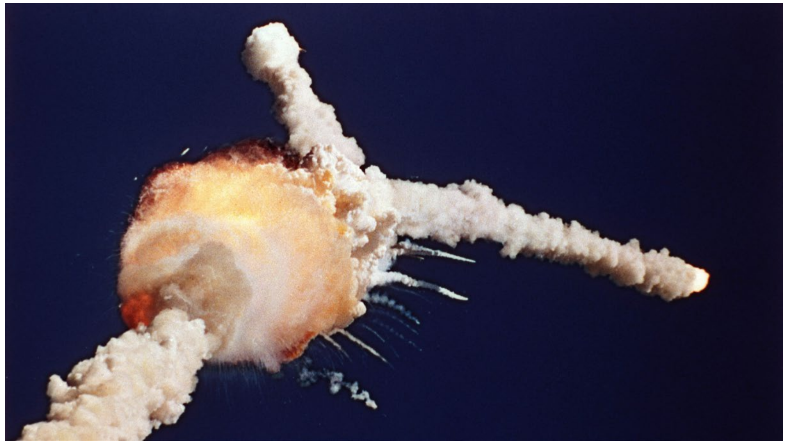
Reliable Data

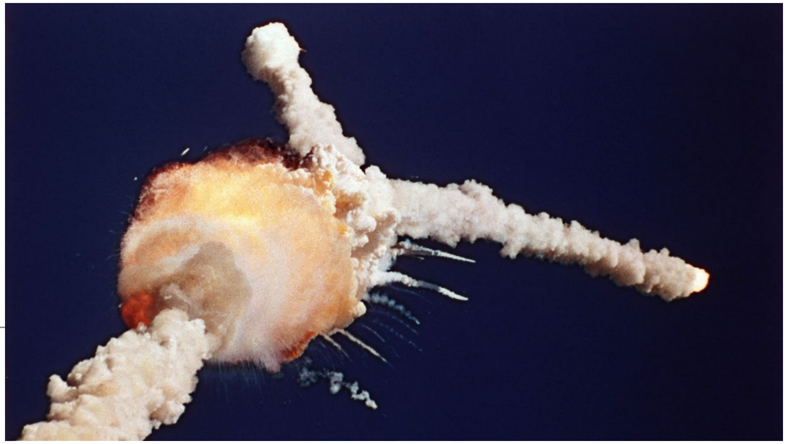
YORK COLLEGE & UNIVERSITY CENTRE

Why reliable data matters

- Engineering decisions are only as good as the data behind them
- Unreliable data = unsafe designs, wasted costs, poor performance
- Reliable data ensures:
  - Safety – critical in aerospace, automotive, medical devices.
  - Quality – products meet specifications and standards.
  - Efficiency – reduces rework, delays, and resource waste.



Example of where unreliable data went wrong

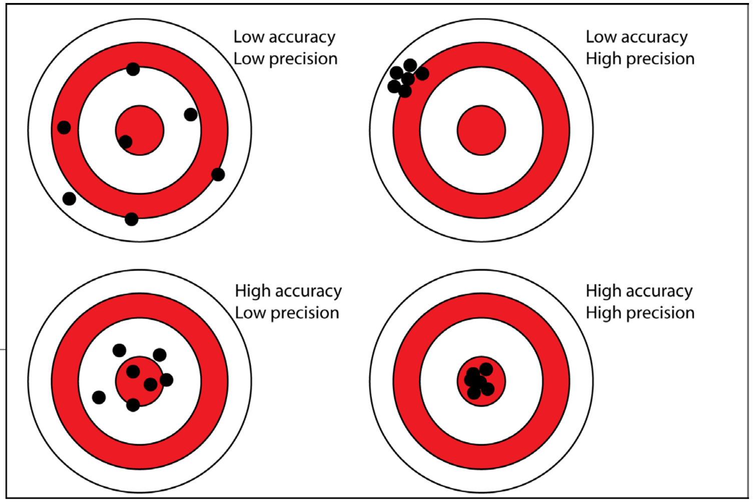


- The challenger disaster happened on the 28th of January 1986
- The shuttle broke apart 73 seconds after launch, killing all 7 crew
- The O-rings became brittle and failed to seal properly in the unusually cold launch conditions (~2 °C)
- **Problem with data:** Most tests were at warmer temperatures. The limited cold-weather data already showed problems but was judged “not conclusive.”
- NASA proceeded with the launch despite engineers warning of the risk.

Key Terms

- **Accuracy**
  - Closeness of a measurement to the true or accepted value.
  - Example: A micrometre giving 10.00 mm when the part is actually 10.00 mm.
- **Precision**
  - How consistent repeated measurements are with each other.
  - Example: Five readings of 9.98 mm, 9.99 mm, 9.97 mm – close together, but maybe not accurate.
- **Reliability**
  - Confidence that results are repeatable and consistent under the same conditions.
  - Combines accuracy and precision.
- **Validity**
  - Whether the test measures what it is supposed to measure.
  - Example: Using a voltmeter to measure resistance is not valid.

Accuracy vs Precision



- **Accuracy**
  - How close a measurement is to the true value.
  - Example: A voltmeter reads 5.01 V when the actual value is 5.00 V → accurate.

- **Precision**
  - How close repeated measurements are to each other.
  - Example: Three readings of 4.85 V, 4.86 V, 4.85 V → precise.

- **Key Difference**
  - Accuracy = correctness
  - Precision = consistency
  - Reliable data needs both.

Human Error

- **Definition**
  - Mistakes made by the experimenter during measurement, observation, or recording.

- **Examples in Engineering**
  - Misreading an analogue scale (parallax error).
  - Incorrectly recording values in a logbook or spreadsheet.
  - Using the wrong unit or conversion (e.g. inches instead of millimetres).
  - Inconsistent use of measuring technique between operators.

Human Error

- **Impact on Reliability**
  - Introduces random variation between repeated measurements.
  - Can reduce both precision and accuracy of results.

- **Reducing Human Error**
  - Use digital instruments where possible.
  - Provide clear training and measurement procedures.
  - Double-check readings and data entries.
  - Automate data logging to reduce manual recording.

Instrument Error

- **Definition**
  - Errors caused by the limitations, faults, or calibration of measuring equipment.

- **Examples in Engineering**
  - A micrometre that is not zeroed correctly.
  - A voltmeter drifting due to low battery or calibration issues.
  - A digital sensor with limited resolution (e.g. only reads to 0.1 V).
  - Wear and tear on tools (e.g. dull calipers, stretched tape measures).

Instrument Error

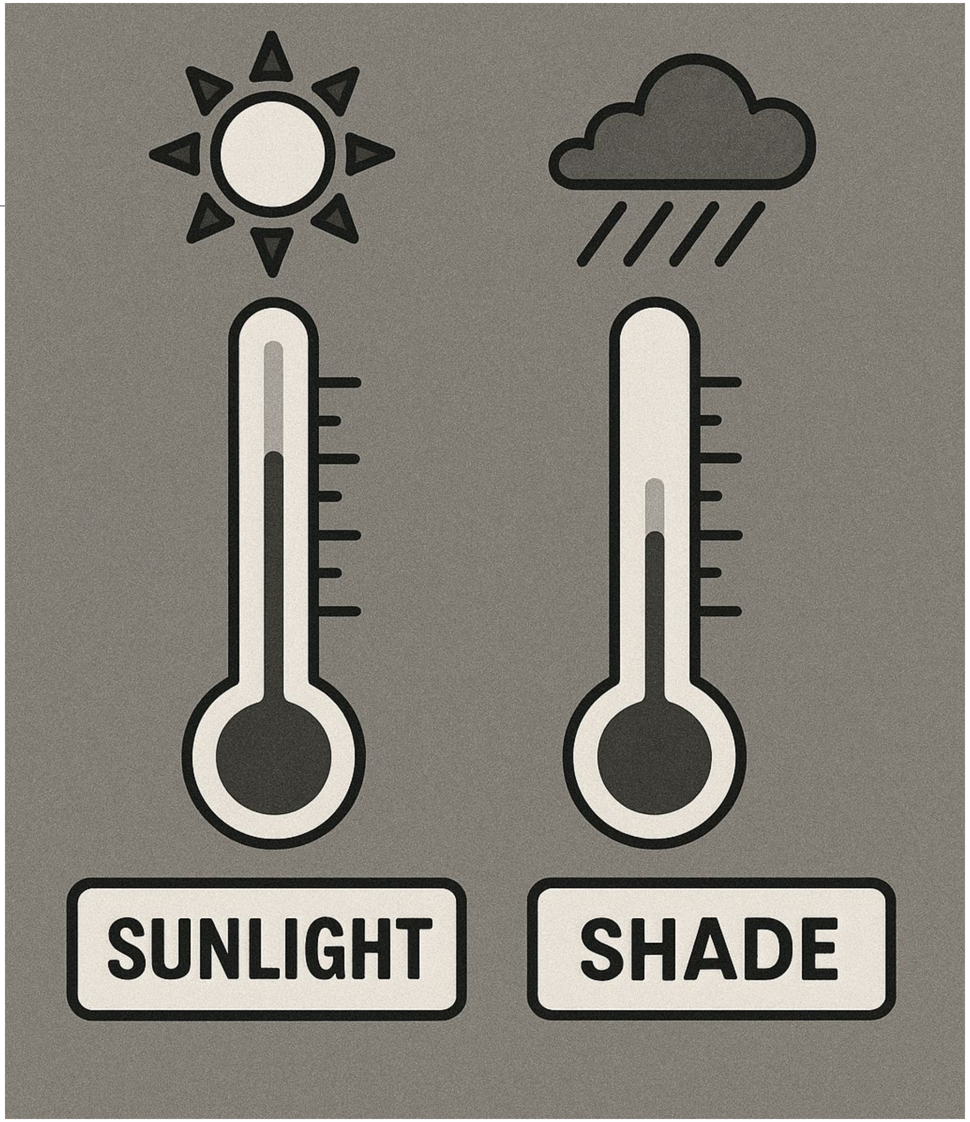
- **Impact on Reliability**
  - Can cause systematic errors (all results shifted the same way).
  - May reduce accuracy even if results are precise.

- **Reducing Instrument Error**
  - Regular calibration against standards.
  - Use the appropriate instrument for the measurement range.
  - Maintain equipment properly.
  - Cross-check with a second instrument where possible.

Environmental Error

- **Definition**
  - Errors caused by external conditions in the testing or measurement environment.

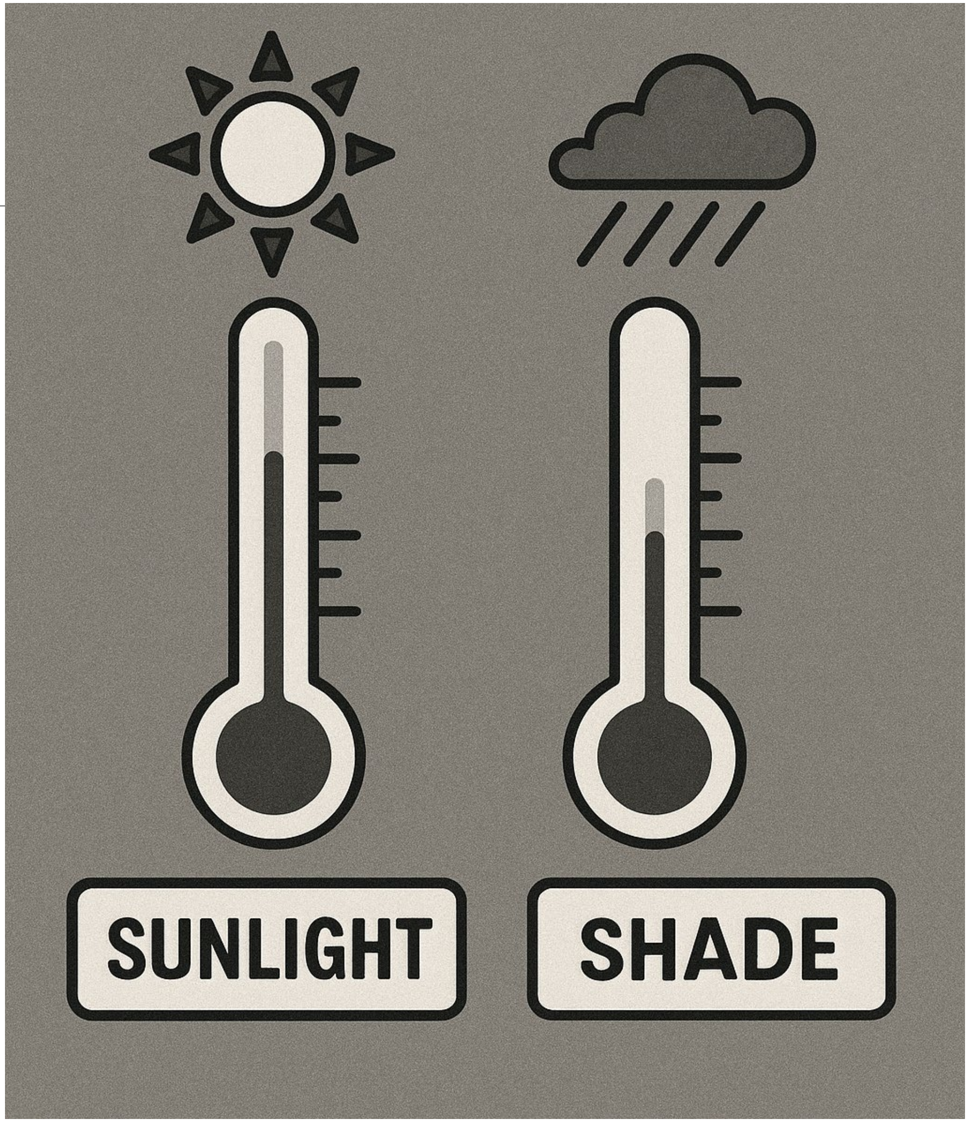
- **Examples in Engineering**
  - Temperature changes causing metal expansion/contraction during measurement.
  - Vibrations affecting sensitive instruments (e.g. strain gauges, balances).
  - Humidity or dust interfering with electronic sensors.
  - Air currents disturbing scales or delicate setups.



Environmental Error

- **Impact on Reliability**
  - Can introduce random variations or systematic shifts.
  - Makes repeated measurements less consistent.

- **Reducing Environmental Error**
  - Carry out tests in controlled conditions (labs, insulated enclosures).
  - Allow instruments to stabilise before use.
  - Use shielding or damping to reduce vibration and interference.
  - Record environmental conditions alongside data for context.



Bias

- **Definition**
  - When results are skewed by preference, expectation, or selective reporting, rather than true measurement.
- **Examples in Engineering**
  - Choosing only data that supports a design or hypothesis.
  - Rounding results to “fit” expected values.
  - Operator unconsciously influencing results (e.g. applying extra force to match a target reading).
  - Ignoring outliers without valid justification.

Bias

- **Impact on Reliability**
  - Creates systematic distortion of results.
  - Makes data appear more reliable than it actually is.
  - Undermines trust in engineering decisions.

- **Reducing Bias**
  - Use blind testing where possible.
  - Apply consistent procedures and standards.
  - Ensure independent verification of results.
  - Report all data, including anomalies.

Improving Reliability of Data

- **Repeat Measurements**
  - Take multiple readings and calculate an average.
- **Calibration**
  - Regularly check and adjust instruments against known standards.
- **Control Variables**
  - Keep conditions consistent (temperature, operator, method).
- **Appropriate Equipment**
  - Use the right tool for the level of accuracy needed.
- **Independent Verification**
  - Have results checked or repeated by others.
- **Automated Recording**
  - Use digital logging to reduce manual errors.