Part II/Risk-Based Siting Criteria – Current and Future Efforts in Risk Management and Siting Applications

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NAVFAC EXWC
CI7 Explosives Effects and Consequences

2018 International Explosives Safety Symposium and Exposition
San Diego, California, USA
7-9 August 2018

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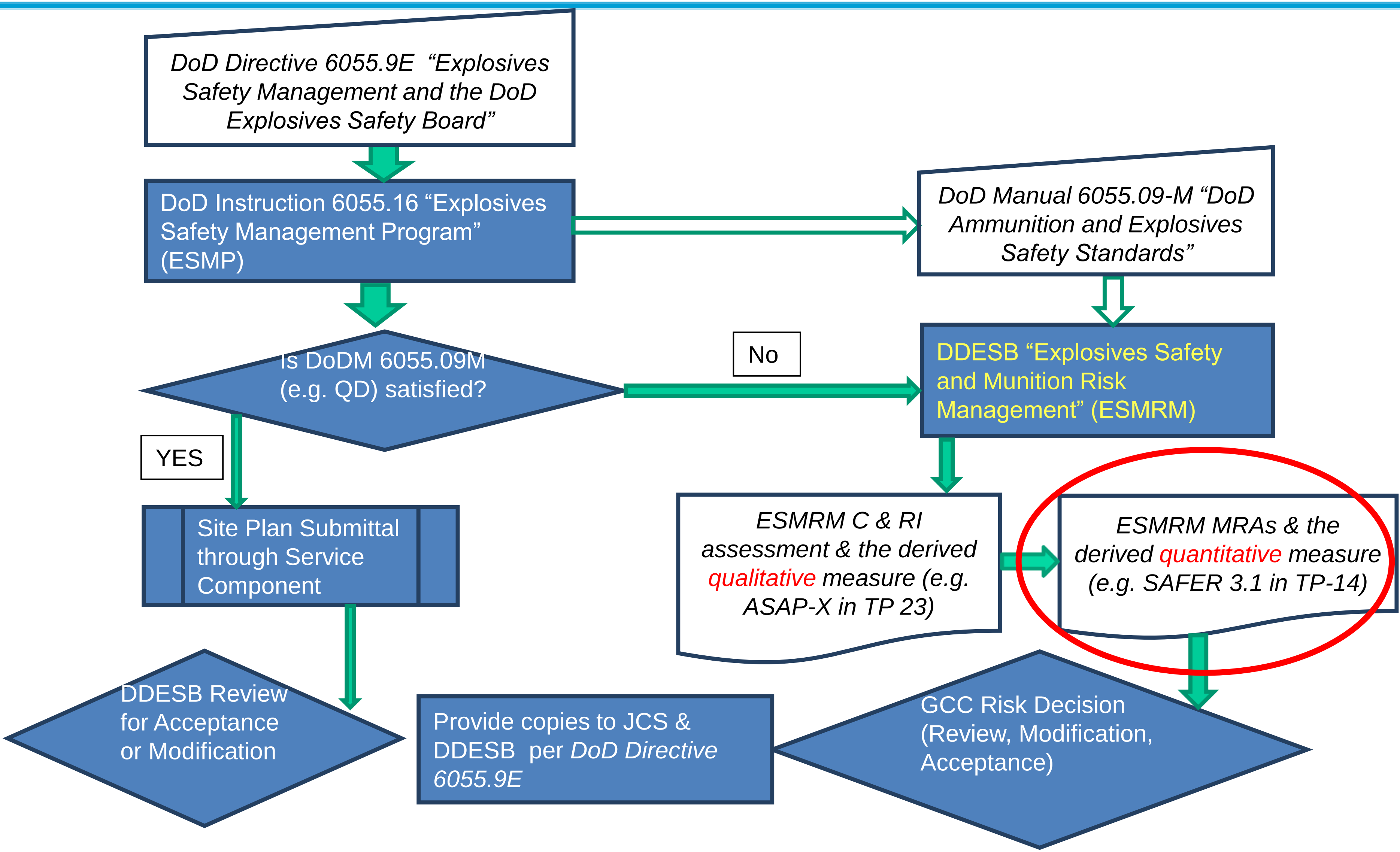
PART I: presents the overview on the future development of Risk Methodology for siting and improvements

Overview of ESMRM Policy



Risk Puzzle

$$Risk = Probability\ of\ Event(\mathrm{P_e}) \times Consequences \times Exposure$$

Current Probability of Event (P_e)

P_e Matrix in TP 14 Rev. 4a

Activity	Element I	Element II	Element III
Assembly / Disassembly / LAP / Maintenance / Renovation	4.70E-03	4.70E-04	1.60E-04
Burning Ground / Demil / Demolition / Disposal	2.40E-02	2.40E-03	8.10E-04
Lab / Test / Training	4.30E-03	4.30E-04	1.40E-04
Loading / Unloading	5.70E-04	5.70E-05	1.90E-05
Inspection / Painting / Packing	8.20E-04	8.20E-05	2.70E-05
Manufacturing	1.70E-03	1.70E-03	1.70E-03
Deep Storage (longer than 1 month)	2.50E-05	2.50E-05	2.50E-06
Temporary Storage (1 day - 1 month)	1.00E-04	3.30E-05	1.10E-05
In-Transit Storage (hours-few days)	3.0E-04	1.0E-04	3.3E-05

Originally developed in the late 1990's

Elements	Compatibility Group
I	L, A, B, G, H, J, F
II	C
III	D, E, N

Notes: The elements in the matrix are comprised of Compatibility Groups. Definitions of the Compatibility Groups can be found in DoD 6055.09-M. Ref 5

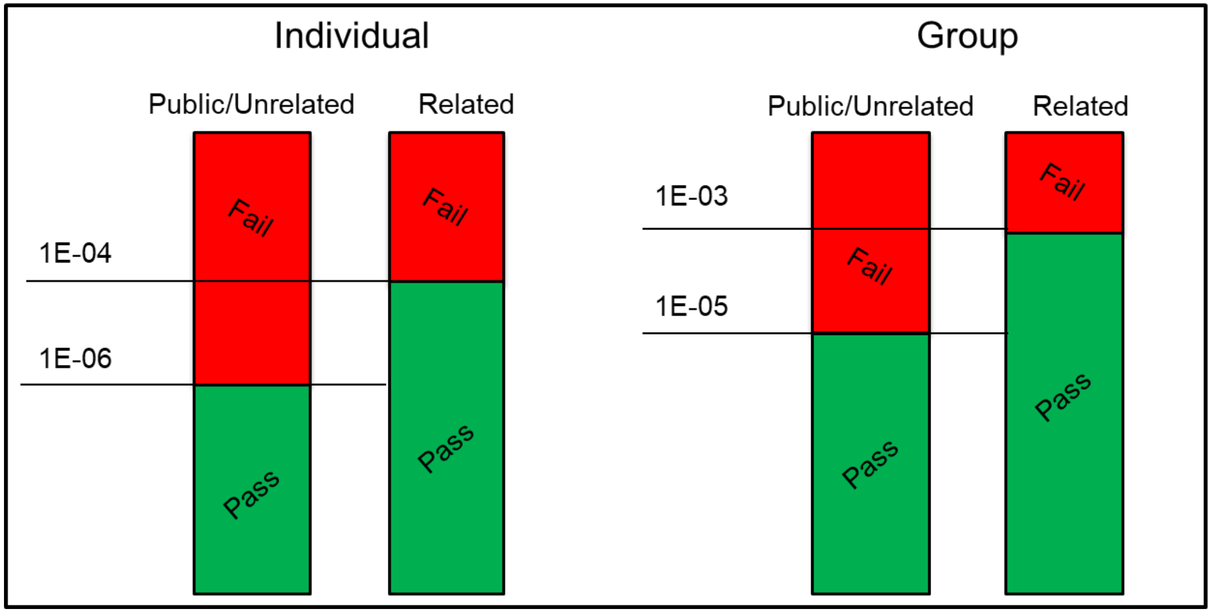
Proposed Probability of Event (P_e)

Activity	HD 1.1/1.2/1.5	HD 1.3	HD1.6
Assembly / Disassembly / LAP / Maintenance / Renovation	5.37E-04	1.61E-03	5.37E-06
Burning Ground / Demil / Demolition / Disposal	7.78E-03		
Lab / Test	9.75E-04		
Training	9.75E-04	2.92E-03	9.75E-06
Loading / Unloading	3.15E-05	9.45E-05	3.15E-07
Inspection / Painting / Packing	2.05E-04	6.16E-04	2.05E-06
Manufacturing	1.90E-03		
Storage	1.20E-05	3.59E-05	1.20E-07

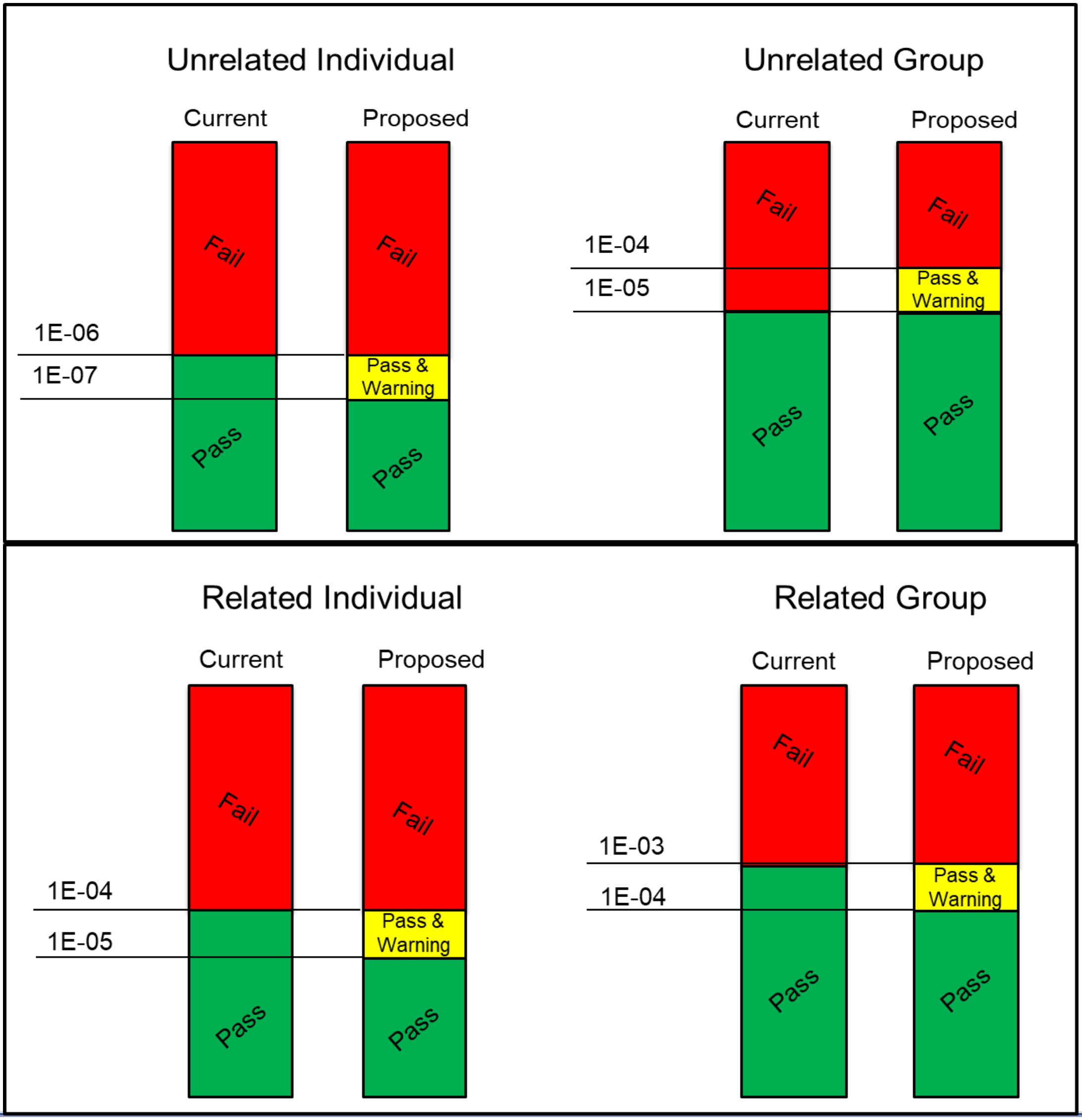
- HD 1.5 blasting agents should have a (beneficial) scaling factor of 0.01. HD 1.5 water-based explosives should have a (beneficial) scaling factor of 0.03.
- CGs L, A, B, G, H, F, J should not have any scaling factor.
- CG C should have a beneficial scaling factor of 0.3 in addition to the environmental factors.
- CGs D, E, N should have a (beneficial) scaling factor of 0.1 in addition to the environmental factors.
- The environmental factors can be beneficial (i.e., < 1.0) in TP-14 Rev 5, in addition to the detrimental environmental factors in TP-14 Rev 4a. Temporary storage and in-transit storage will be added as environmental factors.

Consequences in TP-14 4a

Personnel Category		Current Pass/Fail Criterion
Related	Individual	1E-04
	Group	1E-03
Public	Individual	1E-06
	Group	1E-05



Proposed vs. Current Consequences



Uncertainty Modeling

INPUT VARIABLES		Ref.
median value of delta t	Δt_o	
std dev of delta t	$\sigma_{\Delta t}$	**RV1**
median value of Scale Factor	S_o	
std dev of Scale Factor	σ_S	RV2
median value of λo	λ_{oo}	
std dev of λo	$\sigma_{\lambda o}$	RV3
Ep Median Daily Exposure	E_{oo}	
Rand Var std dev Exposure	σ_e	RV4
Ep std dev of Exposure	σ_{Eo}	RV5
Ep Median Pf|e blast	$P_{f\|1oo}$	
Ep std dev for blast	σ_{1o}	RV6
std dev for variation in blast	σ_1	RV7
Ep Median Pf|e bldg damage	$P_{f\|2oo}$	
Ep std dev for bldg damage	σ_{2o}	RV8
std dev for variation in bldg damage	σ_2	RV9
Ep Median Pf|e debris	$P_{f\|3oo}$	
Ep std dev for debris	σ_{3o}	RV10
std dev for variation in debris	σ_3	RV11
Ep Median Pf|e glass	$P_{f\|4oo}$	
Ep std dev for glass	σ_{4o}	RV12
std dev for variation in glass	σ_4	RV13
Ep std dev Pf|e due to Yield	σ_{yo}	RV14
Std Dev Pf|e due to Yield	σ_y	RV15
Std Dev Rnd Var λ due to NEW	σ_{NEW1}	**RV16**

Input Distribution	Variable	Normal	Lognormal	Triangular
Delta t	Median of delta t	X		
	Std dev of delta t			
Scale Factor	Median of Scale Factor			X
	Std dev of Scale Factor			
Lambda	Median of lambda		X	
	Std dev of lambda			
Daily Exposure	Ep Median Daily Exposure	X		
	Ep std dev of Exposure			
	Rand Var std dev Exposure	X		
Blast	Ep Median Pf|e blast		X	
	Ep std dev for blast			
	Std dev for variation in blast	X		
Building Collapse	Ep Median Pf|e bldg collapse		X	
	Ep std dev for bldg collapse			
	Std dev for variation in bldg collapse	X		
Debris	Ep Median Pf|e debris		X	
	Ep std dev for debris			
	Std dev for variation in debris	X		
Glass	Ep Median Pf|e glass		X	
	Ep std dev for glass			
	Std dev for variation in glass	X		
Yield	Ep std dev Pf|e due to Yield		X	
	Std dev Pf|e due to Yield	X		
NEW	St dev Pfe due to NEW	X		

Monte Carlo Simulation for Uncertainty Modeling

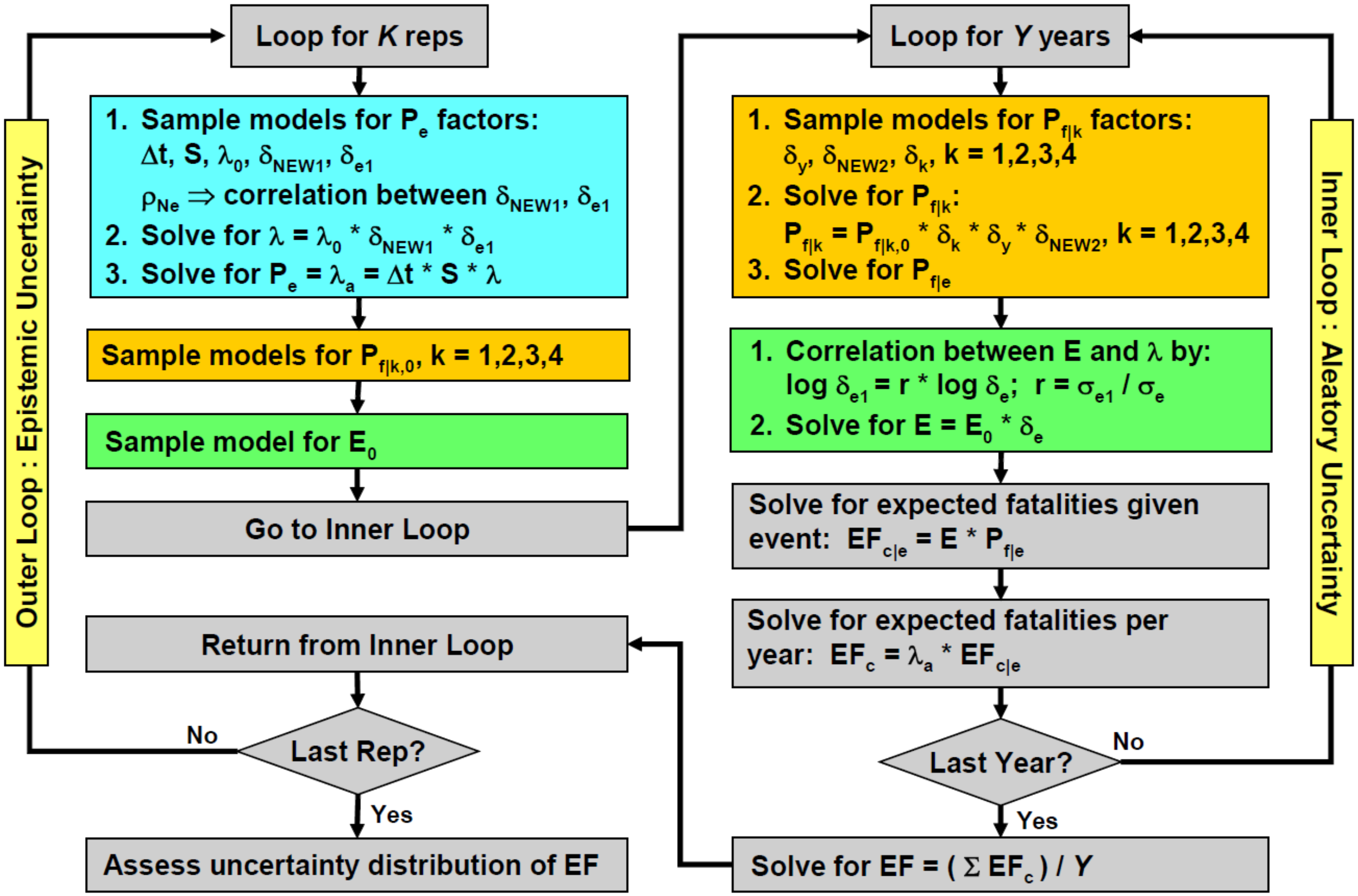
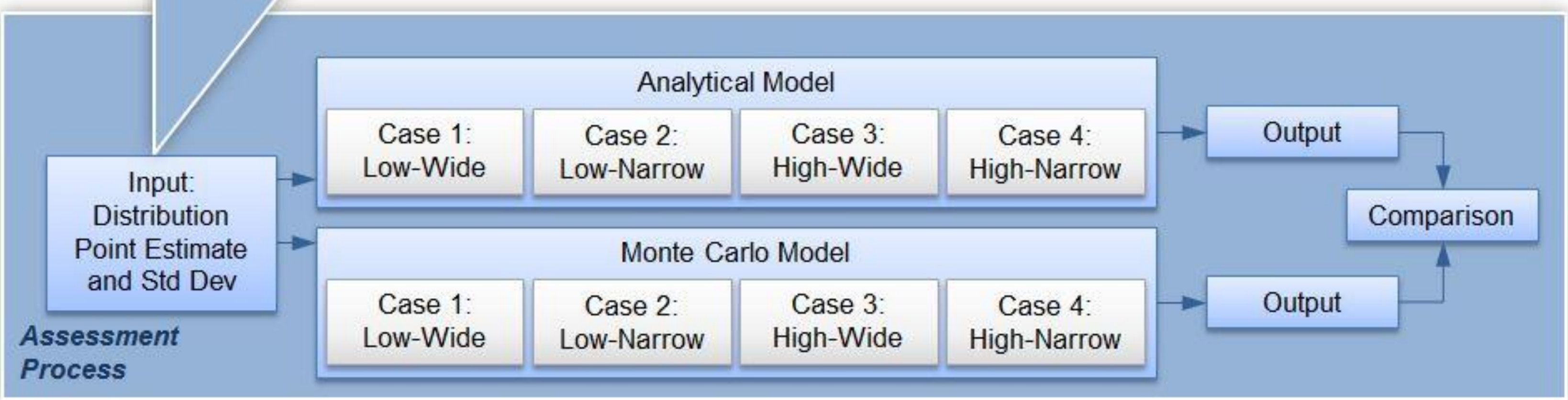


Figure 11. Two-Loop Monte Carlo Experiment to Evaluate SAFER MOW

Uncertainty Updating

Part	Distribution	Point Estimate	Completion References
1	Lognormal	Median	CE1-17-00300
2	Lognormal	Mean	CE1-17-00300
3a	Triangular	Mode	CE1-17-00301
3b	Normal	Median	CE1-17-00301
3c	Mixed*	Median / Mode	
4	Mixed*	Mean / Mode	

* Mixed Distribution Selections detailed on next chart

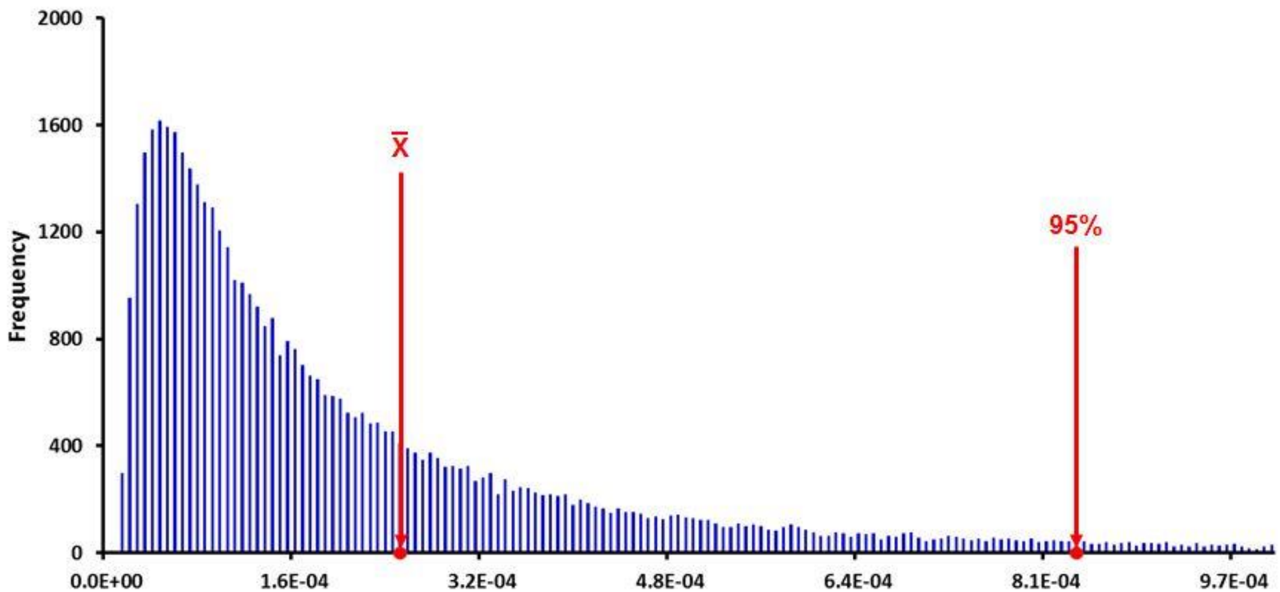


Example

PART 4
CASE 3 (HIGH-WIDE) RESULTS

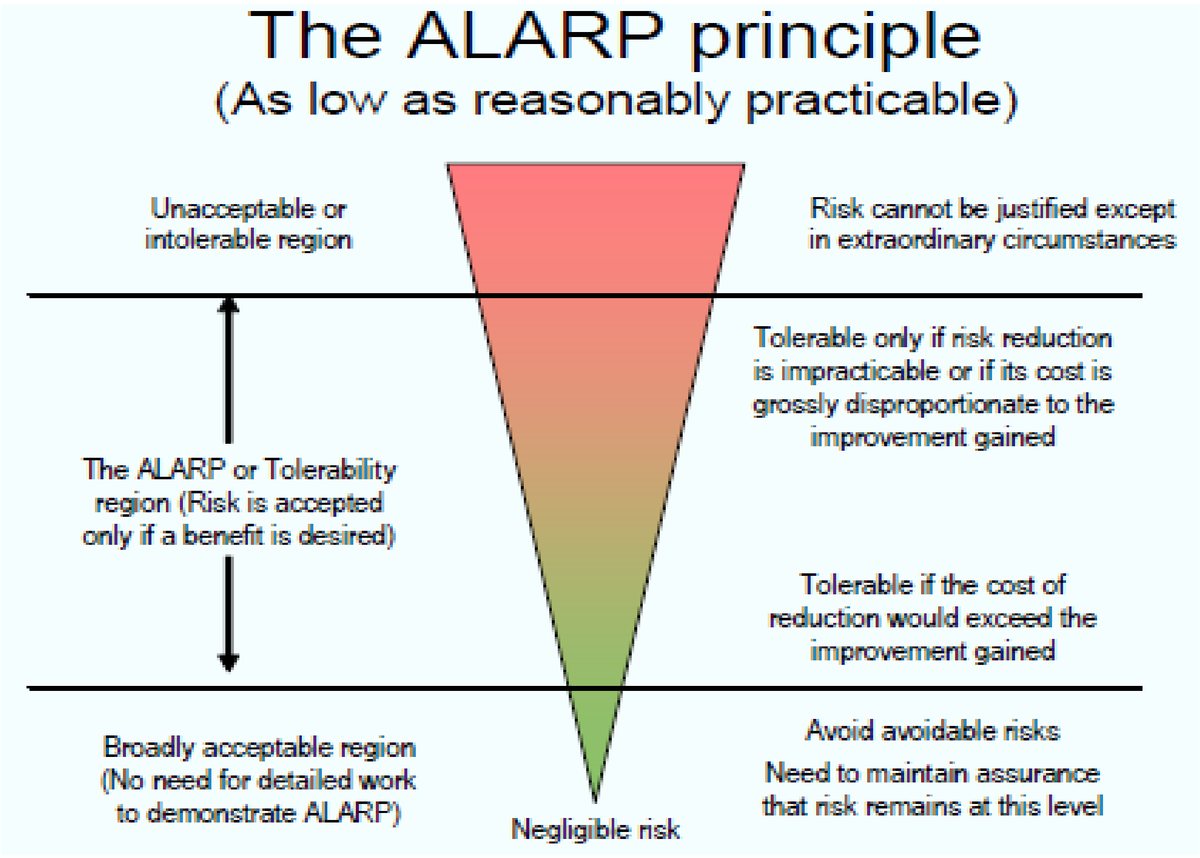
Solution Method	Part 4, Case 3 (High-Wide)		
	Expect Val	Std Dev	95th %
Analytical Method	2.35E-04	3.12E-04	7.42E-04
Experimental (Monte Carlo)	2.47E-04	3.54E-04	8.32E-04
Δ%	5.01%	13.50%	12.11%

Part 4 Experimental Parameters	
Outer Loop : K Reps	50,000
Inner Loop: Y Years	50,000
Random Number Seed	35611

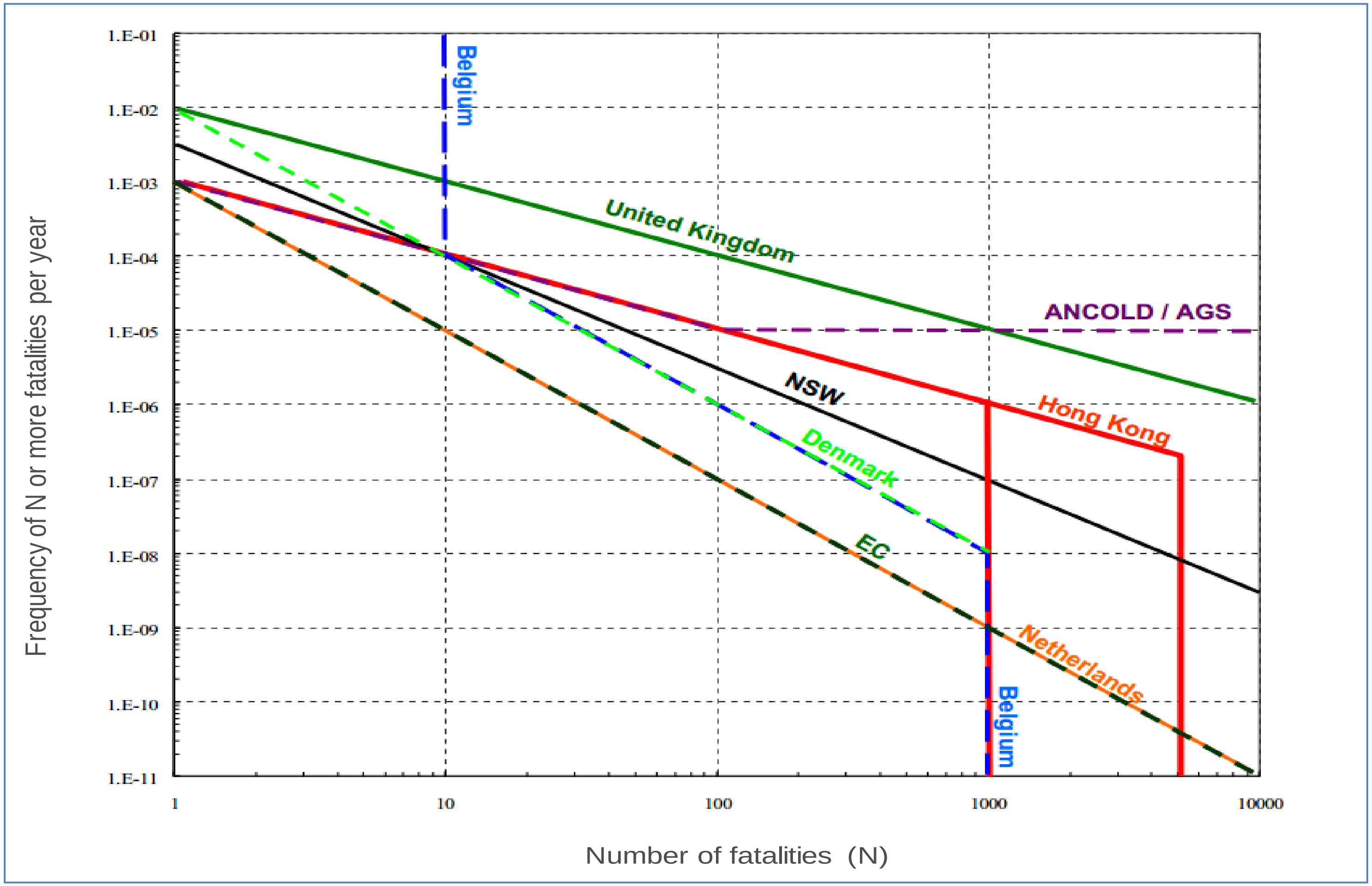


Annual Expected Fatalities, EF
(Part 4, Case 3 Results)

Risk Acceptance Criteria (ALARP)

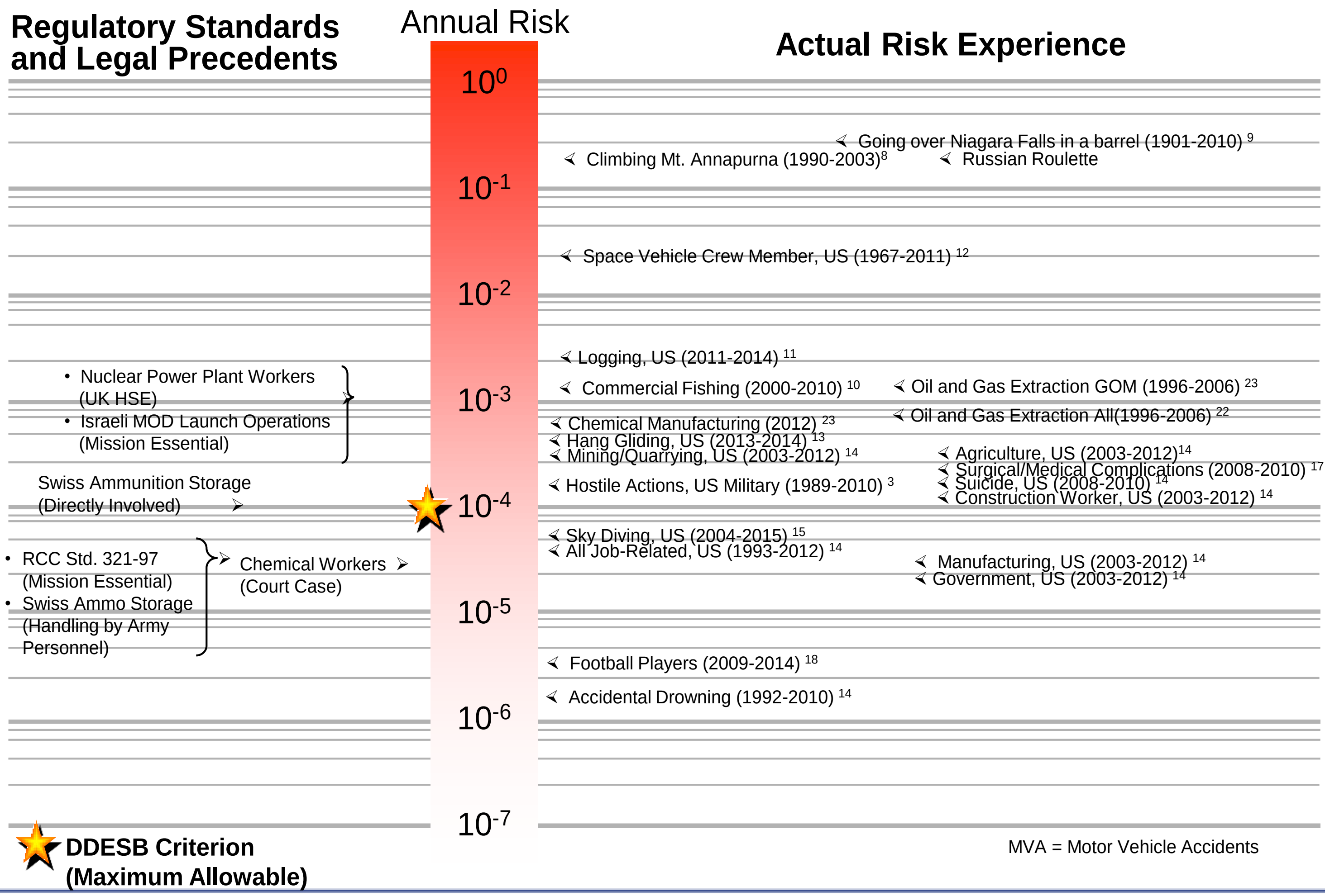


Risk Acceptance Criteria (F-N Curves)

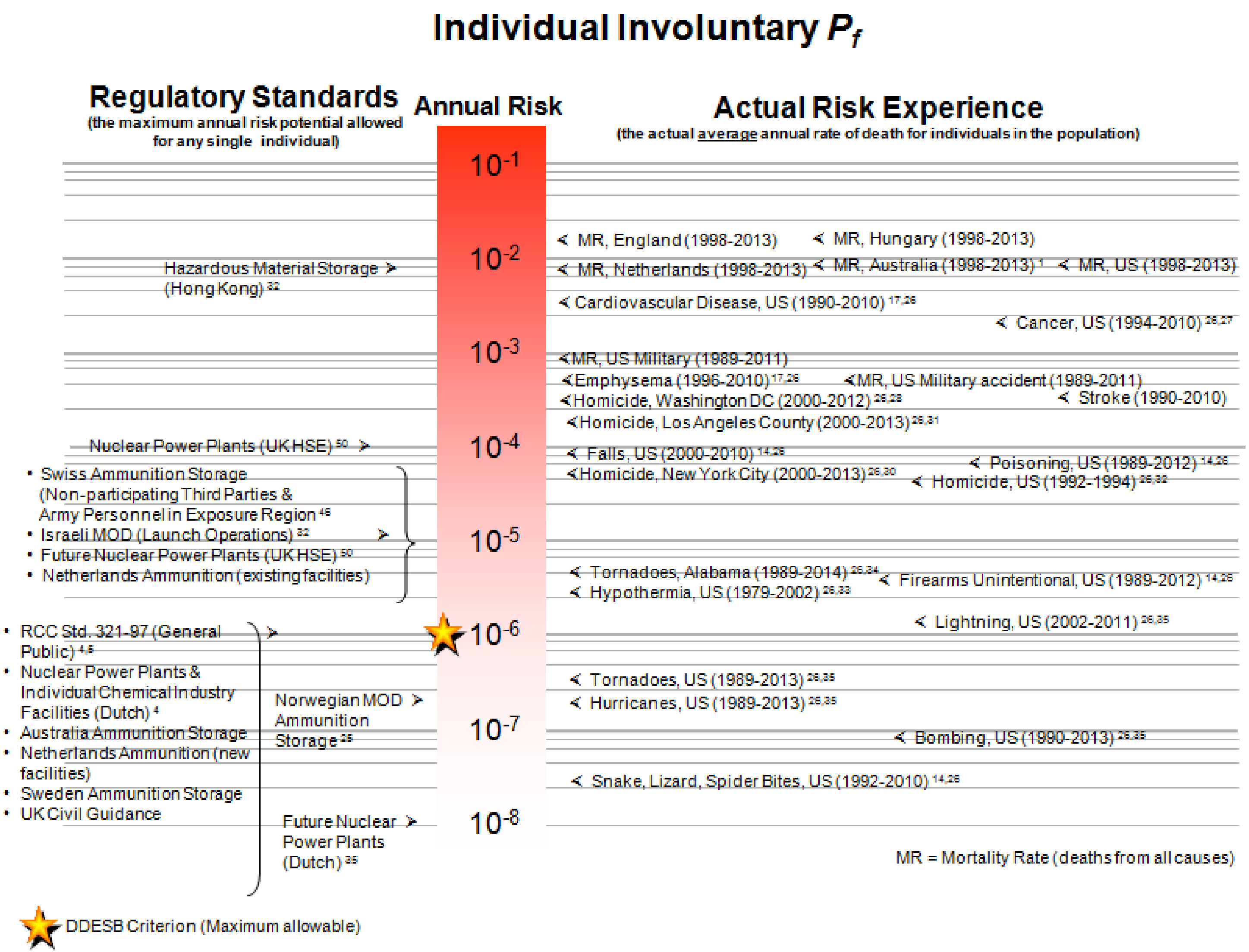


Universal Risk Scales (Voluntary, Individual)

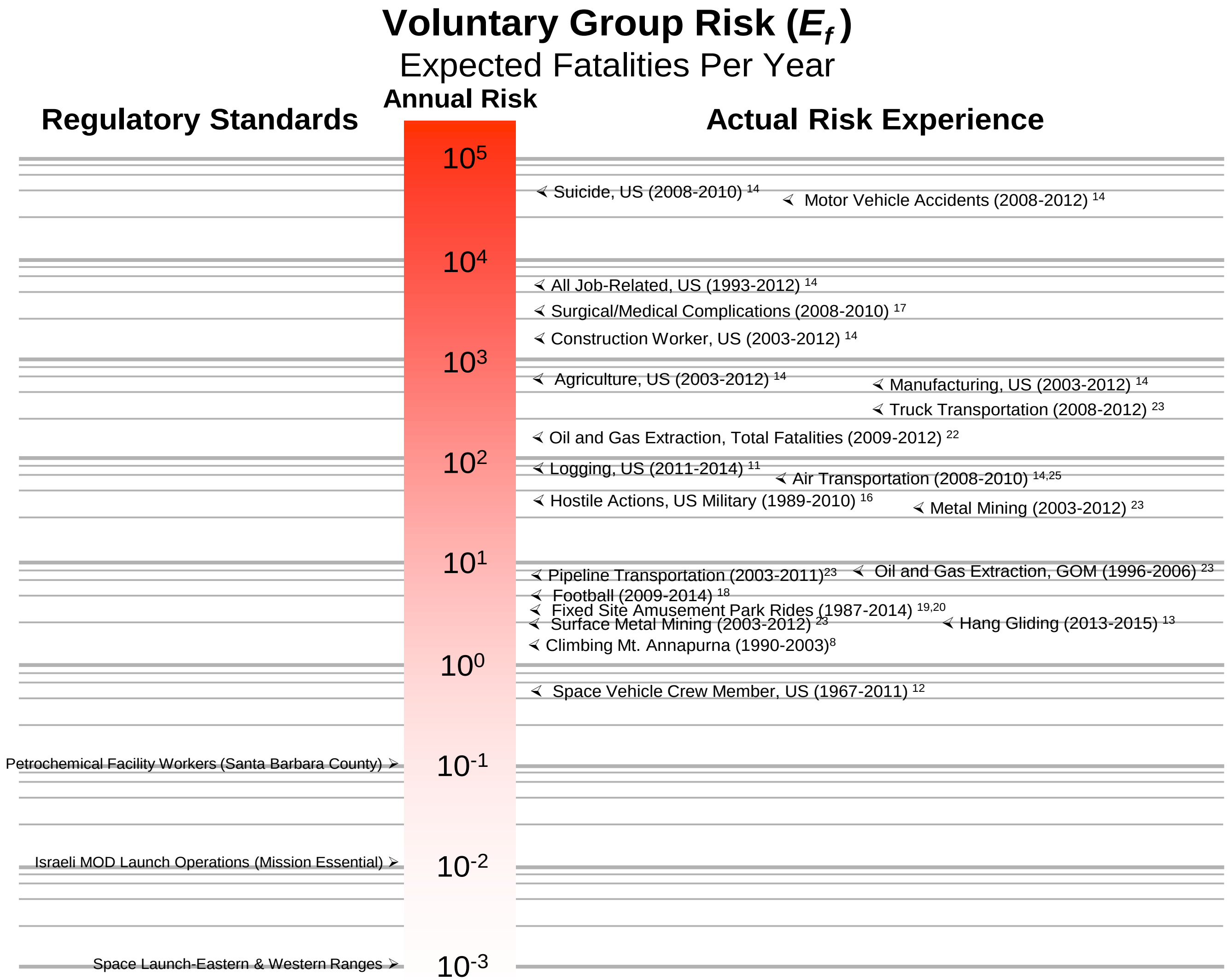
Individual Risk (P_f)
(Voluntary Actions)



Universal Risk Scales (Involuntary, Individual)

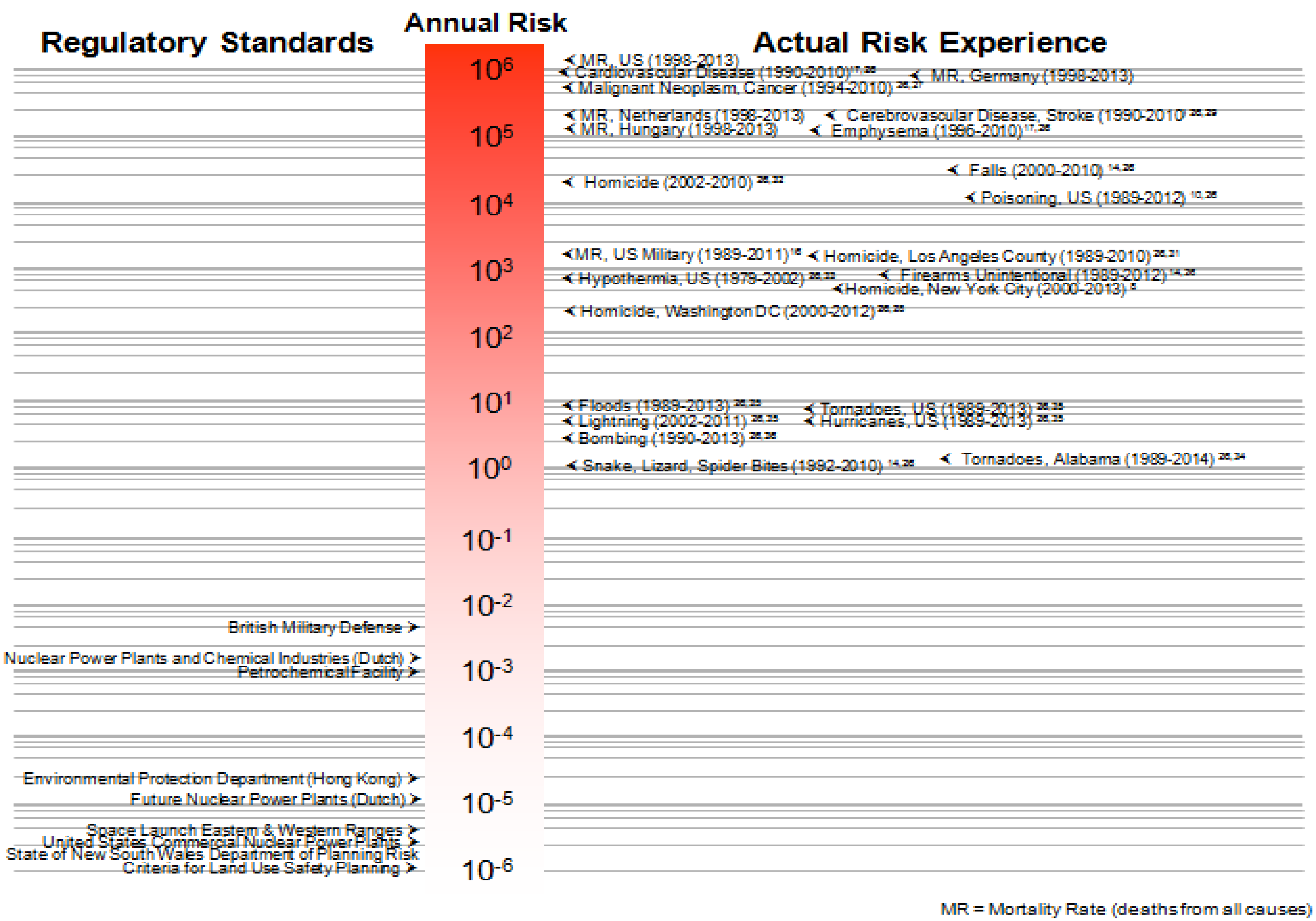


Universal Risk Scales (Voluntary, Group)



Universal Risk Scales (Involuntary, Group)

Involuntary Number of Fatalities Avg/Year



Development of Risk Acceptance Criteria

Key factors

- potential loss;
- costs for risk mitigation;
- decision-maker’s risk attitude preference; and
- stakeholder’s perceptions and biases. *for example,* the public opinion

Approaches in the past, present and future

- public safety with historical data (past);
- cost-benefit analysis (present); and
- multiple criteria decision-making, MCDM (future).

Risk Characteristics for Different Facilities

facility	potential loss	Pe	PAR	causes	benefits	alternative
nuclear plants	huge long term no remedy	remote	large	government	indirect	yes
dams	large	very low	medium	government	indirect	yes
explosives	medium	low	small	government	indirect	maybe
chemical plants	medium	low	small	commercial	indirect	yes
offshore	medium	very low	small	commercial	indirect	yes
health	small to medium	medium	large	natural	direct	no
bridges	small to medium	low	medium	government	direct	maybe
vehicle	small	high	large	voluntary	direct	maybe

Risk Acceptance Criteria for Different Facilities

	Individual (public)	Group (public)	Individual (related)	Group (related)
nuclear plants				
dams		0.001/ N for N < 100		
explosives	3.5×10^{-6}	0.001/ N for N < 15; $0.001/ N^{1.5}$	35×10^{-6}	0.01/ N for N < 5; $0.01/ N^{1.5}$
chemical plants		0.001/ N		0.01/ N
offshore	10×10^{-6}		100×10^{-6}	
health		0.01/ N		
bridges	10×10^{-6}		100×10^{-6}	
vehicle	100×10^{-6}		300×10^{-6}	

Path Forward

Moving forward, the DDESB Risk Analysis Program will focus on

(i) Increasing the usability of QRA for explosives safety management by the Services;

(ii) Developing the computer module to implement the DDESB QRA methodology so that the Services can simply turn on the tool, enter a few new inputs, and complete QRA.

(iii) Improving each of the elements in calculating risk within DDESB's QRA methodology, including estimating the probability of events (P_e,), uncertainty modeling, and establishing risk acceptance criteria, which has been discussed herein to attempt to improve the overall safety associated with explosives operations.