

**Draft Recommendation for
Space Data System Standards**

**CCSDS BUNDLE PROTOCOL
SECURITY SPECIFICATION**

DRAFT 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 Recommended Standard is therefore subject to CCSDS document management and change control procedures, which are defined in the *Organization and Processes for the Consultative Committee for Space Data Systems* (CCSDS A02.1-Y-4). Current versions of CCSDS documents are maintained at the CCSDS Web site:

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PREFACE

This document is a draft CCSDS Recommended Standard. Its ‘Red Book’ status indicates that the CCSDS believes the document to be technically mature and has released it for formal review by appropriate technical organizations. As such, its technical contents are not stable, and several iterations of it may occur in response to comments received during the review process.

Implementers are cautioned **not** to fabricate any final equipment in accordance with this document’s technical content.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

DOCUMENT CONTROL

Document	Title	Date	Status
	CCSDS Bundle Protocol Security Specification, Draft Recommended Standard, Issue 1	October 2021	Current draft

CONTENTS

<i>Introduction</i>	2
1.1 PURPOSE	2
1.2 SCOPE	2
1.3 Applicability	2
1.4 Rationale	3
1.5 ORGANIZATION OF THIS RECOMMENDED STANDARD	3
1.6 Definitions	4
1.7 NOMENCLATURE	4
1.7.1 Normative Text	4
1.7.2 Informative Text	5
1.8 References	5
2 <i>Overview</i>	2
2.1 Security Needs for Bundle Protocol Version 7	2
2.2 Concept of Bundle Protocol Security	2
2.2.1 BPsec Security Services	2
2.2.2 SECURITY CONTEXTS	3
2.2.3 BPsec Security operations and Blocks	4
2.2.4 BPsec Roles and Responsibilities	5
2.3 Notable Features of BPsec	8
2.3.1 General	8
2.3.2 Block-Level granularity	9
2.3.3 Multiple security sources	9
2.3.4 Mixed security policy	9
2.3.5 Deterministic Processing	9
3 <i>CCSDS Profile of RFC 9172</i>	10
3.1 Adoption of Mechanisms From RFC9172	10
3.3 Use of CCSDS-Approved Key Management	10
3.4 Application of CCSDS Policy Considerations	11
3.5 SANA Registry Considerations	11
4 <i>BPsec Service Definition</i>	12
4.1 Overview	12

4.2	BPSec Services	12
4.3	Summary of Primitives	12
4.3.1	The BPSec service shall consume the following request primitives:	12
4.3.2	The BPSec service shall provide the following indication primitives:	12
4.4	Summary of Parameters	13
4.4.1	Target bundle	13
4.4.2	Target block identifiers	13
4.4.3	Modified Bundle	13
4.4.4	New BIB Block ID	13
4.4.5	New BCB Block ID	13
4.4.6	Security context identifier	13
4.4.7	Security context parameters	13
4.4.8	Local Security context parameters	13
4.4.9	Security source	14
4.4.10	Verify result	14
4.5	CCSDS BPSec Service Primitives	14
4.5.1	Overview	14
4.5.2	ApplyBIB.request	15
4.5.2.1	Function	15
4.5.2.2	Semantics	15
4.5.2.3	When Generated	15
4.5.2.4	Effect on Receipt	15
4.5.2.5	Discussion - Additional Comments	15
4.5.2.6	ApplyBCB.request	15
4.5.2.7	Function	16
4.5.2.8	Semantics	16
4.5.2.9	When Generated	16
4.5.2.10	Effect on Receipt	16
4.5.2.11	Discussion - Additional Comments	16
4.5.3	ApplyBIB.return	17
4.5.3.1	Function	17
4.5.3.2	Semantics	17
4.5.3.3	When Generated	17
4.5.3.4	Effect on Receipt	17
4.5.3.5	Discussion - Additional Comments	17
4.5.4	ApplyBCB Return	18
4.5.4.1	Function	18
4.5.4.2	Semantics	18
4.5.4.3	When Generated	18
4.5.4.4	Effect on Receipt	18
4.5.4.5	Discussion - Additional Comments	18
4.5.5	VerifyBIB.request	19

4.5.5.1	Function	19
4.5.5.2	Semantics	19
4.5.5.3	When Generated	19
4.5.5.4	Effect on Receipt	19
4.5.5.5	Discussion - Additional Comments	19
4.5.6	VerifyBCB.request	20
4.5.6.1	Function	20
4.5.6.2	Semantics	20
4.5.6.3	When Generated	20
4.5.6.4	Effect on Receipt	20
4.5.6.5	Discussion - Additional Comments	20
4.5.7	VerifyBIB.indication	21
4.5.7.1	Function	21
4.5.7.2	Semantics	21
4.5.7.3	When Generated	21
4.5.7.4	Effect on Receipt	21
4.5.7.5	Discussion - Additional Comments	21
4.5.8	VerifyBCB.indication	21
4.5.8.1	Function	21
4.5.8.2	Semantics	21
4.5.8.3	When Generated	21
4.5.8.4	Effect on Receipt	21
4.5.8.5	Discussion - Additional Comments	21
4.5.9	AcceptBIB.request	21
4.5.9.1	Function	21
4.5.9.2	Semantics	22
4.5.9.3	When Generated	22
4.5.9.4	Effect on Receipt	22
4.5.9.5	Discussion - Additional Comments	22
4.5.10	AcceptBCB.request	22
4.5.10.1	Function	22
4.5.10.2	Semantics	22
4.5.10.3	When Generated	22
4.5.10.4	Effect on Receipt	22
4.5.10.5	Discussion - Additional Comments	22
4.5.11	AcceptBIB.indication	23
4.5.11.1	Function	23
4.5.11.2	Semantics	23
4.5.11.3	When Generated	23
4.5.11.4	Effect on Receipt	23
4.5.11.5	Discussion - Additional Comments	23
4.5.12	AcceptBCB.indication	24
4.5.12.1	Function	24
4.5.12.2	Semantics	24

4.5.12.3	When Generated	24
4.5.12.4	Effect on Receipt	24
4.5.12.5	Discussion - Additional Comments	24

ANNEX F BUNDLE PROTOCOL SECURITY POLICY CONSIDERATIONS (INFORMATIVE)	F-1
ANNEX F BUNDLE PROTOCOL SECURITY POLICY CONSIDERATIONS (INFORMATIVE)	F-1
ANNEX G SERVICE SPECIFICATION FOR BPSEC POLICY (INFORMATIVE)	G-1

Figure

Figure 2-1: BPSEC security blocks target other bundle blocks.	4
Figure 2-2: BPAs have multiple security roles [C10]	6
Figure 2-3: BPAs process security operations within security blocks. [C10]	7
Figure 2-1: BPSEC security blocks target other bundle blocks.	4

Table

Introduction	14
4.5.12.5 Discussion - Additional Comments	26

INTRODUCTION

1.1 PURPOSE

This document defines a Recommended Standard for the CCSDS Bundle Protocol Security Protocol (BPsec), based on the Bundle Protocol Security Protocol of RFC 9172 (reference [11]). BPsec defines Bundle Protocol version 7 (RFC9171) (reference [1]) extension blocks with associated procedures that may be used with BPv7 bundles. These extension blocks provide a structured method for applying data integrity, authenticity, and/or confidentiality to blocks within a bundle.

1.2 SCOPE

This Recommended Standard defines BPsec in terms of:

- a) the protocol data units employed by the service provider; and
- b) the procedures performed by the service provider.

It does not specify:

- a) individual implementations or products;
- b) the implementation of service interfaces within real systems;
- c) the methods or technologies required to perform the procedures; or
- d) the management activities required to configure and control the service.

This Recommended Standard does not mandate the operational use of any particular cryptographic algorithm with BPsec. Reference [2] provides a listing of algorithms recommended by CCSDS and those algorithms should be preferred by security contexts defined by CCSDS; any organization should conduct a risk assessment before choosing to substitute other algorithms. Annex D (non-normative) defines baseline implementations suitable for a large range of space missions.

The protocol specified here applies only to the Bundle Protocol version 7 and does not interact with other CCSDS protocols. BPsec applies to the Session and Presentation layers of the OSI model as it relates to the Bundle Protocol, as seen in Figure 3-1 of [9].

1.3 APPLICABILITY

This Recommended Standard applies to the creation of Agency standards and for secure data communications over space networks between CCSDS Agencies in cross-support situations.

The Recommended Standard includes comprehensive specification of the service for inter-Agency cross-support. It is neither a specification of, nor a design for, real systems that may be implemented for existing or future missions.

The Recommended Standard specified in this document is to be invoked through the normal standards programs of each CCSDS Agency, and is applicable to those missions for which interoperability and cross-support based on capabilities described in this Recommended Standard

is anticipated. Where mandatory capabilities are clearly indicated in sections of the Recommended Standard, they must be implemented when this document is used as a basis for interoperability and cross-support. Where options are allowed or implied, implementation of these options is subject to specific bilateral cross-support agreements between the Agencies involved.

BPv7 requires that inter-bundle security services (as opposed to the security services provided by overlying application protocols or underlying convergence-layer protocols) be provided in accordance with the BPsec Recommended Standard. BPv7 also requires that any BPv7 Agent (BPA) which sources, cryptographically verifies, and/or accepts a bundle must implement support for the BPsec Recommended Standard. The use of BPsec for any particular transmission of BPv7 bundles is optional for CCSDS missions.

1.4 RATIONALE

The goals of this Recommended Standard are to:

- a) provide a standard method of applying block-specific security for bundle transport, independent of the underlying cryptographic algorithms employed by any particular space mission; and
- b) facilitate the development of common commercial implementations to improve interoperability across agencies.

1.5 ORGANIZATION OF THIS RECOMMENDED STANDARD

This Recommended Standard is organized as follows:

Section 1 presents the purpose, scope, applicability, and rationale of this Recommended Standard and lists the conventions, definitions, and references used throughout the document.

Section 2 (informative) provides an overview of BPsec.

Section 3 (normative) provides a profile of BPsec and specifies the constraints associated with BPsec services.

Section 4 (normative) defines the services provided by the protocol entity.

Annex A (normative) provides a Protocol Implementation Conformance Statement (PICS) proforma for BPsec.

Annex B (informative) provides an overview of security, SANA registry, and patent considerations related to this Recommended Standard

Annex C (informative) provides a list of informative references and a glossary of abbreviations and acronyms that appear in the document.

Annex D (normative) defines baseline implementations suitable for a large range of space missions.

Annex E (normative) defines BPSec managed parameters.

Annex F (informative) provides policy considerations for BPSec.

Annex G (informative) is a service specification for BPSec policy.

1.6 DEFINITIONS

This section provides references to terms and definitions necessary for understanding this Recommended Standard.

Additional terms and definitions related to this Recommended Standard can be found in references [1, 4, 5, 8, 11].

In particular, this document follows RFC9172 in that it defines an integrity security operation. Depending on the mechanism used to provide integrity, such operations may also provide authenticity.

In some cases the input data to an encryption function may itself be encrypted. This is referred to as superencryption.

BP may be deployed in scenarios that prohibit establishing relationships between two or more entities prior to exchanging information. BPSec defines a new term, security context, to refer to the practice of annotating a bundle with contextual information that would otherwise be used to establish a security association.

Security associations may still be used with BPSec under the auspices of BPSec security contexts that allow them.

1.7 NOMENCLATURE

1.7.1 NORMATIVE TEXT

The following conventions apply for the normative specifications in this Recommended Standard:

- 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.

NOTE – These conventions do not imply constraints on diction in text that is clearly informative in nature.

1.7.2 INFORMATIVE TEXT

In the normative sections of this document, informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

- Overview;
- Background;
- Rationale;
- Discussion.

1.8 REFERENCES

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

- [1] Burleigh, S., Fall, K., Birrane, E., “Bundle Protocol Version 7” RFC9171. Reston, Virginia, ISOC, January 2022.
- [2] *CCSDS Cryptographic Algorithms*. Issue 2. Recommendation for Space Data System Standards (Blue Book), CCSDS 352.0-B-2. Washington, D.C.: CCSDS, August 2019.
- [3] *Space Missions Key Management Concept*. Issue 1. Report Concerning Space Data System Standards (Green Book), CCSDS 350.6-G-1. Washington, D.C.: CCSDS, November 2011.
- [4] *Information Security Glossary of Terms*. Issue 1. Report Concerning Space Data System Standards (Green Book), CCSDS 350.8-M-1. Washington, D.C.: CCSDS, February 2012.
- [5] CCSDS Terms. SANA Registry <https://sanaregistry.org/r/terms>.
- [8] R. Shirey. *Internet Security Glossary, Version 2*. RFC 4949. Reston, Virginia: ISOC, August 2007.
- [9] *The Application of Security to CCSDS Protocols*. Issue 3. Report Concerning Space Data System Standards (Green Book), CCSDS 350.0-G-3. Washington, D.C.: CCSDS, March 2019.
- [10] *CCSDS Symmetric Key Management*. Issue 1. Draft Recommendation for Space Data System Practices (Red Book), CCSDS 354.0-R-2. Washington, D.C.: CCSDS, February 2022.

[11] Birrane, E., McKeever, K., “Bundle Protocol Security” RFC9172

[12] E. Birrane, A. White, and S. Heiner. *BPsec Default Security Contexts*. RFC9173. Reston, Virginia: ISOC, January 2022.

2 OVERVIEW

2.1 SECURITY NEEDS FOR BUNDLE PROTOCOL VERSION 7

The Bundle Protocol (BP) provides end-to-end communications across many networking environments, to include delay/disruption tolerant networks (DTNs). The BPv7 specification refers to a DTN as “a networking architecture providing communications in and/or through highly stressed environments” (reference [1]). In this context, the term “highly stressed environment” can refer to multiple challenging conditions including intermittent connectivity, large and/or variable delays, asymmetric data rates, and high bit error rates. Whether deployed in a DTN or some other networking environment, “BP may be viewed as sitting at the application layer of some number of constituent networks, forming a store-carry-forward overlay network” (reference [1]).

BP is presumed to be deployed in circumstances where the networking environment is not trusted, which requires consideration of usual security challenges related to confidentiality, integrity, and authenticity.

Networks may be untrusted for a variety of reasons. Different nodes in a network may cross multiple administrative boundaries (such as on the Internet) such that not every administrative entity is given the same level of trust. Within a given administrative boundary such as an enterprise intranet, nodes may have different physical or logical access controls and policies which may affect trust. Similarly, individual nodes may incorporate components (convergence layers, virtual machines, open source libraries) with differing levels of trust.

The stressed nature of certain networks where BP may be deployed may impose constraints that break or otherwise impede the use of usual transport security mechanisms. BPsec specifies unique security features inherent in securing a store-and-forward based transport protocol, to include protecting data at rest, preventing unauthorized consumption of critical resources such as storage space, and operating without regular contact with a centralized security oracle (such as a certificate authority).

Because transport security mechanisms that require multiple handshakes may not be feasible in the environments where BP functions, new end-to-end security services are needed that can secure bundles in all DTN environments.

2.2 CONCEPT OF BUNDLE PROTOCOL SECURITY

BPsec is a protocol by which space missions can apply security services to individual blocks that comprise a BPv7 bundle. BPsec data units are codified as extension blocks within the BP and only exist in the context of a bundle.

2.2.1 BPSEC SECURITY SERVICES

BPsec provides two security services for blocks within a BPv7 bundle:

1. **Bundle Integrity Block (bib-integrity).** This service specifies an integrity mechanism over the block-type-specific data of a target block. This service also supports the inclusion of additional data beyond the plain text of the block-type-specific data of the target block. Integrity mechanisms (absent confidentiality mechanisms) detect changes resulting from processing errors, environmental conditions, or intentional manipulation. With appropriate mechanisms such as digital signature based authentication, integrity can also provide data authentication / authenticity.
2. **Bundle Confidentiality Block (bcb-confidentiality).** This service specifies authenticated confidentiality over the plain text block-type-specific data of a target block. This service also supports the inclusion of additional authenticated data beyond the plain text of the block-type-specific data of the target block.

2.2.2 SECURITY CONTEXTS

Security contexts in BPSec differ from security associations in IPsec.

Internet IPsec uses the term ‘security association’ defined as:

a one-way (inbound or outbound) agreement between two communicating peers that specifies the IPsec protections to be provided to their communications. This includes the specific security protections, cryptographic algorithms, and secret keys to be applied, as well as the specific types of traffic to be protected.

The specifics of a security association are often negotiated and maintained as state at the endpoints. As a result, endpoints can use a security parameters index (an integer) which, together with the destination IP address and security protocol uniquely identifies a single (active) security association.

RFC9172 uses the term ‘security context’ to refer to the set of assumptions, algorithms, configurations, and policies used to implement security services. One of the main differences between security contexts and security associations is that with security contexts, the specifics needed to invoke the security services (the assumptions, algorithms, configurations and policies) may be pre-defined so that no negotiated state is required at the endpoints.

Security contexts:

- Are parameterizable; for instance a single security context might be configurable to e.g.:
 - allow the use of different cipher suites / key lengths (signaled as part of the block containing the security operation)
 - specify a set of ‘scope’ flags specifying which parts of the target Bundle Block are to be covered by the security operation (e.g. to block-type-specific data only; to include the header of the target block)
 - include an optional parameter that is the encrypted version of a symmetric key used to encrypt block context
- Include configuration and policy information, e.g.:
 - specify what actions should be taken if particular security measures are not present in the bundle or fail acceptance

- specify which blocks should be included in outbound bundles to particular next hops (e.g. previous-hop-block)

For example, one mission may use a 256-bit Advanced Encryption Standard (AES) cipher suite for confidentiality with a negotiated security association identifier (SAID, similar to the security parameters index in IPsec). In this case, at most the SAID must be communicated in the bundles that use confidentiality to process security at a security acceptor. Another mission may use the same 256-bit AES cipher without the ability to negotiate (or sustain) a security association. In this case, cipher suite parameters (possibly included a wrapped key) may be encoded with a symmetric key and included in the security block. In both cases, the same cipher suite is used, but the security context surrounding the cipher suite is very different.

BPSec security blocks identify the security context used in the handling of cryptographic materials associated with the security operations represented by these blocks.

Different security contexts can be used for different bundles, and for different security operations within a single bundle.

The application of a given security context to a security operation is defined by BPA local node policy on the security source.

CCSDS recommended cryptographic algorithms as specified in [2] should be used in the definition of security contexts unless a specific reason exists that does not allow them.

2.2.3 BPSec SECURITY OPERATIONS AND BLOCKS

BPSec security services can be applied to individual blocks within a bundle, providing fine-grained security in a bundle.

Blocks in a bundle may carry different types of information. Payload blocks carry application data. Extension blocks may carry network information, annotative information related to the payload, or special processing instructions for the bundle itself. This combination of network-focused, bundle-focused, and application-data-focused information often requires different security services with different shared secrets (keys), different policies, and different accesses.

BPSec specifies the application of a security service to a specific target block within a bundle. This operation is notated as *OP(service, target)*. For example, applying the of bib-integrity service to a bundle's primary block would be notated as:

OP(bib-integrity, primary block)

BPSec requires that all security operations in a bundle be unique. This means that the same security service cannot be applied to the same target block multiple times. Such a situation would create ambiguity in the order of operation of verifying integrity and cases where some integrity mechanisms succeed and others fail verification.

BPSec security services (such as *bib-integrity*) use security contexts to define cipher suites, parameters, and results. It is possible to define a security context which would calculate multiple integrity results over a single target block. In this case, there is still a single operation, $OP(bib-integrity, target\ block)$, with that operation carrying multiple security results from the generating security context. This avoids the ambiguity of having multiple security services, because this single security service generates all integrity results at the same time, processes all integrity results at the same time, and provides a single mechanism to disposition multiple integrity results that pass/fail verifications.

Security operations for a particular target block are instantiated in a bundle by their inclusion in a security block. Every security block contains at least one, and possible many, security operations.

When multiple security operations share certain common attributes (e.g., the same security source, security service, and parameters) they may be aggregated into a single security block. In this case, there is a one-to-many relationship between a security block and the security operations it carries.

The relationship between security blocks and target blocks is illustrated in Figure 2-1. The figure illustrates a bundle containing 6 blocks: the required primary and payload block and four (4) extension blocks. Security block (1) provides a security service for target block (1) and security block (2) provides a security service for target block (2).

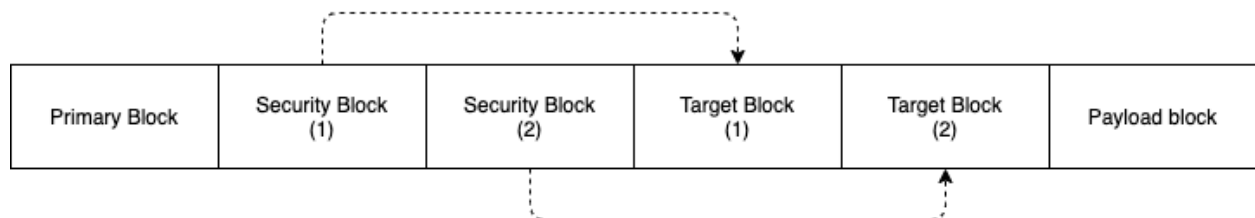


Figure 2-1: BPSec security blocks target other bundle blocks.

2.2.4 BPSec ROLES AND RESPONSIBILITIES

BPSec defines three functions associated with the processing of security operations within security blocks: the security source, security verifier, and security acceptor.

These roles are defined *per security operation*. This means that different security operations in the same bundle might have different security sources, verifiers, and acceptors.

The security source of a security operation is the BPA that added the security block. The source is identified as the Node ID of the BPA. Security sources must ensure that security operations in a security block would not violate any constraints imposed by BPSec.

When a security block contains multiple security operations, all operations share the same security source.

The security verifier of a security operation is one or more BPAs which verify a security operation as a bundle transits through the BPA. If the verification succeeds, the security block(s) remain in the bundle. If the verification fails, the security block and bundle will be processed in accordance with the local BPA security policy.

A given BPA might be identified as a security verifier for some, but not all, of the security operations in a security block. For example, if a security block contains two security operations: *OP(bib-integrity, primary block)* and *OP(bib-integrity, payload block)*, a BPA might be configured as the security verifier for the integrity results over the primary block but not the payload block.

A common use of security verifiers is to verify the integrity and/or authenticity of blocks in a bundle prior to its delivery to its destination. Detecting corrupted data quickly (and removing corrupted bundles early) helps reduce congestion and resource utilization within the network.

The security acceptor of a security operation refers to the single BPA that both verifies and removes a security operation from a bundle. When the last security operation is removed from a security block, the security block is removed from the bundle.

A security acceptor does not have to be the bundle destination. Security operations may be terminated prior to a bundle reaching a destination, particularly when some security results are processed at administrative boundaries in a network.

The bundle destination is considered the default security acceptor for any security operations remaining in a bundle when it reaches its destination.

Figure 2-2 illustrates the operational concepts associated with BPSec. Bundles are created at BN1 and BN2 and received by BN2 and BN3. The BPAs at these nodes serve as the security source, verifier, and acceptor. A BPA may perform multiple functions as shown by BN2 which acts as the security source for bundle 3, security verifier for bundle 2, and security acceptor for bundle 1.

Each security service is added for a target block by a security source and removed by a security acceptor. Some bundles may encounter security verifiers in transit such as bundle 2 at BN2.

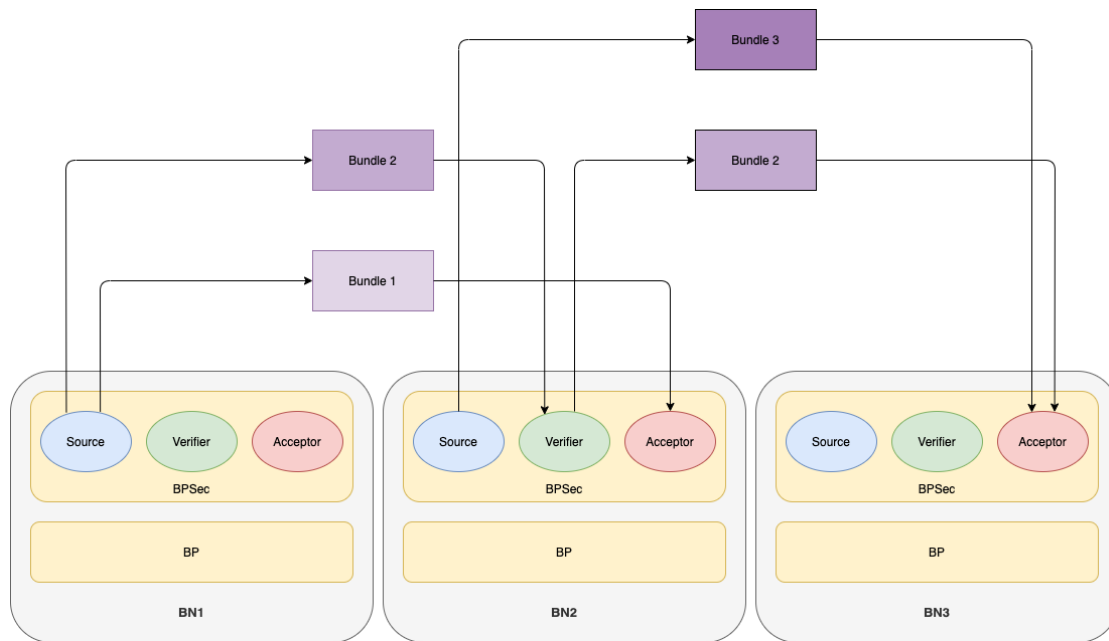


Figure 2-2: BPs May perform multiple security functions

Figure 2-3 illustrates the operations of a security source, verifier, and acceptor on an integrity security block.

At step 1, the security source identifies a target block in the bundle. By policy, integrity must be applied before the bundle is transmitted. At step 2, the security source computes an integrity result and adds it to the bundle in the form of a BPSec block.

Steps 3 and 4 occur at a security verifier. In step 3, the node is identified as the security block security verifier. The security verifier verifies the integrity of the target of the security block at step 4.

Steps 5, 6, and 7 occur at the security acceptor. Step 5 identifies the node as the security block's security acceptor. The integrity of the target block is verified in step 6. The security block is removed from the bundle in step 7.

2.3 NOTABLE FEATURES OF BPSEC

2.3.1 GENERAL

Specifically, BPsec provides the following capabilities.

- a) Security blocks may be added to a bundle by the source BPA or downstream BPAs;
- b) Security blocks may be modified or removed from a bundle by security verifiers and security acceptors;
- c) A security block may represent either a collection of data integrity or a collection of confidentiality security operations;

- d) A security operation may be added to a security block if it represents a unique security operation;
- e) Security mechanisms use a security context that specifies the cipher suite, user parameters for the cipher suite, and any special processing rules related to the use of the cipher suite; and

2.3.2 MULTIPLE SECURITY BLOCKS OF THE SAME BLOCK TYPE MAY EXIST IN A BUNDLE.

2.3.3 BLOCK-LEVEL GRANULARITY

The target block of any security operation is another block in the bundle. The ability to “target” individual blocks enables BPsec to secure information uniquely.

BPsec provides the ability to secure individual target blocks. This requirement is derived from the BPv7 feature allowing extension blocks containing different types of information.

Some blocks carry information about the bundle itself. Other blocks carry application data or annotations related to the application data. Yet other blocks might carry information relevant to the state of the network itself. Block-level granularity allows multiple security services to be applied to blocks with the level(s) of security the target blocks require.

2.3.4 MULTIPLE SECURITY SOURCES

BPsec allows a bundle to contain multiple security blocks from different security sources.

This is a unique provision because blocks might be added to a bundle after the bundle creation and which may need security applied.

BPv7 allows extension blocks to be added to a bundle at any. A downstream node may add a security block to a bundle, in which case that node is the security source for the added security block.

2.3.5 MIXED SECURITY POLICY

BPsec allows different security operations to be governed by different security policies. The determination of security source, security verifier and security acceptor roles are a function of local policy and information resident in the received bundle.

This is a unique ability as it allows elements of policy determination to be driven by security parameters and annotations carried in security blocks within a bundle.

The topology of a DTN might evolve over the lifetime of a bundle such that different nodes along a bundle path have different security capabilities and roles than existed at the time of bundle creation. Therefore, the determination of which BPAs have which security roles is made as part of the configuration of the BPA.

2.3.6 DETERMINISTIC PROCESSING

BPsec ensures that the creation, verification, and acceptance of security services within a bundle always produces deterministic results. To accomplish this, BPsec imposes a strict ordering of operations and restricts features or feature combinations that could endanger this ordering.

3 CCSDS PROFILE OF RFC 9172

3.1 ADOPTION OF MECHANISMS FROM RFC9172

This document adopts the Bundle Protocol Security Protocol as specified in Internet RFC 9172 (Reference [1]), with the constraints and exceptions specific in section 3 of this document.

3.2 USE OF APPROVED SECURITY CONTEXTS

Implementations of this Recommendation shall use security context identifiers (SCIs) that have been assigned by IANA.

SCIs approved by CCSDS are those that are listed in the CCSDS approved security contexts registry.

NOTES

1. IANA assigns BPSec Security Context Identifiers using the registry located at: (<https://www.iana.org/assignments/bundle/bundle.xhtml#bpsec-security-context>). This registry should include a range of context identifiers to be assigned and managed by SANA.
2. Wherever possible, missions should use security contexts that are either approved by the CCSDS or otherwise allocated from the SANA-assigned portion of the BPSec Security Context Identifiers registry.
3. Security contexts are defined in normative specifications, to include the default context provided in Annex E of this document. The appropriateness of a security context for any particular mission use is at the sole discretion of the mission as a function of its own security and threat analysis.
4. Missions may characterize their security requirements as low, medium, or high in accordance with Reference [9]. This characterization refers to the scope of security and associated policy. There is not a direct correlation between a specific security context and a specific mission security characterization.

3.3 USE OF CCSDS-APPROVED KEY MANAGEMENT

Security contexts approved by the CCSDS shall support CCSDS-approved key management mechanisms.

NOTES

1. Key management mechanisms for SANA-Registered security contexts shall conform to Reference [2].

2. Symmetric key management mechanisms for SANA-Registered security contexts shall conform to Reference [3].
3. Key management mechanisms may be specified separate from the definition of a security context in cases where multiple security contexts might use the same key management mechanisms (such as exchanging keys) or in cases where missions may choose to employ different mechanisms based on considerations outside of the scope of the security context itself.

3.4 APPLICATION OF CCSDS POLICY CONSIDERATIONS

The specification and management of security policy on BPAs shall be in conformance with recommended practices outlined in Annex F of this document.

3.5 SANA REGISTRY CONSIDERATIONS

3.5.1 This recommendation does not require the establishment of any new SANA registries, nor the updating of any existing registries.

3.5.2 Security contexts that CCSDS defines for space missions SHOULD be registered with IANA.

4 BPSEC SERVICE DEFINITION

4.1 OVERVIEW

This section provides the service definition for BPSEC.

The definitions of these functions are logical and do not pre-suppose any specific BPA, security context definition, or cipher suite implementation. Function behaviors do not presuppose any configuration approach, policy approach, or method for generating cryptographic material.

This specification allows for the concurrent execution of these functions such that one function can be started prior to some other function completing, regardless of whether these functions operate on different blocks within a bundle or different bundles within the BPA.

The parameters for these functions are documented in an abstract sense and specify the information passed between the BPA entity that calls the function and the BPSEC entity that executes the function. The way in which a specific implementation makes this information available is not constrained by this specification. In addition to the parameters specified in this section, an implementation may provide other parameters on the function interface (e.g., parameters for controlling the service, monitoring performance, diagnosis, and so on).

4.2 BPSEC SERVICES

BPSEC shall provide the following services:

- (a) ApplyBIB
- (b) ApplyBCB
- (c) VerifyBIB
- (d) VerifyBCB
- (e) AcceptBIB
- (f) AcceptBCB

4.3 SUMMARY OF PRIMITIVES

4.3.1 THE BPSEC SERVICE SHALL CONSUME THE FOLLOWING REQUEST PRIMITIVES:

- ApplyBIB.request
- ApplyBCB.request
- VerifyBIB.request
- VerifyBCB.request

4.3.2 THE BPSEC SERVICE SHALL PROVIDE THE FOLLOWING INDICATION PRIMITIVES:

- ApplyBIB.indication
- ApplyBCB.indication
- VerifyBIB.indication
- VerifyBCB.indication
- AcceptBIB.indication
- AcceptBCB.indication

4.4 SUMMARY OF PARAMETERS

4.4.1 TARGET BUNDLE

The Target Bundle parameter shall consist of the bundle containing one or more blocks for which a BPsec service is being requested. The calling BPA must be the BPA identified as the security source for security blocks being added.

4.4.2 TARGET BLOCK IDENTIFIERS

The Target Block Identifiers parameter uniquely identifies the target block(s) within the target bundle being used by the ApplyBIB or ApplyBCB functions.

4.4.3 MODIFIED BUNDLE

Modified bundles are returned as results of security operations that add or remove security blocks from bundles. The modified bundle is a copy of the target bundle that includes any changes made by the BPsec service.

4.4.4 NEW BIB BLOCK ID

The block ID of the BIB block added as a result of an ApplyBIB.request.

4.4.5 NEW BCB BLOCK ID

The block ID of the BCB block added as a result of an ApplyBCB.request.

4.4.6 SECURITY CONTEXT IDENTIFIER

The Security Context Identifier parameter shall identify the security context used to generate cryptographic material associated with the ApplyBIB and ApplyBCB functions.

NOTE – In the context of ApplyBCB, this parameter must reference an “authenticated encryption with associated data” (AEAD) cipher suite.

4.4.7 SECURITY CONTEXT PARAMETERS

The Security Context Parameters parameter shall consist of a set of parameters associated with the security context identified by the Security Context Identifier. These parameters must be provided as inputs to the algorithms used to produce cryptographic material for the bundle.

NOTE – In addition to being input to the suite of algorithms, some of these parameters may also be recorded in the BPsec security blocks added to the bundle for use by downstream security verifiers and security acceptors.

4.4.8 LOCAL SECURITY CONTEXT PARAMETERS

The Local Security Context Parameters parameter shall consist of the information configured at a security verifier BPA for the security context specified in the security block identified in the Security Block parameter. These local security context parameters must be provided as inputs to the security context used to verify the integrity or confidentiality of the target block.

NOTE – The security block’s security context parameters and Local Security Context Parameters may provide conflicting values for the same parameter. When such conflicts exist, local node policy must specify how conflicts are resolved.

4.4.9 SECURITY SOURCE

The Security Source shall consist of the Endpoint identifier (EID) of the node that is inserting the security block into the bundle.

4.4.10 VERIFY RESULT

The result of the verifyBIB and verifyBCB requests, the verify result indicates whether the verification operations passed or failed.

4.5 CCSDS BPSEC SERVICE PRIMITIVES

4.5.1 OVERVIEW

A security block is added to a bundle by the BPA serving as the security source for that block. Each security block may contain one or more related security operations, with each security operation applied to a different target block in the bundle. The BPSEC defines two security blocks: BIB and BCB, and these blocks are added to a bundle using two functions: ApplyBIB and ApplyBCB.

4.5.2 ApplyBIB.request

4.5.2.1 Function

The ApplyBIB.request primitive shall be used to apply a BIB integrity operation to one or more target blocks in a bundle.

All blocks that are targets of the BIB operation must be present in the target bundle before invoking ApplyBIB.request.

4.5.2.2 Semantics

ApplyBIB.request shall provide parameters as follows:

ApplyBIB.request(target bundle, target block list, security context, security context parameters)

4.5.2.3 When Generated

This function shall be invoked on a BPA when local security policy determines that the BPA is the security source of a bib-integrity service for one or more target blocks in the bundle.

4.5.2.4 Effect on Receipt

When invoked, this function shall provide all input parameters to the selected security context, capture the results generated by the security context, and insert the results into the target bundle in the form of a new security block.

The modified target bundle (with the new BIB block) shall be returned to the caller in the ApplyBIB.indication.

4.5.2.5 Discussion - Additional Comments

None

4.5.2.6 APPLYBCB.REQUEST

4.5.2.7 Function

The ApplyBCB.request primitive shall be used to apply a BCB integrity operation to one or more target blocks in a bundle.

All blocks that are targets of the BCB operation must be present in the target bundle before invoking ApplyBIB.request.

4.5.2.8 Semantics

ApplyBCB.request shall provide parameters as follows:

ApplyBCB.request(target bundle, target block list, security context, security context parameters)

4.5.2.9 When Generated

This function shall be invoked on a BPA when local security policy determines that the BPA is the security source of a bcb-confidentiality service for one or more target blocks in the bundle.

4.5.2.10 Effect on Receipt

When invoked, this function shall provide all input parameters to the selected security context, capture the results generated by the security context, and insert these results into the bundle in the form of a new security block.

When the ApplyBIB Function has completed the processing, it shall return the modified bundle with the new BCB block and any other changes via the ApplyBIB.indication.

4.5.2.11 Discussion - Additional Comments

None

4.5.3 APPLYBIB.RETURN

4.5.3.1 Function

The ApplyBIB.return primitive shall be used to provide the BPA the contents of the bundle after the requested BIB security operation has been applied.

4.5.3.2 Semantics

ApplyBIB.return shall provide parameters as follows:

ApplyBIB.return(modified bundle, new BIB block id)

4.5.3.3 When Generated

ApplyBIB.return shall be generated by the BPSec service once the requested BIB security operation has been applied to the target bundle and the contents of the modified bundle have been computed.

4.5.3.4 Effect on Receipt

The effect on receipt of ApplyBIB.return by the BPA is undefined.

4.5.3.5 Discussion - Additional Comments

None

4.5.4 ApplyBCB Return

4.5.4.1 Function

The ApplyBCB.return primitive shall be used to provide the BPA the contents of the bundle after the requested BCB security operation has been applied.

4.5.4.2 Semantics

ApplyBCB.return shall provide parameters as follows:

ApplyBCB.return(modified bundle, new BCB block id)

4.5.4.3 When Generated

ApplyBCB.return shall be generated by the BPsec service once the requested BCB security operation has been applied to the target bundle and the contents of the modified bundle have been computed.

4.5.4.4 Effect on Receipt

The effect on receipt of ApplyBCB.return by the BP application is undefined.

4.5.4.5 Discussion - Additional Comments

None

4.5.5 VERIFYBIB.REQUEST

4.5.5.1 Function

The VerifyBIB.request primitive shall be used to verify a particular BIB.

4.5.5.2 Semantics

VerifyBIB.request shall provide parameters as follows:

VerifyBIB.request(target blocks, BIB to verify, security context, local security context parameters)

4.5.5.3 When Generated

VerifyBIB.request shall be generated by a BPA that is configured to be a security verifier for the particular BIB instance provided.

4.5.5.4 Effect on Receipt

When invoked, VerifyBIB provides all input parameters to the selected security context, captures the results generated by the security context, determines if the integrity verification succeeded, and generates a VerifyBIB.indication.

4.5.5.5 Discussion - Additional Comments

None

4.5.6 VerifyBCB.request

4.5.6.1 Function

The VerifyBCB.request primitive shall be used to verify a particular BCB.

4.5.6.2 Semantics

VerifyBCB.request shall provide parameters as follows:

VerifyBCB.request(target blocks, BCB to verify, security context, local security context parameters)

4.5.6.3 When Generated

VerifyBCB.request shall be generated by a BPA that is configured to be a security verifier for the particular BCB instance provided.

4.5.6.4 Effect on Receipt

When invoked, VerifyBCB provides all input parameters to the selected security context, captures the results generated by the security context, determines if the confidentiality verification succeeded, and generates a VerifyBCB.indication.

4.5.6.5 Discussion - Additional Comments

None

4.5.7 VerifyBIB.indication

4.5.7.1 Function

The VerifyBIB.indication primitive shall be used to verify a particular BIB.

4.5.7.2 Semantics

VerifyBIB.indication shall provide parameters as follows:

VerifyBIB.indication(verify result)

4.5.7.3 When Generated

VerifyBIB.indication shall be generated by a CCSDS BPSec implementation once it has verified a particular BIB.

4.5.7.4 Effect on Receipt

The effect on receipt of VerifyBIB.indication by the BP application is undefined.

4.5.7.5 Discussion - Additional Comments

None

4.5.8 VerifyBCB.indication

4.5.8.1 Function

The VerifyBCB.indication primitive shall be used to verify a particular BCB.

4.5.8.2 Semantics

VerifyBCB.indication shall provide parameters as follows:

VerifyBCB.indication(verify result)

4.5.8.3 When Generated

VerifyBCB.indication shall be generated by a CCSDS BPSec implementation once it has verified a particular BCB.

4.5.8.4 Effect on Receipt

The effect on receipt of VerifyBCB.indication by the BP application is undefined.

4.5.8.5 Discussion - Additional Comments

None

4.5.9 AcceptBIB.request

4.5.9.1 Function

The AcceptBIB.request primitive shall be used by a security acceptor to verify the integrity of security operations within the BIB for which the BPA is configured as a security acceptor

4.5.9.2 Semantics

AcceptBIB.request shall provide parameters as follows:

AcceptBIB.request(target bundle, BIB to verify, security context, local security context parameters)

4.5.9.3 When Generated

AcceptBIB.request shall be generated by a CCSDS BPSec implementation that is a security acceptor for a bundle containing the BIB to verify.

4.5.9.4 Effect on Receipt

When invoked, AcceptBIB provides all input parameters to the selected security context, captures the results generated by the security context, determines if the confidentiality verification succeeded, and generates a AcceptBIB.indication.

4.5.9.5 Discussion - Additional Comments

None

4.5.10 AcceptBCB.request

4.5.10.1 Function

The AcceptBCB.request primitive shall be used by a security acceptor to verify the integrity of security operations within the BCB for which the BPA is configured as a security acceptor

4.5.10.2 Semantics

AcceptBCB.request shall provide parameters as follows:

AcceptBIB.request(target bundle, BCB to verify, security context, local security context parameters)

4.5.10.3 When Generated

AcceptBCB.request shall be generated by a CCSDS BPSec implementation that is a security acceptor for a bundle containing the BCB to verify.

4.5.10.4 Effect on Receipt

When invoked, AcceptBCB.request provides all input parameters to the selected security context, captures the results generated by the security context, determines if the confidentiality verification succeeded, and generates a AcceptBCB.indication. If the verification succeeded the AcceptBCB.indication will include decrypted versions of any encrypted blocks.

4.5.10.5 Discussion - Additional Comments

None

4.5.11 AcceptBIB.indication

4.5.11.1 Function

The AcceptBIB.indication primitive shall be used to verify a particular BIB.

4.5.11.2 Semantics

AcceptBIB.indication shall provide parameters as follows:

AcceptBIB.indication(verify result, modified bundle)

The modified bundle shall be such that accepted security operations are removed from the BIB and, if all security operations are removed from a BIB, that the BIB is removed from the bundle.

4.5.11.3 When Generated

AcceptBIB.indication shall be generated by a CCSDS BPSec implementation once it has completed processing of an AcceptBIB.request.

4.5.11.4 Effect on Receipt

The effect on receipt of AcceptBIB.indication by the BP application is undefined.

4.5.11.5 Discussion - Additional Comments

None

4.5.12 AcceptBCB.indication

4.5.12.1 Function

The AcceptBCB.indication primitive shall be used to verify a particular BCB.

4.5.12.2 Semantics

AcceptBCB.indication shall provide parameters as follows:

AcceptBCB.indication(verify result, modified bundle)

The modified bundle shall differ from the target bundle of the corresponding AcceptBIB.request in two ways:

1. Accepted security operations shall be removed from the BCB and, if all security operations are removed from a BCB, the BCB will be removed from the bundle.
2. The target blocks of the confidentiality service shall be modified based on whether confidentiality was successfully removed. If confidentiality removal was successful, the cipher text contents of the target blocks will be replaced by the plain text outputs from the security context. If confidentiality removal was not successful, the target block will be removed from the bundle.

4.5.12.3 When Generated

AcceptBCB.indication is generated by a CCSDS BPsec implementation once it has completed processing of an AcceptBCB.request.

4.5.12.4 Effect on Receipt

The effect on receipt of AcceptBCB.indication by the BP application is undefined.

4.5.12.5 Discussion - Additional Comments

None

PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT (PICS) PROFORMA

(NORMATIVE)

A1 INTRODUCTION

A1.1 OVERVIEW

This annex provides the Implementation Conformance Statement (ICS) Requirements List (RL) for an implementation of [Specification]. The ICS for an implementation is generated by completing the RL in accordance with the instructions below. An implementation claiming conformance must satisfy the mandatory requirements referenced in the RL.

A1.2 ABBREVIATIONS AND CONVENTIONS

The RL consists of information in tabular form. The status of features is indicated using the abbreviations and conventions described below.

Item Column

The item column contains sequential numbers for items in the table.

Feature Column

The feature column contains a brief descriptive name for a feature. It implicitly means ‘Is this feature supported by the implementation?’

Status Column

The status column uses the following notations:

- M mandatory;
- O optional;
- C conditional;
- X prohibited;
- I out of scope;
- N/A not applicable.

Support Column Symbols

The support column is to be used by the implementer to state whether a feature is supported by entering Y, N, or N/A, indicating:

- Y Yes, supported by the implementation.
- N No, not supported by the implementation.
- N/A Not applicable.

The support column should also be used, when appropriate, to enter values supported for a given capability.

A1.3 INSTRUCTIONS FOR COMPLETING THE RL

An implementer shows the extent of compliance to the Recommended Standard by completing the RL; that is, the state of compliance with all mandatory requirements and the options supported are shown. The resulting completed RL is called an ICS. The implementer shall complete the RL by entering appropriate responses in the support or values supported column, using the notation described in A1.2. If a conditional requirement is inapplicable, N/A should be used. If a mandatory requirement is not satisfied, exception information must be supplied by entering a reference X_i , where i is a unique identifier, to an accompanying rationale for the noncompliance.

A2 PICS PROFORMA FOR CCSDS BUNDLE PROTOCOL SECURITY

A2.1 GENERAL INFORMATION

A2.1.1 Identification of ICS

Date of Statement (DD/MM/YYYY)	
ICS serial number	
System Conformance statement cross-reference	

A2.1.2 Identification of Implementation Under Test

Implementation Name	
Implementation Version	
Special Configuration	
Other Information	

A2.1.3 Identification of Supplier

Supplier	
Contact Point for Queries	
Implementation Name(s) and Versions	
Other information necessary for full identification, e.g., name(s) and version(s) for machines and/or operating systems; System Name(s)	

A2.1.4 Identification of Specification

[CCSDS Document Number]	
Have any exceptions been required?	Yes [] No []
NOTE – A YES answer means that the implementation does not conform to the Recommended Standard. Non-supported mandatory capabilities are to be identified in the ICS, with an explanation of why the implementation is non-conforming.	

A2.2 REQUIREMENTS LIST

Classes				
Item	Description	Reference	Status	Support
1	BPsec Support	4.1.1.1	O	

PDUs								
Item	PDU	Ref.	Sender End-System		Receiver End-System		Relay	
			Status	Support	Status	Support	Status	Support
2	CBF	4.1.2	M		M			
3	ASB	4.1.3	M		M		C1	
4	BIB	4.1.4	O.1		O.1		O	
5	BCB	4.1.5	O.1		O.1		N/A	

O.1: At least one of these options must be supported if BPsec support is provided.

C1: If intermediate BIB verification is supported on a relay then the relay must be able to parse the Abstract Security Block Structure.

Parameters of GSBS-PDU						
Item	Parameter	Ref.	Status	Support	Values	
					Allowed	Supported
6	Number of security targets	4.1.3.2.1	M		>= 1	
7	Optional cipher suite parameters	4.1.3.2.5, 4.1.8	M		0-1, 3-5, 7-8	

DRAFT RECOMMENDED STANDARD FOR BUNDLE PROTOCOL SECURITY

Security Processing				
Item	Description	Reference	Status	Support
8	Canonicalization	4.2.2	M	
9	BCB Decryption	4.2.3.2.1, 4.2.3.2.2, 4.2.3.2.3, 4.2.3.2.4, 4.2.3.2.6, 4.2.3.2.7	M	
10	BCB Status Reports	4.2.3.2.5	O	
11	BIB Reception	4.2.3.3.1, 4.2.3.3.3, 4.2.3.3.4, 4.2.3.3.6, 4.2.3.3.8	M	
12	BIB Optional Checking	4.2.3.3.2	O	
13	BIB Discard if no Primary Block Left	4.2.3.3.5	O	
14	BIB Send Status Report on Failure	4.2.3.3.7	O	

Fragmentation and Reassembly				
Item	Description	Reference	Status	Support
15	Fragmentation	4.2.4.1, 4.2.4.2	M	

Payload-Level Security				
Item	Description	Reference	Status	Support
16	Use of CMS on payload	4.2.5.1	O	
16.1	CMS format and processing	4.2.5.3, 4.2.5.4, 4.2.5.5, 4.2.5.6, 4.2.5.7	c:m	

SECURITY, SANA, AND PATENT CONSIDERATIONS

(INFORMATIVE)

B1 SECURITY CONSIDERATIONS

B1.1 SCOPE

BPsec addresses the security of blocks within a bundle and does not address the security of the underlying network. It may be necessary to apply security services at multiple layers within the protocol stack, to account for distributed processing and cross-support, to account for different classes of data or end users, or to account for protection of data during unprotected portions of the complete end-to-end transmission (e.g., across ground networks). The specification of security services at other layers is outside the scope of this document.

BPsec does not address the fitness of externally defined cryptographic methods nor the security of their implementation. It is the responsibility of the BPsec implementer to choose appropriate algorithms and methods. It is the responsibility of the BPsec implementer to ensure that any cryptographic material, including shared secret or private keys, is protected against access within both memory and storage devices.

B1.2 SECURITY CONCERNS

B1.2.1 General

Security concerns informing the design of BPsec are addressed in more detail in references [C1] and [C6]. References [C1] and [C6] additionally contain information regarding the choice of services and where they can be implemented. Reference [2] contains information regarding the choice of particular cryptographic algorithms.

This section discusses security threats that BPsec will face and describes how BPsec can mitigate these threats. The threat model described here is assumed to have a set of capabilities identical to those described by the Internet Threat Model (reference [C3]), but the BPsec threat model is scoped to illustrate threats specific to BPsec operating within DTN environments and therefore focuses on on-path-attackers (OPAs). Reference [C4] describes security threats against space missions.

B1.2.2 Data Privacy

Malicious nodes may examine the contents of a bundle and attempt to recover protected data or cryptographic keying material from the blocks contained within. The BPsec BCB protects

against this action by enciphering the contents of its target block thereby providing data privacy via a confidentiality service.

Malicious nodes may continue to examine bundles offline in an attempt to recover encrypted data. The security contexts used by the BCB should be selected to provide suitable protection over the useful lifetime of the information being protected.

To provide verifiable integrity checks, the security contexts used by the BCB should utilize encryption schemes that are “indistinguishable under adaptive chosen cipher text attack” (IND-CCA2) secure. Such schemes guard against signature substitution.

Irrespective of whether BPsec is used, traffic analysis will be possible.

B1.2.3 Data Integrity

Malicious nodes may modify blocks within a bundle, to include replacing existing blocks, adding new blocks, and removing blocks. BPsec can detect these activities using both the BIB and BCB blocks, depending on whether plain text or cipher text integrity is required.

The integrity mechanisms used by the BIB and BCB should be strong against collision attacks and malicious nodes should be prevented from accessing the cryptographic material used by the security source. If these conditions can be met, malicious nodes will be unable to modify the target block without being detected.

BPsec does not support an in-bundle mechanism to detect (or correct) cases where a malicious node removes a block from a bundle. If a target block is removed, then any security block associated with that target block will fail to validate. If a security block is removed from the bundle, some other policy must be in place at the security verifier or security acceptor to note that a security block was expected to exist in the bundle.

The implementation of BPsec must be combined with a policy configuration at BPAs which describes the expected and required security operations that must be applied to, or expected to be present for, blocks in bundles processed by the BPA. Further discussion of BPsec policy is found in Annex F.

B1.2.4 Authentication of Communicating Entities

BPsec does not provide a service for authentication of communicating entities. This authentication can be accomplished by combining BPsec services with other components, such as encapsulation.

B1.2.5 Control of Access to Resources

Resource access controls are not directly addressed by this specification.

B1.2.6 Availability of Resources

No mechanisms are defined in this specification to verify or assist with the verification of availability of resources.

B1.2.7 Auditing of Resource Usage

No mechanisms are defined in this specification to audit or assist with the auditing of resource usage by the protocol.

B1.3 CONSEQUENCES OF NOT USING BPSec

If BPSec is not used, bundle delivery must rely on security measures provided by the convergence layer adapter(s) and/or lower layers. For space applications these alternative security measures may be non-existent or shared across a large group of applications and application domains.

The consequence of not using BPSec is that bundle exchange has to rely on security mechanisms either at the link layer or the application layer. Link-layer security might be present on some links and not on others.

B1.4 SANA CONSIDERATIONS

B1.4.1 General

The recommendations of this document request SANA to create or update the registries in this section.

B1.4.2 Security Context Identifiers Registry

B1.5 PATENT CONSIDERATIONS

There are no known patents covering Bundle Protocol Security as described in this document and its normative references.

INFORMATIVE REFERENCES

(INFORMATIVE)

- [C1] *Security Architecture for Space Data Systems*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 351.0-M-1. Washington, D.C.: CCSDS, November 2012.
- [C2] *Security Guide for Mission Planners*. Issue 2. Report Concerning Space Data System Standards (Green Book) CCSDS 350.7-G-2. Washington, D.C.: CCSDS April 2019.
- [C3] E. Rescorla and B. Korver. *Guidelines for Writing RFC Text on Security Considerations*. RFC 3552. Reston, Virginia: ISOC, July 2003.
- [C4] *Security Threats against Space Missions*. Issue 2. Report Concerning Space Data System Standards (Green Book) CCSDS 350.1-G-2. Washington, D.C.: CCSDS, December 2015.
- [C5] *Information Processing Systems—Open Systems Interconnection—Basic Reference Model—Part 2: Security Architecture*. International Standard, ISO 7498-2:1989. Geneva: ISO, 1989. 2015.
- [C6] *The Application of Security to CCSDS Protocols*. Issue 3. Report Concerning Space Data System Standards (Green Book) CCSDS 350.0-G-3. Washington, D.C.: CCSDS, March 2019.
- [C8] E. Birrane and S. Heiner. *Security Context Template*. Work in Progress. draft-birrane-ietf-dtn-scot-00. July 2020.
- [C9] E. Birrane and S. Heiner. *Towards an Interoperable Security Policy for Space-Based Internetworks*. IEEE Space Computing Conference. August 2021.
- [C10] E. Birrane and S. Heiner. *A Novel Approach to Transport-Layer Security for Spacecraft*. Smallsat Conference. 2020.

ABBREVIATIONS

(INFORMATIVE)

<u>Term</u>	<u>Meaning</u>
BCB	Block confidentiality block
BIB	Block integrity block
BP	Bundle Protocol
BPA	Bundle Protocol agent
BPSec	Bundle Protocol Security
DTN	Delay-Tolerant Networking
EID	endpoint identifier
IETF	Internet Engineering Task Force
IV	initialization vector
OPA	on path attacker
RFC	Request for Comments
RL	requirements list

ANNEX D

CCSDS PROFILE OF DEFAULT IANA SECURITY CONTEXTS

(NORMATIVE)

D1 OVERVIEW

A default set of BPSec security contexts that can be used for integrity and confidentiality security operations has been defined in Reference [C7].

D2 CCSDS USE OF SECURITY CONTEXTS FROM RFC9172

D2.1 For the purposes of interoperability testing, implementations shall use security contexts defined in RFC9172.

D2.2 Missions are not required to implement the security contexts defined in RFC9172.

NOTE: CCSDS intends to define a set of security contexts for space missions; those documents will state whether implementation of those contexts by missions is mandatory or not.

ANNEX E

BUNDLE PROTOCOL SECURITY MANAGED INFORMATION**(NORMATIVE)****E1 OVERVIEW**

Managed parameters are those parameters provided by management rather than being included in BPsec blocks. Because BP bundles may be stored in a network for extended periods of time, parameters that identify the state of the network must be provided by management as part of the policy or technical configuration of BPAs in the network.

BP networks cannot assume timely, reliable, end-to-end data exchange. Parameters associated with a specific instance of an integrity or confidentiality function input or output must be provided inline in a BPsec block.

BPsec blocks may specify different security contexts. These contexts may have different input parameters and some of these input parameters may be managed parameters.

E2 MANAGED PARAMETERS

BPsec managed parameters are those parameters that are independent of the security contexts used to generate cryptographic materials. The managed parameters used for BPsec shall be those listed in table E.1.

NOTES:

- The detailed specification of some managed parameters must occur in the context of a specific security context. Such detail is not provided here.
- These parameters are defined in an abstract sense, and are not intended to imply any particular implementation of a management system.

Table E-1 BPsec Managed Parameters

Managed Parameter	Allowed Values	Defined in Reference
Local BPA parameters used to process BPsec blocks.		
Bundle Node Security Roles	Security Source Security Verifier Security Acceptor	This document
Supported Cipher Suites	Integer, Agency-Specific	
Expected security blocks	Block Type(s)	

Known Cipher Suite Keys	Algorithm-specific, Agency-Specific	
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E3 BPSEC APPLICATION DATA MODEL

The information elements described in section E3.2 below shall be maintained by a CCSDS BPsec implementation. How these values are requested / conveyed by any particular network management system is not defined here.

Name	Type	Parameters	Description
num_good_tx_sec_blk	Unsigned integer	Block type (BIB, BCB, Both)	Total successfully transmitted security blocks
num_bad_tx_sec_blk	Unsigned integer	Block type (BIB, BCB, Both)	Total unsuccessfully transmitted security blocks
num_good_rx_sec_blk	Unsigned integer	Block type (BIB, BCB, Both)	Total successfully received security blocks
num_bad_rx_sec_blk	Unsigned integer	Block type (BIB, BCB, Both)	Total unsuccessfully received security blocks
num_missing_rx_sec_blks	Unsigned integer	Block type (BIB, BCB, Both)	Total missing-on-RX security blocks
num_fwd_sec_blks	Unsigned integer	Block type (BIB, BCB, Both)	Total forwarded security blocks
num_good_tx_sec_bytes	Unsigned integer	Block type (BIB, BCB, Both)	Total successfully transmitted security blocks

num_bad_tx_sec_bytes	Unsigned integer	Block type (BIB, BCB, Both)	Total unsuccessfully transmitted security block bytes
num_good_rx_sec_bytes	Unsigned integer	Block type (BIB, BCB, Both)	Total successfully received security block bytes
num_bad_rx_sec_bytes	Unsigned integer	Block type (BIB, BCB, Both)	Total unsuccessfully received security block bytes
num_missing_rx_sec_bytes	Unsigned integer	Block type (BIB, BCB, Both)	Total missing-on-Rx security block bytes
num_fwd_sec_bytes	Unsigned integer		Total forwarded security block bytes
last_update_src	Time	Security source	Last BPSEC update
last_reset	Time	Security source	Last reset

E4 SECURITY CONTEXT MANAGED PARAMETERS

E4.1 Security Context Managed Parameters

The managed parameters of a specific security context definition must be provided in the specification of the security context.

NOTE – Security context managed parameters are those parameters associated with the security context of a BPSEC block, but managed and provided by the BPAs comprising the security source, security verifier (as appropriate) and security source of the security block as part of their local security context parameters.