CCSDS MO Training

Module 1 - Primer

Overview

- Introduction
- Part 1
  - Issues that exist today
  - Introduction to Mission Operations Services
  - MO benefits
  - Today's issues and the MO solution
- Part 2
  - The MO framework
  - MO services
  - MO and the future
- Summary

Introduction

- CCSDS and MO
- About the presenter
- Aims of the training module

CCSDS and the MO Standards

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Mission Operations

About the presenter

Aims of the training module

- The Primer module is intended for anyone new to CCSDS MO
  - Its emphasis is more on the goals and benefits of MO rather than specific technical details
- The module will
  - Outline the fundamental issues that exist today
  - Walk through how MO solves these issues
- Cover the separation of
  - The MO Framework
  - The MO Services
    - And positioning of MO M&C Services in relation to the PUS standard
- The aim of the training is that you leave feeling you have a good grasp on the goals and approach of MO and how it would fit in your world

Part 1

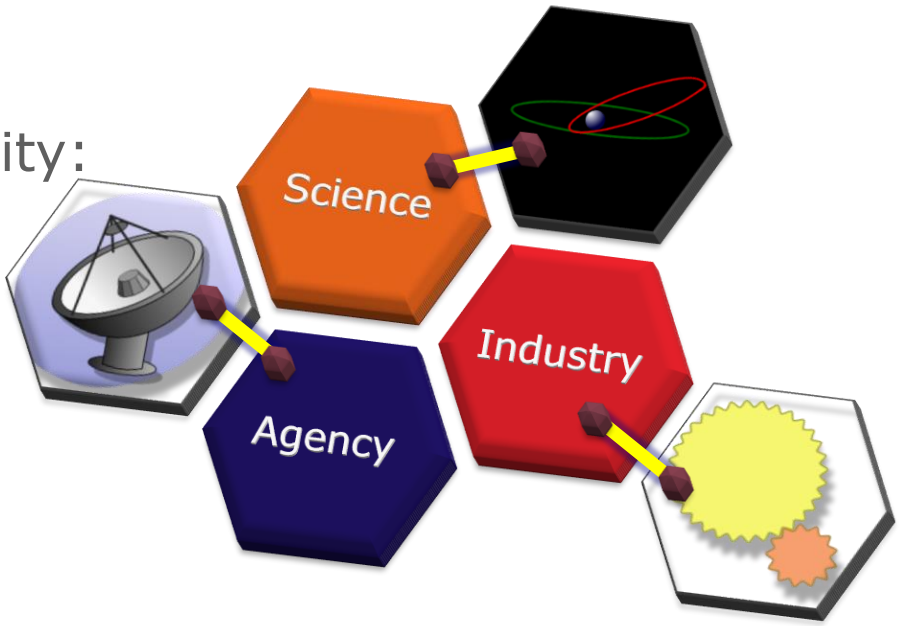
- Issues that exist today
- Introduction to MO Services
- Benefits of MO Services
- Today's issues and the MO solution

A video

- YouTube video link below:
- https://www.youtube.com/watch?v=XdGeaJE7yEk

Issues that exist today

- Two main trends are becoming apparent in current and future missions
- An increase in mission complexity:
  - More organisations
  - More functions
  - More interfaces
  - More technologies
- With an increasing pressure to reduce costs



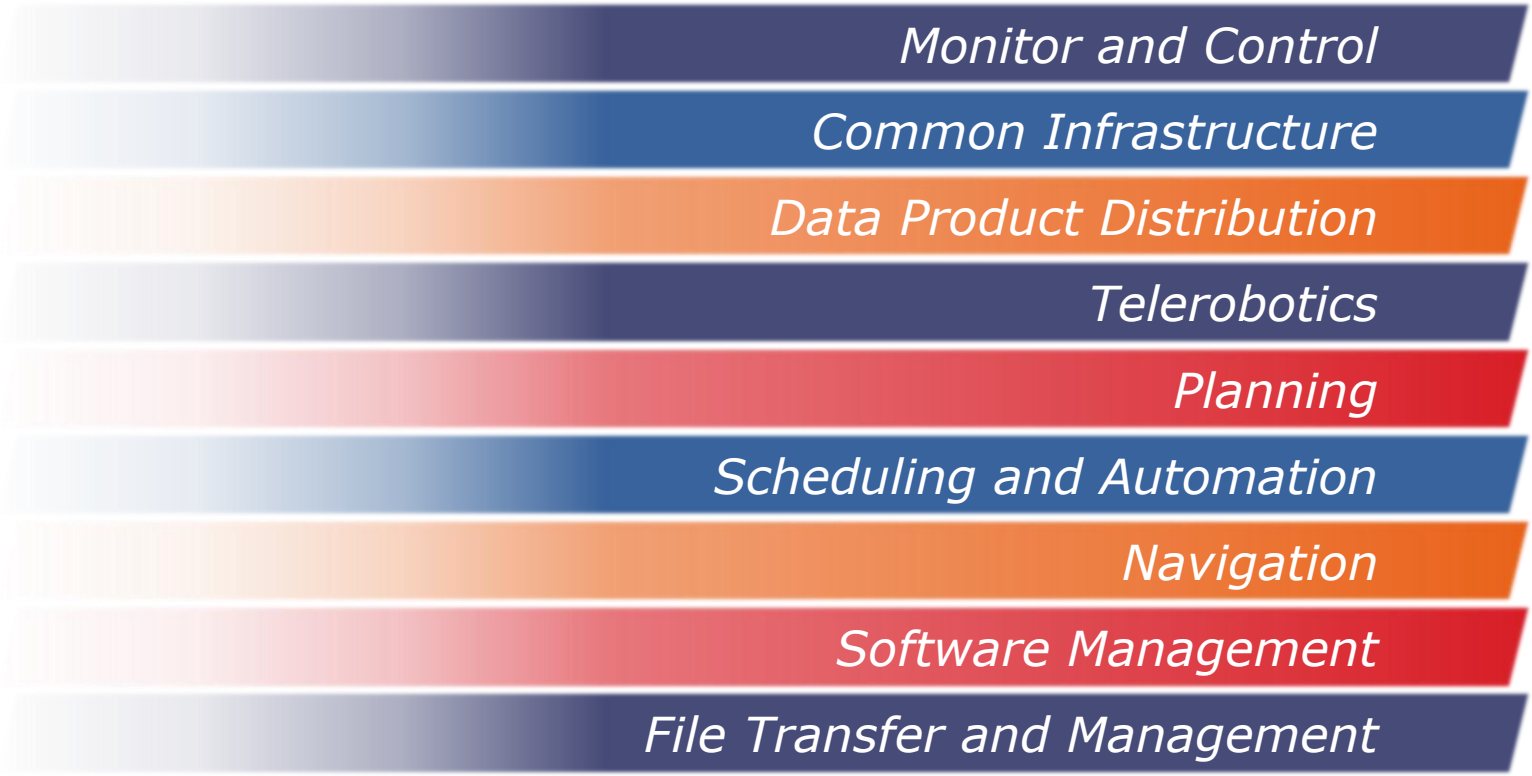
Issues that exist today

- In today's systems a lack of
  - Standardisation between and inside organisations
  - Combined with lack of re-use between missions
  - Has led to increased cost of
    - Development
    - Deployment
    - and operator training
- Whilst over the long lifetimes of space missions the inability to
  - Update technologies and infrastructure
  - Replace systems without major system redesign
    - Including vendor lock in
  - Has led to increased operational costs
- With the expected growth in mission complexity it is clear that future budget pressures are going to rise

CCSDS Mission Operations Services

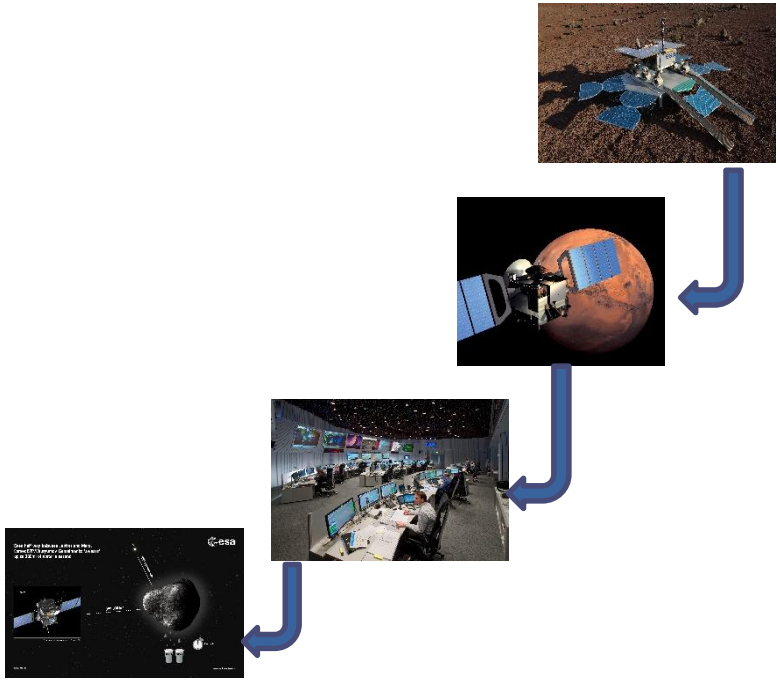
- To alleviate this, CCSDS is standardising a set of services for Mission Operations
  - These services define a single specification for the exchange of similar information
- To support these standardised services CCSDS has also defined an open architecture and framework that is:
  - Independent from technology
  - Able to integrate new and legacy systems of different organisations
  - Designed to support the long lifetimes of space missions
  - Based on a Service Orientated Architecture (SOA)
- The CCSDS Mission Operations services provide the capability to hide the unavoidable difficulties that characterises the space environment whilst supporting future complexity needs

CCSDS Mission Operations Services



CCSDS Mission Operations Services

- For instance, whether Parameters are being accessed by:
  - A rover on Mars,
  - A satellite orbiting Mars,
  - Or centres on Earth
- A standard service for Parameters means:
  - A relay satellite can receive the rovers parameters and forward it to Earth
  - A Mission Control Centre can receive and analyse the Parameters of the satellite or rover
  - An external institution can receive and analyse the Parameters



- Basically, the same service can be used by completely different systems in completely different situations

Images © ESA

MO Services benefits

- Another way of putting this is that
  - By speaking a standard language
    different organisations around the world
    can interact more easily
- This leads to
  - Minimisation of the number of different interfaces for the same functionality
  - Increased cooperation between organisations
  - Increased reuse from one mission to another
  - A reduction in cost
- This improved flexibility will allow
  - Increased distribution of functions between different organisations
    - Including the migration of functions between ground and space
  - Better able to cope with technology obsolescence/longevity
- Increased interoperability and reuse means
  - Faster times for deployment
  - More innovation
  - and always more competitive costs

MO Services benefits

- CCSDS has defined an open architecture and framework that is:
  - Able to integrate new and legacy systems of different organisations
  - Service Orientated
  - Independent from technology
  - Designed to support the long lifetimes of space missions
- The framework allows different systems to communicate and interact together, independently from their
  - Location
  - Programming language
  - Hardware platform
  - Or communications technology
- This independence allows an organisation to choose
  - The technologies that are appropriate for them
  - Whilst still allowing bridging between these different choices where required
- It also increases long-term maintainability over the mission lifetime through replacement of both
  - Systems
  - And infrastructure

Mission Operations

Issues that exist today and MO

- So lets see how MO can help us
  - Lets review those two main issues again
- An increase in mission complexity due to the larger numbers of involved
  - Organisations
  - Interfaces
  - Functionalities
  - And technologies
- An increasing pressure to reduce costs

MO Provides

- Standardised services
- Separate from technologies
- Supports re-use
- Supports technology migration

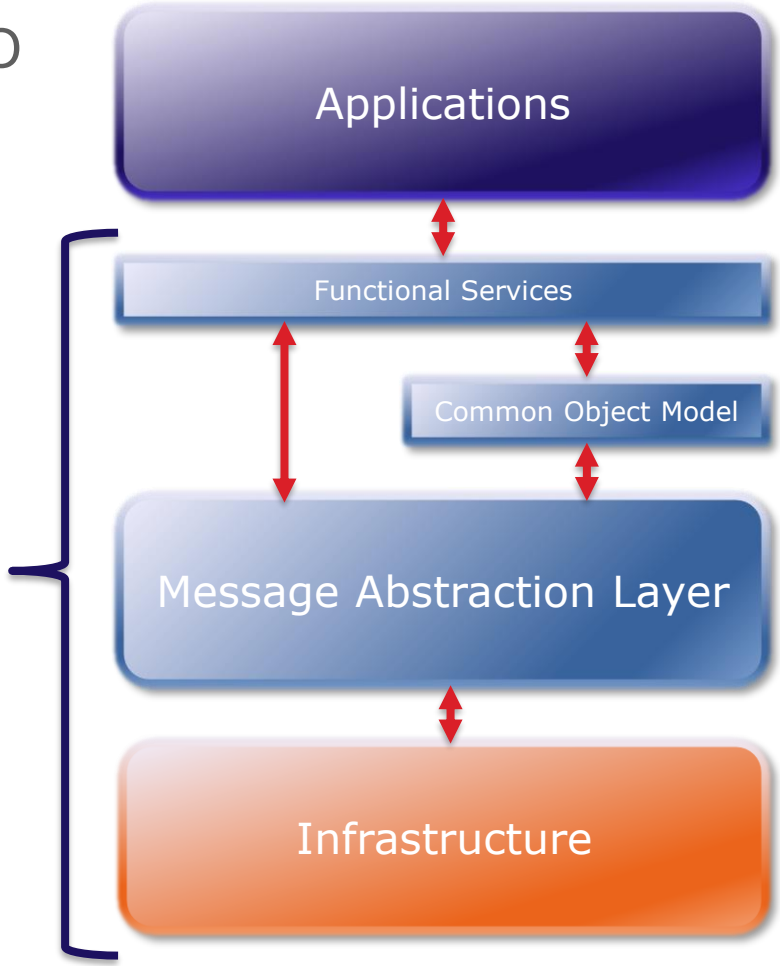
Part 2

- The MO framework
- The MO services
- MO and the future

The MO Framework

- Central to the MO concept is the MO framework
  - Defines structure of an MO application
  - Provides generic model for data
    - Supports generic facilities such as archiving
  - Provides separation from technology

- It is defined by three specifications
  - A reference model
    - (CCSDS 520.1-M-1)
  - A Message Abstraction Layer (MAL)
    - (CCSDS 521.0-B-2)
  - A Common Object Model for data (COM)
    - (CCSDS 521.1-B-1)



The MO Framework and bespoke services

- MO framework also supports bespoke services
  - These are the services that you define for your:
    - Infrastructure
    - Missions
    - Agency
    - Anything else you identify

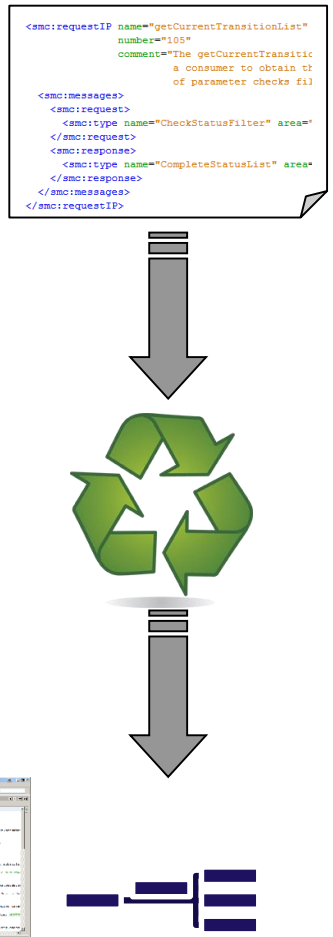
- If you define your bespoke services use the MO framework
  - In the same way the standard services provide future proof technology separation
  - The services specific to your environment can also benefit too

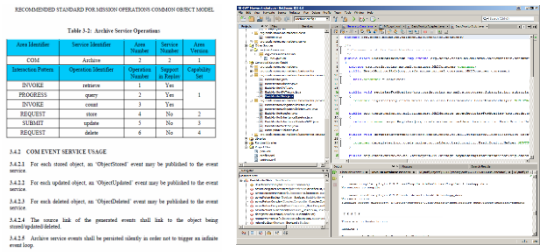
Message Abstraction Layer (MAL)

- The MAL is the building block for all MO services
- Provides the MO framework with its ability to separate from technology
  - Technology independent XML notation used to describe:
    - Service behaviour
    - Available operations
    - Message structures
- Provides the ability to change that technology at any time
  - Mapping from the XML to your chosen technologies
  - Defines the required abilities of communication technologies
- Simplifies the task to develop communicating applications
  - Specifies a fixed behaviour for applications
  - Expected behaviour of service providers
  - Expected behaviour of users of a service

MAL mappings and transformations

- The MAL defines a standard XML notation for service specification
- Mappings define transformations from the XML to:
  - Language mappings for specific programming languages
  - Technology mappings for 'on-the-wire' transports/encodings
  - Bespoke mappings are also supported
- Mappings are not service specific they work for all services
  - Services are defined in terms of the MAL
  - Mappings are defined in terms of the MAL
- So, from this we can automatically generate:
  - Documentation
  - Programming language APIs
  - System databases
  - …





Common Object Model (COM)

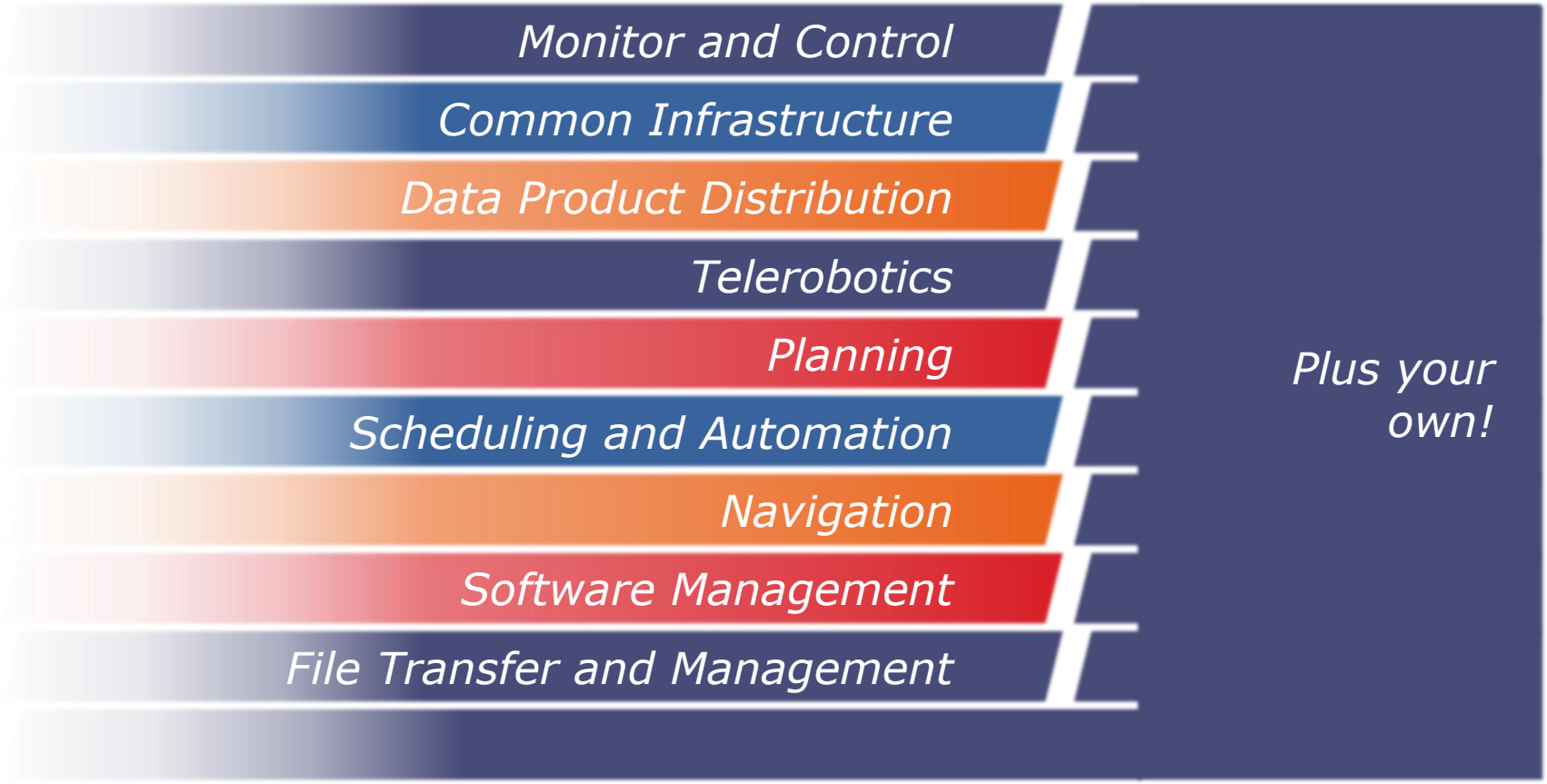
- The COM provides, out of the box:
  - Archiving
  - Tracking of remote activities and operations
  - Asynchronous event reporting

- The object model:
  - Provides a standard way to identify data
  - Allows the development of standard capabilities such as
    - Archiving
    - Activity tracking
    - Event reporting

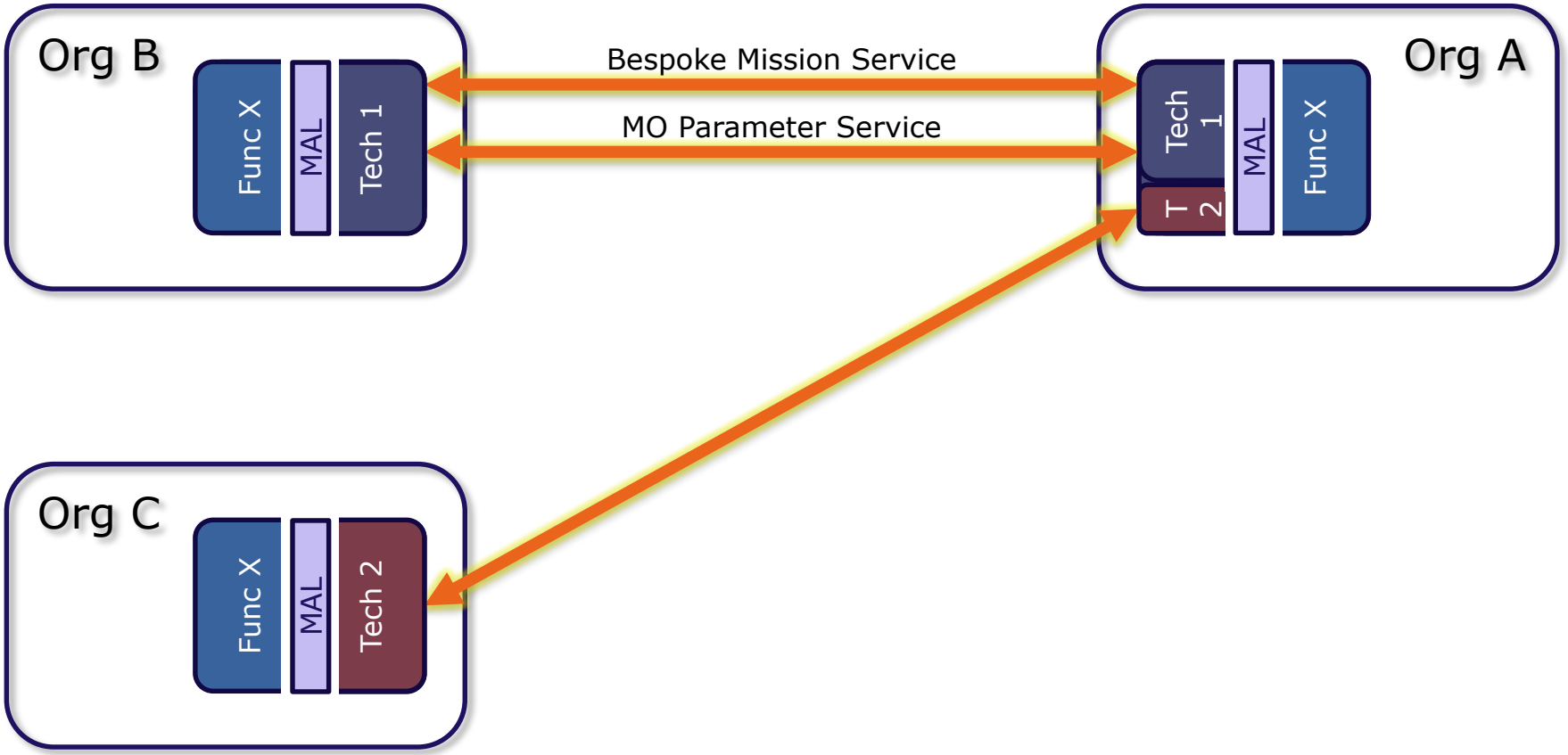
- Defined using the MAL notation
  - Technology agnostic

The MO Services

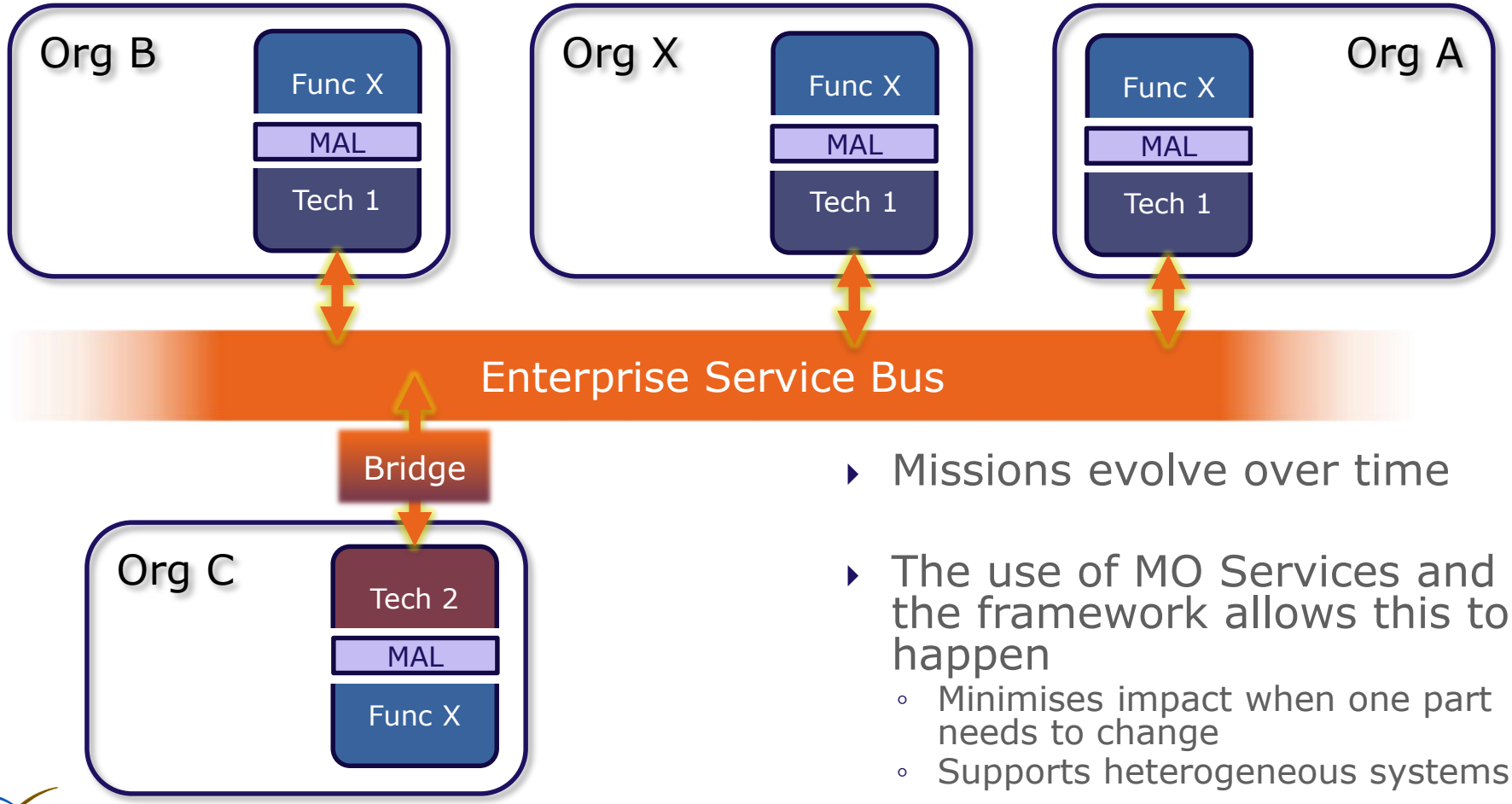
- So what services does MO intend to provide:



An example deployment



An example deployment (alternative view)



- Missions evolve over time
- The use of MO Services and the framework allows this to happen
  - Minimises impact when one part needs to change
  - Supports heterogeneous systems

ECSS Packet Utilisation Standard

- In Europe there is an existing service based standard for mission operations
  - It is called the Packet Utilisation Standard, or PUS
  - It is maintained by a European standards body called ECSS
    - European Cooperation on Space Standardization (ECSS)
- The PUS is used in many European, and wider, missions:
  - It has been around since 1994
  - It is well understood
  - It defines a strong Concept of Operations
    - This is very good for operator familiarity and training
  - Just had a significant update in 2015 (PUS C)
- However:
  - It is fixed to CCSDS Space Packets
    - Not optimal for use outside the spacelink
  - Not machine readable
    - Auto generation of code difficult
  - Low level
    - Interaction behaviour between TC/TM implied in associated text
    - Makes automation more complex
- PUS has a good concept but an implementation focussed on the spacelink

CCSDS MO and ECSS PUS

- The working group used PUS as our starting point
  - Built upon the large experience gained using PUS
  - Uses the same, strong, concept of operations
    - But is flexible to work with your concept
  - Worked to resolve the limitations of PUS
- MO Services are aimed at a wider domain and have been designed to be used:
  - On-ground
  - On-board
  - and not just across the spacelink
- Due to the wider domain MO Services:
  - MO Services cover more functions (Planning, Navigation, etc)
- MO Services take advantage of more modern ideas:
  - The specifications are independent of transport and encoding technology
    - The MAL ensures this
  - Machine readable XML specifications
    - Allows easy auto-generation of mission artefacts
  - Clear relationship between what needs to be sent and what will be received in return
    - The MAL enforces this and is captured in the XML
    - Reduces complexity for automation of operations

CCSDS MO Books and status

Informational	MO Services Concept	(CCSDS 520.0-G-3)	PUBLISHED
Framework	Reference Model	(CCSDS 520.1-M-1)	PUBLISHED
	Message Abstraction Layer (MAL)	(CCSDS 521.0-B-2)	PUBLISHED
	Common Object Model (COM)	(CCSDS 521.1-B-1)	PUBLISHED
Functional Services	Monitor & Control	(CCSDS 522.1-R-3)	PUBLIC DRAFT
	Common Infrastructure	(CCSDS 521.1-R-1)	PUBLIC DRAFT
	Mission Data Product Distribution		DRAFT
	Planning		WG FORMED
	Scheduling & Automation		
	Navigation		
	Software Management		
	File Transfer & Management		
Language Bindings	JAVA API	(CCSDS 523.1-M-1)	PUBLISHED
	C++ API		DRAFT
Technology Binding and Encoding	Space Packet Transport & Binary Encodings	(CCSDS 524.1-B-1)	PUBLISHED
	TCP/IP Transport & Split Binary Encoding		DRAFT
	HTTP Transport & XML Encoding		DRAFT
	ZeroMQ Transport		DRAFT

Mission Operations

MO and the future

- So what does the future hold for MO
  - More importantly what does the future of MO hold for you?
- Basically more!
  - More service specifications
  - More programming languages supported
  - More communications technologies supported
  - More free software
  - More support from industry
- This means
  - More re-use
  - More simplified migration of technology over time
  - Rapid development of missions for less
  - More cost savings
- More for less

Summary

Summary

- Two main trends are becoming apparent in current and future missions:
  - An increase in mission complexity
  - An increasing pressure to reduce costs
- In today's systems a lack of
  - Standardisation between and inside organisations
  - Combined with lack of re-use between missions
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- To alleviate this CCSDS is defining and standardising:
  - A set of services for Mission Operations
  - A open framework, independent from technology
- Whilst over the long lifetimes of space missions the inability to
  - Update technologies and infrastructure
  - Replace systems without major system redesign
    - Including vendor lock in
  - Has led to increased operational costs
- These provide:
  - Increased interoperability and reuse
  - Improved flexibility
  - Independence from location, programming language, hardware platform and communications technology

The CCSDS Mission Operations services provide the capability to hide the unavoidable difficulties that characterises the space environment whilst supporting your future complexity needs

Mission Operations

Links

General

CCSDS Website

http://www.ccsds.org/

MO in Wikipedia

http://en.wikipedia.org/wiki/CCSDS_Mission_Operations

Open Source Software

ESA on GitHub

https://github.com/esa

ESA MO OSS Wiki

https://github.com/esa/CCSDS_MO/wiki