



Design. Analyze. Optimize.

**Design for Reliability, Availability, Maintainability and Safety
by RAMS methods & tools
for overall Risk Assessment and Life Cycle Management**



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Ramentor Inc.

- Founded in 2006 and based in Tampere, Finland
 - Personnel ~10 (Dr. & M.Sc. – Mech. & aut. eng. / Applied math. / Software devt.)
 - Privately owned and independent software and expertise company
- Background: Competitive Reliability Programme 1996-2000
 - Finnish Technology Agency (TEKES) Competitive Reliability Programme 1996-2000
 - Tampere University of Technology (TUT): Probabilistic approach in reliability and maintenance management 2001-2003 followed by Industry Consortium projects: RAM Products 2003-2005, RAM Solutions 2006-2008, RAM Efficiency 2008-2010
 - Ramentor-TUT-CERN FCC RAMS project 2014-2018
- **Methods and Tools for RAMS engineering,
Risk Assessment and Life Cycle Management**

Ramentor – ELMAS Users / Co-developers

Industry Services	Design for Reliability	Quality & Risk mgmt
      	      	        
Operation & Maintenance	After Sales Support Service & Warranty	Research & Education
          	     	        



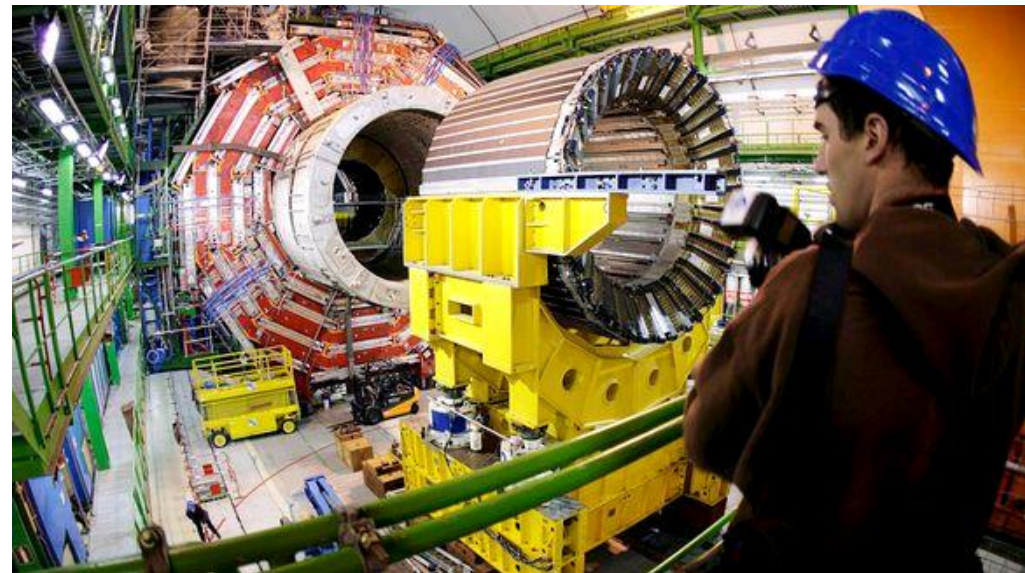
A key quality attribute of a Future Circular Collider - Availability performance (RAMS)



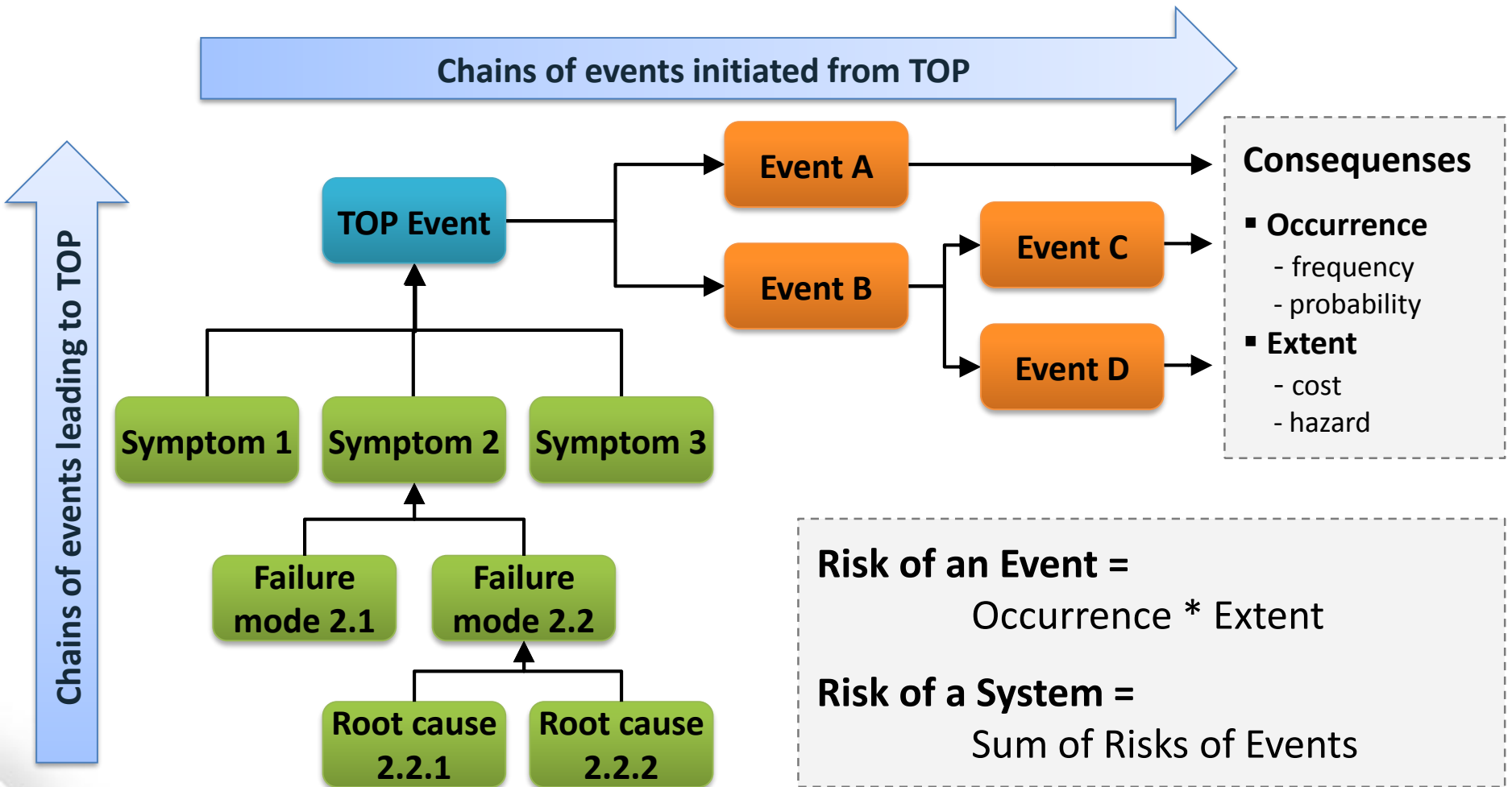
Ramentor Oy has successfully carried out many **RAMS-studies** within **feasibility and conceptual design phase** of large scale investment projects (e.g. Wartsila, Metso, Kone, UPM, Cargotec Corporations and Posiva (Nuclear Waste Management)).



Ramentor has developed ELMAS (Event Logic Modeling and Analysis Software) for the RAMS engineering and management of systems and for probabilistic risk assessment throughout their lifecycle.



Modeling and Analysing Risks of a System



ELMAS – Risk Assessment and RAMS

Risk Assessment

Likelihoods/Events

Consequences/Costs

Failures

Repair durations

PM schedule & effects

External / Conseq. events

Break and Downtime costs

Repair costs

Maintenance costs

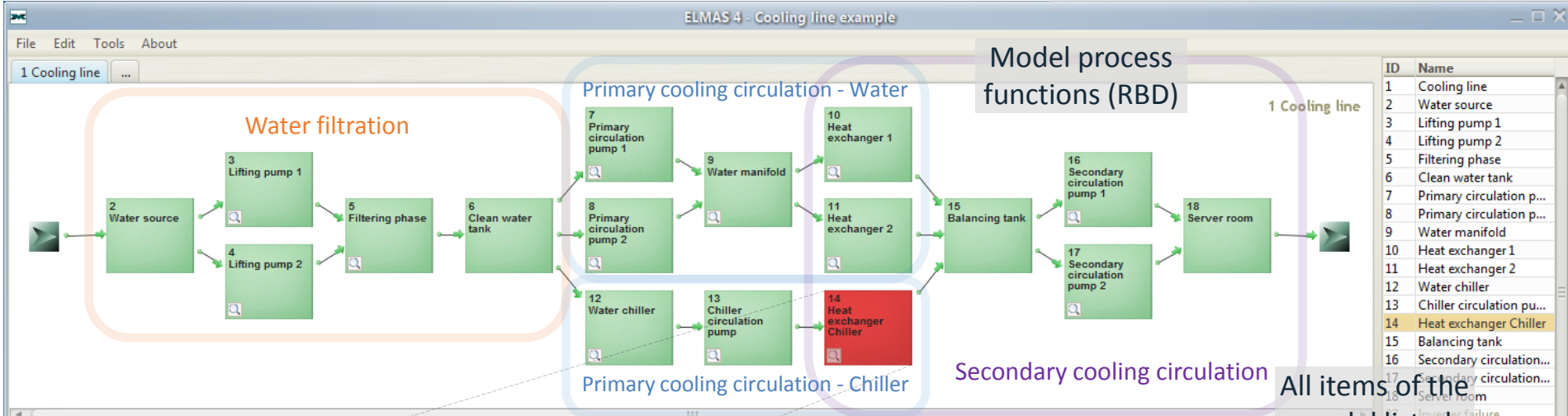
Env., Human, etc hazards

RAMS

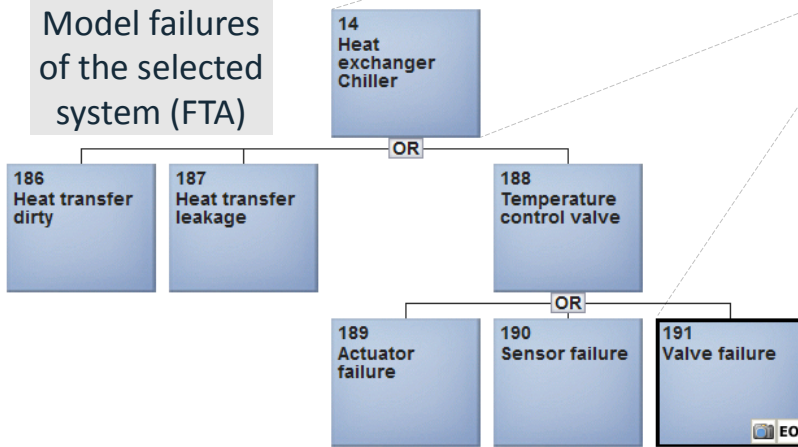
ELMAS

ELMAS 4.8

<http://www.ramentor.com/products/elmas/>



Model failures of the selected system (FTA)



Input data for the selected component

Edit node: 191 Valve failure

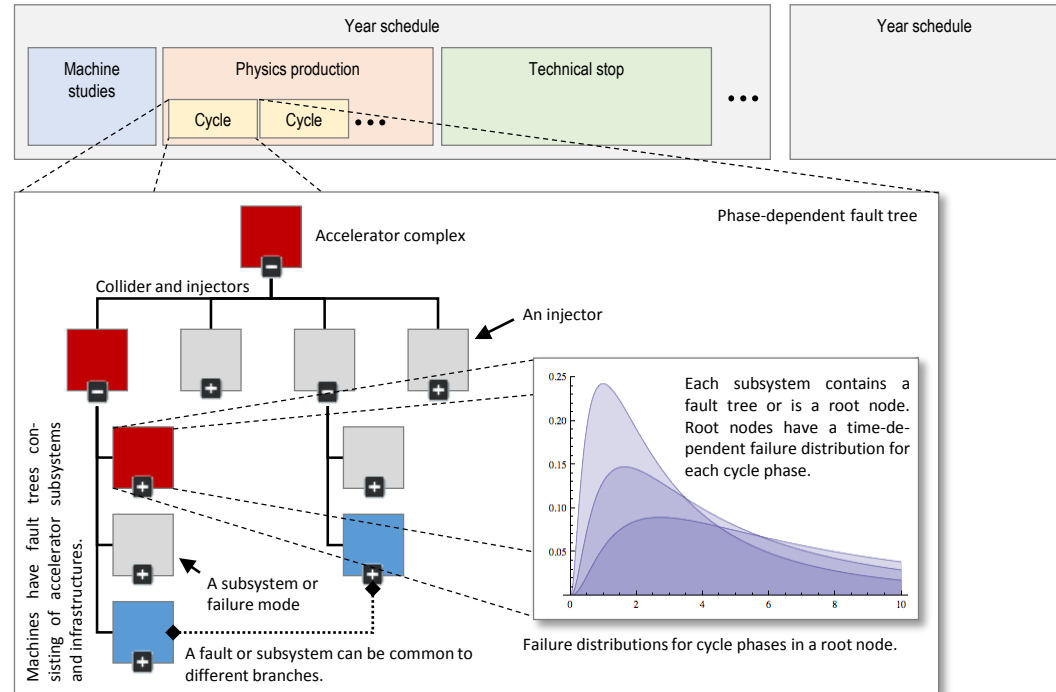
General	Restoration	Replacement	Finding	Redesign	RTF	
Type	Maint. LTA	Preventive	Inspection			
Relations	Inspections					
Classification	Generally it is reasonable to carry out the scheduled condition monitoring actions, if 1) it is possible to define and detect the symptoms of the failure early enough, 2) P-F-period (Point Failure) is moderately solid and 3) it is practical to control the object in shorter time periods than the P-F-period.					
Repair						
Maintenance						
Risks	Active	Name	Interval	Cost (€)	Symptom ti...	Probability
Line	<input checked="" type="checkbox"/>	Valve check	30.0 d	20.0	30.0 d	0.9
Simulation	<input type="button" value="Add inspection"/> <input type="button" value="Remove selected rows"/>					
Add cost from all overlapping (even only first is handled): <input type="checkbox"/>						

All items of the model listed

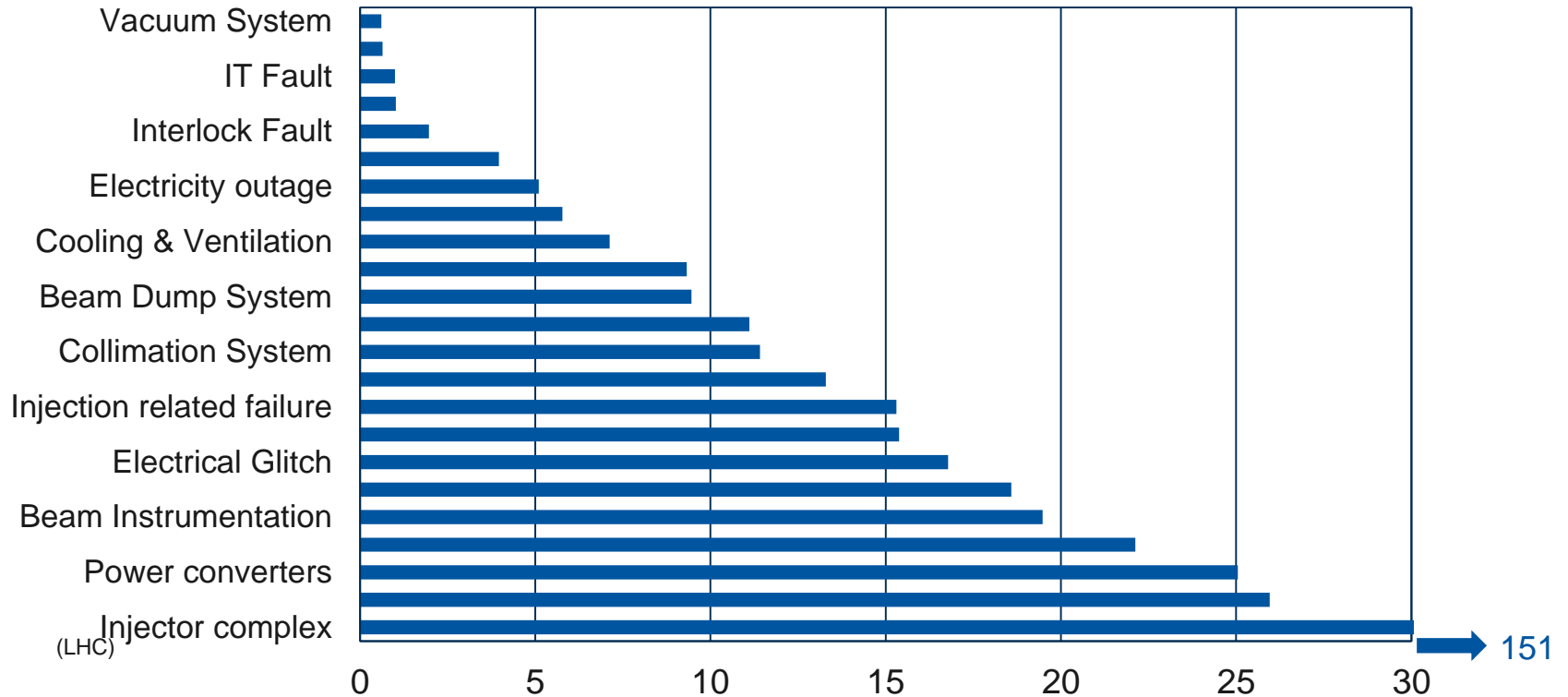
ID	Name
1	Cooling line
2	Water source
3	Lifting pump 1
4	Lifting pump 2
5	Filtering phase
6	Clean water tank
7	Primary circulation p...
8	Primary circulation p...
9	Water manifold
10	Heat exchanger 1
11	Heat exchanger 2
12	Water chiller
13	Chiller circulation pu...
14	Heat exchanger Chiller
15	Balancing tank
16	Secondary circulation...
17	Secondary circulation...
18	Server room
19	Inverter failure
20	Motor failure
21	Pressure sensor failure
22	Pump failure
23	Inverter failure
24	Motor failure
25	Motor failure
26	Motor failure
27	Motor failure
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83	Motor failure
84	Motor failure
85	Motor failure
86	Motor failure
87	Motor failure
88	Motor failure
89	Pressure sensor failure
90	Pump failure
91	Inverter failure
92	Motor failure
93	Pressure sensor failure
94	Pump failure
95	Filters fail
96	Filter 1
97	Inverter failure
98	Motor failure
99	Gearbox failure
100	Gaskets
101	Filter 2
102	Inverter failure
103	Motor failure
104	Gearbox failure
105	Gaskets
106	Filter 3
107	Inverter failure
108	Motor failure
109	Gearbox failure
110	Gaskets
111	Gaskets
112	Gaskets
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173	Chiller stopping failure
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181	Chiller stopping failure
182	Chiller stopping failure
183	Chiller stopping failure
184	Chiller stopping failure
185	Chiller stopping failure
186	Heat transfer dirty
187	Heat transfer leakage
188	Temperature control valve
189	Actuator failure
190	Sensor failure
191	Valve failure
192	Valve failure
193	Valve failure
194	Valve failure
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203	Valve failure
204	Chiller stopping failure

Modelling Approach

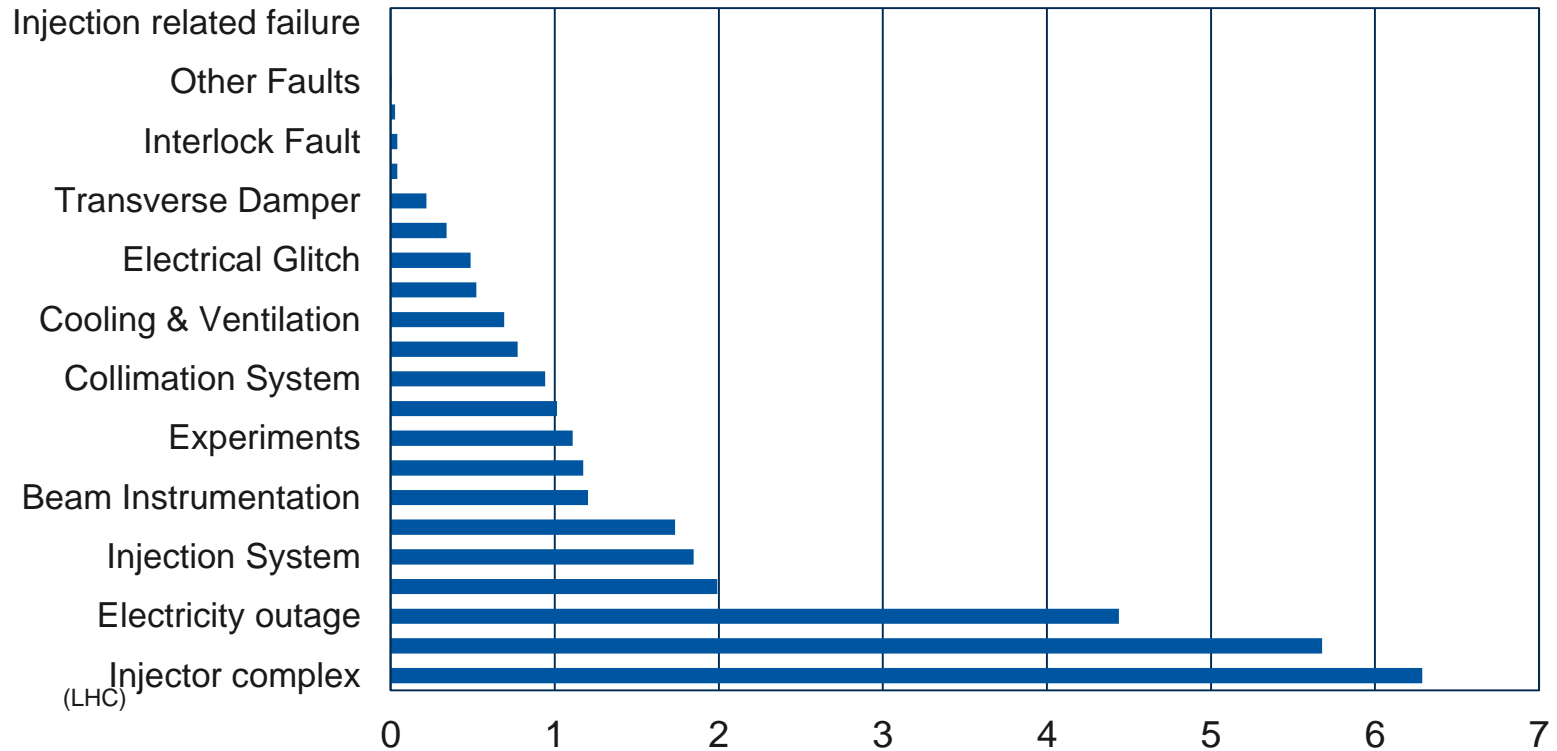
- Monte Carlo model of accelerator operation:
 - accelerator cycles, injections & luminosity production
- Fault tree model of system availability/reliability:
 - Failure rates + repair times



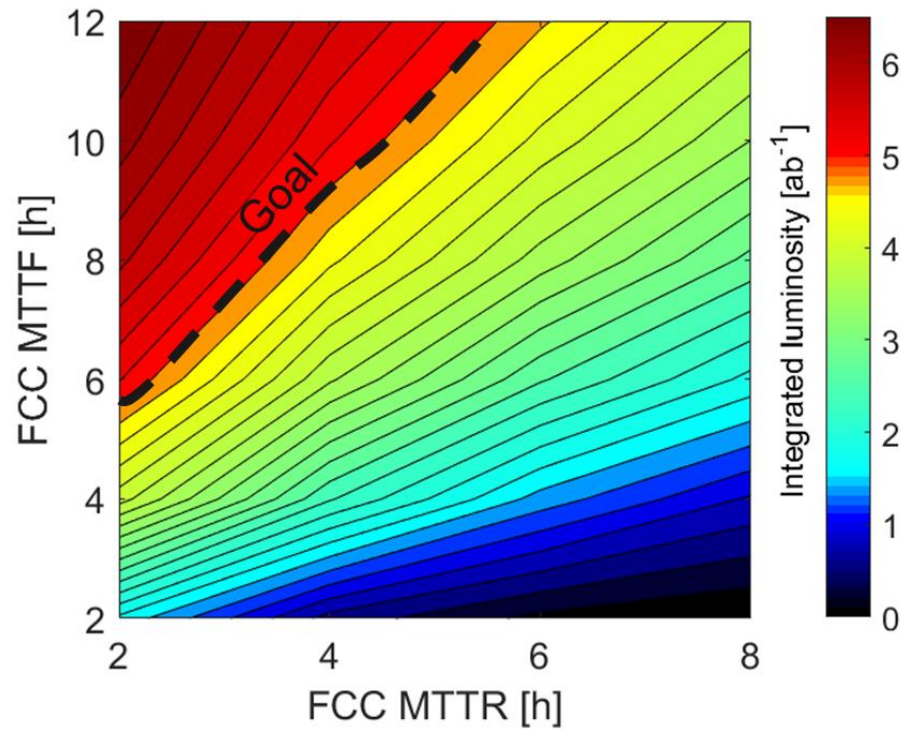
Availability budget: Failures / 100 days



Availability budget: Unavailability [%]



Sensitivity analysis



FCC Study Innovation Award



Read more: <http://www.ramentor.com/news/?x20097=1695208>



CERN Project - RAMS Methods and Tools

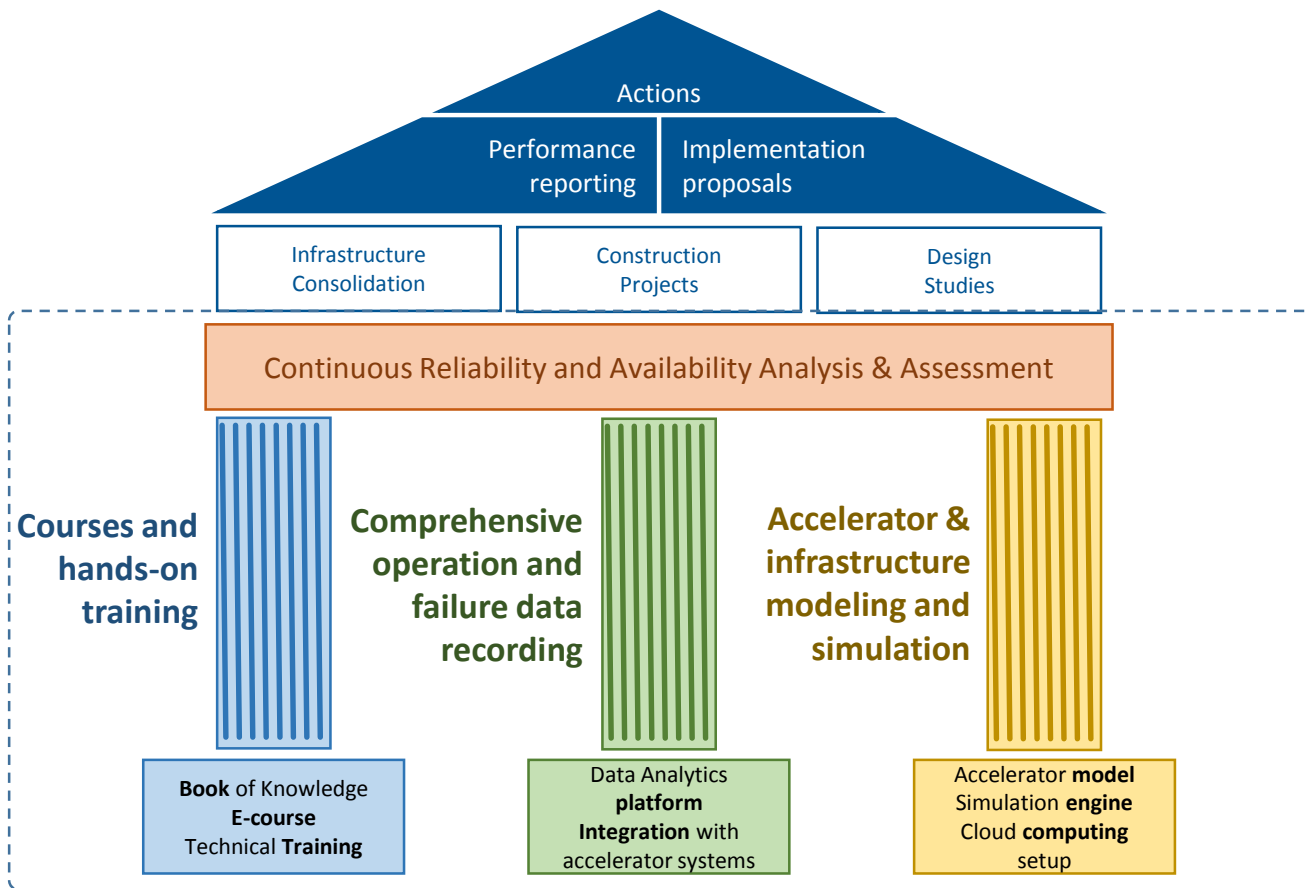
- 1) Use features of ELMAS tool for particle accelerators
 - Analysis made for current Large Hadron Collider (LHC)

- 2) Reliability training given twice a year
 - Train CERN system experts in the best practices of applying the method to study and assess systems' RAMS requirements

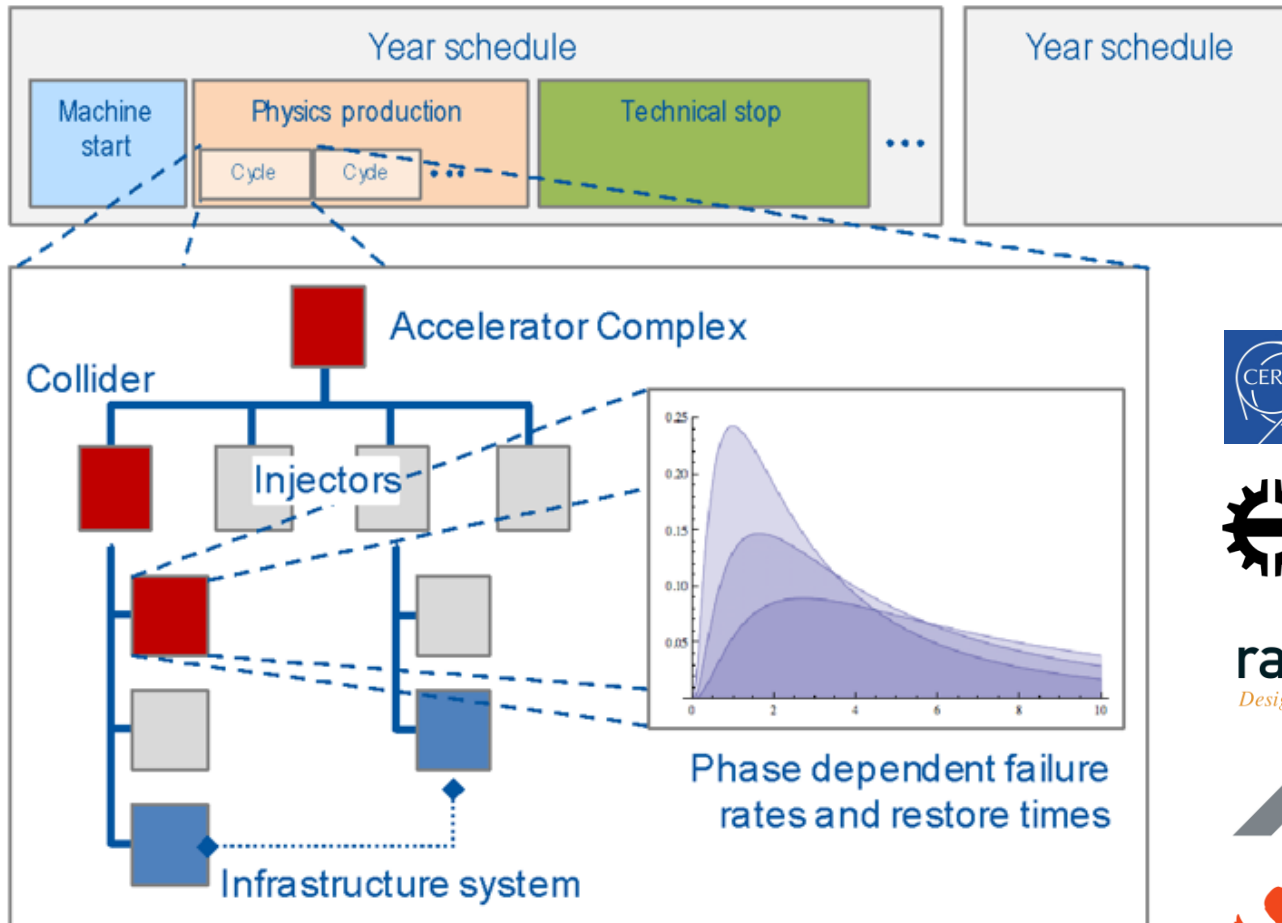
- 3) Enhanced modeling concept and calculation engine
 - Model and analyze the behavior of large systems efficiently

Sector-wide Accelerator Reliability & Availability Initiatives

by Johannes Gutleber, CERN ATS/DO



Towards a Common Method and Tool Federating Industry and Academia



TAMPERE
UNIVERSITY OF
TECHNOLOGY





Finland



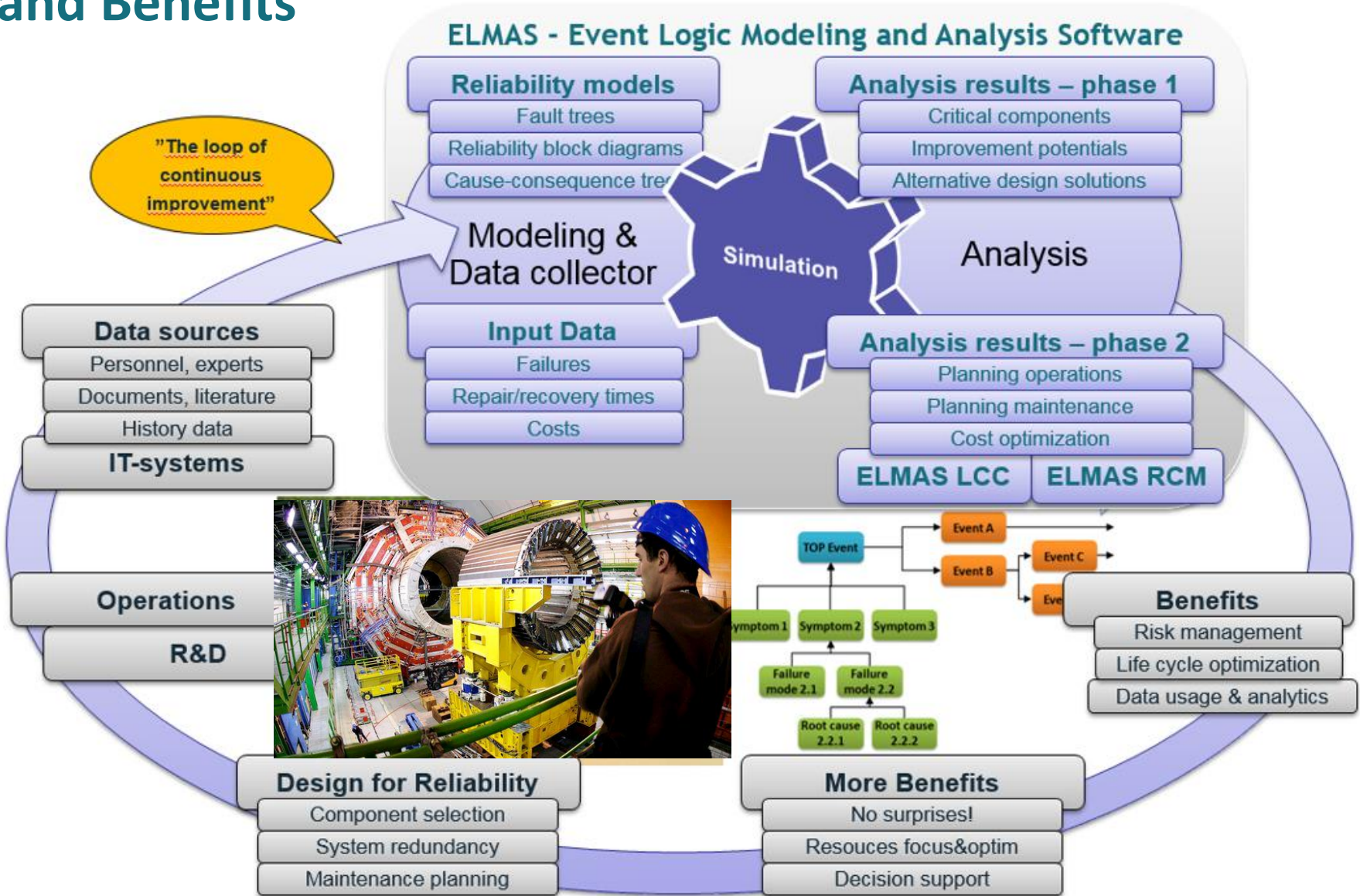
AT CERN

November 1 – 3, 2017



Ramentor engaged carrying out a dedicated R&D project with CERN will be present. The company provides **tools and services for system cost/performance reviews for design and operation with respect to reliability, maintenance optimisation and safety**. The company is also partner in S4FLEET (<https://www.dimecc.com/dimecc-services/s4fleet/>) bringing IoT and analytics to fleet optimisation. The organisers encourage one-to-one meetings with the companies.

RAMS / ELMAS Analysis Implementation and Benefits



Ramentor Oy