engine

Continuously Running Process Simulation
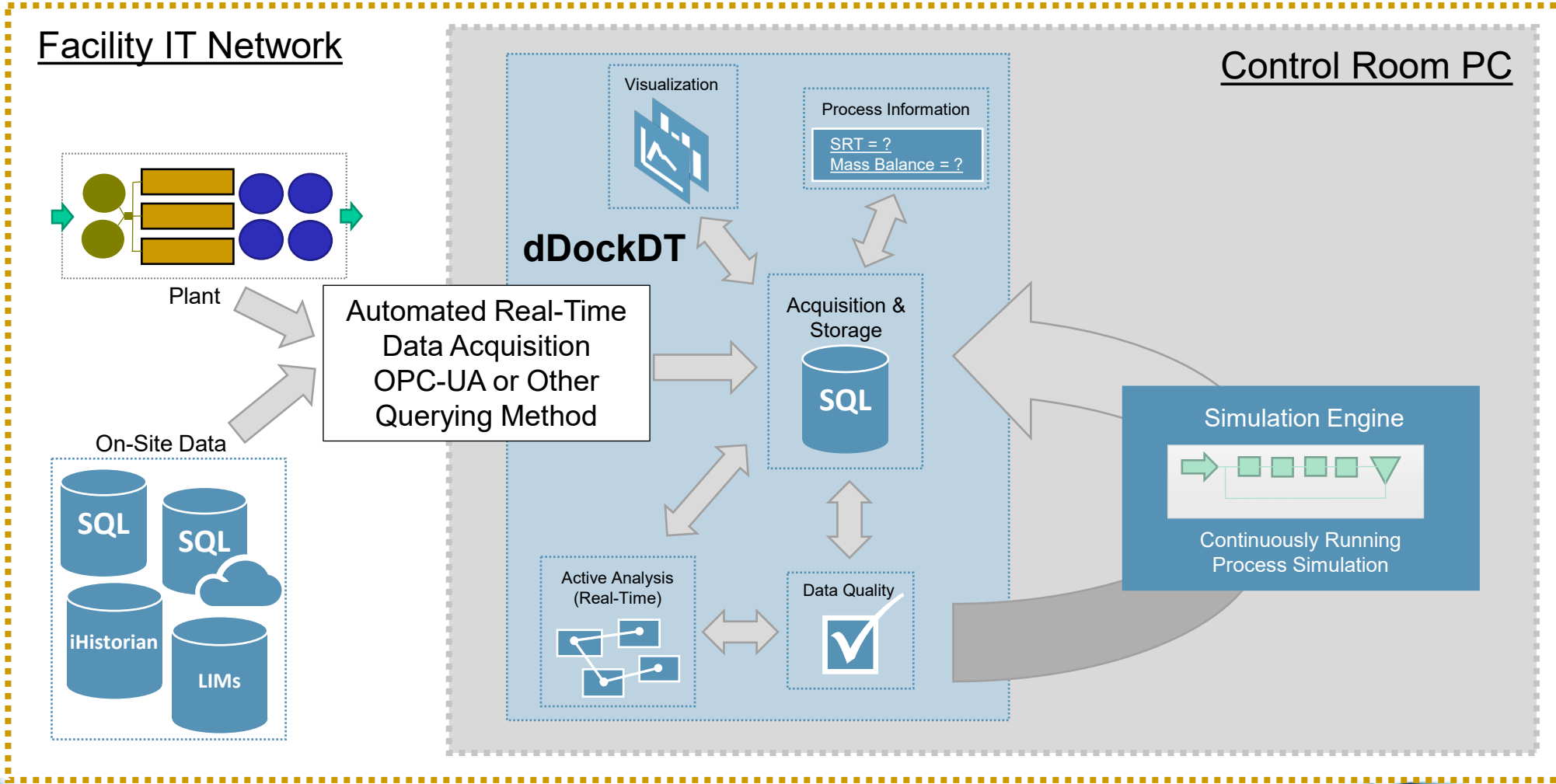
Data Flow: *dDockDT (performance twin)*

PLANT DATA

dDockDT

RAW DATA ANALYSIS

DATA QUALITY EVALUATION

OPERATION ASSESSMENT & KPIs

VISUALISATION

ACTIONABLE INFORMATION
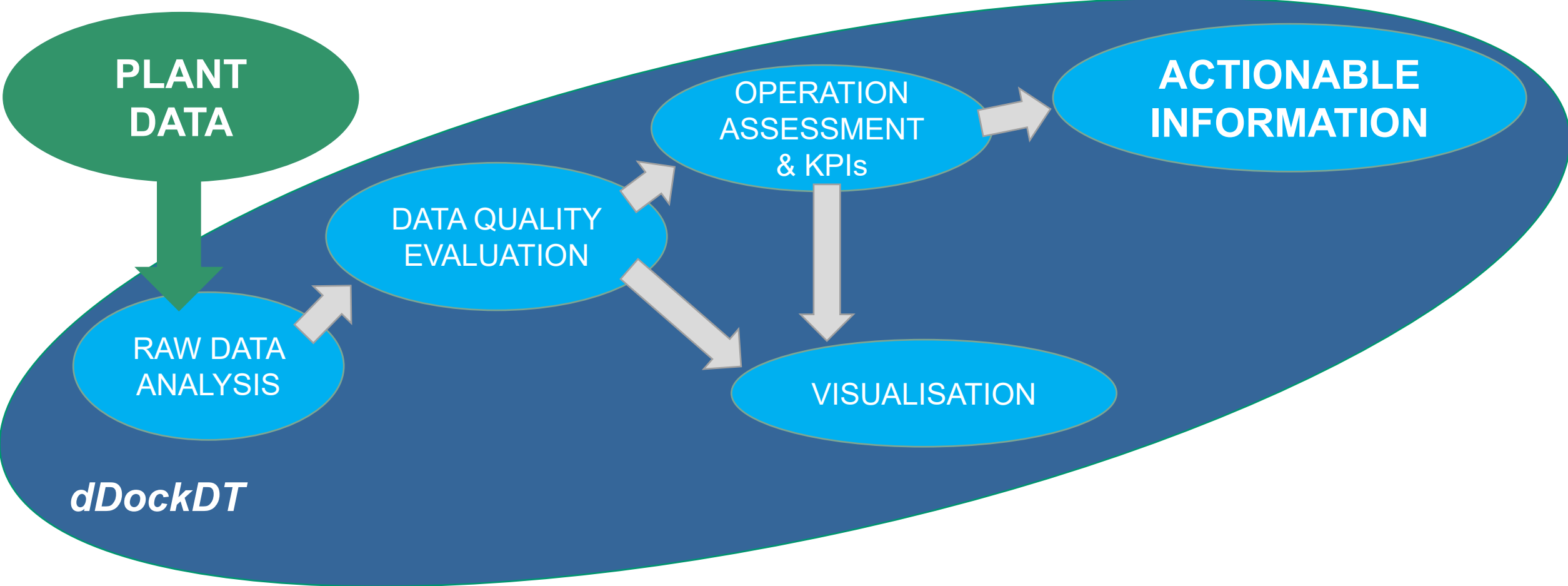
Data Flow: *dDockDT (digital twin)*

PLANT DATA

dDockDT

RAW DATA ANALYSIS

DATA QUALITY EVALUATION

CALIBRATION & SCENARIO PREPARATION

OPERATION ASSESSMENT & KPIs

VISUALISATION

ACTIONABLE INFORMATION

SIMULATION DATA ANALYSIS

SIMULATION ENGINE

Calibration Update
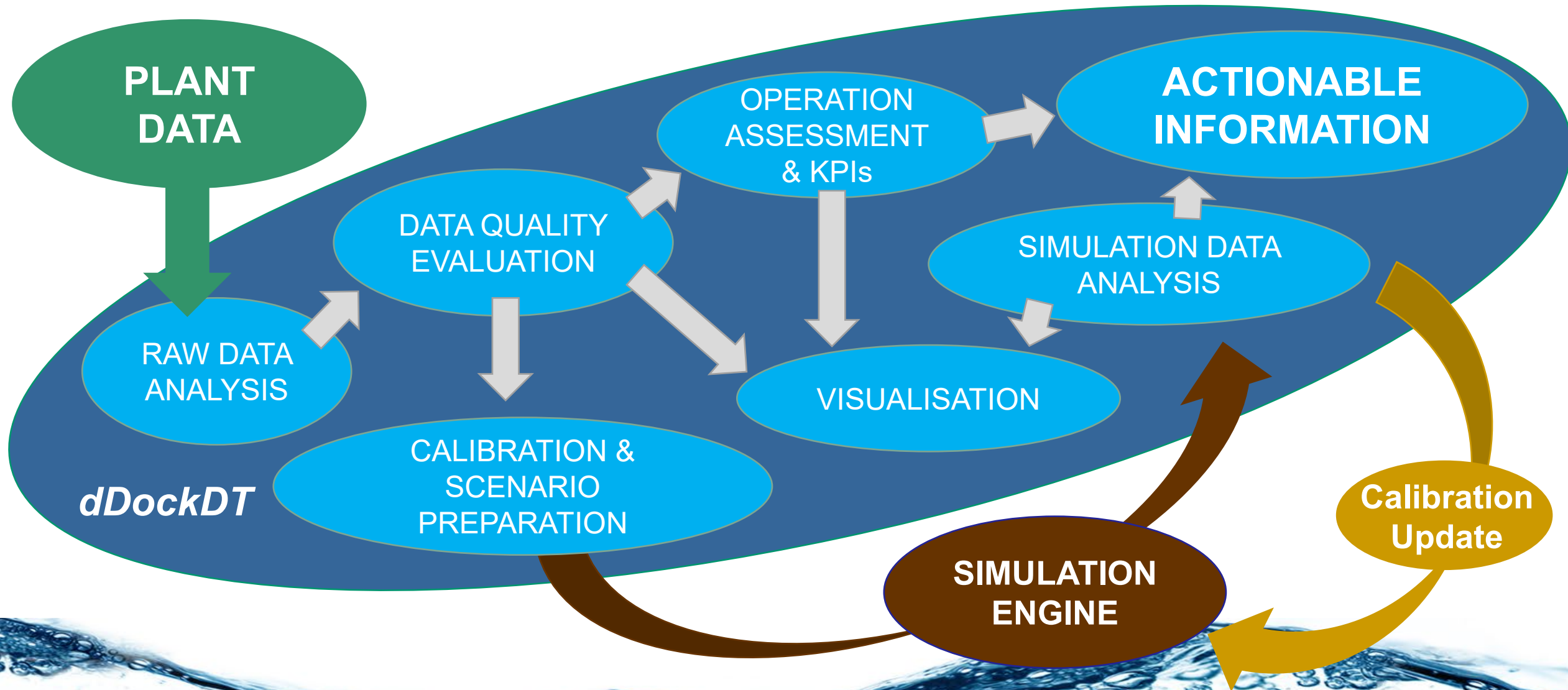
Precision**Now** → *User-Configurable Data Analysis*

- Drag-n-drop your data sources

- Configure your data access settings

Precision***Now*** → *User-Configurable Data Analysis*
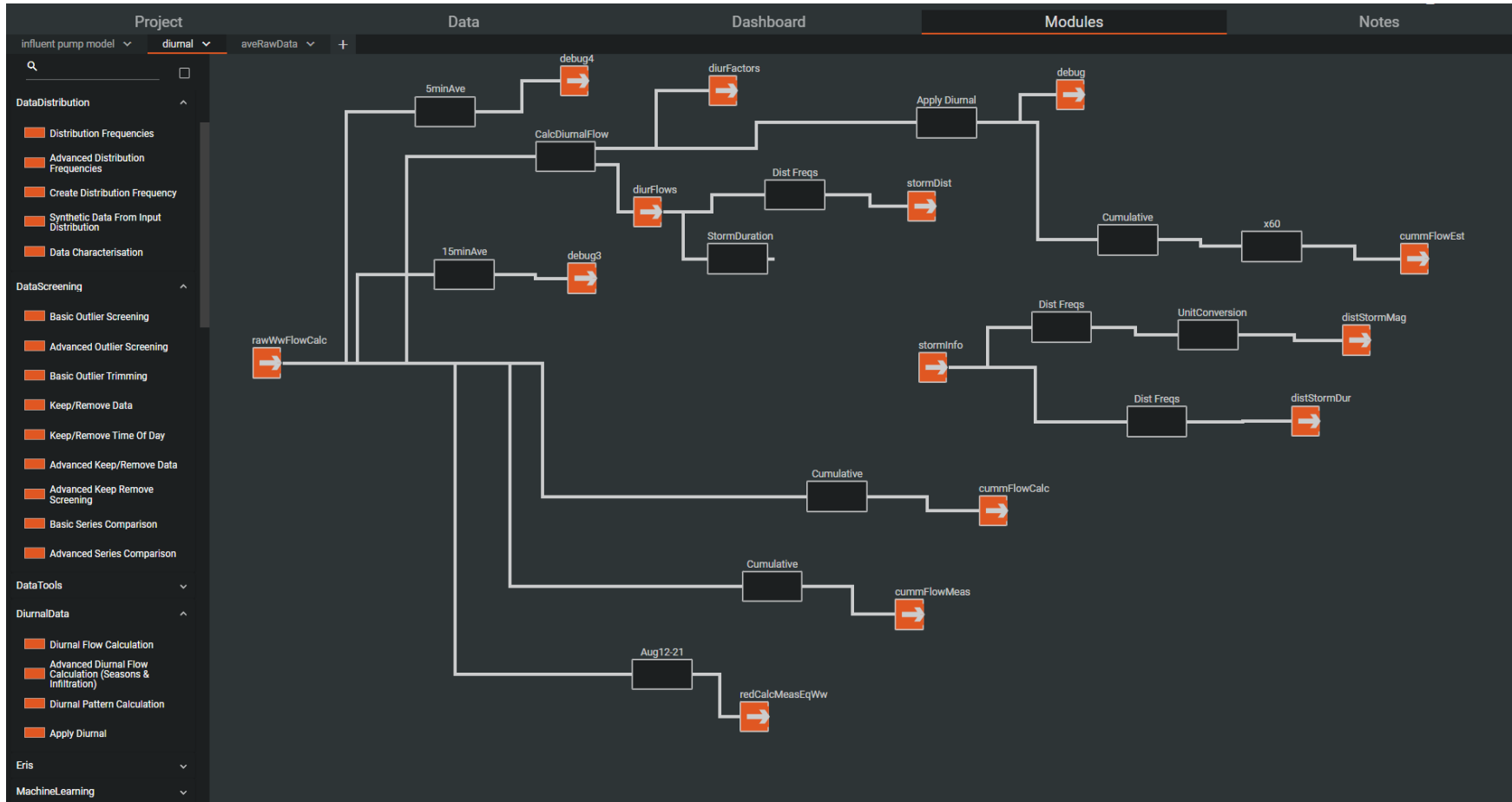
- Drag-n-drop 100s of user-configurable data analysis modules, then connect them up

- Visualise your data analysis flow

Precision*Now* → *User-Configurable Visualisation*

- Choose your own visualisation options

- Configure personalised dashboards
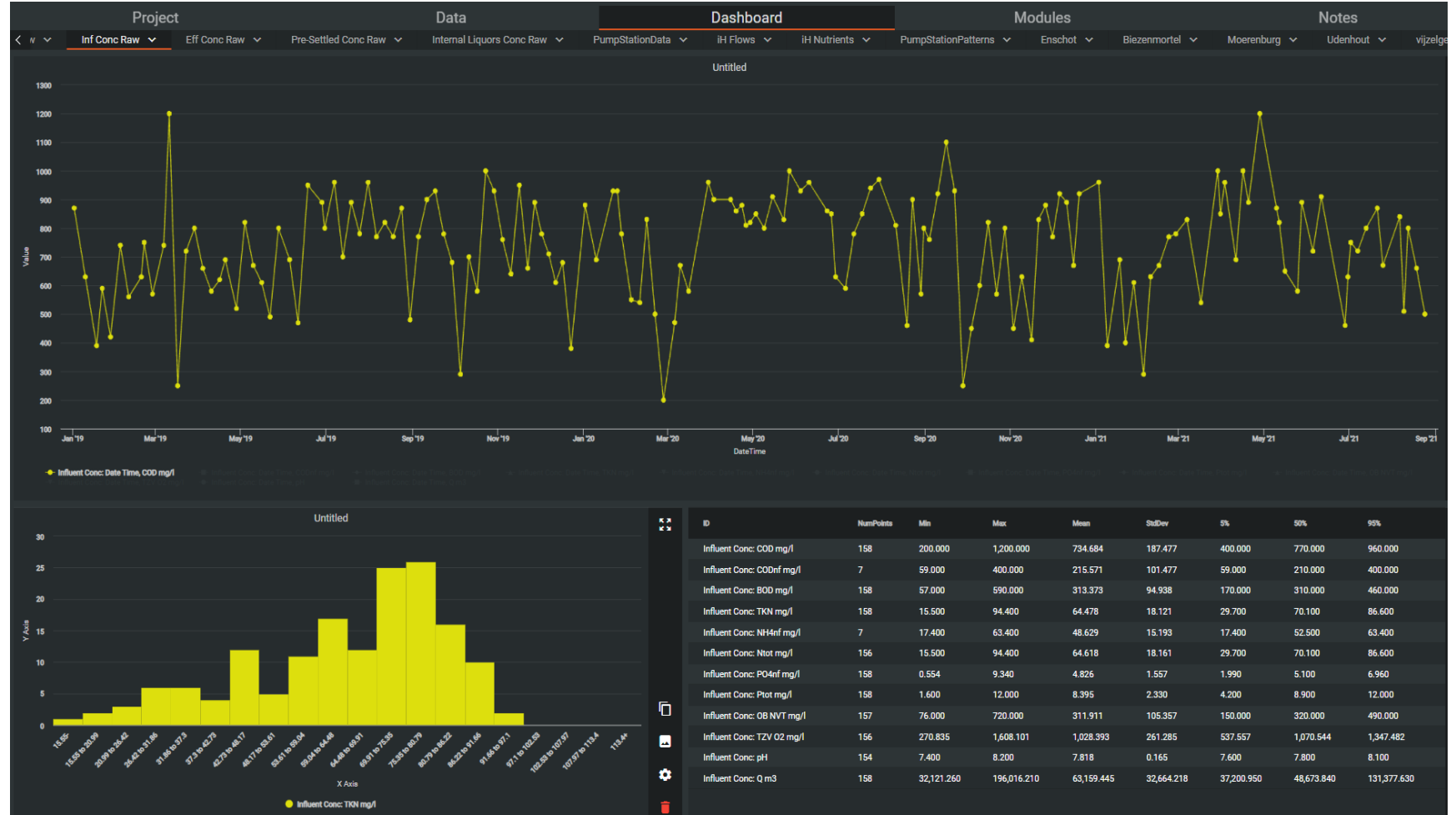
Precision**Now** → *How is this different?*
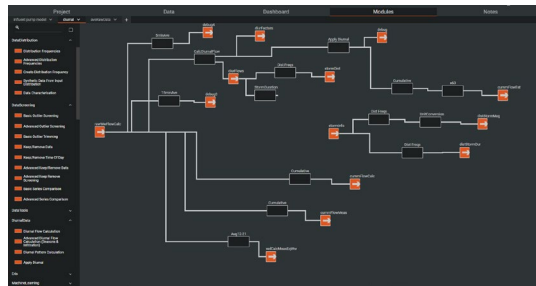
User 1 (Operator)
- Data quality / Sensor status
- Risk of failure custom calculation
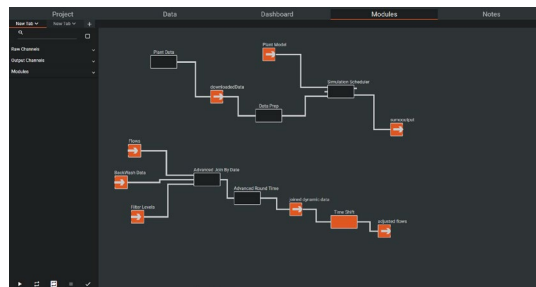
User 2 (Engineer)
- Longterm trends
- Controller behaviour

- **Purpose-Built Real-Time Analyses**
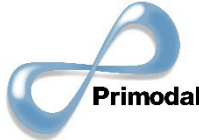 - Individual
  - Shared/Not shared
  - No legacy

??

User 3 (???)
- Short-term study on data quality
- Data analysis for SOP update
- …

Demo – Filter Assessment

Case Study → *Real-Time Filter Assessment*
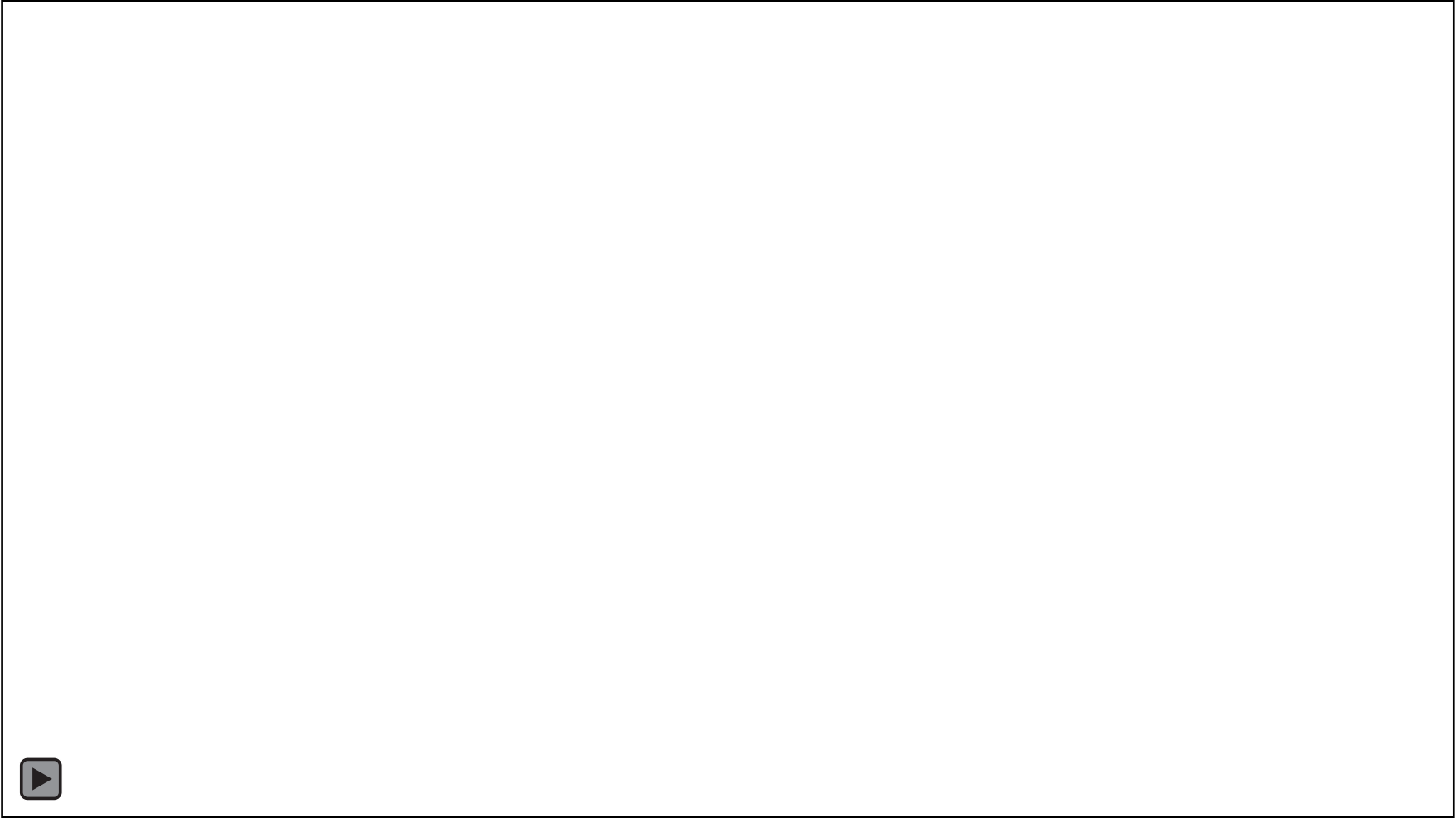
PrecisionNow → Case Study 2 – Risk Assessment
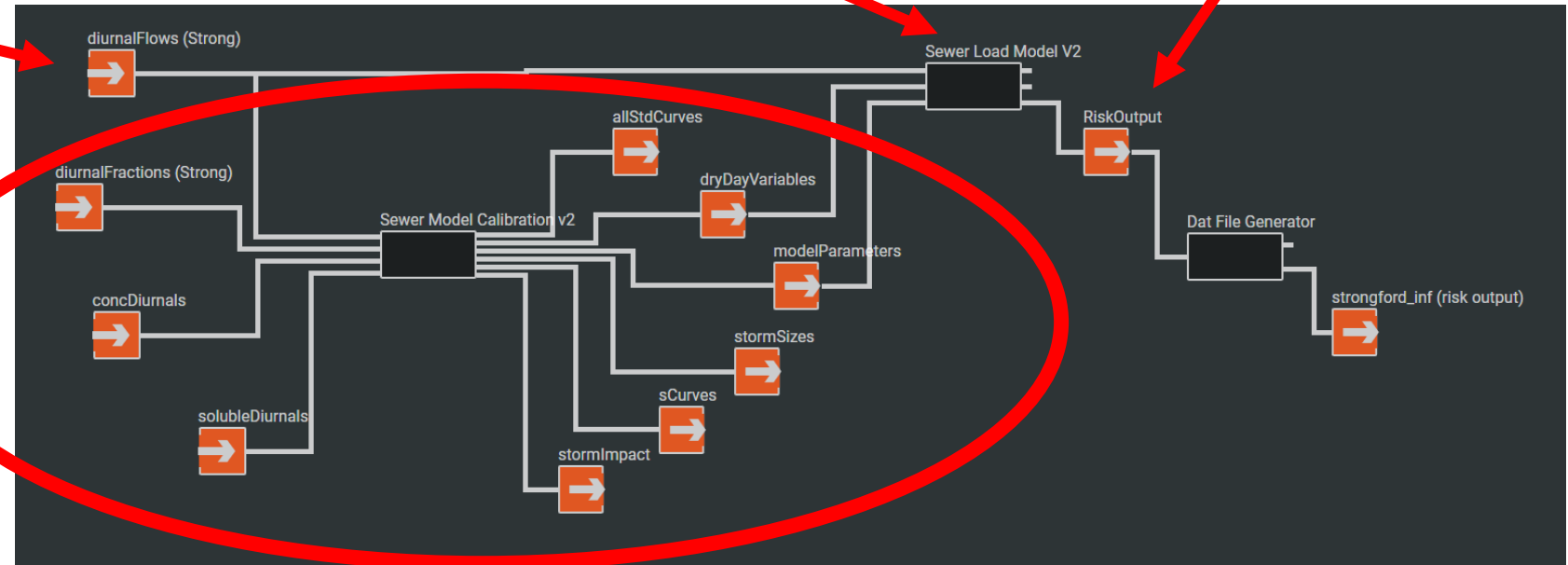

Real-Time Model Input
- Influent Flow

Data Model
- Continuously Running
- Influent Soft-Sensor

Real-Time Risk Assessment Output

Data Model
- Calibrated with Historical Data
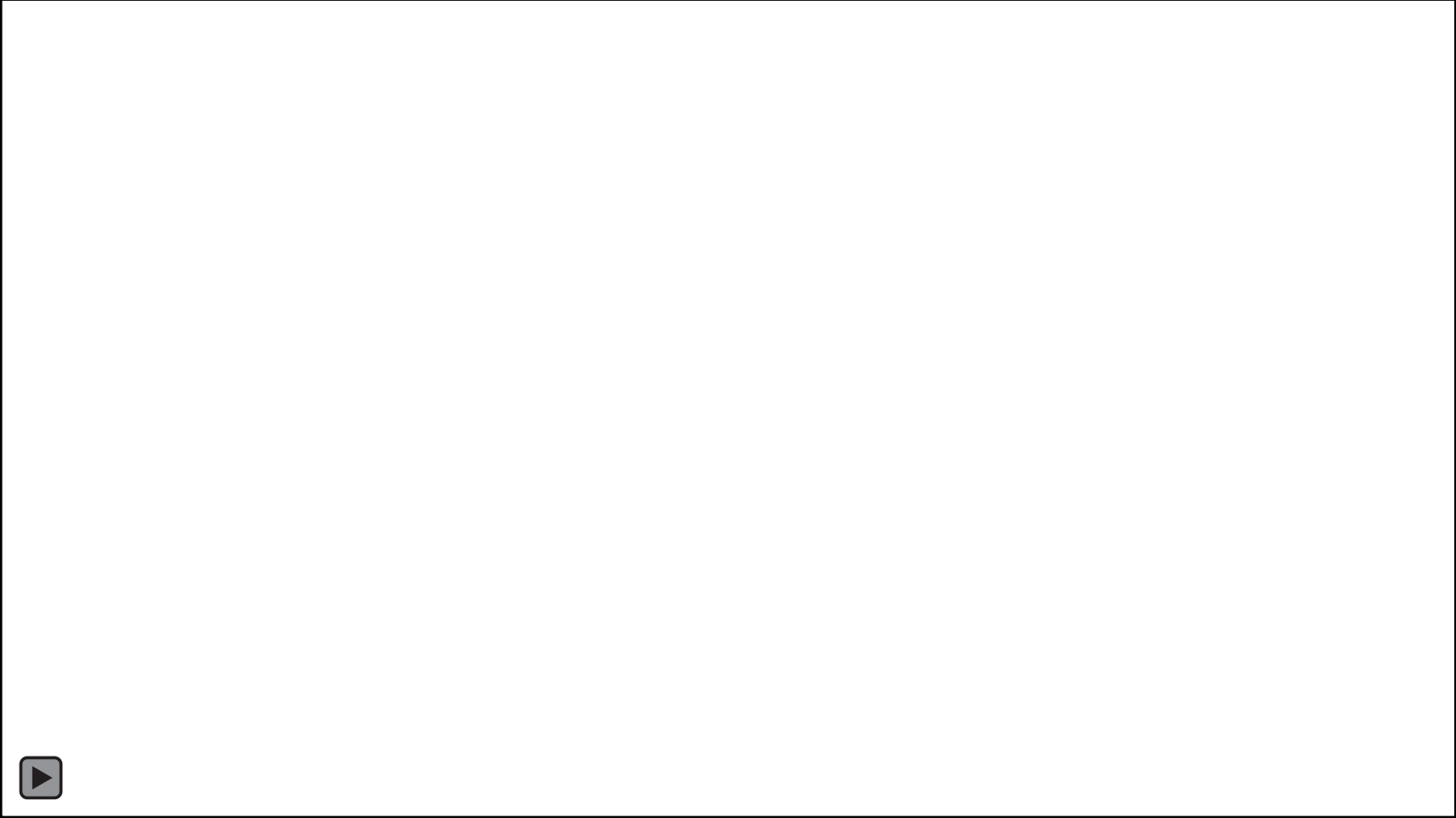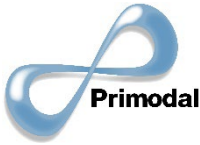
Failures, Process Oddities …

➢ **Predictive Fault Detection & Soft Sensors**
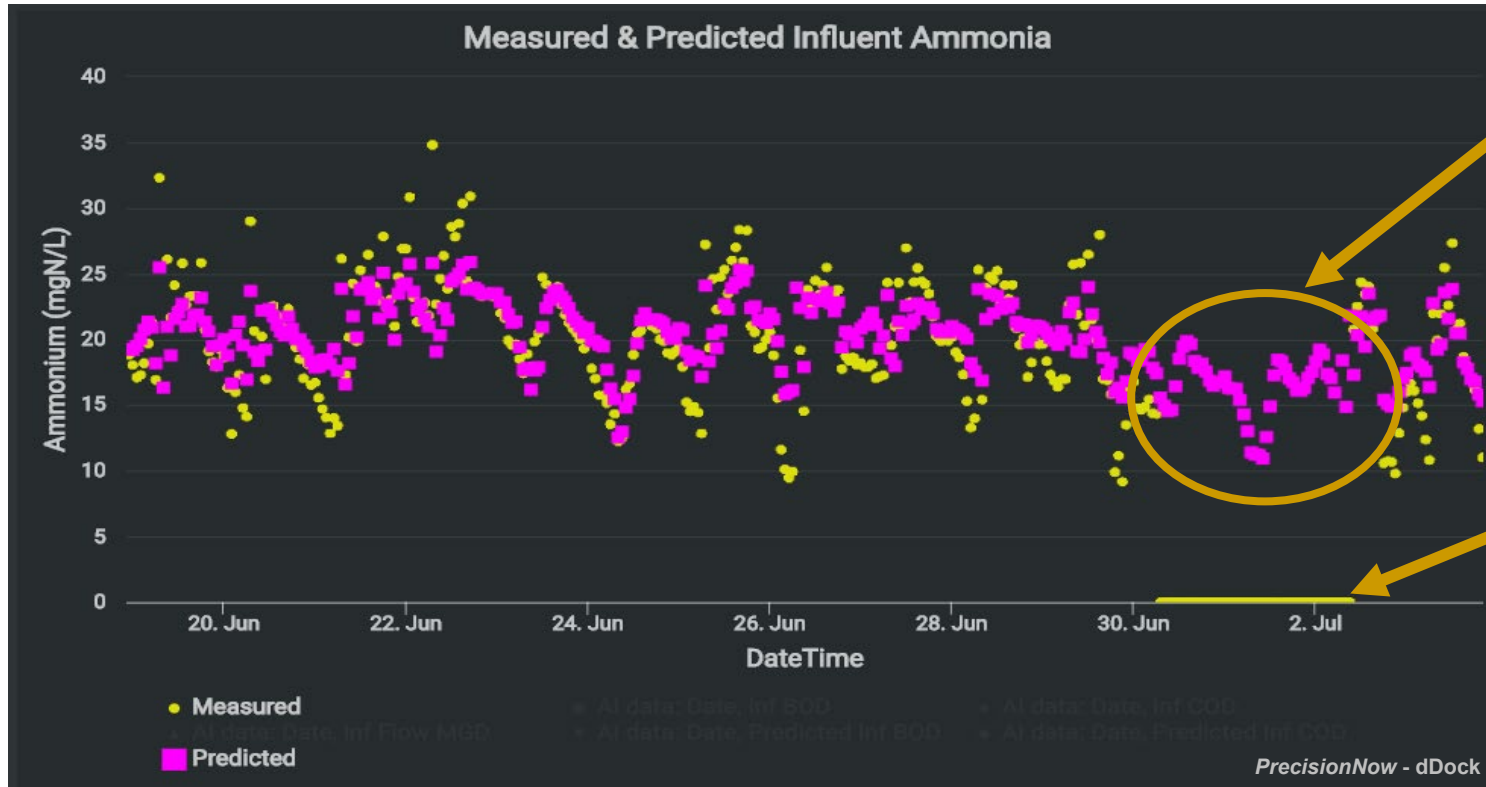
Real-time soft sensors running in parallel, or alone
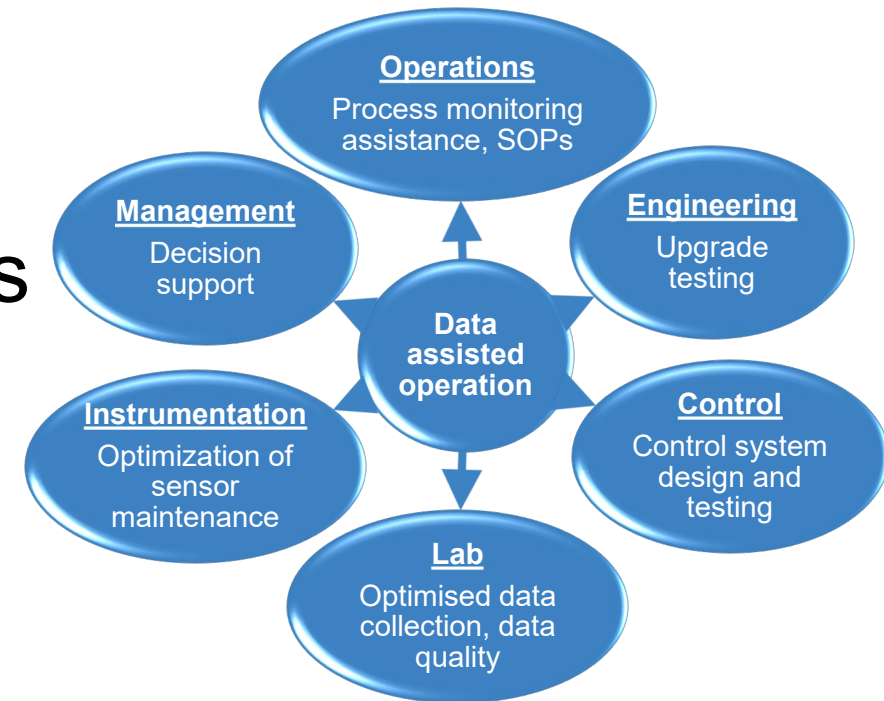
Sensor failure & alarm

Failures, Process Oddities …

- ➢ Predictive Fault Detection & Soft Sensors

- ➢ Optimise and Adaptive (& Model-Based) Control Systems
  - DO, SRT, MLSS, Chemical Dosing, …

- ➢ Flow & Mass Balances
  - Influent/Effluent, Flow splits

- ➢ Identify Maintenance Issues
  - Statistical comparison of parallel ASPs
  - DO probes, Airflows, Valves, Ammonia …
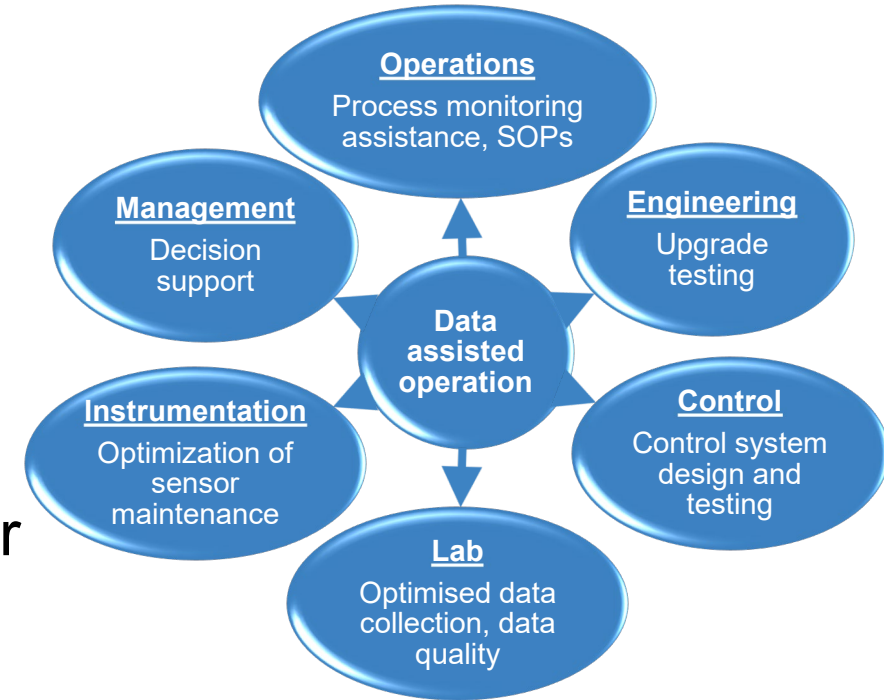
Successful Implementation

- Includes all disciplines

- Creates incentives for all disciplines

- Incorporates existing operations

- Data quality control

- Optimises data usage

- Incorporates new data-driven operational outcomes into existing SOPs and operator work schedules

Operations
Process monitoring assistance, SOPs

Management
Decision support

Engineering
Upgrade testing

Data assisted operation

Instrumentation
Optimization of sensor maintenance

Control
Control system design and testing

Lab
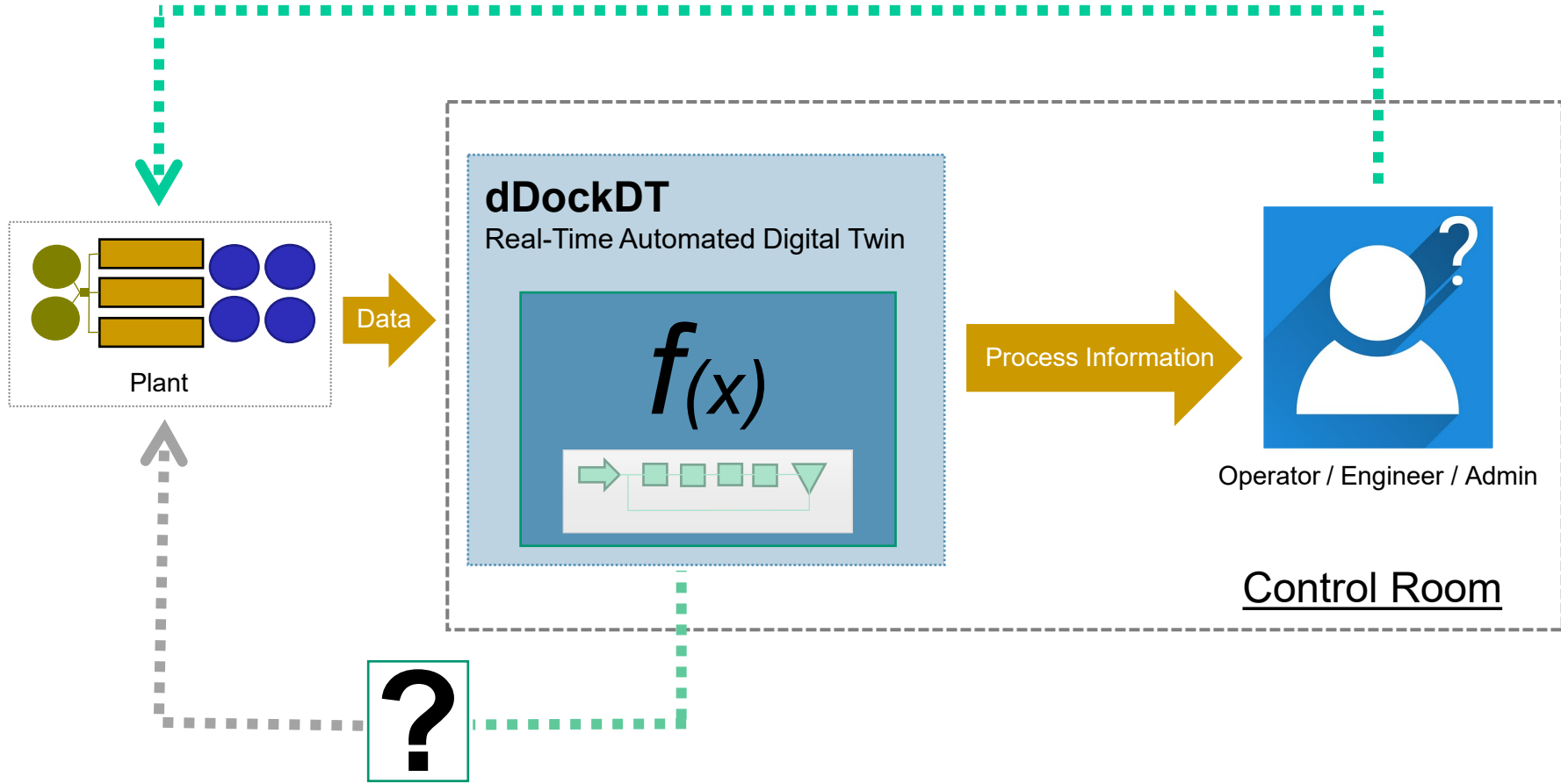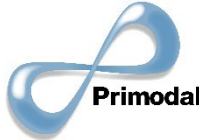Optimised data collection, data quality

Successful Implementation – *Why?*

➢ ## Last Project

- ## 70% of all lab data thrown out
  - Unusable, poor quality, meta-data issues

- ## Sensor maintenance
  - Sensor SOPs lacking, 3rd party service provider

- ## Flow/Mass balances
  - Unable to balance flow and masses due to unknown QC problem
  - Information SILOs resulted in unshared data

- ## Wasted resources storing poor quality data
  - Potential for design/operation errors

Operations
Process monitoring assistance, SOPs

Management
Decision support

Engineering
Upgrade testing

Data assisted operation

Instrumentation
Optimization of sensor maintenance

Control
Control system design and testing

Lab
Optimised data collection, data quality

Conclusion

➢ Data Quality

- ## Data Quality is essential

  - You've invested in the equipment, so spending the time and money ensuring data quality will help realise the benefits

- ## Maintenance

  - Understanding when and how often maintenance is required saves money (avoid *ad hoc* estimates)

Conclusion

➢ **Digital Twins <u>Need</u> Prior and Post Model Data Analysis**

- Raw data analysis for proper data to the model
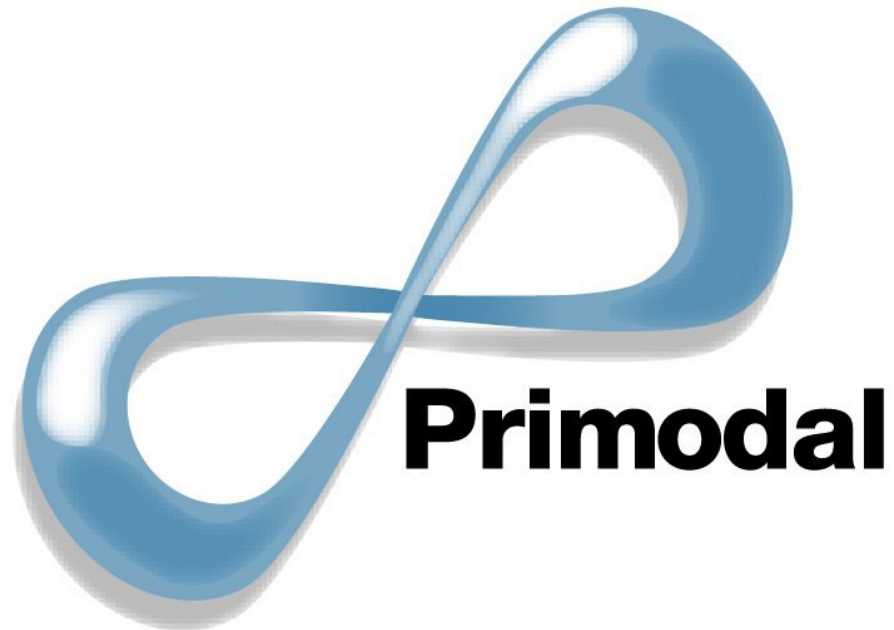- Model output analysis for real-time operational efficiency

➢ **Precision*Now***

- User-Configurable DT technology
  - data analysis & visualisation
  - data flow to/from the model
  - multiple model capabilities, scheduling, optimisation

Thank-you !

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