

Nils Brand

tSDX - trustworthy Software Defined X Reference Architecture



Fraunhofer Institute for Experimental
Software Engineering



Federal Ministry
of Research, Technology
and Space



Fraunhofer Gesellschaft Overview

world leading organization for applied research



Joseph von Fraunhofer
(1787–1826) *symbolic patron*

€ 3.6 billion
research budget

Annual financial statements 2025



74

institutes and research units,
represented in every
German state

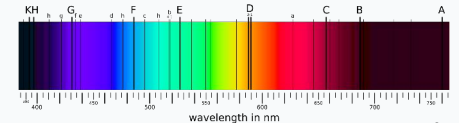


30,000
Employees



Rounded figures

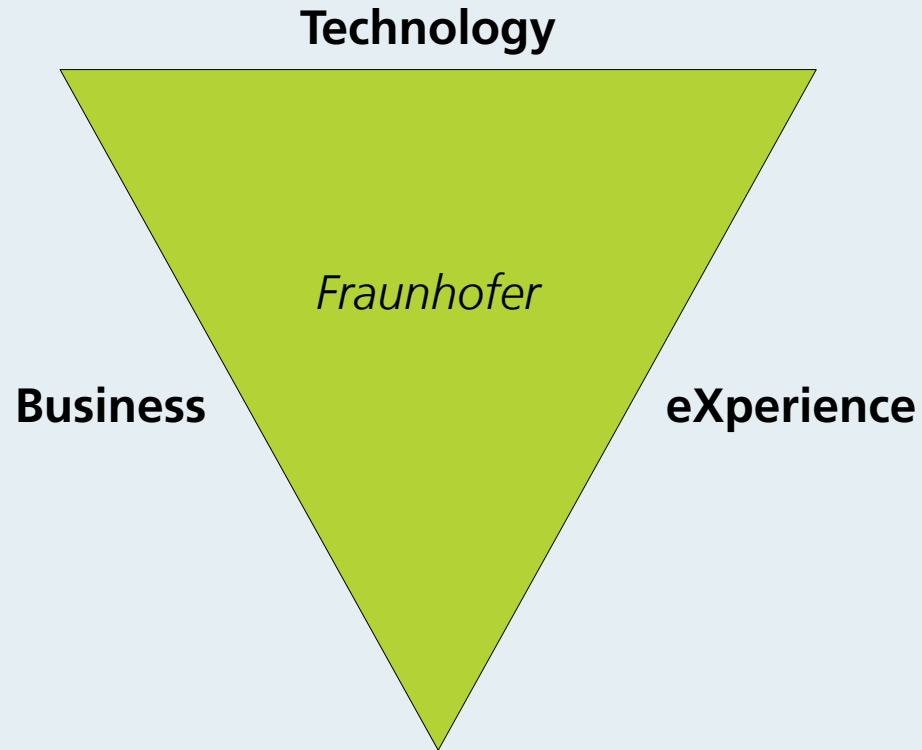
core mission: bridging pure
scientific research with applied
industrial innovation



Fraunhofer lines

Fraunhofer Gesellschaft: An overview

Regarding Martin's
(KRY10) slide:

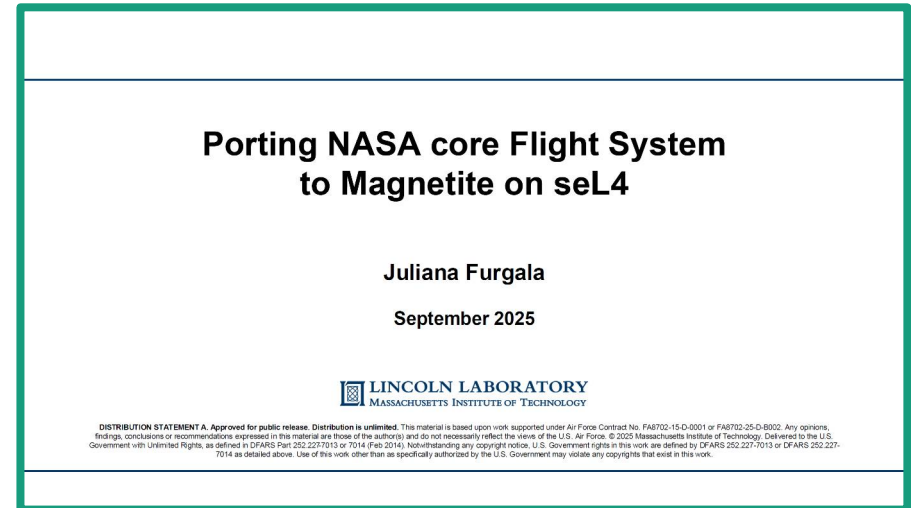
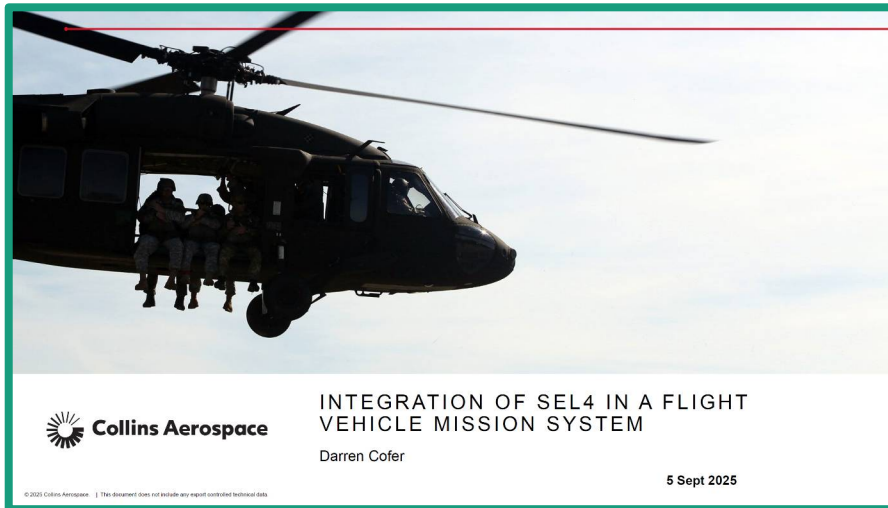


J
(178,

Rounded figures

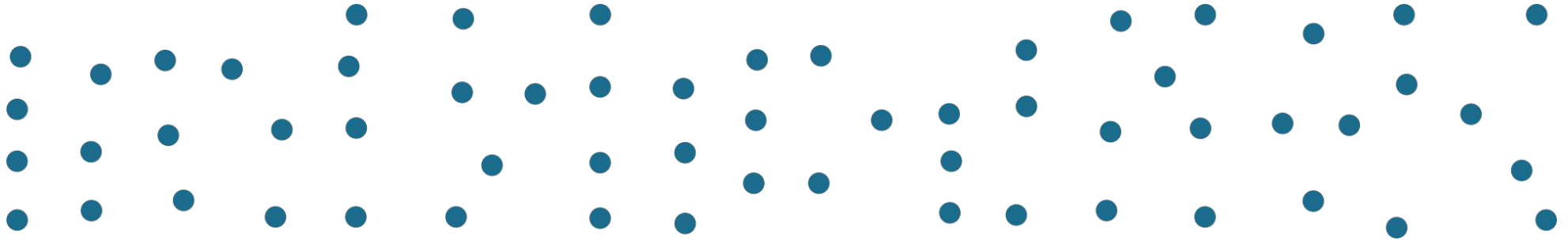
Inspiration from last year

- The attendees of sel4 summit last year welcomed me with open arms.
- Presentation with focus on real-world applications were my favorite part
- Great to know related work, like efforts DornerWorks, Riverside, NIO or KSU/HAMR



Connecting the Dots

„You can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future.”



Connecting the Dots

„You can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future.“ – Steve Jobs ;-)

seL4 + SDX

Using seL4 for Software Defined Systems/X

Motivation & Background

Software Defined X

$X = \{\text{Vehicle, Defence, Satellite, Radio, Truck, Firefighting, ...}\}$

Management

„Greater Efficiency
& Productivity“

„Technological
Sovereignty“

„... just like
automotive
companies!“

„System-of-
Systems“

“Customers are
demanding connected
systems”

„Software Defined Products“

Engineering

„App-Store for our
product“

„... just like
automotive
companies!“

„CI & CD for more
customer focus“

„Cloud-Edge-
Continuum“

„Over-The-Air-
Updates“

„Cybersecurity by
Design“

Saab: *"CAD in the morning, fly in the afternoon"*



***"Code in the morning,
X in the afternoon"***

drive

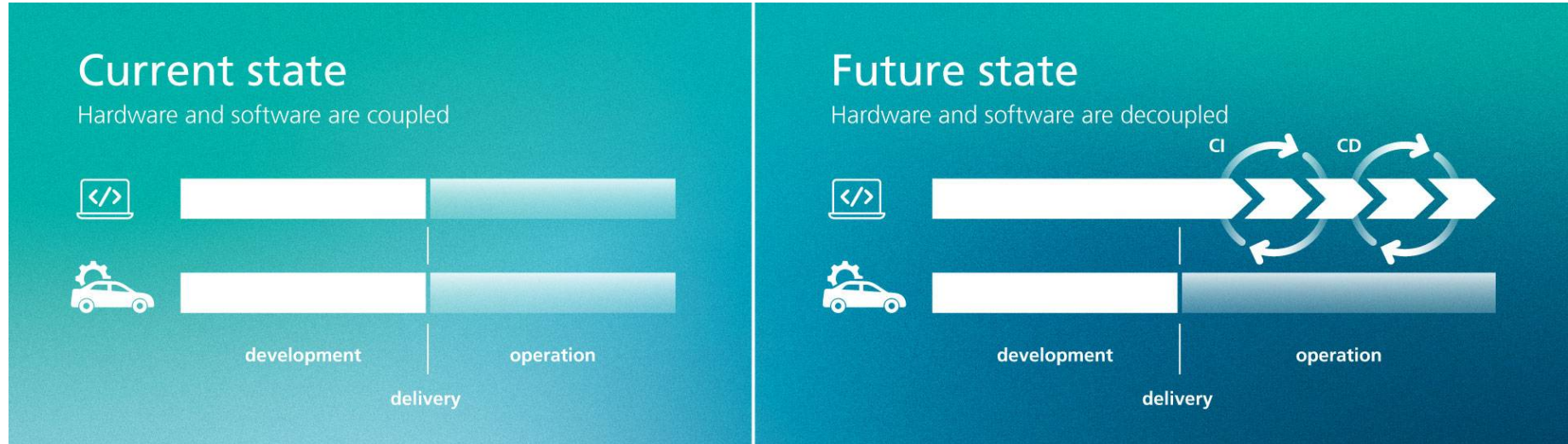
manufacture

fly

sail

explore

Software Defined X: Paradigm



- A more complex world (e.g., **software supply chain**)
- Increasing **regulatory requirements** (time-consuming certification)
- **Tight coupling** of hardware and software
- **Lack of innovation** due to time delays

- Software-Defined-X as **Paradigm Shift**
- Hardware-based products are becoming **Software-centric** products (hardware independent, **decoupled**)
- **Innovation & Efficiency** through Software
- Features: continuous development & deployment

Software Defined X: Promises

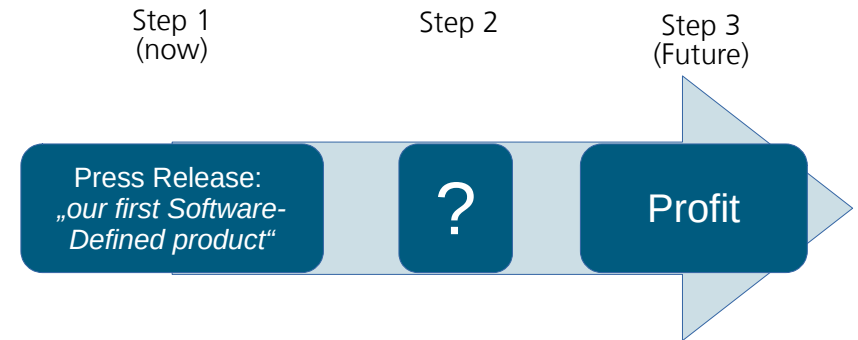
- Extending the **product lifecycle**
- Improving **cybersecurity, modularity** and **flexibility**
- “**Connectivity by Design**” (OTA, app stores, ecosystem)
- Reducing **variant management** (hardware independent)
- **Efficiency** in software **distribution & (re)certification**
- **Quickly responding** to changing markets – accelerating **innovation**
- **Synergies** with zonal **E/E architectures** (hardware, domain & gateway controllers, central HPC)



Current Status Quo in Companies

Behind the scenes:

- What exactly does “Software Defined X” mean?
- What does an SDX tech stack look like?
- How do I integrate this paradigm into existing processes (Excel) or infrastructure (RTOS, Embedded Linux, XEN etc.)?
- How to actually implement?
- We need (high assurance) Operating Systems functionalities!?



Research transfer project needed

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Proposal to BMFTR: tSDX

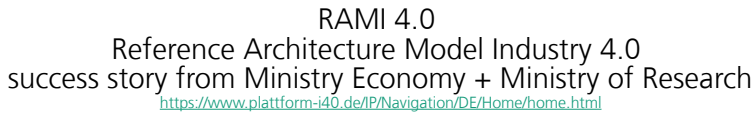


- German industry needs a comprehensive **guideline** for implementing software defined products
- Fraunhofer IESE has identified significant **demand**
- Fraunhofer IESE also recognized the **efforts of Cyberagentur** in conducting basic research (EvIT program)
- Software defined products need a **trustworthy** operating system approach to **realize the vision** (e.g. safe & secure OTA, certification, trustworthiness, sovereignty)
- Microkernels as promising solution

Idea: Let's bring everyone together at one table and have a discussion

- move SDX from buzz words to an architectural discussion
(and in future projects to working implementations)
- to prevent the same questions („we should try Linux for our use-case.“)
- *focus on safety-critical embedded systems (multiple domains)*

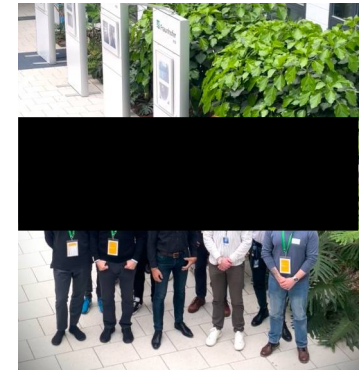
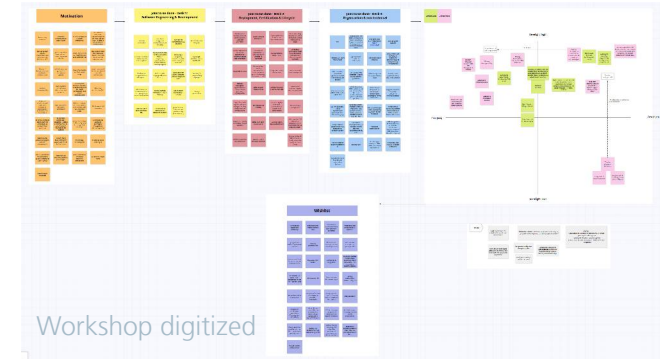




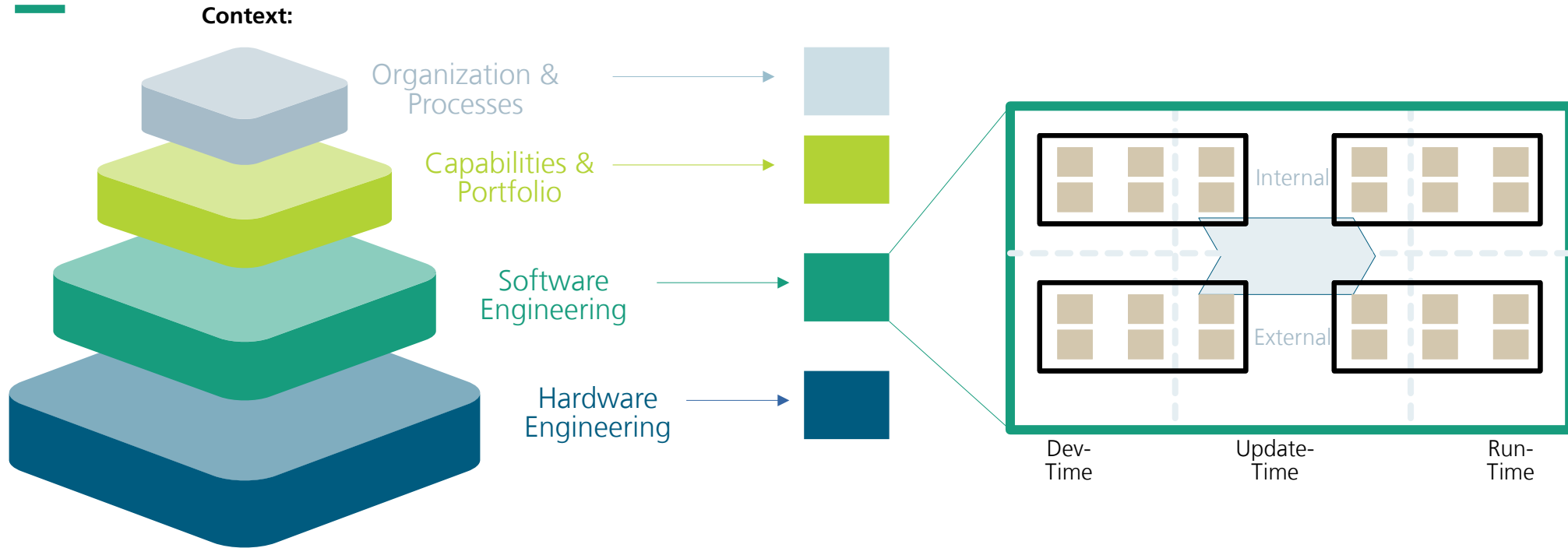
Current State of reference architecture tSDX

First Kickoff Workshop held in May

- Define Pains, Gains, Jobs to be done
- 4 Clusters: High benefit high cost, high benefit low cost, etc.
- Various perspectives from
 - Embedded Systems Engineers (Aerospace, Manufacturing)
 - Certification Entities (Automotive)
 - Microkernel Vendors
- Fraunhofer IESE now concludes the input of the participants
- Feedback session was scheduled (unfortunately postponed to mid September)



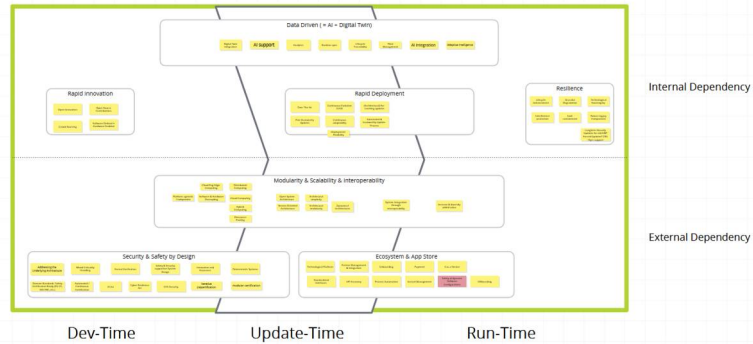
Current State of reference architecture tSDX



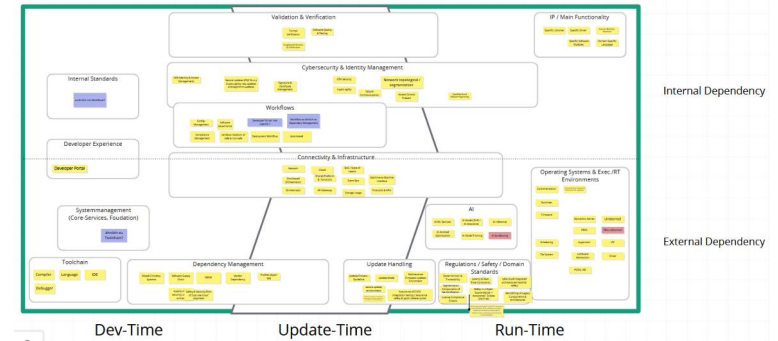
Current State of reference architecture tSDX

DRAFT!
Work in
progress

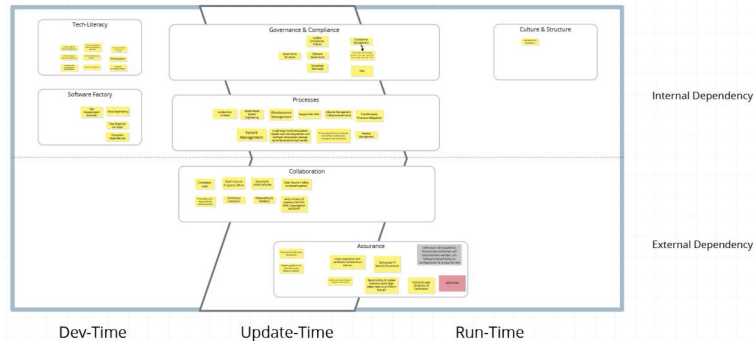
Capability & Portfolio



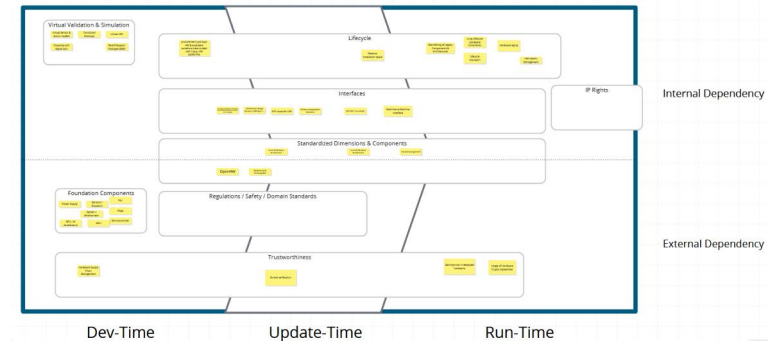
Software Engineering



Organization & Processes



Hardware Engineering



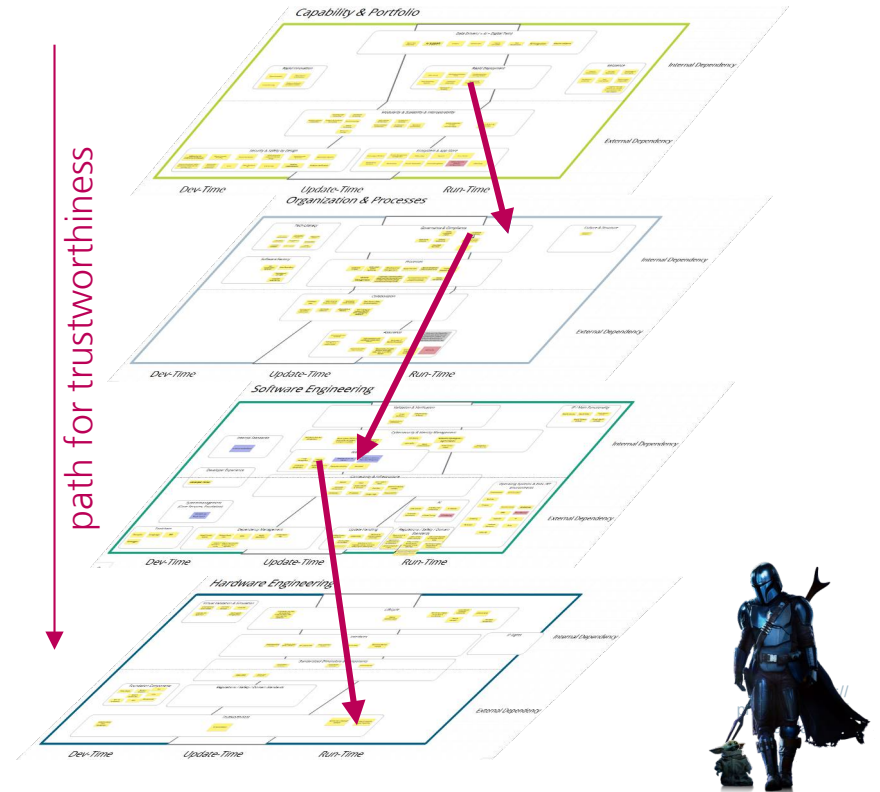
Outlook tSDX: Way of trustworthy System Design

Next steps:

- Session about first draft with partners (*postponed* to mid September)
- Focus more on a traceable path for **trustworthiness**
- Highlight importance of μ K as foundation for SDX

Feedback & engagement welcome!

- soon tSDX specification will be published for collaboration: <https://codeberg.org/tSDX> 
- www.SoftwaredefinedX.de (*coming soon*)
- **Assertion:** everyone in this room can profit when companies use tSDX as a blueprint for their design decision, esp. in using (seL4) Microkernels



This is the way!

Contact

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LET'S CONNECT ON

