MILSATCOM Transformation

... making the Net work
“Battlefield communications have gone through dramatic transformation over the years, perhaps more than any other military field. In fact, last Friday night, National Defense University paid tribute to one of my predecessors as Chairman, General Jack Vessey, who began his military career carrying secure dispatches on a motorcycle.”

General Richard B. Myers
Chairman
of the Joint Chiefs of Staff
3 March 2004
on the occasion of the Smithsonian National Air & Space Museum Trophy Award to the Milstar Team
Military Satellite Communications

circa now -- 2010

Wideband
- 5 Primary DSCS
- 5 WGS
- Augment w/commercial

Protected
- 5 Milstar
- 3 Advanced EHF
- Interim Polar 2, 3, & 4 (TBD)

Narrowband
- 10 UFO
- 5 MUOS

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DSCS-SLEP and GBS II
WGS, DSCS &
GBS Phase II

Milstar
Adv EHF

Polar (Hosted)

UFO & DAMA
MUOS

UFO-11
### Military Satellite Communications

**circa now -- 2010**

<table>
<thead>
<tr>
<th>SATCOM</th>
<th>1994 MS I</th>
<th>2001 Milstar II</th>
<th>2007 AEHF</th>
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* Terminal Developments Required

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**Circuit based / RF systems have served us well but . . .**
The Challenge

Army Objective Force

- Full Spectrum Army – campaign across armed forces with special purpose capabilities
- Joint: Interagency & Multi-National
- Conceptual
- Mobility & Maneuver
- Knowledge - network center, self-sufficient and adaptive Soldier and leader, agility & force enhanced by advanced technologies
- Adaptable Organizations –
  > MA (Ett) – conducts engagements, enabled by the model
  > ML (Ett) – conducts battles
- System of Systems – family of networks/infrastructure designed for good connectivity and interoperability
- Power Projection Space-based Force

Navy SeaPower 21

AF Air Expeditionary Force

All Service Visions require more communications connectivity and capacity
Transformation to Net-Centric Ops

System-of-Systems

Net-Centric Infancy

C4ISR Net-Centric Integration

1995

2003

2010

2015

CONOPS Transition

Transformational Communications Architecture (TCA)

Post-Gulf Architecture

Cold War Imperatives

Desert Storm

Pressures for Transformation

Operation Iraqi Freedom

Static

Static/Dynamic

Dynamic
Transformational Communications Architecture (TCA) Vision

An internet-like transport architecture between space, air and ground nodes

- Integrated Space, Air and Ground Networks
- Global access to deployed / mobile Users (COTM)
- Timely delivery of air and space data to Theater and CONUS (AISR, SISR support)
- Automated, dynamic, high assurance network operations
- Increased capacity and connectivity: RF and laser communications network

Enable Future Innovations and Growth Through A Flexible Yet Secure Network Architecture
Global Information Grid (GIG)
Transport Layer

Tier 4 Global Coverage
Tier 3 Wide Area Coverage
Tier 2 Inter-Team Coverage
Tier 1 Team Coverage

JTRS
TC MILSATCOM (TCM)
GIG-Bandwidth Expansion (GIG-BE)
Joint Tactical Radio System (JRTS)

R = Internet Router or JTRS

Build the Net
TCM Capability Impacts

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* Terminal Developments Required

Facilitates Shorter Kill Chain
Connectivity

- **Circuit Based**
  - Point-to-point circuit for each connection
  - Double hop to connect hubs

- **IP Based (Packet Based)**
  - Internet Protocol (IP)
    - Single circuit to satellite provides ubiquitous connectivity
    - Simplifies mission planning

IP enables the right packet to transit the right satellite, on the right antenna, with the right quality, to the right User!
TC Architecture Circa 2015

Advanced Polar

TSAT

Gateways/Ground stations

TC Mission Operations Centers

Plus SE&I Support

AF TC Acquisitions
TC Network Management

Overall Network Policy (e.g., contingency planning, apportionment)

DoD  IC  NASA

SATCOM Operations Mgt

GIG Network Manager

TC Operations Management Center(s)

Network Policy

Planning  Service assignment & adjudication

UCC OPLAN Support  Global COP/SA

Policy Generation and Validation

Operational Direction

Satellite TT&C

Ranging  Anomaly Resolution

Collision Avoidance  Orbit Determination

Relocation  Ephemeris Server

L&EO

From Policy to Action in Real Time

Quarterly

Daily

Real Time

Network Mgt, Health & Status

Fault  Configuration Mgt

Encryption Key Mgt  Profile & Address Mgt

Network Security  Planning

Performance  Accounting

TC Systems & Network Management Center(s)
TC Network Software Functionality

- Policy Management Implementation
  - Provides the specific TCM software to implement the policy management protocols used by the GIG for the TCM system
- Network Management Reporting
  - Provides commercial standards based data and control plane interfaces to commercial / terrestrial tools and equipment
- SATCOM Management
  - Controls the satellite’s payload configurations, operations and fault responses
- Mission Planning
  - Provides the mission planning tools to determine satellite resource allocations for the space portion of the network
- SATCOM Key Management
  - Provides software for “over the air” distribution of TRANSEC keys
SATCOM Terminals
-- Software Communications Architecture (SCA) compliant

Enables mobile, smaller terminals

Goal: Close a T1 link to a 1 - 1 1/2 foot antenna by 2011

Service Terminal Quantities Based on SDB, FCD and Doctrine
TCM Software Technical Challenges

- Many complex interfaces
  - Key external interfaces – GIG, AISR / SISR, WIN-T / JTRS, DoD security management, AEHF, Teleports, Global Network Ops System Center, others (TBD)
- Internal interfaces:
  - Payload to Terminal
  - Network to Terminal
  - Sat Ops Center to Satellite (TT&C)
  - Network to Satellite
  - Network to Sat Ops Center
  - Key Management to All

- Multiple organization involved: DISA, NSA, NRO, Army / Navy / AF / Marine TC and Terminal programs . . .
- Space Segment: network protocol processing and network management
- Ground Segment: management and control of a world-wide distributed mission critical network
MILSATCOM Software Growth
1985 - 2011

**Space Segment**

- SLOC
- Thousands
- 1985 - 2011
- DSCS II
- DSCS SLEP
- Milstar Blk 1
- Milstar Blk 2
- AEHF
- TSAT

**Ground Segment**

- SLOC
- Millions
- 1985 - 2011
- DSCS II
- DSCS SLEP
- Milstar
- AEHF
- TSAT
What Can We Learn From Our Past?

16 Critical Software Practices for Performance-based management

**What Causes These Symptoms?**

IEPRs/Tri-service Assessment Initiative (TAI) Prospective Recurring Patterns

- Inadequate Change Management
- Ineffective Systems Engineering
- Disconnected Education & Training
- Poor Technology Refresh Management
- Inadequate Resource Infrastructure
- Ineffective Portfolio Management
- Inadequate Process Capability
- Developing the wrong functions and properties
- Continuing stream of requirements changes
- Shortfalls in externally performed tasks
- Straining computer-science capabilities

**Ten Best Practices for Software Development**

1. Aggressively limit development time to no more than 18 months.
3. Highly incentivize development teams – time to market, call rate, product sales.
4. Allow program management to trade functionality for time and stability.
5. Make sure development team has a process but value past performance over process.
6. Set clear goals and decision points that force early termination of off track projects.
7. Use iterative not waterfall development process.
8. Develop an executable architecture first.
9. Use component architectures, model visually, use tools for initial code inspection, not people.
10. Evolve requirements with the design. Don’t freeze requirements first. Don’t rigorously trace requirements to design.

**Program Assessment Toolkit – Common Problem Area**

- Program management
- Multi-organizational collaboration
- Requirements/Systems Engineering
- Funding
- Staffing (of both Government and contractor)
- New technology
- Development Processes
- Schedule

**Boehm’s Top 10 Software Development Risk Items**

- Boeing’s list of the top ten risk items based on a survey of several experienced project managers are:
  - Personnel shortfalls
  - Unrealistic schedules and budgets
  - Developing the wrong functions and properties
  - Developing the wrong user interface
  - Gold plating
  - Continuing stream of requirements changes
  - Shortfalls in externally finished components
  - Shortfalls in externally performed tasks
  - Real-time performance shortfalls
  - Straining computer-science capabilities
Avoiding a “Software Crisis”

Mid 70s “Avionics Software Crisis”

- Analog to digital avionics
- Rapid increase in software size and complexity

System functionality requiring software

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Industry / government not prepared

2000 “Space Software Crisis”?

- Transponded to processed SATCOM
- Circuited vs Internet Protocol (IP)
- Circuit based vs net-centric
- Rapid increase in software size and complexity

Are aerospace industry and government prepared?
Software Intensive System Acquisition Best Practices Assessment Framework

**Project Management**
- Adopt a Program Risk Management Process
- Estimate Cost and Schedule Empirically
- Use Metrics to Manage
- Track Earned Value
- Track Defects against Quality Targets
- Treat People as the Most Important Resource
- Improve Software Skills of Acquisition Managers
- Adopt Effective Contract Incentives
- Stress Past Performance and Process Maturity
- Exploit Independent Expert Reviews

**Product Construction**
- Adopt Life Cycle Configuration Management
- Manage and Trace Requirements
- Use Systems Based Software Design
- Ensure Data and Database Interoperability
- Define and Control Interfaces
- Design Twice, Code Once
- Assess Reuse Risks and Costs
- Use Executable Architectures
- Employ Iterative Design / Development Cycles
- Maintain a Strong Technology Base

**Product Stability & Integrity**
- Inspect Requirements and Design
- Manage Testing as a Continuous Process
- Compile and Smoke Test Frequently

Top TCM Program Risks

1 - Information Assurance
2 - Software
3 – GIG Network Interoperability
4 - Digital Processing and IP Routing
5 - Laser Communications Productization
6 – Schedule
7 – Systems Integration & Testing
8 – Requirements Management

TCM has a very robust risk management approach
TCM Requirements Management Approach

- Develop detailed requirements, baseline and manage
  - Capstone Requirement Document – JROC approved Jan 03
  - Transformational Communications Architecture – JROC approved Sep 03
  - TSAT Capabilities Development Document – JROC approved Jan 04
  - TCM Technical Requirements Document (TRD) – draft Mar 04
  - TSAT Space Segment TRD – draft Mar 04
  - TSAT Network TRD – Oct 04
- New requirements are vetted through HQ AFSPC, STRATCOM and ultimately Joint Requirements Operations Council
Testbed Approach

GIG End-to-End Testbed
- JTRS Network Testbed
- Airborne Network Testbed
- WIN-T Testbed
- FORCENET Testbed

High-speed network connections

DISA Terrestrial GIG/GIG-BE Testbed

DISA Teleport Testbed

JTRS-TSAT-GIG connectivity example

TCM Testbed
- Optical Comm Testbed
- RF Testbed
- Network Testbed

Test the way you operate
Summary

- MILSATCOM systems are transforming from circuit based systems to internet protocol based networks; the associated software is growing exponentially

- Metrics based disciplined systems engineering and software engineering are essential in achieving mission success
A day without software