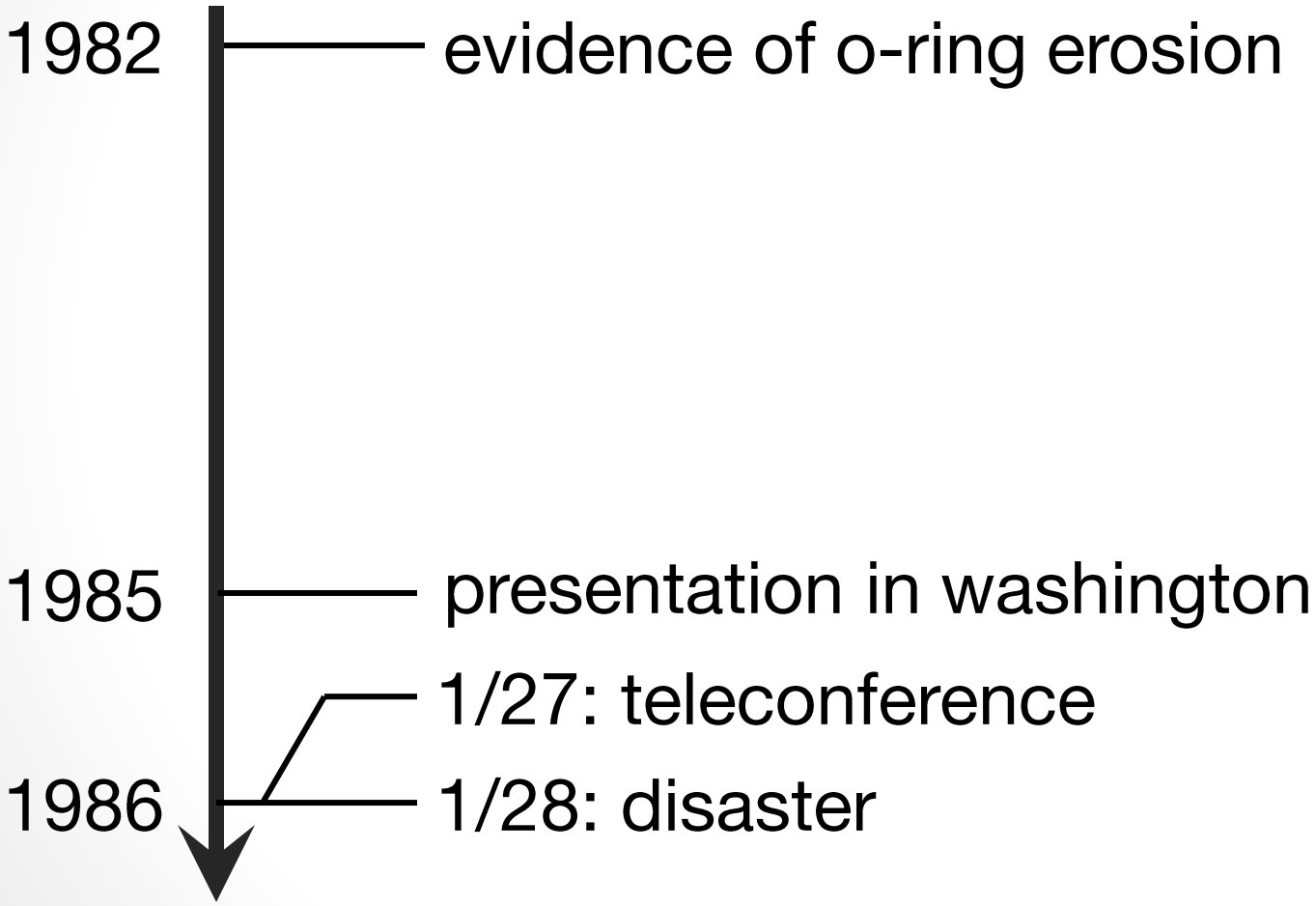
the challenger

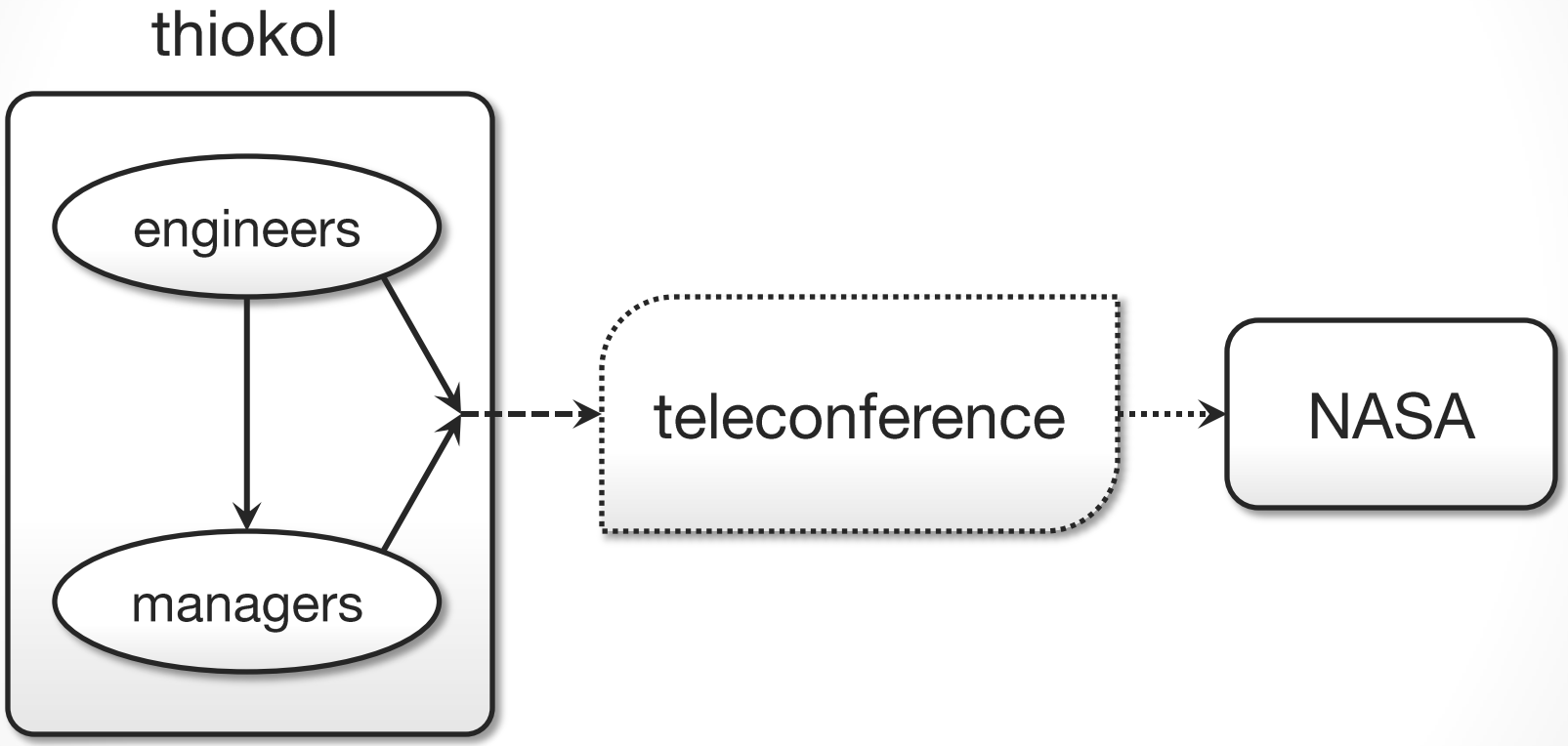
internal communication failures

karan bhatia
jeremy cohen
ian delwiche
jessica wu
jack zhou

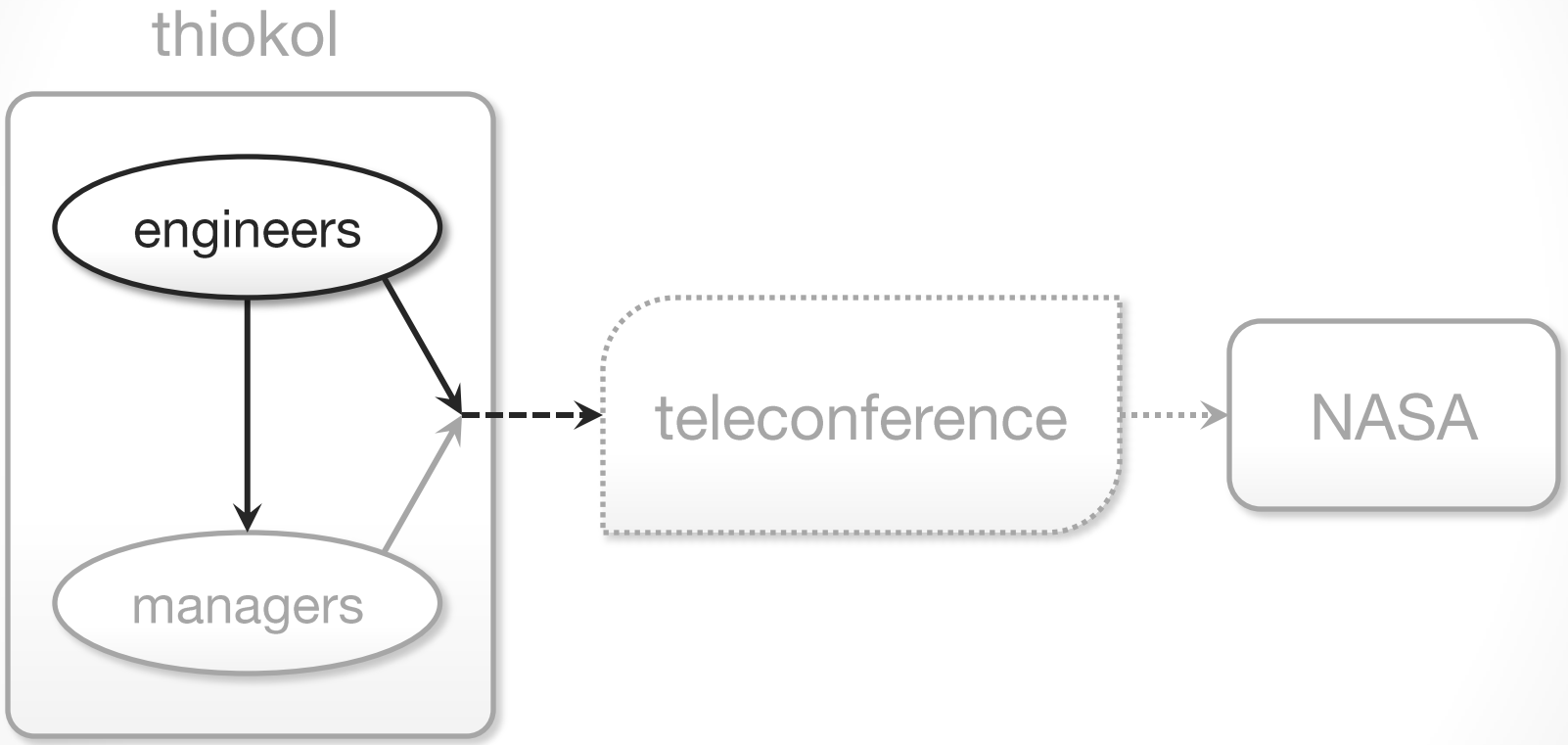
chronology


1982
evidence of o-ring erosion
1985
presentation in washington
1/27: teleconference
1986
1/28: disaster

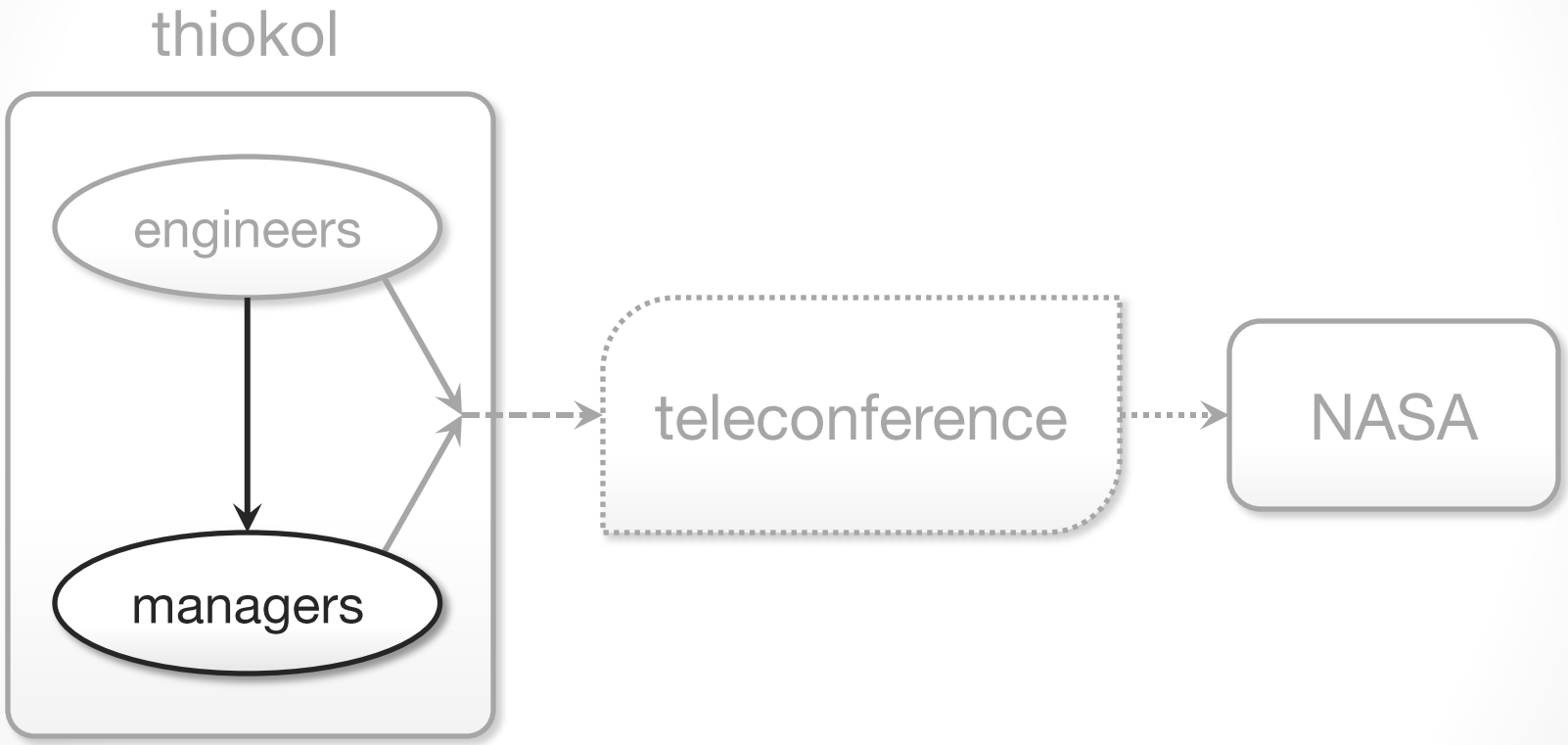
internal communication breakdown



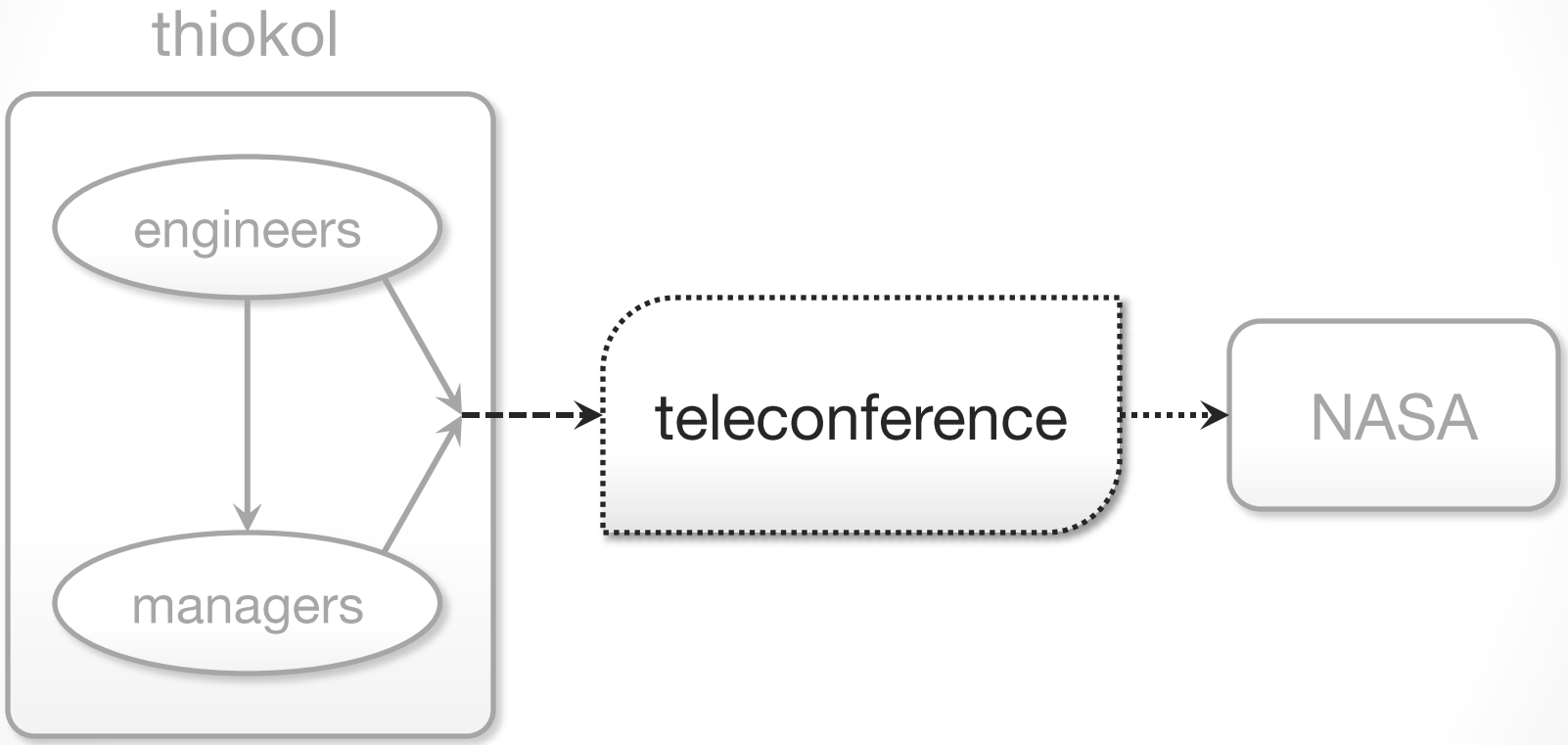
engineers failed to present data clearly



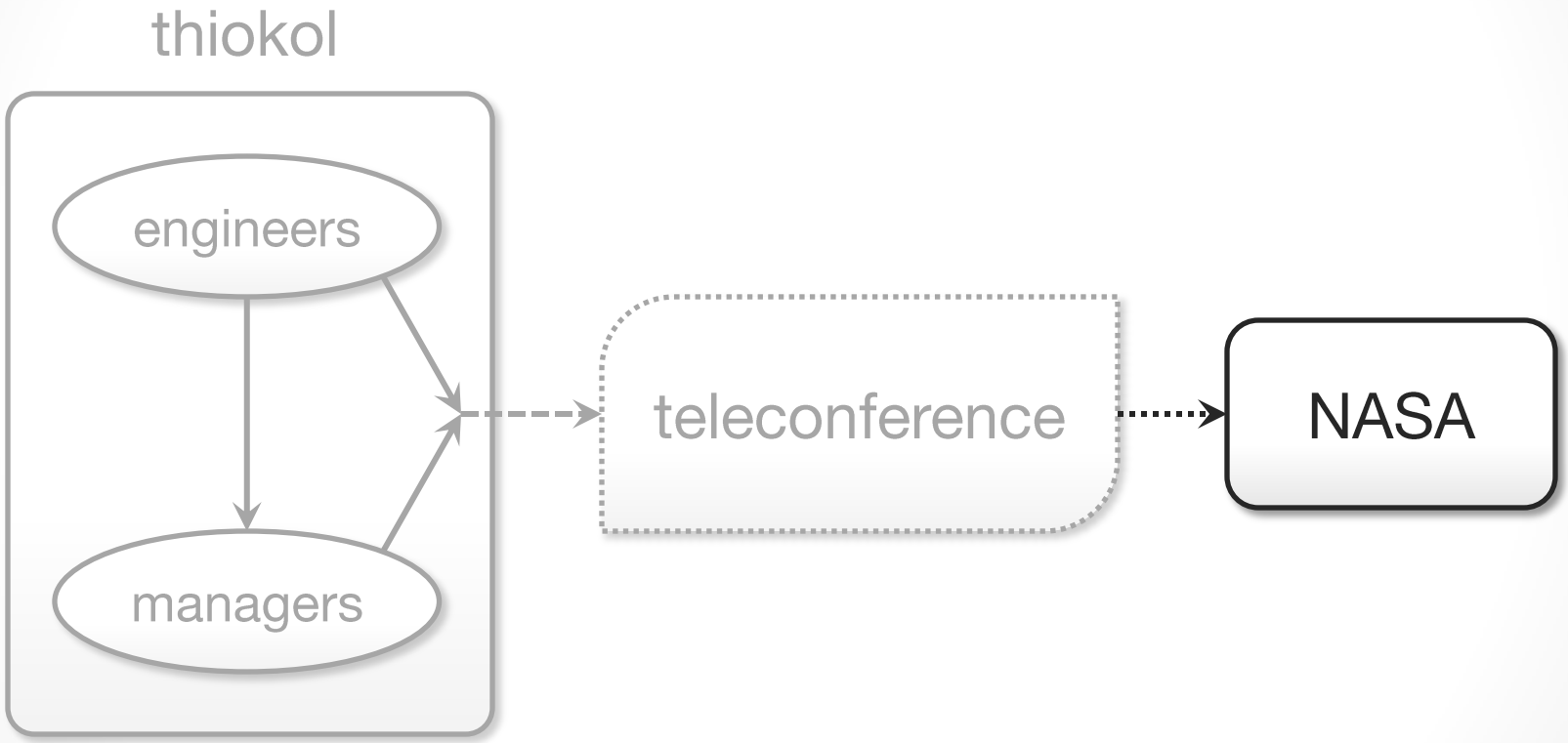
managers failed to listen to engineers

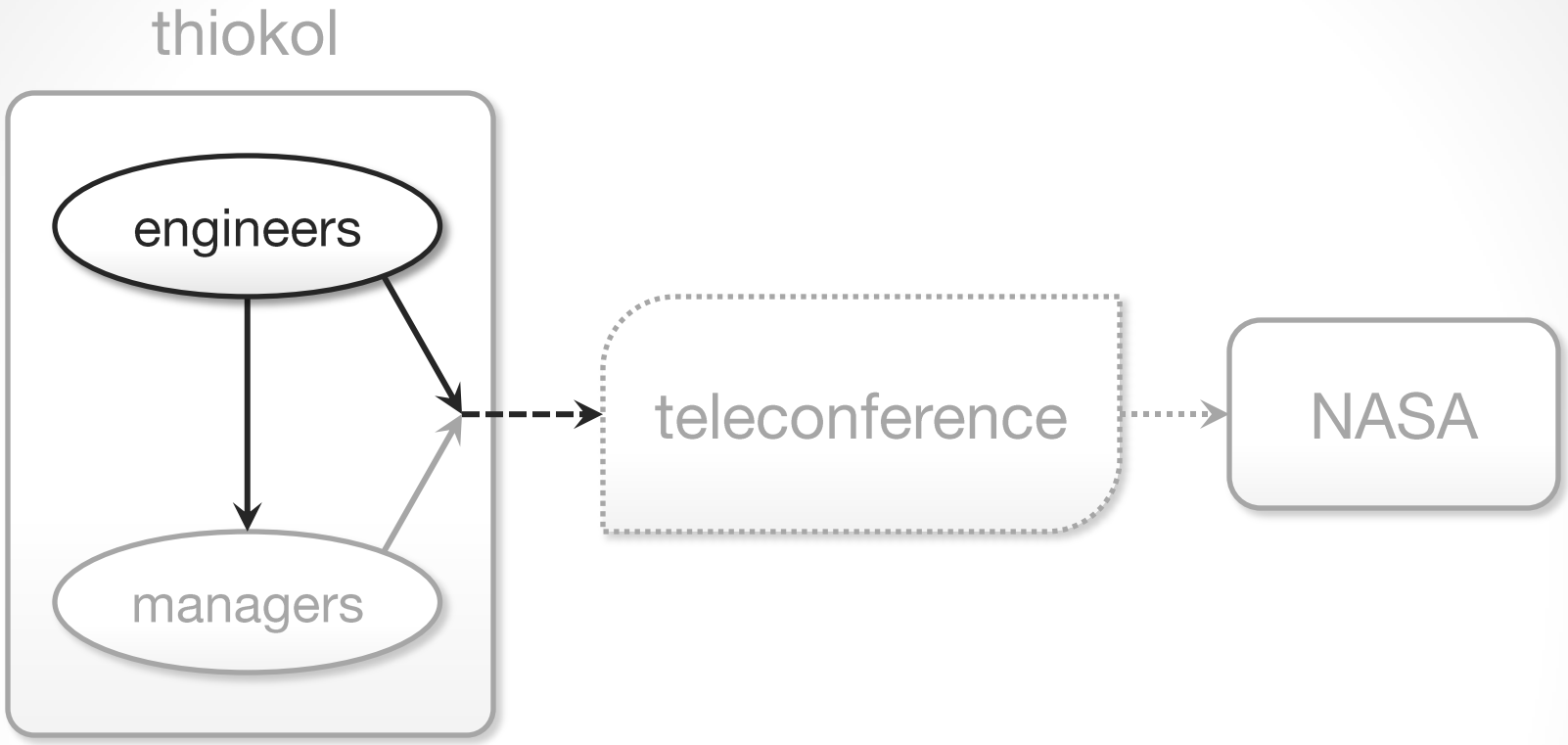


teleconference is not conducive to collaboration



NASA misunderstood basic safety concepts





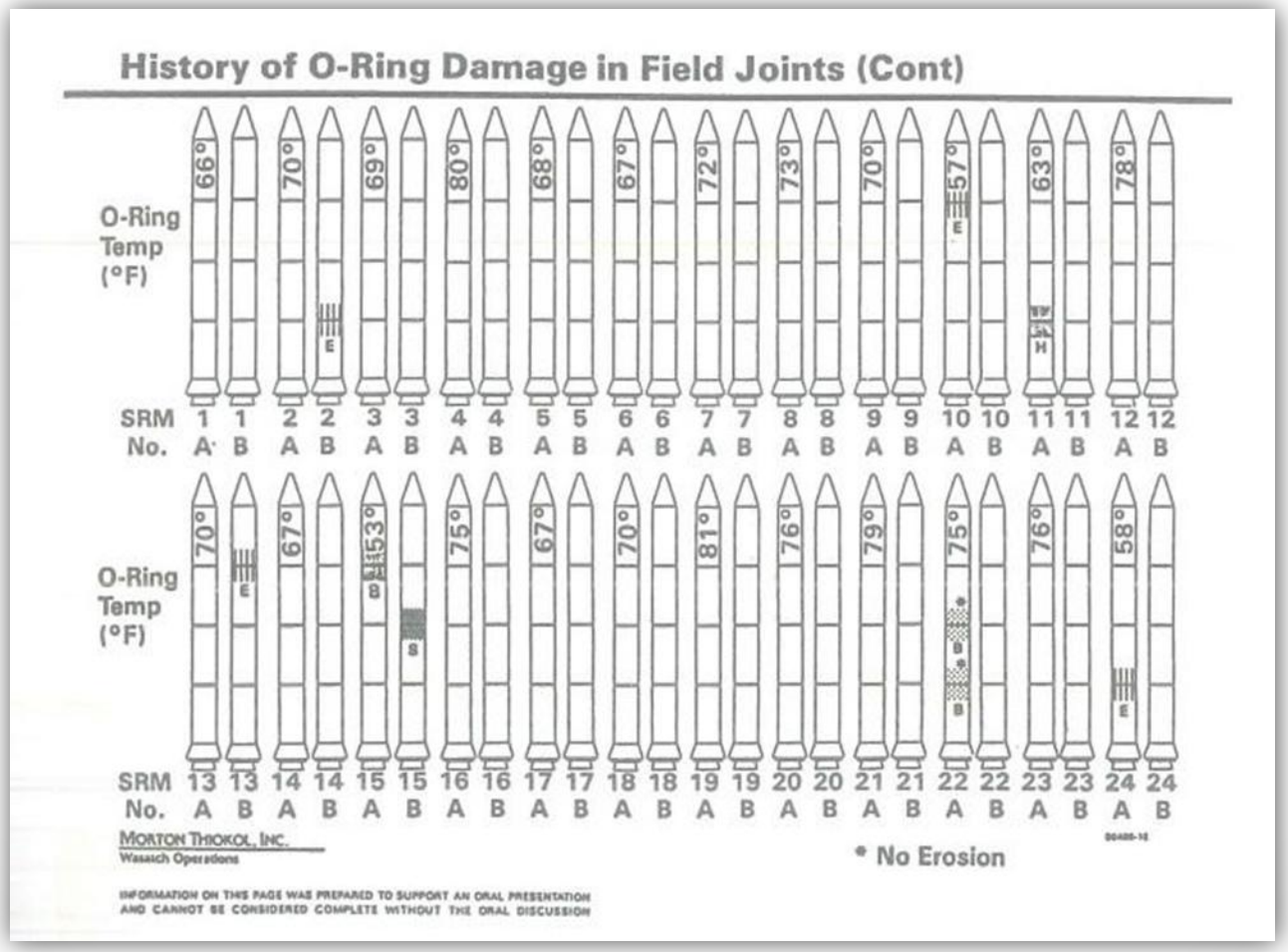
engineers failed to present data clearly

why is a clear presentation important?

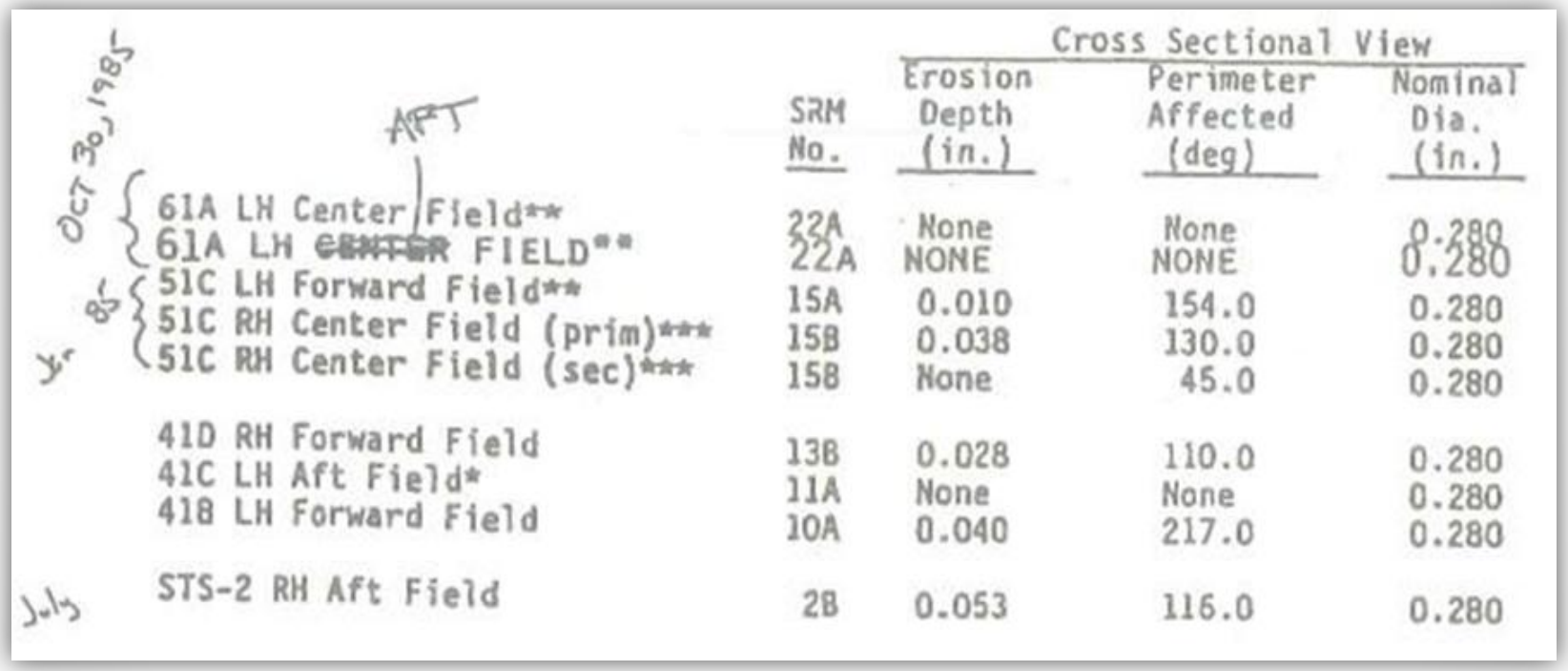
engineers analyzed erosion and blow-by from past launches

- *erosion*: the process O-rings being worn away or corroded
- *blow-by*: the leakage of gas, possibly caused by O-ring erosion

what is wrong with this diagram?

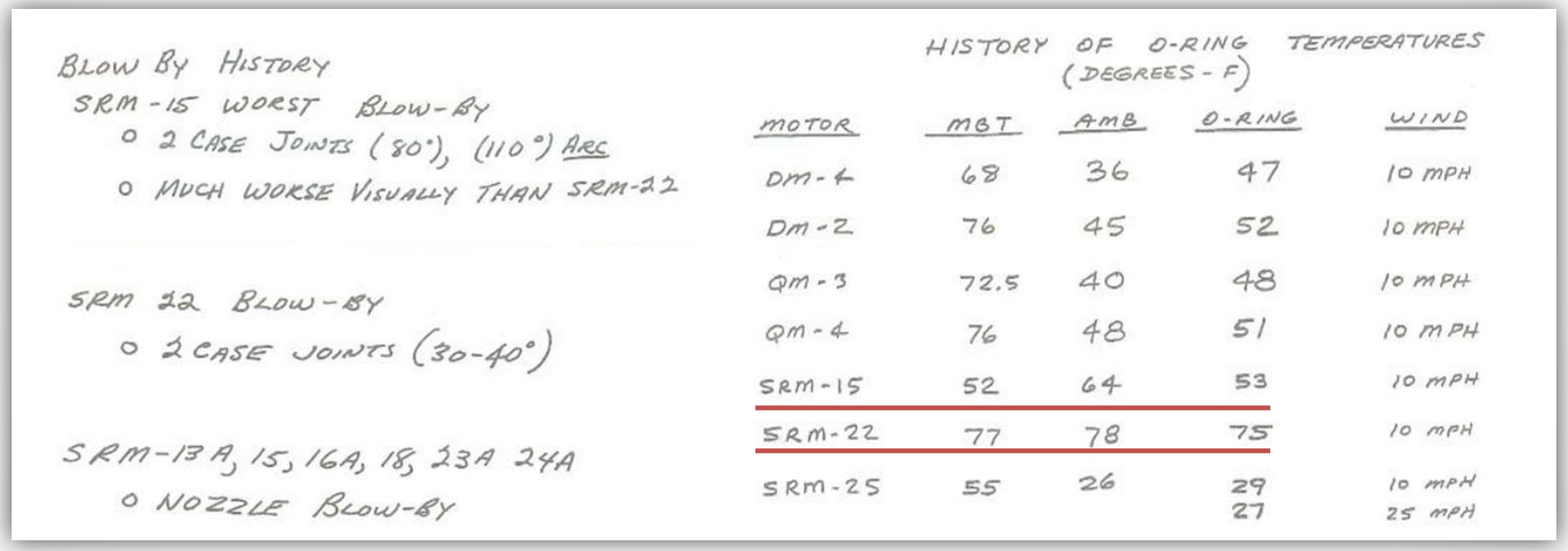


how about this one?



	SRM No.	Cross Sectional View: Erosion Depth (in.)	Cross Sectional View: Perimeter Affected (deg)	Cross Sectional View: Nominal Dia. (in.)
61A LH Center Field**	22A	None	None	0.280
61A LH ~~CENTER~~ FIELD**	22A	NONE	NONE	0.280
51C LH Forward Field**	15A	0.010	154.0	0.280
51C RH Center Field (prim)***	15B	0.038	130.0	0.280
51C RH Center Field (sec)***	15B	None	45.0	0.280
41D RH Forward Field	13B	0.028	110.0	0.280
41C LH Aft Field*	11A	None	None	0.280
41B LH Forward Field	10A	0.040	217.0	0.280
STS-2 RH Aft Field	2B	0.053	116.0	0.280

unclear charts can be interpreted in multiple ways



Blow By History

SRM-15 worst Blow-By
- 2 case joints (80°), (110°) Arc
- Much worse visually than SRM-22

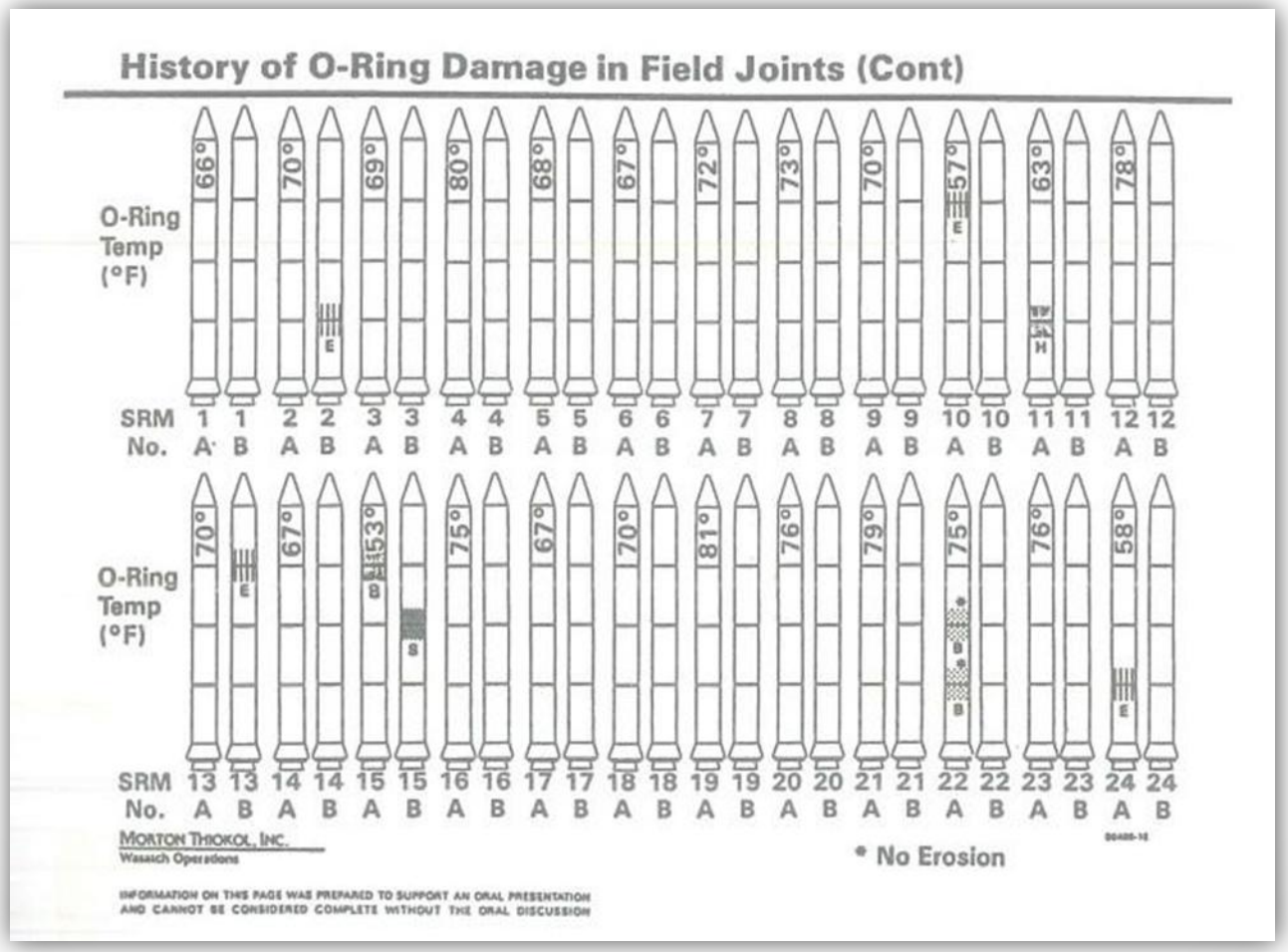
SRM 22 Blow-By
- 2 case joints (30-40°)

SRM-13A, 15, 16A, 18, 23A 24A
- Nozzle Blow-By

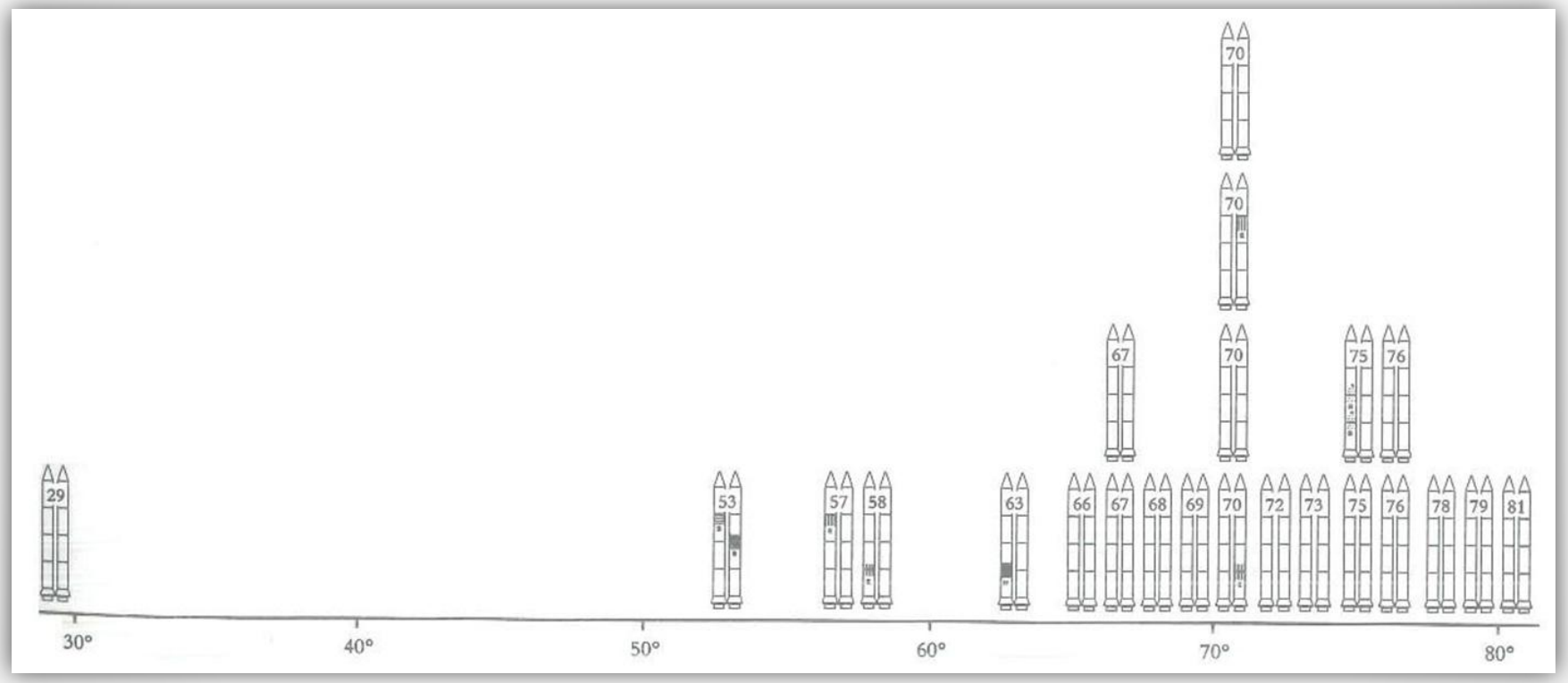
History of O-Ring Temperatures (Degrees-F)

Motor	MBT	Amb	O-Ring	Wind
DM-1	68	36	47	10 mph
DM-2	76	45	52	10 mph
QM-3	72.5	40	48	10 mph
QM-4	76	48	51	10 mph
SRM-15	52	64	53	10 mph
SRM-22	77	78	75	10 mph
SRM-25	55	26	29 27	10 mph 25 mph

correlation not highlighted between *temperature* and *erosion*

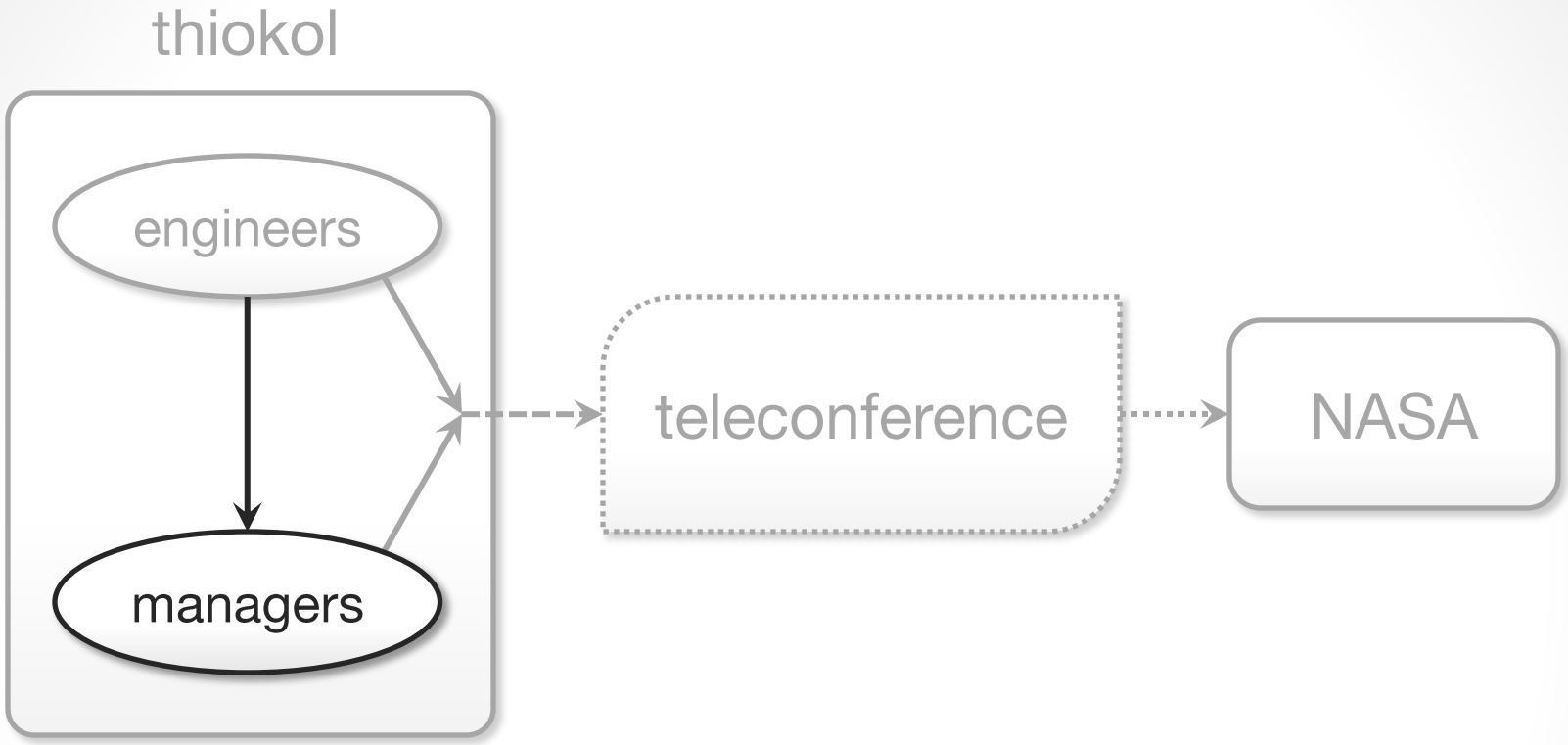


is this one better?



poor presentation

prevents presenters' intentions being understood by the audience



managers failed to listen to engineers

“the mistakenly accepted position on the joint problem was to fly without fear of failure…”

— roger boisjoly

“the result would be a catastrophe of the highest order—loss of human life…”

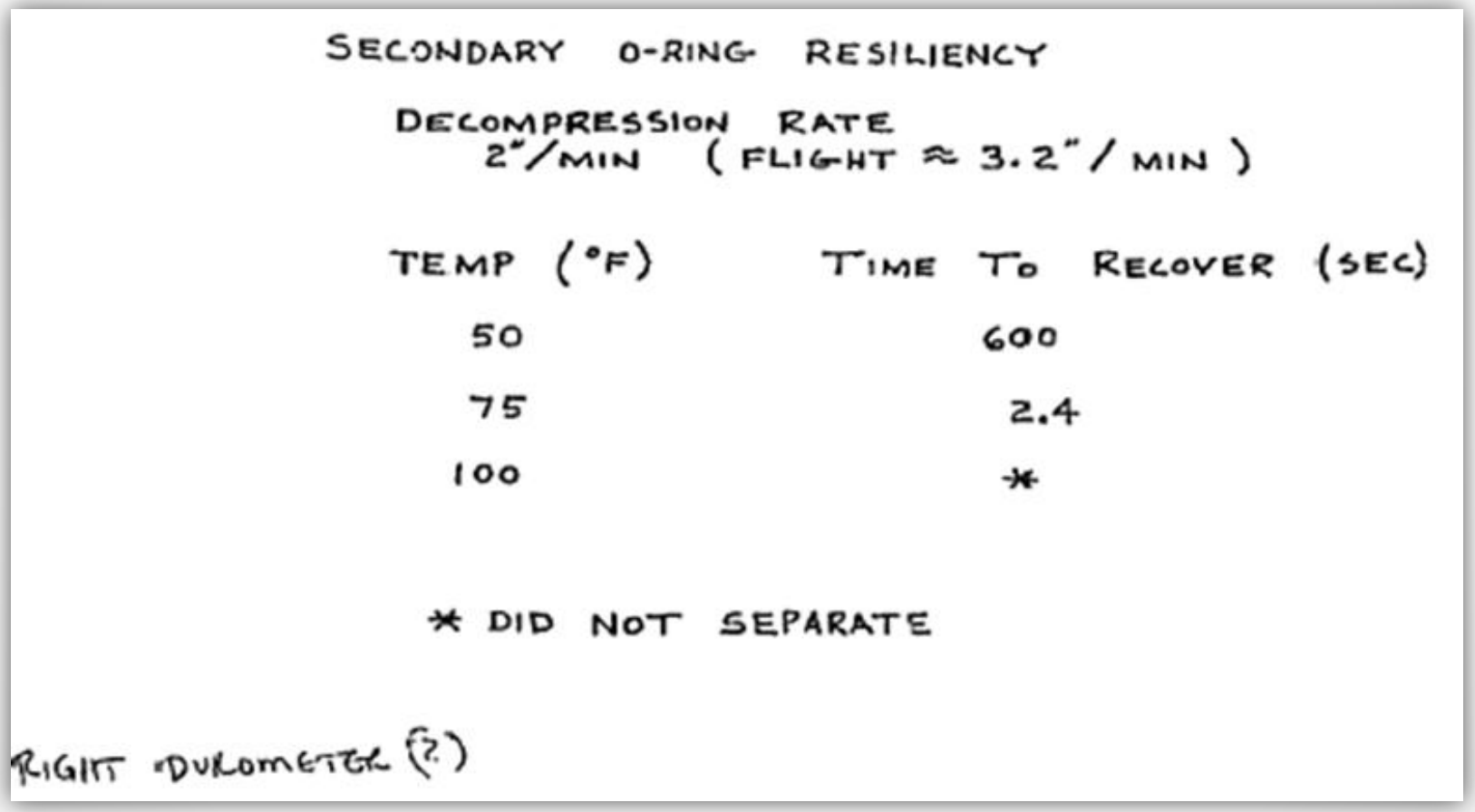
— roger boisjoly

boisjoly's presentation

PRIMARY CONCERNS -

- FIELD JOINT - HIGHEST CONCERN
  - EROSION PENETRATION OF PRIMARY SEAL REQUIRES RELIABLE SECONDARY SEAL FOR PRESSURE INTEGRITY
    - IGNITION TRANSIENT - (0-600 MS)
      - (0-170 MS)HIGH PROBABILITY OF RELIABLE SECONDARY SEAL
      - (170-330 MS) REDUCED PROBABILITY OF RELIABLE SECONDARY SEAL
      - (330-600 MS) HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
  - STEADY STATE - (600 MS - 2 MINUTES)
    - IF EROSION PENETRATES PRIMARY O-RING SEAL - HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
      - BENCH TESTING SHOWED O-RING NOT CAPABLE OF MAINTAINING CONTACT WITH METAL PARTS GAP OPENING RATE TO MEOP
      - BENCH TESTING SHOWED CAPABILITY TO MAINTAIN O-RING CONTACT DURING INITIAL PHASE (0-170 MS) OF TRANSIENT

thompson's presentation



SECONDARY O-RING RESILIENCY

DECOMPRESSION RATE
2"/MIN (FLIGHT ≈ 3.2"/MIN)

TEMP (°F)	TIME TO RECOVER (SEC)
50	600
75	2.4
100	*

* DID NOT SEPARATE

RIGHT DUROMETER (?)

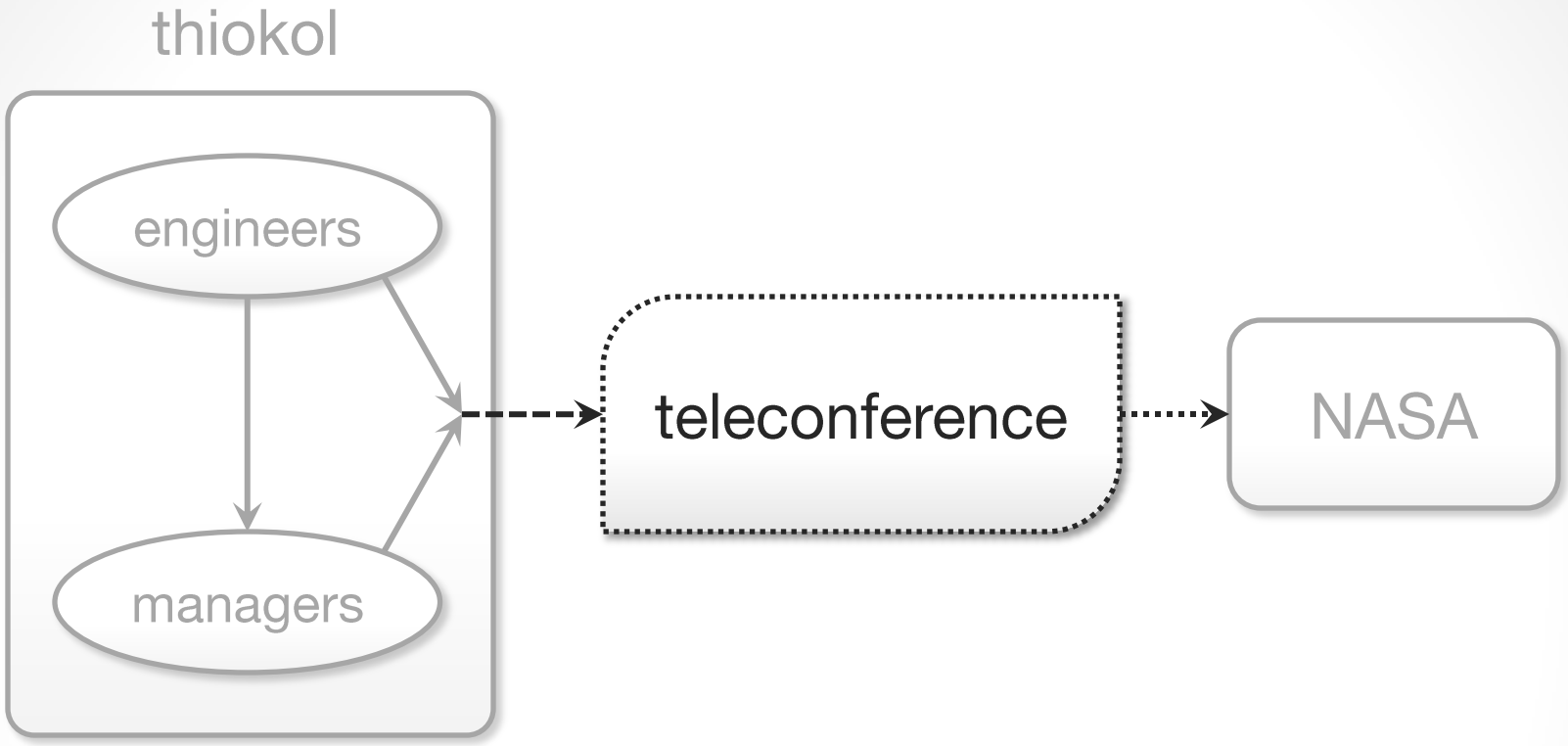
initial recommendation

RECOMMENDATIONS :

- O-RING TEMP MUST BE $\geq$ 53 °F AT LAUNCH

  DEVELOPMENT MOTORS AT 47° TO 52°F WITH PUTTY PACKING HAD NO BLOW-BY
  SRM 15 (THE BEST SIMULATION) WORKED AT 53 °F

- PROJECT AMBIENT CONDITIONS (TEMP & WIND) TO DETERMINE LAUNCH TIME



teleconference is not conducive to collaboration

audio

= teleconference

audio + fax

= teleconference

hyperpersonal theory

lack of cues = existing cues × ∞

“my god, thiokol, when do you want me to launch, next april?”

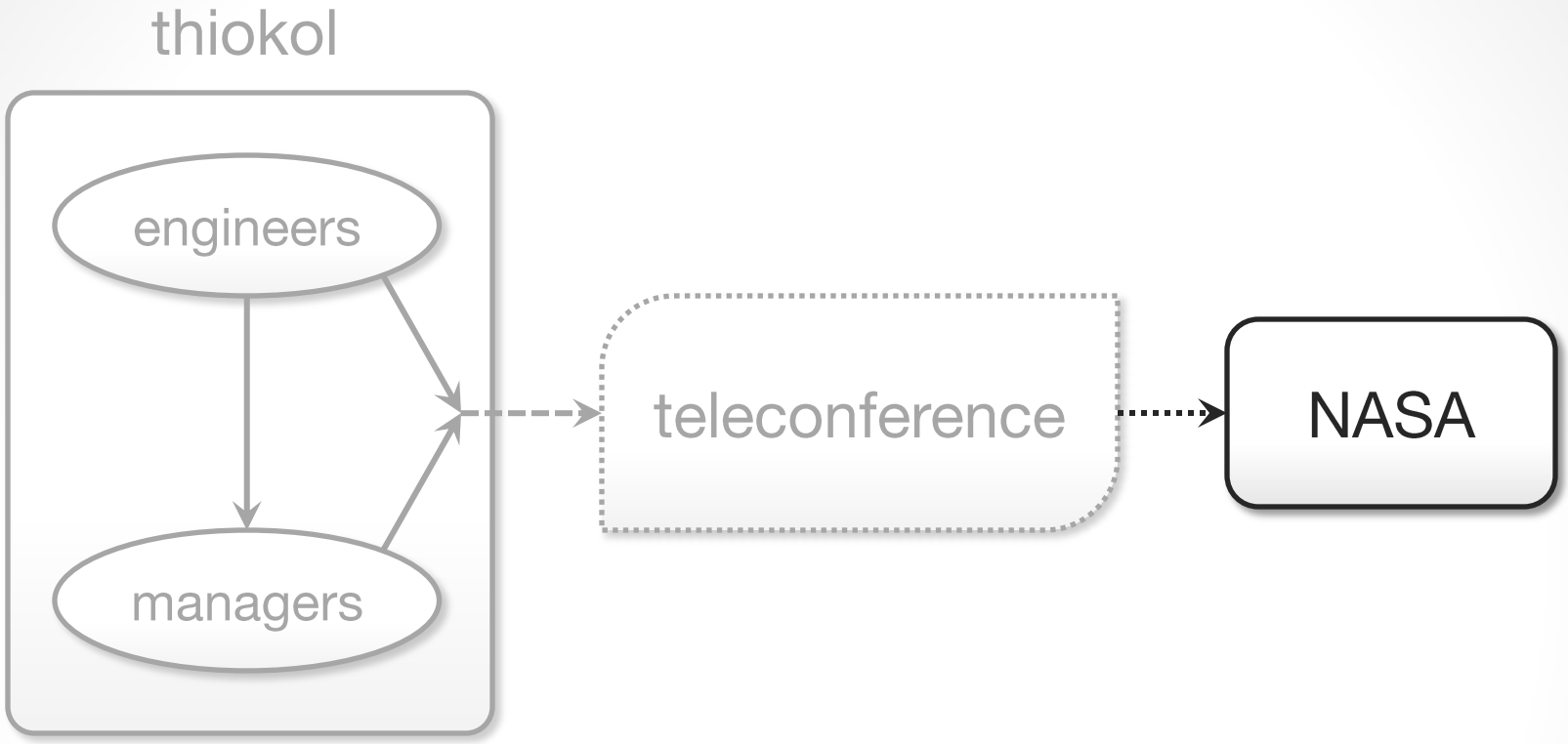
— lawrence mulloy

video

better

face-to-face

best



NASA misunderstood basic safety concepts

safety factor

capacity beyond the expected load that a structure can hold

bridge capacity: 60 tons

max vehicle weight: 25 tons

the bridge's safety factor

$= 60 \div 25 = 2.4$

o-ring eroded 1/3 of the way

ambient temperature: 55°

the o-ring's safety factor

$= 0$

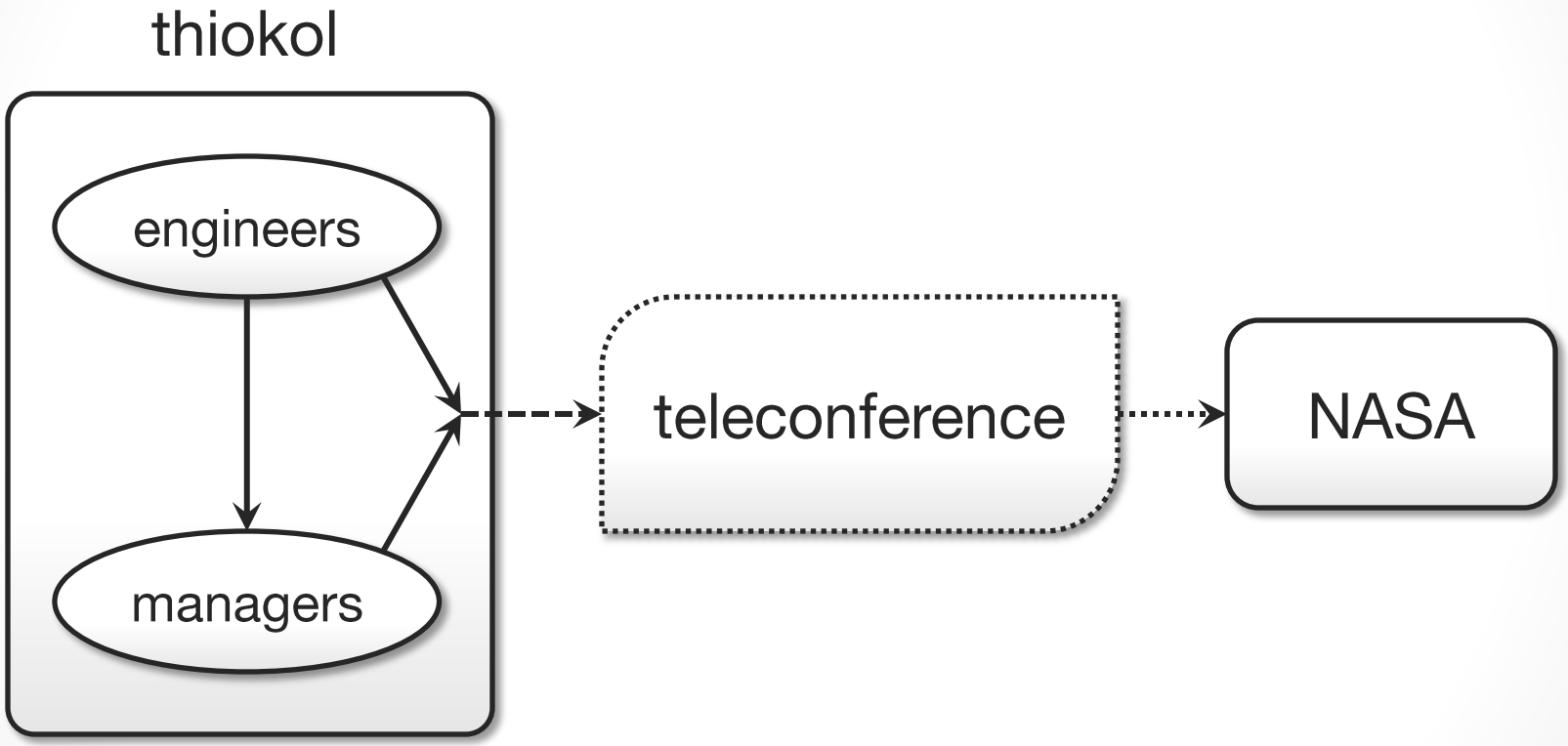
the impossible probability

actual solid rocket failure rate: **1:25**

thiokol engineers' estimates: **1:50–1:100**

NASA's estimates: **1:100,000**

summary



takeaways

- clear presentation is crucial
- be receptive and provide a fair audience
- meet face to face for important discussions