LDCM Ground System

Network lesson learned

SOSTC GSFC May 24- 25 2010

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- ◆ Mission overview

- ◆ RF design

- ◆ Mission RF ETE Test Program

- ◆ Lesson learned

Mission Objectives

- The LDCM will continue the **acquisition**, archiving, and distribution of moderate-resolution multispectral imagery affording **global**, synoptic, and **repetitive coverage** of the earth's land surface at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time.

- The following are the major mission objectives:
  - Define parameters for scheduling and collecting a **minimum of 400 OLI and TIRS WRS-2 scenes per day** for sunlit areas of the Earth's landmasses, islands, coral reefs and atolls
  - Optimize data collection based on science and operational priorities as a function of cloud cover, seasonality (vegetation phenology), solar illumination, existing archive quality, and the availability of observatory resources
  - Expedite collection and processing of high priority imaging data to support monitoring of natural disasters or other high interest targets of opportunity.
  - Provide the capability for users to request LDCM data collections.
  - Provide the capability for International Cooperators to request LDCM data collections.
  - Improve upon the success of previous missions based on lessons learned, improved input data, and algorithm refinements

LDCM Driving Requirements

LDCM

- ◆ **Driving requirement for the mission is to collect 400 scenes/day.**

|		**Total Size**
System	**Daily Volume 400 Scene**	**390 GB**
Spacecraft	**C&DH rate**	**260.92 Mbps**
Space to Ground Comm	**Downlink Rate**	**384 Mbps Data/ 441 Msps Symbol**
	LDPC 7/8 rate packet	**8160 bits**
Ground Station	**Minutes per day (14 contacts)**	**98 minutes**
Science Archive	**5 year archive**	**~ 400 TB**

Mission Segment Responsibilities
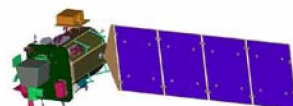
Space Segment

Operational Land Imager
- Multi-Spectral Imaging Instrument
- Pushbroom VIS/SWIR sensor
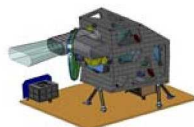
Thermal Infrared Sensor
- 2 thermal channels
- Pushbroom design
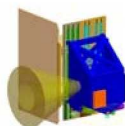
Spacecraft
- 3-axis stabilized
- Accommodates OLI & TIRS

Launch Segment

Atlas V 401

Ground System

MOC at GSFC

Collection Activity Planning Element (CAPE)
Generates high level imaging mission schedules

Mission Operations Element (MOE)
Mission planning & scheduling, command & control, monitoring and analysis, flight dynamics & onboard memory management

Ground Network Element (GNE) :Stations at LGS, GLC & Sval

Antenna & associated equipment for X-Band image & S-Band telemetry data downlink reception and generation of S-Band command uplink

Data Processing and Archive System (DPAS) at EROS

User Portal Element (UPE)
Provides web interface to facilitate: data discovery, product selection & ordering (for Cal/Val), & product distribution

Storage and Archive Element (SAE)
Provides storage and services for data processing & archive services for data and archive products
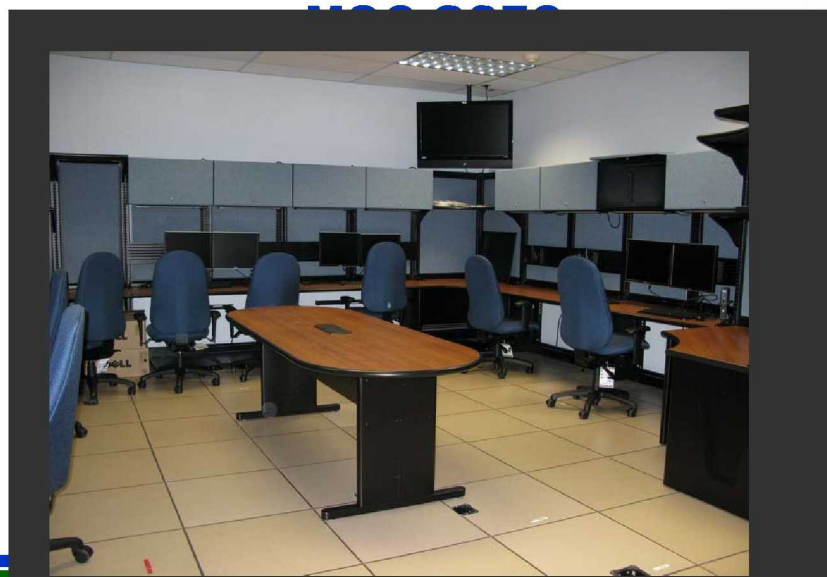
Image Processing Element (IPE)
Provides: Ingest, Product Generation, & Image Assessment

Ground Systems

LDCM

GNE GLC

OS
DPAS & GNE

Ground Network Element

- ◆ **USGS baseline two ground stations at :**
  - ◆ EROS – Sioux Falls Landsat Ground station (LGS)
  - ◆ Gilmore Creek (GLC) /Alaska : NOAA ground station
- ◆ **USGS has funded upgrades to these existing stations to support LDCM**
- ◆ **NASA funded KSAT/Svalbard station for LEOP , through commissioning +90 days**
- ◆ **USGS is evaluating additional Ground stations after IOC**
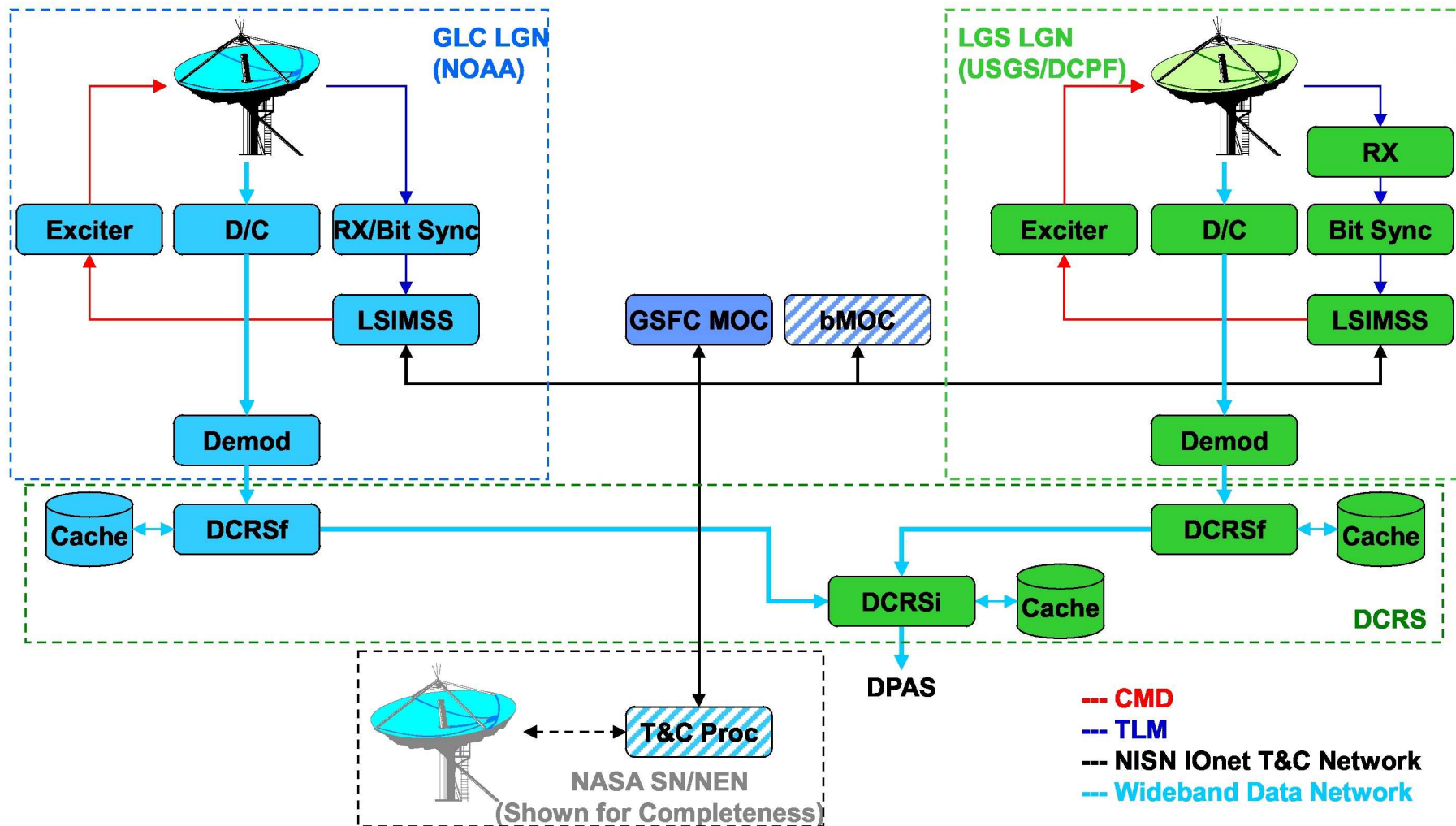 - ◆ Use of GN/NENS possible option if ready by 12/12/12

GNE

GNE SVAL

GNE GLC

GNE Functional Block Diagram

GLC LGN (NOAA)

- Exciter
- D/C
- RX/Bit Sync
- LSIMSS
- Demod
- Cache
- DCRSf

LGS LGN (USGS/DCPF)

- RX
- Exciter
- D/C
- Bit Sync
- LSIMSS
- Demod
- DCRSf
- Cache

GSFC MOC   bMOC

DCRSi   Cache   **DCRS**

DPAS

T&C Proc

NASA SN/NEN (Shown for Completeness)

--- CMD
--- TLM
--- NISN IOnet T&C Network
--- Wideband Data Network
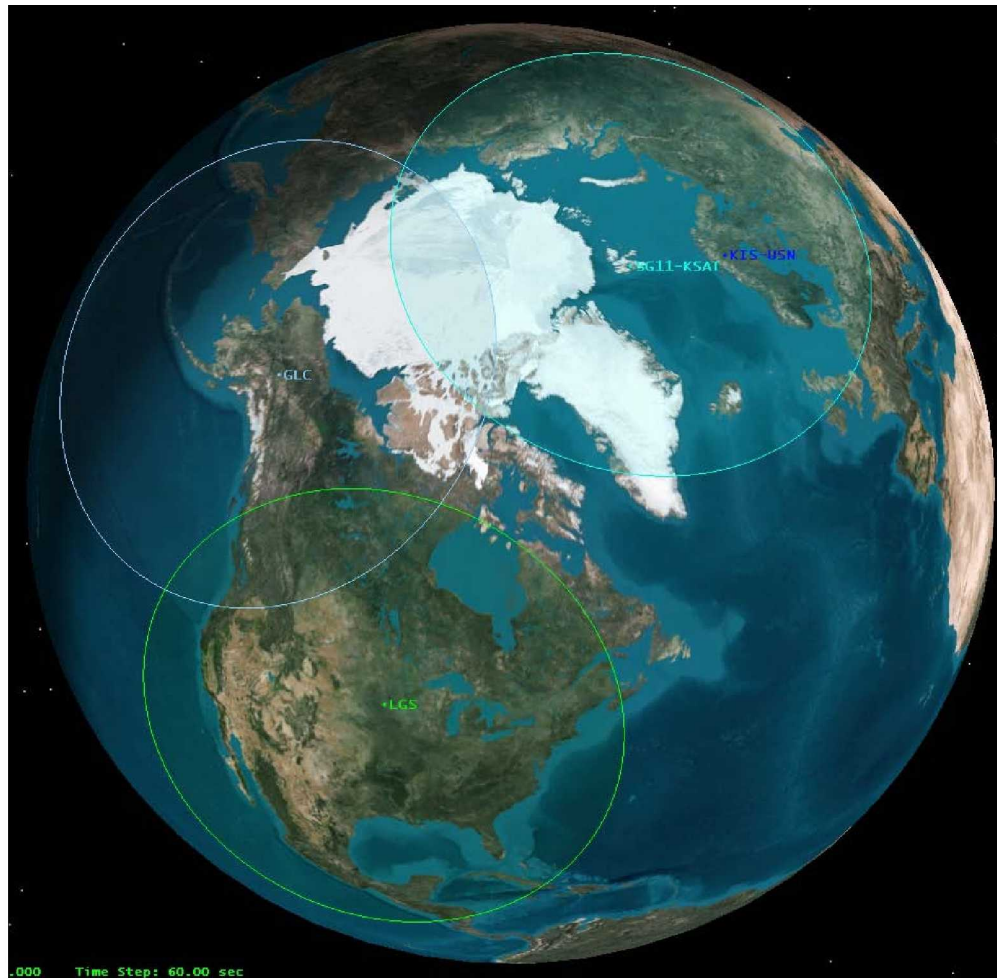
Ground Network Configuration

- **GLC – Gilmore Creek, AK**
  - 10-11 Passes/Day
  - Primary data Delivery via Internet 2
    - Defense Research & Engineering Network (DREN) used as backup

- **LGS – USGS/EROS**
  - 4-6 Passes/Day
  - Local Area Network (LAN) Connection to DPAS

- **Svalbard – NASA/GSFC**
  - Contingency passes to ensure sufficient contact time margin

RF Design

- SC to Ground RF design maximizes data portion of RF link:
  - High date rate (384 Data Mbps) uses entire X-band (8024 MHz - 8400 MHz) spectrum band allocation to near earth missions
  - Innovative design within X-band infrastructure without using Ka band
  - Low Data Parity Code (LDPC) 7/8 (7136/8160 bits) minimize overhead of error coding correction to data
    - DSN filter further challenges the spectrum from 400 to 374 Mhz
  - Compression rate 1.55:1
  - $1e^{-12}$ Bit Error Rate (BER)
- Ground receiver / demod key to meeting requirement
  - Gained understating of ETE RF design
  - Tuned demod performance/ programmable parameters

Avtec HDRM Programmable Demod

- Addresses Key LDCM Requirements
- RF Interface with S/C, OQPSK Demodulation
- Rate-7/8 Low Density Parity Check (LDPC) Forward Error Correction (FEC)
- Fully Configurable CCSDS Processing
  - Frame Synchronization, Virtual Channel Separation, and Packet Processing
    - OLI/TIRS RT, SSR PB, X-Band TLM
- CCSDS File Delivery Protocol (CFDP) class 1
  - Extract mission data files from CFDP wrapper and perform checksum validation on mission data files
  - Error handling of data
- Data capture
  - Write validated data files to internal disk
  - Spool validated data files to DCRSf
- Status and control
  - Return status information to station controller (Includes ACK/NAK messages)
  - Configure, load, enable, and disable stored unit configurations (desktops)

Mission ETE testing RF

LDPC	LDPC	LDPC	LDPC	LDPC	LDPC	LDPC	LDPC
Xmitter	Xmitter	Xmitter	Xmitter	Xmitter	Xmitter	Xmitter	Xmitter
DSN Filter	DSN Filter	DSN Filter		DSN Filter	DSN Filter	DSN Filter	DSN Filter
TWTA				TWTA	TWTA	TWTA	TWTA
Antenna						Antenna	Antenna

Antenna			Antenna			Antenna	Antenna
RF-IF chain		RF-IF chain	RF-IF chain	RF-IF chain	RF-IF chain	RF-IF chain	RF-IF chain
Receiver	Receiver	Receiver	Receiver Demod	Receiver Demod	Receiver Demod	Demod	Receiver Demod

Oct 2009*	**Dec 2009**	**Feb 2010**	**March 2010**	**Jun 2010**	**Aug 2011**	**Oct 2011**	**TBD**
GSFC Code 567 Simulation	GSFC LDPC Test	RF test at GD	Demod FAT at AVTEC	RF test at GD	CTV RF Compat at GD	EMI at GD	RF Suitcase Testing

✓ *✓* *✓* *✓*

* Simulation is updated over time with parameters gleaned from other tests for higher fidelity

Simulated - LOW	Simulated - Better	Similar Unit	Engineering Model	Actual Unit

USGS
U.S. Department of the Interior

RF Test Summary

LDCM

| Test	Objective
GSFC Simulation	Independent verification by analysis to show whether the link will work or not, and determine critical design factors, margins, etc. These models are updated as other tests provide refined data and the simulations are repeated to monitor the overall link predicted performance.
GSFC LDPC Test	Test the Avtec LDPC implementation for compliance against standard (not against spacecraft implementation).
Demod FAT	Factory Acceptance Test, including test of all protocol layers.
RF Test at GD (February)	Test performance of link with EM DSN filter for refined overall performance estimate.
RF Test at GD (April)	Test performance of link with addition of EM TWTA and actual LGN Avtec Demod.
EMI	I&T testing for interference – represents opportunity to test the entire actual observatory RF chain including antenna.
CTV RF Compat	Establish observatory compatibility with NEN, SN and LGN stations. Establish LGN Demod compatibility with observatory.
RF Suitcase	Test compatibility of entire LGN station with observatory. Done at each LGN station. Allows testing of track channels performance and signal optimization.

Ground Demod Test at GE

LDCM

Measured LDCM BER Curve

PN data was rate 7/8 LDPC encoded, modulated on a 1.2 GHz IF, up converted to 8.2 GHz, filtered to avoid the DSN band, down converted to 1.2 GHz IF, combined with AWGN, input to receiver and decoded.
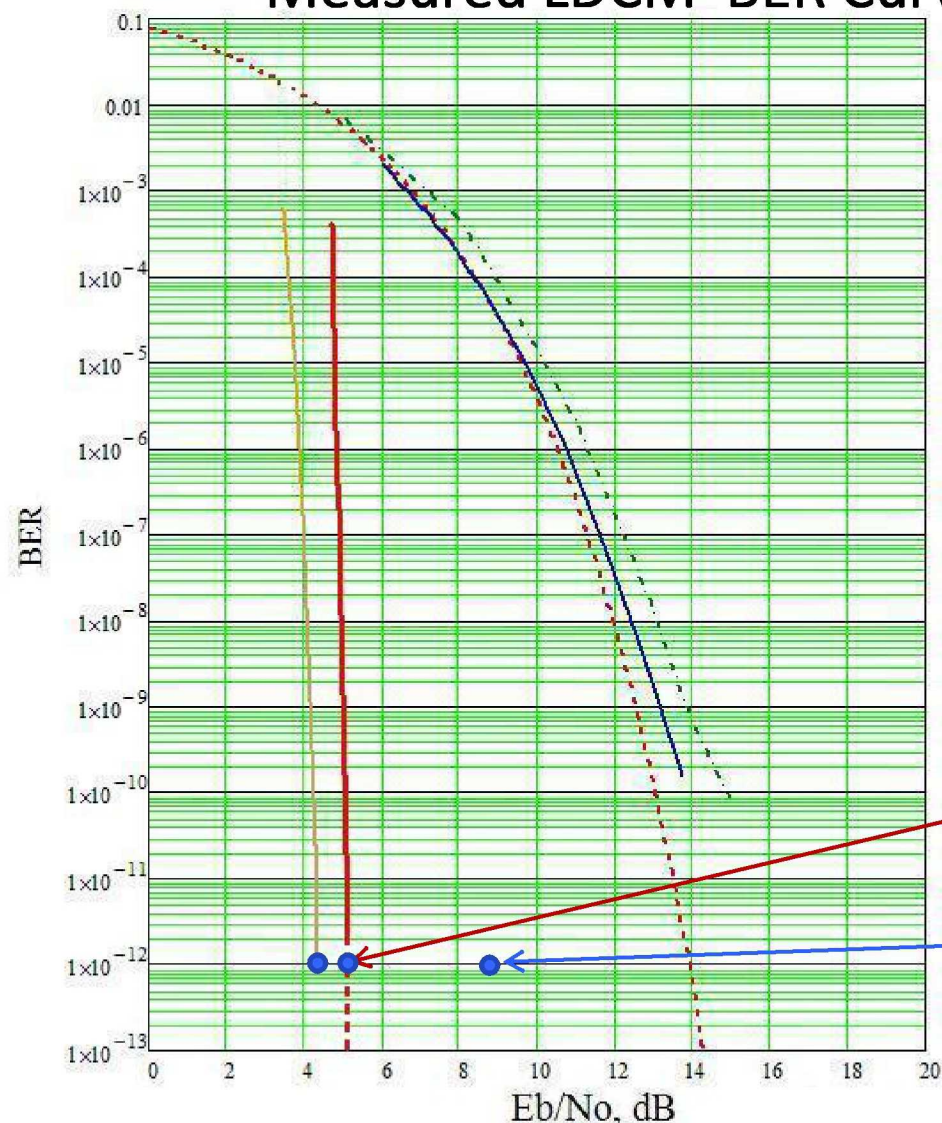
Red Line: Careful measurement with noise source allowed 0.1 dB precision.
Measurement repeated with two other commercial receivers resulted in similar curves.

Measured LDCM BER operating point. Less than 2 dB from ideal. Corrected from Es/No to Eb/No.

Allowed LDCM BER operating point 4.3 dB implementation loss allowed.

GSFC Measurement, Code 567 with receiver equalizer and SC filter
QPSK ideal
Uncoded, no filter
LDPC ideal
Uncoded, with filter

H. Garon, V. Sank, D Fisher, Jan 2010

U.S. Department o

CFDP –File management

- SSR management and relation to science processing key to flight to ground interface
  - LDCM uses Intervals for science, with SSR managed by files
  - CFDP – Class 1 used to send files to ground, Reciver/Demod converts to files, forwarded to Data Router (DCRS).
  - Deletion of files from recorder done as part of Interval management(off line LCDM tailored process).
- CFDF file size;
  - Needs to be defined: based on data rate (open windows), BER and Seaker recorder buffers multiples
  - LDCM – 1 GByte
- Should have simplified design and use files/CFDP with SC, and build intervals on Ground
  - Use CFDP-2 per Ground station, let protocol handled SSR management
  - Retransmit uncompleted Files on next contact

Lesson Learned

	LDCM design	Lesson
LDPC 7/8	Works well, and is a way to optimize spectrum use	
High downlink rate	Design based on maximize use of spectrum and reduce contact time. Downlink rate (384 Mbps) higher than C&DH rate (320 Mbps)	Consider using Real Time rate same as C&DH and increase contact times
DSN /Wide band filter	Requires programmable receiver	Testing indicates that programmable receiver corrects most of filter distortion
RSDO Spec	Specification. Calls for fixed rates	Define multiple data rates in spec (at least one more lower rate)
SSR	. tailoring for directories (scenes), requires complicated SSR management	Use files /structure supported by SSR vendor
CFDP	Class -1.	Use Class -1 or Class 2 simplified (over one GS)
File size	1 GByte	No bigger than 1 Gbit, Allow optional smaller file size
SC interface	Improved interfaces after SC CDR	Work with vendor early/often

Lesson Learned

LDCM

- Build good working relation between operations and with RSDO SC vendor

- Availability of high speed internet link key for station capability
  - Equipment is cheap compared to internet

- Allow flexibility in design with optional data rates and file sizes

- Simplify SSR management file/ mission data management approach

- LDPC works
  - LDPC 7/8 good option to reduce coding overhead
  - Wide band distortion (DSN filter) are corrected by programmable receiver

Summary

- ◆ Hardware to support design is cheap 140K
- ◆ Projects are talking…
  - • IRIS engaged in discussion with LDCM
  - • CLARREO good candidate to use LDCM design features (LDPC, CFDP)
  - • Earth mission require compatibility with NOAA, Internationals
- ◆ NENS to improve interfaces with projects:
  - • NPP and LDCM spent money to upgrade KSAT Svalbard
  - • No clear road map or commitments (e.g OQPSK)
  - • Need single point of contact in 450 (NIMO ?)
- ◆ NENS viable option for LDCM after IOC if upgrades (Svalbard) available by 12/12/12