

Improving Mission Success of CubeSats Product Overview

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Acknowledgments

This document has been produced as a collaborative effort of the Mission Assurance Improvement Workshop. The forum was organized to enhance mission assurance processes and supporting disciplines through collaboration between industry and government across the U.S. Space Program community utilizing an issue-based approach. The process is to engage the appropriate subject matter experts to share best practices across the community in order to produce valuable mission assurance guidance documentation.

The document was created by multiple authors throughout the government and the aerospace industry. For their content contributions, the following contributing authors are acknowledged for making this collaborative effort possible:

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Catherine Venturini	The Aerospace Corporation
Bob Andrews	Ball Aerospace and Technologies Corporation
Greg Berg	The Boeing Company
Jeff Christensen	The Boeing Company
Kim Hicks	The Boeing Company
Mike Tolmasoff	The Boeing Company
Andrew Whiting	The Boeing Company
Tom Wiedenbauer	Harris Corporation
Gary Kushner	Lockheed Martin Corporation
Rick Gebbie	MIT Lincoln Laboratory
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Catherine Venturini	The Aerospace Corporation
Mike Tolmasoff	The Boeing Company
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Andrew Robertson	Millennium Space Systems
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Improving Mission Success of CubeSats

Product Overview

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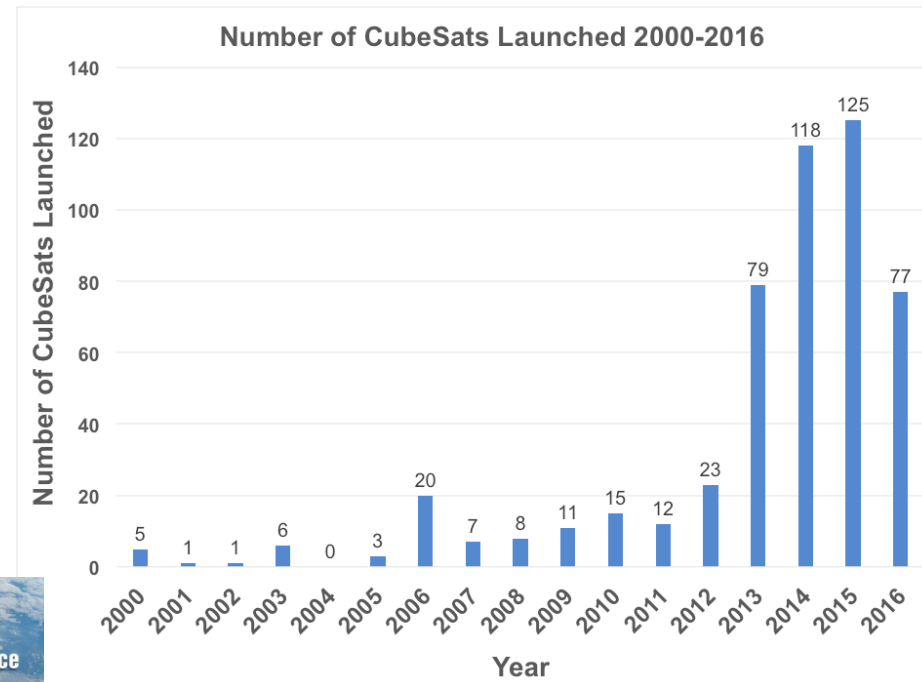
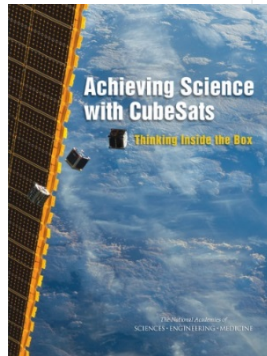
Agenda

- Motivation
- Historical causes of CubeSat failures
- Charter
- Interview process
- Themes
- Recommendations
- Target audience and intended users
- Team membership and recognition



Motivation for Improving Mission Success of CubeSats

- There has been a substantial increase in CubeSats launched since 2013
- University-led CubeSat projects lack the repeatable process rigor routinely found in industry
- Commercial off-the-shelf (COTS) solutions fall short of a space-qualified pedigree
- A recent National Academies report recommends that NASA and the National Science Foundation (NSF) make greater use of CubeSats for science missions
- As the importance of CubeSat payloads and missions increases, what aspects of mission assurance can significantly improve mission success rates?



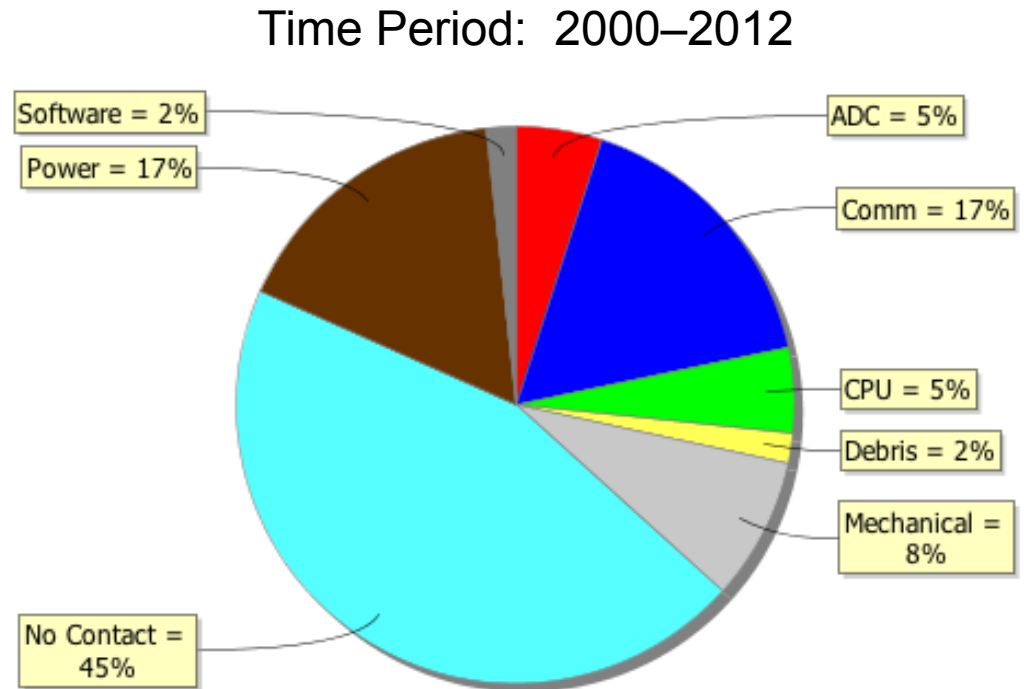
Data Source: M. Swartwout CubeSat Database at Saint Louis University



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Historical Causes of CubeSat Failures

- Over half of the CubeSat mission failures can be attributed to functional integration issues
- Other causes of mission failures include:
 - *Lack of system-level testing due to schedule and budget constraints*
 - *Inadequate thermal design*
 - *Use of COTS electronics*



Adapted from Swartwout, M. (2013): Journal of Small Satellites (JoSS), vol. 2, no. 2, p. 221 (Figure 9).

Improving Mission Success of CubeSats Charter

- Review design and manufacturing processes across industry, academia, and government CubeSat providers to identify best practices
- Interview CubeSat providers from industry, academia, and government to understand approaches taken to increase probability of mission success
- Identify important areas that CubeSat providers have focused on to improve probability of mission success



Interview Process

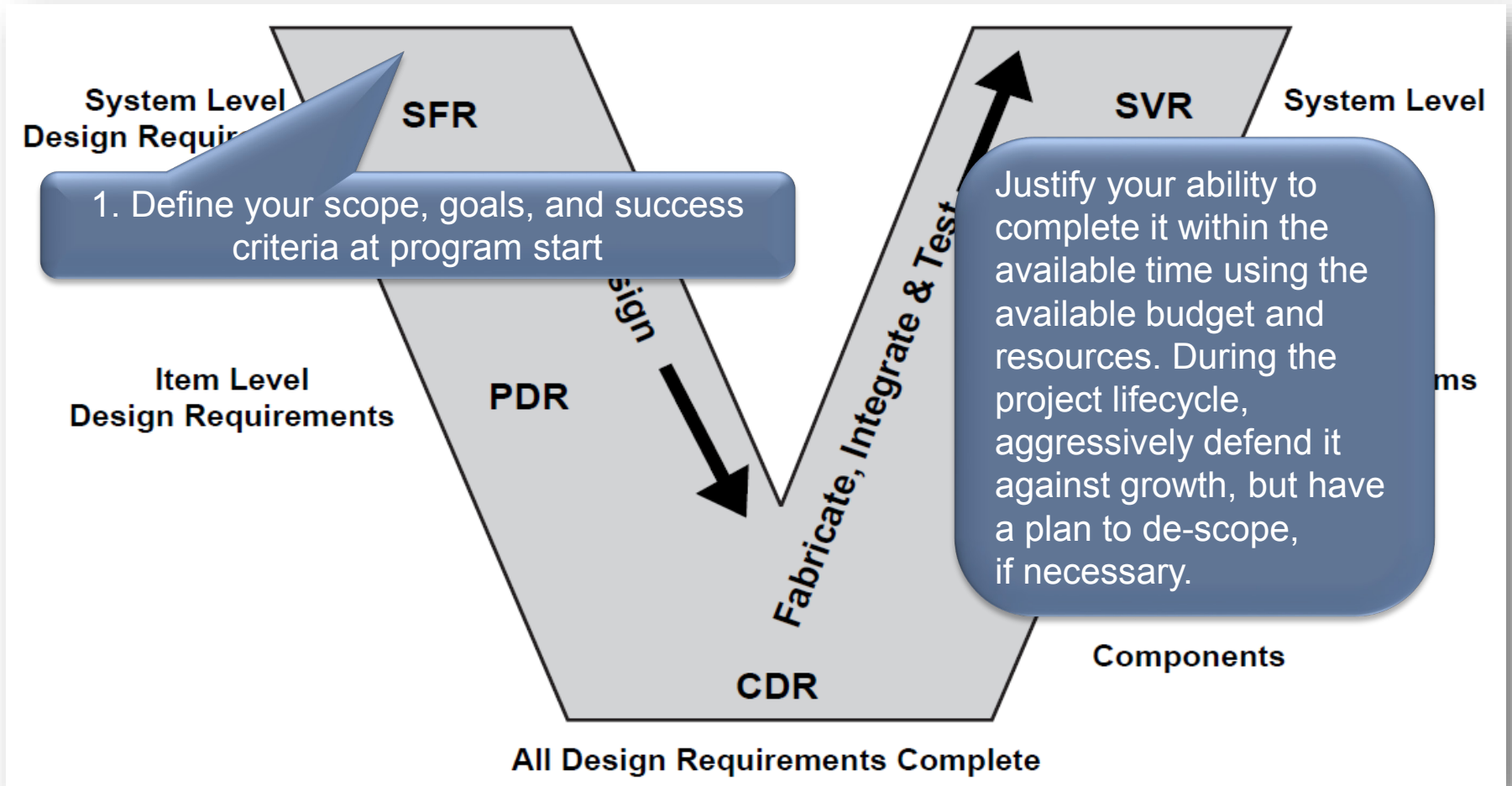
- Sub-divided topic team into four interview teams which were responsible for:
 - *Initiating contact with organizations*
 - *Scheduling and conducting interviews*
 - *Taking interview notes and generating interview summaries*
- Conducted 23 interviews
 - *10 from academia*
 - *5 from industry*
 - *8 from government/FFRDC/UARC*
- Generated final interview summary for each interview
 - *Peer-reviewed and approved by topic team*
 - *Peer-reviewed and approved by organization that was interviewed*



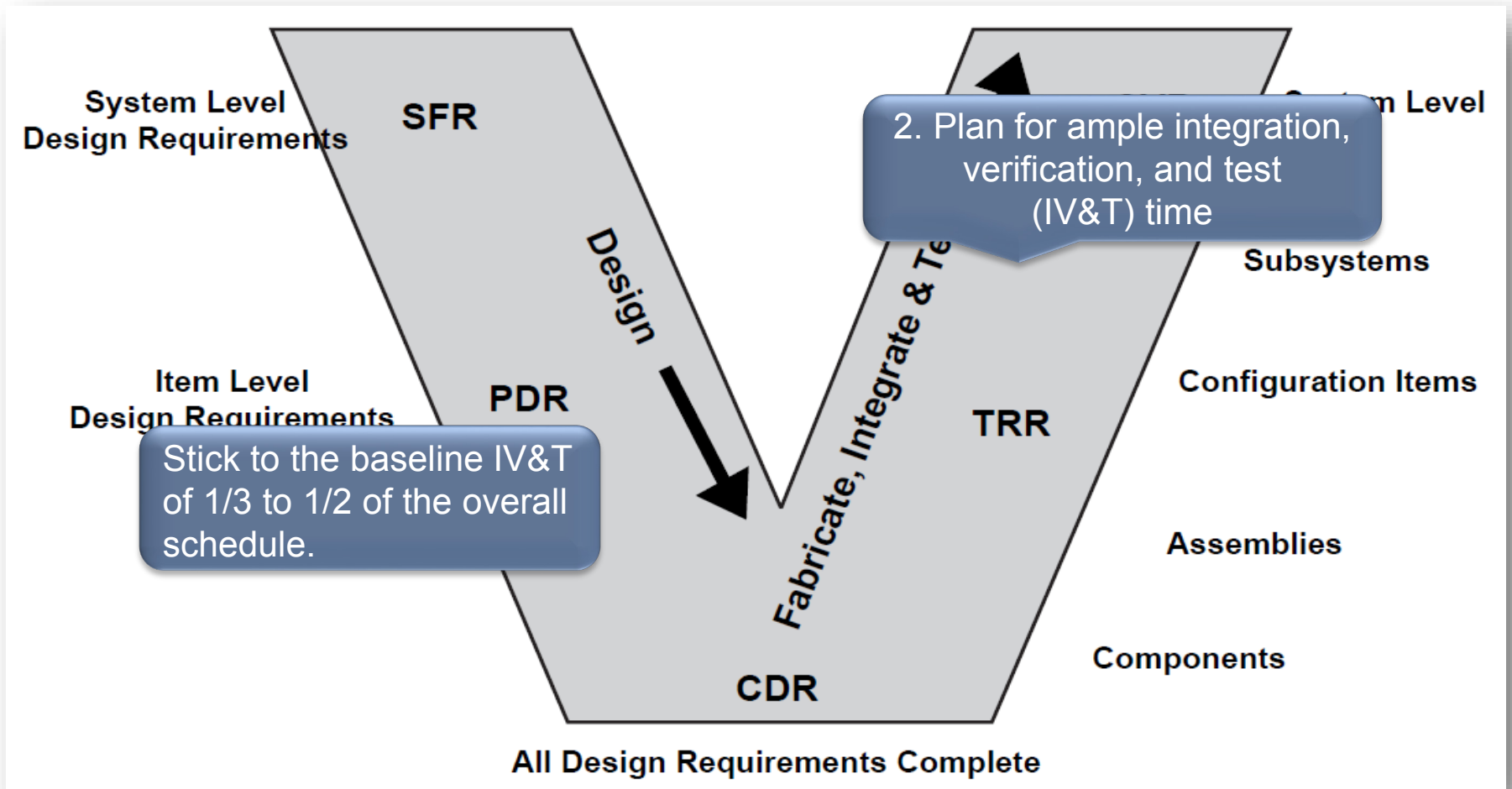
Themes

- The recurring themes identified across the 23 interviews were grouped into 8 categories:
 - *Setting the purpose and vision of the mission*
 - *Establishing the program structure*
 - *The risk process*
 - *Design and analysis*
 - *“Test, test, test”—the importance of testing*
 - *Common CubeSat failures*
 - *Parts quality, availability, and documentation*
 - *Launch is a significant driver*
- These themes were used to develop the recommendations

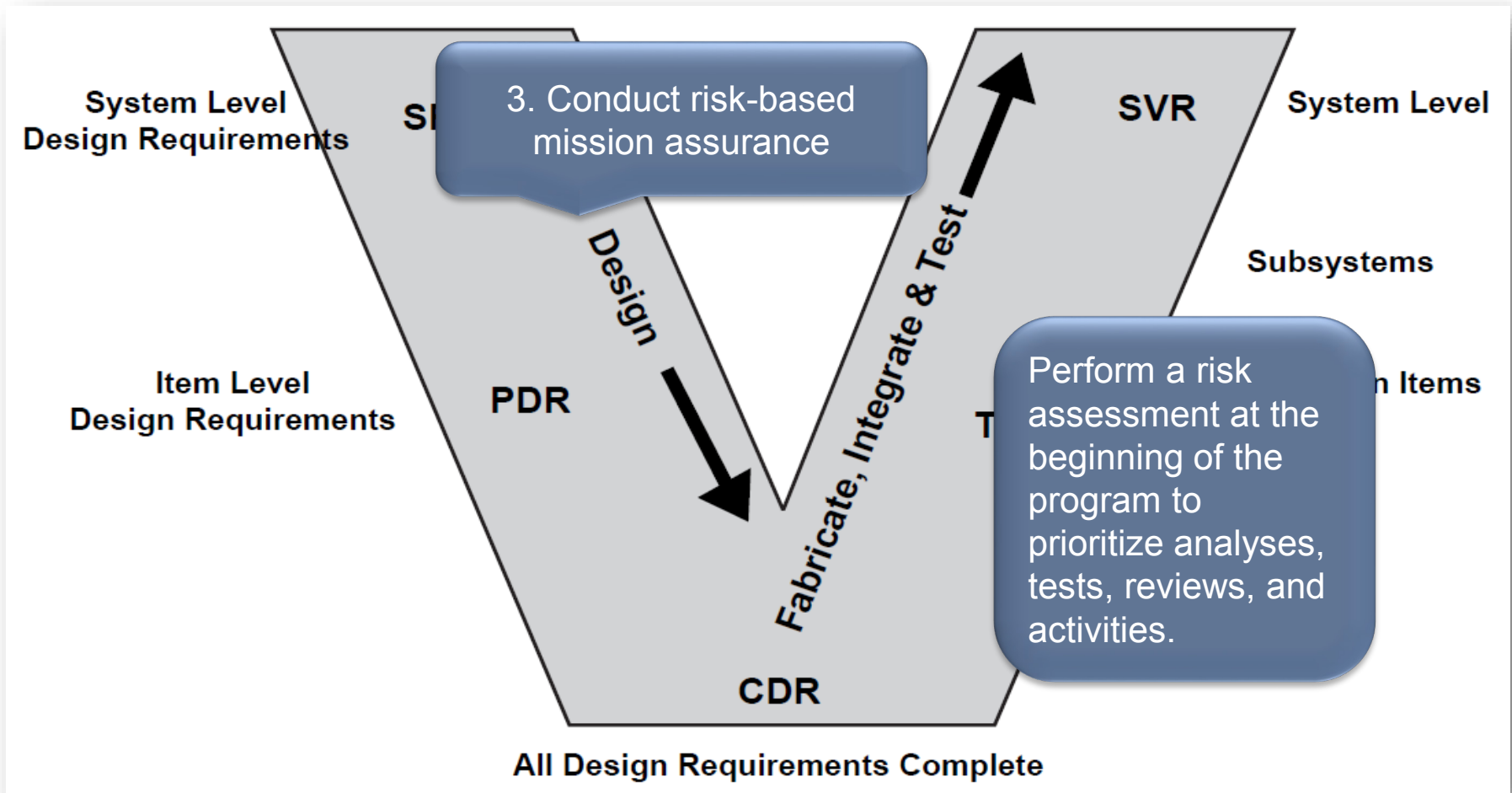
Recommendations



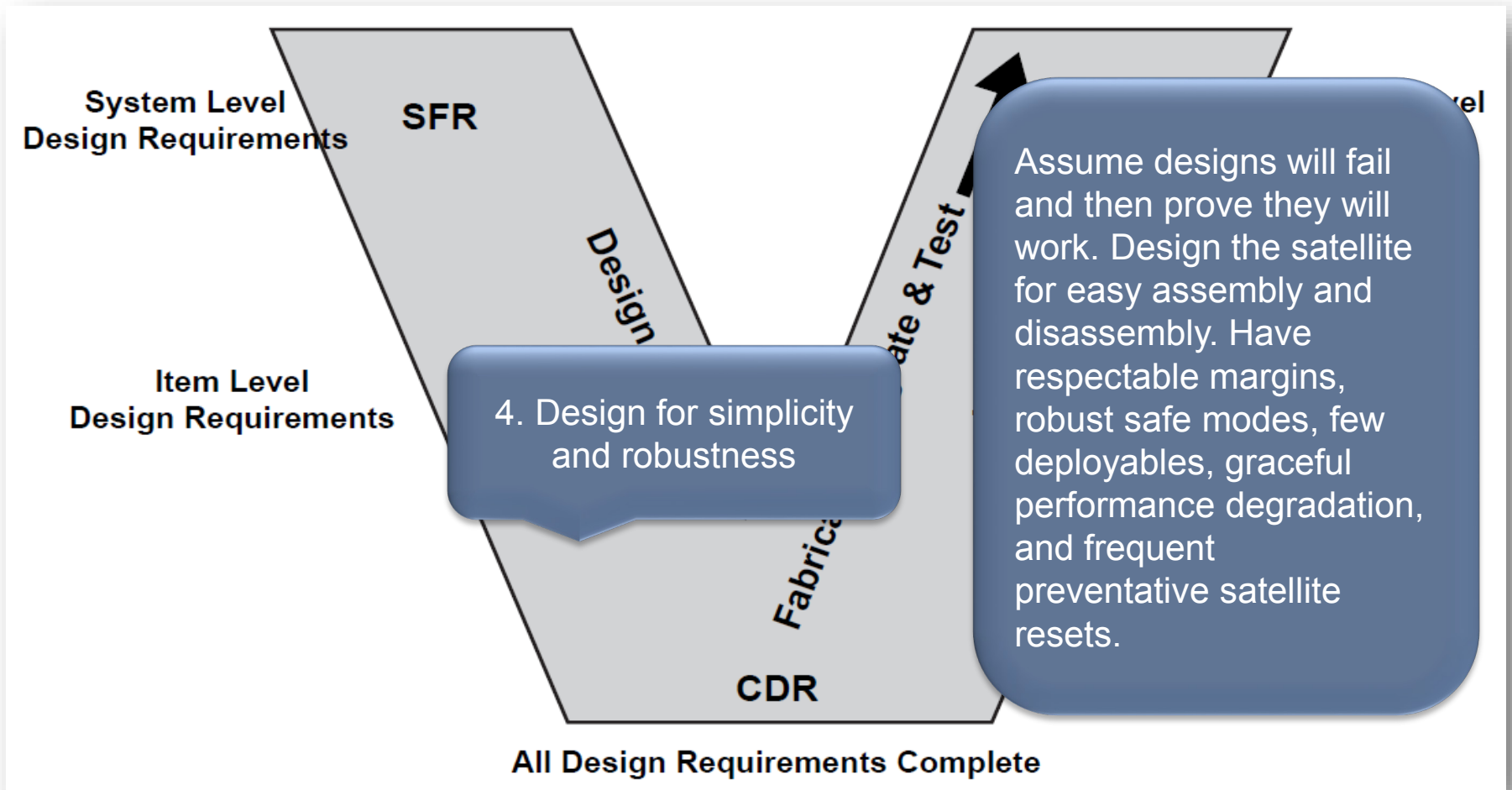
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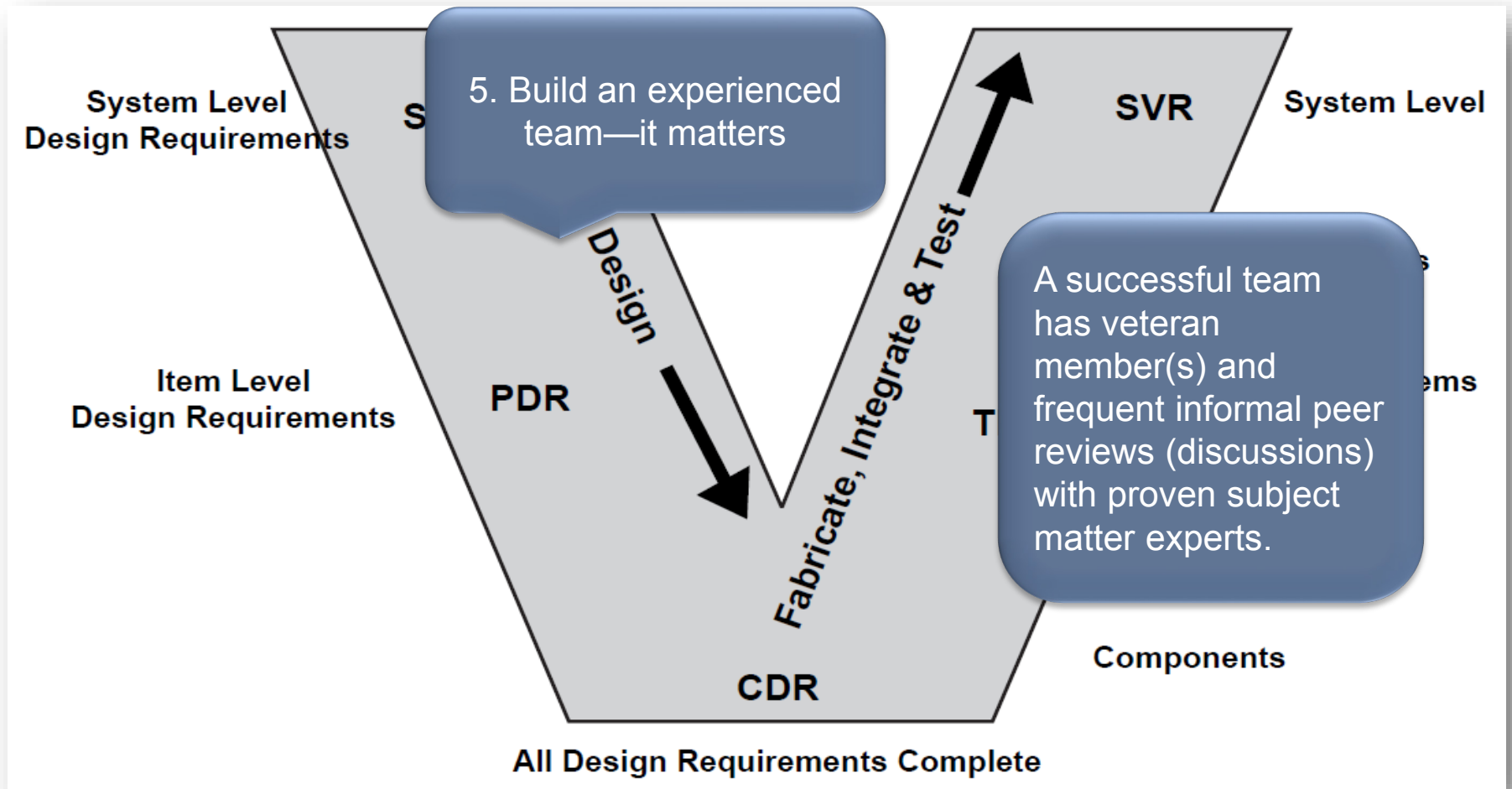
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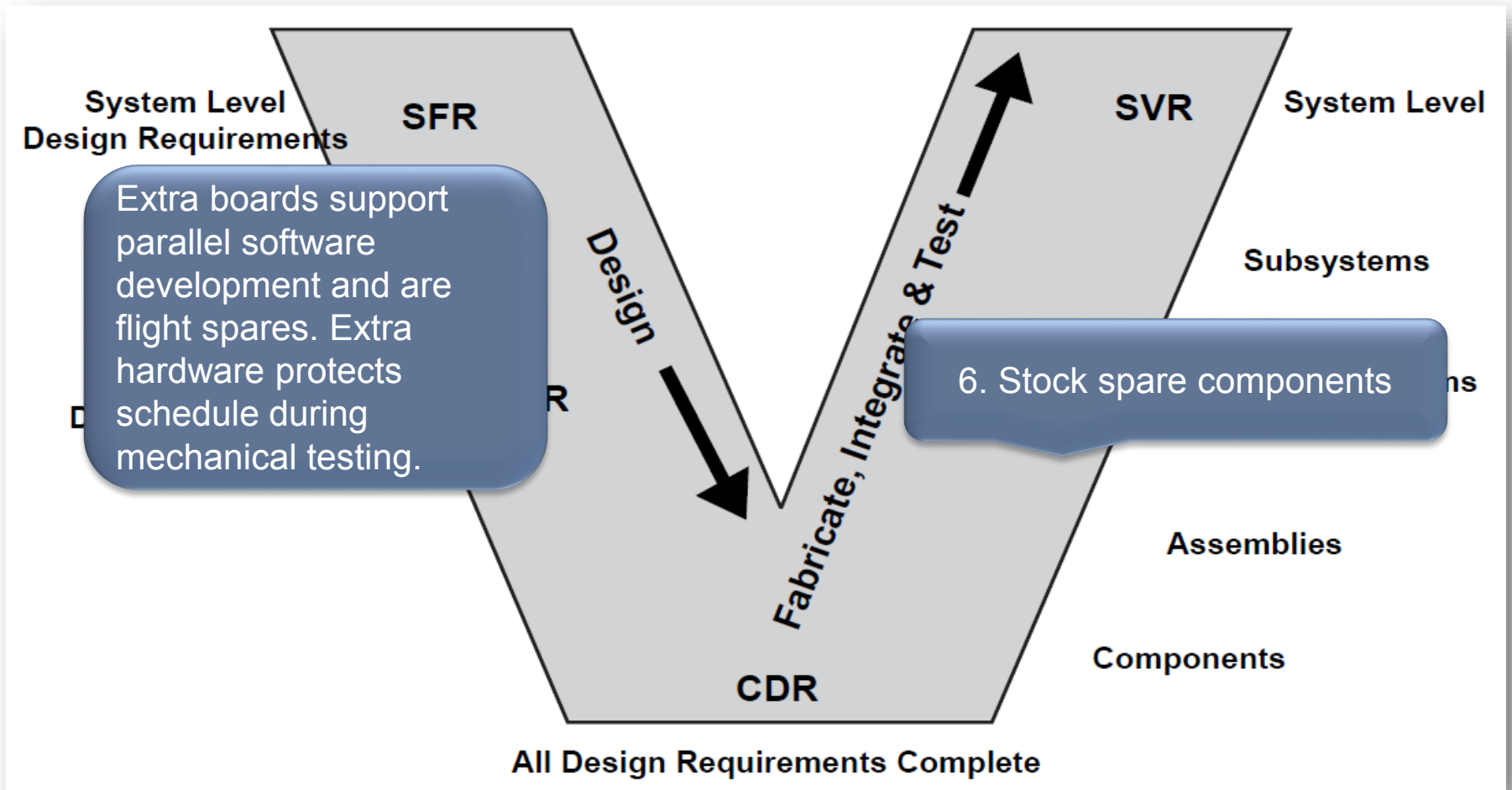
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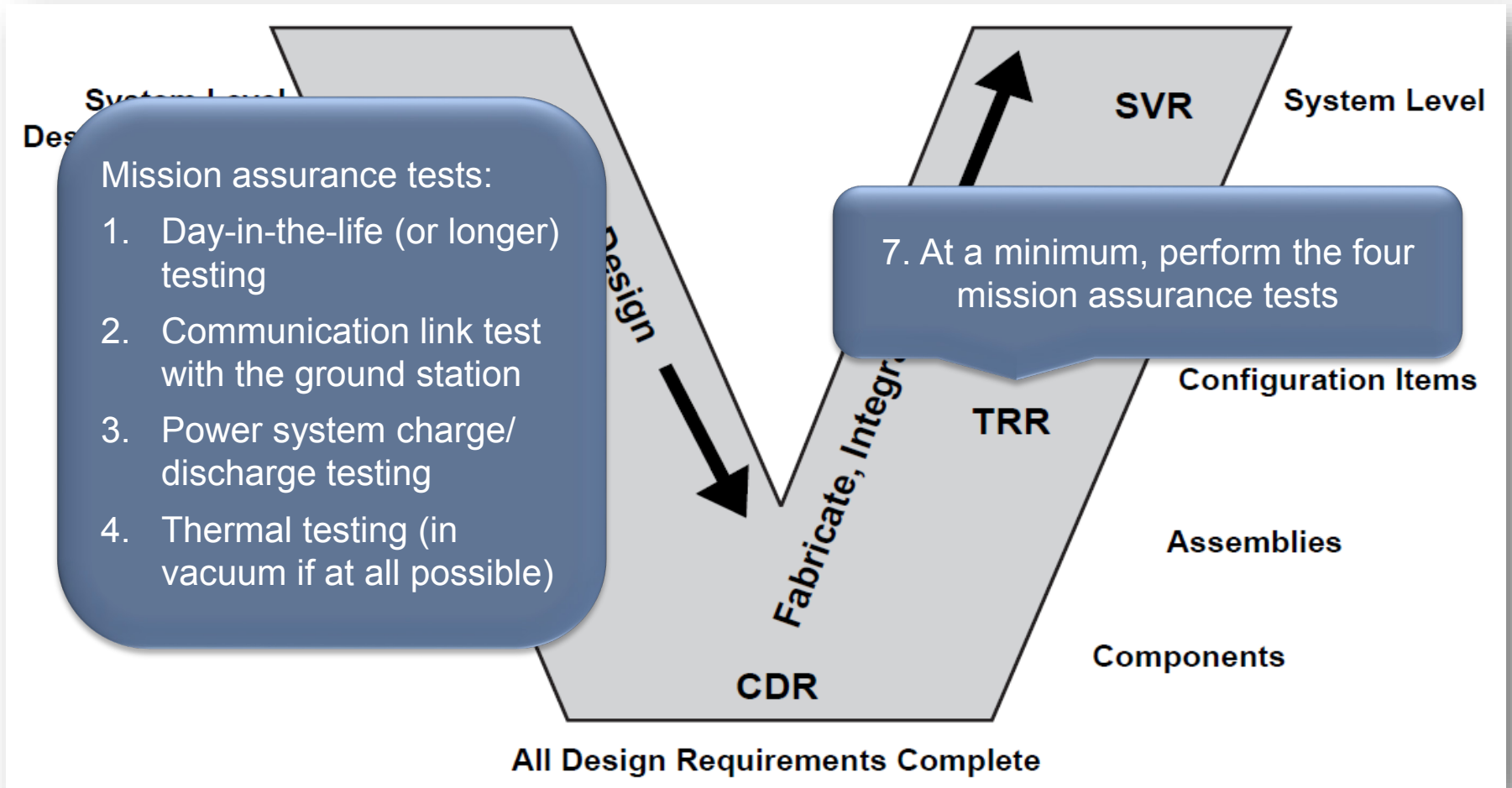
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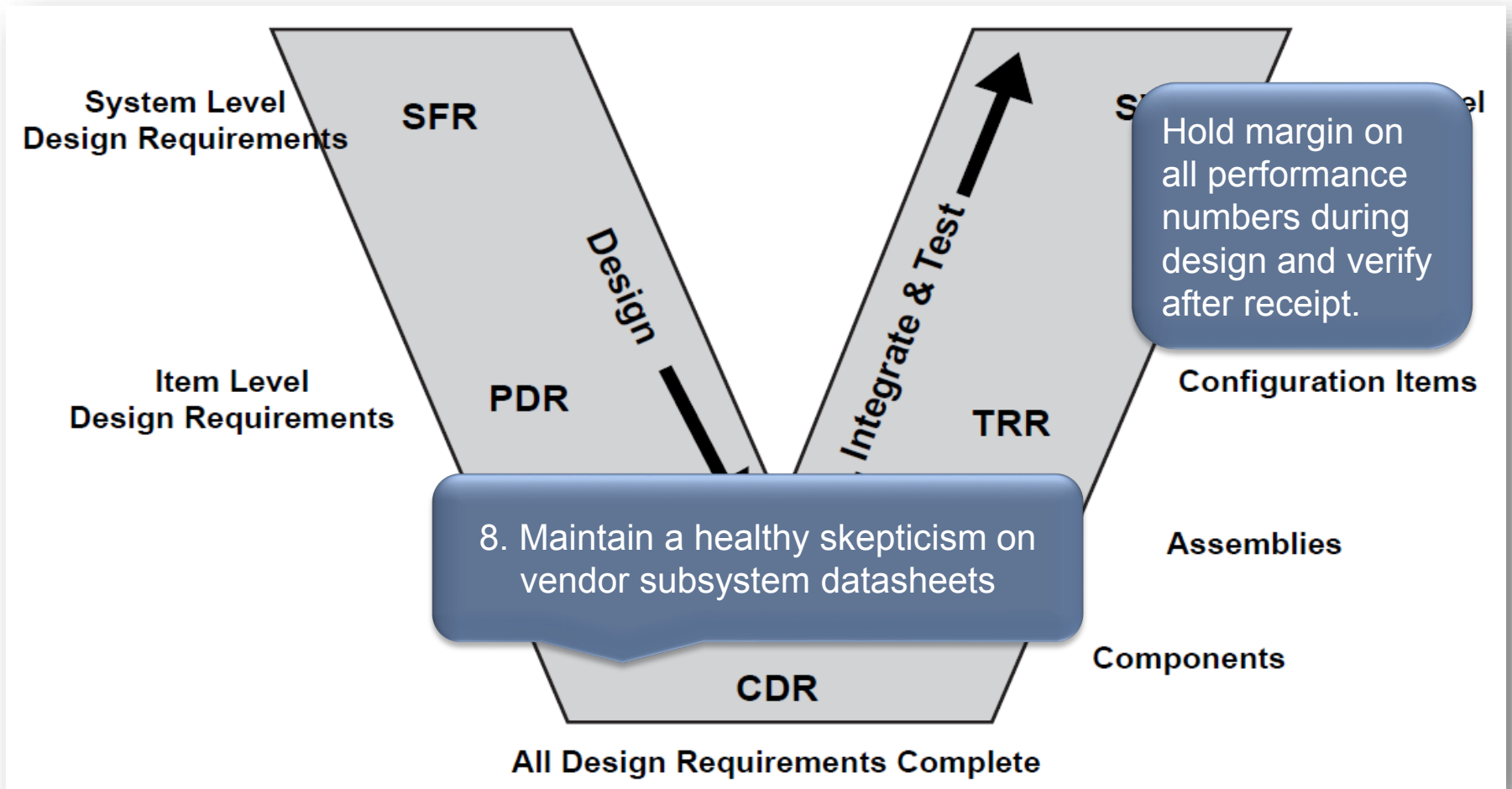
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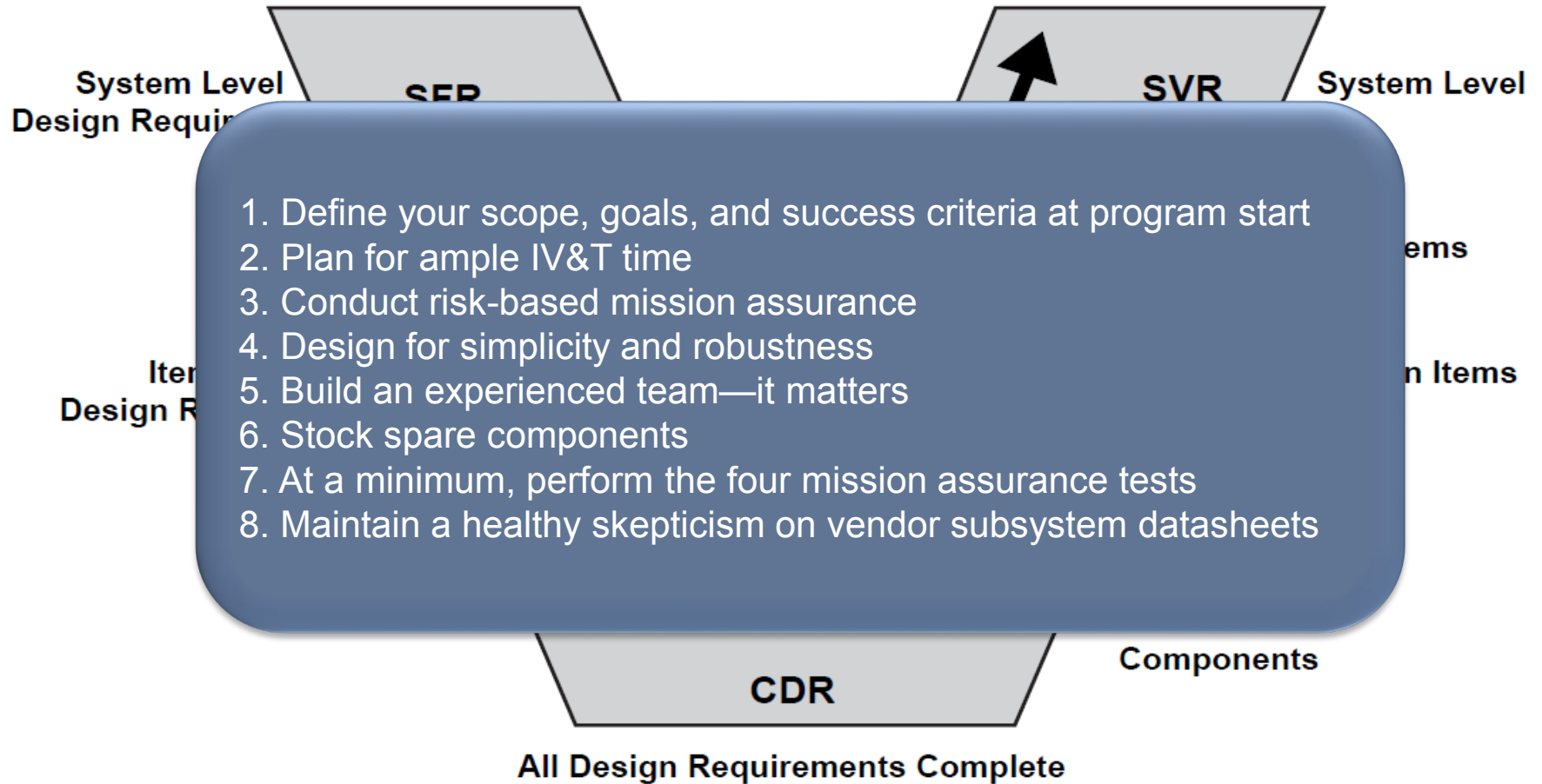
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Recommendations



Recommendations



Target Audience and Intended Product Users

- The target audience for this product consists of:
 - *CubeSat designers and developers (academia, industry)*
 - *CubeSat product suppliers (hardware, software)*
 - *CubeSat customers (government, others)*
- This product is intended to address needs of producers and consumers
 - *CubeSat designers/developers and subsystem suppliers will use this product to improve their design, manufacturing, and IV&T processes*
 - *Government and other customers will use this product to improve their requirements and statement of work documentation*

Team Members – Topic Team

Company	Participant
The Aerospace Corporation	Barbara Braun David Hinkley Catherine Venturini (co-lead)
Ball Aerospace and Technologies Corporation	Bob Andrews
The Boeing Company	Greg Berg Jeff Christensen Kim Hicks Mike Tolmasoff (co-lead) Andrew Whiting
Harris Corporation	Tom Wiedenbauer
Lockheed Martin Corporation	Gary Kushner
MIT Lincoln Laboratory	Rick Gebbie
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Team Members – Additional SMEs

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Millennium Space Systems	Andrew Robertson
MIT Lincoln Laboratory	Conor Galligan
NASA	Sue Aleman Andrew Demo Kenneth LaBel Jesse Leitner Miquel Moe



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