ATLAS P2UG Review

November 2022

General Remarks

- Our thanks to the whole ATLAS team and management for a productive review
  - The reviews are time-consuming on both sides of the table, but of course play a key role in underwriting the ongoing confidence in the project
- Excellent presentations and discussion in all sessions, with good uniformity of approach
- Availability of materials significantly in advance was much appreciated
- Our overall assessment of the situation:
  - Things are going increasingly well in many areas, though many challenges still in play
    - Several new technical problems remind us of just how far we have yet to go
  - The level of schedule contingency is of course not satisfactory, and bringing everything for current due dates remains unlikely – *but still possible if efficiencies can be found*
  - The ‘review pile-up’ is being dealt with effectively, and ATLAS’s self-review procedures are working well

Reviews

- The ATLAS internal review schedule is punishing, but we observe it working effectively
- Good to see that some reviews are delayed or passed only with important recommendations
- Some concern about the availability of review reports in a timely fashion
- P2UG participation in review processes
  - Not our job to ‘put our hands on’ ATLAS procedures, but in this intense period, would be helpful to track the project more closely than once per six months
  - Propose that review materials and reports are made available to P2UG ‘in real time’, allowing us to respond and be efficient at reviews
  - This is particularly important for PRR or where decisions are made to change specifications or design
- In some cases, we will ask for specific update presentations / documents at the February intermediate P2UG meeting

Procurement

- The professional efforts of the CERN procurement office and ATLAS procurement team are (increasingly, obviously) essential in making the project work
- There is a natural tension between the immediate need to follow established rules and the long-term optimization of the project – not unique to ATLAS or CERN
  - The goal of everyone concerned must be to deliver the project at minimum *overall* risk and minimum *overall* cost (including the impacts of delays or changes)
- Essential to maintain a healthy dialogue with the CERN PO in order to:
  - Make ATLAS projects aware of complexity and lead times, and help to devise optimal strategies
  - We see several cases where new problems may be encountered
  - Permit a PO awareness of the ‘global optimization’, e.g. justification where necessary for risks or adaption of the rules to ensure *overall* best outcomes

Scheduling and Tracking

- We appreciate and understand the difficulty of scheduling a project of this scale and complexity
  - ATLAS is encouraged to find the necessary expert effort to make sure the tools and procedures operate properly
- There are still some inconsistencies in definitions and treatment of float
  - E.g. difference in terminology and definitions in TDAQ compared to others
  - E.g. who ‘owns’ the float on integrated systems (our answer: the integrated system)
- Essential to specify realistic and well-justified ‘need by’ dates, otherwise assessments of float are meaningless
  - This might be a particular issue for TDAQ, which has a different relationship with installation than hardware systems
- Reiterate the importance of having quantitative tools to give an assessment of remaining float as the project progresses
  - Perhaps becomes most important when production has started, initial delivery rates are established, and input data are more firm

Integration / Installation resources

- Personnel requirement
  - Clearly a substantial demand for ‘bodies at CERN’ – up to 500 people between ATLAS and CMS?
  - There are major practical considerations to be addressed with CERN ~now
- Understand that discussions with FAs / institutes are under way
  - Important to converge these as soon as possible – it is not too early
  - Would be good to understand the basis for commitments – needs to be ‘formal’ in our view
  - Need to understand any potential ongoing impact of the Russia / Ukraine situation on the installation plan
- Encourage ATLAS to take advantage of all opportunities offered by any ‘extended stops’ in LHC operations
  - We understand the preference for an extended LS3 in preference to multiple shorter stops
  - Nonetheless, important to prepare and take advantage of opportunities if they arise

ITK-Common: Observations

- Environmental monitoring: FDR/PRR passed, with one critical action on humidity sensors remaining from the Humidity Sensor FDR
- Database has a PRR scheduled for 2023 and a transition to the maintenance phase will follow. Experience has been gained in production testing of components and data stored for long-term use.
- Common Structures has had some delays due to supply chain issues, but elements were rearranged to prioritize delivery of barrel structures (Outer Cylinder and Structural Bulkhead) to allow beginning of strip integration
- In software, a task force was set up to determine directions and give recommendation for organization. A reorganization is awaiting the outcome of this taskforce.
- Cooling: demonstrators are running and substantial technical progress has been made, while the PRR has been somewhat delayed.

ITK-Common: Comments

- Presentations were very clear and ITK common projects are making good progress in general.
- We look forward to the results of the Online Software Task Force that was set up to resolve organizational and planning issues that are hampering this effort.
- Monitoring: Substantial progress has been made since the last review. A system needs to be in place to prepare for integration into system tests at CERN + full chain readout in Summer 2023.To make this happen, institutional responsibilities and manpower expectations should be made clear.
- The database team should prepare for a transition for core support after the PRR, estimating the FTE effort that will been needed for the maintenance of the software developed by Unicorn and securing an effective transition of the required expertise.
- Cooling: alternatives to triaxial transfer lines are being considered due to cost issues, but these come with technical, schedule, and space issues whose impact is not clear. Alternate solutions pose a risk of introducing new problems.
- Cooling: the team is at a critical limit and any small loss of effort will result in delays.
- BCM' has made substantial progress since last review. We would like to see a reoptimized schedule for the next review.

ITK-Common: Recommendations

- Procurement priming and advance procurements should be pursued in areas that have been noted in the project (FPGA for MON backend for interlock, PCL components for CO2 cooling) and efforts should continue to identify any other items that might be at risk for long procurement times.

- The manpower needs of the CO2 cooling effort should be assessed, together with a plan of resource sharing between the experiments and CERN, and presented at the next intermediate P2UG meeting

- ITK is asked to provide a presentation at the next P2UG intermediate meeting on the software effort including the results of the task force, the deliverables, the timeline and milestones, management structure and responsibilities.

ITK-Pixels: General Remarks

- The ITk Pixel project gave in 14 presentations a complete tour of the scope, presenting schedule status, milestones, risks, focus in the coming year, and technical progress with several major achievements, like:
  - Completion of the RD53A programme with very beneficial impact with experience in module assembly and testing as well as module loading on local supports
  - Module FDR passed
  - Local support loading tested on all three subsystems (IS, OE, OB)
- The project continues to move steadily from final design to production but faces severe challenges threatening completion within the given timeframe.

ITK-Pixels Observations: Schedule

- The pixel project schedule underwent two BCPs in July and October 2022 taking into account the new LS3 dates and changes in the Inner System (IS) integration.

- The last statusing indicates a **float of 6.5 months** for the outer pixel system (OS) against the need-by date of 25.8.2027. The inner pixel system (IS) integration is following the OS integration and has at present a 7.5 months float.

- New LS3 dates and the recent BCPs did not change the situation that the project continues to burn float at a non-sustainable rate.

Comment:

- The pixel schedule has been optimized intensively, is now extremely tight but **remains the ITk schedule driver**. Compared to the other ATLAS upgrade projects, most tasks across the whole project are sitting close to the critical path leaving only very little flexibility or room for further optimization while the present float is very likely not sufficient. Pixel project management has become increasingly difficult in this situation and pro-active measures to avoid further delays have to be vigorously and thoroughly continued across the full project.

ITK-Pixels Observations: Sensors

- **Planar and 3D 50x50 um^2 sensor pre-productions** and pre-production testing have been **completed**. A PRR is scheduled for mid-November and is followed, in the case of positive outcome, by production orders and productions lasting from Q1 2023 to Q3 2024.

- The **3D 25x100 um^2 sensors are delayed** after a first production failed at the chosen vendor. However, a second pre-production batch is foreseen to be supplied in 12/2022 and a pre-production backup production from another vendor has already been received and tested. This allows to plan for a PRR of the 3D 25x100 um^2 sensors in mid-2023.

- All 10 ITK institutes involved in QA measurements are qualified for the most important measurements.

- **Comment:** P2UG concurs with the decision to drop module results from the requirements for the sensor PRR and performed them as soon as possible.

ITK-Pixels Observations: FE-chip

- ITKPixV1 (RD53B-ATLAS) was submitted in March 2020. A problem was detected during the production but could be mitigated by a small mask change for a subset of the production yielding in March 2021 into ITKPixV1.1 chips that could be used as pre-production chips. The design and verification of the production chip ITkPixV2 is ongoing as the planned submission in June 2022 had to be postponed to the end of November 2022 due to a major bug.

- In case of timely submission, the **engineering run chips are expected to arrive in March 2023** and the first production batch (20%) could be delivered in September 2023.

- **Observation**: The submission in November is critical. Missing the date will give a delay of 2-3 months impacting directly on hybridization and module production.

  - Requiring a re-submission would eat all available float in the project or more.

- Update: submission will be delayed – clear implications for overall ATLAS schedule

ITK-Pixels Observations: Hybridization

- The tendering process for the hybridization has been successfully completed and three out of the resulting four Hybridization contracts have been signed with the last one being close to signature.
  - Pre-production milestones and PRRs delayed due to delays in the tender preparation, material delivery and some technical and organizational issues at the vendors, but expected to be realized within the coming 8 months.
  - **Some worry about remaining supplier** that the contract might fail for technical (indium bump bonding) or commercial reasons with impact on Hybridization rate (that could not be covered by the other vendors).
- Production ramp-up of for hybridization and then modules depending critically on ITKPixV2 availability. Any delay will move hybridization from close to critical path (2-4 month) on the critical path.
  - Optimization of production rates for hybridization and modules will be investigated when the production process is established with final objects allowing e.g. to ‘optimize’ QA/QC procedures.

ITK-Pixels Observations: Modules

- FDR passed in June 2022 (without indium bump studies)
  - Indium based Quads for testing expected in March 2023
- PRRs expected for September 2023 (Quad Modules) and April 2024 (Triplet Modules)
- Module production is a very challenging and complex and highly parallelized process involving 15 assembly sites and 19 test sites for the Quad Modules and 4 assembly sites and 7 test sites for the Triplets.
  - Site qualification is ramping up but faces some delays due to availability of tools and the non-availability of ITKPix assemblies

ITK-Pixels Observations: Local Supports

- **Carbon Foam availability worry (OE, IS)**
  - After the supplier Allcomp was bought by Lockheed Martin contracting is not advancing as to a shift of priorities in the company.
  - Alternative foam and supplier identified, however, new foam (POCO) needs to be qualified because of less favourable properties, e.g. higher and fluctuating density
  - Task force established: Some foam remaining, Strip could supply additional foam, Optimized use of remaining stock; Status: Manage to cover Bare LS pre-production phase and PRR, but not beyond.
- **Glue decision for IS and EC loading**
  - The re-workable glue is no longer available; alternative solutions are not yet qualified
  - Mitigation found: The qualified non-reworkable glue could be used on the cost of lower yield

ITK-Pixels: Recommendations

- Continue to work on the carbon foam availability problem and start preparing the procurement of carbon foam from alternative producer, i.e. avoid procurement delays if being forced for an alternative supplier
  - This means: begin the procurement process *in parallel with* technical investigations
- ~~Submit ITKPixV2 in November 2022~~
- Investigate scenarios and prepare measures to mitigate a drop-out of the fourth Hybridization vendor to reach the required production rate.
- Push module site qualification to site readiness (as far as possible without production chip assemblies)
  - Given recent developments, avoiding any further delay in this area is now critical
  - P2UG will review in detail the progress of site qualification in early 2023.
- We would like to see in the May P2UG an update on the expected module production rate and in the November P2UG an in-depth analysis on the module production across the production clusters, the optimization potential in the production and the according risk of optimization and a production rate forecast .

Tile: Observations

- Project generally in good shape. Since last P2UG Review:
  - Some baseline changes across project (ATCA crates, power supplies, optical fibres) – most cases relate to COVID/supply chain
  - Since last time the front end cards (FENICS) have passed PRR and there is lots of review activity planned for December and early into 2023.
  - Key Vertical Slice Tests performed (LV, HV, and Pre-Processor) plus 2 test beam campaigns (June and November) for electronics chain performance checks
- Schedule float generally healthy especially following LS3 schedule updates e.g. floats of >>300 working days for LB-1,LB-2, EB-1 and EB-2

Tile: Observations

- Daughter Board v3 is still waiting for PDR(now set for first half of 2023). The FPGA and other components are still waiting for final radiation test verification. Delays mean the overall float is down to 8 months. Concerns too about procurement delays and availability of components (e.g. The ProASIC3 FPGA delivery already moved from 26 to 56 weeks). Close management is needed to avoid further loss of float.

- LV bricks: FDR passed in Oct'20 but with recommendations. Radiation qualification of an isolation amplifier still not complete. Limited pre-production has started with the favoured component choice but flexibility to use other choices has to be retained for now. Should be resolved by the end of the year.

- Ongoing issue of lack of effort for the Production Database has been resolved, at least in the short term, by the addition of 2 developers

Tile: Observations

- Prototyping is well underway to identify the optimal way to inject laser signals
- The hydraulic system segmentation (to lower the pressure) and choice of fluid are under study
  - Were expecting to see more priority given to implementing a scheme for segmentation since running at under pressure makes continued running with water viable. A mockup should be the next step (simulation is not enough)
  - Studies of NOVEC as hydraulic fluid look promising (uniform flow, inert effect on connection joints) but effect of a leak on neighbouring materials now the priority

Tile: Comments

- The completion of radiation tests remains an issue for the project (e.g. LV bricks and Daughter Board). In most cases plans are in place to complete by the end of this year or the start of 2023. The P2UG needs to keep a close check on progress.

- Component procurement/availability is still a substantial risk for some sub-projects e.g. Daughter Board. The situation with vendors needs to be closely monitored and the ability to purchase outside of the usual FDR/PRR cycles might be necessary.

- Now that hardware and electronics boards are starting to be produced (e.g. mini drawer mechanics, active voltage dividers, Main Boards etc), the question of safe/optimal storage at CERN is becoming important. Sealed packaging in a dry environment is necessary but storage areas in Bat.175/171 with understood temperature and humidity environments are going to be necessary.

Tile: Recommendations

- For installation we heard that 4-5 dedicated teams (2 people each) are needed. We urge the Tile group to be proactive now in securing key personnel from around the collaboration preferably locked-in via some kind of MOU endorsed by ATLAS/CERN.

- There are a host of reviews and key decision points happening at the end of this year and into the new year. It would be beneficial to keep the P2UG group informed of developments as they happen in between the usual cycle of P2UG meetings. This could be via e.g. sharing documents on Sharepoint and emailing or by inviting P2UG attendance at selected FDR/PRR's.

TDAQ: Observations

- Highly clear, informative and concise in-depth review reports, uploaded well in advance
- After the restructuring of EF Tracking, the new design is evolving
- Conflicts of resources with Run 3 commissioning still exist, but the effect is winding down
  - at this point various BCPs made sense and were done
- Procurement problems, e.g. due to the Si crisis are still a significant risk

TDAQ: Observations

- Situation with L0 Muon trigger processors has significantly improved.
  - sector logic for TGC and RCP, while being delayed, have good chances to catch up with their schedule, and BCP may not be needed. Good progress with firmware development.
  - for MDT, the BCP has been done. Important milestone FDR in Q3 2023. First prototype of command module assembled and being tested.
  - NSW still affected by person power conflicts with Run 3 commissioning. SPR pending Q1 2023. BCP may be appropriate early next year. Mezzanine demonstrator PCB being assembled.
  - float in current schedules ranges from 224-414 days
- L0Calo: experts previously absorbed in Run 3 (jFex/L1Topo) commissioning now becoming available
  - fFex SPR/PDR passed with actions
  - significant progress with fibre remapping (FOX)
  - baseline change +5 months. Still ~2.5 years of float

TDAQ: Observations

- L0Central: requirements & specification converging
  - CTP: BCR move by +21 months
    - SR coming up end 2022
    - "Needed-by-ATLAS" date end 2028: justified by availability of prototype for earlier tests
  - MUCTPI: valuable experience from Run 3 operation
    - preparations for SR in summer 2023
- TTC: addressed worrisome timing-related findings reported at last P2UG meeting
  - Detailed tests of clock and phase jitter
  - found/solved a link configuration problem
  - clock jitter reduced 2 ps -> 1 ps; phase uncertainty 20 ps -> 10 ps
  - this might be good enough for HGTD

TDAQ: Observations

- Global Trigger:
  - thermal tests of GCM with reassuring results
  - in ATCA configuration, thermal load and power consumption well within USA16 specifications -> do not change architecture to PCIe; stay with ATCA
  - FPGA selection completed well in time for PDR
  - very commendable progress on (firmware-based) trigger algorithms for numerous physics objects
    - trigger algorithm panel in place
    - integration in trigger framework

TDAQ: Observations

- Event filter: schedules strongly affected by decision process for EFTracking design
  - technology decision for heterogeneous EF node architecture will proceed along creation and evaluation of three demonstrators (Q4/2025)
  - besides EFTracking, also EFMuon and EFCalo anticipate use of accelerators
  - new milestone: PRR for first batch (10% of final production system) of commercial server purchase 23/02/2026
- EF Tracking:
  - interesting studies on innovative tracking algorithms, making use of accelerators
  - according to the baseline schedule developed in spring, the project is on schedule

TDAQ: Observations

- Network: for technology choice, options have been evaluated
  - ethernet (with RoCE or iWARP protocols) found to be viable
  - Infiniband: only small system could be tested due to long procurement delays. Also disfavored since only one vendor
  - strongly leaning towards ethernet solution
  - decision planned for 11/2023 (after last BCP)
  - would like to benefit from central CERN/IT procurement of network switches, but important that this does not happen too late

TDAQ: Observations

- Dataflow: significant design changes (reminder)
  - huge intermediate high performance SSD disk buffer too expensive
  - instead, plan writing directly from readout handlers to EF memory
  - many useful investigations, focusing on networking in 100 GbE environment, and event transfer/building at 1 MHz
- Readout
  - detailed investigations of FELIX resource needs for all detector components
  - with VM1802 FPGA, some usage parameters are >90%
  - either optimize usage, add more FELIX units or move to more performant FPGA to be studied
  - design of second hardware prototype completed

TDAQ: Observations

- Online software:
  - prototype completed and under review
  - promising tests with full current HLT farm with Kubernetes
  - linear scaling of start time with #processes
  - DAQ-to-SoC communication prototype ready since end last year and under evaluation
  - Physics monitoring: in requirements collection phase

TDAQ: Comments

- Adverse effects due to Run 3 commissioning are gradually winding down
  - with recent or imminent BCPs, hope to arrive at dependable schedules
- Still need to establish viability of new dataflow architecture
  - how much buffering of pre-/post building events are needed, how much memory storage do they need (EF node or R/O handler)
  - realistic modelling of highly stochastic M x N network traffic
  - orchestration of complex set of DMA operations
  - design review in spring 2023 seems tight

TDAQ: Comments

- Interface specifications between LAr (LASP/SRTM) and Global Trigger/Readout seemed to happen quite late (SR only in Sep 2022).
  - Communications with detector components should be improved (outside of reviews)
  - Good to hear of a dedicated group working in this area, but more information needed at next reviews
- In some cases, the needed-by dates (which are used to define the float) appear too generous. For example, a needed-by date of 29-Jul-2029 for the full EF seems too late.
  - Algorithm development for L0 and EF processes becomes increasingly important.
  - Overall, given the challenging times the TDAQ project is in very good shape.
  - However, the impact of the recent design changes has to be monitored carefully.

TDAQ: Recommendations

- TDAQ should check and if necessary revise the "needed-by" dates which are used to define the float. Too generous "needed-by" dates might lead to an exaggerated impression of leeway

- As algorithm development is crucial for triggering in general but also an informed choice of EF technology, it is very important to attract & integrate experts on object reconstruction into these projects

- Would like to see an update on development of new dataflow architecture at next P2UG meeting

LAr

- Very good progress in all area, no major concerns
- Close collaboration with TDAQ is mandatory for the Lar project to progress on the readout interface
  - SR for LASP and SRTM held only in September 2022

Muons

- TDC: wafers received back in September. Still need to be tested. We are very interested in the results of the upcoming tests.
- RPC layout in Sector 11-15: Main institutes involved agree to move toward options with large chamber at larger radii to avoid unsolved installation issues. How will a formal decision be reached?
- RPC FE ASIC is still a schedule concern. If tests second prototype in Mar 2023 are successful, there are fewer concerns.
- RPC FE manpower is still a concern
- RPC FE design and test should be done with the ECO chosen for the future.
- EIL4 TGC Chambers: Successful module-0 production is still required to pass FDR.

Muons

- Installation schedule issues noted in March still exists. This should be addressed before next P2UG.
- Power systems: It is important to revisit the schedule after experience with the tender. The predictive power of the current schedule does not seem very reliable.
- YETS use was examined. Probably no actual installation, but the extra time could be used for installation exercises to identify any issues early and to gain experience with the process.
- Greenhouse gas - more R&D was done. No promising substitutions found for current components (TFE, CO2, SF6). Re-balanced mixture with less TFE and more CO2 and a little more SF6 appears to give acceptable performance and could be used as an interim solution to achieve some greenhouse gas reduction if studies require more time.

ITK-Strips

- Schedule: Float is 3m against present pixel integration starting date.
- Schedule: Float loss since May: 3m in Barrel, 5m in EndCap is worrisome and not sustainable.
- Strip is progressing towards the system test FDR , module Barrel and Endcap PRR (Feb/May) and the start of integration in SR1 (September)
  - FE-Asics are production ready, modules & loaded support cores to follow soon
- Sensor delivery rate continues to fall behind requirements & planning
- Recommendation: investigate the origin of this problem, and work with vendor to bring delivery rate back to nominal

ITK-Strips

- The “Cold noise” problem has effectively stopped the module pre-production and is under intense investigation with indications towards a ‘mechanical’ problem but no clear understanding as to the origin of the problem and its mitigation.
  - Recommendation: Resolve the problem (including radiation tests and different glues) with highest possible priority, using additional resources where necessary, including external experts.
  - We will have an extraordinary P2UG review of the cold noise issues early in 2023.

HGTD

- Clear and substantial progress on several fronts since the last review
- The timely success of the ALTIROC3 development is clearly critical
  - Important that lessons are learnt from other and previous developments
  - As indicated last time, prompt evaluation of first batches is essential to maintain schedule
- The level of float for the project is clearly insufficient
  - Existence of ‘plan B’ helps in this respect, but cannot solve the problem
- Recommendation: more details of the staging (‘Plan Z’) scenario are required, in order to maintain confidence that the project will be delivered in all scenarios, and to assess the technical and resource implications should staging be necessary. An update on this scenario should be presented at the next P2UG meeting.
- Recommendation: adopt existing technical solutions from other projects (e.g. ITK-pixels) for support systems, services, interfaces, and software, wherever possible.

Conclusions

- ATLAS now fully engaged in transition from ‘preparation’ to ‘production
  - As anticipated, the real challenges are now becoming clear
- The project understands its own position, and is able to track progress, schedule and resources effectively
  - Good to see that serious planning for integration / installation has started
  - We continue to have full confidence in both management and execution of the project
- Nonetheless, several key challenges
  - Schedule float is clearly insufficient, and recuperation will require intense, extended management and coordination effort across the collaboration
  - The transition to production must be completed and accelerated at many sites
  - Observe some critical areas where effort must be added by the collaboration or by CERN
- We see the need for significant additional information / review at the Feburary 2022 P2UG meeting