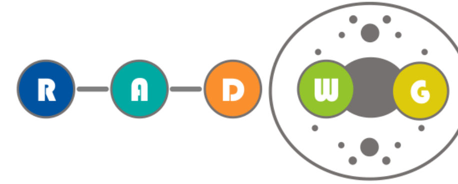

BE-CEM-EPR Radiation Test Service

Focus on Production Qualification & Optical Transceiver COTS

Rudy Ferraro (BE-CEM-EPR)
Salvatore Danzeca (BE-CEM-EPR)
Manoel Barros Marin (SY-BI-BP)

RadWG Workshop – 20th June, 2024

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Radiation Test Service

- BE-CEM-EPR provides, the service of radiation testing of electronic components supporting the Radiation Working Group (RadWG)
- The RadWG **supports** the accelerator sector equipment groups for the assessment of radiation tolerance of electronic equipment to be installed in radiation exposed areas.
- It is as a **forum** for electronic engineers to discuss
  - design practices
  - radiation tests
  - radiation induced failures in the accelerators.
- The RadWG is one of the pillars of the CERN Radiation Hardness Assurance process

Radiation Test Service – BE-CEM-EPR

Request collection

The requests for radiation testing are collected and processed selecting the most suitable methodology and facilities

01

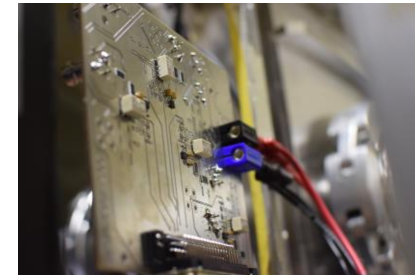
Test planning and structure

Each component/system is analyzed, and all the possible radiation effects are taken into account for planning the test and structure it

02

Board and instrumentation preparation

For each component a dedicated set of test board is prepared and the associated instrumentation is chosen to face the complexity of the radiation test

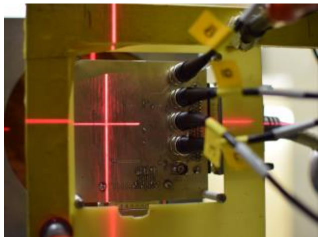


03

04

Testing

The test are carried out at CERN facilities such as CHARM or Co60 and in external facilities. The transport, personnel and instrumentation are selected considering the peculiar aspect of each facility



05

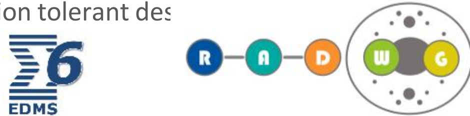
Result analysis

The results are analyzed during and after the tests for each component considering the end application and the possible operational issues

06

Database and Publication

The results are collected, stored and in EDMS and published in the RADWG database to allow an easy research of the best candidates for the new radiation tolerant des



CERN ATS-RHA Procedure: New developments

Time

Phase

Phase 0 Functional Description / Blocks

Phase 1 Radiation Environment

Phase 2 System / Components Description

Phase 3 Exploratory COTS Component Radiation Test

Phase 4 System-Level Prototype Radiation Test

Phase 5 Production batches Component Radiation Qualification

Phase 6 System-Level Radiation Qualification Test

Phase 7 Final Summary Installation Approval

Phase 8 Operation Follow up

Radiation Test Request Document

Component Radiation Test Reports

System Radiation Test Report

Radiation Qualification Request Document

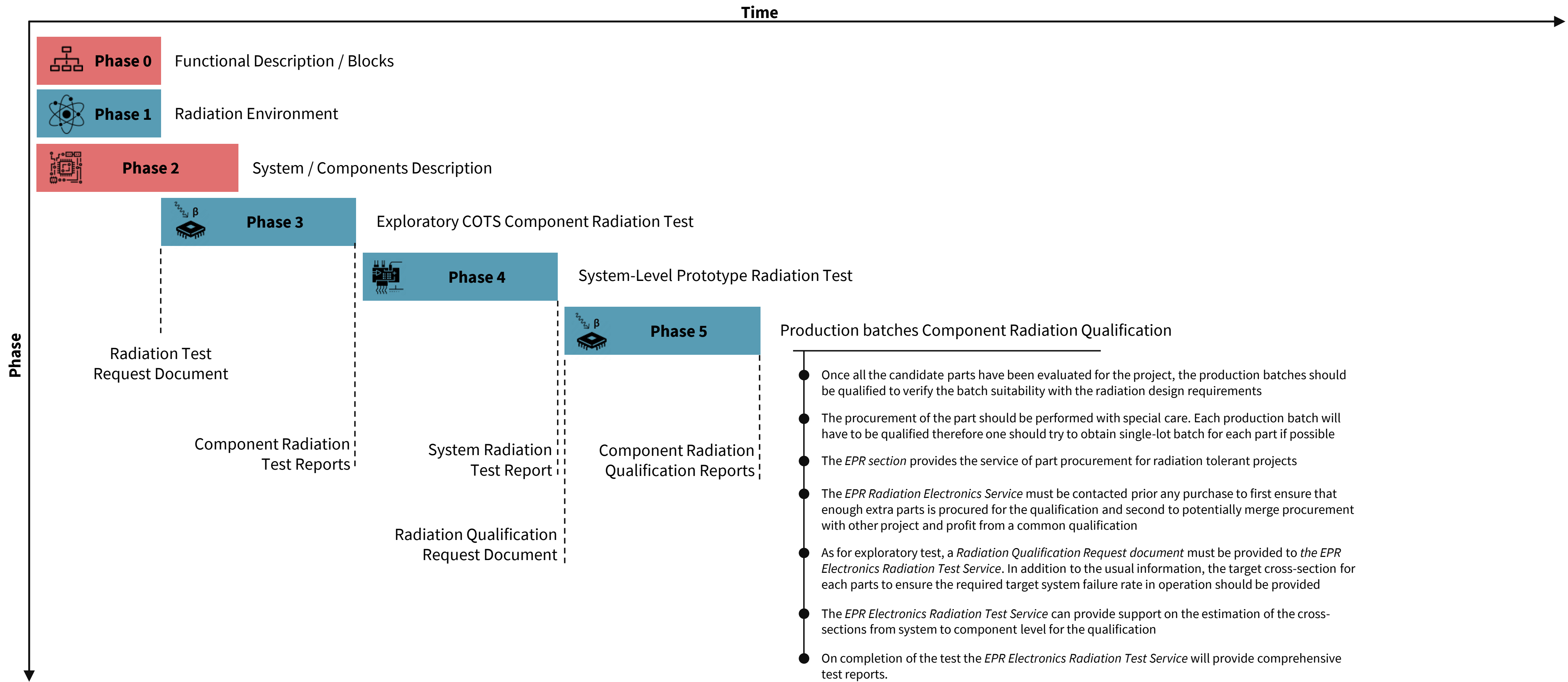
Component Radiation Qualification Reports

System Radiation Qualification Report

Project **R**adiation **H**ardness **A**ssurance **V**alidation (RHAPV) Document

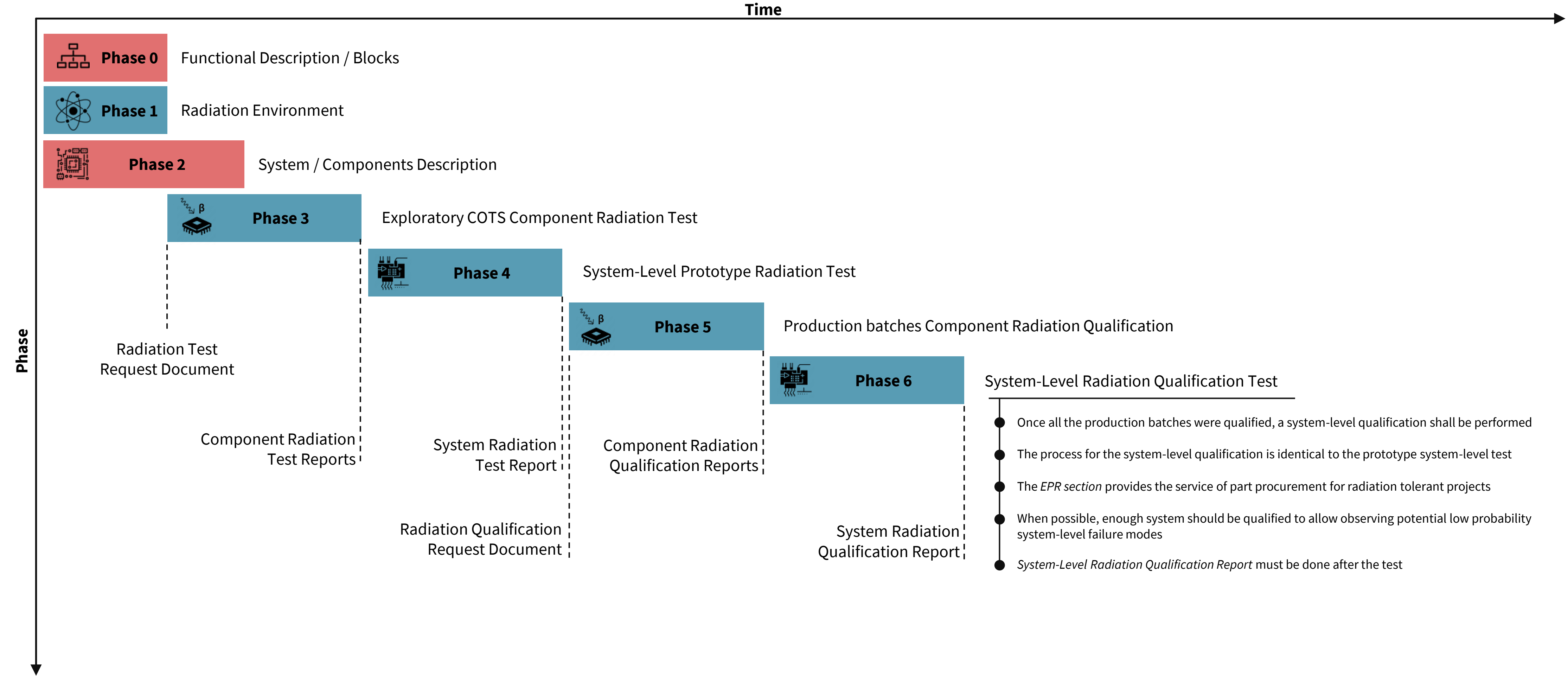
From: EDMS 1740220

CERN ATS-RHA Procedure: New developments



From: EDMS 1740220

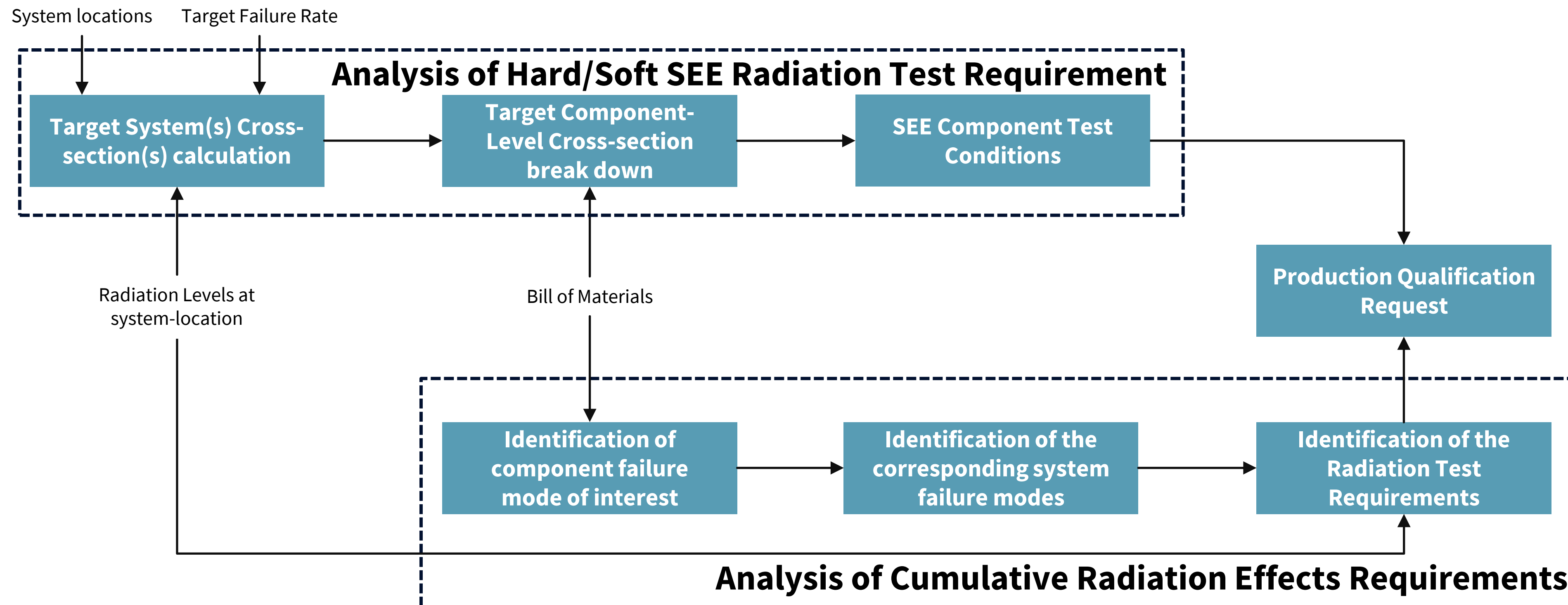
CERN ATS-RHA Procedure: New developments



From: EDMS 1740220

Production Radiation Test Requirement definition Process

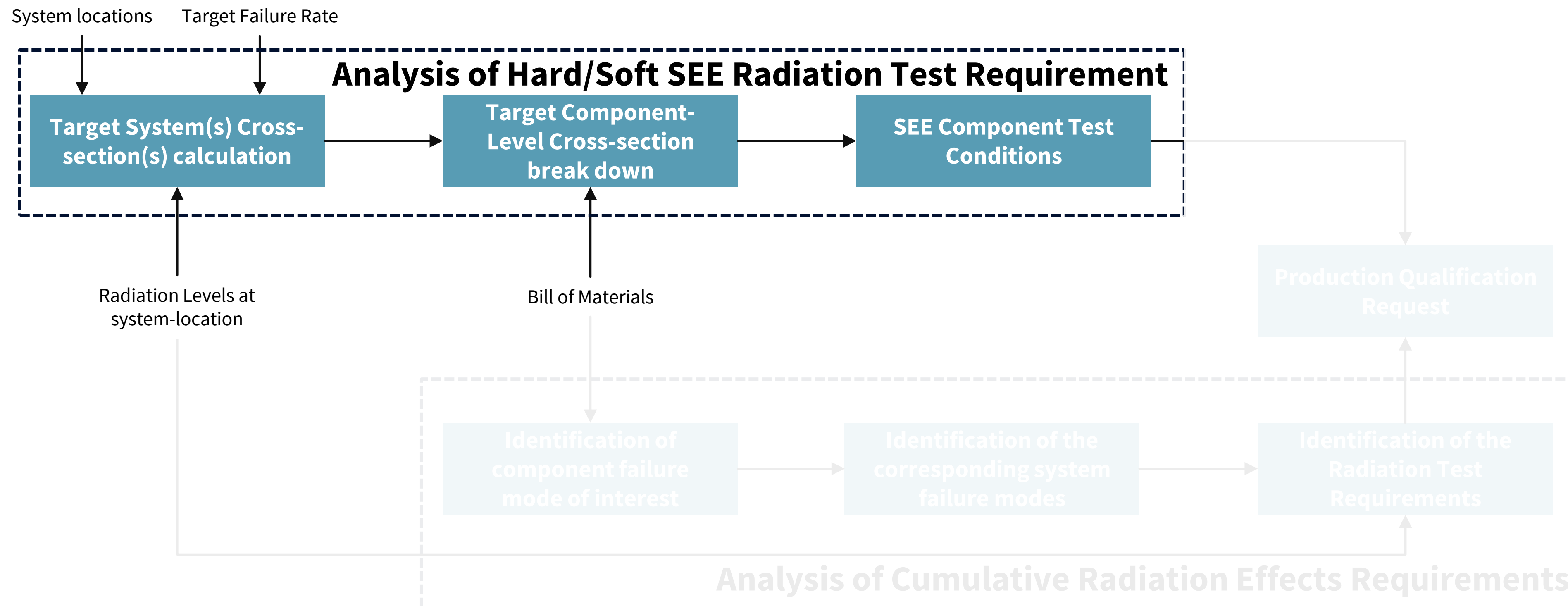
➢ Several information to be provided to perform the qualification of production lots:



➢ **The *EPR Electronics Radiation Test Service* can support the preparation of the request**

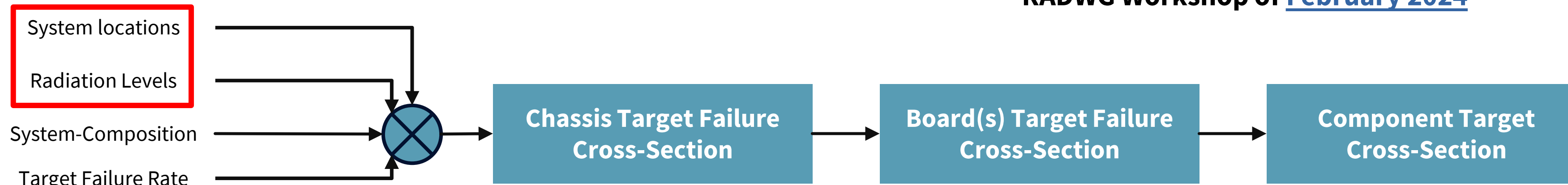
Production Qualification Request Process

➢ Several information to be provided to perform the qualification of production lots:



SEE Radiation Test Requirement Analysis: BLM

- Workflow:



General Method presented during the RADWG Workshop of February 2024

System Location									Radiation Levels								
Accelerator	Point	Area	Cell	Rack Name	DCUM [m]	#Systems	System	Operation Time [y]	Annual Dose [Gy/	Annual HEH [pp/cm2	Annual 1MeV [n/cm	Annual Th.n [n/cm	Total Dose [Gy/	Total HEH [pp/cm	Total 1MeV [n/cm	Total Th.n [n/cm	TID/DD
SPS	1	TS14	102	BYBLM.10293	88.9	1	BLEACT	30	0.3	3.20E+08	3.20E+09	3.20E+09	9.0	9.60E+09	9.60E+10	9.60E+10	1.07E+10
SPS	1	TS14	107	BYBLM.10793	248.9	1	BLEACT	30	11.6	1.16E+10	1.20E+11	1.16E+11	348.0	3.48E+11	3.60E+12	3.48E+12	1.03E+10
SPS	1	TS14	112	BYBLM.11277	405.5	1	BLEACT	30	30.0	3.00E+10	3.00E+11	3.00E+11	900.0	9.00E+11	9.00E+12	9.00E+12	1.00E+10
SPS	1	TS16	123	BYBLM.12397	764.1	1	BLEACT	30	44.8	4.48E+10	4.50E+11	4.48E+11	1344.0	1.34E+12	1.35E+13	1.34E+13	1.00E+10
SPS	1	TS16	127	BYBLM.12773	882.2	1	BLEACT	30	25.8	2.58E+10	2.60E+11	2.58E+11	774.0	7.74E+11	7.80E+12	7.74E+12	1.01E+10
SPS	1	TS16	132	BYBLM.13293	1048.9	1	BLEACT	30	2.3	2.26E+09	2.30E+10	2.26E+10	69.0	6.78E+10	6.90E+11	6.78E+11	1.00E+10
SPS	2	TS24	202	BYBLM.20293	1240.8	1	BLEACT	30	6.8	6.78E+09	6.80E+10	6.78E+10	204.0	2.03E+11	2.04E+12	2.03E+12	1.00E+10
SPS	2	TS24	207	BYBLM.20793	1400.8	1	BLEACT	30	0.6	6.45E+08	6.50E+09	6.45E+09	18.0	1.94E+10	1.95E+11	1.94E+11	1.08E+10
SPS	2	TS24	212	BYBLM.21277	1557.4	1	BLEACT	30	4.8	4.84E+09	4.80E+10	4.84E+10	144.0	1.45E+11	1.44E+12	1.45E+12	1.00E+10
SPS	2	TS26	222	BYBLM.22297	1884.0	1	BLEACT	30	600.0	6.00E+11	6.00E+12	6.00E+12	18000.0	1.80E+13	1.80E+14	1.80E+14	1.00E+10
SPS	2	TS26	227	BYBLM.22793	2040.8	1	BLEACT	30	7.6	7.60E+09	7.60E+10	7.60E+10	228.0	2.28E+11	2.28E+12	2.28E+12	1.00E+10
SPS	2	TS26	232	BYBLM.23293	2200.8	1	BLEACT	30	74.0	7.40E+10	7.40E+11	7.40E+11	2220.0	2.22E+12	2.22E+13	2.22E+13	1.00E+10
SPS	3	TS34	302	BYBLM.30293	2392.8	1	BLEACT	30	1.3	1.29E+09	1.30E+10	1.29E+10	39.0	3.87E+10	3.90E+11	3.87E+11	1.00E+10
SPS	3	TS34	307	BYBLM.30793	2552.7	1	BLEACT	30	3.9	3.87E+09	3.90E+10	3.87E+10	117.0	1.16E+11	1.17E+12	1.16E+12	1.00E+10
SPS	3	TS34	312	BYBLM.31293	2712.7	1	BLEACT	30	4.2	4.19E+09	4.20E+10	4.19E+10	126.0	1.26E+11	1.26E+12	1.26E+12	1.00E+10
SPS	3	TS36	322	BYBLM.32273	3026.1	1	BLEACT	30	4.8	4.84E+09	4.80E+10	4.84E+10	144.0	1.45E+11	1.44E+12	1.45E+12	1.00E+10
SPS	3	TS36	327	BYBLM.32793	3192.7	1	BLEACT	30	0.3	3.23E+08	3.20E+09	3.23E+09	9.0	9.69E+09	9.60E+10	9.69E+10	1.07E+10
SPS	3	TS36	332	BYBLM.33293	3352.7	1	BLEACT	30	3.2	3.23E+09	3.20E+10	3.23E+10	96.0	9.69E+10	9.60E+11	9.69E+11	1.00E+10
SPS	4	TS44	402	BYBLM.40293	3544.7	1	BLEACT	30	4.8	4.84E+09	4.80E+10	4.84E+10	144.0	1.45E+11	1.44E+12	1.45E+12	1.00E+10
SPS	4	TS44	407	BYBLM.40793	3704.7	1	BLEACT	30	11.3	1.13E+10	1.10E+11	1.13E+11	339.0	3.39E+11	3.30E+12	3.39E+12	9.73E+09
SPS	4	TS44	412	BYBLM.41293	3864.6	1	BLEACT	30	1.6	1.61E+09	1.60E+10	1.61E+10	48.0	4.83E+10	4.80E+11	4.83E+11	1.00E+10
SPS	4	TS46	422	BYBLM.42273	4178.0	1	BLEACT	30	40.0	4.00E+10	4.00E+11	4.00E+11	1200.0	1.20E+12	1.20E+13	1.20E+13	1.00E+10
SPS	4	TS46	427	BYBLM.42793	4344.6	1	BLEACT	30	6.1	6.13E+09	6.10E+10	6.13E+10	183.0	1.84E+11	1.83E+12	1.84E+12	1.00E+10
SPS	4	TS46	432	BYBLM.43293	4504.6	1	BLEACT	30	3.9	3.87E+09	3.90E+10	3.87E+10	117.0	1.16E+11	1.17E+12	1.16E+12	1.00E+10
SPS	5	TS54	502	BYBLM.50293	4696.6	1	BLEACT	30	16.5	1.65E+10	1.70E+11	1.65E+11	495.0	4.95E+11	5.10E+12	4.95E+12	1.03E+10
SPS	5	TS54	507	BYBLM.50793	4856.6	1	BLEACT	30	20.3	2.03E+10	2.00E+11	2.03E+11	609.0	6.09E+11	6.00E+12	6.09E+12	9.85E+09
SPS	5	TS54	512	BYBLM.51293	5016.6	1	BLEACT	30	45.2	4.52E+10	4.50E+11	4.52E+11	1356.0	1.36E+12	1.35E+13	1.36E+13	9.96E+09
SPS	5	TS56	522	BYBLM.52277	5333.1	1	BLEACT	30	14.2	1.42E+10	1.40E+11	1.42E+11	426.0	4.26E+11	4.20E+12	4.26E+12	9.86E+09
SPS	5	TS56	528	BYBLM.52873	5521.9	1	BLEACT	30	22.9	2.29E+10	2.30E+11	2.29E+11	687.0	6.87E+11	6.90E+12	6.87E+12	1.00E+10
SPS	5	TS56	533	BYBLM.53377	5685.0	1	BLEACT	30	2.0	2.00E+09	2.00E+10	2.00E+10	60.0	6.00E+10	6.00E+11	6.00E+11	1.00E+10
SPS	6	TS64	602	BYBLM.60293	5848.5	1	BLEACT	30	13.2	1.32E+10	1.30E+11	1.32E+11	396.0	3.96E+11	3.90E+12	3.96E+12	9.85E+09
SPS	6	TS64	607	BYBLM.60793	6008.5	1	BLEACT	30	7.7	7.74E+09	7.70E+10	7.74E+10	231.0	2.32E+11	2.31E+12	2.32E+12	1.00E+10
SPS	6	TS64	612	BYBLM.61277	6170.0	1	BLEACT	30	4.8	4.84E+09	4.80E+10	4.84E+10	144.0	1.45E+11	1.44E+12	1.45E+12	1.00E+10
SPS	6	TS66	622	BYBLM.62293	6488.5	1	BLEACT	30	39.7	3.97E+10	4.00E+11	3.97E+11	1191.0	1.19E+12	1.20E+13	1.19E+13	1.01E+10
SPS	6	TS66	627	BYBLM.62793	6648.4	1	BLEACT	30	7.1	7.10E+09	7.10E+10	7.10E+10	213.0	2.13E+11	2.13E+12	2.13E+12	1.00E+10
SPS	6	TS66	632	BYBLM.63293	6808.4	1	BLEACT	30	44.2	4.42E+10	4.40E+11	4.42E+11	1326.0	1.33E+12	1.32E+13	1.33E+13	9.95E+09

BLM System Locations and Radiation levels:

Total Annual Fluence all systems are exposed: 3.40E+13 HeH/cm²

The maximum desired SEE failure rate in operation defines the target upper-limit cross-section for the tests:

System Failure Rate [%]	Number of Failures Per year For 36 systems	Maximum System Cross-section [cm²]
10%	3.6	3.18 E-12
1%	0.36	3.18 E-13
0.1%	0.036	3.18 E-14
0.01%	0.0036	3.18 E-15

x% * **Number of systems**

Here is 36 for example, but it can scale up very fast depending on LHC projects

SEE Radiation Test Requirement Analysis: BLM

Total Annual Fluence all systems are exposed: 3.40E+13 HeH/cm²

The maximum desired SEE failure rate in operation defines the target upper-limit cross-section for the tests:

System Failure Rate [%]	Number of Failures Per year	Maximum System Cross-section [cm²]	Maximum Component Cross-section [cm²]	For 10 components:	For 100 components:
10%	1% * **Number of systems**	3.18 E-12	3.18 E-12 / **Number of components***	3.18 E-13	3.18 E-15
1%		3.18 E-13	3.18 E-13 / **Number of component*s**	3.18 E-14	3.18 E-16
0.1%		3.18 E-14	3.18 E-14 / **Number of components***	3.18 E-15	3.18 E-17
0.01%		3.18 E-15	3.18 E-15 / **Number of components***	3.18 E-16	3.18 E-18

→ **Hardly Achievable by Testing**

LHC Projects can have from less than 10 active parts to 100

* Rule of thumb, in practice it is less since we are dealing with upper bounds combinations

SEE Radiation Test Requirement Analysis: BLM

Total Annual Fluence all systems are exposed: 3.40E+13 HeH/cm²

The maximum desired SEE failure rate in operation defines the target upper-limit cross-section for the tests:

System Failure Rate [%]	Number of Failures Per year	Maximum System Cross-section [cm²]	Maximum Component Cross-section [cm²]		Test Fluence [HeH/cm²]	Number of Test Samples Required	
			For 10 components:	For 100 components:		For 10 components:	For 100 components:
10%	1% * **Number of systems**	3.18 E-12	3.18 E-13*	3.18 E-15*	3.5 E12 *1 Week in CHARM R13*	~4	~400
1%		3.18 E-13	3.18 E-14*	3.18 E-16*		~40	~4k
0.1%		3.18 E-14	3.18 E-15*	3.18 E-17*		400	40k
0.01%		3.18 E-15	3.18 E-16*	3.18 E-18*		4k	400k

Requirements

Radiation Qualification

Feasible **Not feasible**

* Rule of thumb, in practice it is less since we are dealing with upper bounds combinations

SEE Radiation Test Requirement Analysis: BLM

Total Annual Fluence all systems are exposed: 3.40E+13 HeH/cm²

The maximum desired SEE failure rate in operation defines the target upper-limit cross-section for the tests:

System Failure Rate [%]	Number of Failures Per year	Maximum System Cross-section [cm²]	Maximum Component Cross-section [cm²] For 10 components:	For 100 components:
10%	1% * **Number of systems**	3.18 E-12	3.18 E-13*	3.18 E-15*
1%		3.18 E-13	3.18 E-14*	3.18 E-16*
0.1%		3.18 E-14	3.18 E-15*	3.18 E-17*
0.01%		3.18 E-15	3.18 E-16*	3.18 E-18*

Requirements

Device	Type	Device Failure Cross-Section [cm²]	
FTLC1156RDPL	SFP28	1. 85 E-9	[1]
DDCChh-QLCA	QSP28	< 2. 81 E-11	[1]
D1TThh-QLCA	QSP28	< 6. 92 E-11	[1]
D13399-SLHA	SPF+	4. 70 E-12	[1]
FTLF1436P4BCV	SFP28	< 4. 32 E-12	[1]
ET5402	SFP+	< 8. 54 E-12	[1]
GBTx + VTRx	**CERN EP ASIC**	**~ 8. 70 E-12**	**[2]**

+ 9 devices from BE/BI/QP in [3] but failure cross-section not provided.

→ **Those were only exploratory tests with one or two samples, not qualification, hence the relatively 'low' upper bound.**

So far no systems use optical transceiver COTS in production

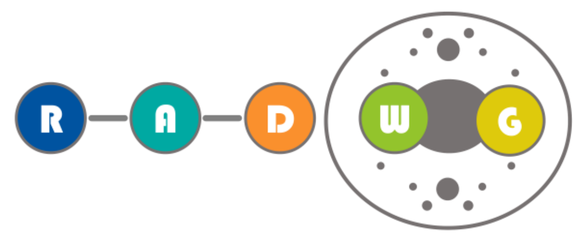
Reports:

[1] EDMS 3088003 By BE-CEM-EPR & SY-BI
[2] EDMS **1863774** By BE-CEM-EPR & SY-BI at system-level with the GEFE Board
[3] EDMS 1289608 By BE-BI-QP

* Rule of thumb, in practice it is less since we are dealing with upper bounds combinations

Conclusions

- To ensure reliable operation of the radiation tolerant systems in the CERN accelerator complex, the systems must undergo proper radiation test qualifications to ensure its failure rate in operation is compliant with the objective
- Within the BE-CEM-EPR radiation test service a workflow has been established to calculate the target system and component cross-sections to be achieved during qualification based on:
  - System Locations
  - Radiation Levels at Locations
  - Number of Systems & Bill of Materials
- The final system and component cross-section is highly dependent on the radiation levels and even more on the number of systems and components
- Target cross-sections can range from 10E-10 to 10E-16 depending on the projects
- This process is crucial to verify that the system radiation tolerance is compliant with the project objectives
- So far, a certain number of COTS transceivers were tested with cross-sections ranging from 10E-9 to 10E-12, which could be a good fit for certain projects
- Those test were only exploratory, no further qualifications were performed since so far, no developments with them are ongoing
- Also for rad-hard devices the testing and evaluation exercise is still fundamental and should be investigated according to the number of devices purchased and on the projects that might embed them



Thank you for your attention!

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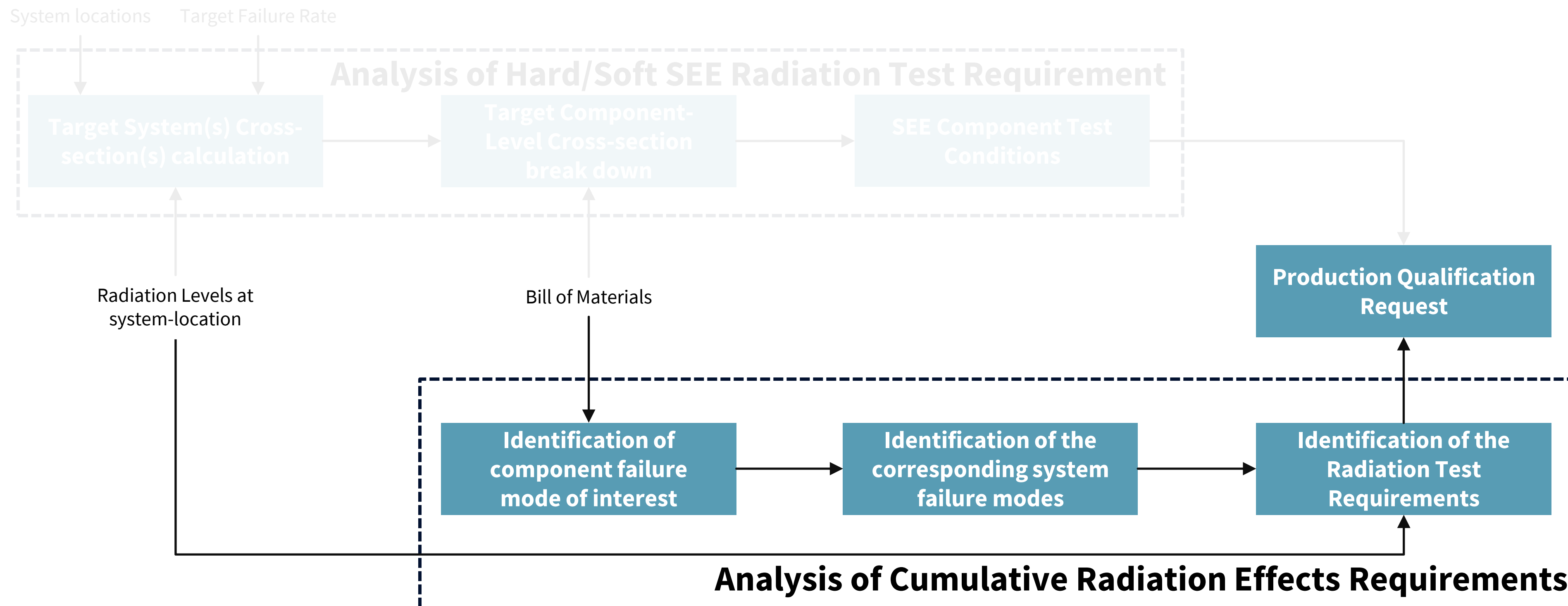
Production Radiation Test Requirement definition Process

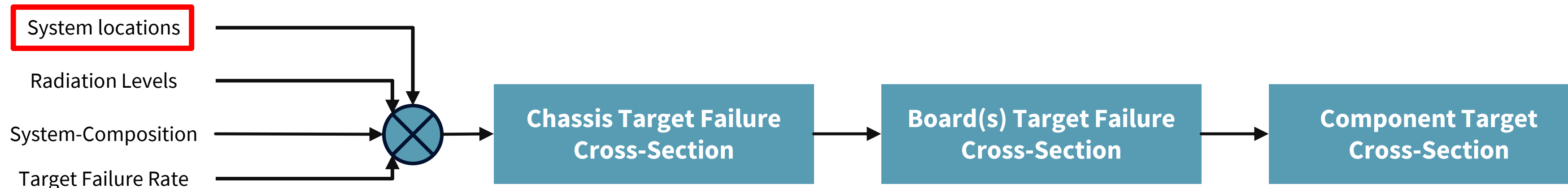
➢ Several information to be provided to perform the qualification of production lots:



➢ **The *EPR Electronics Radiation Test Service* can support the preparation of the request**

SEE Radiation Test Requirement Analysis

- Workflow:

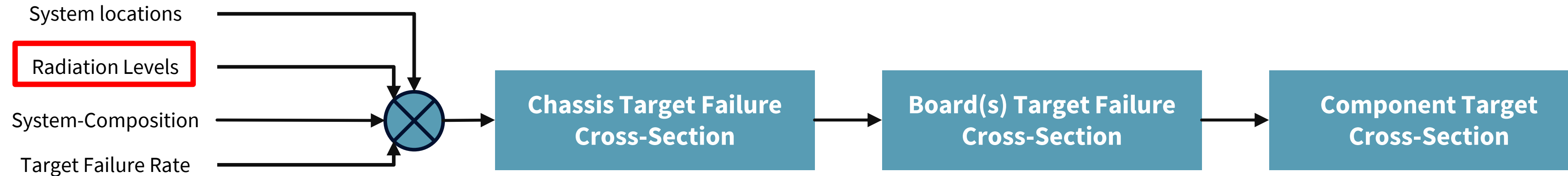


System Location					
Accelerator	Point	CIWRA	#Systems	System	Operation Time [y]
LHC	TI2	20540	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	20940	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	21940	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	22340	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	22844	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	23244	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	23644	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	24044	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	24444	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	24844	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	25244	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	25744	1	WIC DIOT Chassis [2 Boards]	12
LHC	TI2	26240	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	26640	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	27040	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	28040	1	WIC DIOT Chassis [1 Boards]	12
LHC	TI2	28940	1	WIC DIOT Chassis [2 Boards]	12

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: System Radiation Levels)

SEE Radiation Test Requirement Analysis

- Workflow:

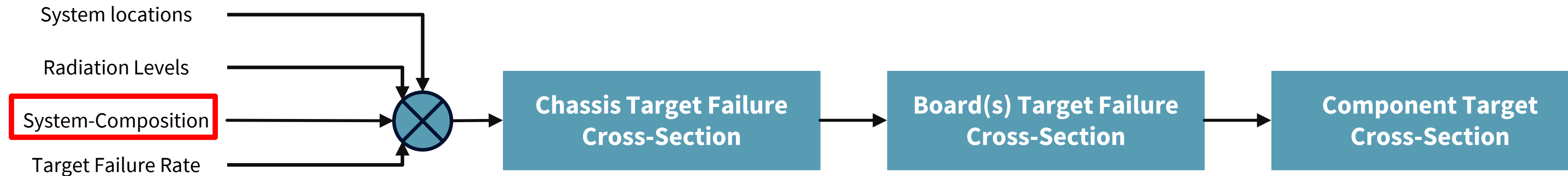


System Location						Radiation Levels								
Accelerator	Point	CIWRA	#Systems	System	Operation Time [y]	Annual Dose [Gy/y]	Annual HEH [pp/cm2]	Annual 1MeV [n/cm2]	Annual Th.n [n/cm2]	Total Dose [Gy/y]	Total HEH [pp/cm2]	Total 1MeV [n/cm2]	Total Th.n [n/cm2]	TID/DD
LHC	TI2	20540	1	WIC DIOT Chassis [2 Boards]	12	0.3	6.00E+08	-	-	3.6	7.20E+09	-	-	-
LHC	TI2	20940	1	WIC DIOT Chassis [2 Boards]	12	0.2	4.00E+08	-	-	2.4	4.80E+09	-	-	-
LHC	TI2	21940	1	WIC DIOT Chassis [1 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	22340	1	WIC DIOT Chassis [1 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	22844	1	WIC DIOT Chassis [1 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	23244	1	WIC DIOT Chassis [1 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	23644	1	WIC DIOT Chassis [2 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	24044	1	WIC DIOT Chassis [2 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	24444	1	WIC DIOT Chassis [2 Boards]	12	0.3	5.00E+08	-	-	3.0	6.00E+09	-	-	-
LHC	TI2	24844	1	WIC DIOT Chassis [2 Boards]	12	0.0	1.20E+07	-	-	0.1	1.44E+08	-	-	-
LHC	TI2	25244	1	WIC DIOT Chassis [2 Boards]	12	0.0	8.00E+06	-	-	0.0	9.60E+07	-	-	-
LHC	TI2	25744	1	WIC DIOT Chassis [2 Boards]	12	0.0	4.00E+06	-	-	0.0	4.80E+07	-	-	-
LHC	TI2	26240	1	WIC DIOT Chassis [1 Boards]	12	0.0	1.60E+06	-	-	0.0	1.92E+07	-	-	-
LHC	TI2	26640	1	WIC DIOT Chassis [1 Boards]	12	0.0	6.00E+05	-	-	0.0	7.20E+06	-	-	-
LHC	TI2	27040	1	WIC DIOT Chassis [1 Boards]	12	0.0	4.00E+05	-	-	0.0	4.80E+06	-	-	-
LHC	TI2	28040	1	WIC DIOT Chassis [1 Boards]	12	0.0	2.00E+06	-	-	0.0	2.40E+07	-	-	-
LHC	TI2	28940	1	WIC DIOT Chassis [2 Boards]	12	0.0	4.00E+07	-	-	0.2	4.80E+08	-	-	-

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: System Radiation Levels)

SEE Radiation Test Requirement Analysis

- The *EPR Electronics Radiation Test Service* can support the different activities required to prepare the production qualification request:

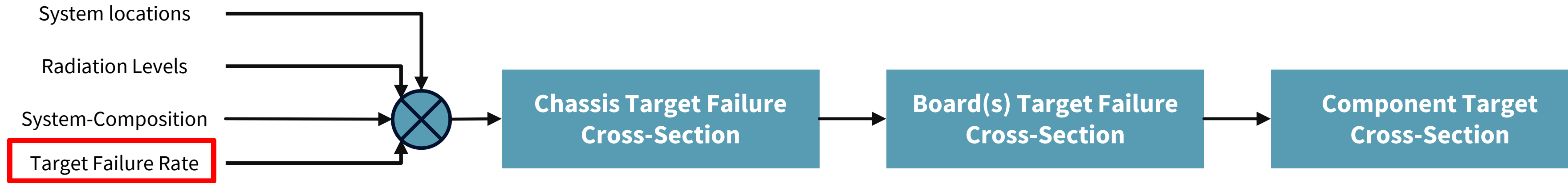


System Configuration	#EDA	Board	#Active Parts	Quantity	Redundancy?
WIC DIOT Chassis [1 Boards]	EDA-03829-V2	DIO 16ch opt 24V	7	1	1
WIC DIOT Chassis [1 Boards]	EDA-04422-V2	RaToPUS DC/DC	18	1	1
WIC DIOT Chassis [1 Boards]	EDA-04326-V1	DI/OT Rad-tol System Board	15	1	2
WIC DIOT Chassis [1 Boards]	EDA-03613-V3	FMC-nanoFIP	5	1	1
WIC DIOT Chassis [2 Boards]	EDA-03829-V2	DIO 16ch opt 24V	7	2	1
WIC DIOT Chassis [2 Boards]	EDA-04422-V2	RaToPUS DC/DC	18	1	2
WIC DIOT Chassis [2 Boards]	EDA-04326-V1	DI/OT Rad-tol System Board	15	1	1
WIC DIOT Chassis [2 Boards]	EDA-03613-V3	FMC-nanoFIP	5	1	1

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: System Radiation Levels)

SEE Radiation Test Requirement Analysis

- The *EPR Electronics Radiation Test Service* can support the different activities required to prepare the production qualification request:

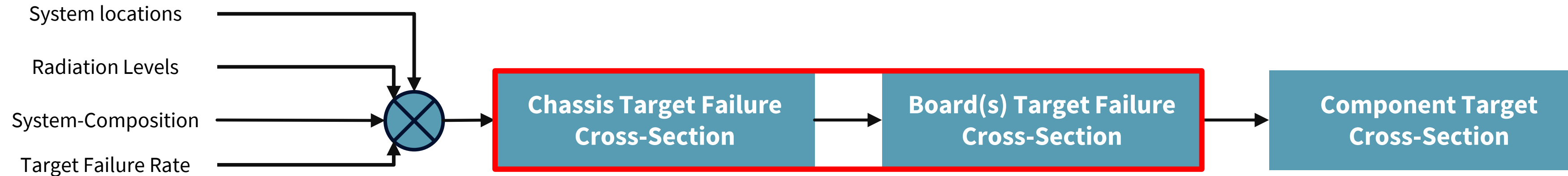


Systems			Target System Failures		
Accelerator	Point	System	Maximum System Annual Failure Rate [system/year]	Maximum Annual Failure Rate [year]	Maximum #Failures for operation
LHC	TI2	WIC DIOT Chassis [1 Boards]	0.0100	0.0800	0.9600
LHC	TI2	WIC DIOT Chassis [2 Boards]	0.0100	0.0900	1.0800

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: System Radiation Levels)

SEE Radiation Test Requirement Analysis

➤ The *EPR Electronics Radiation Test Service* can support the different activities required to prepare the production qualification request:

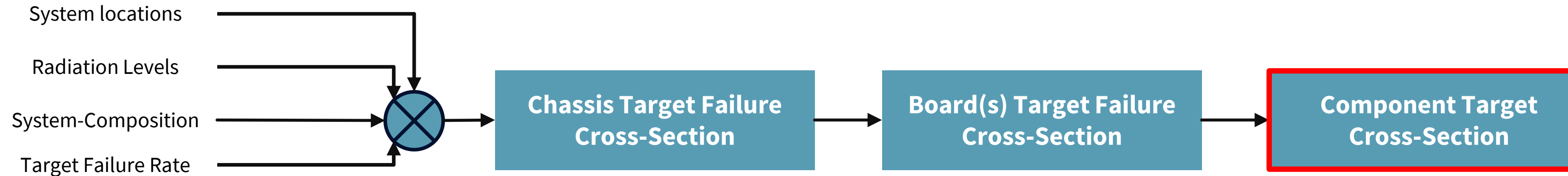


System Configuration	#EDA	Board	#Active Parts	Qty	Redundancy?	Target System Upper Limit Cross-section [system.cm²]	Target Subsystem Upper Limit Cross-section [system.cm²]	Target Board Upper Limit Cross-section [system.cm²]
WIC DIOT Chassis [1 Boards]	EDA-03829-V2	DIO 16ch opt 24V	7	1	1	1.75E-11	4.38E-12	4.38E-12
WIC DIOT Chassis [1 Boards]	EDA-04422-V2	RaToPUS DC/DC	18	1	1	1.75E-11	4.38E-12	4.38E-12
WIC DIOT Chassis [1 Boards]	EDA-04326-V1	DI/OT Rad-tol System Board	15	1	2	1.75E-11	4.38E-12	6.57E-12
WIC DIOT Chassis [1 Boards]	EDA-03613-V3	FMC-nanoFIP	5	1	1	1.75E-11	4.38E-12	4.38E-12
WIC DIOT Chassis [2 Boards]	EDA-03829-V2	DIO 16ch opt 24V	7	2	1	1.97E-11	4.92E-12	2.46E-12
WIC DIOT Chassis [2 Boards]	EDA-04422-V2	RaToPUS DC/DC	18	1	2	1.97E-11	4.92E-12	7.39E-12
WIC DIOT Chassis [2 Boards]	EDA-04326-V1	DI/OT Rad-tol System Board	15	1	1	1.97E-11	4.92E-12	4.92E-12
WIC DIOT Chassis [2 Boards]	EDA-03613-V3	FMC-nanoFIP	5	1	1	1.97E-11	4.92E-12	4.92E-12

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: System(s) Composition)

SEE Radiation Test Requirement Analysis

➢ The *EPR Electronics Radiation Test Service* can support the different activities required to prepare the production qualification request:

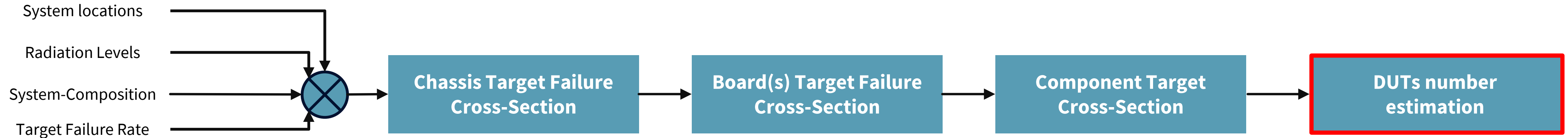


#EDA	Board Name	Schematic Reference	Part Number	Manufacturer	Component Type	Target Cross-Section Upper Limit
EDA-03829-V2	DIO 16ch opt 24V	D3, D5	PMLL4148L	NXP SEMICONDUCTORS	Diode	-
EDA-03829-V2	DIO 16ch opt 24V	D1, D2, D4	SM6T39CA	ST MICROELECTRONICS	Diode	-
EDA-03829-V2	DIO 16ch opt 24V	D7, D8	BAT54	FAIRCHILD SEMICONDUCTOR	Diode	6.25E-13
EDA-03829-V2	DIO 16ch opt 24V	IC3, IC5	LT1930ES5	LINEAR TECHNOLOGY	Voltage Regulator	6.25E-13
EDA-03829-V2	DIO 16ch opt 24V	IC4	LT1763CDE	LINEAR TECHNOLOGY	Voltage Regulator	6.25E-13
EDA-03829-V2	DIO 16ch opt 24V	IC1, IC2	AQW210S	Panasonic	Optocoupler	-
EDA-03829-V2	DIO 16ch opt 24V	IC6	MCP23017-E/SS	MICROCHIP TECHNOLOGY	IO Expander	6.25E-13

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: SubSystems Radiation Tolerance)

SEE Radiation Test Requirement Analysis

➢ The *EPR Electronics Radiation Test Service* can support the different activities required to prepare the production qualification request:



							Corresponding Test Conditions					
#EDA	Board Name	Schematic Reference	Part Number	Manufacturer	Component Type	Target Cross-Section Upper Limit	Facility	Test Fluence	Target Fluence Uncertainty	Target Confidence Interval (CI)	Number of devices for test	Total effective Fluence
EDA-03829-V2	DIO 16ch opt 24V	D3, D5	PMLL4148L	NXP SEMICONDUCTORS	Diode	-					-	-
EDA-03829-V2	DIO 16ch opt 24V	D1, D2, D4	SM6T39CA	ST MICROELECTRONICS	Diode	-					-	-
EDA-03829-V2	DIO 16ch opt 24V	D7, D8	BAT54	FAIRCHILD SEMICONDUCTOR	Diode	6.25E-13	PSI	8.50E+11	10%	95%	8.33	7.08E+12
EDA-03829-V2	DIO 16ch opt 24V	IC3, IC5	LT1930ES5	LINEAR TECHNOLOGY	Voltage Regulator	6.25E-13	CHARM	1.50E+12	20%	95%	5.51	8.26E+12
EDA-03829-V2	DIO 16ch opt 24V	IC4	LT1763CDE	LINEAR TECHNOLOGY	Voltage Regulator	6.25E-13	CHARM	1.50E+12	20%	95%	5.51	8.26E+12
EDA-03829-V2	DIO 16ch opt 24V	IC1, IC2	AQW210S	Panasonic	Optocoupler	-					-	-
EDA-03829-V2	DIO 16ch opt 24V	IC6	MCP23017-E/SS	MICROCHIP TECHNOLOGY	IO Expander	6.25E-13	CHARM	1.50E+12	20%	95%	5.51	8.26E+12

System Radiation Failure Analysis and Prediction Document EDMS 3046605 (Tab: SubSystems Radiation Tolerance)

Final number of components for SEE testing = Required number of devices x margin