University of Kent

Stage 1

PH307

The Space Shuttle Challenger disaster

written by Tilo Hohenschlaeger

Student Number: 07437100

Content

Introduction

“We`ve grown used to the idea of space, and perhaps we forget that we`ve only just begun. We`re still pioneers. They, the members of the Challenger crew, were pioneers. …It`s all part of the process of exploration and discovery. It`s all part of taking a chance and expanding man`s horizons. The future doesn`t belong to the fainthearted; it belongs to the brave. The Challenger crew was pulling us into the future, and we´ll continue to follow them.” (1)

These were the words of the American President Ronald Reagan addressing the nation from the Oval Office, at the White House, at 5 p.m. on the 28th of January 1986. It was the day the Space Shuttle Challenger exploded 72 seconds into their Mission, which was specified as STS - 51L. I still remember watching the Liftoff of the space shuttle and the big white cloud after the massive explosion which destroyed the space craft. I watched in horror to see all seven life`s of the astronauts lost. What went wrong? What caused the disaster? Was there a deeper Problem with the National Aeronautic and Space Administration (NASA)? Should NASA continue with their future plans? This essay will answer some of these questions. Nearly twenty three years later and a second Space Shuttle lost in 2003, NASA continues the quest into Space. New Space Probes, the International Space Station, the James Webb Space Telescope, the planned replacement for the Hubble Space Telescope and the new Constellation Project, just to name few, make the NASA one of the busiest Space Agency on this Planet. Just to say it with the last words of STS-51L Mission Commander Dick Scobee: “Roger, go at throttle up” (2)

Space Shuttle Challenger and the Mission STS-51L

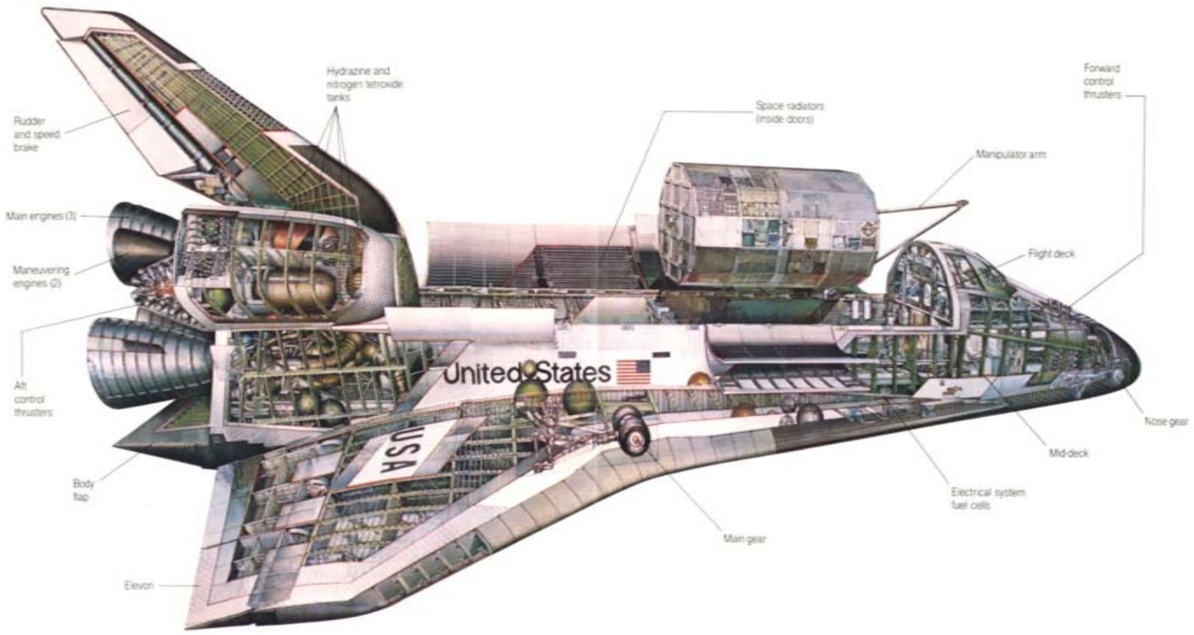

Image 1: Detailed Cutaway Diagram of Orbiter (3)

Space Shuttle Challenger, one of a fleet of 4 Space Shuttles, was the second reusable Spacecraft delivered to the Kennedy Space Centre in July 1982. Originally called STA-099, it was built to serve as a test vehicle for vibration and thermal tests for the space shuttle program. 1979, STA-099 was converted to the space rated orbiter OV-099. “It was named after the British Naval research vessel HMS Challenger, which sailed the Atlantic and the pacific oceans during the 1870`s.”(4) Originally 5 Space Shuttles were planned, but because of financial cutbacks only 4 were originally build. These were the Space Shuttles Columbia, Challenger, Discovery and Atlantis. The 5th Space Shuttle Endeavour was a replacement for the Space Shuttle Challenger and came into service in 1991.

After the loss of Space Shuttle Columbia in 2003, only 3 Space Shuttles remain in Service until their planned retirement in the year 2010. After 4 Test flights of the Space Shuttle Columbia the first operational flight of a Space Shuttle was Mission STS-5. Space Shuttle Challenger made its maiden voyage in April 1983 with a mission called STS-6. Before Mission STS-51L, Space Shuttle Challenger flew a total of nine missions, which produced various highlights for the shuttle program and for NASA.

Mission	Date	Highlights
STS-6	April 1983	1st space walk for shuttle crew
STS-7	June 1983	1st American woman in space
STS-8	August 1983	1st night launch and landing for a space shuttle
STS-41B	February 1984	1st use of manned maneuvering unit and 1st landing in Kennedy Space Center
STS-41C	April 1984	1st on-orbit spacecraft repair
STS-41G	October 1984	1st Space Shuttle flight to include 2 woman
STS-51B	April 1985	1st Spacelab orbital laboratory series developed by the European Space Agency (ESA), 1st cross wind landing at Edwards Air Force Base
STS-51F	July 1985	Spacelab-2
STS-61A	October 1985	German D-1 Spacelab, 1st eight crew flight, 1st flight were payload activities were controlled from outside the United States

Table 1: Completed Missions and Highlights of Space Shuttle Challenger. (5)

1985 was a very busy year for NASA. After 5 space shuttle missions in 1984 the number of flights in 1985 was a record of 9 flights during one year. 1986 was supposed to be a very special year for NASA. The 25th anniversary flight of a space shuttle, the observation of comet Halley and the Teacher in Space Program to name a few. STS-51L was chosen to be the 25th flight of a Space Shuttle. The launch was scheduled for the 22nd of January 1986 at 3:43 pm EST from Launch Pad 39B, which was last used for the Apollo-Soyuz Test project in July 1975 and had been modified for the use of the Space Shuttle.

Table 2 shows the proposed mission highlights for the mission STS-51-L. Looking at Table 2 it becomes self-evident that the teacher in space program was the most significant activity of the whole mission.

Flight Days	**Activities**
Flight Day 1	Tracking And Data Relay Satellite (TDRS) deployment
Flight Day 2	Comet Halley Active Monitoring Program (CHAMP), Fluid Dynamics Experiment (FDE), Teacher in Space activities
Flight Day 3	Spartan Halley deployment, Student experiments
Flight Day 4	CHAMP data take, student experiments, FDE, Teacher in Space activities
Flight Day 5	Spartan Halley capture, FDE, student experiments
Flight Day 6	Teacher lesson (Field Trip), Teacher lesson (Exploration)
Flight Day 7	Landing at Kennedy Space Center

Table 2: Proposed Mission Highlights for STS-51L. (6)

NASA had an image problem. After the very successful Apollo era the public interest and subsequently the funding went down. NASA was looking for a new way to awaken the public interest. For that reason, President Reagan announced in August 1984, that a teacher would be chosen to fly as the first private citizen on space shuttle. After about 11000 received applications, only 114 were recommended and in the end 10 finalists were chosen. Christa McAuliffe and Barbara Morgan were selected as the primary and the backup candidate for the teacher in space project. The media attention was sure for the mission STS-51L.

The Challenger Disaster

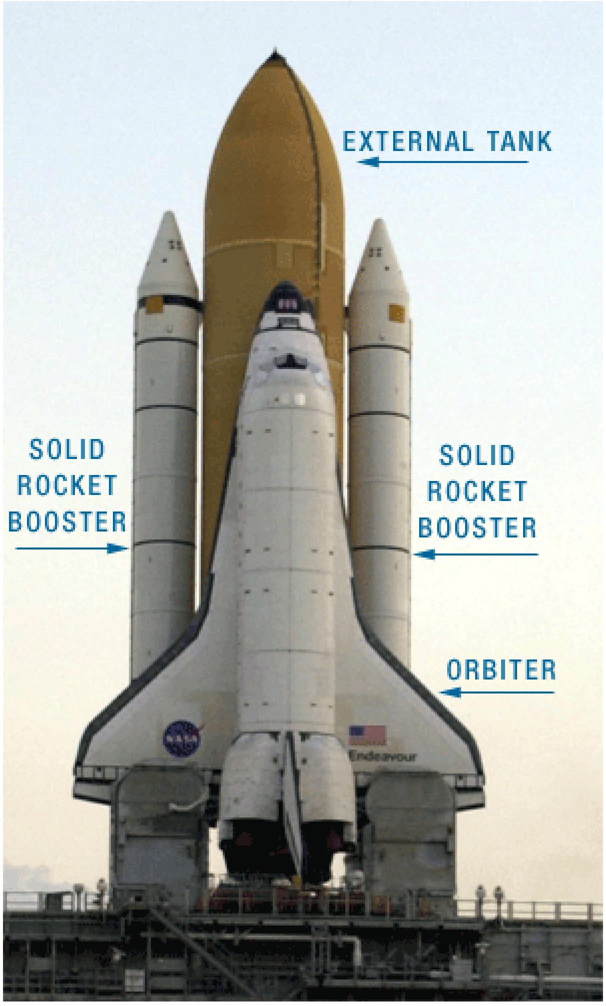

Image 2: The Space Shuttle System. (7)

The Space Shuttle System is made from three main components, the Orbiter, the Solid Rocket Boosters (SRB) and the External Tank (ET). The Orbiter is home to the Crew, while the reusable SRB`s providing the thrust for the Orbiters Launch in the first two minutes. The ET holds the fuel for the Orbiter Main Engines. This is important, because NASA stated the reason for the explosion of the Space Shuttle Challenger was an, “O- Ring failure in the right solid rocket booster. Cold Weather was determined to be a contributing factor” (8).

What had happened? How can be one of the most sophisticated pieces of technology be destroyed from a little O-Ring failure and then partially blamed on the cold weather condition? The Answer is not simple. After the explosion the whole Space Shuttle System was examined to find the cause of the disaster. Many different scenarios were proposed and tested. Videos and pictures of the launch were scanned for clues of the disaster. In the end things pointed to the right Solid Rocket Booster.

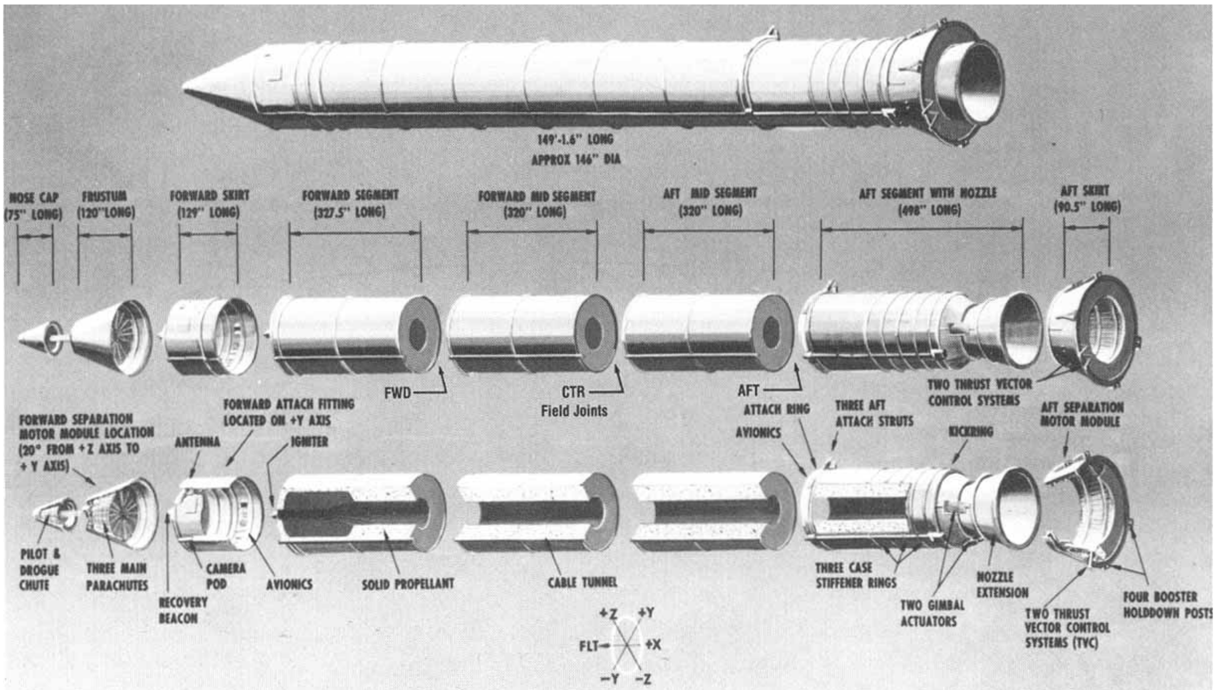

Image 3: Solid Rocket Booster with segments and other technical elements. (9)

In August 1972 Morton Thiokol Corporation was awarded as a prime contractor for the SRB`s. Every Solid Rocket Booster is made up of four Rocket Motor Segments, which are connected through the field joints. Photographic evidence suggested that the aft field joint of the right SRB was where the failure occurred.

Image 4 shows a cutaway view of the Solid Rocket Booster and the aft field joint.

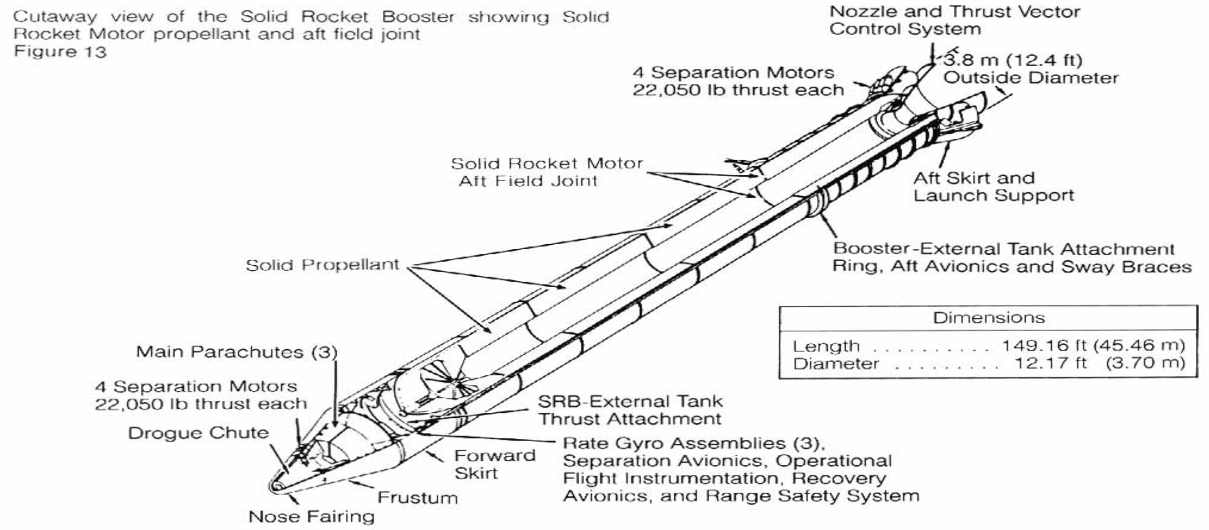

Image 4: Cutaway view of the Solid Rocket Booster with aft field joint. (10)

Each of the field joints is sealed by two rubber O-rings. These are the primary and the secondary O-ring. These O-rings prevent the escape of the hot combustion gasses from the inside of the rocket motor. To make sure the O-rings are not burned out, heat-resistant putty is applied to the inner section of the joint.

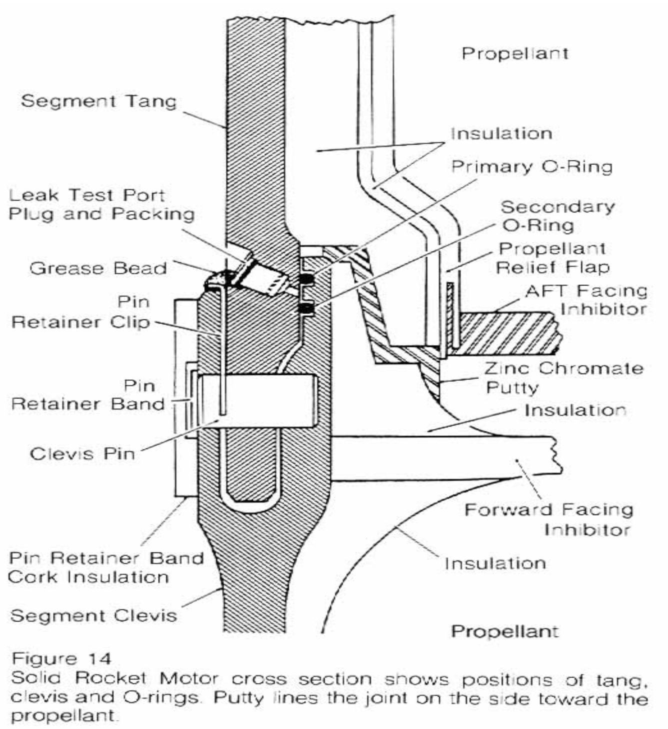

Image 5: Cross section of SRB field joint. (11)

Looking at the photographic evidence it becomes clear, where the failure occurred. The pictures shown were taken during launch of Mission STS-51L.

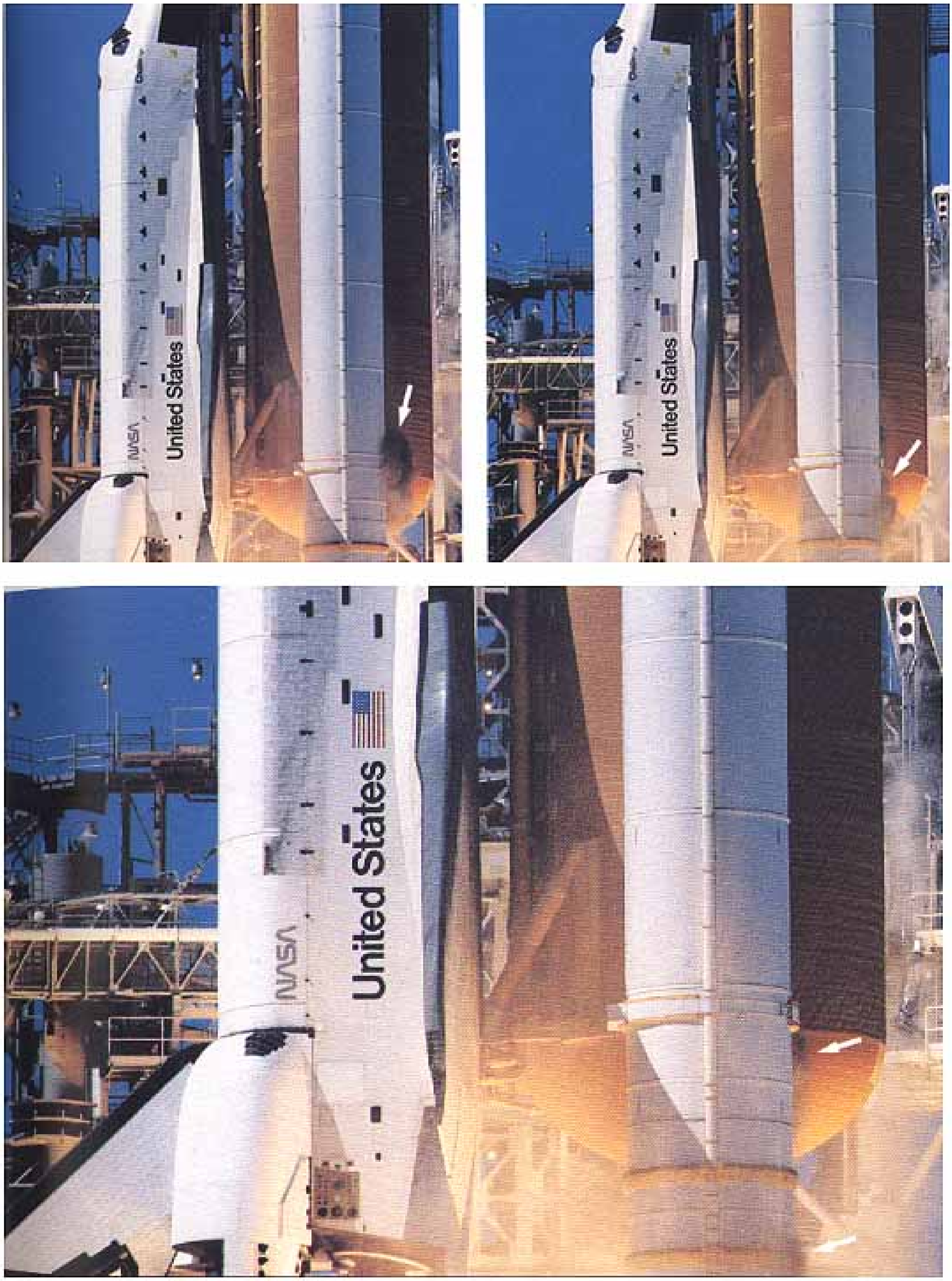

Image 6: 0.678 s into mission dark smoke puffs at aft joint occur (12)

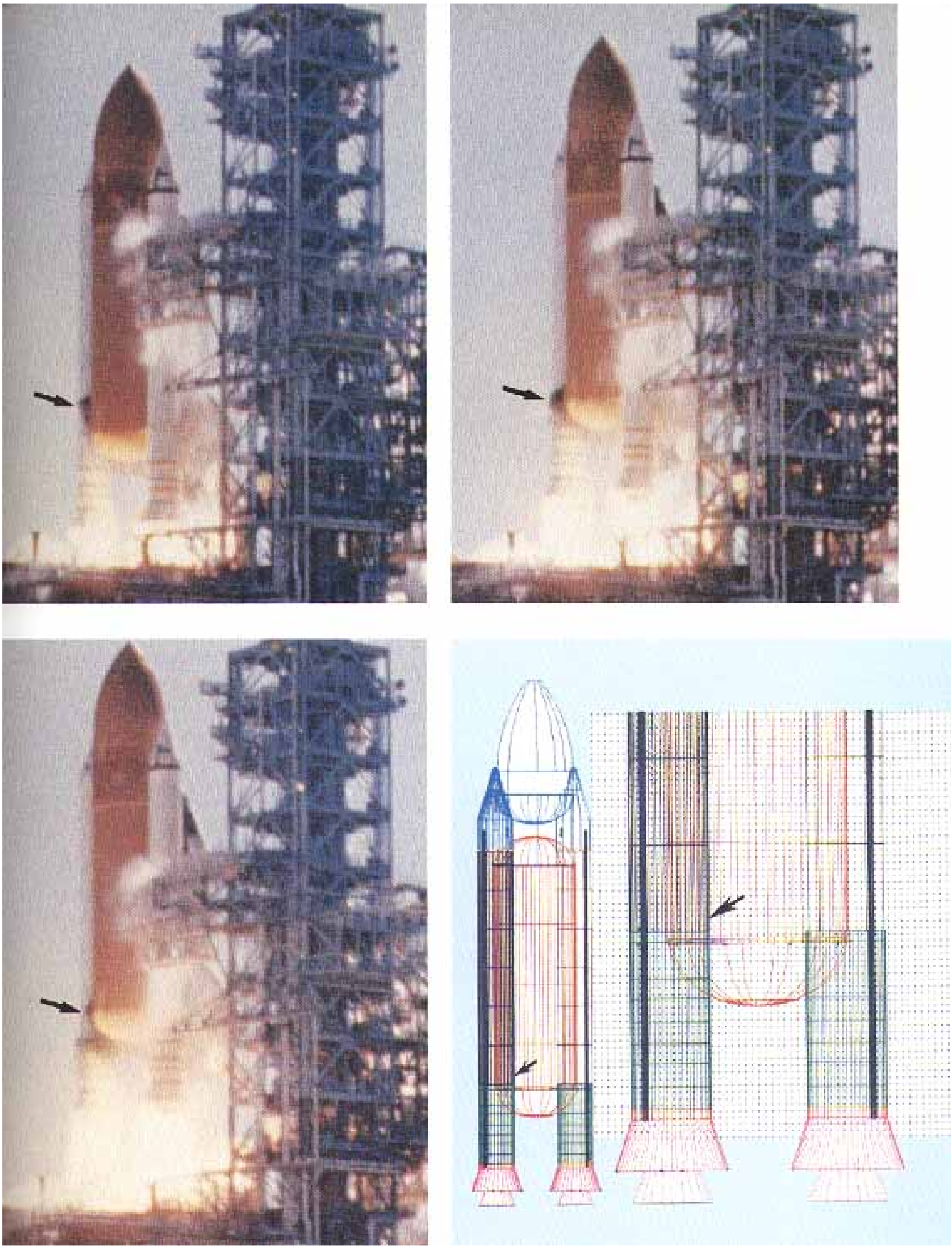

Image 7: Smoke Puffs from 0.836 s continued to 2.500 seconds, occurring about 4 times a second. smoke source shown in computer generated drawing. (13)

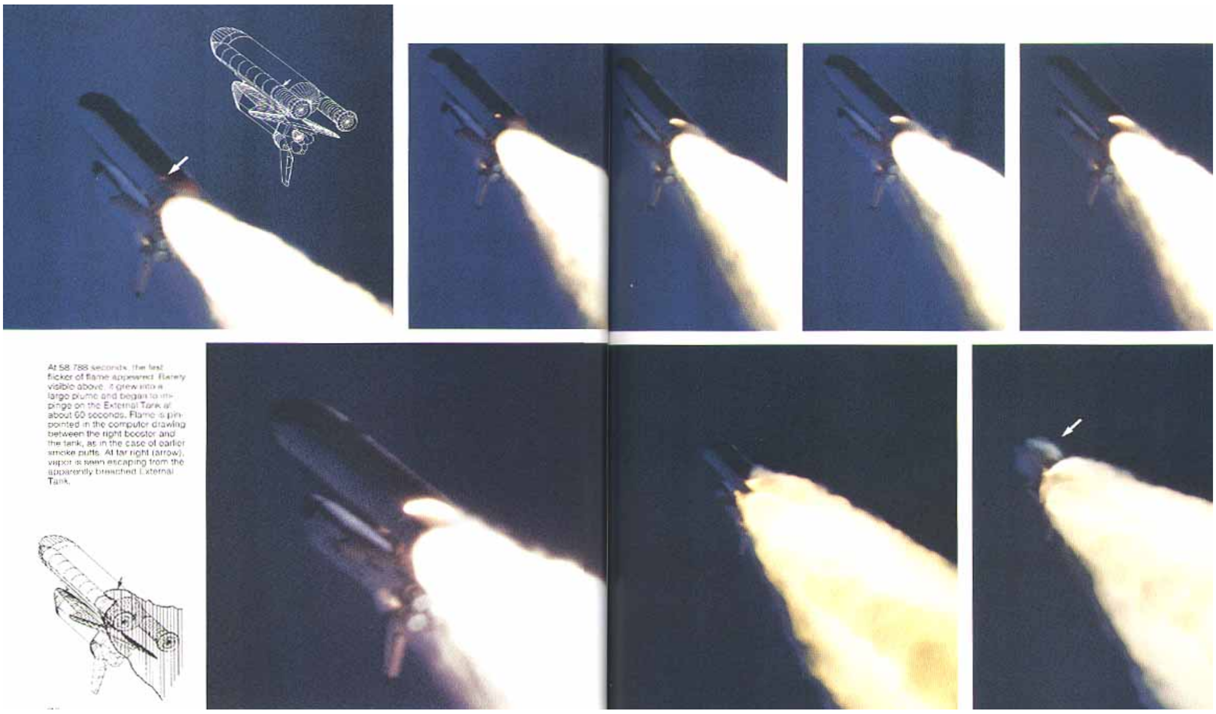

Image 8: 58.788 s first flicker of flame appeared, far right (arrow) vapor is seen escaping from breached External Tank. (14)

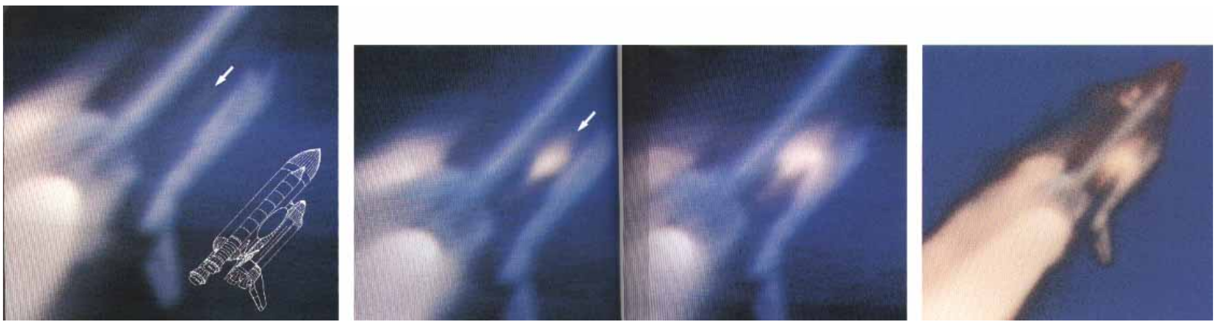

Image 9: Beginning of the rupture of the liquid hydrogen and liquid oxygen tank within the ET. (15)

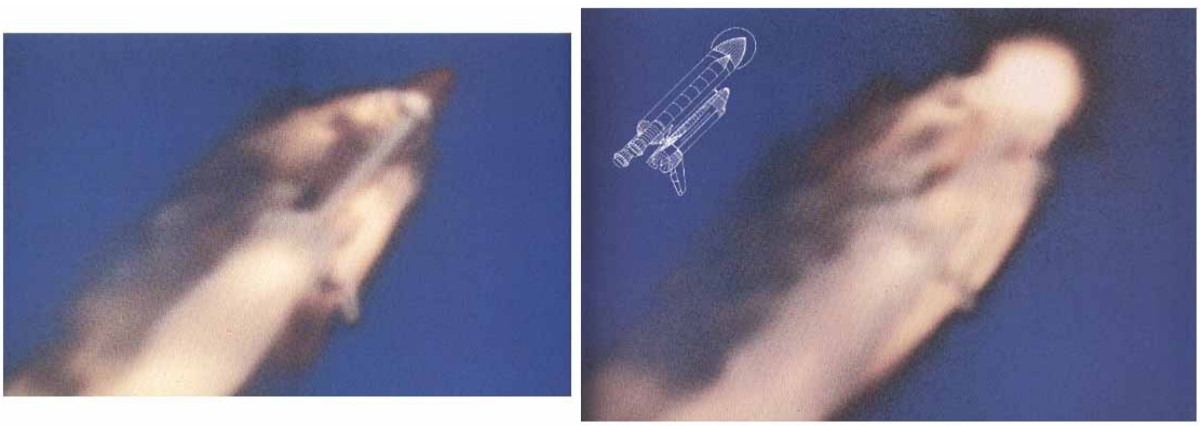

Image 10: rupture of liquid oxygen tank above the booster/tank forward attachment. (16)

Image 11: Explosion at 76 s in flight, left SRB soars away, still thrusting. (17)

The presidential report concluded as follow:”The consensus of the Commission and participating agencies is that the loss of the Space Shuttle Challenger was caused by a failure in the joint between the two lower segments of the right Solid Rocket Motor. The specific failure was the destruction of the seals that are intended to prevent hot gases from leaking through the joint during the propellant burn of the rocket motor….The failure was due to a faulty design unacceptably sensitive to a number of factors. These factors were the effects of temperature, physical dimension, the character of material, the effects of reusability, processing, and the reaction of the joint to dynamic loading.” (18)

Engineering Failure or Human Failure

After the explosion the question, “was the disaster avoidable or not?” was raised. A Presidential Commission was founded which was in charge of finding the reason for the explosion as well as looking in to the practices used by the National Aeronautics and Space Administration for their Space Shuttle Program. This is known as the Rogers Commission Report. This report exposed flawed and alarming practices and unrealistic thinking within NASA. The Rogers Report criticized the management for poor decision making, major communication failures, containing of potentially serious problems without eliminating them and neglecting flight safety in pretending NASA´s perfection in order to ensure the supply of funds. Problems with the O-ring design dated back as early as 1977 / 1978 and were apparent on many as 7 previous Space Shuttle Mission.

Flight	Joint	SRB (right or left)	Angular location	Joint Temp (°F)	Previous Use of Segments	Type of Distress
STS-2	AFT	RH	090	70	none/none	Erosion
41-B	FWD	LH	351	57	1/none	Erosion
41-C	AFT	LH	n/a	63	1/1	O-ring heat
41-D	FWD	RH	275/100	70	2/none	Erosion
51-C	FWD	LH	163	53	1/none	Erosion
51-C (3)	MID	RH	354	53	1/1	Erosion

61-A	MID	LH	36-66	75	none/none	Blow-by
61-A	AFT	LH	338/018	75	none/none	Blow-by
61-C	AFT	LH	154	58	1/none	Erosion
51-L	AFT	RH	307	28	1/2	Flame

Table 3: Filed Joint Distress in previous Space Shuttle Missions. (19)

Letters from NASA to Morton Thiokol regarding a completely unacceptable design of the clevis joint were just ignored. Years later Morton Thiokol proposed a program plan which was named "Protection of SRM Primary Motor Seal".

This highlights a different aspect of the procedures during testing and development in this area. R. Feynman concludes:" The argument that the same risk was flown before without failure is often accepted as an argument for the safety of accepting it again. … The fact that this danger did not lead to a catastrophe before is no guarantee that it will not the next time, unless it is completely understood. When playing Russian roulette the fact that the first shot got off safely is little comfort for the next." (20) Major communication breakdown occurred everywhere. Not only the Ice thickness on the launch date but also the temperature problems of the O-rings were not channeled to the appropriate people. On top of that, NASA Management was under pressure with their tight flight schedule. In 1986 NASA was scheduling a record number of flights and after the delay of mission STS-61C and cancellation of STS-51E the management pressed on to keep up with the proposed flight schedule. Scheduled for the 22nd of January 1986 originally but delayed because of the previous flight and rescheduled another 3 times the 28th of January was chosen to be the launch date. Even if the broken seals caused the disaster, human failure played a major part in it. The Disaster could have been avoided by implementing the appropriate changes.

NASA`s future in space exploration

After the Challenger Explosion, the Space Shuttle Program was halted to investigate the incident and to introduce the changes recommended by the Rogers Report. 17 years and 88 successful Missions later, NASA faced another grim time. STS-107 with Space Shuttle Columbia was lost at the re-entry. Another seven astronauts lost their lives. Did NASA not learn their lesson from 1986? Is NASA ready for the challenges of the future? In January 2004 the American President George W. Bush announced "The Vision for Space Exploration." The goals of this vision are stated as follow:"

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests."

Learning from their previous experience NASA should proceed with this new vision. Space Flight was, is and will be a risky business. Calculating known unknowns and unknown unknowns carefully should minimize the loss of human lives and optimize the scientific achievement.

Conclusion

After the two tragic accidents of missions STS-51L and STS-107 and the great success of the Apollo Project, NASA has a great goal again. Delivering this vision with international partners should not be impossible. Keeping relevant safety measures in place and not having an overloaded launch schedule can be achieved with the financial and political support from the government. Retiring the existent Space Shuttle Fleet in 2010 and developing the Constellation Project will test NASA`s capabilities and will show if the National Aeronautics and Space Administration did learn from their failure in the past. Sending humans back to the Moon and then on to Mars will not be easy and without setback`s or tragedies. Exploring space is the final and ultimate frontier and NASA will play a major part in that. But hopefully they will remember those famous words of Richard Feynman:”For a successful technology, reality must take precedence over public relation, for nature cannot be fooled.”(20)

In Memory

Image 12: The official portrait of the STS-51L crewmembers includes, in the Back row(L-r) mission specialist Ellison S. Onizuka, Teacher in Space Participant Sharon Christa McAuliffe, payload specialist Greg Jarviz and mission specialist Judy Resnik. In the front row(L-r) pilot Mike Smith, mission commander Dick Scobee, and mission specialist Ron McNair

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