Review Panel Statement - Automatic Machine Review Meeting 3rd-4th December 2015

0. **Introduction**

The Review Panel (RP = Michael Boege, Roland Müller, Andreas Luedeke, Gregory Portmann, David Fernández) would like to thank the organization at MAX IV for the great job preparing the meeting. The presentations were relevant, timely, focused and well prepared. The visit of the MAX IV installation areas was very instructive. Introduction to the control room and presentation of some typical console applications gave additional insight. The RP will focus on answering the questions presented as a charge to the RP by Mikael Eriksson at the beginning of the meeting.

1. **Is the control system robust ?**

The Review Panel (RP) agrees that the control system infrastructure is robust and well established and the Control system group is well integrated into the Tango Collaboration with all the advantages given by a large collaboration with a large number of software tools available, maintained and in constant process of development at other laboratories.
The Tango community is active and the particular collaborations of the group such as the Sardana collaboration, icepap collaboration, etc. are fruitful.
The RP agrees on the approach of having knowledge in-house complemented with wise expertise of other laboratories and the option to outsource particular pieces of work to external knowledgeable companies.

2. **Is the control system user friendly ?**

The toolbox already available is flexible and user friendly for building scripts and graphical interfaces. These tools have been tested and used reliably in other installations, such as the Tango tools, PyTango, Taurus, Panic/PyAlarm, Matlab MML, Sardana, etc. At least the commissioning phase will be adequately coverable with this inventory.
The control system is at an early stage, where prototypes will reveal the relevance and deficiencies of the evolving tools. For user operation the applications have to be further developed and tailored.
Some of the existing tools need a particular attention, such as the archiving system or the snapshot tool. The RP sees however that there are issues not solved such as the handling of snapshots of the configuration of the machine (the implementation of Bensikin does not provide the full required functionality). In some cases requirements are not well enough known and defined, the archiving strategies being an example. Even if additional (maybe short term) resources are required, it might be beneficial for the MAX IV project progress to take the lead for certain tools within the Tango collaboration and not wait for them.

3. **Are the diagnostics and feedbacks enough ?**

Being such an innovative machine, MAX IV faces a number of new challenges.
The RP considers that implementing the necessary feedbacks for the Linac have a high priority including laser drift, phase/energy, trajectory, bunch length and charge drift control, since a stable injector is the prerequisite for a successful commissioning and operation of the subsequent facilities. In particular the threefold mode of operation of the Linac, to serve as an injector for the 1.5 GeV, the 3 GeV ring simultaneously and to drive the SPF, makes it a highly complicated machine. Therefore the RP suggests to start the automation at the

Linac, with a strong emphasis on the injection into the rings. Photon pulse shaping of the SPF is probably an endeavour on its own.
All necessary tools and capabilities are available for the Linac, but a lot of work will be required for the implementation. A thorough and reliable integration of the Libera+ BPM system will be a prerequisite for reliable feedbacks of the Linac.
A stable injector will contribute significantly to the successful commissioning of the storage rings and the SPF. Exploring automatic tuning algorithms for the linac and transport lines could be very beneficial.

4. **Machine Protection System (MPS)**
   MAX IV is a new and innovative machine with new requirements and therefore the RP is not in the position of assessing the completeness and safety of the MPS.
   The MPS requirements of MAX IV are much more exigent than those of previous light sources (examples are bunch length and tight orbit interlocks). The review panel is willing to assess the machine protection with more information and dedicated effort. The requirements for the MPS are beyond what the committee has seen at other sources. The PLC part of the MPS was presented, but no information was provided on the fast interlocks. In general the control system interface to the MPS should help with preventing accidental and unintended firing of the MPS.

5. **Personnel Safety System (PSS)**
   The system has to address more modes than other light sources. The PSS requires manual acknowledgement to a number of conditions and therefore is not automatic by definition. However, the PSS provides automation in the way that execute and automate all actions related to safety.
   The RP acknowledges that safety is very well handled and taken very seriously. Besides, safety considerations are beyond the assignments of this panel.
   Keeping in mind that the overall safety shall be maintained, there can be some situations where the PSS conditions and states could be refined (always in the case that the safety conditions are maintained), to facilitate maintenance and certain operations. One example is the RF conditioning (avoiding closing the whole tunnel). Another example is restricted access to certain areas without searching the whole tunnel. This procedure would facilitate several actions and interventions in particular during the commissioning.

6. **Is the error diagnostics sufficient ?**
   There is never enough diagnostics. MAX IV foresees the diagnostics hardware and the tools, but it is a difficult task which can only be accomplished with time (experience).
   The RP understands the desire of MAX IV to go beyond the standard requirements for error and warning messages since they are urgently needed to achieve robust machine operation and a high level of automation. This will need a good collaboration between machine physicists and people from controls. The controls group needs strong support by the definition of error detection requirements: to go beyond health analysis of devices, services, responsiveness towards out of bounds analysis of light source performance requires clear specs of what has to be implemented.
   The BPMs shall be looked at closely. It is a fairly new model of Liberas and they shall be understood well at an early stage. Problems have to be reported back to I-TECH as early as

possible. One application of the Libera+ multi turn capabilities might be the implementation of an online power spectral density calculation and display (both 10kHz (FA) and TBT) in order to judge the residual beam excitation. This could also provide insights on what a future fast orbit feedback (FOFB) has to be capable of. If the higher frequency beam motion happens to be small, the time consuming task of developing and commissioning the FOFB system could be prioritized lower. But have in mind that even for a very quiet machine insertion device motion can lead to significant orbit perturbations since MAX IV is aiming for sub-micron stability.
In the context of failure analysis it is advisable to go a step further, by investing resources to make the machine more reliable. Investment of money can often help to reduce the number of problems, and therefore the required operator actions, if reliability and traceability of hardware problems can be increased.

7. **Is automatic cold start-up a realistic scenario ?**
   Yes. Provided that this means that any operator is able to do the start-up without any trouble; do not expect the machine to start-up without the help of operators. In support the control system configurations should support “bumpless reboot”, i.e. keep the equipment state on any reset, recovery action, as well as “store/recall” buffers for any process variable attribute to be tweaked.

8. **Comments on alarm system**
   Technically all required applications are available. But a large amount of work will be needed from various groups (controls, operators, machine physicists…) to get to a satisfying solution for user operation. The alarm system is a crucial system that takes time to tune. Only when operators can rely on the system, they can focus on other things.

9. **Other remarks**
   a. Resources: In order to achieve these recommendations apparently additional resources are needed.
   b. UPS: Is needed in order to avoid severe problems and protect sensitive hardware. Blackouts are happening too often. One blackout per week is definitely too much even if the recovery procedures of the machine are automatized. Frequent power outages are unusual, they can turn the machine into an unreliable lightsource. Especially at MAX IV with its inherent complexity the consequences might be more severe. Recoveries from blackouts are often not straightforward (hardware losses, repair campaign, non reproducible fine tuning required).
   d. Virtual machines: the reliability of the design of the control system is very good and on good track. Taking the standardization of virtualization a step further to a well tested high availability (Vmware HA) configuration, reduces single points of failure and adds value to the whole installation.
   e. Proposal: Feeding log messages wherever feasible into powerful tools like Kibana and Elasticsearch, which feature sophisticated configuration capabilities, allow for complex queries and correlations. A program like Nagios to monitor your control system infrastructure is very useful.
   f. Pragmatism: the RP endorses the pragmatism observed in the different work packages and control subsystems. The control systems uses the available

packages and focus the efforts in the right way, not falling into pitfalls of investing effort in tools already available. Do not even mind importing EPICS “island” solutions if they can solve problems (see multi-bunch feedback system at ALBA), which you can not tackle with the given man-power and time constraints.

g. Virtual accelerators: consider the implementation of virtual accelerators for the storage rings. They could offer for example beta function and phase information for an optics model, which is ideally dynamically adapting to the operating conditions. They could also be utilized to initialize (response matrices) the slow and fast orbit feedbacks.
h. Feedback Implementation: try to avoid using components in feedback loops which require graphical user interfaces. Feedbacks should be independent of consoles (especially the multi-purpose ones in the control room, which are potentially unstable, if graphics is unavoidable: display into framebuffers in memory and export via VNC). Of course they can be configured and initialized via comprehensive GUIs.
i. Proposal: Export the whole control room console configuration read-only to the outside (offices, home) via dedicated services, nx-client etc. This might mitigate the shortage of on-call personnel. People responsible for modification, repairs, new hardware are willing to help solve problems, tend to check if everything functions as intended even after working hours, especially if it is convenient and there is no need to appear in the control room.
j. Proposal: Consider including visiting scientist to help with the large amount of commission shifts. Particularly since there are many physicist that know the Matlab MML and LOCO software and could be productive in your control room quickly.

10. Conclusion

Time is an essential factor. A lot of work needs to be done simultaneously and not many people are available at MAX IV to carry it out.
The presentations and the discussions at the meeting showed that the problems and the complexity of the automation mission are well understood. For the present state of machine start-up the RP could not find any important item which would be missing.
A large fraction of automation work can only be carried out when the whole machine is running close to specifications.This will probably happen at the same time when the beamlines will require a lot of attention.
Proper automation of an accelerator continues with the life of the machine and the evolving scientific needs of the facility, for instance, new types of insertion device or operational modes. Being dedicated to operational improvement and automation requires proper staffing and availability of machine physics shifts.

Remember

Automation is an incremental process and cannot be done at once. It needs intimate knowledge of all components which is most of the time difficult to acquire in advance.

“Divide each difficulty into as many parts as is feasible and necessary to resolve it”
Descartes