FUTURE
CIRCULAR
COLLIDER

TRANSPORT AND LOGISTICS FOR FCC

For material and people, logistics, transport and handling are of great importance in the construction, assembly and operation of the FCC.
The presentation will focus on transport scenarios, design concept for special vehicles for the underground transportation and handling, design concept for bridge cranes and lifts as well as assembly, testing and storage facilities organization and supply strategies.

Table of content

Logistics study: focus*

- Supply strategies for FCC cryo-units;
- Locations for the storage, assembly and testing facilities;
- Transport scenarios for cryo-units, including analysis of stresses and possibility of intercontinental transport;
- Design concept for a special purpose vehicles for the underground transportation and handling of cryo-units;
- Supply scenarios considering the overall FCC construction schedule.

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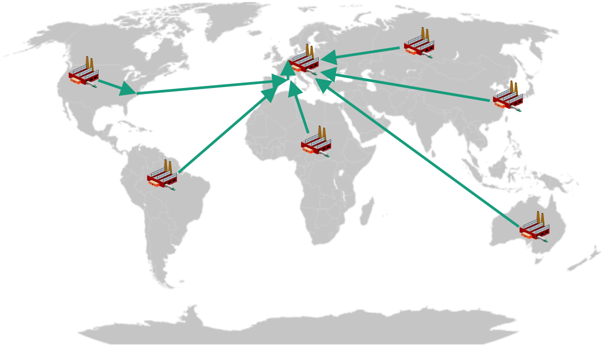
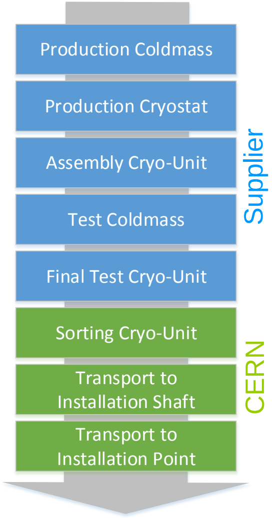
Logistic study : supply strategies for cryo-units*

- High demands for materials that need to be installed
- Construction timeframe for FCC very tight and available space for material storage on site limited -> very important to have effective on-site logistics and suitable supply chain strategy



Issues

- Insourcing ←→ Outsourcing
- Single ←→ Multiple Sourcing
- Global ←→ Local Sourcing
- Central ←→ Decentral Facilites and Storages (+buffer)
- Overground ←→ Undergound Transports



Assumptions

- Maximum shock: 0.1 g - > special protections
- Maximum tilt angle: 5% -> idem
- Weight of the cryo-unit: 60 t (dipole) -> heavy loads transportation
- Dimensions (L/W/H) : 13,4m x 1,5m x 1,64m -> no standard container, roads network not adequate in the region (especially in FR, already problems with LHC)
- Amount of cryo-units to be transported: 5400

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Logistic study : locations of facilities*

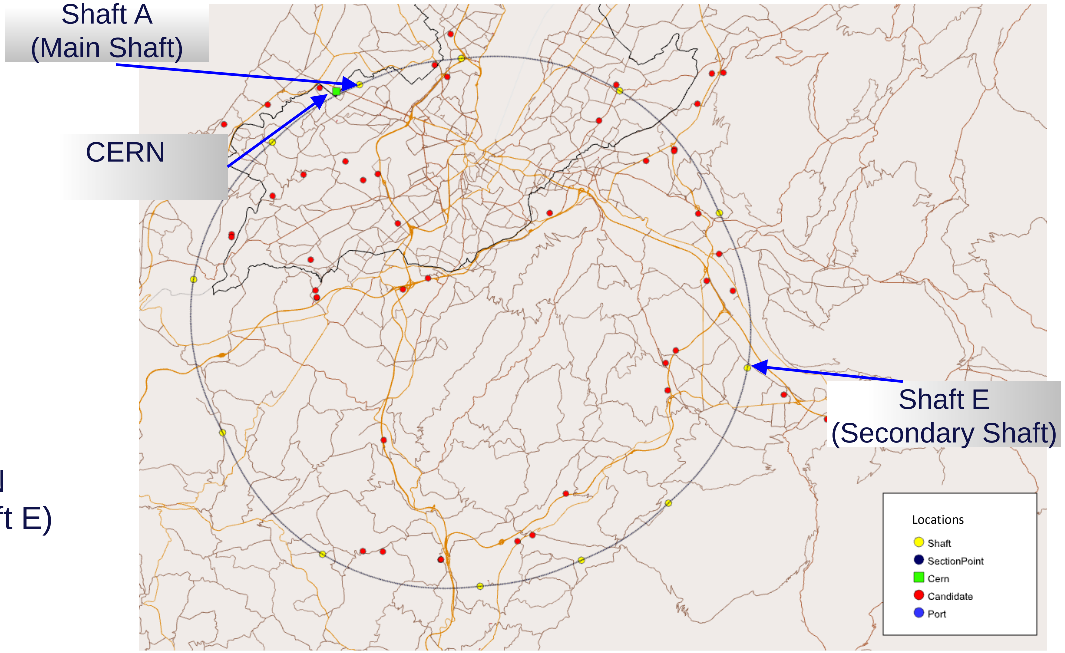
Possible locations for the storage, assembly and testing facilities of cryo-units

Applied criteria

- Suitable size: approx. 10 ha (100.000 sqm)
- Convenient access to major roads
- Not in: city centres, mountain area, nature reserve, e.g. Lake Geneva
- Near to sufficient power supply

Result for two shafts

- Use one Main Shaft (Shaft A) near CERN premises and one Secondary Shaft (Shaft E)



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Logistic study : transport to CERN*

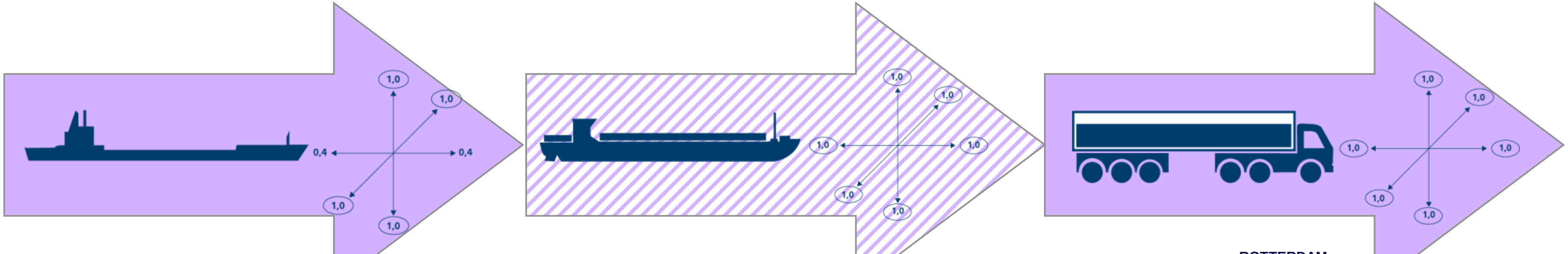
International Transport / Overseas

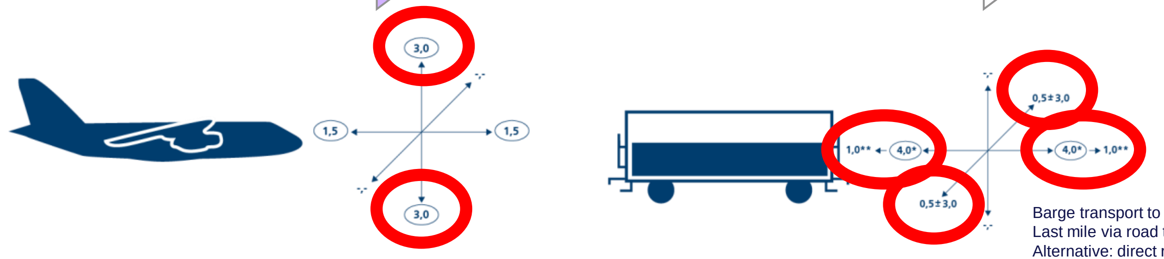
Possible alternatives: containers, roll-on roll-off, cargo, freight with special vessels

Regional Transport

Local Transport / Last Mile

Stresses can be reduced with special transports at low speed





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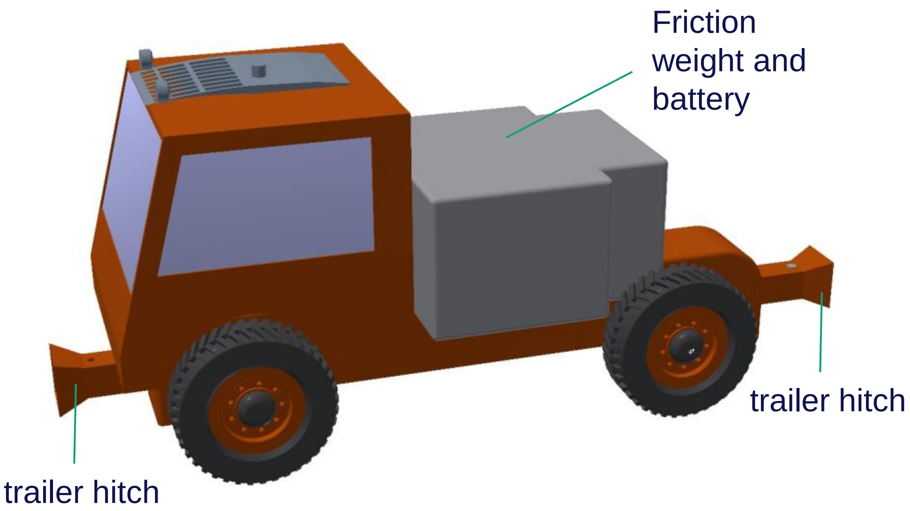
Underground transport*

- Maximum speed: 10km/h – loaded, 20km/h unloaded
- Maximum possible slope: ~3 Degree (ca. 5%)
- Electric drive
- Autonomous driving technology based on contour navigation based on safety laser scanners and navigation scanners

Pulling tractor

The tractor equipped with electric, emission-free and autonomous drive (e.g. with an intelligent navigation and control system allowing autonomous driving in tunnels)



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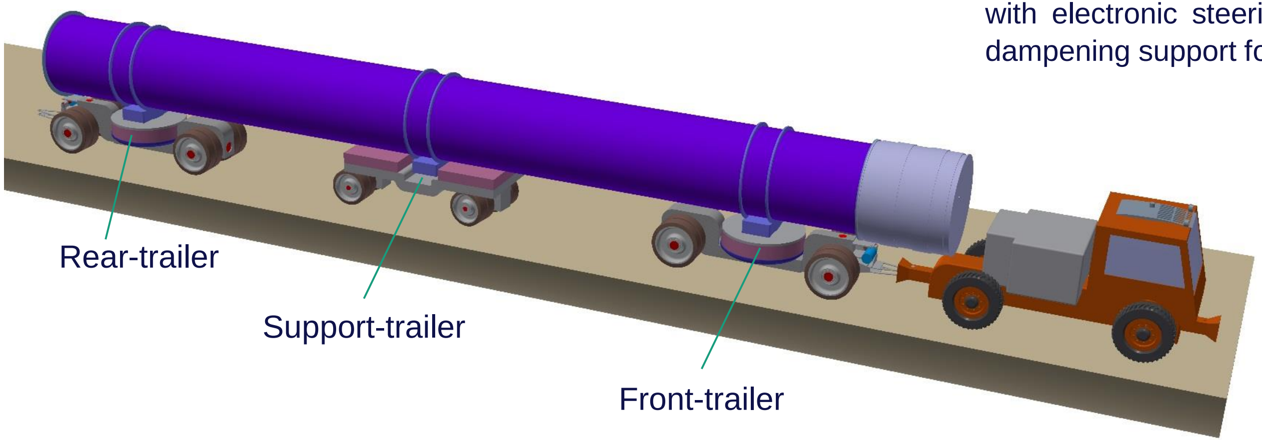
Underground transport*

Transport trailers (rear-trailer and front-trailer) equipped with electronic steering system, drawbar and vibration-dampening support for the loading



Ground contact of the special wheels is secured by using pendulum/swing axles

Support for centre of cryo-unit via supporting third trailer

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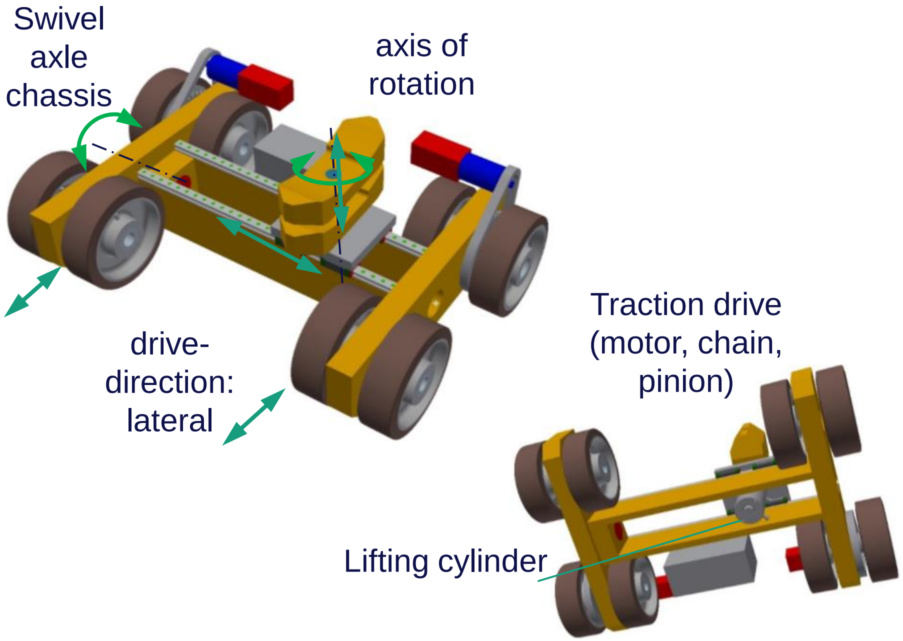
Underground transport*

Two transfer tables equipped with hoists are used for unloading the cryo-units of the transport vehicle

When the tractor with cryo-unit arrives at its designated position (mounting position) in the tunnel, the two transfer tables drive below the cryo-unit

The two transfer tables lift the cryo-unit and move it laterally into the assembling position



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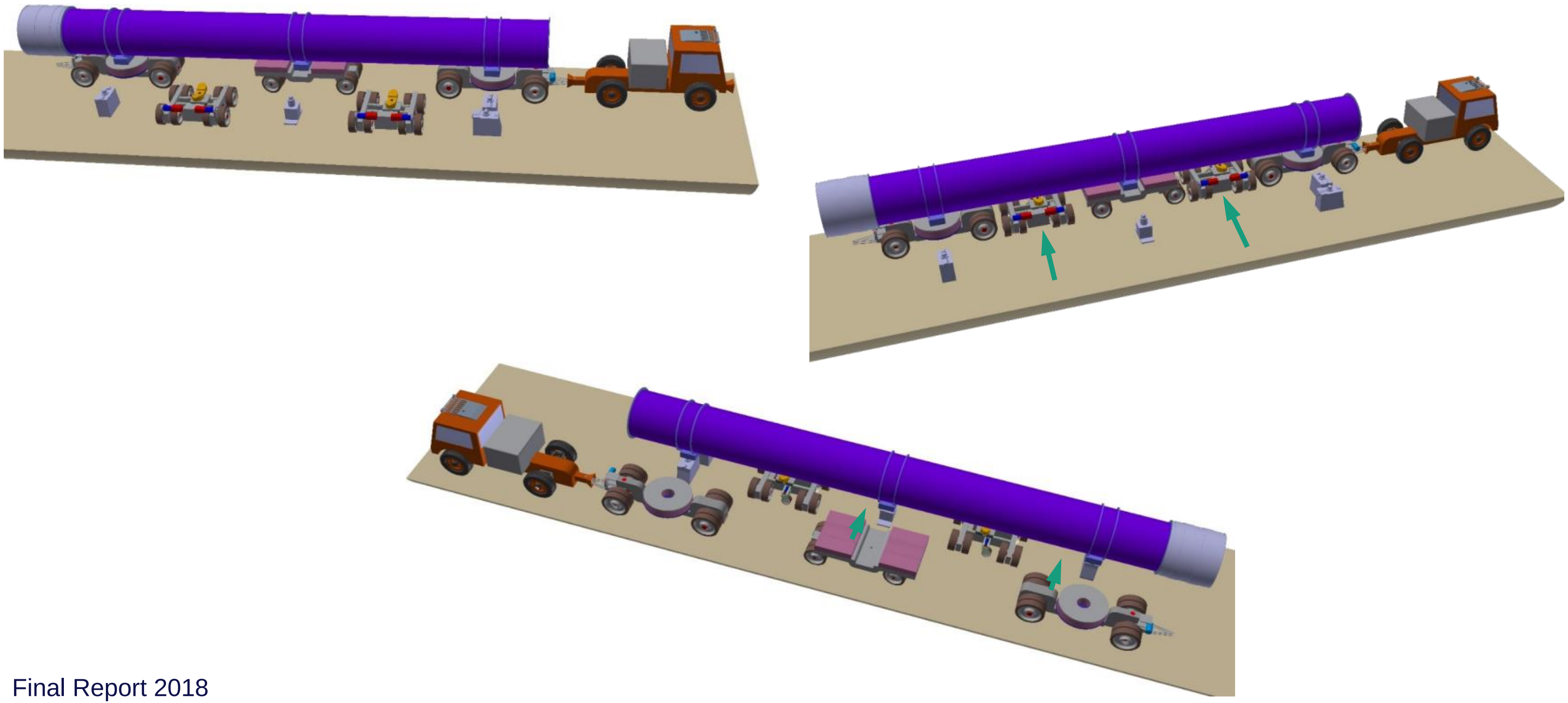
Underground transport*



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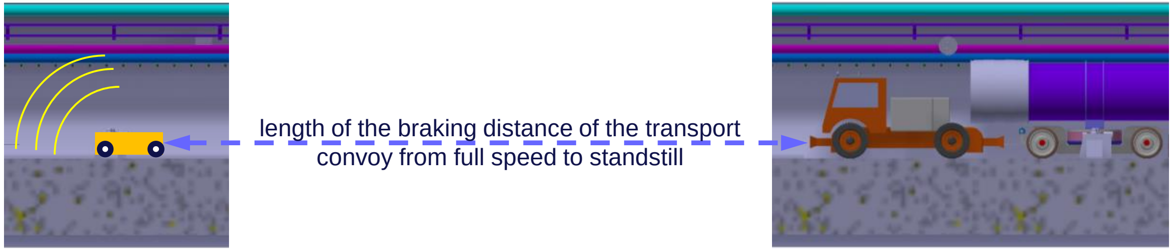
Underground transport*

Speed of vehicles is limited by their capability to do emergency breaks fully loaded within the range of safety sensors

Higher velocities could be realised by the development of a “**watchdog**” principle, where an additional vehicle (or even a drone?) is moving in front of the transport convoy in the tunnel

This watchdog is scanning the environment to identify possible blockings (e.g. assembly tools, cleaning tools, building materials, etc. remaining in the tunnel) and humans on the track

If something is detected the watchdog will trigger an emergency break at the convoy to prevent a collision -> The distance from the watchdog to the transport convoy needs to be at least the distance between the braking distance (length of the braking distance of the transport convoy from full speed to standstill).



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Delivery Scenario*

The aim of the investigations is to analyse different scenarios for a central or decentral organized logistics by CERN. Therefore, a two-step approach was executed:

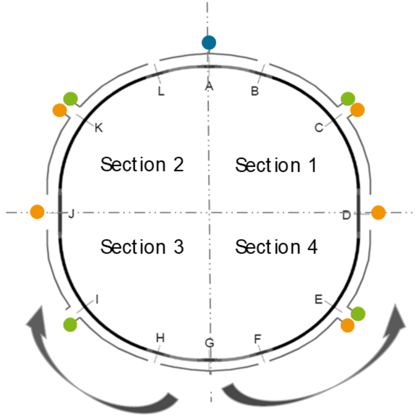
- Identification of a valid tunnel transport scenario
- Identification of a proper delivery strategy

Three different alternatives are investigated

Central Supply Via Shaft A

Decentral Supply Via Two Shafts
Short Overground Transport from CERN: C – K
Opposite Location: E – K
Equal underground Transport Distances: J – D
Combination CERN and additional shaft: A – E

Current Planning
Decentral Supply Via Four Shafts
C – K – E – I



Alternative	Total number of transport vehicles
Alternative 1.1	5
Alternative 1.2	8
Alternative 2.1	4
Alternative 2.2	4
Alternative 2.3	4
Alternative 2.4	6
Alternative 3.1	5

Parameter	Value
Underground transport (speed loaded)	10 km/h
Underground transport (speed unloaded)	20 km/h
Transport time interval	10 PM – 6 AM (Duration: 8 hours)
Loading time (crane transport included)	1h
Unloading time	1h
Duration assembly (LHC x1 / x2 / x3) in days	5.33 / 10.66 / 15.99
Duration coldmass test (LHC x1 / x2 / x3) in days	5 / 10 / 15

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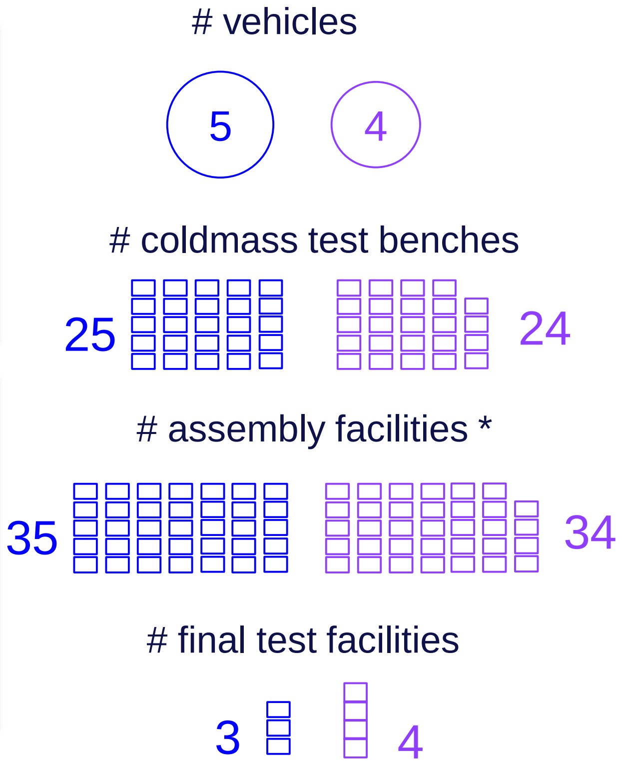
Delivery Scenario*

Central supply via shaft A

+ existing capacities at CERN can be used (cryo-plant, storage capacities,..)
– disturbances in the tunnel or at the shaft like delay in installing, crane failures will have a major impact on compliance of construction schedule

Decentral supply via two shafts A and E

+ existing capacities at CERN can be used (cryo-plant, storage capacities,..)
+ alternative far more robust
– costs for construction higher than central supply alternative,
– additional area outside CERN needed for facilities at second shaft
– long transport ways for tested magnets on public roads if test/assembly facilities remain at CERN area



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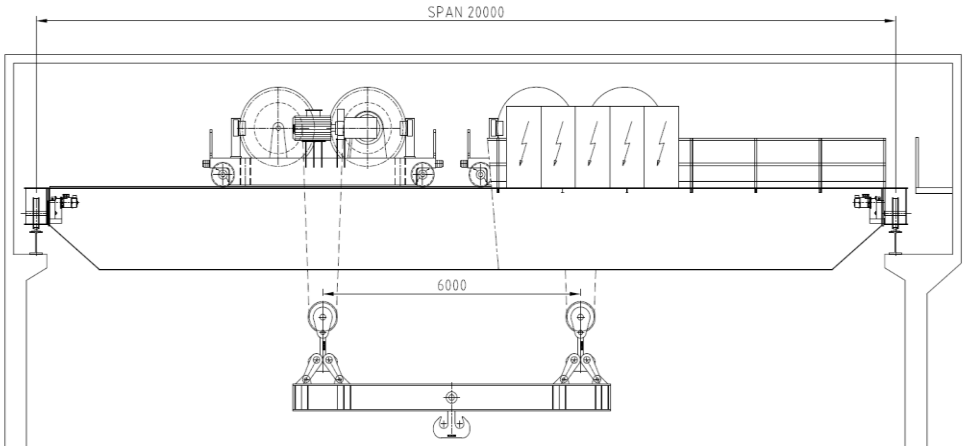
Shaft cranes

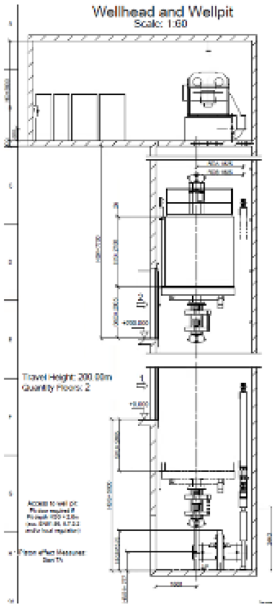
- Crane lifting heights of ~3000m currently feasible and in operation
- offshore and mining industry



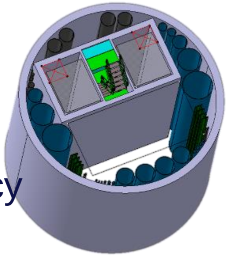
- Lifting heights of 400m in itself not a problem but problematic with standard EOT crane layout
  - Twin rope drum system → major impact on bldg. height and width
  - Or multiple layers of ropes … normally not applied on EOT cranes
  - Push and pull system combined with strand jack lifting systems as applied for CMS also remains an option for handling heavy detector components

Limit, as much as possible, the length of cables (very heavy)

Lifts



- Lifts with standard steel wire ropes should still do for shaft depths of 400m but
  - Will require fix landing systems for 3t lift due to rope extension/flexibility when loading/unloading lift cabin
  - Lift redundancy a must (i.e. one 3t/35people and one 350kg/4people lift operating next to each other in the same shaft)
  - Higher lift speed (min. 5 m/s for 3t lift and 10 m/s for 350kg lift) requires more pit depth and top clearance
  - n° of people in tunnel depends on evacuation means → lift capacity and speed
  - Will not be possible to simply take over the shaft, pit & machine room dimensions from LHC
- By the time of the FCC construction carbon fibre cables in lifts could have become a standard



⚠ Limit, as much as possible, the length of cables (very heavy) and keep redundancy

What's next

Feasibility studies on:

- Vehicles for transport & handling of magnets for FCC-ee
- Logistics up to FCC site & delivery from surface to final position
- Vehicles for transport of people in the tunnel (emergency etc.)
- Cranes for surface buildings and shafts
- Lifts

Some parameters will have to be fixed, e.g. dimension and number of the shafts, slopes -> iterative study

Thank you for your attention.