



InFrame Synapse Manufacturing Execution System (MES)

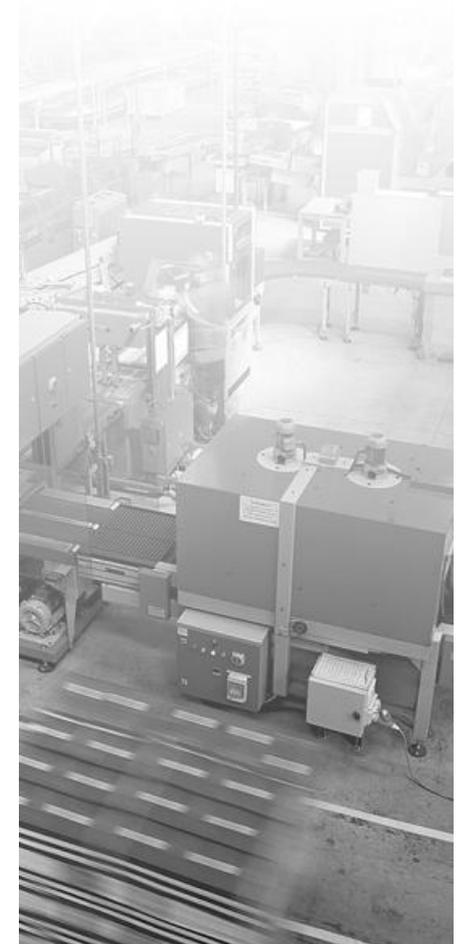
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2 Basics and SOA architecture

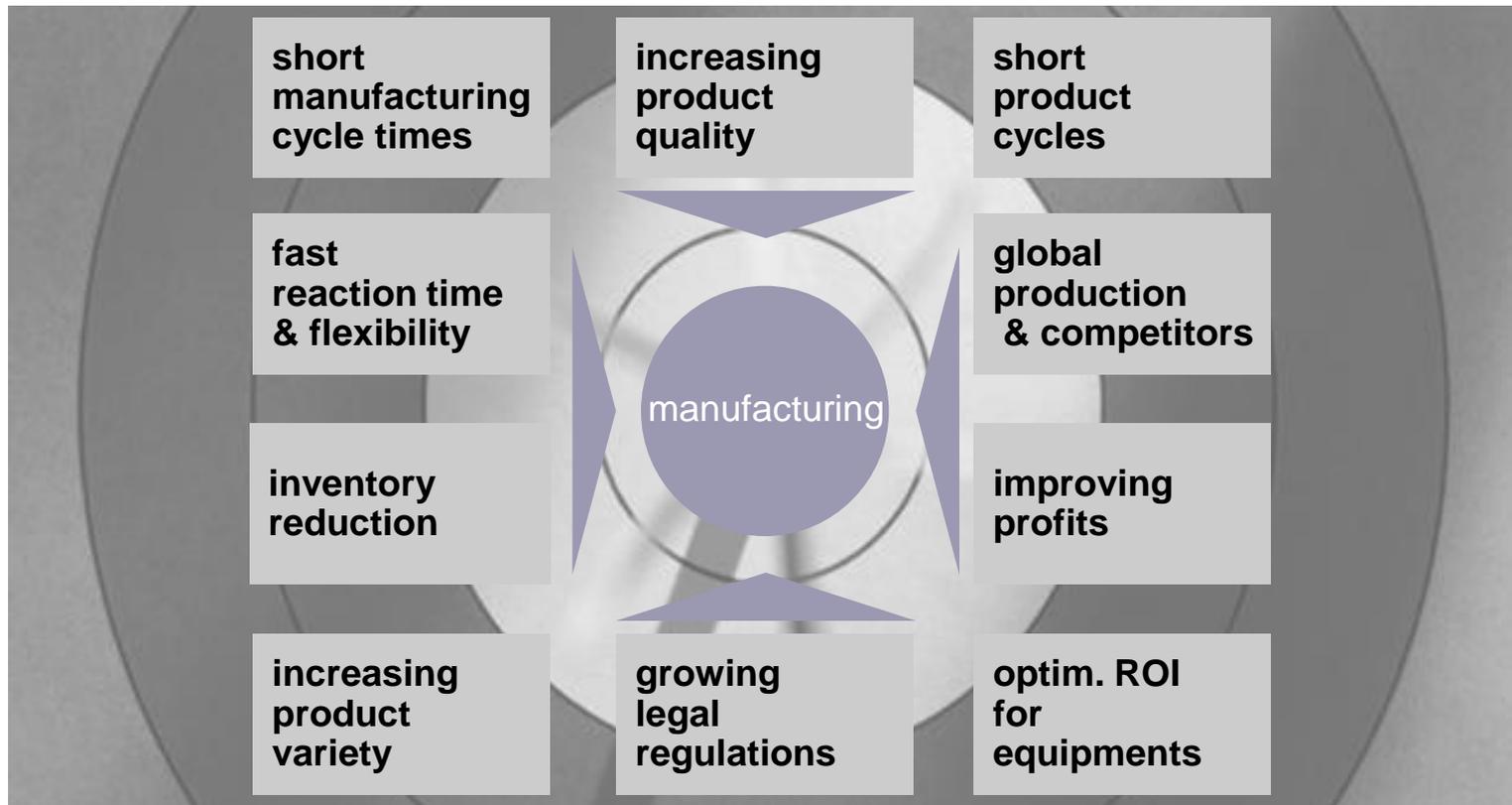
3 GUI

4 MES Functionalities

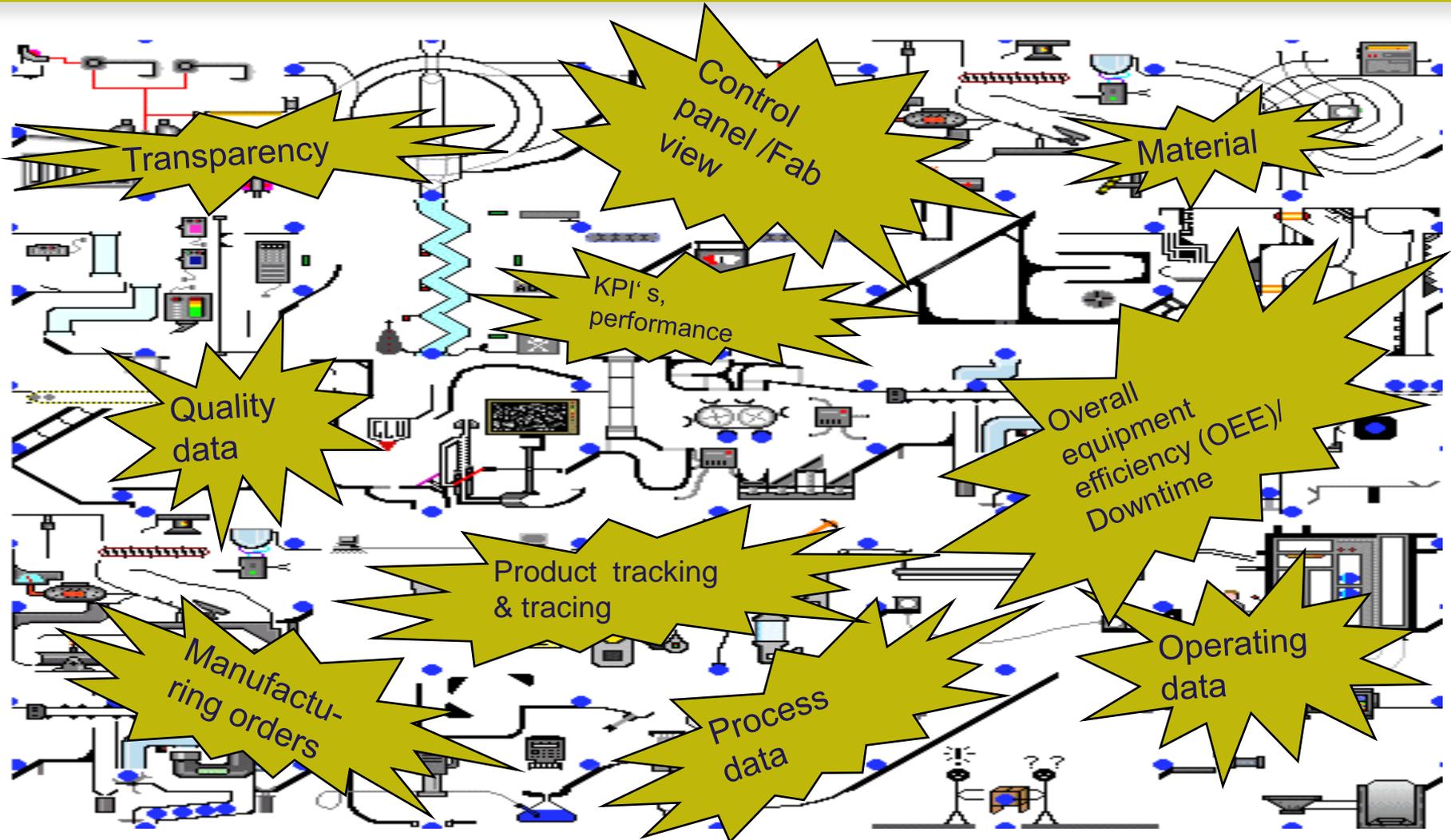


Increasing challenges for manufacturing

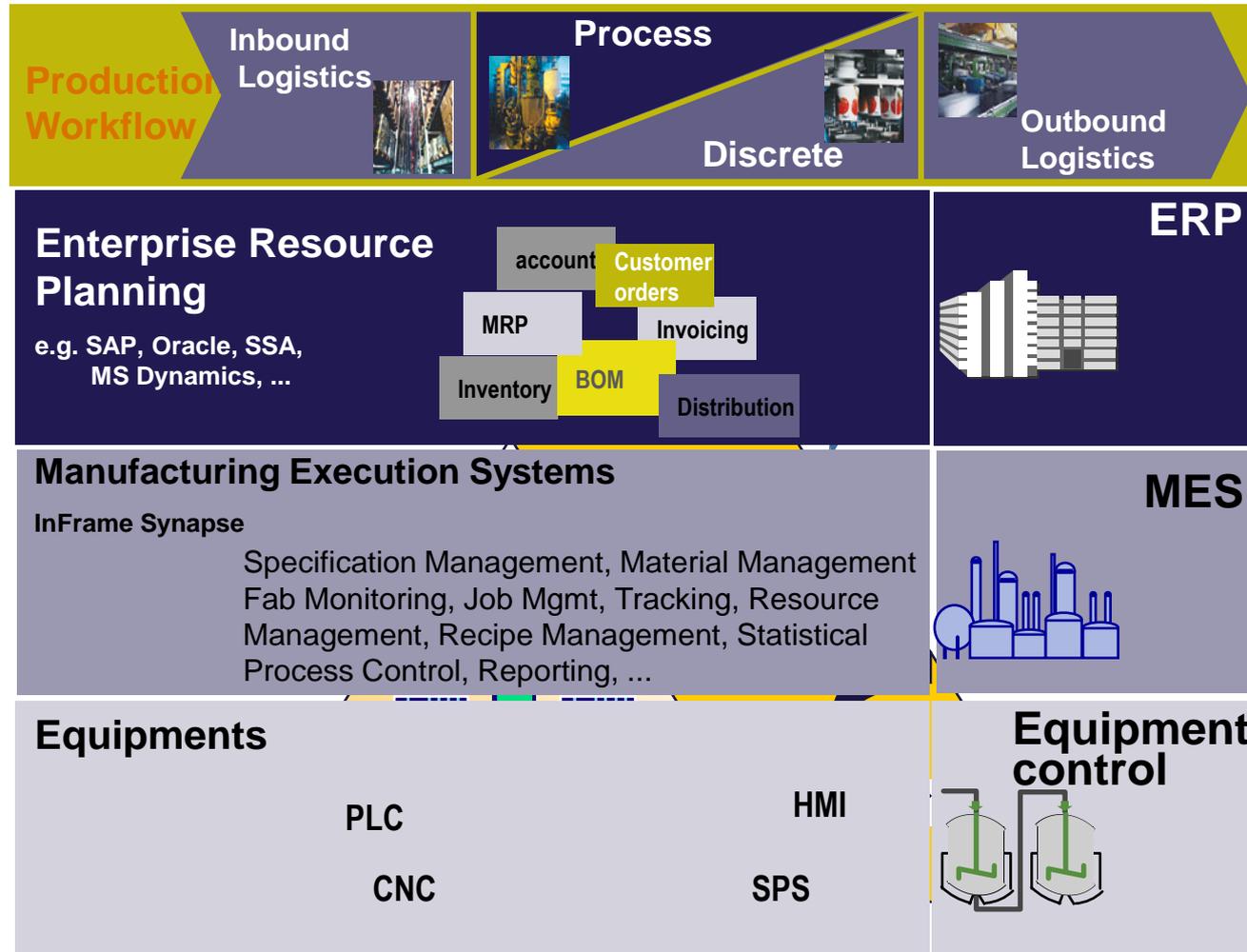
Manufacturing has to meet a complex variety of challenges to stay competitive



Objectives for the MES implementation



Vertical Integration of MES



Customer Orders and Master data

process and manufacturing data are consolidated

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Basic Functionalities of InFrame Synapse

Traceability within production

- **Product** definition and **process** plan
- Material tracking („WIP Tracking“)
- Collection of history data (History Data Tracing)
- Collection of quality data (Quality Data Tracing)
- Statistical Process Control (SPC) / Process Diagnostics / Fault detection and classification (FDC) /Advanced Process Control (APC)

Management of all resources (production equipment, operators, ...)

- State tracking, monitoring and visualization
- Skill management

Production control

- Control, execution and monitoring of all production flows
- Dispatching and Scheduling of production orders

InFrame Synapse SOA architecture and the major advantages

High availability

- Limit the risk of changes within production
- Clear and well defined architecture

Open for extension

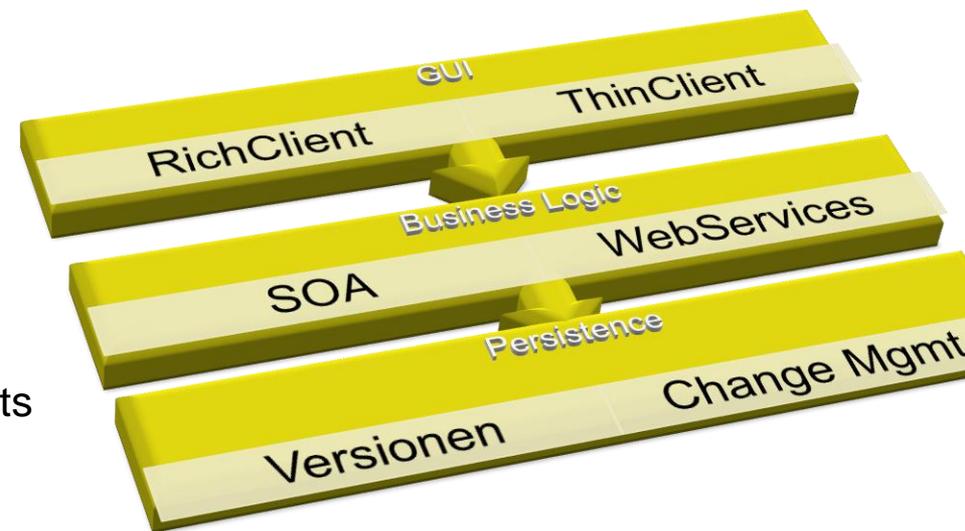
- State-of-the-art system architecture
- Well defined and documented interfaces

Scalability

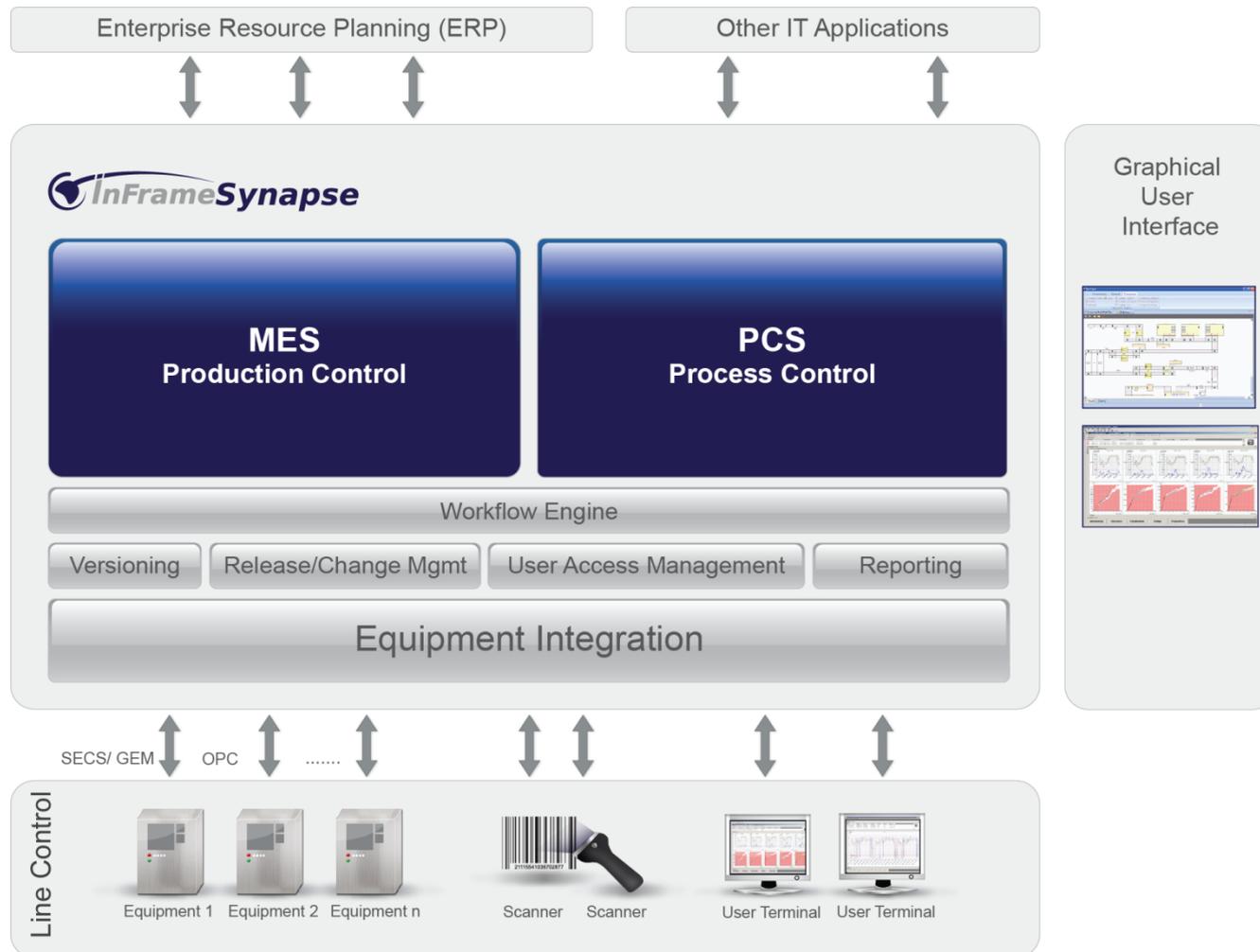
- Scalability for integration of new equipments

Persistence Layer

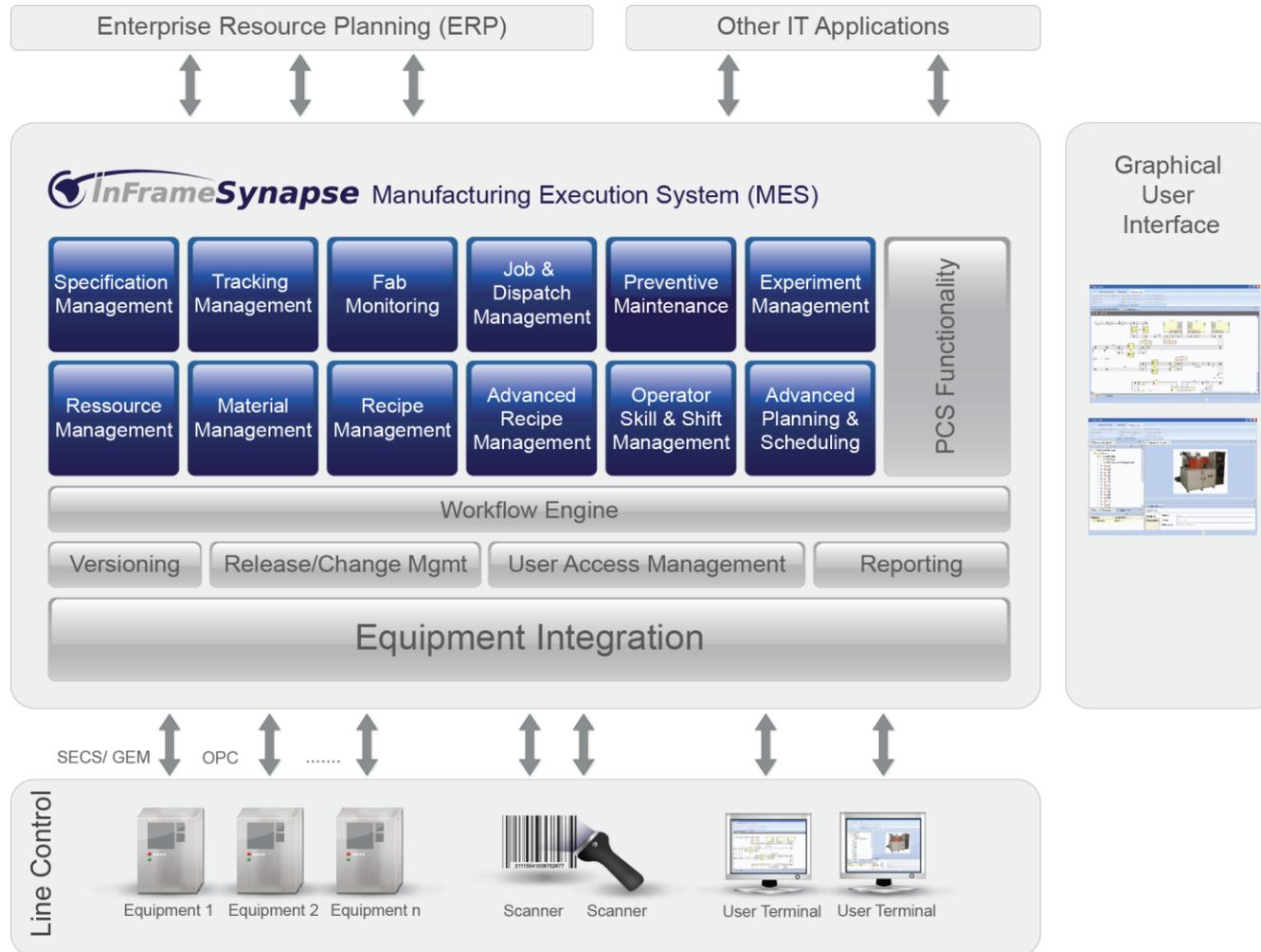
- Decoupling of Business logic and database
- Database is exchangeable depending on customer request (e.g. Oracle, MySQL, ...)



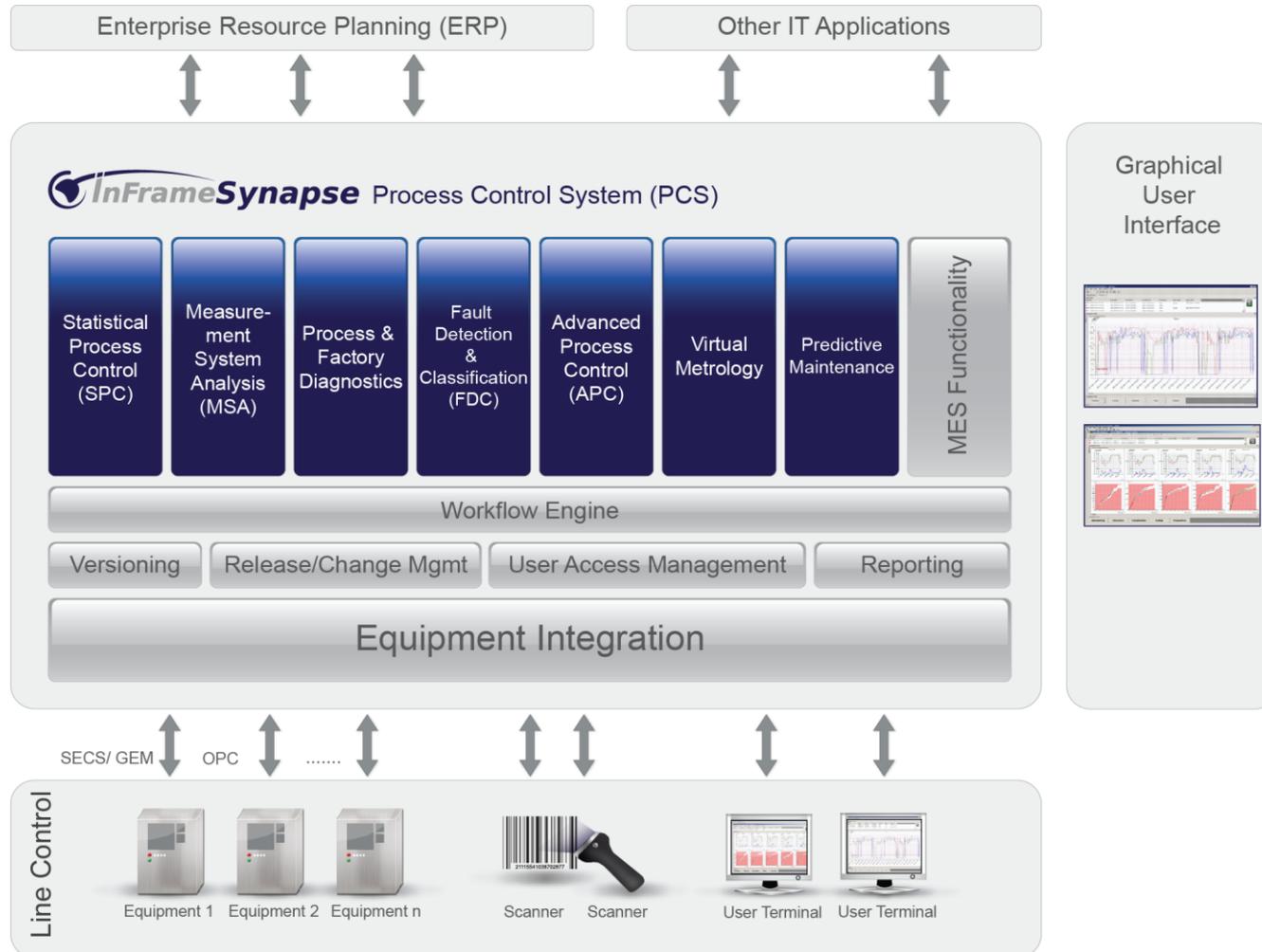
InFrame Synapse offers an Integrated Functionality for Production Control and Process Control



System Overview (1): MES Functionality



System Overview (2): PCS Functionality



Essential features of the Synapse framework: Core

Versioning of persistent Objects

- Access to database always via persistence layer
- Versioning of all persistent objects
- Change of an object leads to a new version
 - Complete history of changes for the complete lifecycle of an object

Change- and Release management

- Based on Versioning management framework
- Related changes will be combined in a „Change Session“
- Objects from different services can be combined in one „Change Session“
 - Process plan, recipes, documents...
- Flow control of “Change Session” by using configurable state machines
- Different (complex) Review / Approval Scenarios are possible
 - E.g.: FMEA, Engineering, Release as Experiment, Review, Release to production



Essential features of the Synapse framework: Core

Workflows und Workflow-Engine:

- Workflows to customize and extend the basic functionality of Synapse MES
- Workflows can also be used by customer to extend the system
- Workflow-Engine to execute workflows
- Workflows are also persistent objects and will be versioned
 - complete history and rollback of all customizing and customer extensions
- Changes of workflows are also related to a „Change Session“
 - Review und Approval also for workflows



Essential features of the Synapse framework: Core

Equipment Integration

- Equipment Integration is completely integrated in Synapse
- Strong coupling between MES and Equipment Integration
- Different protocols are possible (SECS/GEM, OPC, proprietary)
- Each Equipment can be connected using a different protocol
- EI can be extended because it's done using workflows and workflow-engine
- EI changes will be done under Change- and Release management
-> Changes to an EI adapter can be done within runtime



Essential features of the Synapse framework: Core

Graphical User Interface (GUI)

- Modularity
 - Versioning of different GUI features
 - Common look and feel for all roles (Operator, line manager,...)
- Exchangeable Views
 - Different views to the same data are possible depending on the user role
- Each role has its own perspective (build from different views)
- Automatic update mechanism available
- Short response time
 - Multi-Threaded





Thank you for your attention.

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MES Components: Recipe Management

Customer Value:

Management of recipes allows to

- up and download a recipe to a resource /equipment or activate a recipe at an equipment
- manage the usage of all recipes for production
- deploy recipes which are qualified for a product, a process and a resource
- Deploy recipes for human resources (Operator) as a working instruction



Technical features:

- recipes also names managed centrally for all production resources
- active resources use recipes to achieve their process targets
- The Capability Mgr controls the assignment of recipes to resources
- Capabilities are requested by the process and provided by resources
- The Recipe and Capability Manager ensures that only executable recipes are assigned (implicit) to a certain resource.
- Special Operator-Terminals (GUI) are available for interaction with human resources



MES Components: Advanced Recipe Management

Customer Value:

Advanced Management of recipes allows additional to Recipe Management to

- Hierarchical recipe definition
- Management of Recipe Parameters including limits and validation rules
- Based on latest SEMI Recipe and Parameter Standard
- Qualification of Recipes for certain equipments



Technical features:

- Complex recipes for cluster equipment can be managed centrally
- Parameter management enables the support for parameter override in experiments and by Operators



MES Components: Material Management

Customer Value:

Material Management allows to

- Define Raw Materials used in the production process
- Is used to define consumables tracked in the production process
- Free definable material types allows the tracking of all consumables
- Allows the definition of hierarchical Materials (Containers, Boxes, Bottles aso.)
- Enables simple tracking of material for warehouse purposes
- Consumables defined in the Material Management can be assigned to production resources and are tracked in the Job history



Technical features:

- Complex material scenarios can be set up using the hierarchical material definition
- Material Types are the base for Consumable Management



MES Components: Preventive Maintenance

Customer Value:

Preventive Maintenance extends the Resource Management to

- Define recurring maintenance tasks for all active resources
- Maintenance tasks can be run as Operator Tasks or integrated as regular production jobs into Dispatching
- Counter and Time based Tasks can be defined
- Multiple Tasks of each Task type can be assigned to a resource
- A escalation procedure can be defined if tasks are not executed



Technical features:

- Counter based tasks are verified with each state change of a equipment
- Time based tasks can have a grace period before escalations are triggered



MES Components: Resource Management

Customer Value:

Management and tracking of all resource states allows to

- analyze and optimize up time / downtime of resources (MTBF, MTR)
- identify bottle necks
- analyze failures leading to capacity and throughput problems
- to improve ROI of resources (OEE ; SEMI E10)
- schedule preventive maintenance and execute predictive maintenance strategies



Technical features:

- InFrame Synapse differentiates between active and passive MES resources
- Active resources contain technical (equipment) resources as well as human resources
- Passive resources are e.g. carriers, magazines or trays
- Resources can be grouped and setup hierarchically to support the configuration of Clustertools



MES Components: Experiment Management

Customer Value:

Definition of Experiments for Dispatch based Production lines allows

- Easy definition of Experiments including the definition of multiple material groups and process variants for steps
- Each experiment step can contain user definable work instruction as well as modified parameters based on advanced recipe definitions
- The Experiment execution is fully integrated into the regular Job Execution, not need for special Operator training
- Each Material Group can be assigned to different Material Types from the Material Management



Technical features:

- The Advanced Recipe Management provides the basis for flexible recipe parameter override
- Material Management integration allows the reservation of special Material for experiments

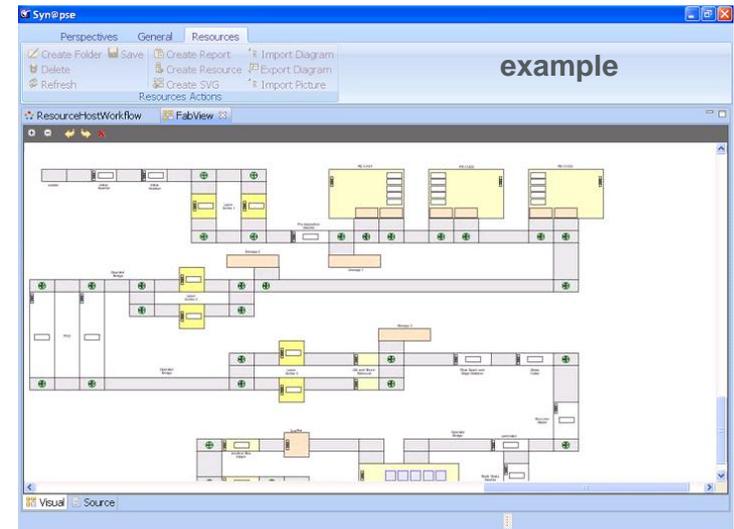


MES Components: Fab-Monitoring

Customer Value:

Fab-Monitoring or FabView

- enables the graphical Online Display of the current shop floor status / equipment states
- includes all resources and production orders currently executed on the production line/ cluster / equipment
- Visualization of product data in the context of resources (e.g. position of lots within production line)
- Displays the status and other information of resources



Technical features:

- The user can define different graphical views and link them to resources
- The view can be comfortably built with graphical library elements (drag & drop)



MES Components: Reporting

Customer Value:

- creation of reports over all stored MES data (Tracking and Resource data) in printable formats.
- reports are defined in a graphical user interface and thus can be adapted and extended by the user.
- powerful filters and grouping functionalities can be used within reports
- reports can either be created directly by user interaction or on a regular basis (e.g. daily/ weekly reports).
- Standard Reports are available:
Tracking data reports, Equipment Data reports, Yield, Scrap and Fault reports, Throughput, Cycle-Time, Work in Progress, Overall Equipment Efficiency (OEE): overall, per line, cluster, or equipment, etc.
various statistics reports
- other user definable reports

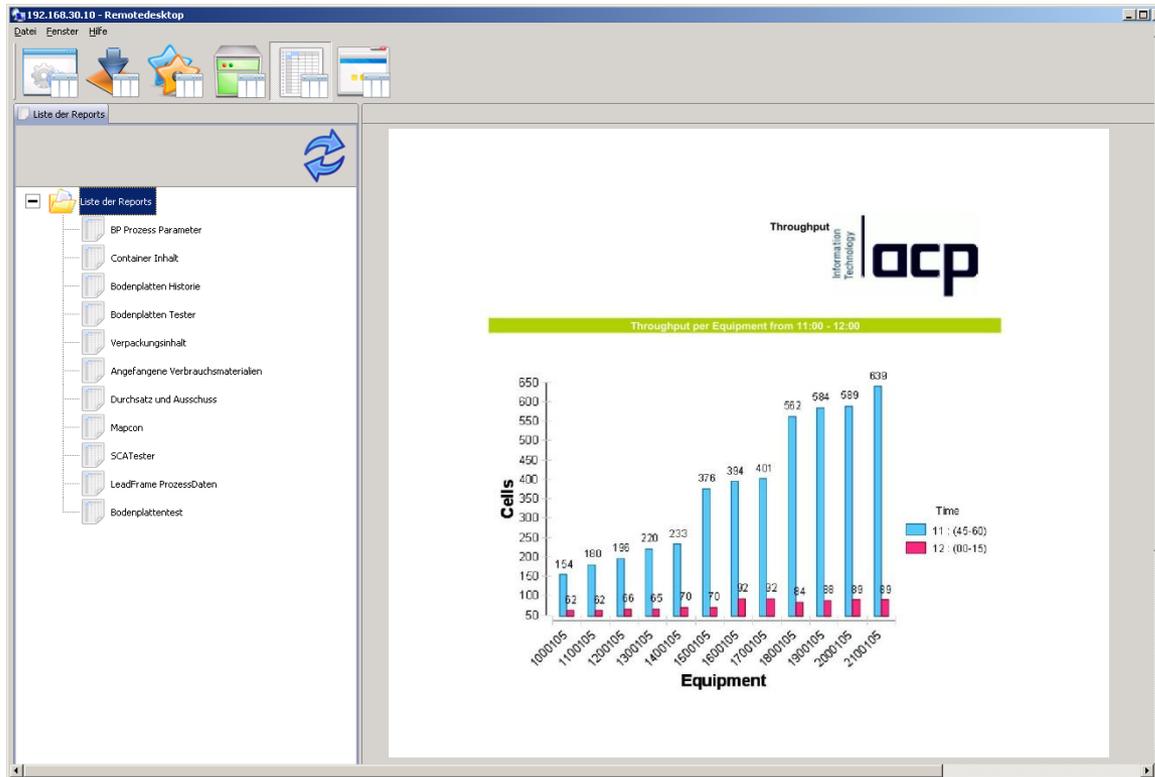


Technical features:

- Reports can either be created directly by user interaction or on a regular basis (e.g. creation of daily or weekly reports).
- Graphical diagrams can be incorporated flexibly
- The user can define different graphical views and link them to resources
- The view can be comfortably built with graphical library elements (drag & drop)



GUI: Examples



List of reports with one throughput example



MES Components: Job Management and Dispatching

Customer Value:

- Planning, dispatching and controlling of manufacturing orders
- definition of production orders, which are brought into the system (e.g. via ERP-system or manually) and covering of their assignment to customer orders.
- Assignment of production order to process plan and material.
- Manages and monitors execution and progress of the orders according to process plan .
- Possibility to group a set of materials using the Batch Manager component
- Capability / process goal will be send to dispatcher
- The execution and prioritization of capability/process goal will be done with workflows
behavior of dispatch rules can be customized
can be extended with complex dispatch rules



Technical features:

- processing sequence of the defined orders can be configured via workflows.
- execution and prioritization of process steps will be done with workflows
 - execution behavior can be customized
 - extensible using different planning algorithms possible after installation
- Using the GUI it is possible to have different customizable views on the orders, e.g.



MES Components: Tracking (&Tracing) Management

Customer Value:

- continuously tracks all executed processes with respect to all MES relevant tracking information online. The following data are tracked:
 - Production Status Data
 - Process Times, Process Data and other Tracing Data (e.g. identification, time stamps, etc.)
 - Equipment Data, Equipment utilization, uptime etc.
 - Errors and Alarms
- evaluation and reporting of the recorded data at any point of time.



Technical features:

- all tracking data can be visualized flexible and in real-time (either table formats or graphical formats using customized views).



MES Components: Skill & Shift Management

Customer Value:

- Allows a easy management of Operator Skills
 - Assignment of Skills required for a certain process
 - Management of skills provided by Operators
 - Integration into dispatch management allows the smart
- Flexible definition of Shifts for production resources.
 - Definition of multiple shift plans e.g. Two and Three shift plans for certain timeframes
 - Assignment of resources to shifts
 - Operator availability (calendar) definitions
 - Management of work and holiday calenders



Technical features:

- Capabilities and resources are automatically filtered when using the Dispatch Manager



MES Components: Advanced Planning & Scheduling (1/2)

Customer Value:

- Calculation of a line-wide process operation schedule based on preconfigured optimization rules e.g. Forward Planning algorithm using Critical Ratio and Static Prioritization
- Alignment to the Dispatching component can be provided
- Considers machines as primary resources and operators with their availability and skills as secondary resources.
- For midterm planning the operator availability and order release to the factory is considered as the input criteria for different planning scenarios.
- Different planning scenarios are calculated and can be compared by an experiment management functionality.



MES Components: Advanced Planning & Scheduling (2/2)

Customer Value:

- The Static Planning Extension
 - provides the possibility to calculate raw process times and resource times for individual orders considering the product structure and the lot size.
 - provides a calculation of required time of each specified resource in the operation plan consumed by specific orders.



Technical features:

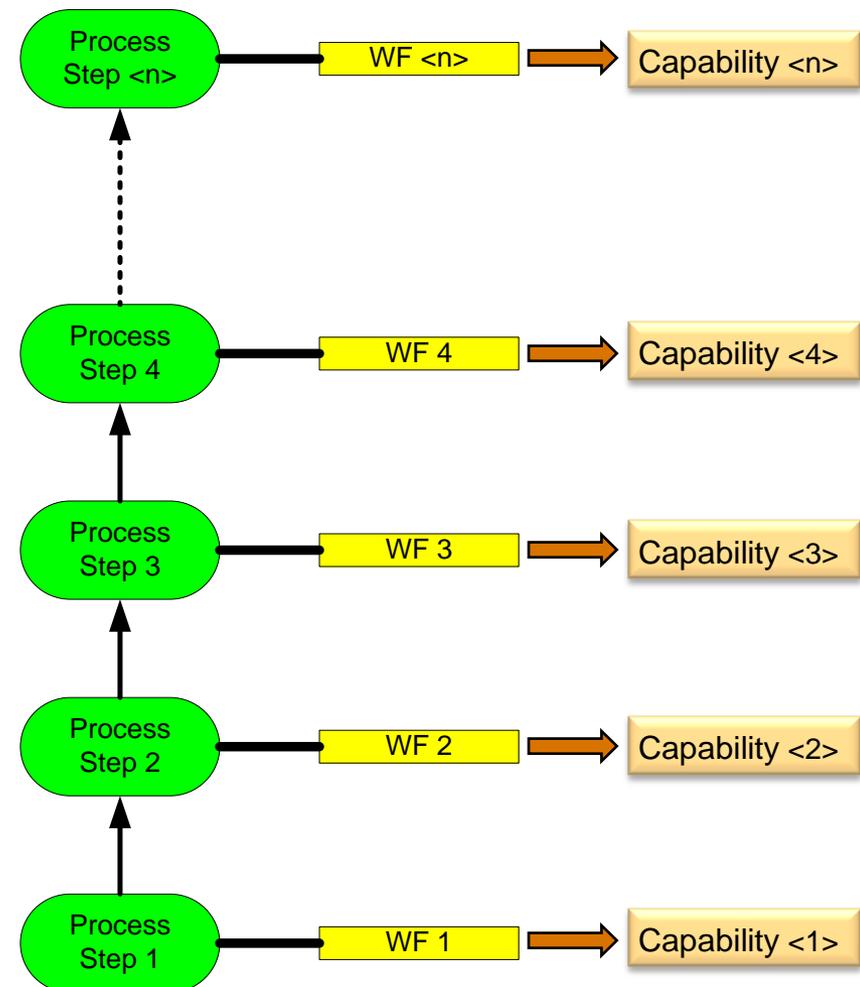
- using customized views the data can be visualized flexible and in real-time (either table or graphical formats).



MES Components: Specification Management (1/4)

Customer Value:

- definition of process plans using a series of process steps
- each process step executes a workflow (WF)
- a process plan can be associated to process step → hierarchical process plans are possible
- a workflow will execute one capability (process goal)
- a capability / process goal is defined by a list of Resource & Recipe
- a (active) resource can be a:
 - techn. resource (equipment)
 - human resource
- the decision of resource will be done immediately before process start



MES Components: Specification Management (2/4)

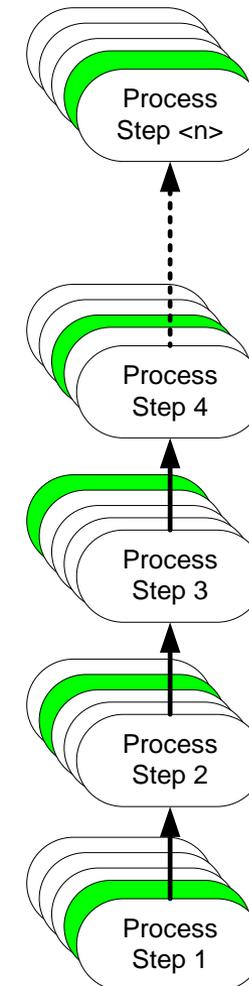
Customer Value:

- enables the definition of products and semi-finished products within a graphical view.
- enables the user to define new products by managing and combining process plans and process targets.
- definition of product variants possible
- the definition of process plans includes the possibility to define alternative process flows, optional measurement process flows, as well as rework process flows.
- the production materials, properties and material groupings (classifications) are managed here.



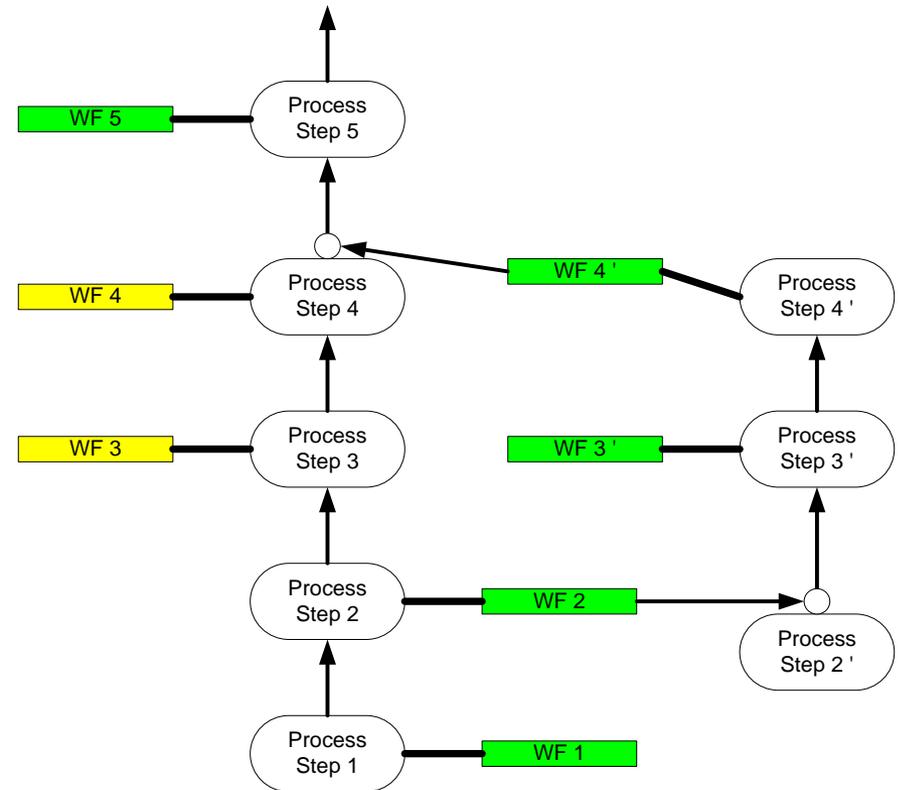
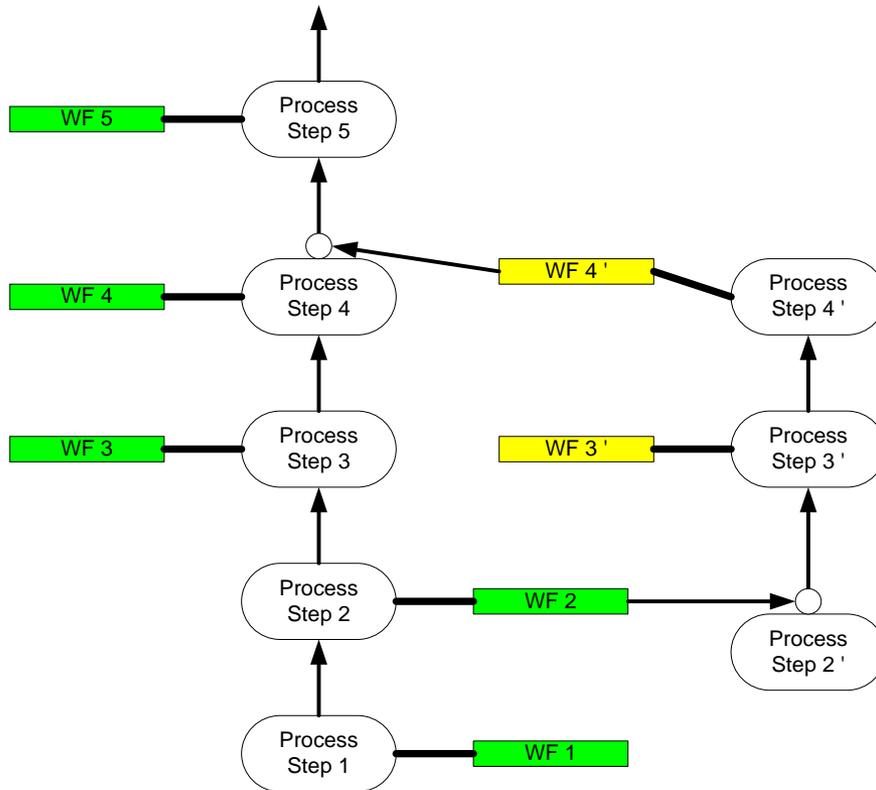
Technical features:

- By using of Version- and Change-Management well defined changes of process steps within production are possible



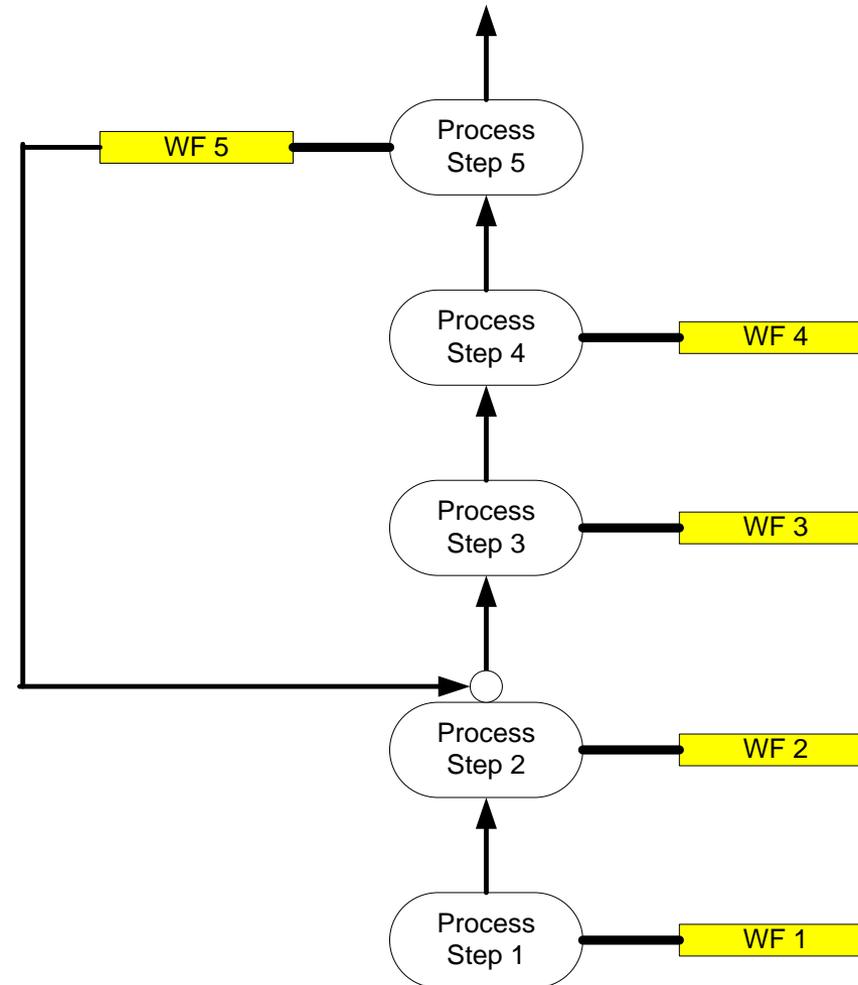
MES Components: Specification Management (3/4)

Definition of alternative flows

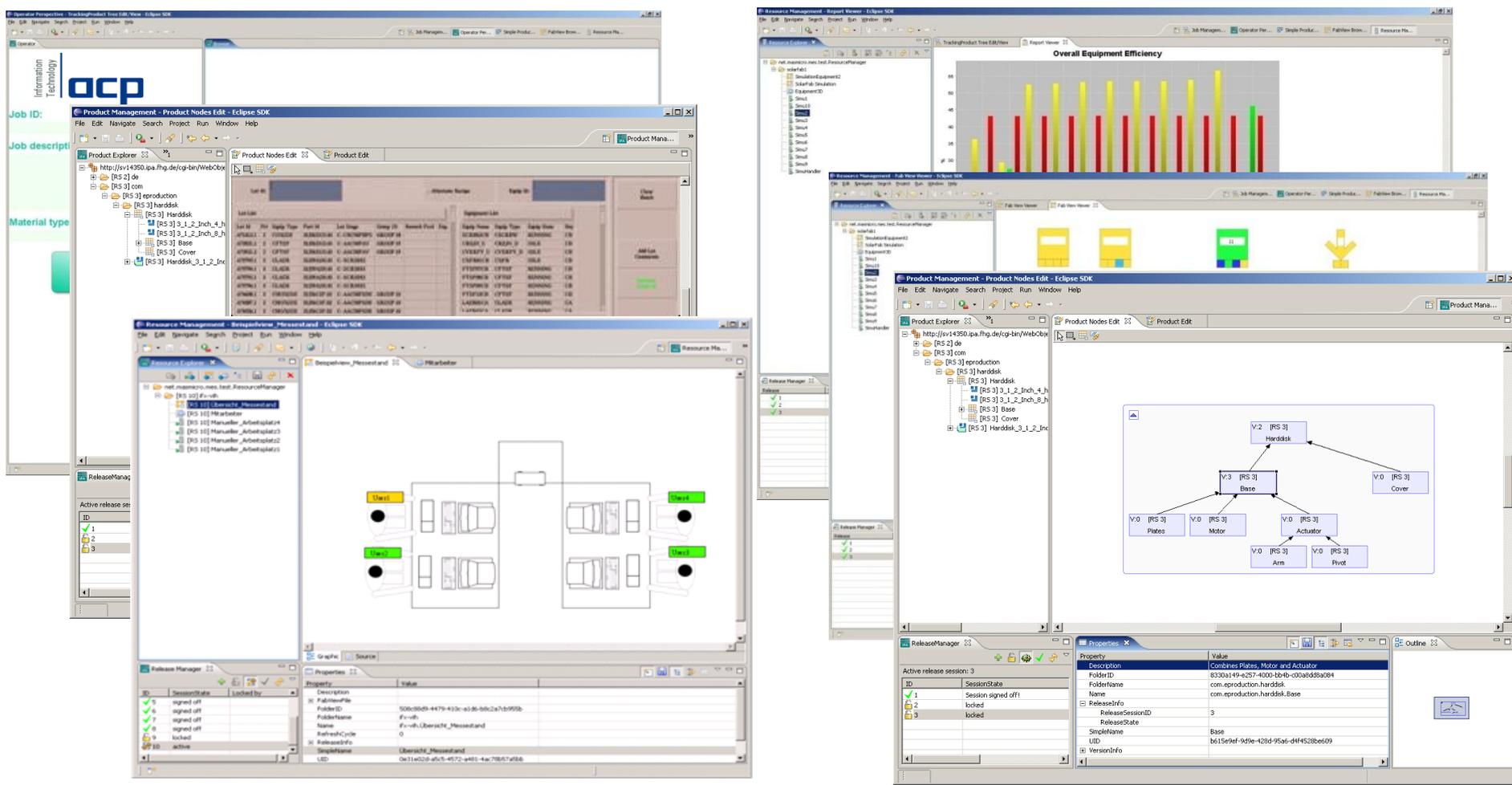


MES Components: Specification Management (4/4)

Definition of flows with rework



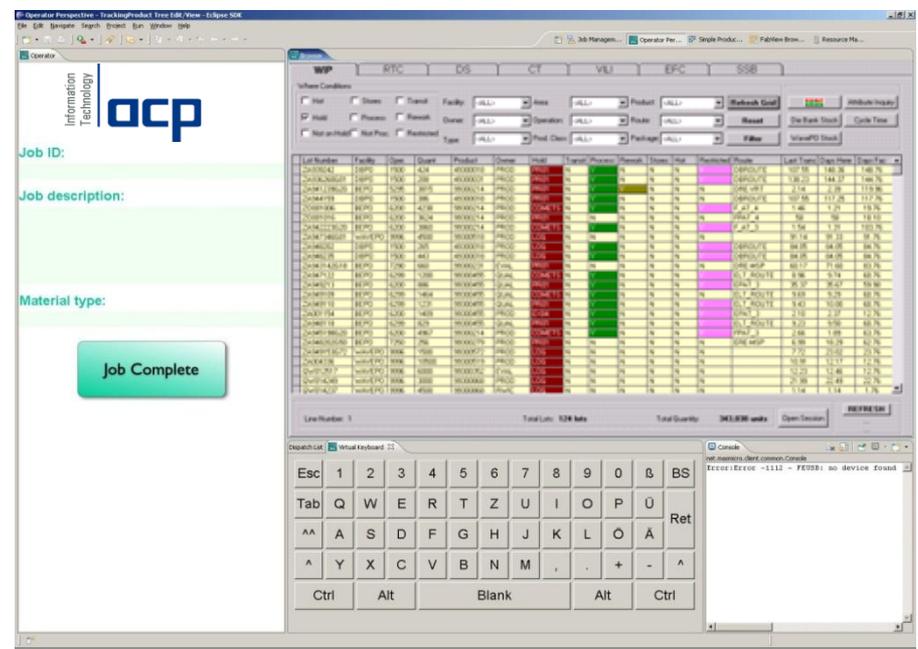
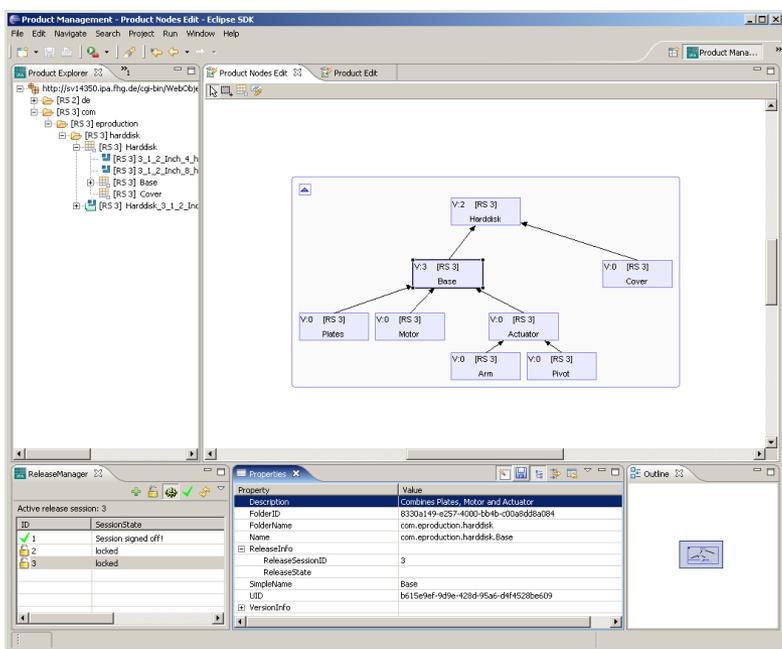
GUI: Examples



Flexible configurable User interface with common look and feel (Eclipse-based)



GUI: Examples

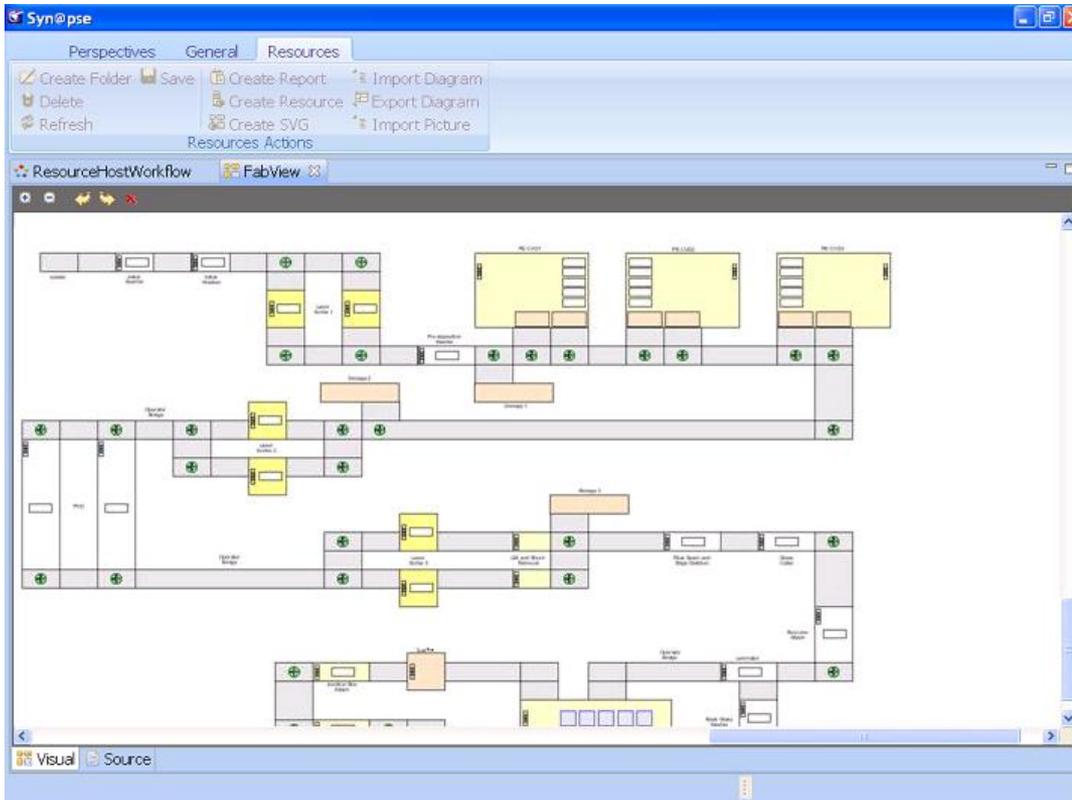


Editor for process plan definition

Operator GUI using Touchscreen



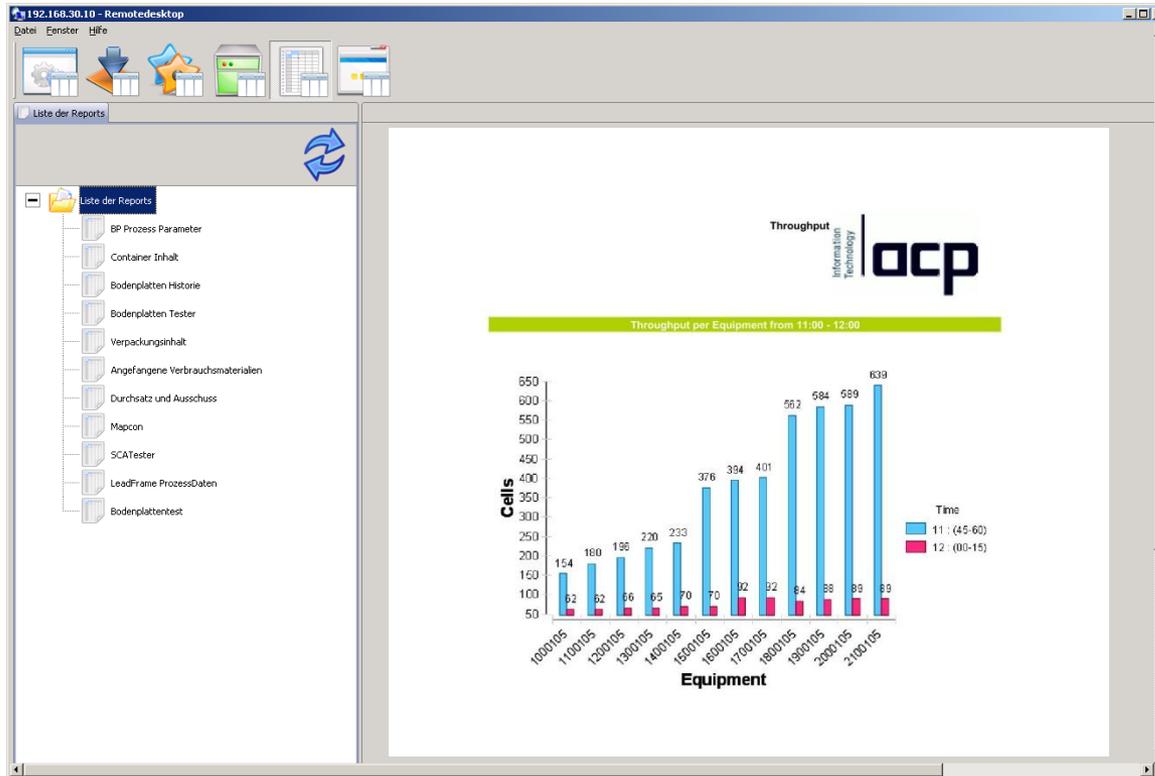
GUI: Examples



FabView



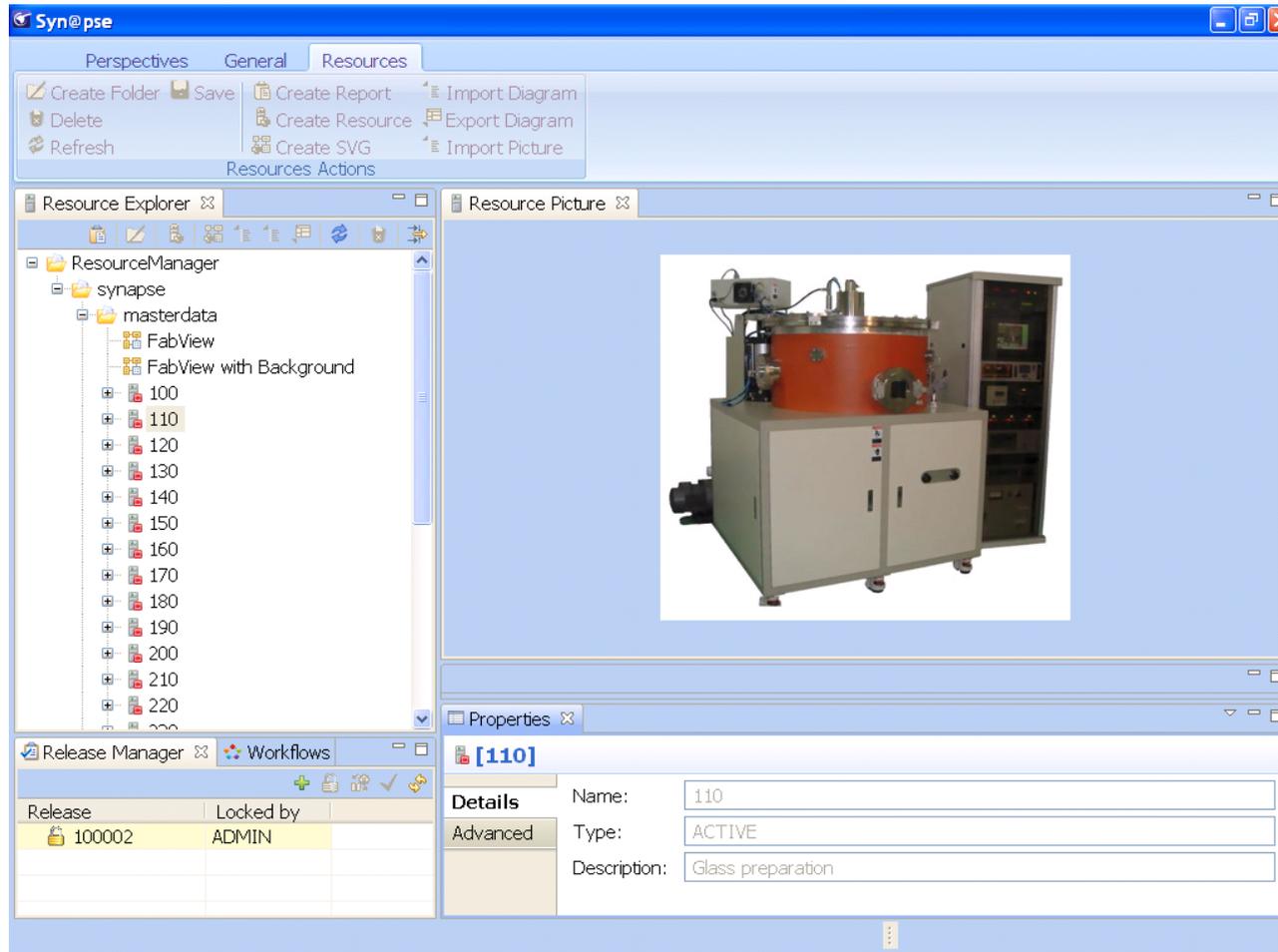
GUI: Examples



List of reports with one throughput example



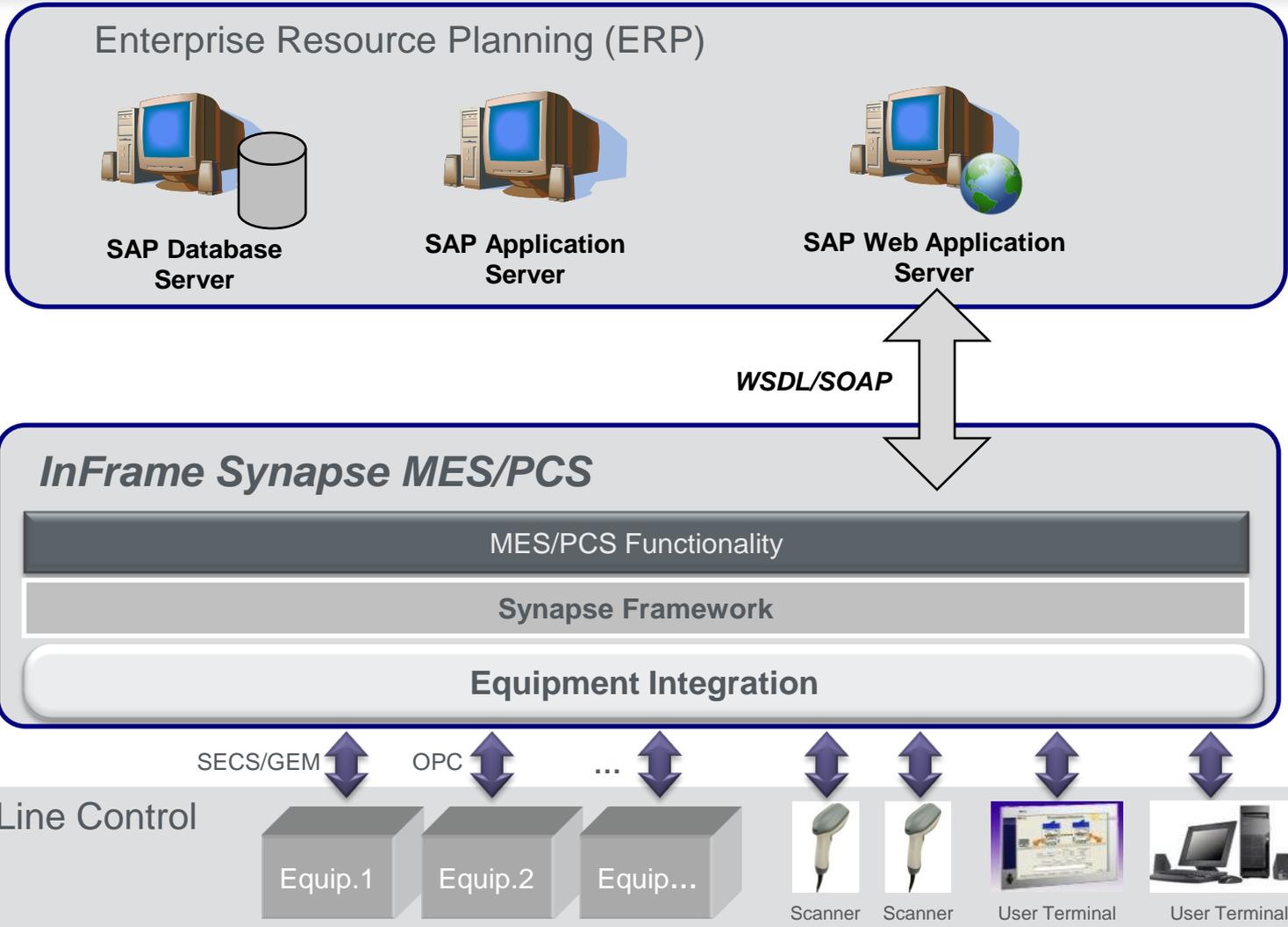
GUI: Examples



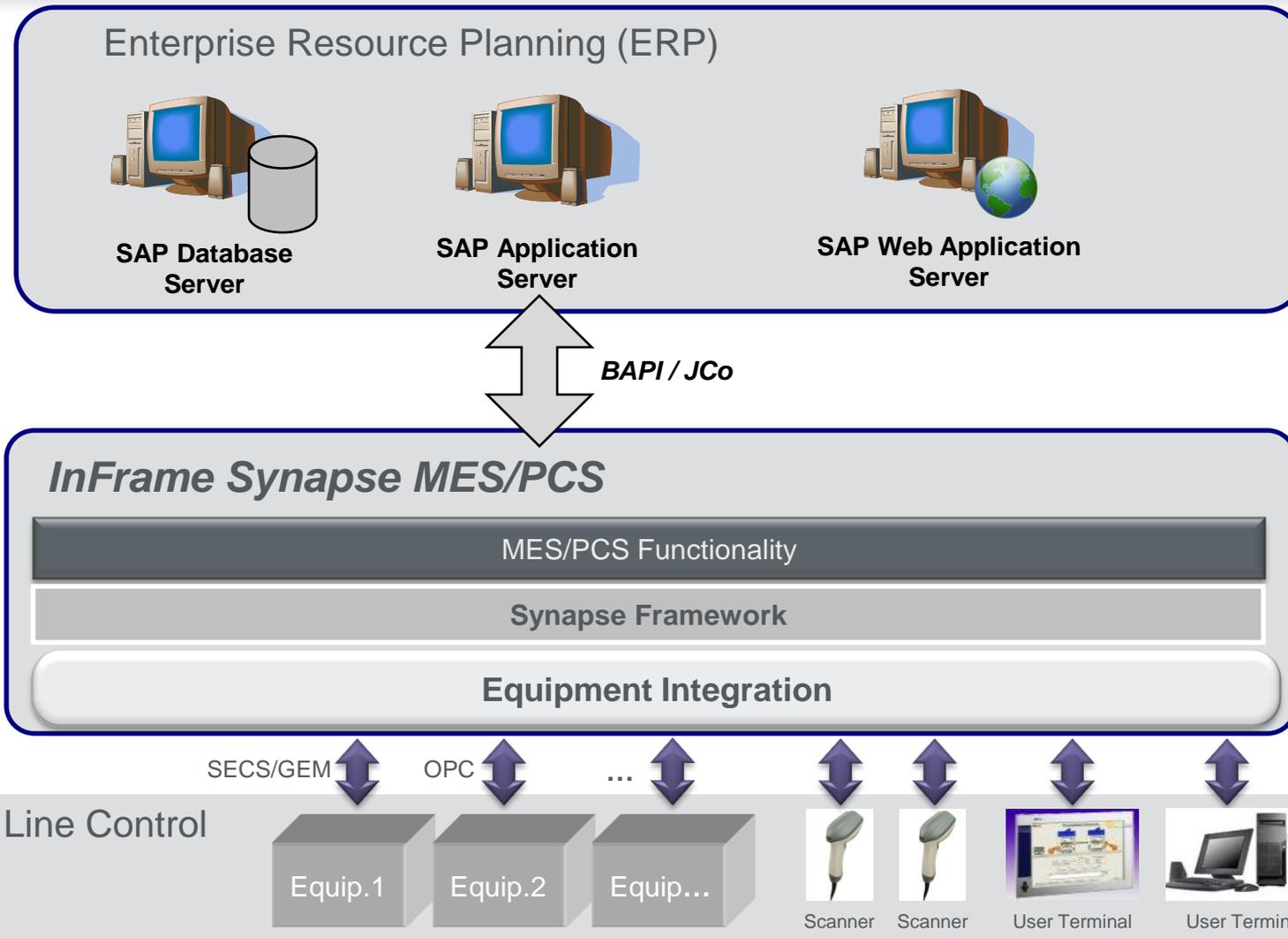
Resource Manager



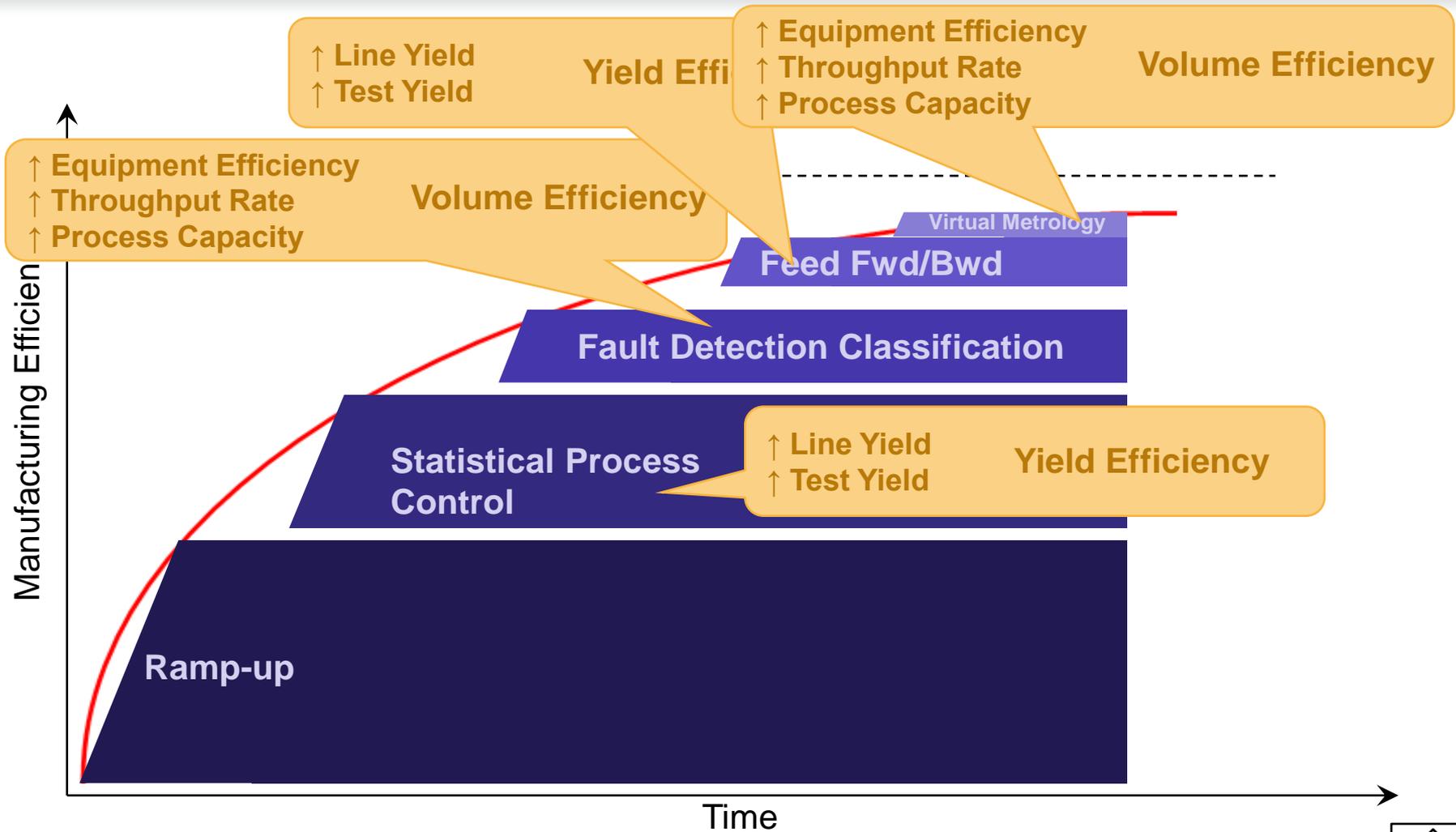
System Overview (3a): SAP Connectivity Var. 1



System Overview (3b): SAP Connectivity Var. 2



Continuous Increase of Manufacturing Efficiency Supported by a Single Control Platform



Statistical Process Control

Several Types of Control Charts

- X-MR Chart, XR Chart, XR-Median Chart, Xs Chart
- cChart, npChart, pChart, uChart

Functions for Definition of Control Charts

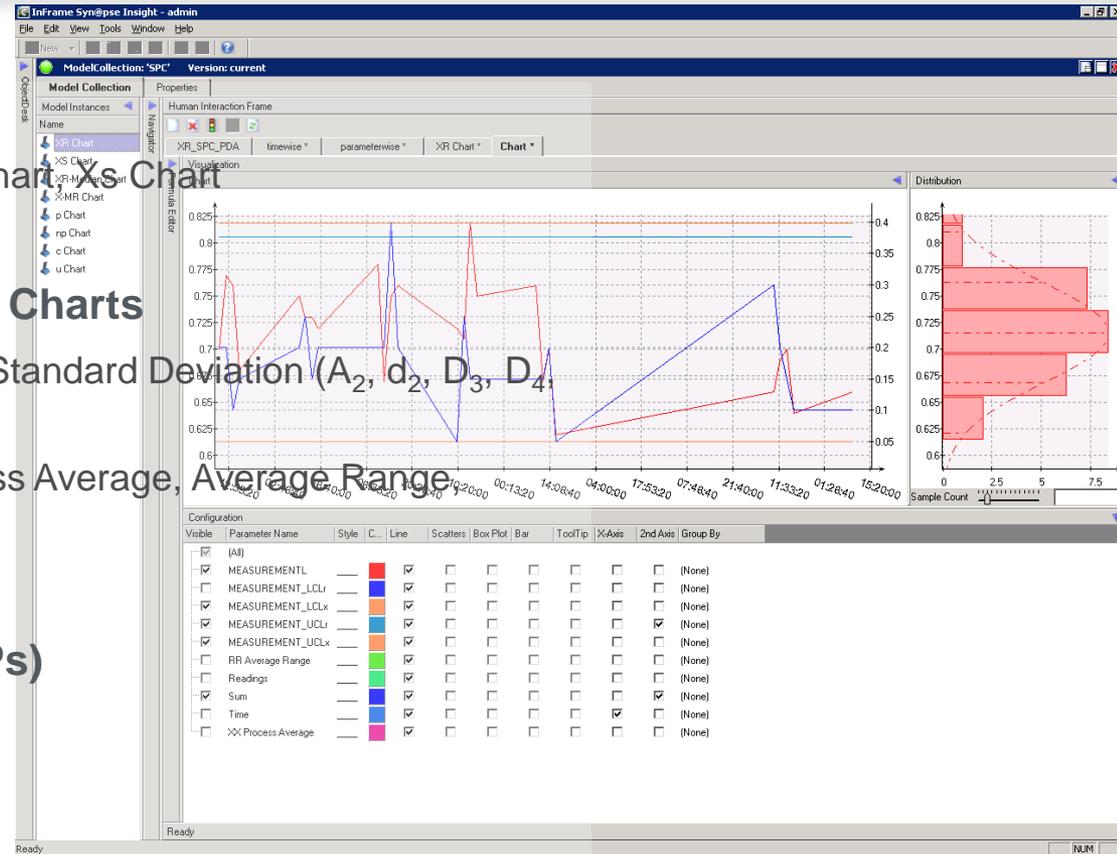
- C_p , C_{pk} , SPC Factors for Limits and Standard Deviation (A_2 , d_2 , D_3 , D_4 , A_3 , c_4 , B_3 , B_4)
- Statistical Standard Functions (Process Average, Average Range, Median, etc.)

Online and Offline Control Charts

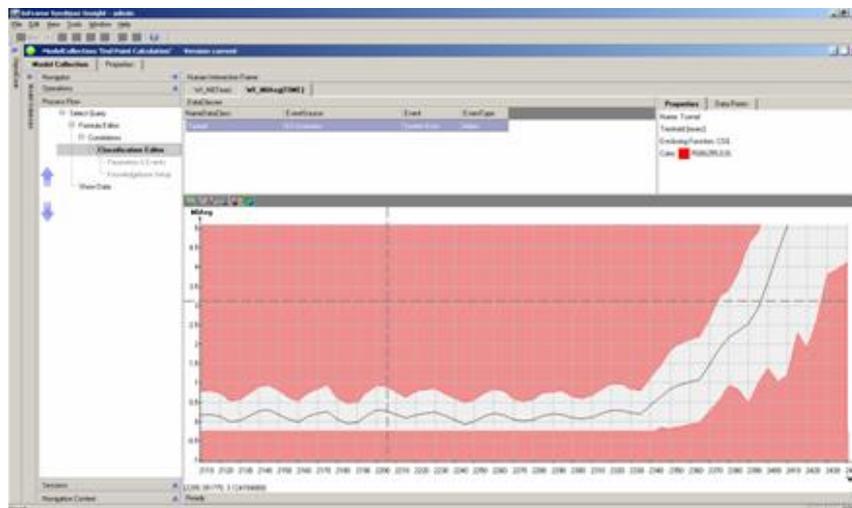
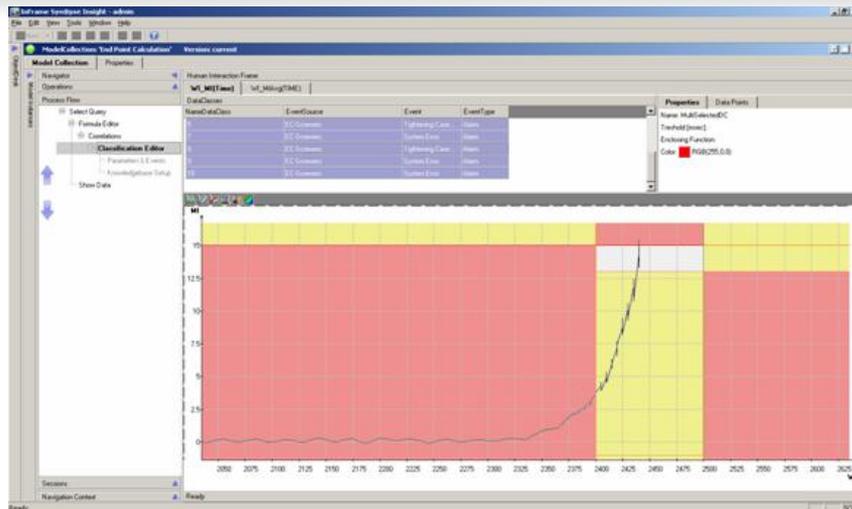
Out of Control Action Plans (OCAPs)

Reaction Rules

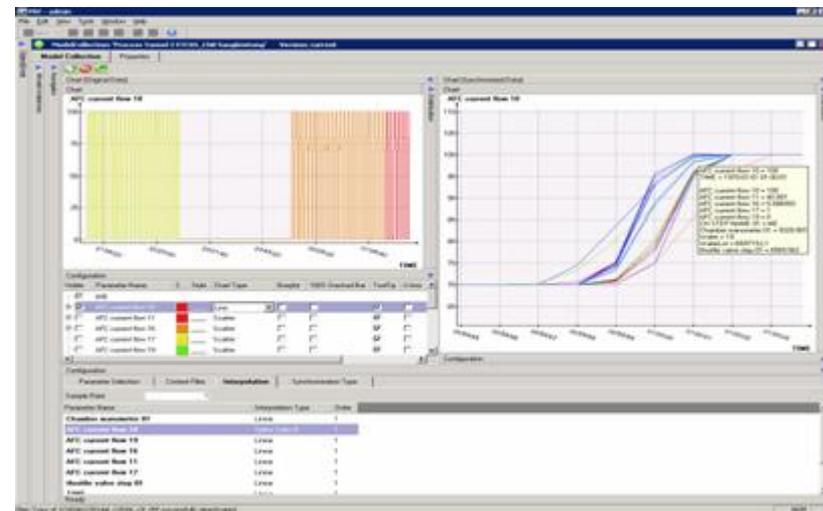
- Western Electric Rules
- Customizable Rules



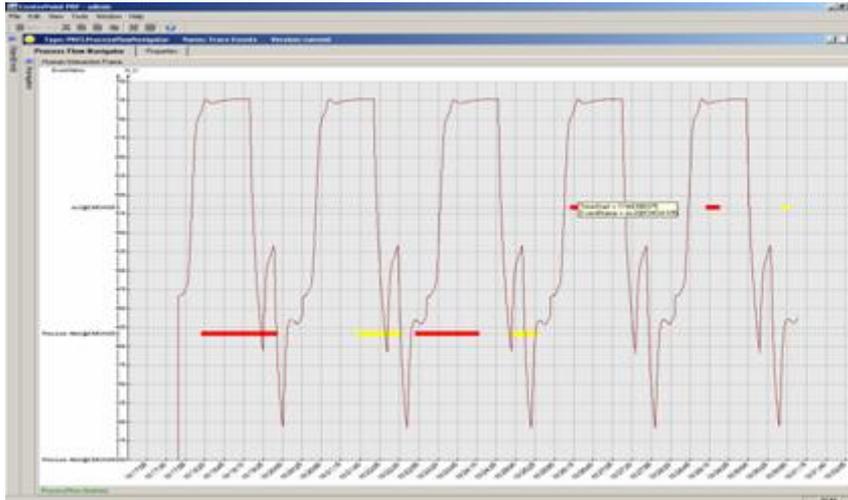
Immediate Detection of Process Excursion Through Online Endpoint Monitoring and Process Tunnels



- Customizable Endpoint Analysis
- Automated Calculation of Process Tunnels
- Online Monitoring of Endpoints and Process Tunnels
- Automated Notification in Case of Excursions



Combined Online Parameter Monitoring and Event Monitoring

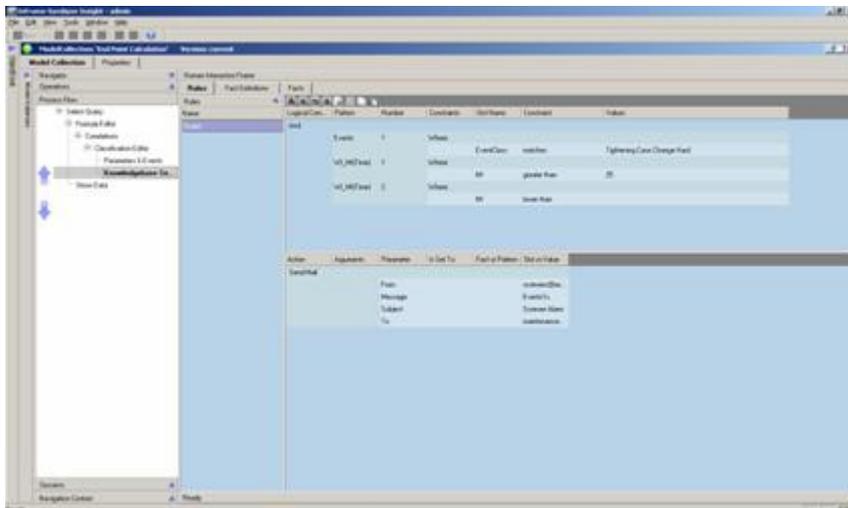


Combined Visualization of Events and Parameteric Data

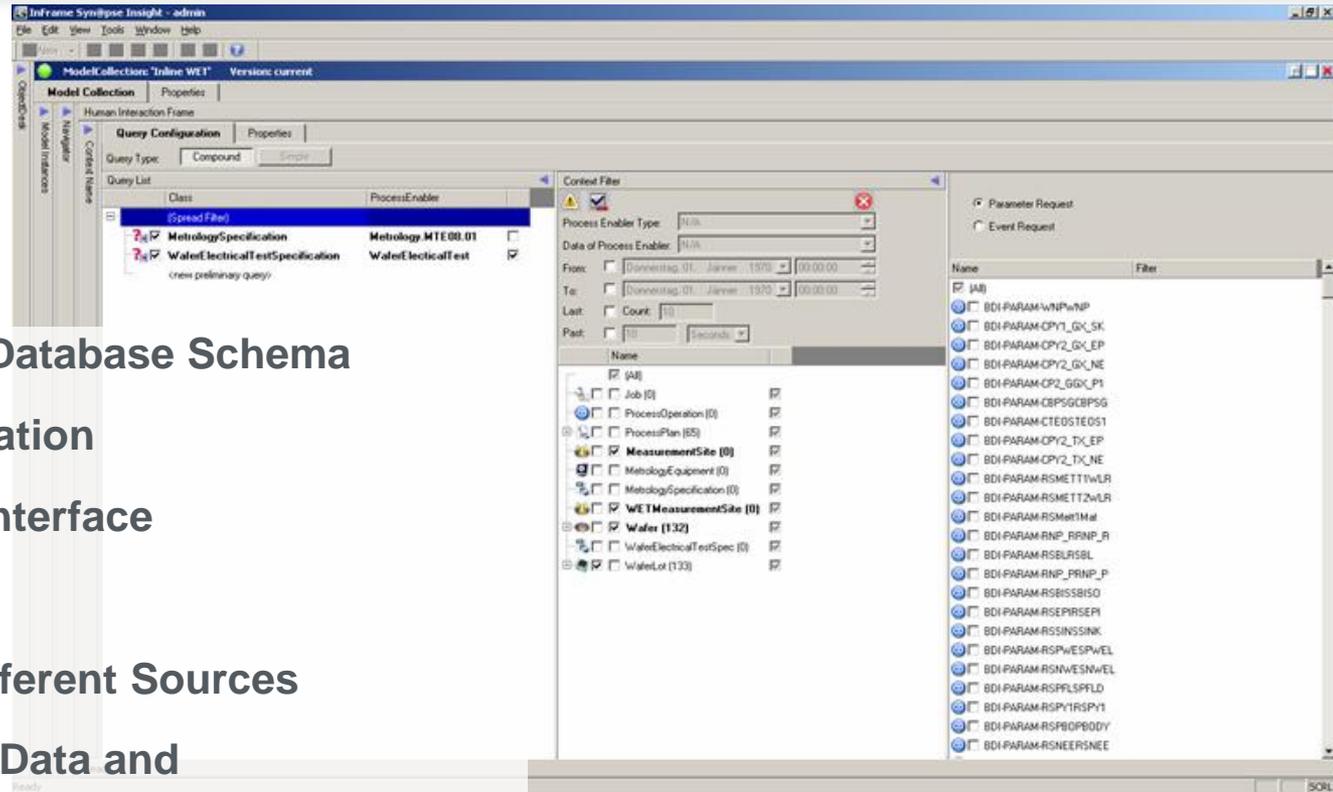
Graphical Rule Editor

→ **Combined Conditions on Parametric Data and Events**

→ **Customizable Automated Actions in Case of Rule Excursions**



Factory-wide Collecting and Filtering of Process Data and Events



Automatically Adapting Database Schema

→ No Schema Administration

Adaptive Filtering User Interface

Compound Filters

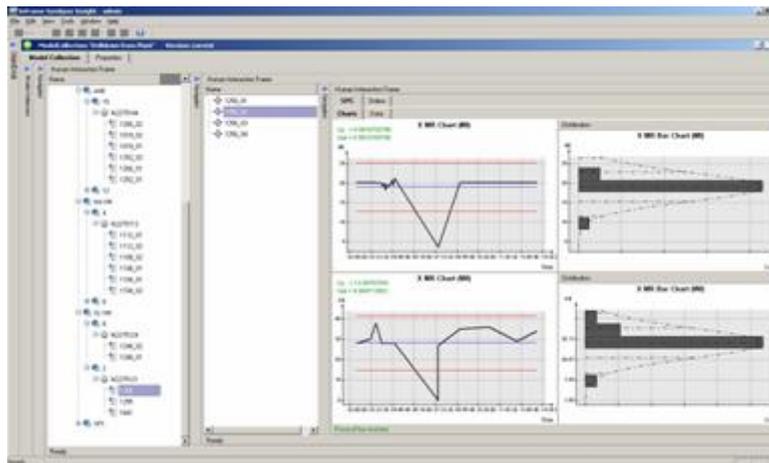
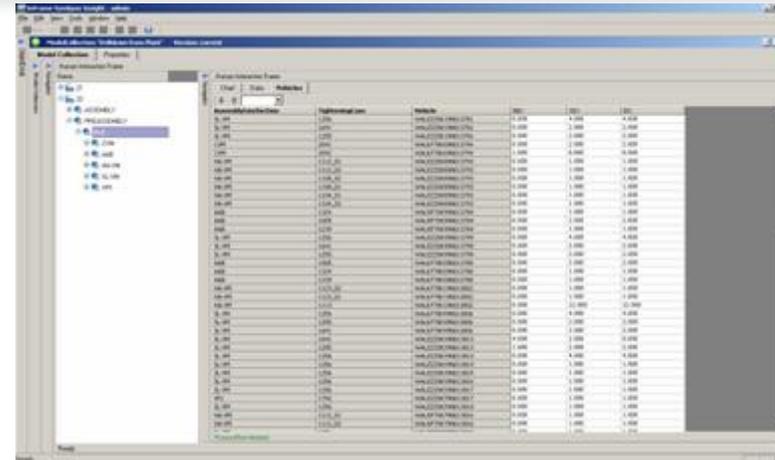
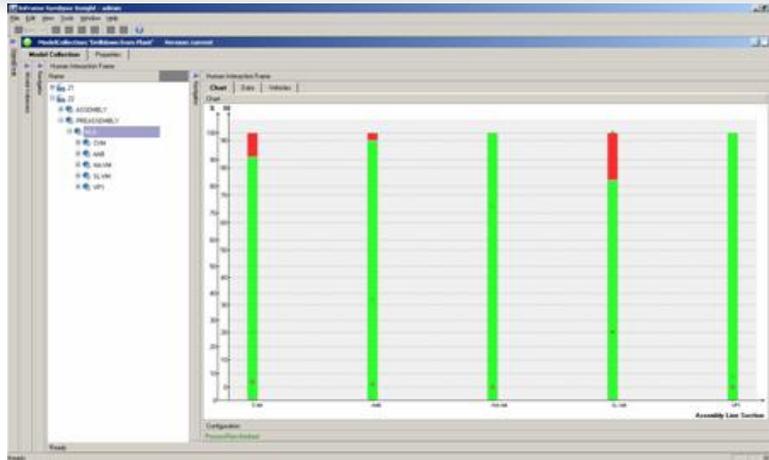
→ Combining Data of Different Sources

Management of Process Data and Process Events

→ Merged with Process Context Information



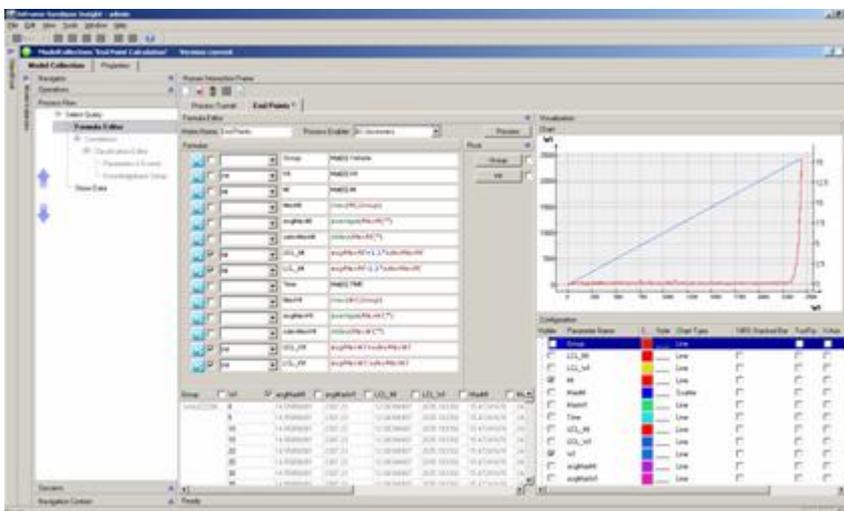
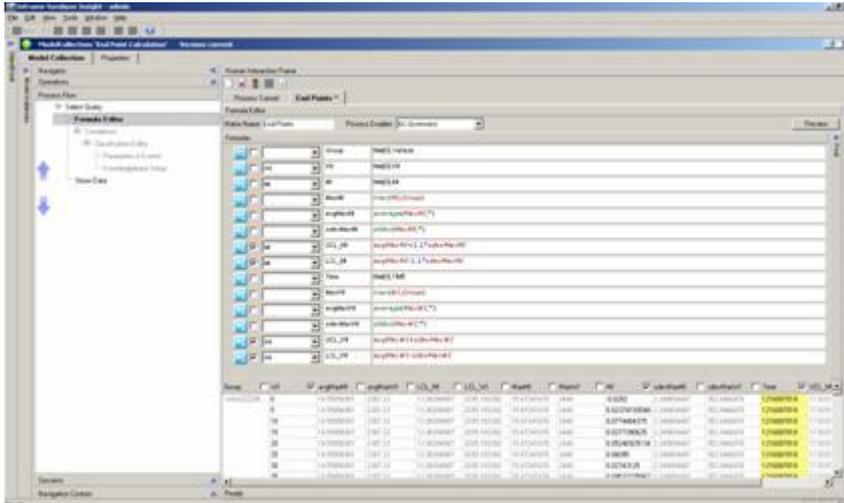
Drill-Down From the Factory to the Single Equipment



Customizable Drill-Down Paths
Any Combination of Visualization Elements
Coupling of Online- and Offline-Data



Fast Adaption Due to Changing Requirements



Interactive Definition of Mathematical and Statistical Models

Off-the-Shelf Libraries with Mathematical and Statistical Models

Features for Process Monitoring and Control

→ EWMA, Outlier-Filter, Cp, Cpk, ...

Derived (Virtual) Parameters

Integration of Context-Specific Process Properties

Logical Process Model

Process Abstraction from Single Equipment to Whole Factory

