Summary of methodologies aspects derived from system level testing

A. Coronetti
CERN, 1211 Geneva, Switzerland

RADSAGA System Level Test Review
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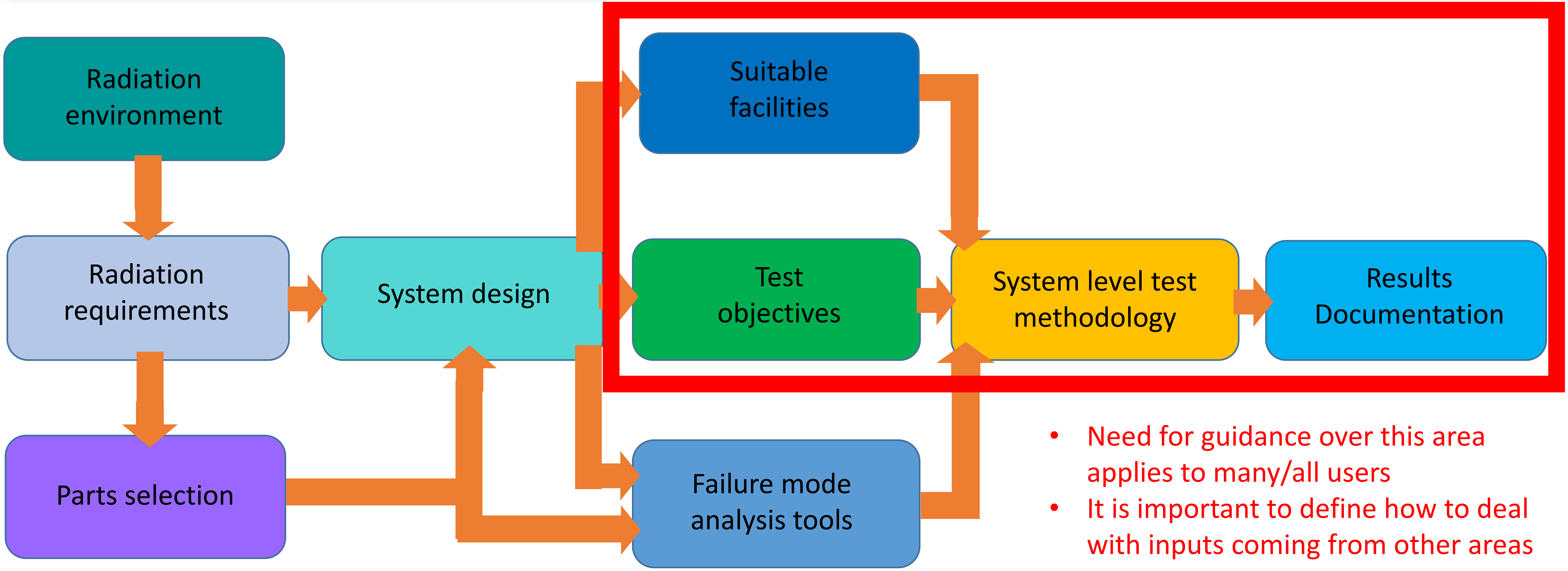
Developing a guideline



- Need for guidance over this area applies to many/all users
- It is important to define how to deal with inputs coming from other areas

System level test objectives

The aim of the test is:

- A **radiation response evaluation** aimed at assessing the current technology and the design
  - No need for rates
  - More debugging information and failure modes identification
- The **qualification** for the final application
  - No destructive events, soft error rates, etc.
- The **lot acceptance** test
  - If I have many systems
  - If critical parts are coming from new batches
- The **requalification of an existing design** for which some components are replaced with more performant parts
  - Change of hardware, but also software, frequency, operating temperature, etc.

Facility selection

System level testing starts well before the test

- Which **radiation effects** do I expect from my system?
- Which radiation effects I want to be capable of **observing** if they manifest?
- Can I find a facility that allows me to test **only the radiation effects that I want** and exclude synergistic dependency? Or, do I need synergistic effects?
- Tradeoffs change according to application/needs:
  - **Environment representativeness vs. beam penetration vs. synergistic effects**

Facility selection

System level testing starts well before the test

- Does the facility allows me testing the system **the way I need**?
  - Long cables, connection limitations
  - Stopping the beam, varying the flux
  - Does the facility impose constraints on the **radiation model** of the system that may alter the measurements or bring undesired effects into play?

- **How do results at different facility compare to each other**?

Inter-facility hadronic equivalence

On SEE cross section:

$$\sigma_{HEH} = \frac{N}{\Phi_{HEH}} \cong \sigma_{neutrons,E>10MeV} = \frac{N}{\Phi_{n,E>10MeV}} \cong \sigma_{protons,E=200MeV} = \frac{N}{\Phi_{p,E=200MeV}}$$

- Does this apply to any **hard fault** and **soft error**?
- Do I see the **same error signatures** independently of the radiation source?
  - No TID effect with neutrons
  - Do error signature have an energy dependency?
  - Do error signature have **beam characteristics dependency**?
    - Pulsed vs. continuous
    - Presence of thermal neutrons
    - Fixed flux constraints
- Can high flux simulate higher LET effects?

Methodologies aspects

System level testing preparation

- Different TID response of analog systems with **3D or 2D** layouts
- **Effect of cabling** causing unwanted triggering of protection systems
- Keep **logging** the simplest possible
- Limit the use of **internal resources**

Methodologies aspects

System level testing considerations

- Test capability to perform **self-recovery**
- Use of **different fluxes/test speeds** to achieve different objectives
  - Avoid being dominated by **hard losses of functionality**
- **Data comparison and portability**
  - Same SoC tested at CHARM had SEFI cross-section differing by 2 orders of magnitude
- Not easy to test a system with its **full functionalities**
  - Flight software not fully available in a early stage of the design
  - SW often tailored to the test
  - Too much overhead for covering every functionality

Methodologies aspects

System level testing considerations

- **Coupling** of sophisticated devices/functional blocks
  - Need for strong synergy with manufacturers

- For sub-systems/blocks aim can be:
  - Determination of sub-systems fault/error rates (**link to component level**)
  - Verification that the system can deal effectively with sub-system faults/errors (**system level validation**)

- Very different **mode of use of analog and power electronics** with respect to how it is tested at component level

Post irradiation analysis

- How to use the data from a system level test for **application fault/error rate prediction** in a very different environment

What needs further study?

Component-to-system link and system-to-component link

- What ‘component level testing + system modelling’ **cannot achieve** and system level testing can?
- If the system level test outcome is **‘fail’**, up to which extent can I find out, through a cheap approach, **what went wrong**? Can I find cheap **countermeasures** to upgrade the system? Do I need to **retest**?
- How do I recognize the **source** of a certain system level radiation effect?
  - Bridging methodologies are not mature
- Up to which extent can I exploit **data portability** from system level testing for the single parts if I want to use one of those parts in a new system?

What needs further study?

What is a **worst case scenario** in system level testing?

- Even nominal specs are not one value for each variables, but rather an **envelope of values**
- According to component level standards some radiation effects may have **competing worst case scenarios**
- How to define an appropriate radiation test envelope?
- Worst case **application**?
- How many **units** shall be tested for qualification?

What needs further study?

Is there a need to include **coupled aging/radiation** effects in the system level testing methodology?

- Some parts are worse when aged, some are better, no clear worst case scenario

How can the methodology be extended to **COTS-systems/black boxes**?

What **information** are needed for a radiation qualified system that has to be **sold to many users**?

- What information the system developer shall provide?
- What information the system user is looking for?
- How can we avoid miscommunication and misuse?

We deal with functional reliability, what about **functional safety**?

Radiative effects

Component level
(good standardization)

- TID
- DD
- SEB
- SEGR
- SEL
- SEFI
- SEHE
- SEU
- SET

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System level
(poor standardization)

- Permanent loss of functionality
- Degradation of functionality leading to degraded mode
- Hard loss of functionality
- Soft loss of functionality
- Data integrity loss
- Performance degradation

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