Efficiency and automation

Concepts, ideas and shared perspectives

“Efficiency through Automation” Workshop

Lukasz Burdzanowski | CERN

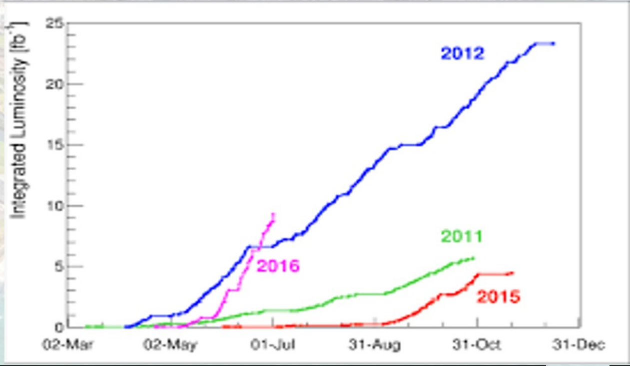
8th October 2023

Efficiency

The system accomplishing desired **outcomes** with **minimal waste**, effort/resources, or deviation from the intended **goal**.

How to define an **efficient system**?

The system achieving its set **objectives**, e.g. in terms of **performance** or reliability whilst utilizing available resources **optimally**.



Aspects of efficiency

When assessing the efficiency of a system, we can think of:

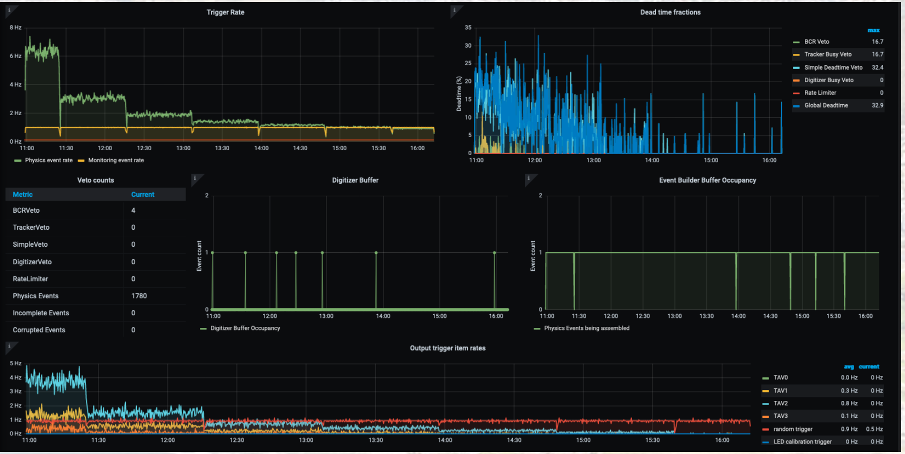
- ➢ **Resource Utilization**
  use of available resources in an optimal manner to achieve the desired output and/or performance.
- ➢ **Stability and Adaptability**
  responding to disturbances in the operating conditions without excessive oscillations or overshooting; continuously adapting.
- ➢ **Minimized Errors**
  limiting errors and/or deviations from the desired set-point;
- ➢ **Time Efficiency**
  reacting with minimal delay to changes and achieve desired states in the shortest possible time, minimising any latencies.

The efficient system can promptly and accurately correct any deviations from the desired target.

Measure and evaluate

Metrics and KPIs, key performance indicators, are tools which help to evaluate and measure the efficiency.

Operational metrics provide insights into how well the system is operating, and specifically, automation software solutions are functioning.



For example, the high-level metrics:

- **Incident Response/Resolution Time:** measure the time it takes from the detection of an incident (such as a system outage or performance degradation) to the response/resolution.
- **Service Availability:** monitor the percentage of time that a service or application is available and operational, e.g. uptime

And system health Indicators, technical metrics, HW resources monitoring e.g.: CPU utilization, Network throughput, Database performance, Batch processing time, Error rate, Latencies (Authentication, Queue processing time, API response time, Backup and recovery Time)

Efficiency and human aspects

To understand how operators, engineers, and other personnel interact with the system to achieve desired system objectives with minimal effort, errors, and stress.

To achieve **optimal system performance**, it is essential to consider the **human aspects of efficiency**.

Then to optimise human-machine interactions and workflows, to enhance the overall performance, safety, and reliability of the control process.

Strive for efficiency

The goal to maximise the efficiency of a system: autonomous machines.

To automate what can be automated and advance the role of system operators from hands-on operations to supervisors of the system.

In this view, the operators supervise the machine and focus on identifying opportunities, enabled with a holistic view at the process and the system.

The focus shifts to physics, experiments, the operations at large.

The autonomous system

Selected aspects supporting the transition to an autonomous system: alerting, monitoring, auto-discovery, integration.

- **Caveat:** growing volume of monitoring and alerting inputs can easily **overwhelm human operators**.
- Auto-discovery can advance a system from being fully declarative to be **imperative and data-driven**.
- The **integration should be designed**, thought-through from the outset when designing the system, from HW to high-level SW.
- **Caveat:** **cost of integration** and/or its lack, when neglected can be costly, growing particularly with the scale of the system.

Getting things done

The way towards more efficient operations and autonomous machines, are shorter turn-around times.

Impacted by:

- ➢ Time required for stages such as: Preparation / Completion / Idle or Wait
- ➢ Resource allocation to accomplish the task and transition to the next
- ➢ Predictive maintenance, to operate optimally and reduce the risk of unplanned downtime.

Identifying and addressing bottlenecks in the workflow is crucial for achieving short turnaround times.

Efficiency Think-Tank Report (CERN):
By reducing the average turn-around time from 4.5 h to 2.7 h, the integrated luminosity would increase by more than 10 % for any bunch intensity

Towards automation

The automation, what it means in a practical relation to daily work?

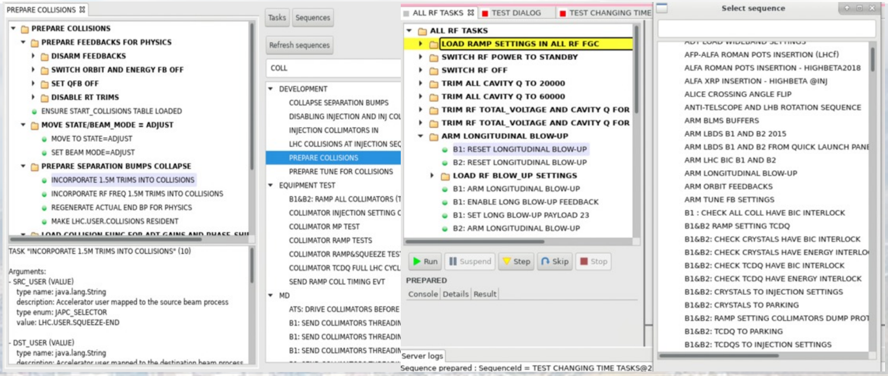
- To look for patterns: by business processes, workflows, tools.
- To identify feedback loops in the system which enable self-healing (automatic recovery, act-measure-diagnose patterns, etc.)
- Ultimately, answer the question: "How long should it take to find a cause of downtime?"

Practically: improvement of diagnostic tools, empowering intervention and supervision teams, the automation of repetitive tasks.

Important, yet out of scope of today: improve and automate equipment.

Generic concepts for automating equipment not as mature as for software, also the equipment automation can potentially be expensive and can only be established on a longer time scale compared to automating software and workflows.

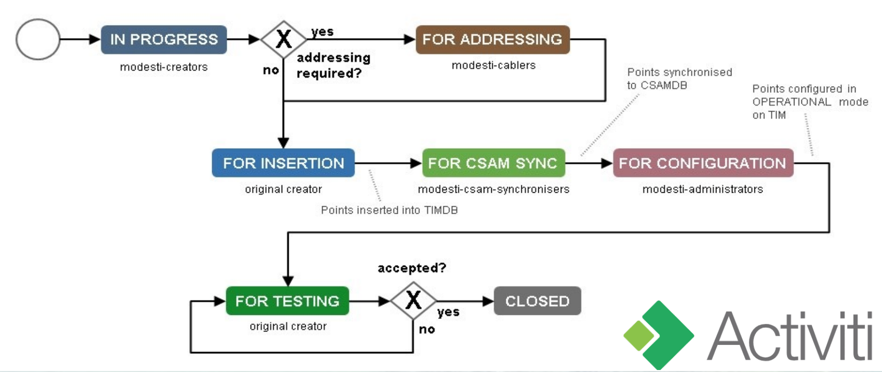
Selected high-level CERN automation software cases



Sequencer

automation of operational procedures and tasks

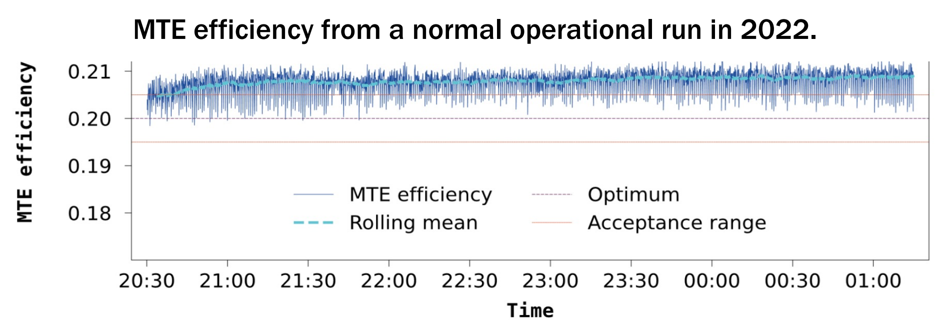
(more in the next talk)

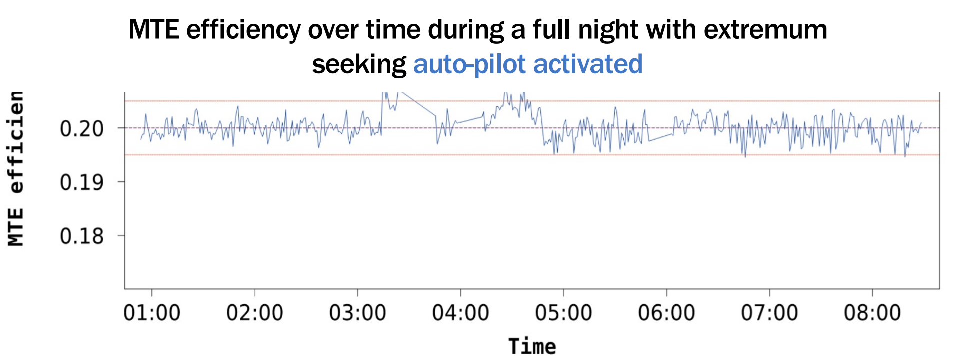


Activity/MODESTI

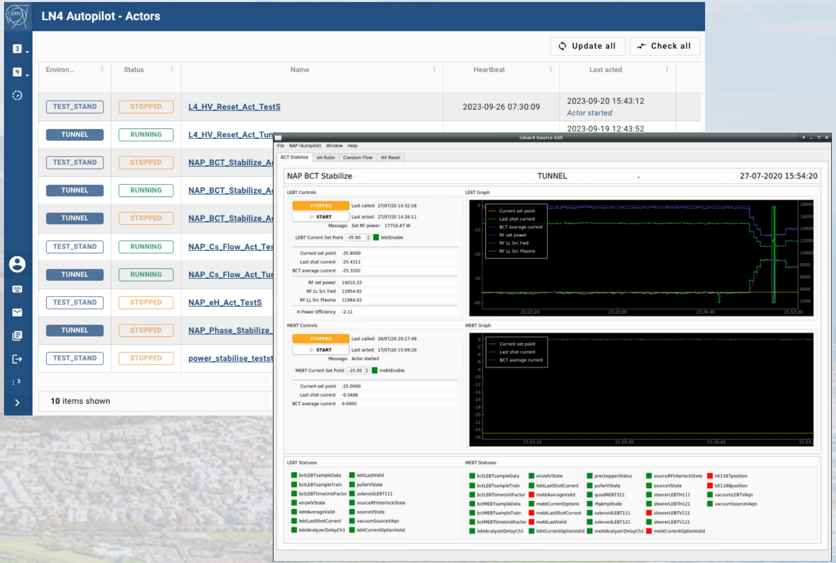
Business Process Modelling solution used to automate configuration workflows of CERN TI alarms.

Selected high-level CERN automation software cases





MTE: Multi-Turn Extraction



"Autopilots"

dedicated automation software based on actors (Python), and feedback loops to tune the machine to desired level

New horizons

New **horizons of automation software** will be driven by **Machine Learning** and **Artificial Intelligence**.

The ML and AI will play a significant role in enhancing automation software for control systems by supporting decision-making.

Predictive maintenance and Anomaly/Fault detection | Optimization and Adaptive control
Process automation and Optimization | Pattern recognition, Data analysis and Insights
Risk assessment | Human-Machine interaction

and many more potential applications of ML and AI for control systems and beyond

Efficiency Think-Tank Report (CERN):
In 2022, the SPS experienced a total of 3817 faults during physics operation. If it took 10 minutes to identify the root cause for just 10% of these faults, 2.5 full days were spent without beam in 2022, simply to understand what was stopping the beam before even launching repair and re-establishing beam conditions.

Summary

By **identifying and measuring the fundamental issues** impacting the efficiency, we can **evaluate return-on-investment** and develop the strategy.

Metrics and KPI can help to identify where to put the effort, and ultimately to **shorten the turn-around times**.

Software solutions do not solve fundamental problems: inefficient processes, organisational and human challenges.