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Common Ground Architecture

Lessons Learned and Identified Barriers to Overcome

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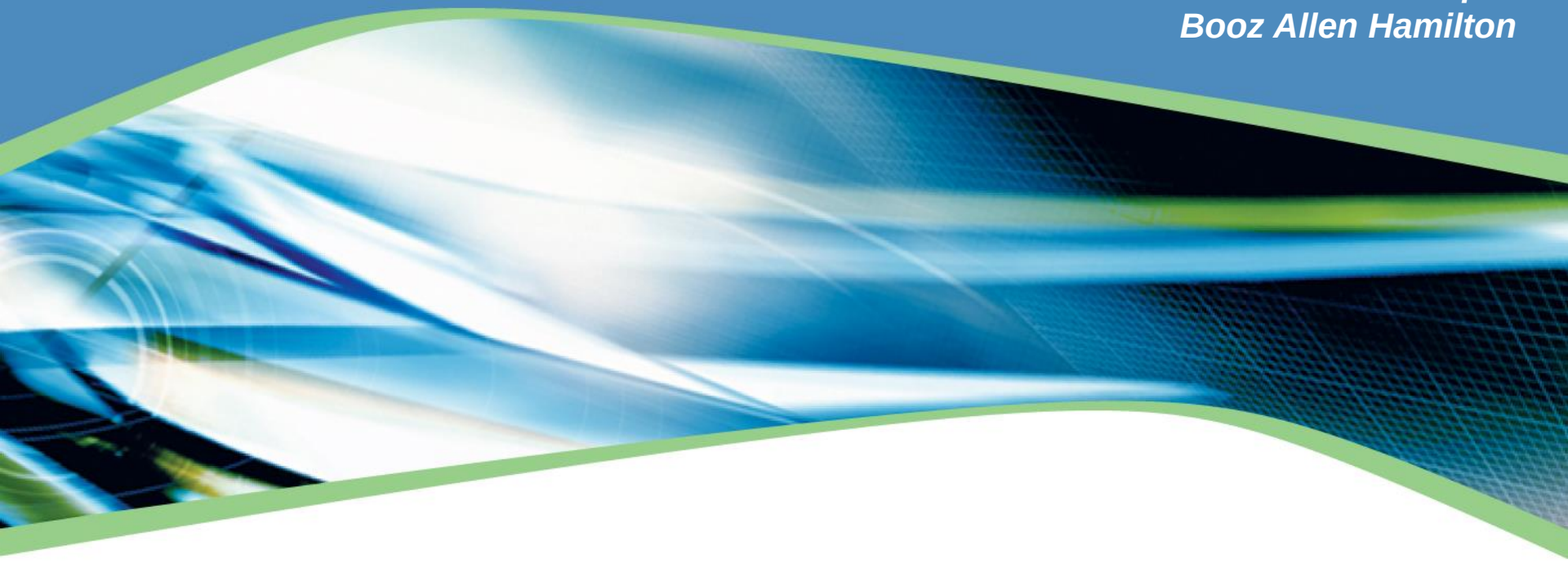

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Agenda

- Common Ground System Overview
  - Background / Motivation
  - Current Approach
  - Results & Findings
- Leveraging Existing Common Ground Systems and Lessons Learned
  - State of Technology Overview - Key Tenents for CGS Implementations
  - State of Technology Overview - Key Challenges in CGS Implementation
- Example ECGS Data Center Architecture Implementation
- Study Conclusions

Common Ground System

Background / Motivation

- The existing Department of Defense (DoD) satellite ground systems infrastructure is redundant. Current infrastructure includes 10 satellites and 8 ground systems
- Department of Defense spent $13.7 billion on ground stations around the world performing the same or similar common functions
- In April 2013, General Pawlikowski directed SMC/EN to explore development of a SMC technical baseline for the ground systems within her portfolio for Phase I of the study

Common Ground System

Phase I Approach

Phase I: Develop As-Is Baseline

1.) Review SMC programs, DoD, NASA/NOAA, NRO and Commercial existing common ground system approaches.

2.) Provide recommendations based on lessons learned from CGS initiatives

3.) Identify potential common ground system items:

- Ground services, interfaces, and activities
- Ground equipment infrastructure (satellite dishes, facilities, power, TT&C processing, crypto)
- Processing of mission data
- Mission data back up services and stations depending on the desired level of resiliency required
- Making data available (exposing) for a more situational awareness ground systems

4.) Develop an Enterprise Reference Model (ERM) identifying the key common ground system items

Future Phases: Develop Reference Architecture

1.) XR to develop a demo of a Common Ground Architecture

SMC As-Is Architecture Technical Baseline

Phase I Data Gathering & Methodology

Data Gathering

		AV-1	AV-2	CV-1	CV-2	CV-3	CV-4	CV-5	CV-6	DIV-1	DIV-2 / OV-7	DIV-3 / SV-11	OV-1	OV-2	OV-3	OV-4	OV-5a	OV-5b	OV-6a	OV-6c	PV-2	PV-3	SV-1 / SvcV-1	SV-2 / SvcV-2	SV-3	SV-4 / SvcV-4	SV-5a / SvcV-5	SV-6 / SvcV-6	SV-7 / SvcV-7	SV-8	SvcV-10a	SvcV-10b	SvcV-10c	StdV-1 / TV-1	StdV-2 / TV-2
MILSATCOM	AEHF	Y	Y								Y		Y	Y	Y	Y		Y						Y		Y	Y	Y						Y	Y
	ISP	*Y*	*Y*								*Y*		*Y*	*Y*	*Y*	*Y*		*Y*						*Y*		*Y*	*Y*	*Y*						*Y*	*Y*
	Global Broadcast Service(GBS)	Y	Y								Y	Y	Y	Y	Y	Y	Y			Y			Y	Y		Y	Y	Y							
	ISP	*Y*	*Y*								*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*			*Y*			*Y*	*Y*		*Y*	*Y*	*Y*							
	Command and Control System–Consolidated (CCS-C)																																	
	TISP																																	
	EPS												Y	Y	Y	Y	Y			Y				Y		Y	Y	Y						Y	Y
	CDD												*Y*	*Y*	*Y*	*Y*	*Y*			*Y*				*Y*		*Y*	*Y*	*Y*						*Y*	*Y*
	WGS												Y	Y	Y		Y			Y			Y			Y								Y	
	C4ISP												*Y*	*Y*	*Y*		*Y*			*Y*			*Y*			*Y*								*Y*	
GP	GPS II																																	
	GPS III	Y	Y								Y		Y	Y	Y	Y		Y	Y				Y	Y		Y	Y	Y						Y	Y
	ISP	*Y*									*Y*		*Y*	*Y*		*Y*			*Y*				*Y*	*Y*		*Y*	*Y*	*Y*						*Y*	
	ADD		*Y*								*Y*		*Y*	*Y*									*Y*	*Y*										*Y*	
SY	JMS												Y																						
	ISP												*Y*																						
IS	SBIRS	Y											Y	Y																					
	ISP	*Y*											*Y*	*Y*																					
RN	LTRS		Y		Y	Y							Y																				Y	Y
	ADD		*Y*		*Y*	*Y*							*Y*																				*Y*	*Y*
	AFSCN	Y	Y										Y																						
	ADD	*Y*	*Y*										*Y*																						
WM	DMSP	Y											Y	Y																					
	ppt	*Y*											*Y*	*Y*																					

Common Services

Assessment Methodology

SV-4 / OV-5 Functions

	Tasking Parsing	COA Development & Selection	Tasking Generation	Crew Management and Scheduling	Ground Equipment Management and Scheduling	Bus Modeling	Bus Ops Planning and Scheduling	Bus Ops Planning/Scheduling Product Generation	Payload Modeling	Payload Operations Planning and Scheduling	Payload Ops Planning/Scheduling Product Generation	Ground Segment Configuration	Telemetry Processing	Real-time Display	Alarms, Warnings, and Events	Command Build	Data File Upload	Data Storage	Data Playback	Space Vehicle Stored Telemetry Processing	Trending Report Generation	User-Tasks Report Generation	Operational Report Generation	Mission-unique Report Generation	Data Product Hosting	Data Product Posting	Report Transmission	Timing	Logging	Document Viewing	Command and Telemetry Database (look-up)	Information Assurance	Resourcing	Collision Avoidance	Attitude/Pointing Planning	Formation Maintenance	Maneuver Planning	Orbit Determination and Propagation	Access Reporting	Visualization
					Ground Segment		Bus Ops Planning		Payload Ops Planning							Status Monitoring		Commanding					Customized Data Product Generation																		Orbit Analysis and Visualization	
	Tasking Parsing			Planning and Scheduling								Real-time Operations							Data Processing						Data Sharing		Shared													
Calculate Predictive RFI						X		X																								X	X	X	X	X	X	X	X
Calculate Predictive SUN RFI						X		X																								X	X	X	X	X	X	X	X
Calculate Prelaunch RFI						X		X																								X	X	X	X	X	X	X	X
Calculate Range Data					X		X		X											X												X	X	X	X	X	X	X	X
Calculate Satellite Visibilities									X																							X	X	X	X	X	X	X	X
Collect & Disseminate Ancillary Messages																					X	X	X	X		X													
Collect Launch Support Requests	X																																						
Collect Resource Requests	X																															X							
Collect Resource Status																		X														X							
Conduct Daily Conflict Briefing		X	X																																				
Conduct Pass												X	X	X	X	X	X																							
Conduct Post-Pass Operations																			X													X							
Conduct Pre-pass Check																																							
Conduct SV Contacts																X	X		X													X							

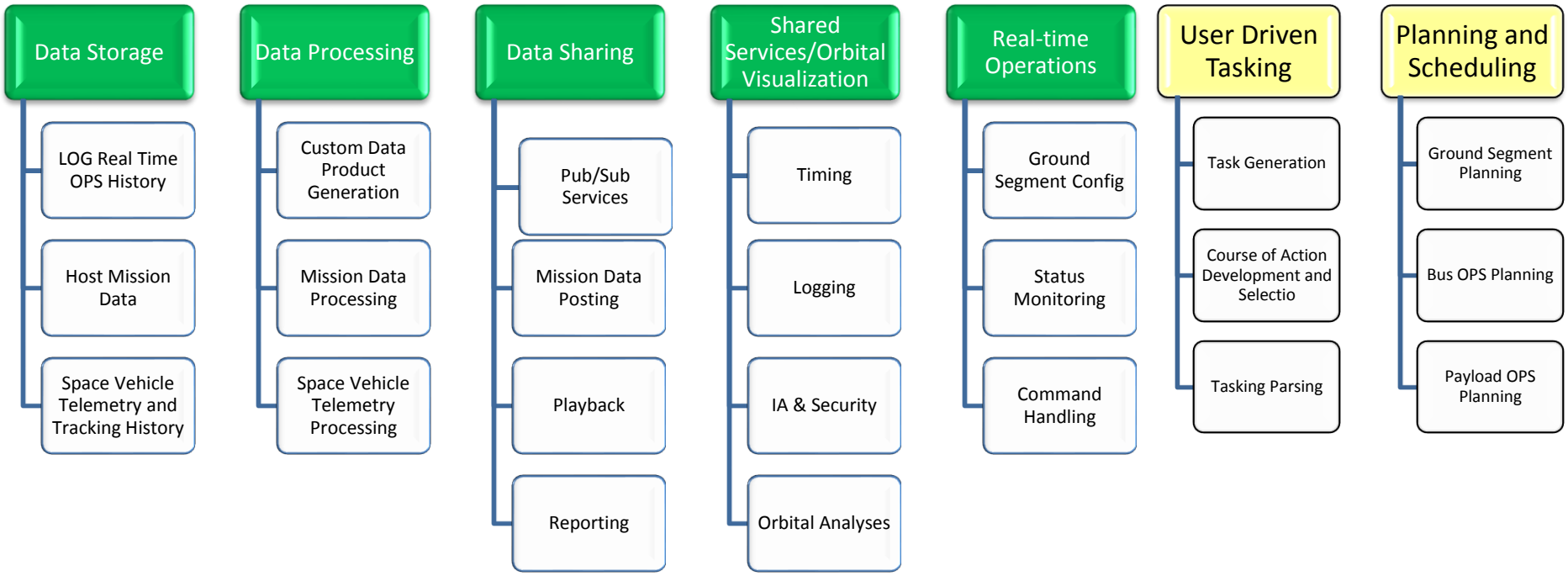
- Includes DODAF architecture views per requirements of CJCSI 3170 and 6212.1F
- Programs included: AEHF, GBS, CCSC, EPS, WGS, GPSII, GPSIII, JMS , SBIRS , LTRS, AFSCN, and DMSP.
- Data sources include 7 program ISPs, 1 CDD, and 3 Architecture Design Documents (ADD).
- 360 DODAF views captured for the key programs (AEHF, CCSC-C, GPS, SBIRS, and AFSCN)

Common Ground System

Phase I Results & Findings

Infrastructure can be shared across satellite families (high efficiency, lower O&M)

Medium Service Reuse items can leverage best of breed applications from existing ground systems and add capability to support multiple satellite families

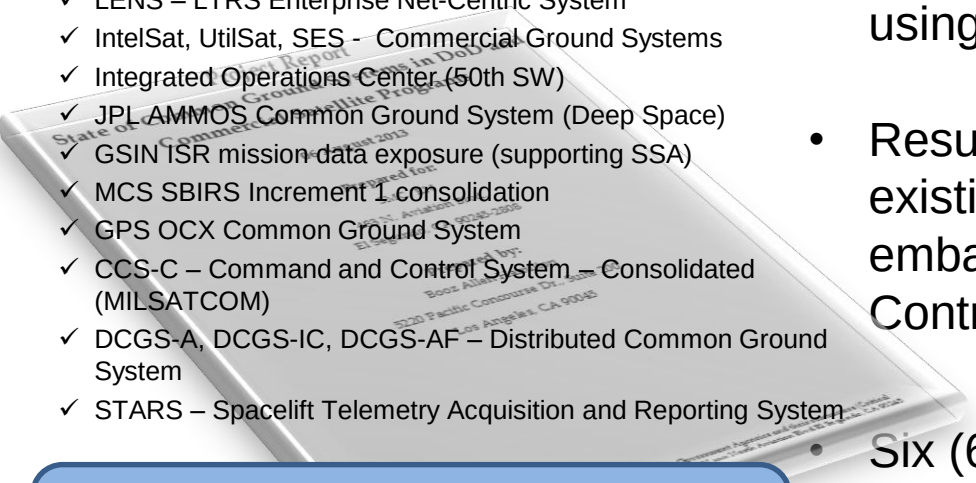


Architectural baseline generated by analyzing the SV-4, SV-5, and OV-5 documents from GPS, AEHF, AFSCN, and SBIRS. Twelve (12) DoDAF documents were analyzed in total (4 SV-4s, 4 SV-5s, 4 OV-5s) for the CGS study.

State of Technology Overview

Key Tenents Study

- ✓ NEPTUNE (Naval Research Laboratory)
- ✓ MMSOC – Multi-Mission Space Operations Center
- ✓ GMSEC – Goddard Mission Services Evolution Center
- ✓ AFSCN – Air Force Satellite Control Network
- ✓ JPSS – Joint Polar Space System
- ✓ FCS – Future Combat System
- ✓ NRO – National Reconnaissance Office
- ✓ JMS – JSpOC Mission Systems
- ✓ AOC-WS – Air Operations Center – Weapon System
- ✓ DISA-GIG, NCES Enterprise services
- ✓ LENS – LTRS Enterprise Net-Centric System
- ✓ IntelSat, UtilSat, SES - Commercial Ground Systems
- ✓ Integrated Operations Center (50th SW)
- ✓ JPL AMMOS Common Ground System (Deep Space)
- ✓ GSIN ISR mission data exposure (supporting SSA)
- ✓ MCS SBIRS Increment 1 consolidation
- ✓ GPS OCX Common Ground System
- ✓ CCS-C – Command and Control System – Consolidated (MILSATCOM)
- ✓ DCGS-A, DCGS-IC, DCGS-AF – Distributed Common Ground System
- ✓ STARS – Spacelift Telemetry Acquisition and Reporting System



20 Ground Systems reviewed as input to Key Tenents

- As part of the Phase I study, 20 existing Common Ground System (CGS) processing capabilities, their ground assets, and the ground equipment infrastructure were evaluated
- Identified the state of technology for CGS to meet the Net Ready KPP leveraging the GIG and using a Service Oriented Architecture (SOA)
- Results of the study recommends reusing the existing satellite CGS mission capability to embark on a Net-Centric Satellite Command and Control (C2) CGS
- Six (6) tenents, shown on the next slide, were identified based on the lessons learned from the evaluation of the 22 existing CGS

State of Technology Overview

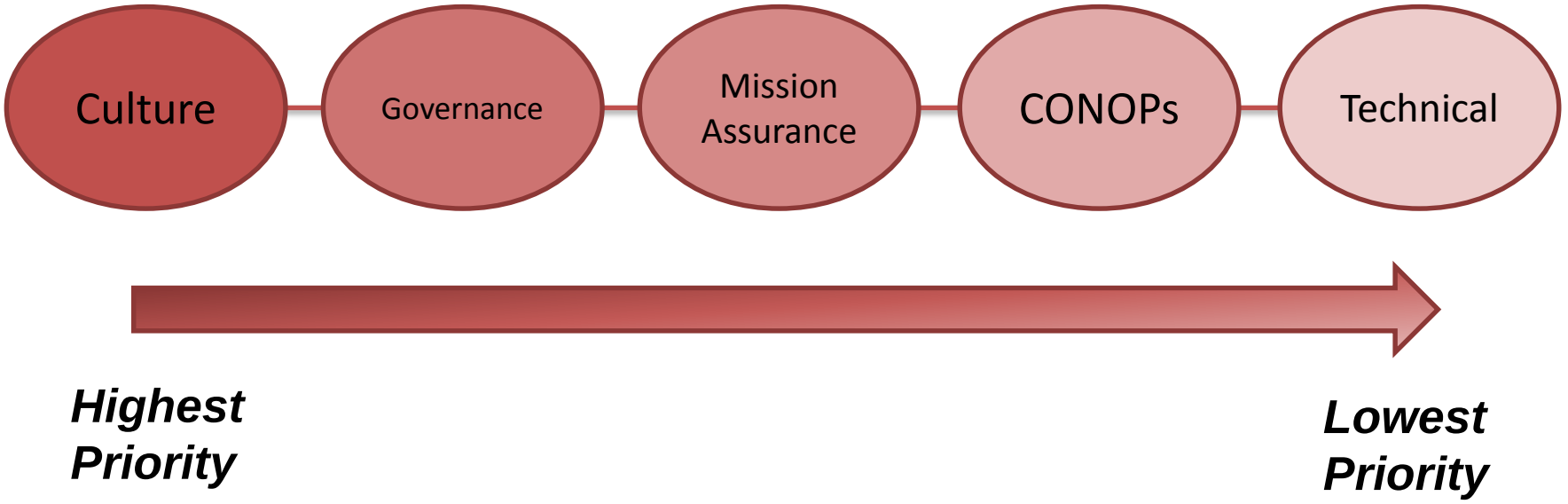
Key Tenents Study

	CGS Key Tenents for Implementation
1	Combine data processing infrastructure (i.e. Cloud type commodity infrastructure and middleware). Consolidate data storage, processing, data sharing across satellite programs. Separate instances geographically separate connected to GIG= resiliency
2	Establish a thin client web browser interface (to the Cloud type Data Center) connected to the GIG. Supports resiliency and distributed operations. Assists with IA strategy.
3	Consolidate ownership and responsibility of shared and dedicated antennas/entry points (including DISA teleports) – connect to the GIG
4	Reuse existing mission services from existing satellite ground systems (best of breed)
5	Expose data as close to the raw data source as possible (at closest data center). Expose in a net-centric format consistent with DoD guidance, including metadata.
6	Each satellite Program Office align with CGS vision by a)connect assets and infrastructure to the GIG, b) expose authoritative data sources (see #5), c) separate out existing applications (many proprietary) into best of breed 'services'

State of Technology Overview

Key Challenges

Key lessons learned study identified five (5) major challenges:



State of Technology Overview

Key Challenge #1: Culture

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
Culture	A single procurement for the entire CGS system with one RFP is high risk and in the past has not been successful	A more effective acquisition strategy is for the Government to take on the Integration role, own the CGS infrastructure and middleware; reuse existing ground system mission services and acquire by mission services for new capability needs. Consolidate common functions when reusing mission services (orbital analysis, data playback, timing, logging, etc)
Culture	Minimal use of autonomous satellite operations in the DoD. Fear of retribution with military operators from autonomous software bugs/mistakes.	Autonomy should be designed in to ground system functionality. During future CGS architecture planning, focus on building in autonomous operations similar to commercial systems (SES, IntelSat, UtilSat, JPL AMMOS). Re-evaluate satellite C2 CONOPS for operator responsibility with autonomous software.

State of Technology Overview

Key Challenge #1: Culture

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
Culture	Historically ground systems are acquired by stove-piped program (SBIRS SPO, MILSATCOM SPO, GPS SPO, etc) with no central ground authority responsible for providing the requirements governance necessary to assure common ground architecture implementation.	Establish a central ground system organization to oversee the implementation of GCS responsible for oversight, governance and the integration of common architecture standards into the Program of Record (PORs).
Culture	Military operation personnel per shift based on historical checklists versus 'right sized'	Leverage Flight examples of reduced proficiency for personnel (resulting in less shifts) based on CGS capabilities, budget cuts and current need. Evaluate 'right sized' satellite operations reducing satellite proficiency contacts, cutting personnel per current budget reality.

State of Technology Overview

Key Challenge #2: Governance

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
Governance	Lack of Governance during CGS development lifecycle results in numerous Configuration Management and mission priority conflicts	Establish a Governance body including Executive, Architecture, Development and Operations Working Groups to manage all Governance aspects.
Governance	Lack of understanding how to update mission service versions and shared service versions between organizations (test, accreditation, cost/benefit, etc) on a shared infrastructure	Leverage the Governance boards including Executive, Architecture, Development and Operations WGs to manage priorities of service updates and details.

State of Technology Overview

Key Challenge #3: Mission Assurance

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
Mission Assurance	The Cyber Risk (Information Assurance) approach and ownership for of a CGS is unknown.	Reuse recent 'type' accreditation IA approaches combined with Service Level Agreements with organizations. Establish one entity as the CGS owner/acquirer. Type Accredit data centers at each enclave with a secure remote connection (VPN-type) thin client provision for mission user screens. Leverage approved Cross Domain solutions.

State of Technology Overview

Key Challenge #4: CONOPs

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
CONOPS	Military leaders and organizations apprehensive to share/expose real-time satellite operations data outside of their mission domain area	Incentivize leaders and organization to share data, adhere to Net-Ready KPP. Implement the Integrated Network and Satellite Operations Center (IOE) at Schriever to enable data sharing at the Space Command and Control (C2) level.
CONOPS	Lack of resiliency in many of the current Space C2 ground systems. Current CGS within a program, within satellite families.	Implement a common infrastructure across satellite programs and families. Implement disaggregated processing data center infrastructure (Cloud) similar to Google/Amazon examples – including geographic separation within architecture. Reuse mission services from existing ground systems and combine infrastructures.

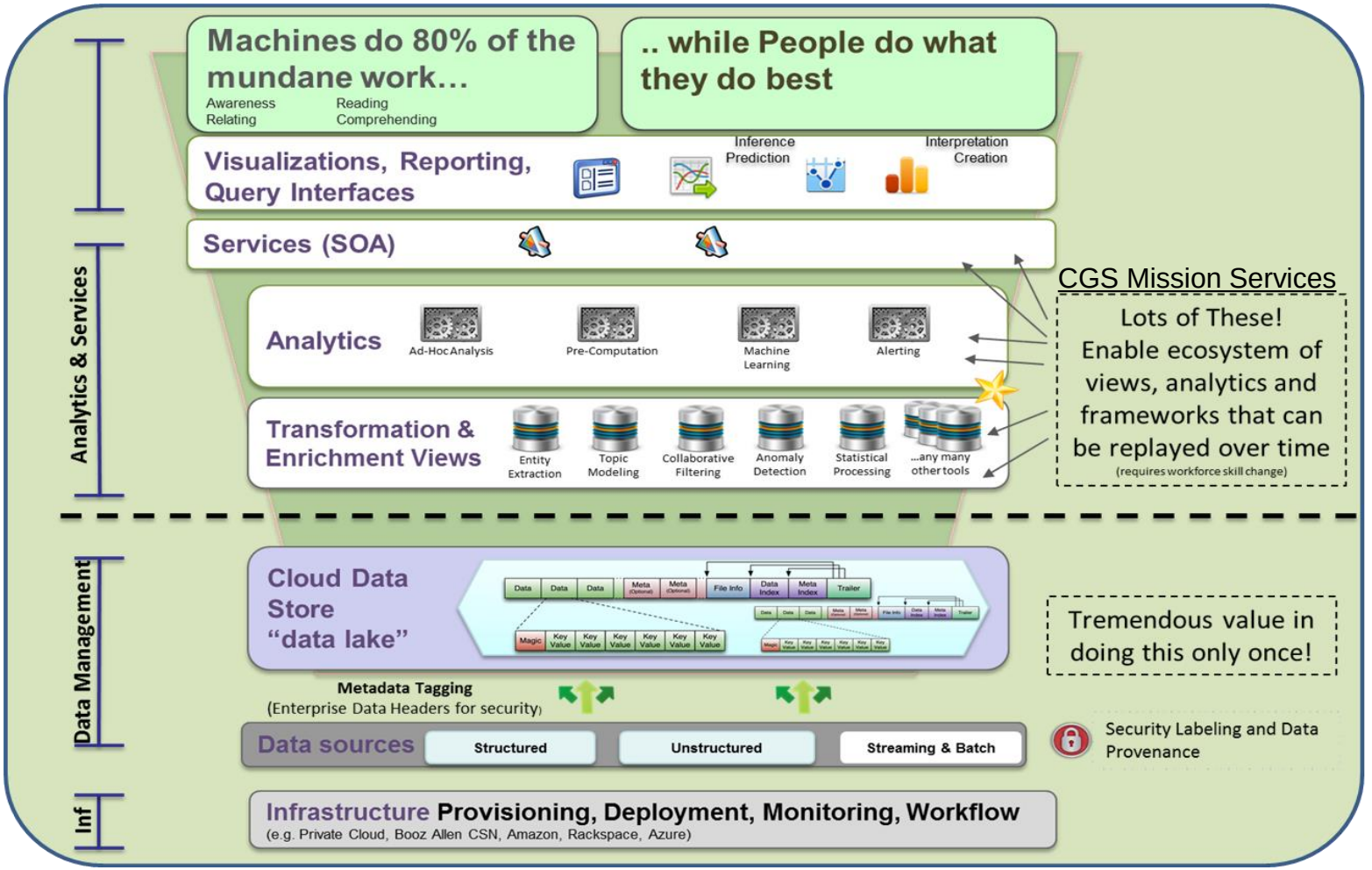
State of Technology Overview

Key Challenge #5: Technical

Challenge Area	Description of Challenge	Lessons Learned/Recommendations
Technical	Lack of operational Satellite C2 Service Oriented Architecture (SOA) (state of technology)	Leverage proven SOA Infrastructure, Middleware and reusing existing Mission Applications from existing Satellite C2 CGS to combine existing/proven CGS technology with existing/proven SOA CGS
Technical	Current CGS initiatives focusing on making interoperable data after being processed and through system outputs.	Expose data to a common infrastructure as close to the raw source as possible for an overall lower CGS transition cost. Converting data to open protocols by systems output (not close to data source) will continue the cycle of maintaining multiple duplicative systems (high O&M). Exposing telemetry data (engineering units) and other raw data sources is the best approach for consolidating duplicative systems, applications and with the overall lowest transition costs.

State of Technology Overview

Recommended Data Center Architecture Implementation



Leverage IC ITE Reference Implementation (RedDisk) & DCGS-Army for CGS reuse
Consistent with DoD Joint Integration Environment (JIE) Guidance

Study Conclusions

- Move toward services based open enterprise architectures is occurring across the USG community
  - Economies of scale – potential cost savings
  - New capabilities at little cost

- Issues to implementation are not technical
  - A common ground technology has been successfully used in operations for many years and prototyped, evaluated and demonstrated in an 50th SW relevant environment
  - There are many other DoD and commercial technologies (at a high Technology Readiness Level) that can be leveraged by CGS

- Considerations for long-term leadership support, organization and agile procurement/management will be critical for success regardless of what technology is chosen to implement an enterprise architecture

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