

The Management of Risk - Land, Sea, Air and Space

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Is it Safe?



Is it Safe?



BP/Transocean Deepwater Horizon explosion on April 20th, 2010, resulting in the loss of eleven crewmembers



Space Shuttle *Columbia* break-up during entry on February 1st, 2003, resulting in the loss of all seven crewmembers

Is it Safe?



United Airlines Flight 232 Incident, Sioux City, Iowa (registration N1819U)
July 19th 1989. 185 Survivors; 111 Fatalities

Is it Safe?



Space Shuttle *Columbia* break-up during entry
on February 1st, 2003, resulting in the loss of all
seven crewmembers

Is it Safe?



Union Carbide India Limited
Pesticide Plant, Bhopal, Madhya Pradesh, India,
December 2nd, 1984. 40 tons of methyl isocyanate release,
resulting in an estimated 25,000 fatalities

Is it Safe?



Space Shuttle *Columbia* break-up during entry
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“Is it Safe?”



A Real Life Scenario

- A critical **circulation pump** in a thermal control system is malfunctioning
 - Required to deliver 1.5 Liters/min @ 950 mmHg
 - Delivering 0.75 Liters/min @ 175 mmHg
- Thermal Control Systems Engineer asks several questions
 - How long has this been going on – **what's the pumps history?**
 - Gradual decline over several months
 - What does the real-time X-Ray show?
 - Shows **potential leakage around inlet and outlet valve seals**
 - What is the effect on downstream systems
 - Lower cooling capacity in the system; could reach **critical point in 6 months** at present rate of decay, leading to **shutdown of life support systems**

A Path Forward

- What are the options?
- Remove and replace the pump
 - Pump no longer manufactured; will take 12 months and \$5 Million to build a new one from scratch
- Remove and replace the valve seals
 - Assumes seal integrity is the contributing factor
 - Can an astronaut be trained to perform the procedure in zero-G?
- Do nothing to the pump; provide secondary cooling to the life support system until replacement pump can be manufactured
 - Secondary cooling system is available on-orbit
 - Relatively simple operation
 - Astronaut is on orbit that has experience with this pump
 - Refresher training available by “Just-in-Time” training
- Do nothing
 - Space Station life has already exceeded expectations
 - Evacuate and terminate Program

These are all Risk versus Risk Trades

The Medical Equivalent

- 82 year-old male **Patient** presents with symptoms of **circulatory** problems
 - Hypotensive
- **Physician** asks several questions
 - How long has this been going on – what's the **patient's** history?
 - What other symptoms are associated with the potential diagnosis?
 - What diagnostic tools are available?
 - **ECG?, Angiography?**

A Path Forward

- What are the options?
- Option A
- Option B
- Option C
- Do nothing

These are all Risk versus Risk Trades

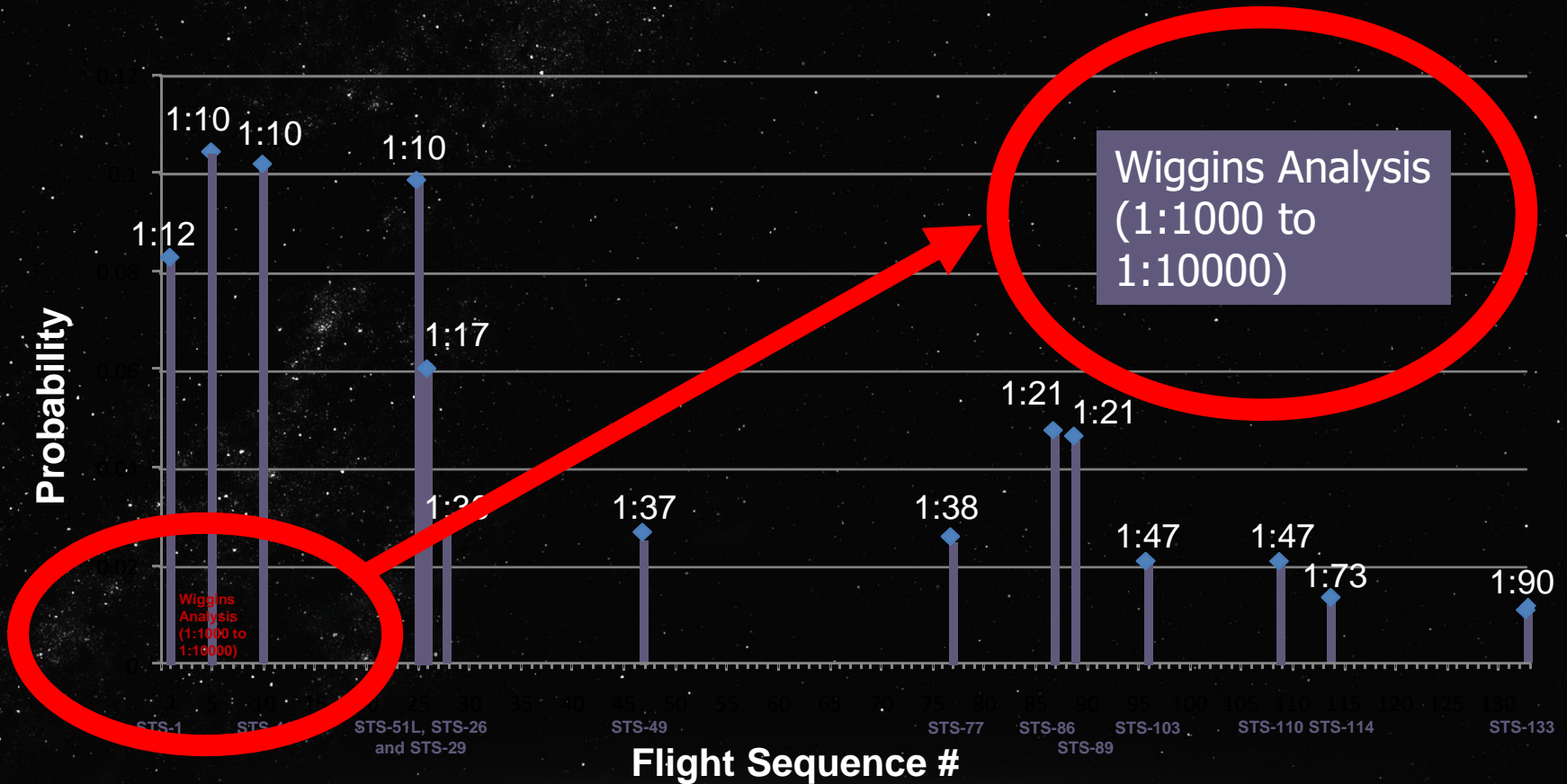
“Is it Safe?”

- Is that really the right question?
- “Is it Safe *Enough?*” is the right question
- “Prove to me that it’s unsafe” versus “Prove to me that it is safe”
- Management of risk is the key
 - Know what the risk is
 - Identify the cause(s)
 - Determine the likelihood (probability) and the consequence(s) (loss of life, mission, \$’s) if the event were to happen
 - Mitigate the risk wherever possible
 - Accept any residual risk
 - Who accepts that residual risk?

The Shuttle Risk

- At the time of the first Shuttle flight (1981), estimated risk to loss of crew (LOC) was calculated at between 1:1,000 to 1:10,000
 - Based on tools available at the time

The "Real" Shuttle Risk



The Shuttle Risk

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 - Based on tools available at the time
- At the completion of the Shuttle Program (2011) after 135 flights, the modern tools estimated the risk for the first flight at ?

The Shuttle Risk

- At the time of the first Shuttle flight (1981), estimated risk to loss of crew was calculated at between 1:1,000 to 1:10,000
 - Based on tools available at the time
- At the completion of the Shuttle Program (2011) after 135 flights, the modern tools estimated the risk for the first flight at 1:12
- Demonstrates that your understanding of risk depends upon the tools and data that you have available at the time

Human Spaceflight Incidents

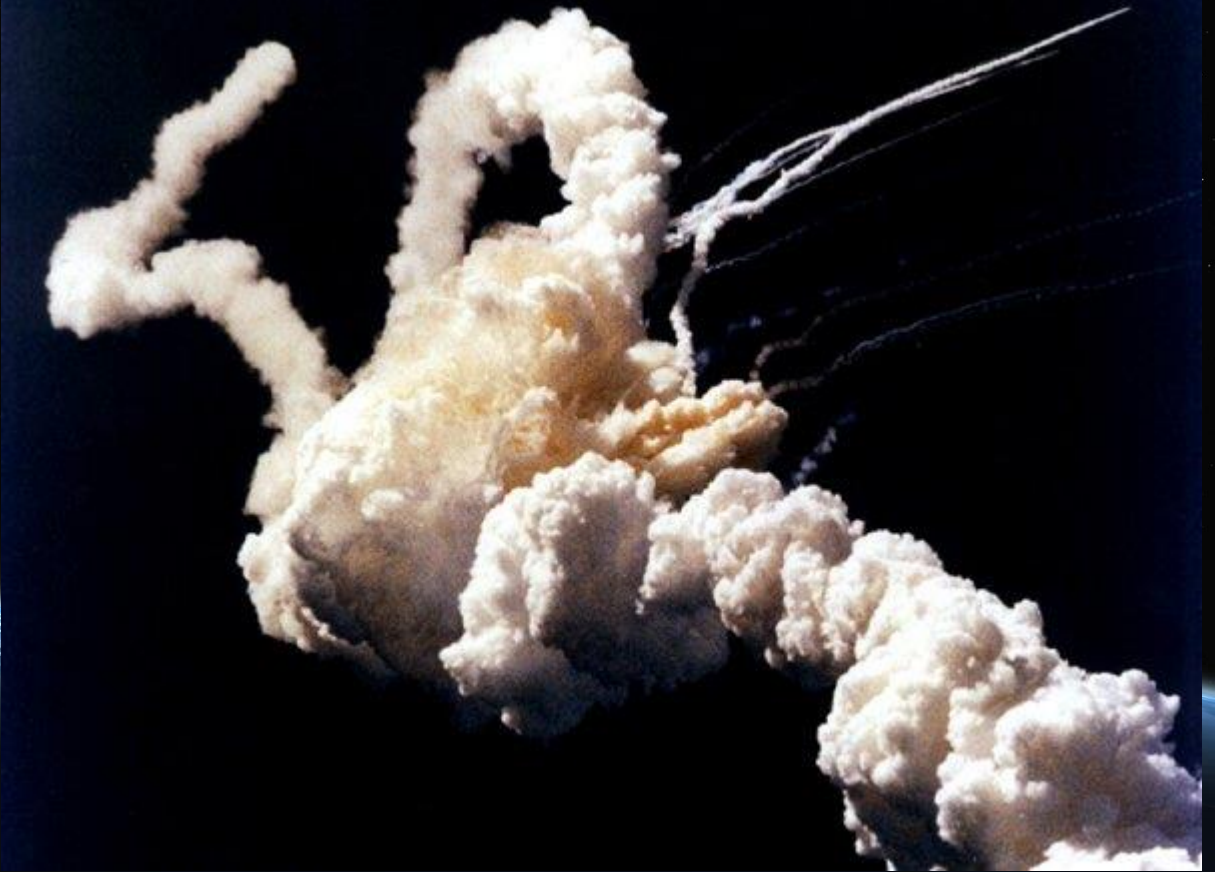
- How many fatalities in human spaceflight history have there been?
 - 3
 - 17
 - 21
 - 18
 - 10



3



7









3



Soyuz 11, 1971

Soyuz TMA-12, 2008



Human Spaceflight Incidents

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