Trends in Migration to Enterprise Space Ground Systems SMC-IT Mini-workshop Summary*

Michael Campbell, PhD
Information Systems & Cyber Division
Computer Applications and Assurance Subdivision
The Aerospace Corporation

Vincent Chen, Capt USAF
Evolved Strategic SATCOM (ESS) Program Office
Space & Missile Systems Center

Ground Systems Architecture Workshop, 2018
"Migrating Toward a Resilient Enterprise"
Wednesday Evening Session

*** Space Mission Challenges in IT Conference, 2017**

Trends in Migration to Enterprise Space Ground Systems
Mini-workshop Outbrief

21 Participants representing ~15 different organizations

SMC-IT Mini-workshop Agenda:
– *Keynote - Nestor Peccia (ESA)*
– *Around the Room*
– *Position Statements from Participants*
– *Discuss Opportunities, Challenges, and Patterns of Successful Migration*
– *Build Out-brief*

A Summary of Key Points Raised by Participants in the Mini-Workshop

Trends in Migration to Enterprise Space Ground Systems

Mini-workshop Product

- Opportunities & Observations
- Challenges & Open Questions
- Common Goals
- Guiding Principles & Recommendations
- Conclusions

Every space organization is adapting to this new environment

Classic architectural considerations, radical new landscape ...

Driven by:

> *Rapid evolution & disruptive change in software & hardware technologies*
> *Extraordinary fluidity in requirements & operational context*

- Form follows Function follows Concept of Operations follows User Needs
- Constraints:
  - *Policy & Security*
  - *Software Reuse & COTS*
  - *Technology (Im)maturity*
- Hard Requirements:
  - *Performance: Throughput, Latency, Bandwidth, Data Volume, & Variability*
  - *External Interfaces & Inter-operability*
- Non-Functional Requirements:
  - *Availability, Reliability, Maintainability*
- Soft Requirements:
  - *Automation*
  - *Agility (Design for Change)*
  - *Continuity Of OPerations (COOP)*
  - *Cost & Schedule (also constraints, to some degree)*
- Governance must become part of the architecture

Examples of Organizations & Projects Migrating

- European Space Agency (ESA)

- NASA

- National Oceanic & Atmospheric Administration (NOAA)

- USAF / SMC:

    - *SDTF*: Enterprise Ground Services (EGS)*

    - *SDTF / RS: HEO Operations Migration to EGS (HOME)*

    - *MC: Evolved Strategic SATCOM (ESS)*

* SDTF = Space Defense Task Force

Every organization is adapting to its own environment

Trends in Migration to Enterprise Ground Systems

Commercial Systems

- Migration to Cloud
- Everything as a Service
- Adoption of Common Services
- Faster Ops Tempo
- Increasing Volume of Data
- Systems of Systems -> Integration -> Orchestration
- Architectural Agility
- Dev/Ops and Continuous Delivery & Deployment

Space Ground Systems

- Progress virtualizing software
- Uneven success
- Exploring migration from vertical to horizontal structures
- Frequently a main driver
- Some organizations in the lead
- Coded -> Scripted -> Dynamic & User-driven
- From years to months to weeks
- Mis-matches between capabilities, desires, & policies

Many organizations facing similar pressures & challenges

Opportunities and Observations

- TT&C functions typically offer opportunities for migration (compared to the more mission-specific Mission Processing functions)
- Commonality across missions offers opportunities for improved human factors and user experience (common GUI)
- Unconventional approaches to evangelize and build confidence, e.g. Hackathons and Challenges
- GMSEC and associated interfaces & tools becoming *de facto* standards
- Broad-based standards organizations are addressing unique needs of space/ground community: OMG SDTF, CCSDS

- Rapid progress in Information Technology is blurring the distinction between space and ground (esp. from the end-users' perspective)
- Perceptible difference in "Traditional Space" and "New Space" communities:
  - *New space is coming from IT culture: More comfortable with rapid rate of change, horizontal information exchange, and open source culture*

Confluence of Commercial IT and Commercial Space is changing entire Space Industry

Challenges and Open Questions

- Large legacy systems/apps/hardware employing dated languages/compilers
- Rapid pace of change in IT:
  - *Mismatch with long lead times in large, interconnected systems*
- Space culture generally very risk-averse
- New business models not fully understood by acquirer or developer organizations

- Migration: Encapsulate vs. Migrate vs. Develop new?
- Architecture: Modular vs. horizontally layered?
- Deployment: Cloud first vs. Services first?
- Enforcing architectural standards and attributes: Mandates vs. Incentives?
- Promotion of capabilities to common services: *a priori* vs. "Rule of Three"?

Most challenges are more cultural than technical
Rapid pace of change in IT is both a challenge and an opportunity

Common Goals

Typical reasons space ground systems consider enterprise approach

- Save time and money: Development, Training, Ops, O&M
- Enhance Inter-operability: Internally and Externally
- Achieve extensibility and Avoid obsolescence
- Improve automation of Ops

Different motivations often lead to similar technical approaches

Guiding Principles and Recommendations

Patterns of success mentioned during mini-workshop discussions

- Understand all stakeholders' business models, incentives, disincentives
- Start small to build trust, *then* build large
- Standardize on interfaces (especially *between* stakeholders), *not on products*
- Design for portability and change
- Build-in resilience (incl. cyber security and identity management)
- Implement monitoring & metrics (and use them)
- Strive for transparency in acquisition, on-boarding, and governance

- Consider whole life cycle in all decision-making
- Make governance part of the architecture
- Educate decision-makers and end-users
- Distribute source code, but maintain configuration control

Best practices are common across different technical approaches and different segments of Space industry

Conclusions

- Rapidly evolving technological trends are *simultaneously* pushes, pulls, enablers, challenges, and constraints
- Every organization responds somewhat differently, depending on their unique environment, yet ...
- ... some nearly universal patterns are emerging:
  - *Multiple clouds with PaaS offerings tailored to culture, policy, and scale*
  - *Layered enterprise architectures -- Governance is key:*
    - Enterprise owns standards between layers:
    - Based on common services from legacy systems and widely-accepted COTS
  - *Design for change everywhere: requirements, users, threats, hardware, software, COTS, interfaces, scale, connectivity -- even standards*
  - *Achieve resilience with geographically dispersed clouds and networking*
- Challenges are mainly *non*-technical:
  - *Difficult transformation from vertical to horizontal structure: organization, funding, autonomy, diverging organizational and personal incentives*
  - *Leadership and policy-makers need to catch-up to increasing tempo*
  - *Layered architectures, common services, and distributed development & deployment all lead to diffusion of responsibility and accountability*
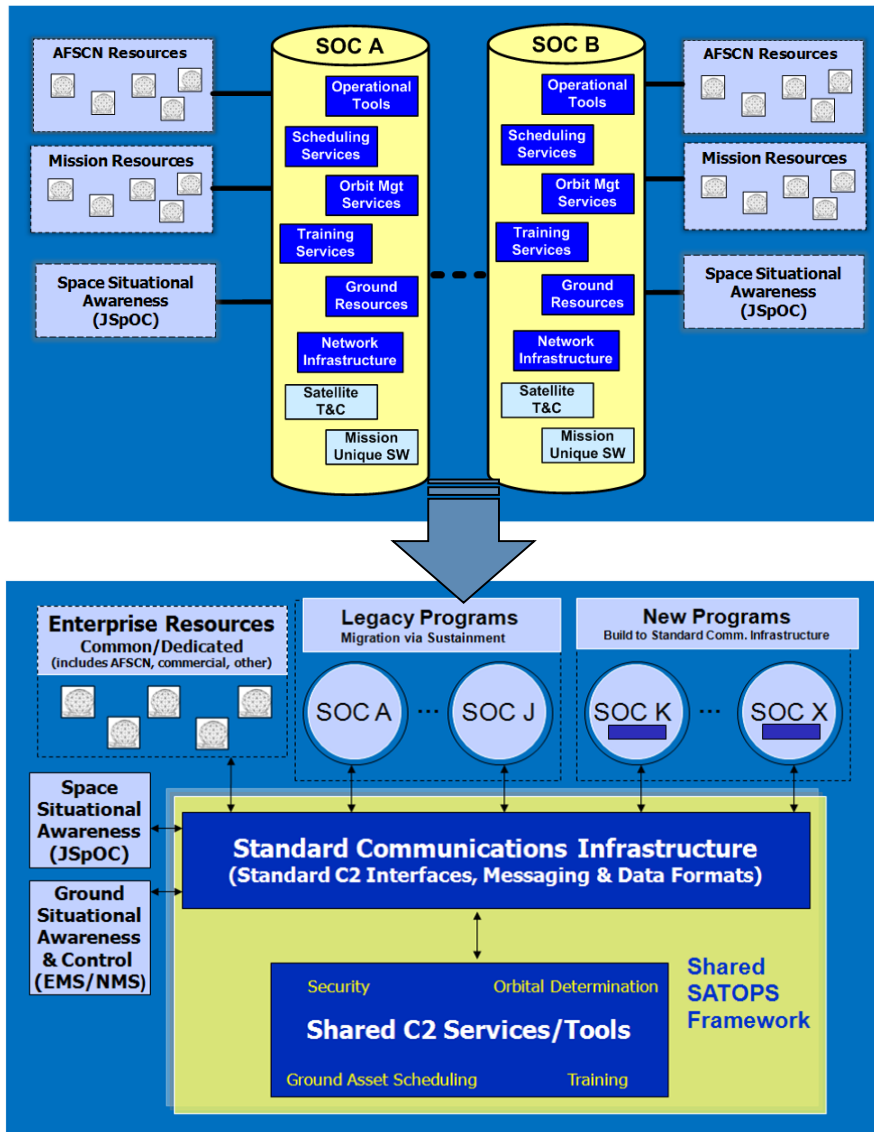
Back-ups

Trends in Migration to Enterprise Space Ground Systems

February 28, 2018

From Vertical to Horizontal Architectures

Transforming Space Ground Systems

Key Benefits

- More cost-effective integration of legacy & commercial systems, tools, and services

- Allows differing CONOPS across programs

- Reduces duplication of services

- Allows program choice of best products from multiple vendors

- Levels playing field for commercial ground vendors – reduces "vendor lock-in"

- Enables space and ground situational awareness

- Amenable to adoption of new standards & technology