TUPDP092

ICALEPCS 2023

19th International Conference on Accelerator and Large Experimental Physics Control Systems

9-13th October 2023, Cape Town, South Africa

LIFE CYCLE MANAGEMENT & RELIABILITY ANALYSIS OF CONTROLS HARDWARE USING OPERATIONAL DATA FROM EAM

E. FORTESCUE, I. KOZSAR, V. SCHRAMM

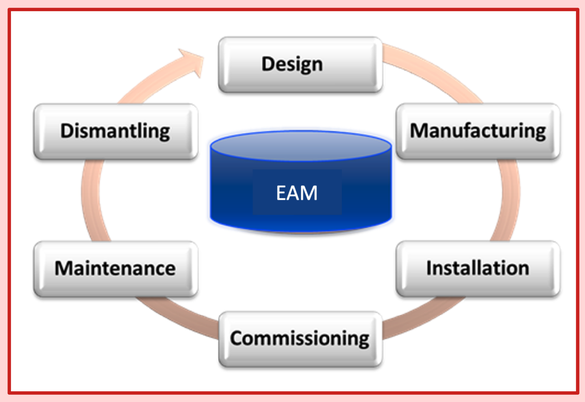
CERN, Geneva, Switzerland

INTRODUCTION

CERN's Infrastructure section is responsible for the life cycle management of a very large collection of electronic hardware components for the Front-End Computers (FECs), distributed throughout the entire CERN accelerator complex.

Planning for replacement and upgrades has become a real challenge. Therefore, having readily available reliability metrics such as the Mean Time To Failure (MTTF), or statistics to determine whether the failure rate is increasing for a given equipment type, known as a part in asset management terminology, can significantly aid strategic decision-making.

WHAT IS AN EAM?



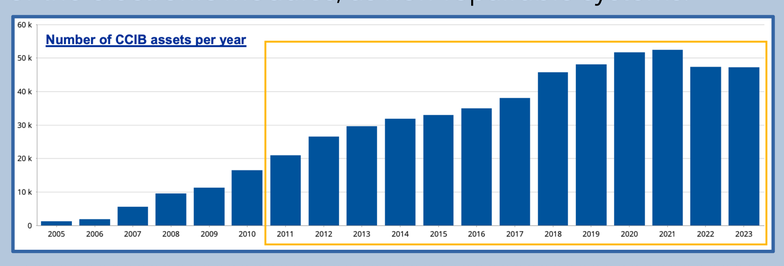
An Enterprise Asset Management (EAM) system [1] allows users to follow equipment through its' life cycle. It provides in-built functionalities such as history tracking, state machines, spare part and store management, and user reporting.

Assets are registered in EAM for instances of any part that need to be individually tracked, such as electronic boards, chassis, power supplies and fans. Barcodes, are attached to the physical equipment upon reception. All events affecting the asset are recorded in EAM, such as installation in a new position, attachment to, or detachment from a parent asset, store transactions or changes in status.

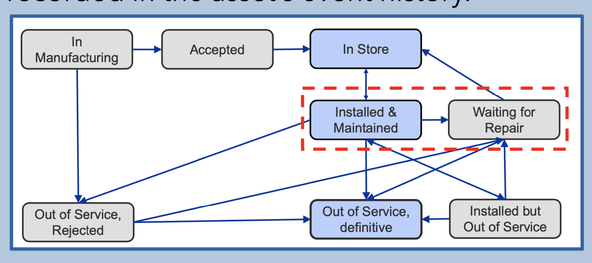
NON-REPAIRABLE MODULES

The Infrastructure section currently manages over 50,000 operational assets and 300 parts in EAM and has acquired enough historical data to attempt a rudimentary reliability analysis, based on EAM's state-transition data.

The first phase of the study aimed to analyse the reliability of the electronic modules, as non-repairable systems.



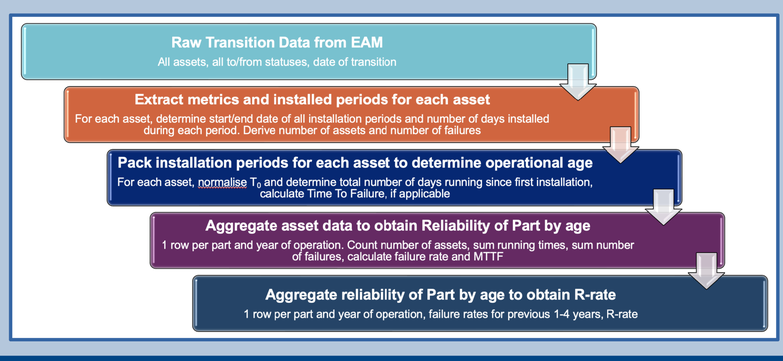
Whenever an asset changes from one state to another, the timestamped state-transition is recorded in the asset's event history.



A failure is deemed to have occurred when an asset's state passes directly from "Installed and Maintained" to "Waiting for Repair", as shown in the EAM state machine above.

By querying and aggregating the state-transition data, statistics were generated for each part such as the MTTF, total running time, number of assets and number of failures.

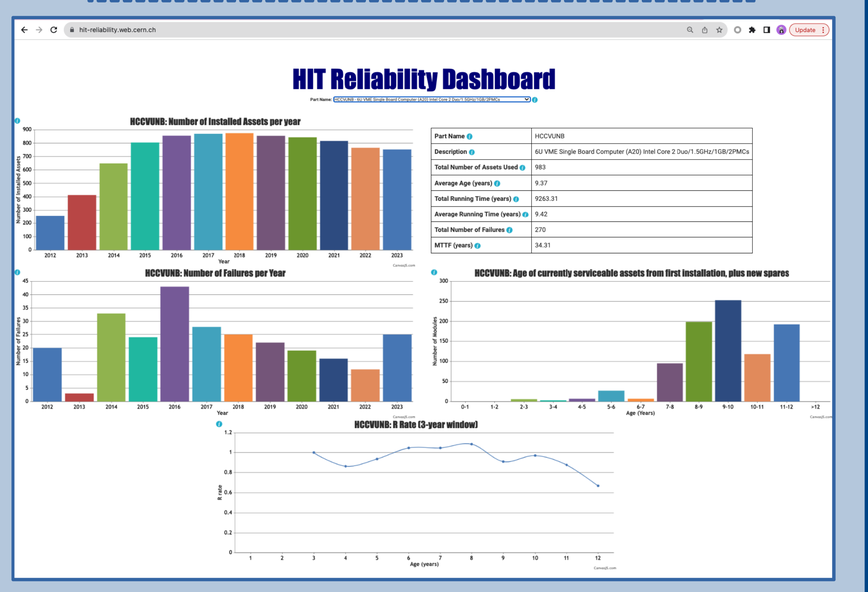
Graphs were produced showing the number of assets and failures over time, the operational age of the assets and the evolution of the failure rate with operational age.



The R-rate shows the evolution of failure rate with operational age.

$$R_x = \frac{Rate\ of\ failure\ in\ last\ x\ years}{Rate\ of\ failure\ since\ t_0}$$

If $R_x > 1$, the failure rate is increasing and investigation is required to determine if the part is reaching its EOL after a certain age.



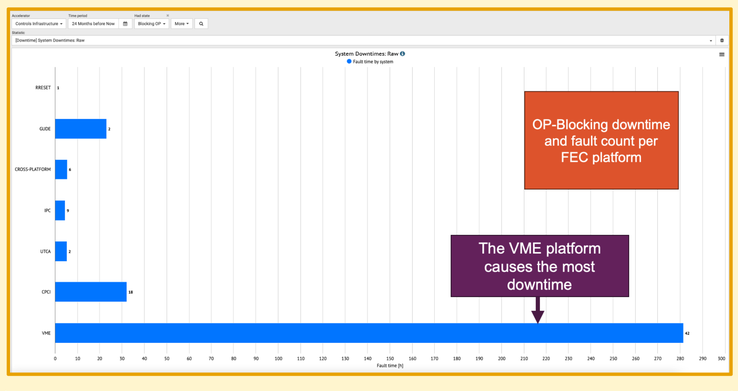
The HIT Reliability Dashboard was developed using PHP, Ajax and ChartJS [2] to allow users to visualise the latest reliability statistics.

FRONT-END COMPUTERS AS REPAIRABLE SYSTEMS

The second phase of the study considers the FECs as repairable systems, composed of non-repairable modules [3]. After an intervention, the failures that occurred on a FEC are registered in CERN's Accelerator Fault Tracking (AFT) system [4] and the type of failed sub-component is selected from a list of parts, classified by hardware platform. The FEC's downtime is obtained from the Controls Survey and Monitoring System (COSMOS)[5].

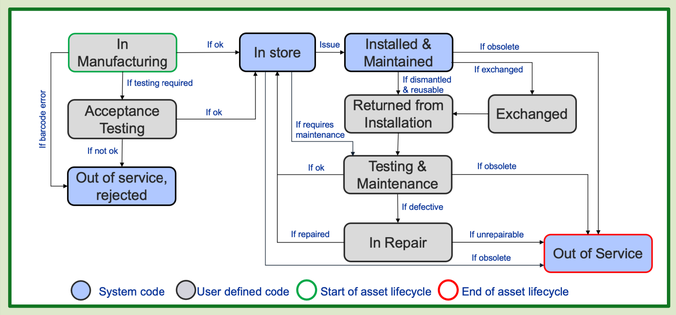
AFT provides in-built statistics and drill-down charting capabilities, which allow the easy identification of the most problematic platforms, the parts that fail most often, and any individual FECs suffering repeated problems.

When combined with the HIT Reliability Dashboard, this information can be used to plan for the consolidation of individual FECs, platforms or parts, improve the efficiency of interventions and potentially pre-empt EOL failure before it occurs and causes significant downtime.



IMPROVEMENTS

The initial EAM state machine had limitations, which affected the quality of the statistics, and was redesigned. Using the new workflow, the failure is registered in AFT at the moment of intervention, but remains unvalidated. The fault is validated if the asset is tested and found to be defective, and only then passes to the status "In repair". If the asset is not faulty, the unvalidated fault is deleted from AFT and the asset is returned to the store. Automatic reports detect the relevant state-transitions in EAM and the asset manager is notified so that AFT can be updated.



CONCLUSIONS

The HIT Reliability Dashboard has been in production since September 2021 and the AFT data is being collected since October 2022. Both systems are regularly consulted to help inform decision making.

The study has demonstrated the potential of EAM operational data to provide valuable insights into equipment reliability, but highlighted the need for high-quality data in order to be able to leverage it for reliability analysis. This feedback led to improvements and refinement of the custom state machine.

It is clear that reliability analysis is likely to become even more critical for ensuring the cost-effective and efficient operation of controls systems for accelerators in the future.

REFERENCES

[1] EAM, eam.cern.ch

[2] ChartJS, https://www.chartjs.org/

[3] S. Hurst, H. Boukabache and D. Perrin, "Repairable System Analysis of the Radioactive Ventilation Gas Monitors at CERN from Field Data", *PHM Society European Conference* vol. 5, no. 1, p. 8, Jul. 2020. https://doi.org/10.36001/phme.2020.v5i1.1242.

[4] Accelerator Fault Tracking, aft.cern.ch

[5] Controls Survey and Monitoring System, cosmos.cern.ch