Business Case for Using a Numbered Logarithmic Risk Severity Scale

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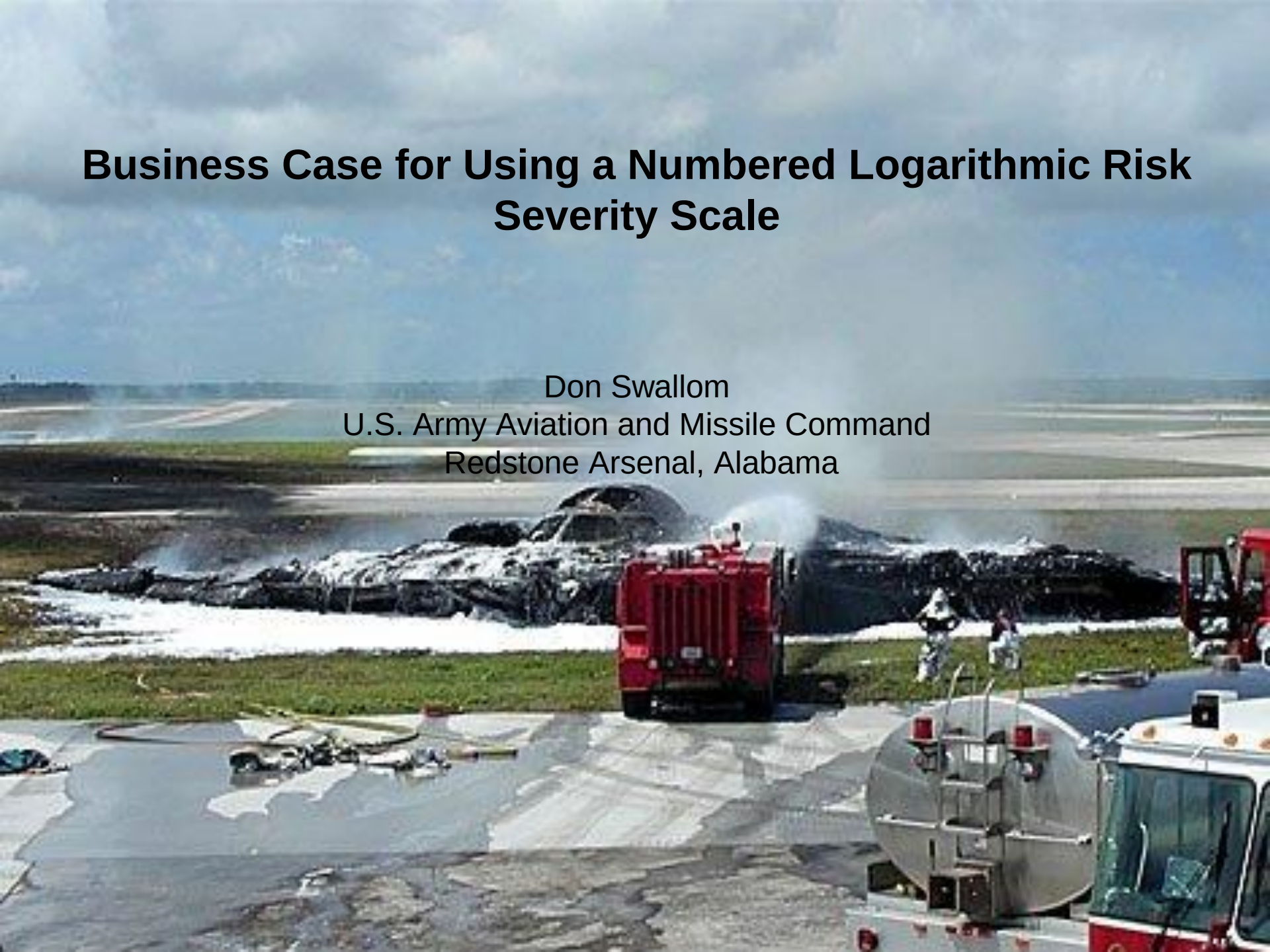
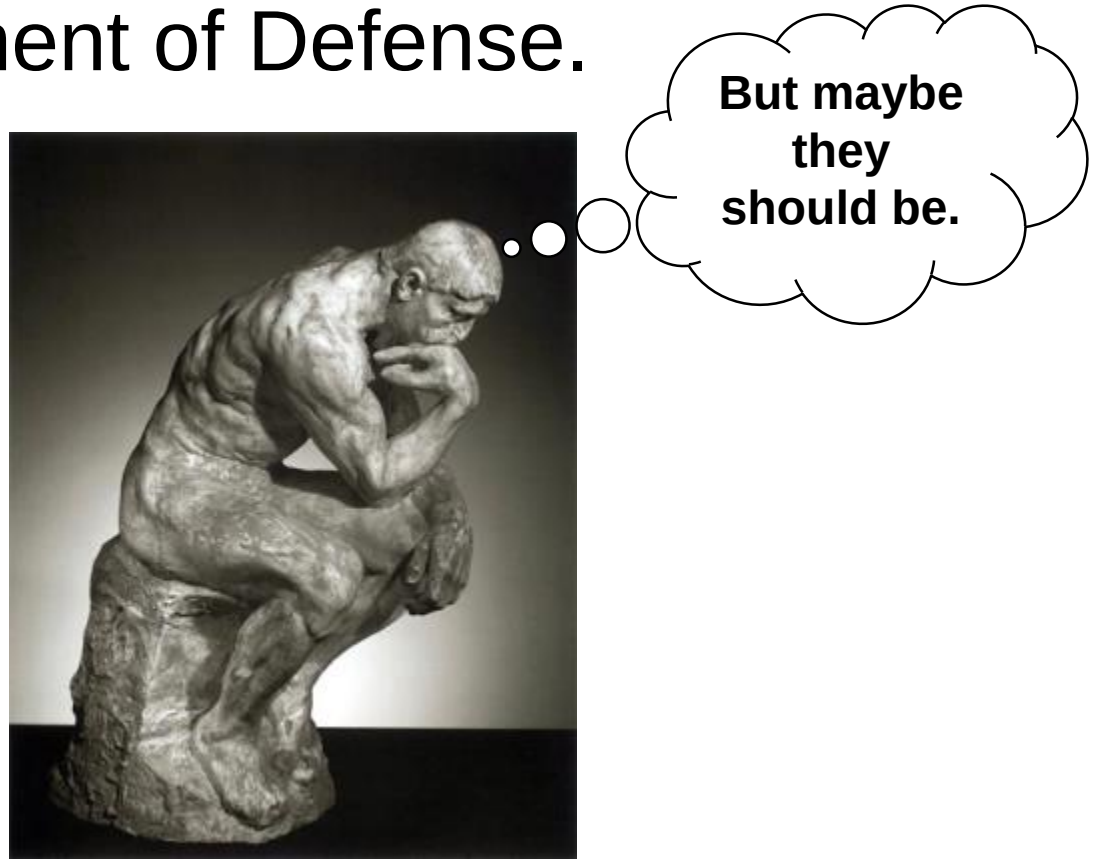


Caveat

Opinions expressed are those of the author and not the coordinated position of AMCOM, Army Materiel Command, the US Army or the Department of Defense.



Business Case

- Executive Summary (Abstract)
- Introduction
- Problem
- Background
- Scope (4 arenas)
- Desired Outcomes (4)
- Alternatives to be Analyzed (2)
- Analysis of Alternatives
- Conclusion
- Recommendation

Executive Summary

- DoDI 6055.07 - actual accidents; MIL-STD-882 - potential accidents
  - High dollar & fatality loss – Not adequate
  - Top Threshold for damage loss increased,
    - 6055.07 to $2 million
    - 882 to $10 million

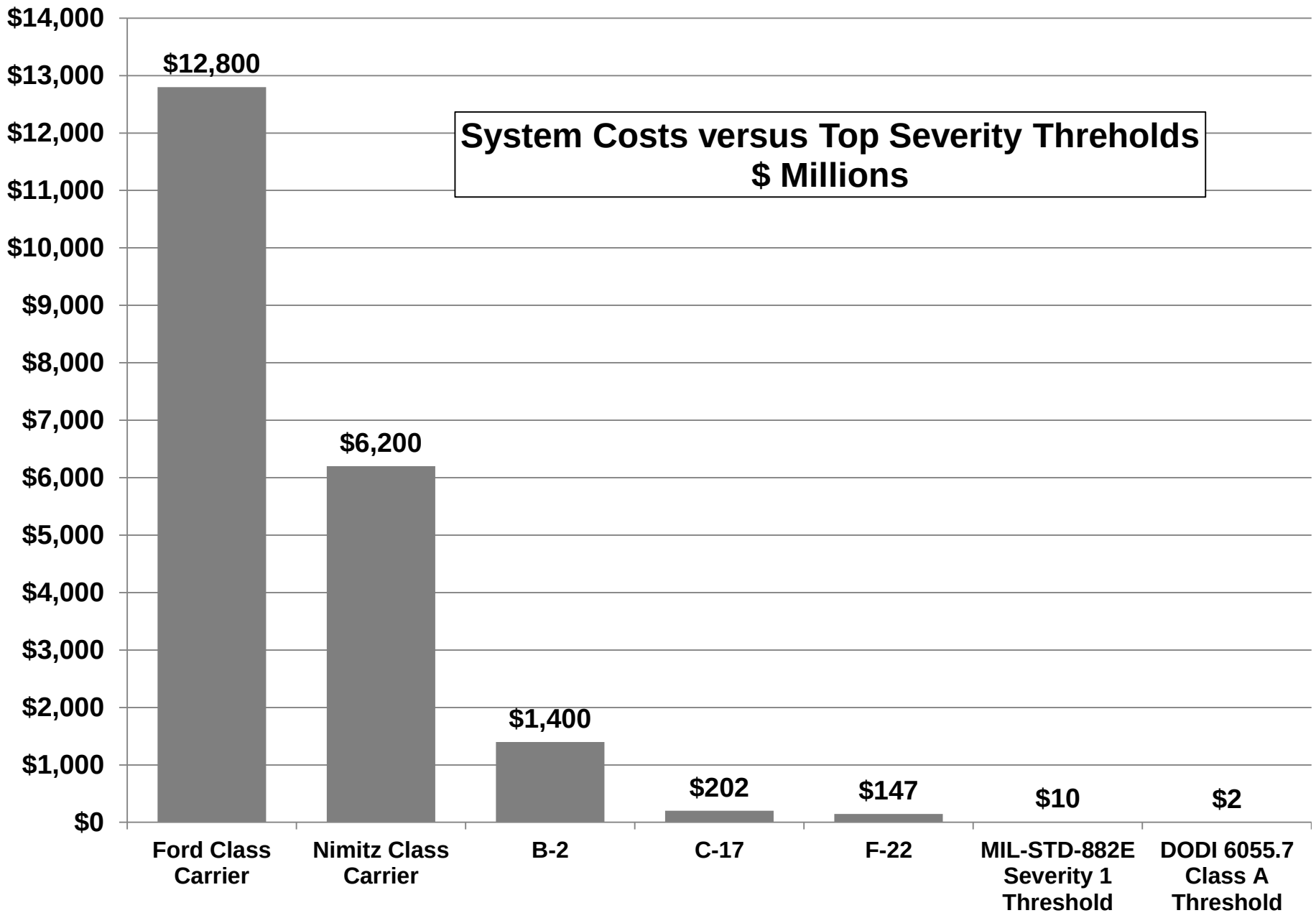
    } Both up from $1 million
    - Threshold for highest injury class remains 1 fatality
  - Systems exceed these values by up to three orders of magnitude
- Solution:
  - Numbered logarithmic severity scale similar to the Richter Scale
    - Improve the risk management of accidents
    - Enhance DOD operational risk management
    - Deals with National Threats (Presidential Policy Directive 8)
    - Deals with Global threats

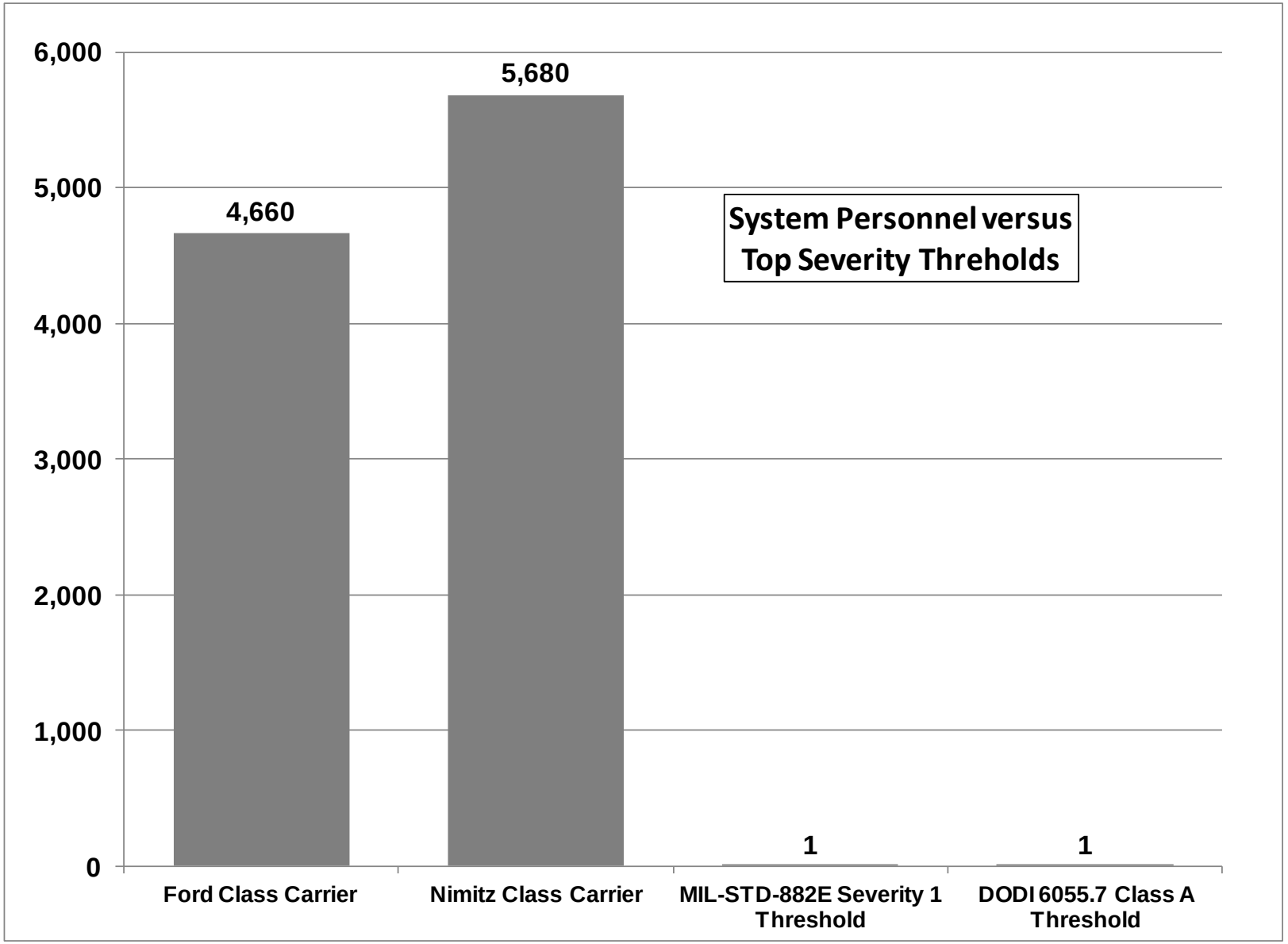
DoD's Accident Classification Structure
DoD Instruction 6055.07

- **Class A mishap**. The resulting total cost of damages to Government and other property is **$2 million** or more, a DoD aircraft is destroyed (excluding UAS Groups 1, 2, or 3), or an injury or occupational illness results in a fatality or permanent total disability.
- **Class B mishap**. The resulting total cost of damages to Government and other property is **$500,000** or more, but less than $2 million. An injury or occupational illness results in permanent partial disability, or when three or more personnel are hospitalized for inpatient care (which, for mishap reporting purposes only, does not include just observation or diagnostic care) as a result of a single mishap.
- **Class C mishap**. The resulting total cost of property damages to Government and other property is **$50,000** or more, but less than $500,000; or a nonfatal injury or illness that results in 1 or more days away from work, not including the day of the injury.
- **Class D mishap**. The resulting total cost of property damage is **$20,000** or more, but less than $50,000; or a recordable injury or illness not otherwise classified as a Class A, B, or C mishap.

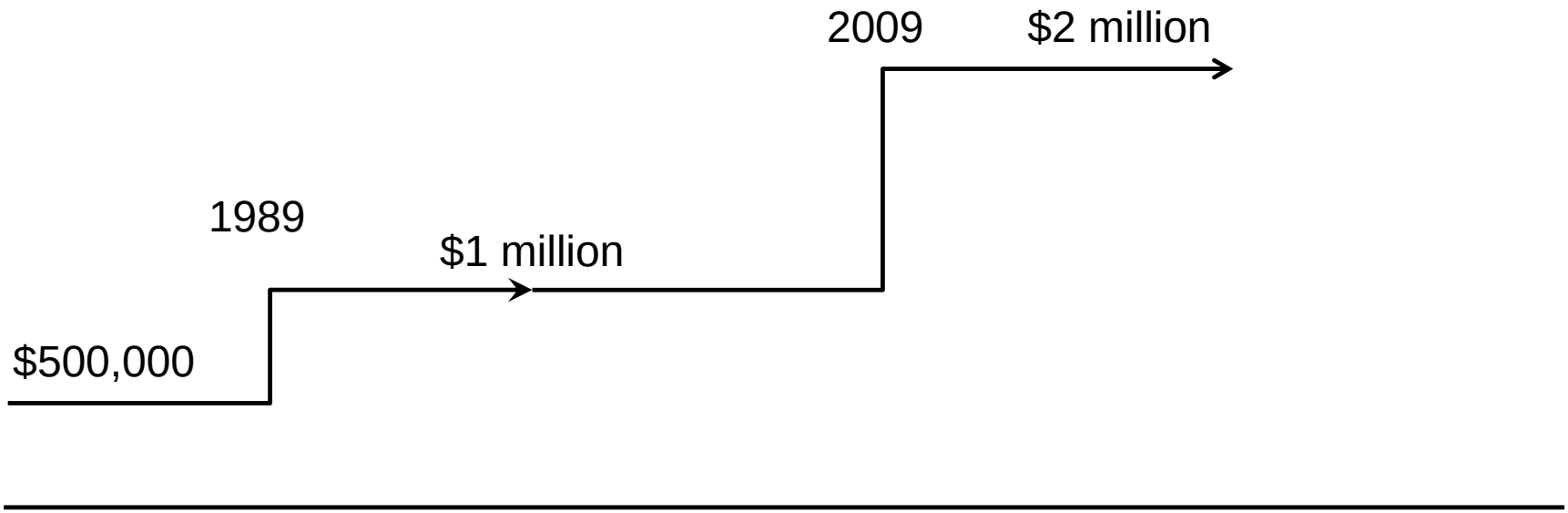
MIL-STD-882E Severity Categories

Description	Severity Category	Mishap Result Criteria
Catastrophic	1	Could result in one or more of the following: death, permanent total disability, irreversible significant environmental impact, or monetary loss equal to or exceeding **$10M.**
Critical	2	Could result in one or more of the following: permanent partial disability, injuries or occupational illness that may result in hospitalization of at least three personnel, reversible significant environmental impact, or monetary loss equal to or exceeding **$1M** but less than $10M.
Marginal	3	Could result in one or more of the following: injury or occupational illness resulting in one or more lost work day(s), reversible moderate environmental impact, or monetary loss equal to or exceeding **$100K** but less than $1M.
Negligible	4	Could result in one or more of the following: injury or occupational illness not resulting in a lost work day, minimal environmental impact, or monetary loss less than $100K.


System Costs versus Top Severity Threholds
$ Millions
$14,000
$13,000
$12,000
$11,000
$10,000
$9,000
$8,000
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
$12,800
$6,200
$1,400
$202
$147
$10
$2
Ford Class Carrier
Nimitz Class Carrier
B-2
C-17
F-22
MIL-STD-882E Severity 1 Threshold
DODI 6055.7 Class A Threshold

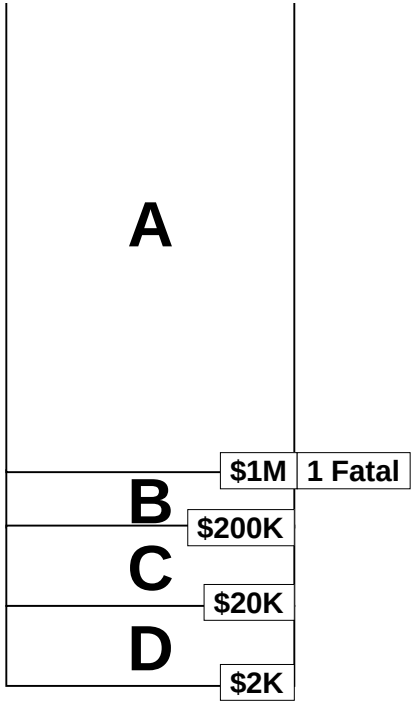

6,000
5,000
4,000
3,000
2,000
1,000
0
4,660
5,680
1
1
System Personnel versus Top Severity Threholds
Ford Class Carrier
Nimitz Class Carrier
MIL-STD-882E Severity 1 Threshold
DODI 6055.7 Class A Threshold

Background
Class A Accident

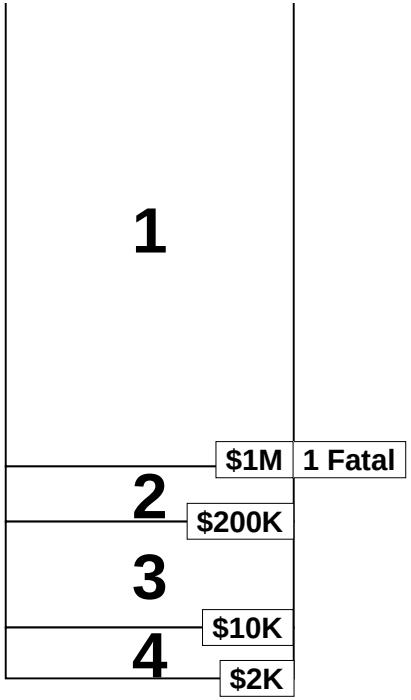


Before

Accident Class

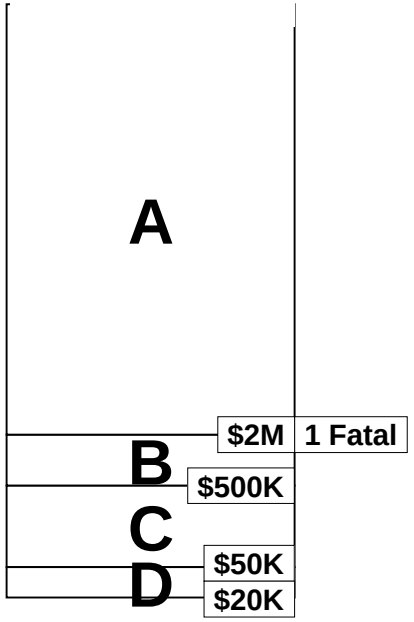


882D

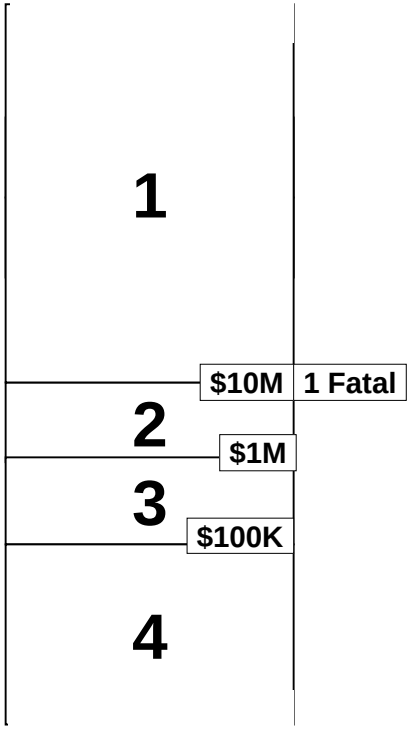


Now

Accident Class



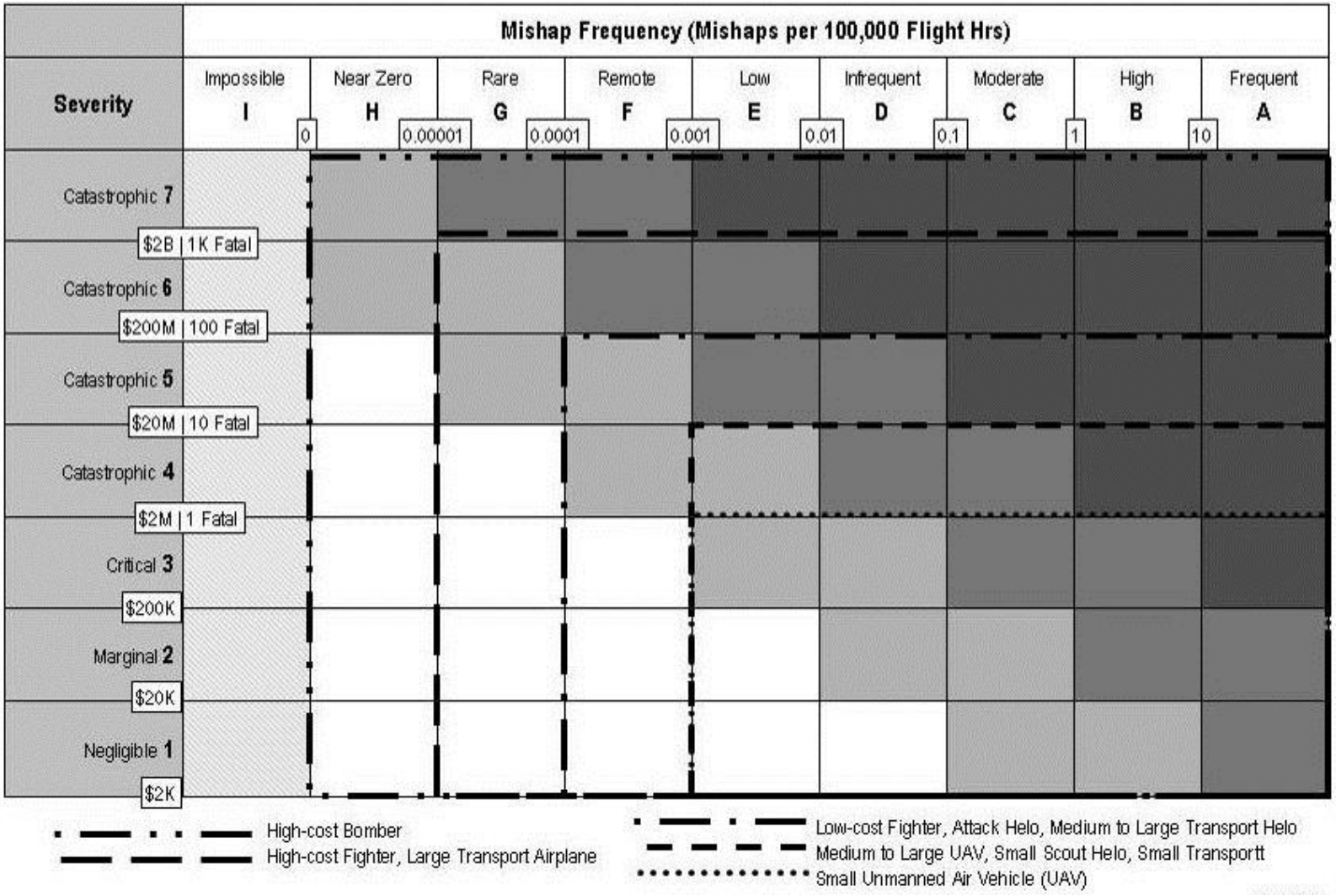
882E



Attributes of a good risk assessment matrix

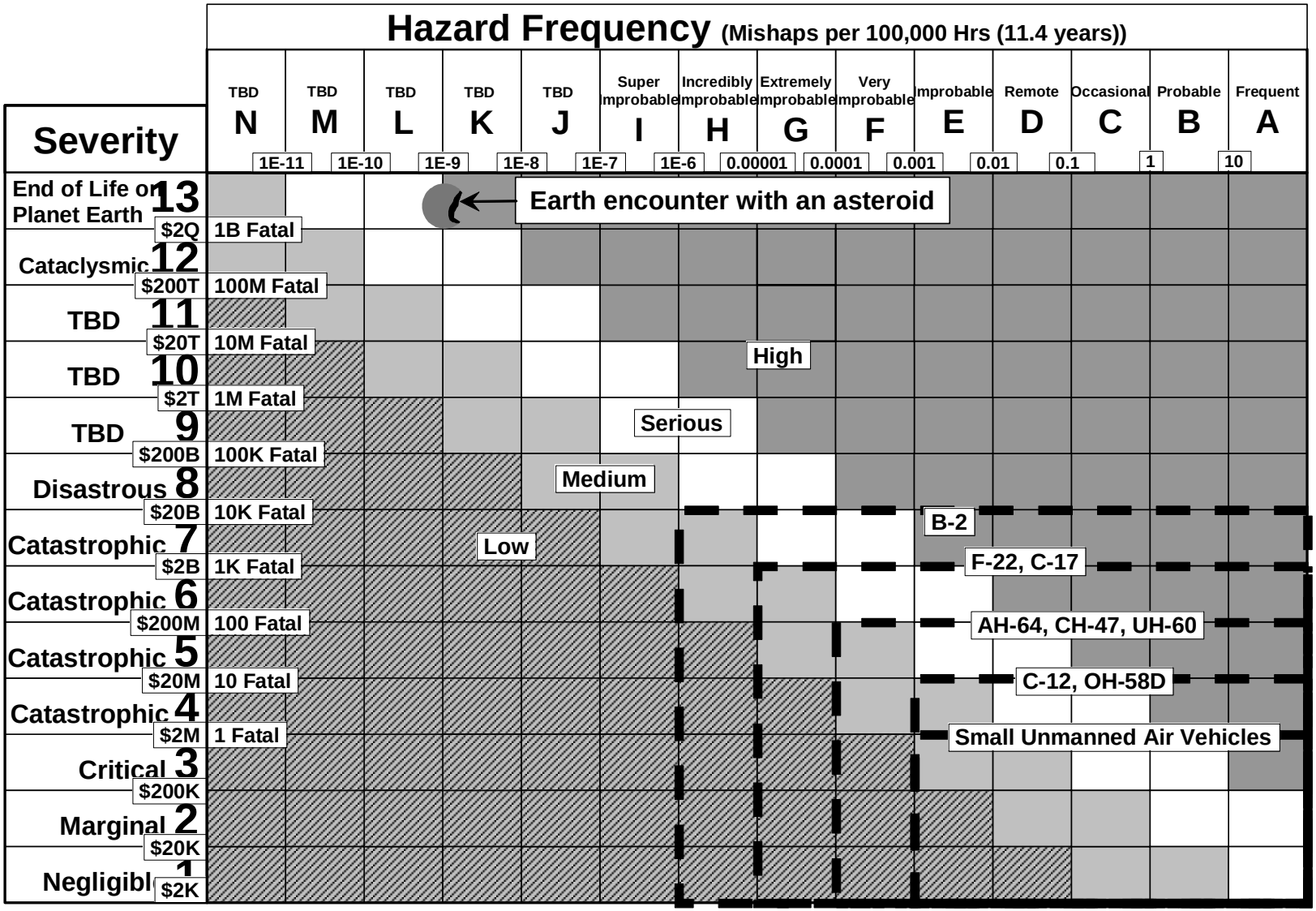
- Severity scale covers full range of possible outcomes
- Probability calibrated with reference to an exposure interval
- Equally proportioned, logarithmic scales (1, 10, 100, 1000…)
- Cartesian Orientation – Increase up and to the right
- Risk levels assigned to cells consistent with contours of equal risk (iso-risk contours)
- Sufficient probability or frequency categories so highest severity level can be assessed at the PM level of risk if the probability or frequency of occurrence is low enough
- A risk assessment code for hazards whose risk has been eliminated
- Easily tailored with reporting of risk consistent with other systems within the family of systems.

A common mishap risk assessment matrix for DoD aircraft systems.



Proposed DOD Matrix

Severity		1	2	3	4	5	6	7	8
		≥$2k	≥$20k	≥$200k	≥$2M	≥$20M	≥$200M	≥$2B	≥$20B
Frequency		Injury, no lost work day	Lost Work Day	Permanent partial disability	≥1 Fatality	≥10 Fatalities	≥100 Fatalities	≥1,000 Fatalities	≥10,000 Fatalities
A	**>100**								
B	**>10**								
C	**>1**						**Prohibitive SECDEF**		
D	**>0.1**					**High - CAE**			
E	**>0.01**				**Serious - PEO**				
F	**>0.001**			**Medium - PM**					
G	**>0.0001**	**Low – SSWG/Principal for Safety**							
H	**>0.00001**								
I	**> 0.000001**								
J	**≤ 0.000001**								


Hazard Frequency (Mishaps per 100,000 Hrs (11.4 years))
Severity
TBD N
TBD M
TBD L
TBD K
TBD J
Super Improbable I
Incredibly Improbable H
Extremely Improbable G
Very Improbable F
Improbable E
Remote D
Occasional C
Probable B
Frequent A
1E-11
1E-10
1E-9
1E-8
1E-7
1E-6
0.00001
0.0001
0.001
0.01
0.1
1
10
End of Life on Planet Earth 13
$2Q 1B Fatal
Cataclysmic 12
$200T 100M Fatal
TBD 11
$20T 10M Fatal
TBD 10
$2T 1M Fatal
TBD 9
$200B 100K Fatal
Disastrous 8
$20B 10K Fatal
Catastrophic 7
$2B 1K Fatal
Catastrophic 6
$200M 100 Fatal
Catastrophic 5
$20M 10 Fatal
Catastrophic 4
$2M 1 Fatal
Critical 3
$200K
Marginal 2
$20K
Negligibl 1
$2K
Earth encounter with an asteroid
High
Serious
Medium
Low
B-2
F-22, C-17
AH-64, CH-47, UH-60
C-12, OH-58D
Small Unmanned Air Vehicles

Scope

Arenas

- DoD Accident Classification and System Safety Risk Assessment
- DOD Operational Risk Management
- National Preparedness
- Global Preparedness

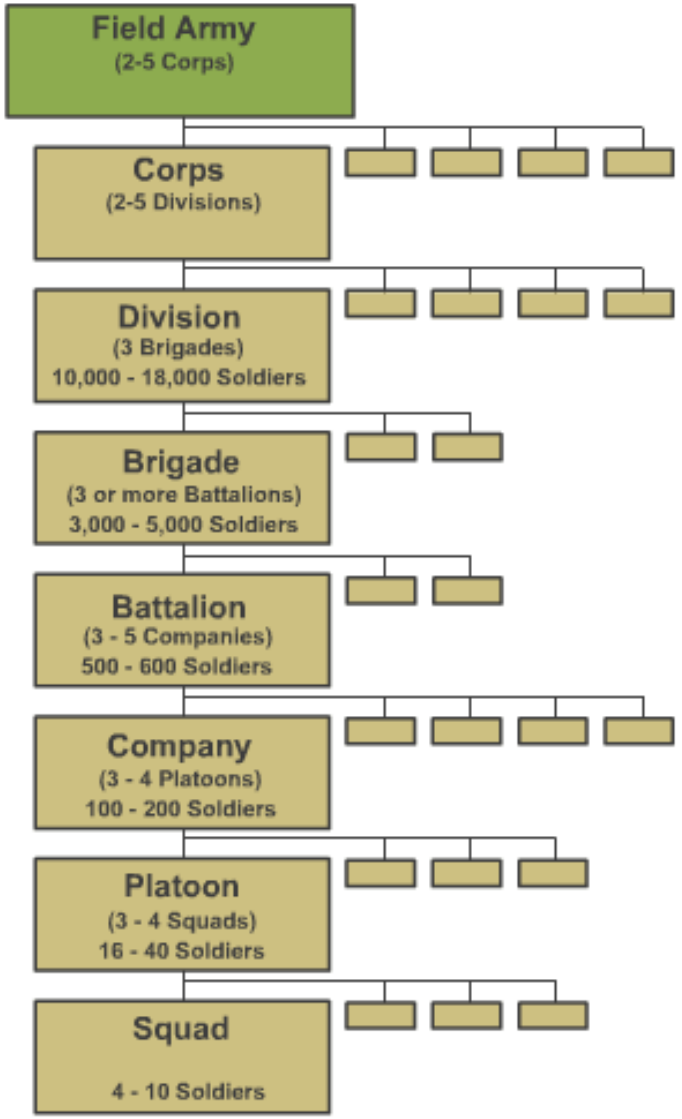
DA Pam 385-30 Standardized Army risk matrix

		Probability				
Severity		**Frequent A**	**Likely B**	**Occasional C**	**Seldom D**	**Unlikely E**
Catastrophic	I	E (1)	E (1)	H (2)	H (2)	M (3)
Critical	II	E (1)	H (2)	H (2)	M (3)	L (4)
Marginal	III	H (2)	M (3)	M (3)	L (4)	L (5)
Negligible	IV	M (3)	L (4)	L (4)	L (5)	L (5)

DA Pam 385–30 Risk acceptance matrix

	Duration of risk				
Category of risk	**1 month or less**	**Greater than 1 month, less than 1 year**	**Greater than 1 year, less than 5 years**	**Permanent or greater than 5 years**	**Chartered system development programs**
Extremely high risk	General officer	MSC CG – General officer	Army Headquarters CG	ASA(I&E)	Component Acquisition Executive (CAE)
High risk	Brigade CO or responsible O-6	General officer[1]	MSC CG – General officer	Army Headquarters CG	Program Executive Officer (PEO)
Moderate risk	Battalion CO[1] or responsible O-5	Brigade CO[1] or responsible O-6	General officer[1]	General officer[1]	Program manager
Low risk	Company CO[2] or responsible O-3	Battalion CO[2] or responsible O-5	Brigade CO[1] or responsible O-6	Brigade CO[1] or responsible O-6	Program manager
Tolerable risk	Not required	Not required	Not required	Not required	Not required

U.S. Army Operational Units



Valley

Clark Air Base

Mt. Pinatubo

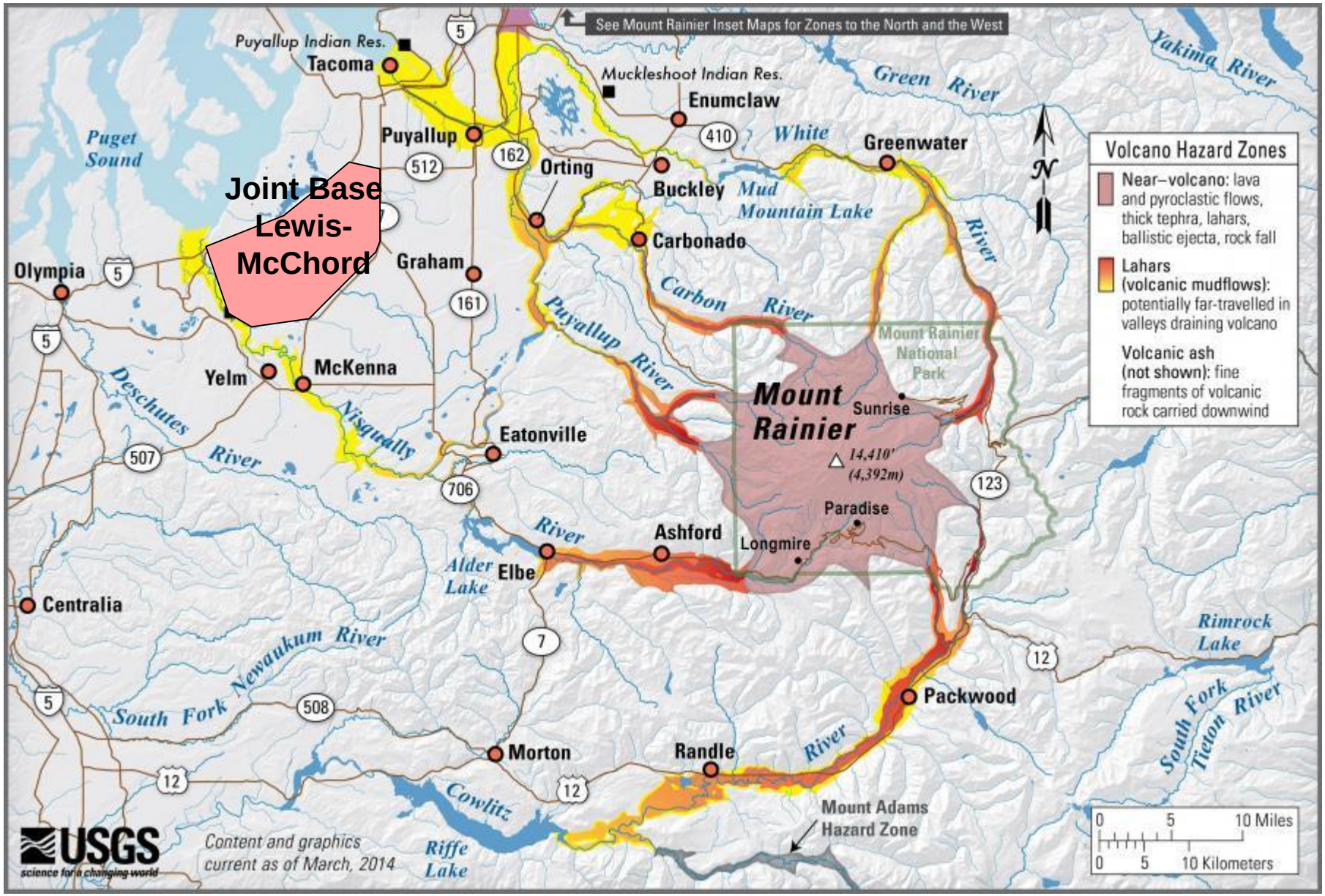
Mt. Arayat

San Miguel NCS

Subic Bay

Aircraft Hangars at Clark Air Base Destroyed by Ashfall

Mt Rainier & Joint Base Lewis-McChord



Strategic National Risk Assessment (SNRA) (2011) National-Level Events

Threat/ Hazard Group	Threat/Hazard Type
Natural	Animal Disease Outbreak
	Earthquake
	Flood
	Human Pandemic Outbreak
	Hurricane
	Space Weather
	Tsunami
	Volcanic Eruption
	Wildfire
Technological/ Accidental	Biological Food Contamination
	Chemical Substance Spill or Release
	Dam Failure
	Radiological Substance Release
Adversarial/ Human-Caused	Aircraft as a Weapon
	Armed Assault
	Biological Terrorism Attack (non-food)
	Chemical/Biological Food Contamination Terrorism Attack
	Chemical Terrorism Attack (non-food)
	Cyber Attack against Data
	Cyber Attack against Physical Infrastructure
	Explosives Terrorism Attack
	Nuclear Terrorism Attack
	Radiological Terrorism Attack

Global Hazards

Global Hazards*

- Extreme Climate Change
- Nuclear War
- Global Pandemic
- Ecological Catastrophe
- Global System Collapse
- Major Asteroid Impact
- Super-volcano
- Synthetic Biology
- Nanotechnology
- Artificial Intelligence
- Unknown Consequences
- Future Bad Global Governance

*Global Challenges – Twelve risks that threaten human civilisation – The case for a new category of risks (February 2015, Global Challenges Foundation)

Desired Outcomes

1. Must support DoD policy regarding the investigation of mishaps and the assessment of environmental, safety, and occupational health hazards for DoD systems
2. Must be a useful tool to all levels of DoD leadership in employing risk management for the full range of DoD operations
3. Must be useful in support of national preparedness to include managing the risk of all 23 "National-Level Events"
4. Must be useful in support of global preparedness.

Alternatives 1

Keep the Status Quo

- Accident classes A, B, C, D
- Severity categories 1, 2, 3, 4
- Increase opposite increasing severity
- Adjust thresholds every 10 to 20 years
  - Small Incremental Changes

Alternative 2

Number severity scales increasing in same direction as increasing severity

- Start numbering with Severity Category 1 for the lowest range of severity
- Add one severity category for each 10 fold increase in severity
- Add categories until full range of potential loss is covered for a specific system.
- Do this for dollar value of damage and for injuries and fatalities
- Eliminate one-word labels (Catastrophic, Critical, Marginal, Negligible)

Alternative 1

Accident Class

A

B — $2M — 1 Fatal

B — $500K

C

D — $50K

D — $20K

882E

1

2 — $10M — 1 Fatal

2 — $1M

3

3 — $100K

4

Alternative 2

13

12 — $2Q — 1B Fatal

11 — $200T — 100M Fatal

10 — $20T — 10M Fatal

9 — $2T — 1M Fatal

8 — $200B — 100K Fatal

7 — $20B — 10K Fatal

6 — $2B — 1K Fatal

5 — $200M — 100 Fatal

4 — $20M — 10 Fatal

3 — $2M — 1 Fatal

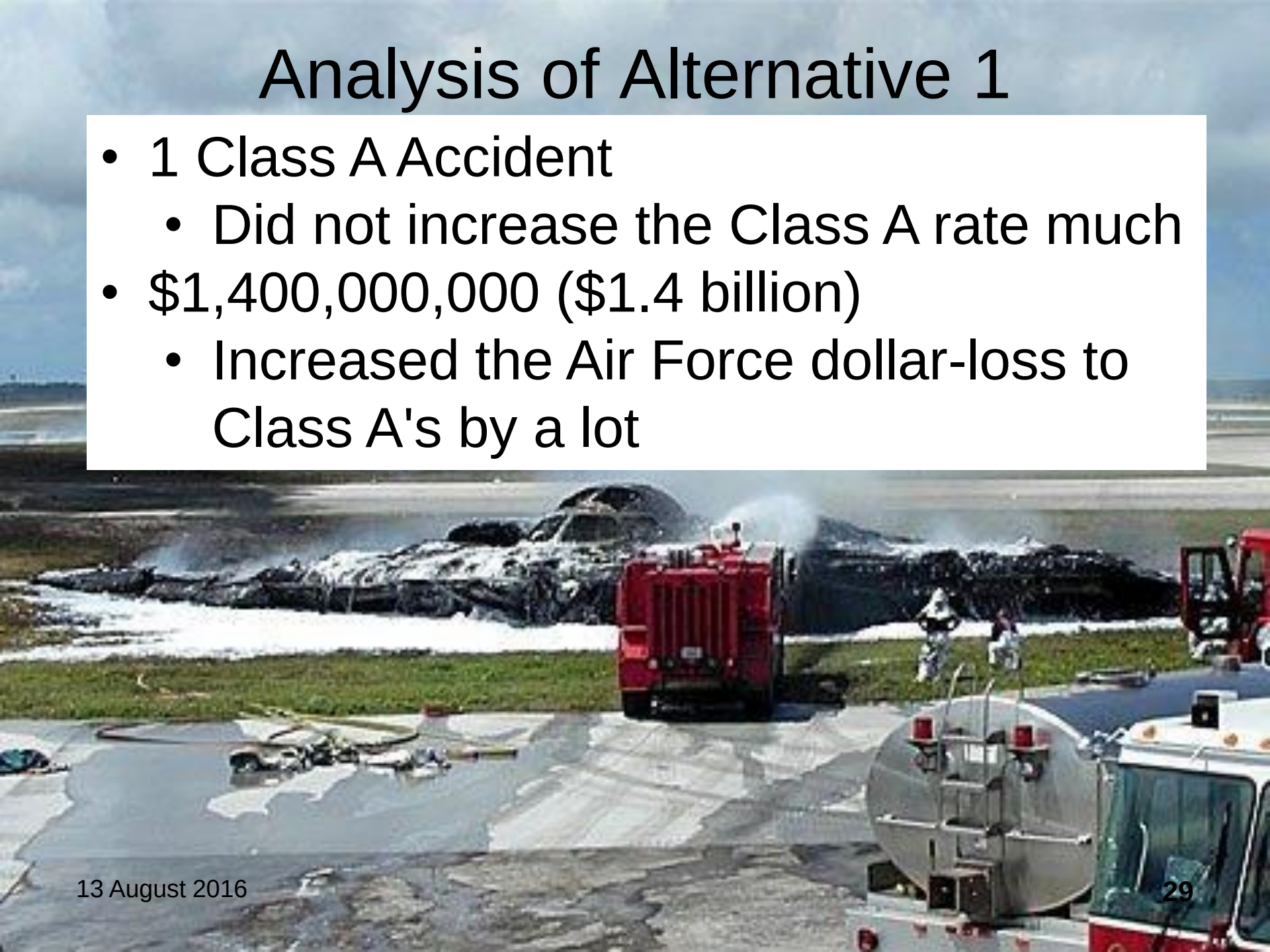
2 — $200K

1 — $20K

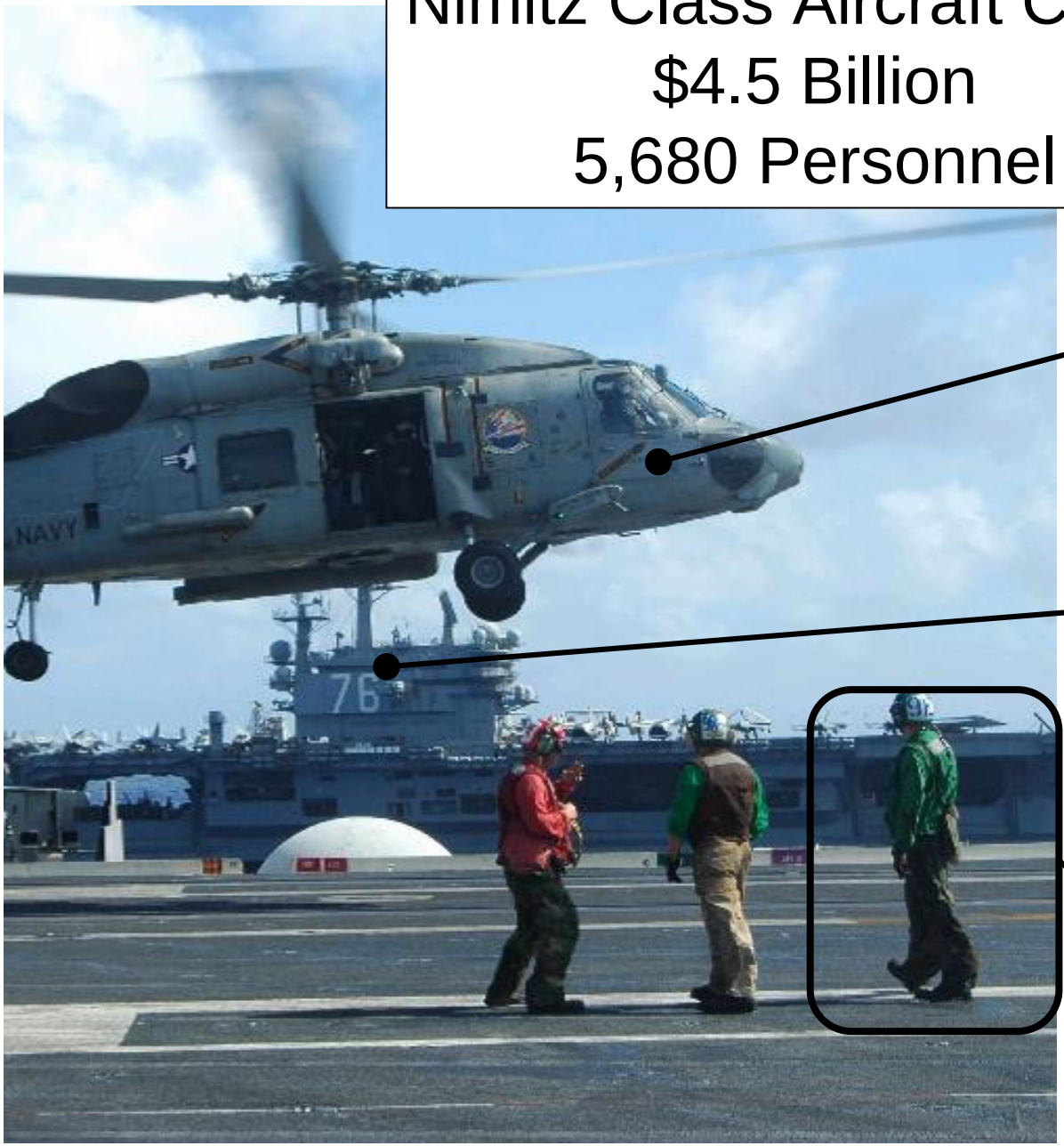
$2K

Analysis of Alternative 1

- 1 Class A Accident
  - Did not increase the Class A rate much
- $1,400,000,000 ($1.4 billion)
  - Increased the Air Force dollar-loss to Class A's by a lot



Nimitz Class Aircraft Carrier
$4.5 Billion
5,680 Personnel



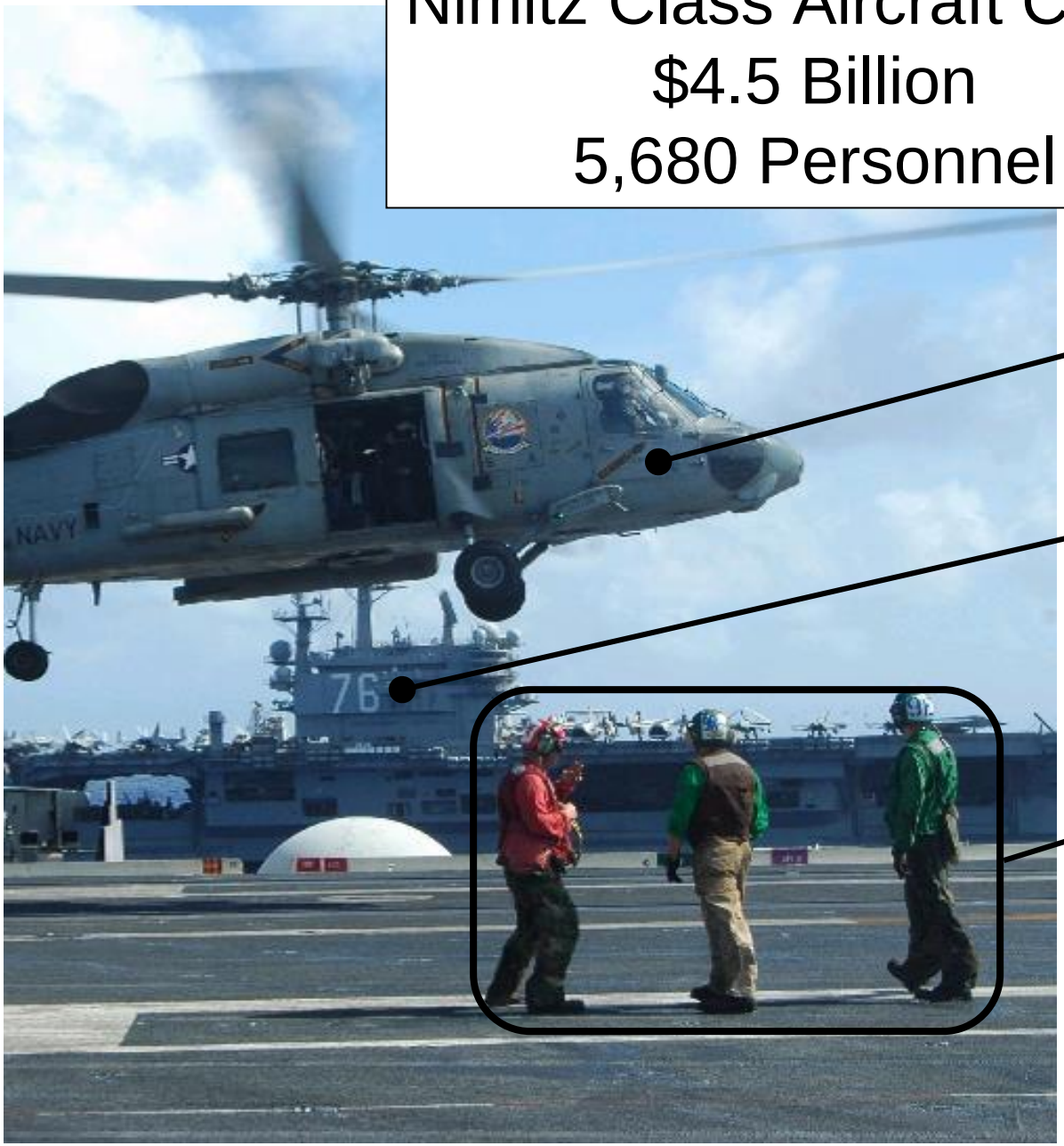
Alternative 1

Severity 1
Class A

Severity 1
Class A

Severity 1
Class A

Nimitz Class Aircraft Carrier
$4.5 Billion
5,680 Personnel



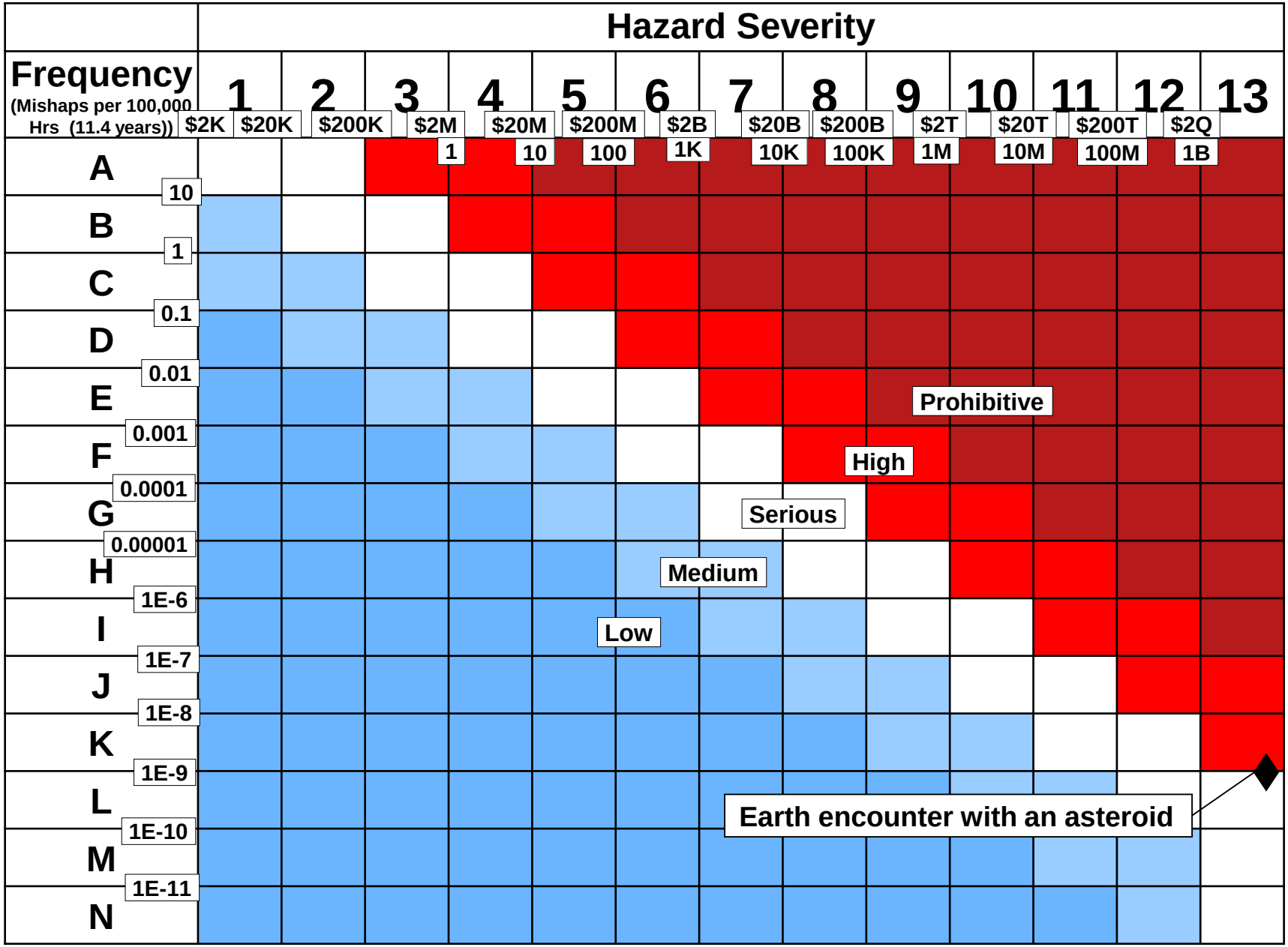
Alternative 2

Severity 5

Severity 7

Severity 4

Mother of All Risk Assessment Matrices (Spaceship Earth)



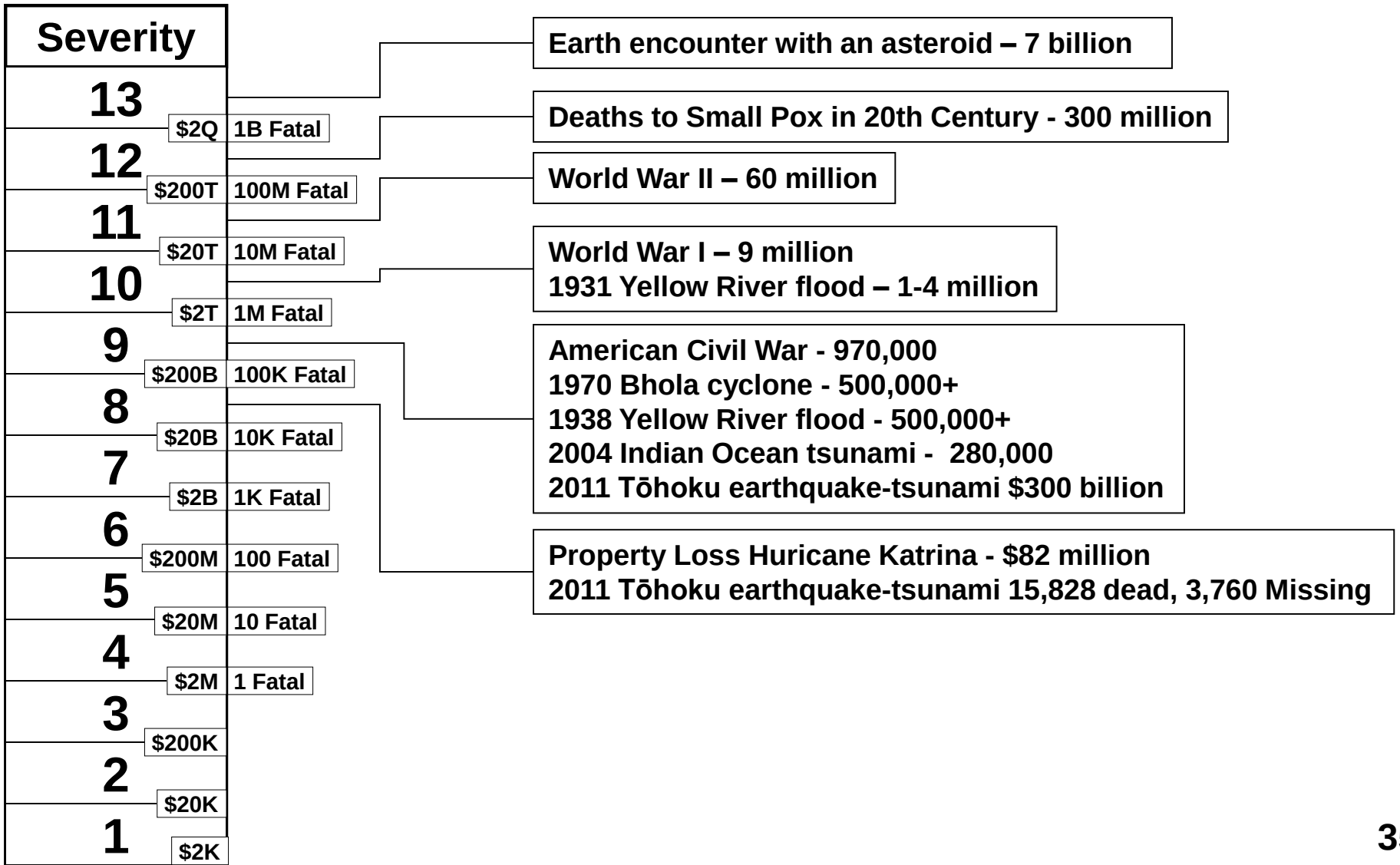
Cost

- Short Term
  - Cost is the same
    - Update publications
    - Update procedures
    - Update database reports
- Long Term
  - Alternative 2 requires no further changes except corrections for inflation which can be automated

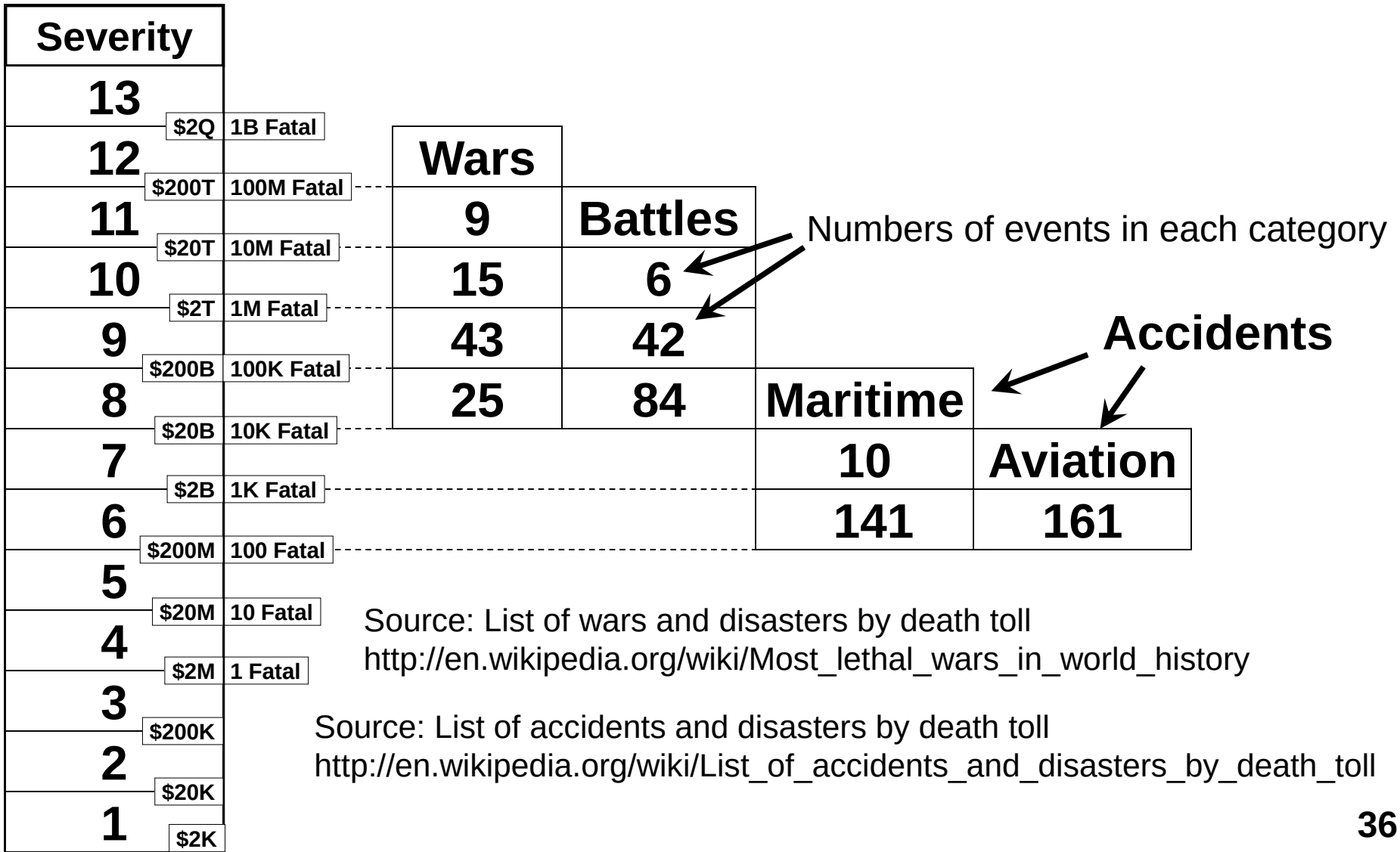
Benefits

- Alternative 1
  - None
- Alternative 2
  - Improved comprehension of the significance of all actual or potential high-loss events
    - For leadership
    - For the public
  - Just as with the Richter scale for earthquakes

Severity Categories of Big Events



Severity of Historical Events Based on Fatalities



Source: List of wars and disasters by death toll
http://en.wikipedia.org/wiki/Most_lethal_wars_in_world_history

Source: List of accidents and disasters by death toll
http://en.wikipedia.org/wiki/List_of_accidents_and_disasters_by_death_toll

Conclusion

- Current severity scales used in DODI 6055.07 and MIL-STD-882E are not structured to deal with the large costs of DoD systems.
- Top thresholds too low.
- Current reversed letters and numbers make it difficult to adjust the scales to reflect cost realities of present and future systems.
- A logarithmic risk severity scale numbered to increase in the same direction as increasing severity can be used for the full range of environmental, safety and occupational health risk management challenges to include global worst case scenarios for the full range of natural and man-made disasters.

Recommendation

- Begin the transition to the new scale
  - Develop reports and risk assessments based on existing accident and other disastrous event data.
  - This will help to educate today's environmental, safety and occupational health risk management personnel and others dealing with these kinds of events on the utility of this tool.
  - It will also help calibrate the thinking of all government leaders on the meaning of risk assessment in the same way that the Richter Scale helped the scientific community and general public of the 1930s to comprehend the nature of earthquake severity data.

Questions?

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