FUTURE CIRCULAR COLLIDER

First thoughts on transport options
FCC Week, Paris 2022

Fraunhofer IML

Within today´s presentation, I will cover the following topics

1. **Summary of the results of the FCC conceptual design phase for underground transportation and handling of magnets**
2. **Vehicle concept for the underground transportation and handling of magnets**
3. **Vehicle concept for the underground transportation of people**
4. **Logistics concept for storage, assembly and testing of magnets including cycle times of different set-ups**

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CONTENT AND RESULTS OF PRELIMINARY STUDY

Results of the previous study

One major design constraint: max. 0.1g shock
→ limiting speed/acceleration/braking

Magnet Transport

Design concept for special purpose vehicle for underground transportation and handling of cryo-units // FCC-hh

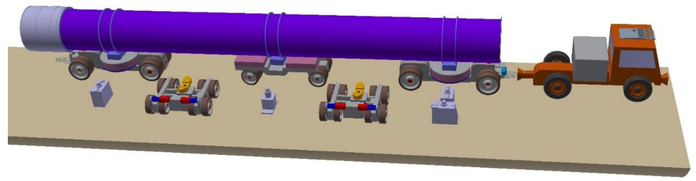
- **Pulling tractor** equipped with electric and emission-free drive
- **Transport trailers** (rear-trailer and front-trailer) equipped with electronic steering system,
  drawbar and vibration-dampening support for the loading
- Two **transfer tables** equipped with lifting platforms are used for unloading the cryo-units of the transport vehicle

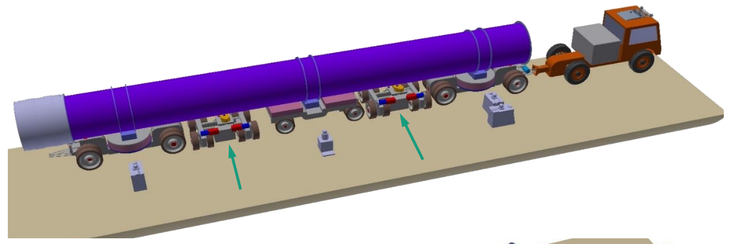
Navigation and control system

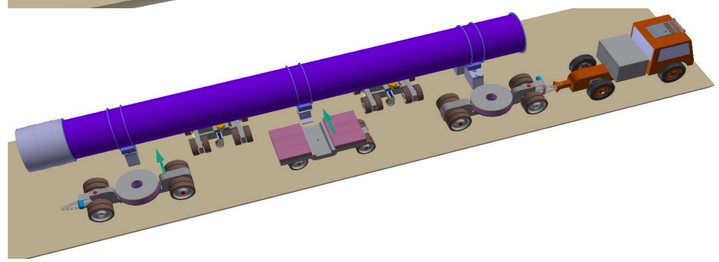
- Navigation for **autonomous driving** in tunnels / no (guiding) rails

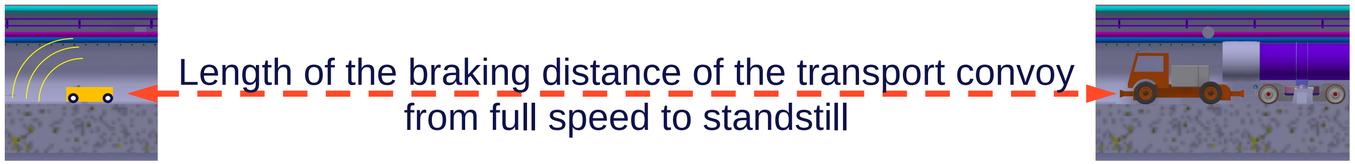
“**Watchdog**” principle

- Additional vehicle or even drone is moving in front of the transport
- Enables early detection of obstacles and low braking acceleration of the transport unit.









Results of the previous study

Supply Scenarios

Scenario 1: Suppling & lowering units via central storage/shaft

- Slight cost and quality advantage: Central assembly and testing facility and existing infrastructure
- Disadvantage in process robustness: Single shaft can be blocked / is prone to disruptions

Scenario 2: Central storage and two shafts for lowering units

- Long transport from central storage to different shafts can influence quality

Scenario 3: Suppling & lowering units via two storage locations and two shafts

- Good balance between robustness and economically

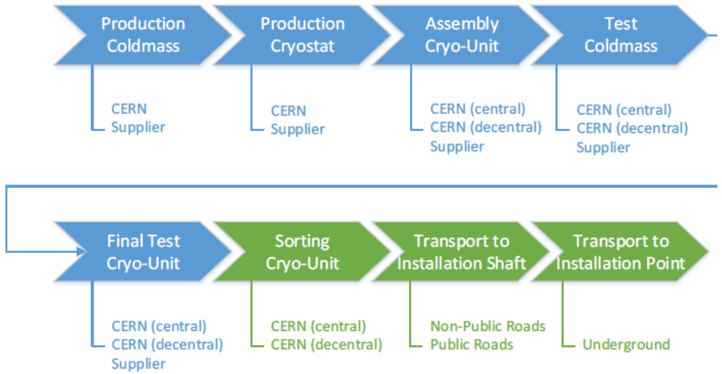


Figure 4-2: Value adding processes in cryo-unit production and CERN logistics

- From logistics perspective we would encourage building two shafts for lowering units/material (→ robustness, underground transport distances).

- Space-requirements for overground facilities (storage, assembly, testing) must be taken into account
  - Sizing/dimensioning to be re-evaluated in upcoming study
  - Input on location and number of shafts for lowering units is required

In the preliminary study we focused on cold magnets. The processes will change for FCC-ee but:
The necessary spaces for facilities and processes should be taken into account in the concept.

CURRENT STUDY – CONTENT, GOALS AND METHODOLOGY

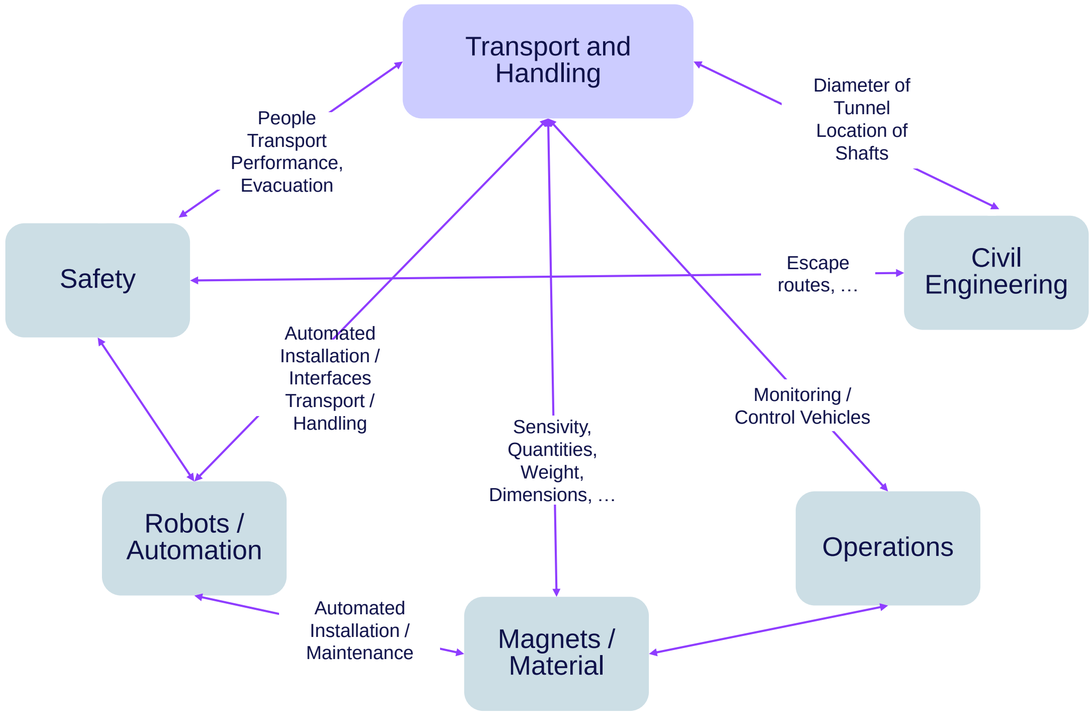
The current project focusses on transportation of magnets and people plus an update of the overall logistics concept

Within this work, different use cases resp. project phases as well as functional units and logistic units will be considered.

Scenarios / Phases

- Supply of Equipment (Magnets / Materials)
- Installation
- Technical Stops during Operation, e.g. maintenance
- Dismantling

Evacuation



WP 1: Vehicle concept for the underground transportation of material (magnets, klystron, …)

Task

Search for and evaluation of suitable principles for the transport and handling of the FCC-ee in the tunnel

- Heavy transport under tight spacial conditions
- Steering and navigation;
- Power supply of the active components;
- safety;
- Performance, (throughput).

Design of a draft concept for the transport and handling of FCC-magnets within the tunnel for:

- transport vehicles and handling equipment.

Deliverables

Preparation of vehicle concepts with focus on

- Design proposals for the transport vehicle;
- Design proposals for the handling equipment;
- Proposal for a technical safety concept (safe operation of the vehicle).

Approach / Method

- Market study of existing solutions
  - Focus on modular, battery powered, freely navigating concepts/solutions
- Developing taxonomy of solution space
  - Deriviation of feasable solutions
  - Exclusion of unsuitable technologies and vehicle concepts
- 3D modelling of vehicle concepts (CAD), incl. alignment with spatial conditions/restrictions (towing curves, clearance profiles, parking and shunting areas or operations)

WP 2: Vehicle concept for the underground transportation of people

Task

Development of vehicle concept (technical feasibility) for the underground transport of people

Search for and evaluation of suitable principles for the transport considering:

- Safety (collision avoidance, personal protection);
- Performance (throughput);
- Emergency interventions, evacuation etc.
- Design of a draft concept for the transport of people within the tunnel.

Deliverables

Preparation of vehicle concepts with focus on

- Design proposals for transport vehicle
- Control principles, e.g. block sections
- Spatial requirements for overtaking operations
- Proposal for a technical safety concept (safe operation of the vehicle)

Approach / Method

- Market study of existing solutions
- Developing taxonomy of solution space
  - Deriviation of feasable solutions
  - Exclusion of unsuitable technologies and vehicle concepts
- Developing taxonomy of solution space
- 3D modelling of vehicle concepts (CAD), incl. alignment with spatial conditions/restrictions (towing curves, clearance profiles, parking and shunting areas or operations)

WP 3: Logistics concept for storage, assembly and testing of magnets including cycle times of different setups

Task

The goal of the simulation study is to provide a solid foundation for decision making by simulating and comparing the feasibility of a variety of realistic scenarios

- Development of a logistics concept for optimizing assembly and delivery processes, taking into account production and environmental influences
- Evaluation of the control or organization of underground transportation for optimal utilization of manufacturing capacities.

Deliverables

- Logistics concept for the delivery of the magnets (above and below ground)
- Evaluation of different underground delivery strategies based on the number of vehicles used
- Statement of space requirements at entry points for pre-assembly

Approach / Method

- Event-discrete simulation for the evaluation of different concept variants
- KPI-based evaluation of the scenarios
- Abstract representation of assembly and transport processes

Simulation possibilities

The variety of scenarios that can be created in the simulation provides a wide picture of the FCC building process

- Different scenarios and individual parameters can be modelled and compared based on defined KPI

Answers the simulation can provide:

- Needed Number transport vehicles
- Required capacity/space of overground storage
- Number of assembly and testing stations
- Suitable underground transport organization concepts and installation schedules
- System resilience to disturbances and process instabilities
- …

Thank you for your attention

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