AUTONOMICS

New systems engineering approach for autonomous systems

Andre Bolles, DLR Institute of Systems Engineering for Future Mobility, November 22nd 2022

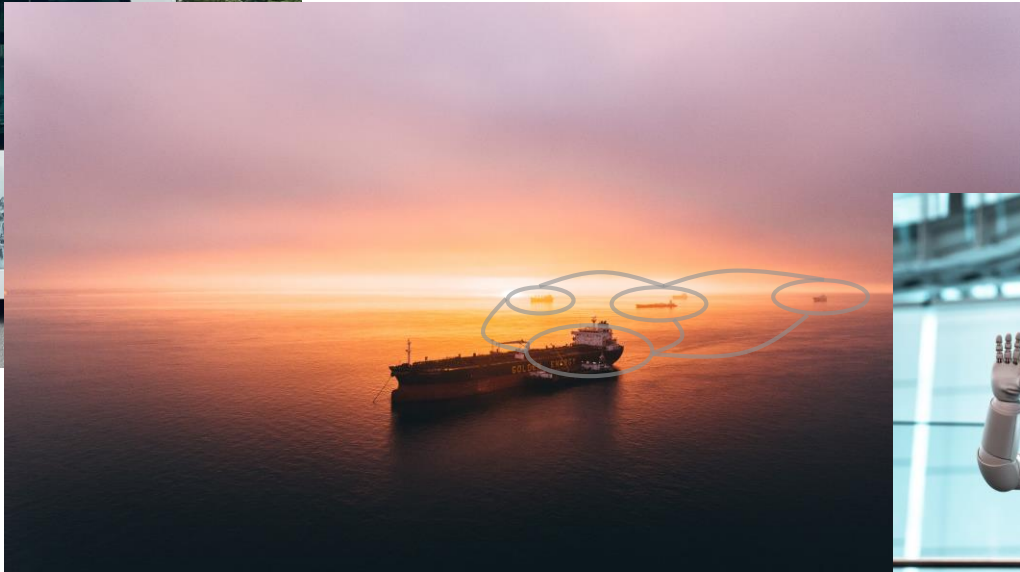# Autonomous Systems

Photo by Bernd Dittrich on Unsplash

Photo by Ian Simmonds on Unsplash,
overlay added by André Bolles

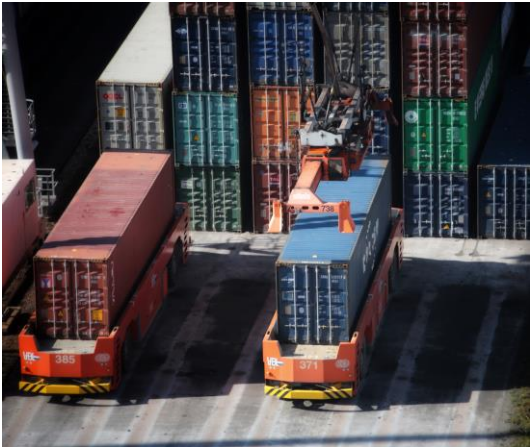Photo by Maximalfocus on Unsplash


Photo by Bernd Dittrich on Unsplash

Scenario 3: Digital ambivalence and (geo-)political standstill

SUMMARY OF THE SCENARIO:
Since 2008, Europe has been in crisis: Financial and Economic Crisis, Euro Crisis, Flight and Migration Crisis, Brexit and the Pandemic. The EU has emerged from these crises with a weakened public image, and in most EU member states - including Germany - national forces have increasingly prevailed that they want to strengthen their own economies but are no longer interested in European or global cooperation. Digitization and the economy are supported and promoted in national lighthouse projects, but the lack of international embedding leads to the weakening of many export-oriented industries. Digitization is being driven forward in isolated solutions, but due to uneven expansion and a widespread lack of regulation, there are negative consequences of digitization in addition to growth-promoting effects.
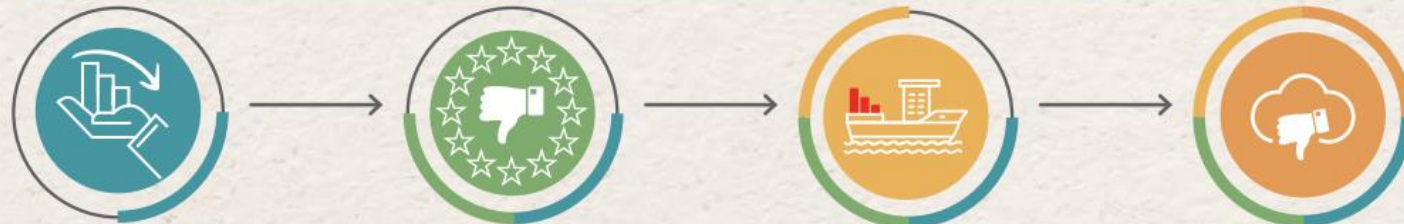
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Scenario 2: Digital islands in an analog world

SUMMARY OF THE SCENARIO:
A global economic recession develops as a result of the Corona pandemic, comparable to the 2008 financial crisis. The merchant shipping industry will be particularly hard hit. Due to a lack of standards and little public or publicly led infrastructure development, no general level of digitization will be achieved. Rather, islands of digital high technology are emerging in an environment of largely analog technology. The effects of this are very different levels of security.

Vision Digital Coast 2030

Scenario 1: Growth through holistic digitization

SUMMARY OF THE SCENARIO:
Digitalization is driving economic growth in the industry. Process redesigns and innovative technologies not only increase efficiency, but also make an essential contribution to climate and environmental protection as well as to safety. An important element for this positive development is the consideration of cybersecurity, which ensures the secure use of digital innovations. The economic consequences of the Corona pandemic remain absent and favor investments in digital technologies.
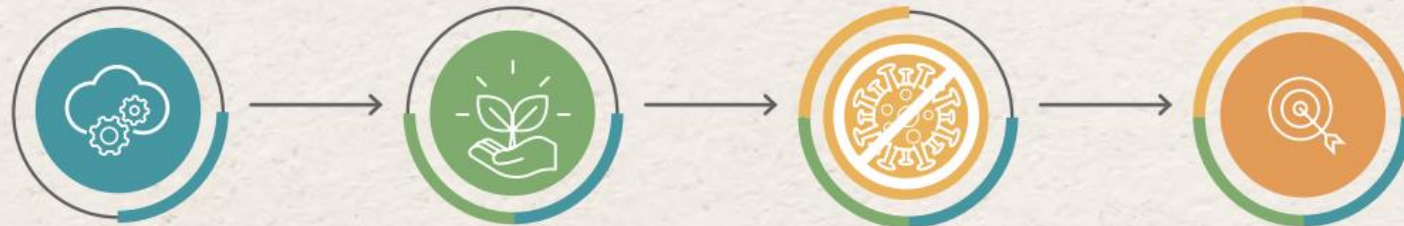
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Roadmap for autonomous systems
Challenges named in the roadmap (excerpt)

- "Which languages and theories do we have to specify systems with changeable properties?"

- "What languages and theories do we use to specify learning cycles in which the knowledge base and patterns of action change?"

- „How can secured confidence statements be derived when using learner methods in environmental perception?"

- "What forms of cooperation are there, and what patterns of cooperation do we need for them?"

- "How is trust represented in a technical system?"

- "How is dignity represented in a technical system?

- " How do machines prove their business capability, especially when they autonomously learn something new?"

- "What can machines be responsible for?"

- …

Source:
SafeTrans e. V. Safety, Security, and Certifiability of Future Man-Machine Systems. 2021.
https://www.safetrans-de.org/de/Uploads/AK_2018_RLE_CPS/SafeTRANS_RM_SSC_FMMS_Roadmap_V2.pdf?m=1611136486,
last visit: 2022-11-17
Translated with deepl.com

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Challenges for Systems Engineering
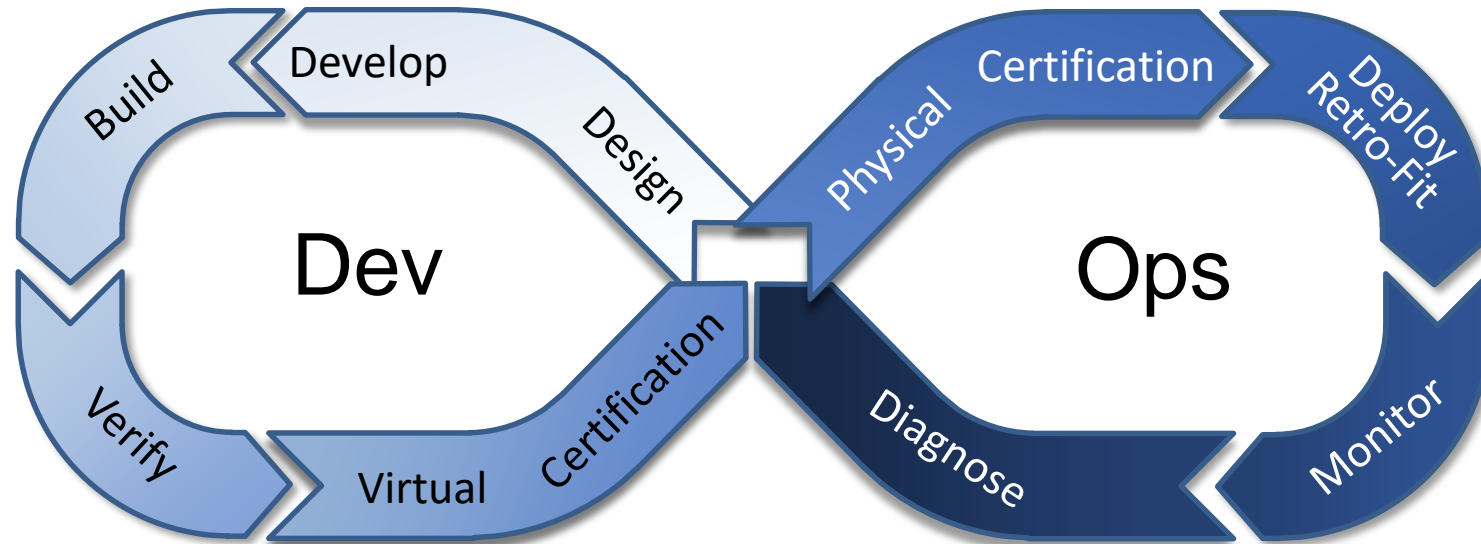
Figure 4: DevOps Process
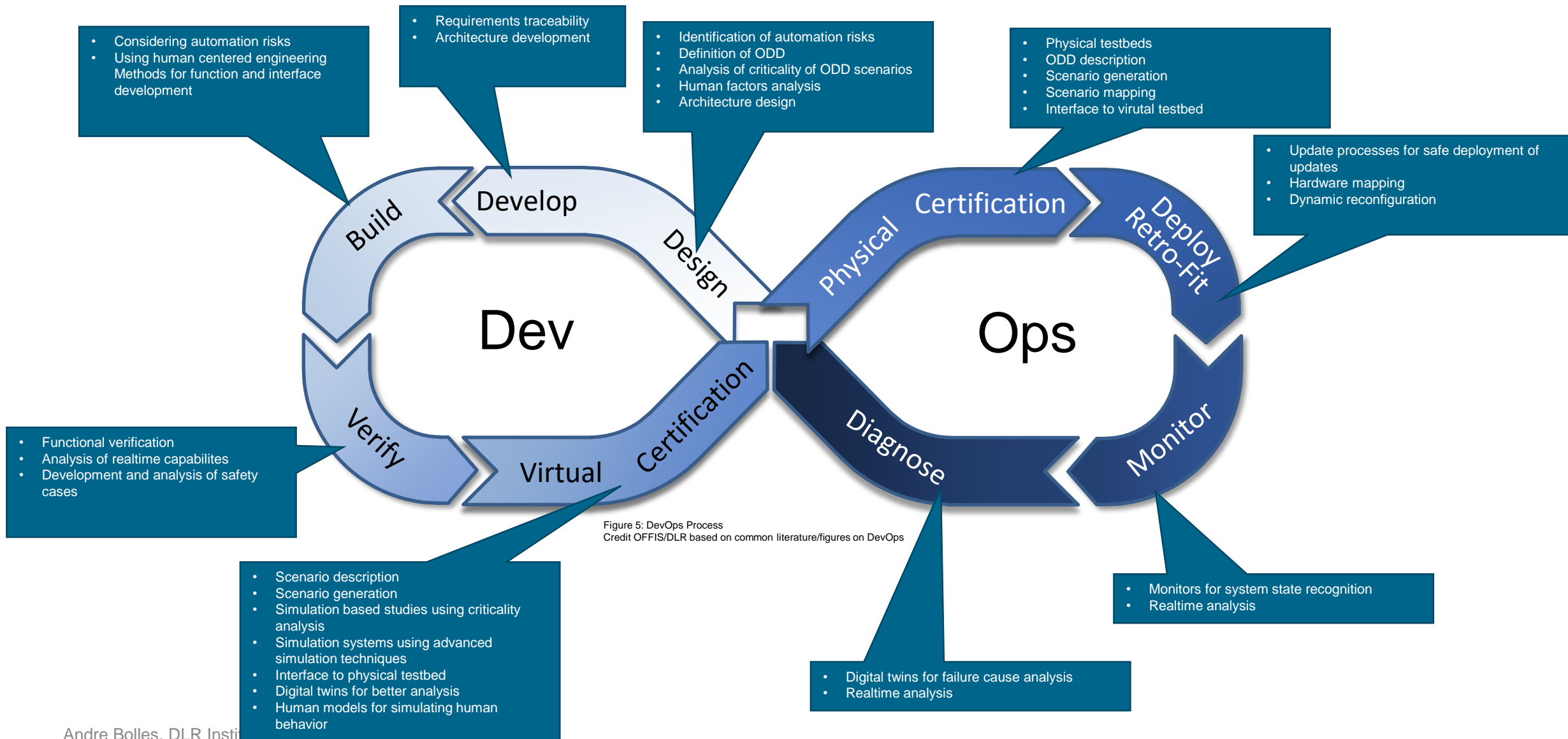Credit: OFFIS/DLR based on common literature/figures on DevOps

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Computer Science Perspective (some examples)

- Considering automation risks
- Using human centered engineering Methods for function and interface development

- Requirements traceability
- Architecture development

- Identification of automation risks
- Definition of ODD
- Analysis of criticality of ODD scenarios
- Human factors analysis
- Architecture design

- Physical testbeds
- ODD description
- Scenario generation
- Scenario mapping
- Interface to virutal testbed

- Update processes for safe deployment of updates
- Hardware mapping
- Dynamic reconfiguration

- Functional verification
- Analysis of realtime capabilites
- Development and analysis of safety cases

- Scenario description
- Scenario generation
- Simulation based studies using criticality analysis
- Simulation systems using advanced simulation techniques
- Interface to physical testbed
- Digital twins for better analysis
- Human models for simulating human behavior

- Digital twins for failure cause analysis
- Realtime analysis

- Monitors for system state recognition
- Realtime analysis

Build **Develop** **Design** **Physical** **Certification** **Deploy Retro-Fit**

Dev   **Ops**

Verify **Virtual** **Certification** **Diagnose** **Monitor**

Figure 5: DevOps Process
Credit OFFIS/DLR based on common literature/figures on DevOps

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Do these things really cover the aspects from slide 7?

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Maybe we should consider autonomous systems as living entities?[1]

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Systems Engineering for Autonomous Systems
# From cradle to grave

∗ Birth

✝ Death
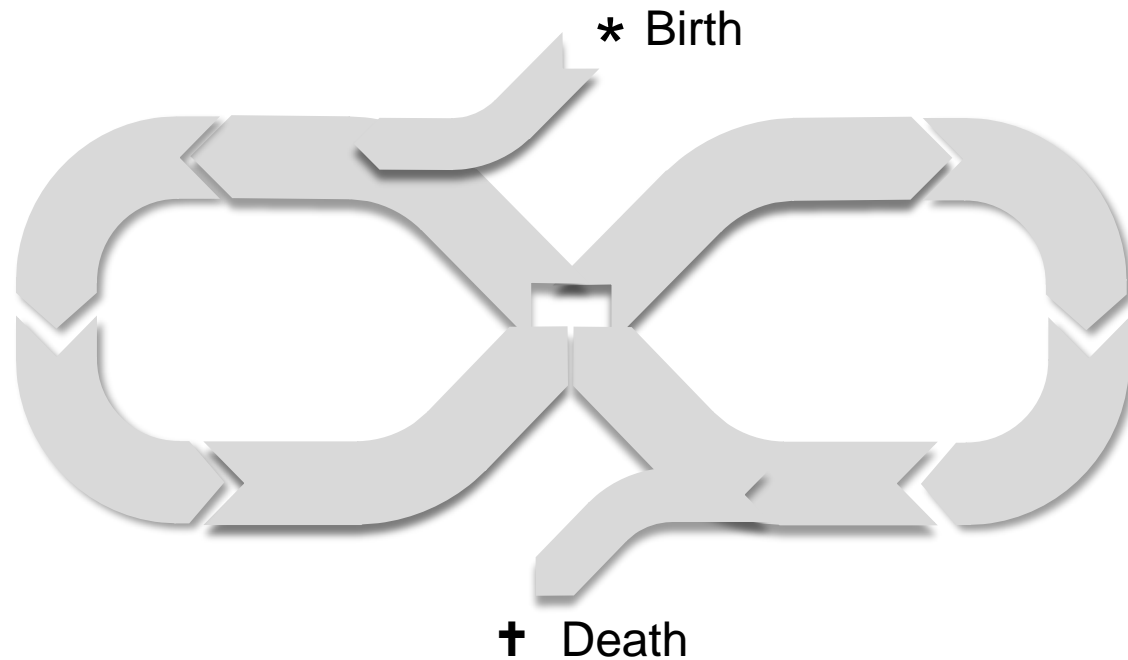
- Be their parents

- Be their brothers and sisters

- Be their friends

- Be their teacher

- Be their colleague

- Be their family

- …

Systems Engineering for Autonomous Systems
From cradle to grave

∗ Birth

✝ Death
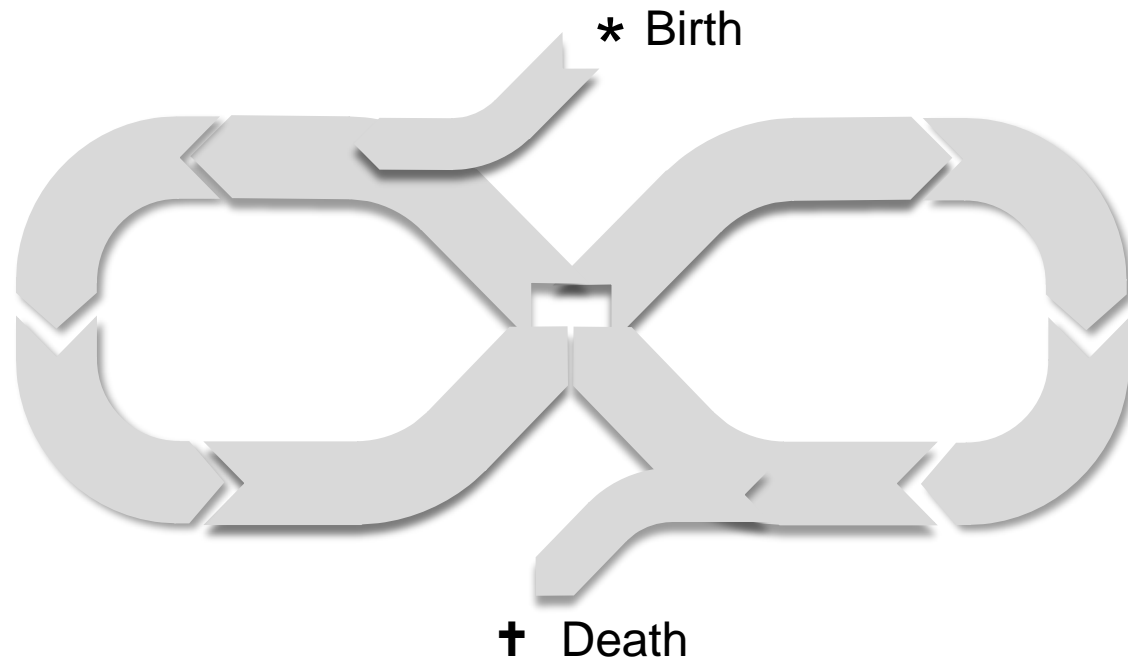
- Not all roles covered by systems engineers but to be considered by them

- Regarding the whole life of autonomous systems

- Integration of new technologies

- Using the systems / cooperating with them

- Evolution of technologies and systems in the field

- Decomissioning of old technologies

- Considering all facets of life (technical and non-technical)

Sociological Perspective
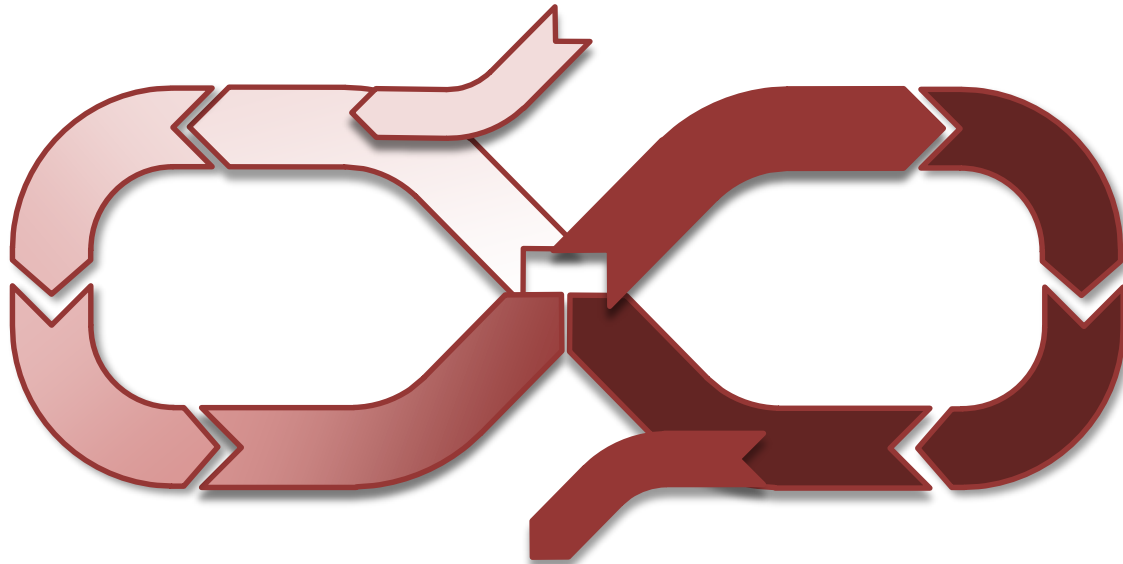
- How does the social interaction between humans and autonomous systems may look like?

- How do we build teams of humans and autonomous systems?

- Exemplary results to be used for engeneering:
  - Cooperation models
  - Trust models
  - Conflict models

- Interesting methods:
  - Experiments
  - Longterm studies
  - Observation techniques

Machine Engineering Perspective

- How do mechanical capabilities interact with software capabilities?

- Interesting results:
  - Advanced mechanics and feedback loops
  - Sensors and actuators
  - CAD-models (digital twins)

- Methods
  - Design methods
  - Drafting
  - Rapid prototyping
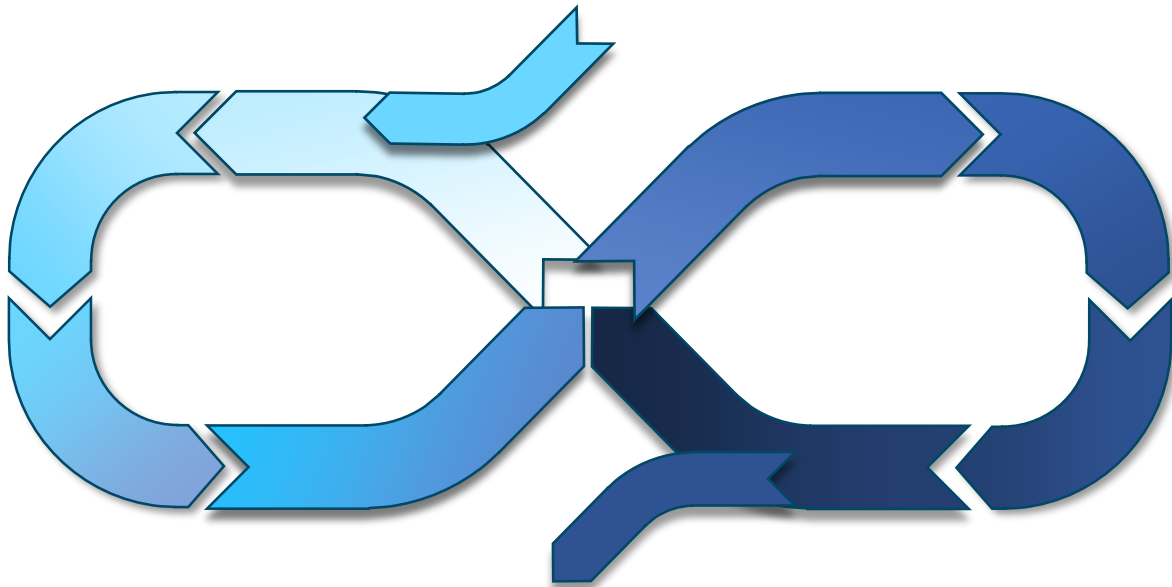
Psychological Perspective

- How can psychological findings be implemented into technical systems
- Which psychological effects will autonomous systems cause with humans?
- Exemplary results / fields
  - Consciousness models
  - Behaviour models
  - Cognitive load
  - Personality (of autonomous systems)
  - Emotions (reaction to…)
- Methods
  - Experiment design methods
  - Specific experiment types

Ethical Perspective[1]
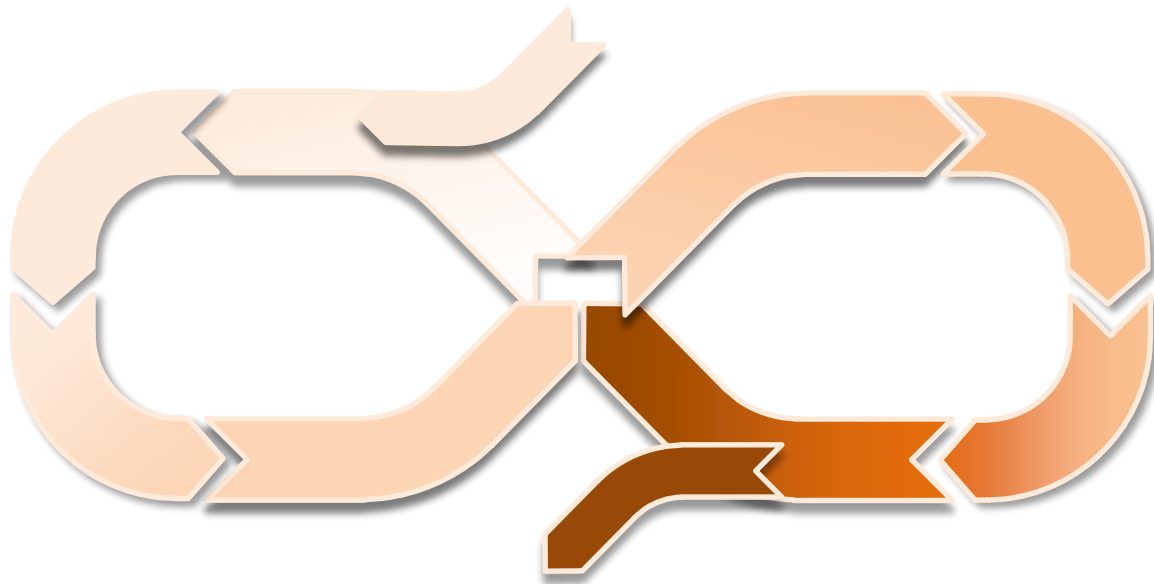
- Which ethical values are important for us?

- How can ethical value systems be implemented into autonomous systems?

- How will autonomous systems be enabled to solve ethical trade offs / dilemmas?

- How can we implement responsibility into autonomous systems?

- Will autonomous systems ever be able to take over responsibility for humans?

- Interesting concepts / theories:
 - Values
  - Fairness
  - Development of norms

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Legal Perspective

[2]cf: SafeTrans e. V. Safety, Security, and Certifiability of Future Man-Machine Systems. 2021.
https://www.safetrans-de.org/de/Uploads/AK_2018_RLE_CPS/SafeTRANS_RM_SSC_FMMS_Roadmap_V2.pdf?m=1611136486, pp.77. last visit: 2022-11-17

[3]cf: SafeTrans e. V. Safety, Security, and Certifiability of Future Man-Machine Systems. 2021.
https://www.safetrans-de.org/de/Uploads/AK_2018_RLE_CPS/SafeTRANS_RM_SSC_FMMS_Roadmap_V2.pdf?m=1611136486, pp.79. last visit: 2022-11-17

- How do legal regulations influence the development and operation process of autonomous systems?

- Can we use legal constructs to formalize and implement legal regulations?[2]

- How will reliability of autonomous systems be realized?[3]

- How can this be considered in the implementation of such systems?[2]
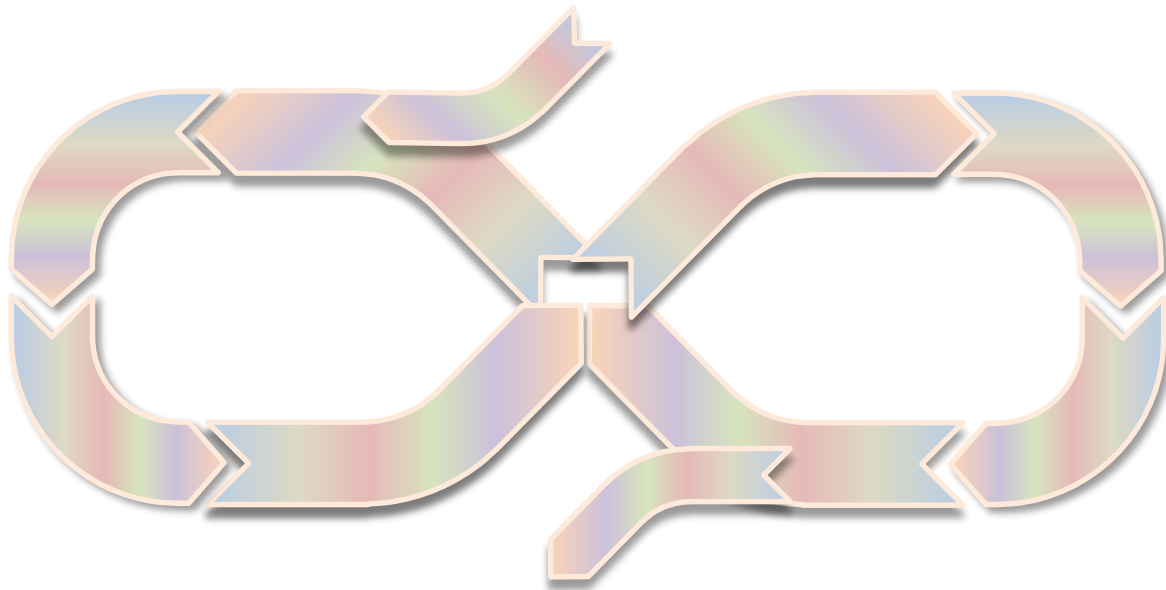
Anthropology Perspective
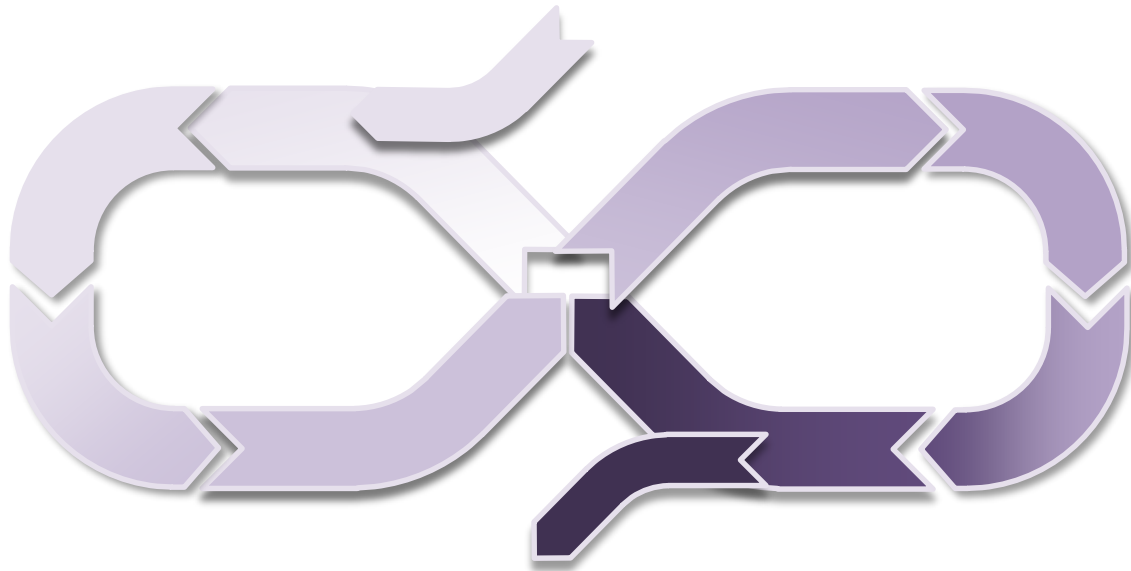
- What can we learn from humans?
- Culture theories as basis for a new culture between humans and autonomous system?
- New way of working together with autononous systems?
- Changes in the political systems when autonomous systems play a major role in societies
- …

AUTONOMICS[4]

- Bring together all relevant disciplines

- Combine methods / tools / results during the life of autonomous systems

- **Create a future in which we live together with autonomous systems in a trustworthy way.**

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Imprint

Topic: **Autonomics – New systems engineering approach for autonomous systems**

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