Launch Ranges

- Site for launching and landing spacecraft
- Typically along a coastline
  - Available launch azimuths for desired orbit inclinations (polar, sun-synchronous, equatorial, ...)
  - Advantageous use of Earth’s rotation (near equator)
  - Need for safe lower-stage impact zones down-range
- Distance from heavily populated areas
- Infrastructure for
  - Vehicle/spacecraft assembly
  - Pre-flight testing
  - Component transport and storage
  - Launch pads
  - Assurance of ground and flight safety
  - Launch control and handoff
  - Tracking, communications, data processing
  - Down-range facilities

List of launch sites
https://en.wikipedia.org/wiki/Spaceport
Launch Operations

Range Safety

FPS-16

Wallops Control Center, c. 1960

Radar Plot
Scout ST-1
July 1, 1960

Range Safety

- Range surveillance
  - Restricted airspace
    - Prohibited airspace
    - NOTAMs (Temporary flight restrictions)
  - Surface vessel monitoring
- Meteorological information
  - Apollo 12 lightning strike during launch
- Monitoring hazardous materials
Space and Ground Segments for Spacecraft Operation

GOES-R System Architecture
Ground Segment Basics

GROUND SEGMENT

Control Center
Flight Dynamics System
Ground Data System
Flight Operations System

Communication links

Customer

Ground Station

RF-link

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Ground Segment Basics

MISSION ELEMENTS
- Ground Station
- System Timing
- Spacecraft Operations Control Center (SOCC)
- Payload Operations Control Center (POCC)
- Mission Control Center (MCC)

Staff Operations

FACILITY ELEMENTS
- Plant
  - Buildings
  - Utilities
  - Staff services
- Maintenance
  - Mission equipment
  - Plant

Staff Operations

Larson Wertz
Ground Segment Basics

Ground Station Location and Antennas

- Coverage of celestial sphere
- Access to low-elevation tracking and communications line-of-sight
- Low radio-frequency (RF) interference from surrounding area
- Stable geology, satisfactory weather
- Adequate, reliable power source
Tracking and Communication

- Low frequencies for
  - Launch and early-orbit phase, launch vehicle and spacecraft
- High frequencies for payload
- Frequency allocations by international agencies

- Antenna control
  - Pointing and tracking
  - Modes: program-, auto-, step-tracking
- Satellite transponders for ranging and range rate
- Uplink/downlink frequency shifts to avoid interference

<table>
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<th>Band</th>
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Ground Station Block Diagram

System Timing

NIST Primary Time Standard, Boulder, Co

Larson, Wertz
Data Handling

Larson, Wertz

In-Orbit Testing

- Telemetry, data communications testing
- Payload checkout
- Calibrations
- Adjacent satellite interference
- Acceptance tests
Ground Control Teams

Flight Dynamics Mission Analysis

- Identification of suitable ground station network
- Launch window determination
- Orbit maneuver planning
- Final orbit acquisition and station-keeping
- Sequence of orbit-related events
- Ground station ephemeris (antenna-pointing)
- Command and telemetry files
- Interface documents
Orbit and Attitude Determination

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<th>Measurement Type</th>
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<td></td>
<td>Raw GPS Data (dual frequency)</td>
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<td>GTO/GEO</td>
<td>Angle, Range, Range-Rate Data</td>
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Communications Links and Flight Readiness
Flight Operations Monitoring and Control

- Raw data extraction
- Translation to engineering values
- Validity & verification of telemetry and commands
- Out-of-limit status, alarms
- Derived parameters
Flight Operations Monitoring and Control

- Collision avoidance
- Space weather

Next Time: Electromagnetic Compatibility
Supplemental Material

Ground Station