The Workshop on Machine Availability and Dependability for Post-LS1 LHC

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Summary:

Several key messages emerged through the course of the workshop and subsequent discussions; these are presented here in the form of suggestions and recommendations with discussions around each. Several issues were re-raised which still remain outstanding from Run 1, these include interlocking of small power converters, the interaction between tune feedback and the quench detection and other such issues. Conclusions in this document do not concern these outstanding issues. Conclusions are split into three different time domains:

1. The Near Future (post-LS1, up to the HL-LHC)
2. The HL-LHC era
3. Beyond the LHC era

The Near Future

The workshop began with a look back over the motivations of the workshop, followed by a recap of observations of the LHC machine during Run 1. It was widely acknowledged that the machine had an impressive availability performance in particular during the 2012 year of operation. This may be interpreted as a combination of:

1. LHC operating point below LHCs design values, giving a higher operating margin.
2. Equipment experts being aware of their availability limitations and optimising accordingly.

It was generally agreed that a central & more refined tool for tracking availability is needed, considering the impact on physics of faults and delays. This implementation requires a top-down view to be created using several sources of information. From the equipment view upwards, the lack of a coordinated tool has led equipment experts and operations to implement their own solutions matching their own particular needs; this means the operational view is obscured. It's very difficult to map physics lost due to particular faults, or processes, using these diverse implementations.

- **A tool linking failure data from operations to the more detailed failure data gathered by the equipment experts must be implemented.**

For the creation of these tools, coordination between MMP and AWG is needed. MMP could ultimately provide information needed to address some availability tracking, but with caveats.

1. MMP tools may not adequately cover physics production loss due to non-faults.
2. MMP tools will likely not be sufficiently mature to be implemented for the start of Run 2.

The relevant packages of the MMP should be prepared in such a way that information which is useful for the LSAT can be incorporated. Hence the LSAT implementation is to be understood as a prototype implementation for an accelerator wide issue tracking system to be developed and deployed by the MMP.

- **Coordination of LSAT with MMP must be ensured to optimise integration.**

There is no central coordination for organising information about availability. Without a dedicated person behind this, information is much harder to consolidate.

- **A dedicated person in BE/OP must be found, who has a significant role in coordinating information related to availability.**
- **The mandate of the AWG should be extended to include reporting on LHC availability, acting as a central team ensuring the coordination of information.**

In addition, to render the concept of LASER for fault diagnostics in the LHC domain equally useful to operations as in the injectors, alarms definitions should undergo a major revision based on Run 1 experience. Additional fault reduction/dependency possibilities within LASER should be addressed in conjunction between controls, operations and equipment groups.

Into HL-LHC

The "easy" and self-evident cases of availability-loss are being addressed. This effort started already at the end of Run 1. Once the easy cases are addressed, it becomes much more difficult to improve availability. The limiting factor becomes the quantity and complexity of the LHC sub-systems. Significant availability increases would require more strategic solutions be adopted such as adding *n out of m* redundancy to systems. This is non-trivial, and potentially very expensive.

Availability information for HL-LHC will need to be modelled. Run 2 is important for generating these models, and in understanding the implications of the 3000fb^{-1} goal of HL-LHC. There is latency between adding availability requirements to equipment specifications and seeing these appear as increased physics production. Increasing the availability of safety systems by reducing the safety margin needs to be studied.

- **An HL-LHC work-package should be created centred on addressing availability needs.**

In summary, even with availability similar to that of 2012, first models show that the physics production of LHC during run 2 will not quite reach 50fb^{-1} per year. These models indicate that availability will be the limiting factor in reaching the HL-LHC goals. Overall, better models, based on stronger raw data create more solid information to work from.

Beyond LHC

Future machines, such as CLIC and the FCC have availability requirements for their sub-systems. To successfully implement systems with an availability specification the organisation needs to grow the core competencies of reliability. Currently islands of information have formed around different sub-

systems. This information needs to propagate between teams and sections, and skills learned in one area need to be applied to others (e.g. the Safety Gauge).