The Consultative Committee for Space Data Systems

Draft Recommendation for
Space Data System Standards

SPACECRAFT ONBOARD INTERFACE SERVICES—RFID TAG ENCODING SPECIFICATION

PROPOSED DRAFT RECOMMENDED STANDARD

CCSDS 881.1-R-0

PROPOSED RED BOOK

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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 881.1-R-0	Spacecraft Onboard Interface Services—RFID Tag Encoding Specification, Proposed Draft Recommended Standard, Issue 0	March 2015	Current draft

CONTENTS

CONTENTS (continued)

1 INTRODUCTION

1.1 PURPOSE

This document provides a Recommended Standard for the utilization of Radio Frequency Identification (RFID) protocol and communication standards in support of inventory management activities associated with space missions. Relevant technical background information can be found in *Wireless Network Communications Overview for Space Mission Operations* (reference [D1]) and in *RFID-Based Inventory Management systems* (reference [D2]).

The recommended standards contained in this report enable member agencies to select the best option(s) available for interoperable RFID-based tag encoding in the support of inventory management applications. The specification of a Recommended Standard facilitates interoperable communications and forms the foundation for cross-support of information systems between separate member space agencies.

1.2 SCOPE

This Recommended Standard is targeted towards providing an augmented namespace definition in support of RFID-based applications.

1.3 APPLICABILITY

This Recommended Standard specifies protocols that enable interoperable wireless inventory management systems that utilize RFID technologies.

NOTE – Inclusion of any specific wireless technology does not constitute any endorsement, expressed or implied, by the authors of this Recommended Standard or the agencies that supported the composition of this Recommended Standard.

1.4 RATIONALE

From an engineering standpoint, mission managers, along with engineers and developers, are faced with a plethora of wireless communication choices, both standards-based and proprietary. A CCSDS RFID tag encoding Recommended Standard provides guidance in the selection of naming conventions necessary to achieve interoperable information exchange in support of RFID-based applications.

1.5 DOCUMENT STRUCTURE

This document provides a normative recommendation for an RFID naming schema that supports the expanded operations of International Space Station (ISS) inventory management systems. More information on space mission use cases addressed by RFID technology can be found in annex E of reference [D2].

Section 2 provides an overview of the basis for the tag encoding.

Section 3 provides a normative description for the recommended standard tag encoding schema.

Annex A provides the Implementation Conformance Statement (ICS) proforma.

Annex B discusses security, Space Assigened Numbers Authority (SANA), and patent considerations pertaining to RFID-based inventory management systems.

Annex C provides an informative tag-encoding example.

Annex D is a list of informative references.

Annex E is a glossary of abbreviations used in this document.

1.6 CONVENTIONS

1.6.1 BIT NUMBERING CONVENTION AND NOMENCLATURE

In this document, the following convention is used to identify each bit in an *N*-bit field. The first bit in the field is defined to be ‘bit *N*-1; the following bit is defined to be ‘bit *N*-2’, and so on up to ‘bit 0’, as shown in figure 1-1.

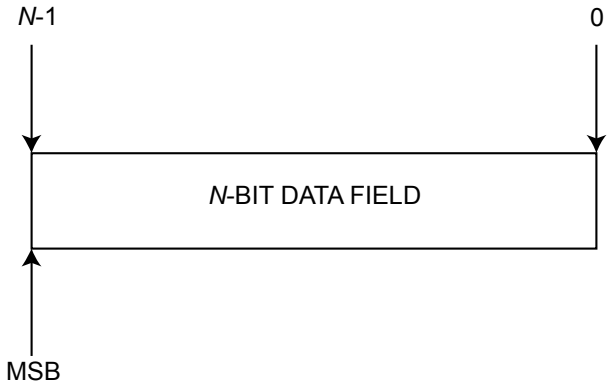

Figure 1-1: Bit Numbering Convention

In accordance with modern data communications practice, spacecraft data fields are often grouped into 8-bit ‘bytes’, which conform to the above convention.

1.6.2 NOMENCLATURE

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.

1.6.3 INFORMATIVE TEXT

In the normative section of this document (section 3), informative text is set off from the normative specifications either in notes or under one of the following subsection headings:

– Overview;

– Background;

– Rationale;

– Discussion.

1.7 ACRONYMS

A glossary of terms including common acronyms is provided in annex E.

2 OVERVIEW

2.1 GENERAL

This Recommended Standard specifies tag-encoding options that augment, yet remain compatible with, a legacy ISS Inventory Management System (IMS) tag encoding scheme established for early flight experiments. This standard will enable more efficient, flexible, and expanded utilization of RFID technology for applications such as Autonomous Logistics Management (ALM) on ISS. The tag encoding schema will allow various multinational operational and experimental applications, including inventory and asset management, sensors, and navigation assistance onboard ISS as a precursor to a more advanced standard for exploration.

2.2 TAG FIELD DESCRIPTIONS

The fields in the proposed standard are designed to represent a hierarchy of information, in which the values encoded in each successive field in the hierarchy may be re-used within different levels of the hierarchy. The order of hierarchical field structure, from most significant to least significant is

{Database ID, Owner ID, Program ID, Object ID, Serial ID}.

Figure 2-1 illustrates how the current IMS tag encoding schema maps onto the hierarchical field structure.

Owner / Program name	Database ID	Owner ID	Program ID		Unique ID (Seria Number ID)					Owner ID	Object ID	
	byte 0	*byte 1*	*byte 2*	*byte 3*	*byte 4*	*byte 5*	*byte 6*	*byte 7*	*byte 8*	*byte 9*	*byte 10*	*byte 11*
IMS	I	X	C	P						J		
IMS Russian	I	X	0	0						R		
coffee	I	X	F	2								
coffee	I	X	F	3								
food BOB	I	X	F	E								
SF Tucker/Kimmel	I	H	R	F						J		
CHeCS BPECG hardwar	I	X	C	B						J		
SF Water Kits	I	X	W	M	S					J		
SD4 Bara medical	M	H	M	S								
MCT Sam Hussey/GRC	M	M	C	T								
EV4 testing	I	E	V	J								
R2 testing	I	R	2	T	E	S	T					
		<---	B	A	R	C	O	D	E	--->		

Figure 2-1: IMS RFID Tag Encoding Schema

The field designated as Database ID, which comprises Byte 0, is intended to represent the organization responsible for defining and administering the namespace to which the tag belongs. This field is the most significant field in the hierarchical structure of the RFID naming convention, and as such, it is mandatory to use only values designated in the SANA registry for this standard. Strictly speaking, a namespace owner need not maintain the

remainder of the recommended hierarchical structure of the standard, and as such, SANA registries are not required for the remaining fields in the standard. In the current ISS utilization, the Database ID is identified with the particular database in which the tagged item is recorded and tracked. Currently only the values 'I' (Inventory Management System) and 'M' (Medical) are utilized.

The field designated as Owner ID, which comprises Bytes 1 and 9, is intended to represent the organization that owns the physical asset to which the tag is attached. This field is the second most significant field in the hierarchical structure specified in this standard. This implies that tags with different Database ID designations may reuse and redefine Owner ID values utilized within other Database ID designations. Alternatively, a SANA registry can optionally be maintained to define Owner ID values that are common across all Database ID designations. In the current ISS utilization, Byte 9 may actually represent either a part of the Serial ID or a part of the Owner ID. That is, if Byte 9 is a number [0-9], then it represents Byte 6 of an extended (6-byte) Serial ID. On the other hand, if Byte 9 is not a number but a character [A-Z] then it represents Byte 2 of the 2-byte Owner ID.

The field designated as Program ID, which comprises Bytes 2 and 3, is intended to represent sub-organizations (such as programs) of the owner organization. This field is the third most significant field in the hierarchical RFID naming conventions specified in this standard. This implies that tags with different {Database ID, Owner ID} designations may reuse and redefine Program ID values utilized within other Database ID designations. Alternatively, a SANA registry can optionally be maintained to define {Owner ID, Program ID} values that are common across all Database ID designations.

The field designated as Object ID, which comprises Bytes 10 and 11, is intended to represent classes of objects (e.g., medical equipment, food, tool, etc.) to which RFID tags will be affixed. This field is the fourth most significant field in the hierarchical RFID naming conventions specified in this standard. This implies that tags with different {Database ID, Owner ID, Program ID} designations may reuse and redefine Object ID values utilized within other Database ID designations. Values in the range

[0 : 32767]

can be assigned at the database manager's discretion; values in the range

[32768 : 65535]

will be maintained in a SANA registry to promote tracking of common items across unique databases.

The field designated as Serial ID, which comprises Bytes 4 through 8, is intended to represent unique objects to which RFID tags will be affixed. This field is the least significant field in the hierarchical RFID naming conventions specified in this standard. This implies that tags with different {Database ID, Owner ID, Program ID, Object ID} designations may reuse and redefine Serial ID values utilized within other Database ID designations.

2.3 EVOLUTION OF THE BOOK

This Recommended Standard addresses RFID tag encoding for inventory management applications. As space-related applications arise that cannot be fulfilled based on the recommendations of this Recommended Standard, evolution of this book will be considered. Methods to extend or adapt previous recommendations will be considered with preference over adoption of new standards, providing the resulting performance and cost are advantageous relative to those associated with adoption of one or more new standards.

3 RFID TAG ENCODING RECOMMENDED STANDARD

3.1 OVERVIEW

This section presents the recommended standard naming specification for RFID tag encoding (96-bit) RFID tags to provide the basis for information interoperability.

The Recommended Standard pertains to RFID systems that provide stored data only, as opposed to sensor telemetry. Applications are considered where no direct active tag power is required, which necessitates short-range communication and Interrogator-Talk-First (ITF) protocols. (See references [D1] and [D2] for supporting technical background.)

Figure 3-1 depicts the logical layout of the 96-bit RFID tag name (ID), and figure 3-2 shows the bit-wise mappings of the fields; while table 3-1 defines the 5 proposed logical data fields encoded on each tag and the allowable range of values for each field.

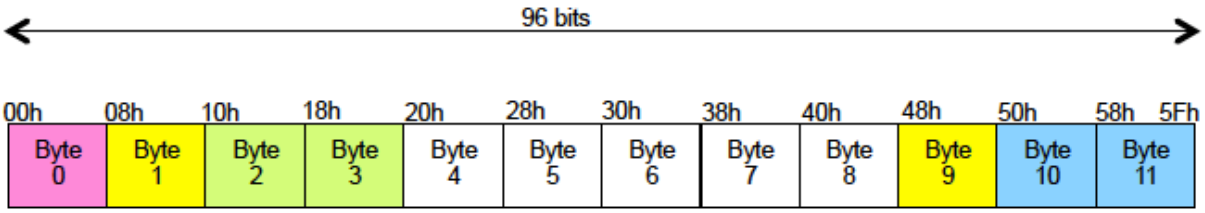

Figure 3-1: 96-Bit Tag ID Logical Layout

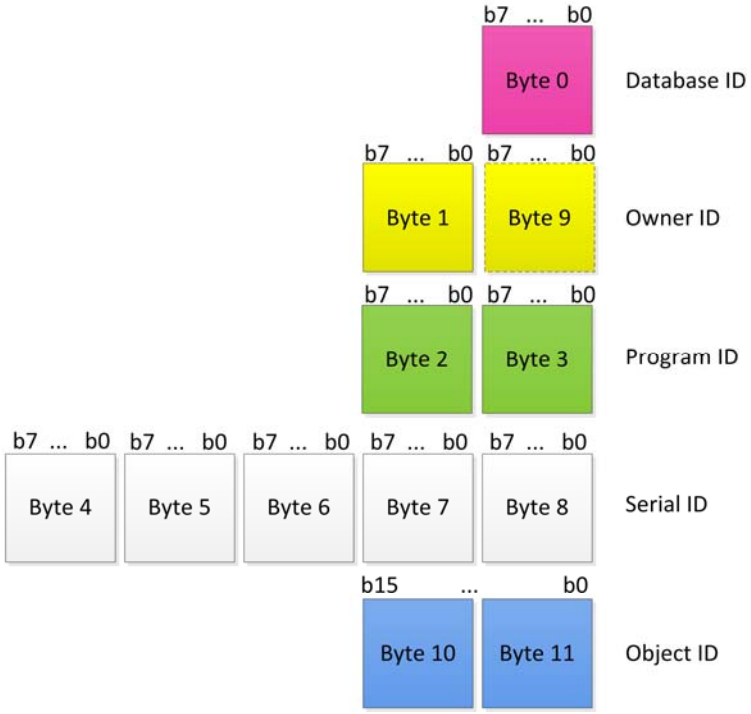

Figure 3-2: Bitwise Mapping of the Fields

3.2 RFID TAG ENCODING

For interoperable onboard spacecraft or internal-vehicle inventory management utilizing 96-bit wireless RFID tags, the tag encoding shall follow the format specified in table 3-1.

Table 3-1: 96-Bit Tag Field Description

Tag ID Field Address	Field Type	Field	Description; [Allowable value range]	Registry Administrator
00_h – 07_h	8-bit ASCII character	Database ID	ID of the database; [A-Z]	SANA
08_h – $0F_h$	8-bit ASCII character	Owner ID Byte 0	Byte 1 of 2-byte Owner ID; [A-Z, 0-9]	Database Owner
10_h – 17_h	8-bit ASCII character	Program ID Byte 0	Byte 1 of 2-byte Program ID; [A-Z, 0-9]	Database Owner
18_h – $1F_h$	8-bit ASCII character	Program ID Byte 1	Byte 2 of 2-byte Program ID; [A-Z, 0-9]	Database Owner
20_h – 27_h	8-bit ASCII character	Serial ID Byte 0	Byte 1 of 5-byte or 6-byte Serial ID; [A-Z, 0-9]	Database Owner
28_h – $2F_h$	8-bit ASCII character	Serial ID Byte 1	Byte 2 of 5-byte or 6-byte Serial ID; [A-Z, 0-9]	Database Owner
30_h – 37_h	8-bit ASCII character	Serial ID Byte 2	Byte 3 of 5-byte or 6-byte Serial ID; [A-Z, 0-9]	Database Owner
38_h – $3F_h$	8-bit ASCII character	Serial ID Byte 3	Byte 4 of 5-byte or 6-byte Serial ID; [A-Z, 0-9]	Database Owner
40_h – 47_h	8-bit ASCII character	Serial ID Byte 4	Byte 5 of 5-byte or 6-byte Serial ID; [A-Z, 0-9]	Database Owner
48_h – $4F_h$	8-bit ASCII character	Owner ID Byte 1	Byte 2 of 2-byte Owner ID; [A-Z, 0-9]	Database Owner
50_h – $5F_h$	16-bit integer	Object ID	[0 – 65535]	Database owner [0:32767] SANA [32768:65535]

ANNEX A

IMPLEMENTATION CONFORMANCE STATEMENT PROFORMA

(NORMATIVE)

[To be supplied]

ANNEX B

SECURITY, SANA, AND PATENT COSIDERATIONS

(INFORMATIVE)

B1 SECURITY CONSIDERATIONS

Security considerations discussed in annex A of reference [D2] apply to this specification.

B2 SANA CONSIDERATIONS

SANA is requested to create and maintain two formal registries:

a) A registry to allocate unique Database IDs.

b) A registry to allocate unique Object IDs that can be utilized by multiple Databases, Owners, and Programs for common item tracking across different Databases, Owners, and Programs.

When creating or processing ‘ADD’ or ‘MODIFY’ registry operations SANA is requested to enforce the field typing, field length, and field restrictions as specified in table 3-1.

B3 PATENT CONSIDERATIONS

[To be supplied]

ANNEX C

INFORMATIVE ENCODING EXAMPLE

Figure C-1 shows the current (as of November 2014) legacy IMS RFID tag encoding schema. This standard expands the available namespace and defines the rules for the addition of new encoding options as per table 3-1. The example will encode a 96-bit RFID tag for the Owner IMS; a serial number of '12345' and an Object ID = 45678 are assumed.

Owner / Program name	Database ID	Owner ID	Program ID		Unique ID (Seria Number ID)					Owner ID	Object ID	
	byte 0	*byte 1*	*byte 2*	*byte 3*	*byte 4*	*byte 5*	*byte 6*	*byte 7*	*byte 8*	*byte 9*	*byte 10*	*byte 11*
IMS	I	X	C	P						J		
IMS Russian	I	X	0	0						R		
coffee	I	X	F	2								
coffee	I	X	F	3								
food BOB	I	X	F	E								
SF Tucker/Kimmel	I	H	R	F						J		
CHeCS BPECG hardwar	I	X	C	B						J		
SF Water Kits	I	X	W	M	S					J		
SD4 Bara medical	M	H	M	S								
MCT Sam Hussey/GRC	M	M	C	T								
EV4 testing	I	E	V	J								
R2 testing	I	R	2	T	E	S	T					
		<---	B	A	R	C	O	D	E	--->		

Figure C-1: Legacy IMS RFID Tag Encoding Schema

Tag Memory Background: The 'Tag ID', which identifies an RFID tag, resides in Memory Bank 01_2 of a tag as shown in figure C-2. By convention each memory bank starts at address 00_h and extends to the end address of the memory bank. Bit 00_h is the Most Significant Bit (MSB) of the memory bank. For binary fields (including the 96-bit tag ID) that are encoded into the memory bank, the MSB of the binary field occupies the lowest-numbered memory bit address. As shown in figure 1-1, the Least Significant Bit (LSB) is numbered 'bit 0'. For a 96-bit tag ID consisting of $b_{95}b_{94}b_{93}...b_0$, b_{95} is the MSB and b_0 is the LSB. When the 96-bit tag ID is encoded onto Bank 01_2 starting at memory bit address 20_h–$7F_h$ the MSB b_{95} is stored at address 20_h and the LSB b_0 is stored at address $7F_h$.

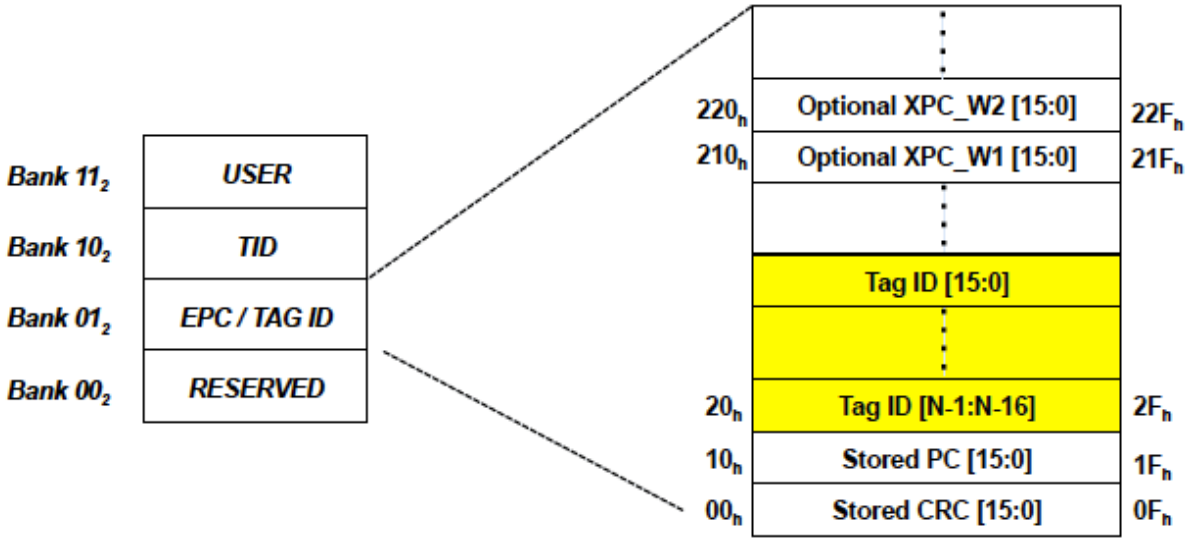

Figure C-2: RFID Tag Bank 01_2 Memory Layout

Example Basis: A 96-bit RFID tag is encoded for the Owner IMS; a serial number of '12345' and an Object ID = 45678 are assumed (cf. figure C-1 for byte positions).

The tag Database ID (Byte 0 of figure C-1) is comprised of the character 'I'.

The tag Owner ID (Byte 1 and Byte 9 of figure C-1) is comprised of the characters 'X' and 'J'.

The tag Program ID (Byte 2 and Byte 3 of figure C-1) is comprised of the characters 'C' and 'P'.

The tag Serial ID (Byte 4–Byte 8 of figure C-1) is given as '1', '2', '3', '4', '5'.

The tag Object ID (Byte 10 and Byte 11 of figure C-1) is given as the integer 45678.

The resulting encoding represented in binary and hexadecimal is given in table C-1.

Table C-1: Example Tag ID Field Encoding

Tag ID Field Address	Field Type	Field	Value	Value (binary)	Value (hexadecimal)
00_h – 07_h	8-bit ASCII character	Database ID	'I'	01001001	49_h
08_h – $0F_h$	8-bit ASCII character	Owner ID Byte 0	'X'	01011000	58_h
10_h – 17_h	8-bit ASCII character	Program ID Byte 0	'C'	01000011	43_h
18_h – $1F_h$	8-bit ASCII character	Program ID Byte 1	'P'	01010000	50_h
20_h – 27_h	8-bit ASCII character	Serial ID Byte 0	'1'	00110001	31_h
28_h – $2F_h$	8-bit ASCII character	Serial ID Byte 1	'2'	00110010	32_h
30_h – 37_h	8-bit ASCII character	Serial ID Byte 2	'3'	00110011	33_h
38_h – $3F_h$	8-bit ASCII character	Serial ID Byte 3	'4'	00110100	44_h
40_h – 47_h	8-bit ASCII character	Serial ID Byte 4	'5'	00110101	35_h
48_h – $4F_h$	8-bit ASCII character	Owner ID Byte 1	'J'	01001010	$4A_h$
50_h – $5F_h$	16-bit integer	Object ID	45678	Byte 0: 01101110 Byte 1: 10110010	$B26E_h$

ANNEX D

INFORMATIVE REFERENCES

[D1] *Wireless Network Communications Overview for Space Mission Operations*. Issue 2. Report Concerning Space Data System Standards (Green Book), CCSDS 880.0-G-2. Washington, D.C.: CCSDS, April 2015.

[D2] *Spacecraft Onboard Interface Services—RFID-Based Inventory Management Systems*. Issue 1. Recommendation for Space Data System Practices (Magenta Book), CCSDS 881.0-M-1. Washington, D.C.: CCSDS, May 2012.

ANNEX E

ABBREVIATIONS

(INFORMATIVE)

ALM	automated logistics management
CCSDS	Consultative Committee for Space Data Systems
CRC	cyclic redundancy code
EPC	electronic product code
IMS	inventory management system
ISS	International Space Station
LSB	Least Significant Bit
MSB	most significant bit
RFID	radio frequency identification
SANA	Space Assigned Numbers Authority
TID	tag ID (manufacturer)