Conventional Safety for HL-LHC

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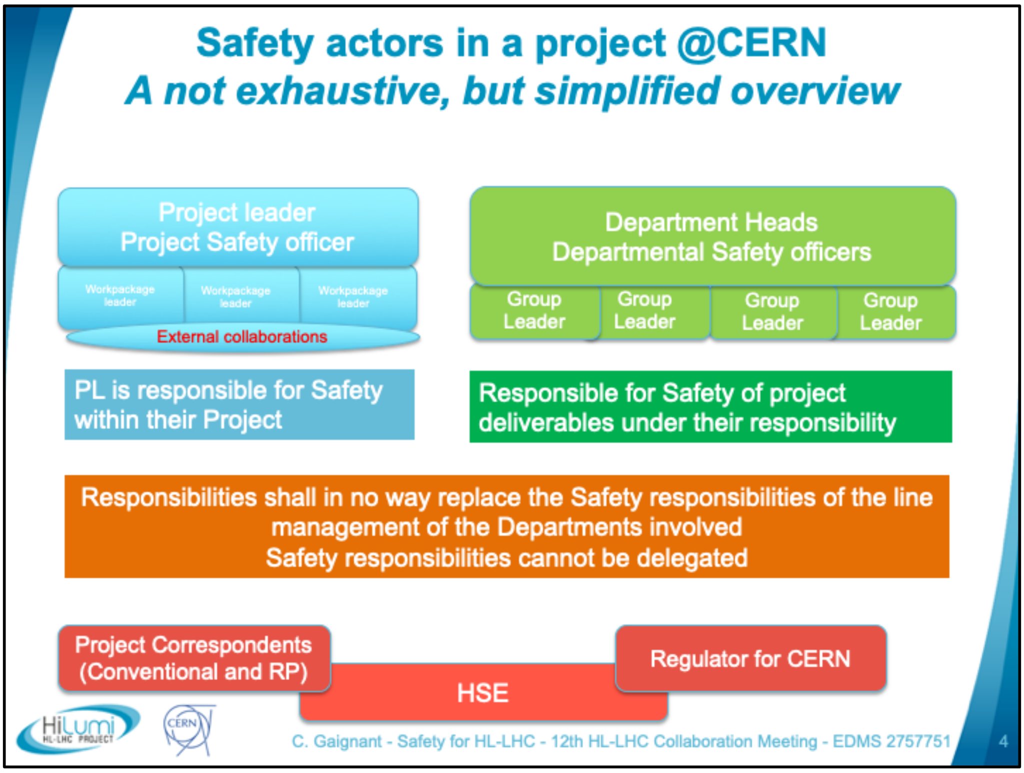
Outline

- HL-LHC Safety Organisation
- HL-LHC Safety Documentation and Challenges for the Collaborations
- Highlights on 3 deliverables
- Summary

HL-LHC Safety Organisation



Responsibilities and organisational structure in matters of Safety at CERN
See: https://edms.cern.ch/ui/file/1389540/LAST_RELEASED/SR-SO_E.pdf and https://hse.cern/content/safety-organisation-so

Projet Leader
The Safety organisation, including Safety responsibilities, of a Project shall be defined in writing, it being understood that such responsibilities shall in no way replace the Safety responsibilities of the line management of the Departments involved.
The Project Leader shall be responsible for Safety within his Project.
He shall in particular:
- keep himself informed regarding all aspects of Safety within his Project;
- take the necessary measures to ensure that Safety Files for his Project are established and updated;
- improve Safety within his Project;
- take the necessary measures to ensure that Safety clearance is obtained in accordance with the applicable CERN Safety Rules;
- appoint a Project Safety Officer if he so deems appropriate;
- collaborate with the HSE Unit and Safety Correspondents, as required.

Department Head (extract)

Each Department Head shall be responsible for Safety within his Department, including for the Safety of Installations, activities and projects under its responsibility, and in particular for the implementation within his Department of the CERN Safety Policy, the CERN Safety Rules, the CERN Safety Objectives and best practices.
Each Department Head shall take the necessary measures to ensure the safe interaction of the Installations, activities and projects under his responsibility with those under the responsibility of other Departments or of Large Experiments.

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Project Safety Officer : https://edms.cern.ch/ui/file/1410233/LAST_RELEASED/GSI-SO-7_E.pdf

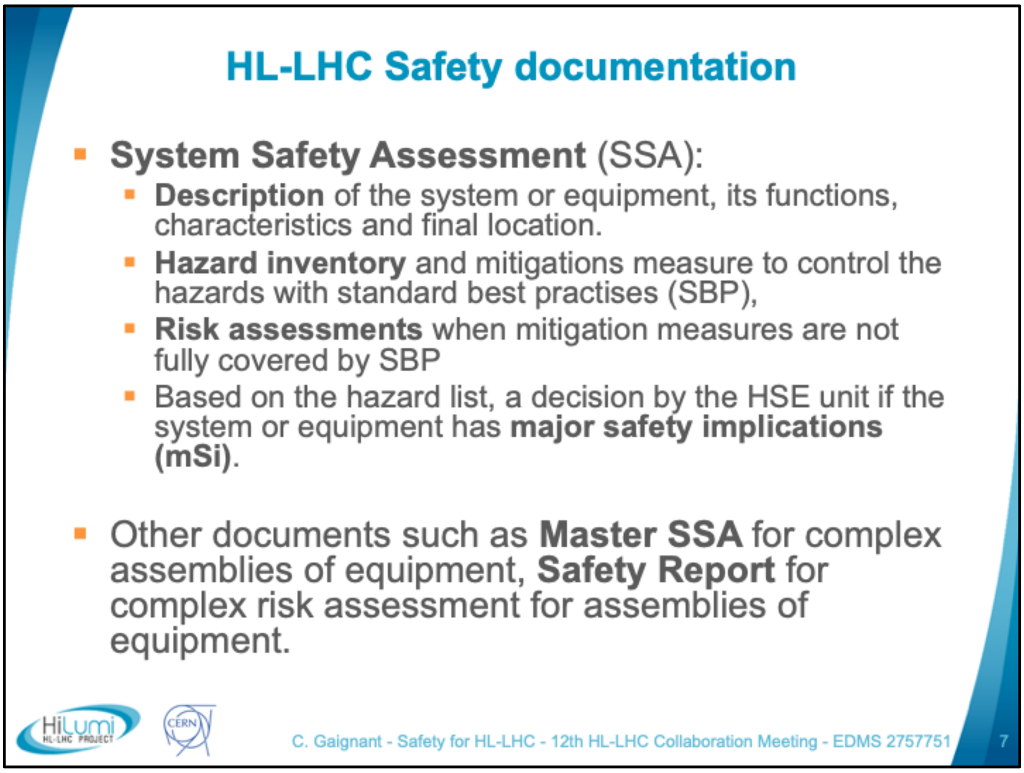
Worksites Category 1 : https://edms.cern.ch/ui/file/1440243/LAST_RELEASED/SR-WS_EN.pdf
Category 1 operation:
all the works and services executed towards the same objective:
- of a total volume greater than 4000 hours; and
- on a single, cordoned-off worksite; and
- involving several operating entities and not interfering with CERN’s operations.

Safety coordination
Every operation requires Safety coordination, which falls under the responsibility of:
- the Project Leader in the case of Category 1 operations;
- the person in charge of the operation in the case of Category 2 operations;
- the organic unit responsible for technical coordination in the case of Technical Stops.

In the case of Category 1 operations, the **Project Leader shall be assisted by a Safety Coordinator** and shall take into account any Safety requirements issued by the latter.

SAFETY COORDINATOR FOR CATEGORY 1 OPERATIONS :
https://edms.cern.ch/ui/file/1440246/LAST_RELEASED/SSI-WS-1-1_EN.pdf
The Safety Coordinator shall act as an advisor to the organic unit responsible for the operation.

HL-LHC Safety Documentation and Challenges for the Collaborations



Safety Organisation for the HL-LHC project: https://edms.cern.ch/document/1313247

In HL-LHC, the following safety document types are used:
System Safety Assessment (SSA): this schematic document, based on a template describes the hazards and their control by SBP. It contains:
- A brief description of the system or equipment, its functions, characteristics and final location.
- An editable hazard list. The hazard list of project deliverables is edited jointly between PSO and work package engineers.
- Based on the hazard list, a decision by the HSE unit if the system or equipment has major safety implications (mSi).
- SBP solutions to control a specific hazard are entered next to it in the hazard list. SBP is found in *LSA Safety Requirements for HL-LHC hardware systems (Conventional Aspects)*, EDMS 1827925 and beyond that in international standards, guidelines by industrial associations, and return of experience.
- short risk assessments with mitigation measures for risks not fully covered by SBP can be described in a dedicated chapter. Safety Reports document complex risk assessments, and their conclusions are reported here.

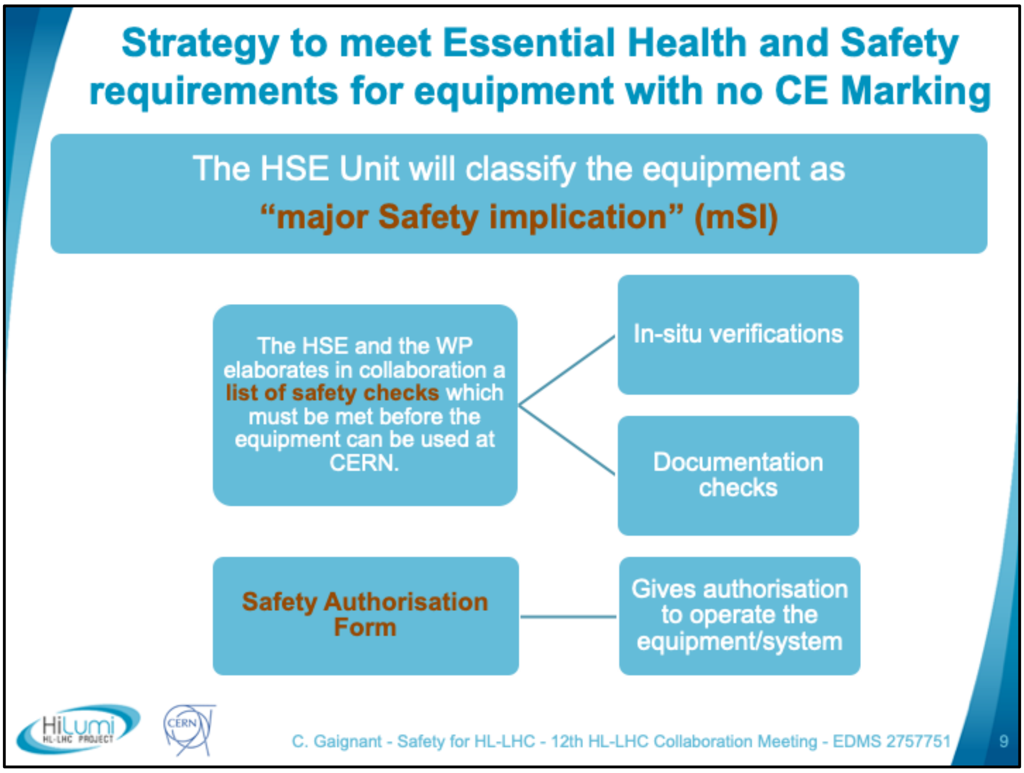
Master SSA: for complex assemblies of equipment (for example, the inner triplet magnet string, assembled from several distinct superconducting magnets, cryogenics, power converters and protection and controls equipment) and for families of equipment having very similar hazards (for example, the different power converters), a Master SSA can be edited. The Master SSA serves as a guideline or table of contents for the equipment-specific SSAs. It groups the common hazards and their SBP or risk assessment at a common place, thus avoiding repetition in the equipment SSAs.

The **Safety Report** is the right format for describing the complex risk assessment for assemblies of equipment, and for hazards for which no SBP exists. An example are the hazards and risks from powering of cryogenically cooled superconducting magnets. In Safety Reports, standard methods of hazard- and risk identification and assessment are used, for example Failure Mode and Effects Analysis (FMEA) or Probabilistic safety Assessment (PSA). The results of such a detailed safety assessment are reported in the corresponding SSA or Master SSA.

Challenges for Collaboration
Conformity with EU standards

CERN Safety regulations generally request that equipment operated at CERN meets the Essential Health and Safety (ESH) Requirements laid down in **European Directives** on Consumer Products.

- Deliverables from countries where other safety standards are legally applied, and where achieving conformity with EU regulations represents a **cost and schedule risk**.
- Deliverables manufactured in universities or research institutes, including CERN, where **no internal structure** exists to attest formally the conformity with EU directives.
- Deliverables with **advanced technologies** for which there are no provisions in the regulations.



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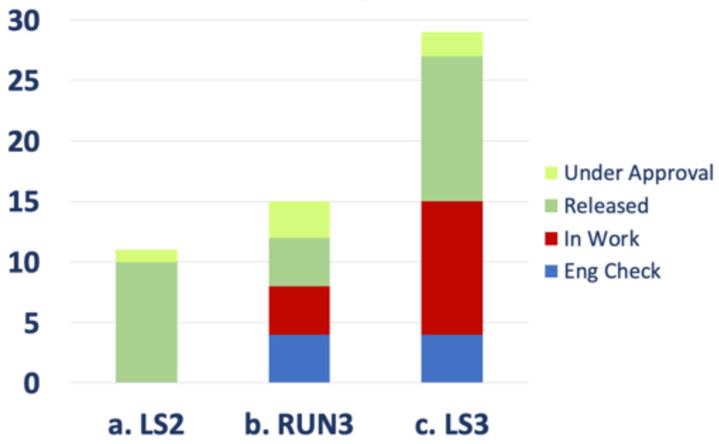
HSE Unit:
Safety clearance
- grant Safety clearance for Installations, including special equipment, activities, projects and CERN Experiments with major Safety implications prior to design, operation or dismantling.

The head of the HSE Unit may decide to refer Safety clearance decisions to the discretion of the Director-General.

Achievements

- All System Safety Assessments and Safety Reports for deliverables installed up to LS2 completed.



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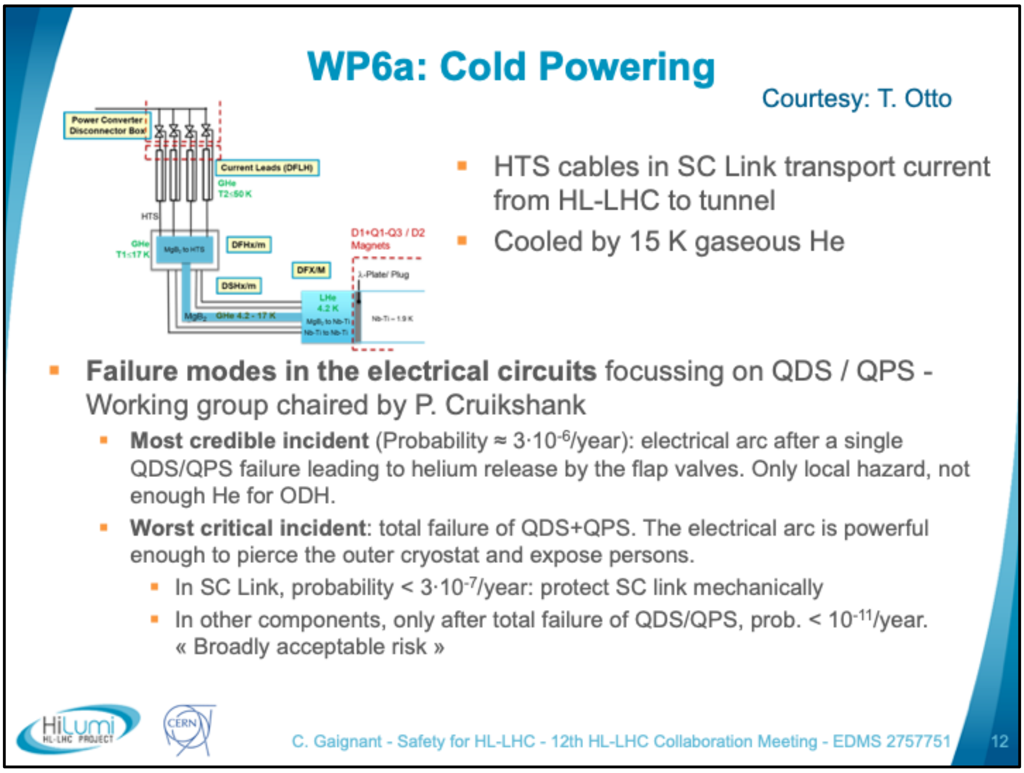
Highlights on 3 deliverables



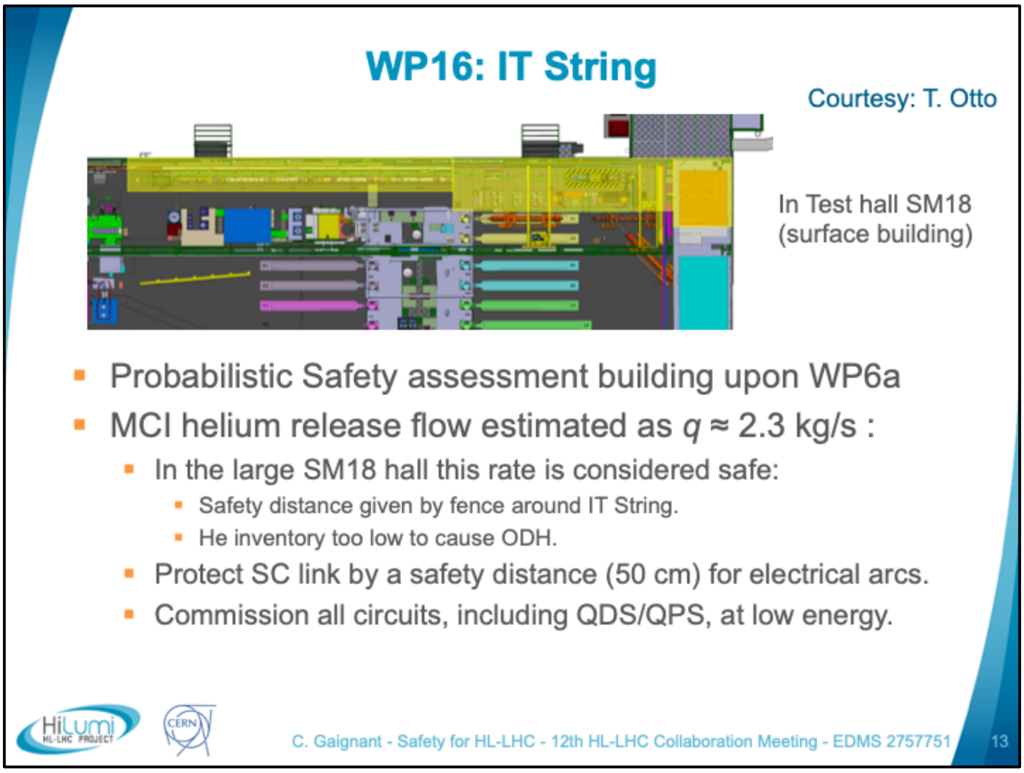
Mitigation of Adverse Outcomes of Electrical Failure Modes of the HL-LHC Cold Powering System (WP 6a) (https://edms.cern.ch/document/2610846/1.0)

Question to be answered: Is there an ODH issue in the HL-LHC galleries?

MCI: The emergency release of helium with a high mass flow following an internal electrical arc or a loss of insulation vacuum is classified as the Most Credible Incident (MCI). The gaseous helium inventory of the DSH and the DFH would be released abruptly ("champagne bottle effect"), creating a **local cryogenic hazard for personnel directly at the release point**. These persons could be exposed to a jet of cold, gaseous helium, and in general the event will generate noise and a cloud of condensed air around the release location. Due to the limited amount of helium released there will **be no persistent ODH condition in the UR or the UA**. The larger, liquid helium inventory in the DFX or DFM is thermally insulated and the small ratio of opening to length of the DSH assures a small heat leakage through the DSH. Release of the liquid helium inventory in the DFX would be slow, probably over many minutes or hours. To protect personnel from the consequences of a cryogenic MCI, the following recommendations are made:
- The passage zone for personnel shall be protected against standard helium release scenarios by **orienting all safety devices in the direction of the gallery wall**, or by equipping them with **deflectors** shielding the passage zone.
- The area between the DFH and the gallery wall shall **be forbidden for access during operation at full current**, unless a dedicated risk assessment for specific interventions shows that they are innocuous.
- The area in the passage zone in front of the DFH shall be marked as **no-stay zone for personnel**.

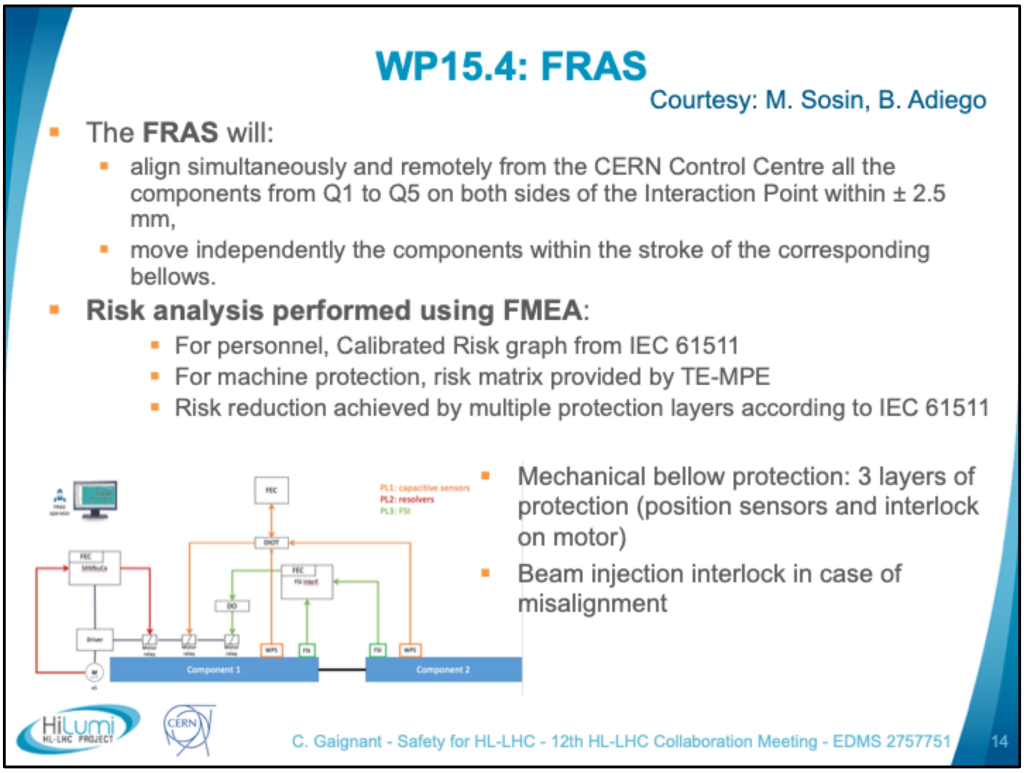
Worst Critical Incident: enough energy to damage the cryostat, more likely to happen within the SC Link because it is the weakest mechanical part. Electrical arc can be visible outside, same He quantity released. Initial risk assessment shows that a protected open arc (WCI) in the DSH falls in the broadly acceptable risk region. Nevertheless inherent technical design features and a simple operational measure provide additional risk reduction:
The following risk reduction measures are available:
- Technical: in the accessible portion of its length, the DSH is installed in a trench with a **heavy cover**, absorbing the radiative energy of a protected open arc
- Technical: in the short open section of the DSH, where it joins the DFHX/DFHM, a **safety distance** to the potential location of an arc can be defined and realised by distancing elements (e.g. a mesh, a tube) around the DSH.

- Organisational: during a first ramp-up of magnet current of the HL-LHC magnets after installation or after modification of the circuits, the HL-LHC areas in the vicinity of the DSH remain **inaccessible until the nominal current has been reached** and the protection systems have been commissioned. This can be realised for example by mobile fencing of the DFH and the corresponding DSH or by access control measures.



Same analysis as before, including the magnets.

Not exposed directly to the He release, fenced area + protection against direct release.
Major Critcal Incident (MCI) likelyhood = 10-6/y
SM18 : He will be locally very cold, rapidly migrate to the ceiling and get dispersed. No ODH.
Major Critcal Incident: interconnect between 2 magnets.



Machine protection:

- Based on experience of the MPE group at CERN – risk matrices for the LHC (EDMS2647876)

Summary

End notes

- Safety assessments are on good track.
- Conformity / Standards
  - May be additional work to prove compliance.
  - We do our best to accommodate the requirements.
  - In case collaborations have questions or concerns, please let the WPL and Project Safety Officers know.

Thanks for you attention