



FUTURE CIRCULAR COLLIDER

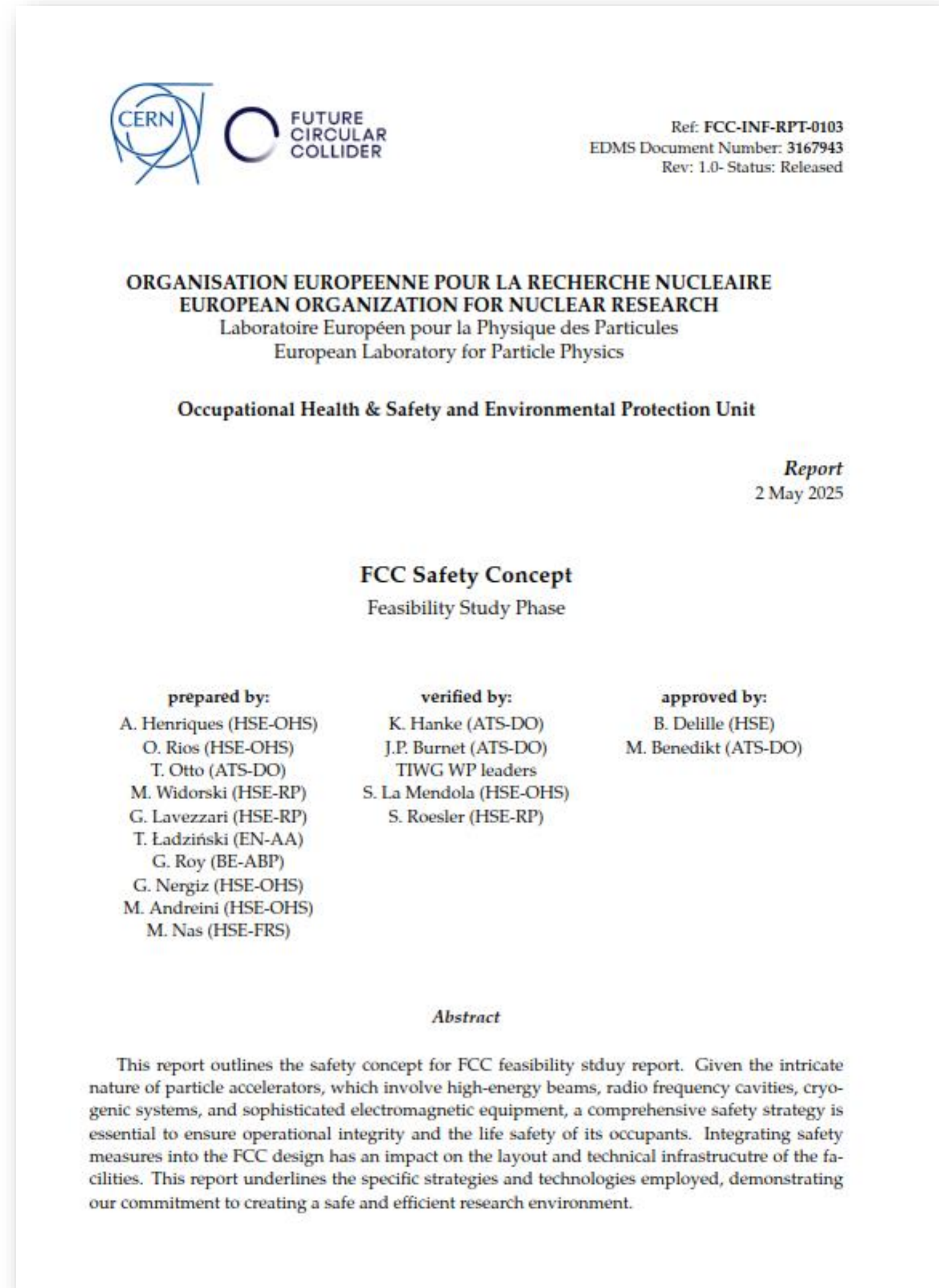
REVIEWED FIRE SAFETY CONCEPT AND FUTURE STUDIES

Oriol RIOS

on behalf of the FCC Safety WP team

CONTENT

- ❑ Fire Safety Concept Recall (as submitted to review and feasibility)
- ❑ The HSE-UK review
 - Outcome
 - Outstanding comments
 - Proposed solutions
- ❑ Workplan and priorities



Fire Safety Concept (I)

FCC-INF-RPT-0103 v. 1.0 - Released

4. Safety concept for the operation phase

4.1 Safety systems supporting the concept

4.1.1 Static confinement (Compartmentalisation)

4.1.2 Air management & dynamic confinement (ventilation)

4.1.3 Personnel transport

4.1.4 Means of emergency response

4.1.5 Secure power network

4.1.6 Access control

4.1.7 Access Safety System

4.1.8 Hazard detection

4.1.9 Emergency Call Points

4.1.10 Evacuation alarms

4.1.11 Emergency lighting and route guidance

4.3 Occupational hazards during accident scenarios

[...]

4.3.2 Fire and Smoke

4.3.2.1 Tunnel Arcs

4.3.2.2 Shafts and safe areas

4.3.2.3 Experiment caverns

4.3.2.4 Service caverns

4.3.2.5 Klystron galleries

4.3.2.6 Alcoves

4.3.2.7 Surface buildings

4.3.2.8 Reaction to fire

4.3.2.9 Fire resistance

4.4 Evacuation

4.4.1 General requirements and considerations

4.4.2 Tunnel arc: evacuation modelling

4.4.3 Technical points: service caverns

4.4.4 Experiment points: experiment and service caverns

4.4.5 Klystron galleries

4.4.6 Alcoves

4.4.7 Surface buildings

[..]

4.5 Emergency preparedness and intervention concept

4.5.1 Support infrastructure for emergency response

4.5.2 Training and implementation strategy

Fire Safety Concept (II)

FCC-INF-RPT-0103 v. 1.0 - Released

Fire Safety General Principles.

- All hot work measures to
- Smoking is
- Fire safety manual alarm
- Maintenance
- Patrols/inspections
- Regular tests
- Unplanned fully implemented

Safety Systems: Compartments & Smoke extraction

Objectives:

- Safe egress:
 - Allows safe evacuation
 - Allows static and dynamic
- Search & Rescue from Fire
 - Enables faster and safer
 - Reduces the smoke density
- Reduces asset loss
 - Limits the propagation to the accelerator and

Main Features

- Every 400 m there is a tunnel
- Length compatible with cell
- Smoke tight
- Dynamic Danger signalization
- Robot automatic hatch
- Pressure compatible doors
- Position controlled
- Fire Resistance performance (proposed EI90)

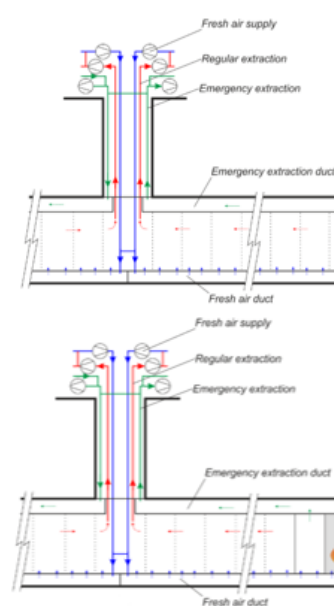
Smoke extraction and Life Safety: PBD Study

Aim and Scope

- ✓ Check that smoke extraction meet safety criteria
- ✓ Explore longitudinal alternatives
- ✓ Compare safety level
- ✓ Study degraded modes

Run/Access

Emergency



PBD: Fire Designs

CABLE TRAY

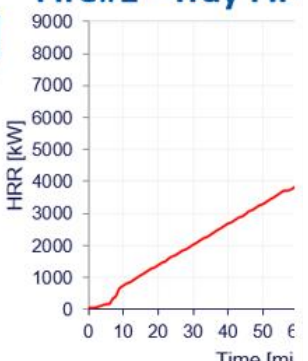
DRUM

KUKA

3.1 Fire designs: Fire#1 - Tray Fire

3.1 Fire designs: Fire#1 - Tray Fire
Possible ignition source: Hot works during installation or electrical overload during commissioning.
Description: This study design is based on the work conducted by Robinson and the authors of [10], [20] that developed a methodology to define the fire curves of several cable trays on vertical alignment in generic compartment conditions.
For the present design, we took the 4 cable trays. The different cable trays are represented considering their size and location according to cross section. The overall fire curve is presented in Figure 3.1. All parameters are detailed in Table 3.1 (see annex).

Fire#1 - Tray Fire



Safety features

- Single personnel shaft in the
- Independent safe path from experiment
- 2 independent lift shafts (2 x layout pending)
- Distance kept below 40m to : layout pending)
- Safety System as well as sp (transformer, etc) in dedicate

Additional Safety Equipment

- Fire-fighting vehicles and eq
- Dry risers/ water reservoir for

Service Cavern @ IPs

Fire Resistance (I)

- Ensure self-rescue and complete evacuation of occupants;
- Allow safe intervention of emergency responders;
- Limit tunnel damage and recovery time.

- ☐ Accelerator tunnel (arc and LSS): EI90 partition (every 400 m) with interlocked door normally open;
- ☐ RF sector - connection between klystron gallery and accelerator tunnel: EI90 partition at the bottom and top of staircases;
- ☐ Service caverns - Safe area (lift shaft): EI120 partition
- ☐ Experimental Point - connections between experimental and service caverns: EI120
- ☐ Alcoves - connection to the main tunnel: EI120 partition
- ☐ Other underground rooms with specific risk (UPS, transformers): EI120

Main Fire risk
• HV equipment,
• Electrical Racks

Table 6: Overview of minimum fire resistance prescribed in underground tunnels. R refers to fire resistance as per ISO 834 curve and EN 13637-2 [1]. RWS/HCM refer to the normalized hydrocarbon time-temperature curves with faster growth and higher temperatures than ISO-834 curve as depicted in figure 26. q stands for fire load density. Clearance is the maximum allowable height of the tunnel.

Source	Fire Resistance [m]	Comment
FR road tunnels [60]	R60	If clearance < 3.5 m for all risk levels
	R120	If clearance > 3.5 m for risk levels N1
	HCM120 R240 + HCM120	If clearance > 3.5 m for risk levels N2 If clearance > 3.5 m for risk level N3
FR railway urban tunnels [67]	R120	for public transportation
CH Industrial Building [68]	R60 (R90)	Height > 11 m < 30 m (if q > 1200 MJ/m ²)
	R90 (R120)	Height > 30 m < 100 m (if q > 1200 MJ/m ²)
CH road tunnels [69]	R60	For lightweight vehicles
	RWS/HCM120	If heavy goods
CH railway tunnels [70]	HCM120	If immerse or below water tables
	R120 (RWS/HCM120) R120	For unstable tunnel (t > trains/day) For stable ground
XFEL [18]	R90	For shaft and underground infrastructure
HL-LHC [71]	R60	tunnel
	R120	safe areas and protected shaft

Review Objective

Objective of the review:

- Evaluate current safety concepts externally (HSE UK).
- Identify any showstoppers and suggest improvements.

Reviewers

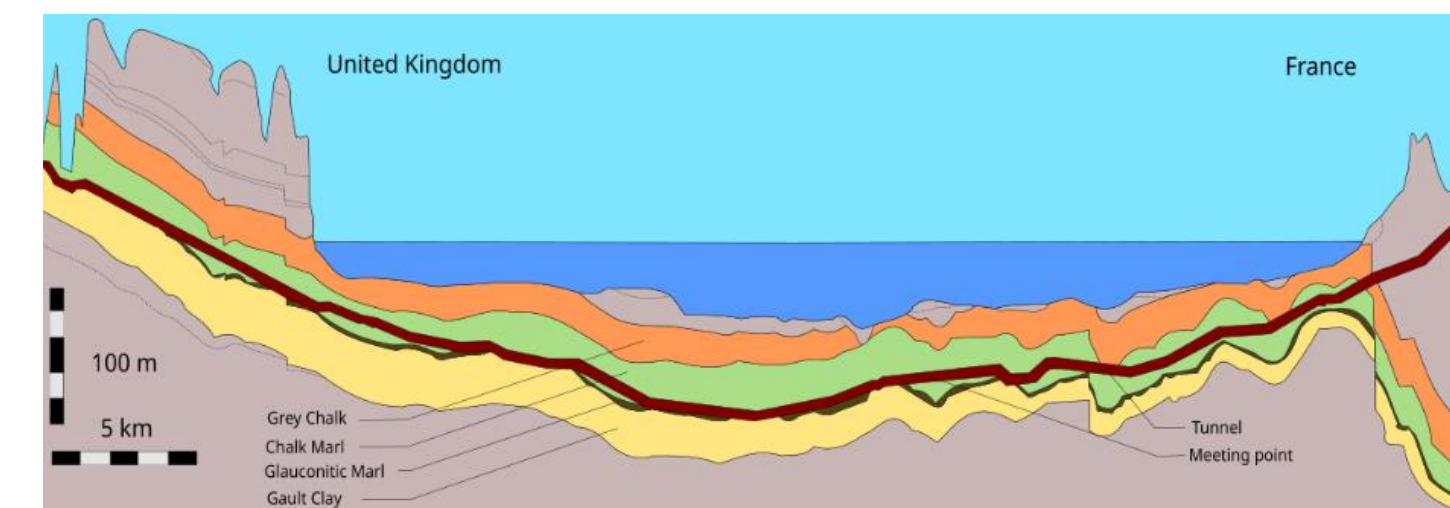
- Fire Safety responsible for HSE-UK
- Involved in Channel Tunnel 'Chunnel' project (50.4km, undersea railway)

Outcome of Review:

"HSE-UK evaluation finds no fundamental barriers in CERN's safety report at this stage"

This conclusion is stated with the following caveat:

That the identified safety areas and processes that require further refinement are resolved adequately



Risk Assessment & Hazard Identification (HAZID I)

Reviewers recommendations:

[for all relevant hazards]

As the concept continues to evolve, moving forward, CERN would benefit from a more rigorous and continuous Risk Assessment – which would include HAZID (e.g. HAZOPs, ‘What If?’ analysis, etc.), Scenario Identification, Likelihood and Severity Assessment (Risk Assessment), and Risk Evaluation and (risk) management by means of adequate risk reduction measures.

Needed Actions

- Common (sub)systems technical concept for baseline → Synergies with EIS inventory
- Technical Designs of main fire-prone areas (alcoves, shafts, arcs, KG...) .
- Use quantitative risk assessment methodologies (already explored in recent LHC studies)
- Agree on CERN tolerable risk (task force recently launched in ATS)

Tasks for pre-TDR

- ❖ **HAZID-Fire-01:** Detailed and extended scenario-based analysis (specific and extensive across FCC facility) for critical hazards.
Use live DB system
- ❖ **HAZID-Fire-02:** Characterize scenario frequency, consequence, and severity analysis (QRA)
- ❖ **HAZID-Fire-03:** Identify cascade/domino effect scenarios (by means of fault tree analysis, (FTA), bow tie, ...)
- ❖ **HAZID-Fire-04:** Time-evolution characterization of such risks

Risk Assessment & Hazard Identification (HAZID II)

Reviewers recommendations:

[...]

Work should be done to consider what would occur **if each safety system failed** in an event tree or HAZOP format, including failure of power, detection, alarms, escape direction information, extraction, and active fire protection

[...]

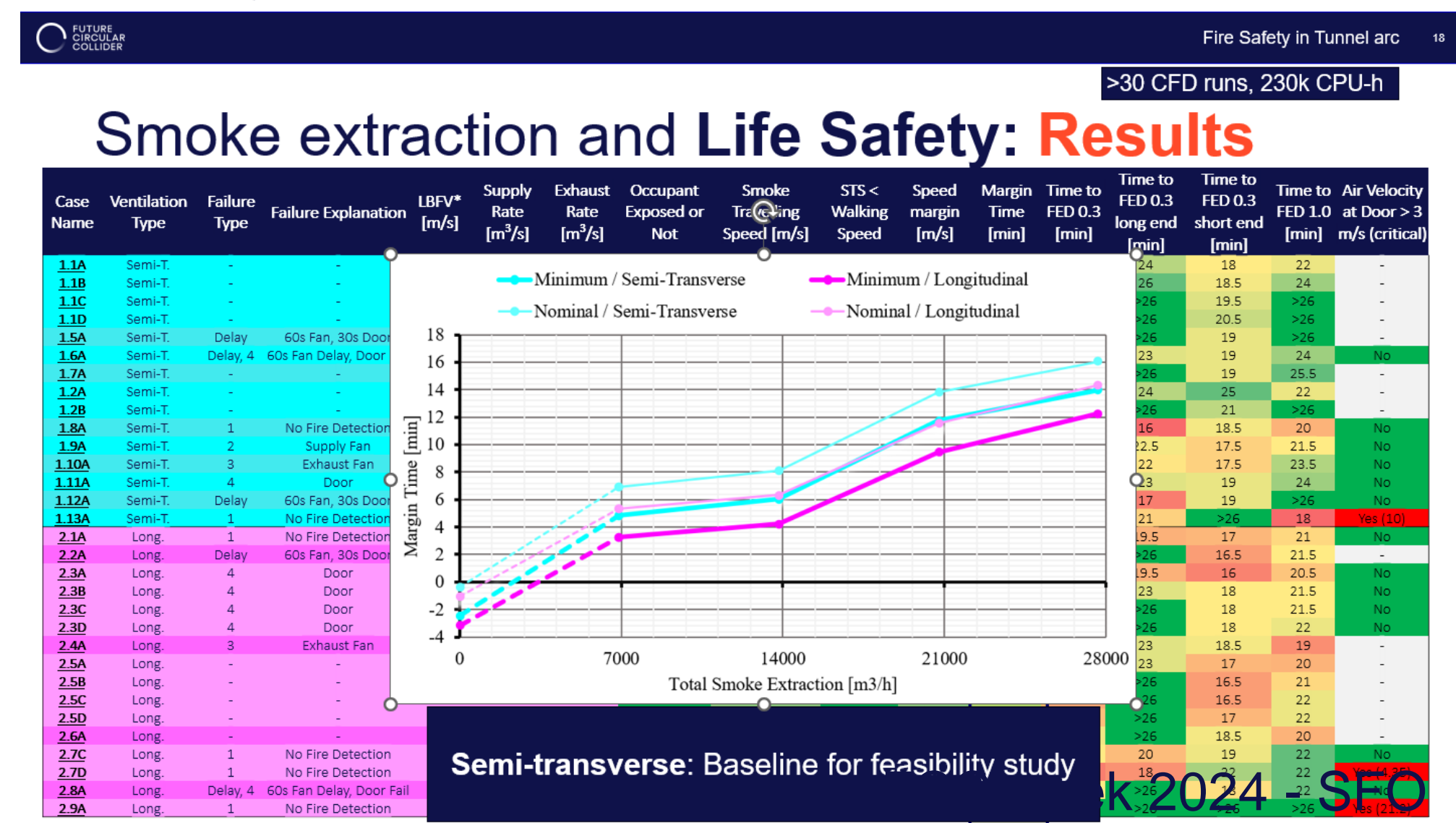
What is the likelihood of failure to close doors on demand (e.g. mechanical failure, blockage of door movement, materials temporarily passing through the doorway)?

Context and needed actions

- HAZOP seems premature at feasibility phase (needs of technical detail design)
- Safety systems failure is to be considered after SIL definition (to commensurate the risk)
- Reliability estimation of safety systems is needed (with EN-AA)
- Establishment of single-point-of-failure and system dependencies.

Tasks for pre-TDR

- ❖ HAZID-Deg-01: Consider safety system failure event tree
 - ❖ HAZID-Deg-02: Develop and apply a probabilistic risk assessment for failure on demand and degraded modes
- (study already performed for feasibility-study proposed ventilation strategy)



Fire Safety. Scenarios (FIRE)

Review statement:

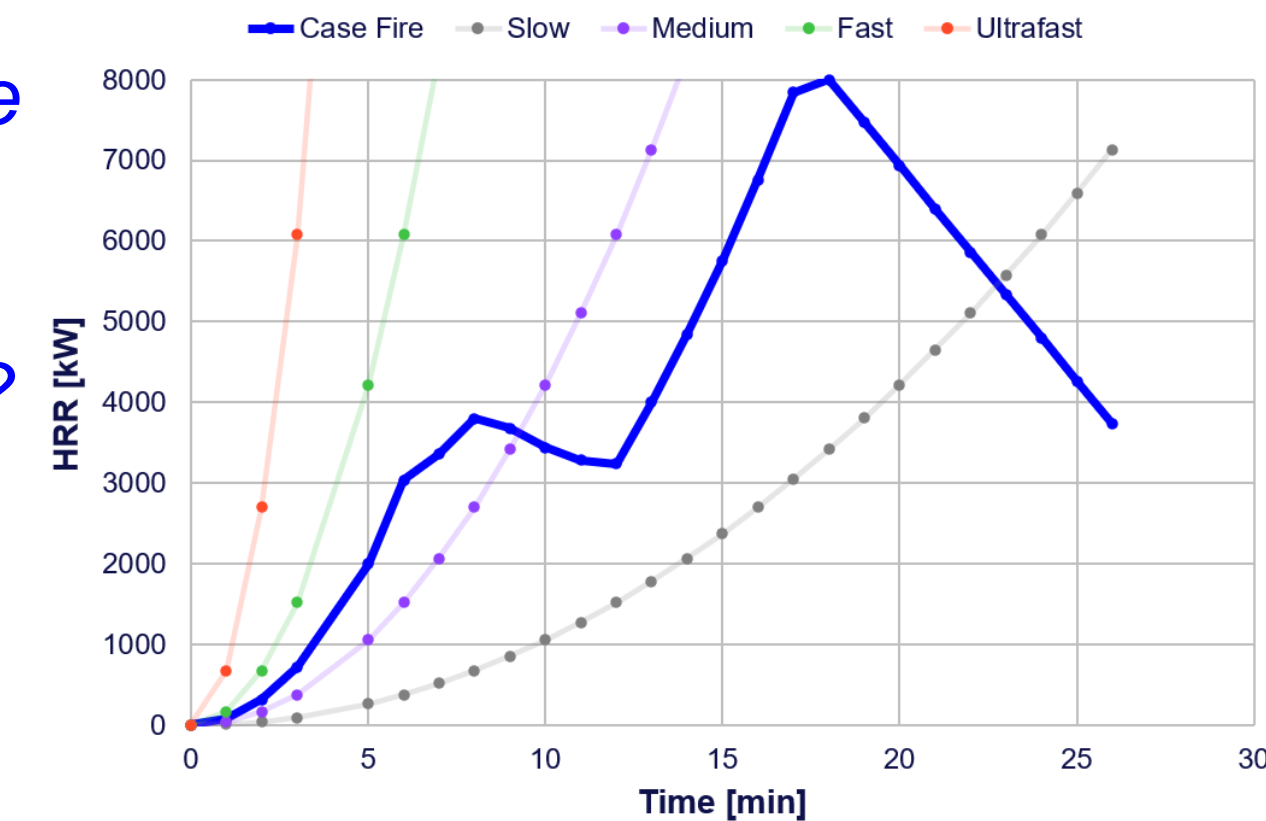
If all combustible material expected in the tunnel were to be involved how does this increase the size of the potential fire?

[...]

fire risk associated with storing between 2 and 7 transport vehicles in this small space been considered?

[...]

the accident of two vehicles colliding as they pass and setting on fire should be considered

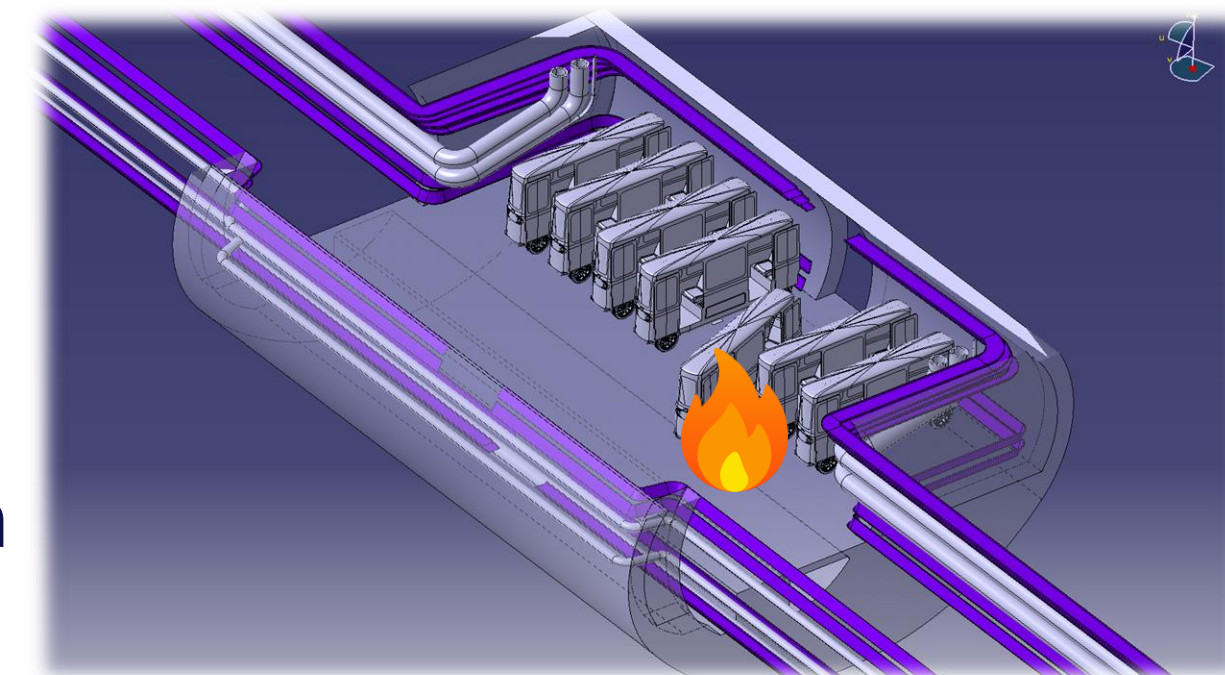


Context

- Current safety concept **focused on life safety**. Important to start analysing: **environmental protection** (in case of incident) and **property protection/operation continuity**
- **Flashover** conditions not expected (if safety systems works). Degraded modes to be considered
- Qualitative fire load inventory done per main areas/types. Needs refinement. (linked to **HAZID-Fire-02 HAZID-Fire-02**)
- **Safety measures** could allow discarding worst-case scenarios (i.e. propagation, vehicle colliding) → **parking box**
- Battery technology unknown (and evolving fast)

Tasks for pre-TDR

- ❖ **FIRE-Load-01**: Map all FCC facility and create fire load class areas
- ❖ **FIRE-Load-02**: Stablish clear mechanisms to ensure revision of mapping is done as design evolves
- ❖ **FIRE-Load-02** extend worst credible scenarios: Consider transport vehicle fire and propagation



Fire Safety. Modelling (FIRE)

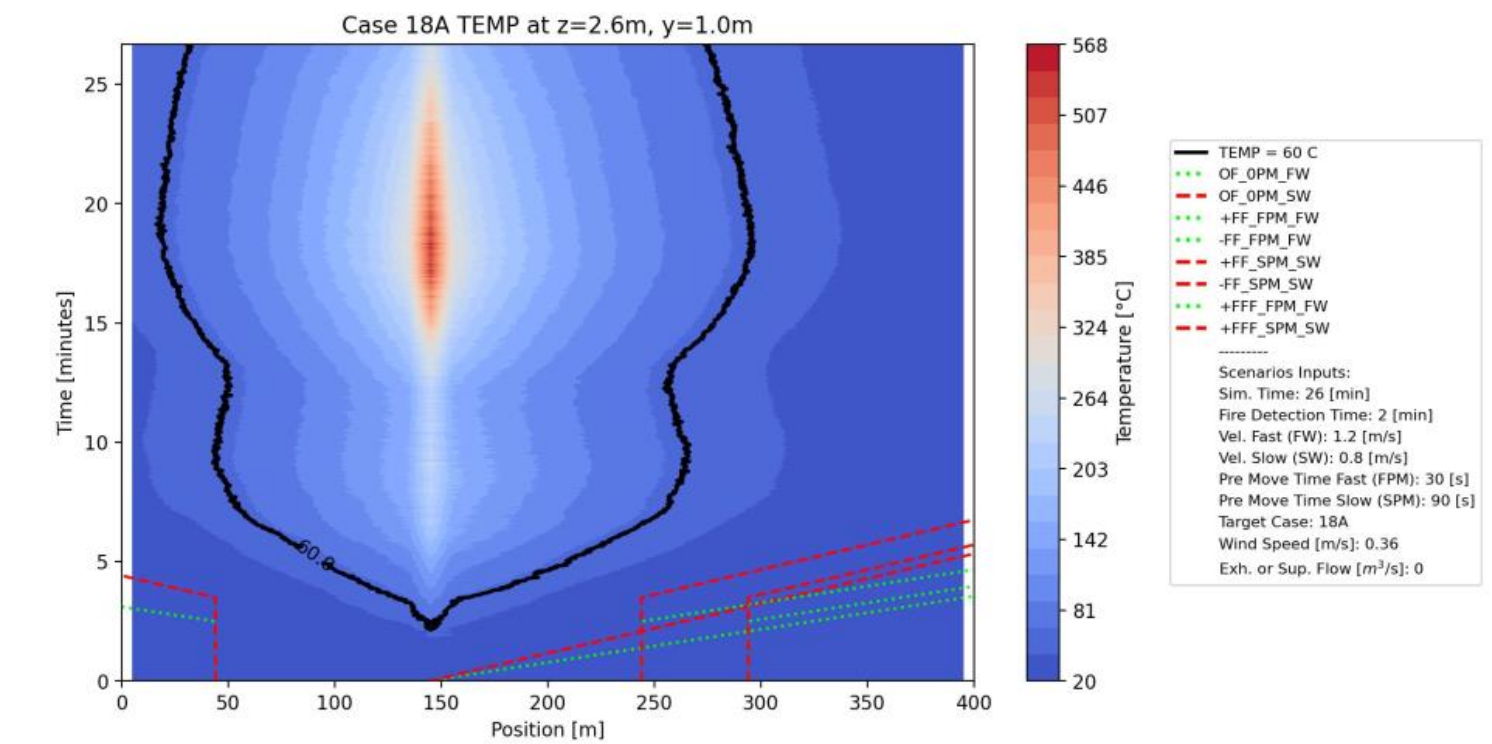
Review statement:

[...]

This type of modelling is highly dependent on appropriate representation of a range of factors: **accurate assumptions** and/or modelling of fire spread, burning properties of all materials involved in the fire, imposed/allowed flows and pressure conditions at the domain boundaries, heat transfer within the domain

[...]

It is advised that a **mesh sensitivity study** should be done, using perhaps some coarser meshes to give an idea of the variability of the results to the mesh resolution



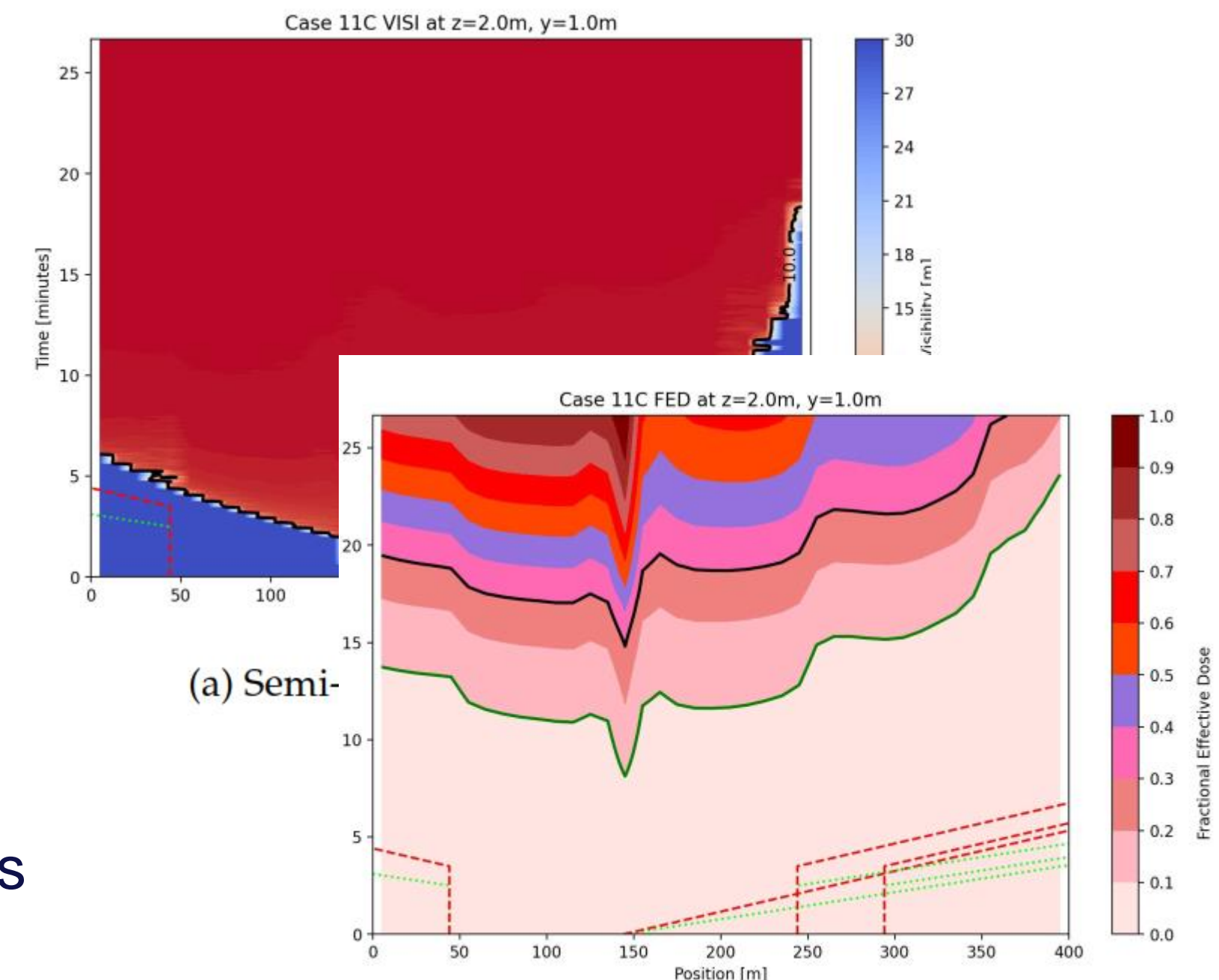
(b) Temperature time-position plot for case 18A as described in Table 10. Air/smoke temperature is measured at 2.6m from the ground. This case represent a failure of smoke extraction system and maximizes the thermal impact to the tunnel for the vehicle fire design. Black line corresponds to the 200 °C threshold. The red and green dashed / dotted lines are evacuation trajectories for worst and nominal human behavioural cases.

Context

- Worst-credible case used for feasibility study
- Mesh sensitivity done for key fire scenarios. Not change in conclusions (report ongoing)
- Main parameter sensitivity study performed for feasibility (HRR, soot yield...)

Tasks for pre-TDR

- ❖ **FIRE-Mode-01:** Complete and report mesh sensitivity analysis
- ❖ **FIRE-Mode-02:** Complete a parameter sensitivity study for additional modelled scenarios



(a) Semi-transverse Case 11C [50]

Fire Safety. Compartmentalization (FIRE-comp)

Review statement:

[...]

How will the Arc Half-Cell Mock-up be used to assess and identify the best locations of the beamline elements of both the collider and the booster and the hatches for overhead robots etc.?

[...]

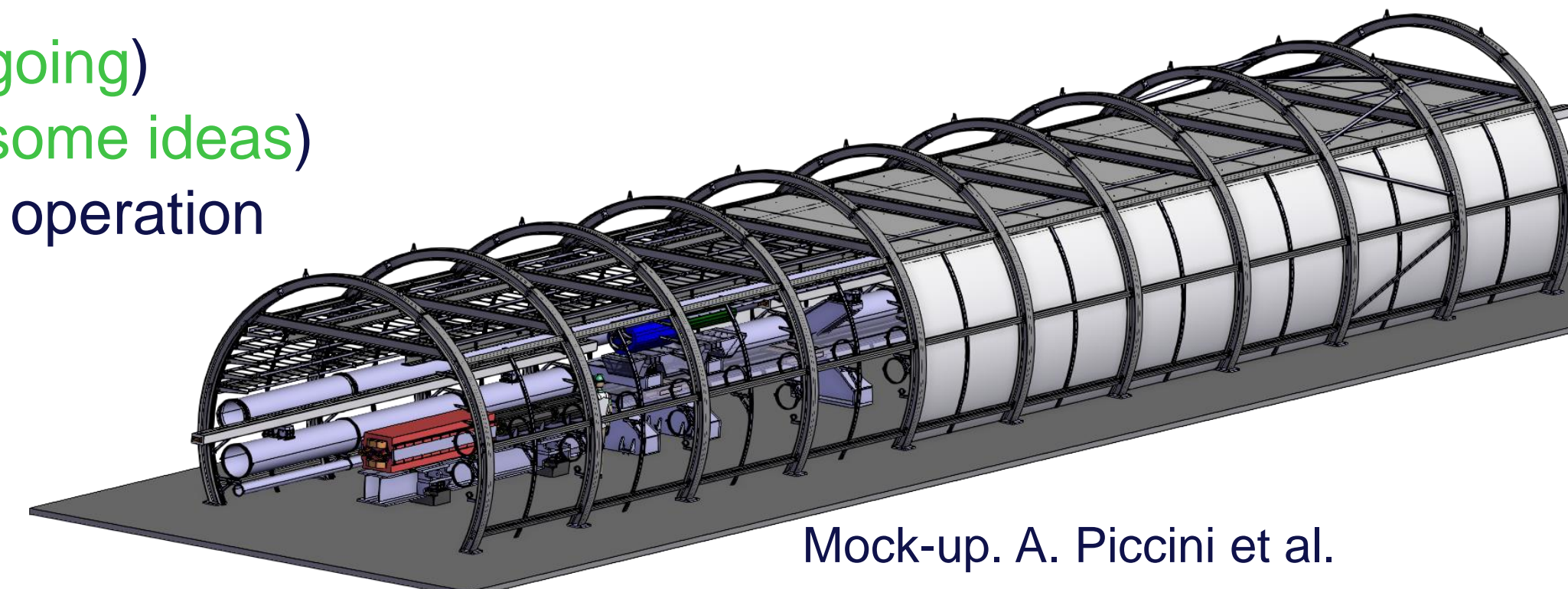
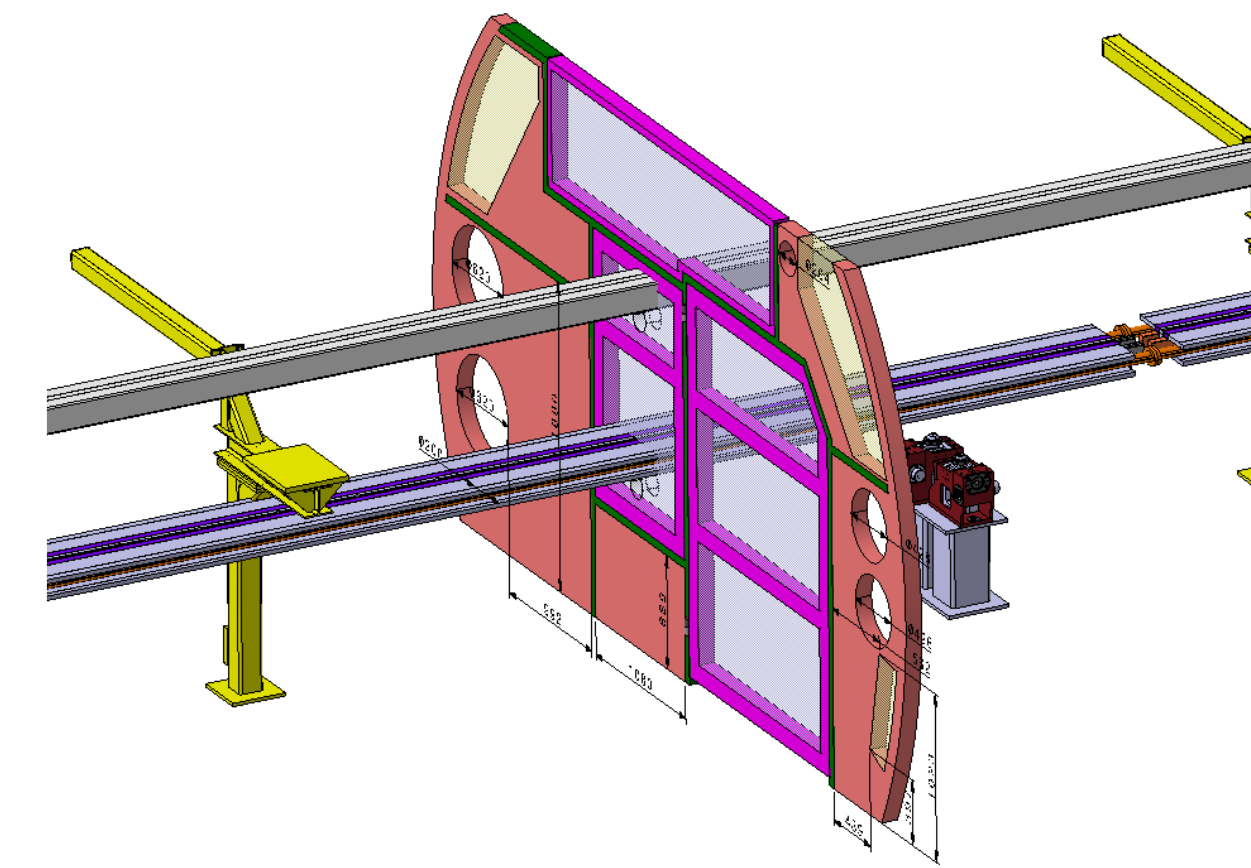
In the event of power failure, the escape time would be increased, as a person would need to get out of their transport vehicle and open the door at each compartment. Additionally in this scenario, presumably, the doors will be self-closing and so it would not be possible to open the door and then continue through the door if a person was alone in a vehicle, as the door would re-close

Context

- Partitions not developed yet
- Learning in recent consolidation campaigns (SPS fire, NA Cons)

Tasks for pre-TDR

- ❖ **FIRE-Comp-01:** Use mock-up to optimise fire compartments and sealing (**ongoing**)
- ❖ **FIRE-Comp-02:** Use mock-up to investigate robot fire rated hatch solutions (**some ideas**)
- ❖ **FIRE-Comp-02:** Start defining technical solution for fire doors integration and operation



Mock-up. A. Piccini et al.

Fire Safety. Surface concept (FIRE)

Review statement:

[...]

*When it comes to the fire safety concept for some **surface buildings**, the **prescriptive approach** may not be appropriate.*

*For example, safety within the **subsurface facility** may rely on services provided from the surface. In this case, it may be more appropriate for the relevant surface building fire safety approach to be designed for property protection/service continuity rather than life safety.*

Context

- Surface buildings not yet conceived-integrated
- **Safety-dependency trees** necessary
- **Safety** will need to **deal with additional constraints** (space, distance, materials)

Tasks for pre-TDR

- ❖ **FIRE-Surf-01:** Consider beyond-prescriptive fire safety when underground systems impacted
- ❖ **FIRE-Surf-01:** Show compliancy with additional safety goals

J. Gutleber, FCCWeek25-Key talk.
Status and next Steps. Illustrative only



Detection and Emergency Systems (DET)

Review statement:

The aspirating detection system suggested has a detection time of 510 s. A response time of 120 s has been stated as a requirement for detection. Is it **likely** that this can **be improved** on significantly? [...]

Navigating issues – [...] People need to know which way to go. **Clear signage is needed** in an emergency, so everyone goes the correct way. **Visibility conditions** in the event of a failure of ventilation and detection systems or failure of compartmentalisation need to be considered.

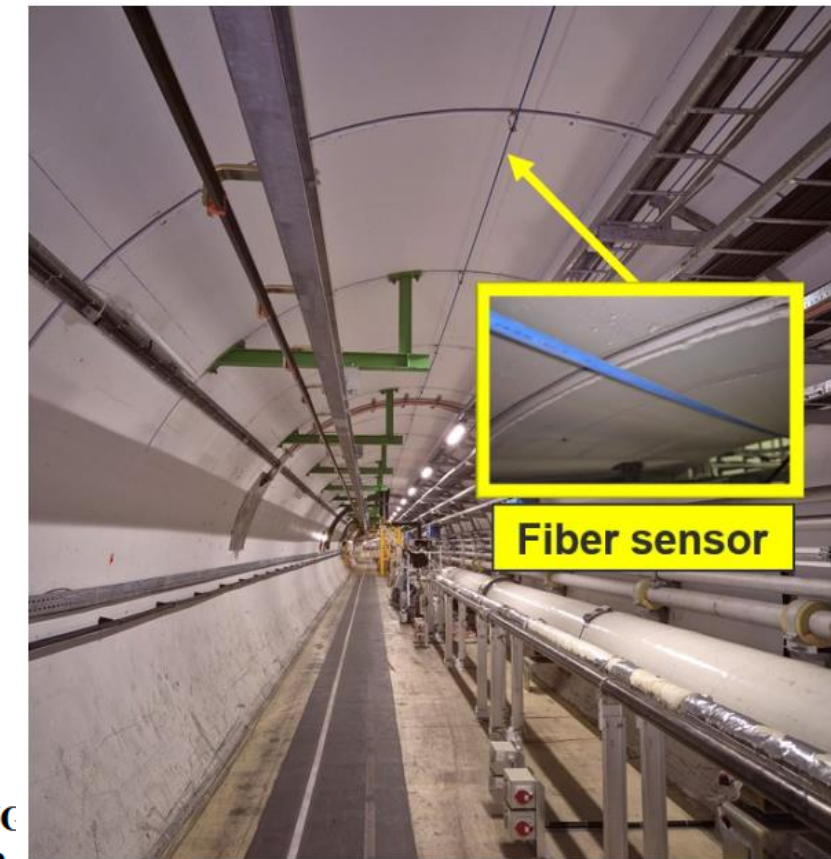


Figure 2: Optical fiber installed in LHC tunnel.

Context

- Response time is dependent on the fire (size, evolution, time). 510s was the response time for 50kW fire, instead of >1MW(t=3') used.
- The faster it grow the easier it is to detect.
- Fiber-optical based distributed-temperature system (DTS), radhard, tests
- Voice alarm system to be implemented in LHC (LS3) and explore *guidance*

Tasks for pre-TDR

- ❖ **DET-Fire-01:** Advanced LASD with hybrid systems for redundancy
- ❖ **DET-Fire-02:** Keep exploring DTS as possible hybrid/optimized solution
- ❖ **DET-Fire-03:** R&D on alternative feasible detection techniques
- ❖ **DET-Evac-01:** Explore detail way-finding technical solutions

APPLICATION OF DISTRIBUTED TEMPERATURE SENSING AND CRYOGENIC LEAK DETECTION IN ACCELERATOR

M. Dole, J. Blanc, J. Bremer, L. Contini, D. Di Francesca, L. Dufay-Chanat, S. Evrard, J. Fernandez, T. Hakulinen, R. Kallada Janardhan, P. Ninin, H. Nissen, O. Rios, M. Van de veire, CERN, Geneva, Switzerland

Abstract

High-energy accelerators like CERN's Large Hadron Collider (LHC) present hazards characterized by temperature variations such as cryogenics leak or fire. Considering that LHC tunnels are large, underground and radioactive areas traditional systems to detect these hazards can't be used CERN is exploring the feasibility of installing a large-scale temperature monitoring system in LHC tunnels using Distributed Temperature Sensing (DTS) technology. Based on optical fiber, such a system would be resistant to the LHC radioactive environment and could detect temperature changes induced by both fire and cryogenic leak events, over LHC large distances. This paper presents on going studies and a prototype of DTS equipment in the LHC tunnel installed

strain, pressure, chemical composition, vibrations, radiation, rotation, shape, EM field, etc. Distributed sensing is a way to obtain spatially continuous, real-time measurements along the entire length of the optical fiber. The result of a distributed measurement is a continuous one-dimensional map.

A RADIATION RESISTANT DISTRIBUTED TEMPERATURE SENSOR FOR CERN'S ACCELERATORS

D. Di Francesca[†], J. Blanc, F. Colaco, L. Contini, M. Dole, S. Evrard, J. M. Fernandez, R. Kallada Janardhan, H. Nissen, D. Ricci, O. Rios, M. Van de veire, CERN, Geneva, Switzerland

Abstract

Optical Fibre Sensors (OFS) offer high sensitivity, versatility, and robustness in harsh environments, making them particularly well-suited for monitoring large-scale facilities such as particle accelerators. As part of CERN's Personnel Safety System Consolidation Program, a dedicated study was conducted to evaluate the performance of a fibre-based radiation-resistant Distributed Temperature Sensor (DTS) for fire and cryogenic leak detection in the LHC. This paper presents a series of fire tests performed in a controlled test environment to assess the DTS response time under emergency conditions. A general methodology was developed to establish a phenomenological model of the DTS thermal response. The approach enables the calibration of reliable and fast response models without requiring detailed knowledge of the cable construction and enabling rapid adaptation to diverse scenarios. This methodology led to the first successful DTS-based fire detection demonstration in the LHC tunnel in January 2025. These results represent a significant innovation opportunity for extending safety systems at CERN.

PSS-CONS, the development of a radiation-hard Distributed Temperature Sensors (DTS) system is being pursued for the early detection of abnormal thermal events, such as fires or cryogenic leaks.

Details on Radiation-Hard DTS

Raman-based DTS utilize optical time domain reflectometry combined with the detection of Stokes and anti-Stokes Raman backscattered signals to enable temperature measurement along an OF [3]. In radiation environments, Radiation Induced Attenuation (RIA) introduces wavelength-dependent losses that distorts the backscattered signals ratio, leading to calibration drift and inaccurate temperature readings [4]. Compensation strategies, such as the use of radiation-resistant fibres and double-ended interrogations schemes [5], reduce these effects. However, they can add complexity and in the event of fibre breakage or high RIA spot along the monitored link, the temperature map is lost. To address this issue, a single-ended DTS architecture using two probe lasers was proposed and experimentally demonstrated [6,7]. The DTS utilizes two lasers with a spectral separation near the main Raman band of silica (~450 cm⁻¹), aligning the Stokes and anti-Stokes signals with the laser wavelengths. This configuration enables au-

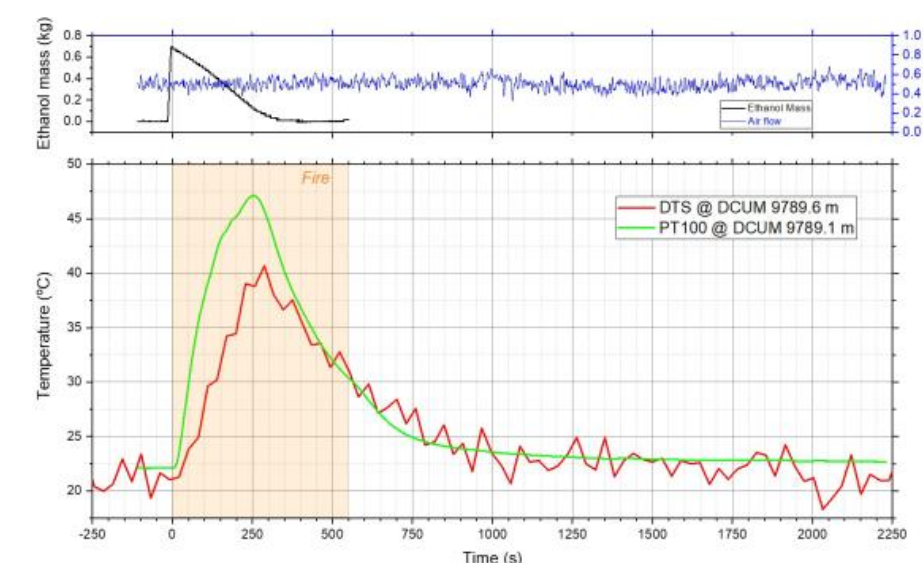


Figure 4: Fire test temperature, mass of ethyl alcohol consumed, and air velocity, as a function of time.

INTRODUCTION

Smoke Management and dynamic confinement (VENT)

Review statement:

[...]

The ventilation system appears to be a vital component, not only for smoke control during fire but also in the day-to-day operation of the FCC

What is the reliability of the various ventilation systems?

[...]

There may be the **potential for heat induced pressure** rise in the fire compartment to exceed the supply pressure and/or overpressure the exhaust system, which could lead to smoke moving into adjacent compartments via one or both extract and inlet duct systems. [...]

Extraction of $3\text{m}^3/\text{s}$ per MW could be used to avoid this.

[...]

Considering a **potential breach in static confinement**, what would the **ramifications** be for the **ventilation systems** and **evacuation plan** be?

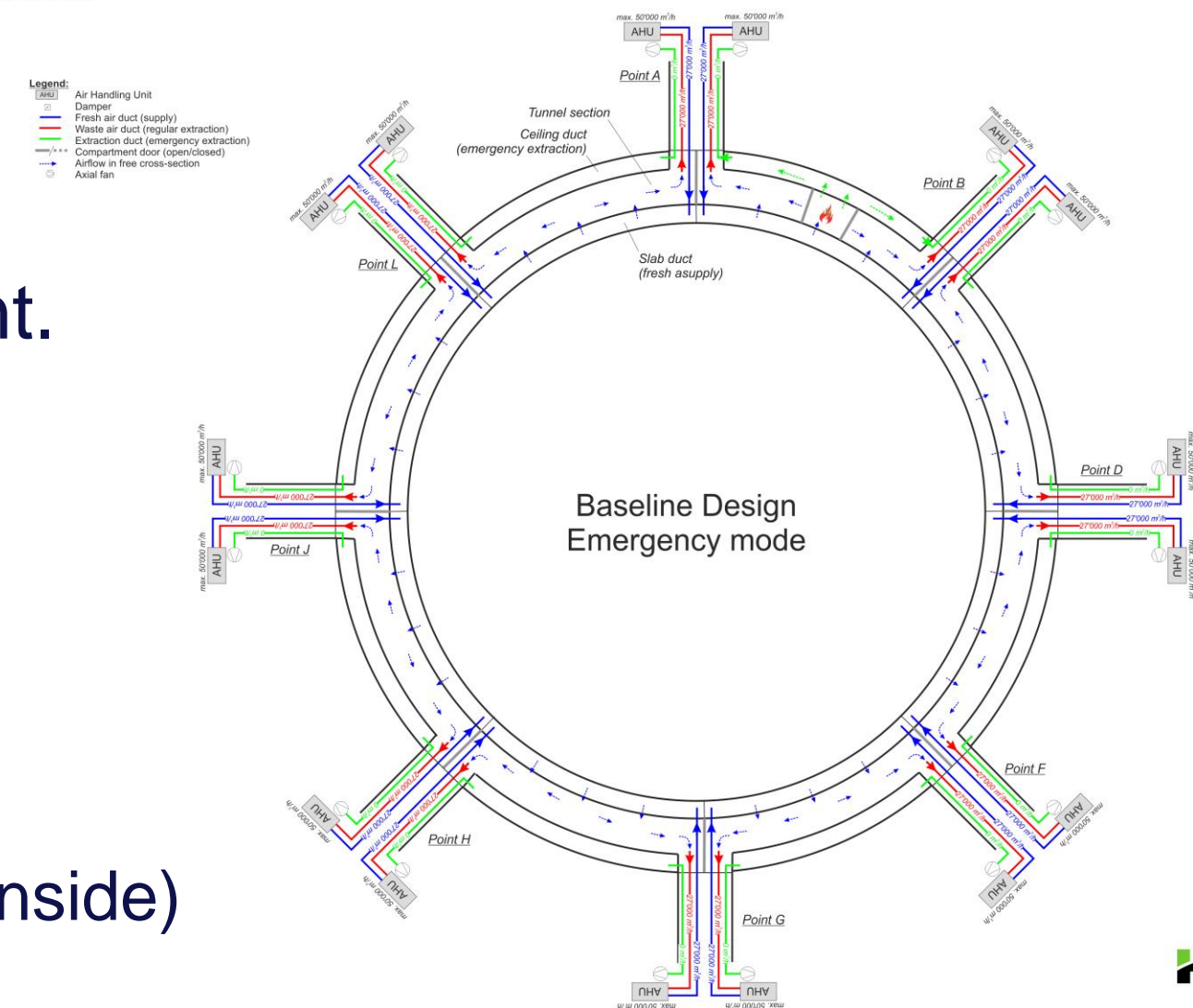
Context

- Ventilation systems are designed as N+1 and power secured system.
- Fire induce pressure considered for nominal cases. Detail modelling needed for realistic
- Full back-layering preventing flow capacity not needed as there is a physical compartment.
- Negative impact on oversized smoke extraction shall be considered
- EN-CV is reviewing extraction concepts and exploring a hybrid alternative (longitudinal normal condition // semi transverse smoke)

Tasks for pre-TDR

- **VENT-01:** Cost-benefit considerations of increasing extraction mode (current $2.7\text{m}^3/\text{s}$ → $15\text{m}^3/\text{s}$) (with downside)
- **VENT-02:** Detail modelling of thermally induced pressure in compartment (also degraded modes)
- **VENT-03:** Advance on technical design for anti-return dampers, Fire Resistant ducts, ...
- **VENT-04:** Advance of CFRS ventilation controls and overrides

CERN Cooling and Ventilation Studies for the Future Circular Collider Study
Baseline tunnel ventilation concepts
Status: 27.05.2024



Evacuation (not only in fire) EVAC

Reviewers statements:

[...]

*A lot of time and effort has been put into estimating the surface of safe areas and development of an evacuation model using plain Monte Carlo simulations. An assumption has been made of a maximum admissible crowding in the safe areas of under 3 occupants/m² [78]. **This approach is sound and logical***

*How the **extended evacuation times** caused by these [what it] scenarios affect risks is unknown.*

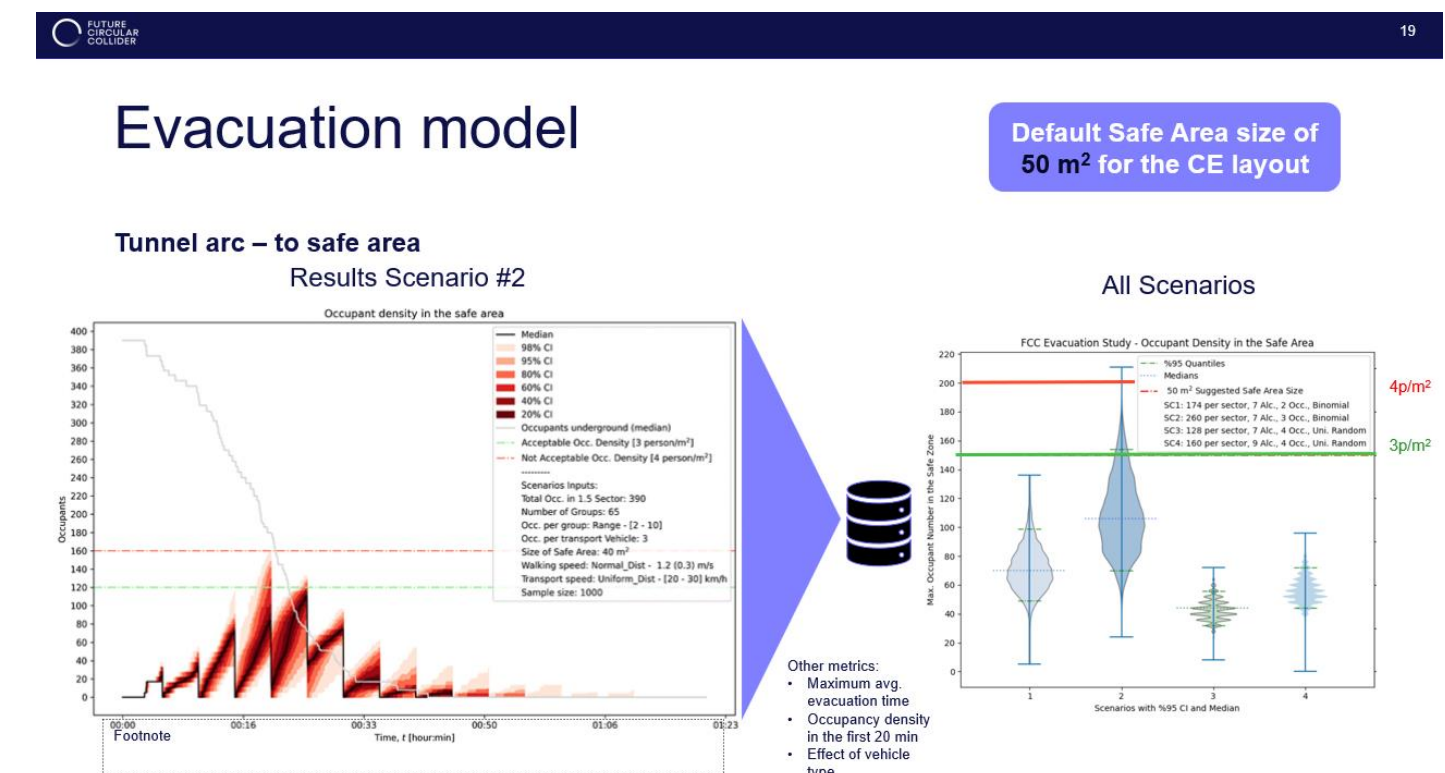
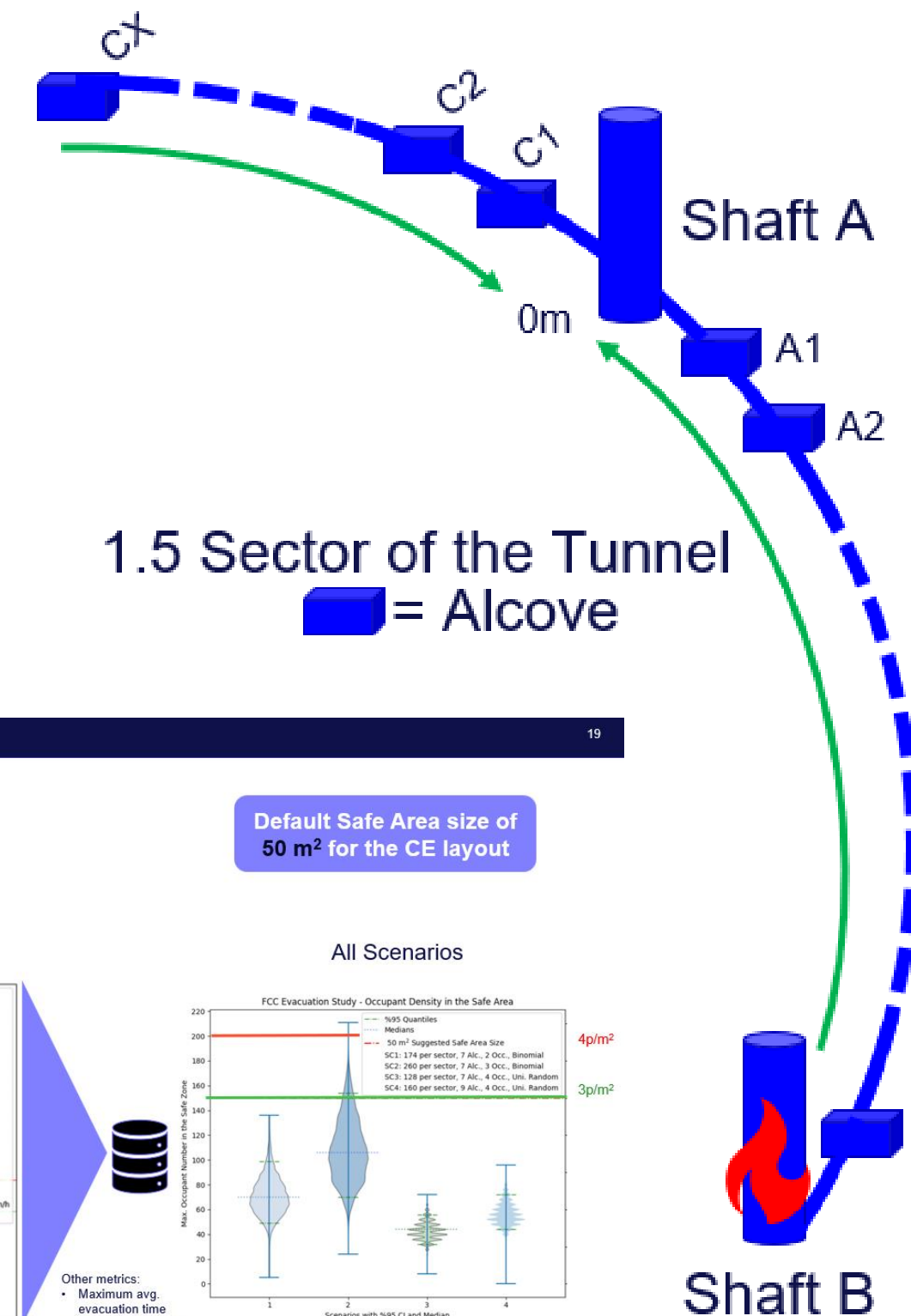
***Ninety seconds** seems very little time to do anything more than have a ‘are we actually going to leave?’ [...] Even one **hundred and eighty seconds** leaves little time for additional tasks before starting to move.*

Context and needed actions

- Pre-movement times compliant with standards (BS PD 7974-6)
- Pre-movement time (90s-180s) are backed up by LHC evac data (detailed assessment ongoing).
- Specific delayed scenarios ‘time-to-stop-in-safe-mode’ not yet investigated

Tasks for pre-TDR

- ❖ **EVAC-01:** Detailed evacuation and behavioural modelling for degraded cases
- ❖ **EVAC-02:** Reconsider pre-movement times for specific activities
- ❖ **EVAC-03:** Explore multilingual comms, adaptive signage.
- ❖ **EVAC-04:** Access/Evac modelling though Klystron Galleries



Evacuation transportation EVAC-tran

Reviewers statements:

[...]

Vehicle autonomy systems failing - How will panic and congestion be avoided with vehicles? Especially if the ventilation systems fail to clear the main tunnel of smoke, etc.

[...]

Vehicle mechanical breakdowns and autonomous system communication loss - In the event of vehicle autonomy systems failing, how will the evacuation work? Can the vehicles be easily self-driven? Will training be given? If vehicles fail, what is the next level of system back up?

[...]

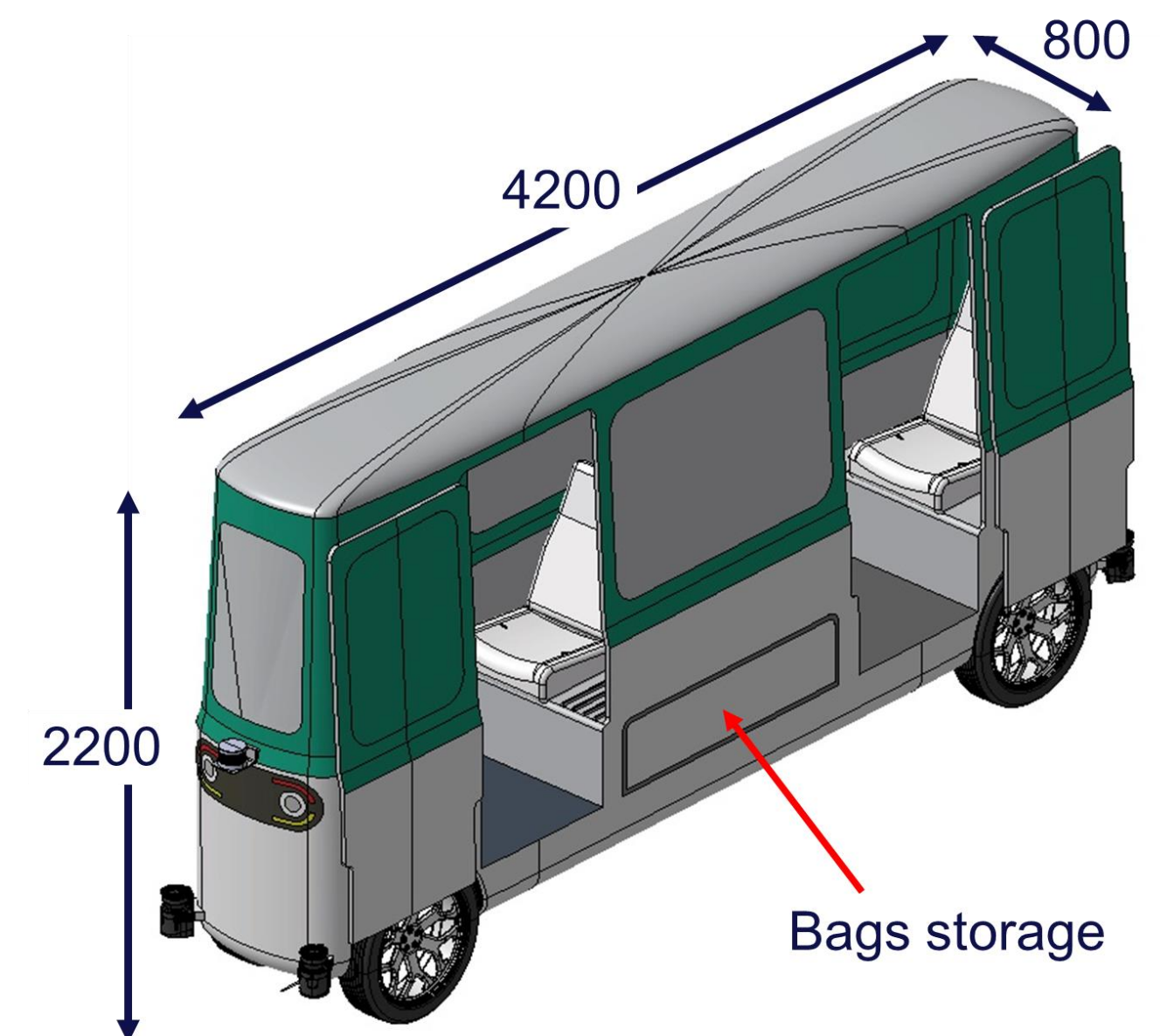
Vehicle parking congestion. Plan parking for alternative evacuation scenarios

Context and needed actions

- Parking zones are identified. Sizing needs to be cross-check with operation-constructions needs
- Vehicle breakdowns and autonomy failures

Tasks for pre-TDR

- ❖ **EVAC-trans-01:** Detailed evacuation and behavioural modelling for degraded cases
- ❖ **EVAC-trans-01:** : Reconsider pre-movement times



Conclusions and way forward

- The review provided a **solid third-party check** on the **fire safety concept** and **did not identify any fundamental barrier**
- Concept **is well founded** but **needs** to be:
 - **extended to uncovered areas** (injection complex, surface buildings)
 - **updated** along the **project changes**
- **Several comments** are **to be addressed** in **upcoming phases** (but are key!)
- Safety concept shall be **extended to environmental protection and property protection/operation continuity**
- A full **what-if analysis** shall be conducted. To be used as input for **Quantitative Risk Assessments**
 - **Maturity** is needed for **closing the HAZID** and detail fire safety concept (i.e. detector technology, mitigation measures)
 - **Safety systems reliability** shall be **understood/stated** to exploit this analysis
- All **open remarks and relevant recommendations** are incorporated in the workplan for upcoming phases
- We set a **clear workplan** and **have consistent resources allocated** to tackle next phase!



Ready for Pre-TDR!

All tasks

HAZID-Fire-01: Detailed scenario-based analysis (specific and extensive across FCC facility) for critical hazards. Use live DB system

HAZID-Fire-02: Characterize scenario frequency, consequence, and severity analysis (QRA)

HAZID-Fire-03: Identify cascade/domino effect scenarios (by means of fault tree analysis, (FTA), bow tie, ...)

HAZID-Fire-04: Time-evolution characterization of such risks

HAZID-Deg-01: Consider safety system failure event tree

HAZID-Deg-02: Develop and apply a probabilistic risk assessment for failure on demand and degraded modes

FIRE-Load-01: Map all FCC facility and create fire load class areas

FIRE-Load-02: Establish clear mechanisms to ensure revision of mapping is done as design evolves

FIRE-Load-02 extend worst credible scenarios: Consider transport vehicle fire and propagation

FIRE-Mode-01: Complete mesh sensitivity analysis

FIRE-Mode-02: Complete a parameter sensitivity study for additional modelled scenarios

FIRE-Comp-01: Use mock-up to optimise fire compartments and sealing (ongoing)

FIRE-Comp-02: Use mock-up to investigate robot fire rated hatch solutions (some ideas)

FIRE-Comp-02: Start defining technical solution for fire doors integration and operation

FIRE-Surf-01: Consider beyond-prescriptive fire safety when underground systems impacted

FIRE-Surf-01: Show compliancy with additional safety goals

DET-Fire-01: Advanced LASD with hybrid systems for redundancy

DET-Fire-02: Keep exploring DTS as possible hybrid/optimized solution

DET-Fire-03: R&D on alternative feasible detection techniques

DET-Evac-01: Explore detail way-finding technical solutions

EVAC-trans-01: Detailed evacuation and behavioural modelling for degraded cases

EVAC-trans-01: : Reconsider pre-movement times

EVAC-01: Detailed evacuation and behavioural modelling for degraded cases

EVAC-02: Reconsider pre-movement times for specific activities

EVAC-03: Establish reliability and performance objectives

Electrical Systems Reliability & Redundancy (ELEC)

Identified Scenarios (ELEC01):

- "Complete power loss, partial failures, cascade failures impacting critical systems."

Suggested Approaches:

- Conduct FMEA for single-point failures (ELEC02).
- Defined recovery protocols for safe restoration.

Specific Reviewer Concern:

- "Risk of single MV link causing simultaneous network failures."

Proposed Mitigation (ELEC03):

- Redundant secured electrical networks.

Emergency preparedness / intervention

4.5 Emergency Preparedness and Intervention Concept

- More detail is required on smoke extraction with County Fire and Rescue Service (CFRS) override and control.
- Do CFRS have all the necessary data?
- Will fire service personnel be able to enter the tunnel while personnel are escaping the tunnel using these vehicles?
- Fire service vehicles and equipment such as fire hoses could block the escape path of vehicles.
- From which location will the emergency response be coordinated? How will communication be managed over the significant distances between surface sites?
- Human / Robotic Intervention needs to be considered, as well as integration of robotic emergency response systems.
- Coordination with external emergency services and the need to involve CERN staff and local fire brigade in any training.

ROBOTIC SYSTEMS

Robots in confined spaces present significant risks:

- Failed robots can block access for other robots and personnel
- Emergency evacuation routes may be obstructed
- Critical equipment access may be prevented

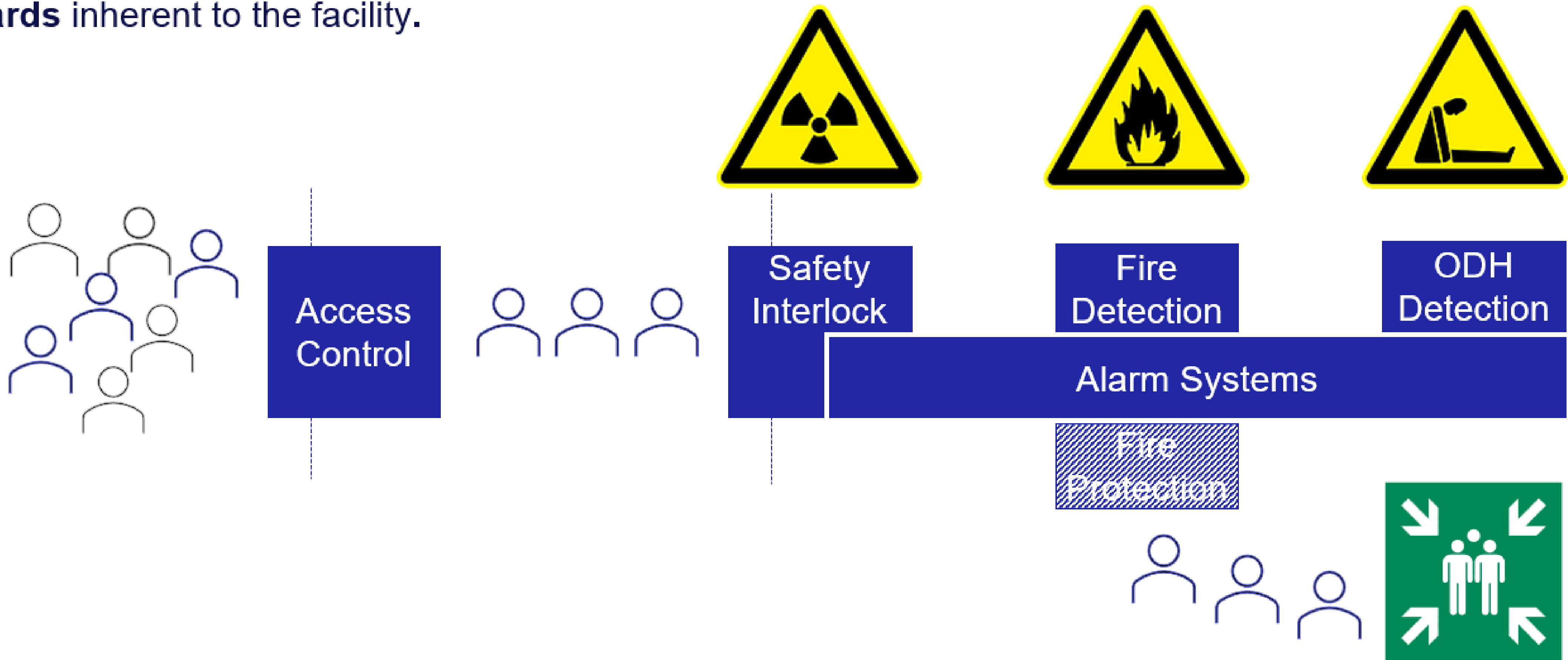
Mitigation requires:

- Retrieval mechanisms for disabled robots
- Manual overrides
- Appropriate sizing of the robots vs. available/manoeuvrable space within the walkway

Risk assessments, emergency procedures and regular drills can help address repair robot failure scenarios.

Personnel Safety Systems

Systems installed to protect the **personnel** from **hazards** inherent to the facility.




Safety concept

Review

- By experts experienced in large research / industrial infrastructures
- From ‘notified body’, experienced in pre-construction authorization processes
- External (expert) review of our studies and assumptions
- Outcome:
 - Generic statement on the validity of the concept (showstoppers Y/N)
 - List of TODOs – basis for the pre-TDR work description





**FUTURE
CIRCULAR
COLLIDER**

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**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Occupational Health & Safety and Environmental Protection Unit

Report
4 October 2024

FCC Safety Concept
Feasibility Study Phase

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Abstract

The first iteration of the safety concept for the FCC study was performed for the Conceptual Design Report (CDR). Following the advancements of the study and the feedback from the Mid-Term Review (MTR), the Safety Work Package of the TIWG pillar performed additional assessments and safety studies, including radiation protection, fire and ODH simulations, and evacuation modelling. This report provides an up-to-date overview of the FCC safety systems, offering a comprehensive summary of the safety concept and serving as the primary reference for the Feasibility Study report.

Feedback from reviewers

Reviewers: 4 experts (HSE UK scientists) + 1 project manager

Preliminary: Executive summary

3. Key Findings

HSE's evaluation finds **no fundamental barriers** in CERN's safety report at this stage.

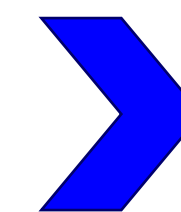
This conclusion is stated with the following caveat:

That the identified safety areas and processes that require further refinement are resolved adequately.

Identified areas and processes **requiring further refinement**.

4. Conclusion

Following HSE's assessment of the CERN Future Circular Collider (FCC) concept safety case, HSE have identified several areas that **require further refinement** to address potential concerns. CERN's responses reflect a **commitment to resolving these issues**. CERN have indicated that certain matters have been or will be addressed and as such HSE's evaluation finds **no fundamental barriers in the concept safety report at this stage**. However, this determination is subject to the consideration of HSE's comments and recommendations.



Several iterations
between HSEs
(CERN and UK)

Feedback from reviewers

Further refinement

- A more detailed assessment of the worst-case scenarios and the inclusion of '*what-if*' analyses
 - System level risk assessment (failure modes, MTBF, redundancy, etc...)
 - Several points raised: transportation vehicle breakdown, 'traffic jam' at service cavern during evacuation, accidental closing of the compartment doors...
- Developing a specific document detailing the basis of safety for each class of risk
 - Admin action: compilation of the separate technical reports
- Study interactions between fire generated effects and the ventilation systems
 - Challenges with pressures
- Multi-voltage (MV) link for both general and secured networks. This could create single points of failure within the MV infrastructure, potentially causing simultaneous network failures
 - Something we already discussed with Mario
- Ensure the integrity of the safety model. Particular attention must be given to mitigating risks associated with large-scale fires and substantial cryogenic releases
 - CFD validation with LHC He spill test
- Surface sites: more in-depth risk assessment needed
 - FS was focused mainly on the underground

Pre-TDR ?



In-depth breakdown during
FCC week 2025

1 STAFF + 1 GRAP

+ input from other TIWG WPs