東京工業大学
Tokyo Institute of Technology

Ethics in Engineering

Unit 2: Engineer Ethical Thinking

Definition of “Ethics”

1. Rooted in popular traditions or customs (or in personality or virtue)
2. A code of conduct for a certain social group
3. A field of academic study

Michael Davis

Michael Davis, *Thinking Like an Engineer: Studies in the Ethics of a Profession*, Oxford University Press, 1998

What Is Ethics?

- "Ethics is the science of conduct." (Oliver A. Johnson)
- Two main questions of ethics
  - What is good (or bad)?
  - What is right (or wrong)?
- Three traditions
  - Virtue Ethics
  - Deontology (concerning duty)
  - Utilitarian Ethics (concerning ends)

Oliver A. Johnson, *Ethics: Selections from Classical and Contemporary Writers*, 7th Edition (Fort Worth, TX: Harcourt Brace College Publishers, 1994), p.g. 1

What Is Ethics?

- Ethics: Human relations, fundamental rules constituting norms for actual morality, or morals (Kojien [Japanese Dictionary, published by Iwanami]).
- Human relations: Order among people, order related to hierarchy, and order related to youth and age (e.g., lords and vassals, fathers and sons, and married couples); by extension, a path to be observed by people and the “path of humanity” (Kojien [Japanese Dictionary, published by Iwanami]).

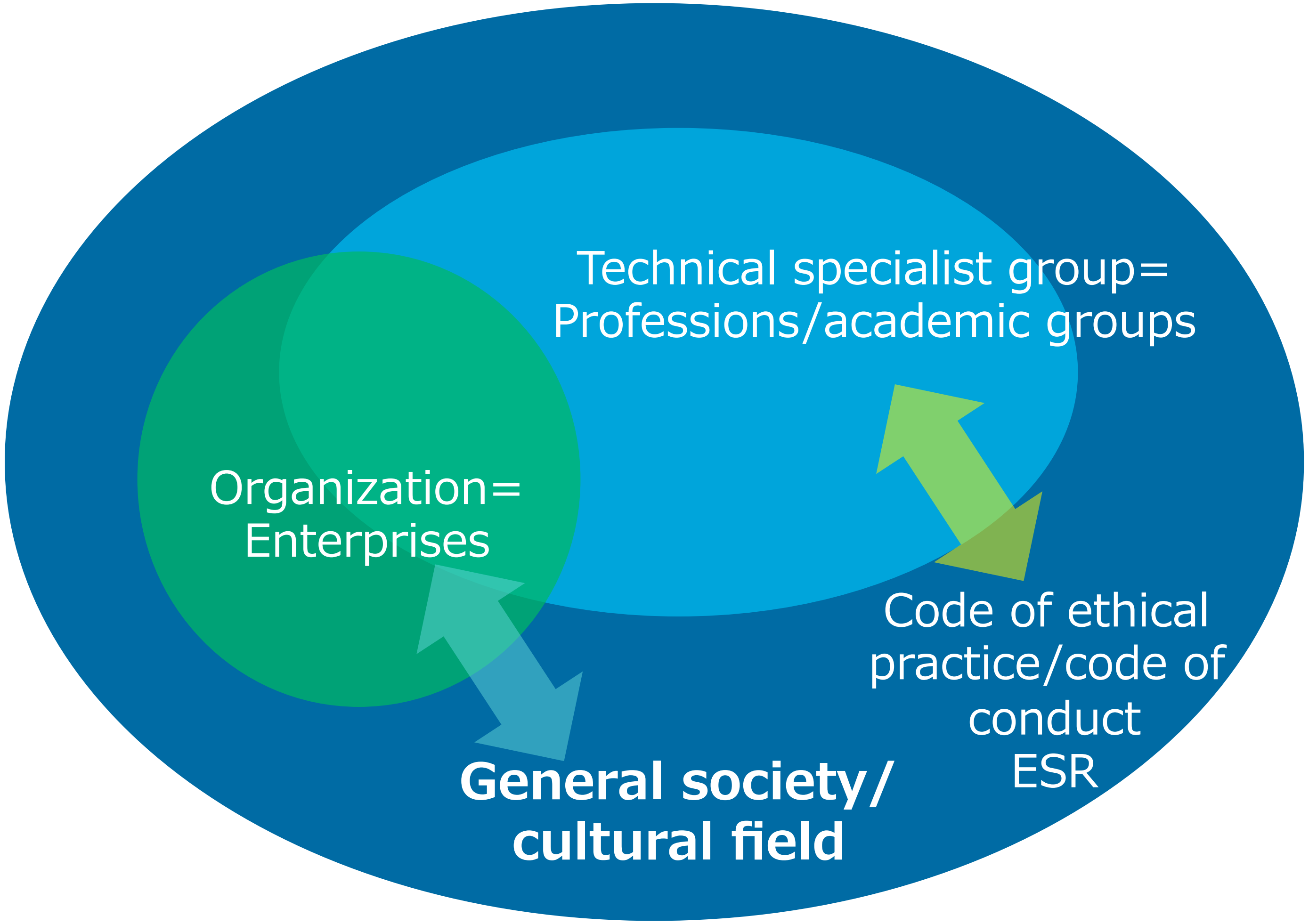
“Ethics = Morality”→What Is Morality?

- Morality: A way of life to be carried out by people, the overall set of norms generally accepted as standards for members of a society or for judging what is right and wrong regarding actions among members, and individual internal fundamental rules without the accompaniment of an external force (e.g., laws). Today, human attitudes regarding tangible and intangible matters (e.g., nature, cultural assets, and technological items) are included (Kojien [Japanese Dictionary, published by Iwanami]).

In short,

- The term “ethics” refers to an entire normative system used for the determination of values, such as what actions are right and wrong, what constitutes injustice within a certain social group, and what intellectual activities are are subject to continuous review in accordance with the aforementioned system (Jun Fudano).

Interactions between Social Groups and Engineers



Codes of Conduct and Values to Be Considered by Engineers

1. Codes of conduct and individual values
2. Codes of conduct and values of members of individual social groups (e.g., families and religious organizations)
3. Codes of conduct and values of the members of occupational organizations (←business ethics→Corporate Social Responsibility)
4. Codes of conduct and values of the members of technical groups (←engineering ethics→Engineering Ethics)
5. Codes of conduct and values in the cultural context and relationship to which one belongs (such as a country)
6. Codes of conduct and the values of members of humanity

Engineering Ethics

What is ethics?

What is engineering?

↓(Practice)

What is an engineer?

What Is Engineering?

"Engineering is the **profession** in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with **judgment** to develop ways to utilize, economically, the materials and forces of the nature for the **benefit** of mankind."

(Accreditation Board for Engineering and Technology: ABET)

What is the Benefit of Mankind?

What is the benefit to humanity?

↓

Value-related issues

That is:

- Engineering and values have an inseparable relationship; and
- Engineering reflects the values of individuals and organizations.

Definition of Engineering Ethics (based on the ABET definition)

The term "engineering ethics" refers to an entire normative system for the determination of values, such as **what actions are right and wrong, what constitutes injustice, and other related values** that are necessary for engineers to utilize in an economical way. It also relates to the forces of nature that benefit humanity (= values) by making use of mathematical and natural science knowledge gained through study, experience, and practice in a certain social group and by the continuous, critical review of the aforementioned system, as well as the ability to make judgements based on normative systems (Jun Fudano).

Peculiarity for Engineering Ethics

Accompanying the development of science and technology, new "values" are always being created and new relationships emerge among them. Therefore, engineers are required to cultivate and balance new value judgments supported by their expertise.

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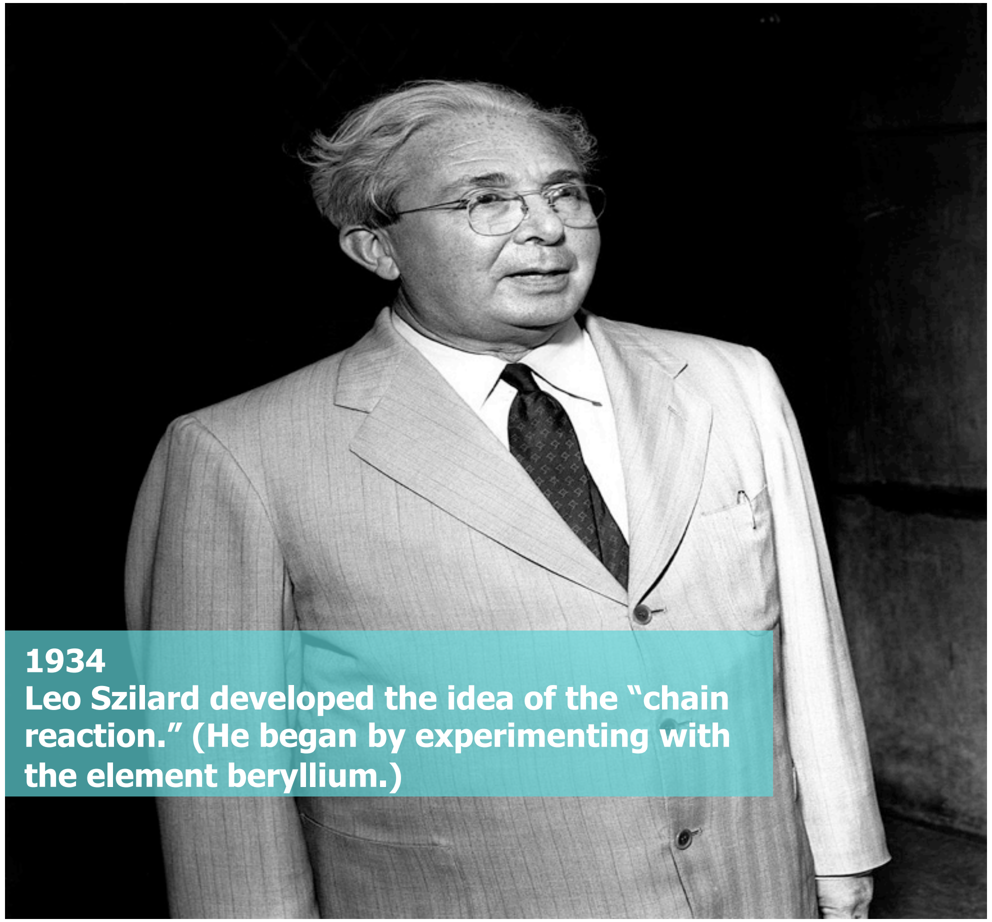
New behavior design

Values Such as Those Related to Uranium

https://no.wikipedia.org/wiki/Fil:James_Chadwick.jpg



Credit: DOE Photo
https://commons.wikimedia.org/wiki/File:Leo_Szilard.jpg

Case Example:
Space Shuttle Challenger Disaster

Credits: NASA
https://commons.wikimedia.org/wiki/File:Challenger_explosion.jpg

What is the Space Shuttle Program?

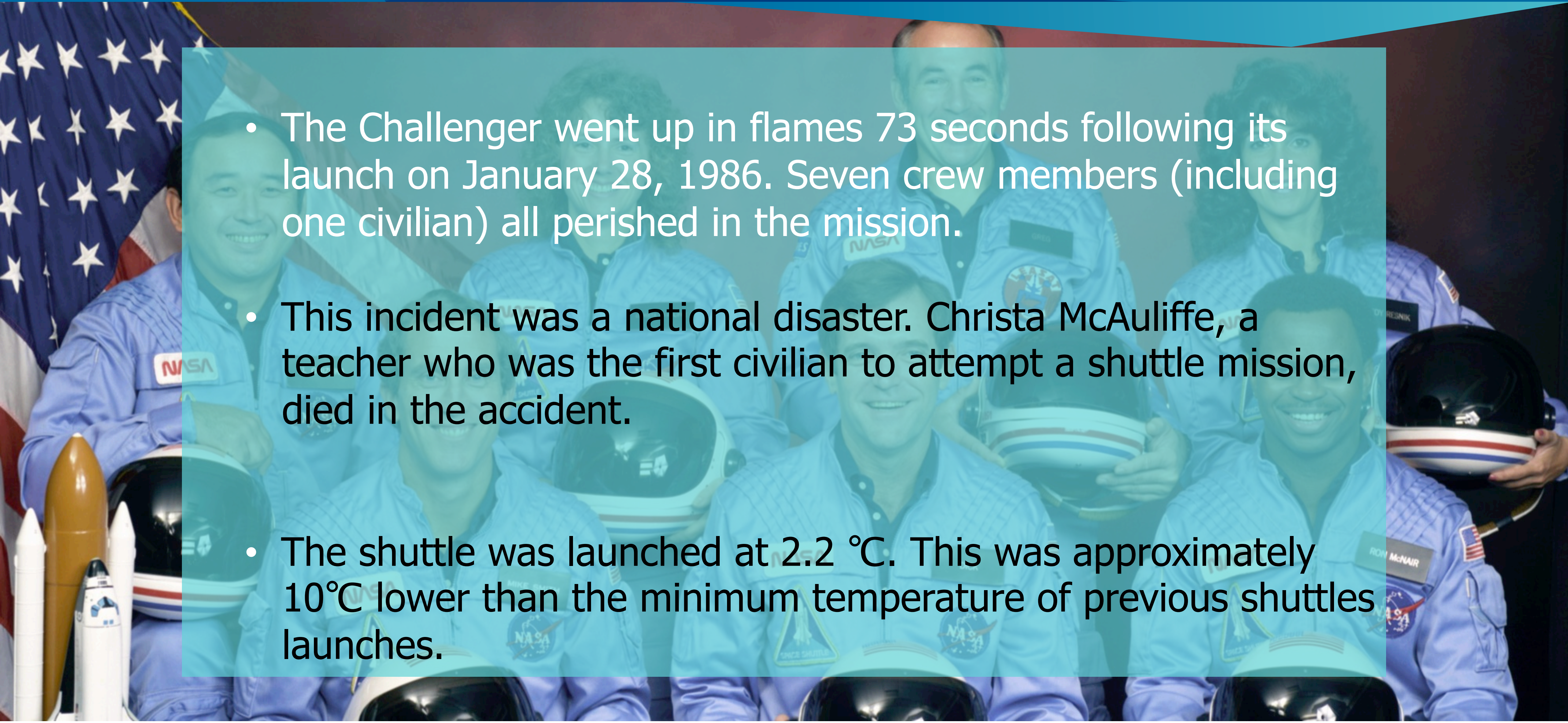
- A program for frequently (i.e., 50 instances a year) and inexpensively sending equipment (e.g., artificial satellites) into outer space (one goal is that parts should be recycled to the utmost extent possible).

Space Shuttle Program

Credits: NASA
https://www.nasa.gov/topics/technology/features/tdrs-era.html

Outline of the Space Shuttle Challenger Disaster

Credits: NASA
https://www.nasa.gov/multimedia/imagegallery/image_feature_256.html

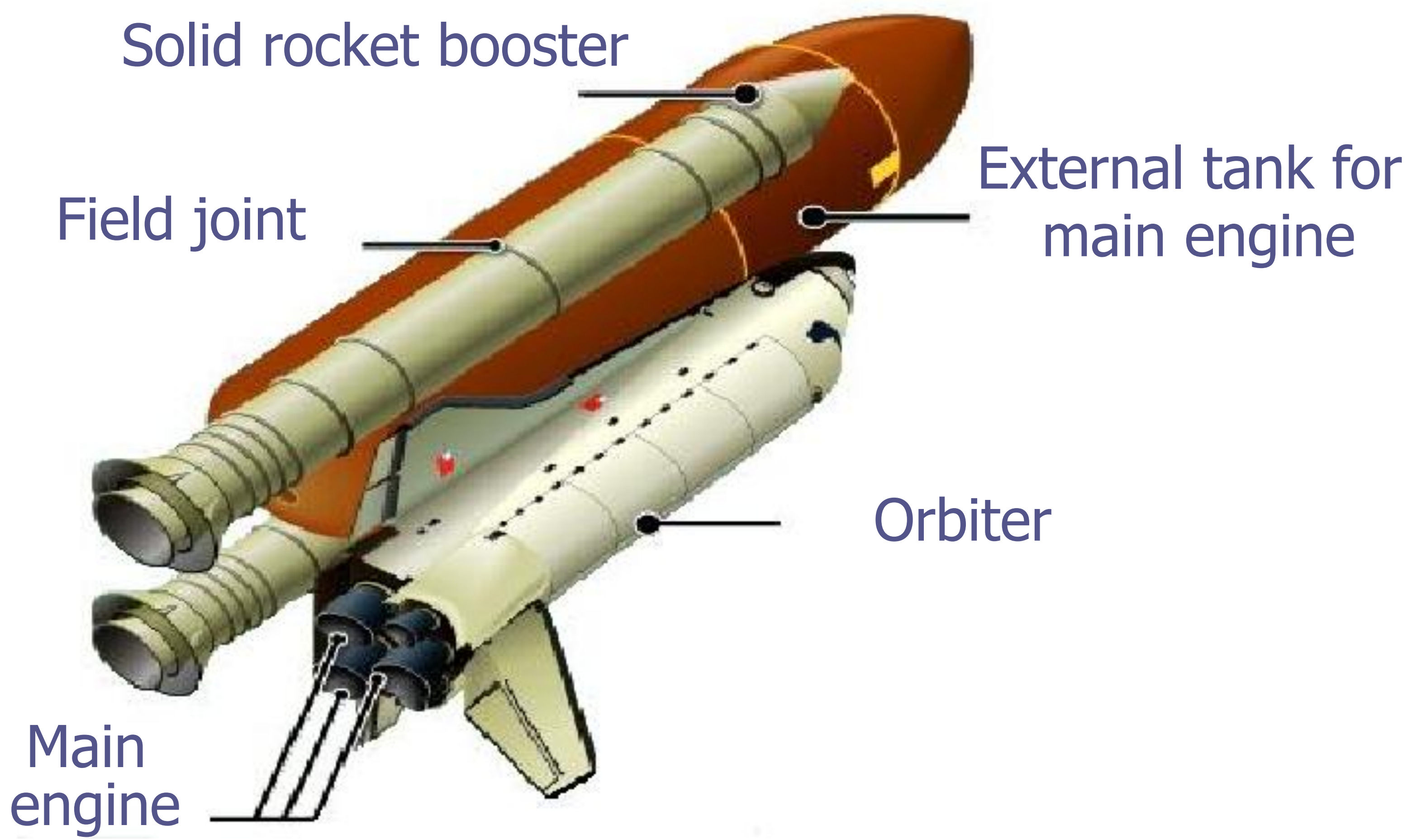


- The Challenger went up in flames 73 seconds following its launch on January 28, 1986. Seven crew members (including one civilian) all perished in the mission.
- This incident was a national disaster. Christa McAuliffe, a teacher who was the first civilian to attempt a shuttle mission, died in the accident.
- The shuttle was launched at 2.2 ℃. This was approximately 10℃ lower than the minimum temperature of previous shuttles launches.

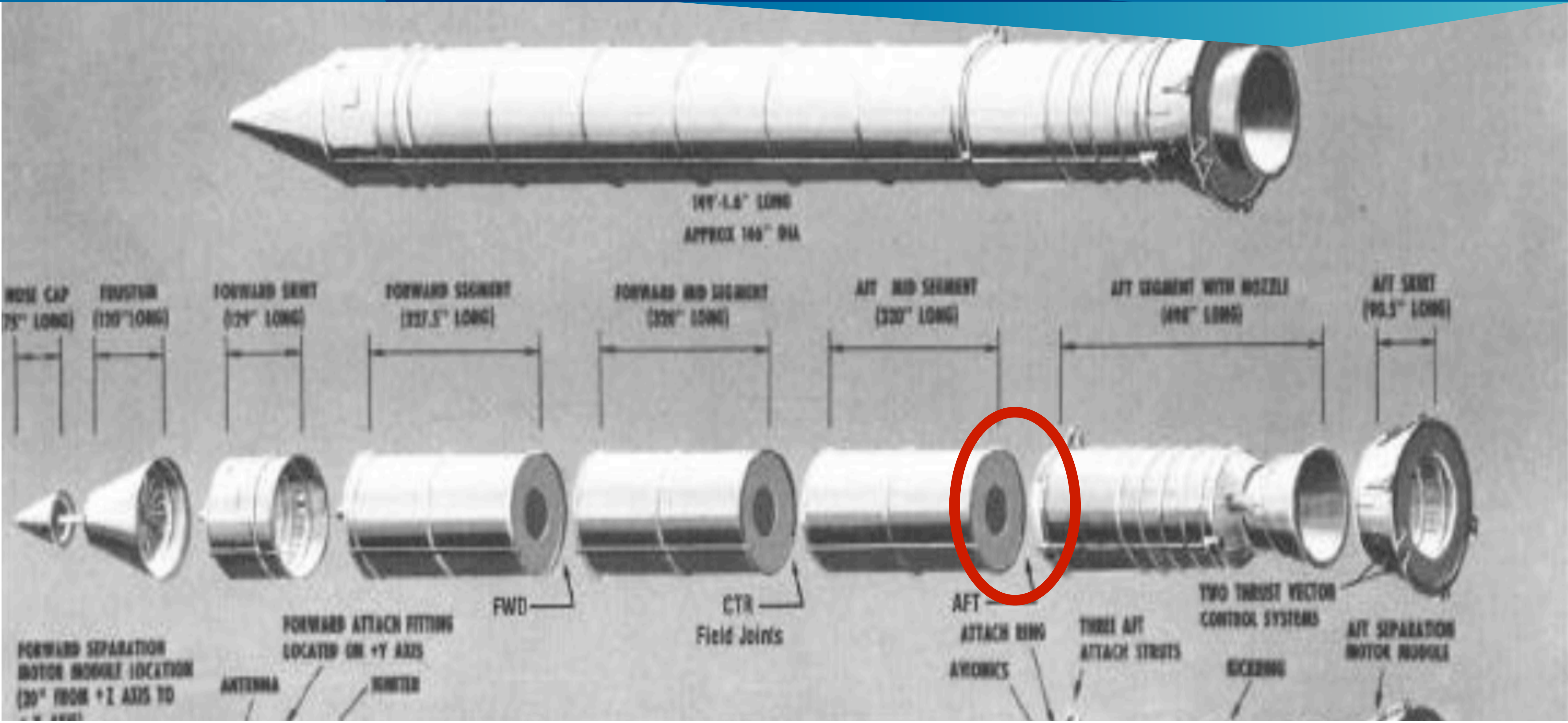
Outline of the Space Shuttle Challenger Disaster

Credits: NASA
https://www.nasa.gov/sites/default/files/images/106994main_image_feature_256_ajhfull.jpg

Overall View of the Space Shuttle



札野順, 「新しい時代の技術者倫理」, 放送大学教育振興会 , p.g. 31, 図2-2



Booster sealing joints

“Report to the President by the Presidential Commission on the Space Shuttle Challenger Accident”, p. 53, Figure 8
https://spaceflight.nasa.gov/outreach/SignificantIncidents/assets/rogers_commission_report.pdf

Parties Involved

NASA
(National Aeronautics and Space Administration)

Morton Thiokol, Inc. (MT)

A private enterprise that received a contract to design and manufacture an SRB

Diane Vaughan, he Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA, University of Chicago Press, Chicago and London Publication, 1996
https://history.nasa.gov/rogersrep/v1p231.htm

Parties Involved

NASA
(National Aeronautics and Space Administration)

Larry Muroi: Person responsible for the SRB project

MT

Roger Boisjoly: Engineer in charge of SRB Development Planning

Arnie Thompson: Same as above

Joe Kilminster: Vice President in charge of SRB

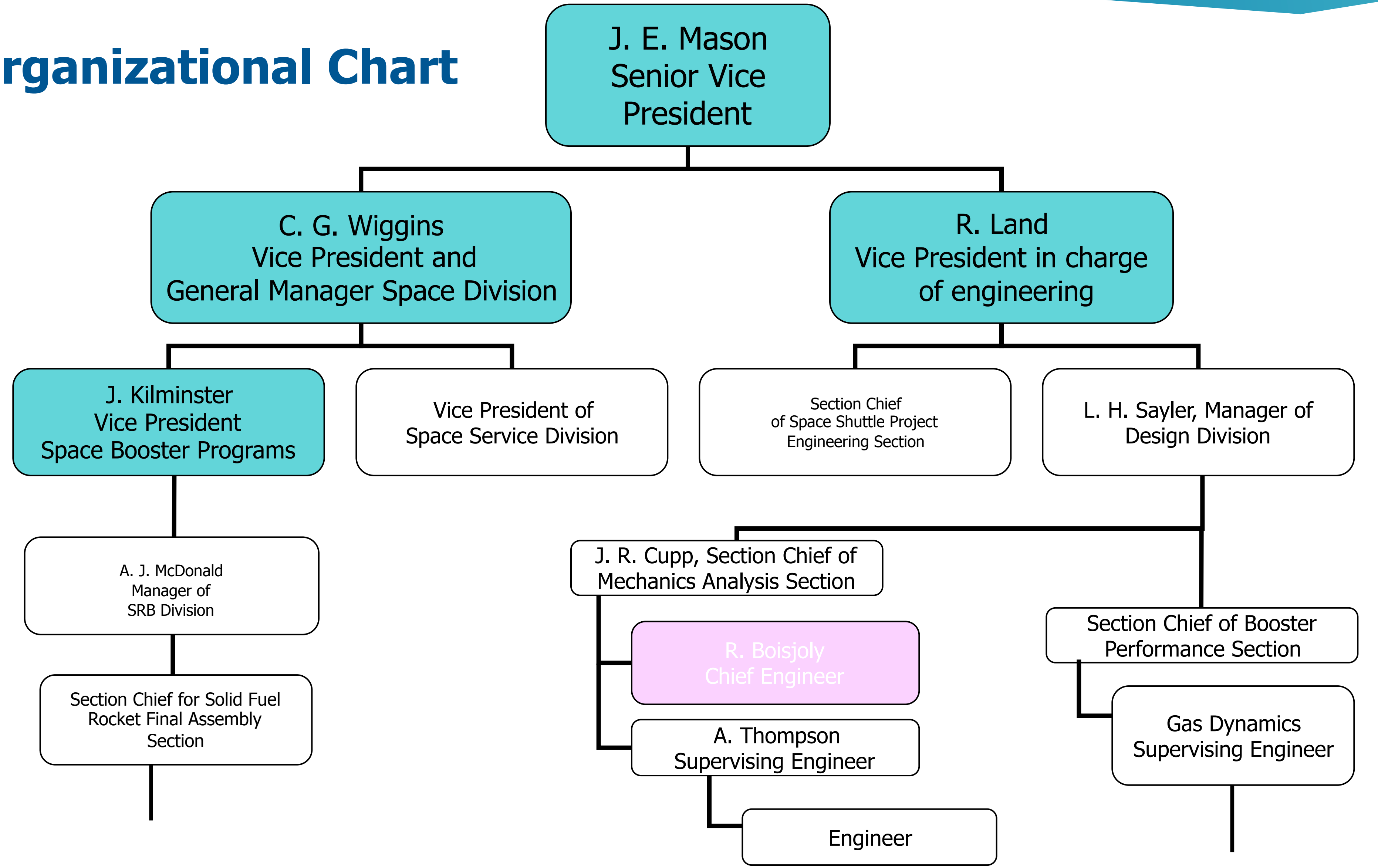
Allan McDonald: Manager of the SRB Division

Bob Land: Vice President in charge of engineering

Jerald Mason: Senior Vice President

Diane Vaughan, he Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA, University of Chicago Press, Chicago and London Publication, 1996
https://history.nasa.gov/rogersrep/v1p231.htm

MT Oorganizational Chart



Diane Vaughan, he Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA, University of Chicago Press, Chicago and London Publication, 1996

https://history.nasa.gov/rogersrep/v1p231.htm

Background

Commencement of the program, first flight, and “operational phase” declaration

- 1973: Approval of the Space Shuttle Program
- 1974: Execution of an agreement between NASA and MT for SRB design and manufacture
- 1976: NASA’s approval of MT’s design
- 1977: Recognition of problems with field joints (O-rings)
- April 1981: First launch (Columbia)
- Nov. 1981: Problems discovered through investigation following the second launch
- July 1982: Declaration of “operational phase” by President Regan

Background (cont.)

High-risk recognition and the night before the launch

- 1985: The presence of soot and grease were confirmed in an investigation following the launch on January 24. Thiokol created a task force (members included Boisjoly) and undertook relevant reviews.
- July 1985: Boisjoly issued a written warning to MT's executives regarding the danger of field joint issues. A review team was established; however, no support was provided by the company and specific activities could not be undertaken.
- Jan. 27, 1986: On the night before the launch, a telephone conference among NASA, MT, and other concerned parties took place regarding the topic of launching the shuttle at a low temperature.

Political Background

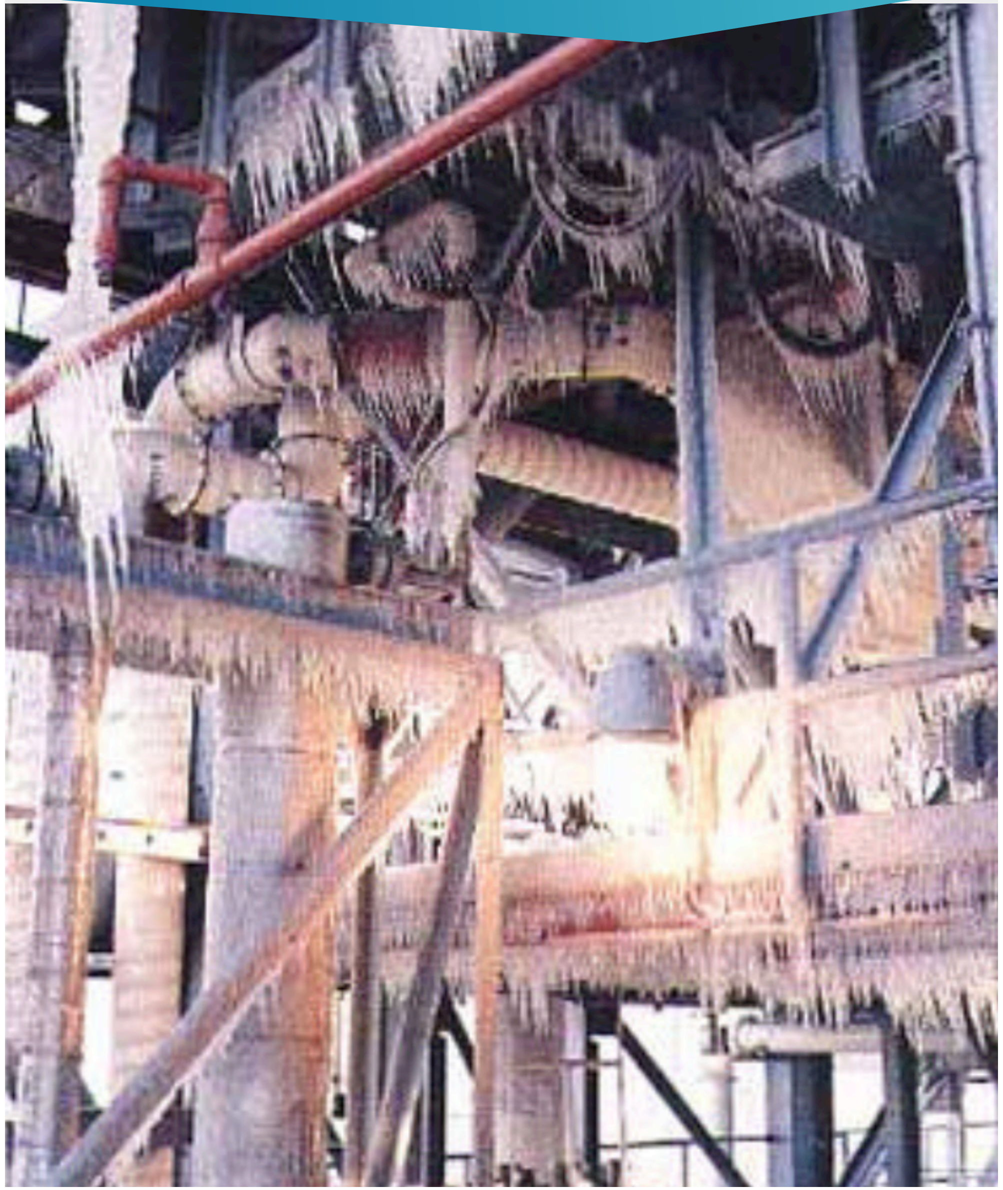
NASA was under political pressure to implement the launch.

- Delay in the overall Space Shuttle Program (benefits were expected initially).
- Existence of rivals = the same types of programs were under way in Europe.
- Congress began to doubt NASA’s budget.
- A tight and hectic schedule for the launch plan was put forward in 1986 (e.g., the launch of a Halley's Comet probe took place as various parties pressured Congress).
- A State of the Union Message was delivered by President Reagan (aimed at avoiding criticism of educational policies, the “space teacher” idea had already been incorporated into the manuscript).

Telephone Conference on the Eve of the Launch

There is some apprehension about the the launch taking place at a low temperature.

- An abnormally low temperature was expected because of the passage of a cold front.
- McDonald, who was stationed at the launch location, expressed his apprehension about a launch at what was expected to be a low temperature. A meeting was held on this issue.
- Onsite engineers opposed the launch (i.e., Boisjoly and Thompson).



"Report to the President by the Presidential Commission on the Space Shuttle Challenger Accident", p. 114
https://spaceflight.nasa.gov/outreach/SignificantIncidents/assets/rogers_commission_report.pdf

Telephone Conference on the Eve of the Launch (cont.)

NASA opposed postponement.

- Land proposed postponement of the launch until there was clear data about the expected low temperature.
- Muroi from NASA opposed postponement because there was no solid evidence: “Do you really want to wait until April?”
- MT executives held offline discussions. Boisjoly and others opposed the launch.

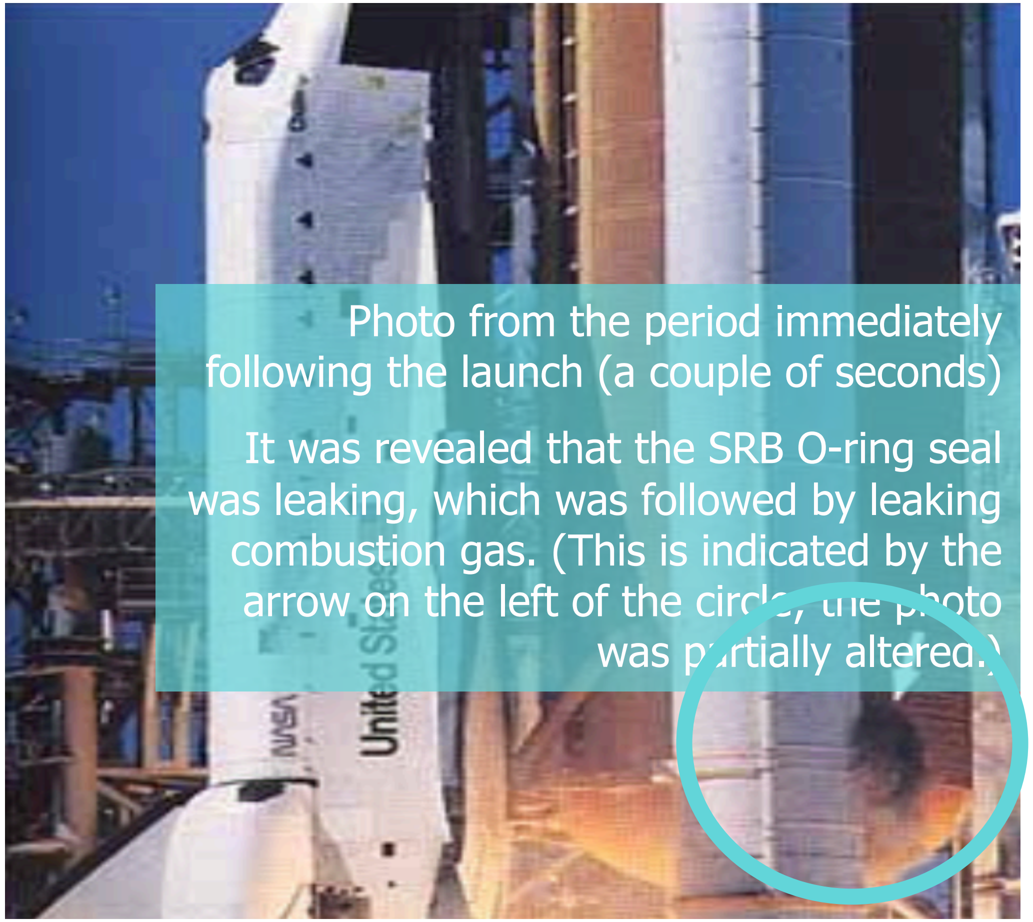
Credits: NASA
https://commons.wikimedia.org/wiki/File:Icicles_on_the_Launch_Tower_-_GPN-2000-001348.jpg

Telephone Conference on the Eve of the Launch (cont.)

MT approved the launch.

- Reexamination took place in internal meetings. The meetings moved along based on launch approval, as no correlation was found between the blow-by of combustion gas and temperature.
- Mason said to Land, who opposed the launch, “Why don’t you take off your engineer hat and put on your manager hat?”
- Land changed his opinion and MT came to the conclusion that the launch should be approved. (The executives concurred with Land’s new opinion.)
- McDonald, who was stationed in Florida, was surprised at this conclusion.

As the Launch Progressed…



"Report to the President by the Presidential Commission on the Space Shuttle Challenger Accident", p. 23
https://spaceflight.nasa.gov/outreach/SignificantIncidents/assets/rogers_commission_report.pdf

Credits: NASA
https://commons.wikimedia.org/wiki/File:STS-51-L_Recovered_Debris_(O-Ring_Tracks_on_Right_SRB_Joint)_-_GPN-2004-00010.jpg