PACE
Ground Segment

Overview

Aug 2, 2022
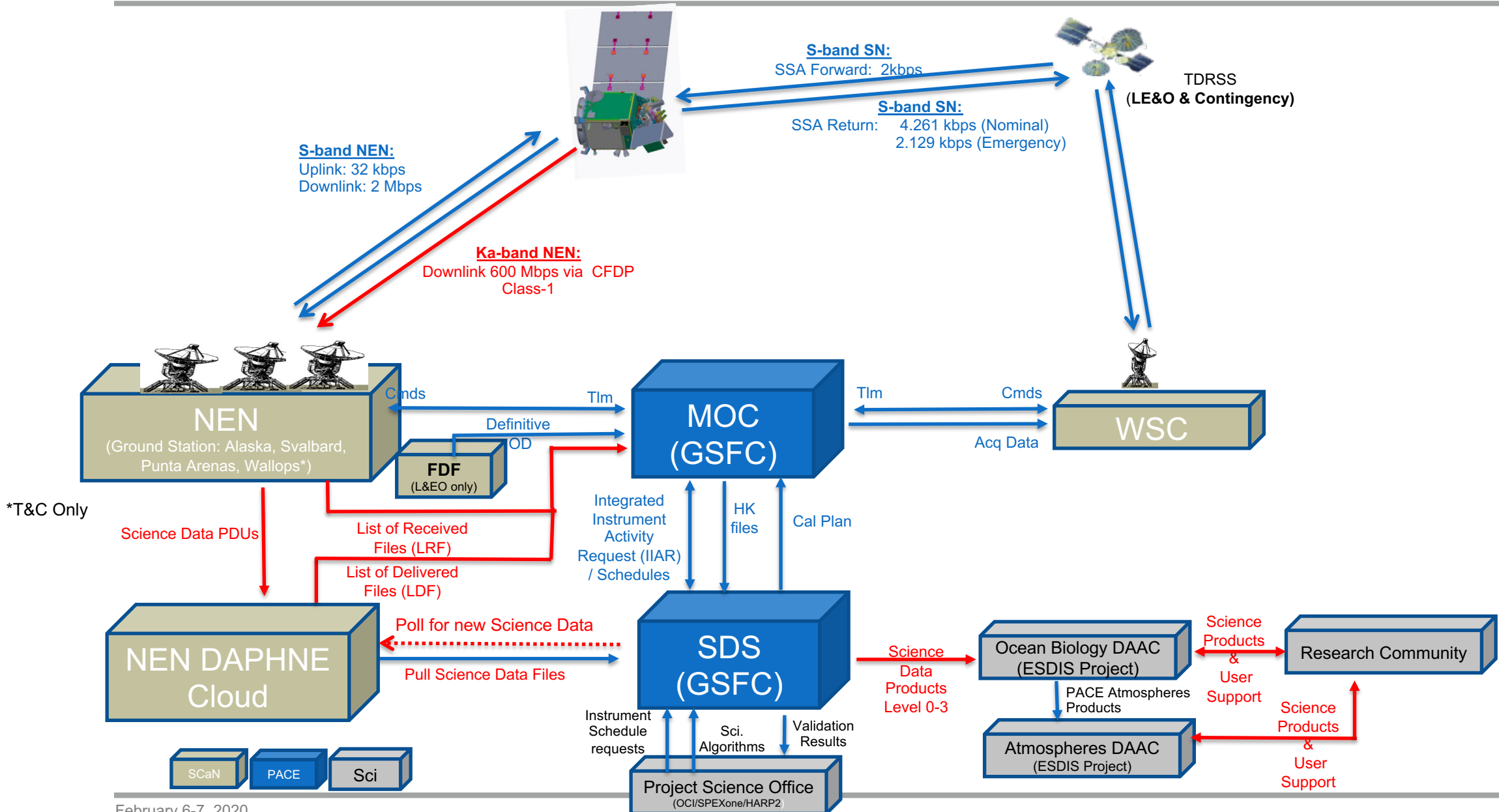
Robert Schweiss / GSM

Svalbard
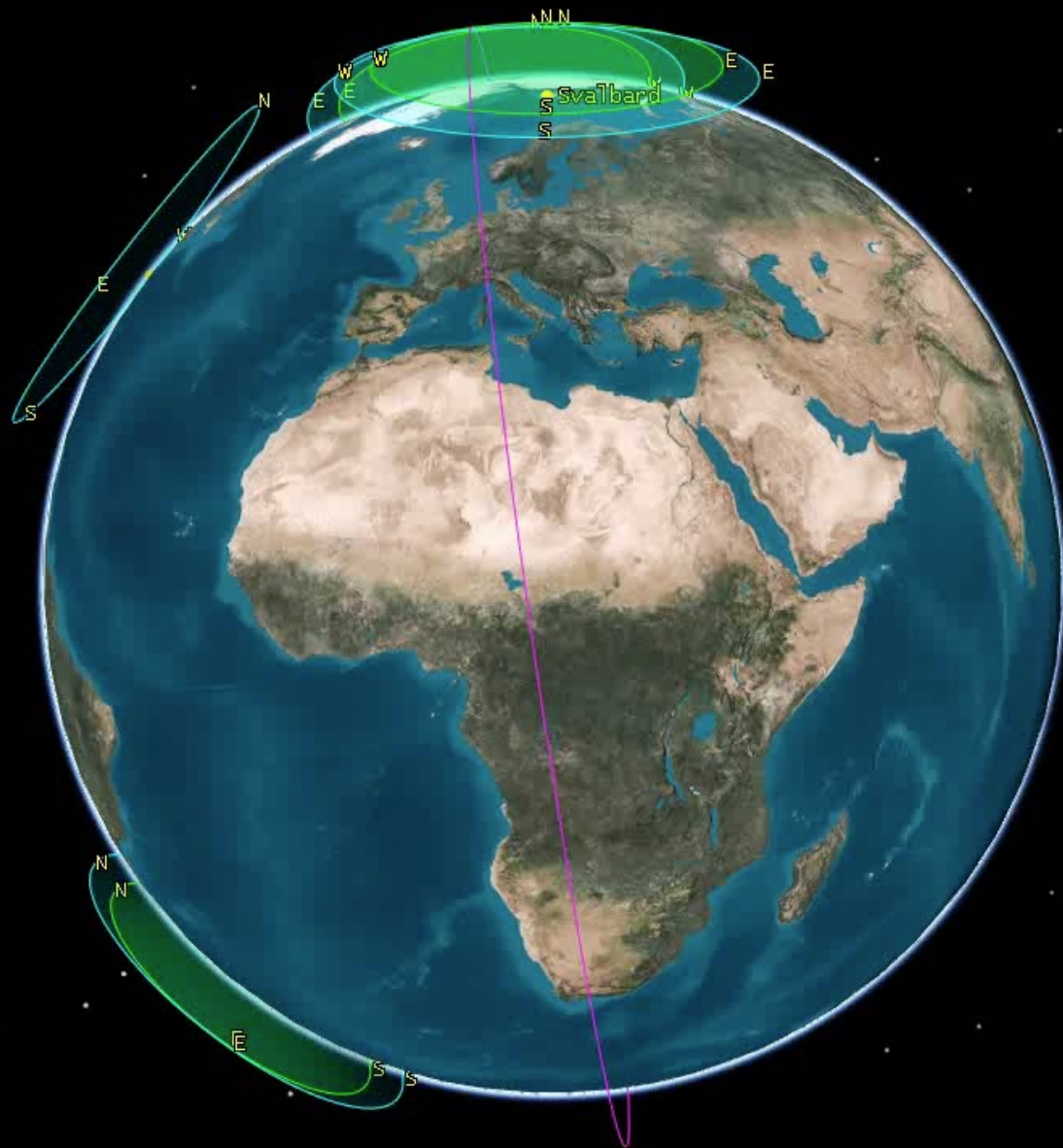
Nominal Mission Data Flow

S-band SN:
SSA Forward: 2kbps

S-band SN:
SSA Return: 4.261 kbps (Nominal)
2.129 kbps (Emergency)

TDRSS
(LE&O & Contingency)

S-band NEN:
Uplink: 32 kbps
Downlink: 2 Mbps

Ka-band NEN:
Downlink 600 Mbps via CFDP
Class-1

NEN
(Ground Station: Alaska, Svalbard,
Punta Arenas, Wallops*)

*T&C Only

FDF
(L&EO only)

Cmds — Tlm → **MOC (GSFC)**

Definitive OD

Tlm — Cmds → **WSC**
Acq Data

Integrated Instrument Activity Request (IIAR) / Schedules

HK files

Cal Plan

Science Data PDUs

List of Received Files (LRF)

List of Delivered Files (LDF)

Poll for new Science Data

Pull Science Data Files

NEN DAPHNE Cloud

SDS (GSFC)

Instrument Schedule requests

Sci. Algorithms

Validation Results

Science Data Products Level 0-3

Ocean Biology DAAC (ESDIS Project)

Science Products & User Support

Research Community

PACE Atmospheres Products

Atmospheres DAAC (ESDIS Project)

Science Products & User Support

SCaN   PACE   Sci

Project Science Office
(OCI/SPEXone/HARP2)

PACE GS & SDS Joint CDR

Ground Segment Overview

- Ground Segment (GS) consists of the following elements:
  - Mission Operations Control (MOC) center (includes backup MOC)
  - Space Communication and Navigation (SCaN),
  - Ground Segment Infrastructure (GSI) (e.g, Networks, Institutional Security Controls)

- Ground Segment architecture draws on ICESat-II, DSCOVR, FERMI, LRO, GPM, & LDCM Missions architectures

- NEN Ground Station selection follows NISAR Mission decisions

GS Block Diagram
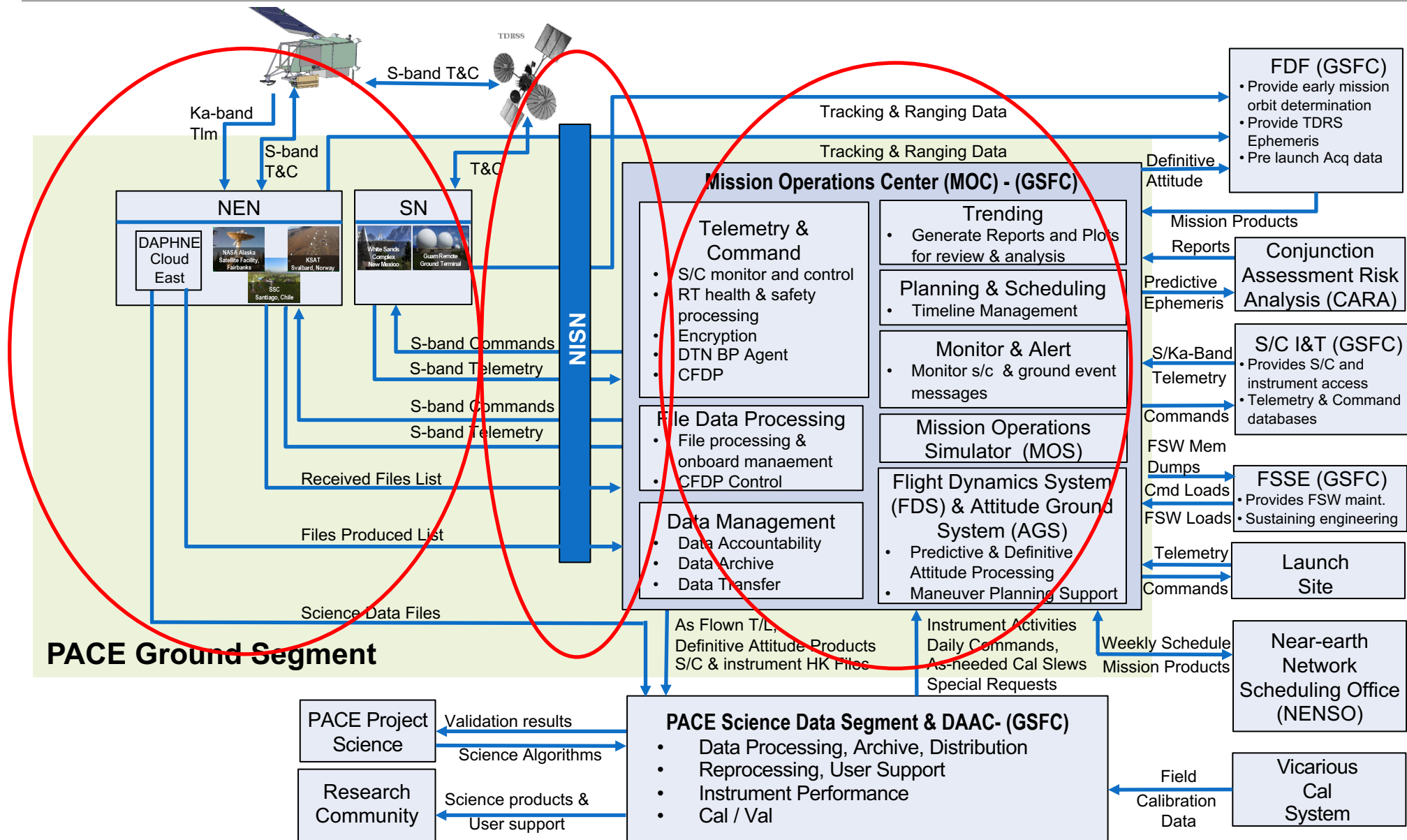
- **Mission Operations Center (MOC) originates all commands to the Observatory**
  - Operations support is 24x7 during LE&O and transitions to 8x5 during normal operations
  - Manage mission schedule and generate command loads for all mission activities
  - Receives Real-time housekeeping data for Observatory health and safety Real-time and play back Monitoring and trending
  - Performs Ground Stations scheduling with NEN Scheduling Office
  - Distributes mission planning products
- **MOC interfaces with NEN and SN**
  - Prime NEN Ground Stations (ASF, KSAT Svalbard, and Punta Arenas)
    - Ka-band carries the Science Data to the NEN Data Acquisition Processing and Handling Network Environment (DAPHNE) via CFDP transfer protocol and science data staging
    - S-Band supports Real-time Telemetry & Command for downlink of s/c housekeeping data and uplink of commands, tables, or FSW patches. Also supports DTN Bundle Protocol for HK file return.
    - DAPHNE Cloud interfaces with the SDS for science data distribution and the MOC for distribution of the the successfully received files list.
  - SN supports Launch and early orbit transitions
    - Provides Telemetry & Command for contingency operations and off-pointing during OCI lunar calibration
    - S-band supports Real-time Telemetry & Command for downlink of s/c housekeeping data and uplink of commands, tables, or FSW patches
- **Network Integrated Services Network (NISN) (or Communication Service Office CSO)**
  - WAN circuits will be coordinated through NEN, NISN/CSO and/or ESMO
  - LAN circuits will be coordinated through NISN/CSO for on campus connections
- **Backup MOC (not shown)**
  - Backup MOC, located at GSFC, consists backup of the primary MOC system capable of all functions of the MOC including maintaining observatory health and safety when the primary MOC is unavailable.   Supports minimally quarterly systems patches.

- **Telemetry & Command (T&C)**
  - Integrated Test and Operations System (ITOS) and supports spacecraft and instrument telemetry monitoring, command generation, and real-time s/c health and safety display
  - Ground Cryptographic Processors (GCP) Encrypts all spacecraft Commands
  - Includes DTN BP for HK file return
- **File Data Processing (FDP)**
  - Manages files on the observatory and their successful receipt on the ground so that the observatory can delete the files
- **Data Management System (DMS)**
  - Supports automatic data file accountability, data archive, and data file transfers to / from end-users, e.g., SDS
- **Trending**
  - Supports trending spacecraft and selected instrument telemetry over time or against various orbital products for the life of the mission
- **Planning and Scheduling system**
  - Supports generation of the mission timeline S/C and instrument command generation and scheduling of ground station contacts
- **Monitor and Alert System (MAS)**
  - Provides automated alert and escalation notification to operations personnel both local in the MOC and off site
- **Mission Operations Simulator (MOS)**
  - Provides the spacecraft simulator functionality within the MOC for simulated telemetry flow and commanding. Supports operator training.
- **Flight Dynamics System (FDS)**
  - Supports the generation of routine observatory orbital and maneuver planning products
- **Attitude Ground System (AGS)**
  - Used to generate predictive and definitive attitude products and supports sensor pointing calibration and observatory slew planning

PACE Ground Segment Interfaces

- **Flight Dynamics Facility (FDF)**
  - FDF provides support for the PACE mission during the pre-launch and early orbit mission phases.
- **Conjunction Assessment Risk Analysis (CARA)**
  - A joint effort between the Joint Space Operations Center (JSpOC), CARA at NASA GSFC, and the PACE FOT for debris collision warning and possible avoidance
- **S/C I&T**
  - Interface with the MOC from spacecraft during I&T for pre-launch interface testing
- **Flight Software Sustaining Engineering (FSSE)**
  - Flight software maintenance / patches, spacecraft table load generation & maintenance, anomalies investigation
  - FSW Loads are received in the MOC by the FOT for subsequent verification / validation with the MOS or FlatSat prior to uploading to the Spacecraft.
- **Launch Site (LS)**
  - Interface from the Launch site to the MOC for final interface checks between flight and ground before launch
- **NEN Scheduling Office (NENSO)**
  - Collects user requirements and requests, considers antenna loading, antenna status, and weighs mission customer priority for development of the ground contact schedule of antenna pass supports
- **Science Data Segment (SDS)**
  - MOC receives instrument activity planning schedules from SDS and provides Observatory HK data to the SDS. SDS acquires Science data from the DAPHNE Cloud

Data Volume Estimates

- **Given:**
  - Average Science data generation rate onboard the Observatory: **40Mbps**
  - Average HK data generation rate onboard Observatory: **100 kbps**
  - Space to Ground Ka-band transmission rate: **600 Mbps**
  - Spacecraft Memory Size: **7 Orbits (~700 min) or 1.68 Tb (210 GB) Science Data**
  - Spacecraft Orbits the earth: **14.6 times per day**

- **Therefore Mission Data Volume is:**
  - Daily Science Data Volume: **~3.456 Tb MEV (~432 GB)**
  - Daily HK Data Volume: **~8.64 Gb CBE (1.08 GB)**

- **Time to downlink daily Science data volume (14.6 orbits) at 600Mbps:**
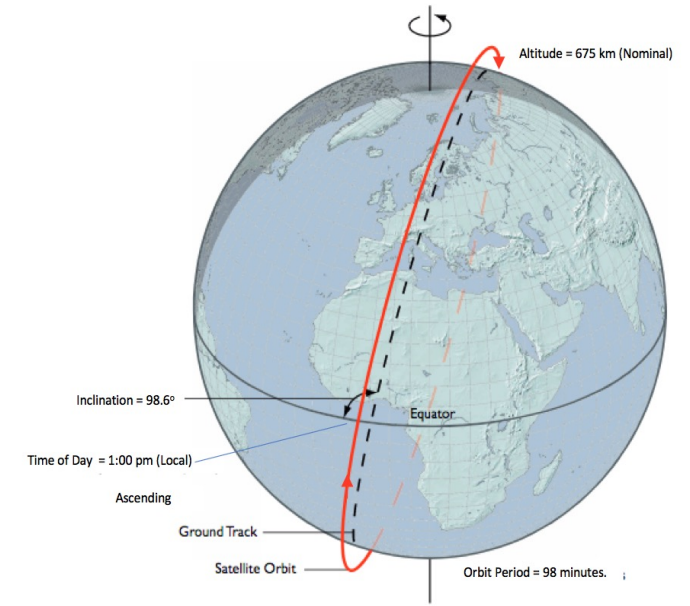 - **5760 Seconds (~96 minutes)**

- **Time to downlink daily HK data volume (14.6 orbits) at ~2.08 Mbps:**
  - **4154 Seconds (~69 minutes)**

- **Technical Allocation Resource PACE-SYS-REQ-0020, RF Data Rates(#17) defines data volume and margins**

> **PACE schedules ~115 minutes of space to ground contact time @ 600 Mbps, which gives us about 20% of margin on contact time for science data and 40% margin for House Keeping Data**
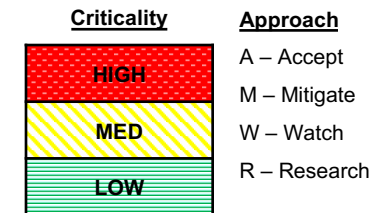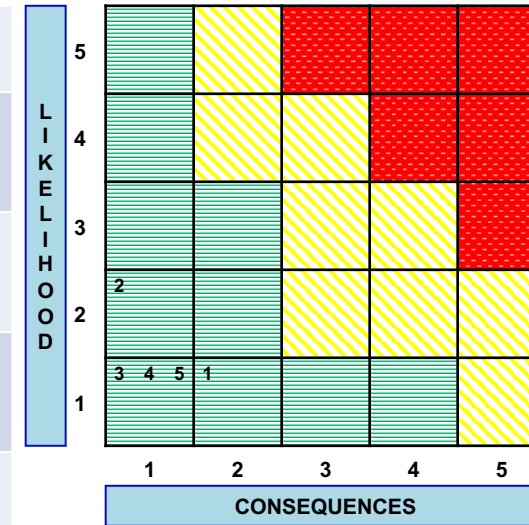

Altitude = 675 km (Nominal)
Inclination = 98.6°
Equator
Time of Day = 1:00 pm (Local)
Ascending
Ground Track
Satellite Orbit
Orbit Period = 98 minutes.

Risks

Rank Risk ID	Summary	LxC Trend	Aprch	Status
1 PACE-00133	NASA GSFC MOVE Voice System	1x2 NEW	W	1/15/2020-- The Communications Services Office (CSO) provided quote for the Mission Operations Voice Enhancement (MOVE) sets is baselined.
2 PACE-00076	Delay Tolerant Networks (DTN) on GS	2x1 ⬇	W	1/15/2020: Completed DTN EPR. 2 ADV and 1 RFA. Review is considered a success.
3 PACE-00098	Network Connectivity to NEN	1x1 ⬇	W	1/15/2020: On track for GS CDR 2/6-7. No surprise fees have been received.
4 PACE-00100	PACE Mission Operations LOE ...	1x1 ⬇	W	1/15/2020: Presented results of staff loading analysis to ESMO on 1/15/2020. Will develop hour / hour analysis.
5 PACE-00123	PACE Primary MOC Facility Selection	1x1 NEW	M	1/15/2020. Furniture buys have been initiated. LRO move out delayed by 2 weeks due to anomaly on their side. No impacts expected. PACE and ESMO have agreed a move in plan

LIKELIHOOD (vertical axis: 5, 4, 3, 2, 1)
Cells: 2 (at row 2, col 1); 3 4 5 1 (at row 1, col 1)

CONSEQUENCES (horizontal axis: 1, 2, 3, 4, 5)

Criticality
- HIGH (red)
- MED (yellow)
- LOW (green)
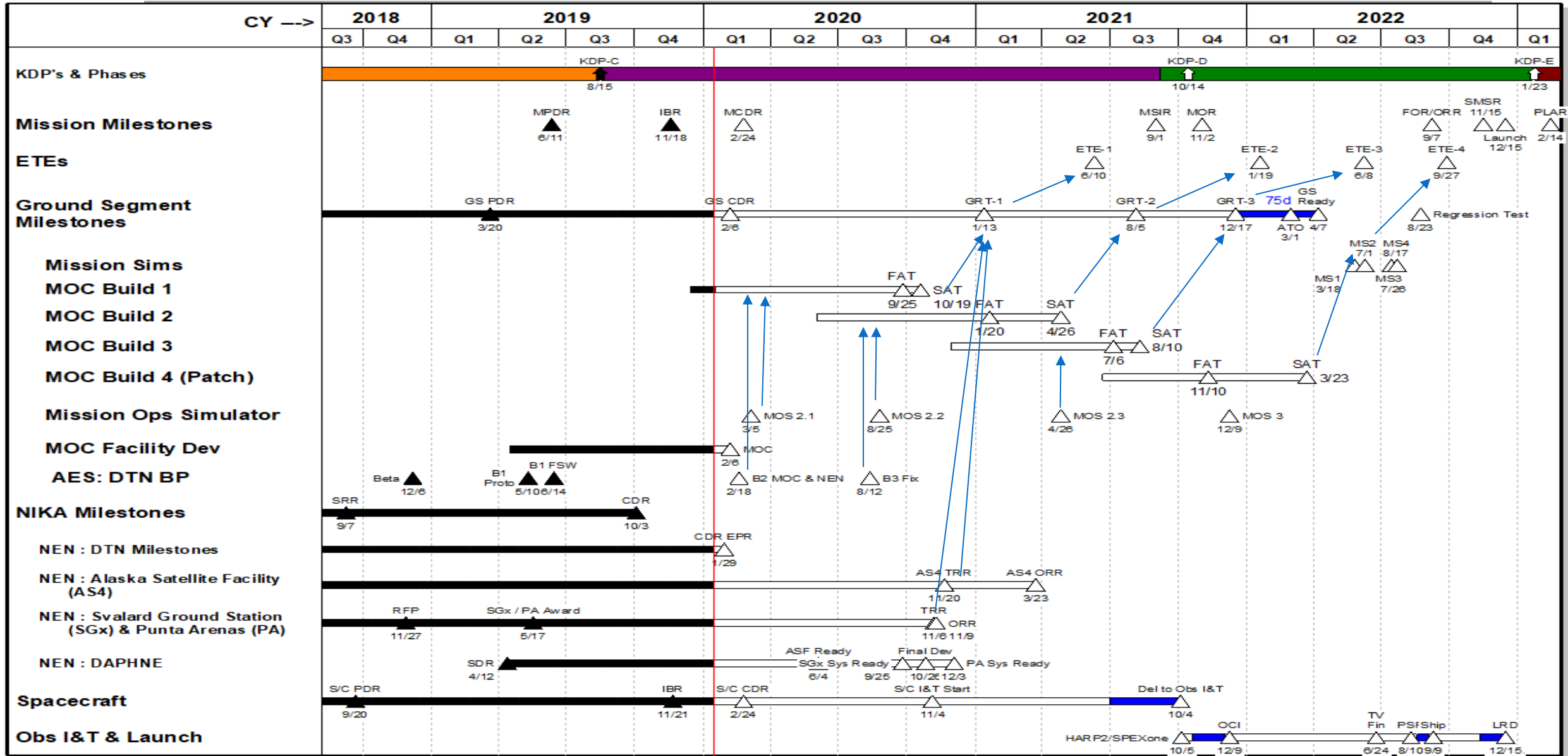
Approach
- A – Accept
- M – Mitigate
- W – Watch
- R – Research

LxC Trend
- ⬇ – Decreasing (Improving)
- ⬆ – Increasing (Worsening)
- ➡ – Unchanged
- NEW – Added this month

Ground Schedule

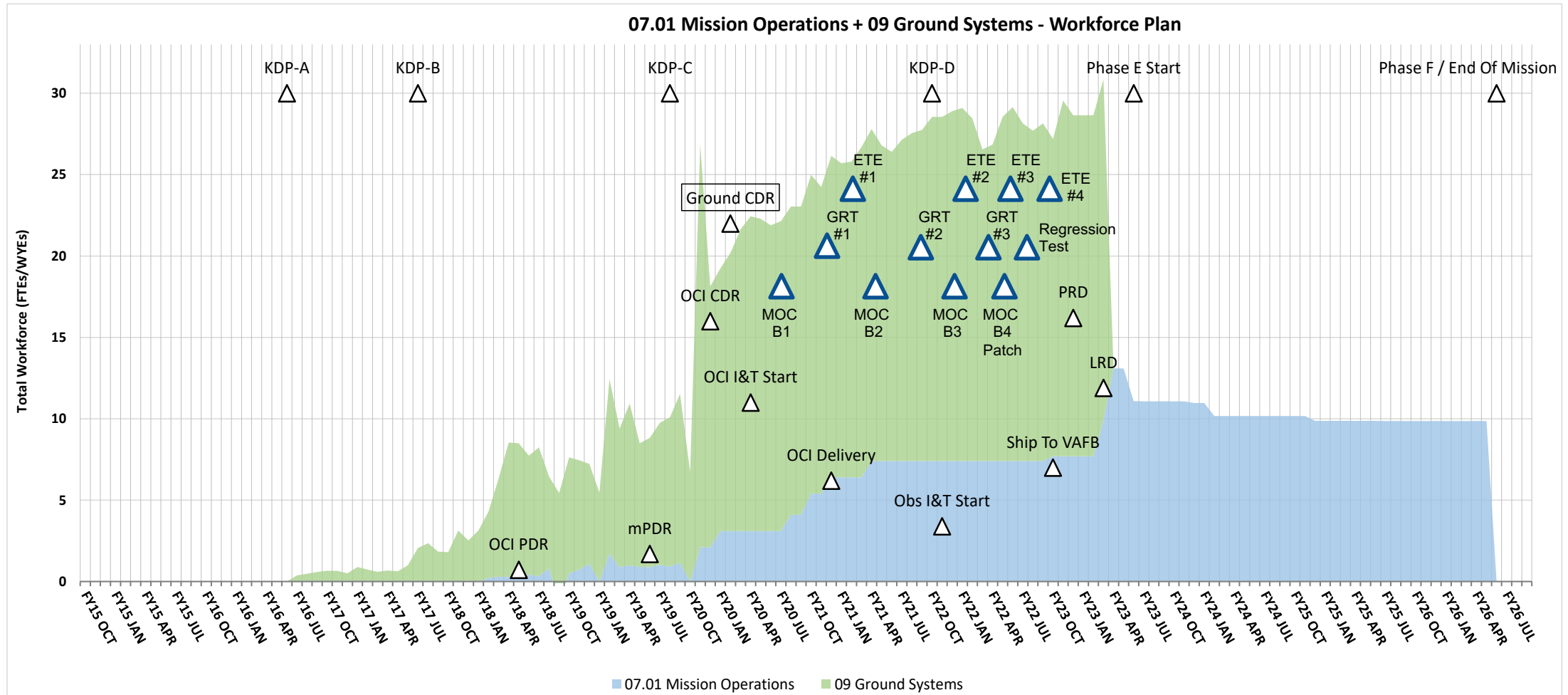# Ground Segment and Mission Operation Work Force

07.01 Mission Operations + 09 Ground Systems - Workforce Plan

Total Workforce (FTEs/WYEs)

KDP-A KDP-B KDP-C KDP-D Phase E Start Phase F / End Of Mission

Ground CDR
ETE #1   ETE #2   ETE #3   ETE #4
GRT #1   GRT #2   GRT #3   Regression Test
OCI CDR
MOC B1   MOC B2   MOC B3   MOC B4 Patch   PRD
OCI I&T Start
LRD
OCI Delivery
Ship To VAFB
Obs I&T Start
mPDR
OCI PDR

Legend: 07.01 Mission Operations | 09 Ground Systems

07.01 Mission Operations + 09 Ground Systems	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	Grand Total (FTEs/WYEs)
Total Workforce (FTEs/WYEs)	0.0	0.1	1.0	5.5	9.1	20.6	26.4	28.2	20.3	10.5	9.9	6.6	138.3

Many roles of Engineering at NASA