Engineering Graphics

- Presentation graphics
- Levels of hardware visualization
  - Sketching
  - Drawing
  - Drafting
  - Solid modeling
- Visual presentation of data

Presentation Graphics

- Always use landscape, not portrait layout
  - Better fit to screens and projectors
  - Follows natural eye motions
  - Not much choice in computer projections, anyway
- When printed as 8.5"x11", all features should be readable when laid on the ground at your feet
- *All* the data goes on the viewgraph - presentations live on after the talk!
- Maximize information density while maintaining legibility, audience comprehension

Choosing a Background Format

- Unifying graphical element throughout the presentation
- Especially important for a multi-person team presentation
- Some critical issues to think about:
  - Do the graphics add or detract from the focus of the presentation?
  - How do they look printed out in B&W?
  - How will be look when projected in each possible format (computer, viewgraphs, etc.)?

Slide Layout

Unobtrusive graphical element(s) for visual interest

- Easy-to-read text
- Adaptable to multiple elements (text, figures, pictures, etc.)

Who's responsible for this product?

What is this presentation?

What does this fit into?

Another Example of Slide Layout

Subtle reminder of what the project is all about

PROJECT DIANA

What is the project or program?

Unobtrusive graphical element
for visual interest

Graphical icon for organization

Who's responsible for this product?

Presentation Pitfalls

- Don't OVERDO The Use Of Capital Letters -And At least Be consistent!
- Proofreed! Chek teh grammer and speling!
- Jest besides you're spell-checker don't flag some ding didn't mean thee slid is all write!
- Resist the urge to play games with lots of multiple fonts and colors and sounds and sIZeS
- Don't read the viewgraphs to the audience
- Don't face the screen when you talk

➥ The audience's attention should be focused on what you're saying, not how you're presenting it!

Low Information Density

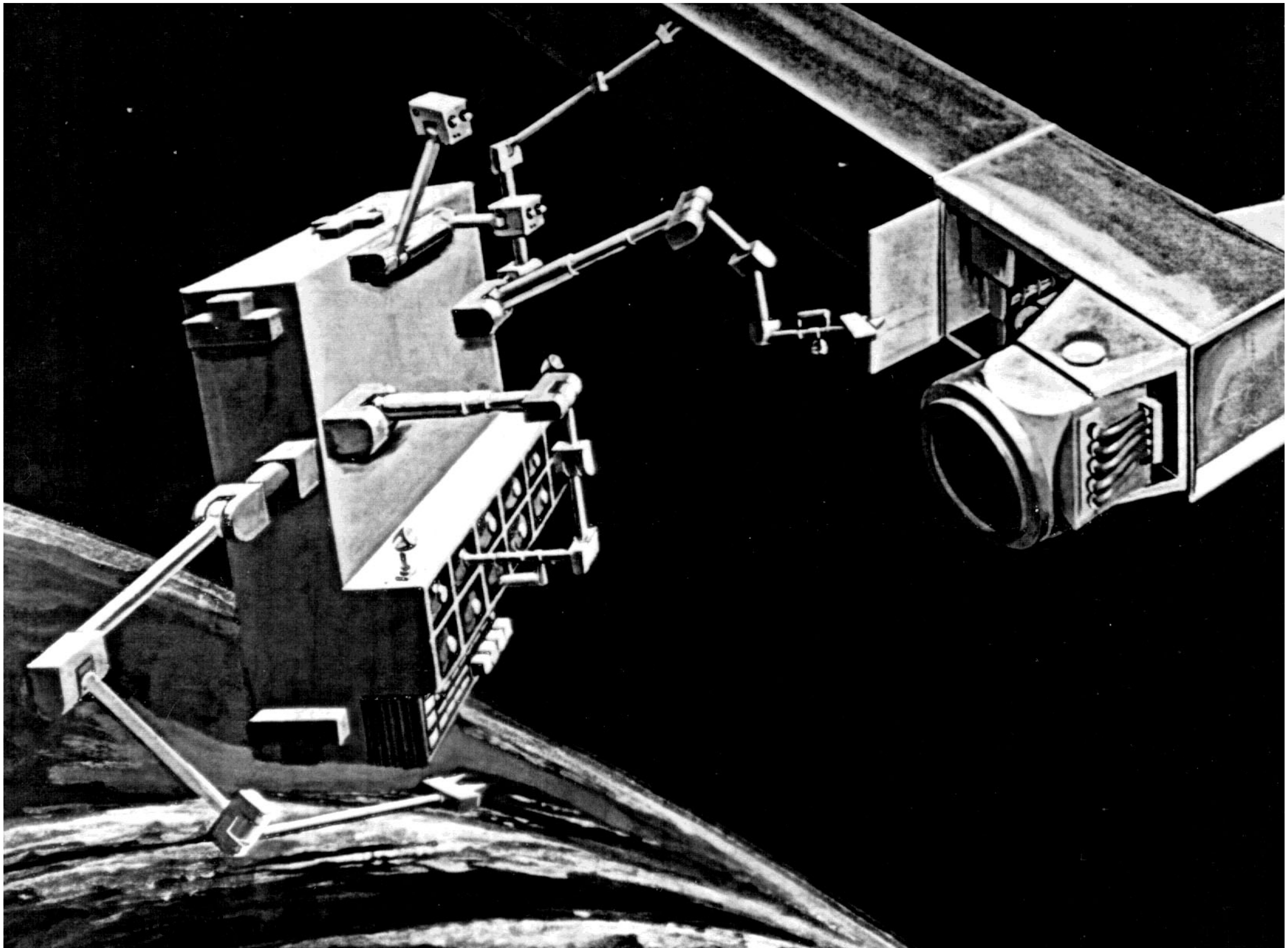
- Some say just six lines
- Only six words on each line
- They're totally wrong!

What are the Unknowns in Space Robotics?

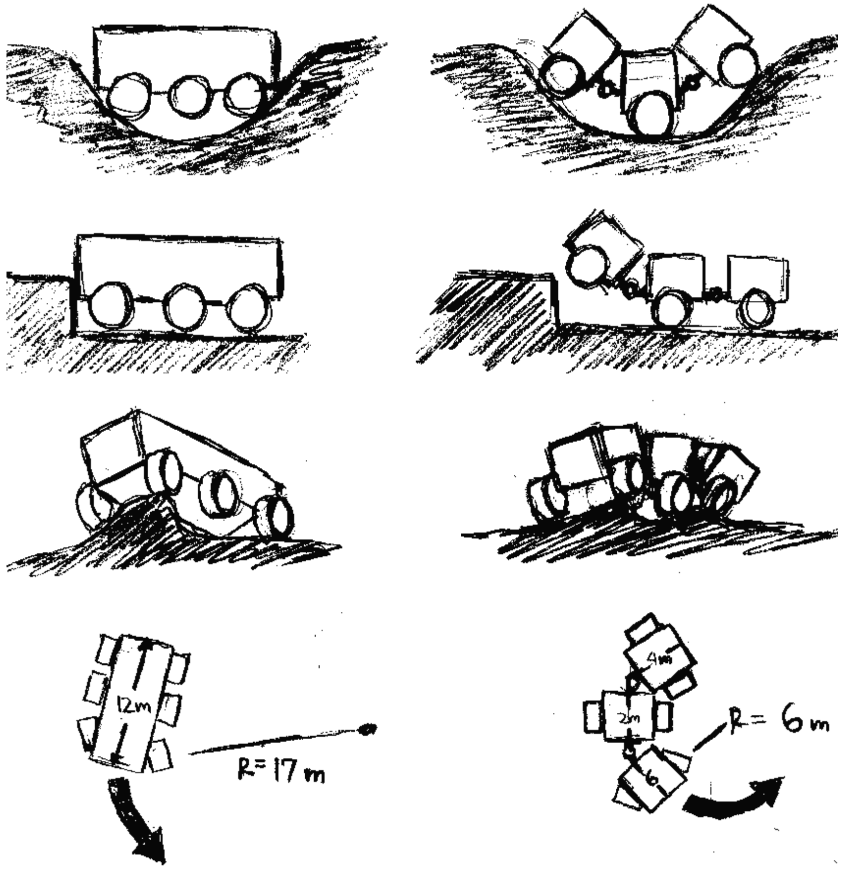
(An example of ineffective information transfer)

- Can we count on dexterous robotics to work when planning future missions? What are their capabilities and limitations? Can we build a useful robot for a reasonable amount of money?
- Can we teleoperate in orbit from the ground? What are the performance hits due to time delays? Can advanced control station technologies ameliorate these hits?
- Can a robot be designed to use interfaces other than ones specifically designed for robots? Can robots adapt to EVA interfaces, reducing (or eliminating!) the design overhead for robotic servicing?
- How does increasing the capabilities of a robot through greater numbers of manipulators affect system performance? How can we increase degrees of freedom without proportional increases in operator workload?
- Are interchangeable end effectors a viable approach to increasing dexterity without increasing degrees of freedom? Can we perform EVA tasks without EVA dexterity?
- How does robotic performance change in the presence of realistic (i.e., not perfectly rigid) attachment to the work site? Can robot repositioning capability add to system performance?

What are the Unknowns in Space Robotics?

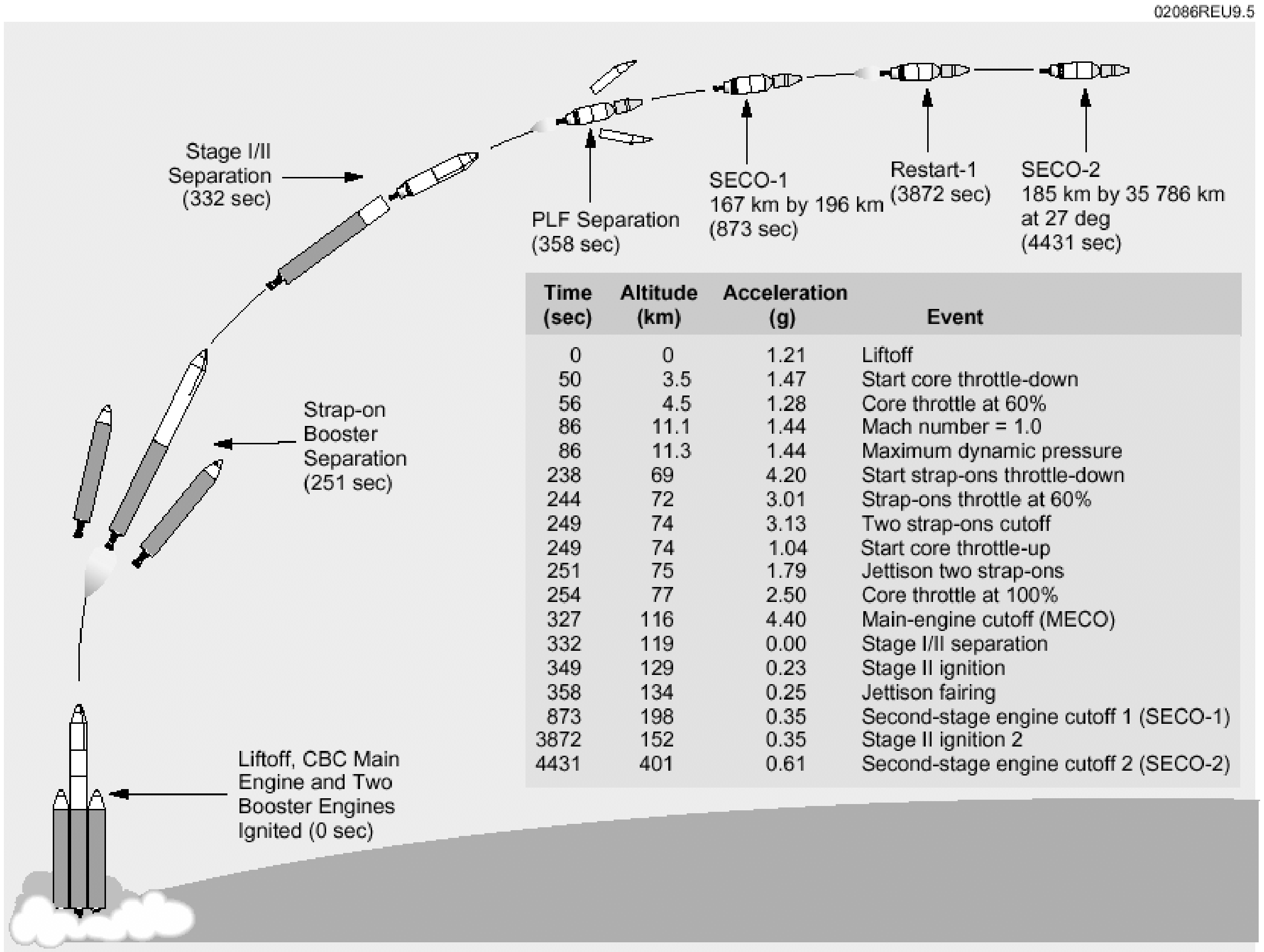


Sketching



- Pencil-and-paper or simple drawing programs
- Quick representation of concepts
- Invaluable for ensuring that all team members share a common concept
- Talent helps - but lack of it isn't an excuse for skipping the sketch

Sketching to Effectively Communicate



Time (sec)	Altitude (km)	Acceleration (g)	Event
0	0	1.21	Liftoff
50	3.5	1.47	Start core throttle-down
56	4.5	1.28	Core throttle at 60%
86	11.1	1.44	Mach number = 1.0
86	11.3	1.44	Maximum dynamic pressure
238	69	4.20	Start strap-ons throttle-down
244	72	3.01	Strap-ons throttle at 60%
249	74	3.13	Two strap-ons cutoff
249	74	1.04	Start core throttle-up
251	75	1.79	Jettison two strap-ons
254	77	2.50	Core throttle at 100%
327	116	4.40	Main-engine cutoff (MECO)
332	119	0.00	Stage I/II separation
349	129	0.23	Stage II ignition
358	134	0.25	Jettison fairing
873	198	0.35	Second-stage engine cutoff 1 (SECO-1)
3872	152	0.35	Stage II ignition 2
4431	401	0.61	Second-stage engine cutoff 2 (SECO-2)

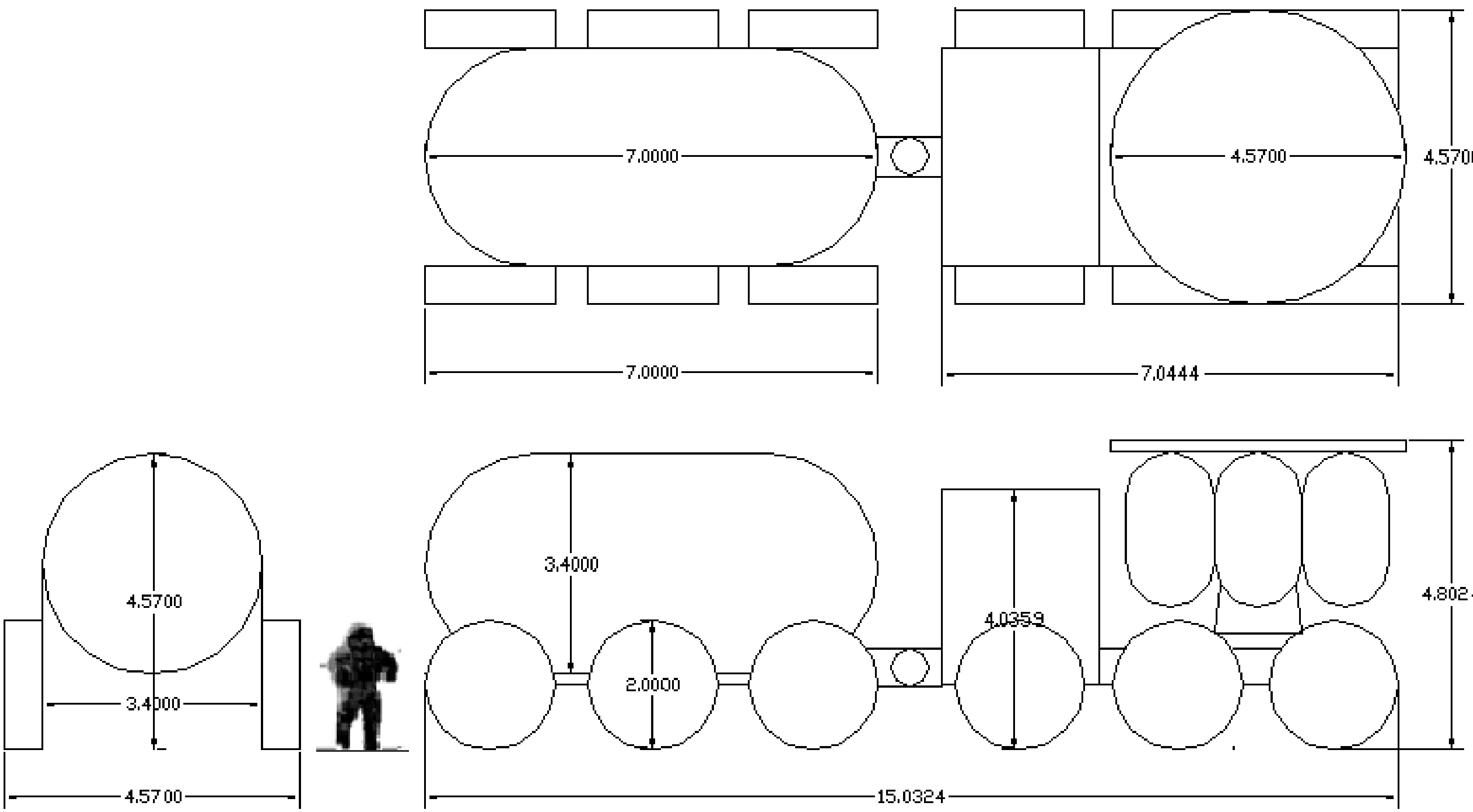
Figure 2-4. Delta IV Heavy Sequence of Events for a GTO Mission (Eastern Range)

From Boeing Corporation, *Delta IV Payload Planners Guide,* 1999

Drawing

- Formal adherence to dimensions, spatial relationships
- Typically done on specialized drawing or 2D drafting packages (or manually)
- More time-consuming than sketching; arguably faster than solids modeling
- Line drawing typically well suited to publication

Technical Drawing (Three-View) Example

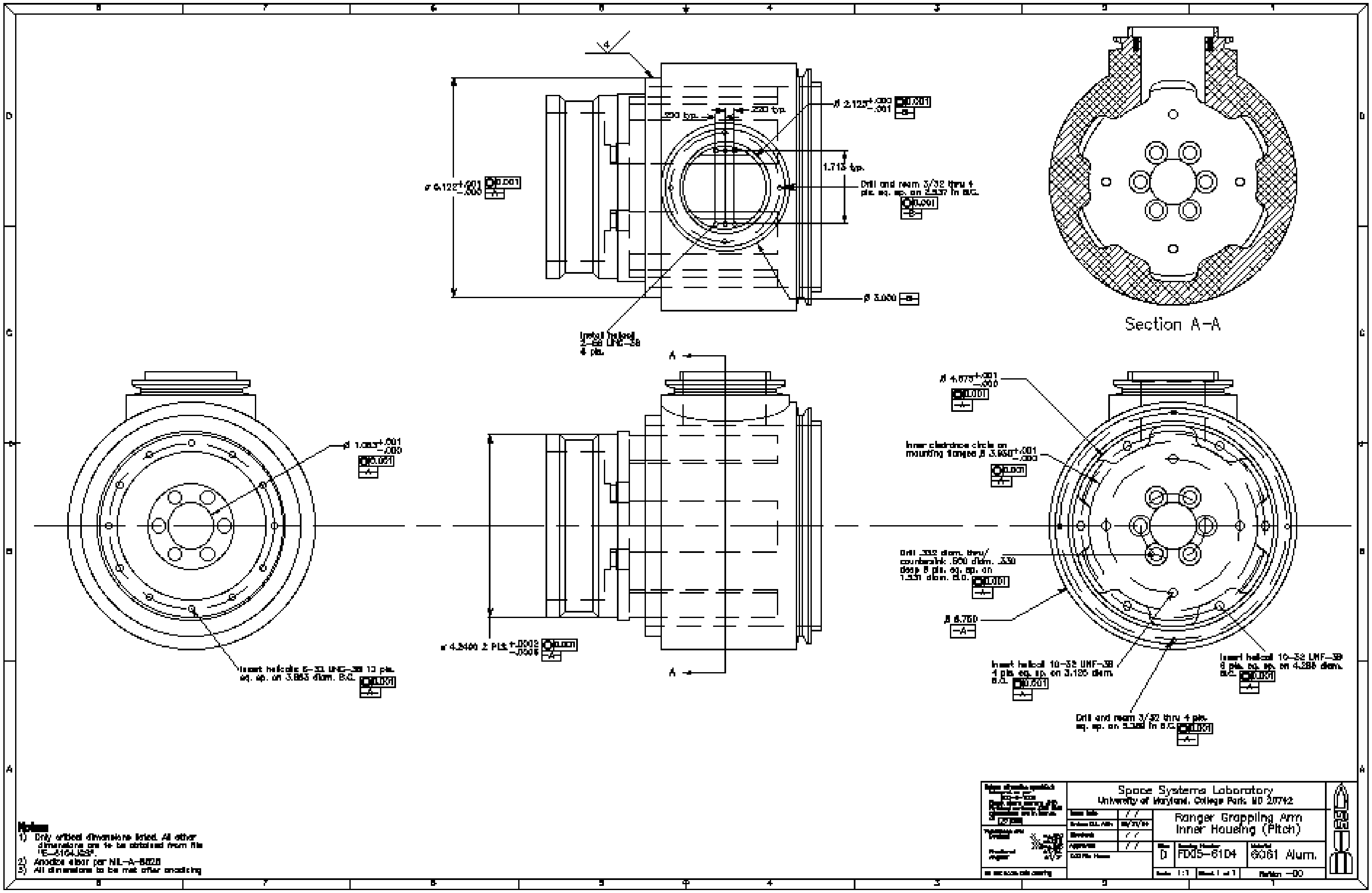


All dimensions in meters

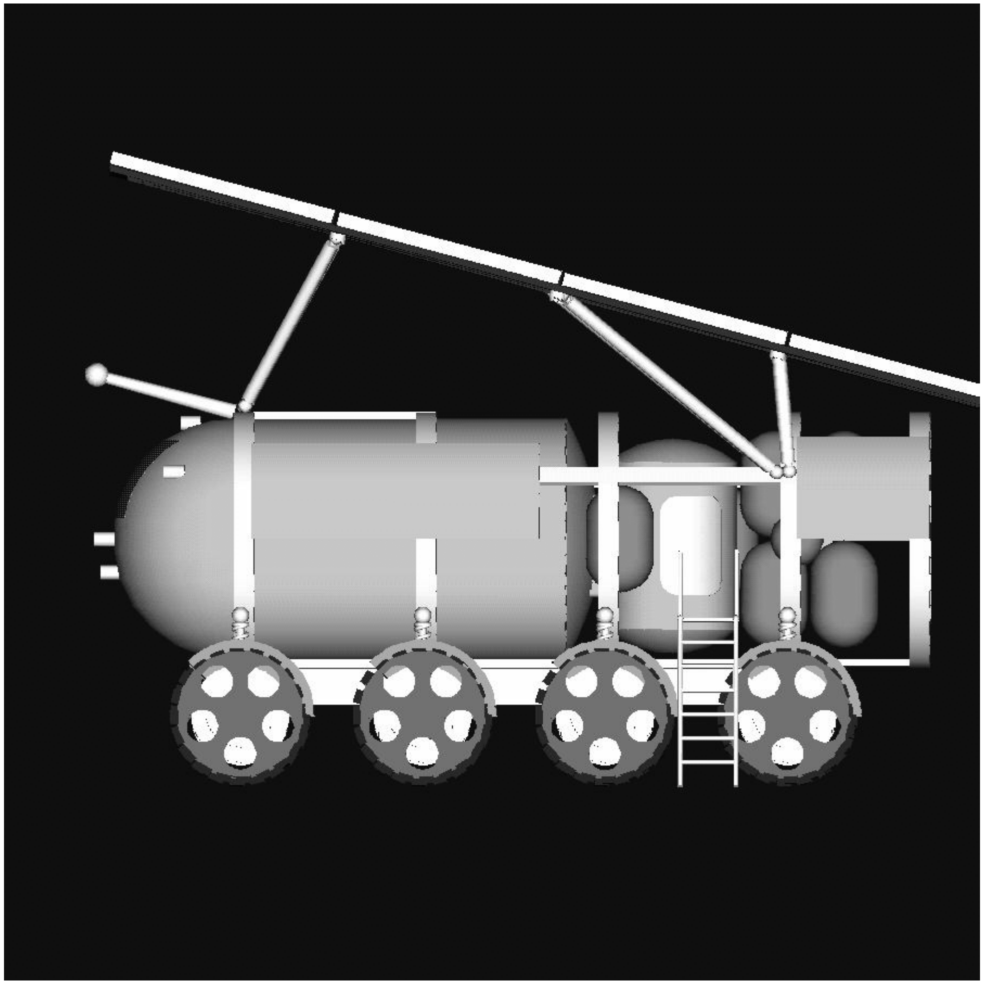
Drafting

- Highly formalized representation of all details of component
- 2D representation of 3D objects through multiple views
- Required mastery of sophisticated software package(s)
- Not generally appropriate for preliminary design activities

Drafting Example



Solid Models



- Allows 3D design, provides most realistic rendering, allows virtual manipulation for comprehension
- Takes the place of several older skills:
  - Technical illustrator
  - Graphic artist
  - Model-maker

Numerical Precision and Units

- Precision: every digit you use says that you know the parameter to that level of accuracy
  - "1 mile" - accurate to ~ 1/2 mile (~800 m)
  - "1.609344 km" - accurate to .0005 m
- Precision is only associated with trailing zeros after the decimal point
  - 13,400; 134; 1.34; .000134 all to 3 places
  - 1.34000 is 6 places of precision
- Only nondimensional parameters should ever appear without units attached

Visual Presentation of Information

The classics in this field are by Edward R. Tufte of Yale University

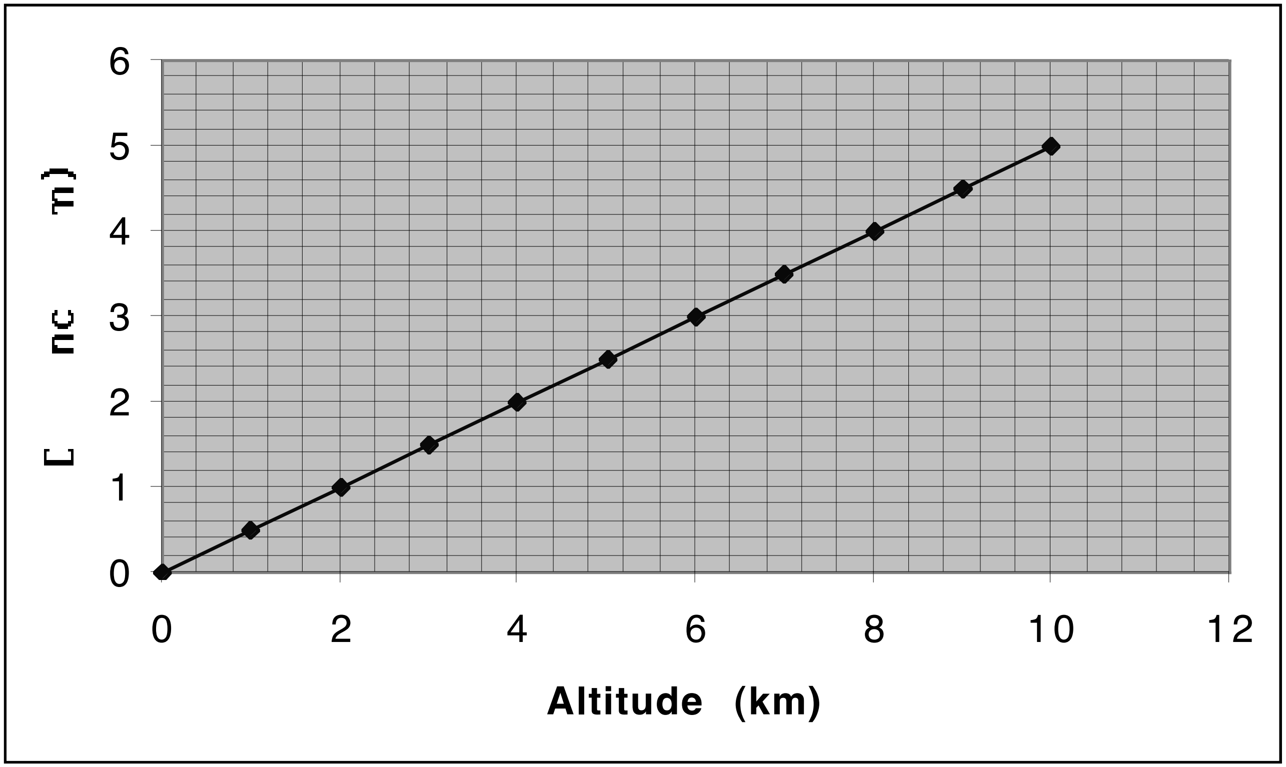
- *The Visual Display of Quantitative Information*
- *Envisioning Information*
- *Visual Explanations*
- *Visual and Statistical Thinking: Displays of Evidence for Making Decisions*

All from Graphics Press

Basic Concepts

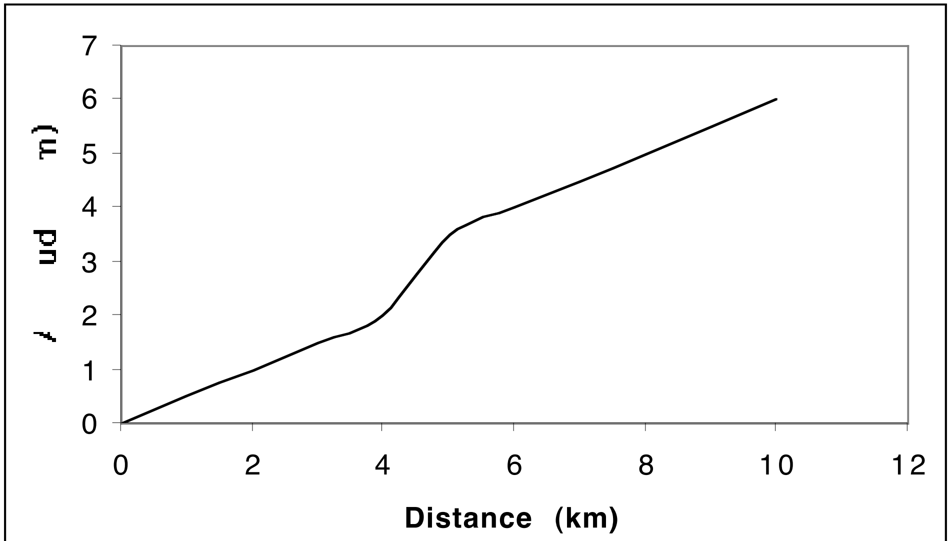
- The primary responsibility is to the data
  - Don't falsify it
  - Don't withhold it
  - Don't obscure it
  - Don't decorate it
- Maximize the data-ink ratio
- Eliminate chartjunk
- Maintain graphical integrity

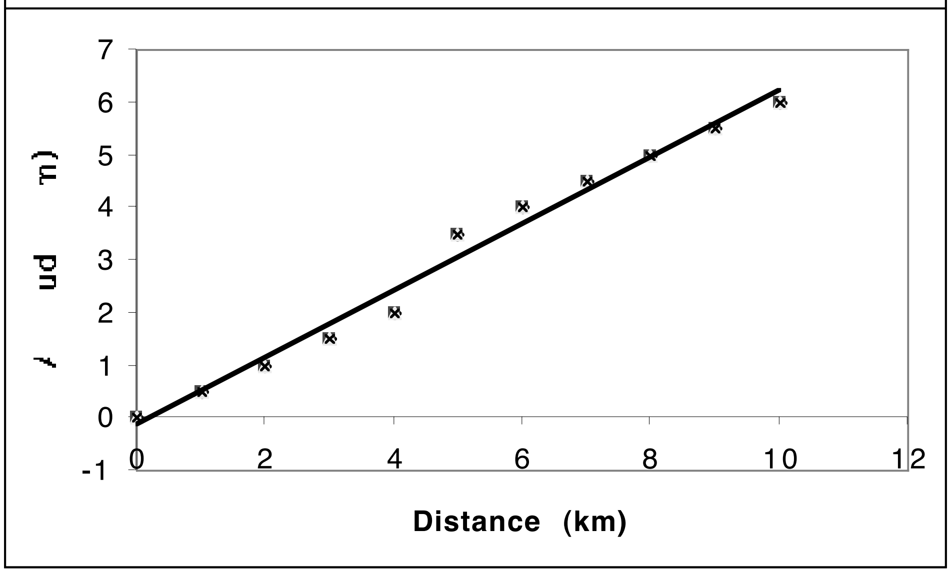
Misrepresentation of Data



- Chart only represents one piece of data (30°)
- Extra chartjunk (lines, shading, symbols) obscure information content

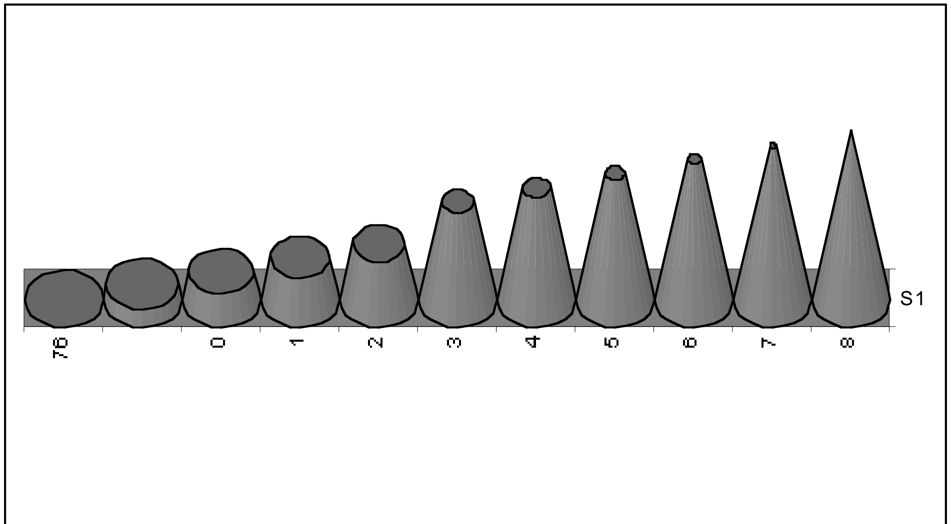
Misuse of Plotting Features

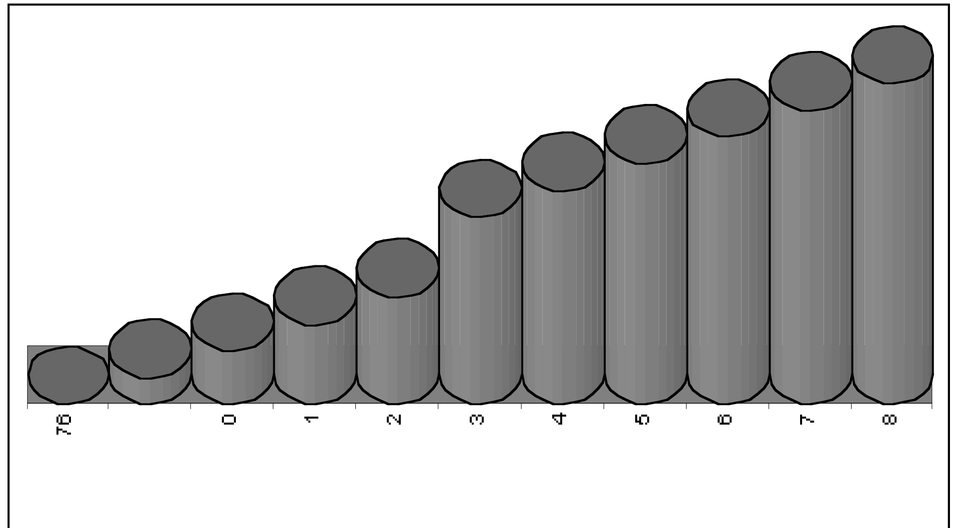


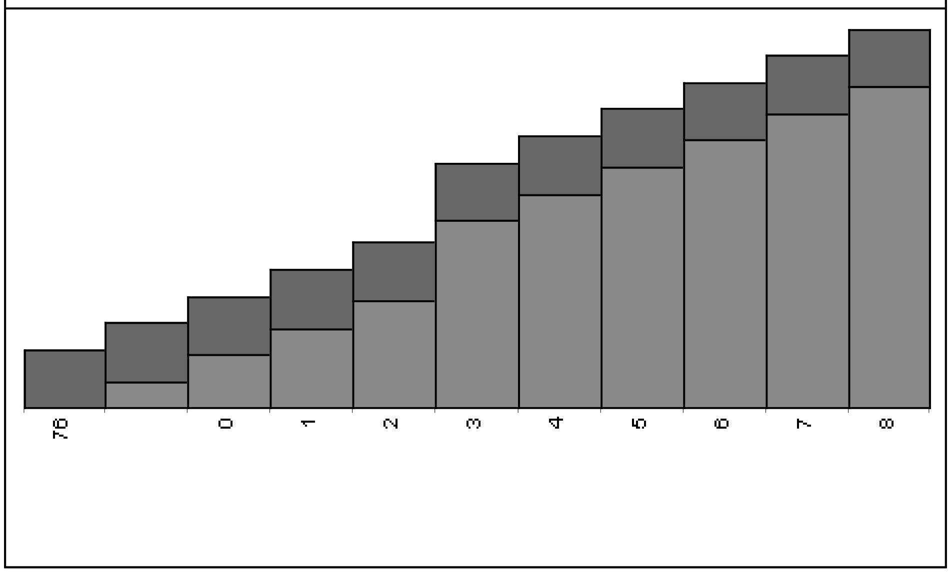


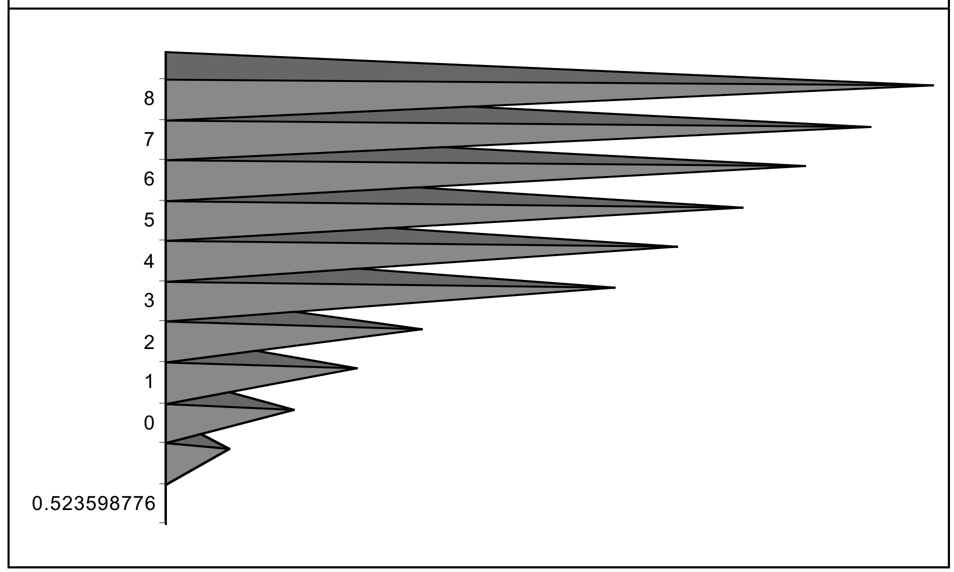
- Smoothing function without data markers implies continuity that doesn't exist
- Show actual data with markers - use line only for analytical curve fit

More Bad Plotting Ideas

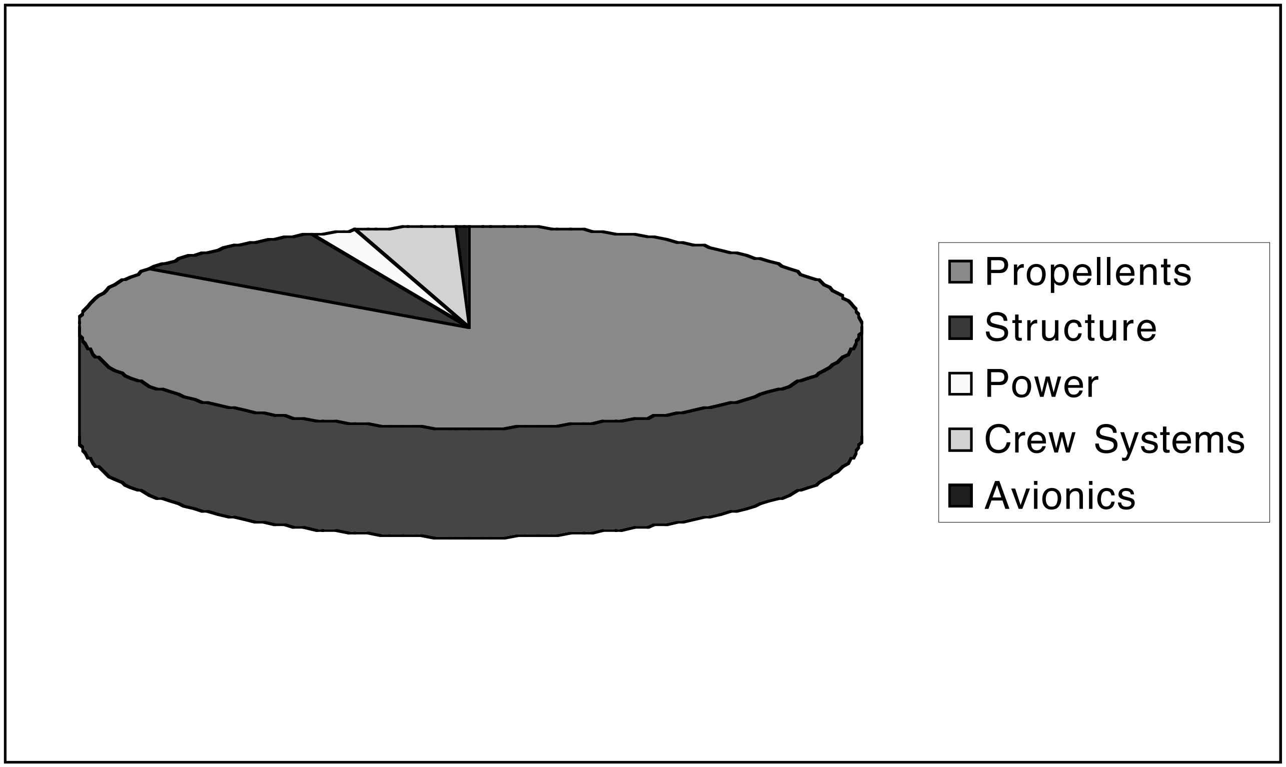






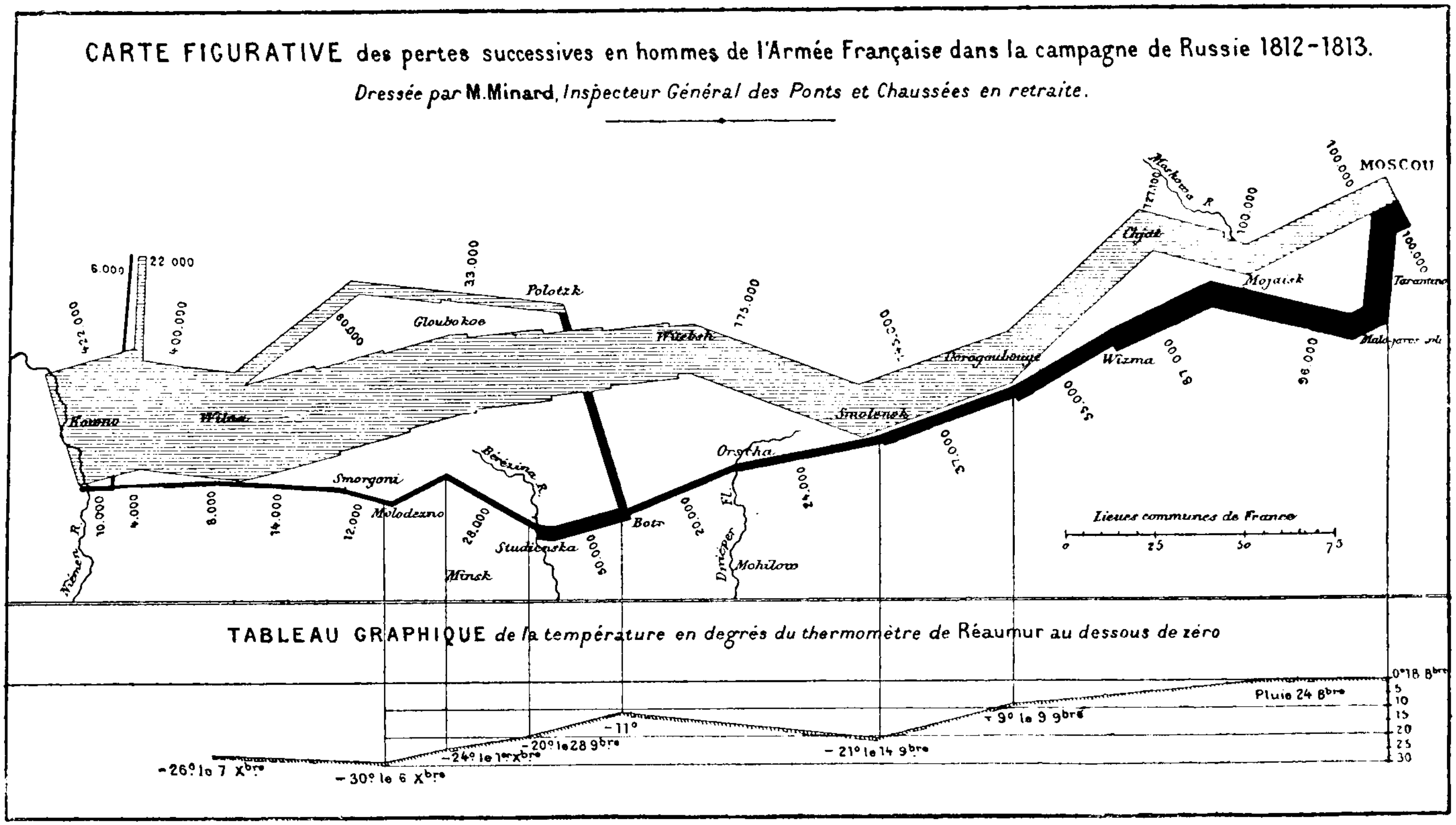


Why Pie Charts Suck



- Absolute data is eliminated in favor of relative comparisons
- Extremely low data-ink ratio

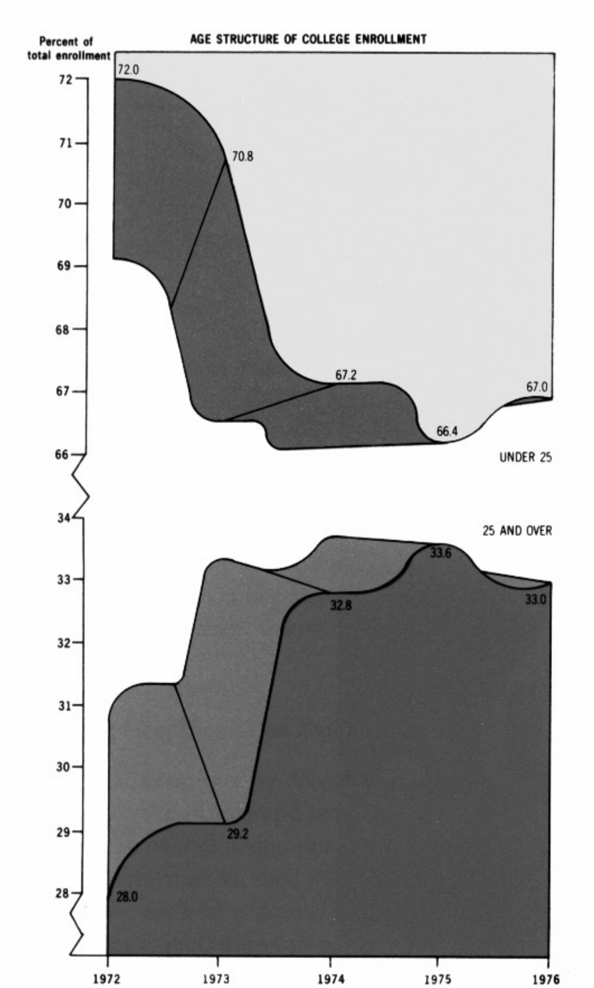
The "Best Graphic Ever Made"



X^bre = December   9^bre = November   8^bre = October

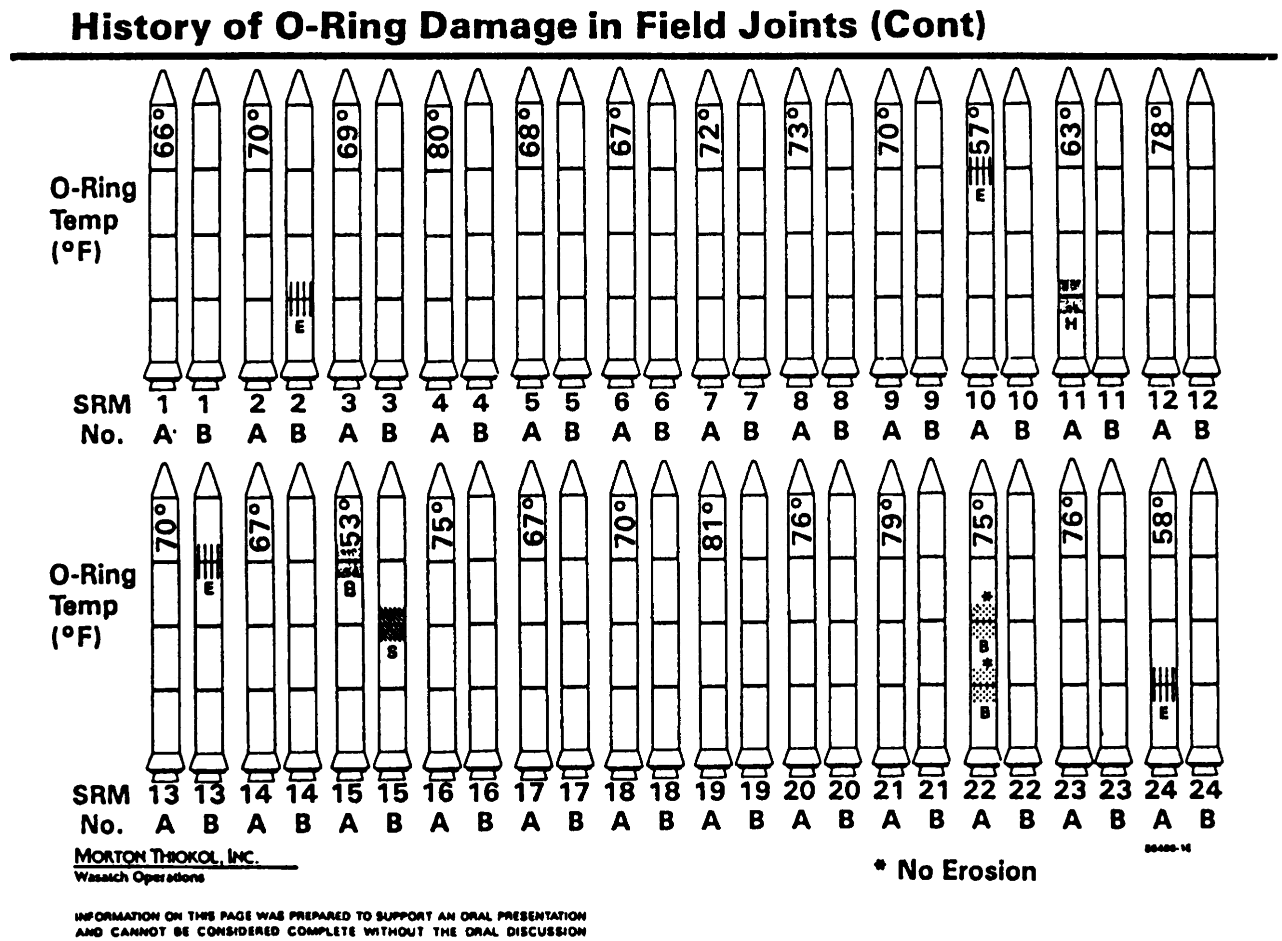
From Edward R. Tufte, *The Visual Display of Quantitative Information* Graphics Press, 1983

The "Worst Graphic Ever Made"



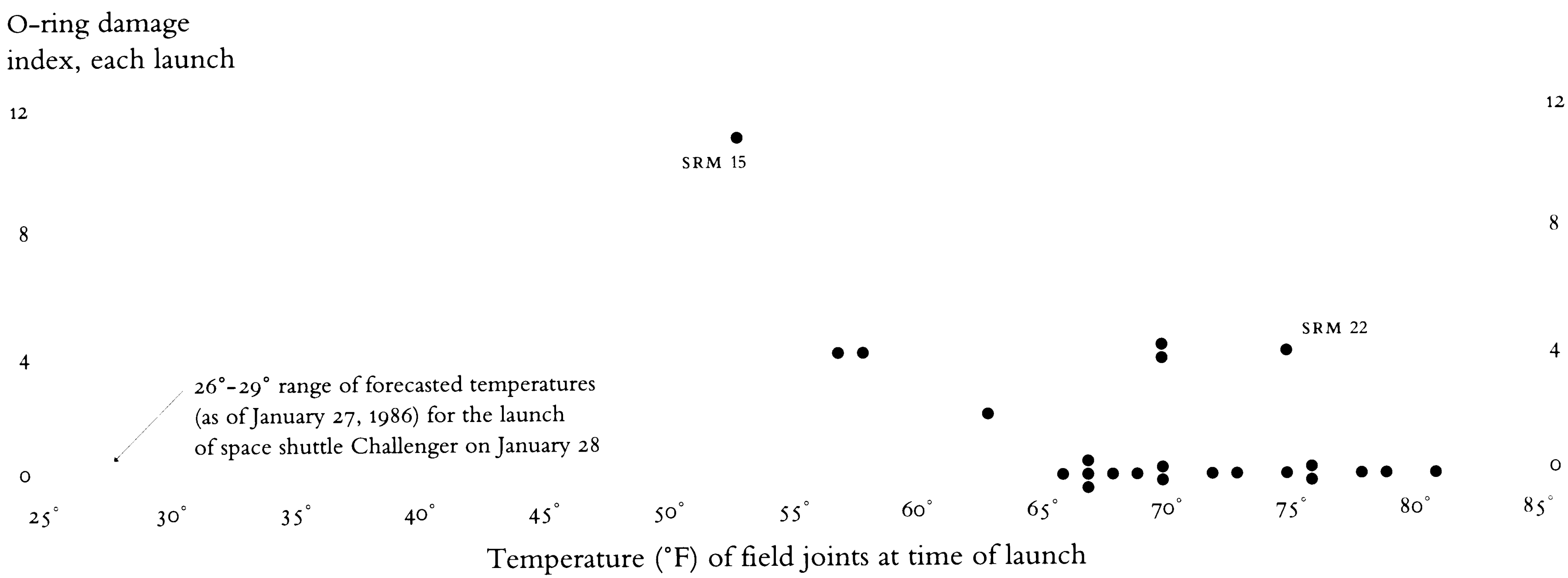
From Edward R. Tufte, *The Visual Display of Quantitative Information* Graphics Press, 1983

The Slide That Was Presented



From Edward R. Tufte, *Visual and Statistical Thinking: Displays of Evidence for Making Decisions*
Graphics Press, 1997

The Slide That Should Have Been...



From Edward R. Tufte, *Visual and Statistical Thinking: Displays of Evidence for Making Decisions*
Graphics Press, 1997

Akin's Laws of Spacecraft Design - #20

A bad design with a good presentation is doomed eventually. A good design with a bad presentation is doomed immediately.