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TECHNISCHE UNIVERSITÄT KAISERSLAUTERN

SSA05 – Design Process

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TU Kaiserslautern, SS2018
Lecture "Software and System Architecture (SSA)"

Organization

Lecture

- **2018-06-18: Architecture Evaluation** will be given by Domink Rost from Fraunhofer IESE.

Exercises

- Original plan -> 2018-06-06: Modeling with tools
  - ***(NEW DATE 13.06.2018).***

- Original planned -> 2018-06-13: Evaluation of Architecture documentation
  - ***(NEW DATE 20.06.2018)***

Discussion

- **RECAP LAST LECTURE**

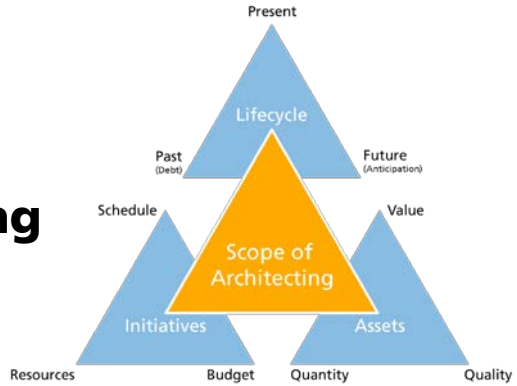
- Explain the contents of the last lecture
  - What were the topics?
  - Why do we need it?
  - How does it work?
  - How is it created, used, and/or evolved?

Design

- It is relatively easy to design for **the perfect cases**, **when everything goes right**, or **when all the information required is available in proper format.**
  [Donald Norman]

- The most difficult part of building software is not coding;
  it is the decisions you make early at the design level.
  Those **design decisions** live with the system for the rest of its lifetime.
  [Pattern-Oriented Analysis and Design - Composing Patterns to Design Software Systems]

The Goals of Design



- **Balancing the Bermuda triangle of architecting** (lifecycle, initiatives, assets)
- **Creation** of a plan or convention for the construction of a software system
  - **Decomposition** of the problem into smaller pieces
  - **Control** of the complexity
    - Coming to a solution and communicating it
  - **Prediction** of effort, quality, impacts, etc.
- **Risk Mitigation** of the impact of change on a software system
  - Change is the inevitable characteristic of any successful software system
  - Prepare **anticipated** changes (before the change is required)
  - Address **unforeseeable** changes (when it occurs)

Architecture vs. Design

- **"Architecture is design, but not all design is architecture"**

  (G. Booch)

  - It depends on the criticality of the decision: is it **architecturally-significant?**
  - Principle of locality
  - Depends on scope and is relative

- We call things architecturally-significant if they are…
  - **Costly to change**
  - **Risky**
  - **New**

Challenges of Architecture Design

- Understand the **domain** and its specifics
- Work on **incomplete and changing** requirements
- Find adequate **solutions**
- Achieve adequate **confidence** that solutions work
- Design a solution **involving many experts** for specific topics
- Refine and adjust architecture while implementation is already ongoing
- Judge technologies for their adequacy
- Select and use **technologies** appropriately
- Become aware of **drift**

Generic Decomposition Steps

- Identify **elements**
  - Identify responsibilities
  - Identify unique, self-contained roles/elements
  - Identify types of composed/aggregated elements
- Identify **relationships**
  - Identify data/information exchange requirements
  - Identify interfaces
  - Identify dependency types
  - The dependency graph of elements must have no cycles
- **Increase semantic cohesion** between elements and **reduce coupling** of elements
  - Elements that change together are grouped together
  - Elements that are used together are grouped together
  - Elements that are owned by the same group are grouped together

Design: Essential Principles

Abstraction

- Extraction of the essentials

Separation of Concerns

- Hierarchical Decomposition
- Divide & Conquer (Top-down)
- Divide & Conquer (multi-dimensional)
- Modularization
- Localization of concerns

Encapsulation

- Information hiding
- Coupling & Cohesion
- Redundancy Free

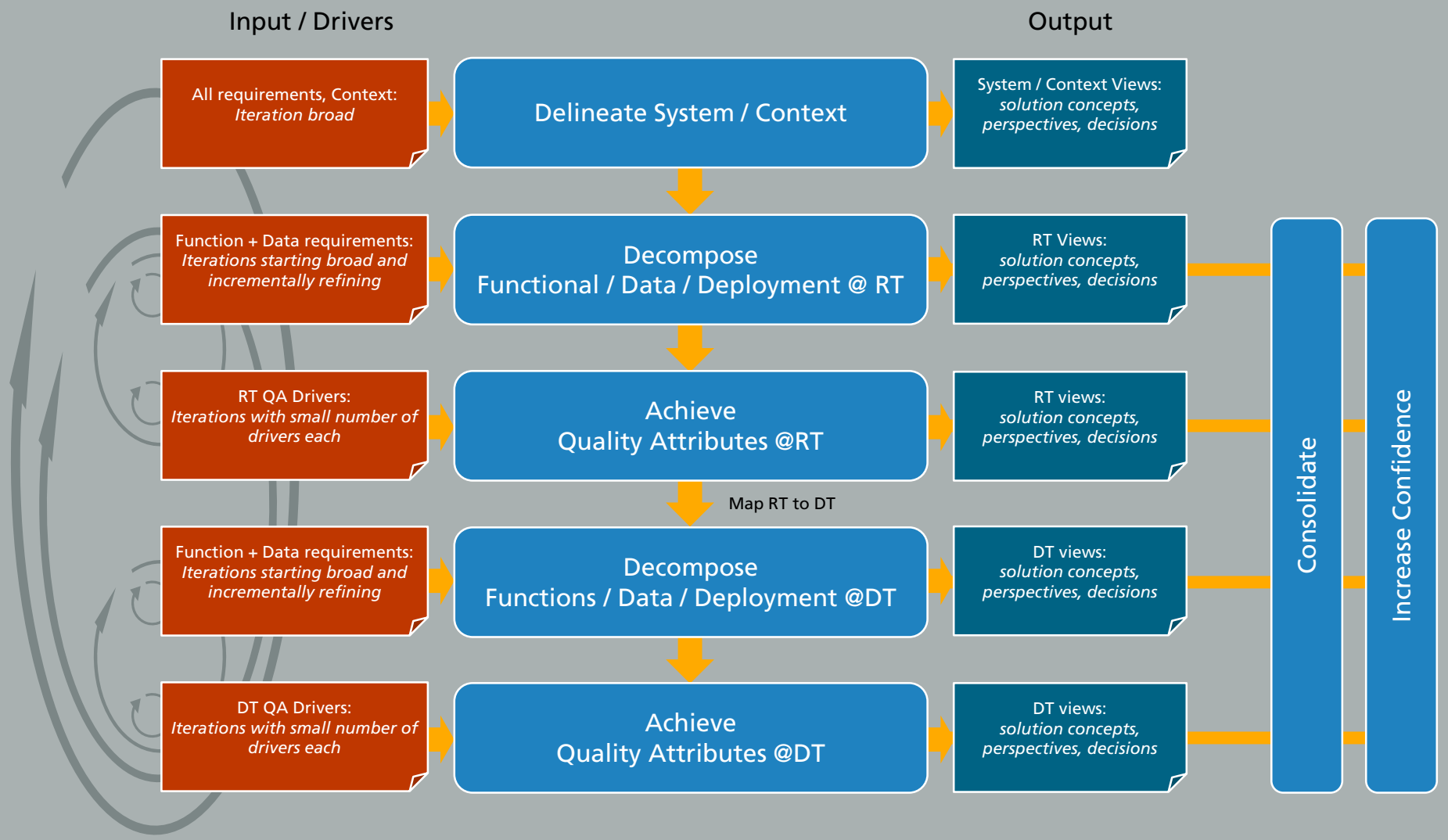
Uniformity

- Common Design Principles

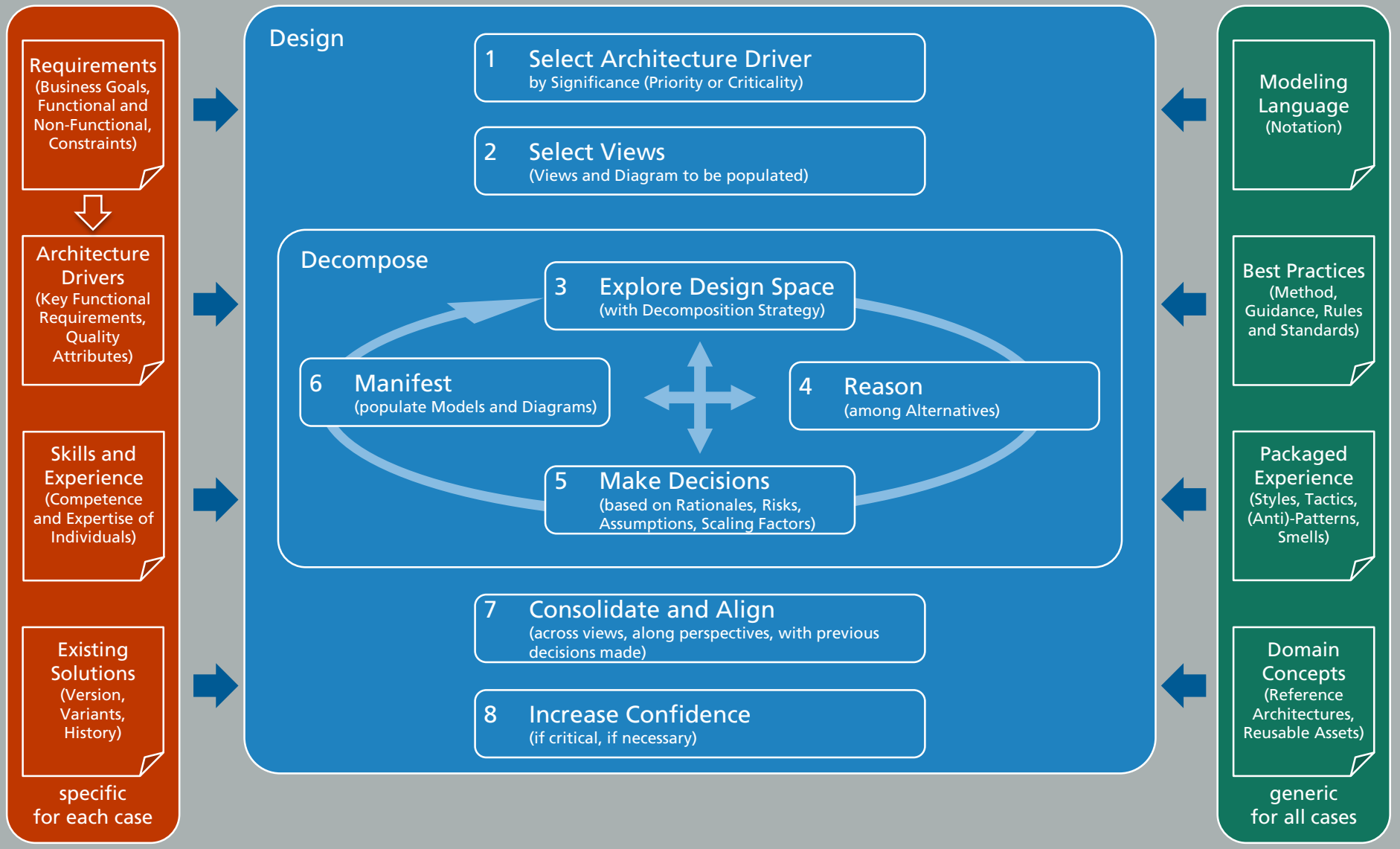
Conceptual "Tools" for Architecture Design

- **Creativity**
- **Classification**
  - Element types, relation types
- **Abstraction**
  - Simplifications, aggregations, processes, end-to-end usages
- **Categorization**
  - Group distinct facets of a solution concepts
    - E.g., functionality, data, data flow, information flows, control flows, deployment, interfaces, physical constraints, technologies
- **Experience**
  - … since there is no "detailed guide to creativity" ☺

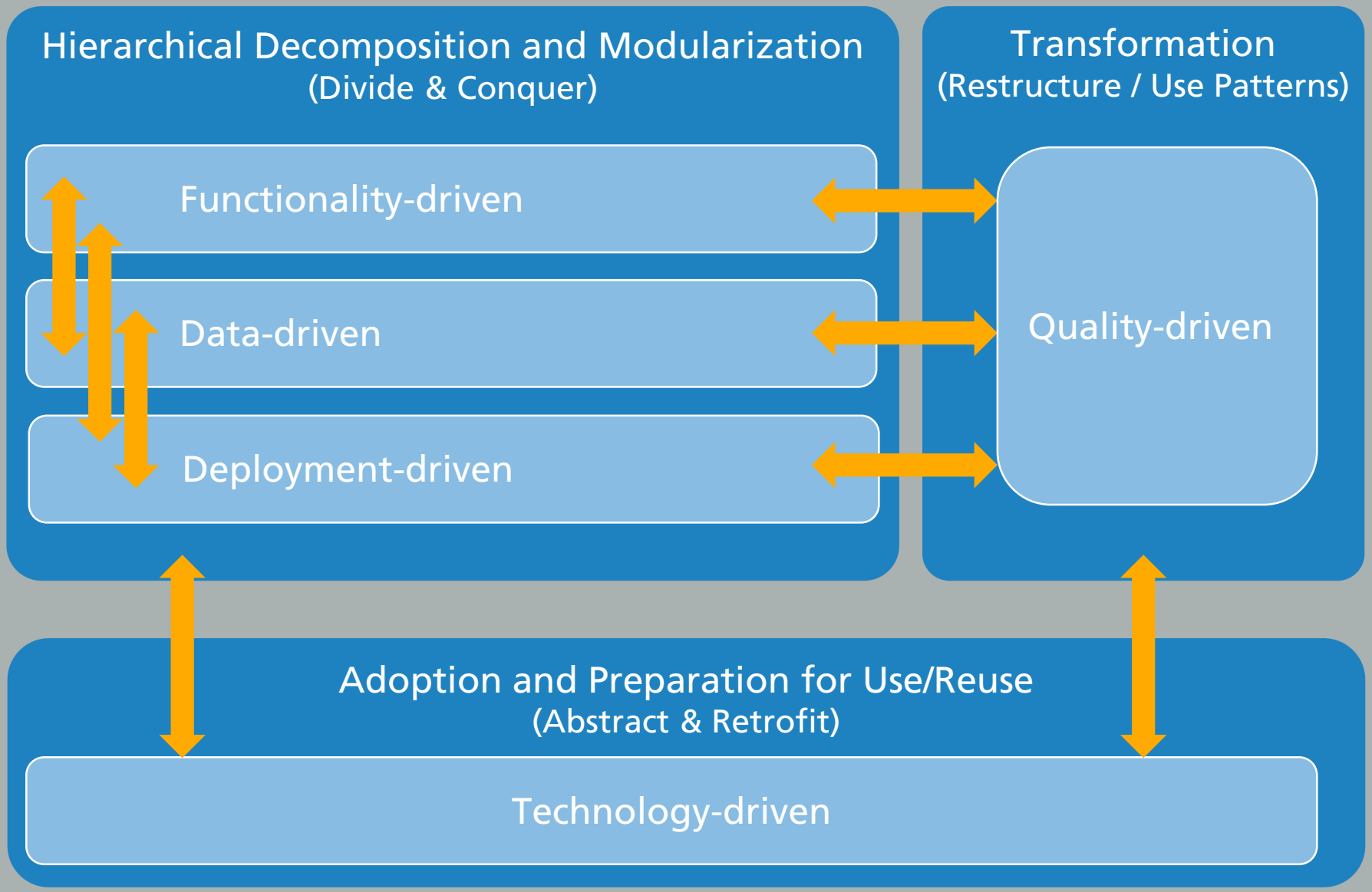
Architecture Design Process



Architecture Design Iteration



Architecture Decomposition Strategies



Context View

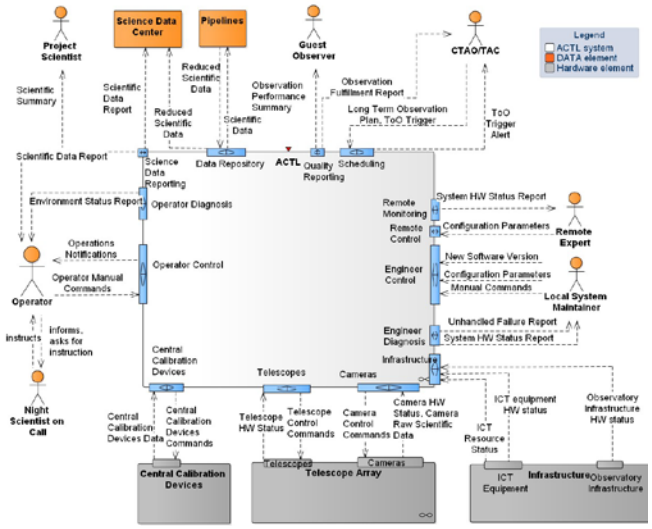
1 - Delineate System and its context

Architecture Design

Context

Main Purposes

- Definition of System Boundary
- Identification of Context:
  - Humans interacting with System
  - Context Systems
  - Information flow
- System seen as a black box!



Aspects to think about

- What does the system do?
- What is the interaction with the environment?
- What data is exchanged?

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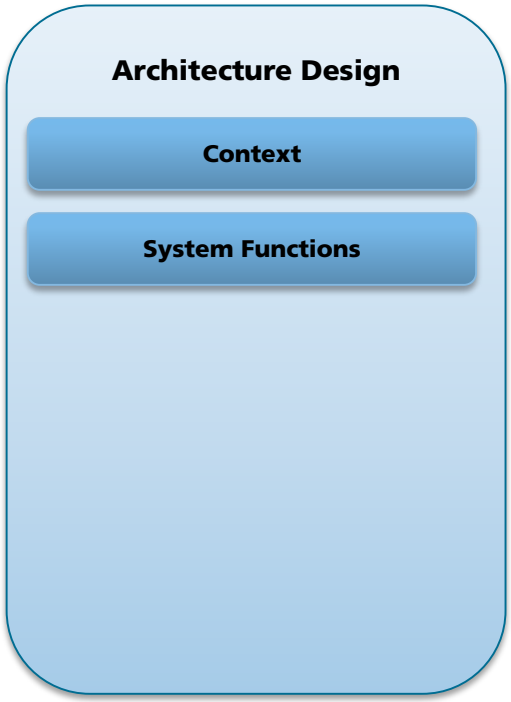
Functional View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services



Main Purposes

- Identification and decomposition of systems functionality
- Linking (functional) requirements to later design steps
- Understanding of functional interrelationships
- Identify missing (functional) requirements

Functional View

1 - Delineate System and its context

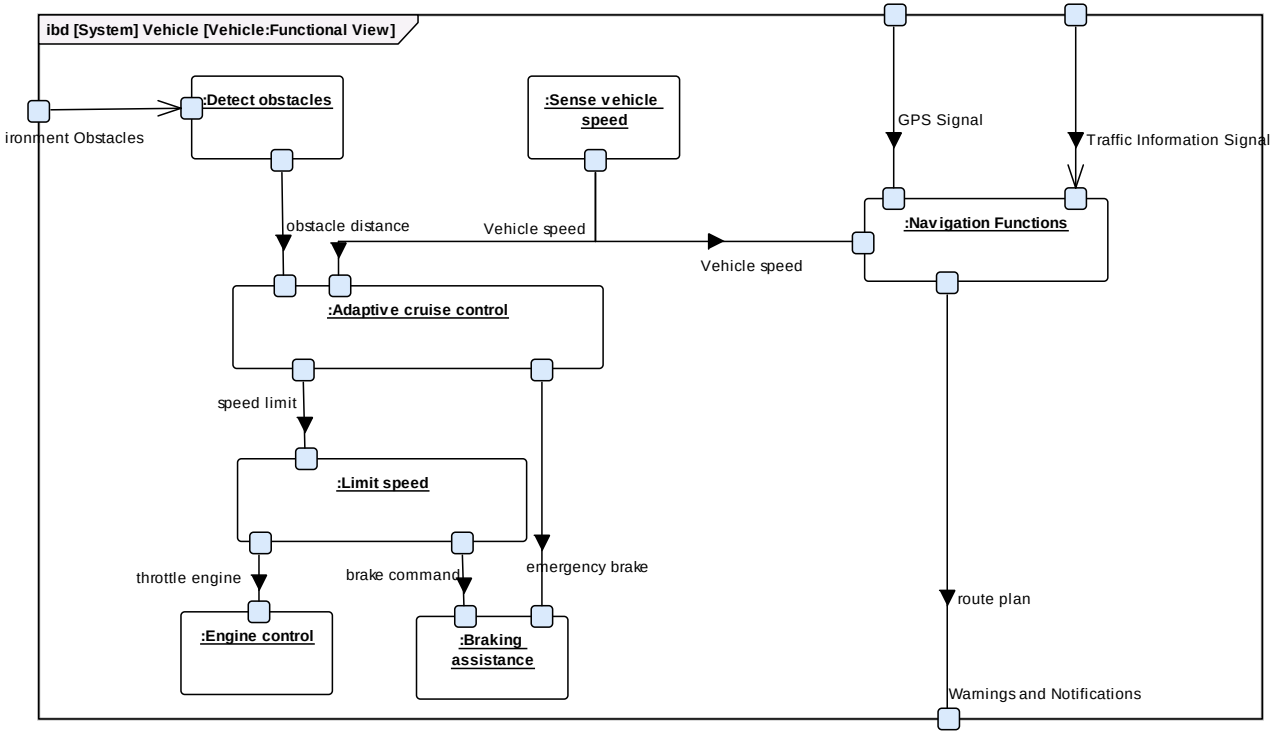
2 - Functional decomposition and orchestration to grant the services

Architecture Design

Context

System Functions

- Decomposition of functionalities.



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Functional View

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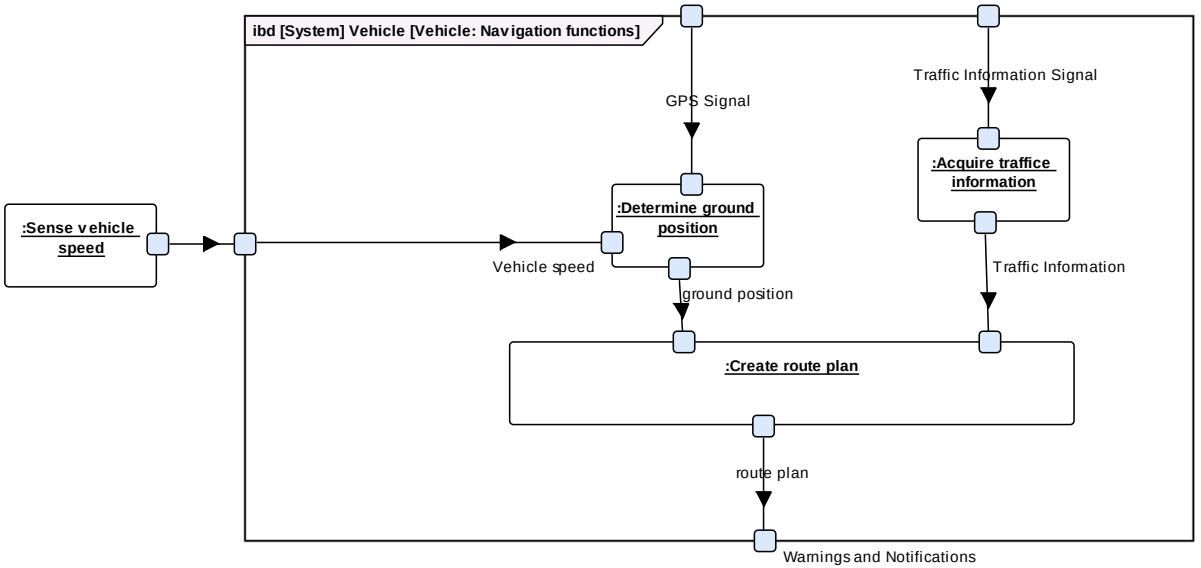
2 - Functional decomposition and orchestration to grant the services

Architecture Design

Context

System Functions

- Decomposition of functionalities.



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Architecture Design

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System Functions

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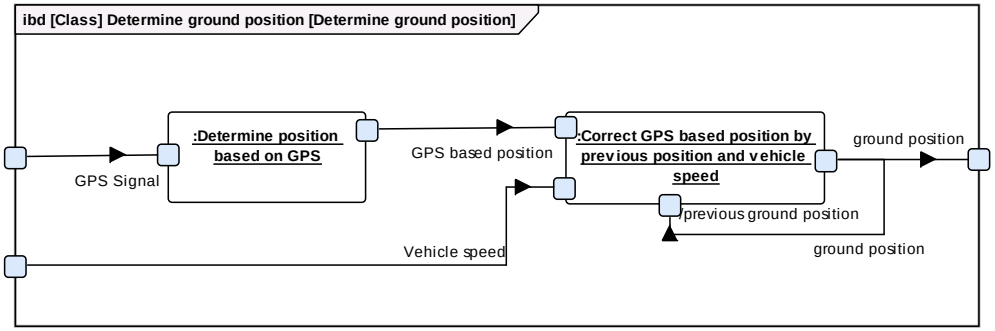

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Functional View

1 - Delineate System and its context

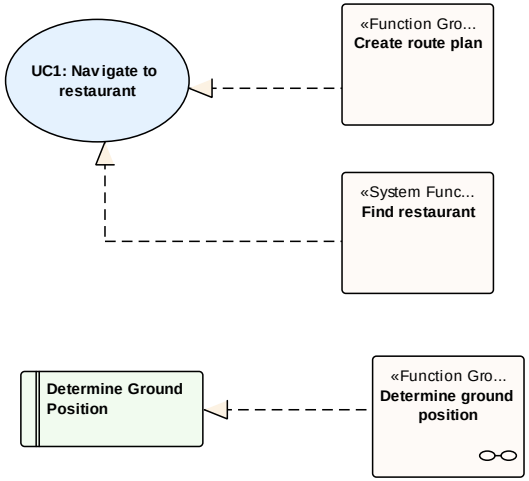
2 - Functional decomposition and orchestration to grant the services

Architecture Design

Context

System Functions

- Linking to functional requirements



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Functional View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

Architecture Design

Context

System Functions

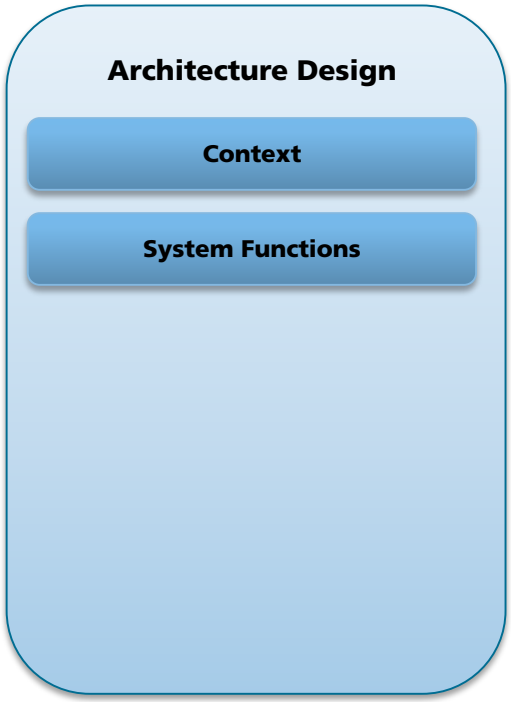
- Consolidate Requirements & Functional View

Source \ Target	Brew Coffee	Interrupt Brewing	Observe Clock Time	Warm up Coffee
Control boiler heater	↑			
Control relief valve	↑	↑		
Indicator Light				↑
Observe plate sensor	↑	↑		↑
Observe start button	↑			
Observe water tank	↑			
Plate Heater		↑		

Functional View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services



Main Purposes

- Identification and decomposition of systems functionality
- Linking (functional) requirements to later design steps
- Understanding of functional interrelationships
- Identify missing (functional) requirements

Aspects to think about

- Which functions are responsible for Data
  - Creation
  - Transportation
  - Processing and Storage
- Which functions communicate?
- What data is exchanged?

Logical View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

3 – Reason on the realization (technology-independent)

Main Purposes

- Describe the internal logical structure of the SUD
- Partition the system into communicating logical components
- Allocate desired functions to cohesive logical units
- Support the reuse of already existent logical components
- Define the total behavior of the system

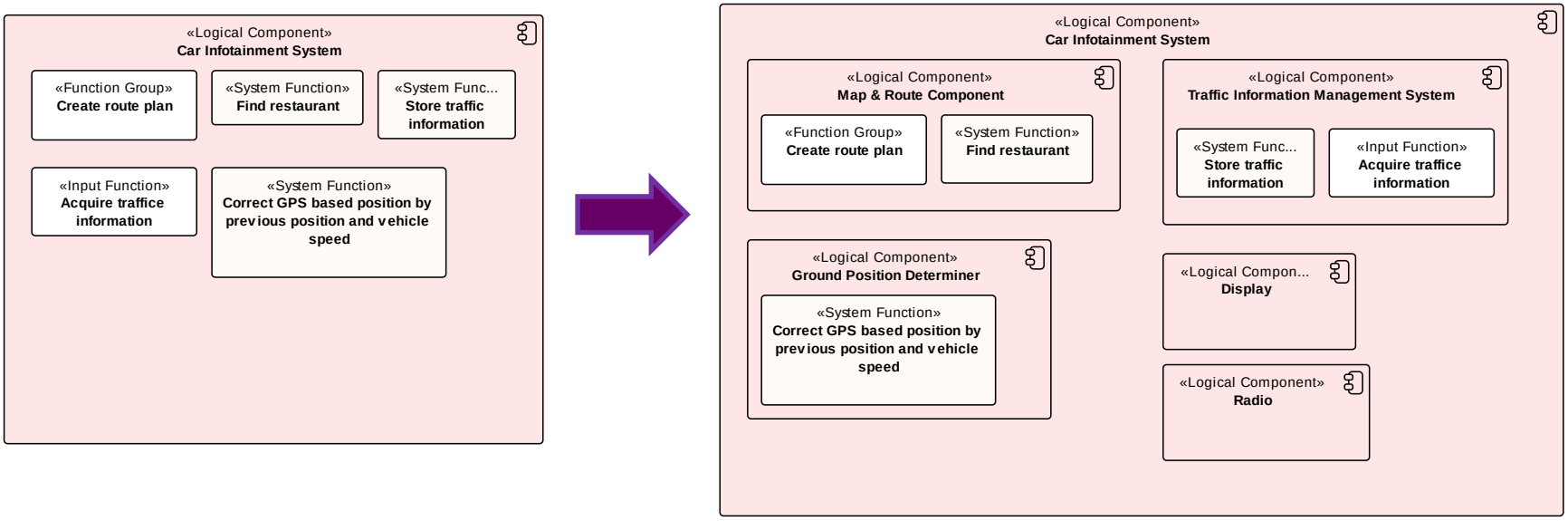
Logical View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

3 – Reason on the realization (technology-independent)

- Mapping of functions to logical components



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Logical View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

3 – Reason on the realization (technology-independent)

- Mapping of functions to logical components: Aspects to consider
  - Increase cohesion: Semantically similar functions go together
    - Development Expertise can be concentrated in one component
    - Similar functions often have the same ASIL-level. Less components can be developed using more rigor. See e.g. Microkernel approach
  - Decrease Coupling: Functions with many interactions go together
    - Reduce communication overhead
    - Reduce testing effort
    - Reduce integration effort

Logical View

1 - Delineate System and its context

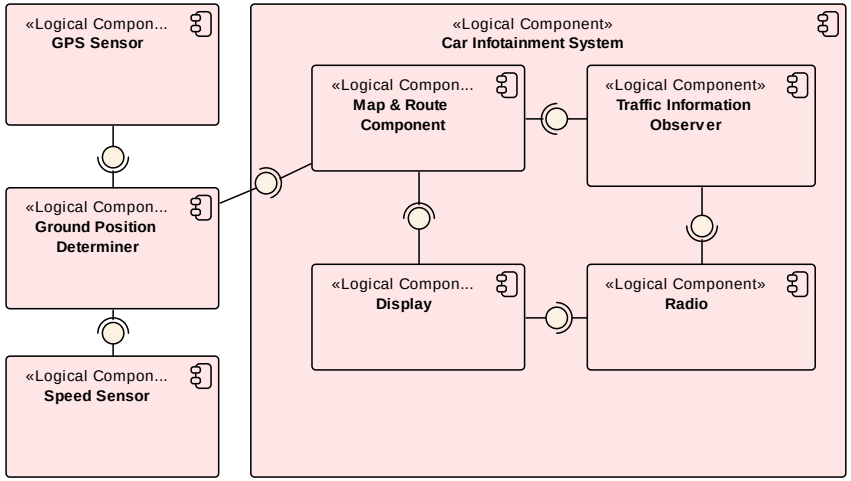
2 - Functional decomposition and orchestration to grant the services

3 – Reason on the realization (technology-independent)

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**

- Identification of Interfaces between logical components



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Logical View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

3 – Reason on the realization (technology-independent)

Aspects to think about

- How should functionality be allocated to executable components?
- How can components be refined into sub-components?
- Are there commonalities between components?
  - So that redundant code can be prevented
- What data is exchanged between the components
- What are the interfaces to be used?
- What Behavior does a component have (statemachine, activity, …)?

Software View

- **Main Purposes**
- Decomposition of software components into sub-components and classes
- Definition of Software Interfaces
- Identification of necessary software datatypes

Aspects to think about

- How are logical components realized by software components?
- How should components be implemented by implementation units
- What are the interfaces to be used
- Which component provides/requires an interface
- What datatypes should be used for data-exchange?

Software View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

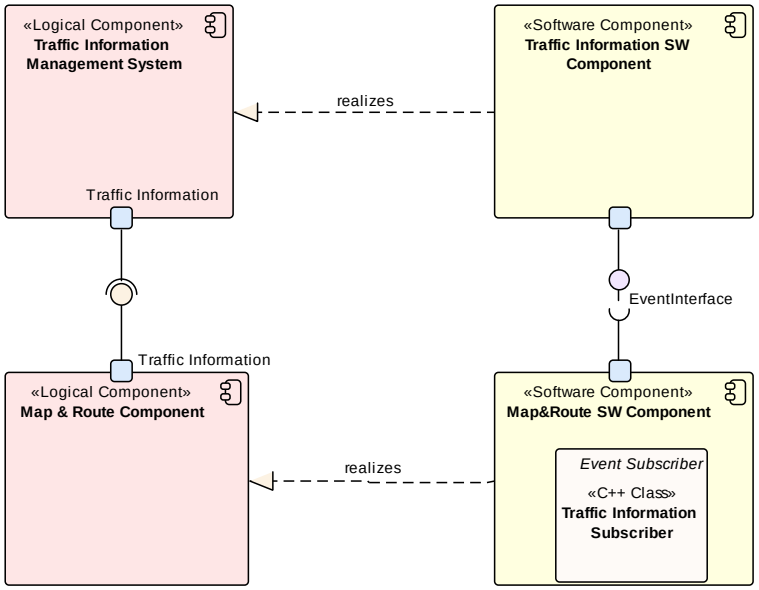
3 – Reason on the realization (technology-independent)

4 - Software Realization of Functions

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**
- **Software Entities**

- How are logical components realized by software components?



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Software View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

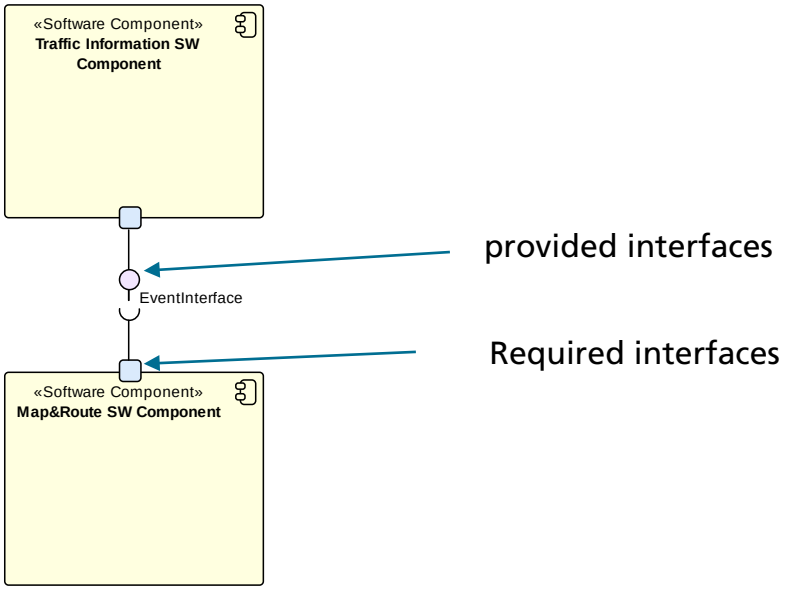
3 – Reason on the realization (technology-independent)

4 - Software Realization of Functions

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**
- **Software Entities**

- Which component provides/requires an interface



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Software View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

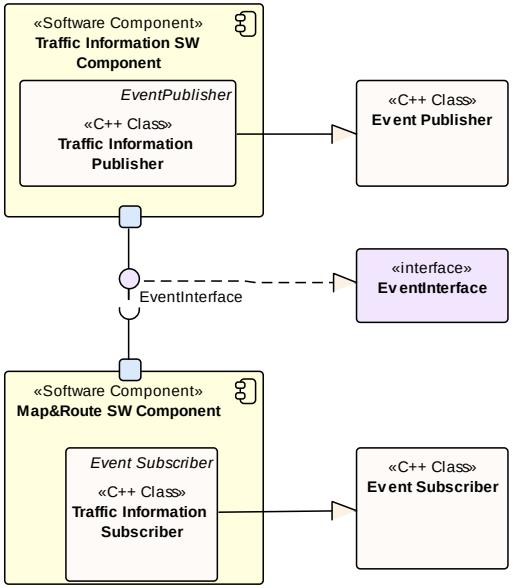
3 – Reason on the realization (technology-independent)

4 - Software Realization of Functions

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**
- **Software Entities**

- How are interfaces implemented?



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Software View

1 - Delineate System and its context

2 - Functional decomposition and orchestration to grant the services

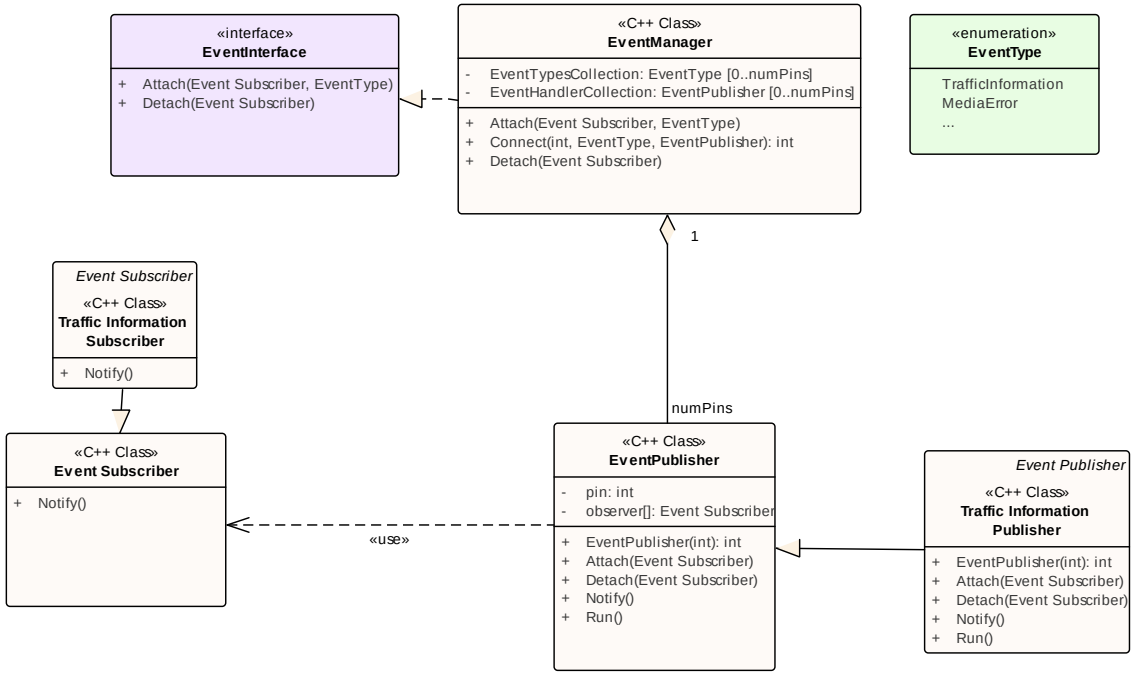
3 – Reason on the realization (technology-independent)

4 - Software Realization of Functions

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**
- **Software Entities**

- Architecture relevant classes, interfaces, datatypes



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Hardware View

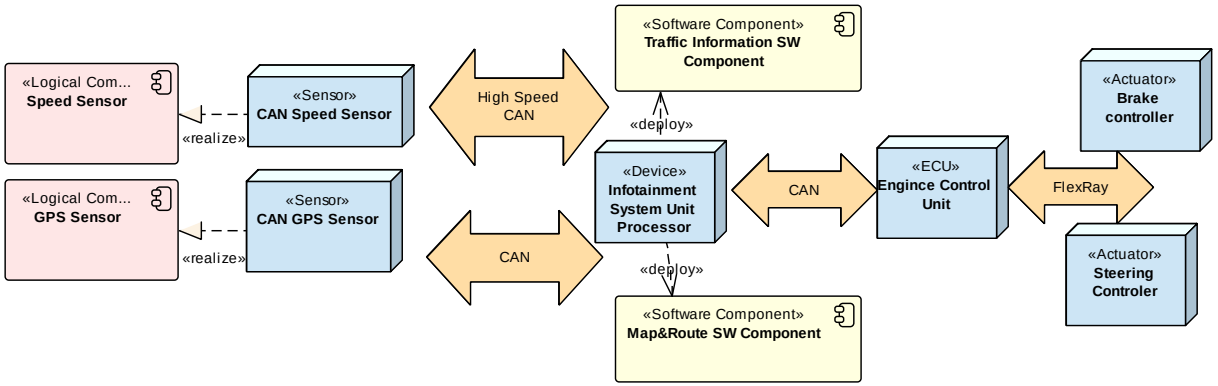
1 - Delineate System and its context → **2 -** Functional decomposition and orchestration to grant the services → **3 –** Reason on the realization (technology-independent) → **4 -** Software Realization of Functions → **5 -** Hardware realization of functions and Deployment of SW Entities

Architecture Design

- **Context**
- **System Functions**
- **Logical Components**
- **Software Entities**
- **Hardware & Networks**

Main Purposes

- Identification of Sensors, actuators, ECUs
- Identification of Communication buses
- Deployment of software components
- Functional realization by hardware entities



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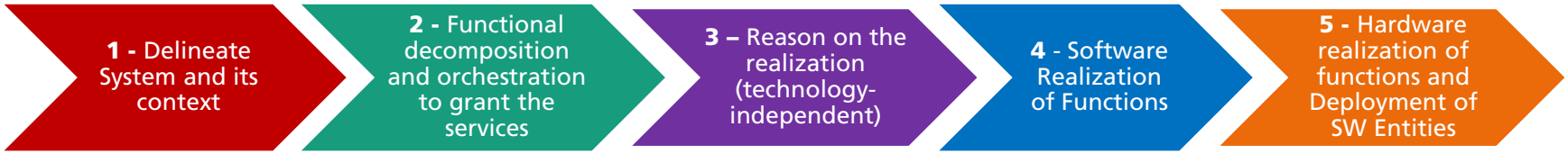
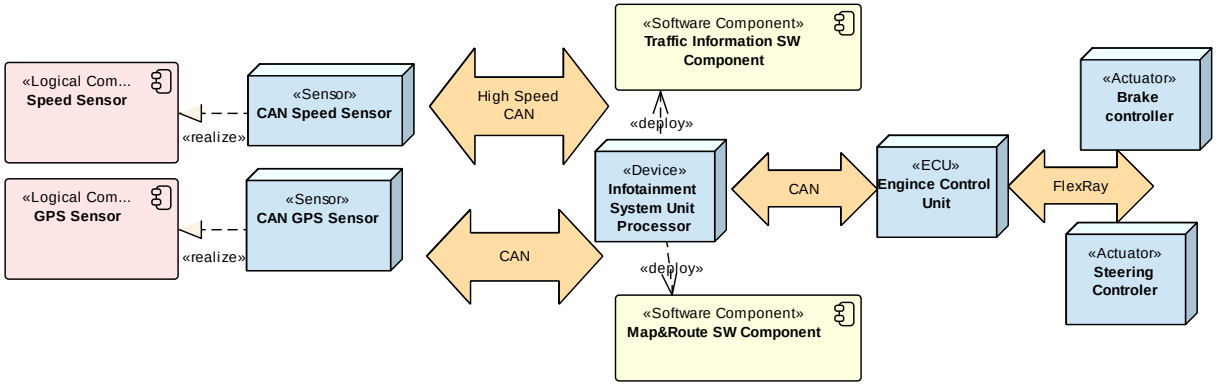
Hardware View



Aspects to think about

- How should software components be deployed to computing nodes?
- What bus systems are used to exchange data?
- Which logical components should be implemented in hardware?
  - Which hardware manufacturer/type should be chosen?



Logical vs. HW/SW View

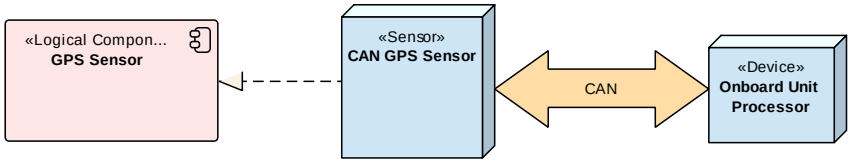
1 - Delineate System and its context → 2 - Functional decomposition and orchestration to grant the services → 3 – Reason on the realization (technology-independent) → 4 - Software Realization of Functions → 5 - Hardware realization of functions and Deployment of SW Entities

Architecture Design

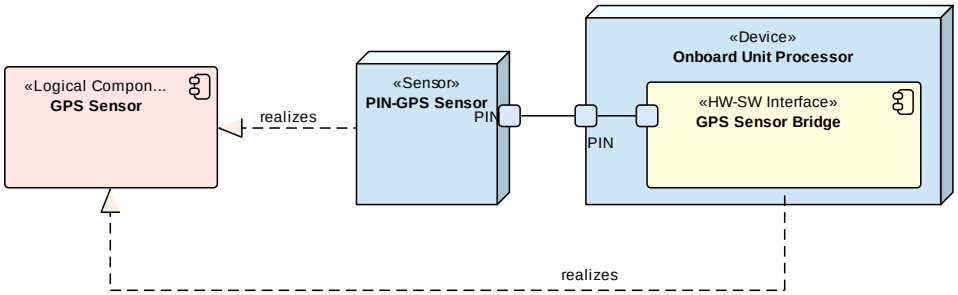
- Context
- System Functions
- Logical Components
- Software Entities
- Hardware & Networks

- Logical View should be Technology-independent
  - Defer design decision as late as possible

Alt.1



Alt.2



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When to Stop Working at the Architecture Level?

- You should stop when…
  - … you addressed the key requirements and quality attributes
  - … you can explain how they are addressed
  - … and have enough **confidence** that they can be achieved
  - … and you can assign work units to developers
  - … and you can control the parallel development and integration
- You might temporarily leave the architecture level…
  - … to collect information, get more confidence
  - … if you do not exactly know what you abstract from and have to try out
  - … in prototyping activities and technical evaluations
- You always have to come back to the architecture level…
  - … to integrate your lessons learned
  - … to judge the results in the context
  - … to reason about change

When to Stop Designing?

- You have covered the most important things when…
  - … you addressed the key requirements and quality attributes
  - … you can explain how they are addressed
  - … and have enough confidence that they can be achieved
  - … and you can assign work units to developers
  - … and you can control their parallel development and integration

- You continue designing during development because …
  - … you refine architectural decisions
  - … you design the methods, data structures
  - … you implement solutions (source code and test cases)
  - … you make the system work
- **But you need to make sure not to break the architecture!**


architecture
software
development
systems
requirements
Architecture
time
product
quality
technologies
decisions
system
support
architectures
competencies
key
activities
context
evaluation
SAVE
control
products
architecture-centric
Systems
organizations
IESE
technology
architectural
challenges
aspects
basis
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making
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implementation
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