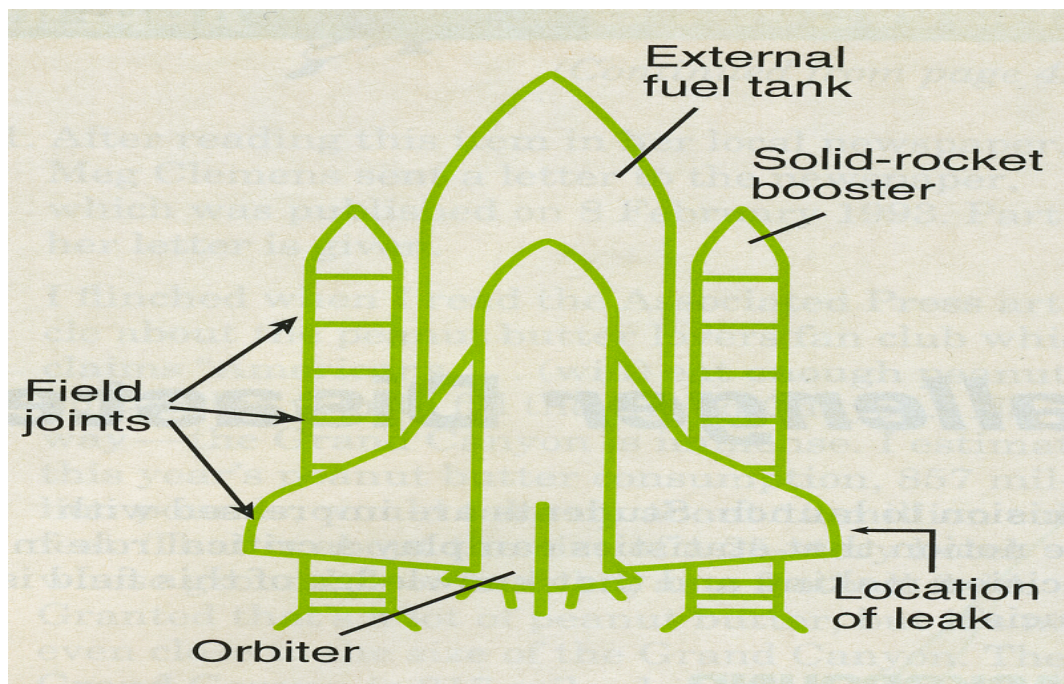


# The Challenger Disaster Revealed!

## 1 Background

- Launch Time: January 28, 1986
- The temperature was 31°F
- Exploded after 73 seconds from its launch leading to the death of its seven crew members
- The Shuttle consisted of:
  - The orbiter: Housed crew and controls
  - An external fuel tank
  - Two solid-rocket booster motors
- The following figure from Tappin (1994) shows the shuttle parts:



- Each rocket-booster was shipped in 4 pieces
- Each rocket-booster has three joints called *O-rings* (6 total)

## 2 Challenger Pre-launch Discussion

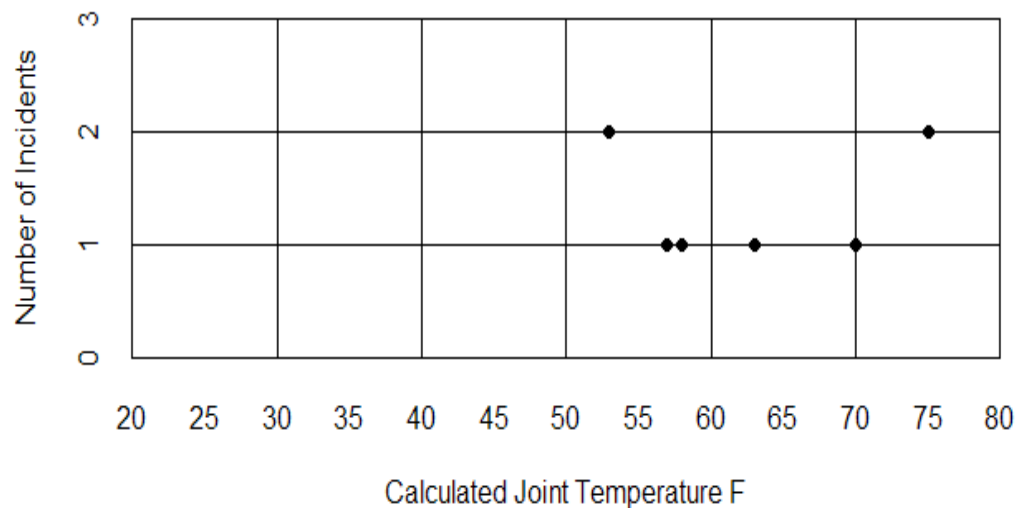
- The night before the scheduled launch, discussions occurred as to whether the launch should be postponed because of the low temperature
- It was believed, by some of the people who were involved in the decision, that low temperatures might harden the O-ring seals, and thus leading to a potentially dangerous combustion-gas leak
- The O-rings had been designated as a "Criticality 1" component
- The engineers and manufacturers of the rocket motors believed that they should abort the flight
- They presented several (hand written) tabulated numbers to show their point. The following figure was taken from Tufte (1997):

BLOW BY HISTORY	HISTORY OF O-RING TEMPERATURES (DEGREES - F)				
	MOTOR	MBT	AMB	O-RING	WIND
SRM-15 WORST BLOW-BY					
◦ 2 CASE JOINTS (80°), (110°) ARC	DM-4	68	36	47	10 MPH
◦ MUCH WORSE VISUALLY THAN SRM-22	DM-2	76	45	52	10 MPH
SRM 22 BLOW-BY	QM-3	72.5	40	48	10 MPH
◦ 2 CASE JOINTS (30-40°)	QM-4	76	48	51	10 MPH
	SRM-15	52	64	53	10 MPH
SRM-13A, 15, 16A, 18, 23A 24A	SRM-22	77	78	75	10 MPH
◦ NOZZLE BLOW-BY	SRM-25	55	26	29	10 MPH
				27	25 MPH

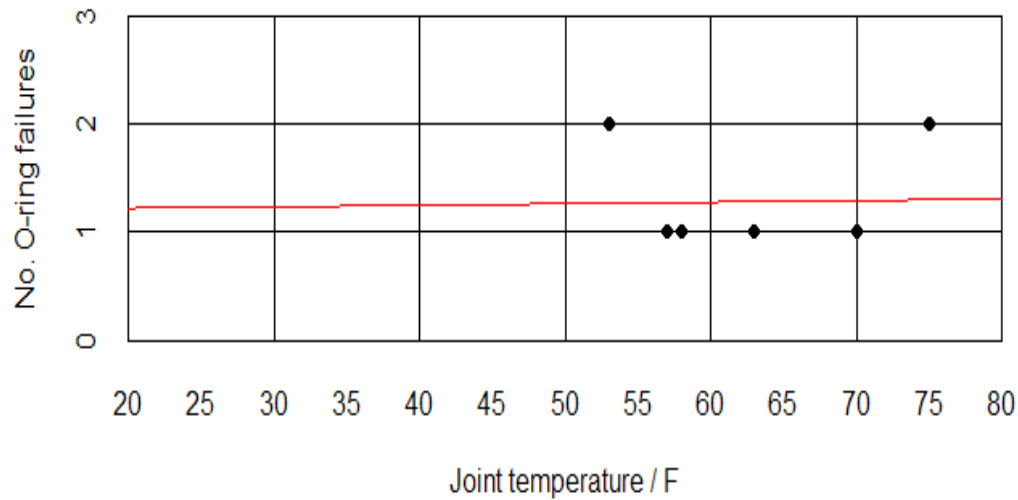
- These tables were unconvincing to their managers because:
  - NASA's pressure
  - Did not show clearly the relationship between temperature and the number of O-rings failing to operate

### 3 Challenger Post-launch Discussion

- Subsequent to the crash, commission staff members tried to graphically replicate the flaws in the prelaunch reasoning process
- They plotted the data from previous twenty three space shuttle launching where there was at least one O-ring failure Wainer (1997)
- The dataset consisted of two variables: the launching temperature and number of damaged O-rings
- The temperature has an average around 63°F and standard deviation equal to 8



- The following graph shows how they fitted a horizontal straight line



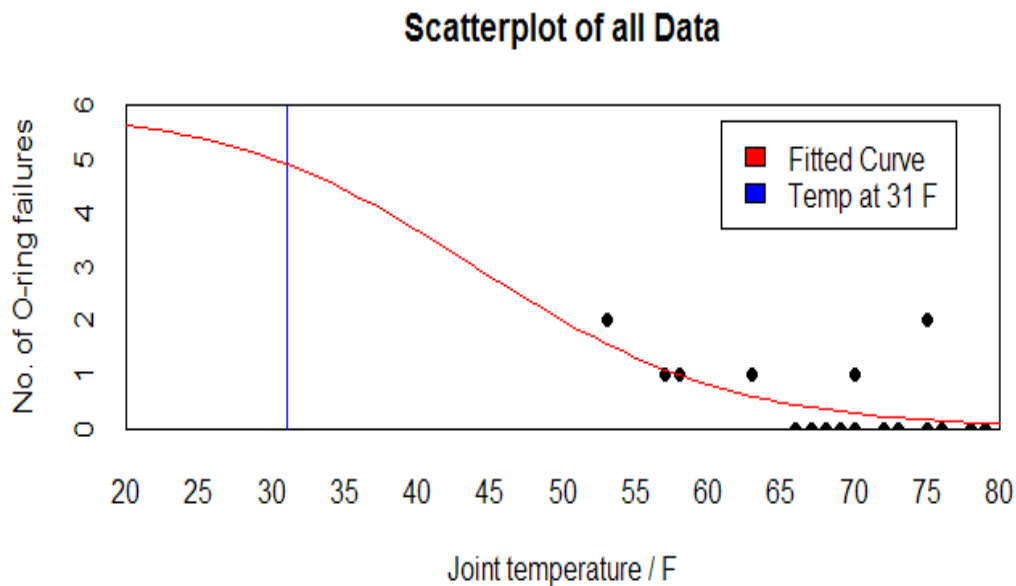
- The conclusion was: there is no effect of temperature

#### 4 What went wrong?

- The data was graphed out of context
- The dataset was so small(7 cases only)
- The points were difficult to view because of the dark grid lines.

#### 5 What would have been done?

- Use the complete dataset, and don't include only failure cases
- Remove the grids
- Extend the “Number of Incidents” axis limit to 6
- The temperature has an average around 69°F and standard deviation equal to 7



## 6 Links to Data and R Code

Click on the following links to get:

- [http://www.math.usu.edu/~symanzik/teaching/2009\\_stat6560/RDataAndScripts/sharif\\_abbass\\_project1\\_challenger.R](http://www.math.usu.edu/~symanzik/teaching/2009_stat6560/RDataAndScripts/sharif_abbass_project1_challenger.R)
- [http://www.math.usu.edu/~symanzik/teaching/2009\\_stat6560/RDataAndScripts/sharif\\_abbass\\_project1\\_challenger.csv](http://www.math.usu.edu/~symanzik/teaching/2009_stat6560/RDataAndScripts/sharif_abbass_project1_challenger.csv)

## References

- Tappin, L. (1994), ‘Analyzing Data Relating to Challenger Disaster’, *Mathematics Teacher* **87**, 423–426.
- Tufte, E. R. (1997), *Visual Explanations: Images and Quantities, Evidence and Narrative*, Graphics Press, Cheshire, CT.
- Wainer, H. (1997), *Visual Revelations: Graphical Tales of Fate and Deception from Napoleon Bonaparte to Ross Perot*, Copernicus/Springer, New York, NY.