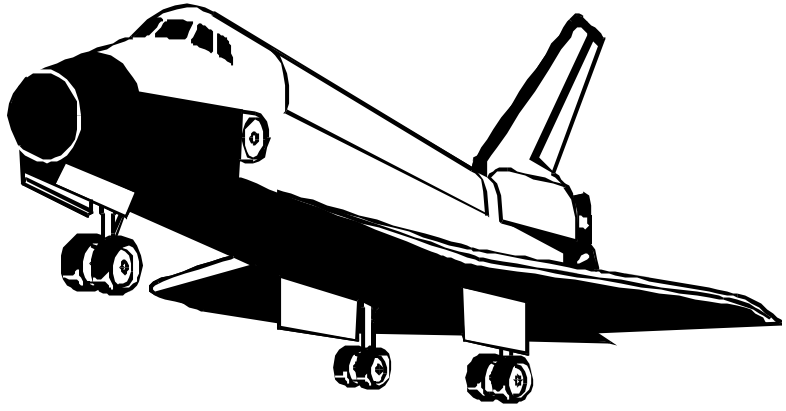
NASA Shuttle Program

By
Jacques Ouellet
Ferri Hassani

CHALLENGER

- The American taxpayers bet 14 Billion Dollars
- NASA bet its reputation
- The air force bet its reconnaissance capability
- The astronauts bet their lives
- **THEN WE ALL TOOK A CHANCE**

The Shuttle



The shuttle

Three main engines fueled, by several million pounds of liquid hydrogen and solid-fuel .

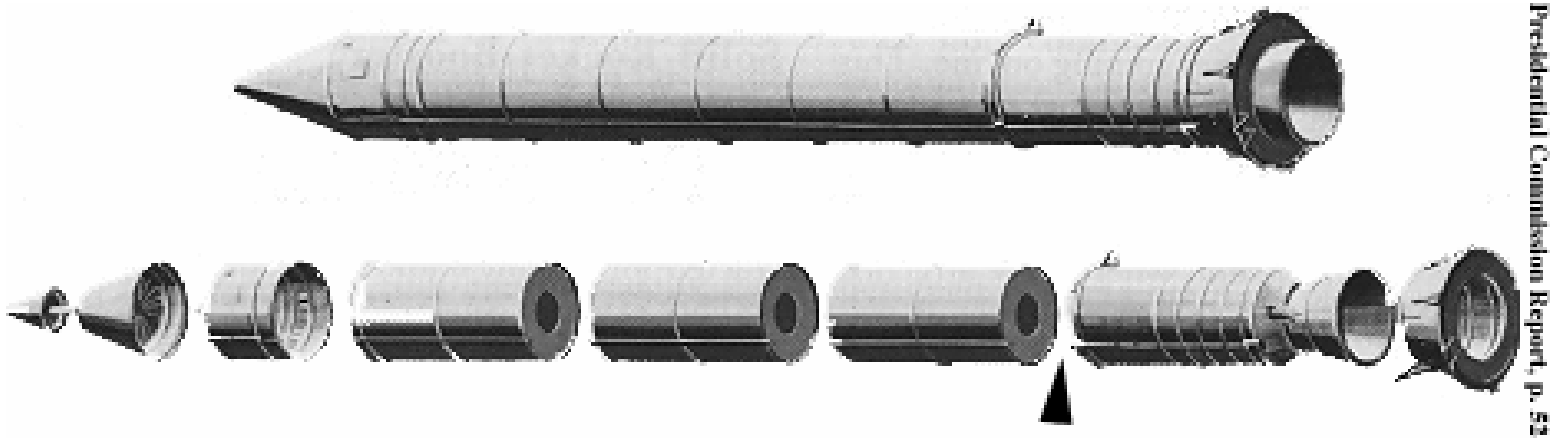
carried in external divided fuel tanks.

At Liftoff main engines fire for 8.5 min

1st two minutes of the lunch main thrust is provided by the booster rocket

Each burning a one-million pound load of a mixture of aluminum,potassium chloride ,and iron oxides

The Shuttle Booster Rocket



Presidential Commission Report, p. 52

150feet long

12 feet diameter

4 field joints

Pair of o ring
Vulcanized
Rubber
Together with
Putty barrier of
Zinc chromide

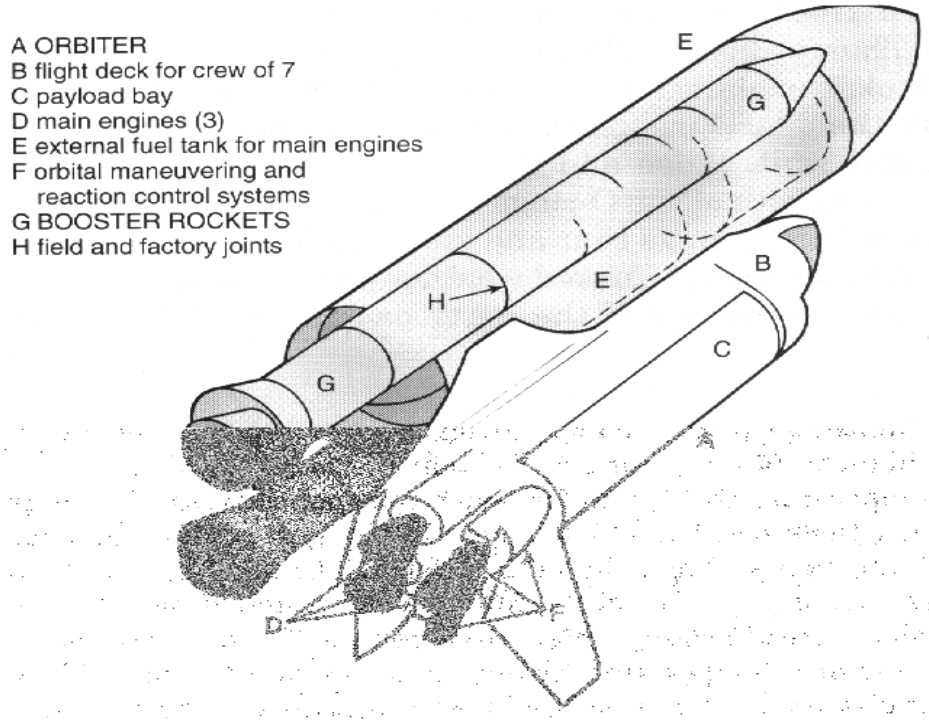
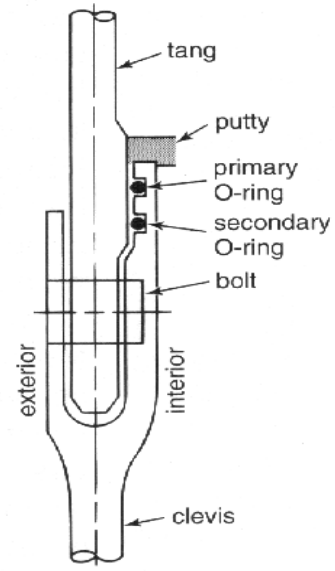
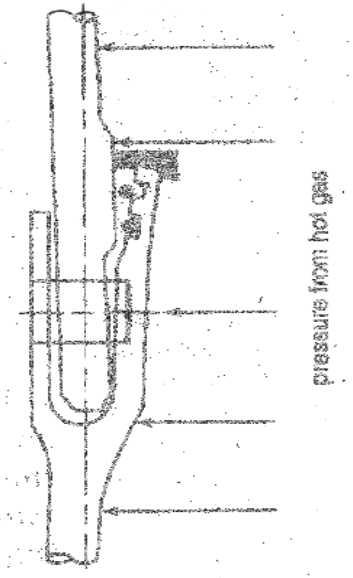


Figure 3-2
Space shuttle *Challenger*.

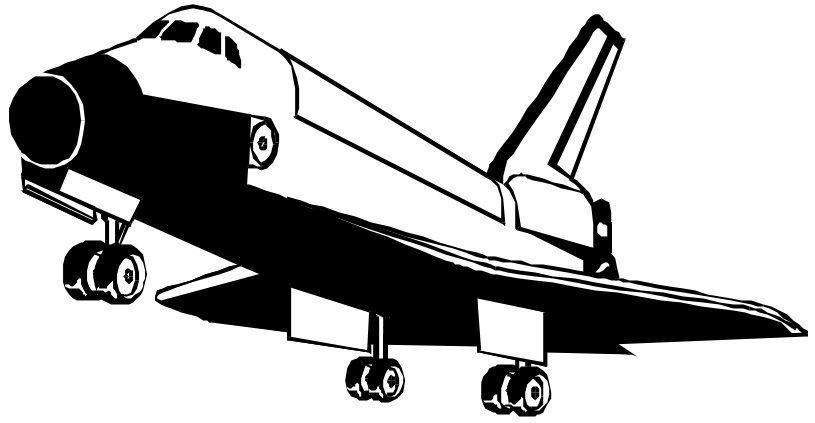


Field Joint
Before Ignition



Field Joint
After Ignition
(movement shown
is exaggerated)

The Shuttle



Aerospace engineers intimately involved in,

Designing, manufacturing ,assembling, testing.

- Rockwell International (Orbiter and main rocket)
- Morton-Thiokol(booster rocket)
- NASA

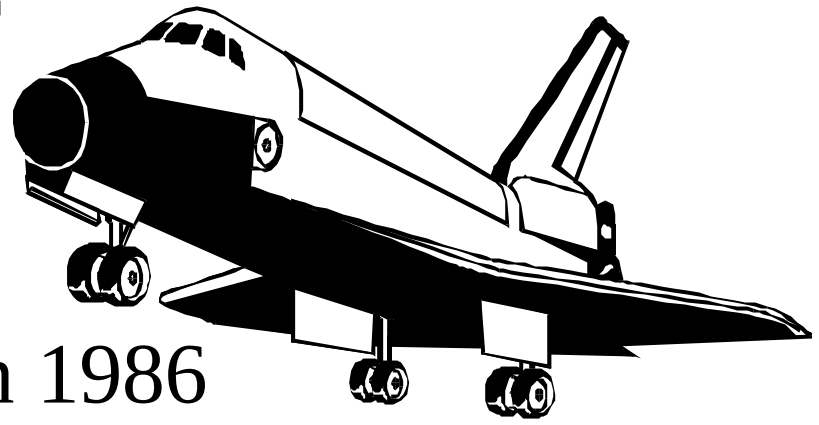
✓ Marshal space flight Center, Alabama (propulsion system)

✓ Kennedy Space Center ,Florida (Launch operation)

✓ Johnson Space Center, Texas (flight control)

✓ Office of chief engineer, Washington (Safety ,etc.)

Leading to disaster



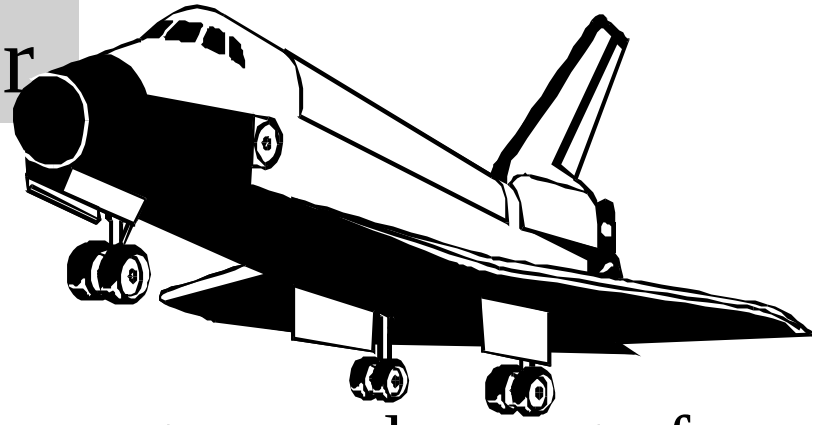
- Challenger's first flight in 1986
- Tuesday January 28th
- Allan J. McDonald rep, of Morton- Thiokol

  -Worried about the cold weather

  -Previous experience not encouraging

  -Arrange a teleconference between NASA and Morton-Thiokol engineers in Utah

Events leading to the disaster



- Roger Boisjoly and Arnold Thomson two seal expert of Morton- Thiokol

-Explain the problem of o ring and temperature

-High Probability of failure below 65 degree

- No flight below 53 degree

Bob Lund(V.P. Engineering) and

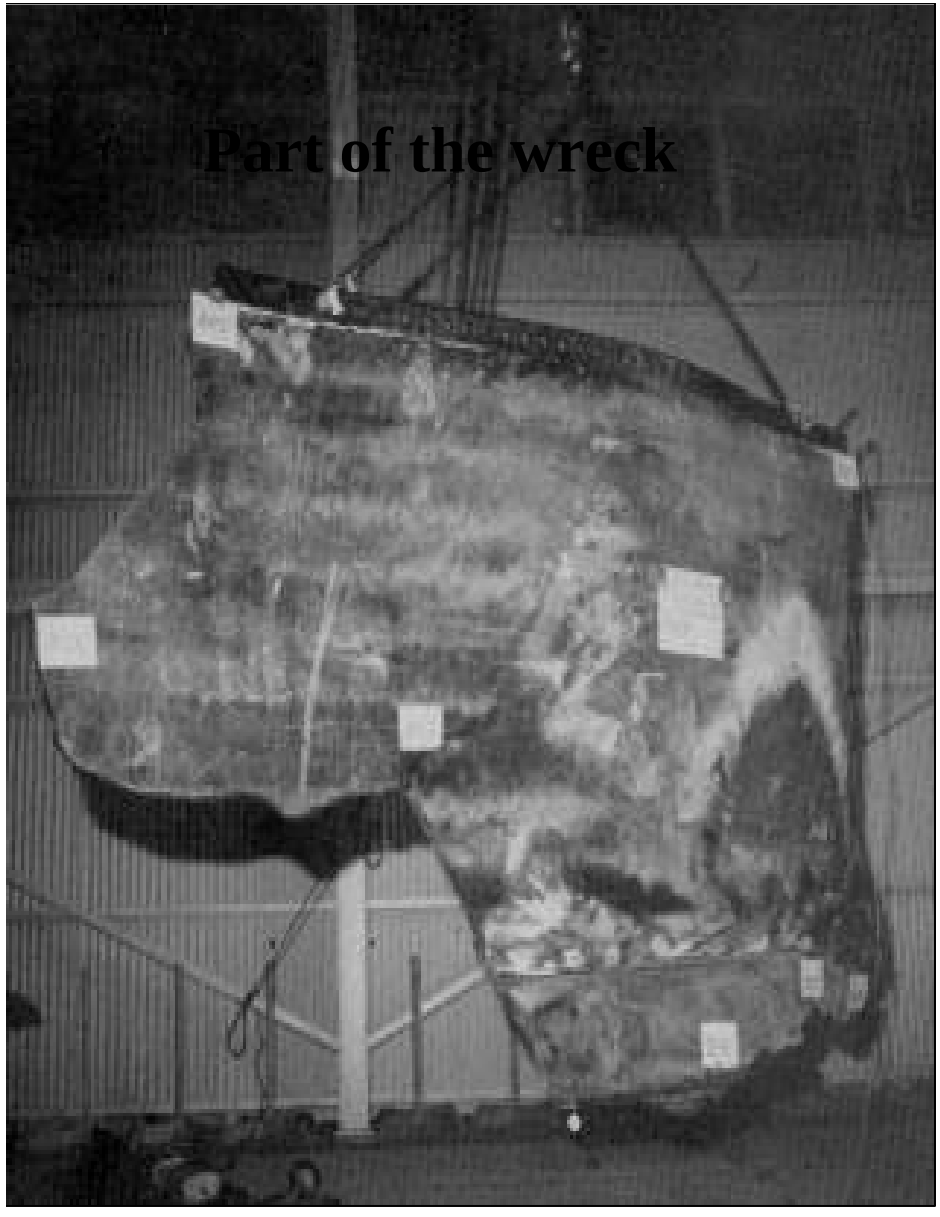
Joe Kilminster (V.P. booster rocket) agreed that there was a problem

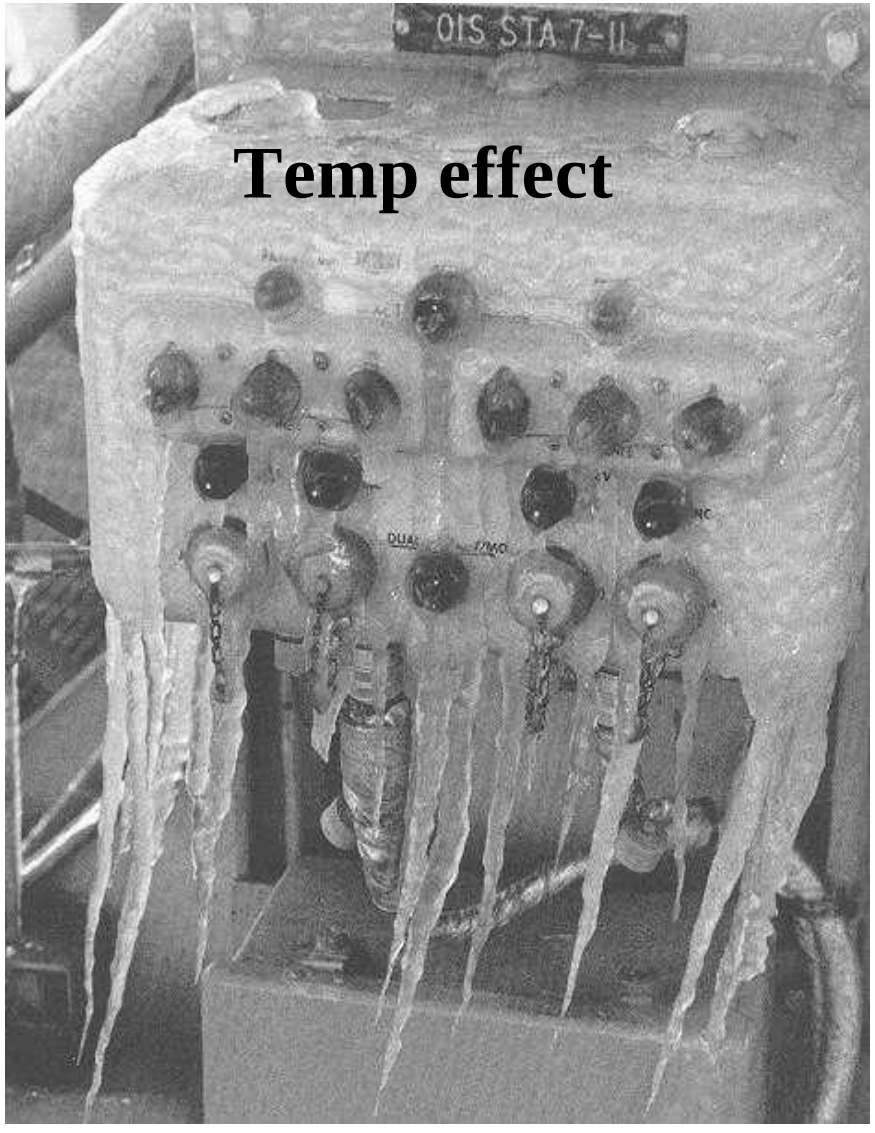
STS 51-F FLIGHT READINESS REVIEW CHART
(Analysis of 51-B Secondary Erosion)

Level I (July 2, 1985)

PROBLEM SUMMARY

PROBLEM	CONCERN	RESOLUTION	STATUS
UNUSUAL EROSION OBSERVED ON PRIMARY AND SECONDARY O-RINGS OF STS 51-B NOZZLE TO CASE JOINT (SRM 16 A) — PRIMARY O-RING APPARENTLY NEVER SEATED RESULTING IN WORST EROSION YET OBSERVED — SECONDARY O-RING HAD 32 MILS EROSION (1ST TIME OBSERVATION)	FLIGHT SAFETY	• EVIDENCE OF HOT GAS PAST PRIMARY O-RING IS NOT UNPRECEDENTED • LEAK CHECK USED ON STS 51-B DID NOT VERIFY CAPABILITY OF PRIMARY O-RING TO SEAL • LEAK CHECK USING 200 PSIG STABILIZATION PRESSURE ON STS 51-F AND SUBS PROVIDES CONFIDENCE THAT PRIMARY O-RINGS HAVE CAPABILITY TO SEAL • LEAK CHECK ASSURES SECONDARY O-RING WILL SEAL AGAINST MOTOR PRESSURE • MAXIMUM EROSION THAT CAN OCCUR ON SECONDARY O-RING IN LIMITED TIME THAT FLOW EXISTS ON AND PAST PRIMARY O-RING IS 75 MILS (CONSERVATIVE ANALYSIS) • —2 SUBSCALE TESTS VERIFY THAT A PROPERLY SEATED O-RING CAN SUSTAIN A MINIMUM OF 125 MILS EROSION BEFORE SEAL IS COMPROMISED	CLOSED


Part of the wreck


OIS STA 7-11
Temp effect

MTI Assessment of Temperature Concern on SRM-25 (51L) Launch

- Calculations show that SRM-25 O-rings will be 20° colder than SRM-15 O-rings
- Temperature data not conclusive on predicting primary O-ring blow-by
- Engineering assessment is that:
  - Colder O-rings will have increased effective durometer ("harder")
  - "Harder" O-rings will take longer to "seat"
    - More gas may pass primary O-ring before the primary seal seats (relative to SRM-15)
      - Demonstrated sealing threshold is 3 times greater than 0.038" erosion experienced on SRM-15
  - If the primary seal does not seat, the secondary seal will seat
    - Pressure will get to secondary seal before the metal parts rotate
      - O-ring pressure leak check places secondary seal in outboard position which minimizes sealing time
- MTI recommends STS-51L launch proceed on 28 January 1986
  - SRM-25 will not be significantly different from SRM-15

Joe C. Kilminster

Joe C. Kilminster, Vice President
Space Booster Programs

Morton Thiokol Inc.
Wasatch Division

On Mistake, Mishap and Disaster:
The Normalization of Deviance in Organizations

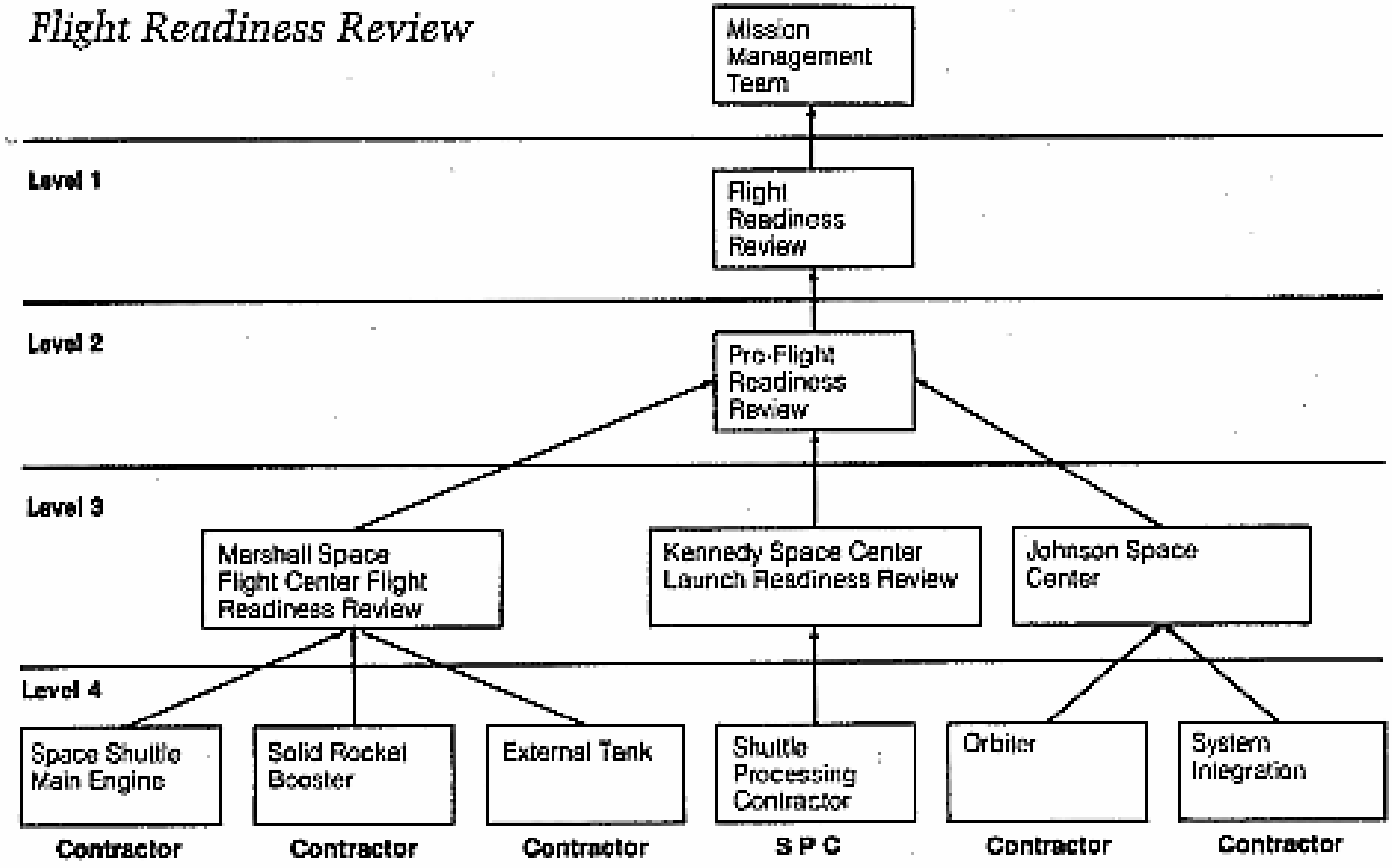
"The explanation of the Challenger launch is a story of how people who worked together developed patterns that blinded them to the consequences of their actions.

"...how small changes...gradually became the norm, providing a basis for accepting additional deviance."

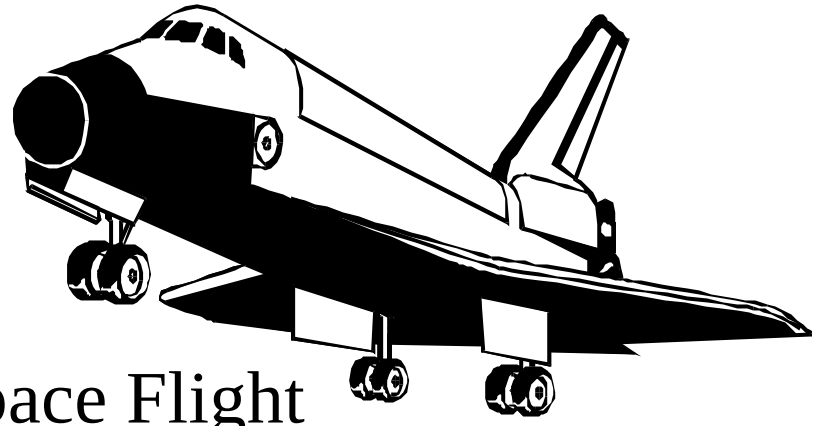
"No rules were violated.
There was no attempt to do harm"

The Challenger Launch Decision, p. 409
Diane Franklin

FLIGHT READINESS REVIEW AND SHUTTLE PROGRAM MANAGEMENT STRUCTURE



Events leading to the disaster



-Engineering team from Marshall Space Flight

Not happy as the specification called for operating temperature of 40 to 90 degrees .

-They did not want to face another postponement

-Executive of Morton-Thiokol were also in on the teleconference

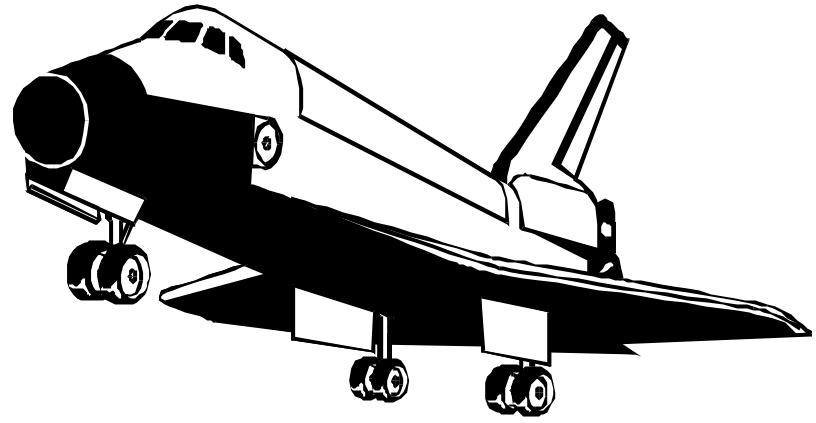
-Their concern company image and the next contract from NASA

Events leading to the disaster

In a recess Jerry Mason (Senior V.P.) tells Bob Lund

"To takeoff your engineering hat and put on your management hat"

Events leading to the disaster



-Only the managers voted ,stating that the seals could not be shown to be unsafe.

-Allan McDonald at Cape Kennedy refused to sign the formal recommendation to lunch

-The countdown ended at 11:38 A.M. ,the temperature was 36 degrees

The rest is history

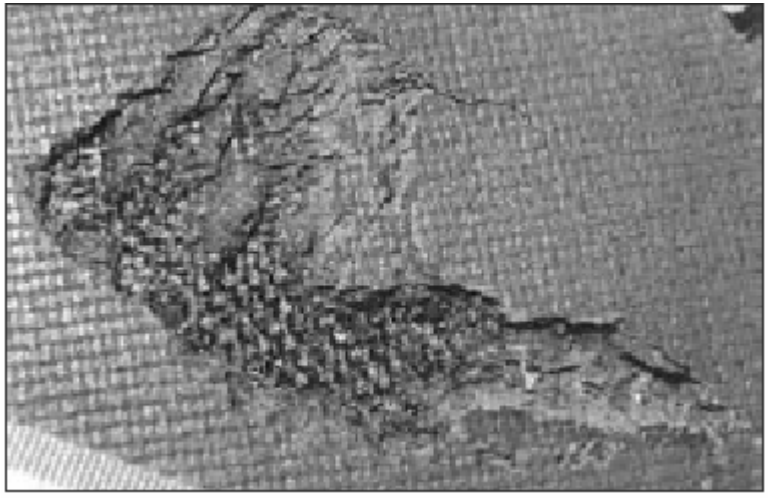
Roger Boisjoly

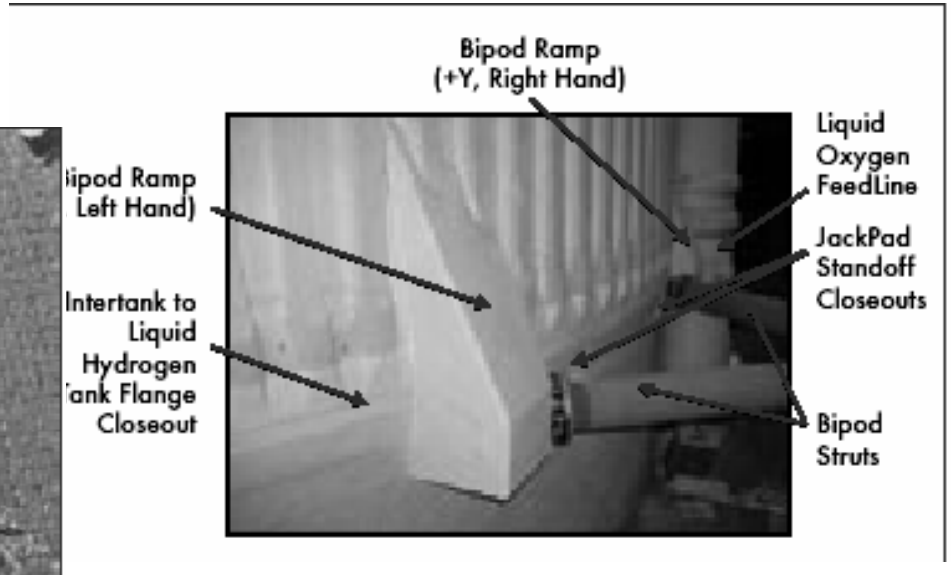
Roger Boisjoly has had over a quarter century of experience in the aerospace industry. Boisjoly has spent his entire career making well-informed decisions based on his understanding and belief in a professional engineer's rights and responsibilities. Roger Boisjoly was awarded the Prize for Scientific Freedom and Responsibility from the American Association for the Advancement of Science for his actions associated with his strong beliefs.

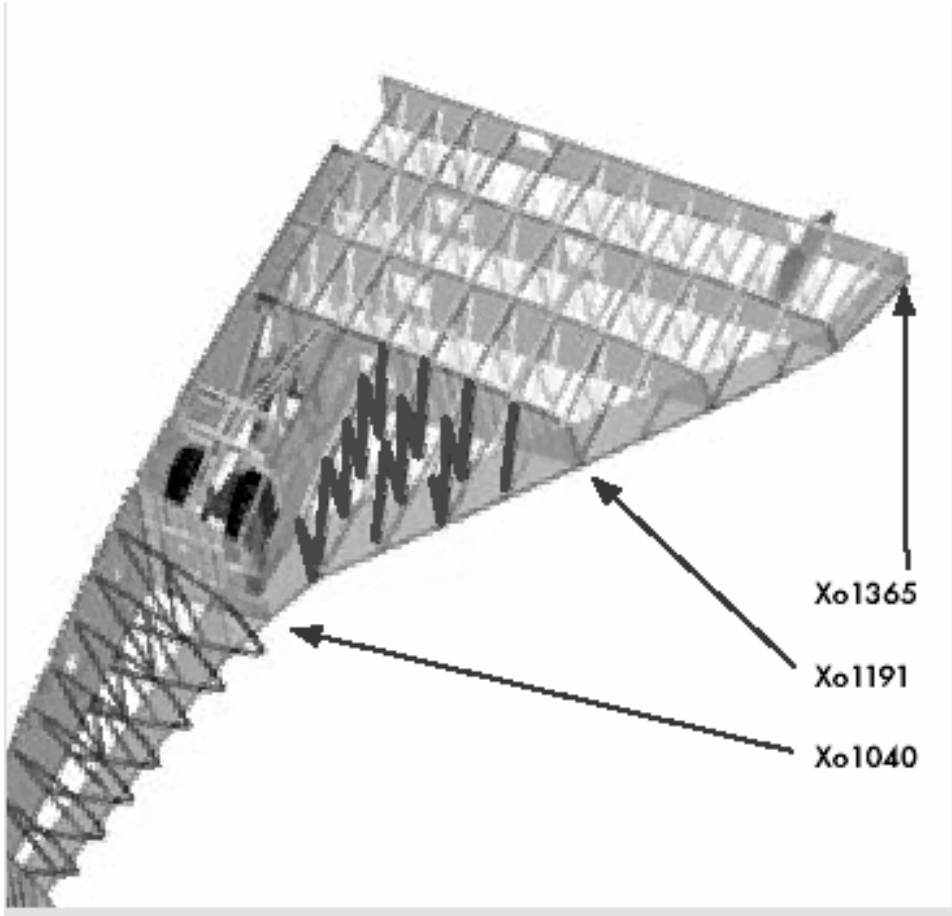
Columbia’s Accident

- Columbia launched on January 16, 2003
- For a scientific mission
- Duration of 16 days
- Burned at rentry on February 1st, 2004
- At 8:52 am Columbia radio contact is lost

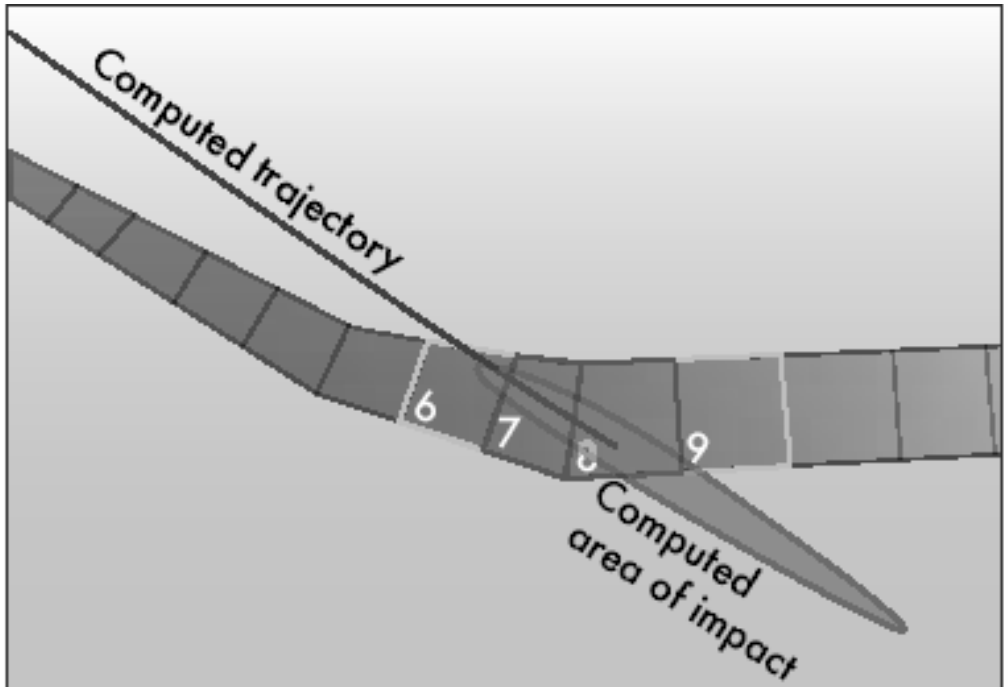

Liquid Oxygen Tank
Intertank
Liquid Hydrogen Tank

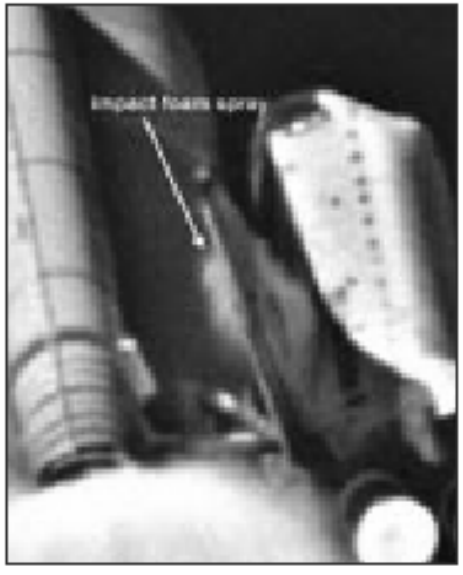



Bipod Ramp
(+Y, Right Hand)
ipod Ramp
Left Hand)
Intertank to
Liquid
Hydrogen
ank Flange
Closeout
Liquid
Oxygen
FeedLine
JackPad
Standoff
Closeouts
Bipod
Struts



The major internal support structures in the mid-wing are constructed from aluminum alloy. Since aluminum melts at 1,200 degrees Fahrenheit, it is likely these truss tubes in the mid-wing were destroyed and wing structural integrity was lost.


Computed trajectory
6
7
8
9
Computed
area of impact


impact foam spray

New Times, Same Old Habits

- Trying to do too much with too little
- A culture of «can do» that can win seemingly impossible challenges
- Infrastructures and shuttle getting old and difficult to maintain
- Obsolescence of the technology

Reading

- Investigation report on Columbia is uploaded on WebCT
- Students must read Chapter 2 for sequence of events
- Read Chapter 3 for accident causes
- Read Chapter 5for conclusions