



# Full Remote Alignment Safety aspects

Christelle Gaignant – HL-LHC Project Safety Office

Thanks to:

H. Mainaud Durand (WP15.4 leader), M. Sosin (EN-SMM)

J. Wenninger (BE-OP)



International Review of the HL-LHC Alignment and Metrology, 26th to 28th August 2019  
CERN

# Outline

- Safety requirements for HL-LHC and the FRA
- Safety requirements
  - Hardware
  - Controls
  - Operation and organisation
- Safety Information
- Conclusion

# Conventional Safety requirements for HL-LHC and FRA

EDMS 1827925

## Safety Requirements for HL-LHC hardware systems (Conventional aspects)

### PURPOSE & SCOPE

This document, named **Safety Requirements for the HL-LHC hardware systems (Conventional aspects)** is adapted from the Launch Safety Agreement (LSA) procedure. Whereas the general LSA fits the needs of smaller scale projects and experiments, the procedure is modified to better address the challenges of HL-LHC.

This document, elaborated in close collaboration between HL-LHC Safety Officers and the HSE unit, is the reference for Safety requirements applicable to all HL-LHC hardware systems.

HL-LHC hardware systems are designed, built and operated according to the regulations in force at the time they are designed, traceable by the version number of this document. Should the regulations evolve, this document will be updated accordingly and a new version issued.

### HISTORY OF CHANGES

REV. NO.	DATE	PAGES	DESCRIPTION OF THE CHANGES
1.0	13-11-2017	All	Safety requirements Released
2.0	08-02-2019	All	Updates

CERN **Safety Instruction IS 41** - The **use of plastic** and other non-metallic materials at CERN with respect to fire safety and radiation resistance.

### Electrical Safety

Safety Code C1 - Electrical safety code  
Safety Instruction IS 5 - Emergency stops

### Artificial Optical Radiation – Lasers

IEC 60825-1: Safety of laser products

### Machinery

SR-M Mechanical equipment



European Machinery Directive  
2006/42/EC

*All new machinery shall be designed in accordance with and shall conform directly to the **Essential Health and Safety Requirements (ESHR)** as defined in Annex 1.*

The *FRA* will not be CE-marked  
Not liable to have major safety implication

# Safety requirements - Hardware

- The durability of the materials used must be adequate for the nature of the environment.
  - ✓ The hardware is designed to be robust enough to minimise mechanical hazards : jacks, beam line element, alignment tolerances defined ...
- Moving parts
  - Use protective covers to prevent from crushing or shearing of extremities

# Safety requirements - Hardware

- Use of plastic
  - ❖ Safety Instruction 41 (IS41) proscribes the use of many plastics.
    - Use of non-authorised plastic is subject to an HSE derogation.
- Infra-red
  - Laser beam encapsulated and interlocks
    - The FSI will have its dedicated safety assessment.
- Information panels
  - Local flashing lights while the FRA is performed

# Safety requirements - Controls

- Safety and reliability of the control systems:
  - they shall withstand the intended operating stresses and external influences,
  - a fault in the hardware or the software of the control system does not lead to hazardous situations,
  - errors in the control system logic do not lead to hazardous situations,
  - reasonably foreseeable operating error does not lead to hazardous situations.

# Safety requirements - Controls

## ■ Start

- It must be possible to start the FRA only by voluntary actuation.
- Access and machine conditions for starting the remote alignment should be defined (see further)

## ■ Normal stop

- The FRA must be fitted with a control device whereby it can be brought safely to a complete stop.
- Each workstation must be fitted with a control device to stop some or all of the functions of the FRA, so that it is rendered safe.
- The FRA's stop control must have priority over the start controls.
- Once the FRA has stopped, the energy supply to the motors must be cut off.

# Safety requirements - Controls

- Emergency stops
  - The AUG in the tunnel shall cut the powering of the motors
  - The FRA must be fitted with one or more emergency stop devices (to be defined where for remote operation)
  - The emergency stop function must be available and operational at all times, regardless of the operating mode.
- Incidents
  - After power outage, the FRA shall *not* resume automatically.



# Safety requirements – Operational aspects

- Machine conditions
  - In addition to the operational modes in chapt. 3.6:
    - There should be no FRA during cool-down and warm-up.

# Safety requirements – Operational aspects

- Access conditions
  - During beam ON, Access is OFF
    - No people in the tunnel, no safety restriction for the FRA
  - During Access ON:
    - FRA and work on equipment are not compatible activities.
      - Lock-out procedures to prevent unexpected start-up
      - Schedule management
      - Operational management of the FRA (who is in charge?)
    - FRA and passage in the transport zone
      - Local warning signs
      - Access to FRA experts only?

# Safety requirements – Operational aspects

- To ensure no unexpected start-up, consider:
  - Systematic lock-out after alignment
  - Clear key management and responsibility
- Lock-out procedure to authorise work on the different equipment
  - Lock-out should isolate the motors from all energy sources.
  - Any equipment not cut by the AUG should be clearly identified (orange stripes)

# Safety requirements – Operational aspects

- Roles and responsibilities
  - Who authorises the FRA?
  - Who performs the FRA?
  - From where ? (from CCC if beam ON, during YETS from the tunnel?)
  
- This has to be clearly defined.

# Safety Information




Safety-related information shall be kept

In the hardware database and/or

In the system safety folder.

The Safety assessment form is the  
safety file for the FRA.

Full remote alignment WP15.4 - Safety  
Assessment Form  
EDMS 2144080

  		EDMS NO. 2144080	REV. 0.2	VALIDITY DRAFT
REFERENCE : HL-LHC SAFETY				
<b>LAUNCH SAFETY AGREEMENT</b> <b>SYSTEM SAFETY ASSESSMENT</b>				
<b>WP 15.4: FULL REMOTE ALIGNMENT SYSTEM (FRAS)</b>				
<b>Abstract</b> This document concerns the Full Remote Alignment System (FRAS) implemented in the LS51 and LS55 for the HL-LHC project. FRAS will allow aligning rigidly and remotely from the CCC all the components from Q1 to Q5 on both sides of the Interaction Point within $\pm 2.5$ mm. It will also allow to move independently the components within the stroke of the corresponding bellows.				
<b>Prepared by:</b>	<b>Checked by:</b>	<b>Approved by:</b>		
<b>WP Engineer</b> Hélène Mainaud Durand  <b>HL-LHC PSO</b> Christelle Gaignant	<b>EN-SMM</b> Andreas Herty <b>EN DSO</b> Ramon Folch, Simon Chérault  <b>HL-LHC PSO</b> T. Otto, N. Grada <b>HL-LHC HSE Correspondants</b> Cristina Adorisio, José Gascon, Owain Williams <b>HSE Experts</b> S. Marsh, J.-P. Jullien, O. Tison	<b>WP Leader</b> Paolo Fessia <b>WP Engineer Group Leader</b> Alessandro Masi, Hélène Mainaud Durand  <b>HSE-OHS Group Leader</b> Y. Loertscher  <b>HL-LHC Project Leader</b> L. Rossi		
EDMS reference of this form: 1361970				

This document is uncontrolled when printed. Check the EDMS to verify that this is the correct version before use

# Conclusions

- Based on the current specification:
  - Hardware: risks minimised by design
  - Controls: integrate safety requirements
  - Organisational and operational aspects remain to be clearly defined



***Thanks for your attention***



# Legal framework

- New machinery shall comply with the CERN Safety Regulation on mechanical equipment ([SR-M](#)). The Safety regulation sets the minimum safety requirements relating to the life cycle of mechanical equipment and its related activities.
- Machinery shall be designed and manufactured, so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen but also taking into account any reasonably foreseeable misuse thereof.



# Hazard identification

- **Machinery safety**

- « an assembly, (...) with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application »
- Should follow the EU Directive on machinery
- CE marked or Risk assessment by the WP

- **Electrical safety**

- Low-voltage equipment : IP2

- **Mechanical safety**

- During displacements

# Major Safety Implication evaluation

- Based on the preliminary discussions, the HSE experts have classified the system as :
  - ☒ standard
  - ☐ liable of having major Safety implications (mSi) and therefore needs a HSE Safety Clearance before operation

# Risk assessment

- The risk assessment shall demonstrate that:
  - The risk control measures can eliminate the risk or,
  - That the residual risks can be reduced to an acceptable level.
- Either by :
  - Conformity (e.g. IP2 for electrical risk)
  - Design (e.g. no collapse of the jacks)
  - Technical (e.g. interlocks)
  - Organisational (e.g. alignment procedures)