Risk Management Best Practices

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Outline

- Comparison of Risk Assessment Criteria
- Aerospace Process Overview
- Aerospace Case Study
- JPL Process Overview
- JPL Case Study
- Emerging consensus
  - What is "Standardized"
  - What is "Standardizable"
  - What should be "Tailorable"
    - / Across Space Industry
    - / Within an organization's process
- Where we choose to disagree
- Conclusion

Comparison of Risk Assessment Criteria

1. Risk Management Guide For DoD Acquisition, June 2003
2. ISO 17666, Space Systems – Risk Management
3. Risk Assessment at Aerospace
4. Risk Assessment at JPL
5. Proposed Example of "Geometrically-Calibrated" Qualitative Matrix
6. Proposed Semi-Quantitative Geometric Likelihood & Consequence Scales and Risk Rating Matrices (In Percents & In Dollars)
7. Proposed Quantitative Geometric (Log-Log) Risk Rating Field (In Dollars)

1. Risk Management Guide For DoD Acquisition, June 2003
Example of Risk Assessment

Level	What is the Likelihood the Risk Event Will Happen?
a	Remote
b	Unlikely
c	Likely
d	Highly likely
e	Near certainty

Process Variance refers to deviation from best practices. Likelihood/Probability refers to risk events.

ASSESSMENT GUIDE

Likelihood					
e	M	M	H	H	H
d	L	M	M	H	H
c	L	L	M	M	H
b	L	L	L	M	M
a	L	L	L	L	M
	a	b	c	d	e

Consequence

RISK ASSESSMENT

- **R** **HIGH**—Unacceptable. Major disruption likely. Different approach required. Priority management attention required.
- **Y** **MODERATE**—Some disruption. Different approach may be required. Additional management attention may be needed.
- **G** **LOW**—Minimum impact. Minimum oversight needed to ensure risk remains low.

Level	Technical Performance	and/ or	Schedule	and/ or	Cost	and/ or	Impact on Other Teams
a	Minimal or no impact		Minimal or no impact		Minimal or no impact		None
b	Acceptable with some reduction in margin need dates		Additional resources required; able to meet		<5%		Some impact
c	Acceptable with significant reduction in margin		Minor slip in key milestones; not able to meet need date		5-7%		Moderate impact
d	Acceptable; no remaining margin		Major slip in key milestone or critical path impacted		7-10%		Major impact
e	Unacceptable major program milestone		Can't achieve key team or		>10%		Unacceptable

2. ISO 17666, Space Systems – Risk Management
Example of Risk Assessment

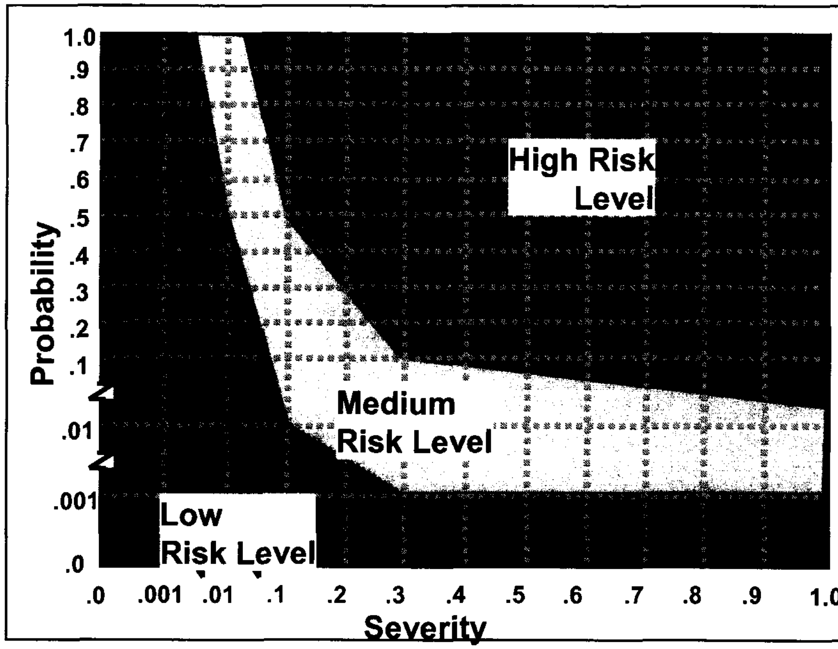
Risk Index	Risk Magnitude	Proposed Actions
E4, E5, D5	Very High	Unacceptable risk: implement new team process or change baseline - seek project management attention at appropriate high management level as defined in the risk management plan.
E2, D3, C4, B5	**Medium**	**Unacceptable risk: aggressively manage, consider alternative team process or baseline - seek attention at appropriate management level as defined in the risk management plan.**
C1, B1, A1, B2, A2, A3, A4	Very Low	Acceptable risk: See above.

	1	2	3	4	5
E		M		VH	VH
D			M		VH
C	VL			M	
B	VL	VL			M
A	VL	VL	VL	VL	

Score	Likelihood	Likelihood of Occurrence
E	**Maximum**	**Certain to occur, will occur one or more times per project**
D	**High**	**Will occur frequently, about 1 in 10 projects**
C	**Medium**	**Will occur sometimes, about 1 in 100 projects**
B	**Low**	**Will seldom occur, about 1 in 1,000 projects**
A	**Minimum**	**Will almost never occur, 1 of 10,000 or more projects**

Score	Severity	Severity of consequence: impact on (for example) cost
5	**Catastrophic**	**Leads to termination of the project**
4	**Critical**	**Project cost increase > tbd %**
3	**Major**	**Project cost increase > tbd %**
2	**Significant**	**Project cost increase > tbd %**
1	**Negligible**	**Minimal or no impact**

3. Risk Assessment at Aerospace
The Continuous Aerospace Risk Management and Assessment (CARMA) Tool



NOTES:

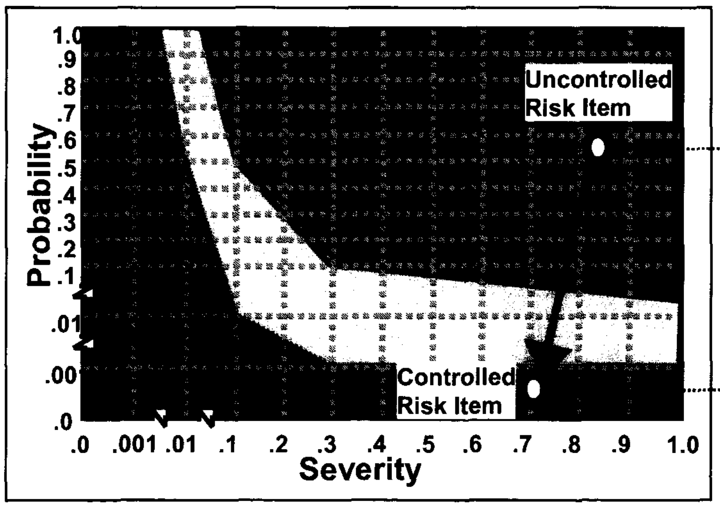
1. Colored areas are to be defined by each program manager
2. Required actions to be defined by each program manager

Likelihood scale (0 – 1)
- Uses actual estimates of event probability
- Log scale in lower region to capture low consequence – high probability events
- User can select order of magnitude if better data not available

Consequence scale (0 – 1)
- considers mission or program loss as maximum potential impact
- relates major cost and schedule impacts to fractions of mission loss
- program defines schedule delay and cost overrun "programmatically equivalent" to loss of a full mission)

3. Risk Assessment at Aerospace (Cont'd)
Cost-Benefit Evaluation

- Risk control measures for major items is applied from perspective of maximizing benefit (risk-reduction equivalent worth) and minimizing cost (resources and $ needed for implementation)
  - Saves program resources
  - Focuses risk control on actions with best return-on-investment



Cost-Benefit Indices :

Ratio = ΔR / C

Net Benefit = ΔR - C

- **ΔR = Risk Reduction Worth of a Control = Δ(Prob. X Severity)**

  (normalized to cost dimension)

C = Implementation Cost of a Control

4. Risk Assessment at JPL

Type of Risk (Check one or both)

☐ Mission Risk

☐ Implementation Risk

Likelihood of Occurrence (Circle One)

Level	Level Definition	
5	Very High	>70%, almost certain
4	High	>50%, More likely than not
3	Moderate	>30%, Significant likelihood
2	Low	>1%, Unlikely
1	Very Low	<1%, Very unlikely

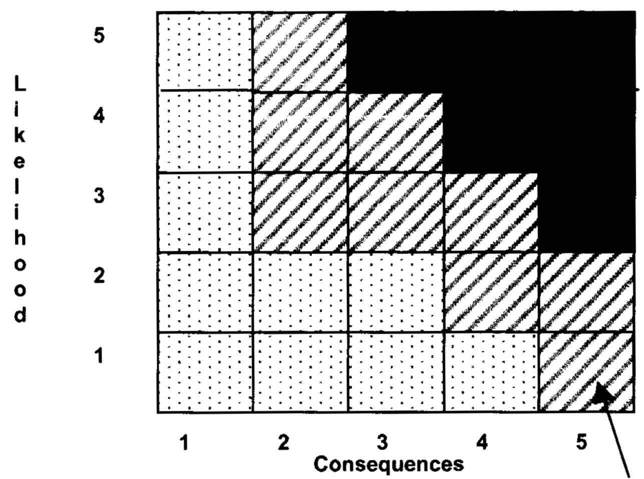
Consequence of Occurrence

(Circle one for each type checked above)

Level	**Mission Risk** Level Definitions
5	Mission failure
4	Significant reduction in mission return
3	Moderate reduction in mission return
2	Small reduction in mission return
1	Minimal (or no) impact to mission

Level	**Implementation Risk** Level Definition
5	Overrun budget and contingency cannot meet launch
4	Consume all contingency, budget or schedule
3	Significant reduction in contingency or launch slack
2	Small reduction in contingency or launch slack
1	Minimal reduction in contingency or launch slack

Risk Matrix



Green or Yellow ?

LEGEND

- **High -** Implement new process(es) or change baseline plan(s)
- **Med -** Aggressively manage; consider alternative process
- **Low -** Monitor

JPL/ NASA "Near-Standard" Risk Assessment Criteria (5X5 Matrix)

5. Proposed Example of "Geometrically-Calibrated" Qualitative Matrix (S. Guarro)

"Geometric" Risk Matrix Compatible with Quantitative Framework

Likelihood					
E		Medium	High	High	Very High
D		Medium	Medium	High	High
C			Medium	Medium	High
B					Medium
A					
	1	2	3	4	5
	Severity				

Likelihood Table

Bin / Category	Qualitative Descriptor	Quantitative Probability OOM *	Quantitative OOM Definition
		p ~ 1/1000 per mission	0 < p <= 3/1000 per mission
		p ~ 1/100 per mission	4/1000 < p <= 3/100 per mission
C	Medium	p ~ 1/10 per mission	4/100 < p < 2/10 per mission
		p ~ 1/3 per mission	2/10 <= p <= 3/10 per mission
		p ~ 2/3 per mission	4/10 < p <= 1 per mission

* OOM = Order of Magnitude

Outcome Severity Table

Bin / Category	Summary-Level Qualitative Descriptor	Quantitative Order of Magnitude of Outcome Severity	Qualitative Severity Definition / Assessment in Mission Performance Terms	Qualitative Severity Definition / Assessment in Mission Schedule Terms
		~3% Performance / Schedule Utility Loss (1-5% range)	Minor deviation from required performance of primary mission	Minor deviation from required primary mission schedule
		~10% Performance / Schedule Utility Loss (6-15% range)	Significant but non-impairing deviation from required performance of primary mission; or Impairing deviation from required performance of secondary mission	Significant but non-impairing deviation from required primary mission schedule; or Impairing deviation from required secondary mission schedule
3	Medium	~30% Performance / Schedule Utility Loss (16-45% range)	Impairing deviation from required performance of primary mission; or severely-impairing deviation from required performance of secondary mission	Impairing deviation from required primary mission schedule; or severely-impairing deviation from secondary mission schedule
		~60% Performance / Schedule Utility Loss (46-75% range)	Severely-impairing deviation from required performance of primary mission; or failure of secondary mission	Severely-impairing deviation from primary mission schedule; or massive schedule delay makes secondary mission worthless
		~100% Performance / Schedule Utility Loss (86-100% range)	Failure of primary mission	Schedule delay makes primary mission worthless

6. Proposed Semi-Quantitative Geometric Likelihood & Consequence Scales (R. Dar)

Score	Consequence	Severity of consequence
5	Very High	100% of mission cost is lost
4	High	10% of mission cost is lost
3	Medium	1% mission cost is lost
2	Low	0.1% of mission cost is lost
1	Very Low	0.01% f mission cost is lost

Score	Likelihood	Likelihood of occurence
E	Very High	Will certainly occur, about 1 in 1 mission
D	High	Will occur frequently, about 1 in 10 missions
C	Medium	Will occur sometimes, about 1 in 100 missions
B	Low	Will seldom occur, about 1in 1000 missions
A	Very Low	Will almost never occur, about 1 in 10000 missions

6. Proposed Semi-Quantitative Geometric Risk Rating Matrix (In Percents) (R. Dar)

LIKELIHOOD					
1.0		Medium		Very High	Very High
0.1			Medium		Very High
0.01	Very Low			Medium	
0.001	Very Low	Very Low			Medium
0.0001	Very Low	Very Low	Very Low		
	0.01%	0.1%	1%	10%	100%

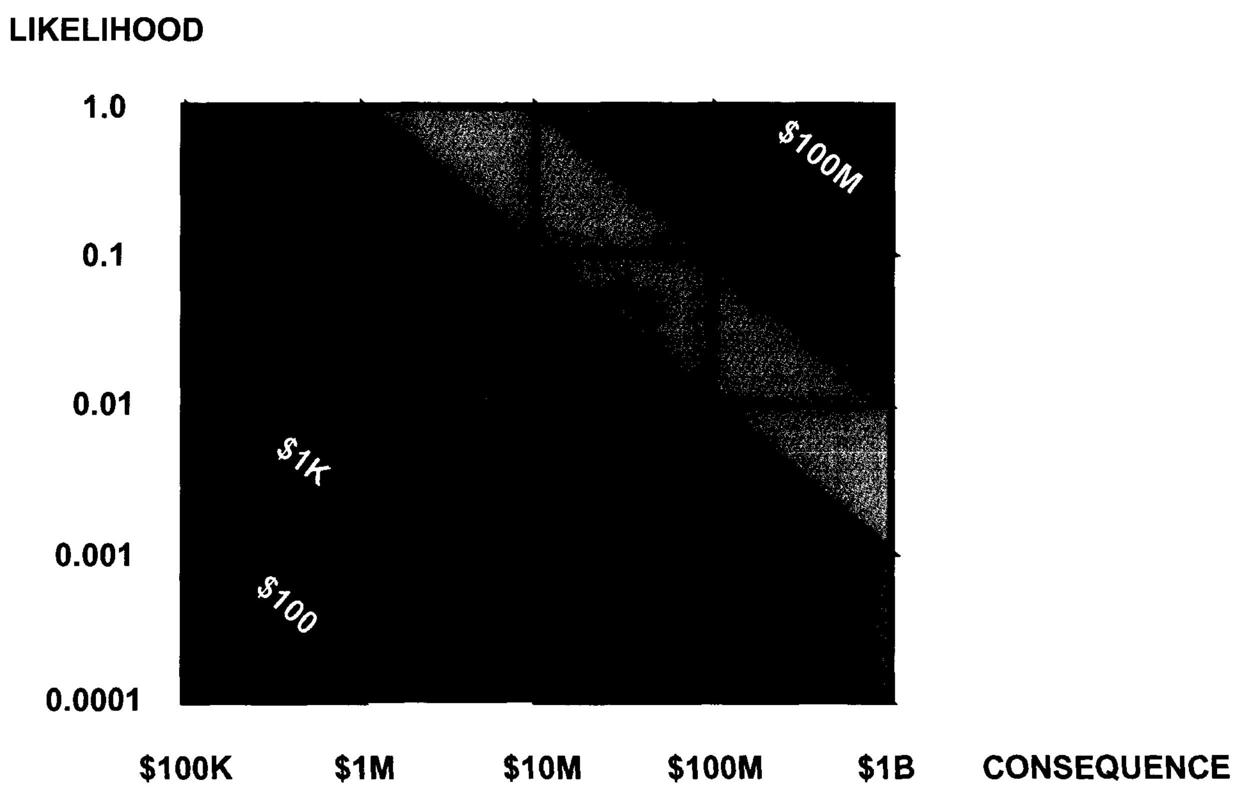
CONSEQUENCE

6. Proposed Semi-Quantitative Geometric Risk Rating Matrix (In Dollars) (R. Dar)

LIKELIHOOD	$100K	$1.0M	$10M	$100M	$1B
1.0		$1M		$100M	$1B
0.1			$1M		$100M
0.01	$1K			$1M	
0.001	$100	$1K			$1M
0.0001	$10	$100	$1K		

CONSEQUENCE

7. Proposed Quantitative Geometric (Log-Log) Risk Rating Field (In Dollars) (R. Dar)



Aerospace Process Overview

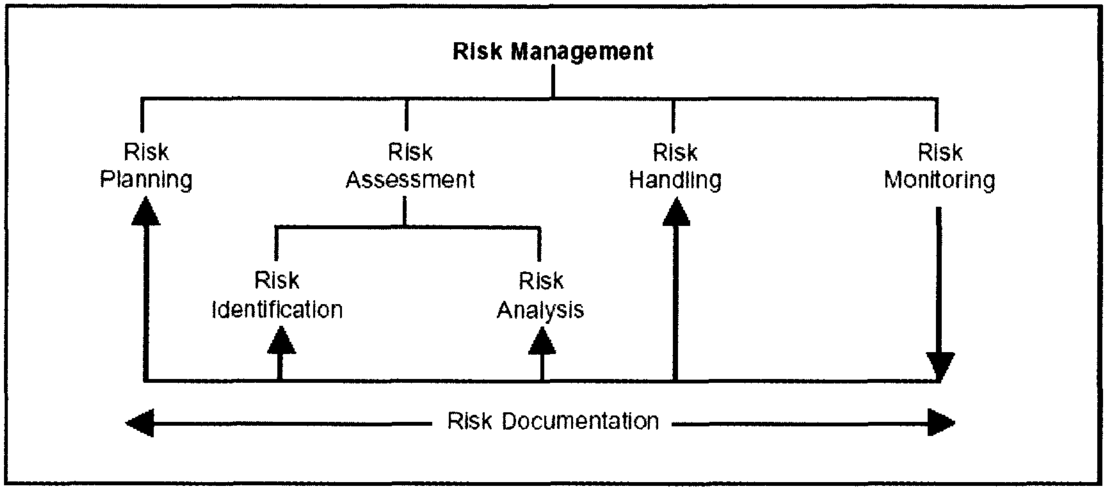
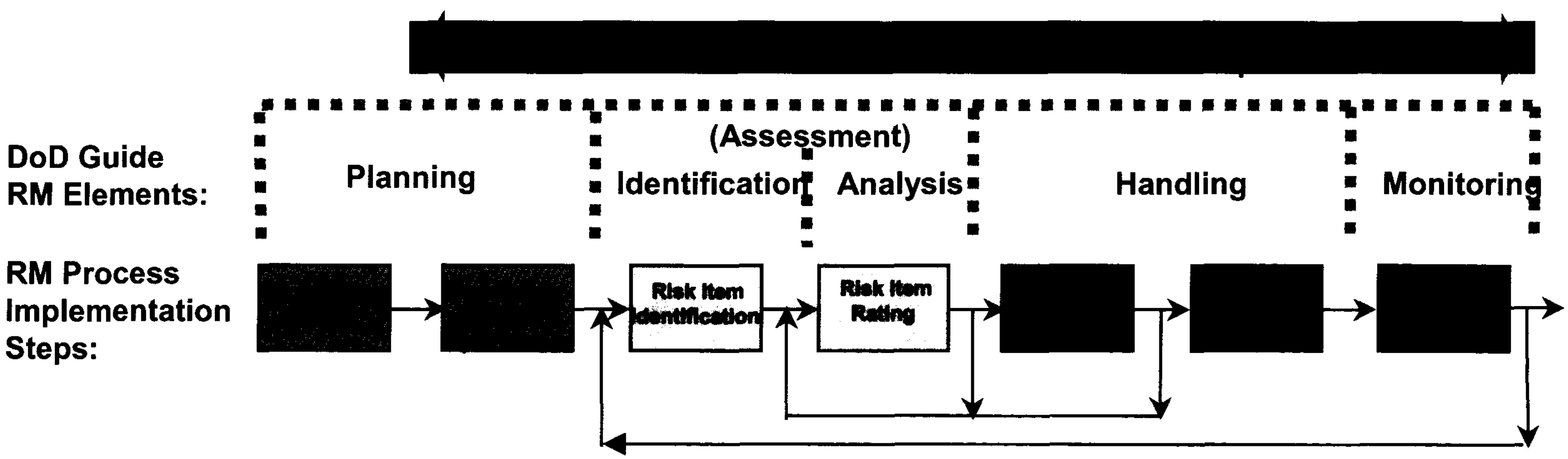


Figure 2-1. Risk Management Structure

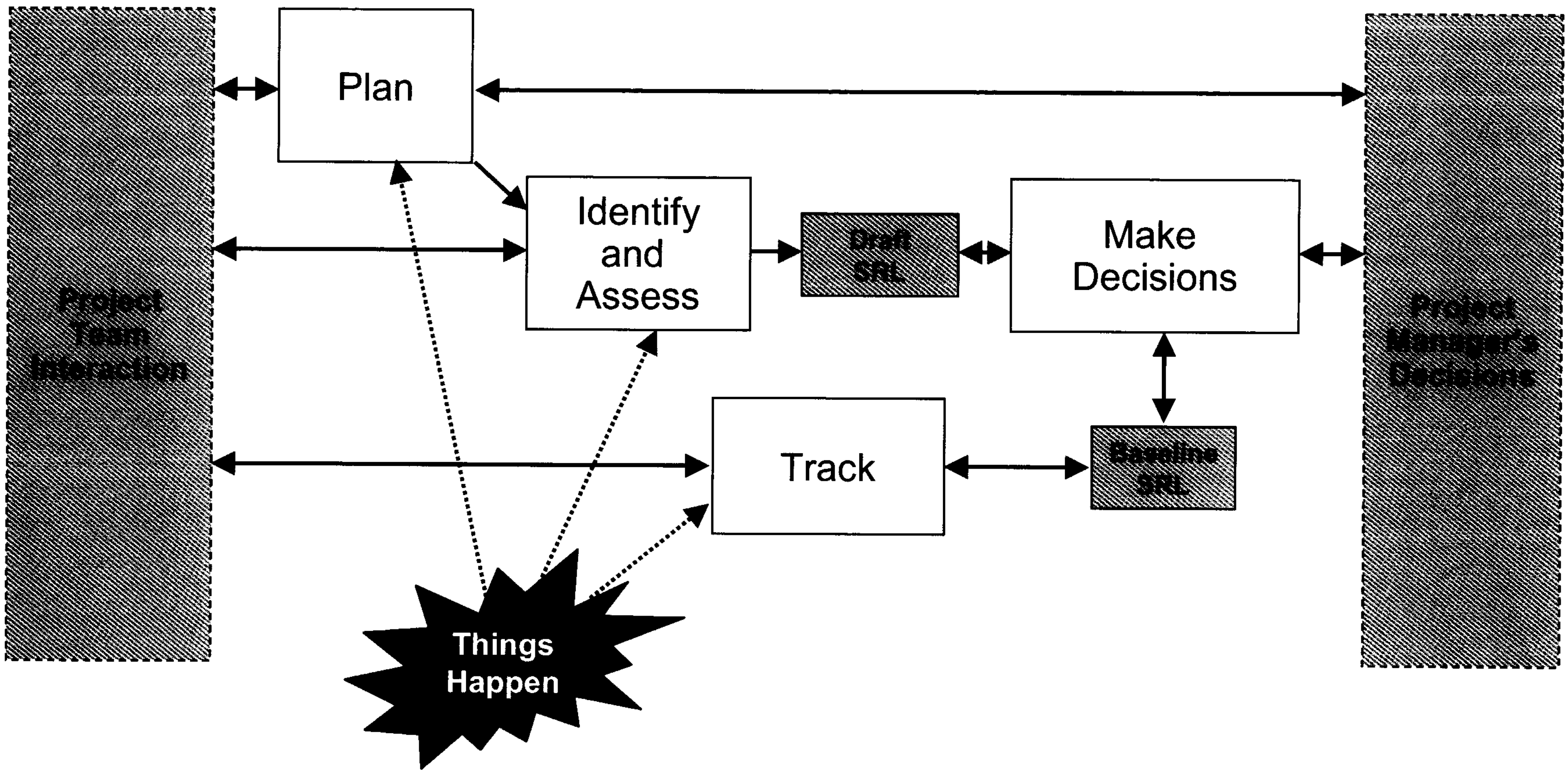
Ref. Risk Management Guide for DoD Acquisition, June 2003



Aerospace Case Study

- Program used CARMA scales for an independent risk management process (separate from contractors)
- Set end of scale values equivalent to loss of most expensive vehicle
  - Maximum cost to total cost of single vehicle Maximum schedule delay to 1 year (center on which vehicles were launched)
- Risks affecting less expensive vehicles were scaled accordingly
- Selected likelihood based on order of magnitude only, did not use more precise values
- Risk identification forms were made available to entire team
- Lessons
  - Risk review and boards should be held <u>at least</u> once per month
  - It may take several months to get process moving
  - Automating transfer of data speeds the process
  - Need to ensure the entire team understand the scales and the way risks will be ranked
  - Team must clearly see the benefit of participating in the process

JPL Process Overview



SRL= Significant Risk List

JPL Case Study

Project XYZ Risk Management Summary

- Used 3X3 matrix
- Combined mission and Implementation Risk in same consequence definitions
- Required a mitigation plan for all red and yellow risks
- Used risk liens as a measure of adequacy of budget reserves
- Integrated risks from major partner/ suppliers into project risk list if criteria were met
- Found that outside risk consultants (part time) did not work – process needs to be managed by a team member

Lessons Learned

- Process needs advocacy at the PM level
- Can best get team members attention from a respected team member
- Need one project list, and need to tie resource liens to the risks
- Needs regular (more frequently than 1/ month) team attention
- 5X5 matrix would probably allow less "centralization" of the risk assessments
- Needs half-time dedicated to keeping the process moving

What is Standardized?

- Assess Risk by “measuring” risk likelihood and consequence against a “measuring stick”
- At least at the beginning of a program/ project, the “measuring stick should be not too highly resolved – a scale of 5 levels (bins) is widely used
- Likelihood goes from ~0 to 1!

What is Standardizable?

- Should the scales (measuring sticks) be linear?
  - Aerospace believes that the log scale they use, at least for the lower level risks, allows more accurate differentiation (risks high in consequence but < 10% likelihood)
  - JPL/ NASA have not consensed on this corner of the 5X5
- Should the scales be standardized?
  - JPL not too sensitive to varying scales among projects
- Should the allocations of the boxes in the matrix (whatever the dimensions) be standardized?
  - JPL management favors a common reporting format – standardized distribution of red, yellow and green, even though not sensitive to varying scales.

What should be Tailorable?

- Scales
  - Most JPL projects not sensitive to the green levels for project risks – but the likelihood scales offer a tailorable measure of the degree of risk aversion
- Risk Strategy
  - JPL has some variability on how to deal with red and yellow risks. All treat green risks as "accept and watch"
- Other aspects of Risk Management
  - Tools/ data bases are selected by the practitioners – no tool seems easy to everyone.
  - Quantitative methods
    - Many use dollars to quantize risk against the reserves
    - Little or no use of other measures, except in the PRA sense of assessing risk to mission objectives.

Where We Choose to Disagree

- Scales
  - NASA/ JPL using basically "Linear" scales
  - Aerospace looking to emphasize distinction of low likelihood/ low consequence risks by using "logarithmic" scales
- Degree of Standardization possible
  - NASA and JPL tending to standardize risk matrix and criteria
  - Differences in approach between Risk Management and Risk Reporting being sorted out
  - Aerospace does not have standardization as a desirable objective