Technology Performance Risk Measure

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Multi-Dimensional Assessment of Technology Maturity Workshop

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Outline

- General Problem Statement
- Why is This a Problem for DoD?
- Specific Problem Statement
- Hypothetical Example
- Technology Performance Risk Measure: Methodology
- Case Study Examples
- Next Steps

General Problem Statement

- DoD Weapon System Failures are Attributed to Premature Transfer of Technology
- Current DoD Methods to Determine Technology Readiness are Inadequate
  - Insufficient Measures to Assess Technology Readiness
  - Lack of Quantifiable and Comparable Risk Assessments
- Maturity, by Itself, is Inadequate to Determine Transition Readiness
- Unmet Performance is Insufficient Measure of Risk

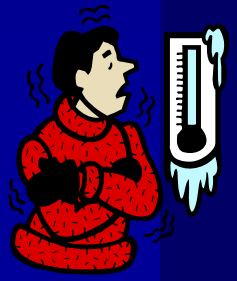
Why is this a Problem for DoD?

- Environment: Technology Development Separated from Weapon System Development
  - Different Priorities
  - Different Perspectives
- Inconsistent Application of TRLs
- Unique Technology Assessments
- Qualitative
- Immature Transition of Technology Leads to Significant Cost and Schedule Impacts Upon DoD Weapon Systems

What We Know & Need to Know

- At TRL 3, Technologists Know:
  - Who.....Customers
  - What.....Requirements
  - When.....Schedule
  - How.....Program Plan
- In Addition, Technologists **NEED** to Know:
  - How Well.....**PERFORMANCE & RISK**

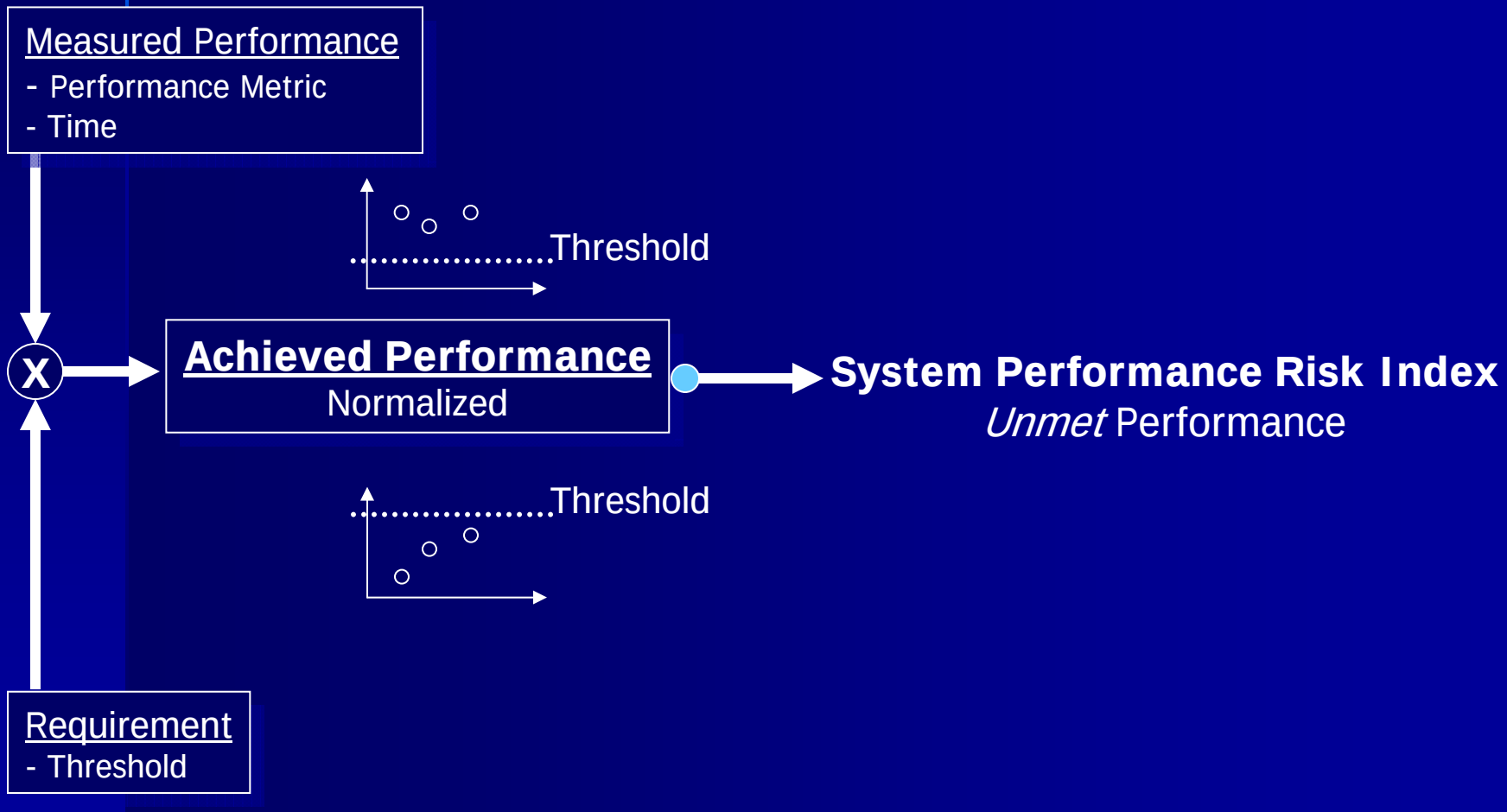
- While a Thermostat Measures Actual Temperature, the Wind Chill Factor is More of Concern



- The Proposed Methodology for Calculating Technology Performance Risk Measure Provides More Realistic Measure of the Actual Performance Risk, Just as the Wind Chill Factor Does for Temperature.

System Performance Risk Index

Garvey & Cho, Spring 2003



Garvey, Paul R. and Cho, Chien-Ching, "An Index to Measure a System's Performance Risk", Acquisition Review Quarterly, Spring 2003.

Specific Problem Statement

- Maturity, as a One-Dimensional Metric, is NOT Adequate to Determine Technology Transition Readiness
- Unmet Performance is NOT Adequate Risk Measure
- The Amount of Risk Associated with Each Requirement, or a Composite Risk at the System Level, Must Be Incorporated to Provide Realistic and **Quantitative** Risk Measure.

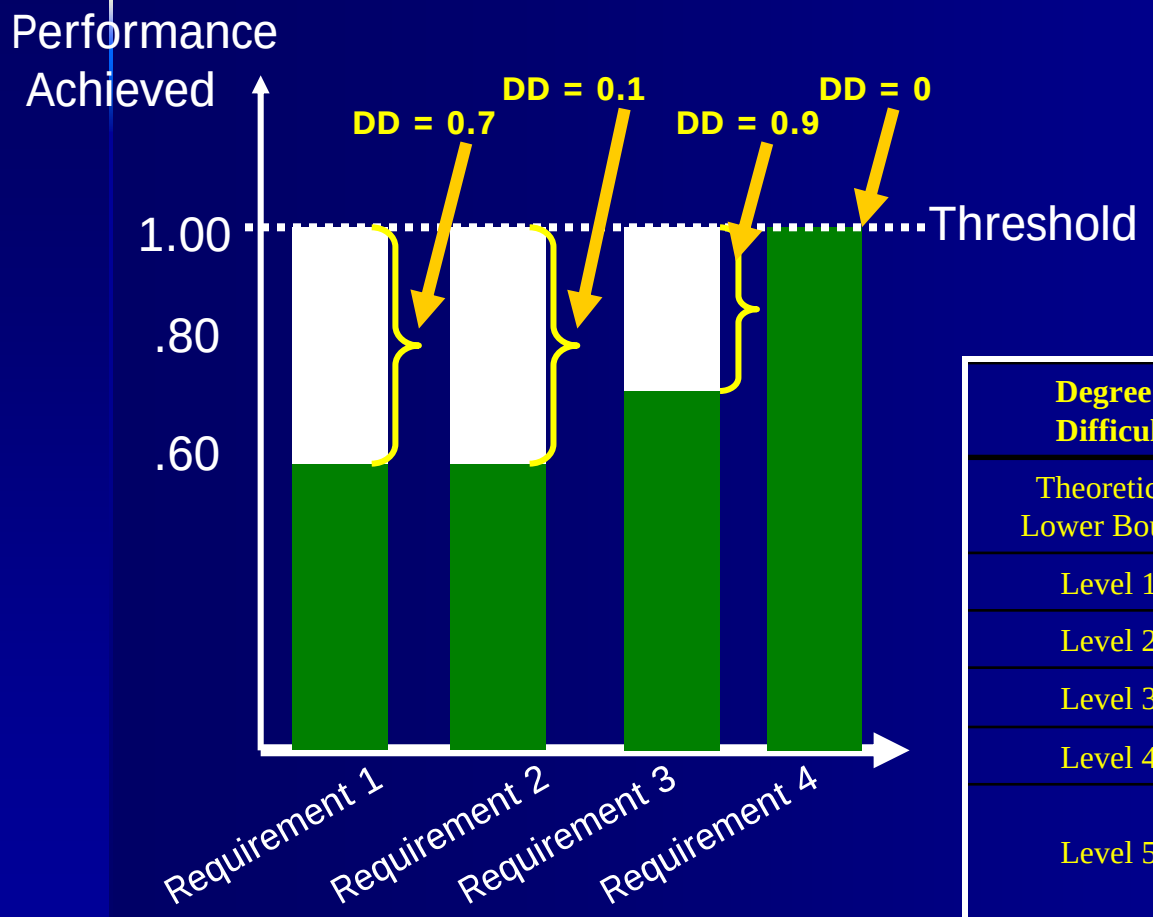
Degree of Difficulty

Mankins, 1998 & 2002

	DESCRIPTION	
I	**Very low degree of difficulty anticipated in achieving research and development objectives for this technology;** only a single, short-duration technological approach needed to be assured of a high probability of success in achieving technical objectives in later systems applications	0.1
II	**Moderate degree of difficulty anticipated in achieving R&D objectives for this technology;** a single technological approach needed; conducted early to allow an alternate approach to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications	0.3
III	**High degree of difficulty anticipated in achieving R&D objectives for this technology;** may need two technological approaches; conducted early to allow an alternate subsystem approach to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications	0.5
IV	**Very high degree of difficulty anticipated in achieving R&D objectives for this technology;** risk so high that multiple technological approaches needed; conducted early to allow an alternate system concept to be pursued to be assured of a high probability of success in achieving technical objectives in later systems applications	0.7
V	**The degree of difficulty anticipated in achieving R&D objectives for this technology is so high that a fundamental breakthrough in physics/ chemistry/etc. is needed;** basic research in key areas needed before feasible system concepts can be refined	0.9

Technology Performance Risk Measure

Hypothetical Example



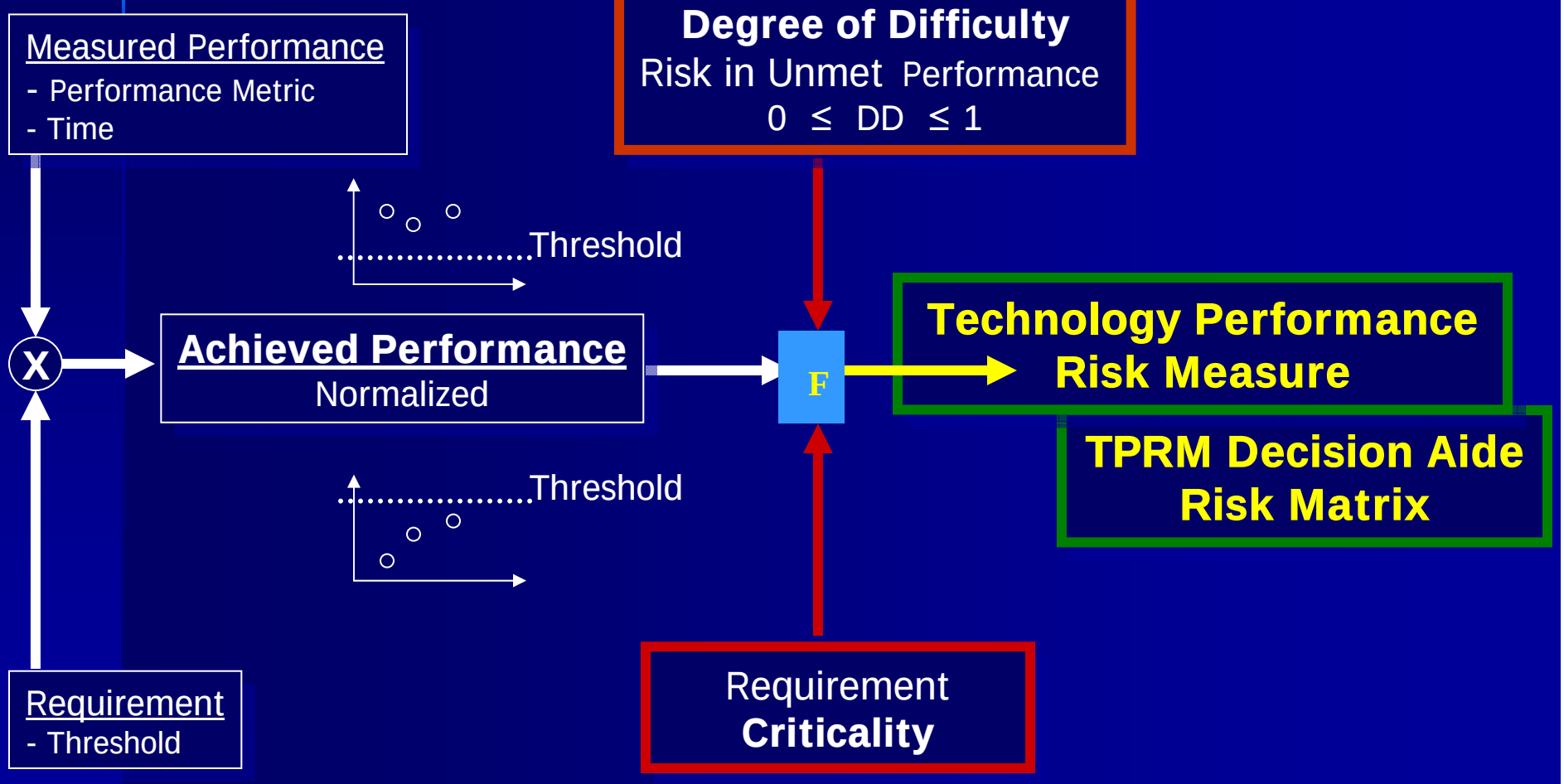
Degree of Difficulty	Risk Level	DD Value
Theoretical Lower Bound	No Risk; Guaranteed Success	**0.0**
Level 1	Very Low Risk	**0.1**
Level 2	Low Risk	**0.3**
Level 3	Medium Risk	**0.5**
Level 4	High Risk	**0.7**
Level 5	Very High Risk, Requiring Fundamental Breakthrough	**0.9**
Theoretical Upper Bound	Guaranteed Failure	**1.0**

Key Assumptions

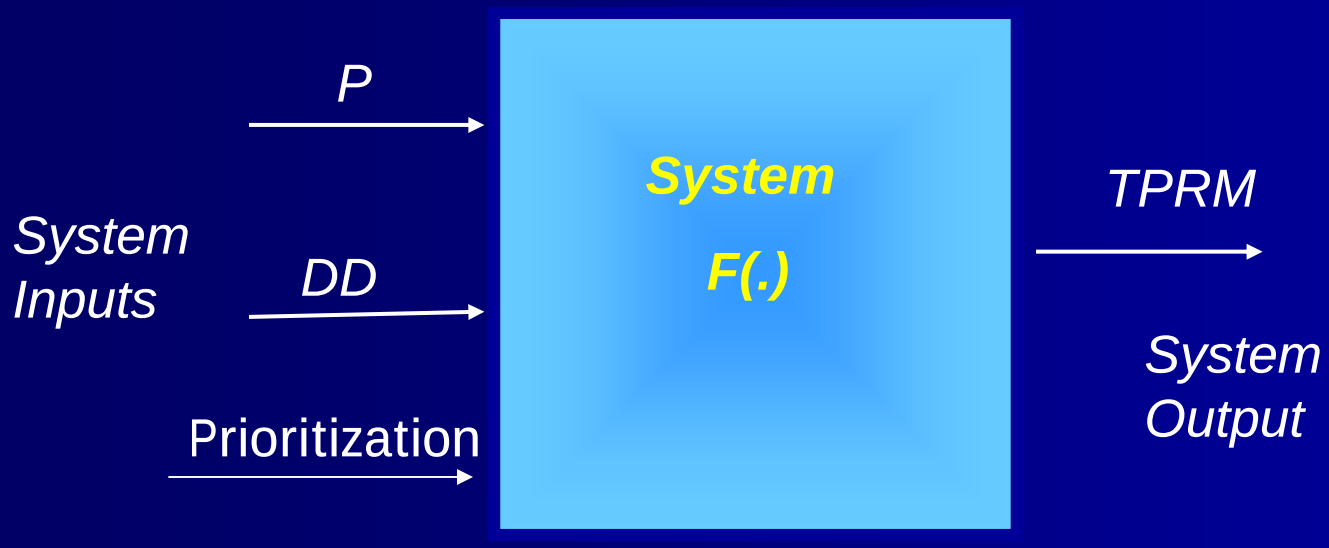
- Acquisitionist and Technologist Reach Agreement Regarding Technical Performance Measures
- Technical Performance Measures Provide Sufficient Quality-Level Requirements to Measure Progress
- The Degree of Difficulty Numerical Assignments Provide Sufficient Measure and Distinction of Performance Risk As the TPM Threshold is Achieved, the Technology has Moved into the Acceptable Performance Region
- As the TPM Threshold is Achieved, the Technology has Moved into the Acceptable Performance Region

Technology Performance Risk Measure

Methodology



System Block Diagram

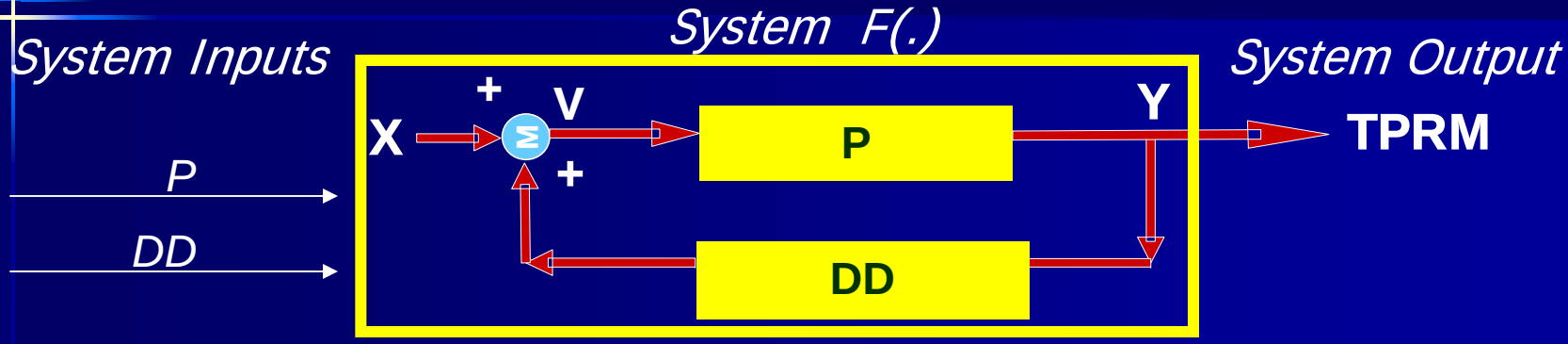


$$TPRM = \lim_{DD \to 0} \{F(P; DD)\} = (1 - P)$$

$$TPRM = \lim_{P \to 1} \{F(P; DD)\} = 0$$

Technology Performance Risk Measure

Mathematical Model



Y = V * P

V = X + Y*DD

X = (1-P)/P

By substituting for V,

Y = **(X** + **Y*DD)** * P

Y = [(1-P)/P]*P + Y *DD*P

Y(1-DD*P) = [(1-P)/P]*P

Y = (1-P)/(1-P*DD) = TPRM

Technology Performance Risk Measure

Methodology

Measured Performance
- Performance Metric
- Time

Threshold

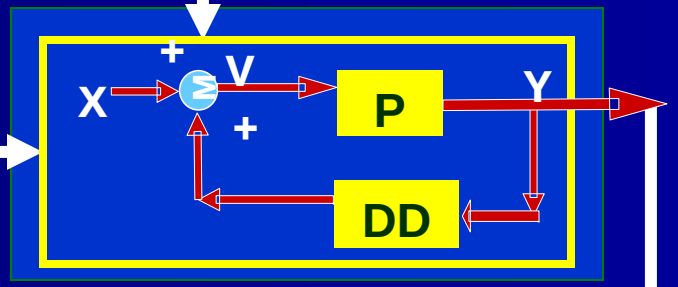
Achieved Performance
- TPMs Reduce to Meet Threshold
- TPMs Increase to Meet Threshold

Threshold

X

Requirement
- Threshold

Degree of Difficulty
Risk in Unmet Performance
$0 \leq DD \leq 1$

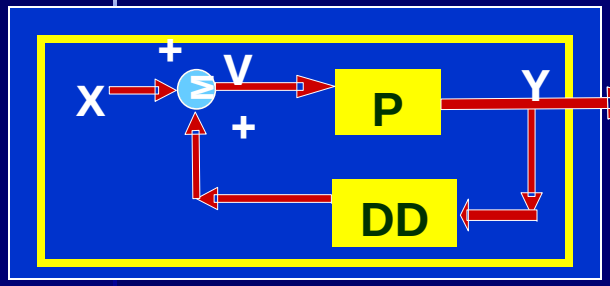


Requirement **Prioritization**

Technology Performance Risk Measure

TPRM Decision Aide Risk Matrix

Technology Performance Risk Measure
Mathematical Model



$$TPRM = (1-P) / (1-P*DD)$$

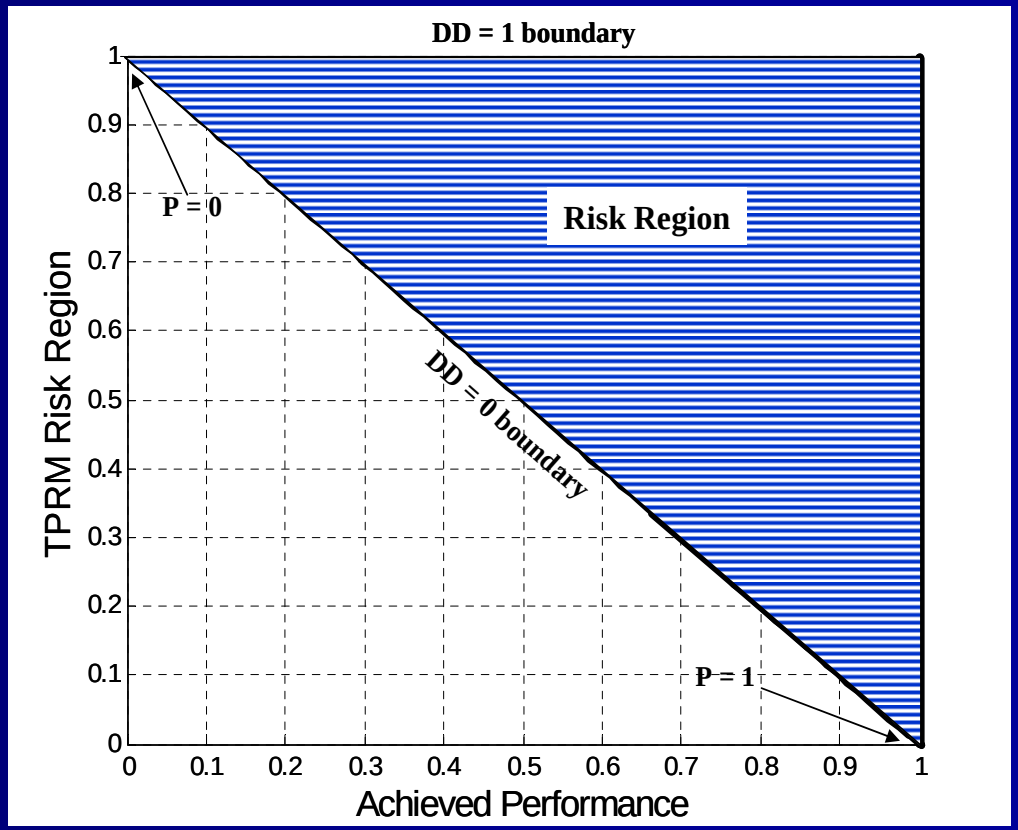
Boundary Conditions

$$TPRM = \lim_{DD \to 1} \{F(P; DD)\} = 1$$

$$TPRM = \lim_{DD \to 0} \{F(P; DD)\} = (1-P)$$

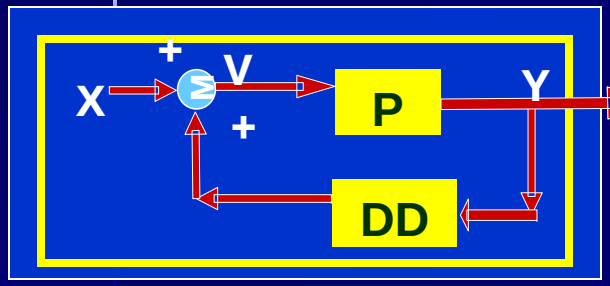
$$TPRM = \lim_{P \to 0} \{F(P; DD)\} = 1$$

$$TPRM = \lim_{P \to 1} \{F(P; DD)\} = 0$$

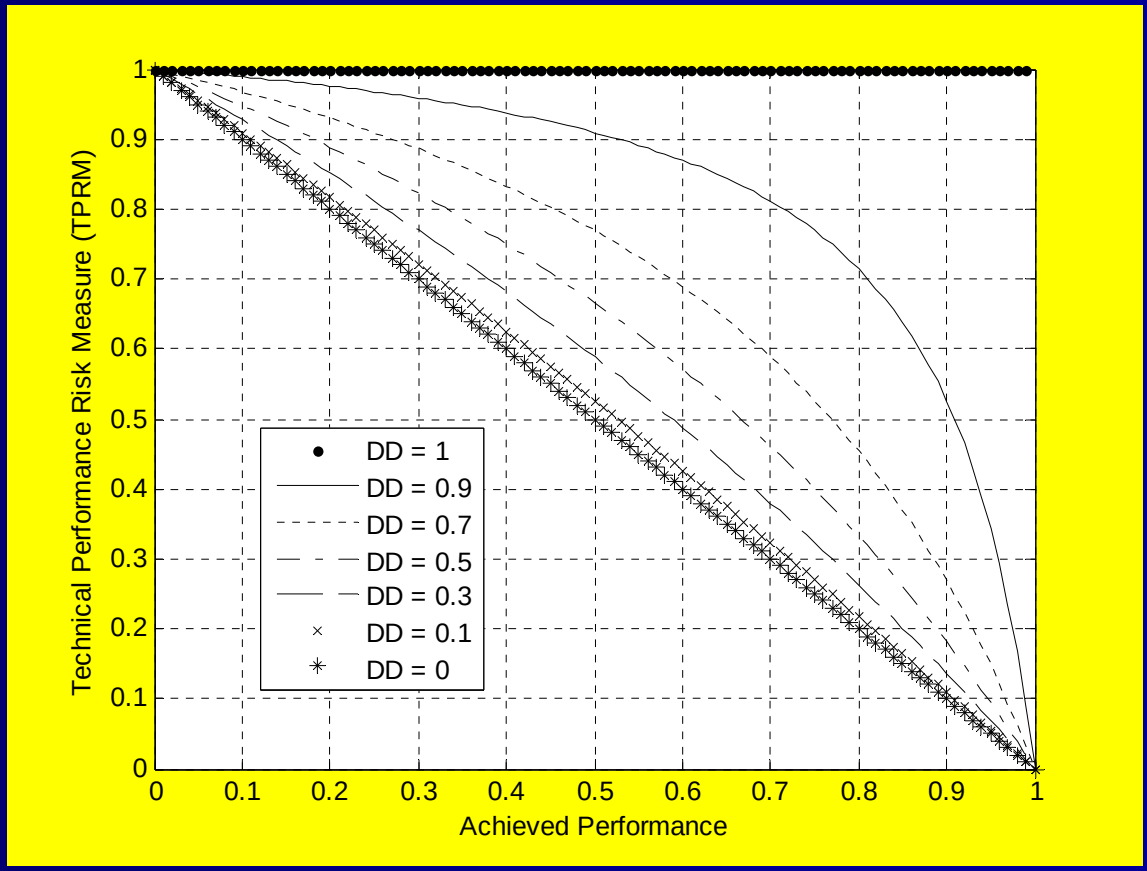


Technology Performance Risk Measure

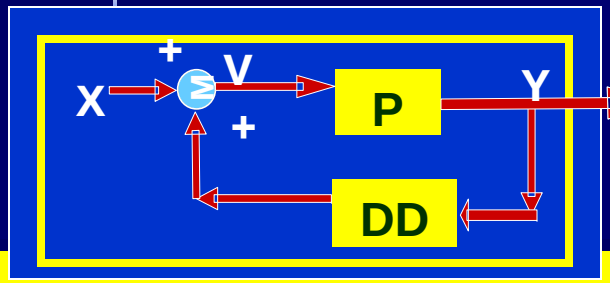
Degree of Difficulty as Parameter



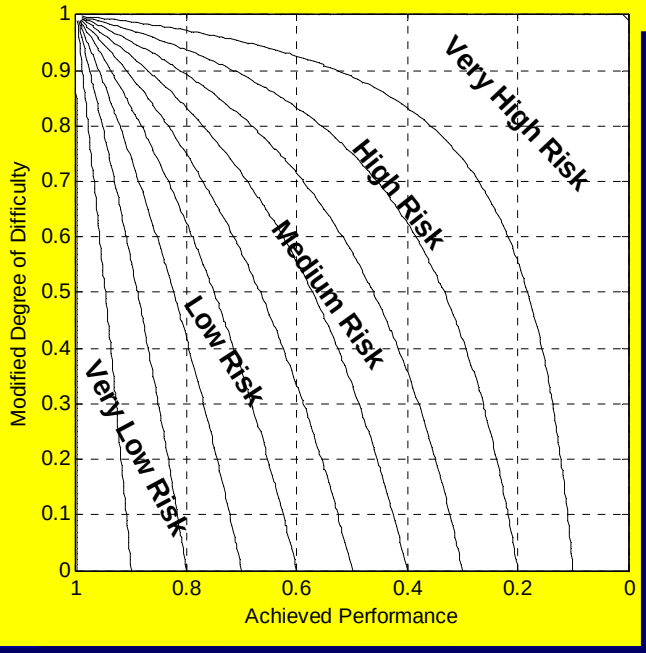
$$TPRM = (1-P) / (1-P*DD)$$

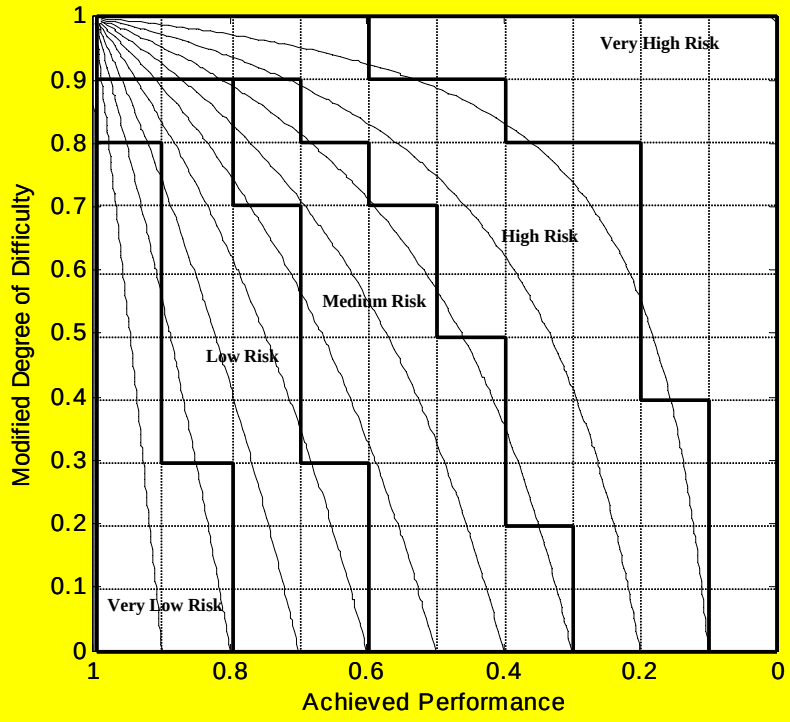


TPRM Risk Regions

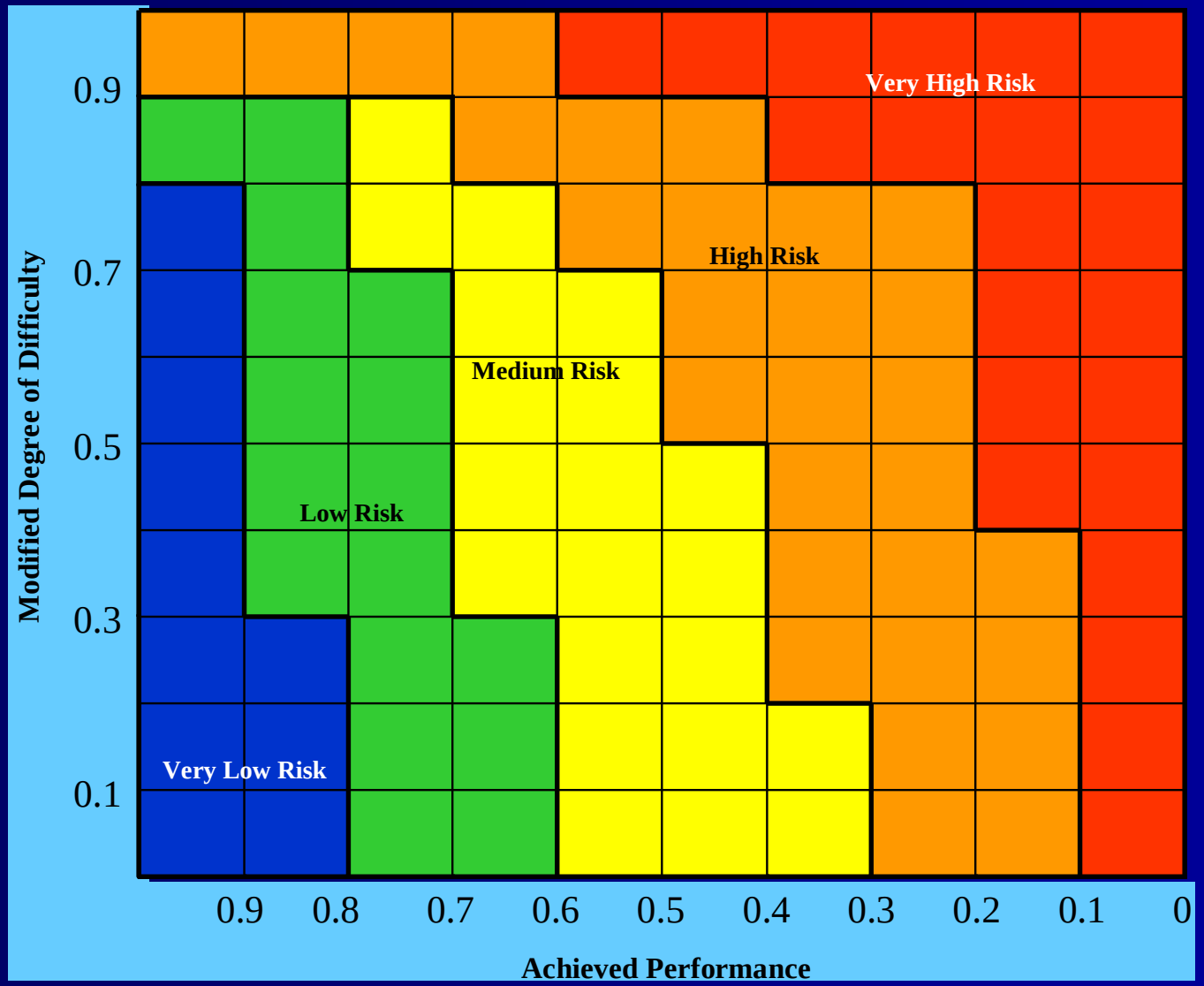


TPRM = (1-P) / (1-P*DD)



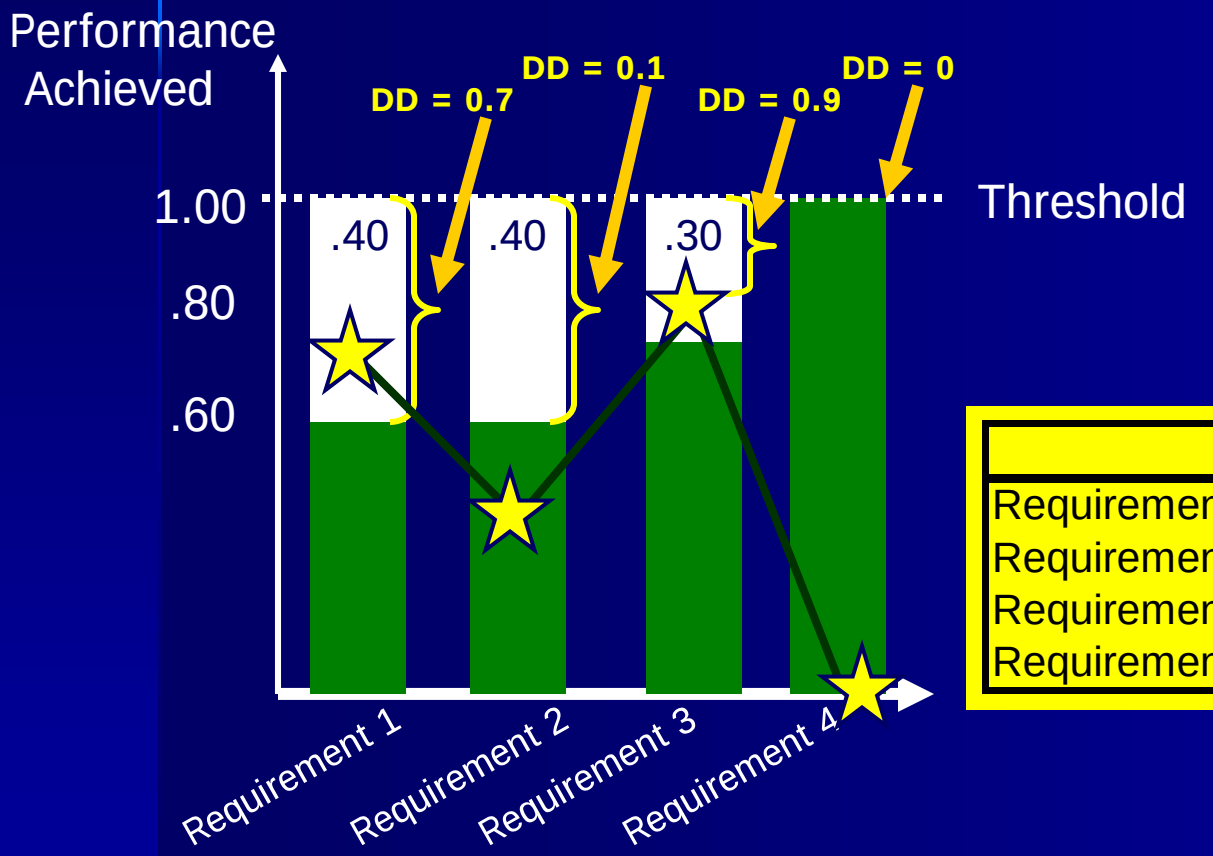


TPRM Decision Aide Risk Matrix



Technology Performance Risk Measure

Technology Performance Risk Measure
Hypothetical Example

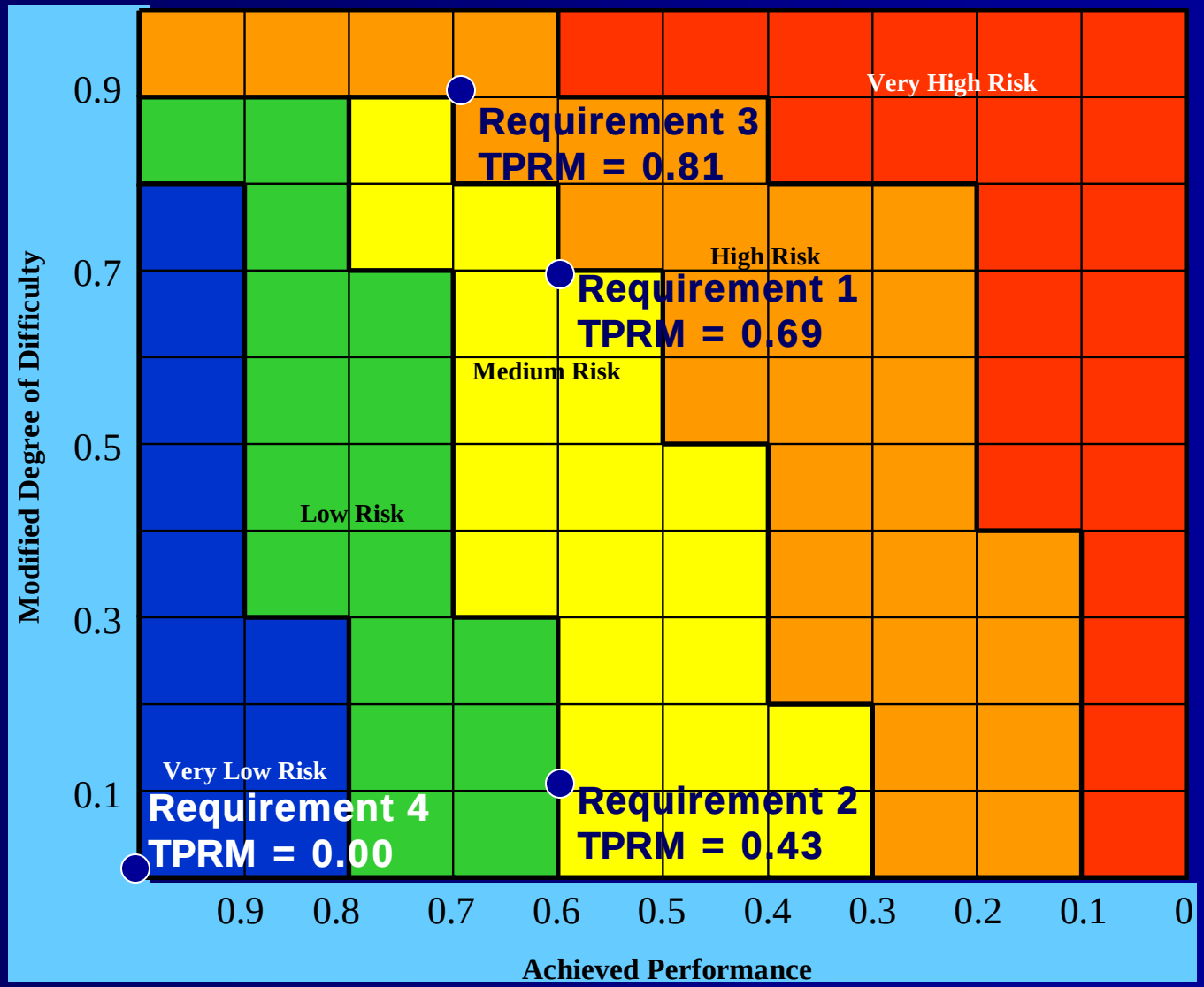


	P	DD	TPRM
Requirement 1	0.6	0.7	0.69
Requirement 2	0.6	0.1	0.43
Requirement 3	0.7	0.9	0.81
Requirement 4	1	N/A	0.00

Aggregated TPRM = 0.48

TPRM Decision Aide Risk Matrix

Hypothetical Example



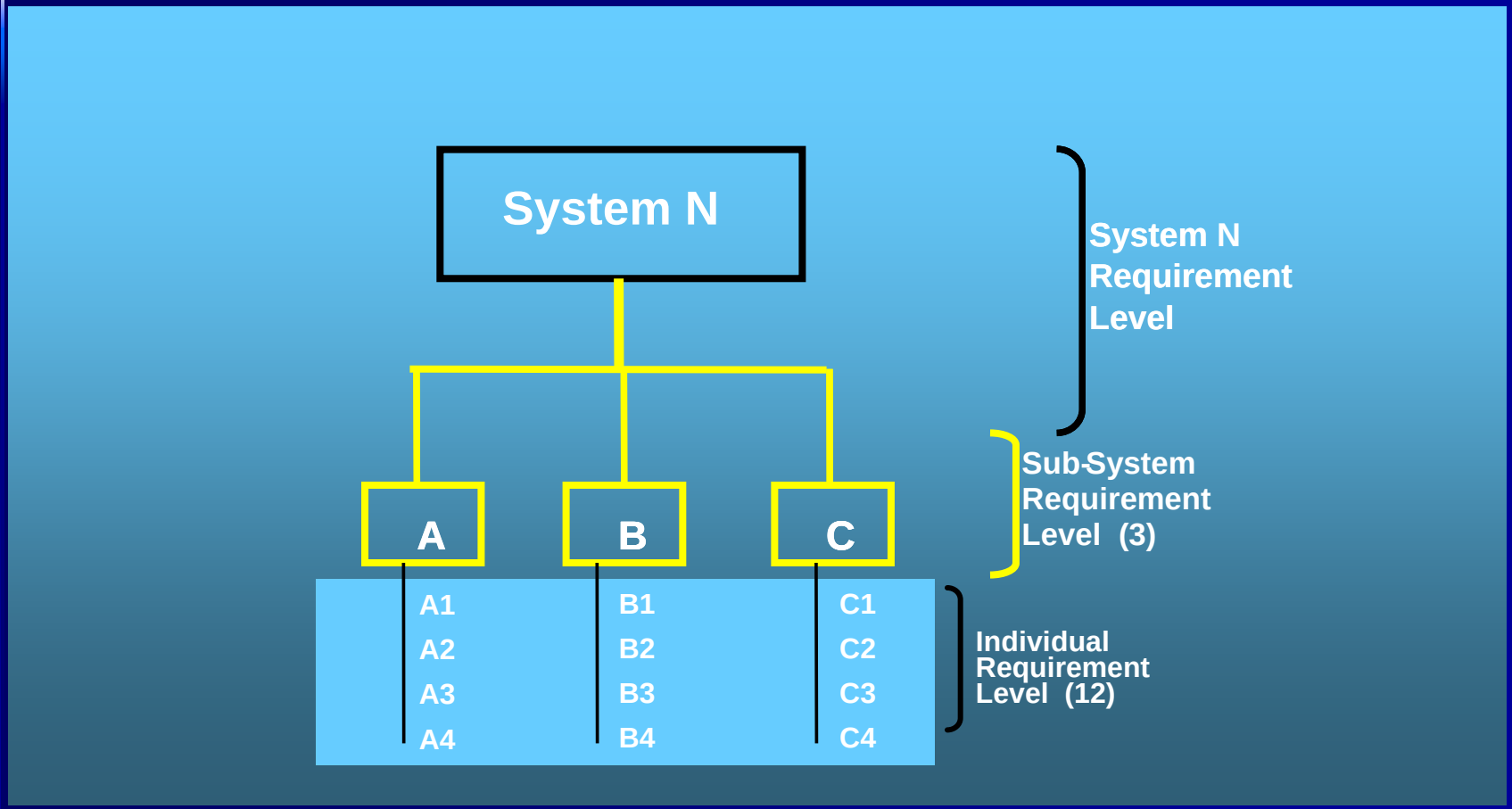
Technology Performance Risk Measure

TPRM Success Criterion

TPRM Transition Recommendation	Program Impact	TPRM Successful?
Yes	Greater than 15% cost over run and/or greater than 6 months schedule delay	No
No	Greater than 15% cost over run and/or greater than 6 months schedule delay	Yes

Technology Performance Risk Measure

System N: System Architecture



Technology Performance Risk Measure

Case Study – System N

Sub-System	Requirements	Achieved Performance	Degree of Difficulty	Individual Requirement TPRM	Rank Reciprocal Weights	Subsystem Level TPRM	
A	A1	0.48	0.70	0.79	0.08	0.12	0.59
	A2	0.86	0.90	0.62	0.06		
	A3	1.00	0.00	0.00	0.04		
	A4	0.39	0.70	0.84	0.05		
B	B1	1.00	0.00	0.00	0.32	0.00	
	B2	1.00	0.00	0.00	0.16		
	B3	1.00	0.00	0.00	0.05		
	B4	1.00	0.00	0.00	0.11		
C	C1	1.00	0.00	0.00	0.03	0.05	0.45
	C2	0.46	0.90	0.92	0.04		
	C3	0.98	0.70	0.06	0.03		
	C4	0.63	0.70	0.67	0.03		

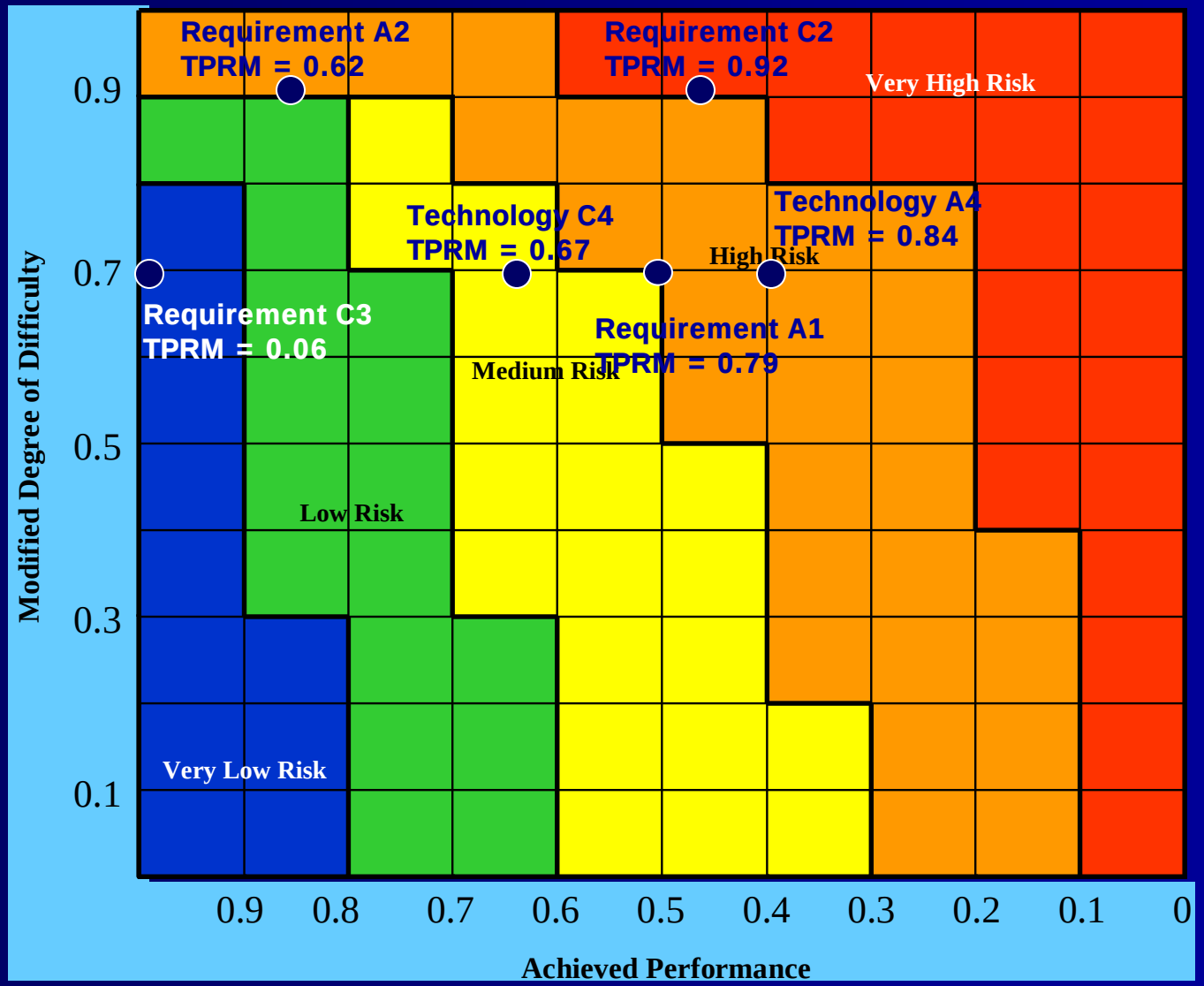
TPRM (System N) = 0.17

Government Decision: Continue Development but do not Transition.

TPRM Agrees with Government Decision to Continue Technology Development. Do not Transition Since Risk for Individual Requirements within Sub-Systems A and C Remains High

TPRM Decision Aide Risk Matrix

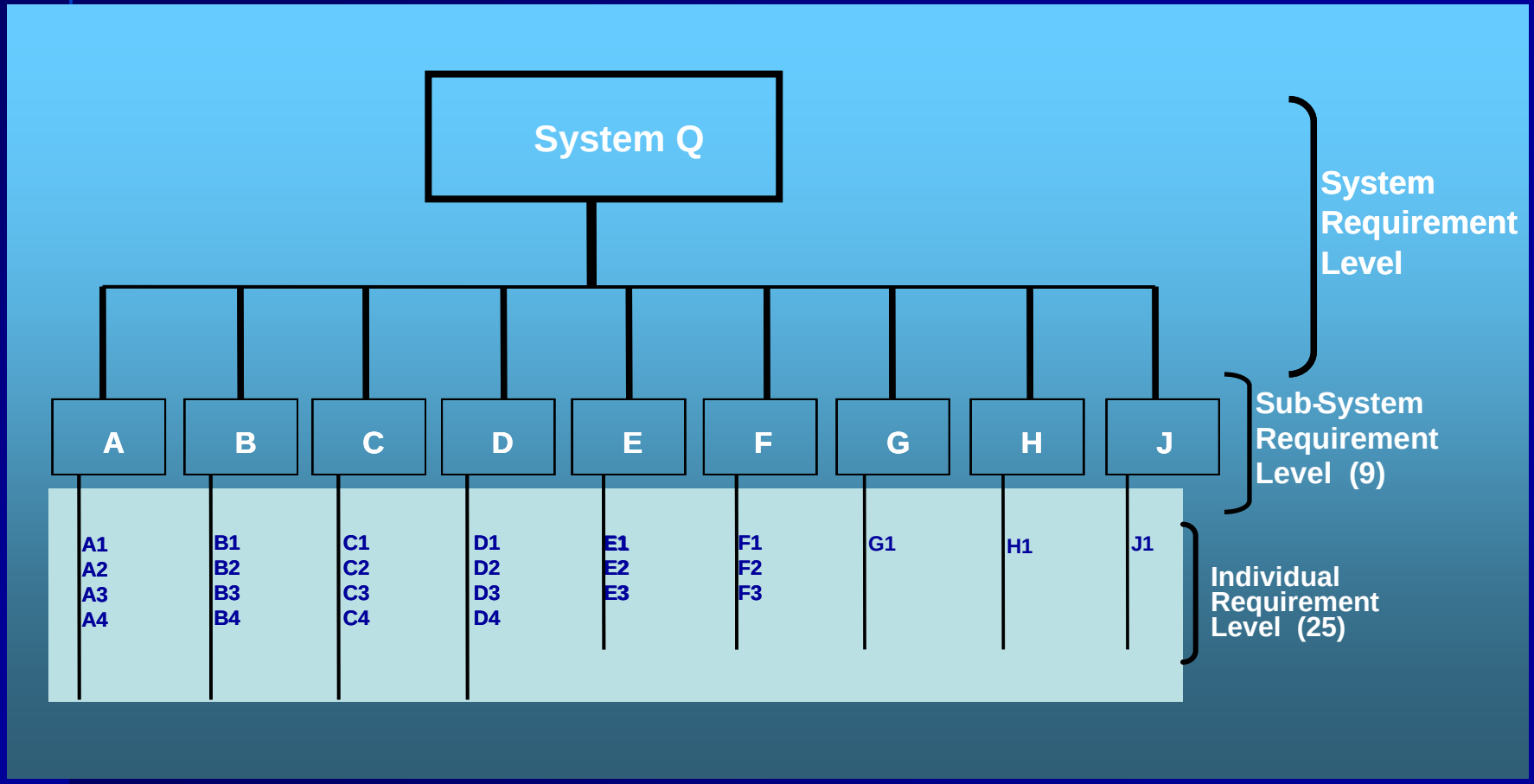
Case Study – System N



Technology Performance Risk Measure

System Q: System Architecture

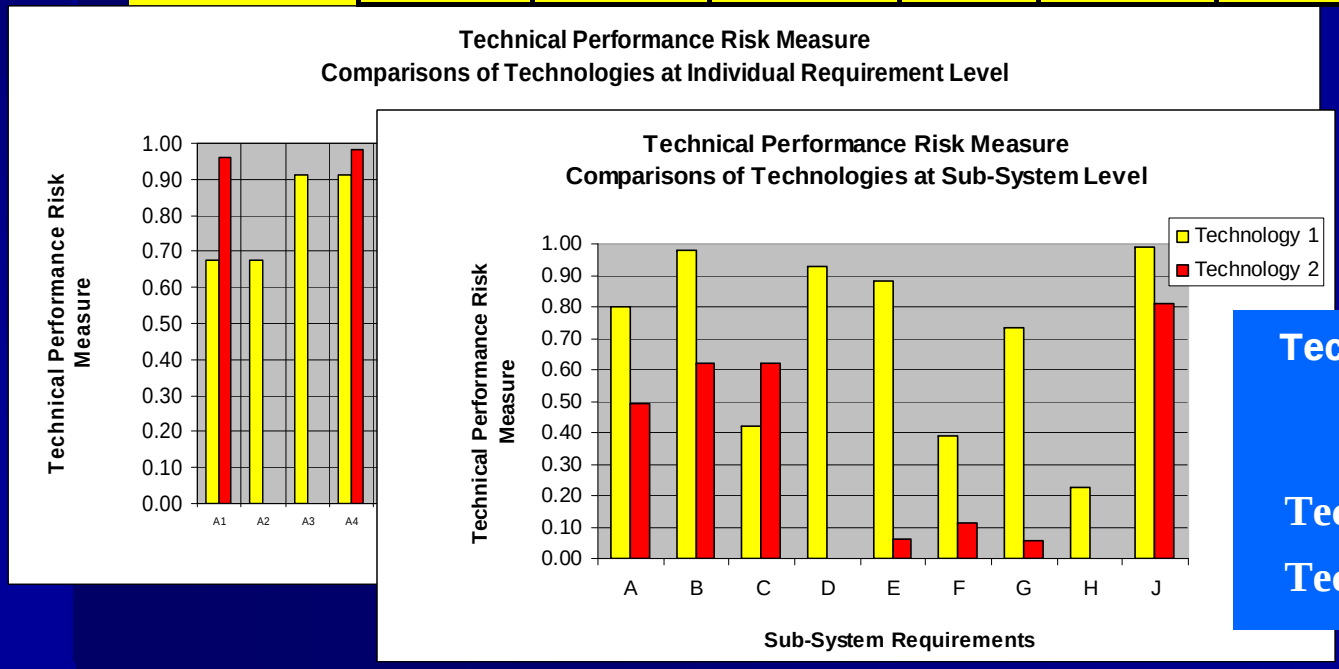
Evaluation of 2 Technologies



Technology Performance Risk Measure

System Q: Technology Comparisons

	Requirement	Performance Achieved	Unmet Performance RISK INDEX	Degree of Difficulty	TPRM Individual Requirement	Rank Reciprocal Weight	TPRM Sub-System Level
Technology 1	A1	0.49	0.51	0.5	0.68	1.72	
	A2	0.49	0.51	0.5	0.68	1.97	
	A3	0.24	0.76	0.7	0.91	1.83	
	A4	0.24	0.76	0.7	0.91	2.12	**0.80**
Technology 2	A1	0.29	0.71	0.9	0.96	1.72	
	A2	1	0	0	0.00	1.97	
	A3	1	0	0	0.00	1.83	
	A4	0.16	0.84	0.9	0.98	2.12	**0.49**



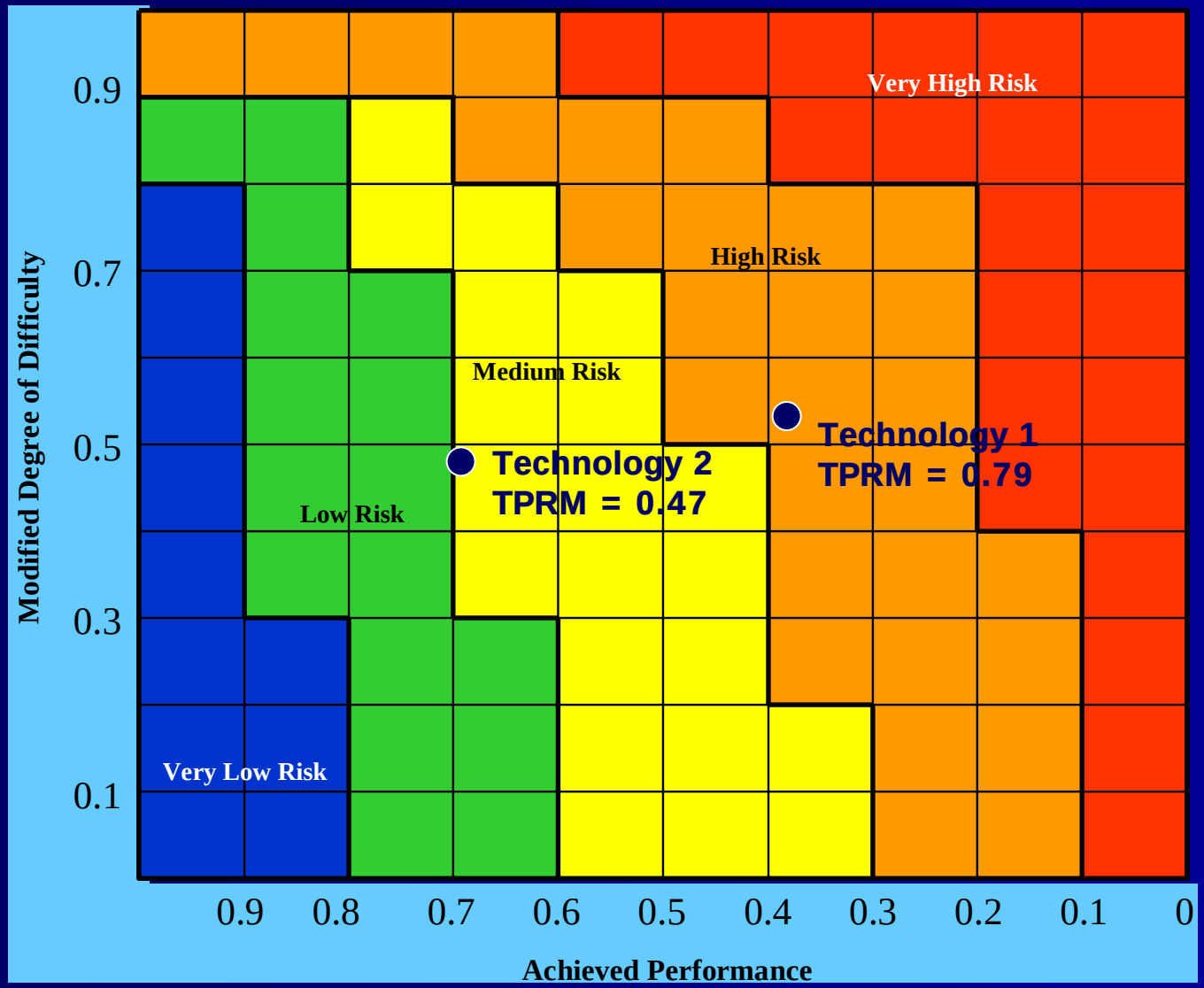
Technology Performance Risk Measure

Technology 1	0.79
Technology 2	0.47

Government Selected Technology 1

TPRM: Select Technology 2

TPRM Decision Aide Risk Matrix
System Q



Technology Performance Risk Measure

Technology Performance Risk Measure
Summary

- ✓ Requisite Decision Model
- ✓ Easy to Utilize and Understand
- ✓ TPRM Case Studies Indicated Significant Enhancement in Determination of Technology Transition Readiness Level
- ✓ Flexibility to Apply to Each Level of Technology
  - ➢ Individual Requirement Level
  - ➢ Sub-System Category Level
  - ➢ Total Technology System Level
- ✓ Provides a Quantitative-based Assessment
- ✓ Value-Added Information Regarding Performance Risk to Support Technology Assessment Related Decisions
- ✓ Supports Monitoring of Risks Over Time
- ✓ Supports Prioritization of Resources to Mitigate Identified Risks

Next Steps….

Key Metrics

Performance	Integration	Software
Manufacturing	Materials	-Ilities
Human	Tools & Capabilities	

TPRM

Technology P m Management
del

TRL Calculator

Key Metrics Provide Information to Support Technology Maturity & Transition Readiness Assessments

Questions ?

Technology Performance Risk Measure

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May 10, 2006

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