Quality assurance for CMS Tracker Phase II upgrade 2S modules

Forum on Tracking Detector Mechanics 2017
Marseille, France

Julien Bonnaud, Alan Honma

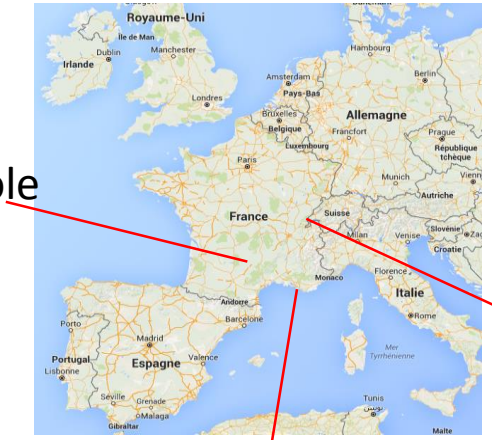
3rd July 2017

Outline

I. Introduction
II. QA : But why? By whom? For what?
III. Quality Management: What is the difference with QA?
IV. Example of QA plan
V. QA plan example for 2S modules
VI. QA plan example for 2S module assembly
VII. Conclusion

I. Introduction:

- I am a Electronic technology engineer coming from Space industry.
- I am coming from a small village of France called Laguiole



Laguiole
1200p

CERN
12500p

Marseille
1.8 millions

I. Introduction:

- This knife is a symbol across the borders. It's well known and a lot of people around the world are trying to make it.
- Knife from the XIXth century made of steel and wood (or other more luxury materials)

- The first people who made it, made it for one reason, to have tool for everything and forever
- They created a simple knife with a lot of care, implementing experiences, materials and processes over the decades…

II. QA : But why? By whom? For what?

- I don’t have a master degree in QA

- So why, am I talking about quality assurance ?

  1/ Just to have a time slot to speak with my French accent in Marseille about my brother

  2/ For fun, because I didn’t find any interesting topic

  3/ Because it’s a collective state of mind and each operator, technician, physicist and engineer should keep in mind a QA approach while working on his/her task(s)

II. QA : But why? By whom? For what?

- People in general doesn't like the word "Quality". "Assurance" neither
  - They are bad words in the technical and scientific worlds.
  - Synonym of constraint, burden, weight… for any one

- There is too much blather about Quality / Quality Assurance :

Those logos are only communication.

QA is not communication, it's an opportunity to create reliable and well built products.

II. QA : But why? By whom? For what?

- What matters is the following :
- Quality Assurance is a global expression summarizing several detailed fields (sometimes too **implicit**):
  - **It's a pro-active method**
  - **It's a global approach**
  - **It's an adaptive methodology**
  - **Essential for High reliability and complex applications (like CMS)**

- Definition : Create a plan covering design, manufacturing, assembly, logistic, commissioning and operation of a system. The success of it depend on the persons who are creating it and the other persons who apply and perform it.

II. QA : But why? By whom? For what?

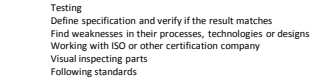
- Why QA is important ? And specially for CMS SI Tracker Upgrade Phase II?
  - A huge number of identical or similar modules (at least 15000 modules ➔ industrial like)
  - Environmental conditions are extreme (radiation, operating temperatures…)
  - No excess so no chance to repair it (reliability of the product and reliability verifications)
  - Mass production for complex and delicate products within a tight time scale (methods & processes)
  - Limited budget (anticipation of risks or issues to avoid budget overrun)

I will not present the QA plan of CMS Si Tracker neither 2S modules.
I will present an example…

II. QA : But why? By whom? For what?

- The objectives of Quality Assurance is to ensure that :
  - The methods, procedures and tools have been defined and are implemented to prove that each requirement is verified through one or more of the following methods: analysis, quality control, review of design, audits
  - The design is manufacturable and repeatable. The subsystems can be verified and operated within the required operating limits
  - The verification process is complete and includes clear tests, test models and verification logic
  - The defined qualification approach is implemented to demonstrate that the final product (system) performs satisfactorily in the intended environment

II. QA : But why? By whom? For what?

- Usually, people thinks that | 

| is QA.

  - Testing
  - Define specification and verify if the result matches
  - Find weaknesses in their processes, technologies or designs
  - Working with ISO or other certification company
  - Visual inspecting parts
  - Following standards

This is only few parts of QA

II. QA : But why? By whom? For what?

- Testing
- Define specification and verify if the result matches
- Find weaknesses in their processes, technologies or designs
- Working with ISO or other certification company
- Visual inspecting parts
- Following standards

II. QA : But why? By whom? For what?

- QA is product/system oriented.
- For CMS, the products/systems could be :
  - the Si Tracker
  - The ECAL
  - The HCAL
  - The Super conducting solenoid
  - The Muon chambers…

- And for each products/systems we could consider subsystems. For the Si Tracker, it could be :
  - Regional subsystems (Barrel, endcaps, TBPS, TP2S, …)
  - Electronics subsystems (Readout, power, data collection…)
  - Mechanics subsystems (Support structures, cooling…)

II. QA : But why? By whom? For what?

- Since it's a pro-active method, QA plans should be created during the early phase of the project. When the product is in research and development phase. Then the QA plans are implemented along the project development

- Each subsystems implement their own QA plan to their quality manager.

Oh wait!!! Quality manager ???

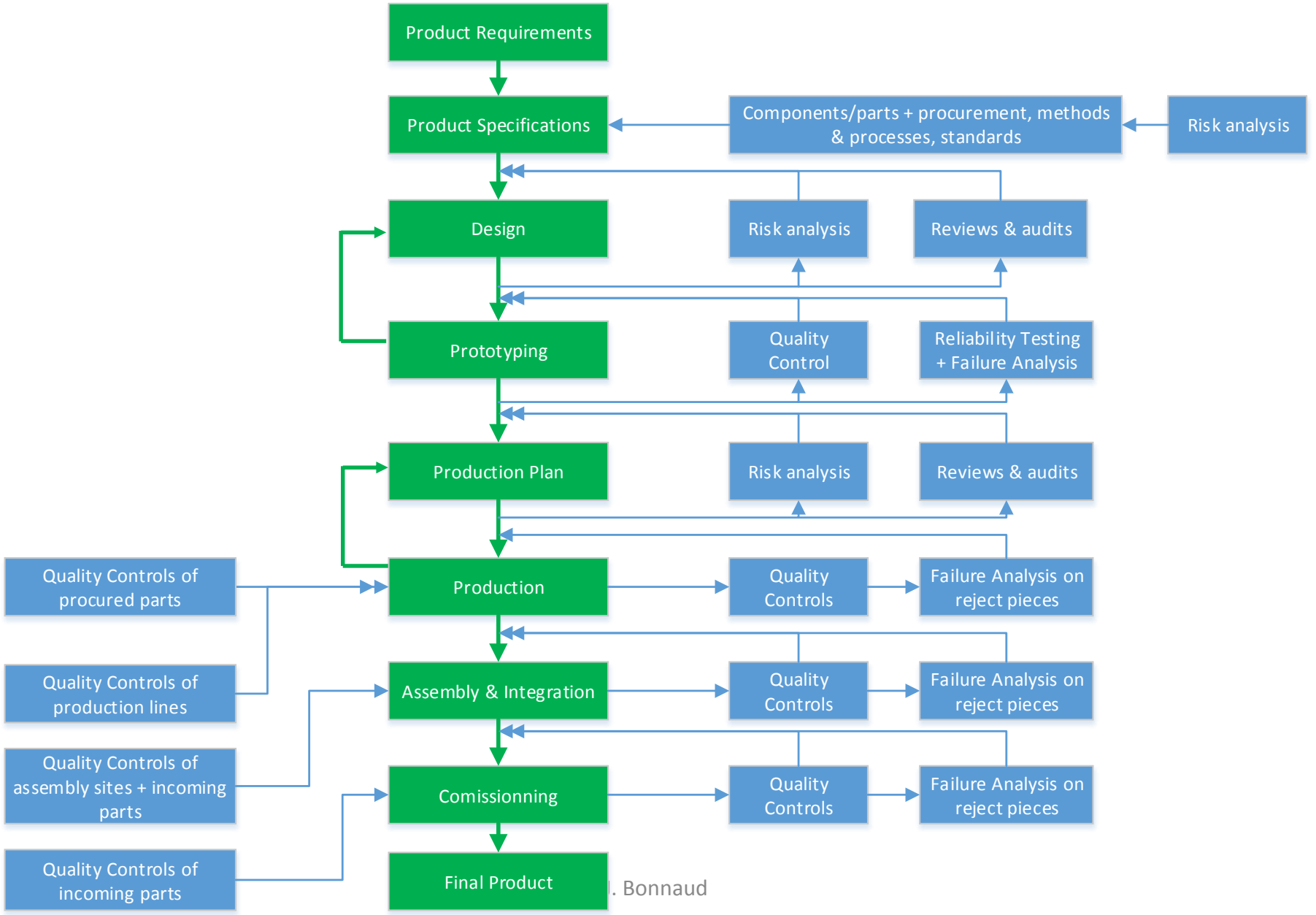
III. Quality Management: What is the difference with QA?

- Quality management is the highest level of quality. It is project oriented.

- QM integrates :
  - QA
  - Organisational structure
  - Human ressources
  - Budget
  - Training
  - Other quality concerns

Project ≠ Product
QM ≠ QA

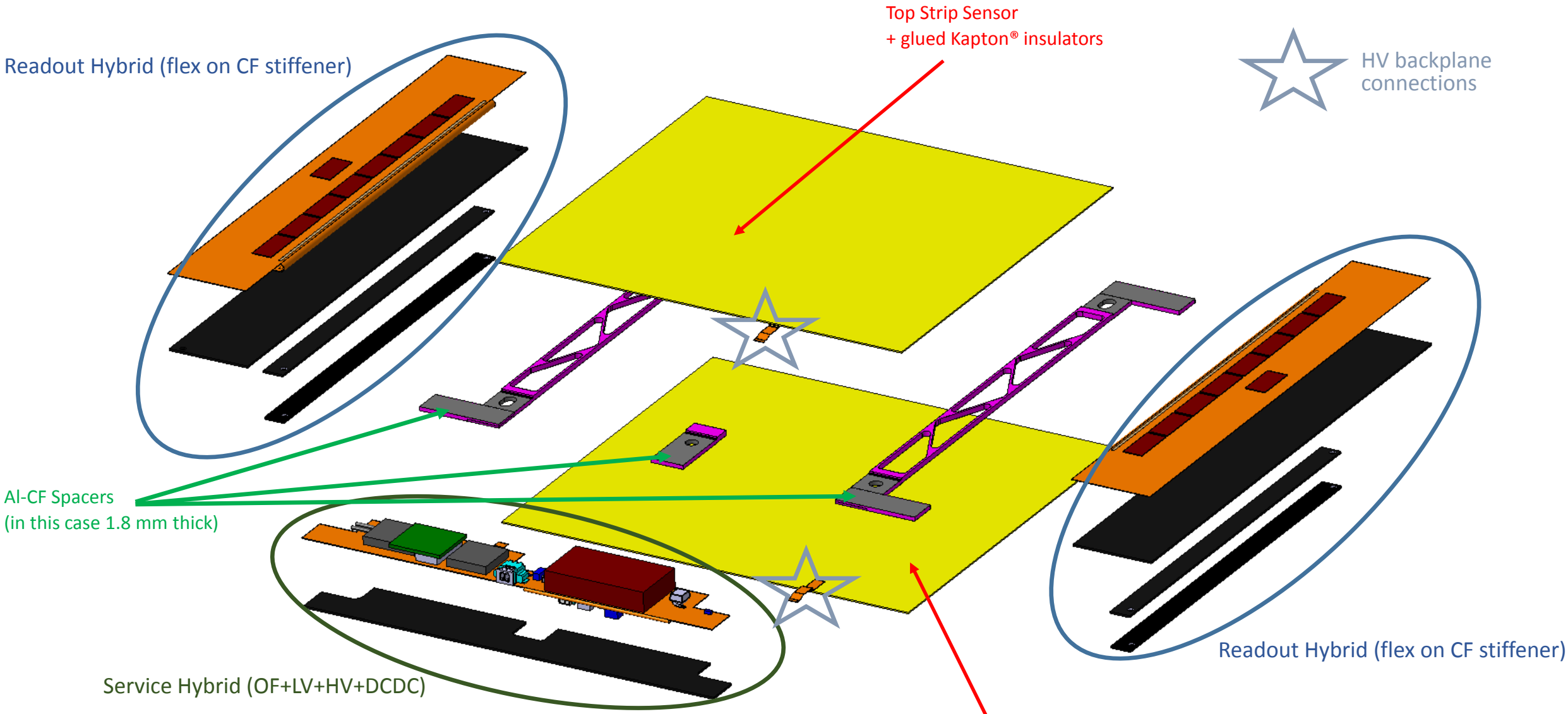
IV. Example of QA plan



V. QA plan example for 2S modules

- For example : How could we apply this QA plan to the 2S module production?
- What could we do now and in the coming months?
- How should we prepare the production phase?

V. QA plan example for 2S modules



V. QA plan example for 2S modules

- Define the quality requirements for 2S module
- Define the risk analysis for 2S module
- Define specifications for the 2S module + Design of the 2S module
- Define specifications of the parts and related quality requirements :
  - Hybrids : service and read-out (active & passive components, stiffener, assembly)
  - Sensors
  - Spacers
  - Kapton® insulators
- Identify procurement sources + acceptance criteria.
- Define the module assembly procedure
- Define the acceptance criteria

V. QA plan example for 2S modules

- Define the assembly site requirements (production lines). Could be done in relation with QM concerning the personnel and their associated training
- Define the quality control points in the assembly procedure
- Define reliability testing plan and associated requirements for evaluation
- Define the qualification criteria for the assembly (incl. dimensional measurements, mechanical tests, thermal tests, electrical tests, screening tests)
- Define the NC actions procedures for module production
- Define the production follow-up (from the part procurement to final product). Implementation of the data-base (traceability)
- Define repair procedure (for production)
- Define logistic procedure (incl. handling, storage and transportation)
- Define quality control points in the logistic procedure

And many more for the assembly, integration and commissioning

V. QA plan example for 2S modules

- Key factors of a QA plan :
  - Anticipation. Most of the QA plan applies to pre-production. Testing during this phase should be the most rigorous. The implementation of the QA plan should be important during this phase (the design can evolve, so can the specifications)
  - Quality Control. QC is part of QA, but QA does not specify specific tests. Dedicated documentations has to be written.
    This includes : Visual inspections, dimensional measurements, mechanical tests, electricals tests, thermal tests...
  - Results. If QA plan is completed, the production yield will be high and only few modules should rejected.

VI. QA plan example for 2S modules **assembly**

Alan's last year presentation

Case of the 2S module assembly will follow the method using the jigs

1. Have a complete set of technical requirements (= specification document) for the assembled module, not just electronic but mechanical and thermal.
2. Have a complete set of acceptance criteria for all components and tooling used in the assembly.
3. Make a written procedure for the assembly, including all steps to be taken from reception of components through to final acceptance tests.
4. An assembly site qualification criteria list should exist and the assembly site should conform to those requirements. This would cover the aspects of environmental conditions (temperature, humidity, ventilation), cleanliness (clean room quality), ESD protection, proper handling tools, work space requirements, inspection equipment, storage conditions, etc.
5. After an evaluation of the manpower required, define the training and testing requirements for the personnel, for each step in the assembly procedure requiring personnel.

VI. QA plan example for 2S modules **assembly**

Alan's last year presentation

6. The written procedure will require QC at various stages in the assembly. The QC may require specialised equipment and software, which must be specified and checked for compliance.

7. The assembly procedure should include the actions to be taken in the case of non-conformity. This should include the repair scenario and the actions in the case of a high failure rate.

8. A database (DB) should be defined and used to track the components and the assembly such that information on all components of a module can be easily found.

9. A module traveller document should be implemented which should include a checklist for all major assembly steps, including each QC step with the result (if appropriate). The date and person responsible should be noted for each entry. This information should be entered in the DB.

10. Each module should have an easy means of identification, usually a small self-adhesive barcode which also must be radiation hard.

11. Depending on the required reliability, either stress screening or sampling HALT (highly accelerated lifetime tests) tests should be performed to check that the module quality remains sufficient.

VII. Conclusion

- QA is not only words, it's the chance to achieve complex products of high quality with restricted ressources
- No QA plan or bad QA plan can cost a lot, financially, in term of time and manpower.
- For CMS Si tracker upgrade phase II, high reliability is needed
- We need to work all together to move in the same direction to have a complete QA plan

Thank you for your attention

QA is not a curse, it’s an opportunity…