SDO Ground System

Raymond J. Pages

SDO Ground System Manager

Agenda

- **Ground System Overview……..R. Pages (15 min.)**
  - Requirements Overview
  - Ground System Architecture
- **SDO Ground Station & Data Facility……...C. Liptak (20 min.)**
  - Implementation Concept
    - Location
    - Station Implementation
    - Testing/Verification
- **Data Distribution System & Communications……..…T. Bialas (20 min.)**
  - Implementation Concept
    - Latency
    - Retransmission
    - Storage
- **SDO MOC & Spacecraft Operations…….……H.Tann (20 min.)**
  - Operations phases
  - Implementation Approach
  - I&T Support
- **Summary……..……W. Potter (20 min.)**
  - Ground System Heritage
  - Trade Studies/White Papers
  - Risk Assessment & Mitigation
  - Ground System Status

Ground System Overview

Raymond J. Pages

Ground System Requirements

Driving Mission Requirements on the Ground System

- **Data Capture – 99.99% of all science data, 95% of the time**
  - Antenna location needs to be in a dry environment
  - 30-day science archive with retransmission capability
  - Redundant systems in data capture path, i.e., antennas and Front-End Processors

- **Data Delivery –**

  Ka-band data delivered within 3 minutes (due to data volume)

  S-Band data delivered within 1 minute (due to instrument status needs)
  - Dedicated Ka-band ground station capability
  - Dedicated High-speed, large bandwidth and reliable science data network
  - Ground station and data transport infrastructure

Ground System Requirements (cont.)

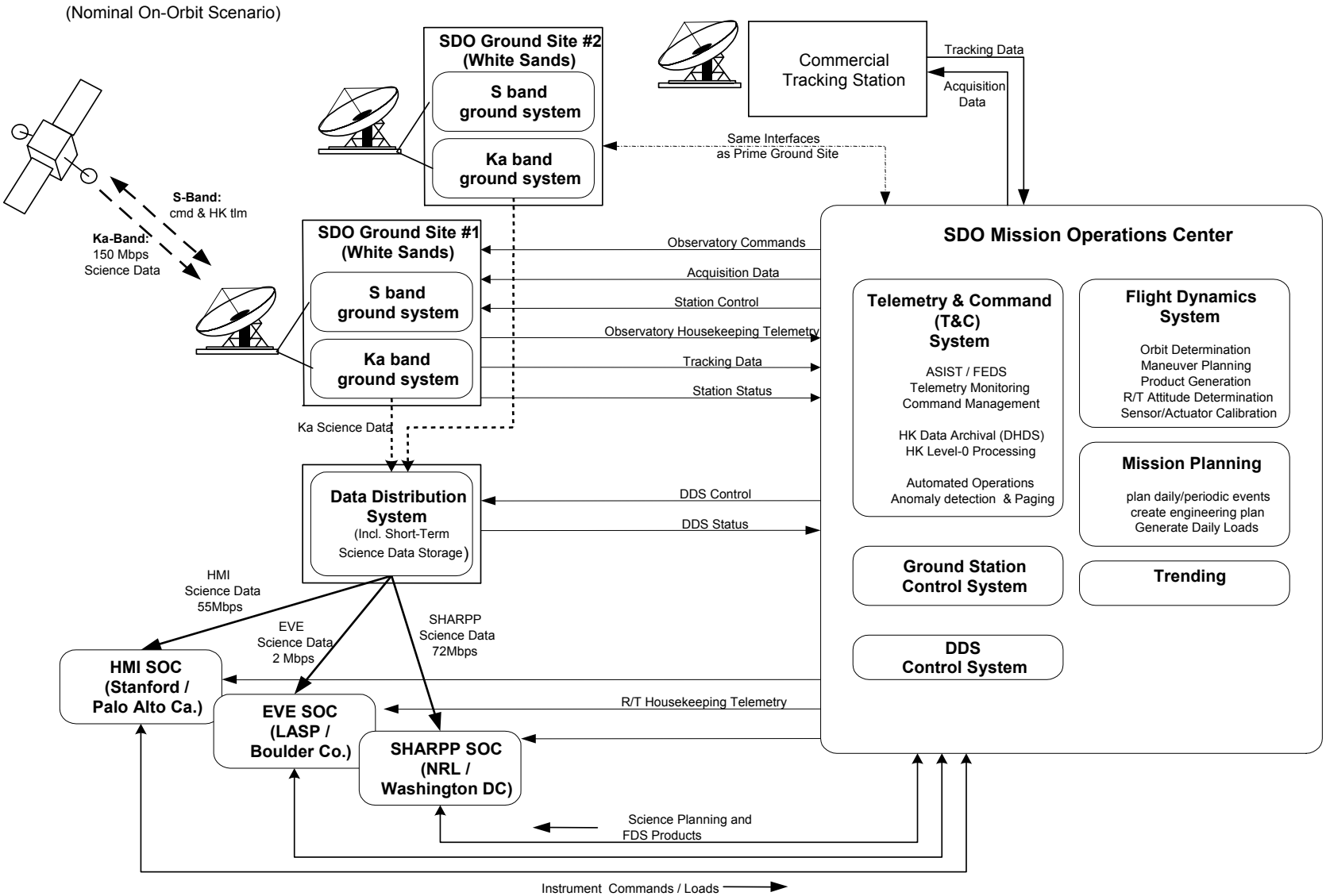
Driving Mission Requirements on the Ground System

- **Continuous Science Telemetry – Approximately 150 Mbps of science data, 24x7 for the 5-year life of the mission**
  - Ground system automation
  - Long-term reliability of system components
  - Dual data capture streams

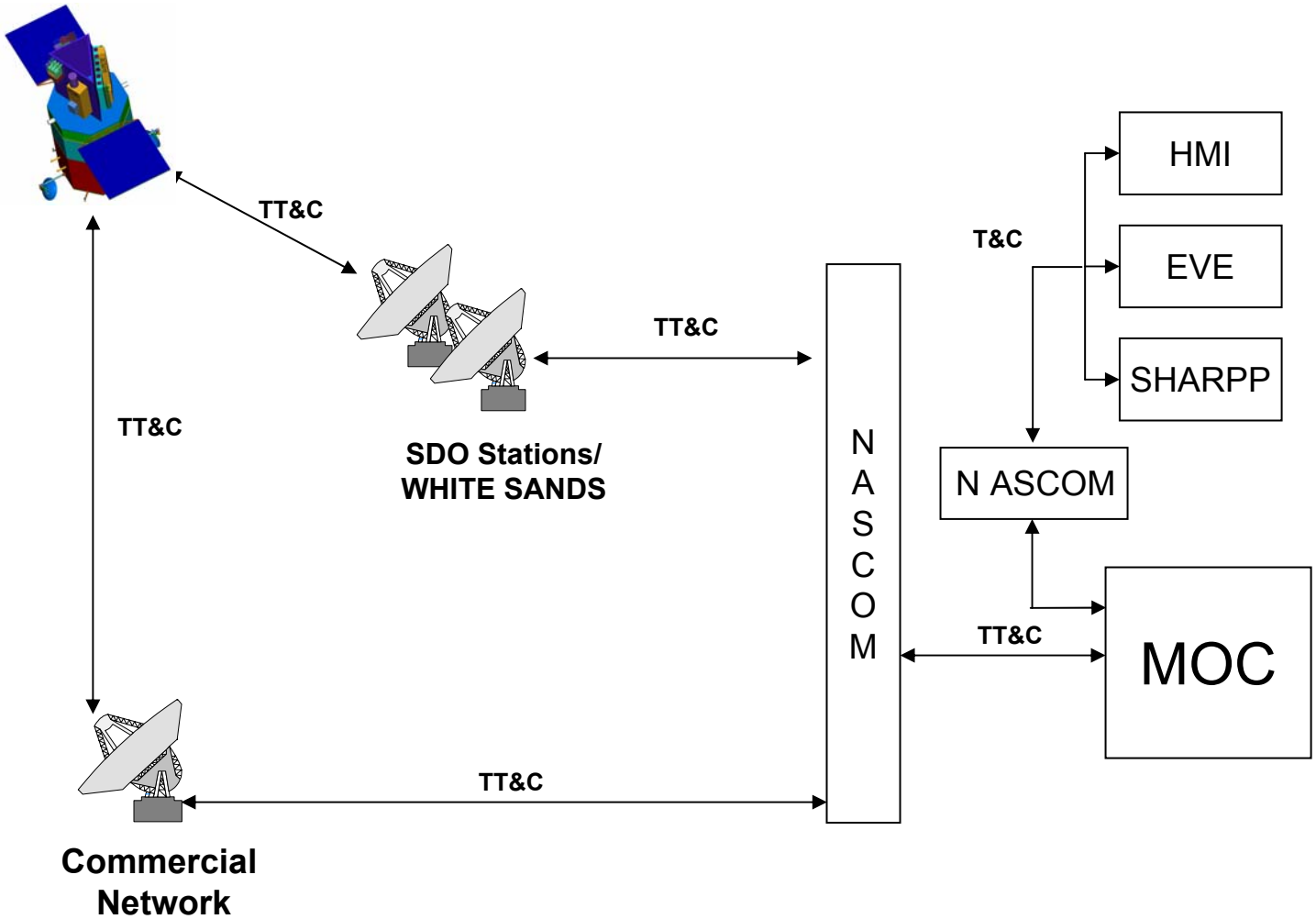
- **Science Ops Centers – SOCs located with investigator teams**
  - High-speed, large bandwidth and reliable science data network
  - Remote instrument commanding relative to MOC location

- **All ground system requirements to date are captured in the MRD (Level-1 and Level–2) and the Detailed Mission Requirements (DMR) (Level-3) with traceability back to the MRD**

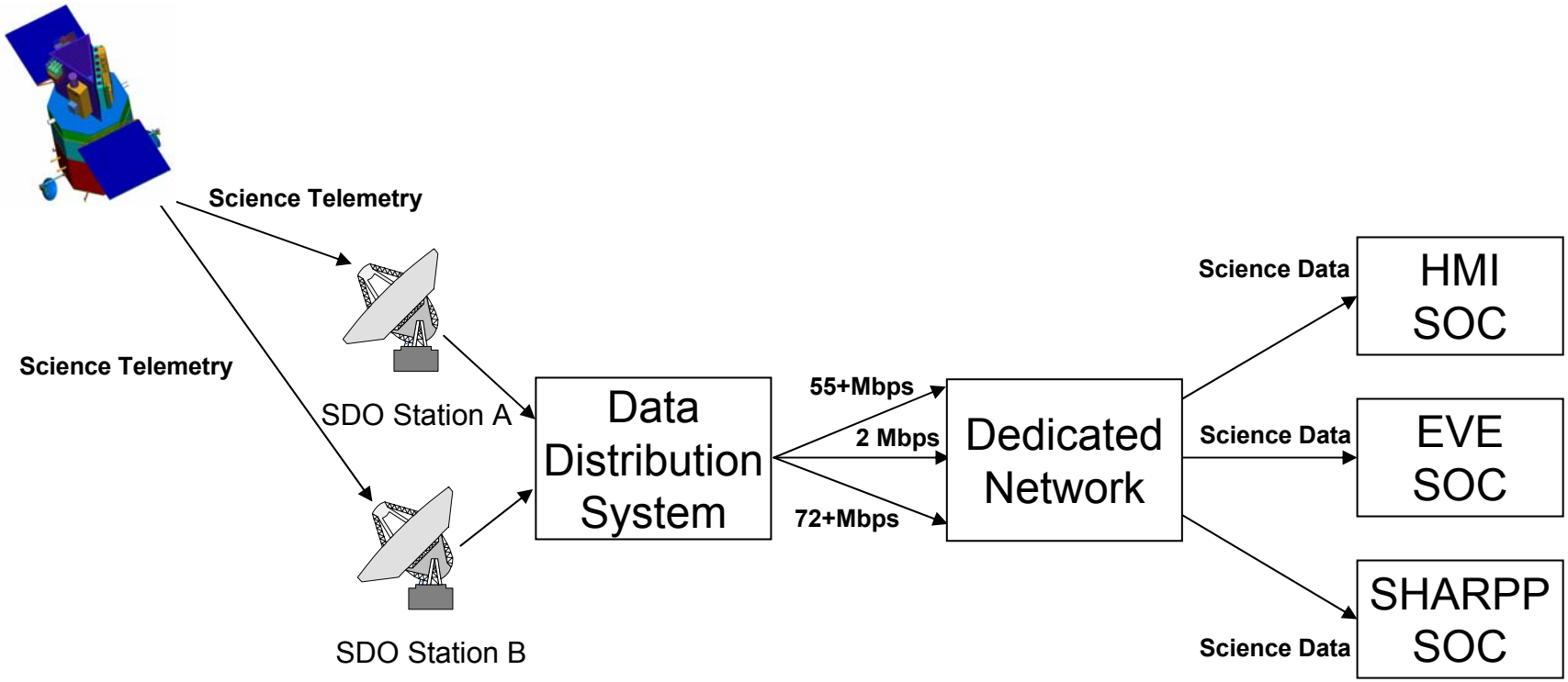
SDO Ground System Architecture



Commanding & Housekeeping Telemetry - S-Band Data Flow



Science Telemetry - Ka-Band Data Flow



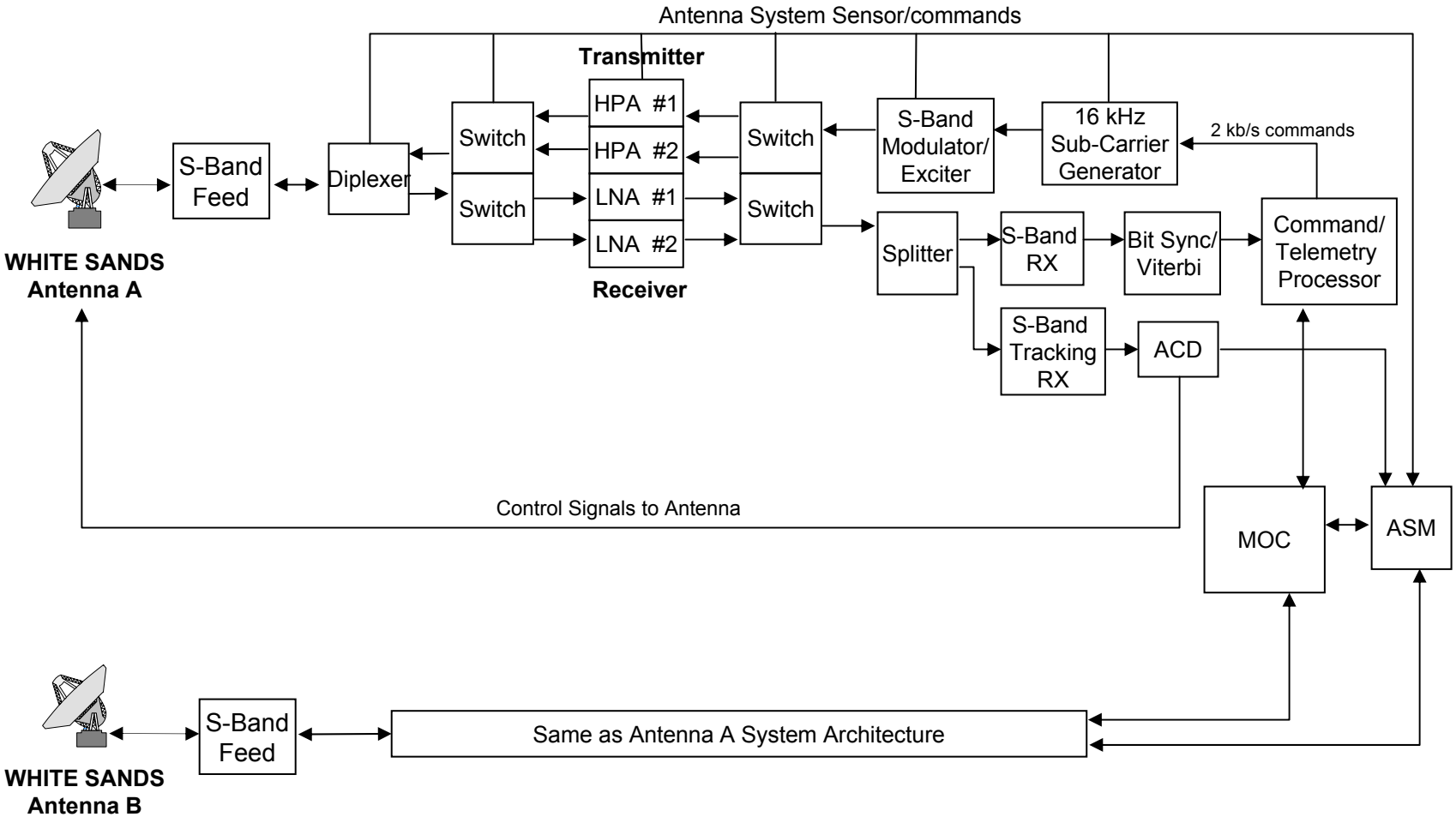
SDO Ground Station
&
Data Facility

Chuck Liptak

Antenna Utilization

- **Two 9-meter antennas configured for S-band and Ka-band; both required to support high rate data capture**
  - Weather (rain, clouds)
  - Maintenance
  - Failures (mechanical, electrical)
- **Antennas will be located at White Sands NM approximately 3 miles apart**
- **RF to optical converters will be used to provide Ka-band connectivity between secondary and primary sites or a co-located Front-End Processor (FEP) will be installed**
- **Both antennas will be online all the time capturing telemetry and forwarding it to the DDS**
- **Each antenna will have redundant low noise amplifiers (LNA's) and power amplifiers**
- **All critical antenna components will contain health and safety sensors feeding data to the MOC**
- **Antenna operations will be automated but monitored and controlled from the MOC during normal mission operations**

S-Band RF Configuration



S-Band Description

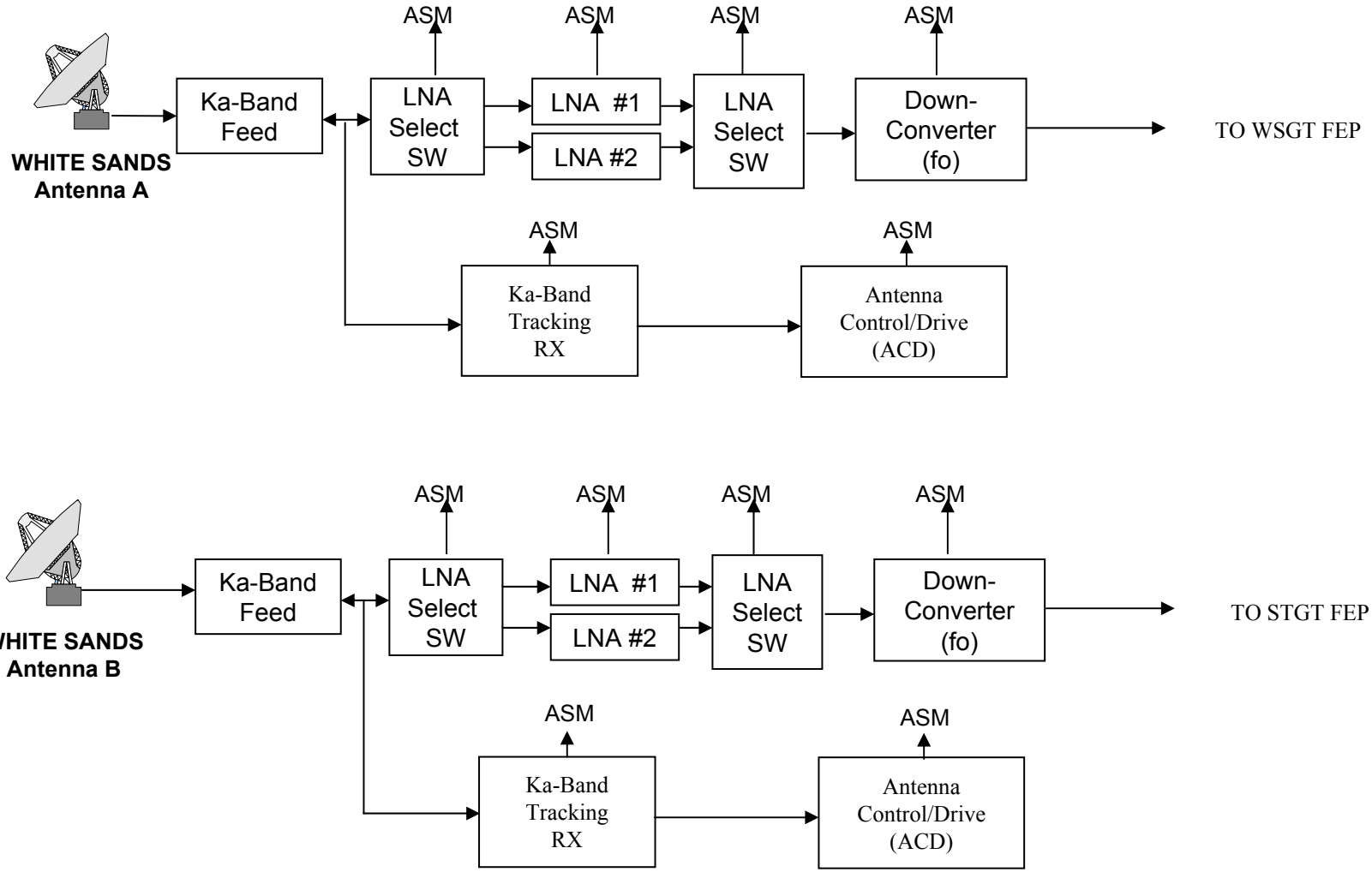
- **A diplexer is used to isolate the uplink and downlink paths**

- **The downlink path consists of a LNA, main S-band receiver and a tracking receiver**
  - The main S-band receiver's output is routed through a Bit Sync to the command and telemetry processor which forwards the data to the MOC
  - The output of the tracking receiver is routed to the antenna control and drive which ensures proper pointing of the antenna (Auto-track)

- **The uplink path consists of an S-band modulator exciter and a power amplifier**
  - Commands destined for the spacecraft come through the command and telemetry processor to the S-band modulator exciter

- **The S-band will provide:**
  - 2 Kbps uplink for commanding
  - 32 Kbps for health and safety real-time downlink, plus 32 Kbps for housekeeping dumps to the MOC
  - Initial signal acquisition
  - Provide tracking and Doppler data

Ka-Band RF Configuration



Ka-Band Description

- **The spacecraft signal will be received on a frequency of 26.5 GHz and amplified by the LNAs prior to down conversion to a lower intermediate frequency (IF)**

- **An optical converter will be used to allow the signal from the STGT (northern antenna) to reach the WSGT (southern) site using fiber optics or co-located FEP**

- **The Ka-band receiver demodulates high rate science data from the spacecraft**

- **The Ka-band system will provide:**
  - continuous downlink, high rate science data
  - precision antenna pointing

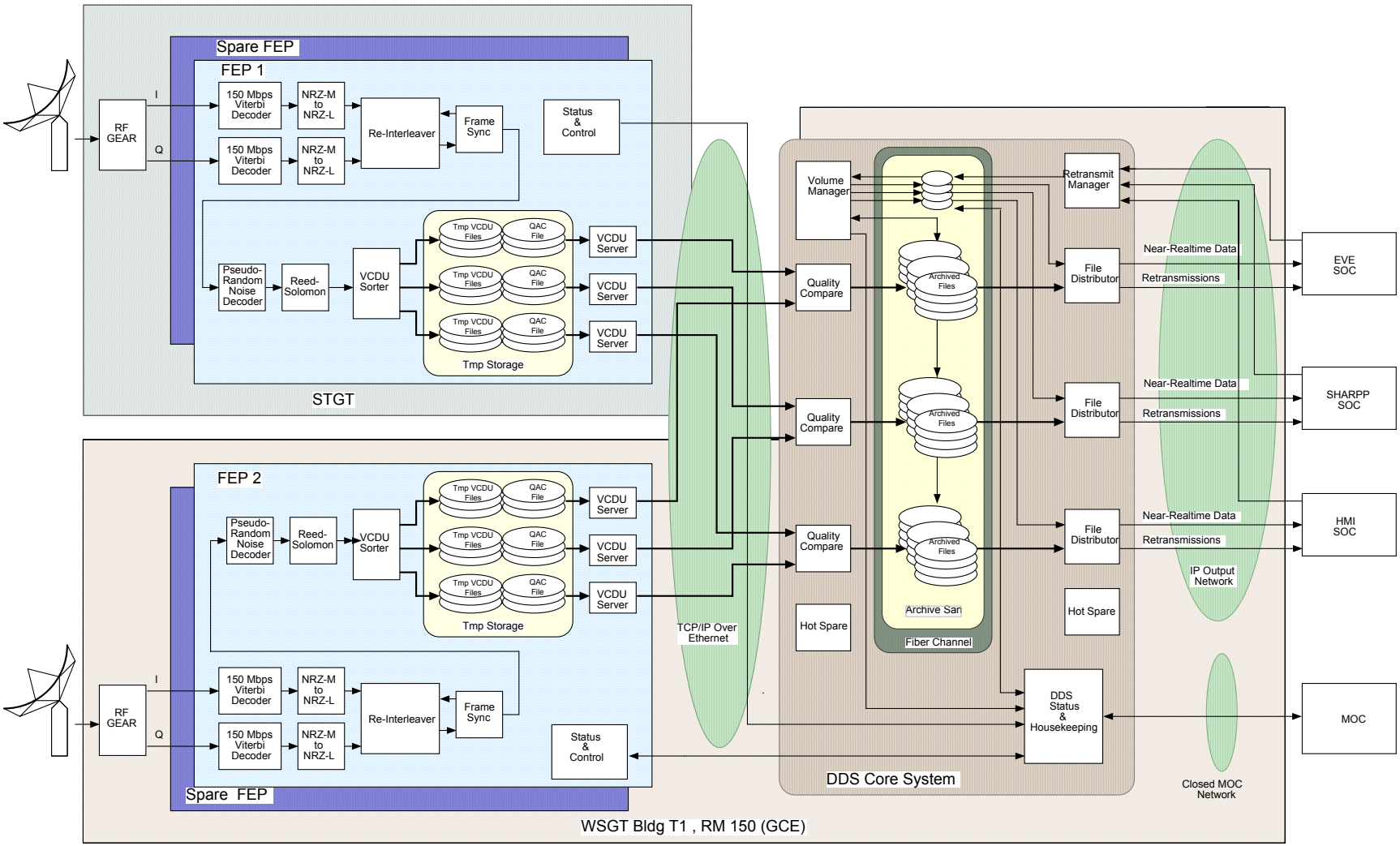
Ground Station Facility

- **White Sands weather studies indicate the environment is highly desirable for Ka-band**
- **White Sands Complex has extensive infrastructure resources available for SDO**
  - One pad is already poured; the second will require a pad to be installed
  - Building T1, Room 150 is available to house SDO systems with raised flooring and air conditioning in place
  - Facility UPS is currently at 33% capacity and includes diesel and battery sources
  - Secure facility
  - Fiber-optics connectivity in place between pad sites and Building T1
  - MOU between GSFC and JSC is being written and expected to be signed by July 2003
- **White Sands Complex has experienced staff on GSFC-managed contracts**

Data Distribution System
&
Communications

Tom Bialas

DDS Block Diagram



DDS Description and Functions

- **All Ka Band data will be decoded and temporarily stored as VCDUs at the Front End Processor (FEP) in a 2 day circular Buffer**
  - A set of files will be created for each Instrument
- **The FEPs will be located at the antenna sites**
- **Instrument VCDU Files will be transferred from the FEPs in real time to the DDS Core System**
- **The DDS Core system will accept data from either or both FEPs**
- **A "Best Quality" Instrument data file will be generated from the FEP data sets**
  - Whether “Best Quality” is file or VCDU based is TBD
  - The "Best Quality" data files will be stored on line for 30 days then deleted
  - Quality and Accounting (QAC) files will be generated for each Instrument file
- **Instrument data files and QACs will be automatically transferred to the SOCs with minimal delay (Approx. 1 min)**
- **A data catalog will be maintained to facilitate re-transmission and deletion**
- **Re-transmissions will be done only at the request of the SOCs via a file handshake protocol**

DDS - SOC Interface

- **As data sets (VCDU and QAC files) become available, the DDS will attempt to deliver them one time**
- **Once an hour, on the hour, the DDS will send a delivery status file (DSF) to each SOC containing the file names of all the telemetry files that the DDS has, that have not yet been acknowledged by the SOC(s)**
  - The DSF will contain ASCII text entries as follow:

    <filename>, <size>, <status>

    <filename> will be formatted as shown above.

    <size> will be the size of the file in bytes.

    <status> will be a numerical field that can have one of three values:

    0 - Delivery Pending; File has not been delivered for whatever reason

    1 - Delivered; DDS thinks file has been delivered, waiting for SOC ACK

    2 - Retransmit; SOC requested a retransmit, retransmit queued
- **Upon receipt of the DSF, the SOC will check all the delivery pending and delivered files against what it has successfully received and create an acknowledgement status file (ASF)**
- **The ASF file will contain ASCII text entries identical in format to that of the DSF file.**
  - The <status> field will have one of 3 values:

    0 - Delivery Pending; File has not been delivered for whatever reason

    1 - N/A

    2 - Retransmit; SOC requested a retransmit

DDS - SOC Interface (cont.)

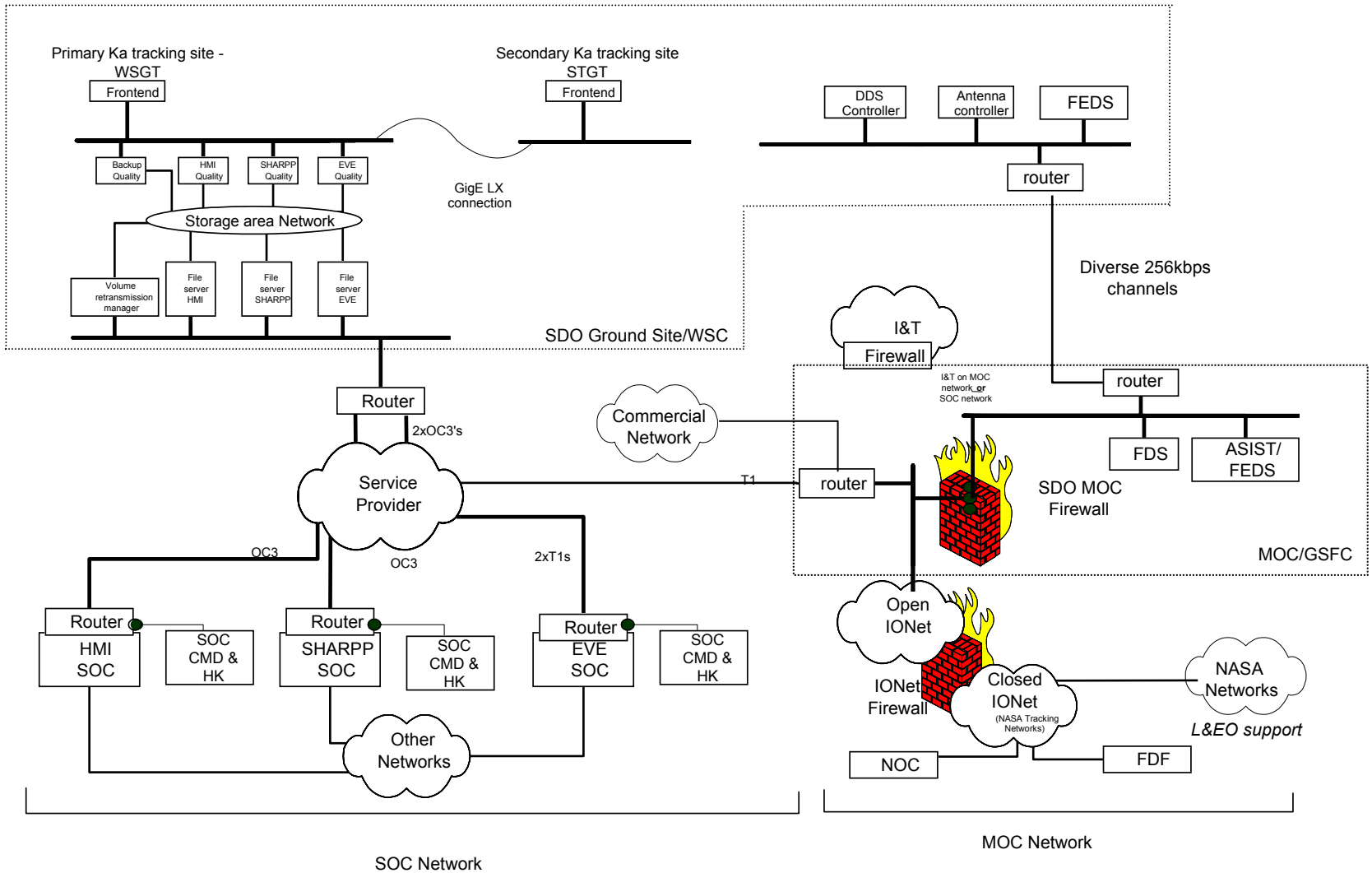
- **DDS will retrieve the ASF and retransmit all files with status of "2" as bandwidth allows**
  - Any file in the DDS inventory can be added and marked for retransmission
- **At the end of each day the SOC will create an acknowledgement file (ACK) containing the TLM file names that have been archived successfully on that day**
  - The ACK file will contain ASCII text entries identical in format to that of the DSF file
  - The <status> field will have one value:

    3 - SOC Acknowledged, SOC acknowledging receipt of file
- **The DDS will notify the SOC via email of any files that have not been acknowledged and are more than 20 days old**
- **Files 30 days old will be deleted**

Expected Latency and Throughput

- **150Mbps aggregate downlink**
- **HMI**
  - 55 Mbps
  - ~1 minute latency through DDS expected
  - Files of VCDUs will be delivered to HMI SOC
- **SHARPP**
  - 72 Mbps
  - ~1 minute latency through DDS expected
  - Files of VCDUs will be delivered to SHARPP SOC
- **EVE**
  - 2 Mbps
  - ~1 minute latency through DDS expected
  - Files of Packets will be delivered to EVE SOC

SDO Network Connectivity Diagram



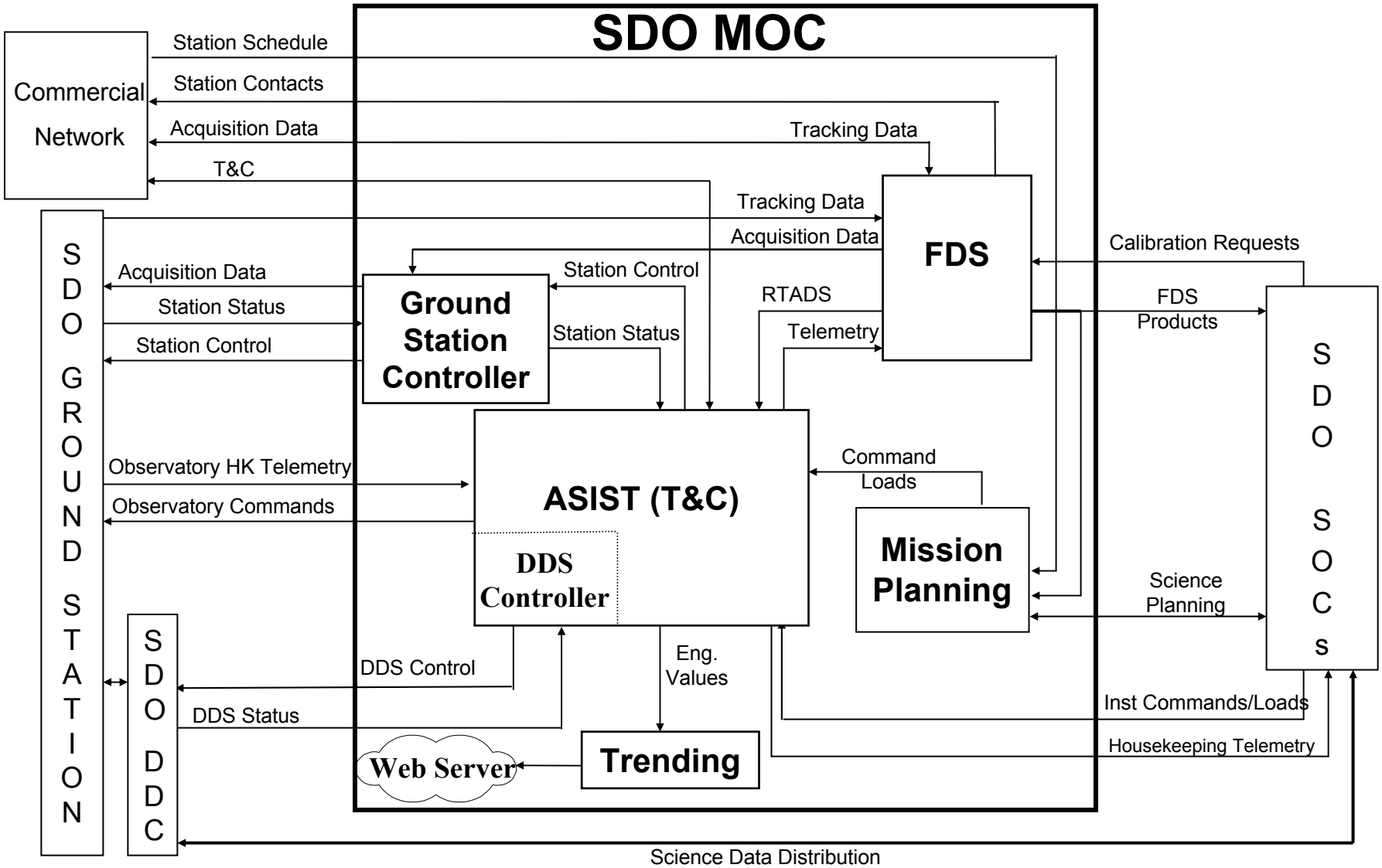
Communications Rationale

- Dedicated MOC connection will be used for TT&C, antenna control, and DDS control
- Provides operational isolation for high rate science interfaces without firewalls
- Ground station-to-MOC link is real-time mission critical; mean time to restore service should be no more than 2 minutes
- DDS-to-SOCs links are not mission critical; mean time to restore service should be no more than 8 hours
- Based on today's pricing structure, the bandwidth of science data lines for HMI and SHARPP would each be OC3 and two T1s to EVE
- Leverage NASA communication assets: network operations personnel and data lines wherever possible

SDO Mission Operations Center

Hun Tann

Mission Operations Center - Architecture



Telemetry & Command System

ASIST is the SDO Telemetry & Command (T&C) system which will be used for spacecraft integration and test activities as well as on-orbit operations. It will:

- **Process and send commands conforming to the CCSDS protocol to the spacecraft via the SDO ground station**
- **Accept real-time commands from FOT inputs, command loads generated by the Mission Planning System (MPS), and spacecraft table or flight software memory loads**
- **Allow science command capability from each SDO SOC for instrument commands only (via the MOC)**
- **Validate all commands and flag critical commands; the FOT must approve all critical commands before uplink to the spacecraft**
- **Accept and process the SDO Observatory housekeeping telemetry conforming to the CCSDS data format**

Telemetry & Command System (cont.)

- Monitor the Observatory health and safety in both real time and offline data analysis
- Distribute housekeeping telemetry from the MOC in real-time to each SOC
- Capture clock correlation data to ~100 msec accuracy
- Create and maintain one sequential archive of Observatory housekeeping data at the VCDU level for the life of the mission
- Automatically transmit 24-hour data sets of recorded housekeeping telemetry to SOCs

Ground Station Controller

- Requirements analysis for possible candidate systems is in progress
- Allow the FOT to remotely control the ground station and monitor the status of the RF link from the MOC
- Ground Station operates autonomously. It can be controlled locally, but the default operational mode is set to the MOC
- The controlling capability may be integrated within the ASIST or may be via a dedicated workstation in the MOC

Data Distribution System Controller

- Requirements analysis for possible candidate systems is in progress
- Monitor the Data Distribution System operational status including data capture, science data distribution, and retransmissions
- A controlling capability will be integrated within the ASIST

Mission Planning System

- Requirements analysis for possible candidate systems is in progress
- Generate a consolidated timeline of activities for observatory planning
- Ingest and display FDS products and generate maneuver plan and commands
- Schedule activities/commands related to orbital/GS/USN/TDRSS events
- Produce spacecraft stored command plans and output them to the ASIST for load generation and uplink

Flight Dynamics System

- **Systems identified for SDO Flight Dynamics support include**
  - STK PRO for planning and scheduling
  - GTDS/RTOD for orbit determination and state vector generation
  - MATLAB ADS for attitude solutions and residuals
  - RTADS for real-time attitude determination
  - FREEFLYER for maneuvers, ephemeris and acquisition data generation

- **Orbit determination and prediction**
  - Ingest and pre-process 2-way coherent tracking data and/or GPS state vectors and use to compute orbit solutions. Tracking data will be delivered directly to the MOC
  - Propagate the orbit solutions for product generation and OBC validation

- **Orbit maneuver control and station keeping**
  - Plan and calibrate orbit maneuvers required to achieve the mission orbit and provide East-West station keeping; approximately two station-keeping maneuvers per year

- **Acquisition data generation and delivery**
  - Provide acquisition data to all ground stations. Generate and deliver the acquisition data directly from the MOC

Flight Dynamics System (cont.)

- **Attitude Determination**
  - Provide validation of on-board attitude and compute real time attitude for display in the MOC
- **Attitude control & momentum management**
  - Compute data to generate attitude slew commands for orbit maneuvers and sensor and instrument commands
  - Develop a momentum management plan in concert with the ACS and Instrument teams; currently analysis indicates a momentum dump once per month
- **Orbit and attitude product generation**
  - Generate all required orbit and attitude products for spacecraft health and safety and science planning and operations

Flight Dynamics Operations

A Week in the Life of the SDO Flight Dynamics in the MOC

S	M	T	W	T	F	S
	EXTRACT PLAYBACK ATTITUDE DATA FROM TELEMETRY	PLAN STATIONKEEPING MANEUVER *(IF REQUIRED)*	EXECUTE STATIONKEEPING MANEUVER *(IF REQUIRED)*	EXTRACT PLAYBACK ATTITUDE DATA FROM TELEMETRY	CALIBRATE STATIONKEEPING MANEUVER *(IF REQUIRED)*	
	VALIDATE ONBOARD ATTITUDE	COMPUTE POST-MANEUVER EPVs & IIRVS *(IF REQUIRED)*	DUMP MOMENTUM *(IF REQUIRED)*	VALIDATE ONBOARD ATTITUDE	UPDATE PROPELLANT USAGE	
	PREPROCESS TRACKING DATA	CALIBRATE ADS SENSORS, TAMS, STARTRKR, ETC. *(IF REQUIRED)*	COMPUTE INSTRUMENT CALIBRATION PLANS *(IF REQUIRED)*	PREPROCESS TRACKING DATA	COLLECT S-BAND TRACKING DATA	
	PERFORM S -BAND ORBIT DETERMINATION	COLLECT S-BAND TRACKING DATA	COMPUTE AND UPLOAD ON -BOARD TABLES & EPVs *(IF REQUIRED)*	PERFORM S-BAND ORBIT DETERMINATION		
	COMPUTE (8 -DAY) ORBIT EPHEMERIS STARTING TUESDAY @ 0:00 UTC			COMPUTE (37 -DAY) ORBIT EPHEMERIS STARTING THURSDAY @ 0:00 UTC		
	COMPUTE & DELIVER EPVs & IIRVs			COMPUTE & DELIVER EPVs & IIRVs		
	COMPUTE THE REAL TIME ATTIUDE DISPLAY (RTADS) RUNS CONTINUOUSLY			COMPUTE & DELIVER (35-DAY) FDS PRODUCTS SET STARTING FRIDAY @ 0:00 UTC		

Note: RTADS IS RUNNING NEAR CONTINUOUSLY

Trending System

- Requirements analysis for possible candidate systems is in progress
- Subset and store engineering data
- Provide for easy plotting of selected mnemonics (all samples available for 30 days)
- Provide easy plotting of Min, Max, Mean of selected parameters for the life of the mission (pre-defined subset time frame – hourly, daily)

Automated Operations

- Requirements analysis for possible candidate systems is in progress
- Monitor observatory telemetry, event log, ground station and DDS performance
- Monitor for line outages
- Page FOT and SOC personnel based on an event trigger and send pre-programmed data via the paging system that will include limited event messages and telemetry mnemonics

MOC Facility

The SDO MOC will be located on the second floor of Building 14, at GSFC

- **2,800 ft^2 of raised floor space allotted**
- **Two technical load centers for redundant power sources**
- **Diesel Power available for Launch support**
- **Plenty of UPS power and cooling capacity**
- **More floor space available for expansion if needed**
- **Existing NASCOM voice, GMT, data line drops**
- **Keycard system in place**
- **Lower renovation cost using existing MOC**

Spacecraft Operations

Hun Tann

SDO Operations Team Roles

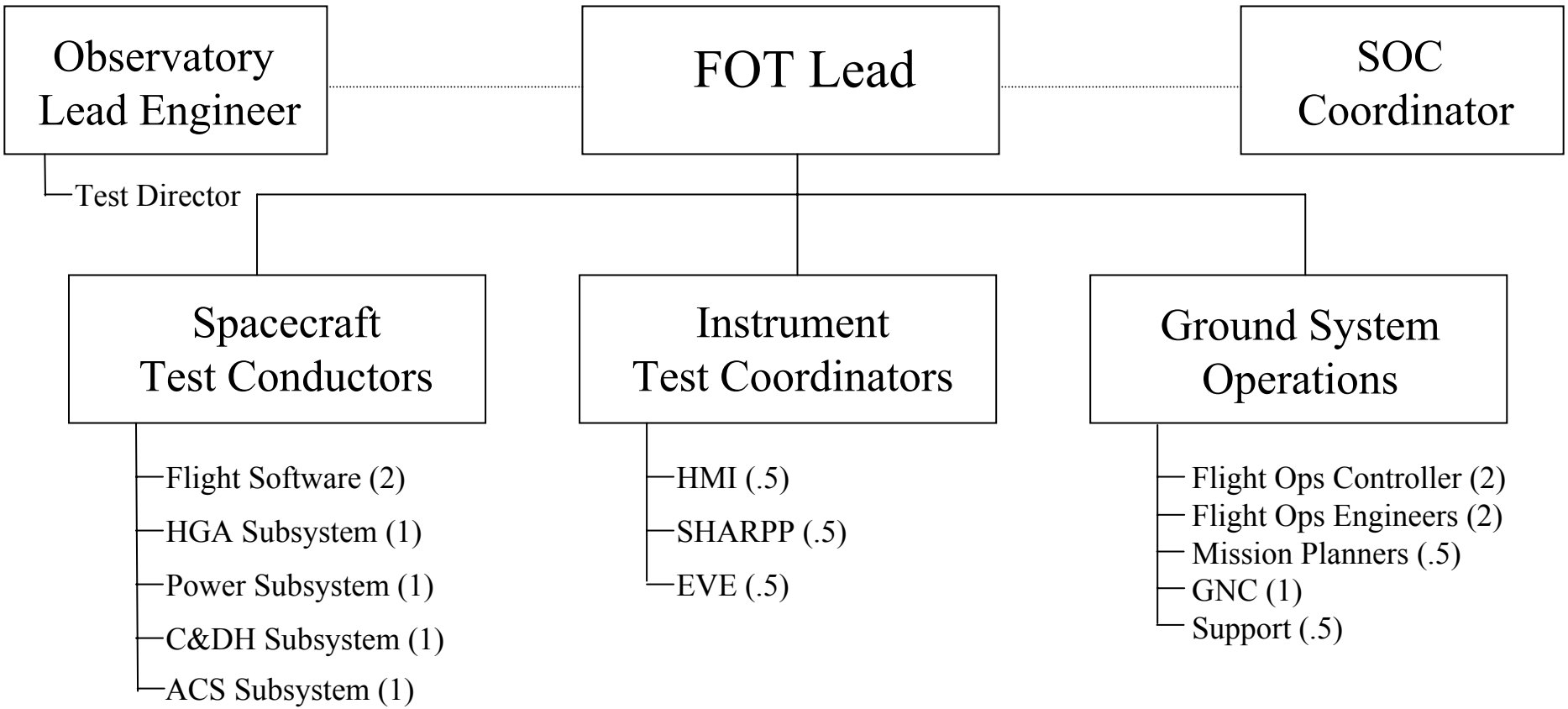
- **SDO flight operations members provide support in three areas**
  - Pre-mission operations support
  - Test conductor support for spacecraft, instrument and observatory I&T
  - On-orbit operations support

- **Members perform cross-functional tasks**
  - Personnel will have primary roles but will perform additional functions to provide backup support for I&T and/or operations testing/development
  - Operations team will have previous I&T and/or pre-mission experience

- **Observatory lead engineer will coordinate I&T activities with pre-launch ground system testing**

- **SOC coordinator will facilitate principal investigator interfaces and support science planning activities**

Preliminary Operations Organization



Observatory I&T Phases

	SDO Ground Elements	Bread Board	Flight Subsystems	Spacecraft Integration	Instrument I&T	Observatory I&T	End-to-End Testing	Simulations	Launch Site
GSFC	**FOT**	• FSW Lab test support • Deliver & operate 4 ASIST W/S	• FSW procs • C&DH procs • PSE procs • HGA procs • ACS procs • Deliver & operate 6 ASIST W/S	• Update & test procs • Begin D/B development • Deliver & operate 3 ASIST W/S	• EVE procs • HMI procs • SHARPP procs • Augment D/B w/ instrument inputs	• Complete D/B dev	• Training • System validation • Test • Exercise • Control	• Training • Proc validation • Exercise	• Launch rehearsals • Observatory checkout
GSFC	**MOC**			• Support Spacecraft testing		• Support Observatory testing	• Subsystem coordination • MOC validation	• Proc & subsystem validation	• Command & control Observatory
GSFC	**DDS**		• High-Speed FEDS Prototype	• High-Speed FEDS	• Maintain High-Speed FEDS	• Maintain High-Speed FEDS	• Validate & exercise	• Validate & exercise	
SOC	**Instrument GSE**				• Provide command & proc inputs •Validate instruments	• Provide command & proc inputs	• Provide command & proc inputs	• Provide command & proc inputs	• Provide command & proc inputs
SOC	**SOC**						• Validate commands & procs	• Validate & exercise	

Instrument I&T Ground System Support

- **Instrument Integration and Observatory level testing will be conducted locally at GSFC**
  - Instrument test coordinators and spacecraft Test Conductors (TC)s to be located at the I&T center to facilitate coordination with observatory engineers
  - Housekeeping Telemetry will be distributed in real-time to the SOCs

- **The core Telemetry and Command system for SDO observatory I&T is the ASIST/FEDS system**
  - TCs will support the instrument teams for component and observatory level testing as well as database and procedure development
  - An ASIST T&C system may be supplied to instrument teams on request for component (and observatory) level testing
  - SOCs using their own system for On-Orbit Telemetry and Command (T&C) are expected to use the same system for Instrument I&T
    - The Instrument T&C system will to interface with ASIST/FEDS for I&T (just as it will for On-Orbit operations)
    - A subset of the Project Database must be available to the ASIST system to facilitate observatory level tests, where instrument cmd and tlm may need to be integrated into observatory procedures, or for integrated analysis of instruments and S/C data

Science Data & Spacecraft E-T-E Testing

- **Assumptions for High Rate Science Data Testing**
  - Must have a way to test each interface of the E-T-E high rate science data path
    - Verify science data integrity from its generation at the instrument through the S/C downlink path during environmental tests etc
    - Separate composite science data into individual instrument data streams
    - Validate the science data ground segment infrastructure from the ground station, through DDS, to each SOC
  - Currently, there are no plans to deliver science data to the SOCs in real-time, either directly or via a connection from GSFC to the White Sands Ground Station at ~150Mbps
    - Typically, recorded science data will be shipped to White Sands for replay and distribution to the SOCs
    - For certain E-T-E tests, it will be desirable to ship encoded science data to White Sands for distribution to the SOCs to exercise the full E-T-E path from the observatory to the SOCs . Cost and resource availability will be considered.
  - The Ka downlink rate is fixed at 150 Mbps and cannot slow down to support E-T-E in R/T
  - Science data will be evaluated locally and during the tests
    - Provide immediate evaluation of data integrity through the S/C and real-time problem detection during time constrained tests (i.e. Thermal-Vac)
  - Instruments' data contents will support Mission Readiness Testing (MRT) E-T-E data validation
    - instrument electronics can produce a pattern inside the data, or instrument has GSE stimulus "or target" to provide a valid science data source

Ground System I&T Phases

SDO Ground Elements	Subsystem Tests	Ground System I/F Tests	S-Band T&C Data Tests	Science Data Process Test	S-Band & Ka-Band RF Tests	End-to-End Testing	Simulations	Launch Site
FOT	• Perform acceptance testing	• Test • Exercise	• Test • Exercise • Verify	• Exercise DDS control & status	• Exercise antenna control & status	• Training • Requirements validation • Test • Exercise • Control	• Training • Proc validation • Exercise	• Launch rehearsals • Observatory checkout
MOC	• Acceptance testing	• Test • Exercise	• Test • Exercise	• Test • Exercise	• Test • Exercise	• Control FOT ops	• Control FOT ops	• Control FOT ops
DDS	• Acceptance testing	• Test • Exercise	NA	• Test & exercise data distribution	• Exercise data ingest/ distribution	• Exercise data ingest/ distribution • Requirements validation	• Training • Proc validation • Exercise	NA
Ground Station(s)	• Acceptance testing	• Test • Exercise	• Test • Exercise	NA	• RF Test • Exercise	• Test • Exercise • Requirements validation	• Training • Proc validation • Exercise	NA
SOC	NA	• Verify connectivity	• Test housekeeping ingest	• Test • Exercise	• Test • Exercise	• Test • Exercise • Requirements validation	• Training • Proc validation • Exercise	NA

Ground System Integration Tests

- I&T #1 Telemetry & Command (S-band data)
- I&T #2 Science Data Processing Test (Ka-band data)
- I&T #3 Mission Operations & RF Communications Test
- I&T #4 Fully Integrated End-to-End Test
- I&T #5 Launch Readiness Test

Ground System Readiness Testing - RF

- **RF Compatibility Testing**
  - Compatibility testing is performed during spacecraft I&T
  - Verifies compatibility of the spacecraft with the ground network (antenna site)
  - Compatibility test reports will be published
  - CTV (Compatibility Test Van) is a GSFC supplied resource
- **CTV and Digital Evaluation Lab (DEL) will record and process data during I&T**
  - Instrument data
  - Observatory data
- **U2/ER2 testing will provide "dynamic" antenna testing**

Operations Phases - On-Orbit

SDO System Elements	Launch & Acquisition	In-Orbit Checkout	Orbit Circularization	On-Orbit Operations				
				Normal Ops	Calibration	Eclipse	Stationkeeping	Safehold
S/C	Transmitter powered on before separation	Activate subsystems then instruments	Perform thruster firings to achieve geosync orbit	Maintain Sun orientation & collect science	Perform attitude changes and slews	Use star tracker for attitude; increase instr. heaters	Station keeping burns every six months/ momentum dumps every month	S/C maintains RF link
Commercial Networks	Realtime telemetry acquired at separation	Support realtime, eng recorder dumps, & tracking passes	Prime support for early burns; backup for later ones	Two 30-min. tracking passes/week			Backup support for TT&C	Contingency support for TT&C
SDO Ground Station		Support realtime, eng recorder dumps, & tracking passes	Prime support for later burns	Prime support for TT&C	Prime support for TT&C	Prime support for TT&C	Prime support for TT&C	Prime support for TT&C
DDS				Process and distribute science data	Process and distribute science data	Process and distribute science data		Process and distribute science data if Ka-band up
MOC	Monitor realtime separation telemetry	Support subsystem activation & forward eng data to SOCs	Plan & execute maneuvers	Monitor S/C, station & DDS; forward eng data to SOCs	Plan & execute cal maneuvers	Monitor S/C power & thermal conditions	Plan & execute maneuvers/ momentum management	Momentum management is only required operation
SOC		Receive eng from MOC; activate instruments	Safe instruments during burns	Receive science from DDS, eng from MOC; send cmd info to MOC	Develop calibration maneuver requests	Monitor instruments health & safety	Receive eng from MOC	Monitor instruments health & safety

Operational Commanding Concept

- All procs will be approved by subsystem lead, ops lead and systems engineer
- All possible commands and procs will be tested pre-launch
- All commanding will occur through a documented process
- Post-launch there will be a daily planning meeting
- Any mods will be tested against simulator
- There will be an 8 hour commanding window each work day
- Off hour commanding will be treated as contingency
- All remote commands will be funneled through the primary ASIST workstation
- Further commanding details to be worked as spacecraft and instrument commanding requirements mature

Instrument Commanding Approach

- Instrument commands will be verified with the observatory during I&T
- Instrument commands will be checked by ASIST for hazardous commands
- If commands are hazardous, ASIST will hold commands for FOT acknowledgement prior to uplink
- New instrument commands will be identified and discussed prior to proposed use at weekly SDO science planning telecon with all instrument teams and the FOT (CCB activity)
- Operation teams will man respective facilities during execution of new instrument commands and monitor results

Summary

William Potter

Ground System Heritage

- **The ground stations, MOC and networks require no new technology**
- **Commercial communication networks currently exist to support SDO high-rate science distribution**
- **NASA has Ka-band experience**
  - Glenn Research Center's Advanced Communications Test Satellite (ACTS)
  - Wallops' Ka-band Prototype activities
  - JPL/DSN's Cassini spacecraft
- **NASA/GSFC has delivered several new ground stations**
  - EOS Polar Ground Network (4)
  - Landsat-7 (1)

Ground System Trade Studies

Performed several trade studies and white papers to address key aspects of SDO ground system

- **Ka-Band Antenna Location by Raymond J. Pages and Chuck Liptak**
- **RF Attenuation Study by Code 450**
- **Telemetry & Command Candidate System Evaluation by William Potter, Peter Gonzales and Craig Weikel**
- **SDO MOC Location Evaluation by Hun Tann and Craig Weikel**
- **Distribution of SDO Science Data from White Sands Ground Terminal by Chris Spinolo**

Risk Assessment & Mitigation

Risk #1. Science Data Network –

The ability to reliably forward science data from the SDO ground stations to the SOCs within the estimated costs.

Mitigation: Baseline communication network is within the current cost envelope. Engineers are pursuing several alternate approaches as documented in the Communications White Paper to potentially reduce costs further with equal or improved service

Risk #2. High-Rate Front End –

The ability to develop a front-end system with Viterbi decoders capable of processing data at SDO rates.

Mitigation: Engineers are evaluating several commercial vendors as well as on-going in-house efforts and will complete a cost/benefit trade analysis at GS SRR.

Ground System Status

- The ground system team understands all requirements levied upon it at this time
- Ground system development activities are either on or ahead of schedule
- Budget analysis indicates the ground system architecture can be completed within the Project scope
- Risks are understood, documented and have a mitigation plan
- The ground system team is proceeding with preliminary design activities in preparation for the Project Preliminary Design Review

SDO Acronyms

SDO Acronyms

ACD	Antenna Control Drive
ACK	Acknowledgement File
ACS	Attitude Control System
ADS	Attitude Determination System
ACTS	Advanced Communications Technology Satellite
APID	Application ID
APL	Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
ASF	Acknowledgement Status File
ASIST	Advanced Spacecraft Integration and System Test
ASM	Antenna Status Mux
C&DH	Command & Data Handling
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CMD	Command
CTV	Compatibility Test Van
D/B	database
DDC	Data Distribution Center
DDS	Data Distribution System
DEL	Digital Evaluation Laboratory
DHDS	Digital History Data Store
DMR	Detailed Mission Requirements
DSF	Delivery Status File
DSN	Deep Space Network

SDO Acronyms

EOS	Earth Observing System
EPV	Extended Precision Vector
E-T-E	End to End
EVE	Extreme Ultraviolet Variability Experiment
FDF	Flight Dynamic Facility
FDS	Flight Dynamic System
FEDS	Front End Data System
FEP	Front End Processor
FOT	Flight Operations Team
FSW	Flight Software
GEO	Geosynchronous
GHZ	Gigahertz
GMT	Greenwich Mean Time
GNC	Guidance, Navigation & Control
GPS	Global Positioning System
GS	Ground System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GSM	Ground System Manager
GTDS	Goddard Trajectory Determination System
GTO	Geosynchronous Transfer Orbit
HGA	High Gain Antenna
HK	Housekeeping
HMI	Helioseismic and Magnetic Imager

SDO Acronyms (cont.)

HPA	High Power Amplifier
I&T	Integration & Testing
ICD	Interface Control Document
IF	intermediate frequency; interface
IIRV	Improved Interrange Vector
IOC	In-Orbit Checkout
IONet	Internet Protocol Operational Network
IP	Internet Protocol
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
Kbps	Kilobits per second
KHz	Kilohertz
KSC	Kennedy Space Center
L&EO	Launch and Early Orbit
LAN	Local Area Network
LASP	Laboratory for Atmospheric and Space Physics
LNA	Low Noise Amplifier
LV	Launch Vehicle
LWS	Living With a Star
Mbps	Mega bits per second
MBps	Mega Bytes per second
MOC	Mission Operations Center
MOU	Memorandum Of Understanding
MPS	Mission Planning System

SDO Acronyms (cont.)

MRD	Mission Requirements Document
msec	millisecond
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications
NENS	Near Earth Network Services
NISN	NASA Integrated Space Network
NM	New Mexico
NOC	Network Operations Center
NRL	Naval Research Laboratory
NRZ-L	Non Return to Zero - Level
NRZ-M	Non Return to Zero - Mark
OBC	On-Board Computer
OC12	Optical Carrier 12 (12 x 51.84 Mbps)
OC3	Optical Carrier 3 (3 x 51.84 Mbps)
OPS	Operations
P/B	Playback
PC	Personal Computer
POCC	Payload (or Project) Operations Control Center
Proc	procedure
PSE	Power Subsystem Electronics
QAC	Quality And Accounting
RF	Radio Frequency
RT (R/T)	Real Time
RTADS	Real Time Attitude Determination Sensor

SDO Acronyms (cont.)

RTOD	Real Time Orbit Determination
RX	Receiver
SC	Spacecraft
SDO	Solar Dynamics Observatory
SHARPP	Solar-Heliospheric Activity Research and Prediction Program
SN	Space Network
SOC	Science Operations Center
SRR	System Requirements Retreat
STGT	Second TDRS Ground Terminal
STK	Satellite Tool Kit
SW	software
T1	1.544 Mbps Data Communication Service
T&C	Telemetry & Command
TBD	To Be Determined
TC	Test Conductor
TCP/IP	Transfer Control Protocol/Internet Protocol
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TLM	Telemetry
TT&C	Telemetry Tracking & Command
UPS	Uninterruptible Power Supply
USN	Universal Space Network
UTC	Universal Time Coordinated
VCDU	Virtual Channel Data Unit

SDO Acronyms (cont.)

WHSS	SDO White Sands Station
W/S	workstation
WSC	White Sands Complex
WSGT	White Sands Ground Terminal