Automatic Fault Analysis & Prognostics

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Introduction

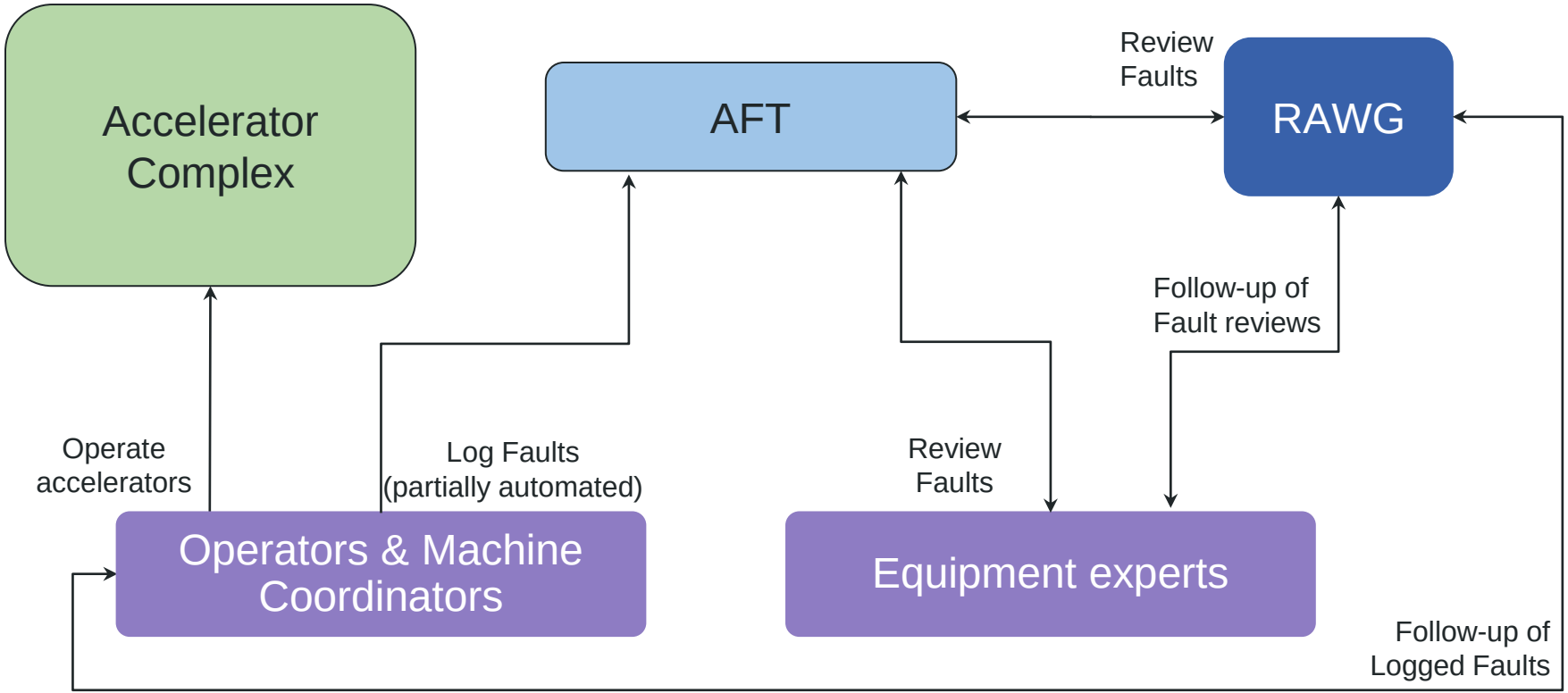
For this presentation I had the chance to talk to **different experts** and get more **details** in their tools, frameworks etc. I will attempt to present the **current status** and high level **workflows** on…

- **Accelerator** fault tracking & **Equipment** fault tracking
- Fault **diagnostics**, **prognostics** & **data analysis**
- **Needs & Ideas** for a **future** vision on the above

Disclaimer: I am not an equipment expert

Aim to stimulate discussions on the future of fault tracking, diagnostics & prognostics

Accelerator Fault Tracking (AFT) - Current status



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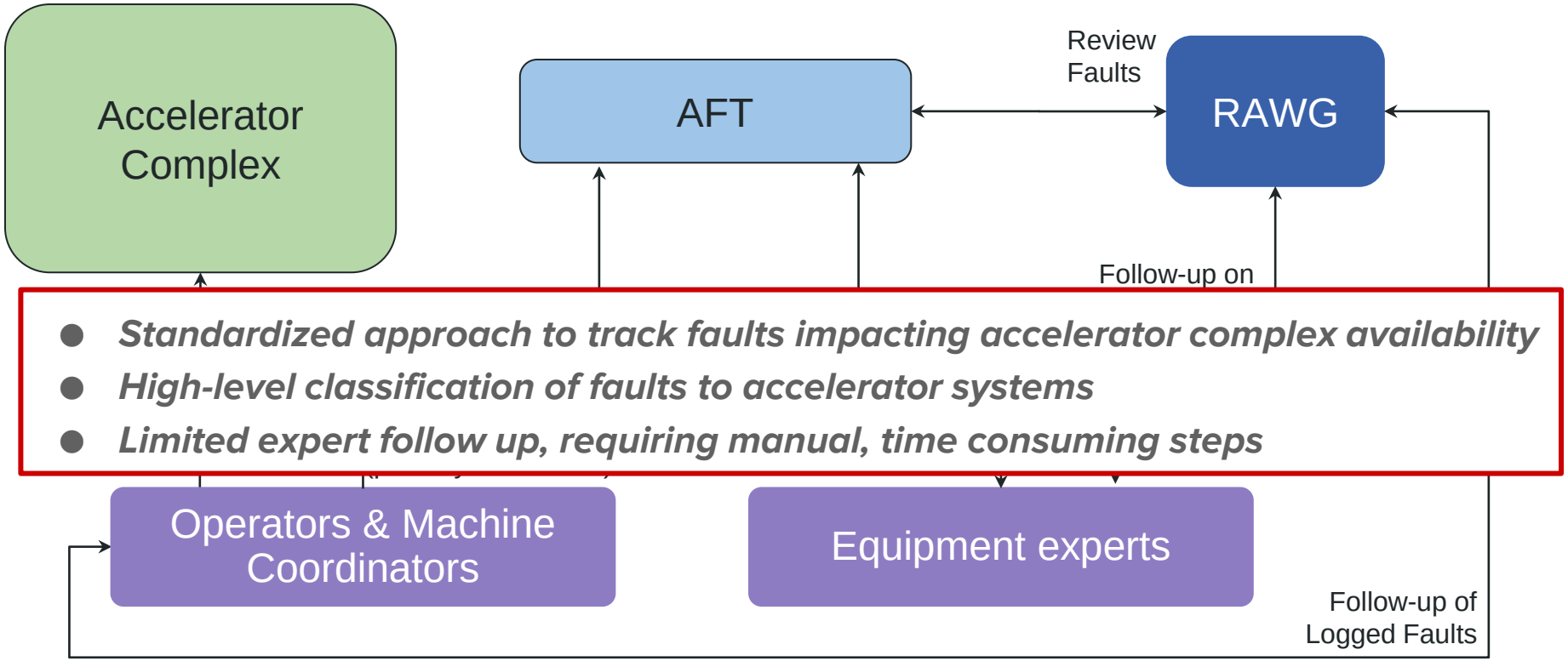


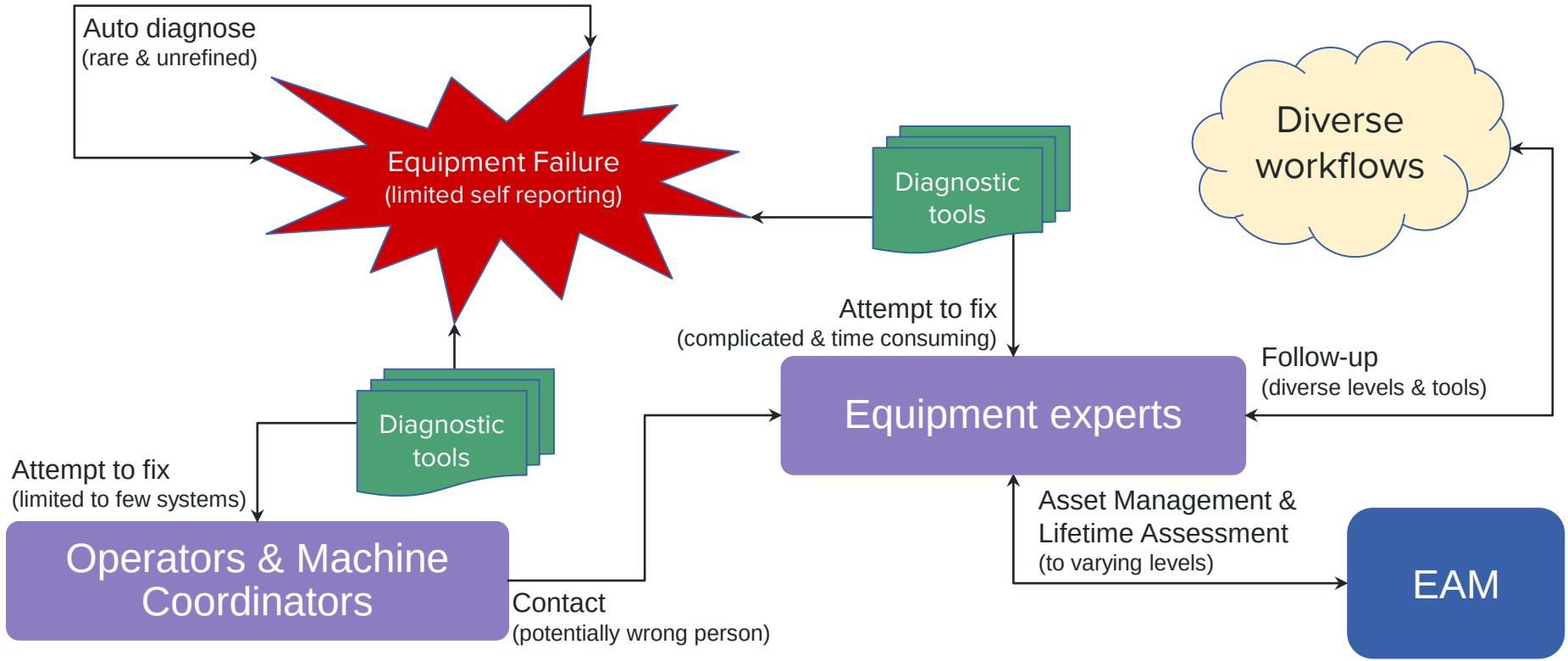
Equipment Fault Tracking - Current status

Equipment fault tracking is **diverse** ➔ different **workflows** & **tools** in each system…

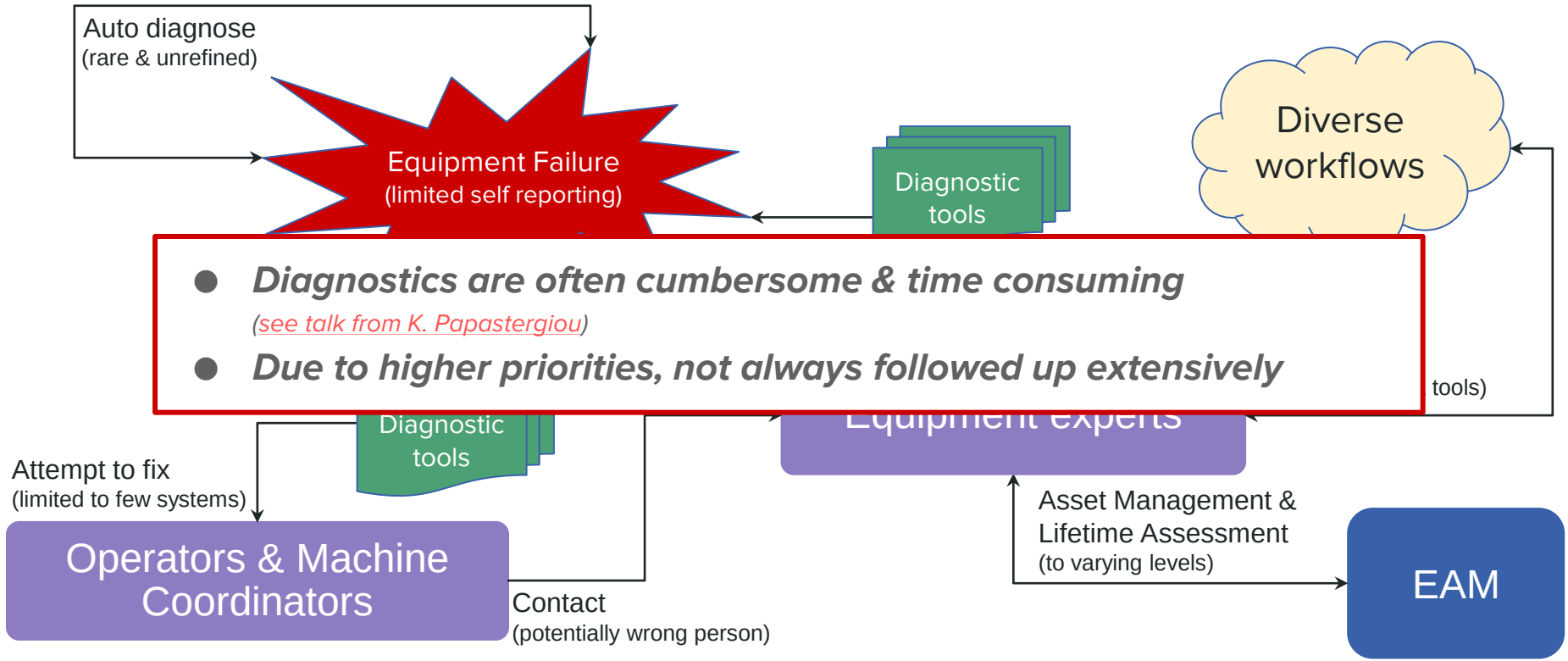
- Directly **affected** by the system **complexity**
  (the more complex the system the more challenging to track faults precisely)
- **Automation** of equipment fault reporting exists **in some systems** but often at a **rudimentary level**
- **EAM** is used by most equipment groups for **asset management**, but only to **varying levels** for lifetime assessment

Equipment Fault Tracking is sometimes primitive & distributed with limited common workflows

Equipment Fault Diagnostics - Current status



Equipment Fault Diagnostics - Current status



Fault Prognostics - Current status

A lot of data is being gathered in various systems that can be used for fault analysis and prognostics, but...

- **Data** is **distributed** among different systems making **analysis challenging**
  (NXCALS, AFT, EAM, etc.)
- Data **analysis**, when existing, sometimes **primitive** & **diverse** between teams
  (due to data gathering complexity, lack of time etc.)
- A lot of **manual effort** & **expertise** required to make sense of available data

Currently challenging to establish a common workflow
& proactively use existing data

Fault Prognostics - Proactive analysis

In some cases **significant effort** has been invested to proactively **analyse** existing data to:

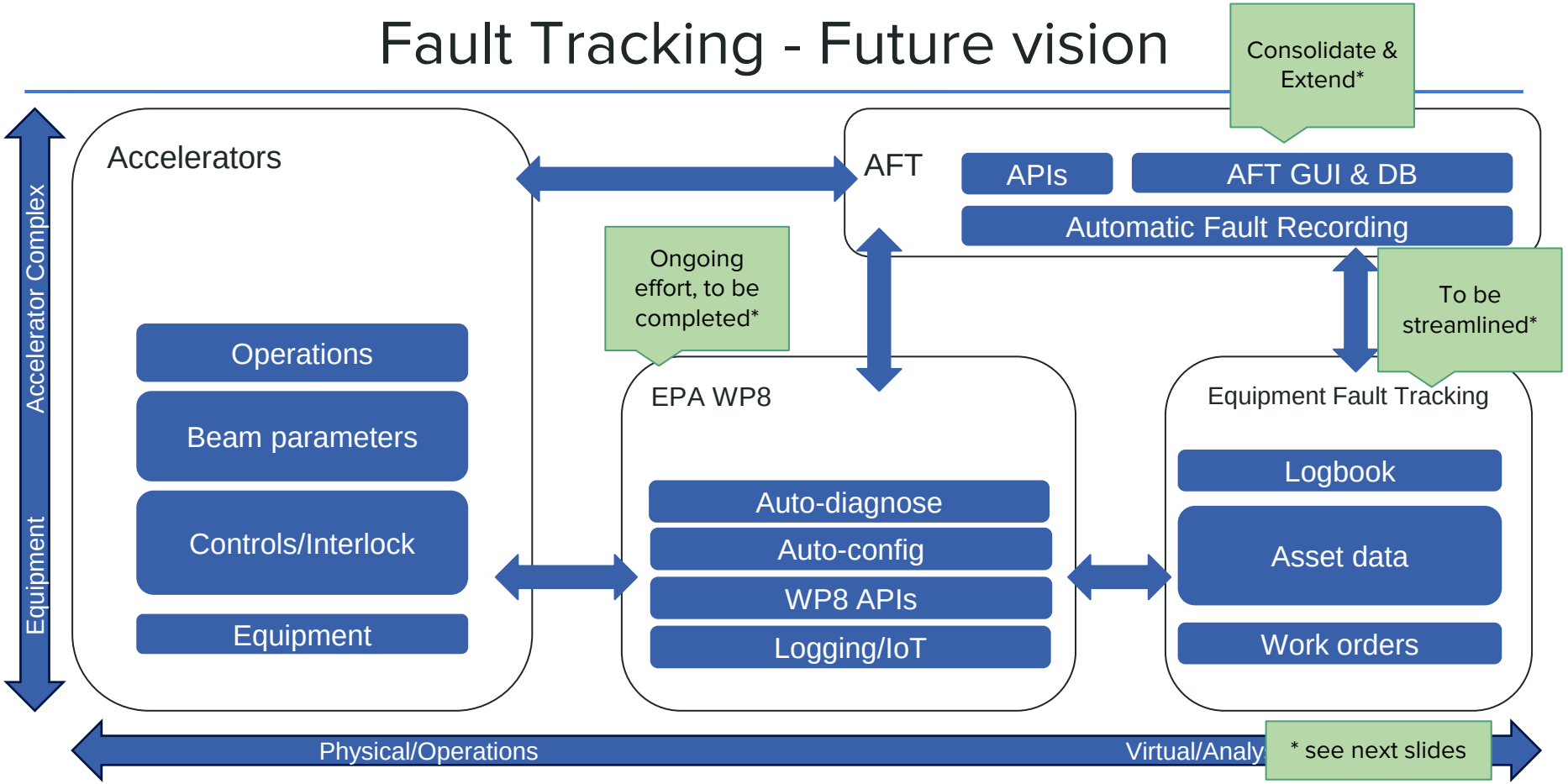
- Generate detailed reports on system condition *(see talk from R. Murillo-Garcia)*
- Validate potential problems and prevent faults
- Identify needed interventions and future consolidations *(CRG, BLM)*

Further **research** on…

- Anomaly detection for prognostics is visible in multiple expert teams
- Initial ML & AI attempts are slowly being developed *(MSC, HSE, LHC Dipole Circuits)*

Various efforts are in place but progress is slow due to limited resources

Fault Tracking - Future vision



Equipment Fault Diagnostics - Future vision

Automation of fault recording on **equipment level** will provide a lot of **valuable** data
(hardware failures, software failures, degrading of operation, etc.)

Requires:

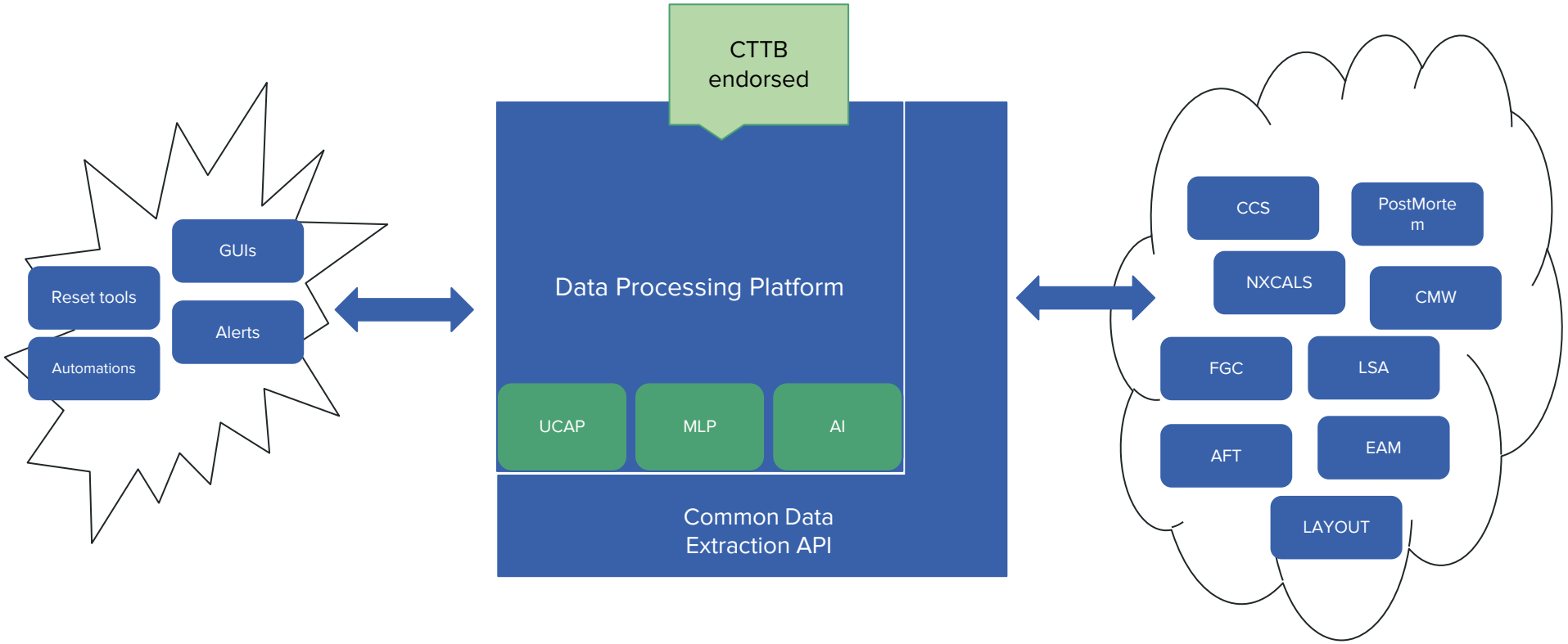
- Creating a **common language** for equipment reporting
- Using **common tools** supporting **shared workflows** & **diagnostics** as well as knowledge sharing *(NXCALS, UCAP, EAM etc.)*
- Investing in **automatic hardware diagnostics**, wherever possible *(crucial for fault recovery)*

Supports: Automated fault **recovery** (in addition to a basis for prognosis)

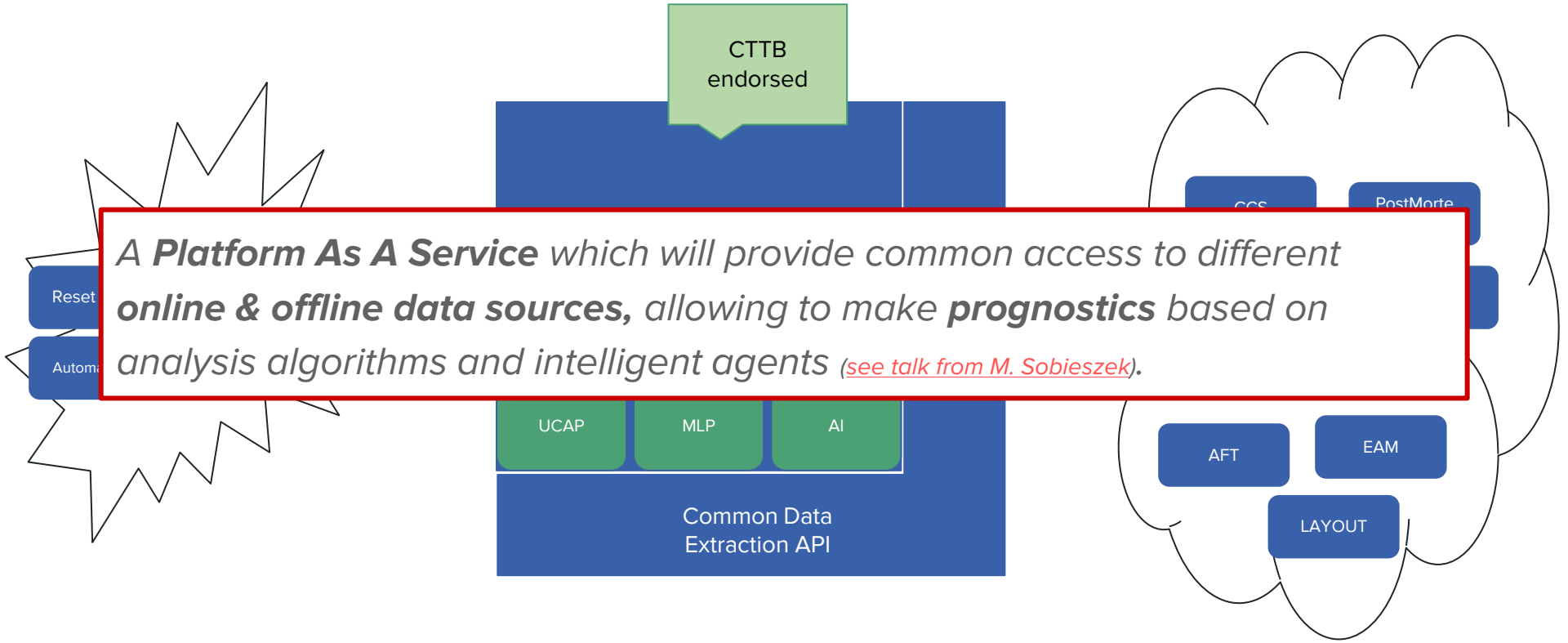
EPA - WP8

Need to minimise human interactions & automate procedures
empowering experts to focus on other things ***(development, system evolution, research, etc.)***

Fault Prognostics - Future vision



Fault Prognostics - Future vision



*A **Platform As A Service** which will provide common access to different **online & offline data sources,** allowing to make **prognostics** based on analysis algorithms and intelligent agents (see talk from M. Sobieszek).*

Some next steps

2025 Q1

- Initial **AFT & EAM integration**
- **AFT 2.0** project definition, endorsement & resource allocation
  (AFT is 10 years old, requirements have evolved, & technical consolidation is needed)

On-going

- **Close collaboration** with **EPA WP8** to "**Automate Equipment**"
- Providing framework for **standardized** state **reporting**, actor classes for **communication**, fault **recovery** design, access to accelerator context information & pre-built **integrations** *(inc. AFT)*

2025 Q3

- New **Data Processing Platform** PoC will be in place *(see talk from M. Sobieszek)*

What other concrete steps need to be taken in the short term?

Summary

Accelerator fault tracking is **well established** *(but **needs consolidation** → AFT 2.0)*.

Equipment fault tracking is diverse & **less mature** & **needs streamlining**.
Advanced fault **diagnostics** can **build on the above** & support **automated recovery** *(EPA WP8)*. Then **prognostics can follow** in a robust & standardised manner.

Key points for improvement:

- **Integration of existing tools** is the natural next step *(e.g. AFT/EAM, UCAP/DPP)*.
- **Diagnostics, recovery** *(EPA WP8 as a driver)*, **& prognostic frameworks** to be **established** on top of existing & emerging tools *(DPP)*.
- Agree on **common solutions across teams** to **minimise duplication** of efforts.
- **Long-term maintainability** should be **considered up-front**.

Questions?