Cost & Schedule
US Perspective

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Outline

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- **Observations**
- **General Methodology and Issues**
- **Questions in the Charge**
- **Proton Driver Example**
- **Summary**

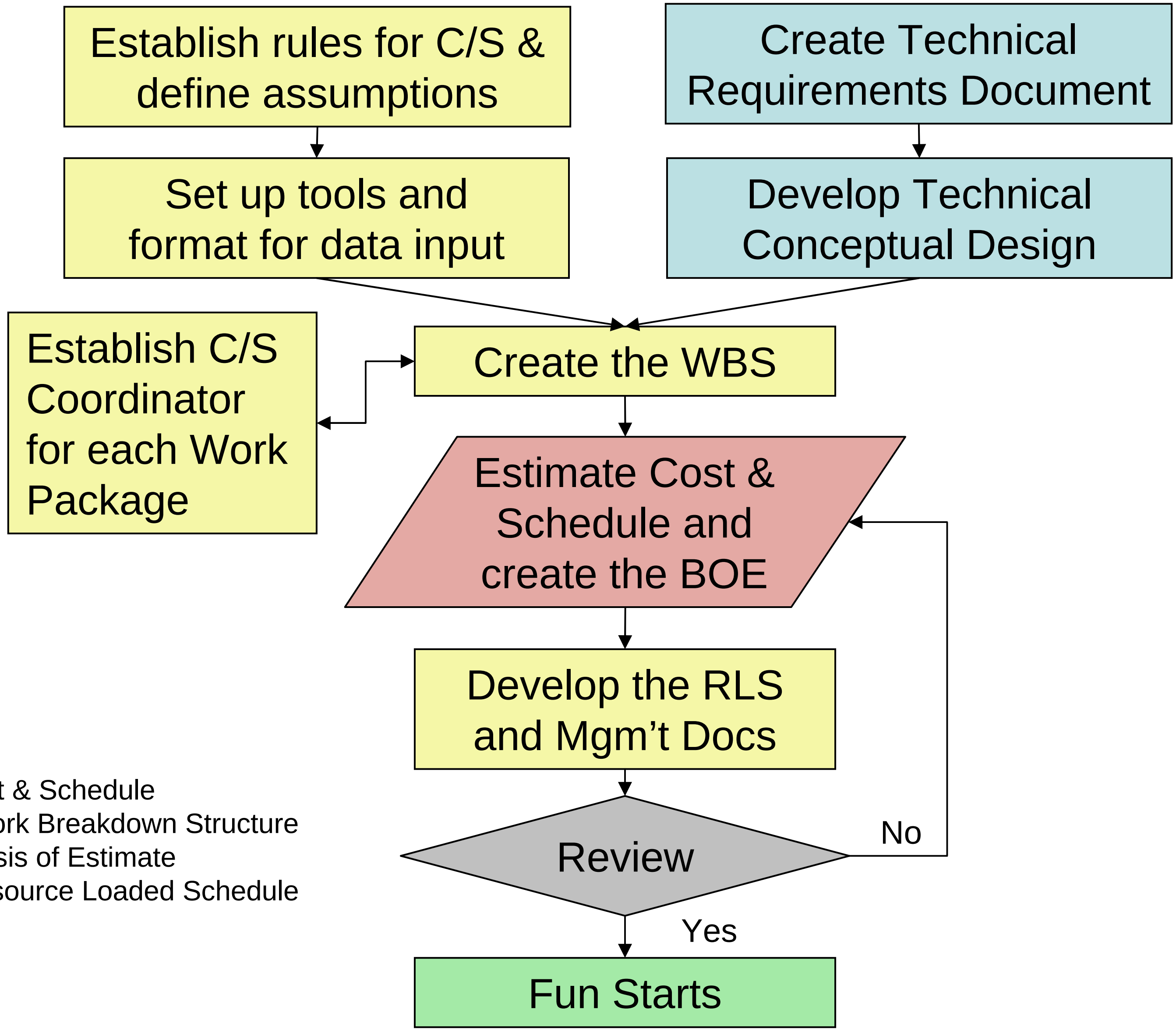
Opening Comments

- My view of this Cost & Schedule (C/S) Session:
  - This talk => More of a guideline to stimulate further discussion rather than a prescription/tutorial for how to do it
- Globally, there are differences in C/S methodology
  - Assumptions (what's in and what's out, who's responsible for overruns, how to calculate contingency…)
  - How detailed an estimate is required
  - Basis of Estimate (how one justifies the numbers)
  - Software used (commercial, home-grown)
  - General emphasis/goals of the process are even different
- Need to agree on the approach for Cost/Schedule exercise
  - An all inclusive estimate with nothing hidden or assumed
  - A more global estimate that acknowledges different approaches in the three regions => keeps ILC from being "priced out of the game"

Observations

- If you know the answer before you perform the Cost & Schedule exercise => expect problems
  - Cost overruns and schedule slippage
  - Technical compromises
    - Reduced performance to begin with or less QC steps (more risk)
    - Possible descoping (leads to required "upgrades")
  - Results in "Blame Game"
- Set the rules for the C/S exercise and develop the tools before asking people to fill in the numbers
  - Helps to assure consistency
  - Allows estimation of the cost, schedule and risk concurrently
- People are taking this more seriously (these days)
  - Shock of projects actually being cancelled

General Methodology



C/S = Cost & Schedule
WBS = Work Breakdown Structure
BOE = Basis of Estimate
RLS = Resource Loaded Schedule

Some Issues to Resolve

- Defining end of R&D vs. beginning of the Project?
- How to handle (not all inclusive):
  - Assembly and test facilities (if needed in the R&D phase)
  - Scientist salaries
  - G&A that varies widely across institutions
  - Overheads such as space, floor or utility charges
  - Efficiency or error rates and learning curves
- Basis of Estimate can be made up by
  - Catalog price
  - Vendor quote
  - Compare to similar projects
  - Time in motion study
  - Parametric analysis
  - Physicist/Engineer estimate

All have different risks and require different levels of contingency

Some Issues to Resolve (cont'd)

- Work Breakdown Structure (WBS)
  - How to structure it and how deep to go?
  - What's the appropriate level to allocate costs?
- Cost Estimate
  - Define level of confidence/risk (50/50 Rule, probabilistic…)
  - Contingency methodology
  - EDIA (bottoms up, % of cost or complexity of work [# of drawings])
- Resource Loaded Schedule (RLS)
  - Common resource file
  - Fully loaded salaries
  - Common calendar
- Cost Accounting (Earned Value Analysis)
  - Compare $ or hours

Tools Required

- What are the tools?
  - Data/Information Manager (web accessible)
  - WBS development software
  - Requirements database and risk assessment software
  - Spreadsheet (or equivalent) for cost estimate (MS Excel…)
  - Schedule Software (MS Project, Open Plan, Primavera…)
  - Cost Accounting Software (COBRA…)
  - Would like all to be interoperable
  - Simple user interface for data input and monitoring

Current Practice

- What is the current practice and methodology for project cost and schedule estimates?
- Surprisingly, there seems to be agreement (in the US) as to how to address cost and schedule methods for DOE projects => a direct result of DOE Guidelines (DOE Order 413.3) and Lehman Reviews
  - Critical Decisions and what is required to meet them
  - WBS, Cost Estimate including contingency, Basis of Estimate, Resource Loaded Schedule, Milestones & a way to track them, and a plethora of management documents (including risk analysis and management)
  - In all large projects => Earned Value Reporting is required
  - Peer Review is a powerful tool for forcing consistency and accuracy

Rules

- What should be the process for establishing a set of "rules" for ILC cost and schedule estimates?
- Need agreement as to which C/S System will be used
  - Can/should this be different in each region?
  - Include all costs? => Nothing hidden or assumed
  - How detailed (what level of the WBS to go down to)?
  - How to handle "in kind" contributions, currency variations, vendor estimates, contingency, risk, or common calendar for work?
- Need to have some level of "stable" conceptual design
- Need a consistent set of tools to perform the C/S work
- With this in hand => form a Global C/S team with representatives from each region and give them the necessary resources to manage the effort
- Data needs to be globally accessible (ILC/PDM System)

Specific Issues

- How should we handle contingency, overheads, "in kind" contributions, lab or university contributions?
- Two approaches
  - Manage the project the same way no matter where or how the component is built or funded (ILC managers are part of process)
  - Treat components as deliverables and let the responsible party worry about overruns, overheads, etc. (fixed price contract)
    - Who really controls the specification?
- How to "value" contributions?
  - Cost everything as if it were being done in one country
    - Value the contribution at this estimated cost => don't get extra credit if it costs you more
- "True" contingency should be managed by the project
  - Held at a high level by each Region/Funding Agency
  - Part of a common fund (but still tied to the source of funding)

Industrial Work

- Should we include actual estimates for industrial work in a public cost estimate?
- Cost estimates must have an accurate BOE
  - **Vendor estimates are a critical part of this process**
  - Should keep the name of the vendor classified (Vendor A) and not release confidential back up calculations or analysis
  - Be Careful ! => Budgetary estimates are non-binding and conditions in industry change with time
  - Need to factor in the risk of a single sourced procurement and the "strain" that a project of the ILC scope can place on the system

Vendor Profit

- What is the correct methodology to include profit in estimates for industrial work?
- Needs to be included in a bottoms up estimate
- Vendor budgetary quotes include profit, overhead, etc.
- Civil estimates (depends on the level of complexity)
  - Estimates tend to be bottoms up and parametric
  - Overhead & Profit (OH&P) ~ 20-25% on top of the whole job
- Components => moderate-size company (generalization)
  - Overhead ~ 40-60%, G&A ~ 12-15%, Profit ~ 10-15%
- Components => large-size companies
  - Numbers could double
  - Tends to be more negotiation involved in setting percentages
- Machined parts (competition drives the cost down)
  - $60 to $120/hour (or more) depending on type of machine required

Industrial Cost Studies

- Should ILC commission industrial cost studies of ILC in all 3 regions?
- Independent cost studies are a good way to certify the accuracy of the cost estimate
  - In the US, one could certainly imagine that the estimate would be scrutinized, reviewed and audited by agencies outside of the DOE
  - Work currently going on in Europe is an excellent start
- The “need” to do it in all three regions is a function of the belief that the results would be substantially different
  - Better yet could there be a common industrial cost study in which vendors from different regions participate?

Developing a Cost Model

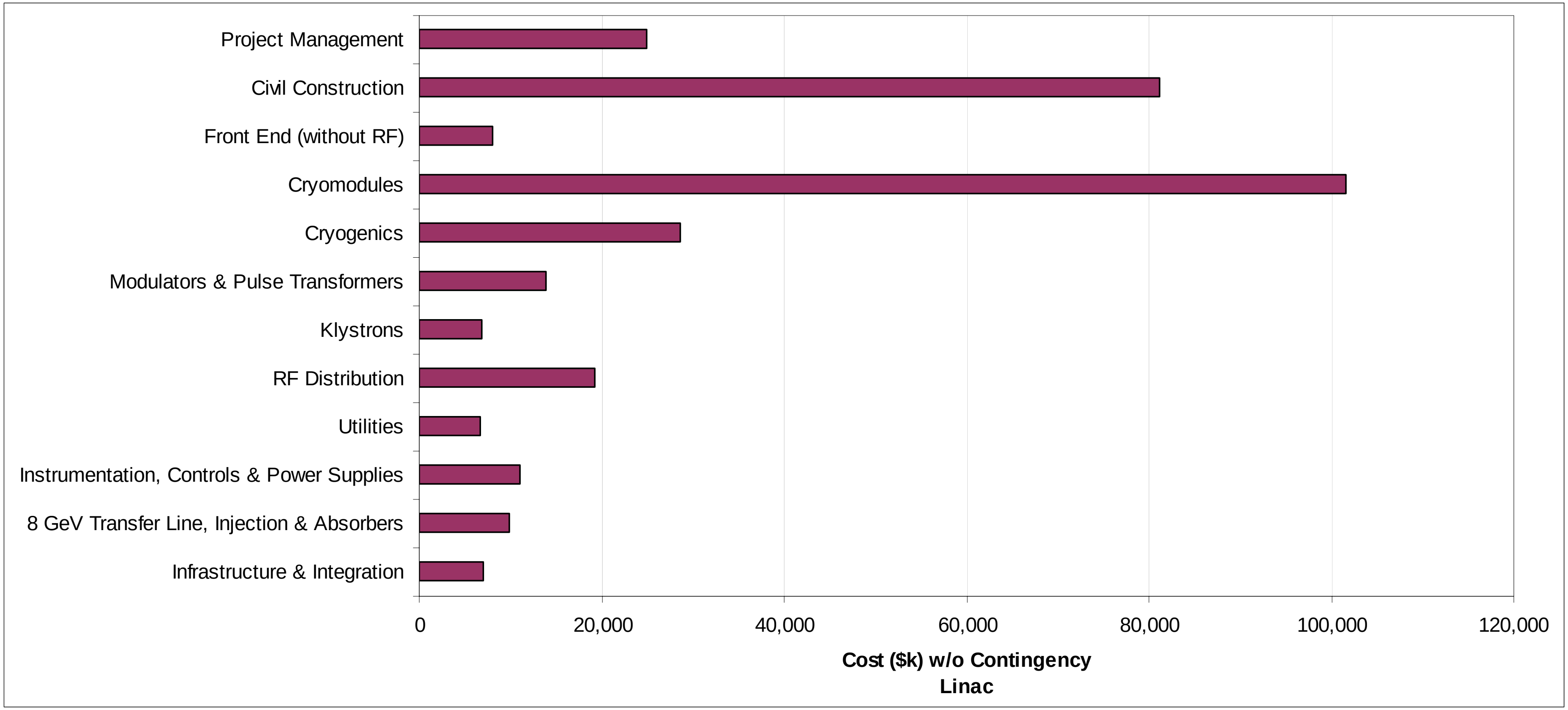
- How do we develop a cost model for ILC?
- Don't jump into creating the numbers too quickly
  - You probably won't like the results
- Focus on "the big picture"
  - Get agreement as to what the model is first
    - Involves: ILC management, Funding Agencies, Legislatures, etc.
  - Put the tools in place
  - Use the work of previous projects and current proposals for similar work to act as a guide for the ILC estimate
    - TESLA Report, XFEL, SNS, Proton Driver can all help to verify the accuracy of the ILC approach
  - Clearly, industry has to get involved in developing the cost estimate as they will be the only possible source for the scope of components required
    - Need to involve manufacturing experts

Cost Model (cont'd)

- Looking at potential cost drivers
- Hopefully the Civil Planning Group can develop an accurate civil construction cost estimate based on representative sites in each region
  - SNS, XFEL, PD and NuMI experiences will all help
- Won't know the "bottom line" cost of building a cryomodule until a factory is set up to produce them and you run it like an assembly line (understand each step of the assembly process and look to optimize each part) => industrial studies help
- Costs for cryogenic plants and distribution should be able to be estimated based on similar projects and an accepted cost function relationship (cost vs. capacity)
- Electronics and rf power sources benefit from constant technology advances (lowers price) => translates to reliable estimates
  - As long as you are not too aggressive on taking advantage of expected "learning curves" and things like Moore's Law

Proton Driver Example

Recently, a preliminary cost estimate was developed for the FNAL Proton Driver in order to establish a reasonable Range of Values. The base cost estimate was $412M (using an across the board 30% contingency) with a range up to $500M. As always, the assumptions are key to understanding the estimate (what's in and what's not).



Proton Driver (cont'd)

- Cryomodule cost was estimated based on a combination of vendor quotes, DESY, JLab and SNS experience and FNAL engineering estimates. Review Committee felt that this cost was appropriate for this stage of the project. *The cost for setting up the assembly and testing facilities was not included.* (Synergy between PD and ILC) A Resource Loaded Schedule is currently being developed which will further refine the cost estimate.

WBS LEVEL					ITEM	Unit	M&S Cost	Quantity	M&S Tot.	Eng/Mgr	Tech	Phys	Labor	Total
1.	2.	3.	4.	5.			$		$k	FTE-yr	FTE-yr	FTE-yr	$k	$k
4.	**5.**				**Beta=1 Elliptical Cavities Cryomodules**	**C.M.**	**1,531,000**	**36**	**55,116**	**20.03**	**66.81**	**5.35**	**8,082**	**63,198**
4.	**5.**	**1.**			**Beta=1 Cryomodule Components**	**ea**	**1,521,000**	**36**	**54,756**	**4.80**	**0.00**	**1.20**	**624**	**55,380**
4.	5.	1.	1.		Vacuum Vessel & Pipes	ea	300,000	1 /CM	300					300
4.	**5.**	**1.**	**2.**		**Cavities**	**ea**			**742**	**0.00**	**0.00**	**0.00**		**742**
4.	5.	1.	2.	1.	Raw Niobium	ea	26,000	8 /CM	208					208
4.	5.	1.	2.	2.	Cavity	ea	34,000	8 /CM	272					272
4.	5.	1.	2.	3.	Processing	ea	14,000	8 /CM	112					112
4.	5.	1.	2.	4.	Helium Vessel	ea	150,000	1 /CM	150					150
4.	5.	1.	3.		Quads	ea	29,000	1 /CM	29					29
4.	5.	1.	4.		Supports	lot	70,000	1 /CM	70					70
4.	5.	1.	5.		Magnetic Shields	lot	21,000	1 /CM	21					21
4.	5.	1.	6.		Couplers	ea	31,500	8 /CM	252					252
4.	5.	1.	7.		Tuners	ea	11,500	8 /CM	92					92
4.	5.	1.	8.		Instrumentation	lot	1,000	1 /CM	1					1
4.	5.	1.	9.		Interconnection Parts	lot	14,000	1 /CM	14					14
4.	5.	1.	10.		EDIA	lot			0	4.80		1.20	624	624
4.	**5.**	**2.**			**Beta=1 Cryomodule Assembly**	**ea**	**10,000**	**36**	**360**	**15.23**	**66.81**	**4.15**	**7,458**	**7,818**
4.	5.	2.	1.		Assembly (LHC experience)	ea		36 /CM	0	13.85	64.04	3.46	7,051	7,051
4.	5.	2.	2.		Installation	ea	10,000	36 /CM	360	1.38	2.77	0.69	407	767

Summary

- Cost and Schedule methodologies differ in the three regions of the ILC Project
- A common approach must be formed to allow comparison and to be able to incorporate input from all three regions
- Basic method for cost and schedule estimation involves
  - Set the rules for the C/S process
  - Define the assumptions
  - Establish a Technical Conceptual Design
  - Develop a Work Breakdown Structure
  - Estimate the Cost & Schedule (including contingency & risk)
  - Create the Basis of Estimate
  - Input the data to a Resource Loaded Schedule (with milestones)
- **We are ready to move forward with the process of developing a cost and schedule estimate for the ILC**