

Constant tension between performance and safety; a lot of elements had to be guessed, due to pure uncertainty.

- severe weight constraints; every element added had to have a defensible purpose. How do you defend intuitive guesses against these constraints?

Slides:

- photo of the LM
- Schematic: general tools astronaut has to work with
- Piece of the computer-generated flowchart that describes user-interface (one of several hundred pages).
- “LM Three-phase powered descent,” proposed in lunar landing symposium
- Mission planning and analysis division’s logo, with all their signatures, and a cartoon of a cowboy riding a donkey and falling straight down a cliff, symbolizing what they were trying to *prevent*. This branch ran all the trajectories, did a lot of mission planning; were in operation until the 1980s.
- Phases of landing; shows when the radar kicks in. Radar is the only direct measurement of how high the craft is above the surface of the moon; other methods (at this point) are all theoretical/derived.
- Image from Klumpp’s paper: “pilot” and “systems engineer” looking at Apollo computer, looking for their landing site
- Image of the LM’s window, showing the landing-point designator
- Another Klumpp image; a redrawing of a computer simulation showing what looking for a landing site through the landing-point designator would look like
- Landing point designation (by Cheatham, 1967). Vehicle is automatically honed in on a landing site, but commander can designate a new site, and the computer will automatically adjust the trajectory of the craft.
- Variation of footprint capability with altitude
- One of many different views from a Grumman publication showing flowchart of controls
- Photo of Apollo computer inside the LM
- Closer-up photo of the computer.
 - o Attitude control (pitch, roll and yaw) – you can control the individual axes separately
 - o Controls on the right are more systems-oriented, controls on the left are more control-oriented
 - o Abort button
 - o Joystick with 3-axis control
 - o Guidance systems (including abort guidance system)
- Timeline of what the computer’s doing as the craft approaches the Moon and as the LM descends. Asynchronous, multi-process operation.
- Timeline/checklist (with Mindell’s annotations); instructions for both computer and the astronauts