27th annual INCOSE international symposium

Adelaide, Australia

July 15 - 20, 2017

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The Boeing Company

Conducting a Model Based Systems Engineering Tool Trade Study Using a Systems Engineering Approach

Background of MBSE within Boeing

MBSE within Boeing

Requirement & Use Case Development

Evaluation

Results

Conclusion

MBSE Within Boeing

History

- MBSE tool suites have become vital for airplane design and configuration at Boeing Commercial Airplanes (BCA) in order to:
  - manage the evolution of aerospace systems
  - manage a globally distributed supplier base
  - reduce cost and schedule risk

- A trade study was conducted in 2002 to choose the tool suite that was used to model integrated modular architectures (A664 Network) for BCA airplanes and a tool was chosen.

- The tool had significant capability gaps that were overcome through significant custom coding (~1 million lines of custom code).

- Due to tool obsolescence and continued capability gaps, however, the need to find a new tool suite became necessary.

MBSE Within Boeing

Launching Trade Study

- Boeing is deploying MBSE as a common approach (process, tools and training) at the enterprise level.
- In 2014, Boeing launched another trade study to select a new COTS platform on which to base the future Boeing Enterprise MBSE tool suite.
- The Trade Study assessed COTS platforms against a set of Boeing requirements and identified where gaps existed between these requirements and COTS solution features.

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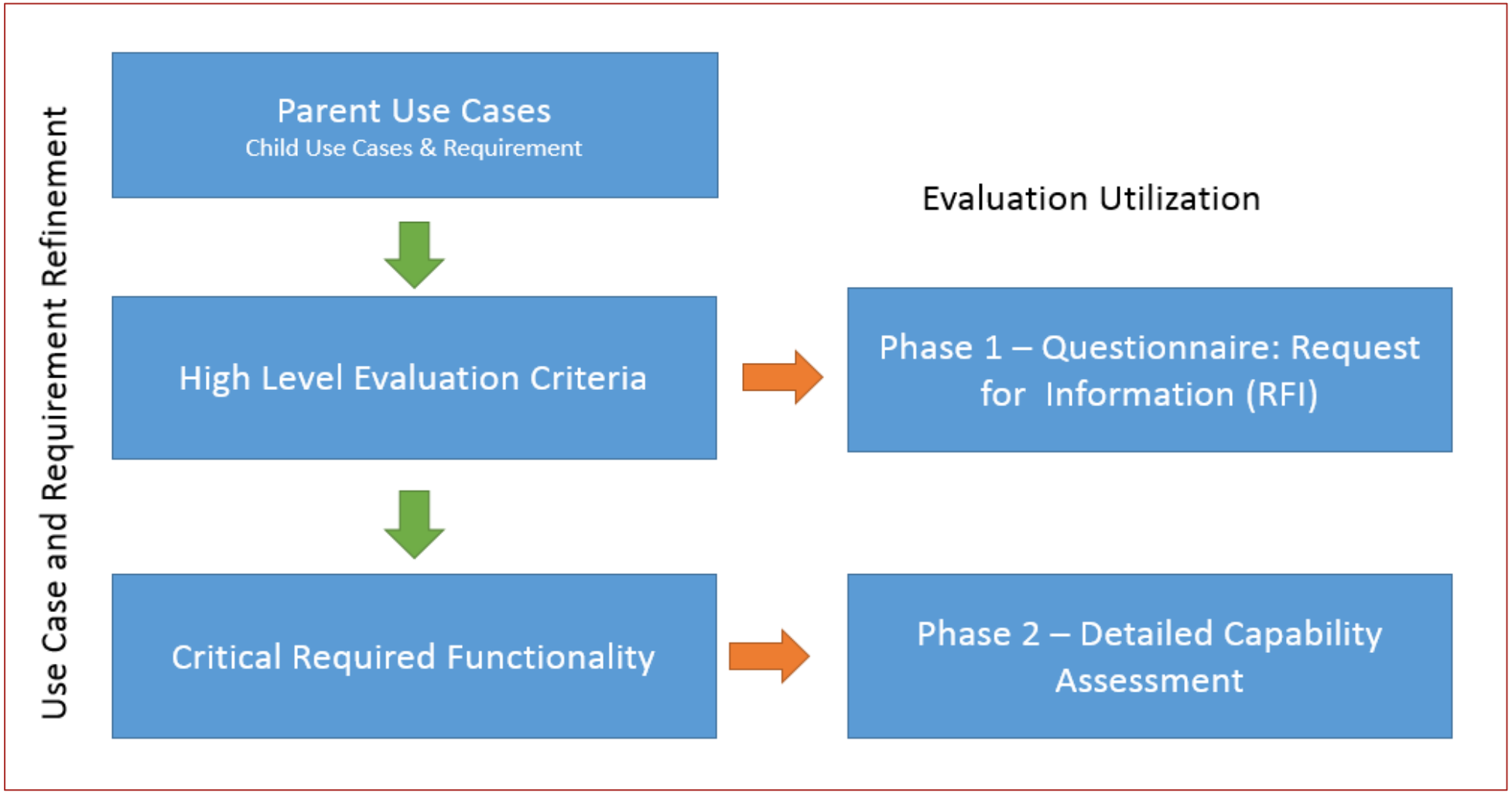
Requirement and Use Case Development

High Level Trade Study Process



Requirement and Use Case Development

High Level Use Case Categories

- Requirements Management –The process of documenting, analyzing, tracing and prioritizing requirements.
- Functional Architecture – An architectural model that identifies system functions and their interactions.
- Logical Architecture – Defines how the system will realize the required functionality
- Change and Configuration Management – Managing change and configuration for all documents, links and model elements
- Multi-Variant Capability - Allows product lines to simultaneously share design data ensuring that design changes to common elements are properly propagated to the affected models
- Enhanced Functionality – Includes Network Configuration, Tool Qualification, Simulation/Analysis and Verification/Certification

Requirement and Use Case Development

General Evaluation Criteria

Evaluation Criteria Category	Definition
General Application	Ability to support systems definition design innately or by interacting / importing information from other tools or data formats
Query Engine	Ability to perform logical queries that are customizable and has robust batch processing capabilities
Access to the Tool Suite	Requirements for roles to be customizable and user groups are supported. Data, attribute, objects, containers and links are accessible and controllable
Import / Export Capability	Capability which will support data import/export, allows data to be modified and supports Web Services (integration with outside tools), OSLC, SysML, DOORS interface and UML
Change & Configuration Management	Ability to perform change management capabilities on the model such as baselining, versioning and managing links. Also the ability to branch/merge and support variants
Data Model	Ability to create custom subtype objects and custom attributes. User definable business rules for objects and links are supported
Creating Architecture	Ability to represent architecture hierarchies, objects, attributes and relationships are viewable in a tree structure. Can data be copied and referenced.
Application Training and Support	Availability of training material for end-users and application support; includes the ability for users to retain expertise
Usability	Ability for users/developers to manipulate the interface and add new capabilities. Supports bulk creation, deletion and modifications of objects, links and attributes.
General Technology	Understand the customization and configuration points, open source dependencies, client technologies, workflows and cloud based offerings.
Computing Architecture	Understand the ability for multi-tiered architecture, platforms, interoperability (integration with outside tools), infrastructure, and cloud based platform support
Scalability & Database Management	Ability to work in a load balanced and high availability environment. Ability to support multiple databases and have a configurable and modifiable schema
Computing Security	Ability to support Boeing security requirements through single sign-on and authentication through APIs is available.

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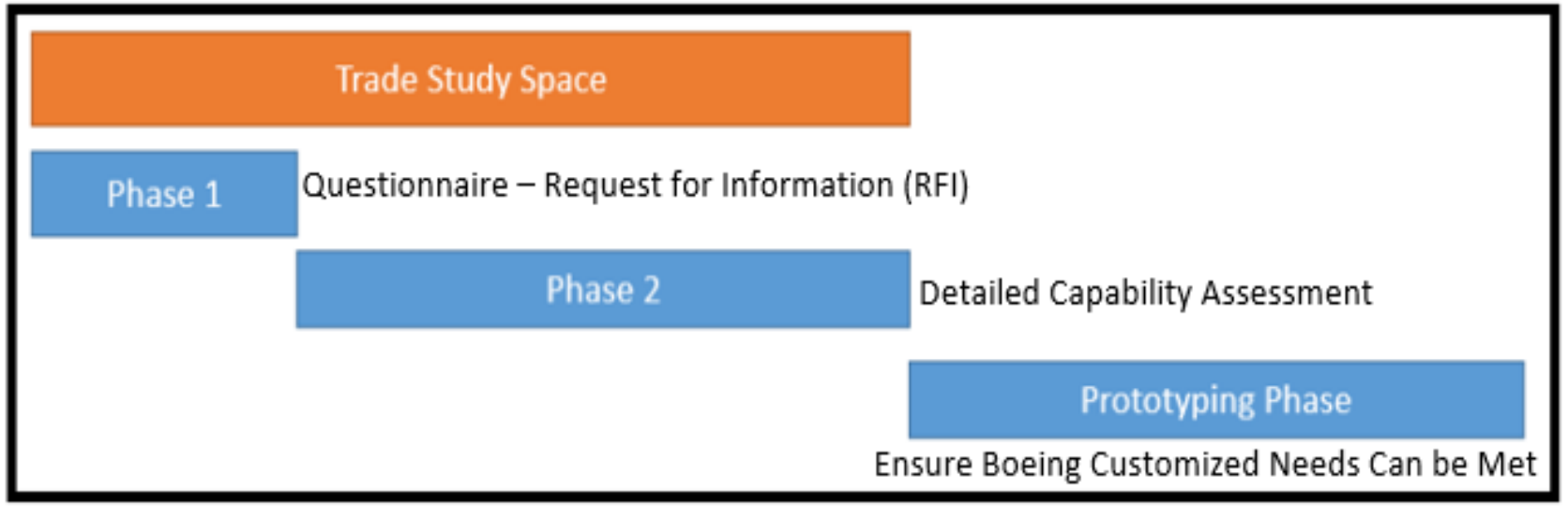
High Level Process

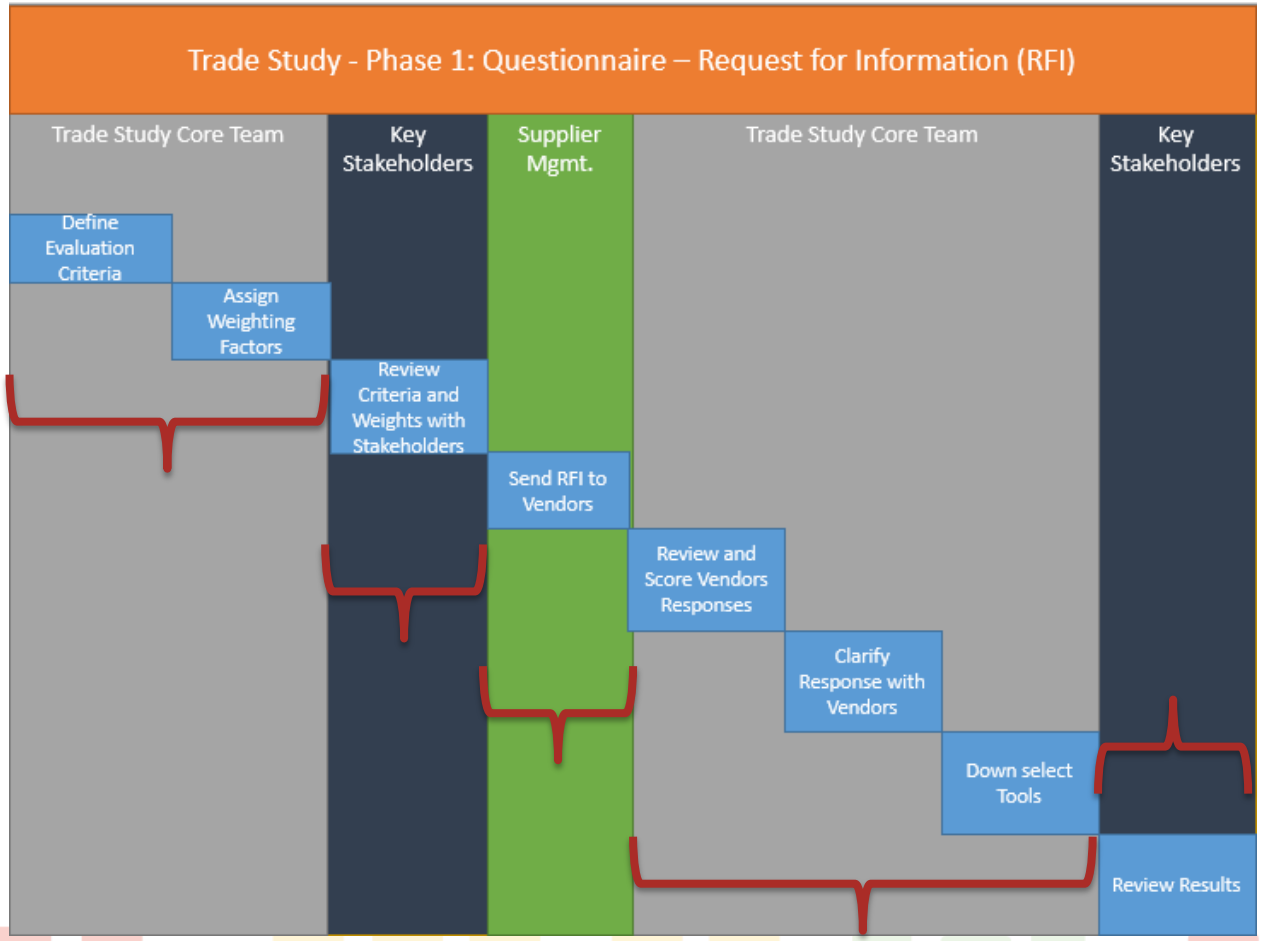
- Boeing evaluated 25 COTS platforms using a two-phased approach



Evaluation

Phase 1 Process

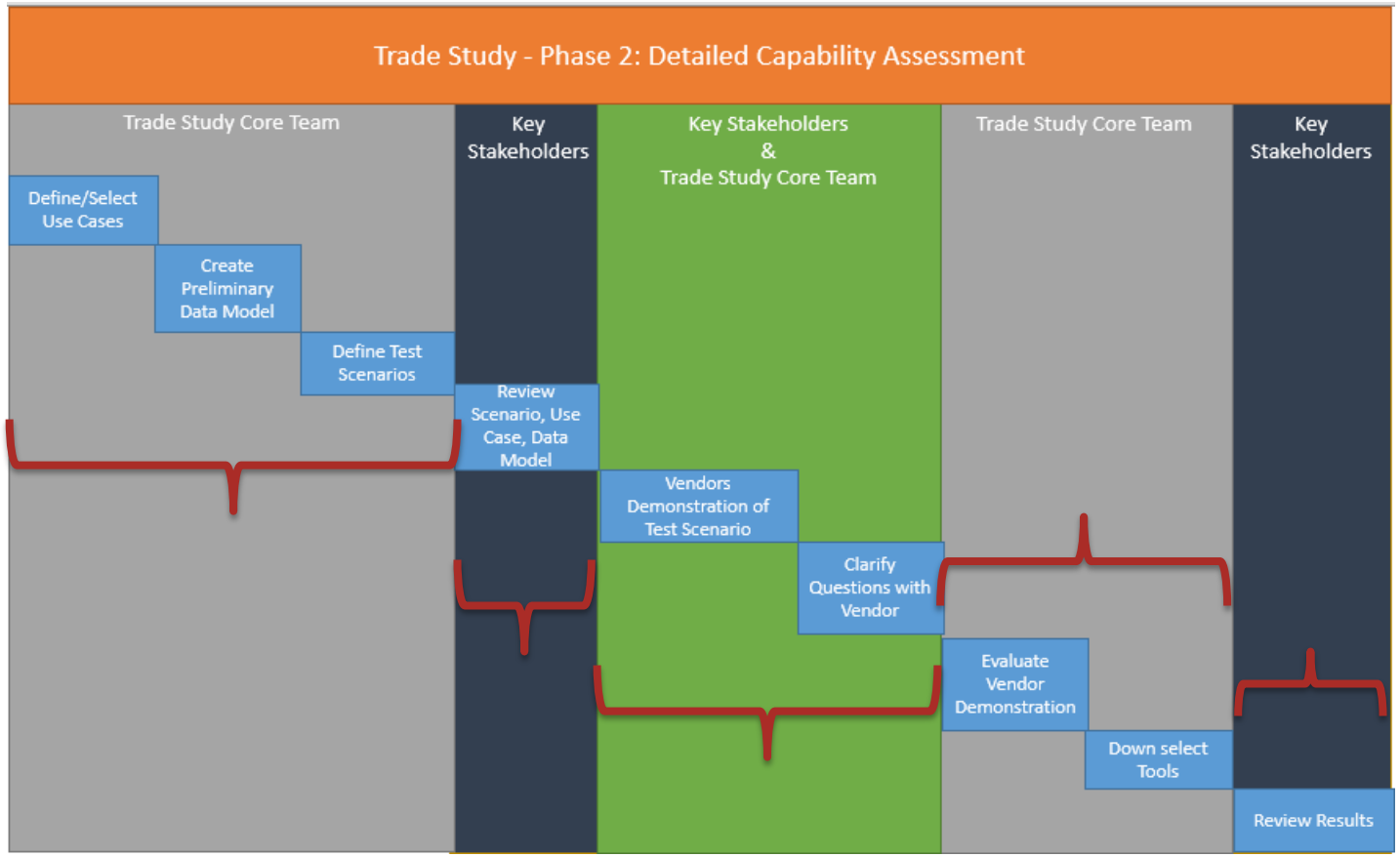
Phase 1. The objective of the first phase was to perform an initial assessment of the known set of MBSE applications currently available in industry.



Evaluation

Phase 2 Process

Phase 2. The objective of the second phase was to perform an assessment of the COTS platform vendor's ability to demonstrate their platform's capability



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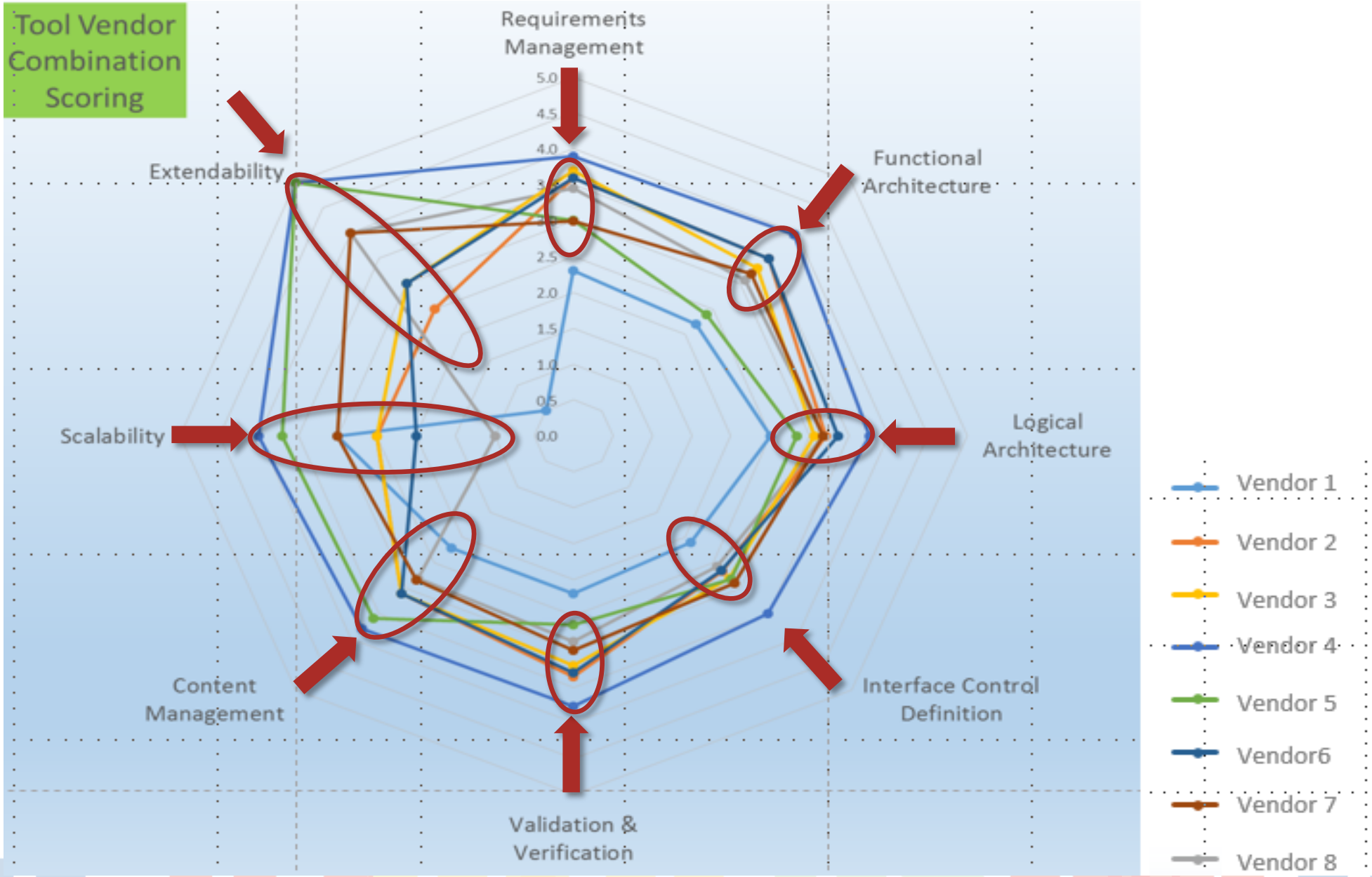
Phase 1 Results

General Application	Ability to support systems definition design innately or by interfacing / importing information from other tools or data formats.	◕
Query Engine	Ability to perform logical queries that are customizable and has robust batch processing capabilities.	●
Access to the Tool Suite	Requirement for roles to be customozable and user groups are supported. Data, attribute, objects, containers and links are accessible and controllable.	●
Import/Export Capability	Capability which will support data import/export, allows data to be modified and supports Web Services/OSLC, SysML, DOORS interface and UML	◕
Change & Configuration Management	Ability to perform change management capabilities such as baselining, versioning, and managed links. Also the ability to branch/merge, support variants and is	●
Creating Architecture	Ability to represent architecture hierarchies; object, attributes and relationships are viewable in the tree structure. Data can be copied and referenced and	◕
Data Model	Ability to create custom subtype objects and custom attributes. User definable business rules for objects and links are supported.	●
Application Training and Support	Availability of training materials for end-users and application support; includes the ability for users to retain expertise.	●
Usability	Ability for users/developers to manipulate the interface and add new capabilities. Supports bulk creation, deletion, and modification for objects and attributes.	◔
General Technology	Understand the customization and configuration points, open source dependencies, client technologies, workflows and cloud based offerings.	◕
Computing Architecture	Understand the ability for multi-tiered architecture, platforms, interoperability, infrastructure, and cloud based platform support.	●
Scalability & Database Management	Ability to work in a load balanced and high availability environments. Ability to support multiple databases and have a configurable and modifiable schema.	◕
Computing Security	Ability to support Boeing security requirements through single sign-on and authentication through APIs is available.	●

Scoring Legend		
○	0%	20%
◔	20%	45%
◑	45%	65%
◕	65%	90%
●	90%	100%
X	Showstopper	

Results: *Phase 2 Results*

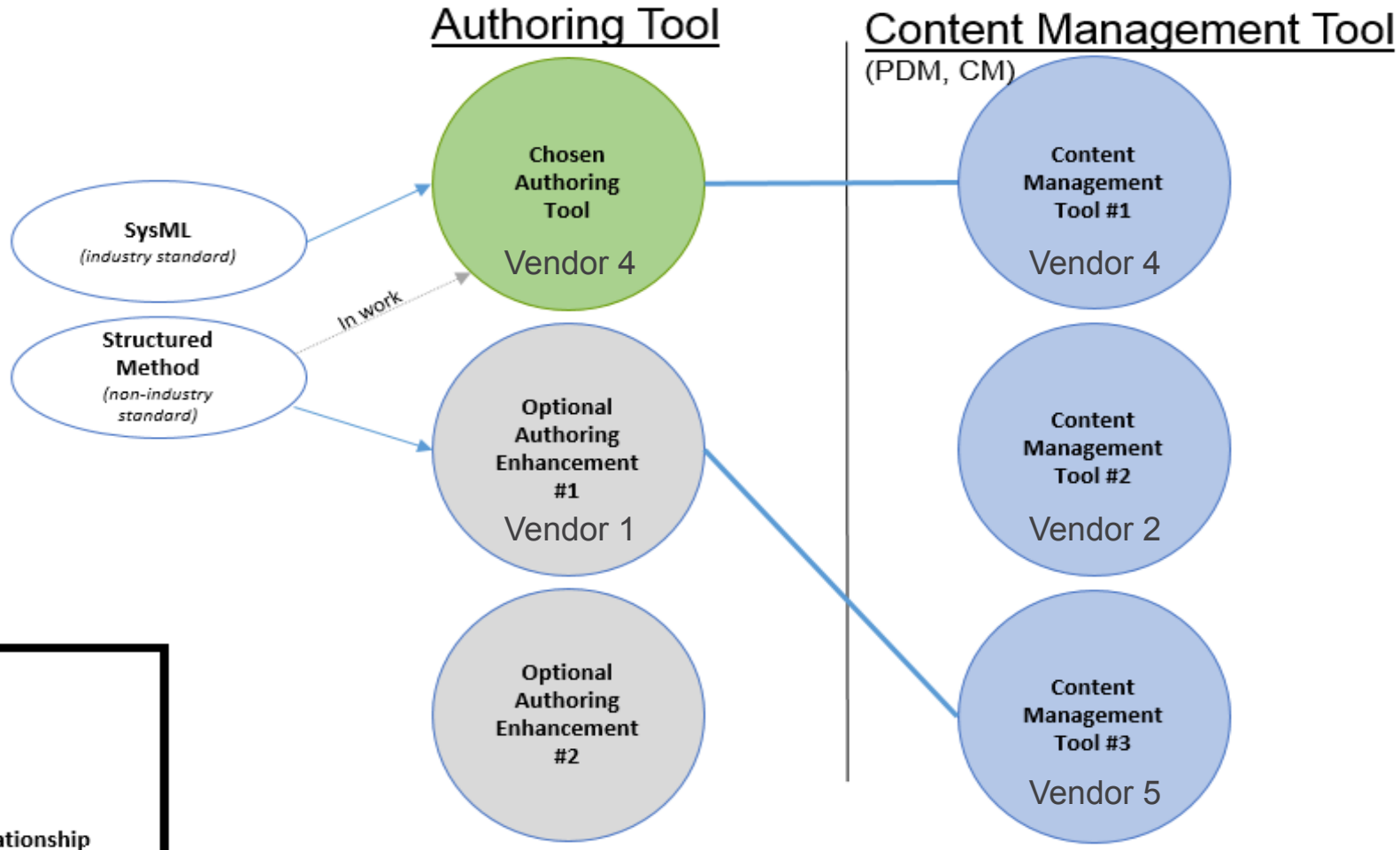
Scale: 0-5, 0.5 increments



Results

Phase 2 Results

- 4 COTS platform vendors were recommended to go into the prototyping phase
- Each combination was chosen based on the evaluated capability strengths of the individual tools to fulfill the greatest number of capability requirements



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- The trade study results indicate that, in general, the COTS platforms evaluated were strong in the following areas:
  - Requirements Management
  - Functional Architecture
  - Logical Architecture
  - Verification/Validation capability

The trade study results also indicated that, in general, the evaluated COTS platforms lacked necessary functionality in the following areas:

  - Interface Control Definition
  - Scalability
  - Content Management
  - Extendability

- Boeing estimates that the combined COTS platforms will fulfill about 30% of specified capability requirements.
- 70% of the solution will, therefore, need to be customized due to the evaluated COTS tools lacking the necessary functionality to meet the scalability, interface control definition and content management requirements

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