通信・データ処理アーキテクチャ
タイム管理

(Part 8: Time Management (SCDHA8))

2019年12月10日 制定
宇宙航空研究開発機構
免責条項
ここに含まれる情報は、一般的な情報提供のみを目的としています。JAXA は、かかる情報の正確性、有用性又は適時性を含め、明示又は黙示に何ら保証するものではありません。また、JAXA は、かかる情報の利用に関連する損害について、何ら責任を負いません。

Disclaimer
The information contained herein is for general informational purposes only. JAXA makes no warranty, express or implied, including as to the accuracy, usefulness or timeliness of any information herein. JAXA will not be liable for any losses relating to the use of the information.
本文書は英語で書かれた草案を日本語に翻訳し、日本の宇宙機関 JAXA により制定された。本標準は日本語を正とする。ただし、図表の一部で英語表記しかないものについては、それらが正本となる。文章の内容に疑問点がある場合は、日本語及び英語の双方を参照の上、JAXA 安全・信頼性推進部まで連絡をすること。

This document was originally drafted in English, then subsequently translated into Japanese and authorized by the Japanese space agency, JAXA. The English translation is for reference purposes only, except for some tables and figures that contain English only, in which case they are the original. If there is anything ambiguous about the content of the text, please refer to both the Japanese version and the English version and contact JAXA Safety and Mission Assurance Department.
Standard of Communications and Data-Handling Architecture

Part 8: Time Management

(SCDHA8)

SCDHA 180-1.0
Issue 1.0
10th December 2019

Japan Aerospace Exploration Agency (JAXA)
## CONTENTS

1. INTRODUCTION // はじめに ................................................................. 1
   1.1. Purpose // 目的 ............................................................................. 1
   1.2. Scope // 範囲 ............................................................................. 1
   1.3. Applicability // 適用先 .................................................................. 2
   1.4. References // 関連文書 .................................................................. 3
   1.5. Structure of this document // 文書構成 ......................................... 4
   1.6. Definitions and Notations // 定義及び表記法 ............................... 5
   1.7. Verbal forms // 表現形式 ................................................................ 11
   1.8. Conventions // 規則 ....................................................................... 13

2. OVERVIEW // 概要 ........................................................................ 14
   2.1. General // 一般 ........................................................................... 14
   2.2. Overall Architecture // 全体構造 .................................................. 14
   2.3. Time Management ........................................................................ 15

3. SPACECRAFT TIME ........................................................................ 19
   3.1. General // 一般 ........................................................................... 19
   3.2. Primary Clock Functional Object, Primary Clock, and Supplementary Counter .................................................. 20
   3.3. Operation Modes of Clocks // 時計の運用モード ............................ 21
   3.4. Spacecraft Time Code Combination ............................................... 23

4. DISTRIBUTION OF SPACECRAFT TIME // SPACECRAFT TIME 配信 .......................... 33
   4.1. General // 一般 ........................................................................... 33
   4.2. Distribution with SpaceWire // SpaceWire による配信 .................. 34

5. CALIBRATION SCHEME OF SPACECRAFT TIME .............................. 38
   5.1. General // 一般 ........................................................................... 38
   5.2. Time Measurement aboard Spacecraft // 卫星上の時刻計測 ................ 39
   5.3. Time Measurement on the Ground // 地上における時刻計測 ............... 46

6. SYNCHRONIZATION SCHEME AND DESCREATE TIME ADJUSTMENT SCHEME OF SPACECRAFT TIME ..................................................... 47
   6.1. General // 一般 ........................................................................... 47
   6.2. Descrete Time Adjustment Scheme with a Clock in a Ground Station // 地上局の時計による Descrete Time Adjustment Scheme .................................................. 47
   6.3. Synchronization Scheme with a Clock with a GPS Receiver GPS 受信機内の時計との Synchronization Scheme .................................................. 47

7. METHOD TO SPECIFY MANAGED PARAMETERS IN EACH PROJECT // PROJECT 固有な MANAGED PARAMETERS の定め方 ..................................................... 48
   7.1. General // 一般 ........................................................................... 48
   7.2. Spacecraft Monitor and Control Protocol ........................................... 48

APPENDIX A. ACRONYMS // 略語 .................................................................. 51

APPENDIX B. EXAMPLE OF MANAGED PARAMETERS USED FOR A PROJECT // PROJECT が用いる MANAGED PARAMETERS の例 ..................................................... 52
   B.1. General // 一般 ........................................................................... 52
   B.2. Spacecraft Monitor and Control Protocol ........................................... 52
1. INTRODUCTION // はじめに

1.1. PURPOSE // 目的

This document is a part of the Standard of Communications and Data-Handling Architecture (SCDHA) [A1]. This part specifies the framework for Time Management for spacecrafts and spacecraft operation systems.

This part introduces some concepts beyond the CCSDS recommendations.

The SCDHA specifies the standard framework for the onboard and ground systems for communications and data-handling that are used in spacecrafts for science missions developed by space science projects. This model sets a set of standardized methods to specify functions of any spacecrafts and to manage electronically information of the functions. This standardized model would make systematic development of spacecraft functions easier and make reusing the existing onboard instruments or parts of them practical. Then, the ultimate purpose is to reduce the cost of development of new spacecrafts and to enhance their reliability.

1.2. SCOPE // 範囲

This document specifies the framework for Time Management for spacecrafts and spacecraft operation systems.

This document does not specify how these requirements are implemented with hardware or software.

本書は、Standard of Communications and Data-Handling Architecture (SCDHA) [A1] の一部を成す。本パートでは、衛星と衛星運用システムで用いる Time Management を定める。

本パートは、CCSDS 勧告を超えた幾つかの概念を導入する。

SCDHA は、space science projects が開発する科学ミッション等のための、衛星搭載及び地上の通信・データハンドリングシステムの開発に用いられる標準的な枠組みを定める。このモデルは衛星の機能を定め、その機能の情報を電子的に管理する標準化された一群の手法を与える。この標準化されたモデルは、衛星の機能を系統的に開発する事を容易にすると共に、既存の衛星搭載機器やその一部の再利用を現実的なものとする。これらの究極的な目的は、新たな衛星の開発コストを削減し、信頼性を向上する事にある。

本書は、衛星及び衛星運用システムで用いる Time Management の枠組みを定める。

本書は、ハードウェアやソフトウェアによるこれらの要求の具現化は定めない。
1.3. APPLICABILITY // 適用先

The standards of spacecraft-onboard and ground systems presented in this document apply to the projects that have decided to adopt the SCDHA. If a project has decided to adopt the SCDHA, the SCDHA shall apply to all of the onboard and ground systems for communications/data-handling used in the project.

If a project needs to use protocols not specified in this document in addition to those specified here in order to meet its mission requirements or to develop their spacecrafts efficiently, it may choose to do so.

The standards described in this document also apply to the standard instruments.

本書が提示する衛星搭載及び地上のシステムの標準は、SCDHA を採用する事を決めた projects に適用される。Project が SCDHA を採用する事を決めた場合、project が用いる衛星搭載及び地上の通信・データハンドリングシステム全てに SCDHA を適用すること。

もし project がそのミッション要求を満たすためや、衛星を効率的に開発するために、本書で定めたものに加えて、本書で定めていないプロトコルを用いる必要がある場合は、それを選択して良い。

本書で規定される標準は本アーキテクチャに準拠した標準機器にも適用する。
1.4. REFERENCES // 関連文書

1.4.1. Normative References // 引用文書


(*1) Version of the document is intentionally kept to the older version for consistency with [R2].

1.4.2. Informative References // 参考文書


1.5. STRUCTURE OF THIS DOCUMENT / 文書構成

This document is organized as follows.

Chapter 1 (this chapter) states the purpose, scope, and applicability of the document, and lists the references, definitions, and notations used throughout the document.

Chapter 2 presents an overview of the architecture.

Chapter 3 specifies the core part of the framework of Time Management.

Chapter 4 presents the methods to specify the project-specific selection result of the parameters/options of the Time Management.

Appendix A lists the acronyms used in this document.

Appendix B gives an example of the project-specific selection result of parameters/options of the Time Management, using a sample project.
1.6. DEFINITIONS AND NOTATIONS // 定義及び表記法

1.6.1. Terms defined in the SCDHA Part 1 // SCDHA Part 1 で定義される用語

This document adopts the following terms defined in “Standard of Communications and Data-Handling Architecture, Part 1: General (SCDHA1)” [A1]:

managed parameter,
Node, and
space science project (or simply project).

本书では、“Standard of Communications and Data-Handling Architecture, Part 1: General (SCDHA1)” [A1] で定義される次の用語を採用する。

managed parameter
Node
space science project (または単に project)

1.6.2. Terms defined in the Spacecraft Monitor and Control Protocol // Spacecraft Monitor and Control Protocol で定義される用語

This document adopts the following terms defined in the Spacecraft Monitor and Control Protocol (SMCP) [A2]:

Attribute ID,
Attribute Sequence,
Controller,
Functional Object Identifier (FOID),
Monitors,
SMCP Message (or simply Message),
Message Time,
Target, and
VALUE Telemetry Message.

本書では、Spacecraft Monitor and Control Protocol (SMCP) [A2] で定義される次の用語を採用する。

Attribute ID
Attribute Sequence
Controller
Functional Object Identifier (FOID)
Monitors
SMCP Message (または単に Message)
Message Time
Target
VALUE Telemetry Message

This document refers to the following fields in the VALUE Telemetry Message:

Time Code field,
Attribute Values field, and
Attachment field.

本書は、VALUE Telemetry Message の次のフィールドを参照する。

Time Code フィールド
Attribute Values フィールド
Attachment フィールド
1.6.3. Terms defined in the Space Packet Protocol

This document adopts the following terms defined in the Space Packet Protocol [A3]:

- Application Process Identifier (APID),
- Mission Phase, and
- Space Packet.

1.6.4. Terms defined in the AOS Space Data Link Protocol

This document adopts the following terms defined in the AOS Space Data Link Protocol [A4]:

- AOS Transfer Frame (or simply Transfer Frame),
- Virtual Channel Frame Count, and
- Virtual Channel Identifier (VCID).

This document refers to the following fields in an AOS Transfer Frame:

- Transfer Frame Data field.

1.6.5. Terms defined in the TM Synchronization and Channel Coding

This document adopts the following terms defined in the TM Synchronization and Channel Coding [A6]:

- Attached Sync Marker.

1.6.6. Terms defined in JERG-2-432

This document adopts the following terms defined in JERG-2-432 [A7]:

- SpaceWire TimeCode.
1.6.7. Terms defined in the SCDHA Part 2 // SCDHA Part 2 で定義される用語

This document adopts the following terms defined in “Standard of Communications and Data-Handling Architecture, Part 2: End-to-End Protocol Architecture (SCDHA2)” [R1]:

- blocking
- Packet Time
- segmenting

1.6.8. Terms defined in the Time Code Formats // Time Code Formats で定義される用語

This document adopts the following terms defined in the Time Code Formats [A5]:

- CCSDS Unsegmented Code (CUC)
- epoch
- TAI (International Atomic Time)
- Time Code
- unsegmented time code

This document refers to the following fields in the CCSDS Unsegmented Code:

- P-field (Octet 1 and Octet 2)
- T-field

1.6.9. Terms defined in the Space Link Extension – Return All Frames Service Specification // Space Link Extension – Return All Frames Service Specification で定義される用語

This document adopts the following terms defined in “Space Link Extension – Return All Frames Service Specification” [R6]:

- Earth Receive Time
1.6.10. Terms defined in the Functional Model of Spacecrafts

This document adopts the following terms defined in “Functional Model of Spacecrafts (FMS)” [R7]:

- Attribute
- Operation
- Functional Object

1.6.11. Terms defined in this document //

The following definitions are used throughout this document.

**absolute time:** (see Section 3.1)
Time which is measured by a clock and can be converted to TAI without any calibration.

**Calibration Scheme (calibrate):** (see Chapter 5)
Operation to establish the relation between time values indicated by a clock in the Uncorrected clock-mode with those by a clock in the Corrected clock-mode.

**Coarse Time:** (see Section 3.1)
Integer part of time in units of seconds (seconds).

**Fine Time:** (see Section 3.1)
Fractional part of time in seconds (subsecond, i.e. in the range of 0 to 1 second) expressed by an integer in units of fractions of a second (e.g. 1/256 seconds, 1/1000 seconds).

[Note] The units of the Fractional Time field in the CCSDS Unsegmented Code (CUC), which is specified in [A5] and holds a value of Fine Time, are limited to a set of numbers of 1 second divided by a power of 2.

**Marker Transmission Time (MTT):** (see Section 5.2)
Time at which the first bit of the Attached Sync Marker attached to a Reference Transfer Frame is transmitted.

[Note] [A5] が定め、Fine Time の値を保持するものである CCSDS Unsegmented Code (CUC) の Fractional Time フィールドは、2 のべき乗分の 1 秒の単位のみである。

**Marker Transmission Time (MTT):** (5.2 項参照)
Reference Transfer Frame に付与した Attached Sync Marker の最初のビットを送信する時刻
**Onboard Subnetwork Time Code:** (see Section 3.4.1)
Time Code used in the distribution of a Spacecraft Time in onboard subnetwork.

**Primary Clock:** (see Section 3.2)
The clock aboard a spacecraft, from which the indicated time value is copied into the other clocks aboard the spacecraft.

**Primary Clock Functional Object:** (see Section 3.2)
Functional Object which has the functions of the Primary Clock.

**Reference Transfer Frame:** (see Section 5.2)
Telemetry Transfer Frame whose transfer timing is measured for time calibration.

**relative time:** (see Section 3.1)
Elapsed time, time difference.

**Spacecraft Time:** (see Section 3.1)
The master time, *i.e.* the reference time, in a spacecraft.

**Supplementary Counter:** (see Section 3.2)
A time counter which measures Fine Time (*i.e.* subsecond, whose value is between 0 and 1 second).

**Synchronization Scheme (synchronize):** (see Section 2.3)
Time management scheme for synchronizing time value from the Primary Clock to Synchronized Clocks.

**Synchronized Clock:** (see Section 2.3)
An onboard clock which maintains the same time value with the Primary Clock.

**Discrete Time Adjustment Scheme (adjust):** (see Section 6.2)
Time management scheme for one-time copying of a time value from the Primary Clock to a Synchronized Clock.

**Time Frame:** (see Section 5.2.1)
An AOS Transfer Frame which holds the measured value of an MTT.

**TIME Message:** (see Section 5.2.1)
A VALUE Telemetry Message which holds the measured value of an MTT.

**Onboard Subnetwork Time Code:** (3.4.1 項参照)
衛星搭載サブネットワークにおける Spacecraft Time 配信で用いる Time Code

**Primary Clock:** (3.2 項参照)
衛星に搭載の時計（示す時刻値が、その衛星に搭載の他の時計にコピーされる。）

**Primary Clock Functional Object:** (3.2 参照)
Primary Clock の機能を持つ Functional Object

**Reference Transfer Frame:** (5.2 項参照)
時刻校正のため、送出タイミングが計測される テレメトリ Transfer Frame

**relative time:** (3.1 項参照)
経過時間、時刻と時刻の差分

**Spacecraft Time:** (3.1 項参照)
衛星上のマスタ時刻、つまり基準時刻

**Supplementary Counter:** (3.2 参照)
Fine Time （サブ秒、つまり 0～1 秒の範囲）を計測する時刻カウンタ

**Synchronization Scheme (synchronize する):** (2.3 項参照)
Primary Clock を Synchronized Clocks に同期させる時刻管理の方法

**Synchronized Clock:** (2.3 項参照)
Primary Clock と同じ時刻値を持つ衛星搭載時計

**Discrete Time Adjustment Scheme (adjust する):** (6.2 項参照)
Primary Clock から Synchronized Clock への時刻値を単発でコピーする時刻管理の方法

**Time Frame:** (5.2.1 項参照)
MTT の計測値を保持する AOS Transfer Frame

**TIME Message:** (5.2.1 項参照)
MTT の計測値を保持する VALUE Telemetry Message
1.6.12. **Notations // 表記**

The following notations are used throughout this document.

A paragraph that begins with “[Example]” (or “[Example \( n \)]”, where \( n \) is a positive integer) presents an example that is aimed to help readers to understand the specification, and is not a part of the specification.

A paragraph that begins with “[Rational]” (or “[Rational \( n \)]”, where \( n \) is a positive integer) contains a rational for the specification, but is not a part of the specification.

A paragraph that begins with “[Note]” (or “[Note \( n \)]”, where \( n \) is a positive integer) contains an informative note that is aimed to help readers to understand the specification, and is not a part of the specification.

本书は次の表記を用いる。

“[例]”（または “[例 \( n \)]”，\( n \) は正の整数）で始まる段落は、読者の仕様の理解を助けるための例であり、仕様の一部ではない。

“[根拠]”（または “[根拠 \( n \)]”，\( n \) は正の整数）で始まる段落は、仕様の根拠を記したものであり、仕様の一部ではない。

“[注]”（または “[注 \( n \)]”，\( n \) は正の整数）で始まる段落は、読者の仕様の理解を助けるための付加情報を記したものであり、仕様の一部ではない。
1.7. VERBAL FORMS // 表現形式

The following conventions apply throughout this document.

a) the auxiliary verb ‘shall’ implies mandatory conditions.

b) the auxiliary verb ‘should’ implies optional but desirable conditions.

c) the auxiliary verbs ‘may’ implies optional conditions.

d) the auxiliary verb ‘can’ implies capability or ability to do something.

e) the words ‘is’, ‘are’, and ‘will’ imply statements of fact.

The words ‘shall’, ‘should’, ‘may’ are highlighted in red and bold font.

本書では以下の決まりに従い記述する。

「…こと」「…なければならない」とは、必須な仕様です。

「…べき…」は、任意であるが推奨される仕様を示す。

「…良い…」は、許容される仕様を示す。

「…できる…」は、何かをする事が可能な事を示す。

他のパターンの記述は、事実を示す文である。

「…こと」「…なければならない」「…べき…」「…良い…」は読者の仕様の理解の助けのため、赤字・太字で示す。

[注] 本書では、要求事項を電子的に検索しやすいように、英文の‘shall’の訳語として、「こと」を使用している。逆に、「shall」の訳語以外では「こと」は使用せず、「事」を用いている。また、英文の‘may’に対応する訳語として、「良い」という当て字を使用している。逆に、「may」の訳語以外で「良い」は使用していない。

「A, B, 及び C」という表記は、英文の‘A, B, and C’に対応し、「A 及び B 及び C 」であることを意味する。

「A, B, または C」という表記は、英文の‘A, B, or C’に対応し、「A または B または C」であることを意味する。
When a translation into Japanese is provided, the original English version and its Japanese translation are given in the left and right sides, respectively, in principle, as in this paragraph. In some cases, e.g., titles of sections and captions of figures/tables, the English and Japanese versions are put in a single line separated by “//” in this order (“English // Japanese”) or in separate lines with no delimiter in between (“English [Line-Break] Japanese”).

In the most of cases, the technical terms are not translated into Japanese. The English words in alphabet remain as they are in their Japanese translation. The forms in alphabet in English, which distinguish the singular and plural forms remain as they are in the Japanese translation to preserve the information of the quantity, although the Japanese language does not inherently distinguish the singular and plural forms.

Technical terms are basically highlighted in green and in some cases in blue. The latter consists of names of documents, protocols, widely used technical terms, and those locally used in some sections (e.g., field names). Note that the head character of an English word in a technical term is written in the capital letter excluding that in the widely used technical terms.

日本語への翻訳が存在する場合、原則として、この段落のように、英語を左側に示し、日本語を右側に示す。また、章や図表のタイトル等は、英語、日本語の順に一行中に // で区切る（「英語 // 日本語」）か、二行に分けて区切り文字なし（「英語 [改行] 日本語」）で、記述する場合もある。

多くの場合、技術用語の翻訳は行わず、英単語を維持する。そこで、日本語にもアルファベットが登場する。それらは正本である日本語文中においてもアルファベット表記される。日本語の名詞に単数形、複数形の区別はないが、単複の情報を保つため、日本語文中においても、英語の単数形、複数形の違いはアルファベットでそのまま表記する。

技術用語は読者の便のため基本的に緑字、場合により青字で示す。後者は、文書名、プロトコル名、広く用いられている技術用語、及び、局所的にしか登場しないもの（フィールド名等）からなる。ここで、技術用語は、広く用いられているものを除き、基本的に大文字始まりの英単語で表記する。
1.8. CONVENTIONS // 規則

In this document, the following conventions are used to identify each bit in an N-bit field. The first bit in the field to be transmitted (i.e., the leftmost part in associated diagrams, if given) is defined as ‘Bit 0’, the next bit is defined as ‘Bit 1’, and so on up to ‘Bit N-1’.

![Figure 1-1: Bit Numbering Convention](image)

When a field is used to express a binary value (such as a counter), the Most Significant Bit (MSB) shall be the first transmitted bit of the field, i.e., ‘Bit 0’ (see Figure 1-1).

In accordance with the standard data-communications practice, data fields are often grouped into a series of eight-bit ‘words’. Throughout this document, this unit of an eight-bit word is referred to as an ‘octet’.

Numbering for octets within a data structure starts with 0.

By the CCSDS convention, all ‘spare’ bits shall be always set to ‘0’.

In this document, a hexadecimal number is expressed by hexadecimal characters (‘0’-‘9’, ‘A’-‘F’) followed by a ‘h’ (e.g. 1ABh = 427 in decimal).

In this document, a binary number is expressed by characters ‘0’ s and ‘1’ s followed by a lower-case ‘b’ (e.g. 101b = 5 in decimal).

本书では、N-bit のフィールドの各ビットを識するため、次の規則を用いる。フィールドの中で伝送する最初のビット（つまり、図示する場合、図中の最も左側）を‘Bit 0’と定義する。以下、次のビットを‘Bit 1’というように‘Bit N-1’まで定義する。

フィールドがバイナリ値（カウンタ等）を表わす場合、最上位ビット（MSB）はフィールドの最初に伝送するビット、つまり、Figure 1-1に示す‘Bit 0’であること。

標準的なデータ通信の慣例に則り、データフィールドは、しばしば、8 ビットワードの連なりにまとめる。本書では、この 8 ビットワードの単位を‘octet’と称する。

Octets データ内の番号付けは 0 から開始する。

CCSDS の慣例により、全ての‘spare’ビットは常に ‘0’ すること。

本書では、1 進数の数を 16 進文字（‘0’-‘9’, ‘A’-‘F’）の後に‘h’を記す事で表す（例: 1ABh = 427 (10進数)）。

本書では、2 進数の数を文字 ‘0’ 及び ‘1’ の後に‘b’（小文字）を記す事で表す（例: 101b = 5 (10進数)）。

13
2. OVERVIEW // 概要

2.1. GENERAL // 一般

This chapter presents an overview of the Standard of Communications and Data-Handling Architecture (SCDHA) and its Part 8 (Time Management). 本章は、Standard of Communications and Data-Handling Architecture (SCDHA) とその Part 8: Time Management の概要を示す。

2.2. OVERALL ARCHITECTURE // 全体構造

The overall concept of the SCDHA is shown in Figure 2-1 in a layered manner. Parts 2-8 of the SCDHA specify the method to select and use communications protocols. The overview of each Part is given in Section 2.3 of Part 1 (General [A1]).

SCDHA の全体の概念を、層状構造として Figure 2-1 に示す。SCDHA の Parts 2-8 は、通信プロトコルをどのように選択し、どのように用いるかを定める。各パートの概要は、Part 1: General [A1] の 2.3 項にまとめられている。

Figure 2-1: Overall protocol structure of the SCDHA

SCDHA のプロトコルの全体構造

The left and right sides in the figure show the onboard and ground subnetworks, respectively, and the middle part shows the space-link subnetwork.

図中の左側に衛星搭載サブネットワーク、右側に地上サブネットワーク、そして中央にスペースリンクサブネットワークを示している。

[Note] The layers shown in the figure are defined in the CCSDS. The data-link layers in both the Onboard Subnetwork Protocols and Ground Subnetwork Protocols have also the characteristics of the network layer in the OSI Basic Reference Model.

[注] 図に示す層 (Layers) はいずれも CCSDS で定義されたものである。Onboard Subnetwork Protocols と Ground Subnetwork Protocols の双方の data-link layers は、OSI Basic Reference Model のネットワーク層の性格も併せ持っている。
2.3. TIME MANAGEMENT

Time is a key concept for systems for communications and data handling and is a base of all the functions in spacecrafts and spacecraft operation systems. This part (Part 8) of the architecture specifies the Time Management for a spacecraft and spacecraft operation system, as follows.

In this architecture, time which is measured by a clock and can be converted to TAI without any calibration is called absolute time and Elapsed time, time difference, is called relative time (see Section 3.1).

In the SMCP, monitoring and controlling of a spacecraft is specified as interaction between Controllers/Monitors and Targets [A2]. In the interaction, a device which measures time, i.e., a clock, is a basic building component. Attributes [R7] of a spacecraft are monitored with telemetry. The values of Attributes of a Target are transferred with telemetry that contains the information of the time at which the values of the Attributes are measured (Message Time specified in Section 5.3.4 of [A2]). At the side of a Controller/Monitors on the ground and aboard a spacecraft, on the other hand, telecommands are issued at a specified time. It is required that the format of time and how it is interpreted be specified consistently for telemetry and telecommands.

Each of Targets and Controllers/Monitors often has a clock. Since a spacecraft and spacecraft operation system have multiple Targets and Controllers/Monitors, the system as a whole often has multiple clocks. Whereas some of the clocks indicate absolute time, the others count up in regular interval and indicate relative time only by themselves. In operation, all the clocks in the system are coordinated so that their times are interpreted in terms of the absolute time. This action is referred to as Time Management.

In this document, two operation modes of clocks, Corrected clock-mode and Uncorrected clock-mode, are specified.
The Corrected clock-mode is the operation mode where a time value of a clock is guaranteed to be consistent with the absolute time within error. Each project [A1] determines the required accuracy and corrects time values of the clocks. In the Corrected clock-mode, the epoch [A5] of a Time Code [A5] during a Mission Phase [A3] is constant.

The Uncorrected clock-mode is the operation mode where a time value of a clock is not guaranteed to be consistent with the absolute time without calibration. Time values of the clocks are not corrected and cannot be compared with the absolute times without calibration. Thus, the epoch of a Time Code changes during the Mission Phase.

Level-1, 2 Time Codes specified in [A5] are used only in the Corrected clock-mode and Level-3 Time Codes specified in [A5] are used in both the Corrected clock-mode and Uncorrected clock-mode.

Three approaches for clock coordination are presented in this document: Calibration Scheme (see Chapter 5), Discrete Time Adjustment Scheme (see Section 6.2) and Synchronization Scheme (see Section 6.3) (see Figure 2-2).

In the Calibration Scheme, a time value of a clock in the Uncorrected clock-mode is made related to a time value of a clock in the Corrected clock-mode. By contrast, in the Discrete Time Adjustment Scheme and Synchronization Scheme, different clocks are synchronized (i.e. adjusted to have the same time value).

[Note] In order to operate a clock in the Corrected clock-mode, the Synchronization Scheme or Discrete Time Adjustment Scheme is mandatory to be used to keep the required time accuracy.


Uncorrected clock-mode は、時計の時刻値が誤差の範囲内で absolute time との一致する事を保証しない運用モードである。時計の時刻値は補正せず、校正（較正）無しでは absolute time と比較できない。そこで、Time Code の epoch は Mission Phase において変化する。


本書では、時計の協調の方式として、Calibration Scheme (校正方式, 5 章参照)、Discrete Time Adjustment Scheme（時刻調整方式; 6.2 項参照）、及び、Synchronization Scheme（同期方式; 6.3 項参照）の三つを適用する (Figure 2-2 参照)。

Calibration Scheme では、Uncorrected clock-mode の時計の時刻値を、Corrected clock-mode の時計の時刻値に関連付ける。一方、Discrete Time Adjustment Scheme と Synchronization Scheme では、異なる時計を、同期（つまり、同じ時刻値を持つように修正）する。

[注] Corrected clock-mode で時計を使うには、要求された時刻精度を維持するために、Synchronization Scheme または Discrete Time Adjustment Scheme を用いる事が必須である。
While actions in the **Calibration Scheme** are performed after measurement of a time, actions in the **Synchronization Scheme** and **Discreate Time Adjustment Scheme** are performed before measurement of a time.

In order to synchronize clocks, time values are required to be transferred.

When all clocks aboard a spacecraft are synchronized, the operation modes of all the clocks become the same, *i.e.* either the **Uncorrected clock-mode** or the **Corrected clock-mode**.

Figure 2-3 shows the configurations of clocks aboard a spacecraft and somewhere outside; whereas all clocks aboard a spacecraft in configuration (a) are used in the **Uncorrected clock-mode**, those in configurations (b) and (c) are used in the **Corrected clock-mode**. Whereas configurations (a) and (b) use a clock in a ground station as a reference for the **absolute time**, configuration (c) uses GPS satellites.

Figure 2-3 **Configurations of clocks aboard a spacecraft and somewhere outside**

In these configurations, three types of clocks aboard spacecrafts are considered: 1) a **Primary Clock**, 2) **Synchronized Clocks**, and 3) clocks in **GPS receivers**.

これらの構成では、衛星に搭載の時計には三つのタイプが考えられる。1) **Primary Clock**, 2) **Synchronized Clocks**, 及び 3) **GPS 受信機内の時計**である。
A Primary Clock is the master clock aboard a spacecraft. The Primary Clock maintains Spacecraft Time (see Section 3.2). Spacecraft Time is expressed with the value of a Time Code.

A Synchronized Clock is a clock synchronized to the Primary Clock. Time measure by a Synchronized Clock is Spacecraft Time except for non-stationary cases.

An operation to change the time value of a clock instantaneously is referred to as Time Adjustment. With a Time Adjustment, the time value of a clock discontinuously changes. In the Discrete Time Adjustment Scheme, only Time Adjustments can synchronize a clock to have the same time value as another clock. In the Synchronization Scheme, Time Adjustment is performed when the time difference between a clock and the Primary Clock is larger than a certain threshold value.

Whereas the Discrete Time Adjustment Scheme guarantees the time accuracy of clocks for only a limited period after its operation is performed (see Section 6.2), the Synchronization Scheme guarantees the time accuracy of clocks for the entire duration while its function is active (see Section 6.3).

Absolute time has errors in measurement. Correction of potential errors after measurement of time is out of scope of this document.

In Chapter 3, Spacecraft Time is specified. In Chapter 4, the Synchronization Scheme of a Primary Clock with Synchronized Clocks is specified. In Chapter 5, the Calibration Scheme of a Primary Clock in the Uncorrected clock-mode with a clock in a ground station is specified.

In Section 6.2, the Discrete Time Adjustment Scheme of a Primary Clock in the Corrected clock-mode with a clock in a ground station is specified. In Section 6.3, the Synchronization Scheme of a Primary Clock in the Corrected clock-mode with a GPS receiver is specified.
3. SPACECRAFT TIME

3.1. GENERAL // 一般

The master time in a spacecraft is referred to as Spacecraft Time (see Figure 3-1 (iii)).

In this architecture, time which is measured by a clock and can be converted to TAI without any calibration is referred to as absolute time and elapsed time, time difference, is referred to as relative time.

Integer part of time in units of seconds (seconds) is referred to as Coarse Time and fractional part of time in seconds (subsecond, i.e. in the range of 0 to 1 second) expressed by an integer in units of fractions of a second (e.g. 1/256 seconds, 1/1000 seconds) is referred to as Fine Time.

In this chapter, the concepts related to how Spacecraft Time is handled and used is specified. Figure 3-1 illustrates the overall concepts related to Spacecraft Time.

<table>
<thead>
<tr>
<th>Functional Object</th>
<th>Function</th>
<th>Time</th>
<th>Encoding</th>
<th>Operation Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Clock</td>
<td>(ii) Primary Clock</td>
<td>(iii) Spacecraft Time</td>
<td>(iv) Time Code</td>
<td>*(v): Corrected clock-mode, Uncorrected clock-mode</td>
</tr>
<tr>
<td></td>
<td>(vi) Supplementary Counter</td>
<td>(*1)</td>
<td>(*2)</td>
<td>(*3)</td>
</tr>
</tbody>
</table>

Figure 3-1: Concepts related to Spacecraft Time

(*1) A Supplementary Counter measures time difference by counting up at a certain time interval (see Section 3.2).

(*2) A count value indicated by a Supplementary Counter is encoded by a binary integer in units of fixed time intervals (see Section 3.2).

(*3) The origin of measurement is specified in Section 3.2.
3.2. PRIMARY CLOCK FUNCTIONAL OBJECT, PRIMARY CLOCK, AND SUPPLEMENTARY COUNTER

A master clock aboard a spacecraft is referred to as a Primary Clock (see Figure 3-1 (ii)).

A Primary Clock shall maintain Spacecraft Time.

A Functional Object [R7] which has a Primary Clock is referred to as a Primary Clock Functional Object (see Figure 3-1 (i)).

A spacecraft shall have at least one Primary Clock Functional Object.

[Note] A Primary Clock Functional Object needs not be a Functional Object dedicated to maintain Spacecraft Time. It can have multiple functions.

The Spacecraft Time indicated by a Primary Clock shall be reset to zero when the power of the Primary Clock Functional Object is turned on.

A Primary Clock shall be activated at the timing of reset.

The time value of a Primary Clock shall be able to be reset to an arbitrary value with a telecommand.

A Primary Clock Functional Object may have a time counter referred to as a Supplementary Counter (see Figure 3-1 (vi)).

The Supplementary Counter measures Fine Time (see Section 3.4.2).
3.3. OPERATION MODES OF CLOCKS // 時計の運用モード

3.3.1. General // 一般

Operation modes of clocks (see Figure 3-1 (v)) shall be either the Corrected clock-mode specified in Section 3.3.2 or Uncorrected clock-mode specified in Section 3.3.3.

Each project [A1] shall determine the operation mode of its clocks.

If a GPS receiver is placed aboard a spacecraft, the Primary Clock of the spacecraft shall always be used in the Corrected clock-mode.

3.3.2. Uncorrected clock-mode

The Uncorrected clock-mode is the operation mode where a time value of a clock is not guaranteed, where a time value of the clock cannot be compared with absolute time without calibration. In the Uncorrected clock-mode, clocks are not corrected. Thus, the epoch of a Time Code changes during the Mission Phase.

Uncorrected clock-mode は、時計の時刻値を保証しない運用モードであり、時計の時刻値は、校正（校正）無しでは、absolute time と比較できない。Uncorrected clock-mode では、時計は、補正しない。したがって、Time Code の epoch は Mission Phase において変化する。
3.3.3. Corrected clock-mode

The Corrected clock-mode is the operation mode where a time value of a clock is guaranteed, where the clocks indicate absolute time. The clocks shall be corrected in order to guarantee their time values. A project shall determine the requirement for their accuracy. In the Corrected clock-mode, the epoch [A5] of a Time Code [A5] during a Mission Phase [A3] shall be a constant within the required accuracy.

The time range of the Time Code for clocks in the Corrected clock-mode shall cover the entire Mission Phase.

The epoch of a Time Code for clocks in the Corrected clock-mode shall be either that recommended by the CCSDS (1958 January 1; TAI; International Atomic Time [A5]) or the epoch of the GPS (i.e. 1980 January 6, UTC). Note that the former and the latter are in the category of Level-1 and Level-2, respectively, both specified by [A5]. Each project shall determine the epoch.

[Note] The epoch of the GPS is recommended because heritages from the JAXA’s past space science spacecrafts are available.

A Primary Clock in the Corrected clock-mode has an incorrect time value before the initial Time Adjustment (see Section 2.3). Each project shall determine the time range of time value valid as absolute time.


Corrected clock-mode の時計の Time Code の時刻範囲は、Mission Phase の全体をカバーすること。

Corrected clock-mode の時計の Time Code の epoch は CCSDS 勧告（1958 年 1 月 1 日; TAI; International Atomic Time [A5]）または GPS の epoch（つまり、1980 年 1 月 6 日、UTC）である。ここで、前者及び後者は、それぞれ、[A5] が定める Level-1 及び Level-2 のカテゴリに属する。各 project は、その epoch を決めること。

[注] JAXA の宇宙科学衛星の実績があるため、GPS の epoch が推奨される。

Corrected clock-mode の Primary Clock は、初回の Time Adjustment（2.3 項参照）の前は正しくない時刻値をもつ。各 project は、その時刻値が absolute time として有効な時刻範囲を決めること。
3.4. SPACECRAFT TIME CODE COMBINATION

3.4.1. General // 一般

Spacecraft Time shall be expressed with a Time Code [A5] (see Figure 3-1 (iv)).

Spacecraft Time at the timing when a Space Packet [A3] is edited (see Section 5.6.1 in [R1]) is referred to as Packet Time.

Packet Time is held in the Time Code field [A3] of a Space Packet (see Section 5.4.6 in [R1]).

One of the following four types of Time Codes shall be used to express Spacecraft Time depending on the usage.

- A Time Code referred to as a Packet Time Code, which expresses Packet Time in the Time Code field of Space Packets

- A Time Code referred to as an Onboard Subnetwork Time Code, which is used in the distribution of a Spacecraft Time in onboard subnetwork (see Chapter 4)

- A Time Code referred to as an MTT Time Code, which expresses Marker Transmission Time (MTT) in Time Telemetries (see Section 5.2.1)

- CCSDS Unsegmented Code (CUC) defined in [A5] which is used to express the Message Time of a VALUE Telemetry Message (see Section 5.3.4 in [A2]).

[Note] Relation between the Packet Time and the Message Time is specified in Section 3.4.3 in [R1].

A combination of a Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code is referred to as Spacecraft Time Code Combination.

In this section, the method to express time with Spacecraft Time Code Combination is specified.

Spacecraft Time は、Time Code [A5] で表現すること (Figure 3-1 (iv) 参照)。

Space Packet [A3] を編集するタイミングにおける Spacecraft Time ([R1] 5.6.1 項参照) を、Packet Time と称する。

Packet Time は、Space Packet の Time Code フィールド [A3] により保持される ([R1] 5.4.6 項参照)。

Spacecraft Time の表現として、目的に応じ、以下の四種類の Time Codes の何れかを用いること。

- Packet Time を Space Packets の Time Code フィールドにて表現する Time Code (Packet Time Code と称する)

- 衛星搭載サブネットワークにおける Spacecraft Time の配信 (4章参照) で用いる Time Code (Onboard Subnetwork Time Code と称する)

- Time Telemetries にて Marker Transmission Time (MTT) （5.2.1 項参照）を表現する Time Code (MTT Time Code と称する)

- VALUE Telemetry Message の Message Time の表現に用いる CCSDS Unsegmented Code (CUC) ([A2] 5.3.4 項参照)

[注] Packet Time と Message Time の関係は、[R1] 3.4.3 項が定めている。

Packet Time Code, Onboard Subnetwork Time Code, 及び MTT Time Code の組み合わせを、Spacecraft Time Code Combination と称する。

本項では、Spacecraft Time Code Combination による時刻の表現方法を定める。
3.4.2. Common Specification // 共通規定

A Packet Time Code shall consist of an optional P-field and a mandatory T-field. An Onboard Subnetwork Time Code shall consist of only a T-field.

The T-fields of a Packet Time Code and Onboard Subnetwork Time Code are referred to as Packet Time Indicator and Onboard Subnetwork Time Indicator, respectively. Therefore, the Onboard Subnetwork Time Code is identical with the Onboard Subnetwork Time Indicator.

Each of a Packet Time Indicator and an Onboard Subnetwork Time Indicator shall be a binary integer with a fixed bit-length (i.e., unsegmented time code specified in [A5]).

Each of a Packet Time Indicator and an Onboard Subnetwork Time Indicator shall be composed of one or two fields. One (upper bits; hereafter referred to as a Basic Time field) shall be a mandatory fixed-bit-length binary integer in units of seconds, which measures a Coarse Time. The other (lower bits; hereafter referred to as a Fractional Time field) shall be an optional fixed-bit-length binary integer in units of seconds to a negative power of 2, which measures a Fine Time. The bit length of a Fractional Time field may be 0.

[Note 1] T-field, P-field, Basic Time field, and Fractional Time field are concepts defined for CUC and are generalized to other cases in this document.

[Note 2] The unit of LSB of a Basic Time field is 1 second and the unit of MSB of a Fractional Time field is 0.5 seconds.

The Basic Time field of a Packet Time Indicator shall be all or the lower part of the Basic Time field of an Onboard Subnetwork Time Indicator.

The Fractional Time field of a Packet Time Indicator shall be all or the upper part of the Fractional Time field of an Onboard Subnetwork Time Indicator.
A Supplementary Counter, if it exists, shall hold the value of Fine Time in MTT Time Code.

The precise specification about the Spacecraft Time Code Combination (e.g. bit allocations) shall be either STCC-Type 1 (see Section 3.4.3) or STCC-Type 2 (see Section 3.4.4).

Table 3-1 summarizes the difference between STCC-Type 1 and STCC-Type 2. Note that the Time Codes in STCC-Type 1 are the CUC. The Time Codes in STCC-Type 2 have bit field allocation, which is specified in this document, and may not be compatible with the CUC.

Whereas the bit length of each of Basic Time fields and Fractional Time fields of the Time Codes in STCC-Type 1 is a multiple of 8 bits, that in STCC-Type 2 is arbitrary.

The bit length of a Packet Time Indicator is fixed to be 32 bits in any cases.

[Note 3] Use of STCC-Type 1 in the categories of Level-1, 2 is preferable because the combination satisfies the CCSDS standard ([A5]).

Table 3-1: Comparison of the Time Codes in STCC-Type 1 and STCC-Type 2

<table>
<thead>
<tr>
<th>Bit field allocation</th>
<th>STCC-Type 1</th>
<th>STCC-Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit field allocation</td>
<td>CCSDS Unsegmented Code (CUC)</td>
<td>Original</td>
</tr>
<tr>
<td>Total length of Packet Time Indicator</td>
<td>32 bits</td>
<td></td>
</tr>
<tr>
<td>Total length of Onboard Subnetwork Time Indicator</td>
<td>48 bits</td>
<td>38 bits (STCC-Type 2a) or 40 bits (STCC-Type 2b)</td>
</tr>
<tr>
<td>Length of Basic Time field</td>
<td>(a multiple of 8 bits)</td>
<td>(not necessarily multiple of 8 bits)</td>
</tr>
<tr>
<td>Length of Fractional Time field</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[注3] Level-1, 2 のカテゴリで STCC-Type 1 を用いる事が、CCSDS 勧告 ([A5]) を満たす観点から好ましい。
For STCC-Type 2, two sub-types STCC-Type 2a and STCC-Type 2b are specified in Section 3.4.4; however, only STCC-Type 2a is fully specified in this document.

The following items shall be specified in each project.

- The type of the Spacecraft Time Code Combination: either STCC-Type 1 or STCC-Type 2a.
3.4.3. **STCC-Type 1: CUC**

Each of a Packet Time Code and an Onboard Subnetwork Time Code shall be the CUC.

Packet Time Code と Onboard Subnetwork Time Code は、何れも、CUC であること。

Figure 3-2 shows the STCC-Type 1 formats of Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code.

Figure 3-2 に、Packet Time Code, Onboard Subnetwork Time Code, 及び MTT Time Code の STCC-Type 1 におけるフォーマットを示す。

![Figure 3-2: Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code in STCC-Type 1](image)

In STCC-Type 1, **P-field** specified in [A5] shall be attached in Packet Time Codes.

Octet 2 defined in [A5] shall be absent in P-field.

Octet 2 の存在しない P-field を付与すること。

[Rational 1] Time span of ~136 years can be allocated for a Fractional Time field with use of only Octet 1 defined in [A5].

[Rational 2] Sufficient time resolution can be allocated for a Fractional Time field with use of only Octet 1 for operations of monitoring and controlling.

[Note 1] Because Octet 2 is absent, the first bit of a P-field is always 0.
A Packet Time Code shall consist of only a Basic Time field with a length of 4 octets and shall not contain a Fractional Time field.

An Onboard Subnetwork Time Code shall consist of a Basic Time field and a Fractional Time field with lengths of 4 octets and 2 octets, respectively.

[Note 2] The value of the P-field of a Packet Time Code is either 0 001 11 00b or 0 010 11 00b, depending on the epoch.

For STCC-Type 1, Coarse Time in the MTT Time Code shall be expressed with a Packet Time Code.

For STCC-Type 1, a Supplementary Counter in 24 bits shall be used. A Supplementary Counter shall count up every 1/2-16s. The nominal value of a Supplementary Counter is in the range of 0 to 65535 (the cases out of this nominal value will be specified in Section 6.3 in the future).

Packet Time Code は、長さ 4 octets の Basic Time フィールドを持つこと。また、Fractional Time フィールドを持たないこと。Onboard Subnetwork Time Code は、長さ 4 octets の Basic Time フィールドと長さ 2 octets Fractional Time フィールドを持つこと。

[注 2] Packet Time Code の P-fields の値は、epoch によって、0 001 11 00b か 0 010 11 00b かの何れかである。

STCC-Type 1 では、MTT Time Code において、Coarse Time は Packet Time Code で表現すること。

STCC-Type 1 には、24 ビットの Supplementary Counter を用いること。Supplementary Counter は、1/2-16s 毎にカウントアップすること。Supplementary Counter のノミナル値は 0〜65535 の範囲内にある（オフノミナル値は将来 6.3 項に定める）。
3.4.4. **STCC-Type 2**: Arbitrary Binary Counter

In STCC-Type 2, a P-field **shall** be absent in Packet Time Code. Therefore, the Packet Time Code is identical with the Packet Time Indicator.

The bit length of a Packet Time Indicator **shall** be 32 bits (*i.e.* 4 octets).

A Packet Time Indicator is specified with the following parameters.

- The bit length of the Fractional Time field of a Packet Time Indicator: \(F_p\).

An Onboard Subnetwork Time Indicator is specified with the following parameters.

- The bit length of the Basic Time field of an Onboard Subnetwork Time Indicator: \(B_c\).

- The bit length of the Fractional Time field of an Onboard Subnetwork Time Indicator: \(F_c\).

Then,

- the bit length of the Basic Time field of a Packet Time Indicator: \(B_p\) is given by the equation \(B_p = 32 - F_p\) and

- the bit length of an Onboard Subnetwork Time Indicator: \(N_c\) is given by the equation \(N_c = B_c + F_c\).

For the values of the parameters, the following combinations (STCC-Type 2a and STCC-Type 2b) are allowed.

[Rational] These are supported by the common on-ground software for the Calibration Scheme.

[Note] Only STCC-Type 2a can be used between STCC-Type 2a and STCC-Type 2b because one of the conditions for STCC-Type 2b to be used, the configuration of “SMCP without the SMCP Message” [A2], is beyond the scope of the current version of this document.
Figure 3-3 shows the STCC-Type 2a formats of Packet Time Code, Onboard Subnetwork Time Code and MTT Time Code.

For STCC-Type 2a, the values of the parameters shall be as follows.

- $B_c=32$, $F_c=F_p=6$.

These imply the following:

- $B_p=26$, $N_c=38$,
- A Packet Time Indicator is lower 32 bits of an Onboard Subnetwork Time Indicator,
- the time span expressed with a Packet Time Indicator is $\sim2.1$ years,
- the time span expressed with an Onboard Subnetwork Time Indicator is $\sim136$ years, and
- the time resolutions of an Onboard Subnetwork Time Indicator and Packet Time Indicator are both 15.625msec (64Hz).

For STCC-Type 2a, Coarse Time in the MTT Time Code shall be expressed with a 30-bit binary integer.

For STCC-Type 2a, a Supplementary Counter with 20 bits shall be used. A Supplementary Counter shall count up every $1\mu s$. The nominal value of a Supplementary Counter is in the range of 0 to 999999 (the cases out of this nominal value will be specified in Section 6.3 in the future).

These imply the following:

- (The value of a Fractional Time field) $=$ (the value of a Supplementary Counter) / 15625 (in the nominal case).

Figure 3-3 に、Packet Time Code, Onboard Subnetwork Time Code, 及び MTT Time Code の STCC-Type 2a におけるフォーマットを示す。

STCC-Type 2a では、パラメータの値は以下である。

- $B_c=32$, $F_c=F_p=6$

これらの事は以下を意味する。

- $B_p=26$, $N_c=38$
- Packet Time Indicator は、Onboard Subnetwork Time Indicator の下位 32 ビット
- Packet Time Indicator が表現する期間は $\sim2.1$ 年
- Onboard Subnetwork Time Indicator が表現する期間は $\sim136$ 年
- Onboard Subnetwork Time Indicator と Packet Time Indicator の時間分解能は、何れも、15.625msec (64Hz)

STCC-Type 2a では、MTT Time Code において、Coarse Time を、30 ビットの二進整数表現すること。

STCC-Type 2a には、20 ビットの Supplementary Counter を用いること。Supplementary Counter は、$1\mu s$ 毎にカウントアップすること。
Supplementary Counter のノミナル値は 0 〜 999999 の範囲内にある（オフノミナル値は将来 6.3 項に定める）。

これらの事は以下を意味する。

- (Fractional Time フィールドの値) = (Supplementary Counter の値) / 15625（ノミナル）
Figure 3-3: Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code in STCC-Type 2a
Figure 3-4 shows the STCC-Type 2b formats of Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code.

For STCC-Type 2b, the MTT Time Code shall be the same as the Onboard Subnetwork Time Code.

For STCC-Type 2b, the values of the parameters shall be as follows.

- \( Bc = 27 \), \( Fc = 13 \), \( Fp = 5 \).

This implies the following.

- \( Bp = 27 \), \( Nc = 40 \),

- a Packet Time Indicator is upper 32 bits of an Onboard Subnetwork Time Indicator,

- the time span expressed with both a Packet Time Indicator and Onboard Subnetwork Time Indicator is \(~4.25\) years,

- the time resolution of a Packet Time Indicator is \(31.25\) msec (32 Hz), and

- the time resolution of an Onboard Subnetwork Time Indicator is \(122\) μs (2-13s).

This implies the following.

- \( Bp = 27 \), \( Nc = 40 \)

- a Packet Time Indicator is upper 32 bits of an Onboard Subnetwork Time Indicator,

- the time span expressed with both a Packet Time Indicator and Onboard Subnetwork Time Indicator is \(~4.25\) years,

- the time resolution of a Packet Time Indicator is \(31.25\) msec (32 Hz), and

- the time resolution of an Onboard Subnetwork Time Indicator is \(122\) μs (2-13s).

\[ \text{Packet Time Code} = \text{Packet Time Indicator} \cdots 4\text{octets} \]

Coarse Time in the Basic Time Field \( \cdots \text{Fine time in the Fractional Time Field} \)

\[ Bp = 27 \text{ (bits)} \quad Fp = 5 \text{ (bits)} \]

\[ \text{Onboard Subnetwork Time Code} = \text{Onboard Subnetwork Time Indicator} \cdots 5\text{octets} = \text{MTT Time Code} \]

Coarse Time in the Basic Time Field \( \cdots \text{Fine time in the Fractional Time Field} \)

\[ Bc = 27 \text{ (bits)} \quad Fc = 13 \text{ (bits)} \]

Figure 3-4: Packet Time Code, Onboard Subnetwork Time Code, and MTT Time Code in STCC-Type 2b
4. DISTRIBUTION OF SPACECRAFT TIME

SPACECRAFT TIME 配信

4.1. GENERAL // 一般

Each onboard Node [A1] may have a clock referred to as a Synchronized Clock. 各衛星搭載 Node [A1] は、Synchronized Clock と称する時計をもって良い。

A Synchronized Clock maintains Spacecraft Time. Synchronized Clock は、Spacecraft Time を維持する。

Each project shall specify which Nodes have Synchronized Clocks. 各 project は、どの Nodes が Synchronized Clocks を持つか定めること。

This chapter specifies the scheme, referred to as Synchronization Scheme, to synchronize time value from the Primary Clock to Synchronized Clocks. 本章は、Primary Clock と Synchronized Clocks を同期させるための Synchronization Scheme と称する方法を定める。

A Synchronized Clock shall be periodically synchronized to the Primary Clock. Synchronized Clock は、Primary Clock と定期的に同期されること。

A Primary Clock Functional Object shall distribute the value of Spacecraft Time indicated by the Primary Clock to the Nodes which have Synchronized Clocks. Primary Clock Functional Object は、Primary Clock が示す Spacecraft Time の値を、Synchronized Clocks を持つ Nodes に配信すること。
4.2. DISTRIBUTION WITH SPACEWIRE // SPACEWIRE による配信

4.2.1. General // 一般

In this section, the Synchronization Scheme to be used with the SpaceWire Protocol is specified. In the Synchronization Scheme, SpaceWire TimeCodes [A7] are used to distribute the timing information.

[Note1] Section 3.2 in [A7] states that Time-Code is issued across the entire system, allowing synchronization to a microsecond precision. However, how SpaceWire TimeCode is used for time synchronization is not clearly specified.

In this architecture, among the methods to pass on the timing, those with which the timing of SpaceWire TimeCodes are synchronous and asynchronous with the timing of Spacecraft Time are referred to as Synchronous method and Asynchronous method, respectively.

[Note2] This definition implies that the time interval of SpaceWire TimeCodes in the Synchronous method is 1/64 seconds.

Asynchronous method shall be used if STCC-Type 1 is used.

Synchronous method shall be used if STCC-Type 2 is used.

A Spacecraft Time distributed in an onboard subnetwork is called Time Information in [A7]. In this architecture, the Time Code to express Time Information is called the Onboard Subnetwork Time Code (see Section 3.4.1).
The upper bits of Time Information cannot be synchronized with SpaceWire TimeCodes. [A7] specifies that a Synchronization Service passes from the time-master device to the user device the information of the upper time digits that SpaceWire TimeCodes cannot synchronize. Section 8.4 in [A7] specifies the Master Trigger Time Write service as the Synchronization Service by the SpaceWire-RMAP, which passes time information at specified intervals with RMAP Write Commands. Similarly, Sections 9.3 and 10.3 in [A7] specify the Synchronization Service by the protocols SpaceWire-PTP and SpaceWire-R, respectively.

If the SpaceWire Protocol is used for the Onboard Subnetwork Protocol in this architecture, the Synchronization Services with one of the SpaceWire-RMAP ([A7] Section 8.4), the SpaceWire-PTP ([A7] Section 9.3), and the SpaceWire-R ([A7] Section 10.3) shall be employed to distribute the upper bits of Time Information. This document refers to the Onboard Subnetwork Time Code’s upper bits which are synchronized with the Synchronization Services as Synchronization Service field (see Figures 4-1 and 4-2).


4.2.2. **Synchronous Method**

In the **Synchronous method**, a SpaceWire TimeCode with the value of zero **shall** be transmitted at timings of counting up of the Coarse Time of Spacecraft Time.

In the **Synchronous method**, the value of a SpaceWire TimeCode **shall** be used to distribute the lower 6 bits of Time Information.

In the **Synchronous method**, Onboard Subnetwork Time Code consists of a Synchronization Service field and a SpaceWire TimeCode field (see Figure 4-1).

In the **Synchronous method**, the number of bits of the Synchronization Service field **shall** be 32. The lower 6 bits of the Onboard Subnetwork Time Code in the **Synchronous method** is referred to as SpaceWire TimeCode field.

The Synchronization Service field and the SpaceWire TimeCode field hold the value of Coarse Time and that of Fine Time, respectively.

The Synchronization Service field and the SpaceWire TimeCode field hold the value of Coarse Time and that of Fine Time, respectively.

The Synchronization Service field and the SpaceWire TimeCode field hold the value of Coarse Time and that of Fine Time, respectively.

<table>
<thead>
<tr>
<th>Synchronization Service field</th>
<th>SpaceWire TimeCode field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Time</td>
<td>Fine Time</td>
</tr>
</tbody>
</table>

**Figure 4-1: The structure of Time Information (Synchronous Method)**

**Time Information の構造 (Synchronous Method)**
### 4.2.3. Asynchronous Method

In the Asynchronous method, the value of a SpaceWire TimeCode is not used to distribute any bits of Time Information.

In the Asynchronous method, Onboard Subnetwork Time Code consists of only a Synchronization Service field (see Figure 4-2).

In the Asynchronous method, the number of bits of the Synchronization Service field shall be 48.

The Synchronization Service field contains a 32-bit value of Coarse Time and 16 bits value of Fine Time (see Section 3.4.3).

<table>
<thead>
<tr>
<th>Time Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onboard Subnetwork Time Code</td>
</tr>
<tr>
<td>Synchronization Service field</td>
</tr>
<tr>
<td>Coarse Time (32 bits)</td>
</tr>
<tr>
<td>Fine Time (16 bits)</td>
</tr>
</tbody>
</table>

**Figure 4-2: The structure of Time Information (Asynchronous Method)**

Asynchronous method では、SpaceWire TimeCode の値を、時刻情報のどのビットの配信にも用いない。

Asynchronous method では、Onboard Subnetwork Time Code は、Synchronization Service フィールドのみからなる (Figure 4-2 参照)。

Asynchronous method では、Synchronization Service フィールドのビット数は、48 ビットであること。

Synchronization Service フィールドは、Coarse Time の値 32 ビットと Fine Time の値 16 ビットを含む (3.4.3 項参照)。
5. CALIBRATION SCHEME OF SPACECRAFT TIME

5.1. GENERAL // 一般

A Calibration Scheme relates time values of a clock in the Uncorrected clock-mode to time values of a clock in the Corrected clock-mode.

This chapter specifies the Calibration Scheme referred to as the Spacecraft-to-Ground Calibration Scheme, which relates time values of a Primary Clock in the Uncorrected clock-mode to time values of a clock in a ground station in the Corrected clock-mode.

Section 5.2 specifies time measurement aboard a spacecraft. Section 5.3 specifies time measurement on the ground.
5.2. TIME MEASUREMENT ABOARD SPACECRAFT // 衛星上での時刻計測

5.2.1. Common Specification // 共通規定

Figure 5-1 shows the relation between the Spacecraft-to-Ground Calibration Scheme and the lower-layer telemetry protocols. Information required for the Spacecraft-to-Ground Calibration Scheme is transferred with one of the following protocols: the Space Packet Protocol [A3], Spacecraft Monitor and Control Protocol (SMCP) [A2], and AOS Space Data Link Protocol [A4].

Figure 5-1 に、Spacecraft-to-Ground Calibration Scheme と下位層のテレメトリプロトコルとの関係を示す。Spacecraft-to-Ground Calibration Scheme に必要な情報は、三つのプロトコル: Space Packet Protocol [A3], Spacecraft Monitor and Control Protocol (SMCP) [A2], 及び AOS Space Data Link Protocol [A4] の何れかにより伝送する。

The value of Spacecraft Time when a specific AOS Transfer Frame [A4] is transmitted to the ground (hereafter referred to as Marker Transmission Time or MTT) shall be measured.

An MTT shall be transferred to the ground by a telemetry. A telemetry which contains an MTT is referred to as Time Telemetry.

A spacecraft shall have a function to generate Time Telemetries periodically.

The AOS Transfer Frame whose transmission time is measured is referred to as a Reference Transfer Frame and the measured point and timing in a wave form are referred to as a Measurement Point and Measurement Timing, respectively.

特定の AOS Transfer Frame [A4] を地上に送信する時点の Spacecraft Time の値（以降、Marker Transmission Time または MTT と称する）を計測すること。

MTT は、テレメトリで地上に伝送されること。MTT を含むテレメトリを Time Telemetry と称する。

衛星は、Time Telemetries を周期的に生成する機能を持つこと。

送信時刻を計測する AOS Transfer Frame を、Reference Transfer Frame と称する。また、波形の計測点及び計測時間を、それぞれ、Measurement Point 及び Measurement Timing と称する。
The **Measurement Point** should be the first bit of an **Attached Sync Marker** [A6] attached to a **Reference Transfer Frame**.

[Rational] In the specification of the **SLE** [R6], which is the CCSDS standard of the ground protocol, the **Earth Receive Time** is measured with the first bit of an **Attached Sync Marker** ([R8], Section 3.6.2.3 in [R6]). For consistency, measurement of the first bit of an **Attached Sync Marker** is preferable.

If a **Measurement Point** has an offset from the first bit of an **Attached Sync Marker**, the offset **shall** be a constant in units of bits.

[Example] The offset in the measured position in units of bits is +32 if the **Measurement Point** is not the start but end position of an **Attached Sync Marker**.

A **Measurement Timing** should be the timing when a **Measurement Point** is transmitted from a spacecraft.

If a **Measurement Timing** has an offset from the timing when the **Measurement Point** is transmitted from a spacecraft, the offset **shall** be constant time in units of seconds.

A **Time Telemetry** shall be either a **VALUE Telemetry Message** (hereafter referred to as a **TIME Message**; see Section 5.2.2) or a **Reference Transfer Frame** itself (hereafter referred to as a **TIME Frame**; see Section 5.2.3).

The value of a **MTT Time Code** of **STCC-Type 2** shall be held in a **TIME Message**.

[Note 1] The method of **TIME Messages** is compatible with the **Packet Method** specified in Section 3.3.1 of [R5].

[Note 2] A **Transfer Frame** which contains a **TIME Messages** is generated after generation of a **Reference Transfer Frame**.

The value of a **MTT Time Code** of **STCC-Type 1** shall be held in a **TIME Frame**.

Measurement Point は、**Reference Transfer Frame** に付随する **Attached Sync Marker** [A6] の先頭ビットであるべきである。

[根拠] 地上プロトコルの CCSDS 標準である SLE [R6] の仕様では、**Attached Sync Marker** の先頭ビットで **Earth Receive Time** を計測する ([R6] の 3.6.2.3 項、[R8])。整合をとるため、**Attached Sync Marker** の先頭ビットの計測が望ましい。

Measurement Point が **Attached Sync Marker** の先頭ビットからオフセットを持つ場合、そのオフセットは、ビットの単位の固定値であること。

[例] Measurement Point が **Attached Sync Marker** の先頭では無く末尾である場合には、ビットの単位の計測点のオフセットは+32 である。

Measurement Timing は、**Measurement Point** を衛星から送信するタイミングであるべきである。

Measurement Timing が Measurement Point が衛星から送信されるタイミングからオフセットを持つ場合、そのオフセットは、秒の単位の固定時間であること。

**Time Telemetry** は、**VALUE Telemetry Message**（以降、**TIME Message** と称する; 5.2.2 項参照）または **Reference Transfer Frame** そのもの（以降、**TIME Frame** と称する; 5.2.3 項参照）の何れかであること。

**STCC-Type 2** の **MTT Time Code** の値は、**TIME Message** に保持されること。

[注 1] **TIME Message** の方式は、[R5] 3.3.1 項が定めるパケット方式と互換性がある。

[注 2] **TIME Messages** を含む **Transfer Frame** は、**Reference Transfer Frame** の生成後に生成する。

**STCC-Type 1** の **MTT Time Code** の値は **TIME Frame** に保持されること。
[Note 3] The method of TIME Frames is compatible with the Frame Method specified in Section 3.3.2 of [R5].

In the SLE, information of the Bit Rate required for the Calibration Scheme is not available. Therefore, if a Measurement Point has an offset from first bit of an Attached Sync Marker, the information of the Bit Rate shall be encoded into a Value Telemetry Message. A fixed position field of a Space Packet which has the APID value determined by a project shall contain this information of the Bit Rate, in order to avoid causing unnecessary complexity in data processing in the ground systems.

The following items shall be determined in each project and specified in a project-specific document using the table provided in Section 7.2.3.

- Delivery method of Sampling Timing (TIME Message or Time Frame),
- Offset of Measurement Timing (constant in units of seconds),
- Offset of Measurement Point (constant in units of bits), and
- Time interval with which TIME Messages are generated (e.g. once per five Transfer Frames).

[注 3] TIME Frame の方式は、[R5] 3.3.2 項が定めるフレーム方式と互換性がある。

SLE では、Calibration Scheme が要求するビットレートの情報が入手できない。そこで、Measurement Point が Attached Sync Marker の先頭ビットからオフセットを持つ場合、ビットレートの情報を Value Telemetry Message にエンコードすること。地上システムにおけるデータ処理が必要以上に複雑になるのを避けるため、project が定めた APID 値を持つ Space Packet の固定位置のフィールドが、このビットレートの情報を含むこと。

以下の項目を、project 毎に決め、7.2.3 項に示す表を用いて project 固有の文書で定めること。

- サンプルタイミングの配信方式 (TIME Message または Time Frame)
- Measurement Timing のオフセット（秒の単位の定数）
- Measurement Point のオフセット（ビットの単位の定数）
- TIME Messages を生成する時間間隔（例えば、5 個の Transfer Frames に一回）
5.2.2. TIME Message

If TIME Messages are used, a Primary Clock Functional Object shall be able to generate also one-shot TIME Message as a result of executing an Operation specified in [R7].

A TIME Message shall contain the values of the Attributes [R7] listed in Table 5-1. The format of the Attribute Values field [A2] of a TIME Message is shown in Figure 5-2.

Neither a Time Code field nor Attachment field [A2] is present in a TIME Message.

Neither blocking nor segmenting by the ADU protocol [R1] shall be used for Time Messages.

Table 5-1: Attributes held in a TIME Message (STCC-Type 2)

TIME Message に保持される Attributes (STCC-Type 2)

(a) STCC-Type 2a

<table>
<thead>
<tr>
<th>Attribute / Field Name</th>
<th>Length (bits)</th>
<th>Unit</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCID</td>
<td>6</td>
<td>N/A</td>
<td>Virtual Channel Identifier (VCID) [A4] of the Reference Transfer Frames</td>
</tr>
<tr>
<td>Virtual Channel Frame Count</td>
<td>24</td>
<td>N/A</td>
<td>Virtual Channel Frame Count [A4] of the Reference Transfer Frames</td>
</tr>
<tr>
<td>MTT Coarse Time</td>
<td>30</td>
<td>second</td>
<td>Value of the Basic Time field of the Onboard Subnetwork Time Code of the MTT</td>
</tr>
<tr>
<td>MTT Fine Time</td>
<td>20</td>
<td>1μs</td>
<td>Value of the Supplementary Counter of the MTT</td>
</tr>
</tbody>
</table>
(b) **STCC-Type 2b**

<table>
<thead>
<tr>
<th>Attribute / Field Name</th>
<th>Length (bits)</th>
<th>Unit</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserve</td>
<td>2</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>VCID</td>
<td>6</td>
<td>N/A</td>
<td>Virtual Channel Identifier (VCID) of the Reference Transfer Frames</td>
</tr>
<tr>
<td>Virtual Channel Frame Count</td>
<td>24</td>
<td>N/A</td>
<td>Virtual Channel Frame Count of the Reference Transfer Frames</td>
</tr>
<tr>
<td>MTT</td>
<td>40</td>
<td>31.25msec</td>
<td>Value of the MTT</td>
</tr>
</tbody>
</table>

**Figure 5-2: Attribute Values field of a TIME Message (STCC-Type 2)**

The field marked as “Reserved” shall not be used and be filled with zeros. “Reserved”となっているフィールドは、使用を避け、ゼロで埋めること。
The following items **shall** be determined in each project and specified in a project-specific document, using the table provided in Section 7.2.3:

- **APID** (specified in [A3]) of the Space Packet which contains TIME Messages,
- Name of the Primary Clock Functional Object,
- Name of the Operation for generating a TIME Message (only STCC-Type 2a),
- **FOID** (specified in [A2]) of the Primary Clock Functional Object (only STCC-Type 2a), and
- **Attribute ID** of the Attribute Sequence specified in [A2] held in TIME Messages (only STCC-Type 2a).

以下の項目を、project 毎に決め、7.2.3 項に示す表を用いて project 固有の文書で定めること。

- TIME Messages を含む Space Packet の ([A3] が定める) APID
- Primary Clock Functional Object の名称
- TIME Message を生成する Operation の名称（STCC-Type 2aのみ）
- Primary Clock Functional Object の ([A2] が定める) FOID（STCC-Type 2aのみ）
- TIME Messages に保持される、[A2] が定める Attribute Sequence の Attribute ID（STCC-Type 2aのみ）
5.2.3. **TIME Frame**

A TIME Frame shall contain the values of the Attributes listed in Table 5-2. TIME Frame は、Table 5-2 に示す Attributes の値を含むこと。

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Length (bits)</th>
<th>Unit</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTT Coarse Time</td>
<td>32</td>
<td>Second</td>
<td>Value of the Basic Time field of the Onboard Subnetwork Time Code</td>
</tr>
<tr>
<td>MTT Fine Time</td>
<td>24</td>
<td>1/2¹⁶s</td>
<td>Value of the Supplementary Counter</td>
</tr>
</tbody>
</table>

The format of the Transfer Frame Data field [A4] of an AOS Transfer Frame is shown in Figure 5-3 AOS Transfer Frame の Transfer Frame Data フィールド [A4] のフォーマットを Figure 5-3 に示す。

Figure 5-3: **Time Frame**

The field marked as “Reserved” shall not be used and be filled with zeros. “Reserved”となっているフィールドは、使用を避け、ゼロで埋めること。

The following items shall be determined in each project and specified in a project-specific document, using the table provided in Section 7.2.3:

- VCID of TIME Frames
- TIME Frames の VCID

以下の項目を、project 毎に決め、7.2.3 項に示す表を用いて project 固有の文書で定めること。
5.3. TIME MEASUREMENT ON THE GROUND // 地上における時刻計測

For time calibration of the Spacecraft Time, a ground station shall measure time of the timing when the first bit of the Attached Sync Marker attached to a Reference Transfer Frame is received (Earth Receive Time).

Note that the Earth Receive Time can be related to the sampled timing of the Spacecraft Time (MTT) with correction for delays in propagation and processing.

[Note] The Earth Receive Time is carried with telemetry in the ground subnetwork as specified in [R8] and [R9].
6. SYNCHRONIZATION SCHEME AND DESCREE TIME ADJUSTMENT SCHEME OF SPACECRAFT TIME

6.1. GENERAL // 一般

This chapter specifies the function required to maintain the time accuracy of the Primary Clock in the Corrected clock-mode. In Section 6.2, the Time Adjustment Scheme using a clock in a ground station is specified. In Section 6.3, the Synchronization Scheme using a GPS receiver is specified.

6.2. DESCREE TIME ADJUSTMENT SCHEME WITH A CLOCK IN A GROUND STATION // 地上局の時計による DESCREE TIME ADJUSTMENT SCHEME

The Discrete Time Adjustment Scheme shall specify the method to make multiple clocks have the same time value.

The Discrete Time Adjustment Scheme shall guarantee the time accuracy of the clocks for a certain period after an operation of adjustment is performed.

Each project shall specify the Discrete Time Adjustment Scheme with a clock in a ground station if needed.

6.3. SYNCHRONIZATION SCHEME WITH A CLOCK WITH A GPS RECIVER // GPS 受信機内の時計との SYNCHRONIZATION SCHEME

The Synchronization Scheme shall specify the method to make multiple clocks have the same time value.

The Synchronization Scheme shall guarantee the time accuracy of the clocks for the duration while its function is active.

Each project shall specify the Synchronization Scheme with a GPS receiver if needed.
7. METHOD TO SPECIFY MANAGED PARAMETERS IN EACH PROJECT 固有な MANAGED PARAMETERS の定め方

7.1. GENERAL // 一般

This chapter presents the method to specify values of the project-specific managed parameters for Time Management.

The managed parameters for Time Management are tabulated in the tables in this chapter. Every project shall specify all the parameter values in all the tables and shall present them in a project-specific document, using the corresponding tables in this chapter, including the notes in and below each table if any, as the template.

[Example] Appendix B presents an example of specifying the values of the managed parameters for Time Management used for a project.

7.2. SPACECRAFT MONITOR AND CONTROL PROTOCOL

7.2.1. Spacecraft Time

The values of the managed parameters related with Onboard Subnetwork Time Code (see Chapter 3 in this document) shall be specified in a form of Table 7-1.

Table 7-1: Values of the managed parameters related with Onboard Subnetwork Time Code に関連する managed parameters の値

<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of the Spacecraft Time Code Combination</td>
<td>Either STCC-Type 1 or STCC-Type 2a</td>
<td>---</td>
</tr>
<tr>
<td>The operation mode of onboard clocks</td>
<td>Either Corrected clock-mode or Uncorrected clock-mode</td>
<td></td>
</tr>
<tr>
<td>For Corrected clock-mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epoch</td>
<td>GPS or TAI</td>
<td>---</td>
</tr>
<tr>
<td>Long-term accuracy of Primary Clock for clock correction</td>
<td>(Recommended value is ±0.5 sec)</td>
<td>Second</td>
</tr>
<tr>
<td>Maximum invalid time value</td>
<td>(Recommended value is 10 × 365 × 86400 sec (~10 years))</td>
<td>Second (from the epoch)</td>
</tr>
</tbody>
</table>
7.2.2. Distribution of Spacecraft Time

The values of the managed parameters related with distribution of Spacecraft Time (see Chapter 4 in this document) shall be specified in a form of Table 7-2.

**Table 7-2: Values of the managed parameters related with distribution of Spacecraft Time**

<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes to which the Spacecraft Time is distributed</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Protocol</td>
<td>One of SpaceWire-RMAP, SpaceWire-PTP or SpaceWire-R</td>
<td>---</td>
</tr>
<tr>
<td>Lower bits of Space Time</td>
<td>SpaceWire TimeCode or Absent</td>
<td>---</td>
</tr>
</tbody>
</table>

7.2.3. Calibration Scheme of Spacecraft Time

The values of the managed parameters related with TIME Messages and TIME Frames (see Chapter 5 in this document) shall be specified in a form of Table 7-3.
Table 7-3: Values of the managed parameters related with TIME Messages and TIME Frames

<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Timing delivery method</td>
<td>Time Message / Time Frame</td>
<td>---</td>
</tr>
<tr>
<td>Time interval with which Time Messages are generated</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>Offset of a Measurement Point from the first bit of an Attached Sync Marker</td>
<td>(Constant)</td>
<td>Bits</td>
</tr>
<tr>
<td>Offset of Measurement Timing from the timing when a Measurement Point is transmitted from a spacecraft</td>
<td>(Constant)</td>
<td>Seconds</td>
</tr>
<tr>
<td>Value Telemetry Message definition of the Bit Rate Information (*1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCIDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APIDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attribute IDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position from the head of a Space Packet</td>
<td>Octets</td>
<td></td>
</tr>
<tr>
<td>Bit Position</td>
<td>Bits</td>
<td></td>
</tr>
<tr>
<td>Number of bits</td>
<td>Bits</td>
<td></td>
</tr>
<tr>
<td>Definition of the value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Message (STCC-Type 2a, STCC-Type 2b) only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APID of the Space Packet which contains a Time Message.</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>Name of the Primary Clock Functional Object</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>Time Message (STCC-Type 2a) only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of the Operation for generating a Time Message</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>FOID of the Primary Clock Functional Object</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>Attribute ID of the Attribute Sequence held in Time Messages</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>Time Frame (STCC-Type 1) only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCID of Time Frames.</td>
<td></td>
<td>---</td>
</tr>
</tbody>
</table>

*1: This information is required if ‘difference in measured position in units of bits’ is non-zero.
### APPENDIX A. ACRONYMS // 略語

This chapter lists the acronyms used in this document.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOS</td>
<td>Advanced Orbiting System</td>
</tr>
<tr>
<td>APID</td>
<td>Application Process Identifier</td>
</tr>
<tr>
<td>CUC</td>
<td>CCSDS Unsegmented Code</td>
</tr>
<tr>
<td>FOID</td>
<td>Functional Object Identifier</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>MTT</td>
<td>Marker Transmission Time</td>
</tr>
<tr>
<td>SCDHA</td>
<td>Standard of Communications and Data-Handling Architecture</td>
</tr>
<tr>
<td>SLE</td>
<td>Space Link Extension</td>
</tr>
<tr>
<td>SMCP</td>
<td>Spacecraft Monitor and Control Protocol</td>
</tr>
<tr>
<td>STCC</td>
<td>Spacecraft Time Code Combination</td>
</tr>
<tr>
<td>PTP</td>
<td>Packet Transfer Protocol</td>
</tr>
<tr>
<td>RMAP</td>
<td>Remote Memory Access Protocol</td>
</tr>
<tr>
<td>TAI</td>
<td>Temps Atomique International (International Atomic Time)</td>
</tr>
<tr>
<td>TM</td>
<td>Telemetry</td>
</tr>
<tr>
<td>UTC</td>
<td>Coordinated Universal Time</td>
</tr>
<tr>
<td>VCID</td>
<td>Virtual Channel Identifier</td>
</tr>
</tbody>
</table>
APPENDIX B. EXAMPLE OF MANAGED PARAMETERS USED FOR A PROJECT// PROJECT が用いる MANAGED PARAMETERS の例

B.1. GENERAL// 一般

This chapter gives an example of specifying the properties of the Time Management used in a project with a sample spacecraft. This chapter is not a part of the specification given in this document.

B.2. SPACECRAFT MONITOR AND CONTROL PROTOCOL

B.2.1. Spacecraft Time

The managed parameters related with Onboard Subnetwork Time Code (see Chapter 3 in SCDHA8) shall have the values listed in Table B-1.

Table B-1: Values of the managed parameters related with Onboard Subnetwork Time Code

<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of the Spacecraft Time Code Combination</td>
<td>STCC-Type 2a</td>
<td>---</td>
</tr>
<tr>
<td>The operation mode of onboard clocks</td>
<td>Corrected clock-mode</td>
<td></td>
</tr>
<tr>
<td>Epoch</td>
<td>GPS</td>
<td>---</td>
</tr>
<tr>
<td>Long-term accuracy of Primary Clock for clock correction (*1)</td>
<td>±0.5</td>
<td>Second</td>
</tr>
<tr>
<td>Maximum invalid time value (*1)</td>
<td>10 x 365 x 86400</td>
<td>Second (from the epoch)</td>
</tr>
</tbody>
</table>
B.2.2. Distribution of Spacecraft Time

The managed parameters related with distribution of Spacecraft Time (see Chapter 4 in SCDHA8) shall have the values listed in Table B-2.

<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes to which the Spacecraft Time is distributed</td>
<td>PI1-A, PI1-B, PI2-A, PI2-B</td>
<td>---</td>
</tr>
<tr>
<td>Protocol</td>
<td>SpaceWire-RMAP</td>
<td>---</td>
</tr>
<tr>
<td>Lower bits of Space Time</td>
<td>SpaceWire TimeCode</td>
<td>---</td>
</tr>
</tbody>
</table>

B.2.3. Calibration Scheme of Spacecraft Time

The managed parameters related with TIME Messages and TIME Frames (see Chapter 5 in SCDHA8) shall have the values listed in Table B-3.
<table>
<thead>
<tr>
<th>Managed Parameter Name</th>
<th>Allowed Value</th>
<th>Unit / Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling Timing delivery method</td>
<td>Time Message</td>
<td></td>
</tr>
<tr>
<td>Time interval with which Time Messages are generated</td>
<td>128 Transfer Frames</td>
<td>---</td>
</tr>
<tr>
<td>Offset of a Measurement Point from the first bit of an Attached Sync Marker</td>
<td>+32 Bits</td>
<td></td>
</tr>
<tr>
<td>Offset of Measurement Timing from the timing when a Measurement Point is transmitted from a spacecraft</td>
<td>0 Seconds</td>
<td></td>
</tr>
</tbody>
</table>

**Value Telemetry Message** definition of the Bit Rate Information (*1)

| VCIDs | 0 |
| APIDs | 100h |
| Attribute IDs | 00h |
| Position from the head of a Space Packet | 20 Octets |
| Bit Position | 0 Bits |
| Number of bits | 8 Bits |
| Definition of the value | 00h: 32kbps, 01h:256kbps |

**Time Message (STCC-Type 2a, STCC-Type 2b) only**

| APID of the Space Packet which contains a Time Message. | 123 | --- |
| Name of the Primary Clock Functional Object | Clock_FO | --- |

**Time Message (STCC-Type 2a) only**

| Name of the Operation for generating a Time Message | Generate_Time_Message | --- |
| FOID of the Primary Clock Functional Object | 216Bh | --- |
| Attribute ID of the Attribute Sequence held in Time Messages | 02A1h | --- |

**Time Frame (STCC-Type 1) only**

| VCID of Time Frames. | --- |

---

*1: This information is required if ‘difference in measured position in units of bits’ is non-zero.