

Mark 5 – Status and Developments

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Current Mark 5A Status

- ~150 Mark 5 systems deployed; nearly all tape systems have been replaced
- ~1300 Mark 5A '8-pack' disk modules deployed (>2 PB of storage!); growing rapidly!
- 1 Gbps experiments are now routine for both geodesy and astronomy
- Correlator efficiency has improved by factor of ~2 over tape!
- Challenge –support of systems in field!
 - Mostly due to large variety of system configurations

Mark 5B Status

- Mark 5B fully operational
- Mark 5B DIM software is complete except for phase-cal extraction
- Mark 5B system is in routine use at Westford, GGAO, Badary
- Mark 5B support on correlators
 - Haystack, MPI and USNO support Mark 5B (including phase-cal/state-count)
 - JIVE support under construction
 - NRAO will use Mark 5A+ for foreseeable future

Mark 5A/B Compatibility

Problem: Mark 5A cannot playback Mark 5B recordings –
how can Mark 5B recordings be processed on correlators
that support onlyly Mark 5A?

Solution: Mark 5A+ (upgraded FPGA code for Mark 5A)

- Upgraded Mark 5A (“Mark 5A+”) can play:
 - All Mark 5A recordings
 - All Mark 5B recordings, playback is in VLBA-track-format
- Mark 5A+ design complete and tested
- Mark 5A+ not compatible with 2Gbps recording from Mark 5B+

Mark 5B+ (2048Mbps)

- Upgraded StreamStor (dubbed “Amazon”) supports up to ~2 Gbps on FPDP2 interface
- Mark 5B I/O card has been designed and tested to support input VSI-H clock rate of 64 MHz
- Can record to one disk module at 2 Gbps; plan to support recording across 2 disk modules (16 disks) for improved robustness in face of slow disks
- Playback is limited to 1024 Mbps
- Compatibility: Mark 5B+ recordings compatible with playback on Mark 5B and Mark 5A+ (except 2048Mbps)
- Mark 5B+ is operational and has been used in a number of experiments with DBEs at 2Gbps and 4Gbps (w/dual Mk5B+s)

Mark 5C (under development)

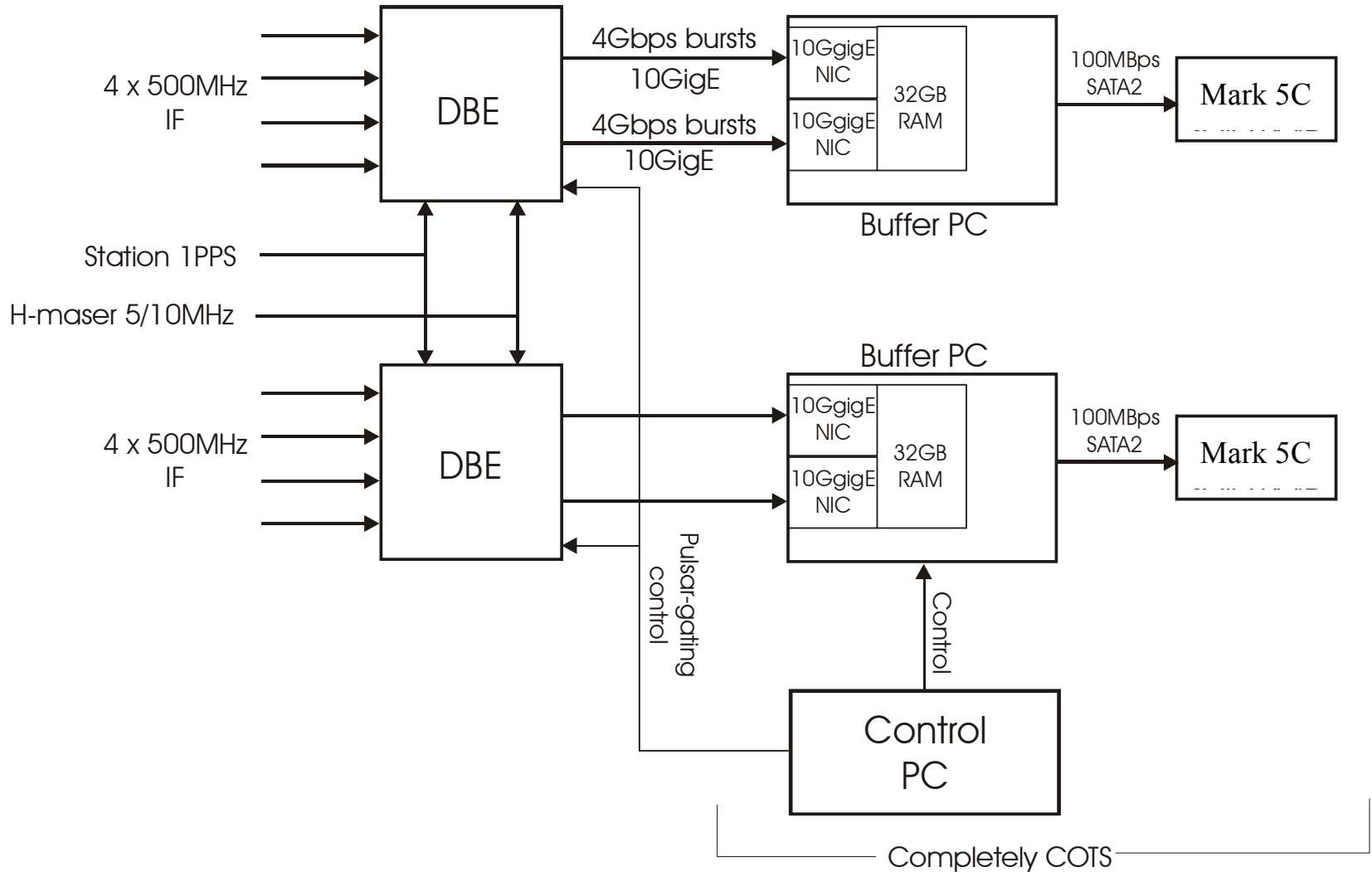
- Conduant developing new 10GigE daughter board for Amazon StreamStor card (no separate I/O board – unlike Mark 5A/B/B+)
- Will accept single-stream 10 Gigabit Ethernet (OSI Layer 2 or 3)
- 4096 Mbps max data rate to two standard Mark 5 disk modules in “non-bank” mode
- Record-only through SS 10GigE interface
- Mark 5C spec developed jointly by Haystack & NRAO; distributed to community for comment
 - Will support an arbitrary # of channels (i.e. not constrained to 2^n like current VSI-E, Mark 5A/B)
 - Requires extension of VSI-E specification
- Mark 5C data spec has been distributed to community
 - A Mark 5B compatibility mode will be supported (i.e. 2^n channels; readable on Mark 5B)
- Playback of Mark 5C will be through host computer
 - Natural for software correlators
- Prototype expected by ~mid 2008

Mark 5 Upgrade Costs

| Target \ Existing | Mk5A | Mk5B (requires VSI-H data source) | Mk5B+ | Mk5C (not yet available; rough estimates) |
|-------------------|-------------|--------------------------------------|----------------------------------|--|
| 0 | Unavailable | \$20.8K | ~\$22.3K | \$20-25K |
| Mk5A | - | ~\$3.5K (Mk5B I/O) | ~\$13K (Amazon plus Mk5B I/O) | Est. \$12-14K (Amazon plus 10GigE DB) |
| Mk5B | - | - | ~\$9.6K (Amazon) | Est. \$12-14K (Amazon plus 10GigE DB) |
| Mk5B+ | - | - | - | Est. \$2-4K (10GigE DB) |

Note: Costs do not include cost of creating data source

16 Gbps Burst-mode System



Mark 5 OS support

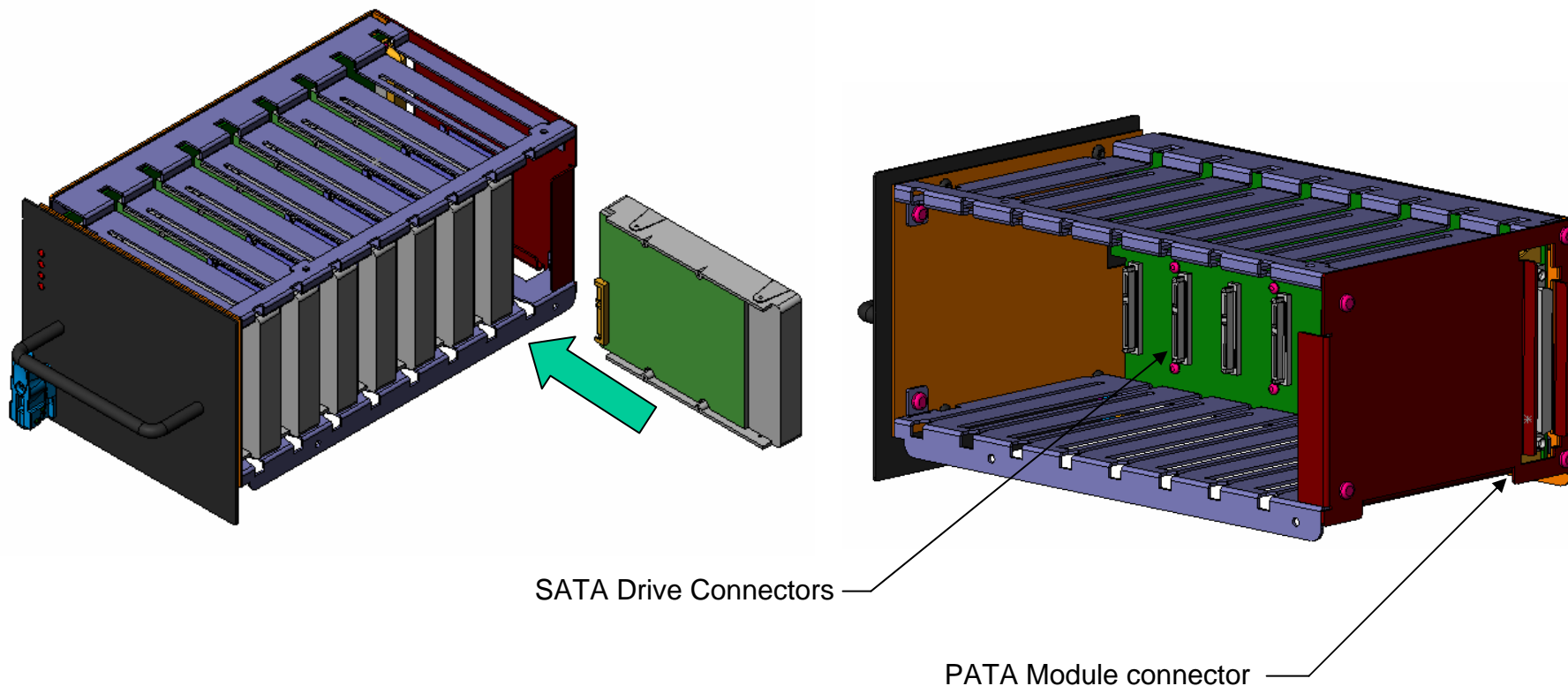
- Goal is to standardize OS and help reduce variations between Mark 5 systems
- Haystack has developed standardized Debian (Linux kernel 2.4) distribution; no fees; available at Haystack website soon
- Support for Linux kernel 2.6 under development; particularly critical for Mark 5B, which depends on interrupt driver
- Conduant working on 2.6.18 support; unresolved memory leak in StreamStor driver (Jungo) has slowed progress
- Some sites (NRAO, USNO, others?) will remain Red Hat for various reasons

Linux Mark 5 data access

- Jan Wagner at Metsahovi has implemented Linux-type data access for Mark 5 using FUSE
- Has been successfully implemented at Haystack and works well
- Thank you, Jan!

SATA disk module

- Now available from Conduant
- Interchangeable with PATA disk module
- New mechanical design allows very easy access to insert/remove individual disks; increased module stiffness for better mechanical stability

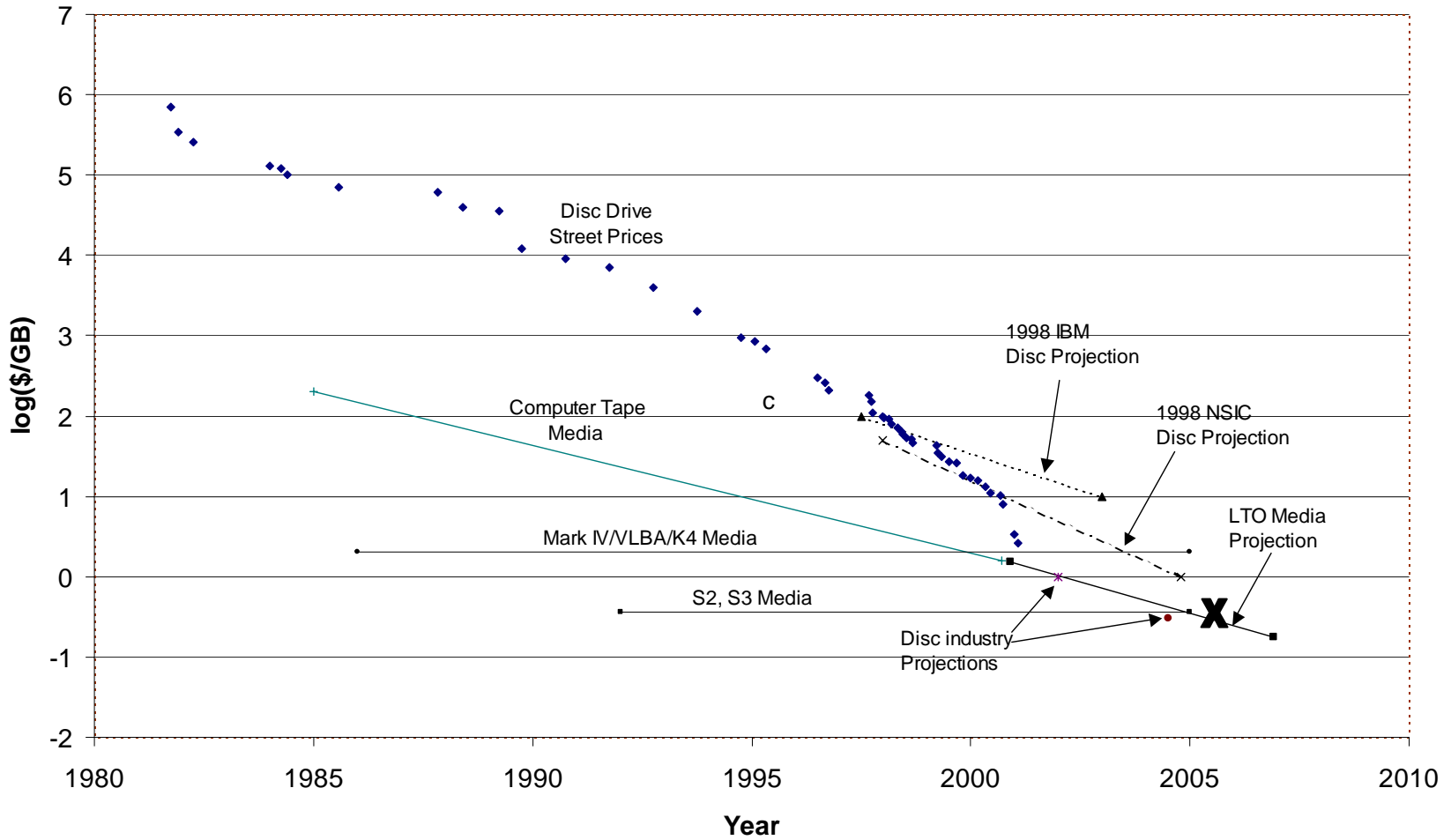


Questions?

Reasons to adopt Mark 5B

- Eliminate need for expensive external formatters; particularly important for new stations or stations without existing Mark 4 or VLBA formatters
- With a 14-BBC Mark4 or VLBA4 system, up to 1792 Mbps can be recorded with two parallel Mark 5B systems; current 14-BBC systems can only generate a maximum of 1024 Mbps of formatted data
- Extensive phase-cal extraction and state counting capabilities for better diagnostics and better system calibration
- Replace unreliable Station Units on Mark 4 correlators; SU capability is built into Mark 5B
- Stepping stone to Mark 5B+ (2Gbps)

Tape vs. Disc Price Comparison



Disk-Media Status

- Hard disk price vs capacity/performance continues to drop
 - Now well below ~\$0.50/GB and continue to drop
(Mark 4/VLBA tape is ~\$2.00/GB)
- 400 GB disks are commonly used –
Two 8-packs of 400GB disks comparable to ~13 VLBA/Mark 4 tapes
- 750 GB disks now available –
Two 8-packs of 750GB disks comparable to ~24 VLBA/Mark 4 tapes;
~26 hours @ 1 Gbps unattended!

Mark 5B Data System Characteristics

- Full VSI-H compatibility
- Same chassis as Mark 5A; uses same disk modules; requires Mark 5B I/O card
- 1024 Mbps record/playback
- Eliminates need for external formatters, but requires VSI-H data source
- Station Unit capabilities for connection to Mark 4 correlators is designed into Mark 5B
- Extensive built-in phase-cal extraction and state counting on both data record and data playback
- DIM and DOM capabilities are separate FPGA downloads
- FPGA is programmable via software

Development support 2001-2004 from Mark 5 development consortium –
NASA, NRAO, USNO, MPI, BKG, EVN, KVN, JPL

Options to create a VSI-H data source

1. Use Digital Back End unit (dBBC or DBE)
2. Acquire VSI-C adapter to VLBA samplers (from Metsahovi)
3. Acquire Japanese VSI-H sampler unit
4. Modify Mark 4 formatter to “VSI4 Sampler Adapter”
 - Two VSI-H outputs; 1792Mbps total
 - Cost ~\$2K (board and new rear panel from Haystack)
 - Pretty much irreversible

Mark 5A/B/B+/C System Comparisons

| | Mk5A | Mk5B | Mk5B+ | Mk5C (under development) |
|------------------------|----------------------------------|------------------------------|------------------------------|-----------------------------|
| Data Interface | Emulates Mk4/VLBA tape transport | VSI-H (64MHz max clock rate) | VSI-H (64MHz max clock rate) | 10 GigE (OSI Layer 2) |
| Max data rate | 1024 Mbps | 1024 Mbps | 2048 Mbps | 4096 Mbps |
| Record modes | 8, 16, 32, 64 “tracks” | 1,2,4,8,16,32 bitstreams | Same as Mk5B | — |
| Disks | Mk5 “8-pack” | Same | Same | Same |
| Chassis | Mk5 | Same | Same | Same |
| I/O card | Mk5A | Mk5B | Mk5B | None |
| SS card | XF2 | XF2 | Amazon | Amazon |
| I/O-SS intf | Modified FPDP | FPDP | FPDP2 (clocks on both edges) | 10GigE Direct to Amazon |
| Max playback rate | 1024 Mbps (to VSI-H) | 1024 Mbps (to VSI-H) | 1024 Mbps (to VSI-H) | ~4Gbps (to host) |
| Playback Compatibility | Mk5A (to VSI-H) | Mk5A+ (to VSI-H) | Mk5B Mk5A+ (except 2Gbps) | — |

Flexible “Front-End Converter” for DBE

- Problem: Different systems need different IF frequency ranges
 - Even Mark 4 and VLBA systems use different IF ranges
 - Many modern RF/IF systems, particularly those at mm wavelengths, employ IF frequency ranges as high as 10-12 GHz
 - Often requires custom electronics at each such VLBI site
- Proposal is to couple a flexible dual-polarization IF frequency converter to the DBE for easy adaptability to almost any existing RF/IF system

Concept for flexible Up/Down Converter (UDC)

