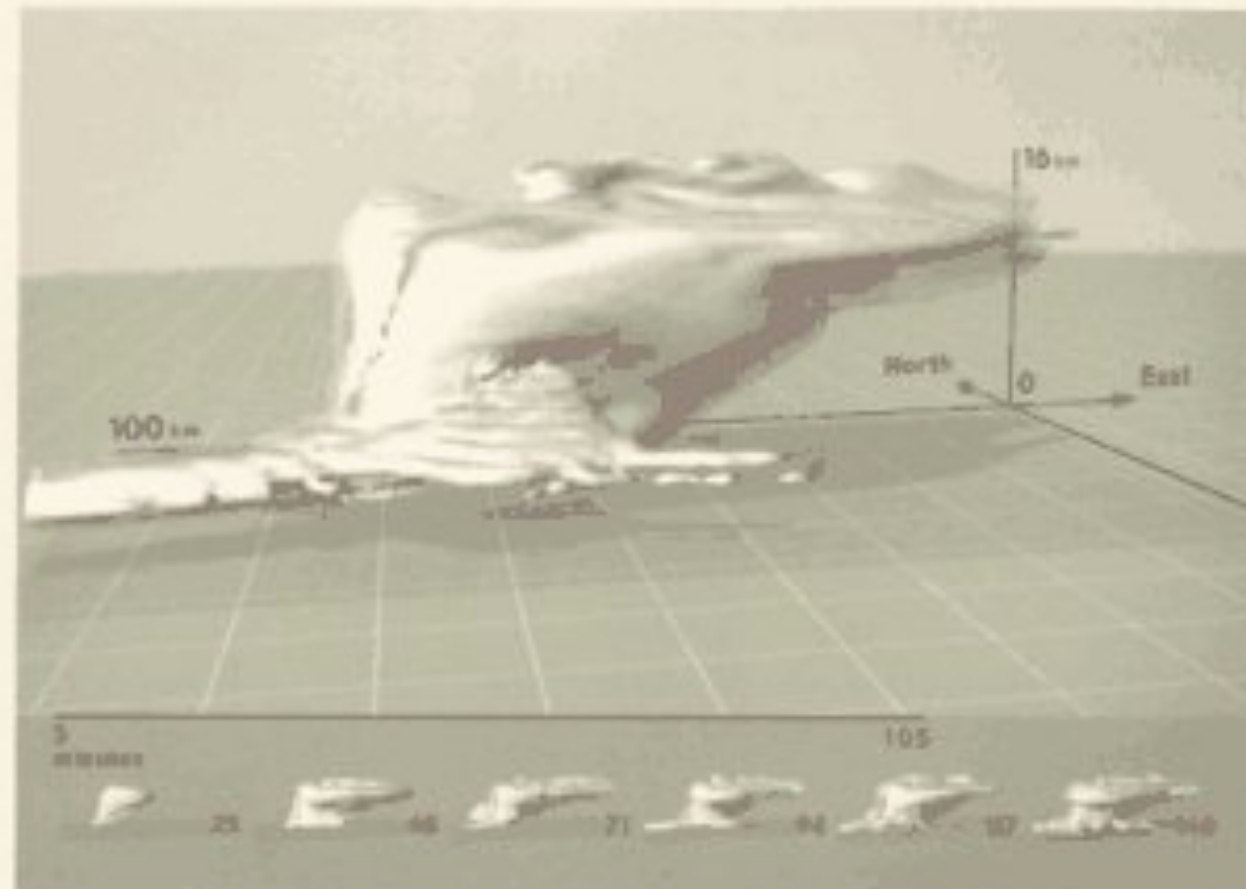


EDWARD R. TUFTE

VISUAL EXPLANATIONS



IMAGES AND QUANTITIES, EVIDENCE AND NARRATIVE

Visual Explanations by Edward Tufte (1997)

Mike Gallaspy

Kevin Kannappan

[Specifically Chapter 2: Visual and Statistical Thinking: Displays of Evidence for Making Decisions](#)



Visualization as *Life* or *Death*

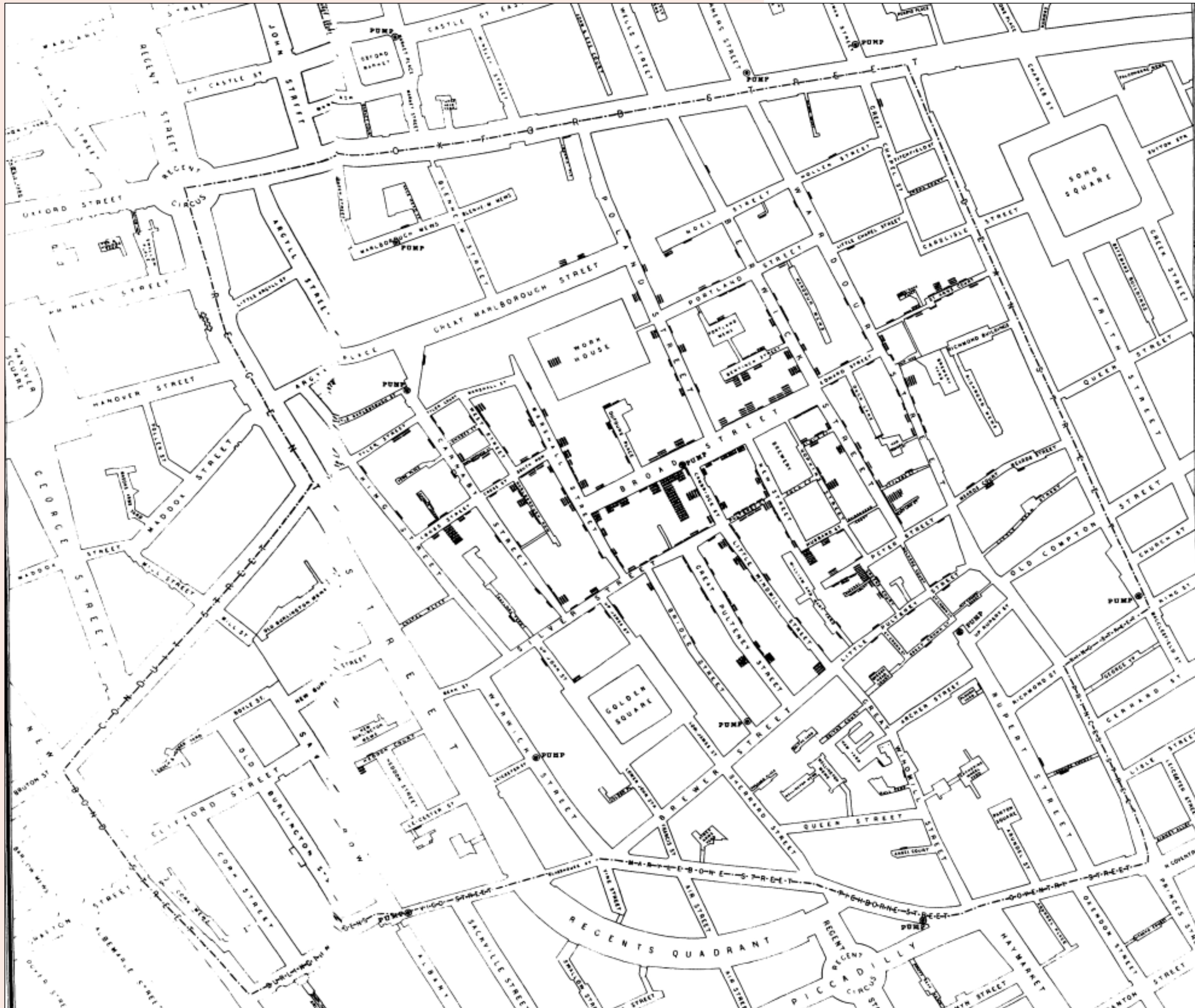
Tufte explores the magnitude of how important visualizing information can be, specifically through visuals developed to:

1. Stop a Cholera Outbreak in 1854
2. Launch the Challenger Shuttle in 1986

Cholera in 1854

Within 10 days, more than 500 casualties occurred in a few block radius in London (specifically Broad St.)

- At the time, Cholera was not known to be a waterborne illness
- Testing the water yielded no suspicious impurities
 - Causal bacteria discovered in 1886
- Visualization (and paper) provided the evidence to act



Cholera Outbreak

John Snow plotted the deaths of cholera in a spatial map of Broad Street

- Bars – frequency of deaths
- Dots – well pumps

Cholera in 1854: Tufte's Analysis

Snow was effective because he followed a causal theory through visualization

What: Data & Derived

Data

- Deaths from cholera during an outbreak in London in 1854
- Water pump Locations

Derived:

- Residences of victims

Why: Tasks

- Explore spatial relationships of cholera death
- Identify epicenter of the outbreak (Broad Street)

How: Encode

- Number of deaths per residence drawn as proportional bars

Scale

- From zero to tens of deaths per residence
- Graph becomes busy if the number of deaths is too large

Challenger in 1986

On January 28, 1986, the Challenger space shuttle took off from Cape Canaveral, FL and exploded killing all 7 astronauts onboard.

- Reasoning was rubber O-rings malfunction due to cold weather
- Engineers who were aware of issue were unable to convince powers to postpone launch
 - Evidence clear but not communicated effectively
 - Needed to answer: *in relation to what?*

161
OCT 30, 1985
AFT
61A LH Center Field**
61A LH CENTER FIELD**
51C LH Forward Field**
51C RH Center Field (prim)***
51C RH Center Field (sec)***
410 RH Forward Field
41C LH Aft Field*
41B LH Forward Field
STS-2 RH Aft Field

HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

SRM No.	Cross Sectional View			Top View		Clocking Location (deg)
	Erosion Depth (in.)	Perimeter Affected (deg)	Nominal Dia. (in.)	Length Of Max Erosion (in.)	Total Heat Affected Length (in.)	
22A	None	None	0.280	None	None	36° -- 66°
22A	NONE	NONE	0.280	NONE	NONE	338° - 18°
15A	0.010	154.0	0.280	4.25	5.25	163
15B	0.038	130.0	0.280	12.50	58.75	354
15B	None	45.0	0.280	None	29.50	354
13B	0.028	110.0	0.280	3.00	None	275
11A	None	None	0.280	None	None	--
10A	0.040	217.0	0.280	3.00	14.50	351
2B	0.053	116.0	0.280	--	--	90

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.
SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.

O-Ring Damage

Tables used to convey that O-Ring damage was present in testing.

Second table designed to convince launch temperature matters.

BLOW BY HISTORY
SRM-15 WORST BLOW-BY
o 2 CASE JOINTS (80°), (110°) ARC
o MUCH WORSE VISUALLY THAN SRM-22

HISTORY OF O-RING TEMPERATURES (DEGREES - F)

	MOTOR	MGT	AMB	O-RING	WIND
	DM-1	68	36	47	10 MPH
	DM-2	76	45	52	10 MPH
SRM 22 BLOW-BY o 2 CASE JOINTS (30-40°)	QM-3	72.5	40	48	10 MPH
	QM-4	76	48	51	10 MPH
SRM-13A, 15, 16A, 18, 23A 24A	SRM-15	52	64	53	10 MPH
o NOZZLE BLOW-BY	SRM-22	77	78	75	10 MPH
	SRM-25	55	26	29 27	10 MPH 25 MPH

Challenger Shuttle Viz: Tufte's Analysis

Not enough focus on the problem identified

Data not as a story

- Relevant and irrelevant information on temperature
- Univariate analysis insufficient:
 - Needed bivariate on temperature and O-Ring failure

Missing data

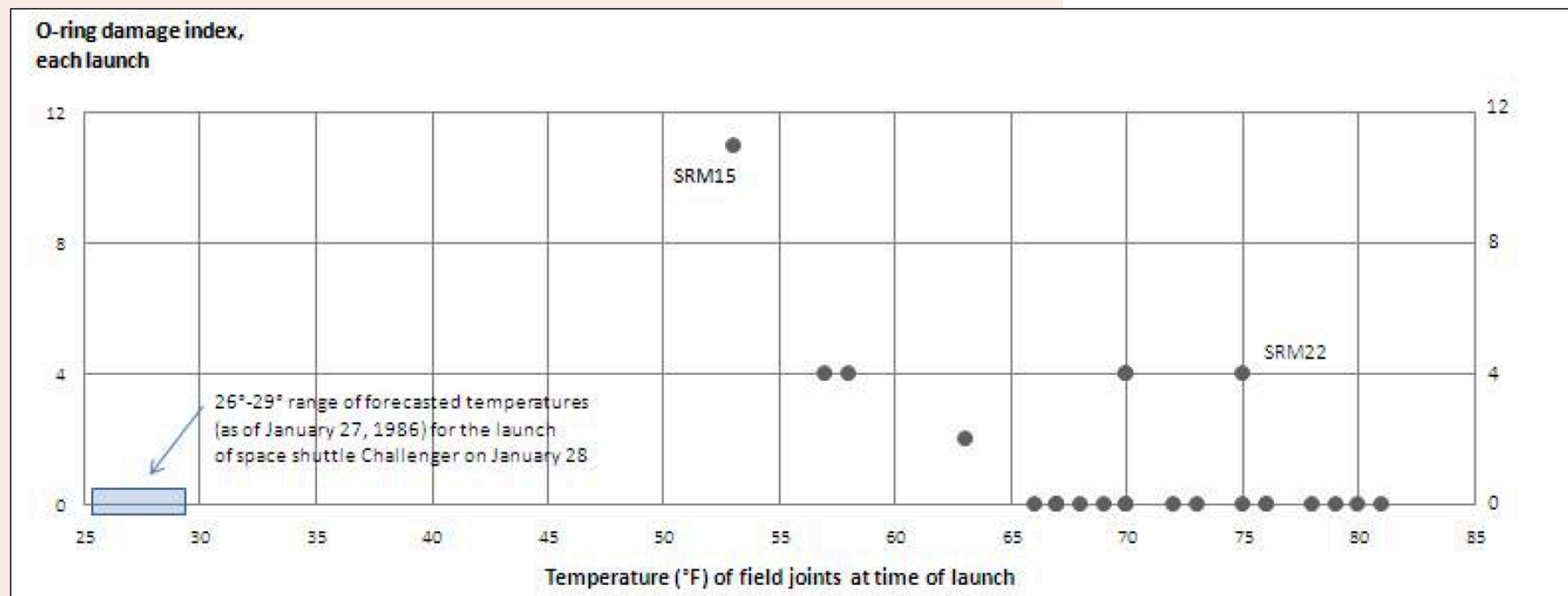
Created illusion of lack of evidence, important to include all data possible!

Other issues

- Legend disappeared
- Lack of cause and effect visuals
- Lack of clarity (junk)

Challenger in 1986

Tufte's visual might have resulted in a different ending...





Thank you