Satellite Task Force (SATTF) Final Report

14 Nov 2012

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Chair
On behalf of the SATTF

Purpose

- Present highlights and recommendations from the Satellite Task Force review of NOAA planning for future satellite systems

- Written report outline:
  - Background
  - Fiscal and Technical Challenges
  - Summary Findings and Observations
  - Summary Recommendations
  - Specific Observations and Findings
    - Policy
    - Budget
    - Requirements Prioritization
    - System Engineering
    - Alternative Architectures
    - Ground Segment
    - Risk Mitigation

SATTF Terms of Reference
Charge

SATTF will: *"…recommend a way forward for NOAA's satellite program, starting with initial NESDIS recommendations and seeking a more affordable, flexible and robust satellite and services architecture…"*

SATTF Members & Liaisons

- **Robert Winokur, Chair**
  - **Deputy and Technical Director (Acting Oceanographer of the Navy)**
  - **Oceanography, Space and MDA Division, Chief of Naval Operations**
- **Dolly Perkins, consultant**
  - **Former Deputy Center Director - Technical**
  - **NASA Goddard Space Flight Center**
- **Robert E. Gold**
  - **Space Department Chief Technologist**
  - **The Johns Hopkins University Applied Physics Laboratory (JHU/APL)**
- **Thomas C. Adang**
  - **Systems Director, The Aerospace Corporation**
  - **Department of Defense - Operationally Responsive Space (ORS) Office**
- **Michael D. Tanner**
  - **Acting Deputy Director, National Climatic Data Center**
- **Paul Menzel**
  - **Professor/Senior Scientist, University of Wisconsin**
  - **Formerly Chief Scientist, NESDIS STAR**
- **Diane Evans**
  - **Director, JPL Earth Science and Technology Directorate**
- **J. Marshall Shepherd, SAB Liaison**
  - **Department of Geography/Director, Atmospheric Sciences Program, University of Georgia**
- **David Hermreck, NESDIS Liaison**
  - **Senior Advisor, NESDIS Office of System's Development**

SATTF Considerations

- **Long term sustainability of NOAA satellite programs (and gap risks)**
- **Current plans, including flight segment of Joint Polar Satellite System (JPSS)-2 and the Geostationary Operational Environmental Satellites (GOES)-T and beyond**
- **Ground segment, including data receipt, distribution and processing**
- **Cost estimates and the estimating methodology**
- **The National Space Policy call on NOAA for operational continuity**
- **Research and technology plans and investments by NASA and others**
- **System adaptability to accommodate changing technical and programmatic environments**
- **International collaborations and opportunities**
- **Collaborations and opportunities with DoD, NASA and the USGS**
- **Effective and enhanced use of academia and the private sector**
- **Feasibility, considering the anticipated difficulty in achieving needed future funding**
- **Flexibility to accommodate unpredictable future appropriations**

Bottom Line Up Front

- NOAA **budget** for planned space systems appears to be **unsustainable**
  - Fiscal environment could lead NOAA to increase risk or decrease scope – maintain high impact capability
  - Constrained fiscal environment requires prioritization of threshold space-based observational requirements
- NOAA has taken steps **to prepare a future satellite system architecture**
  - Additional effort and continued commitment is required toward meeting that goal building on progress
- NOAA needs a **total systems approach** to satellite architecture
  - NOAA is in a position to undertake this with sole responsibility for JPSS and GOES
- Given the ten year timeline required to develop new satellite systems, NOAA should **conduct an analysis of alternatives**, starting in FY2013, considering cost, performance, risk and resiliency, and assessing trade space vs. requirements

Background

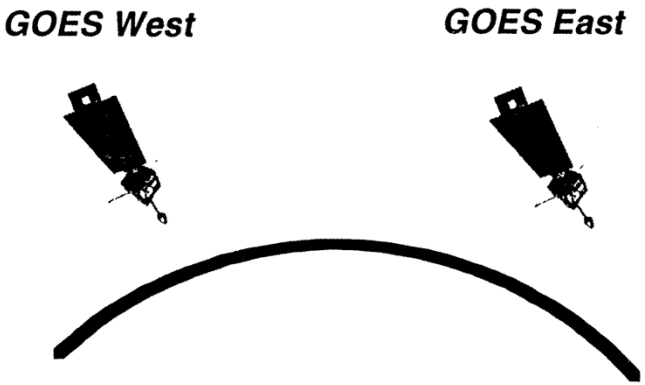
- NOAA and NASA have provided increasingly advanced operational satellite systems
  - Satellites have evolved from basic weather satellites to complex environmental systems
- NOAA has built strong relationships with national and international partners
- System costs have become increasingly more expensive
- NOAA is facing unprecedented budget challenges
- SATTF established by the SAB to provide advice on planning for future satellite systems

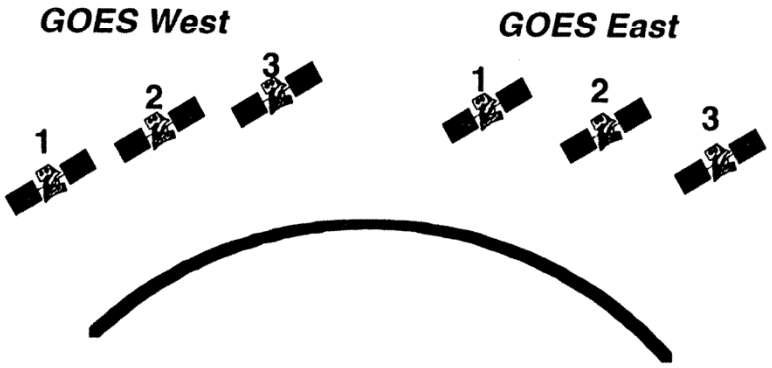
Satellite System Scope

- Includes polar and geostationary
- Applications include weather, climate, space weather and oceans
- Key sensors include imaging, sounding and altimetry
- Large multi-sensor satellites
- Constellations of smaller satellites with specific sensors
- Ground segment

Satellite Architecture Concept (an example)

Consolidated vs. Distributed GOES Architecture





Consolidated Architecture

- Current Architecture
- Multiple critical payloads per S/C

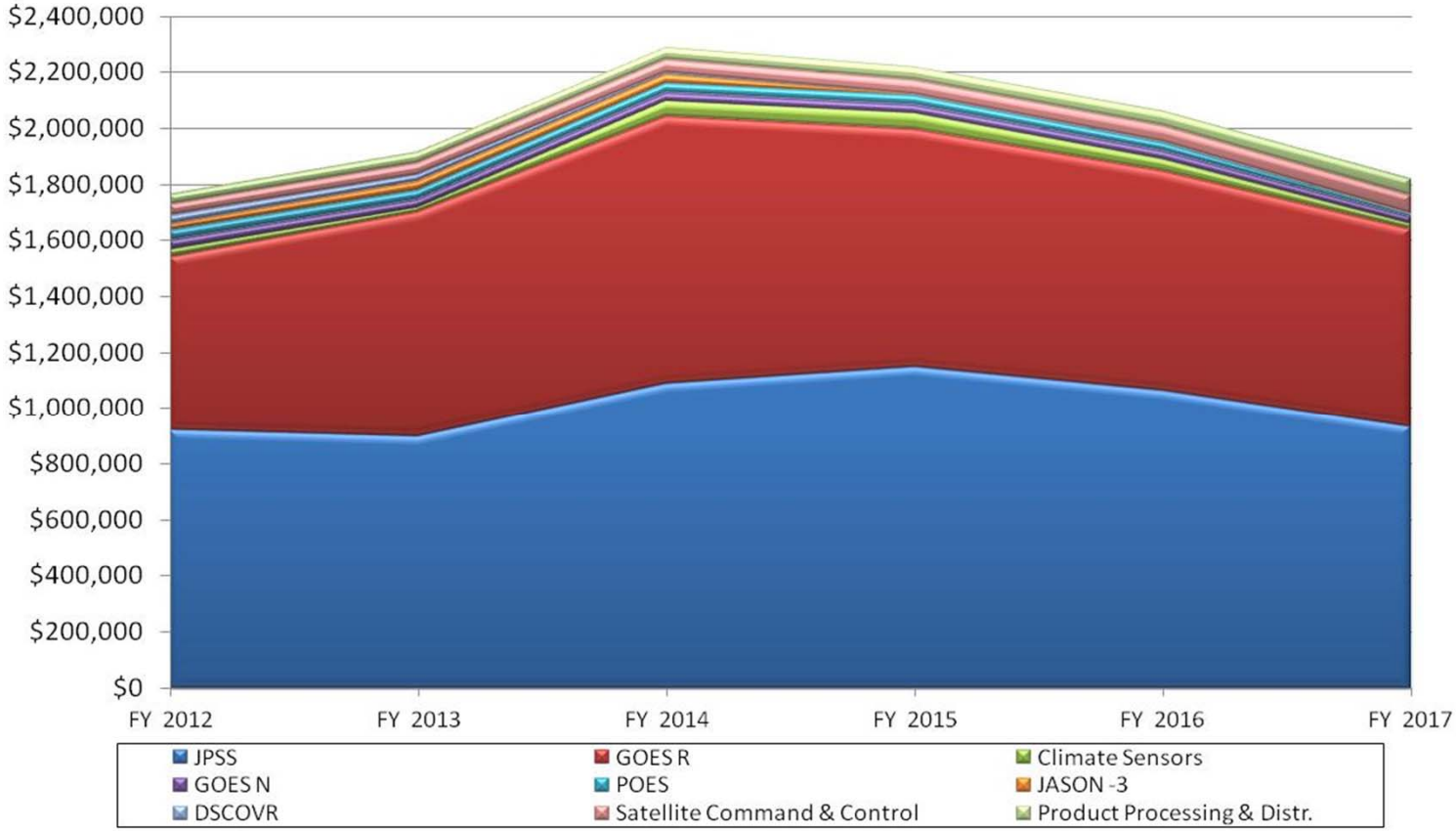
Distributed Architecture

- Future architecture option
- One primary payload per S/C
  - Imager
  - Infrared Sounder
  - Microwave Sounder

Fiscal and Technical Challenges

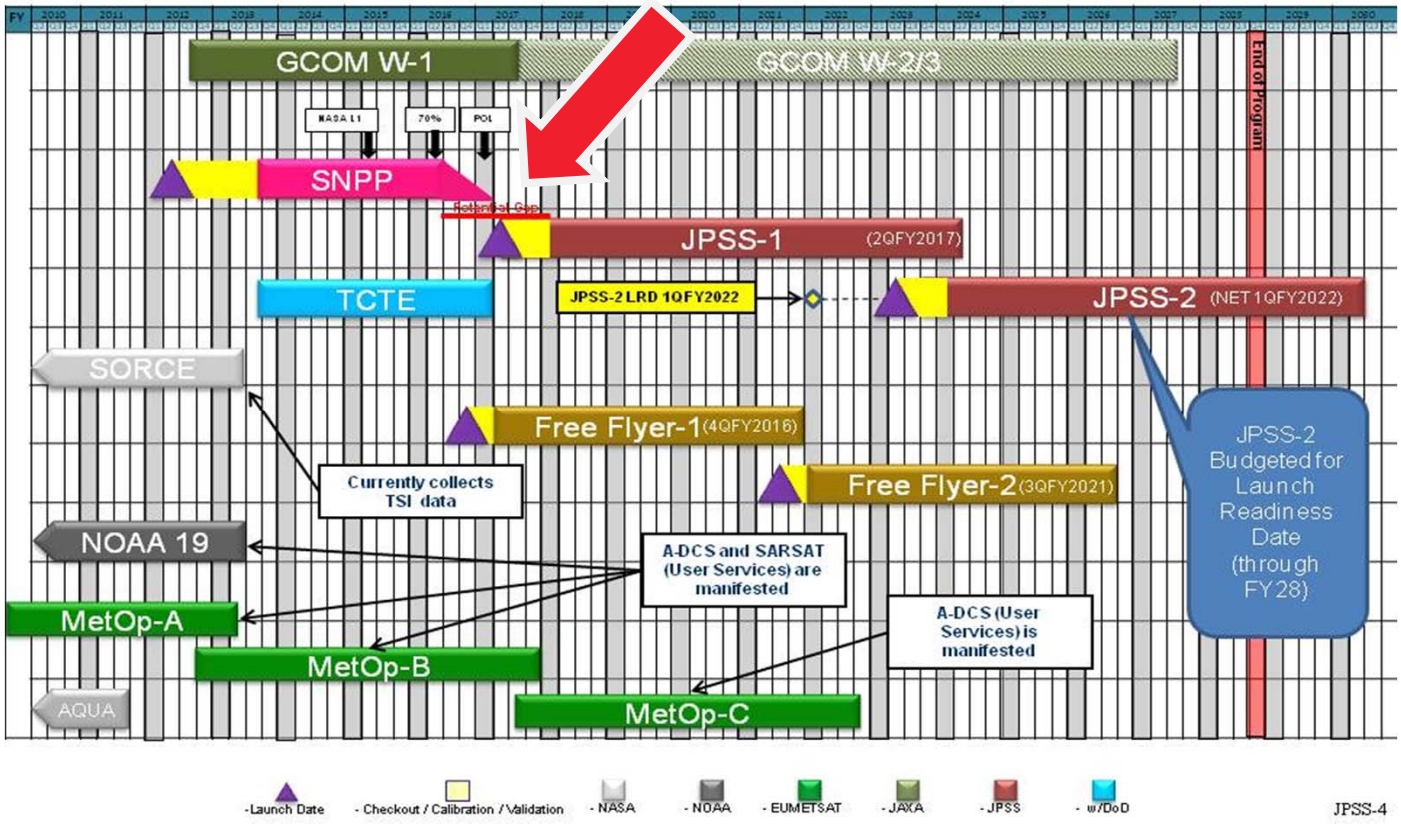
- Key challenges influence planning:
  - Increasing satellite system costs and uncertain fiscal environment
  - Satellite Continuity
  - Balancing requirements push and technology pull
  - Sustaining partnerships

Increasing Costs and Fiscal Environment



- Increases in system costs impact budgeting in a constrained fiscal environment – **decreased ability to invest in future capacity and capability**
- Budget resources are uncertain and limited

Maintaining Satellite Continuity



- Increased costs and budget **uncertainty could result in a break** in operational satellite observations and service
- Mitigation plans must be developed to maintain continuity

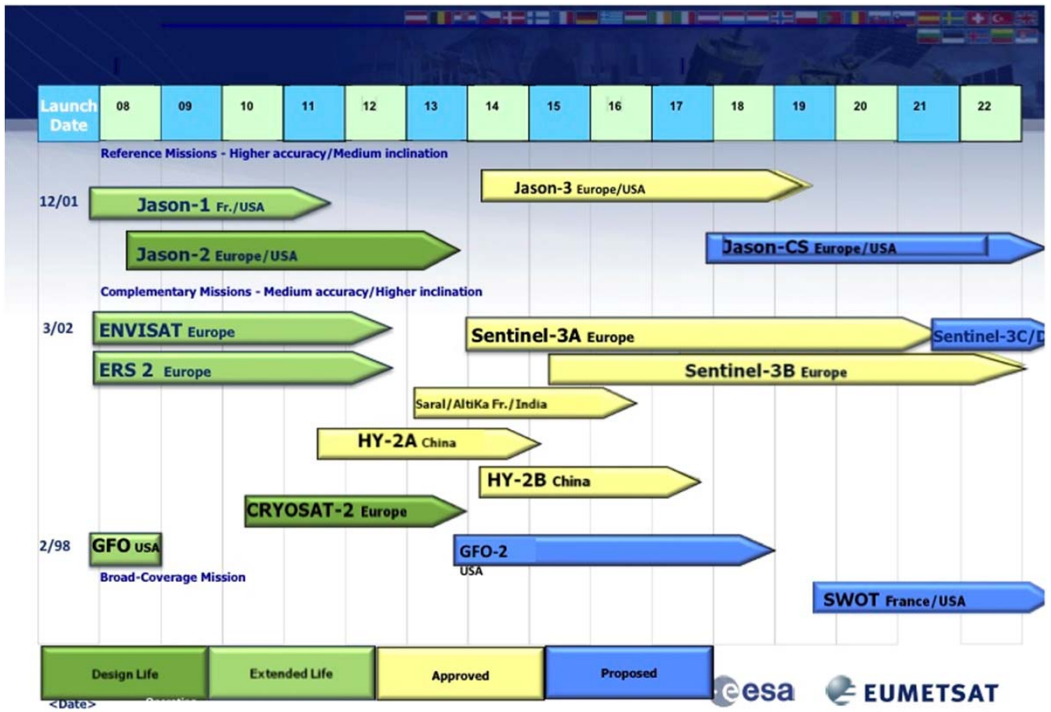
Requirements Push and Technology Pull

- Technology and complexity of satellite observations increased significantly during past 25 years resulting in:
  - Expanded missions
  - New sensors
  - Increased resolution
  - Integrated approach for data collection and analysis
- Challenge is to **balance increased demands** and expanding requirements versus **keeping pace with technology and costs**

Sustaining Partnerships

- Partnerships provide a means to reduce or avoid costs, obtain new data and mitigate potential breaks in continuity
- Reliance on partnerships brings a **risk and challenge**
- Partnering has grown in the past 20 years
- Partnering requires the ability to establish agreements, maintain collaboration and define data exchanges
- Careful stewardship, rebalancing – deliver on commitments

Flyout chart for Ocean Altimetry



Summary Findings and Observations

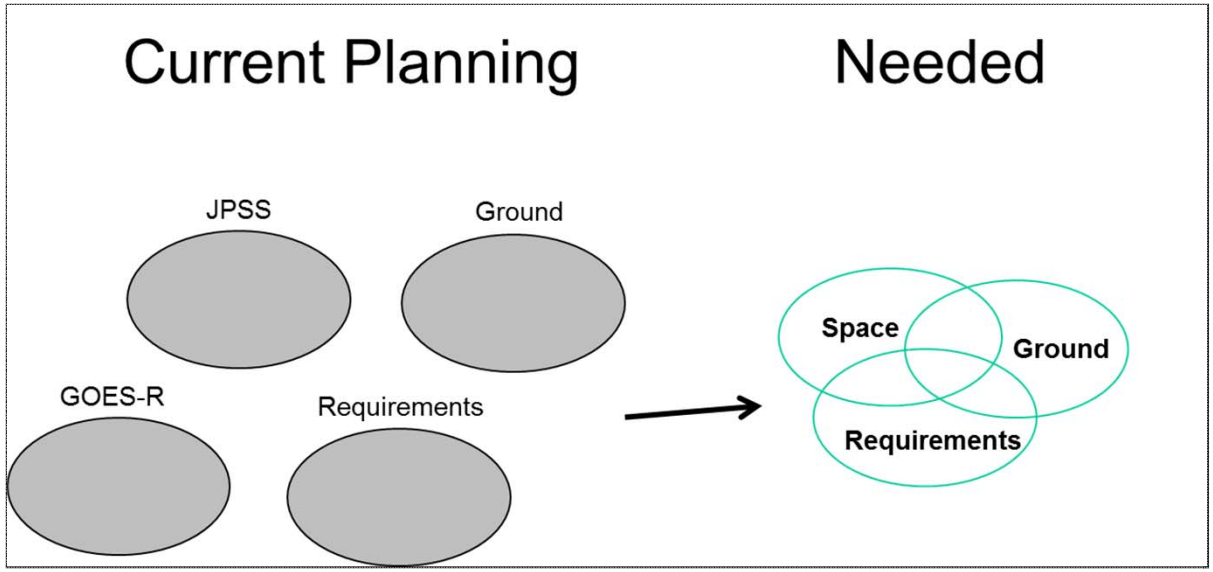
- NOAA's budget for currently planned space systems appears to be unsustainable
- Fiscal environment could lead NOAA to increase risk or decrease scope while balancing satellite system cost, performance and schedule
- Fiscal environment requires prioritization of threshold space-based observational requirements
- NOAA needs a total systems approach to satellite architecture planning
  - NOAA is in a position to undertake this with sole responsibility for both JPSS and GOES
  - Develop affordable, flexible and resilient satellite architecture alternatives to address the budget challenge
  - Address constellation management
- NOAA has taken steps to address the need for a future satellite system architecture
- NOAA has established a process capable of prioritizing needs for space-based observations
  - Process is incomplete since it cannot always be used to demonstrate impacts from the removal of capabilities

Recommendations

1. NOAA leadership should create a stable funding and management environment to support satellite activities
2. NOAA should establish a prioritized list of threshold space-based observational requirements that maintains high impact capabilities
    1. Define NOAA core functions and align them with national space policy and agency guidance
    2. Coordinate with all stakeholders (including national and international), with respect to prioritization of requirements and architectural tradeoffs
    3. Update the prioritization process database regularly with current information from subject matter experts

Recommendations

3. NOAA should create a Chief Systems Engineering function within NESDIS to address end-to-end linkages to include goals, architectures, concepts of operation, individual system development and integrated systems



Recommendations

4 Develop a cost-capped implementation plan for a NOAA Enterprise Ground System building on the recently completed study and analysis of alternatives

5 Develop an integrated master schedule addressing the entire satellite system architecture, including identification of the critical path(s).

5. Develop a tailored overarching risk-management plan consistent with alternative architectural decisions to ensure a sustainable future satellite program

Recommendations

7. Create a plan and a process for developing innovative and contingency options to mitigate gaps and potential reductions in capability and capacity
   - Establish a small, agile team to create the plan and process
   - Capitalize on technology developments across all sectors, e.g., industry, academia, national labs and other agencies
   - Consult other innovative organizations with space architecture experience; for example, DoD's Operationally Responsive Space (ORS) office provides one model for rapid response and lower capability alternatives, especially for observational reconstitution in the case of single instrument failures
   - Balance Technology Readiness Levels (TRL) with the criticality of the measurements

Recommendations

8. Given the ten year timeline required to develop new satellite systems, **NOAA should conduct an analysis of alternatives, starting in FY2013**, considering cost, performance, risk and resiliency, and assessing trade space vs. requirements for at least the following approaches:
   - Continue JPSS and GOES architecture,
   - New multi-sensor satellites,
   - Assess a hybrid of current polar and geostationary satellites,
   - Investigate a federated architecture with defined missions for individual partners, and
   - Develop a new distributed architecture
   - Scenario based

Conclusion

- NOAA has established **starting point** for assessing and re-planning its satellite system architecture
- NOAA is faced with **a demanding and evolving set of challenges** - addressing those challenges will take time
- Given current JPSS and GOES efforts it may **take up to a decade** to implement an alternate, less costly **future** satellite system architecture
- SATTF has identified **specific areas for action** that could be taken in the **near term to improve** NOAA satellite system planning
- SATTF believes these actions can provide a **way forward** to provide an architecture that is **affordable, flexible and resilient**

Action

Approval by the SAB of the SATTF Final Report for forwarding to NOAA is requested

Questions

- SATTF appreciates the support provided by NESDIS
- Chair appreciates the contributions and commitment made by the SATTF members

Backup

SATTF Process

- Met in person and via teleconference calls:
  - 14 March, 19-20 June , 13-14 Sept 2012 in-person meetings
  - 4, 30 April, 7 June 2012 (telcon)
- Presented interim reports to SAB – 5 April, 2012, 16 July 2012
- Reviewed NESDIS general plans for space architecture development including:
  - Requirements analysis and results
  - Space segment: status, plans and alternative analysis
  - Ground segment: status, workshop results and enterprise approach
- Examined Space System Alternative Approaches
  - DoD Operationally Responsive Space (ORS)
  - NAS smallsat “meeting of experts”
- Final report consists of statements of Observations, Findings and Recommendations

Specific Observations: Budget

- NOAA budget for currently programmed space systems may be unsustainable in today's fiscal environment
- Given the foreseeable future funding profile, NOAA will be challenged to deliver the same level of capability as today
- NOAA needs to be prepared for budget shortfalls given uncertainty in fiscal future
- JPSS-2 alternative architectures provides an opportunity for minimizing the cuts in capability while responding to a budget shortfall
- Reliability of international partners, given developing economic conditions may falter requiring risk management

Specific Observations: Requirements

- Requirements prioritization is incomplete
  - What is most important; e.g.: Weather, Climate or Space Weather?
  - NOAA needs to establish a prioritized list of threshold space-based observational requirements
    - There is not an agreement on the baseline required for NOAA operational continuity for satellite observations to maintain high impact capability
    - What are the minimum capabilities required to sustain weather forecasting at today's level? Future capability?
  - Need capability of assessing impact to outcomes from removing specific observations
- Unclear linkages between the NOAA space-based observational requirements process and the external user community
- Unclear linkages between NOAA satellite requirements and dependence on National and international partners?

Specific Observations: Systems Engineering

- Needs an integrated and comprehensive approach
  - Initial approach to satellite architecture design was fragmented (separate space and ground architecture studies) with no apparent link to a systems-level design nor clear link to a streamlined requirements process
- Needs an integrated approach to a space-based observational strategy, including teaming with national and international partners
  - Did not see a constellation management plan
- Needs a systems engineering function that addresses the link from goals, to architectures, to concepts of operation, to individual system development and finally to delivery of the integrated systems across the organization

Specific Observations: Ground

- Commend NESDIS for conducting an analysis of alternatives and embarking on a study for the Enterprise Ground System approach
- Implementation of an enterprise approach to the ground system architecture has potential for cost savings because of the integrated systems approach
  - NOAA is now in the position to undertake this as they now have sole responsibility for JPSS, GOES-R and legacy systems
  - Support pursuit of near-term cost-savings activities, such as increased automation of the ground system
  - Implementing the Enterprise Ground System approach in a manner that will result in cost savings will be challenging
- The relationship between the ground and space segment architectures is unclear
- Ultimate implementation of the enterprise ground system is dependent upon clear expression of the long-term vision and required next steps

Specific Observations:
Risk

- Moving towards an alternative architecture, such as a distributed system, involves both risks and benefits
- Alternative architectures require a tailored risk management plan that defines levels of risk for different types of missions
- Operational continuity and constellation reconstitution continues to be a significant risk
- No plan has been seen that mitigates gap risks nor deals with tailored risk management
- A distributed system may help mitigate budget risk
- Quick Reaction capability can help mitigate catastrophic failures, relatively quickly and at managed cost

Specific Observations:
Satellite Enterprise Top Risks

- The SATTF take note of NOAA's characterization of satellite enterprise risks
- Two risks are noted as "High Likelihood" and "High Consequence":
  - Environmental Observations Continuity
  - Budget Availability and Stability
- The SATTF also notes (and questions) Risk Item #5, "Space System Architectural Robustness," which is shown as both Medium Likelihood and Medium Consequence

Specific Observations: Policy

- Severe budget cuts could dictate less capable satellites, leading to major policy implications, such as:
  - Meeting National Space Policy responsibility
  - Impacts on international commitments
  - Impact on non-NOAA users
- “National” relationship is not clear in NOAA requirements.
- Alternative architectures could lead to International Traffic in Arms Regulations (ITAR) challenges
- NOAA management commitment required to pursue alternative architectures, given potential hard choices and their repercussions

Specific Observations: Alternative Architectures

- A spectrum of alternative space-based architectures have not been examined to date
  - These include varying orbits, mixed instruments, hosted payloads, partners, and sensors on distributed satellites
  - DoD's Operationally Responsive Space office provides one model for rapid response, lower capability alternatives
- The Aerospace study did a good job of evaluating JPSS 2-based alternatives from the JPSS-1 baseline
  - The study used a budget-based approach
  - The study was a first step in looking at a distributed system; however, it was too narrow
  - Alternatives not based on the existing configuration may be more affordable and still meet the threshold requirements