The Performance Improvement Initiative at ISIS

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Abstract

The ISIS accelerator at Rutherford Appleton Laboratory in Oxfordshire, UK has been growing its new Performance Improvement (PI) team for 4 years. A team of three engineers and one student have been uncovering operational challenges and improvement opportunities. Ideas progress to solutions through projects, developing unique and proprietary tools and process improvements. While some projects are proving fruitful, others are developing with still unknown results. We will report on how we do our business, our mission, our methodology and the progress of some projects, explaining the rationale behind them. These projects include FLD (First Line Diagnosis), now four years on and becoming the backbone of ISIS's fault analysis toolkit. We report some unintended consequences, continued challenges and attempts to measure results. We will also cover provision of an Electronic Log for ISIS, a difficult journey, from inception through to delivery. Failing magnets and large power supply components have led to us investigating innovative fault diagnosis solutions; vibration analysis, acoustic mapping and condition monitoring, collaborating with major UK university engineering research departments. Performance Improvement is all about pushing boundaries so we will also touch on future speculation and our wish to explore new ideas by developing contact with industry and discovering how they do business looking for Best Practice.

Introduction

ISIS is a world-leading centre for research in the physical and life sciences at the STFC national laboratory facility near Oxford. Our suite of neutron and muon instruments gives unique insight into the properties of materials on the atomic and molecular scale. We support a national and international community of more than 3000 scientists for research into subjects ranging from clean energy and the environment, pharmaceuticals and health care, through to nanotechnology, catalysis and polymers and fundamental studies of materials. The availability of the accelerator is critically important and poses a key challenge for an ageing machine.

Figure 1: ISIS Accelerator, Harwell Didcot Oxford UK

The Performance Improvement team was set up 4 years ago with the objective to reduce beam downtime. The accelerator, approaching 30 years of operations, had availability below 90%. All ISIS groups look for performance improvements as part of their remit and have been successful with a number of initiatives: increased beam intensity (Synchrotron Group) and helium recovery (Sample Environment Group). However it was felt a more holistic approach, across all groups and divisions would encourage more facility-wide improvements. The PI team initially focused on operational ideas but would expand its remit across ISIS over time. The first project, called FLD (First Line Diagnosis) was set up to provide an interactive tool to support the ISIS operational crew during live fault finding. The project has grown in content and coverage. Other projects were taken on: new and improved status display screens with real-time operational statistics, an upgrade to the ISIS Wi-Fi system allowing more robust access to the network throughout ISIS's tunnels and voids. The latest project, a feasibility study to test vibration sensors for remote condition monitoring of ISIS magnets and machines aims to provide predictive fault analysis. Performance Improvement projects are now being developed on a regular basis using a methodology that is detailed below.

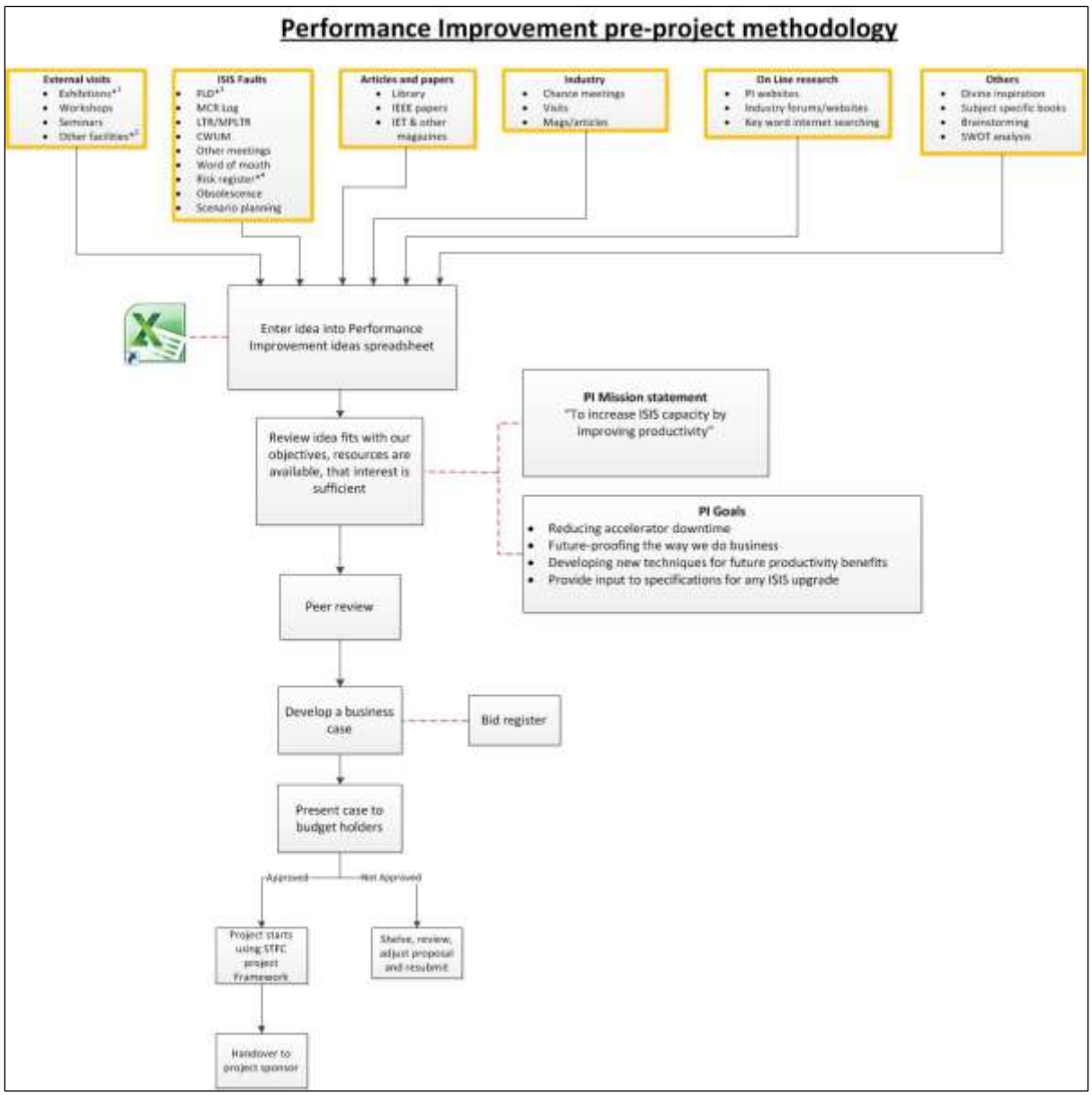

Figure 2: Performance Improvement pre-project methodology

Project Methodology

The important factor for any performance improvement initiative is to make sure a due diligence process is followed, a need is established and resources are made available. At ISIS the PI team has developed a systematic approach to delivering projects by; investigating, filtering, peer reviewing, making a business case and gaining management approval before any project goes forward. Locating potential projects comes from several areas both internal and external to the organisation. Real life ISIS operational faults provide a key source of potential improvements through interrogating the operational logs, lost time reports, cycle wash up meetings and reviewing the ISIS risk register and the sustainability programmes. A regular review of papers and articles from websites and publications also provides a useful source of ideas while external visits to trade shows, seminars and workshops are a great way to talk directly to experts. The interesting thing found was that industries including; marine, nuclear, power & manufacturing offered a number of ideas that we had not originally thought of. One such idea was Vibro-Acoustics which is heavily used in car production for designing noise characteristics. Such technology provides highly granular sound and vibration mode identification for pinpointing sources of noise. The marine industry had a number of condition monitoring successes that predicted faults down to root causes on large ships. Discussions with universities and private

companies allowed us to interrogate such methods and then map them to our own facility needs. Once we have agreed that our idea follows our mission and goals, our findings are presented to our peers and stakeholders. We review their feedback and develop a business case based on cost benefit analysis and risk. This is then presented to management for approval and if agreement is received we take it to full project stage by entering it into the ISIS project register. The organisation project framework is then used during 4 stages: feasibility, requirements, implementation and signoff. Completed projects are handed back to the sponsor when entering the Business As Usual phase. PI may continue to be involved with the project beyond completion in an enabling role like in the case of FLD.

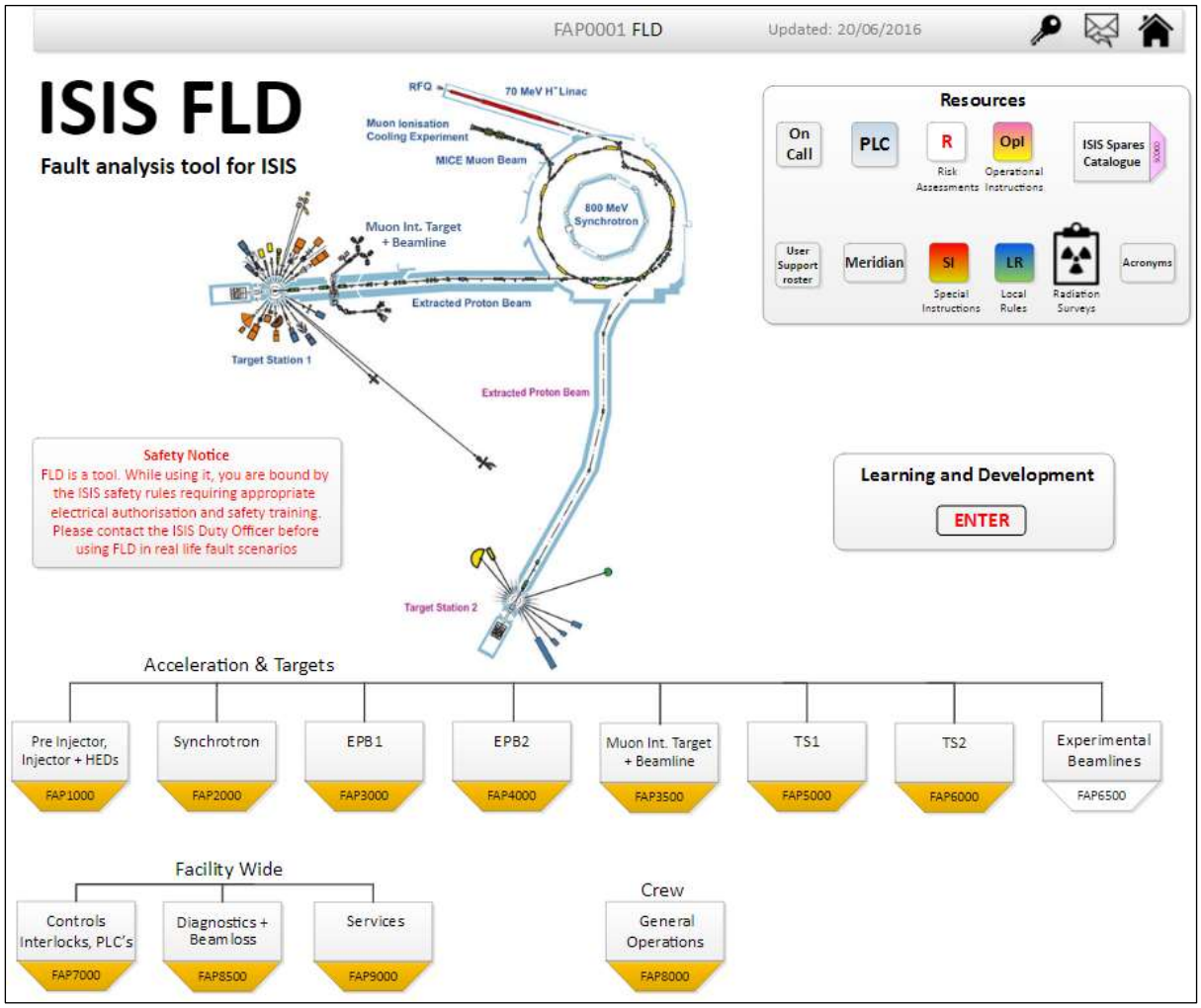

Figure 3: Front page of FLD

Case study: FLD (First Line Diagnosis)

The first project that was taken on by Performance Improvement was FLD, First Line Diagnosis, a software tool for ISIS operational staff with interactive fault analysis pathways and technical knowledge library, for use by the ISIS crew running the accelerator. By using valuable time efficiently and effectively, FLD aimed to decrease the response time to resolve high consequence, high impact faults. From the outset, the system was designed to grow organically to incorporate as many ISIS accelerator systems and as much equipment as possible. FLD offers hierarchical fault flow charts, providing additional information to help drill down to fault modes and root causes. To date the system has over 350 fault pathways developed by equipment owners including videos tutorials, procedures and appendices. The project was conceived by the then operational group leader who was concerned about the loss of skills and knowledge of fault analysis as staff changed or

were promoted. An initial concept was developed and presented at a number of forums including ARW 2013, 2015 and WAO2014 in Mainz. Extensive peer review discussions took place in house to hone the concept and develop strong stakeholder engagement, a critical element to its success. The system required extensive interaction with equipment owners and the challenge was to convince them of its effectiveness without removing their responsibility to fix equipment. The business case was written and presented to management who approved the initial funding and resources. The project was then set up using the STFC project framework with the support of the PMO (Project Management Office). FLD took 3 years to develop and add sufficient content to become effective. Today it continues in a Business As Usual stage with PI as an enabler, as extensive content is added to the platform. Success has been difficult to gauge. It is measured by using metrics; usage figures, crew feedback, lost time report feedback and constructive emails. There are many cases where FLD has saved downtime and the additional benefits include improving training and having a centralised point of technical information all allowing FLD to become part of the fabric of ISIS operations.

Case study: Vibro-acoustic analysis

One ongoing project was conceived during a visit to an industrial asset management trade show where the latest condition monitoring technology was being displayed within a number of industrial environments. Vibro-acoustics was being used by the motor trade and white goods manufacturers to design products with desirable sound signatures and minimise vibration. ISIS has a large number of magnets, pumps and rotating machines in potentially high gamma, fast and thermal neutron radiation environments [4] and we believed vibration could be a contributor to fault modes and increase downtime. The PI team opened discussions in house with all interested parties; electrical engineering, machine physics, vacuum and water services, mechanical engineering and health physics. PI located vibrations and condition monitoring expertise in Southampton University [1], Salford University [2] and Huddersfield University [3] and visited them to see if they could help us develop our Vibro-Acoustic condition monitoring system. Specifically, our main bending magnets were subject to unpredictable failures, in some cases costing days of downtime. PI and stakeholders peer reviewed the idea then presented our business case to management who approved an initial funding package. All the universities offered unique solutions so we initially chose to collaborate with one but with a view to expand collaboration once our initial study was completed. Additional EPSRC [5] funding was obtained by Southampton University and we progressed to a project called 'Feasibility study of vibrational sensors on dipole magnets'. We have chosen to install our first round of 10 sensors on dipole 7 in the ISIS synchrotron. Southampton University specialise in railway vibration analysis and have provided advice about suitable sensors, low noise cables, data collection hardware and software and analytical software.

Figure 4: Vibration sensor on dipole in Synchrotron

Our first vibration data should be available by Feb 2017. We will then establish the feasibility of rolling out the vibration sensors to several other dipole magnets and provide condition monitoring software in the crew main control room (MCR).

Case study: Electronic Log (elog)

ISIS MCR has used a paper operational log since 1985. This has resulted in a large library of log books that are difficult to search through. Many attempts were made to introduce an electronic logbook but in 2015 a request was sent to the PI team to review the available elogs on the market. PI spoke to software developers and stakeholders to establish a long list of requirements. These requirements were peer reviewed and the business case was approved by management to take the project forward. PI then went out to

several elog companies and other accelerator facilities and located a number of potential systems.

Figure 5: Crew operations in ISIS MCR

The PI team arranged for a number of live demonstrations to stakeholders and crew members. At this stage, a working budget has been agreed and ISIS awaits the outcome of a competitive tender process (Oct 2016). The PI team has maintained an enabling role bringing together stakeholders making sure the project remains live and current and will help to deliver the chosen system by bringing together all the technical expertise from across ISIS.

Conclusion

Whilst ISIS groups and divisions all contribute actively to performance improvements, the idea of having a separate team specifically focused to search out and enable new ideas has been a challenging but progressive activity. The success is based on a clear vision, purpose and a methodology that prevents time being spent on unrealistic and unnecessary projects. Success has been achieved with FLD with some reduction in accelerator downtime but has noticeably improved the time taken to developing skills and knowledge for new and promoted staff. The massive collection of technical information now available in one location has saved untold time though the administrative overhead of maintaining FLD remains quite high. The flexibility to explore other industries has led us to a feasibility study on vibro-acoustics with Southampton University, the aim being to condition monitor and predict faults in advance, preventing catastrophic failures. However the eventual outcome of this study depends on the ability to gather clear data, a challenge in a high radiation and EM field environment. The elog will futureproof access to lessons learned from operating ISIS and allow statistics and reports to be produced with ease. Several other projects from other groups and divisions, beyond the initial scope on operations, have been suggested and are under consideration including; using alarm data to provide statistics on accelerator operations and integration to FLD, a site wide CMMS (computerised maintenance management systems) with Electronic Engineering group, QR codes requested by many groups, including Experimental Operations, for asset management and finally a new software platform for FLD. The enabling ability of the Performance Improvement team at ISIS has paved the way for increasing productivity of our accelerator through its ability to bring together stakeholders, maintain focus and energy, encourage collaborations with external expertise in search of Best Practice and manage projects to a successful completion and beyond.

References

[1] Southampton University, Institute of Sound and Vibration Research.

[2] University of Salford, Dept. of Vibro-Acoustics

[3] University of Huddersfield, Dept. of Diagnostic Engineering.

[4] Neutron fluxes in ISIS synchrotron room, D.Findlay

[5] EPSRC, Engineering and Physical Science Research Council, Swindon UK