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Advanced Data Description Exchange Services for Heterogeneous Vehicle and Spaceport Control and Monitor Systems

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Rodney Davis & Greg Hupf
davisrd@cctcorp.com, hupfg@cctcorp.com
Command and Control Technologies
1425 Chaffee Drive, Titusville, FL 32780
321-264-1193, www.cctcorp.com

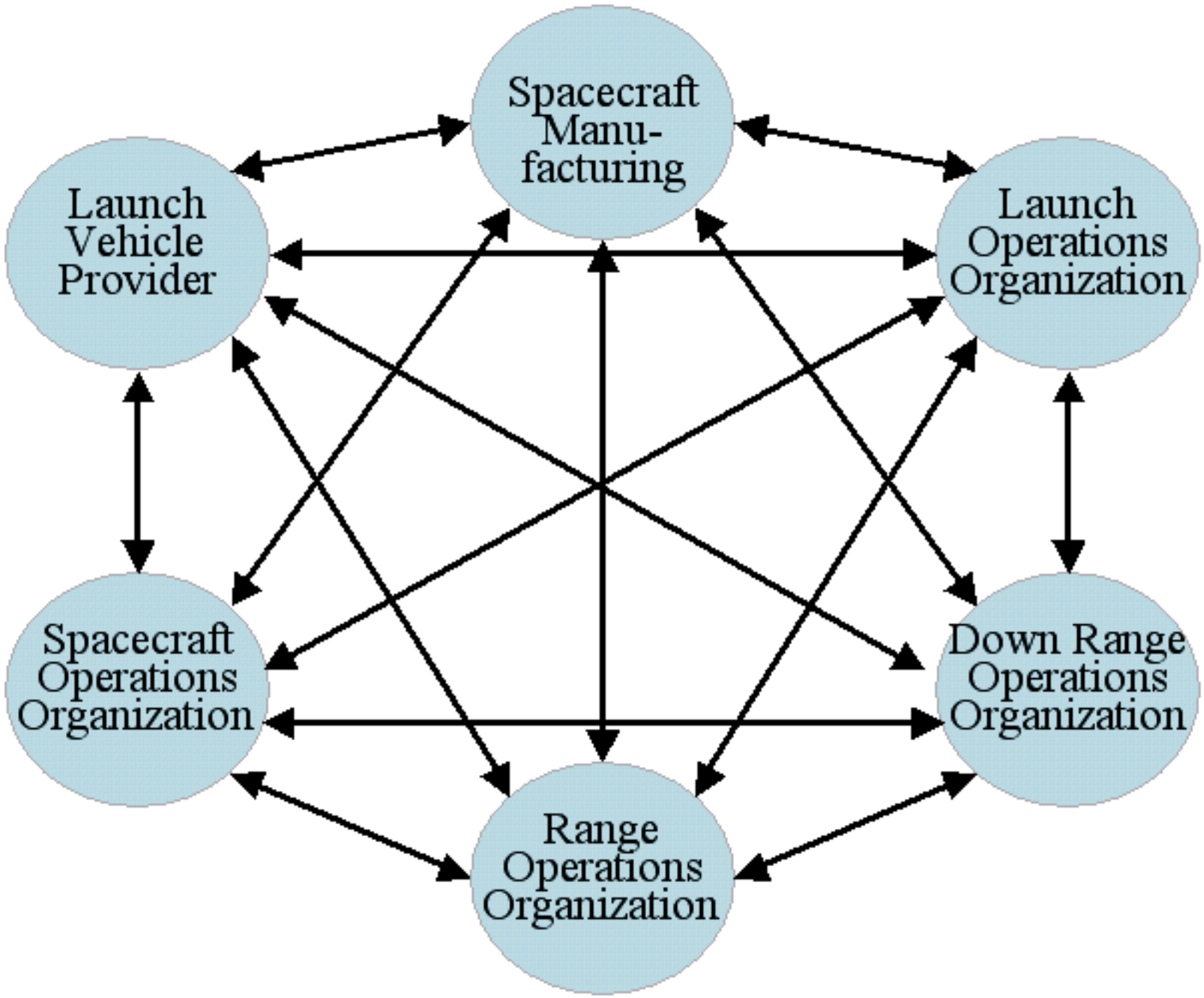
Synopsis

- CCT is doing research sponsored by NASA to provide an advanced data description exchange approach for space/spaceport systems that will provide a generic platform-independent software capability for exchange of semantic control and monitoring information
  - This new strategy will reduce development, operations, and support costs for legacy and future systems that are part of ground and space based distributed control systems
  - This research will establish a space systems information exchange model that can support future highly-interoperable and mobile software systems
  - The implementation approach seeks to provide a solution that will ease the adoption of a common data definition and exchange standard for legacy and future systems by minimizing or eliminating the need for custom software modifications

The Problem Summary

- The current lack of standardization requires custom ingestion of telemetry and commanding information across a variety of systems and organizations throughout a mission lifecycle
  - Drives up life cycle cost
  - Causes proliferation of custom exchange software. Inherently error-prone customization results in revalidation of data representation at each transition
- Future space systems (spaceport, spacecraft, launch vehicles, ranges) will need to be able to operate adaptively, with more autonomy than systems do today
  - Future concepts of ubiquitous communications infrastructure, dynamic service discovery, and mobile agents will enable loosely-coupled systems to collaborate to establish objectives and achieve broad mission goals
  - Need to establish a vocabulary and mechanisms for exchange of a wide range of configuration, control, and instrumentation information
- Mission operations would be more efficient if consistent telemetry and command definitions could be easily exchanged among all of the lifecycle phases, systems, and organizations
  - The emerging OMG XTCE standard can help fill the standardization void. However, tools are needed to reduce impact of adoption
    - Object Management Group, XML Telemetry, and Telecommand Data Specification Draft Adopted, http://www.omg.org/docs/dtc/03-05-07.pdf, May 2003

Current Situation

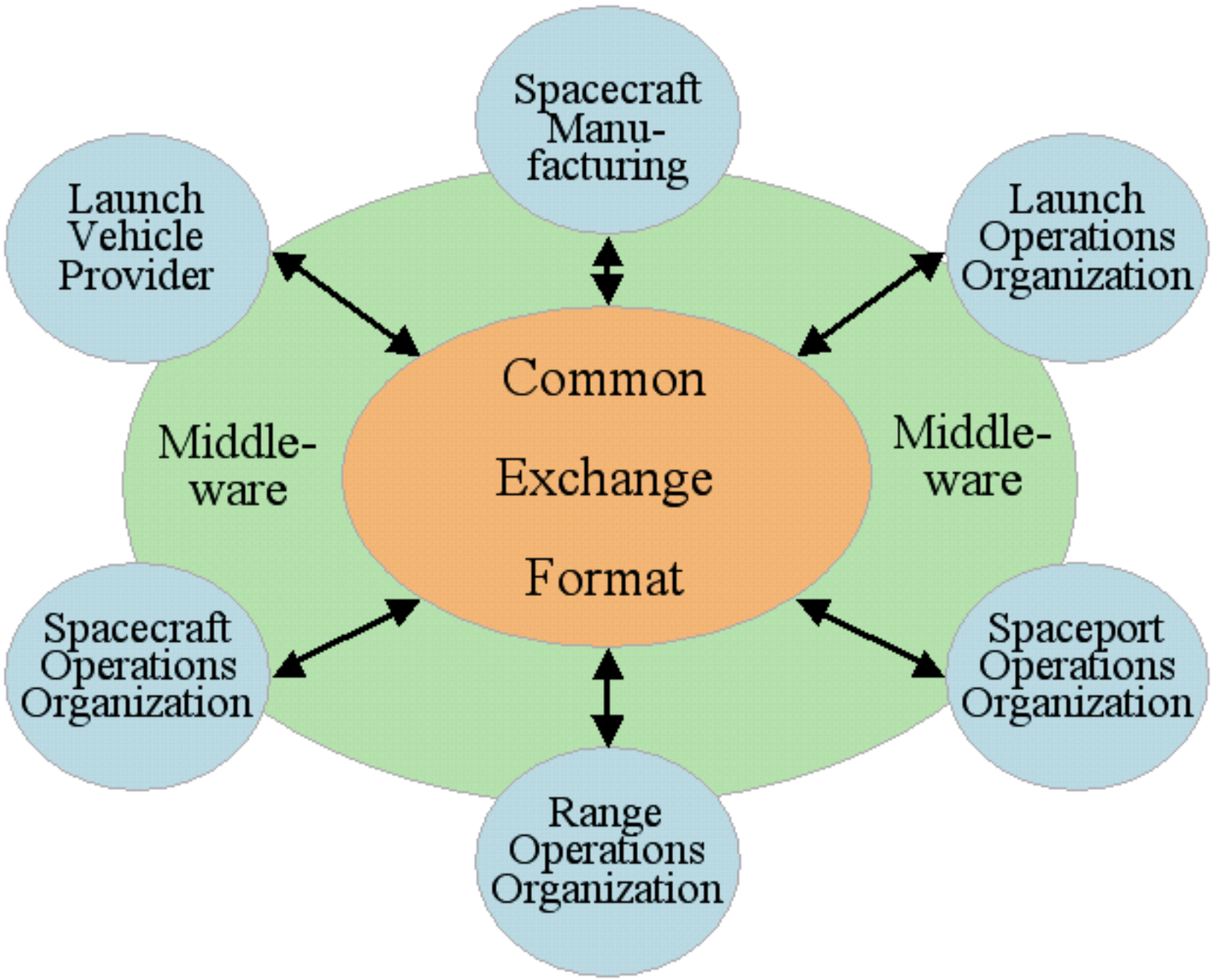


- N(N-1) number of interfaces between producers and consumers of telemetry and command description information

The Solution

- Provide a generic cross-platform software capability for exchange of telemetry and command description language between spacecraft and spaceport systems
- Develop a program generator for creating cross-platform control and monitor exchange application programs from high-level languages or specifications
- Planned Results:
  - Enable legacy and future space systems to exchange common control and monitor (command and telemetry) format descriptions
  - Reduce operations and support costs associated with sharing descriptions of control and monitor definitions for launch systems and ranges
  - Reduce the up-front cost of transition to a common extensible data exchange standard for legacy and future systems
  - Prolong the life of existing systems by providing a standards-based infrastructure that enables interoperability and transition to new technologies without requiring a major redesign or system replacement
  - Build an initial information exchange model to support future mobile software by demonstrating technologies that provide interoperable control and monitor capabilities

Future State



- 2N potential interfaces

XML – An Enabling Technology

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- Existed since 1996, & established as a standard in 1998 (www.w3.org/TR/REC-xml)
- Structural and semantic markup language
  - Origins in other markup languages HTML and SGML
  - Enables essential data and structural meaning of information to be captured in a human readable form, rather than embedded in software
  - Consists of an *extensible* set of rules for designing text formats to structure data
- Key features: simplicity, commercial community support, & relationship to the Internet
- Community of users can define a set of markup tags that capture the inherent structure of the data
- Portable and license-free, there is no cost to use it
  - but you still have to build your own database and your own programs and procedures that manipulate it
- Supports OO design concepts without burden of expensive OO DBMS
- Database information can be formally defined yet loosely coupled to software application
- Open source software tools and libraries are numerous, readily available, and free (or inexpensive)

XTCE – An Emerging Std

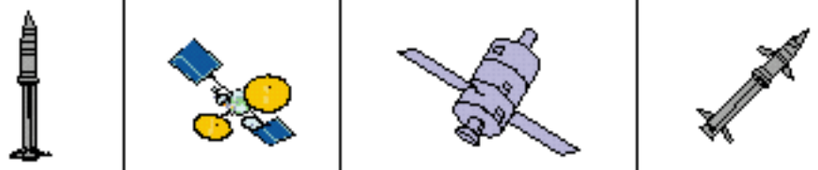
- The Object Management Group[1] and a number of major US and international industry and government aerospace organizations have collaborated to produce the XML Telemetry and Telecommand Data (XTCE) Specification
  - Describes telemetry and command "databases"
  - Vision is that it will one day be the "native" format for ground systems
- Currently in 2nd draft release, the XTCE standard is projected for approval in 2004. The scope of the specification includes:
  - Telemetry data definition including support for CCSDS packets & TDM frames
  - Data manipulation algorithms
  - Commanding data definition
  - Data representation definitions
  - Data properties (default value, validity criteria, and data dependencies)
  - Extensible formats
- The XTCE uses *XML Schema* to describe TM/TC information
  - Hierarchical structure, mimicking systems within systems
    - Hierarchy minimizes name space collisions, more manageable organization, and implicit inheritance of features from higher levels to lower levels
  - Consists of: space assets, ground assets, multi-satellite systems and subsystems
    - Includes a standardized provision to incorporate additional custom/unique information

[1] Object Management Group (OMG), www.omg.org

General Concept

Current space operations and legacy systems can be loosely-coupled to new technologies and standards, avoiding major upgrades or forced replacement

Vehicle and spacecraft-unique data definitions enable remote control and monitor



Various Protocol Adapters and Data Streams

Transport Layer

Various Protocol Adapters and Data Streams

Input definitions drive system-unique re-configuration efforts for different vehicles and missions

Common Data Exchange Services support all features necessary to access data descriptions based on the adopted Data Definition Standard

Initialize
Query
Validate

Access
Get
Set

Control
Monitor

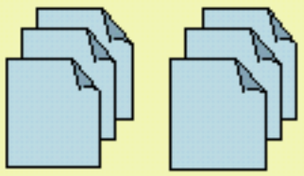
Command
Measurement

Convert
Import
Export

XML Standard

DD Standard

Data Descriptions are exchanged and stored as validated XML 'documents'



Variability Adapters enable different vehicle providers, range services, and other legacy systems to evolve and interoperate via the common set of Data Exchange Services

Legend:
- Enabling Technologies
- Exchange Services
- Indirect Contributors
- Direct Stakeholders

TM Concept (Phase 1 Focus)

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Industry Partners

OMG, LM, Boeing and ESA establish XTCE interoperability standards for TM definition using XML

Standardized TM Definition

W3C XML Specifications

implements

XML Libraries

Industry Standards

Implementation framework based on open industry standards, readily available COTS products and fully supported open source resources

extends

uses

XTCE Schema

implements

XTCE API

extends

Domain experts from NASA, LSP and Ranges provide TM DD information and practical mission experience

Vehicle Schemas

System Schemas

Range Schemas

uses

TM DDL Middleware

Vehicle Providers

Launch Sites

Ranges

Domain Knowledge

implements

TM DDL APIs

TM DDL middleware developed to provide a layered SW architecture that is reusable, flexible and modular

Generic XTCE is extended to establish specialized schemas that address needs of specific vehicles and systems and remain compliant with the overall TM DDL standards

Adapt legacy systems and develop TM tools that use a common DDL.

uses

TM Tools

TM Systems

New development incorporates standard TM DDL middleware and schemas to reduce mission template, minimize maintenance costs, and ensure continued interoperability

Phased Research Plan

- Phase 1
  - Determine the viability of creating common access services for the space ground systems domain based on use of emerging exchange standards for telemetry description
  - Drive out architecture strategies for cross-platform generation of monitoring (e.g. health and status) service middleware
- Phase 2
  - Expand the scope of the target domain to include control services, and focus effort on creating a comprehensive suite of services that can be used across a broader range of heterogeneous systems.