A DELTA INFORMATION SYSTEMS COMPANY

AMPEX

Feature Creep for Efficiency

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Background (aka “The Story So Far…”)

- For years, events like ETTC and ITC have hosted talks and even demos of network-based instrumentation systems
  - Generally Flight Test Instrumentation, FTI.
- However, few have gone beyond discussing networking vs traditional instrumentation systems
  - i.e. little insight in what else the network could do!
- This presentation discusses that surrounding ecosystem
  - How an FTI solution became a platform hub

Disclaimer…

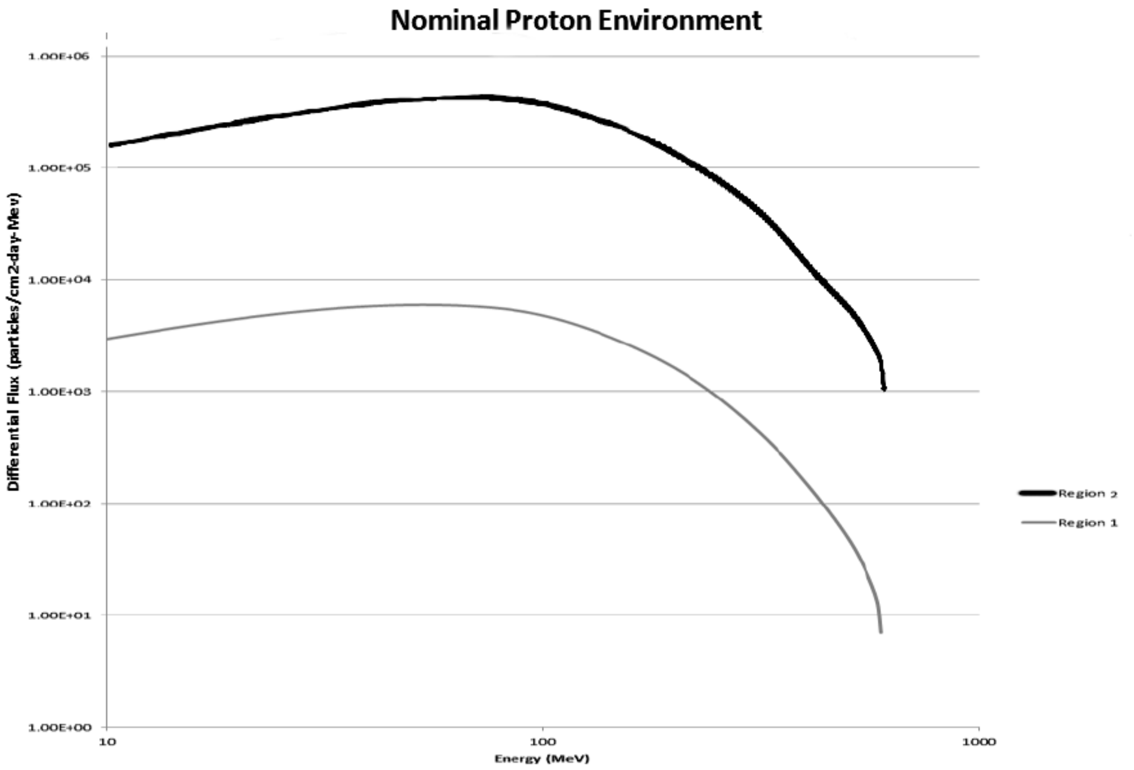
"The following is a true story. Only the names have been changed to protect the guilty…"

- For narrative purposes, and for consistency with ETTC preferences, most of this presentation has been simplified so that it addresses the requirement & the "broad brush" solution
  - Avoiding implementation details

- It may appear that Ampex's customer had not considered a number of issues ("feature creep")
  - In fact, the problems were well understood, this only "creep" was to our device instead of some other solution

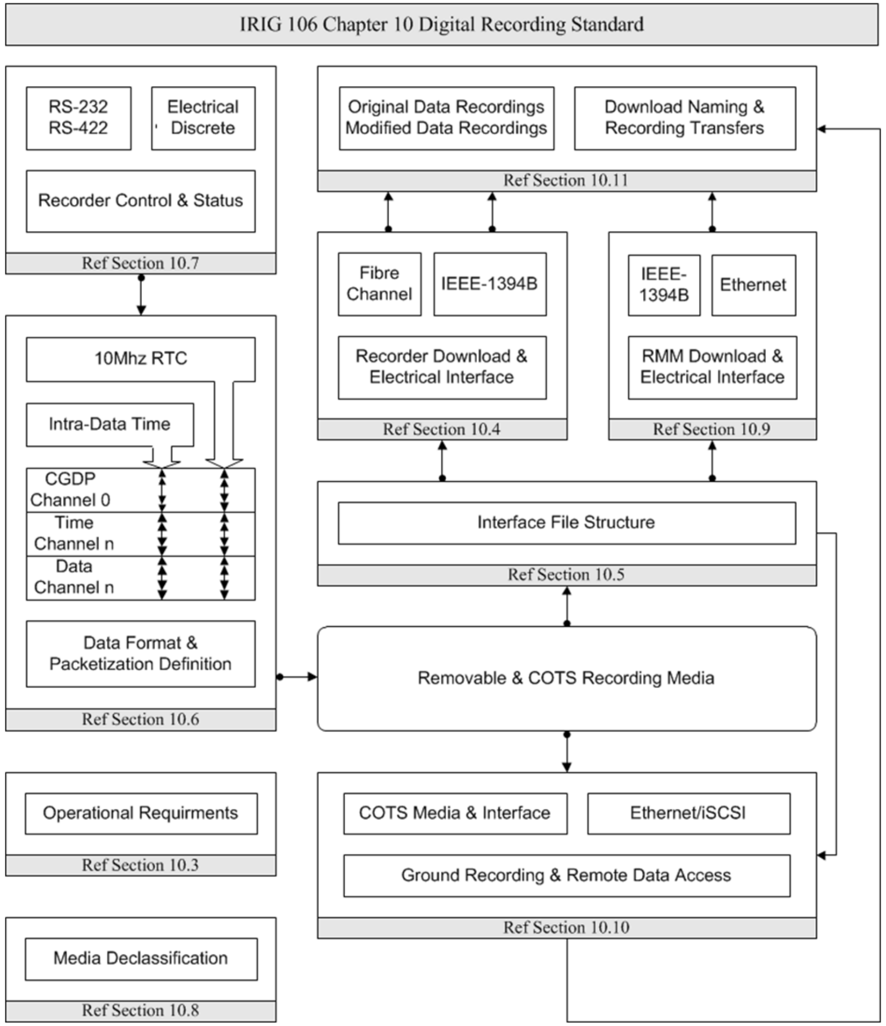
In the beginning,,,

- The initial requirement set was for:
  - A Chapter 10 recorder
    - Using Ethernet I/O
      - Both acquisition and distribution
    - Data to be telemetered to US Government
  - Ethernet time
  - Additional data access protocols
    - FTP & TLS
  - Video manipulation
    - Down-sampling, etc
  - High radiation environment
    - Recorder to operate in two zones



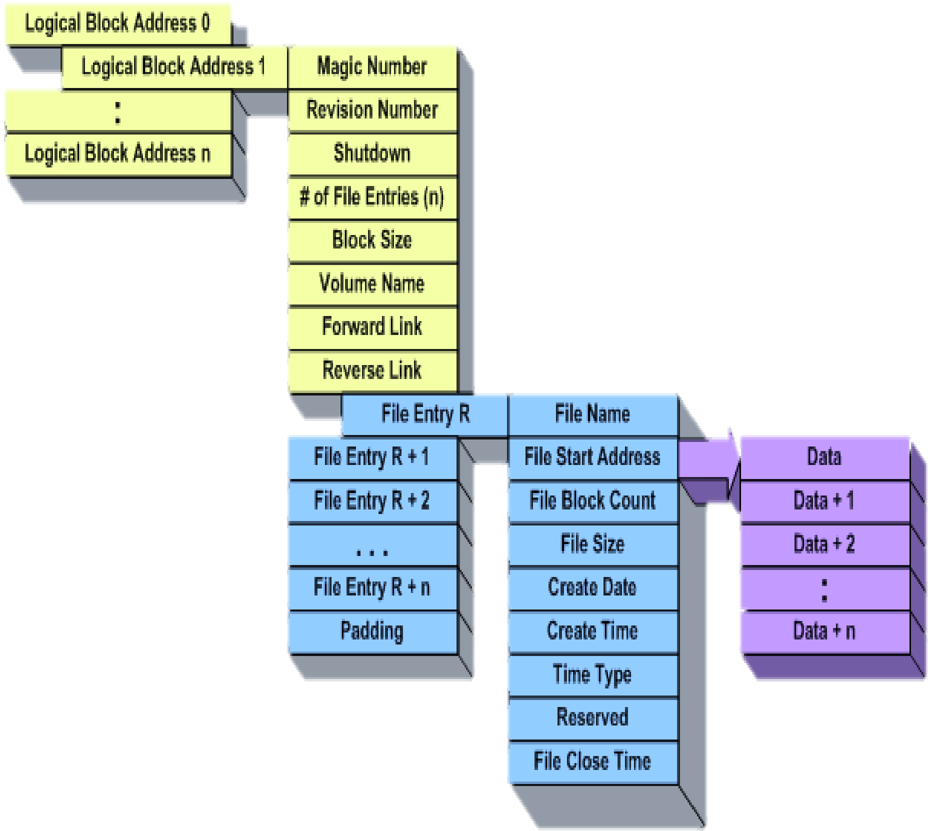
First Step: Trim Chapter 10

- Chapter 10 is a massive collection of requirements
  - Some good and valid
  - Some not so much
    - E.g. file naming
    - There is a handbook which should be used (more) for such “advisory” details
- “Core” of the standard has been the data formats
  - Formerly section 10.6
  - Now Chapter 11
- There are two significant problems
  - See next slides



The Chapter 10 Filesystem Problem

- Ch10 adopted a filesystem originally designed as a virtual abstraction of several competing underlying filesystems
- Because Ch10 was originally targeted at lighter weight systems, assumptions were made:
  - That the “virtual” abstraction = physical layout
  - That “LBA 0” was the first sector on the disk
    - Not the first on a partition
    - This prevents partitioning
- This filesystem forces contiguous files
  - Limits concurrent writes
- So this was removed to increase efficiency



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Chapter 10 Data Type Fidelity (aka “the TSPI problem”)

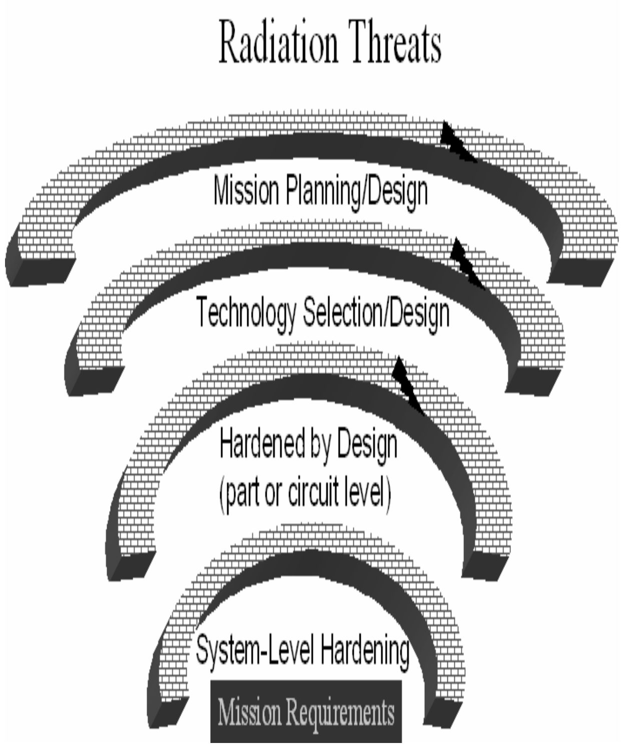
- Chapter 10 was designed with some rigid assumptions
  - The Relative Time Counter would only advance
  - Data would be committed to media within 100ms of the occurrence
  - Data would be recorded in the format it was received
- This precludes a recorder manipulating the data
  - E.g. TSPI data is usually received over RS-232/RS-422 or MIL-STD-1553 interfaces
    - But less useful for processing
  - And what’s the appropriate level?
    - Do we record RS-232 as an analog signal, and if not, why not?
- Ethernet is largest “offender”
  - Receiving Ethernet is “supposed” to result in a channel full of low-level frames
  - But if those frames are an MPEG Transport Stream, you want a VIDEO channel
  - Storing data “properly” increased efficiency

Where to begin?

- The initial call was whether to add Chapter 10 handling to a server product, or add file serving to a Chapter 10 product
  - We opted for the former, as the video manipulation was going to be easier
- On a file server, we could host the *ffmpeg* package
  - Use Chapter 9 “TMATS” to provide a single config point
  - *ffmpeg* supports a lot more than down-sampling
- Using a general purpose server also facilitated the provision of parameter extraction / manipulation software
  - Standard platform = easy for third parties to develop
  - Less work (for us) = more efficient (for us)

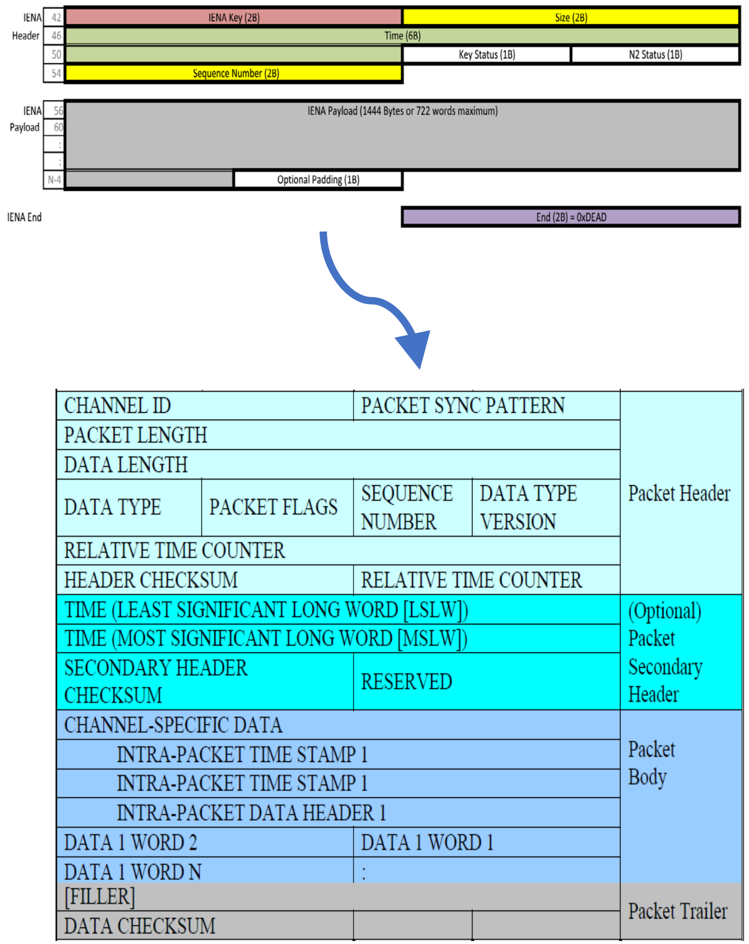
Radiation ~~Hardening~~ Tolerance Strategy

- On evaluation, *hardening* was not strictly necessary
  - The recorder wasn't "mission critical"
  - A "detect and reset" approach was satisfactory
  - The result is termed "rad tolerant", not "rad hardened"
- To obtain rad tolerance, a rad hard PSU and resilient watchdog are required
  - Watchdog resets the system on hang ups
  - Implemented with three voting pieces
- The rest of the tolerance comes from specific component choices
  - CPU based on "well known" technology (14nm Fin-FET)
  - ECC Everywhere
  - Simpler interfaces where practical (SATA vs NVMe)



Why Rad Tolerance/Hardening Mattered…

- But the DAUs providing most of the data had to be hardened too…
  - Limited sources of rad-hard DAUs
  - And those weren't in the Chapter 11 ecosystem
- So adding to the "data type conversion" task was conversion from (a few) IENA packet types to Chapter 11
  - The alternative was to convert "a bunch" of DAUs to produce Ch11 packets
- Because of the constrained set of requirements, shortcuts could be taken
  - Not every IENA packet would be convert-able

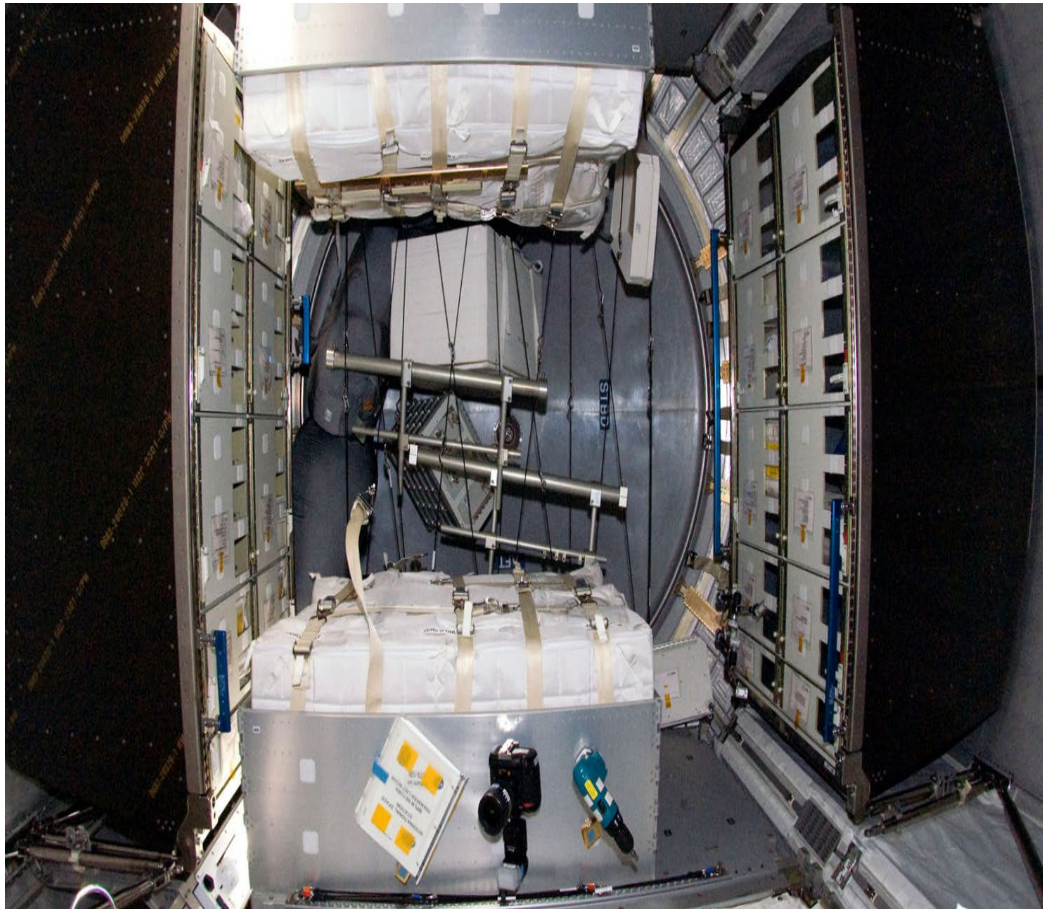


Vehicle Infrastructure Management

- The initial design had the recorder as an endpoint
  - With other devices acting as traffic managers
- Because the recorder was a general-purpose system, those functions got moved to it. This included both:
  - “Firewall” type operations
  - Cargo hold monitoring
    - Lights and cameras
- The management/configuration of the recorder (via TMATS) provided a convenient single point for upload/version control/etc
- The result makes the recorder more of a data hub

Cargo Management

- The vehicle is designed to carry payloads from third parties
- There is an need to provide a pathway to the cargo payloads from the ground
  - Owner can monitor health & status
- The approach is to use Linux containers
  - Docker/LXC/etc
  - Lightweight virtual machines using “the same” OS kernel as the host
  - Isolating the third party applications / utilities / libraries, different payloads coexist & are blissfully ignorant of the environment or indeed each other



Lessons Learned

- Understand background to requirements
- Look at software platforms over hardware
  - General purpose over specific
  - “Software Defined Recorder”
- Don’t reinvent the wheel
  - Even if it’s a bit wonky
- Reuse technology baselines
  - Containers
  - *ffmpeg*

THANK YOU

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