Report from the Upgrade Cost Group

RRB Meeting
April 23, 2018

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Step 1 Approval: RRB September 2015

- Both ATLAS and CMS have attained levels of preparation and understanding that meet, and in some areas exceed, requirements for Step 1 approval.
  - Estimates are detailed, and based on experience and vendor quotes
  - The reference scenario is well matched to the science, without overkill.
    - cost savings via further optimisation are possible.
  - The lesser scenarios will diminish capability and reduce efficiency.
  - For ATLAS, the forward region presents the most serious challenges and largest risks to cost and schedule, involving LAr, Muons and infrastructure.
  - For CMS, though the cost and schedule estimates for the HG Endcap Calorimeter are reasonable for this stage, much R&D is needed to produce a detailed design and TDR.
  - Though the UCG deals only with core costs, clearly these projects depend on adequate and sustained support for manpower and other resources at the participating institutes.
- **We recommend that you strongly support this … program, and approve resources to allow the experiments to develop detailed designs and TDR's in preparation for Step 2:**
  - **Scientific/technical review by LHCC → Review of baseline cost and schedule by the UCG → approval by the CERN RB.**

Instructions for Phase II TDR submissions to UCG (Sept 2016)

Each TDR should demonstrate that:

- The work scope is complete, well organized with clear assignment of responsibilities.
- Cost estimates are based upon standardized and disciplined processes.
- A well-detailed resource-loaded schedule exists, and provides the basis for all cost and schedules.
- A well-detailed risk registry has been developed and implemented.
- Staffing needs are well identified and achievable.
- The project is poised to initiate and effectively manage the final detailed design phase of the project as well as begin long lead procurements.

Preparations for UCG reviews of TDRs (starting Jan 2017)

- Goal: Review the 10 TDRs in time for RB approval in April 2018 (Mission impossible!)
  - First LHCC review Feb 2017; LHCC review of final 3 TDRs Feb 2018
  - First UCG review May 2017; UCG review of final 3 TDRs Apr 2018
    - **Required two extra dedicated UCG weeks: January 2018 and April 2018**
- Process:
  - Set up separate ~10 person review panels for each TDR -- large overlap with LHCC panels.
  - "Rejuvenate" the core UCG: Mauro Morandin and Frank Simon come aboard in Nov 2017
  - Standard review cycle to allow in-depth evaluations, ***including three meetings with experiment.***
    1. UCG cost package submitted ~1 month before LHCC review
       – Cost estimate and WBS, schedule, manpower survey, risk register, funding profile, MM.
    2. **Kickoff UCG meeting** at CERN during week of the LHCC review, to go through UCG material and raise issues.
    3. UCG compiles questions (typically 150 – 200) for experiment.
    4. **Vidyo meeting** with experiment to answer questions and have discussion of arising issues.
    5. **Face to Face final meeting** with experiment (whole day). Deep drill downs into BOE's, WBS, schedules, resources.

Agenda for UCG Review of ATLAS ITk Strips, May 8-9, 2017

Monday May 8

Morning Plenary Session 0900-1300

ITk Project Overview and Organization: McMahon
Strip Project Organization: Gregor
Common Mechanics: Anderssen, Viehauser
Common Electronics: Grillo
Pixel Detector: Morettini
Strip Sensors (2.2.1): Lacasta, Unno
Strip ASICs (2.2.2): Gonella, Teuscher
Strip Modules (2.2.3): Affolder, Bloch
Local Support and Off-Detector Electronics Bernabeu,
Strip Local Supports (2.2.5): Diez, Jones, Lynn
Strip Global Mechanics, Lacasta, Wilmut, Vreeswijk
Risk Management (Tuesday): Proudfoot

Afternoon breakout sessions 1400-1800

Session I **Drilldown of wbs, costs, etc, for the strip sensors and modules**
Nahn, Honma, Petagna

Session II a and II b **ASICS, Local Supports, off-detector Electronics**
Moll, Forti, Klempt, Touramanis

Session III a and III b **Local Support Mechanics, Global Mechanics, Services and Integration; Common Electronics, Common Mechanics and Pixels**
Wisniewski, Kunne, Smith, Burrows

Tuesday morning May 9– Discussion of Homework Questions

Comments on the 6 ATLAS Phase II Upgrade Projects

- **Cost:** Current estimate (267M) stable since Scoping Document (271M). Reduced by not implementing forward LAr, added HGTD.
  - Cost risk is relatively low, QF's are converging.
  - Long-term uncertainty in TDAQ estimate because procurements are 5 years away. A significant opportunity for cost saving could be realised if a central order could be negotiated for most if not al of the huge number of FPGA's in the TDAQ!
- **Schedule:** The ITk Pixel schedule is extremely tight, and will likely expand after critical path analysis has been done:
  - time to transfer RD53 prototypes into production FE ASIC, assembly model, etc.
  - Installation, integration and commissioning will be particularly critical given the short time available, the many dependencies, in particular with the TDAQ system
  - Impact of the delayed NSW Phase I project.
- **Risks:** Mainly in schedule, for reasons above.
  - Risk management of some systems does not yet take into account correlated risks, either within a system or global to ATLAS.
  - RPC leak fixing poses technical, and possibly financial risk.
- **Resources:** Money matrix is close to convergence, needs more contributions to HTT (~5M) and resolution of smaller mismatches (~1M). Manpower OK, need to watch for new peaks if more work has to be done in parallel.

Comments on the 4 CMS Phase II Upgrade Projects
(TDAQ still to come)

Cost: Currently 279 M CHF, an increase of 14M CHF from the Scoping Document.

- The increase is due to the MIP Timing Detector, which was not in the original scope.
- Current cost estimates and cost risks look reasonable, with possibilities for small reductions.
- Most quality flags should converge to 1 or 2 within a year. (They have quotes for Silicon.)

- Resources: Good manpower availability; MM is converging. Enormous Silicon-based activities. Need to be sure that the IT, OT, and EC do not exhaust the supply of appropriately-skilled manpower and facilities, at CERN and throughout the collab.
- Schedule: Credible at this stage, but there are major risks:
  - IT: Delay in production of FE ASIC; Phase I issues raise short-term potential resource confllcts.
  - Coping with immensity of Tracker and EC projects. QA/QC/Management must be first rate. Plans are being developed for extra sites to increase throughput if needed.
  - Schedules for Muon System and Barrel Calorimeter are well-developed and low risk.
- Risks: Mainly to schedule. Also technical risks to IT till FE ASIC is in production.
  - Correlated risks are described on a following slide.

Correlated risks: multiple subdetectors, both experiments

- Exchange rate fluctuations.
- RD53 program takes longer to produce final front end chips.
- Delays in other common programs, like the lpGBT and optical modules.
- Underestimates of scope for major facilities, e.g. cooling
- Unavailability of current gases for muon systems, or major cost increases.
  - Mitigation: Reduce consumption by factor ~10 by fixing leaks
    Early purchases to accumulate reserves
    R&D to find acceptable environmentally friendly gas mixture
- Increase in price or slow delivery of silicon.
  - Mitigation: Lock in prices, find second or multiple vendors
- Overdemands on CERN services
  - Mitigation: Coordination of tasks among projects and experiments
    Identify industrial possibilities to handle peak periods.
- Correlated ***Opportunities:*** Common FE chip design for pixel detectors.
  Central orders, e.g. for FPGAs

Conclusions from the UCG reviews of the most challenging upgrades: ATLAS ITk Pixels and CMS Inner Tracker

- The ATLAS and CMS Pixel trackers are the most complex projects in the Phase II upgrade program, involving new technology that still has important R&D and design development ahead before launching production.
- It is therefore urgent to select among the various open options for technology and front-end ASIC development.
- The assembly model involves transfers of delicate components around the world, requiring tight management controls and QC/QA.
- The schedules are a real challenge, but there are opportunities to contain them if the experiments get on top of the issues early.
- The costs appear to be reasonably understood, so the main risk lies in the schedules.
- Overall, these projects are in good shape for this early stage. We therefore recommend Step 2 approval by the RB and RRB to allow resources to become available and MOU's to be signed. Vigorous oversight of these projects, including external reviews, is essential.

Observations on cost containment

- Important for project planning to get institutional commitments (and recognition) in MOUs for non-core deliverables, e.g. software, firmware, etc., as well as for design and construction of equipment and hardware.
  - Timely availability of experts is critical for the success of most projects.
  - Engineering manpower includes physicists with appropriate expertise as well as engineers.
- Boundaries between project, Technical Coordination, M&O, common fund must be carefully defined.
- Money matrices are well aligned on the whole, but there still are a few mismatches to deal with. Experiments need flexibility and cooperation to complete the process.
- Central procurement contracts, usually managed through CERN, are extremely effective in reducing costs, which will increase dramatically if they cannot be negotiated.
  - In reviewing the TDRs we saw cases, often involving large FPGA purchases, where the current cost estimate is based on a central contract, generating a cost risk should this prove unfeasible.
  - We also observed cases where combining now-separate FPGA orders would save significant costs.

Cost containment, cont'd

- Treatment of spares should be clear:
  - Sufficient number of parts in initial procurements to ensure completion of detector and have stock of items that will be unavailable in later years because of obsolescence.
  - Allowance in M&O budget for long-term replacements
- QA, QC, and Project Management are of critical importance in achieving cost and schedule.
  - Silicon-based detectors and muon systems have many fabrication sites and long supply lines.
  - Vendors need intensive oversight.
  - Proactive management of delays and problems can minimise impact on critical path.
  - Completion of Phase I upgrades before they impinge on Phase II manpower and/or schedule; or failing that, revisions as necessary of global schedule to minimise delay in readiness for operations.

Proceeding to Step 3 [readiness for construction]

- Need to converge on Money Matrices in order to negotiate MOUs.
  - How precise does the MM have to be?
  - How much flexibility is there to level out mismatches?
  - When should they become final?
- Need a process to authorize long-term purchases in advance of Step 3 approval.
- External reviews: Following Step 2 approval reviews à la UCG are essential to keep the experiments on track as they transition through R&D, detailed design development ,and long-term procurements, toward Step 3 approval, and thereafter throughout the construction/production phase.
  - We envisage two 10-12 person panels of technical experts, one for ATLAS, one for CMS, covering all the relevant technologies as well as project management.
  - “Intelligent scheduling” is important to reduce burden on CMS and ATLAS

Conclusions

- Three years after receiving Step I approval, CMS and ATLAS have produced credible baselines for all their upgrade projects (except CMS TDAQ, which will appear in ~2 years).
- The resource picture looks very good, with remarkable matching between needs and interests. Money matrices are nearing convergence. Remaining mismatches can be evened out by flexibility and cooperation among FA's, institutions and the collaboration managements.
- Inevitably there are significant risks in projects of this scale, especially concerning schedule, but the mitigation strategies appear adequate for this early phase. Correlated risks must be carefully watched.
- These are very large, complex projects, requiring excellent and comprehensive project management to succeed. External reviews will be set up by CERN to monitor progress.

General Recommendation: ATLAS and CMS should receive Step 2 approval, so MOU's can be signed, long-term items procured, and resources made available to complete R&D, prototyping, etc.; and proceed toward Step 3 approval (readiness for construction).