WHAT TCR OPERATION NEEDS FROM A MONITORING SYSTEM?

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Abstract

The Technical infrastructure (electricity, cooling, etc.) is expected to have a more serious impact on the operation of the LHC than that of the SPS and LEP. For the prevention of major breakdowns and for an efficient recovery afterwards, it is mandatory to define the activities and responsibilities of the different actors contributing to the overall accelerator system operation. Additionally, a method common to all actors to monitor the status of the equipment needed for a given mode of accelerator operation is essential to improve the overall co-ordination and efficiency. This method covers the analysis, documentation and presentation of systems and system interactions and has successfully been applied to the SPS. The implications and the recommendations for its implementation in the TCR with respect to the existing accelerators or experimental areas and in particular for the LHC are discussed.
1 INTRODUCTION

As the technical infrastructure (electricity, cooling, etc.) of the LHC is expected to have a serious impact on its operation, the prevention and management of major breakdowns become more important to increase the accelerator's efficiency. To achieve this the activities and responsibilities of the different actors (MCR, PCR, TCR, stand-by services, etc.) contributing to the overall accelerator system operation have to be defined, and a common and homogenous method has to be established to monitor the status of the equipment needed for a given mode of accelerator operation [1].

The work objective of all actors, who are each in charge of different processes, has to be focused on maximising the overall availability of the accelerator by reducing the time to restart after a breakdown. In addition, the workload, knowledge and background of the different actors have to be assimilated and the faults, failures and the progress of the restart of processes have to become transparent.

This paper proposes an approach to achieve this and defines monitoring needs that were applied with success for SPS operation. As the TCR is responsible for the operation of the infrastructure that all the CERN accelerators and experiments rely on, it has a natural interest to bring this integrating approach forward.

2 MONITORING ENGINEERING

2.1 What to do?

The monitoring of accelerator systems and the technical infrastructure is engineered from a task-oriented and functional point of view to improve especially the management of incidents and major breakdowns. It covers the analysis, documentation and presentation of systems and system interactions. All the systems necessary for the functioning of the accelerators or experiments are considered, such as electricity, cooling, vacuum, access, RF systems, power converters, control system, interlocks, safety systems. They are decomposed into subsystems, correlations and critical paths with respect to a set of modes of accelerator operation (operation scenarios) to satisfy different classes of users.

2.2 Why to do it?

The analysis results in monitoring tools assisting the control room operator in the correct and rapid assessment of equipment faults and their implications for the user. They help as well to find the best restart strategy based on process dependencies (critical paths), process functions and nominal operation values and limits (e.g. trip temperatures of magnets). With this, priorities for the interventions of stand-by services and experts are established to respond to the accelerator’s operation scenarios. It also provides basic criteria to estimate the impact of a failure on the users and to redefine priorities and schedules in a transparent way. It especially increases the understanding and collaboration between the different control rooms and equipment groups by creating a common language.

This approach can also be used to evaluate the impact of preventive maintenance on a piece of equipment and provide additional input for scheduling machine exploitation. Furthermore, it can help to assess the impact of an equipment fault, which is in a warning state (degraded operation). Reduction of the down time can be achieved by implementing an early detection system of deteriorations of operating parameters of equipment in the critical path (e.g. an increase in the temperature of the demineralised water of the main magnets could trigger a warning so that the main power converters can be stopped before the trip level is reached).

2.3 How to do it?

Figure 1 shows the main elements of the engineering needed for this type of monitoring. On the basis of Accelerator Operation Scenarios the application of the Monitoring Engineering results in Operation Oriented System Documentation, which is in turn implemented in Task Oriented Monitoring Diagrams and Tools. The documentation is extracted from the system and process documentation of the concerned accelerator and its technical infrastructure, and is optimised for operation in close collaboration with equipment specialists and shall become part of the regular system documentation.
The monitoring information that is needed to integrate all this in the remote supervision systems is defined and becomes part of the system specification.

2.4 How to implement it?

The implementation of the HCI’s is done in the form of task-oriented tools, which integrate the more detailed process monitoring tools into a global structure and become the standard tool for operation, see Figure 2.
a) The “General States Overview” enables the operator to evaluate the availability of systems necessary for the functioning of the entire accelerator and the technical infrastructure directly connected to the latter at a glance. It shows all systems and all locations together.

b) With the “Accelerator Functionality Level” the operator can assess system states quickly, verify the correctness of the standard restart procedure and establish alternative procedures, if the situation requires it at the time of a breakdown. One of these diagrams is necessary per operation scenario, representing the details of the accelerator equipment and the general states of the technical infrastructure on one single diagram [2].

c) The “Detailed Technical Infrastructure Monitoring Diagram” serves the same purpose but concerns the details of the complex technical infrastructure. It shows the systems and sub-systems required by the machine in detail [3].

d) On the “Process Equipment Level” specific diagnosis programs for the accelerator and technical infrastructure are available. Those correspond to today’s operation tools and allow the analysis of the processes in detail and remote equipment control.

2.5 Tests and Maintenance

The effectiveness of the monitoring and of the procedures to re-establish or maintain beam conditions depends on the correctness of the information available on the systems and their correlation. Therefore an important effort both from operation and equipment groups must be devoted to keep the results of this method up-to-date. A validation and maintenance procedure will have to be established and adequate time for tests will have to be provided during shutdown, cold checkout or setting-up with beam.

Post-mortem analyses of the incidents shall systematically be carried out to find possible improvements to the operation tools. In that respect the ST Major Event Report could be extended [4]. The following aspects should be covered by the analysis:

- Completeness of system information and their correlation
- Synchronisation of the restart of the technical infrastructure and accelerator systems; e.g. to have the technical infrastructure ready just-in-time to start an accelerator or experiment
- Identification of potential sources of faults that would need an early detection system; e.g. unusual temperature increases that are still in the acceptable limits but risk exceeding them
- Identification of (critical) systems that shall be secured against breakdowns (e.g. due to electrical perturbations)
- Completeness of monitoring information in the form of alarms, process diagrams etc.

3 PERSPECTIVES

The natural extension of experience gathered on the mentioned engineering method with the SPS, is the SPS experimental areas and the PS complex and its experimental areas. Future facilities such as the LHC and CNGS will be operated concurrently with existing ones (e.g. the North and West SPS experimental areas, the PS East hall, the nToF facility, ISOLDE). Early diagnosis of an equipment failure and of its implications will be an important input to establish alternative operating scenarios and to re-schedule beam time distribution among the users that fit with the estimate recovery time.

The LHC machine will present the following peculiarities:

- The consequences of a fault in the technical infrastructure might lead to a stoppage of several weeks [5].
- The correlation between system operation and beam parameters will be stronger. The beam-induced electron-cloud [5] with its impact on vacuum, cryogenics and beam quality is an example of such a strong link. The decisions concerning the beam parameters will not be based only on the availability of these systems but also on their dependencies.
The experiments are more strongly linked to the ‘machine’: for example, the availability of the experimental magnetic spectrometers (solenoids, dipoles, toroids, …) might have an important impact on the machine operation even if they will not be strictly necessary for it. Furthermore, access to the experiments or other underground areas will require stopping the beam.

No operation experience exists in particular as far as the interaction of the different technical systems is concerned.

4 CONCLUSION

The operation of the technical infrastructure and thus the TCR operation has to be focused on maximising the overall availability of the accelerator by reducing the time to restart after a breakdown. This can only be achieved if the faults, failures and the progress of the restart of processes are transparent for all actors and common task oriented monitoring tools are provided that integrate all the systems involved in accelerator exploitation into a global picture.

The monitoring engineering described in this paper has been developed in collaboration with the PCR and MCR and it’s application to the SPS proved that it covers the above mentioned requirements and objectives. The extension to other CERN accelerators and experimental areas is appropriate and any future engineering of TCR monitoring will be based on this method.

The extension to the LHC is, however, challenging and the following considerations have to be taken into account to prepare TCR and accelerator operation in time:

- Little or no operational experience exists for the new facilities and the users and actors are not yet defined
- The system documentation must be available early, containing process inputs, outputs, positioning, functionality to fulfil, it’s purpose and the user
- The results of the monitoring engineering method and the needs described have to be integrated in the specifications of monitoring and control systems, so that they are fully considered during development and contract execution
- The monitoring tools shall be available for the commissioning phase so that errors can be detected and corrected before the beginning of LHC operation.

5 REFERENCES

[2] PCR-SPS restart diagrams, EDMS 320374
[3] TCR-SPS restart diagrams, EDMS 320376