

Solid-state Data Recording.....
Where We've Been, Where We Are, and Where We're Going

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- You'll Never Get to Where You Need to Be If You Only Look at the Past and the Present
- Moore's Law States That the Number of Transistors on a Chip Will Double Every 18 Months
 - This Law Has Held True Since 1968
 - This Phenomenal Growth Makes Today's Technologies Quickly Obsolete
 - Requirements for New Systems Must Provide for the Infusion of New Technology Into the System
 - New Systems Must Be Specified With Future Requirements in Mind
- Before We Look Towards the Future, Let's Look at Where We've Been and Where We Are Now



- Ronald Reagan Was President and Solid-state Data Loaders Were Making Revolutionary Strides
- These Early Systems:
 - Used MIL-STD-1553 To Provided a “High” Theoretical Bandwidth of 1 Mbit Per Second
 - Provided Several Kilobytes of Memory
 - Loaded Mission Planning Data Eliminating “Fat-fingering”
 - Reduced Data Entry Time
 - Improved Accuracy of Data Entry
 - Recorded In-flight Fault Data

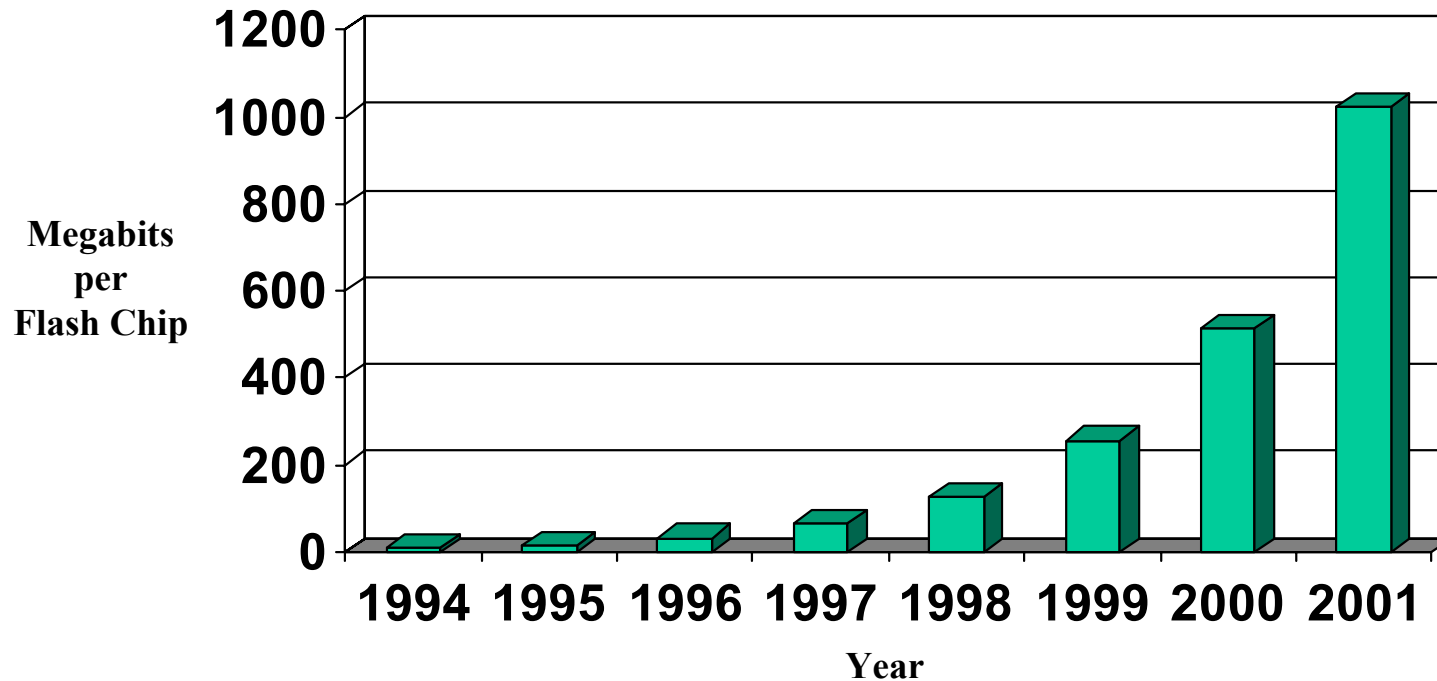


16 Kilobyte SRAM
Data Transfer Cartridge

- Solid-state Memory Systems Were Beginning to Proliferate and Find Their Way Onto an Increasing Number of Military Aircraft
- The Increasing Memory Density of EEPROM Allowed Non-volatile Systems to Be Offered Without the Use of a Battery
- Solid-state Memory Systems Were Still Limited to Simple Tasks Such As the Loading of Mission Planning Data and the Recording of Fault Data Due to Limited Access Speeds and Achievable Memory Capacity

Mid 1980's

- During the 1990's, Flash Memory Chip Densities Experienced Exponential Growth.
 - This Growth Is Expected To Continue Well Into the New Millennium
 - 8 Mbits in 1994
 - 1 Gbit by 2001



- Flash Memory Quickly Became the Memory Media of Choice
 - Wide Acceptance in the Commercial Market
 - Rapidly Expanding Memory Densities Coupled With Rapidly Dropping Cost Per Megabyte
- The Use of Non-Military Qualified Flash Chips Forced Avionics Designers To Solve Several Problems Typically Associated With Flash Memory
 - Environmental Limitations
 - Memory Wear-out
 - Known Bad Sectors
 - Slow Access Rates
- Flash Memory Is the Enabling Technology in Modern Solid-state Mass Memory Systems

Flash Memory
Flash Memory

- The Advent of Dense, Solid-state Memory Technology and High Speed Interfaces Allowed Aircraft Primes to Include High Speed “Backbones” in Aircraft
 - F-22 and Comanche Architectures Included a Fibre Optic High Speed Data Bus
 - B-1B CMUP Program Incorporated a Mass Memory System and Mission Computer with 1 Gbit/sec Fibre Channel Interfaces
 - F/A-18E/F Incorporated a 1/4 Speed Fibre Channel Interface Within the Tactical Aircraft Moving Map Capability (TAMMAC)



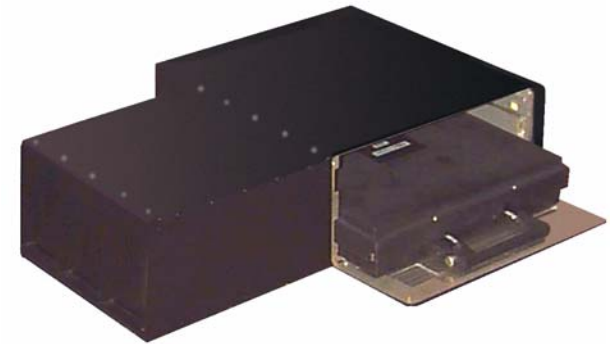
**Data Transfer Equipment
With Mass Memory
and Video Recording**



**Fibre Channel
Data Transfer Equipment**



- Solid-state Storage Systems That Functioned as Form, Fit, and Functional Replacements of High Speed Tape Recorders Became Feasible
 - Instrumentation and Reconnaissance Tape Recorder Replacements Achieved Densities of Between 50 and 100 Gbytes and Eliminated Environmental Problems of High Speed Tape Recorders
 - Large Recorder Volume Permitted Large Memory Capacity
 - Sustained Data Rates of Up to 1 Gigabit Per Second Became Feasible



**High Speed
Solid-state Recorder**



- F-22 Became the First Platform to Eliminate Video Tape Recorders and Replace Them With a Solid-state Equivalent
 - System Combined Data Transfer and Video Recording Into a Single Line Replaceable Unit (LRU)
 - Eliminated Environmental, Reliability, and Maintenance Problems of The Original Tape Recording System
 - Saved the F-22 Program \$166 Million in Life Cycle Costs
 - Used Commercial PCs for Ground Debrief



**Data Transfer Equipment
With Mass Memory
and Video Recording**



Debrief Station

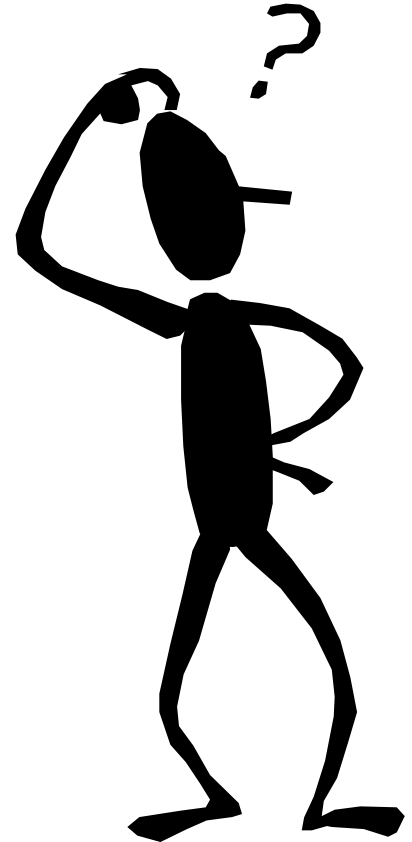
**Data Transfer
Cartridge**

- Solid-state Drop-in Replacements for Tape Recorders are Now Available
 - MPEG Compression Permits Significant Reduction in Required Mass Memory
 - Solid-state Memory Allows New Features
 - Read-While-Write
 - Instant Access to Events
 - Synchronization of Video from Multiple Aircraft
 - DVD Archiving
 - Ground Station Consists of a Commercial PC



**Airborne Video
Solid-state Recorder
(AVSR™)**

- The Challenge For The Future Is To Specify Systems That Take Full Advantage Of The Growth That Will Occur During The Next Decade.
- Cognizance of Enabling Technologies Must Be Maintained
 - Memory Densities Will Continue to Follow Moore's Law
 - Compression Technologies Will Continue To Improve
 - High Speed Interfaces Will Continue to Grow in Speed and Will Be Incorporated Into Additional Aircraft Architectures
 - COTS Equipment Will Influence The Direction Of Avionics



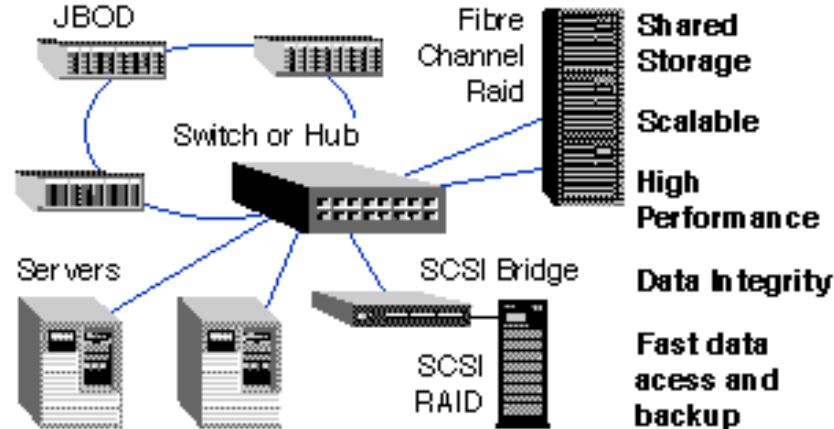
- Memory Densities Have Increased by More Than 1,000,000 to 1 Over the Last 20 Years
- This Phenomenal Growth Is Expected to Continue
 - Flash Chip Sales Grew 70% in 1999
 - Flash Chip Sales Are Expected to Surge 60% to \$6.8 Billion in 2000
 - Jump in Sales Due To:
 - MP3 Audio (More Than 1 Million Players Sold in 1999)
 - Cell Phones (1 Billion Units Should Be Shipped in 2002)
 - Digital Cameras
 - Set-top Boxes

Flash Memory
Flash Memory

- H.261
 - Designed for Video Conferencing
 - Supports Image Resolutions of 144 x 176 Pixels and 288 x 352 Pixels
 - Supports Data Rates of Between 64 Kbytes Per Second and 1.5 Mbits Per Second
 - Low Data Rates Lead to Jerkiness and Other Artifacts
- MPEG-II
 - Targets Higher Fidelity Marketplace (HDTV, DVD, Satellite TV)
 - Supports 480 x 720 Pixels
 - Supports Data Rates Between 2 and 16 Megabits Per Second
 - 4 Megabits Per Second Provides Video Quality Comparable to Digital Video Disks

- High Speed Interfaces Are Being Incorporated Into Military Aircraft At An Ever-increasing Rate
- Ethernet
 - Standard Interface Used in the Office
 - Available As Part of Microprocessor Chipsets
 - Fast Ethernet (100 Mbits / Sec) Is Already Starting to Look Slow
 - IEEE 802.3's High-speed Study Group Has Formed the 10-Gigabit Ethernet Alliance
 - A Final 10-Gbit Standard Will Be Ready in the Spring of 2002
- IEEE 1394
 - Conceived by Apple Computer
 - FireWire Is Apple's Implementation of IEEE 1394
 - Supports Both Asynchronous and Isochronous (Pre-determined Rate) Data Transfer Modes
 - Data Rates of up to 400 Megabits Per Second Are Available

- Fibre Channel
 - Rapidly Becoming Most Popular High Speed Interface for Aircraft
 - 1 Gigabit / Sec Systems Are in Use on Aircraft Today
 - 2 Gigabit / Sec Components Are Now Available
 - Ground-based Architectures Can Easily Be Extended to Aircraft Architectures



- Commercial Off The Shelf Equipment Has Pluses and Minuses
 - Pluses:
 - Large Commercial User Base
 - Well Defined Standards
 - Perceived Cost Is Low
 - Minuses
 - Not Designed for Military Environment
 - Standards May Disappear Quickly
 - 8-track Tapes, 5 1/4 Inch Floppy Disks
 - Life Cycle Costs May Be High Compared to Systems Designed for Military Use

- Solid-state Memory Systems Are Finding Widespread Acceptance in the Military Marketplace
 - Superior Performance When Compared to Magnetic Media Based Systems
- Users Must Look Towards the Future When Specifying New Systems
 - Solid-state Memory Densities, Compression Techniques, and Interface Speeds Will Continue to Increase
 - Cost Per Megabyte Will Continue to Decrease
 - COTS Equipment Should Be Carefully Evaluated Prior to Making a Purchase

