

24 April 2015

LARGE HADRON COLLIDER COMMITTEE
LHC Experiments Phase-II Upgrades Approval Process

1. MOTIVATION AND SCOPE

The HL-LHC programme will require significant upgrades of the existing experiments to maintain detector performance in the presence of high radiation damage, increased pile-up, challenging trigger rates.

The upgraded detectors will have to be installed during the LS3, currently scheduled for two and half years starting at the beginning of 2023. The LHCC and UCG will work in close connection to ensure a timely review of the scientific and technical feasibility as well as of the budget and schedule of the upgrade program. Given the significant cost and scope of the Phase-II upgrade program, a multi-step approval and verification process is required, outlined below and detailed in the rest of the document:

- In the first step, the overall scope and cost for the entire upgrade program for each experiment will be defined, with the possibility to maintain different options which may depend on technical issues and/or on funding availability.
- In the second step, the detailed technical design reports (TDR) for the various subsystems will be reviewed. These TDRs will naturally come at different times depending on the maturity of the projects, and will be reviewed individually, with the requirement that each fits in the overall approved plan.
- In the third step, the final design and construction readiness of the major detector components will be reviewed. As in the second step, different subsystems, and in some cases also different elements of subsystems, will be ready at different times, and will be reviewed accordingly, with the requirement that they are compatible with the overall construction and installation plan.
- In the fourth step, as sub-systems are coming together in the experiment, an operations readiness review should be held to evaluate the capability of the completed detectors to provide the expected performance and mark the end of the Phase-II upgrades construction project. The exact timing, scope, and procedure of the operations readiness review will be defined at a later stage.

The entire process will be driven by the scientific goals of the experiments, captured with the aid of a few detector and physics performance benchmarks.. The benchmarks can be

used to gauge the cost-effectiveness of different detector options as well to provide a quantitative assessment of the degree of success of the detector construction. Technical feasibility and suitability will be also part of the LHCC review.

Detector construction financial information, which will be reviewed by the UCG, should be provided in the form of an unescalated CORE cost without contingency denominated in Swiss Francs, complemented by an indication of the required work expressed in person-month, typically separated in various work categories. Specific forms will be provided, as for the Phase-I upgrades, to ease the review and guarantee the uniformity of the information provided. A risk analysis and estimate of the uncertainties should also be carried out at each stage of the project.

2. STEP 1: Approval of preliminary design for the complete set of Phase-II upgrades

1. The experiment will provide an overall description of the intended upgrade program in the form of a Letter of Intent or Technical Proposal, supplemented by a “Scoping Document” (SD) with the specific goal of exploring different detector scoping options. The combined documentation will contain conceptual designs for all elements of the upgrade, and will include:
 - Physics motivation and performance, with a discussion of the optimization of cost vs. capability. In particular it is important to produce good quantitative justification for any detector extension or improvement, for instance in term of solid angle coverage.
 - A detailed description of each detector element, supported by R&D or prototyping results
 - Plan and schedule for remaining R&D, prototyping, etc. needed to develop detailed designs, and to determine final cost estimates and schedule.
 - Plans for selecting among alternative technical solutions, if any.
 - Current estimates of approximate total CORE project costs, manpower, schedule and needed funding profile, in sufficient detail to allow a meaningful review.
 - A list of expected Technical Design Reports and an overall plan with milestones and schedule for producing them.
 - Options for detector scoping with a total cost in the approximate range 200–235–275 MCHF with a discussion of the impact on the physics performance and in particular on the performance benchmarks.
2. The experiment will provide a separate, confidential document containing a preliminary funding plan with the “money-matrix” expected from the various funding agencies.

3. The LHCC will review the documentation for technical feasibility and capability to address the science, while the UCG will specifically evaluate cost and schedule.
4. The LHCC/UCG positive recommendation and approval by the RB, followed by a presentation to the RRB, will allow the experiment to proceed with the process needed to establish a firm budget, schedule and funding profile. CERN Management will propose to the RRB a reference number for the total CORE cost of the Phase-II upgrades for each experiment.

3. STEP 2: Approval of baseline design, cost and schedule

1. For each upgrade element, the experiment will submit a TDR to the LHCC and UCG, with the purpose of validating the element's design and establish a firm cost and schedule. TDRs are expected to cover the entirety of a complex system and not be limited to small specific items. A TDR should include:
 - Physics motivation and performance, with a discussion of the optimization of cost vs capability and of the performance benchmarks connected with the specific detector element.
 - Detailed description and design of all the components of the detector system
 - Detailed budget with risk register, estimate of uncertainties, and mitigation plan.
 - Technical and scientific manpower required, and its availability at the participating institutions.
 - Scenarios for less than full funding, documenting the science tradeoffs.
 - Project management plan.

The experiment will provide also a separate, confidential appendix containing:

- A money matrix indicating how the costs will be shared among the funding agencies
 - A funding profile showing that funds will be available as needed to meet the schedule.
2. The LHCC and the UCG will review each TDR separately, assessing the scientific soundness as well as the technical, financial, and schedule viability of the project, convening technical subcommittees as needed. Approval is contingent on the anticipated availability of adequate funding. A set of relevant benchmarks defining project success will be defined and agreed in the process.
 3. Upon a positive review, the LHCC/UCG will recommend to the RB the acceptance of the technical design, cost estimate, and schedule as firm baselines for the project. The CERN management will keep the RRB constantly informed of the TDRs review

process and, upon approval, the appropriate MoU-addenda will be drawn up and opened for signatures.

4. STEP 3: Approval for construction

1. The experiment, in consultation with CERN and LHCC, will convene construction readiness reviews, to ensure that any open issues at the time of TDR approval have been resolved, and that the detailed plans for construction and integration of the upgrade are consistent with the baseline set by TDR approval.
2. A successful review allows the construction spending to start. The experiment may request specific approval for the acquisition of long-lead-time items prior to full approval for construction.
3. Progress in construction will be constantly monitored by the LHCC through its regular quarterly sessions and with dedicated in-depth reviews organized once a year for each experiment. The entire process will also be monitored by the RRB through its scrutiny group.