An Implementation of Chapter 7 Packet Telemetry System

19th Test Instrumentation Workshop: *Tools, Training and Intellectual Capital Workshop* ITEA

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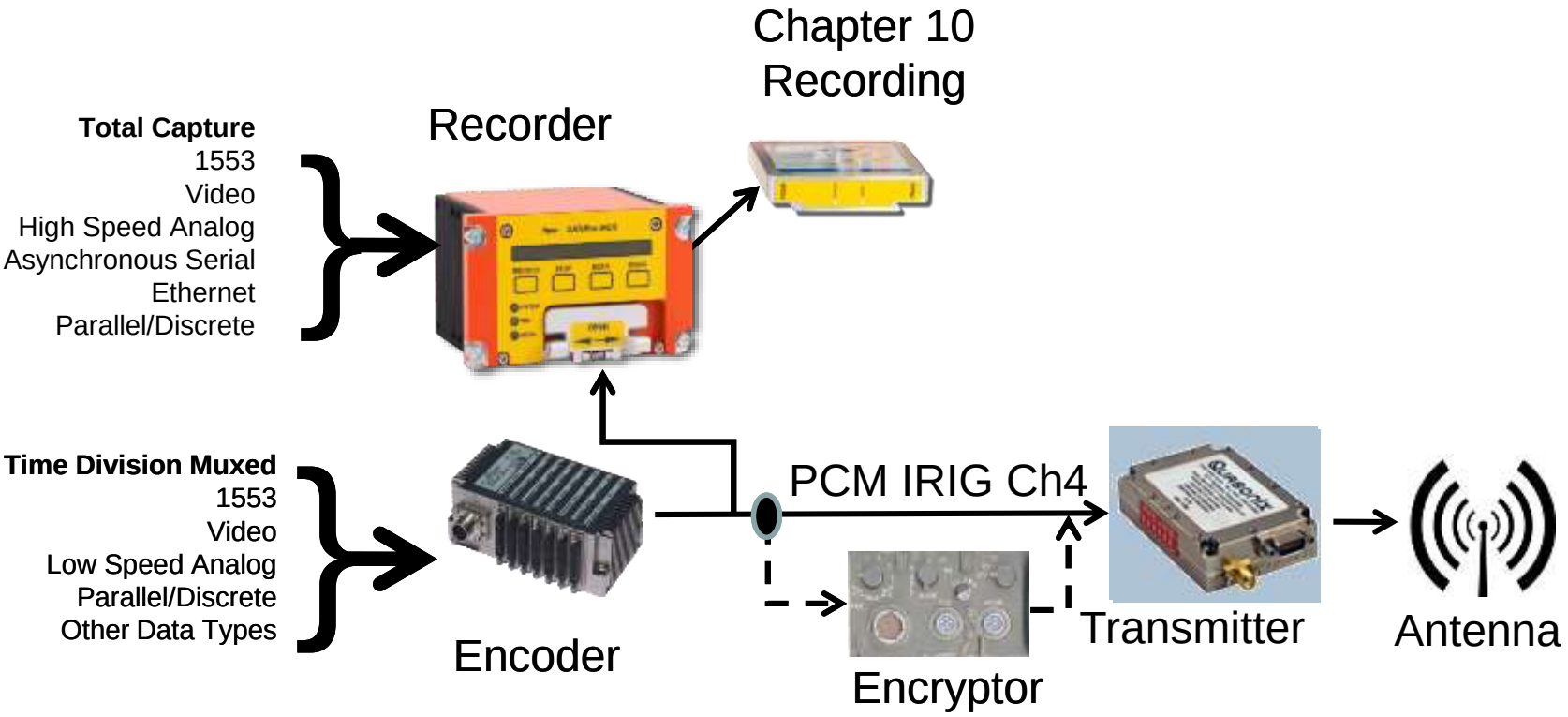
Typical Airborne System Architecture

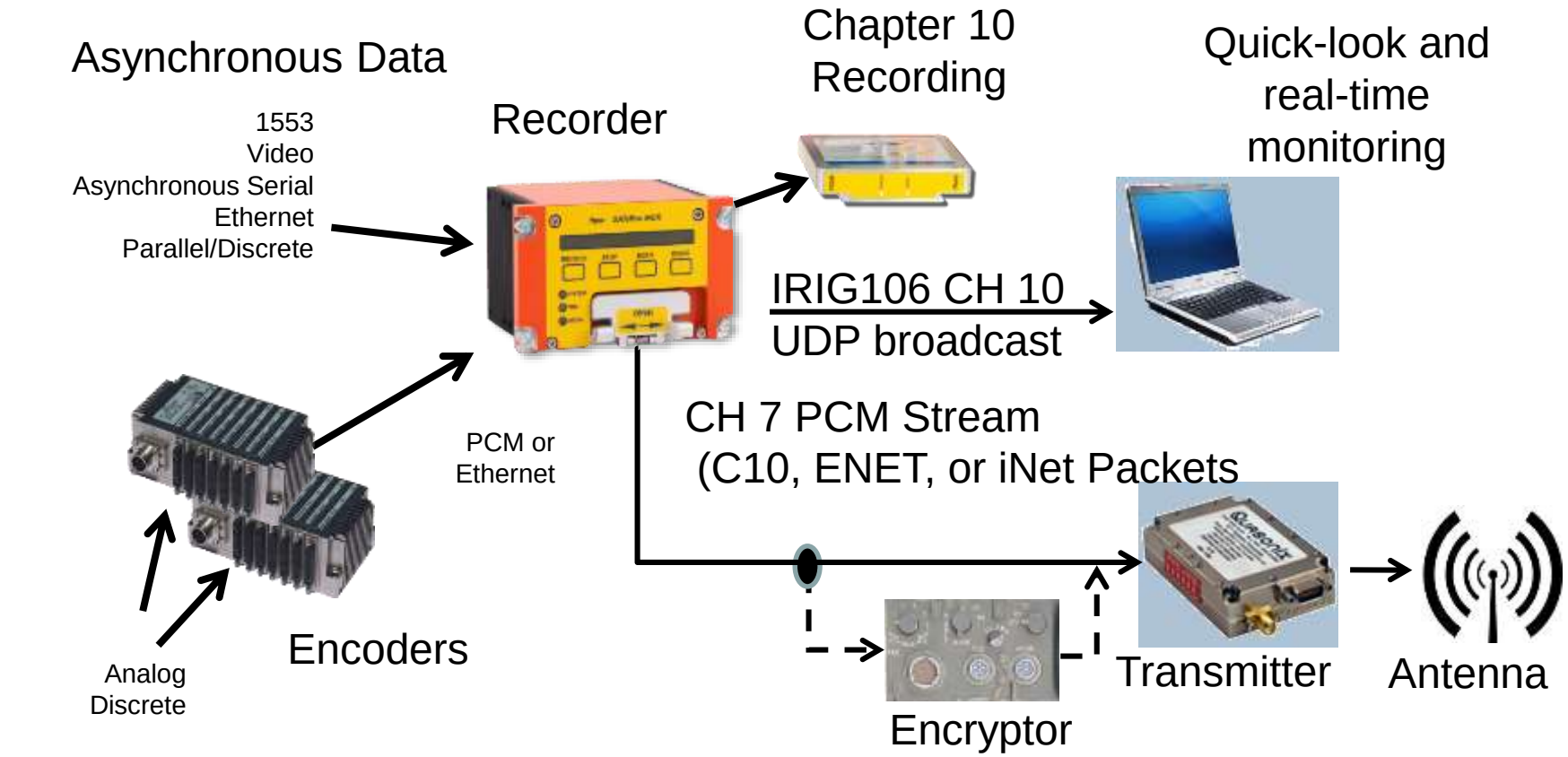


How do you want to send your Telemetry Data ?

- **Continuous or Periodic Data-**
  - PCM Time Division Multiplexing is optimal
- **Asynchronous Data-**
  - Asynchronous Packet transmission is optimal

Due to major increase in high speed Asynchronous Busses on test platforms and reduced PCM Telemetry Bandwidth. This is an extremely important aspect to consider.

ZDS C7 Notional C10, iNet, or Enet Telemetry Downlink Airborne Scenario



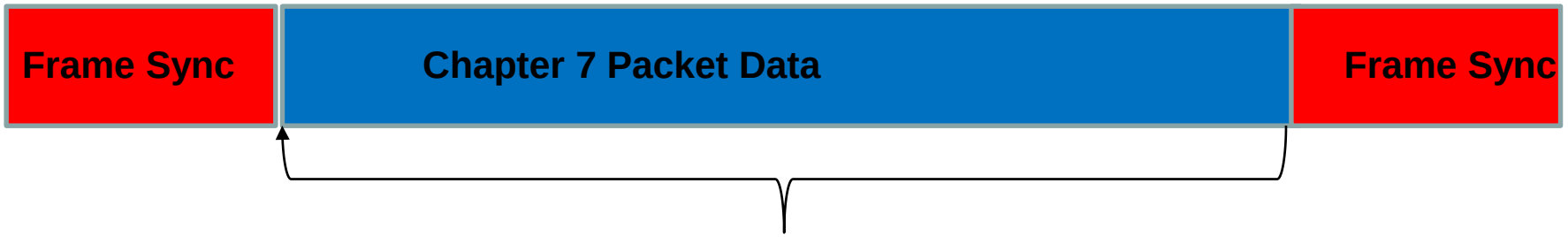
What Is Chapter 7- Packet Telemetry?

Method to Telemeter the following Packet types over a Class II IRIG 106 Chapter 4 PCM Stream

Fill Packet
Application Specific Packet
Test Counter Packet
Chapter 10 Packet
Raw Ethernet Media Access Control (MAC) Frame Packet
Ethernet Internet Protocol (IP) Packet
iNET TmNS Packet

PCM Chapter 4 Format

FS= FE6B2840



Word Length= 8 Bits
Words per Frame= N x 233 N=1 to 8

	7 0
1	SYNC WORD (bits 31..24)
2	SYNC WORD (bits 23..16)
3	SYNC WORD (bits 15..8)
4	SYNC WORD (bits 7..0)
5	DATA BYTE 1
	…
	…
4+N*223	DATA BYTE N*223

Figure 7-1. Minor Frame Illustration as a Series of Bytes

More PCM Format Detail

Minor Frame Header=
Unprotected Part

b. Minor Frame Header Unprotected Part. The minor frame header has a one-byte-long unprotected part. This byte is static for each PCM stream. The minor frame header, unprotected part can be seen in Figure 7-6.

7	6	5	4	3	2	1	0
Stream ID				Reserved		Version	

Figure 7-6. Minor Frame Header, Unprotected Part

- Stream ID (bits 7..4). The stream ID can identify up to 16 different streams. Its usage is application-specific.
- Reserved (bits 3..2). These bits are reserved, and shall be set to 0.
- Version (bits 1..0). These bits are coding the Chapter 7 version:

  00: Version 1
  01: reserved
  10: reserved
  11: reserved

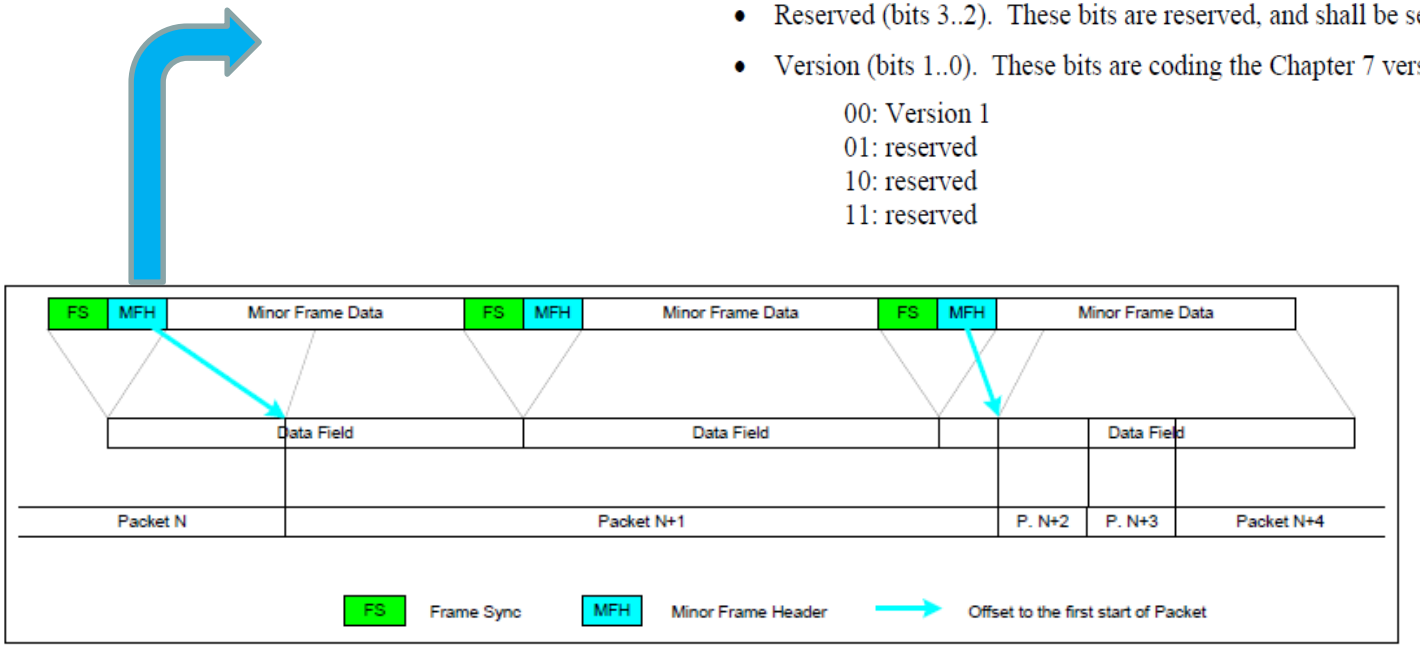


Figure 7-3. Overview of the Packet Encapsulation Mechanism

More PCM Format Detail

11	10	9	8	7	6	5	4	3	2	1	0
LL	Offset to First Packet Header (bits 10.. 0)										

Figure 7-7. Minor Frame Header, Golay Code Protected Part

Minor Frame Header= Protected Part

- LL: LLP Exists (bit 11)

  = 1 indicates if the minor frame data part contains one or more optional LLPs and the closing LLP end byte.
  = 0 means that no LLP and no LLP end byte exists.

- Offset to First Packet Header (bits 10..0). These bits provide a byte offset to the first byte of the first start of packet in this minor frame – provided a start of packet exists in this minor frame. The value is relative to the first data byte following the packet header (the value of 0 represents the first byte following the header.)
  If there is no start of packet in this minor frame, all bits shall be set to 1 (binary 11111111111).

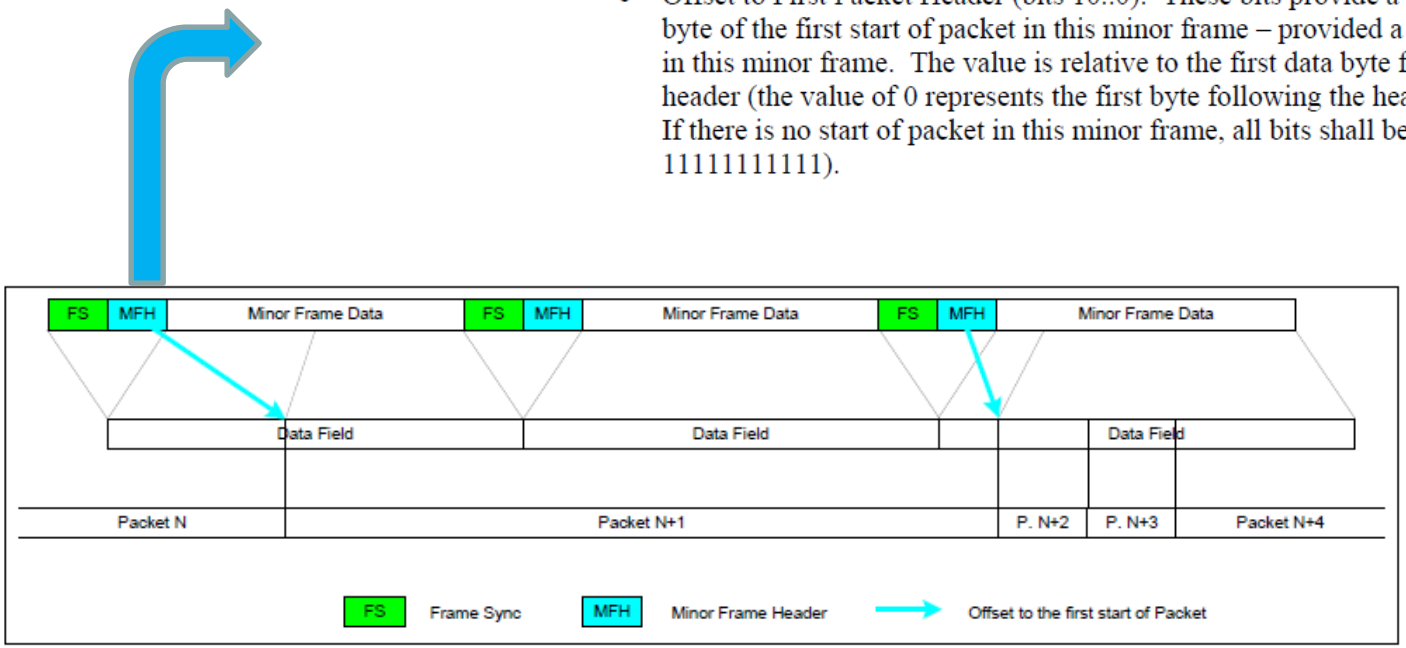


Figure 7-3. Overview of the Packet Encapsulation Mechanism

PCM Format Detail

The minor frame structure with LLPs is shown in Figure 7-4.

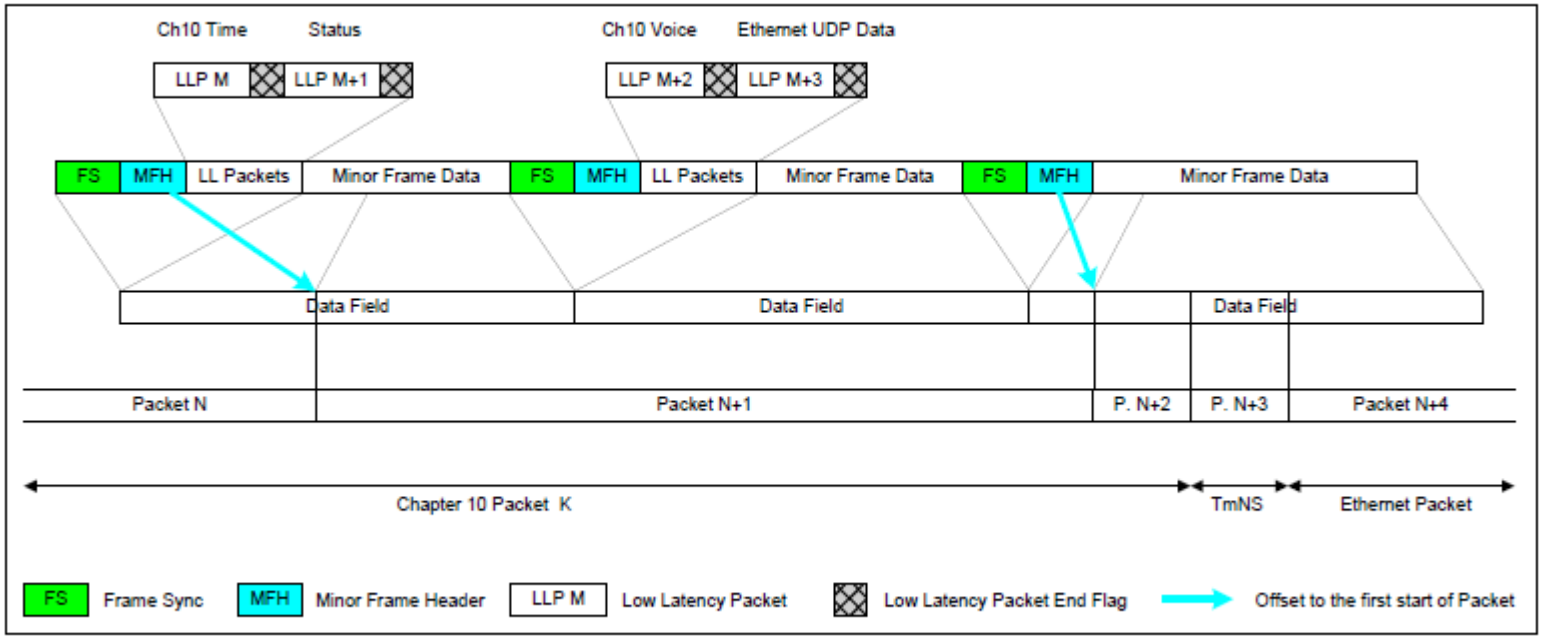


Figure 7-4. Packet Encapsulation Mechanism with Low-Latency Packets

Protection of Packet and Minor Frame Header- Golay Code

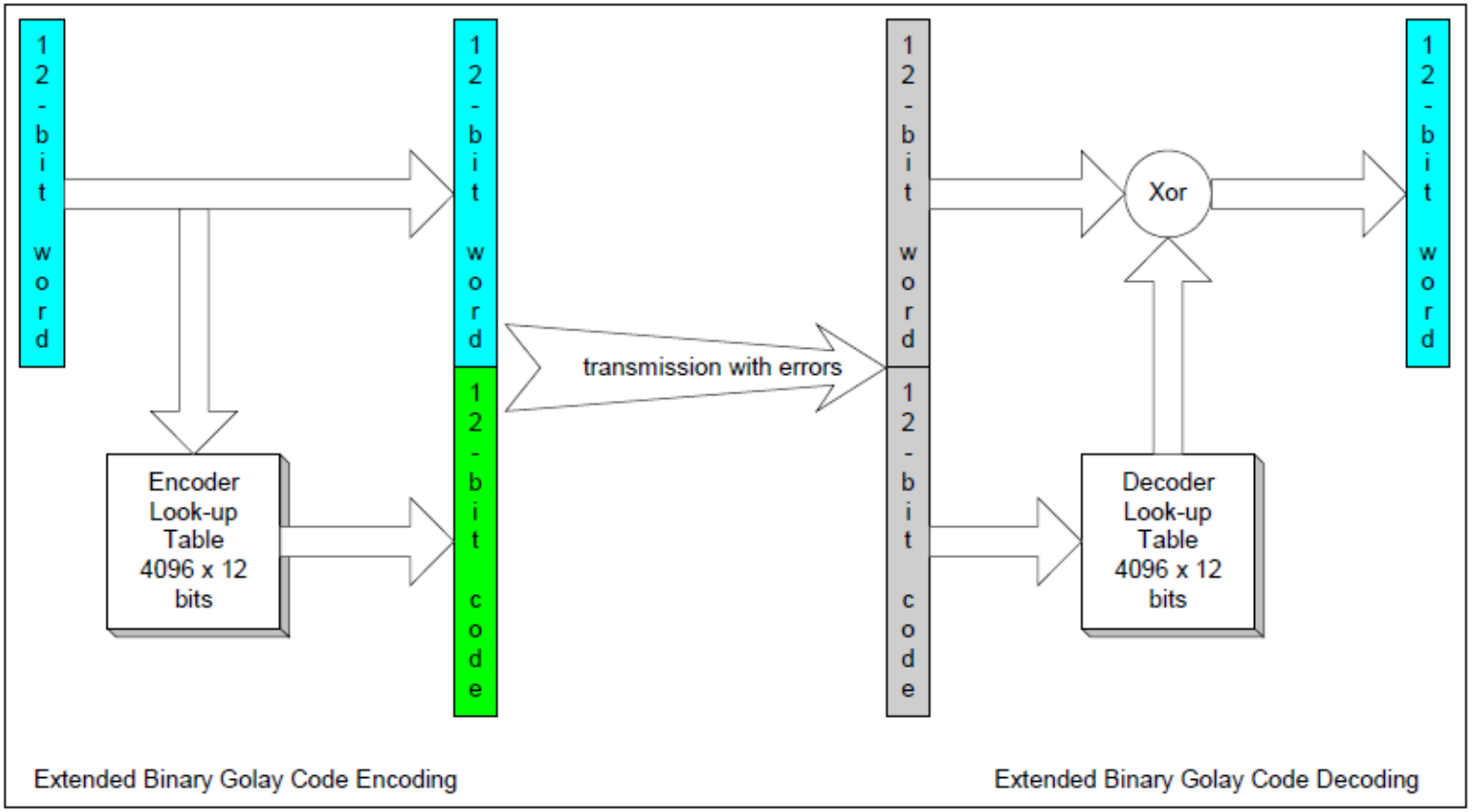


Figure 7-2. Golay Code Encoding and Decoding

Simplified Example of Packets in Chapter 7 PCM Stream

	Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	
Sync Word	Fill Word	Fill Word	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	Fill Word	Fill Word	1553IN Chan1	1553IN Chan1	1553IN Chan1	Sync Word
Sync Word	1553IN Chan1	1553IN Chan1	1553IN Chan1	Fill Word	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	Fill Word	PCMIN Chan1	PCMIN Chan1	Sync Word
Sync Word	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	Fill Word	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	Fill Word	VIDIN Chan2	VIDIN Chan2	Sync Word
Sync Word	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	Fill Word	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	Fill Word	Fill Word	Fill Word	Sync Word
Sync Word	Fill Word	Fill Word	Fill Word	Fill Word	Fill Word	1553IN Chan1	1553IN Chan1	1553IN Chan1	1553IN Chan1	1553IN Chan1	1553IN Chan1	Fill Word	Fill Word	Fill Word	Fill Word	Sync Word
Sync Word	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	Fill Word	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	Fill Word	Sync Word
Sync Word	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	Fill Word	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	PCMIN Chan1	Fill Word	Sync Word
Sync Word	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	VIDIN Chan1	Fill Word	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	VIDIN Chan2	Sync Word

C7 Packet Format

7.4 Packet Format

The packet consists of a packet header and a packet data part as shown in Figure 7-8.

PACKET HEADER, Golay Coded (3 bytes)
PACKET DATA 1
…
PACKET DATA N

Figure 7-8. Packet Structure

a. Packet Header. The size of the packet header is 24 bits and coded as 2 x 12 bit parts. It is coded and transmitted on 2 x 24-bit Golay code words. The order is first the bits 23..12, then the bits 11..0. Packet header, protected bytes can be seen in Figure 7-9.

Packet Header- Protected Part

23	22	21	20	19	18	17	16	15	14	13	12
Reserved		Content				Fragment		Length (15..12)			
11	10	9	8	7	6	5	4	3	2	1	0
Length (11..0)											

Figure 7-9. Packet Header, Protected Bytes

The packet header consists of the following.

- Reserved (bits 23..22). These bits are reserved and shall be set to 00.
- Content: Packet Content (bits 21..18). These bits are identifying the content of the packet. The following values assigned:

  0000: Fill Packet
  0001: Application Specific Packet
  0010: Test Counter Packet
  0011: Chapter 10 Packet
  0100: Raw Ethernet Media Access Control (MAC) Frame Packet
  0101: Ethernet Internet Protocol (IP) Packet
  0110: iNET TmNS Packet
  0111 – 1111: reserved

- Fragment: Packet Fragmentation. (bits 17..16).

  00: Complete Packet
  01: First Fragment of a Packet
  10: Middle Fragment of a Packet
  11: Last Fragment of a Packet

Zodiac Data System Chapter 7 Hardware Implementation

Traditional Chapter 4 PCM TM downlink

Quick-look and real-time monitoring

UDP

All MDR Data Types

Selected C10 Packets internal from the MDR

Chapter 7

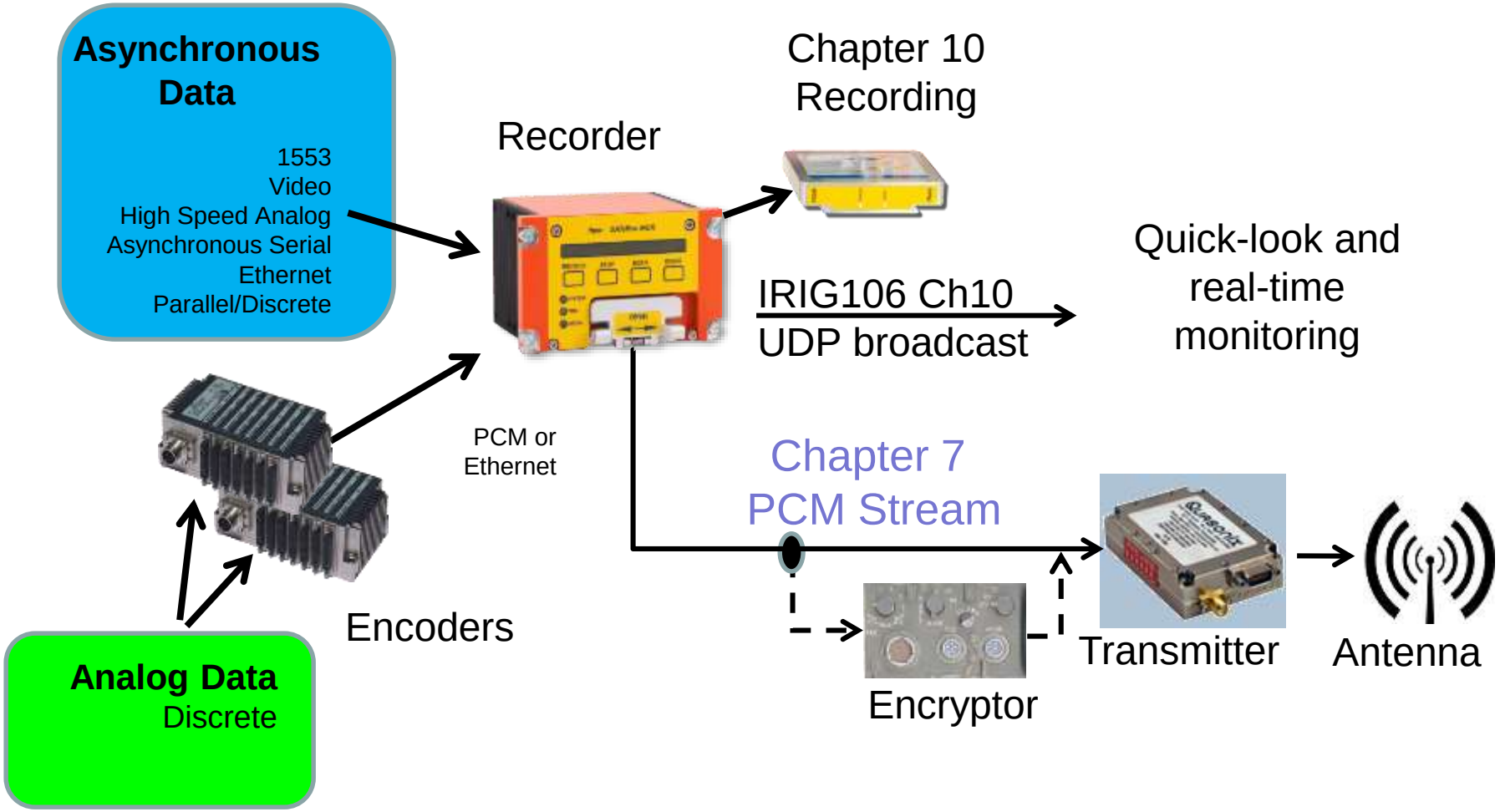
Chapter 4 Class II PCM Strream

Any other UDP data stream

Hot MIC Audio

Transmitter Antenna

Ideal Chapter 7 Downlink Airborne Scenario



Ground Scenario

Receiver and bit synchronizer

UDP

Live Streaming Ethernet
C10 .Publish

Chapter 7
PCM

Native Signal Reconstruction

- HD Video
- Hot MIC Audio
- Ethernet
- PCM

Ground Recorder
Chapter 7 Native Signal Reconstruction

Or Small Blue Modules

Simplified End to End System

Chapter 7
Encoder and
C10 Recorder

Encoder
PCM
inserted

Ch4 PCM and Ch10 UDP
merged together

Antenna

IRIG106 Ch10
UDP
broadcast

Reproduce
Native Signals
-Video
-PCM
-Enet

Encoder PCM
output

Decom

What is the Future Objective for Chapter 7 PCM- Objective

- All of the DECOM Front Ends to handle Chapter 7 exactly like any other Chapter 4 Class I or II PCM Stream

- Telemetry and Ground Operations exactly identical for Chapter 4 and Chapter 7 Telemetry

How Does C7 TM Work

- Determine Maximum bandwidth available for telemetry downlink
- Determine the channels you want to downlink
- Determine if you want to transmit all data for that channel or transmit data at a lower rate (I.E Filtering)
- For lower rate packet downlink, determine the lower rate amount of data to be down linked

NOTE: PACKET DOWNLINK DOES NOT REQUIRE ANY PROGRAMMING ASSIGNMENT OF DATA IN THE PCM STREAM TYPICALLY REQUIRED FOR ENCODERS. THE PACKET PLACEMENT IN THE PCM STREAM FLOATS IN THE STREAM. PACKETS ARE STUFFED FIFO INTO THE PCM STREAM.

Filtering- PCM

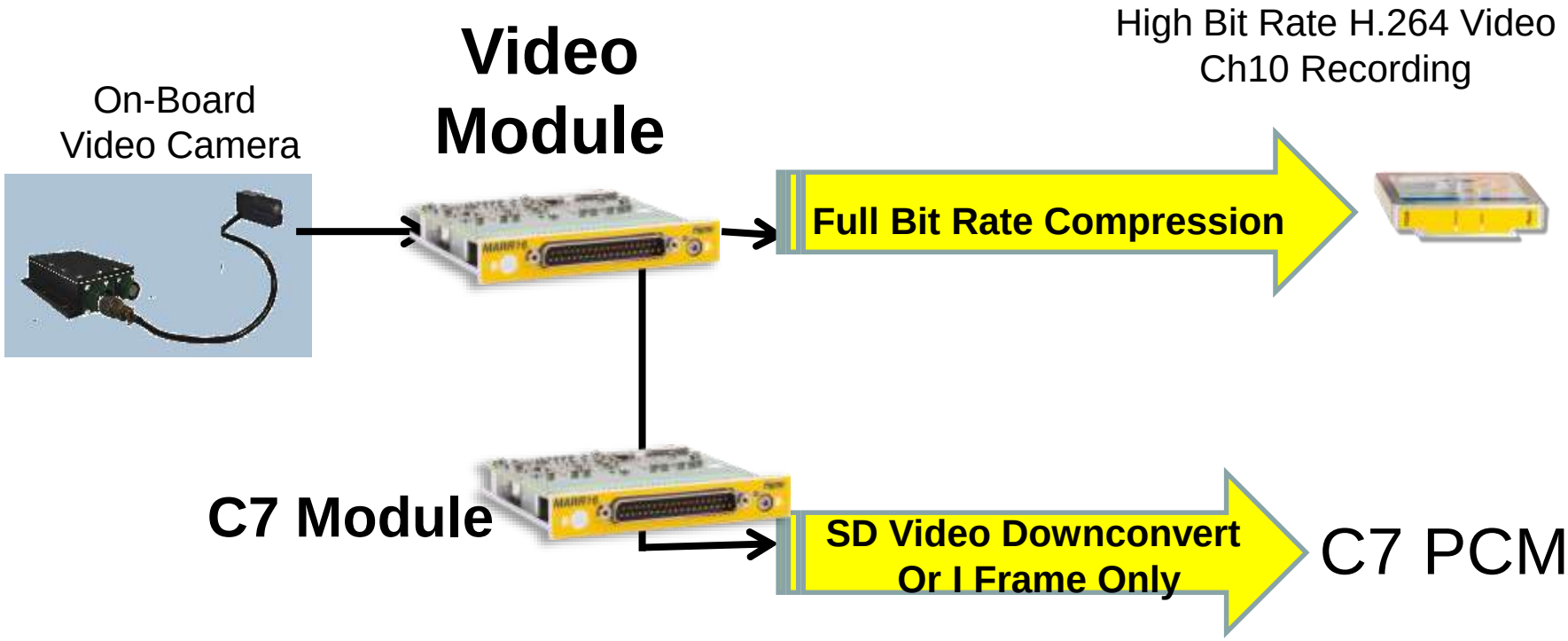
- Filtering based on Minor Frame Words
- Minor Frame Rate is unchanged
- Example of approximate 25% reduction in Bit rate

Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word
Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word
Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word
Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word
Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word
Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7	Word 8	Word 9	Word 10	Word 11	Word 12	Word 13	Word 14	Word 15	Sync Word

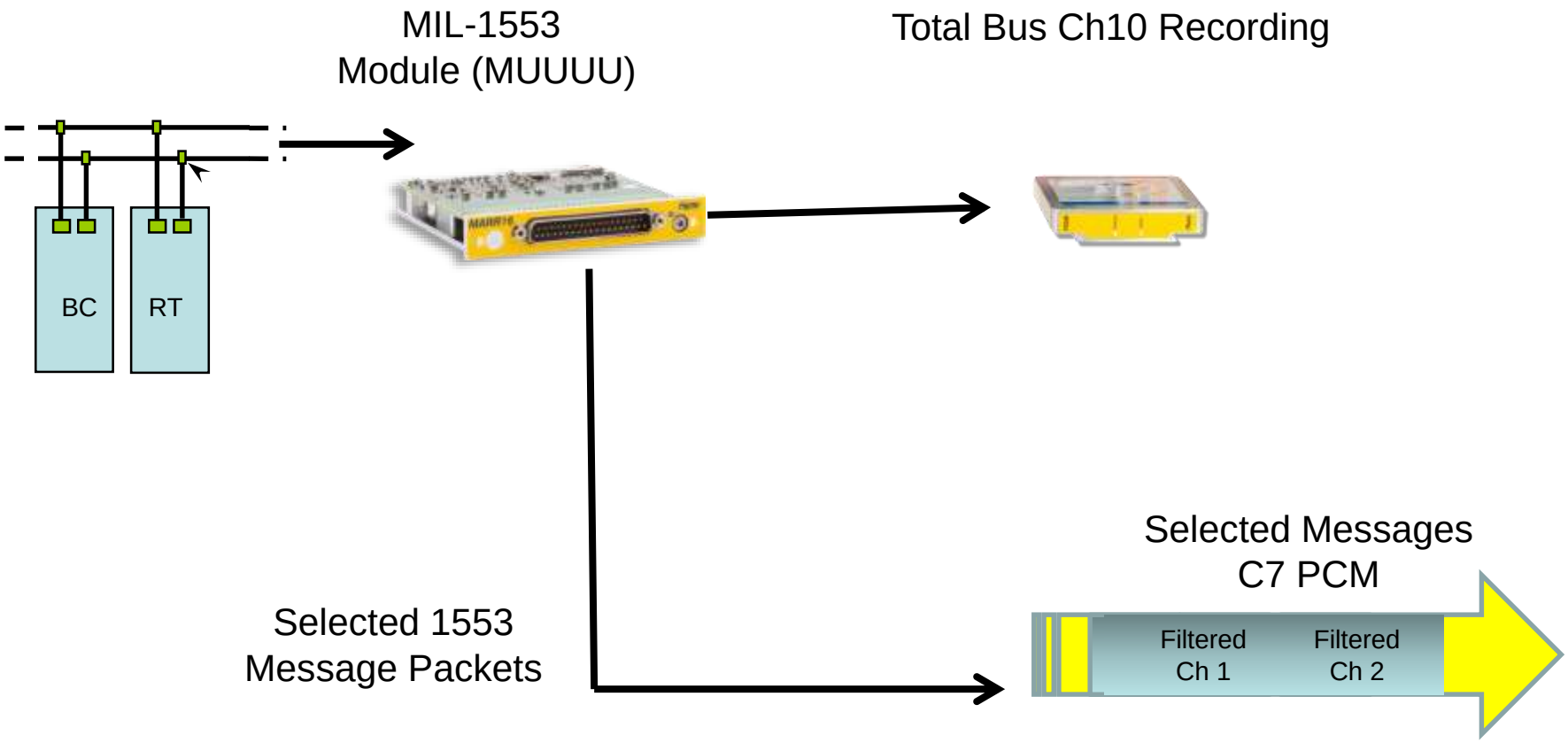
Minor Frame Time = X Seconds

Word 1	Word 3	Word 5	Word 6	Sync Word
Word 1	Word 3	Word 5	Word 6	Sync Word
Word 1	Word 3	Word 5	Word 6	Sync Word
Word 1	Word 3	Word 5	Word 6	Sync Word
Word 1	Word 3	Word 5	Word 6	Sync Word
Word 1	Word 3	Word 5	Word 6	Sync Word

Filtering Video



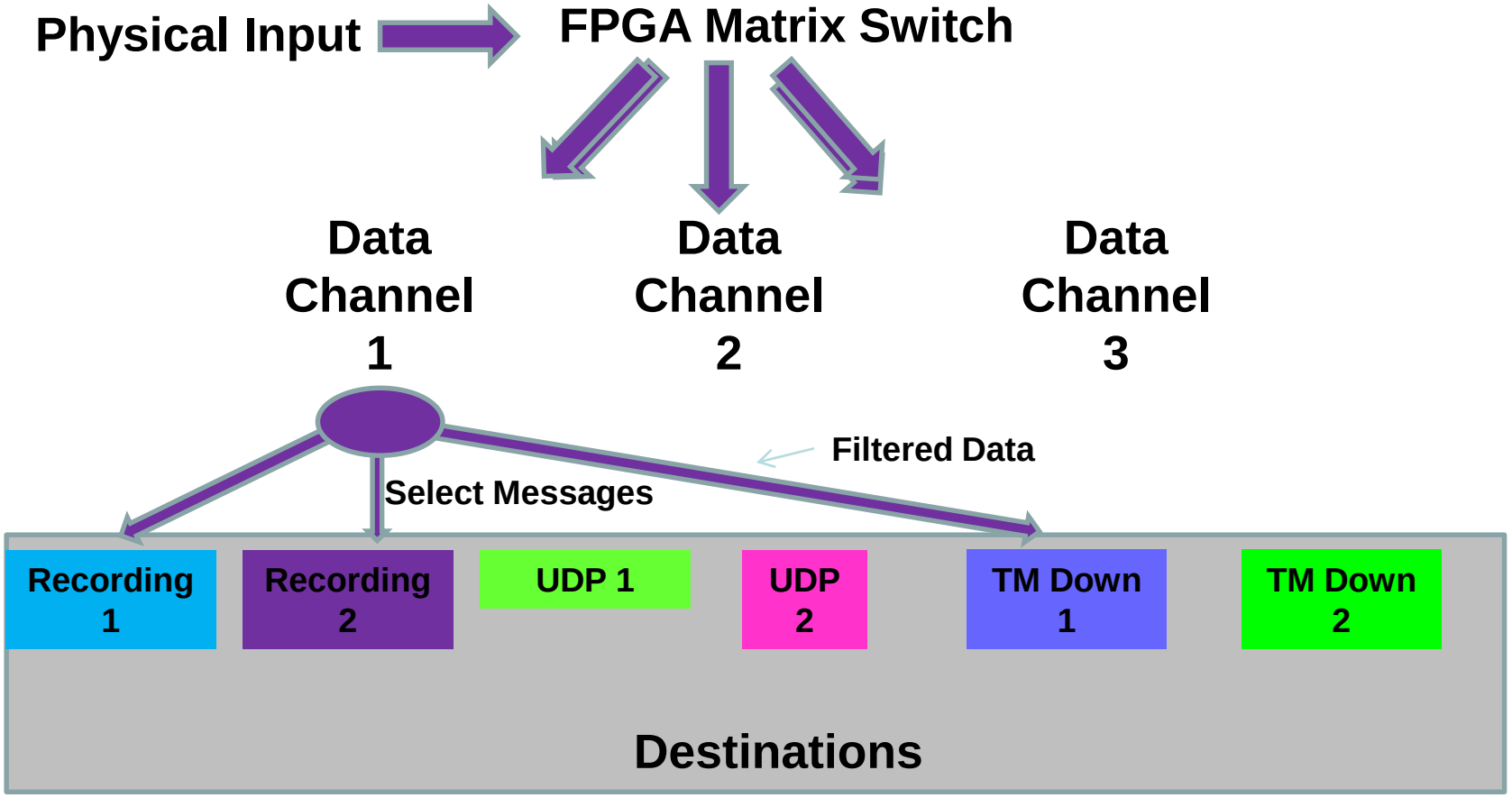
Lower Rate 1553 Channel TM Downlink



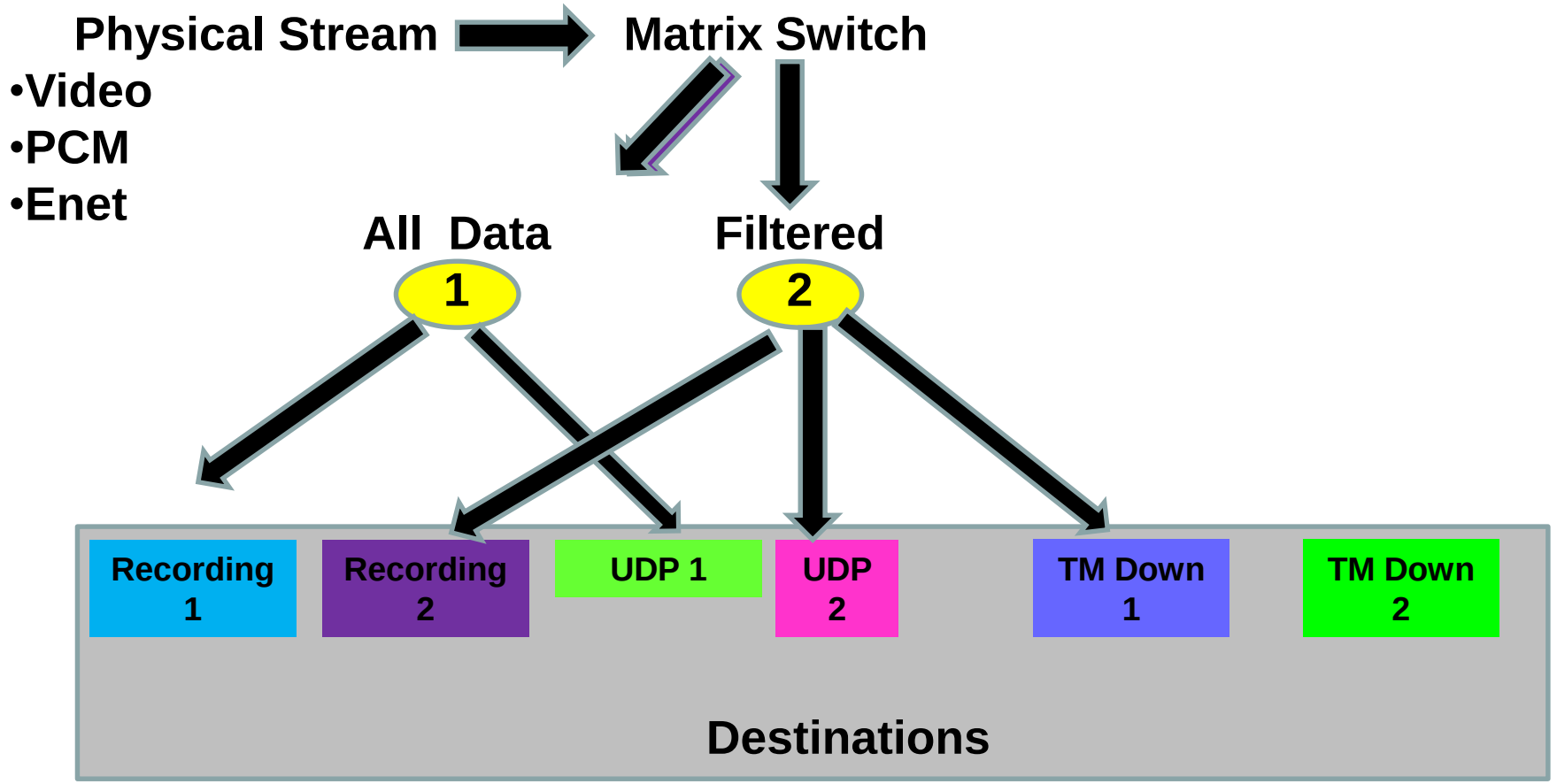
Implementation of Data Management System

- **Number of Output Streams and Destinations from a single signal has increased**
  - Recorded Streams
  - UDP Live Streaming (.publish)
  - Chapter 7 Filtered Streams

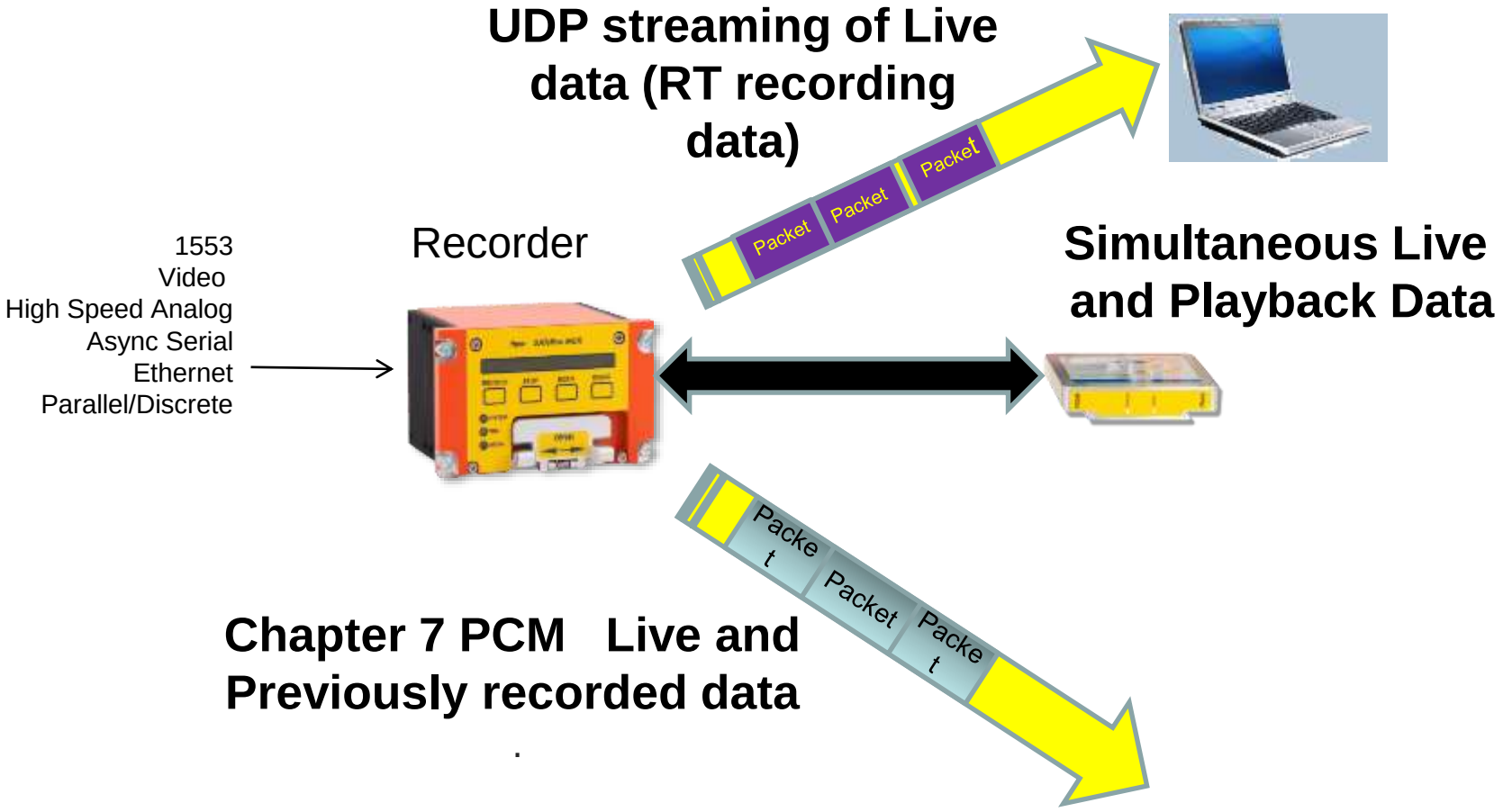
Physical Input and Data Channel Concept



Virtual Channel Example

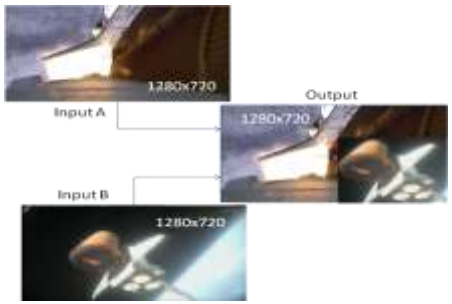


Advanced Features- Playback Previous Recorded Data while Recording Real-Time Data



Advanced Features

- **USING C10 .Dot Commands**
  - .Setup- (fully tested configurations)
    - Switching of Sources Recorded In Real-time
    - Select Data Channels for Broadcasting (.publish)
    - Select Data Streams Sent to C7 PCM TM Link
    - Select Video Streams Downlinked




The End