# Civil Engineering :

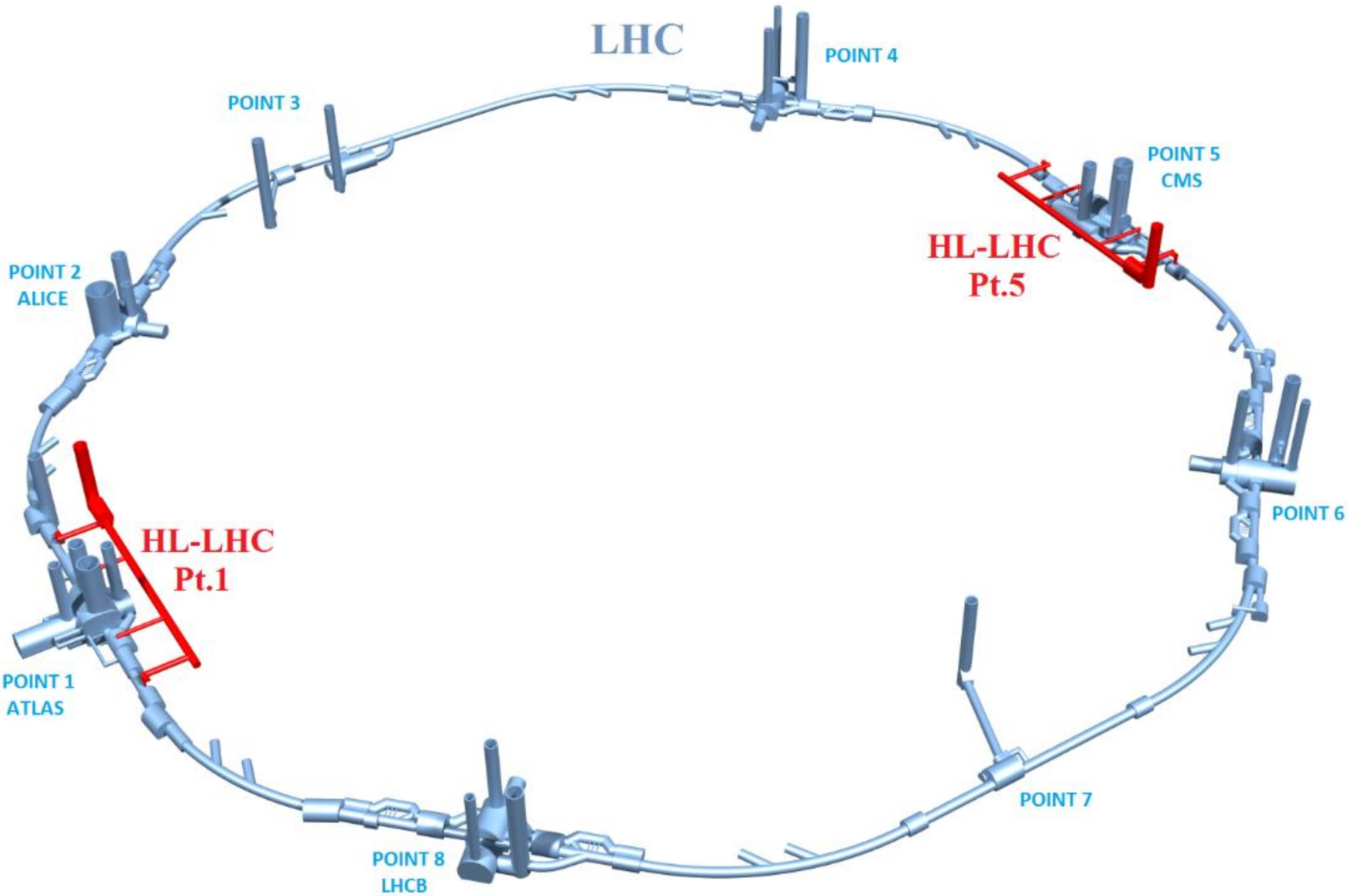
# Latest Layouts and Key Challenges

John Osborne GS/SE/FAS on behalf of Civil Engineering WP 17.1

5th Joint HiLumi LHC-LARP Annual Meeting : 27 October 2015

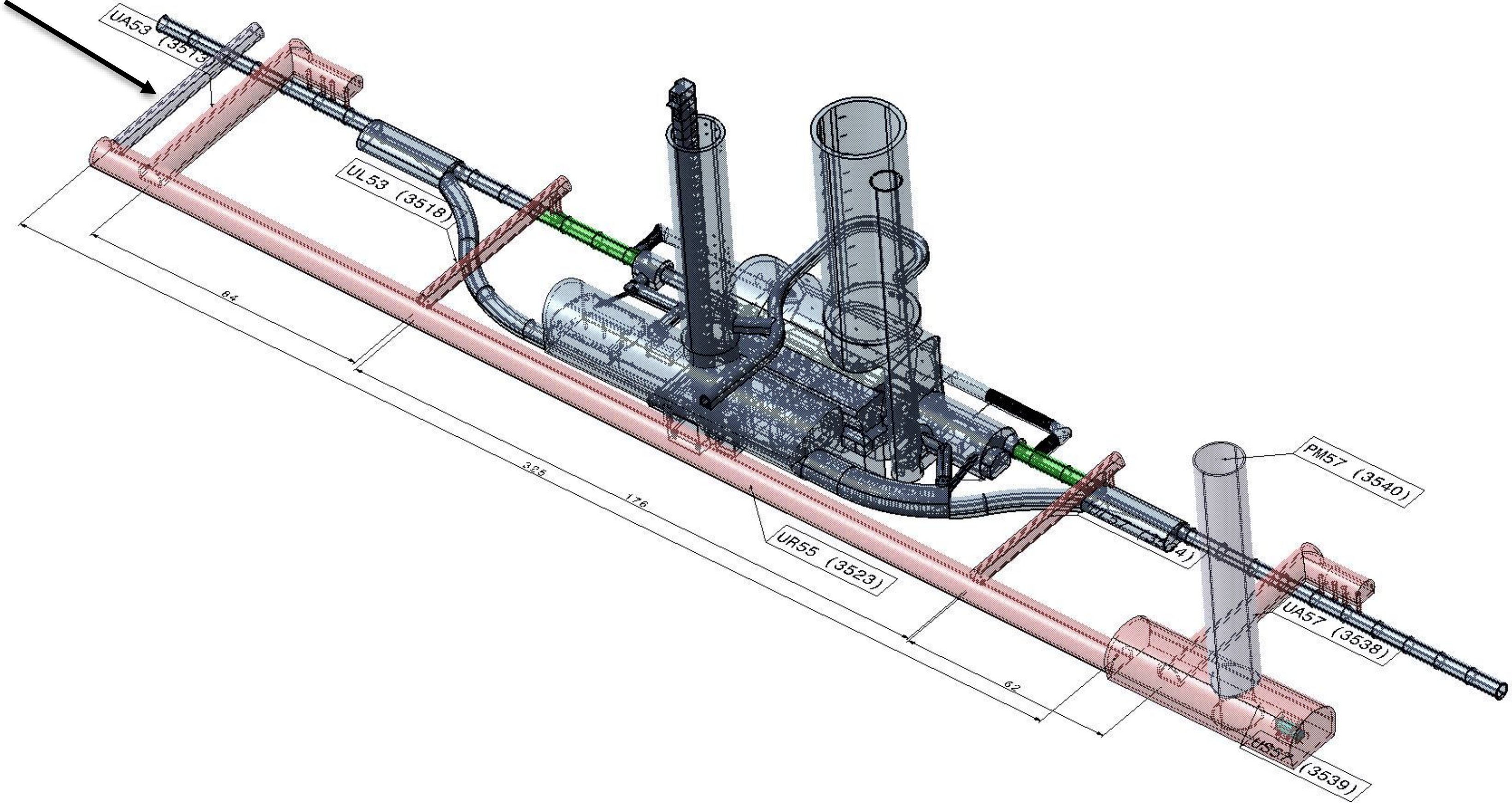
- ***Latest Layouts for civil engineering works :***
  - LHC Point 1 ATLAS
  - LHC Point 5 CMS
  - Proposed contract strategy and planning for civil works
- ***Key challenges and lessons learnt from LHC civil works :***
  - Technical (unforeseen ground conditions, vibration impact on LHC, water ingress)
  - Environmental (rock disposal, noise)
  - Planning (Delay in Bld permits, vibration, revised LS2 schedule, installation windows for other CERN contractors)

# Underground works at LHC Point 1 & 5

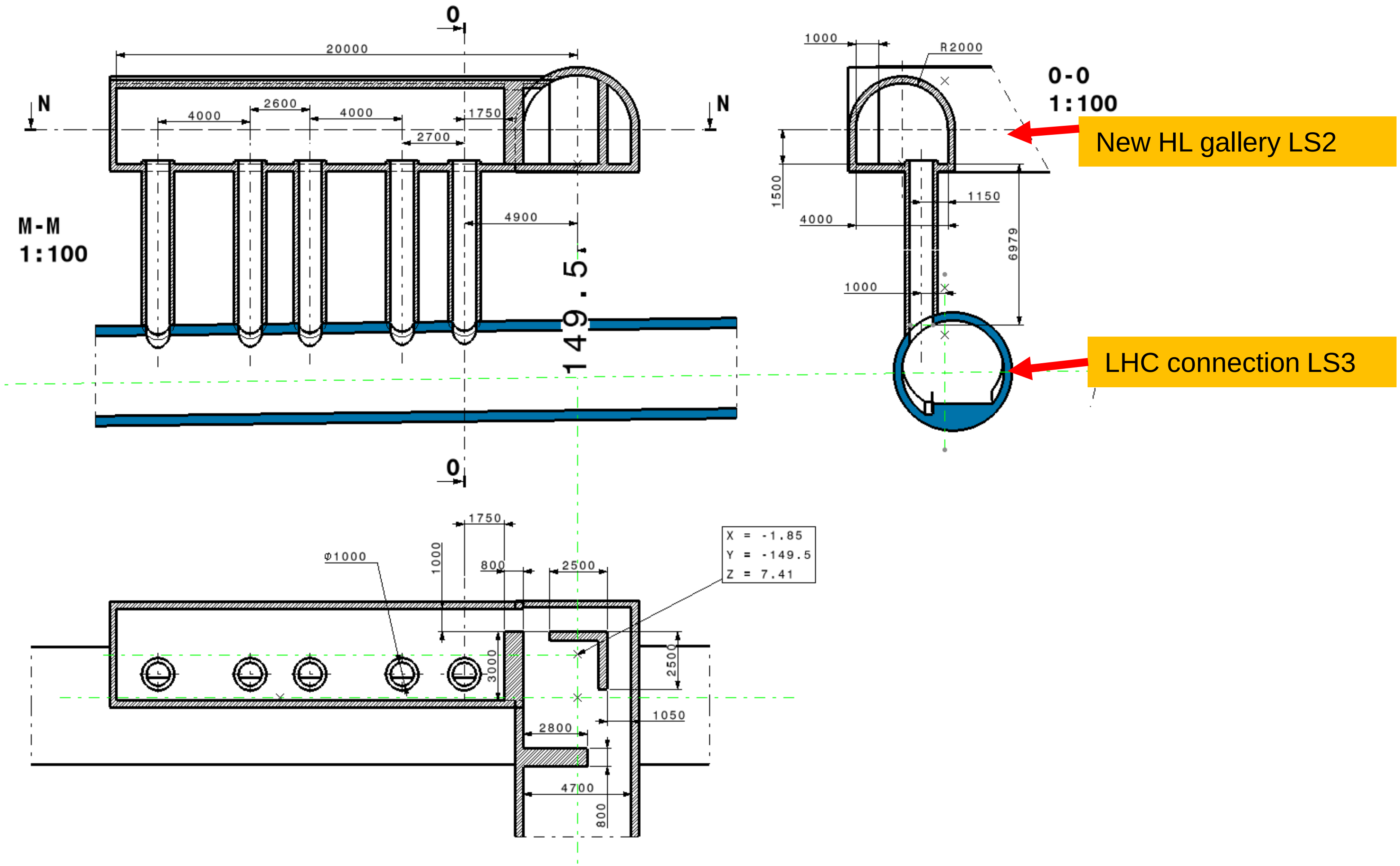


# Underground works at Point 5

**Emergency escape tunnel option**



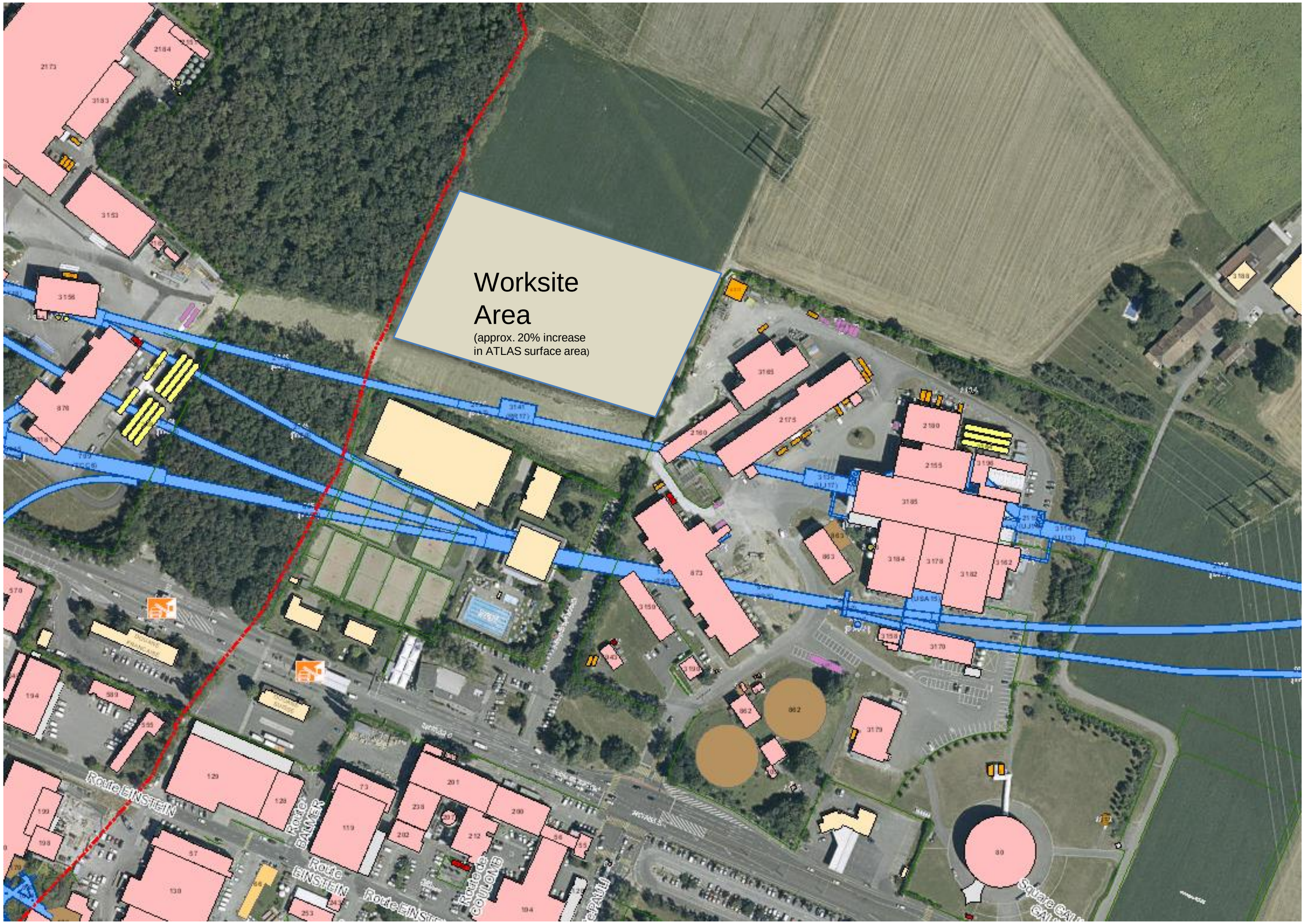
# Vertical cores will be drilled down into LHC



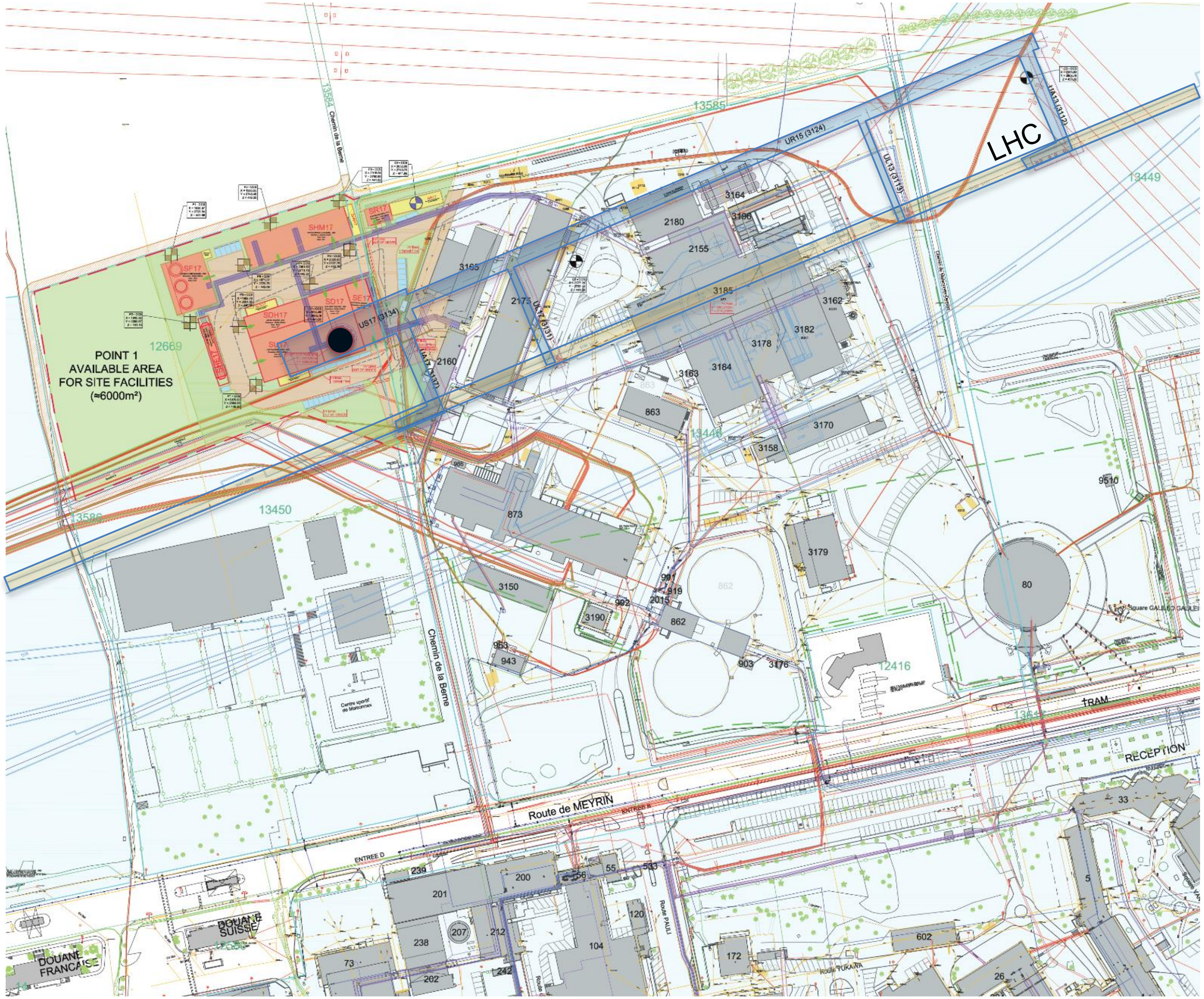
# Proposed site Boundary enlargement for civil works : Point 5 CMS

# Surface Works at Point 5 CMS

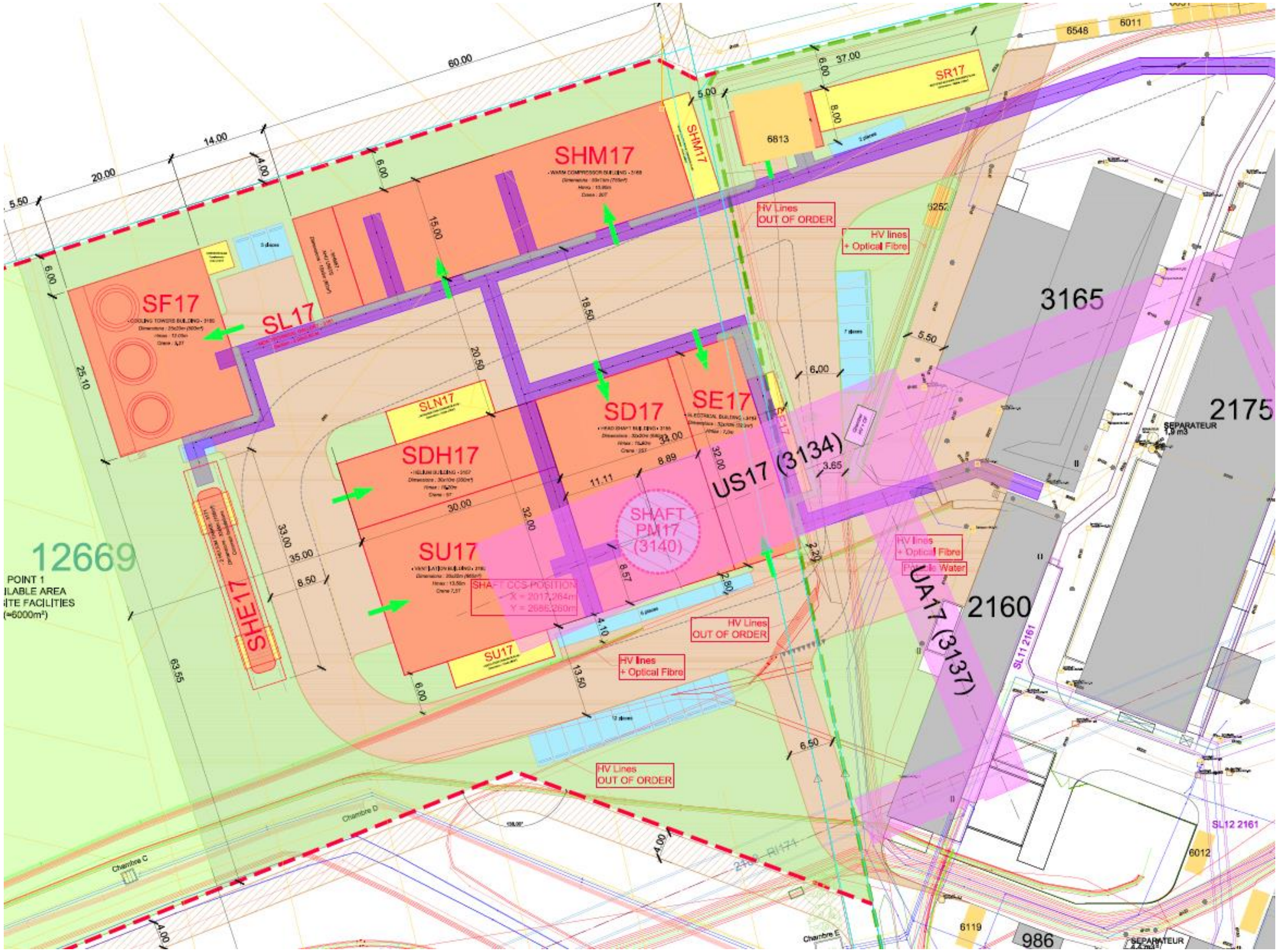
# Proposed site Boundary enlargement for civil works : Point 1 ATLAS



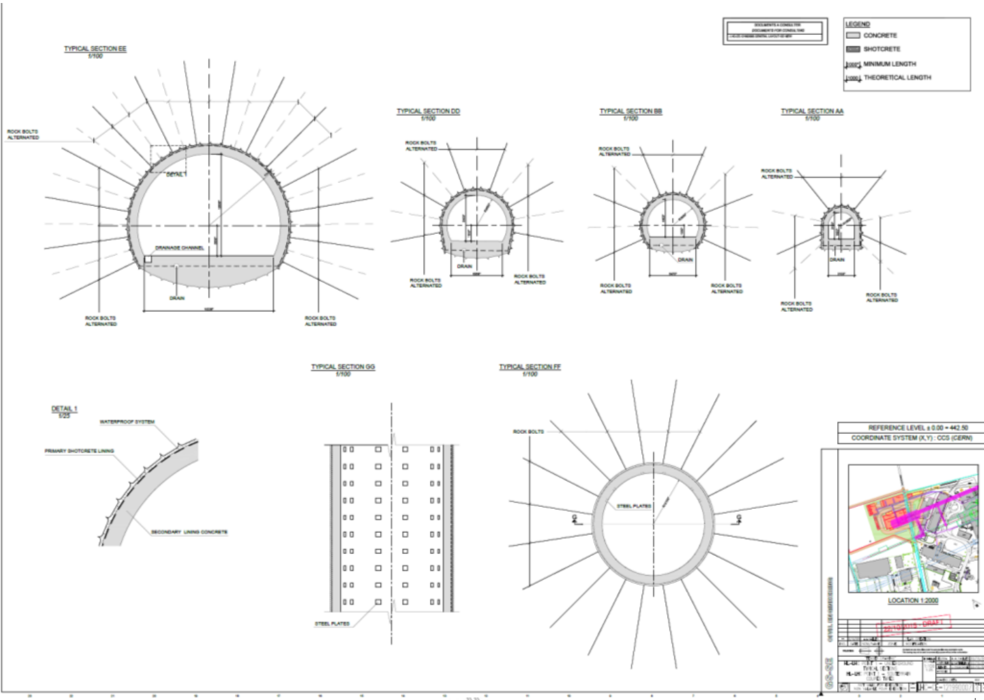
# Surface Works at LHC Point 1 ATLAS (1)

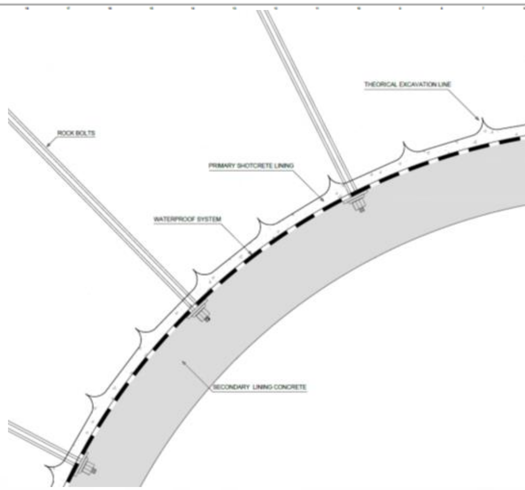


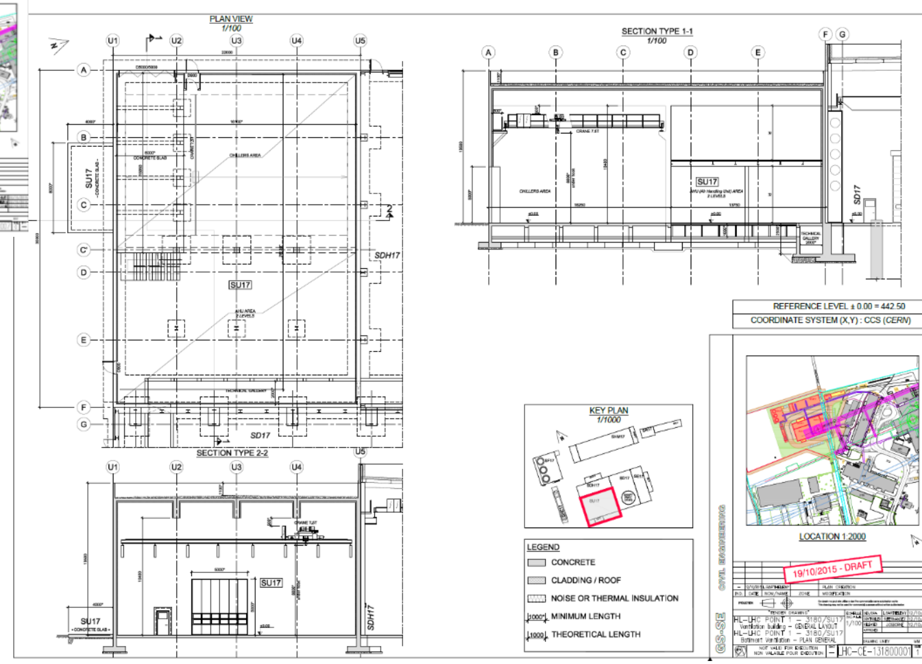
# Surface Works at Point 1 ATLAS (2)



# More detailed civil drawings are being prepared for design tenders

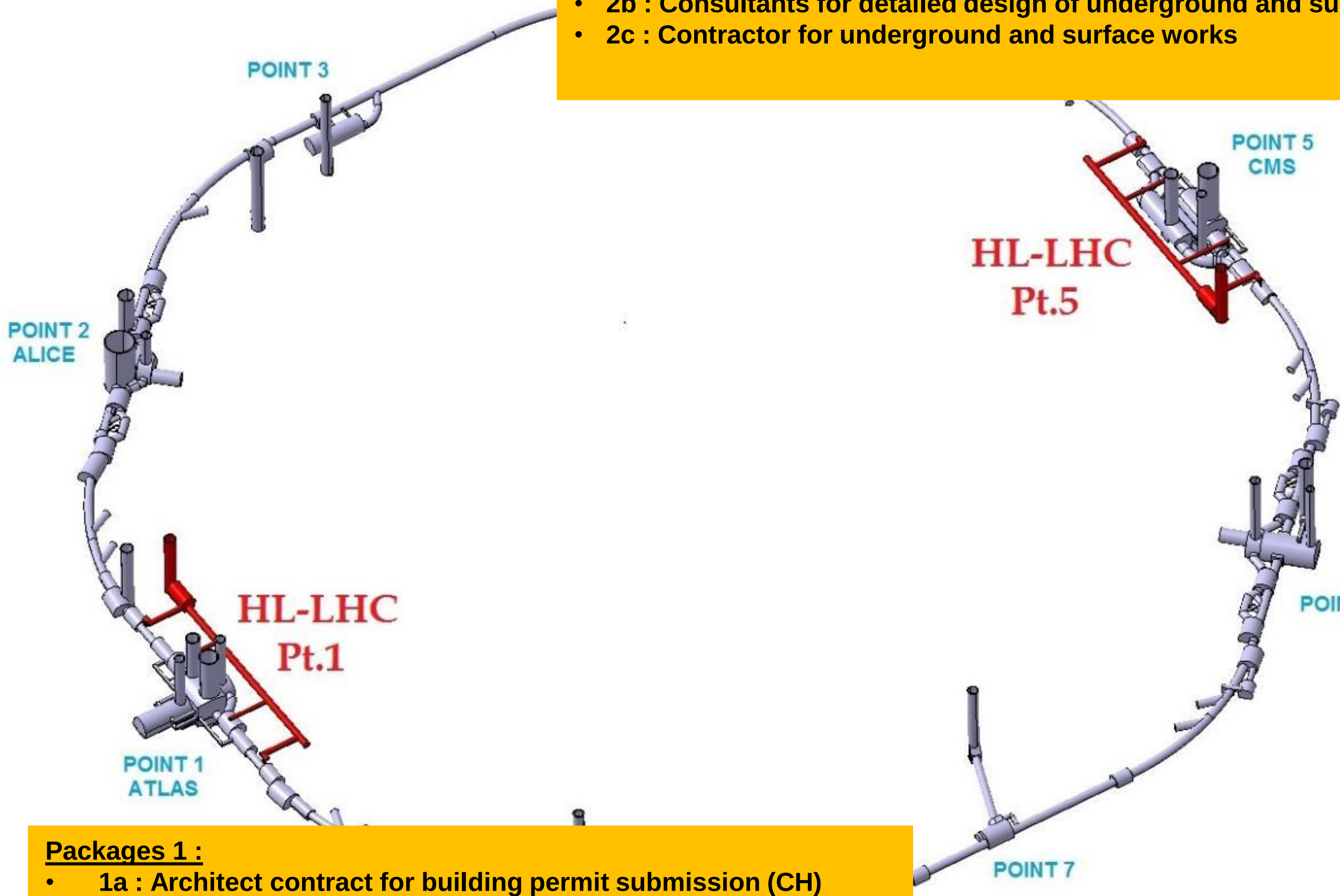


# Proposed civil engineering contract strategy

**Packages 2 :**
- **2a : Architect contract for building permit submission (F)**
- **2b : Consultants for detailed design of underground and surface**
- **2c : Contractor for underground and surface works**

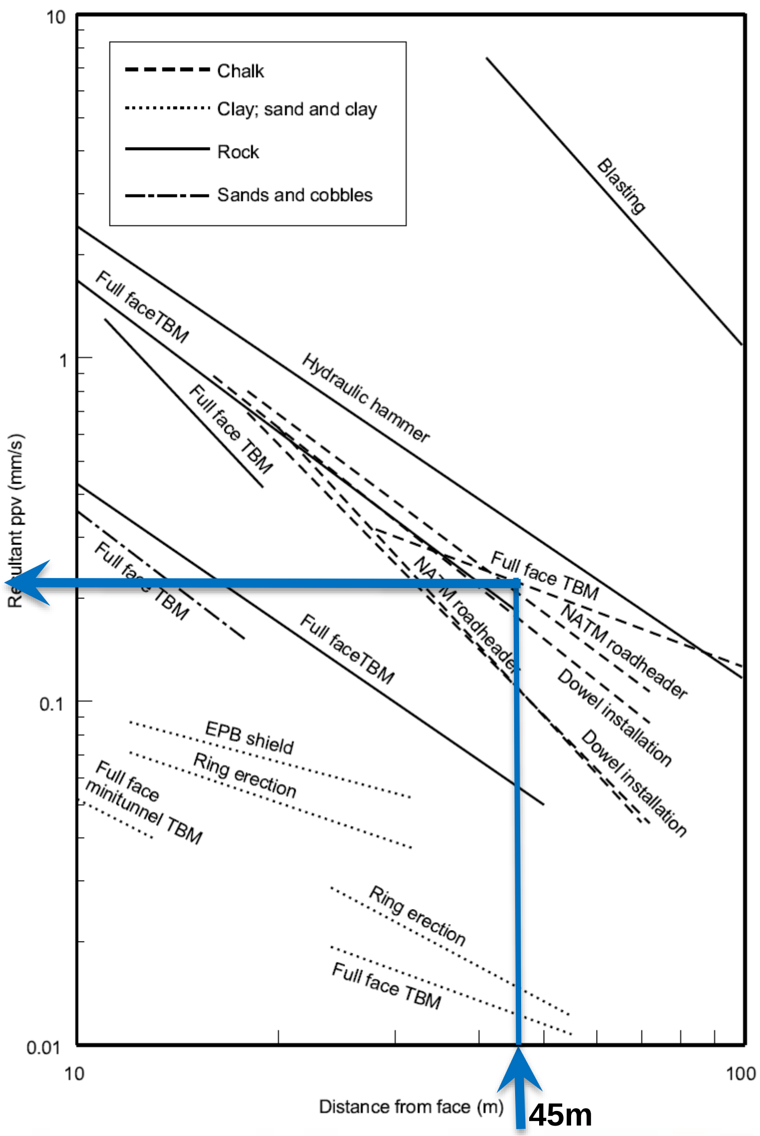



**Packages 1 :**
- **1a : Architect contract for building permit submission (CH)**
- **1b : Consultants for detailed design of underground and surface**
- **1c : Contractor for underground and surface works**

# The main ‘vibration’ activities are driving the civil engineering planning

Results from Dr Hiller’s (Arup) studies - Vibration from tunnelling

**0.2 mm/s**
**$2x10^{-4}$ m/s**
**200μm/s**

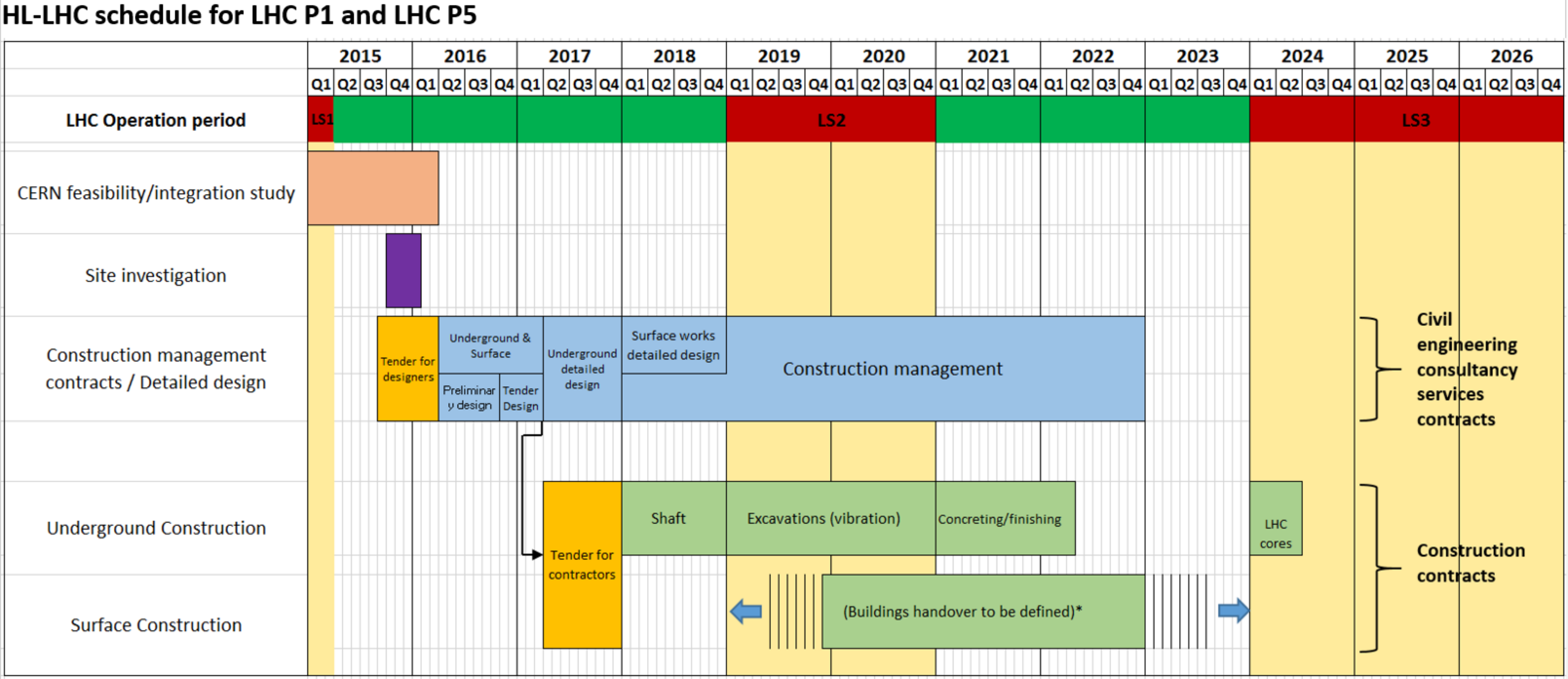



Roadheaders will be used for excavation

**At 45m, tunnelling vibration would give ~200μm/s peak**

More testing planned with EN/MME

# Proposed civil engineering planning



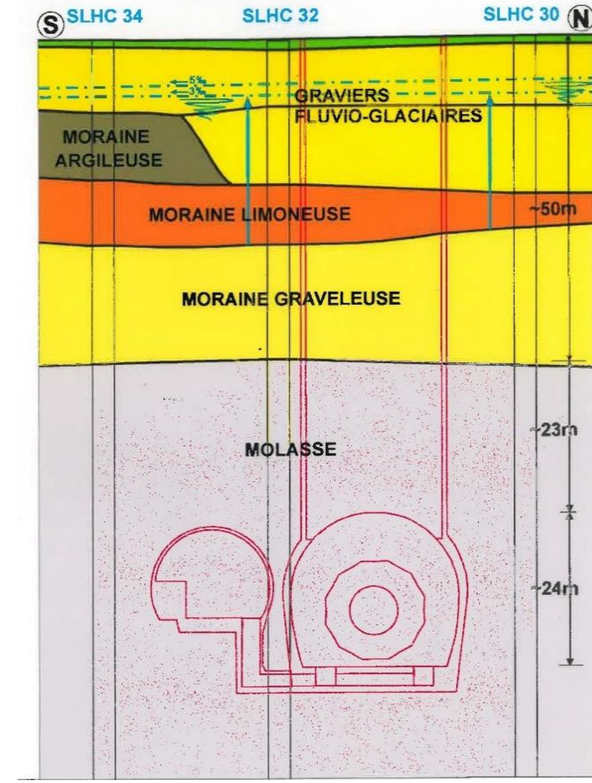

*Civil engineering only (fit-out with services and equipment occurs after these completion dates)

John Osborne GS/SE/FAS

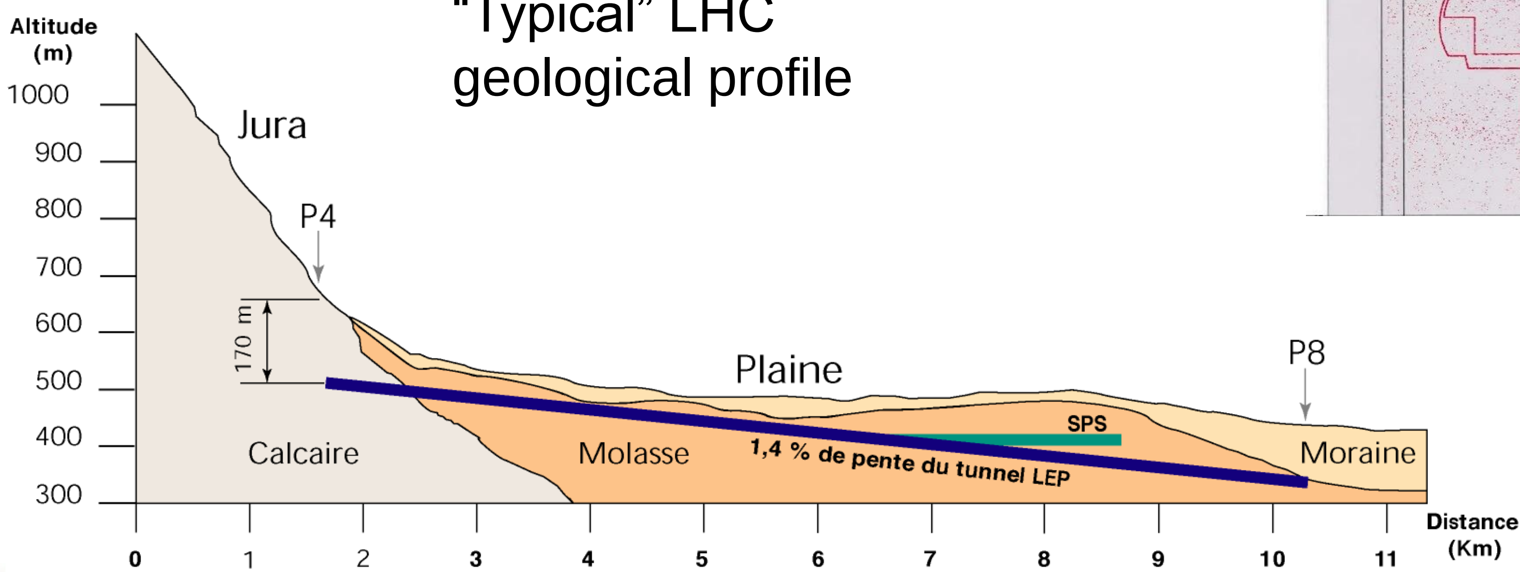
- ***Key challenges and lessons learnt from LHC civil works :***
  - Technical (e.g. unforeseen ground conditions, vibration impact on LHC, water ingress)
  - Environmental (e.g. rock disposal, noise)
  - Planning (Delay in Bld permit, vibration, revised LS2 schedule, installation windows for other CERN contractors)

# Technical Challenges : Unexpected ground conditions

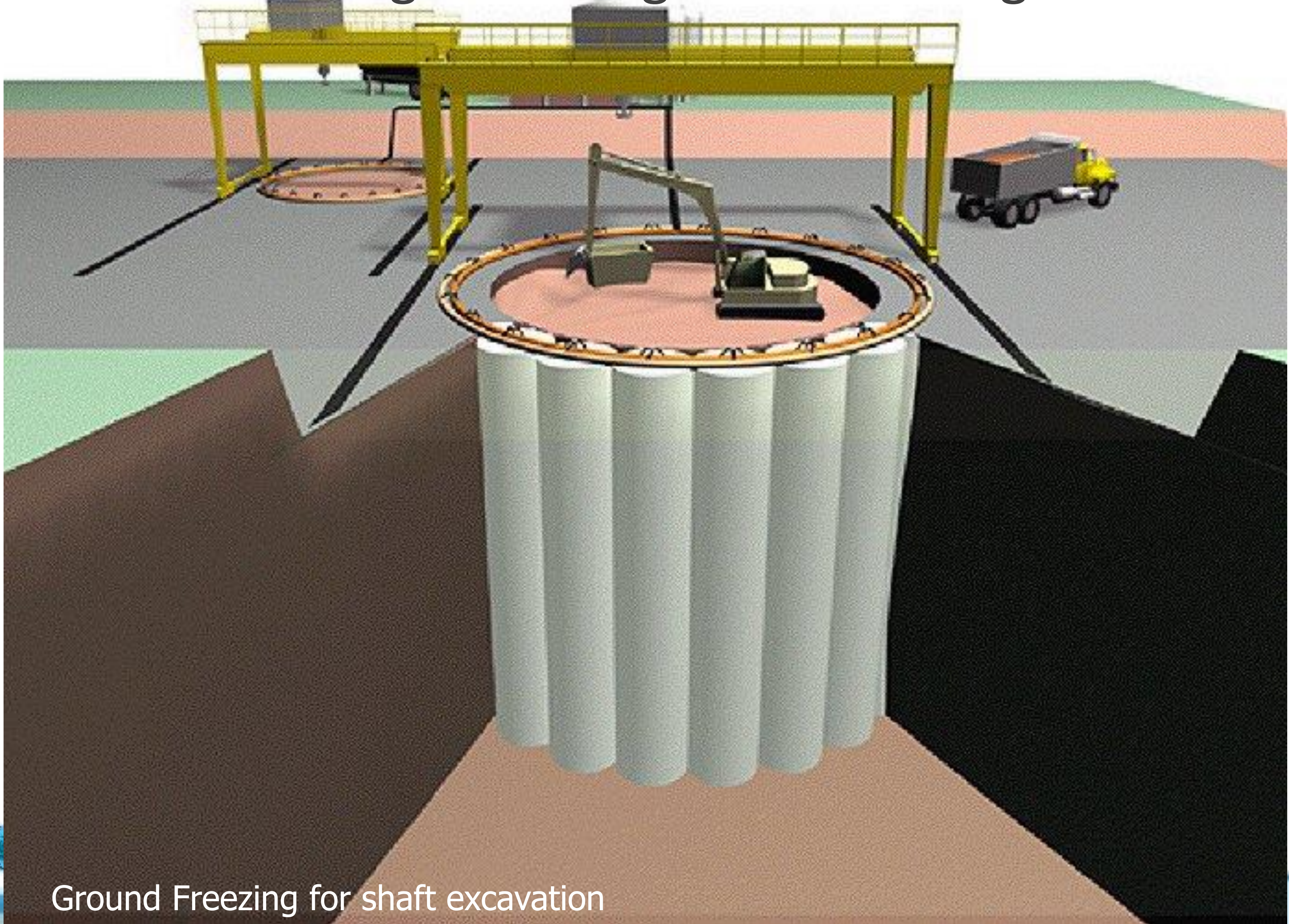
Point 5 CMS geological profile is complex




"Typical" LHC geological profile



# Technical Challenges : CMS ground freezing : 1998-2000




1999

Point 5 -Excavation commencement of PM54 shaft - July 09, 1999 - CERN ST-CE


Dragados


Higher than expected groundwater velocities between shafts

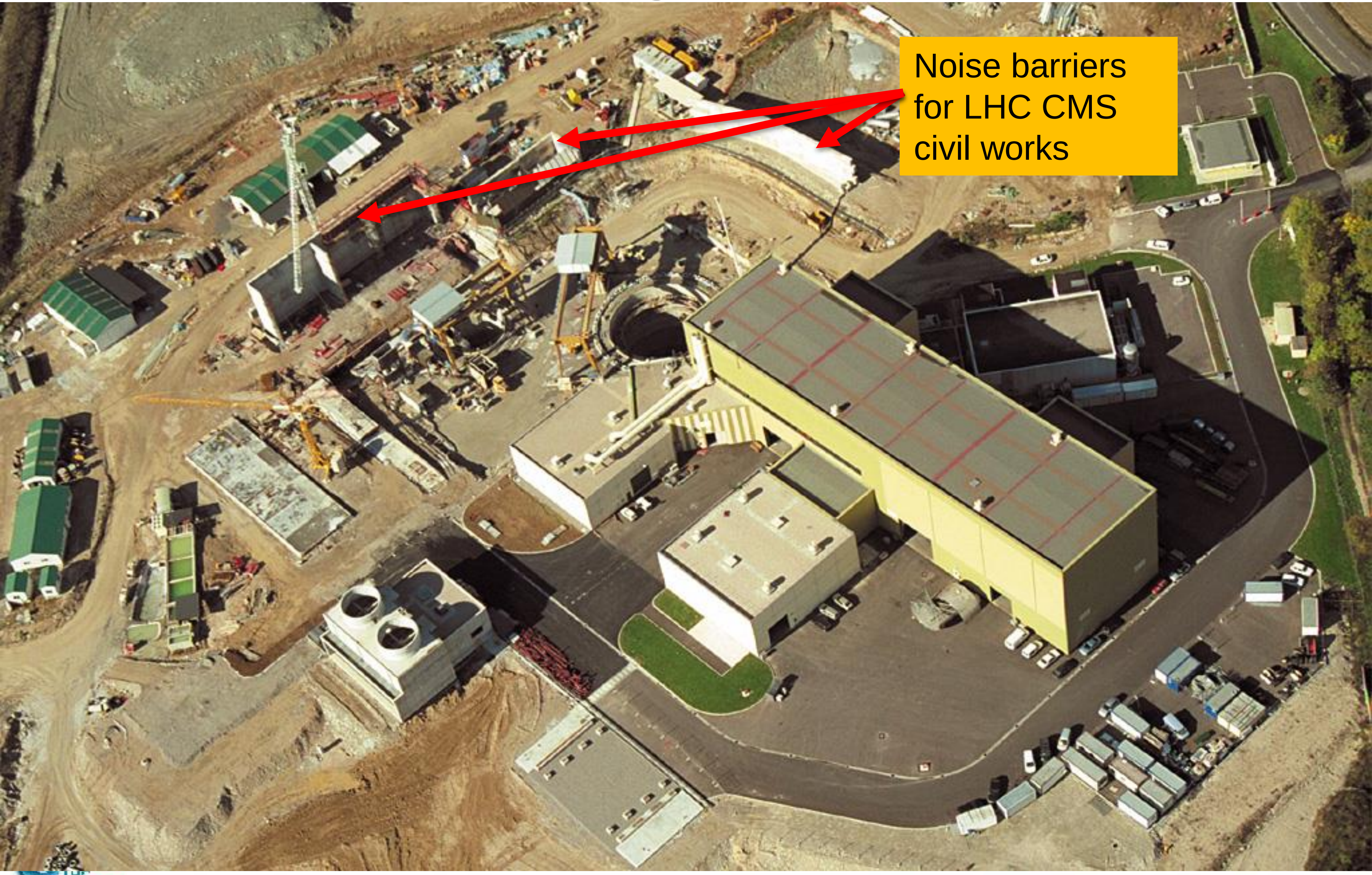
# For HL shaft at CMS we will study Diaphragm Walls

# Good Site Investigation records are essential

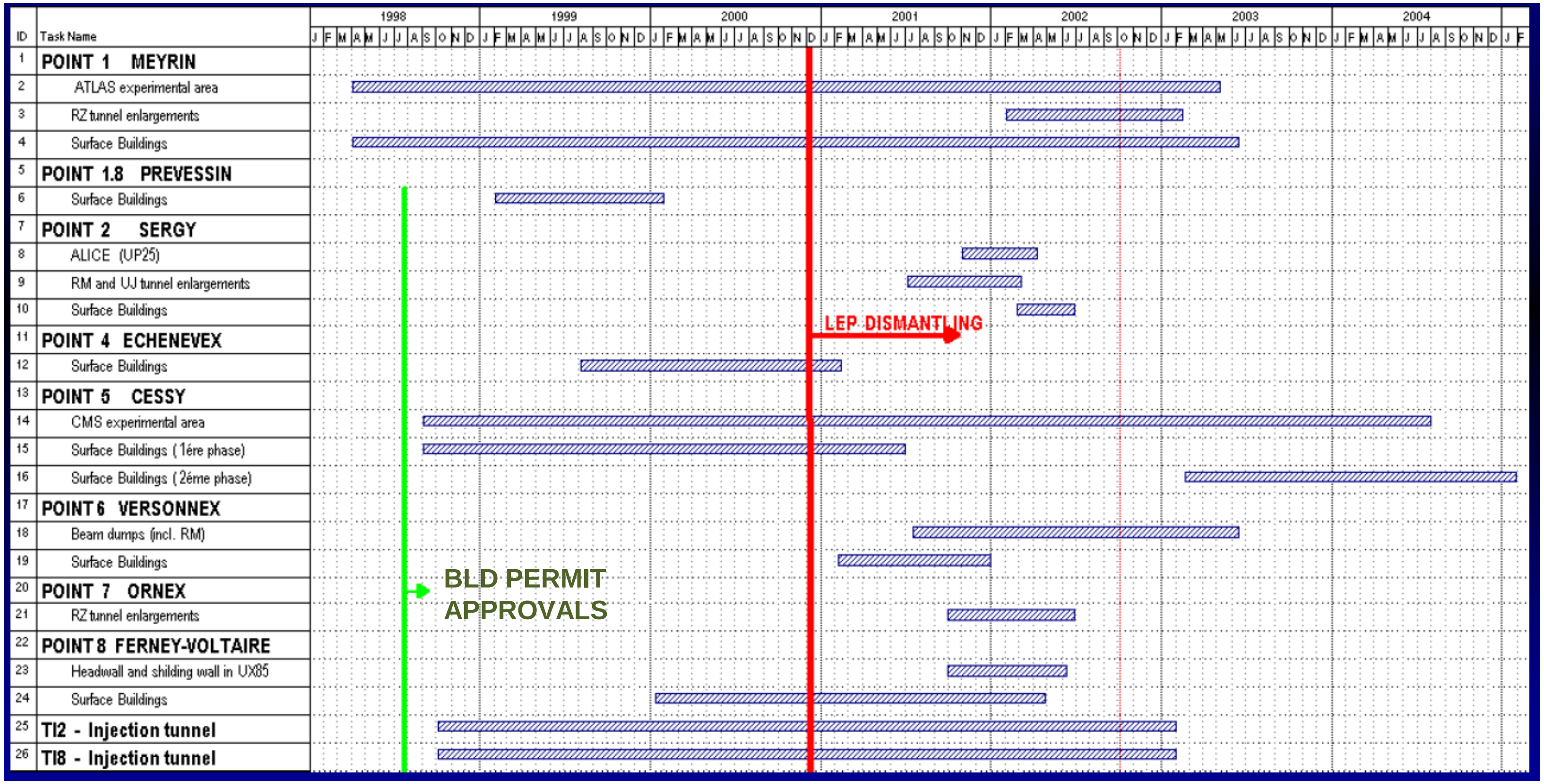

Test drilling for new shaft at LHC Point 5 CMS

# Environmental Challenges : Rock disposal

# Environmental Challenges : Noise disturbance



# Planning (Delay in Bld permits, vibration, revised LS2 schedule, installation windows for other CERN contractors)




**LHC AS-BUILT CIVIL ENGINEERING PLANNING**

# Planning challenges : Intervention windows for ‘other’ contractors

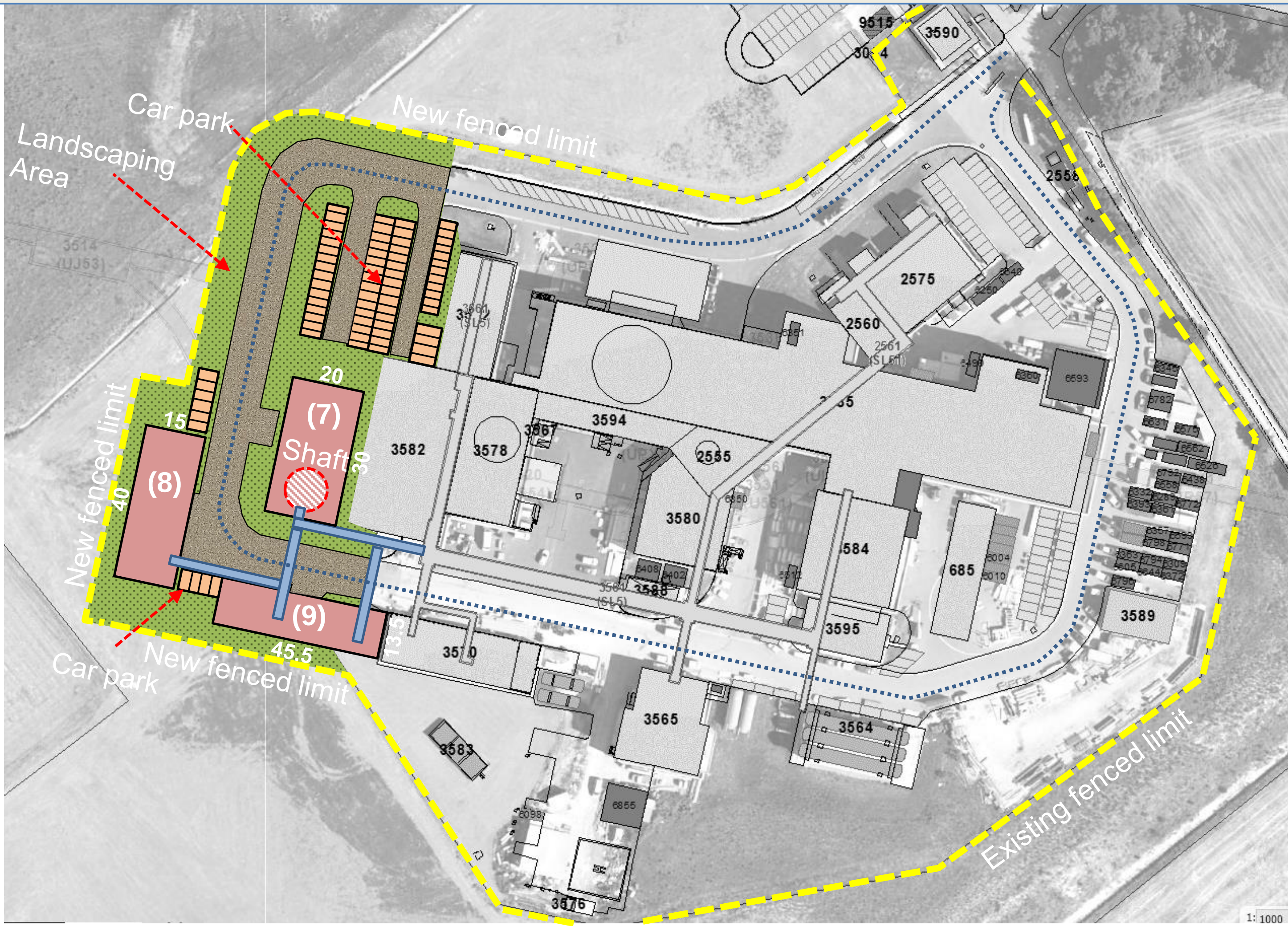
Precast Concrete lift modules in shaft

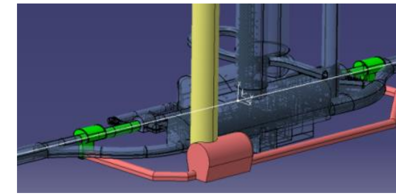
Metallic staircase in shaft for services

# Thank you for your attention

John Osborne GS/SE/FAS on behalf of Civil Engineering WP 17.1

# HL-LHC at Pt.5: SURFACE BUILDINGS (hypothetical surface arrangement)



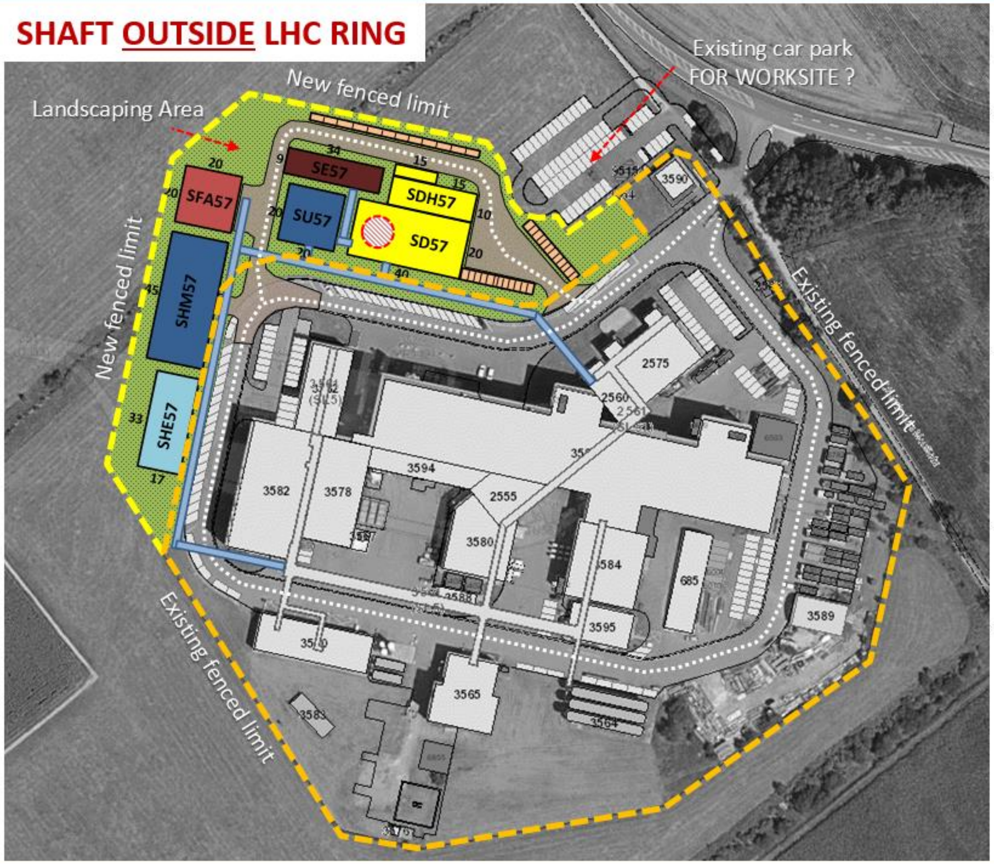
TRANSPORT SIDE, WITH NEW SHAFT

Shaft positions have moved many times during 2015

# Shaft positions have moved many times during 2015

General Infrastructures Services Department

## HL-LHC: SURFACE BUILDINGS (Underground Option). **New layout proposition**



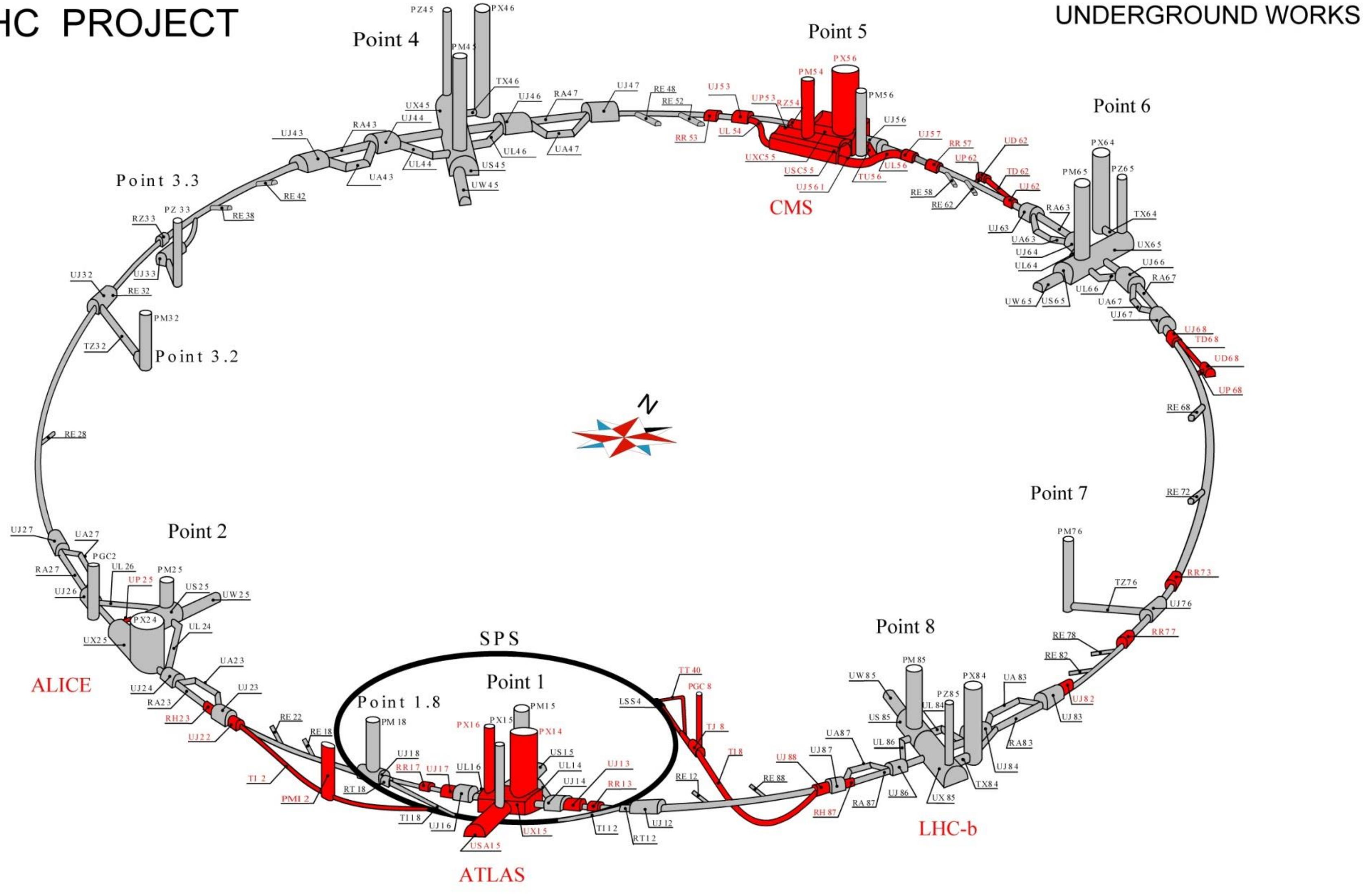

## Few considerations..

- Worksite Access
- New buildings and related area are close to the CESSY Village (Environmental Impact ?);
- The expansion area identified is in an open field, within CERN domaine, partially used as landfill in the past;
- Soil level is higher compared to the average CMS site level;
- New fenced area (~10'000m2) increases by ~23% the current perimeter.

18/06/2015 J. Osborne, M. Manfredi, GS-SE-FAS 05

# LHC PROJECT

UNDERGROUND WORKS




TS-CE
2005

**Peak particle velocity** refers to the maximum speed of a particular **particle** as it oscillates about a point of equilibrium that is moved by a passing wave. It is a term used to describe vibration, or elastic movement, resulting from excitation by seismic energy as it passes a particular point.

# Scope of work – Task 1: Roadheader data

**Task 1: Roadheader Vibration Support**

→ Investigate roadheader suppliers

→ Case studies

→ Potential vibrations and impacts on the LHC from the HL-LHC tunnelling works

*Nota:* need to know understand tolerable limits along the LHC.

$$PPV = 2 * \pi * f * A$$

With PPV = Zero-to-Peak, or Peak Particle Velocity (Units: m/sec, mm/sec)

f = Frequency (Units: Hertz)

A = Zero-to-Peak, or Peak Displacement (Units: m, mm)

i.e. for 1 µm:

| Frequency Hz | Amplitude µm | PPV mm/s |
|---|---|---|
| 50 | 0.6 | 0.19 |
| 50 | 1 | 0.31 |
| 100 | 1 | 0.63 |
| 150 | 1 | 0.94 |
| 200 | 1 | 1.26 |

3) Acceptable amplitude will vary according to the time scale:

- Long time scale (weeks/months):

  few 10th of mm

- Time scale < hours (based on present mode of operation of the machine without orbit feedback in stable beams):

  well below 1 µm (at the triplet)

- up to a few hundred Hz:

  1 µm (at the triplet)

  in order to avoid visible effects on luminosity and losses (emittance blow-up effect to be studied)

- kHz range:

  <1 nm (at the triplet)

  likely pessimistic, but dependent on exact frequency range and spectrum (frequency spectrum could overlap with betaron sidebands) => emittance growth

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ARUP