SPACE SHUTTLE PROBABILISTIC RISK ASSESSMENT (SPRA) ITERATION 3.2

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- Shuttle PRA Evolution
- Overall Risk
- Top Risk Drivers
- Risk by Phase
- Risk by Element
- Lessons Learned

INTRODUCTION

- As improvements are made to the Shuttle or its processes and as more is learned regarding its operation, the Shuttle PRA is updated
- Updates incorporated into Iteration 3.2 include
  - Addition of Orbiter Flight Software
  - Updated Pyro modeling
  - Incorporation of Orbiter Review Summit comments
  - Updated MMOD and Ascent Debris
  - Data was updated based upon iteration 3.0 review.

INTRODUCTION (2)

The following table is a cross-referenced list showing the features included in each model iteration.

Model Features	Model Iteration						
	1.0	2.0	2.1	2.2	3.0	3.1	3.2
Integrated Model	✓	✓	✓	✓	✓	✓	✓
Phased Approach	✓	✓	✓	✓	✓	✓	✓
Engineering and Peer Reviewed Data		✓	✓	✓	✓	✓	✓
Documented Model		✓	✓	✓	✓	✓	✓
TPS Inspection and Repair				✓	✓	✓	✓
Contingency Shuttle Crew Support (CSCS)				✓	✓	✓	✓
Intact Aborts (RTLS, TAL, ATO)					✓	✓	✓
Collision During Rendezvous and Docking					✓	✓	✓
Orbiter Flight Software							✓

SHUTTLE PRA EVOLUTION

- The Shuttle PRA has been incrementally developed over many years
  - Mission Phases (Ascent, Orbit, Entry)
  - Number of Systems Modeled
  - Risk Factors considered (systems failures, phenomenological failures, human reliability, external events, etc.)
- The advent of established NASA requirements, standards, and tools - as well as the development of a strong shuttle program PRA team have resulted in significant recent progress
- Iteration 3.2 is the most comprehensive Shuttle PRA to date

Mean Probability of LOCV

1:70	1:55	1:73	1:131	1:234	1:78	1:61	1:67	1:77	1:81	1:85	1:89
1987 Proof of concept study for applying PRA to Space Shuttle. Scope was limited to APUs for Orbiter and SRB	1988 First somewhat integrated PRA conducted on the Space Shuttle. Done in support of Galileo Mission. (Ascent Only).	1993 Update of the Galileo study results to reflect then current test and operational base of the shuttle. (Ascent Only)	1995 First major integrated (multi phase) shuttle PRA. Done with input from prime contractors.	1998 Unpublished analysis using QRAS. No integration of elements. Limited to three Orbiter systems and the Propulsion elements	2003 Integrated PRA with all elements, 18 Orbiter Systems, MMOD and human actions included. Presented to Peer review Team.	2004/2005 Integrated PRA with all elements, 18 Orbiter Systems, MMOD and human actions included. Peer reviewed.	2005 Integrated PRA with all elements, 18 Orbiter Systems, MMOD and human actions included. Peer reviewed. Updated Pre-valve modeling	2006/2007 Updated SPRA iteration 2.1 with Inspection with Repair and Crew Rescue. Updated MMOD and Ascent Debris Modeling	2008 Updated SPRA iteration 2.2 with Abort modeling, Rendezvous and Docking. Updated Functional Data, MMOD and Ascent Debris	2009 Updated SPRA iteration 3.0 with corrected APU Hydrazine Leak Probabilities	2010 Updated SPRA iteration 3.1 with updated MMOD, Ascent Debris, Orbiter Flight Software, Incorporated Orbiter Review Summit Comments
Proof of concept Study 1987	Galileo 1988	Phase 1 1993	Shuttle PRA 1995	Shuttle PRA 1998	SPRAT PRA Iteration 1.5 2003	*SPRAT PRA Iteration 2.0 2004/2005*	*SPRAT PRA Iteration 2.1 2005*	*SPRAT PRA Iteration 2.2 2006/2007*	*SPRAT PRA Iteration 3.0 2008*	*SPRAT PRA Iteration 3.1 2009*	*SPRAT PRA Iteration 3.2 2010*

INCREASING FIDELITY AND EXPANDED SCOPE

OVERALL SPRA ITERATION 3.2 RESULTS

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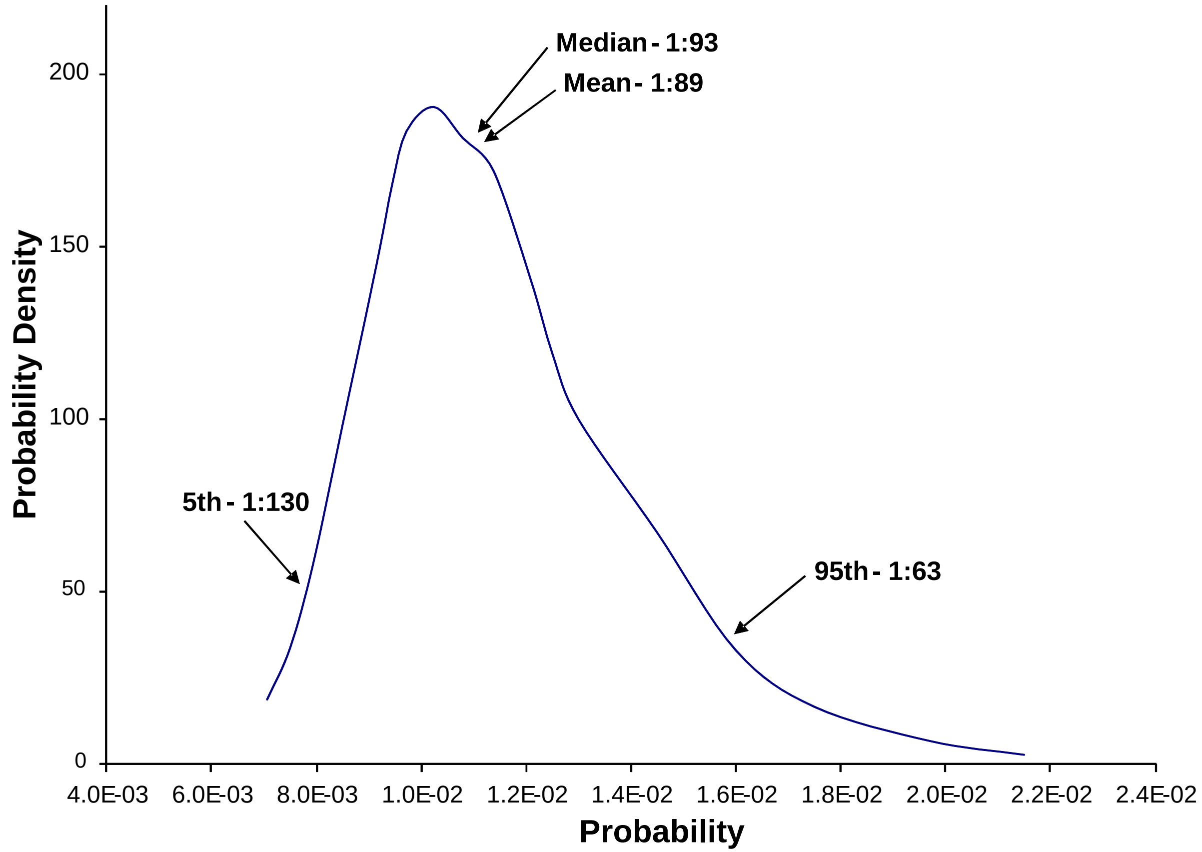
- The mean probability of LOCV for Shuttle as currently calculated by iteration 3.2 of the SPRA is:

Mean – 1.1E-02 (1:89)

Median – 1.1E-02 (1:93)

5th percentile – 7.9E-03 (1:130)

95th percentile – 1.6E-02 (1:63)



- This is a decrease from SPRA Iteration 3.1 which had a mean estimate of 1:85
- Considering the improvements that have been made, these results are consistent with an empirical calculation of 2 failures in 131 missions which gives a 1 in 66 probability of LOCV

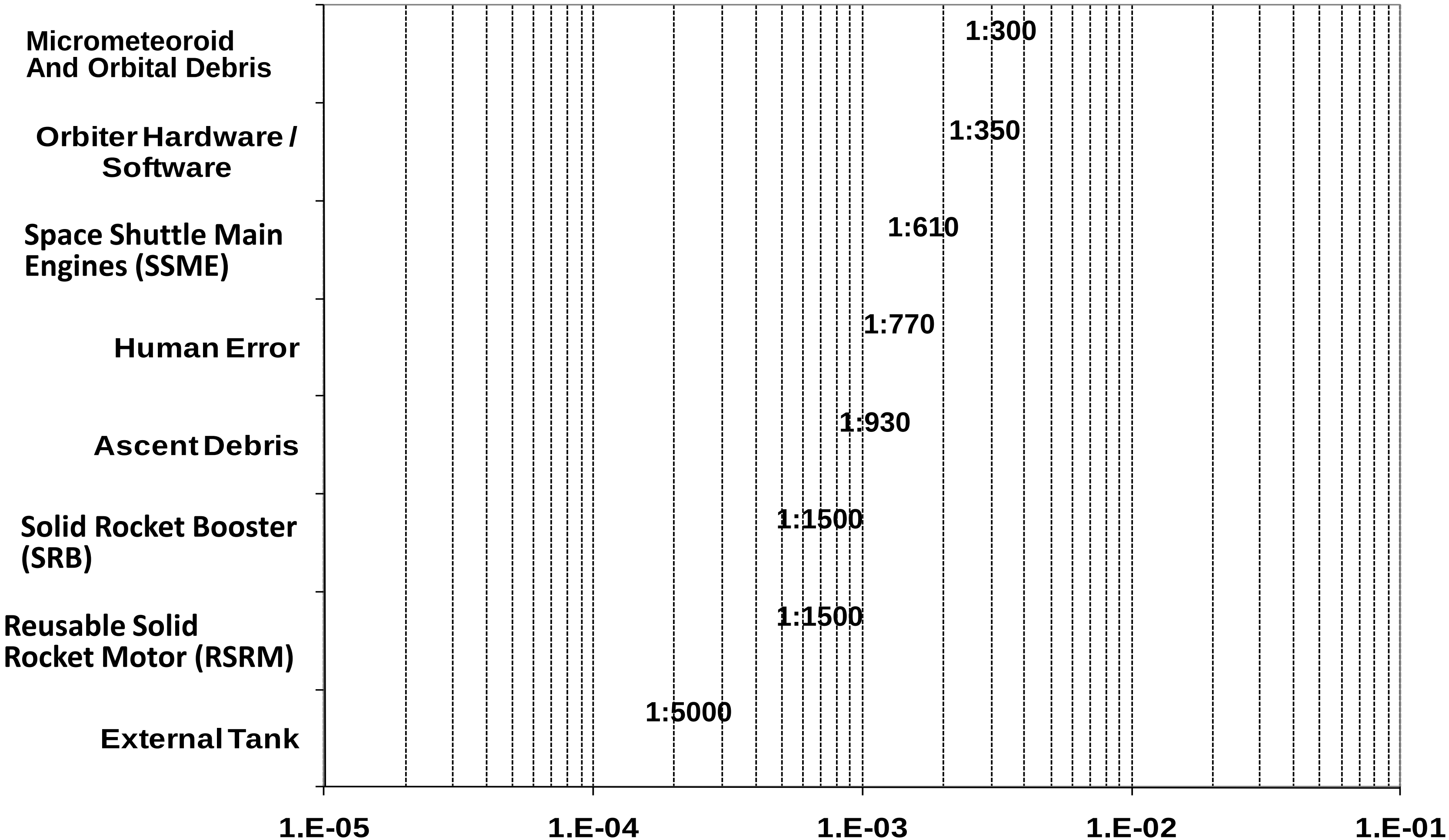
SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO

Rank	%age of Total	Cumulative Total	Point Estimate Probability (1:n)	Failure Scenario Description
1	29.4	29.4	3.3E-03 (1:300)	Micrometeoroid and Orbital Debris (MMOD) strikes Orbiter on orbit leading to LOCV on orbit or entry
2	13.4	42.8	1.5E-03 (1:670)	Space Shuttle Main Engine (SSME)-induced SSME catastrophic failure
3	9.5	52.3	1.1E-03 (1:940)	Ascent debris strikes Orbiter Thermal Protection System (TPS) leading to LOCV on orbit or entry
4	7.3	59.6	8.2E-04 (1:1200)	Crew error during entry
5	5.8	65.4	6.5E-04 (1:1500)	Reusable Solid Rocket Motor (RSRM)-induced RSRM catastrophic failure
6	2.0	67.4	2.3E-04 (1:4400)	Orbiter flight software error results in catastrophic failure during ascent

SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (2)

Rank	%age of Total	Cumulative Total	Point Estimate Probability (1:n)	Failure Scenario Description
7	1.6	69.0	1.8E-04 (1:5600)	Ammonia Boiler System (ABS) isolation valve leaks on Orbit overcooling the H20 loops and crew is unable to prevent rupture of the interchanger resulting in Loss of All Cooling
8	1.5	70.5	1.7E-04 (1:5900)	Solid Rocket Booster (SRB) APU shaft seal fracture
9	1.2	71.7	1.3E-04 (1:7600)	Flow Control Valve (FCV) poppet failure causes rupture in the GH2 re-pressurization line
10	1.2	72.9	1.3E-04 (1:7700)	Collision of the Orbiter with the International Space Station (ISS) during rendezvous and docking

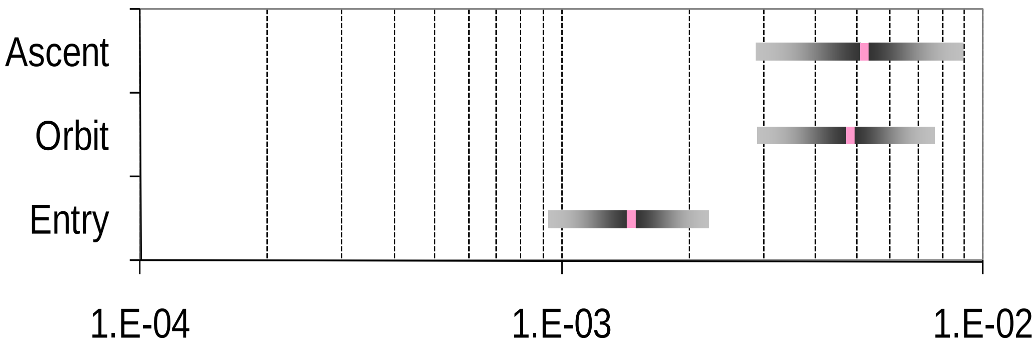
ITERATION 3.2 CONTRIBUTIONS BY ELEMENT OR MAJOR AREA*



* Some overlap in risk exists. For example, a cut set containing both a mechanical failure and a human error that result in failure to lower the landing gear is counted in both the Orbiter hardware contributor and the human error contributor.

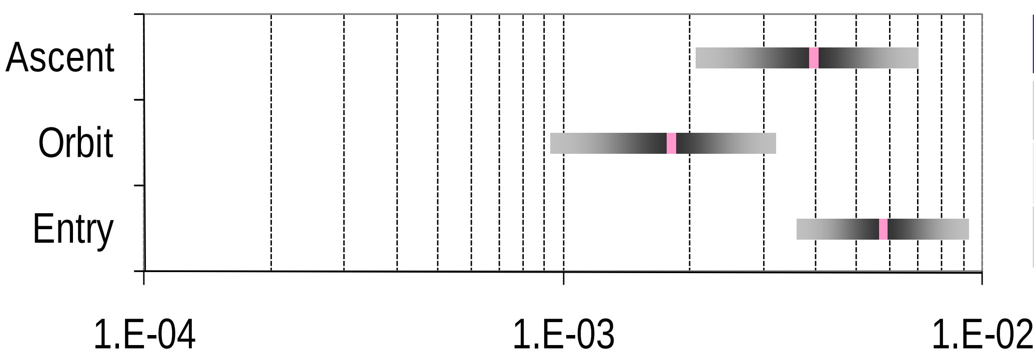
SPRA ITERATION 3.2 CONTRIBUTIONS BY PHASE

ESTIMATED PHASE CONTRIBUTIONS TO WHEN LOCV IS INITIATED



Phase	5th	Mean	95th
Ascent	1:350	**1:200**	1:110
Orbit	1:340	**1:210**	1:130
Entry	1:1100	**1:700**	1:460

ESTIMATED PHASE CONTRIBUTIONS TO WHEN LOCV IS REALIZED



Phase	5th	Mean	95th
Ascent	1:480	**1:260**	1:150
Orbit	1:1100	**1:570**	1:320
Entry	1:280	**1:180**	1:110

SPRA ITERATION 3.2 ASCENT RISK PROFILE

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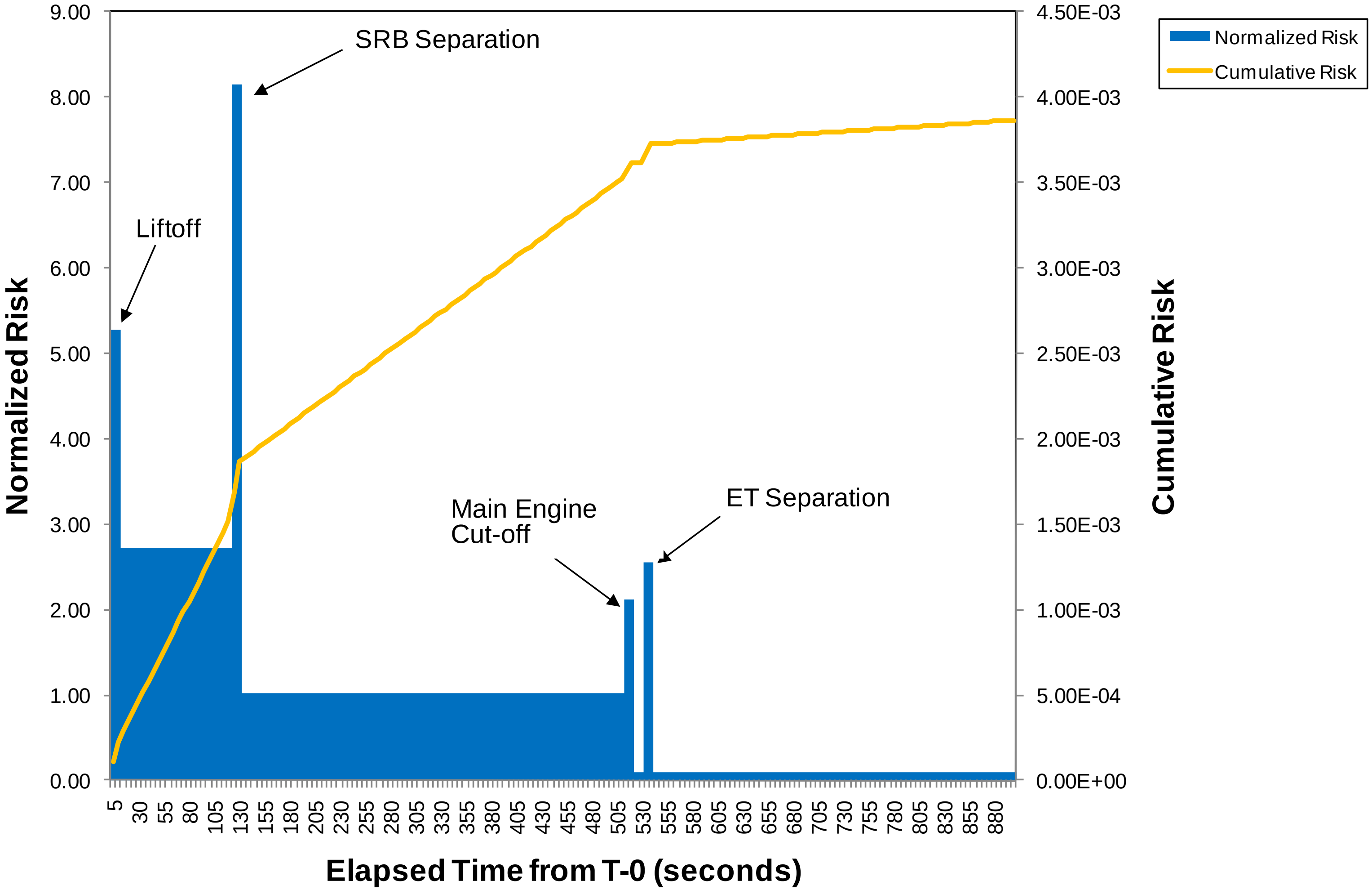
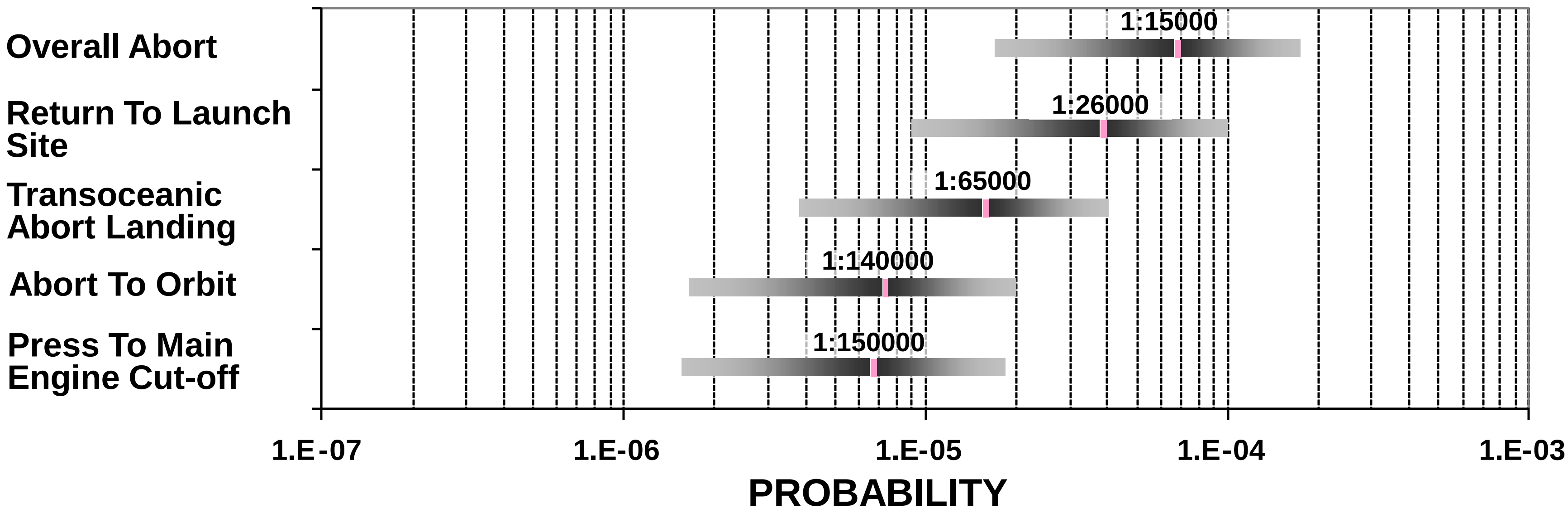


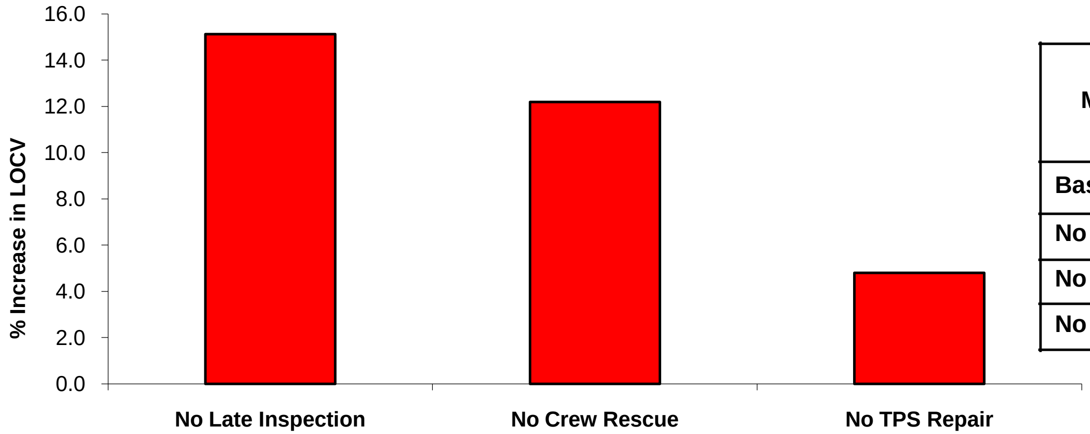
SPRA ITERATION 3.2 ABORT RISK

- **Intact abort due to Benign Engine Shutdown or Stuck Throttle represent <1% of the overall risk.**
  - The probability of a Benign Engine Shutdown is ~ 1:320
  - Return to Launch Site (RTLS) abort represents the largest fraction of the abort risk (57%) mainly due to the higher likelihood of having an engine out early



SPRA ITERATION 3.2 SENSITIVITIES

- **Iteration 3.2 of the SPRA lends itself to any number of sensitivities being performed; however, given its current applications, the following sensitivities studies were considered to be the most informative:**
  - No late inspection
    - In this sensitivity the basic event capturing the probability of detecting damage during late inspection is set to 1.0 and the false positive TPS damage during late inspection and late inspection induced TPS damage are set to zero.
  - No crew rescue
    - In this sensitivity crew rescue is set to 1.0 and the risk from false positive TPS damage is zeroed out because since there is no critical damage the vehicle returns safely
  - No TPS repair
    - In this sensitivity the all TPS damages are considered irreparable and crew rescue is chosen as the mitigation for detected critical damage



Mission Risk	Per Mission Probability		
	5th Percentile	Mean	95th Percentile
Baseline	1:130	1:89	1:63
No Late Inspection	1:110	1:77	1:54
No Crew Rescue	1:110	1:79	1:55
No TPS Repair	1:120	1:85	1:59

- **Establish project management and funding through the same path**
  - If you don't, your team will have different bosses thus you will not have a team
- **Establish a single overall PRA technical authority**
  - Don't call desired methods as guidelines, if you want the team to follow them…
- **Document, document, document (capture the basis of the PRA) provide tracability (the rabbit trail) of assumptions to results, if you wait to document after presenting the results you will be embarrassed as a minimum.**
- **Get buy in from domain experts early (i.e. before going to present to management)**

LESSONS LEARNED (Cont'd)

- **Start the independent peer review up front with them reviewing the plan, then coming back later to ensure that the plan was followed correctly (also make sure you are ready for the peer review). The peer review should cover both the scope/content of the PRA as well as the PRA methodology used.**
- **Configuration control should be initiated when the PRA is initiated.**
- **Begin with the end in mind. Sounds simple. Now try implementing it.**
  - Get the Hazard analysis, FMEA, and PRA teams working together versus answering the same questions with different approaches and minimum to no communication and/or integration.
  - Mission phases definition is very important as the number of potential phases increases the complexity of the model orders of magnitude. For example, abort modeling from ascent to on-orbit initiated.

CONCLUSION

- The Shuttle is a very reliable vehicle in comparison with other launch systems. Much of the risk posed by Shuttle operations is related to fundamental aspects of the spacecraft design and the environments in which it operates. It is unlikely that significant design improvements can be implemented to address these risks prior to the end of the Shuttle program.

- The model will continue to be used to identify possible emerging risk drivers and allow management to make risk-informed decisions on future missions. Potential uses of the SPRA in the future include:
  - Calculate risk impact of various mission contingencies (e.g. late inspection, crew rescue, etc.)
  - Assessing the risk impact of various trade studies (e.g. flow control valves)
  - Support risk analysis on mission specific events, such as in flight anomalies.
  - Serve as a guiding star and data source for future NASA programs

BACKUP

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
1	29.4	29.4	3.3E-03 (1 in 300)	Micrometeoroid and Orbital Debris (MMOD) strikes Orbiter on orbit leading to LOCV on orbit or entry	Orbit	Orbit, Entry
2	13.4	42.8	1.5E-03 (1 in 670)	Space Shuttle Main Engine (SSME)-induced SSME catastrophic failure	Ascent	Ascent
3	9.5	52.3	1.1E-03 (1 in 940)	Ascent debris strikes Orbiter Thermal Protection System (TPS) leading to LOCV on orbit or entry	Ascent	Orbit, Entry
4	7.3	59.6	8.2E-04 (1 in 1200)	Crew error during entry	Entry	Entry
5	5.8	65.4	6.5E-04 (1 in 1500)	Reusable Solid Rocket Motor (RSRM)-induced RSRM catastrophic failure	Ascent	Ascent
6	2.0	67.4	2.3E-04 (1 in 4400)	Orbiter flight software error results in catastrophic failure during ascent	Ascent	Ascent
7	1.6	69.0	1.8E-04 (1 in 5600)	Ammonia Boiler System (ABS) isolation valve leaks on Orbit overcooling the H20 loops and crew is unable to prevent rupture of the interchanger resulting in Loss of All Cooling	Orbit	Orbit
8	1.5	70.5	1.7E-04 (1 in 5900)	Solid Rocket Booster (SRB) APU shaft seal fracture	Ascent	Ascent
9	1.2	71.7	1.3E-04 (1 in 7600)	Flow Control Valve (FCV) poppet failure causes rupture in the GH2 re-pressurization line	Ascent	Ascent
10	1.2	72.9	1.3E-04 (1 in 7700)	Collision of the Orbiter with the International Space Station (ISS) during rendezvous and docking	Orbit	Orbit
11	1.1	74.0	1.3E-04 (1 in 7900)	Auxiliary Power Unit (APU) external leak on entry	Entry	Entry
12	1.0	75.0	1.2E-04 (1 in 8600)	SRB booster separation motor debris strikes Orbiter windows	Ascent	Ascent

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (2)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
13	1.0	76.0	1.1E-04 (1 in 8900)	Reaction Control System (RCS) thrusters burnthrough on orbit	Orbit	Orbit
14	1.0	77.0	1.1E-04 (1 in 9300)	RCS Fuel System external leakage on orbit reacts with O2 on entry	Orbit	Entry
15	1.0	77.9	1.1E-04 (1 in 9300)	Orbital Maneuvering System (OMS) Fuel System external leakage on orbit reacts with O2 on entry	Orbit	Entry
16	0.9	78.9	1.0E-04 (1 in 9500)	Orbiter inspections (Flight Day 2 and late) produce false positive indications of damage, resulting in a failed crew rescue attempt	Orbit	Orbit
17	0.9	79.8	1.0E-04 (1 in 9700)	Power Reactant Storage and Distribution (PRSD) tank rupture	Orbit	Orbit
18	0.9	80.7	1.0E-04 (1 in 9800)	External Tank (ET) separation pyro-bolt or frangible nut fail to separate (Including Pyrotechnic Intiator Controller (PIC)/NASA Standard Initiator (NSI))	Ascent	Entry
19	0.9	81.6	9.6E-05 (1 in 10,000)	Functional failure booster separation motor during SRB separation	Ascent	Ascent
20	0.9	82.4	9.6E-05 (1 in 10,000)	SRB separation pyro-bolts fail to separate (includes PIC/NSI)	Ascent	Ascent
21	0.8	83.3	9.4E-05 (1 in 11,000)	Common cause failure of the Electrical Power System (EPS) on orbit	Orbit	Orbit
22	0.8	84.1	9.3E-05 (1 in 11,000)	Flight control surface (elevons, rudder, body flap) actuators fail/jam during entry	Entry	Entry
23	0.8	84.9	9.2E-05 (1 in 11,000)	ET leaks result in fire/explosion	Ascent	Ascent
24	0.8	85.7	9.1E-05 (1 in 11,000)	Common cause failure of the APU System on entry	Entry	Entry
25	0.8	87.0	9.0E-05 (1 in 11,000)	Frangible nuts on SRB holdown bolts fail during launch (includes PIC/NSI)	Ascent	Ascent

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (3)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
26	0.7	87.8	8.4E-05 (1 in 12,000)	Control or mechanical failure causes Main Propulsion System (MPS) prevalves to fail to close	Ascent	Ascent
27	0.7	88.5	7.5E-05 (1 in 13,000)	Fuel supply failure to the OMS during orbit and crew rescue fails	Orbit	Orbit
28	0.7	89.1	7.5E-05 (1 in 13,000)	MPS failures lead to helium overpressure on ascent	Ascent	Ascent
29	0.7	89.8	7.5E-05 (1 in 13,000)	MPS component failures cause a catastrophic overpressure condition in the aft compartment during entry	Entry	Entry
30	0.5	90.3	6.0E-05 (1 in 17,000)	RCS thruster fail leak or off on orbit	Orbit	Orbit
31	0.5	86.2	5.7E-05 (1 in 18,000)	Orbiter flight software error results in catastrophic failure during entry	Entry	Entry
32	0.5	90.8	5.7E-05 (1 in 18,000)	Flow Control Valve (FCV) poppet failure causes excessive GH2 ullage pressure resulting in LH2 venting	Ascent	Ascent
33	0.5	91.3	5.5E-05 (1 in 18,000)	SSME-induced benign shutdown of the SSME	Ascent	Ascent
34	0.4	91.8	4.9E-05 (1 in 20,000)	Debonding of TPS during ascent	Ascent	Orbit, Entry
35	0.4	92.2	4.6E-05 (1 in 22,000)	APU external leak on ascent	Ascent	Ascent
36	0.3	92.5	3.9E-05 (1 in 26,000)	Loss of SRB TPS	Ascent	Ascent
37	0.3	92.9	3.8E-05 (1 in 26,000)	Structural failure of the ET during ascent.	Ascent	Ascent
38	0.3	93.2	3.8E-05 (1 in 27,000)	Loss of ET anti-vortex capability leads to SSME catastrophic overspeed	Ascent	Ascent
39	0.3	93.5	3.4E-05 (1 in 29,000)	Orbiter structural failures	Ascent	Ascent

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (4)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
40	0.3	93.8	3.3E-05 (1 in 30,000)	Fuel cell leak and a subsequent failure of the crew to respond appropriately causes a catastrophic failure	Orbit	Orbit
41	0.3	94.1	3.2E-05 (1 in 31,000)	Water Coolant Loop component failure results in a cooling failure on orbit	Orbit	Orbit
42	0.3	94.4	3.1E-05 (1 in 32,000)	Orbit inspections (Flight Day 2 and late) result in damage to the TPS	Orbit	Orbit
43	0.3	94.6	2.9E-05 (1 in 34,000)	ET failure causes a fuel feed anomaly, resulting in SSME shutdown due to insufficient net positive suction pressure	Ascent	Ascent
44	0.3	94.9	2.9E-05 (1 in 34,000)	Landing Deceleration System (LDS) brake failures	Entry	Entry
45	0.2	95.1	2.7E-05 (1 in 38.000)	Common cause failure of the Data Processing System (DPS) on orbit	Orbit	Orbit
46	0.2	95.4	2.5E-05 (1 in 40,000)	Mechanisms failure and subsequent failure of a crew rescue attempt	Ascent, Orbit	Orbit
47	0.2	95.6	2.3E-05 (1 in 44,000)	Flight Software error result in catastrophic failure during orbit	Orbit	Orbit
48	0.2	95.7	2.1E-05 (1 in 48,000)	Flight control surface (elevons, rudder, body flap) actuators fail/jam during ascent	Ascent	Ascent
49	0.2	95.9	2.1E-05 (1 in 49,000)	Loss of Active Thermal Control System (ATCS) cooling due to ammonia (NH3) tank rupture on orbit	Orbit	Orbit
50	0.2	96.1	2.0E-05 (1 in 51,000)	Pyrotechnic Initiator Controller (PIC) failure during SRB ignition	Ascent	Ascent
51	0.2	96.3	1.9E-05 (1 in 51,000)	MPS GO2 or GH2 disconnect valves fail closed, causing SSME shutdown due to insufficient net positive suction pressure	Ascent	Ascent

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (5)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
52	0.2	96.4	1.9E-05 (1 in 51,000)	Cabin depressurization due to leaks beyond the make-up capability of the Pressure Control System (e.g., penetration leaks) or pressure control system fails	Orbit	Orbit, Entry
53	0.2	96.6	1.9E-05 (1 in 52,000)	Active Vent Door (AVD) failure on entry	Entry	Entry
54	0.2	96.8	1.8E-05 (1 in 54,000)	MPS disconnect valves fail in the closed position during ascent	Ascent	Ascent
55	0.2	96.9	1.7E-05 (1 in 59,000)	Flight Control System (FCS) switching valve fails during entry	Entry	Entry
56	0.2	97.1	1.7E-05 (1 in 59,000)	Catastrophic fire/explosion due to MPS interface leakages	Ascent	Ascent
57	0.1	97.2	1.6E-05 (1 in 61,000)	Common cause failure of two APUs, Hydraulic Systems, or WSBs result in a failure to land the Orbiter with a single APU in high cross winds	Ascent, Entry	Entry
58	0.1	97.4	1.4E-05 (1 in 73,000)	LDS, APU, hydraulic, or WSB component failure results in a failure to properly deploy or a structural failure of the landing gear	Entry	Entry
59	0.1	97.5	1.3E-05 (1 in 74,000)	Environmental Control and Life Support System (ECLSS) O2 oversupply on orbit leads to fire	Orbit	Orbit
60	0.1	97.6	1.3E-05 (1 in 74,000)	Common cause failure of the Orbiter APU/Hydraulics/Water Spray Boiler (WSB) System components during ascent	Ascent	Ascent
61	0.1	97.7	1.3E-05 (1 in 76,000)	FCS gear box loses output or jams	Entry	Entry
62	0.1	97.8	1.3E-05 (1 in 77,000)	OMS failure and insufficient RCS propellant (+X jets unavailable) result in deorbit failure	Orbit	Orbit

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (6)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
63	0.1	97.9	1.3E-05 (1 in 80,000)	Electrical failure during orbit	Orbit	Orbit, Entry
64	0.1	98.0	1.2E-05 (1 in 81,000)	APU heater fails on and human error failure results in catastrophic failure on orbit	Orbit	Orbit
65	0.1	98.2	1.2E-05 (1 in 83,000)	Loss of OMS due to improper targeting of OMS burn (human error)	Orbit	Orbit
66	0.1	98.2	1.0E-05 (1 in 96,000)	Common cause failure of Guidance Navigation and Control (GN&C) (failure of crew rescue for failures occurring on orbit)	Ascent, Orbit, Entry	Ascent, Orbit, Entry
67	0.1	98.3	9.9E-06 (1 in 100,000)	Cabin Fan System failure combined with a human error during landing brought about by high heat or humidity	Orbit	Entry
68	0.1	98.4	8.3E-06 (1 in 120,000)	Independent failure of two APUs, Hydraulic Systems, or WSBs result in a failure to land the Orbiter in high cross winds	Ascent, Entry	Entry
69	0.1	98.5	8.1E-06 (1 in 120,000)	MPS liquid H2 feedline flowliner crack leads to fire/explosion due to feedline contamination	Ascent	Ascent
70	0.1	98.5	7.3E-06 (1 in 140,000)	FCS switching valve fails during ascent	Ascent	Ascent
71	0.1	98.6	6.6E-06 (1 in 150,000)	Landing Deceleration System (LDS) tire ruptures	Entry	Entry
72	0.1	98.7	6.6E-06 (1 in 150,000)	Flash Evaporator System freeze up and failure to recover leads to LOCV during entry	Orbit, Entry	Entry
73	0.1	98.7	6.6E-06 (1 in 150,000)	Rudder speed brake jams during entry	Entry	Entry
74	0.1	98.8	6.6E-06 (1 in 150,000)	Fire/explosion resulting from the auto-decomposition of hydrazine due to a leak in the SRB APU fuel pump	Ascent	Ascent

COMPLETE LIST OF SPRA ITERATION 3.2 CONTRIBUTIONS BY SCENARIO (7)

Rank	%age of Total	Cumulative Total %	Probability	Description	Phase Initiated	Phase Realized
75	0.1	98.8	6.1E-06 (1 in 160,000)	Trapped fuel due to FRCS failure prior to de-orbit preparation combined with failure of recovery measures results in CG imbalance	Orbit	Entry
76	0.1	98.9	5.9E-06 (1 in 170,000)	Common cause failure of all N2 relief valves to close on Ascent combined with failure of crew rescue	Ascent	Orbit
77	0.1	98.9	5.7E-06 (1 in 170,000)	Fire/explosion caused by MPS contamination	Ascent	Ascent
78	0.1	99.0	5.7E-06 (1 in 180,000)	Icicle formed at the water dump breaks off and damages the Orbiter	Orbit	Entry
79	0.1	99.0	5.6E-06 (1 in 180,000)	Drag chute door opens prematurely leading to LOCV	Ascent, Entry	Ascent, Entry

PRA DEVELOPMENT PROCESS

Presenter **Roger Boyer**

Date **10/26/10**