LLRF Planning for the Engineering Design Phase

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Outline

- Preamble

- Goals

- Scope

- Deliverables
  - *Interim*
  - *Final*

Preamble 1

- Most important goal of the LLRF System: Integrated Luminosity

- The LLRF System has a high impact on luminosity

- The LLRF system is very complex, yet the cost is comparatively low

- The performance to cost ratio is very high.

Preamble 2

- Work must go on in all three regions
- Must have test facilties in each region
  - *Every region must design, build and operate their own facilities*
- Develop expertise in all regions
  - *Requires some duplication of efforts*
- Collaboration must provide synergy effects

Goals for Engineering Design Phase

- Primary goal: An overall design to allow machine construction to start within 3 years.

- Secondary goals:
  - *Capture Requirements*
  - *Develop Conceptual Designs*
  - *Build Prototypes and Perform Critical R&D*
  - *Update the Cost Estimate (Value Engineering)*

Scope of Engineering Design

- WBS for the EDR

- Requirements

- Conceptual Designs

- Critical R&D Results

- Cost & Schedule

WBS for EDR

- **System Requirements and Subsystem Interface Documentation**
  - *Master Oscillator and Phase Referene Distribution*
  - *Beam current stability*
  - *HLRF Phase and Amplitude Stability*
  - *Cavity Microphonics*
  - *Lorentz Detuning constant and modes*
  - *RF Power Overhead*
  - *Control system requirements*
  - *LLRF System Integration*
  - *Interface to HLRF, MPS, Global Feedback*
  - *Availability and Operability*

WBS for EDR (C'tnd)

- ## Hardware
  - *Digital Signal Processing*
  - *Analog Signal Conditioning*
  - *Piezo Control*
  - *Radiation Measurement - online*
  - *Communication – physical layer*
  - *Fast Control Interstation Links*
  - *Control system requirements*

- ## Infrastructure/Inst./Maint
  - *Cable Plant*
  - *Racks and Crate*
  - *Documentation Standards*
  - *QA and QC*
  - *Availability*

- ## Software
  - *Controller*
  - *Low Level Applications*
  - *High Level Applications*
  - *Communication Protocols*
  - *Control System*

- ## Commissioning/Ops.
  - *Procedures*
  - *Automation*
  - *Diagnostics*

Capture Requirements

- **Process**:

  – *Top Requirements are worked out by the LLRF EDR team*

  – *Everyone can propose subsystem requirements*

  – *Establish approval and change process*

  – *Use cases will be used for functional requirement (mainly for software)*

Example: Top Requirements XFEL

1. Provide settability of voltage and phase to the desired values in all 4 quadrants and close to klystron saturation
2. Maintain stability of voltage and phase … within specified tolerances
3. Provide highly stable rf references at specified frequencies at selected locations.
4. Provide adequate interfaces to other accelerator subsystems.
5. Diagnose faulty or missing hardware and software …
6. Optimize and/or limit operational and system internal parameters such that the performance function based on rms field stability, accelerator availability, and component lifetime is maximized.

Example Top Requirements XFEL

7. Provide a simulation mode, where the klystron cavity system is replaced by a simulator and which provides performace predictions for planned parameter changes.

8. Provide a high degree of automation …

9. Provide calibration functions for selected signals.

10. Provide low and high level applications supporting automation.

11. Provide exception detection and handling.

12. Provide operating modes for rf system conditioning

13. Support rf system and accelerator commissioning procedures.

Develop Conceptual Designs

- Distribute work for conceptual designs to different regions. Propose concepts.

- Evaluate proposals (LLRF team)

- Modify proposals if necessary

- Review and approve concepts by PM (may be assisted by review committee)
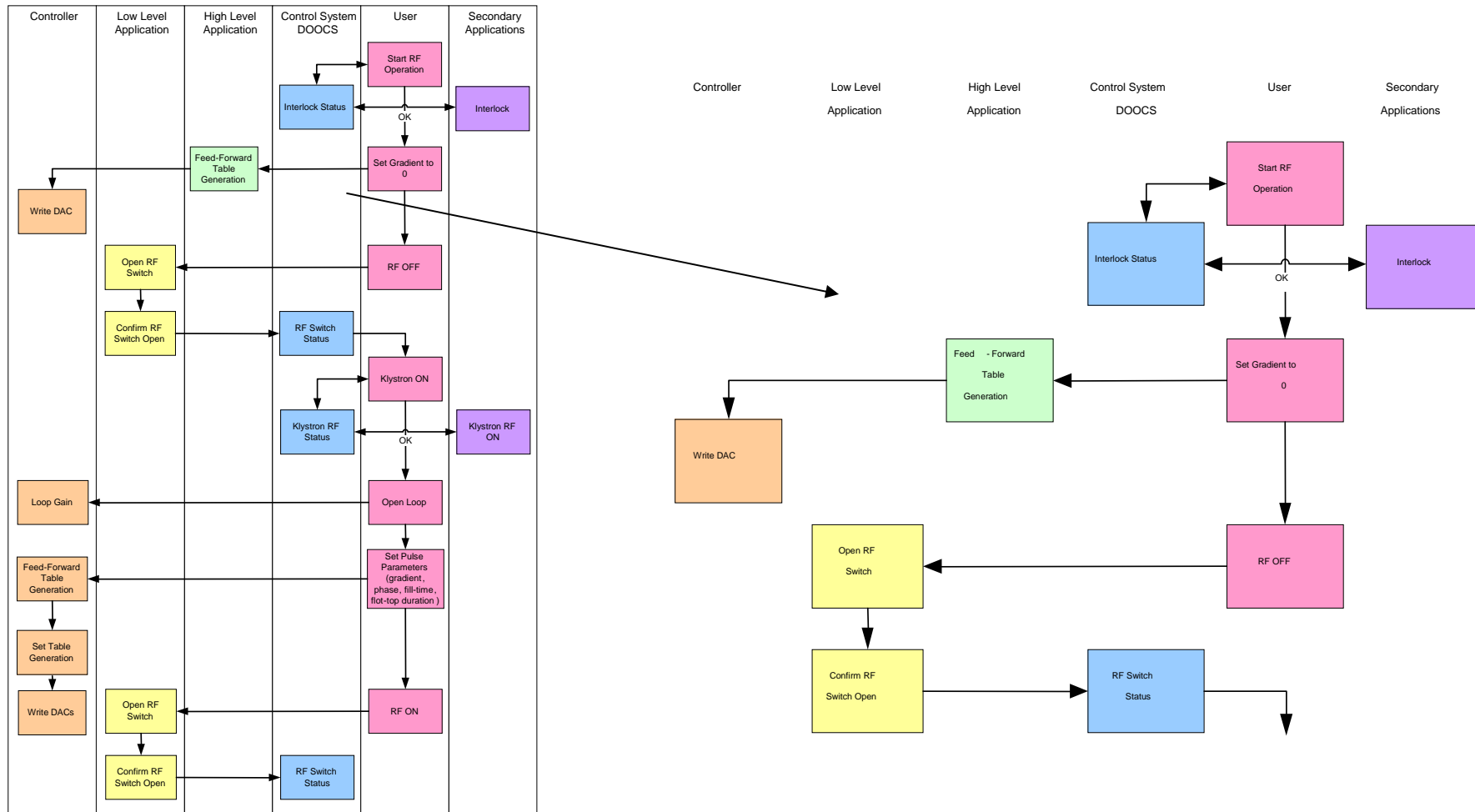
- Document conceptual designs

Example: Concept ATCA LLRF XFEL
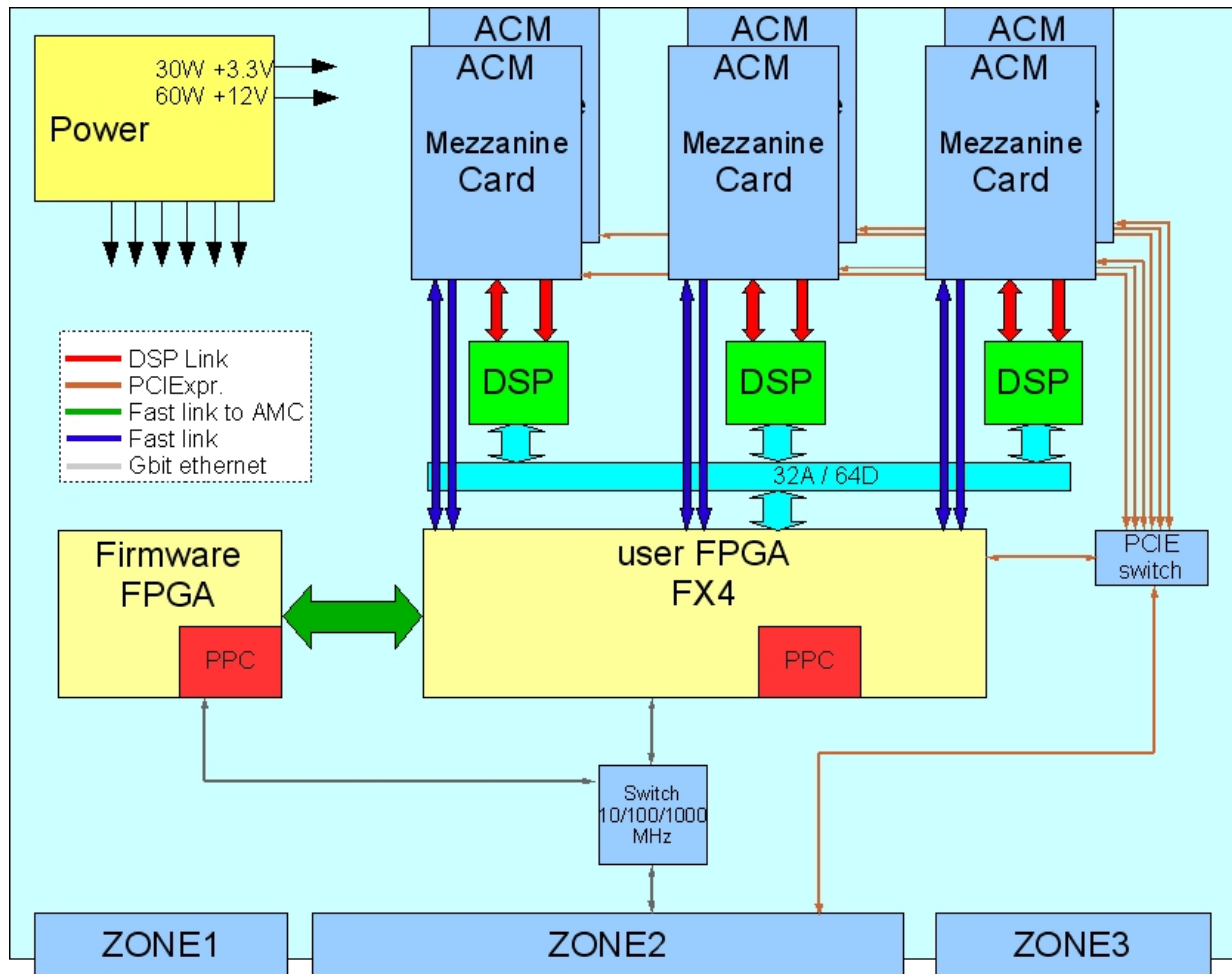
Example: Software Topology LLRF/XFEL
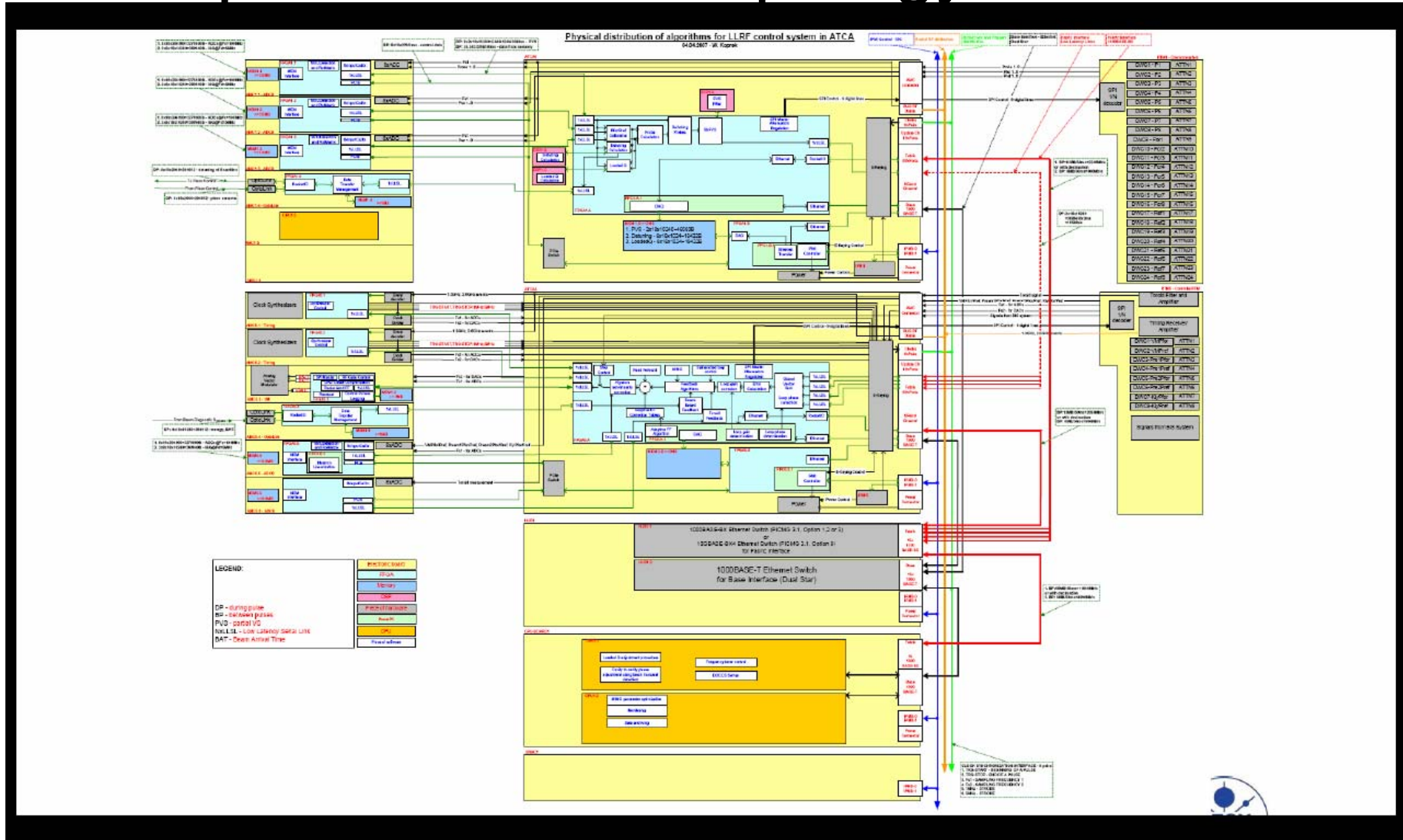
Example: Use Case LLRF XFEL

R&D for Test Facilities

- **Develop test plans to study S2 issues**

  Test 4 : Develop and demonstrate RF fault recognition and recovery software

  Test 5 : Evaluate Quench rates and recovery time

  Test 7 : What gradient spread can be handled by the LLRF

  Test 10: Check beam phase and energy stabilit

  Test 21: Understand RF control issues with many cavities and large physical distances in the system (phase drift !)

- **Develop extensive list of possible test with priorities**
- **Develop prototype HW/SW for test facilities**
  - *Regional expertise must be developed*
- **Identify main focus of each test facility**
- **Perform appropriate tests at existing test facilities**
- **Share test results**
- **Information exchange between people**
- **Sharing hardware/software where possible**

Cost and Schedule

- Conduct a comprehensive value-engineering
  - *Compare different alternatives*
- Develop cost/schedule from WBS, requirements, concepts, prototypes
  - *Must be aligned with general schedule*
- Refining existing cost estimate
- Costing EDR Work
  - *EDR writing 50% (Brian, Shin, Stefan)*

Define Interim Deliverables

- Decide on process for EDR
- Analysis of current status of work
- Identify critical R&D items
- Develop test plans for R&D
- Review of requirements
- Review of concepts
- Documentation of test results
- Elaborate and apply Spiral Model

Define Final Deliverables

- **Requirements (+ acceptance tests)**
- **Conceptual Designs**
  - *Includes simulations*
- **Critical R&D Results**
  - *Includes LLRF Prototypes at Test Facilities*
- **Cost & Schedule**
- **Plan for future R&D if necessary**

Deliverable at each phase of work (ex. XFEL)

Phase	Phase description	Month/ phase	Total months	Date
Ph. 0	Project plan (MS Project)	0 m	0 m	09/2007
Ph. 1	Requirements (Rhapsody, Doors)	1-2 m	1 m	09/2007
Ph. 2	Conceptual design	1-2 m	2 m	10/2007
Ph. 3	R&D of critical components	1-6 m	6 m	2/2008
Ph. 4	Specification	2-3 m	6 m	2/2008
Ph. 5	Detailed design (documentation)	1-6 m	8 m	4/2008
Ph. 6	Prototype	1-3 m	12 m	8/2008
Ph. 7	Evaluate prototype in lab. test	1-2 m	14 m	10/2008
Ph. 8	Evaluate prototype in accelerator	1-2 m	14 m	10/2008
Ph. 9	Improve design	1-2 m	17 m	01/2009
Ph. 10	Repeat 7-9 until design is finalized	n x (1-3) m	n=0	n=0

Deliverable at each phase of work (ex. XFEL)

Phase	Phase description	Month/phase	Total months	Date
Ph. 11	Procure components	1-2 m	18 m	02/2009
Ph. 12	Produce several pre-production systems	1-6 m	20 m	04/2009
Ph. 13	Perform quality control of fab. systems	1-2 m	26 m	10/2009
Ph. 14	Evaluate systems in test facilities	1-2 m	28 m	12/2009
Ph. 15	Full production run	1-6 m	30 m	02/2010
Ph. 16	Quality control	1-2 m	32 m	04/2010
Ph. 17	Install systems	1-4 m	36 m	08/2010
Ph. 18	Commission systems	1-4 m	40 m	12/2010
Ph. 19	Operate systems	not spec.	?	?
Ph. 20	Maintain systems	not spec.	?	?
Ph. 21	Upgrading systems	not spec.	?	?