

# Risk-Based VV&A (RBA) Methodology Update

Presented to the  
NDIA M&S Committee

15 June 2010

*Ms. Simone Youngblood*  
(240) 228-7958  
[Simone.Youngblood@jhuapl.edu](mailto:Simone.Youngblood@jhuapl.edu)

**APL**  
*The Johns Hopkins University*  
**APPLIED PHYSICS LABORATORY**

# Acquisition Community VV&A Campaign Plan

## Practitioner-Based Use Cases

V-C-2  
T&E LVC DSE VV&A  
(SIMAF)

V-C-2  
Vehicle Survivability VV&A  
(BMVVB)

V-C-2  
VV&A Shortfalls  
(SERC)

Acquisition  
Community

## Guidance & Standards Development

V-AQ-2 Risk-Based VV&A  
Methodology  
(JHU/APL)

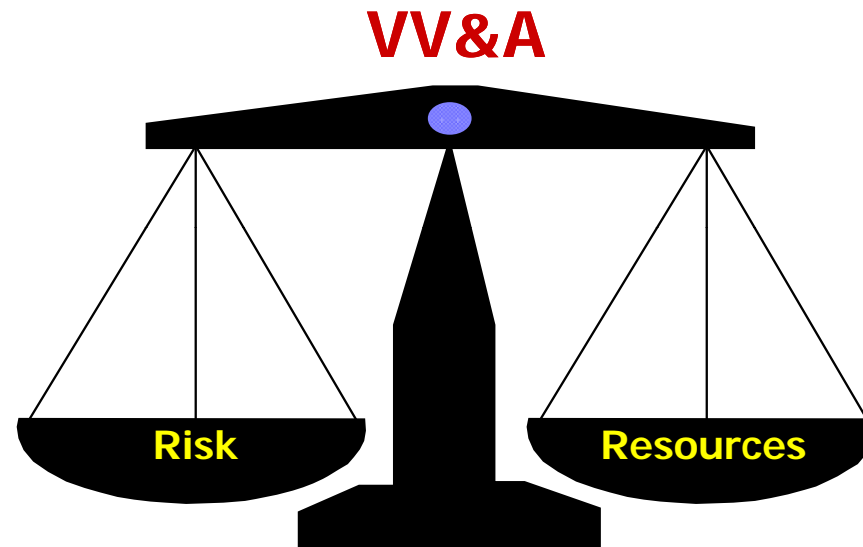
V-C-2 Improving  
VV&A Implementation  
(JHU/APL)

### V-C-2 Roadmap: Improving VV&A Implementation

#### Task Performers:

1. The Johns Hopkins University Applied Physics Laboratory (a DoD University Affiliated Research Center)
2. Aeronautical Systems Center's Simulation and Analysis Facility (SIMAF)
3. Naval Air Systems Command's Battlespace Modeling Verification & Validation Branch (BMVVB)
4. Systems Engineering Research Center (SERC) (a DoD University Affiliated Research Center)

# Risk Based Accreditation (RBA)



***Balancing the cost of knowing against the risk of assuming.***

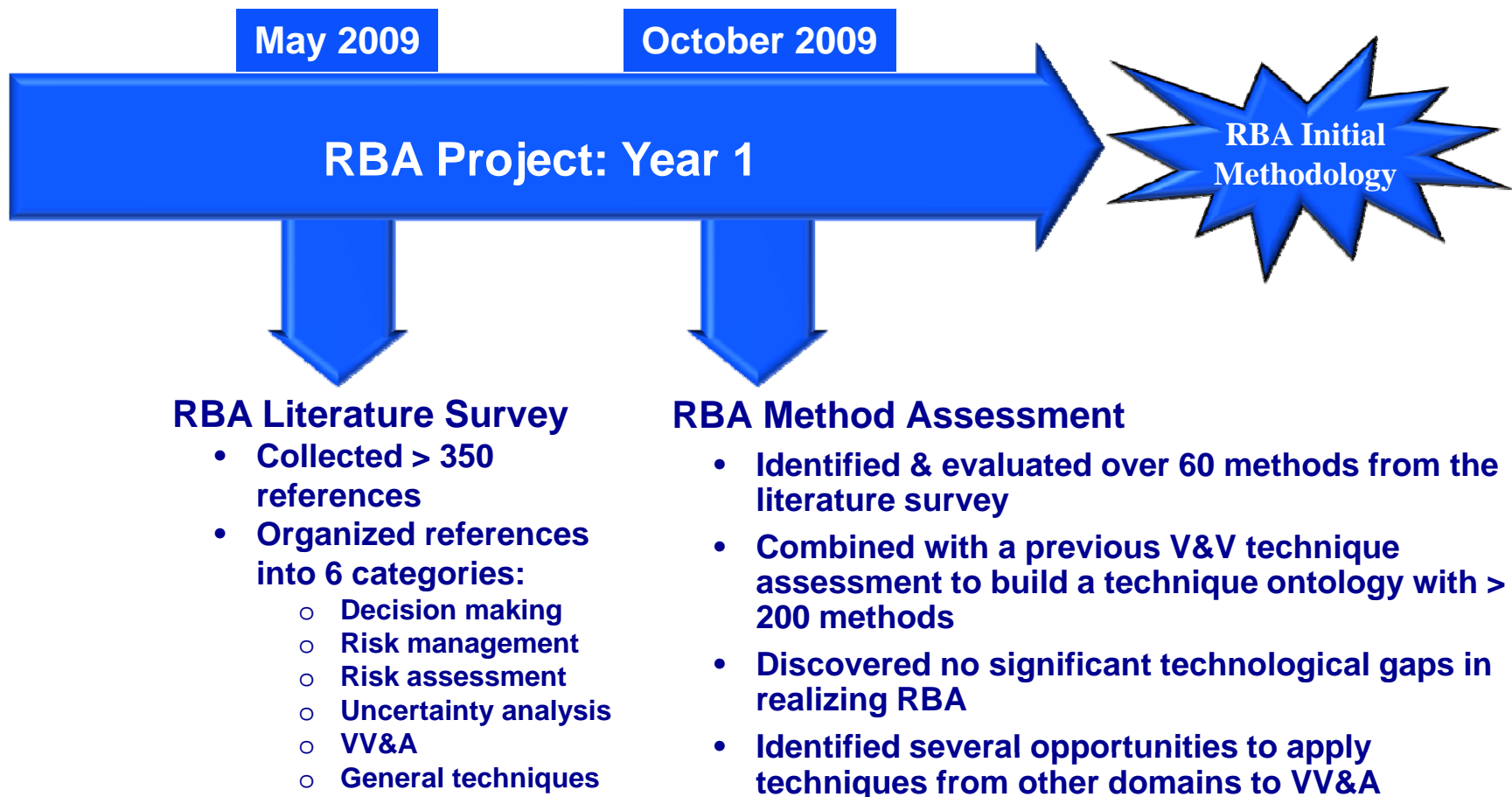


# RBA Project Objectives

**Leverage existing concepts to evolve a methodology to:**

- **Weigh VV&A investments against the risk of making a bad decision due to unreliable M&S results**
- **Tailor the V&V and Accreditation Efforts based on risk**
- **Perform Methods/Technique/Resource Trade-offs**

# Steps in Building the RBA Approach



# The RBA Methodology Builds upon the Concepts from Many Sources and Thinkers

- Communication to decision makers
- Uncertainty quantification
- Credibility assessment
- Sensitivity analysis
- Risk assessment

- Severity categories
- Probability levels
- Risk assessment values
- Risk acceptance levels

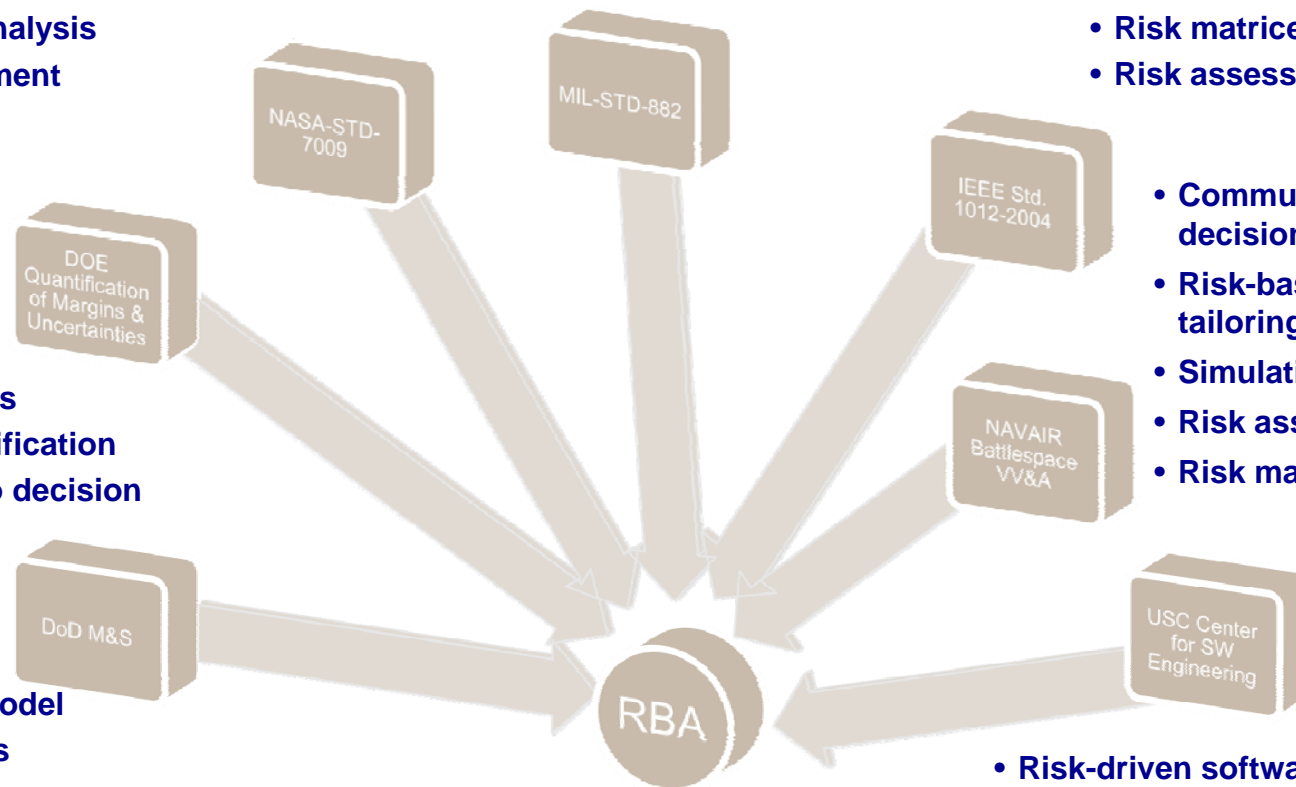
- Risk-based V&V tailoring
- Software integrity level
- Risk matrices
- Risk assessment

- Confidence ratios
- Sensitivity analysis
- Uncertainty quantification
- Communication to decision makers

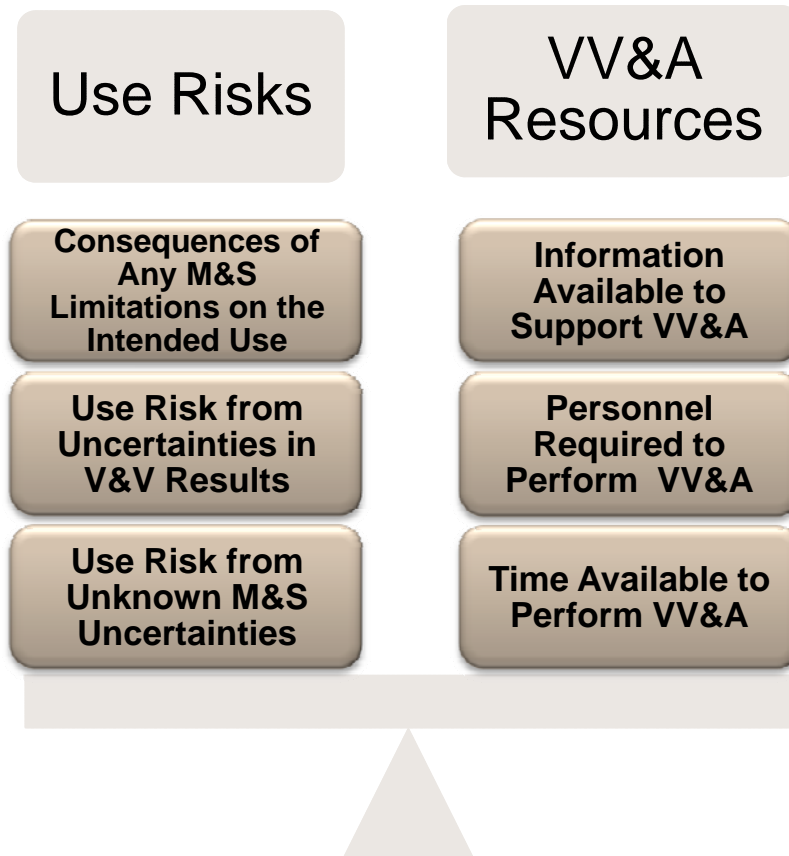
- Communication to decision makers
- Risk-based VV&A tailoring
- Simulation importance
- Risk assessment
- Risk matrices

- V&V Composite Model
- Validation Process Maturity

- Risk-driven software development
- Spiral development model



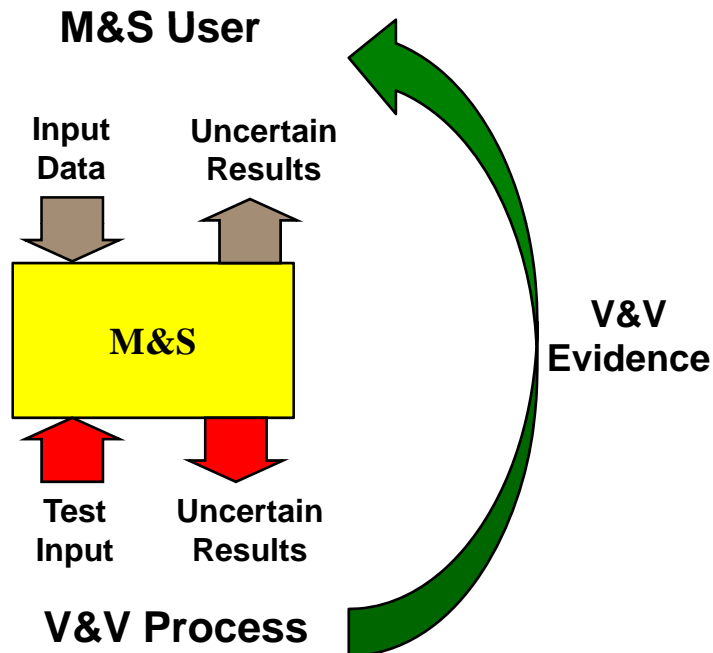
# RBA Aims to Optimize VV&A Resource Use & Minimize the Risks of Using M&S



## Motivation for Tailoring VV&A Processes:

- Every VV&A problem is different because of differences in
  - Uses of M&S
    - M&S requirements
    - Tolerable use risks
  - Resource constraints
    - Available information
    - People & skills
    - Funding
    - Time
  - When VV&A starts in the M&S life cycle
- No single set of VV&A activities & tasks can efficiently accommodate all of these differences.
- Today, VV&A practitioners lack concrete tailoring guidance so they re-invent their VV&A processes with each problem.
- This solution works but produces results that cannot be reliably independently repeated or efficiently taught.

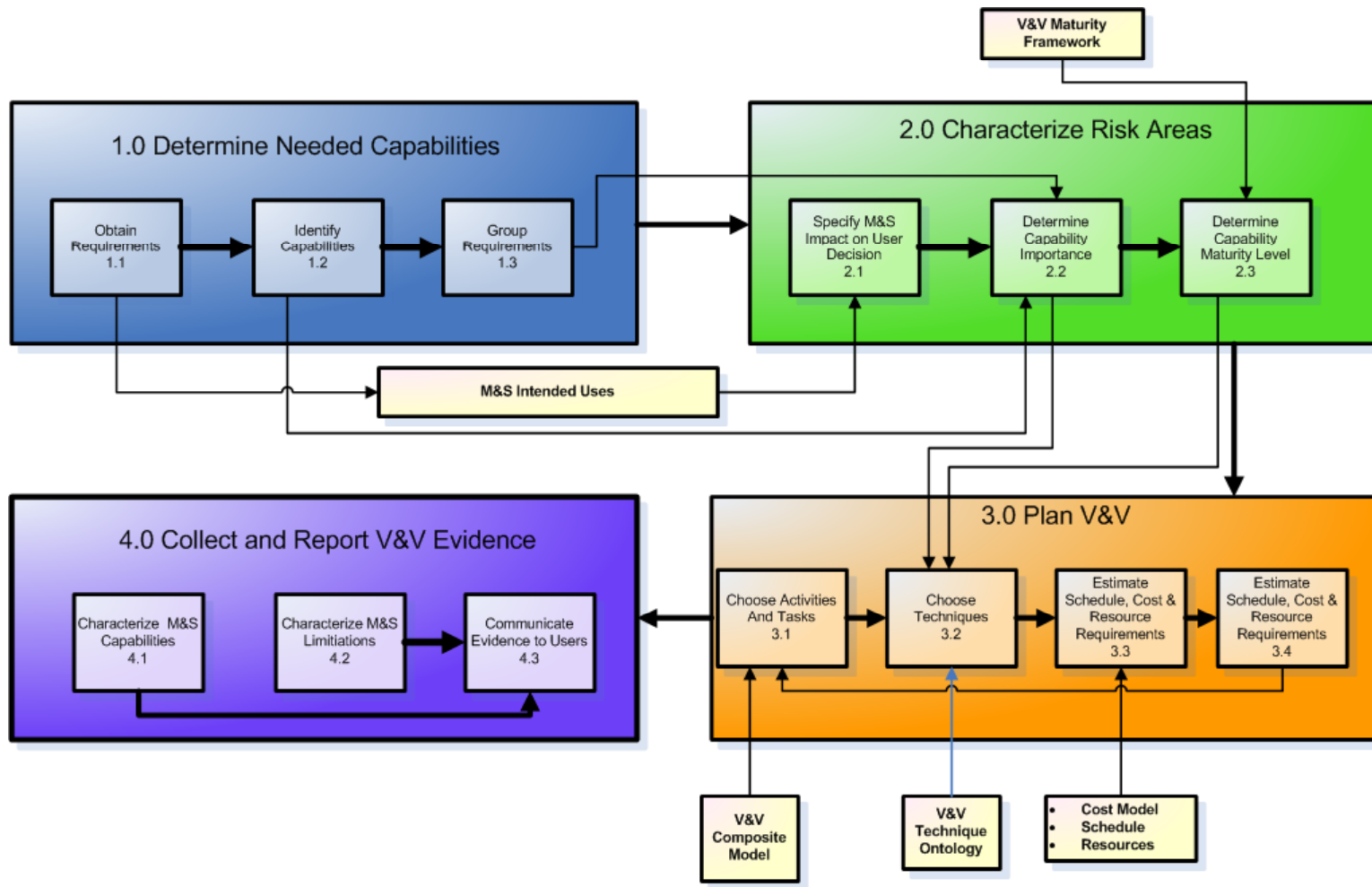
# Use Risk Concepts



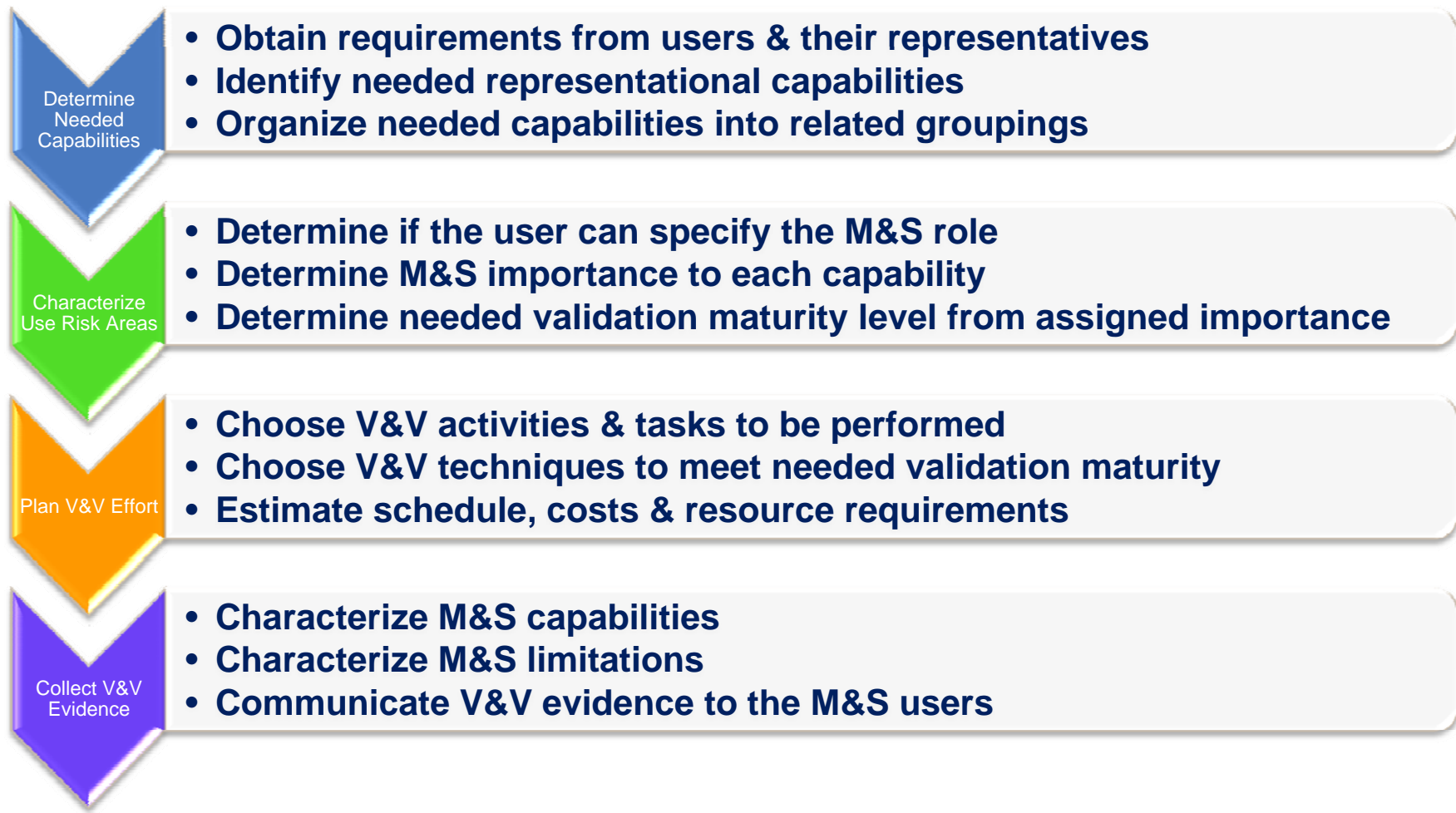
- **Use Risk Estimate is a function of:**
  - simulation prediction uncertainty
  - V&V evidence uncertainty
  - simulation importance measure
- **M&S Importance Measure is a function of:**
  - probability that M&S limitations will adversely affect the intended use
  - consequences of those effects

The simplest functions for describing use risk are the products of the uncertainties and importance measure.

# The Initial RBA Overview

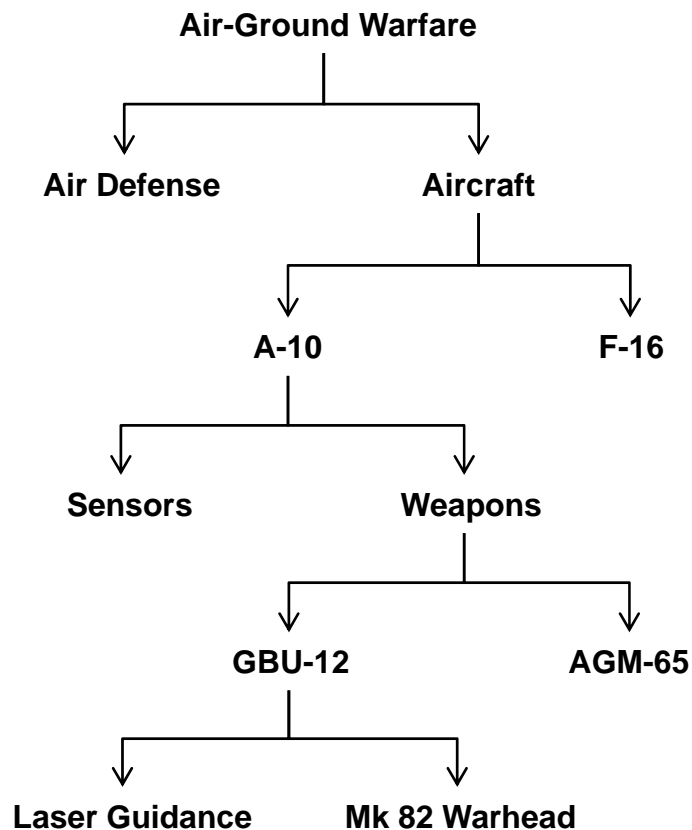


# Steps in the RBA Methodology



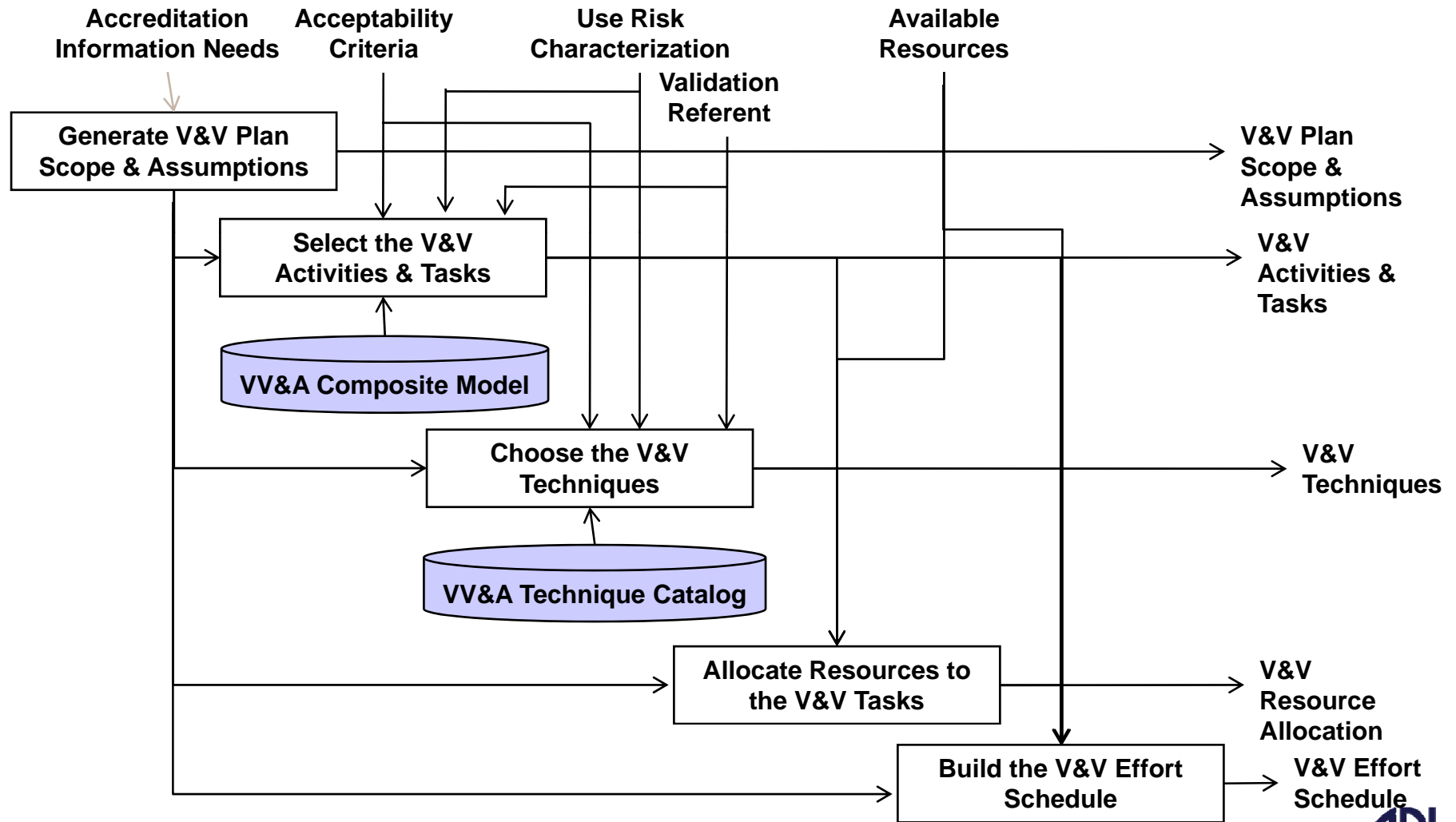
# Decomposing M&S Capabilities and Assigning Importance Levels to Identify Risk

Object Hierarchy



Object	M&S Importance Level
<b>Air-Ground Warfare</b>	<b>3</b>
– <b>Air Defense</b>	<b>2</b>
– <b>Aircraft</b>	<b>3</b>
> <b>F-16</b>	<b>1</b>
> <b>A-10</b>	<b>3</b>
- <b>Sensors</b>	<b>2</b>
- <b>Weapons</b>	<b>3</b>
> <b>AGM-65</b>	<b>2</b>
> <b>GBU-12</b>	<b>3</b>
• <b>Laser Guidance</b>	<b>1</b>
• <b>Mk-82 Warhead</b>	<b>2</b>

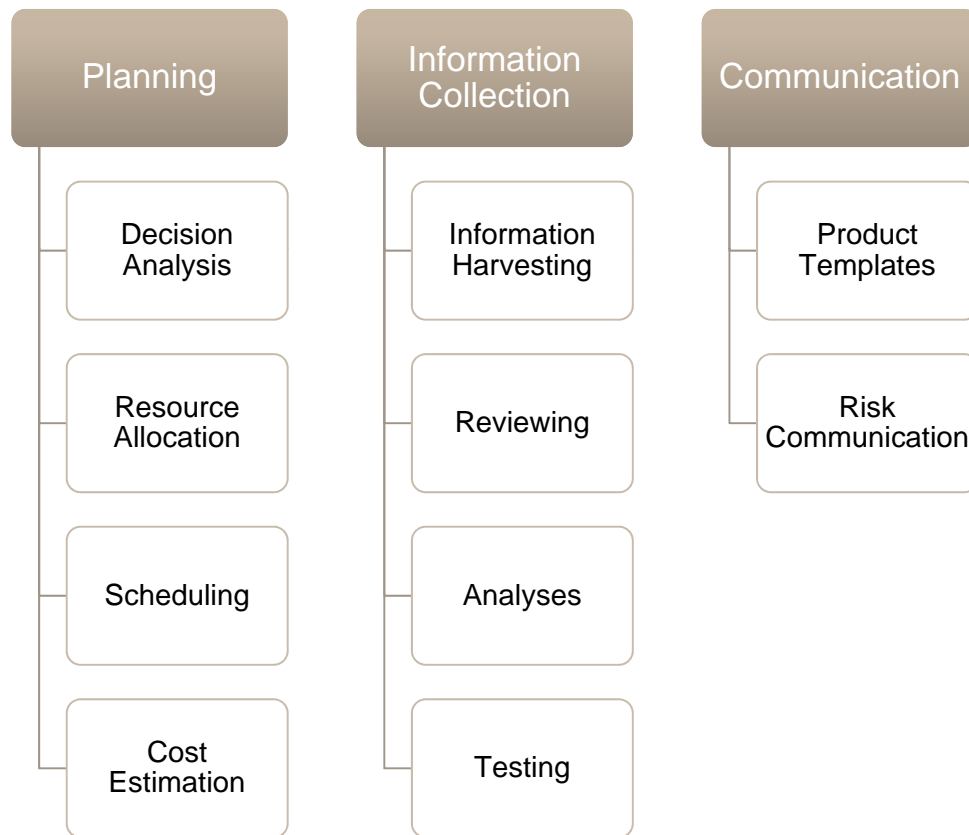
# The RBA Tailoring Concept



# The VV&A Composite Model

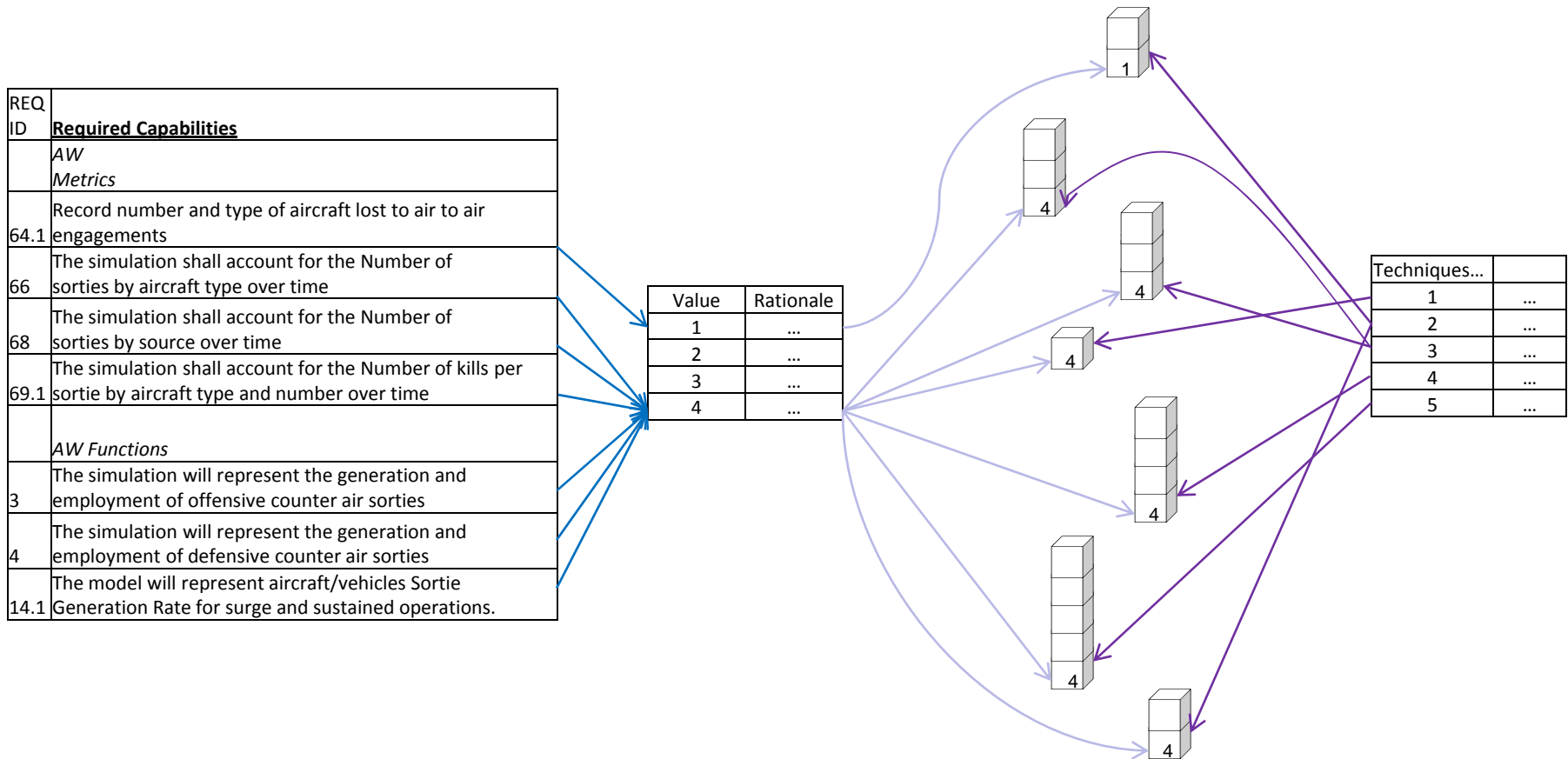
- **Plan the V&V Effort**
  - Develop the V&V Approach
  - Identify the V&V Resources
  - Build the V&V Schedule
  - Estimate the V&V Costs
  - Prepare the V&V Plan
  - Execute & Evolve the V&V Plan
- **Apply Relevant Historical Information**
  - Collect & Analyze Developer Accounts of Simulation Capabilities & Limitations
  - Collect & Analyze the V&V and Testing Histories
  - Collect & Analyze Prior Use History
  - Integrate & Employ the Historical Evidence
- **Verify & Validate the Simulation Conceptual Model**
  - Verify the Simulation Conceptual Model
  - Validate the Simulation Conceptual Model
  - Verify & Validate Available Scenarios
  - Integrate & Employ the Conceptual Model V&V Evidence
- **Perform Supplemental Verification**
  - Determine the Scope of Supplemental Verification Needed
  - Verify the Simulation Design Products
  - Verify the Simulation Object Code
  - Verify the Simulation Executable
  - Verify the Development Products against the Simulation Conceptual Model
  - Verify the Development Products for Standards Compliance
- **Apply the Verification Products to Validation**
  - Infer the Simulation Capabilities from the Verification Products
  - Infer the Simulation Limitations from the Verification Products
  - Infer the Information Gaps from the Verification Products
  - Employ the Verification Evidence
- **Verify & Validate the Data & Knowledge Sets**
  - Identify the Data & Knowledge Sources & Their Pedigrees
  - Verify the Data & Knowledge Sets
  - Validate Data & Knowledge Sets Where Needed
  - Integrate & Employ the Data & Knowledge V&V Evidence
- **Validate Simulation Results**
  - Leverage Developer Test Results for Results Validation
  - Derive Results Validation Test Scenarios
  - Plan for Results Validation
  - Collect Simulation Output for Results Validation
  - Integrate & Employ the Validation Testing Results
- **Integrate the V&V Evidence**
  - Integrate the V&V Evidence
  - Prepare the V&V Report
  - Support Any Archival of the V&V Products

# The VV&A Technique Catalog



- **Constructed upon the foundation first established by Balci, 1996**
- **Significantly augmented by the results from a massive search of the risk and VV&A literature to identify techniques that could support risk-based accreditation**
- **Currently, catalogs and organizes techniques into a tentative taxonomy**
- **Will evolve that taxonomy into an ontology by**
  - **Maturing the elements of the taxonomy**
  - **Capturing the relationships between techniques**
  - **Capturing the relationships between techniques & VV&A tasks**

# The RBA Map of Known Use Risks across the Capabilities Landscape

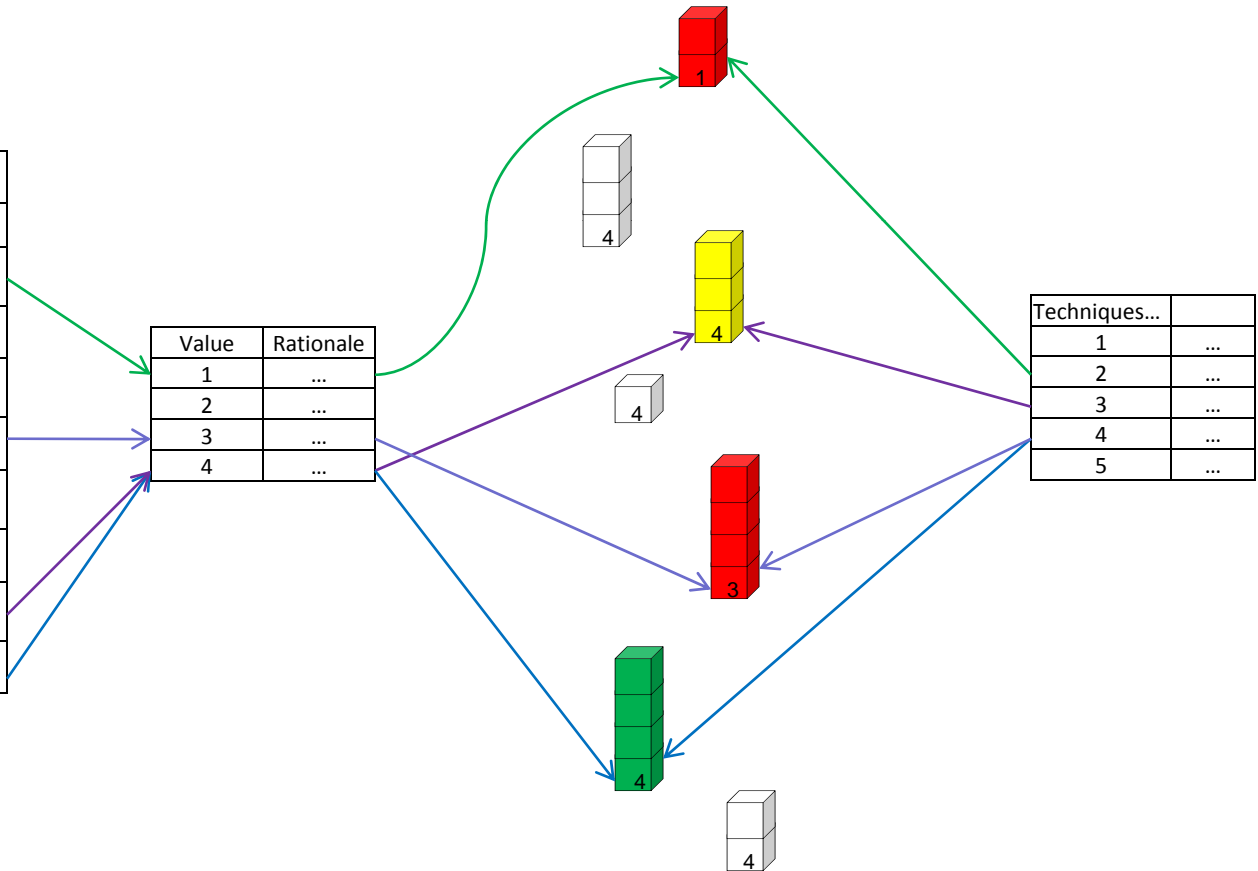


# An Example RBA Map

REQ ID	<b>Required Capabilities</b>
	<i>AW Metrics</i>
64.1	Record number and type of aircraft lost to air to air engagements
66	The simulation shall account for the Number of sorties by aircraft type over time
68	The simulation shall account for the Number of sorties by source over time
69.1	The simulation shall account for the Number of kills per sortie by aircraft type and number over time
	<i>AW Functions</i>
3	The simulation will represent the generation and employment of offensive counter air sorties
4	The simulation will represent the generation and employment of defensive counter air sorties
14.1	The model will represent aircraft/vehicles Sortie Generation Rate for surge and sustained operations.

Value	Rationale
1	...
2	...
3	...
4	...

Techniques...	
1	...
2	...
3	...
4	...
5	...

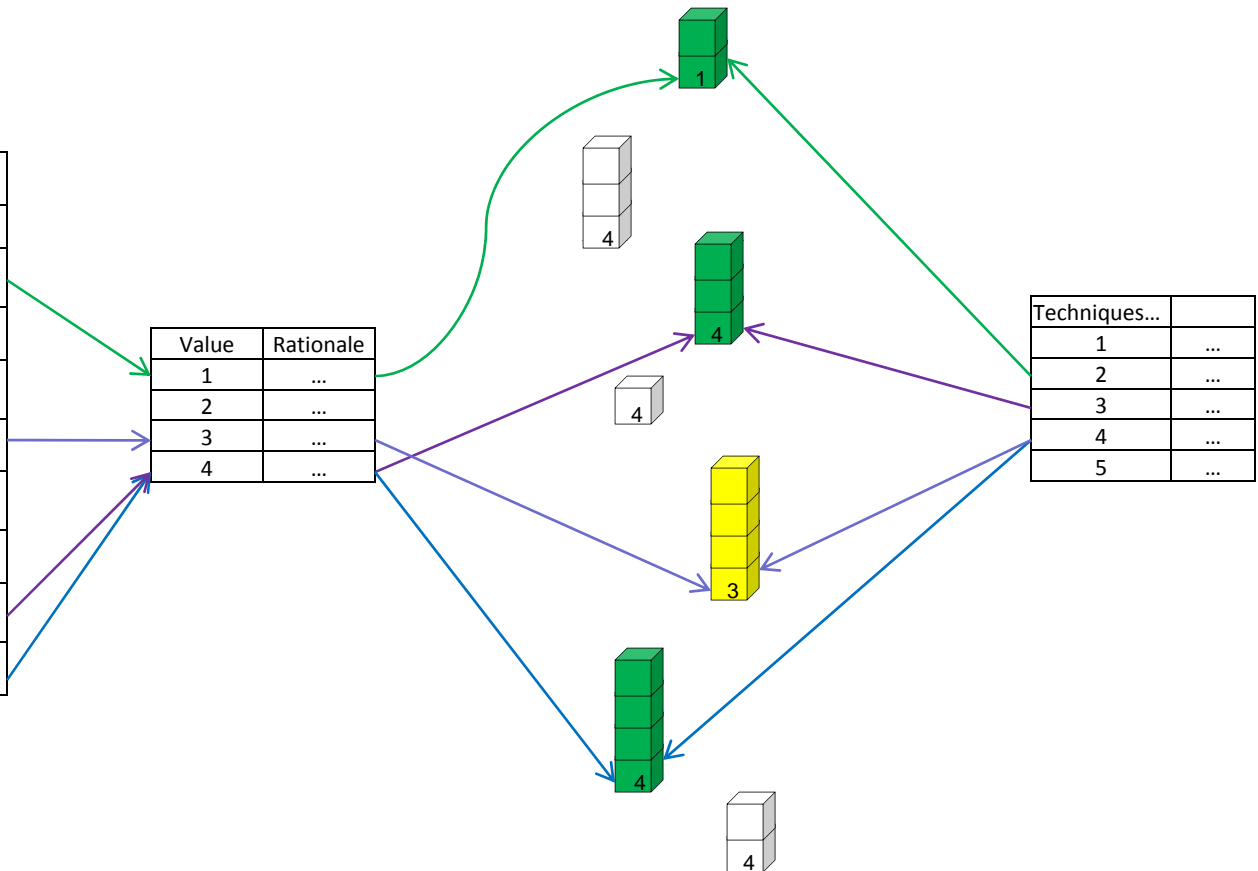


# An Example RBA Map

REQ ID	Required Capabilities
	<i>AW Metrics</i>
64.1	Record number and type of aircraft lost to air to air engagements
66	The simulation shall account for the Number of sorties by aircraft type over time
68	The simulation shall account for the Number of sorties by source over time
69.1	The simulation shall account for the Number of kills per sortie by aircraft type and number over time
	<i>AW Functions</i>
3	The simulation will represent the generation and employment of offensive counter air sorties
4	The simulation will represent the generation and employment of defensive counter air sorties
14.1	The model will represent aircraft/vehicles Sortie Generation Rate for surge and sustained operations.

Value	Rationale
1	...
2	...
3	...
4	...

Techniques...	
1	...
2	...
3	...
4	...
5	...



# Summary of the RBA Approach

## Optimize the V&V Process

- Group M&S capability needs to focus the V&V process
- Prioritize capability need groups by M&S importance to tighten the focus of the V&V effort upon the important capabilities
- Choose V&V tasks to provide the needed coverage
- Choose techniques according to the maturity required by M&S importance
- Reduce & quantify uncertainties according to M&S importance
- Execute the RBA methodology as turns around a spiral that successively refine & enhance the V&V evidence

## Minimize Use Risk

- Use M&S importance as a V&V process optimization criterion
- Quantify M&S uncertainties
- Reduce V&V process uncertainties where possible
- Quantify the V&V process uncertainties that cannot be reduced
- Estimate the use risks from the M&S importance & uncertainties
- Provide the user with a map of M&S capabilities & use risks so they can minimize their use risks