Controls Global System Review

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(For Controls Global Group Team)

Outline

- Scope of controls costing exercise.
- Status of design.
- Assumptions.
- Bases of estimates.
- Manpower and M&S pie-chart breakdowns.
- Plans.

Included in the costing…

- Global Control System hardware and software.
- Computing for the accelerator control system.
- Control system databases.
- Control system network infrastructure.
- 5Hz feedback infrastructure.
- Control system front-end electronics and cabling.
- Personnel Protection System logic
- Machine Protection System logic.

- LLRF electronics and cabling.

Not included…

- Out of scope
  - **Local control electronics for technical systems.**
  - **Local protection logic for technical systems.**

- Not included …but not out of scope
  - **Control systems for on-site test facilities for technical equipment.**

- Out of scope for controls, but is being costed by FNAL:
  - **Computing infrastructure for everything else: desktop computing, technical/scientific computing, Information Systems, CAD/CAE, etc**

Design & costing status: controls

- Conceptual design done for all sub-systems but MPS.
- Simplified costing model developed for front-end electronics.
- Initial device counts are known for all area systems.

- Area System costing details and roll-ups are complete.
- Global control system costing details and roll-ups are complete.

Design & costing status: LLRF

- LLRF for Main Linac and RTML are well understood.
- Crab Cavities and Damping Ring LLRF are less well defined but are a small percentage of the total system.

- Key components exist as prototypes at DESY and FNAL
  - **Designs will progress for test stands in all regions and will be upgraded as technology improves.**

- RF phase reference specs are beyond state of the art
  - **Design concepts in the costing model have been tested, but performance is not demonstrated**
  - **Will require simple harmonic relationships between 1.3GHz and other generated frequencies.**

Assumptions: standardization

- A standard LLRF building block is assumed across all machine areas and HLRF technologies.

- A high level of standardization is assumed for the technical system interfaces to the control system
  - **Not just defined as "Ethernet", but also specify protocols, equipment behavior, functionality, etc**

- Standardization is necessary to…
  - **Reduce controls manpower.**
  - **Have consistent look/feel for similar equipment.**
  - **Ensure that equipment can be fully integrated.**

Assumptions: High Availability

- HA is inherent in the control system baseline.

- Impact on overall controls methodology (QA):
  - **More formalism in the design process.**
  - **Greater emphasis on standards, standardization, testing, and configuration control.**

- Impact on design choices
  - **HA compliant front-end platform (ATCA).**
  - **Additional functionality to support automated diagnosis and recovery from failures.**
  - **HA for computing & networking infrastructure.**

Assumptions: manufacturing

- Individual components manufactured off site, either to specification, COTS, or “built to print.”
- Where possible, equipment assembly, integration, testing will be done on site and on the surface
  - **Deliver fully assembled and pre-tested electronics relay racks to Installations Group.**
  - **Deliver pre-terminated, pre-tested cables.**

Basis of estimates: controls

- Global Integrated Control System
  - **Conceptual design uses a 3-tier architecture.**
  - **Assume control system will be founded on an existing well-established software framework.**

- Front-end electronics
  - **High level interfaces assumed in most cases ("Ethernet") rather than discrete I/O.**
  - **Costing model uses ATCA, redundant processors.**
  - **Bottom-up estimates from AS device counts.**

Bases of estimates: LLRF

- LLRF
  - **Cost estimates are extrapolations of current systems at DESY, KEK, SNS, and FNAL.**
  - **Consolidated estimates from all three regions.**

- RF Phase reference distribution
  - **Global (fiber): costing of conceptual design component parts.**
  - **Local (copper): extrapolated from SNS design.**
  - **Assumes simple harmonic relationships between 1.3GHz and all other frequencies.**

Basis of estimates: computing

- Computing and network infrastructure
  - **Costing model derived from assumptions about data rates, processing, and 5Hz feedback needs.**
  - **Component costs come from COTS products.**

- Control Rooms
  - **Costs based on recent designs for other facilities.**

Basis of estimates: PPS, MPS

- Personnel Protection System
  - **Conventional dual-chain PLC-based system.**
  - **Costing based on existing equipment with assumed zone sizes (eg 500m in linac)**

- Machine Protection System
  - **“Pre-conceptual” design stage.**
  - **Made assumptions about numbers of electronics modules and data distribution links.**

Basis of estimates: manpower

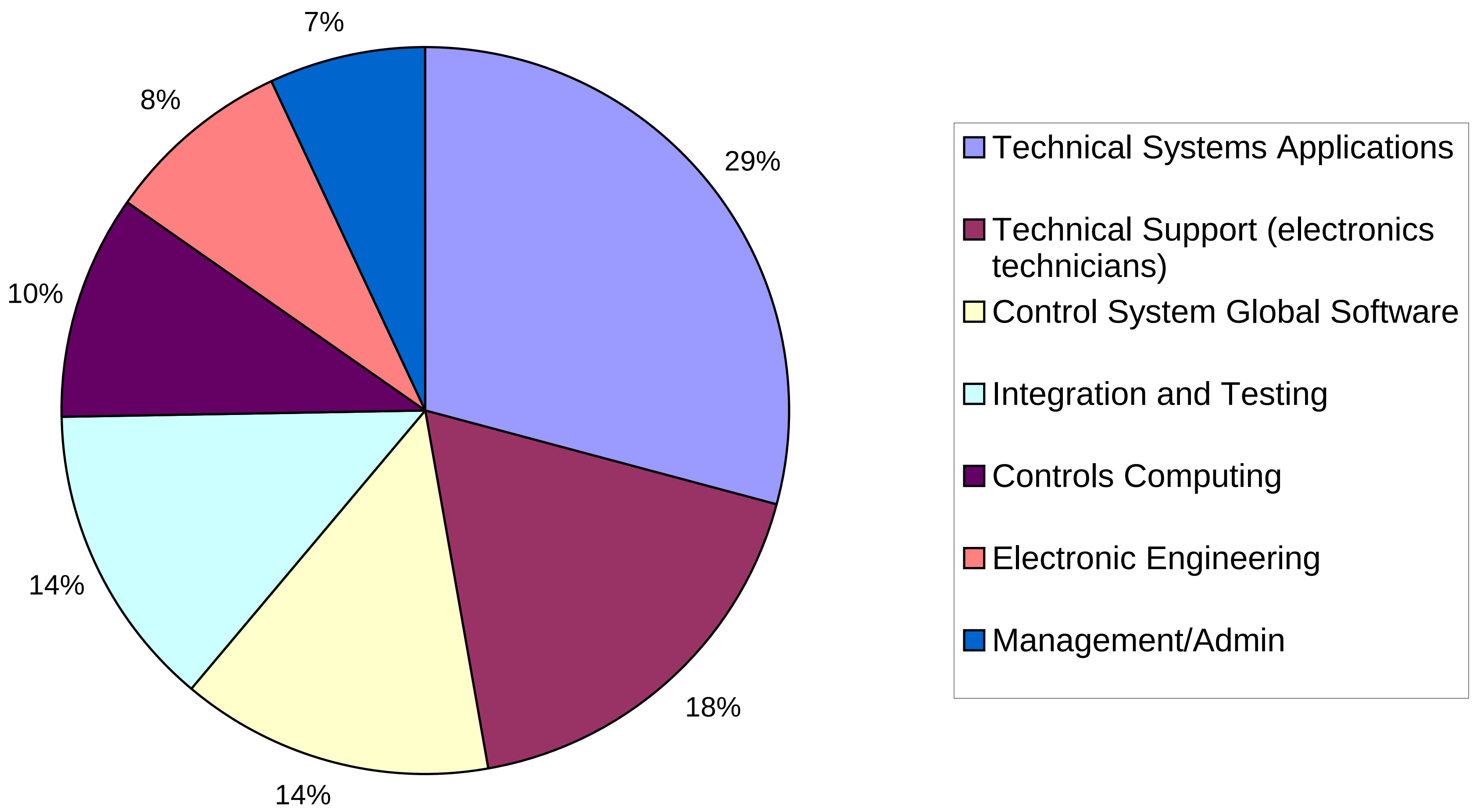
- Top-down estimate based on ‘typical’ functional needs
  - **Common core software development.**
  - **Applications engineers embedded in each technical area (eg PS, RF, Vac, Cryo, MPS, …)**
  - **Engineering & technical support functions.**
  - **Manufacturing function for relay rack assembly.**
  - **LLRF hardware and software.**

- We did not include any additional manpower overhead for managing a globally distributed controls effort.

Manpower ramp-up

- The following tasks are assumed to have been completed prior to project start:
  - **Essential R&D has been completed.**
  - **Critical state-of-the-art requirements have been demonstrated through prototyping.**
  - **Major hardware and software design tasks have been completed.**
  - **Controls standards & interface specifications have been communicated to technical groups.**
  - **Requirements from the technical groups are broadly known.**

Manpower by category (no LLRF)



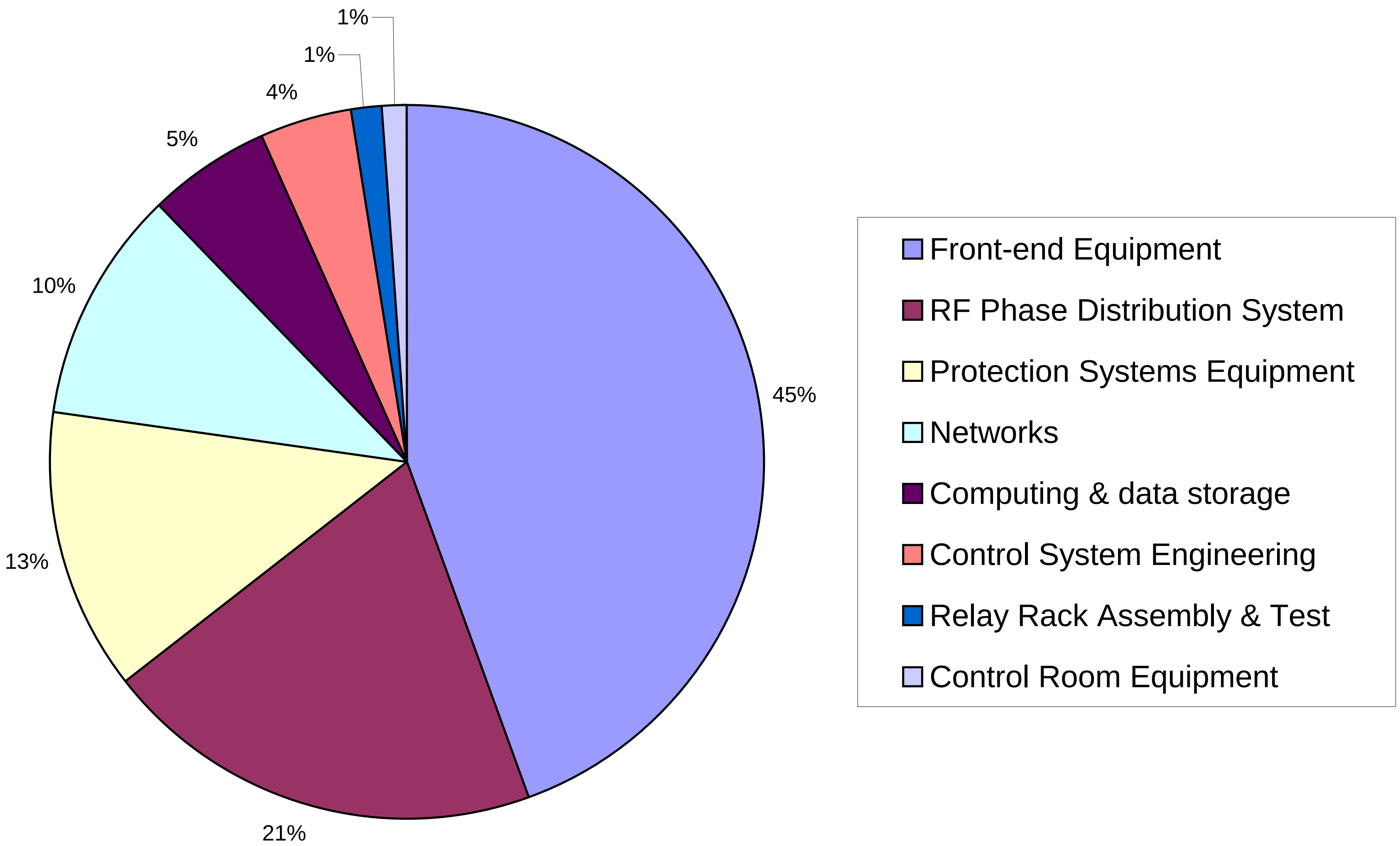
Controls front-end equipment by AS

	e- source	e+ source	DR	RTML	Linac	BDS
ATCA I/O Card Total	11	311	2,052	641	2,625	818
ATCA CPU Card Total	24	102	674	214	1,890	302
ATCA Shelf Mgr Total	12	51	337	107	945	151
AMC Card Total	7	50	403	172	1,380	591
ATCA AMC Carriers	2	13	101	44	345	158
ATCA Shelf Total	12	51	337	107	945	151
Rack Total	6	17	113	36	630	76
Cables (Signals)						
RF	36	9,937	6,156	1,930	1,875	1650
Fiber Optic	284	1,886	36,536	12,744	80,843	27080
Twisted Pair	48	32	4,800	268	5,000	448

Many Assumptions

- Not all shelves and racks are expected to be fully populated in all areas
- - utilization factors incorporated into model, but may be too general
- LLRF, Cryo, Timing not included here
- General networking and computing not included here
- Medium/large power supplies have their own embedded local control
- Packaging of signals into actual cables with connectors not handled here
- Every ATCA shelf has 2 cpu's, 1 shelf manager, 1 event receiver

M&S by category (no LLRF)



Cost impact of High Availability

- HA-specific M&S costs in baseline (~20% of total):
  - **ATCA with redundant processors vs VME/VXI.**
  - **Redundant networks.**
  - **Redundant RF phase distribution links.**

- HA-specific manpower in baseline (~7% of total):
  - **HA framework management, QA, testing.**
  - **HA specific core software development.**

- Further R&D is required to better assess the cost of HA implementation.

Potential for cost optimizations

- Local RF phase reference distribution.
- Front-end electronics rack utilization
  - **Could reduce the total number of relay racks.**
- Technical System interfaces
  - **Add a low-complexity front-end for equipment with signal-level interfaces.**
- Cabling and connector costs
  - **Optimize selections and manufacturing costs.**
- Place electronics in the accelerator tunnel
  - **eg mixers.**
- Custom vs COTS electronic modules

Cross-checks on our costing

- Benchmarking against common “rules of thumb”
  - **Control system costs as a percentage of accelerator technical system costs.**
  - **Cost per I/O channel.**
- Peer reviews
  - **Estimates have been reviewed by team members in all three regions.**
  - **Limited informal external reviews of top-level estimates and costing methodology.**
- Informal comparisons have been made with other facilities: SNS, NLC, Fermilab, NIF, LHC,...

R&D activities with cost implications

- High precision local & global RF phase reference distribution.
- Implementing High Availability.
- Implementing system level automated diagnosis and recovery.

Plans…

- At Vancouver:
  - **Resolve any issues regarding our assumptions or scope with technical systems groups.**

- By Valencia
  - **Develop conceptual design for MPS.**
  - **Refine costing model for cable plant.**
  - **Rack optimization (depends on how well we know the technical system interfaces).**
  - **Update BCD with the latest design information.**
  - **Respond to feedback/assignments from DCB.**

Towards the TDR

- Continue to develop the engineering design
  - **Refine integrated control system design.**
  - **Develop integrated detailed views of MPS, Timing, beam-based feedback, etc**
  - **Further refine the technical interfaces.**
  - **Define site-wide controls infrastructure: networks, timing, etc**

- Establish basis for standards for controls hardware, software, protocols, etc.
- Define controls expectations of the technical systems.
- Implement an R&D program to address critical issues.