

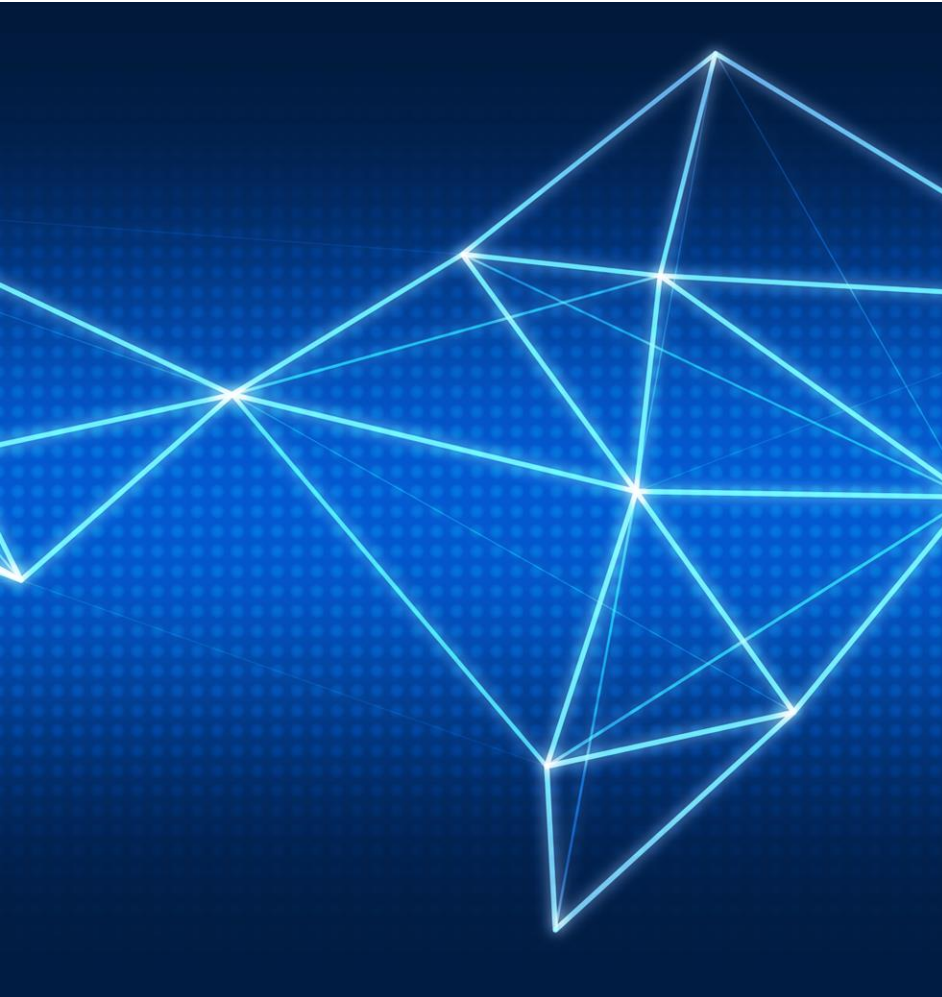
Digitalization in Machine Engineering

Siemens MCD and Cadenas smart catalog components

Siemens MCD and Cadenas smart catalog components

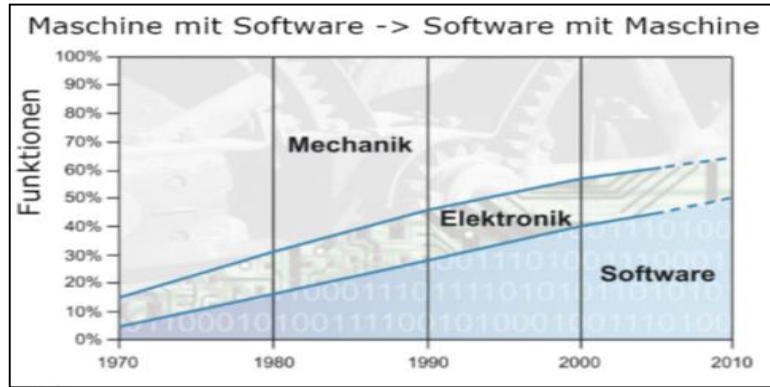
Table of content

SIEMENS



- Overview: Interdisciplinary engineering of machinery and equipment with the Mechatronics Concept Designer
- Early mechatronic simulation in the design and development with support from CADENAS SmartParts
- Reuse of simulation objects and "smart" catalog parts
- Virtual commissioning with the Mechatronics Concept Designer

Complexity, globalization, customization and Compliance - Decisive factors for change in industrial machines



Complexity is the new standard in industrial engineering

| | <u>Country</u> | 2012 (est.) <u>\$-Millions</u> |
|----|---------------------|-----------------------------------|
| 1. | China, Peoples Rep. | 27,540.0 |
| 2. | Japan | 18,252.9 |
| 3. | Germany | 13,622.9 |
| 4. | Korea, Rep. of | 5,705.0 |
| 5. | Italy | 5,667.7 |
| 6. | Taiwan | 5,430.0 |
| 7. | United States | 4,983.2 |

New providers with low cost structures generate global competition



The demand of the end users for customized products



The pressure by law affects many aspects of industrial engineering

Increased pressure to innovate to component suppliers while maintaining profitability and satisfy delivery expectations

Complexity

- Change of Configure-to-Order (CTO) for Engineer-to-Order (ETO) increases complexity
- All software in the machine increases product complexity
- A higher number of product types makes the reuse of knowledge difficult

Globalization

- Global design, local manufacturing: Customers have individual demands on the configuration
- Increasing process complexity
- To maintain the competitive edge, products must be innovative

Customer specific obligations

- Demand for adaptation of standard deals
- Fewer opportunities for reuse of previous constructions
- Better management of customer requirements

Legal regulations

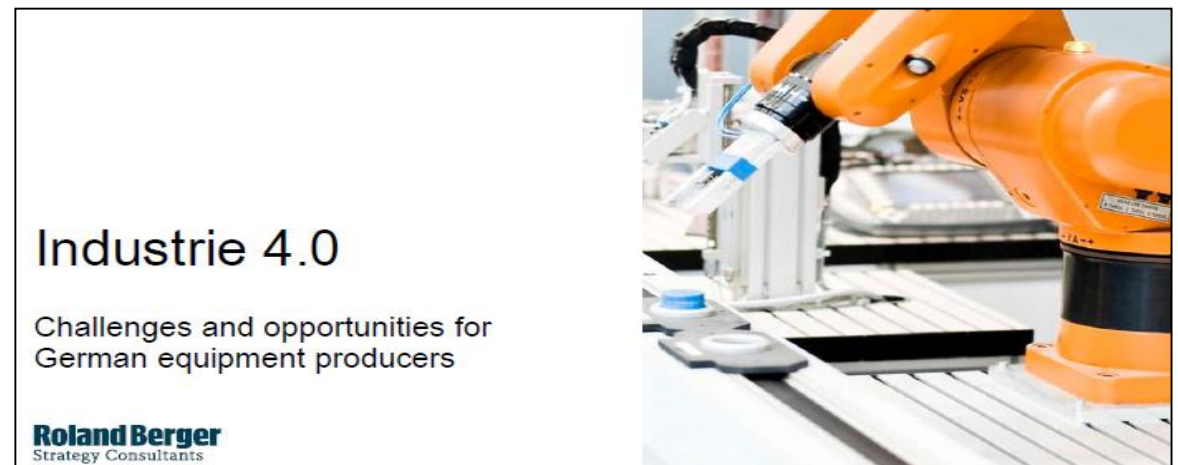
- Higher complexity of structures to ensure compliance
- Not for sale to markets without compliance; Risk of legal action

The situation in industrial engineering

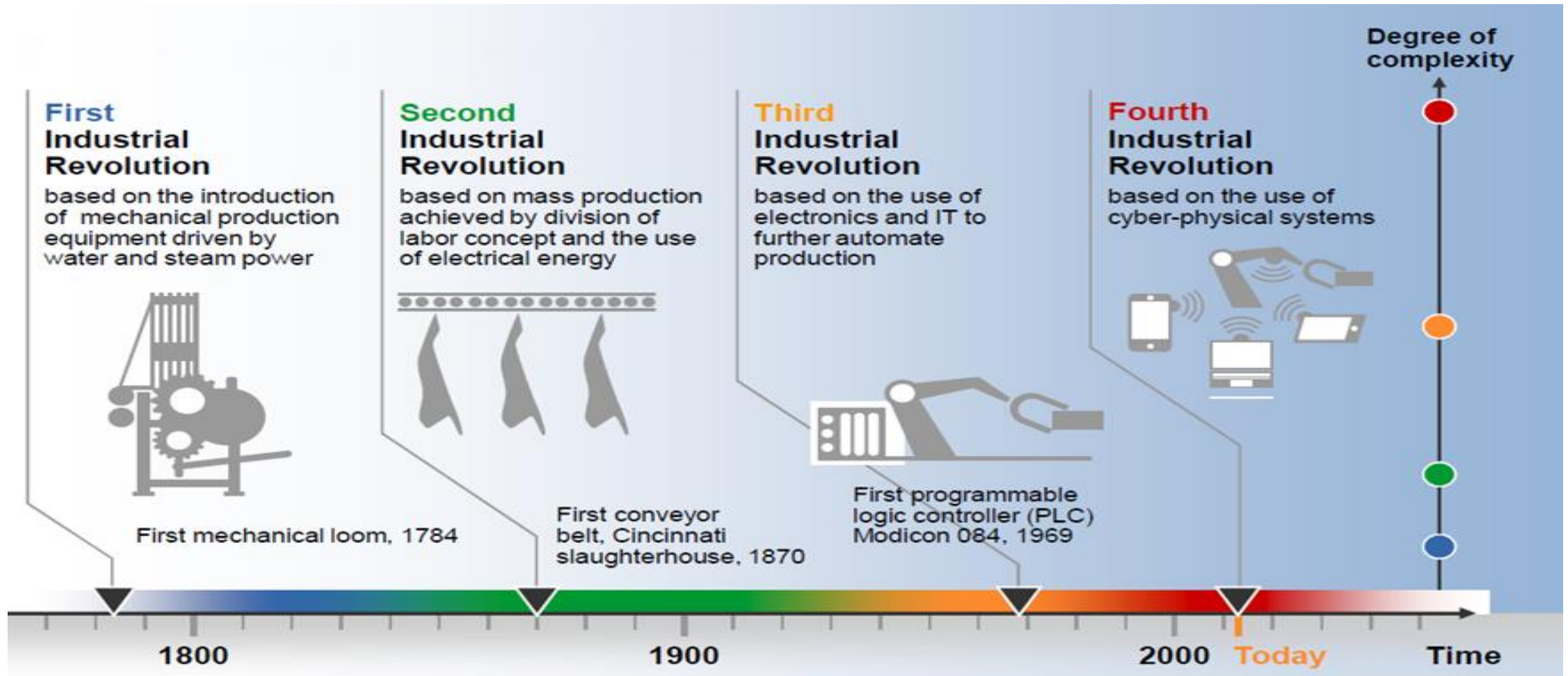
TREND:

Complexity is the new standard in industrial engineering

Industry 4.0: The German government has provided € 200 million to support industry associations, research institutes and companies in the development of an implementation strategy for industry 4.0.



The Evolution of Industry 4.0 in production

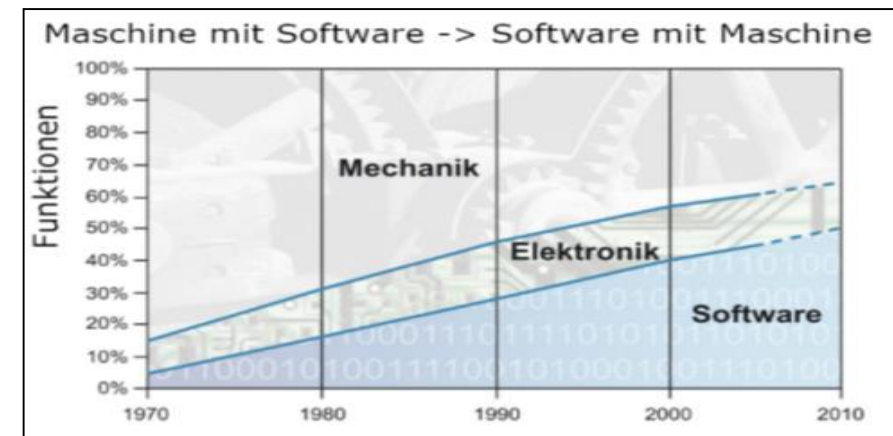
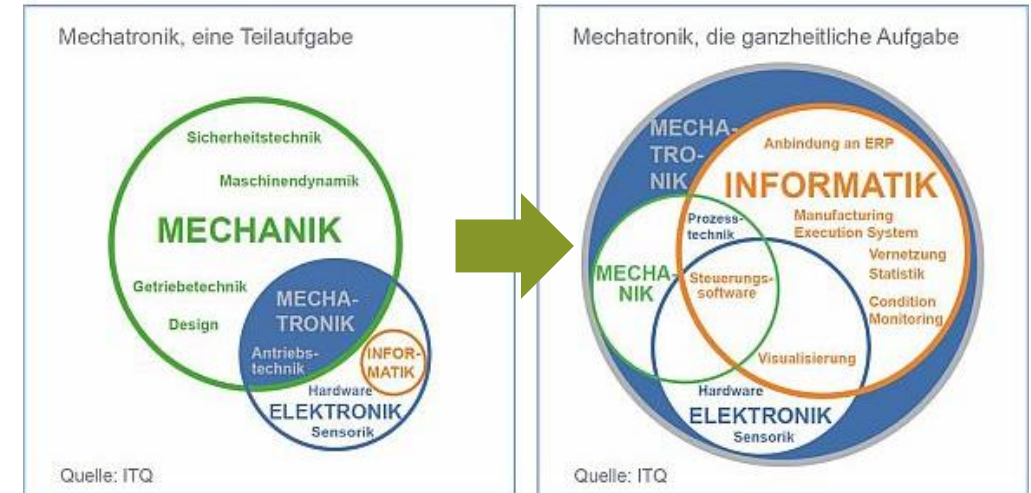


Source: DFKI (2011)

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The influence on the companies

- **CONSEQUENCES:**
- **Machines must be smarter.**
- **Machine users need more functionality in the machine.**
- **Machines must be networked to manage performance and service at all times.**
- **The machine complexity increases in areas that are new for machinery OEMs.**
- **There is more system information required (self-diagnostics, communication).**



Quelle: VDMA

Objectives for an intelligent machine development with increasing complexity

More control

Simpler service

Efficient designing

Fewer risks

Topics to manage complexity

Modularization

Service Engineering

Interdisciplinary collaboration

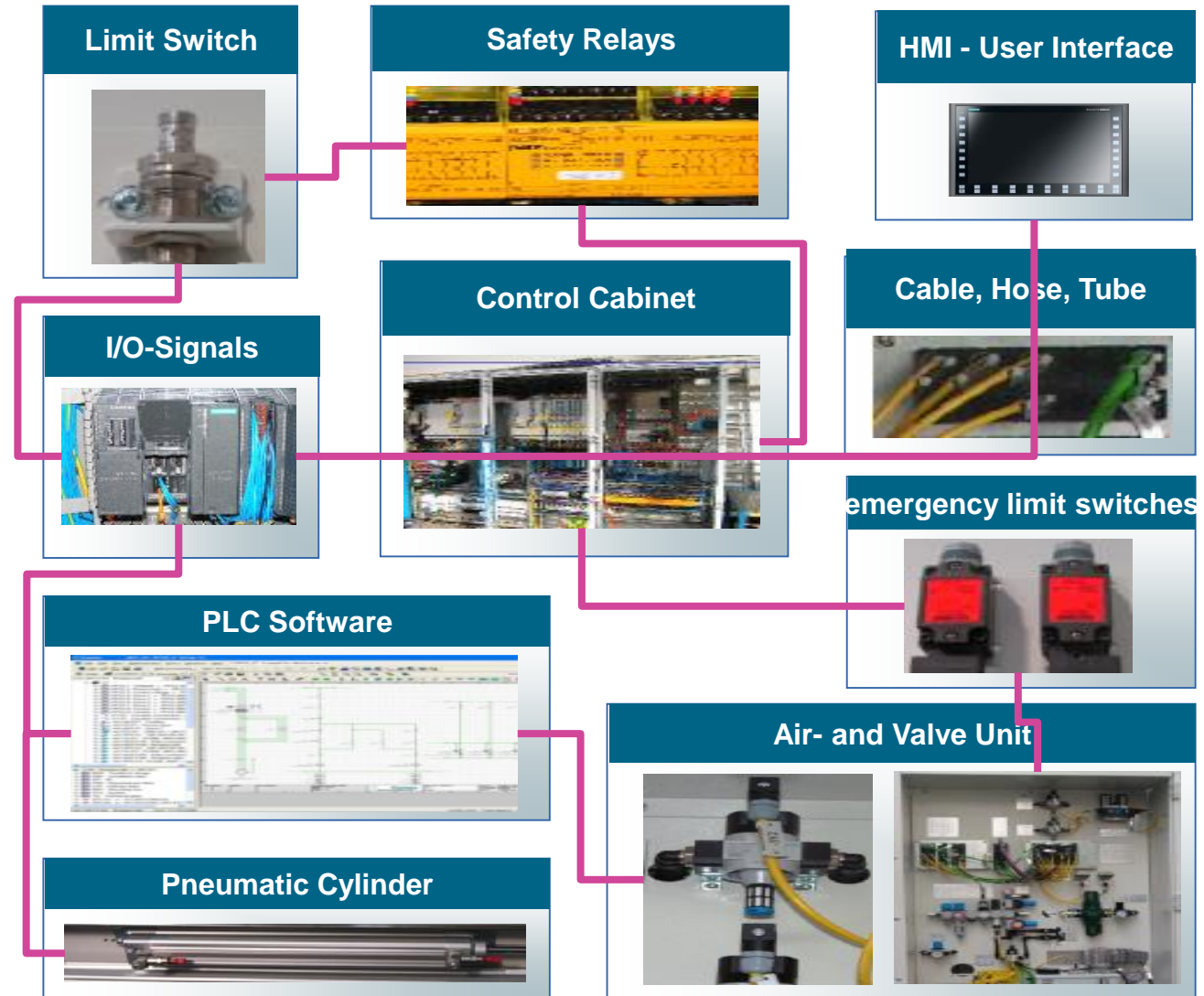
Virtual Commissioning

Current Industrial engineering challenges

If this is "just" a loading door?

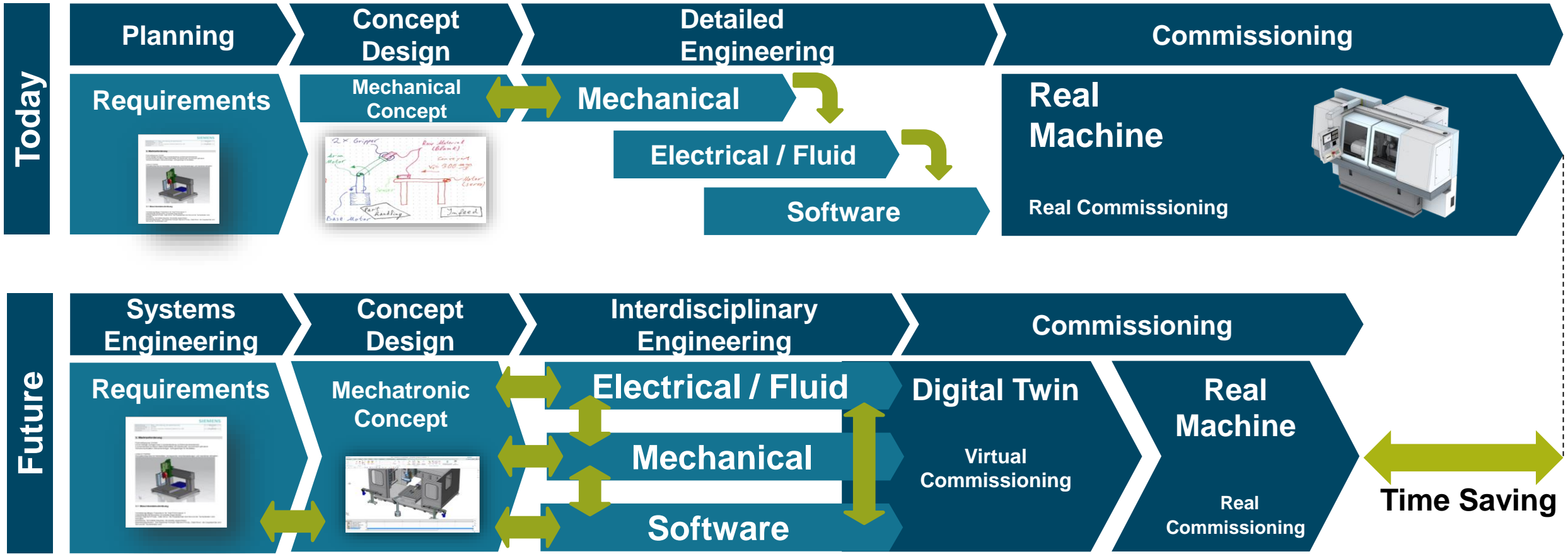


Solutions never refer exclusively to the mechanics!



Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine

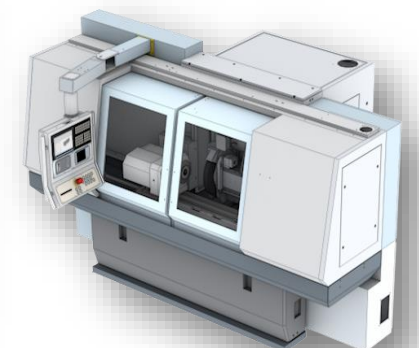
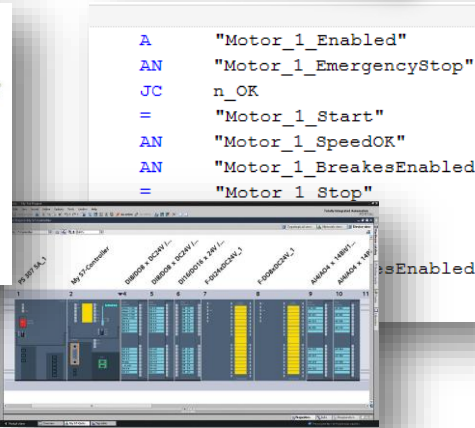
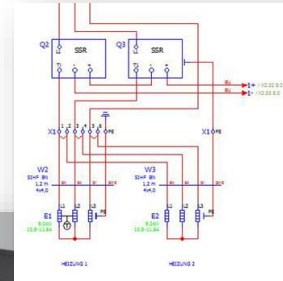
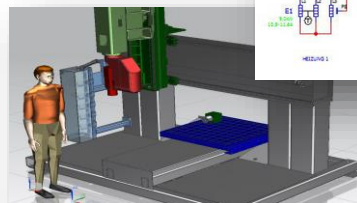
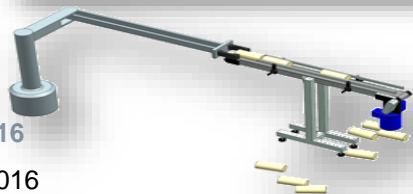
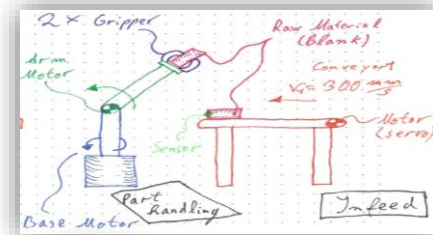
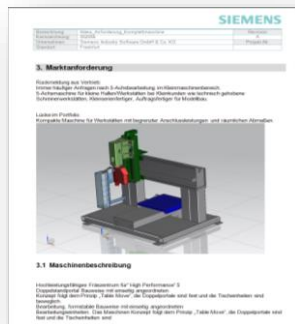
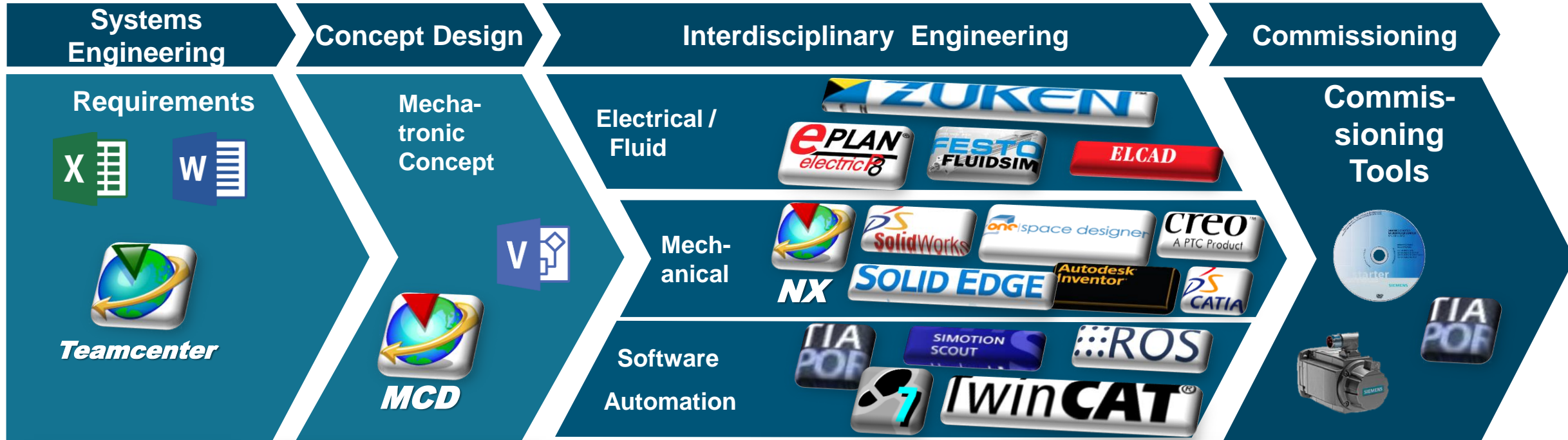


Siemens products already support modern development methods today 

Integrated Engineering (Machine Design)

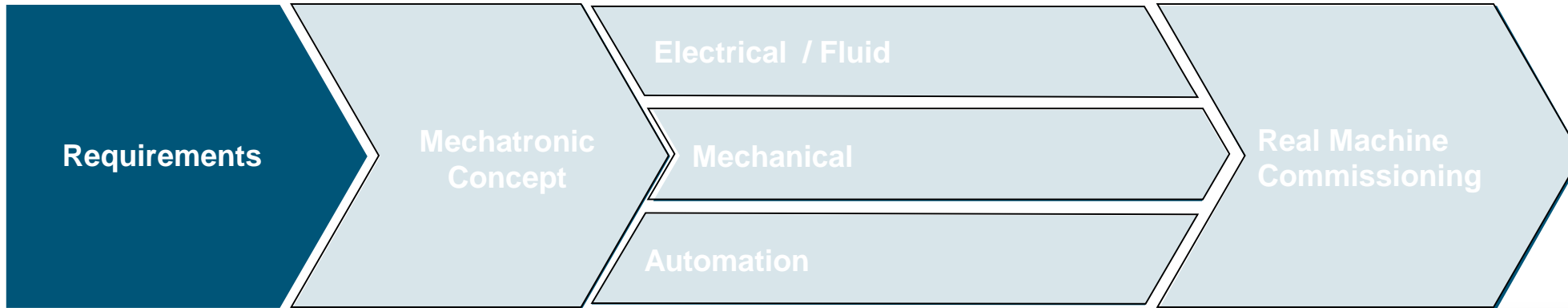
reduces the time from the first idea to the Machine (Authoring systems)

SIEMENS



Integrated Engineering (Machine Design)

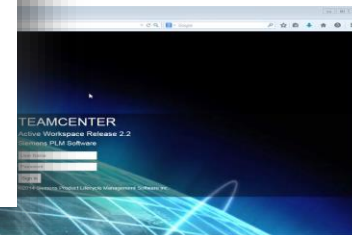
reduces the time from the first idea to the Machine



- Microsoft Office Integration
- Easy to use
- Simple structure of the product requirement and specifications

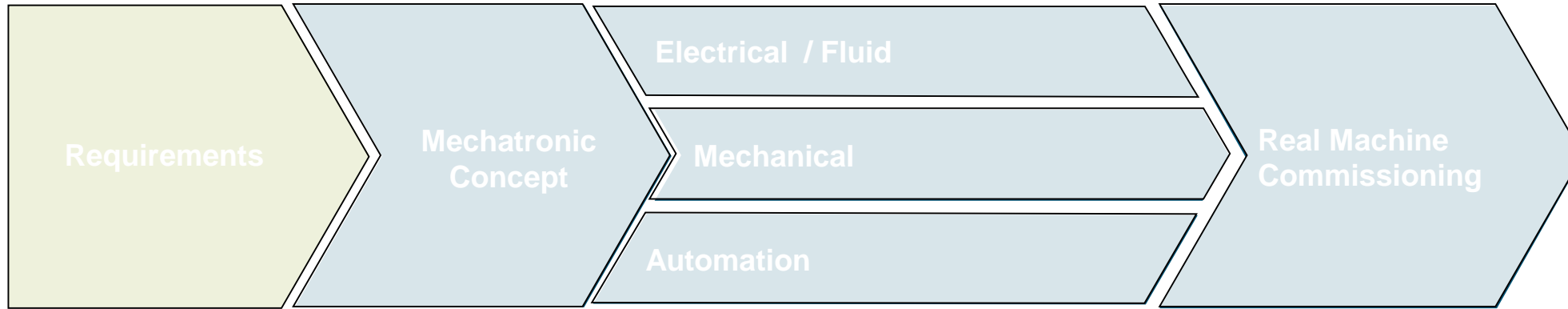


| Anforderung | Änderungsstan... | Elementtyp |
|---|--------------------|-----------------|
| 002096/A;1-Maka_Anforderung_Komplettmaschine (Ansicht) | Maka_Anforder... | Anforderungs... |
| REQ-000059/A;1-Änderungen des Dokumentes | Änderungen de... | Anforderung |
| REQ-000060/A;1-Inhalt | Inhalt | Anforderung |
| REQ-000061/A;1-Marktanforderung (Ansicht) | Marktanforderu... | Anforderung |
| REQ-000062/A;1-Maschinenbeschreibung | Maschinenbesc... | Anforderung |
| REQ-000063/A;1-Werkstoffe die auf der Maschinen gefertigt | Werkstoffe die ... | Anforderung |
| REQ-000064/A;1- Umgebungsanforderunegn (Ansicht) | Umgebungsanf... | Anforderung |
| REQ-000065/A;1-Aufstellmaß | Aufstellmaß | Anforderung |
| REQ-000066/A;1-Umweltanforderungen | Umweltanforde... | Anforderung |
| REQ-000067/A;1-Gewicht | Gewicht | Anforderung |
| REQ-000068/A;1-Werkstücke | Werkstücke | Anforderung |
| REQ-000069/A;1-Werkzeug | Werkzeug | Anforderung |
| REQ-000070/A;1-Bewegung | Bewegung | Anforderung |
| REQ-000071/A;1-Elektrik (Ansicht) | Elektrik | Anforderung |
| REQ-000072/A;1-Aufstellort | Aufstellort | Anforderung |
| REQ-000073/A;1-Aufstellland | Aufstellland | Anforderung |
| REQ-000074/A;1-Leistung | Leistung | Anforderung |
| REQ-000075/A;1-Steuerung | Steuerung | Anforderung |
| REQ-000076/A;1-Hydraulik | Hydraulik | Anforderung |
| REQ-000077/A;1-Pneumatik | Pneumatik | Anforderung |
| REQ-000078/A;1-Sicherheitsvorschriften | Sicherheitsvors... | Anforderung |
| REQ-000079/A;1-Anforderungen an die Dokumentation | Anforderungen... | Anforderung |
| REQ-000080/A;1-Abnahme der Maschine (Ansicht) | Abnahme der ... | Anforderung |
| REQ-000083/A;1-Software Test (Ansicht) | Software Test | Anforderung |



Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine



- **Requirements directly linked to the product structures**
- **Changes are tracked in all disciplines**

Interdisciplinary Conception

Acquiring interdisciplinary aspects from the beginning

How should the machine work?

The image shows a screenshot of the Siemens NX software interface. The central focus is a 3D CAD model of a machine assembly, possibly a robotic cell or a specialized workstation. The model is rendered in a light gray color, showing various mechanical parts, actuators, and sensors. The software interface includes a top menu bar with options like File, Home, Modeling, Assemblies, Developer, Curve, Analysis, View, and Render. Below the menu bar is a toolbar with various icons for modeling and simulation. On the left side, there is a 'Physics Navigator' panel with a tree view showing components like FrontDoor_K, CAxis, FrontDoor_L, Door2, ZSlide, Tool5, Materials, Couplers, FrontDoor_Sync, Sensors and Actuators, Lightbarrier, FrontDoors, and ZPositionControl. At the bottom, there is a 'Sequence Editor' panel with a table of operations. The model is surrounded by several callout boxes with white text on a dark blue background, pointing to specific parts of the machine. The callouts are: 'Operations' (top left), 'Mechanical' (top right), 'Motion Control' (middle left), 'Reusing older components' (middle right), 'Actuators' (bottom left), and 'Sensors' (bottom right). A large green circular arrow graphic is overlaid on the model, indicating a cycle or process.

Creation of a mechatronic concept with the MCD

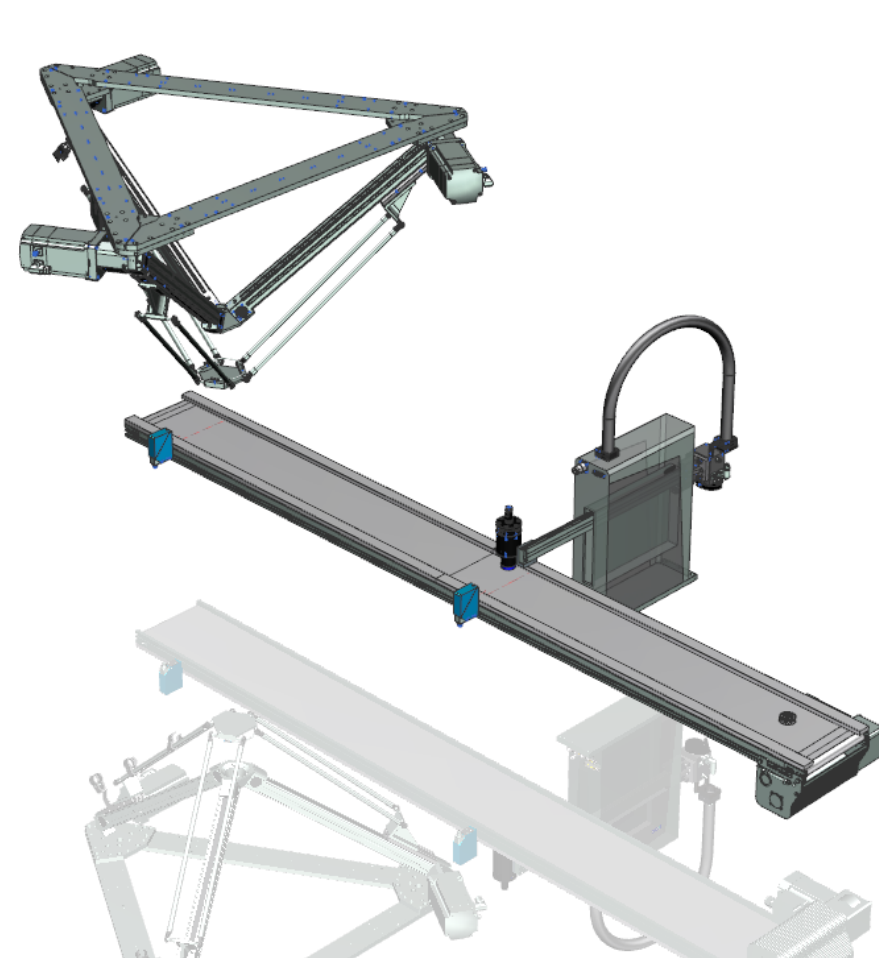
Using CADENAS Intelligent catalog parts in the design

SIEMENS

Using CADENAS Intelligent catalog parts in the design

- Directly in the engineering / conception software MCD or NX
- The Intelligent catalog items are considered as full-reusable parts in NX / MCD
- Editing of the catalog parts possible directly by right-clicking

→ Fast, Simple and with less change effort than before



Mechatronic Concept as a data source

Generating information for the following engineering disciplines

What data is provided from the Mechatronic Concept?

Machine sequence

3D Geometry

Electrical Cams

Sensor-Actuator Lists

Path-Time Charts

Reference Designations

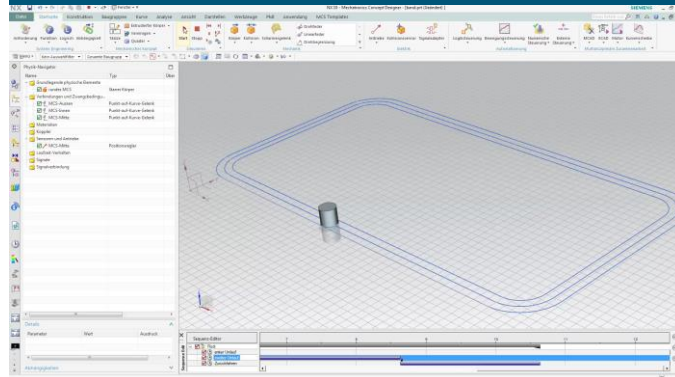
Control Signals

Force / Load Profiles

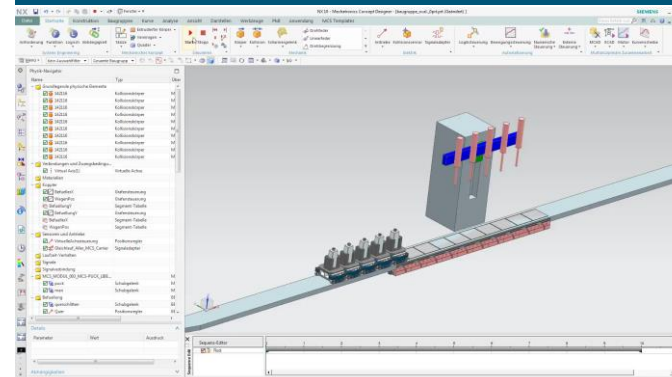
Stages of the simulation in the Conception

Continuous refinement of Concepts and Simulation

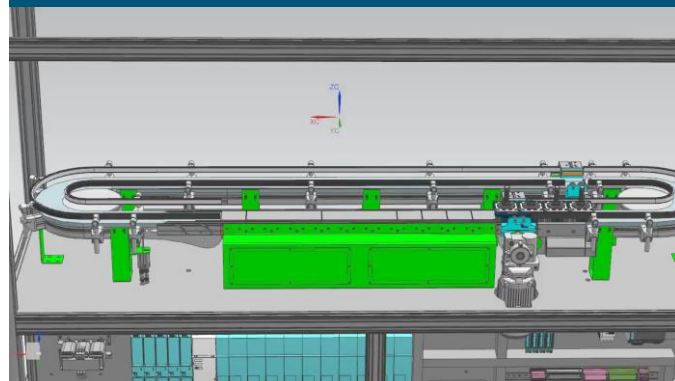
Simple Sequence



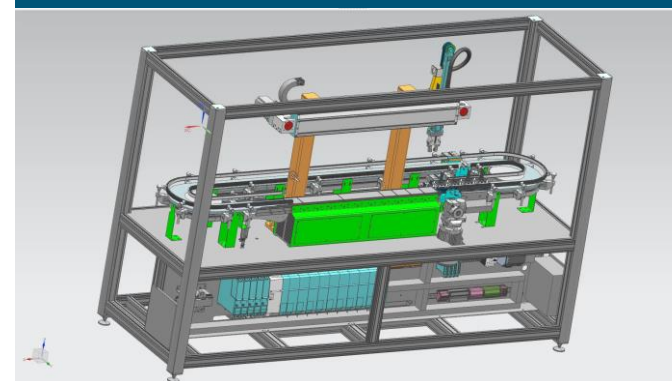
Detailed Sequence



Refined Sequence



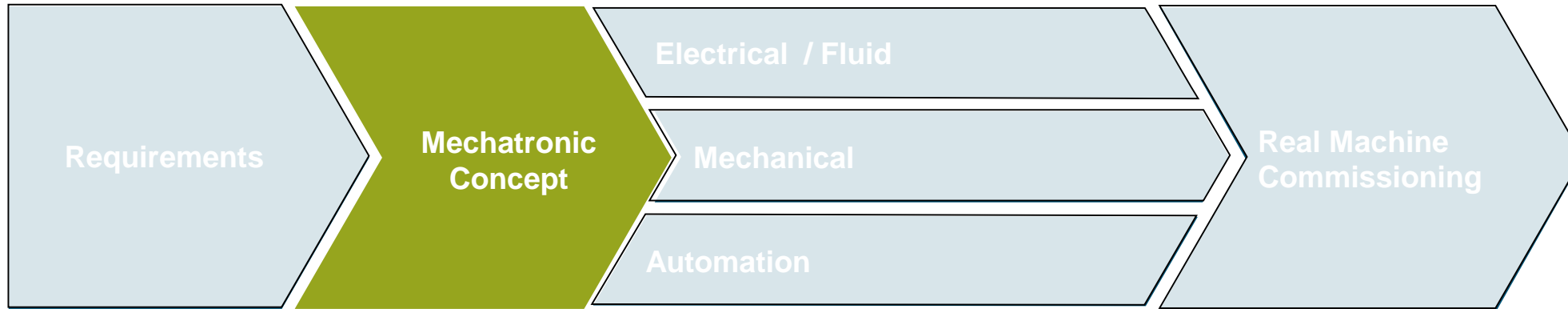
Komplex Sequence



- Mechatronic simulation during design phase
- Validating the design idea
- Presentation
- Data basis for all derivatives

Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine



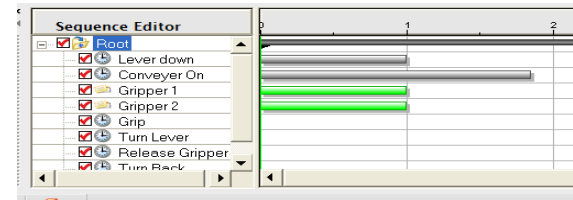
- Requirements transparent in design disciplines

- Changes are Traceable

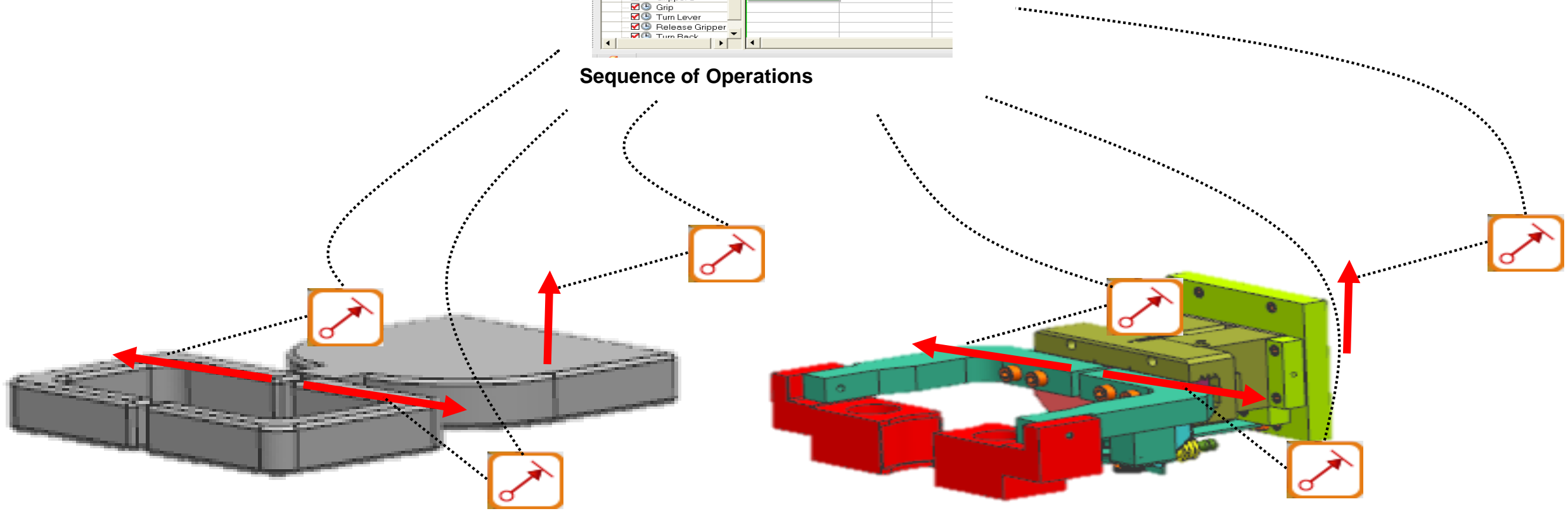
- Mechatronic simulation during design phase
- Validating the design idea
- Presentation
- Data basis for all derivatives

Mechatronic Reuse Wizard

Replace the concept geometry with detailed mechanism



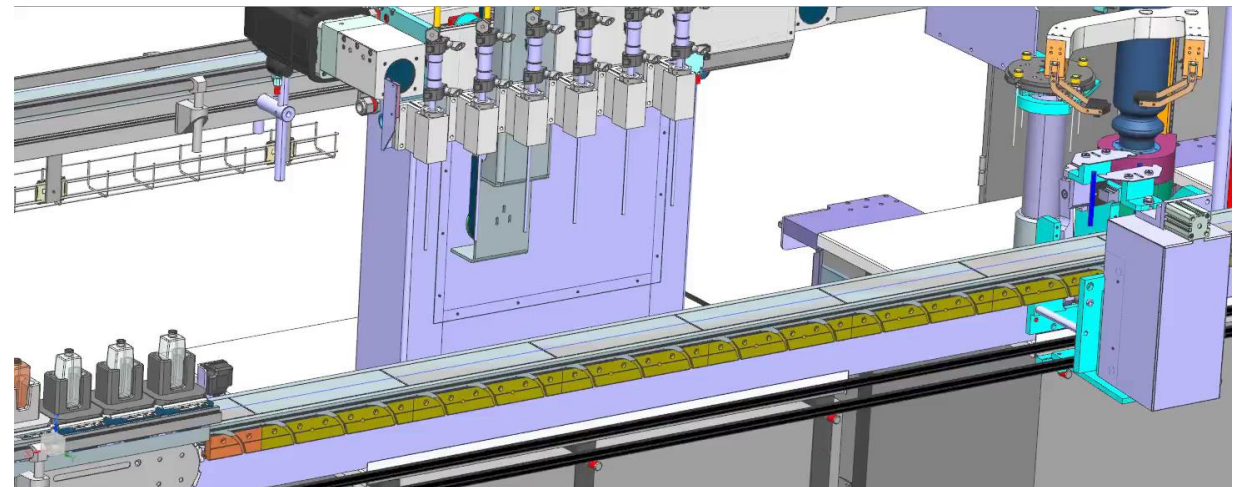
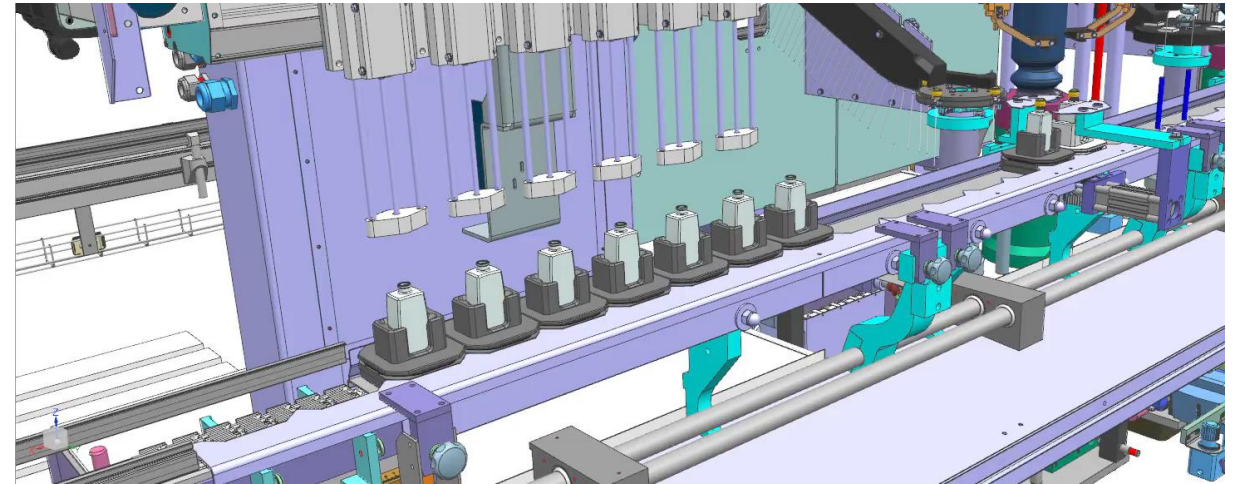
Sequence of Operations



Design Alternatives

- Different design alternatives can easily be simulated
- Simulation instead of an animation

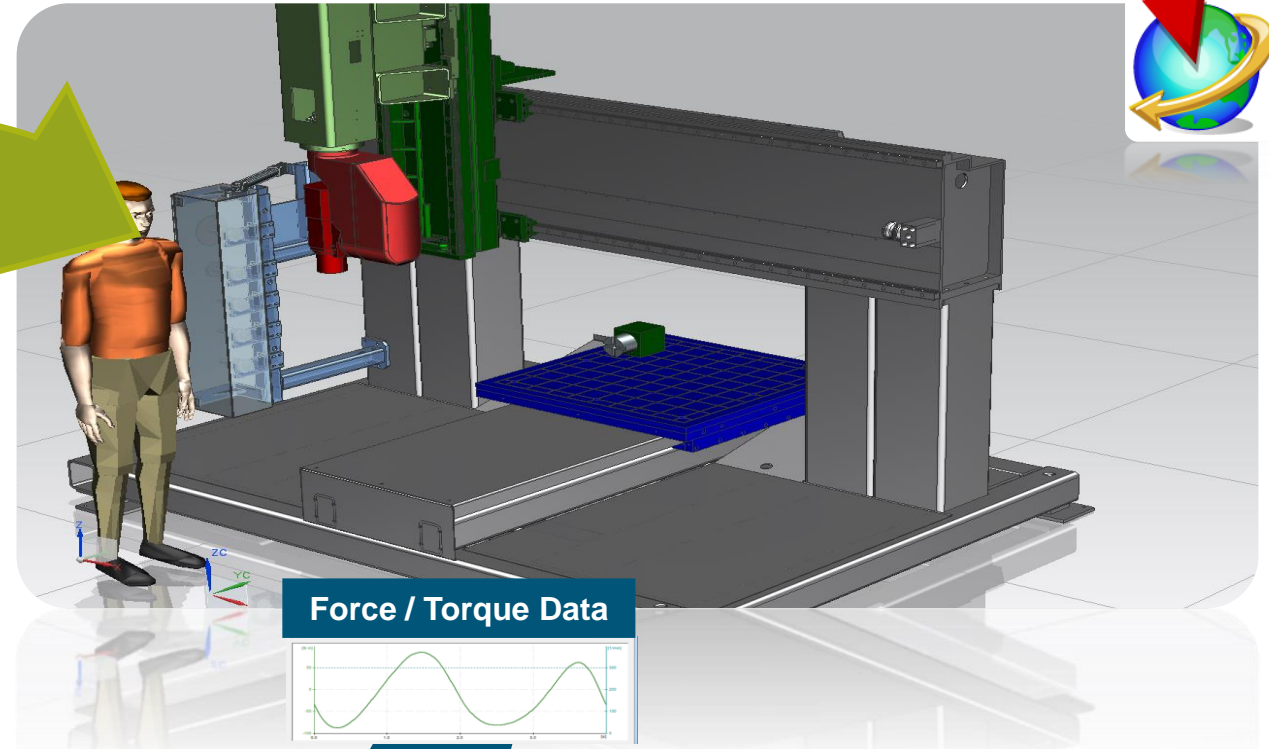
➤ Evaluating the options in the individual disciplines now much easier possible



Siemens Tool-Integration: NX/MCD – SIZER Interface

SIEMENS

Transfer of 3D CAD data
Or Select fitting component
from other product catalogs



SIZER Project1 - SIEMENS SINAMICS MICROMASTER SIZER - [Workflow]

Add drive system

New drive system: Drive system (1) In supply node: Line - 3AC 400V, 50Hz

3D-CAD

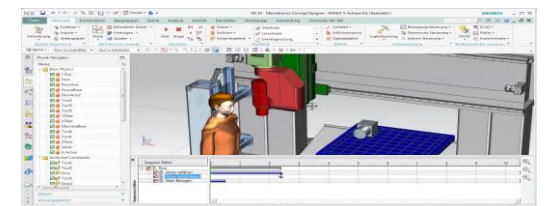
verter Motor starter load feeders

SIMATIC ET200 SINAMICS S120 AC/AC SINAMICS S110 SINAMICS G120

Motor Library

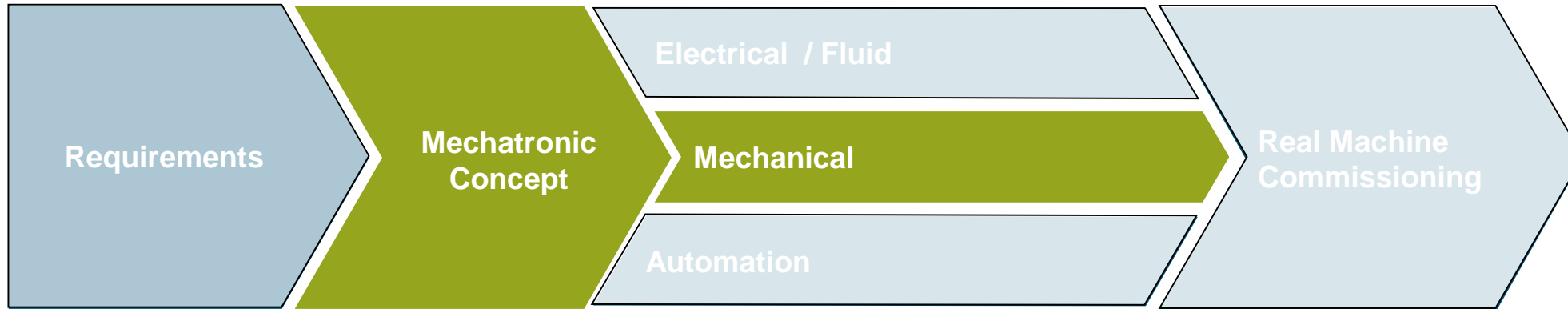
1PH7/1PL6 1FN 1FW

Dimensioning of drive systems



Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine



- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • Requirements transparent in design disciplines • . • Changes are Traceable | <ul style="list-style-type: none"> • Mechatronic simulation during design phase • Validating the design idea • Presentation • Data basis for all derivatives | <ul style="list-style-type: none"> • Benefits of 3D design data • Multi CAD functionality • Behavioral model with logic, mass, acceleration-conditions, collisions ... |
|--|--|---|

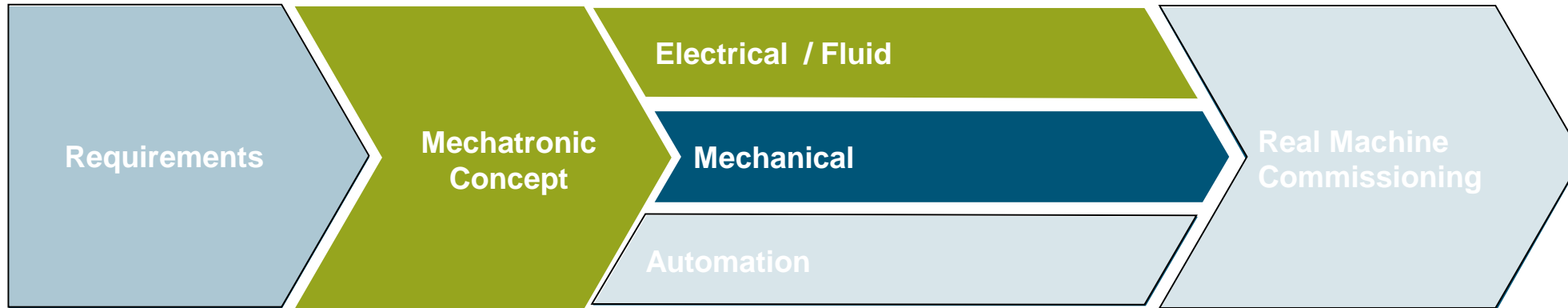
MCD Schnittstelle ins ECAD

Einheitliche Datenbasis im ECAD und MCAD



Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine



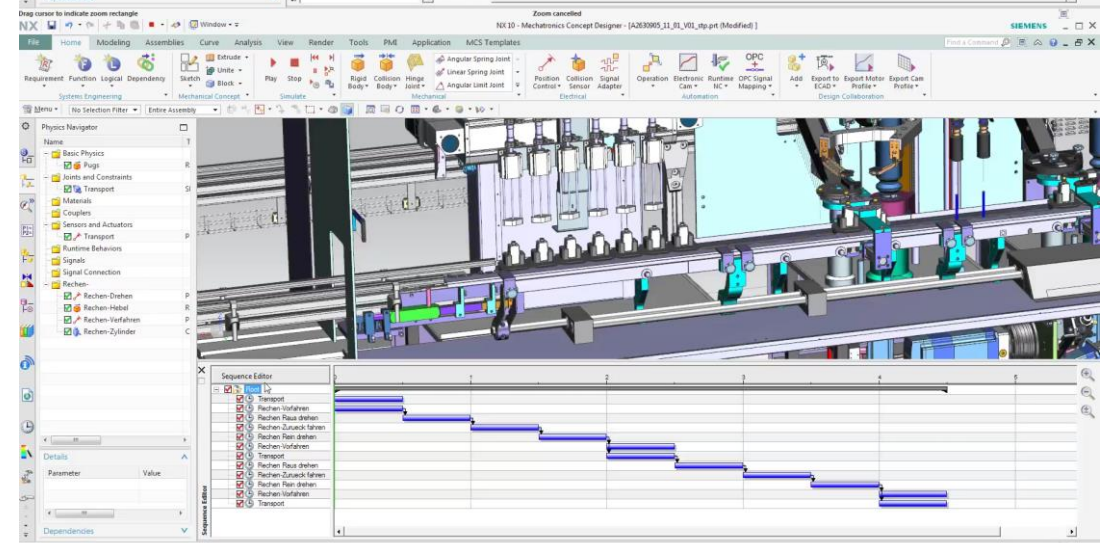
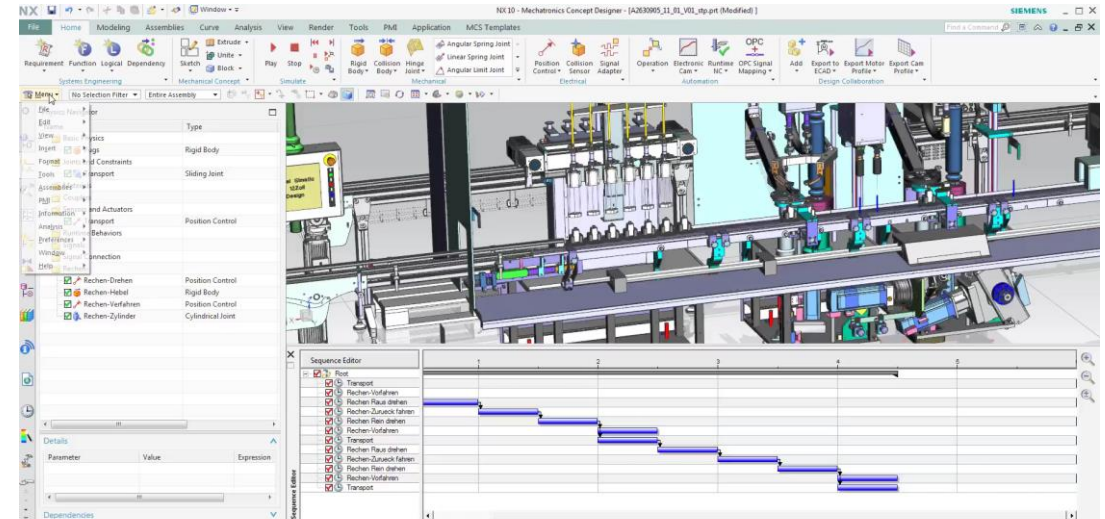
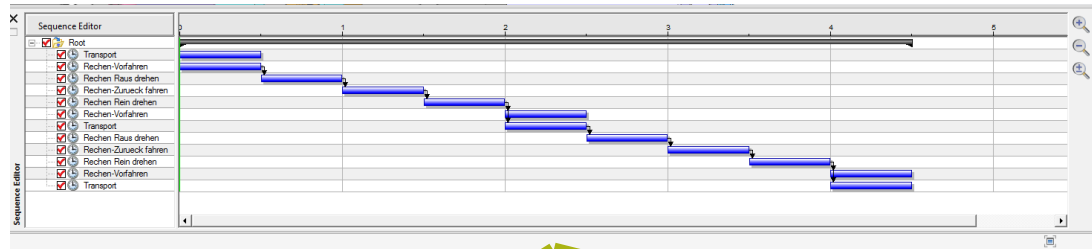
- **Requirements transparent in design disciplines**
- **Changes are Traceable**
- **Mechatronic simulation during design phase**
- **Validating the design idea**
- **Presentation**
- **Data basis for all derivatives**
- **Benefits of 3D design data**
- **Multi CAD functionality**
- **Behavioral model with logic, mass, acceleration-conditions, collisions ...**
- **Bi-directional Interface between ECAD and MCAD of sensors and actuators**
- **Device designations consistently across all derivatives**

Communication of the machine sequence to the Automation department

Exporting timing chart and the Sequence Function Chart from the Sequence Editor

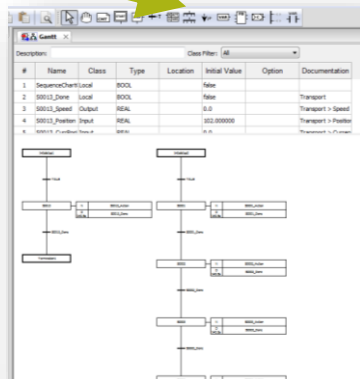


- Easy to use Sequence Editor (Gantt Chart)
- Export Chart of Operations (Timing Chart)
- Export of the SFC (Sequence Function Chart) as PLCOpenXML



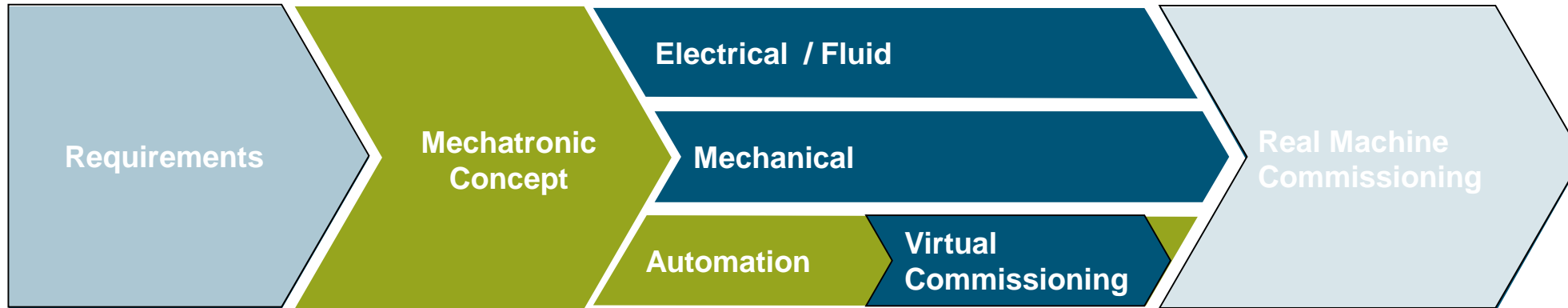
Import template for Sequence Designer

| Step | Action | Preconditions | Signal out | Signal in | Time | Start | Out | Sum |
|------|-----------------------|---------------|--|-----------|------|-------|-----|-----|
| 1 | Transport | | Transport.speed = 204.000000mm/sec;Transport.position = 132.000000mm | | 4.4 | 4.4 | | |
| 2 | Rechen-Raus-drehen | | Rechen.Vorfahren.speed = 224.000000mm/sec;Rechen.Vorfahren.position = 132.000000mm | | 4.4 | 8.8 | | |
| 3 | Rechen-Raus-fahren | | Rechen.Drehen.speed = 220.000000mm/sec;Rechen.Drehen.position = 130.000000mm | | 4.4 | 13.2 | | |
| 4 | Rechen-Zurueck-fahren | | Rechen.Vorfahren.speed = 224.000000mm/sec;Rechen.Vorfahren.position = 132.000000mm | | 5.6 | 18.8 | | |
| 5 | Rechen-Raus-drehen | | Rechen.Drehen.speed = 220.000000mm/sec;Rechen.Drehen.position = 130.000000mm | | 5.6 | 24.4 | | |
| 6 | Rechen-Raus-fahren | | Rechen.Vorfahren.speed = 224.000000mm/sec;Rechen.Vorfahren.position = 132.000000mm | | 5.6 | 30.0 | | |
| 7 | Transport | | Transport.speed = 204.000000mm/sec;Transport.position = 204.000000mm | | 5.6 | 35.6 | | |
| 8 | Operation[1] | | | | 5.6 | 41.2 | | |
| 9 | Rechen-Raus-drehen | | Rechen.Drehen.speed = 220.000000mm/sec;Rechen.Drehen.position = 130.000000mm | | 5.6 | 46.8 | | |
| 10 | Rechen-Zurueck-fahren | | Rechen.Vorfahren.speed = 224.000000mm/sec;Rechen.Vorfahren.position = 132.000000mm | | 5.6 | 52.4 | | |
| 11 | Rechen-Raus-drehen | | Rechen.Drehen.speed = 220.000000mm/sec;Rechen.Drehen.position = 130.000000mm | | 5.6 | 58.0 | | |
| 12 | Rechen-Raus-fahren | | Rechen.Vorfahren.speed = 224.000000mm/sec;Rechen.Vorfahren.position = 132.000000mm | | 5.6 | 63.6 | | |
| 13 | Transport | | Transport.speed = 204.000000mm/sec;Transport.position = 204.000000mm | | 4.4 | 68.0 | | |



Integrated Engineering (Machine Design)

reduces the time from the first idea to the Machine



- Requirements transparent in design disciplines
- Changes are Traceable
- Mechatronic simulation during design phase
- Validating the design idea
- Presentation
- Data basis for all derivatives
- Benefits of 3D design data
- Multi CAD functionality
- Behavioral model with logic, mass, acceleration-conditions, collisions ...
- Bi-directional Interface between ECAD and MCAD of sensors and actuators
- Device designations consistently across all derivatives
- Verification of test cases on digital twin
- Early test of modules and code
- Consistency: work on the real CAD data!

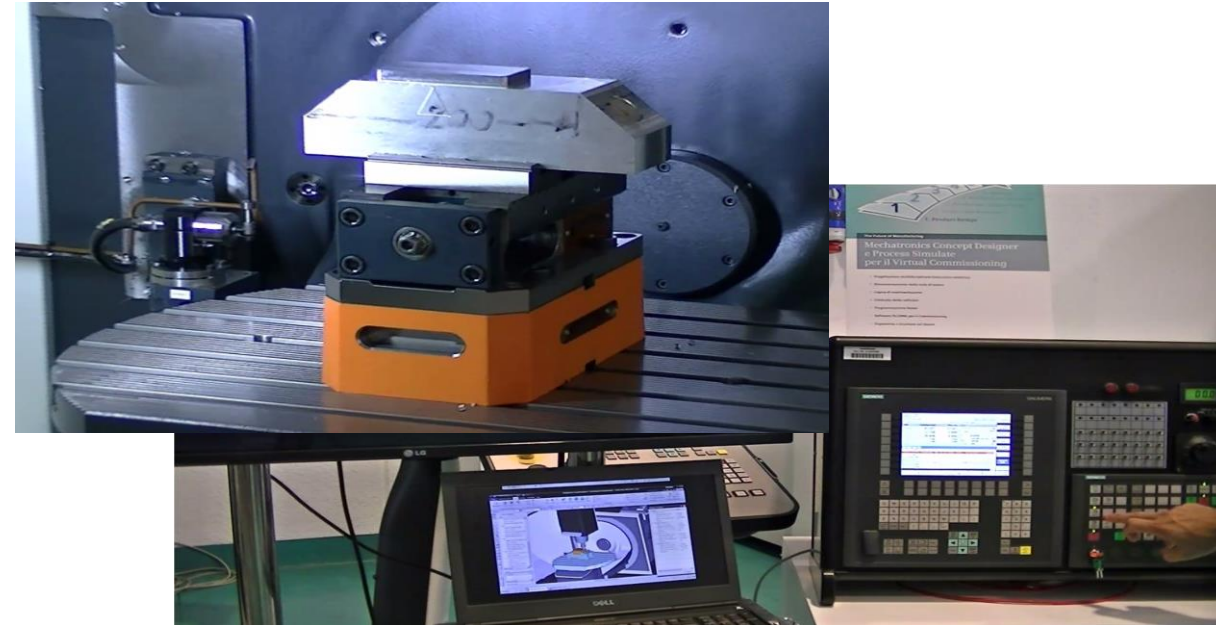
Virtual Commissioning (VC)

Challenges

- Prototypes are expensive and time consuming to manufacture.
- Changes in commissioning phase are very expensive.
- Non-operational machines in the workshop cost money.

Main Benefits

- Verify and validate system behavior
- optimize automation program and prepare physical Commissioning
- Validate machine variants and options, for which no prototypes were created



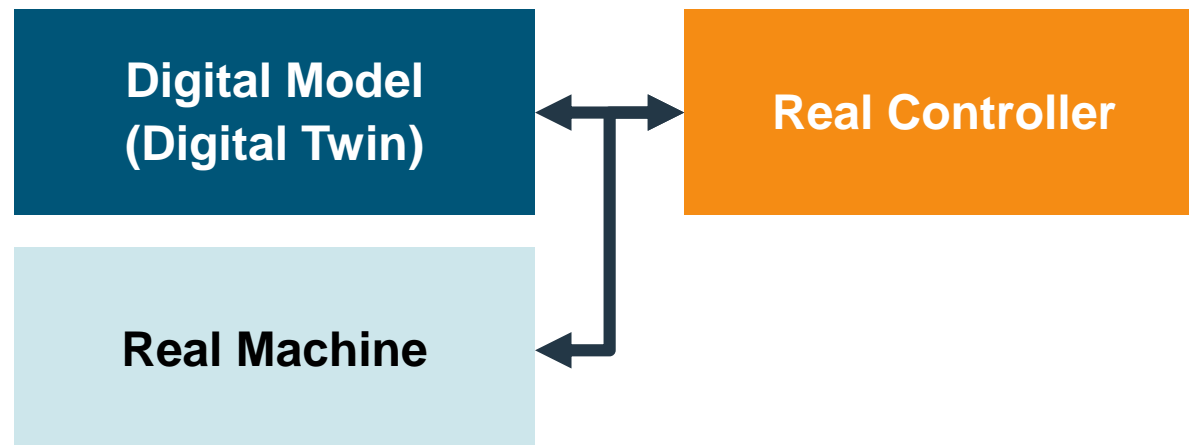
VC with the Mechatronic Concept Designer

Virtual Commissioning (VC)

- HiL (Hardware in the Loop)
- SiL (Software in the Loop)

Motivation for Virtual Commissioning

- Real machine is not available
- Real commissioning is incalculable
- Concept errors usually appear at Commissioning
- Customer requirements are usually not available in detail
- Testing the program processes in the early phase



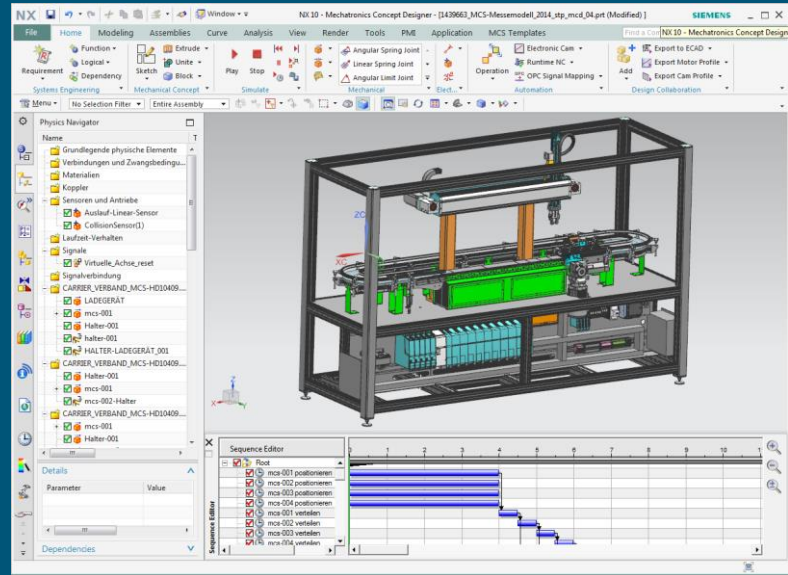
Interaction in the VC

Digital Model

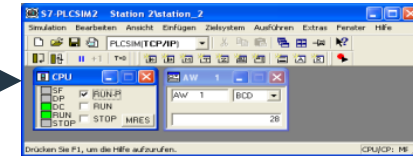
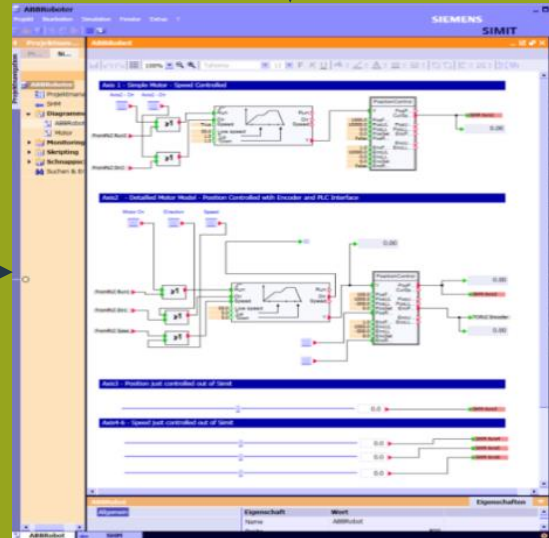
Behavior Model

Real Controller

NX / MCD



SIMIT



PLCSim



Simatic



Sinumerik



Simotion



Various....

Real Controller

SU / SIMBA BOX

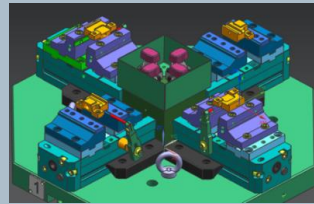
Profibus / Profinet

Applications for machine construction

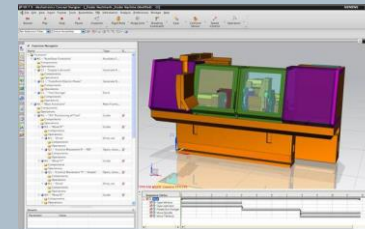
Design, Configuration and Validation of the product idea

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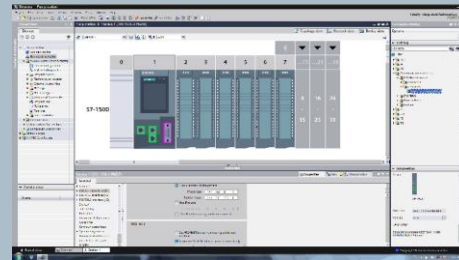
Mechatronic Concept



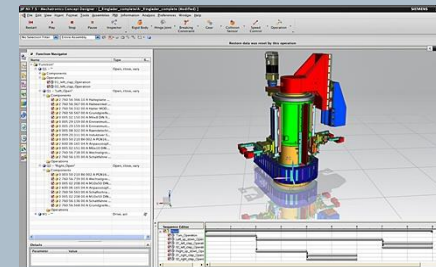
Mechanical Design



Electrical / Automation



Virtual Commissioning



Digital Twin

Real Machine
Commissioning
Service

The digital Twin enables:
... that the Product Requirements are met
....up to date Information in all disciplines
... manageable complexity

- ▶ Shorter innovation cycles
- ▶ Productivity improvements

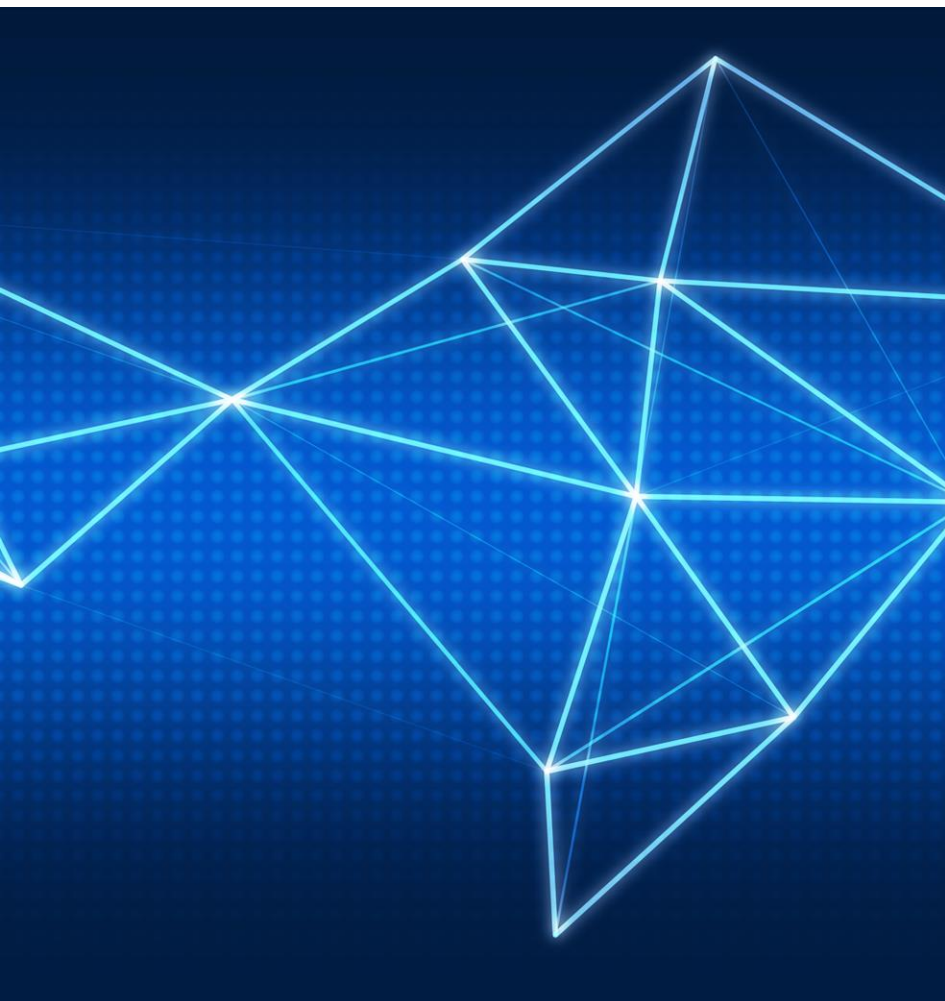
bi-directional
interface
between ECAD
and MCAD of
sensors and
actuators

Service
designations
consistently
across all
derivatives

- verification of test cases on digital twin
- Early test of modules and code
- Consistency: work on the real CAD data!



Thank you!



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