LARGE CAPACITY
AIRBORNE DATA RECORDERS
FOR RECONNAISSANCE APPLICATIONS

Alain Queau
Enertec, Clamart, France
Tel : +33-1-41 28 88 43   Fax : +33-1-41 28 87 00
queau@enertecavicore.com

Presented at the THIC Meeting at the Hilton Hotel
Virginia Beach VA 23451-3528
on October 12, 1999
Data Storage on-board: Why?

- **Sophisticated airborne sensors** are getting versatile and generate more and more data
- **Data links** between air vehicles and ground stations have limited bandwidth
- **Satellite or Earth relays** may not be available at all time
- **Missing data** during the mission can cost very much
- **Replay and/or reprocessing** are mandatory
Sensor data storage requirements

- Following payloads have needs for on-board storage:
  - tactical optical reconnaissance (EO, IR)
  - radar (Conventional & SAR)
  - video surveillance (Analog or Digital)
  - electronic warfare (ELINT, COMINT)

- **Sustained output data rates** are in excess of 500 Mbit/sec with bursts at even higher rates (more than 1 Gbit/s).

- **All these Data** are pre-processed on board before Recording

- **Duration of operational phases** (with recording on) can be up to several hours for Reconnaissance Aircraft's and Endurance UAV's
Existing Data Storage Technologies

- **MAGNETIC TAPE RECORDERS** are widely used in airborne platforms for analog or digital data storage.
- **HIGH END TAPE RECORDERS** match the performances of airborne sensors, but...
- **VOLUME AND WEIGHT** are not always compatible with small payloads.
- **ACCESS TO DATA ON TAPE IS ONLY SEQUENTIAL**
- **SOLID STATE NON VOLATILE MEMORY** is a COSTLY EMERGING Storage Technology.
- **RAM DVD** and others magneto optical devices are ARCHIVAL ORIENTED.
Disk Features and Advantages

- **HIGHEST CAPACITY/cu.ft/ lb/ $**
- **TODAY**: 25 GB on a 2.5” HDD, 36 GB (50 GB) on a 3.5” HDD
- **BIT DENSITY**: + 60% / YEAR
- **R/W OR R WHILE W** RANDOM ACCESS
- **EASY ”PLUG-AND- PLAY” INSTALLATION AS A DIRECT ACCESS(DISK) PERIPHERAL**
- **CONNECTION TO INDUSTRY STANDARD WORK STATIONS**
- **WELL KNOWN ROAD MAP IMPROVEMENT**
- **RELIABILITY AND ENVIRONMENTAL CHARACTERISTICS ARE COMPATIBLE WITH OPERATION IN AIRBORNE PLATFORMS**
ADVANCED STORAGE ROAD MAP

- Super Paramagnetic Limit
- AFM - Like Storage
- MicroMechanics
- 20 Gb / in² - Demo Travelstar 25 GB
- 10 Gb / in² - Demo Ultrastar 2
- 3 Gb / in² - Demo Ultrastar Spifire
- Allicat Corsair 2
- Corsair
- 3390-3
- 3390-2
- 3380k
- 3380E
- Thin film high coercivity disks
- Advance detection channel
- No - ID MR head / nano slider
- Giant MR head / pico slider
- Small form factors
- PRML data channel

Areal Density (Gb / in²)

MEMORY COSTS & CAPABILITIES

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D-RAM Bit cell (µm²)</td>
<td>50</td>
<td>20</td>
<td>10</td>
<td>2.5</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Memory</th>
<th>Solid states</th>
<th>HDD</th>
<th>Magnetic Tapes</th>
</tr>
</thead>
<tbody>
<tr>
<td>US $ /GB</td>
<td>5,000</td>
<td>35</td>
<td>0.2</td>
</tr>
</tbody>
</table>
MARKET TREND Vs FORM AND MEDIA

Computer Economics report 99

<table>
<thead>
<tr>
<th>Ø (inch)</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,25&quot;</td>
<td>4,074</td>
<td>2,175</td>
<td>1,095</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>3,5&quot;</td>
<td>123,047</td>
<td>145,189</td>
<td>168,385</td>
<td>193,330</td>
<td>220,330</td>
</tr>
<tr>
<td>2,5&quot;</td>
<td>17,730</td>
<td>20,817</td>
<td>24,090</td>
<td>27,740</td>
<td>31,850</td>
</tr>
<tr>
<td>≤ 1,8&quot;</td>
<td>116</td>
<td>173</td>
<td>250</td>
<td>475</td>
<td>750</td>
</tr>
<tr>
<td>Unit shipments in thousands</td>
<td>144,967</td>
<td>168,354</td>
<td>193,820</td>
<td>221,945</td>
<td>252,930</td>
</tr>
<tr>
<td>Growth</td>
<td>11%</td>
<td>16%</td>
<td>15%</td>
<td>15%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Products & Systems

HDS SERIES
CARTRIDGE RECORDERS

DS4000:
compact airborne,
wide interface flexibility,
220 Mbit/s, 72 GBytes/cartridge

DS2000:
ultra-compact airborne,
8-bit parallel interface,
60 Mbit/s, 25 GBytes/cartridge

VS2000:
compact airborne,
multi-channel video,
30 image/s, 5 hours of record time
DS4000
COMPACT AIRBORNE DIGITAL CARTRIDGE DATA RECORDER

A FIELD-PROVEN RUGGEDIZED PRODUCT
FOR AIRBORNE RECCE AND UNMANNED AIRBORNE VEHICLES.
DS4000 Design Concept

MODULAR CONCEPT : 2 LRU's

- **DS 4100 Record/Reproduce Unit (RRU)**:
  - houses the data & control interfaces
  - houses the cartridge removable media
- **DC 3000 Digital Data Cartridge (DDC)** = removable media
DS4000
Design Features

- **RRU** is based on Compact PCI backplane architecture
  - Open standard
  - Robust packaging
  - COTS electronic cards (3U form factor)
  - High bandwidth bus
  - Shock mounted removable Data Cartridge

- **DDC Sealed Data Cartridge for Housing 2 x 3.5” Disk Drives**
  - Standard computer peripheral interface (SCSI Ultra Wide)
  - RAID or software data stripping for maximum bandwidth
  - Suitable for daisy-chaining for extra-capacity
  - 10000 insertion extraction connector (Patent Pending)
  - Operates up to 70000 feet
DS4000
Record & Playback Characteristics

- **Record & playback data rate:**
  - Sustained: 0 to 220 Mb/s
  - Burst: up to 480 Mb/s
  - Growth potential: to 600 Mb/s sustained (1 Gb/s for burst) for field applications starting 2003.

- **Storage capacity:**
  - 36 GB per DDC (72 GB late 1999)
  - Evolving rapidly: 150 GB available for field applications starting 2003

- **Record time:** 1 hour @ 160 Mb/s (72 GB DDC)

- **Directory** for Fast Search
DS4000
Physical Interface

- **RRU**
  - Dimensions: 192 H x 255 W x 240 D (mm)
  - Weight: < 10 kg (DDC not included)

- **DDC : SEALED CARTRIDGE**
  - Dimensions: 138 H x 115 W x 190 D (mm)
  - Weight: 3.8 kg

- **OPERATING ENVIRONMENT**
  - Temperature: -40°C to +60 °C (Warm up below -10°C)
  - Humidity: 5% to 95% RH without condensing
  - Altitude: 0 to 70,000 feet
  - Vibrations: up to 7.8 g RMS
  - Acceleration: 9 g Shocks 13 g, 11ms
DS4000
Operational Features

- Built-in buffer memory allowing:
  - Instant recording
  - Variable rate and burst data record / playback
- $10^{-13}$ bit error rate
- Simultaneous Read-while-Write of different record sections
- Full remote control capability
- Search capability:
  - Data block address
  - Time code data
  - Annotation data
  - Event marker
- Lossless data compression capability
DS4000
Ground Replay Work Station

- **Connection** to industry-standard work stations.
- **Easy "plug-and-play" installation** as a direct access (disk) peripheral.
- **Direct and instant access** to any recorded data regardless of its location.
- **Control protocol** fully compliant with SCSI standard.
- **Data recovery software**, for Windows NT and SUN operating systems.
DS4000
Project Milestones

- Technology validation in 1996-1997
- Airborne prototypes available 09/98
- Environmental qualification testing starting 10/98, completed in 03/99
- Full scale flight test campaign on a French Air Force Mirage 2000 aircraft starting 12/98, completed 03/99
- First shipment of airborne unit: 11/99
DS4000 Full Scale Flight Test Campaign

Date: February 1999
Place: Brétigny, France
Platform: Mirage 2000, Center Pod
Test unit: airborne prototype, flight test configuration
Record Mode: Test data, continuous recording
Conditions: 3 flights covering flight domain, including high "g" flight maneuvers and high vibration flight phases
DS4000
Full Scale Flight Test Campaign

Date: May 1999
Place: Brétigny, France
Platform: Puma Helicopter
Test unit: airborne prototype, flight test configuration
Record Mode: Test data, continuous recording
Conditions: 1 flight covering flight domain, high vibration stationary flight
DS2000
ULTRA-COMPACT AIRBORNE DIGITAL CARTRIDGE DATA RECORDER

A FIELD-PROVEN RUGGEDIZED PRODUCT FOR AIRBORNE RECCE AND FLIGHT TEST APPLICATIONS.
DS2000
Design Concept

MODULAR CONCEPT : 2 LRU's

- DS 2100 Record/Reproduce Unit (RRU) :
  houses the data & control interfaces
  houses the cartridge removable media

- DC 2000 Digital Data Cartridge (DDC) = removable media
DS2000
Record & Playback Characteristics

RECORD & PLAYBACK DATA RATE:
- SUSTAINED: 0 to 60 Mbit/s
- BURST: up to 120 Mbit/s during 2 seconds
- GROWTH POTENTIAL to 120 Mbit/s sustained doubles every 24 months

STORAGE CAPACITY:
- 14 GBytes per DDC
- EVOLVING RAPIDLY:
  25 GBytes available mid-2000 doubles every 18 months

RECORD TIME:
- > 30 minutes @ 60 Mbit/s
- (14 GB DDC) > 3 hours @ 10 Mbit/s
DS2000
Physical Interface

• **RRU**
  – **Dimensions**: 270 H x 160 W x 136 D (mm)
  – **Weight**: < 5 kg (DDC not Included)
• **DDC : SEALED CARTRIDGE**
  – **Weight**: 0.5 kg
• **OPERATING ENVIRONMENT**
  – **Temperature**: - 40°C to + 60 °C (Warm up below -10°C)
  – **Humidity**: 5% to 95% RH without condensing
  – **Altitude**: 0 to 70,000 feet
  – **Vibrations**: up to 7.8 g RMS
  – **Acceleration**: 9 g
  – **Shocks**: 13 g, 11ms
VS2000
4-CHANNEL VIDEO
RECORD/REPLAY SYSTEM

A RUGGEDIZED PRODUCT
FOR AIRBORNE DIGITAL VIDEO ACQUISITION AND RECORDING.
VS2000
4-CHANNEL VIDEO RECORD/REPLAY SYSTEM
A COMPLETE SYSTEM SOLUTION

AIRBORNE VIDEO RECORDING
4 VIDEO CHANNELS + AIRCRAFT DATA
5 HOURS OF RECORD TIME

DS2100 Airborne Video Recorder

PC WORK STATION

Ethernet Mission Data Analysis System

SCSI Ultra 2

Mission Analysis

DATA DOWNLOAD

VIDEO DATA ARCHIVAL

DDR

CARTRIDGE REPLAY UNIT # 1

CARTRIDGE REPLAY UNIT # 2

CARTRIDGE REPLAY UNIT # 3

CARTRIDGE REPLAY UNIT # 4

TIME

Video # 1

Video # 2

Video # 3

Video # 4

DDC

DV5830 Mass Storage Cassette Drive

ENERTEC
VS2000
Design Concept

MODULAR CONCEPT : 2 LRU’s

- VS2100 Video Acquisition & Recording Unit (VARU)
  houses the video & control interfaces
  houses the cartridge removable media
- DC2000 Digital Data Cartridge (DDC) = removable media

DDC

RS-422A
CONTROL

AUDIO IN

28 Vdc IN

VIDEO 1
Composite, Y/C, RGB

VIDEO 2
Composite, Y/C, RGB

VIDEO 3
Composite, Y/C, RGB

VIDEO 4
Composite, Y/C, RGB

AIRCRAFT DATA IN

ENERTEC
VS2000
Key Features

• Replacement of multiple-cassette analog video recorders
• Single LRU
• Multiple-channel video acquisition, digitization, compression and recording
• Acquisition and recording of avionics bus data
• Single digital data cartridge
• Transfer rate to storage media: 5 - 8 Mbit/s
• Storage capacity: 14 Gbytes
• Record time: up to 5 hours
VS2000
Video/Audio Compression

• ISO MPEG 2 video compression algorithm
• Simultaneous processing of up to 4 independent video sources
• Adaptive compression algorithm: best trade-off between image rate and image quality at constant average data rate
• Audio compression 2 sources
• Supports multiplexing of uncompressed auxiliary digital data
• MPEG Program stream
VS2000
Physical Interface

• PHYSICAL CHARACTERISTICS:
  – SINGLE STANDALONE UNIT
  – DIMENSIONS: 270 H x 160 W x 136 D (mm) excluding connector cage
  – WEIGHT:
    • VS2100: 5 kg, not including DDC
    • Digital Data Cartridge: 0.5 kg

• HARD MOUNTING:
  – BUILT-IN VIBRATION / SHOCK ISOLATORS

• COOLING / TEMPERATURE CONTROL:
  – SELF-COOLING (NO FAN)
  – SEALED DDC
  – AUTOMATIC PRE-HEATING (50 W max.)
VS2300
GROUND VIDEO REPLAY SYSTEM
DESIGN CONCEPT

COMPOSED OF :

• PC WORK STATION :
  – houses 1 to 4 Cartridge Replay Units (CRU)
  – performs video & audio reconstruction,
  – supports data & control interfaces

• 21" MONITOR :
  – displays all 4 reconstructed video sources,
  – displays time information
VS2000 Ground Replay Unit

- Direct playback from DDC
  - Simultaneous display of 4 video channels and time code
  - Time relation between displayed video channels better than 500 ms
  - User-selected replay speed
- Local or remote control
- SCSI interface
  - Used for download/storage to/from storage device
VS2000 is dedicated to multi-video acquisition and storage:
  - Two LRUs, weight :5kg  Suitable for small payloads

DS 2000 can acquire and record digital data up to 60 Mb/s
  - Two LRUs, weight :5kg  Suitable for small payloads

DS4000 can acquire and record any type of digital data with a bandwidth compatible with multi-sensor payloads
  - Two LRUs, weight < 15 kg
  - Suitable for larger vehicles

Replay system features standard bus interfaces for easy coupling to ground facilities