Systems Engineering in an evolving context
ESI symposium 2019
Ton Peijnenburg – VDL ETG, TU/e HTSC
VDL Enabling Technologies Group – market segments
We serve many high-end equipment markets as Tier-1 supplier

Semiconductor Capital Equipment

Analytical Equipment

Led Manufacturing Equipment

Medical Equipment

Solar Production Equipment

Science & Technology

From…

… turnkey projects to…

… full Life Cycle Management

4/9/2019

2019 ESI symposium
From sketch to design to (volume) manufacturing

- 0.5 year 10 pp
- 0.5 year 20 pp
- 5 years 200 pp

Want to know more? Go to the slide 'Video instructions – YouTube links' and open it in the slide show and click the desired video link.
Multi-disciplinary – mechatronics as an example
Multi-disciplinary teams

depth of know-how

multi-disciplinary team

topic
Multi-disciplinary teams

not a multi-disciplinary team

multi-disciplinary engineers?

depth of know-how
Multi-disciplinary capable profile

T-shaped engineers

depth of know-how

topic

Want to know more? Go to the slide named ‘Instruction slide: YouTube links’, open it in the slideshow and click on the preferred hyperlink.
Systems Engineering

- Question: User requirements
- Answer: Requirements, Design

Validation and Verification

Philips CFT, SEM group, 2001, some additions
Systems Engineering
Heinz Nixdorf Institut + Fraunhofer IPT view

Figure 2-1: Joint analysis of system and project – the core aspects of SE

SYSTEMS ENGINEERING in industrial practice, Heinz Nixdorf, Fraunhofer IPT
Systems Engineering
Key topics for high-tech system development
Systems Engineering
Key SE topics for engineering of high-tech systems

- Requirements engineering
- Model based
- Trade-off analysis
Requirements engineering

- Key to **effective** (and efficient) system development
- Requirements **model**, not just plain docs
- Need **version control**, baselining, traceability
- Basis for medical and other **certifications**
- **Flow-down** of requirements
- **Scenarios**
- **Alternative** concepts
Model-based

- Models **instead of documents** (capture knowledge, drive development)
- No multi-multi, rather **co-evolving separate models**
- Baselining, version control, **configuration** management
- **Formal language** models can be treated as software
- **General modeling** should come back as course
- **Model-based SE** is gaining interest
- Close gap between “**software & the others**”
- “**Live**” models for reviews
- “**Zoom in & out**” to deal with complexity
Quantified trade-off – synthesize and compromise

- Multi-parameter, multi-objective **optimization** for various concept alternatives
- **Formal methods** to deal with complexity
- Strong linkage to **requirements**
- Knowledge of (system level) **sensitivities**
- Cost of **future change**
Good Systems Engineers

- Intellectual curiosity—ability and desire to learn new things
- Ability to see the big picture—yet get into the details
- Exceptional two-way communicator
- Comfortable with change
- Diverse technical skills—ability to apply sound technical judgment
- Appreciation for process—rigor and knowing when to stop
- Ability to make system-wide connections
- Strong team member and leader
- Comfortable with uncertainty and unknowns
- Proper paranoia—expect the best, but plan for the worst
- Self confidence and decisiveness—short of arrogance

two aspects of engineering

design

science
Want to know more? Go to the slide named "Instruction slide: YouTube links", open it in the slideshow and click on the preferred hyperlink.

Select the preferred video and click 'Insert'.

Click with the right mouse button on the miniature slide on the left side of the screen and choose 'Reset slide'.
Modeling of wafer handler
A wide variety of tools is used for development & engineering

- Mechanics and dynamics – Siemens NX, ANSYS
- Dynamics and control – MATLAB and Simulink
- Supervisory control, logistics – (ESI) Concerto
- Heat & flow – ANSYS
- Mechanisms and dynamics – SimMechanics
- Electronics – Mentor
- Electro mechanics – ANSYS, Vector Fields, FEMM
- Particle flow, generation – special
- Vacuum – special

- Tolerance stacks – Excel
- Reliability – Excel
- Cost – Excel
- Bill of Material – Excel

What about architecture-level alternatives?

e.g. a better robot vs a better serviceable robot

Evaluation of Conceptual Design Choices using Dependency Structure Matrix Methods, K.A. Meeuwsen, MSc thesis, 2019
Design Structure Matrix – the good ol’ N² re-invented

Evaluation of Conceptual Design Choices using Dependency Structure Matrix Methods, K.A. Meeuwsen, MSc thesis, 2019
RoboCup

2018 Eindhoven Maker Faire
... promoting **robotics** and **AI research**, by offering a **publicly appealing**, but formidable challenge...

"By mid-21st century, a team of fully autonomous humanoid robot soccer players shall win the soccer game, complying with the official rule of the **FIFA**, against the winner of the most recent World Cup."
Robotics

- Mechanistic
- Hardware
- Functions
- Control
- Functional design

Artificial Intelligence

- Reasoning
- Software
- Data
- Respond
- Machine learning

Want to know more?
Go to the slide named 'Instruction slide: YouTube links', open it in the slideshow and click on the preferred hyperlink.
VDL Group

- Established in 19 countries
- > 100 operating companies
- > 17,000 employees, privately owned
- Turnover > €6 billion (2018)

Sub contracting
- mechatronic systems
- module assembly
- part and sheet metal
- surface treatments
- plastic processing
- other specialties

Bus group
- touring cars
- public transport bus
- mini and midi busses
- chassis modules
- second hand trade

Finished products
- medical equipment
- process installations
- consumer products
- production automation
- various products
- packaging equipment

Car assembly
- MINI
  - Hatchback
  - Cabrio
  - Countryman
- BMW
  - X1

Enabling Technologies Group