3DSE
Management Consultants

3DSE internes SE Basis Training

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Exercise

Exercise on Requirements Engineering

30 min 

Tasks
• Check the given requirements regarding the S.M.A.R.T. criteria (excluding Traceable)
• Write down a short comment for those requirements which are not fulfilling one or more S.M.A.R.T. criteria

How to write good requirements – S.M.A.R.T. criteria

S.M.A.R.T.:

S – Specific
Clear, concise and unmistakable. Easy to understand and read. No room for interpretation. Consistent i.e., consistent terminology, no contradictions within the requirements. Avoid redundancies. Apply appropriate level of detail.

M – Measurable
Measurable means that requirements must be verifiable with a predefined set of test cases.

A – Atomic
Each requirement should be an atomic/alone requirement. I.e,. a requirement is atomic if it cannot be divided into further requirements at the same level.

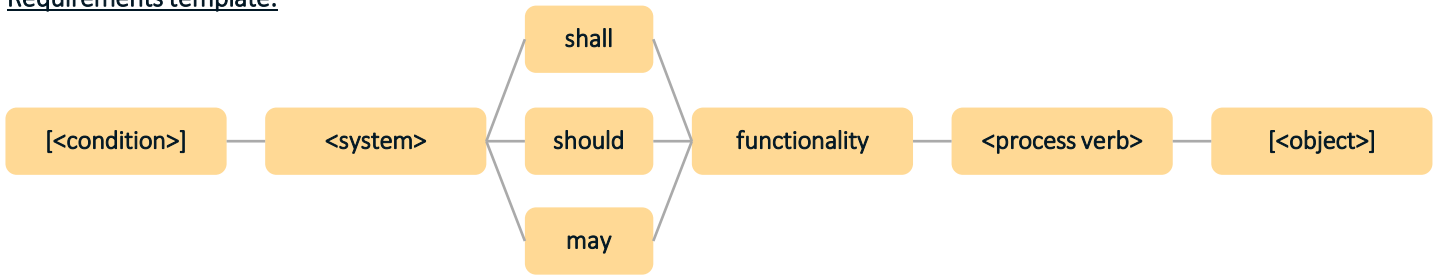
R – Realistic
Every requirement should be realistic and achievable.

T – Traceable
Requirements must be traceable from its conception through its specification to its subsequent design, implementation and test.

Avoid weak word choices:

- Avoidance of superlatives, e.g., the best, the most
- Avoidance of unclear pronouns, e.g., he, you, it, those who, whose
- Avoidance of ambiguous adverbs or adjectives, e.g., approximate, many, minimal, corresponding, diverse, limited
- Avoidance of non-measurable expressions, e.g., provide support, not limited, at least
- Avoidance of comparisons, e.g., better than, higher quality, higher value
- Avoidance of back doors, e.g., if possible, feasible
- Avoidance of indefinite words, e.g., etc., sometimes
- Avoidance of subjective expressions, e.g., user-friendly, cost-effective, easy to use

Requirements template:



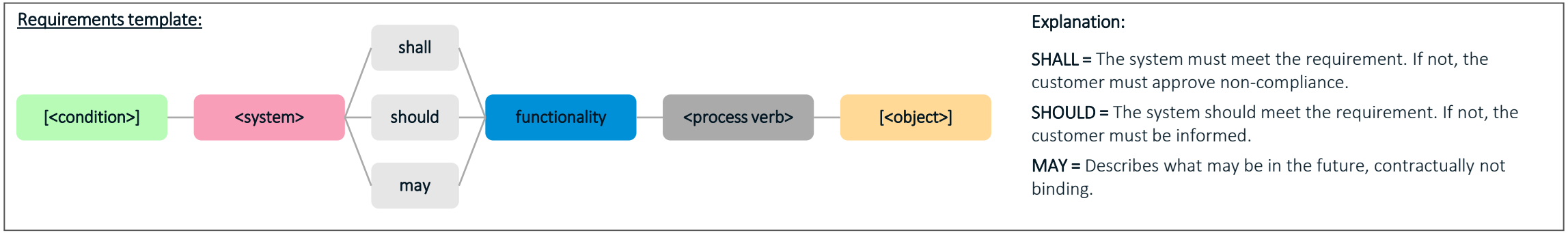
Explanation:

SHALL = The system must meet the requirement. If not, the customer must approve non-compliance.

SHOULD = The system should meet the requirement. If not, the customer must be informed.

MAY = Describes what may be in the future, contractually not binding.

How to write good requirements – Examples



Examples:

- Provided that the cooling is switched on, the Steering Console shall reduce the internal temperature under +55° C.
- As long as the diving depth is greater than 9 m, the depth autopilot shall be selectable.
- The user manual shall be written in English language.

Exercise on Requirements Engineering
Check S.M.A.R.T. criteria

Requirement ID	Requirement	S.	M.	A.	R.	T.	Comment
REQ_1001	Under normal usage conditions the e-scooter should drive for 500 kilometers per charge before the first purchase.	X	X	X			500 km are not realistic. Also, the requirement is not traceable, because it is no reference to a named function. • Under normal usage conditions the e-scooter should drive for 30 kilometers per charge before the first purchase.
REQ_1002	The e-scooter should be foldable and weigh no more than 19,5 kg to ensure easy portability.						
REQ_1003	The e-scooter should be charged very fast.						
REQ_1004	While driving full speed shall the e-scooter be very quiet.						

Exercise on Requirements Engineering
Check S.M.A.R.T. criteria

Requirement ID	Requirement	S.	M.	A.	R.	T.	Commentary & Correction
REQ_1005	The scooter should be able to transport people.						
REQ_1006	While using the scooter, technical data such as range etc. must be available for the customer.						
REQ_1007	The scooter must have built-in anti-theft mechanisms so that it automatically detects the theft and drives away from the thief.						
REQ_1008	The scooter should last a very long time before essential parts need to be replaced.						

Anwendungs-Beispiel: SE Assesment mit Referenzmodell

Erfolgreiches SE braucht 8+1 Dimensionen, die nur Wirksamkeit entfalten, wenn sie miteinander in Einklang gebracht werden.

3DSE Systems Engineering Reference-Model

System architecture
(in terms of system concept and structuring)

Development logic, life cycle and SE processes

Interdisciplinary work organization and SE roles

Target system, leadership model and incentives

Consistency of the reference dimensions to each other

System competence, career path and qualification

Systems thinking, change and engagement

SE methods

Digital skills and tools

Case Study
Setting the Stage

- There has been a dynamic increase in **smart mobility alternatives** for the past 10 years in European and Asian regions.
- Increasing **ecological awareness** and media coverage of **traffic congestion** and **noise pollution** motivate professionals and commuters to find alternative transportation options.
- Furthermore, growing interest in **eco-friendly and alternative energies** is reported.
- An **increasing number of extreme weather conditions** yield market opportunities to offer exchangeable tires for dry and wet roads and surfaces.
- Increasing interest in **private travel** and **occupational mobility** brings up the need for e-scooters that are transportable.
- **Smart APP connectivity** is regarded as a lasting trend with high success potential.

Case Study
Requirements Setting

Non-negotiable requirements for a smart e-scooter:

- The e-scooter consists of at least 4 modules: chassis, propulsion, steering, app connectivity.
- Compliance with legal regulations regarding safety in traffic.
- Offer different driving modes to meet various customer needs.
- Customers can easily replace or modify various hardware options on their own.
- Compatible with locally available charging standards for convenient charging.

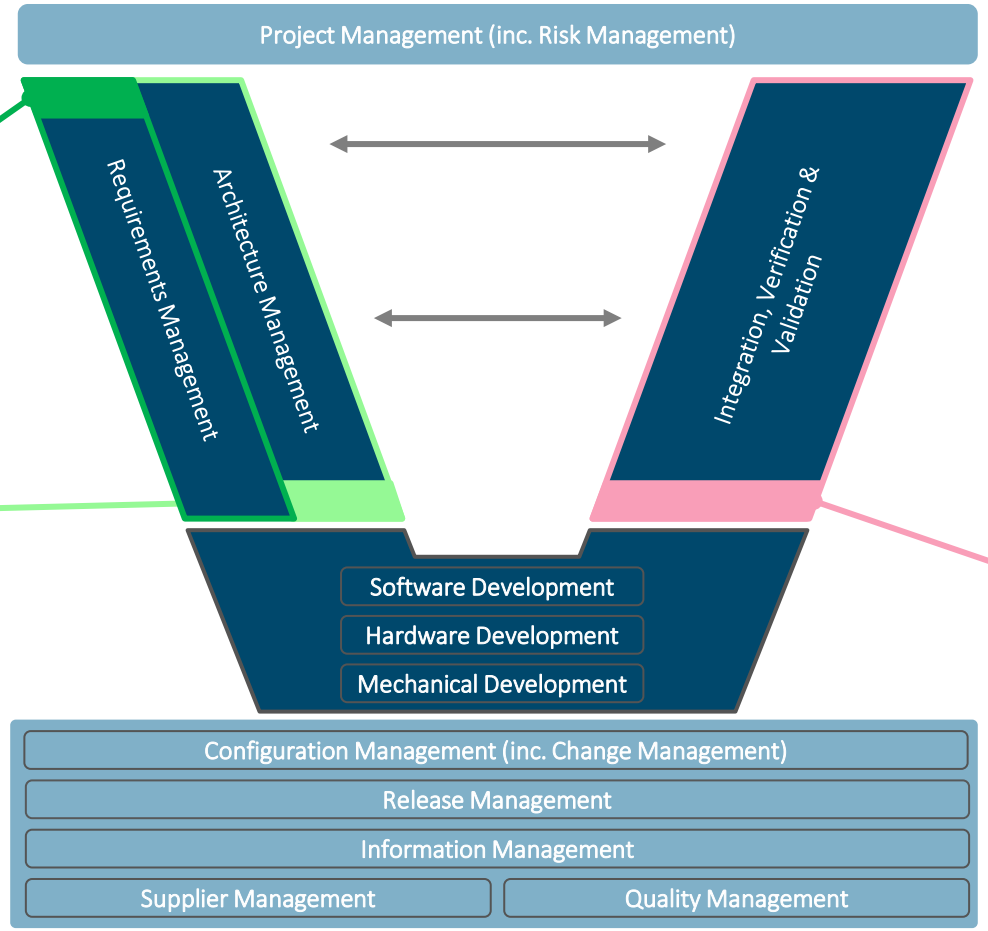
Overview of the main SE processes we will focus during the case study.

Requirements Management

- Identification stakeholder needs
- Translation of needs to requirements
- Allocation of requirements to systems
- Analyzing how requirements can be tested

Architecture Management

- Providing system context
- Developing functional, logical and FLP architectures
- System specification and element description



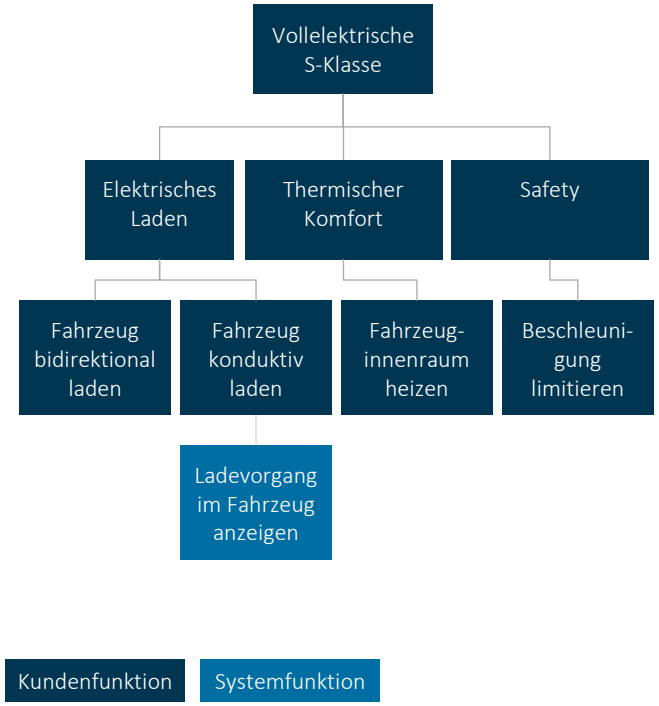
IVV Management

- Verification and Validation strategy, planning and reporting
- Requirements Verification Traceability Matrix (RVTM)
- Assessing technical maturity and devising an integration strategy

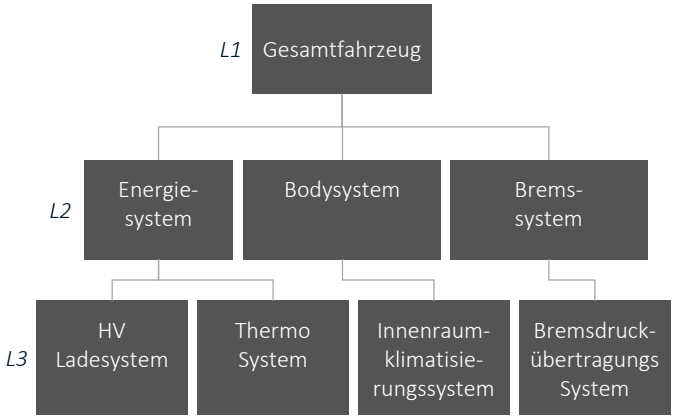
Legend *Development processes* *Support processes*

Methodical approach to the case study.

Functional Breakdown



System Breakdown

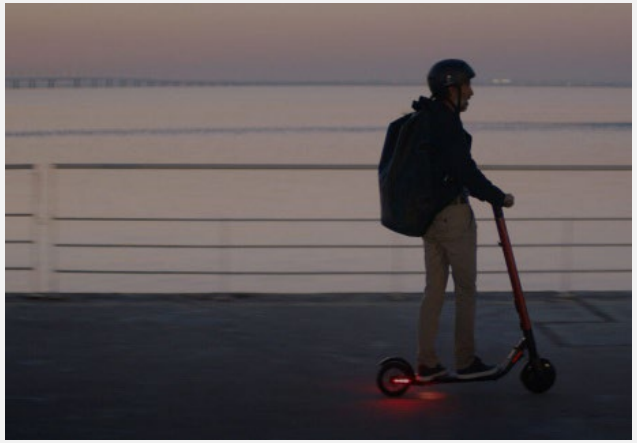


Requirements Breakdown

Gesamtfahrzeug	The stopping distance of the vehicle shall not exceed a maximum of 50 m during emergency braking.
Bremssystem	The deceleration build up time shall be less than 250 ms to reach 1 g.
Bremsdrucksübertragungs System	If applying a pedal velocity (on the pedal tread) > 4 m/sec, the delay between the pedal force increase and the requested brake pressure increase shall be smaller than 40 ms.

Case Study
Persona Carlos Alvarez

Carlos Alvarez:
I am 29 years old and live alone in a large Spanish city. Because I work, I get up early in the morning every day. To get to work quickly, I have an old racing bike that I sometimes take on the subway or bus. However, when I take the bike, I enjoy the peace and relaxation of cycling, but in some corners of the city I have to be wide awake, because I have to react quickly to the city traffic and people or, if necessary, avoid them. When I arrive at work all sweaty, I want to get changed as quickly as possible and therefore sometimes forget to lock my bike. I usually lock it hours later, but it doesn't actually get stolen because it's so old. On the other hand, it's reliable and durable, which is important to me with the things I own. After work I ride to my friends who live all over the city. I usually have a beer, talk with them a little bit and drive back to my apartment afterwards, which means I'm usually home by around 10 pm.

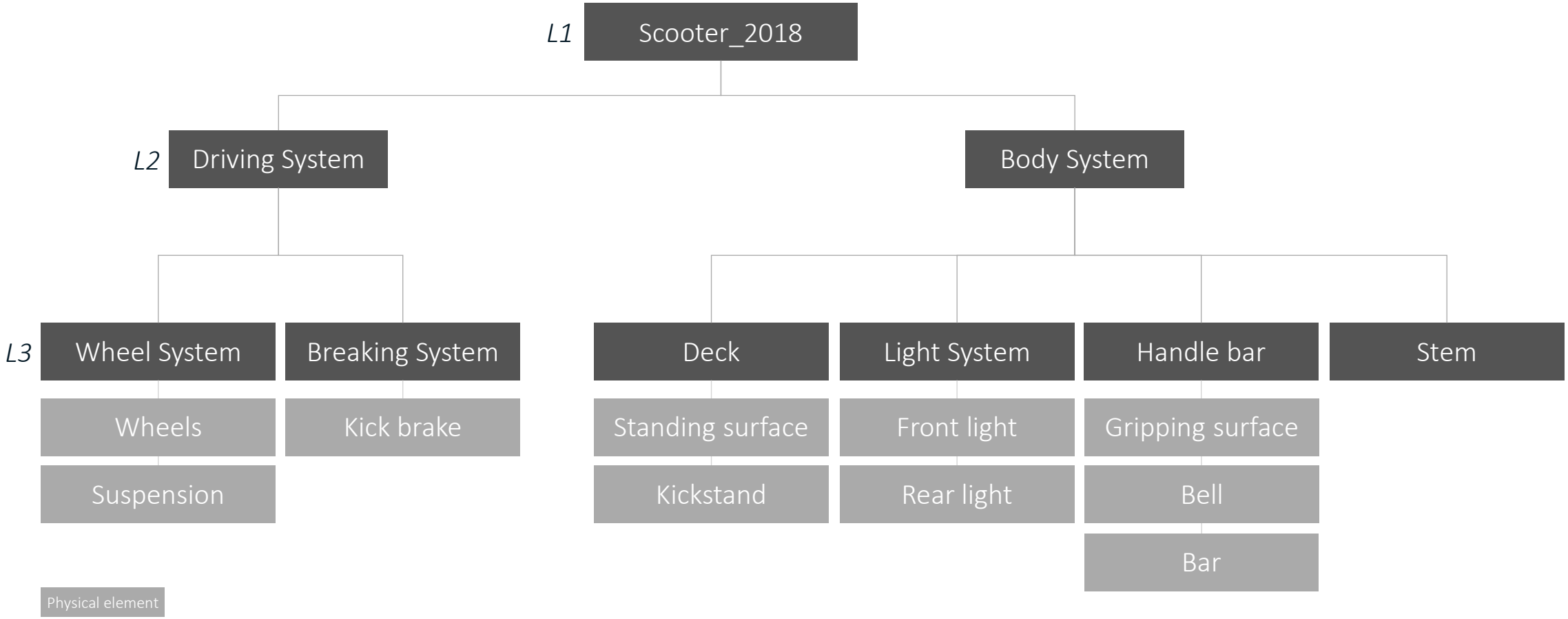



What is a Function?
How to formulate a Function?

- In systems engineering, a function refers to a **specific action** or set of actions that a system performs to **achieve a particular outcome or goal**.
- Functions are the **building blocks of a system's behavior** and are essential for fulfilling the system's objectives.
- They can be thought of as the tasks or operations that the system must perform to meet its requirements.
- In simple words, a function is what a system does.

„Function = Noun + Verb“

Case Study
Product Breakdown Structure (PBS) "Scooter_2018“



Case Study
Assign functions to Product Breakdown Structure (PBS) "Scooter_2025“

Function ID	Function	Driving system	Body system	…	…
FU_1001	Provide connectivity	x			
FU_1002	…				
FU_1003					
FU_1004					
FU_1005					
FU_1006					
FU_1007					
FU_1008					
…					

Case Study
Your tasks

30 min

Task
• Based on your functional breakdown define requirements for the system level 1 “e-scooter”. • Consider the S.M.A.R.T. criteria when writing the requirements. • Afterwards allocate the requirements to your Product Breakdown structure (PBS) for the "Scooter_2025“.

Case Study
Requirement definition

Function ID	Function	Requirements
FU_1001	Show durability	
FU_1002	Enable range	
FU_1003	Have a low weight	
FU_1004	Enable transportation	
FU_1005	Driving forward	
FU_1006	Enable day & night driving	
FU_1007	Provide connectivity	
FU_1008	Provide energy for motion	
FU_1009	Enable brakes	

Case Study
Your tasks

30 min 

Task
• Based on your requirements set up a Requirements Verification Traceability Matrix (RVTM). • For each requirement choose the appropriate Verification Method and describe the Acceptance Criteria.

Case Study
Requirements Verification Traceability Matrix (RVTM)

Req. ID	Requirement Description	Verification Method	Acceptance Criteria	Test Case ID
REQ_1001	While using the e-scooter, technical data for range shall be available for the customer by a mobile app.	*Test*	*Technical data for range is shown in the mobile app.*	TC_001
REQ_1002	The e-scooter should weight 19,5 kg to ensure easy portability.	*Analysis, Inspection*	*Simulation shows a first weight indication of 19,5 kg.* *Weight of the e-scooter after final assembly is 19,5 kg.*	TC_002
REQ_1003	Under normal conditions, the e-scooter should be charged in 2 hours.			TC_003
REQ_1004	At the time of the purchase while driving fullspeed the noice level of the e-scooter shall be less than 40 db.			TC_004
REQ_1005	The e-scooter should be able to transport men and women from 14-60 years.			TC_005
REQ_1007	The e-scooter must have built-in anti-theft mechanisms in the form of a GPS tracker that transmits its location every second.			
REQ_1008	In normal use, the e-scooter should travel 10,000 km before major parts need to be replaced.			

Verification Method: Analysis, Inspection, Test