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Space data and information transfer systems — Space communications protocol specification (SCPS) — Transport protocol (SCPS-TP)

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National foreword

This British Standard is the UK implementation of ISO 15893:2010.

The UK participation in its preparation was entrusted to Technical Committee ACE/68/-/7, Space systems and operations - Space data and information transfer systems.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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INTERNATIONAL STANDARD

ISO 15893

Second edition
2010-09-15

Space data and information transfer systems — Space communications protocol specification (SCPS) — Transport protocol (SCPS-TP)

Systèmes de transfert des informations et données spatiales — Spécification de protocole pour communications spatiales (SCPS) — Protocole de transport (SCPS-TP)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

This second edition cancels and replaces the first edition (ISO 15893:2000), which has been technically revised.

ISO 15893 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 714.0-B-2, October 2006) 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*.

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INTERNATIONAL STANDARD ISO 15893:2010(E)

Space data and information transfer systems — Space communications protocol specification (SCPS) — Transport protocol (SCPS-TP)

1 Scope

This International Standard specifies the requirements for the services and protocols of the space communications protocol specification (SCPS) transport service. These requirements are meant to allow independent implementations of this protocol in space and ground segments of the SCPS network to interoperate.

This International Standard is applicable to any kind of space mission or infrastructure, regardless of complexity.

The scope and field of application are further detailed in subclauses 1.2 and 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 714.0-B-2, October 2006, *Space communications protocol specification (SCPS) — Transport protocol (SCPS-TP)*

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 714.0-B-2.

Pages i to v

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

Page 1-8

Add the following information to the reference indicated:

[10] Document CCSDS 713.0-B-1, May 1999, is equivalent to ISO 15891:2000.

[11] Document CCSDS 713.5-B-1, May 1999, is equivalent to ISO 15892:2000.

3 Revision of publication CCSDS 714.0-B-2

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 714.0-B-2. To this end, NASA will act as a liaison body between CCSDS and ISO.

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The Consultative Committee for Space Data Systems

Recommendation for Space Data System Standards

SPACE COMMUNICATIONS
PROTOCOL SPECIFICATION (SCPS)—

TRANSPORT PROTOCOL

(SCPS-TP)

RECOMMENDED STANDARD

CCSDS 714.0-B-2

BLUE BOOK
October 2006

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AUTHORITY

Issue:	Recommended Standard, Issue 2
Date:	October 2006
Location:	Washington, DC, USA

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 Recommendations 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.

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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 **Recommended Standards** and are not considered binding on any Agency.

This **Recommended Standard** is issued by, and represents the consensus of, the CCSDS members. Endorsement of this **Recommendation** is entirely voluntary. Endorsement, however, indicates the following understandings:

- o Whenever a member establishes a CCSDS-related **standard**, this **standard** will be in accord with the relevant **Recommended Standard**. Establishing such a **standard** does not preclude other provisions which a member may develop.
- o Whenever a member establishes a CCSDS-related **standard**, that member will provide other CCSDS members with the following information:
  - -- The **standard** itself.
  - -- The anticipated date of initial operational capability.
  - -- The anticipated duration of operational service.
- o Specific service arrangements shall be made via memoranda of agreement. Neither this **Recommended Standard** nor any ensuing **standard** is a substitute for a memorandum of agreement.

No later than five years from its date of issuance, this **Recommended Standard** 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 Standard** is issued, existing CCSDS-related member standards and implementations are not negated or deemed to be non-CCSDS compatible. It is the responsibility of each member to determine when such standards or implementations are to be modified. Each member is, however, strongly encouraged to direct planning for its new standards and implementations towards the later version of the Recommended Standard.

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FOREWORD

Through the process of normal evolution, it is expected that expansion, deletion, or modification of this document may occur. This Recommendation is therefore subject to CCSDS document management and change control procedures as defined in reference [B1]. Current versions of CCSDS documents are maintained at the CCSDS Web site:

http://www.ccsds.org/

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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- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)/Germany.
- European Space Agency (ESA)/Europe.
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- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- Japan Aerospace Exploration Agency (JAXA)/Japan.
- National Aeronautics and Space Administration (NASA)/USA.

Observer Agencies

- Austrian Space Agency (ASA)/Austria.
- Belgian Federal Science Policy Office (BFSPO)/Belgium.
- Central Research Institute of Machine Building (TsNIIMash)/Russian Federation.
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DOCUMENT CONTROL

Document	Title	Date	Status
CCSDS 714.0-B-1	Space Communications Protocol Specification (SCPS)—Transport Protocol (SCPS-TP)	May 1999	Original issue, superseded
CCSDS 714.0-B-2	Space Communications Protocol Specification (SCPS)—Transport Protocol (SCPS-TP), Recommended Standard, Issue 2	October 2006	Current issue: – adds optional support for Selective Acknowledgements (SACK) and Explicit Congestion Notification (ECN); – defines semantics to extend SCPS-TP signaling to allow optional inclusion of vendor- and community-specific options; – clarifies some ambiguities in the original specification regarding: • inclusion/position of compressed short-form SNACK options in compressed SCPS-TP headers (the position of the compressed SNACK option within the header is given); • what connection identifier is transmitted in compressed headers (the one sent to the peer during the SYN exchange); • what N-user protocol ID is used to calculate the pseudo header checksum when header compression is in use (decimal 105).

NOTE – Revision bars in the inside margin indicate changes from the previous issue.

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommendation is to define the services and protocols that provide the Space Communications Protocol Specification (SCPS) Transport service. This definition will allow independent implementations of the protocols in the space and ground segments of the SCPS Network to interoperate.

1.2 SCOPE

This Recommendation is intended to be applied to all systems that claim conformance to the SCPS Transport protocols.

1.3 APPLICABILITY

This Recommendation is designed to be applicable to any kind of space mission or infrastructure, regardless of complexity. It is intended that this Recommendation become a uniform standard among all CCSDS Agencies.

1.4 RATIONALE

The CCSDS believes it is important to document the rationale underlying the recommendations chosen, so that future evaluations of proposed changes or improvements will not lose sight of previous decisions. The concept and rationale for SCPS-TP may be found in reference [B2].

1.5 ORGANIZATION OF THIS RECOMMENDATION

This Recommendation contains six sections and four annexes. This section presents introductory material that establishes the context for the remainder of the document. Section 2 contains an overview of the protocols, summarizing the main technical requirements and describing the approach used to provide the protocols' services. Sections 3 and 4 present the specifications for Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) in the SCPS environment. Section 5 establishes the requirements for maintaining management information. Section 6 presents conformance requirements for implementations.

The four annexes to this Recommendation provide supporting information. Some of the annexes contain normative material, while some contain informative material. Annex A is informative and contains the acronyms and abbreviations used commonly throughout the document. Annex B is informative and contains the informative references cited throughout the document. Annex C is normative and contains the proforma for the Protocol Implementation Conformance Statement (PICS). The PICS unambiguously describes the capabilities provided by an implementation of the protocol. Annex D is normative and contains the service specification.

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1.6 HOW TO READ THIS DOCUMENT

This document makes modifications and extensions to TCP and UDP for use in spacecraft communications environments, characterized by potentially long delays, unbalanced forward- and return-link data rates, and potentially high error rates. It is anticipated that some readers of this document will be protocol implementers, probably with TCP implementation experience. Other readers will be individuals more familiar with the particular application environment than with the protocols.

For readers and implementers already familiar with the internals of TCP and UDP, this document may best be used in the following manner:

1) Review section 6 of this document. It describes the implementation requirements for TCP and UDP, and gives an indication of those capabilities within TCP and UDP that have been modified (indicated by text to the effect 'as amended by a.b.c of this document', where a.b.c is a section reference in this document).

   Also in section 6 is a list of mission-specific capabilities that, depending on the needs of the mission, may be beneficial to add to the basic functionality of the protocols. Section 6 provides an introduction to these capabilities, and pointers back to sections 3 and 4, in which the capabilities are specified. Readers should use section 6 as a means of identifying the capability set required for their mission(s).

   Some of the capabilities required for a mission depend on the availability of other capabilities. These dependencies, along with a restatement of the implementation requirements, are documented in table form in the Protocol Implementation Conformance Statement that appears in annex C. Annex C specifies the format in which an implementer must document the details of his or her implementation.

2) Review sections 3 and 4, which specify SCPS-TP-unique options and modifications for TCP and UDP.

3) Review section 5, which identifies the management information requirements.

For readers and implementers who are generally familiar with the operation of TCP and UDP, but not the internals of the protocols, the following approach to reviewing this document may be useful:

1) Read over the UDP and TCP RFCs. The UDP specification is quite short (3 pages). The TCP specification is significantly longer, but also provides a substantial amount of background information. These documents were written in 1980 and 1981, respectively.

2) Read section 4 of RFC 1122. This document captures the 'lessons learned' from using TCP and UDP as of 1989. In addition to placing requirements on implementations of TCP and UDP, it provides a significant amount of explanatory information and discussion about rationale for particular requirements. RFC 1122 constitutes an extension to the base TCP and UDP specifications, in addition to describing implementation requirements.

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3) Read over section 6 of this document. It refers to the TCP and UDP RFCs and to RFC 1122, and either endorses or revises the requirements put forward in RFC 1122. Read the 'Mission-Specific Capabilities' subsection, and identify whether any of these capabilities are necessary. If so, review the references identified in each of the mission-specific capability sections.

4) Finally, read sections 3 through 5.

Readers with little previous familiarity with TCP or UDP should consider reviewing an introductory text on the subject. One excellent example is TCP/IP Illustrated, Volume 1, by W. Richard Stevens (Copyright 1994, Addison-Wesley Professional Computing Series). Chapters 1, 11, and 17-24 are particularly relevant. Note that additional information about one of the mission-specific capabilities—the modifications to TCP to support Transactions—is presented in Chapters 1-12 of TCP/IP Illustrated, Volume 3, by W. Richard Stevens (Copyright 1996, Addison-Wesley Professional Computing Series).

1.7 CONVENTIONS AND DEFINITIONS

1.7.1 OCTET NUMBERING CONVENTION AND NOMENCLATURE

This document does not deal with transmission of any data elements smaller than one octet. As such, the transmission order of bits within an octet is an issue to be dealt with at lower layers. However, the relative ordering of octets within a word and the unambiguous numbering of bits within an octet are relevant here. The order in which multi-octet fields defined in this document are submitted for transmission is called 'Big Endian' byte ordering. When applied to networking, it is called 'network byte order'. In this ordering scheme, bit 0 of a 32-bit value is the most significant bit; bit 31 is the least significant bit. The octet containing bits 0-7 is transmitted first, followed by the octet containing bits 8-15, followed by the octet containing bits 16-23, and finally the octet containing bits 24-31. Note that 'Big Endian' byte ordering is NOT what some machines (notably the 80x86 class of machines) use internally. Implementers must ensure that headers are converted to network byte order for transmission.

The following conventions apply throughout this Recommendation:

a) the words 'shall' and 'must' imply a binding and verifiable specification;

b) the word 'should' implies an optional, but desirable, specification;

c) the word 'may' implies an optional specification;

d) the words 'is', 'are', and 'will' imply statements of fact.

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1.7.2 DEFINITIONS

Address Family: An address family specifies the structural rules required to interpret the internal fields of an address. The SCPS Network supports three address families: the SCPS address family, the Internet Protocol (IP) address family, and the Internet Protocol version Six (IPv6) address family.

Address Type: An address type defines the meaning that the addresses have (that is, whether they identify end systems or a path between end systems), the number of addresses that appear in a SCPS Network Protocol header (two addresses if the addresses identify end systems, only one if the address identifies a path between end systems), and the address family that is valid for the addresses.

Connection: A connection is defined by information that is named, persistent, and shared across the systems supporting an instance of communication. For transport protocols, these systems are the endpoints that terminate the transport protocol, but not intermediate systems.

End System: An addressable network entity within the SCPS Network.

Extended End System Address: The Extended End System Address identifies a single end system or an end-system group. The Extended End System Address conforms to the structural rules of either the SCPS Address Family or the IP Address Family. Extended End System Addresses may be parameters to the primitives of the Unit Data service.

Gateway: A network-addressable system that terminates a protocol at a given layer and invokes similar services at the same layer of an adjacent network.

Host: A network-addressable system that may send or receive network-layer packets, but does not forward packets.

Internet Protocol Number: The Internet Protocol Number is the transport protocol identifier used by Internet Protocols. Values may range from 0 through 255, and valid values are defined in reference [1].

IP Address Family: The IP Address Family specifies a set of structural rules for the interpretation of Extended End System Addresses, and is defined in reference [1], and the possible formats are refined in section 3.2.1.3 of RFC 1122 (reference [2]).

Maximum Segment Size: The maximum amount of user data that can be carried in a Segment. This value is calculated by subtracting the size of the network, security, and transport layer headers from the MTU size.

Maximum Transmission Unit: The Maximum Transmission Unit (MTU) specifies the maximum amount of data that the subnetwork layer will accept in a single subnetwork service request. The MTU for a route is the minimum of all known MTUs along that route.

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NOTE – It is anticipated that this value will be known and managed as part of the routing table information; however, techniques for dynamically discovering the MTU of a route exist. Refer to RFC 1191, 'Path MTU Discovery' (reference [B3]) for more information.

N-Address: an address in the SCPS Network. The attributes of an N-Address are the Address Type and the Address Family.

N-Basic_Quality_of_Service parameter: The Basic Quality of Service (QOS) parameter of the N-UNITDATA service primitives carries information necessary to provide special network processing services for the datagram. It is a data structure that contains three sub-parameters: precedence, routing requirements, and a program-specific field.

N-Destination_Address: The N-Destination_Address is a parameter of all of the SCPS Network service primitives. It is an N-Address that identifies the destination end system of a packet in the SCPS Network. The N-Destination_Address parameter must be of the Extended End System address type, and may be of either the IP or the SCPS address family.

Network-Service Data Unit: See N-SDU.

N-Expanded_Quality_of_Service parameter: The Expanded QOS parameter provides a mechanism for specifying ground-relevant QOS requests. The valid values of this parameter are defined in RFC 2474 (reference [B7]).

N-SDU: The Network Service Data Unit (N-SDU) is a parameter of the Unit Data service primitives. It is a variable-length, octet-aligned data unit of arbitrary format. The maximum length of an N-SDU is 8145 octets.

NOTE – The maximum size of the N-SDU field is limited to the length resulting from subtracting the maximum length of a SCPS-NP header from the maximum SCPS-NP PDU length. The maximum length of the SCPS-NP header is 46 octets. The length field in the SCPS-NP header is 13-bits, which allows an 8191-octet total packet length. Therefore, the maximum size of an N-SDU that is guaranteed to fit in a SCPS-NP PDU is 8145 octets. Local restrictions on packet size or extensions to the protocol may further limit this size, and the maximum implementations size of N-SDU must be documented by the implementer.

N-Source_Address: The N-Source_Address is a parameter to many of the primitives of the SCPS network service. It is an N-Address that identifies the end system originating a packet in the SCPS Network. The N-Source_Address must be of the Extended End System address type and may be of either the IP or the SCPS address family. The N-Source_Address may not be a multicast or a broadcast address.

N-Source_Timestamp parameter: The N-Source_Timestamp is a parameter of several SCPS Network service primitives. This parameter permits the Network Service user to provide a source timestamp to accompany the N-SDU. The Source Timestamp parameter consists of a timestamp format field and a timestamp value field.

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N-User_Internet_Protocol_Number parameter: The N-User_Internet_Protocol_Number is a parameter to several of the SCPS Network service primitives. The values of this parameter used by the SCPS-TP are shown in table 1-1.

Table 1-1: Values of the N-User_Internet_Protocol_Number Parameter Used by SCPS-TP

Network Service User	Internet Protocol Number (decimal)
TCP	6
UDP	17
Compressed TCP	105

Port: An identifier of the transport service user.

Precedence parameter: The precedence parameter is an element of the N-Basic_Quality_of_Service parameter of the N-UNITDATA service primitives. The precedence parameter is specified by a network service user to identify the relative importance of this data compared to other data within the network. It is an integer with a valid range from 0 to 15, with 0 being the lowest precedence and 15 being the highest. Local policy may cause the user-specified precedence parameter to be overridden. The network service user may also supply a null value for the precedence parameter, in which case the network service would assign a default value for the precedence parameter.

Program Specific parameter: The program-specific parameter is an element of the N-Basic_Quality_of_Service parameter that provides a mechanism for programs to carry two bits of information in the SCPS-NP header. This information is interpreted by program-specific extensions to the SCPS-NP and has a default value of 0.

Pseudo-Header: A pseudo-header, in TCP and UDP, is a collection of information that is used for the purposes of checksum calculation, but not actually shipped as part of the transport layer protocol data unit. The information in the pseudo-header consists of the source and destination addresses, the Internet Protocol Number of the transport protocol, and the length of the transport protocol data unit.

Router: A network-addressable system that may send, receive, or forward network-layer packets.

Routing Requirements parameter: The Routing Requirements parameter is an element of the N-Basic_Quality_of_Service parameter of the N-UNITDATA service primitives. The Routing Requirements parameter has two currently defined values: ‘normal’ routing and ‘flood’ routing.

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SCPS Network Address: A SCPS Network Address specifies one of the possible SCPS Address formats (via the FMT-ID parameter) and the values of the parameters required by that format.

Segment: A segment is the Protocol Data Unit of the Transmission Control Protocol (TCP).

Service-Access-Point: A Service-Access-Point (SAP) is the point at which the services of a layer are made available to the layer above it.

Silently Discard: A packet is 'silently discarded' if no error message is generated (either to a local user or to a remote user) as a result of the discard.

NOTE – The practice of silently discarding packets reduces the possibility that a misconfigured host will uncontrollably generate erroneous traffic. The term 'silent discard' differs from 'discard' in that certain actions, such as informing network service users about the discard, are not performed in a silent discard. When the term 'discard' is used, other information must be used to determine whether the network service user is informed.

T-SDU: The Transport Service Data Unit (T-SDU) is a parameter of several of the SCPS-TP service primitives. It is a variable-length, octet-aligned data unit of arbitrary format. The maximum length of a T-SDU is an implementation issue.

Timestamp Format field: The Timestamp Format field of the N-Source_Timestamp parameter identifies the format of the source timestamp that is supplied by the Network User. The available formats are specified in reference [10].

Timestamp Value: The Source Timestamp Value field of the N-Source_Timestamp parameter contains the value of the timestamp that shall accompany the Network Service Data Unit.

Transport-Service Data Unit: See T-SDU.

1.8 REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All documents are subject to revision, and users of this Recommendation 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 Recommendations.

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[1] J. Postel. *Internet Protocol*. STD 5, September 1981. [RFC 791, RFC 950, RFC 919, RFC 922, RFC 792, RFC 1112]†

[2] R. Braden. *Hosts Requirements*. STD 3, October 1989. [RFC 1122, RFC 1123]

[3] J. Postel. *User Datagram Protocol*. STD 6, August 1980. [RFC 768]

[4] J. Postel. *Transmission Control Protocol*. STD 7, September 1981. [RFC 793]

[5] D. Borman, R. Braden, and V. Jacobson. *TCP Extensions for High Performance*. RFC 1323, May 1992.

[6] P. Karn & C. Partridge. "Round Trip Time Estimation." In *Proceedings of SIGCOMM '87: Symposium on Communications Architectures and Protocols*, August 1987.

[7] V. Jacobson. "Congestion Avoidance and Control." In *Proceedings of SIGCOMM '88: Symposium on Communications Architectures and Protocols*, August 1988.

[8] J. Nagle. *Congestion Control in IP/TCP Internetworks*. RFC 896, January 1984.

[9] K. McCloghrie and M. Rose. *Management Information Base*. STD 17, March 1991. [RFC1213]

[10] *Space Communications Protocol Specification (SCPS)—Network Protocol (SCPS-NP)*. Recommendation for Space Data System Standards, CCSDS 713.0-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, May 1999.

[11] *Space Communications Protocol Specification (SCPS)—Security Protocol (SCPS-SP)*. Recommendation for Space Data System Standards, CCSDS 713.5-B-1. Blue Book. Issue 1. Washington, D.C.: CCSDS, May 1999.

[12] L. S. Brakmo, S. W. O'Malley, and L. L. Peterson. "TCP Vegas: New Techniques for Congestion Detection and Avoidance." In *Proceedings of SIGCOMM '94: Symposium on Communications Architectures and Protocols*, August 1994.

[13] R. Braden. *T/TCP—TCP Extensions for Transactions—Functional Specification*. RFC 1644, July 1994.

[14] R. Ramakrishnan, S. Floyd, and D. Black. *The Addition of Explicit Congestion Notification (ECN) to IP*. RFC 3168, September 2001.

[15] M. Mathis, et al.. *TCP Selective Acknowledgement Options*. RFC 2018, October 1996.

† Internet Request for Comments (RFC) texts are available on line in various locations (e.g., http://ietf.org/rfc/). In this list, Internet Standards are identified by 'STD' followed by the number of the standard, and RFCs are identified by 'RFC' followed by the number of the RFC. RFCs comprised by Internet Standards are given in square brackets following the citation.

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2 OVERVIEW

This SCPS Recommendation is designed to support current communication environments and those of upcoming missions. The modifications to the base protocols are intended to address the communication environments and resource constraints that space-based systems face.

The Technical Requirements for the Recommendation include:

- support for communication with full reliability, best-effort reliability, and minimal reliability;
- efficient operation in a wide range of delay, bandwidth, and error conditions;
- efficient operation in space-based processing environments;
- support for precedence (priority) based handling;
- support for connectionless multicasting;
- support for packet-oriented applications.

The SCPS Transport Protocol (SCPS-TP) refers collectively to the protocols that provide the full reliability, best-effort reliability, and minimal reliability services. The full reliability service is provided by TCP. The best-effort service is provided by TCP with minor modifications. The minimal reliability service is provided by UDP.

The SCPS-TP addresses the environmental requirements with the following extensions:

- TCP for Transactions (RFC 1644, reference [13])—reduces the handshaking necessary to start a TCP connection and provides 'reliable datagram' operation to handle command-response traffic, for very long delay environments in which it is desirable to begin data transfer without waiting for a connection handshake;
- Window scaling (RFC 1323, reference [5])—addresses communication environments that may have more than 65k octets of data in transit at one time;
- Round Trip Time Measurement (RFC 1323, reference [5])—addresses environments that have high loss, changing delays, or large amounts of data in transit at one time;
- Protect Against Wrapped Sequence Numbers (RFC 1323, reference [5])—addresses very long delay environments or very high bandwidth missions;
- Selective negative acknowledgment (adapted from RFC 1106, reference [B5])—addresses high loss environments;
- Selective acknowledgement (RFC 2018, reference [15])—addresses high loss environments;
- Record Boundary Indication—the ability to mark and reliably carry end-of-record indications for packet-oriented applications;

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- Best Effort Communication—the ability for an application to select correct, in-sequence, but possibly incomplete delivery of data;
- Header compression (adapted from RFC 1144, reference [B6])—addresses low-bandwidth environments;
- Low-loss congestion control or optional non-use of congestion control;
- Explicit Congestion Notification (ECN)—can provide improved performance in ECN-capable networks;
- Retransmission strategies for space environments that accommodate loss due to data corruption, link outages, and congestion.

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3 SCPS-TP EXTENSIONS TO STANDARD TCP

3.1 RELATIONSHIP BETWEEN SCPS-TP AND TCP

SCPS-TP adopts the Transmission Control Protocol (TCP) as specified in Internet Standard 7 (reference [4]) and its supporting RFCs, with the modifications and options specified in section 3 of this document.

NOTE – Section 6 of this document summarizes requirements for implementing TCP in the SCPS environment.

3.2 CONNECTION MANAGEMENT

3.2.1 INITIAL SEQUENCE NUMBER SELECTION

A SCPS-TP conforming implementation is not required to use a clock as the basis for Initial Sequence Number (ISN) selection. As long as ISN selection is robust against a possible crash, increases slightly faster than the maximum possible transmission rate, and does not wrap too quickly, then the algorithm used for ISN selection meets the intent of the requirement and is acceptable (refer to reference [4], RFC 793, section 3.3, and reference [2], RFC 1122, section 4.2.2.9).

NOTE – The ISN does not have to be updated at every clock tick. Rather, it only needs to be computed at the time a connection is established.

3.2.2 PRECEDENCE HANDLING

3.2.2.1 Security

The TCP shall convey a user's security requests and replies to the security provider and shall report responses and indications as required.

NOTES

1 Security is handled external to the TCP, at a protocol layer that is conceptually lower in the 'stack'.

2 All other references to security in this document shall be considered non-normative.

3.2.2.2 Precedence

3.2.2.2.1 The precedence parameter used in TCP is as defined in the SCPS Network Protocol (reference [10]), the intent being that connection shall be allowed at the higher of the precedence levels requested by the two ports attempting to connect.

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3.2.2.2.2 If the TCP is operating over a network protocol that does not support precedence, or supports fewer precedence levels than are defined in [10], then a locally defined mapping between the user-specified precedence level and the system-supported precedence levels shall be performed.

3.2.2.2.3 The following paragraphs describe specific actions for handling the precedence parameter in SCPS-TP:

a) an endpoint shall request the precedence level specified by the calling application;

NOTE – Any local policy constraints on precedence level requested by the application are outside the scope of this Recommendation.

b) if the remote TCP responds with a higher precedence level, the precedence of the connection shall be raised to the higher requested level;

c) if local policy prohibits raising the precedence of the connection, a reset shall be sent;

d) a listening endpoint that receives a connection request containing a higher precedence level than the endpoint's configuration shall, if permitted by local policy, raise its precedence level to that specified by the remote endpoint and proceed with connection establishment;

e) if local policy does not permit such an increase in precedence level, the listening endpoint shall reject the connection with a reset;

f) if an endpoint has more than one socket with service requests to the transport protocol pending, the service order of those requests shall be determined by the precedence level of the socket and shall proceed starting with the highest precedence level.

3.2.3 NEGOTIATION OF SCPS CAPABILITIES

3.2.3.1 SCPS Capabilities Option Format

The SCPS Capabilities Option shall be located in the options area of the TCP SYN segment[1] header and shall contain the following fields:

	Length in octets
– Option Type (mandatory)	1
– Option Length (mandatory)	1
– Capabilities Option Bit-Vector (mandatory)	1
– Connection ID (mandatory)	1

[1] Refer to reference [B3] for a definition of the TCP SYN segment.

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3.2.3.2 SCPS Capabilities Option Fields

3.2.3.2.1 The Option Type field

a) is mandatory and shall occupy the first octet of the Option;

b) shall contain the decimal value 20.

3.2.3.2.2 The Option Length field

a) is mandatory and shall occupy the second octet of the Option;

b) shall contain the decimal value 4.

3.2.3.2.3 The Capabilities Option Bit-Vector field

a) is mandatory and shall occupy the third octet of the Option;

b) shall indicate which SCPS Capabilities are in effect for a connection, as detailed in table 3-1.

3.2.3.2.4 The Connection ID field

a) is mandatory and shall occupy the fourth octet of the Option;

b) shall contain a non-zero Connection Identifier if the Com bit is set to '1'.

NOTE – The SCPS Capabilities Option format is illustrated in figure 3-1.

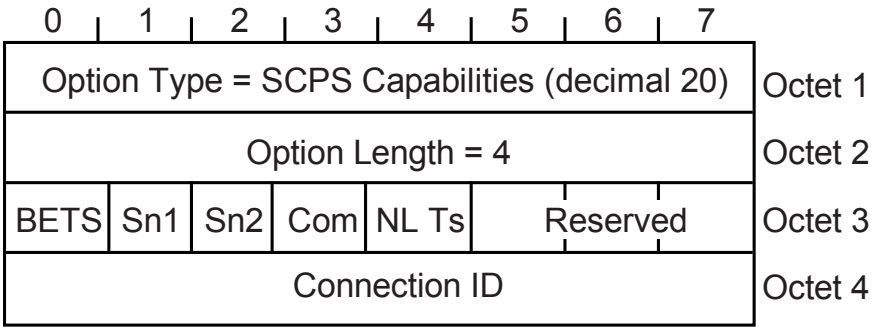

Figure 3-1: SCPS Capabilities Option

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Table 3-1: SCPS Capabilities Option Bit-Vector Contents

Bit	Meaning if = 0 ('Not OK')	Meaning if = 1 ('OK')
BETS	Connection may not operate in BETS mode.	Sender willing to operate connection in BETS mode.
SN1	Do not send short form (length = 4) of SNACK Option (refer to 3.5).	OK to send short form of SNACK Option.
SN2	Do not send long form (length > 4) of SNACK Option (refer to 3.5).	OK to send long form of SNACK Option. Note: if the SN2 bit is set to '1' then the SN1 bit must also be set to '1'.
Com	Do not send compressed TCP headers.	OK to compress TCP headers—send connection identifier.
NL Ts	Network-layer timestamps not available or unsuitable for use in compressing TCP timestamps Option.	Network-layer timestamps available and a timestamp accompanies this segment. If received, suitable, and available at both ends, use for compressing TCP Timestamps Option.

NOTES

1. If both TCP endpoints send the BETS bit set to '1', the connection will operate in BETS mode.

2. The semantics for the combination of the Com bit and the connection identifier are as follows:

Com	Connection ID	Meaning
'0'	'0'	Will not send or accept compressed headers.
'0'	X≠'0'	Will not accept compressed headers. Would like to send compressed headers, using Connection ID X. (If SYN, will send compressed headers if and only if SYN-ACK contains Com bit set to '1'. If SYN-ACK, not a valid response if Com bit set to '0' on SYN.)
'1'	'0'	Will accept compressed headers, will not send compressed headers.
'1	X≠'0'	Will accept compressed headers, would like to send compressed headers, using Connection ID X. (If SYN-ACK, not a valid response if Com bit set to '0' on SYN.)

3. If compressed headers are in use and both TCP endpoints indicate that use of Network Layer Timestamps (NL Ts) is acceptable, then outbound timestamps shall be carried in the timestamps field of the Network-layer header.

3.2.4 SCPS CAPABILITIES INVOCATION

3.2.4.1 The TCP initiating a connection shall invoke SCPS Capabilities by including the SCPS Capabilities Option in the header of the SYN segment.[1]

3.2.4.2 The listening TCP shall indicate its willingness to use the specified capabilities by including the SCPS Capabilities Option in the header of its SYN ACK segment:

a) accepted capabilities shall be indicated with their corresponding Capabilities Option Bit-Vector bits set to '1';

b) if the Com bit is set to '1', the Connection ID field shall contain a non-zero value.

[1] Refer to reference [B3] for a definition of the TCP SYN segment.

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NOTE – The determination of which capabilities to use on a particular connection is implementation specific, possibly based on information from the routing structures as specified in 5.2. An application MUST be involved in the decision to use the Best Effort Transport Service (BETS)—refer to 6.2.4.1.2.

3.2.4.3 If either endpoint does not send the SCPS Capabilities Option, the respective SCPS capabilities are unavailable on the connection.

3.2.4.4 If use of SCPS capabilities is declined by a listening TCP (by its failure to return a corresponding SCPS capabilities option after one was sent by the initiating TCP):

a) the connection may continue using standard TCP capabilities, if standard TCP capabilities have been implemented;

b) if standard TCP capabilities have not been implemented, the initiating TCP shall abort the connection by sending a RST segment.

3.2.4.5 If the SCPS Capabilities Option is not present on a SYN, then the protocol shall conform to the end-to-end semantics of Internet TCP, as specified in Internet Standards 7 and 3 (references [4] and [2], respectively), and possibly as extended by other RFCs.

NOTE – A connection using Internet (i.e., 'normal') TCP may include the non-SCPS options of window scaling, timestamps, RFC 1644 (reference [13]), fast retransmit, fast recovery, and so on.

3.2.4.6 If the SCPS Capabilities Option is present on a SYN but none of the bits are set to '1', then none of the capabilities in the Capabilities Option Bit-Vector will be used on the connection.

3.2.5 SCPS-TP EXTENDED CAPABILITIES OPTION

3.2.5.1 General

The following format is used to signal 'extended' SCPS capabilities. Extended capabilities allow endpoints to perform signaling in addition to that supported by the 'standard' SCPS Capabilities Option described above.

Extended capabilities are identified by reuse of the SCPS Capabilities Option (option 20) two or more times on a particular SYN packet (TCP packet with the SYN bit set). These extended option 20s are prohibited from having length = 4 to help differentiate them from 'standard' SCPS Capabilities Options. The *first* SCPS Capabilities Option present on a SYN segment must have length = 4 and is interpreted as above.

The intent of allowing extended capabilities is to allow vendors and communities of interest to implement features unique to particular environments. Each vendor or community of interest will be assigned a unique identifier.

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3.2.5.2 Extended Capability Format

3.2.5.2.1 General

The first part of an extended capability signal is the presence of a second (third, etc.) SCPS Capabilities Option (TCP option 20). This option has the standard TCP option format, as shown in figure 3-2. The type of this option is SCPS Capabilities (20), and the length is variable, but prohibited from being 4 (the mandated length of the base SCPS Capabilities option above).

NOTE – The first SCPS Capabilities option on a SYN segment **must** be the 'standard' SCPS Capabilities Option defined in 3.2.3 with length = 4. It is not possible to have an extended SCPS capabilities option (length ≠ 4) without preceding it with a 'standard' SCPS capabilities option of length = 4, formatted as in section 3.2.3.

0	1	2	3	4	5	6	7	
Option Type = SCPS Capabilities (decimal 20)								octet 1
Option Length (≠ 4)								octet 2
Extended Capabilities								variable, determined by Option Length field

Figure 3-2: Beginning of Extended Capabilities Signaling

Option Length: The value of this field equals the total number of octets in all of the extended capability options signaled by this (extended) SCPS capabilities option, including octets 1 and 2. That is, the length field of extended SCPS capabilities options behaves as a normal TCP option length field. The value of the length field may **not** be equal to 4 to ensure that implementations that do not understand extended capabilities do not confuse an extended capability SCPS option with a 'standard' SCPS capabilities option (3.2.3).

Figure 3-3 shows the format for each individual extended capability.

0	1	2	3	4	5	6	7	
Extended Capability Binding Space ID								octet 1
Extended cap. length				Extended				octet 2
Capability Data								variable, determined by extended cap. length field

Figure 3-3: Format for Extended Capabilities

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3.2.5.2.2 Extended Capability Fields

3.2.5.2.2.1 Extended Capability Binding Space ID

The extended capability binding space ID identifies the particular extended capability binding space. The extended capability data is interpreted in the context of this identifier.

The extended capability binding space identifier is an arbitrary integer that identifies the format of the extended capability data, which could contain information about one or more extended capabilities. For example, a particular vendor might use a single binding space identifier and signal a number of individual capabilities with flags in the extended capability data field. The format for identifying the particular capabilities would be completely vendor-specific. In general there would be at most one extended capability binding space ID per vendor or community of interest. If vendors or communities want to implement multiple extended capabilities, they will need to define their own signaling/multiplexing method for those capabilities within a particular extended capability *data* area. Vendors are strongly encouraged to make the format of their extended capabilities public knowledge.

NOTE – Assignment of extended capability binding space IDs is discussed in 3.2.5.4 below.

3.2.5.2.2.2 Extended Capability Length

The extended capability length field specifies the length of the extended capability, exclusive of the octets containing the extended capability type and length, in 16-bit words. Thus in figure 3-3 an extended capability length of ‘0’ would indicate that only octets 1 and 2 in the figure were present, a value of ‘1’ would indicate a total length of four octets (octets 1 and 2 in figure 3-3 plus two additional octets of extended capability data). A value of ‘2’ would indicate a total length of six octets, etc.

NOTE – The minimum length of an extended capability is two octets (the octet containing the binding space identifier and the octet whose first four bits contain the length). The last four bits of the second octet are the first four bits of the extended capability data, and are always present, even if unused by the particular capability.

3.2.5.2.3 Support for Multiple Extended Capability Binding Spaces

More than one extended capability binding space identifier can be indicated under a single extended SCPS Capabilities Option, as shown in figure 3-4.

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0	1	2	3	4	5	6	7	
Option Type = SCPS Capabilities (decimal 20)								octet 1
Option Length (≠ 4)								octet 2
Extended Capability Binding Space ID1								octet 3
Extended cap. len1				Extended capability data1				octet 4 variable
Extended Capability Binding Space ID2								octet n
Extended cap. len2				Extended capability data2				octet n+1 variable

Figure 3-4: Single Extended SCPS Capabilities Option with Multiple Extended Capability Binding Spaces

3.2.5.2.4 Alternate Support for Multiple Extended Capability Binding Spaces

Although it is less bit-efficient than the method described in 3.2.5.2.3, multiple extended capabilities can also be signaled with additional SCPS Capabilities Options as shown in figure 3-5.

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0	1	2	3	4	5	6	7	
Option Type = SCPS Capabilities (decimal 20)								octet 1
Option Length (≠ 4)								octet 2
Extended Capability Binding Space ID1								octet 3
Extended cap. len1				Extended capability data1				octet 4
								variable
Option Type = SCPS Capabilities (decimal 20)								octet n
Option Length (≠ 4)								octet n+1
Extended Capability Binding Space ID2								octet n+2
Extended cap. len2				Extended capability data2				octet n+3
								variable

Figure 3-5: Using Multiple SCPS Capabilities Options to Express Multiple Extended Capabilities

3.2.5.2.5 Extending the Extended Capability Binding Identifier Space

An extended capability binding space identifier value of 255 decimal shall be used to extend the extended capability binding space from 255 to 511 values. A value of 255 in the extended capabilities binding space identifier field shall indicate that the actual extended capability binding space identifier is calculated by adding 256 to the value of the octet following the octet containing the extended capability length (octet 5 in figure 3-6 below). If octet 5 in figure 3-6 were itself 255, the extended capability binding space identifier would be 512 plus the value of the octet following octet 5.

NOTE – Using this extension method, the position of the extended capability length field is fixed relative to the start of the extended capability binding space identifier, regardless of the number of octets needed to express the extended capability binding space identifier.

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0	1	2	3	4	5	6	7	
Option Type = SCPS Capabilities (decimal 20)								octet 1
Option Length (≠ 4)								octet 2
Extended Capability Binding Space Esc (decimal 255)								octet 3
Extended cap. len				Reserved				octet 4
Extended Capability Binding Space ID'								octet 5
Extended Capability Data								variable (defined by extended cap. Length field)

Figure 3-6: An Extended SCPS-TP Capability Specified by a Binding Space Identifier in the 256-511 Range

If extended capability binding space extensions are in use (i.e., octet 3 of figure 3-6 is 255) then the four bits following the extended capability length shall be set to 'zero' on transmission and must be ignored on receipt.

3.2.5.3 Meanings of Specific Extended Capability Binding Space Identifiers

3.2.5.3.1 Processing Unrecognized Extended Capability Binding Spaces

As with TCP options, implementations must ignore extended capability binding spaces that they do not understand. In these cases the implementations can read the extended capability length field and skip over the unknown data to continue processing the rest of the extended capabilities (if any).

NOTE – Extended capabilities that require negotiation (presumably most) should be handled similarly to other TCP options. That is, if the sender of the SYN signals that it wants to use extended capability X, presumably the sender of the SYN-ACK will accept/reject the use of that capability via an appropriate option in the SYN-ACK. As with other TCP options, failure to explicitly accept an extended option should be treated as a reject, so that the correct action is taken in the case that the receiver simply did not parse the extended capability.

3.2.5.3.2 Standard Extended Capabilities Binding Space Identifiers

Decimal values 0 through 15 for the extended capability binding space identifier are reserved for standards use.

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3.2.5.3.3 Experimental Extended Capabilities Binding Space ID

Extended capability binding space identifier 254 decimal is reserved for experimentation. Implementations using this experimental extended capability binding space **must** take precautions to ensure that they are interpreting the extended capability data correctly.

3.2.5.4 Assignment of Extended Capability Binding Space Identifiers

CCSDS will assign extended capability binding space identifiers to interested parties. These parties may be individual vendors of SCPS-TP products, or communities of interest that jointly want to define a set of extended capabilities for a particular environment.

3.3 DATA TRANSFER

3.3.1 RECORD BOUNDARY OPTION

3.3.1.1 Record Boundary Option Format

The Record Boundary Option shall be located in the options area of the TCP header and shall contain the following fields:

	Length in octets
– Option Type (mandatory)	1
– Option Length (mandatory)	1

3.3.1.2 Record Boundary Option Fields

3.3.1.2.1 The Option Type field

a) is mandatory for the Record Boundary Option and shall occupy the first octet of the Option;

b) shall contain the decimal value 22.

3.3.1.2.2 The Option Length field

a) is mandatory for the SCPS Capabilities Option and shall occupy the second octet of the Option;

b) shall contain the decimal value 2.

3.3.1.3 Record Boundary Option Invocation

3.3.1.3.1 A sending application shall invoke the Record Boundary Option by providing an Application Program Interface (API) specific indication to the Transport service that the final octet of data in the associated service request represents the end of a record.

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3.3.1.3.2 The end-of-record indication supplied by the sending application shall be associated with the last octet in the service data unit with which it was submitted.

3.3.1.3.3 The ending delimitation of the record shall be preserved during transmission (and possible retransmission) and across the remote service interface interfaces.

3.3.1.3.4 The sequence number of the octet associated with the record marker shall be the highest sequence number in the segment carrying the Record Boundary Option (i.e., it shall be the final octet in the segment), and a read shall associate the end of record with that octet.

NOTE – This modifies the effect of the Nagle algorithm and constrains the Transport protocol in performing repacketization during retransmission. Refer to RFC 896 (reference [8]) for a description of the Nagle algorithm.

3.3.1.3.5 The octet associated with the Record Boundary Option shall not be changed by the Transport Service Provider (TSP).

3.3.1.3.6 If any portion of a segment carrying the Record Boundary Option falls to the right of the receiver's window, the Record Boundary Option shall be discarded until the final octet of the segment with which the Record Boundary Option is associated is received.

3.3.1.3.7 Applications at both ends of a prospective connection must determine that a Transport service provides record boundary capability before connection establishment.

3.3.1.3.8 The Protocol Implementation Conformance Statement (PICS) shall state whether an implementation provides the Record Boundary Option.

NOTE – For a run-time method of determining whether the Record Boundary Option is available, refer to the Application Program Interface specification for the particular system on which the protocol is hosted.

3.3.1.3.9 If an application requests BETS and Record Boundaries, the application developer must ensure that the applications are robust against the possible loss of a record boundary.

NOTE – This may include incorporating a record length indication in the application record structure.

3.3.2 BEST EFFORT TRANSPORT SERVICE

3.3.2.1 Best Effort Transport Service Invocation

The Best Effort Transport Service shall be invoked using the SCPS Capabilities Option.

NOTE – Refer to 3.2.3 for a discussion of the SCPS Capabilities Option and its use.

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