Engineering Department

Issue 2 NEWSLETTER June 2021

Inside this issue:

Editorial:

Dear readers of the EN Newsletter.

It is my pleasure to present the 2nd EN newsletter. This edition contains articles witnessing just how widespread the activities of the EN Department are. The topics cover safety analysis, tools for scheduling technical stops, pollution simulations, optical fibres, asset management and additive manufacturing!

I hope that you find the material interesting and that it inspires you to contact me or your supervisor about providing an article in English or French for a future release.

Lars Jensen, EN Newsletter editor-in-chief

DAO Corner

I wish to make a short note this time about Data Protection and recommendations regarding surveys. Please note that several supported 'IT tools' are available for CERN to create surveys and for immediate use where applicable.

See list below:

- DRUPAL – to host a survey on a DRUPAL CERN web site (https://surveys-docs.web.cern.ch/drupal/);
- Indico surveys – to create a survey at the occasion of an event managed with Indico;
- Newdle (http://newdle.cern.ch) should be used as a replacement for Doodle;
- LimeSurvey is the recommended platform to host your survey outside CERN.

For any further queries, please do not hesitate to consult the 'IT page' IT_Tools_For_Surveys.pdf (cern.ch) and to contact me.

Rachelle Decreuse-Michaud EN DAO

EN safety risk analysis

This year, one goal defined by the EN Safety Office is to perform risk analysis in all workshops under EN responsibility. This challenge was presented by the EN Head of Department, Katy Foraz, on 21st January 2021, during the annual meeting.

This objective was motivated following the return of experience on accidents (16 since 2018 in EN workshops), and feedback from operators. Industrial activities can be a source of risks. Even though the "zero risk" doesn't exist, a risk control remains mandatory. The chosen control method follows different steps from the identification to the implementation of preventive and corrective measures, all the while aiming to reduce, prevent and even eliminate the risk altogether.

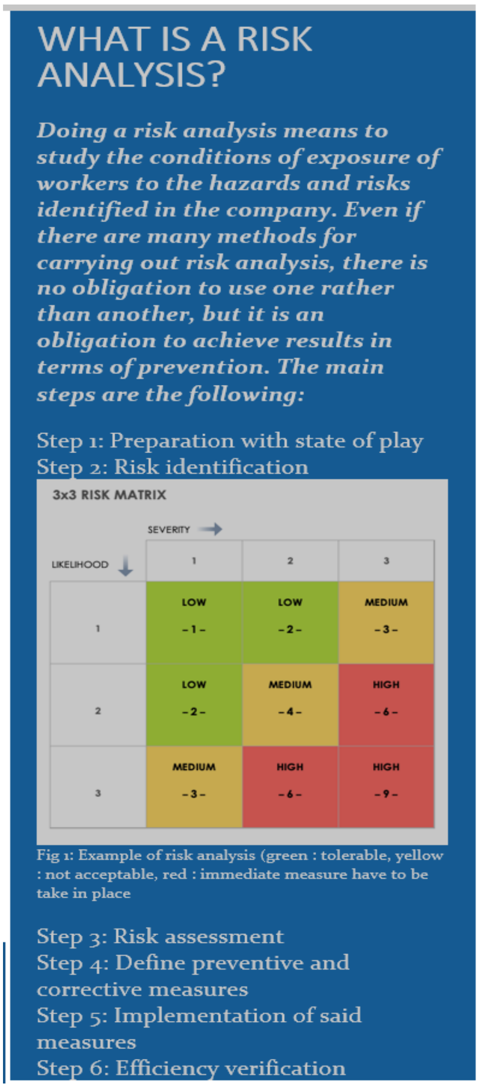
CERN rules and regulations are part of the process and reinforce the employer responsibility.

To reach these objectives, an additional person will join the Safety Office team from 1st June 2021 for 6 months to work in close collaboration with EN workshop supervisors, operators and all safety actors concerned. A successful risk analysis is one that has been performed with a working team.

In the EN department, 15 workshops are concerned by this campaign, from AA, ACE, CV, EL, HE and MME groups. Several risks, such as mechanical, chemical, environmental, electrical, magnetic, thermal, etc. are present in each workshop. A safety form M-4-0-1 provided by HSE, "WORKSHOP - HAZARD IDENTIFICATION AND CONFORMITY ASSESSMENT FORM", allows you to verify the conformity of workshops, machinery and activities in workshops with the applicable Safety requirements and CERN procedures. It will be used as step 1 to know the safety level of a workshop.

> The benefits of risk assessment in the workplace are both psychological and financial. In addition to improving the sense of belonging and strengthening team spirit, this approach considerably reduces accidents in the workplace.

We are counting on you to make that mission a success and to welcome our new collaborator!



EN Safety office

Questions? - Contact us!

Analyse des risques dans EN

Cette année, l'un des objectifs définis par le bureau de sécurité du département EN est de réaliser l'analyse des risques dans tous les ateliers qui sont sous la responsabilité du département. Ce défi a été présenté par la chef de département, Katy Foraz, le 21 janvier 2021, lors de la réunion annuelle.

Cet objectif a été motivé suite aux retours d'expérience sur les accidents (16 depuis 2018 dans les ateliers EN), et aux retours d'expérience des opérateurs. Les activités industrielles peuvent être sources de risques. Même si le "risque nul" n'existe pas, une maîtrise des risques est obligatoire. La méthode consiste à suivre plusieurs étapes depuis l'identification des risques jusqu'à la mise en place de mesures préventives et correctives. Ces étapes visent à éliminer le risque lorsque cela est possible, à le prévenir ou à le réduire.
Les règles et la législation du CERN prennent place dans ce processus et renforcent la responsabilité de l'employeur.
Pour atteindre ces objectifs, un nouvel employé viendra à partir du premier juin 2021 pour 6 mois. Cette personne travaillera en étroite collaboration avec les responsables des ateliers EN, les opérateurs et tous les acteurs de la sécurité concernés. Une analyse des risques réussie est une analyse réalisée avec une équipe de travail.

Dans le département EN, 15 ateliers seront concernés par cette campagne, dans les groupes AA, ACE, CV, EL, HE et MME. Plusieurs risques sont présents dans chaque atelier, comme les risques mécaniques, chimiques, environnementaux, électriques, magnétiques, thermiques, etc. Un formulaire de sécurité M-4-0-1 fourni par HSE, "WORKSHOP - HAZARD IDENTIFICATION AND CONFORMITY ASSESSMENT FORM", vous permet de vérifier la conformité des ateliers, des machines et des activités dans les ateliers avec les exigences de sécurité applicables et les procédures du CERN. Il sera utilisé comme étape 1 pour connaître le niveau de sécurité d'un atelier.

> Les avantages de l'évaluation des risques sur le lieu de travail sont à la fois psychologiques et financiers. En plus d'améliorer le sentiment d'appartenance et de renforcer l'esprit d'équipe, cette approche réduit considérablement les accidents du travail.

QU'EST-CE QU'UNE ANALYSE DE RISQUE ?

Faire une analyse des risques, c'est étudier les conditions d'exposition des travailleurs aux dangers et risques identifiés dans l'entreprise. Même s'il existe de nombreuses méthodes pour réaliser l'analyse des risques, il n'y a pas d'obligation d'utiliser une méthode plutôt qu'une autre, mais une obligation de résultat en termes de prévention. Les principales étapes sont les suivantes

Étape 1 : Préparation avec état des lieux
Étape 2 : Identification des risques

3x3 RISK MATRIX

LIKELIHOOD ↓ / SEVERITY →	1	2	3
1	LOW -1-	LOW -2-	MEDIUM -3-
2	LOW -2-	MEDIUM -4-	HIGH -6-
3	MEDIUM -3-	HIGH -6-	HIGH -9-

Fig 1 : Exemple d'analyse de risque (vert : tolérable, jaune : non acceptable, rouge : des mesures immédiates doivent être prises)

Étape 3 : Évaluer les risques
Etape 4 : Définir les mesures
Étape 5 : Mise en place des mesures
Étape 6 : Vérifier l'efficacité

Nous comptons sur vous pour faire de cette mission un succès et souhaiter la bienvenue à notre nouveau collaborateur !

Service Sécurité EN, Questions ? Contactez-nous !

Scheduling Tools Project

Applying a continuous improvement approach, the EN-ACE group decided during LS2 to launch a project to enhance scheduling tools (software, application, viewer, dashboards, etc.) in view of future programmed stops, and especially LS3. This project is mainly managed by the OSS section in charge of organizing and scheduling the programmed stops (TS, YETS, LS) of the accelerator chain (LHC and its injectors), and EN-IM-PLM for the development part.

The purpose of this project is to further improve the effectiveness of coordination teams by optimizing their working procedures and better communicate the schedule information to all stakeholders. There is no need for a complex application to succeed in scheduling and coordinating activities, but it is important to have an application with specific features. If you take the example of a toolbox with hundreds of tools, do you really need all of them to build your kitchen? No, you just need a few, dedicated and efficient ones. For scheduling, this is the same. The project is all about defining user requirements and finding the best implementation with respect to cost and maintenance, while keeping the successful scheduling methods that are in place today.

Extract of the project management plan (EDMS 2311175). The project goal is ensuring the scheduling and coordination of CERNs accelerator facilities managed within the EN-ACE Group after the Long Shutdown 2 (LS2), in collaboration with EN-IM. The project is defined according to the following objectives:

- Transfer the data from the current scheduling tool (MS Project and Project Online) into a CERN database;
- Define the scheduling software to be used during LS3;
- Put in place a GANTT view to read the schedules;
- Put in place a Calendar view to read the schedules;
- Put in place a Linear view on web interface to read the schedules;
- Put in place a Broken Line indicator on Linear Views;
- Put in place a dedicated view for the safety, access and logistics constraints;
- Put in place a dedicated view for resource levelling.

The priorities between the project objectives will be redefined when necessary, according to the manpower availability.

The development of any new tools shall ensure a collaborative approach with the other tools developed at CERN (ex. Track-It, IMPACT, InforEAM, LayoutDB, PLAN, etc…)

Currently, EN-ACE scheduling tools are composed of several items:

- The schedules are built with **MS Project**, based on a template which allows homogenizing the type of information and format.
- The schedules are centralized in a **MS Project Online** workspace, which allows having a central source of data through lookup tables. The Project Online platform was chosen before LS2 as the first alternative for reading schedules from a web interface without MS Project desktop software. This was also our first test of extracting the schedule data from several planning in a transversal way.
- The schedule data is extracted from Project Online and copied in a **CERN database**, twice a day (during the night and in the afternoon). The web viewers are built on top of this database and allow any user to read and extract the data in a transversal way.
- The detailed schedules are accessible without any MS Project licence for any CERN users on a **Gantt viewer** (https://oss-coordination.web.cern.ch/gantt/latest).
- The **linear views** are built with VBA macros in **MS Excel** files, extracting the schedule data from MS Project files. Despite the improvements of the macros done before LS2 to gain time in this process, a lot of manual steps remain to be performed, especially when editing the view, updating it and setting the baseline.
- The **broken line**, which is one of the main indicators chosen to monitor the progress of activities in the schedules, is also built with VBA macros in **MS Excel** files, extracting the schedule data from MS Project and comparing it with the baseline set in the linear view.
- The schedule of activity constraints is manually done in **MS Excel** every week in a linear view. The information is static and shared in PDF format by e-mails and on websites. The same information is again manually written on a **web interface** developed by EN-AA and is displayed on the accelerator **TV screens** close to the Personnel Access Devices (PAD).
- The resource levelling analysis is done in **MS Excel**, extracting the data from MS Project files. Calculations and associated graphs are defined manually by the scheduling and coordination officers. MS Excel provides more options than MS Project to make these types of analysis (ex. graph with multiple resources).

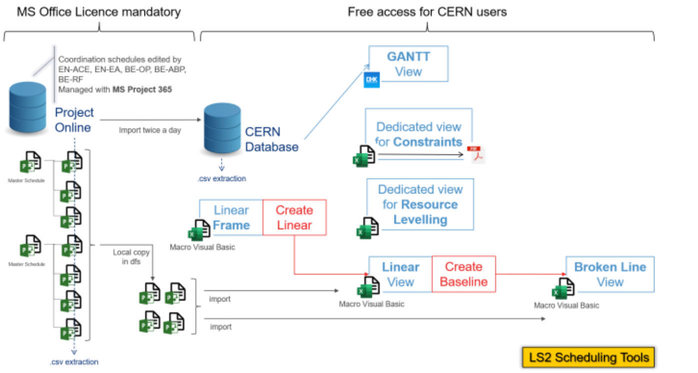


Figure 1 - schematic process of the scheduling tools

The objective for LS3, is to provide more efficient viewers of the coordination schedules that could be used by coordination teams and read by any CERN user with free access, based on the information contained in the CERN database:

- The decision to keep working with MS Project or using another application is not taken yet. Analysis is ongoing. The option to keep working with MS Project is part of the Scheduling Tools Project and remains compatible with the improvement of the web-based viewers.
- Several viewers will be put in place for dedicated use and with dedicated formats (ex. Gantt, calendar, linear, etc.). The viewers will be implemented with features and functionalities to help finding or extracting the information that the user is looking for.

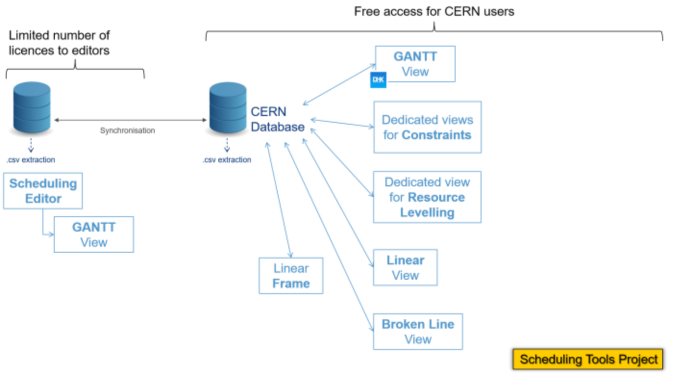


Figure 2 - schematic process of scheduling tools targets

Driven by the announcement of the IT Department about the cost increase of Microsoft licences at CERN, EN-IM developed a web interface to give access to the schedule information to any user at CERN, without the need for a MS Project licence.

This web interface is built on top of our CERN internal database and is therefore completely independent from MS Project. It has been designed using a Java backend, and a React frontend together with the [DHTMLX library](). DHTMLX is a JavaScript library that provides many UI component, and in particular a Gantt viewer and editor.

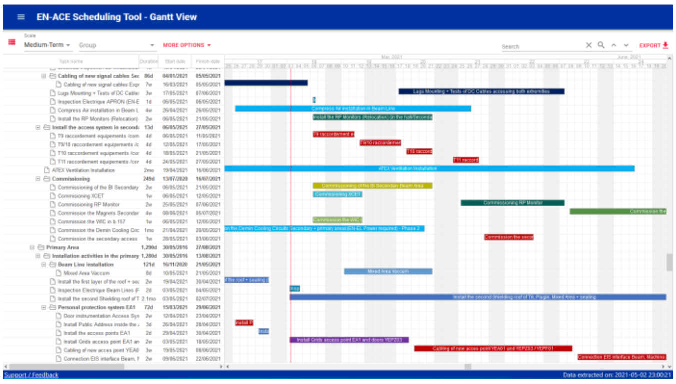


Figure 3 - Gantt viewer of the coordination schedules

This viewer displays all detailed schedules from LS2. This will be the first time that we will be able to navigate in schedules on one interface for past, current and future technical stops and shutdowns. A dedicated time filter has been implemented to focus on a chosen period (e.g. LS2, YETS21-22, etc.). This new navigation interface gives a transversal view of all schedules for a same period. This will help the equipment groups to see where and when their teams are foreseen in the different machines of the accelerators chain. Standardization of the information and improvement of the navigation is foreseen (navigation per location, per vacuum sector, per coordination tag, etc).

A new format to display information defined as potential constraints by the coordination teams from schedules is being tested. The first tests have been done using the calendar type format to get the granularity of hours (lift maintenance, AUG tests, sirens tests, X-rays, etc). The advantage of this kind of viewer is to filter information related to potential constraints from the database and display this information on web pages that can be accessible from any computer, smartphone, tablet or screen installed close to the PADs at the entrance of machines. The first feedback is very positive, and we continue to further improve the ergonomics.

Developing new scheduling interfaces at CERN will generate innovation and modernization in the way the coordination information of technical stops and shutdowns is used and communicated. We are documenting user requirements, technical specifications and how decisions are taken. In addition, we are editing user manuals and guidelines.

The user manual for using the Gantt viewer of the coordination platform is already available on this link: https://scheduling-tools.web.cern.ch/scheduling-tools/guidelines-ganttview.html.

More Information about the Project

If you wish to know more about this project, please find below some useful links:

- Scheduling Tools Project Website: https://scheduling-tools.web.cern.ch/
- Discussion forum for users on Mattermost (public channel): https://mattermost.web.cern.ch/en-ace-group/channels/en-ace-scheduling-tools-forum

E-mail contact: scheduling-tools.support@cern.ch

Julie Coupard (EN-ACE) and Antoine Ansel (EN-IM)

Pollution Dispersion Simulations with ANSYS Fluent in the CFD Team

The Computational Fluid Dynamics (CFD) team of the EN/CV Group has provided a wide simulation support to the FIRIA (Fire-Induced Radiological Integrated Assessment) project.

The FIRIA project was launched in 2018 to develop a risk assessment methodology aimed at predicting the radiological consequences of fires that could potentially develop inside the Organisation's research facilities. The application of FIRIA methodology to CERN's research facilities allows a better preparation of the emergency response of the CERN Fire and Rescue Service, as well as the identification of risk mitigation measures for safety, environmental and property protection.

The propagation and dispersion of potential radioactive clouds, in the case of an accident, were simulated in order to evaluate the doses absorbed both by onsite CERN personnel and the citizens outside CERN's fences. Two main accident scenarios have been identified as critical and were therefore studied: the ISOLDE facility and the ATLAS cavern.

The HSE unit performed the first assessment: analysis of fire risk, investigation of particle properties, and simulations of the fire development inside the buildings using an FDS (Fire Dynamics Simulator) to determine the deposition inside buildings and the mass released into the atmosphere. These results were finally used as input data for the CFD model to simulate the release into the atmosphere.

The CFD model covers an area of 3 × 3 km^2 around CERN. It was created using GIS information to define the buildings and the green areas inside and around the Meyrin site. The airflow simulations on this model allow a realistic prediction of the released particles' dispersion and an accurate prediction of the doses that people could receive in accidental scenarios. Apart from the already available analytical models, which provide good estimations for a flat far field, CFD simulations are needed to provide accurate solutions in the near field with a high density of tall buildings: the flow-dynamics around the buildings can be complex and the analytical calculation methods are not adapted to predict these local effects.

The outdoor dispersion simulation studies were performed with ANSYS Fluent, which is a commercial software package, and the simulations are done in CERN's HPC infrastructure. While parallel scaling is excellent, the computational effort to reach high-quality results is considerable with the current version of the model. For instance, simulating one wind direction for one scenario takes approximately five days of computing time on 400 cores; the modelled domain is 500 m high, and it is defined using ~30 million polyhedral cells with a mesh resolution on the ground of approximately 1 m. For each of these cells Navier Stokes equations are numerically solved and the preeminent method of Large Eddy Simulation (LES) is used. The simulated release time is around two hours depending on the scenario. Not only can soot particles be considered, but multiple species can also be used to simulate, for example, the Argon dense gas release.

The pictures below show some of the results obtained from the ATLAS argon dispersion case study under different wind directions.

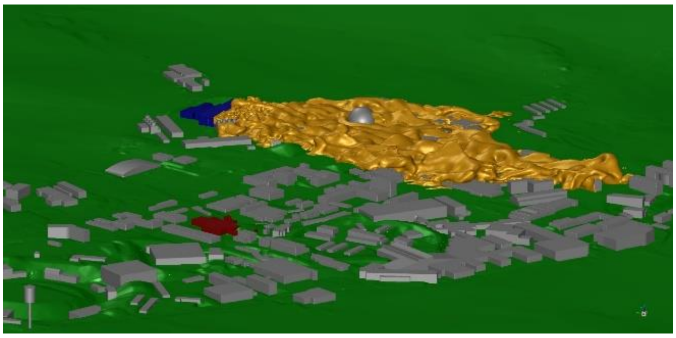


Figure 1: ATLAS – Argon Release Scenario (Wind Blowing South)

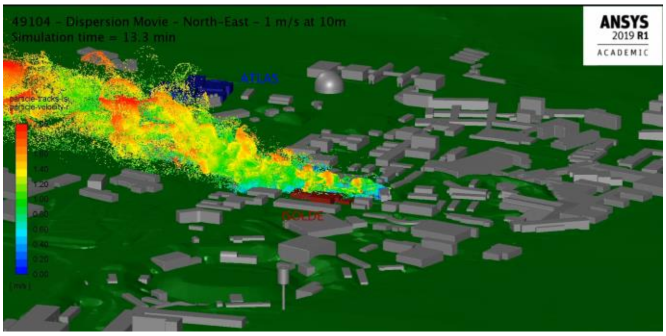


Figure 2: ISOLDE – Fire Release Scenario (Wind Blowing North-East)

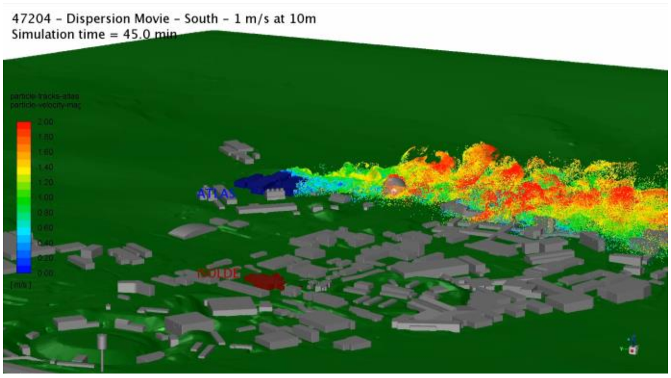


Figure 3: ATLAS – Fire Release Scenario (Wind Blowing South)

Atmospheric dispersion simulations are needed in the assessment chain starting with the identification of possible releases, indoor simulations and the dose assessment. Therefore, outdoor simulations are important to realistically predict the consequences of fires and to estimate the movement of a plume for emergency preparedness.

As shown in the pilot cases investigated (ISOLDE/ATLAS), simple analytical models are only able to predict values correctly, when the model gets more complex. Physical effects, i.e. dense gas plume downwash, or the geometrical impacts, like flow channelling or building downwash effects, further emphasise the need of CFD models.

Uwe Kauflin EN-CV

Optical fibre sensing technology

During the last few decades, optical fibre (OF) sensing technologies have been growing at a very fast rate, thanks to the unique advantages that they offer compared to conventional technologies. Some key enabling elements are the immunity to electromagnetic interference, the mechanical flexibility, small size, light weight, and low cost. The single most extraordinary feature of OF sensors is their ability to allow distributed one-dimensional online measurement of relevant physical quantities (temperature, strain, etc.) over kilometre ranges.

Despite the extensive scientific research on radiation effects on OF, the real potential of OFs for radiation sensing remained mainly unexplored. Over the last few years, CERN has been importing the ground-breaking sensing capabilities of OFs to this new domain. This happened in the context of R2E projects (Radiation to Electronics), whose objective is to ensure optimal operation of CERN's accelerator complex with respect to reliability of radiation exposed electronic components, systems, and materials.

Nowadays, a dedicated fibre optics infrastructure allows distributed real-time monitoring of radiation levels in a significant portion of the accelerator complex: PSB, PS, SPS and TT20, and six parts of LHC. The system, called Distributed Optical Fibre Radiation Sensors (DOFRS), is developed, operated, and maintained by the EN-EL-FC section.

To explain the working principle of the DOFRS it is sufficient to consider two key components: a suitable radiation sensitive OF and an optical interrogator. The optical attenuation in OFs generally increases when exposed to ionizing radiation. This phenomenon is called Radiation Induced Attenuation (RIA). At low radiation doses, it is largely due to the trapping of radiolytic electrons and holes at precursor sites in the glass matrix, i.e., the formation of point defects. At the same time, the reduction of point defects population by thermal or optical processes causes a recovery, usually resulting in a decrease of the RIA. It is important to emphasize that RIA and its recovery, occur simultaneously under radiation exposure. RIA and RIA recovery depend on many variables including chemical composition of the fibre, dose, dose rate, temperature, type of radiation, injected light power etc. Although in most cases OFs are not adapted to be used as sensors in dosimetry applications, some P-doped OFs operated at specific wavelengths are an exception to this rule and possess excellent properties as it was demonstrated in here. In particular, the radiation response of such P-doped fibres presents a suitable RIA level at telecom wavelengths, no dose rate dependence, no recovery process after irradiation, no dependence on the irradiation history, no photo-bleaching effect at telecom wavelengths, no temperature dependence around room temperature, and no dependence on the incident particle type. When these conditions are verified, it is meaningful to define the radiation sensitivity of an OF as the increase of RIA per unit of dose. The second most important element of the DOFRS system is the optical interrogator, which in the case of CERN application is constituted by Optical Time Domain Reflectometers (OTDR). OTDR are devices that allow measuring the optical attenuation along an OF with a spatial resolution as low as one meter over kilometres range. Such devices are widely available because they have been routinely used in telecom applications for many years. When an OTDR is used in combination with a qualified and calibrated OF dosimeter, it becomes possible to perform distributed measurements of the radiation dose levels along the OF. This way, with a few OF cables and a few OTDRS it is possible to monitor the radiation levels over long distances, which is a remarkably well adapted solution for large facilities such as CERN accelerators.

The figure below shows an example of the radiation maps that were produced in 2018 for the PS, during a full year of operations. The DOFRS system acquired data continuously for 270 days, with an acquisition period of a few minutes. Several radiation peaks are detected by the DOFRS systems. Those peaks correspond to hot regions of the machine, corresponding to extraction, injection and internal beam dumps areas.

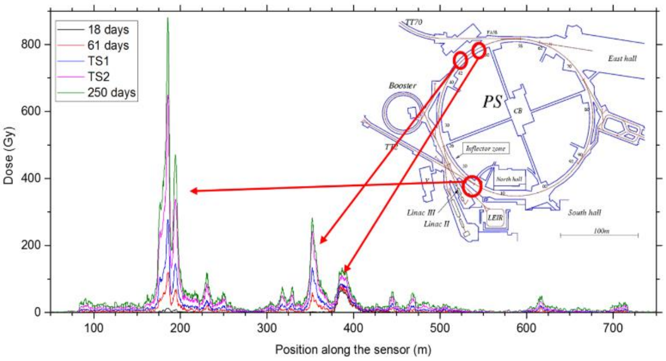


Figure 1 Example of radiation maps generated in the PS during 2018 run

The data collected by all DOFRS systems are automatically processed and stored on CERN central servers, from where the Monitoring and Calculation Working Group, which is part of the R2E project, can collect and analyse the information. That is used to address specific users' requests and to maintain a clear view of the current and future levels of prompt dose in CERN accelerator complex. Several internal collaborations have been instrumental to the implementation of the DOFRS system, in particular the ones with BE-CEM-EPR and SY-STI-BMI.

In parallel to the operation of the recently deployed DOFRS systems, the EN-EL-FC section and R2E project continue the R&D activities around OF radiation sensing with the aim of improving the overall performance of the system, increasing the lifetime and reusability of the OF sensors and exploring new applications. The developed technologies can be of interest not only for the monitoring of CERN radiation environment, but also in space applications, nuclear industries (power-plants and waste repositories), and nuclear fusion facilities, leading to an increasing level of reliability for the equipment operating in harsh environments and, more generally, to a safer environment for the end users.

Diego Di Francesca and Daniel Ricci EN-EL

Infor EAM: Asset & Maintenance Management Platform at CERN

You may already have heard of an application called Infor EAM, which is the commercial Enterprise Asset Management (EAM) platform, in use at CERN for many years already. However, what you might not know, is that this platform every year is used by more than 3500 people from all over CERN and that it receives input from users and integrated systems about 5 million times per month, with peaks at over 30 times per second.

Asset Management is often defined as the coordinated activity of an organisation to realise value from its assets. More practically, this comprises the systematic approach of deploying, operating, maintaining upgrading and disposing of assets cost-effectively. In order to support this work, specialised IT applications exist, often called Enterprise Asset Management (EAM) tools. The tool used at CERN, Infor EAM, is one of the market leaders in the domain. Thanks to its highly configurable functionality, it is particularly suitable for an organisation like ours, where we have a very wide array of different types of equipment to manage. Several other research organisations around the world decided to use the same EAM platform as us. This includes for example ESS, ESA, CEA, Canadian Light Source, Oak Ridge National Lab as well as Lawrence Livermore National Lab. Thanks to regular contacts with these organisations, we can exchange best practices and experiences gained.

The most basic functionally of Infor EAM is to provide an inventory of the organisation's physical assets, to manage and record interventions carried out on these assets, as well as to manage spare parts and materials required to carry out these interventions. While this functionality is enough for certain groups and services, the real advantages are often seen when starting to study and analyse the captured information, optimising the ratio between corrective and preventive maintenance or using the reliability-centred maintenance module. We are starting to move towards predictive maintenance, with the goal of increasing equipment availability while keeping the maintenance cost to a minimum. In a similar manner, by comparing the asset's financial value to its maintenance costs, this might as well bring additional insights regarding both individual assets and entire asset categories. This might for example help in estimating maintenance budgets or to understand which assets to repair, and which to replace. Some of the more experienced users benefit from the different work planning or forecasting functionality whereas others rely on SCADA or IoT integrations to optimise their maintenance schedules based on actual asset usage or other operational input. For groups that outsource maintenance work or who need to invoice internally performed activities, Infor EAM can assist here as well thanks to its integrations to the financial applications at CERN.

Whereas Infor EAM originally was implemented for mainly supporting operation and maintenance work, the platform is today covering a much broader scope that includes the complete lifecycles of the Organisation's physical assets and technical installations. In order to do so, several tailored and simplified web interfaces for activities have been created on top of Infor EAM to simplify the usage for normal users. Thanks to this approach, many of the basic tasks can therefore often be carried out with little or no training. Below is a non-exhaustive list of applications at CERN that are all based on functionality and data of Infor EAM.

- EAM Light: A simplified and mobile user interface to Infor EAM specifically designed for mobile devices (see figure 1 below).
- EAM Store Kiosk: A self-service kiosk for managing store rooms.
- EAM Logbook: A configurable logbook integrated with Infor EAM.
- TREC: Allows traceability and measurements of radioactive equipment and waste.
- Track-It: Coordination tool for the execution of accelerator related activities.
- MTF: Asset manufacturing and installation follow-up. (gradually being replaced by EAM Light.).

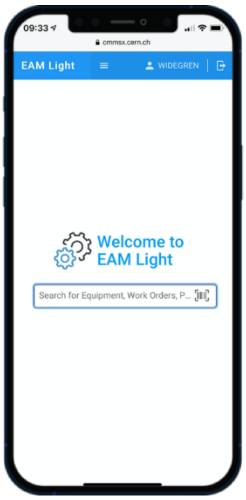
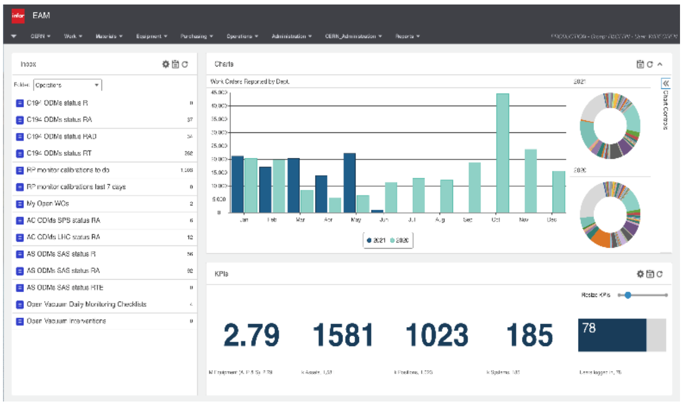


Figure: screenshot of EAM Light on a mobile phone

Equipment at CERN are these days often labelled with barcodes in order to allow quick and easy identification, for example using the built-in camera on a modern smartphone or tablet. Via the EAM Light application (www.cern.ch/eam-light), anyone with a CERN user account can scan the barcode of an equipment in front of him or her. This way, information about what it is, whom it belongs to or even to see which equipment risks and hazards have been registered in the Infor EAM Safety Management module. Currently, close to 3 million individually traced pieces of equipment are stored and managed in Infor EAM.

The Asset and Maintenance Management service is provided as a CERN-wide service and includes not only the IT tools but also user support and assistance (cmms.support@cern.ch) as well as a training program consisting of five different course modules (lms.cern.ch). The service is provided by EN-IM and if you have any questions or would like to know more about it, please don't hesitate to contact your colleagues in EN-IM-AMM directly or by using the email address indicated above.

Finally, it is important to remember that asset management only covers the physical part of the installation's lifecycles and that many of our equipment are specified, designed and manufactured specifically for us. Therefore, one of the current efforts in the EN-IM group is to improve and strengthen the links between data generated throughout these phases of the lifecycle. For example, by making it quicker and easier to find the drawings or 3D models used to manufacture a particular asset - and vice versa. This set of interlinked engineering data originating from various tools and different project phases is often called the Digital Thread. Our goal is to reinforce and better visualise this Digital Thread, which is an effort where CERN's new PLM platform will play a key role in managing such links.



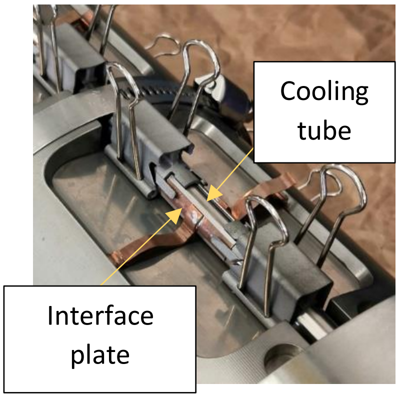
David Widegren for the inforEAM service

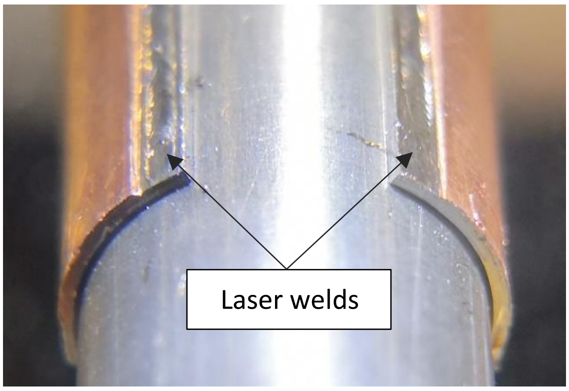
Additive Manufacturing, let your imagination take over!

Metal Additive Manufacturing (also called metal 3D printing) is a novel manufacturing technology, which works by adding material instead of removing it. The selective laser melting (SLM) technology used in the Mechanical and Materials Engineering Group use a high-power laser to fuse layers of fine metal powder to produce 3D parts. Components from Titanium alloy, stainless steel, niobium and other metals can be manufactured.

This technology can generate very different shapes from what you traditionally see coming out of a milling machine.

With Additive Manufacturing (AM) technologies, it is possible to go faster from idea to prototype and to final component. For the HL-LHC octagonal beam screens, we profited from AM to design a clamping tool for robotic laser welding. The challenge is to position with high precision thousands of interface plates for welding onto the cooling tubes for heat dissipation.





AM clamping tool assembly on the beam screen (top) and laser welds (bottom)

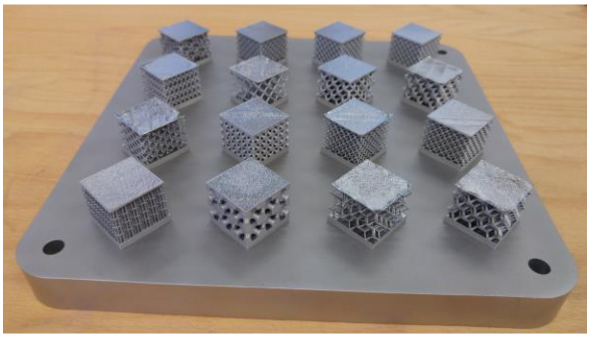
We had the idea of rethinking the concept of a paperclip spring and exploit the 3D design freedom of AM to add precise mechanical positioning of these interface plates on the clamping tool. The final additive manufactured component provided a quick and cost-effective solution for the project.

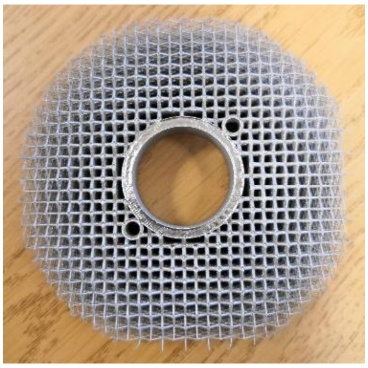
This technology has found its way to the core of our accelerator system. As an example, some of the new pumping port shields for LIU (LHC Injector Upgrade) are made via Additive Manufacturing. These components enabled the transition between two elements with different shapes (MBB and QD magnets). For this project, special care was given to the quality of the surfaces as they can be rough right out of the AM process. In this case, the combination of a traditional vibration barrel polishing and an electropolishing, enabled smooth and clean surfaces.

SPS MBB-QD pumping port shields: batch of 6 shields out of the AM machine (left), MBB-QD shield after polishing (right)

SPS shields after flange assembly

By fusing the material only where needed, this technology opens the doors to open internal structures. These structures are often used to lighten the component but can also be functional for heat dissipation (thermal sink), changing the density of the components and potentially many other applications.





Examples of lattice structures. The material can be solidified only where needed enabling a wide range of internal structure with graded density/properties.

Additive Manufacturing complements the traditional methods of manufacturing metallic components. It is most impactful when taken on board early in the design process, when assemblies can be made in one part and functions can be added for free. The creativity of the designer is his best tool to fully benefit from Additive Manufacturing. Feel free to discuss with us if you have some ideas or challenges to tackle with this technology!

If you want to know more, an article on CERN's bulletin explains further how the process works and how we can develop new materials like niobium:

https://home.cern/fr/news/news/engineering/additive-manufacturing-opens-new-prospects-cern

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