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A Framework for the design, implementation and evaluation of a multi-variant Augmented Reality application

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Session 2 – Augmented reality systems: design and implementation
Paper 2.1.

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Multi-variant Augmented User Manual

Industrial AR

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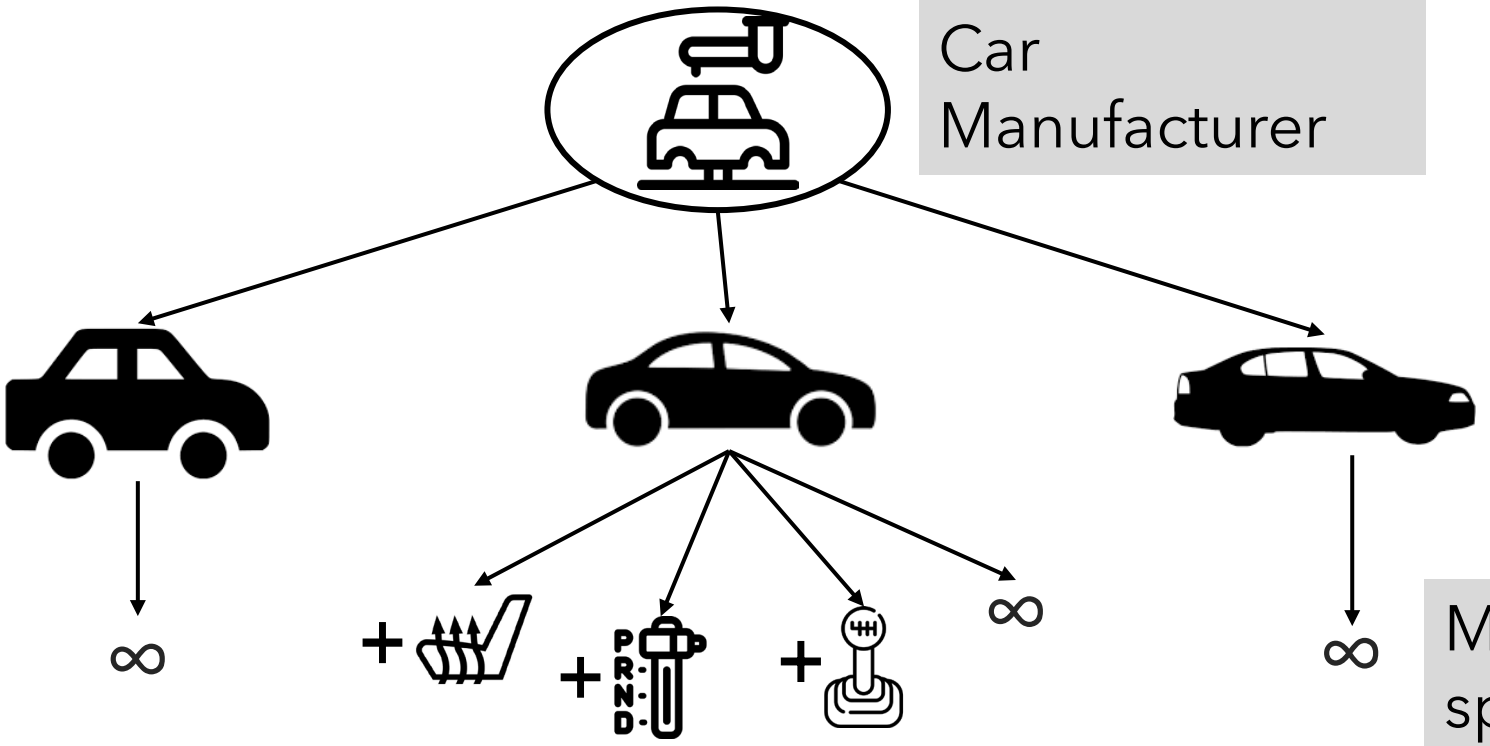
Multi-variant Augmented User Manual



- Same producer, different models
- In combination with variation elements = 100s of variants
  → 100s of user manuals?

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Outline

1. Motivation and Challenges
2. Methodology
3. Cycle 1: Fundamental Approach for model-based AR
4. Cycle 2: Framework for handling multiple models and variants
5. Cycle 3: Evaluation of the final Prototype
6. Summary
7. Conclusion

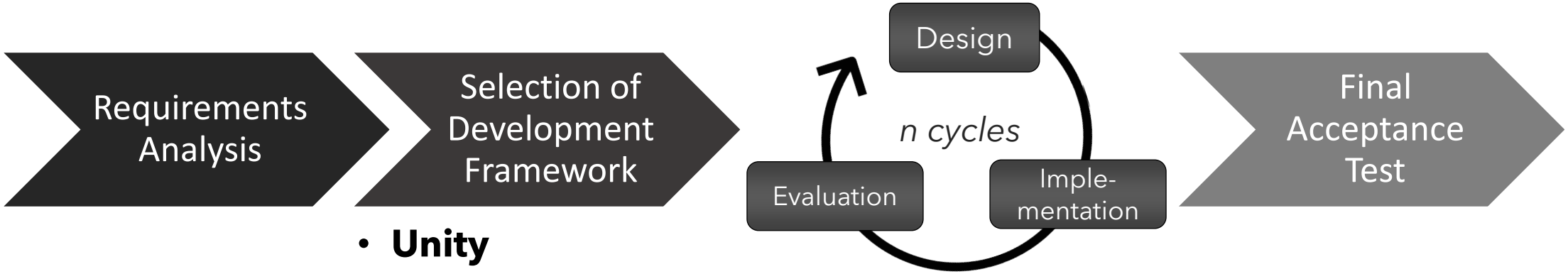
Motivation and Challenges

- Augmented Reality is one of the key technologies of the **fourth Industrial Revolution** (4IR)
- AR is an **innovative and competitive** way of presenting information and enhancing the customer's experience
- In automotive industry, customer-specific variations has been **standard** and must be implemented as **efficiently as mass production** which also includes an efficient creation of instruction material
- Scarcity of fundamental best practices and frameworks for the **industrial AR** sector
- Framework for the design and efficient implementation of AR applications with **multiple models and variants**
- Scarcity in **evaluation approaches** of model-based AR applications

M. Hüllenkremer, "Erfolgreiche Unternehmen arbeiten mit Produktkonfiguratoren/Companies boost success with product configurators," Industrie Management, Publisher, Location, vol. 19 no. 1, pp. 37-40, 2003.

Methodology

Based on Design Science Research method according to Oesterle et al.



- **Unity**
- **Vuforia Engine**

- **Technology Prototype**
- **Variation Prototype**
- **Final Prototype**

H. Oesterle, J. Becker, T. Hess, D. Karagiannis, H. Krcmar, P. Loos, P. Mertens, A. Oberweis, and E. Sinz, "Memorandum zur gestaltungsorientierten Wirtschaftsinformatik, Zeitschrift für betriebswirtschaftliche Forschung", vol. 6 no. 62, pp. 664–672, 2010.

Methodology

Real world (car) → Abstraction (train)

Cycle and Prototype	1. Cycle Technology Prototype	2. Cycle Multi-variant prototype	3. Cycle Final prototype
Applied and tested on	3D printed train 	Train + multiple wagons e.g.  or	Real product 
Evaluation Focus	Object tracking	Performance of multi-variant handling	Usability *(System Usability Scale)*

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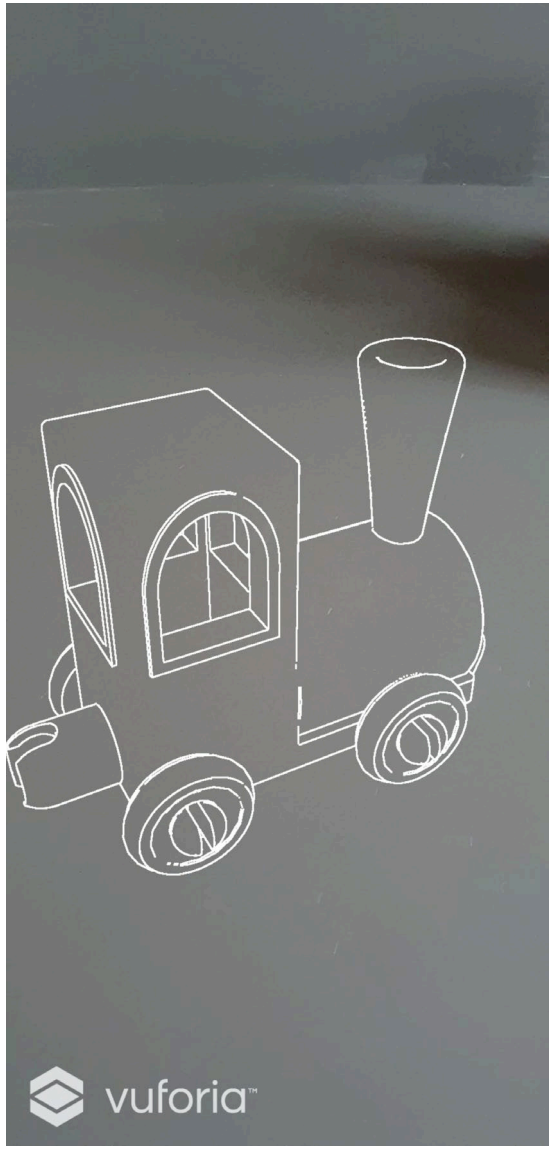
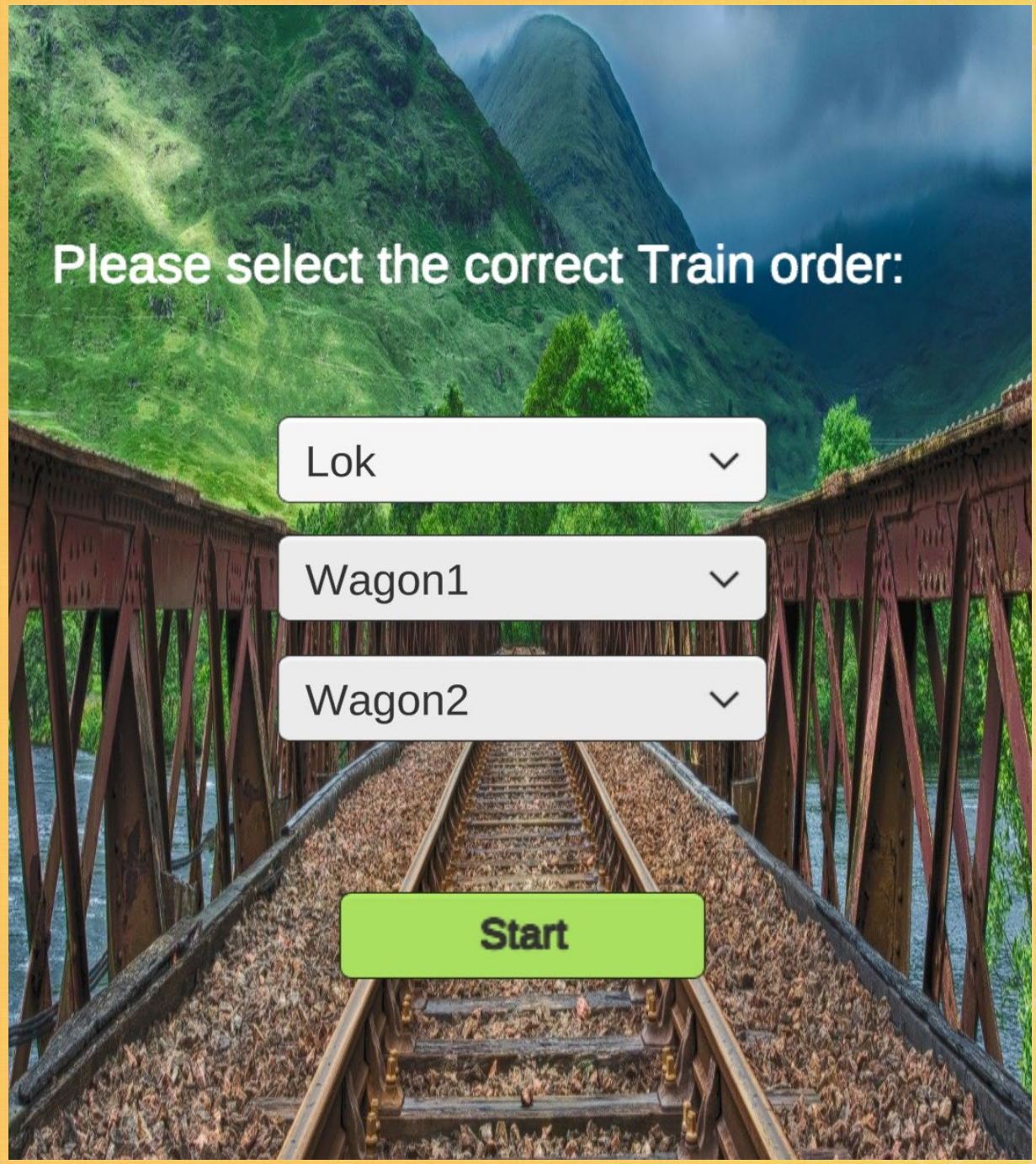
CYCLE 1: Technology Prototype

Implementation

- 3D Models are transformed into a **Vuforia Model Target** (MT)
- Import of MT to Unity and development of prototype: AR content as child object of MT
- Building the application

→ Object tracking ✓





CYCLE 2:
Multi-variant Prototype

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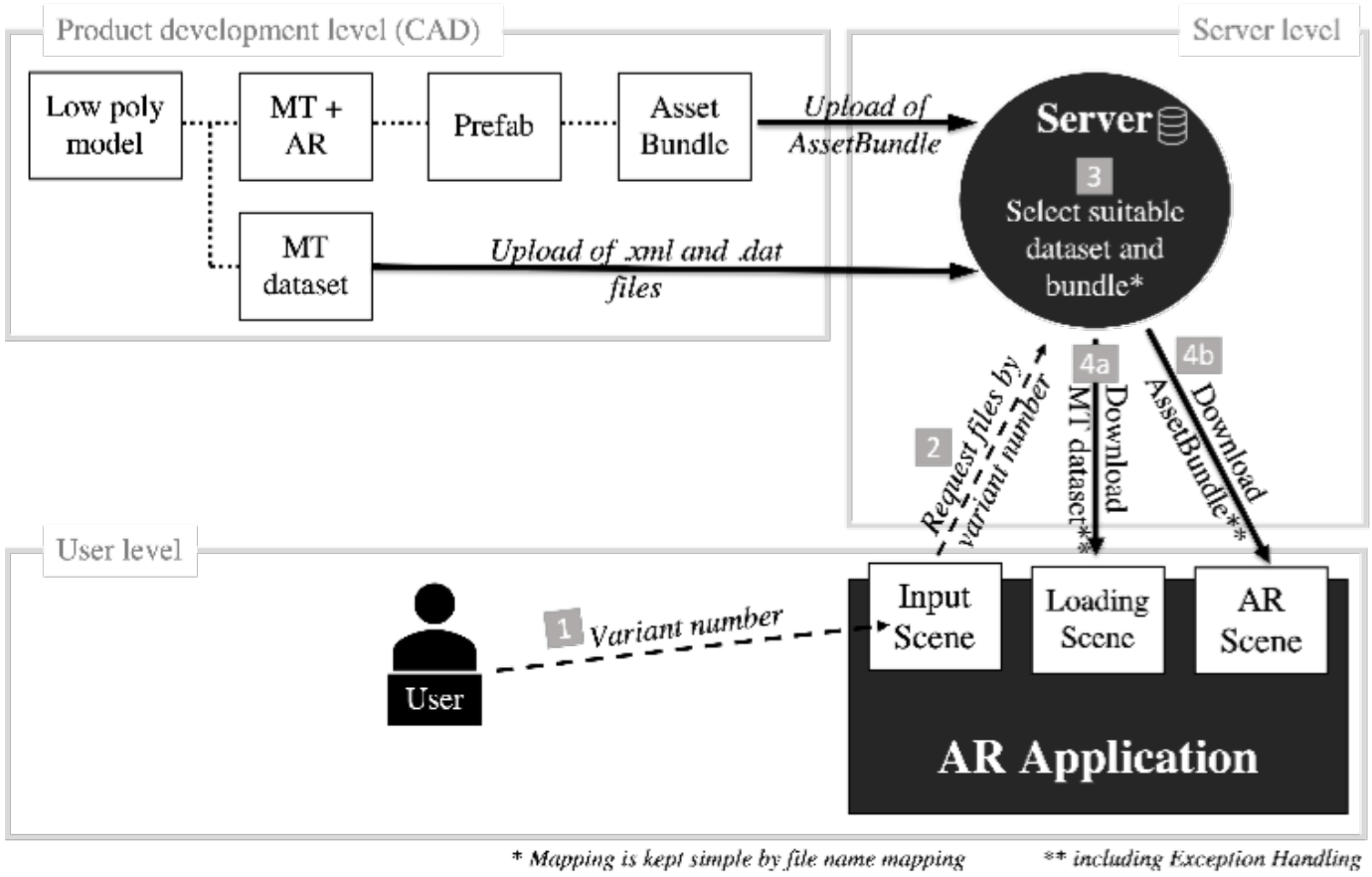
Design

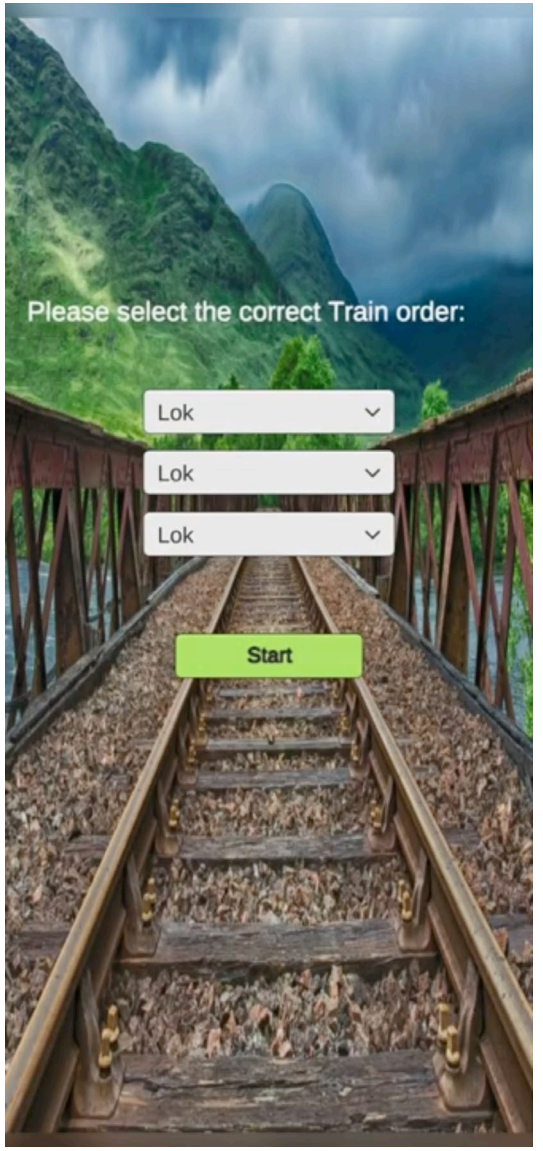
- MT with AR content is stored remotely as **Asset Bundle**
- MT dataset stored **remotely**
- Download to the application **on demand** during runtime
- Implementation for **endless number** of MTs possible



Implementation

- Each MT and dataset is stored on a **virtual server**
- User selects models, only these are downloaded from the server
- After selection, all datasets are downloaded
- MTs with AR content (green sphere) are **temporarily** downloaded in each scene

→ Dynamic download of MTs ✓,
All MTs are detected ✓



Evaluation of Performance

- Major actions were **tracked** with a time stamp during runtime
- Results are given by time but are not compared to other frameworks or applications because there is no reference
- For the given use case, results are **acceptable and reasonable** for the User

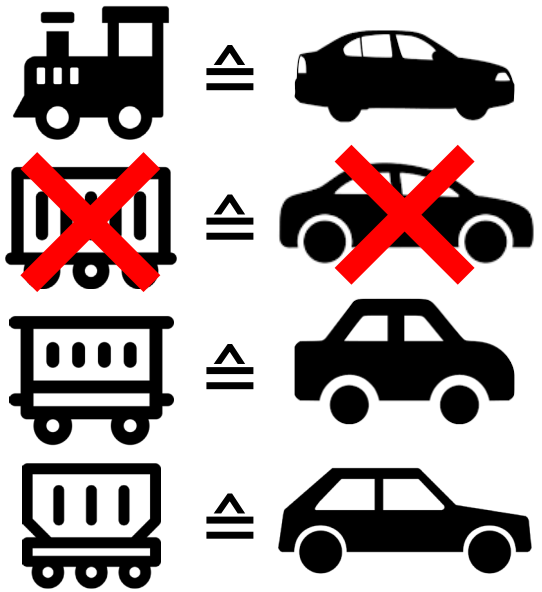
line	*XCode* Console output
1	14:35:14.39 Vuforia Initialized
2	14:35:15.46 Entering Start scene
3	14:35:29.56 Components selected.
4	14:35:30.09 Entering Loading Scene
5	File saved at: */var/mobile/Containers/Data/Application/Documents/Vuforia/Lok.xml*
6	File saved at: . . . */Vuforia/Lok.dat*
7	File saved at: . . . */Vuforia/Wagon1.xml*
8	File saved at: . . . */Vuforia/Wagon1.dat*
9	File saved at: . . . */Vuforia/Wagon2.xml*
10	File saved at: . . . */Vuforia/Wagon2.dat*
11	14:35:30.77 Entering AR Scene 1
12	Requesting bundle at *http://www.westfahlsophie.com/Lok-IOS*
13	Creating dataset: Vuforia/Lok.xml/Lok
14	14:35:30.83 Target: - EMPTY - NO_POSE - NOT_OBSERVED
15	Loaded: ModelTarget (4)(Clone)
16	14:35:31.43 Target: Lok NO_POSE - NOT_OBSERVED
17	14:35:31.48 Target: Lok NO_POSE -RECOMM_GUIDANCE
18	14:35:32.41 Target: Lok TRACKED - NORMAL
19	14:35:34.52 Target: Lok NO_POSE - NOT_OBSERVED
20	UnloadTime: 7.174000 ms
21	14:35:34.49 Entering AR Scene 2
22	14:35:34.53 Target: - EMPTY - NO_POSE - NOT_OBSERVED
23	Requesting bundle at *http://www.westfahlsophie.com/Wagon1-IOS*
24	Creating dataset: Vuforia/Wagon1.xml/Wagon1
25	Loaded: ModelTarget (1)(Clone)
26	14:35:34.89 Target: Wagon1 NO_POSE - NOT_OBSERVED
27	14:35:34.95 Target: Wagon1 NO_POSE -RECOMM_GUIDANCE
28	14:35:38.97 Target: Wagon1 TRACKED - NORMAL

Different multi-variant use cases

SCENARIO 1

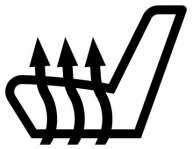
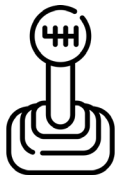
Back from Abstraction to Real World:

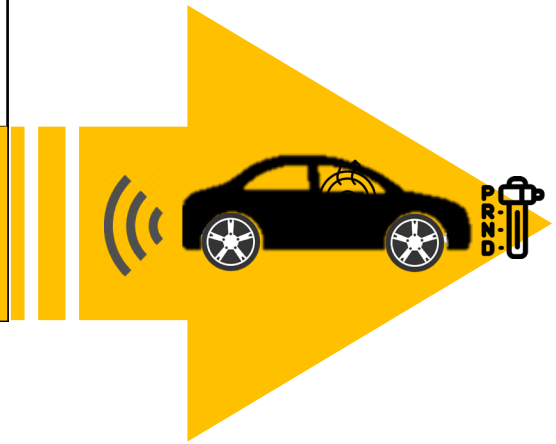
- One train/ wagon model ≙ one car model
- User selects his/her car model(s) and only these are downloaded
- Advantage: smaller application size, because **only required models** are downloaded, no application updates for new models



SCENARIO 2

Different multi-variant use cases

Basic Model	Comfort & Convenience	Transmission	Parking Assistance	Wheel disks
			Park Pilot	
			Radar distance sensor	
	-	-	Front camera	



Combinatorial explosion

Before: e.g. **108** customer specific variations &user manuals)

→ After: **13 variation elements**

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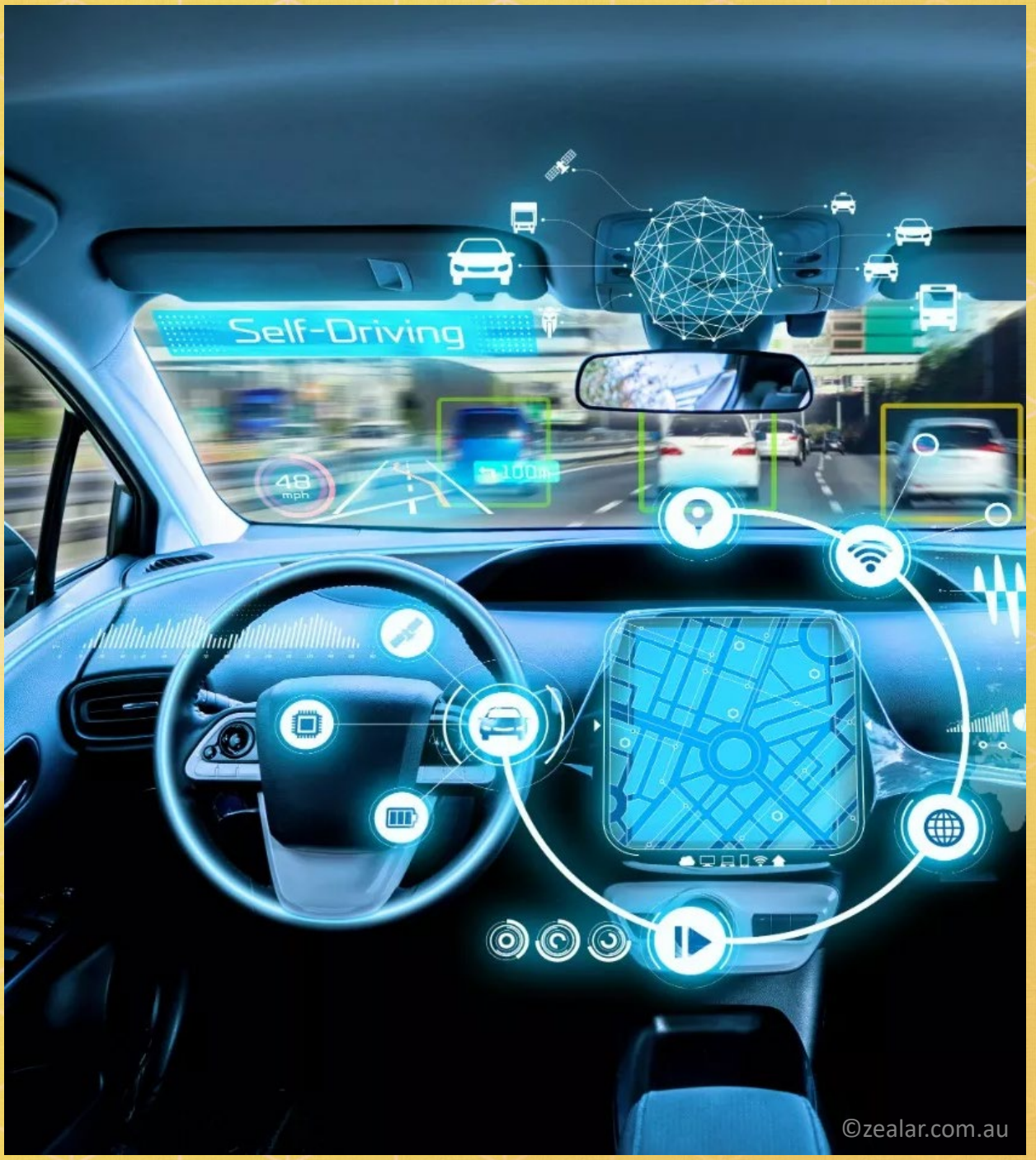
CYCLE 3:
Final Prototype



Implementation

- Application implemented on the **real product**
- **Combination of knowledge** from the first two cycles
- No demonstration due to legal reasons
- Evaluation of Performance was repeated and confirmed, furthermore a **usability evaluation** was conducted

Evaluation: System Usability Scale

- **Standardized Questionnaire:** Ten given statements about the user-friendliness of an app
- Statements are rated on a Likert scale from one to five
- Result (SUS value) is calculated and can range from 0 to 100

→Conduction with eleven test subjects

→No representative results

→**SUS-value of 90** which corresponds to an A+

J. Brooke, "SUS: A quick and dirty usability scale," Usability Eval. Ind., vol. 189, 1995.

Summary: Our Contribution

Framework for the implementation of a mobile AR application with model-based tracking for multi-variant products

1. Fundamental approach for designing and implementing **model-based AR** applications with one model
2. Framework for the design and implementation for **numerous variants** and products
3. Quantitative and qualitative **evaluation** based on the performance and usability

Conclusion: Selected Outcome

A Framework (Technology and Process) can be understood and implemented by **novices** as well as experienced users

B Generic multi-variant approach **not limited** in number of models, in use cases and neither in MTs

C No need to update application for new models due to remote storage

D Planned **go-live** and **roll-out** to other products

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References

Video Squence 1: https://youtu.be/XK_SVBiS7DA

Video Squence 2: https://youtu.be/HefZ7DHyn_c

Icon-Images: https://www.flaticon.com/, https://www.iconsdb.com/

Unity: https://unity.com/

Vuforia Engine: https://developer.vuforia.com/

M. Hüllenkremer, "Erfolgreiche Unternehmen arbeiten mit Produktkonfiguratoren/Companies boost success with product configurators," Industrie Management, Publisher, Location, vol. 19 no. 1, pp. 37-40, 2003.

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Thank you!