ESTIMATING V&V RESOURCE REQUIREMENTS AND SCHEDULE IMPACT

Session B4

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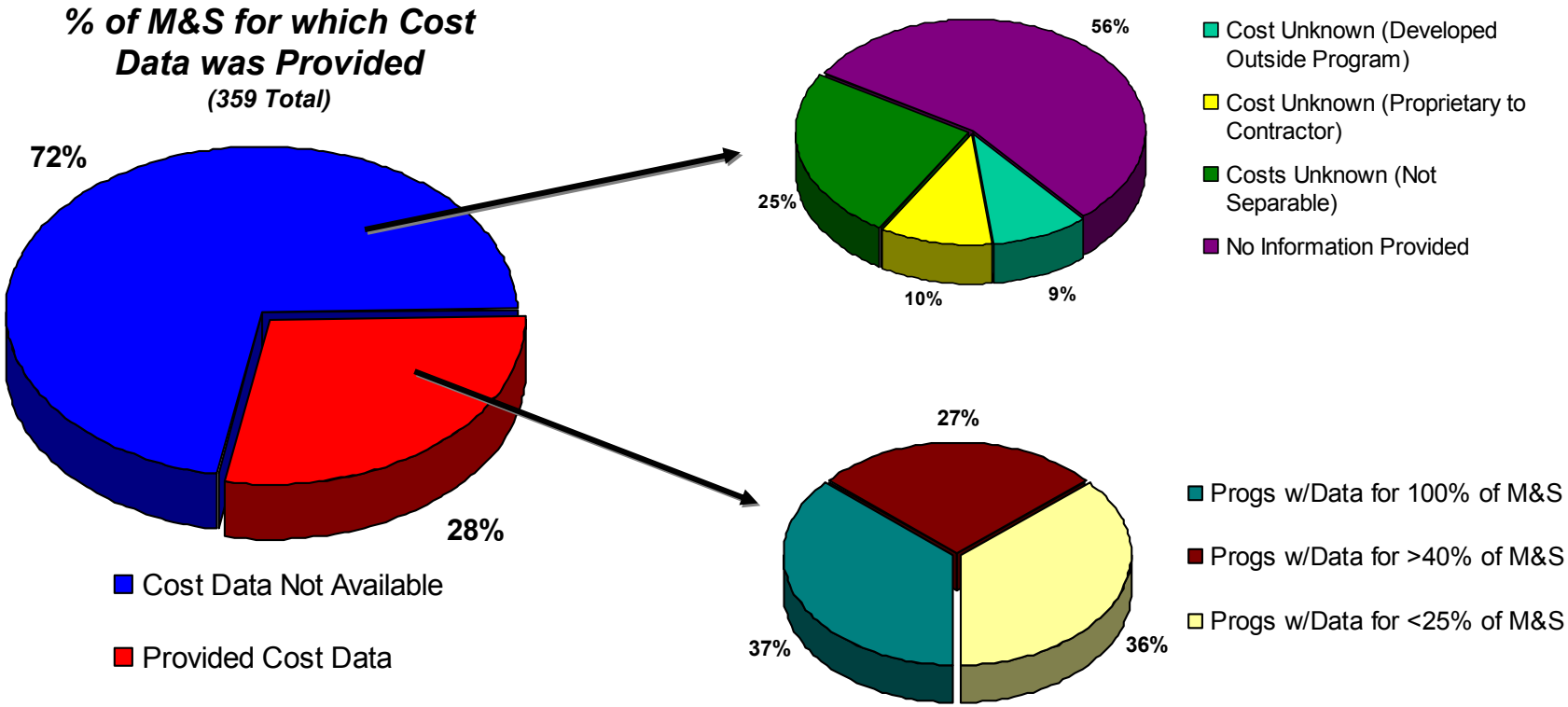
Outline

- Motivations for VV&A Cost Estimation
- Factors influencing the scope of V&V
- Estimating V&V Resource Requirements: the State of the Art
- Case Histories
- Analysis of state of the art and program case histories
- Summary
- Recommendations

Motivations for VV&A Cost Estimation:
Results of a Modeling & Simulation Survey
What Do M&S Cost in DOD?



- *M&S development and application costs data are not readily available within acquisition programs*

"Survey Says…"

- **Only 28% of the programs surveyed could provide any M&S cost data at all**
  - **Only 37% of those who provided data could track 100% of costs**
- **Most of the programs who responded simply did not track M&S costs, let alone V&V costs**
- **There is a lack of management visibility into program expenditures for M&S activities in general**
  - **Standard cost accounting procedures do not provide for segregation, reporting or tracking of M&S costs**
  - **M&S activities often are not listed as deliverable items in contracts**
- **Programs are not required to track M&S expenditures, so they don't track them**
  - **Including VV&A costs**

Software Testing During Development

Allocation of Effort in M&S Developments over 4 Decades*

	Requirements Analysis	Preliminary Design	Detailed Design	Coding and Unit Testing	Integration and Test	System Test
1960s – 1970s	10%			80%	10%	
1980s	20%		60%		20%	
1990s	40%	30%		30%		

- **Formal testing conducted by independent test groups accounts for about 20 percent of labor costs**
- **But estimates of total labor resources spent on testing by all parties range from 30 to 90 percent**

***The Economic Impacts of Inadequate Infrastructure for Software Testing*, National Institute of Standards**

Preliminary Conclusions

- Misperceptions of VV&A reduce the cost-effectiveness of DOD M&S and VV&A programs
- Nobody knows how much it costs DOD programs to use M&S
  - And nobody knows how much those programs actually spend on M&S VV&A
- Nobody knows how much is actually spent on software testing
  - But the trend is to spend more up-front defining requirements, and less testing at the end of S/W development

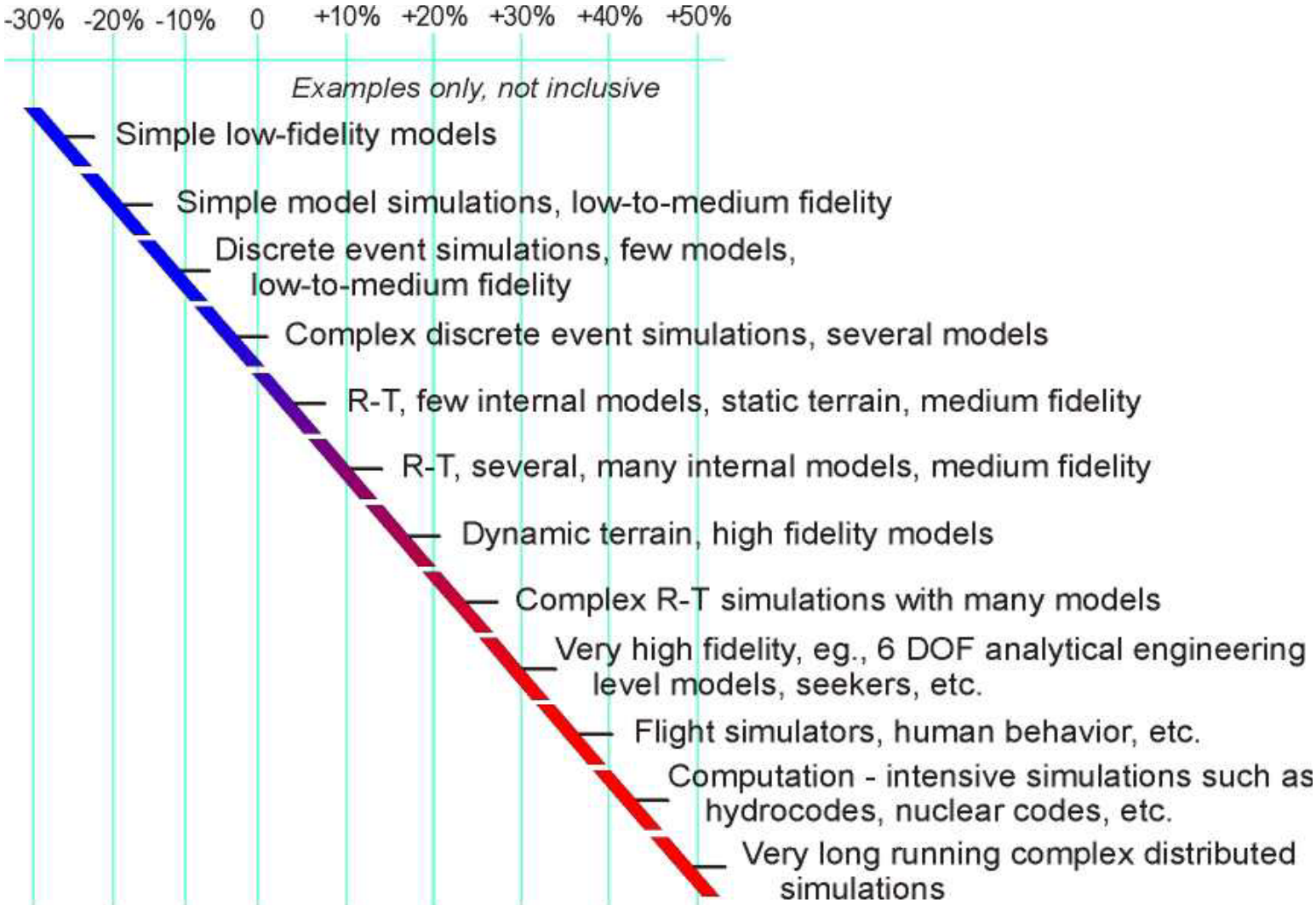
Factors Influencing the Scope of V&V

- Model complexity
- Availability of information about the model
- Availability of validation data
- Application complexity
- Application Risk
- Software Risk and Uncertainty
- Accreditation Authority Requirements
- M&S Task Accounting
- Practitioner Expertise

Factors Influencing the Scope of V&V

Model Complexity

Complexity Factor in the Cost Estimating Tool (CET)

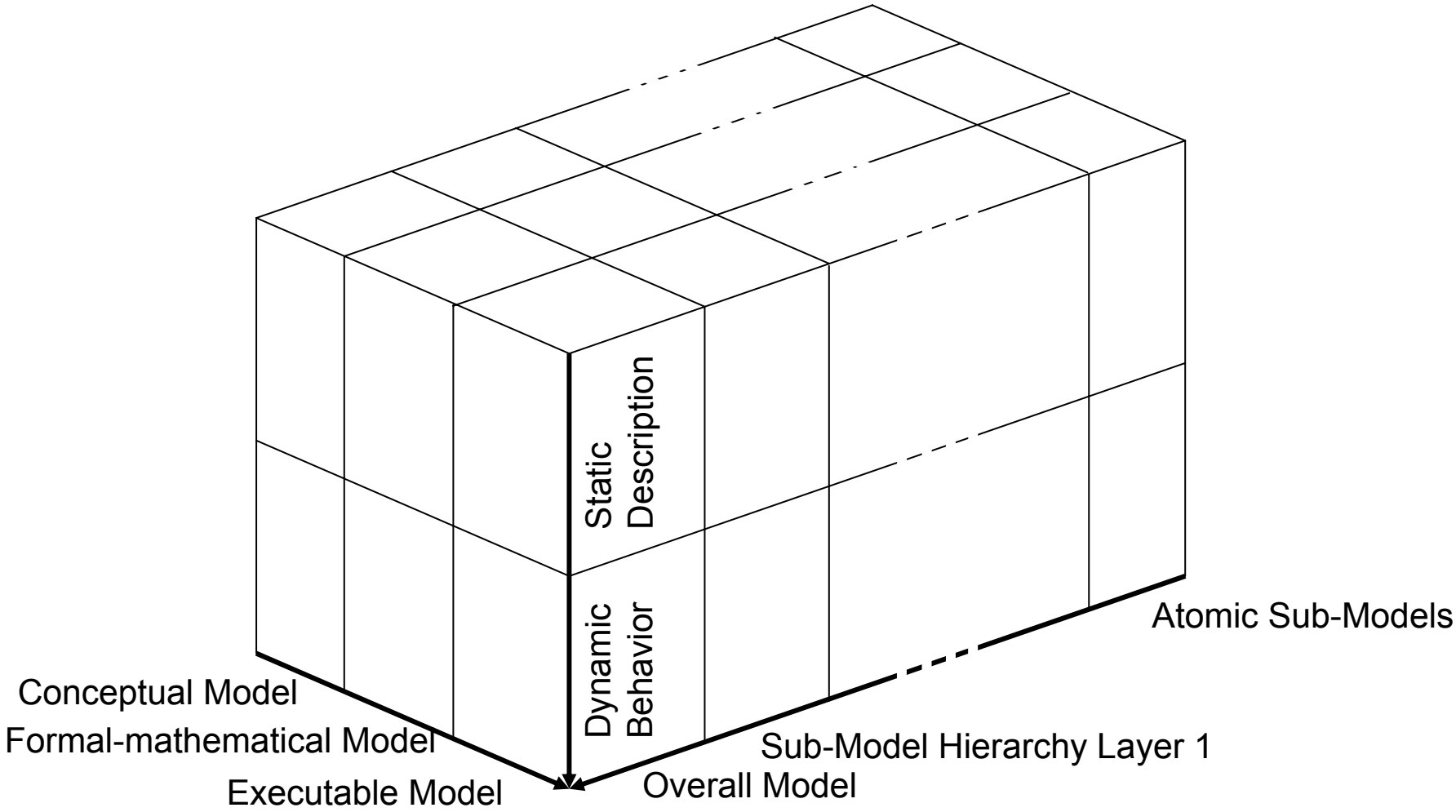


Factors Influencing the Scope of V&V

Availability of Information about the M&S

- **Quality of M&S documentation affects the cost of V&V (especially verification)**
  - e.g., no S/W design documentation means you have to reverse engineer the code to do verification
- **Three cost factors:**
  - Cost of buying information about the model
  - Cost of reconstructing unavailable information
  - Cost difference incurred when forced to replace a relatively "cheap" V&V technique with a more expensive V&V technique

3d Information Framework



„Cost of buying model information“ is determined by the V&V activities best associated with each 3d cell of the framework

Factors Influencing the Scope of V&V

Availability of Validation Data

- **M&S Validation requires data from dynamic behavior of the system being modeled**
  - Test costs are the biggest driver of validation data collection cost
- **Test data may not be available for M&S validation**
  - Test events are not generally done for validation purposes
  - Program sensitivities may preclude release of data
  - Classification issues may get in the way
  - Data collected may not be suitable for validation
    - Insufficient instrumentation
    - If the program doesn't need it, they won't measure it

Factors Influencing the Scope of V&V

Application Complexity

- **V&V requirements may be difficult to separate out for highly integrated simulations**
  - **Integrated live, virtual and constructive simulations, for example**
- **If the M&S are only a part of the analysis process, V&V requirements may be subjective at best**
  - **Accuracy requirements for simulation federates may be difficult to quantify, for example**
  - **Likely to be subjective at best, political at worst**

Factors Influencing the Scope of V&V

Application Risk

- **High risk applications require more V&V resources than lower risk applications**
  - **Both impact and probability of wrong answers must be evaluated to determine V&V resource requirements**
- **Most VV&A processes used in DOD are based on risk assessment**
  - **Usually subjective judgments of risk based on expert opinion**
- **VV&A activities not only reduce the risk associated with using M&S to support decisions, but also provide estimates of residual risk**
  - **No model can be completely verified and validated**

Factors Influencing the Scope of V&V

Software Risk and Uncertainty (R&U)

- An approach to identifying R&U is part of the Cost Estimating Tool (CET)
- Based on 15 questions about the M&S to develop a "Risk and Uncertainty Profile"
  - Questions about software maturity, documentation, development process, data sources, fidelity, user support services, formal conceptual model, etc.
- Directly affects the V&V cost estimates from the CET

Factors Influencing the Scope of V&V

Accreditation Authority Requirements

- "Sponsor" requirements may not be driven by technical issues
  - May not always seem logical to the VV&A practitioner
- Driven by:
  - Policy
  - Previous experience
  - Politics
  - Preconceived opinions about M&S (for or against) on the part of the program manager
  - Funding
- All of these are subjective at best, and inherently non-measurable

Factors Influencing the Scope of V&V

M&S Task Accounting

- How to count V&V costs?
  - Is verification counted as S/W development, but validation as V&V?
  - Is a development team peer review, with outside experts, an "SME" review and part of verification? Or part of development?
  - Is pre-test prediction part of validation or a test cost?
  - If post-test analysis is useful for validation, does it get charged as V&V or as a test cost?
- For simulations of real objects that are under development, which costs go into the "item" development bin, the "M&S" development bin, the "V&V" bin, etc.
- The more that good software/simulation development practices are followed, the harder it is to sort out development costs from V&V costs
  - Software V&V is integrated into the software development process

Factors Influencing the Scope of V&V

Practitioner Experience

- **Experience under the SMART* program**
  - **5 models varied between 30,000 and 100,000 lines of code, but the V&V tasking and resources expended on each was about the same**
  - **Conclusion: the experience and expertise of the people doing the V&V was much more of a factor in determining resource requirements than the size of the code**
- **That conclusion may not be applicable everywhere, but the level of experience of the practitioner is likely to be a significant driver of VV&A cost requirements**

***Susceptibility Model Assessment with Range Test**

Estimating V&V Resource Requirements: The State of the Art

- **Risk Based Approaches:**
  - Managed (Marginal) Investment
  - Joint Accreditation Support Activity
  - United Kingdom
- **The Cost Estimating Tool (CET)**

AEgis TECHNOLOGIES

Risk Based Approaches

Managed (Marginal) Investment

Managed Investment Strategy

- As a first step, let us define the term.
  - Managed Investment is the execution, from all the possible candidate V&V activities, of a carefully selected subset of V&V activities:
    - Offering the "best return on investment" by providing the essential information necessary from V&V findings, and
    - Providing the required evidence supporting the Accreditation decisions of Service and DOD Accreditation Authorities.
- In this approach, cost is considered as an independent variable during the selection and execution of VV&A assessment activities.
- An optimal subset of VV&A activities can then be chosen based upon the:
  - Assessment data needs of the Accreditation Authority
  - Realities of the program (schedule)
  - Fixed resources (budget) available for assessment and V&V activities

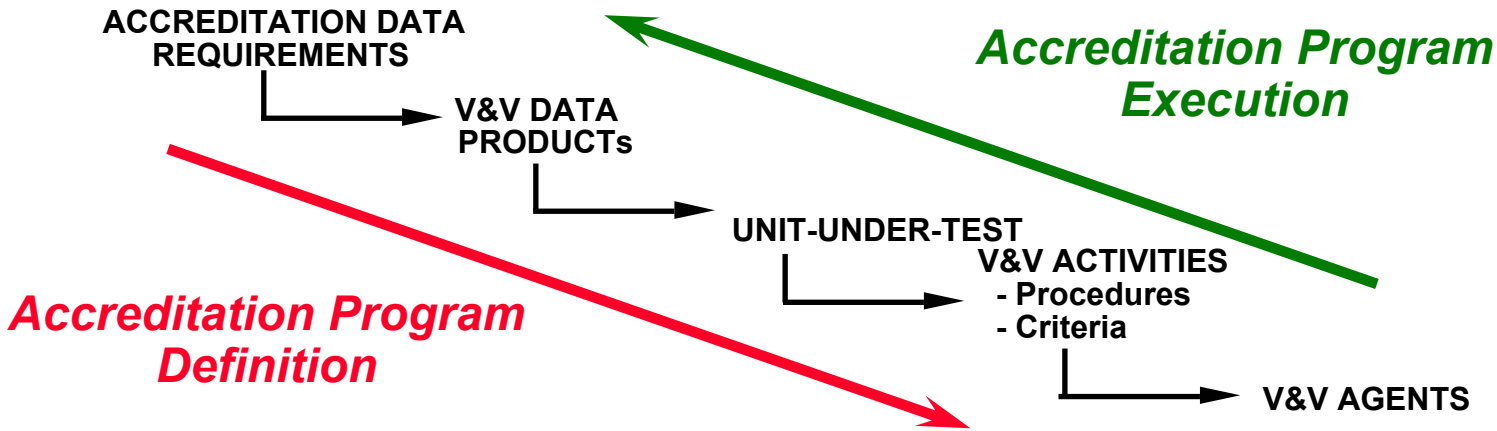
Put the A in Front of V&V!

- Within the Department of Defense (DOD), accreditation is broadly defined as "the official certification that a model or simulation is acceptable for use for a specific purpose."
- Individual M&S and agency accreditation plans may be unique, but the M&S V&V activities selected for execution should provide essential, fundamental information about the simulation to support M&S accreditation decisions.
- The VV&A goal is to establish that a M&S produces realistic, unbiased, credible measurements of performance when operated within a specific domain of scenario and environmental conditions for it to be acceptable (accredited) for use.
- As a consequence, accreditation must be the primary objective in the definition of the M&S V&V activities.

The planning for A must come before the V&V planning

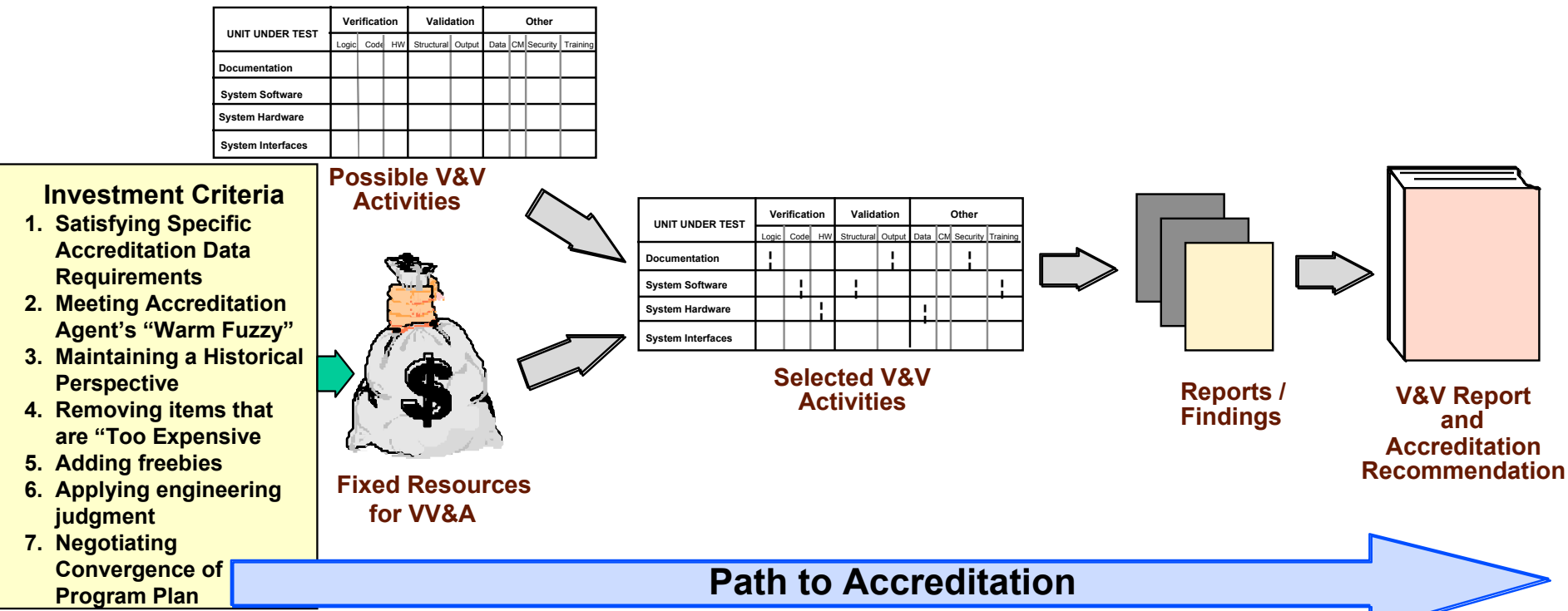
Using A Requirements Flow-Down

- Any M&S VV&A program can be defined top-down
  - Accreditation-decision information needs drive V&V data products
  - Data requirements are contingent on accreditation scope
  - Requirements are flowed down to V&V activities
  - ...In a perfect world...



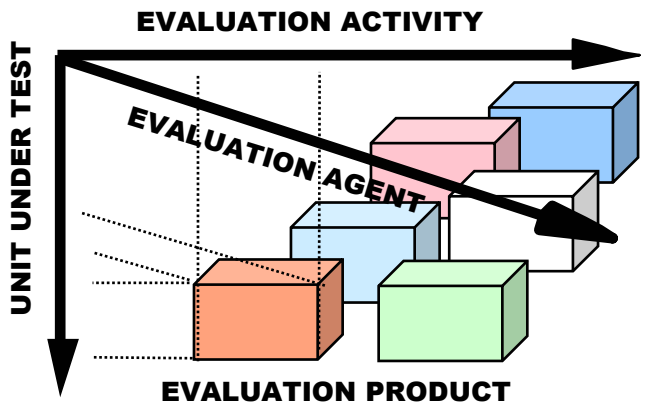
What's the Investment Planning Process?

- Managed investment is an iterative process balancing of what could be done with what can be done based on resources available
  - Selecting the most cost-effective subset within the space of possible V&V activities.
  - Prioritizing their execution so that activities can be added or deleted based on program exigencies.



What Is A VV&A 'Evaluation Activity Space'?

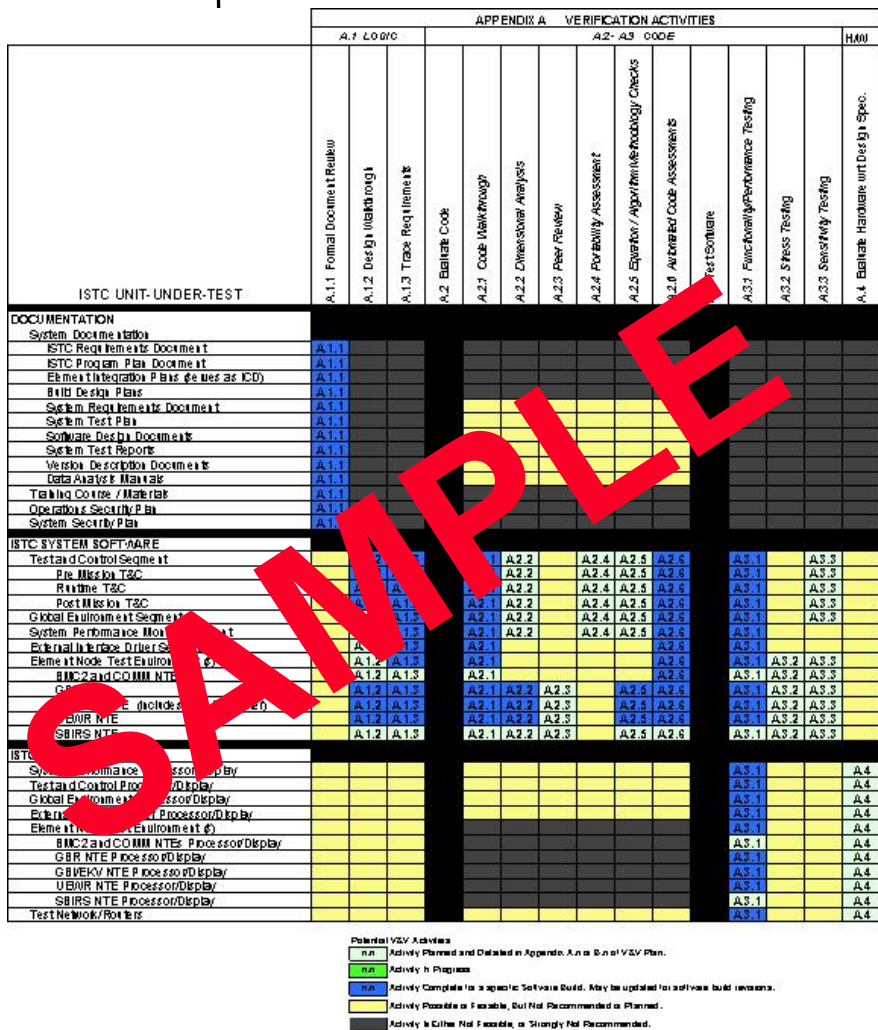
- Another concept key to the "Managed Investment" strategy and supports M&S VV&A program definition is a familiar one - it is the systems engineer's multi-dimensional view of the enterprise whose dimensions exhaust the important attributes of the conceptual space.
- The recommended "evaluation space" whose (relatively orthogonal) dimensions consist of:
  - Unit-under-test *(**UUT**)*
  - Evaluation ***activity***
  - Evaluation ***agent***
  - Evaluation ***product***
- The VV&A Program domain-of-interest is comprised of the most cost-effective set of cells in the Program Space.



- An explicit activity domain-of-interest assures complete, systematic evaluation and intelligent choices within each dimension (UUT, Activity, Agent, & Product)

How Can We Plan and Cost V&V Activities?

- A crosswalk of Evaluation Activities versus UUT, using spreadsheets generated with commercial, off-the-shelf (COTS) software can be developed.
  - Using spreadsheets the cells trace to Assessment Procedures and the expected assessment data products for a particular M&S UUT.
  - This process supports the exploration of alternative suites of V&V program activities that can be correlated to low, medium, and high risk and high, medium, and low investment programs.
- This representation of an evaluation space (i.e., the space projected on the Evaluation Activities-UUT plane) is a valuable representation of the V&V space.



Managed Investment Supports Identification of Alternatives

- This approach results in a set of spreadsheets that serve as a convenient medium to support the balancing of 'investment' in V&V and test activities.
  - It is a simple form from which to generate generate the cost and resource estimates required to execute a proposed VV&A program.
  - Such a representation assures a systematic, complete (but not exhaustive) basis for describing and revising the proposed V&V program, and further tailoring as required during the process of staffing and obtaining approval of the VV&A Plan.

GBR High Cost-Low Risk Alternative V&V Program Cost Summary.

	FY97		FY98		FY99	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	12	24	17	34	10	20
System Software	76	152	176	352	60	120
System Hardware	18	36	35	70	29	58
Interfaces	8	16	50	100	40	80
Environmental Models and Data	106	212	220	440	110	220
Sp Purpose Tools and System Capabilities	29	58	63	126	22	44
TOTAL EFFORT BY YEAR	**249**	**498**	**561**	**1122**	**271**	**542**

Note: Current Year $ in Thousands

	High Cost-Low Risk Alternative
TOTAL FUNDING REQUIRED	**$ 2,162 K**

GBR Medium Cost-Medium Risk Alternative V&V Program Cost Summary.

	FY97		FY98		FY((	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	7	14	9	18	6	12
System Software	47	94	77	154	35	70
System Hardware	7	14	12	24	13	26
Interfaces	7	14	32	64	22	44
Environmental Models and Data	62	124	117	234	63	126
Sp Purpose Tools and System Capabilities	21	42	41	82	12	24
TOTAL EFFORT BY YEAR	**151**	**302**	**288**	**576**	**151**	**302**

Note: Current Year $ in Thousands

	Medium Cost-Medium Risk Alternative
TOTAL FUNDING REQUIRED	**$ 1,180 K**

GBR Low Cost-High Risk Alternative V&V Program Cost Summary.

	FY97		FY98		FY99	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	7	14	5	10	3	6
System Software	33	66	48	96	21	42
System Hardware	6	12	13	26	3	6
Interfaces	4	8	22	44	4	8
Environmental Models and Data	26	52	88	176	28	56
Sp Purpose Tools and System Capabilities	6	12	24	48	8	16
TOTAL EFFORT BY YEAR	**82**	**164**	**200**	**400**	**67**	**134**

Note: Current Year $ in Thousands

	Low Cost-High Risk Alternative
TOTAL FUNDING REQUIRED	**$ 698 K**

The Bottom Line

- **Notwithstanding an essentially sound basis, M&S VV&A Programs are frequently less than successful…**
  - **Residual Issues include:**
    - **Deliberate VV&A Program Planning**
    - **Explicit evaluation criteria**
    - **Consensus on the rules of evidence**
- **M&S VV&A Successes are MADE not found**
- **A Managed Investment Strategy for VV&A:**
  - **Provides A Means Of Communicating to Decision Makers a Way Forward, Leading to Success.**
  - **Is Predicated on Investing for development of Specific Data required for the Accreditation Decision Support.**

Joint Accreditation
JASA
Support Activity

Risk Based Approaches

Joint Accreditation Support Activity (JASA) Approach

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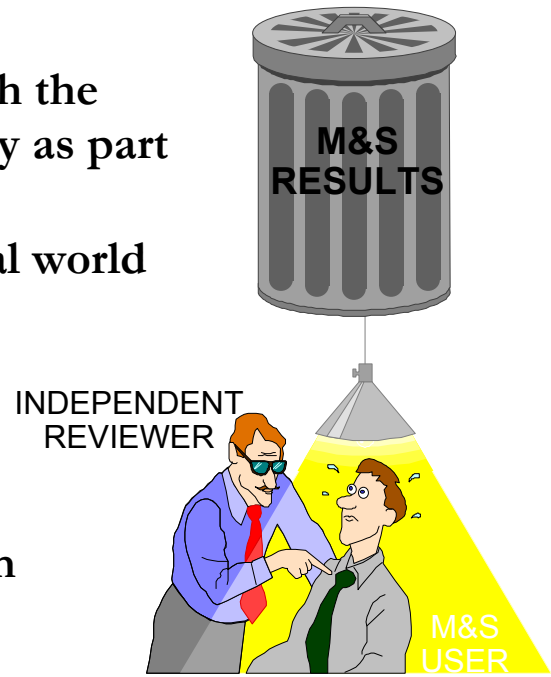
VV&A as Risk Reduction

- **VERIFICATION**
  - Reduces the risk that the software you build (or use) has undetected errors in it that are fatal to your intended use
  - Reduces the risk that the data are inappropriate for the intended application or improperly prepared

- **VALIDATION**
  - Reduces the risk that simulation outputs won't match the "real world" well enough for you to use them credibly as part of the solution to your problem
  - Reduces the risk that the data don't represent the real world with sufficient accuracy for the application



- **ACCREDITATION**
  - Reduces the risk that an inappropriate or unsuitable simulation is selected for use in solving your problem

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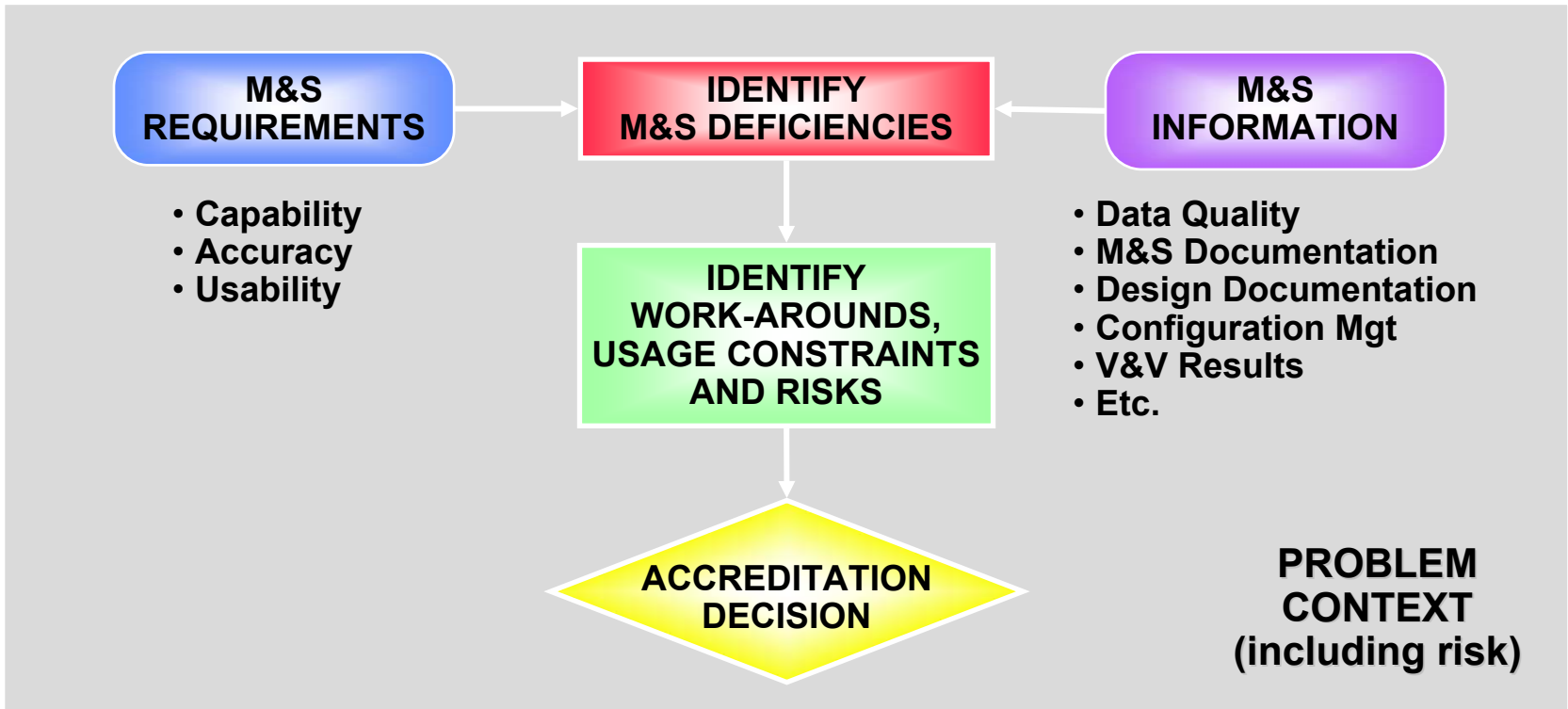
Accreditation

PROVING THE M&S IS SUITABLE FOR YOUR NEEDS

REQUIRES AN OBJECTIVE COMPARISON OF M&S INFORMATION WITH M&S REQUIREMENTS DERIVED FROM THE CONTEXT OF THE PROBLEM

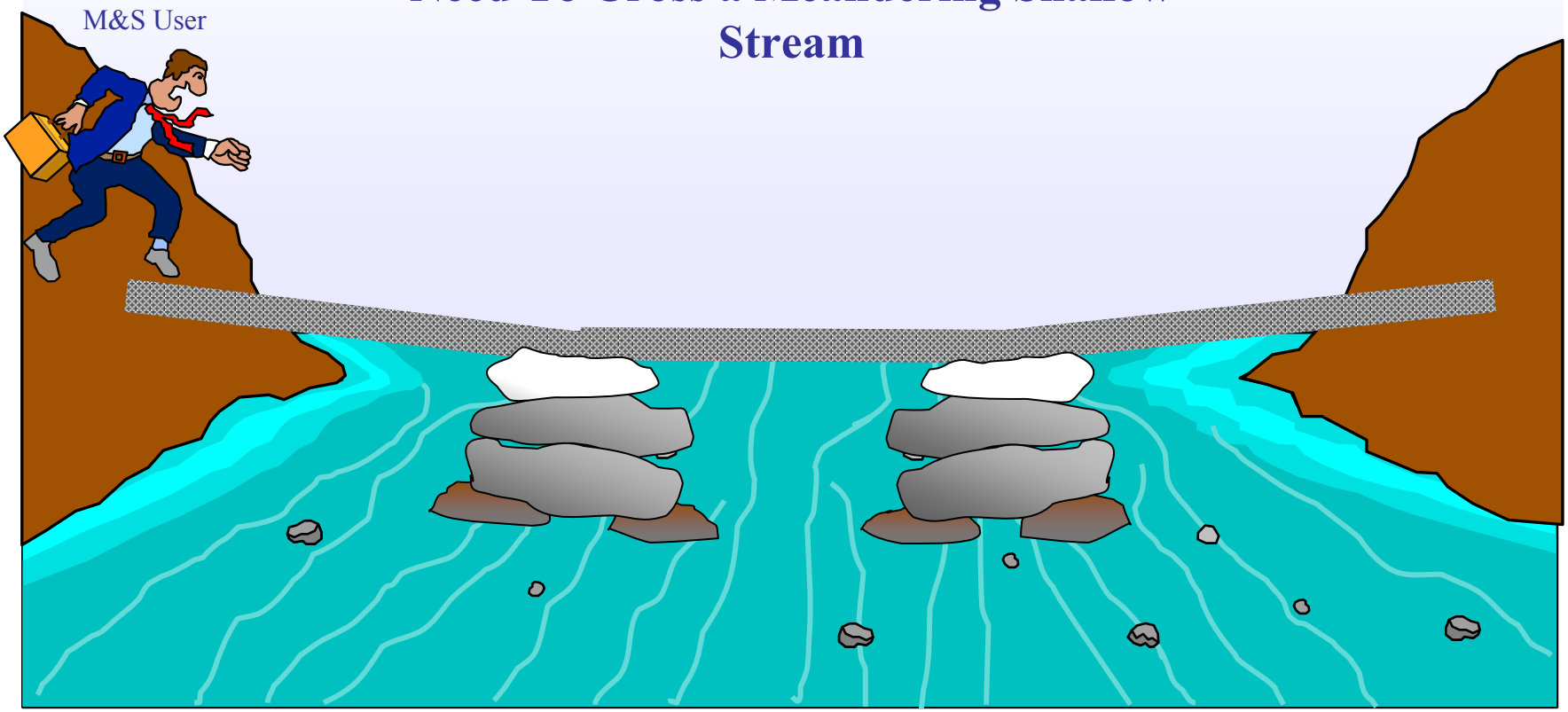


Joint Accreditation JASA Support Activity

How Much Credibility Is "Enough"?

It Depends on Risk

A Makeshift Bridge is Good Enough If You Need To Cross a Meandering Shallow Stream



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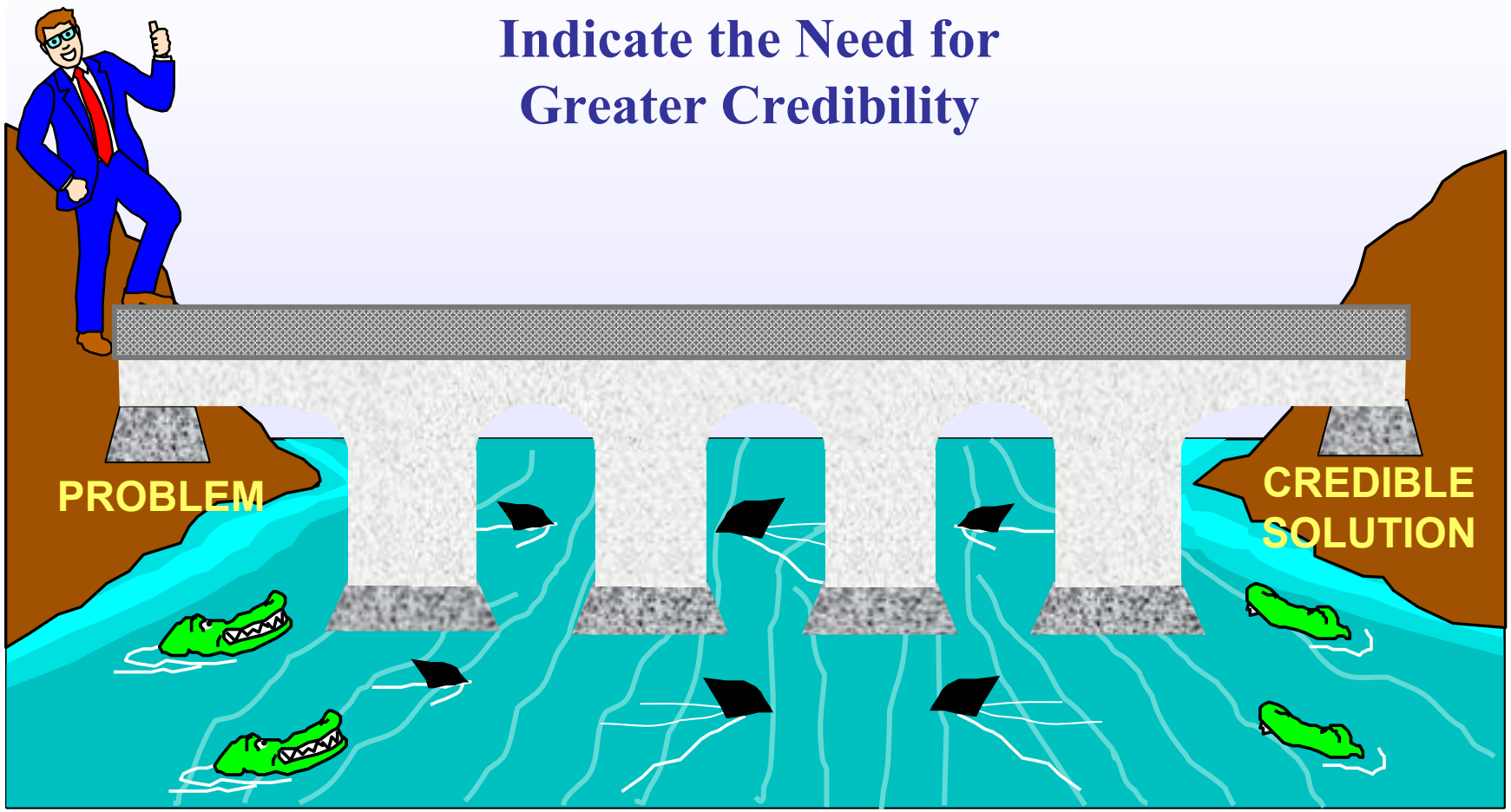
But Greater Risks...



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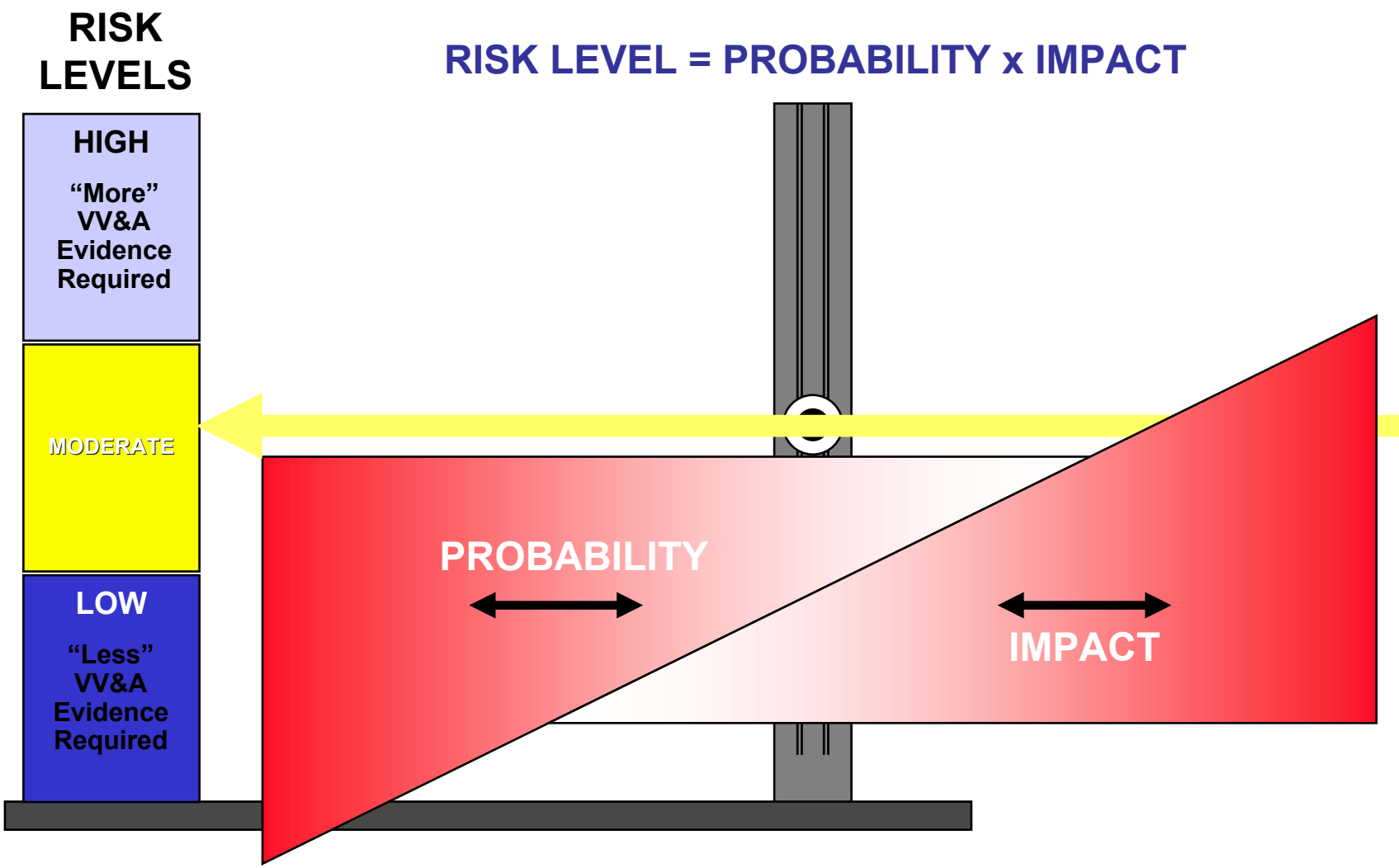
Quantifying Risk



Joint Accreditation JASA Support Activity

"Quantifying" Risk Probability

PROBABILITY DESCRIPTION	LIKELIHOOD OF OCCURRENCE OVER LIFETIME OF AN ITEM	LIKELIHOOD OF OCCURRENCE PER NUMBER OF ITEMS**
FREQUENT	Likely to Occur Frequently	Widely Experienced
PROBABLE	Will Occur Several Times in Life of Item	Will Occur Frequently
OCCASIONAL	Likely to Occur Some Time in Life of Item	Will Occur Several Times
REMOTE	Unlikely but Possible to Occur in Life of Item	Unlikely but can Reasonably be Expected to Occur
IMPROBABLE	So Unlikely, it can be Assumed Occurrence May Not be Experienced	Unlikely to Occur but Possible

**The number of Items should be specified

Joint Accreditation JASA Support Activity

"Quantifying" Risk Impact

IMPACT CATEGORIES	IMPACT LEVELS			
	CATASTROPHIC	CRITICAL	MARGINAL	NEGLIGIBLE
PERSONNEL SAFETY	Death	Severe Injury	Minor Injury	Less than Minor Injury
EQUIPMENT SAFETY	Major Equip Loss; Broad Scale Major Damage	Small Scale Major Damage	Broad Scale Minor Damage	Small Scale Minor Damage
ENVIRONMENT DAMAGE	Severe (Chernobyl)	Major (Love Canal)	Minor	Some Trivial
OCCUPATIONAL ILLNESS	Severe & Broad Scale	Severe or Broad Scale	Minor & Small Scale	Minor or Small Scale
COST	Loss of Program Funds; 100% Cost Growth	Funds Reduction; 50% to 100% Cost Growth	20% to 50% Cost Growth	< 20% Cost Growth
SCHEDULE	Slip Reduces DoD Capabilities	Slip Causes Cost Impact	Slip Causes Internal Turmoil	Republish Schedules
POLITICAL	Nat'l or Internat'l (Watergate)	Significant (Tailhook '91)	Embarrassment ($200 Hammer)	Local
OPERATIONAL	Widespread Add'l Combat Deaths	Limited Add'l Combat Deaths	Moderate Add'l Casualties	Minimal Add'l Casualties

Joint Accreditation JASA Support Activity

"Quantifying" Risk Level

Probability	Level of Impact			
	Catastrophic	Critical	Marginal	Negligible
Frequent	High	High	Medium	Low
Probable	High	High	Medium	Low
Occasional	Medium	Medium	Low	Low
Remote	Medium	Medium	Low	Low
Impossible	Medium	Low	Low	Low

RISK LEVEL VALUES ARE:

- Subjective
- Consistent with MIL-STD-882C*
- Tailorable to each problem

HIGHER RISKS MEANS MORE CREDIBILITY EVIDENCE IS NEEDED

* System Safety Standard

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Correlation with V&V Activities

Example: M&S Software Accuracy Issue

How Much confidence do you have in the accuracy of the S/W?

Items Required	Typical Sources	Needed when Risk is…		
		Low	Medium	High
S/W Dev't Process Description	S/W Development Plan, CM Plan	Either	Required	Required
S/W Dev't Resources Description	SDP, CMM reports		Any two	Required
S/W Dev't Artifacts	CM logs, User Manual, Programmer's Manual, SW Design docs			Any Two
S/W Dev't Results	Requirements Trace Reports, Review Reports, Code Walkthroughs, S/W Test reports	Any one	Any two	Any Three
S/W Mgmt Process Desc	S/W Mgmt Plan, CM Plan, V&V Plan	Any Two	Required	Required
S/W Mgmt Resources Desc.	Mgmt Plans, S/W Documentation, anecdotal		Desired	Required
S/W Mgmt Artifacts	CM Database, SCR's, S/W Docs,, CCB minutes, S?W Design Documentation		Any One	Any Two
S/W V&V Results	SPCR logs, test reports, verification reports, usage history		Any One	Any Two

Joint Accreditation JASA Support Activity

VV&A Cost Estimating

- Using cost data from SMART program
- Example: Work-Months required to develop M&S "Capabilities Description"
  - As a function of the number of "FE (Functional Elements)" in the M&S that must be evaluated
  - The application drives which FE need to be evaluated

Information Element	Application Risk Level		
	Low	Moderate	High
Functional Breakdown	2	2	2
Functional Element Description (conceptual model)			2/FE
Summary of Limitations due to assumptions and errors		3	3
Total Resource Requirement (work-months)	**2**	**5**	**5+2/FE**

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JASA Approach

- **Establish Risk Levels For Each Application**
  - Identify Risk Types
  - Determine Impacts and Probabilities
  - Determine Risk Level
- **Determine Appropriate Information Products based on Risk**
  - For Each Credibility Component (Usability, Accuracy, Capability)
  - Greater Risk Levels Dictate More In-depth Information and more formal documentation
- **Determine Appropriate V&V Activity For Each Information Product**
  - Cost estimates can be based on historical data

Risk Based Approaches

UK Approach*

- Based on an analysis of M&S failure modes
  - Identify functional requirements
  - Conduct Functional Failure Analysis
    - Identify failures, probabilities, impacts
    - Develops the same risk, impact matrix as the JASA approach
- Also conduct M&S Benefits Analysis
  - Identifies benefits, probabilities and impacts
  - Allows for a cost/benefit analysis to support VV&A task prioritization
- V&V activities are described by level (1-5) from least "stringent" to most
  - Activities selected will depend on cost/benefit analysis results for credibility requirements
- Cost data not identified
  - But can be correlated to historical data in the same way as the JASA approach

* Taken from "Verification, Validation and Accreditation of Models and Simulations Used for Test and Evaluation – A Risk/Benefit Approach"

Verification, Validation, and Accreditation (VV&A) Cost Estimating Tool (CET)

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Why & How the CET Evolved Like it Did

- **There was need for a single VV&A cost estimating tool that covers all situations**
- **In the creation and development of the tool we found that we needed to:**

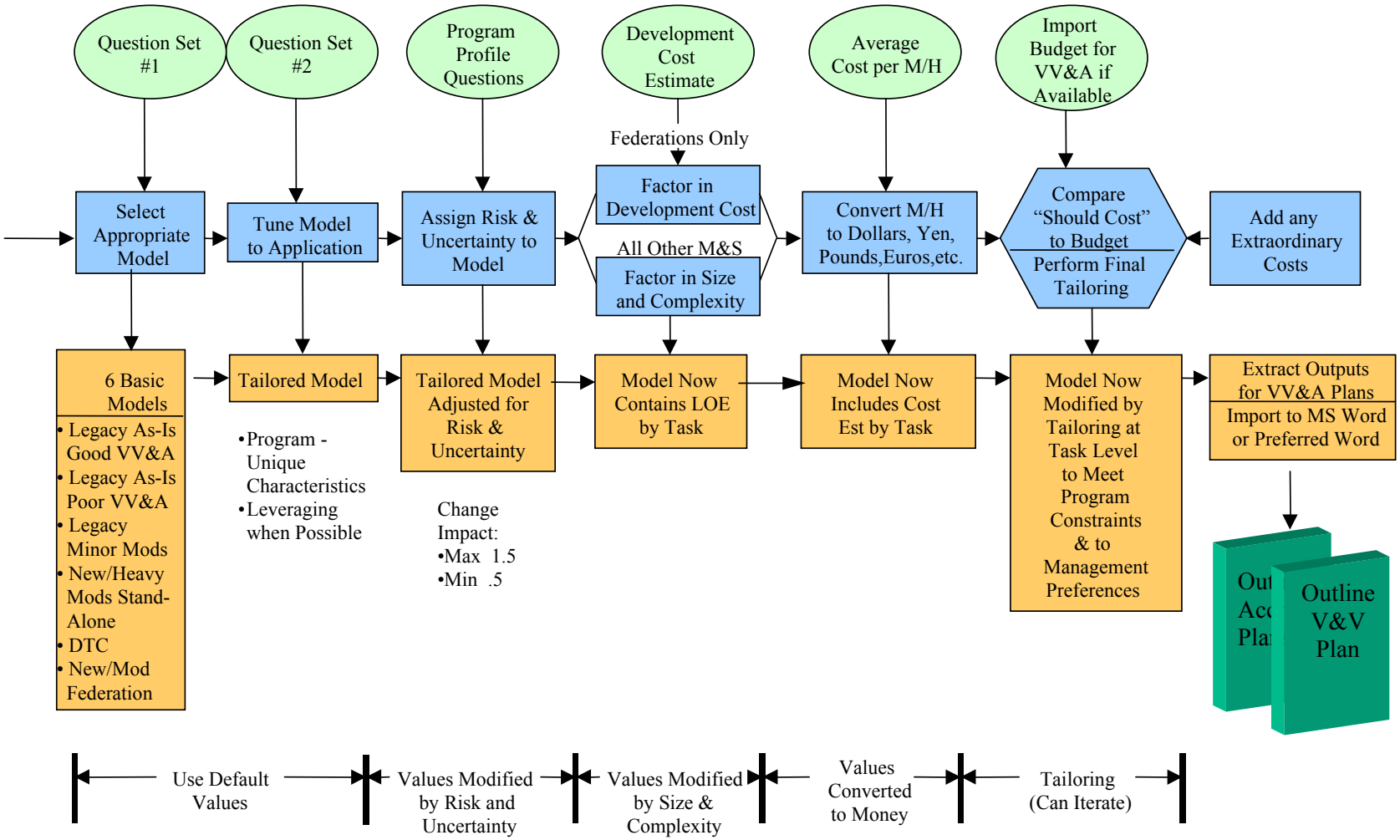
  - Define a robust set of six models tailored to legacy (as-is, minor, or major mods), new stand-alone (federates), federations, and one special case.

  - Incorporate a way to accommodate and track extraordinary costs, such as unusual validation requirements and other direct costs (ODCs) as separate line items.

  - Incorporate methods for handling leveraging, risk and uncertainty, complexity, ten different software languages, incremental and evolving development efforts, etc.

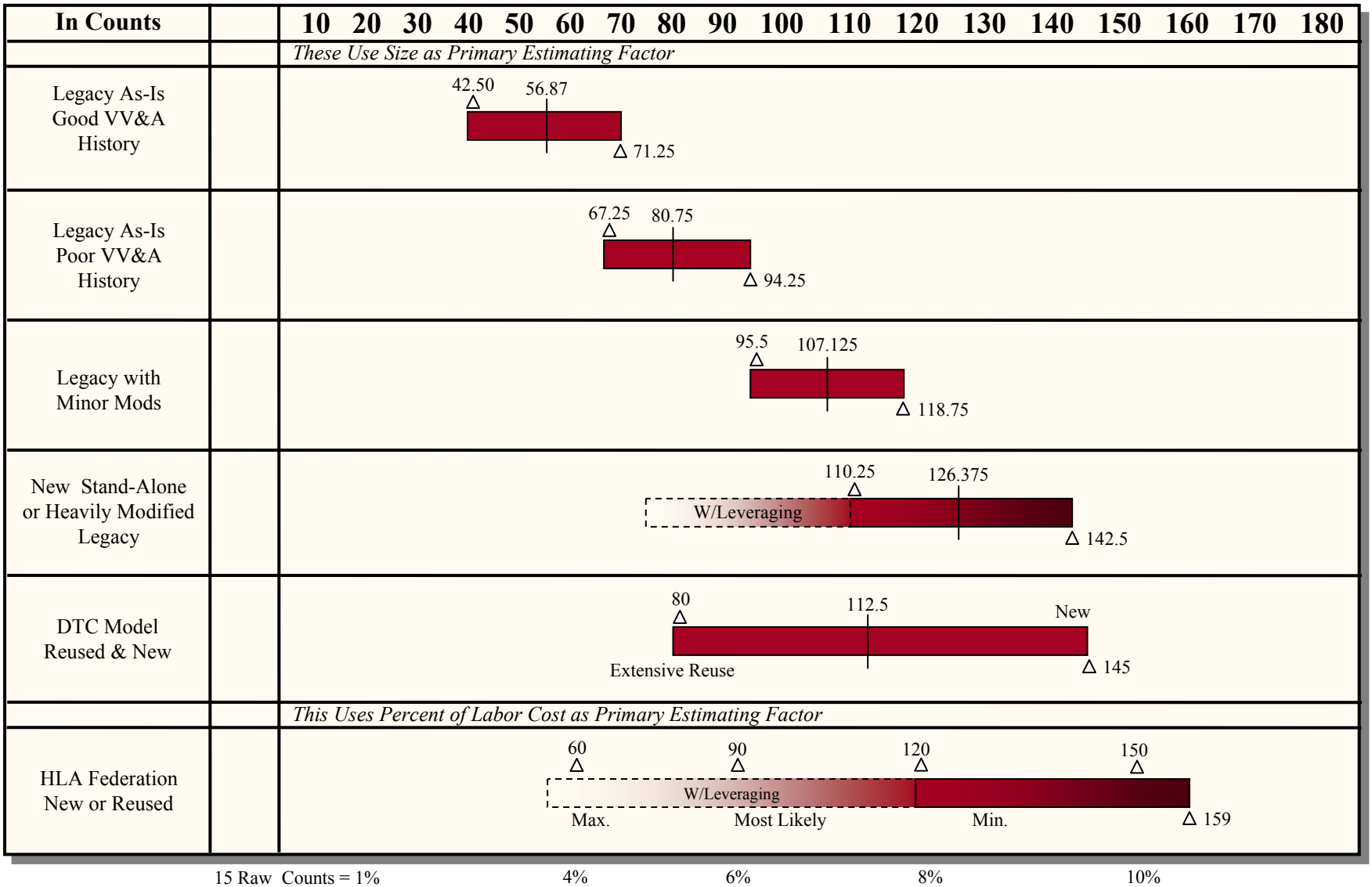
  - Incorporate an object-oriented, extensible design that can add new models efficiently. The DTC model is living proof.

Cost Estimating Tool (CET) Flow Diagram



Relative LOE By VV&A Program Type

(Not adjusted by Risk and Uncertainty or Complexity)



CET Features & Functions

Size/Cost

- **Software Size is the basis of estimate for all M&S except federations.**
- **Federation cost is the basis of estimate for federation VV&A.**

Initial Tailoring

- **A few questions enable selection of appropriate model.**

VV&A Man-year Cost

- **Tool requires average man-year loaded cost of VV&A team.**

Fine Tuning

- **Using appropriate model, additional questions narrow focus and adjust the basic list of core activities.**

Risk & Uncertainty

- **15 questions adjust the estimate based upon risk and uncertainty factors.**

Complexity

- **This factor is used in modifying the estimate for all M&S except federations.**
- **Federation estimates are self-compensating in terms of VV&A.**

Leveraging

- **Leveraging off the work of others an be factored into the estimate.**

Extraordinary Cost Terms

- **Unusual costs associated with VV&A are planned and added as ODCs allowing them to be separately priced and tracked.**

Lengthy Incremental Development Efforts

- **Tool recommends planning each increment as a separate VV&A effort, when required.**

Status of the CET as of Oct 2002

- **Thanks to our past sponsors, Army AMIP, TRAC and DTC, the tool is free.**
- **Currently available on CD or from the Tec-Masters website in Huntsville.**
- **The developers will continue to support and configuration-manage the tool for the next few years.**
- **Any issues, problems, or requests should be sent to our help disk at pjanssen@tecmasters.com or to me at Boeing.**
- **We want users and either Paul or I will help you when you need assistance!**
- **If I get sufficient interest, I will develop a CMMI V&V Model and add it to the CET.**
- **Demo follows. . .**

Case Histories

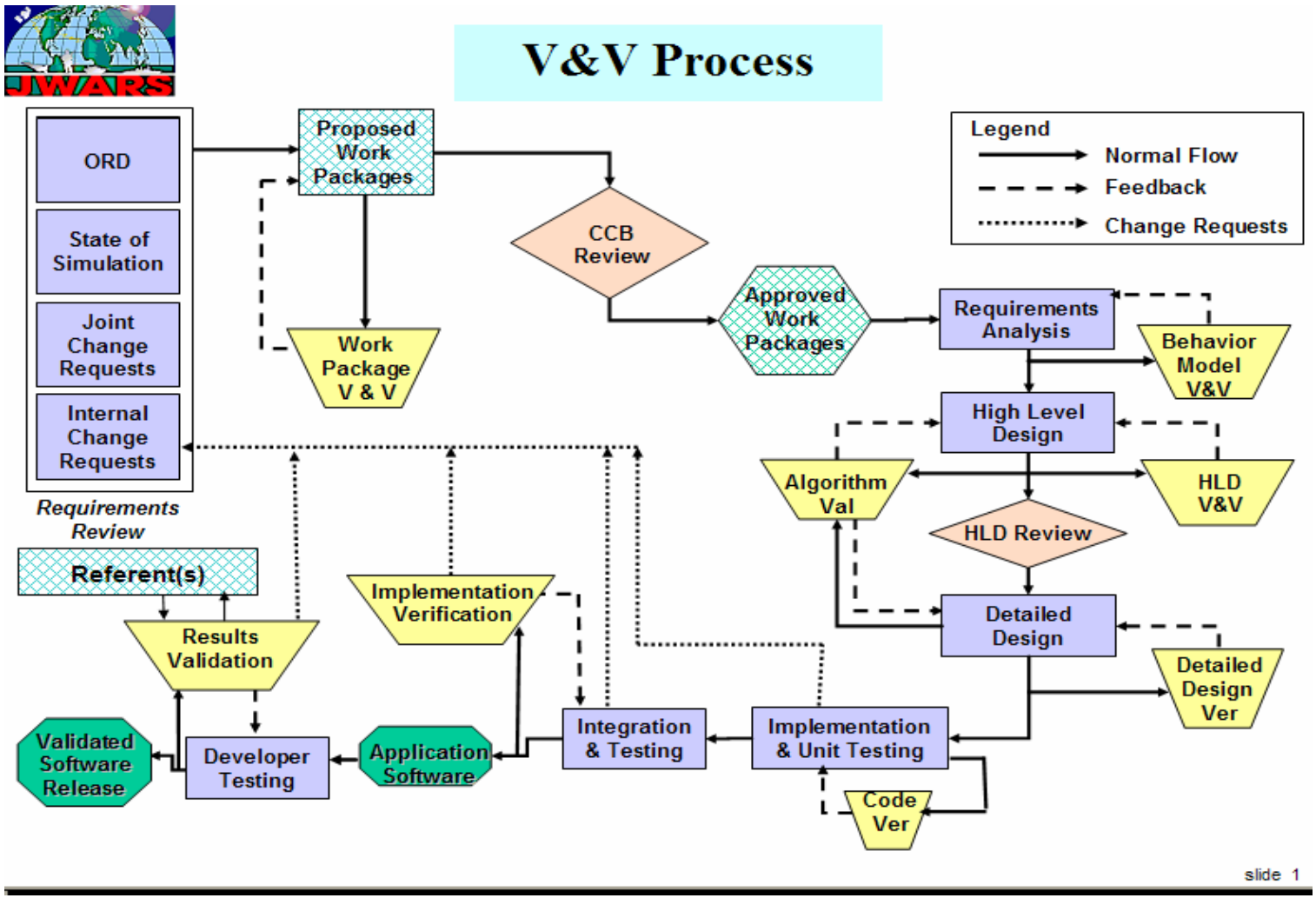
- The Joint Warfare System (JWARS)
- VV&A of MDA's Ground-Based Radar Prototype (GBR-P) HWIL Testbed
- AIM-9X
- Joint Strike Fighter (JSF)
- Susceptibility Model Assessment with Range Test (SMART)

Case History

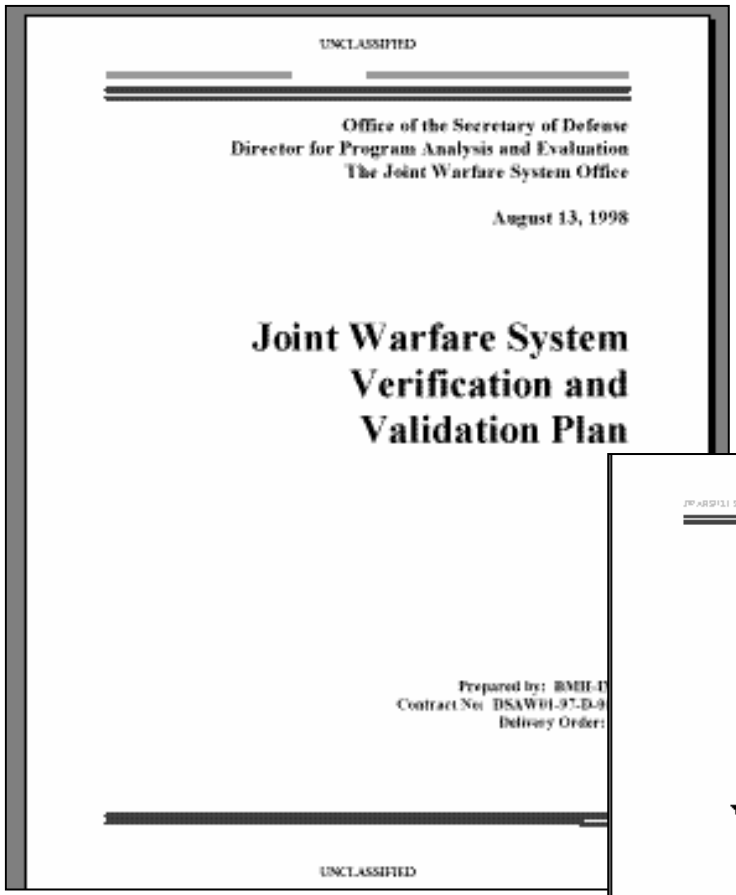
The Joint Warfare System (JWARS)

- JWARS is a joint force analysis model intended to replace TACWAR, MIDAS, ITEM, and THUNDER
- JWARS development began in 1995 with a prototype
  - Development contract was awarded in July 1997 to GRCI (now part of AT&T) and CACI
- Users are OSD PA&E, Joint Staff J-8 and J-4, the Service analysis agencies (CAA, AFSAA, N-81, MCCDC), and the Combatant Command analysis organizations

JWARS V&V Process



JWARS V&V Plan, Processes, Reports Documents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Office of the Secretary of Defense
Director for Program Analysis and Evaluation
The Joint Warfare System Office

August 13, 1998

Joint Warfare System
Verification and
Validation Plan

Prepared by: BMH-I
Contract No: DSAW01-97-D-0
Delivery Order:

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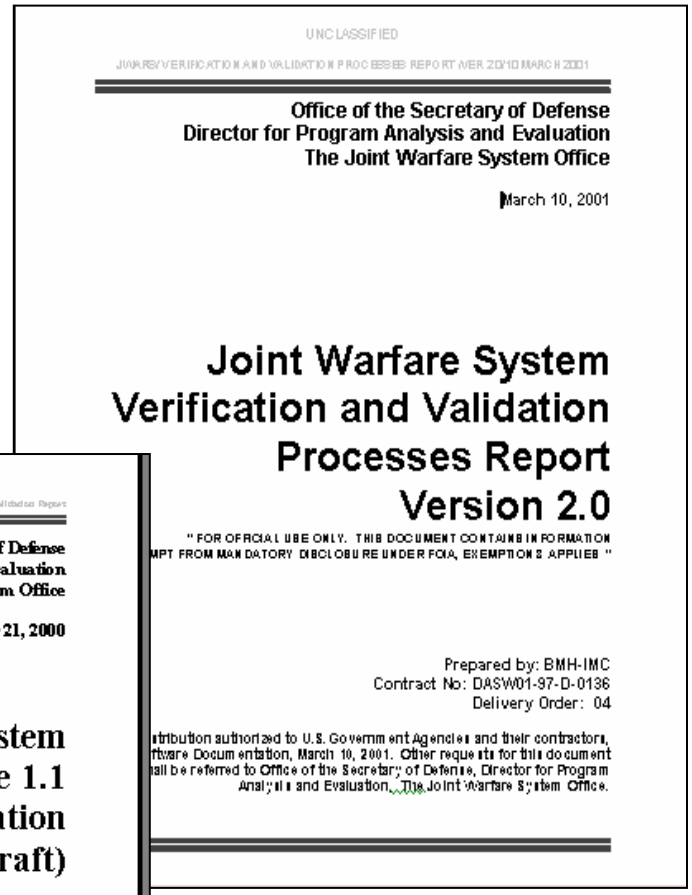
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JWARS V&V Processes Report Ver 2.0 10 March 2001

Office of the Secretary of Defense
Director for Program Analysis and Evaluation
The Joint Warfare System Office

March 10, 2001

Joint Warfare System
Verification and Validation
Processes Report
Version 2.0

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Prepared by: BMH-IMC
Contract No: DASW01-97-D-0136
Delivery Order: 04

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ftware Documentation, March 10, 2001. Other requests for this document
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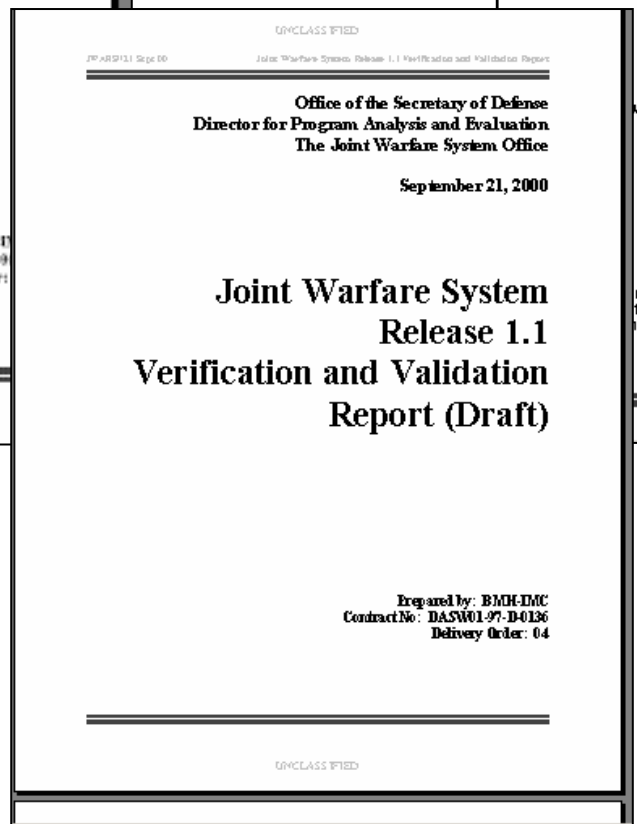
Analysis and Evaluation, The Joint Warfare System Office.


UNCLASSIFIED

JWARS 2.0 Sept 00 Joint Warfare System Release 1.1 Verification and Validation Report

Office of the Secretary of Defense
Director for Program Analysis and Evaluation
The Joint Warfare System Office

September 21, 2000

Joint Warfare System
Release 1.1
Verification and Validation
Report (Draft)

Prepared by: BMH-IMC
Contract No: DASW01-97-D-0136
Delivery Order: 04

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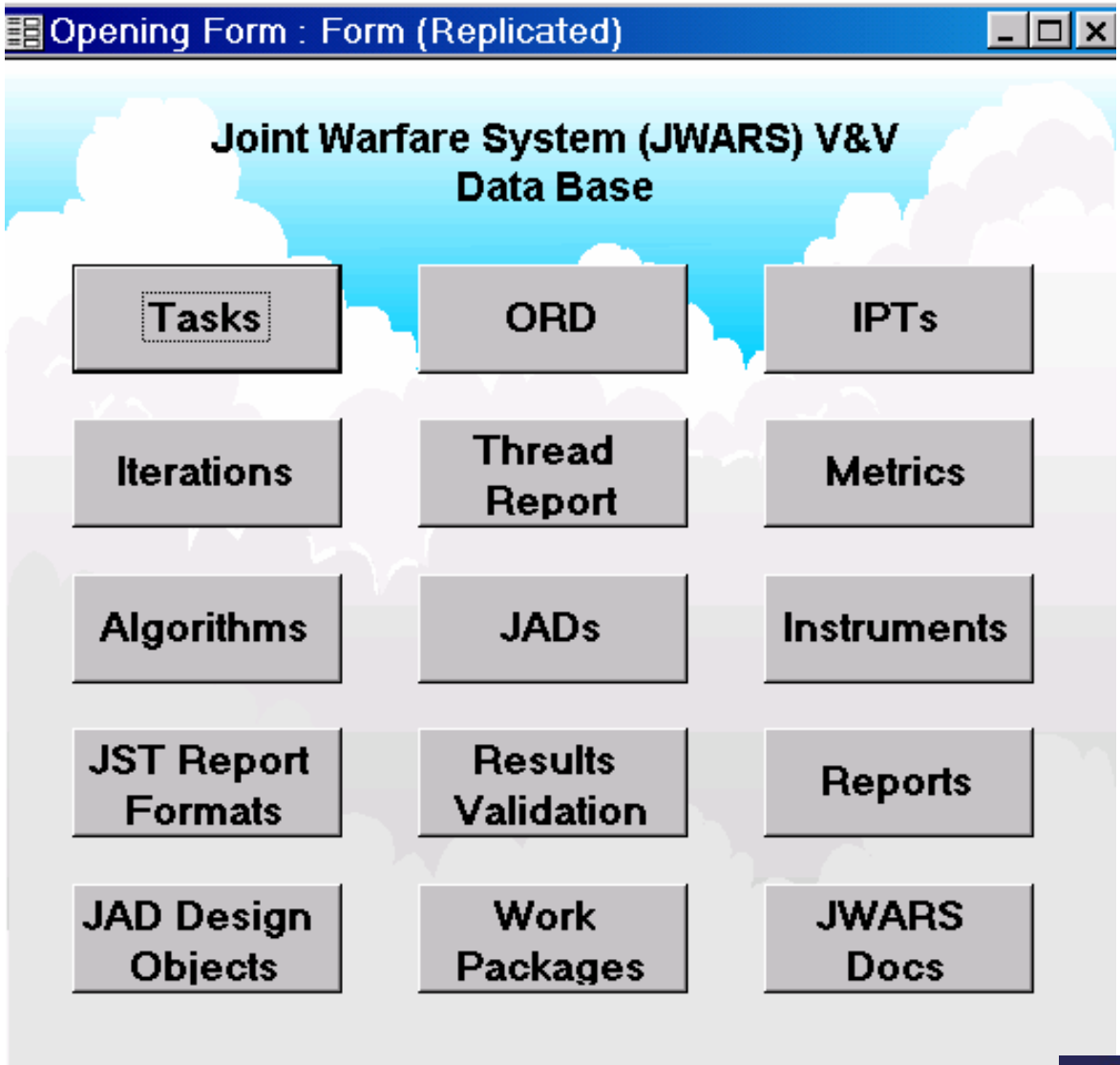
IMC
Innovative Management Concepts, Inc.

BMH Associates, Inc.

JWARS V&V Database



JWARS V&V Delivery Orders (Schedule and Funding)

DO #	Start	End	Value
1	30 Sept 97	9 Aug 98	$279,254
2	10 Aug 98	9 Aug 99	$489,674
3	10 Aug 99	9 May 00	$387,348
4	10 May 00	11 Mar 01	$494,566
5	12 Mar 01	12 Nov 01	$363,099
6	13 Nov 01	12 Nov 02	$557,050
			$2.57M

Other Costs of the JWARS V&V Effort

- **JWARS Office Technical Direction**
  - GM-15 Task Monitor (2%?)
  - Navy 0-5 V&V Program Coordinator (10%?)
  - GS-13 COR (5%?)
- **JWARS Developer Coordination**
  - Thousands of hours to work with V&V Agent to provide development artifacts, explanations
- **WIPT Member Effort**
  - Thousands of hours (DoD civilians, military officers, contractors) preparing for and attending the WIPT

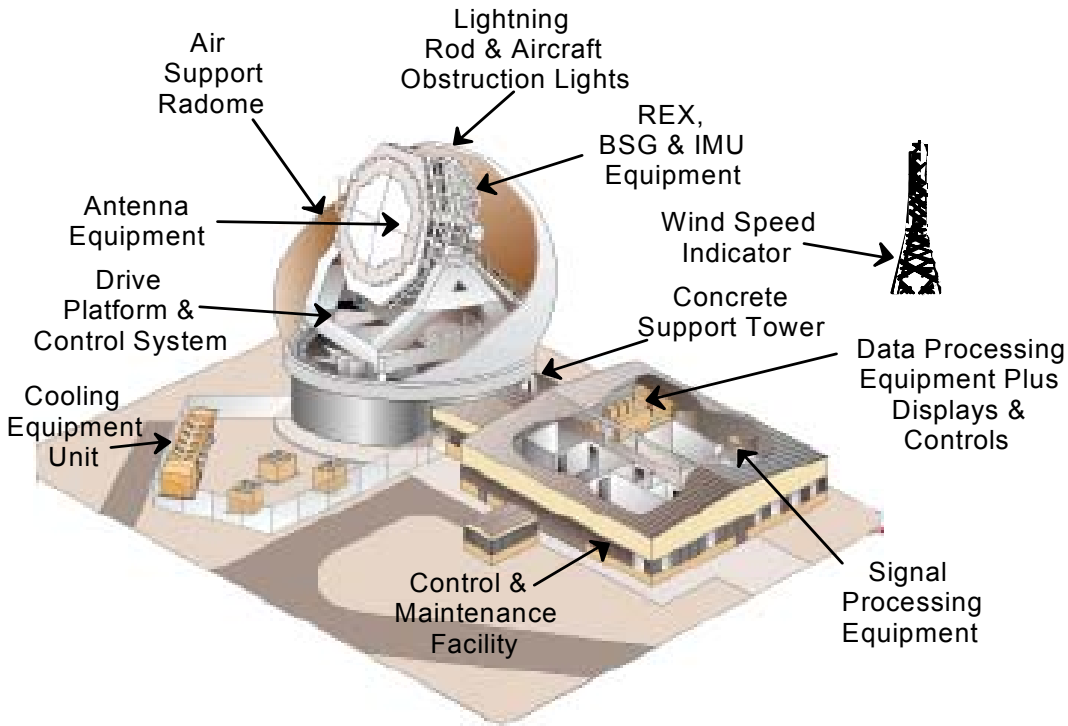
Case History

MDA's Ground-Based Radar Prototype (GBR-P) HWIL Testbed

A Case Study – Using A Managed Investment Strategy

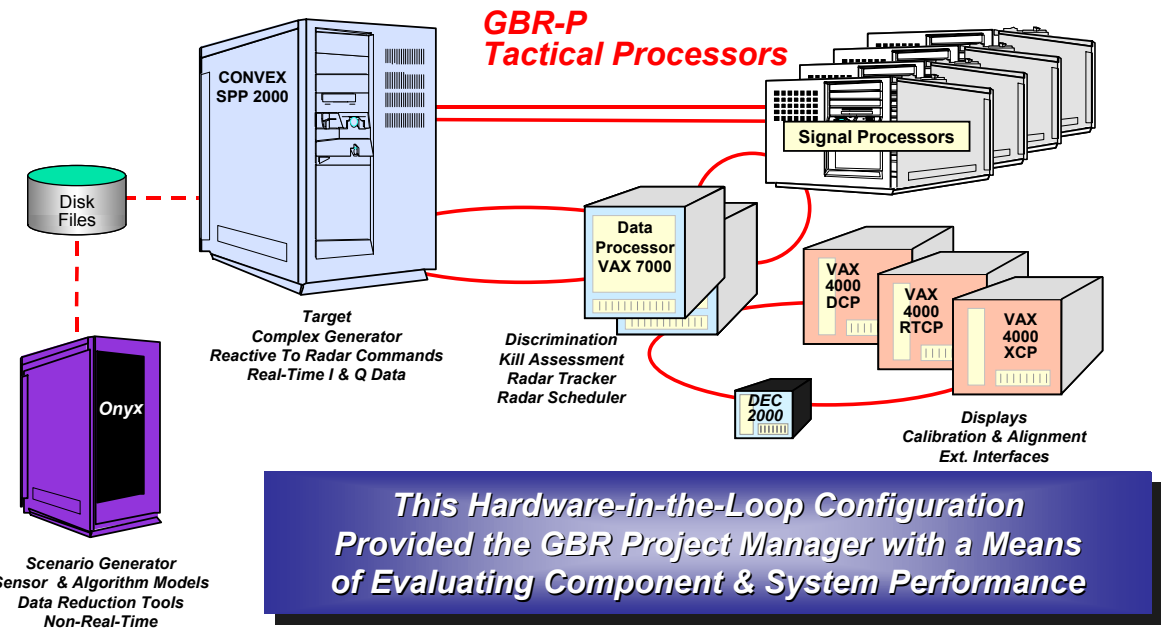
Ground Based Radar Prototype GBR-P

- The GBR-P is an Anti-Ballistic Missile (ABM), treaty-compliant, test radar built to resolve and demonstrate critical technology issues for the X-Band Radar (XBR) element for the Ground-Based Midcourse Defense (GMD) Segment.
- The GBR-P Radar System is a key test resource for resolving critical technology issues for the XBR, and supports integrated GMD system testing.
  - The primary objective of the GBR-P is to perform surveillance, acquisition, tracking, discrimination, interceptor support, and kill assessment in the exo-atmospheric threat flight regime.
  - The GBR-P performs coordinated operations and interfaces with external installations via the Kwajalein Mission Control Center (KMCC) and the GMD BM/C3.



GBR-P HWIL Simulation Testbed

- The GBR HWIL Simulation Testbed consisted of:
  - Simulation Framework
  - Set of generic "common models"
  - A variety of GBR-P system specific and GBR-P component representations of corollary, real-world GBR-P radar components.



- The common models provided "methods" for representing generic object classes from which representations of real-world systems were composed.
- These representations were comprised of:
  - Legacy models.
  - Associated "characteristics" (parametric) and "instance" (initial condition) data.
  - Decision processor "rule sets".
- VV&A activities had to confirm both that the generic model methods were correct, and that the components and systems composed from them adequately represent the "real-world" prototype system.

GBR-P HWIL Accreditation Data Requirements Discovery

The planning for GBR Accreditation came before the V&V planning

- Using a Managed Investment Strategy, the first issue regarding accreditation of the GBR HWIL Simulation Testbed was establishing its scope of application.
  - DOD and Service direction indicated that for GBR-P HWIL:
    - Accreditation was contingent on Application Scope (Intended Use).
    - The application domain was to be specified explicitly.
    - It could be incrementally accredited for a progressively wider scope of application.
  - Department of the Army guidance also recognized that accreditation could be conferred for either a particular study, or for a "class of applications".

Using Managed Investment for Cost Assessment / Planning

AEgis TECHNOLOGIES

UUT

- Documentation
  - -System Design Documentation
  - -Software Design Documentation
  - -User Documents
  - -Other Documents
- System Software
  - -Scenario Generator
  - -Target Complex Generator
  - -Control and Display
  - -Analog Conversion
  - -External Interface Simulation Data
  - -GBR Hardware Configuration Item Simulators
- System Hardware
  - -Data Processor VAX 7000 (2)
  - -DEC 2000 Operator Control Console
  - -VAX 4000 Display and Control Program
  - -VAX 4000 Radar Test Control Program
  - -VAX 4000 External Communications Program
  - -Massively Parallel Signal Processors (4)
  - -Convex SPP 2000
  - -Scenario Generator SG Onyx
- Interfaces
  - -Scenario Generator to Target Complex Generator
  - -Target Complex Generator to Radar
  - -Radar to Scenario Generator (Data files for Data Reduction)
  - -Target Complex Generator to Ext. Interface Simulation
  - -GBR Hardware Configuration Item Simulator to Radar
  - -External Interface Simulator to Radar
- Environment Representations
  - -Earth's Rotation and Gravitational Field
  - -Atmosphere Density and Ionization
  - -Rain and Clouds
  - -Sun/Moon Position
  - -Noise Models: Sky, Ground, Sun, Moon
  - -Intercept Debris
  - -Nuclear Weapons
  - -Resident Space Objects
- Data
  - -Scenario Engagement Files
  - -Logical Record Identifiers
- Special Purpose Data Analysis Tools
  - -Data Analysis Tool
- System Capabilities
  - -Test Preparation
  - -Test Execution
  - -Test Analysis
  - -User Interface
  - -Test Utilities

Possible V&V Activities

Verification	Validation	Others
• Logic	• Structural	• Data
• Code	• Output	• CM
• HW		• Security
		• Training

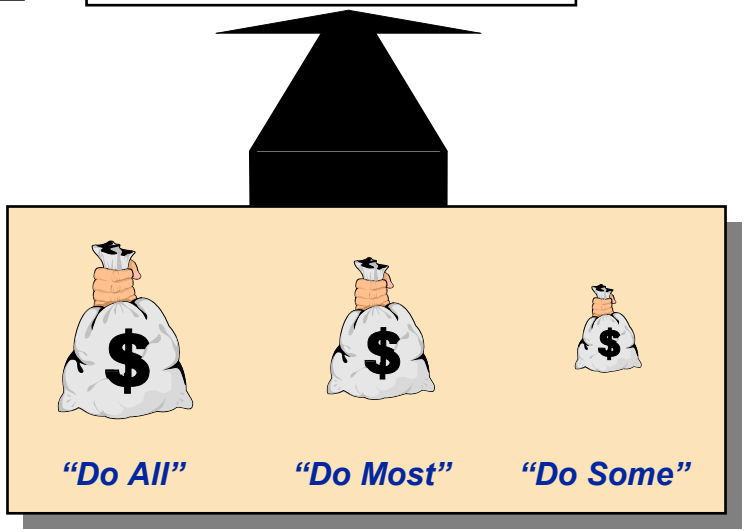
Selected V&V Activities

UNIT UNDER TEST	Verification			Validation		Other			
	Logic	Code	HW	Structural	Output	Data	CM	Security	Training
Documentation	!				!			!	
System Software		!		!					!
System Hardware			!			!			
System Interfaces									

Low Risk Alternative

Medium Risk Alternative

High Risk Alternative



Level of Effort

GBR-P Low Risk Assessment Investment Strategy

- Selected V&V activities were programmed with LOE sufficient for an in-depth assessment - *Baseline Program*
- **Resultant cost to execute ~ $2,162k over three years**
- GBR PM able to Direct (Manage) the VV&A Investment & Trade-Off Risks
  - Approach strongly accepted by Program Management and Budget Analysts
  - Used "Consumer's Report" format to depict Investments
- Investment managed at the UUT Level
- Enabled Portrayal of V&V Investment in Terms of:
  - UUT
  - Depth (Extent of Effort)

GBR High Cost-Low Risk Alternative V&V Program Cost Summary

	FY97		FY98		FY99	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	12	24	17	34	10	20
System Software	76	152	176	352	60	120
System Hardware	18	36	35	70	29	58
Interfaces	8	16	50	100	40	80
Environmental Models and Data	106	212	220	440	110	220
Sp Purpose Tools and System Capabilities	29	58	63	126	22	44
TOTAL EFFORT BY YEAR	**249**	**498**	**561**	**1122**	**271**	**542**

Note: Current Year $ in Thousands

	High Cost-Low Risk Alternative
TOTAL FUNDING REQUIRED	**$ 2,162 K**

UNIT UNDER TEST (UUT)	VERIFICATION			VALIDATION		RELATED V&V ACTIVITIES			
	Logic	Code	HW	Structural	Output	Data	CM	Security	Training
Documentation	●						●		●
System Software	●	●		●	●				
System Hardware	●		●		●				
System Interfaces	●	●	●		●				
Environment Representations	●	●		●	●				
Data				●	●				
Data Analysis Tools	●	●		●					
System Capabilities	●				●			●	

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Relative LOE and Scope of Effort Based Upon Executing Candidate UUT/V&V Activities

100% 75% 50% 25% 15% 0%

GBR-P Medium Risk Assessment Investment Strategy

- Using a Managed Investment Strategy, Program Alternatives were identified to the GBR PM
  - V&V activities were reduced in scope compared to Low Risk Alternative => Higher Risk than the Baseline Program
  - Intent - **to scope an effort that could still lead to a favorable Accreditation decision** - but, with higher risk
- **Resultant Cost to execute a less robust effort was $1,180k over three years**
  - V&V activities were de-scoped or dropped – resulting in a decrease in effort of ~$1M over three years

GBR Medium Cost-Medium Risk Alternative V&V Program Cost Summary

	FY97		FY98		FY99	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	7	14	9	18	6	12
System Software	47	94	77	154	35	70
System Hardware	7	14	12	24	13	26
Interfaces	7	14	32	64	22	44
Environmental Models and Data	62	124	117	234	63	126
Sp Purpose Tools and System Capabilities	21	42	41	82	12	24
TOTAL EFFORT BY YEAR	**151**	**302**	**288**	**576**	**151**	**302**

Note: Current Year $ in Thousands

	Medium Cost-Medium Risk Alternative
TOTAL FUNDING REQUIRED	**$ 1,180 K**

UNIT UNDER TEST (UUT)	V&V EVALUATION ACTIVITIES								
	VERIFICATION			VALIDATION		RELATED V&V ACTIVITIES			
	Logic	Code	HW	Structural	Output	Data	CM	Security	Training
Documentation	●						●		●
System Software	●	●		●	●				
System Hardware	◔		●		●				
System Interfaces	●	●	●		●				
Environment Representations	●	●		●	●				
Data				●	●	●			
Data Analysis Tools	●	●		●					
System Capabilities	◒				●			◒	

000129b

Relative LOE and Scope of Effort Based Upon Executing Candidate UUT/V&V Activities

100% ● 75% ◕ 50% ◑ 25% ◔ 15% ○ 0%

GBR-P High Risk Assessment Investment Strategy

- Lowest Cost – Highest Risk Alternative identified to the GBR PM
  - V&V activities were further reduced in scope compared to the Medium Risk Alternative => Much Greater Risk than the Baseline Program.
  - Activities de-scoped or dropped - resulting in an additional decrease in effort of ~$400k over three years.
  - Intent was to scope an effort that *might* lead to a favorable Accreditation decision – *but, with even greater risk.*
- **Resultant Cost to execute this more modest effort was $698K over three years.**

GBR Low Cost-Low Risk Alternative V&V Program Cost Summary

	FY97		FY98		FY99	
	MW	Cost ($)	MW	Cost ($)	MW	Cost ($)
Documentation	7	14	5	10	3	6
System Software	33	66	48	96	21	42
System Hardware	6	12	13	26	3	6
Interfaces	4	8	22	44	4	8
Environmental Models and Data	26	52	88	176	28	56
Sp Purpose Tools and System Capabilities	6	12	24	48	8	16
TOTAL EFFORT BY YEAR	**82**	**164**	**200**	**400**	**67**	**134**

Note: Current Year $ in Thousands

	Low Cost-High Risk Alternative
TOTAL FUNDING REQUIRED	**$ 698 K**

UNIT UNDER TEST (UUT)	V&V EVALUATION ACTIVITIES								
	VERIFICATION			VALIDATION		RELATED V&V ACTIVITIES			
	Logic	Code	HW	Structural	Output	Data	CM	Security	Training
Documentation	◒						◒		◒
System Software	◒	◒		◒	◒				
System Hardware	◒		◒		◒				
System Interfaces	◒	◒	◒		◒				
Environment Representations	◒	◒		◒	◒				
Data				◒	◒	◒			
Data Analysis Tools	◒	◒		◒					
System Capabilities	◒				◒			◒	

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Relative LOE and Scope of Effort Based Upon Executing Candidate UUT/V&V Activities

● 100% ◕ 75% ◒ 50% ◔ 25% ◔ 15% ○ 0%

GBR-P Use Case Conclusions

- As in M&S itself, the specification of **SCOPE, DETAIL,** and **LEVEL OF EFFORT** for accreditation is problematic.
- Managed investment addresses the problem of specifying the scope and detail of V&V activity for accreditation and allows near-optimal investment in assessment activities and products for an economically constrained environment.
- Managed investment provides for the deliberate, progressive, ***INVESTMENT IN INFORMATION VALUABLE FOR ACCREDITATION DECISION SUPPORT.***
- **TIME** and **RESOURCES** will constrain which V&V activities may be undertaken, what products generated, and the degree to which all accreditation data needs are met.
- Program funding will establish available LOE and selection of V&V activities
- **PROGRAM MANAGEMENT COMMITMENT** is required to effectively plan for M&S VV&A programs.

Case History

AIM-9X

- **Integrated Flight Simulation (IFS) and Joint Services Endgame Model (JSEM) supported AIM-9X development, test and evaluation**
  - **Pre- and post-flight test prediction**
  - **Specification compliance**
  - **Operational test and evaluation (OT&E)**
  - **Live Fire Test and Evaluation (LFT&E)**
- **Approach to M&S accreditation:**
  - **JASA as Accreditation Agent**
  - **Established Accreditation Review Panel**
    - **Evaluated V&V Plans and Results**
    - **Developed Accreditation Recommendation to Accreditation Authority**
  - **Separate Validation Review Panels evaluated each missile firing for M&S validation opportunities**

AIM-9X V&V Cost Experience

- **V&V costs difficult to reconstruct**
  - V&V costs for IFS distributed over multiple contractors and contract vehicles
  - V&V of JSEM done by government with contract support
- **Many validation opportunities from live fire shots**
  - Costs were not counted as validation, but as test costs
  - Only costs of validation review panel meetings can be reconstructed
  - Missile S/W identical to IFS modules meant every shot was also a verification opportunity for IFS
- **Verification cost experience**
  - Costs for module documentation development (approx. 35 SMDD written) can only be estimated in part (for support contractor)
  - Verification effort per subsystem module did not seem to be strongly linked to number of source lines of code

AIM-9X Accreditation Costs

- **Accreditation Agent costs can be tracked**
  - **Approximately 1 ½ - 2 work-years per year**
  - **Total cost over four years was approximately $1.5M**
  - **Does not include costs for Accreditation Panel members, or for labor costs of IFS & JSEM experts**
- **Model documentation efforts could be charged against accreditation, vice verification costs**
  - **Required to support both verification efforts and accreditation panel reviews**

AIM-9X Summary

- M&S VV&A integrated into the overall missile development process
  - Test firings support validation and accreditation reviews
  - Actual missile software used in simulation
    - Providing verification opportunities from flight tests
  - Accreditation reviews ensured M&S supported application requirements
- Integrated approach made it difficult to separate VV&A costs from system development and test costs
  - V&V documentation costs can be tracked, but not the cost of V&V activities

Case Study

Joint Strike Fighter (JSF)

- The JSF Program is a Department of Defense (DoD) effort to field an affordable next generation strike aircraft weapon system for joint service use
- The Joint Accreditation Support Activity (JASA) was hired by JSF as Accreditation Support Agent
- For the most part, JSF represents an application of the JASA approach to VV&A tasking

JSF Accreditation Process

1. Define the Application
   - Determine and document the analysis objectives
2. Define the Model Requirements
   - Determine and document model requirements (general, functional, fidelity, and operational) which will serve as model acceptance criteria.
3. Compare Model Capabilities to Model Requirements
   - This assessment highlights areas where the model meets the assessment criteria, indicates weaknesses, which reduce the credibility of model results, and reveals areas where information is insufficient to support any conclusions about credibility.
4. Risk Assessment and Accreditation Recommendation
   - The assessment of the risk incurred by use of the model as is, and recommendations for risk mitigation.
5. Accreditation Decision

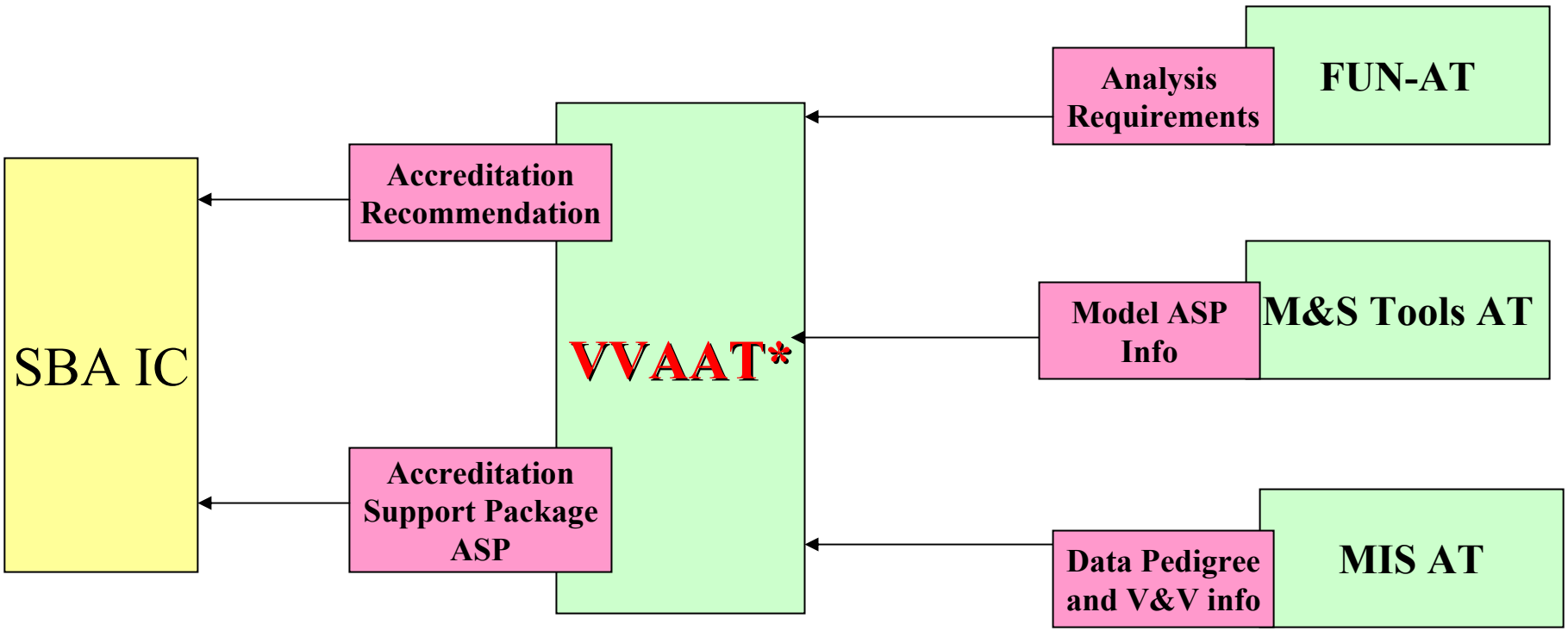
M&S Used to Support System Development

- **JSF Strike Warfare Collaborative Environment (SWCE)**
  - 28 Models
  - Engagement, Mission, and Campaign
  - Government managed
  - Examples: ESAMS, Brawler, JIMM, Thunder
- **JSF Engineering and Manufacturing Collaborative Environment (EMCE)**
  - 300 + models and tools
  - Mostly engineering level
  - Lockheed-Martin managed
- **JSF Suite of M&S (SoM&S) is the combined SWCE and EMCE**

VV&A Cost Concerns

- JSF has had a well-defined VV&A process in place since their Requirements Development Phase
- It is the size of the effort that challenges JSF resources
  - During the Requirements Phase JSF recognized that they could not totally VV&A all models in the SWCE
  - The models have large and dynamic databases which must be supported as well
- JSF needed to organize to obtain credibility information in a timely manner
  - To avoid "take-it-or-leave-it" decisions
  - Developed "action teams" specifically to address VV&A issues

Accreditation Product Flow



*VV&A Action Team

JSF Summary

- JSF developed a management structure to:
  - Produce VV&A related data in an effective an efficient manner
  - Support the accreditation decisions of the JSF Accrediting Authority and the testing community
- This process was required because there are insufficient resources to develop detailed V&V information for all M&S in the JSF suite
  - VVAAT will set priorities based on risk and application
  - Cost for VV&A drove this arrangement, but has not been tracked directly

Case History

Susceptibility Model Assessment with Range Test (SMART)

- **SMART Goal: develop a cost-effective VV&A process**
  - **Approach is based on developing V&V tasking around high priority functions within the M&S**
- **Demonstrated the process and tracked V&V costs for five models using a detailed work-breakdown structure (WBS)**
  - **ALARM, ESAMS, RADGUNS, BRAWLER, TRAP**
  - **Provides about the only detailed historical data on M&S V&V costs over several M&S**
- **SMART process provided the foundation for the JASA approach**

SMART VV&A WBS*

- **Perform VV&A**
  - **1.0 Precursors**
    - 1.1 Define Application
    - 1.2 Develop M&S Requirements
    - 1.3 Select Candidate M&S
  - **2.0 Planning**
    - 2.1 Determine Accreditation Requirements
    - 2.2 Develop Accreditation Plan
  - **3.0 Verification**
    - 3.1 Decompose Model into Functions
    - 3.2 Assess S/W Quality
    - 3.3 ID M&S Assumptions, Limitations & Errors
    - 3.4 Produce Design Documentation
      - 3.7 Document Verification Results
      - 3.6 Perform Code Verification
    - 3.5 Perform Logical Verification
  - **4.0 Validation**
    - 4.1 Conduct Sensitivity Analysis
    - 4.2 Perform Face Validation
    - 4.3 Perform Results Validation
    - 4.4 Document Validation Results
  - **5.0 Accreditation**
    - 5.1 Perform non-V&V Tasks
    - 5.2 Perform Acceptability Assessment
    - 5.3 Make Accreditation Decision
    - 5.4 Document Accreditation Decision

**How to VV&A Without Really Trying: SMART VV&A Lessons Learned*, Nov 1997

Three Categories of VV&A Tasking

I. Characterizing the General Credibility of the M&S

- V&V and Usage History
- Model Management processes
- Documentation quality
- Assumptions & Limitations

II. Expert Reviews

- Sensitivity Analysis
- Conceptual Model & Functional Breakdown and Description
- Data V&V results
- Face Validation, Logical verification

III. "Classical" V&V

- By Functional Element (FE) and for end-to-end model
- Code verification
- Results validation with test data

SMART Average V&V Costs

WBS#	Task Name	LOE (WM)*	Cost ($K)
1.1.1	Assess Current Documentation	3	
1.1.2	Assess Software Quality	3	
1.1.3	ID Assumptions, Limitations, Errors	3	
1.2.1	Decompose Model into FE's	2	
1.2.2	Define Functional Templates	1	
1.3.1	Define Configuration Baseline	1	
1.3.2	Evaluate Existing CM Procedures	2	
1.3.3	Survey Model History	3	
	TOTAL Category I Tasks	18	252
2.1.2	Prepare S/W Design Documents	2/FE	
2.2.2	Perform Sensitivity Analysis	1/FE	
	TOTAL Category II Tasks	3/FE	42/FE
3.1	Code Verification Tasks	2/FE	
3.2	Validation Analysis Tasks	6/FE	
	TOTAL Category III Tasks	8/FE	112/FE
	GRAND TOTALS	18+11/FE	252+154/FE

* WM = Work-Months

SMART V&V Cost Summary

- Average Costs for V&V tasking:
  - Category I: 18 WM $250K
  - Category II: 3 WM/FE $42K/FE
  - Category III: 8 WM $112K/FE
    - Validation 6 WM
    - Verification 2 WM

Notes:
- All dollar costs in 1996 dollars
- Cat II costs did not include costs for SME reviews, only to develop data to support a review
- Cat III costs did not include the cost of system tests that supplied validation data

SMART Summary

- Functional Element Approach
  - Facilitated prioritizing V&V effort around application requirements
  - Not necessarily the "least cost" approach to verification
  - Used successfully by JASA for numerous programs
- Costs collected during SMART can be useful for "validating" VV&A cost models

Analysis of State of the Art and Program Case Histories

- Common Experiences of Case Study Examples
- Cost Estimating Relationships
- Leveraging

SURVICE ENGINEERING COMPANY

Common Experiences of Case Study Examples

- Developing accreditation (and M&S) requirements in the design of a V&V program
  - The common challenge: what is "good enough" V&V?
- Requirements are all based on Risk
  - No-one can afford a comprehensive V&V program
- There is little detailed historical data on V&V resource requirements
  - Difficulty in tracking V&V costs in programs, for several reasons
- Constrained costs
  - "Fixed Resources, variable benefits"; how much credibility can I get for this amount of funding?
- Documentation costs
  - V&V effort often has to fund S/W documentation
- Schedule impact of V&V
  - V&V lags M&S usage; often accrediting M&S that have already been used to support the program

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Cost Estimating Relationships

- CET is a parametric cost model that makes use of a number of factors about the M&S
  - Complexity, SLOC, Risk and Uncertainty, previous V&V, etc.
  - Needs to include level of expertise of practitioners
- CET does not cover M&S validation (comparison with test data)
  - Software V&V only
- Cost Estimating Relationships need to be validated

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Leveraging

- **Common usage M&S would benefit from shared V&V information across users**
  - **Examples are M&S in SURVIAC, used to support survivability assessments for a wide variety of applications**
    - **SMART conducted V&V on 5 SURVIAC M&S**
- **Sharing V&V across users would reduce overall V&V costs**
  - **Especially using FE approach to V&V**
  - **Users may have different priorities across M&S functions, leading them to "V&V" different functional elements within the M&S**
  - **As more users conduct V&V, more functions in the M&S are verified and validated**
- **Requires users to document their results!**
  - **Preferably in a standard format**

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SUMMARY

- Risk is a primary driver of VV&A resource requirements
  - Described several approaches to estimating risk and developing VV&A tasking
- Real world programs are very constrained by resources
  - Even VV&A programs tailored to their requirements (based on risk) often are not executable due to cost constraints
  - Schedule demands often are not compatible with V&V tasking
- There exists very little historical V&V cost data of any fidelity
  - Programs do not track those cost data
  - Difficult to separate development costs from V&V costs
  - No universally accepted definition of what is V&V tasking and what is development tasking
- CET appears to be state of the art for cost modeling
  - But cost data need validation

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Recommendations

- **Standard VV&A Tasking Definitions and WBS**
  - Need standard definitions of what is V&V tasking and what is development
  - Need to sort out test range data collection costs, system development costs, software development costs, etc from VV&A
  - Best accomplished by a standard, accepted WBS for VV&A activities
  - Will also facilitate contracting for VV&A support
- **Cost Data Collection**
  - Need real-world M&S VV&A cost data
  - Need to start collecting that data based on the VV&A WBS
- **Data Pedigree for Cost Estimating Relationships (CER)**
  - Using the cost data collected we can "validate" the CER in the Cost Estimating Tool
  - WBS cost data also can be used to support VV&A support contract negotiations
  - Links real-world cost data with theoretical models of VV&A cost

Supplemental Slides

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Introductory Material

Scope and Structure of the Paper

- Based on authors' experiences planning and conducting VV&A efforts, mostly in DOD
- Successful approaches to VV&A planning and cost estimation
- Case Histories: experiences of DOD programs and historical VV&A costs
- Analysis of approaches and case histories
- Recommendations for further study

Why Listen to Us?
(Authors' Backgrounds)

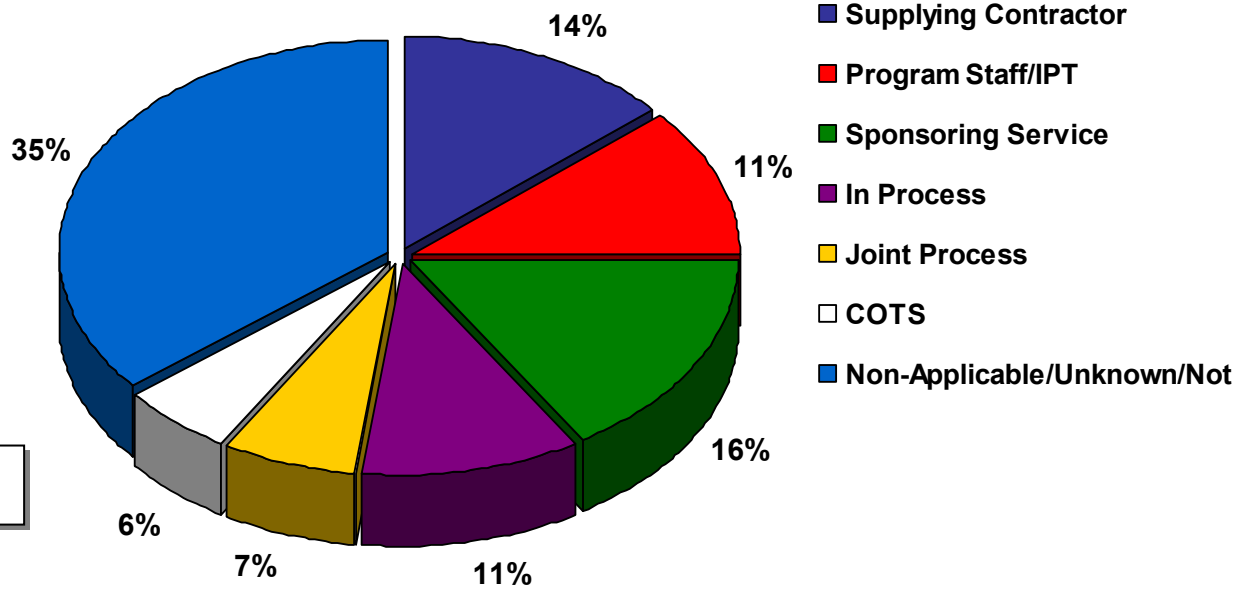
- **Michelle Kilikauskas** – Joint Accreditation Support Activity (JASA) Director, accreditation agent for numerous programs
- **Dirk Brade** – Published basic research in VV&A, German delegation to ITOPS VV&A Working Group
- **Robert Gravitz** – VV&A Director for numerous programs, including hardware in the loop, as well as digital M&S
- **David Hall** – Past JASA director, SMART Joint Program Manager, VV&A support to numerous programs
- **Martha Hoppus** – Accreditation agent for AIM-9X and RAM programs
- **Ronald Ketcham** – Accreditation Agent for JSF, Chairman of Reno VV&A Workshop
- **Robert Lewis** – Developed VV&A Cost Estimating Tool, authored textbook on IV&V, supported VV&A Recommended Practices Guide (RPG) development
- **Michael Metz** – Tech Director for JWARS V&V program and others, primary author of VV&A RPG Millennium Edition

Motivations for VV&A Cost Estimation:

Results of a Modeling & Simulation Survey

H&AI
Hicks & Associates, Inc.

Who does VV&A in DOD?



- 359 M&S

- *Uncertainty about "pedigree" of M&S being used (35%)*
- *Potential conflicts of interest (25%)*
- *VV&A standards for COTS M&S?*
- *Use of joint/independent processes low (7%)*

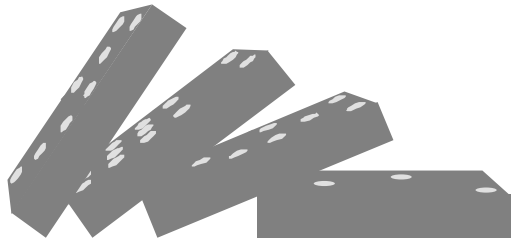
Joint Accreditation
JASA
Support Activity

Common (Mis)perceptions Affecting VV&A Resource Requirements

- **VV&A IS A ONE-TIME EVENT**
  - It means that someone "looked at" the model and decided it was "good", so we don't need any more work
- **VV&A IS A "CHECK IN THE BOX"**
  - Done just to fulfill direction or policy guidance
- **VV&A IS A "S/W DEVELOPMENT ISSUE"**
  - Done just to catch and correct S/W development errors
- **SOFTWARE V&V = SIMULATION V&V**
  - Software V&V is all that's needed
- **VV&A IS ONE WORD, AND V+V=A**
  - Accreditation is an automatic result of doing V&V
- **VV&A costs too much, takes too long, adds risk**
  - VV&A is nice in theory but impossible to complete under normal resource constraints

Joint Accreditation JASA Support Activity

Impact of Misperceptions on VV&A Cost



- VV&A's true usefulness as a risk management tool goes unrecognized
- VV&A is treated as a mere "administrative problem"
- Simulation developers spend $ where they shouldn't and don't spend $ where they should

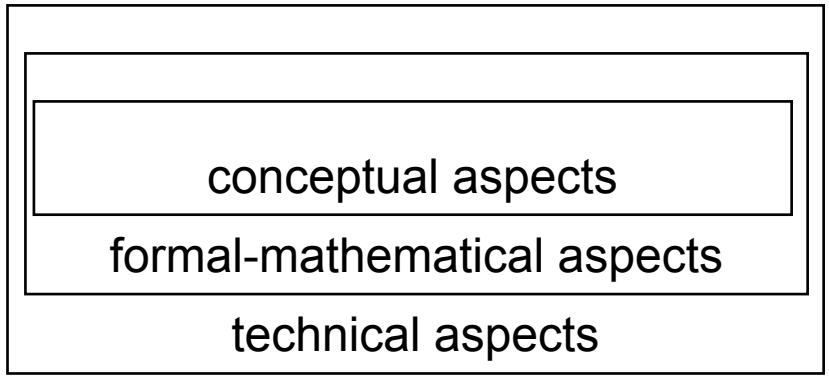
BOTTOM LINE

Perceived and actual lack of return on investment

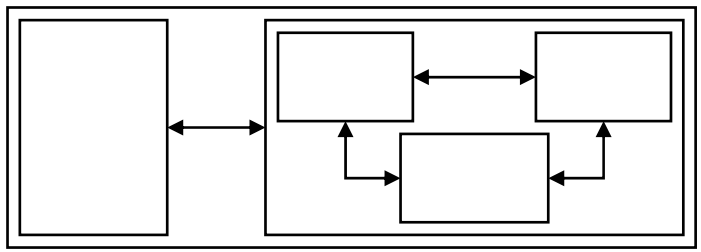
VV&A as "too costly and time consuming" becomes a self-fulfilling prophecy

Information contained in a Model

1. **Conceptual, formal-mathematical, and technical aspects**

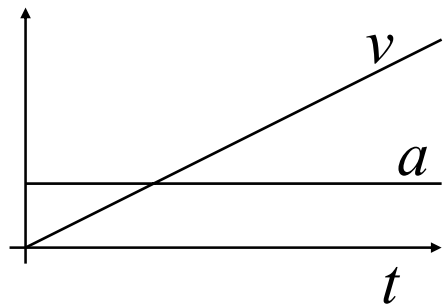


2. **Sub-models hierarchy**



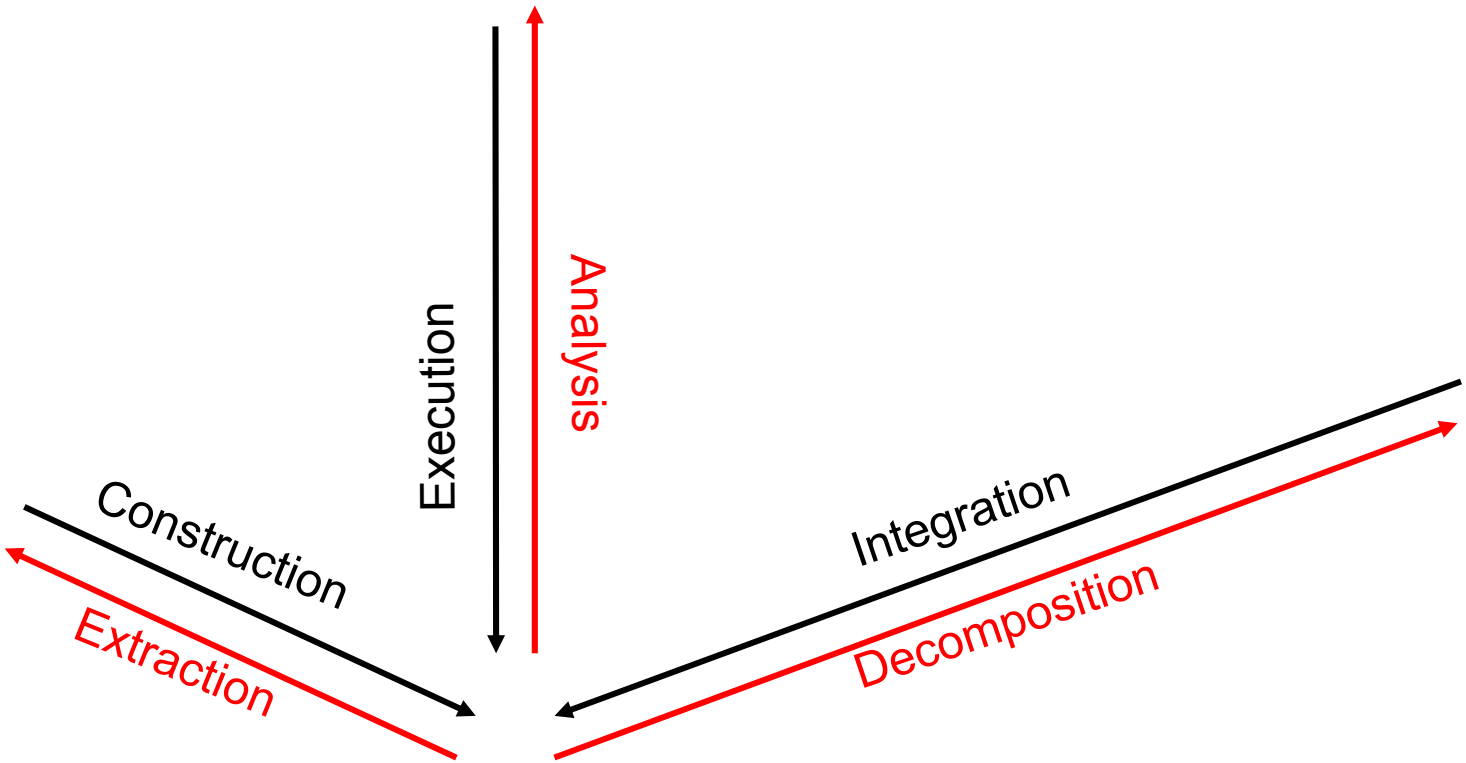
3. **Static description and dynamic behavior**

$$v = at + v_0$$



Generating Model Information

Expense of reconstructing unavailable model information



Cost of V&V Statements

		What do I know about the model?		*What do I know about the real system?*		
Cost of particular V or V statement	=	Cost of required **model information**	+	Cost of required real **system information**	+	Cost of execution of **evaluation**
		Model documentation		System Knowledge		Mature techniques
		3d information framework		Data		Tools

Risk of M&S Use

$$R_{Sim} = P_{Sim}(E) \cdot I(E)$$

$$P_{Sim}(E) = P(E \mid O_E) \cdot P(O_E)$$

$$R_{Sim} = P(E \mid O_E) \cdot P(O_E) \cdot I(E) \leq R_{Max}$$

$$P(O_E) \leq \frac{R_{Max}}{P(E \mid O_E) \cdot I(E)}$$

- **The lower the maximum acceptable residual risk R_{Sim}, the lower the acceptable $P(O_E)$**
- **With increasing $P(E/O_E)$, $P(O_E)$ must decrease**
- **If $P(O_E)$ cannot be reduced below a certain threshold, $P(E/O_E)$ or $I(E)$ must be decreased and/or R_{Max} must be increased**

Managed Investment

The Need for Deliberate VV&A Investment

- The essence of M&S V&V is establishing the degree to which decision-makers have confidence in the results of studies, analyses, tests, and training exercises conducted using the M&S; e.g. that the M&S sufficiently reflects the real world from the perspective of the intended use.
- The scope of evidence applicable to that determination includes:
  - M&S development activities, test and integration activities and the supporting M&S developmental, test and integration documentation
  - Configuration management (CM) processes for the M&S and the CM supporting documentation, including trouble reports, deviations, waivers; notices of revision
  - VV&A activities that have been completed to date for the M&S and formal documentation of the results
- Thus, much of the VV&A planning and execution process consists of generating, organizing, and reporting the evidence developed or originated in M&S development, test, and configuration management activities, as well as M&S VV&A activities documented in an auditable form for the Accreditation Authority.

What To Do First?

- But, **"What V&V should be done?"** and **"How much will it cost?"**
- These questions are implicit to the M&S VV&A planning conundrum
  - Financial resources for M&S VV&A execution almost always come from, and compete with, all other requirements levied on the financial resources of the program.
- A "Managed Investment" strategy for M&S VV&A provides for a deliberate and progressive outlay of resources to garner the information necessary to support M&S accreditation decisions.
- Thus, an actual V&V evaluation suite can be identified which is the most cost-effective within the space of possible candidate V&V activities.
  - This is essential for VV&A projects since most simulation programs operate within an economically constrained environment.
  - This sub-domain then constitutes an optimal investment in V&V activities and products.
- So, *"How Do We Proceed With Implementing A Managed Investment Strategy?"*

Avoid A Common Pitfall

- We want to distinguish between **"Managed Investment"** and the more commonly marketed **"Exhaustive M&S VV&A Strategy"**
  - We should ……
    - do every kind of verification and validation technique we can think of
    - fix every error we find, and
    - we should keep assessing the simulation until the sponsor pries it from "our cold, dead fingers", or "runs out of money".
- Some VV&A practitioners appear not to know when to say **"when",** or even care that an **"Exhaustive M&S VV&A Strategy"** is unworkable
  - They continue to advocate this strategy as a means of obtaining what they believe is their "fair share" of the M&S budget.
  - The M&S program becomes "exhausted" in the process of discovering the strategy itself is not executable as the planned V&V activities themselves have not been completed due to resource constraints
- But, most M&S VV&A practitioners know an Exhaustive VV&A strategy is irresponsible and unsustainable even if they are unable to articulate a viable alternative.

Doing What Makes Sense

- **Certainly, nearly every Program Manager, systems engineer, and software developer knows that an exhaustive software testing, M&S V&V, (and IV&V) effort is impossible, in both principle and practice, due to financial and schedule constraints.**
  - **However, that doesn't stop some M&S programs, on the advice of VV&A practitioners or outside consultants, from pursuing an "Exhaustive M&S VV&A Strategy"**
  - **The unintended consequence is ruining the program financially, and leaving the simulation sponsor with a deeply-held conviction that V&V is a "black hole" draining program resources better spent on M&S development (or avoiding M&S in the first place, and concentrating on other program requirements).**
- **Although an "Exhaustive M&S VV&A Strategy" usually fails, a "Managed Investment" strategy often can be implemented**
  - **Focused on the timely completion of selective M&S VV&A activities that, although reduced in scope or level of effort, are still sufficient to support an accreditation determination.**

What Is The Way Forward?

- **Thus, for any situation or simulation, the Managed Investment Strategy asks the same question:**
  - ***"How do I know if I'm doing, or have done, enough of the right V&V?"***
- **There is no objective or rigorous calculus for answering this question**
- **But in attempting to answer it, we can:**
  - **Identify what to consider, and**
  - **Build a heuristic framework around the question.**

The Challenge?

- **The challenge in moving to a "Managed Investment" strategy is being able to articulate (and perhaps quantify) to decision makers and budget analysts why certain M&S V&V techniques make sense for some simulations, but are unnecessary or wasteful for others.**
  - **Let us show you how to make such an argument.**

How Can I Get these "Data Requirements"?

- Difficulties exist, of course, in anticipating all user (accreditation) data requirements and information needs, associated acceptability criteria, and preferences for evidentiary support.
- Still, in those cases, it is expedient to assume those positions (inferred and derived requirements from the intended use).
  - Build a program of action while preserving an audit trail of requirements.
  - This serves as a ready basis for the tailoring of a practical, effective, and reasonably low-risk strategy for any M&S VV&A program.
- Managed Investment then attempts to select the most cost-effective subset within the space of possible V&V activities, resulting in a near optimal V&V investment of the fixed resources available.

But Which "Requirements"?

- Do we start with the:
  - "simulation requirements"
  - "software requirements"
  - "design requirements"

  which need to be verified or validated?
- The short answer is "No – Start With The Accreditation Data Requirements".
  - "Why is that?"
    - Because the goal of any V&V activity is to achieve the appropriate qualification (accreditation) of a given tool for a given purpose by a particular agency.
- Therefore it makes sense to start by:
  - Identifying the basis of such a *judgmental* decision.
  - Inferring the forms of evidence sufficient to support a positive outcome.
  - Further deriving the means to generate that data.
- Then prepare for review and deliberation such evidence as is necessary and sufficient to support the accreditation decision.

What Are These Units Under Test (UUT)?

- **UNITS-UNDER-TEST (UUT)** are those **Components of the M&S** to which V&V evaluation activities are applied and upon which judgments are made.
- For most simulations, several entities (sub-models, objects, etc.) exist which needed to be verified and validated to establish user confidence and establish credibility of the M&S:

SYSTEM SOFTWARE
- System Configuration Code
- Framework
- Model Code

SYSTEM CAPABILITY
- Experiment Preparation
- Experiment Execution
- Experiment Analysis

DOCUMENTATION

SYSTEM MODELS
- Algorithms
- System Representations

DATA
- Rule sets
- Characteristics Data
- Gameboard and Environmental Data
- Scenarios

ANALYSIS TOOLS

- The design of V&V exercise activities will depend on the nature of the UUT (for example, we could validate analytical models, verify code, review documents, validate system models, certify (validate) input data, etc.).

Why Must We Explicitly Define the Units Under Test (UUT)?

- **Because….**
  - **The variety of entities that comprise a particular M&S may be large,**
  - **These items themselves may be so disparate, a variety of evaluation procedures may be required,**

    …..it is imperative that we explicitly identify each UUT and the associated V&V activity in the VV&A Plan.
- **These V&V activities must yield data sufficient for the Accreditation Authority to determine if the M&S should be accredited for its intended use.**
- **The duration of these V&V activities and their inter-relationship are what determine the V&V program schedule and costs.**
- **The art in tailoring a V&V program to the accreditation decision is the selection of appropriate V&V activities for each UUT.**
- **Let's examine the selection of V&V techniques….**

Use What V&V Techniques?

- **V&V TECHNIQUES** are those assessment procedures applied to relevant UUTs to generate V&V data of interest and upon which acceptance criteria can be established.
- There are many potential evaluation (V&V) activities.
- Considerations pertinent to M&S V&V and assessment activity planning include:
  - First, defining evaluation activities requires us to carefully specify the evaluation procedures and criteria.
  - Second, the details of activity specification effectively define the V&V program:
    - The choice of assessment activities determines the level-of-effort (LOE) and associated resource requirements.
    - Activity flow and duration determine the program schedule
  - Finally, every V&V evaluation activity should yield a valuable data product that facilitates user understanding and acceptance (accreditation).

DMSO's V&V Taxonomy

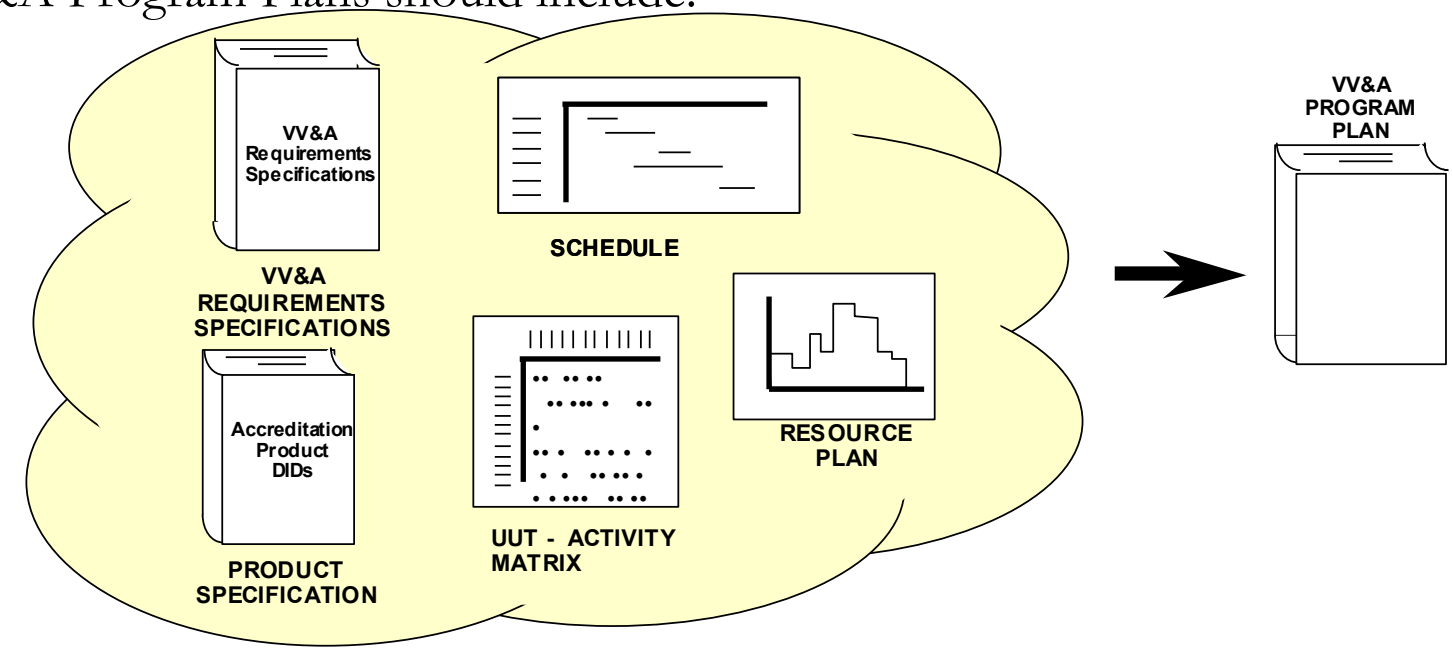
Informal	Static	Dynamic	Formal
Audit	Cause-Effect Graphing	Acceptance Testing	Induction
Desk Checking	Control Analysis	Alpha Testing	Inference
Face Validation	Calling Structure	Assertion Checking	Logical Deduction
Inspections	Concurrent Process	Beta Testing	Inductive Assertions
Reviews	Control Flow	Bottom-Up Testing	Lambda Calculus
Turing Test	State Transition	Comparison Testing	Predicate Calculus
Walkthroughs	Data Analysis	Compliance Testing	Predicate Transformation
	Data Dependency	Authorization	Proof of Correctness
	Data Flow	Performance	
	Fault/Failure Analysis	Security	
	Interface Analysis	Standards	
	Model Interface	Debugging	
	User Interface	Execution Testing	
	Semantic Analysis	Monitoring	
	Structural Analysis	Profiling	
	Symbolic Evaluation	Tracing	
	Syntax Analysis	Fault/Failure Insertion Testing	
	Traceability Assessment	Field Testing	
		Functional (Black-Box) Testing	
		Graphical Comparisons	
		Interface Testing	
		Data	
		Model	
		User	

Who Is Assigned To Execute these V&V Activities?

- **EVALUATION AGENTS** are those principals that:
  - Serve at the behest of the M&S Program Manager, Simulation Sponsor and, or other Accreditation Authorities.
  - Execute the planned V&V and assessments activities.
  - Generate reports that serve to document the V&V activity.
- A wide variety of agents are available for M&S VV&A Programs:
  - Accreditation Authority / Sponsor - Program strategy and oversight
  - V&V Proponent / M&S Proponent - SME support for characteristics data, and simulation prediction of system performance
  - M&S Developer - Systematic development support, verification, validation, testing, & documentation
  - SETA Contractors - Document reviews, SMEs, & engineering analysis
  - M&S V&V & IV&V Contractors - Independent review & analysis
  - Other Services / Agencies - Program strategy, documentation review, SME support for benchmarking, peer reviews, & service evaluations
  - Intelligence Agencies- Threat models & SME support
  - Others - Joint community SME support, specialized analyses, & senior reviews

Specifying Roles, Expectations and Products

- Each V&V agent should be selected based on their capability to serve as the appropriate executor of one of more activities.
  - Each agent's role must be clearly defined.
  - Some V&V Agents contribute to the execution of activities by bringing special capabilities and tools to their respective efforts:
    - Intelligence Organizations like DIA or MSIC for Threat Validation
    - National Labs like Sandia for Warhead, Fuse, & Nuclear Effects Validation
- VV&A Program Plans should include:



Managed Investment Summary

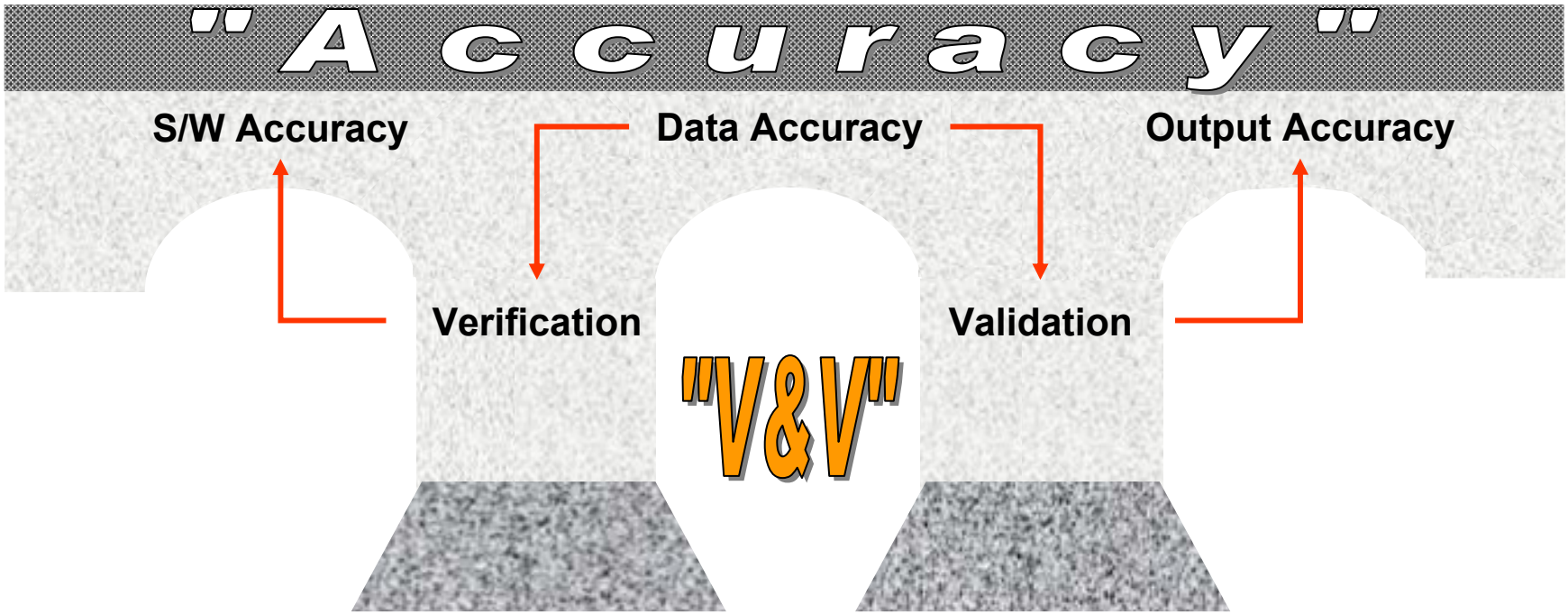
- **The M&S VV&A practitioner who refuses to face the fact that exhaustive V&V is impractical chooses to seek an impossible level of testing.**
  - **This is purely political refuge.**
  - **If the M&S Sponsor doesn't use the simulation due to missing V&V data, the exhaustive V&V practitioner can say:**
    - ***"I told them I needed more resources for V&V!"***
  - **If the M&S Sponsor uses the simulation over the inevitable objections of the V&V staff, then the V&V practitioner can blame management for every bug found in the field:**
    - ***"I told them it needed more V&V!"***
- **Within the V&V community, we're struggling with how to know when to say when.**
  - **For the last few years we have been discussing and debating it.**
  - **We are meeting and working with a growing community of V&V agents, M&S sponsors, and accreditation authorities using a Managed Investment strategy who have become "Good Enough" proponents**
- **Now is the time to propose specific models of "Good Enough" testing using a managed Investment Strategy.**

Joint Accreditation
JASA
Support Activity

JASA Approach

Joint Accreditation
JASA
Support Activity

V&V: The Twin Pillars of Simulation Credibility



S/W ACCURACY

Simulation meets design requirements, operates as designed and is free of errors in software

DATA ACCURACY

Simulation input data, validation data and data manipulations are appropriate and accurate

OUTPUT ACCURACY

Simulation outputs match the real world "well enough" to be of use in a particular problem

Joint Accreditation
JASA
Support Activity

But there are Other Components Of Simulation Credibility

CAPABILITY

Simulation possesses all required functionality and fidelity for the problem being solved

USABILITY

Simulation has adequate user support to facilitate correct operation and interpretation of its outputs

Accreditation Should Assess All of These Factors!

Joint Accreditation
JASA
Support Activity

Elements of Simulation Credibility

S/W ACCURACY

Simulation meets design requirements, operates as designed and is free of errors in software

DATA ACCURACY

Simulation input data, validation data and data manipulations are appropriate and accurate

OUTPUT ACCURACY

Simulation outputs match the real world "well enough" to be of use in a particular problem

CAPABILITY

Simulation possesses all required functionality and fidelity for the problem being solved

USABILITY

Simulation has adequate user support to facilitate correct operation and interpretation of its outputs

Accreditation Should Assess All of These Factors!

Joint Accreditation JASA Support Activity

Assessing Simulation Accuracy*

- **Documented and Appropriate Processes**
  - Development team has a common view of what to do, how to do it and how to report the results
- **Sufficient and Appropriate Resources**
  - Adequate numbers of qualified resources are available to implement and document the results
- **Appropriate Artifacts**
  - Appropriate documentation is produced during S/W development and testing that supports end-user confidence
- **Acceptable Results**
  - Documented results of S/W development, testing and configuration management activities meet end-user requirements

SOFTWARE

DATA

OUTPUTS

* Measures of merit depend on type of accuracy being evaluated

Joint Accreditation JASA Support Activity

Assessing Simulation Capability & Usability

- **SIMULATION CAPABILITY**
  - Clearly defined and documented descriptions of simulation functionality and fidelity
    - Data flow diagrams, top-level design documentation, engineering descriptions, I/O relationships, etc.
  - Clearly articulated assumptions & limitations

Ensures that end-user fully understands capabilities and limitations of simulation

- **SIMULATION USABILITY**
  - Good Configuration Management
    - Documentation, Data, Test Sets, Software
  - Current User manuals, training materials, User groups, on-call technical support

Ensures that end-user knows what he's getting, that he can run simulation properly and can interpret its outputs credibly

Joint Accreditation JASA Support Activity

VV&A Planning with the AIRGuide

1. Determine what V&V information exists or is planned.

2. Compare to Typical Sources in Guide .

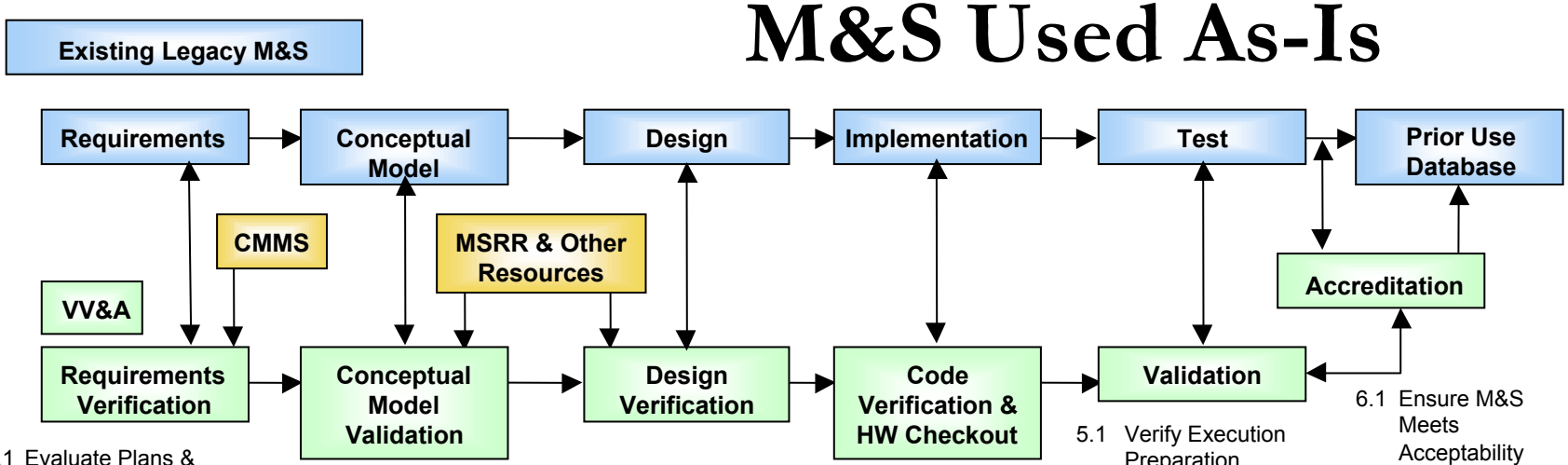
3. Enter Risk Level and ID minimum evidence required.

4. Identify additional evidence and tasks needed to satisfy credibility requirements

M&S S/W Accuracy Issue	Items Required	Typical Sources	Type, Scope and Depth of Information Required When Risk Is...		
			Low	Moderate	High
How much confide... do you have in the accuracy of the software?	S/W development and maintenance process description				
	S/W development and management resources description				
	S/W development and ...nagement artifacts a... ...cumentation				
	S/W verification results	Module, subsystem and system test reports; SPCR logs to correlate verification results with specific version of the simulation; alpha- or beta- test reports; ...ic verification reports for the M&S version ...&V reports	System level verification test results desirable.	System and subsystem level verification test documentation is required.	System, subsystem and module level verification test documentation is required. IV&V results are desirable.
	S/W Quality Assessment				

Cost Estimating Tool (CET)

VV&A Process For Legacy M&S Used As-Is



1.1 Evaluate Plans & Requirements Adequacy & Traceability
1.2 Evaluate Accumulated Problem Reports and Change History
1.3 Develop Requirements Tracing Database, if Required
1.4 Verify Requirements to Authoritative Sources
1.5 Assess New Scenario and Compare to Those Previously Used for Applicability
1.6 Assess Security Needs
1.7 Assess Risks & Uncertainties
1.8 Prepare V&V Report Inputs

2.1 Assist/Develop Conceptual Model If Absent
2.2 Assess Conceptual Model for Adequacy
2.3 Ensure All Requirements Are Addressed
2.4 Evaluate Fidelity of M&S in Respect to Intended Uses
2.5 Review/Analyze Acceptability Criteria (MOP's,MOE's,etc.)
2.6 Verify Sample Input Data
2.7 Validate Conceptual Model for Functionality, Behaviors, and Performance Needs
2.8 Prepare V&V Report Inputs

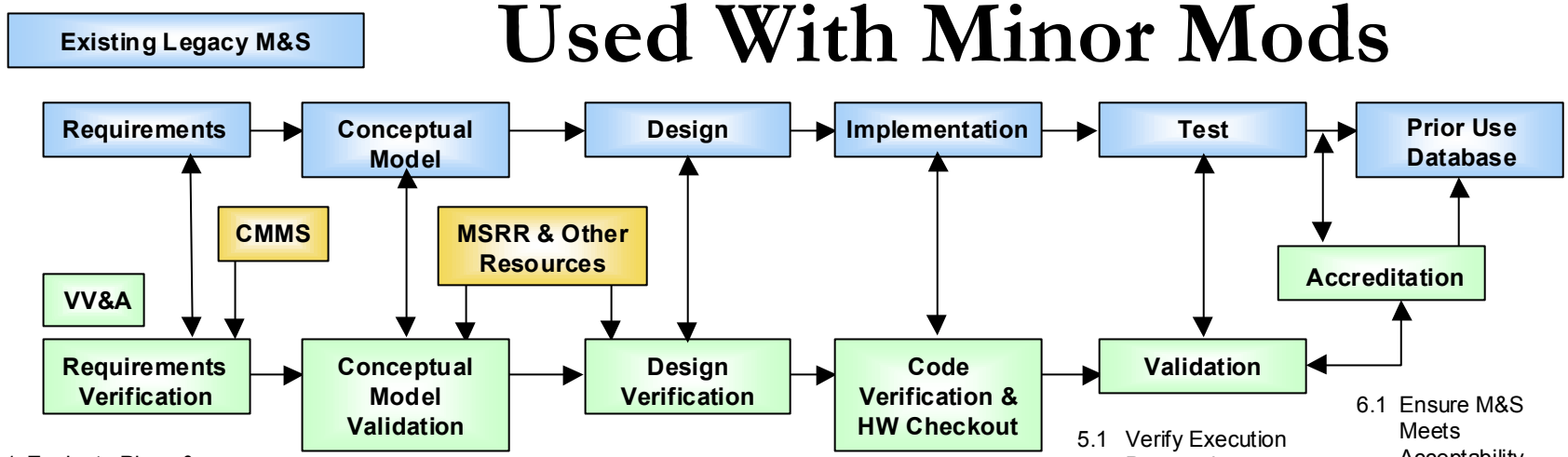
3.1 Assess Existing Architecture
3.2 Verify Data Model
3.3 Verify Key Algorithms
3.4 Verify Behaviors
3.5 Verify External Interfaces, if any
3.6 Verify Adequacy of Test Plans
3.7 Verify Requirements Tracing Into Design
3.8 Prepare V&V Report Inputs

4.1 Run Code on Static & Dynamic Analyzers
4.2 Examine SCM Records to Ensure Problems Are Corrected
4.3 Verify Baseline Test Procedures
4.4 Verify User/Operator Manuals Are Sufficient
4.5 Verify Requirements Are Covered in Code
4.6 Verify Operation of HW Platforms
4.7 Prepare V&V Report Inputs

5.1 Verify Execution Preparation Instructions
5.2 Validate Input Data
5.3 Validate Baseline Test Meets Published Acceptability Criteria (MOPs, MOEs, etc.)
5.4 Validate Behaviors of Models
5.5 Validate Synthetic Environment & Common Databases
5.6 Validate Visualization and Spatial Accuracy
5.7 Prepare V&V Report Inputs

6.1 Ensure M&S Meets Acceptability Criteria
6.2 Ensure M&S Meets User's and Sponsor's Needs
6.3 Ensure M&S Meets Quality, Fidelity, and Accuracy Required for Application
6.4 Prepare Accreditation Package for Review and Approval
6.5 Conduct Accreditation Process Including Report

VV&A Process For Legacy M&S Used With Minor Mods



1.1 Evaluate Plans & Requirements Adequacy & Traceability
1.2 Evaluate Accumulated Problem Reports and Change History
1.3 Develop Requirements Tracing Database, if Required
1.4 Verify Requirements to CMMS & Other Sources
1.5 Assess New Scenario and Compare to Those Previously Used for Applicability
1.6 Assess Security Needs
1.7 Assess Risks & Uncertainties
1.8 Prepare V&V Report Inputs

2.1 Assist/Develop Conceptual Model if Absent
2.2 Assess Conceptual Model Adequacy
2.3 Ensure All Requirements Are Addressed
2.4 Evaluate Fidelity of M&S in Respect to Intended Uses
2.5 Review/Analyze Acceptability Criteria (MOP's,MOE's,etc.)
2.6 Verify Sample Input Data
2.7 Validate Conceptual Model for Functionality, Behaviors, and Performance Needs
2.8 Prepare V&V Report Inputs

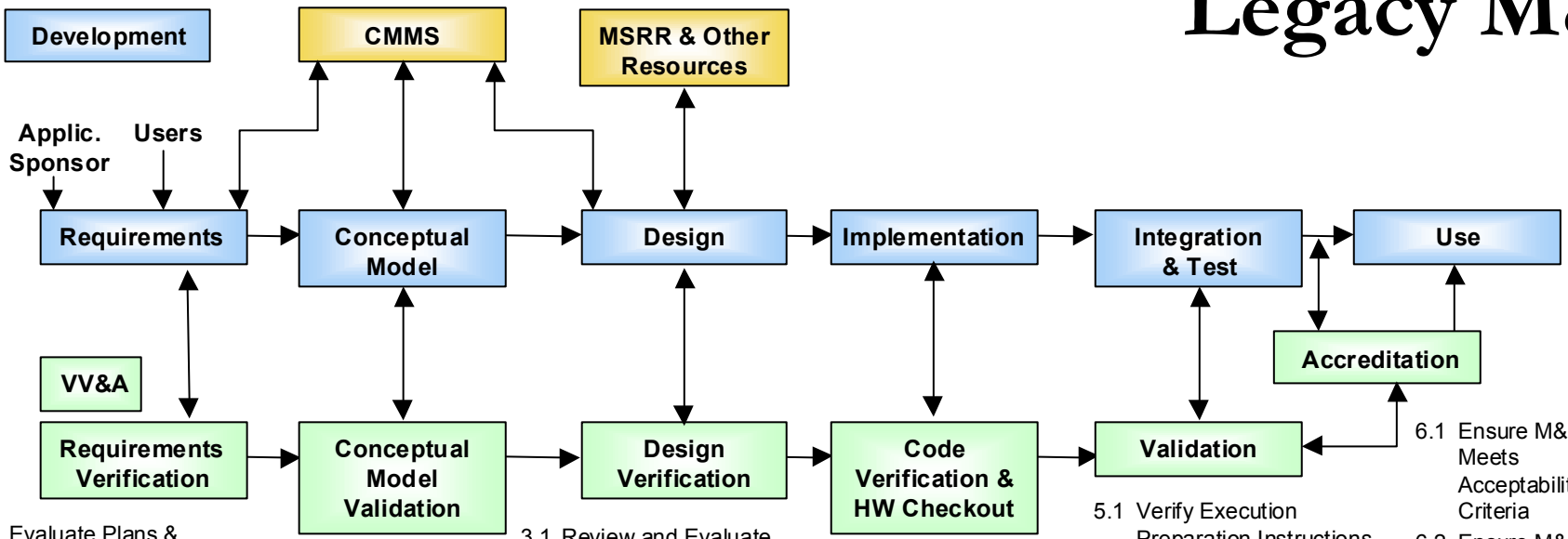
3.1 Assess Existing Architecture
3.2 Verify Data Model
3.3 Verify Key Algorithms
3.4 Verify Behaviors
3.5 Verify External Interfaces, if any
3.6 Verify Adequacy of Test Plans
3.7 Verify Requirements Tracing Into Design
3.8 Prepare V&V Report Inputs

4.1 Run Code on Static & Dynamic Analyzers
4.2 Examine SCM Records to Ensure Problems Are Corrected
4.3 Verify Baseline Test Procedures
4.4 Verify User/Operator Manuals Are Sufficient
4.5 Verify Requirements Are Covered in Code
4.6 Verify Operation of HW Platforms
4.7 Assess/Participate in Verification Testing
4.8 Prepare V&V Report Inputs

5.1 Verify Execution Preparation Instructions
5.2 Validate Input Data
5.3 Validate Baseline Test Meets Published Acceptability Criteria (MOPs, MOEs, etc.)
5.4 Validate Behaviors of Models
5.5 Validate Synthetic Environment & Common Databases
5.6 Validate Visualization and Spatial Accuracy
5.7 Assess/Participate in Validation
5.8 Prepare V&V Report Inputs

6.1 Ensure M&S Meets Acceptability Criteria
6.2 Ensure M&S Meets User's and Sponsor's Needs
6.3 Ensure M&S Meets Quality, Fidelity, and Accuracy Required for Application
6.4 Prepare Accreditation Package for Review and Approval
6.5 Conduct Accreditation Process Including Report

VV&A Process For New Or Heavily Modified Legacy M&S



1.1 Evaluate Plans & Requirements
1.2 Verify Requirements Traceability
1.3 Develop Requirements Tracing Database if Required
1.4 Evaluate Scenario Adequacy
1.5 Assess MOPs & MOEs, etc.
1.6 Assess Security Needs
1.7 Assess Risks & Uncertainties
1.8 Prepare V&V Report Inputs

2.1 Verify Requirements Tracing To Conceptual Model
2.2 Verify CMMS Data Is Correct & Consistent
2.3 Evaluate Fidelity Requirements
2.4 Evaluate Scenario & Timeline
2.5 Evaluate Data Requirements
2.6 Assess Architecture
2.7 Verify Acceptability Criteria
2.8 Validate Conceptual Model
2.9 Assist in Completing Conceptual Model ,if Found Inadequate
2.10 Prepare V&V Report Inputs

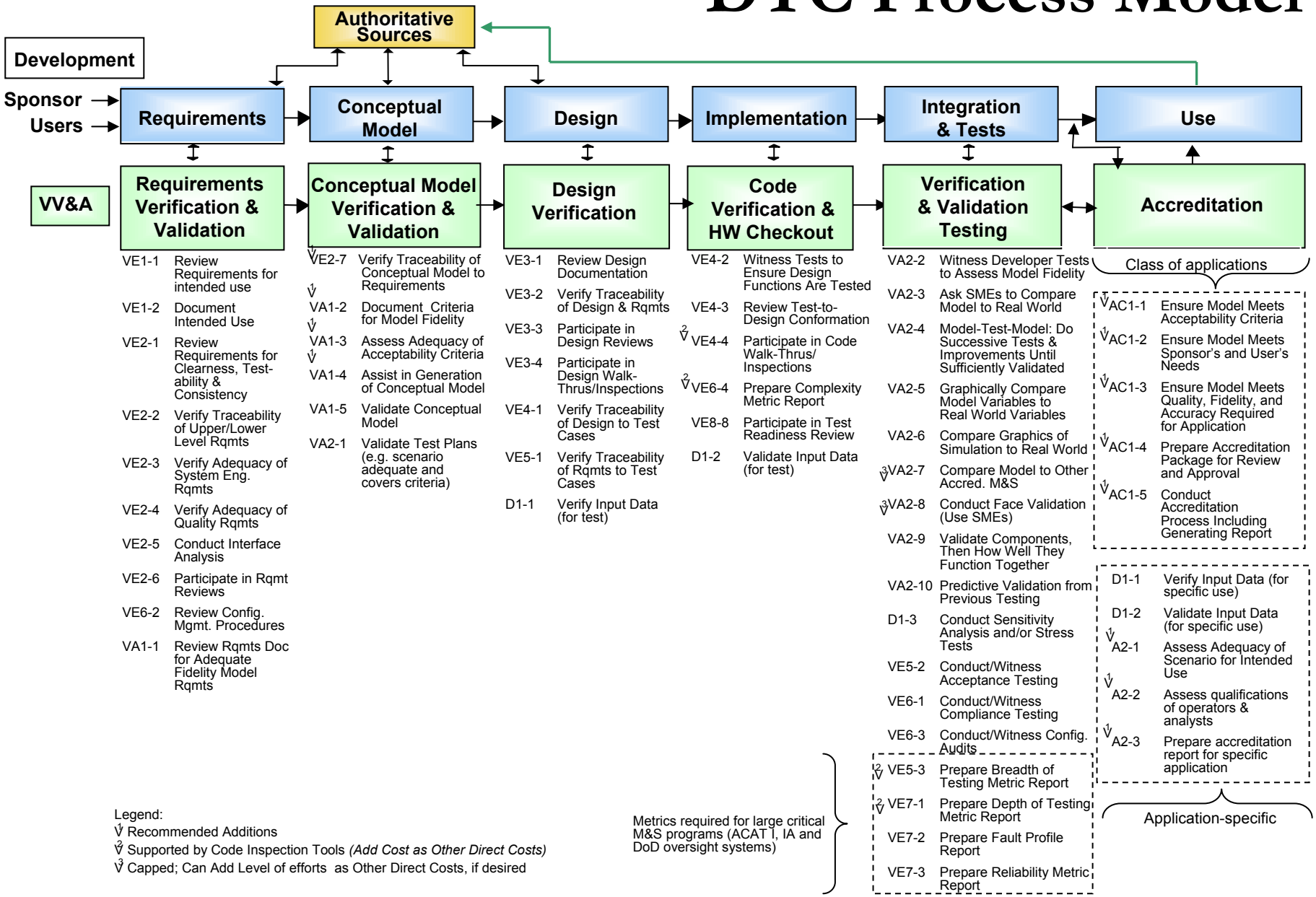
3.1 Review and Evaluate Design Documents and Representations
3.2 Assess Key Algorithms
3.3 Verify Behaviors and Control
3.4 Verify Data Model & Databases
3.5 Verify Interfaces
3.6 Assess Timing & Sizing
3.7 Assess Design Fidelity
3.8 Verify External Interfaces, if Any
3.9 Verify Requirements Tracing Into Design
3.10 Verify Adequacy of Test Plans
3.11 Prepare V&V Report Inputs

4.1 Perform Design Implementation
4.2 Verify Requirements to Code Tracing
4.3 Verify SW Mapping to HW Capabilities
4.4 Run Code on Static and Dynamic Analyzers
4.5 Verify HW Configuration & Interfaces
4.6 Verify Test Procedures
4.7 Verify User/Operator Manuals Are Adequate
4.8 Participate in Verification Testing
4.9 Assess SW Configuration Management
4.10 Prepare V&V Report Inputs

5.1 Verify Execution Preparation Instructions
5.2 Validate Input Data
5.3 Validate Testing Adequately Covers Requirements
5.4 Validate Testing Satisfies Acceptability Criteria(inc. MOP's and MOE's
5.5 Validate Behaviors & Systems and/or Other Validated Sources
5.6 Perform Stress/Excursion Testing When Possible
5.7 Assess/Participate in Validation Tests
5.8 Validate Synthetic Environment and Common Databases etc.
5.9 Validate Visualization and Spatial Accuracy
5.10 Prepare V&V Report

6.1 Ensure M&S Meets Acceptability Criteria
6.2 Ensure M&S Meets User's and Sponsor's Needs
6.3 Ensure M&S Meets Quality, Fidelity, and Accuracy Required for Application
6.4 Prepare Accreditation Package for Review and Approval
6.5 Conduct Accreditation Process Including Report

DTC Process Model



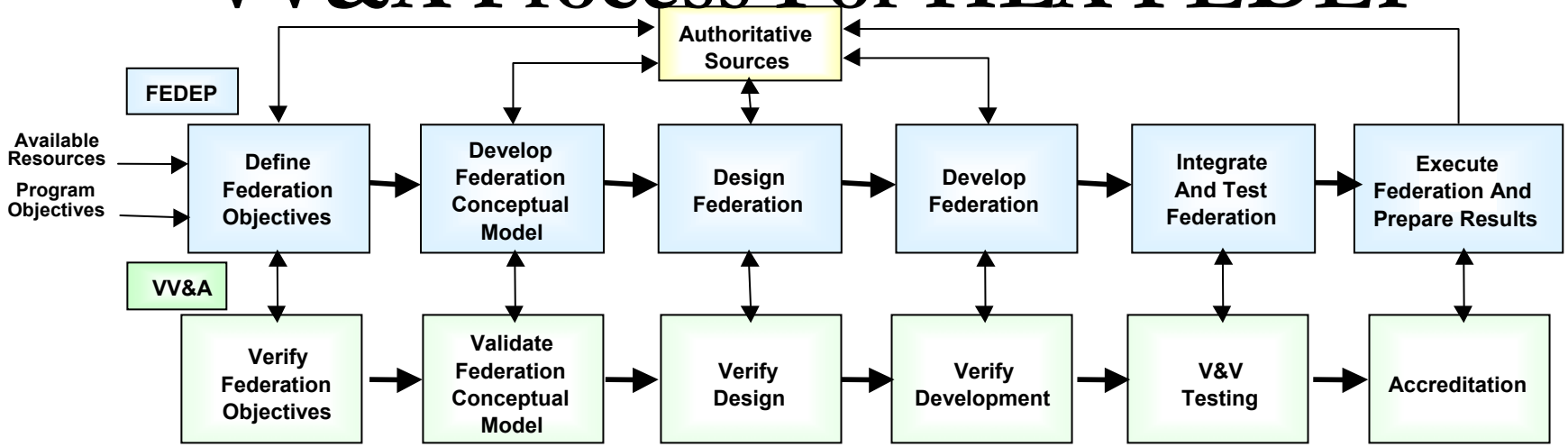
Legend:
- √ Recommended Additions
- √² Supported by Code Inspection Tools *(Add Cost as Other Direct Costs)*
- √³ Capped; Can Add Level of efforts as Other Direct Costs, if desired

Metrics required for Large Critical Programs *(ACAT I, IA and DOD oversight systems):*

VE8-1,2,4,5,6 Metrics	VE8-1,2,4,5,6 Metrics	VE8-1,2,4,5,6,7 Metrics	VE8-1,2,3,4,5,6,7 Metrics	VE8-1,2,3,4,5,6,7 Metrics

12/03/99

VV&A Process For HLA FEDEP



1.1 Assess Federation Objectives Statement
1.2 Review Input Rqmts Using Authoritative Sources
1.3 Review Configuration Management Planning
1.4 Initiate V&V Planning
1.5 Assess Technical Risks
1.6 Review Initial Tool Selection
1.7 Prepare V&V Report Inputs

2.1 Trace Objectives and User Needs Into Federation Rqmts
2.2 Verify Scenario Meets Federation Objectives
2.3 Assess Synthetic Environment
2.4 Assess Fidelity Requirements
2.5 Verify Real-World Domains Covered by Federations
2.6 Validate Federation Conceptual Model
2.7 Verify Federation Requirements
2.8 Assess Acceptability Criteria
2.9 Prepare V&V Report Inputs

3.1 Review Suitability of Candidate Federates to Meet Federation Requirements, Scenario, and Conceptual Model Criteria
3.2 Assess Allocated Responsibilities to Selected Federates
3.3 Trace Federation Rqmts Into the Design
3.4 Review Technical Issues Relating to Each Federate
3.5 Review Tool and Design Strategies
3.6 Review Federation CONOPS
3.7 Assess Adequacy of Coordinated Plans for Development, Test and Execution
3.8 Prepare V&V Report Inputs

4.1 Assess Adequacy of OMT Products that Relate to FOM
4.2 Verify Data Exchange Rqmts Among Federates
4.3 Review OMDD and OML Contents Relating to FOM
4.4 Assess Interfaces for Compatibility and Completeness
4.5 Assess OMDT Artifacts and Outputs
4.6 Trace Requirements and Conceptual Model Behaviors Into FOM
4.7 Verify Common Databases and Key Algorithm Across Federation for Consistency
4.8 Verify Input Data for Each Scenario Instance
4.9 Monitor and Verify Federate Modifications
4.10 Prepare V&V Report Inputs

5.1 Review FEPW, FOM, and FED File
5.2 Verify the Interfaces Among All Federates
5.3 Assess Performance Required by Federation and Determine if RID File Should Be Modified
5.4 Assist in Verifying Correctness and Interoperation of all HW and SW Assets per Rqmts and Federation Agreement
5.5 Verify Adequacy Federate Testing
5.6 Verify Adequacy of Integration Testing for Basic Interoperability
5.7 Perform Validation on Federation Tests
5.8 Validate Key Behaviors Between Interacting Entities
5.9 Assess Satisfaction of Acceptability Criteria During I&T
5.10 Prepare V&V Rpt

6.1 Ensure Federation Meets Acceptability Criteria
6.2 Ensure Federation Meets User's and Sponsor's Needs
6.3 Ensure Federation Meets Quality, Fidelity, and Accuracy Required for Application
6.4 Prepare Accreditation Package for Review and Approval
6.5 Support Accreditation Process

JWARS

JWARS V&V IPT Evolution

- **Originally the JWARS V&V Oversight Group**
  - **JWARS Management, JWARS Developers, J-8, J-4, OSD PA&E, DMSO, Mitre, IDA, CAA, AFSAA, N-81, and MCCDC**
- **JWARS V&V – T&E Working IPT (WIPT)**
  - **Added oversight of the T&E functions**
  - **Army Test and Evaluation Command (ATEC) added**
- **JWARS Working IPT (WIPT)**
  - **Added oversight of external support (installation, user training, help desk), configuration management, Joint Data Support (JDS)**

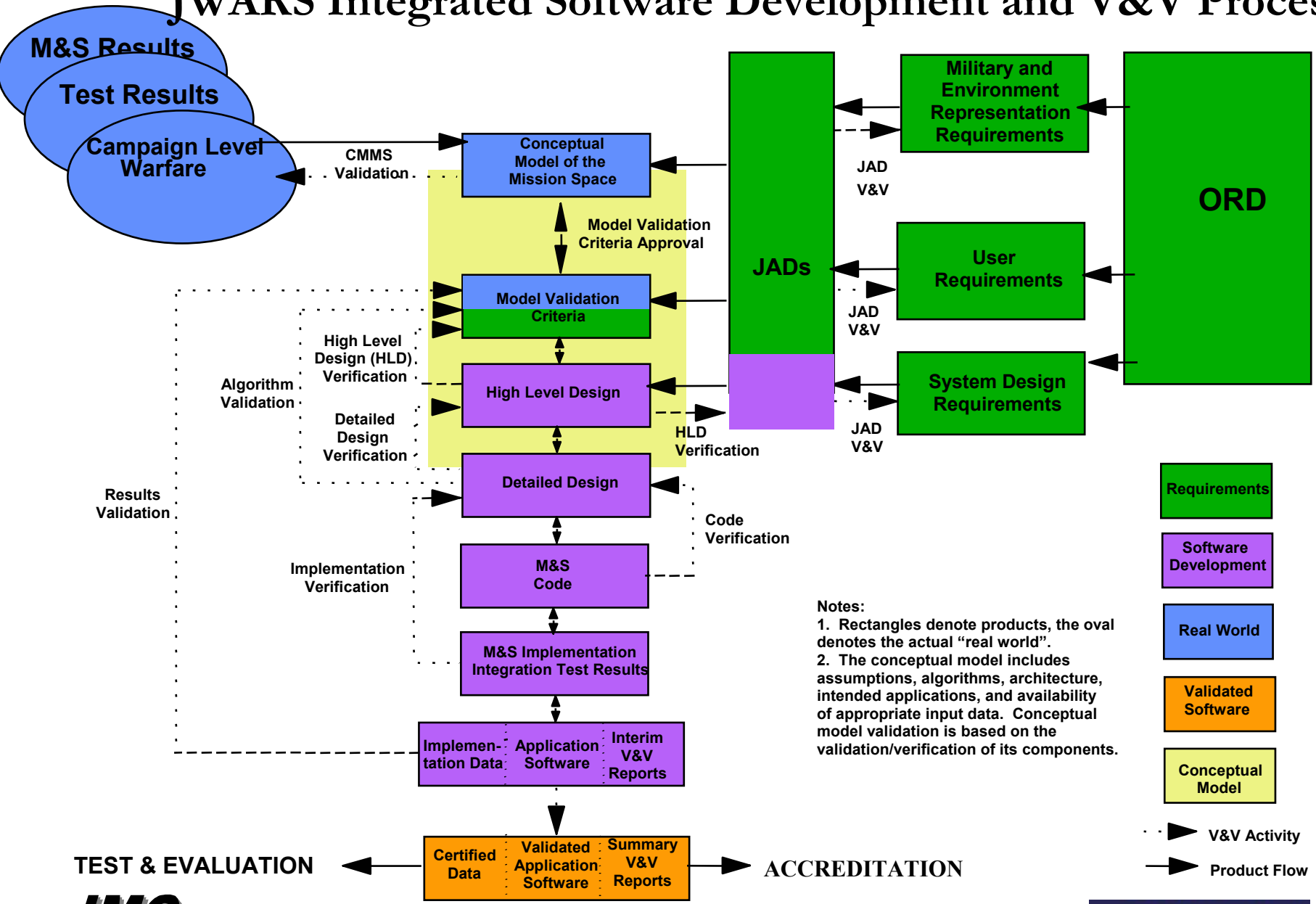
JWARS V&V Program

- **Began in September 1997 with contract award to JWARS V&V (joint venture of IMC and BMH)**
- **Form an Integrated Product Team (IPT) for JWARS V&V management**
- **Use the DoD VV&A RPG as the basis for the V&V processes and reports**
- **Tailor the program to fit the JWARS software/simulation development process**
- **Combine, whenever possible, V&V activities with developer testing (DT) and operational testing (OT)**
- **Report periodically to the JAMIP Steering Committee and Executive Committee**
- **Store all development artifacts, V&V products, and V&V reports in a database**

JWARS WIPT V&V Tasks

- Development of JWARS V&V Process
- Approval of JWARS V&V Plan
- Periodic review of JWARS V&V status
- Suggested changes in JWARS V&V process and priorities
- Reported JWARS V&V activities and status to members of the JAMIP Steering Committee

JWARS Integrated Software Development and V&V Process



Notes:
1. Rectangles denote products, the oval denotes the actual "real world".
2. The conceptual model includes assumptions, algorithms, architecture, intended applications, and availability of appropriate input data. Conceptual model validation is based on the validation/verification of its components.

IMC
Innovative Management Concepts, Inc.

BMH Associates, Inc.

JWARS V&V Processes

- Conceptual Model of the Mission Space (CMMS) validation
- Conceptual Model Validation
- Algorithm Validation
- Design Verification (both High Level and Detailed Design)
- Code Verification
- Implementation Verification
- Results Validation

JWARS V&V Program Changes

- Decided to add a new deliverable for detailed JWARS V&V processes descriptions
- Modified V&V process when major change in simulation development process was made from Joint Application Development (JAD) pre design artifacts to JWARS Work Packages
- Changed reporting process from one linked to the nine planned JWARS Iterations to the JWARS release cycle (.5, 1.0, 1.1, 1.2, 1.3, 1.4)
- Determined that Code Verification and Implementation Verification were not possible with existing funding

JWARS V&V Status Report (as of October 02)

- Have completed V&V Reports for Releases .5, 1.1, 1.2, and 1.3
- V&V Database is current for all artifacts up through Release 1.4
- Release 1.4 Results Validation is ongoing and will be completed by 31 October 02
- Release 1.4 Report will be delivered by 12 Nov 02

Bottom Line: V&V effort has reduced development risk and provided the body of evidence needed by future accreditation activities

GBR-P HWIL Testbed

A Case Study – Using A Managed Investment Strategy

- The Managed Investment Strategy and associated methodologies for M&S VV&A planning and execution have been successfully used by AEgis Technologies for several major simulation programs within the acquisition and test domains.
- This strategy has been, or is being used for a wide variety of constructive and virtual simulations including:
  - Boeing Company's Prime Consolidated Integration Laboratory (PCIL) for the Ground-based Midcourse Defense Element;
  - Ground Based Mid-Course Defense Element's Integrated System Test Capability (ISTC);
  - Missile Defense Agency's Missile Defense System Exerciser (MDSE); and
  - MDA's Ground-Based Radar - Prototype (GBR-P) HWIL Testbed.
- A VV&A effort for GBR-P HWIL Testbed has been completed.
  - This instance can serve as a use case to illustrate the application of a "Managed Investment" strategy for M&S VV&A.

Background On GBR-P HWIL

- The GBR Project Office, concurrent with fabrication of the GBR-P Radar, developed the GBR HWIL Simulation Testbed.
- With delivery of an initial operational capability in July 1996, the GBR HWIL supported developmental and operational testing, as well as material developers, combat developers, and operational commanders.
- The GBR HWIL provided the capability to define, execute, and collect HWIL and software-in-the-loop (SWIL) simulation experiments over a wide range of GBR-P system design, test and evaluation, and operational areas of interest.
- The scope of systems represented in the GBR HWIL simulation testbed included:
  - Ballistic missile threats
  - Satellite, ground & air-based sensors
  - Weapons effects environments
  - Surrogate battle management and command, control and communications (BMC3).
  - Air-breathing threats
  - Electronic countermeasures
  - Terrain phenomena
  - Atmospheric phenomena

Identification of GBR-P HWIL Accreditation Data Requirements

- Per Army guidance, while study managers are responsible for conducting study-specific accreditation, the accreditation for classes-of-application are to be managed by the simulation developer or sponsor, which in this instance was the GBR-P Project Office.
- The classes of application for which the GBR-P HWIL Simulation Testbed was expected to eventually apply include:
  - Test and Evaluation
  - Research and Development
  - Analysis
  - Education and Training
- Consequently, GBR-P HWIL accreditation data requirements and associated V&V activities were selected to:
  - Accredit the GBR HWIL initially by the GBR Project Manager as a *test resource* for SWIL tests, coupled with ground and flight test pre-mission and post mission support functions.
  - Establish the Simulation Testbed as a *functional and performance representation* of the GBR-P Radar at USAKA through execution of additional V&V activities focused on this application.

GBR-P HWIL Accreditation Process Planning

- A key consideration in specifying the M&S accreditation data information requirements was establishing the level and span of authority of the Accreditation Agent.
- In the case of the NMD GBR HWIL, a BMDO accreditation at the level of the Director, System Test and Evaluation, NMD Joint Project Office was considered appropriate, notwithstanding the additional difficulty in coordinating the decision.
  - A management and administrative mechanism for accreditation of the GBR HWIL for a specified class-of-applications was in place via the NMD T&E Resources VV&A Advisory Panel and the NMD T&E Program Integrated Product Team (PIPT) that existed at that time in the program.
- Within resource and schedule constraints, additional V&V activities were planned to support GBR HWIL accreditation by:
  - Other Accreditation Agencies interested in using the GBR HWIL to support their independent assessments of the GBR system
  - BMDO in support of an NMD contingency deployment decision in CY 2000.

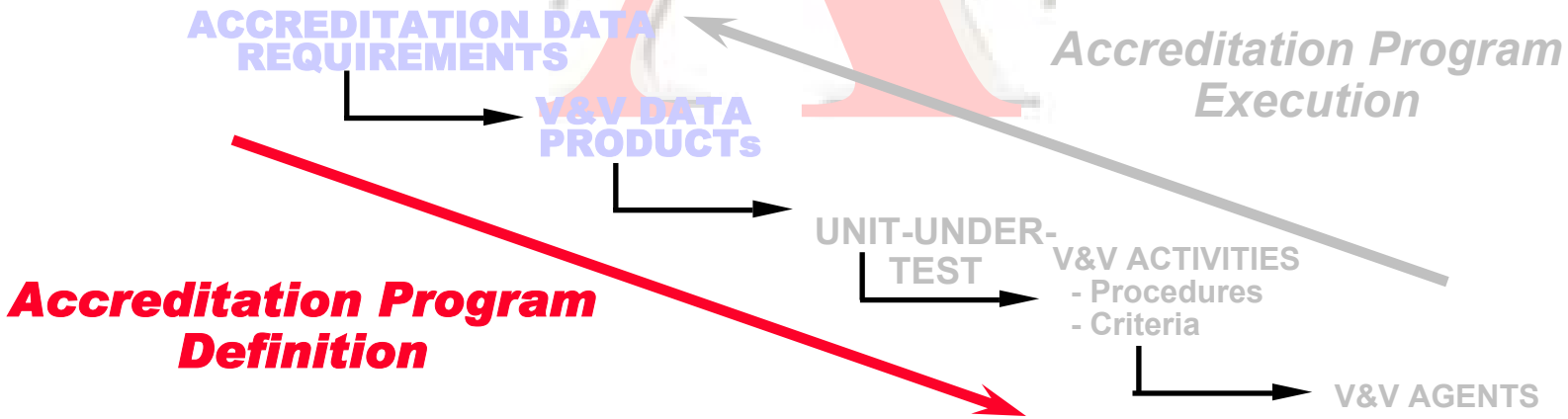
Accreditation Data Requirements and V&V Data Products

- To expedite accreditation by Operational Testers, accreditation data requirements were also derived or inferred from the guidance provided in the USA OPTEC Handbook 73-21, US Army OPTEC Handbook 73-21, *"Introduction to M&S to Support Operational Test and Evaluation"*.

1. **Review of configuration management procedures.**
2. **Logical verification review of documentation to ensure that the M/S adequately addresses tactical and technical considerations required for the OT&E application.**
3. **V&V Documentation Review to determine the completeness of code verification, logical verification, sensitivity runs, and comparisons with external sources.**
4. **Face validation which might include recognition of previous successful applications of the M/S for similar purpose or recognition of acceptance by users.**
5. **Determination whether the number of current users of the M/S indicates widespread acceptance.**
6. **Review of how input data and scenario data are used or modified internally to the M/S.**
7. **Review the credentials and performance record of the personnel responsible for developing, running, maintaining, and VV&A of the M/S.**
8. **Review comparisons of M/S results with development test results and, if necessary, plan for future developmental testing to fill critical validation voids for the Accreditation.**
9. **Review comparisons of M/S results with operational results such as combat data or OT data.**
10. **List shortfalls of the M/S with respect to the real world.**

GBR-P HWIL Accreditation Program Definition

- It was envisioned the GBR Project Office, with contractor support, would execute the GBR HWIL VV&A plan, generating records of original entry, preparing reports and abstracts supporting accreditation determinations.
  - Reports would be provided to the NMD T&E Resources VV&A Advisory Panel.
  - The NMD T&E Resources VV&A Advisory Panel would periodically review and provide comments and suggestions throughout the planning and execution of the NMD GBR HWIL VV&A program.
  - The NMD T&E Resources VV&A Advisory Panel would make recommendations regarding potential BMDO accreditation decisions and provided feedback to the NMD T&E PIPT.



GBR HWIL V&V Activities Detailed

- The V&V effort for the GBR HWIL captured the V&V activities and results across the broad spectrum of potential GBR UUTs

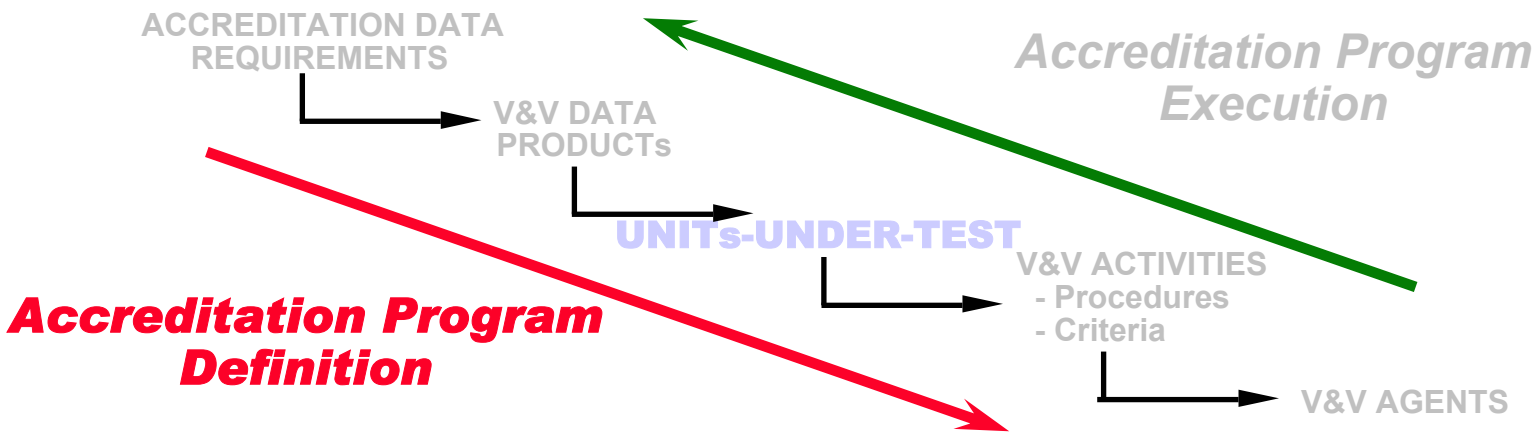
(Specific GBR V&V activities were defined in the VV&A Program Plan)

- **Name of the V&V Activity**
- **Evaluation Process(es)**
- **Evaluation Criteria**
- **Executing Agents**
- **Activity Schedule**
- **Specific Object Representation or Unit-Under-Test (UUT)**
- **VV&A Data Products**
- **Resources Required/Expended**

7.0 VERIFICATION ACTIVITIES																8.0 VALIDATION ACTIVITIES															OTHER				
7.1 LOGIC			*7.2 - 7.3 CODE*													*8.1 - 8.3 STRUCTURAL*													*8.4 OUTPUT*			*8.5 - 8.8 V&V ACTIVITIES*				
7.1.1 Formal Document Review	*7.1.2 Design Walkthrough*	*7.1.3 Trace Requirements*	**7.2 Code Verification**	*7.2.1 Evaluate Code*	*7.2.2 Dimensional Analysis*	*7.2.3 Peer Review*	*7.2.4 Portability Assessment*	*7.2.5 Algorithm Checks*	*7.2.6 Automated Code Assessments*	**7.3 Software Testing**	*7.3.1 Functional Testing*	*7.3.2 Performance Testing*	*7.3.3 Stress Testing*	*7.3.4 Sensitivity Testing*	**7.4 Evaluate Hardware Design Spt**	**8.1 Structural Validation**	*8.1.1 Evaluate Source Code/Detail*	*8.1.2 Evaluate Functionality Modeled*	*8.1.3 Evaluate Consistency of Representation*	**8.2 Output Validation**	*8.2.1 Compare with Historical Data*	*8.2.2 Compare Models and Simulations*	**8.3 Sensitivity Analysis**	*8.3.1 Evaluate Sensitivity to Model Inputs*	*8.3.2 Evaluate Model-to-Model Interactions*	*8.3.3 Evaluate Sensitivity to Scenario Changes*	**8.4 Test/Field Comparisons**	*8.4.1 Compare with OT/DT Results*	*8.4.2 Exercise Results*	**8.5 Data Qualification**	*8.5.1 Verify, Validate, and Certify Data*	**8.6 Audit Configuration Management**	**8.7 Audit System Security Process**	**8.8 Audit System Training Process**

GBR-P HWIL
UUT Definition

- To obtain a favorable accreditation decision, the GBR HWIL Testbed had a wide variety and large number of model entities which needed to be verified and validated.
- The approach to addressing these concerns included:
  - Careful and explicit identification of the GBR HWIL UUT.
  - Diligent distribution of V&V effort across the GBR HWIL UUTs.
  - Explicit qualification of results.



GBR-P HWIL UUTs Detailed

- The VV&A Planning Effort Identified Relevant GBR-P HWIL UUTs
  - Specific GBR-P UUTs were defined in the VV&A Program Plan
- Intention Was To Populate A V&V Data Base With V&V and Related Test Data for Each System and Component Level UUTs
- UUTs Were Aggregated for Ease of Reference
  - Interfaces
  - Environmental Representations
  - Special Purpose Analysis Tools
  - Overall System Capabilities
  - System Software
  - System Hardware
  - Documentation

GBR HWIL Testbed INTERFACES
- Scenario Generator to Target Complex Generator
  - Mission Control to Radar Returns Generator
- Target Complex Generator to Radar
  - Radar Commands
  - Radar Replies
  - Digital (I&Q) Data
- Radar to Scenario Generator (Data files for Data Reduction)
- Target Complex Generator to Ext. Interface Simulation
- GBR Hardware Configuration Item Simulator to Radar
  - Beam Steering Generator
  - Receiver Exciter/Test Target Generator
- External Interface Simulator to Radar
  - BM/C3 Simulation to Radar
  - ISTC to HWIL

GBR HWIL Testbed ENVIRONMENT REPRESENTATIONS
- Earth's Rotation and Gravitational Field
- Atmosphere Density and Ionization
- Rain and Clouds
- Sun/Moon Position
- Noise Models: Sky, Ground, Sun, Moon
- Intercept Debris
- Nuclear Weapons
- Resident Space Objects

DATA
- Scenario Engagement Files
  - Scattering Files
  - Motion Files
  - Environment
- Logical Reco entifiers

SPECIAL PU NA SIS TOOLS
- Data Analysis Too

SYSTEM CAPAB
- Test Preparation
- Test Execution
- Test Analysis
- User Interface
- Test Utilities

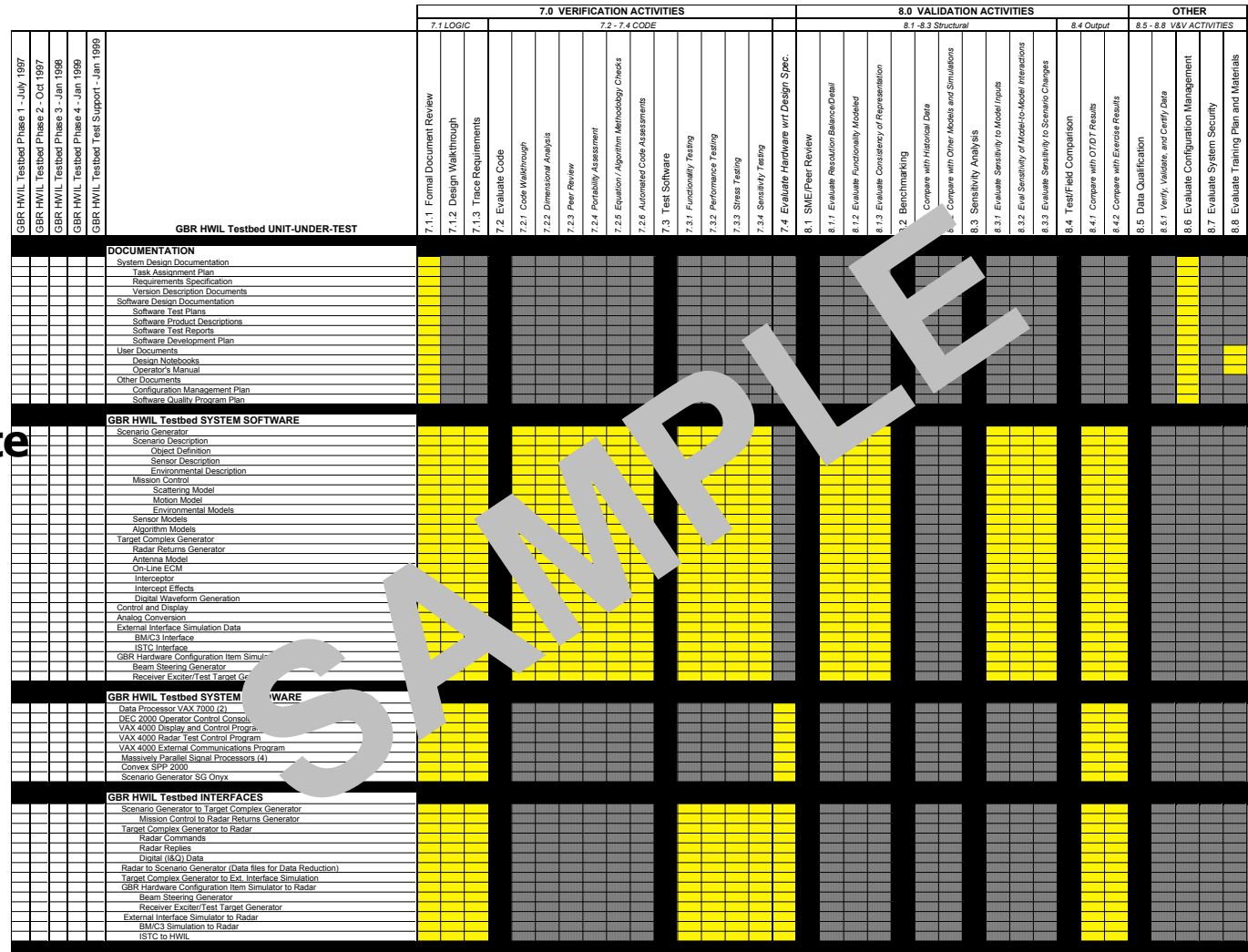
DOCUMENTATION
- System Design Documentation
  - Task Assignment Plan
  - Requirements Specification
  - Version Description Documents
- Software Design Documentation
  - Software Test Plans
  - Software Product Descriptions
  - Software Test Reports
  - Software Development Plan
- User Documents
  - Design Notebooks
  - Operator's Manual
- Other Docume
  - Configura anagement Plan
  - Software Qu rogram Plan

GBR HWIL Testbed SYSTEM SOFTWARE
- Scenario rator
- Sc Description
- Object Definition
- Sensor Description
- Environmental Description
- M n Control
  - Scattering Model
  - Motion Model
  - Environmental Models
- Sensor Models
- Algorithm Models
- Target Complex Generator
  - Radar Returns Generator
  - Antenna Model
  - On-Line ECM
  - Interceptor
  - Intercept Effects
  - Digital Waveform Generation
- Control and Display
- Analog Conversion
- External Interface Simulation Data
  - BM/C3 Interface
  - ISTC Interface
- GBR Hardware Configuration Item Simulators
  - Beam Steering Generator
  - Receiver Exciter/Test Target Generator

GBR HWIL Testbed SYSTEM HARDWARE
- Data Processor VAX 7000 (2)
- DEC 2000 Operator Control Console
- VAX 4000 Display and Control Program
- VAX 4000 Radar Test Control Program
- VAX 4000 External Communications Program
- Massively Parallel Signal Processors (4)
- Convex SPP 2000
- Scenario Generator SG Onyx

GBR-P HWIL V&V Activities – UUT Crosswalk Detailed

- **Appropriate V&V Activities Were Applied to GBR-P UUTs**
  - **A Relational Data Base Was Designed, Developed, Implemented and Populated To Capture the Enterprise**
  - **Subsequently, a Resource Estimate for Each UUT – Activity Was Developed Identifying:**
    - **Cost (LOE)**
    - **Time (Schedule)**
  - **This enabled a Managed Investment of Resources**



Expedited Identification of GBR-P HWIL Verification Risks

AEgis TECHNOLOGIES

UUTs	Verification Activities	Level of Effort (MW) FY 97 L	FY 97 M	FY 97 H	FY 98 L	FY 98 M	FY 98 H	FY 99 L	FY 99 M	FY 99 H
Doc	**Logic Verification**									
	Formal Document Reviews	7	4	4	9	5	3	7	4	2
	Other V&V Activities									
	Evaluate Configuration Management	5	3	3	8	4	2	3	2	1
System Software	**Logic Verification**									
	Formal Document Reviews	6	5	4	8	4	2	0	0	0
	Design Walkthrough	10	5	4	12	4	2	0	0	0
	Trace Requirements	6	5	4	12	4	2	0	0	0
	Code Verification									
	Evaluate Code	4	4	3	8	4	2	0	0	0
	Code Walkthrough	0	0	0	7	3	2	0	0	0
	Dimensional Analysis	3	2	0	8	4	2	0	0	0
	Peer Review	0	0	0	6	3	2	0	0	0
	Portability Assessment	4	3	3	8	4	2	0	0	0
	Equation/Algorithm Checks	4	3	2	8	4	2	0	0	0
	Automated Code Assessments									
	Software Tests	8	4	3	10	4	3	4	3	2
	Functionality Testing	8	4	3	10	4	3	4	3	2
	Performance Testing	8	4	3	10	4	3	4	3	2
	Stress Testing	8	4	3	10	4	3	4	3	2
	Sensitivity Testing									
System Hardware	**Logic Verification**									
	Formal Document Reviews	5	0	0	4	0	0	3	0	0
	Design Walkthrough	3	0	0	5	0	0	3	0	0
	Trace Requirements	3	0	0	5	0	0	2	0	0
	Evaluate Hardware with Design Spec	4	4	4	8	4	2	5	3	0

Low Risk Alternative
Medium Risk Alternative
High Risk Alternative

UUTs	Verification Activities	Level of Effort (MW) FY 97 L	FY 97 M	FY 97 H	FY 98 L	FY 98 M	FY 98 H	FY 99 L	FY 99 M	FY 99 H
Interfaces	**Logic Verification ***									
	Formal Document Reviews	4	3	2	6	4	2	5	3	0
	Design Walkthrough	0	0	0	4	3	2	3	2	0
	Trace Requirements	0	0	0	4	3	2	3	2	0
	Evaluate Hardware with Design Spec	4	4	2	6	4	2	5	3	0
	Code Verification									
	Software Tests									
	Functionality Testing	0	0	0	5	3	2	4	2	0
	Performance Testing	0	0	0	5	2	2	4	1	0
	Stress Testing	0	0	0	5	3	2	4	2	0
	Sensitivity Testing	0	0	0	5	2	2	4	1	0
Environment M&S	**Logic Verification**									
	Formal Document Reviews	6	3	4	8	4	3	0	0	0
	Design Walkthrough	6	4	3	8	5	3	0	0	0
	Trace Requirements	6	3	4	8	4	3	0	0	0
	Code Verification									
	Evaluate Code									
	Code Walkthrough	6	4	4	8	5	3	0	0	0
	Dimensional Analysis	4	3	0	6	3	3	0	0	0
	Peer Review	6	4	0	8	5	3	0	0	0
	Portability Assessment	6	4	0	8	3	3	0	0	0
	Equation/Algorithm Checks	6	4	4	8	3	3	0	0	0
	Automated Code Assessments	4	3	0	6	3	3	0	0	0
	Software Tests									
	Functionality Testing	5	4	2	7	4	3	0	0	0
	Performance Testing	5	4	2	7	4	3	0	0	0
	Stress Testing	5	0	0	7	3	3	0	0	0
	Sensitivity Testing	5	0	0	7	3	3	0	0	0
Data Analysis Tools	**Logic Verification**									
	Formal Document Reviews	5	3	2	6	4	2	4	3	2
	Design Walkthrough	5	3	2	6	4	2	4	3	2
	Trace Requirements	5	3	2	6	4	2	0	0	0

Expedited Identification of GBR-P HWIL Validation Risks

AEgis TECHNOLOGIES

UUTs	Validation Activities	Level of Effort (MW) FY 97 L	FY 97 M	FY 97 H	FY 98 L	FY 98 M	FY 98 H	FY 99 L	FY 99 M	FY 99 H
System Software	**Structural Validation**									
	SME/Peer Review									
	Resolution Balance/Detail	0	0	0	4	3	2	5	3	0
	Functionality Modeled	4	3	0	7	3	2	0	0	0
	Representation Consistency	3	2	0	6	3	2	0	0	0
	Sensitivity Analysis									
	Sensitivity to Model Inputs	0	0	0	6	3	2	5	4	3
	Sensitivity to M-to-M Interactions	0	0	0	6	3	2	5	4	3
	Sensitivity to Scenario Changes	0	0	0	6	3	2	5	4	3
	Output Validation									
	Test/Field Comparisons									
	Compare with OT/DT Results	0	0	0	12	5	3	12	4	2
	Compare with Exercise Results	0	0	0	12	5	3	12	4	2
System Hardware	**Output Validation**									
	Test/Field Comparisons									
	Come with OT/DT Results	0	0	0	0	0	0	6	4	0
	Compare with Exercise Results	0	0	0	8	5	3	6	4	2
	Other V&V Activities									
	Evaluate Configuration Management	3	3	0	5	3	2	4	2	1
Interfaces	**Output Validation**									
	Test/Field Comparisons									
	Come with OT/DT Results	0	0	0	5	4	3	4	3	2
	Compare with Exercise Results	0	0	0	5	4	3	4	3	2

UUTs	Validation Activities	Level of Effort (MW) FY 97 L	FY 97 M	FY 97 H	FY 98 L	FY 98 M	FY 98 H	FY 99 L	FY 99 M	FY 99 H
Environmental M&S	**Structural Validation**									
	SME/Peer Review									
	Resolution Balance/Detail	5	2	0	7	3	2	6	4	0
	Functionality Modeled	5	2	0	7	3	2	6	4	0
	Representation Consistency	5	2	0	7	3	2	6	4	0
	Benchmarking									
	Compare with Historical Data	4	3	0	3	4	2	4	5	0
	Compare to Other M&S	4	3	0	5	4	2	4	0	0
	Sensitivity Analysis									
	Sensitivity to Model Inputs	4	3	0	5	3	2	3	2	1
	Sensitivity to M-to-M Interactions	0	0	0	5	3	2	3	2	1
	Sensitivity to Scenario Changes	4	3	0	5	3	2	3	2	1
	Output Validation									
	Test/Field Comparisons									
	Compare with OT/DT Results	0	0	0	6	5	3	6	4	2
	Compare with Exercise Results	0	0	0	6	5	3	6	4	2
Data	**Structural Validation**									
	SME/Peer Review									
	Resolution Balance/Detail	0	0	0	7	2	3	5	1	2
	Functionality Modeled	0	0	0	7	2	3	5	1	2
	Representation Consistency	0	0	0	7	2	3	5	1	2
	Benchmarking									
	Compare with Historical Data	0	0	0	5	3	2	4	2	1
	Compare to Other M&S	0	0	0	5	3	2	4	2	1
	Sensitivity Analysis									
	Sensitivity to Model Inputs	0	0	0	3	3	2	6	4	2
	Sensitivity to M-to-M Interactions	0	0	0	3	3	2	6	4	2
	Sensitivity to Scenario Changes	0	0	0	3	3	2	6	4	2
	Output Validation									
	Test/Field Comparisons									
	Compare with OT/DT Results	0	0	0	5	3	2	6	4	2
	Compare with Exercise Results	0	0	0	5	3	2	6	4	2
	Other Validation Activities									
	Data Qualification									
	Verify, Validate, and Certify Data	5	4	3	10	5	4	10	5	3

Low Risk Alternative
Medium Risk Alternative
High Risk Alternative

Alternative GBR-P V&V Costs Summary

- V&V Program Alternatives then could be compared in terms of scope (evaluation activity), depth and breadth (investment), and associated risk.

Note: Current year $ in thousands

	FY97			FY98			FY99			
	LOW	MED	HIGH	LOW	MED	HIGH	LOW	MED	HIGH	
Documentation	24	14	14	34	18	10	20	12	6	
System Software	152	94	66	352	154	96	120	70	42	
System Hardware	36	14	12	70	24	26	58	26	6	
Interfaces	16	14	8	100	64	44	80	44	18	
Environmental Models and Data	212	124	52	440	234	176	220	126	56	
Special Purpose Tools and System Capability	58	42	12	126	82	48	44	24	16	
Low Risk	**498**			**1122**			**542**			**2162k**
Medium Risk		**302**			**576**			**302**		**1180k**
High Risk			**164**			**400**			**134**	**698k**

GBR-P V&V Activity Risk Assessment Matrix Summary

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Unit Under Test	Risk Assessment		
Evaluation Activity	*LOW*	*MEDIUM*	*HIGH*
Documentation			
Logic Verification	100%	50%	25%
Configuration Management	100%	50%	15%
Training	100%	25%	25%
Software			
Logic Verification	100%	50%	50%
Code Verification	100%	50%	50%
Structural Validation	100%	75%	50%
Output Validation	100%	75%	50%
Hardware			
Logic Verification	100%	25%	25%
HW Verification	100%	50%	25%
Output Validation	100%	50%	25%
Interfaces			
Logic Verification	100%	75%	25%
Code Verification	100%	50%	25%
Structural Validation	100%	50%	15%
Output Validation	100%	50%	50%

Unit Under Test	Risk Assessment		
Evaluation Activity	*LOW*	*MEDIUM*	*HIGH*
Environment Representation			
Logic Verification	100%	50%	50%
Code Verification	100%	50%	25%
Structural Validation	100%	50%	50%
Output Validation	100%	75%	50%
Data			
Structural Validation	100%	50%	25%
Output Validation	100%	50%	25%
Data Validation	100%	50%	25%
Data Analysis Tools			
Logic Verification	100%	75%	50%
Code Verification	100%	50%	25%
Structural Validation	100%	75%	25%
System Capabilities			
Logic Verification	100%	50%	25%
Output Validation	100%	75%	50%
Security	100%	50%	25%

100% 75% 50% 25% 15% 0%

000130

JSF

Accreditation Support Package (ASP)

- Documents the information collected to support the accreditation decision
  - Generic Model Information - not application specific
  - Standard Format
- Type of info:
  - Model Description
  - Assumptions, Limitations, and Known Errors
  - Model Management (e.g. CM)
  - VV&A History
  - Usage History

JSF SBA Implementation Team

SBA Implementation Council

Responsibilities

- SBA implementation/ overall MS&A management
- MSSP evolution
- Strategic relationships
- Action Team oversight
- Accreditation package sponsorship
- DMIP decisions
- Resource allocation
- Personnel assignments
- Communication
- Technical Interchange Meetings

Mission Systems
M&S working group

Associated work groups

V&V Action Team
Quality control/risk reduction

Deliverables include:
- VV&A process
- Documentation
- Accreditation packages

Funct User Needs Action Team
Functional reqs & processes
Anal | Trng | OT

Deliverables include:
- Identification of functional needs/deficiencies of the tool suite
- Nomination of work allocations for distributed analysis process
- Nomination of authoritative sources (organizations) for analytically derived data

M&S Tools Action Team
Software applications

Deliverables include:
- SWCE & EMCE configuration management
- DMIP Decision Support Package
- Distributed Exercises (Matt Landry group)

Modeling Information Sources Action Team
Authoritative data

Deliverables include:
- Network/access control reqmnts (to appropriate work group)
- Repository system & user interface (RAS)
- Database structure (information model, data dictionary, DIFs)
- Translation/mapping procedures
- Configuration management procedures
- Database fill/update