

Jim Lloyd, 05:34 AM 2/2/2003 +0000, SMA Telecon

From: Jim Lloyd <jlloyd@hq.nasa.gov>

To: <dvecellio@arescorporation.com>, <snewman@hq.nasa.gov>, <boconnor@hq.nasa.gov>, <prutledg@hq.nasa.gov>, <jlloyd@hq.nasa.gov>, <pnapala@hq.nasa.gov>, <wfrazier@hq.nasa.gov>, <fchandle@hq.nasa.gov>, <Tom.Whitmeyer@hq.nasa.gov>, <mkowales@hq.nasa.gov>, <wbihner@mail.hq.nasa.gov>, <jlemke@hq.nasa.gov>, <Laura.W.Doty@nasa.gov>, <Humberto.T.Garrido@nasa.gov>, <Amanda.H.Goodson@nasa.gov>, <Michael.Smiles@ssc.nasa.gov>, <yolanda.y.marshall@nasa.gov>, <mark.d.erminger@nasa.gov>, <sbartell@ksc.nasa.gov>, <A.H.Phillips@larc.nasa.gov>, <Wentworth.O.Denoon@nasa.gov>, <jmullin@hq.nasa.gov>

X-your-intranet: <http://107team.intranets.com>

X-Intranets-helpdesk: <mailto:help@intranets.com>

Date: Sun, 02 Feb 2003 05:34:27 GMT

X-mailer: AspMail 4.0 4.03 (SMT412E7EF)

Subject: SMA Telecon

X-OriginalArrivalTime: 02 Feb 2003 05:34:29.0469 (UTC) FILETIME=[C1B930D0:01C2CA7C]

Here's a new posting on 107 Team that I'd like you to see. To go directly to the posting, click the link below or paste it into your web browser. Please note that some email clients require that all the letters and numbers in the link appear on one line, or else it won't go to the right place.

<<http://107team.intranets.com/r.asp?a=3&id=8529>>

02/03/03 8:00 AM Michael Stamatelatos, Code QE

A potential scenario for STS-107 that has not been considered in the Space Shuttle PRA is the following one:

- A piece of insulation from ET debonding detaches and impacts the orbiter
- The impact causes removal or partial detachment of tile(s)
- Alternately, the impact causes an indentation of significant size
- Damage progresses due to air loads and thermal heating during ascent but without great consequences due to decreasing atmosphere density
- During reentry, the mechanical and thermal loads from aerodynamic heating continue the damage to the orbiter that began during launch
- The aerodynamic heating and mechanical loads are exacerbated by the presence of local hot spots generated in the areas of damage
- Heating increases and propagates to the orbiter through conducting surfaces
- Fuel lines or cells become exposed to excessive heating and explosion occurs.

Important points of this scenario that were not considered in the Shuttle PRA are

- damage incurred in the ascent phase continues in the reentry phase, and
- heating in damaged area causes hot spots, i.e., higher thermal and structural loads than heating of smooth surfaces.

RAILSBACK, JAN (JSC-NX) (NASA)" , "BOYER, ROGER L. (JSC-NC) (SA, 09:42 AM 2/3/200

To: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>, "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>, "Bill Vesely"

From: Michael Stamatelatos <mstamate@hq.nasa.gov>

Subject: Sequence

Cc:

Bcc:

Attached: C:\Documents and Settings\mstamate\Desktop\Scenario.doc;

Gentlemen:

Here is a STS-107 scenario that I thought of and I believe it deserves consideration for further analysis.

The important points of this scenario are that

1. damage incurred in the ascent phase continues and is built upon in the reentry phase, and that
2. heating in damaged area causes hot spots, i.e., higher thermal and structural loads than heating of smooth surfaces.

I am not sure if you considered this sequence in your shuttle PRA analyses. Let's discuss it at the 11:30 EST telecon.

Michael

Request from Bryan O'connor

Feb. 3, 2003

- “I need out of the current Shuttle PRA a list of all the accident scenarios that lead to loss of vehicle during early entry. I imagine it will show things like SRB and ET debris, MMOD, APU hydraulic failures, GNC, etc. Mark Erminger has already culled out the hazreps, and the PRA may help us organize our thoughts more”.
- Give [Yolanda] a status of where we are on the activity and when [Yolanda] can give [Bryan] this information by noon today.

RAILSBACK, JAN (JSC-NX) (NASA), 09:58 AM 2/3/2003 -0600, Request from HQ

From: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@NASA.GOV>
To: "MARSHALL, YOLANDA Y. (JSC-NA) (NASA)" <yolanda.y.marshall@NASA.GOV>
Cc: "Mike Stamatelatos (E-mail)" <mstamate@mail.hq.nasa.gov>,
"BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>,
"SHAW, LARRY C. (JSC-NX) (NASA)" <larry.c.shaw@NASA.GOV>,
"Dennis Moore (E-mail)" <Dennis.R.Moore@msfc.nasa.gov>
Subject: Request from HQ
Date: Mon, 3 Feb 2003 09:58:08 -0600
X-Mailer: Internet Mail Service (5.5.2653.19)

Rich Patrick of Code Q called and requested a one-pager on the Shuttle PRA with the following for General Kostelnik:

- * A status of the PRA
- * A discussion of the overall pre-accident values pre-accident; and
- * Any prediction about how the model may change since the accident (i.e., what additional modeling will we be doing).

We have been asked to route this through Yolanda, who will pass it by the Shuttle Program before it goes to HQ.

Jan W. Railsback
Lead Analyst
Safety, Reliability, and Quality Assurance
Advanced Programs and Analysis Division
Ph: 281-483-7265
Fax: 281-244-2318
jan.railsback-1@nasa.gov

X-Sender: rpatrica@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Mon, 03 Feb 2003 16:30:24 -0500
To: prutledg@hq.nasa.gov, mstamate@hq.nasa.gov, mkowales@hq.nasa.gov
From: Richard Patrican <rpatrica@hq.nasa.gov>
Subject: Fwd: Re: Shuttle PRA

FYI, The HQCAT has asked for data on the Shuttle PRA - this is to keep you in the loop.

Date: Mon, 03 Feb 2003 10:44:59 -0500
To: "ERMINGER, MARK D. (JSC-NC) (NASA)" <mark.d.erminger@nasa.gov>, ymarshall
From: Richard Patrican <rpatrica@hq.nasa.gov>
Subject: Re: Shuttle PRA

Done, Jan has a telecon at 10:30 with his team and will discuss this - he doesn't believe it will be too hard to accomplish.

At 09:28 AM 2/3/2003 -0600, you wrote:
We are all in the MRT right now. Suggest calling Jan Railsback

-----Original Message-----

From: Richard Patrican <rpatrica@hq.nasa.gov>
To: MARSHALL, YOLANDA Y. (JSC-NA) (NASA) <yolanda.y.marshall@nasa.gov>;
ERMINGER, MARK D. (JSC-NC) (NASA) <mark.d.erminger@nasa.gov>
Sent: Mon Feb 03 09:24:12 2003
Subject: Shuttle PRA

Yolanda/Mark, Kostelnik has asked for a one pager on the Space Shuttle PRA effort. This would include a discussion of the overall top level pre Columbia accident numbers for ascent and mission, overall status of the PRA effort, and prediction on possible changes to the numbers due to Columbia. I have spoken to Bill Harris right before the HCAT, called you but you were in the 10:00 ET telecon and also called Roger Boyer and left a voice mail to the same effect. Please roll this through the program before being sent up here. Thanks.

Rich Patrican
Manager, International Space Station
Office of Safety and Mission Assurance
Headquarters Office 5X35
Phone: 202-358-0569

Fax: 202-358-2772

**Rich Patrican
Manager, International Space Station
Office of Safety and Mission Assurance
Headquarters Office 5X35
Phone: 202-358-0569
Fax: 202-358-2772**

X-Authentication-Warning: spinoza.public.hq.nasa.gov: majordom set sender to owner-code-q using -f

X-Sender: prutledg@mail.hq.nasa.gov

X-Mailer: QUALCOMM Windows Eudora Version 4.3.2

Date: Tue, 04 Feb 2003 09:52:27 -0500

To: code-q@lists.hq.nasa.gov

From: Pete Rutledge <prutledg@hq.nasa.gov>

Subject: Information we prepare and provide in support of HCAT and/or the MIT/CAIB

Sender: owner-code-q@lists.hq.nasa.gov

Code Q staff members,

Please make sure Jim or I get to see and initial off on any new material we prepare for the HCAT and/or the MIT/CAIB. This is not necessary when responding to a request for copies of existing material that has already had management approval in the past. When seeking management buy-off on new material, please bring two copies; one will go to Pam Richardson, who is keeping the official collection of what we have done. When providing existing material, it would be helpful if you would at least let Pam know what you provided (no copy needed as long as you identify it), so that we will have a complete record of what goes out.

Thanks,

Pete

Peter J. Rutledge, Ph.D.
Director, Enterprise Safety and Mission Assurance Division
Acting Director, Review and Assessment Division
Office of Safety and Mission Assurance
NASA Headquarters, Code QE, Washington, DC 20546

ph: 202-358-0579

FAX:202-358-2778

e-mail: pete.rutledge@hq.nasa.gov

Mission Success Starts with Safety!

X-Authentication-Warning: spinoza.public.hq.nasa.gov: majordom set sender to owner-code-q using -f
X-Sender: prutledg@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 04 Feb 2003 12:20:54 -0500
To: jlloyd@hq.nasa.gov
From: Pete Rutledge <prutledg@hq.nasa.gov>
Subject: Fwd: Questions/issues for Bryan's use
Cc: code-q@lists.hq.nasa.gov
Sender: owner-code-q@lists.hq.nasa.gov

Jim,

Attached is first batch of questions/issues for Bryan's use on the Columbia Accident Investigation Board. These are a combination of inputs from SMA Directors and from OSMA staff members; Pam Richardson is pulling them together and maintaining the list. We would propose that you send to Bryan daily--only the new questions/issues (to minimize e-mail download time on Bryan's end). They are numbered sequentially and in chronological order, so it will be easy to send just the new ones. By means of this e-mail, I'm sending the list of questions/issues to all OSMA staff members. As Ron Moyer suggested, seeing these questions/issues may prompt thoughts of new ones.

Suggest sending this batch to Bryan ASAP.

Thanks,

Pete

X-Sender: prichard@mail.hq.nasa.gov
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2
Date: Tue, 04 Feb 2003 11:19:40 -0500
To: Pete.Rutledge@hq.nasa.gov
From: Pamela Richardson <prichard@hq.nasa.gov>
Subject:

~~~~~  
Pamela F. Richardson  
Aerospace Technology Mission Assurance Manager  
Enterprise Safety and Mission Assurance Division, Code QE  
Office of Safety and Mission Assurance, NASA Headquarters  
300 E. Street, S. W., Washington, DC 20546

phone: 202-358-4631, fax: 202-358-2778

~~~~~  
"The meek can *have* the Earth. The rest of us are going to the stars." --- Robert Heinlein

"We have to learn to manage information and its flow. If we don't, it will all end up in turbulence." --- RADM Grace Hopper
~~~~~



questionsforbryan.doc

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Peter J. Rutledge, Ph.D.  
Director, Enterprise Safety and Mission Assurance Division  
Acting Director, Review and Assessment Division  
Office of Safety and Mission Assurance  
NASA Headquarters, Code QE, Washington, DC 20546

ph: 202-358-0579  
FAX:202-358-2778  
e-mail: [pete.rutledge@hq.nasa.gov](mailto:pete.rutledge@hq.nasa.gov)

**Mission Success Starts with Safety!**

X-Sender: pphillip@mail.hq.nasa.gov  
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2  
Date: Wed, 05 Feb 2003 13:30:59 -0500  
To: mgstamatelatos <mstamate@mail.hq.nasa.gov>  
From: Pepper Phillips <pphillip@hq.nasa.gov>  
Subject: HCAT Question

Question for you from the HCAT:

Was the potential of Foreign Object Debris impact damage considered in the existing PRA model?

jan.railsback-1@nasa.gov, roger.l.boyer1@jsc.nasa.gov, 02:06 PM 2/5/2003 -0500, Fwd: HCA

To: jan.railsback-1@nasa.gov, roger.l.boyer1@jsc.nasa.gov  
From: Michael Stamatelatos <mstamate@hq.nasa.gov>  
Subject: Fwd: HCAT Question  
Cc:  
Bcc:  
Attached:

Jan/Roger:

HCAT is asking the following question:

**"Was the potential of Foreign Object Debris impact damage considered in the existing PRA model?"**

I need an official answer ASAP.

Thanks,  
Michael

**Pepper Phillips, 02:14 PM 2/5/2003 -0500, Re: HCAT Question**

---

**To:** Pepper Phillips <pPhillip@hq.nasa.gov>  
**From:** Michael Stamatelatos <mstamate@hq.nasa.gov>  
**Subject:** Re: HCAT Question  
**Cc:**  
**Bcc:**  
**Attached:**

**Pepper:**  
I'll get you an official answer ASAP.  
Michael

**At 01:30 PM 2/5/2003 -0500, you wrote:**  
Question for you from the HCAT:

Was the potential of Foreign Object Debris impact damage considered in the existing PRA model?

From: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>  
To: "'Michael Stamatelatos'" <mstamate@hq.nasa.gov>  
Cc: "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>, "Dennis Moore (E-mail)" <Dennis.R.Moore@msfc.nasa.gov>  
Subject: RE: HCAT Question  
Date: Wed, 5 Feb 2003 13:51:11 -0600  
X-Mailer: Internet Mail Service (5.5.2653.19)

Michael,

The answer is, yes, we do consider the probability of Foreign Object Debris hits to the Orbiter TPS, but we make no distinction regarding where the debris came from. The debris could come from anywhere on the vehicle during ascent, micrometeoroid and orbital debris (MMOD) from on-orbit, and debris from the runway during Landing/Deceleration.

We also have a model for the probability of loss of External Tank (ET) insulation, but only in regards to overheating of the ET due to the loss of insulation. This is a MSFC model.

If you need a more in-depth answer, let me know.

**Jan W. Railsback**  
**Lead Analyst**  
**Safety, Reliability, and Quality Assurance**  
**Advanced Programs and Analysis Division**  
Ph: 281-483-7265  
Fax: 281-244-2318  
jan.railsback-1@nasa.gov

-----Original Message-----

**From:** Michael Stamatelatos [mailto:mstamate@hq.nasa.gov]  
**Sent:** Wednesday, February 05, 2003 1:06 PM  
**To:** RAILSBACK, JAN (JSC-NX) (NASA); BOYER, ROGER L. (JSC-NC) (SAIC)  
**Subject:** Fwd: HCAT Question  
**Importance:** High

Jan/Roger:

HCAT is asking the following question:

**"Was the potential of Foreign Object Debris impact damage considered in the existing PRA model?"**

I need an official answer ASAP.

Thanks,

**Michael**

\*\*\*\*\*

Dr. Michael Stamatelatos  
Manager, Agency Risk Assessment Program  
NASA Headquarters - Mail Code QE  
Office of Safety and Mission Assurance  
300 E Street, SW  
Washington, DC 20024  
Phone: 202/358-1668 Fax: 202/358-2778  
E-mail: Michael.G.Stamatelatos@nasa.gov  
(Please note change in e-mail address)

\*\*\*\*\*

**"Mission success starts with safety"**

To: Pepper Phillips <pPhillip@hq.nasa.gov>  
From: Michael Stamatelatos <mstamate@hq.nasa.gov>  
Subject: Fwd: RE: HCAT Question  
Cc: pete.rutledge@hq.nasa.gov  
Bcc:  
Attached:

Pepper:  
Jan Railsback is the current acting Shuttle PRA project manager.  
His answer is given below.  
Michael

From: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>  
To: "'Michael Stamatelatos'" <mstamate@hq.nasa.gov>  
Cc: "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>,  
"Dennis Moore (E-mail)" <Dennis.R.Moore@msfc.nasa.gov>  
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Date: Wed, 5 Feb 2003 13:51:11 -0600  
X-Mailer: Internet Mail Service (5.5.2653.19)

Michael,

The answer is, yes, we do consider the probability of Foreign Object Debris hits to the Orbiter TPS, but we make no distinction regarding where the debris came from. The debris could come from anywhere on the vehicle during ascent, micrometeoroid and orbital debris (MMOD) from on-orbit, and debris from the runway during Landing/Deceleration.

We also have a model for the probability of loss of External Tank (ET) insulation, but only in regards to overheating of the ET due to the loss of insulation. This is a MSFC model.

If you need a more in-depth answer, let me know.

**Jan W. Railsback**  
**Lead Analyst**  
**Safety, Reliability, and Quality Assurance**  
**Advanced Programs and Analysis Division**  
Ph: 281-483-7265  
Fax: 281-244-2318  
jan.railsback-1@nasa.gov

-----Original Message-----

From: Michael Stamatelatos [<mailto:mstamate@hq.nasa.gov>]

Sent: Wednesday, February 05, 2003 1:06 PM  
To: RAILSBACK, JAN (JSC-NX) (NASA); BOYER, ROGER L. (JSC-NC) (SAIC)  
Subject: Fwd: HCAT Question  
Importance: High

Jan/Roger:

HCAT is asking the following question:

"Was the potential of Foreign Object Debris impact damage considered in the existing PRA model?"

I need an official answer ASAP.

Thanks,  
Michael

\*\*\*\*\*

Dr. Michael Stamatelatos  
Manager, Agency Risk Assessment Program  
NASA Headquarters - Mail Code QE  
Office of Safety and Mission Assurance  
300 E Street, SW  
Washington, DC 20024  
Phone: 202/358-1668 Fax: 202/358-2778  
E-mail: Michael.G.Stamatelatos@nasa.gov  
(Please note change in e-mail address)

\*\*\*\*\*

"Mission success starts with safety"

From: "HSU, FENG (JSC-NC) (SAIC)" <feng.hsu1@jsc.nasa.gov>

To:

Cc:

"mstamate@hq.nasa.gov"

<mstamate@hq.nasa.gov>

Subject: Proposal for effective use of Shuttle PRA models in STS-107 Investigation

Date: Fri, 7 Feb 2003 16:02:15 -0600

X-Mailer: Internet Mail Service (5.5.2653.19)

Thanks for the MMOD uncertainty document. I have drafted a proposal express our views regarding how our NASA/SAIC management are using the fault trees in their efforts for the Columbia investigation. Please help review the attached proposal and to see if you agree with my opinion. I hope that we can put out a joint proposal to help out NASA on this important accident investigation. Any comments at your earliest convenience will be very much appreciated. I have spoken a number of times on this issue during our meetings, however nobody here would seem to listen this kind of technical suggestions. I really feel frustrated with the kind of bureaucracies that rooted deeply here in the NASA environment.

Feng

-----Original Message-----

**From:**

**Sent:** Friday, February 07, 2003 9:45 AM

**To:** RAILSBACK, JAN (JSC-NX) (NASA); Roger Boyer; Moebes, Travis A.; ROELANT, HENK (JSC-NC) (NASA); Michael Stamatelatos

**Cc:** HSU, FENG (JSC-NC) (SAIC)

**Subject:** Revised Version of the MMOD Uncertainty Document

Enclosed is the revised version of the MMOD Uncertainty Document. The last sections give application of the methodology for the Space Shuttle PRA. Travis, please send Nick and Mark a copy. Eric might also be interested..

 EIPAS-proposa.ppt

# A Proposed Approach to Utilize the Existing Integrated Shuttle PRA Model to Help Guide the Effective Identification of Possible Accident Scenarios on STS-107

## *(The EIPAS Approach)*

*Feng Hsu*

### **OBJECTIVES:**

1. Need to identify the most likely orbiter sub-systems which could have contributed to the accident
2. Need to identify a list of most likely accident initiators which appear to be directly related to the accident
3. Need to identify a list of most likely accident scenarios which best explain the accident sequences based on available crash data & scientific evidence
4. Need to identify most likely root causes that triggered the occurrence of accident initiating events in the first place

### **REQUIREMENT:**

**“No possibilities of accident scenario will be ruled out” in the investigation**

# **Why This Proposal Is Important ?**

- 1. Because our current policy in this investigation is “Not to rule out any possible accident scenario” – quote from Ron Dittmore**
- 2. The on-going activities to identify initiators & likely scenarios (by searching through only system-level fault trees, and cutting away pages and tree branches) will not help achieve our goal, and it is working against our “nothing ruled out” policy**
- 3. Our currently available resources and techniques are not fully utilized for this investigation, such as the “Integrated Shuttle PRA model” for which we have been working on for the past several years, let alone our key technical staffs who know how this “big-picture” Over-arching model can help expedite the investigation without ruling out a single possible scenario**
- 4. Even if the current system level tree-searching task must be carried out, the manual searching on graphical tree branches will not help much (because the logic is too complex to be followed correctly by manual effort) , instead we need to first screen the basic events within the system, and re-set these events as “false” (house events), and then looking through all the re-generated Minimal Cut Sets (MCSs – a single MCS represents a possible accident scenario) to identify what we are looking for?**

# How to Achieve These Objectives?

## 1. On-going Method: (Isolated use of sub-system FTs)

Subjectively selected a list of sub-systems, and screen through each page of sys-level FTs to reduce the fault tree logic, therefore wish to narrowing the target of identifying the accident initiators

*Advantages:* The concept appeared easier to be understood by managers, and easy to be carried out by various sub-system engineers

*Disadvantages:* The concept is flawed if our objectives are to be achieved, because cross dependencies between mission phases & sub-systems do exist, and manually reduce logic by simply cutting away FT pages would eliminate numerous accident scenarios, and this will hardly achieve our intended objectives

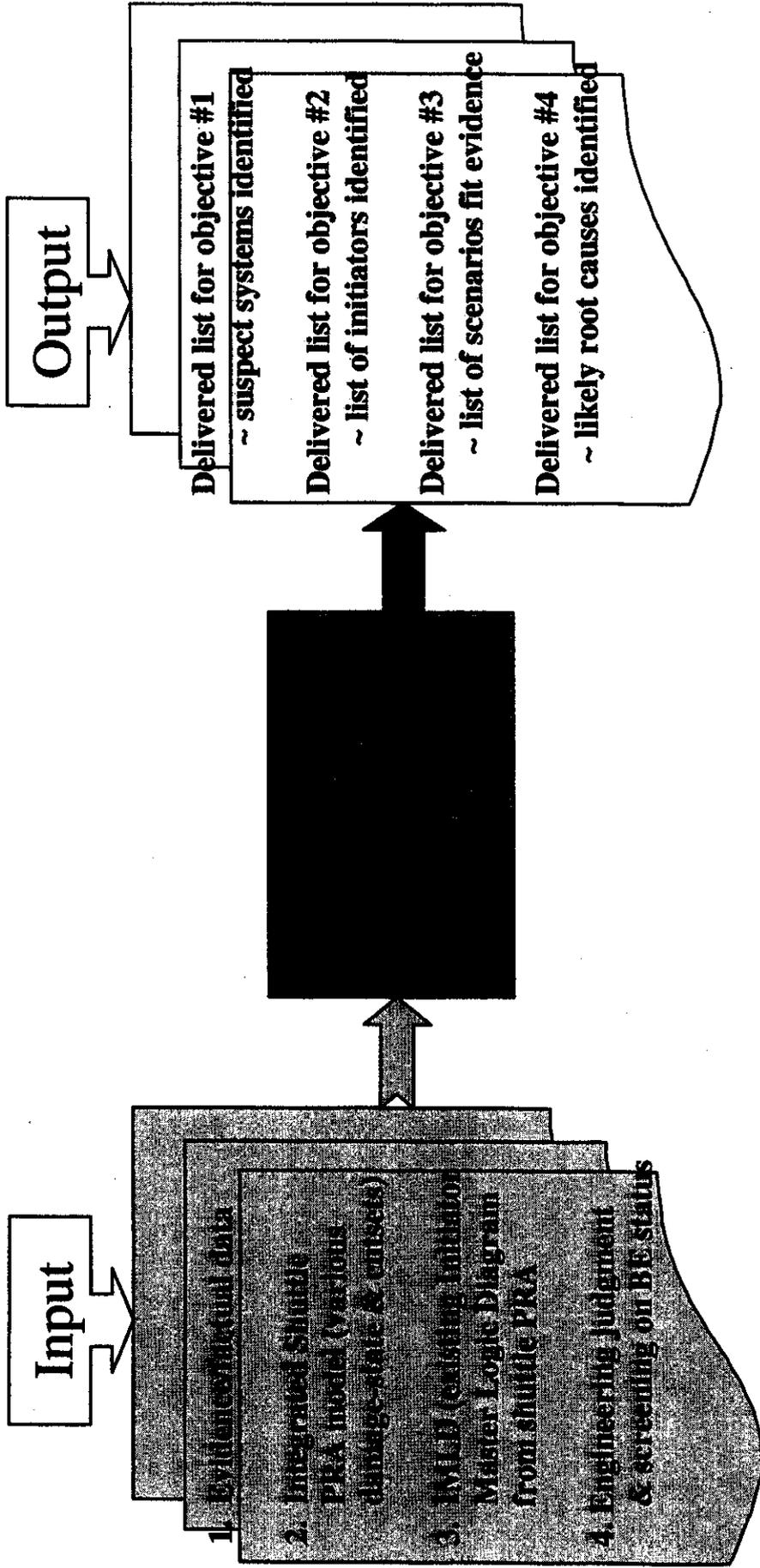
## 2. Proposed Method: (Use Integrated Shuttle PRA)

Effective use of existing Integrated shuttle PRA results (both qualitative/quantitative) to achieve our objectives based on scientific method and powerful tools/resources already available

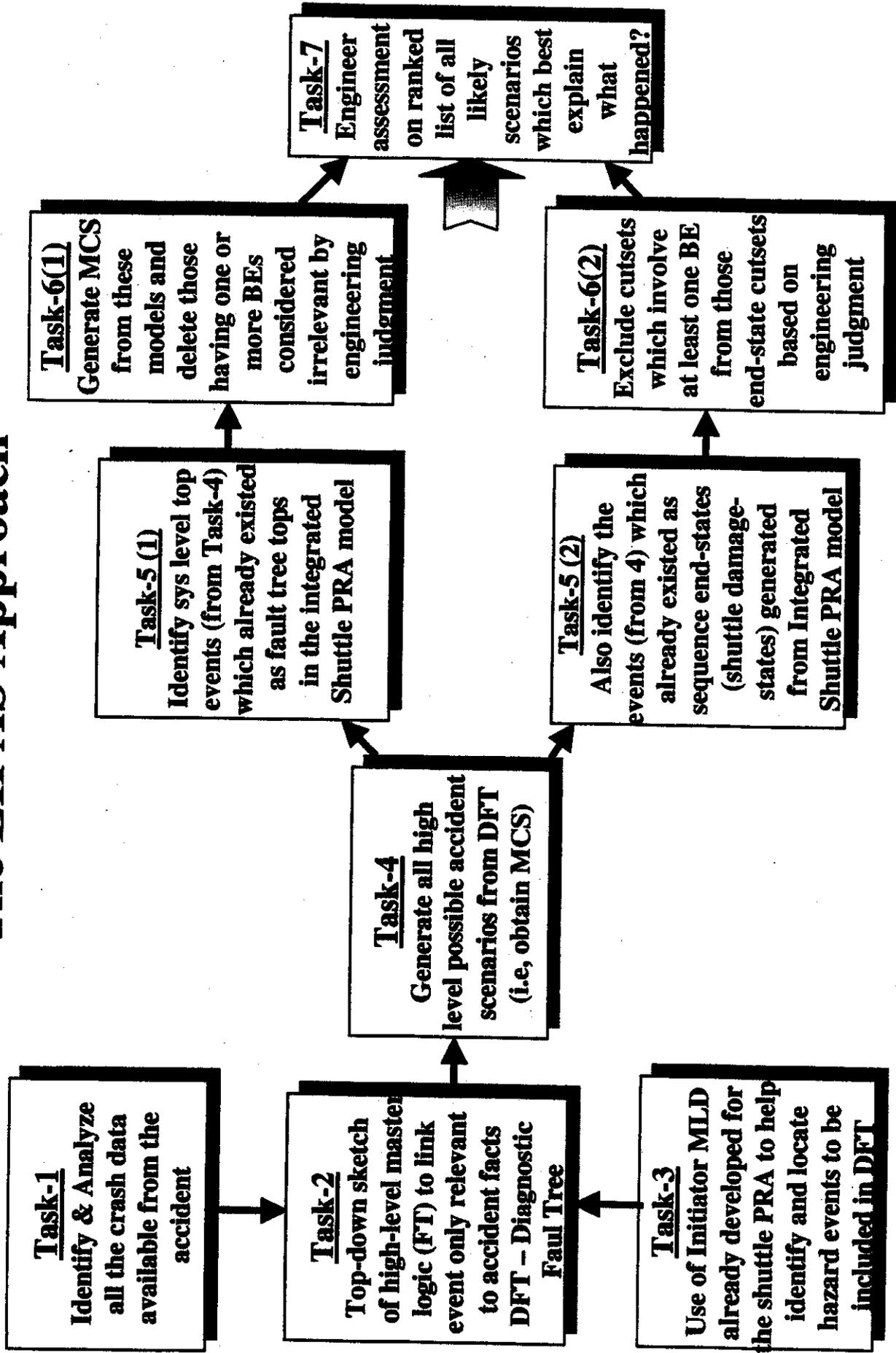
*Advantages:* can achieve objectives in shorter time & much greater confidence

*Disadvantages:* Need in-depth PRA knowledge to perform, need to know why?

# How EIPAS Approach Work?



# The EIPAS Approach



# **Examples**

**To Help Understand the Proposed “EIPAS”  
Approach and the Integrated Shuttle PRA Model**

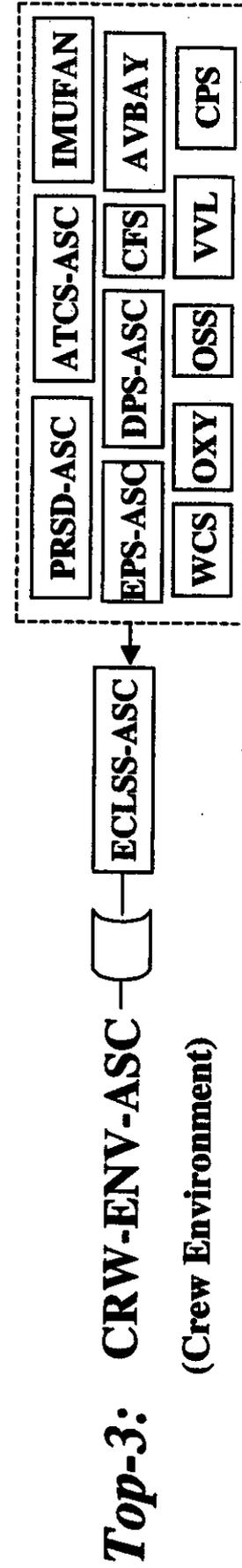
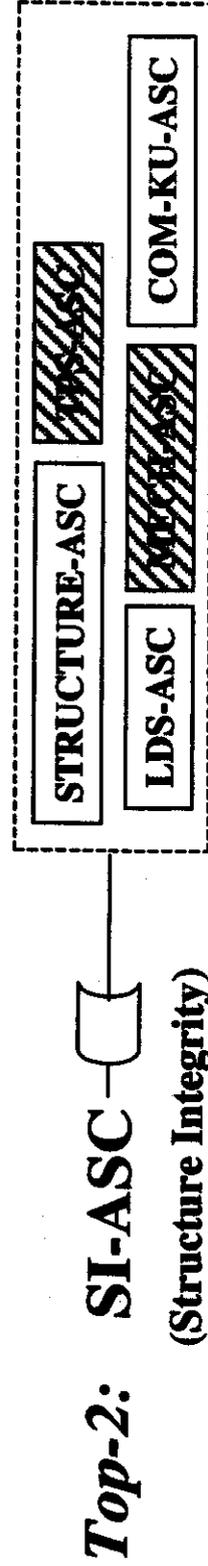
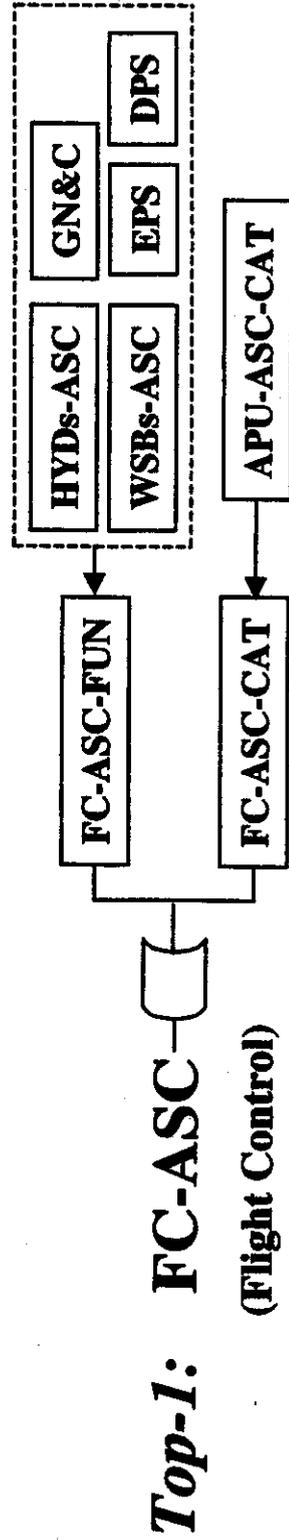


# An Example List of High-level Accident Scenario Generated from Task-4

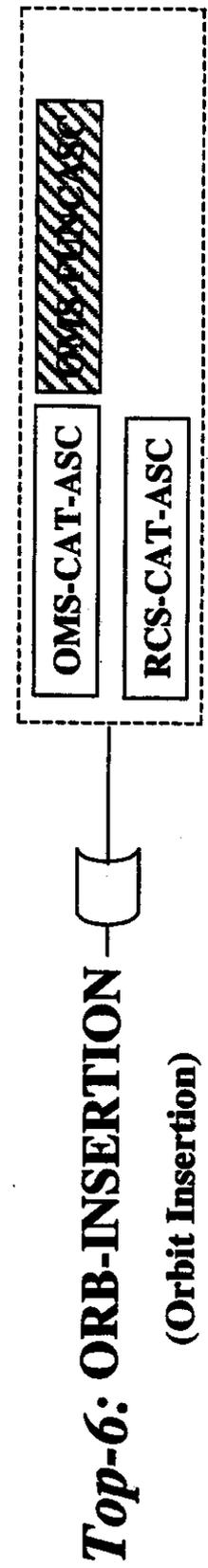
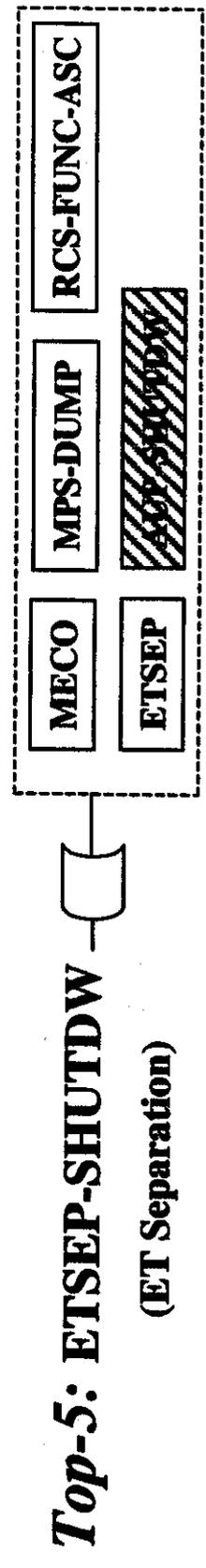
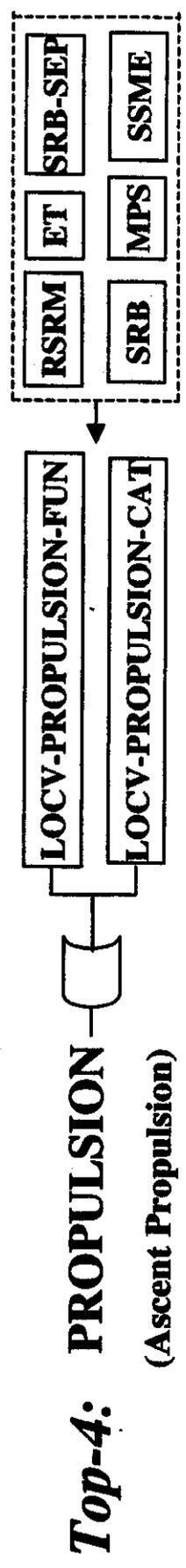
| List of Possible High Level Accident Scenarios Generated from DFT (Diagnostic Fault Tree) |         |           |                   |                                                              |
|-------------------------------------------------------------------------------------------|---------|-----------|-------------------|--------------------------------------------------------------|
| Project : DIAGNOSIS-MODEL-107                                                             |         |           |                   |                                                              |
| Mincut Upper Bound: 1.000E+000                                                            |         |           |                   |                                                              |
| Cut No.                                                                                   | % Total | % Cut Set | Basic Event       | Description                                                  |
| 1                                                                                         | 100     | 100       | FC-M-ENTRY        | Loss of FC on entry (linked Seq# 1-1-6,5 HYD/APU/Surf contr) |
| 2                                                                                         | 100     | 100       | LDS-M-ENTRY       | Loss of LDS on entry LOCV-LDS-ENT (Linked Seq# 1-1-2)        |
| 3                                                                                         | 100     | 100       | OMS-RCS-CAT-ENT   | Fire/Exp due to OMS/RCS cat failure on entry                 |
| 4                                                                                         | 100     | 100       | HYD-APU-CAT-ENT   | Fire/Exp due to HYD/APU cat failure on entry                 |
| 5                                                                                         | 100     | 100       | MPS-LOCV-ENT      | Fire/Exp due to MPS residual probl on entry                  |
| 6                                                                                         | 100     | 100       | MECH-LOCV-ENT     | Orbiter Mechanical Sys failure on entry                      |
| 7                                                                                         | 100     | 100       | STRUCT-AGING      | Orbiter structural failure due to Aging                      |
| 8                                                                                         | 100     | 10        | PROB-SI-TPS       | Prob. of total SI failure on entry given damaged TPS         |
| 9                                                                                         | 100     | 10        | TPS-DMG-ORB       | TPS damage on orbit                                          |
| 10                                                                                        | 100     | 10        | PROB-SI-TPS       | Prob. of total SI failure on entry given damaged TPS         |
| 11                                                                                        | 100     | 10        | TPS-DMG-ICE-DEBRI | TPS damage in ascent due to Icebuildup/debris hit            |
| 12                                                                                        | 100     | 10        | PROB-SI-TPS       | Prob. of total SI failure on entry given damaged TPS         |
| 13                                                                                        | 100     | 10        | TPS-DMG-ENT       | TPS damage during entry                                      |
| 14                                                                                        | 100     | 10        | PROB-SI-TPS       | Prob. of total SI failure on entry given damaged TPS         |
|                                                                                           | 100     | 10        | TPS-DMG-DEBOND    | TPS damage in asc due to TPS debond/pupcoming                |
|                                                                                           | 100     | 10        | MMOD-DMG-ORB      | MMOD impact occurred on Orbit                                |
|                                                                                           | 100     | 10        | PROB-SHMMOD       | Prob. of total SI failure on entry given MMOD hit            |
|                                                                                           | 100     | 10        | MMOD-DMG-ENT      | MMOD impact occurred on entry                                |
|                                                                                           | 100     | 10        | PROB-SHMMOD       | Prob. of total SI failure on entry given MMOD hit            |
|                                                                                           | 100     | 10        | PROB-SI-TPS       | Prob. of total SI failure on entry given damaged TPS         |
|                                                                                           | 100     | 10        | TPS-DMG-LIGHTN    | TPS damage in asc due to external event/lightning strk       |
| 2/6/2003                                                                                  | Page #  | 23:04:54  |                   |                                                              |

# The Top Event Hierarchies of Model Integration

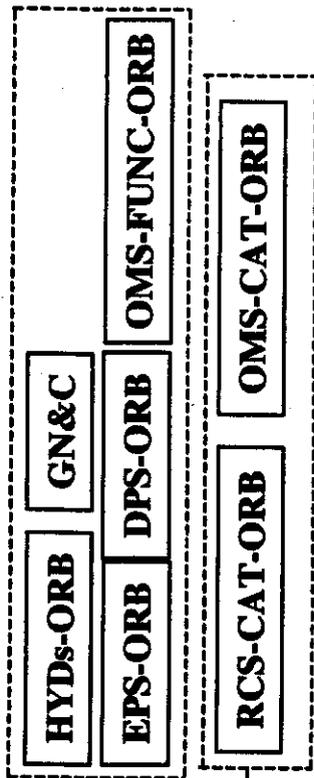
## ASCENT Event Tree



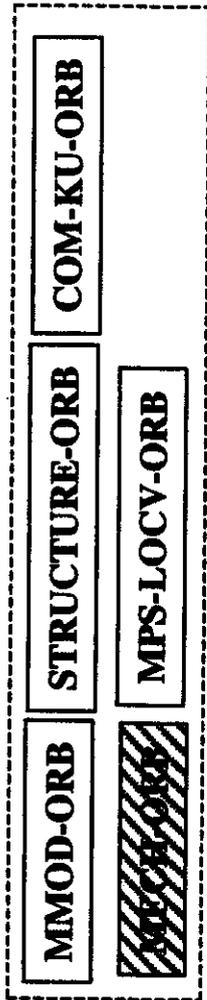
# ASCENT Event Tree



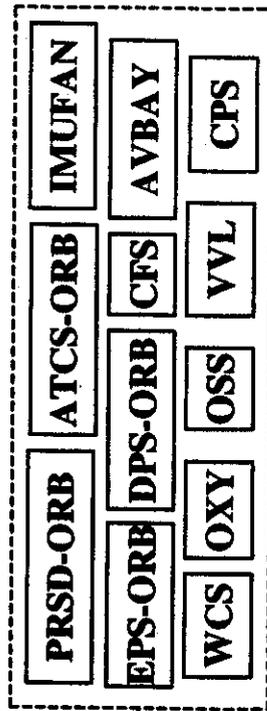
# ORBIT Event Tree



**Top-1: FC-ORB**  
(Flight Control)



**Top-2: SI-ORB**  
(Structure Integrity)



**Top-3: CRW-ENV-ORB**  
(Crew Environment)



**Top-4: DOC-EVA-ORB**  
(Crew EVA & Docking)

# Example List of Lowe-level (Detailed) Accident Scenario Generated from Task-6(2)

| Sort/Slice Cut Set Report |         | Project End State: LOCV-FC-M-ENT (Total risk scenario for Flight Control - all phases) |                                                                                                    |
|---------------------------|---------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Mincut U                  |         | This Partition: 1.412E-003                                                             |                                                                                                    |
| MCS                       | % Cut S | Prob./Frequ                                                                            | Basic Event                                                                                        |
| 1                         | 7.1     | 9.97E-05                                                                               | LAUNCH_START                                                                                       |
| 2                         | 6.5     | 9.17E-05                                                                               | E_O_MCH_EMAADS_CC<br>LAUNCH_START                                                                  |
| 3                         | 5.9     | 8.25E-05                                                                               | E_O_APU2_IN_LKE_CC<br>LAUNCH_START                                                                 |
| 4                         | 5.9     | 8.25E-05                                                                               | E_O_APU1_IN_LKE_CC<br>LAUNCH_START                                                                 |
| 11090                     | 0       | 2.59E-09                                                                               | E_O_APU3_IN_LKE_CC<br>A_O_WSB1_LVL5_XFC<br>E_O_HP2CO_PVLC_FTO<br>O_O_HP3_CPMTR_FTR<br>LAUNCH_START |
| 11091                     | 0       | 2.59E-09                                                                               | A_O_WSB1_LVL5_XFC<br>E_O_HP3_PVLC_FTO<br>O_O_HP2_CPMTR_ELEC<br>LAUNCH_START                        |
| 11092                     | 0       | 2.59E-09                                                                               | E_O_HP2_MVLC_FTO<br>E_O_HP3_PVLC_FTO<br>O_O_HP1_CPMTR_ELEC<br>LAUNCH_START                         |
| 11093                     | 0       | 2.59E-09                                                                               | E_O_HP2_MVLC_FTO<br>E_O_HP3_MVLC_FTO<br>O_O_HP1_CPMTR_ELEC                                         |

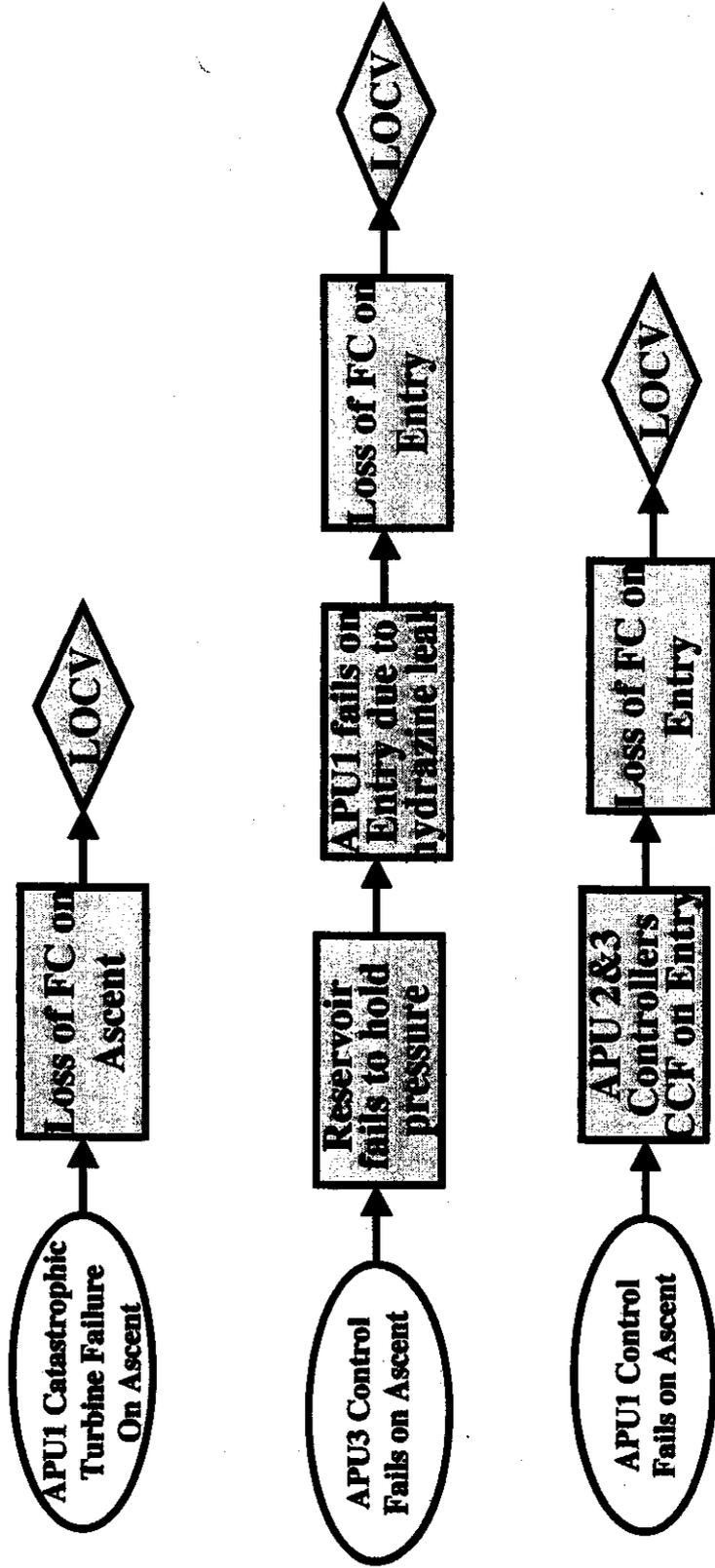
| Description                                                        |
|--------------------------------------------------------------------|
| Developed Event                                                    |
| Common Cause Failure of Air Data Sensor Deployment Actuator -entry |
| Developed Event                                                    |
| CATASTROPHIC INJECTOR LEAK - APU2 on entry                         |
| Developed Event                                                    |
| CATASTROPHIC INJECTOR LEAK - APU1 on entry                         |
| Developed Event                                                    |
| CATASTROPHIC INJECTOR LEAK - APU3 on entry                         |
| Lube oil water-supply valve transfers closed on ascent             |
| Priority check valve fails to open on entry                        |
| Circulation pump motor fails to run on orbit                       |
| Developed Event                                                    |
| Lube oil water-supply valve transfers closed on ascent             |
| Priority check valve fails to open on entry                        |
| ELECTRICAL FAILURE OF MAIN BUS B & C on orbit                      |
| Developed Event                                                    |
| Lube oil water-supply valve transfers closed on ascent             |
| Main check valve fails to open on entry                            |
| ELECTRICAL FAILURE OF MAIN BUS B & C on orbit                      |
| Developed Event                                                    |
| Main ck vv fails to open on entry                                  |
| Priority check valve fails to open - entry                         |
| ELECTRICAL FAILURE OF MAIN BUS A & B on orbit                      |
| Developed Event                                                    |
| Main ck vv fails to open                                           |
| Main check valve fails to open                                     |
| ELECTRICAL FAILURE OF MAIN BUS A & B                               |



# Example Output from Integrated Shuttle

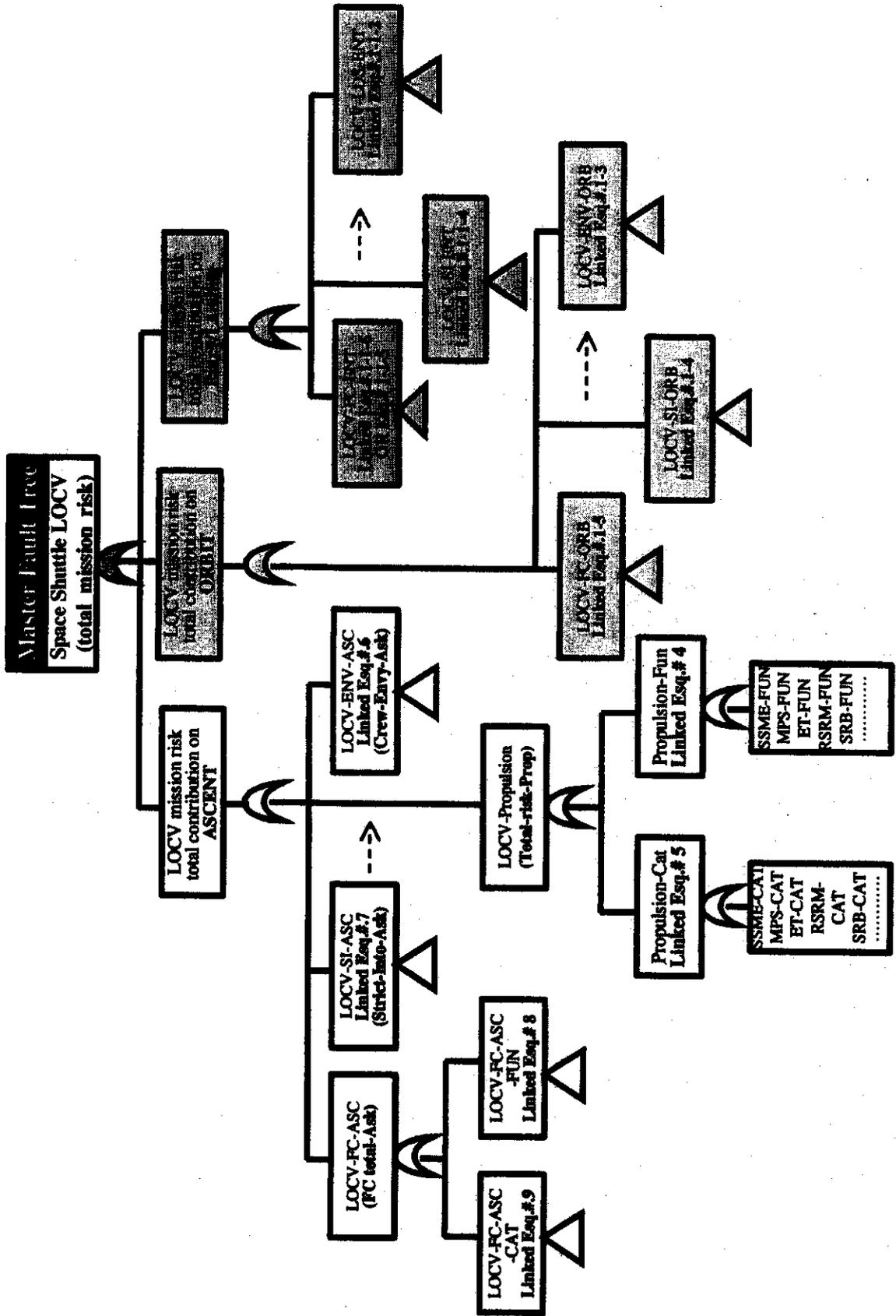
## PRA

### Example End-State Sequences in "Flight Control" Accidents:



# Space Shuttle PRA Model Integration Approach (Cont'd)

## Phase III - Shuttle Mission Risk Quantification Master Logic



# Revisit of the Major Top Event Models (FTs/ETs)

## ASCENT Mission Event Tree & Detailed Model Structure (Updated)

| Top#1                       | Top#2                                 | Top#3                         | Top#4                           | Top#5                             | Top#6                           |
|-----------------------------|---------------------------------------|-------------------------------|---------------------------------|-----------------------------------|---------------------------------|
| FC-ASC<br>FT<br>(developed) | STRUCT-INITG-ASC<br>FT<br>(developed) | CRW-ENV<br>FT<br>(to develop) | PROPULSION<br>ET<br>(developed) | ETSEP-SHUTDW<br>ET<br>(developed) | ORB-INSERT<br>ET<br>(developed) |

Sub Event Tree for Top#4 } RSRM } FT  
 (SE-PROPULSION): } MPS } FT  
 } SSME } FT

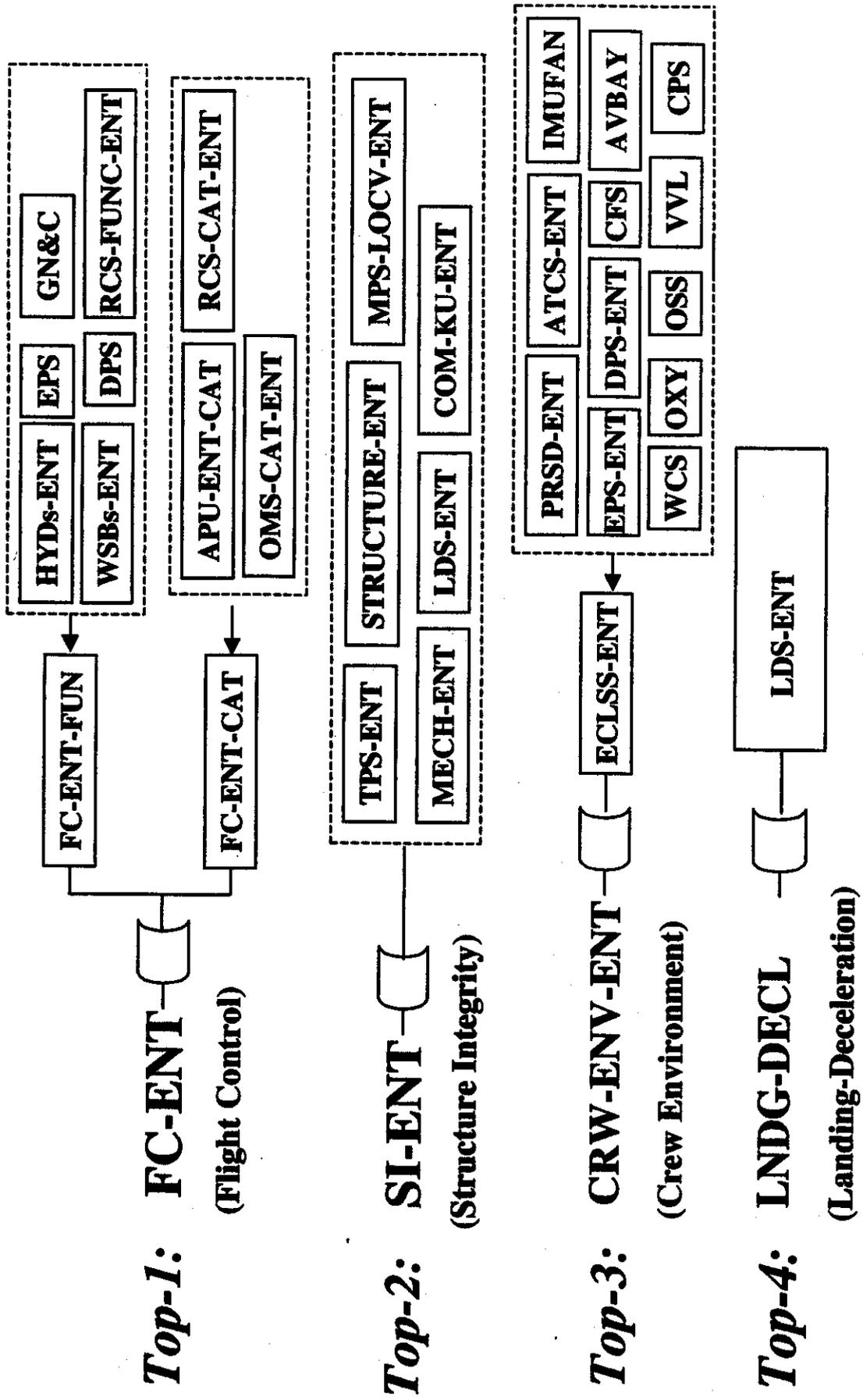
Sub Event Tree for Top#6 } MECO } ET-SEP } FT  
 (SE-ETSEP-SHUTDW): } ET or FT } ET

Lower level sub Event Tree } CLS-17DCVL RETRA-ETUMB ETSEP } MAUL-SEP ET-JUMB-DRS } FT  
 (SSE-ET-SEP): } FT } FT } FT

Sub Event Tree for Top#7 } OMS2-THR } FT  
 (SE-ORB-INSERT): } RCS-FIRINGS } FT

Nomenclatures {  
 ASC - Ascent  
 FT - Indicated top event to be modeled by Fault Trees  
 ET - Indicated top event to be modeled by Event Trees  
 EST - Top event to be modeled by probability data estimates

# ENTRY-LANDING Event Tree



From:

Date: Sun, 9 Feb 2003 10:18:17 EST

Subject: Fwd: Comments on PRC Risk Assessment Mis-statements in Chronology Slide Prese...

To: jan.railsback1@jsc.nasa.gov, dwhittle@ems.jsc.nasa.gov

CC: mstamate@hq.nasa.gov, wvesely

X-Mailer: AOL 7.0 for Windows US sub 10641

Gentlemen: As the PRC Technical Manager in 1998-1991 on what is identified as the 1989 PRA, I prepared the forwarded email to try to correct misstatements about the subject PRA. Yohon Lo has provided a copy of the referenced Chronology document to me. The effort was initiated as an accident probability analysis for the Galileo and Ulysses Missions that utilized the Shuttle as an on-orbit launching platform for the Spacecraft. The over 200 fault trees interfaced with the overlying DOE prepared event trees (Lockheed Martin-King of Prussia, PA). At the request of NASA HQ and NASA JSC, I re-assembled the fault trees to provide risk contribution at the Shuttle element, system and subsystem levels. I have a copy of the Summary Report Volume 1 and the detailed fault trees and supporting data in Volume 2. Volume 2 also contains risk ranking at the subsystem and component level. The report was published by PRC through NASA Headquarters but was not published as a NASA wide document. The fact that it covered the Pre launch propellant loading operations, as well as the ascent phase, included five abort scenarios, and on-orbit Orbiter Vehicle Breakup until release of the Spacecraft, seems to have been obscured by recent descriptions of this Project that I have seen.

I can provide more information if required.

Bob

Return-path:

From:

Full-name: Mulvihill

Message-ID:

Date: Fri, 7 Feb 2003 13:50:12 EST

Subject: Comments on PRC Risk Assessment Mis-statements in Chronology Slide Presentation

To: Yohon.Lo@msfc.nasa.gov

CC: Jim.H.Rogers@msfc.nasa.gov

MIME-Version: 1.0

Content-Type:

X-Mailer: AOL 7.0 for Windows US sub 10641

Yohon: Please pass on my response to the description of the 1989 Galileo Risk Assessment as presented in the Executive Summary: Chronology of Space.Shuttle Quantitative Risk Assessments Powerpoint slide. As you know, I was the PRC Technical Manager, and was charged with the responsibility of developing the detailed fault trees that interfaced with the Department of Energy event trees. The latter presented release sequences of Plutonium 238 present in the three Radioisotope Thermoelectric Generators. I have a copy of the Summary Report (Volume 1 ) and Volume 2 which contains over 200 fault trees, as well as listings of the data for the fault tree basic events and the relevant sources. NASA requested that the Accident Probability Analysis that was incorporated in the Department of Energy Safety Analysis Report (Required by Law) into a Shuttle Risk Assessment. I had to rearrange some of the fault trees to group by Shuttle Systems/Major Components. The SSMEs and combined SRB/PSRMs had detailed fault trees. Detailed fault trees for the SRB APUs ignition and control logic were present. The US Air Force maintained a solid rocket booster database (including Titan, Poseiden), but would only give us the relative failure contributions of major components (igniter, nozzle etc. We used data in the open literature for some SRB failure modes, modified

for similarity, and used the relative frequency information in a top down method. The overall approach for the 1989 Risk Assessment was a bottom up approach, not a top down approach. Historical data for the prior missions up to the Galileo Launch were used in Bayesian updating processes. The information on the PowerPoint viewgraph is incorrect in many respects. SAIC supported the SRB data analysis under a subcontract, and the discussion in the Chronology could have come from that source, because they were not involved in the overall approach and modeling. This is just a guess.

The 1989 PRA covered more than the Ascent Phase as listed below:

Pad Fire/Explosion: Phase 0A (T-8 hours to T-0)  
SSME Ignition: Phase 0B (T-6 seconds to Liftoff)  
Ascent Phase: 1 (A, B, C, D) (T=0 to T+128 seconds)  
Ascent Phase 2; (T+128 seconds to T+532 seconds)  
ON Orbit Phase 3A (T+532 sec. to Payload Bay Doors Open)  
Phase 3B (OMS 1 and 2 Payload Spacecraft Deployed).

Five Abort Fault Trees were included including Return to Launch Site (RTL), Abort Once Around (AOA), Abort to Orbit (ATO), Transatlantic Abort Landing (TAL) and Abort From Orbit (AFO).. Landing sequences were included in the associated abort fault tree logic.

The median value is correct at 1/78. The 20th percentile was determined to be 1/168 and the 80th percentile was determined to be 1/36. The contribution of the SRB/RSRM during Phase 1 was determined to be a median of 1/278, The 20th percentile was determined to be 1/624 and the 80th percentile was determined to be 1/124. Incidentally, Phase 3 Orbiter Breakup was determined to be a median of 1/2200. Phase 2 Abort was determined to have a median value of 1/11,000 and Phase 3 Abort was determined to be 1/15,000.

I have no specific knowledge of the quoted QRAS numbers in the Chronology document, except for the External Tank. My Summary Report, dated July 25, 1999 shows the following for the SLWT: Median 1/7,000, mean 1/6,800, 5th perc. 1/10,000, and 95th 1/4,600. The plotted QRAS Range on the Executive Summary slide is Median 1/7,246 and a range from approximately 1/250 to 1/10,000. The 2,000 QRAS plot is consistent except for the lower limit.

I am rewriting the Remarks Wording for the Chronology of Space Shuttle Risk Assessments. It is attached.

Bob

 REVISI-1.DOC

# **REVISION FOR CHRONOLOGY OF SPACE SHUTTLE RISK ASSESSMENTS**

**Robert J. Mulvihill, HEI, 2/7/03**

- 1) **Under Mission Heading**, replace N/A by “1/78 value includes on –orbit phases and aborts”
- 2) **Under REMARKS Heading** replace current description with “Phase II SSMEs. Risk assessment covers Prelaunch, Ascent, Aborts and On –orbit risk up to Galileo Spacecraft deployment. Included Orbiter Vehicle Breakup scenarios.

**Method:** Extensive fault trees which interfaced with Department of Energy FAST Event Trees for Pu-238 release scenarios. A bottom –up analysis based on fault tree quantification was used, with Bayesian updating using test and flight history. Several hundred failure modes were included as fault tree basic events. Some SRB failure modes were quantified using similarity analysis with other solid rocket motors, and entered in fault trees, while others such as the SRB APUs were modeled directly in the fault trees.

**RAILSBACK, JAN (JSC-NX) (NASA)" , "BOYER, ROGER L. (JSC-NC) (SA, 08:49 AM 2/10/20**

To: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>, "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>

From: Michael Stamatelatos <mstamate@hq.nasa.gov>

Subject: Code M Question

Cc:

Bcc:

Attached:

Jan/Roger:

I need the answer to the following urgent questions:

1. How many single point failures are there in the entire Space Shuttle?
2. Do you have a breakdown of single point failures by Shuttle system (e.g. Orbiter, ET, SRB, etc.)? If so, what is it?

Michael

X-Sender: rpatrica@mail.hq.nasa.gov  
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2  
Date: Mon, 10 Feb 2003 09:03:20 -0500  
To: HCAT@hq.nasa.gov, whill@hq.nasa.gov  
From: Richard Patrican <rpatrica@hq.nasa.gov>  
Subject: Space Shuttle PRA response  
Cc: mstamate@hq.nasa.gov, prutledg@hq.nasa.gov, prichard@hq.nasa.gov,  
jlloyd@hq.nasa.gov, mkowales@hq.nasa.gov

Per the HCAT's request, here is the response to questions concerning the Space Shuttle PRA.



Kostelnik Action 221.doc

Rich Patrican  
Manager, International Space Station  
Office of Safety and Mission Assurance  
Headquarters Office 5X35  
Phone: 202-358-0569  
Fax: 202-358-2772

From: "Goodson, Amanda" <Amanda.H.Goodson@nasa.gov>  
To: "'James Lloyd'" <jlloyd@hq.nasa.gov>, yolanda.y.marshall1@jsc.nasa,  
Oscar.Toledo-1@ksc.nasa.gov, Amanda.Goodson@msfc.nasa.gov,  
Michael.Smiles@ssc.nasa.g  
Cc: mark.d.erminger@nasa.gov, GarriH@ksce.ms.ksc.nasa.gov,  
Alex.Adams@msfc.nasa.gov, prutledg@hq.nasa.gov,  
jlemke <jlemke@hq.nasa.gov>, wfrazier@hq.nasa.gov,  
mgstamatelatos <mstamate@mail.hq.nasa.gov>, dmoore@hq.nasa.gov,  
smadir@hq.nasa.gov, wreaddy@hq.nasa.gov, jmarnix@hq.nasa.gov  
Subject: RE: Hearing Questions (Code Q's been assigned a role in 5 out of 24)  
Date: Mon, 10 Feb 2003 11:37:30 -0600  
X-Mailer: Internet Mail Service (5.5.2653.19)

Comments to the attached subject questions are forwarded for your consideration.

Amanda

-----Original Message-----

From: James Lloyd [<mailto:jlloyd@hq.nasa.gov>]  
Sent: Monday, February 10, 2003 7:49 AM  
To: yolanda.y.marshall1@jsc.nasa; Oscar.Toledo-1@ksc.nasa.gov;  
Amanda.Goodson@msfc.nasa.gov; Michael.Smiles@ssc.nasa.g  
Cc: mark.d.erminger@nasa.gov; GarriH@ksce.ms.ksc.nasa.gov;  
Alex.Adams@msfc.nasa.gov; prutledg@hq.nasa.gov; jlemke;  
wfrazier@hq.nasa.gov; mgstamatelatos; dmoore@hq.nasa.gov;  
smadir@hq.nasa.gov; wreaddy@hq.nasa.gov; jmarnix@hq.nasa.gov  
Subject: Hearing Questions (Code Q's been assigned a role in 5 out of  
24)  
Importance: High

Dear Human Space Flight SMA Director,

We have been handed 5 questions for which we at Code Q will play a role in answering. For one question we are assigned the lead role and the remaining 4 we are playing a support role to either Code M or Code G. I have only sent the 5 out of the entire batch of 24 to you for your information.

By noon we have to have an answer assembled for our External Affairs Office. What I would like from you are short bulletized thoughts on what you think should be addressed in the NASA answer. Although you may have thoughts on question 4 and question 24 (and these are certainly welcome), I would really like you to concentrate on the three questions numbered 8, 11,

Goodson, Amanda, 11:37 AM 2/10/2003 -0600, RE: Hearing Questions (Code Q's been assign

and 16. Provide your feedback in the next two hours directly by email to the named action lead with a copy to me.

We will talk at 1 PM EST this afternoon at the normally established teleconference.

 Hearing Questions 2 12 03 - Response.doc

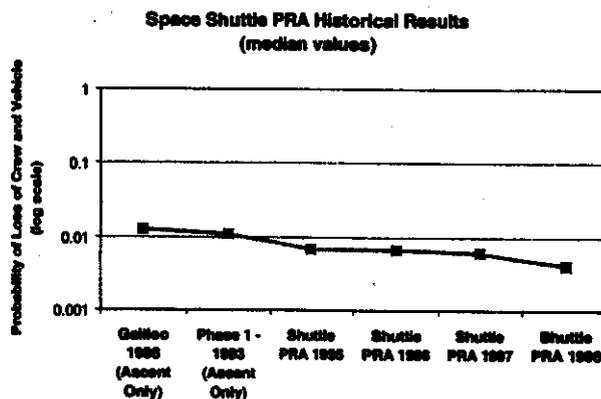
**A Report on the Status of the Shuttle Probabilistic Risk Assessment (PRA) Model for the Contingency Action Team – February 5, 2003**  
 (For questions, please contact Jan Railsback, 281-483-7265)

**1) An overview of the status of the Shuttle PRA model as of 1/31/2003**

| Element             | Status                                         | Future Work                                                                           |
|---------------------|------------------------------------------------|---------------------------------------------------------------------------------------|
| SSME, RSRM, SRB, ET | Preliminary Models and Data Complete           | Acceptance of Models and Data by respective Project Offices by mid-March              |
| MMOD                | Preliminary Models and Data Complete           | Acceptance of Models and Data by Vehicle Engineering Control Board (VECB)—Early March |
| Orbiter             | Preliminary Models Complete; Data 75% Complete | Acceptance of Models and Data by VECB—Early March                                     |

- a) Future Shuttle PRA Modeling Reviews and Reports
  - i) PRA documentation to be completed, June 2003
  - ii) Independent Peer Review to be completed, October 2003
  - iii) Configuration Management activities to be completed, January 2004
- b) Abort Modeling Activities - The Dynamic Abort Risk Evaluation (DARE) method provides Probabilistic Abort Modeling
  - i) Independent Peer Review was conducted January 16-17, 2003 of DARE
  - ii) Draft Results Report due end of February, 2003
  - iii) Final Results Report due end of March, 2003

**2) A discussion of the overall pre-accident values, ascent and mission, preliminary values –** The Shuttle PRA model results have changed over the past several years of iterations, but the median results have consistently converged to between ~1/100 to ~1/250 for a loss of crew and vehicle for an entire mission. The differences in results are due to the amount of available data, the omission of systems from the analysis due to lack of analysis resources, and the addition of data and information from subsequent Shuttle flights. The present model (Shuttle PRA 2003) is the most comprehensive model to date, but is not yet ready for release. Previous Shuttle PRA models are not sanctioned results by the Shuttle program office. The SPRA 2003 will be the first model carrying the Shuttle program office approval.



- 3) A prediction about how the model may change since the accident –** Adding in the failure mode from the Columbia accident may change the final results but how significantly it changes depends on the investigation results. The SPRA 2003 model is currently being used to help the program with possible accident scenarios. Other than making a distinction between sources of debris hits on the Orbiter, there is presently no specific change in modeling philosophy planned due to the Columbia accident. Upon completion of the current initial development effort, future Shuttle PRA activities include three major work efforts:
- a) Maintenance and control of the model
  - b) Applications and studies using the model, and
  - c) Expansion of the model to include ground processing, software, and additional human errors

To: "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>, "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>  
From: Michael Stamatelatos <mstamate@hq.nasa.gov>  
Subject: RE: Code M Question  
Cc:  
Bcc:  
Attached:

Thank you very much. When you give me the answer, also please give me the calculations.

At 06:43 PM 2/10/2003 -0600, BOYER, ROGER L. (JSC-NC) (SAIC) wrote:  
Michael,

I rec'd your message and will have the answer tomorrow.

Roger

-----Original Message-----

From: Michael Stamatelatos [<mailto:mstamate@hq.nasa.gov>]  
Sent: Monday, February 10, 2003 7:49 AM  
To: RAILSBACK, JAN (JSC-NX) (NASA); BOYER, ROGER L. (JSC-NC) (SAIC)  
Subject: Code M Question  
Importance: High

Jan/Roger:

I need the answer to the following urgent questions:

1. How many single point failures are there in the entire Space Shuttle?
2. Do you have a breakdown of single point failures by Shuttle system (e.g. Orbiter, ET, SRB, etc.)? If so, what is it?

Michael

\*\*\*\*\*

Dr. Michael Stamatelatos  
Manager, Agency Risk Assessment Program  
NASA Headquarters - Mail Code QE  
Office of Safety and Mission Assurance  
300 E Street, SW  
Washington, DC 20024  
Phone: 202/358-1668 Fax: 202/358-2778  
E-mail: Michael.G.Stamatelatos@nasa.gov  
(Please note change in e-mail address)

\*\*\*\*\*

"Mission success starts with safety"

From: "BOYER, ROGER L. (JSC-NC) (SAIC)" <roger.l.boyer1@jsc.nasa.gov>  
To: "'Michael Stamatelatos'" <mstamate@hq.nasa.gov>  
Cc: "RAILSBACK, JAN (JSC-NX) (NASA)" <jan.railsback-1@nasa.gov>,  
"ROELANT, HENK (JSC-NC) (NASA)" <henk.roelant-1@nasa.gov>  
Subject: RE: Code M Question  
Date: Wed, 12 Feb 2003 12:48:00 -0600  
X-Mailer: Internet Mail Service (5.5.2653.19)

Michael,

Michael,

Here's what we pulled from the Critical Items List (CIL) for each of the Shuttle elements. I have more detail, but not electronically.

- 1) 1687 single point (Crit 1/1) failures for the Shuttle
- 2) By element, they are follows:

|         |      |
|---------|------|
| Orbiter | 688  |
| ET      | 453  |
| RSRM    | 90   |
| SRB     | 143  |
| SSME    | 313  |
| <br>    |      |
| Total   | 1687 |

The attached table also provides the number of failure modes requiring multiple failures for each element (Crit 1R). I hope this answers the mail.

Roger

-----Original Message-----

From: Michael Stamatelatos [<mailto:mstamate@hq.nasa.gov>]  
Sent: Monday, February 10, 2003 7:49 AM  
To: RAILSBACK, JAN (JSC-NX) (NASA); BOYER, ROGER L. (JSC-NC) (SAIC)  
Subject: Code M Question  
Importance: High

Jan/Roger:

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1. How many single point failures are there in the entire Space Shuttle?
2. Do you have a breakdown of single point failures by Shuttle system (e.g.

Orbiter, ET, SRB, etc.)? If so, what is it?

Michael

\*\*\*\*\*

Dr. Michael Stamatelatos  
Manager, Agency Risk Assessment Program  
NASA Headquarters - Mail Code QE  
Office of Safety and Mission Assurance  
300 E Street, SW  
Washington, DC 20024  
Phone: 202/358-1668 Fax: 202/358-2778  
E-mail: Michael.G.Stamatelatos@nasa.gov  
(Please note change in e-mail address)

\*\*\*\*\*

"Mission success starts with safety"

 Shuttle Failure Mode Counts by Element.doc

### Shuttle Failure Mode Counts by Element

| Shuttle Element | Failure Mode Criticality Count |             |             |
|-----------------|--------------------------------|-------------|-------------|
|                 | Single                         | Multiple    | Total       |
| <b>Orbiter</b>  | 688                            | 2628        | 3316        |
| <b>ET</b>       | 453                            | 94          | 547         |
| <b>RSRM</b>     | 90                             | 51          | 141         |
| <b>SRB</b>      | 143                            | 209         | 352         |
| <b>SSME</b>     | 313                            | 237         | 550         |
|                 |                                |             |             |
| <b>Total</b>    | <b>1687</b>                    | <b>3219</b> | <b>4906</b> |

**Gary G. Borda, 03:46 PM 2/20/2003 -0500, Re: Fwd: Pate-Cornell-Fischbeck Report Request**

---

X-Sender: gborda@mail.hq.nasa.gov  
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2  
Date: Thu, 20 Feb 2003 15:46:46 -0500  
To: James Lloyd <jlloyd@hq.nasa.gov>  
From: "Gary G. Borda" <gborda@hq.nasa.gov>  
Subject: Re: Fwd: Pate-Cornell-Fischbeck Report Request  
Cc: Lynn Heimerl <n.l.heimerl@larc.nasa.gov>, Frank.E.Jones@nasa.gov,  
mgstamatelatos <mstamate@mail.hq.nasa.gov>, prutledg@hq.nasa.gov,  
rmoyer@hq.nasa.gov, John.Dollberg-1@ksc.nasa.gov

Jim,

I concur with your response. The subject report was a report to NASA under cooperative agreement NCC10-0001 and NASA has the right to publicly disseminate the report. As long as there are no export control issues, CASI may make this report available without restriction. With respect to export control issues, I have read the report and assume there are none, however, you may want to touch base with our export administrator John Hall.

Gary

At 05:25 PM 2/13/2003 -0500, James Lloyd wrote:  
Frank,

Regarding our phone conversation of about 30 minutes ago -- I just received this note and it seems like the problem of release has already been resolved since Gary Borda in our General Counsel has indicated it is already publicly available on a NASA website. I will respond to CASI tomorrow to their note indicating that we have no objections to their intent to make it available without restriction on a technical content basis.

I'll wait a day for Gary Borda to advise if this is appropriate. In the meantime the report is available for people to read/download.

X-Sender: n.l.heimerl@pop.larc.nasa.gov  
X-Mailer: QUALCOMM Windows Eudora Version 5.0.2  
Date: Thu, 13 Feb 2003 16:08:46 -0500  
To: jlloyd@hq.nasa.gov  
From: Lynn Heimerl <n.l.heimerl@larc.nasa.gov>  
Subject: Pate-Cornell-Fischbeck Report Request  
Cc: n.l.heimerl@larc.nasa.gov

Dear Jim:

I am the NASA technical monitor for the NASA Center for AeroSpace Information (CASI), NASA's contractor that archives and disseminates NASA-funded scientific and technical information.

We would like to add "Safety of the Thermal Protection System of the Space Shuttle Orbiter - 1990" by Pate-Cornell and Fischbeck to our collection, and Gary Borda has advised me that it is available to the public via <http://www.spaceflight.nasa.gov/shuttle/investigation/index.html>

Normally, we request that the originating NASA organization do a DAA (Document Availability Authorization (NF 1676)) to advise us how to release the document; however, since it is already available to the public via the NASA website, I just need a return email verifying that we may add it to the CASI collection and release it without restrictions. KSC has advised me that Code Q funded this activity.

I appreciate your help.

Best Regards,

Lynn Heimerl  
STI Program Office  
Agency-wide STI Program

Jim

Gary G. Borda  
Senior Patent Attorney  
Office of the General Counsel  
NASA Headquarters, Code GP  
Washington, DC 20546-0001

Phone: (202) 358-2038  
Fax: (202) 358-4341  
[gborda@hq.nasa.gov](mailto:gborda@hq.nasa.gov)

X-Authentication-Warning: spinoza.public.hq.nasa.gov: majordom set sender to owner-code-q using -f  
X-Sender: prutledg@mail.hq.nasa.gov  
X-Mailer: QUALCOMM Windows Eudora Version 4.3.2  
Date: Sun, 02 Feb 2003 19:49:16 -0500  
To: code-q@lists.hq.nasa.gov  
From: Pete Rutledge <prutledg@hq.nasa.gov>  
Subject: Supporting Bryan on the Columbia Accident Investigation Board (CAIB)  
Sender: owner-code-q@lists.hq.nasa.gov

Code Q staff members,

As you may know Bryan is the ex-officio member of the Columbia Accident Investigation Board. He left for Barksdale AFB this afternoon around noon time. That is where he will meet up with the other CAIB members.

One of our main jobs in the immediate future will be to support him. We can support him in at least three ways: 1. We can respond to his requests. 2. We can collect, on our own initiative, data that could be of use to him (but we need to proceed most carefully on this one). 3. We can suggest questions or avenues of investigation that he might be able to inject into the work of the board.

Attached is a rough list we prepared today of investigative areas--for the most part these are areas in which the SMA community has some special expertise. For each area we have tentatively named an OSMA lead (and in some cases more than one person to work together). If you can think of other areas that we have not captured, and should, let me know. If we've associated you with the wrong area(s) or failed to associate you with the right area(s), let me know. We don't want to disrupt the investigation--we want to be prudent; we want to help Bryan. Think about whether and how you might be able to be helpful in these areas; then, before you take any action, write down your plan in a clear, concise manner, and send it to me--state what you might be able to do and how you would propose to do it. Then wait for a go-ahead from Jim or me. Keep in mind that we have asked the SMA directors at JSC, MSFC, KSC, LaRC, ARC, and SSC to work with us as needed, so this can be part of your plan, if appropriate.

We have also asked all 10 SMA directors to think of questions or issues that Bryan might pursue with the CAIB. I will be collecting these inputs. Your questions and issues are solicited, as well. Put your investigator hat on, think about this, do your own personal fault trees and hazard analyses, send me your ideas. I'll collect them up, as well, to send to Bryan.

Let's do a great job for Bryan on this important matter.

Thanks,

Pete



OSMA Support to Bryan O.doc

Peter J. Rutledge, Ph.D.  
Director, Enterprise Safety and Mission Assurance Division  
Acting Director, Review and Assessment Division  
Office of Safety and Mission Assurance  
NASA Headquarters, Code QE, Washington, DC 20546

ph: 202-358-0579  
FAX:202-358-2778  
e-mail: [pete.rutledge@hq.nasa.gov](mailto:pete.rutledge@hq.nasa.gov)

***Mission Success Starts with Safety!***

As of: February 2, 2003

SMA Support to Bryan O'Connor as Ex-Officio member of Space Shuttle Mishap Investigation Board (SSMIB)

| SMA-Related Investigative Area      | Remarks                                                                                                                                                 | OSMA Lead                                       |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| Hazard reports, Fault Trees, FMEA   | Relates to work of Space Shuttle System Safety Review Panel (SSRP); especially pertaining to ET foam; e.g., impact on Orbiter                           | Mark K., Bill B.                                |
| Risk                                | Accepted risks for this mission?                                                                                                                        | Mark K., Bill B.                                |
| Payload safety (as cause of mishap) | Relates to work of Payload Safety Review Panel (PSRP). Interest includes potential for hazardous payloads to have caused catastrophe..                  | Mike Card, John Castellano                      |
| Payload safety (safety of recovery) | Includes radiological and other hazardous payload contents                                                                                              | John Lyver/Gil White                            |
| Problem trends (HW/SW)              | Relates to Problem Reporting and Corrective Action (PRACA); initially PRs dealing with ET foam problems may be of most interest?                        | Paul Boldon (SW PRs), Mark K., Bill B. (HW PRs) |
| Quality                             | Material Review Board actions, repairs, etc., initially especially in regard to foam and tile installation and repair; contractor/supplier surveillance | Tom Whitmeyer                                   |
| Probabilistic Risk Assessment (PRA) | Initial interest includes 1990 Pate-Cornell PRA of Shuttle tile installation process, as well as current Shuttle PRA                                    | Michael Stamatelatos                            |
| Pre-launch reviews                  | Includes Pre-launch Assessment Reviews, Mission Safety Evaluations, waivers, deviations, rules changes, <u>limited life items</u> , etc.                | Mark K., Bill B.                                |
| Expected casualty, Ec (post-mishap) | Includes collecting/using data from this mishap to calculate Ec for Shuttle re-entry                                                                    | Pat Martin (with Maria Tobin)                   |