TECHNICAL SERVICES

UNAVAILABILITY ROOT CAUSES, STRATEGY AND LIMITATIONS

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Abstract

CERN's technical infrastructure is a common root cause source of unavailability impacting the accelerators, injectors, experiments and the computer center.

The Technical Infrastructure Operation Committee (TIOC) monitors, analyses and coordinates the technical infrastructure operation in order to increase the overall availability of the LHC. All events impacting or potentially affecting directly or indirectly the LHC runs are analyzed and recommendations are made for immediate intervention or long term actions. Tools and performance indicators are progressively being implemented considering a more structured approach to system breakdown identification and fault tree analysis.

The unavailability caused by the technical infrastructure during 2016 has been analyzed and compared with previous years together with the impact of electrical power glitches. Tools and strategies to perform availability analysis across all systems and equipment are proposed and the tracking of the root cause analysis and dependences assessed to explain past and future performances.

SYSTEMS MONITORED BY TI

The Technical Infrastructure control room in the CCC is mandated to monitor the technical infrastructure needed to run the accelerators complex. The main systems monitored are:

- Electrical distribution network covering everything from the 400 kV / 130 kV supply from EDF / RTE and SIG / EOS to the 66 kV and 18 kV distribution internally at CERN to the 400 V / 3.3 kV for end users.
- Ventilation for the accelerators and experiments as well as machine buildings
- Cooling for accelerators, experiment and machine buildings including primary water, demineralized water, chilled water, reject water, tap water and more.
- Safety systems including fire detection, gas detection, evacuation systems, emergency stops. All technical parameters are monitored by TI while level 3 alarms are monitored by the fire brigade.
- Access system to the experiments and accelerators as well as access to buildings and sites
- IT network interventions and break downs are coordinated with the 513 operators. TI also monitors part of the industrial controls.

Systems monitored by TI are not under the category of Technical Services in AFT, this inevitably causes inconsistencies between the TI logbook and AFT. The proposal is to make a joint effort to make the categories in AFT aligned with the ones used in the TI logbook.

SYSTEM BREAKDOWN STRUCTURE

For many years, major events are recorded and ordered using the group "responsible" for the fault. This has shown to be unprecise because of two main reasons:

- The groups change from time to time at CERN, and sometimes groups expand and change responsibilities which makes it difficult to compare from one year to another.
- A cooling fault can be under EN-CV responsibility, but also TE-EPC when the fault is on a power converter or BE-RF if it is inside a BE-RF rack.
- There is more technical interest in knowing what type of equipment the failure belongs to than the actual owner.

After thorough analysis of previous major faults at CERN a new system breakdown structure has been developed and will be proposed to be implemented in AFT for all technical infrastructure faults. This new structure consists of 2 parts: The first part defines the faulty system breakdown structure, as shown in figure 2.

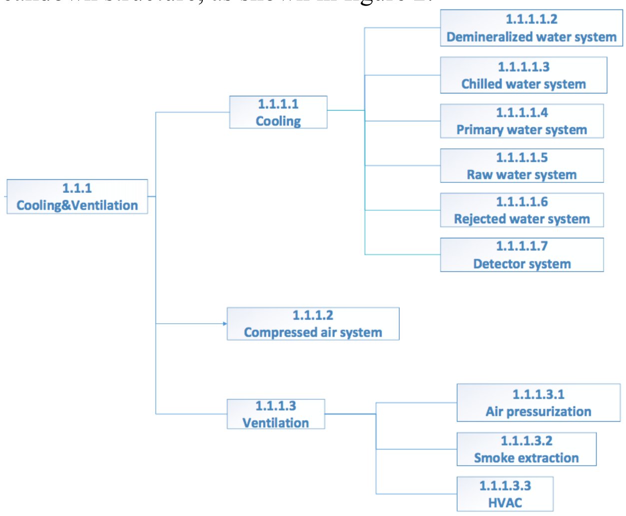

Figure 1: System breakdown structure

The second part of the system breakdown structure is the type of fault that can occur to the system chosen as shown in figure 3.

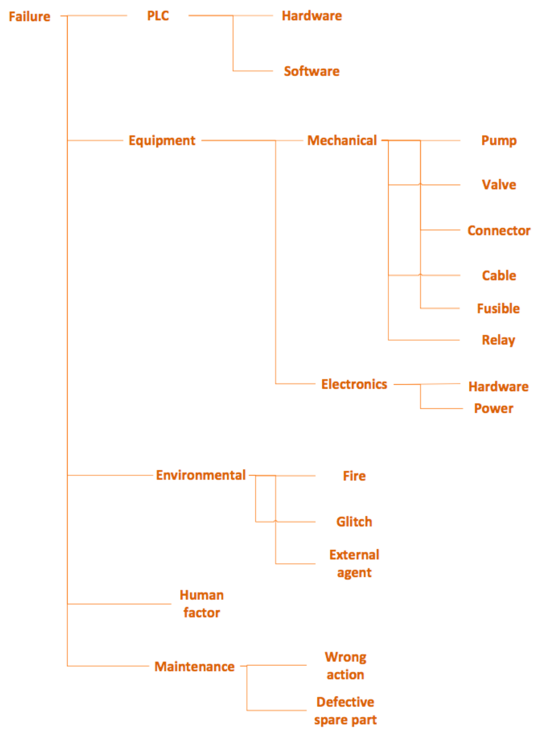

Figure 2:Faults breakdown structure

Using the combination of the faulty system, the type of the fault and the group responsible for the fault it is straightforward to extract statistics and perform analysis based on equipment, fault typology and owners, e.g. all PLC faults regardless the system, faults on the electrical distribution network other than EN-EL..

TIOC MEETING

The mandate of the TIOC is:

- monitor, record and analyze events related to the infrastructure systems serving the accelerator complex, the experiments and the computer centre.
- Recommend consolidations paths which would correct situations originating from the reduced maintenance, non-conformities or weaknesses of the technical infrastructure
- Coordinate bigger technical interventions and incidents.

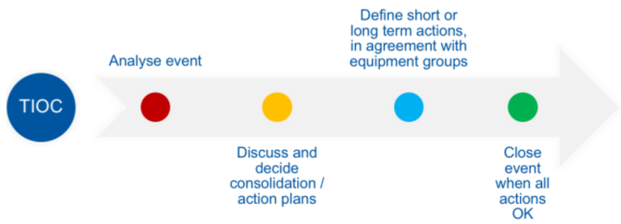

Figure 3: TIOC committee workflow

The committee consists of members from all groups concerning the technical infrastructure, the LHC coordination, LHC experiments technical coordinators and the technical infrastructure.

When a major event is created by the TI operator, the next step is to analyse it at the TIOC meeting. To help clarifying the event all equipment groups and users of the systems can add comments to the report, in form of group reports.

The actions to be taken and consolidations necessary are discussed during the meeting, and once all actions are completed the report is closed and validated for the statistics.

2016 FAULTS BY GROUPS, SYSTEMS AND FAULT TYPES

In 2016 the faults were distributed using the groups and calculated on downtime. The distribution is seen in figure 5. Figure 6 presents the same data set, but using the new system breakdown structure.

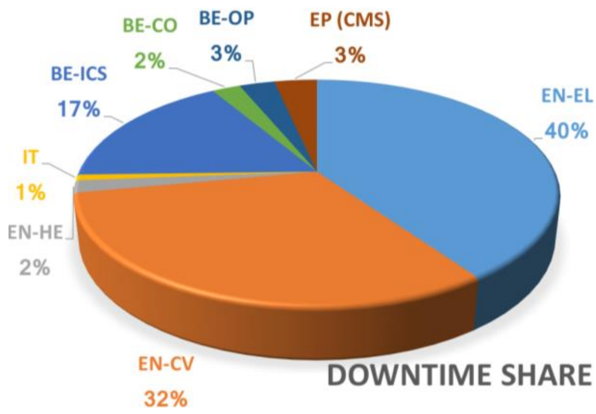

Figure 4: Fault distribution calculated on downtime

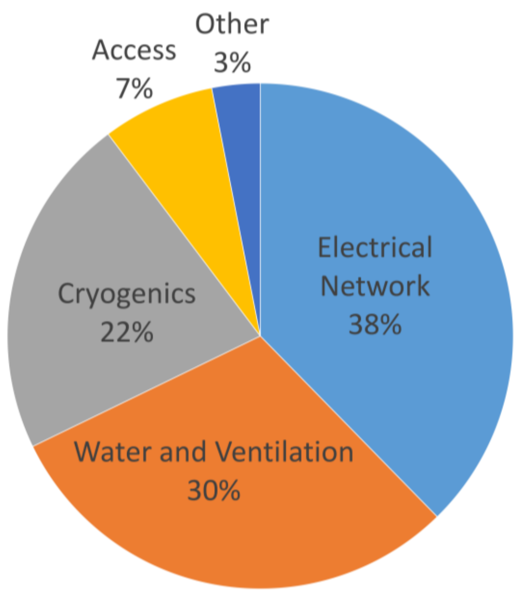

Figure 5: Fault distribution calculated on downtime using the new system breakdown structure

The sharing of all major events, based on the downtime and not the number of events highlight 3 categories of fault stand: Equipment faults, controls and instrumentation faults and electrical perturbations. The distribution is shown in figure 7.

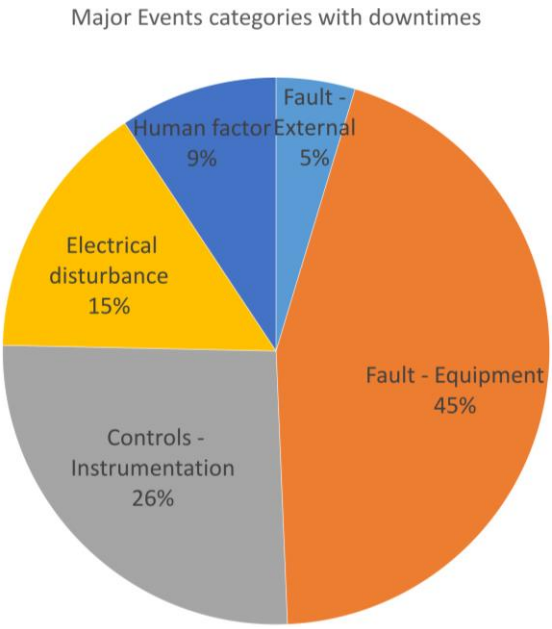

Figure 6: Fault types calculated on downtime

In 2016 we recorded 48 perturbations compared to 16 in 2015. There are 2 ways a recording of a perturbation can be triggered in TI: Either the perturbation is big enough to be detected on the electrical network and therefore causes alarms to be raised, which will be seen by the operator, or 1 or more of CERN's accelerators stop due to the perturbation. In the case of a stop of an accelerator EDF is contacted and can normally correlate with some action on the network or some recording of a minor perturbation. It is worth noting that if EDF would have not been contacted, we would not necessarily have recorded the perturbation.

Several reasons why we saw more in 2016 can be considered:

- We saw more time in stable beams in 2016, which obviously makes the complex more vulnerable to electrical perturbations.
- A fair amount of the perturbations recorded were relatively small in amplitude and were only stopping the LHC on a trip of the FMCM. The exchange of some of the older power converters in the YETS will solve this problem and could potentially bring down the number of perturbations by 30%
- 2016 was generally a very bad year for thunderstorms in France, whereas 2015 was noted as the most stable year in the last 30 years.

The comparisons can be seen in figure 7 where the bars represent the downtime and the lines correspond to the number of perturbations.

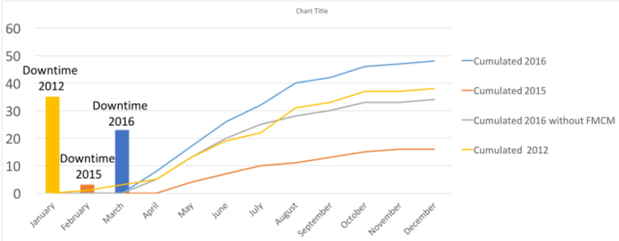

Figure 7: Electrical perturbations

All of the electrical perturbations recorded in 2016 were due to external perturbations coming from either EDF / RTE or SIG / EOS distribution network. 50% of the perturbations recorded were causing less than 10% of voltage dip.

These events are based on meteorological conditions and are outside the control of CERN. Nevertheless, the sensitivity of equipment to perturbations can and shall be reviewed in order to guarantee the lowest downtime while still considering their safe operation.

The faults on controls and instrumentation can be further split in to 4 categories as seen in figure 8. 75% of the faults can be considered as PLC faults. PLC faults have gone down by a remarkable 67% since 2015.

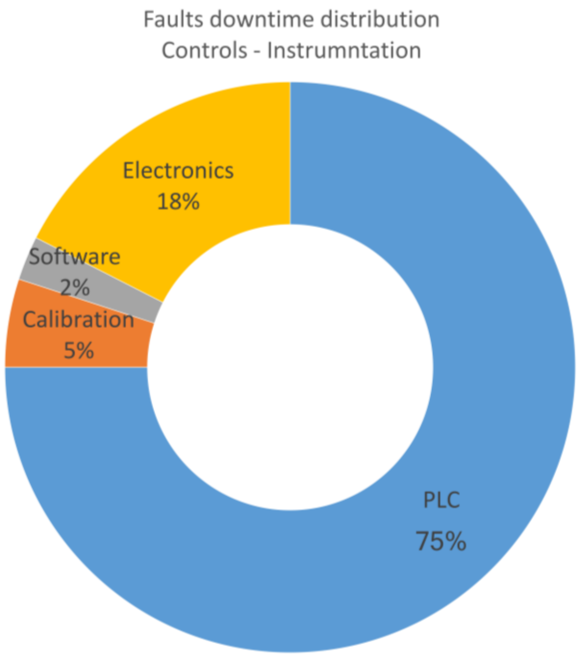

Figure 8: Breakdown of controls and communication faults

The equipment faults can be further split in to 6 categories as seen in figure 9. 28% are due to equipment in short circuit. The faults can sometimes be hard to detect because the breaker that trips is usually not the faulty element. Another 34% can be classified as equipment faults.

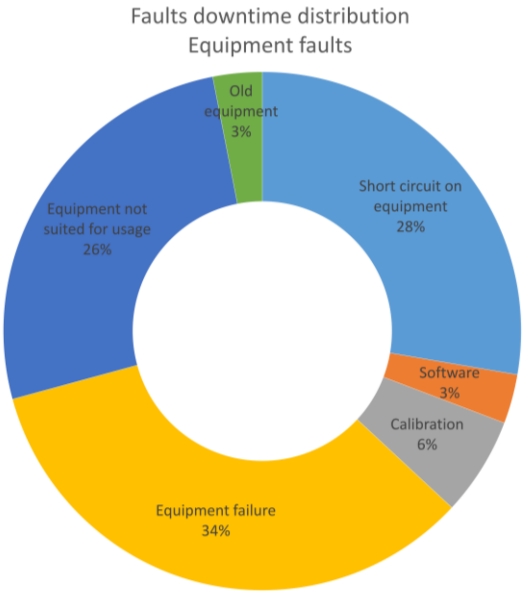

Figure 9: Breakdown of equipment faults

DOWNTIME 2016 COMPARED TO 2015

In 2016 a long downtime was recorded due to a long cut of the 66kV network by an external event. By removing this external event and statistically not significant, the total downtime went down and was 30% below what accumulated in 2015.

CONCLUSION AND OUTLOOK

In 2016 the coordination of events by the TIOC committee has proven very effective, and minimized downtime during the intervention of EDF on the 400kV network.

It has been proposed to put in service a "best effort" service for the TIOC committee, with a list of persons available to coordinate emergencies on the technical infrastructure.

The organization and structure of the major faults can be improved to simplify and improve the analysis. This is being implemented now with the new system breakdown structure. The work will now be focused on harmonizing this structure with the AFT, which will allow everyone to compare systems on the same level in AFT.

The electrical perturbations are hard to avoid, but we can definitely make equipment less sensible. A lot of work has gone in to this by the TIOC and in particular all the equipment groups. 2017 will be a very interesting year to prove the efforts put in place during the YETS and the preparations done in 2016 allow to maintain the high level of availability reached in 2016.

Last but not least, even though the LHC saw a remarkable time in stable beams and therefore higher sensitivity to perturbations, the technical infrastructure recorded less downtime than in 2015 or 2012. Part of the success in the 2016 run is to be attributed to the TIOC follow up, monitoring and proposal for consolidations as well as the efforts done by all the equipment groups on consolidating the equipment.

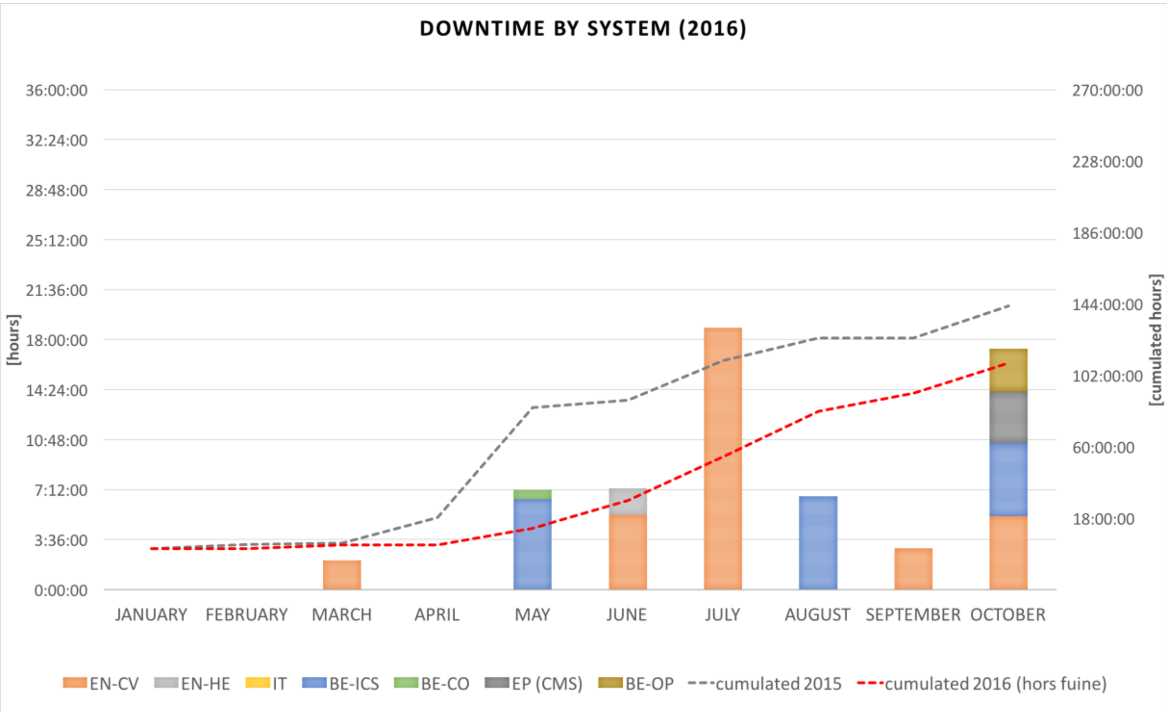

Figure 10: Downtimes compared 2016 to 2105