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Space data and information transfer systems — Protocol specification for space communications — Network protocol

*Systèmes de transfert des informations et données spatiales —
Spécification d'un protocole pour communications spatiales — Protocole du
réseau*



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

International Standard ISO 15891 was prepared by the Consultative Committee for Space Data Systems (CCSDS) (as CCSDS 713.0-B-1) and was adopted (without modifications except those stated in clause 3 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 — Protocol specification for space communications — Network protocol

1 Scope

This International Standard specifies the requirements for the services and protocols of the space communications protocol specification (SCPS) network layer. These requirements are to allow independent implementation 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.

2 Conformance

This International Standard is applicable to all systems that claim conformance to the ISO/CCSDS SCPS network protocol.

3 Requirements

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

CCSDS 713.0-B-1, May 1999, *Recommendation for space data system standards — Space communications protocol specification (SCPS) — Network protocol (SCPS-NP)*.

For the purposes of international standardization, the modifications outlined below shall apply to the specific clauses and paragraphs of publication CCSDS 713.0-B-1.

Pages i to v

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

Page 1-6

Add the following information to the reference indicated in paragraph 1.7:

[2] Document CCSDS 301.0-B-2, April 1990, is equivalent to ISO 11104:1991.

Page B-1

Add the following information to the references indicated in annex B:

[B4] Document CCSDS 701.0-B-2, November 1992, is equivalent to ISO 13420:1997.

[B5] Document CCSDS 202.0-B-2, November 1992, is equivalent to ISO 12172:1998.

[B6] Document CCSDS 102.0-B-4, November 1995, is equivalent to ISO 13419:1997.

[B7] Document CCSDS 713.5-B-1, May 1999, is equivalent to ISO 15892:2000.

[B8] Document CCSDS 714.0-B-1, May 1999, is equivalent to ISO 15893:2000.

4 Revision of publication CCSDS 713.0-B-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 713.0-B-1. To this end, NASA will act as a liaison body between CCSDS and ISO.

Consultative Committee for Space Data Systems

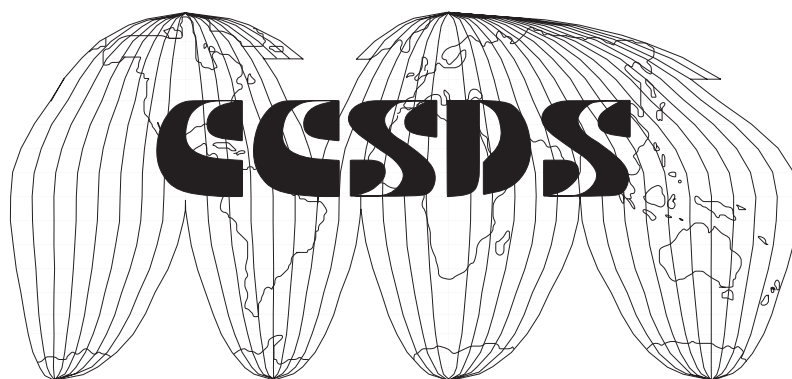
RECOMMENDATION FOR SPACE
DATA SYSTEM STANDARDS

SPACE COMMUNICATIONS PROTOCOL SPECIFICATION (SCPS)— NETWORK PROTOCOL (SCPS-NP)

CCSDS 713.0-B-1

BLUE BOOK

May 1999



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CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

AUTHORITY

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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 Recommendations is detailed in reference [B1], and the record of Agency participation in the authorization of this document can be obtained from the CCSDS Secretariat at the address below.

This Recommendation is published and maintained by:

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CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

STATEMENT OF INTENT

The Consultative Committee for Space Data Systems (CCSDS) is an organization officially established by the management of member space Agencies. 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 considered binding on any Agency.

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 - The **standard** itself.
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CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

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:

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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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CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

DOCUMENT CONTROL

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CCSDS 713.0-B-1	Space Communications Protocol Specification (SCPS)—Network Protocol (SCPS-NP)	May 1999	Original issue

CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

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CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

1 INTRODUCTION

1.1 PURPOSE

The purpose of this Recommendation is to define the services and protocols of the Space Communications Protocol Specification (SCPS) Network layer. 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 Network 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-NP may be found in reference [B3].

1.5 ORGANIZATION OF THIS RECOMMENDATION

This Recommendation contains four 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 protocol, summarizing the main technical requirements and describing the approach used to provide the protocol's services. Section 3 presents the protocol specifications. Section 4 establishes the requirements for maintaining management information.

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 CONVENTIONS AND DEFINITIONS

1.6.1 OCTET NUMBERING CONVENTION AND NOMENCLATURE

This document does not deal with transmission of any 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, this is called 'network byte order'. In this ordering scheme, bit 0 of a 32-bit value is the Most Significant Bit (MSB); 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 also 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:

- the words 'shall' and 'must' imply a binding and verifiable recommendation;
- the word 'should' implies an optional, but desirable, recommendation;
- the word 'may' implies an optional recommendation;
- the words 'is', 'are', and 'will' imply statements of fact.

1.6.2 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. Refer to table 3-5 for a list of Address Types supported in the SCPS Network.

Basic End System Address: A Basic End System Address identifies a single end system or an end-system group. The Basic End System Address conforms to the structural rules of the SCPS Address Family, and consists of the least-significant octet of an Extended End System Address. Basic End System Addresses may be used in networks in which it can be guaranteed (through network configuration) that the remaining portion of the address will be unambiguous through the life of the datagram. (Note that Basic End System Addresses are NOT parameters to the Unit Data service primitives.)

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Basic Path Address: A Basic Path Address identifies a managed virtual connection between two or more end systems. The Path Address conforms to the structural rules of the SCPS Address Family and consists of the least-significant octet of an Extended Path Address. Basic Path Addresses may be used in networks in which it can be guaranteed (through network configuration) that the remaining portion of the address will be unambiguous through the life of the datagram. (Note that Basic Path Addresses are NOT parameters to the Unit Data service primitives.)

Confirm (primitive): A primitive issued by a service-provider to complete, at a particular service-access-point, some procedure previously invoked by a request at that service-access-point.

Domain Identifier: The Domain Identifier (D-ID) is an element of the Extended End System Address and of the Extended Path Address. When part of the Extended End System Address, it identifies groups of Basic End System Addresses. When part of the SCPS Extended Path Address, it identifies groups of Basic Path Addresses. (Note that groups of addresses does *not* mean group addresses.)

End System Identifier: The End System Identifier (ES-ID) is an element of Basic End System Addresses and of Extended End System Addresses. It allows the identification of individual systems or of multicast groups (when qualified by the multicast flag). It has valid values between 0 and 127, although specific programs may choose not to make all of these available.

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.

Extended Path Address: The Extended Path Address identifies a managed virtual connection between two or more end systems. The Path Address conforms to the structural rules of the SCPS Address Family. (Note that Extended Path Addresses are NOT parameters to the Unit Data service primitives.)

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 datagrams but does not forward datagrams.

Indication (primitive): A primitive issued by a service provider either to invoke some procedure or to indicate that a procedure has been invoked by the service user at a peer service-access-point.

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Intermediate Delivery flag: A control field element that indicates whether the network user data (the N-SDU) should be delivered to the destination system only (the typical case) or to the destination and all intermediate systems. The parameter has two values: DESTINATION (the default, value '0'), which indicates that the N-SDU shall be delivered only to the destination address; and INTERMEDIATE (value '1'), which indicates that the N-SDU shall be delivered to the destination address and to all intermediate systems encountered.

NOTE – The INTERMEDIATE setting of Intermediate Delivery flag is intended for diagnostic use, to provide a single-transmission 'traceroute' service. The 'traceroute' service, used in the Internet, provides a response from each intermediate router between a source and destination by repeatedly sending echo messages to the destination, but starting the maximum hops at one, and incrementing it one for each message. This results in the return of an error message to the source from the router that discarded the datagram. The traceroute service is simple, but it generates a significant amount of traffic and takes a significant amount of time to trace a route. The Intermediate Delivery capability is intended to cause all intermediate systems to provide a response to the same Echo Request. The address information and hop count information can be used to construct the route to the destination.

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 [B14].

IP Address Family: The IP Address Family specifies a set of structural rules for the interpretation of Extended End System Addresses; it is defined in reference [B11], and the possible formats are refined in section 3.2.1.3 of reference [B12].

IPv6 Address: The IPv6 Address Architecture is defined in RFC 2373 (see reference [B16]). Note that the IPv6 address is not currently one of the valid types for the N-Destination_Address or the N-Source_Address (refer to Annex D).

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.

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 [B2]) for more information.

Multicast Flag: The Multicast Flag (M-Flag) is an element of addresses within the SCPS Address Family. The M-Flag indicates whether the address refers to a single end system or path, or identifies a group address. Group addresses may identify zero or more end systems or paths.

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

Network Service Data Unit: See N-SDU.

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 8141 octets. Local restrictions on datagram size or extensions to the protocol may further limit this size; the maximum length of an N-SDU for an implementation **shall** be documented by the implementer.

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 50 octets. The length field in the SCPS-NP header is 13-bits, which allows an 8191-octet total datagram length. Therefore, the maximum size of an N-SDU that is guaranteed to fit in a SCPS-NP PDU is 8141 octets.

Path Identifier: The Path Identifier (P-ID) is an element of the Basic Path Address and the Extended Path Address. It identifies a static, managed communication path between two (or more) systems. Path Identifiers may range in value from 0 through 127, although specific programs may restrict the P-IDs available.

Precedence field: A sub-field within the Basic Quality of Service field of the SCPS Network Protocol header. When present, the Precedence field may vary from 0 to 15, with 0 being the lowest precedence and 15 being the highest.

Primitive (also known as service-primitive): An abstract, implementation-independent interaction between a service-user and the service-provider.

Program Specific field: A sub-field within the Basic Quality of Service field of the SCPS Network Protocol header. When present, the Program Specific field may vary from 0 to 3.

Request (primitive): A primitive issued by a service-user to invoke some procedure.

Response (primitive): A primitive issued by a service-user to complete, at a particular service-access-point, some procedure previously invoked by an indication at that service-access-point.

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

Routing Requirements field: A sub-field within the Basic Quality of Service field of the SCPS Network Protocol header. When present, the Routing Requirements field may vary from 0 to 3. Refer to 3.2.3.6 for the assigned values of this field. The default value for the Routing Requirements field is 0, which indicates 'normal' routing.

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SCPS Network Address: A SCPS Network Address specifies one of the possible SCPS Address formats and the values of the parameters required by that format.

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

Service-Primitive: See Primitive.

Silently Discard: A datagram 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. The practice of silently discarding datagrams 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.

Transport Protocol Identifier field: The Transport Protocol Identifier (TP-ID) is a field in the SCPS-NP header that identifies the SCPS Network user (i.e., the transport protocol) from which the datagram originated and to which the datagram should be delivered at its destination(s). It is a 4-bit field that carries a translation of the N-User_Internet_Protocol_Number parameter of the Unit Data service primitives. The translation table appears in table 3-3.

Tuple: A tuple is an ordered set of arbitrary length.

1.7 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.

- [1] K. Nichols, S. Blake, F. Baker, and D. Black. *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*. RFC 2474, December 1998.[†]
- [2] *Time Code Formats*. Recommendation for Space Data Systems Standards, CCSDS 301.0-B-2. Blue Book. Issue 2. Washington, D.C.: CCSDS, April 1990.

[†] Internet Request for Comments (RFC) texts are available on line in various locations (e.g., <http://ietf.org/rfc/>).

CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

2 OVERVIEW

This Recommendation specifies a new service and protocol to meet the needs of current and future space missions. It supports communication environments with static, highly managed communication through fully connectionless communication with dynamic routing. All of these types of operations are supported with near-optimal bit efficiency.

This Recommendation is based on concepts that have been drawn from a number of sources: the notion of ‘Path Service’, or essentially a permanent-virtual-circuit form of addressing, is drawn from the Consultative Committee for Space Data Systems (CCSDS) Recommendation for Advanced Orbiting Systems, CCSDS-701.0-B-2 (reference [B4]), from the CCSDS Recommendation for Telecommand, Part 2, CCSDS-202.0-B-2 (reference [B5]), and from the CCSDS Recommendation for Packet Telemetry, CCSDS 102.0-B-3 (reference [B6]); other ideas are taken directly or indirectly from the Internet Protocol specification and numerous explanatory publications; and the SCPS-NP header construction approach is based on the header compression concepts elaborated in RFC 1144 (reference [B17])—see annex B).

The Technical Requirements for the Recommendation include:

- support for connectionless and managed-connection operation;
- efficient operation in constrained bandwidth conditions;
- support for precedence (priority) based handling;
- support for datagram lifetime control;
- support for multiple routing options;
- signaling of information pertinent to upper-layer protocol processing.

The SCPS Network Protocol (SCPS-NP) uses a technique called ‘capability-driven header construction’ as a means to control bit overhead. Capability-driven header construction simply means that the format of the SCPS-NP header is based (exclusively) on the protocol capabilities required for the communication of the particular datagram in question. That is, a datagram carries those header elements that are required to provide service properly to the datagram, but no others.

The capabilities required to support a datagram are derived from three sources: the protocol itself, the operating environment, and the network service user. Some capabilities are required to support a particular protocol version. An example of this is the capability of datagram length delimiting. Other capabilities are required to address particular network environmental conditions. An example of an environmentally required capability is header error protection. The third source of capability requirements is the network service user. An example of a user-required capability is precedence (priority).

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The capability requirements from these three sources are used to select the set of header elements necessary to provide the required services in the transmission of the datagram. One key header element is a variable-length control field that identifies the remaining header elements that are included in the datagram. This control field is present in all versions of the SCPS-NP, and is the last header element before those header elements specified in the control field.

In addition to user data transfer, this Recommendation specifies the means for exchanging network-layer control information through the SCPS Network, and for selectively passing that information to SCPS Network users.

CCSDS RECOMMENDATION FOR SCPS NETWORK PROTOCOL (SCPS-NP)

3 PROTOCOL SPECIFICATION

3.1 ADDRESSING

3.1.1 ADDRESS FAMILIES

A Network Address (N-Address) in the SCPS Network shall meet the structural requirements of one of three address families:

- a) **SCPS Address Family.** The SCPS address family contains both End System Addresses (identifying a single end system) and Path Addresses (identifying a pair of communication systems). SCPS-family N-Addresses are structured as follows:

- 1) N-Addresses in the SCPS family are four octets in length and are represented in this text as four eight-bit quantities separated by periods, e.g., w.x.y.z, where the range of each of the alphabetic characters is from 0 to 255 decimal.

NOTE – The form w.x.y.z is the Extended form of a SCPS address. The Basic form of the SCPS address (z) may be used if it can be guaranteed (through network configuration) that the w.x.y portion of the address will be unambiguous through the life of the datagram.

- 2) The most-significant octet (the w octet) of a SCPS-family N-Address contains the value 10 (decimal), which is the value reserved by the Internet Assigned Numbers Authority (IANA) for private Internet address spaces.
- 3) The x and y octets are combined to form the addressing domain for various programs; the x.y field is known as the Domain Identifier (D-ID).

NOTE – A single mission may be allocated more than one D-ID for its needs. Determination of the registration authority to allocate and deallocate domain identifiers is beyond the scope of this Recommendation.

- 4) The z octet is administered by the program to which the D-ID is allocated and is subdivided as follows:
 - bits 0-6 form a field, which contains either an End System Identifier (ES-ID) or a Path Identifier (P-ID) in the range 0 to 126 (the value of 127 is reserved for use in conjunction with the Multicast Flag to form the broadcast address);
 - bit 7 is the Multicast Flag (M-Flag), which signals whether the address is a multicast or unicast address:
 - the M-Flag shall be set to '1' for multicast addresses;
 - the M-Flag shall be set to '0' for unicast addresses.

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- b) **Internet Protocol (IP) Address Family.** The IP address family contains End-System Addresses that are appropriate for routing and delivery across the Internet. The structure of Internet addresses is defined in reference [B11] (RFC 791, section 2.3, and RFC 1112, section 4) and reference [B12] (RFC 1122, section 3.2.1.3).
- c) **Internet Protocol version Six (IPv6) Address Family.** IPv6 format addresses are intended for those programs that do not have significant bit-efficiency issues and require global addressability. IPv6 address formats are specified in reference [B16].

3.1.2 BROADCAST ADDRESS DEFINITION

3.1.2.1 SCPS Address Family Broadcast Address Definition

3.1.2.1.1 Unless otherwise stated, the SCPS Address family conforms to the same broadcast address definitions as the IP Address Family, described in 3.1.1.

3.1.2.1.2 A SCPS Address of 10.x.y.255 is the broadcast address for the x.y addressing domain and shall be treated in the same manner as an IP-address family subnet-directed broadcast with a subnet mask of 255.255.255.0 (refer to 3.1.2.2, below).

3.1.2.1.3 A SCPS Address of 10.255.255.255 is the broadcast address for the entire SCPS addressing domain and shall be treated in the same manner as an IP-address family net-directed broadcast (refer to 3.1.2.2, below).

3.1.2.2 Internet Protocol Address Family Broadcast Address Definition

NOTE - much of this text is from reference [B18].

3.1.2.2.1 Limited Broadcast Address

- a) The *limited broadcast address* is defined as 255.255.255.255, where the form of the address is specified in 3.1.1 a) 1), above.
- b) Datagrams destined to the limited broadcast address shall be transmitted on all local interfaces that support broadcasting.
- c) Datagrams destined to the limited broadcast address shall not be forwarded upon receipt.

3.1.2.2.2 Net-Directed Broadcast Address

- a) The net-directed broadcast address has as its host ID all one-bits.
- b) The Class A net-directed broadcast address is netid.255.255.255.

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NOTE – The net-directed broadcast address for the entire SCPS Address Family is 10.255.255.255.

- c) The Class B net-directed broadcast address is netid.255.255, since the network identifier of a Class B network is the most-significant 16 bits of the address and the host identifier is the least-significant 16 bits.
- d) The Class C net-directed broadcast address is netid.255, since the network identifier of a Class C network is the most-significant 24 bits of the address and the host identifier is the least-significant 8 bits.
- e) Routers shall be capable of forwarding datagrams addressed to net-directed broadcast addresses.
- f) Routers shall be capable of disabling the forwarding of net-directed broadcasts.

3.1.2.2.3 Subnet-Directed Broadcast Address

- a) The subnet-directed broadcast address has as its host ID all one-bits with the exception of those bits that specify the subnetwork.
- b) Identification of an address as a subnet-directed broadcast address requires knowledge of the subnet mask. If the subnet mask is not known, the datagram shall be treated as a unicast transmission.
- c) Datagrams addressed to subnet-directed broadcast addresses shall be broadcast only within the specified subnetwork.

3.1.2.2.4 All-Subnets-Directed Broadcast Addresses

All-subnets-directed broadcast addresses shall not be supported.

NOTE – These addresses are identical in structure to *net-directed broadcast addresses*; however, there is a subnet mask defined for the destination.

3.1.2.3 IPv6 Address Family Broadcast Address Definition

There are no broadcast addresses defined in IPv6.

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3.2 SCPS NETWORK PROTOCOL SPECIFICATION

3.2.1 SCPS-NP DATAGRAM

A SCPS-NP datagram shall consist of a header followed by zero or more octets of N-SDU.

3.2.2 SCPS-NP HEADER

3.2.2.1 SCPS-NP Header Format

The SCPS-NP header is mandatory for the SCPS-NP datagram and shall consist of mandatory and capability-defined elements positioned contiguously in the following sequence:

	Length in bits
– Version/Protocol Identifier Field (mandatory)	3
– Datagram Length Field (mandatory)	13
– Transport Protocol ID Field (mandatory)	4
– Control Field (first four bits mandatory)	4, 12, or 20
– Destination Address Field (mandatory)	8, 32, or 128
– Source Address Field (capability dependent)	8, 32, or 128
– Basic QOS Field (capability dependent)	8
– Hop Count Field (capability dependent)	8
– Timestamp Field (capability dependent)	24 or 32
– Expanded QOS Field (capability dependent)	8
– Header Checksum Field (capability dependent)	16

NOTE – The general format of the SCPS-NP datagram is shown in figure 3-1. Fields that are included based on capability requirements are shaded.

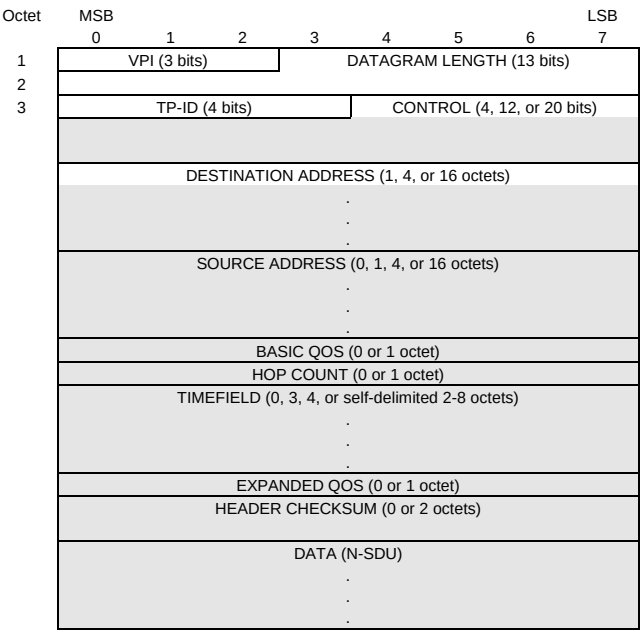


Figure 3-1: SCPS-NP Datagram

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3.2.2.2 SCPS-NP Header Construction

The SCPS-NP header shall be constructed by concatenating elements that satisfy the datagram capability requirements of the protocol, the network, and the user, as shown in table 3-1.

Table 3-1: Relationship of Header Elements to Selected Protocol Capabilities

Requirement Origin	Selected Protocol Capability	Header Element
Protocol	Version and protocol identification	Version/Protocol ID
	Datagram length delimiting	Datagram Length Field
	Transport protocol selection	Transport Protocol ID Field
	Requirements-based capability selection	Control Field
	Destination address	Destination Address Field
Network	Header error protection	Header Checksum Field
	Routing loop control	Hop Count or Timestamp Field
User	Source address	Source Address Field
	Time of transmission signaling	Timestamp Field
	Precedence	Basic QOS Field
	Routing requirements	Basic QOS Field
	Intermediate system delivery	Control Field
	Program-specific signaling	Basic QOS Field
	Ground type-of-service request	Expanded QOS Field

3.2.3 SCPS-NP HEADER ELEMENTS**3.2.3.1 Version/Protocol Identifier Field**

3.2.3.1.1 The Version/Protocol Identifier (VPI) Field shall be three bits in length and shall occupy bits 0–2 of the SCPS-NP header.

3.2.3.1.2 The VPI field shall be set to ‘001’.

3.2.3.2 Datagram Length Indicator Field

3.2.3.2.1 The Datagram Length Indicator field shall be 13 bits in length and shall occupy bits 3–15 of the SCPS-NP header.

3.2.3.2.2 The Datagram Length Indicator field shall contain the total length of the datagram, including all network-layer header information, in octets.

NOTE – When the VPI is set to ‘001’, the minimum legal value for the Datagram Length field is four, corresponding to a SCPS-NP Data Unit consisting only of a header, with the header containing only the VPI, Datagram Length Indicator, TP-ID, the first four bits of the Control Field, and an eight-bit destination address.

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3.2.3.3 Transport Protocol Identifier Field

3.2.3.3.1 The TP-ID field shall be four bits in length and shall occupy bits 16–19 of the SCPS-NP header.

3.2.3.3.2 The TP-ID field shall contain a binary value corresponding to a network service user number as defined in table 3-2.

Table 3-2: Assigned TP-ID Values

Binary Value	Protocol	Binary Value	Protocol
0000	Reserved	1000	SCPS-SP (reference [B7])
0001	SCMP (see 3.1.2.1)	1001	Unassigned
0010	Unassigned	1010	IPv6 ATH (reference [B9])
0011	Unassigned	1011	IPv6 ESP (reference [B10])
0100	Compressed SCPS-TP TCP (reference [B8])	1100	Unassigned
0101	SCPS-TP UDP (reference [B8])	1101	Unassigned
0110	SCPS-TP TCP (reference [B8])	1110	Unassigned
0111	Unassigned	1111	Unassigned

NOTE – Correspondence between TP-ID values and IP numbers is indicated in table 3-3.

Table 3-3: Mapping of Assigned SCPS TP-ID Values to IP Numbers

Protocol	SCPS TP-ID Number	IP Number
SCMP	1	None
Compressed SCPS-TP TCP (reference [B8])	4	105
(SCPS-TP) UDP (reference [B8])	5	17
(SCPS-TP) TCP (reference [B8])	6	6
SCPS-SP (reference [B7])	8	99
IPv6 ATH (reference [B9])	10	51
IPv6 ESP (reference [B10])	11	50

3.2.3.4 Control Field

3.2.3.4.1 The Control Field shall be either 4, 12, or 20 bits¹ in length and shall begin in bit 20 of the SCPS-NP header:

3.2.3.4.2 The Control Field shall consist of some or all of the subfields described in table 3-4.

3.2.3.4.3 When an octet of the Control Field is not present, the values of the subfields of that octet shall be assumed to be zero.

¹ The maximum length of the Control field may be increased in future versions of this specification.

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Table 3-4: Control Field Elements

Header Bit #	Control Field Element	Permitted Values	Cf. Sub-section	Notes
20	Bit Field Continues	'1' Control field continues in octet 4 of the SCPS-NP header '0' Control field is contained within octet 3 of the SCPS-NP header		1,2
21	Reserved by CCSDS	'0' Undefined		1
22	Destination Address Present (Dest Addr)	'1' Destination Address field present '0' Undefined	3.2.3.5	1, 3
23	Header Checksum	'1' Checksum present '0' Checksum not present	3.2.3.10	1
24	Bit Field Continues	'1' Control field continues in octet 5 of the SCPS-NP header '0' Control field is contained within octets 3 and 4 of the SCPS-NP header		2
25	Source Address Present (Source Addr)	'1' Source Address field present '0' Source Address field not present	3.2.3.5	4
26	Hop Count	'1' Hop Count field present '0' Hop Count field not present	3.2.3.7	
27-28	Timestamp Format	'11' 32-bit Binary Timestamp present '10' CCSDS CUC Timestamp (Explicit P-field) present '01' CCSDS 24-bit CUC Timestamp (Implicit P-field) present '00' Timestamp field not present	3.2.3.8	
29	Reserved by CCSDS	'0' Undefined		
30	Basic QOS	'1' Basic QOS field present '0' Basic QOS field not present	3.2.3.6	
31	Extended Addresses	'1' Extended Addresses '0' Basic Addresses	3.2.3.5	4
32	Bit Field Continues	'0' Control field is contained within octets 3, 4, and 5 of the SCPS-NP header		2
33	IPv6 Addresses (IPv6)	'1' IPv6 Addresses present '0' IPv6 Addresses not present	3.2.3.5	5
34	Expanded QOS	'1' Expanded QOS field present '0' Expanded QOS field not present	3.2.3.9	
35	Intermediate Delivery	'1' intermediate systems should deliver the datagram to the local transport protocol identified by the TP-ID as well as queue for forwarding to the destination '0' no special actions required for intermediate systems		
36	Not Assigned	'0' Undefined		
37	Not Assigned	'0' Undefined		
38	Not Assigned	'0' Undefined		
39	Not Assigned	'0' Undefined		
NOTES 1 Inclusion of this subfield is mandatory regardless of its value. 2 The 'Bit Field Continues' bits in the control field bit-vector are used to determine its length. If bit 20 of the header = '0', the control field bit vector length = 4 bits. If bit 20 = '1' and bit 24 = '0', the control field bit vector length = 12 bits. If bits 20 and 24 = '1' and bit 32 = '0', the control field bit vector length = 20 bits. If bits 20, 24, and 32 = '1', the control field bit vector length exceeds 20 bits. 3 When the Destination Address Present Flag is set to '1', the header contains a destination address. A value of '0' for the Destination Address Present flag is undefined. When this flag is set to '1' and the Source Address Present flag is not set to '1', the Destination Address is treated as a unidirectional permanent virtual circuit (a Path). When the Destination Address Present flag and the Source Address Present flag are both set to '1', the Destination Address is treated as a connectionless datagram address. 4 Shall not be set to '1' unless Destination Address Flag is set to '1'. 5 Shall not be set to '1' unless both Destination and Source Address Flags are set to '1'.				

NOTE – The elements of the control field are illustrated in figure 3-2.

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Octet	MSB				LSB			
3					20 Bit Field Continues	21 Reserved by CCSDS	22 Dest Addr	23 Header Cksum
	24 Bit Field Continues	25 Source Addr	26 Hop Count	27 Timestamp Format	28 Reserved by CCSDS	29 Reserved by CCSDS	30 Basic QOS	31 Extended Addrs
	32 Bit Field Continues	33 IPv6 Addrs	34 Expanded QOS	35 Intermed. Delivery	36 Reserved by CCSDS	37 Reserved by CCSDS	38 Reserved by CCSDS	39 Reserved by CCSDS

Figure 3-2: Control Field Subfields**3.2.3.5 Address Fields**

An N-Address used in the SCPS-NP header shall be one of five address types, shown in table 3-5, encoded from the three address families described in 3.1.1.

Table 3-5: SCPS Network Protocol Address Types

Address Type	Address Length	Addresses per header	Address Family	Description
Extended End System Address	4 octets	2	IP or SCPS	Registered IP addresses or SCPS Address family addresses
Extended Path Address	4 octets	1	SCPS	Managed connection between source and destination(s)
Basic End System Address	1 octet	2	SCPS	Least significant octet of SCPS Extended End System Addresses
Basic Path Address	1 octet	1	SCPS	Least significant octet of SCPS Extended Path Addresses
IPv6 Address	16 octets	2	IPv6	Registered IP Version 6 addresses

NOTE – The relationship between the four address flags in the Control field, as well as the significance of their possible combinations of values, is indicated in table 3-6.

Table 3-6: Control Field Flag Settings for SCPS Address Formats

Address Format	Control Field Flags			
	Dest Addr	Src Addr	Extended Addrs	IPv6 Addrs
Extended End System	'1'	'1'	'1'	'0'
Extended Path	'1'	'0'	'1'	'0'
Basic End System	'1'	'1'	'0'	'0'
Basic Path	'1'	'0'	'0'	'0'
IPv6	'1'	'1'	'0'	'1'

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NOTE – The broadcast addresses for ‘Basic’ Format addresses (End System and Path) are consistent with other types of Basic Format addresses: the least significant octet of the Extended Format address becomes the Basic Format of the address. The most significant three octets are assumed to be the local address domain. Therefore, the Extended Format broadcast address for addressing domain x.y would be 10.x.y.255, and the Basic Format would be 255. Note that this Basic Format has meaning *only within addressing domain x.y*.

3.2.3.6 Basic QOS Field

3.2.3.6.1 The Basic QOS field shall be one octet in length and shall begin on the next octet boundary following the location of the header address field(s).

3.2.3.6.2 The Basic QOS field, shown in figure 3-3, shall consist of the following three subfields in the following sequence:

	<u>Length in bits</u>
– Precedence subfield	4
– Routing Requirements subfield	2
– Program Specific subfield	2

3.2.3.6.3 Precedence Subfield

- The Precedence subfield shall contain a value between 0 (lowest precedence) and 15 (highest precedence) describing the precedence of the datagram.
- The SCPS-NP shall use the precedence field as described in 3.2.6.2 and 3.3.
- If the Basic QOS field is not present in a datagram header, the precedence of the datagram shall be the default value specified in the Management Information Base (MIB) parameter npDefaultPrecedence (see 4.1.3.3).

3.2.3.6.4 Routing Requirements Subfield

The Routing Requirements subfield shall contain a value between 0 and 3 signaling a routing method selected from table 3-7.

Table 3-7: Routing Requirements Field Values

Routing Rqts Value	Interpretation
‘00’	Point-to-point routing
‘01’	Reserved by CCSDS
‘10’	Reserved by CCSDS
‘11’	Flood routing

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3.2.3.6.5 Program Specific Subfield

- a) The Program Specific subfield shall contain a value between 0 and 3 and shall be used by the user application to convey control information that is parsed in a program-specific way.
- b) The default value of the Program Specific subfield shall be 0, which corresponds to 'No program-specific action'.

NOTE – The Program Specific subfield is present to allow program-specific extensions to SCPS-NP, and the appropriate mechanisms to parse and respond to the values of this field are the responsibility of the program implementing the modifications.

Octet	MSB							LSB	
	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	
n	Precedence				Routing Rqts		Program-Specific		

Figure 3-3: SCPS-NP Header - Basic Quality of Service Field

3.2.3.7 Hop Count Field

3.2.3.7.1 The Hop Count field shall be one octet in length and shall be located on the next octet boundary following the location for the Basic Quality of Service field(s).

3.2.3.7.2 The Hop Count field shall contain an eight-bit decrementing counter that shall be initialized to the maximum number of hops (relays through an intermediate system) that a SCPS-NP datagram is permitted to experience before being discarded.

3.2.3.8 Timestamp Field

NOTE – The Timestamp field may be used for two purposes:

- to provide a limit on the time that datagrams can exist in the network (to eliminate routing loops or to bound the time that TCP segments exist);
- to provide datagram identification for flood-routed datagrams (this use of timestamps is discussed in more detail in 3.2.5.5).

3.2.3.8.1 Timestamp Field Length and Location

- a) The Timestamp field, if present, shall either be three or four octets in length, or shall be of a self-delimiting format as specified in this subsection.

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- b) The Timestamp field shall be located on the next octet boundary following the location for the Hop Count field.

3.2.3.8.2 General Timestamp Formats

- a) The Timestamp field shall conform to one of two general formats:
 - 1) the CCSDS Unsegmented Time Code (CUC), or
 - 2) the Binary Timestamp Format.
- b) Within the CUC format, there are two supported versions:
 - 1) one with an *implicit* Preamble Field (P-Field), and
 - 2) one with an *explicit* P-Field.
- c) All implementations of the SCPS-NP shall support at least one of the formats specified in this subsection.
- d) Implementations of the SCPS-NP SHOULD support all formats.

NOTE – In particular, ground-based routers that may support more than one flight element SHOULD support all timestamp formats in order to minimize the possibility that the router may not be able to perform routing loop control for some datagrams.

- e) The supported formats shall be documented in the Protocol Implementation Conformance Statement, the proforma for which appears in annex C.

3.2.3.8.3 Timestamp Field Formats

The Timestamp field shall contain a timestamp in one of the following formats:

- a) CCSDS Unsegmented Time Code (CUC) Timestamp Format with Implicit P-Field:
 - 1) When the Timestamp Format bits of the Control Field (bits 27–28) are set to ‘01’ then the CUC Timestamp Format with Implicit P-Field shall be included in the header.
 - 2) The length of the CUC Timestamp Format with Implicit P-Field shall be three octets.

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3) CUC Format:

- the CUC shall be composed of two fields, the Preamble field (P-field) and the Time field (T-field), as specified in reference [2];
- the P-field shall *not* be carried with the timestamp, but is constant and defined in this subsection;
- the T-field shall be carried in the SCPS-NP header and shall consist of three contiguous eight-bit time elements.

4) Timestamp definition:

- the P-Field shall be set to ‘0010 0010’, or hexadecimal 22:
 - the Extension flag of the P-field shall be set to ‘0’,
 - the time code identification field (bits 1-3) shall be set to ‘010’, indicating an Agency-defined epoch,
 - bits 4 and 5 of the P-field shall be set to ‘00’ (the value resulting from subtracting one from the number of octets of coarse time),
 - bits 6 and 7 of the P-field shall be set to ‘10’ (the number of octets of fine time);
- the T-Field shall consist of one octet of whole seconds (coarse time) and two octets of fractional seconds (fine time), which establishes the range of the time code to be 256 seconds, and the resolution to be 1/65536 seconds (approximately 15 microseconds).

5) The time-to-live value for datagrams carrying the CUC Timestamp Format with Implicit P-Field shall be taken from the MIB parameter npTimeToLivePField1.

b) CCSDS Unsegmented Time Code (CUC) Timestamp Format with Explicit P-Field:

- 1) When the Timestamp Format bits of the Control Field (bits 27–28) are set to ‘10’ then the CUC Timestamp Format with Explicit P-Field shall be included in the header.
- 2) The length of the CUC Timestamp Format with Explicit P-Field shall be variable, as determined by the P-Field, and shall be greater than or equal to two octets in length and less than or equal to eight octets in length.
- 3) The CUC Timestamp Format with Explicit P-Field shall be transmitted with the P-Field as the most significant octet of the timestamp and the T-Field as the least significant octet(s). The order of octets within the T-Field shall be in accordance with reference [2].

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- 4) The time-to-live value for datagrams carrying this timestamp format shall be taken from the MIB parameter npTimeToLivePField2.
- c) Binary Timestamp Format (four octets):
- 1) When the Timestamp Format bits of the Control Field (bits 27–28) are set to ‘11’ then the binary timestamp shall be included in the header.
 - 2) The binary timestamp shall be a 32-bit quantity representing the microseconds since 00:00 GMT, 1 January 1970, modulo 2^{32} .
 - 3) The time-to-live value for datagrams carrying this timestamp format shall be taken from the MIB parameter npTimeToLivePField2.

3.2.3.9 Expanded QOS Field

3.2.3.9.1 The Expanded QOS field shall be one octet in length and shall begin on the next octet boundary following the location of the Timestamp field.

3.2.3.9.2 The format and content of the Expanded QOS field shall conform to the requirements of RFC 2474 (reference [1]).

3.2.3.9.3 When carried in the SCPS-NP header, the information in the Expanded QOS field shall be supplied to IP-based internetworks (on the ground) for provision of the appropriate service through the ground internetwork.

NOTE – The role of the SCPS-NP regarding this field is merely to convey the Differentiated Services Field information and to request it at gateways in which the SCPS-NP data is carried by IP.

3.2.3.10 Header Checksum Field

3.2.3.10.1 The Header Checksum field shall be two octets in length and shall occupy the final two octets of the SCPS-NP header.

3.2.3.10.2 The Header Checksum field shall contain the 16-bit one’s complement of the one’s complement sum of all 16-bit words in the SCPS-NP header.

3.2.3.10.3 For purposes of computing the checksum,

- a) the value of the Header Checksum field shall be zero;
- b) if the SCPS-NP header contains an odd number of octets, the header shall be conceptually padded with a single zero-valued octet, which shall not be transmitted with the header.