Architecting of Systems for Participation in Systems-of-Systems

Dieter Scheithauer
Dr.-Ing., INCOSE ESEP

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- Introduction
- Systems Architecting – The Better Systems Engineering?
- The Overall Systems Engineering Value Stream
- The System Life Cycle
- Conclusions

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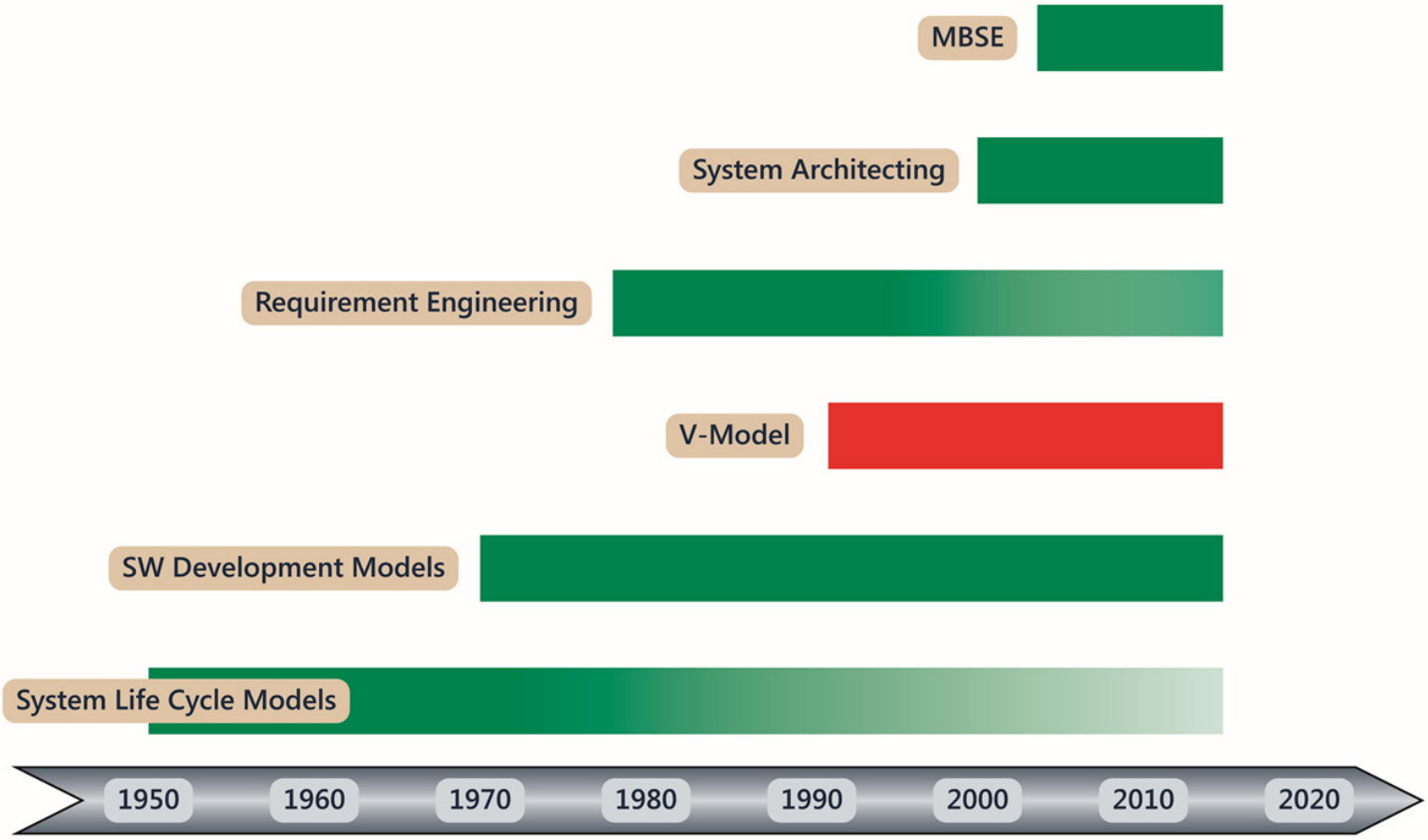
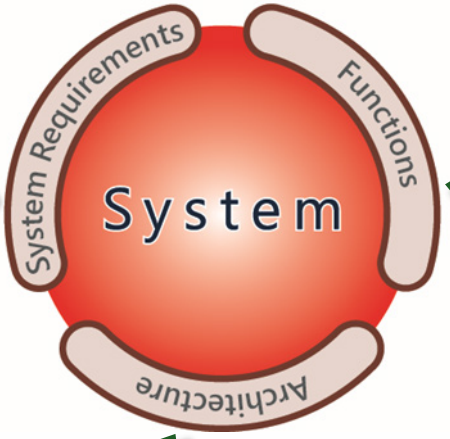
A Short Historical Narrative About the Evolution of Systems Engineering



The Three Essential Views on a System

- Complete system definition by three complementary and consistent views
  - System Requirements,
  - Functional Definition, and
  - Architecture Definition

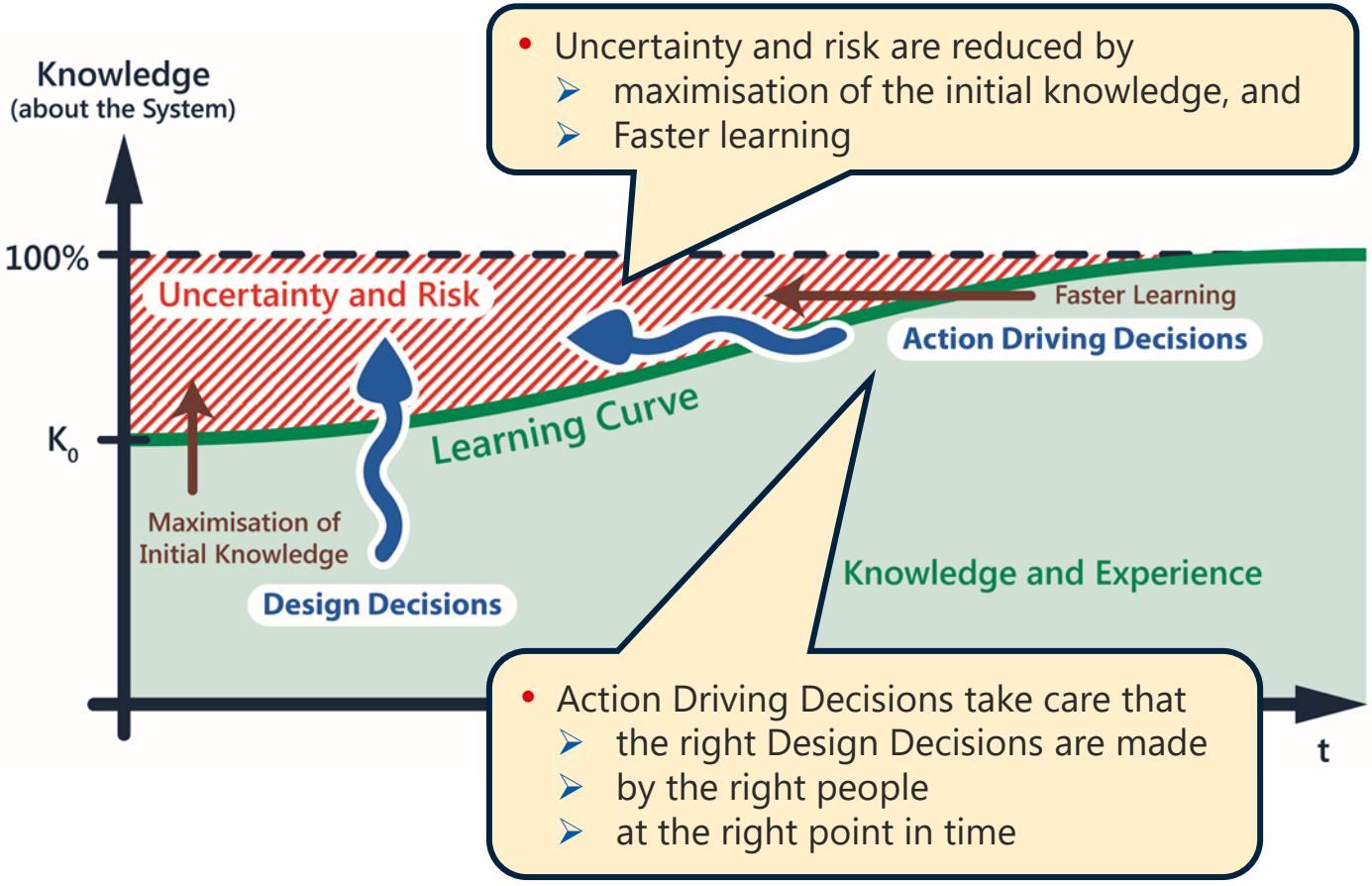
System requirements describe the commitment of the design team for which system features they take responsibility, and for which compliance will be demonstrated accordingly



Functional descriptions utilise the associative human cognitive capabilities for the fast perception of complex situations
(Fast Thinking)

Architectural descriptions utilise the human cognitive capabilities for making distinctions and generating categories
(Slow Thinking)

The Systems Engineering Learning Curve



- Uncertainty and risk are reduced by
  - maximisation of the initial knowledge, and
  - Faster learning

- Action Driving Decisions take care that
  - the right Design Decisions are made
  - by the right people
  - at the right point in time

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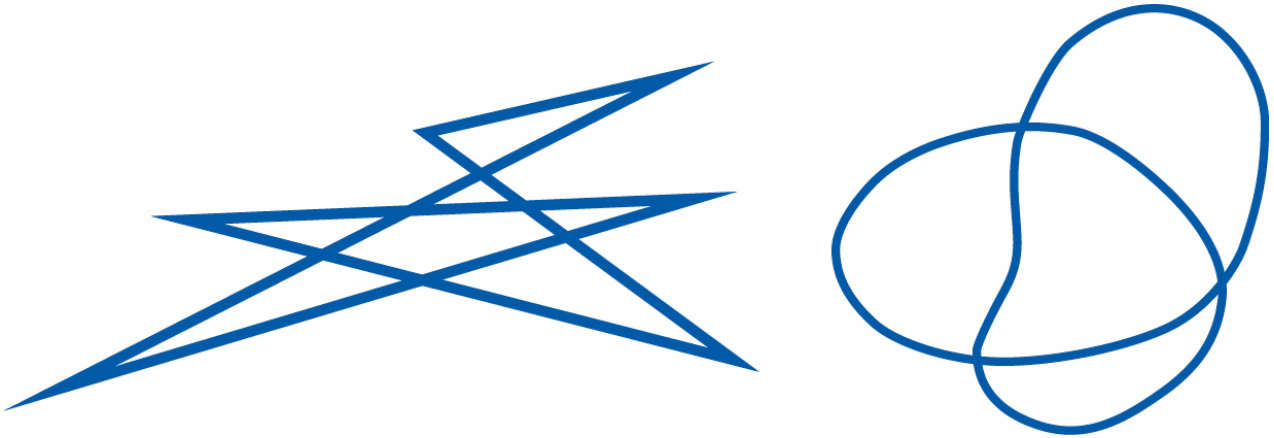
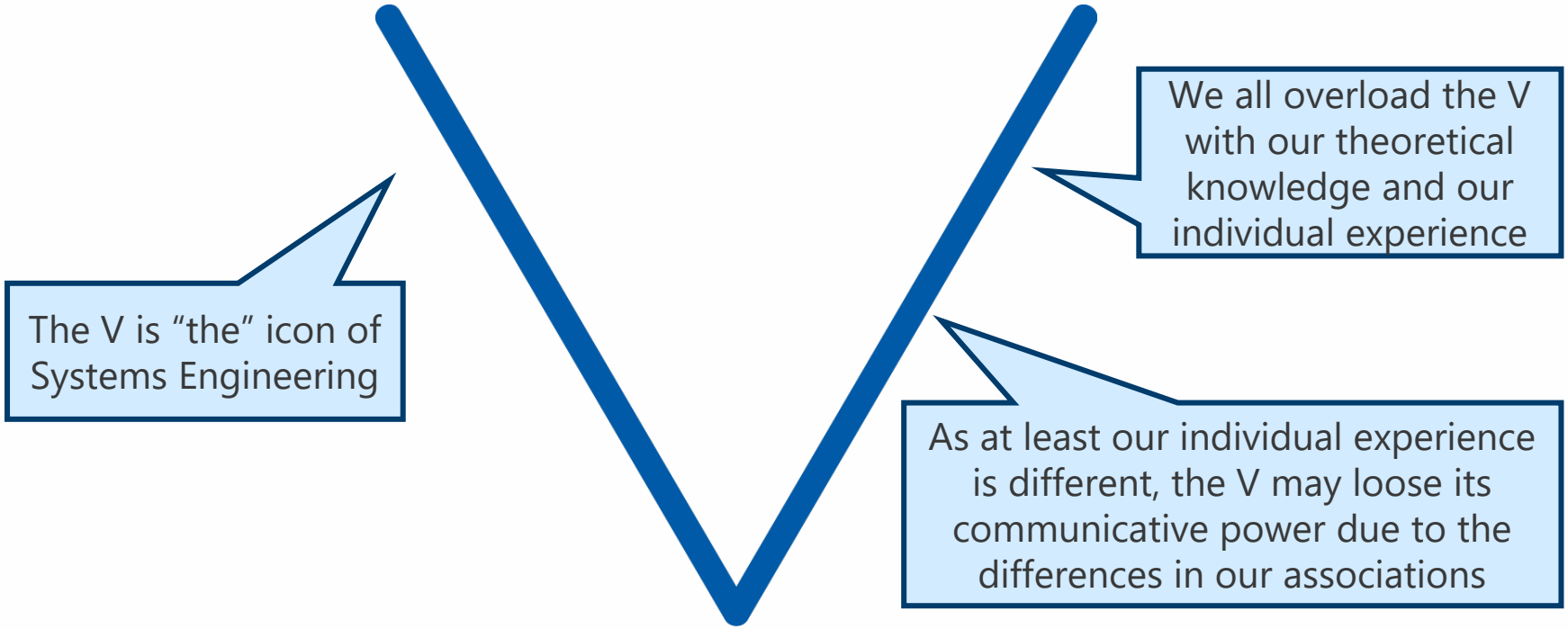
Omulvo and Takete



- Around 90% of all people correlate the two terms with the two figures in the same way although there is no further meaning behind the terms and the figures
- The reason is a natural correlation in the brain between phonemes and figures

➢ ***Icons have communicative power***

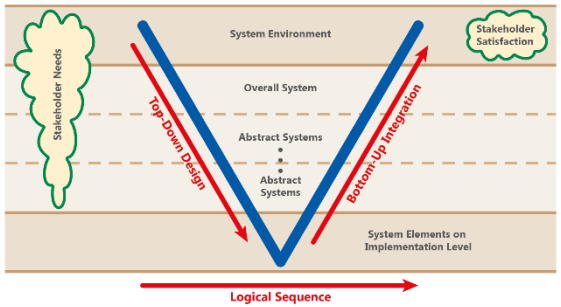
What is This?



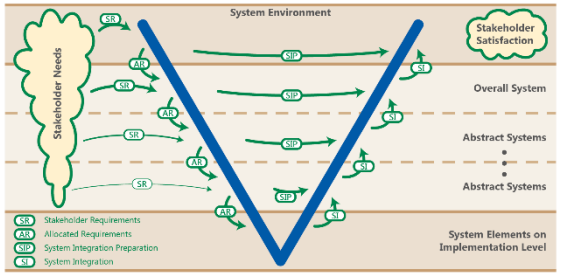
It is the objective of the V-Model Views to define the Overall Systems Engineering Value Stream consistently and unambiguously by strictly applying the flow principle

The Four Vs

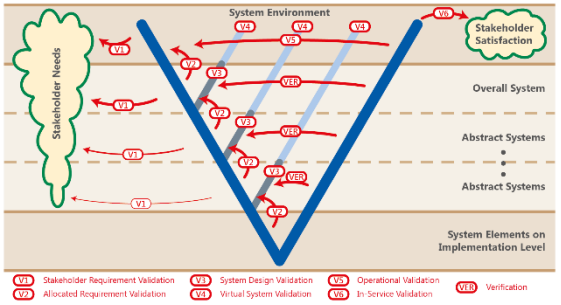
1 The Basic V



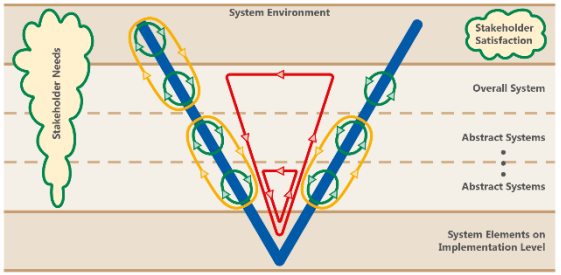
2 The Development V



3 The Assurance V



4 The Dynamic V



The Basic V

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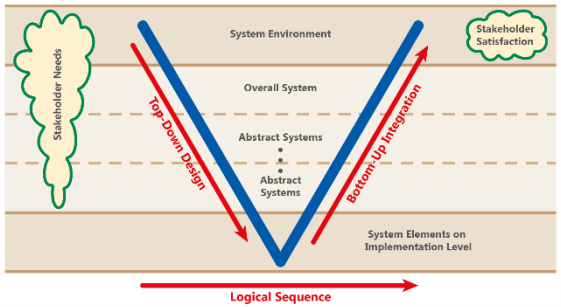

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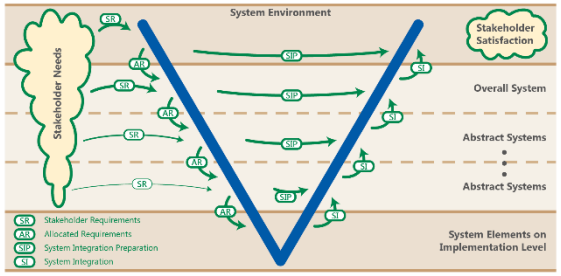

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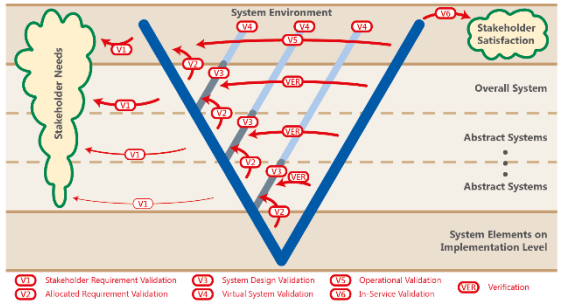

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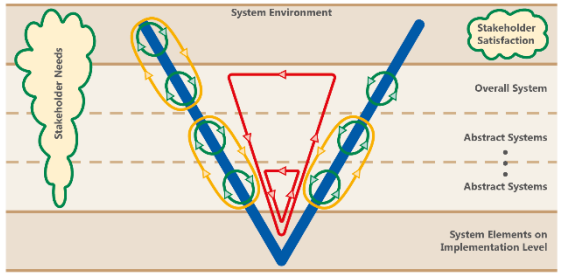
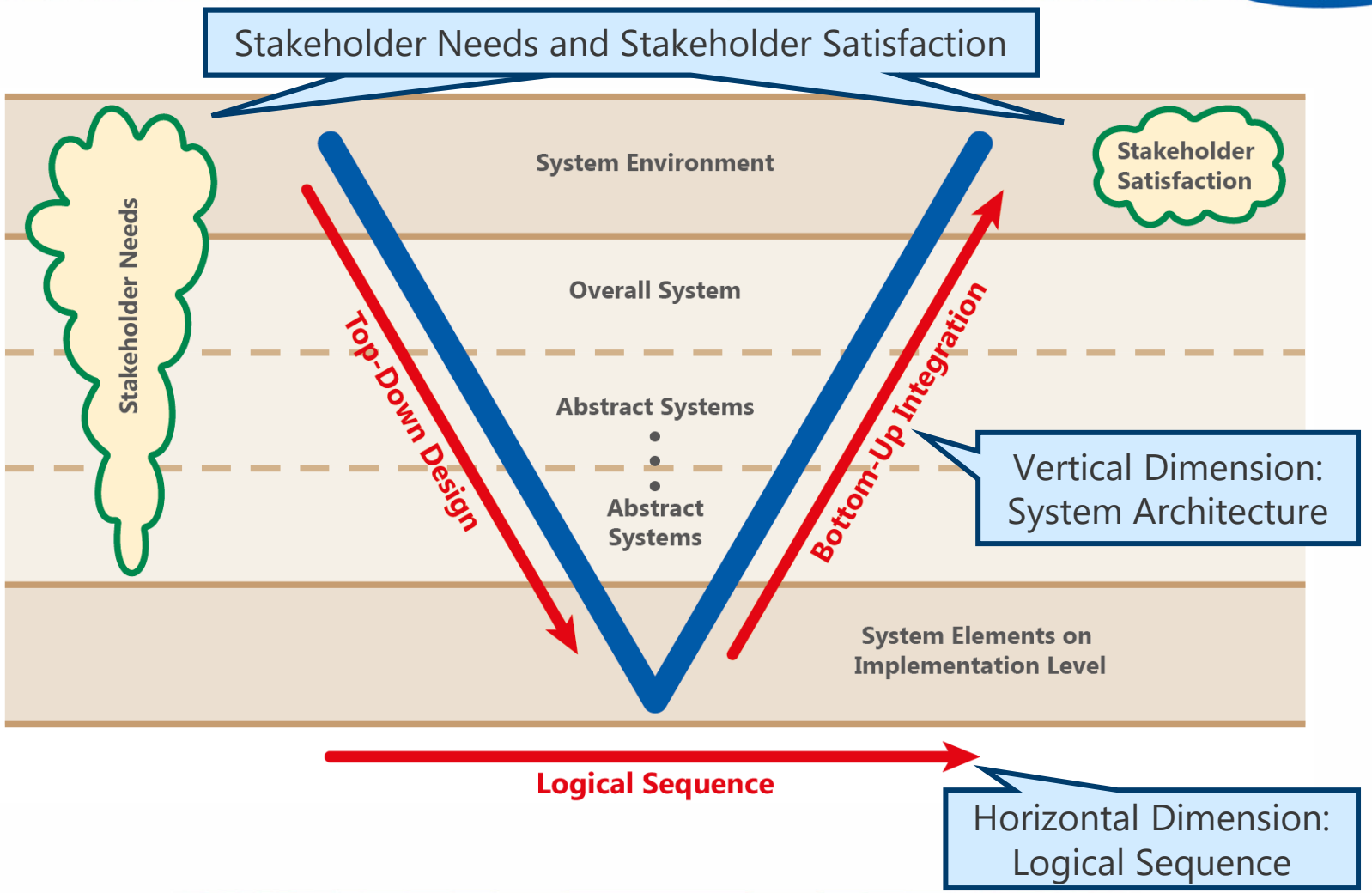
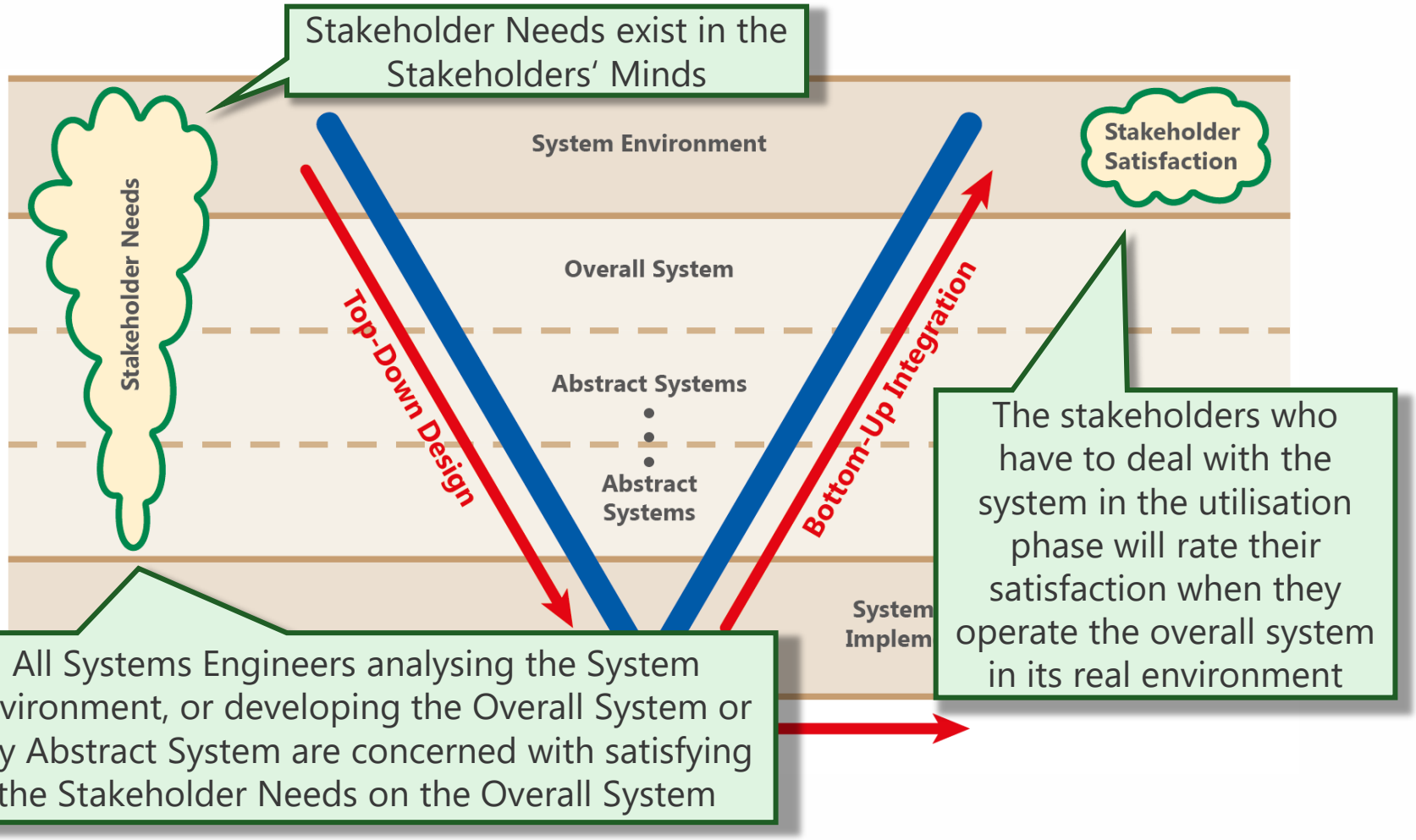


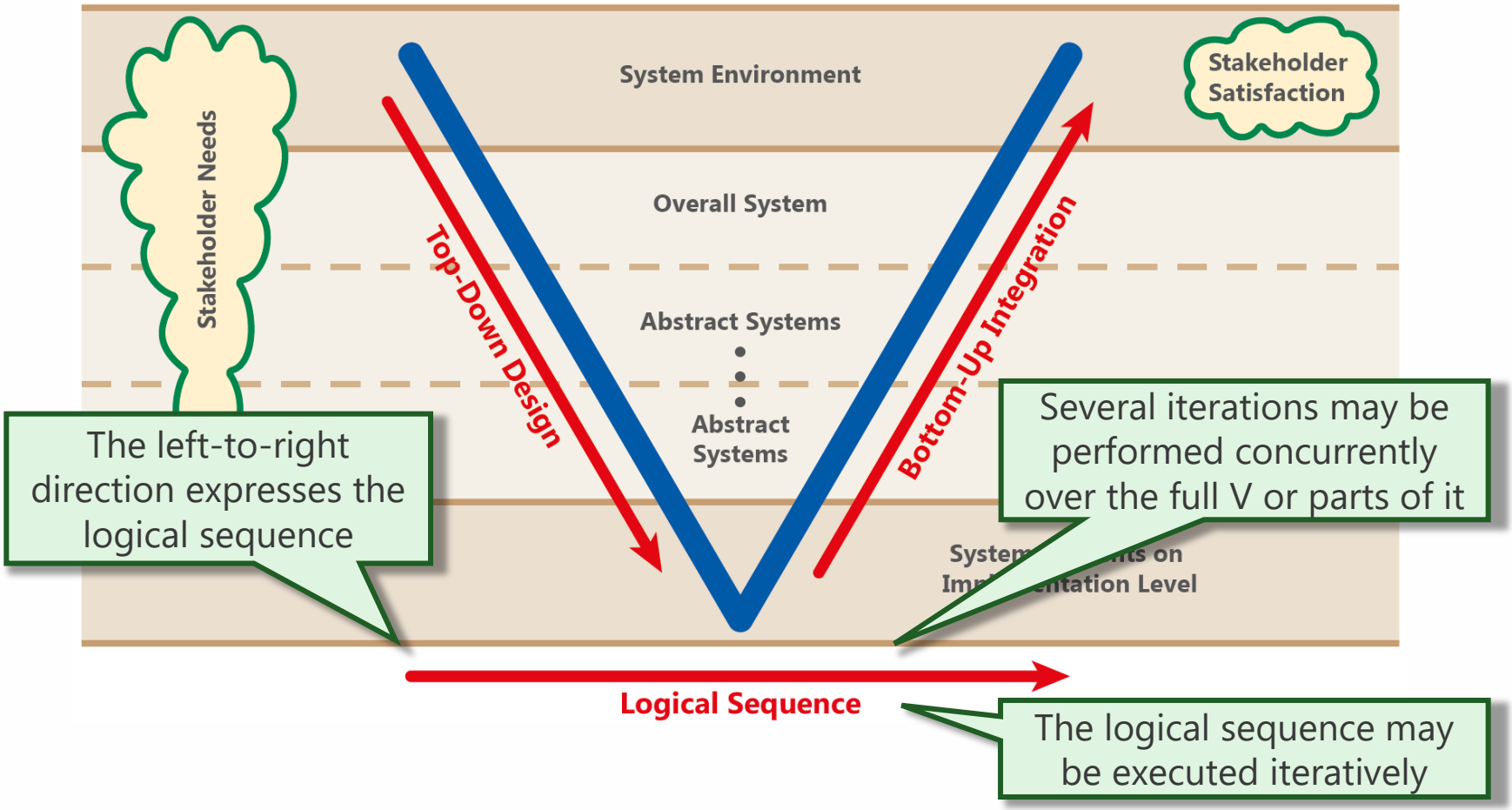
Top-Down Design and Bottom-Up Integration



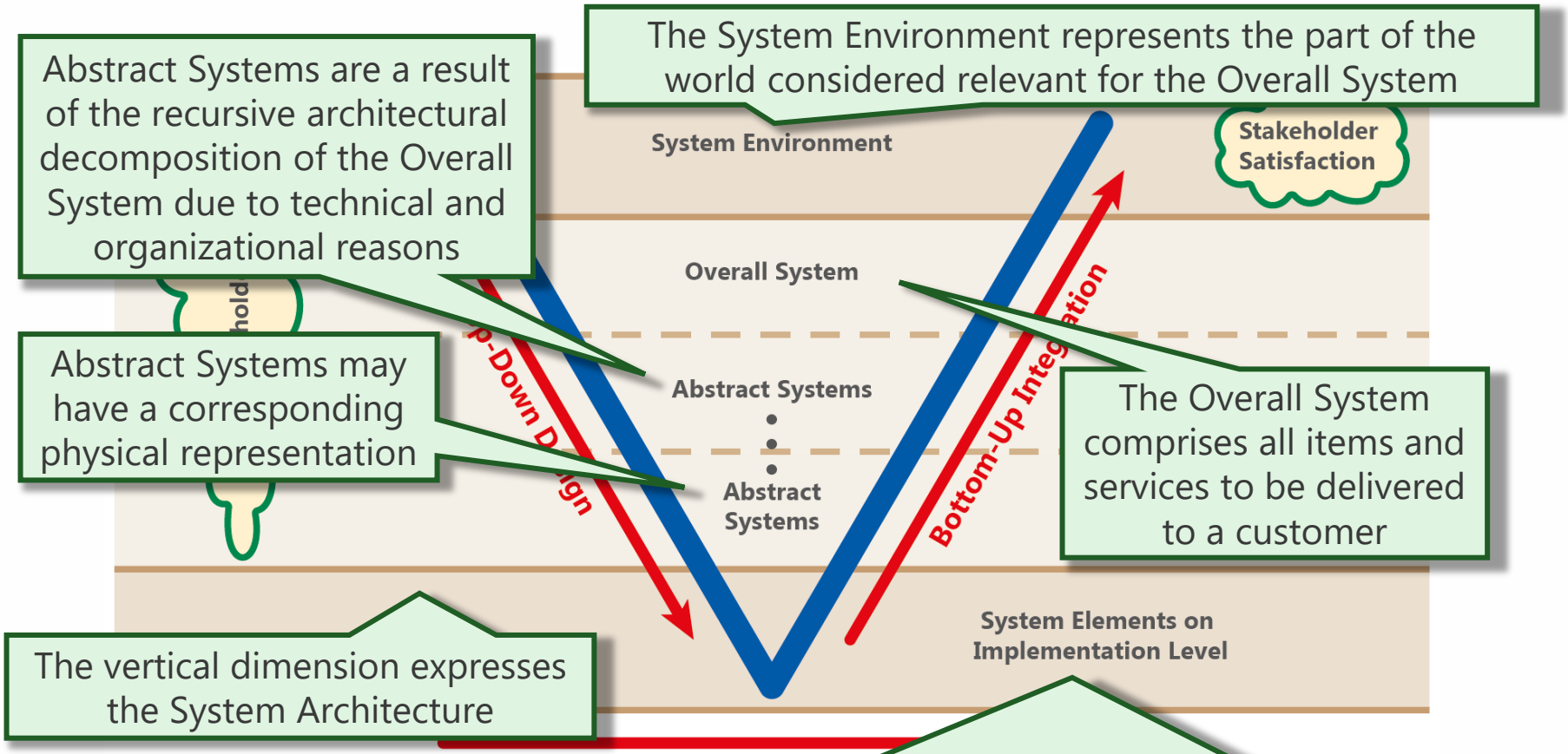
Stakeholder Needs and Stakeholder Satisfaction



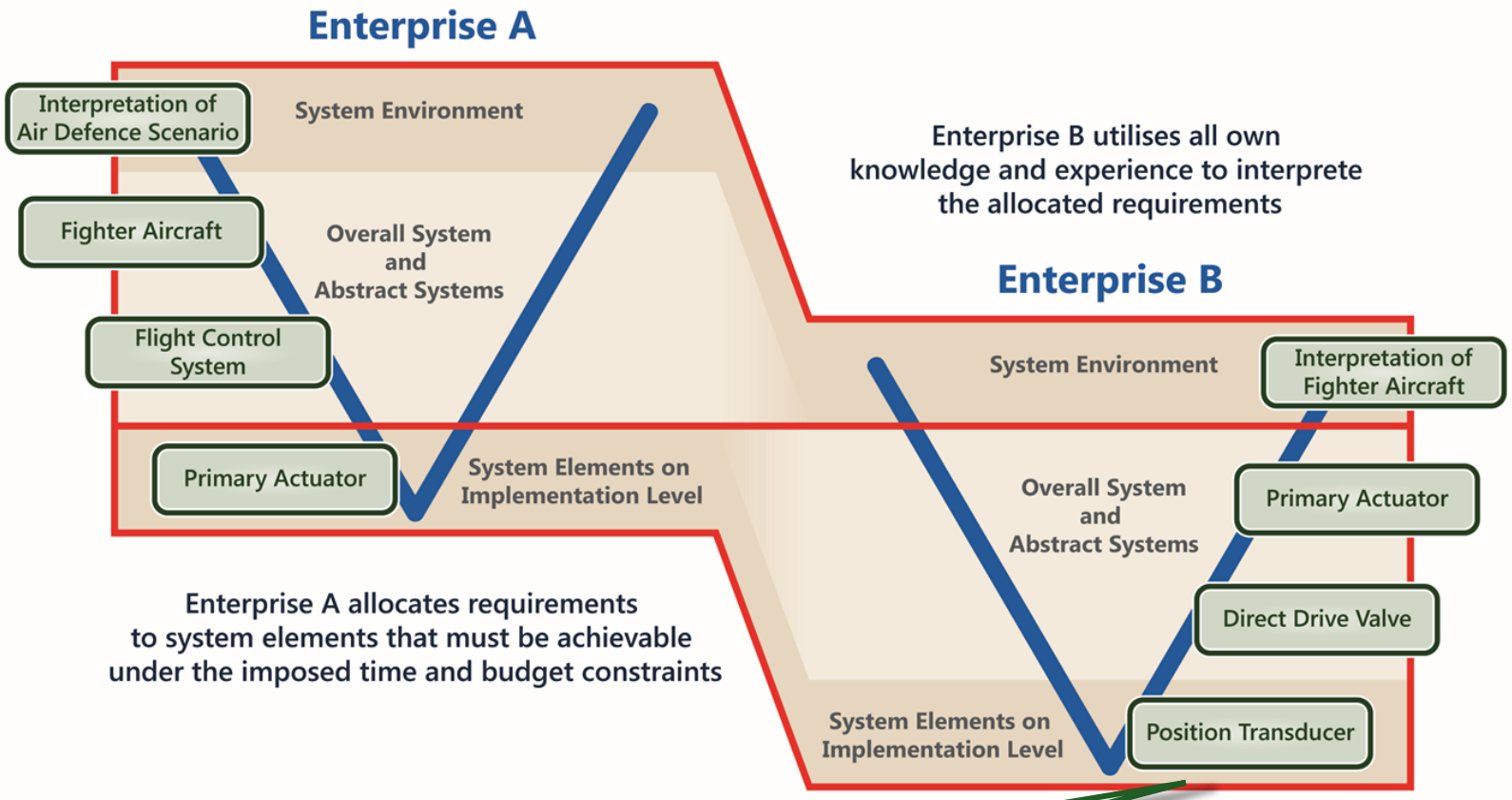
Logical Sequence



System Architecture



Organisational Workshare



The Position Transducer may be an available part not specifically designed for the particular aircraft

The Development V

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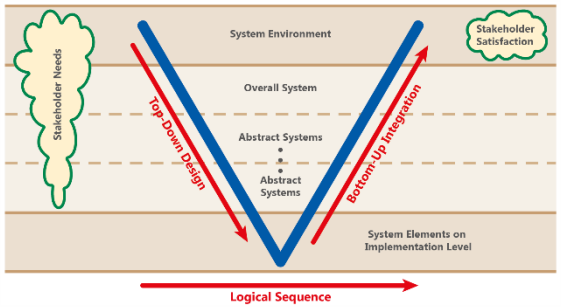

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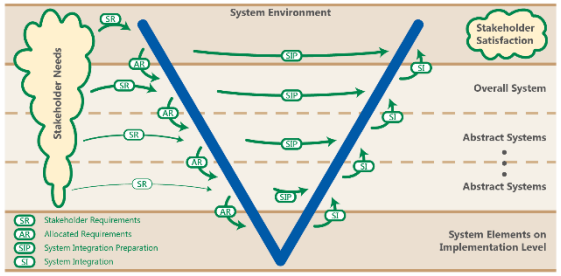

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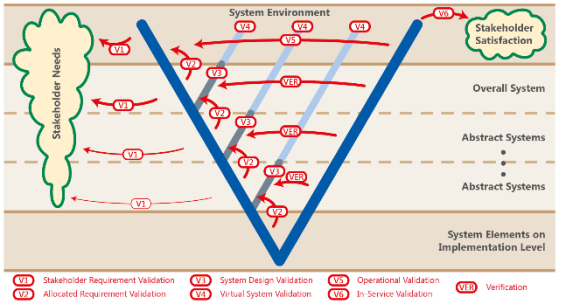
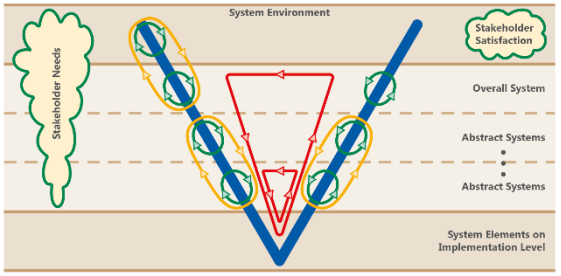
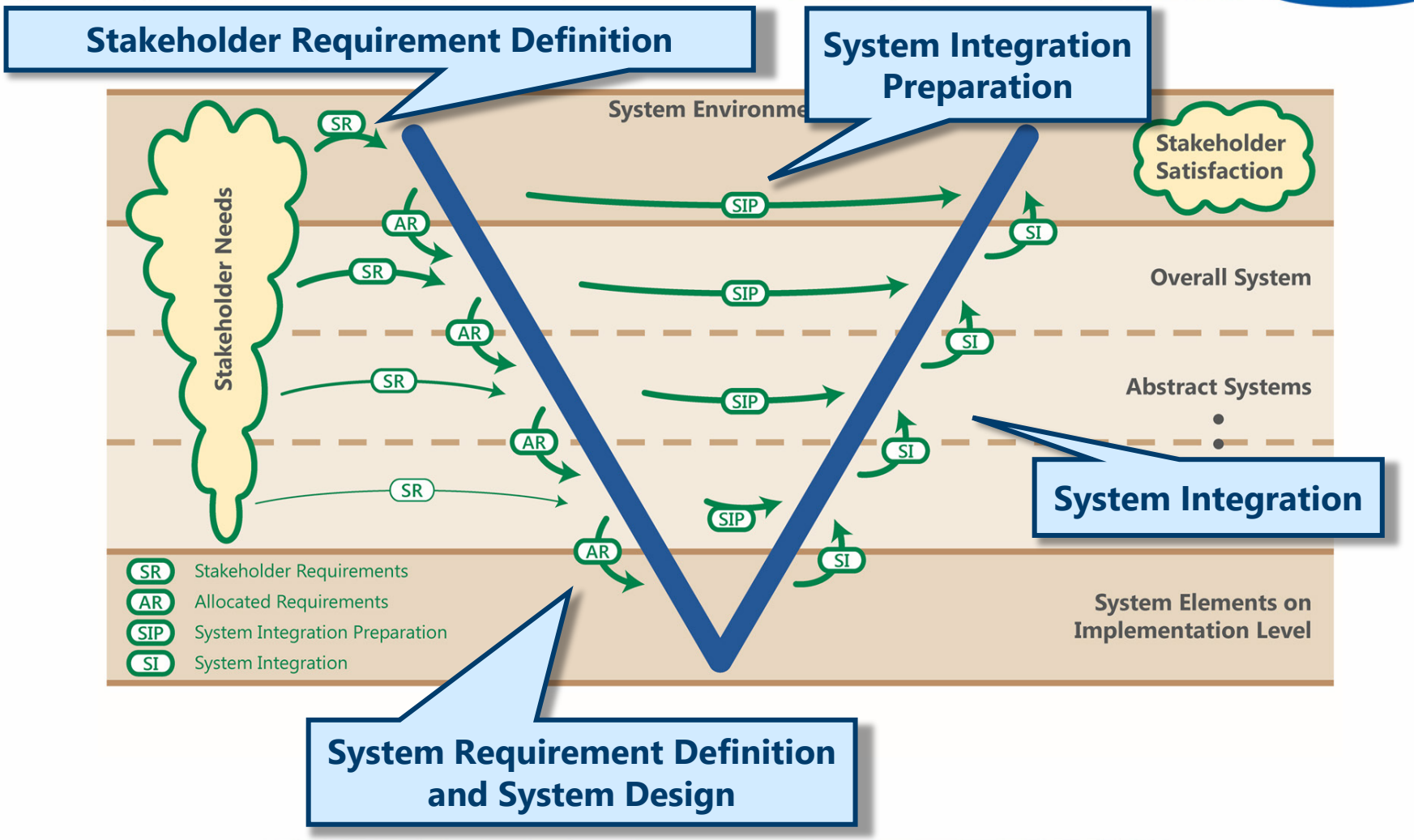


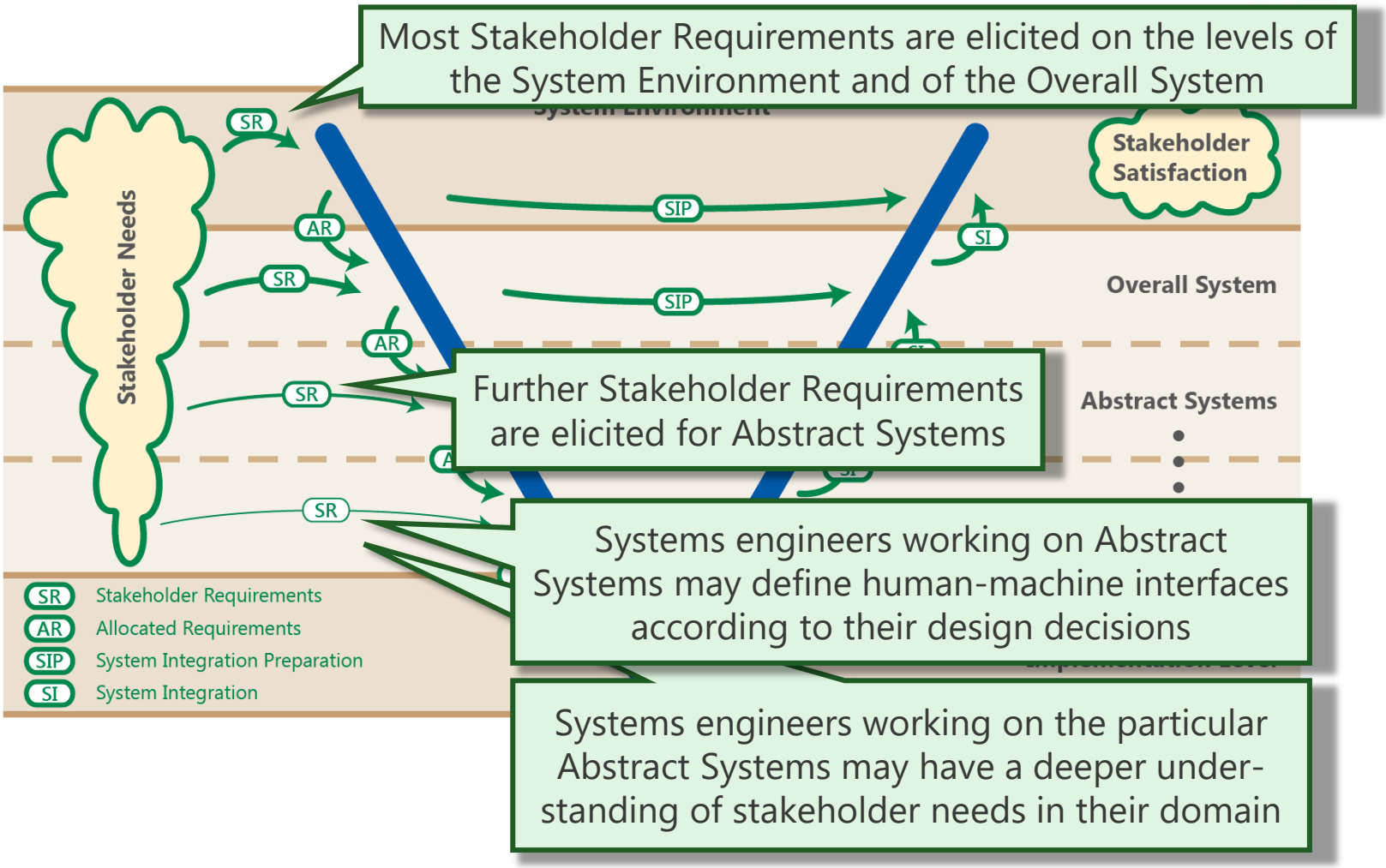
4 The Dynamic V



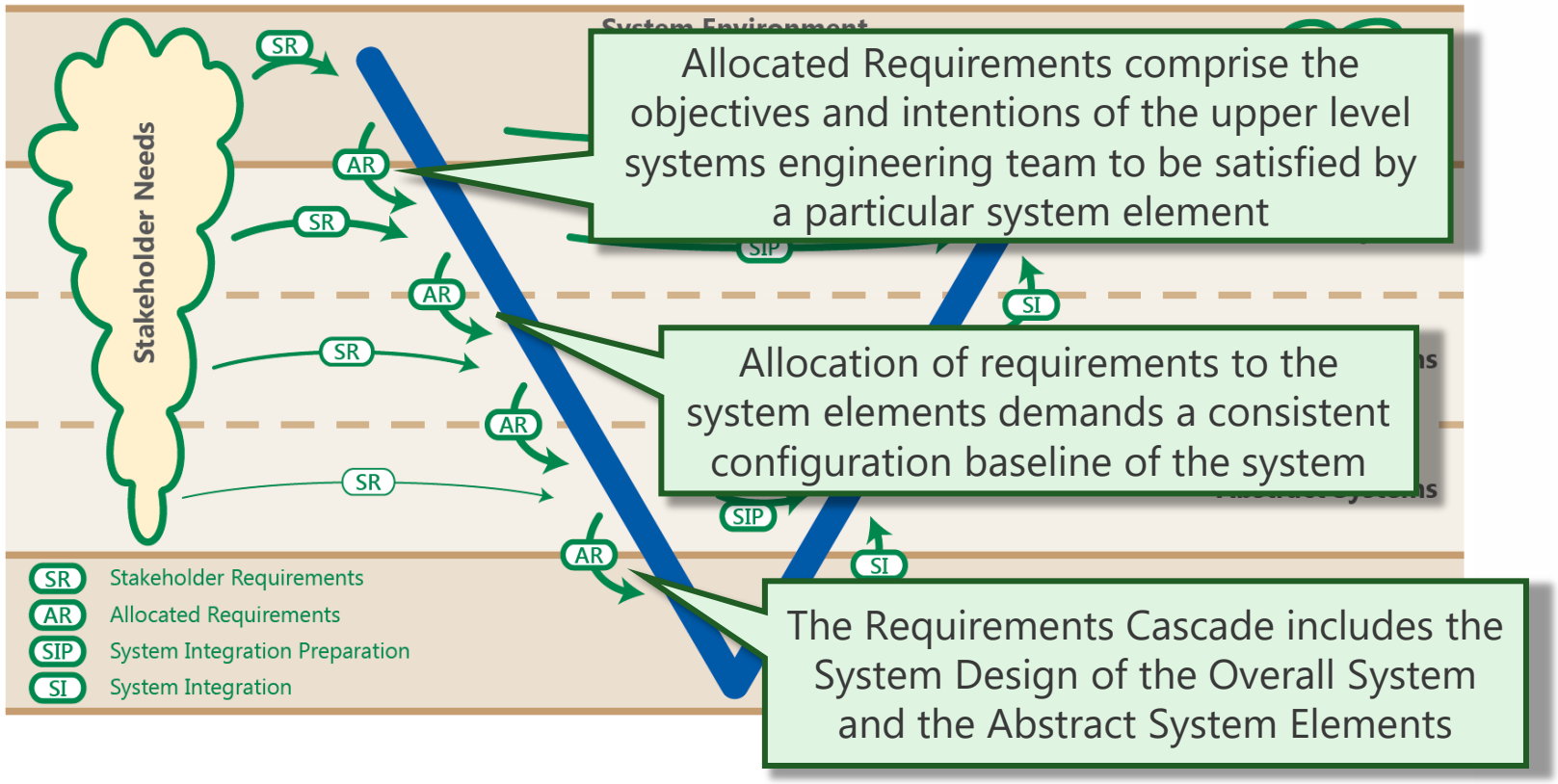
Development Processes



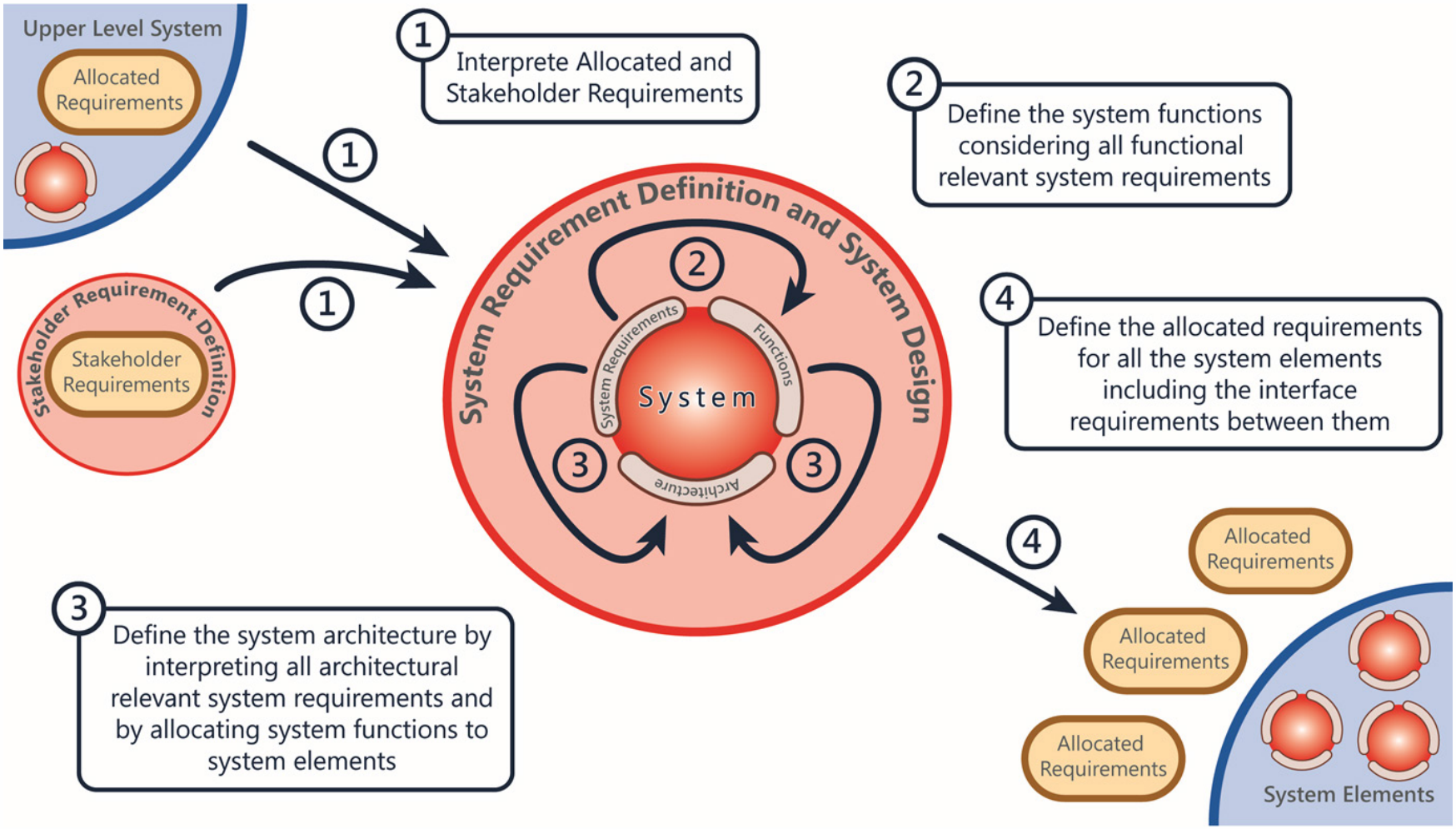
Stakeholder Requirement Definition



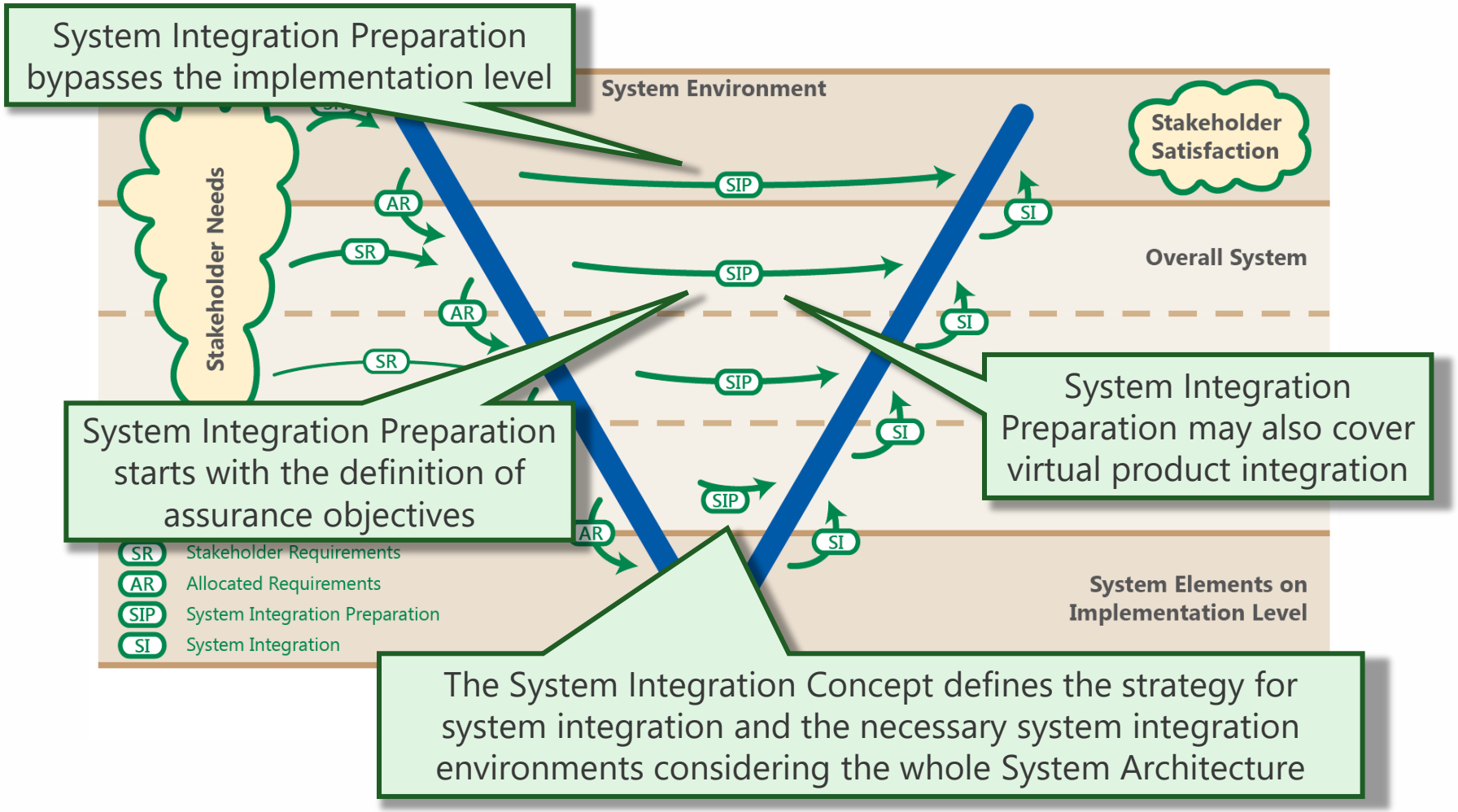
The Requirement Cascade



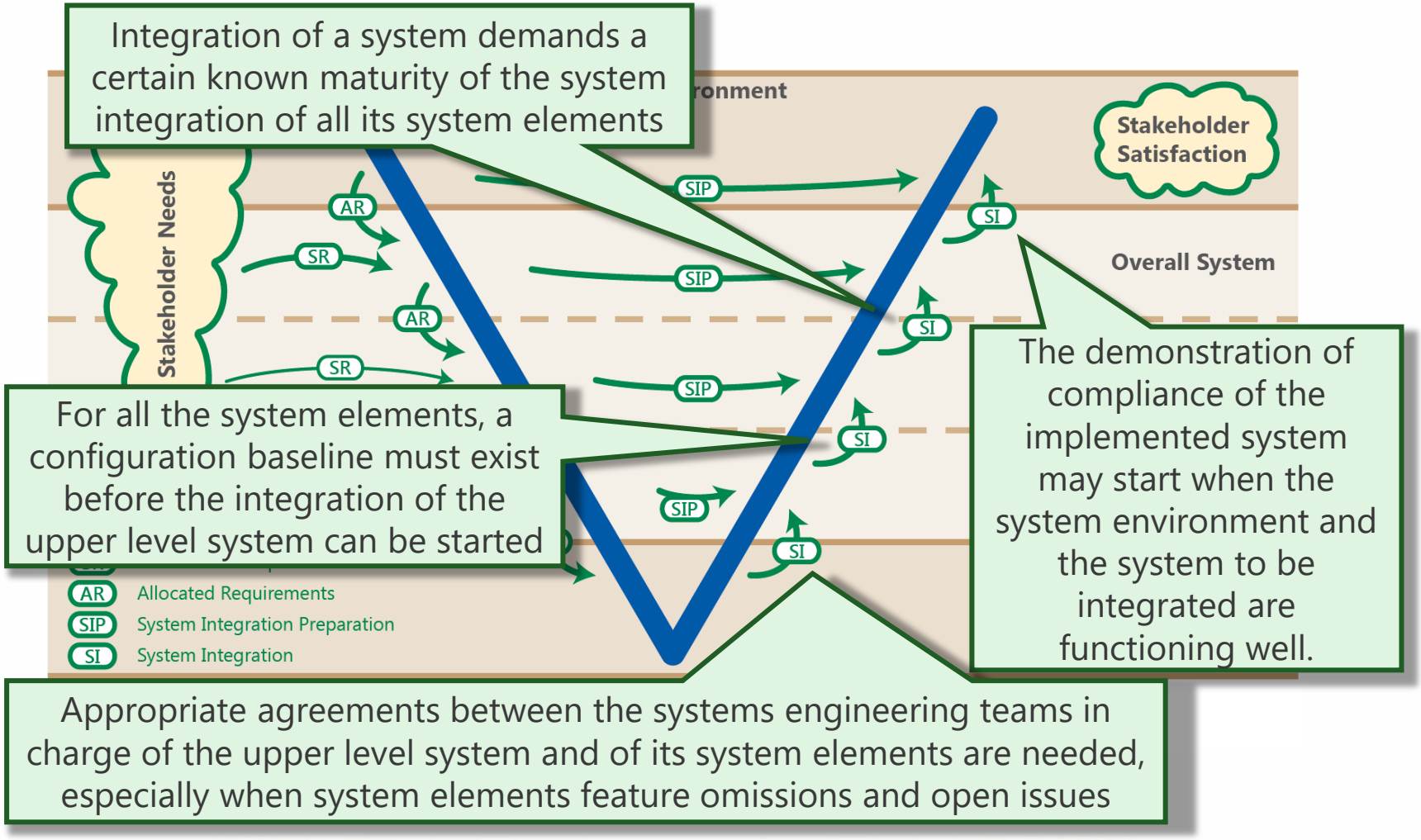
System Requirement Definition and System Design



System Integration Preparation



System Integration



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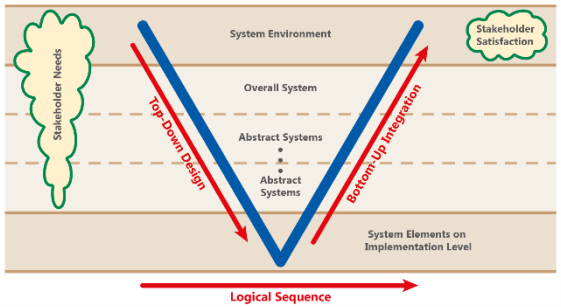

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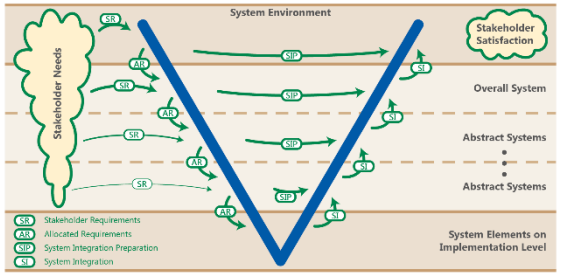

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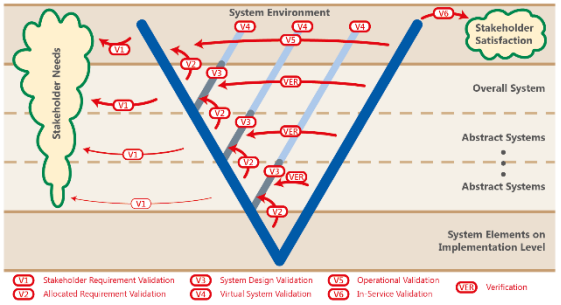

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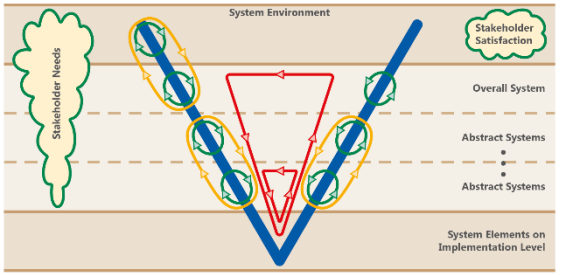

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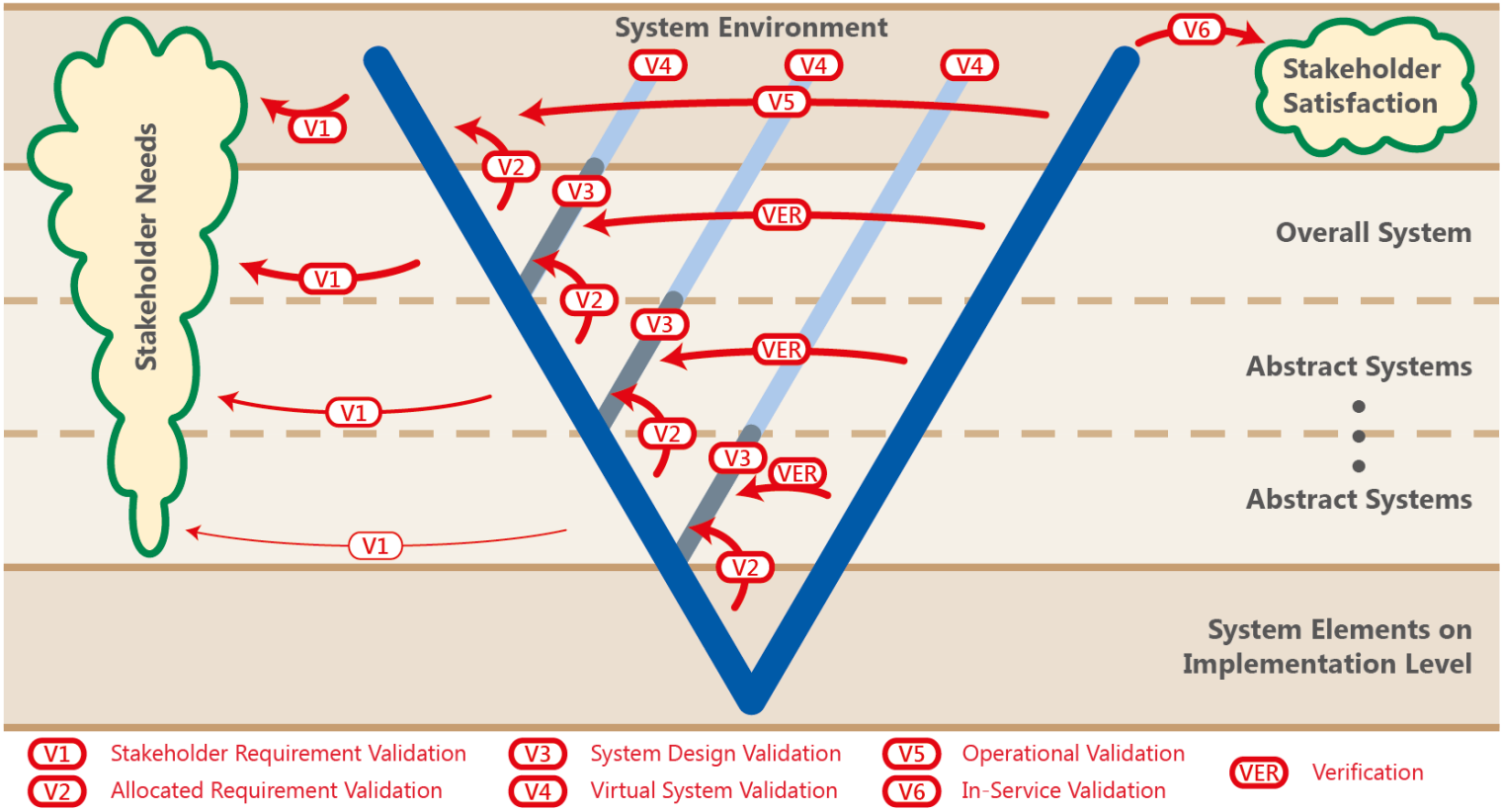

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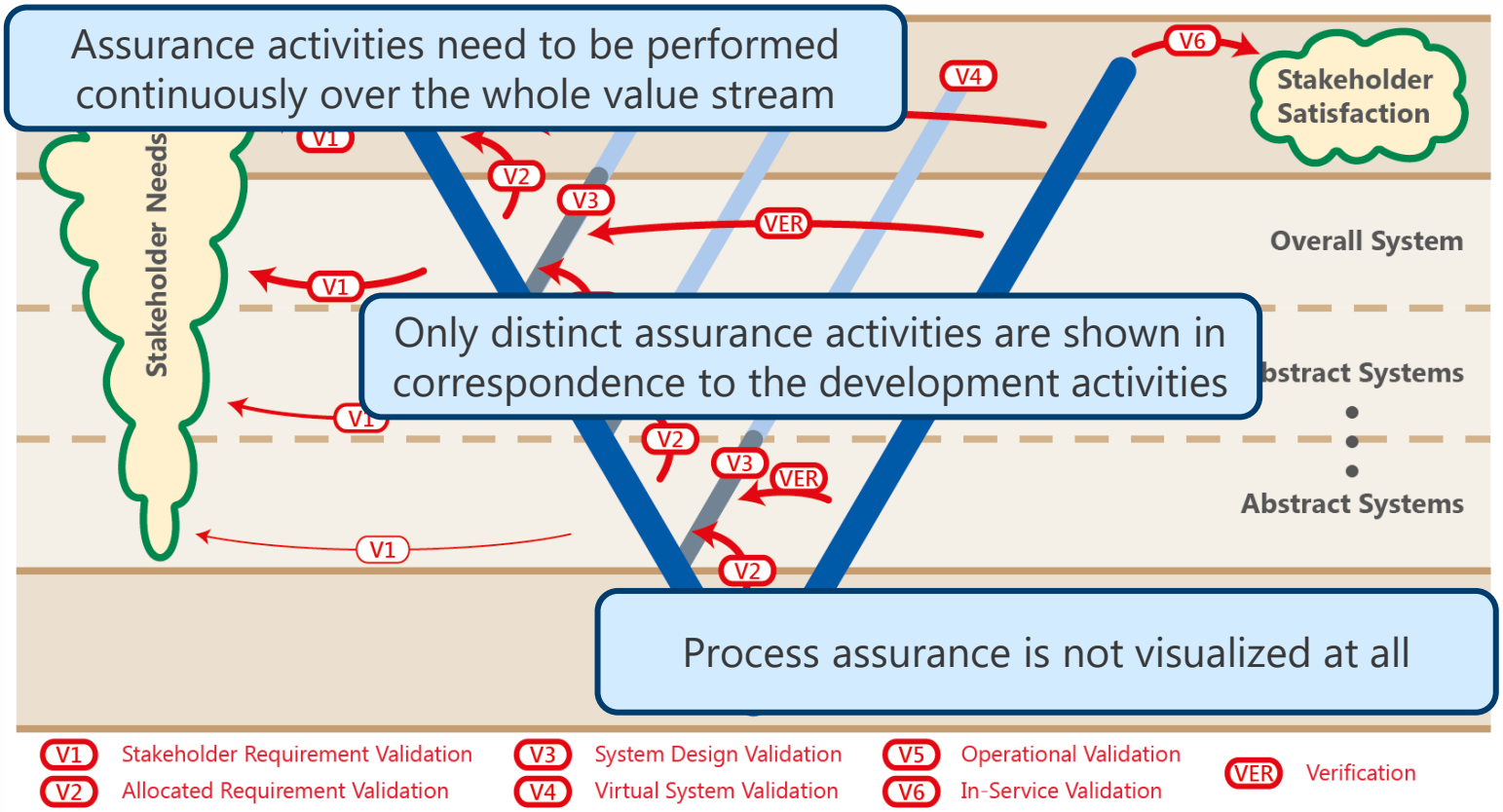
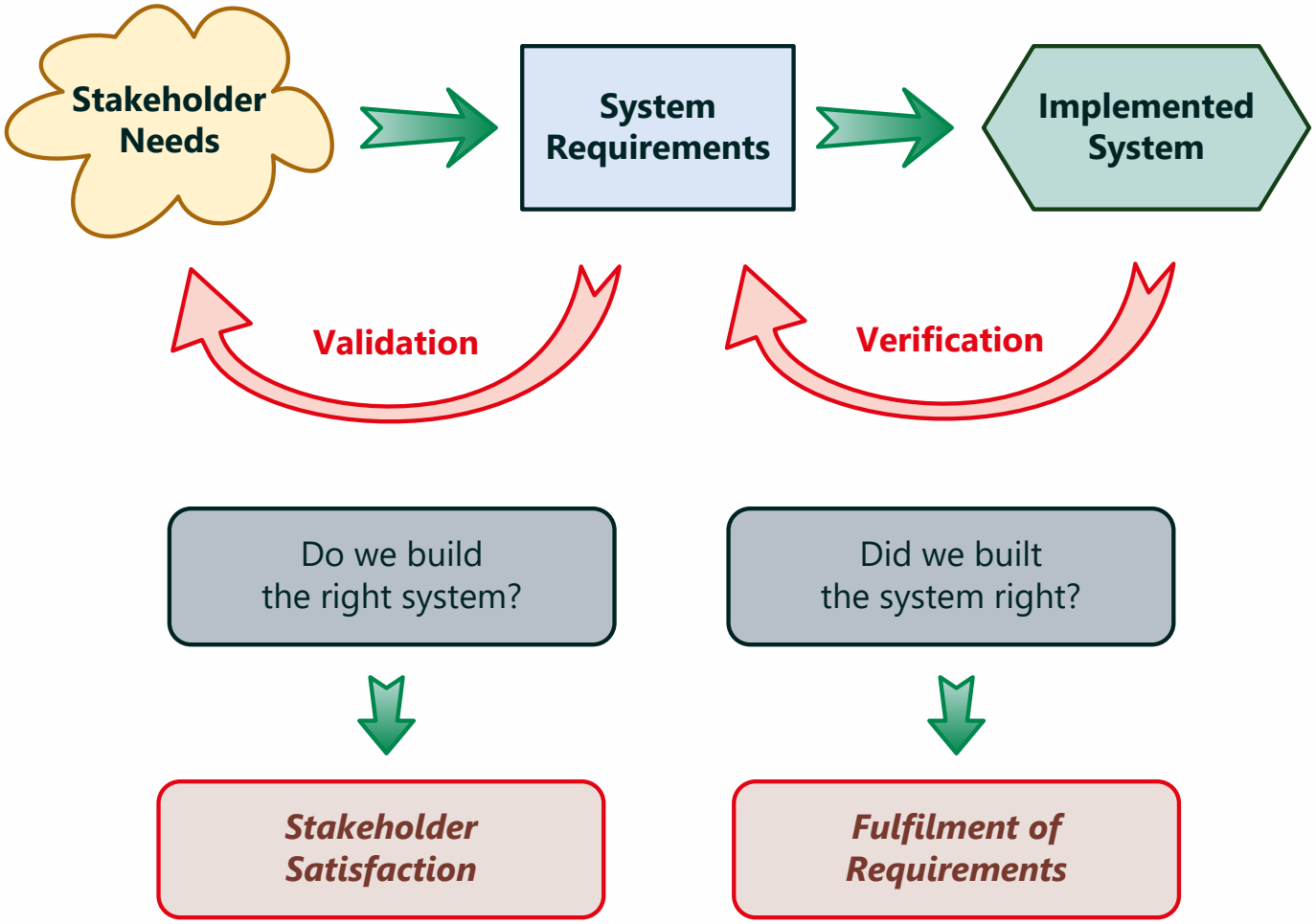
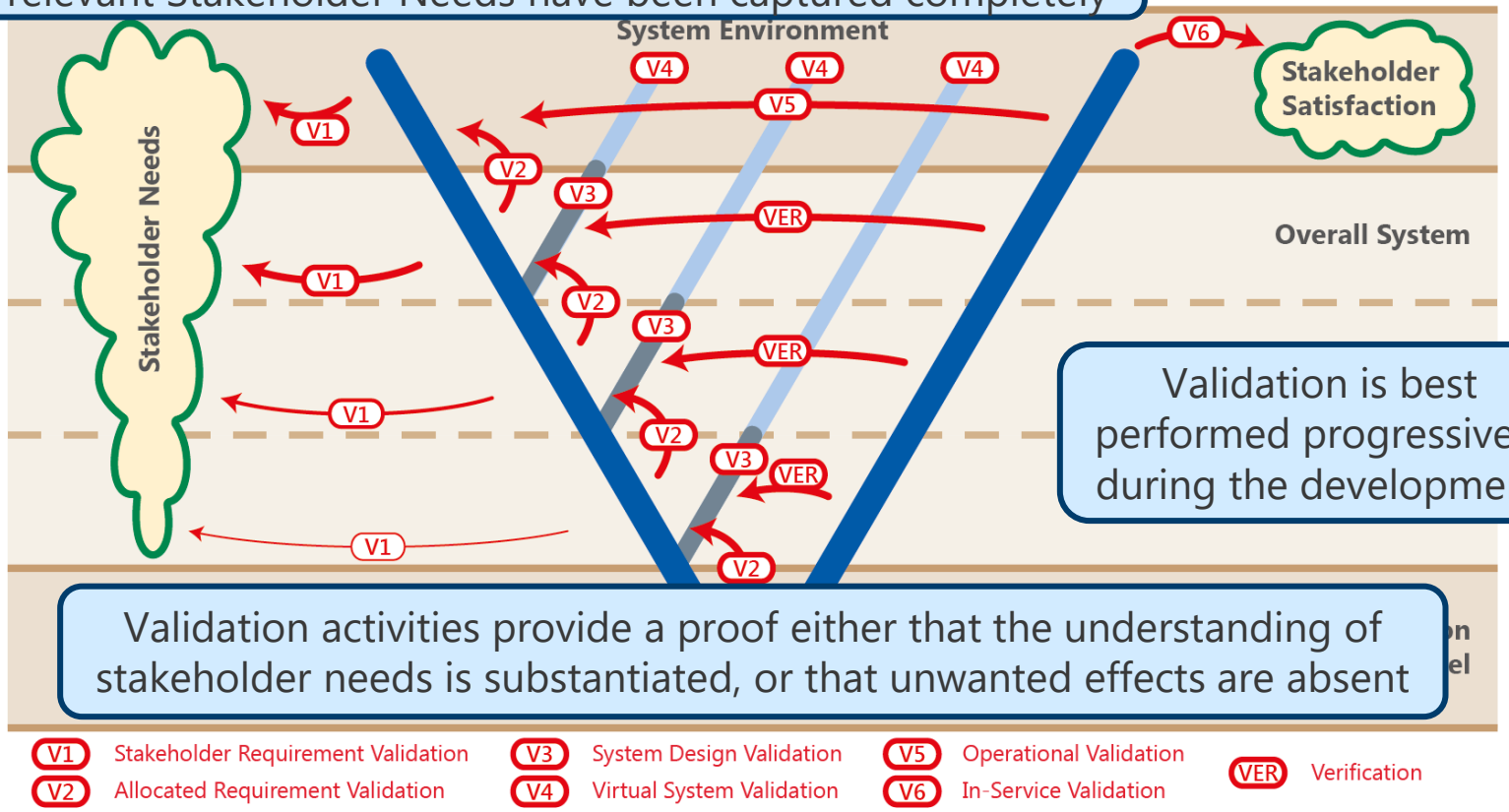


Validation and Verification

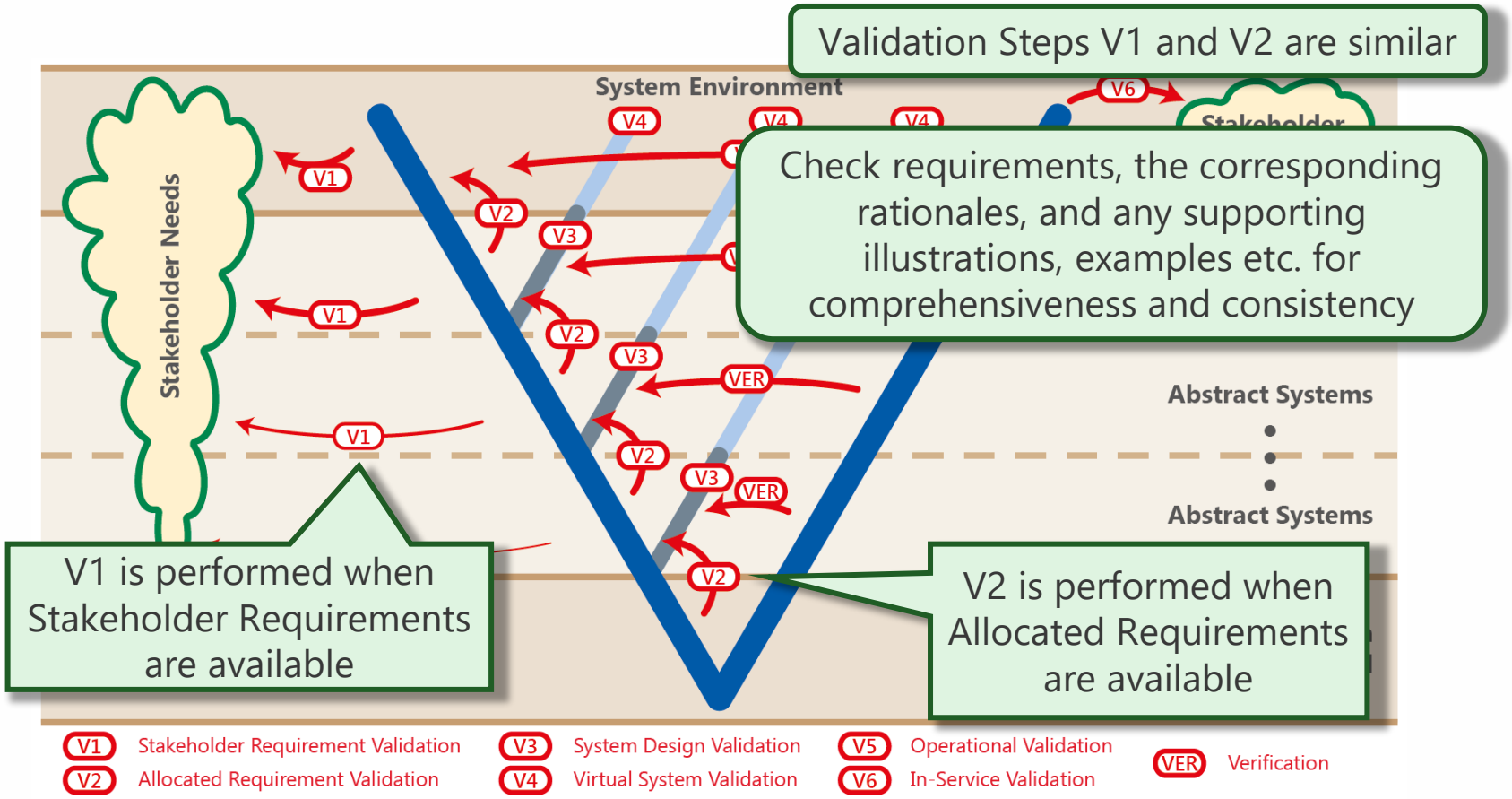


Validation Principles

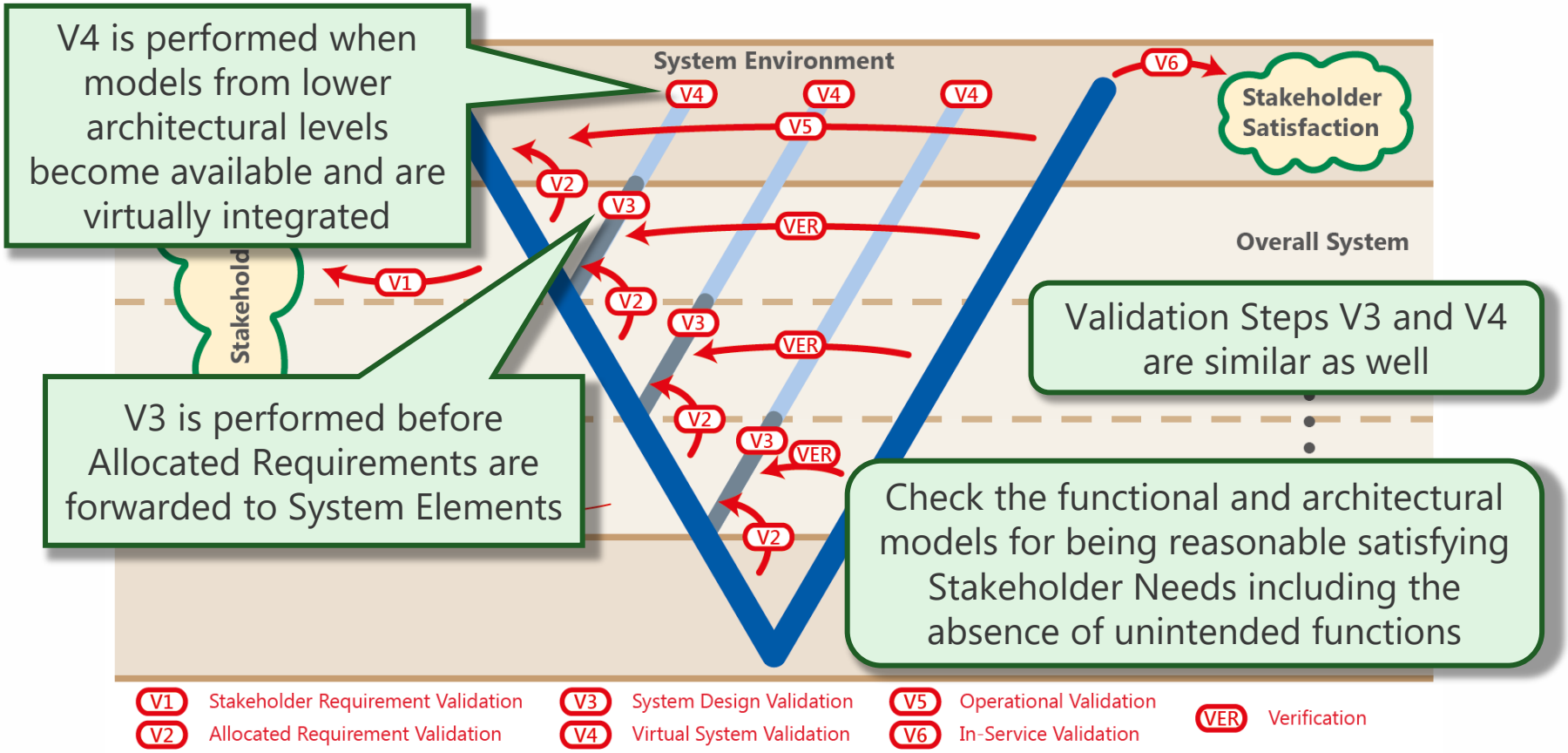
It can never been proven during development that all relevant Stakeholder Needs have been captured completely



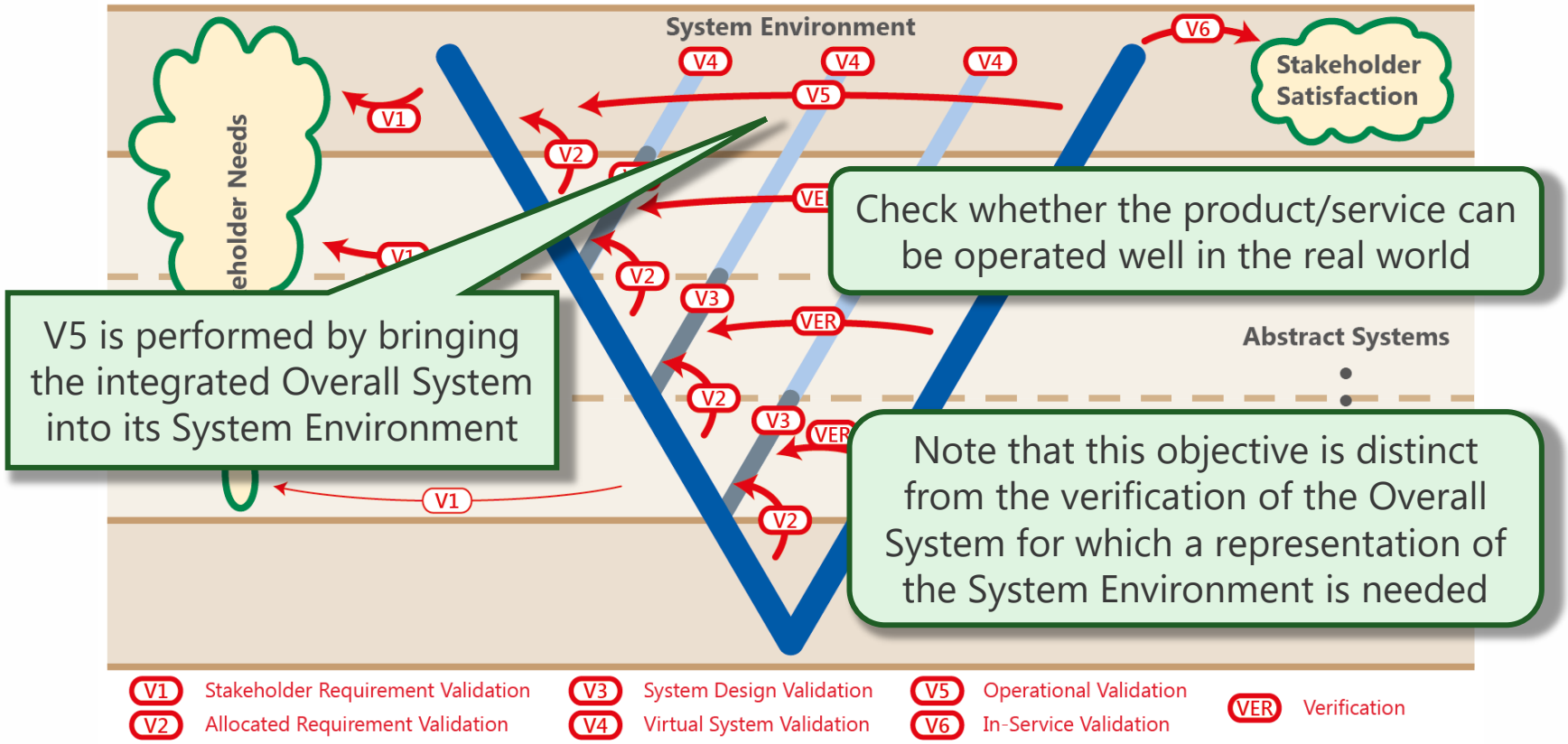
Stakeholder Requirement Validation and Allocated Requirement Validation



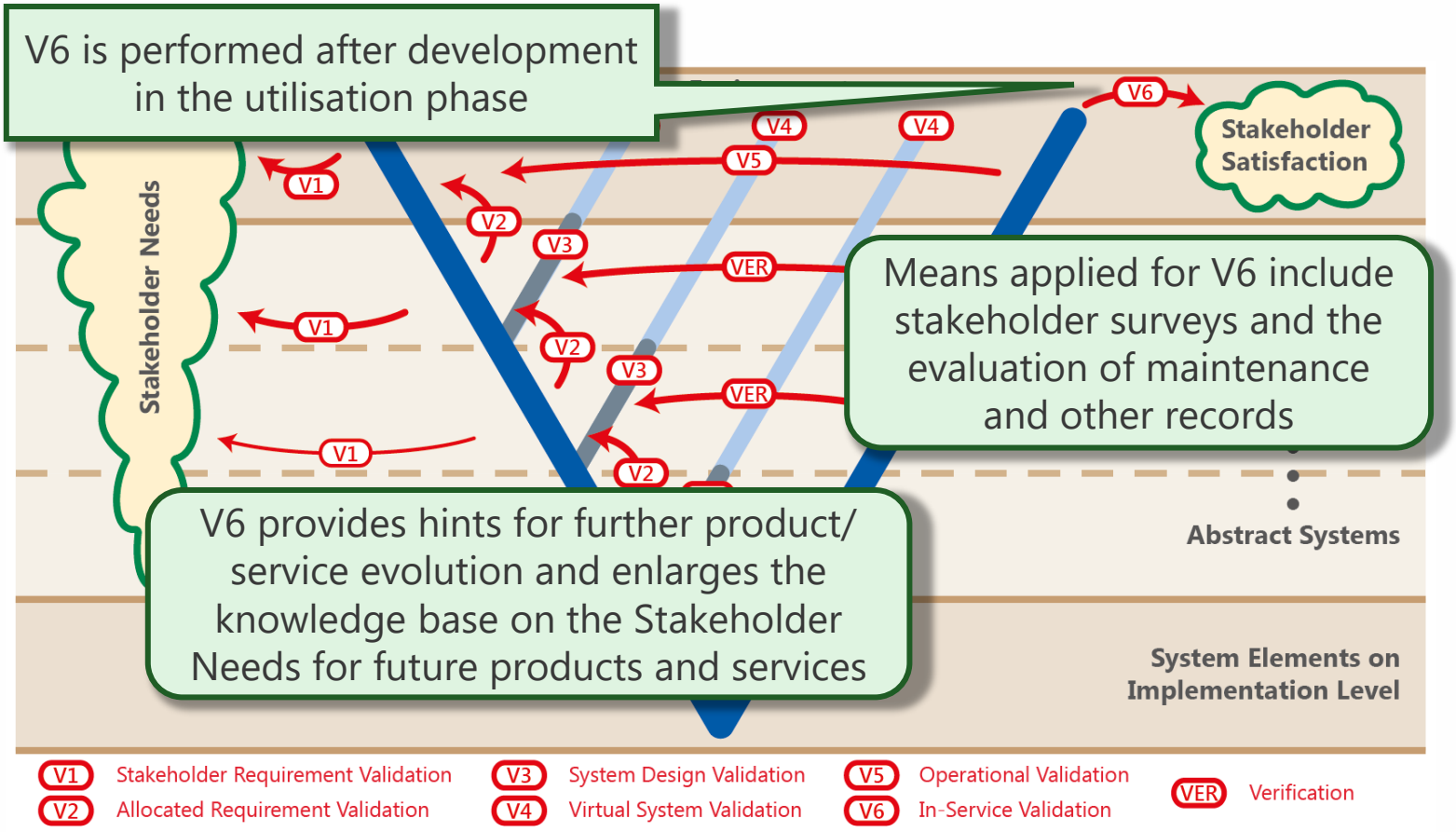
System Design Validation and Virtual System Validation



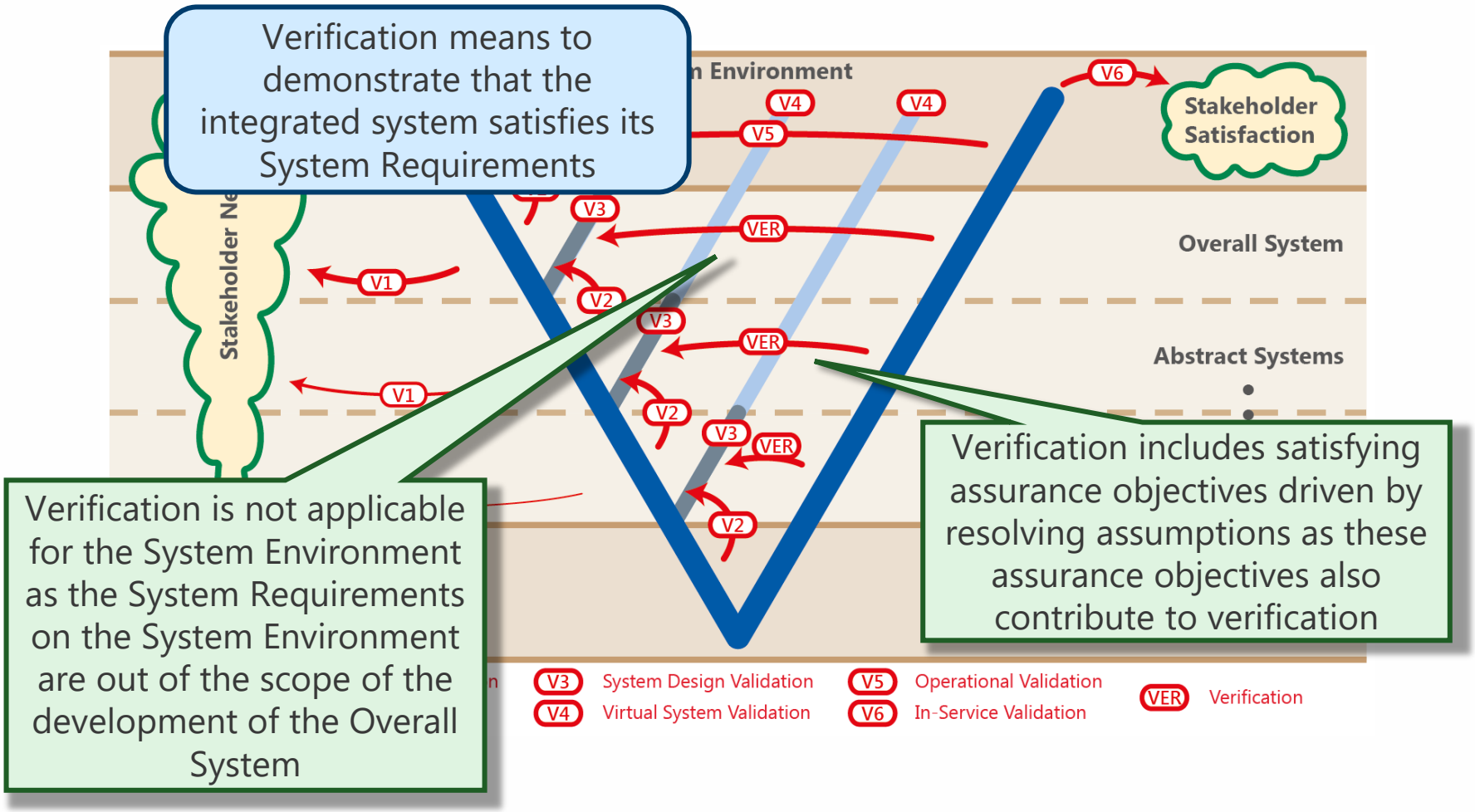
Operational Validation



In-Service Validation



Verification



The Dynamic V

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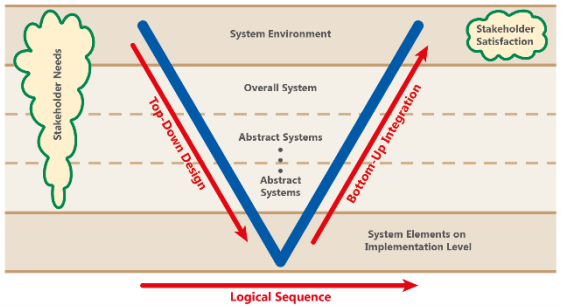

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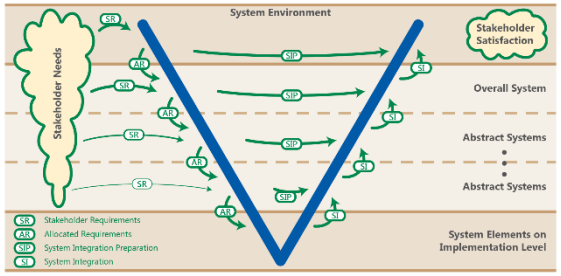

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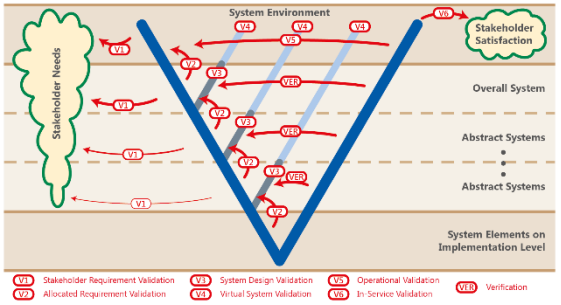

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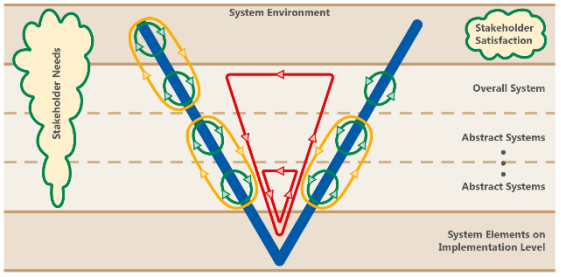

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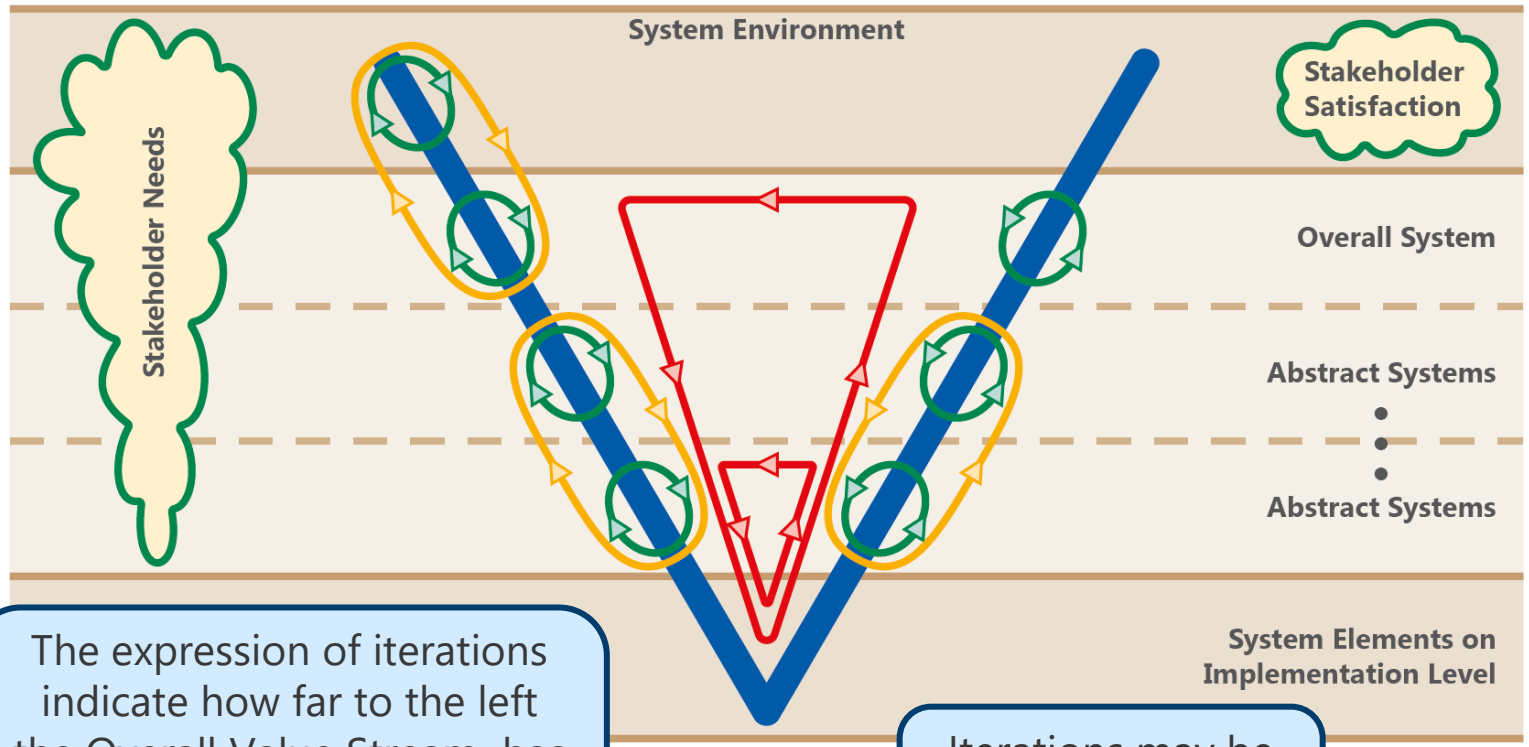


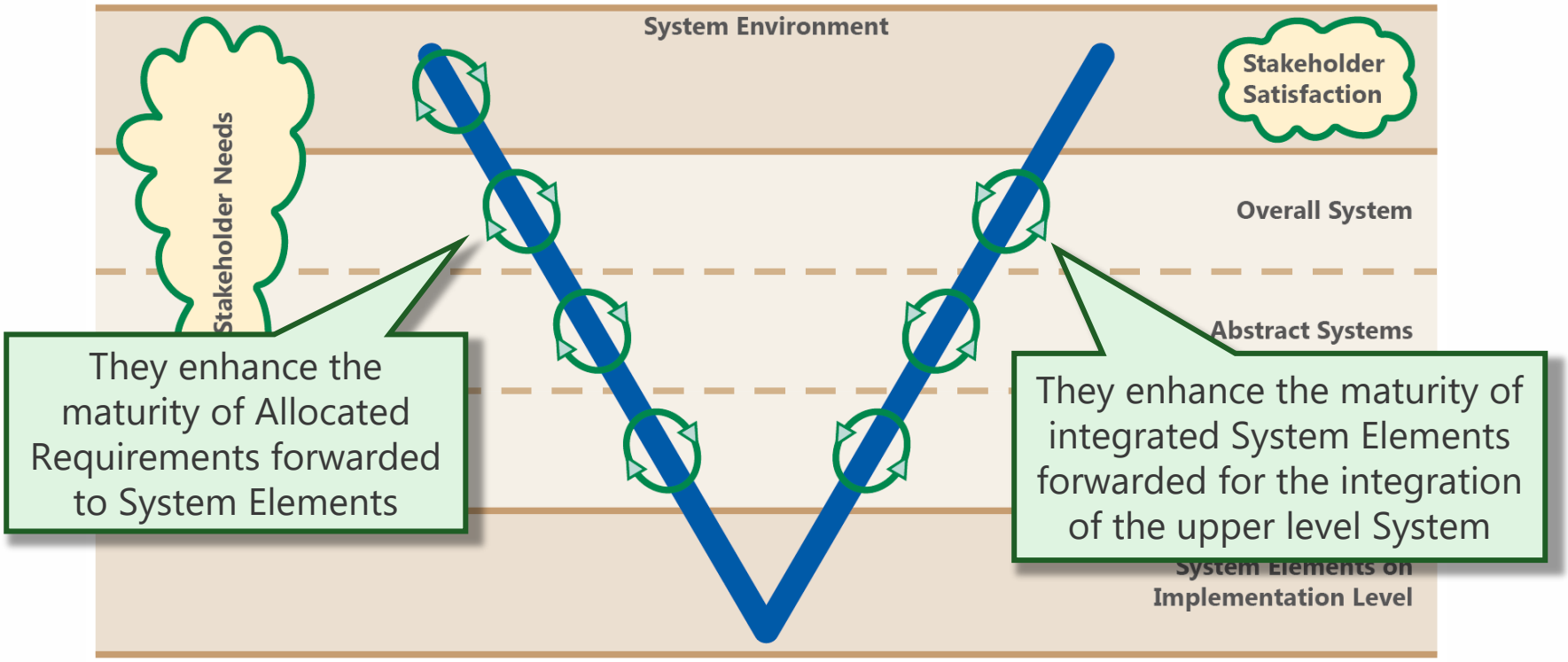
The expression of iterations indicate how far to the left the Overall Value Stream has to be re-entered in order to incorporate lessons learned

Iterations may be pre-planned or event-driven

Iterations Over the V

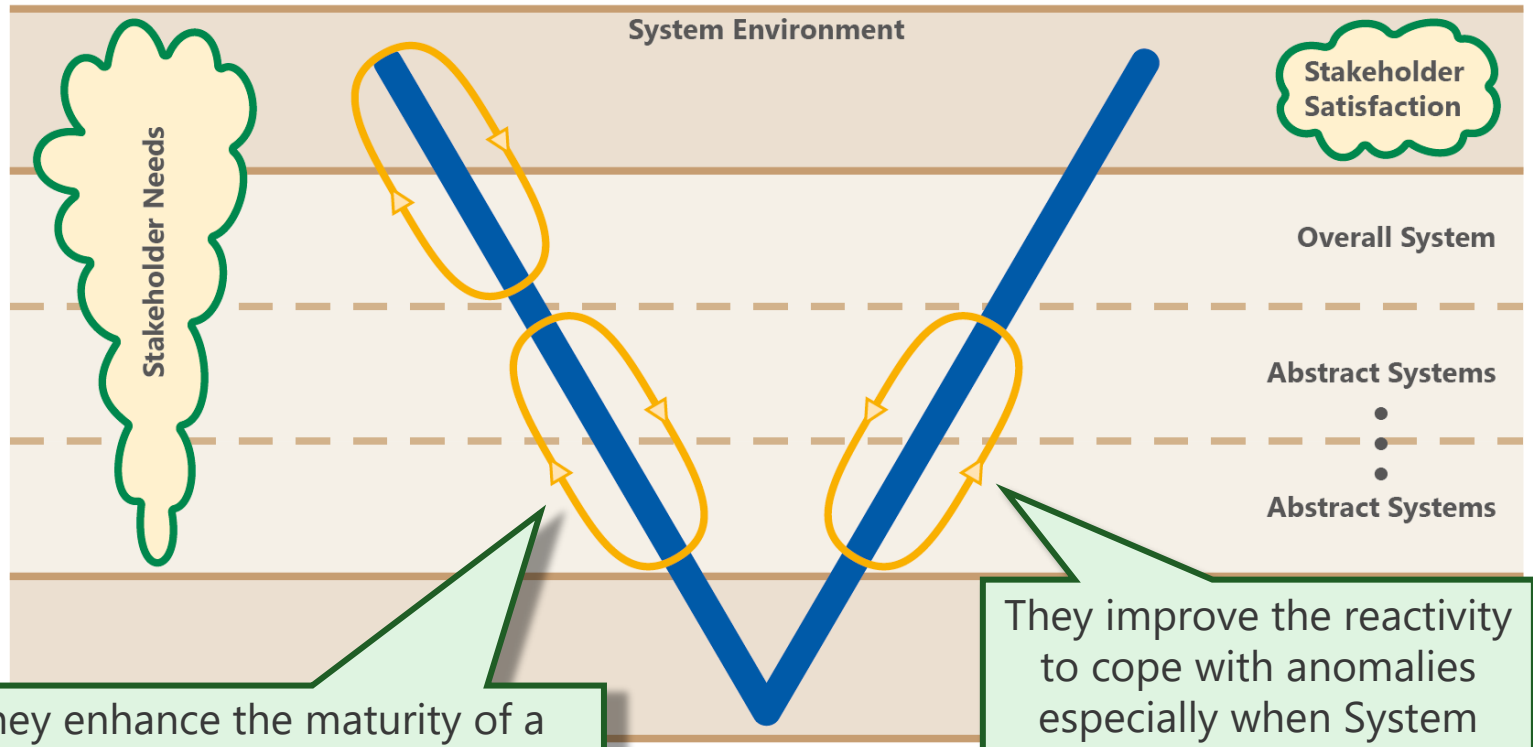
- Iterations are unavoidable when the initial knowledge is significantly below 100 percent of the final knowledge
- Iterations over the V are caused by
  - performing systems engineering activities repeatedly in different system life cycle phases satisfying the same or different objectives
    - with the main focus on problem finding in conceptual phases
    - with the focus of system improvement when utilising the product
  - applying incremental or evolutionary development philosophies
  - incorporating lessons learned
- Iterations of all kinds need to be properly managed to maintain high integrity

Iterations Over a Single System Element

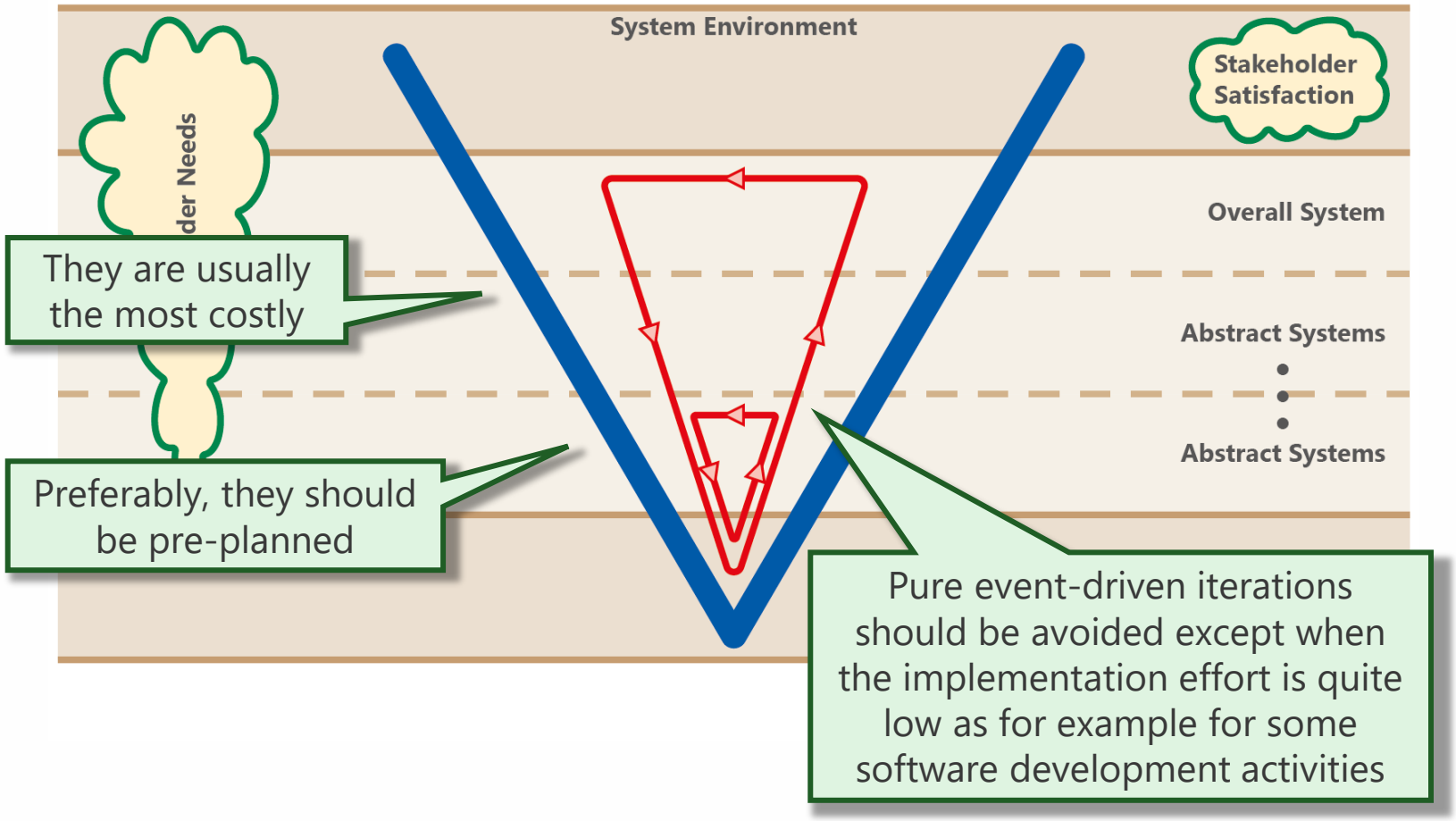


Improved maturity of the configuration baselines of every System reduces the load on the heavier change control over the System Architecture !

Iterations over Several System Elements Either on the Left Leg or the Right Leg of the V



Iterations Over Several System Elements including System Elements on the Implementation Level



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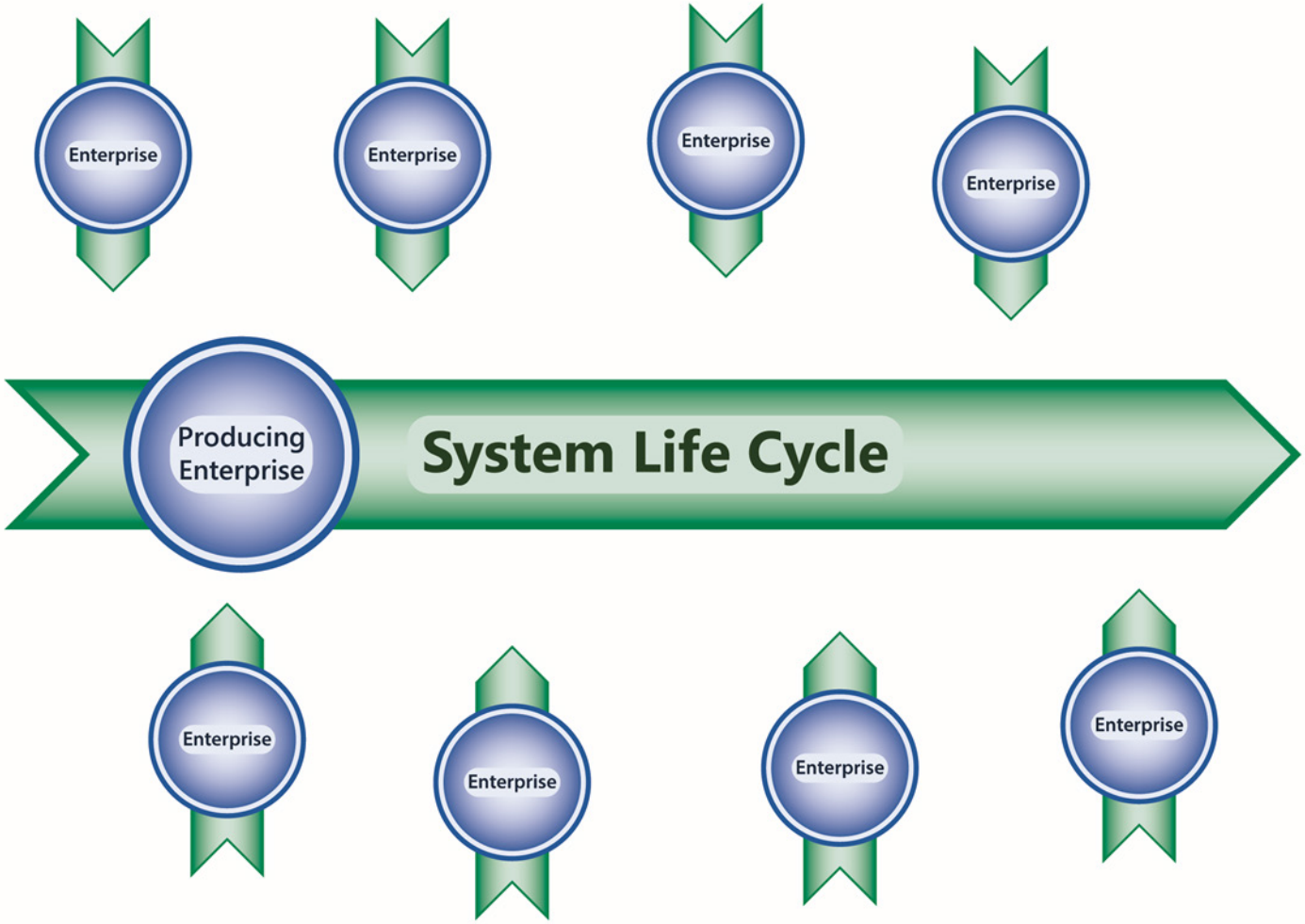
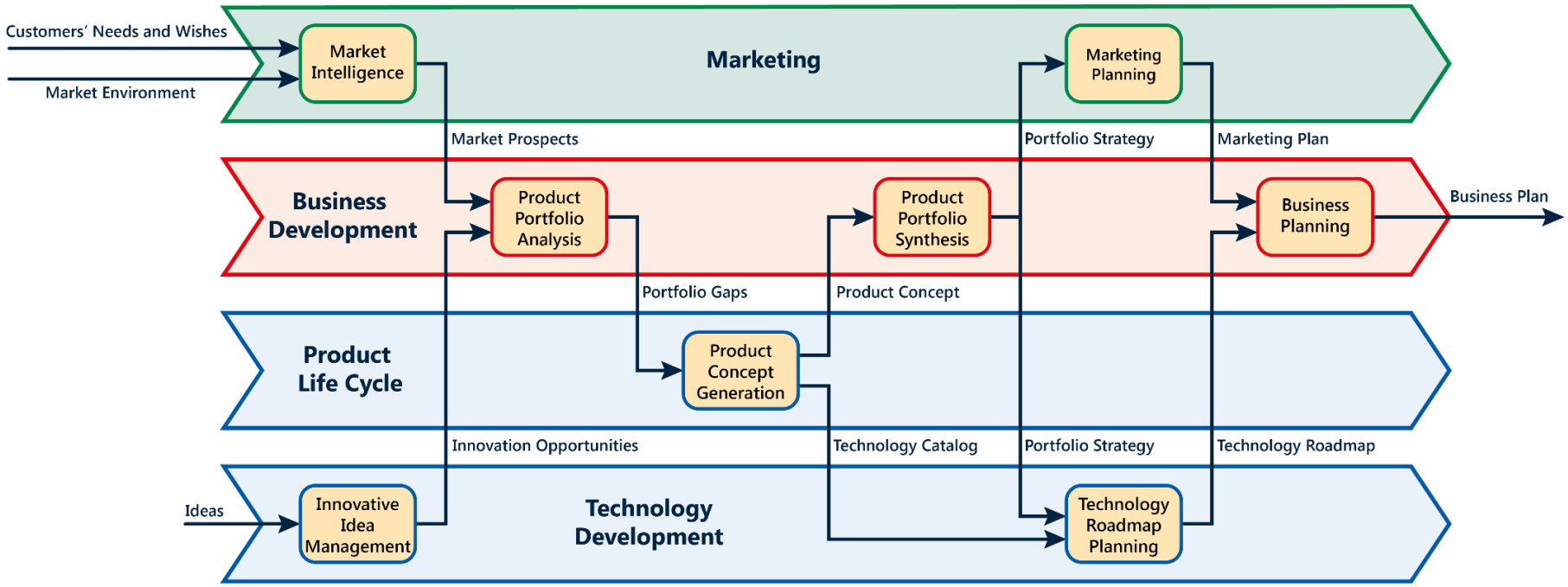
The System Life Cycle



System Life Cycle Efficiency and Sustainability

- **System Life Cycle Efficiency**
  - Ratio of the Benefit of a system over the system life cycle to the resources spent for the system throughout its system life cycle
  - Of course, quantification of both figures is not easy
  - Ratios greater than One are allowed and welcomed
- **Sustainability**
  - Maximised system life cycle efficiency plus
  - All enterprises (including individuals) interfering with the system over its system life cycle profit from it

The Role of Systems Engineering in Business Planning



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Conclusions

- The architecting of systems comprises a part of systems engineering emphasising the value adding creative aspects that are especially important rather early in the system life cycle
- Integrated multi-disciplinary teams defining the system by complementary system requirement, functional and architectural views are best suited to maximum use of human cognitive capabilities
- The use of MBSE throughout the systems engineering value stream needs further investigations due to
  - Consistency of too many views
  - Limitations of binding models of a system for the engineering teams in charge of the system elements
  - How to implement model based virtual product integration
- The systems engineering value stream is defined to enable concurrent execution of several iterations with consistent configuration baselines

Thank You

for your attention

Dieter Scheithauer
Dr.-Ing., INCOSE ESEP

Breitensteinstr. 26
83727 Schliersee
Germany

Phone: +49 (0) 80 26 - 97 68 00
Fax: +49 (0) 80 26 - 97 67 99
Mobile: +49 (0) 170 - 23 50 23 4

dieter.scheithauer@hitseng.eu
www.hitseng.eu

