High Level RF Technical System Review

GDE Cost Review July 19-23 2006
Vancouver Canada

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For the HLRF Cost Team
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Status: Engineering & Cost Estimate(1)

- How much of the HLRF-TS scope have we covered?
  - **What level of detail have we achieved?**
    - 1.3GHz HLRF System Cost Driver Estimates are completed in three Regions: *Modulator, Klystron, RF Distribution, Infrastructure. Estimates made at WBS level 6 or 7 in most cases.*
    - DR HLRF System Cost Driver Estimates are completed in three Regions: *HV Power Supply, Klystron, RF Distribution, Infrastructure.*
    - Parts of the Small Cost Driver estimates are not completed in all three Regions.
      - Americas Region close to complete in all details of acquisition, factory test, on-site staging, test system design, tunnel integration and testing.

Status: Engineering & Cost Estimate(2)

- **What accuracy of cost estimate have we to-date?**
  - *We have not compared Region and inter-Region methodologies in sufficient detail to evaluate accuracy.*
  - In ML Area, Cost Drivers of Klystron and Modulator give consistent results in all three Regions (+/-10?) even though the fractions of details are different(+-20%?) and methodologies were different.
  - One Region's Estimation of RF Power Distribution deviates largely from the other two and it is necessary to investigate the reason.

Status: Engineering & Cost Estimate(3)

– **What have we not dealt with?**

i.e. where we have the information available, but we did not manage to make even a first-pass estimate

- We have estimates for all critical elements in all three Regions and for all elements in at least one Region.
- This includes ML, DR, Sources and RTML Systems.
- Methodologies and details differ among the systems estimates.
- ML accounts for 81% of total RF systems cost and 10MW station contains the most detail.

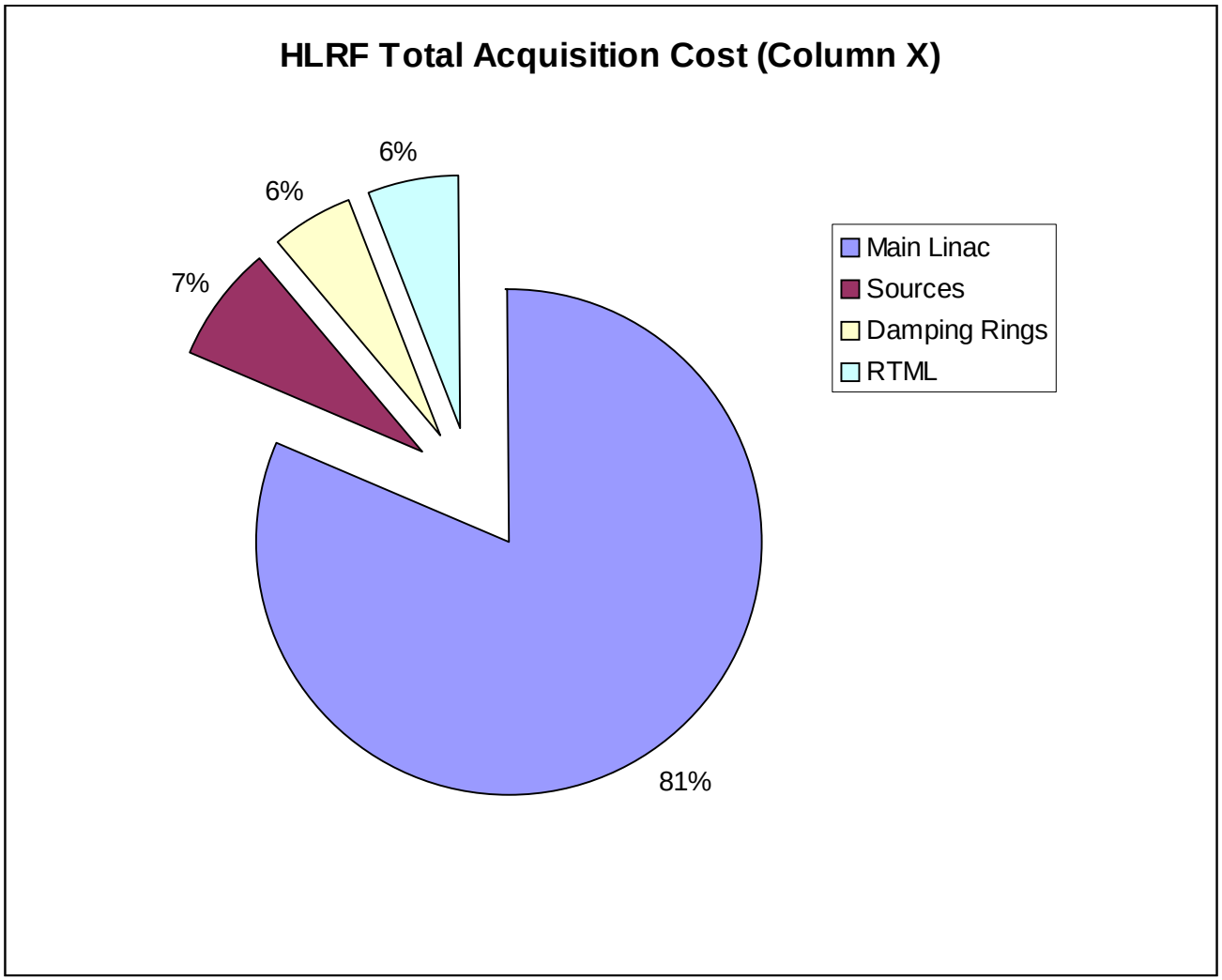
Status: Engineering & Cost Estimate(4)

- **What information is missing from our estimate? Where are the weaknesses in our estimates?**
  - Klystron bottom-up estimate compares well with one vendor quote but is 80% lower than second vendor quote, raising questions.
  - Assumed labor rates and overheads for factories and bottom-up engineering estimates not consistent.
  - Distribution bottom-up varies by ~2X from two vendor quotes in one Region; need to investigate.
  - Did not include shipping costs in factory estimates in all Regions.

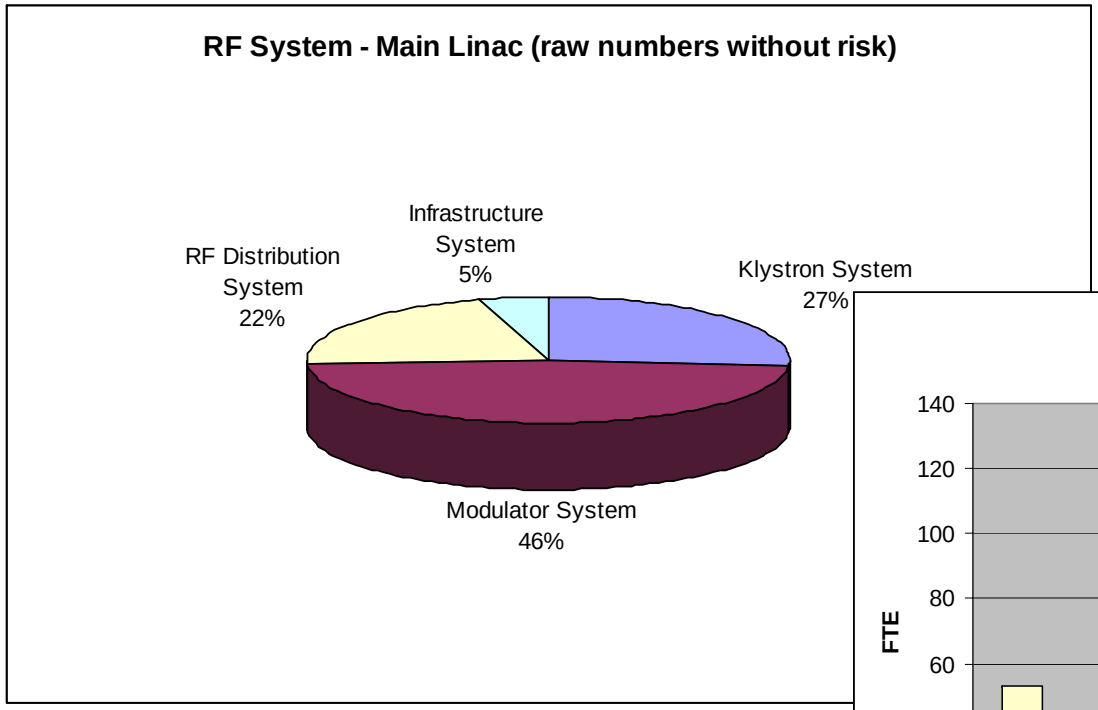
Status: Engineering & Cost Estimate(5)

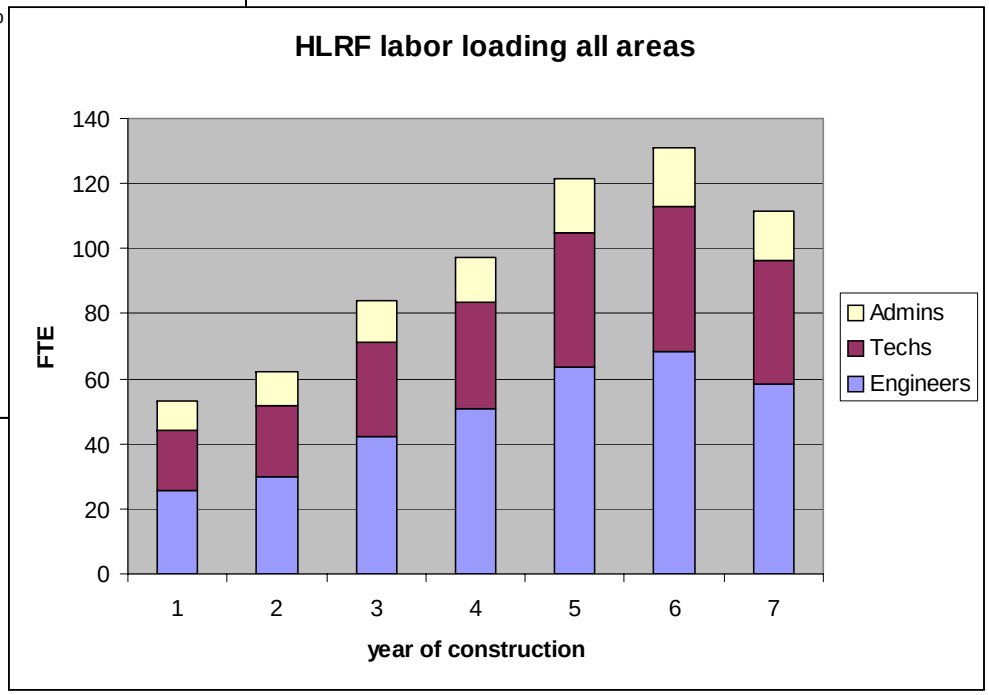
- **What cost-critical information did we not receive?**
  - Estimates for DR system extrapolated from several sources without backup documentation.
  - Used higher of two vendor estimates for new 650 MHz 800kW CW klystron design.
- **What do you estimate is the impact of the above on your cost estimate?**
  - +80% cost variance of klystron *or* +100% of distribution would impact total RF system cost ~ +20%; both together would impact total ~+40%. Assumes modulator cost well known and accurate.

HLRF Total Systems Acquisition Cost



HLRF Cost Ratios & Labor Loading





Pre-Mfg.

Mfg-Stage-Install

Cost Methodology(1)

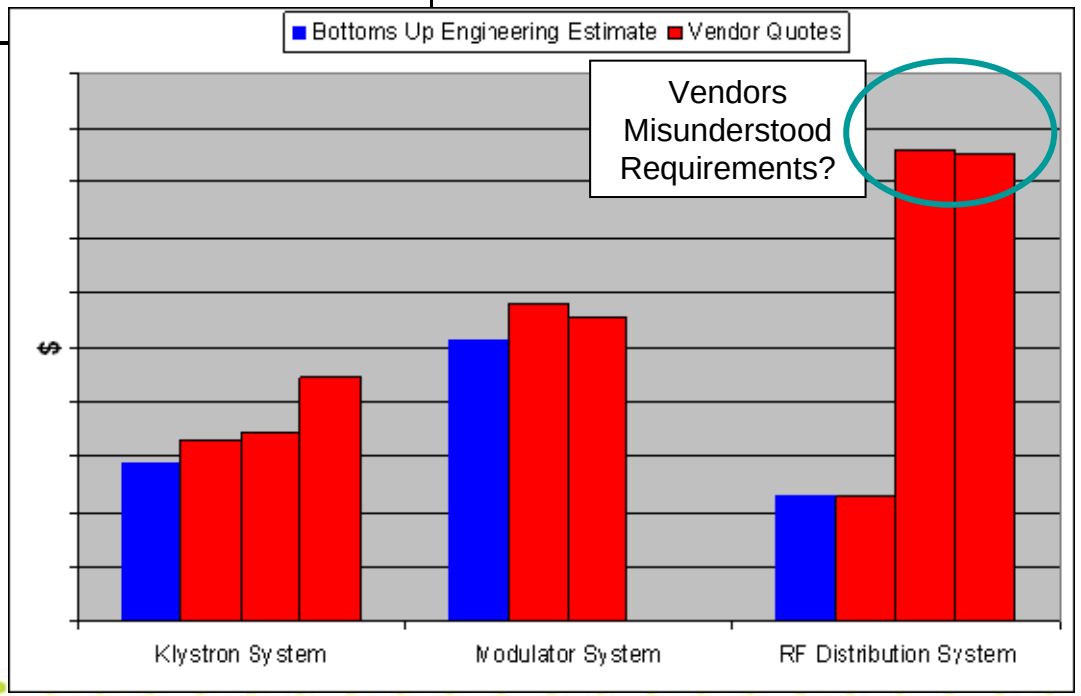
- **What methods (justification) you used to arrive at your cost estimates?**
  - Three Region's methods are different but all have a reasonable basis of cost justification
    - Europe-Based on XFEL cost studies, vendor quotes, experience
    - Americas - Based on bottom-up cost models
    - Asia-Based on Companies' mass production experience.
- **What Learning Curves (or other approaches) have you used for large scale production (where applicable)?**
  - Americas bottom-up estimates used the following:
    - Klystron factory model, bottom up estimate with full cost recovery and profit over ten years; imbedded learning curve
    - Modulator factory model, bottom up from existing units plus Learning Curve with Mfgr. ED&I & Profit
    - RF Distribution from bottom up fabrication models and estimates, plus Learning Curve with Mfgr. ED&I & Profit

Cost Methodology(2)

- **Have you integrated estimates from all three regions?**
  - So far, cost of all three regions are independently presented and not yet integrated.
  - We have not the detail information of European region's cost due to confidentiality issues.
- **What are your risk factors?**
  - See Table from Americas study next slide.
  - Largest risk factors assigned to Klystron at this time due to incomplete demonstration of full specifications.
    - For construction approval, risk must be reduced through demonstration working prototypes from 2 or more mfgrs.
  - RF Distribution model needs R&D
    - Demonstrate technical, cost reduction of integrated, pre-tuned subassembly per cryo-module.
  - BCD modulator, DR systems both relatively low cost risk.

Cost Methodology (3)

HLRF % RISK ASSESSMENT SUMMARY										
	DESIGN		TECHNICAL		COST		SCHEDULE		TOTALS	
ITEM	min	max	min	max	min	max	min	max	min	max
ML 10 MW KLYSTRON	0	0	40	80	8	16	8	8	56	104
ML RF DISTRIBUTION	0	0	2	4	3	6	8	8	13	18
ML MODULATOR	0	0	4	8	4	8	8	8	16	24
DR KLYSTRON	0	0	4	8	3	6	8	8	15	22
DR HV POWER SUPPLY	0	0	4	8	4	8	8	8	16	24



Possibilities for Cost Reductions(1)

- Possible cost reductions by the Valencia workshop:
  - **Component-level cost reduction:** ideas for possible reduction in component costs not currently included in your estimate – give reasons why not.
    - ACD developments not included at this time by GDE policy decision.
  - **For significant cost reductions, must attack *all main cost drivers*.**
    - Modulator: Reduce cost >50%
      - ACD Marx in progress. first prototype demonstration scheduled before Valencia
      - Include in ACD Cost Estimate.
    - Klystron: Reduce cost >50%
      - Possible ACD: Sheet Beam (SLAC), MBK's of ~20 beams (KEK).
      - Require 2 years R&D to demonstrate SBK and MBK prototypes
      - Promote to ACD status, include in ACD Cost Estimate.

Possibilities for Cost Reductions(2)

- Possible cost reductions by the Valencia workshop:
  - **Design-level cost reduction**
    - R&D: Reduce cost RF Distribution ~50%
      - Eliminate expensive circulators, replace 3-stub tuners w/ simpler shifter design
      - Pursue conceptual design, cost-risk analysis
      - Produce ACD cost, R&D plans by Valencia
      - Promote to ACD status; include in ACD Cost Estimate
    - Risks:
      - Damage to klystrons, cavities due to arcs, reflected power - intolerable
      - Need simulations, real tests on cryo-module
- Total Reductions of “Big Three” of 2X possible.

Plans and Goals(1)

- Plans for Vancouver Workshop

GDE/RF Power			
Friday, 21 July 2006		**Comments**	**Conveners/ Presenters**
SUB 212: 08:30 - 10:00			
0830-1000	**Open discussion and information exchange on Cost Estimates**	Summarize Regional cost estimates to date and to clarify any questions about the current estimates or methodologies. The group will determine the most urgent questions and estimators will come prepared with background material.	Convener R. Larsen. Presentations as needed from S. Fukuda, W. Bialowons, M. Neubauer, C. Corvin, C. Jensen
break (1000-1030)			
SUB 212: 10:30 - 12:30			
10:30-12:00	**Cost Reduction Strategies for HLRF**	Identify significant cost reduction potential for major systems. An ACD strategy now in progress could reduce modulator cost by 50%. ACD strategies aiming at similar major cost reduction on klystrons & distribution will be discussed/ proposed.	Group discussion Convener R. Larsen
lunch (1230-1330)			
Henn 302: 13:30 - 15:30			
1330-1500	**Plans and goals for Valencia**	Develop plan to capture cost reduction strategies and goals in an "ACD Cost Model". Assess resources for FY07-09 to support ACD R&D programs. Identify resources for continuing cost modeling, RDR report writing.	Group discussion Convener R. Larsen
break (16:00 - 18:00)			
Henn 302: 16:00 - 18:00			
16:00 - 1800	**Completing, optimizing and/or merging estimates**	Assess cost risk factors from current Regional estimates. Discuss guidance for Labor rates and overheads (Garbincius). Discuss scope, estimates of HLRF Installation costs (Asiri). Cost optimization/merger discussion by Estimators.	Group Discussion Convener R. Larsen. Presenters P. Garbincius, F. Asiri, Cost Estimators.

Plans and Goals(2)

- Plans for Interim before Valencia Workshop
  - **Refining cost estimate for RDR**
    - Complete cost for components where information still incomplete or tentative.
    - Obtain backup materials for “Cost Book” references
    - Identify/ define/ initiate formal ACD programs with longer term payoff – Marx, Sheet Beam or MBK, Optimized Distribution System
    - Estimate payoffs for ACD efforts for Marx, Sheet Beam or new MBK, Distribution
    - Create Alternate Budget Models and ACD Cost Estimate
  - **Resource Availability**
    - Present cost team must remain fully engaged in remodelling, costing efforts
    - Part of team must focus on RDR writing assignments
    - *Resources must be applied to FY07-09 R&D efforts on all critical components if cost reductions to become reality.*

Towards the TDR (1)

- Design & Engineering: Post-RDR Phase
  - **R&D, DFM:**
    - Next 2-3 years design, prototype manufacturing versions of ACD klystrons, modulators, distribution
    - Assuming success with Marx, design & build up to 4 Design for Manufacture (DFM) units starting FY07
    - Demonstrate significantly lower cost, reliable klystron
    - Demonstrate optimized Distribution on cryo-module under full power conditions.
    - Develop, evaluate industrial sources for all critical components
  - **Resources**
    - All R&D programs require strong engineering support to achieve success
    - ACD Marx is on stable track & should be well-supported in FY07; additional funds for industry-built units needed FY08-09
    - ACD Klystrons, Distribution need new resources (none in FY06)

Towards the TDR (2)

- Project Management: Post RDR Phase
  - **Technical Management**
    - New leadership staff needed to develop project plans, budgets and schedules using PM tools
    - Transition from R&D to Project status requires significant buildup of project engineering, engineering associates, drafters, technicians, field supervisors, coordinators, other TS liaisons.
    - *Tasks include:* Design of staging and test facilities, equipment, factory models; design & adoption of instrument, diagnostic standards; introduction of engineering best practices for project; documentation of all designs for vendor negotiation and quotes; buildup of full project resources-loaded schedule; detailed manufacturing, staging, integration and test models.

Towards the TDR (3)

- Project Management: Post RDR Phase
  - **Resources**
    - ***Resources must be planned soon after RDR to assure smooth transition from current R&D mode into Project operational mode***
    - ***Requires significant transfer of responsibilities from R&D to new engineering personnel with proven successful experience in large project management.***
    - ***Requires significant new funding and progress on overall project planning starting in FY07.***