
**Space data and information transfer
systems — Space communications
cross support — Architecture
requirements document**

*Données spatiales et systèmes de transfert d'information - Support
croisé des communications spatiales - Exigences d'architecture*

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CONTENTS

<u>Section</u>	<u>Page</u>
1 INTRODUCTION.....	1-1
1.1 PURPOSE.....	1-1
1.2 SCOPE.....	1-1
1.3 APPLICABILITY.....	1-3
1.4 RATIONALE.....	1-4
1.5 DOCUMENT STRUCTURE.....	1-4
1.6 DEFINITIONS AND CONVENTIONS.....	1-5
1.7 REFERENCES.....	1-12
2 OVERVIEW.....	2-1
2.1 BACKGROUND.....	2-1
2.2 ROLE OF THIS ARCHITECTURE REQUIREMENTS DOCUMENT.....	2-1
2.3 STRUCTURE OF THE ARD: FOUR VIEWS OF SYSTEM ARCHITECTURE.....	2-3
2.4 RELATIONSHIPS BETWEEN SCCS AND OTHER CCSDS DOCUMENTS.....	2-5
2.5 CROSS SUPPORT SERVICE SYSTEM ELEMENTS.....	2-6
2.6 BASIC SYSTEM-ELEMENT CONFIGURATIONS.....	2-9
2.7 NETWORK TERMINOLOGY.....	2-11
2.8 PRACTICAL LIMITS ON PROTOCOL CHOICES.....	2-14
2.9 HOW TO USE THIS DOCUMENT.....	2-15
3 CROSS SUPPORT OVERVIEW OF ABA AND SSI TECHNICAL ARCHITECTURE—CROSS SUPPORT BUILDING BLOCKS.....	3-1
3.1 OVERVIEW.....	3-1
3.2 BUILDING-BLOCK FUNCTIONS.....	3-2
4 SERVICE VIEW.....	4-1
4.1 OVERVIEW.....	4-1
4.2 ABA SERVICES.....	4-2
4.3 SSI SERVICES.....	4-7
4.4 SECURITY REQUIREMENTS FOR SERVICES.....	4-12
5 PHYSICAL VIEW.....	5-1
5.1 OVERVIEW.....	5-1
5.2 ABA-SPECIFIC ELEMENTS.....	5-2
5.3 SSI PHYSICAL ELEMENTS.....	5-13
5.4 SECURITY REQUIREMENTS FOR PHYSICAL ELEMENTS.....	5-25

CONTENTS (continued)

<u>Section</u>	<u>Page</u>
6 COMMUNICATIONS VIEW	6-1
6.1 OVERVIEW	6-1
6.2 PROTOCOL BUILDING BLOCKS	6-6
7 END-TO-END DEPLOYMENT VIEW	7-1
7.1 OVERVIEW	7-1
7.2 ABA END-TO-END PROTOCOL VIEWS—REQUIREMENTS	7-1
7.3 SSI END-TO-END PROTOCOL VIEWS: REQUIREMENTS.....	7-3
7.4 DISCUSSION—SECURITY REQUIREMENTS FOR END-TO-END DEPLOYMENTS	7-5
ANNEX A SECURITY AND SANA CONSIDERATIONS (INFORMATIVE).....	A-1
ANNEX B GLOSSARY (INFORMATIVE)	B-1
ANNEX C ABBREVIATIONS (INFORMATIVE).....	C-1
ANNEX D INFORMATIVE REFERENCES (INFORMATIVE)	D-1

Figure

1-1 Graphical Conventions	1-10
2-1 Roles of the SCCS Architecture Documents.....	2-2
2-2 Basic ABA Configuration.....	2-10
2-3 SSI Core Configuration	2-11
2-4 The SSI	2-13
3-1 Generic ABA End-to-End Deployment.....	3-1
3-2 Generic SSI End-to-End Deployment	3-2
4-1 ABA Service Interfaces	4-2
4-2 SSI End-to-End Run-Time Service Interfaces.....	4-7
4-3 SSI ESLT Service Interfaces for Earth Routing Node	4-8
5-1 ABA Node—Generic Building Block.....	5-2
5-2 SSI Node—Generic Building Block.....	5-13
6-1 ABA ESLT Protocol Building Blocks.....	6-8
6-2 ABA ESLT Radiometric Processing Protocol Building Blocks.....	6-10
6-3 ABA ESLT Service Management Protocol Building Blocks.....	6-11
6-4 ABA ESLT Service Management Configuration and Execution Building Blocks....	6-12
6-5 ABA ESLT Monitor Data Protocol Building Blocks	6-13
6-6 ESLT Service Control Service-Provider Protocol Stack Building Blocks.....	6-14
6-7 ESLT Delta-DOR Service-Provider Protocol Stack Building Blocks.....	6-15
6-8 ABA ESLT Forward-File Protocol Building Blocks.....	6-16
6-9 ABA ESLT Return File Protocol Building Blocks.....	6-17

CONTENTS (continued)

<u>Figure</u>	<u>Page</u>
6-10 ABA Earth User Forward Protocol Building Blocks	6-19
6-11 ABA Earth User Node Return Protocol Building Blocks	6-20
6-12 ABA Earth User Radiometric, Monitor and Control Protocol Building Blocks	6-22
6-13 ABA Space User Forward Protocol Building Blocks.....	6-25
6-14 ABA Space User Return Protocol Building Blocks	6-26
6-15 ABA Space User Ranging Protocol Building Blocks.....	6-27
6-16 ABA Space User Delta-DOR Protocol Building Blocks.....	6-28
6-17 Secure ABA Earth User F-Frame and Forward-File Protocol Building Blocks	6-28
6-18 Secure ABA Space User F-Frame and Forward-File Protocol Building Blocks.....	6-29
6-19 SSI ESLT and User DTN Protocol Building Blocks.....	6-32
6-20 SSI ESLT and User DTN Forward-File Building Blocks	6-33
6-21 SSI ESLT and User Service Management Building Blocks.....	6-35
6-22 SSI Space User and Routing Node DTN Protocol Building Blocks	6-36
6-23 SSI ESLT and Space Routing DTN Network Management Building Blocks.....	6-37
6-24 SSI Earth Routing Node Forward Building Blocks.....	6-38
6-25 SSI Earth Routing Node Return Building Block.....	6-39
6-26 SSI Earth User Node DTN Forward Building Blocks.....	6-40
6-27 SSI Space User DTN Forward-File Building Blocks.....	6-42
6-28 SSI Space User and Routing Node Local LAN Building Blocks.....	6-42
6-29 SSI Secure Forward-File Building Blocks	6-43
6-30 SSI Secure Space User and Space Routing Node Building Blocks.....	6-45
6-31 SSI Last-Hop/First-Hop Delivery Agent Building Blocks.....	6-47
6-32 SSI User Last-Hop/First-Hop Transfer File Building Block.....	6-50
7-1 ABA End-to-End Forward: ABA Agency Supporting ABA Agency	7-2
7-2 SSI End-to-End Forward: SSI Agency Supporting SSI Agency	7-3
7-3 ABA Secure End-to-End Forward: ABA Agency Supporting ABA Agency	7-6
7-4 SSI Secure End-to-End Forward: SSI Agency Supporting SSI Agency	7-6

Table

2-1 Cross Support Service Elements and Nominal Locations	2-7
2-2 User Elements and Nominal Locations	2-8
2-3 Examples of Provider Cross Support Service Systems and Related Elements	2-9
2-4 Examples of User Cross Support Service Systems and Related User Elements	2-9
2-5 Example BDPs for Different Earth and Space Applications	2-15
2-6 Examples of Mission Application-Specific Views.....	2-17
5-1 ABA CSSE Node Type, Interfaces, and Functions	5-3
5-2 ABA UE Node Types, Interfaces, and Functions.....	5-7
5-3 SSI CSSE Node Types, Interfaces, and Functions	5-14
5-4 SSI UE Node Types, Interfaces, and Functions	5-21

CCSDS RECOMMENDED PRACTICE FOR SPACE COMMUNICATIONS CROSS SUPPORT—
ARCHITECTURE REQUIREMENTS DOCUMENT

CONTENTS (continued)

<u>Table</u>	<u>Page</u>
6-1 Referenced Communications Protocols.....	6-2
6-2 Referenced Cross Support Protocols	6-4
6-3 Referenced Security Protocols.....	6-5
6-4 Required and Optional ABA ESLT Terrestrial Side Protocols	6-6
6-5 Required and Optional ABA ESLT Space Side Protocols	6-7
6-6 Required and Optional ABA Earth User Node Protocols	6-18
6-7 Required and Optional ABA Space User Node Protocols.....	6-24

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommended Practice is to define a set of requirements for CCSDS-recommended configurations for secure Space Communications Cross Support (SCCS) architectures. This architecture is to be used as a common framework when CCSDS Agencies 1) provide and use SCCS services, and 2) develop systems that provide interoperable SCCS services. These SCCS services include both elements on the ground and elements in space. These services cover both single-hop, space Data Link Layer services (Mission Operations Center [MOC]-to-spacecraft), and Solar System Internet (SSI), multi-hop, Network Layer services that involve data routing and internetworking using multiple space assets.

NOTE – The term ‘agency’ is used in CCSDS, but users of CCSDS cross support concepts include satellite operators and service providers, and the context of the cross support is not limited to a user/provider interface with an agency.

This Space Communications Cross Support—Architecture Requirements Document (SCCS-ARD) provides normative specifications and definitions; its companion Space Communications Cross Support—Architecture Description Document (SCCS-ADD) (reference [D5]) provides the descriptive information, explanatory materials, and other graphical representations that support the understanding of these requirements.

1.2 SCOPE

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This document describes SCCS architecture in terms of the following:

- definitions of all key elements, on ground and in space, that are involved in space communications;
- definitions of concepts that characterize SCCS services;
- requirements on system elements and components that provide secure SCCS services;
- recommended protocol stack configurations for each element type; and
- recommended end-to-end system configurations to provide interoperable and cross-supportable space communications services.

This document does not specify:

- the details of how to implement systems that provide SCCS services;
- explicit technologies needed to implement SCCS services;
- application or mission operations protocols except for those used for data transfer;

CCSDS RECOMMENDED PRACTICE FOR SPACE COMMUNICATIONS CROSS SUPPORT—
ARCHITECTURE REQUIREMENTS DOCUMENT

- mission operations except for those involved in planning, scheduling, and executing space communications;
- spacecraft onboard cross support, except for space communication services.

This document contains references to other CCSDS technical engineering and architectural recommendations describing how systems doing space communication cross support should be engineered, deployed, organized, and operated to provide interoperable SCCS services. While this document does not specify detailed internal implementation approaches, which are a private matter, it does recommend specific protocols and protocol stacks, service interfaces, element behaviors, and end-to-end architectures.

Some of the standards that are referenced in this document, especially those relating to the SSI, are still in development. They are included here so the reader gets a clear understanding of how they fit into an overall architecture.

The protocol-related parts of this document make liberal reference to the layers defined in the Open Systems Interconnection (OSI) Basic Reference Model (reference [4]). Subsection 6.2 of the Architecture Description Document (ADD) (reference [D5]) contains a discussion of the OSI stack and the functions associated with each layer.

The technical scope of single-hop cross support is the provision of Data Link Layer (Layer 2) data communications services across the Solar System in support of space mission users, using the *interoperable infrastructure of one or more space agencies*. Services above the Data Link Layer, such as CCSDS File Delivery Protocol (CFDP), Cross-Support File Service (CXFS), or Delta-Differential One-way Range (DOR), may also be provided. All mission operations application in CCSDS-compliant, interoperable, single-hop deployments are expected to utilize these underlying space link and file communications layers.

The technical scope of the SSI is the provision of internetworked (Layer 3) data communications services across the Solar System in support of space mission users, using the *confederated and interoperable infrastructure of one or more space agencies* to achieve a level of service that individual agencies would otherwise be unlikely to achieve. All mission operations application in CCSDS-compliant, interoperable, SSI deployments are expected to utilize these underlying space internetworking communications layers.

The temporal scope of this document covers current, single-hop, secure interoperable cross support installations, future deployments of an interoperable and evolving space networking infrastructure, and the transition strategies to evolve from current deployments to a future SSI state. Included in this discussion are mission-driven considerations, such as use of hybrid science/routing missions, as well as identification of optional configurations that are considered acceptable because they are in line with the transition strategies defined in this document.

Any agency that wishes to participate as a peer in the SSI should implement interoperable services and interfaces at least up to the Network Layer, along with related support services, as described in this document and specified in the relevant CCSDS and Internet standards.

Agencies that are not yet ready to adopt the SSI themselves, but that wish to offer compliant ground station cross support services that can support SSI services, may also take advantage of this document for guidance on developing Data Link Layer services that will both meet their immediate needs and also interoperate with SSI-enabled missions.

1.3 APPLICABILITY

1.3.1 APPLICABILITY OF THIS RECOMMENDED PRACTICE

This Recommended Practice provides a set of reference architecture requirements for the development of CCSDS compatible agency systems for space communications. This Recommended Practice is applicable to all space communication systems that are involved in cross support.

The SCCS systems that are addressed in this Recommended Practice explicitly include ground stations and related systems that provide cross support services, user mission control and mission operations ground systems, and a variety of spacecraft systems. In all cases the applicability is to both single space link (ABA) and internetworked (SSI) systems. The term ‘spacecraft systems’ includes free-flying spacecraft, landers, rovers, and even balloons and other ‘platforms’ that are users of space communication services. It also includes spacecraft that are themselves providers of space communication services.

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1.3.2 LIMIT OF APPLICABILITY

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This Recommended Practice is not a design for real SCCS systems that may be implemented for communication with existing or future missions. It provides detailed, but broadly stated, requirements that may be tailored or adapted for use in constructing such systems.

Future CCSDS requirements (e.g., service interfaces, protocols, or data formats) that are planned, but still under development, are included for completeness so that the directions of CCSDS are clear; these are marked ‘[Future]’ to avoid ambiguity. Any requirements that are considered optional are marked ‘[Opt]’. The [Opt] requirements are things like security, which may or may not be implemented by any given system. All other core standards, those that are expected to be used by the bulk of missions and implemented by the bulk of service providers, are defined as mandatory, with ‘shall’ rather than ‘should’ language. Any specific system deployment may treat these as ‘shall’ if they are required for that use.

Any requirements marked ‘[Future]’ should not be relied upon in the design of current real SCCS systems. This Recommended Practice will be updated periodically. When updates of this document are published, any requirements now marked ‘[Future]’ whose conditions are met will be reviewed and evaluated for inclusion as full requirements. Many of these future specifications are completely applicable to either ABA or SSI deployments.

CCSDS RECOMMENDED PRACTICE FOR SPACE COMMUNICATIONS CROSS SUPPORT—
ARCHITECTURE REQUIREMENTS DOCUMENT

1.4 RATIONALE

CCSDS has developed a body of space communications recommendations that specify protocols and related services for specific types of functionality that are usually defined at a single layer of the OSI stack, or define how to format and exchange a specific type of information. In order to build end-to-end space communications systems that will interoperate, systems designers need to understand how to select, configure, and deploy different kinds of system elements that implement a complete stack of protocols in each element and how these are assembled to deliver end-to-end services. Single-hop communications configurations often require cross support, where one space agency develops the spacecraft and the corresponding MOC, and another agency provides the ground communications assets. This is the typical cross support configuration used today. Multi-hop communications configurations may require that space assets developed by one agency offer cross support to space elements developed by another agency, with both being supported by ground communications assets from yet another agency.

Since cross support among agencies has become the norm, and since future agency collaborative missions require elements developed by different agencies, at different times, to interoperate as a network, agreed-upon interoperable standards and architectures must be adopted in an end-to-end sense. As the only international body that defines standards to link space communication service providers with space missions, CCSDS is defining this recommended standard architecture for SCCS services, so that interoperable cross support between agencies can be defined and operated more efficiently and effectively for single-hop and multi-hop mission configurations.

Similar to existing ABA architectures, it is fundamental to the SSI concept that all full participants in the confederation must expose standard and agreed-upon cross support services at the Network Layer of the OSI communications stack, while observing common network management strategies and governance mechanisms. Agencies that provide only single-hop Data Link Layer services may still participate in the SSI if they provide compliant services at that layer.

1.5 DOCUMENT STRUCTURE

This document consists of several sections plus annexes.

- Section 1 presents the purpose, scope, and rationale of this document and lists the definitions, conventions, and references used throughout the document.
- Section 2 provides context and an overview of the SCCS architecture.
- Section 3 provides a brief overview of ABA and SSI technical architecture and some guidance on how to use the document.
- Section 4 defines top-level service requirements of ABA and SSI configurations from user and provider perspectives.