

GSAW2007

Ground System Architectures Workshop



**Session 6: Challenges Returning to
the Moon and Beyond**

Command & Control for the Constellation Program

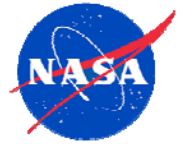
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CONSTELLATION



NASA's Constellation Command and Control Challenge



◆ Constellation Command and Control Systems Challenges

- Wide variety of space, ground and surface assets (“Systems”)
- Wide variety of operations needs and concepts
- Multiple development contractors
- 20+ year deployment schedule
- Needed today to support integration labs
- Constrained budgets

◆ NASA's early role is to develop the overarching vision and details to be followed by all Systems

- Operations concepts
- Interface definitions and Specifications
- Common requirements



Basic Command and Control System Concepts



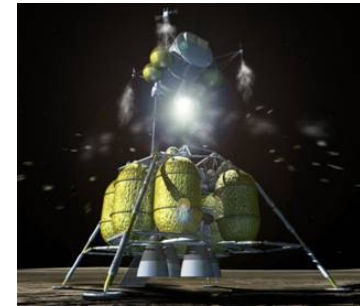
- 1. Driven by extensive information model**
- 2. Utilizes layered architecture**
- 3. “Adopt-Adapt-Develop” priority for using standards**
- 4. Identical functions should appear identical across Systems**
- 5. Commonality across Systems should be highly encouraged**
- 6. Plan for the short- and mid-term needs, but have an awareness of the long-term and don’t preclude the future capabilities**

A “notational” Future Scenario

- ◆ **Astronaut on the moon approaches a piece of mining equipment**
 - The suit is the control system
 - The mining equipment is being controlled

- ◆ **The suit and the mining equipment synch up**
 - Communications may be wireless while in proximity
 - Characteristics file requested from mining equipment
 - Telemetry and command list is moved to the suit

- ◆ **Operations begin**
 - Procedural video sent from mining equipment, displayed on astronaut’s sleeve
 - Telemetry and command activities proceed
 - The suit may also relay status data back to the basecamp



The Constellation C2 Approach must be applicable to a huge range of System types.

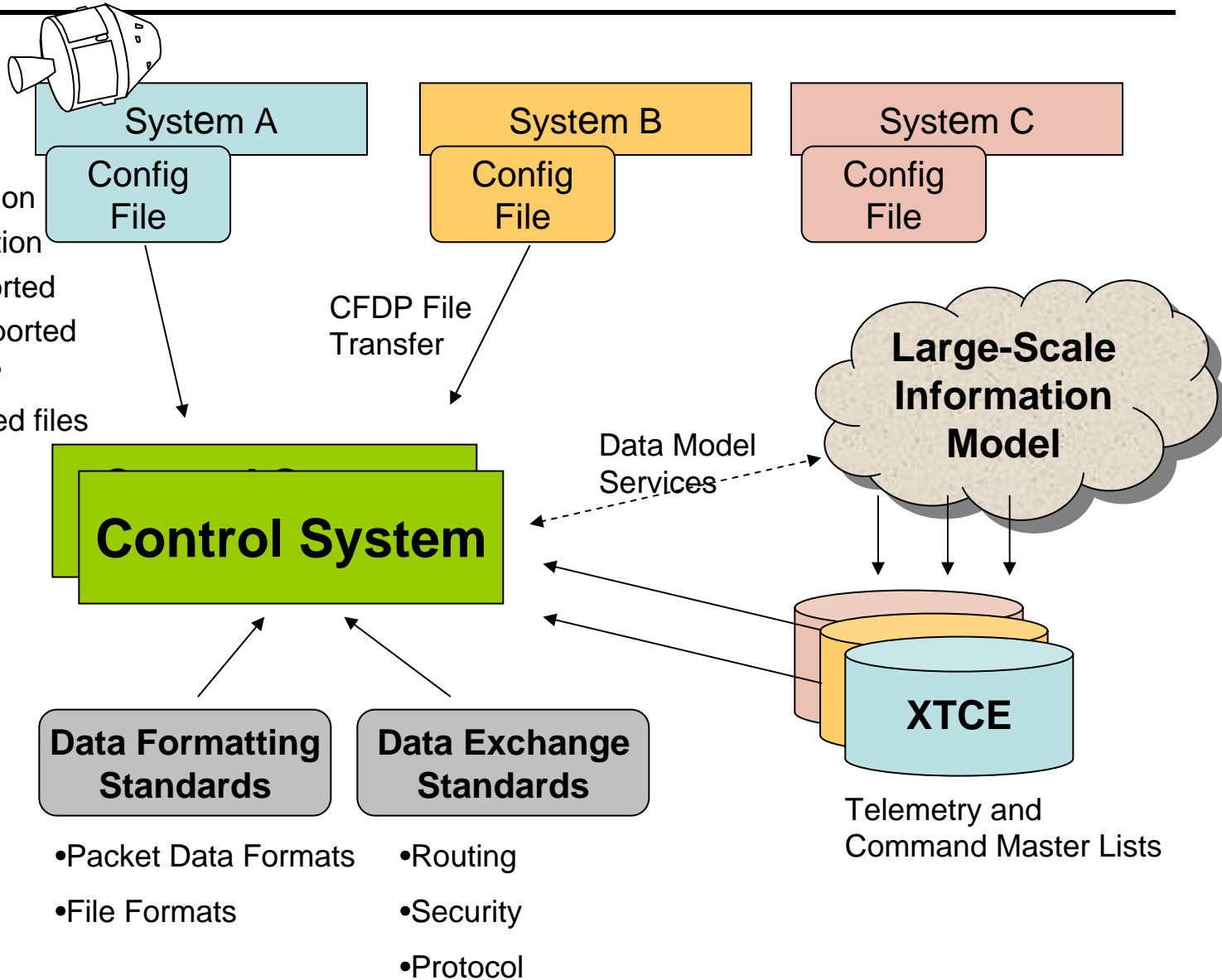


CONSTELLATION



Info-Model-Driven Approach

- Sys Name
- CMD Rate
- XTCE file version
- XTCE file location
- Formats supported
- Protocols Supported
- Routing Node?
- List of supported files
- <more>



Commanding Concept Flexibility

Construct Commands
Per XTCE definitions

Select an allowable
Command Applications
Packet Format

Select an allowable
transmission package

Mnemonic:

Fields:

Bits:

Description:

Reason:

Execute Time:

Etc.

CMDs
packed into
applications
structures.

Annotated/XML

Bit-Efficient

Goal-Oriented,
Free-Form

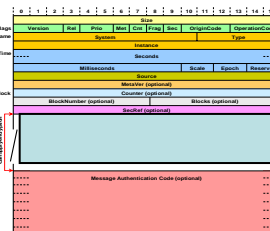
Time-Tagged or
Event Triggered

Future

Applications
packets can
use any type
of transport.

Add routing, security, quality of
service, other control flags

CCSDS



Future

Heritage

Cx Phase 1
(IP-based)

TBD

We Can Achieve Interoperability



- ◆ We have a solid approach to **INTEROPERABILITY**.

Is that enough?

- ◆ We believe that **COMMONALITY** is also needed.
 - Simplifies crew and ground operations
 - Helps with cost and schedule risks
 - Re-enforces interoperability concepts

“Beautiful World” Commonality

Let’s have all flight and ground systems use the same processors, software and behaviors – just think how much money we save and how much easier operations will be.



Rose-colored glasses



Aspects of Commonality



CAPABILITY AREA	COMMON?
File Management System	YES
Control Commands (bandwidth, security, quality of service, etc.)	YES
Vehicle commands with same function as on other vehicles	MAYBE, could be handled operationally
Telemetry names with same purpose across different missions	MAYBE, could be handled operationally
On-board command buffers, cmd validation logic, etc.	MAYBE, currently under study
Scripting languages	WOULD LIKE TO, but may not be practical
Displays	NO
File formats for multiple commands, data dumps, schedules, etc.	YES
Software shared across Systems	ENCOURAGED

- ◆ **Some ideas expressed in these slides are still preliminary**
 - An formal “RFI” is being prepared to solicit industry comment

- ◆ **Phasing plans are being developed to allow incremental progress towards end-goal capabilities**
 - Delay/disruption tolerant networking
 - Space/ground publish/subscribe
 - Dynamic discovery

- ◆ **The scope of this effort raises new questions**
 - How far do we push commonality requirements?
 - What are Constellation C2 impacts on standards and industry direction?
 - What is the role of vendors/industry vs NASA in setting future directions?
 - Can we really specify things to a level that it works for everyone and fulfills our key objectives?



Acronyms and Abbreviations



C2	Command and Control
CCSDS	Consultative Committee for Space Data Systems
CMD	Command
Cx	NASA's Constellation Program
GSAW	Ground System Architectures Workshop
IP	Internet Protocol
NASA	National Aeronautics and Space Administration
RFI	Request for Information
Sys	System
TBD	To Be Determined
XTCE	XML Telemetric & Command Exchange
XML	Extensible Markup Language