Japan Aerospace Exploration Agency

Institute of Space and Astronautical Science

BepiColombo
Mercury Magnetospheric Orbiter [MMO]

MMO Telemetry / Command Design Criteria (MMO-C-TCDC)

MMOテレメトリ/コマンド設計基準書

(JX-MMO-C0007)

Version 1.0

Mar. 2010

	Signature	Print Name
Approved:		Hajime Hayakawa

JAXA/BepiColombo Project Office
Institute of Space and Astronautical Science (ISAS)
Japan Space Exploration Agency (JAXA)
3-1-1 Yoshinodai, Sagamihara, Kanagawa 229-8510, JAPAN
E-mail : bepi-hq@stp.isas.jaxa.jp
Fax : +81-42-759-8456

CHANGE LOG (改訂記録)

VER.	DATE	ITEMS
0.1	16 May 2007	Draft
0.2	30 Aug. 2007	Red: Revised Part
		Only Turbo code support -> Concatenated code and Turbo code are selectable, Transfer Frame Trailer in Turbo Code is CLCW and CRC -> CLCW in Transfer Frame Trailer and Fill Data in Transfer Frame Insert Zone . (Section 4.1, 4.1.1, 4.1.1(4), 4.1.1(5), 4.5, 4.6, Figure 4.1.1-1 ~ 4.1.1-4, Figure 4.5-1~2, Table 4.5-1~2)
		Time Line is prohibited to call Long Macro Command. -> Time Line is able to call Long Macro Command. (Section 3.2.2)
		APID of DR and TCIU is added. (Table 3.1.2-2, 4.2-2)
		Component Name is changed. MDP1 -> MDP-DPU1 MDP2 -> MDP-DPU2 PCU -> PCD
		MMO SpaceWire User's Manual (TBD) is added in Applicable Documents.
		Memory Load/Dump support on SpaceWire RMAP (Remote Memory Access Protocol) is added.(Section 5)
		Report Packet -> Report Telemetry User Packet -> User Telemetry Mission Packet -> Mission Telemetry HK Packet -> HK Telemetry
		Usage of DR is updated. (Section 6.2, 6.3)
		Constraint on Time TICK is added. (Table 4.3-1)
0.3	28 Feb. 2008	Blue: Revised Part
		Insert Zone is changed to CRC in Transfer Frame Trailer
		The name of Processing Frame is changed to Processing Slot
		The name of "MMO SpaceWire User's Manual" is changed to "MDP Payload Interface Requirement Document"
		Discrepancy about Maximum number of registration time for system timer command is corrected (8 in apanese, 32 in English -> 8 is correct)
		Maximum number of autonomous command registration is changed from 32 to 64
		Following description about sequence count check is added. If the number of sequence count of command packet is the same as that of previously received command, user component should neglect the command.
		The name of Packet Message Memory Load/ Dump is changed to Memory Load/ Dump. The name of RMAP Direct Memory Load/ Dump is changed to Memory Load / Dump (RMAP)
1.0	Mar. 2010	**Official Release for CDR** The following items have been revised in this version. Each revised part is indicated with red-coloured letters in the text.
		Devided Section 2.1 into Section 2.1 "Applicable Documents"and 2.2 "References" and updated. Added Section 2.3 "Definitions"
		Requirement of sequence count check is deleted in section 3.1.2.
		Revised Table 3.1.2-2, Table 4.2-2. Components name in APID is revised. Components extention bits in APID is clarified. Definition of broadcast command is clarified. Definition of System HK Telemetry is clarified.

VER.	DATE	ITEMS
1.0	Mar. 2010	Added explanation that component shall receive realtime and stored command. (update due to EM test #2)
		Space Craft ID is assigned in Table 3.1.4-1, Table 4.5-1.
		Deleted explanation of MPO Packet Structure in section 3.1.6 and 4.7. Data type ID for MMO Data Block is assigned in Table 3.1.6-4 and Table 4.7-3.
		Added explanation that parameter no.1 is necessary for serial magnitude command in figure 3.2.1-1 and section 3.2.1. (update due to EM test #2)
		Operation Mode Change Command format is updated in Table 3.2.1-2.
		Time interval unit of Long Macro Comamnd is corrected in Table 3.2.2-1. (2s unit in Table 3.2.2-1, while 1s unit in sentence -> 1s unit is correct)
		Explanation of autonomous command is appended in section 3.3.2.2.
		Revised Explanation of ADU in section 4.1.1 and in Figure 4.2-2.
		Added information of corresponding Packet Sequence Flag for each ADU in Table 4.2-2.
		Added explanation that ADU Length in secondary header is defined by byte in Table 4.2-3.
		DMC report packet format is changed back to Hayabusa format inTable 4.2-4.
		Explanation of memory load and memory dump in section 5 is appended.
		Number of DR Partition is changed (256 -> 192) in section 6.1 (4).
		System HK Telemetry maximum size is clarified (864byte MAX) in section 6.1(5).
		Added Figure 6.3-1 (schematic overview of DR and category usage).
		Overall MMO data block is classified into MMO TC data block and MMO TM data block.
		Overall HK Telemetry is classfieied into System HK Telemetry and User HK Telemetry, and the explanation is appended. (in section 3.3.2.2, section 4.1.1, in Table 4.3-2, in section 6)
		Overall TBC and TBD are deleted except for following item Table 3.2.1-2 Operation Mode Change Command format User Packet Acquisition when Operation mode change command is executed in Table 3.2.1-2 Memory Load/dump applicability for PCD and MEA1,2

REVISED PAGE LIST

page	Revision	page	Revision	page	Revision	page	Revision	page	Revision
1	1.0	45	1.0	89	1.0				
2	1.0	46	1.0	90	1.0				
3	1.0	47	1.0	91	1.0				
4	1.0	48	1.0	92	1.0				
5	1.0	49	1.0	93	1.0				
6	1.0	50	1.0	94	1.0				
7	1.0	51	1.0	95	1.0				
8	1.0	52	1.0	96	1.0				
9	1.0	53	1.0	97	1.0				
10	1.0	54	1.0	98	1.0				
11	1.0	55	1.0	99	1.0				
12	1.0	56	1.0	100	1.0				
13	1.0	57	1.0	101	1.0				
14	1.0	58	1.0	102	1.0				
15	1.0	59	1.0	103	1.0				
16	1.0	60	1.0	x					
17	1.0	61	1.0						
18	1.0	62	1.0						
19	1.0	63	1.0						
20	1.0	64	1.0						
21	1.0	65	1.0						
22	1.0	66	1.0						
23	1.0	67	1.0						
24	1.0	68	1.0						
25	1.0	69	1.0						
26	1.0	70	1.0						
27	1.0	71	1.0						
28	1.0	72	1.0						
29	1.0	73	1.0						
30	1.0	74	1.0						
31	1.0	75	1.0						
32	1.0	76	1.0						
33	1.0	77	1.0						
34	1.0	78	1.0						
35	1.0	79	1.0						
36	1.0	80	1.0						
37	1.0	81	1.0						
38	1.0	82	1.0						
39	1.0	83	1.0						
40	1.0	84	1.0						
41	1.0	85	1.0						
42	1.0	86	1.0						
43	1.0	87	1.0						
44	1.0	88	1.0						

CONTENTS

1　適用範囲 (Scope of Application)

本設計条件書は、MMO に搭載される機器のテレメトリ／コマンド設計に関して適用する。本条件書によりがたい場合は、個別に調整するものとする。

This document is applied to the Telemetry & Command design of the components onboard MMO. If this document includes something doesn't fit to your component, please contact the system side.

2　適用文書(Applicable Documents)

2.1　適用文書(Applicable Documents)

(1) MMO 電気設計基準書 (MMO Component Electrical Design Criteria) (JX-MMO-C0005)
(2) MMO SpaceWire ネットワーク仕様書 (MMO SpaceWire Network Specifications) (JX-MMO-DMC-0001) (for MDP and PCD)
(3) MDP Payload Interface Requirement Document (JX-MMO-MDP-0001) (for other sensors)

2.2　関連文書(References)

(1) TM Synchronization and Channel Coding (CCSDS 131.0-B-1)
(2) Space Packet Protocol (CCSDS 133.0-B-1)
(3) Telecommand Summary of Concept and Rationale (CCSDS 200.0-G-6)
(4) TC Synchronization and Channel Coding (CCSDS 231.0-B-1)
(5) TC Space Data Link Protocol (CCSDS 232.0-B-1)
(6) Advanced Orbiting Systems, Networks and Data Links:
Summary of Concept, Rationale, and Performance (CCSDS 700.0-G-3)
(7) AOS Space Data Link Protocol (CCSDS 732.0-B-2)
(8) Space Engineering, Ground system and operations – Telemetry and telecommand packet utilization (ECSS-E-70-41A)
(9) MMO Interface Requirement Document (MMO IRD) (BC-EST-RS-02181)
(10) 衛星の機能モデル (Functional Model of Spacecraft (FMS)) (GSTOS 201-0.6)
(11) 衛星監視制御プロトコル (Spacecraft Monitor & Control Protocol (SMCP)) (GSTOS 200-0.7)
(12) SMCP を MMO に適用するための規則 (Rules for Applying SMCP to MMO (RASM)) (GSTOS 280-0.1)
(13) MMO Telemetry / Command List (JX-MMO-0014)
(14) MMO MDP DMC/DR Usage Definition Document (JX-MMO-MDP-0004)

2.3 定義(Definition)

Note:本文書で規定する Format 中の Field が値を表す場合は、先頭の bit が MSB であるとする。

Note: If a field of the format described in this document expresses the numerical value, the first bit of the field is MSB (Most Significant Bit).

3 コマンド(Command)

3.1 Command Data Structure

3.1.1 概要 (Outline)

分離後(Mercury Orbit Phase)の MMO では、「はやぶさ」等と同様、地上からのコマンド伝送方式としては、CCSDS(Consultative Committee for Space Data Systems) TELECOMMAND を適用する。詳細については、以下に示す。

① データ伝送単位：CCSDS で規定される Space Packet 形式のコマンドパケット(TC Packet)を単位として伝送する。

② ビット同期対策：CCSDS が規定している Randomizer を使用する。

③ 伝送誤り対策：
Frame 単位で CRC(Cyclic Redundancy Check)符号化を行う。
上記 Frame を Randomize 後、さらに BCH(Bose-Chaudhuri-Hocquenghem Code)(56,7)符号化を行う。

④ 再送制御：
COP(Command Operation Procedures)-1 に準拠した Frame Level の再送制御を行う。
本 Frame 再送方式は、Go-Back-N 方式(ある一定の Data Frame までは連続して送信し、誤りがあった場合には当該 Frame 以降を全て再送信する方式)である。
ARQ(Automatic Repeat reQuest)の方式としては、タイプ 1 ハイブリット ARQ(Frame 内部を誤り訂正符号化する方式)に相当する。

In the MMO satellite of Mercury Orbit Phase, TELECOMMAND, one of the CCSDS (Consultative Committee for Space Data Systems) Recommendations, which is now the international standard, is applied as the data transfer method in the similar way as “HAYABUSA”. It is shown below for details.

① Data Transfer Unit: TC Packet of CCSDS Space Packet format is the unit of transmission.

② Guarantee of bit transition: The randomizer defined in the CCSDS Recommendation is used.

③ Error Correction Method: BCH cording (56,7) and CRC (Cyclic Redundancy Check) cording(for the TC Frame) are used.

④ Retransmission Control:
COP-1 (Retransmission method of Flame level) is used.

Mercury Orbit Phase の MMO の CCSDS command の各レイヤと、ネットワーク構成要素との関係はTable 3.1.1-1の通りである。また、同様にクルーズ中(Cruise Phase)の関係をTable 3.1.1-2に示す。両時ともユーザ機器側としては、Packet 以上のレイヤを理解していれば良い。Cruise Phase の MPO Packet より下のレイヤは、本文書では定義しない。

The relation between CCSDS command layer and Network element in Mercury Orbit Phase is shown in Table 3.1.1-1. In the same way, the relation between them in Cruise Phase is shown in Table 3.1.1-2. In each phase, User components should just understand the layer higher than Packet layer. In this document, the layer below MPO Packet in Cruise Phase is not defined.

Table 3.1.1-1　CCSDS command layer and Network element　(Mercury Orbit Phase)

Application Process	Procedure→	→□				□
System Management		□				□
(MMO) Packet	SIB →	→□			□→	→□
Segmentation		□			□	
Transfer		□			□	
Coding		□→	→□	□→	→□	
Physical			□→	→□		
Layer	User	Satellite Control	Ground System	C&DH	DMC and MDP	Component

→ → → →

RF　　SpaceWire

Table 3.1.1-2 CCSDS command layer and Network element (Cruise Phase)

Application Process	Procedure→	→□				□
System Management		□				□
(MMO) Packet	SIB →	→□			□→	→□
MMO Data Block		□	→□	□→	□	
MPO Packet			□	□		
:			□→	→□		
Layer	User	MMO Ground System	MPO Satellite Control & Ground System	MPO	DMC and MDP	Component

FTP RF 1553B SpaceWire

3.1.1.1 Outline in Mercury Orbit Phase

以下に、Mercury Orbit Phase の MMO の地上からの Command 伝送フロー概要を示す。（Figure 3.1.1.1-1参照）

In the following, it is shown the outline of the command transmission flow from the ground system for MMO in Mercury Orbit Phase (Refer to Figure 3.1.1.1-1).

(1) パケット層 ((MMO) Packet Layer)

TC Packet (MMO TC Packet)の生成 (Generation of TC Packet (MMO TC Packet))

Command は、TC Packet として送出する。この TC Packet は3.1.1.2 項で述べる MPO TC Packet と区別するために、特に MMO TC Packet と呼ぶ。TC Packet は、CCSDS で定義される TC Frame に挿入される。MMO では、TC Packet の最大長を 1016bytes に抑えることにより、1TC Packet が 1TC Frame(最大長 1024bytes)に入るような運用を行うこととする（ただし、3.1.1.2 項で述べるように、Cruise 中 MPO を介してのリンクでは、TC Packet 長は 208bytes に限られる。）。これは、Command の分割/結合の煩雑さを防ぐためである。実際の運用では、SIB(Satellite Information Base)に予め分かりやすい Command 名称と Command Data を登録しておくことにより、手順書の作成は、上記 Command 名称ベースで行う。Command 名称から TC Packet への変換は衛星管制装置が行う。

Command の種類については、3.2 項で定義する。3.2.2 項および3.3.2 項で述べる TimeLine / Macro と呼ばれる、オンボードで保持されるコマンドの最大の TC Packet 長は 32bytes である。

Each command is sent as TC Packet. The TC Packet is especially called as MMO TC Packet to be distinguish from MPO TC Packet described in 3.1.1.2 . Each TC Packet is inserted into the TC Frame defined by CCSDS. In the case of MMO, the length of the TC Packet is determined to be shorter than 1016bytes. Therefore, one TC Packet is inserted into one TC Frame (maximum length is 1024bytes). (As described in 3.1.1.2 , the maximum length of TC Packet is however limited to 208bytes through MPO in Cruise Phase.) This is for preventing the complicatedness of division/combination of Command. Actually, by registering a Command name and Command data for SIB (Satellite Information Base), Command name is used in the procedure document. Satellite control ground system performs conversion to TC Packet from a Command name.

The types of commands are defined in the subsection 3.2 . The maximum TC Packet length of onboard stored command called as TimeLine / Macro, described in 3.2.2 and 3.3.2 , is 32bytes.

(2) セグメンテーション層 (Segmentation Layer)

TC Segment の生成 (Generation of TC Segment)

MMO では、1TC Packet が 1TC Frame に入るような運用を想定しているが、今後の拡張性を考慮し、（TC Frame 長）＜（TC Packet 長）の場合にも対応できるよう、TC Packet を分割して TC Frame に挿入し伝送するための、Segmentation の機能を持つこととする。このため、衛星管制は、Segment Header を TC Packet の先頭に付加し、TC Segment を生成する。

In the case of MMO, one TC Packet is inserted into one TC Frame, as explained above. However, for the future extension, the Segmentation function is also installed in DHS and Ground System in order to deal with the case "(TC Frame length) < (TC Packet length) ". (By the segmentation function, the TC Packet is divided into TC Segments, and each TC Segment is inserted into the TC Frame respectively.) Therefore, the Segment Header is added to the head of each TC Packet, and the TC Segment is generated even when the TC Packet is not divided.

(3) トランスファ層 (Transfer Layer)

TC Frame の生成 (Generation of TC Frame)

TC Segment は、その前に TC Frame Header が付けられた後、CRC（Cyclic Redundancy Check）方式の誤り制御用符号化器に入力され、16bits の Frame 誤り制御 Word (FECW: Frame Error Control Word)が生成される。TC Frame Header＋TC Segment にこの FECW(16bits)を付加して、TC Frame が生成される。TC Frame の長さは可変長（TC Packet の長さに合わせて変化）である。

VC(Virtual Channel)は 1ch とし、MAP(Multiplexer Access Point)は DMC Hard Decode Command 用、通常 Command 用、Program Load 等の長い Data 伝送用の 3 種を用意する。

"TC Frame Header + TC Segment" are inputted into CRC（Cyclic Redundancy Check）encoder and 16bit FECW(Frame Error Control Word) is generated. Then, the TC Frame is generated as "TC Frame Header + TC Segment + FECW". The length of TC Frame is variable (adjusted to the length of the TC Packet).

MMO has only one VC (Virtual Channel) and three MAP (Multiplexer Access Point); one is for the DMC Hard Decode Command, next is for Normal Command, the last is for the long data transmission such as Program Load.

(4) 符号化層(Coding Layer)

CLTU (Command Link Transmission Unit)の生成 (Generation of CLTU)

生成された TC Frame は、Bit Transition 確保のために擬似 Randomize される。擬似 Randomize された TC Frame は、BCH 符号化（56bits ごとに 7bits の Check Bit と 1bit の Filler Bit (=0)を付加）される。

符号化された TC Data の先頭には、Start Sequence として 16bits (EB90H 固定)が、末尾には CLTU の終わりを識別するために Tail Sequence として 64bits (C5C5C5C5C5C5C579H)が付加され、CLTU が生成される。1CLTU には、1TC Frame が入るものとする。

TC Frame is randomized in order to insure the bit transition. Randomized TC Frame is encoded by BCH encoder; Parity Check Bit (7bit) and Filler Bit (1bit, =0) follow the each 56bits of Randomized TC Frame.

Start Sequence (16bits)(=EB90H) is added at the head of encoded TC Data and Tail Sequence (64bit)(=C5C5C5C5C5C5C579H) is added at the tail of them. This is called as CLTU (Command Link Transmission Unit).

One CLTU includes one whole TC Frame.

(5) 物理層(Physical Layer)

最初の CLTU の前には Acquisition Sequence が付加される。Acquisition Sequence は、"0"と"1"を 16bytes 以上交互に繰り返したものである。CLTU がない場合には、Idle Sequence がシンボル同期維持のために出力される。Idle Sequence は、"0"と"1"を交互に 1byte 以上繰り返したものとする。

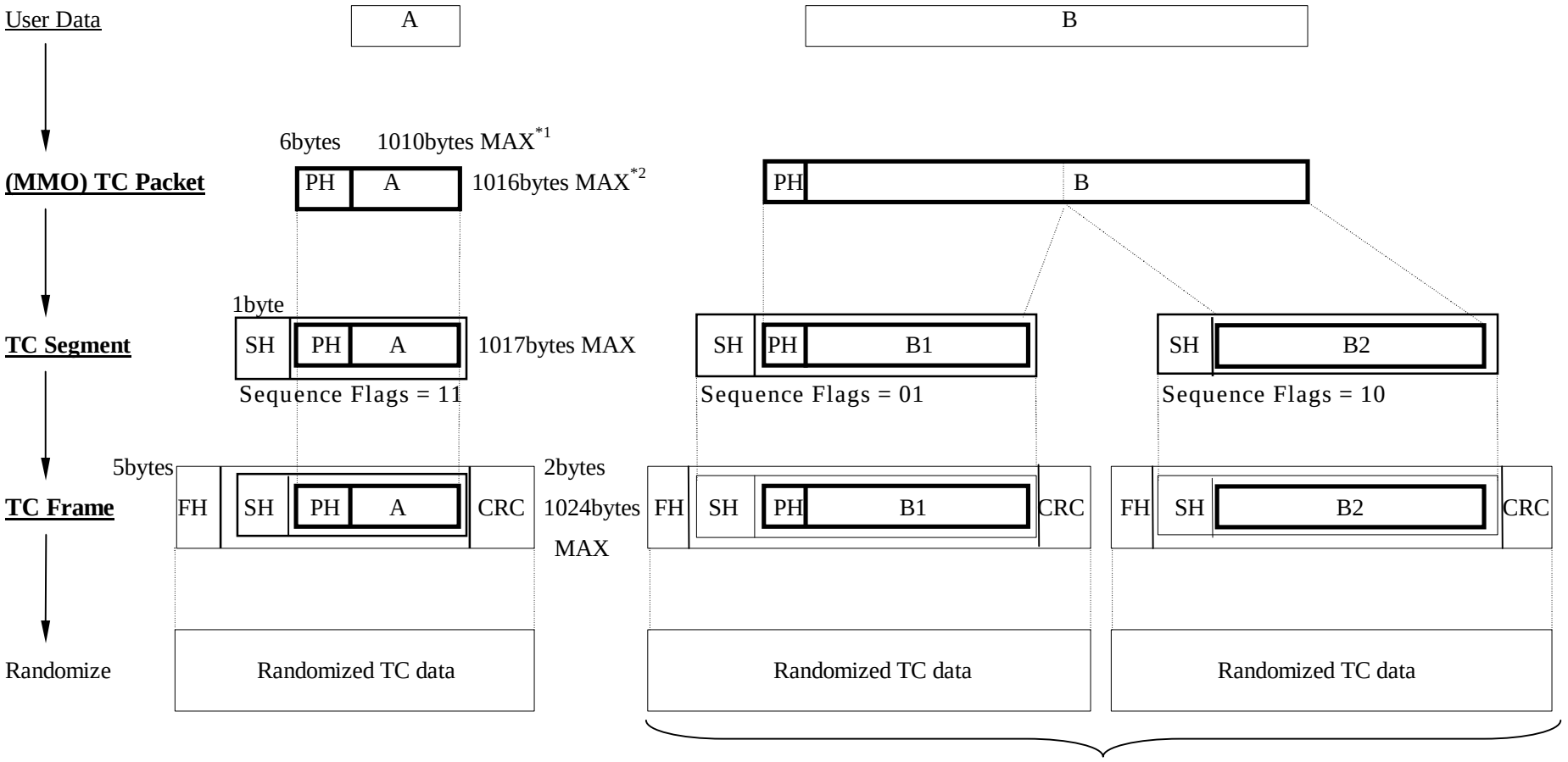
上記信号によりサブキャリアを PSK 変調し、その信号によりキャリアを PM 変調する。

Physical Layer Operations Procedures (PLOPs)としては、PLOP-2 を採用する。PLOP-2 では、CLTU を一つ送るごとに変調を止めることはせず、一連の CLTU に対して変調を行う。

The Acquisition Sequence is added to the first CLTU as preamble. The pattern of the Acquisition Sequence is alternating "ones" and "zeros" (The minimum length is 16 bytes.). The Idle Sequence is provided for maintenance of symbol synchronization in the absence of CLTUs. The bit pattern is a sequence of alternating "ones" and "zeros" (The minimum length is 1 byte.).

The carrier is PSK-PM modulated by the signal described above.

PLOP-2 is adopted for Physical Layer Operations Procedures. PLOP-2 is a procedure whereby the physical telecommand channel is not deactivated after each transmitted CLTU.



NOTE :) PH: TC Packet Primary Header
SH: TC Segment Header
FH: TC Frame Header

Not applicable to MMO

*1 In Cruise Phase, the maximum length is 202bytes.

*2 In Cruise Phase, the maximum length of TC Packet is 208bytes.

Figure 3.1.1.1-1 Summary of command data flow in Mercury Orbit Phase (1/2)

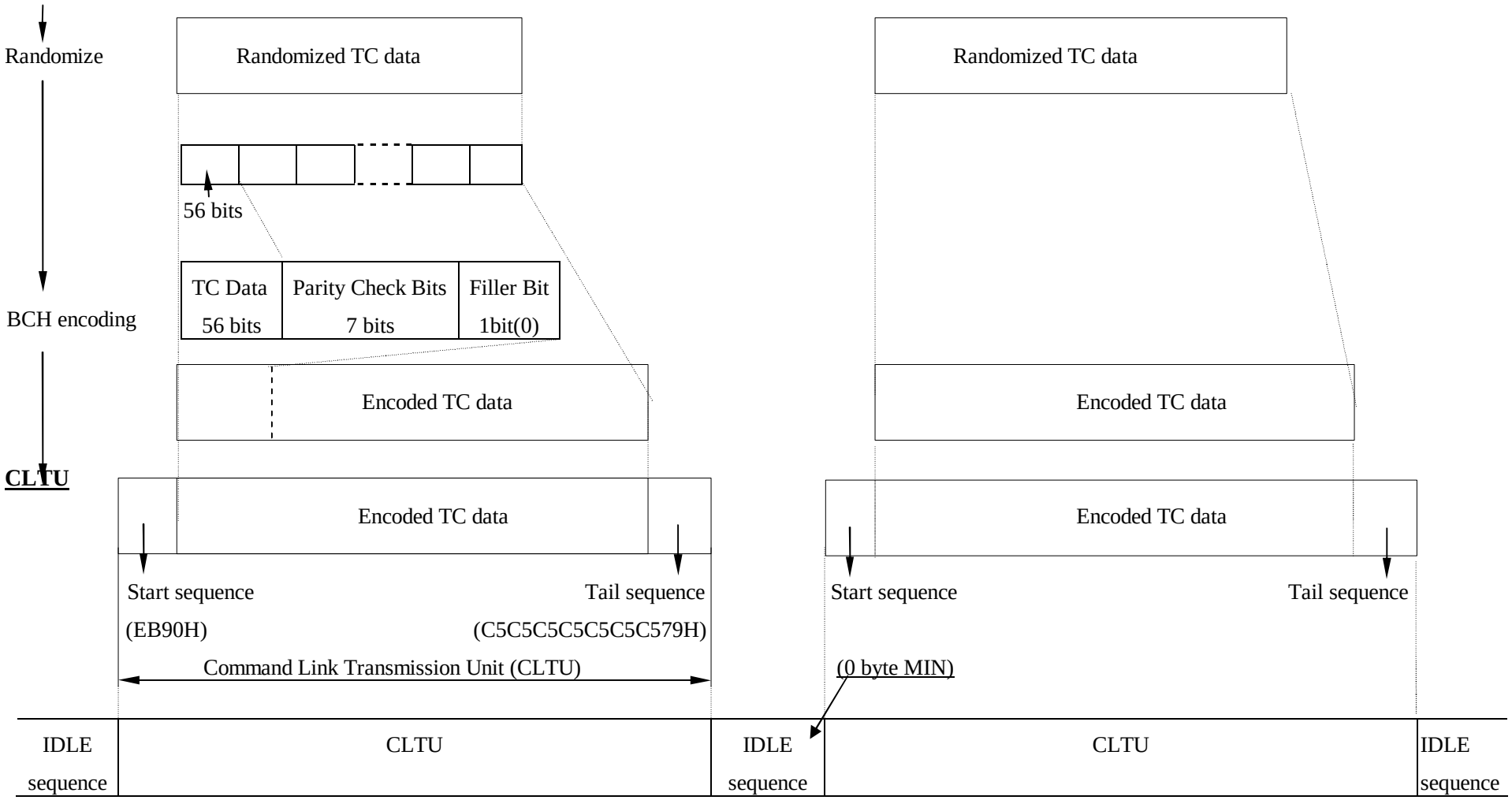


Figure 3.1.1.1-1 Summary of command data flow in Mercury Orbit Phase (2/2)

3.1.1.2　Outline in Cruise Phase

Figure 3.1.1.2-1に、Cruise Phase の MMO の Command データ Flow 概要を示す。

The outline of the command data flow in Cruise Phase is shown below and in Figure 3.1.1.2-1.

(1) MPO Packet / MMO Data Block 層 (MPO Packet / MMO Data Block Layer)

Cruise Phase の Command も Mercury Orbit Phase と同様に、MMO TC Packet として送出される。MMO の地上局で計画されたコマンドは、MPO の地上局へ MMO TC Packet に 2byte の Data Type ID を付加した MMO TC Data Block のフォーマットで FTP により転送される。この MMO TC Data Block は、MPO の地上局においてヘッダ情報を付加された MPO TC Packet として、MPO 側へ RF リンクにより送信される。MPO 側において、MPO の地上局により付加されたヘッダ情報を取り除かれ、MMO の DMC は、MIL-STD-1553B に準拠したデータバスを通して、MMO TC Data Block の単位で受信し、DMC において MMO TC Packet に変換される。Cruise Phase においては MPO での制約により、MMO TC Packet の最大長は 208bytes に抑えられる。

In Cruise Phase, each command is sent as MMO TC Packet in the same way as in Mercury Orbit Phase. The command sequence planed at the MMO ground system is transferred in MMO TC Data Block format, that 2bytes header called as Data Type ID is appended to MMO TC Packet, to the MPO ground system by FTP. MPO TC Packet, that header is appended to each MMO TC Packet in the MPO ground system, is transferred to the MPO in RF linkage. The header of each MPO TC Packet is removed and converted to MMO TC Packet in MPO, and the MMO TC Data Block is transferred to the MMO DMC through the MIL-STD-1553B bus. Then, DMC transforms the MMO TC Data Block to MMO TC Packet format. In Cruise Phase, the length of the MMO TC Packet is determined to be shorter than 208 bytes.

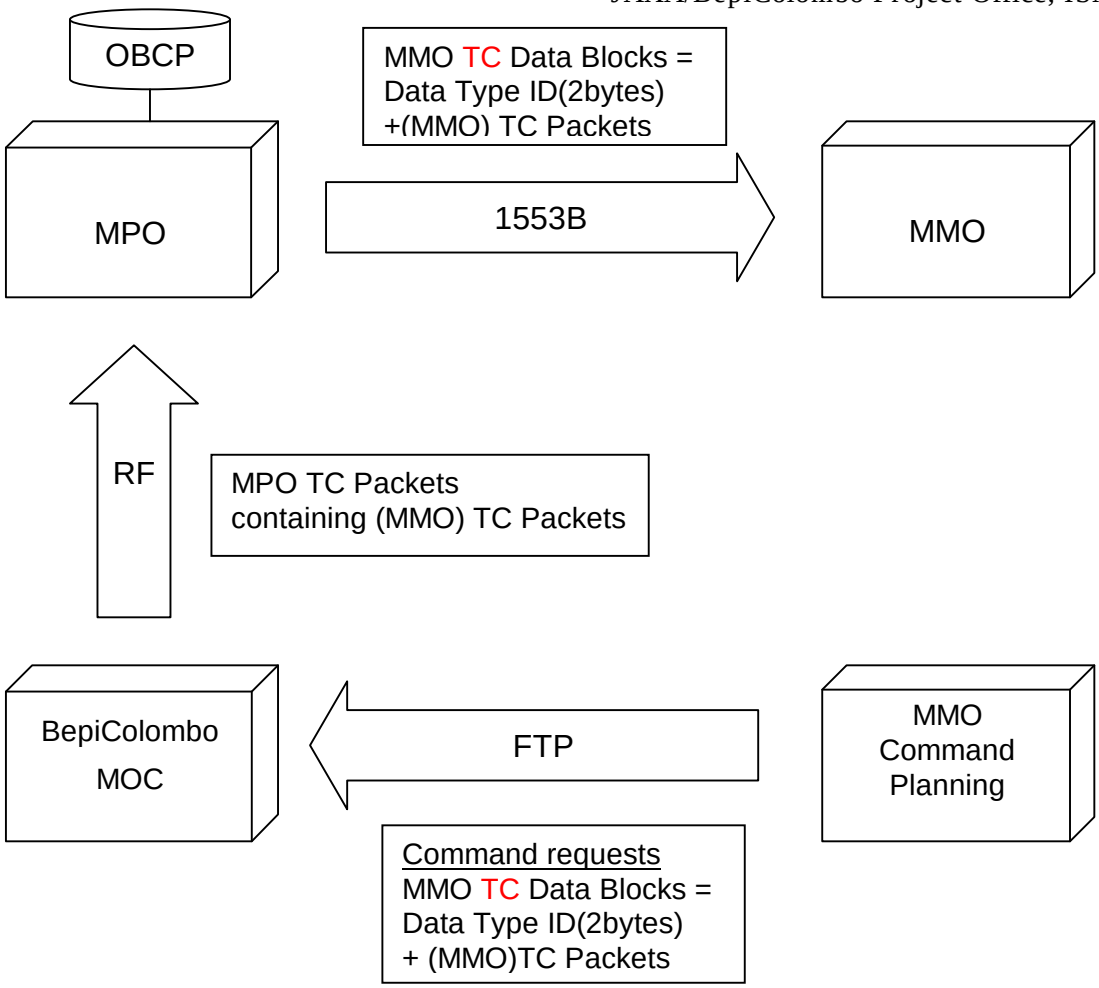


Figure 3.1.1.2-1 Summary of command Data Flow in Cruise Phase

3.1.2 TC Packet (MMO TC Packet) Format

本項では、MMO における(MMO) TC Packet Format を記述する。

TC Packet は 6 bytes の Primary Header と 2～1010 bytes (Mercury Orbit Phase)もしくは 2～202bytes (Cruise Phase)の可変長の User Data から構成される。TC Packet Format 詳細を Figure 3.1.2-1に、Primary Header の詳細をTable 3.1.2-1に、APID(Application Process ID) 詳細をTable 3.1.2-2に示す。~~User 機器は、Packet Sequence Count の値が、1 つ前に受信した Command の Packet Sequence Count と同じである場合に、その Command を破棄すること。~~

Check SUM も含めて、Option である 1010bytes (Mercury Orbit Phase)もしくは 202bytes (Cruise Phase)を越える User Data を Command として送る場合は、各 User で User Data を分割し、Packet Sequence Flag により、元々の User Data の先頭/中間/最後尾の識別をする。Command 受信側の User 機器では、Packet Sequence Flag と Packet Sequence Count により、元々の User Data の再構築を行う。元々の User Data の分割/再構築は、各 User が行い、DMC は関与しないこととする。Packet の内容の Check は、Packet を最終的に受信する User 機器が行うこと。

This section describes the (MMO) TC Packet Format.

The TC Packet consists of 6 bytes Primary Header and user data varies from 2 to 1010bytes (Mercury Orbit Phase), or from 2 to 202bytes (Cruise Phase) . The detailed TC Packet Format is shown in Figure 3.1.2-1, the detailed Primary Header Format of TC Packet is shown in Table 3.1.2-1 and the detailed APID (Application Process ID) Format is shown in Table 3.1.2-2.~~If the number of sequence count of command packet is the same as that of previously received command, user component should neglect the command.~~

If you want to send the User Command Data which exceeds 1010bytes in Mercury Orbit Phase (includes optional Check SUM) or 202bytes in Cruise Phase, you must divide the User Data into small parts and identify each data (Fist, Continuation or Last part) by the Packet Sequence Flag. When the user components receive these divided User Data, it should reconstruct the original User Data according to Packet Sequence Flag and Packet Sequence Count. The Division and Reconstruction of the original User Data should be done by not DMC but each user. The Packet should be checked by the user component (the end point of the transmission), and if necessary, the user component should request the retransmission.

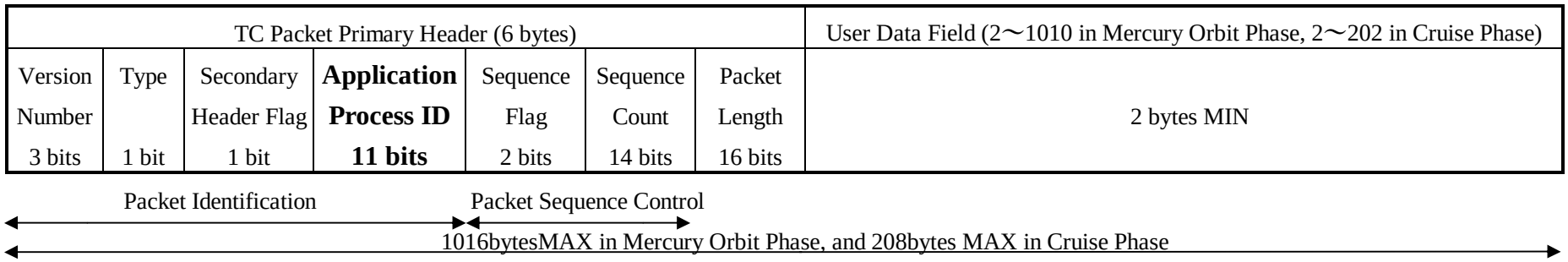


Figure 3.1.2-1　MMO TC Packet Format

Table 3.1.2-1　MMO TC Packet Primary Header

Field	Number of bits	Value (binary)	Note
Version Number	3	000 FIX	Version-1
Type	1	1 FIX	Telecommand Packet
Secondary Header Flag	1	1 FIX	Secondary Header is used.
Application Process ID	**11**	**To be defined in Table 3.1.2-2**	
Packet Sequence Flag	2	00: Continuation component of higher data structure 01: First component of higher data structure 10: Last component of higher data structure 11: Standalone Packet	
Packet Sequence Count	14	Variable Satellite Control Equipment uses only 00H for this field. (Except User Data Command Packet)	Modulo 16384
Packet Length	16	Variable (Value = the number of remaining bytes - 1)	the length of User Data Field -1

Table 3.1.2-2 Application Process ID for MMO TC Packet(Tentative)

Application Process ID for Command (11 bits)					
Common Use (3 bits)			NODE ID (5 bits)		Component Extension Bits (3bits) (BIN)
Command/ Telemetry (1bit) (BIN)	Real or Stored Command		Value (HEX)	Component NAME	
	Real Time (1bit) (BIN)	Stored (1bit) (BIN)			
0 FIX (Command)	10: Real Time Command 01: Stored Command (Refer to 3.3)		0	N/A	
			01	DMC	000: Common 001: DHFS 010: ACFS 011: TCFS 100: DR 111: HW
			02	PCD	000 FIX
			03	MDP-1	000: MDP-Firm1 001: MDP-User1
			04	MDP-2	000: MDP-Firm2 001: MDP-User2
			05	MEA1	000 FIX
			06	MEA2	000 FIX
			07	MIA	000 FIX
			08	MSA	000 FIX
			09	HEP-e	000 FIX
			0A	HEP-i	000 FIX
			0B	ENA	000 FIX
			0C	PME/MGF-O	000 FIX
			0D	PME/MGF-I	000 FIX
			0E	MDM	000 FIX
			0F	MSASI	000 FIX
			10	PME/EWO-E	000 FIX
			11	PME/EWO-B	000 FIX
			12	PME/SORBET	000 FIX
			13	PME/MEFISTO	000 FIX
			14	PME/MASTWPT-E	000 FIX
			15-1E	Spare	
			1F	Broadcast	000 FIX

Note1: Each component should declare the usage of "Component Extension Bits".

Note2: NODE ID "1F" is used for Broadcast Command, which is the command sent to the Intelligent Components which have System SpaceWire interface (DMC, PCD, MDP1 and MDP2) simultaneously (in the same Processing Slot).

Note3: Each component shall receive both real time command and stored command.

3.1.3 TC Segment Format

Segment Header は、Sequence Flags と MAP (Multiplexer Access Point) ID で構成される。Sequence Flags は、各 TC Segment の元の Data における位置に関する情報を示す。MAP ID は、同一 VC(Virtual Channel)内で、TC Frame 単位での multiplex 処理を行うために使用される。

MMO では、MAP ID(6bit)は以下のように使用することとする。

000001：DMC Hard Decode Command

000010：通常 Command

000100：Program Load 等、長い Data 伝送用　(binary 表記)

個々の Command が上記分類のどれに相当するかは、SIB (Satellite Information Base)で規定する。

Segment Format 詳細をFigure 3.1.3-1に示す。また、Segment Header 詳細をTable 3.1.3-1に示す。

The Segment Header consists of the Sequence Flags and MAP (Multiplexer Access Point) ID. The Sequence Flags indicate the position of each TC Segments in the original data. MAP ID is used to multiplex the TC Frame in the same VC (Virtual Channel).

In the case of MMO, MAP ID (6bit) is defined as below.

000001: DMC Hard Decode Command

000010: Nominal Command

000100: For Long Command such as Program Load (expressed in binary)

SIB (Satellite Information Base) describes which group each command belongs to.

The detailed Segment Format is shown in Figure 3.1.3-1, and the detailed Segment Header Format is shown in Table 3.1.3-1.

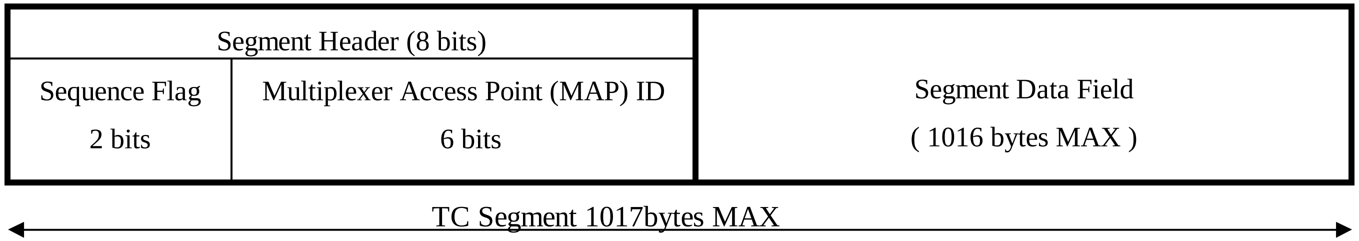


Figure 3.1.3-1　Telecommand Segment Format

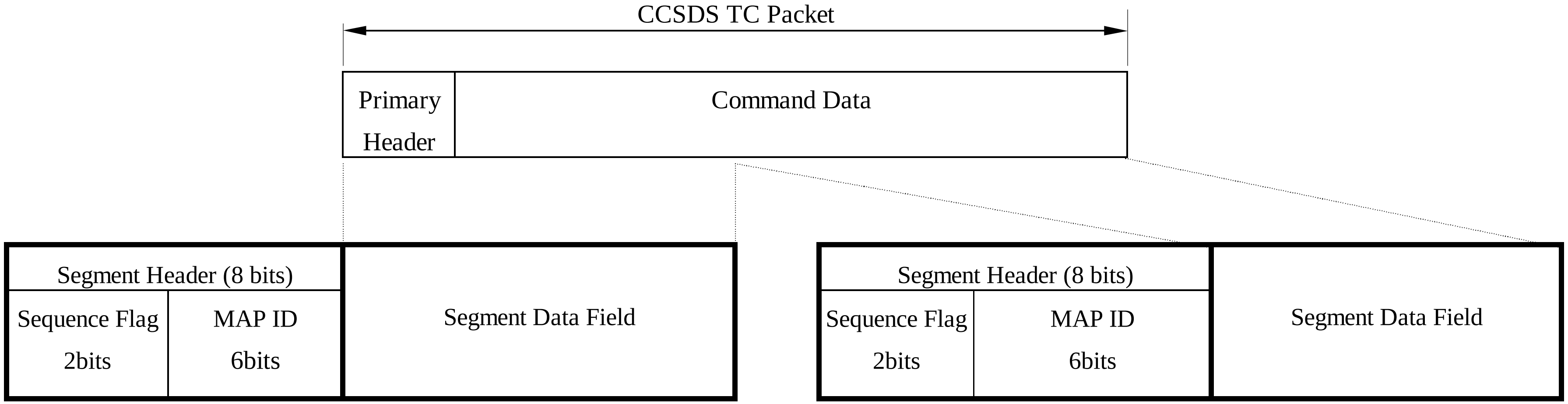


Figure 3.1.3-2　Example of Segmentation (Not applicable to MMO)

Table 3.1.3-1 Segment Header Format

Field	Number of bits	Value (binary)
Sequence Flag	2	01: First Segment of Command Data on one MAP 00: Continuing Segment of Command Data on one MAP 10: Last Segment of Command Data on one MAP 11: No segmentation 11 FIX for MMO
Multiplexer Access Point(MAP) ID	6	000001 : DMC Hard Decode Command Packet 000010 : Normal Command Packet 000100 : Long Command Packet (Program Loading, etc.)

3.1.4 TC Frame Format

TC Frame は、TC Segment の先頭に、衛星 ID や VCID 等 5 bytes からなる TC Frame Header を付加し、Segment の最後に、FECW(Frame Error Control Word) として CRC (Cyclic Redundancy Check) 2 bytes を付加したものである。

TC Frame format 詳細をFigure 3.1.4-1に、TC Frame Header 詳細をTable 3.1.4-1に示す。

The TC Frame consists of 5 bytes TC Frame Header (includes satellite ID and VCID etc), TC Segment and 2 bytes CRC as FECW (Frame Error Control Word).

The detailed TC Frame Format is shown in Figure 3.1.4-1 and the detailed TC Frame Header Format is shown in Table 3.1.4-1.

■VCID (仮想チャネル ID: Virtual Channel ID)

仮想チャネルとは衛星/地上間の回線を仮想的に複数の回線に分けて扱う機能であるが、MMO では、コマンドとしては、1ch の VCID のみを使用し、仮想チャネルによる多重化は行わないこととする。

Virtual channel is used to divide the connection between a satellite and ground into two or more channel virtually. The MMO uses only one VCID for the command system and doesn't use the multiplexing function among the Virtual Channels.

1024bytes MAX

TC Frame Header (5 bytes)								User Data Field (1019 bytes max.)	
Version No.	Bypass Flag	Control Command Flag	Spare	Spacecraft ID	Virtual Channel ID	Flame Length	Frame Sequence No.	Frame Data Field	FECW (CRC)
2 bits	1 bit	1 bit	2 bits	10 bits	6 bits	10 bits	8 bits	1017 bytes MAX	16 bits

Figure 3.1.4-1 TC Frame Format

Table 3.1.4-1 TC Frame Header and FECW

Field	Number of bits	Value (binary)	Note	
Version No.	2	00	00 : Version "1"	
Bypass Flag	1	00 or 10 or 11	0:Type-A(Acceptance): FARM(Frame Acceptance and Reporting Mechanism) operates 1: Type-B (Bypass): FARM is bypassed.	00: Type AD (For nominal use) 10: Type BD 11: Type BC
Control Command Flag	1		0: D mode: Frame Data Field contains the Command Data 1: C mode: Frame Data Field contains the Control Command to FARM.	
Spare	2	00		
Spacecraft ID	10	338H(FIX)		
VCID	6	000001	Only one Virtual Channel ID is used by MMO.	
Frame Length	10	Variable	Value = (Total Number of Bytes) –1 (MAX value = 1023 DEC)	
Frame Sequence No.	8	Variable	In the case of Type-A : modulo 256, In the case of Type-B : All “0”	
Frame Data Field	～1017 bytes	Variable	Includes one TC Segment.	
FECW	16	variable	The generator polynomial : **G(x)=x^16+x^12+x^5+1 (CRC)**	

Note: Type AD: For nominal use, Type BD: For the time when FARM doesn't work, Type BC: For FARM Control Commands

3.1.5 CLTU Format

1CLTU(Command Link Transfer Unit)内には、必ず 1TC Frame が入ることとする。
CLTU の Format は以下の通り。

1CLTU (Command Link Transfer Unit) includes whole one TC Frame.
CLTU Format is shown below.

Start Sequence (2bytes)	Encoded TC data	Tail Sequence (8bytes)
EB90H FIX	BCH Code (64bits)×n	C5C5C5C5C5C5C579H FIX

3.1.6 MPO TC Packet and MMO TC Data Block Format

MMO TC Data Block は、1 つの MMO TC Packet に、2byte のヘッダとしてTable 3.1.6-4 に示す Data Type ID を付加したものである。MMO TC Data Block の最大長は 210byte である。
MPO TC Packet は、1 つの MMO TC Data Block を user data として含む。

The MMO TC Data Block consists of a MMO TC Packet and Data Type ID shown in Table 3.1.6-4 as 2bytes header.
The MPO TC Packet includes a MMO TC Data Block as user data.

Figure 3.1.6-1, Table 3.1.6-1, Table 3.1.6-2 and Table 3.1.6-3 are deleted

Table 3.1.6-4 MMO Data Type ID for MMO TC data Block

Data Type ID	Definition
0000h	MMO TC Packet
FFFFh	Specific TC data, mainly supposed for the status request TC during the MMO separation, which may not have the standard Space Packet format.

3.2 Command 種別とその Data 構造 (Command type & Data Format)

3.2.1 Single Command

Command は、使用目的に応じ、Table 3.2.1-1に示す３種類に分類される。それぞれにおける、TC Packet 内に入る Command Data の Format をFigure 3.2.1-1に示す。

Commands are classified into three types as shown in Table 3.2.1-1 according to its purpose. The Formats of Command Data inserted into TC Packet are shown in Figure 3.2.1-1.

Table 3.2.1-1　コマンド種別 (Command Type)

No.	Command Packet Type	Command Data Format	Verification Method	DMC Process
1	Control Command Packet	To be defined in Figure 3.2.1-1	To be verified by the telemetry data. (Success Verify)	-Packet Extraction -Distribution
2	User Data Command Packet	To be defined in Figure 3.2.1-1	Depends on user.	-Packet extraction -Distribution
3	Memory Load Command Packet	To be defined in Figure 3.2.1-1	To be compared with the dumped memory data	-Packet Extraction -Distribution (Memory Load by user)

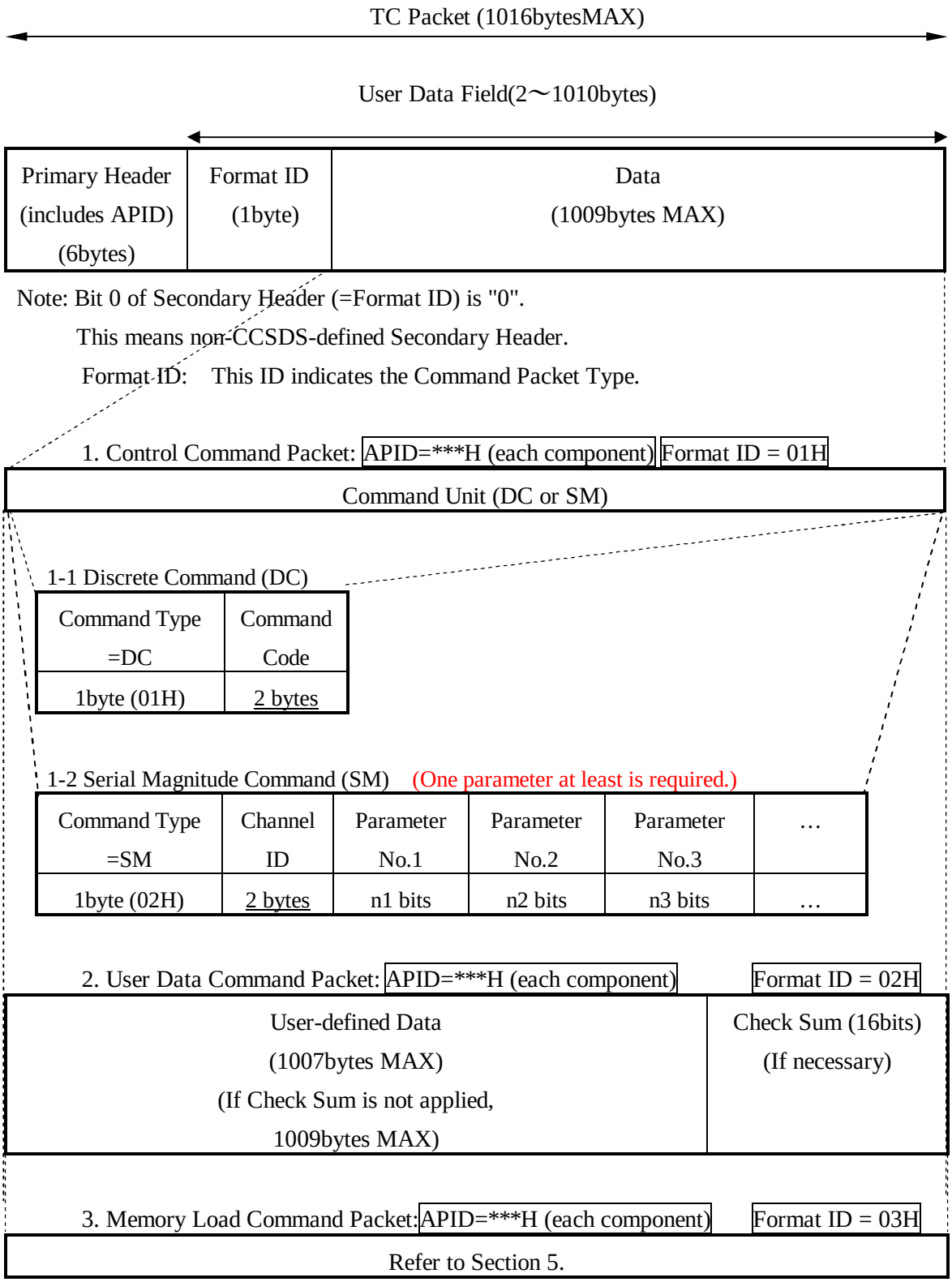


Figure 3.2.1-1 Command Packet Type & Data Format

以下では、Figure 3.2.1-1上の 3 種類の Command のそれぞれについて、詳細を記述する。

The details about the three command packet types shown in Figure 3.2.1-1 are described as under.

(1) Control Command Packet

本 Format は、SIB(Satellite Information Base)で管理される機器制御用 Command として使用される。本 Command Format では、1 TC Packet に 1 Command Unit のみが入る。

APID で DMC 内の TCIU が指定された場合は、TCIU が Decode を行い、User に対しては、Pulse Command または、Serial Magnitude Command の形で配信される。

Command Unit の構造を以下に示す。

1) DC (Discreet Command)の場合

・Command Code：Command の内容。動作を規定する。

・Command Code の長さは、2bytes 固定とする。

・以下の Code は、各機器で共通に定義すること。

0000～000FH：Spare (Reserved)

2)SM (Serial Magnitude Command)の場合

・Channel ID：Data が送られる Channel を識別するための ID。

・Channel ID の長さは、2bytes 固定とする。

・以下の Code は、各機器で共通に定義すること。

0003H：Operation Mode Change
（パラメータの内容はTable 3.2.1-2による）
0004H：Memory Dump Command
（パラメータの内容は5　章に示す。）
0001～0002H、0005～000FH：Spare (Reserved)

・パラメータの個数はChannel ID毎に固定。Channel ID が異なればパラメータの個数は異なってよい。ただし、搭載機器によっては、パラメータの個数をChannel IDによらず固定にしてもよい。

・Parameter：Commandの内容。

・n1、n2、n3等の値はChannel ID毎に固定。 Channel ID が異なればこれらの値は異なってよい。ただし、搭載機器によっては、パラメータの長さをChannel IDによらず固定にしてもよい。

Serial Magnitude Command は 1 つ以上のパラメータをもつこと。

(1) Control Command Packet

This format is used for the component control commands defined in SIB (Satellite Information Base). In the case of this command format, one TC Packet includes only one Command Unit.

When TCIU within DMC is designated by APID, TCIU decodes the command and sends the Pulse Command or Serial Magnitude Command to the specified user, according to the Command Unit.

The structure of Command Unit is shown below.

1) In the case of DC (Discreet Command):

- Command Code：the content of the command which defined the operation.
  - The length of Command Code is fixed to 2bytes.
  - Command Code shown below must be defined by each component as described below.

    0000～000FH：Spare (Reserved)

2)In the case of SM (Serial Magnitude Command):

- Channel ID：This ID indicates the Channel to which command should be sent.
  - The length of Channel ID is fixed to 2bytes.
  - Channel ID shown below must be defined by each component as described below.

    0003H：Operation Mode Change

    (The definition of Parameter is described in Table 3.2.1-2.)

    0004H：Memory Dump Command

    (The definition of Parameter is described in Section 5 .)

    0001～0002H、0005～000FH：Spare (Reserved)
  - The numbers of parameters must be fixed for each Channel ID, but they can be different between Channel IDs. However, they can be fixed to the same number for the component, if you want.
- Parameter：the content of the command which defined the operation.
  - The values of "n1","n2" and "n3" must be fixed for each Channel ID, but they can be different between Channel IDs. However, they can be fixed to the same number for the component, if you want.

    One or more parameters shall be included in Serial Magnitude Command.

Table 3.2.1-2　Operation Mode Change Command Format (TBC)

No. of byte	Contents	Note
6	Primary Header	
1	Format ID：01H (Control Command Packet)	
1	Command Type：02H (SM)	
2	Channel ID：0003H	
1	Downlink Bit Rate：n (→2^n×4bps, 8～64Kbps)	64Kbps is used only on ground
1	DMC Rate Check Mode	= Telemetry Operation Mode
1	Category Definition Table No.	= Telemetry Operation Mode
1	DHS Mode	
1	ACS Mode	
1	TCS Mode	
1	DR Mode	
1	PCD Mode	
MSB 4bit / 4bit LSB	MDP –DPU1 / MDP-DPU2 Mode	
MSB 4bit / 4bit LSB	MEA1 Mode /MEA2 Mode	
MSB 4bit / 4bit LSB	MIA Mode /MSA Mode	
MSB 4bit / 4bit LSB	HEP-e Mode/HEP-i Mode	
MSB 4bit / 4bit LSB	ENA Mode / MDM Mode	
MSB 4bit / 4bit LSB	MGF-o Mode / MGF-i Mode	
MSB 4bit / 4bit LSB	EWO-E Mode /EWO-B Mode	
MSB 4bit / 4bit LSB	PWI-SORBET Mode /MEFISTO-E Mode	
MSB 4bit / 4bit LSB	MSASI Mode / MAST/WPT-E Mode	

Note1: Each component's mode shall be defined as 00～0FH (4bits only).

Note2: In the Processing Slot when "Operation Mode Change Command" is sent, "On Demand Telemetry Packet" will not be gathered by DMC.　(TBD)

~~Note3: "Operation Mode Change" is executed only when Processing Slot No. change to 1. "Operation Mode Change Command" is issued more than 75ms (TBD) before the timing shown above (in Processing Slot No. = 8) to the Intelligent Components which have System SpaceWire interface. Refer to Section 5 in MMO Component Electrical Design Criteria.~~

Note4: Each component shall output its "Operation Mode" as HK.

Note5: Example of component mode definition is shown in Table 3.2.1-3.

Table 3.2.1-3　Example of Component Mode Definition

No	Component Operation Mode	Operation Mode	Minimum Interval time of Mission telemetry and Memory dump telemetry	Packet Length (Total)
1	00H	Standby	－	0bytes
2	01H	Observation #1	20s	500bytes
3	02H	Observation #2	10s	500bytes
4	03H	Observation #3	1s	200bytes

(2) User Data Command Packet

本 Format は、User が自由に定義する Command 用に使われる。

This format is used for the command, which is freely defined by User.

(3) Memory Load Command Packet

Refer to section 5　.

3.2.2 Macro Command (MC)

良く使うコマンドシーケンスをパッケージ化するものとして、相対時刻指定可能な Macro Command (MC)を用意する。MC は DMC 内に蓄積され、様々な Trigger 源から呼び出されて使用される。

上記 MC は、Table 3.2.2-1で示すように、MC No., MC 内の TC Packet 数, 実行される TC Packet 及び Time Interval で構成される。

Macro Command (MC) is the command sequence in which the time intervals can be specified between every two commands side by side. MCs are stored in DMC and called from the various origins of trigger.

MCs mentioned above consist of MC No., the number of TC Packets in the MC, TC Packets and Time Intervals (See Table 3.2.2-1).

Table 3.2.2-1 Example of MC Table

Area-1 (MCS; Short MC) (Time Interval = 0 FIX)

MC No.	The number of Packets in MC (1byte)	#00H TC Packet (32bytes)	#01H TC Packet (32bytes)	…	#0FH TC Packet (32bytes)
#00H	10H	TC Packet	TC Packet	…	TC Packet
#01H	1H	TC Packet	—	…	—
#02H	2H	TC Packet	TC Packet	…	—
#03H	2H	TC Packet	TC Packet	…	—
#FFH	10H	TC Packet	TC Packet	…	TC Packet

Note: Necessary Memory Area in DMC = 128.25Kbytes

Area-2 (MCL; Long MC)

MC No.	The number of Packets in MC (1byte)	#00H TC Packet (32bytes)	#00H Time Interval (1byte)	#01H TC Packet (32bytes)	#01H Time Interval (1byte)	…	#7FH TC Packet (32bytes)
#100H	80H	TC Packet	5H(5s)	TC Packet	5H(5s)	…	TC Packet
#101H	01H	TC Packet	—	—	—	…	—
#102H	6EH	TC Packet	AH(10s)	TC Packet	5H(5s)	…	—
#103H	15H	TC Packet	FFH(255s)	TC Packet	AH(10s)	…	—
#11FH	80H	TC Packet	10H(16s)	TC Packet	10H(16s)	…	TC Packet

Note: Necessary Memory Area in DMC = 132Kbytes

MC の仕様は以下の通りである。

(1)登録できる TC Packet の種類

MC に登録できる TC Packet は、Control Command Packet および User Data Command Packet のみとし、Memory Load Command Packet は扱わないこととする。また、DMC へのハードウェアコマンドは登録できない。

(2)登録される TC Packet の仕様

MC では、Command は、TC Packet として登録される。

登録される TC Packet の仕様は以下の通りである。

- 送出時には、Table 3.1.2-2に示すように、Real Time Command 時とは別の APID が使用される。
- Packet Sequence Flag は 11BIN 固定(Standalone Packet)とする。
- Packet Sequence Count は Support しない。All Zero で固定とする。
- TC Packet の長さは、TC Packet Primary Header を含めて 32bytes 以下とする。

(3)Time Interval

MC では、TC Packet 間に、Command の実行 Start の時間間隔として Time Interval を指定する。Time Interval は、1s×n (n=0～255)で指定できるとする。

(4)Command の連続実行の保証

Time Interval を 0 に設定した場合、TC Packet は、毎 Frame(125ms 間隔)連続して送出され、その部分には、他の Command （Onboard Trigger の Command や地上からの Real Time Command）は割り込めない。

(5)他の Command の割り込み

Time Interval を 0 以外に設定した場合には、他の Command(Real Time Command や Onboard Trigger の Command)が割り込める。

(6)実行中の MC の stop

実行中の MC を止めるものとして、以下のような DMC Command を用意する。

- All MC Stop：すべての実行中の MC を Stop する。
- Other MC Stop：自分以外の MC を Stop する。MC 内での使用可。

All MC Stop, Other MC Stop とも実行後はマクロコマンド機能が中止される。

なお、実行中の MC が上記 Command により Stop するのは、Time Interval 指定が 0 以外の部分においてであるとする。

(7)Trigger 源

MC は、以下の Trigger 源から呼び出される。

なお、MC から MC を再帰的に呼び出すことはできないとする。

- Real Time Command (RT)
- Time Line (Table 3.2.2-1参照。)
- 各機器からの Request Command (RQ)
- DMC における自律処理の結果として発行(AT)。

The specification of MC is shown as bellow.

(1)The type of TC Packet for MC

The type of TC Packet used in MC is only the Control Command Packet. The User Data Command Packet and the Memory Load Command Packet cannot be used in MC. Hardware Command to DMC cannot be used.

(2)The specification of TC Packet used in MC

In MC, every command is registered as the TC Packet.

The specification of TC Packet registered in MC is shown as bellow.

- When TC Packets in MC are sent, the APID different from Real Time Command is use (See Table 3.1.2-2).
- Packet Sequence Flag is fixed to 11BIN(Standalone Packet).
- Packet Sequence Count is not supported. It is fixed to all zero.
- The length of TC Packet (includes TC Packet Primary Header) doesn't exceed 32bytes.

(3)Time Interval

In MC, Time Intervals between the times when TC Packets were sent can be specified. Time Interval can be specified as 1s×n (n=0～255).

(4)Guarantee of the continuous execution of commands

If the Time Intervals are set to zero, TC Packets were sent continuously at every Frame (every 125ms) , and the other commands (Onboard Trigger Command or Real Time Command) can not interrupt them.

(5)Interruption of the other commands

When the Time Interval is set to non-zero, commands of the other type (Real Time Command or Onboard Trigger Command) can interrupt the MC command sequence there.

(6)How to stop the MC execution

To stop the MC execution, DMC commands shown below are available.

- All MC Stop：Stop the execution of all MC. (For Real Time Command)
- Other MC Stop：Stop the execution of the other MC (For MC)

After each command is executed (All MC Stop or Other MC Stop), All MC function is stopped. The execution of MC will be stopped by the commands above only at the point where the Time Interval is set to non-zero.

(7)Origin of Trigger

MC can be called by origins shown below.

MC can not call other MC, especially itself.

- Real Time Command(RT)
- Time Line (Refer to Table 3.2.2-1.)
- Request Command issued by user component (RQ)
- Autonomous Process of DMC(AT)

本 MC の MMO での制約条件は以下の通りである。

(1)MC の Parameter

登録できる TC Packet の bytes 数、個数等の Parameter は、MMO で定義するものである。他の衛星では変更の可能性がある。

(2)連続実行時間の上限

MMO では、MC 内の Time Interval を 0 とし、連続的に実行できる TC Packet の最大個数を 16 個とする。従って、MC の占有により生じる可能性のある Command 実行の遅延時間は 2s MAX である。

(3)Time Line からの相対時刻指定 Command 列呼び出しの禁止

MMO では、Time Line から、後述する相対時刻指定付の MC(Area-2, MCL; Long MC)を呼び出すことを可能とする。ただし、MC 展開後の実行コマンドタイミングの重なりがないことを、地上系の計画において確認すること。

The limitations of MC in MMO Project are shown below.

(1)Parameters of MC

The parameters of MC such as the maximum number of TC Packets or the maximum length of TC Packet are defined in MMO Project. It will be changed in the other projects.

(2)Limitation of the continuous execution time

In MMO Project, the number of the commands which are executed continuously (by the means of setting the Time Interval zero) is restricted to 16(MAX). Therefore, the maximum execution delay time of command, derived from the occupation of MC, is 2sec.

(3)Prohibition to call the MC with non-zero Time Interval from Time Line

In MMO Project, it is enabled to call the MC with non-zero Time Interval (Area-2, MCL; Long MC) from Time Line (mentioned later). However, it should be confirmed in the plan by a ground system that the execution command after the expansion of MC is not overlapped.

3.3 コマンド運用体系(Command Operation Scheme)

3.3.1 Real Time Command (RT)

Real Time Command は、機上で受信後、すぐに実行される Command である。Real Time Command となる Command には、次のものがある。

(1)Single Command

(2)Macro Command (MC)を実行するための Command

Real Time Command は、連続する 256 個の Command Packet の平均 Packet 長が 16bytes 以上という条件下で使用するものとする。

Real Time Command is the command, which will be executed just after it is received at the spacecraft. The commands, which can be used as Real Time Command, are shown below.

(1)Single Command

(2)The command to call Macro Command (MC)

Real Time Command shall be used under the condition that average length of 256 continuous Command Packet is larger than 16bytes.

3.3.2 蓄積コマンド (Stored Command)

蓄積コマンドは、一旦衛星内部に蓄積され、しかるべき時に実行されるコマンドである。蓄積コマンドには、3.2.2 項で述べた Macro Command 以外に、以下のものがある。

Stored Commands are commands, which are stored in the spacecraft and executed when they are needed. Stored Commands include the Macro Command mentioned at the section of 3.2.2 and commands shown below.

3.3.2.1　Time Line (TL)

Time Line とは、予め指定した絶対時刻に実行されるコマンドの列である。衛星の運用は、主にこの Time Line により行われる。Time Line の仕様は以下の通り。

"Time Line" is the line of commands whose absolute execution times are specified previously. The operation of the spacecraft is mainly performed by using this Time Line.
The specification of Time Line is shown below.

(1)登録できる TC Packet の最大数は 512 個~~(TBD)~~。
(2)TC Packet の最大長は 32bytes。
TC Packet としては、MC を Call する Command も指定できる。
(3)Time Line の実行状態としては、以下の 3 つの状態(モード)がある。
これらは Command で切り替えるものとする。
・All Stop：すべての Command を実行しない。
・Safe Run：選択実行 flag が 1 の Command のみを実行する。
・All Run：すべての Command を実行する。
なお、上記 Command により、現在実行中の Time Line の実行を制限する場合、Time Line から呼ばれて実行中の Macro Command が stop するのは、Time Interval 指定が 0 以外の部分においてであるとする。
(4)登録された個々の Time Line Command には、選択実行 Flag を付ける。
選択実行 Flag の仕様は以下の通り。
・選択実行 Flag =1：Safe Run モードの時にも実行される。
・選択実行 Flag =0：Safe Run モードの時には実行されない。
(5)Time Line の時間指定は 1s 単位とし、同一時刻への複数 Command の設定はできないものとする。
(6)Time Line に登録できる TC Packet は、Control Command Packet のみとし、User Data Command Packet と Memory Load Command Packet は扱わないこととする。

(1)The maximum number of TC Packets, which can be registered in Time Line, is 512~~(TBD).~~

(2)The maximum length of TC Packet registered in Time Line is 32bytes.

The TC Packet, which calls MC, can be registered in Time Line.

(3)There are three execution states of Time Line shown below.

One of these states is selected by the command.

- All Stop：All commands registered in Time Line will not be executed.
- Safe Run：Only the command, whose Selective Execution Flag is 1, will be executed.
- All Run：All commands registered in Time Line will be executed.

In the case of restricting the execution of the running Time Line by the command mentioned above, Macro Command called from the Time Line can stop only at the point where the Time Interval is set to non-zero.

(4)Each Time Line Command has the Selective Execution Flag.

The specification of the Selective Execution Flag is shown below.

- Selective Execution Flag = 1：

  In the case of Selective Run state, this command will be executed.
- Selective Execution Flag = 0：

  In the case of Selective Run state, this command will not be executed.

(5) LSB of the execution start time of each Time Line Command is 1s. Two or more Time Line Commands can not be set at the same execution start time.

(6)The type of TC Packet used in Time Line is only the Control Command Packet. The User Data Command Packet and the Memory Load Command Packet cannot be used in Time Line.

< Time Line Table >

Time Code (4bytes)	TC Packet (32bytes MAX)
T1	TC #1(Call MC#5)
T2	TC#2
T3	TC#3(Call MC#7)
•	•
•	•
T512	TC#512

512sets MAX ~~(TBD)~~

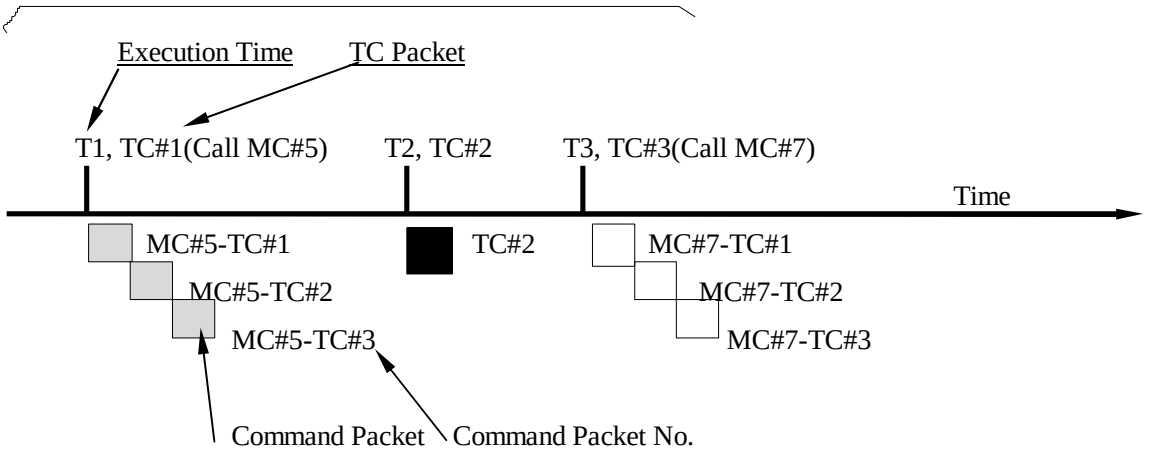


Figure 3.3.2.1-1 Example of Time Line Execution Sequence

3.3.2.2　Onboard Trigger Command

オンボードトリガコマンドとは、軌道上において衛星が地上からの要求なしに自律的に生成し、関係機器に送出するコマンドの事をいう。本機能は項目毎に"ENABLE"、"DISABLE"**状態の指定が可能である。**

DMC has the function of Onboard Trigger Command. Onboard Trigger Command is the command, which is generated onboard without any requirement from the ground system and delivered to the specified component. For each Onboard Trigger Command, one of the two statuses ("ENABLE" or "DISABLE") can be selected.

(1) **汎用自律化機能**(Multipurpose Autonomous Command, AT)

汎用自律化機能は、DMC **が** System HK (House Keeping) Telemetry **を周期的に収集・生成し、そのデータから衛星の状態を判断し、指定された** Command **を実行するものである。汎用自律化**(AT)**の仕様を以下に示す。**HK Telemetry **の考え方について詳細は** 6.1 (5) **に示すが、**DMC **が生成する汎用自律化対象の** HK Telmetry **を** System HK Telemetry **と呼ぶ。**

DMC gathers and generates System HK Telemetry periodically and judges the spacecraft status and, if necessary, executes the specified AuTonomous command (AT). The specification of AT is shown as bellow. As guideline of HK Telemetry is described in 6.1 (5), HK telemetry intended for multipurpose autonoumous command, which is generated by DMC, is defined as System HK Telemetry.

(1)**登録項目数：**64 **(自律化登録番号** 0x00-0x3F)
(2)**予め設定した** System HK Telemetry **について、予め設定した条件が満たされた場合に、予め設定した** Command **を実行する。**
(3)**登録できる** Command **は、**32bytes **以下の** TC Packet**。**
Short/Long MC **を呼び出すコマンドも登録可。**
(4)**スレショルドとの比較周期：**8s
(5)**項目ごとに** Enable/Disable **の設定可能**
(6)**汎用自律化テーブルには以下のような情報を登録する。**
①System HK Telemetry **位置：**"Word **位置**"-13
②**イベント連続回数：**
比較条件が連続して成立すべき回数。
指定された回数連続した場合に登録された Command **を発行。**
1**：**1 **回、**2**：**2 **回、**3**：**3 **回　・・・・　**255**：**255 **回(最大)**

③比較 Type：01H：ビット比較、10H：値比較

④比較対象：

現 HK と比較する対象を指定する。01H：前ＨＫ、10H：定数

⑤比較条件： Table 3.3.2-1に示す。

⑥定数値：比較対象の定数値

⑦バイアス値：比較対象のバイアス値

⑧マスクパターン：

ビット比較の際に、どのビットを比較対象とするか決定する。

全ビット対象であれば、FFh を指定。

例えば、Table 3.3.2-1 の"cHK＝1 & pHK＝0"の条件は、

"(現 HK & mask) == mask) && ((前 HK & mask) == 0x00)"

の意味。

⑨合致時他条件判定有無：

条件が合致した場合に、以下のどちらを実施するかを識別する。

・登録した TC Packet の Command を実行する。

・次に判定を行う自律化登録番号を指定して、判定を行う。

(複数の自律化の AND 条件での判定となる。)

⑩継続判定条件番号：

複数の自律化の AND 条件で判定を行う際に指定する、次に判定を行う自律化登録番号

Table 3.3.2-1　Comparison Condition of AT

	Comparison Type	Bit comparison (01H)		Value comparison (10H)	
	Object for comparison	Previous HK (01H)	Constant (10H)	Previous HK (01H)	Constant (10H)
Comparison Condition Equation	00H	N/A	N/A	N/A	N/A
	01H	cHK＝1 & pHK＝0	cHK＝1 & C＝0	cHK > pHK+B	cHK > C
	02H	cHK＝0 & pHK＝0	cHK＝0 & C＝0	cHK ＝ pHK	cHK ＝ C
	03H	cHK ＝ pHK	cHK ＝ C	cHK < pHK－B	cHK < C
	04H	cHK＝1 & pHK＝1	cHK＝1 & C＝1	cHK ≠ pHK	cHK ≠ C
	05H	cHK＝0 & pHK＝1	cHK＝0 & C＝1	| cHK－pHK | > B	N/A
	06H	cHK ≠ pHK	cHK ≠ C	N/A	:
	07H	N/A	N/A	:	:
	:	:	:	:	:
	FFH	N/A	N/A	N/A	N/A

*) cHK is current System HK telemetry, pHK is previous System HK telemetry, C is Constant value, and B is bias value.

(1) Maximum Number of registration item：64 (AT comparison condition number = 0x00-0x3F)

(2)In the case that previously specified condition about System HK telemetry is implemented,

corresponding command, which is registered previously, is executed.

(3) Registration Command is one TC Packet (The maximum length is 32bytes). The TC Packet, which calls Short/Long MC, can be registered.

(4)Period of comparison with the threshold：8s

(5)Each item is able to be set up as Enable/Disable, respectively.

(6)The following information is registered into a multipurpose autonomous table.

①System HK telemetry position："System HK telemetry Word position"-13

②The number of times of event continuation：

When the condition is implemented in specified times (1～255 times), registered command is executed.

③Comparison Type：01H：bit comparison、10H：value comparison

④Object for comparison：

Object to be compared with current System HK telemetry is specified in the following format.

01H：previous System HK telemetry、10H：Constant

⑤Comparison Condition is shown in Table 3.3.2-1.

⑥Constant value for comparison

⑦Bias value for comparison

⑧Mask pattern：

In the case of bit comparison, the coverage of the compared bit is specified. If full bit is object, FFh is assigned.

For example, ”cHK＝1 & pHK＝0” in Tabele 3.3.2-1 indicates

“(cHK & mask) == mask) && ((pHK & mask) == 0x00)”.

⑨Flag indicateing which of following actions is performed when state meets the AT comparison condition

・Execute of Registerd TC Packet

・Another judgement for the AT comparion condition, whose number is indicated as the next item.

(i.e., AT command is executed only when state meets every comparison condition of multiple AT.)

⑩AT comparison condition number corresponding to above another judgement in the case of multiple AT.

汎用自律化により、以下のようなことを実現する。

The followings are realized by the Multipurpose Autonomous Command.

A) UVC (Under Voltage Control)

バッテリが過放電状態になることが予想された場合、DMC **は**"UVC"**用** Command **を実行し、衛星消費電力の調整を行う。調整は、指定された機器に**"STAND-BY"**ま**

たは"OFF"コマンドを自動送出する方法で実行される。調整は消費電力を削減する方向にのみ実施される。

If there is the possibility of the battery over-discharge, DMC will execute the specified AT for UVC to restrict the power consumption of the spacecraft. In the UVC operation, DMC will send "STAND-BY" or "OFF" commands to the specified components. This control will be performed only to restrict the power consumption.

(2) User Request Command (RQ)

DMC はユーザからの Request Code に応じ、予め登録された Command を実行する。Request Command (RQ)の仕様は以下の通りである。

(1)登録項目数：32

(2)予め指定された機器から、予め設定された Request Code が出力されることにより、予め設定された Command を実行する。

(3)登録できる Command は、32bytes 以下の TC Packet。Short/Long MC を呼び出すコマンドも登録可。

(4)項目ごとに Enable/Disable の設定可能

試験を容易にするため、User Request Command を使用するユーザ機器は、上記要求を Command 等、何らかの手順により発生させる機能を設けること。

DMC executes the specified ReQuest command (RQ) according to the Request Code issued by User component. The specification of RQ is shown as bellow.

(1)Maximum Number of registration item：32

(2)Corresponding Command registered previously is executed by outputting Request Code specified previously from the user components specified previously.

(3)Registration Command is one TC Packet (The maximum length is 32bytes). The TC Packet, which calls Short/Long MC, can be registered.

(4)Each item is able to be set up as Enable/Disable, respectively.

User components, which use User Request Command, shall have the function to generate it by some kind of method, such as command to generate User Request Command, in order to make the system test easier.

(3) System Timer Command (ST)

DMC は、汎用タイマとして使用できる System Timer 機能を備える。System Timer の仕様は以下の通りである。

(1)登録項目数：8

(2)タイマ時間設定：128×n 秒(n=1～65535)、128s～約 97 日間
(n=0 とした場合には、n=1 と同一の動作となる)

(3)System Timer を Enable にすると、カウントダウンを開始し、タイムアップ後、予め登録した Command を実行。その後、タイマの値は設定値に戻り、そこから再びカウントダウン。

(4)登録できる Command は、32bytes 以下の TC Packet。
Short/Long MC を呼び出すコマンドも登録可。

(5)項目ごとに Enable/Disable の設定可能

(6)タイマカウントダウン中のリセット可能。
リセット後は、登録されている値に戻り、そこから再びカウントダウン。

DMC is equipped with the System Timer function which can be used as a general-purpose timer. The specification of System Timer is shown as bellow.

(1)Maximum Number of registration item：8

(2)Timer setting：128×n 秒(n=1～65535)、128s～approximately 97days

(Setting of n=0 is the same operation as n=1.)

(3)When System Timer is set to Enable, countdown is started and Command registered previously is executed after deadline. Then, the value of a timer returns to a setting value and is again counted down from there.

(4)The Command which can be registered is one TC Packet (The maximum length is 32bytes). The TC Packet, which calls Short/Long MC, can be registered.

(5)Each item is able to be set up as Enable/Disable, respectively.

(6)The reset under timer countdown is possible.

After reset, timer returns to the value registered and is again counted down from there.

(4) DMC Fault Detection, Isolation and Re-configuration command (FDIR)

MMO では DMC により、(1)で述べた汎用自律化機能の他に、あらかじめ決められた Fault Detection, Isolation and Re-configuration (FDIR)機能を有する。これは DHS(Data Handling Subsystem)、TCS (Thermal Control Subsystem)および ACS (Attitude Control Subsystem)で従来有している機能を DMC 内で行うものである。

In MMO, DMC has the Fault Detection, Isolation and Re-configuration (FDIR) function previously specified, besides Multipurpose Autonomous Command described in 1). This is the function performed within DMC, which is conventionally carried out by DHS (Data Handling Subsystem), TCS (Thermal Control Subsystem), and AOCS (Attitude and Orbit Control Subsystem), respectively.

3.3.3 Broadcast Command

DMC が下記 Command を受けた場合、System SpaceWire に接続された各機器に対し同時(同じ Processing Slot 内)に同一 Command を送出する。

(A) 各機器の動作 Mode 指定

（Real 及び蓄積用の最大 Data 発生 Rate の指定に相当）

Table 3.2.1-2 Operation Mode Change Command Format を参照。

(B) TI (Time Indicator) Counter Set/Reset

When DMC has received the following command from the ground system, DMC will send it to all the user components which are linked with System SpaceWire, simultaneously (in the same Processing Slot).

(A)The command which specifies the operation mode (or Maximum data rate of Real and Record) of each component.
Refer to Table 3.2.1-2 "Operation Mode Change Command Format".

(B)TI (Time Indicator) Counter Set/Reset

3.4 コマンド出力優先順位 (Command Output Priority)

DMC 内においてコマンドの要求が複数あった場合、Table 3.4-1に示す優先順位に基づき順次実行される。尚、Macro Command 実行中も、Time Interval 指定が 0 以外の部分では、他コマンドの実行は可能である。

If DMC have several command to be executed at the same command slot, DMC will execute them in accordance with the priority shown in Table 3.4-1. During the Macro Command execution, other command can be executed only at the point where Time Interval is set to non-zero.

Table 3.4-1 Command Output Priority ~~(TBD)~~

Priority	Type	Note
1(High)	Time Line (TL)	
2	System Timer Command (ST)	
3	Autonomous Command (AT)	
4	Real-time Command (RT)	
5	User Request Command (RQ)	
6(Low)	Memory Load/Dump	

4 テレメトリ (Telemetry)

4.1 概要 (Outline)

分離後(Mercury Orbit Phase)の MMO の telemetry は、「はやぶさ」と同様 Packet Telemetry とし、CCSDS (Consultative Committee for Space Data Systems) AOS(Advanced Orbiting Systems;発展型宇宙機システム) Space Data Link Protocol を適用する。

を適用する。Command の方は AOS ではなく Telecommand 勧告を採用しているため、いわゆる Hybrid 構成となる。以下に詳細を示す。

①データ伝送単位:CCSDS で規定される Space Packet 形式のテレメトリパケット(TM Packet)を単位として伝送する。TM Packet の上位概念として ADU(Application Data Unit)を定義し、User Data は ADU 単位で扱うこととするが、User 機器と DMC との I/F は TM Packet とする。

②ビット同期対策：CCSDS が規定している擬似 Randomizer を使用する。

③伝送誤り対策：

以下をコマンドにより切替可能

(a)Transfer Frame を Randomize 後、外符号として Reed-Solomon (I=2)符号、内符号として畳み込み符号(K=7,R=1/2)を使用する、連接符号化を行う。

(b)Transfer Frame を Turbo 符号化(information block length k = 3568 bits (interleaving depth I = 2 in Reed-Solomon に対応), code rate r = 1/2)後、Randomize を行う。

④再送制御：無し。

The AOS (Advanced Orbiting Systems) Recommendation, one of the recommendations written by the CCSDS (Consultative Committee for Space Data Systems) that are now the international standards, is applied to the MMO telemetry system of Mercury Orbit Phase in the similar way as “HAYABUSA”. In more concrete terms, Grade-2 Path Service is applied. As for the command system, not AOS but Telecommand Recommendation is applied. Therefore, it becomes the so-called Hybrid Configuration. It is shown below for details.

①Data communications unit:

Data is transmitted with TM Packet of CCSDS Space Packet format as a unit. Although ADU (Application Data Unit) is defined as a higher level concept than TM Packet and user data is treated as ADU unit, Interface between User components and DMC is TM Packet.

②Improvement for bit synchronization :

Pseudo-Randomizer prescribed by CCSDS is applied.

③Transmission error:

Following measures are selectable by command.

(a) After randomization of Transfer Frame, concatenated codes, which consist of an inner convolutional code (K=7,R=1/2) and an outer Reed-Solomon code (I=2), is applied.

(b)After Turbo encoding (information block length k = 3568 bits (corresponding to interleaving depth I = 2 in Reed-Solomon), code rate r = 1/2) of Transfer Frame, Randomization is applied.

④Resending control: Nothing.

Mercury Orbit Phase の MMO のネットワーク構成要素と CCSDS telemetry Layer の関係はTable 4.1-1の通りである。また、同様に Cruise Phase における関係をTable 4.1-2 に示す。両時ともユーザ機器側としては、Packet 以上のレイヤを理解していれば良い。Cruise Phase の MPO Packet より下のレイヤは、本文書では定義しない。

The relation between CCSDS telemetry layer and Network element in Mercury Orbit Phase is shown in Table 4.1-1. In the same way, the relation between them in Cruise Phase is shown in Table 4.1-2. In each phase, User components should just understand the layer higher than Packet layer. In this document, the layer below MPO Packet in Cruise Phase is not defined.

Table 4.1-1　CCSDS telemetry layer and Network element (Mercury Orbit Phase)

Application Process	□					□
System Management	□					□
(MMO) Packet	□←	←□			□←	←□
Segmentation		□			□	
Transfer		□			□	
Coding		□←	←□	□←	←□	
Physical			□←	←□		
Layer	User	Satellite Control	Ground System	C&DH	DMC and MDP	Component

Table 4.1-2　CCSDS telemetry layer and Network element (Cruise Phase)

Application Process	□					□
System Management	□					□
(MMO) Packet	□←	←□			□←	←□
MMO Data Block		□		□	□	
MPO Packet		□←	←□	□		
:			□←	←□		
Layer	User	MMO Ground System	MPO Satellite Control & Ground System	MPO	DMC and MDP	Component

4.1.1 Outline in Mercury Orbit Phase

連接符号の場合の Mercury Orbit Phase の MMO の Telemetry 処理 Flow 概要をFigure 4.1.1-1に、MMO の Telemetry Format の概要をFigure 4.1.1-2に示す。

Turbo 符号の場合については、Mercury Orbit Phase の MMO の Telemetry 処理 Flow 概要をFigure 4.1.1-3に、MMO の Telemetry Format の概要をFigure 4.1.1-4に示す。

In the case of concatenated code, the outline of the telemetry flow in Mercury Orbit Phase is shown below and in Figure 4.1.1-1, and the outline of the MMO telemetry format is shown in Figure 4.1.1-2.

In the case of Turbo code, the outline of the telemetry flow in Mercury Orbit Phase is shown below and in Figure 4.1.1-3, and the outline of the MMO telemetry format is shown in Figure 4.1.1-4.

(1) ADU (Application Data Unit)

Telemetry の内容に依存した処理を、意味のある単位ごとに、DMC あるいは地上系で行えるようにするため、TM Packet の上位構造として ADU（Application Data Unit）という Data 単位を定義する。各 ADU には、次の情報が関連づけられる。これらの情報は、Data を発生する機器で、ADU の先頭に、TM Packet の Secondary Header として付加する。(詳細 Format は、4.2 項参照)

①発生時刻：ADU の発生時刻

②Packet 識別 ID (Packet Identifier)

APID と本 Packet 識別 ID により Packet の Format が規定される。APID ごとに独立に定義可であるため、User 側で定義すること。なお、APID のみで Format が一意に決まる場合には、00H 固定とすること。

③Category

7 章を参照のこと。

④ADU Count

本 Count 値は、ADU を発生する度に、各 User 機器が Count Up する Modulo 64 の数値である。この数値は、User 機器ごとに一連の番号であり、機器が発生する Packet の APID や Category が異なっても、横断的に一連の番号が付加されるとする。ADU が一つ発生する度に increment され、同じ ADU に属している Packet には、同じ数値が入る。

⑤Packet Sequence Flag for each ADU：ADU 分割に関する情報（4.2 項参照）

To make the DMC and the ground system be able to deal with the telemetry data in the form of a suitable unit that has the meanings itself, a new data unit, ADU (Application Data Unit) is introduced as the upper unit of the TM Packet. Each ADU has the information shown as under. These information should be added to the head of each ADU as the Secondary Header of TM Packet. (The detailed format is shown in the section 4.2 .)

①Time

This is the time when ADU is generated.

②Packet Identifier

APID and Packet Identifier define the format of the packet. Packet Identifier can be defined independently for each APID. User shall define this field. If every packets of the same APID have only one format, this field shall be 00H FIX.

③Category

Refer to section 7 .

④ADU Count

This "Count" is the value of modulo 64 and incremented by each user component when it produces ADU. This number is sequential in each user component, i.e., independent to APID or Category of Packet produced by each user component. This number shall be incremented when new ADU is generated and each Packet belonging to the same ADU shall have the same number.

⑤Packet Sequence Flag for each ADU

This is the information about the division of ADU. Refer to the section 4.2 .

(2) テレメトリパケット ((MMO)TM Packet) の生成(Generation of (MMO)TM Packet)

各機器は、ADU を、その大きさに応じて一つあるいは複数の TM Packet に分割すること。この TM Packet は4.1.2 項で述べる MPO TM Packet と区別するために、特に MMO TM Packet と呼ぶ。分割した TM Packet には、Secondary Header として、以下の情報を付加する。

①発生時刻：Packet の発生時刻

②パケット識別 ID

③Category

④ADU Count

⑤Packet Sequence Flag for each ADU

⑥Packet Sequence Count for each ADU

本 Count 値は ADU 内の Packet を数えるための Modulo 65536 の数値である。各 ADU に属する最初の Packet では 0000H であり、Packet 毎に increment されていく。

⑦ADU 長

Each component should divide the ADU into one or more part(s) and insert them into the TM Packet(s). The TM Packet is especially called as MMO TM Packet to be distinguish from MPO TM Packet described in 4.1.2　. To the divided parts, the information shown as under should be added as the Secondary Header of TM Packet.

①Time
②Packet Identifier
③Category
④ADU Count
⑤Packet Sequence Flag for each ADU
⑥Packet Sequence Count for each ADU
This "Count" is the value of modulo 65536 to count up packets in each ADU. The first TM Packet of each ADU has the Count value of 0000H. The Count value is incremented when new TM Packet, belonging to the same ADU, is generated.
⑦ADU length

Intelligent 機器 (DMC,PCD,MDP や各センサのように SpaceWire による接続を持つ機器) は、DMC もしくは MDP と I/F をとり、Telemetry Data を TM Packet 単位で出力する。また、決められたメモリ空間の HK 領域に Data を出すことにより、DMC もしくは MDP がそれを収集し、以下で述べる TCIU 経由の Data と合わせて、DMC が TM Packet 形式の HK Telemetry を生成する。このようにして DMC で生成する HK Telemetry を System HK Telemetry と呼び、これは汎用自律化の対象である。一方、User 機器が生成する Telemetry を User Telemetry と呼ぶが、User 機器が生成する機器 Status を示すような HK Telemetry を User HK Telemetry と呼ぶ。

Non-intelligent 機器 (SpaceWire による接続を持たない機器)については、DMC 内の TCIU が Telemetry Data を収集し、TM Packet を生成する。また、Intelligent 機器と同様、TCIU 経由で DMC が Data を収集し、TM Packet 形式の System HK Telemetry を生成する。

DMC 内の Data Recorder(DR)への記録及び再生は、TM Packet 単位で行う。TM Packet は、Category で指定される Partition 内に格納される。再生は、Partition ごとに Command で指定された順番に行われる。

Intelligent components (the components, which is linked with SpaceWire: DMC, PCD, MDP and each sensor) have the interface with DMC or MDP, and send the telemetry data as TM Packet. They also output the data to HK Area in the specified address space, DMC or MDP gathers these data and DMC generates HK Telemetry, which also includes the data through TCIU within DMC from the components mentioned below. HK Telemetry generated by DMC in this way is called as System HK Telemtry, which is intended for multipurpose autonoumos command. On the other hand, telemetry generated by user compont is called as User Telemetry,

especially called as User HK Telemetry for HK Telemetry generated by user componsnet, which describes status of component.

In the case of Non-intelligent components, TCIU gathers their telemetry data and generates the TM Packets. DMC also gathers the data from them through TCIU and generates the System HK Telemetry.

In the case of the recording and reproducing, DMC deals with the data in the form of TM Packet in Data Recorder (DR) within DMC. Each TM Packet is stored at the partition specified by the Category. These data are reproduced, partition by partition, in the order specified by the command.

(3) Transfer Frame の生成 (Generation of Transfer Frame)

DMC は、各機器で生成した TM Packet を、各仮想チャネル(Virtual channel)ごとに多重化 (Multiplex)し、Transfer Frame とよばれる固定長の Data Unit の、Transfer Frame Data Unit Zone に挿入する。

Transfer Frame の Trailer 部には、コマンド受信状態をフレームレベルで地上系に通知するために、CLCW (Command Link Control Word)と呼ばれるデータ(受信機の Lock ON/OFF, Bit Rate, Up Link コマンド伝送フレーム Error の有無等)が付加される。

なお、仮想チャネルは、リアルタイムデータ用、再生データ用の 2 チャンネルとする。これらは伝送フレーム単位で多重化されるが、CLCW は、全チャネルに共通に挿入される。

Turbo Code の場合、Transfer Frame Traler として、CLCW の次に 2byte の CRC が挿入される。

DMC multiplexes the TM Packets generated by each component, and inserts them into VIDU Data Unit Zone of the fixed-length Virtual Channel Data Unit.

At the Trailer part of each Transfer Frame, CLCW (Command Link Control Word, to which the information such as the receiver's Lock ON/OFF status, Bit Rate and the error status of the up link command transfer frame, etc) is added, in order to inform the command receiver status to the ground system, frame by frame.

MMO has two Virtual Channel, one is for the real time data and the other is for the reproduced data. They are multiplexed by the Transfer Frame and the CLCW is inserted into both channels continuously.

In the case of Turbo code, 2byte CRC followed by CLCW is inserted as Transfer Frame Trailer.

(4) Coded Transfer Frame の生成 (Generation of Coded Transfer Frame)

生成された Transfer Frame はバースト的な伝送誤り対策として、連接符号の場合はリードソロモン符号により符号化される。リードソロモンエンコーディングにて生成したチェックシンボルが Transfer Frame の末尾に付加され Coded Transfer Frame が生成される。

Turbo 符号の場合は、Turbo 符号により符号化され、Coded Transfer Frame が生成される。

In the case of concatenated code, the generated Transfer Frame is encoded by the method of Reed Solomon to deal with the burst errors, which would occur in the transmission. The Check Symbols generated by Reed Solomon encoder are added at the tail of Transfer Frame and they

become Coded Transfer Frame.

In the case of Turbo code, the generated Transfer Frame is encoded by the method of Turbo encoding and becomes Coded Transfer Frame.

(5) PCA_PDU(Physical Channel Access Protocol Data Unit)の生成

(Generation of PCA_PDU)

生成された Coded Transfer Frame は、地上システムとのビット同期を維持するため、疑似ランダムシーケンス発生器と排他的論理和をとる事により、疑似ランダマイズされる(疑似ランダマイズの手順は CCSDS に準拠)。疑似ランダマイズされた Coded Transfer Frame には 4bytes (連接符号の場合)もしくは 8bytes (Turbo Code の場合)の SYNC マーカが付加され、全 Bit について畳み込み符号化(1/2)が行われた後、RF 系に配信される。

The generated Coded Transfer Frame is pseudo-randomized (Exclusive OR with the output of pseudo random sequence generator; the method defined in CCSDS) in order to guarantee the bit synchronization in the ground system. Then, 4bytes SYNC marker (in the case of concatenated code) or 8bytes SYNC marker (in the case of Turbo code) is added to this pseudo-randomized Coded Transfer Frame. After that, they (all bits) are Convolutional-Encoded (1/2) and sent to RF system.

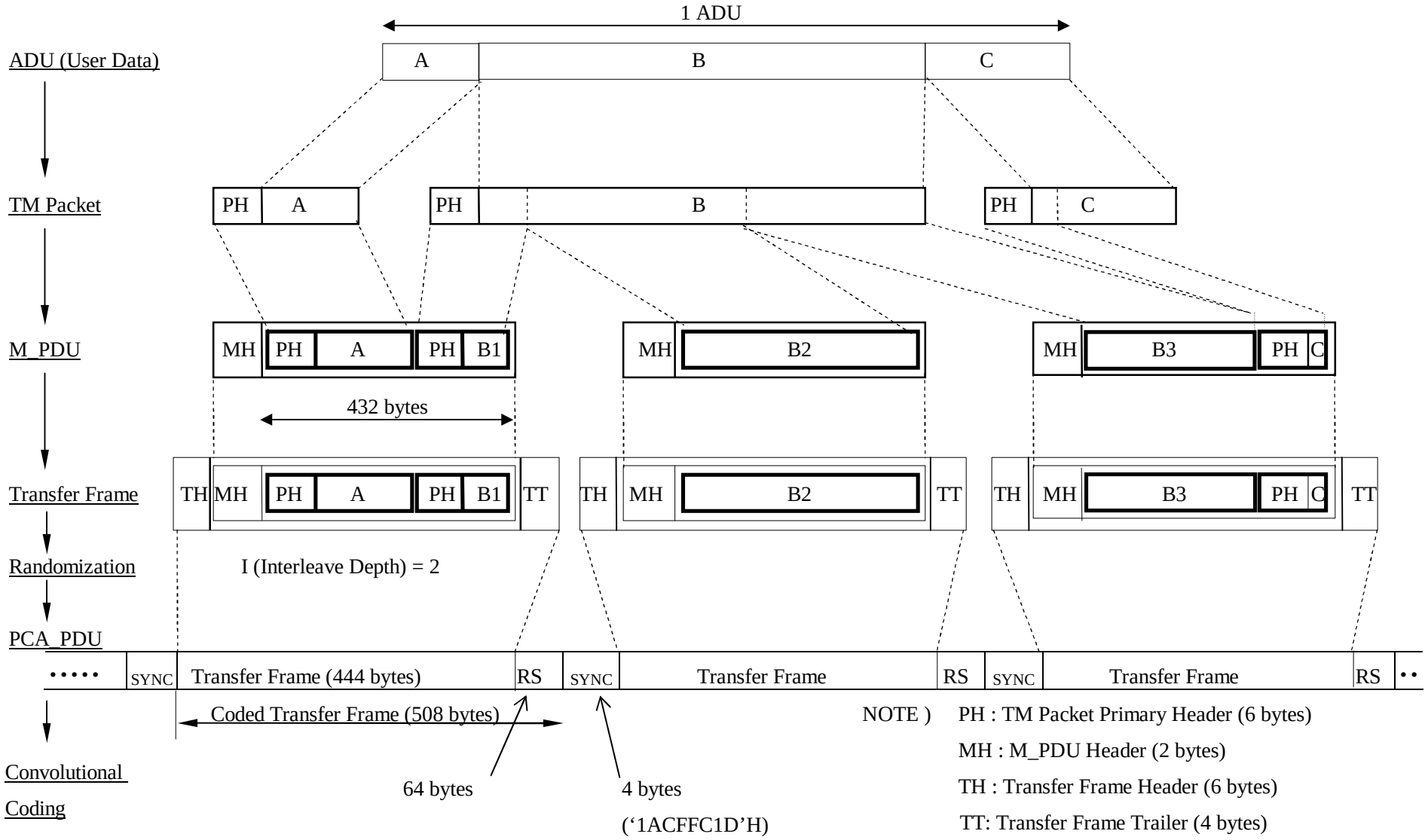


Figure 4.1.1-1 Summary of Telemetry Data Flow in Mercury Orbit Phase (concatenated code)

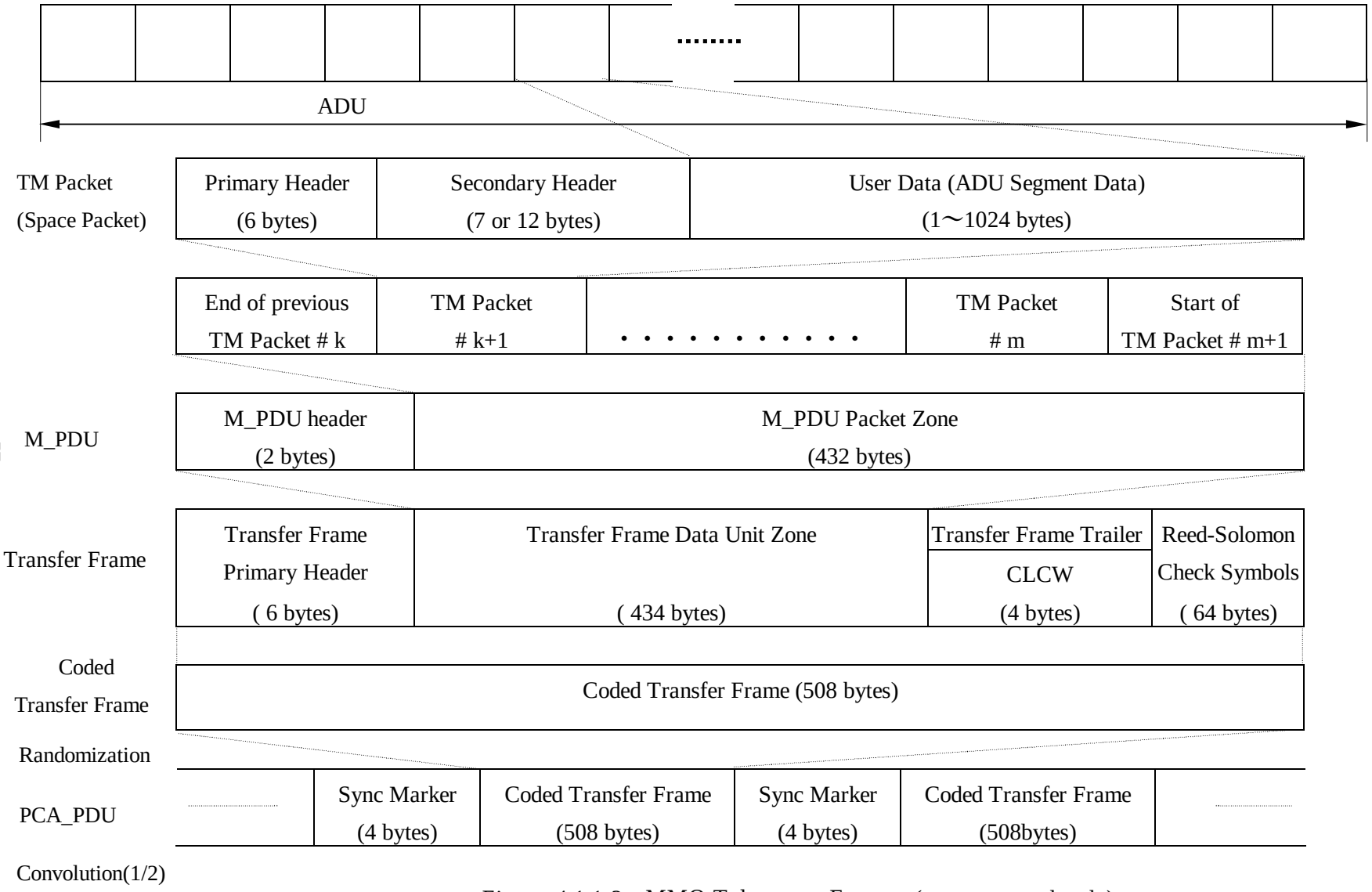


Figure 4.1.1-2 MMO Telemetry Format (concatenated code)

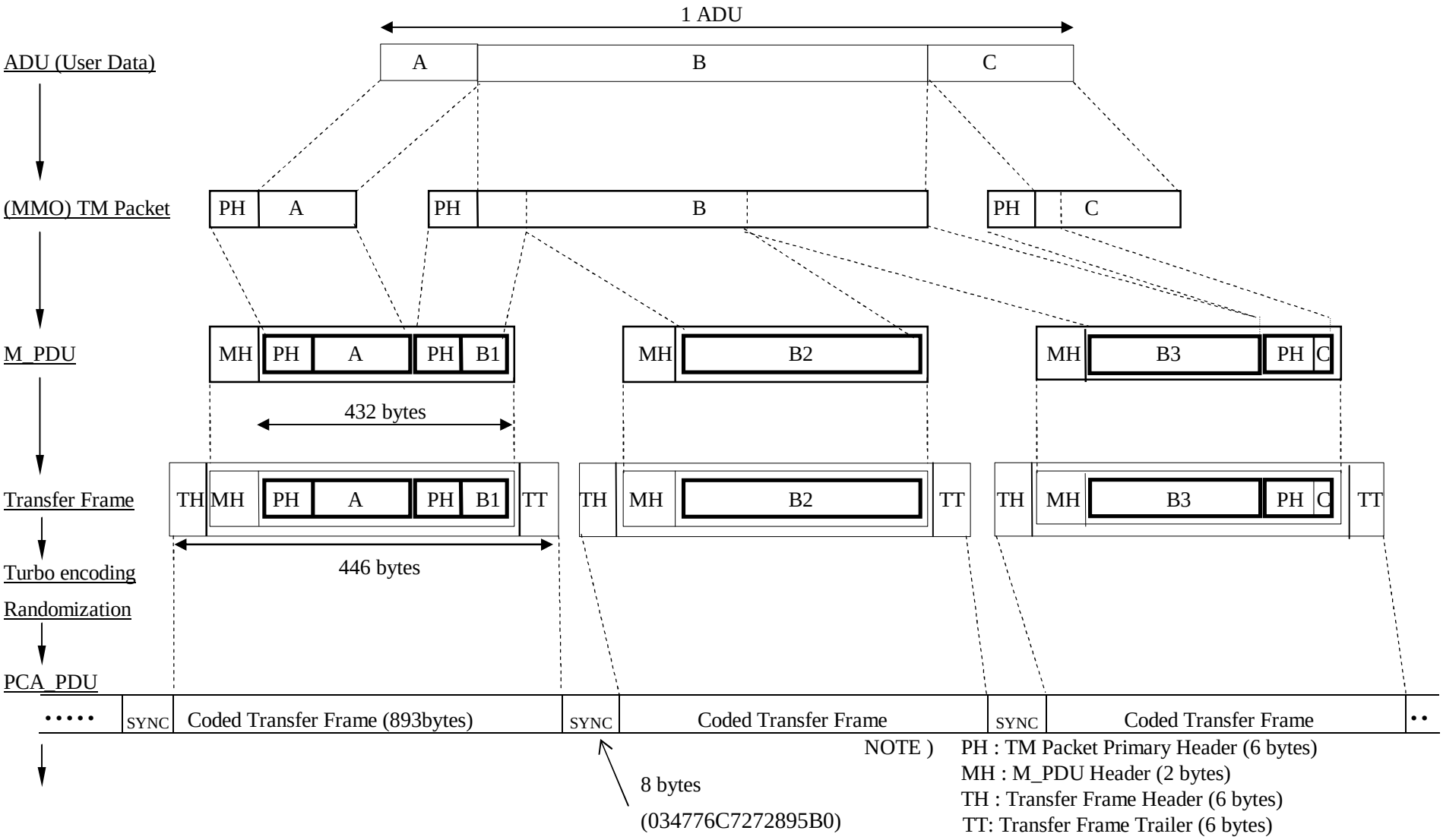


Figure 4.1.1-3 Summary of Telemetry Data Flow in Mercury Orbit Phase (Turbo Code)

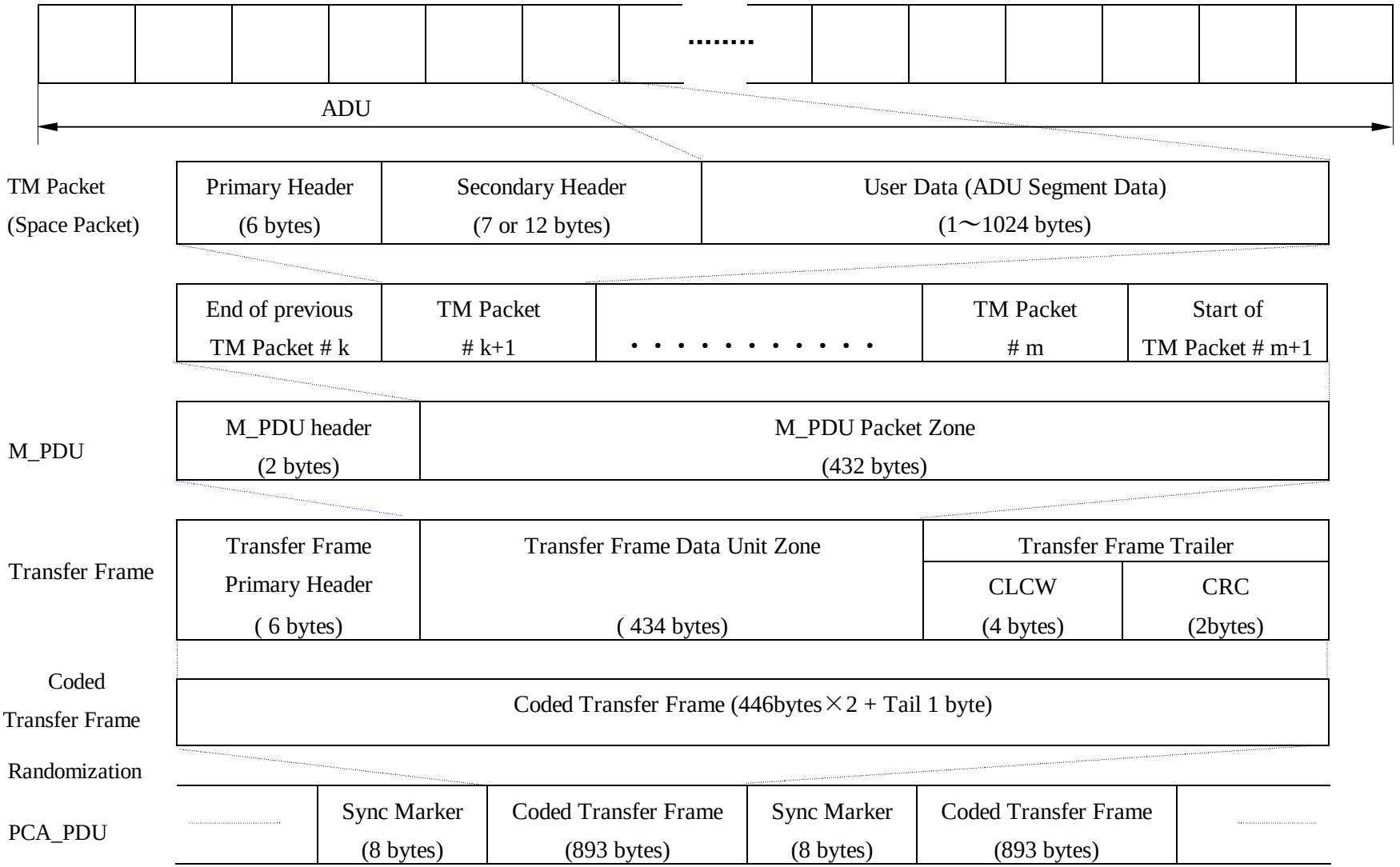


Figure 4.1.1-4　MMO Telemetry Format (Turbo Code)

4.1.2 Outline in Cruise Phase

Figure 4.1.2-1に、Cruise Phase の MMO の Telemetry 処理 Flow 概要を示す。

The outline of the telemetry flow in Cruise Phase is shown below and in Figure 4.1.2-1.

(1) MPO Packet / MMO Data Block 層 (MPO Packet / MMO Data Block Layer)

Cruise Phase の Telemetry も User 機器および DMC により MMO TM Packet として生成される。DMC は、MIL-STD-1553B に準拠したデータバスを通して、1 つまたは複数の MMO TM Packet に 2byte の Data Type ID を付加した MMO TM Data Block の単位で MPO に送信する。この MMO TM Data Block は、MPO 側においてヘッダ情報を付加された MPO TC Packet として、MPO の地上局へ RF リンクにより送信される。MPO の地上局から MMO の地上局へは、MPO TM Packet の単位で、FTP により転送される。MMO の地上系は、付加されたヘッダ情報を取り除き、MMO TM Packet の単位で MMO のユーザに配信する。

In Cruise Phase, DMC or user components produce generate the MMO TM Packet in the same way as in Mercury Orbit Phase. MMO TM Data Block, whose format is that 2bytes header called as Data Type ID is appended to one or more MMO TM Packets, is transferred from MMO DMC to MPO through the MIL-STD-1553B bus. MPO TM Packet, that header is appended to each MMO TM Packet in MPO, is transferred to the MPO ground system in RF linkage. Telemetry is transferred from MPO ground system to MMO ground system in MPO TM Packet format by FTP. The header of each MPO TM Packet is removed and converted to MMO TM Packet at MMO ground system, and the MMO TM Packet is distributed to each user.

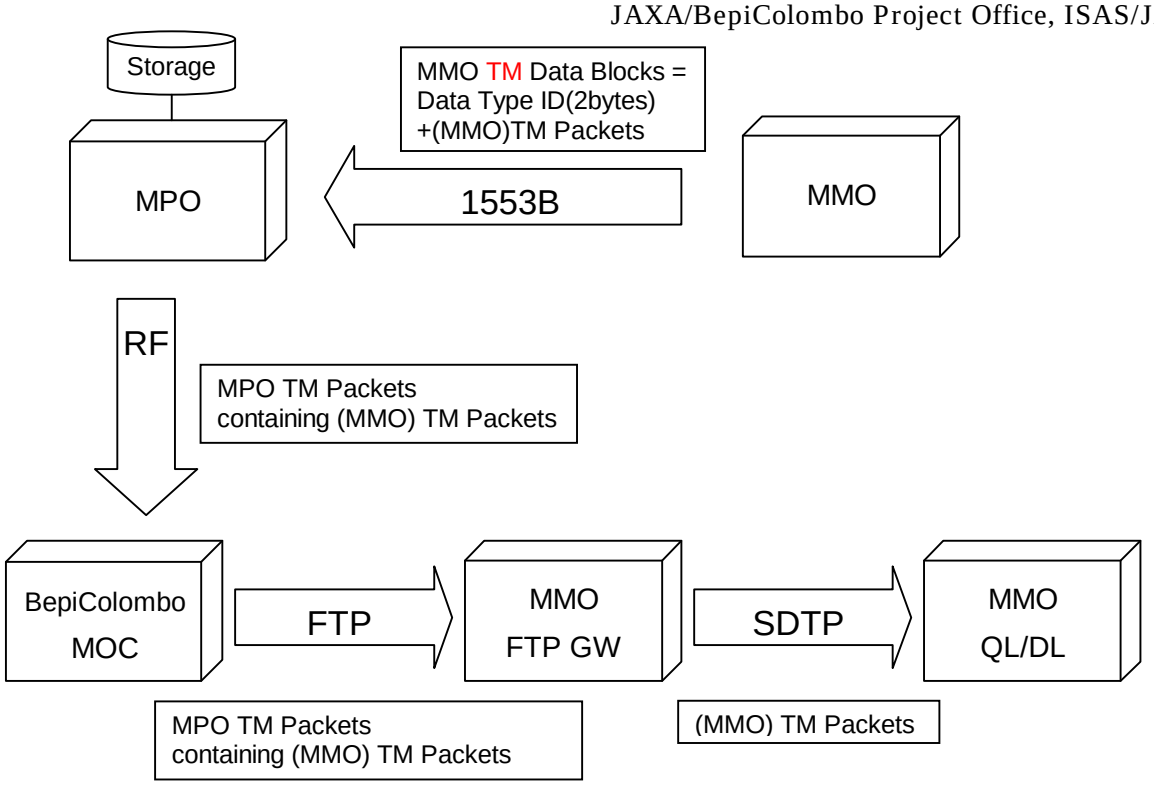


Figure 4.1.2-1 Summary of Telemetry Data Flow in Cruise Phase

4.2 TM Packet (MMO TM Packet) Format

(MMO) TM Packet は 6bytes の Primary Header と 7bytes(ADU 分割なし) or 12bytes(ADU 分割時)の Secondary Header と 1～1024 bytes 可変長の User Data からなる。

TM Packet Structure をFigure 4.2-1に Primary Header 詳細をTable 4.2-1に、APID(Application Process ID)の定義をTable 4.2-2に、Secondary Header 詳細をTable 4.2-3に示す。

The (MMO) TM Packet consists of the Primary Header (6bytes), the Secondary Header (7bytes for the packet includes whole ADU, 12bytes for the packet of the divided ADU) and variable-length User Data (from 1 to 1024bytes).

The TM Packet Structure is shown in Figure 4.2-1, the detailed Primary Header Format is shown in Table 4.2-1, the detailed Secondary Header Format is shown in Table 4.2-2and the definition of APID (Application Process ID) is shown in Table 4.2-3.

TM Packet Primary Header (6 bytes)							Secondary Header	User Data
Version	Type	Sec.Header Flag	**Application Process ID**	Sequence Flag	Sequence Count	Packet Length	7 or 12 bytes	(Up to 1024 bytes)
3 bits	1 bit	1 bit	**11 bits**	2 bits	14 bits	16 bits		

Figure 4.2-1 MMO TM Packet Fromat

Table 4.2-1 MMO TM Packet Primary Header

Field	Number of bits	Value (binary)	Note
Version No.	3	000(FIX)	Version -1 TM Packet
Type	1	0(FIX)	Not used within CCSDS AOS
Secondary Header Flag	1	1(FIX)	Secondary Header is present.
Application process ID	**11**	**Refer to Table 4.2-2**	
Packet Sequence Flag	2	11(FIX) 00:a continuation segment of User Data 01:the first segment of User Data 10:the last segment of User Data 11:unsegmented User Data	In the case of MMO, the information about the division of an ADU is included in the TM Packet Secondary Header.
Packet Sequence Count	14	variable (incremental)	Modulo 16384
Packet Length	16	variable (Value = the number of remaining bytes minus one)	
Secondary Header	56 or 96	**To be defined in Table 4.2-3**	

Table 4.2-2 Application Process ID for Telemetry (Tentative)

Application Process ID for Telemetry (11 bits)				
Common Use (3 bits)		**NODE ID (5 bits)**		**Component Extension Bits**
Command/ Telemetry (1bit) (BIN)	**Telemetry ID (2bits) (BIN)**	**Value (HEX)**	**Component NAME**	**(3bits) (BIN)**
1 FIX (Telemetry)	00: Report Telemetry (User Telemetry) 01: Mission Telemetry (User Telemetry) 10: HK Telemetry 11: Dump Telemetry	0	N/A	
		01	DMC	000: Common 001: DHFS 010: ACFS 011: TCFS 100: DR 111: HW
		02	PCD	000 FIX
		03	MDP-1	000: MDP-Firm1 001: MDP-User1
		04	MDP-2	000: MDP-Firm2 001: MDP-User2
		05	MEA1	000 FIX
		06	MEA2	000 FIX
		07	MIA	000 FIX
		08	MSA	000 FIX
		09	HEP-e	000 FIX
		0A	HEP-i	000 FIX
		0B	ENA	000 FIX
		0C	PME/MGF-O	000 FIX
		0D	PME/MGF-I	000 FIX
		0E	MDM	000 FIX
		0F	MSASI	000 FIX
		10	PME/EWO-E	000 FIX
		11	PME/EWO-B	000 FIX
		12	PME/SORBET	000 FIX
		13	PME/MEFISTO	000 FIX
		14	PME/MASTWPT-E	000 FIX
		15-1E	Spare	
		1F	N/A	000 FIX
APID(Decimal)=2047 : Idle Packet 2032-2046 : Reserved by CCSDS				

Note1: Each component should declare the usage of "Component Extension Bits".

Note2: Report Telemetry：

非定常的な Packet。**非可視中の履歴をコンパクトに残すため、次のような事象の通知に使用する。異常の発生、**RQ Command **の発行** etc.(Table 4.2-4**参照**)

Report Telemetry is the packet irregularly generated. This kind of packet reports the events such as; Contingency, Execution of RQ command, etc. (Refer to Table 4.2-4)

Note3:

HK Telemetry： APID の Telemetry ID = HK Telemetry であるもの。
System HK Telemetry： HK Telemetryで、APIDのNode ID = DMC, Component Extension Bits = Commonであるもの
User HK Telemetry： HK TelemetryでSystem HK Telemetry でないもの

HK Telemetry： Telemetry whose Telemetry ID of APID = HK Telemetry.
System HK Telemetry： HK Telemetry whose Node ID of APID= DMC and Component Extension Bits of APID = Common
User HK Telemetry： HK Telemetry which is not System HK Telemetry

ADU **分割なしの場合**(For the packet includes whole ADU)： Packet Sequence Flag for each ADU = 11b (except for Dump Telemetry)

TM Packet Secondary Header (ADU Header) : 7bytes				
Time (32 bits)	Category (8bits)	Packet Identifier (8bits)	Packet Sequence Flag for each ADU (2bits)	ADU Count (6bits)

ADU **分割時の最初の** Packet **の場合**(For the first packet of the divided ADU)：Packet Sequence Flag for each ADU = 01b or 11b (in the case of Dump Telemetry)

TM Packet Secondary Header (ADU Header) : 12bytes						
Time (32 bits)	Category (8bits)	Packet Identifier (8bits)	Packet Sequence Flag for each ADU (2bits)	ADU Count (6bits)	Packet Sequence Count for each ADU (16 bits)	ADU Length (24 bits)

ADU **分割の** 2 **番目以降の** Packet **の場合**(For the second or later packet of the divided ADU)：Packet Sequence Flag for each ADU = 00b or 10b

TM Packet Secondary Header (ADU Header) : 12bytes						
Time (32 bits)	Category (8bits)	Packet Identifier (8bits)	Packet Sequence Flag for each ADU (2bits)	ADU Count (6bits)	Packet Sequence Count for each ADU (16 bits)	ADU Length (24 bits)

Figure 4.2-2　MMO TM Packet Secondary Header (ADU Header) Format

Table 4.2-3　MMO TM Packet Secondary Header

Field	Number of bits	Value (binary)	Note
Time	32	variable (LSB : 31.25ms)	
Category	8	**Refer to Table 6.1-1 ～6.1-2**	
Packet Identifier	8	Defined by each component side. This field can be defined independently for each APID. This filed and APID define the packet format.	If this filed is not used, this field shall be 0000B.
Packet Sequence Flag for each ADU	2	00:a continuation segment of User Data 01:the first segment of User Data 10:the last segment of User Data 11:unsegmented User Data	
ADU Count	6	variable (incremental)	Modulo 64
Packet Sequence Count for each ADU	16	Variable	Modulo 65,536
ADU Length	24	variable (Value = the amount of whole data [byte] generated as ADU(Primary/Secondary Header is not included) - 1)	16M-1=16,777,215MAX

Table 4.2-4　Report Telemetry Format

<DMC>		
LENGTH：17 bytes		
FORMAT：	[Primary Header]	6 bytes
	[Secondary Header]	7 bytes (Whole ADU: Refer to Figure 4.2-2)
	[Report Code]	1 byte (Code for Report Telemetry generation trigger.)
	[Node ID+Extension bits]	1byte (Node ID+Extension bits for Report Telemetry generation trigger)
	[Information Code]	2 bytes (Additional Information which should be reported. Example; AT number or RQ number.)
<Other components>		
LENGTH：16 bytes		
FORMAT：	[Primary Header]	6 bytes
	[Secondary Header]	7 bytes (Whole ADU: Refer to Figure 4.2-2)
	[error code]	1 byte (Error code, which explain the malfunction of the component. Defined by each user.)
	[user request code]	1 byte (User Request Code, or 00H when no request command is executed.)
	[user use]	1 byte (This field can be freely defined by each user.)

4.3 Telemetry 種別 (Telemetry Type)

Telemetry は、Table 4.3-1に示す 3 種類に分類される。

Table 4.3-1 Telemetry Type

Telemetry Type	Explanation	Telemetry Data Format
1. System HK Telemetry	DMC が各ユーザ機器の HK Data 領域から Data を収集し TM Packet として生成する。各機器では、同期のために Time TICK(*1)を使用すること。(*2) DMC gathers the data from the HK Data area of each user component and generates this as a TM Packet. Each component should use Time TICK(*1) to synchronization. (*2)	SIB で定義される。 To be defined in SIB (Satellite Information Base)
2. User Telemetry	各ユーザ機器が TM Packet として生成する。 Each user component generates this as a TM Packet.	各サブシステムで定義される。 To be defined by each subsystem
3. Memory Dump Telemetry	各ユーザ機器が TM Packet として生成する。もしくは、PCD, MDP に対しては DMC が RMAP(Remote Memory Access Protocol)によりデータを収集し TM Packet として生成する。(*2) Each user component generates this as a TM Packet. Or DMC collects data by RMAP (Remote Memory Access Protocol) and generates this as a TM Packet for PCD and MDP. (*2)	5 章で定義される。 To be defined in section 5

*1)Time TICK は、ノミナル時 1/512s=1.953ms 間隔で配布される、連続的にカウントアップする 6bit カウンタである。ただし、DMC の CPU が冗長系への切替わる際に、Time TICK の配布が停止し、カウンタが非連続に変化する可能性があるため、各機器は設計上考慮すること。

In nominal case, Time TICK is continuously counted-up 6bit counter which is distributed at 1/512s = 1.953ms intervals. However, in the case that DMC switches to redundant CPU, distribution of Time TICK will be aborted, and the counter may change discountinuously. Therefore, this constraint shall be considered in the design of each component.

*2) MDP, PCD に対しては、SpaceWire ネットワーク仕様書、その他の機器に対しては、MDP Payload Interface Requirement Document を参照。

Refer to "SpaceWire Network Specifications" for MDP and PCD, “MDP Payload Interface Requirement Document” for the other component.

Note：System HK Telemetry について。

衛星管制に必要な情報はすべて System HK Telemetry として収集し、DMC が TM Packet 化することとする。その Data 量は衛星全体で 864bytes 以下とする。(6.1　(5) 参照)

User Telemetry の分類をTable 4.3-2に示す。

Note：System HK Telemetry:

All information needed for the control of the spacecraft shall be gathered as System HK Telemetry and DMC shall generate TM Packet from them. The quantum of whole HK data is expected to be less than 864bytes. (Refer to 6.1　(5))

Classification of User Telemetry is shown in Table 4.3-2.

Table 4.3-2　Classification of User Telemetry

APID classification	Format	Operational classification	Data Example
Report Telemetry	Fixed (Table 4.2-4)	[Onboard Event trigger] One or a few packets are generated by onboard event trigger.	Report of RQ or AT command execution.
HK Telemetry (= User HK Telemetry)	Defined by each subsystem	[Command trigger] One or a few packets are generated by command trigger. Called as "One-shot Telemetry"	(TCFS) Temperature setting table Priority setting table Heater duty setting table (DHFS) DR partition division table DR pointer position Information
		[Continuous Output] Packets are generated continuously.	Temperature data (TCFS) DR pointer position Information
Mission Telemetry	Defined by each subsystem	[Command trigger] One or a few packets are generated by command trigger. Called as "One-shot Telemetry"	DMC Time Telemetry (when command is executed)
		[Continuous Output] Packets are generated continuously.	Science data

4.4 M_PDU Format

M_PDU(Multiplexing Protocol Data Unit) は固定長の Transfer Frame Data Unit Zone に TM Packet を挿入するために、TM Packet を統合、分割したものである。 M_PDU Header には、M_PDU Packet 内に最初に現れる TM Packet Header の位置を示す情報 bit が挿入される。

M_PDU Format 詳細をFigure 4.4-1に示す。また、M_PDU Header 詳細をTable 4.4-1に示す。

M_PDU (Multiplexing Protocol Data Unit) is a part of the concatenated TM Packets and inserted into the fixed-length Transfer Frame Data Unit Zone. The M_PDU header includes the information bits, which indicate the position of the first TM Packet header in the M_PDU Packet Zone.

The detailed M_PDU Format is shown in Figure 4.4-1. The detailed M_PDU Header Format is shown in Table 4.4-1.

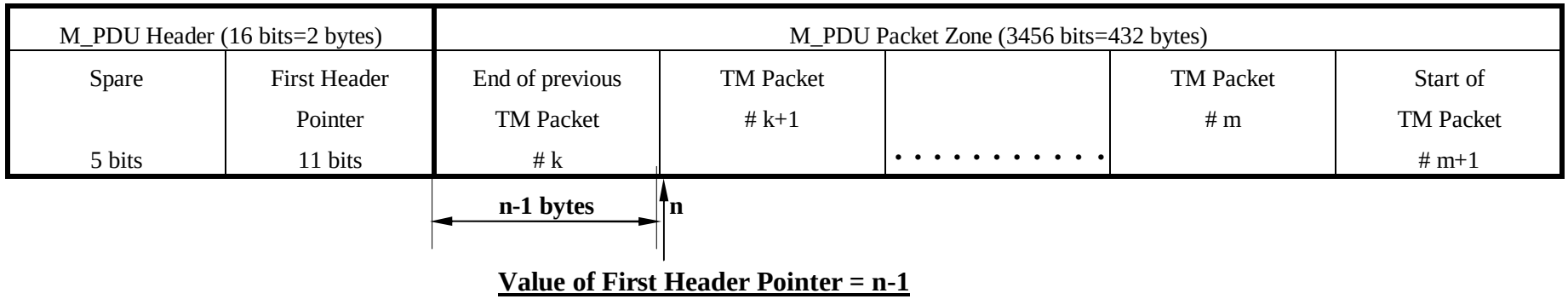


Figure 4.4-1　M_PDU Format

Table 4.4-1　M_PDU Header

Field	Number of bits	Value (binary)	Note
Spare	5	00000(FIX)	
First Header Pointer	11	(1) If M_PDU Packet Zone contains a TM Packet Primary Header: (M_PDU Packet Zone に TM Packet Primary Header を含む場合) **Value = n -1 (See Figure 4.4-1)** (2) If M_PDU Packet Zone doesn't contain a TM Packet Primary Header: (M_PDU Packet Zone に TM Packet Primary Header を含まない場合) **Value = 11111111111 (all 1)** (3) If M_PDU Packet Zone doesn't contain any valid user data: **Value = 11111111110 (all 1-1)**	Modulo 2048

4.5 Transfer Frame /Coded Transfer Frame Format

(a) **連接符号の場合** (In the case of concatenated code)

Transfer Frame **は** M_PDU **に衛星** ID **や** VCID **等の** Transfer Frame Primary Header 6 bytes**、**Transfer Frame Trailer (CLCW) 4 bytes **を付加したものである**。Transfer Frame **はリードソロモンにて符号化**(Interleave Depth: I = 2)**され、リードソロモンチェックシンボル** 64bytes **が末尾に付加される**。Transfer Frame＋**リードソロモンチェックシンボル全体を** Coded Transfer Frame **と呼ぶ**。

Transfer Frame Format **詳細を**Figure 4.5-1**に、**Transfer Frame **の** Primary Header **詳細を**Table 4.5-1**に、**CLCW (Command Link Control Word) **詳細を**Table 4.5-3**に示す**。

MMO **においては、リアルデータと再生データの識別を** VCID **にて行う**。

The Transfer Frame consists of the Transfer Frame Primary Header (6bytes; Spacecraft ID, VCID and so on), the M_PDU and the Transfer Frame Trailer (4bytes; CLCW (Command Link Control Word)). The Transfer Frame is encoded by the method of Reed-Solomon (Interleave Depth: I = 2); 64bytes Reed-Solomon Check Symbols are added to the tail of the Transfer Frame. The Transfer Frame + Reed-Solomon Check Symbols are called by the name of Coded Transfer Frame.

The detailed Transfer Frame Format is shown in Figure 4.5-1, the detailed Transfer Frame Primary Header Format is shown in Table 4.5-1, and the detailed CLCW (Command Link Control Word) Format is shown in Table 4.5-3.

In the case of MMO, the VCID is used to distinguish between the real time data and the reproduced data.

(b) Turbo 符号の場合 (In the case of Turbo code)

Transfer Frame はM_PDU に衛星IDやVCID等のTransfer Frame Primary Header 6 bytes、Transfer Frame Trailer であるCLCW 4 bytes およびCRC 2bytes を付加したものである。Transfer Frame は、Turbo 符号化(information block length k = 3568 bits (interleaving depth I = 2 in Reed-Solomon に対応), code rate r = 1/2)され、(Transfer Frame 長×2+1)bytes のCoded Transfer Frame となる。データ長が約2倍となっているのは、code rate=1/2 に対応しており、従来のReed Solomon 符号と畳み込み符号による連接符号化と同等以上の符号化利得を得るためである。

Transfer Frame Format 詳細をFigure 4.5-2に、Transfer Frame のPrimary Header 詳細をTable 4.5-2に、CLCW (Command Link Control Word) 詳細をTable 4.5-3に示す。

MMO においては、リアルデータと再生データの識別をVCID にて行う。

The Transfer Frame consists of the Transfer Frame Primary Header (6bytes; Spacecraft ID, VCID and so on), the M_PDU and the Transfer Frame Trailer (CLCW (Command Link Control Word) 4bytes, and CRC 2bytes). The Transfer Frame is encoded by the method of Turbo (information block length k = 3568 bits (corresponding to interleaving depth I = 2 in Reed-Solomon), code rate r = 1/2). This is called by the name of Coded Transfer Frame whose length is (Transfer Frame length×2+1)bytes. Thus, the data length becomes roughly double size (corresponding to code rate = 1/2), because the Turbo codes provide greater encode gain than the past way of concatenated codes which consist of an inner convolutional code (K=7,R=1/2) and an outer Reed-Solomon code (I=2).

The detailed Transfer Frame Format is shown in Figure 4.5-2, the detailed Transfer Frame Primary Header Format is shown in Table 4.5-2, and the detailed CLCW (Command Link Control Word) Format is shown in Table 4.5-3.

In the case of MMO, the VCID is used to distinguish between the real time data and the reproduced data.

<table>
<tr><td colspan="7">Coded Transfer Frame (508 bytes)</td></tr>
<tr><td colspan="6">Transfer Frame (444 bytes)</td><td rowspan="2">Reed-Solomon Check Symbol</td></tr>
<tr><td colspan="5">Transfer Frame Primary Header (6 bytes)</td><td rowspan="2">Transfer Frame Data</td><td rowspan="2">Transfer Frame trailer (CLCW)</td></tr>
<tr><td rowspan="2">Version No.</td><td colspan="2">Transfer Frame Identifier</td><td rowspan="2">Transfer Frame counter</td><td colspan="2">Signaling Field</td></tr>
<tr><td>Spacecraft ID</td><td>VCID</td><td>Replay Flag</td><td>Spare</td><td>Unit Zone</td><td>32 bits</td><td>512 bits</td></tr>
<tr><td>2 bits</td><td>8 bits</td><td>6 bits</td><td>24 bits</td><td>1 bit</td><td>7 bits</td><td>434 bytes</td><td>= 4 bytes</td><td>= 64 bytes</td></tr>
</table>

Figure 4.5-1 Transfer Frame /Coded Transfer Frame Format (concatenated code)

Table 4.5-1 Transfer Frame Primary Header, Trailer and Reed-Solomon Check Symbol (concatenated code)

	Field	Number of bits	Value (binary)	Note
Transfer Frame Primary Header	Version No.	2	01(FIX)	Version-2 (CCSDS Virtual Channel Data Unit)
	Spacecraft ID	8	27H(FIX)	
	VCID	6	(1) Real data : Value = 000001 (2) Reproduced data : Value = 000010 (3) Fill data : Value = 111111	
	Transfer Frame Counter	24	variable (incremental)	Modulo 16,777,216
	Replay Flag	1	0FIX for MMO ("0"=Realtime,"1"=Replayed in CCSDS definition)	
	Spare	7	0000000	
Transfer Frame Trailer	CLCW	32	Refer to Table 4.5-3	
R-S Check Symbol		512	variable	Interleave Depth: I = 2 , Coded Transfer Frame length = 508 bytes

<table>
<tr><td colspan="7">Coded Transfer Frame (446×2 + 1 = 893bytes)</td></tr>
<tr><td colspan="7">Transfer Frame (446 bytes)</td></tr>
<tr><td colspan="5">Transfer Frame Primary Header (6 bytes)</td><td rowspan="2">Transfer Frame Data Unit Zone</td><td colspan="2">Transfer Frame trailer</td></tr>
<tr><td rowspan="2">Version No.</td><td colspan="2">Transfer Frame Identifier</td><td rowspan="2">Transfer Frame counter</td><td colspan="2">Signaling Field</td><td>(CLCW)</td><td>(CRC)</td></tr>
<tr><td>Spacecraft ID</td><td>VCID</td><td>32 bits</td><td>Spare</td><td>32 bits</td><td>16bits</td></tr>
<tr><td>2 bits</td><td>8 bits</td><td>6 bits</td><td>24 bits</td><td>= 4 bytes</td><td>7 bits</td><td>434 bytes</td><td>= 4 bytes</td><td>=2bytes</td></tr>
</table>

Figure 4.5-2 Transfer Frame /Coded Transfer Frame Format (Turbo code)

Table 4.5-2 Transfer Frame Primary Header, Trailer (Turbo code)

	Field	Number of bits	Value (binary)	Note
Transfer Frame Primary Header	Version No.	2	01(FIX)	Version-2 (CCSDS Virtual Channel Data Unit)
	Spacecraft ID	8	27H(FIX)	
	VCID	6	(1) Real data : Value = 000001 (2) Reproduced data : Value = 000010 (3) Fill data : Value = 111111	
	Transfer Frame Counter	24	variable (incremental)	Modulo 16,777,216
	Replay Flag	1	0FIX for MMO ("0"=Realtime,"1"=Replayed in CCSDS definition)	
	Spare	7	0000000	
Transfer Frame Trailer	CLCW	32	Refer to Table 4.5-3	
	CRC	16	The generator polynomial : **G(x)=x^16+x^12+x^5+1**	

Table 4.5-3 CLCW (Command Link Control Word) Format

Bit	Field	Length (Bits)	Value	Note
B0	Control Word Type	1	0	Always "0" For CLCW
B1-2	CLCW Version	2	00	"Version-1" CLCW
B3	Status Field	1	0: TRP-A 1: TRP-B	CMD SEL A/B
B4		1	0: OFF 1: ON	TRP-A Carrier Lock On/Off
B5		1	0: OFF 1: ON	TRP-B Carrier Lock On/Off
B6-7	COP in Effect	2	01	COP-1
B8-13	Virtual Channel ID	6	VCID	
B14-15	Reserved Spares	2	00	
B16-17	Sub-carrier Lock / Bit Rate	2	00: OFF 01: ON + Low 10: ON + Mid 11: ON + High	Sub-carrier Lock Off Sub-carrier Lock On, 15.625bps Sub-carrier Lock On, 125bps Sub-carrier Lock On, 1000bps
B18	Flags -Lockout	1	0: Not in Lockout 1: Lockout	
B19	-Wait	1	0: Don't Wait 1: Wait	1:Receiving end of the Transfer layer is unable to pass data.
B20	-Retransmit	1	0: No Retransmit 1: Retransmit	1: Retransmissions are required.
B21-22	FARM-B Counter	2	Two least significant bits of a FARM-B.	
B23	Reserved Spares	1	0	
B24-31	Report Value	8	N(R)	Next Expected Frame Sequence Number

Note: According to CCSDS, B16: No RF available, B17: No bit lock.

4.6 SYNC Marker

SYNC Marker code
= 1ACFFC1D hex (concatenated code)
= 034776C7272895B0 hex (Turbo code)

4.7 MPO TM Packet and MMO TM Data Block Format

MMO TM Data Block は、1 つもしくは複数の MMO TM Packet に、2byte のヘッダとしてTable 4.7-3に示す Data Type ID を付加したものである。MMO TM Data Block の最大長は 1044byte である。
MPO TM Packet は、1 つの MMO TM Data Block を user data として含む。

The MMO TM Data Block consists of one or more MMO TM Packets and Data Type ID shown in Table 4.7-3 as 2bytes header. Maximum length of MMO TC Data Block is 1044bytes.
The MPO TC Packet includes a MMO TC Data Block as user data.

Figure 4.7-1, Table 4.7-1 and Table 4.7-2 are deleted.

Table 4.7-3 MMO Data Type ID for MMO TM data Block

Data Type ID	Definition	Corresponding Telemetry Type
0000h or 00FFh	MMO TM Packets, which are not necessary to be checked by MPO/ESA. Length of MMO TM Packets in this Data Type ID may vary per each transmission. One or more TM Packets are contained.	-
0000h	Private real time data	Realtime data except for System HK Telemetry
00FFh	private playback data	Playback data except for System HK Telemetry
FFFFh	A MMO TM Packet of housekeeping data, which may be checked by MPO/ESA. This TM Packet has the fixed format with fixed length. 1 data type ID is assigned for this because housekeeping data has only one format.	System HK Telemetry

5 メモリ管理 (Onboard Memory Management)

5.1 Program 格納の考え方(Program Storage)

CPU を持つ機器における Program の格納法については、MMO では以下のように考えることとする。

「Program は、ROM または EEPROM に格納する。機器立ち上げ時は、電源 On 直後に、ROM 内に格納された IPL(Initial Program Loader)により、Main Program を ROM または EEPROM から RAM に展開し実行するものとする。この Main Program を IPL Program と呼ぶこととする。また、IPL Program とは別の領域の EEPROM に Main Program を有するものとする。この Main Program を Normal Program と呼ぶこととする。IPL Program は、Normal Program を EEPROM から RAM に展開し実行する機能を有するものとし、EEPROM に対する Memory Load/Dump 機能を有するものとする。」

MMO's guideline on the program storage of components with CPU is shown below.
"Program shall be stored in ROM or EEPROM. When a component is powered on, IPL (Initial Program Loader) stored in ROM shall transfer the main program from ROM or EEPROM to RAM immediately and execute it in RAM. This program shall be called as IPL Program. There is also main Program in different area of EEPROM from one of IPL Program. This main Program shall be called as Normal Program. IPL Program shall have a function to transfer Normal Program from EEPROM to RAM and execute it in RAM, and shall support Memory Load/Dump of EEPROM area."

5.2 EEPROM の書き換え(Rewriting of EEPROM)

EEPROM の書き換えは、Program 書き換えがどうしても必要になった場合にのみ行う。その場合の方法としては、以下の 2 種類がある。Memory Load の方法の概要をFigure 5.2-1に示す。

①当該機器に対する TC Packet による方法 (Memory Load (Packet service))

この場合、Figure 5.2-2およびTable 5.2-1に示す Format の Memory Load Command Packet を各機器に対して送信する。Memory Load Command Packet 内の APID および Node ID は Memory Load 対象機器を指定する。各機器は、上記 Command を Buffering した後、各機器内の EEPROM に適合した Timing で書き込みを行う。一度に書き込むべき byte 数についてはシステムへ通知すること。書き込みの周期は 125msMIN。

②RMAP(Remote Memory Access Protocol)による方法 (Memory Load (RMAP direct))

この場合、DMC でFigure 5.2-2に示す Memory Load Command Packet を解読し、PCD および MDP に対して RMAP Write により直接 EEPROM への書き込みを行う。Memory Load Command Packet 内の APID には DMC (Common)を指定し、Node ID には Memory Load 対象機器を指定する。PCD および MDP について詳細は MMO

SpaceWire Network Specifications を参照すること。EEPROM への書き込み速度の制限についてはシステムへ通知すること。

Memory Load の Sequence を以下に示す。

(1)書き込み File を衛星管制にて指定する。

(2)選択された書き込み File と地上の Memory 管理 File(書き込み時点での衛星 Memory と同内容のもの)を比較し、地上にてコマンド(Memory Load Command Packet)を自動生成する（相違する部分のみコマンドとする等の最適化を実施）。

(3)必要により、各ユーザ機器を Memory Load/Dump を行うことができるモードに設定する。

(4)Memory Load Command Packet を衛星に対して送出する。

(5)Memory Load (Packet service)の場合、Memory Load Command Packet を DMC もしくは User 機器が受信し、EEPROM 領域に対し書き込みを行う。
Memory Load (RMAP direct)の場合、DMC が Memory Load Command Packet を受信し、RMAP Write により User 機器(PCD および MDP)の EEPROM 領域に対し直接書き込みを行う。

EEPROM shall be rewritten only when it must be done. There are two methods shown below to rewrite. Outline of Memory Load method is shown in Figure 5.2-1 and Table 5.2-1.

①Method by the TC Packet to the component (Memory Load (Packet service))

In this case, Memory Load Command Packet of the format shown in Figure 5.2-2 is sent to each component. APID and Node ID within Memory Load Command Packet specify the target component of Memory Load. Each component shall buffer this command and write data into EEPROM with the timing suitable to its EEPROM. Each user shall inform the length of data, which shall be written at once, to system side. The period of writing is 125msMIN.

②Method by Remote Memory Access Protocol (Memory Load (RMAP direct))

In this case, Memory Load Command Packet shown in Figure 5.2-2 is de-packetted in DMC, and EEPROM of MDP and PCD is directly written by RMAP Write. Node ID within Memory Load Command Packet specifies the target component of Memory Load, while APID is for DMC (Common). For MDP and PCD, refer to MMO SpaceWire Network Specifications in detail. Each user shall inform the writing speed limit of EEPROM to system side.

Memory Load Sequence is shown below.

(1)The load file is specified at the ground system.

(2)The selected load file is compared with the memory management file (It has the same contents as the onboard memory.) and Memory Load Command Packets are automatically generated. (Only different blocks will be sent.)

(3)If necessary, each user component is set as the mode where it can perform Memory Load/Dump.

(4)Memory Load Command Packets are sent to the spacecraft.

(5)In the case of Memory Load (Packet service), Memory Load Command Packets are de-packetted by each user component and the data are sent to the EEPROM of the user component.

In the case of Memory Load (RMAP direct), Memory Load Command Packets are de-packetted by DMC, and EEPROM of each User component (MDP and PCD) is directly written by RMAP Write.

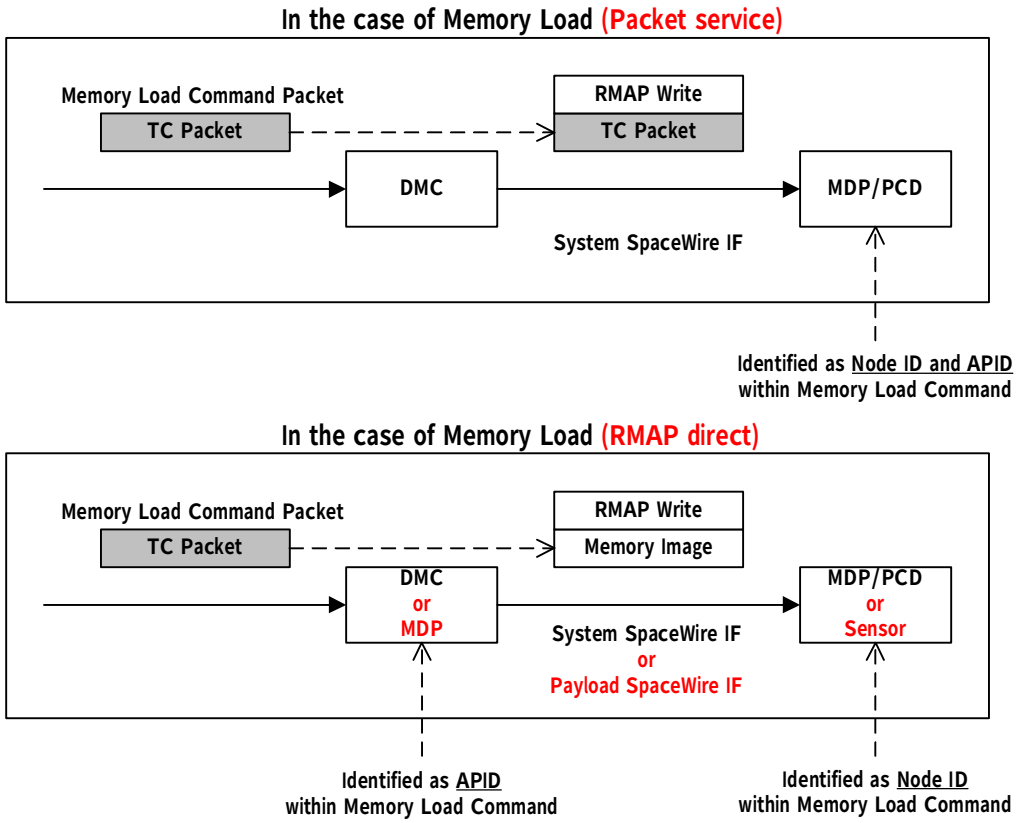


Figure 5.2-1 Outline of Memory Load method

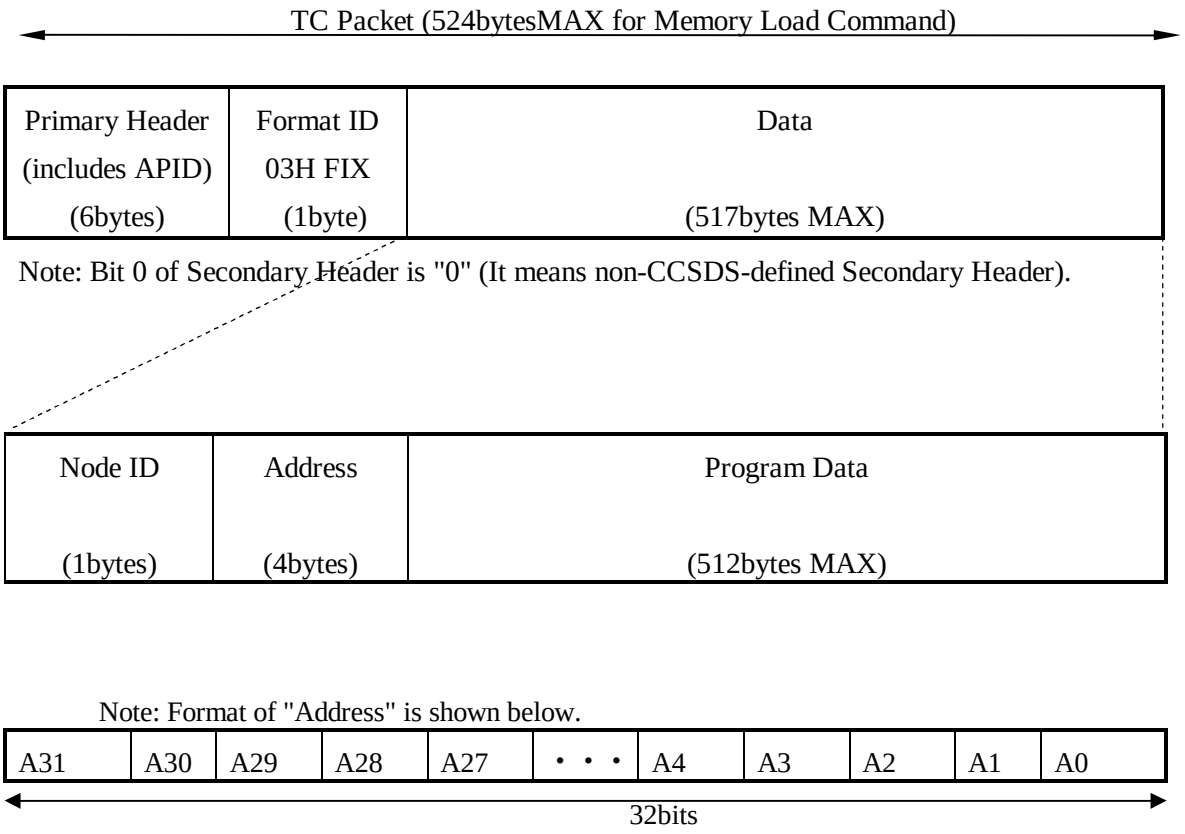


Figure 5.2-2 Memory Load Command Format

Table 5.2-1　Each field definition of Memory Load Command

Field	Number of bits	Value (binary)	Note
Primary Header	48	Refer to Table 3.1.2-1.	APID shall specify the node which decodes TC packet
Format ID	8	03H (FIX)	Memory Load Command
Node ID	8	Refer to Table 3.1.2-2	Node ID of target component of memory load.
Address	32	Variable	The first address of memory load area.
Program Data	～512 bytes	Variable	

5.3 EEPROM の Verification (Verification of the contents of EEPROM)

EEPROM の書き換えの Verification は Memory Dump の Dump Telemetry により行う。その場合の方法としては、以下の 2 種類がある。Memory Dump 方法の概要を Figure 5.3-1 に示す。

①当該機器による TC Packet 受信/TM Packet 生成による方法 (Memory Dump (Packet service))

この場合、Figure 5.3-2に示す Format の Dump Command を各機器に対して送信する。Dump Command 内の APID および Node ID は Memory Dump 対象機器を指定する。各機器は、上記 Dump Command を受信した後、Figure 5.3-3に示す Dump Telemetry を生成/出力する。出力の周期は 125msMIN ~~(TBC)~~。

②RMAP(Remote Memory Access Protocol)による方法 (Memory Dump (RMAP direct))

この場合、DMC で Figure 5.3-2に示す Dump Command を解読し、PCD および MDP に対して RMAP Read により直接メモリを読み、DMC で Figure 5.3-3に示す Dump Telemetry を生成する。Dump Command 内の APID には DMC (Common)を指定し、Node ID には Memory Dump 対象機器を指定する。詳細は MMO SpaceWire Network Specifications を参照すること。

Memory Dump の Sequence を以下に示す。

① 衛星管制装置上で、DMC もしくは User 機器に対する Dump Command (Figure 5.3-2およびTable 5.3-1参照)を生成。
Dump を実施する機器、Dump 先頭アドレス、Dump Byte 数、Dump 繰り返し数 (maximum 4)を設定する。

②衛星に対し、Dump Command を送出。

③Memory Dump (Packet service)の場合、DMC もしくは User 機器が Dump Command を受信し、指定された Parameter に従って、メモリ領域(EEPROM の領域を想定)を 512bytes 単位で読み出し、Dump Telemetry (Figure 5.3-3参照)(Data 領域は 512bytes 固定)を生成/出力する。この時、1 回の Dump で 1ADU が発生する。(繰り返し数が 3 であれば 3ADU が発生する。)
Memory Dump (RMAP direct)の場合、DMC から RMAP Read により User 機器 (PCD および MDP)の EEPROM 領域に対し直接メモリを読み、DMC で Figure 5.3-3に示す Dump Telemetry を生成する。

④メモリ照合
地上系にて Dump Telemetry から照合 file を生成し、衛星管制系に登録された Memory 管理 File（書き込み File）と照合する。

Rewriting of EEPROM shall be verified by the Dump Telemetry. There are two methods of Memory Dump shown below. Outline of Memory Dump method is shown in Figure 5.3-1.

①Method by the TC packet de-packetted by the component / TM Packet generated by the component (Memory Dump (Packet service))

In this case, Dump Command of the format shown in Figure 5.3-2 is sent to each component. APID and Node ID within Dump Command specify the target component of Memory Dump. Each component shall de-packet the Dump Command and generate Dump Telemetry shown in Figure 5.3-3. The period of the generation is 125msMIN ~~(TBC)~~.

②Method by Remote Memory Access Protocol (Memory Dump (RMAP direct))

In this case, DMC de-packets the Dump Command shown in Figure 5.3-2, and directly reads the memory of PCD and MDP by RMAP Read, and generates the Dump Telemetry shown in Figure 5.3-3. Node ID within Dump Command specifies the target component of Memory Dump, while APID is for DMC (Common). For MDP and PCD, refer to MMO SpaceWire Network Specifications in detail.

Memory Dump Sequence is shown below.

①Dump Command (Refer to Figure 5.3-2 and Table 5.3-1) is generated by the Satellite Control Equipment (the ground system). Every parameter of the dump sequence are set, for example, the name of component, the first address of dumped memory area, the number of byte for dumped data, the number of dump cycle (maximum 4), etc.

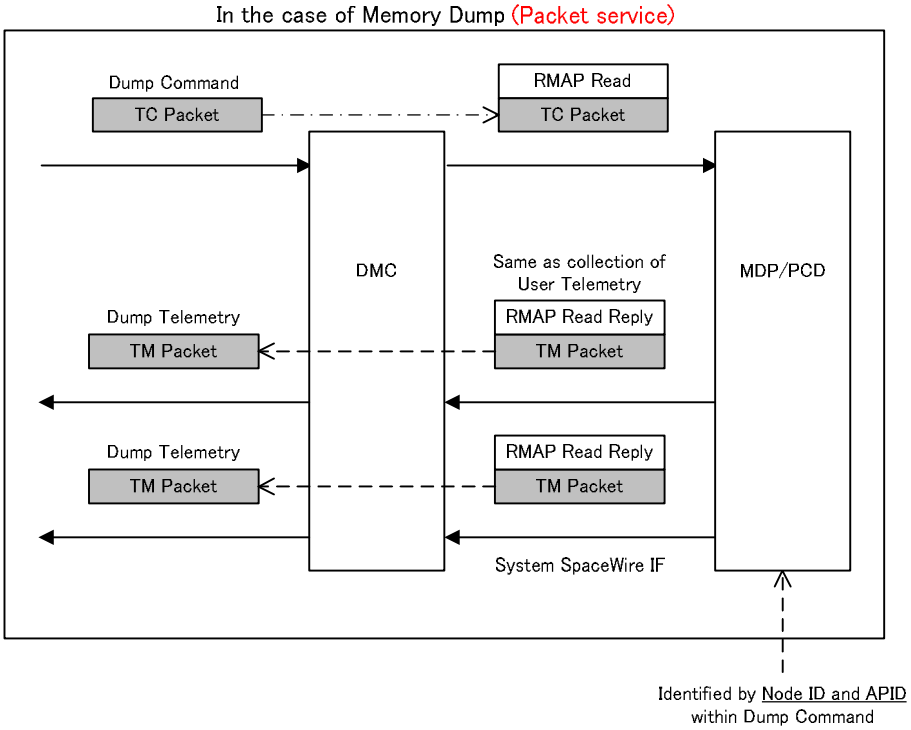
②The Dump Command is sent to the spacecraft.

③In the case of Memory Load (Packet service), DMC or User component receives the Dump Command, gathers the data from the memory area (EEPROM) (512bytes per one access) according to the specified parameter, generates the Dump Telemetry(Refer to Figure 5.3-3) (Data area is 512bytesFIX) and sends them to the ground system. 1ADU is generated per 1DUMP. (If repetition No is 3, three ADU will be generated.)

In the case of Memory Load (RMAP direct), DMC directly reads the memory of each User component (PCD and MDP) by RMAP Read, and generates the Dump Telemetry shown in Figure 5.3-3.

④Memory verification

The ground system generates the verification file (file to be verified) from the Dump Telemetry and compares it with the memory control file (load file) registered in the ground system.



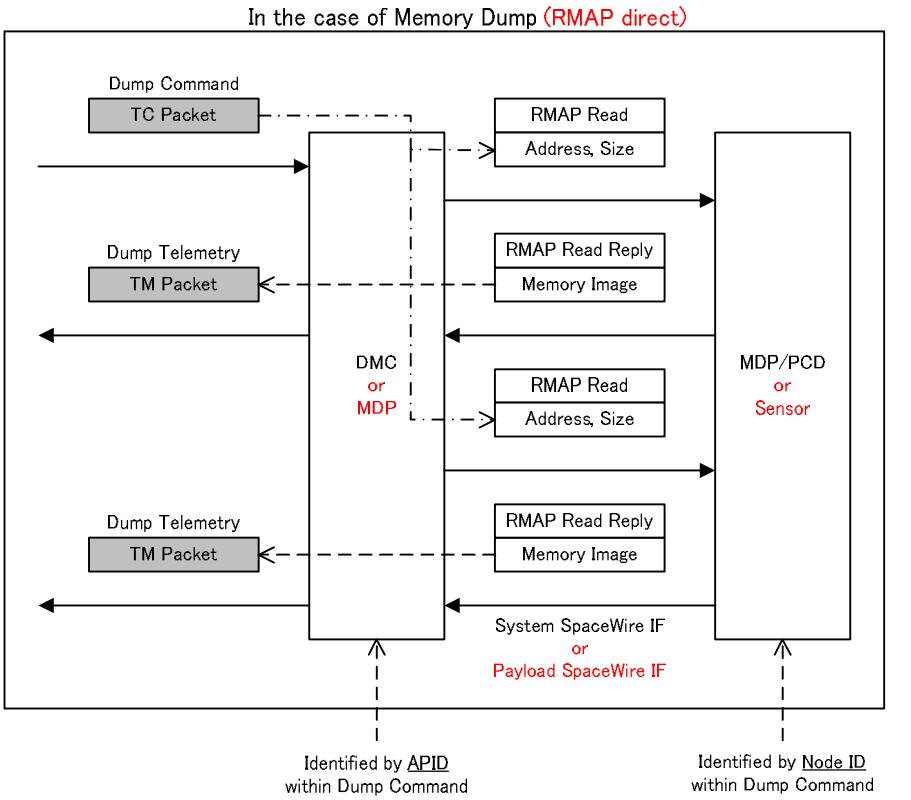


Figure 5.3-1 Outline of Memory Dump method

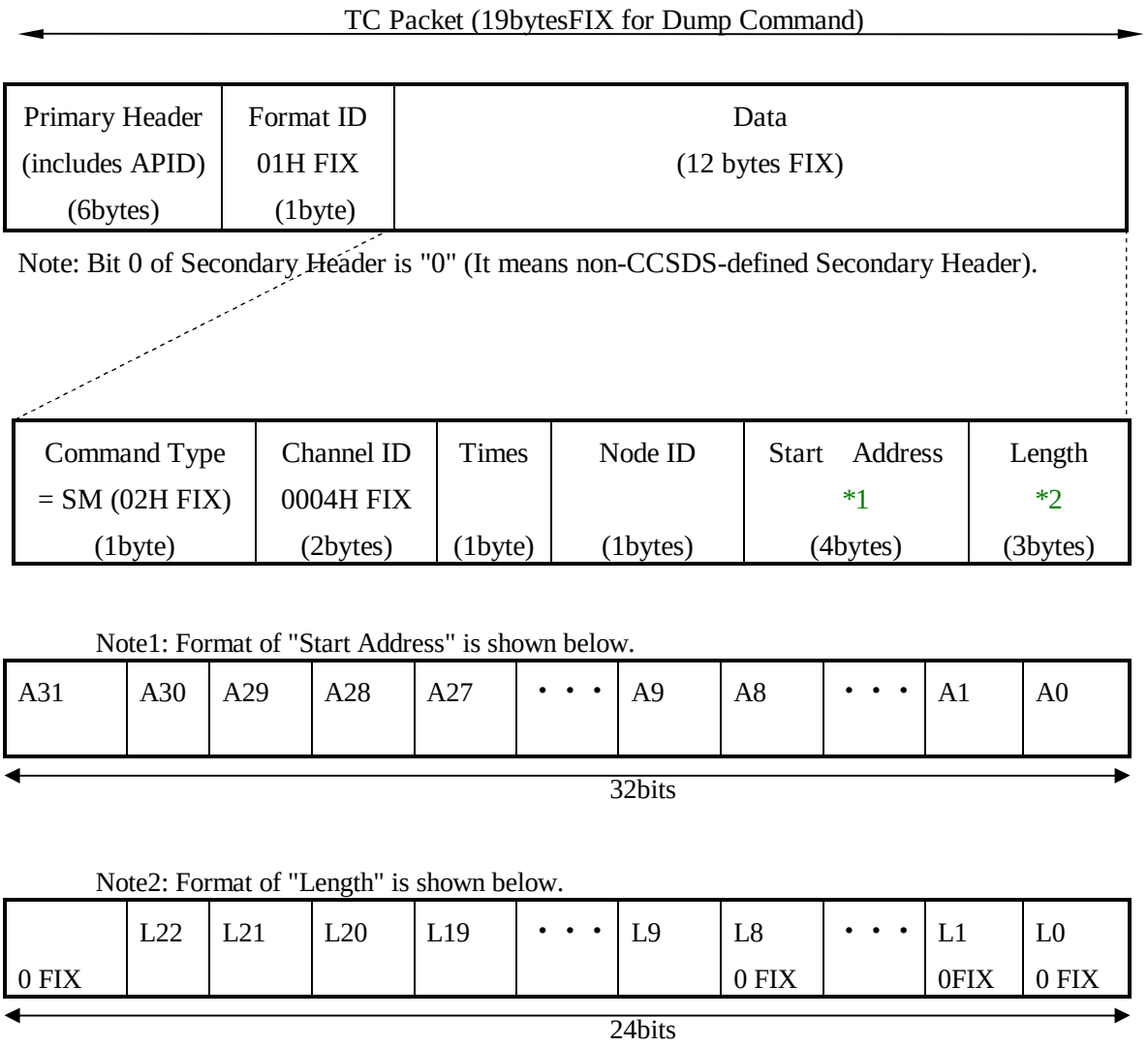
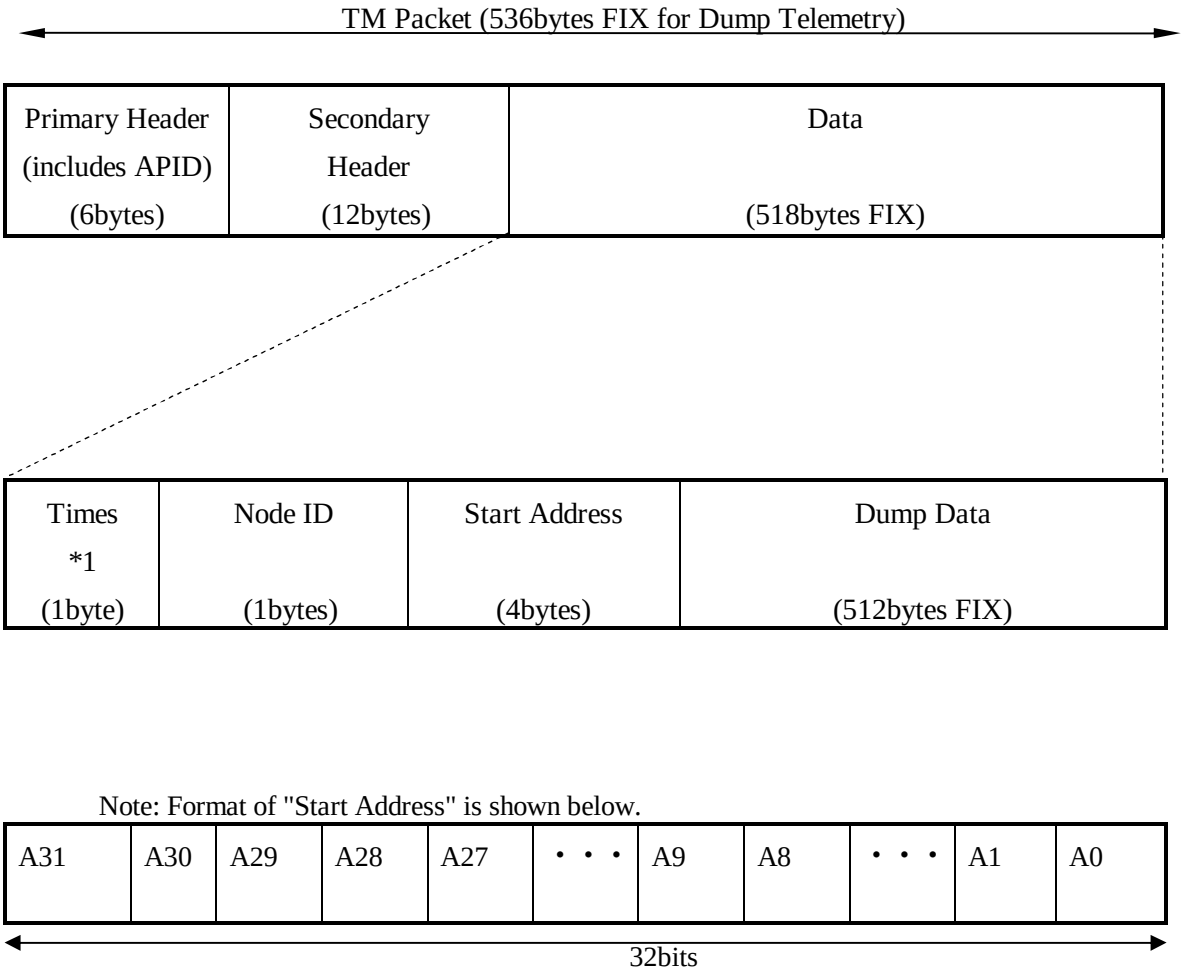


Figure 5.3-2 DUMP Command Format

Table 5.3-1　Each field definition of DUMP Command

Field	Number of bits	Value (binary)	Note
Primary Header	48	Refer to Table 3.1.2-1.	APID shall specify the node which decodes TC packet.
Format ID	8	01H (FIX)	Control Command
Command Type	8	02H (FIX)	Serial Magnitude Command
Channel ID	16	0004H (FIX)	Dump Command
Times	8	Only 2bits from LSB are effective. 11：4times cycle (4ADU) 10：3times cycle (3ADU) 01：2times cycle (2ADU) 00：1time (1ADU)	Number of dump cycle (Maximum 4)
Node ID	8	Refer to Table 3.1.2-2	Node ID of target component of memory dump.
Start Address	32	Variable	The first address of memory dump area.
Length	24	Variable	Total dump data size [byte] (512byte unit).



Note: **繰り返しを含まない、1 回分の** Dump Data **の全体が** 1ADU **となる**。
Whole, not repeated dump data form one ADU.

Figure 5.3-3　DUMP Telemetry Format

Table 5.3-2　Each field definition of DUMP Telemetry

Field	Number of bits	Value (binary)	Note
Primary Header	48	Refer to Table 4.2-1.	APID shall specify the node which generates TM packet.
Secondary Header	96 FIX (Even if 1ADU consists of 1 Packet)	Refer to Table 4.2-3. Packet Identifier = 00H FIX for Dump Telemetry.	ADU Length indicates the length of ADU inlduding not only Dump Data but also Tims, Node ID and Start Address.
Times	8	Only 2bits from LSB are effective. 11：3times cycle remains (last fourth ADU) 10：2times cycle remains (last third ADU) 01：1times cycle remains (last second ADU) 00：No cycle remains (last ADU) For example, if Times field of Dump Command is "11"BIN, Times field of DUMP Telemetry Packet shall be "11"(first ADU), "10"(second ADU), "01"(third ADU), and "00"BIN (last ADU) in order of packet generation.	Number of remaining dump cycle (Maximum 3)
Node ID	8	Refer to Table 4.2-1.	Node ID of target component of memory dump.
Start Address	32	Variable	The first address of memory dump area.
Dump Data	512bytes	Variable	

5.4 EEPROM から RAM への Load 及び Verification
(Load from EEPROM to RAM & Verification)

本内容については、特に規定を設けない。各サブシステムで設計すること。

There is no requirement about this topic. Each user may design properly.

5.5 Memory Load/Dump 対象機器(Components for Memory Load/Dump)

Table 5.5-1 Components List for Memory Load/Dump

Component	Memory Load	Memory Dump	Remark
DMC	○	○	
PCD	TBD	TBD	*1
MDP-1	○	○	*1
MDP-2	○	○	*1
MEA1	TBD	TBD	
MEA2	TBD	TBD	
MIA	○	○	*2
MSA	○	○	*2
HEP-e	N/A	N/A	
HEP-i	N/A	N/A	
ENA	N/A	N/A	
PME/MGF-O	N/A	N/A	
PME/MGF-I	N/A	N/A	
MDM	N/A	N/A	
MSASI	N/A	N/A	
PME/EWO-E	○	○	*2
PME/EWO-B	N/A	N/A	
PME/SORBET	N/A	N/A	
PME/MEFISTO	N/A	N/A	
PME/MASTWPT-E	N/A	N/A	

*1 Memory Load/Dump (Packet service) and Memory Load/Dump (RMAP direct) are supported.

*2 Only Memory Load/Dump (RMAP direct) is ssupported

6 Category の使用法(How to use Category)(Tentative)

6.1 一般事項(General Outline)

(1) Category

MMO では、「はやぶさ」と同様、蓄積伝送の優先順位に関連づけられる概念として Category というものを定義する。同じように扱われるべき Telemetry は同一の Category として定義し、蓄積伝送の観点から異なる扱いを必要とする Telemetry は別の Category として定義すること。

Category is defined as the field, which is related to the priority of storing and transmitting. Telemetry, which should be treated in the same manner, shall belong to the same Category. Telemetry, which should be treated in the different manner from the point of storing or transmitting, shall belong to the different Category.

① MMO では、Category の Bit 数を 8bit とする。

In the case of MMO, "Category" is a number of 8bits.

② 各 Category は、各機器で共通に使用するものと、各機器に固有のものがある。
割り当ての例をTable 6.1-1に示す。各機器側では、必要な Category 数を申告すること。
カテゴリは MMO Telemetry Command List (JX-MMO-0014)において定義する。

There are two types of "Category". One is commonly used by each component, and the other is used by only one component. Example of Category assignment is shown in Table 6.1-1. Each component side shall declare the necessary number of Category.
Category is defined in MMO Telemetry Command List (JX-MMO-0014).

Table 6.1-1 Example of Category Assignment Table (Tentative)

(This kind of table will be determined after the negotiation with each User)

Category(8bit) (HEX)	Number of Category (DEC)	Assignment
00	1	Report Telemetry
01	1	Dump Telemetry
02-0C	11	System HK Telemetry
0F	1	DHS User HK Telemetry (SpaceWire Router, Check)
10	1	DR User HK Telemetry (Write Pointer)
11	1	DR User HK Telemetry (Partition etc.)
12	1	TCS User HK Telemetry
13-1D	11	ACS User HK Telemetry
20-BF		Mission Telemetry of Payload User HK Telemetry of Payload Report Telemetry of Payload
FE	1	DMC Time Telemetry
FF	1	DMC H/W Telemetry

(2) Category Definition Table

① 各 Category に対し、Level(2bit)を関連づける。この関連付けは、DMC 内部にTable 6.1-2 に示すような Category 定義 Table を持つことにより行う。
Category 定義 Table は MMO Telemetry Command List (JX-MMO-0014)において定義する。

Each Category is related to the Level (2bit). This relationship is defined by the Category Definition Table in DMC, such as Table 6.1-2.
Category Definition Table is defined in MMO Telemetry Command List (JX-MMO-0014).

②この Table は、Down Link Bit Rate 等、探査機の状態を変化させる Command(Operation Mode Change Command)の実行に伴って変更される。(Table 3.2.1-2参照)

This table is changed when Operation Mode Change Command, which changes the status of spacecraft (Down Link Bit Rate etc.), is executed. (Refer to Table 3.2.1-2)

Table 6.1-2 Example of Category Definition Table

Category(8bit) (HEX)	Level(2bit)	
	Real(BIN)	Record(BIN)
00	1	1
01	1	1
02	1	0
:	:	:
10	0	1
11	0	1
12	0	1
13	0	1
14	0	1
15	1	1
16	0	1
17	0	1
18	0	1
19	0	1
1A	0	1
:	:	:
FF	0	0

(3) Level

①Level とは、その Category として発生した Telemetry が、Real Time で Downlink されるのか、DR(Data Recorder)に記録されるのか、またはその両方であるのかを識別するものである。Table 6.1-3にその定義を示す。

Level defines the data flow (Real Time Downlink or DR (Data Recorder) storage or both of them) of Telemetry belonging to the related Category. The definition of Level is shown in Table 6.1-3.

Table 6.1-3 List of Level value

Bit	Process in DMC
01	No Real Time Telemetry, only DR storage.
10	Only Real Time Telemetry, No DR storage
11	Real Time Telemetry & DR storage
00	N/A (No Real Time Telemetry, No DR Storage)

Note: Upper Level Bit is related to Real Time Telemetry.
Lower Level Bit is related to DR storage.

(4) Partition

①Partition の個数は DR の仕様上は 192 個 MAX~~(TBC)~~とする。
②Partition と Category は一対一で対応する。
③DR に格納された Telemetry Data は、Partition ごとに指定して Downlink される。
なお、この時、再生 Address は Command により指定できる。

①The number of Partition is 192MAX as the specification of DR ~~(TBC)~~.
②Each Category is corresponded to one Partition.
③Telemetry Data stored in DR(Data Recorder) are downlinked by designating the Partition. Address to reproduce can be designated by command.

(5) HK (House Keeping)

HK Telemetry は、DMC が生成する System HK Telemetry と、それ以外で User 機器が生成する User HK Telemetry に分類される。System HK Telemetry と User HK Telemetry の考え方を以下に示す。

基本的に、衛星管制上必要と思われる情報（具体的にはシステム/サブシステム間で調整）は、DMC が収集/編集する System HK Telemetry として出力し、Data の同時性を確保する。その中には、以下の Data が含まれる。それ以外の機器の Status を表す Data については、各機器が User HK Telemetry として出力する。

なお、System HK Telemetry として出力する Data については、単一のフォーマットとし、サブコミは行わないこと。

a. 自律管制用 Data

衛星の自律管制において Check される Data。(Subsystem と System で調整後決定)

b. Hardware 出力 Data

通常は、Software を介して TM Packet として出力されるが、CPU-OFF 時及び異常時にも、Monitor 用もしくは不具合解析用として参照したいため、DMC 経由でも出力しておきたい Data。

c. CPU を持たない Bus 機器の Data

TCIU 等、CPU を持たない Bus 機器が出力する Data。

HK Telemetry is classified as System HK Telemetry (generated by DMC) and User HK Telemetry (generated by user component).

In the case of MMO, the guideline of System HK Telemetry & User HK Telemetry is as follows.

Basically, the information needed in the spacecraft control shall be generated as HK Telemetry to guarantee the synchronization. It shall include the data shown below. The other data, which describe the status of each component, shall be generated by each component and outputted as User Telemetry.

System HK shall have uniquely identified data formant, and sub-commutation is prohibited for the data outputted as System HK.

a. Data used in Autonomous Control

These are the data that shall be checked by the Autonomous Control Process.

These data shall be defined by the negotiation between subsystem side and system side.

b. Hardware Output Data

The data, which are usually outputted by software as TM Packet, but also shall be outputted by DMC, because it should be watched even in the case of CPU-OFF or contingency for monitor or analysis.

c. Data of bus components, which don't have CPU

These are the data outputted by bus components, such as TCIU, which don't have CPU.

なお、System HK Telemetryの仕様は以下の通りである。

a.System HK Telemetryの種類

1種類のみ：データ量 864 bytes以下~~(TBC)~~。

上記中、自律管制で Check するのは任意の 2byte×64。

b.System HK Telemetry収集/編集レート： 1s周期

c.自律判断周期： 8s周期

a. Type of System HK Telemetry

Only one type: Data size is 864bytes MAX~~(TBC)~~

The number above includes the data (64bytes), which are checked in the Autonomous Process.

b. Frequency of System HK Telemetry gathering/generation： Period = 1s

c. Frequency of Autonomous Judgment： Period = 8s

(6) 動作 Mode の規定(Determination of Spacecraft Operation Mode)

① 探査機の動作 Mode は、Operation Mode Change Command で、以下の 4 つを指定することにより規定される。(Table 3.2.1-2参照)

a.機器の動作 Mode

Operation Mode Change Command 内の、指定の Field の Code により、各機器の動作 Mode が規定される。機器の動作 Mode を特定することにより、以下の 2 点が決まること。

・発生する Data の Category

・Category ごとの Data 発生 Rate（暫定）

User機器は、各Categoryごとに、発生するData量と、そのDataを出力するためのリクエストの間隔を決めることにより、Data発生Rateを制御する（暫定）。

b. DMC 内の Category 定義 Table

c. Downlink Bit Rate

d. DMC Rate Check Mode

② 上記の動作 Mode は、Real/Record のそれぞれにおいて Data が溢れることなく動作するように、地上で計画するものとする。

③ ただし、PCD,MDP については予め機器ごとに設定された Rate をオーバして Telemetry を出力する機器がある場合(Rate の算出方法については MMO SpaceWire Nework Specification を参照)、もしくは予め機器ごとに設定された 1Processing Slot あたりのデータ量を超える場合、その Processing Slot において DMC は当該機器の予め設定された上限以上の Telemetry 収集を TM Packet 単位で行わない。~~(TBC)~~

①Spacecraft Operation Mode is determined by 4 items mentioned below, which is specified by Operation Mode Change Command. (Refer to Table 3.2.1-2)

a. Operation Mode of each component

Each component's operation mode is determined by the specified field in Operation Mode Change Command. Component operation mode determines 2items shown below.

- Category of generated data
- Data generation rate of each Category (Tentative)

Each user component must control the data generation rate by control of data amount and the period between each data output, which is the trigger of data output.

(Tentative)

b. Category Definition Table in DMC

c. Downlink Bit Rate

d. DMC Rate Check Mode

②The Operation Mode described above shall be planed in the ground system not to exceed the available Real/Record rate respectively.

③For PCD and MDP, in the case that output data rate exceeds the upper limit previously defined for each component (Refer to MMO SpaceWire Network Specification regarding to calculation method of data rate) and that output data size per 1 Processing Slot exceeds the upper limit previously defined for each component, DMC does not collect the telemetry by a unit of TM Packet which exceeds the upper limit ~~(TBC)~~.

6.2　Data 格納法(How to record the data)

①Telemetry Data を、Real Time で Downlink するべきか、DR に記録するべきか、もしくはその両方であるかは、User が付加する Category No.とTable 6.1-2により指定される。また、Table 6.1-2は、DMC に対する Mode 指定の Command の結果として切り替えられる。
②DR の各 Partition 内は Ring Buffer とする。
③記録を開始する場所を Command で指定することも可能である。
④Partition ごとに記録不可/上書き不可/上書き可の設定ができるが、通常は上書き可で運用する。
⑤DR へは、TM Packet の形で記録される。
⑥Partition の Size は Command で変更可能。ただし、境界変更時は、その前後の Partition の内容は保証されない。

Partision については、MMO MDP DMC/DR Usage Definition Document (JX-MMO-MDP-0004)で定義される。

①How to deal with Telemetry Data (Real Time Downlink, DR storage or both) is determined by Category No attached by each user component and Table 6.1-2. Table 6.1-2 is changed by the mode definition command to DMC.
②Each partition of DR is ring buffer.
③Start point of record can be changed by the command.
④Write-disable-mode / Overwrite-disable-mode / Overwrite-enable-mode are selectable for each partition. However, it is usually used in Overwrite-mode. (Tentative)
⑤Telemetry data are saved in DR as TM Packets.
⑥The size of each partition is changed by command. When a boundary of partitions is changed, the data in partitions, whose boundary is changed, are not kept.

Partision is definded in MMO MDP DMC/DR Usage Definition Document (JX-MMO-MDP-0004).

6.3　Data 再生法(How to reproduce the data)

①DR の再生は、Command により、Partition 単位で行われる。
②再生は Sequential に行われる。
③再生を開始および終了する場所を Command で指定することも可能である。
④Data の Clear は、Partition 単位で行われる。

①Reproduction of data saved in DR is performed partition by partition, according to the command.
②Reproduction is performed sequentially.
③Start point and End point of reproduction can be changed by the command.
④Deletion of data saved in DR is performed partition by partition.

DR と category の使用方法の全体の概念図をFigure 6.3-1にまとめる。

Schematic overview of DR and category usage is illustrated in Figure 6.3-1.

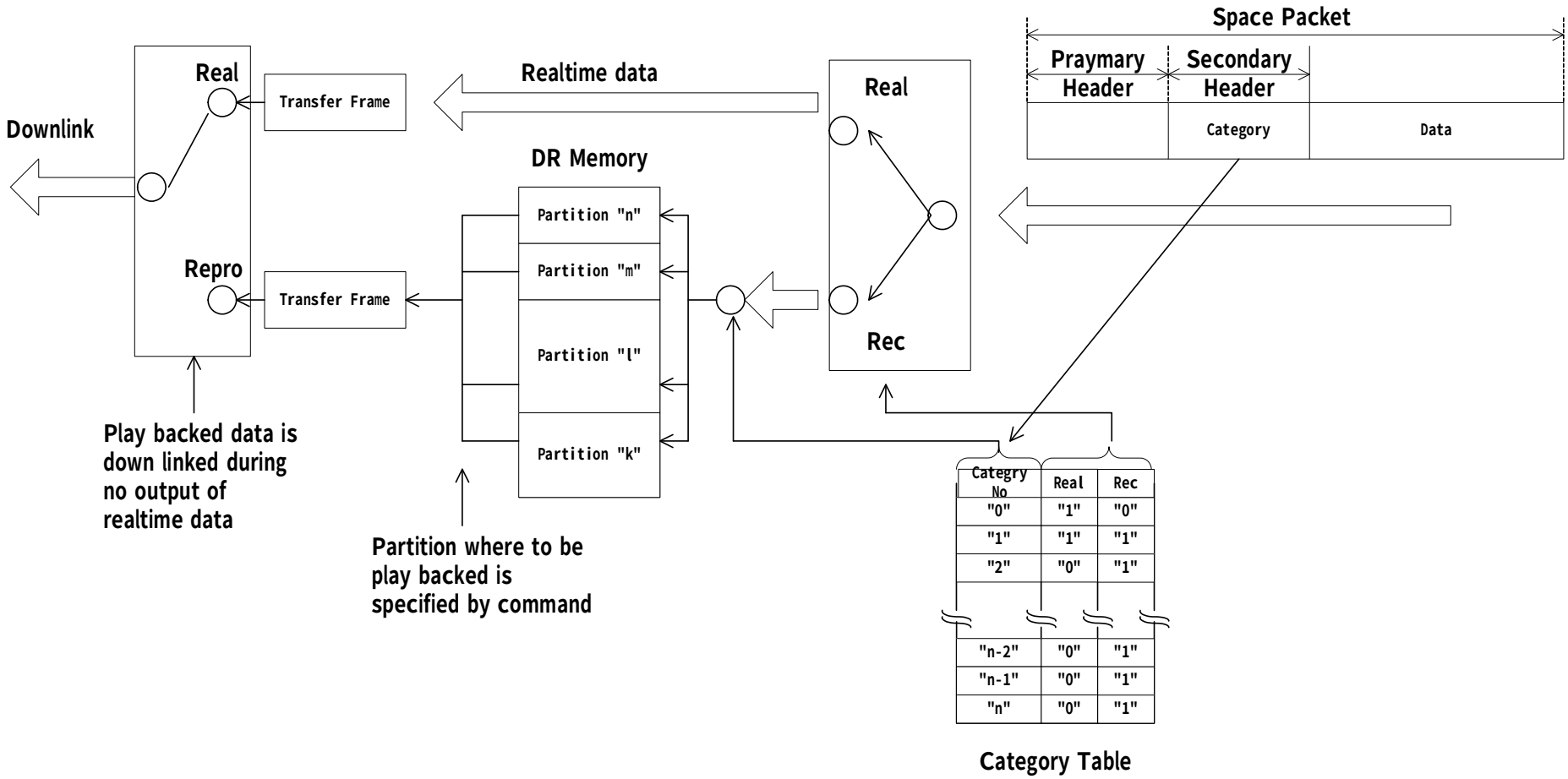


Figure 6.3-1 Schematic overview of DR(Data Recorder) and category usage

7　その他 (Others)

7.1　ダブルコマンド(Double Command)

火工品作動／展開／伸展／高圧電源に関するコマンドは必ずダブルコマンド化（該当コマンドの Enable/Disable コマンドを設ける）を行うこと。Enable にし Command を実行した後は、自動的に Disable される仕様とすること(暫定)。さらに ENA/DIS を含むステータスが System HK Telemetry 内で確認出来ること。また、上記のような動作進行中に異常が発生した場合の最低限の対処は、オンボードで自動的に実行できるようにしておくこと。

例）火工品冗長系作動、伸展モータ停止、高圧電源シャットオフ。

The user should prepare double command systems, which consist of original command, its "ENABLE" command and its "DISABLE" command, for the commands related to Pyro Firing/Deployment/Extension/High Voltage Power Supply. And the status of ENA/DIS should be confirmed by the System HK Telemetry information. The onboard function to cope with accidents arising during above-mentioned operation should be prepared by the specified component side.

Ex.) Firing redundant device, Stopping motor, shutting off the power supply etc.

7.2　Toggle Command の禁止 (Prohibition of Toggle Command)

当該 Command を受信する度に、機器の状態が変わるような Command (Toggle Command)は使用しないこと。例えば、ある Command を受信する度に、Enable/Disable が切り替わるといった設計にはせず、Enable Command と Disable Command の両方を用意すること。

The command, which changes the status of the component alternately (Toggle Command), is prohibited. For example, you should not make the component to change its Enable/Disable status alternately according to the particular command, but you should prepare both the Enable Command and the Disable Command.