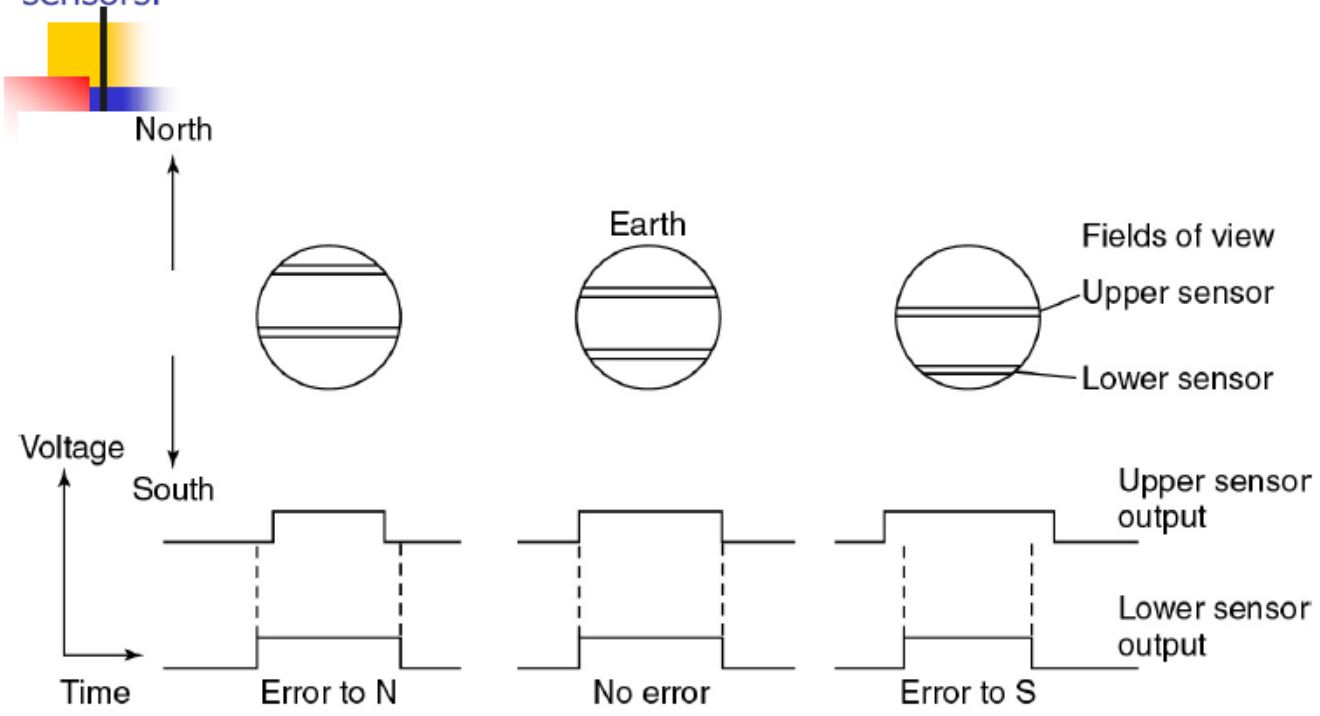
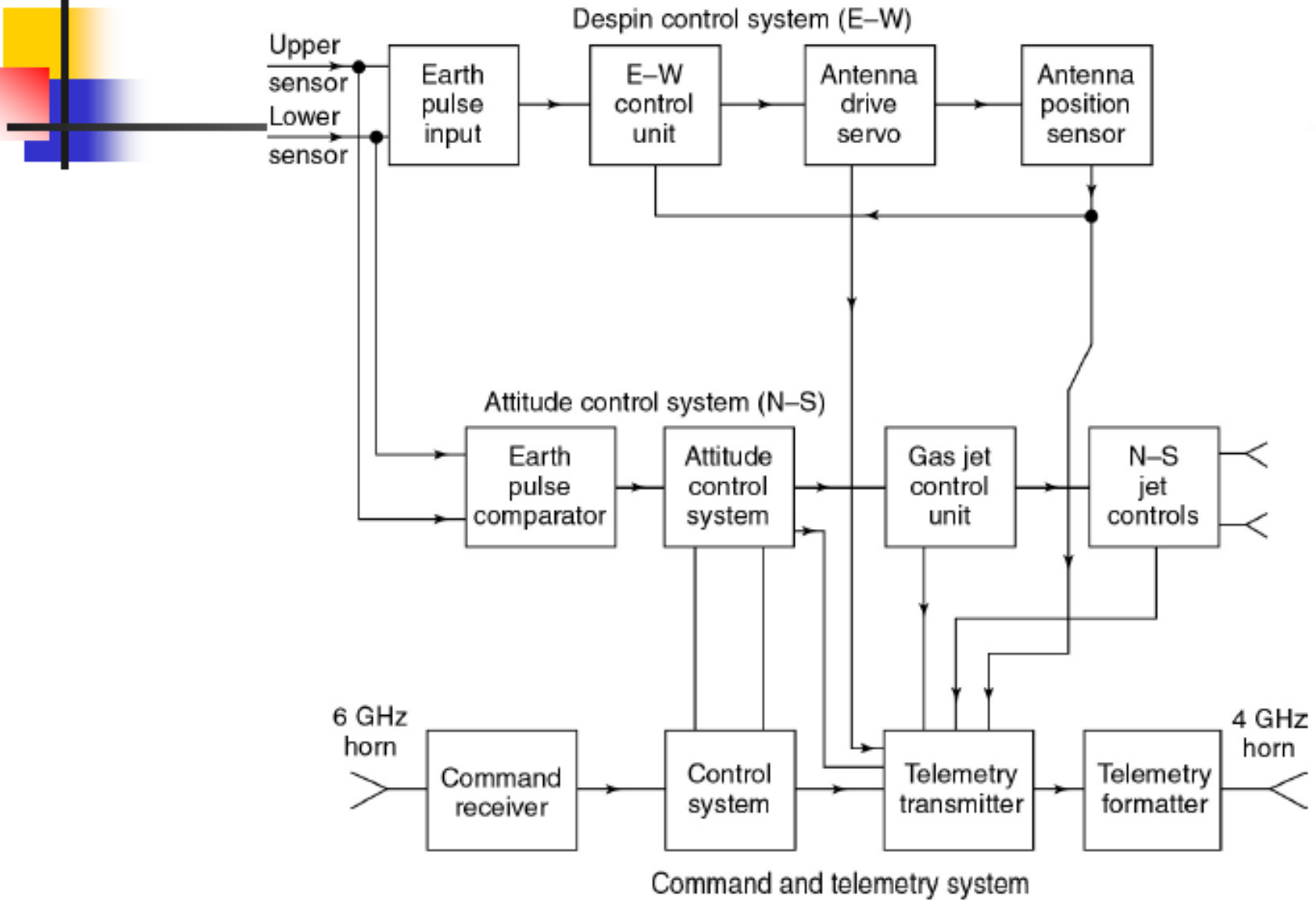
Figure 3.5 (p. 65)
Principle of N-S control of a spinner satellite using infrared Earth sensors.



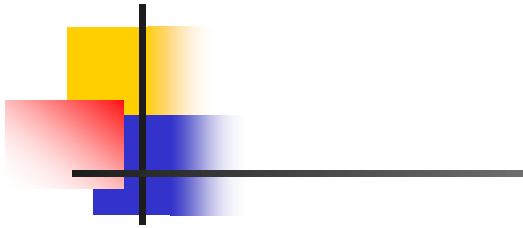
Typical onboard control system for a spinner satellite.



TTC&M

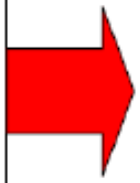
- Major functions
  - Report spacecraft health
  - Monitor command actions
  - Determine orbital elements
  - Launch sequence deployment
  - Control of thrusters
  - Control of payload (communications, etc.)

TTC&M is often a battle between ***Operations*** (who want every little thing monitored) and ***Engineering*** who want to hold data channels to a minimum



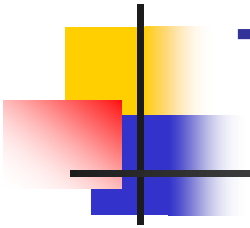
- Monitor all important functions
  - Temperature
  - Voltages
  - Currents
  - Sensors
- Transmit data to earth
- Record data at TTC&M stations

NOTE: Data are usually multiplexed with a priority rating. There are usually two telemetry modes.



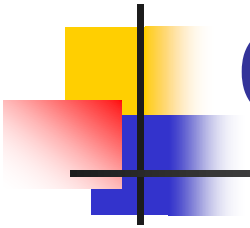
Telemetry Modes

- Non-earth pointing
  - During the launch phase
  - During "safe mode" operations when spacecraft loses tracking data
- Earth-pointing
  - During parts of the launch phase
  - During routine operations



Tracking

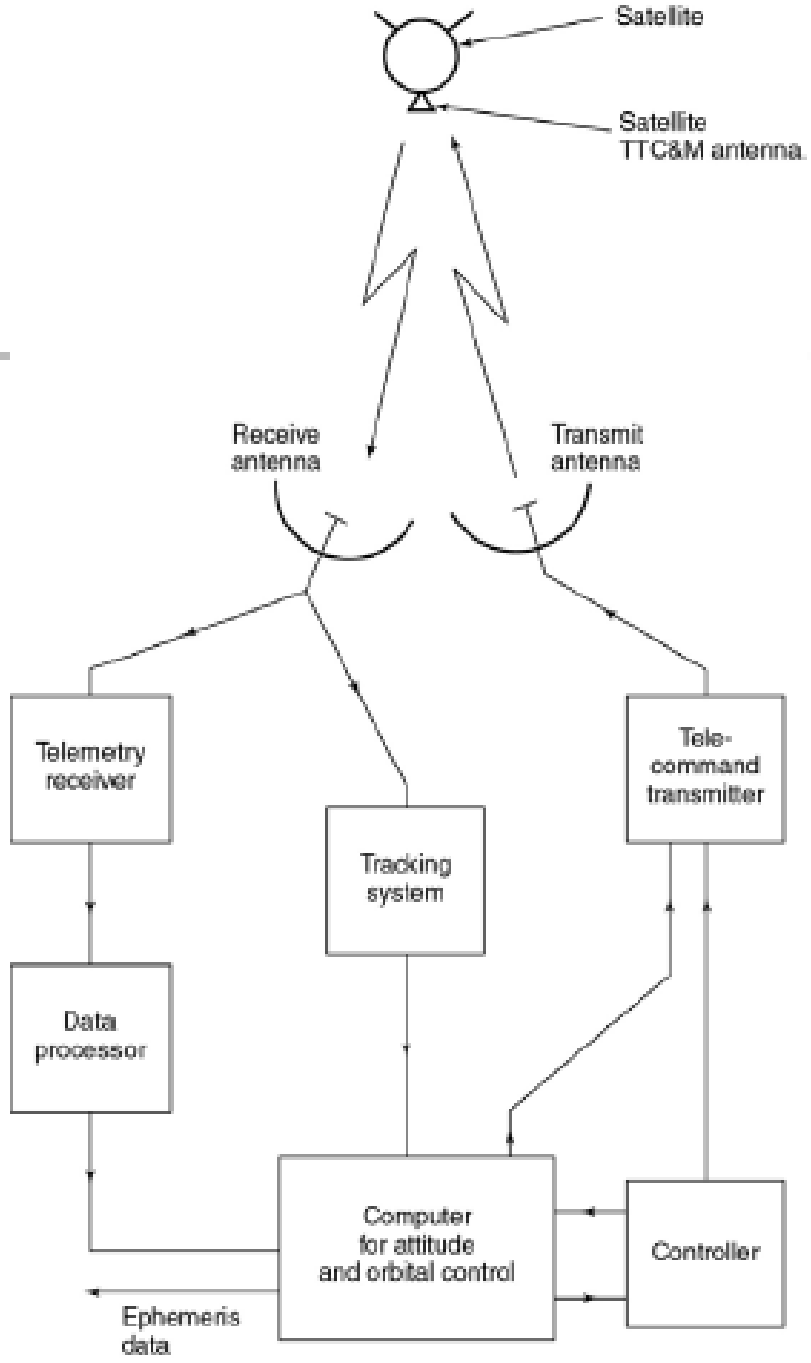
- Measure range repeatedly
- Measure beacon Doppler or the communication channel
- Compute orbital elements
- Plan station-keeping maneuvers
- Communicate with main control station and users



Command

- During launch sequence
  - Switch on power
  - Deploy antennas and solar panels
  - Point antennas to desired location
- In orbit
  - Maintain spacecraft thermal balance
  - Control payload, thrusters, etc.

Typical TTC&M system



Power systems-1

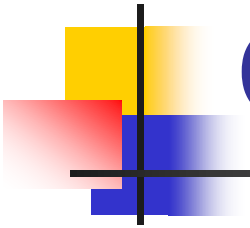
- Solar cells
  - 1.39 kW/m^2 available from Sun
  - Cells 10 - 15% efficient (BOL = beginning of life)
  - Cells 7 - 10% efficient (EOL = end of life)
- Solar cell output falls when temperature rises
  - 2mV/°C
  - Three-axis is hotter (less efficient) than a spinner

Power systems-2

- Batteries needed
  - During launch
  - During eclipse (< 70 minutes)
- Battery limits
  - NiCd 50% (DOD=depth of discharge)
  - NiH_2 70% DOD

Power systems-3

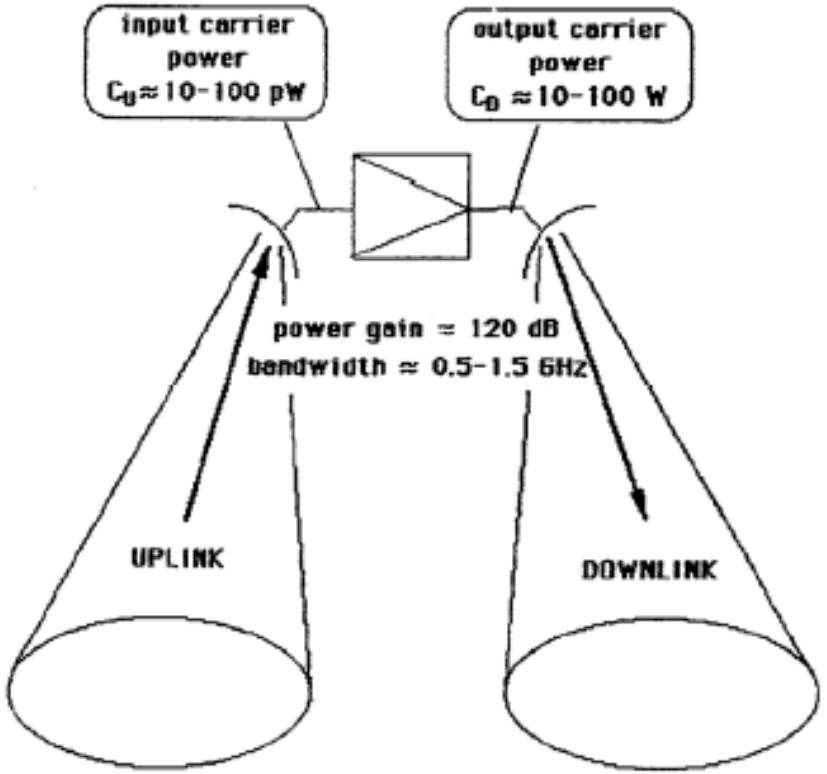
- Batteries are "conditioned" before each eclipse season
  - Batteries discharged to limit
  - Batteries then recharged
- Typical NiH_2 battery can withstand 30,000 cycles (ample for GEO; would be 5 years in LEO)



Communication subsystems

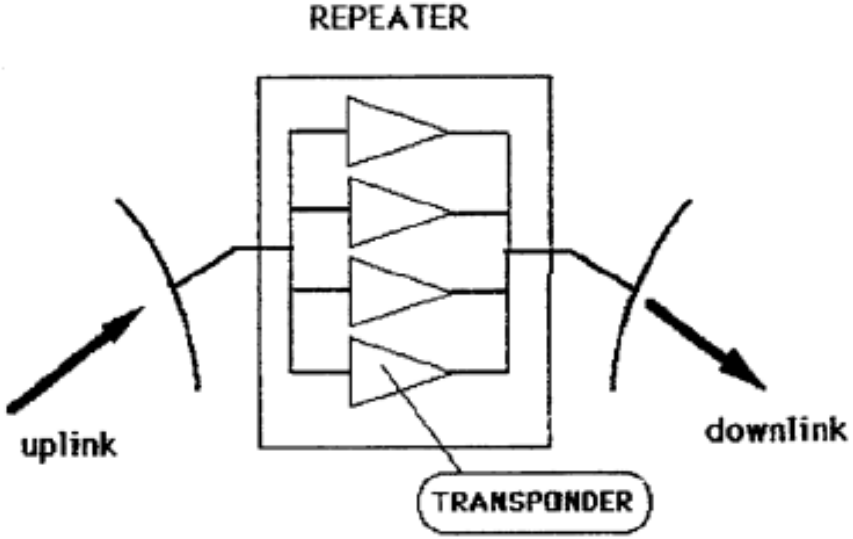
- Primary function of a communications satellite (all other subsystems are to support this one)
- Only source of revenue
- Design to maximize traffic capacity
- Downlink usually most critical (limited output power, limited antenna sizes)
- Early satellites were power limited
- Most satellites are now bandwidth limited

Payload functions



Repeaters and Transponders

- The total bandwidth (up to 500MHz-1.5GHz) is too large to be accommodated by a single amplifier.
- On the other hand, no carrier occupies such a bandwidth on its own.
- Hence the total REPEATER bandwidth is split into subbands (a few tens of MHz each). Each subband is amplified by a TRANSPONDER.



Types of payloads/Transponders

- Regenerative Transponders
  - Uplink is demodulated (IF=Baseband) and signal remodulated before transmission on downlink (not necessarily digital)
- On board Processing Transponders
  - Essentially digital in nature the uplink is demodulated and data recovered prior to processing. After processing, the data is reformated for transmission on the downlink (store and forward transponders are an example)