INCOSE International Symposium
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June 24-27, 2013

# V-Model Views

by

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# Omulvo and Takete

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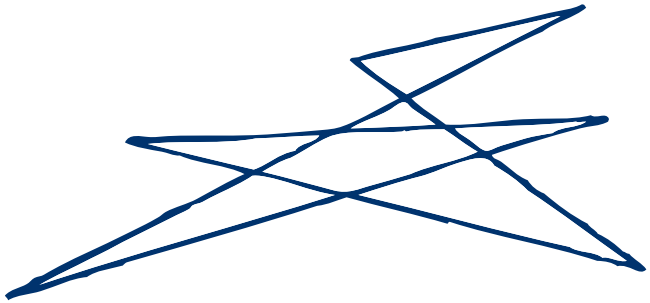

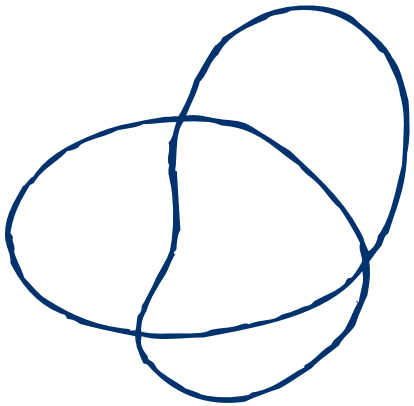

- Around 90% of all people correlate the two terms with the two figures in the same way although there is no further meaning behind the terms and the figures
- The reason is a natural correlation in the brain between phonemes and figures

➢ ***Icons have communicative power***

# What is this?

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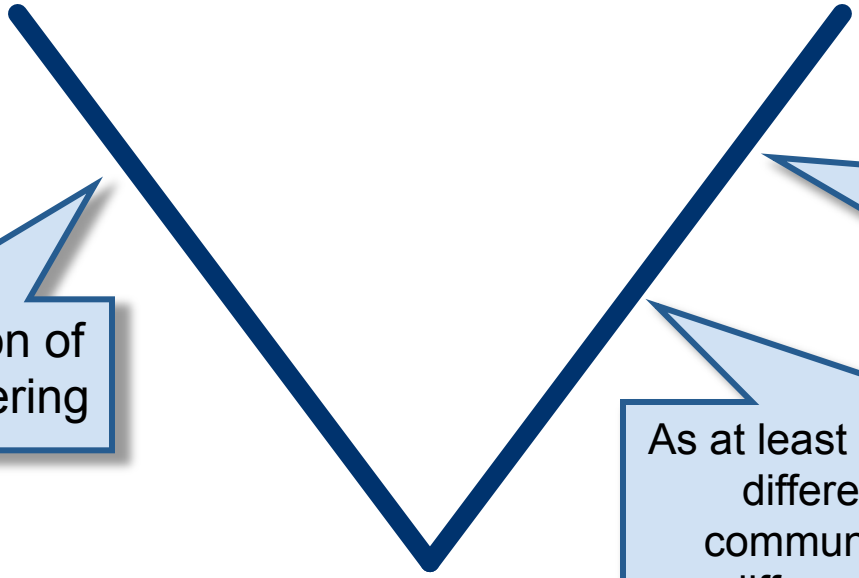

The V is “the” icon of Systems Engineering

We all overload the V with our theoretical knowledge and our individual experience

As at least our individual experience is different, the V may loose its communicative power due to the differences in our associations

***It is the objective of this paper to propose a set of consistent V-Model Views describing the Overall Systems Engineering Value Stream***

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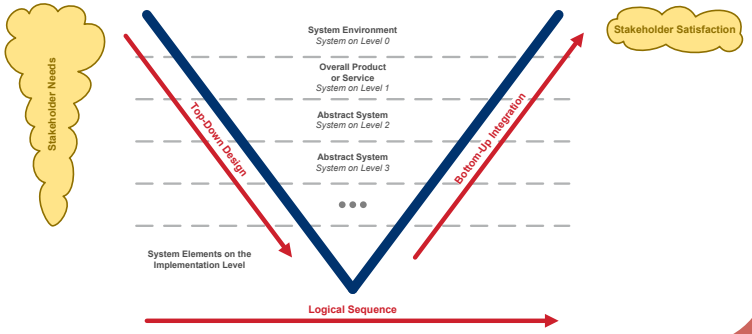
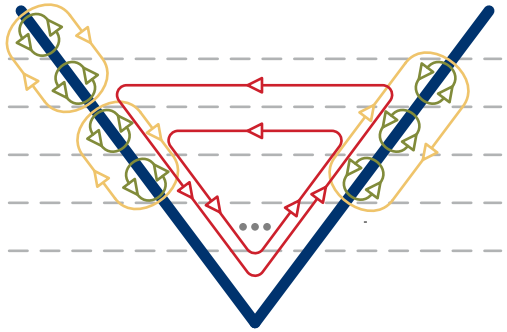
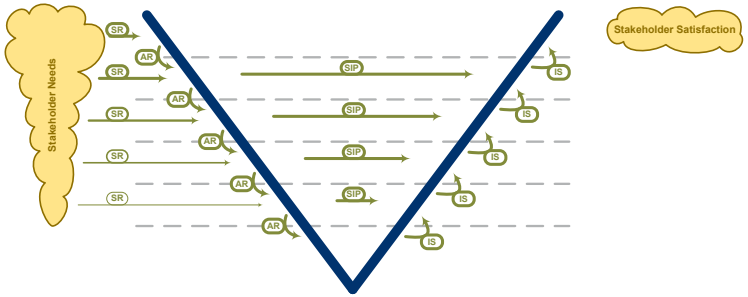


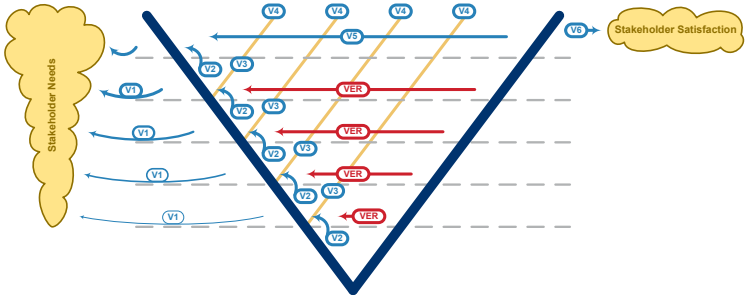

## 4 The Dynamic V



## 2 The Development V




## 3 The Assurance V



# The Basic V

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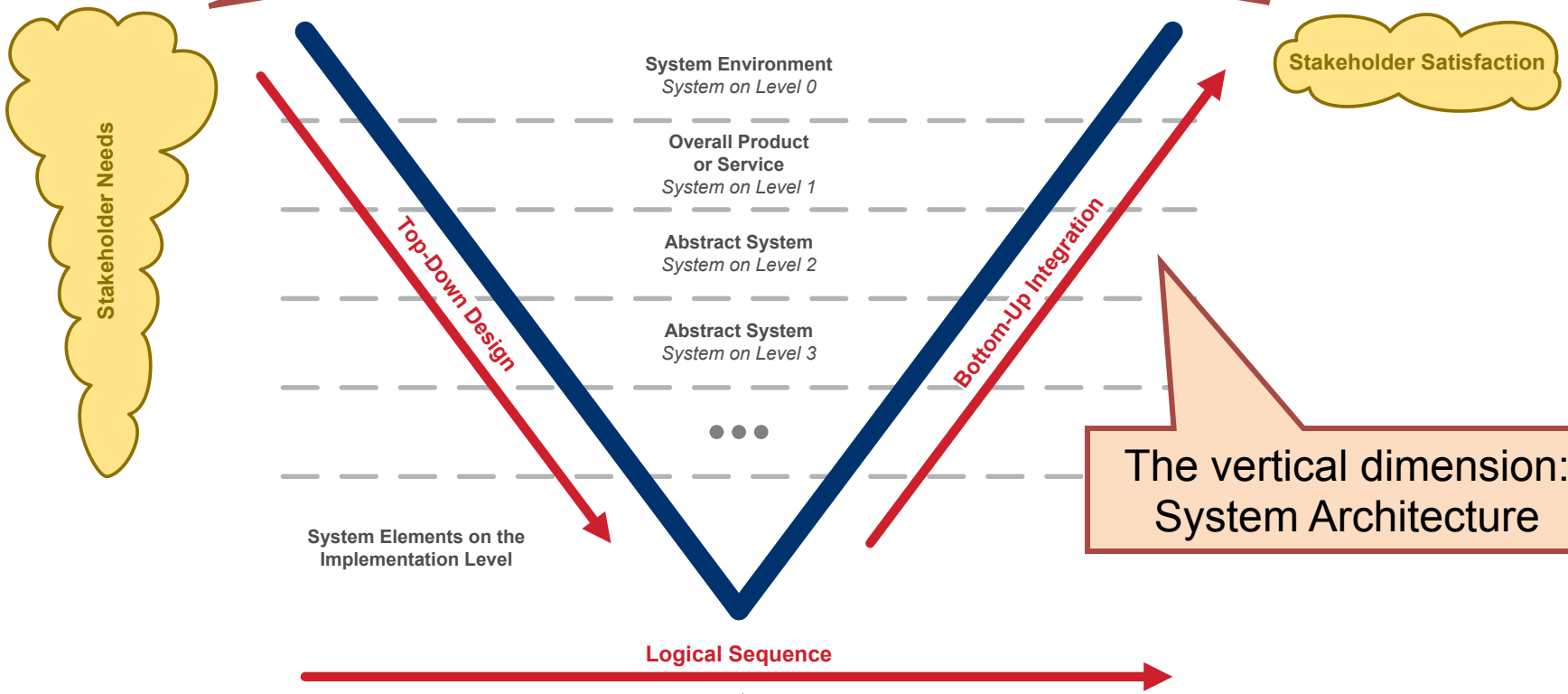
Stakeholder Needs and Stakeholder Satisfaction




The vertical dimension:
System Architecture

The horizontal dimension:
Logical Sequence

# The Basic V

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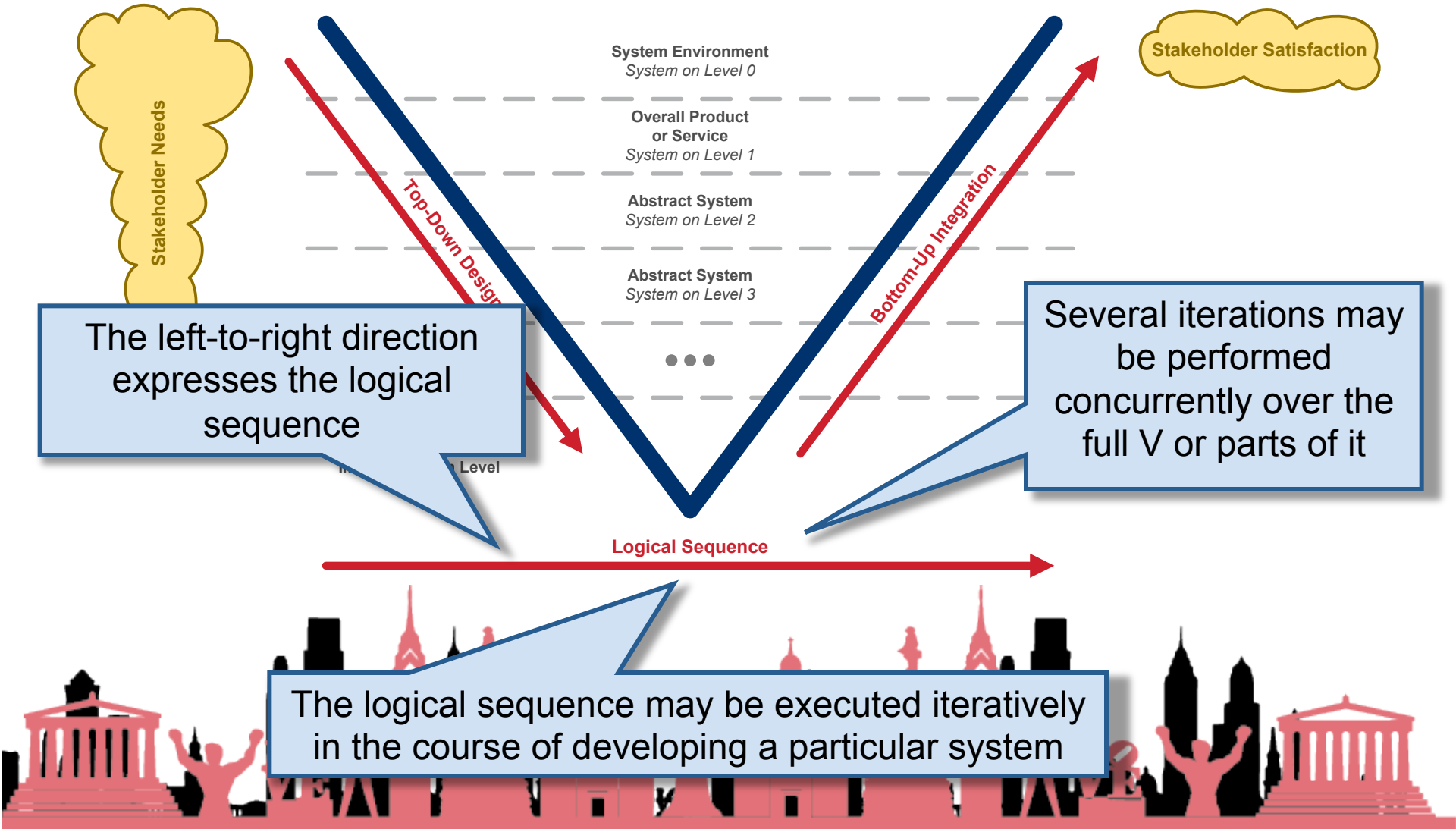


The left-to-right direction expresses the logical sequence

Several iterations may be performed concurrently over the full V or parts of it

The logical sequence may be executed iteratively in the course of developing a particular system

# The Basic V

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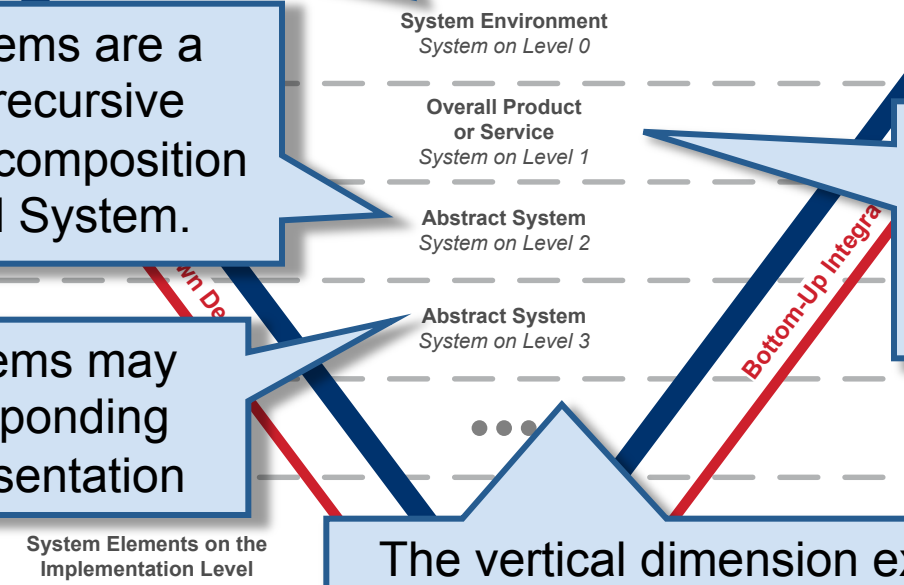
The System Environment represents the part of the world considered relevant for the Overall System

Abstract Systems are a result of the recursive architectural decomposition of the Overall System.




Stakeholder Satisfaction

The Overall System comprises all items and services to be delivered to a customer

Abstract Systems may have a corresponding physical representation

The vertical dimension expresses the System Architecture

Logical Sequence

System Elements on the Implementation Level represent all the supplies from other parties not concerned with achieving stakeholder satisfaction on the Overall System

# Organizational Workshare

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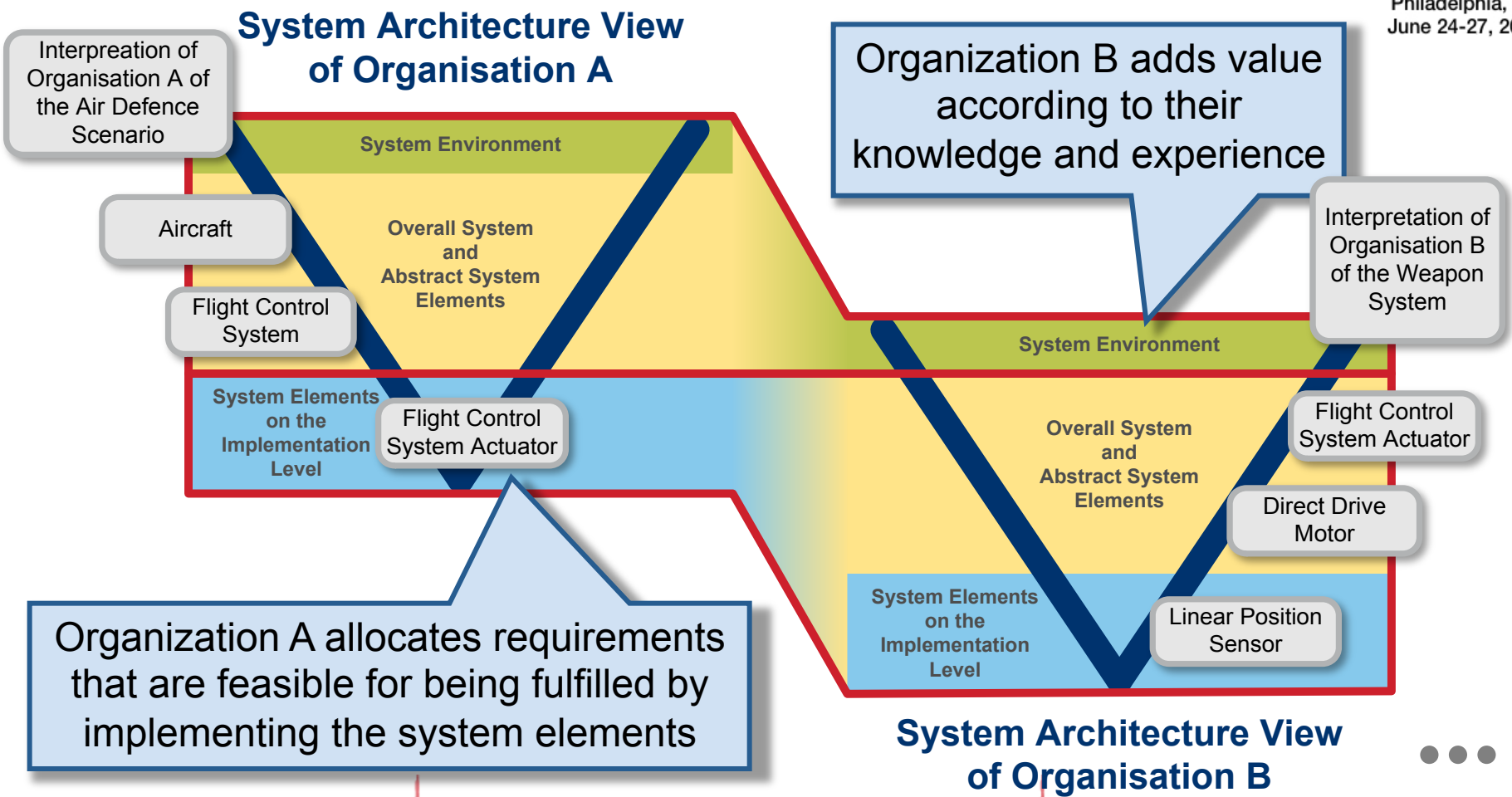

# The Basic V

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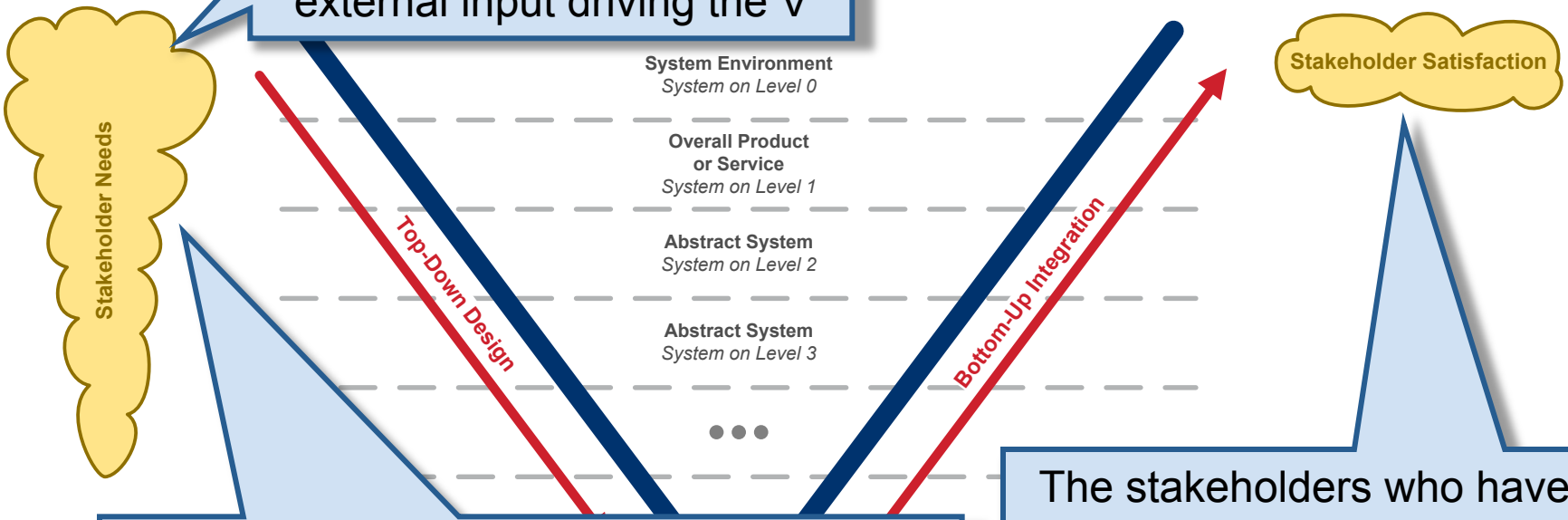
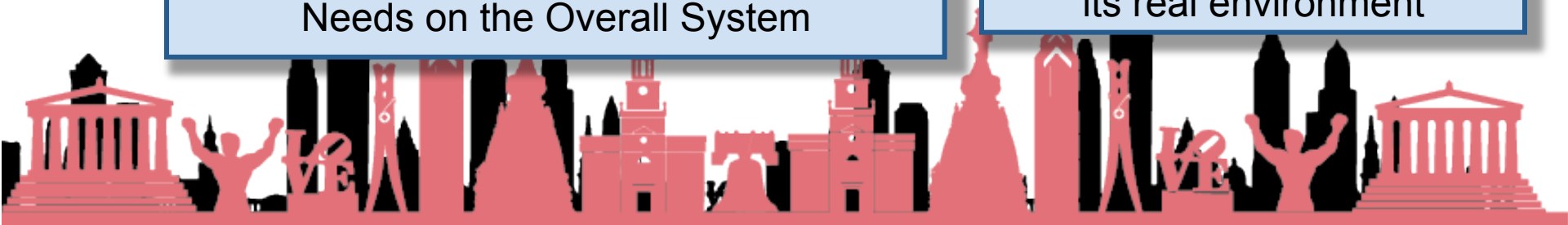
Stakeholder Needs exist outside the V as they are an external input driving the V




All Systems Engineers analyzing the System Environment, or developing the Overall System or any Abstract System are concerned with satisfying the Stakeholder Needs on the Overall System

The stakeholders who have to deal with the system in the utilization phase will rate their satisfaction when they operate the overall system in its real environment



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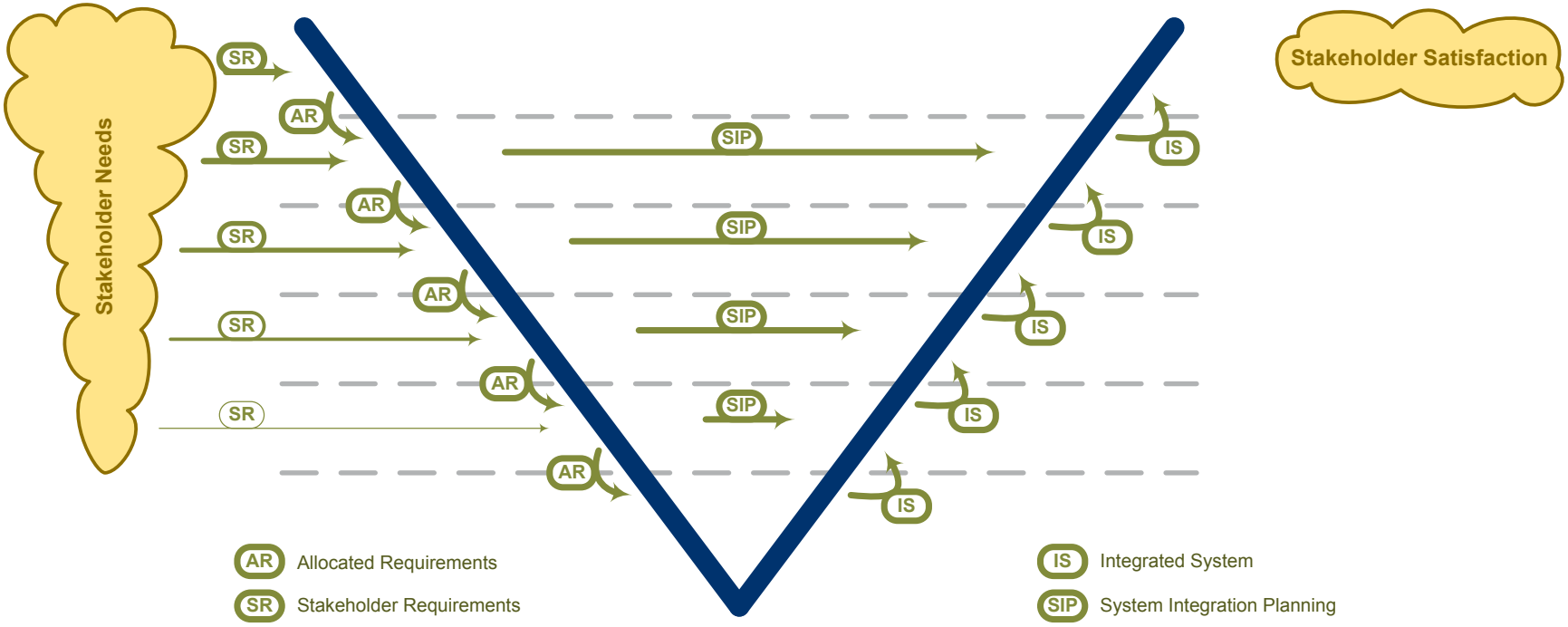


# The Development V

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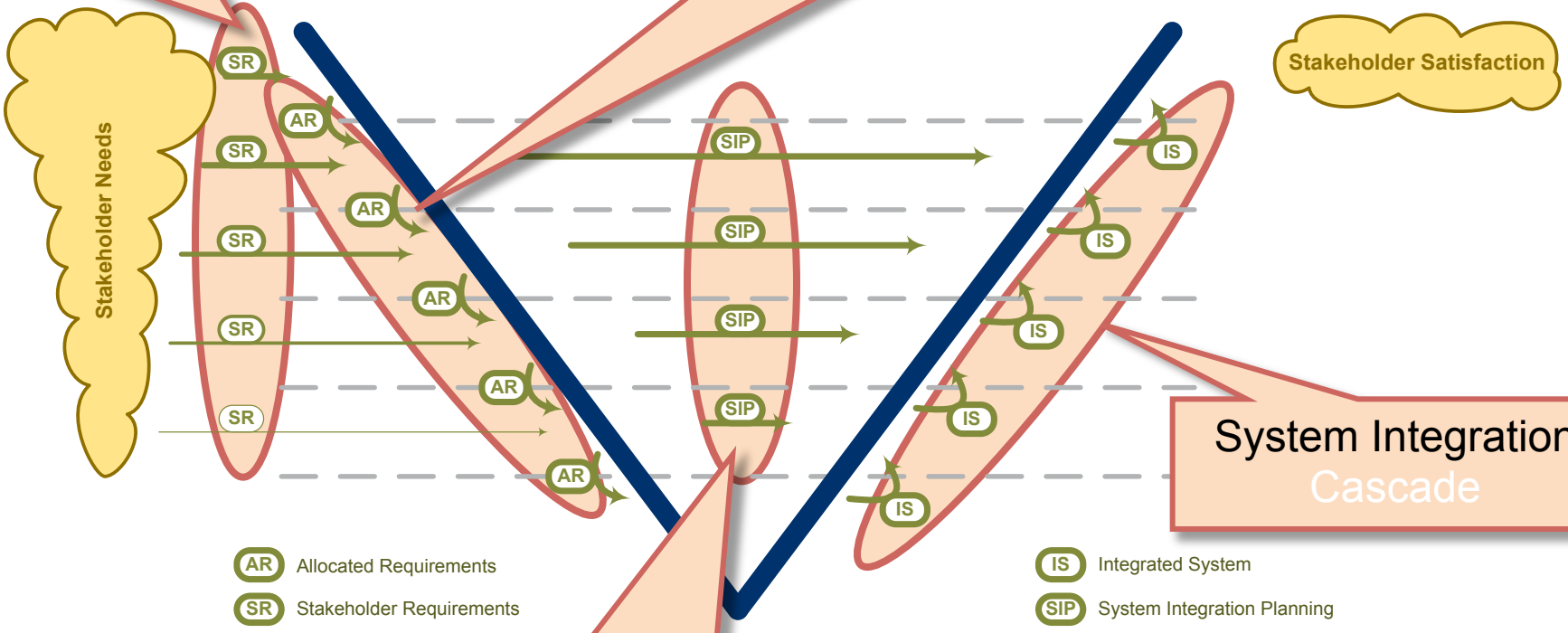
From Stakeholder Needs to Stakeholder Requirements

Requirement Cascade




System Integration Preparation

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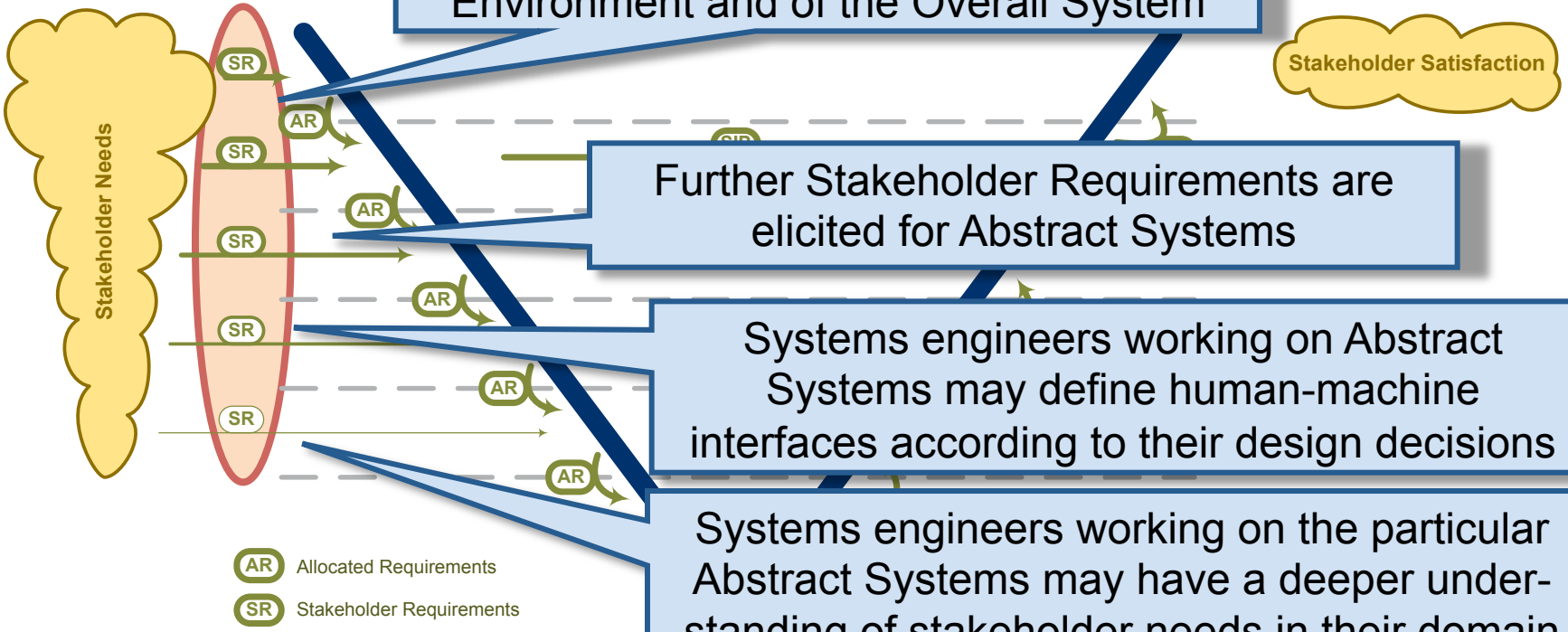
Most Stakeholder Requirements are elicited on the levels of the System Environment and of the Overall System




Further Stakeholder Requirements are elicited for Abstract Systems

Systems engineers working on Abstract Systems may define human-machine interfaces according to their design decisions

Systems engineers working on the particular Abstract Systems may have a deeper under-standing of stakeholder needs in their domain

# The Communication Problem

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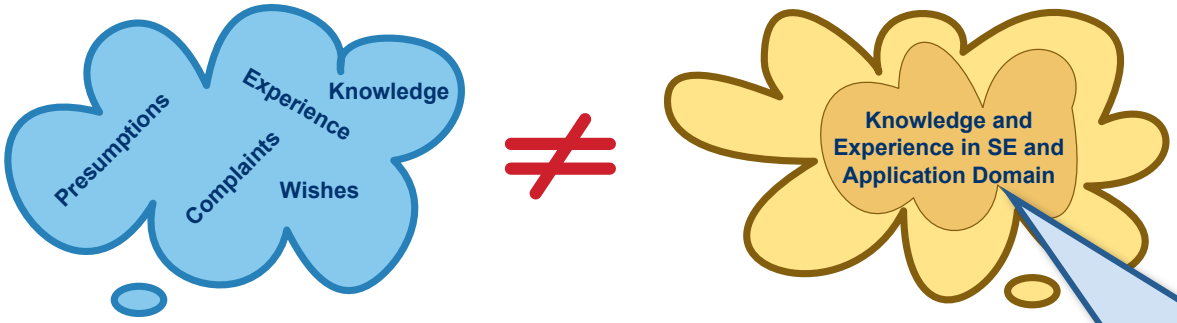


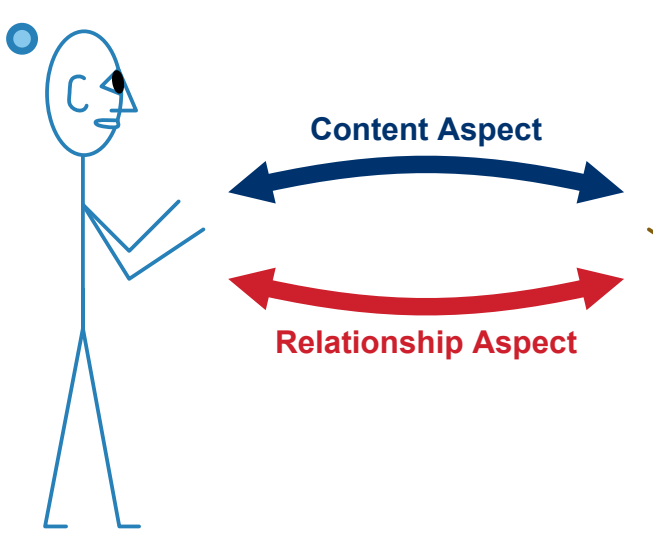


A comprehensive understanding of Stakeholder Needs demands in-depth knowledge about the stakeholder's application domain.

**Problem solving without knowing about the problem is impossible, at least not in a controlled way !**

# Needs, Stakeholder Requirements, and System Requirements

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- Stakeholders are unconscious of many expected properties and functions of the system.
- Stakeholders focus on desired capabilities current solutions do not provide.
- Stakeholders insist on solutions implemented to overcome problems with previous or existing solutions.

- Stakeholder requirements represent stakeholder needs, but may not cover all stakeholder needs.
- Stakeholder requirements are worded in a language understandable to the particular group of stakeholders and the systems engineers in charge of designing the system.
- Stakeholder requirements serve for communication between different stakeholder groups including the systems engineers in charge of designing the system.

- System requirements are complete and consistent with respect to the system solution.
- System requirements are worded in the domain specific language of the engineering disciplines developing the system.
- System requirements fulfil the quality criteria of the engineering disciplines developing the system.

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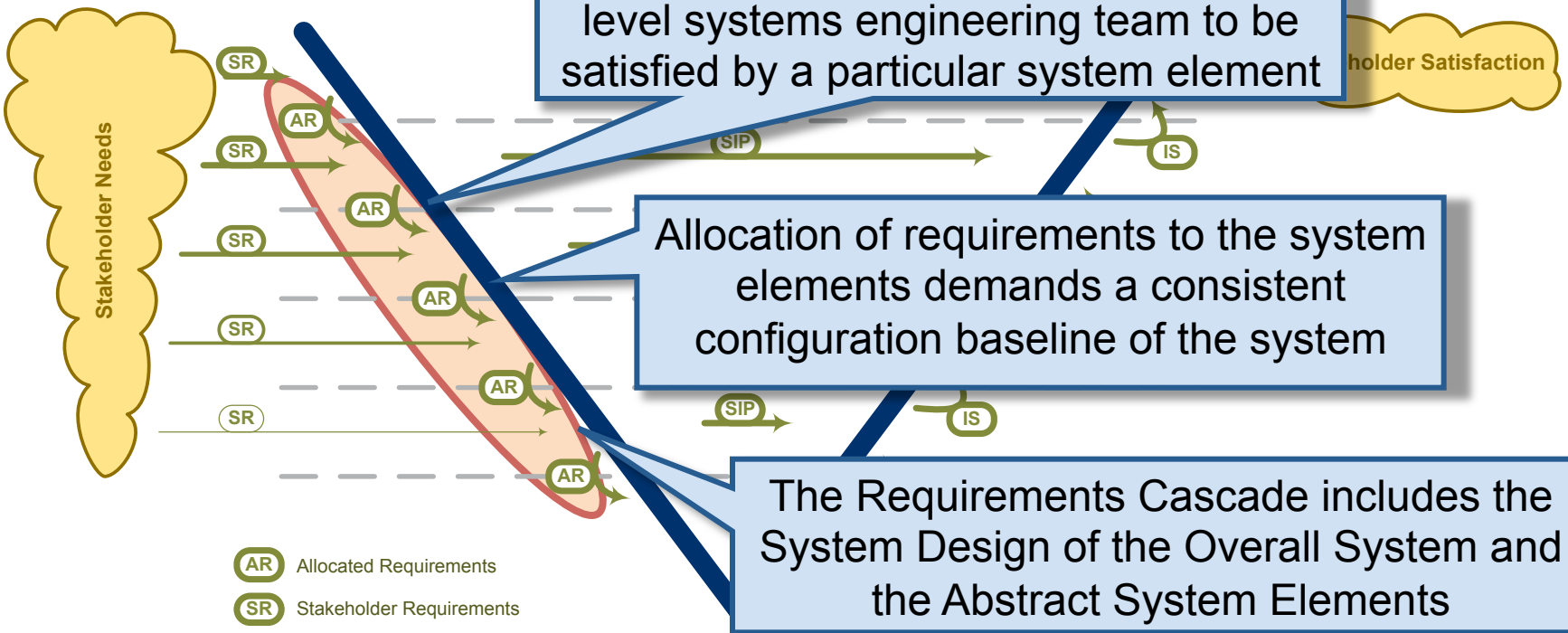
Allocated Requirements comprise the objectives and intentions of the upper level systems engineering team to be satisfied by a particular system element

Allocation of requirements to the system elements demands a consistent configuration baseline of the system

The Requirements Cascade includes the System Design of the Overall System and the Abstract System Elements




# System Design

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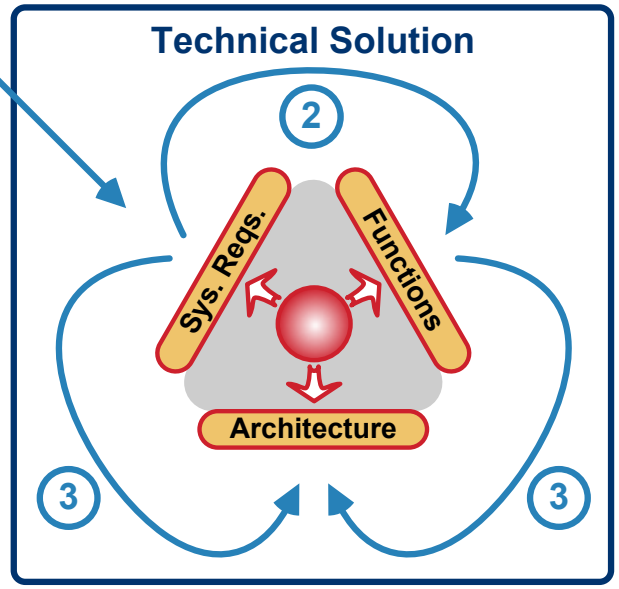
**Allocated/Stakeholder Requirements**




1 Interprete Allocated and Stakeholder Requirements

2 Define the system functions considering all functional relevant system requirements

3 Define the system architecture by interpreting all architectural relevant system requirements and by allocating system functions to system elements

4 Define the allocated requirements for all the system elements including the interface requirements between them

4

**Allocated Requirements (System Element A)**

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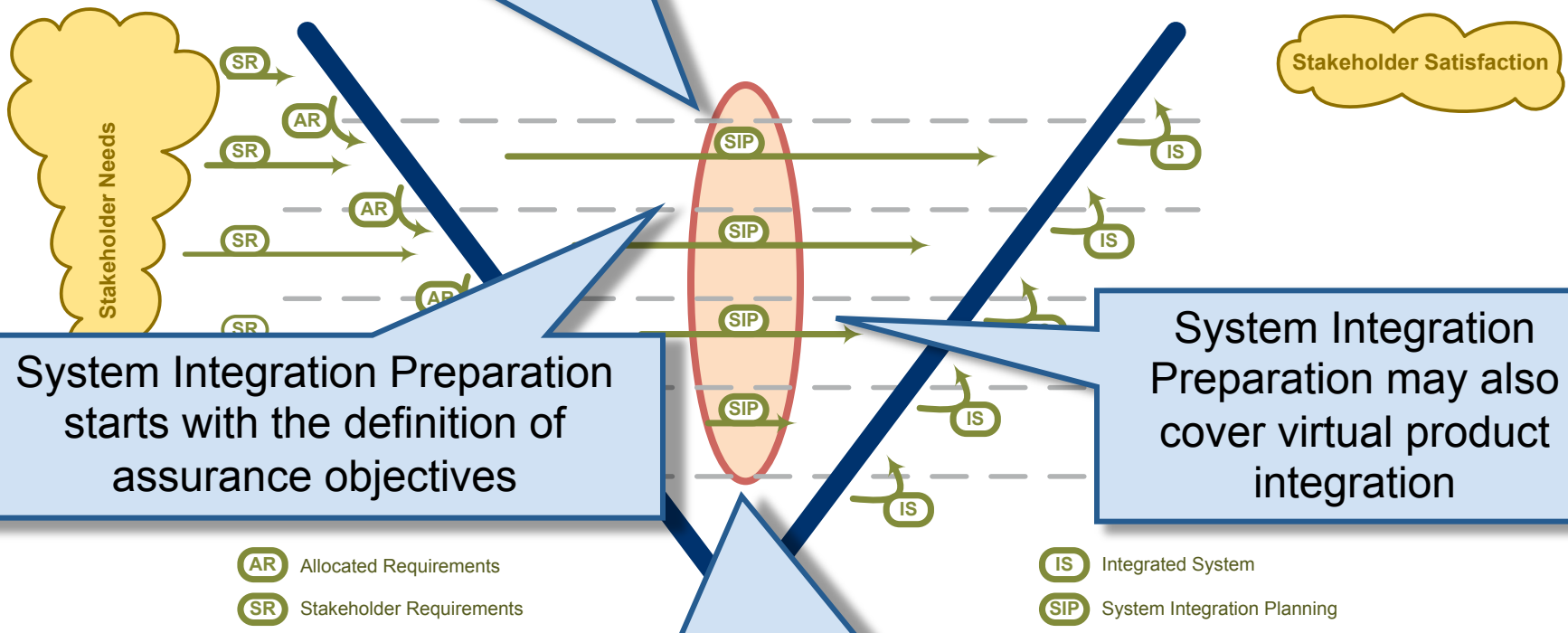
System Integration Preparation bypasses the implementation level




System Integration Preparation starts with the definition of assurance objectives

System Integration Preparation may also cover virtual product integration

The System Integration Concept defines the strategy for system integration and the necessary system integration environments considering the whole System Architecture

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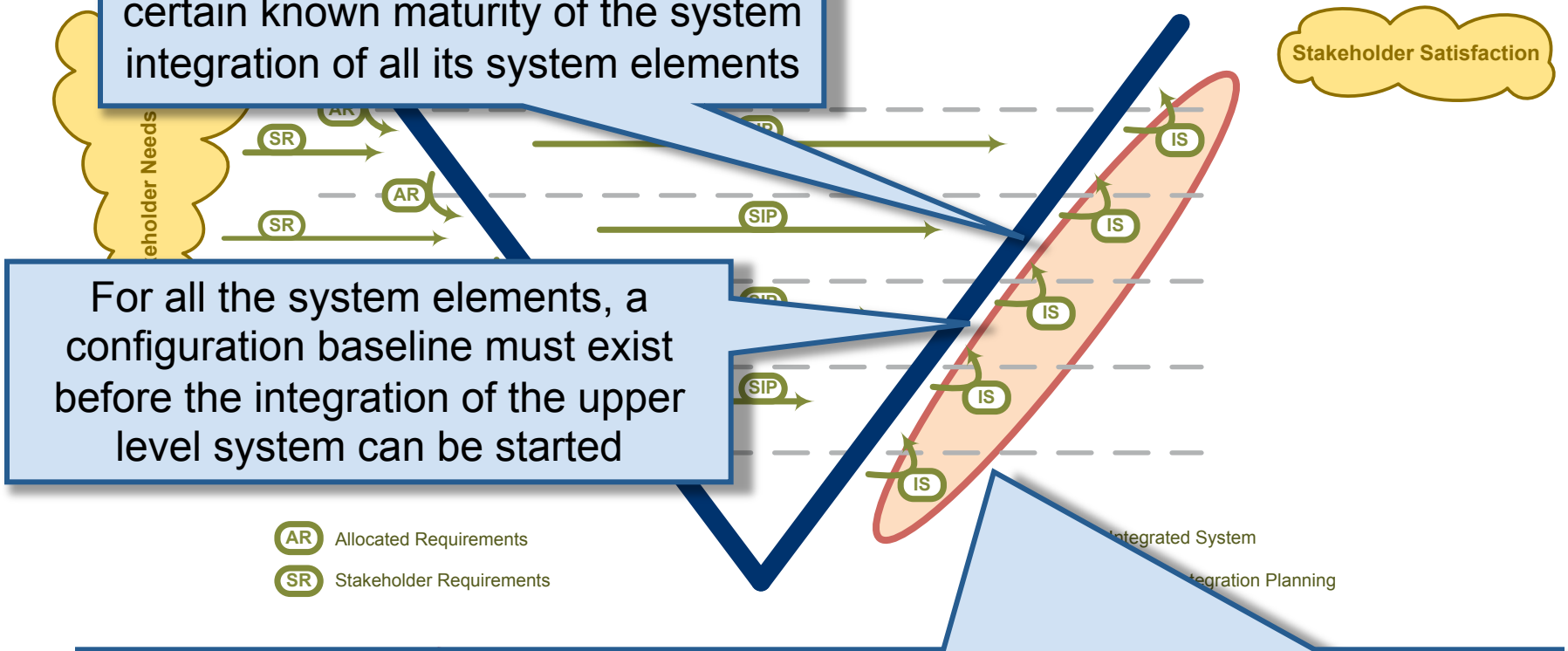
Integration of a system demands a certain known maturity of the system integration of all its system elements

For all the system elements, a configuration baseline must exist before the integration of the upper level system can be started




Appropriate agreements between the systems engineering teams in charge of the upper level system and of its system elements are needed, especially when system elements feature omissions and open issues

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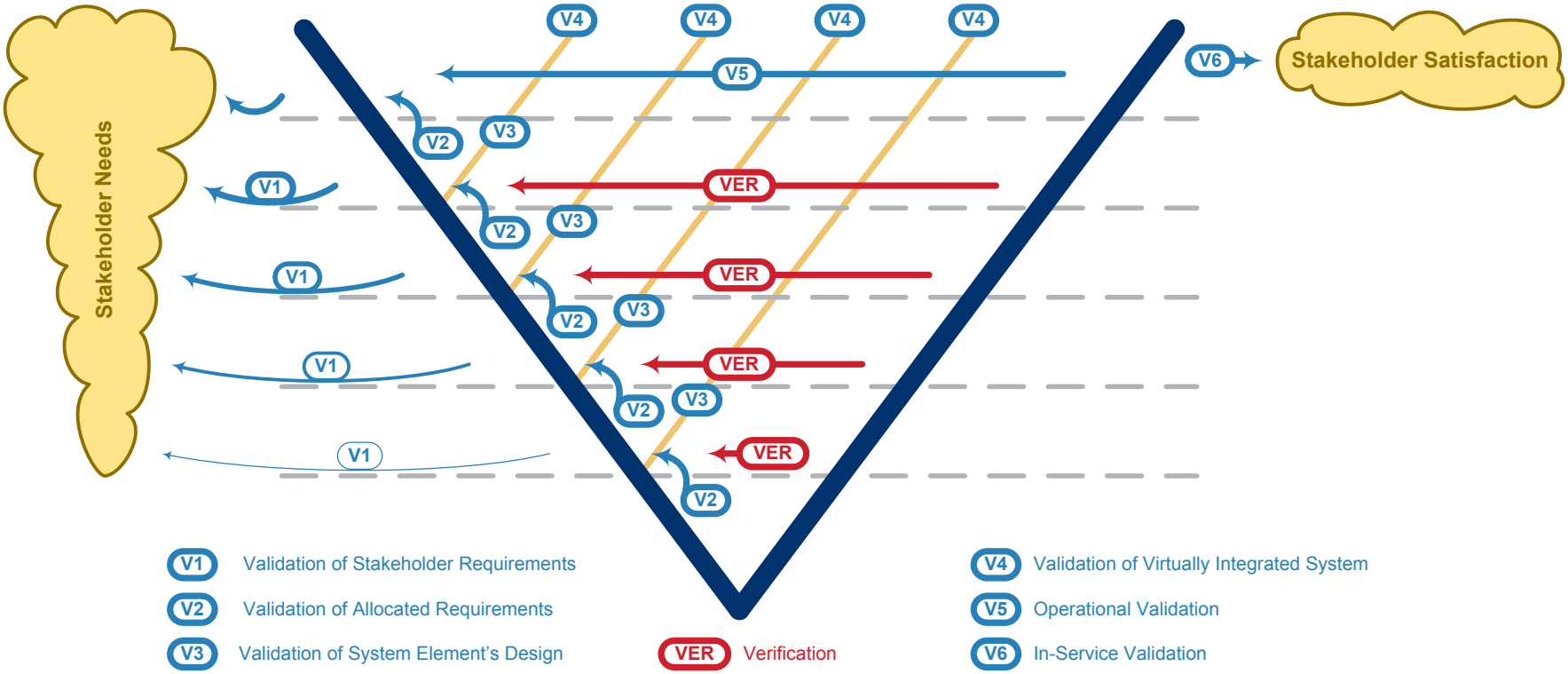


V1 Validation of Stakeholder Requirements
V2 Validation of Allocated Requirements
V3 Validation of System Element's Design
VER Verification
V4 Validation of Virtually Integrated System
V5 Operational Validation
V6 In-Service Validation

# The Assurance V

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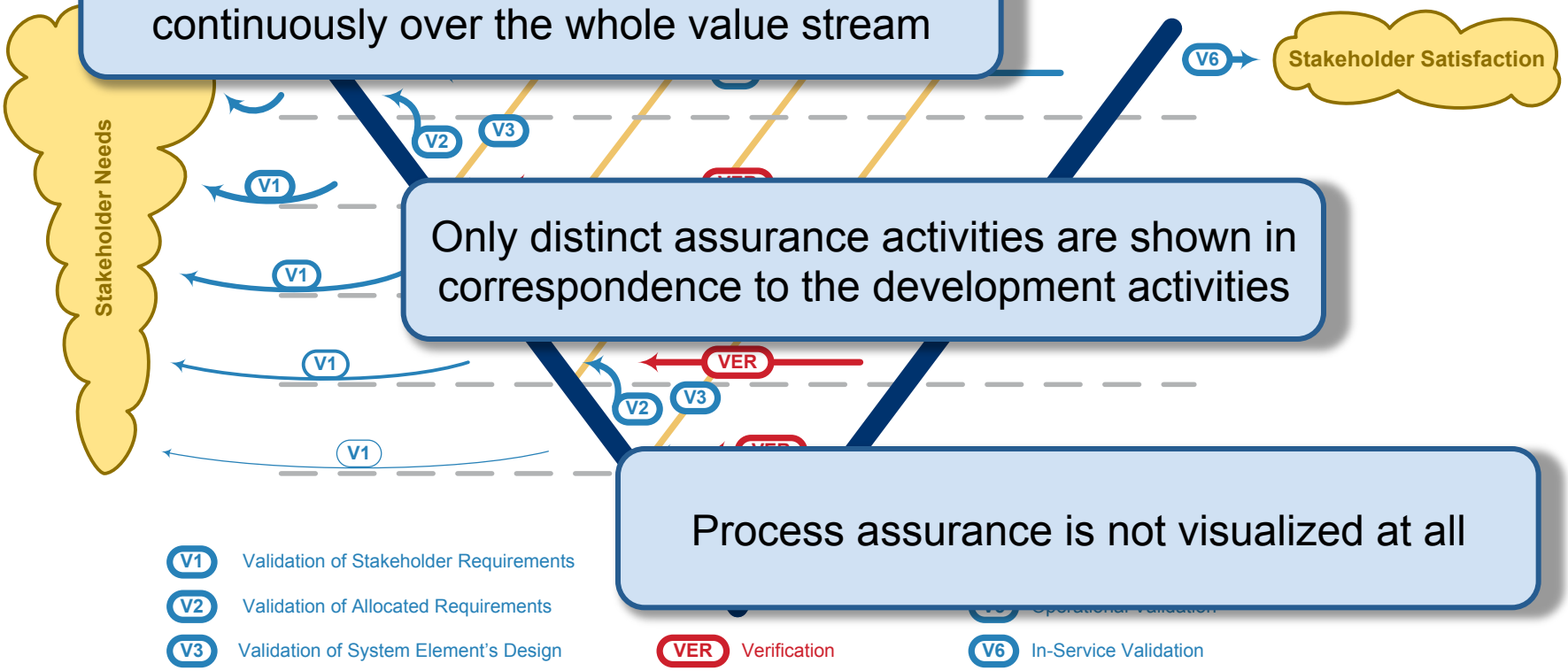
Assurance activities need to be performed continuously over the whole value stream




Only distinct assurance activities are shown in correspondence to the development activities

Process assurance is not visualized at all

V1 Validation of Stakeholder Requirements
V2 Validation of Allocated Requirements
V3 Validation of System Element's Design
VER Verification
V6 In-Service Validation

# Validation and Verification

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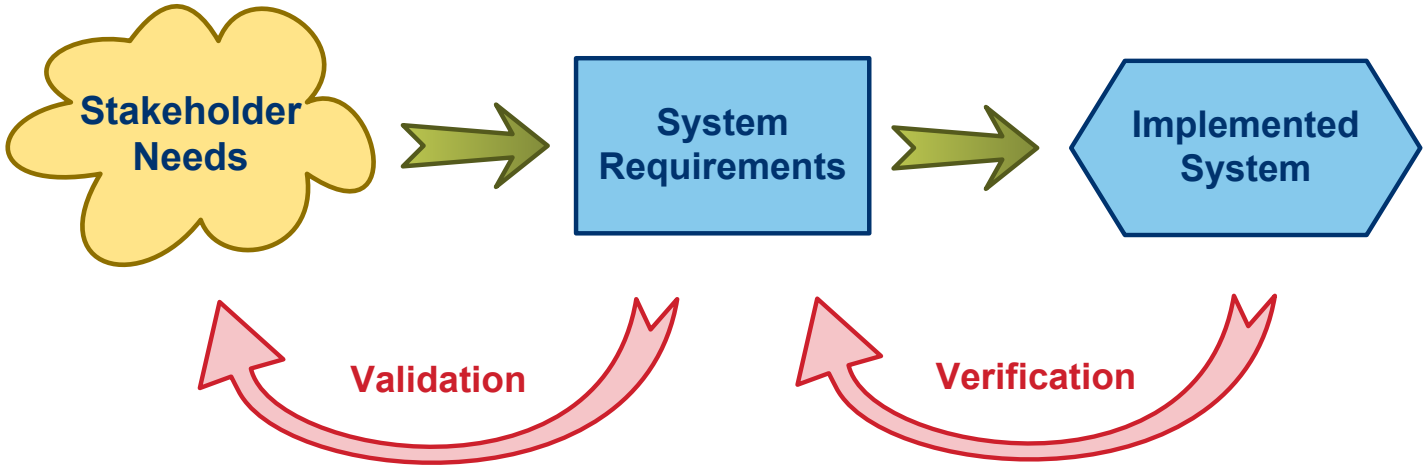


Do we build the right system?

Did we built the system right?

***Stakeholder Satisfaction***

***Fulfilment of Requirements***

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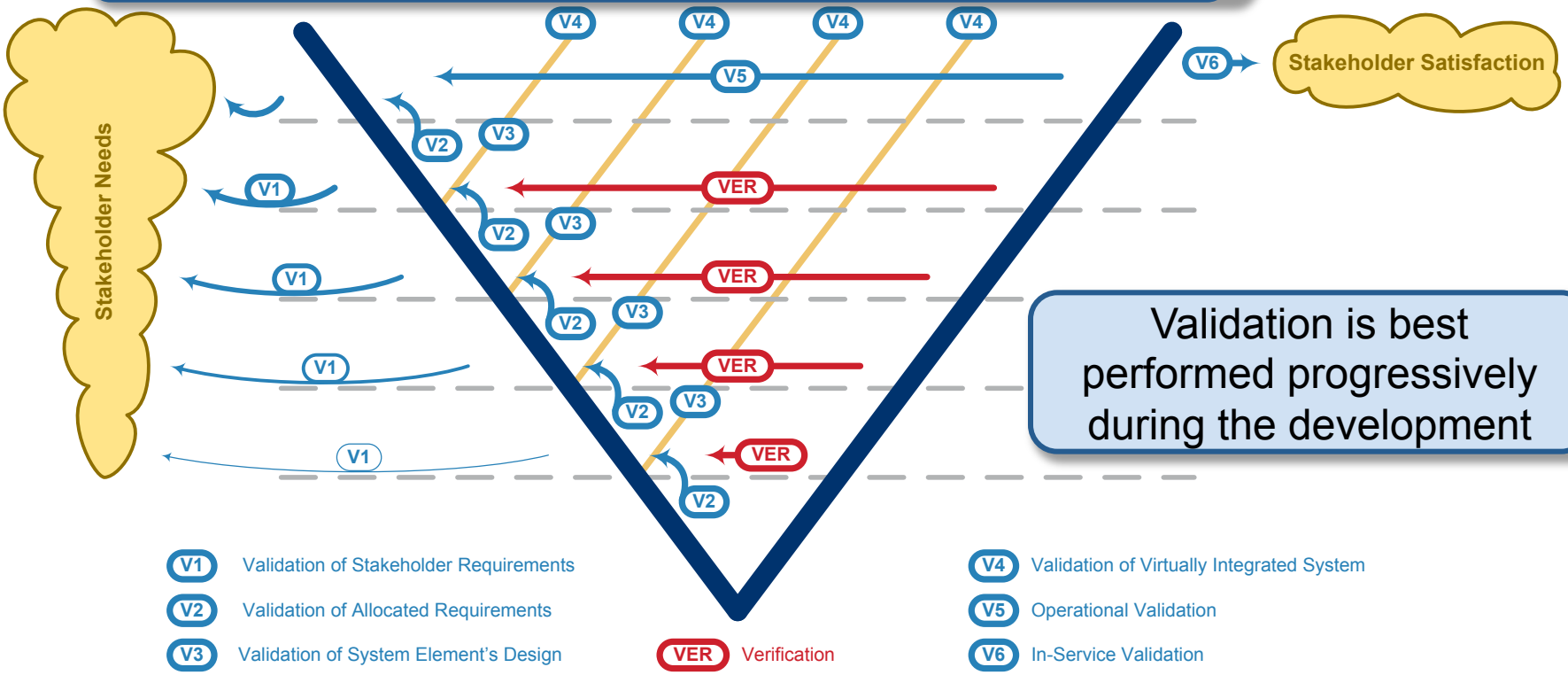
It can never been proven during development that all relevant Stakeholder Needs have been captured completely




Validation is best performed progressively during the development

- V1 Validation of Stakeholder Requirements
- V2 Validation of Allocated Requirements
- V3 Validation of System Element's Design
- VER Verification
- V4 Validation of Virtually Integrated System
- V5 Operational Validation
- V6 In-Service Validation

Validation activities provide a proof either that the understanding of stakeholder needs is substantiated, or that unwanted effects are absent

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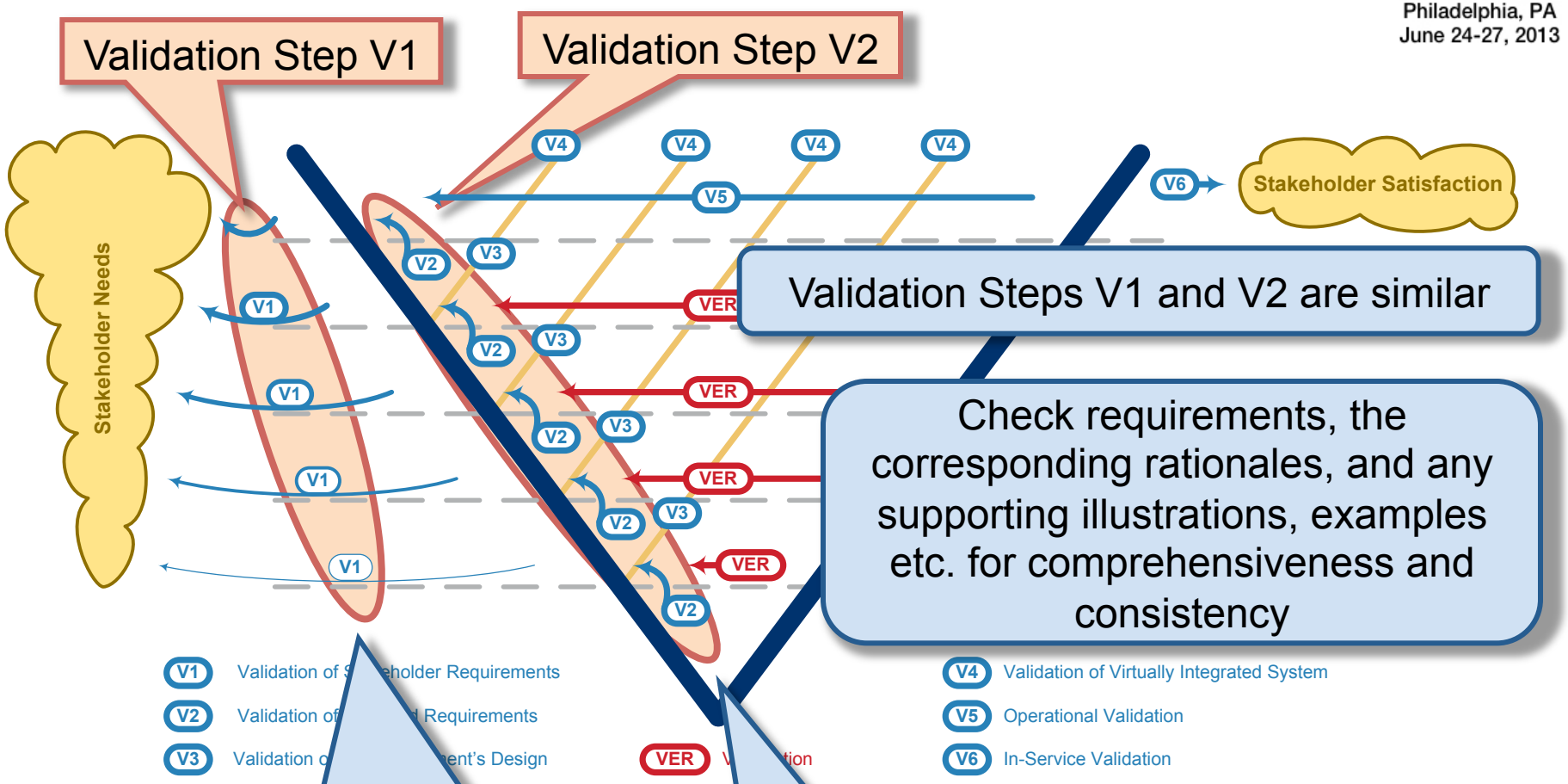

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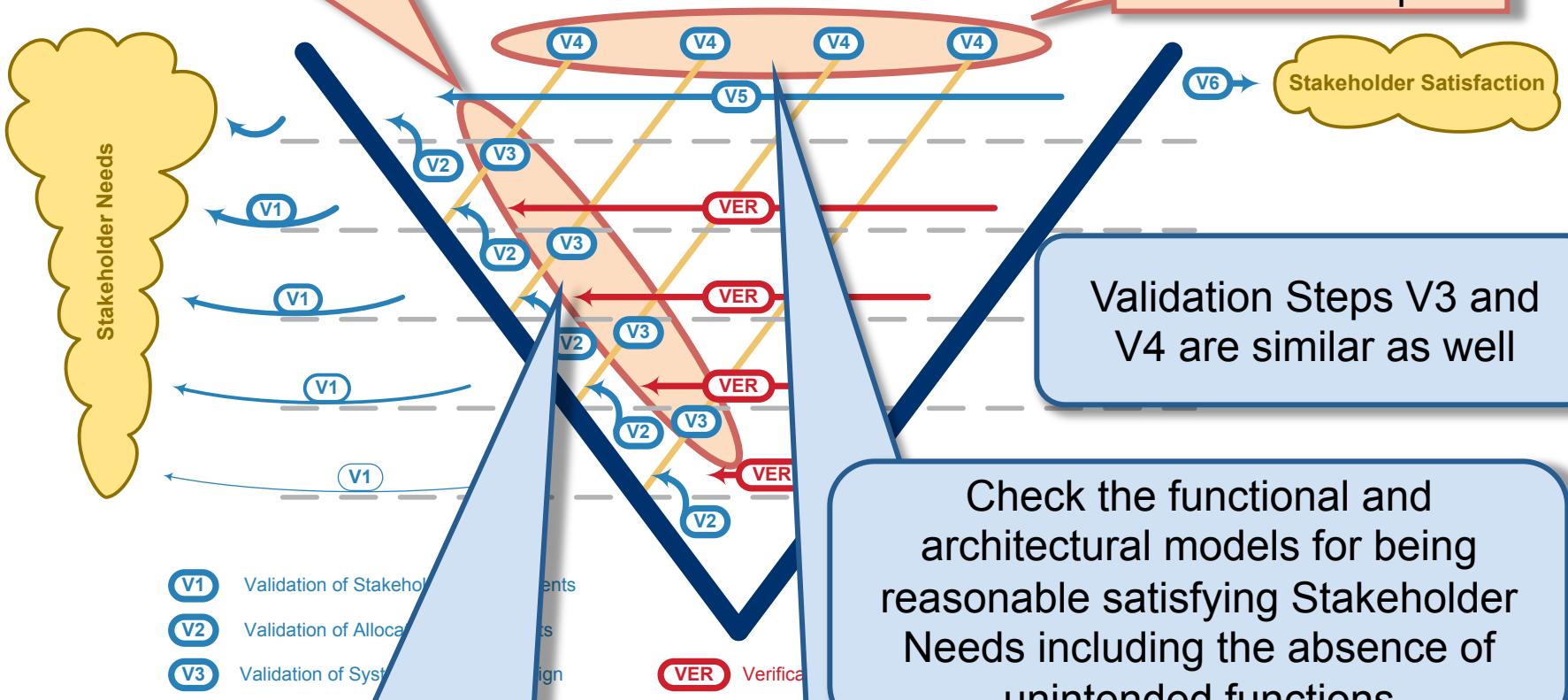
Validation Step V3

Validation Step V4




Validation Steps V3 and V4 are similar as well

Check the functional and architectural models for being reasonable satisfying Stakeholder Needs including the absence of unintended functions

V3 is performed before Allocated Requirements are forwarded to System Elements

V4 is performed when models from lower architectural levels become available and are virtually integrated

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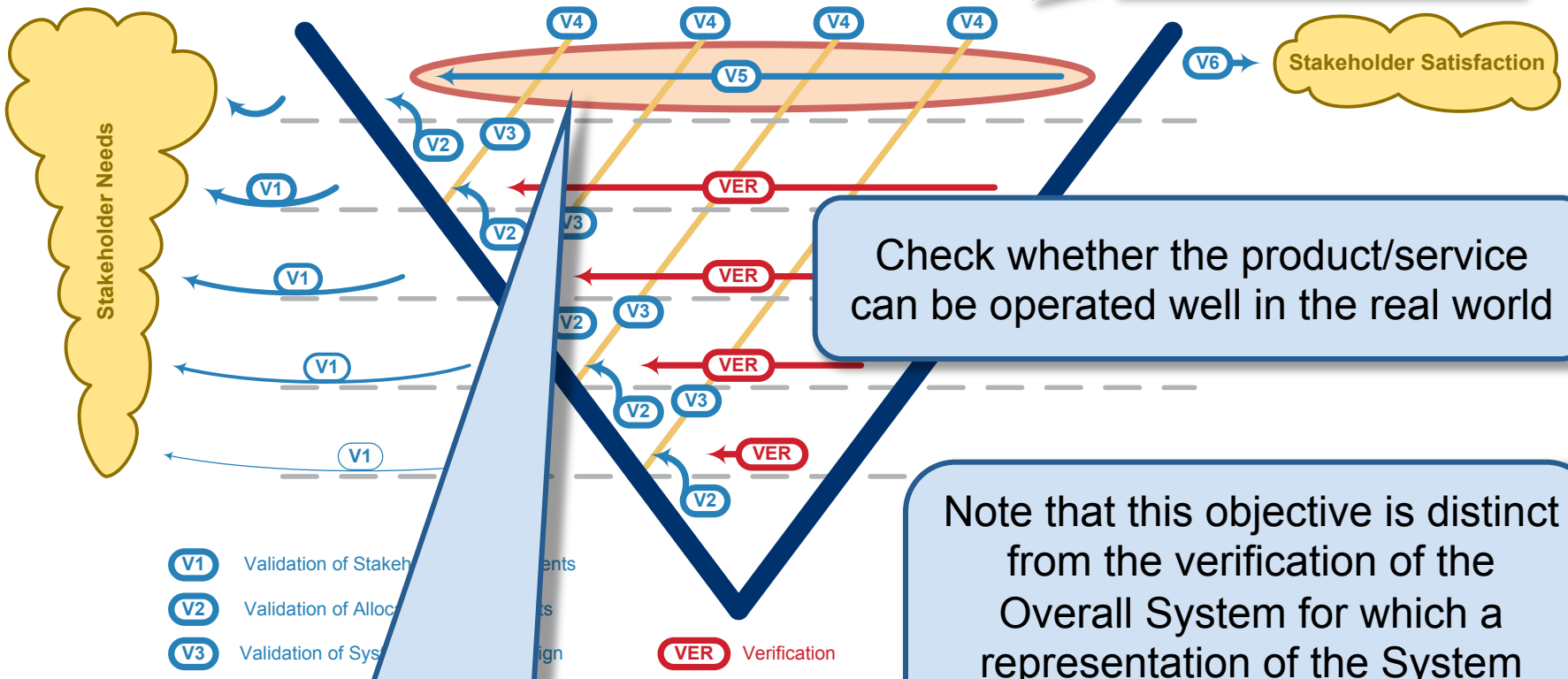
Validation Step V5




Check whether the product/service can be operated well in the real world

Note that this objective is distinct from the verification of the Overall System for which a representation of the System Environment is needed

V5 is performed by bringing the integrated Overall System into its System Environment

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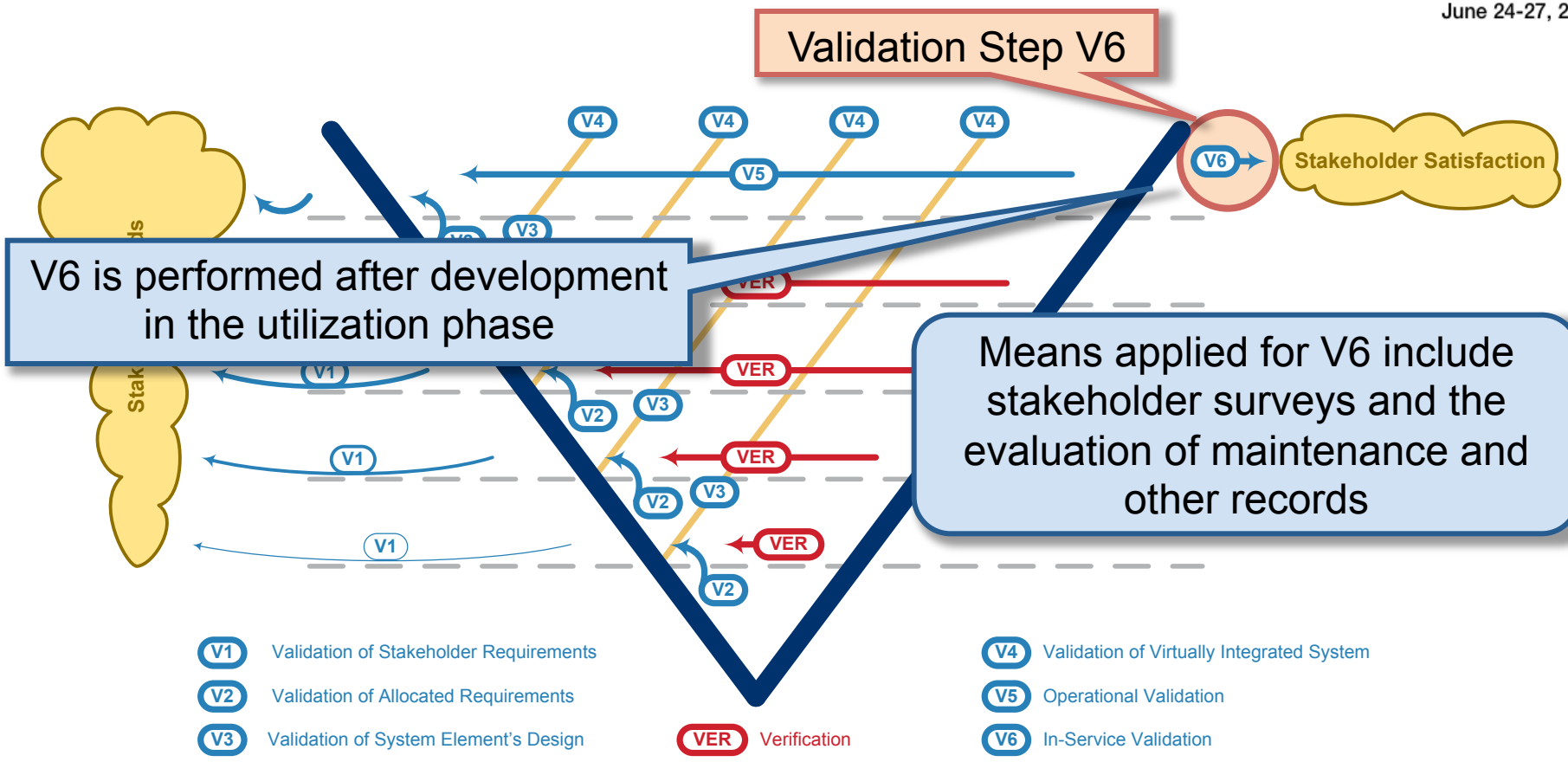


V6 is performed after development in the utilization phase

Means applied for V6 include stakeholder surveys and the evaluation of maintenance and other records

V1 Validation of Stakeholder Requirements
V2 Validation of Allocated Requirements
V3 Validation of System Element's Design
VER Verification
V4 Validation of Virtually Integrated System
V5 Operational Validation
V6 In-Service Validation

V6 provides hints for further product/ service evolution and enlarges the knowledge base on the Stakeholder Needs for future products and services

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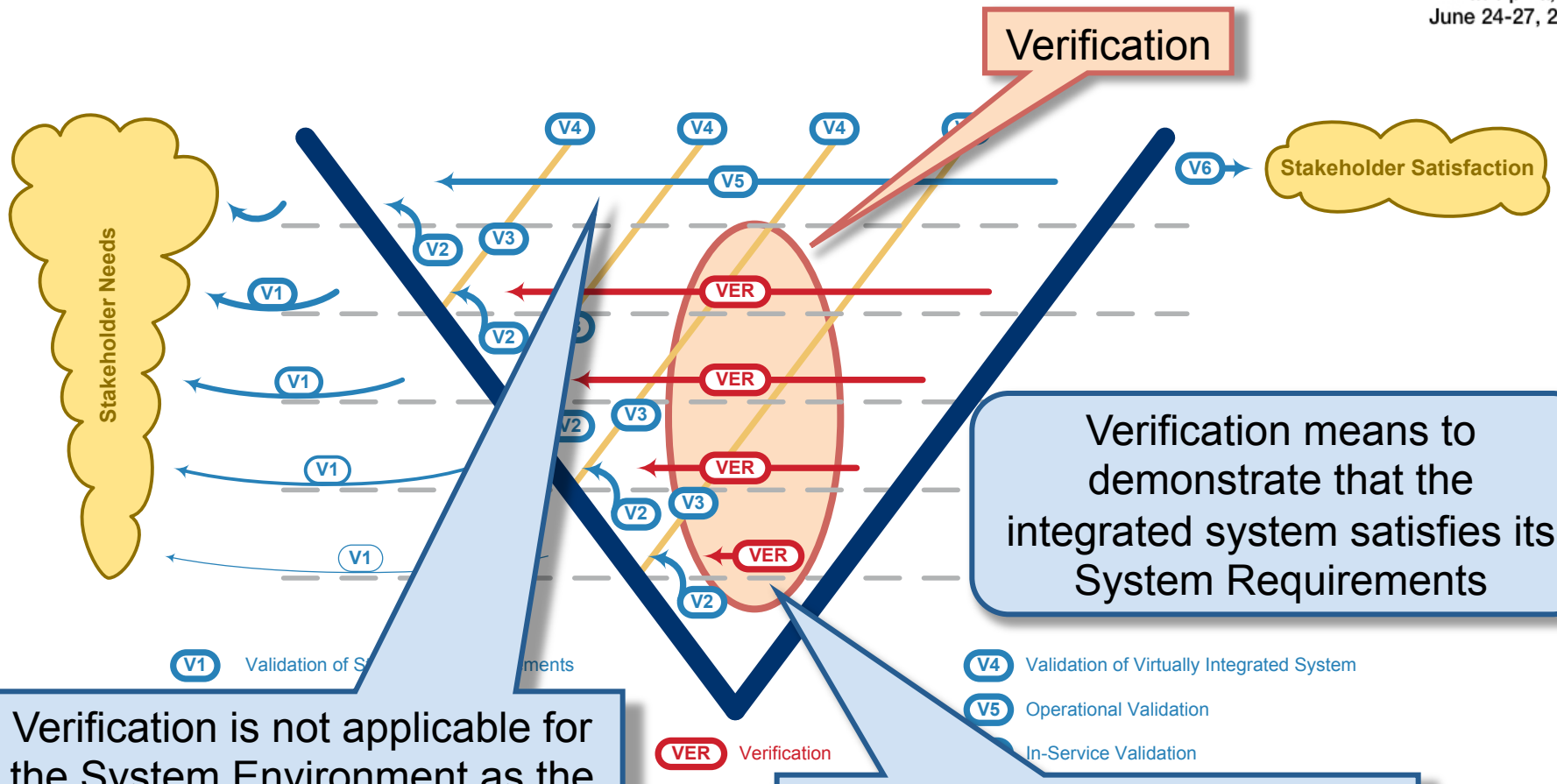


Verification means to demonstrate that the integrated system satisfies its System Requirements

Verification is not applicable for the System Environment as the System Requirements on the System Environment are out of the scope of the development of the Overall System

Verification includes satisfying assurance objectives driven by resolving assumptions as these assurance objectives also contribute to verification

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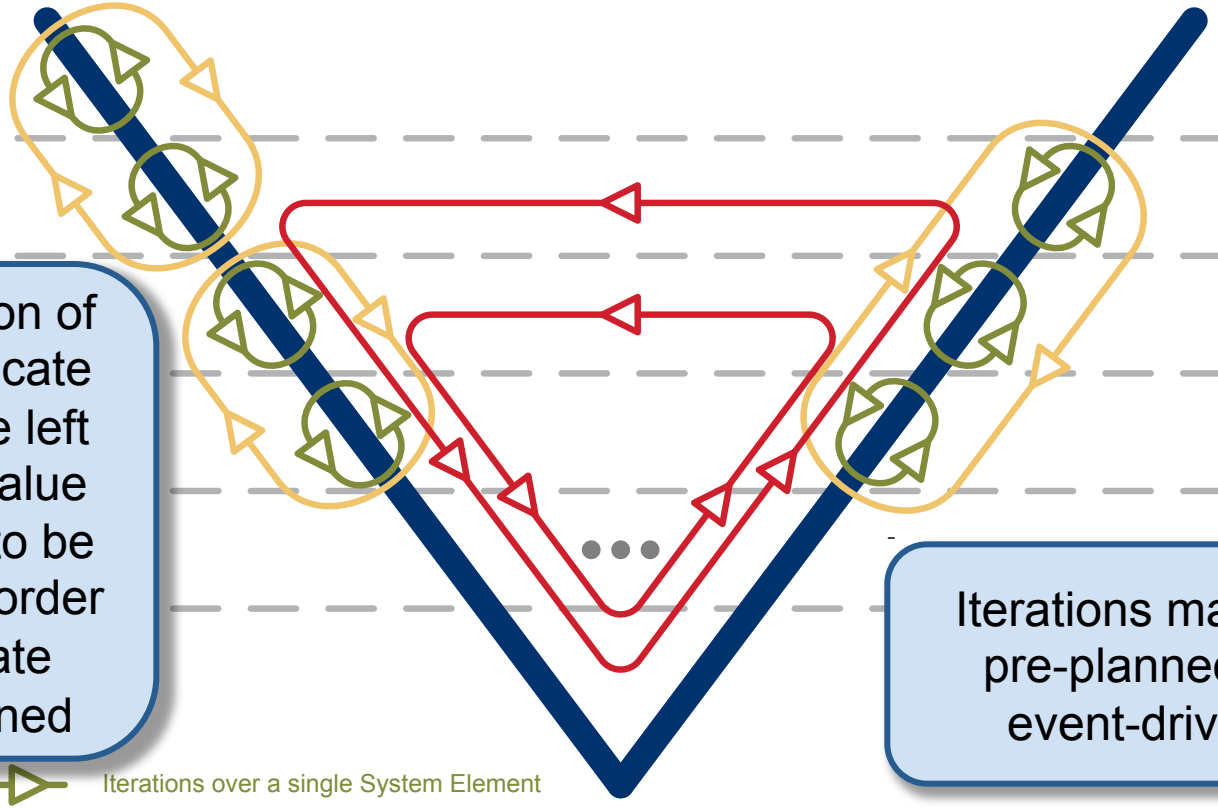

The expression of iterations indicate how far to the left the Overall Value Stream has to be re-entered in order to incorporate lessons learned

Iterations may be pre-planned or event-driven

Iterations over a single System Element

Iterations over several System Architecture Levels either on the left or the right leg of the V

Iterations over several Systems Architecture Levels including the Implemenation Level

# Learning in SE

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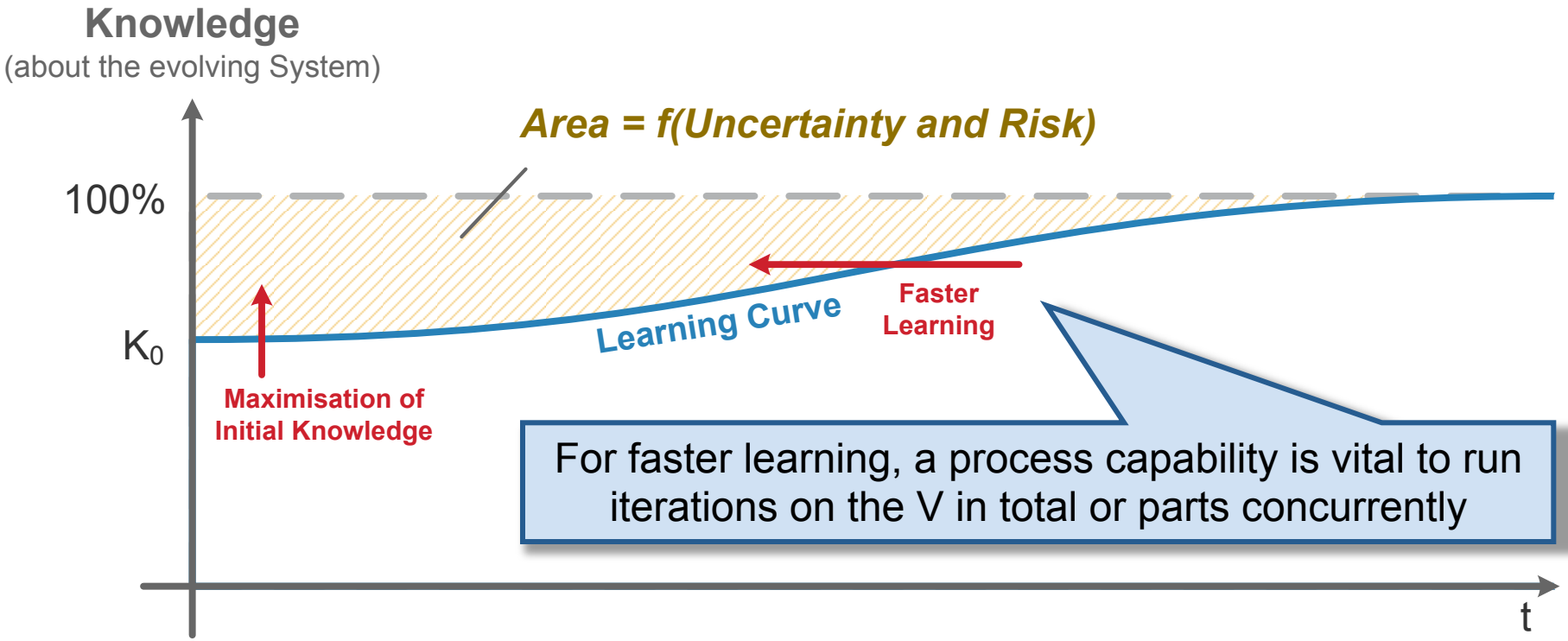


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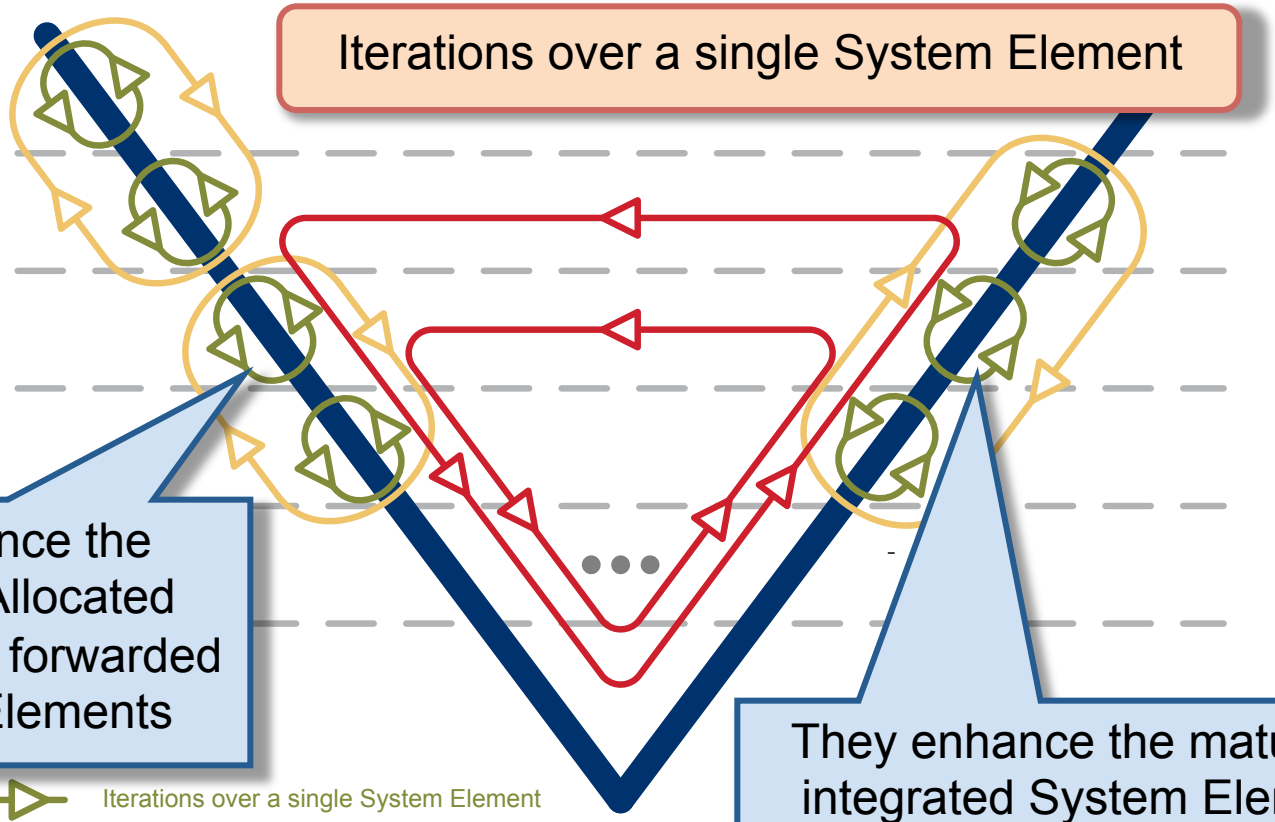


They enhance the maturity of Allocated Requirements forwarded to System Elements

They enhance the maturity of integrated System Elements forwarded for the integration of the upper level System

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

# The Dynamic V

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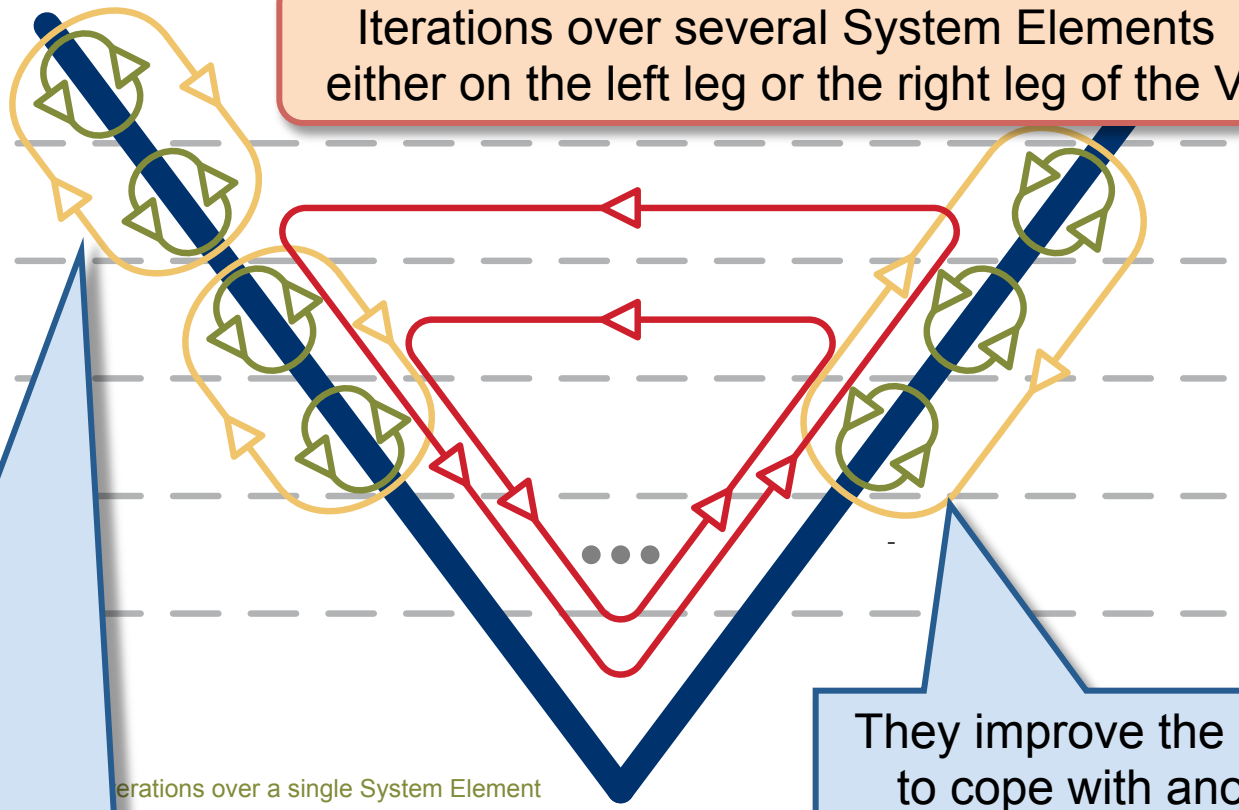
Iterations over several System Elements either on the left leg or the right leg of the V



erations over a single System Element

erations over several System Architecture Levels either on the

the

They enhance the maturity of a System Architecture before System Elements on the Implementation Level are procured from suppliers

They improve the reactivity to cope with anomalies especially when System Integration is performed on various architectural levels concurrently

# The Dynamic V

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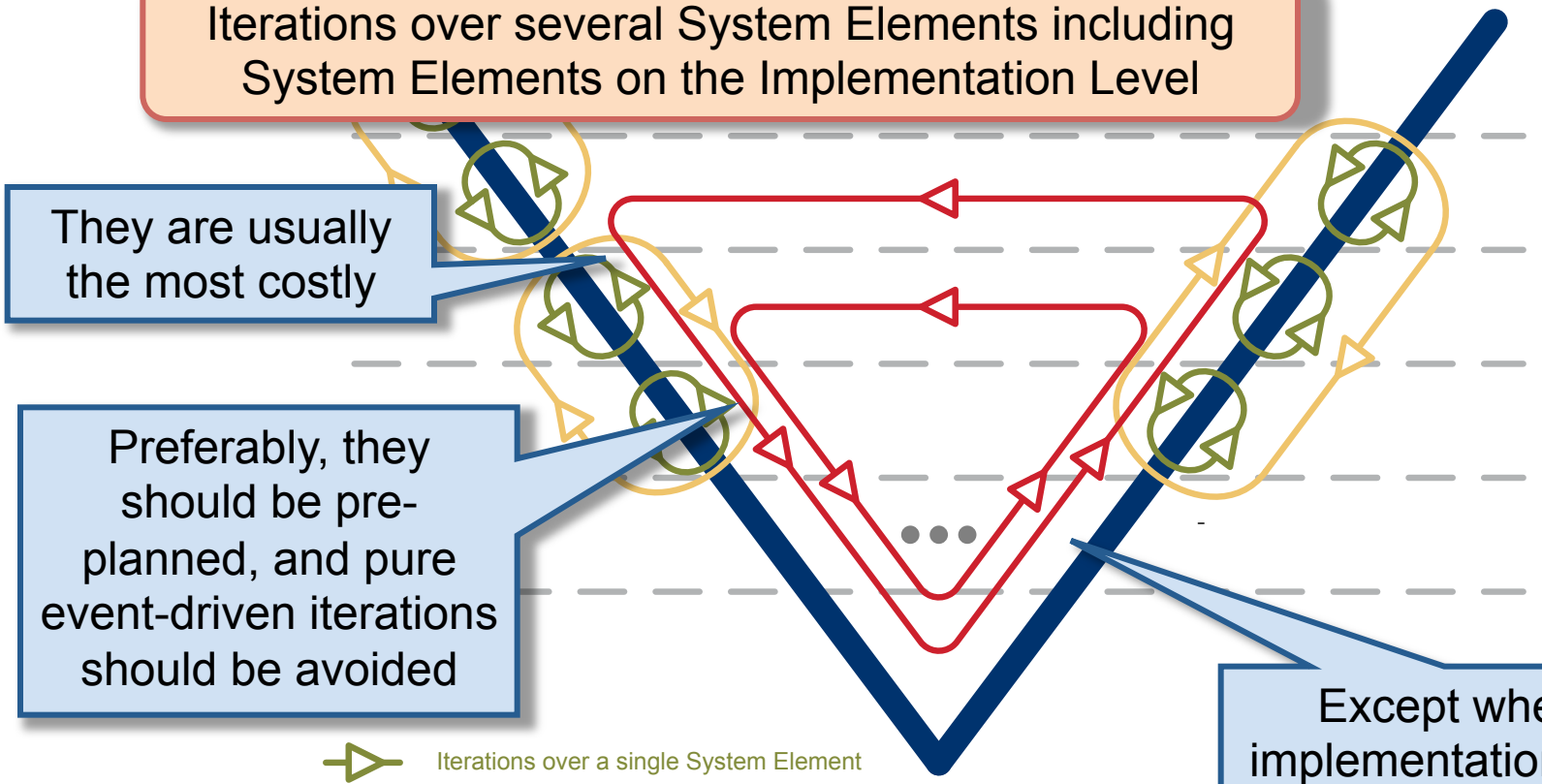
Iterations over several System Elements including System Elements on the Implementation Level

They are usually the most costly

Preferably, they should be pre-planned, and pure event-driven iterations should be avoided



Iterations over a single System Element

Iterations over several System Architecture Levels either on the left or the

Iterations over several Systems Architecture Levels including the Impleme

Except when the implementation effort is quite low as for example for some software development activities


# Questions? Comments? Requests?

# Survey

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