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Can a FAILURE MODES and EFFECTS ANALYSIS (FMEA) improve RELIABILITY?

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Outline of This Talk

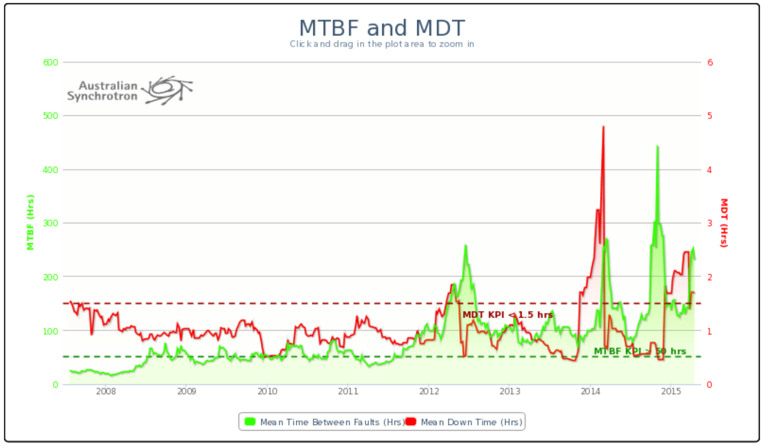
- What is a Failure Modes and Analysis (FMEA)?
- Goals - Why we undertook an FMEA?
- Process - How we undertook the FMEA?
- An example analysis on one system?
- Results of FMEA for the Accelerators
- High priority failure modes identified
- Work so far
- Other issues identified
- Conclusions

What is a Failure Modes and Analysis (FMEA)?

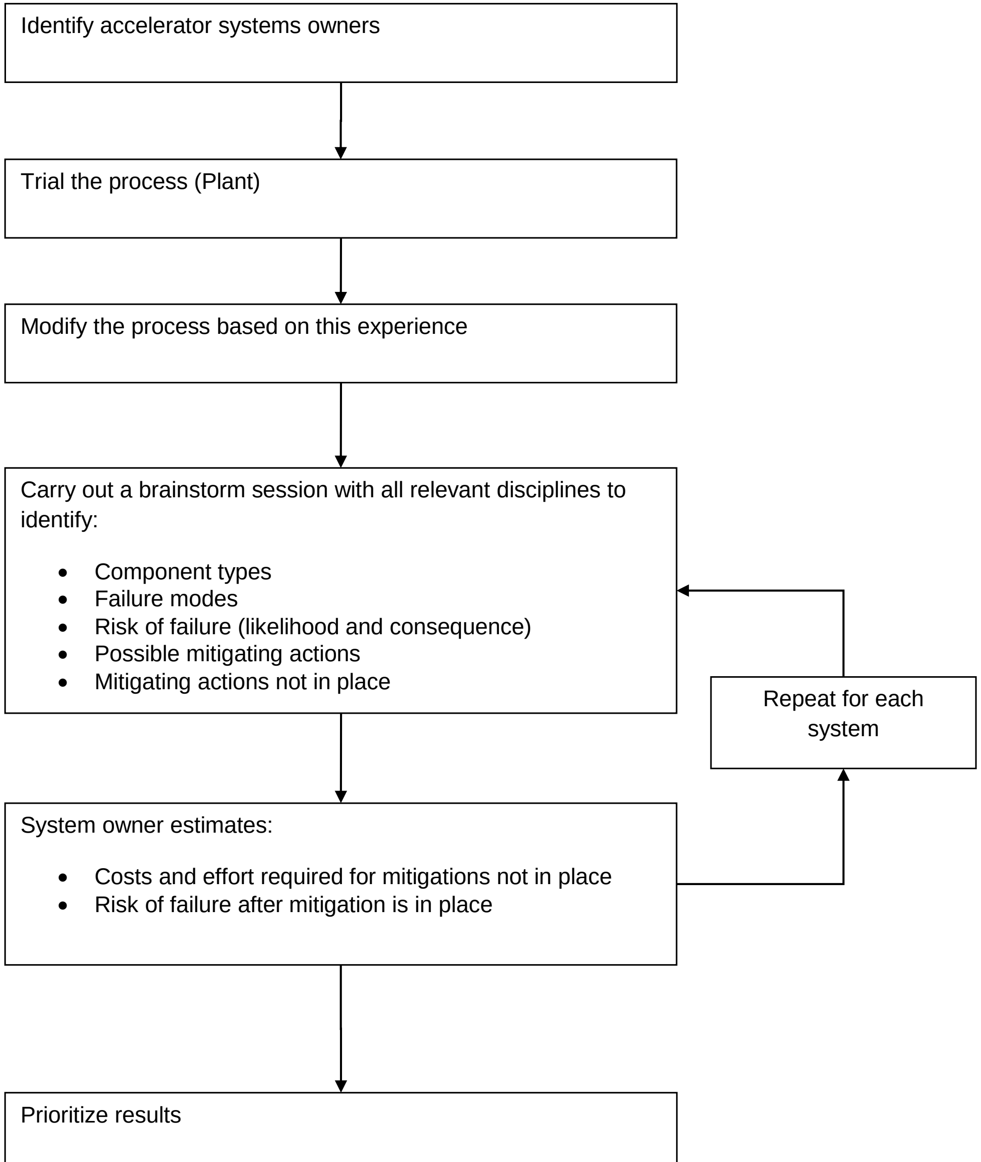
- Reliability Centered Maintenance (RCM) developed within the Aviation Industry in the 1960's
- It is now the Standard approach to maintenance in many industries
- An integral part of this process is to undertake a Failure Mode and Effects Analysis (FMEA) on a regular basis.
- It is important to include all major systems of your machine
- It is critical to try to identify all possible failure modes
- A key part of the process is to engage the support of the system owners, the system maintainers and the system users

Goals of the Failure Modes and Effects Analysis

- Address Key Performance Indicators
- Consider the Accelerators as a group of systems
- Define failure modes, risks and mitigating actions for each system
- Estimate risks associated with a failure after mitigation is in place
- Prioritize mitigating actions based on the risk reduction and the cost of the mitigation
- Produce a Management wish-list (hit list)   ($$$$$ + people)



Process



Plant

81 failure modes identified

- 21 Preventative Maintenance or Condition Monitoring
- 6 Re-engineer the subsystem
- 20 Replace faulty subsystem
- 9 Staff Training
- 3 Low Risk - No action
- etc

Plant Analysis

- 10 At Risk Plant Systems
- 2 systems with benefit/cost of 1.0 or greater.

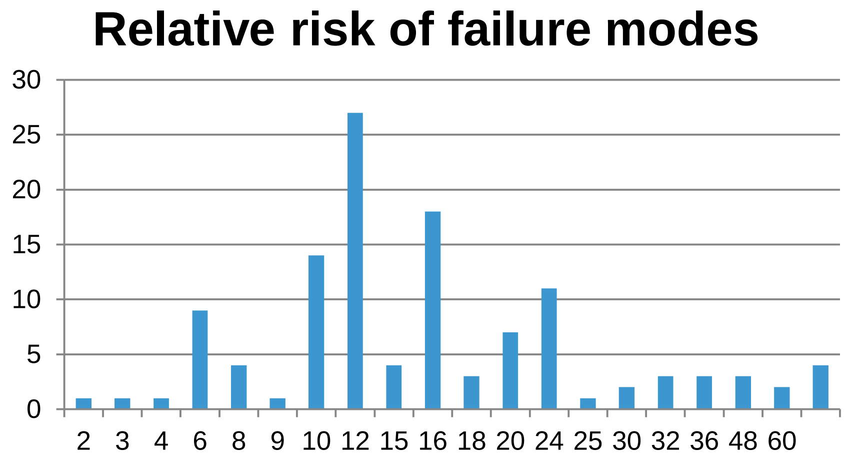
FMEA Spreadsheet

Spread sheet consisting of 40 columns X number of failure modes

Failure Analysis	Likelihood of occurrence	Cost of Mitigation	Effort Required one off / ongoing
Critical system (beam loss) < 1 hour	In next 1 year	<$2K	0 days per year
< 1 day	In next 3 years	$2K - $5K	5 days
< 1 week	In next 10 years	$5K - $15K	20 days
< 1 month	Has occurred and likely to reoccur	$15K - $50K	
> 1 month	Has occurred and unlikely to reoccur	$50K -$150K	
Loss of Beam Control	Not expected in life of facility	$150K-$500K	
Loss of Beam Quality		> $500K	
Redundant system			
No impact			

Results for the Accelerators

- 460 failure modes identified
- 25 failure modes without complete mitigations and a risk rating above 20 (approximate cost: $2.0M)
- 32 possible re-engineering projects identified (approximate cost: $3.0M)
- 115 failure modes without complete mitigations.(many requiring confirmation of spares holding)



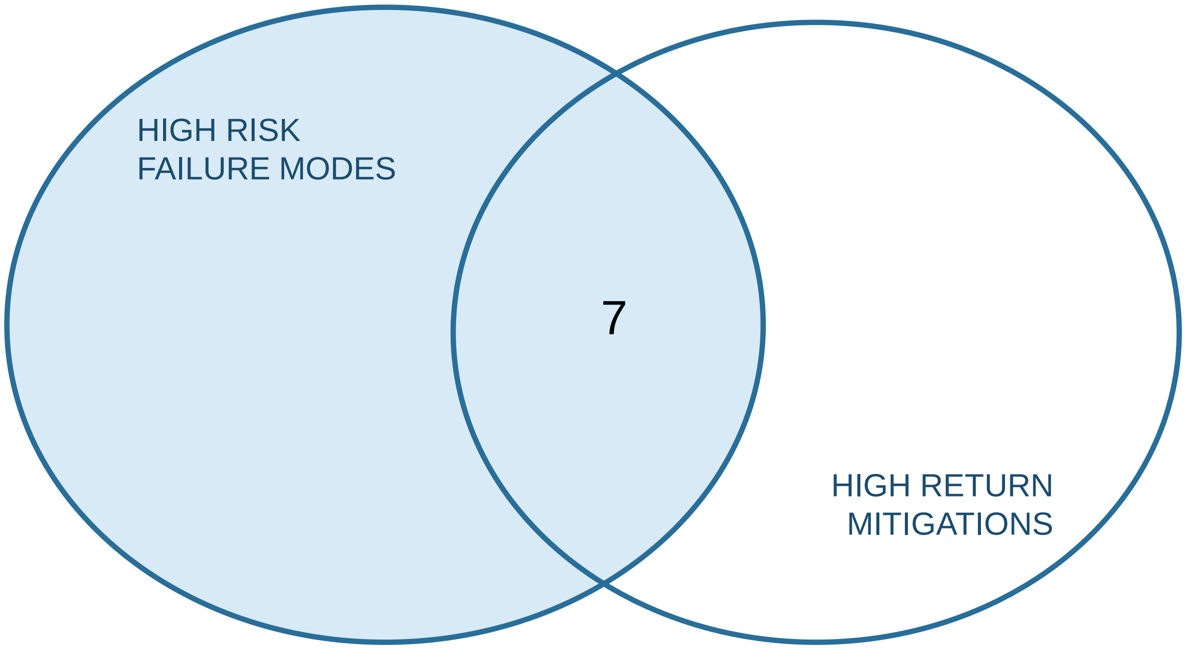
High risk failures

Ref #	System(s)	System owner	Sub-system	Description	Failure mode (if specific)
169	Power supply & distribution	Craig Millen	Power supply & distribution	SV 19 feed	Overvoltage (eg: 66kV on 22kV feed)
172	Power supply & distribution	Craig Millen	Power supply & distribution	SVW44 feed	Overvoltage (eg: 66kV on 22kV feed)
262	RF	Karl Zingre	LINAC (LI) RF system	LI-LLRF system	failure or performance issues
264	RF	Karl Zingre	LINAC (LI) RF system	LI-PFN-Network system	sub system failure, arcing, limited life time or sudden failure of thyratrons or HV capacitors
265	RF	Karl Zingre	LINAC (LI) RF system	LI-Klystron tank	"sub system failure" but mainly trips and oil replacement due to contamination.
266	RF	Karl Zingre	LINAC (LI) RF system	LI-Klystron	failure focusing coils limited life time klystrons or sudden failure.
268	RF	Karl Zingre	LINAC (LI) RF system	LI-GUN- system	sub systems failure or poor performance, triggers
273	RF	Karl Zingre	LINAC (LI) RF system	LI-PLC	sub systems failure, bugs
287	RF	Karl Zingre	Booster Ring (BO) RF system	BO-PLC	PLC modules, poor MTTB due to poor system integration, bugs
405	Plant	Graham Harding	Machine LCW	SRRF Cavities - HOM antennae	Insufficient flow to prevent heat damage to part

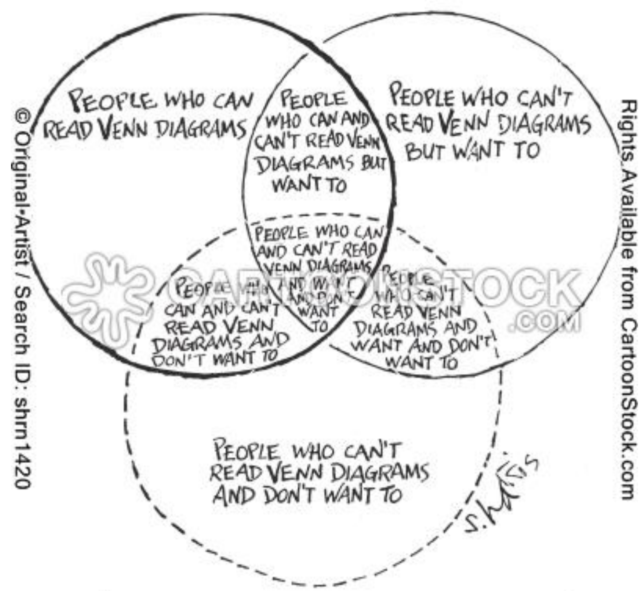
High return mitigations

Ref #	System(s)	System owner	Sub-system	Description	Failure mode (if specific)
169	Power supply & distribution	Craig Millen	Power supply & distribution	SV 19 feed	Overvoltage (eg: 66kV on 22kV feed)
172	Power supply & distribution	Craig Millen	Power supply & distribution	SVW44 feed	Overvoltage (eg: 66kV on 22kV feed)
182	Power supply & distribution	Craig Millen	Power supply & distribution	LV switchroom - boards	Fire in a board
263	RF	Karl Zingre	LINAC (LI) RF system	LI-Modulator system	Focus P/S, PSS relays, Insulation monitoring relays or failure of other sub systems
264	RF	Karl Zingre	LINAC (LI) RF system	LI-PFN-Network system	sub system failure, arcing, limited life time or sudden failure of thyratrons or HV capacitors
265	RF	Karl Zingre	LINAC (LI) RF system	LI-Klystron tank	"sub system failure" but mainly trips and oil replacement due to contamination.
266	RF	Karl Zingre	LINAC (LI) RF system	LI-Klystron	failure focusing coils limited life time klystrons or sudden failure.
268	RF	Karl Zingre	LINAC (LI) RF system	LI-GUN- system	sub systems failure or poor performance, triggers
271	RF	Karl Zingre	LINAC (LI) RF system	LI-LCW-Cooling	LCW sensors, leaks
405	Plant	Graham Harding	Machine LCW	SRRF Cavities - HOM antennae	Insufficient flow to prevent heat damage to part

Target projects



7 Subsystems identified which had both
- High Risk of Failure
- High Return Mitigations
- “good bang for buck” projects



Recommendations

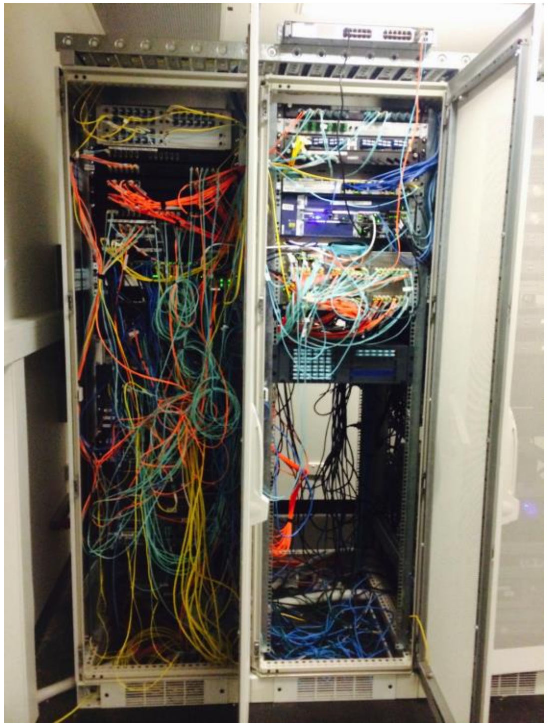
Failure modes

- High return and high risk failure modes were reviewed
- Each failure mode identified as being high risk or having a mitigation with a high return was investigated further by the system owner and the risk assessments and planned mitigations confirmed
- The proposed mitigations were then costed in terms of capital cost and effort required
- The resulting action list was used to drive improvements in the accelerator's reliability.

Work so far

- Machine FMEA – projects initiated
  - Input to project selection
  - SLED cavity – provide redundancy
  - T1 & T2 consolidation – Provide UPS backup and protection
  - SRRF flow and temperature monitoring (failing diagnostics)
  - Injection system PLC work
  - Linac gun spares
  - Injection system vacuum upgrade

- Disaster recovery planning
  - Machine/facility core switch upgrade



Recommendations for Further Work

Obsolescence issues

- Develop a set of criteria for prioritizing obsolescence issues
- Components identified as having a risk of obsolescence are confirmed by the person accountable for the system
- Plans to address major obsolescence issues being developed

Spare parts

- The management of spare parts to be reviewed and issues addressed
- Check spares held (29 items with uncertain spares holding)

Recommendations

Preventative maintenance

- Any preventative maintenance that is not yet in place and can be justified is put in place (~5% of all failure modes)
- The FMEA has increased awareness of the value of many existing preventative maintenance processes

"My grandfather always used to say 'Son, if it ain't dysfunctional, don't attempt pre-emptive maintenance intervention on it.' Or something like that."

Recommendations

Other observations

- Review technical issues identified by the system owners (such as diagnostic systems that are not functioning), including estimates of costs and effort required to rectify the issue.
- The FMEA has raised the awareness of technical support staff of the criticality of functional diagnostic systems.

Conclusions

- The FMEA identified 460 failure modes of the machine
- Each of these modes has been scored for Risk, Benefits of mitigations and costs.
- The FMEA has resulted in 7 critical projects being funded and allocated resources to be undertaken immediately
- It has lead to improvements in many processes
- It has highlighted deficiencies in spare parts management
- Outcomes require good group co-operation
- It is an ongoing process

AKNOWLEDGEMENT

The FMEA project was developed and run by David Tokell, the Head of Engineering at the Australian Synchrotron Light Source.

"The kid's good."