Coriolis Mission Operations Collaboration - Lessons Learned

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Working Group Session
"Teaming Early, Teaming Often"
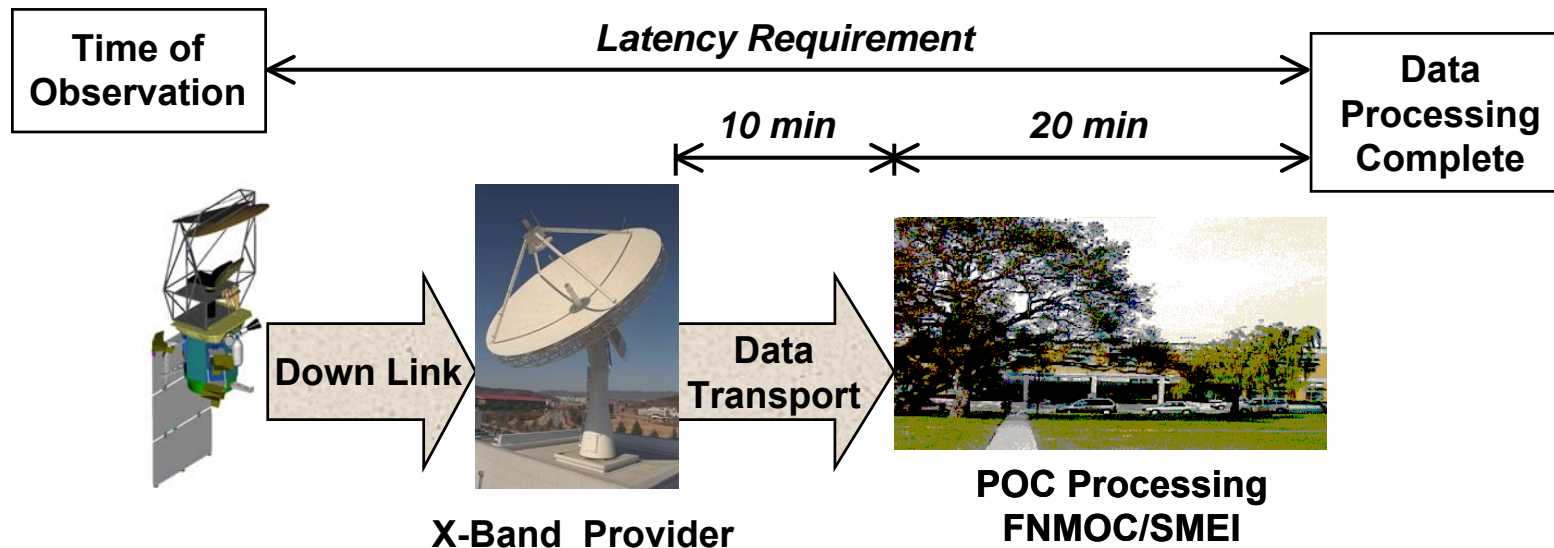**March 2, 2005**

Coriolis Program – Key Participants

- **Space Test Program**
  - **Bus procurement, mission integration, launch, 1st year of Ops**

- **Naval Research Laboratory**
  - **WindSat design/development, Years 2+ Ops, WindSat data processing**

- **AFRL**
  - **SMEI design/development, SMEI data processing**

- **RSC**
  - **C^2; Mission planning and scheduling**

- **NPOESS Integrated Program Office (IPO)**
  - **X-band ground stations and data distribution**
  - **NOAA/NESDIS**
    - **X-band ground station scheduling**
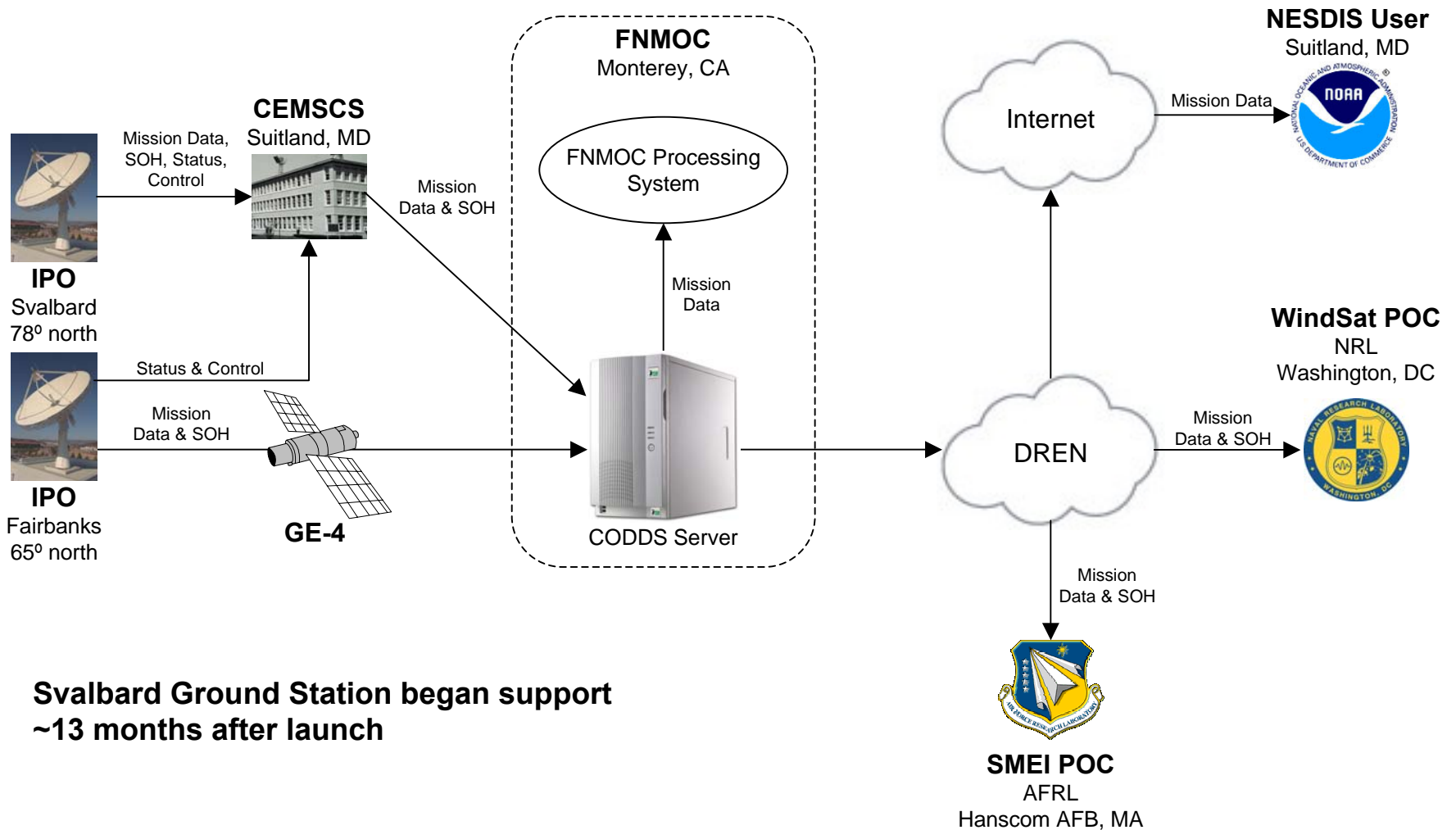   - **Fairbanks Command & Data Acquisition Station (FCDAS)**

Coriolis Space Vehicle @ Vandenberg AFB Dec 2002

What's the Big Picture?

- **Coriolis Orbit: 830km, sun synchronous, polar**

- **Payload science data Latency Requirements**
  - **Defined as inclusive time from ground observation through completion of ground data processing**
  - **Year 1 : 24 hours**
  - **Years 2 and beyond: WindSat = 4 hrs; SMEI = 6 hrs**

| Time of Observation | *Latency Requirement* | Data Processing Complete |

10 min *20 min*

Down Link **Data Transport**

X-Band Provider **POC Processing FNMOC/SMEI**

Coriolis X-band Data Distribution (Current)

FNMOC
Monterey, CA

FNMOC Processing System

CEMSCS
Suitland, MD

Mission Data, SOH, Status, Control

Mission Data & SOH

Mission Data

IPO
Svalbard
78⁰ north

Status & Control

Mission Data & SOH

IPO
Fairbanks
65⁰ north

GE-4

CODDS Server

Internet

Mission Data

NESDIS User
Suitland, MD

DREN

Mission Data & SOH

WindSat POC
NRL
Washington, DC

Mission Data & SOH

SMEI POC
AFRL
Hanscom AFB, MA

Svalbard Ground Station began support ~13 months after launch

What's the Problem?

- **Year 1**
  - **Due to polar orbit, high latitude ground stations provide required coverage**
  - **Downlinking on-board data recorder 4x/day using commercial X-band provider**

- **More stringent Year 2 Latency Requirement drove overall ground system design**
  - **Requires downlinking recorder every orbit (14x/day)**
    - **350% cost increase (over 1st year) just for ground station pass time**
    - **Additional ground comm line bandwidth required, which increased program cost by an additional $360K/year for years 2 and beyond**

Why Collaborate?

- **WindSat Mission Objectives**
  - **Measure Ocean Surface Wind Speed and Direction**
  - **WindSat instrument is a risk reduction for NPOESS CMIS (Conical Scanning Microwave Imager/Sounder) Instrument**
   - **NPOESS IPO has a strong interest in WindSat continuation**

- **NPOESS would eventually need to test their ground system concept**
  - **If NPOESS ground segment funds and development schedule could be moved up by 1-2 years, it could support Coriolis X-band downlink and data distribution**
  - **Early deployment yields early test phase for NPOESS ground segment concept**
    - **Funds well spent for both programs – more bang for the buck**
  - **No significant NPOESS program cost Δ – money would just be expended earlier**

Who's Involved?

- **The NPOESS-Coriolis collaboration is mainly a Government-Government effort, including the NRL, NOAA, and USAF**
  - **Aerospace Corp. provided requirements analysis, system engineering, and technical performance assessment**

- **NPOESS contractors (Harris/Omaha, Raytheon/Aurora) and RSC Contractor (Northrop Grumman) are key participants**

Coriolis Data Users

SMEI POC

WindSat POC
NESDIS User, Suitland, MD

FNMOC

RSC

Spectrum Astro
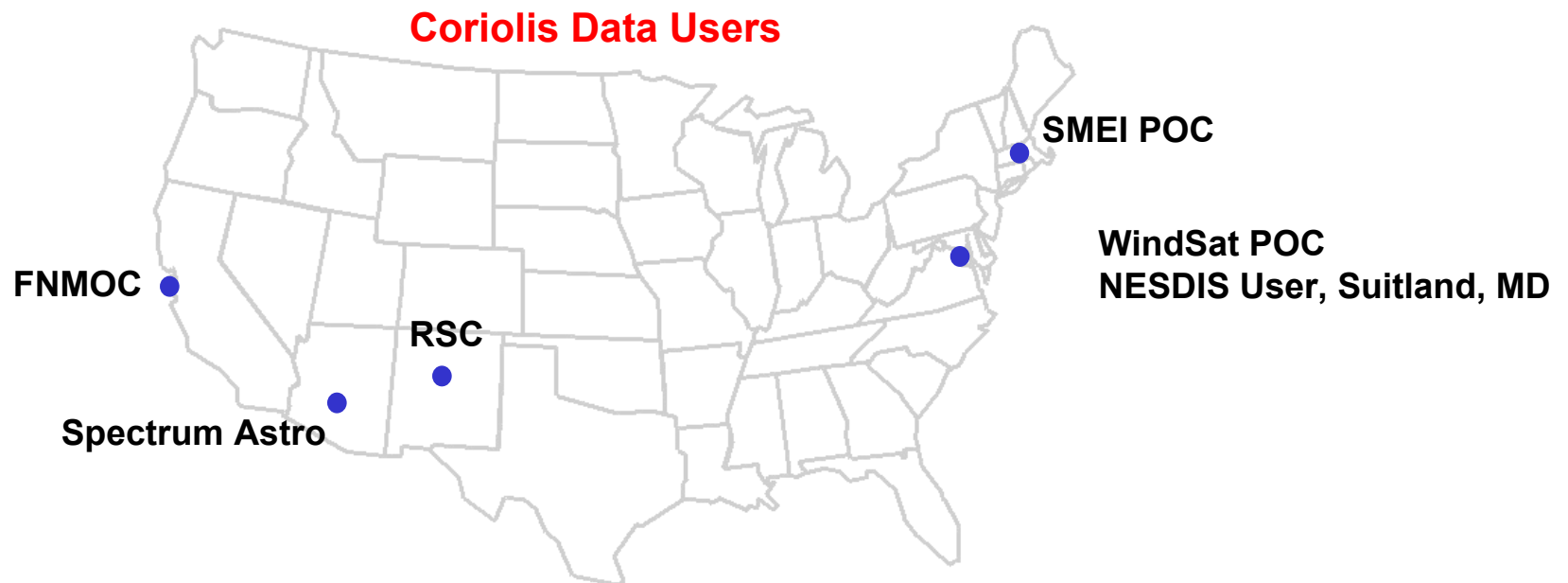
How Did You Do It?

- **WindSat instrument had high visibility within the NPOESS IPO**

- **IPO came up with plan, received approval by management**

- **Loading study completed to evaluate whether FCDAS could handle the extra workload**

- **Coriolis downlink signal f_c = DMSP - 1MHz**

- **IPO funded, designed, and implemented upgrades to FCDAS and Svalbard**
  - **All changes planned to minimized impact to on-orbit operations**

- **Progress tracked by coordinating IPO effort with Coriolis Mission Manager**
  - **MOA/MOU/Mission Support Plans**
  - **Test plans**
  - **Program schedule**

Did it Work?

- **Coriolis has been on-orbit since January 2003**

- **Ground data distribution system consistently outperforms data latency requirements**

- **Has undergone two significant upgrades with very little impact to data users**
    - **New antenna system at Svalbard**
    - **Changeover and upgrade of international communication lines**

- **Will save Coriolis program $13.5M over the 5 year design life**

What Helped?

- **Early on, NPOESS System Program Director approved concept**
  - **True Win-Win situation provided high motivation to succeed**
  - **Made funding available earlier than originally anticipated, i.e. NPOESS ground system development effort accelerated by about 1 year**

- **Good people**
  - **Creative thinkers; Outside-the-box thinking**
  - **Technical expertise**
  - **Word is bond – Integrity of agreements**
    - **Minimal documentation**

- **Extensive COTS use**
  - **From antenna to user – nearly all COTS**
  - **CCSDS-compliant data formats**
  - **RF downlink compatible with existing ground stations (DMSP)**

- **Small, empowered ops team**
  - **Rapid decision making**
  - **Good team communications – no one "out of the loop"**

- **Close proximity of IPO (Maryland) and NRL (DC)**
  - **Collaborative effort was somewhat simplified**

What Didn't?

- **Data distribution network troubleshooting procedures should have been better defined and earlier**

What's Next?

- **Coriolis**
  - **Goal is to fly one year simultaneously with CMIS (2009-10)**

- **NRL**
  - **Blossom Point Satellite Tracking Facility (southern Maryland)**
    - **Government Owned Contractor Operated (GOCO) facility currently supports >165 satellite contacts per day for <$200/contact**
    - **Engineering and operational support to all manner of space assets**
    - **Reconfigurable hardware coupled with an open, distributed software environment**
    - **Currently L-, C-, S-band compatible; STDN, SGLS**
    - **Interested in teaming with other space and ground segment assets for all aspects of space operations, calibration, and technical demonstrations**