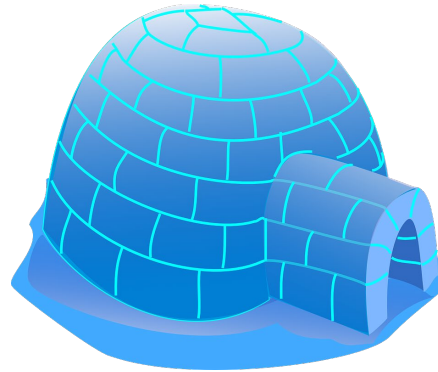# Validation & Verification

What is what?

- **Validation:** Are you building the right thing?

or

- **Verification:** Are you building it right?

In other words…

- Validation is proving that your outcomes are true and based on strong (scientific) evidence

AND

- Verification is proving that your method of research have been used in the way are supposed to be used and are suitable for your research topic.

Why needed?

- To add credibility to your results and conclusions

- To allow your results to be used in a professional environment

- To allow for academic reproducibility and transparency

Validation & verification completes your research cycle
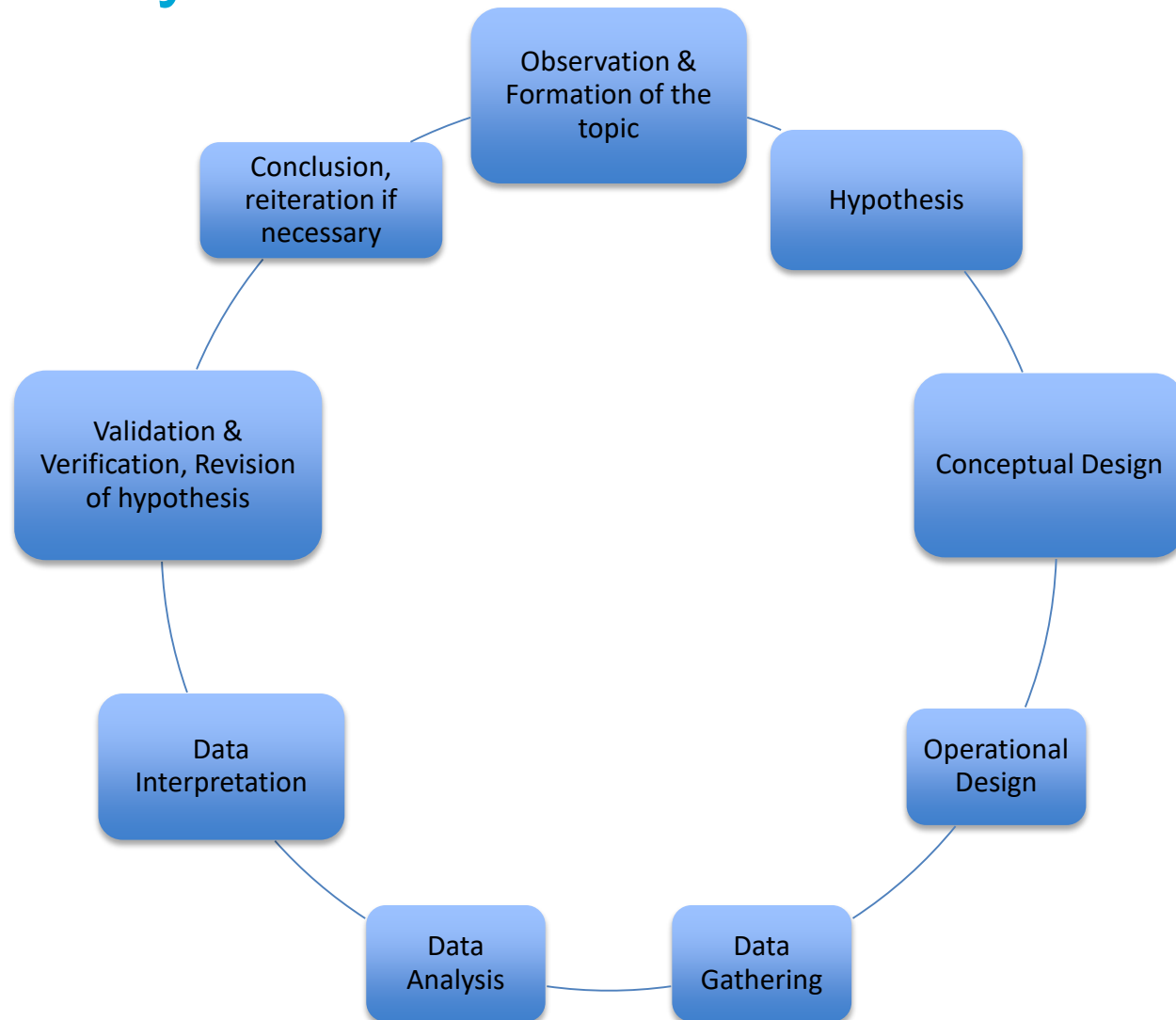
Industry verification and validation

- <u>Verification</u> is a <u>quality control</u> process
    - Used to evaluate whether a product, service, or system complies with regulations, <u>specifications</u>, or conditions imposed at the start of a development phase.
    - Verification can be in development, scale-up, or production.
    - Often an internal process.

- <u>Validation</u> is a <u>quality assurance</u> process
    - establishing evidence that provides a high degree of assurance that a product, service, or system accomplishes its intended requirements.
    - often involves acceptance of fitness for purpose with end users and other product stakeholders.
    - often an external process.

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Industry validation: most tested attributes

- [Selectivity](#)/[specificity](#)
- [Accuracy](#)
- [Precision](#)/[Repeatability](#)
- [Reproducibility](#)
- [Limit of detection](#) - especially for trace elements
- [Limit of quantification](#)
- [Curve fitting](#) and its range
- [System suitability](#)

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The famous industry 'V' diagram
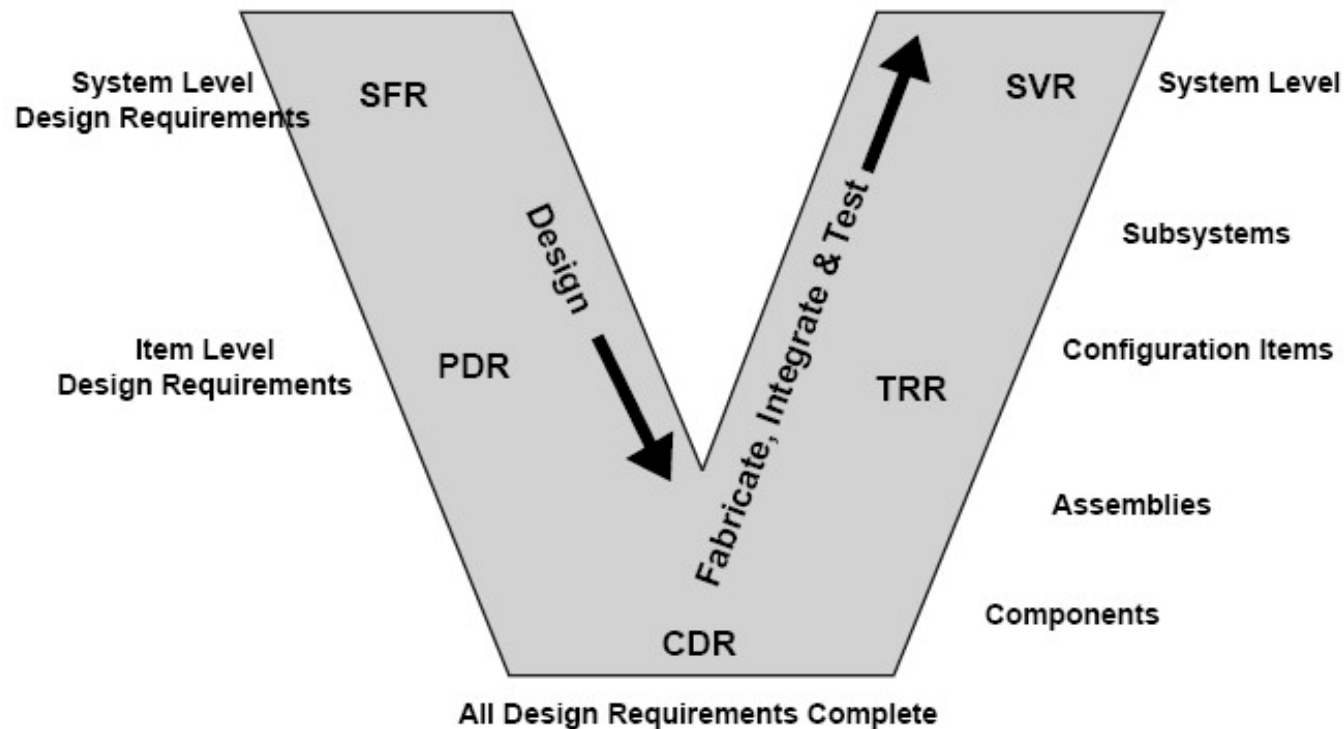
Design verification test (DVT)
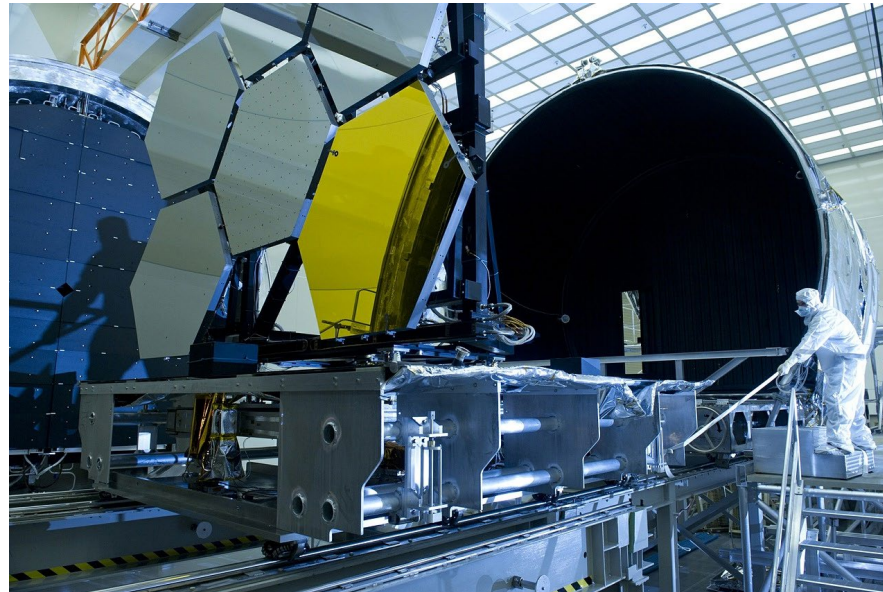
Intensive testing program which is performed to deliver objective, comprehensive testing verifying all product specifications, interface standards, OEM requirements, and diagnostic commands.

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Areas of DVT testing

- Functional testing (including usability)
- Performance testing
- Climatic testing
- Reliability testing
- Environmental test
- Mechanical test
- MTBF prediction
- Compliance and regulatory testing
- EMC test and certification
- Safety certification

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Six Sigma Validation Example

IQ - Installation Qualification
OQ - Operational Qualification
PQ - Performance Qualification
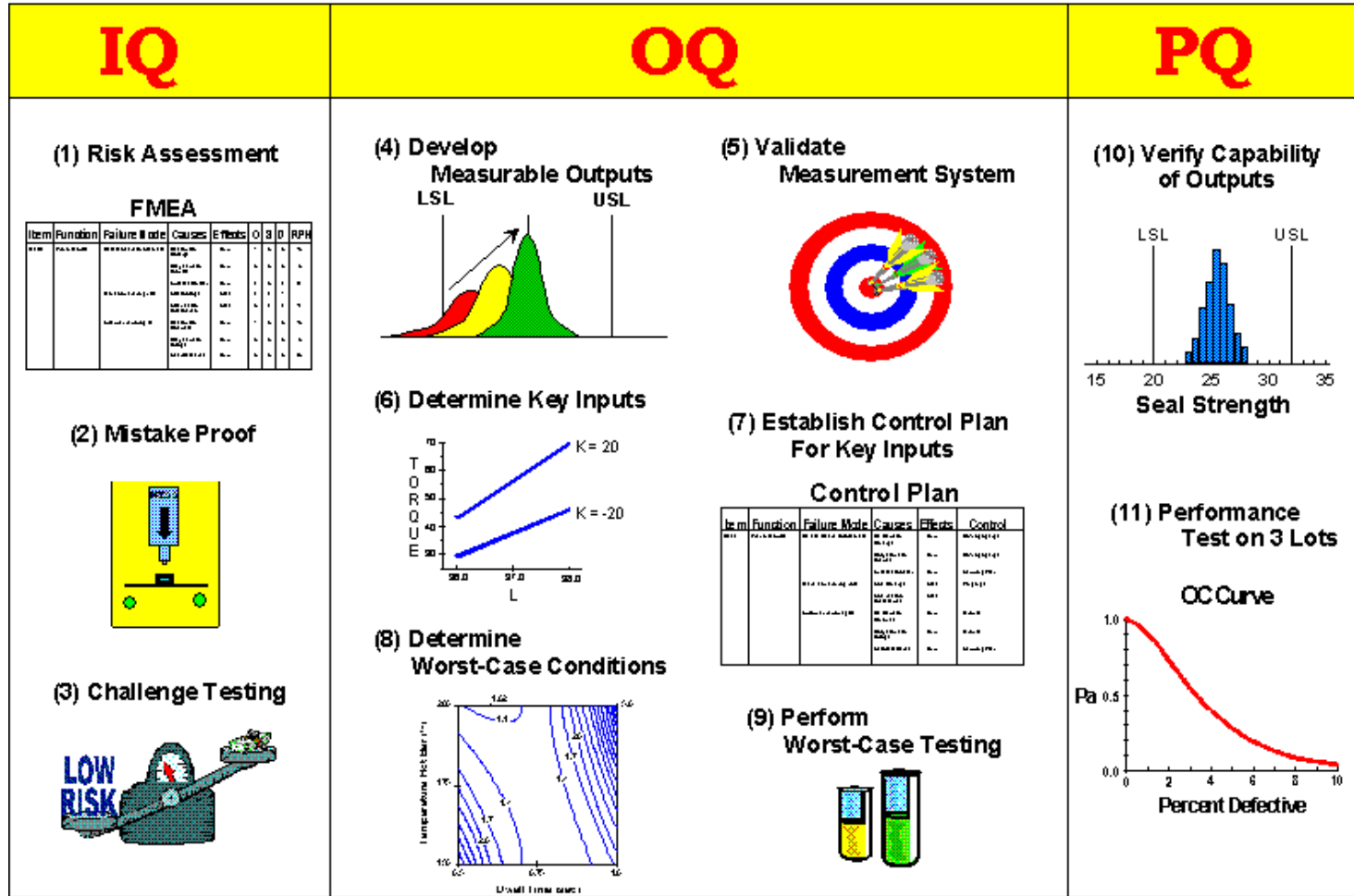
EUROCONTROL validation example

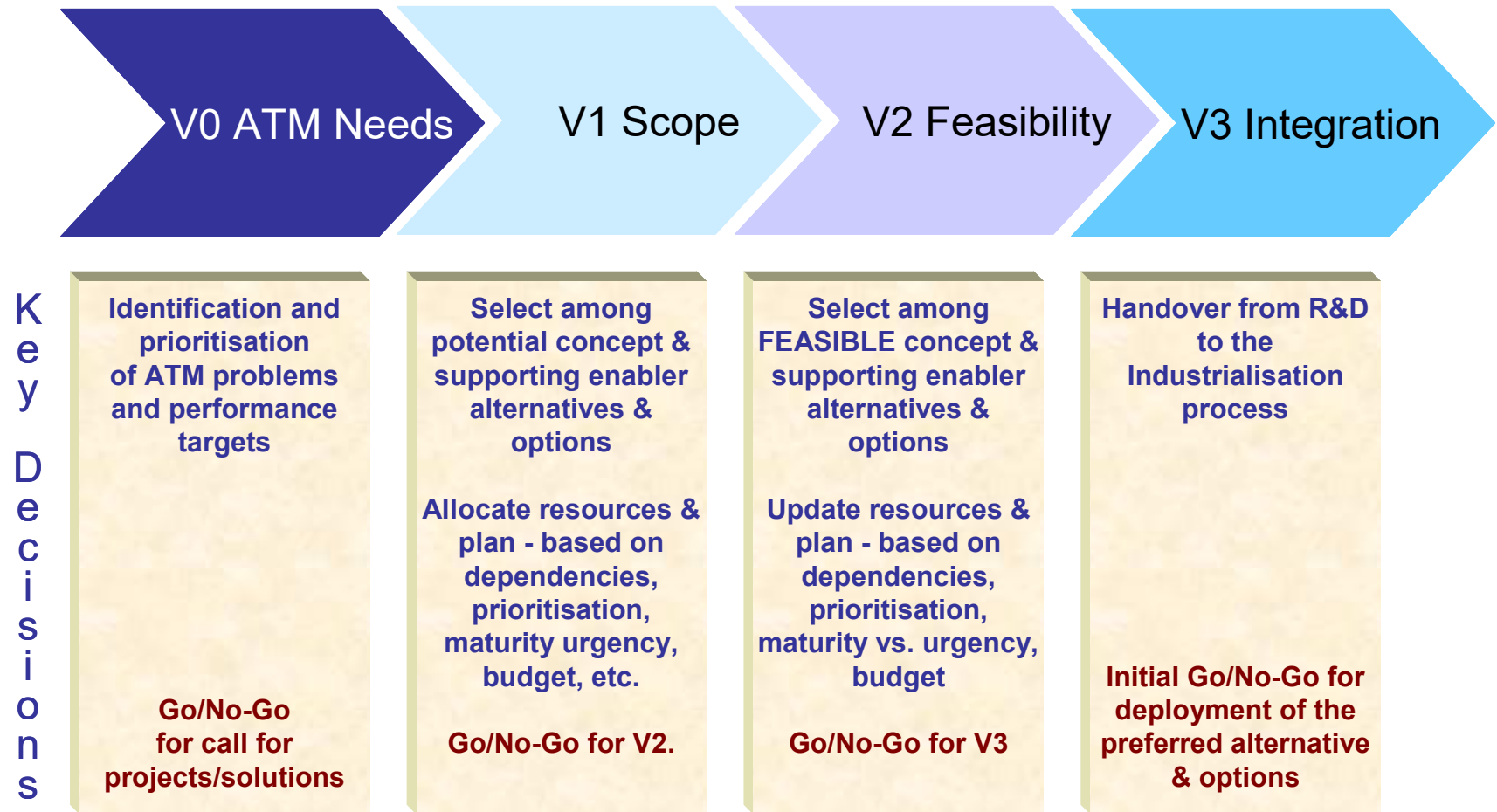| Year	Event
mid 90s	Recognition of lack of Business Case support to decision making
2000	
2001	
2002	EUROCONTROL makes the Validation Data Repository available (June)
	MAEVA provides first version of the Validation Guide Handbook (June)
2003	
2004	MAEVA project completed (April)
	CAATS project started (April)
	First meeting of the Joint Programme Board (JPB) (Oct)
2005	JPB endorses E-OCVM for collaborative projects for EC and EUROCONTROL (Jan)
	Validation Forum Supervisory Board set-up (May)
	Release of E-OCVM v 1.0 (June)
	First meeting of Validation Forum Supervisory Board (Nov)
2006	CAATS project completed (March)
	CAATS II project started (Nov)
2007	**Release of E-OCVM v 2.0**
	Episode 3 project started (April)
2008	
2009	CAATS II project completed (Nov)
	Episode 3 project completed (Dec)
2010	**Release of E-OCVM v 3.0**

[Source:E-OCMV3 Eurocontrol, 2010]

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Validation at the early concept stage

V0 ATM Needs	V1 Scope	V2 Feasibility	V3 Integration

Key Decisions

Identification and prioritisation of ATM problems and performance targets	Select among potential concept & supporting enabler alternatives & options	Select among FEASIBLE concept & supporting enabler alternatives & options	Handover from R&D to the Industrialisation process
	Allocate resources & plan - based on dependencies, prioritisation, maturity urgency, budget, etc.	Update resources & plan - based on dependencies, prioritisation, maturity vs. urgency, budget	
Go/No-Go for call for projects/solutions	Go/No-Go for V2.	Go/No-Go for V3	Initial Go/No-Go for deployment of the preferred alternative & options

[Source:E-OCMV3 Eurocontrol, 2010]

Concurrent activities

| ATM Needs | Scope | Feasibility | Pre-industrial development & integration | Industrialisation | Deployment | Operations | Decommissioning |

V0 V1 V2 V3 V4 V5 V6 V7

Concept Validation (E-OCVM)

Requirements development

Concept development

Technical development and Verification

Integration

Examples of other key ATM system development activities

[Source:E-OCMV3 Eurocontrol, 2010]

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Interdisciplinary activities

[Source:E-OCMV3 Eurocontrol, 2010]
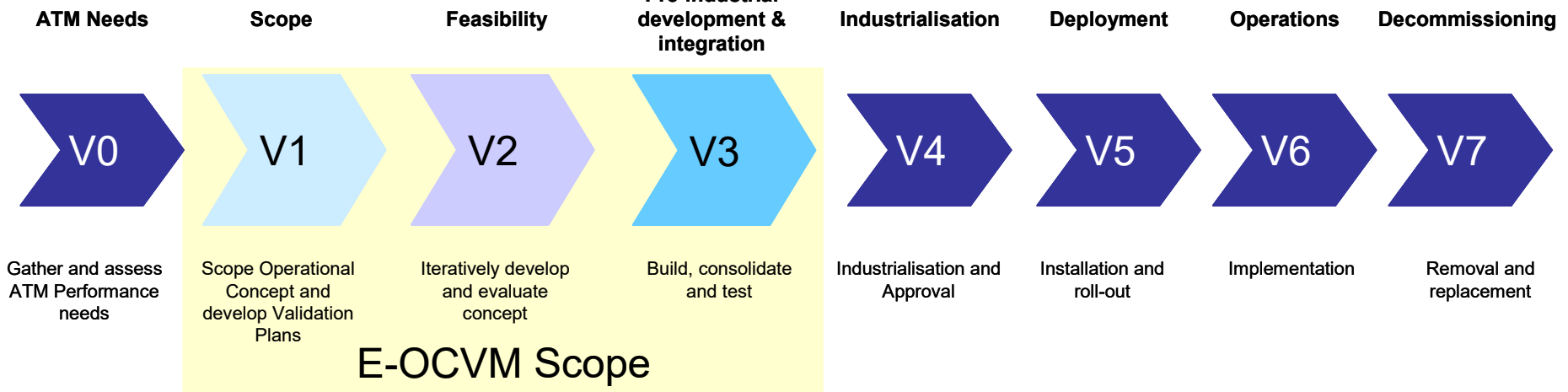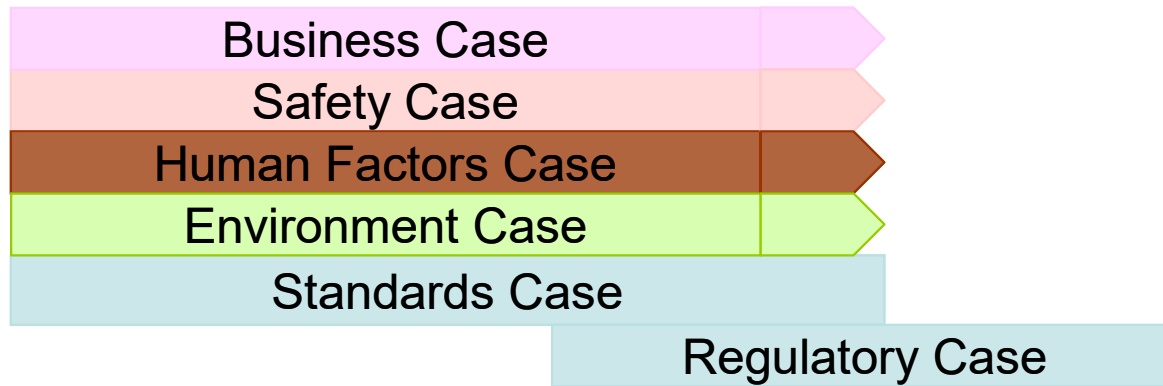
V&V in your MSc thesis

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What does all this mean to you?

- Is the basic hypothesis of your thesis research a valid formulation, i.e. relative to your fundamental statement where you identify a potentially causal link between variables & parameters and an outcome?
  - *Be very careful in formalizing your research hypotheses!*
- Can your research goal be validated and proven to be true?
  - *Plan your research design to accommodate the required validation, not just explore and implement!*
- How high will be the quality of the validation in your thesis research?
  - *Design a validation exercise into your thesis work!*

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Practically, MSc design for validation through:

- A clear research hypothesis to be tested – positive, negative or null!
- A clear way to test it, how could you prove it beyond all shadow of doubt?
- Design your research program (your test!) with a realistic view on the time scales, data acquisition, analysis quality, and sensitivities.
- Validate sub-components of the work as well as the overall outcome.
- Don't leave it to the last minute; 2 weeks at the end or even the last month!
- In the final examination, being able to argue with scientific evidence that your findings are original, proven, and relevant!

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The ultimate proof of proper validation

- An engineering relevant journal paper!
- Most rejections (75%) of academic journal submissions are due to either insignificant impact or poor validation!
- One can 'argue':
  - Academia is about the pursuit and development of new knowledge
  - A piece of original TUD MSc work that is validated is new knowledge and needs to be disseminated (published) in the most reputable journals.
  - Therefore journal publication is the ultimate success of an MSc project!
- And lets not forget, industry want to have confidence in the reliability of the results from university models and tools!
- And eventual industrial application should lead to value creation (value engineering) and the improvement of societal quality of life!

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