FUTURE
CIRCULAR
COLLIDER

SUMMARY OF PRESENTATIONS ON IMPLEMENTATION STUDIES AND CIVIL ENGINEERING

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Host States and Civil Engineering Pillar Coordinator

gratefully acknowledging the contributions and presentations made by the FCC Host States and Civil Engineering WG and all FCC study teams and collaborating partners

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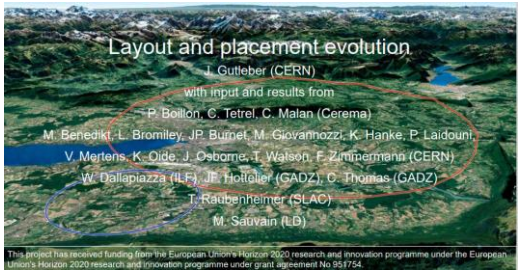
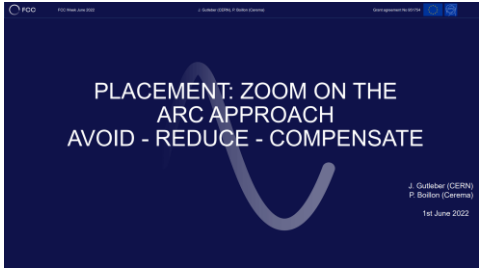
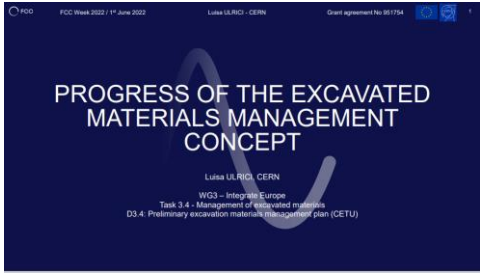
FCCIS WP3: Placement Studies and ARC Approach



Johannes Gutleber (CERN)

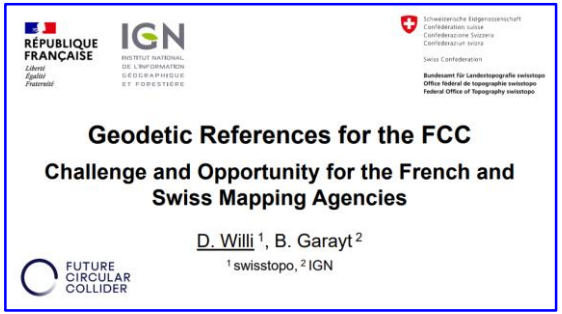


Pierre Boillon (Cerema)



Luisa Ulrici (CERN)

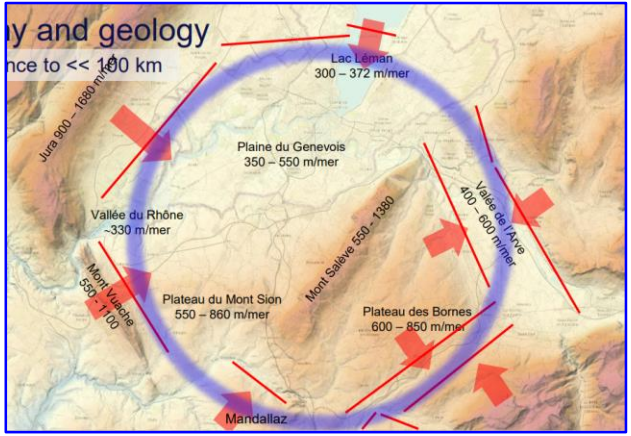
Patrycja Laidouni (CERN)



Daniel Willi (Swiss Topo)

Placement

- History and progress of the placement studies presented.
- More than 100 alignments have been studied over a number of years
- Comparison of all these options was done using a rigorous multi-criteria process enabling a transparent and logical outcome to be derived
- Finally an 8 point option was deemed beneficial



PROS:

8 sites **use less land** (36 ha vs. 62 ha)

Possibility for 4 FCC-ee **experiment** sites

All sites **close to road infrastructures** (3.5 km of road constructions needed for all sites)

RF sites **close to 400 kV grid lines**

PA **profits from LHC Pt8 infrastructures** and main CERN cooling water supply line

Less excavated materials

Good connection of PD, PF, PG, PH **to Annecy** putting IN2P3/LAPP in the position to acts as a second pole for design, construction and operation.

CONS:

Smaller (91 km vs. 98 km)

Longer distance between sites generates different requirements and constraints for technical infrastructures (water supply, electricity, cryogenics, tunnel transport)

Only a **single shaft to experiment** cavern

Some technical shafts are displaced along the ring

Deepest shaft at **PF (400 m) requires a horizontal connection** tunnel to the ring at the bottom of the shaft (400 m long).

Placement

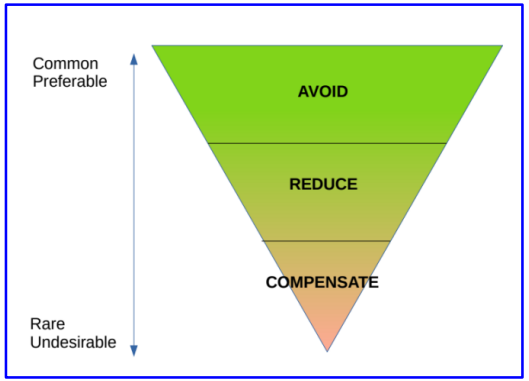
Ongoing / future work that needs to be done includes:

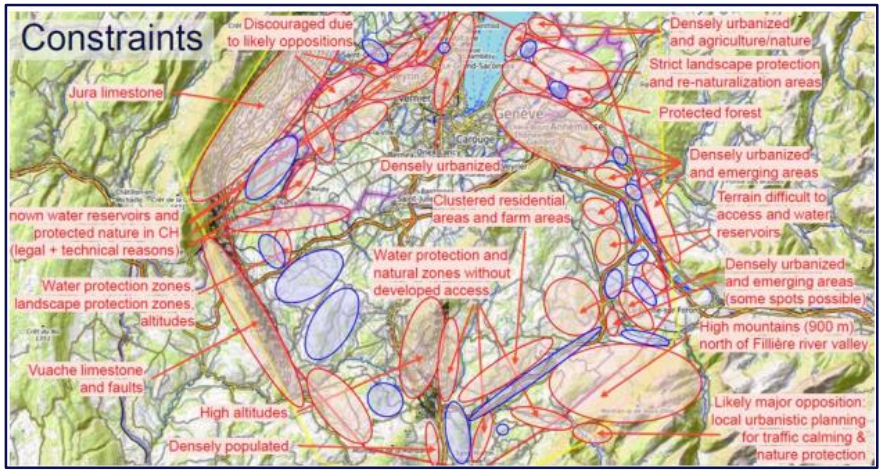
- Identify potential locations to access the 400 kV national electricity grid
- Identify potential sources for cooling water
- Optimise surface site locations according to the “avoid-reduce-compensate” approach
- Highway access feasibility study (carried out by Cerema)
- Railway terminal use, (call for tender open)
- Identification of mines and quarries for backfill opportunities
- Agricultural study to determine economic value and loss
- urbanistic initial state analysis (call for tender open)

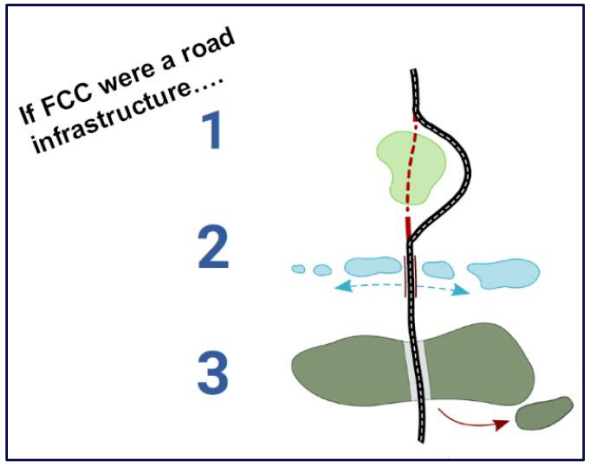
CAUTION: the baseline is not yet discussed with local elected representatives of the population and not with affected local stakeholders. This is a risk! Usually, detailed studies are only engaged, once in principle feedback about acceptability is obtained. By law, stakeholders must also be engaged in the choice. We have requested the launch of the process, but we need and rely on host state support for this type of activity.

Avoid Reduce Compensate Approach

- CEREMA have been working with CERN on the placement studies
- ARC approach has been adopted when assessing the territorial constraints aspect of the placement optimisation. It is a requirement of French law,
- Pierre Boillon presented the principles of the approach
- Approach requires a global and local view of the impacts (each land plot)



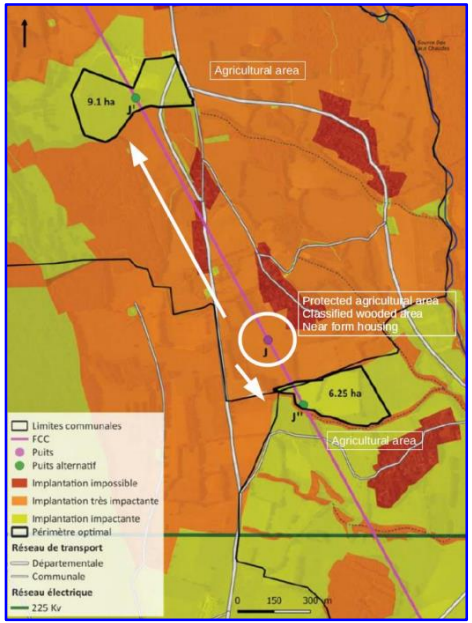




Avoid Reduce Compensate Approach

Specifically for FCC Placement Study

- Global approach eg preferred location of the overall ring to minimise impact and avoid critical areas such as Nature 2000, water sources etc..
- Multi-criteria approach to produce a visual colour-coded risk map
- Local approach at specific surface sites for example displacing shaft locations, increasing road slopes to reduce footprint..
- Minimise site footprints and move infrastructure to satellite sites if appropriate/possible.



Recall:

- **Assessment requires in-depth knowledge of the territory.**
- **Constant monitoring required as territory is continuously evolving**

Excavated Materials Management

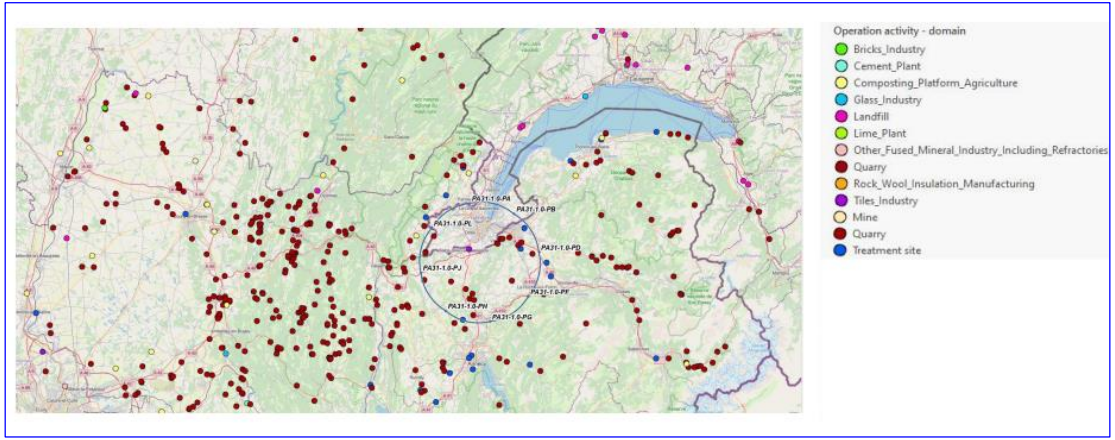
A technical/managerial report that summarises the approach for managing the approximately 9(*) million cubic meters of excavation materials in a resource- and cost-effective way, pointing to innovation potentials with economic benefits for companies and environmental advantages for the European society.

- Progress report 1 is complete and contains the Geotechnical, mineralogical and chemical analysis as well as general overview of the strategy for a risk management process.
- Reuse/recycle/disposal pathways have been studied with re-use considered (bricks, tiles etc). This work continues with identification of quarries/mines where the rock could be used for remediation.
- Current activities ongoing include the regulatory framework to be considered, summary of management options that CERN could consider for the excavated material, the return on experience with TELT (Lyon Turin high speed train link) and a railway access feasibility study..

Excavated Materials Management

Future work will include:

- Refinement of possible re-use scenarios once additional geotechnical data is obtained.
- Assessment of excavation methods to assess physical characteristics of excavated material and potential pollution risks.
- Potential re-use at the surface sites (noise and visual barriers, possible re-use to form construction material…
- Mining the Future Study outcomes to be incorporated/assessed.



Note the importance of having a robust plan for dealing with the excavated rock cannot be over-emphasised and CERN will be expected to demonstrate a full and thorough investigation of all avenues as part of the feasibility study.

Initial State Analysis

- Patrycja gave a thorough run-down of the planned and ongoing work related to the critical “ Initial State Analysis” that will be needed for any surface sites impacted by the project.

- The legal framework and requirements were presented which are slightly different in France and Switzerland however with generally the same aim.

- The environmental initial state analysis is an objective study carried out in order to determine the characterization of an area prior the development of a project and to establish the baseline state of the environment. It is a critical part of the overall Environmental Impact Analysis for the whole project.

- An FCC project-specific taxonomy of environmental aspects has been established which integrates best practices from France and Switzerland.

II	NAT_FLO	Flora	Inventory of all plant life present in the studied area	• Occurrence • Rarity • Protection status • Type (e.g. native, alien, invasive, anthropogenic)
II	NAT_FAU	Fauna	Inventory of animal life present in the studied area	• Occurrence • Rarity • Protection status • Type (e.g. native, alien, invasive, anthropogenic)

Initial State Analysis

- An Environmental Information system will be built on a GIS platform to enable efficient storage and use of the data gathered.
- The EIS will allow for rapid access to the data for CERN and external stakeholders. The visual format of maps, tables an graphs will support the overall authorisation processes within the host states.
- Contracts will soon be signed with external specialists for both the initial state analysis and the development of the specific EIS.
- Future works includes:

  - *validation of the list of environmental aspects*
  - *establishment of environmental indicators for aspects*
  - *establishment of mathematical methods for calculating criticality*
  - *reation of the environmental information system – long term task*
  - *carrying out the environmental initial state analyses – long term task*

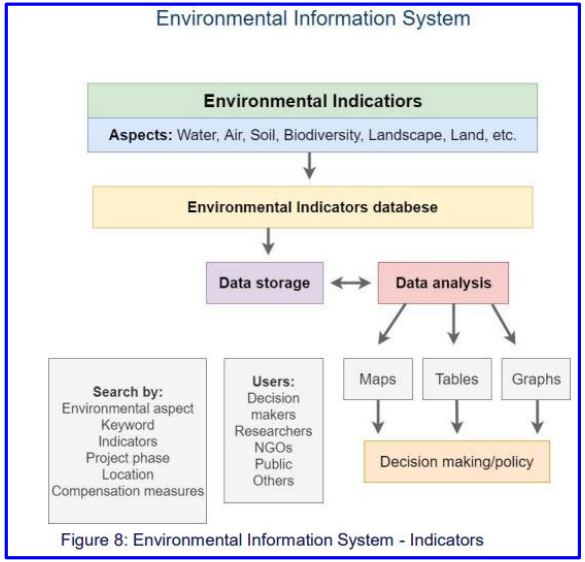


Figure 8: Environmental Information System - Indicators

Geodetic References for FCC

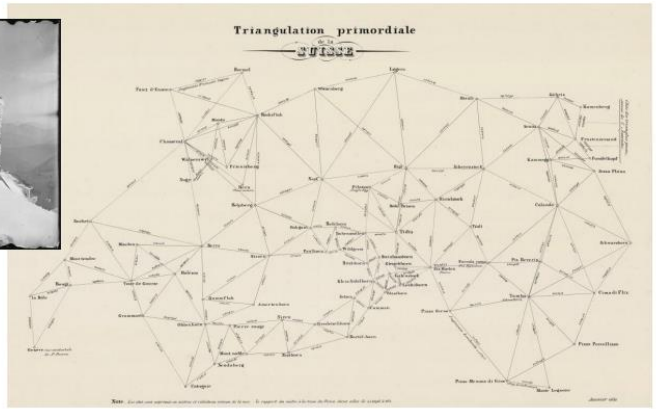
Geodesy being the science that studies the dimensions and shape of the Earth, as well as its gravity field
Quick review of history and current state of art presented.

GPS has now superseded triangulation. Differences of 3m between triangulation and GPS.

La Nouvelle Triangulation de la France

Triangulation net starting from the end of the 19th century. Below: installation of marker in 1938.

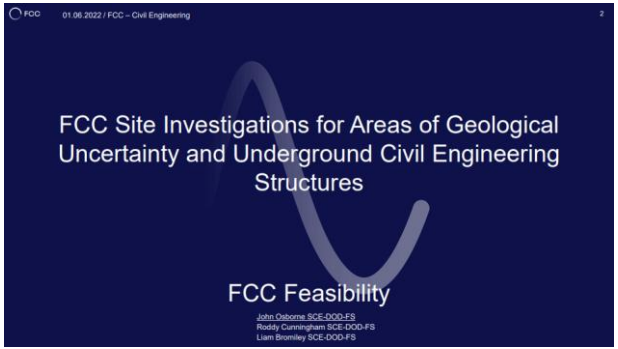
Triangulation primordiale 1809 – 1840



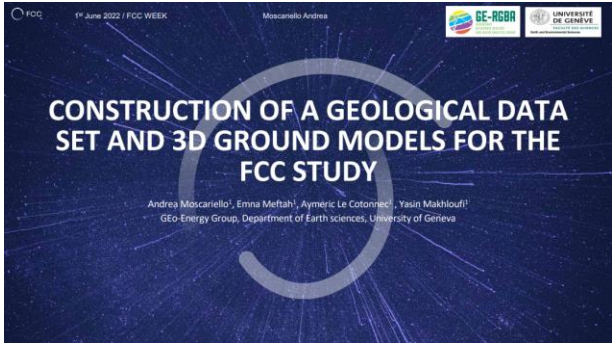
Geodetic References for FCC

- As each country has a different system, it is necessary for large infrastructure projects to develop a project specific reference system.
- For FCC additional points will need to be added to and incorporated within the two national networks.
- As well as benefiting FCC, the additional Pillars and Stations will improve the quality of the national reference systems which are widely used by society..

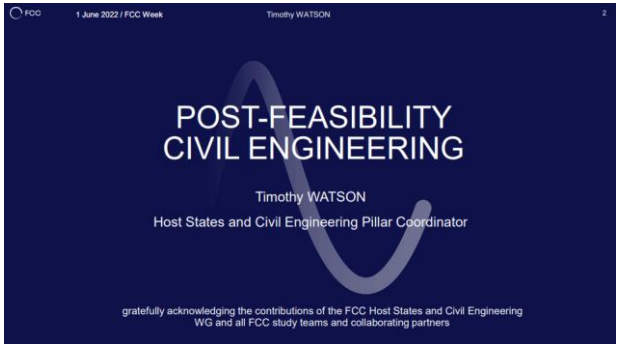
Civil Engineering



John OSBORNE (CERN-SCE)

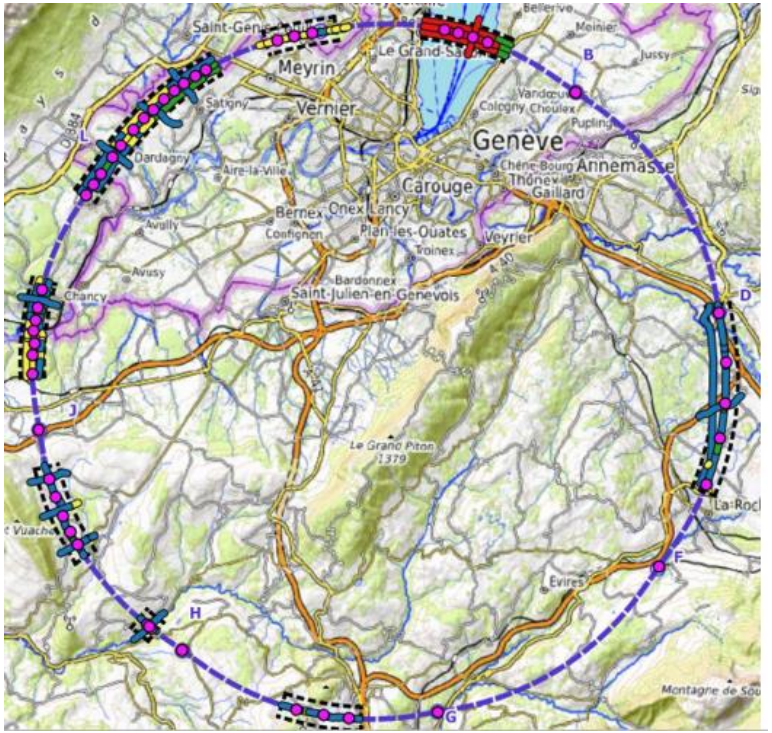


Prof. Andrea MOSCARIELLO (UNIGE)



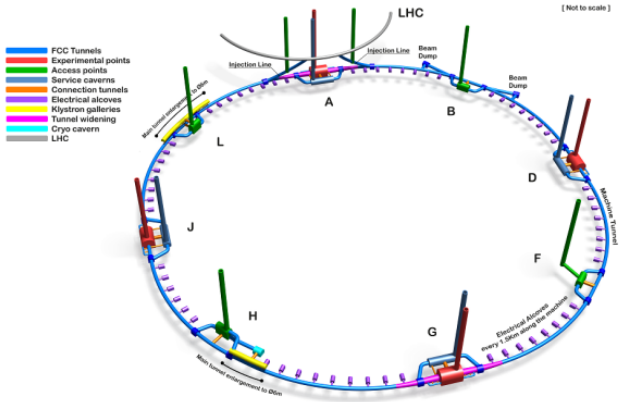
Tim WATSON (CERN-SCE)

- John Osborne provided an overview of the site investigation work needed to assess areas of geological uncertainty.
- The works will require 40 to 50 new deep boreholes and up to 90km of geophysical investigations
- Consultants contract will be signed after FC on 15 June
- Procurement of drilling/geophysics contractor will start by end 2022
- SI expected to completed by mid-2025 as input for Feasibility Study report.

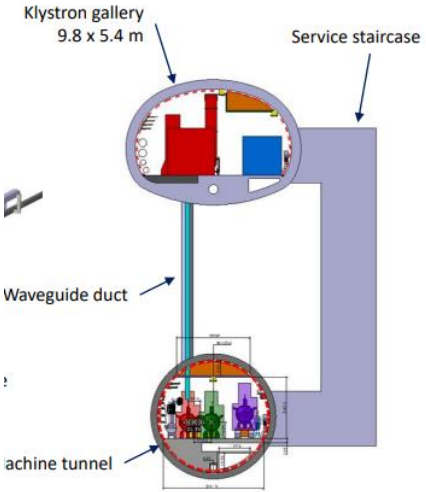


Revised – 8 Point FCC

Schematic

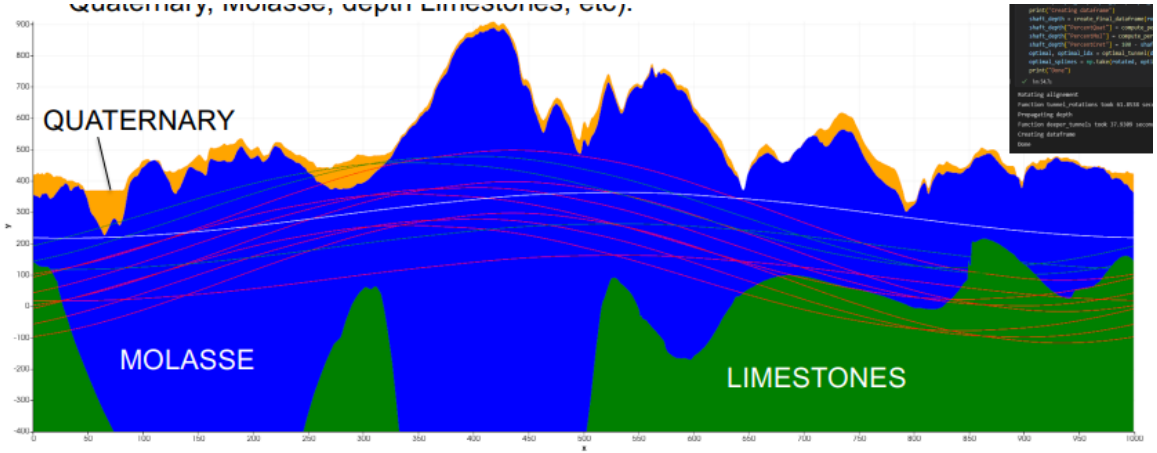


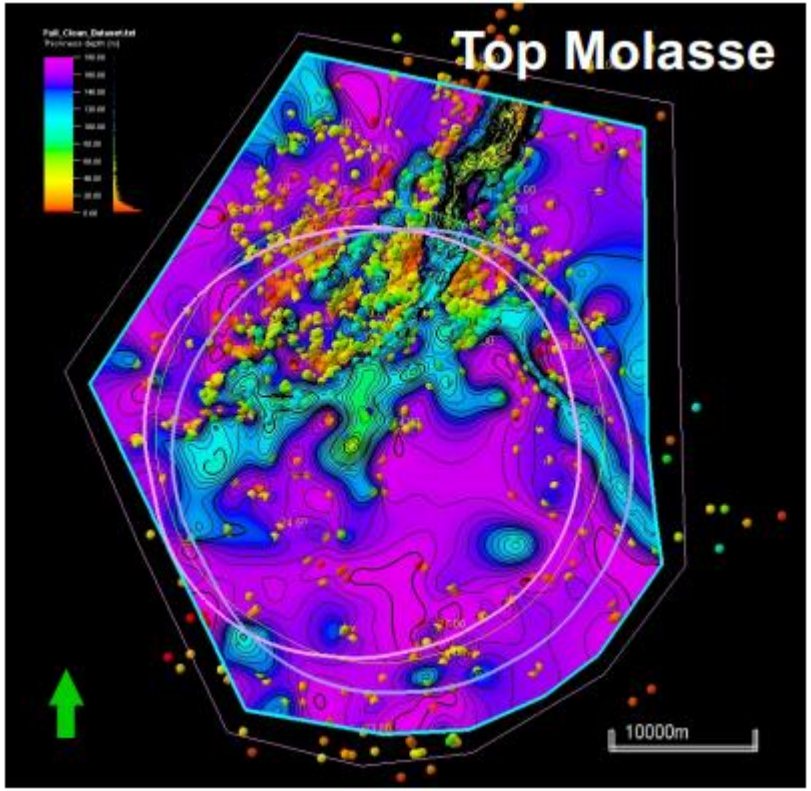
- John also provided an update of the underground layouts since CDR Report.
- Main changes are the reduction of shafts (12 to 8) and the inclusion of the Klystron galleries and the offset shafts at a number of points.
- Total shaft depths reduced from 2005m to 1849

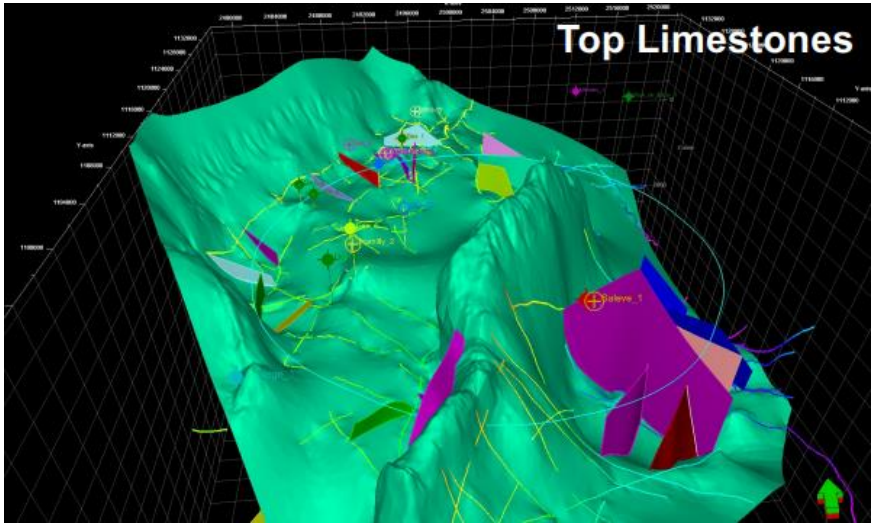


- Frozen layouts required by end 2022 in order that the CE consultants can update cost and schedule for the interim review in Q3 2023.
- Two new resources (1 staff and 1 fellow) recently started working in SCE/FS team dedicated to FCC Study.

- Prof. Moscariello presented the ongoing work under a collaboration agreement with CERN.
- The works requires the compilation of a comprehensive database of geological data in the region of the proposed tunnel as well as the construction of 3D geological models.
- These models will be used to assess location specific risks such as molasse/limestone interface, potential zones of hydrocarbons or water ingress etc.
- The FCC tunnel trajectory can be placed in the 3D model enabling quick extraction of key parameters

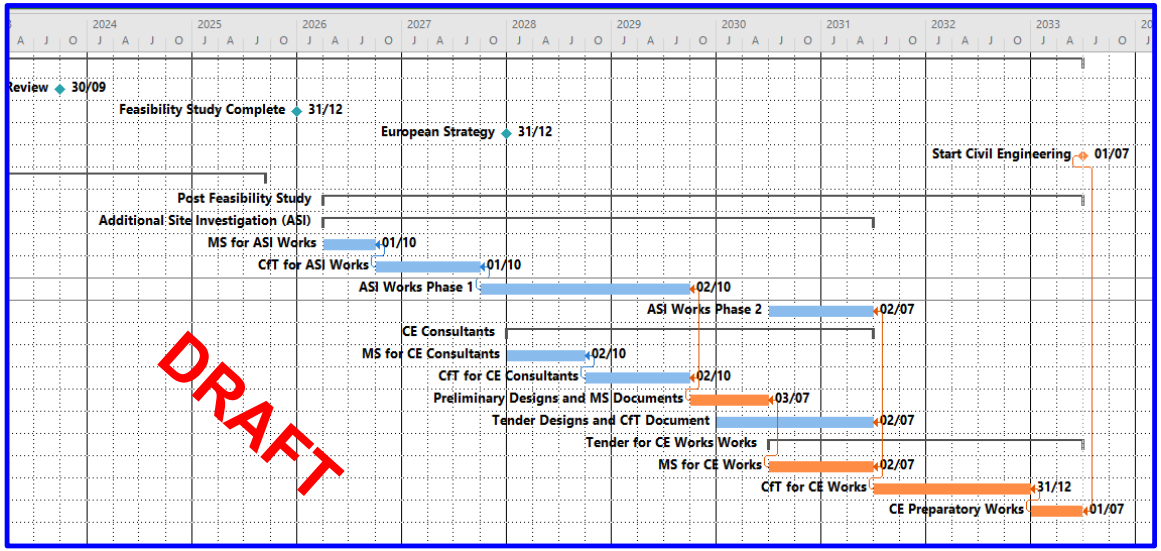



Top Molasse
10000m


Top Limestones

Post Feasibility Study Schedule

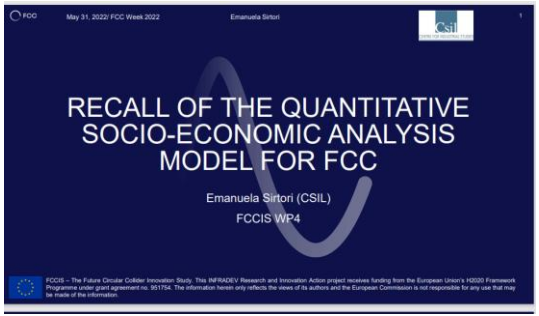
- With a now mature placement for the accelerator, work has started on developing plans for the surface buildings.
- A collaboration agreement currently under preparation will allow for FNAL staff to work with CERN on development of designs and Bills of Quantities for experimental and technical surface sites.
- To meet a construction commencement date in mid-2030's CERN must already start planning for the post-feasibility study contracts and site investigation works.
- Careful consideration with regard to CERNs future in-house capabilities will need to be taken into account when drawing up strategies for delivery of the FCC civil engineering.
- Schedule may be driven not by the civil engineering contracts but by the host state administrative processes required to allow construction to proceed.



FCCIS WP4: Socio-Economic Studies

Prof. Massimo Florio

(University of Milan)



Emanuela Sitori

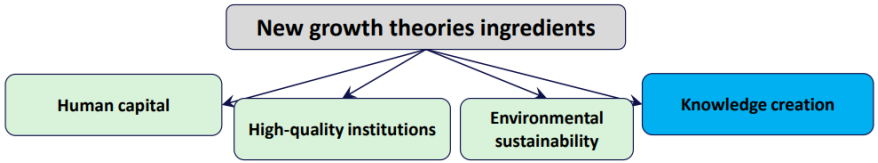
(CSIL Centre for Industrial Studies)

Francesco Giffoni

(CSIL Centre for Industrial Studies)

Riccardo Crescenzi (LSE)

Key Points



- Knowledge is a function of R&D expenditure (private and public)

- Economic growth requires knowledge creation
- EU spent EUR 311 Billion on R&D in 2020 (2.3% of GDP)
- Horizon Europe Budget 2021-2027 is EUR 95 Billion
- Socio-economic impact studies increasingly required by international and national institutions to fund large scale research infrastructures
- Build on historical data, probabilistic economic modelling, expert opinion
- Prudence and transparency needed when undertaking economic impact study
- Procurement Economic Multiplier (PEM) – CERN value is about 3 (as per ESA, NASA)

Key Points

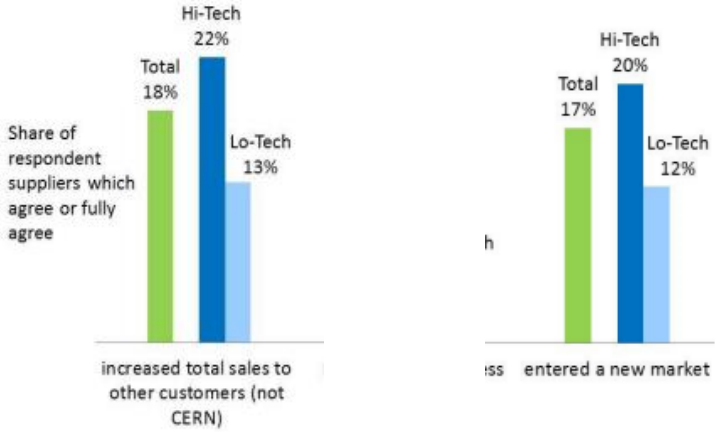
$$EBIT_{i,t} = \beta_o + \gamma \text{ CERN procurement} + \beta_1 Size_{i,t} + \beta_2 \overline{Macro_t} + \beta_3 \bar{Z}_i + \varepsilon_{i,t}$$

Suppliers' profit

Impact of CERN on suppliers' profit

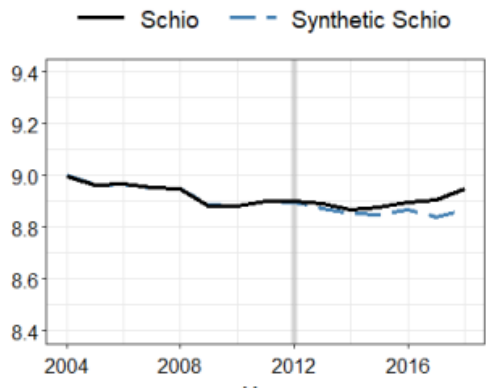
- Analysis of significant proportion of CERN suppliers balance sheets (HL-LHC) clearly indicated a higher benefit to " high-tech" suppliers who contracted with CERN
- The analysis showed little benefit when contracting with CERN for "low tech" industries
- Model will be used to assess the economic benefit the FCC will bring to industry with whom CERN will procure from

Economic performance. Because of the work with CERN, we …



Key Points

- XFEL used as case study to investigate local and regional benefits of a high-tech industrial contract (for RF cavities)
- A so called Trajectory Balancing Method was used to replicate the region without the presence of the manufacturer.
- Initial results indicate an increase in employment in local area due to presence of the new supplier… further results expected for next FCC week.



Socio-economic Studies - Conclusions

- Modern economic models identify the need for research and innovation in order for economic growth to occur.
- In Europe (and other geographical areas) significant funds are available for investment in research and innovation.
- Socio economic analysis of major projects is no longer a “nice to have” but an essential input to the assessment process of funding agencies leading to “go/no-go” decisions.
- Robust and transparent analysis methodologies now exist which use factual data to generate robust and transparent output data.
- These methodologies will continue to be developed under FCCIS WP4 to provide data on the economic benefits of FCC to specific companies, industries and geographical areas.

Overall Conclusions

Good progress in a number of key areas of particular note being:

- Placement studies – now need to convince host states of the robustness of the study
- Initial state analysis progressed with contracts almost ready for placement and methodology established
- Site Investigations and civil works designs progressing. Contract about to be placed.

Now at a critical point when we need engage with host state and local stakeholders in order to enable us to move forward with “ in the field” work..

FCC

Thank you
for your attention.