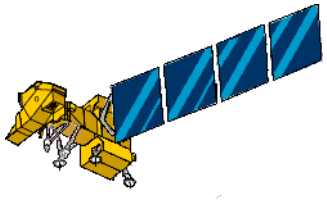
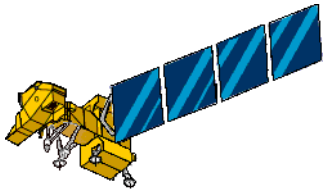


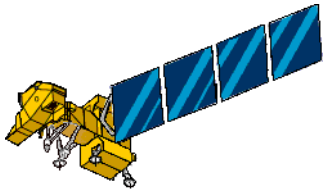
RF Interface Status

Armen Caroglanian
Landsat-7 Ground Station (LGS) Manager
NASA / GSFC Code 567
Microwave Systems Branch

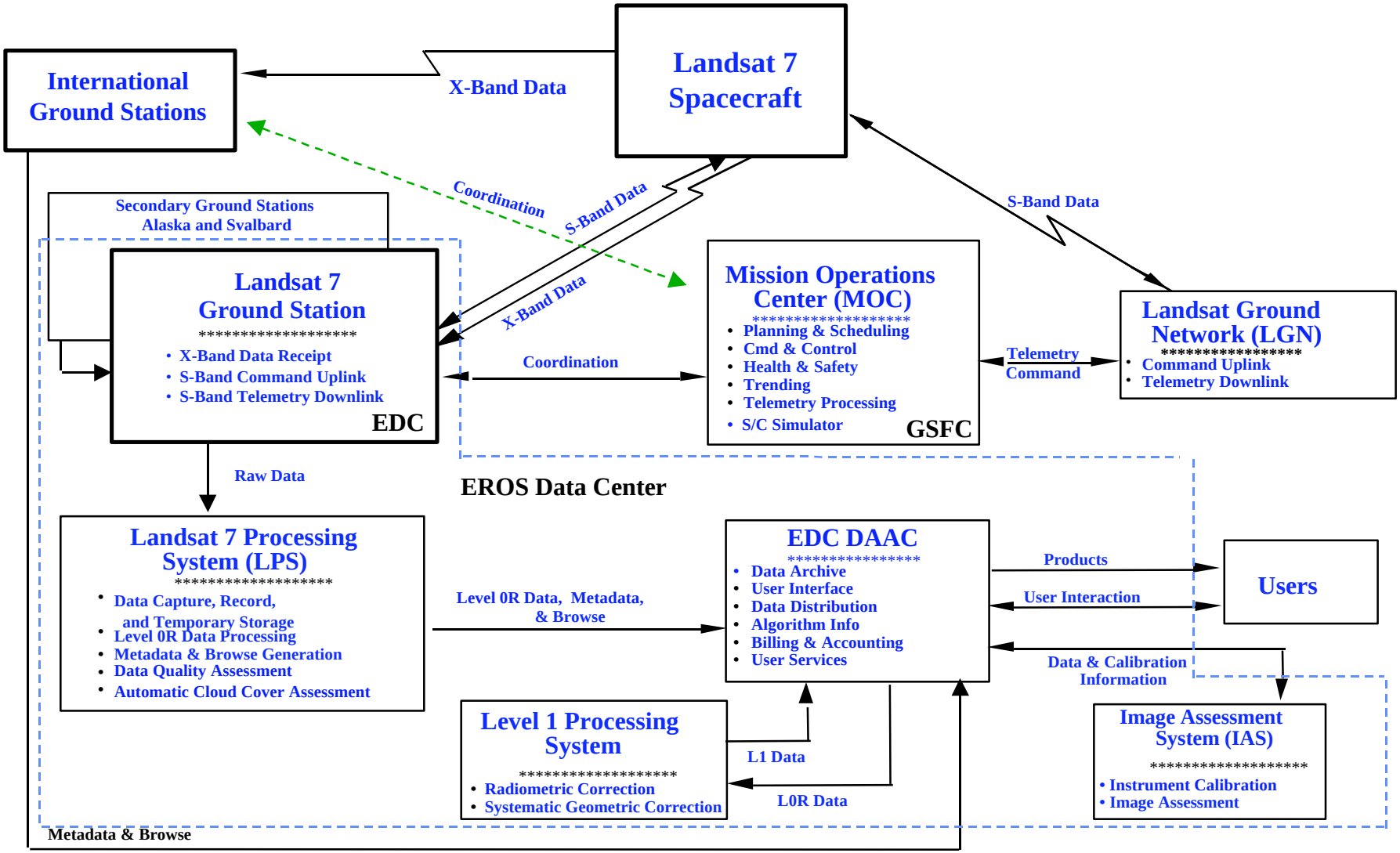


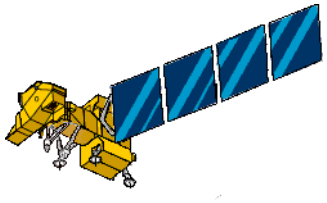
Outline

- Review the Landsat-7 to IGS X-Band Downlink
- X-Band Downlink Characteristics
- L-7 Spacecraft X-Band Hardware
- Link Budget
- Acquisition Timeline
- Landsat Ground Station Overview
  - Antenna System
  - X/S-Band Equipment
- Documentation



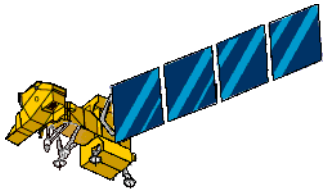
Landsat 7 Ground System





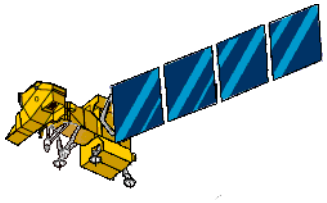
X-Band Downlink - Signal Characteristics

- **Data**
  - **150 Mbps ETM+ Wideband Data**
  - **Exact Data Rate: 149.836 Mbps +/- .015 Mbps**
- **Downlink Modulation**
  - **Asynchronus QPSK (AQPSK)**
  - **I/Q 75 Mbps**
  - **Data Format: NRZ-L**
  - **I/Q Data Asymmetry < 5%**
  - **Independent Clock recovery Bit Synchronizers required.**



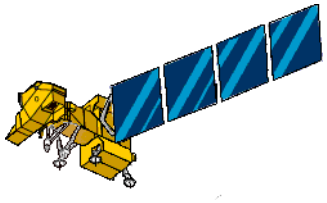
Signal Characteristics (cont.)

- **Unbalanced QPSK**
  - **I and Q power ratio imbalance**
  - **Specification .8 dB**
  - **Mid.-frequency transmitter during some tests showed an I/Q power ratio of 1.1 dB.**
  - **Additional link degradation expected to be < .3 dB.**
  - **Link budget is absolute worst case.**
  - **Overall link margin expected to be met / exceeded.**
  - **I/Q power ratio is not an issue.**



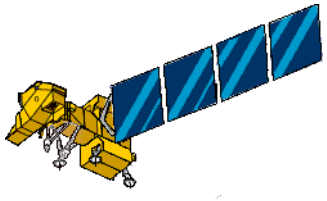
X-Band Downlink - RF Characteristics

- **Frequencies**
  - **Low: 8082.5 MHz**
  - **Mid: 8212.5 MHz**
  - **High: 8342.5 MHz**
- **Downlink Filtering - Triplexer**
  - **Required to fit 3 simultaneous downlinks into X-Band frequency allocation.**
  - **Filter degradation loss calculated to be 2.5 dB.**
- **RF link details**
  - **EIRP (minimum): 24.2 dBW**
  - **Polarization: RHCP**
  - **Maximum expected Doppler < 190 KHz**



Landsat-7 Spacecraft X-Band Hardware

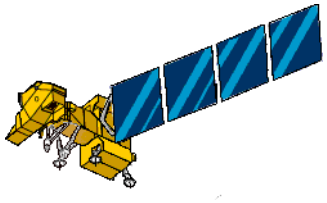
- Baseband Switching Unit (BSU)
- Four 3.5 Watt X-Band Transmitters
- Three Triplexers
- Three Gimbaled X-Band Antennas
  - 37 cm (14.6 inch) diameter parabolic reflector
  - Gain specification 26.2 dBi



LGS X-Band Link Budget

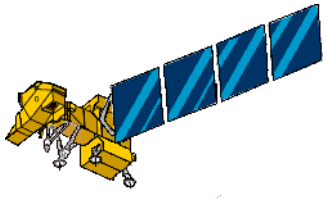
Link: **X-Band downlink**
Carrier Freq.: (MHz) **8342.5 MHz (150 MBps)**

	PARAMETER:			COMMENTS:
1	**EIRP (dBW)**	**24.24**		Landsat-7 System Requirement
	Transmit Power (dBW)		5.44	3.5 watts
	Passive Loss (dB)		-6.90	
	Antenna Gain (dB)		26.20	
	Pointing Loss (dB)		-0.50	Reduced from - 1dB
2	**Modulation loss**	**-0.40**		1:1 I/Q Ratio with +/- .8 dB
3	**Space Loss (dB)**	**-179.08**		5 Deg. Elevation, Range = 2575 Km
4	**Polarization Loss (dB)**	**-0.35**		ARt = 3.5 dB, ARr = 1.5 dB
5	**Scintillation Loss**	**-1.00**		Estimate for Sioux Falls
6	**Propagation Loss (dB)**	**-1.82**		
	Rain Attenuation		-1.13	4 mm/hr, 5 deg. elev. 99.6% Avail. Crane Model
	Atmospheric / Cloud Loss		-0.69	28 deg . C , 70% Rel. Humidity
7	**Receive G/T (dB/K)**	**32.10**		30.4 dB/K Spec. at 5 deg. with rain
	Clear Sky G/T (dB/K)		**34.00**	**LGS Antenna Specification**
	T increase due to Rain		-1.90	Increase of 101 K
8	**Pointing Loss**	**-0.50**		
9	**Boltzmann Const (dBW/Hz-K)**	**-228.60**		10*log(Boltzmann's Constant)
10	**Received C/No (dB-Hz)**	**101.79**		
11	**Noise Bandwidth (dB-Hz)**	**81.76**		150 MBps
12	**Link Eb/No (dB)**	**20.03**		
13	**Implementation Loss (dB)**	**-5.5**		
	Filter degradation (dB)		-2.50	Simulation Estimate
	Implementation Loss(dB)		-3.00	Estimate
14	**Req. Eb/No (dB)**	**9.60**		BER 10e-5 (QPSK Uncoded, NRZ-L)
15	**Available Signal Margin (dB)**	**4.93**		
16	**Required Signal Margin (dB)**	**3.00**		Landsat-7 System Requirement
17	**Excess Signal Margin (dB)**	**1.93**		



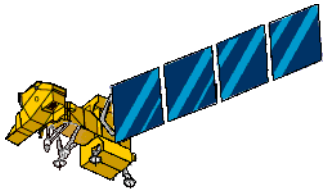
X-Band Acquisition Timeline

- **Nominal image data start time is 5 degrees above the local horizon mask.**
- **Order of events**
  - **PN Data**
  - **Payload Correction Data (PCD)**
  - **Image Data**
  - **PCD**
  - **PN Data**

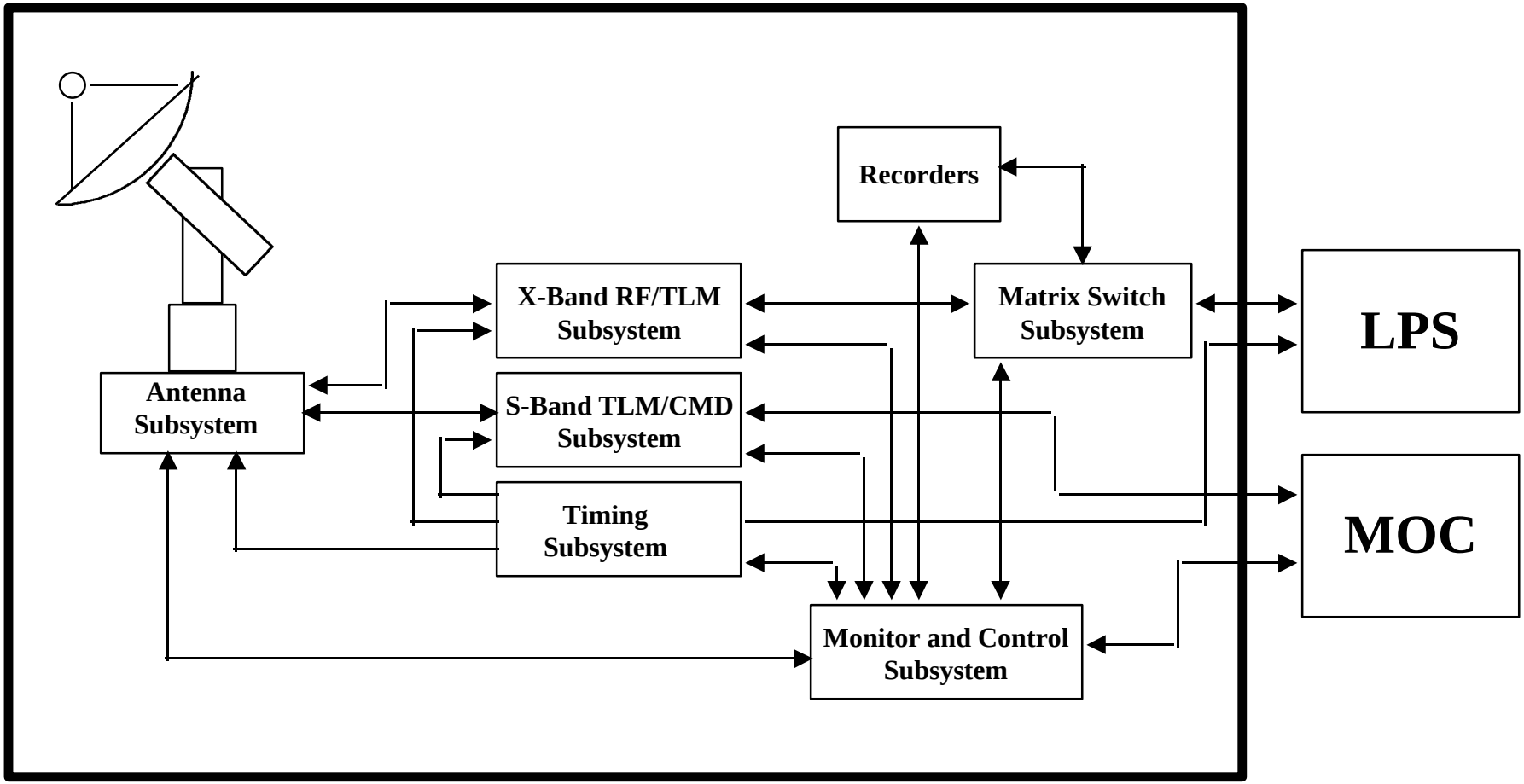


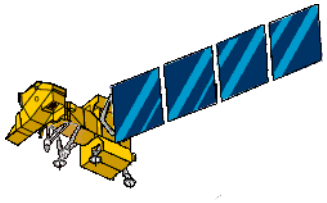
Landsat-7 Ground Station (LGS) Overview

- **X-Band**
  - **Receive 2 simultaneous ETM+ downlinks.**
  - **Demodulate and bit synchronize I and Q channels.**
  - **Provide 4 ETM+ data channels to the Landsat Processing System for recording.**
- **S-Band**
  - **Transmit command data to the Landsat-7 Spacecraft.**
  - **Receive Landsat-7 spacecraft telemetry downlink.**
  - **Provide two way Doppler tracking data.**
- **Data Playback**
  - **Playback image data received from Polar Ground Stations to the LPS.**



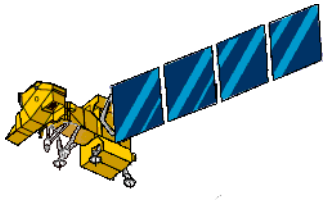
LGS System Diagram





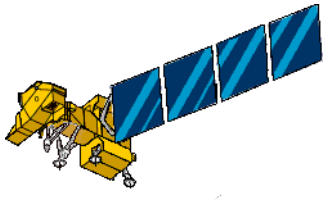
LGS Antenna System

- Datron 10-meter S/X band antenna
  - Installation completed - March 1998.
- G/T
  - X-Band: 34 dB/K
  - S-Band: 22 dB/K
- Elevation over azimuth / tilt axis mount
- S/X band autotrack
- Accepts both IIRVs and NORAD 2-line elements
- Collimation Source



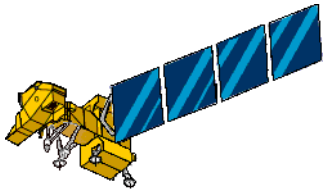
LGS RF Equipment

- Scientific Atlanta 924 Series X-Band Hardware
  - Installed at EDC - 1997
  - X-Band Downconverter (SA Model 924-4)
  - QPSK/AQPSK Demodulators (SA Model 924-1)
  - Bit Synchronizers (SA Model 924-2)
    - Dual Standard Bit Synchronizers
    - New L-7 AQPSK Bit Synchronizers
  - Test Modulator (SA Model 924-6)
  - Upconverter (SA Model 924-4)
  - Bit Error Rate Tester (Anritsu ME520B)



LGS RF Equipment (cont.)

- Three identical X-Band receiving equipment chains
- ETM+ Data routed via a Matrix Switch
- AMPEX DIS-160i Data Recorders
- S-Band Equipment
  - Microdyne Exciter and Receivers
- GPS Timing System
- Monitor and Control System



Key Documents

- **LGS Functional and Performance Requirements (F&PR)**
  - **Web Address: http://ntipalpha/code/531doc.htm**
- **Landsat 7 to International Ground Station (IGS) Interface Control Document (ICD)**
- **Interface Control Document Between Landsat 7 and the Landsat 7 Ground Network (LGN)**