Add value.
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Digitization
AI in HAZOP – HAZOP+
Your path to a safe and
optimized plant

Rainer Semmler

Digitization and AI approaches in HAZOP application within TÜV SÜD

- HAZOP+ (TÜV SÜD Chemie Service GmbH) ← My presentation today

- Interactive HAZOP (TÜV SÜD Industrie Service GmbH)
  - Strict structuring and standardization of the HAZOP process based on defined rules
  - Split a plant into defined modules
  - Manual or automized generation of HAZOP
    i. based on modules,
    ii. application of safety rules or
    iii. a digital safety twin and
   iv. supported by AI

Challenges in operating plants and advantages HAZOP+

- Increasing energy and raw material costs
  - Operational optimization => less energy per unit of production => excellent basis for the implementation of energy efficiency projects (DIN EN ISO 50001)

- Sustainable plant operations becomes a must within the political consensus => Impact on sustainability
  - e. g. less energy => less CO_2 per unit of production
  - Better utilization of the raw materials used = > resource conservation

- Holistic approach in the sense of HAZOP = HAZard and OPerability in contrast to the current use with a focus on HAZard, increased utilization of "real data" incl. knowledge of close to critical states instead of design data

- Reduction of the variation of operational parameters, e.g. pressure and temperature, means less "stress" for a system
  ⇒ less wear / plant aging

- Seamless integration in future Big Data application and advanced process control with AI on 24/7

HAZOP + OPEX4.0* = HAZOP+

HAZOP
- Deep process analysis method of Process Safety
- Results: recognition of safety gaps and determination of corresponding risk reducing measures
- Deepest and most resource intensive analysis, through which a plant is put after its original design process during its utilization life
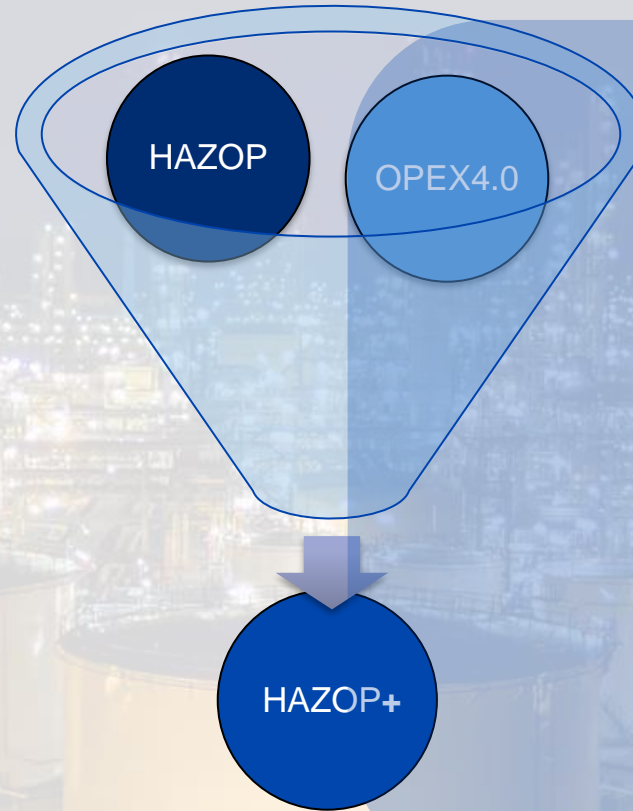
Cooperation partner**

OPEX4.0
- Many companies have a systematic OPEX (Operational Excellence) process, which is used to optimize yields, utility usage, minimize unplanned downtime, and optimize other parameters with an impact on costs.
- The optimization of operating parameters is optimally based on data centered methods, and AI for the interpretation of process parameter data, such as T, P, L, F, Q.
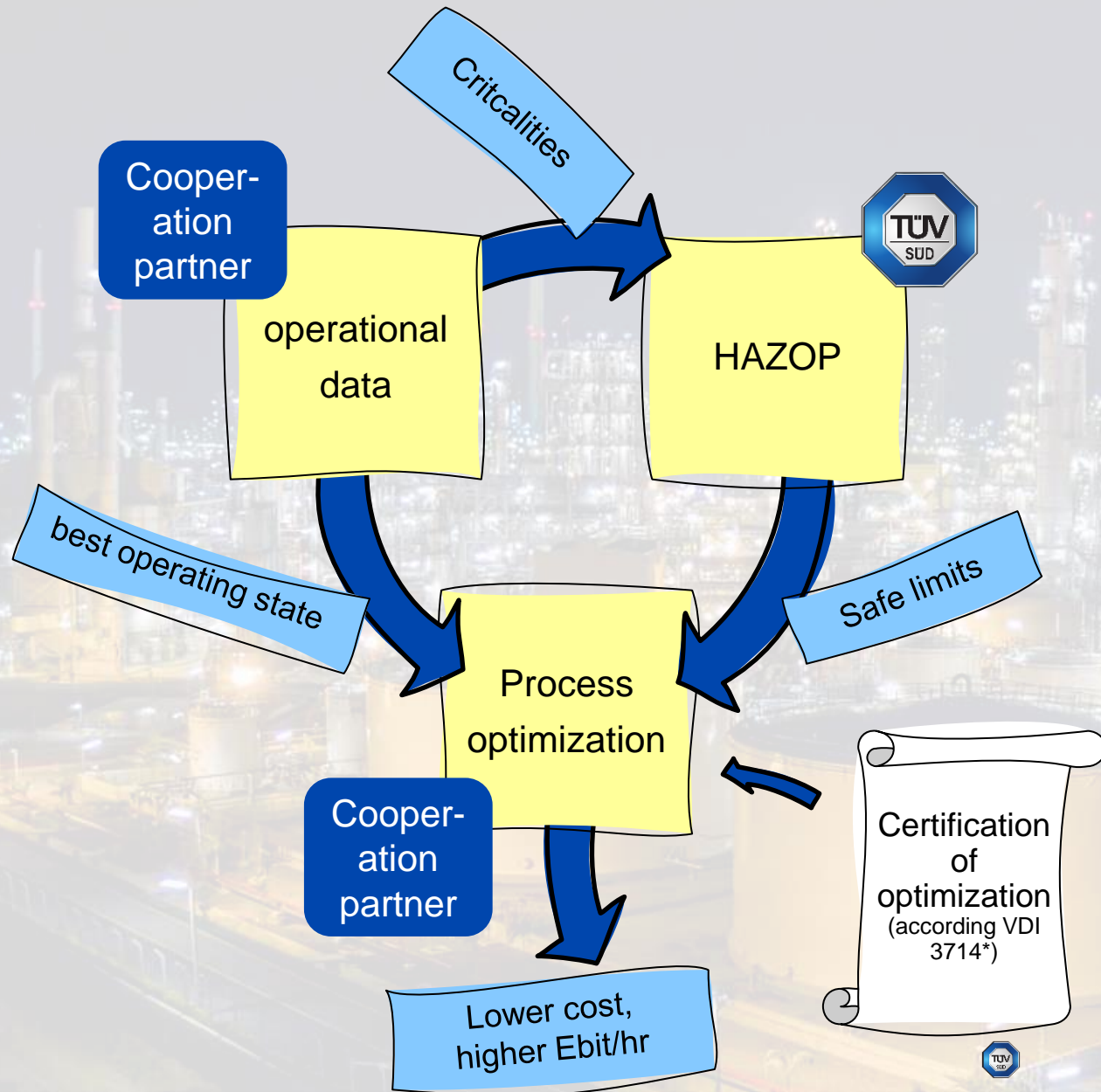
HAZOP+
- is the combination of a HAZOP study with an OPEX4.0 project, realizing synergies between the two
- The target of HAZOP+ is a safe plant running at stable conditions with optimized economic performance

*OPEX4.0 = Combination of Operational Excellence and Industry 4.0

**Cooperation partner (internally= specialist department of customer, externally= partner of TÜV SÜD)

HAZOP+ workflow

- Combination of process safety review (HAZOP) and operational optimization (OPEX 4.0)

- HAZOP study performed by experienced TUV SUD experts

  - *Operating periods with upsets/problems:* Systematic consideration during the HAZOP study

- OPEX4.0 performed by cooperation partner (internally= specialist department of customer, externally= partner of TÜV SÜD)

  - *Based on best operating periods:* Optimization of operating parameters using Machine Learning

- Certification of optimization project according VDI 3714*

*VDI3714: German engineering standard for the optimal execution of big data projects

Execution of HAZOP+ Projects

Preparation	Analysis	Implementation	Follow up, Finetuning
- Needed documents - Updates needed ? - Data (from DCS, Lab..)	-HAZOP study -Data- & AI- based analysis of operation	-HAZOP action items -Optimisations	

Preparation
- P&ID, Control scheme, plot plan, equipment data, process data, substance data,….
- Plant upsets, repairs, incidents, …
- Operating parameter data from DCS, LIMS, optimally from several years
- Simulation results (if available)

Analysis
- HAZOP:
  - Review of all P&IDs, Check of all safety devices (SIL, PSVs,…), etc.
  - Review of critical operating periods
- OPEX4.0:
  - Analysis and formation of models
  - Determining good and bad run periods
- Synergies:
  - Limits of optimization
  - Including plant upsets and bad run periods in the HAZOP study

Implementation
- Safety measures, resulting from HAZOP
- Optimized setpoints of relevant control loops
  - Offline, Operator input
  - Closed loop: AI feeds optimized setpoints directly to DCS
- Certification of the Optimization Project according VDI3714 through TÜV SÜD

Follow up, Finetuning
- Follow up on HAZOP measures/action items
- Further optimization of operating parameters with statistical models of the AI
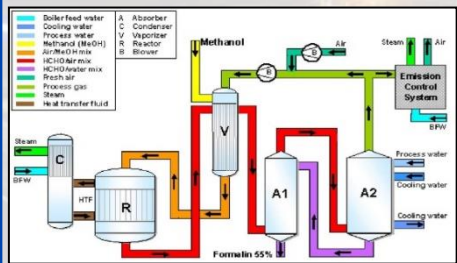
Analysis, OPEX4.0

Project follows
Standard VDI 3714

1. Readiness Check
2. Definition
3. ETL/Structure & Clean
4. Analyze & Model
5. Model-Validation
6. Analyze & Optimize
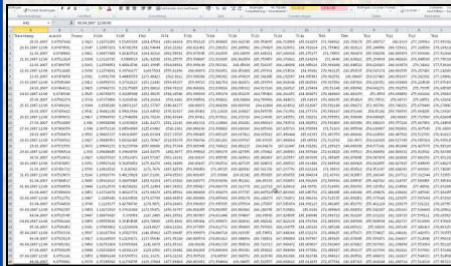7. Implement & Operate
Store – „SingleSource of Truth"
Capture

*VDI3714: German engineering Standard for optimal Execution of Big Data Projects
DCS = Distr. Control System
LIMS = Laboratory Information Management System

- Optimization of operating parameters using AI / Machine Learning

- Operating data from the DCS* and LIMS* are filtered regarding relevance for the optimization

- Operating data are processed into statistical models, which identify optimal operating parameters

- models are tested and further optimized - Optimizer software uses the models to maximize target functions such as EBIT/hr

- The new setpoints are fed manually or automatically to the DCS, in order to control the the plant as close as possible at the optimal operating conditions

- The Optimization follows the steps of standard VDI3714* (Big Data Projects in Production)

- Plan for 2023: Certification through TÜV SÜD

Optimization of operating parameters using advanced machine learning

Costs/ton

Statistical model

Advanced Analytics / NeuroModel®

Historical Data

Process design
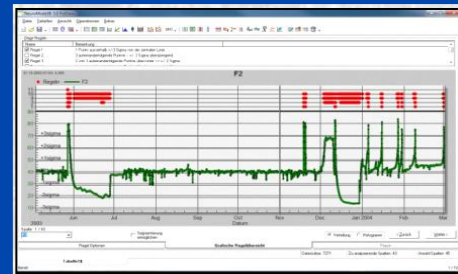
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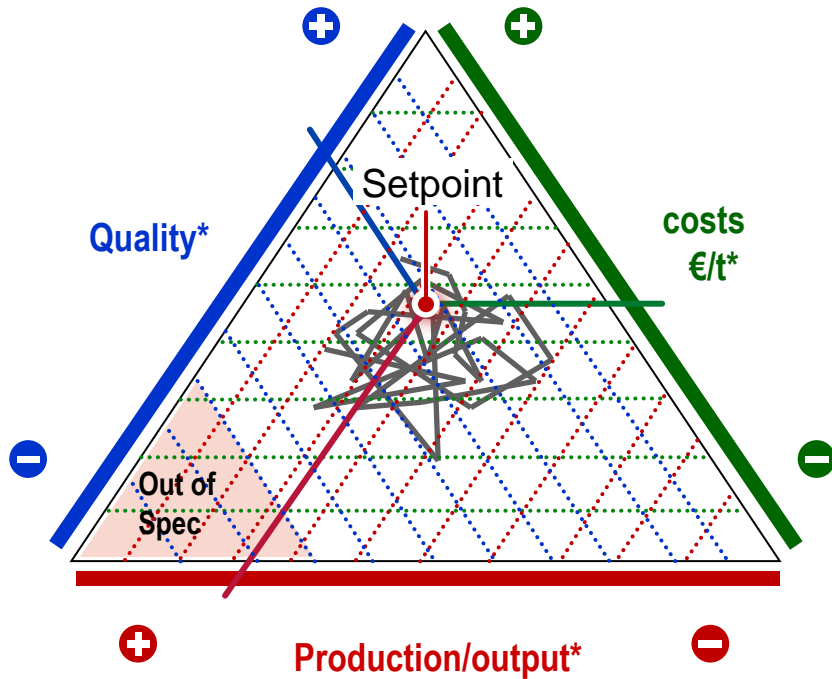AI2945
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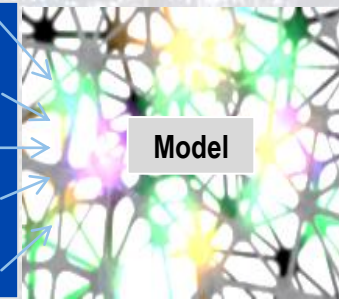
Model

Constructing a statistical model, which connects process variables with costs/ton (or alternative focus for optimization)

# Optimization of operating parameters using Machine Learning

From traditional process control with fluctuations / suboptimal performance…	… to optimized operation according APC 4.0 with minimized costs / higher efficiency
higher variability of important process parameters requires wider safety margins relative to optimal conditions	optimization reduces variability by factor 10 → **higher production rate, more stabil process, lower costs**
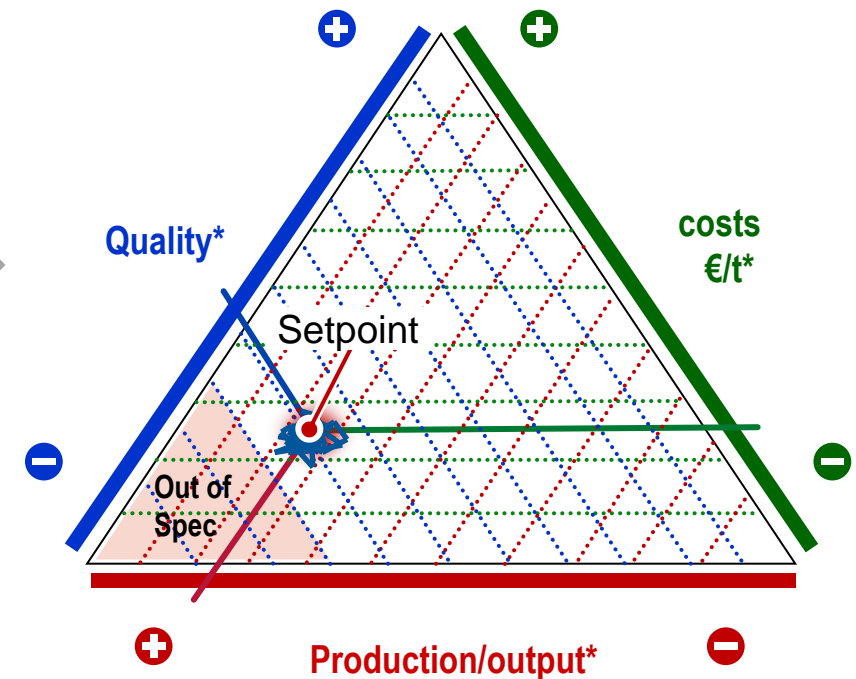
ML based Optimization + HAZOP

*alternative parameters can be defined as necessary based on focus of optimization - the graphs is are qualitative and not quantitative illustration only

Summary

- Goal of HAZOP+ is a safe plant, running at stabile conditions with optimized performance due to a target function
  - Target function 'minimized costs' or 'maximized Ebit/hr' or others with regard to safety

- Synergies of HAZOP and ML/AI based operational optimization
  - Efficient preparation of data & documents (P&IDs, functional plans, operating data, etc.)
    - o Strong overlap of required data & documents
  - Quality of HAZOP study improved by systematic use of the operational data from the optimization project
    - o 'Bad' operating periods and plant upsets show the actual problems, which often cause safety incidents
  - More room for optimization and reduced risk of operational optimization through certification and exactly calibrated safety limits resulting from the new HAZOP study
    - o Safety limits are fixed in awareness of the optimization effort, not more conservative than needed
    - o Certification of optimization project according VDI3714

- Tools (online or offline) for a readiness assessments are supporting the preparation phase

TÜV SÜD AI application family

TÜV SÜD Chemie Service GmbH

- **HAZOP +**
  - Synergistic combination of HAZOP and OPEX4.0

- **OPEX4.0**
  - Optimization of a plant's operating/process parameters by means of AI/Machine Learning
  - Target functions 'minimized costs' or 'maximized Ebit/hr' or others
  - Following the recommendations of VDI3714 (execution of big data projects in production environment)

- **AMAIS**
  - Sensor based Asset Monitoring, AI supported
  - Plant integrity is monitored by permanent sensors (e.g. for corrosion, erosion, vibrations, fouling,..)
  - Sensor data evaluated by AI and visualized on a Dashboard

TÜV SÜD Industrie Service GmbH

- **Interactive HAZOP**
  - Modular plant design
  - Manual or automized generation of HAZOP based on modules, application of safety rules or a digital safety twin

Questions?
Talk to us!

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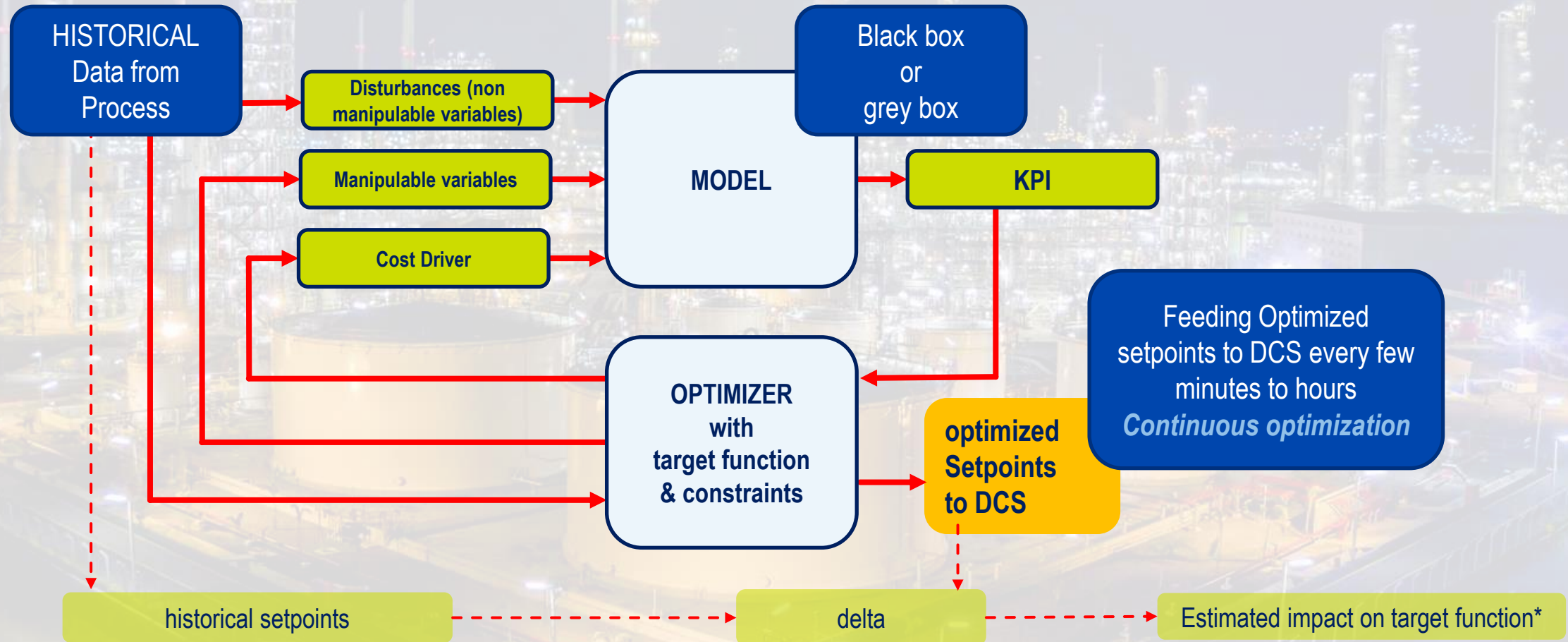vertrieb.chemieservice@tuvsud.com

or +49 214 86910-106

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BACKUPs

Optimization of operating parameters using advanced Machine Learning

Optimization using model and optimizer:

* Target function = benefit as 'costs savings' or 'Ebit/hr increase', 'energy reduction', 'CO_2 reduction' or specific others with regard to safety

AMAIS: Innovative Product for Industry 4.0

- AMAIS – Asset Health Monitoring AI supported

- Consortium:
  - TÜV SÜD
  - Partners: For AI application, MAT solutions, ProsafeX, Flexora,..

- AMAIS offered as plug & play system for the monitoring of 'asset health'

- Permanently installed sensors, e.g. for wall thickness, vibrations, fouling,..
  Transmit their data wireless to central data system, where they are evaluated
  by AI. Corrosion- erosion- trends and other critical informations are visualized
  on a dashboard, which issues early warnings. The AI also detects correlations
  between process parameters (e.g. T, P, F, L, conc.,..) and corrosion/degradation
  rates. For this purpose, process data from the DCS are analyzed in parallel.