

Mission Operations Services by the CCSDS: a step towards the future



CCSDS Spacecraft Monitor & Control Working Group (SM&C)
Mario Merri (ESA), Chair

Presentation Motivations and Agenda

- Communicate and promote our standardisation effort
 - ⇒ Share SM&C approach with decision makers for future missions
 - ⇒ Dissipate unjustified fears (e.g. re-use of legacy systems, pre-defined system architecture, prescribed functionalities)
 - ⇒ Share benefits of application-level services and not only communication protocol standardisation

- Agenda covers main SM&C WG responsibility, i.e. standardisation in the context of:
 - ⇒ Spacecraft Monitoring & Control (SM&C)
 - ⇒ Status, strategy and outlook
 - ⇒ Overview
 - ⇒ Prototype
 - ⇒ XML Telemetric and Command Exchange (XTCE)
 - ⇒ Very brief status and outlook



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SM&C in Numbers

- 3 year lifetime
(started in Dec 2003)
- 10 active Space Agencies
- 1 partner standardization organization
- 7 CCSDS workshops
- 40 telecons



■ XTCE Splinter Group



ASI: C Labonia



BNSC: R Thompson (deputy chairman), B Harnett



CNES: B Béhal, E Poupart, R Soumagne



CSA: P Melanson



DLR: H Hoffman



ESA: M Merri (chair), M Schmidt, A Ercolani, I Dankiewicz, S Cooper



FSA: L Kudrin



INPE: PG Milani, AM Ambrosio



JAXA: T Yamada



NASA/GSFC: DC Lokerson, F Johnson, JK Marquart, JS Gal-Edd, C Fatig, R Jones, K Rice
NASA/JPL: A Oyake, P Shames, J Moholt



OMG: G Simon (Lockheed Martin), B Kizzort (Harris Corp.)

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- 2 published GBs
- 2 Agencies Reviews (XTCE)
- 2 internal Reviews (SM&C)
- 3 advanced draft HP SM&C RBs



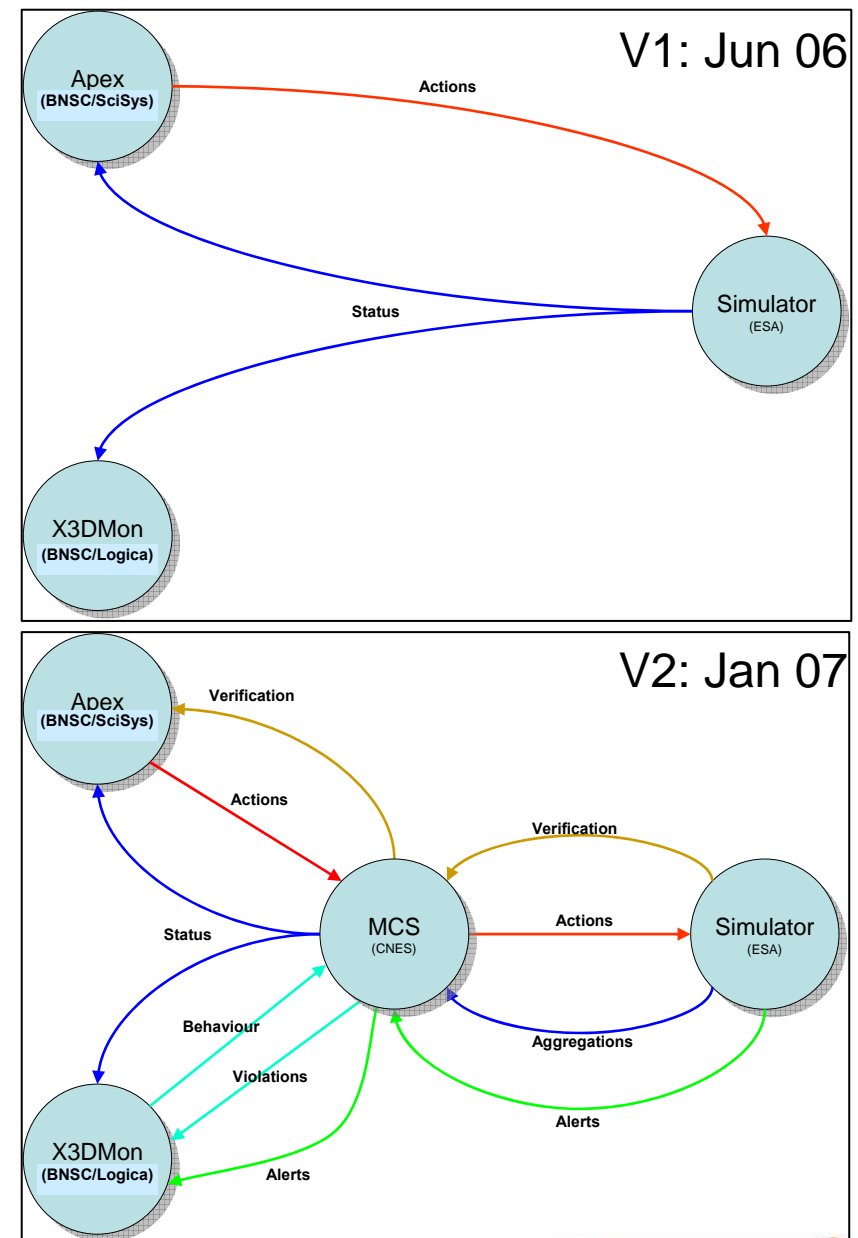
- Mission Operations Service Concept, CCSDS 520.0-G-2, August 2006
 - ⇒ <http://public.ccsds.org/publications/archive/520x0g2.pdf>
 - ⇒ Web hits: 158 in Feb 06; 259 in Jan 07
- XML TELEMETRIC AND COMMAND EXCHANGE (XTCE), CCSDS 660.0-G-1, July 2006
 - ⇒ <http://public.ccsds.org/publications/archive/660x0g1.pdf>
 - ⇒ Web hits: 303 in Feb 07; 445 in Jan 07
- SM&C Message Abstraction Layer (ESA)
- SM&C Common Service (ESA)
- SM&C Core Service (ESA)

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- 4 initial draft SM&C RBs

- SM&C Time Service (CSA)
- SM&C Remote Software Management (BNSC)
- SM&C Automation Service (CNES)
- SM&C Planning Service (BNSC)

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Spacecraft Monitoring and Control

■ What it is

- ⇒ Comprises application level services that are needed to monitor, control and operate a remote system including:
 - ↙ Classical TM monitoring
 - ↙ TC generation (manual, pre-planned, automatic, time-tagged, ...)
 - ↙ Remote software management
 - ↙ Time management
 - ↙ Mission product data management
 - ↙ Mission planning and automation
 - ↙ Orbit, Attitude and Position determination
 - ↙ Standard interaction with the operator
 - ↙ ... more to come

■ What it is not

- ⇒ Does not prescribe the system architecture and functionality
 - ↙ service provider/consumer may be located differently depending on the specific deployment
 - ↙ No predefinition of applications' implementation, but only of their management interfaces
- ⇒ Does not prescribe the technology to be used

■ Must allow expansion to accommodate future needs

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What Do we Want to Achieve?

■ Prepare for the future

- ⇒ Future missions will be more complex and require more collaboration across organisation
 - ↪ Better interoperability between systems (e.g. X monitoring its lander via Y's orbiter, Z submitting planning requests for its payload on W's S/C, ...)
 - ↪ Scalability
- ⇒ Expandable systems
 - ↪ Difficult to predict now what will be needed tomorrow
- ⇒ Protect from technology evolution
 - ↪ Replace implementation technology without major system redesign

■ Reduce cost (i.e. schedule, risks, ...) of

- ⇒ [On-board and Ground-based] system development
 - ↪ Facilitate availability of generic software infrastructure
 - ↪ Facilitate availability of new, state-of-the-art, plug-in [commercial] components
 - ↪ → Re-use components (including legacy systems)
- ⇒ ... and mission operations
 - ↪ Re-use operational concepts across missions
 - ↪ Increase operational commonality across components (less training costs)



How Can Standardisation Help?

- **Standardisation of interfaces for SM&C**
 - ⇒ Reduce cost of Flight Components and Ground Segment Infrastructure
 - ⇒ Enable “plug and play” architecture with components from different Agencies, systems and suppliers

- **SM&C Framework technology keywords**
 - ⇒ Service Oriented Architecture
 - ⇒ Plug & Play
 - ⇒ Layering
 - ⇒ Isolation and Grouping of generic and common services
 - ⇒ Publish/Subscribe
 - ⇒ Technology Adapters (e.g. integration of legacy systems)



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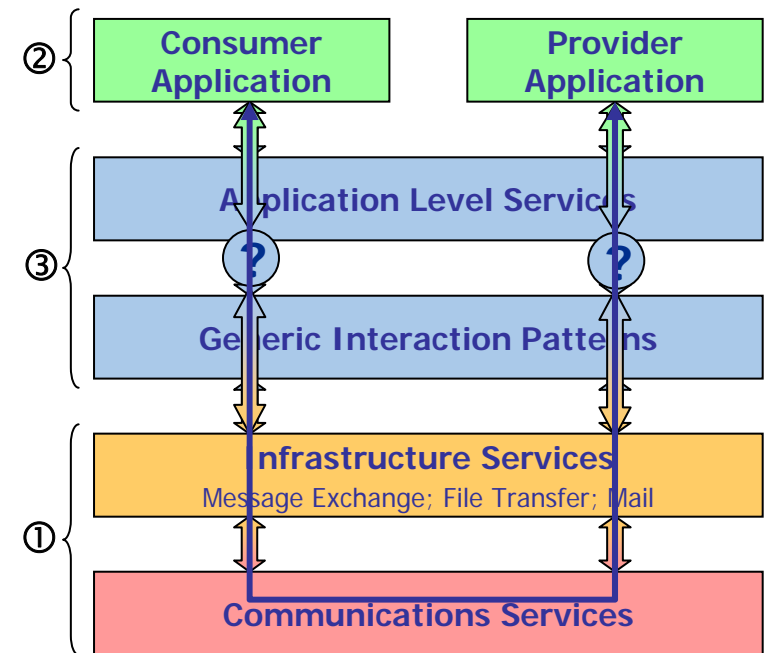
Why Application-Level Service Standardisation?

■ Protocol-Level standardisation

- ⇒ is necessary (allows communication), but not sufficient for seamless plug-in of components and interoperability
- ⇒ some commercial world examples:
 - ↪ Bluetooth/Infrared
 - ↪ USB
 - ↪ Internet (HTTP and TCP/IP)

■ Application-Level service standardisation

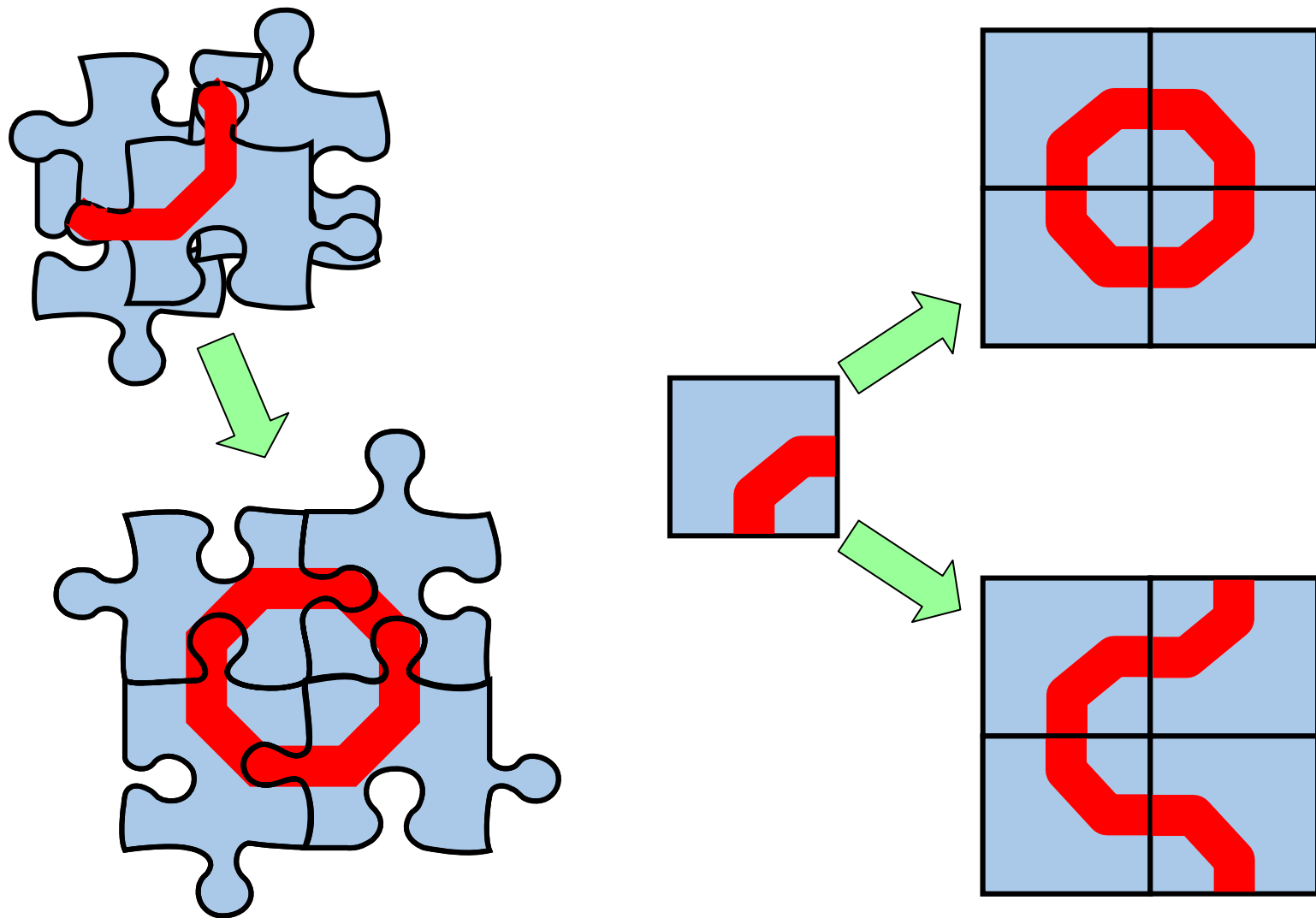
- ⇒ allows seamless plug-in of components and interoperability
- ⇒ Examples
 - ↪ Calendar/Contacts/To do List/... management
 - ↪ Plug & Play of modern memory sticks
 - ↪ e.g. tailor-made holidays package (Expedia, LastMinutes, ...)



- ① Technology Specific Infrastructure
- ② SM&C Specific Applications
- ③ SM&C Service Framework



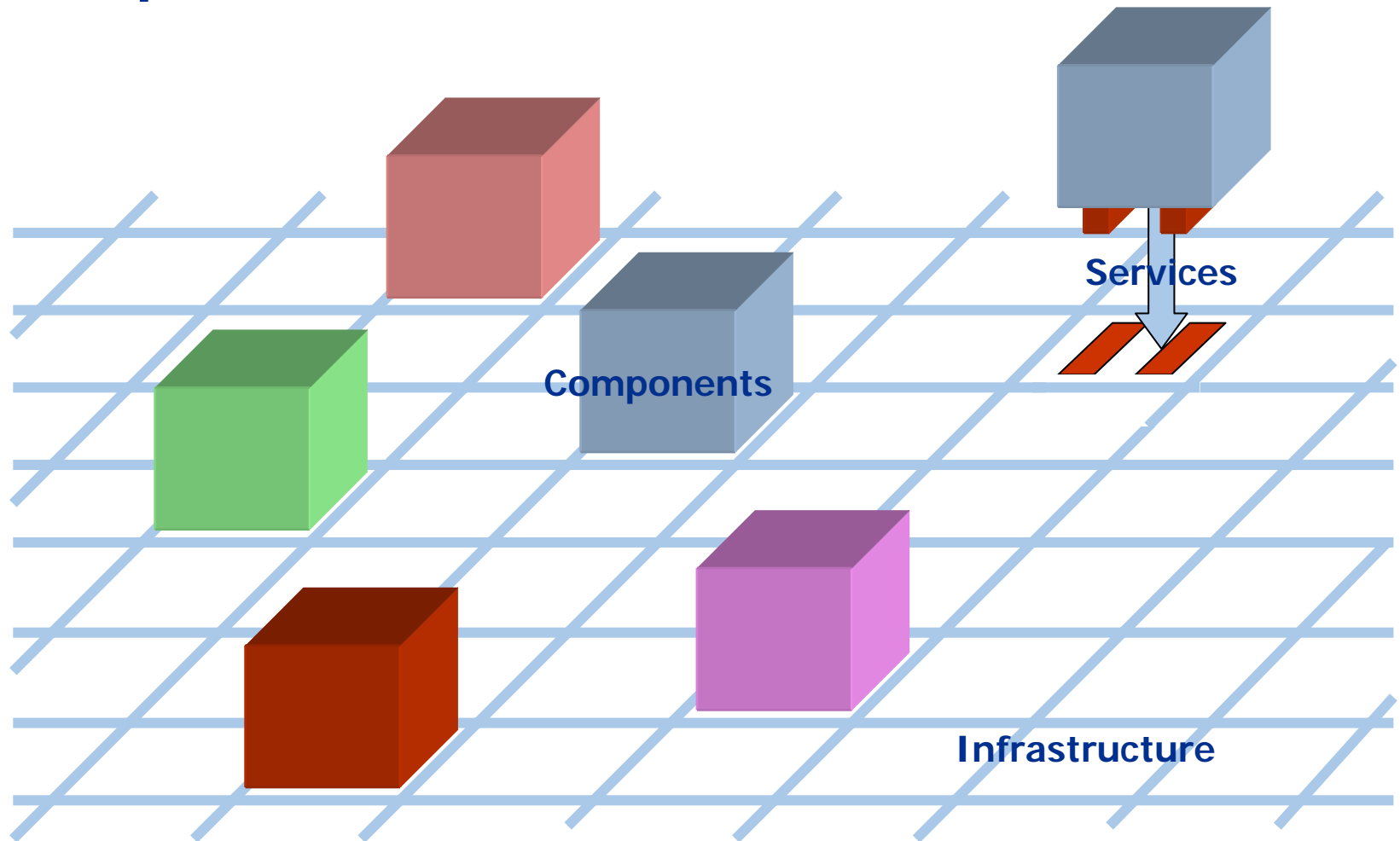
Integrated Systems vs. Modular Components



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Service-Oriented Architecture: Plug-in Components



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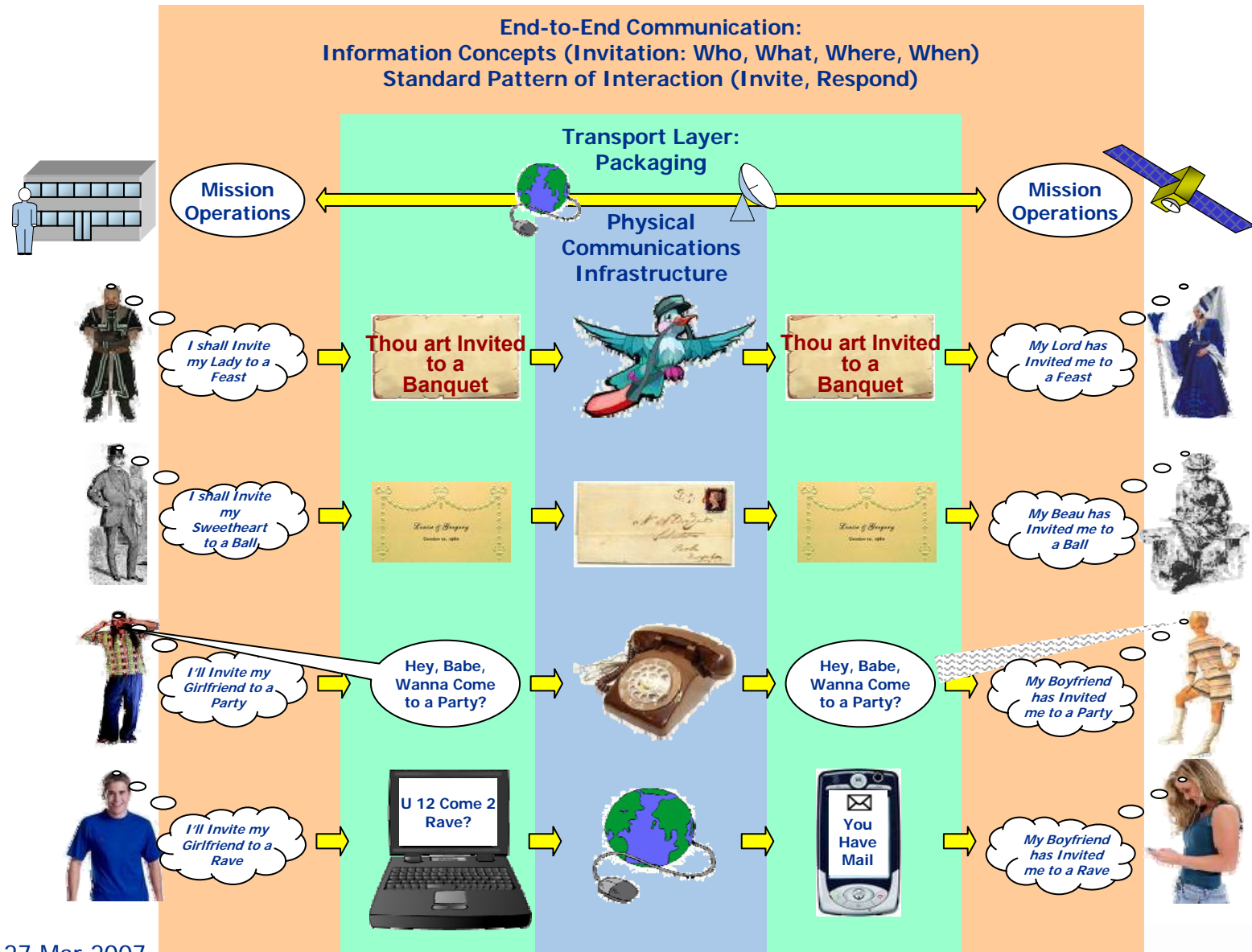
Benefits of the SOA Approach

- **Components exchangeable for others supporting same Service Interfaces**
 - ⇒ *Plug-and-play interoperability of MCS components*
- **Common Service Framework**
 - ⇒ *Re-use of common infrastructure across multiple systems*
 - ⇒ *Independence of mission configuration data and history from system implementation*
- **Infrastructure Implementation can be changed without change to core Applications**
 - ⇒ *Independence of core application software from underlying implementation technology – platform and communications*
- **Components rapidly deployable in different combinations**
 - ⇒ *Reduced mission-specific deployment costs*
- **Extensible: easy to add new components**
 - ⇒ *Scope to evolve a system, by replacing components or changing underlying technologies*
- ***Success is dependent on the Granularity of the service architecture selected***

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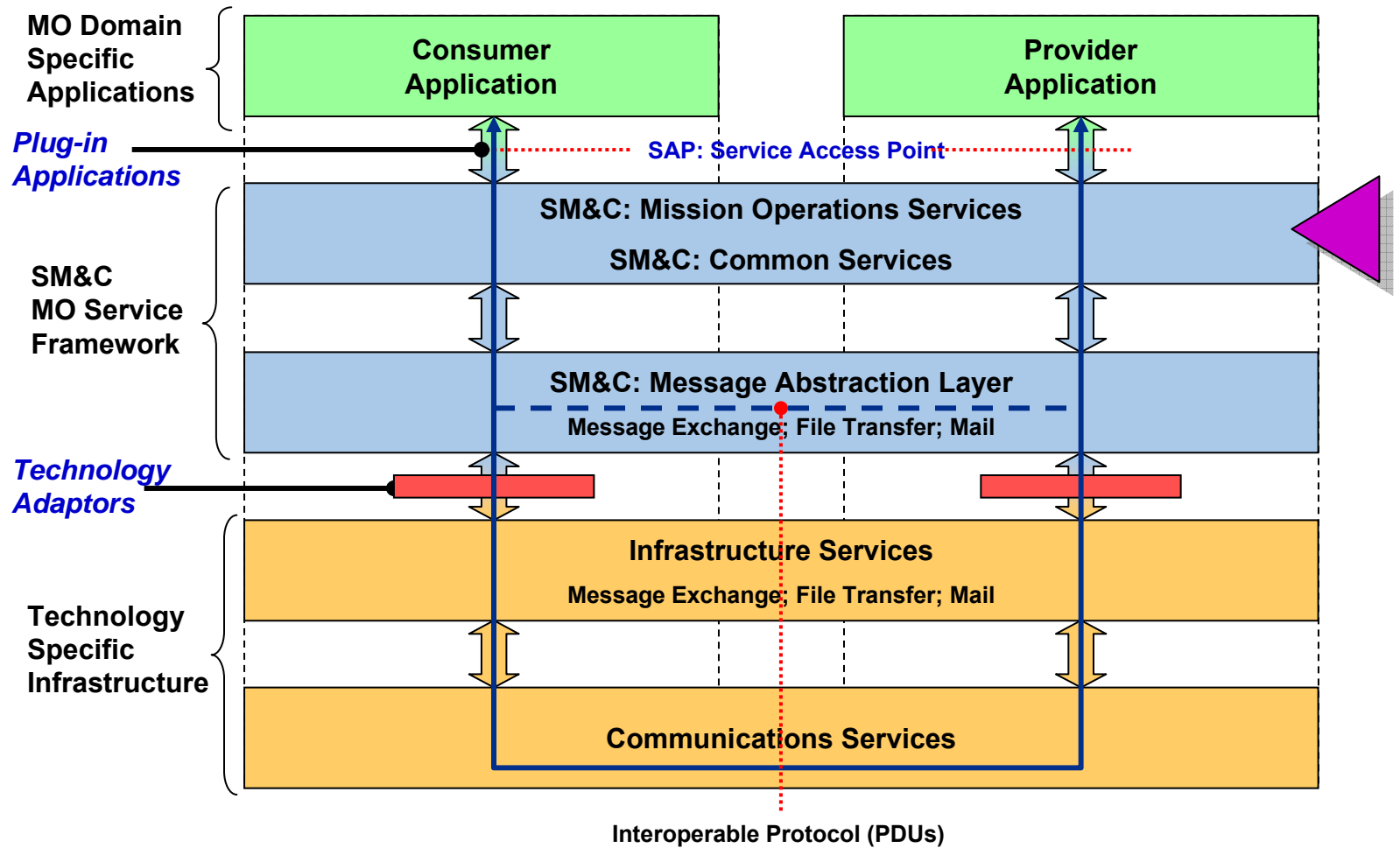
End-to-End Services and Layering



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SM&C Service Layering (a)



Identified SM&C MO Services

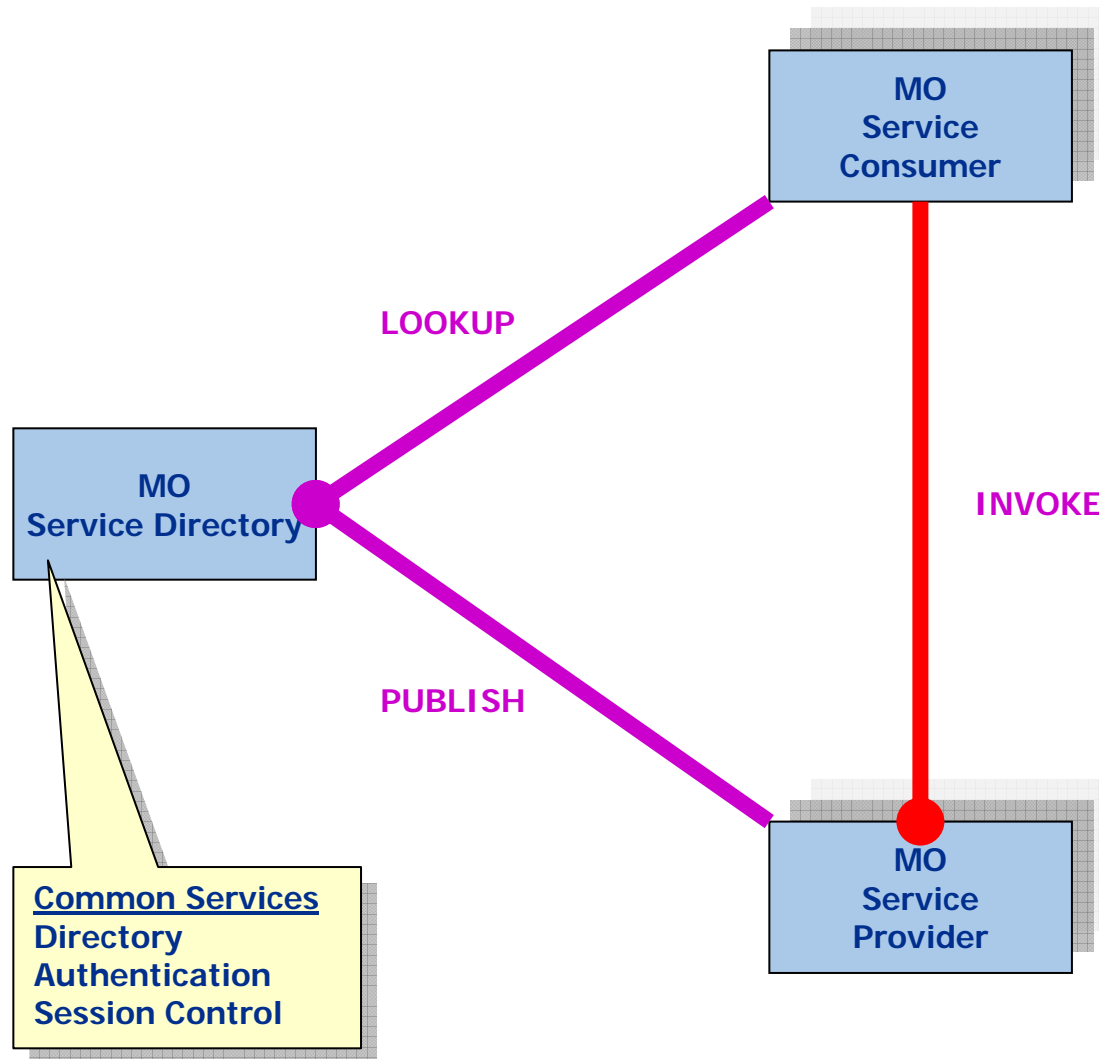
Name	Service Objects and Operations	Priority
Core Monitoring & Control	Parameters: publish status; set Actions [Commands]: publish status; invoke/send Alerts [Events]: notify; raise	1
Time	Time: report; set; correlate; notify	2
Software Management	On-board Software: load; dump	2
Planning Request	Planning Request/Goal: request; response	3
Scheduling	Schedule: distribute; edit; control; progress reporting	3
Automation	Procedure/Function: control; progress reporting	2
Data Product Management	Data Product [Payload Data File]: directory; transfer	3
Location	Position: tracking, ranging, onboard positioning	3
Flight Dynamics	Orbit/Attitude/Predicted Events: determination, propagation, manoeuvre preparation	4
Operator Interaction	Message/Alarm/Query: notify; operator response	4
Remote Buffer Management	Buffer: catalogue; retrieve; clear	4



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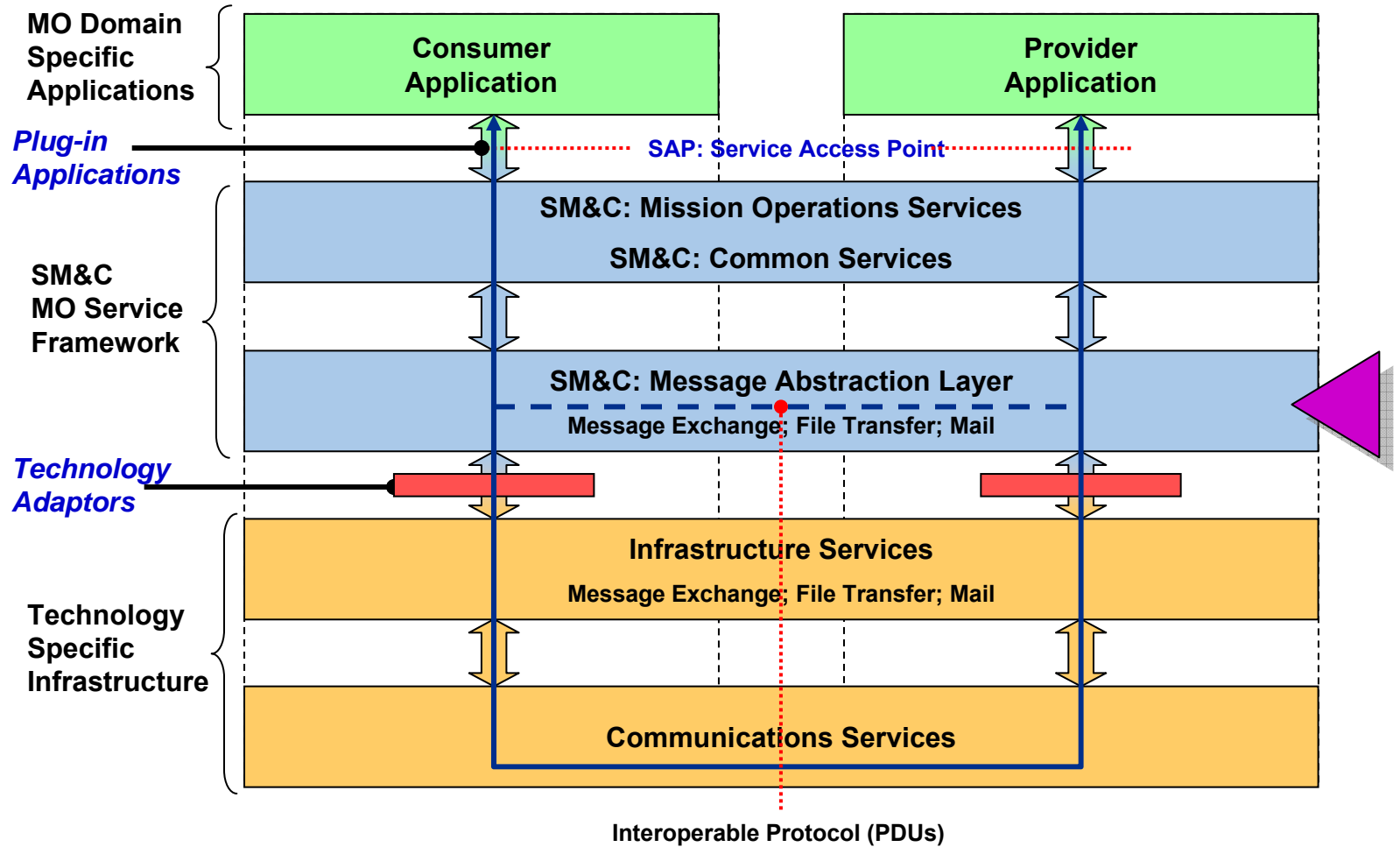
SM&C Common Services



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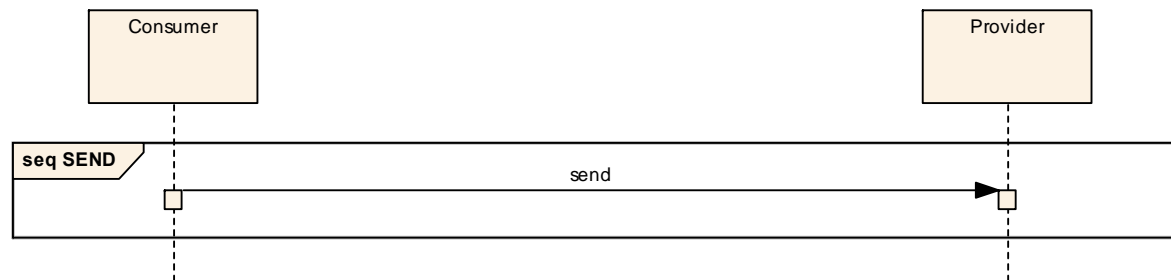
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SM&C Service Layering (b)

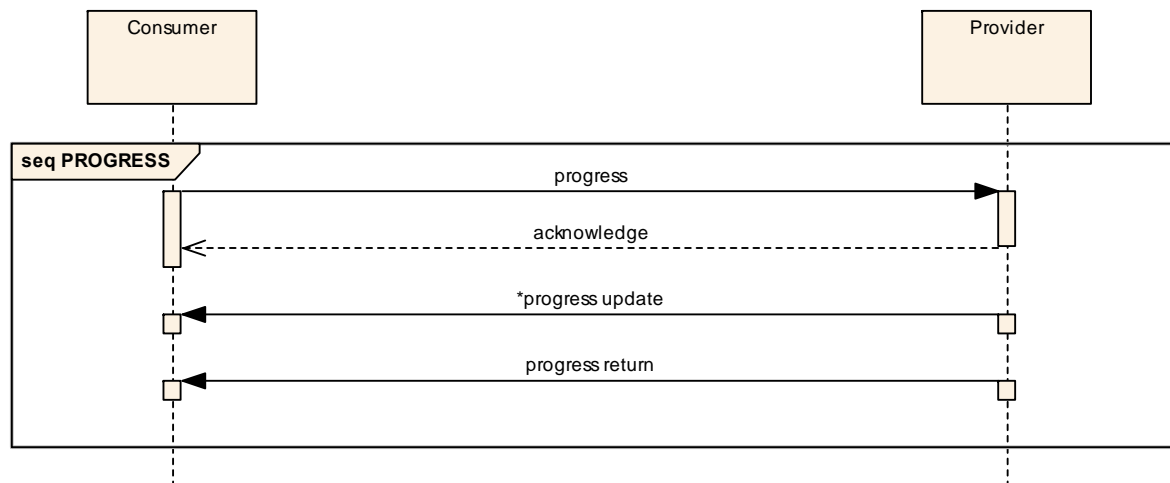


Message Abstraction Layer (1)

- Generic Interaction Patterns (IP)
 - ⇒ limited set used by MO services in the SM&C framework
 - ⇒ Each operation of a service uses one IP



SEND IP



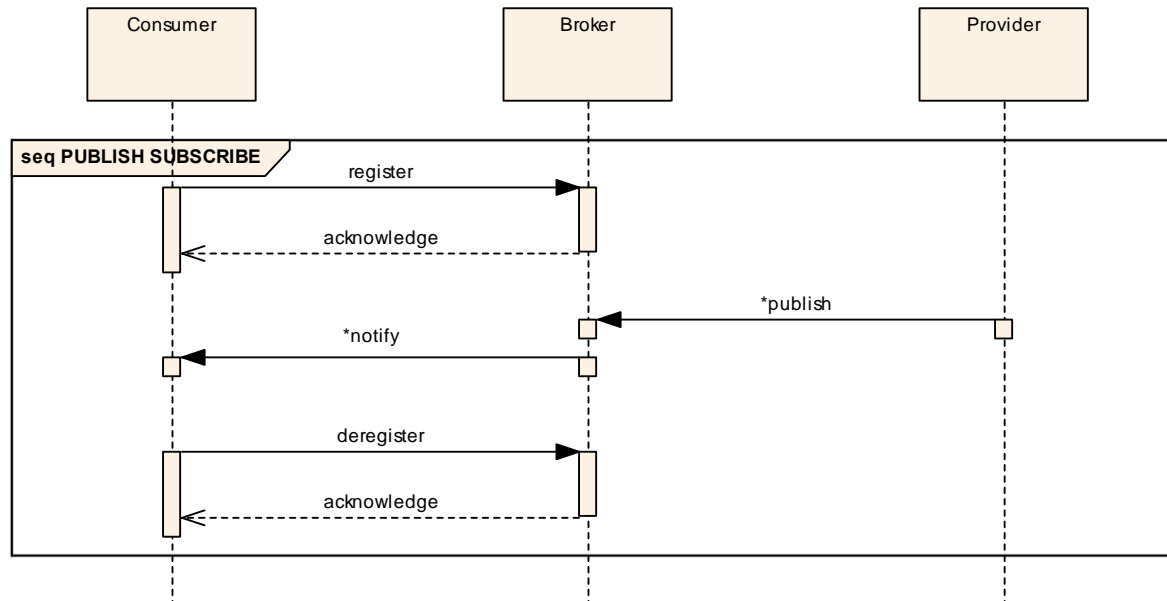
PROGRESS IP

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Message Abstraction Layer (2)

- Generic Interaction Patterns (IP)

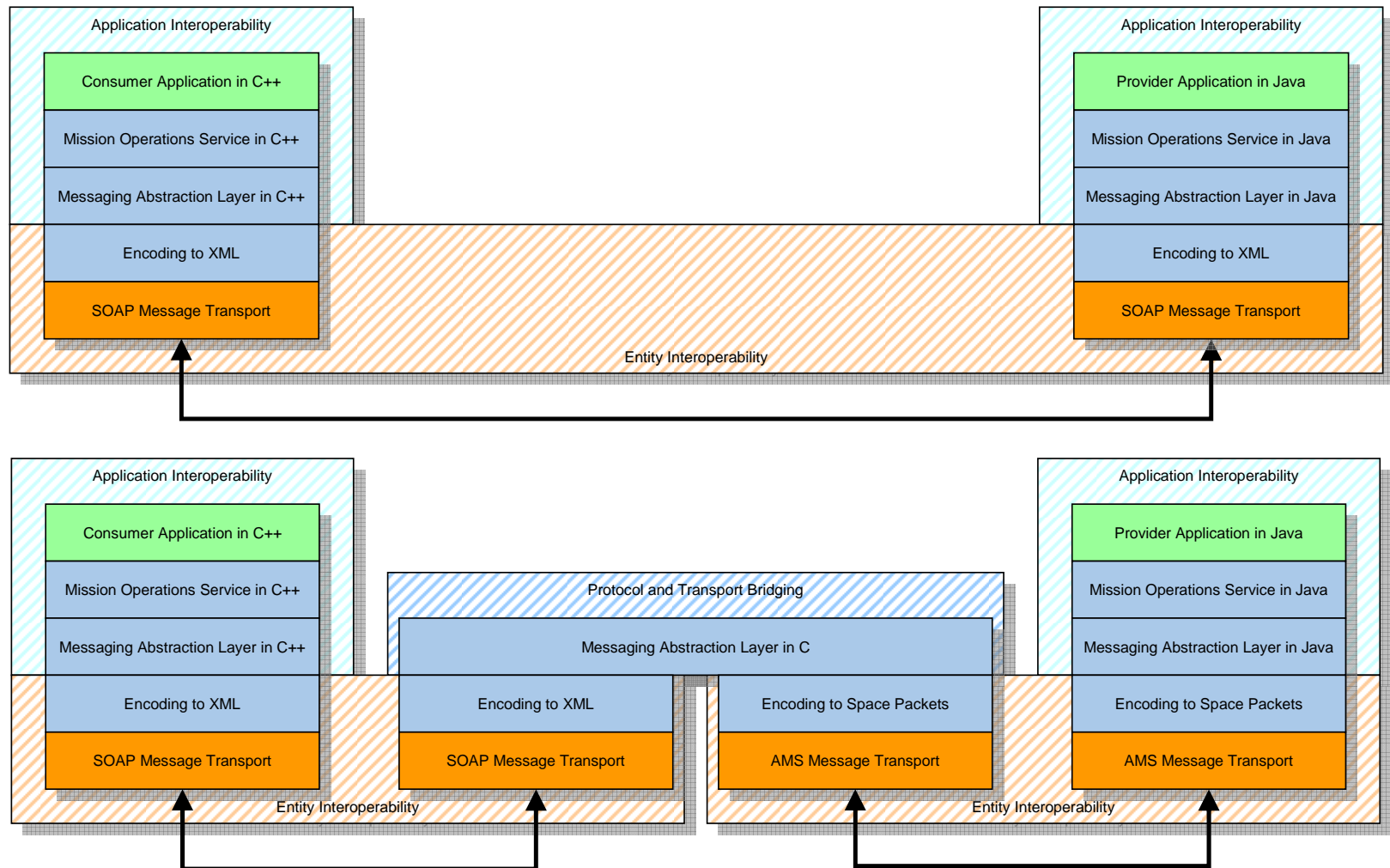


- Other features:

- ⇒ Multiplicity of services (Session, Domain, Network Zone)
- ⇒ Security and access control
- ⇒ Quality of Service

Message Abstraction Layer (3)

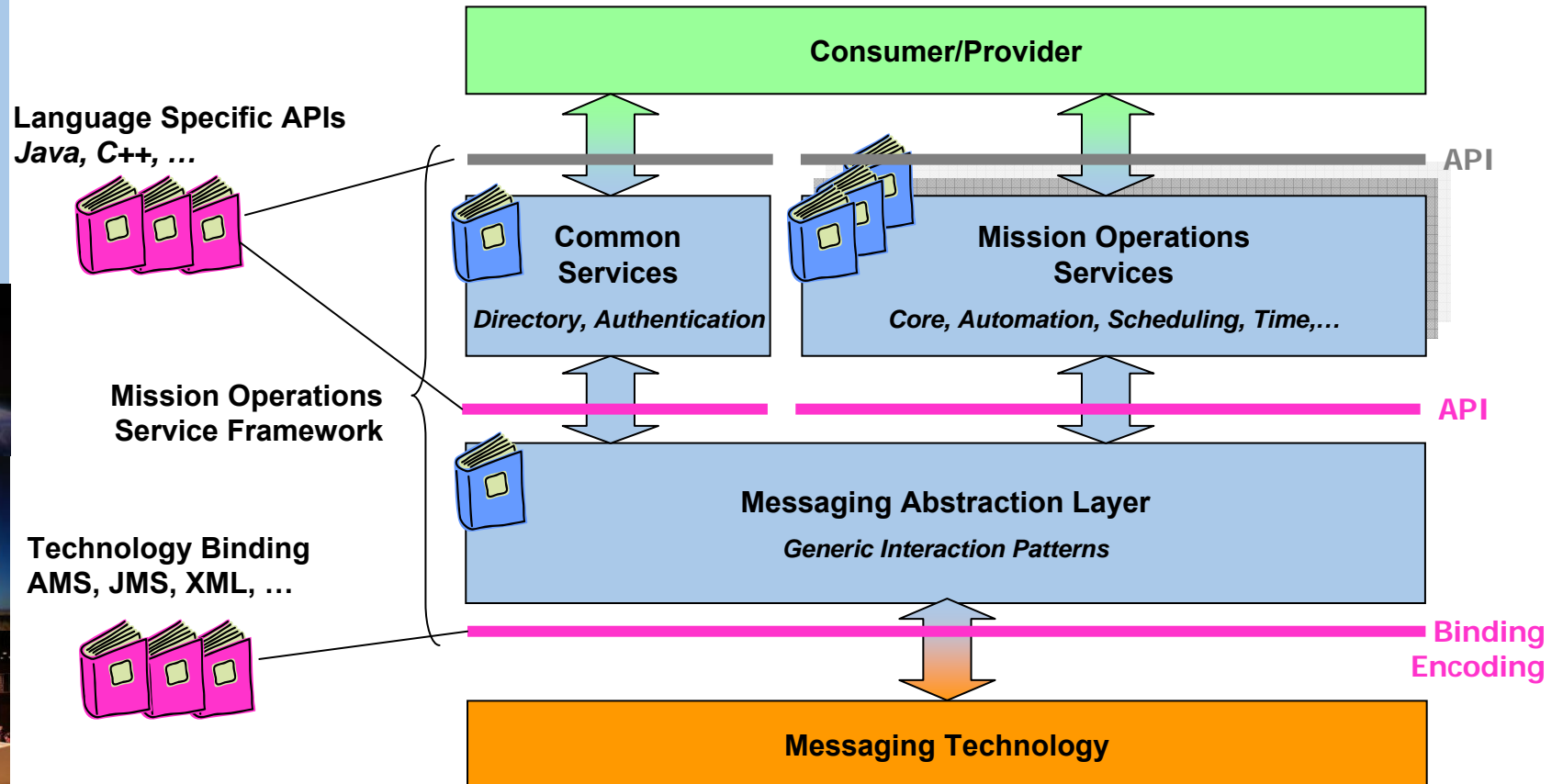
- Interoperability (language and encoding/transport)



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SM&C CCSDS Books



Conclusions and Outlook

- The Mission Operations Services will provide a framework for development of
 - ⇒ Interoperable systems (across and within Agencies)
 - ⇒ Re-usable components
 - ⇒ Systems-of-Systems

- At the last CCSDS workshop (Jan 07), NASA agreed to increase support to the SM&C effort while continuing to identify the candidate enabling technologies for the future Constellation Programme

- Target plan
 - ⇒ SM&C Message Abstraction Layer - end 2007
 - ⇒ SM&C Common Service - Q2/2008
 - ⇒ SM&C Core Service - Q2/2008



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