The TornadoHD™
A Solid State Solution for Multi-Sensor Data Acquisition and Storage

Richard Wise
101 West Sixth Street, Suite 200
Austin, TX 78701-2932

Phone: +1-512-479-7732 x 2182 Fax: +1-512-494-0756
E-mail: wise@spec.com

Presented at the THIC meeting at the Westcoast Silverdale Hotel, Seattle, WA, October 9, 2001
Background/History

• **Founding**
  - SPEC is a privately held corporation established in 1986

• **Profitability**
  - SPEC has operated profitably since its inception

• **Growth**
  - SPEC has grown an average of 50% annually for the past three years, and employees nearly 100 engineers, scientists and support personnel in its Austin, O’Fallon, Illinois, and Washington DC offices.

• **Partnering**
  - SPEC has established collaborative relationships with more than 30 companies worldwide, several in the Fortune 500
The Need for Speed, Capacity, and Space

• **High Resolution/High Frame-Rate Imagers**
  - CCD, Hyperspectral
  - 512 pixels X 512 pixels X 1000 fps @ 10 bits/pixel = 2.62Gbps
  - 1,000,000 fps imagers on the horizon

• **High Capacity Analog or Digital Sensors**
  - Synthetic Aperture Radars, IR Sensors
  - 100Gbyte - 1Tbyte capacities needed now
  - Multi-Tbyte requirements on the horizon

• **Limited Physical Space**
  - Aircraft applications
  - Space applications
  - Autonomous missile applications

• **Multi-sensor applications**
**SPEC Data Storage System Architecture**

- **Dual Processor Board**
- **Media Independent Translator System (MITS)**
- **Imager Data**
- **Flight Control Data**
- **EO/IR Sensor Data**
  - **RF Sensor Data**
  - **User Specific Data**
- **Storage Media Interface PMC**
- **SPEC Recorder I/F Master**
- **RAID I/F Controller**
- **User Defined Interface PMC**
  - **Fibre Channel**
  - **LVDS**
  - **Ethernet**
  - **Your Interface**
- **6U VME Card(s)**
  - **IRIG**
  - **1553**
  - **DCRsI**
  - **ARINC**
- **LVDS Channel Link Interface**
- **RS232 Control / Config Ethernet Data Download**
- **Removable Memory Unit(s)**
  - (RMUs do not need to be co-located with MITS)
TornadoHD (Commercial Configuration)

- Incorporates VMEbus architecture w/ RACEway switch fabric for interface flexibility
- Accommodates multiple sensor interfaces
- Memory capacities from 13.8GBytes to 221.2 GBytes per RMU (up to 16 RMUs)
- Compact design reduces size, weight, and power requirements
- Accommodates data rates in excess of 6 Gbits/sec
Airborne Packaging Options

Integral RMU/MITS

Single Hard-Mounted Unit (Raytheon Tucson Configuration)

ATR Configuration in Eglin Flight Test Pod

Two Unit, Removable Memory Configuration
TornadoHD™ Design Overview

• **Media-Independent Translator System (MITS)**
  - Accepts data from multiple wide-bandwidth sources (standard or custom)
  - Coordinates recording of data to memory and memory playback
  - Each channel consists of:
    - Interface Adapter PMC (Fibre Channel, LVDS, RS-170, custom, etc.)
    - Recorder Interface Master (RIM) PMC
    - VME-based dual PowerPC I/O controller
    - VME-based support cards (DCRsi™, Digital I/O, IRIG, etc.)

• **Removable Memory Unit (RMU)**
  - Each RMU contains up to eight memory cards of 13.8GB each (221.2GB per RMU)
  - Current configuration accommodates up to sixteen RMUs (3.6 TB)
  - Design capacity limited only by customer space/power constraints
TornadoHD™ Features

- **High-speed LVDS Channel Link for MITS/RMU communication**
  - 960Mbps sustained data rate per Channel Link
  - Increase throughput in approximately 1Gbps steps by adding parallel Channel Links

- **VMEbus Open-Architecture MITS**
  - COTS I/O Controller with two independent PCI interfaces
  - Can accommodate multiple controllers
  - Can accommodate multiple 6U VME interface cards

- **Removable Memory Unit (RMU)**
  - 960Mbps throughput capacity per RMU
  - Playback-while-Record (Read-while-Write) capability
  - Each RMU can be re-packaged with multiple Channel Links as the need for higher data rates arises
TornadoHD™ Design Block Diagram (Single Link System)

- VMEbus / RACE++
- Control/Status
- Sensor Data
- VME 6U
- Data/Control
- Channel Link (1 Gbps)
- COTS Interface Controller
- Customer Defined PMC Interface
- I/O Controller
- RIM PMC
- RMU
- PMC Interface
- Controller
- Customer Defined PMC
- Data/Control
Media-Independent Translator System (MITS)

- **Customer Specific PMC Interface Adapter**
- **COTS I/O Controller**
  - Dual PowerPC processors
    - 250MHz PowerPC 603e core
    - Dedicated local PCI bus, RACEway bridge, & PMC slot for each processor
  - Fully-compliant VMEbus and RACE++ interfaces
  - On-board quad 64MB SDRAM Buffers
- **Recorder Interface Master (RIM) PMC**
  - Full channel link command structure
  - Playback-while-record synchronization
  - 64KB FIFO buffer storage to/from PCI bus interface
  - Channel link synchronization & integrity BIT
  - Can be installed in PMC slot of any I/O Controller
  - Portable low-level software driver (VxWorks™ based)
MITS (Continued)

- Additional COTS VME6U Interface Controllers as required by customer (1553, DCRsi, IRIG, ARINC)
- Installed in a 1/2 ATR tall, short VME avionics chassis
- RIM may be replaced with any COTS interface adapter to provide interface to any solid-state or disk-based storage media
Detailed MITS Block Diagram

SPEC
Systems & Processes Engineering Corporation
Removable Memory Unit (RMU)

- ARINC 1/4 ATR form-factor, ATR Tall
- Conduction-cooled & ruggedized for harsh environments
- Contains up to eight Memory Matrix Modules for a storage capacity of 221.2GB
- Data rate of a single channel link is 960Mbps
- Modular design allows parallel channel links for faster data rates in parallel RMUs (or the same RMU)
- RMUs may be linked together to attain system storage capacity of up to 3.6TB per channel link
- Scalable storage density
Memory Matrix Module

- **Total storage capacity 27.6GB per module**
- **Memory Array Controller (MAC) FPGA**
  - Complete bad block mapping (maps 100% of EEPROM blocks)
  - Channel link bypass/cell data transceiver/EEPROM control
  - Modular design allows easy reconfiguration of cell arrangement
- **Design is transparent to all EEPROMs with capacities of 128Mbits and above using SmartMedia™ format**
- **Unique cell structure allows concurrent data throughput and EEPROM commanding**
- **Burst playback design allows read-while-write**
TornadoHD™ Software Architecture
Software Architecture Features

• **Input Process**
  - Fibre channel driver
  - Analog and digital video
  - EO/IR/RF
  - User defined interface

• **Data Process**
  - Image/Data compression
  - RF processing (FFT/Filter)
  - Error encoding

• **Output Process**
  - Channel link to SPEC RMU
  - RAID (SCSI)
  - Etc.
TornadoHD™ General Specifications

• **Power (Front End plus one fully-loaded RMU)**
  • 59 Watts maximum, record and/or playback

• **Physical Properties**
  • Front End:
    - Dimensions: 10.6”H X 4.5”W X 12.5”D (ARINC 1/2 ATR Tall chassis)
    - Weight: 15.9 lbs. Maximum
  • RMU:
    - Dimensions: 10.6”H x 2.25”W x 16.8” D (1/4 ATR Tall) or 7.7”H X 2.25”W X 19.6”D (1/4 ATR Long)
    - Weight: 18 lbs. Maximum

• **Solid State Reliability**
Conclusions

- **The recorder meets requirements for a ruggedized, medium to high-bandwidth, multi-channel solid-state data storage system**
- **VMEbus-based MITS design provides data rate, interface, media, and data processing flexibility to meet future growth needs**
  - Multi-channel capability and increased data rates with additional processor/RIM PMC assembly
  - Interface flexibility using COTS PMC and VME cards
  - Compatible with other storage media
- **The RMU was developed to be scalable in both memory depth and data rates**
  - Up to 16 RMUs may be linked (3.6 TB per channel link)
  - Increased data throughput provided by increasing number of parallel channel links
- **Successful flight test series completed May 24, 2001**
- **First production unit shipped in September 2001**
- **In low rate initial production for follow on orders**