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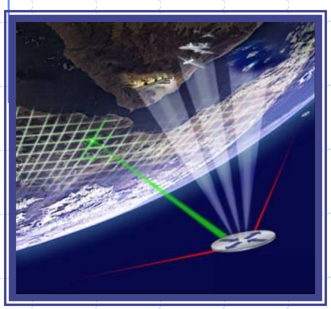
National Defense Industrial Association (NDIA) 2007 Summer Study – AFSPC Satellite Operations Enterprise Assessment



Joe Wysocki
Study Chair

19 December 2007

Overview

- Problem Statement
- Methodology, Organization and Participants
- The Imperative for Change
- Observations and Findings
- How to Cope With the Crunch
- Summary and Recommendations

Problem Statement

(Summarized from study Terms of Reference)

- The AFSPC Space Enterprise will expand substantially in the 2008 to 2018 timeframe. A host of new and upgraded systems will provide enhanced warfighting capabilities. Their deployment will also substantially increase the Command's organize, train and equip requirements.
- Given budget realities, there are likely to be gaps between resources required and resources available to test, deploy, train for and operate these additional systems.
- *How can AFSPC continue to conduct successful satellite operations with fewer personnel while still delivering unprecedented operational warfighting effects and preserving important military satellite operations competencies?*

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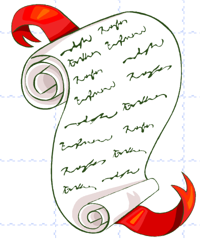
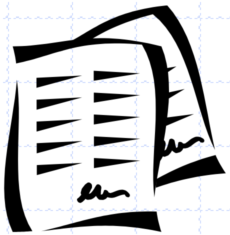
Methodology

Terms of Reference



Senior Staff Inputs

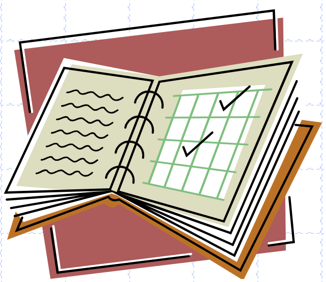
Current Civil and Space Industry Operating Models



Aerospace Industry Recommendations

Current Service and NRO Operating Models

Baseline AFSPC system schedule and manning #s



- Observations
- Findings
- Recommendations

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Study Organization

NDIA Study Lead
Joe Wysocki, Scitor

Government Liaison
Col Cathy Perro, USAF

NDIA Space Division
Russ Anarde, NGC

Panel 1
Enterprise Baseline
Marty Medina
HTSI

- Examine DoD, commercial, and civil sat ops baseline
- Identify key differentiators and factors driving *efficiency*
- Compare blue-suit models across AFSPC and national

Panel 2
Current Operations Assessment
Pete Gaffney/Jeff Benesh
ISI

- Evaluate current ops concepts, org structures, and training
- Compare with like functions across other sat ops communities and develop notional ops efficiency metric

Panel 3
Future Options
Gayle White
CSC

- Examine future AFSPC satellite baseline – systems and people projections
- Identify options to improve AFSPC sat ops efficiency

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Study Participants

- **Enterprise Baseline Panel:** Leland Horn and Gary Dieter (Boeing), Phil Rojas and Jon Levinson (Honeywell), Jan North (JPL), Michael Rader (Rader Networks), Dave Beadner (Scitor)
- **Operations Assessment Panel:** Betsy Pimentel (Stellar Solutions), Dave Finkleman (AGI), Ed Huber & Gary Nunn (ARINC), Jim Painter (NG), John Bystroff (Boeing), Kent Trailor (LM), Lad Curtis (Microsatsystems), Milt Phenneger (ASRC), Steve Savaiko (Odyssey Systems), Tim Lemmons (GD), Tom Cavalli (Barrios Technology)
- **Future Options Panel:** Arnold Berry and Stephen Gourley (Raytheon), Richard Russell (NG), Larry Dikeman and Wayne Kaufman (GD), Bill Shelton (Paragon Dynamics). Mike Drennan, Bill Fruland and Gordon Oransky (Aerospace), John Johnson and Glenn Davis (ITT), Brad Michelson (Infinity), Deforest Hamilton (Boeing), David Wagner (Harris), John Kelley and Mike Findley (Master Solutions) Bob Peterson (LM), Lauri Cross (Patch Plus), Jason Wilkenfeld (SAIC), Sarah Blake and Bryan Graves (Ball Aerospace)
- Military Liaison: Colonel Catherine Perro (AFSPC Deputy A5)
- Site Visits:
  - 460 SW
  - 50 SW
  - ADF
  - Blossom Point (NRL)
  - Echostar
  - GSFC
  - INMARSAT
  - Intelsat
  - Iridium
  - NAVSOC
  - Other Classified
  - TDRSS

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Other Data Sources

- Documents and Briefings
  - AFSPC-NRO Best Practices Study, July 2001
  - AIAA Satellite Operations Best Practices Study, May 2003
  - SMC Standard Practice Publication, HM-RB-2001-1
  - Future of Satellite Command and Control Briefing, 50 SW/CC, 2007
  - The Changing Structure of Military Satellite Ops Briefing, AFSPC/A5, 2007
  - AFSPC/A8IB Briefing on Bed down Process, June 2007
- Interviews

• AFSPC A1MR
• AFSPC/A5
• AFSPC/A8
• AFSPC/Dep A3 (NRO Perspective)
• AFRL (Tech Advisor)
• AFSPC NASA Liaison
• SIDC/CC*
• 50 SW CC
• Technical Director, NAVSOC
• JFCC Space
• SMC/CC
• SMC/RN
• Various staff members at HQ AFSPC, 50 SW, ADF, 460 SW

* Perspective as 14AF/CV

Factors and Considerations

- Identify options or approaches that preserve blue-suit/military competencies in satellite operations
  - Knowledge and expertise in effects
  - Systems operations expertise
- Focus on organizational, policy, training, and manpower alternatives that improve efficiency or allow for a smaller military workforce
- Avoid *point solutions* that can be attributed to a particular system developed by any NDIA affiliated company

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The Imperative for Change

AFSPC Satellite Ops Today

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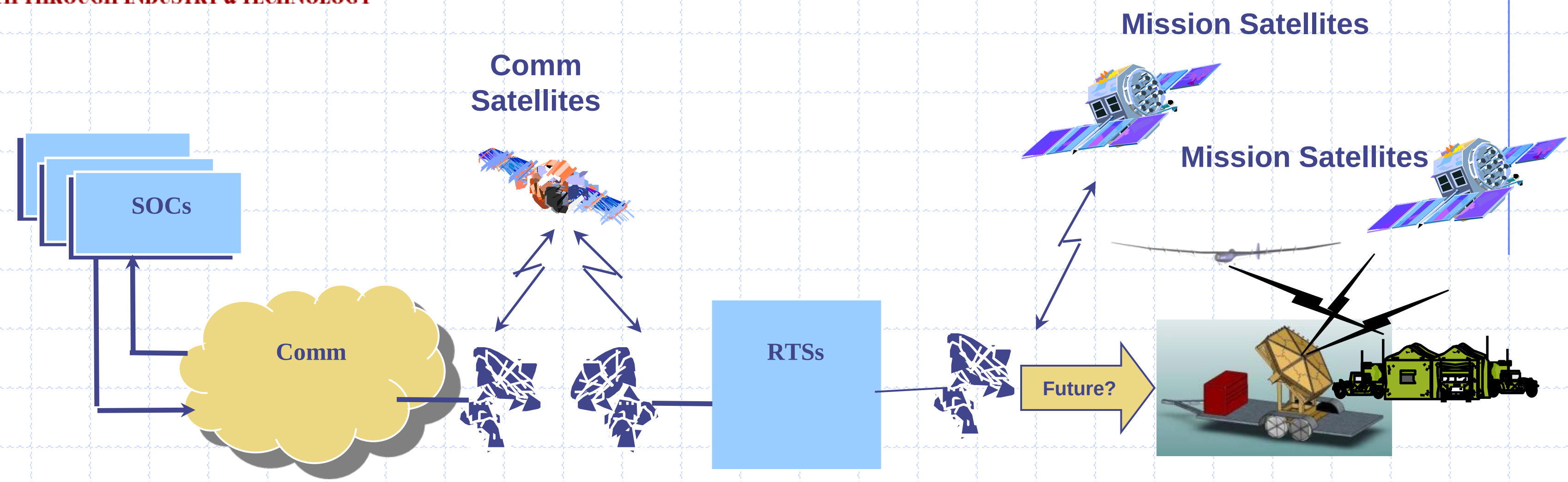
Accomplishing the mission today, but characterized by . . .

- Stovepiped systems operating well beyond end-of-life
- One-of-a-kind ground systems
- Relatively manpower intensive ops
- Segregated operations within SOCs
- Manually driven requirements
- Unresponsive to system improvements
- Antiquated concepts
- Late to need
- Long, expensive logistics tails

Source: Briefing, *The Changing Structure of Military Satellite Operations,* AFSPC/A5, 26 June 2007

Today's Force Structure is Based on Outdated Ground Systems and Stovepipes



Common SOC Systems (1980-1996) → **"Stovepiped" SOC Systems (1997-Present)** → **Integrated/Interoperable SOC Systems (Future)**

Common SOC Systems (1980-1996)

- Common systems (DSM, CCS) for TT&C
- Dedicated ground systems for mission data processing
- Expensive to implement new capabilities for satellites
- Replacement for DSM/CCS (SSCS) terminated
  - Not supported by business case
  - Too slow for mission timelines

"Stovepiped" SOC Systems (1997-Present)

- Each satellite program procures own TT&C system to replace CCS
  - CCS still supports GPS ($17M/year)

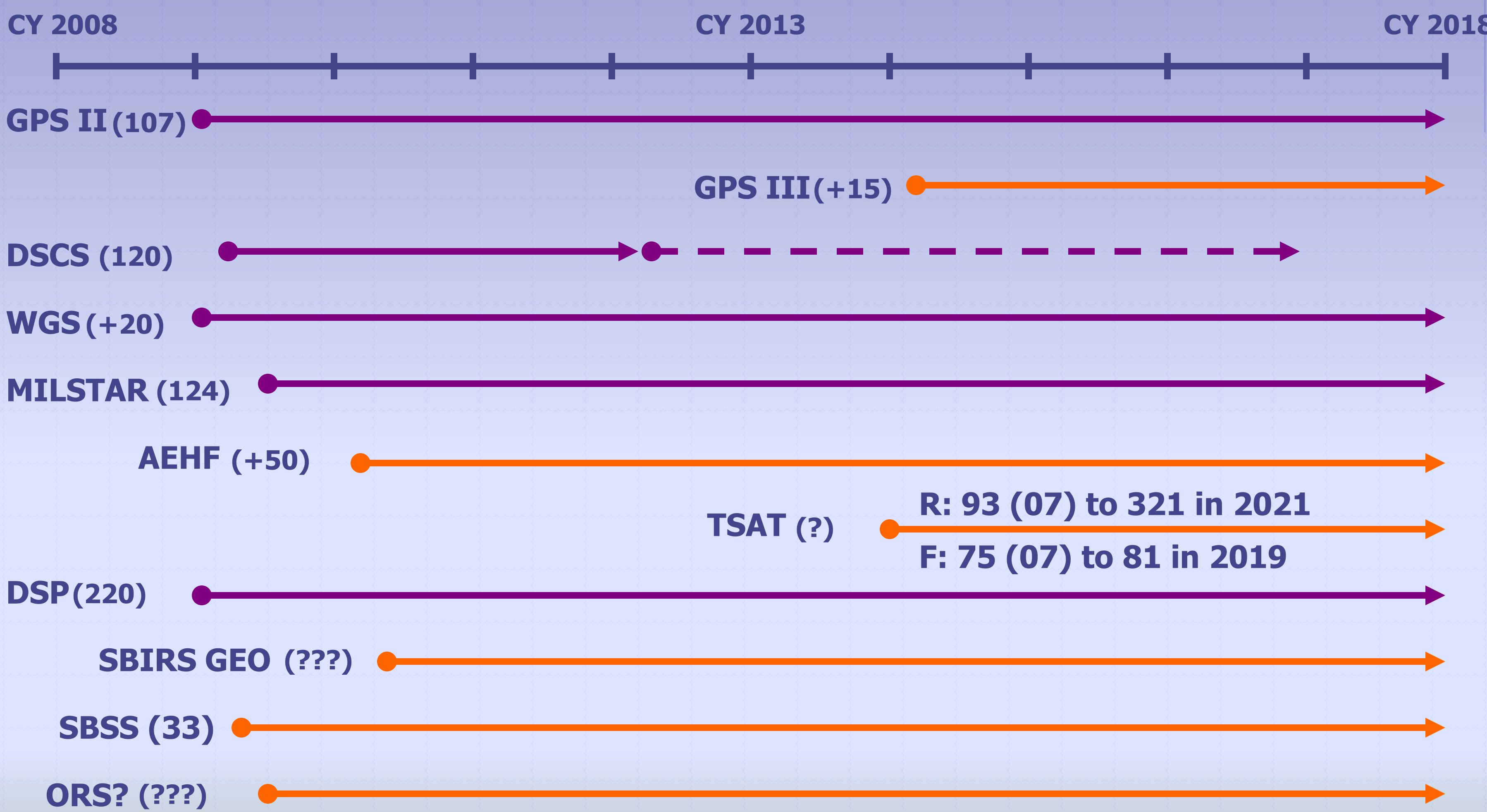
Integrated/Interoperable SOC Systems (Future)

- Shared TT&C services for compatible systems
- Focused on effects
- Technological advances enables more compatibility across programs

Source: Briefing, *The Changing Structure of Military Satellite Operations,* AFSPC/A5, 26 June 2007

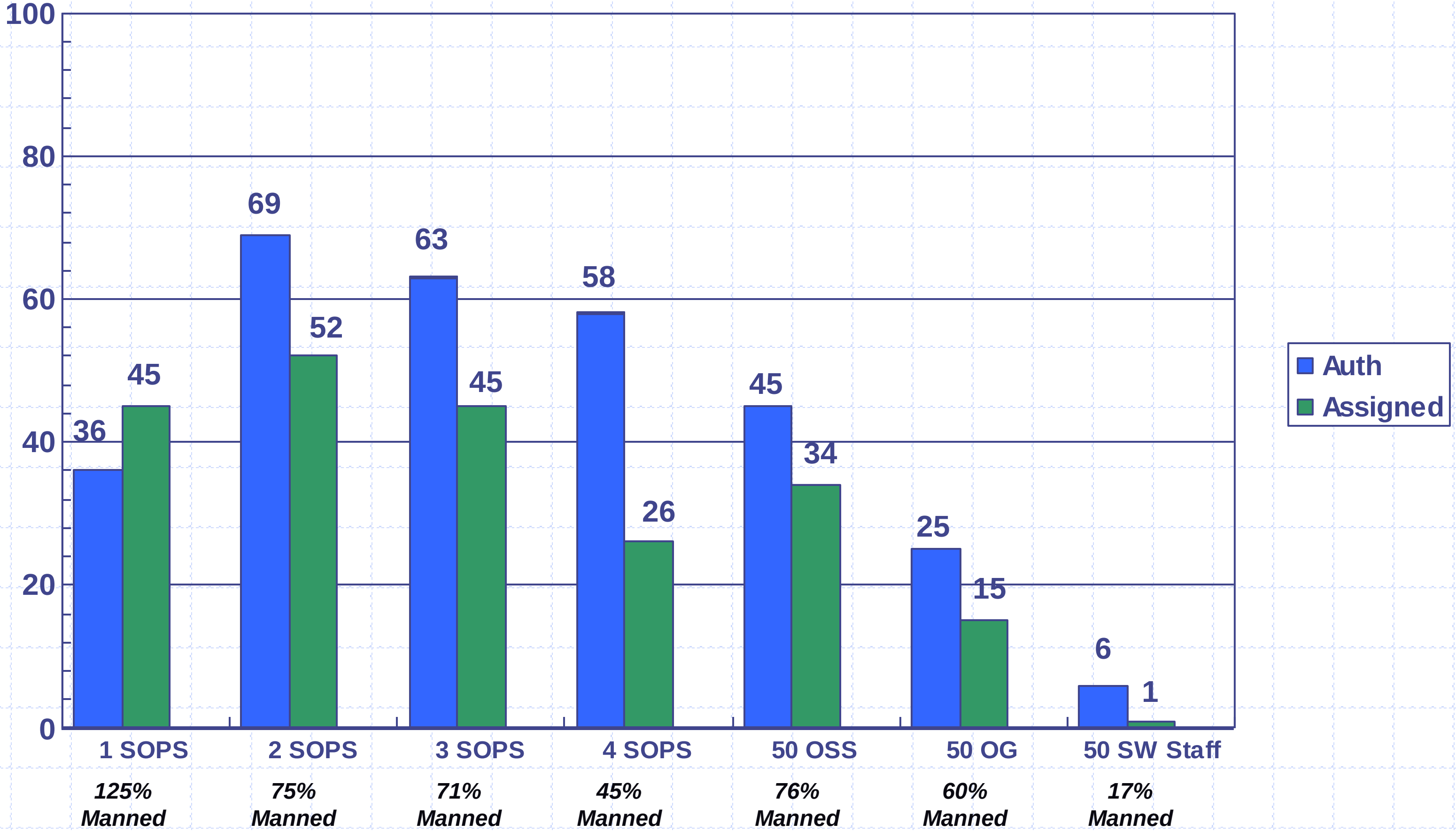
AFSPC Satellite Ops Baseline

(*Ballpark* personnel numbers from A5 interview and 50 OG)



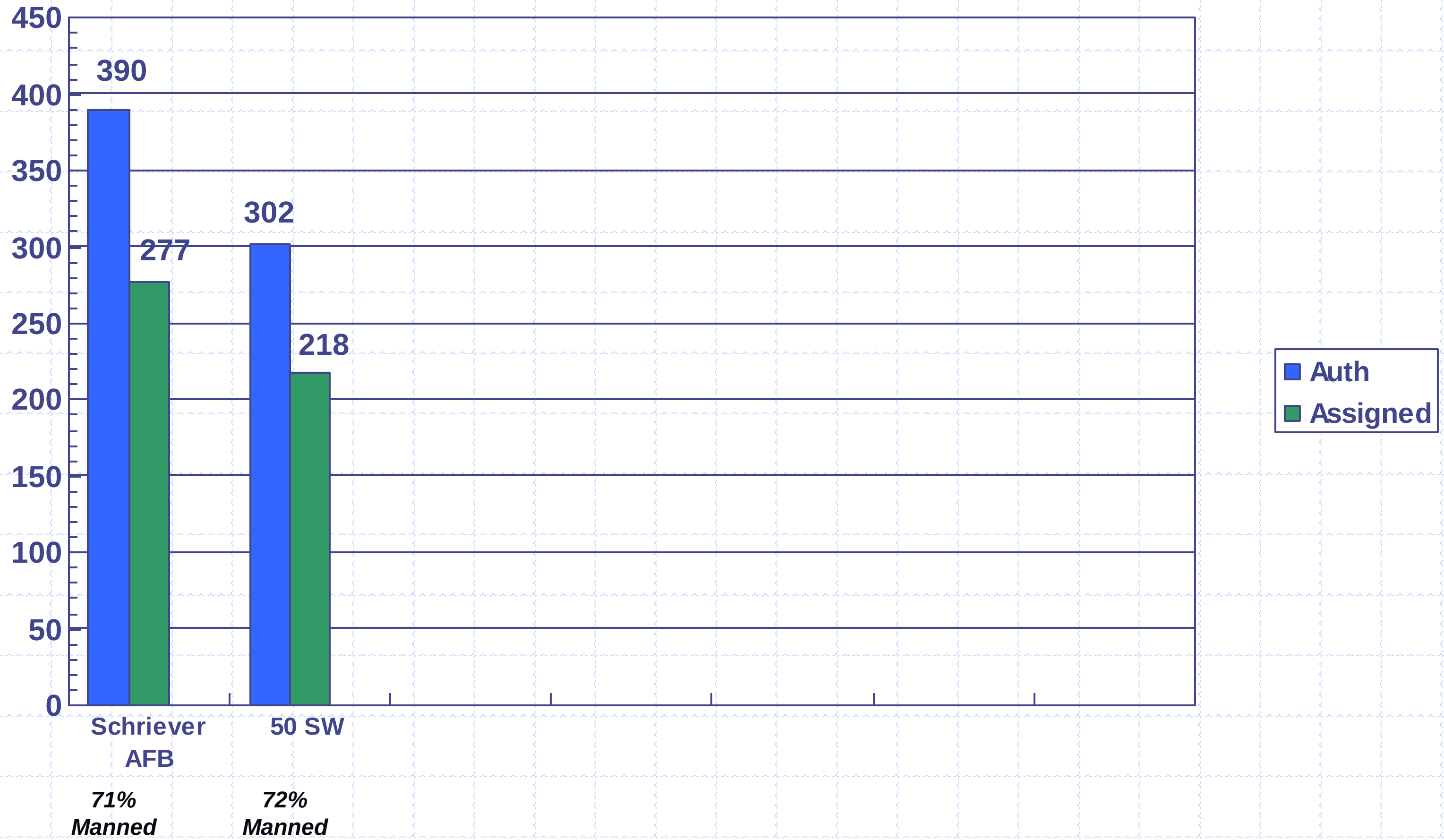
CY 2008 manpower: 600+ CY 2018: 800+

50 SW Manning (con't)



Source: Briefing, HQ AFSPC/A1F Roll Call, Feb 07. Numbers reflect 1C6 manning only.

Schriever AFB Manning



Source: Briefing, HQ AFSPC/A1F Roll Call, Feb 07. Numbers reflect 1C6 manning only.

Observations and Findings

A comparative look at culture, efficiency, and processes

Analysis Targets

- Primary Analysis
  - Site Visits
  - Telephone Interviews

- Secondary Analysis
  - Review of IEEE, NDIA, Defense Science Board and other studies

More than 20 Satellite Operation Centers Surveyed

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Commercial/Civil *Cultural* Observations

- Authority and responsibility to improve efficiency and drive down costs invested with ops teams
  - High tenure and high technical competency enables this
  - Teams staffed with appropriate skill sets to exploit their system capabilities
  - Improvements often incrementally rolled out to gain operational acceptance before proceeding with subsequent steps
- Automate as much as possible
  - Automate routine SOC operations minimizing console operators' work load and human errors.
    - Ranging
    - Command procedures
    - Spacecraft maneuvers – via procedures
  - Automate anomaly responses, especially if they disrupt service
    - Command uplink responses to well known, well defined, repeatable spacecraft events

System, Personnel, and Organizational Observations

- Contact with the spacecraft is 24/7
  - Allows automated constant monitoring of spacecraft telemetry through limit, value, and condition checks
  - Allows automation of ranging, maneuvers, event responses
  - Reduces amount of operator time spent coordinating and configuring antenna assets
- TT&C assets are remotely controlled from the operations center
  - TT&C sites can be unmanned
  - No time consuming coordination with TT&C staff is needed
- Consolidated operations – systems and staff
  - Single system for bus and payload ops
  - All ops (bus and P/L) conducted by a single team w/multi-skilled operators
    - Any operator can operate any spacecraft--even where multiple systems are flown
- High levels of operational experience
  - 7+ years of tenure; technical degrees
  - Experience level minimizes dependence on engineering support staff to resolve many ground system and spacecraft problems

Features of Most Efficient Sites

- High level of operator involvement with automation initiatives
- Automation of all routine operations
- Some had achieved and others were moving towards:
  - Common/Integrated Ground Software
  - Common Interface/GUI across all satellites
- High levels of operator cross training where commonality existed
- SOCs had combined bus and payload ops
- Operations teams had remote control of antenna assets
- Minimal turn-over (high tenure among satellite operators)

Factors Enabling Efficiency

- Several key factors drive efficiency in civil and commercial ops
  - Satellite type (complexity), number of passes per day, average duration of passes, orbit type, number of payload instruments, number of back-up systems, operator involvement with automation, level of crew cross training, constellation size
  - Most variation observed between scientific and communications/earth observation missions
    - NASA SOC architecture based primarily on a one-to-one (SOCC to Satellite) ratio – few satellites to few operators/SOCs
    - Commercial sites commonly had multi-system SOCs with many satellites to fewer SOCs & operators
  - Ops concept and operator involvement with automation, plus level of cross-training were significant factors in more efficient operations

Comparative Look at National and AFSPC Satellite Operations Culture and Processes

National SOC Observations

- All aspects of satellite operations executed by contractors – system builders typically retain ops responsibilities for their unique systems
- Contractor operators have long term experience, driving efficiencies and enabling cross-utilization of work force
- Bus and payload operations are generally combined
- Unique satellite C2 applications drive requirements for dedicated ops support personnel
- Consistently looking for efficiencies by challenging long-held assumptions with respect to CONOPS
  - NRO recently established a Ground Enterprise Manager

AFSPC Observations

- Multiple Stove Piped Ground Systems
  - Requires more manpower than consolidated operations due to dissimilar training
  - Personnel tend to be *binned* to only one system
- Increased manpower to monitor satellite and ground system functions
  - Manual operations used to check satellite and ground system status
  - Automated systems can find problems faster and more reliably – some progress being made
  - Checklists can be automated – 3 SOPS leading the way
- Time consuming interface and setup with AFSCN
  - Interface for pass setup is manual for some ops
  - Requires manpower for setup and checkout at SOC and at remote ARTS site
- Limited operator technical knowledge
  - Assumption seems to be that crew members must *specialize* in functional areas
  - Narrowly focused training limits space vehicle and ground system technical knowledge
    - Results in heavy reliance on *back room engineering or SPO experts* to diagnose ground system and space vehicle problems
    - Frequent rotation and dissimilar experience and training perpetuates this problem

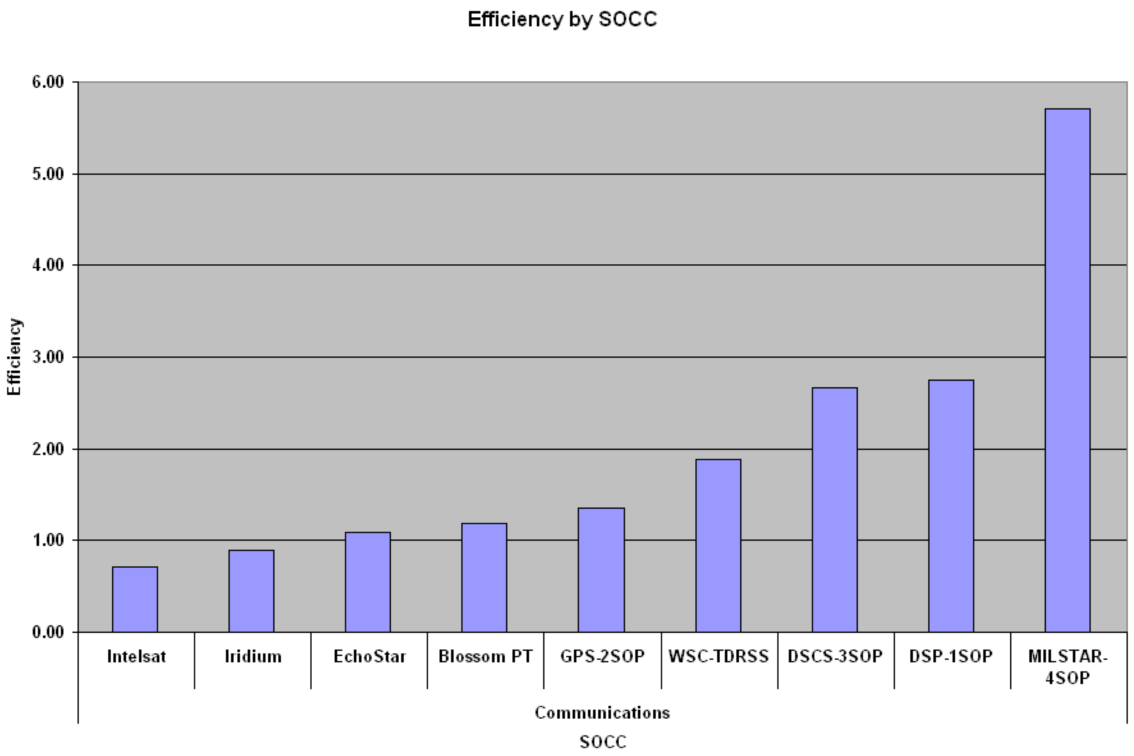
Some Good News About 50 SW and Automation

- Automated State of Health Checks
  - The 3 SOPS system can automatically check the spacecraft configuration against the expected state to verify its current state
  - Automated limit checks can be performed
  - Automated multi-point checks can be made to look for hazardous conditions
- Automated responses to well defined recurring events can be performed to correct anomalous conditions
  - The system can detect predefined conditions and initiate a correction procedure automatically
- Automation capability available in ops procedures
  - Automated telemetry checks prior to commanding
  - Automated decision making based on telemetry and other status points
  - Automated maneuver procedure execution
- Post-Pass Processing
  - Post pass automated trending can be performed on spacecraft telemetry and derived parameters for SOH predicts
  - Automated periodic reports can be generated to show spacecraft health, status, and trends

Implementing various elements of the above enabled 3 SOPS to reduce crew size 50%, from 12 to 6 personnel.

What do the numbers show?

Relationship of SOC staffing levels to numbers of satellites operated across civil, commercial and government entities



- For purposes of comparison, limited architecture to elements of the ground system concerned with the satellite bus (TT&C, anomaly detection and resolution, orbital analysis, etc. Mission data elements not considered in staffing comparisons.)
- Clear relationships existed between satellite mission/complexity, degree of dedicated TT&C assets, and personnel required to operate system constellations

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A Metric to Compare

- SOC Efficiency = Staffing levels relative to # of Satellites operated
  - For purposes of comparison, limited architecture to elements of the ground system concerned with the satellite bus
    - (TT&C, anomaly detection and resolution, orbital analysis, etc. Mission data elements not considered in staffing comparisons.)
- Commercial SOCs visited were more efficient than civilian and military SOCs
- For comparison purposes, commercial SATCOM SOCs operate at an average ratio of 8.6 sats/crew position; MILSATCOM average ratio is 2.1

	# Satellites	Operators / shift	Shifts / day	Sats per Operator
Comm-A	11	2	3	5.5
Comm-B	76	9	2	8.4
Comm-C	59	6	2	9.8
TDRSS	9	8	3	1.1
Milstar	5	7	3	0.7
DSCS/WGS	11	6	1	1.8
DSCS/WGS-M	11	3	1	3.7
GPS	31	11	3	2.8

Summary of Key Components and Their Differentiators

	Space Industry	AFSPC	Key Differentiator	Benefits to:
Ground System	Integrated/ standard	Stove-Piped	Emphasis on commonality and HMI standardization	Reduced training, increased efficiency, multi-system certifications
Operations	Automated	Manual to semi-automatic	Degree of empowerment	Reduced error rate, task minimization
Organization	Multi-mission, consolidated	Satellite system/family specific	Like system consolidation	Reduced overhead, increased flexibility, improved problem solving
Personnel	Highly technical, long tenure, small numbers	Less technical, short tenure, large numbers	Technical depth/ continuity	Quality vs. Quantity, domain expertise, multiple certifications, reduced training, improved systems comprehension & technical competence

How to Cope With the Crunch and Improve The Future

Drivers to Effect Change – and Some Early Targets

ORGANIZATIONAL	PROCEDURAL	TECHNICAL

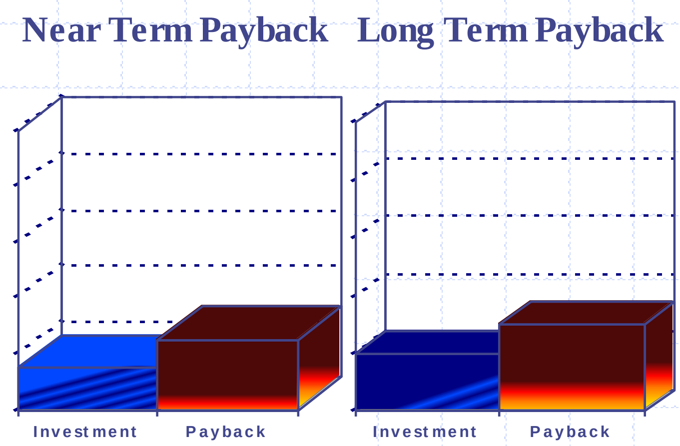
- Commonality / Standardization
- Force Tailoring and Management
- Technology & Automation
- Organization Restructuring / Consolidation

Commonality and Standardization

Recommendation

- Implement common elements among systems including:
  - Functions & processes
  - GUI & Icons
    - Measures
    - Warnings
  - Checklist formats
  - Naming conventions
  - Displays (schematics)
  - Hardware/software

METRICS



BENEFITS

- More responsive training pipeline
- Faster qualification
- Reduced error rates
- Flexibility in crew assignments
- Basis for "family of satellite" organization (i.e. org by similar ops)

Approach

- Research industry standards
- Review and re-invigorate SMC Human Machine Interface Review Board
- Establish "standards" and **enforce them**
- Cull and employ related "best practices" for satellite operations across civil, commercial, and national entities

Force Tailoring and Management

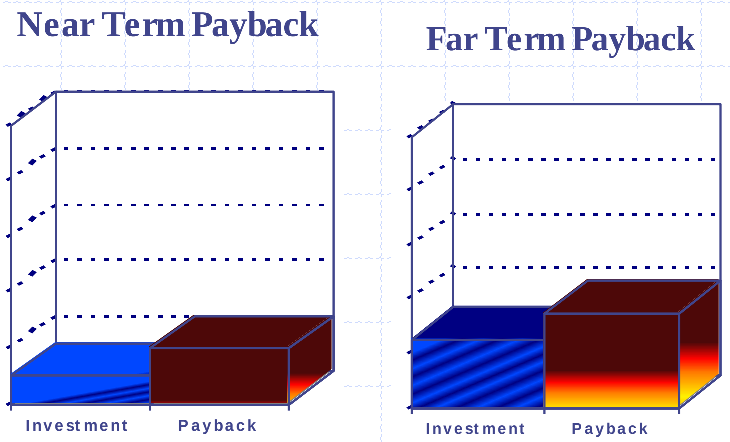
Recommendation

- Target new accessions to sat ops jobs requiring lesser clearance levels
    - Target SCI cleared personnel to those units and systems requiring such
- Tailor force mix based on DoD and other Federal Guidance (GSA and OMB)
    - Focus on “space warfighter” functions
    - Clearly defined roadmap for military experiential learning and higher airman retention

BENEFITS

- Reduces delays in employment of newly assigned operations
- Focuses experience for career progression
- Provides basis/justification for military positions
- Roles are more fulfilling for military personnel
- Residual positions provide for long-term civilian support (less training, turnover, vacancies)

METRICS



Approach

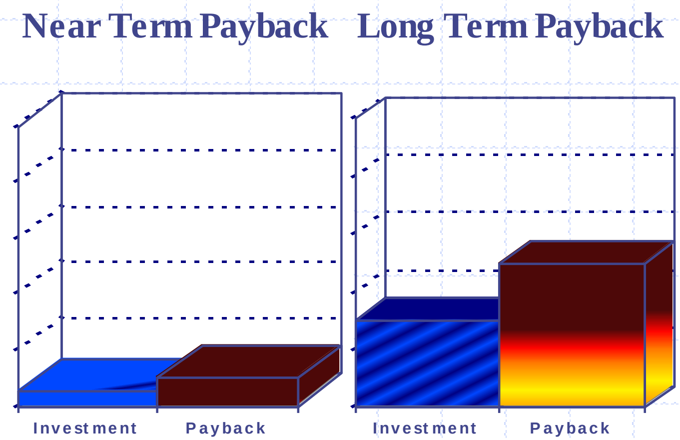
- Immediately implement a command-wide assignment policy consistent with clearance requirements
- Carefully assess criteria for “inherently” military Government and officer/enlisted positions
    - Clinger-Cohen Act 1996 (IT Mgmt Reform Act)
    - Govt Performance and Results Act 1993
    - AFI 38-203
- Conduct cost-benefit analysis of transitioning positions that are not “inherently military” and implement a plan to transition to stable Government civilian or contractor positions where feasible

Technology and Automation

Recommendation

- Extend and expand early successes in 3 SOPS
- Automate operations functions where feasible, including:
  - Checklist actions
  - System monitoring
  - Operator actions in anomalies
  - Two person control (via a warning system vice over-the-shoulder review)

METRICS



BENEFITS

- Reduces error potential in many areas
- Directly reduces manpower
- Allows increased focus on "mission payloads"
- Allows increases time for trend analysis
- Reduces two-man control workload Reduces potential for "operator overload"
- Facilitates cross-training via reduced operations complexity

APPROACH

- Define criteria for automation of AFSPC satellite operations
- Include associated requirements in OPS standardization requirements
- Extend current capabilities in 3 SOPS
- Migrate enabling modifications or system upgrades to like SOCs
- Begin installing broader automated capabilities via change requests and new system requirements

Organization Restructuring / Consolidation

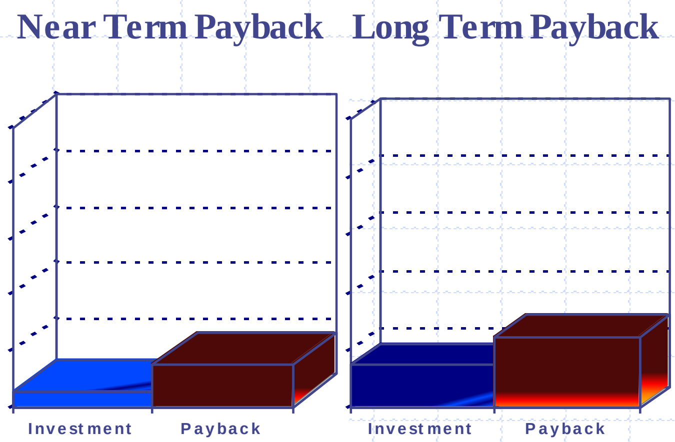
Recommendation

- Structure organizations around “family of systems”
  - MILSATCOM
  - ISR
  - PNT
- Link to standardization of systems especially within system families
- Maximize cross training across systems
- In a broader sense – seek multi-service consolidation to leverage greater gains
  - Army DSCS OCs
  - NAVSOC Systems

BENEFITS

- Increases crew assignment flexibility
- Provides for minimum crew sizes, taking advantage of flexible assignments and scheduling
- Leverages manpower, expertise, and ground systems across services

METRICS



Approach

- Restructure MILSATCOM systems
- Development requirements for common operations and training environment for future system families
- Cross train operations personnel within system families
- Seek Higher Headquarters backing for multi-service consolidation study

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Insertion Points for Change

Lifecycle Management Framework

Concept Refinement	Technology Development	System Development & Demonstration	Production & Deployment	Operations & Support

Commonality and Standardization

Commonality and Standardization

Force Tailoring and Management

Force Tailoring and Management

Technology and Automation

Technology and Automation

Organization Restructuring / Consolidation

Rough Order of Merit Personnel Calculations

- High confidence numbers difficult to predict due to wide range of possible implementations
- Demonstrate art-of-the possible looking at MILSATCOM only
  - Compare crew & squadron numbers using current ops paradigm against what could be possible with consolidation and other initiatives
  - Use metrics from slide 26 (A Metric to Compare) and notional squadron manning from slide 12 for 2013 timeframe (mid-point)
- Current mean sats/operator ratio in commercial world is 8.6
- Projected (2013) mean MILSATCOM ratio in AFSPC is 2.9 (current is 2.1) – using combined DSCS/WGS and MILSTAR crews
- *Guestimate* being able to become half as efficient as commercial entities in 2013 allowing AFSPC to go from 2.9 to 4.3
- Estimate conservative savings of 1/3 in *support staff* of combined MILSATCOM squadrons by consolidating OA, planning, engineering support, and administrative functions

An Approximation With No Changes

Operating with ave. 2.1 satellites/operator ratio per shift

Current Ops (Summer 2007)

System	# Satellites	AF Crew	X 4/5 crews	+ sq staff	Est Total
DSCS/WGS	11	6 (3-M)	18	102	120
MILSTAR	5	7	35	89	124

Approx Total Manning: 244

Circa 2013 w/WGS and AEHF driving increase of 2 positions/crew

System	# Satellites	AF Crew	X 4/5 crews	+ sq staff	Est Total
DSCS+WGS	14	8 (4-M)	24	102	126
MILSTAR + AEHF	8	9	45	89	134

DSC/WGS crew size averaged between day and mid shifts (mid shift adding only 1 for WGS)

Approx Total Manning: 260

Assumptions and Potential Resultant Savings

- Assumptions:
  - Adapt various elements in four areas previously identified: Commonality and Standardization, Force Tailoring and Management, Technology and Automation, and Organizational Restructuring and Automation—and combine 3 & 4 SOPS
  - Seek a goal to become *half as efficient* as commercial Satcom community and reduce squadron staff component by 1/3, combining like ops support functions (e.g., OA, planning, engineering, admin)
  - Allows working crew ops with ratio of 4.3 satellites/operator ratio per shift, or 5.1 operators per shift to fly 22 satellites (allocate 2 positions to contractors)

Truncate total crew size to 5 per shift

System	# Satellites	AF Crew	Contr Pos	X 5 crews	+ sq staff	Est Total
DSCS+WGS +MILSTAR+ AEHF	22	3	2	25 (15 military)	127	152 (142 military)

- ***Becoming half as efficient as commercial entities in MILSATCOM could allow AFSPC to operate with 142 military positions (45% less than otherwise needed)***
- ***The key goals are to consolidate organizations and broaden the scope of crew duties to reduce the squadron tail (reducing this tail further to ½ reduces total military to 111)***

Summary of Key Findings

- Substantial manpower savings are possible . . . But,
  - *Estimates* here are based on assumptions. A detailed manpower study can provide more confidence.
  - The numbers should be viewed as what is possible to achieve in MILSATCOM. They **should not** be viewed as cut targets.
- Industry views of future options are diverse, but four areas show the greatest promise
- Not all changes require "system" changes
  - But, system changes can be a "force multiplier"
- Success in this journey requires change led by strong and consistent leadership at all levels in operations and acquisition
- **Cultural change is needed to facilitate these improvements**

Summary of Key Findings (cont)

- Specific focus areas:
  - Improving the satellite to operators ratio provides a good target to drive efficiency gains. Backroom consolidation also offers large potential gains
  - 3 SOPS has implemented major automation initiatives already. They are a leader in this area. More can be done in other systems
  - Changes can be “inserted” in the system lifecycle at multiple points

Recommendations

(From low-hanging fruit to enduring cultural change)

- Seek immediate changes to force management and policy to make more efficient use of space cadre (units where clearance delays have impacts)
- Consolidate training and organize to leverage like systems in MILSATCOM (combine 3 & 4 SOPS) – create multi-system capable crew force
- Leverage current automation capabilities in SOCs – seek design upgrades to the AFSCN allowing unmanned, remote ops for all passes
- Make common HMI standards a formal process and requirement for SMC-developed space systems
- Evaluate inherent military roles across all AFSPC satellite ops to identify smart conversion options (Military to civil service or contractor)
- *Empower and incentivize* commanders at all levels to seek more efficient operating models
  - Emphasize satellites-to-crew position ratio as a metric to improve efficiency
  - Empower leaders within squadrons, provide them with skills & tools to innovate
  - Couple to robust training and education on effects *and systems*

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Q & As . . . Discussion