

WORLD LEADERSHIP IN MODELING AND SIMULATION
ALABAMA ARKANSAS CANADA COLORADO FLORIDA NETHERLANDS NEW MEXICO TEXAS WASHINGTON DC

Metrics for Modeling and Simulation (M&S) Investments



**In-Progress-Review (IPR)
for M&SCO and DoD M&S Steering Committee**

November 6, 2008

Prepared by:

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DynamX
Consulting



- **INTRODUCTION**
 - Background – Circumstance, Need and Opportunity
 - Study Principals
 - Key Terms
- **STUDY EXECUTION**
 - Analysis
 - Synthesis
 - Evaluation
- **CONCLUSION**
 - Findings
 - Recommendations
 - Bottom Line

Circumstance, Need, and Opportunity

- **M&S is important to the United States [HR-487]**
- **M&S is important to the DoD ... and expensive!
[June 2008 Report on DoD M&S Efforts]**
- **DoD is committed to Enterprise Management of
M&S [M&S Strategic Vision]**
- **Investment is needed in every area of the vision
[inspection]**
- **Therefore M&S investment best-practice
specification and deployment is desired [QED]**

- **Tasking:** “Develop a recommended, uniform set of measures to assess the effectiveness and benefits of (M&S investment) actions and an appropriate methodology by which to utilize the metrics.”
- **Challenges:**
 - Govt. business practice ≠ Commercial business practice (profit, investment, budget)
 - M&S diversity – variety of assets in which to invest
 - Benefit-result metrication
 - Scope of metric evaluation (asset, organization, stakeholder, calendar, etc)
- **Requirements:**
 - Leverage commercial business and accounting practice
 - Common core process with tailoring guidance (for asset, decision type, stakeholder role, enterprise scope)



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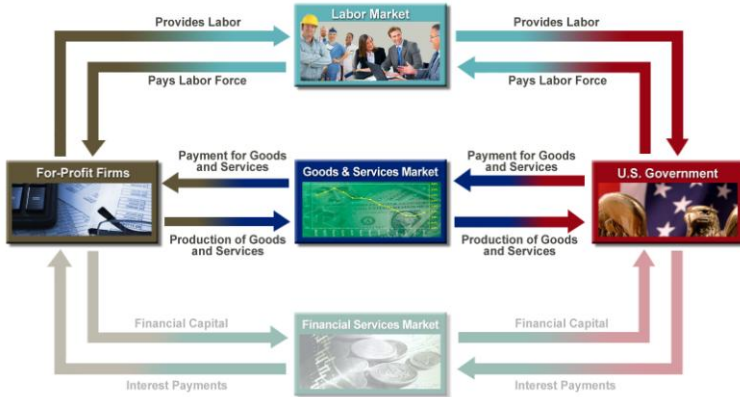
Ivar Oswalt

- **Community-of-Practice**
- **Enterprise**
- **Business Practice**
- **Stakeholder**
- **Use Case**
- **(Substitution) Cost ... Benefit / Result**
- **Investment ...Return-on-investment**
- **Multi-Variable Decision Process**
- **Business Case**

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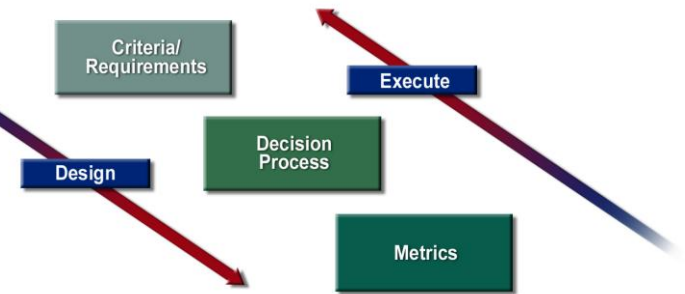
Analysis

1. Market Context & Business Practice



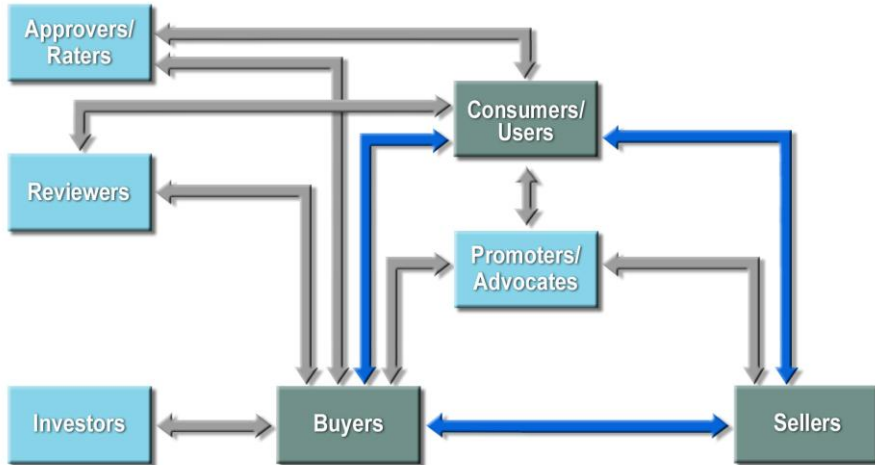
Study strategy entails discriminating DoD technology investment from commercial practice and leveraging commercial terminology and best practice suitably modified for the peculiarities of government executive business practice.

2. Needs and Requirements Analyses



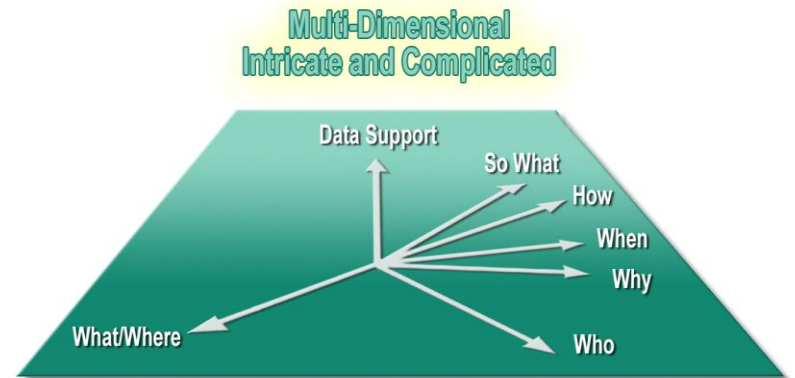
Requirements analysis entails educing the sufficient conditions of M&S investment metrics and process to support the M&S DoD Vision.

3. Stakeholder & Community of Practice



Recognizing how investment preferences vary and understanding transaction dynamics across the DoD M&S communities and action-agent role players is essential.

4. Use Case



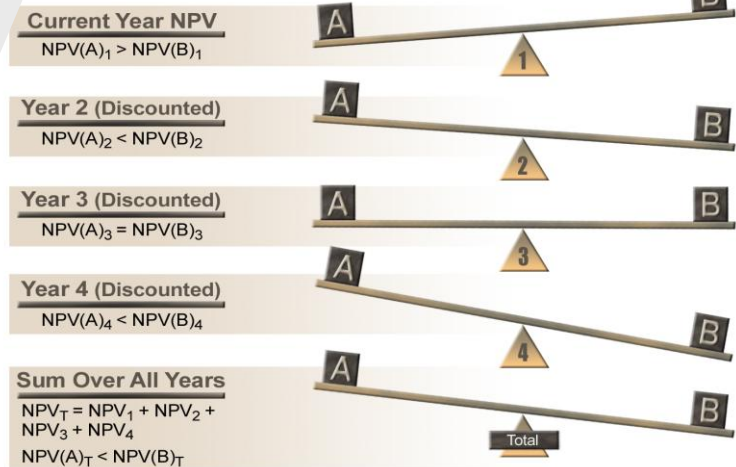
Establishing use case specification and analysis serves as a basis for explication and evaluation of recommended process.

5. Asset Identification

Hardware	Software	Networks	Facilities	People	Products & Procedures
Computers	Models	Lines	Buildings	Expertise	Plan
Electronic HW	Simulation	Architecture	Labs	Experience	Policies
Hardware in the Loop	Tools (CAD/CAM)	Transaction Protocols	Ranges	Skills / Education	Analysis Results
Mock-ups	Data / Databases		Physical Models	Operational Knowledge	Conceptual Models
Spares	Repositories				Management Processes
					Standards

Addressing the set of processes and product artifacts that are candidates for DoD M&S investment and identifying their cost and benefit dependencies is difficult based on classification of asset as M&S

6. Asset Investment Cost Analysis



Identifying asset cost factors and their circumstantial dependencies is challenging insofar as M&S costs are typically under-accounted

7. Asset Benefit Analysis

Depending on match between M&S capability and application requirements

There is no other way ...

There are other ways but M&S is better ...

M&S can augment current means and methods ...

Current M&S may provide negative impact ...



Its value is relative to a defined alternative within a well specified role

Identifying asset result factors and their circumstantial dependencies is challenging – particularly addressing ‘intangible’ results.

8. ROI Algorithm Options

The M&S ROI ‘results’ metrics applicable are different for each of the three relevant DoD perspectives:

- The Enterprise View metric categories focus on implementation, business, community, infrastructure and system of systems.
- The M&S Community View metric categories reflect application-wide indicators of success or failure.
- The Program View metric categories include individual M&S systems or specific M&S support.

Metrics are manifest in all phases of cost, benefit, ROI, and decision analysis; but benefits metrication pose significant challenges

* The crash was “directly traceable to deficiencies” in M&S performed as part of the data analysis of the first flight... DarkStar was a \$10M per aircraft (FY94 \$), Recon UAV - Jane's Defense Weekly, 17 July 1996

9. Investment Decision Technique

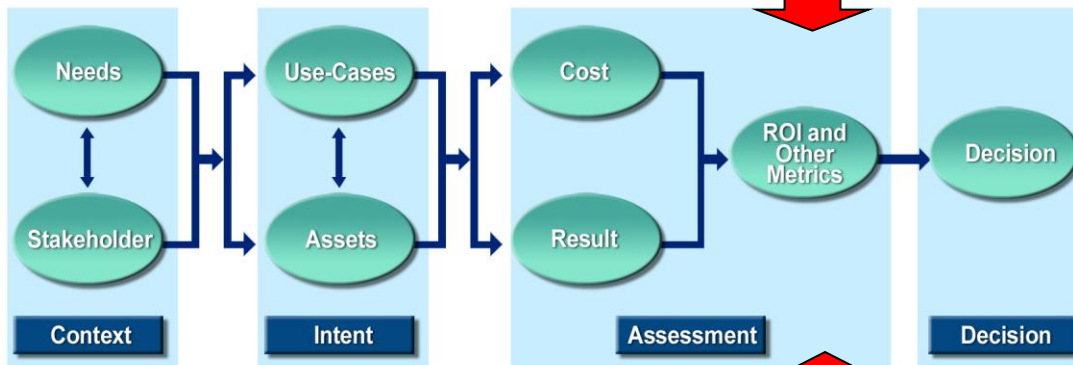
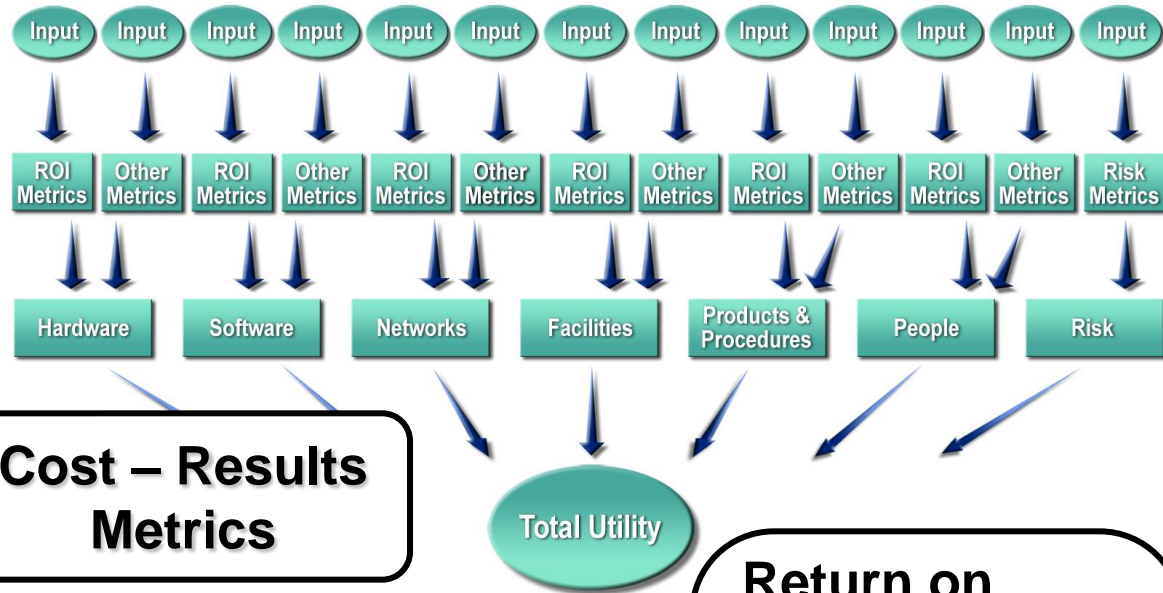
	Multiple Inputs	Repeatable Results	Transparency ⁱⁱⁱ	Tailorable	Simple Concept	Considers all alternatives	Multiple Types Data
Payoff Tables		X	X		X	X	
Decision Trees		X		X	X	X	
Markov Chains	X			X		X	
MADM	X	X	X	X	X	X	X
AHP	X	X	X	X	X	X	X
Game Theory	X					X	
Linear Programming	X	X		X	X	X	X
Dynamic Programming	X	X		X		X	X
Non-Linear Programming	X	X		X	X	X	X
Metaheuristic Algorithms	X	X		X		X	X
Neural Networks	X	X		X		X	X
Expert Systems		X	X		X	X	
Delphi Method	X			X	X	X	

Evaluating suitable alternative decision process candidates and selection of core process is essential to establish a basis of common practice.

ⁱⁱⁱ Transparency is the property that it is easy to determine how each input impacted the final result from the method.

Synthesis

Macro-process, metrics, and MADM decision technique comprise recommended practice



Return on investment (ROI)
= [(benefit) / (base)] * 100

Net Present Value (NPV): $\sum [CF_t / (1+r)^t] - \text{Outlay ...}$

Process Evaluation via Use Case Exercises

- **Use Case #1 (Alaska) Testing the Combat Benefit of a Position Determination System**
[Relevant to: Test, Program-Level, Pick one (LVC decision...)]
- **Use Case #2 Live Virtual Constructive Simulation Infrastructure Investment**
[Relevant to: Training, Enterprise- Level, Standards implications, Pick-one (business model) decision...]
- **Use Case #3 - MDA Conceptual Modeling Investment**
[Relevant to: Acquisition, Program / Enterprise-levels, Standards implications, Go-nogo decision...]

Use Case # 2

- **Joint Forces Command (JFCOM) is responsible for war-fighter training. Constructive simulation alone is not providing sufficient training effect. The existence and use of a standard, seamless live-virtual-constructive (LVC) practice could significantly improve training quality. Attention has been focused on ways to improve interoperability within and across architectures.**
- **Based on the prevailing circumstances, which is the preferred investment:**
 - a) **DoD-wide licensing of commercial products, all other things being equal,**
 - b) **Develop a fully supported certified GOTS middleware solution,**
 - c) **Do nothing (maintain the status quo),**
 - d) **In addition to (c), move existing government middleware code to open source, or**
 - e) **Develop and enforce middleware standards for LVC across DoD.**

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- F1: Re-use of commercial practices based on private and public sector business practices.**
- F4: Specification of stakeholder types ... and influence on process.**
- F6: Use-case analysis for 'hardening' draft processes..., and cultivating receptiveness of process users.**
- F9: Investment-type identification is essential to cost and results identification and estimation.**
- F11: Cost analysis must be systematic and clearly documented to facilitate follow-up reviews and analyses.**
- F13: Audit traceability of results categories to mission and vision topics is essential**
- F16: ROI metrics generated from cost and results factors ... [must be] significant to M&S mission and vision.**
- F18: Multi Attribute Criteria Decision Process Making (MADPMCDM) meets all criteria and is preferred as a baseline decision approach.**

- **Phase 1 - Socialize report findings:**
 - Brief Report results to steering committee
 - Compile comments and consequent requirements
 - Amend recommended process accordingly
- **Phase 2 - Refine and show practical viability of recommended process:**
 - Re-evaluate and harden process
 - Simulate recommended process
 - Conduct proof-of-principle demos. of process with “vision”-relevant use cases and actual stakeholders
- **Phase 3 - Deploy the recommended process:**
 - Draft deployment and operational use plan
 - Modify process and develop tools for deployment
 - Launch deployment with bell-weather coaching

Prospective Activity

6 months \$239k

~ 1 yr. ~\$750k

TBD



▲ PDR

▲ CDR



- **Study was conducted to:**
 - **Be responsive to Congressional expectations and Departmental initiatives;**
 - **Leverage commercial investment practice consistent with the particular requirements of DoD stakeholder communities and business practice imperatives; and**
 - **Provide guidance for business process re-engineering for DoD M&S investment that will support the DoD M&S vision.**
- **IOC for M&S investment mgmt. now available to:**
 - **systematically monitor and inform future DoD M&S investment... move toward widespread best-practice**
 - **leverage future investments to best economic and practical advantage both within stakeholder domain of operation and across the DoD mission enterprise; and**
 - **systematically and persistently capture the value of M&S as a national critical technology for the DoD.**

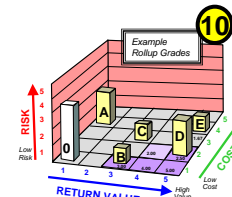
BACKUP

Key Features of AHP-Based Decision Model for M&S Program ROI Assessment

The key features for using AHP for comparison of ROI of multiple alternative candidates are as follows:

- 1 Define the evaluation purpose, goals, and objectives
- 2 Define the alternative candidates
- 3 Define the Decision Criteria (Risk, Value, and Cost)
- 4 Define a hierarchical set of measurable evaluation factors for each Decision Criterion
- 5 Derive normative weighting for each level of the hierarchical criteria set
- 6 Assess the value or ranking of each alternative candidate for each bottom-level criterion
- 7 Calculate the weighted grades (rank x weight) for each alternative candidate for each criterion
- 8 Sum the weighted grades for each top-level criterion for each alternative candidate
- 9 Use the summed Value and Costs for each candidate to determine its ROI
- 10 Plot the results on a 3D chart to aid visual understanding of the outcomes

1 The purpose of the evaluation is to identify the alternative candidate that has the best combination of Risk Preference [lowest risk], Value Preference [highest value], and Cost Preference [lowest cost].



Summary Results for Decision-Making

