



**34<sup>th</sup>** Annual **INCOSSE**  
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hybrid event

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July 2 - 6, 2024



A practice insight in a German OEM

# SE roles for emergent properties and behaviors

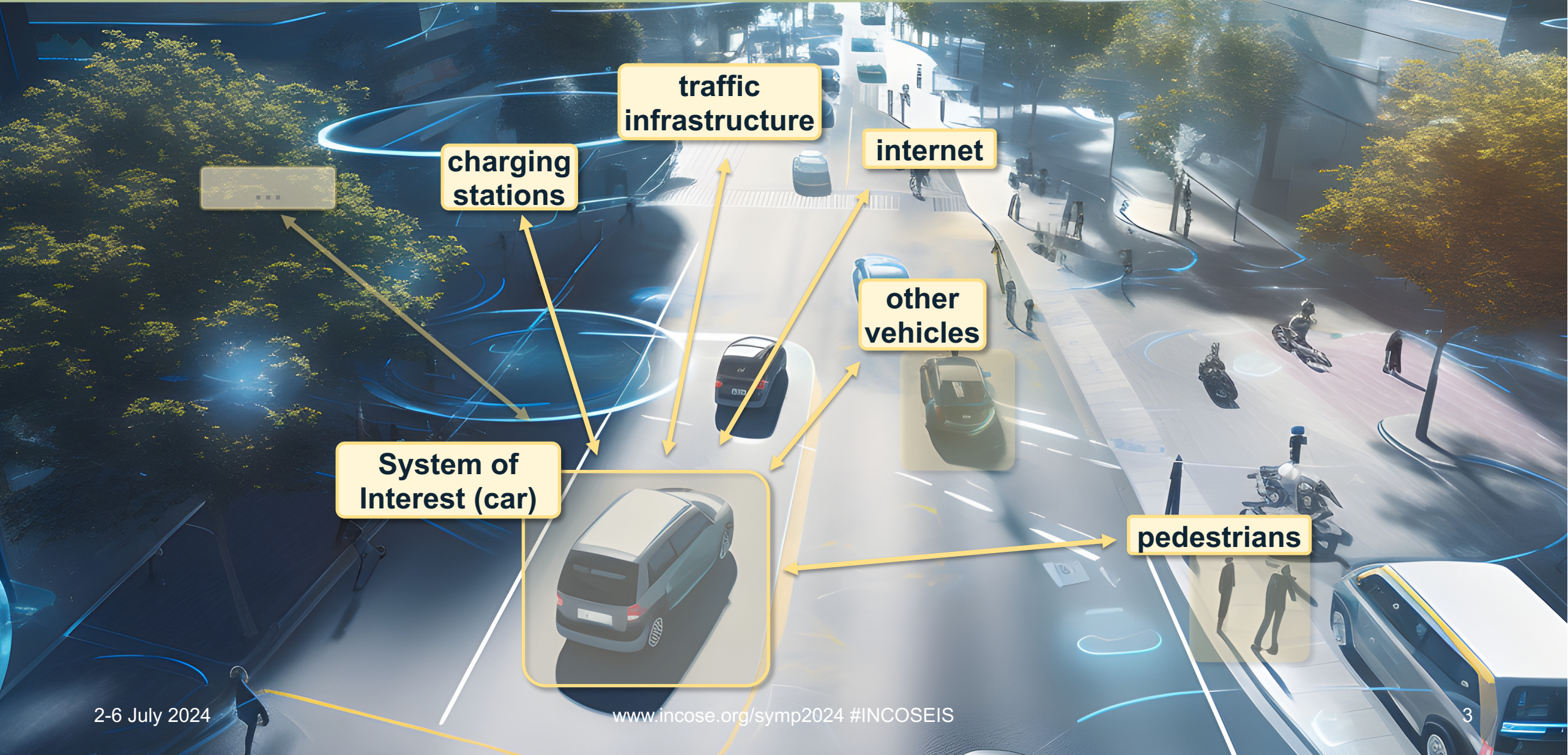
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# The paper is based on a scientifically inductive approach.





A vehicle (SoI) is part of the mobility ecosystem in the sense of a System of System (SoS).





# The development of vehicles faces new challenges.



## mobility ecosystem

“The use of a vehicle takes place in an increasingly complex environment with complex interactions.”



## emergent phenomena

“The increasing complexity of the vehicle leads to [emergent] system behavior that is difficult to predict.”



## wide stakeholder base

“Due to the complex operating environment, there are more and more stakeholders and resulting requirements.”



“Emergent phenomena create challenges for both the development department and the organizational structure of OEMs.”



# Emergent Phenomena were divided in functional features and non-functional properties.

i

„Emergence is a fundamental [characteristic] of all systems. It describes characteristics the system has but the elements themselves do not.“

[INCOSE Handbook v5]

## non-functional property

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- Technical perspective
- Can not be experienced directly by the customer
- Concrete product characteristics
- Examples (charging speed, weight, aerodynamics)

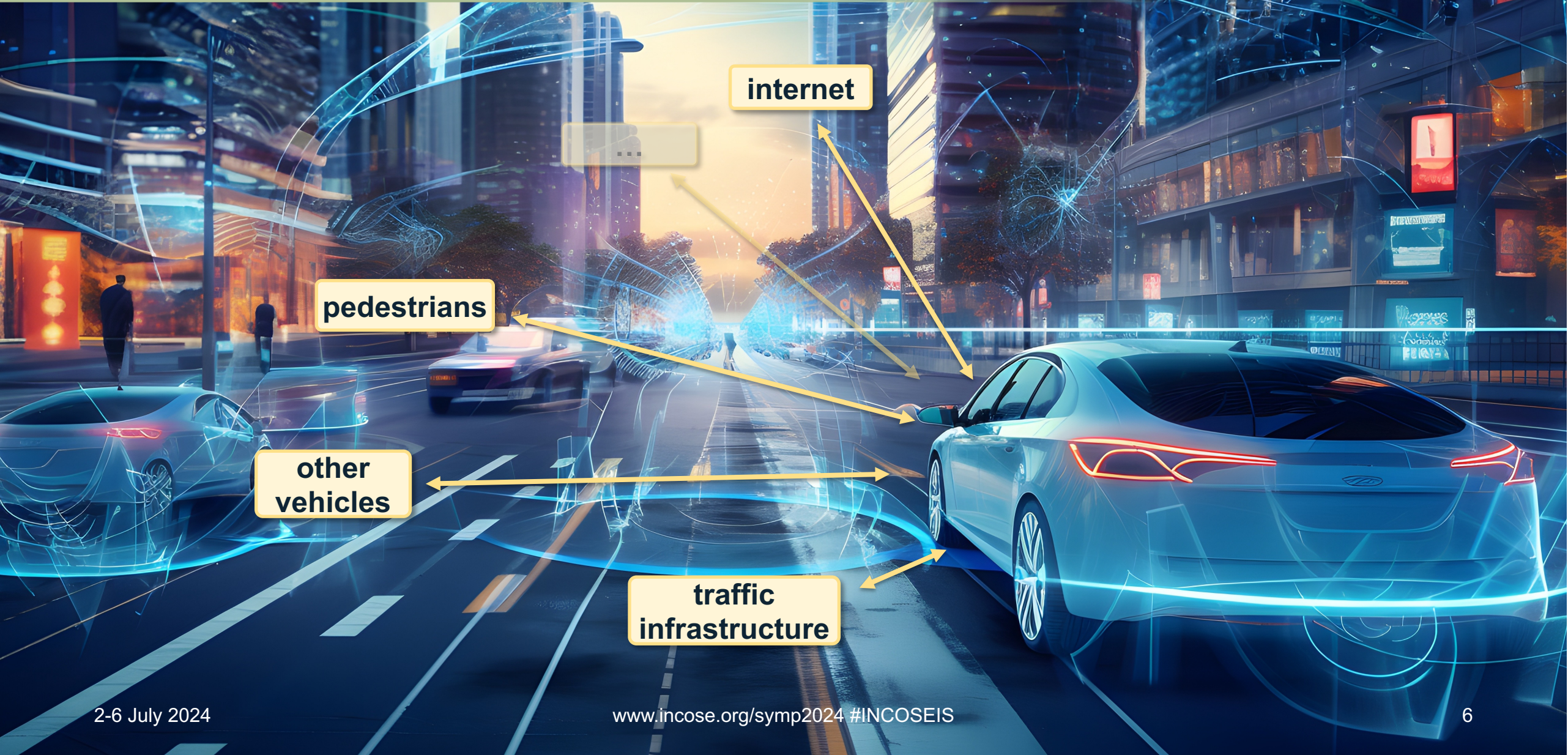
## functional feature

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- Customer oriented perspective
- Can be experienced directly by the customer
- Addition of several functions
- Examples (autonomous driving, navigation)

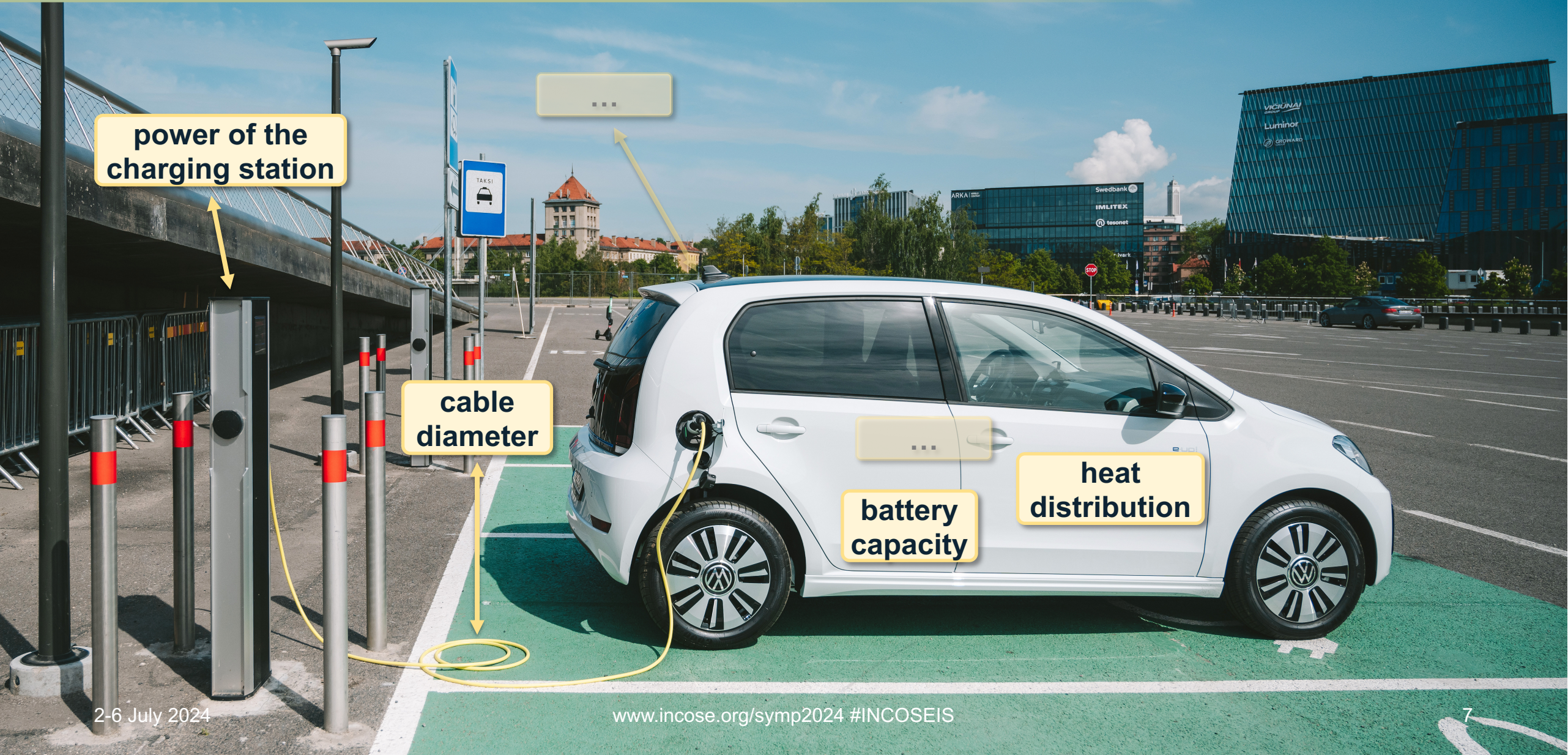


The expression of the feature “**autonomous driving**” depends on numerous influences.





The expression of the property “charging speed” depends on numerous influences.



power of the  
charging station

cable  
diameter

...

battery  
capacity

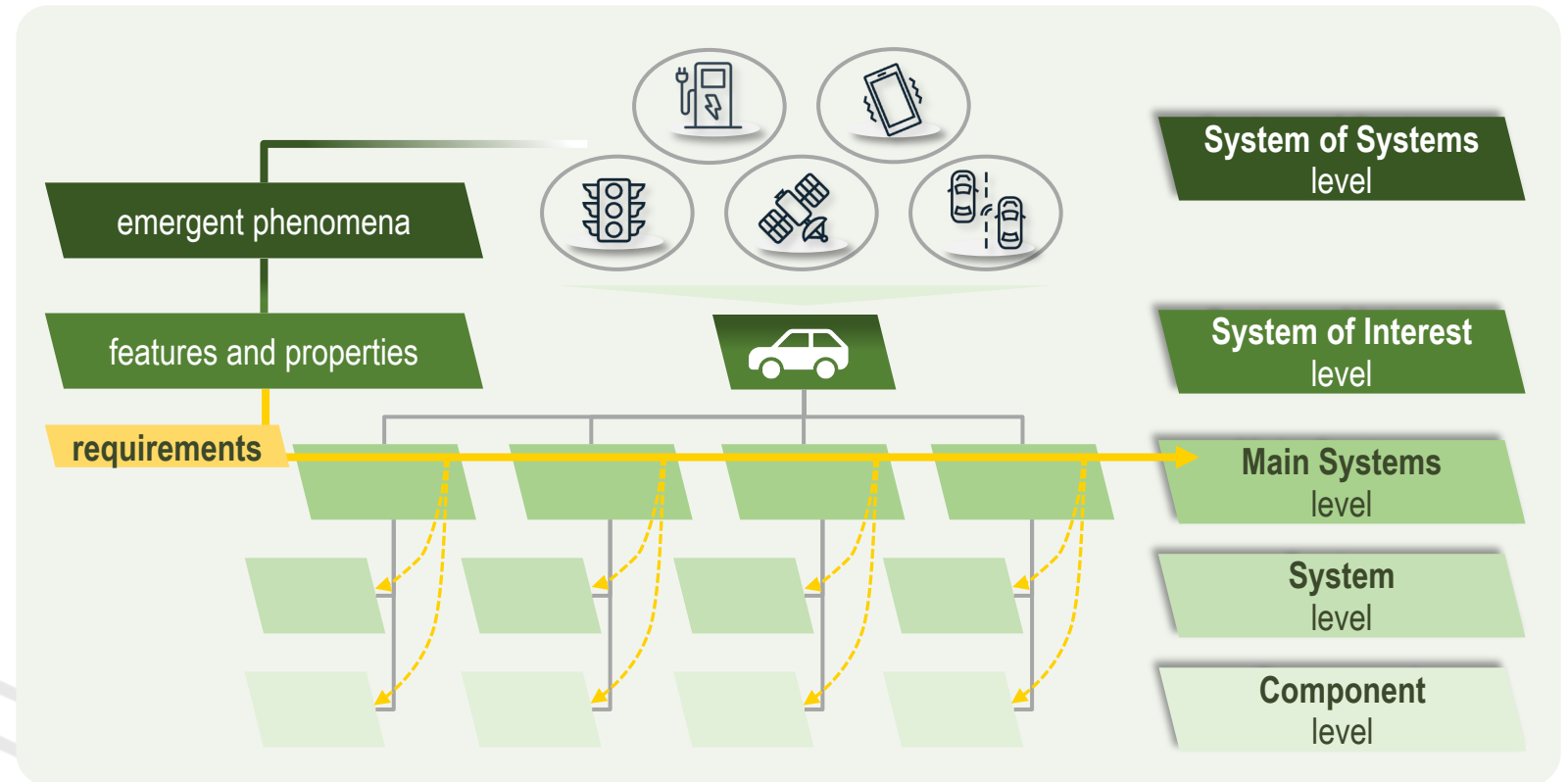
heat  
distribution



# Emergent Phenomena result in cross system requirements on different system levels.

## Emergent Phenomena ...

- have their origin in the SoS and Sol.
- result in several requirements over all system levels at the OEM.
- exceed responsibilities of individual persons and departments.
- can not be handled as a part-time job by “standard” personnel.



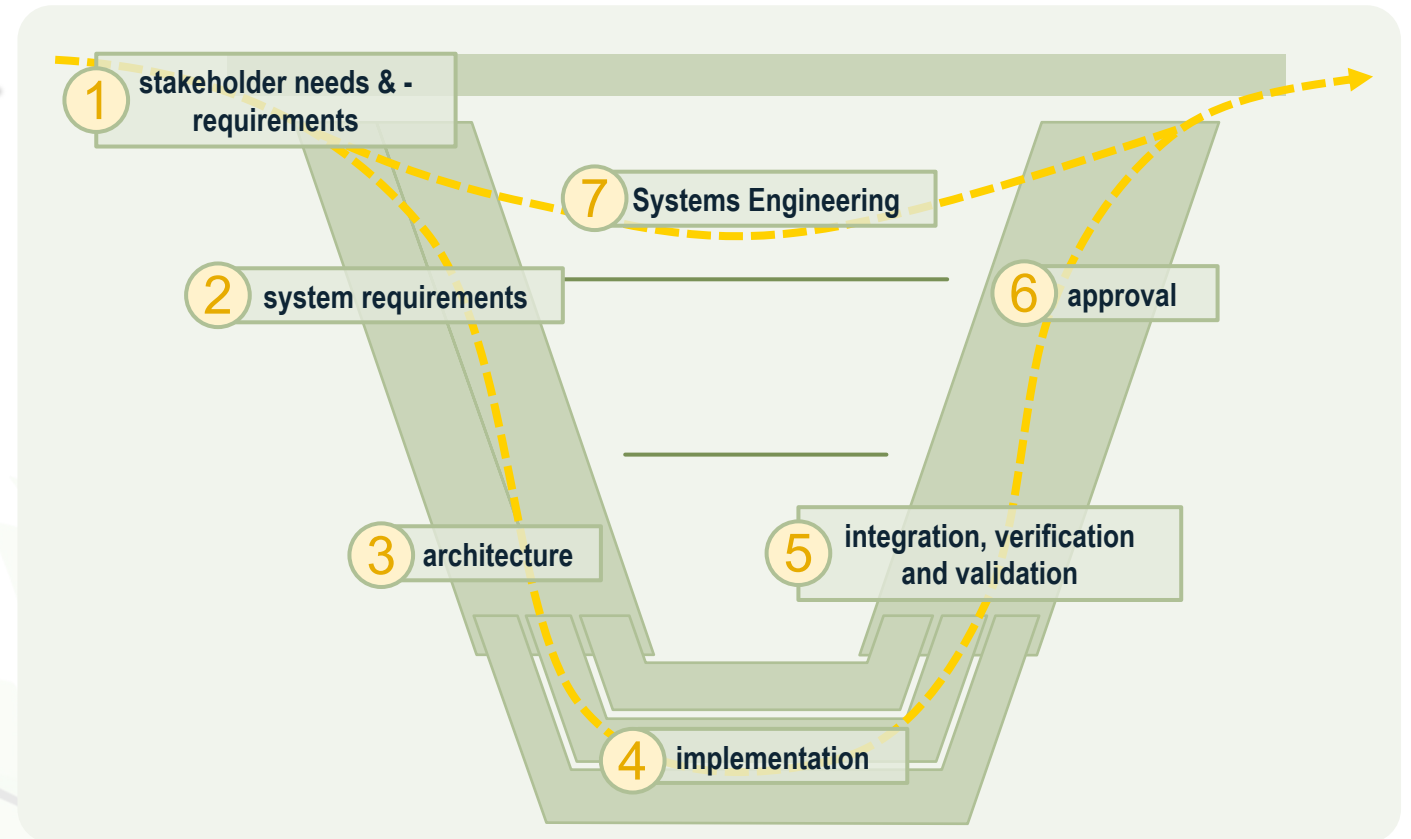
“There is a need for an organizational structure (roles) at the OEM that requires support from R&D consulting and academia in the development.”



# Emergent phenomena create tasks along the v-model. (I/II)

## Tasks of Emergent Phenomena

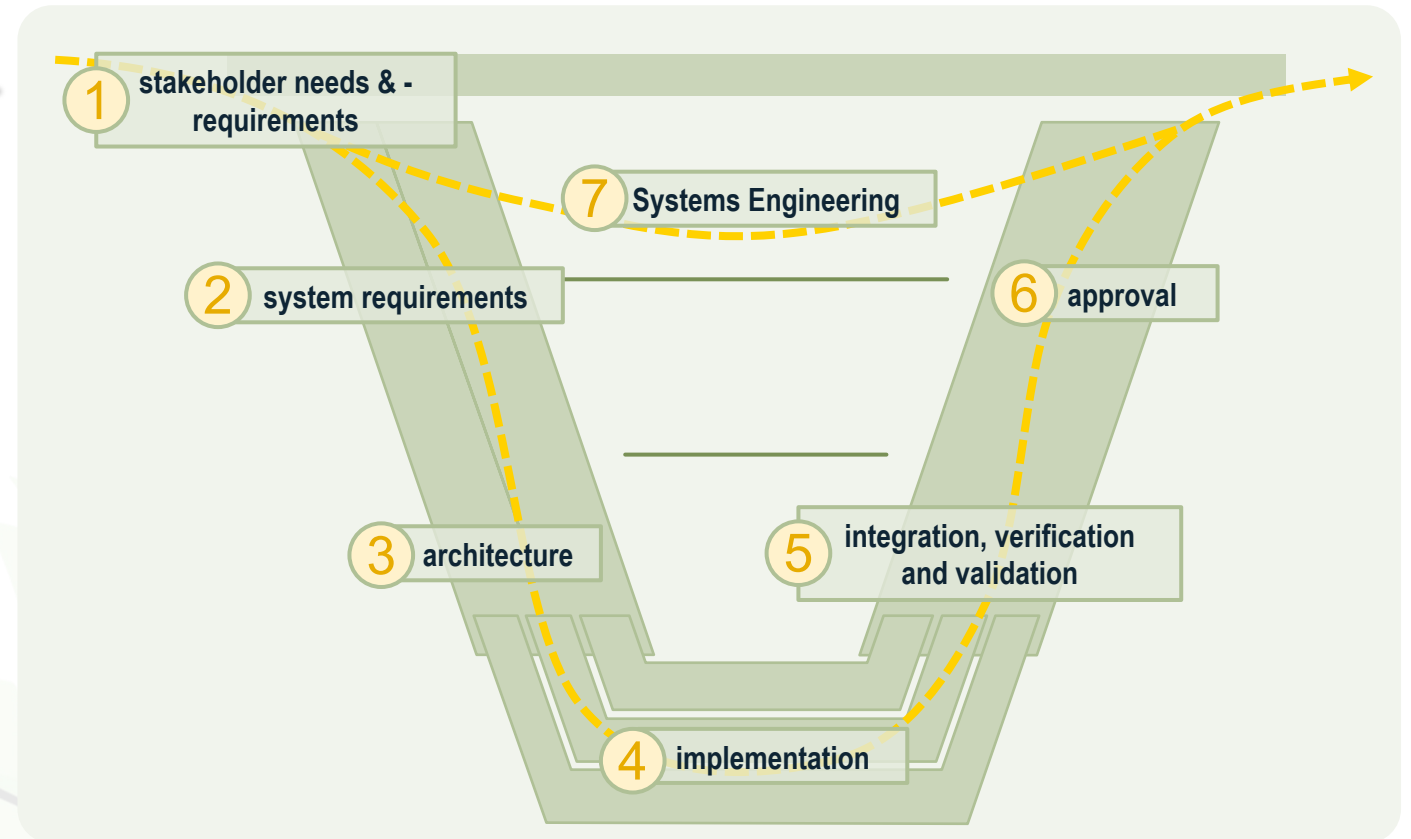
1. formulation and evaluation of the stakeholder perspective
2. formulation and solving of conflict goals of system requirements along the system levels
3. Allocation of system requirements on system levels / discussion of solution and realization approaches
4. Consideration of emergent phenomena in the implementation of every relevant system element



# Emergent phenomena create tasks along the v-model. (II/II)

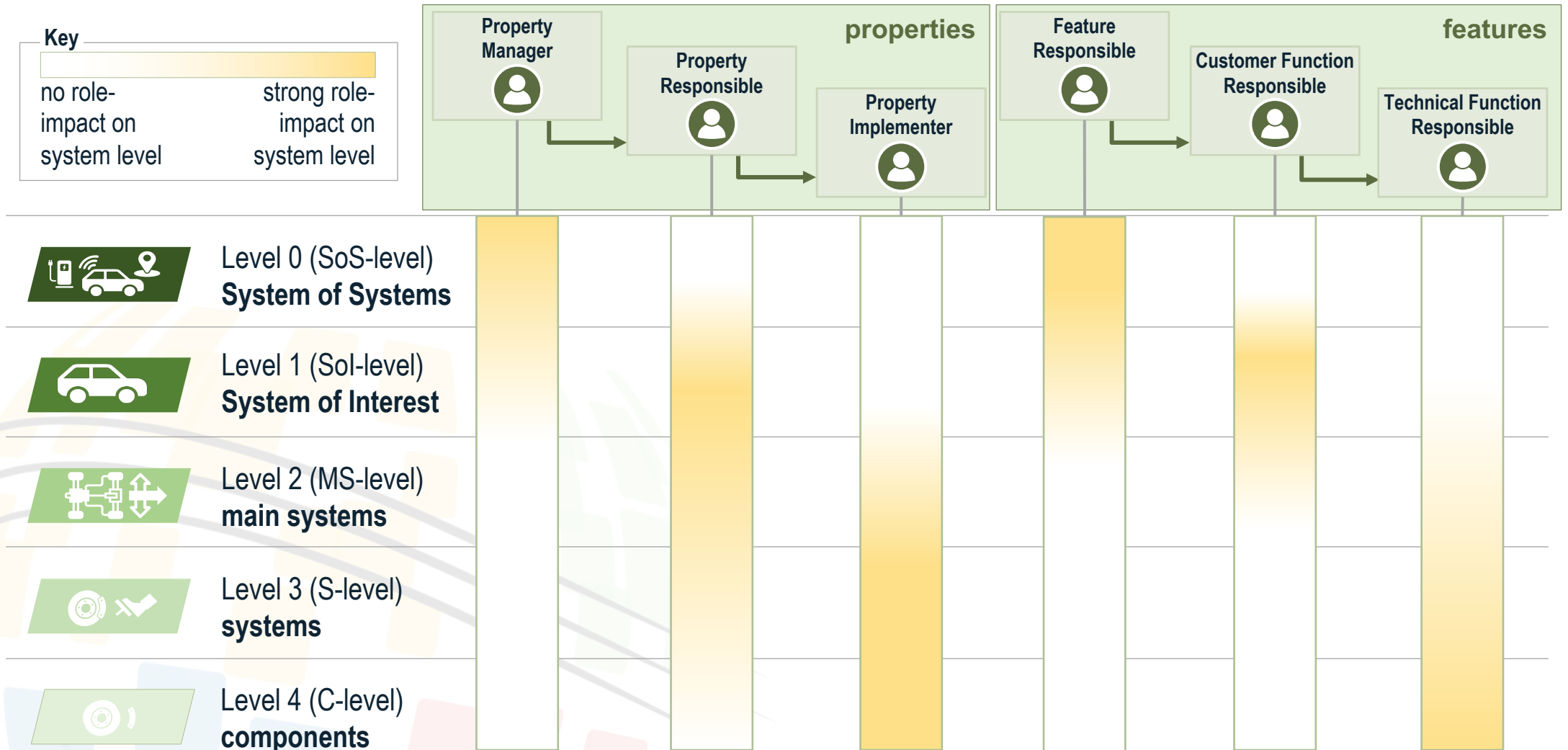
## Tasks of Emergent Phenomena

- 5. Definition of verification and test criteria for emergent phenomena, definition of test cases
- 6. Release of cross-sectional content
- 7. Derivation of schedules, estimation of efforts, support in decision making





# Features and Properties result in three individual roles.



# Roles for non-functional properties have certain core tasks and responsibilities.

## Hierarchy

### Property Manager (PM)

- **Overall responsibility** for the design, control and strategy of properties
- Developing, coordinating, controlling, and pursuing **property goals at Sol-level**
- **Management** of other property roles

### Property Responsible (PR)

- Responsible for **one explicit property**
- **Discusses and coordinates requirements** with the responsible architects on the Sol-level
- Discussion and coordination of **solution alternatives** with the developers on the MS-level

### Property Implementer (PI)

- **Implementation** of a property in lower system levels
- **Realization** of requirements in lower system levels



# Roles for functional features have certain core tasks and responsibilities.

## Hierarchy

### Feature Responsible (FR)

- **Represents features** towards internal and external stakeholders
- **Responsible for feature requirements** on SoS-level and Sol-level
- **Represents a feature** throughout the entire engineering project





































### Customer Functions Responsible (CFR)

- **Responsible for the realization** of feature requirements on Sol- and SoS-level
- Ensures **cross-company coordination**
- **Represents a customer function**

### Technical Functions Responsible (TFR)

- **Realization of technical functions** (requirements) on lowest system levels

# The roles from practice can be categorized partly in the SHEARD role model. (I/II)

Role (SHEARD)		PM	PR	PI	FR	CFR	TFR
Role 1 Requirements Owner	1						
Role 2 System Designer							
Role 3 System Analyst							
Role 4 V&V Engineer	2						
Role 5 Logistic/Ops Engineer							
Role 6 Glue Among Subsystems	3						

[Sheard ,1996]

## Anomalies

1. Strong overlap of every role with the **Requirements Owner**.
2. Strong overlap of every role with the **V&V Engineer**
3. Strong overlap of every role with the **Glue Among Subsystems**.

## Conclusion

- OEM roles have a strong impact in **requirements engineering** along the entire vehicle.
- OEM roles have a strong **system overlap**

# The roles from practice can be categorized partly in the SHEARD role model. (II/II)

Role (SHEARD)		PM	PR	PI	FR	CFR	TFR
Role 7 Customer Interface	4						
Role 8 Technical Manager	5						
Role 9 Information Manager							
Role 10 Process Engineer							
Role 11 Coordinator	5						
Role 12 Classified Ads SE							

[Sheard ,1996]

## Anomalies

4. FR and CFR have a strong overlap with the **Customer Interface**.
5. Property Manager and Feature Responsible have a strong overlap with the **Technical Manager and the Coordinator**.

## Conclusion

- Feature oriented roles have a **strong focus on the customer**.
- PM and FR are **management/coordination focused roles**.



# The OEM roles have been evaluated in three perspectives.

## industry VOLKSWAGEN AKTIENGESELLSCHAFT

- OEM roles **bundle essential vehicle characteristics**
- OEM roles enable a **clear requirements breakdown** on every system level
- OEM roles defuse the **conflict between generalists and specialists**

## consulting 3DSE Management Consultants

- OEM roles **focus on critical project attributes** instead of core processes
- OEM roles **complete existing ones**
- **Coexistence** of OEM roles and classic roles has to be investigated in the future

## research HEINZ NIXDORF INSTITUT UNIVERSITÄT PADERBORN | PE

- Emergent phenomena occur in an **uncertain manner**
- An inter-systemic and inter-disciplinary approach **is necessary**
- Compatibility with SE frameworks like **ISO 15288 and ISO 24748** has to be **investigated** in the future



The OEM roles are valid and can be used in industrial practice. They differ in parts from the common role model according to SHEARD and extends it in parts.

# The OEM roles can help in handling emergent phenomena in complex organizational structures.

## What is the problem?

*The complexity of products and the need to take environmental systems into account is becoming increasingly relevant and cannot be avoided. Existing organizational structures in large corporations are reaching their limits.*

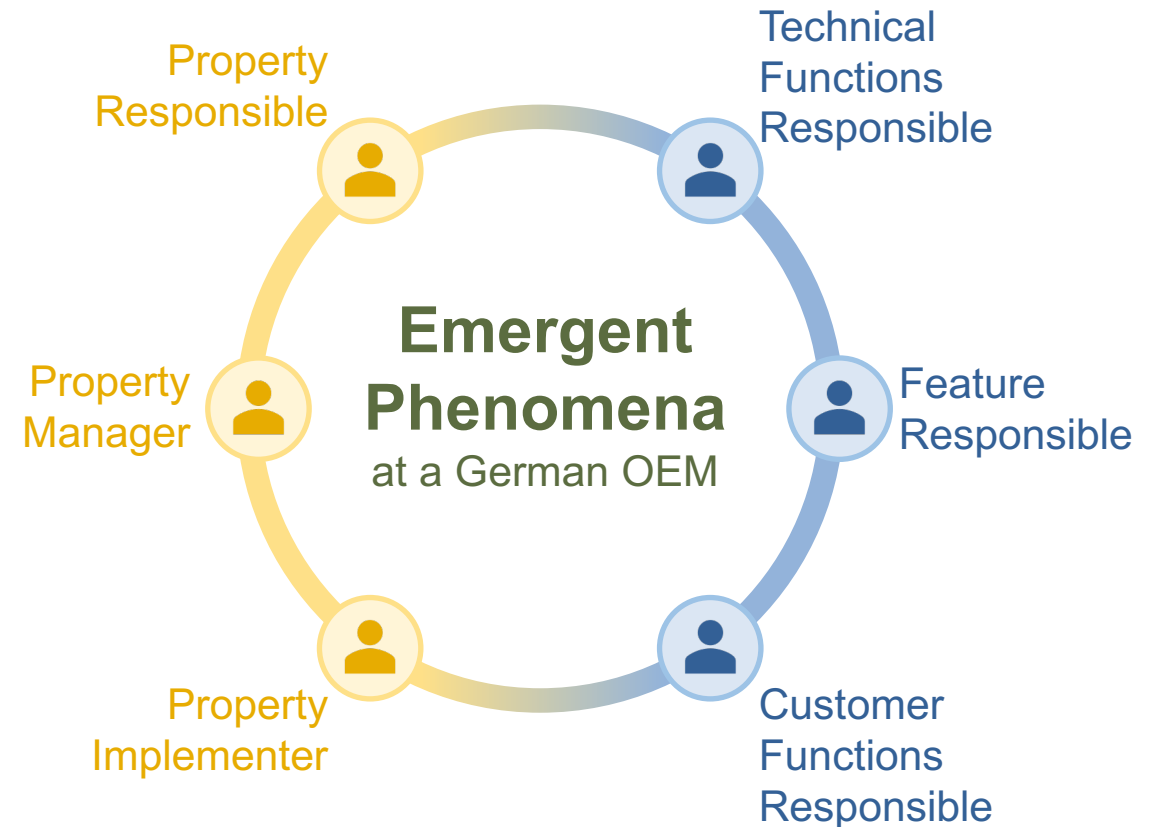
## What is the solution?

*Volkswagen has introduced roles for emergent phenomena in collaboration with 3DSE Management Consultants and the Heinz Nixdorf Institute. They offer both content-related and organizational-structural solutions for the consideration of system behavior that is difficult to predict (emergent phenomena).*

## What are next steps?

*Differentiation of other common SE guidelines, further investigation of the OEM roles into industrial transferability,*

...



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