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Space data and information transfer systems — Mission operations reference model

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Space data and information transfer systems — Mission operations reference model

*Systèmes de transfert des informations et données spatiales — Modèle
de référence des opérations de mission*



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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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ISO 18201 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 520.1-M-1, July 2010) and was adopted (without modifications except those stated in Clause 2 of this International Standard) by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 13, *Space data and information transfer systems*.

Space data and information transfer systems — Mission operations reference model

1 Scope

This International Standard defines a Mission Operations (MO) reference model which provides a common basis for coordinating the development of CCSDS Recommended Standards for MO service specifications and serves as a reference to maintain the consistency of these Recommended Standards.

The scope of this International Standard is the definition of all concepts and terms that establish a common basis for coordinating the development of CCSDS Recommended Standards for MO service specifications.

The scope and field of application are furthermore detailed in subclause 1.3 of the enclosed CCSDS publication.

2 Requirements

Requirements are the technical recommendations made in the following publication (reproduced on the following pages), which is adopted as an International Standard:

CCSDS 520.1-M-1, July 2010, Mission operations reference model.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 520.1-M-1.

Pages i to vi

This part is information which is relevant to the CCSDS publication only.

Page B-1

Add the following information to the reference indicated:

[B3] Document CCSDS 911.1-B-3, January 2003, is equivalent to ISO 22669:2007.

[B4] Document CCSDS 912.1-B-2, December 2004, is equivalent to ISO 22671:2011.

[B5] Document CCSDS 727.0-B-4, January 2007, is equivalent to ISO 17355:2007.

[B6] Document CCSDS 735.1-B-1, is equivalent to ISO 17807:2013.

[B7] Document CCSDS 133.0-B-1, September 2003, is equivalent to ISO 22646:2005.

[B8] Document CCSDS 502.0-B-2, November 2009, is equivalent to ISO 26900:2012.

[B10] Document CCSDS 504.0-B-1, May 2008, is equivalent to ISO 13541:2010.

[B11] Document CCSDS 851.0-M-1, December 2009, is equivalent to ISO 18425:2013.

3 Revision of publication CCSDS 520.1-M-1

It has been agreed with the Consultative Committee for Space Data Systems that Subcommittee ISO/TC 20/SC 13 will be consulted in the event of any revision or amendment of publication CCSDS 520.1-M-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Recommendation for Space Data System Practices

MISSION OPERATIONS REFERENCE MODEL

RECOMMENDED PRACTICE

CCSDS 520.1-M-1

MAGENTA BOOK

July 2010

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CCSDS RECOMMENDED PRACTICE FOR MISSION OPERATIONS REFERENCE MODEL

AUTHORITY

Issue:	Recommended Practice, Issue 1
Date:	July 2010
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This document has been approved for publication by the Management Council of the Consultative Committee for Space Data Systems (CCSDS) and represents the consensus technical agreement of the participating CCSDS Member Agencies. The procedure for review and authorization of CCSDS documents is detailed in the *Procedures Manual for the Consultative Committee for Space Data Systems*, and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This document is published and maintained by:

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Washington, DC 20546-0001, USA

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of its members. The Committee meets periodically to address data systems problems that are common to all participants, and to formulate sound technical solutions to these problems. Inasmuch as participation in the CCSDS is completely voluntary, the results of Committee actions are termed **Recommendations** and are not in themselves considered binding on any Agency.

CCSDS Recommendations take two forms: **Recommended Standards** that are prescriptive and are the formal vehicles by which CCSDS Agencies create the standards that specify how elements of their space mission support infrastructure shall operate and interoperate with others; and **Recommended Practices** that are more descriptive in nature and are intended to provide general guidance about how to approach a particular problem associated with space mission support. This **Recommended Practice** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommended Practice** is entirely voluntary and does not imply a commitment by any Agency or organization to implement its recommendations in a prescriptive sense.

No later than five years from its date of issuance, this **Recommended Practice** will be reviewed by the CCSDS to determine whether it should: (1) remain in effect without change; (2) be changed to reflect the impact of new technologies, new requirements, or new directions; or (3) be retired or canceled.

In those instances when a new version of a **Recommended Practice** is issued, existing CCSDS-related member Practices and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such Practices or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new Practices and implementations towards the later version of the Recommended Practice.

CCSDS RECOMMENDED PRACTICE FOR MISSION OPERATIONS REFERENCE MODEL

FOREWORD

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommended Practice is therefore subject to CCSDS document management and change control procedures, which are defined in the *Procedures Manual for the Consultative Committee for Space Data Systems*. Current versions of CCSDS documents are maintained at the CCSDS Web site:

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Questions relating to the contents or status of this document should be addressed to the CCSDS Secretariat at the address indicated on page i.

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- Swedish Space Corporation (SSC)/Sweden.
- United States Geological Survey (USGS)/USA.

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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 520.1-M-1	Mission Operations Reference Model, Recommended Practice, Issue 1	July 2010	Original issue

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1 INTRODUCTION

1.1 PURPOSE OF THIS RECOMMENDED PRACTICE

This Recommended Practice defines a Mission Operations (MO) reference model which provides a common basis for coordinating the development of CCSDS Recommended Standards for MO service specifications and serves as a reference to maintain the consistency of these Recommended Standards.

1.2 SCOPE

The scope of this Recommended Practice is the definition of all concepts and terms that establish a common basis for coordinating the development of CCSDS Recommended Standards for MO service specifications.

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDED PRACTICE

This Recommended Practice serves as a guideline for the development of compatible Agency standards for MO systems. It is considered normative on the other Blue Book specifications produced by this working group. In this context, Mission Operations refers to end-to-end services between functions, resident on-board a spacecraft or based on the ground, that are responsible for mission operations.

1.3.2 LIMIT OF APPLICABILITY

This Recommended Practice is neither a specification of, nor a design for, real MO systems that may be implemented for the control and monitoring of existing or future missions.

1.4 RATIONALE

The primary goal of CCSDS is to increase the level of interoperability among Agencies. This Recommended Practice furthers that goal by establishing the basis for a set of MO Services to be used in the operation of ground as well as space-based assets.

1.5 DOCUMENT STRUCTURE

This Recommended Practice is organized as follows:

- a) Section 1 provides purpose, scope, applicability and rationale of this Recommended Practice and lists the definitions, conventions, and references used throughout the document.

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- b) Section 2 provides the context of MO, presents the MO documentation structure, and shows how this Recommended Practice fits into that framework. It expands on the scope of this document to provide an overview.
- c) Section 3 defines the MO system environment, data handled by a MO system, and introduces MO Services.
- d) Section 4 defines an architectural model for the MO system. This architectural model comprises two views:
 - 1) The functional view defines the functionality that is performed by that component, without regard to the way this functionality is implemented in real systems. The functional view decomposes the layers into elementary components that transfer messages between the peer layers.
 - 2) The interaction view models the flow of messages inside each of the layers. The interaction view also shows the error return paths and conditions for each of the layers.
- e) Section 5 defines the common characteristics of MO Services.

1.6 DEFINITIONS

Software Component (component): a software unit containing the business function. Components offer their function as Services, which can either be used internally or which can be made available for use outside the component through Provided Service Interfaces. Components may also depend on services provided by other components through Consumed Service Interfaces.

Hardware Component: a complex physical entity (such as a spacecraft, a tracking system, or a control system) or an individual physical entity of a system (such as an instrument, a computer, or a piece of communications equipment). A Hardware Component may be composed from other Hardware Components. Each Hardware Component may host one or more Software Components. Each Hardware Component has one or more ports where connections to other Hardware Component are made. Any given Port on the Hardware Component may expose one or more Service Interfaces.

Service: a set of capabilities that a component provides to another component via an interface. A Service is defined in terms of the set of operations that can be invoked and performed through the Service Interface. Service specifications define the capabilities, behaviour and external interfaces, but do not define the implementation.

Service Interface: a set of interactions provided by a component for participation with another component for some purpose, along with constraints on how they can occur. A Service Interface is an external interface of a Service where the behaviour of the Service Provider Component is exposed. Each Service will have one defined 'Provided Service

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Interface’, and may have one or more ‘Consumed Service Interface’ and one ‘Management Service Interface’.

Provided Service Interface: a Service Interface that exposes the Service function contained in a component for use by Service Consumers. It receives the MAL messages from a Consumed Service Interface and maps them into API calls on the Provider component.

Consumed Service Interface: the API presented to the consumer component that maps from the Service operations to one or more Service Data Units(s) contained in MAL messages that are transported to the Provided Service Interface.

Management Service Interface: a Service Interface that exposes management functions of a Service function contained in a component for use by Service Consumers.

Service System: the set of Hardware and Software Components used to implement a Service in a real system. Service Systems may be implemented using one or more Hardware and Software Components.

Service Provider (provider): a component that offers a Service to another by means of one of its Provided Service Interfaces.

Service Consumer (consumer): a component that consumes or uses a Service provided by another component. A component may be a provider of some Services and a consumer of others.

Service Data Unit (SDU): a unit of data that is sent by a Service Interface, and is transmitted semantically unchanged, to a peer Service Interface.

Binding: the access mechanism for a Service. Bindings are used to locate and access Service Interfaces. Services use bindings to describe the access mechanisms that consumers have to use to call the Service. The binding specifies unambiguously the protocol stack required to access a Service Interface. Bindings may be defined statically at compile time or they may use a variety of dynamic run-time mechanisms (DNS, ports, discovery).

Service Connection (connection): a communications connection between a Consumed Service Interface and a Provided Service Interface over a specific Binding. When a component consumes the services of a provider component, this link is known as a Service Connection (connection).

Service Extension: addition of capabilities to a base Service. A Service may extend the capabilities of another Service with additional operations. An extended Service is indistinguishable from the base Service to consumers such that consumers of the base Service can also be consumers of the extended Service without modification.

Protocol Stack: the stack of Protocol Layers required for communication.

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Protocol Layer: the implementation of a specific Protocol. It provides a Protocol Service Access Point to layers above and uses the Protocol Service Access Point of the layer below.

Protocol Service Access Point (SAP): the point at which one layer's functions are provided to the layer above. A layer may provide protocol services to one or more higher layers and use the protocol services of one or more lower layers. A SAP defines unambiguously the interface for a protocol that may be used as part of a Service Interface Binding specification.

Protocol: the set of rules and formats (semantic and syntactic) used to determine the communication behaviour of a Protocol Layer in the performance of the layer functions. The state machines that operate and the protocol data units that are exchanged specify a protocol.

1.7 CONVENTIONS

1.7.1 STYLE

Within this Recommended Practice, each formal statement stands in a paragraph by itself and is identified uniquely by a subsection number or by a combination of subsection number and list item number.

1.7.2 NOTES

Notes are not formally part of this Recommended Practice. They are isolated from the formal statements and are introduced by the word NOTE.

NOTE – This is an example of a note.

1.7.3 USE OF CAPITAL LETTERS

Names of system components, data units, and other elements of the reference model are shown with the first letter of each word capitalized.

1.7.4 DRAWING CONVENTIONS

1.7.4.1 General

In figures illustrating this reference model, UML modelling diagrams are used (see reference [B1]). For the specification of the service model the following UML diagrams are used to represent specific views of the model.

1.7.4.2 Services and Service Extension

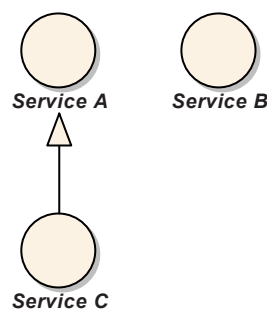


Figure 1-1: Service Extension Drawing Convention

Figure 1-1 shows three services (A, B, and C) and that Service C is an extension of Service A.

1.7.4.3 Components, Service Interfaces and Bindings

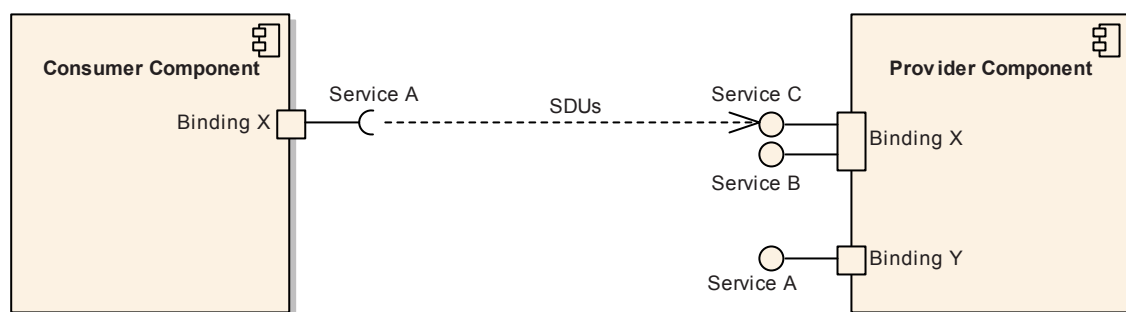


Figure 1-2: Component Drawing Convention

Diagram key:

- UML Components are Software Components.
- Small boxes on the edge of components are Bindings, the label next to these shows the actual binding in use.
- UML Provided Interfaces (Lollypops) are Provider Service Interfaces and must only be attached to Bindings.
- UML Required Interfaces (Cups on sticks) are Consumer Service Interfaces (that reference provider interfaces) and must only be attached to Binding.
- Service Connections are shown as dashed lines.
- SDUs travel over Service Connections.
- Consumer and Provider interfaces and Bindings must match.

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Therefore, figure 1-2 shows two Software Components ('Consumer Component' and 'Provider Component'), where 'Consumer Component' consumes 'Service A' through a specific Binding 'X'. 'Provider Component' provides 'Service A' through a specific Binding 'Y', but also 'Service B' and 'Service C' through specific Binding 'X'. Because 'Service C' is an extension of 'Service A', 'Consumer Component' is able to consume it using a 'Service A' consumer service interface, this connection is shown as a dashed line.

1.7.4.4 Software and Protocol Layering

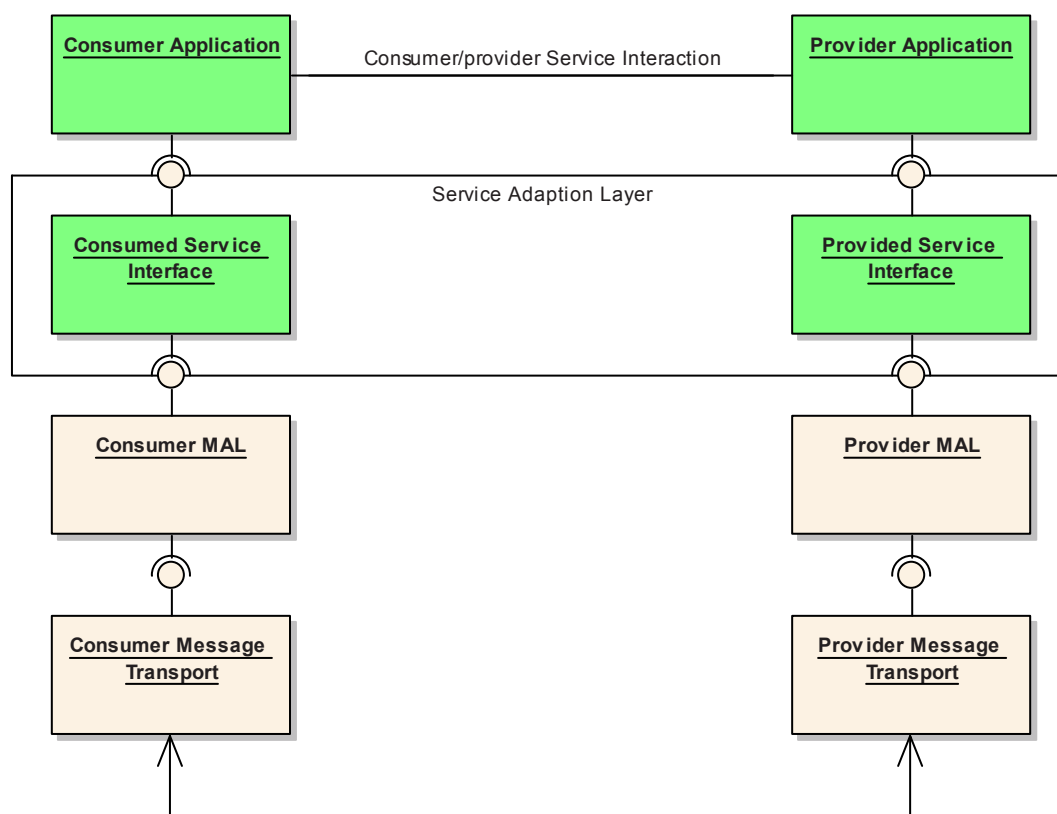


Figure 1-3: Layering Drawing Convention

Figure 1-3 shows a software and protocol stack for two Software Components. Protocol layers are shown as UML Objects, software layers are shown as green UML Objects. The UML assemblies (joined lollipop and 'cup on stick') show a Protocol Service Access Point.

Standard UML sequence diagrams are used to show the interaction sequence between layers and standard UML class diagrams are used to show structure relationships.

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1.8 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommended Practice. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommended Practice are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS Documents.

- [1] T. Berners-Lee, R. Fielding, and R. Fielding. *Uniform Resource Identifier (URI): Generic Syntax*. STD 66. Reston, Virginia: ISOC, January 2005.
- [2] *Mission Operations Message Abstraction Layer*. Recommendation for Space Data System Standards, CCSDS 521.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, [forthcoming].
- [3] *Spacecraft Monitor and Control—Common Services*. Draft Recommendation for Space Data System Standards, CCSDS 521.1-R-1. Red Book. Issue 1. Washington, D.C.: CCSDS, September 2007.

NOTE – Informative references are listed in annex B.