



(New) Reliability and Availability Studies Working Group (RASWG) – Kick-off meeting

A. Apollonio, B. Todd, V. Schramm

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A Brief History of Reliability at CERN

Brief History ...

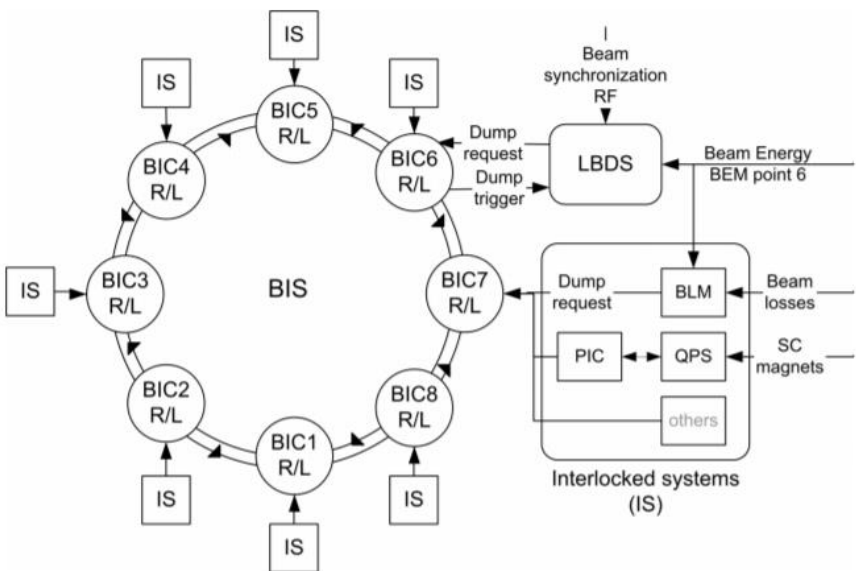
~2006: *A new machine...* “Will we ever get the **green light** for operation?” asked by Machine Protection Working Group

Q. How many beam aborts would the protection systems create each year?

Q. What is the likelihood that the protection systems don’t work?

- **Reliability Sub Working Group (RSWG)** launched – reporting to Machine Protection Working Group

J. Uythoven (chair), B. Todd (scientific secretary)



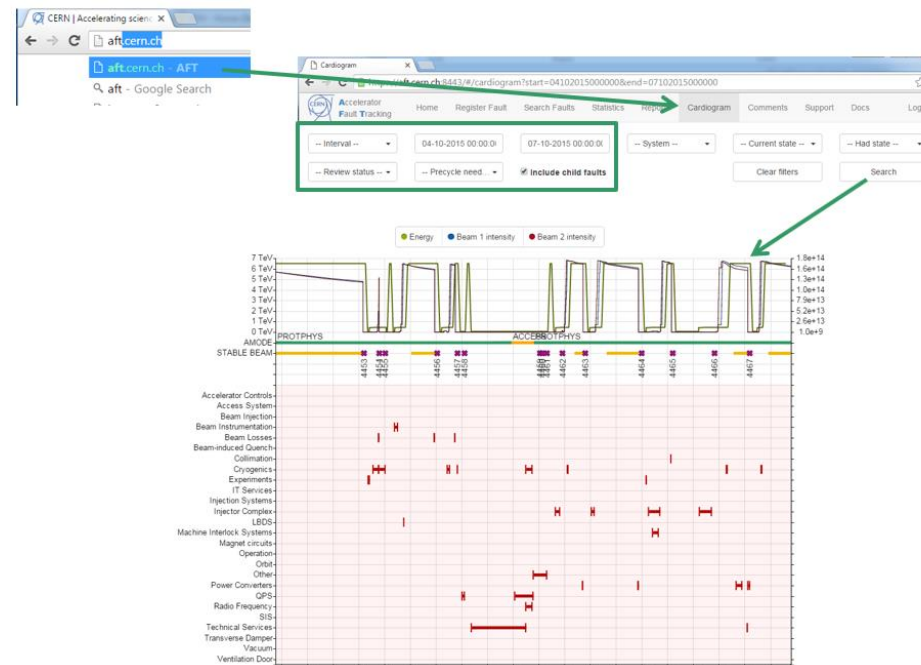
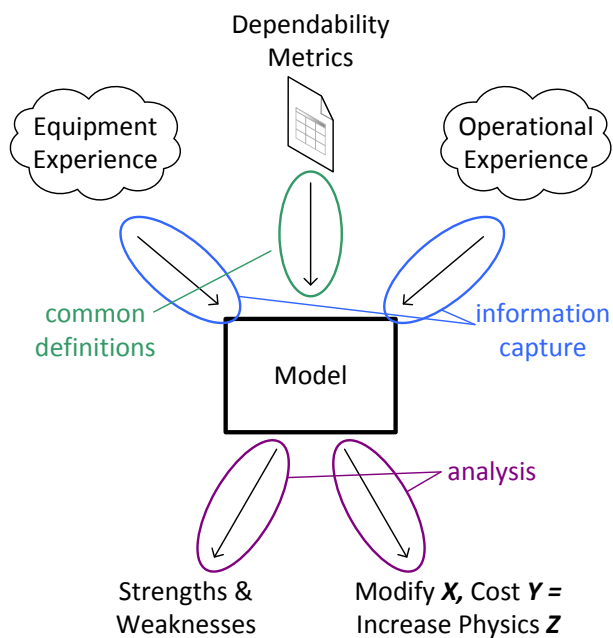
System	Unsafty/year	False dumps/year Average	Std. Dev.	Analysis including	Not included
LBDS [8]	1.4×10^{-7} (2X)	2.6 (2X)	(+/-1.6)	(Re-)triggering system, MKD (MIL-217F) BET, BEM (assumptions)	MSD, Q4, MKB TDE
BIC [9]	0.7×10^{-3}	1.6	(+/-1.3)	User Boxes only (MIL-217F)	BIC core, VME and permit loops
BLM [10]	1.7×10^{-3}	4.8	(+/-2.1)	Focused loss on single monitor (MIL-217F, SPS data)	Design upgrades
PIC [11]	0.5×10^{-3}	1.5	(+/-1.2)	Complete system (MIL-217F)	PLC
QPS [12]	0.4×10^{-3}	15.8	(+/-3.9)	Complete system (MIL-217F)	
OVERALL RESULTS					
MPS	3.3×10^{-3}	28.9	(+/-11.7)		

Brief History ...

~2010: *Green light... so...* “What are the **LHC availability** bottlenecks” asked by LHC Machine Committee

- **LHC Availability Working Group (AWG)** launched – reporting to LHC Machine Committee

B. Todd + L. Ponce, A. Apollonio (scientific secretary)



- integrated luminosity is the real Key Performance Indicator
- coherent & objective information capture is primary concern

Specified the AFT, invented several new tools & views (e.g. cardigram)

- Reports to LMC every technical stop
- Reports to Evian Workshop every year.

Brief History ...

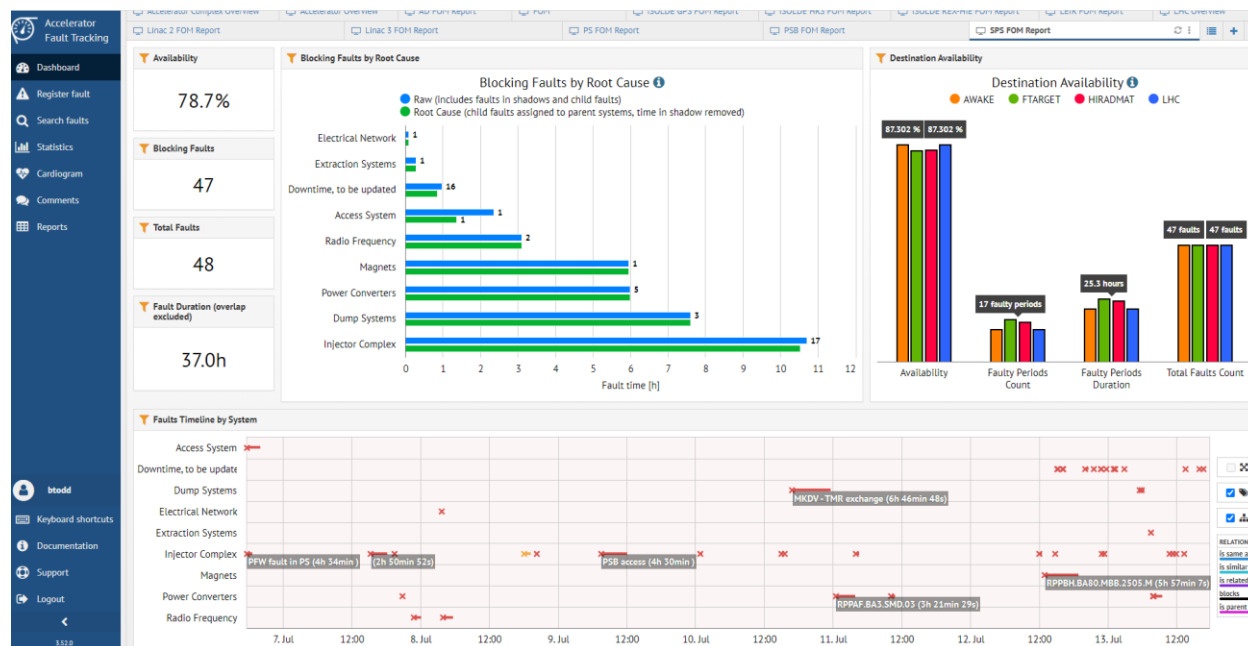
~2016: *LHC looking better.. “What are availability bottlenecks in the **whole complex?**” asked by CMAC*

- **Availability Working Group (AWG)** – LHC reporting to LHC Machine Committee

B. Todd + L. Ponce, A. Apollonio (scientific secretary)

– Injectors reporting to FOM / IEFC

A. Apollonio



Example SPS FOM report – automatically generated

- Weekly reviews
- Consistent approach
- Early identification of new root causes
- Working to understand complex cases

~2018: *Hold on a minute...* “What do we do to prepare the future: **levelled luminosity**”? asked by the accelerator sector

For a levelled High Luminosity machine:

- availability increases will be the only means to increase integrated luminosity production

For FCC:

- what can you tell us – what should an FCC look like physically and operationally?
- What are the questions we need answering?

- **Machine Availability and Reliability Panel (MARP)** – reporting to ATS

A. Apollonio (chair), J. Gutleber, R. Steerenberg, L. Serio, J. Uythoven, B. Todd, M. Zerlauth, O. Bruning, T. Cartier-Michaud (scientific secretary)



J. Uythoven, L. Felsberger (scientific secretary)

- Forum for like-minded researchers
- Aimed at students and fellows
- Share ideas, tools, approaches
- Mutual help and open discussions

~2021: Rebranding and **realignment** to be consistent with the new Common Technologies initiatives!

MARP → **Reliability, Availability Studies Working Group (RASWG)** – reporting to Common Technologies Boards

Reliability and Availability Studies Working Group

formed MARP's mandate – addressing six areas of strategic interest for the organisation:

Designing Dependable Systems

- Define reliability workflows & guidelines for dependable design.
- Add a reporting metrics to CERN's templates.
- Establish a team of expert to assist others where needed.

Tracking Availability, and Availability Optimisation

- Coordinate weekly fault reviews in the accelerator complex.
- Produce periodic availability reports for management.
- Provide recommendations & priorities for AFT developments.

Build Collaborations Internally and Externally

- Coordinate collaborations with universities, institutes and companies
- Take part in the organization of international workshops
- Organise, where needed, internal workshops.

Reliability Analysis & Assessment for High-Luminosity

- Coordinate reliability/availability activities and studies for HL-LHC.
- Provide HL-LHC support, and share results for the evaluation of performance as a function of machine availability.
- Contribute to the risk assessment approach definition for HL-LHC.

Risk Assessments for Consolidation Requests

- Contribute to the definition of the quantitative risk assessment approach for consolidation

Development of Analysis Tools and Methods

- Promote and support the use of standard methods and practices
- Coordinate additional developments concerning tools and methods

Chair: A. Apollonio

Co-Chair: B. Todd

Scientific Secretary: V. Schramm

Membership: membership list reviewed in collaboration with new groups, following AT Sector restructuring. Welcome to all new members!
More interested people welcome, feel free to forward invitations to further colleagues depending on the topics of interest

Format: meet once / twice per month, minutes, website, as a working group.

Reporting: to the CTTB.
tacit reporting also to LMC, IEFC, Chamonix, Evian, projects, as before.

Design for reliability is very similar to **Quality Assurance**:

- Design Reviews – a lot like those in the **Electronics Forum**
- Formal Methods – a lot like those in **Software Forum**

The **methods** are quite mathematical:

- Deep Learning – links to the **Machine Learning forum**

The **results** from reliability studies can drive others

- System architectures – links to the **Electronics forum**
links to the **Future Circular Collider**

- Some of typical topics concern **more than one forum**
- we should put these topics where they have the **best support**
- Some studies **influence choices** in other forums

interest group in Formal Methods and Verification launched

- H. Boukabache (HSE)
- B. Borja Fernandez Adiego (BE-ICS)

Covering programmable logic devices (FPGA + CPLD) and PLCs.

Opportunities to consolidate and cooperate

For discussions within CCTB

What are the main **challenges** you are facing moving towards the **HL-LHC** era in terms of reliability/availability?

- Does anything change wrt LHC?
- Are you doing reliability/availability studies and can RASWG support you?

What are the main system **consolidations** in which you are/will be involved?

- How do you prioritize consolidation actions? (quantitative/qualitative risk assessment/expert judgement)
- Would we profit from a common metric/**risk evaluation** scale?

For system design (electronic systems in particular), is there an interest to have **common guidelines** for reliability-driven design?

- Measure **criticality** of different systems
- Agree on a common **workflow**, depending on criticality
- Define a strategy for system **testing**, depending on criticality
- Adopt **software tools** for reliability/availability analyses in use at CERN
- Design checklist already developed in the past

How can we further **improve the fault data capture** for our systems?

- Integration of different tools (AFT, Infor EAM,...)
- **Automatic fault recording** in the accelerators

Looking at **next generation machines** (FCC, CLIC), what are the major challenges for your systems?

- Can a simple scaling (e.g. LHCx4 for FCC) work?
- What **R&D efforts** are necessary to cope with outstanding problems? (logistics, maintainability, fault tolerance,...)

Thanks!