H·I·T·S Engineering

# Three Major Risk Areas of Iterative System Integration Approaches

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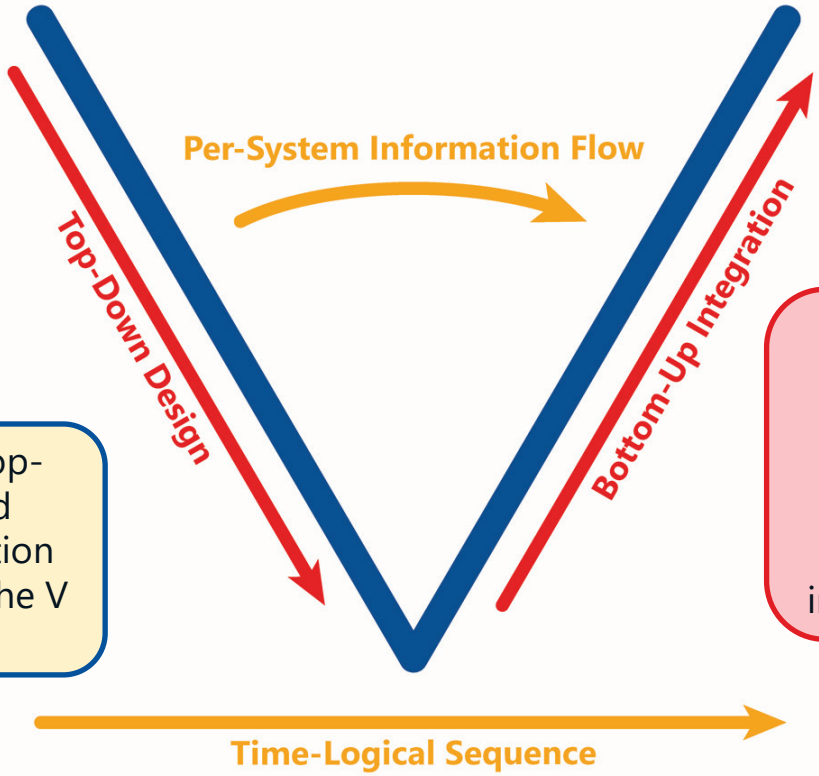
# The V Interpreted as Model of the Information Flows per Iteration

The V is the basic Icon in Systems Engineering

It is good starting point for developing a detailed information flow model suitable for iterative development processes

The principles of Top-Down Design and Bottom-Up Integration are represented by the V directly

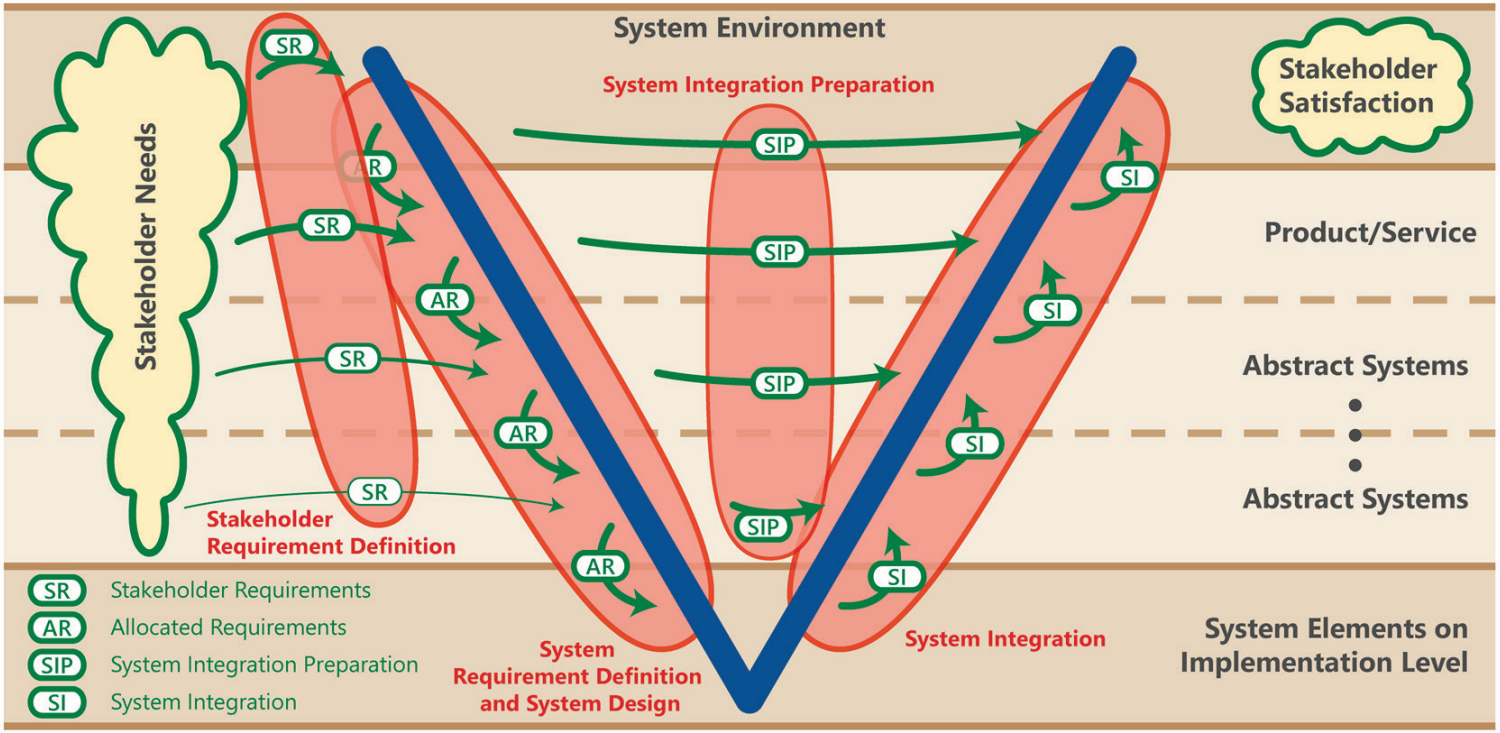



However, some Information flows directly from the Left Leg to the Right Leg of the V for each System or System Element

In order to cope with iterative development approaches in general, the horizontal axis has to be interpreted as time-logical sequence instead of absolute time

*Dieter Scheithauer, Kevin Forsberg: V-Model Views. IS 2013.*

# System Development Processes in the V




*Dieter Scheithauer, Kevin Forsberg: V-Model Views. IS 2013.*

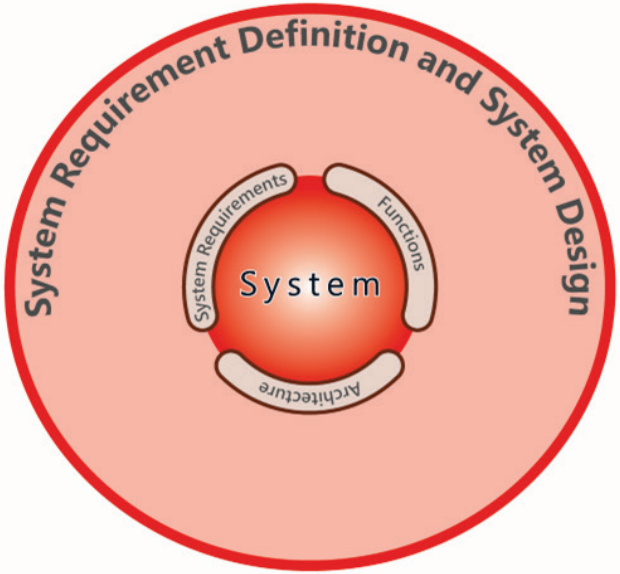
# Major Risk Areas

- *Major Risk Area 1 (MRA1):*
  Diffusion of System Design Responsibilities
- *Major Risk Area 2 (MRA2):*
  System Integration Environments Incapable to Cope With Innovative Functions
- *Major Risk Area 3 (MRA3):*
  Flawed Configuration Information for Commencing System Integration
- This 3 major risk areas are selected due to their possible severe adverse impact
  - on the quality of the generated system integration evidence for verification and validation,
  - for damaging system integration environments and/or test articles, and
  - on time schedules and overall costs
- The following slides consider each of the major risk areas in terms of their process context, the corresponding issues, and measures for risk mitigation and risk avoidance

# MRA1 – The Context: System Requirement Definition and System Design

## The Main Process Objective

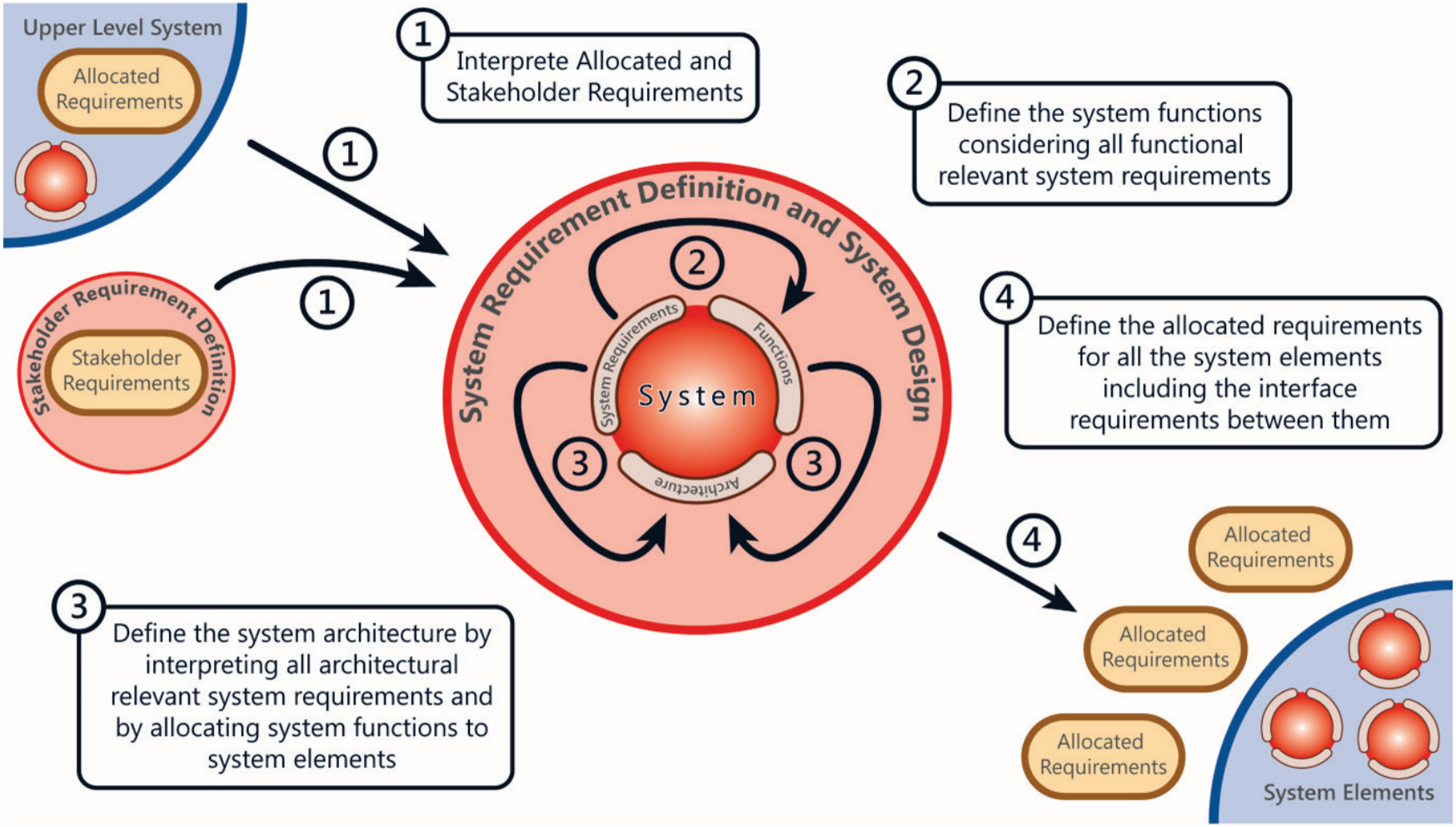
- A Complete and consistent description of the system design by complimentary
  - System Requirements,
  - Functional Definitions, and
  - Definition of the Archi-tectural Decomposition




## System Requirements

- They are an output of the system's design, and not an input
- They define the external commitments of the responsible design team for which compliance has to be demonstrated
- They satisfy the applicable quality criteria from the viewpoint of the contributing disciplines
- They are worded in the discipline specific languages of the contributing disciplines

# MRA1 – The Context: System Requirement Definition and System Design



# MRA1 – The Issues

- ISO15288, para. 6.4.5.3 b)1): „Allocate system requirements to system elements“
- This phrase may be misinterpreted that system requirements at its best should be scoped and worded to match with demands from individual system elements without further interpretation and refinement
- On the other hand, system requirements need
  - to express the commitments regarding the system itself,
  - for enabling demonstration of compliance with the main focus on functions and features that are emergent on the particular architectural level, and
  - are not anymore reducible to and fully visible on the next lower architectural level of the system elements
- In case of development-on-demand projects, it may be indeed an intention to let the design responsibles of the system elements do most of the job for integrating them, but this is not possible for system elements that are commercial-off-the-shelve
- With respect to the balance between the left leg and the right leg of the V, the system integration responsibility does not align anymore clearly with the system design responsibility
- In consequence, the quality assessment of system integration iteration compatibility with incomplete system and system elements becomes cumbersome and error-prone as the incompleteness may not be consistent among all the system and system element entities

# MRA1 – Risk Mitigation and Risk Avoidance

- System requirements shall express the commitments of the system design responsibles, e.g. concentrating on emergent system functions and features of the particular system
- The system requirements shall establish the demands for the demonstration of compliance during the system's integration
  - Note: General assurance criteria from project plans are the only other source
- System requirements shall be refined and reworded as appropriate to establish the allocated requirements regarding each system element
- *The general issue of dealing with inconsistent incompleteness among system and system elements at a particular system integration iteration cannot be coped with by the measures above completely, and is further considered below as configuration management issue (see MRA3)*

# MRA2 – The Context: System Integration Preparation in the ISO15288

## System Integration Preparation in ISO 15288

- ISO 15288:2015 does not feature a dedicated System Integration Preparation Process
- Instead all system integration preparation activities are part of the system integration process itself


- ISO 15288, Para. 6.4.8.3 a) : Prepare for Integration
  - 1) Identify and define check points for the correct operation and integrity of the assembled interfaces and the selected system functions
  - 2) Define the integration strategy
  - 3) Identify and plan for the necessary enabling systems or services needed to support integration
  - 4) Obtain or acquire access to the enabling systems or services, and materials to be used
  - 5) identify system constraints from integration to be incorporated in systems requirements, architecture or design

## Conclusion regarding ISO 15288:2015

- The process breakdown of ISO 15288 in combination with the weak system life cycle considerations is not well composed to support iterative development approaches including any waterfall model with repair cycles, or incremental and evolutionary development philosophies as no provisions for agility and continuous learning are incorporated

# MRA2 – The Issues

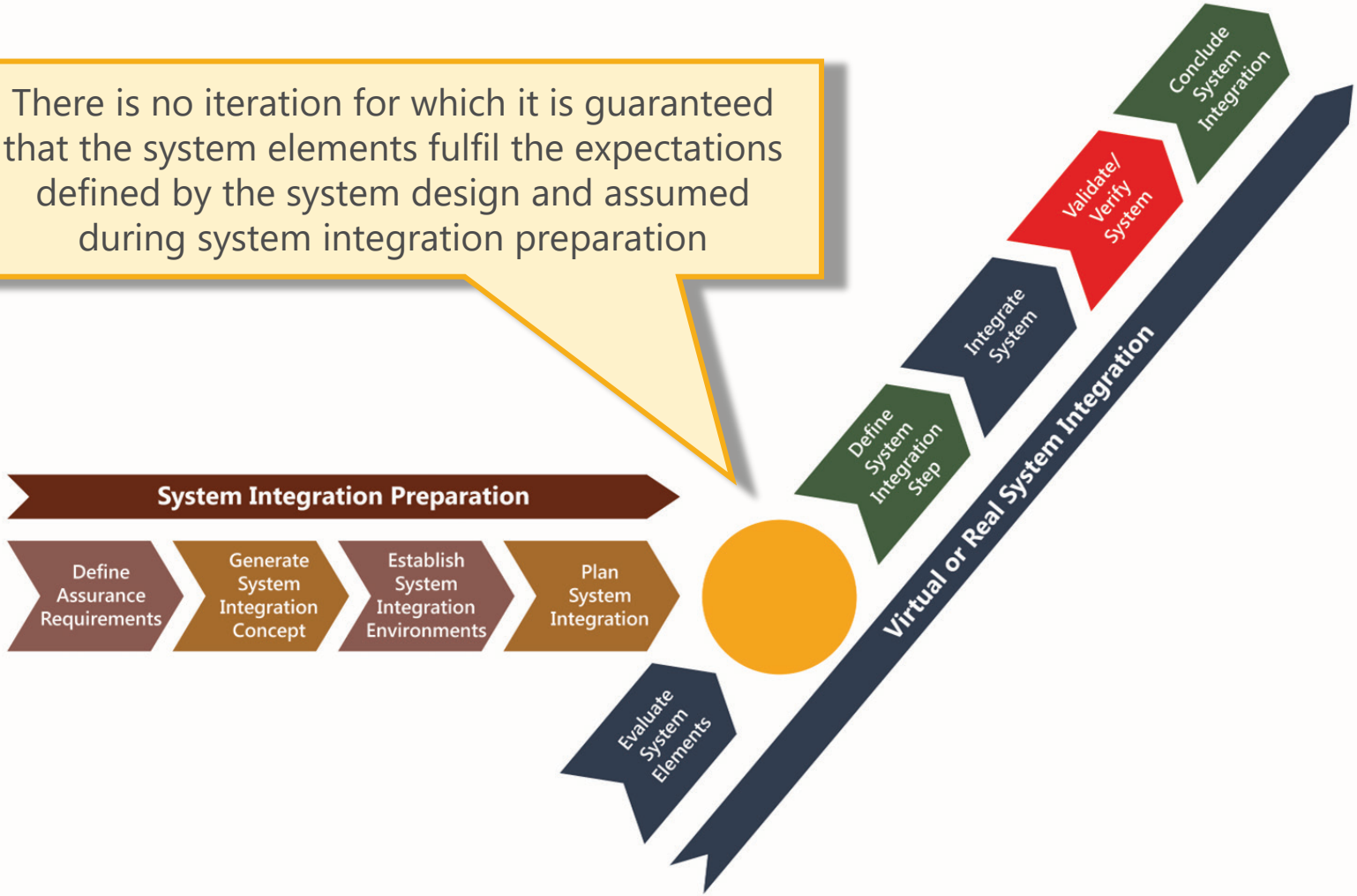
- Sophisticated system integration environments for testing hardware in-the-loop may have remarkable long lead times
- Procurement of such system integration environments has to be commenced long before the system requirements are stable
- The system definition of the system integration environments is widely based on past experience
- Past experience does not include much guidance how to cope with innovative functions and features
- As innovative functions and features require usually an intense demonstration of compliance with the most sophisticated means, missing capabilities of system integration environments may raise severe concerns
- In consequence, intense analyses and discussions with relevant stakeholders are needed to define acceptable work-arounds, if any exist at all

# MRA2 – Risk Mitigation and Risk Avoidance

- The definition of system integration environments need information about the system requirements expressing the demands on innovative functions and features, and the foreseeable means of compliance as early as possible
- This information is most likely generated from early conceptual studies onwards that at their best will focus especially on the innovative part considering many variations
- In order to establish a sound basis for the procurement of system integration environments as early as possible, corresponding maturity gates for performing conceptual studies are an essential element for risk mitigation
- In addition, configuration management in the concept phase needs to be performed with more rigour than practiced usually for monitoring the further evolution of the conceptual design continuously

# MRA3 – The Context: Merging the Information Flows

There is no iteration for which it is guaranteed that the system elements fulfil the expectations defined by the system design and assumed during system integration preparation



# MRA3 – The Issues

- Performing system integration with incomplete system designs and incomplete system elements carries a remarkable high risk of damages to the system integration environment and/or the test articles
  - System integration environments and test articles are rare entities in general
- The incompleteness among the system and system elements cannot be assumed to be consistent

# MRA3 – Risk Mitigation and Risk Avoidance

- For each iteration in system integration, a sound analysis of the integration readiness has to be performed in order
  - to avoid damages to system integration environments and test articles, and
  - to enable the evidence generated during a particular iteration being sufficient to finally demonstrate the compliance of particular system functions and features
- Sound configuration baselines need to be maintained continuously considering the contents of each system design and system integration iteration on the left leg and the right leg of the V providing the following information
  - The functions and features available complete or partially
  - Functions and features not available
  - The foreseeable resulting risks from trying to execute functions and features not available or only partially available
  - Open issues found and their concession status

# Conclusions

- The three major risks considered in this presentation have been observed by the author repeatedly resulting finally always in
  - high efforts in terms of time and costs in order to find technically feasible work-arounds for risk mitigation
  - with remaining quality concerns including safety and security issues
- In the V, the top-down design and bottom-up integration principles need to be amended by the direct information flows from the left leg to the right leg of the V for each system and system element to increase development effectivity and efficiency
  - Neglecting these flows may not harm systems engineering process models based on a first-time-right assumption with everything perfect from the start, at least in theory
  - In practice, particular emphasis has to be spend for managing the learning during the conceptual and full-scale development of innovative complex systems by a leaner and more efficient model of all information flows

*„It is easy to derive a perfect design from requirements as it is easy to walk over water, in case both are frozen“* *Kevin Forsberg*

# Thank You

## for your attention

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