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MATURITY OF THE MAX IV LABORATORY IN OPERATION AND PHASE II DEVELOPMENT

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Abstract

MAX IV Laboratory, the first 4th generation synchrotron located in the south of Sweden, entered operation in 2017 with the first three experimental stations. In the past two years the project organisation has been focused on phase II of the MAX IV Laboratory development, aiming to raise the number of beamlines in operation to 16. The KITS group, responsible for the control and computing systems of the entire laboratory, was a major actor in the realisation of this phase as well as in the continuous up-keep of the user operation. The challenge consisted principally of establishing a clear project management plan for the support groups, including KITS, to handle this high load in an efficient and focused way, meanwhile gaining the experience of operating a 4th generation light source. The momentum gained was impacted by the last extensive shutdown due to the pandemic and shifted toward the remote user experiment, taking advantage of web technologies. This article focuses on how KITS has handled this growing phase in term of technology and organisation, to finally describe the new perspective for the MAX IV Laboratory, which will face a bright future.

MAX IV GENERAL STATUS

MAX IV Laboratory [1] is a synchrotron based research facility which consists of two storage rings of 1.5 GeV and 3 GeV respectively fed by a full energy linear accelerator. These two rings provide X-rays to 16 beamlines, of which 14 are today in user operation (see Fig. 1) and the remaining two will come online during the period 2022-2023.

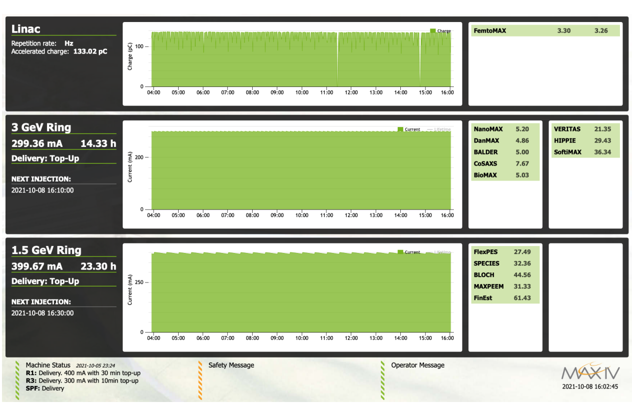

Figure 1: The Machine Status web application accessible for the public, showing all accelerators and beamlines in operation.

Beamlines Status

The first phase beamlines have rolled out into their normal operation and the number of articles published by MAX IV compared to the previous MAX-Lab are rising (Fig. 2). Beamlines already in operation have increased their performance above the baseline, aided by the support from the KITS group.

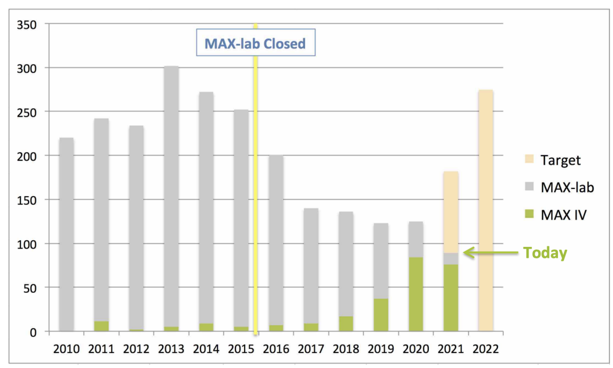

Figure 2: Publication of MAX IV Laboratory vs MaxLab.

For example Balder has achieved a unique performance with a continuous scanning down to 30 s per EXAFS in combination with a powerful analysis software [2], opening up more experiments for environment science.

In the meantime the beamlines which started in 2020 are getting excellent commissioning results while welcoming expert user experiments, in preparation for general users. Four new beamlines have completed the portfolio of full user operation since then. After achieving baseline requirements, FemtoMAX could open its first user call with a time precision of 250 fs and enough signal to complete an experiment in a standard beamtime. Thanks to large resource investment, the X-Ray pulse of the LINAC has been upgraded to 10 Hz operation while on the beamline, a precise data acquisition system has been developed by KITS to acquire all the precious shots while applying a time-over-threshold computation within 10 ms.

In 2021 the new beamlines have started operation early 2021 with limited offer. These new phase II beamlines are increasing the global level of efficiency by profiting on new standards using more stable equipment such as the PandABox [3]. DanMAX has just finished the commissioning phase and started to accept expert Users for the PRXD experiment. In order to guarantee the expected performance of the experiment, KITS have developed a position-based hardware triggered continuous scan [4]. COSAXS started early in 2021 with a basic SAXS experiment based on time

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constant continuous scan with a Eiger 4M detector. The unique Coherence properties of a 4th generation synchrotron light has been demonstrated [5] on CoSAXS which will also open unique XPCS experiments in few years. In continuous 6 months pace development, the beginning of the year brought time resolved capabilities, while WAXS is expected to be available by the end of the year.

Accelerator Status

The 3 accelerators have been in operation since 2017 and they are continuously improving their characteristics with examples being the stability in the storage rings and the increase of repetition rate in the linear accelerator from 2 Hz to 10 Hz.

Several projects have been carried out over the past years such as X-ray beam position monitors on the front end of beamlines. New corrector magnets have been deployed and feed-forward control loops implemented to compensate the distortion in the beam orbit due to the motion of the undulators. To characterize the longitudinal phase space and slice parameters for the linac, a Transverse Deflecting Cavity (TDC) system has been developed and partly installed. This new system gives valuable information to tune beam parameters. These are some of many other projects to improve the stability and beam quality of the MAX IV accelerator.

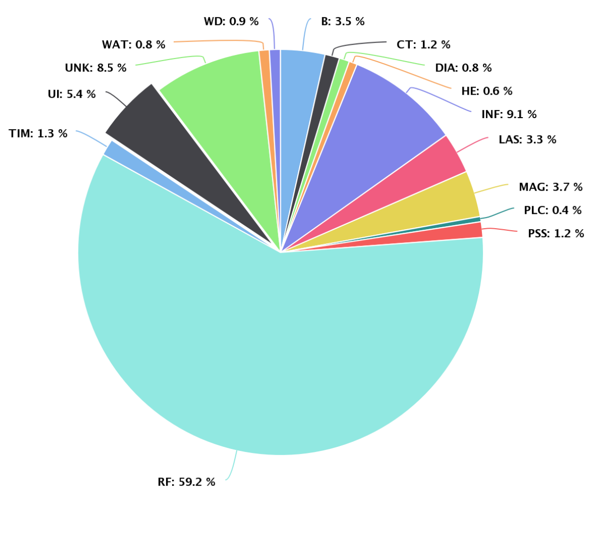

Figure 3: The downtime of MAX IV from 2021-01-01 till 2021-10-06. Biggest downtime corresponds to RF system due to the long recovery time for RF cavity conditioning.

Since October 2020 combined Slow Orbit Feedback (SOFB) and Fast Orbit Feedback (FOFB) has been used during delivery in the 3 GeV ring, a key milestone in the machine for reaching its design goals in terms of beam stability. This system was developed between KITS and the Accelerator Development group and was the final step in this project following the implementation of a purely Tango [6] software based SOFB, running at 10 Hz on the VM infrastructure [7]. The FOFB is implemented in custom hardware with a 10 kHz feedback loop but communicates via Tango with the SOFB in order to periodically offload the cumulative effects of the fast correctors to avoid their saturation.

The operators involved in the daily user operation have tracked and classified all the beam interruption via a web application [8]. Based on the accumulated data, and since 2020, the main efforts have been focused on tracking the Mean Time Between Failure (MTBF) which has led to different actions on the Machine and Beamline Protection System, specially to avoid human error. In 2021, the major downtime which requires a longer Mean Time To Repair corresponded to the RF section of the LINAC, mostly due to the inherent nature of time consuming conditioning, see Fig. 3. An application for accelerator failure prevention based on Machine Learning was develop to track the non obvious causes [9].

The total delivery plan for all MAX IV accelerators from the period 2021-01-01 till 2021-10-06 was 7104 hours, with a downtime of 310.68 hours. The control system represented 1.2 % of this downtime (3.72 hours) due to a control system failure over all three accelerators.

KITS Improvement

In terms of development an important effort has been made in the last two years in a quite large number of projects. Partly due to the increased capabilities due to the growing numbers of staff, but also due to the demanding request coming from our stakeholders and the necessity of gaining knowledge to better support MAX IV needs. The following activities are the most remarkable ones.

Hardware Standard MAX IV has entered in the PandABox collaboration started by Soleil and Diamond synchrotron facilities. This has become a standard with so far, 20 units manufactured and 15 units deployed in the facility mainly at the endstations. The main purpose of the PandABox is synchronized triggering as they can receive time stamped bunch clock triggering from accelerators and fan it out with configurable delay. The PandABox are also often equipped with a D-tAcq 1 MSps 18 bit analog input and 25 018 kSpsbit 16 bit analog output card integrated into the 1u 19 inch rack.

With maintaining the philosophy that electronics are closely integrated with the control system software, which is a collaborative environment at MAX IV, much of the work revolves around collaborative projects, e.g. the IcePAP motor driver [10] and Em# electrometer [11].

Monitoring On the Hardware part, important and labor-intensive task moving into operation of a synchrotron facility is continuously monitoring and refining performance of commissioned equipment. This is done in a systematic way as e.g. described in [12] for monochromators at the soft x-ray beamlines and in [13] for many of the mirror chambers in the facility.

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In general a substantial effort has been focused on the monitoring infrastructure using Prometheus and the Elastic Stack (Filebeat, Logstash, Graphana). The alarm system has the potential to profit from this ecosystem and some projects like the notification system by Android or IOS [14].

Deployment In terms of software infrastructure Conda [15] is also used for the deployment when system dependency does not fulfill the requirement of the application. As no decision has been made on the CentOS 8 replacement after the announce of Red Hat to change its scope, the current CentOS 7 became quickly obsolete. In addition, the continuous integration has been fully migrated from Jenkins to Gitlab pipeline.

Detector and Streaming Particle Detectors are the most complex piece of hardware to integrate in the experimental stations. Previously a reliance on reusing existing software meant that diagnosing problems in operation was difficult due to the lack of knowledge of the detector systems. In 2019, 2 Full Time Equivalents (FTE) were dedicated to increase the group knowledge in Particle Detectors. The major development was to focus on the data retrieval in order to match the performance of the detector and slowly gain expertise in this challenging domain.

Approximately half the KITS software effort is now spent on data acquisition (DAQ) mainly on high frame and data rate photon counting detectors. There is an ongoing effort to unify all detectors under a common data and metadata streaming standard. In term of infrastructure the architecture has been shifted from file exchange paradigm to streaming data with ZMQ over 40 Gb/s links to a central DAQ cluster (see next section). The data can be consumed directly by online processing pipelines which simplify the all process. In combination with this activity, the KITS group has validating the physics performance of the detectors, for example in site acceptance tests, and offering the beamlines support in case of issues, for example in liaising with the companies.

Continuous Scanning The stability of the scanning system has increased by mastering the behaviour of the detectors and simplification of the data retrieval. In order to deliver the top performance, the continuous scanning of the sample has become the standard implementation and the development has been streamlined by the use of the PandABox to manage the synchronisation between motion, triggers and I/O, consequently making the previously used delay generators and counter cards obsolete.

The accelerators have continuously made a series of changes to the insertion devices described in [16] to allow for synchronized motion between monochromators and insertion devices. With this feature fully implemented the insertion device will be integrated into the overall scan capability.

Taranta In the User Interface (UI) domain, web technology has started to replace the traditional desktop applications. Inspired by Taurus, a Taranta application [17] allows the user to compose themselves their dashboards by drag and drop of basic widgets. The resulting UI is immediately usable in the real control system.

Remote Operation During the pandemic the laboratory has been in limited operation. Remote users were supported by beamline staff working extra hours for tasks that are not automated, for example mounting samples. In some limited examples like Macromolecular Crystallography (MX), the MXCuBE web application is already prepared and facilitates the users remote interaction with the beamline. Simultaneously, a large effort went into making safe use of the hardware in remote operation on other beamlines similarly to the BioMAX beamline, which was MAX IVs first beamline to run fully remotely. For other cases, a low cost solution via remote desktop has been used for bringing the experiment control room to the users home, and being able to share the experience with a user elsewhere. Additional steps have been made to ensure the safety of the remote operation, i.e. prohibiting certain motions from happening and, preventing users from accessing critical control system parameters while being remote.

Kubernetes Clusters

Various systems at MAX IV are relying on containerization technologies for a flexible and reproducible way of application management. This includes classical web-applications, computing workloads and data acquisition pipelines. With a growing demand on running containerised workloads, introducing the container orchestration was a step forward for the facility. Currently the IT infrastructure team at MAX IV is operating several on-premises Kubernetes (K8S) clusters, targeting different application vectors:

- General Services cluster based on OKD, the community upstream of RedHat OpenShift, is targeting web-services (e.g. wiki, AWX, Taranta, etc.).
- DAQ cluster with high performance bare-metal worker nodes is used for acquiring the experimental data (Fig. 4). The nodes are connected to a high-speed 40 Gbps network fabric for data ingest, another 40 Gbps for streaming data out and to the IBM Spectrum Scale (GPFS) filesystem via InfiniBand fabric.
- JupyterHub cluster nodes with GPU accelerators are used for high performance processing. Similar architecture than the DAQ cluster specific application-level feature (LXCFS) improves the user experience of resource visibility.

Infrastructure side also includes two shared HAProxy load-balancer machines with Keepalived to route the HTTP traffic mainly towards the K8S Ingress controllers.

MAX IV chose Helm Chart and GitLab CI pipelines for the application deployments on K8S. For example the "daq-pipeline" Helm Chart creates the necessary set of resources to start the data acquisition for the specified beamline, the detector and DCU network endpoints.

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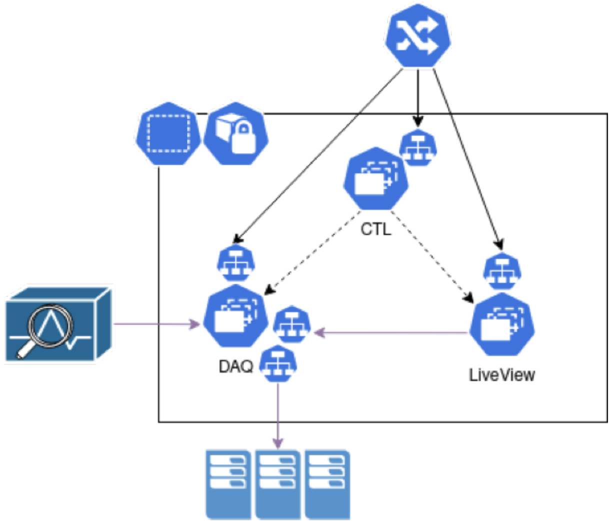

Figure 4: The kubernetes architecture for the Data Acquisition Cluster.

Scientific Software

With the improvement brought by the 4th generation synchrotron, many experiments have improve the rate of their data acquisition moving the bottleneck to preparatory phase or data processing. In Macromolecular X-ray crystallography (MX) an automatic sample centring would streamline the process avoiding human intervention which is possible with a Machine Learning processing [18]. Another development in MX, FragMax [19] has been developed to speed up the interpretation of the results and to facilitate processing by running multiple user configured analysis on a set of datasets. In Small Angle X-ray Scattering and Power Diffraction, the Azimuthal Integration is the first qualitative appreciation of the raw data. A real time processing with FPGA would give substantial advantage for the User [20].

Data Management

SciCat is database together with a web user interface to display information for the data acquisitions performed by a user. It includes a detailed set of metadata information for adding appropriate context to the experiments. Metadata keys range from common beamline parameters, the particular experiment setup but also free comments added by the user. It is under development as part of a collaboration with ESS and PSI facilities. A companion application has been developed in MAX IV, Scanlog, that provides a different user interface on top of exisiting Scicat database, the main different is that this new ui is desgined to provide a quick overview of the scans during the beamtime. It also provides some filtering so the user can customize the view. It is also possible to rate your data and write comments for a quick overview of if a scan was successful or not.

SciDog is used to choose which metadata should be stored. The beamline staff in this case, can save a configuration with selected metadata, or use all the device/attribute combinations that are in the database. This metadata is gathered mostly by specific Sardana recorders, but there is also ongoing development to allow other beamlines to store metadata that do not rely on Sardana for data acquisition, e.g. commercial spectroscopy solutions.

KITS OPERATION

Having three accelerators and 14 beamlines in operation has been a major change for the KITS group, together with the shift of focus toward a stable and reliable system.

The Controls groups are responsible for the development and maintenance of the experimental system formed by the stack from hardware to software component. For the operation, a system based on Kanban handle a continuous flow of high priority support tasks, representing 15 % of the Controls groups resources. While other operational maintenance represented 25 % of the resource, the figure has even rocketed during the pandemic period to rose above 50 %.

A support system has been established to answer rapidly by phone to any blocking issue regarding user operation. Each call is registered in the electronic logbook Elogy [21] in order to follow up on any critical issues.

In parallel a local contact system follows up closely the issues that arose during beam delivery. When the resolution is minor, the contact can fix it directly by documenting (case UI), by the reconfiguration the system, or by diagnosing a more complex issue. The role of this contact is important to understand the context and usage of the Control system at each beamlines and accelerators. Issues are raised to a two weeks plan revision when it involves more than one resource groups or days of work.

Main Issues

The lab-wise issues are not quantified in regards of User beam time loss, nevertheless the issues are mainly due to the maturity of the system. The more a system is used in production, the more corner cases are solved. But the challenge comes when many beamline are operating while introducing changes e.g. a new usage, a new firmware, a new model of equipment, etc. which is often a necessity for the development of the new features. Others cause have been identified.

Priority on the Feature by the product owner or,in other cases, quality requirement are skipped by the accumulated delay in the project with fixed deadline. Since the development in the project phase is mainly focusing on new features, the new system appears in operation with its most optimised "happy" path.

Behaviour of the Equipment is the cause of many instabilities, mainly visible through the data acquisition system. After the strong focus on detectors, the focus has shifted in 2021 toward the scanning orchestration system which is the main interface for the user to generate experimental data.

User Friendliness is one of the main weakness of the current software solution which generates confusion by hiding the true cause of failure. Thus the importance of the

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software group and the KITS contact to be present during the commissioning phase and the first experts users experiments, until the usage forces the non-nominal cases to surface. Additionally Software developers, by knowing the intrinsic details of the system, can easily accommodate with a complex user interface [22].

Resource of the SW group was impacted by a huge turnover while the projects management estimated 160 % of SW resource to reach the new beamlines in operation. A successful recruitment campaign was established to increase the SW staff from 12 to 18 while maintaining the effort with 4 FTE from the consultant companies S2Innovation and DVel.

KITs Operations Service (KITOS)

From summer 2021 the operation support is increasing its quality of service in order to minimise the downtime of User operation. Due to the restriction of time many project were focus on the functionality of the system rather than the non-functional side like the usability and the reliability of the system, which is usual focus for the commissioning period. By consequence the operation, especially on the new beamlines, suffers from the all the non nominal cases which need a reactive support. The phenomena was multiplied by the new beamlines coming in operation at the same time. The follow up of the main important cases could help to improve the situation although the effort to cover all the cases often required synchronisation of several stakeholders. Previous choice of standard are being reconsidered to obtain a sustainable maintenance, while other are improve to follow the expectation above baseline.

On the critical path of generating data the scanning and data acquisition system is highly sensitive to the weakest element in the chain. Since most of the time the 3rd party components are hardly possible to improve, a large effort is being roll-out to increase the robustness of the Sardana, appearing like the top of the iceberg.

The concept for a KITs Operations Service (KITOS) will provide a stronger focus and wider access to expertise through a single number on support from the KITS group. Inspired by the EuXFEL this service will be dedicated only to supporting actual user operation which includes accelerator operational support, beam line commissioning and setup for experiments, but not the daily work which consists of tasks and project development activities.

The support crew of the week will be covered by two shift crews consisting of 2 people each. Members of the shift crew will be drawn primarily from the KITS team and will consist of a shift leader and shift deputy. During the initial phase it will be important to look for complementary pairings in expertise and experience for the crew, for example experienced and inexperienced. Ideally the shift crew will perform shifts over the on call period to provide continuity.

A KITS Run Coordinator (KRC) will be assigned over one week periods. The role of the KRC will be to support the KITOS and facilitate communication on a wider basis which will allow the KITOS to prioritise supporting the accelerator and beamlines for the running experiments. Issues which arise that require more time and involvement from several parties, possibly with the scheduling of ad-hoc meetings will be addressed by the KRC. In general, the KRC cannot be a member of the shift crew while they are acting as KRC, although in cases where a shift crew member is unable to perform their duties, the KRC may step in until an alternative solution is found. KRC will attend important meetings for reporting.

The shift leader will be responsible for operational decision-making related to KITS systems during x-ray delivery, but shall seek advice from 2nd level oncall in cases of doubt. If the shift leader does not feel able to take a certain operational decision, this decision may be escalated to the KITS run coordinator. The next, and final level of escalation will be the head of KITS, or appointed substitute.

PROJECT MANAGEMENT

The new Central Project Office (CPO) project management organisation made visible the resource demanding schedule for the beamlines' projects . With the new time plan established in 2019 the projects responsible have been able to identified what and when the resource groups could realistically work (Fig. 5). After the identification of several bottlenecks, a lab-wise priority was determined to avoid competing resource and unsustainable deadlines.

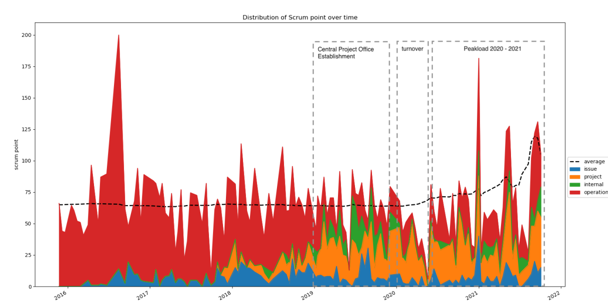

Figure 5: Evolution of the workload distribution over the years. In 2019 the new project management was established.

The new approach breaks down the projects into limited scope i.e optic installation, 1st experimental set up, etc., making the request of resource more formal. The control of feature and time at the beginning of the project introduces an overhead which become less insignificant along the timeline of the project. The enumerated specifications help to define the close-out of the project, freeing resource for the next one. On the overall the gain allows to efficiently manage the resource groups.

On the other hand small jobs don't fit the project schema, becoming very bureaucratic. Also simple request can trigger unnecessary long discussion and often complex organisation of the conception, instead of reusing the standard solution with known but acceptable drawbacks. For this purpose these small requests are routed toward the operation management with much less overhead. Newly created in 2020

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the Beamline Project Advisory Group (BPAG), a group of Science Division representatives, acts as toll gate to manage the priority and appoint a dedicated manager to follow up the request with the resource groups. It's expected to streamline the process by adapting step by step the process of each resource group to the operation management.

KITS Integration

The KITS Controls groups were involved in 28 priority projects in 2020 and 21 in 2021. The projects portfolio has included two beamlines delivered for operation per year representing approximately 25 % of the work load while the improvement of the beamlines in operation and the accelerators above baseline representing respectively 50 % and 25 %. The tight schedule to deliver the new beamlines ready for user operation in their baseline configuration was the main concerning challenge.

The new phase II beamlines projects have profited a lot of the standardisation and improvement of theirs optics section from the phase I beamlines. In return the new development has improved the current infrastructure which has indirectly profited to the system already in operation.

From the Control System point of view the new project management organisation settled in 2019 has allowed to increase to 1 year the visibility in term of minimal requirement and priority of projects. The development could foresee a shift in domain from control and monitoring to data acquisition.

A first approximation of the workload, made by comparing the new plan in 2020 helps to identify a 75 % (250 % including low priority request) increase of work load mainly due to the increase of required feature above baseline design of the system.

On the macroscopic view the waterfall based CPO process has been replaced by a more iterative approach in 2020, although still keeping a focus on requirement and specification in order to define the backbone milestone. The KITS Controls activities arrived late in the overall process which the Agile methodology could not compensate the risk of unclear requirement.

A lot of effort has been initiated to make compatible the global management and the local Control System project management. Figure 6 introduces a streamlined process in which a stronger focus is put on requirements and validation. In this sense, a new key role has been introduced, the beamline software owner, who is the main contact for KITS Controls for a given project, and it also must ensure that validations can be properly scheduled and completed, an issue that was not the case in the past in all cases.

In this sense the project managers have been flexible to accommodate their process to the know-unknown. For example the commissioning of the beamline end station has now been integrated into the project process which helps the quality in order to make operable a minimum viable product, although the constraint of the User call deadline at the end of the project does not cover for a full user friendly system.

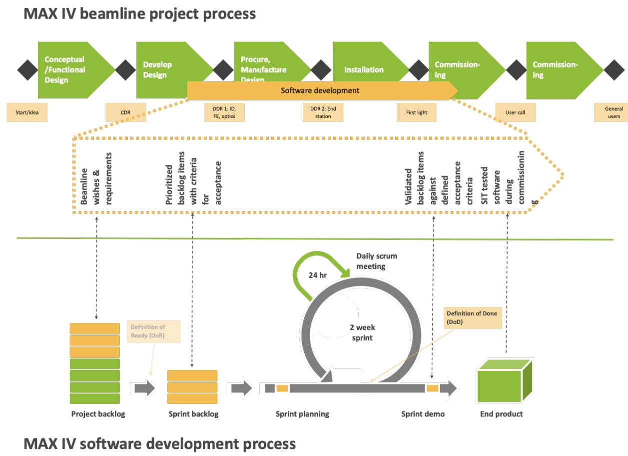

Figure 6: Workflow of SW development integrated in the global management.

During the COVID pandemic the Agile process had accumulated over several months many new features which were awaiting for validation from the requestors mainly due to the low availability of beam time. This has decreased the efficiency of the Agile method based on rapid feedback.

Lessons Learned

The role of CPO to determine where we invest effort was definitely needed, even if it brings an overhead. It is a price to pay but we would have had difficulties without them. Looking at lessons learned regarding the CPO project structure, it is based on a fixed scope and allows very few deviations which fits perfectly with installation projects. On the other hand experimental projects need flexibility for the development of very new features. Change management with impact analysis may improve the process if working on a fixed budget and time. The CPO project management has also improved the testing phase to include a longer commissioning time to verify and validate the operation of new systems (2021).

When BPAG and CPO manage projects with a dedicated project manager (PM), the process becomes more efficient contrary to a mixed position with conflicting responsibilities.

Moving away from pure installation, it is increasingly hard to close the projects due to difficulties pinning down the scope. CPO is trying to move towards a more agile way of working. CPO is also raising the understanding among the stakeholders for the importance of timely validation, and adjusting the ambition depending on how complex a feature turns out to be. There have been examples of arbitrary closure/end point without actual commissioning. In reality, the most successful projects are the ones where the KITS contact (a member with very tight contact with the beamline needs) has played an important role as technical project leader, leaving the big picture for the project manager avoiding to be involved in the details.

The unclear responsibility of which resource group the development has been assigned to was a recurrent impediment although not identified as risk in the project organisation but

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causing a substantial effort. Two majors cases were identified which have caused delays, waste of resource and conflicts.

In the first case causing 3–4 months delay, resource stakeholders were identified at the start of the project but not the responsibility of the subsystem delivery which led to the reconsideration of an important standard. In order to mitigate any future issue, the PM process has been revised to include a risk assessment session to complete the kick off of a project. Also, in parallel, a technical forum has been established to identify in advance any change in the standard portfolio and assess the impact on all the MAX IV resource groups before it appears in a project timeline.

The second case happened when one resource stakeholder were not clearly identified as being part of the project which led to a competitive situation triggered by the request to multiple channels of communication. By passing the project management, the waste of resource was the direct consequence but minor compare to the indirect consequence on the MAX IV organisation. Whereas 2 resource groups should collaborate on a gray zone (shared responsibility), this led to a confuse direction, protective division and resource competition between engineering and scientific concerns for which a cohesion is a fundamental for big research facility such MAX IV. An investigation for a clear organisation of responsibility is in progress in coherence with the latest recommendation from the Swedish Research Council (VR) review committee [23].

FUTURE

SXL FEL

To allow the study of dynamic phenomena at the atomic and molecular scales a X-Ray free-electron laser (FEL) is necessary in order to provide X-ray beams of sufficient intensity and coherence in short enough pulse duration. MAX IV is designing a Soft X-ray Laser (SXL) beamline [24]. SXL consists of four parts: the already operating MAX IV linear accelerator, a new 40 m undulator, a corresponding beamline and a set of experimental stations. SXL thus capitalizes on the capabilities of the MAX IV linear accelerator. SXL will be placed in a building extension of the Short Pulse Facility (SPF), today housing the FemtoMAX beamline.

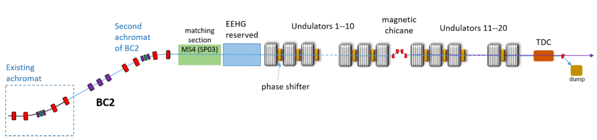

Figure 7: Layout of the SXL FEL line.

The Fig. 7 illustrates FEL SXL with 20 APPLE-X helical undulators, a combined phase shifter and delay chicane. This will trigger updates and new challenges for the MAX IV control system such as a more accurate timing system, synchronized motion control for all undulators, more feedback and feed-forward control loops.

Improve Beamline Capabilities

Among the existing operational beamlines the challenge will be to continue the development of the End Stations' increased capabilities and then new upcoming sample environments. This requires a more streamlined experimental orchestration synchronization with the data acquisition in order to achieve higher rates. Moreover, new sample environments demand a user friendly setup change which in turns requires an increased stability of the overall control system.

Two new beamlines are already in advanced phase of development. They will both bring a high challenge to KITS. MicroMAX [25] aims at improving further data acquisition capabilities for Macromolecular Crystallography (MX) at MAX IV, expanding the current MX capabilities with new SSX techniques as well as a new high performance detector Jungfrau [26]. A high degree of automation an complex web user interfaces are required, as well as increased capabilities of the existing computing infrastructure. ForMAX will offer to the users full-field tomographic imaging with small- and wide-angle x-ray scattering focused on wood related materials. The fast acquisition not only requires the capability of ingesting a high data rate and volume, but is also needs to provide very precise synchronization on the acquisition axis.

New detectors and techniques will require dedicated and specialised efforts, for example:

- measuring and applying count rate correction.
- gaining expertise in FPGA frame grabber for the tomography cameras.
- rethink the DAQ architecture for ever higher rates, e.g. for the Jungfrau with dedicated 100G connection.

Just as trying to standardise the DAQ, all these subjects needs custom solutions and deep knowledge of each system, from the hardware to the scientific processing which challenges the organisation of the KITS group.

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