

Keynote Paper: Vähäaho, I., "HELSINKI EXPERIENCE WITH MASTER PLANNING FOR USE OF UNDERGROUND SPACE", Proceedings of the Joint HKIE-HKIP Conference on Planning and Development of Underground Space, 23-24 September 2011, Hong Kong, pp. 1-9

### Workshop on "Use of Underground Space in Hong Kong"

Ilkka VÄHÄAHO, Head of Geotechnical Division Helsinki City Real Estate Department, Finland

26 September 2011

## Introduction

Seven million residents live in the 200 km² Hong Kong Special Administrative Region. This means that the inhabited area only equals with the size of Helsinki. At the request and expense of the Government of Hong Kong I made a lecture trip to that densely populated city state from September 21 to September 27, 2011.

At the conference (Planning and Development of Underground Space), which was organised jointly by the local Institution of Engineers and the Institute of Planners, I gave a Keynote lecture (HELSINKI EXPERIENCE WITH MASTER PLANNING FOR USE OF UNDERGROUND SPACE) and in addition a full-day Workshop for the Government's engineers and city planners. The topics I had been given were:

- Key Considerations for Use of Underground Space in Helsinki
- Planning for Use of Underground Space in Helsinki
- Geotechnical Engineering for Underground Space Development in Helsinki Non-geotechnical Engineering for Underground Space Development in Helsinki

#### It is my wish that this material could be useful for others, too.

All comments are also welcom

Updated in Helsinki on Monday 10th of October 2011

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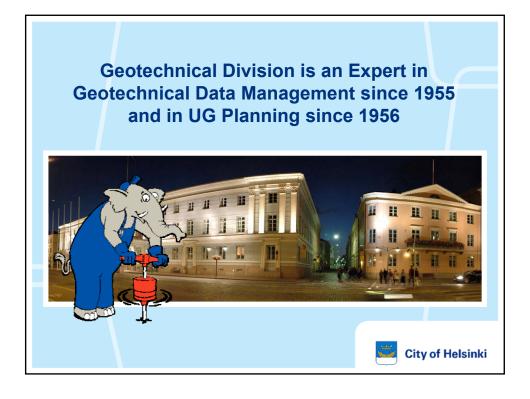
www.geotechnics.fi

PS Photos from this trip can be viewed in the following albums:

Conference and Workshop photos are in: https://picasaweb.google.com/112121213616786687160/HONGKONG2011 PlanningAndDevelopmentOfUGSpace#

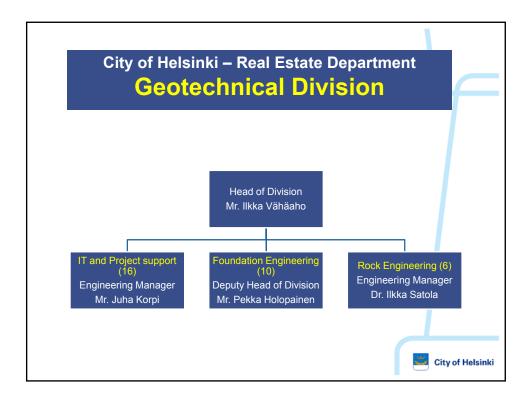
2) Technical excursion photos are in: https://picasaweb.google.com/112121213616786687160/HongKongMTRWestIslandLine25Sep2011#

3)
Photos from the six-hour round tour are in:
https://picasaweb.google.com/112121213616786687160/6TuntiaKuudessaMinuutissaHongKongMikkoLNOhjeenMukaan24Syyskuuta2011?authkey=Gv1sRgCMHemvrlrM7RaQ#
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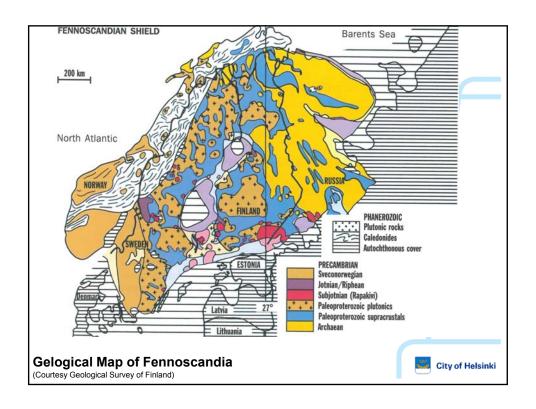


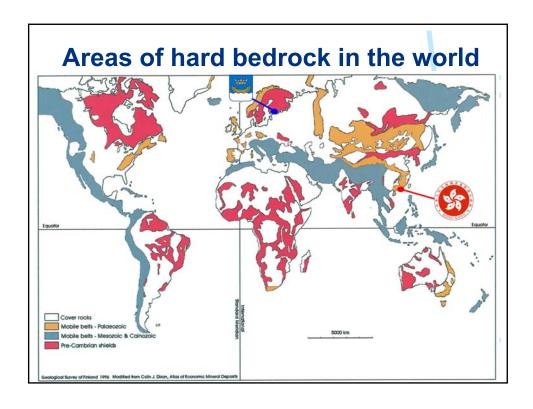
- Deeper than Skin, Geotechnics of the City of Helsinki Real Estate Department since 1955, published in April 2005. Available in Finnish, 40 pp.
- Compressed leaflet in three languages
   "Pintaa syvemmältä På djupet med Deeper than Skin"













## **Further information:**

- · www.geotechnics.fi CaseBank
  - UNDERGROUND MASTER PLAN OF HELSINKI A city growing inside bedrock
  - TECHNICAL SERVICES AND UTILITY TUNNELS IN HELSINKI

Reliable and optimised large-scale networks in bedrock





## **Finnish Tunnelling Association (MTR-FTA)**

#### Helsinki hosted World Tunnel Congress 2011

❖Plenty of material still on <u>www.wtc11.org</u>

#### Other valuable MTR-FTA publications

- ❖Rock -sound of countless opportunities, 2011
- ❖The Fourth Wave of Rock Construction, 1997
- ❖See <u>www.mtry.fi</u> or straight to the publications: <u>www.getunderground.fi/web/page.aspx?refid=192</u>





## Statistics of Underground Helsinki

- Underground space (parking, sports, oil and coal storages, metro etc.) 10,000,000 m<sup>3</sup>
   average 1 m<sup>2</sup> per 100m<sup>2</sup> ground surface
- More than 400 premises
- ❖ Technical tunnels 220 km
- Raw water tunnels 24 km
- Utility tunnels "all in one" (district heating and cooling, electrical and telecommunications cables, water) 60 km



# **Underground Reservation Categories**

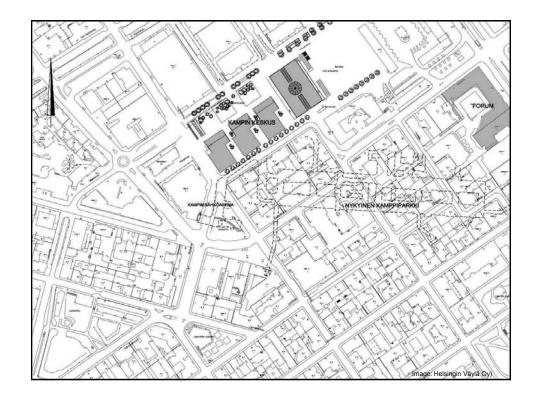
- 1. Community technical systems
- 2. Traffic and parking
- · 3. Maintenance and storage
- 4. Services and administration
- Unnamed rock resource (does not yet have a designated purpose)

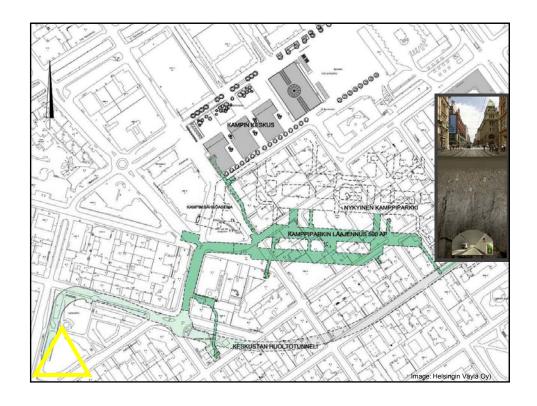
# The Underground Master Plan of Helsinki

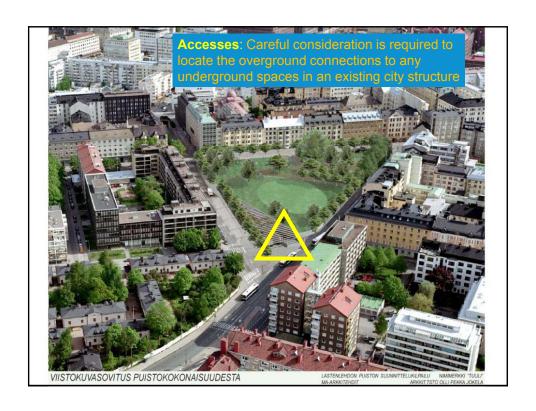
- Reserves designated space for public utilities and private utilities in various underground areas of bedrock over the long term
- Provides the framework for managing and controlling the city's underground construction work
- Allows suitable locations to be allocated for underground facilities



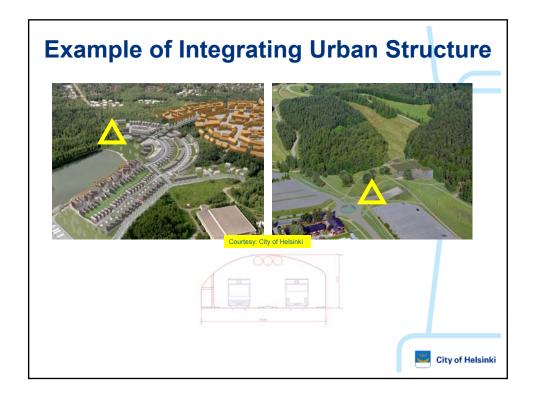








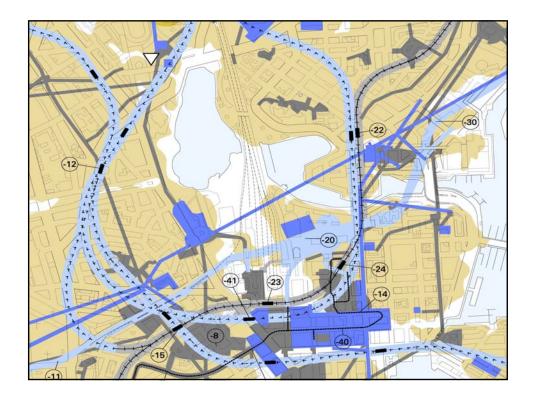
# The Underground Master Plan of Helsinki Connects underground premises to each other to form coherent and interrelated complexes Makes sure that space reservations for public long-term projects, such as tunnels and ducts for traffic and technical maintenance, are retained for future construction City of Helsinki



# **Underground Master Plan of Helsinki Includes**

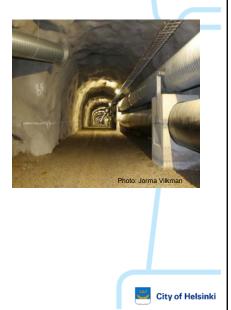
- More than 400 existing underground spaces and tunnels
- More than 200 new reservations in the register for long-term underground projects
- Both existing and future underground facilities and tunnels (grey indicating existing facilities and blue planned facilities)
- Space reservations on the Master Plan map are presented two-dimensionally
- · In the city centre area, approximate floor elevations are indicated using circled figures
- Existing vital access links to underground technical maintenance facilities/tunnels are shown on the map with triangles

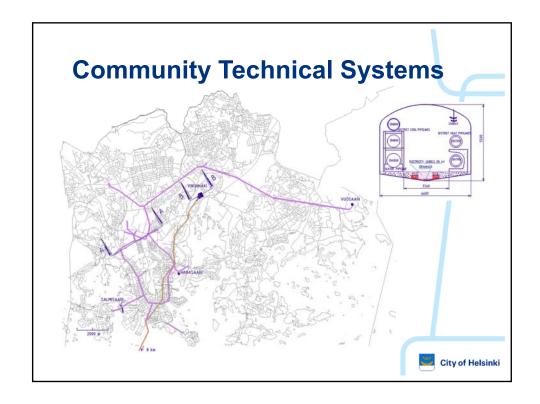


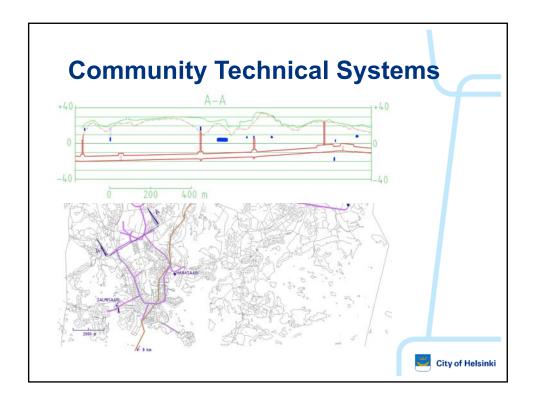


## **Community Technical Systems**

- Underground facilities for municipal and other technical services (such as energy, water supply and telecommunications) are large-scale closed networks
- Coordination is done by the Helsinki Committee on Utility Tunnels
- Utility tunnels are located at such a depth that space reservations for them do not have a significant effect on other underground facilities (exception: deep bore holes for heating/cooling)







## **Benefits and Dilemmas**

#### of Underground Community Technical Systems

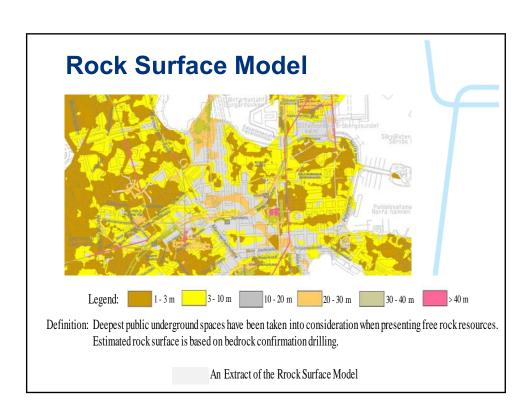
- 1. Reliable energy supply via a network
- 2. Optimisations of energy generation with major transmission networks
- 3. Expenses are shared by several users
- 4. Land is released for other construction purposes
- 5. The city's appearance and image are improved, as the number of overhead lines can be reduced
- 6. Construction work carried out on underground pipes and lines has significantly fewer disadvantages
- 7. Excavated rock resulting from construction of the tunnels can be utilised
- 8. Pipes and lines in tunnels require less maintenance, and are easier to maintain
- 9. Any breakages in pipes, lines and cables do not pose a great danger to the public
- 10. Tunnels are a safer option against vandalism



# Initial Survey for Unnamed Rock Resources (= reserved for unclassified future use)

- An initial survey examined the areas and elevation levels in Helsinki which are suited for construction of large, halllike facilities
- A model was used based on rock surface data and applying a standard-sized measurement cave (width 50 m, length 150 m, height 12 m)
- The model of the bedrock is based on base map data for exposed rock and land surface elevations and point data obtained using drill machine borings
- The survey also took into account local weakness zones and rock resources that have already been put to use





# Initial Survey for Unnamed Rock Resources

- Bedrock in Helsinki is in general not far below the ground surface and there are plenty of locations suitable for construction of underground facilities
- Average price of underground space is only 100 €/m³, including excavation, rock reinforcement, grouting and underdrainage
- Outside the city centre, the survey found 55 rock areas that had a sufficient size for accommodating large underground facilities near major traffic arteries
- In many areas future underground projects can make use of entrances to existing underground facilities, which have been marked with triangles on the Master Plan map



# **Unnamed Rock Resource Reservations**

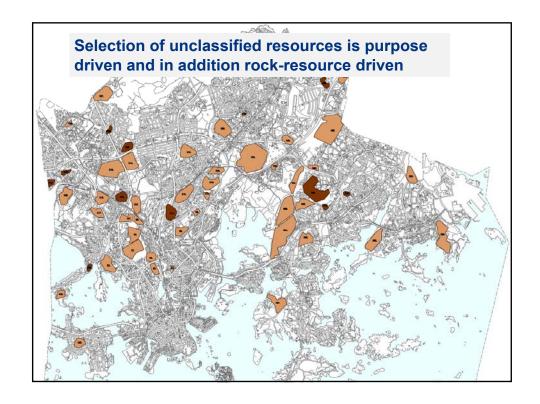
- When selecting these resources for unclassified future use the survey took into account their
  - Rock conditions
  - Accessibility from existing tunnel network
  - The present and planned ground-level uses of these areas
  - Traffic connections on ground
  - Land ownership
  - Possible recreational, landscape and environmental protection values



# **Underground Master Plan of Helsinki Includes**

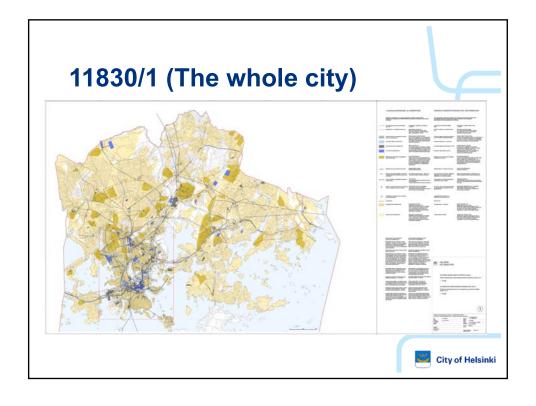
- About 40 unnamed rock resource reservations without a designated purpose
  - The average area of these reservations is 30 ha
  - Unnamed reservations have a total area of 1,400 ha (= 14 km²) representing 6.4% of the land area of Helsinki

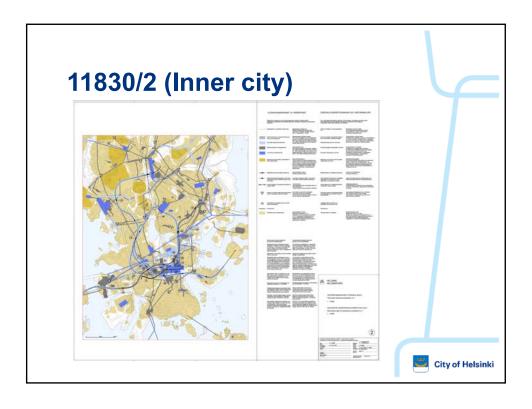




# The First UG Master Plan of Helsinki

- Accepted by the City Council on 8<sup>th</sup> of December 2010
- · Two competent and legally valid documents
  - > 11830/1 (The whole city)
  - > 11830/2 (Inner city)







A worldwide model in underground planning is Helsinki. The city is labelled by the harbour and protected buildings. So, underground is the place to build. Mr. Ilkka Vähäaho, the leading planner of underground spaces, is a modest man. Or this is what he claims himself. However, he feels the need to say: 'Here in Helsinki we have the best soil maps in the world. There is a bore hole in every 30 metres.'

Vähäaho's post was founded as early as in 1955. The 200 square-kilometre-city lies on special ground: massive bedrock and soft soil. It is therefore important for the planner to know the levels of solid layer for foundations. In addition, Finns look forward to having a sound and airy metropolis: although Helsinki has gigantic backwoods, the city itself should have green areas so let there be space for parks and avenues. Similar ideas can be found in Zurich, too. An example is served by Professor Ulrich Weidmann who wants all tramlines underground by the year 2045.

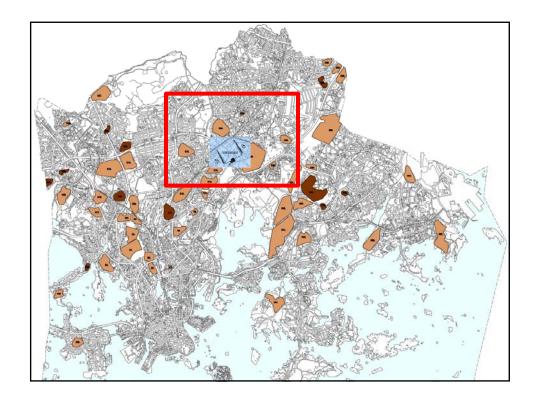
In Helsinki, functions that are not wanted on the ground are already situated underground: a waste water treatment plant or a swimming pool where - thanks to a steady 7-degree-temperature - heating is only needed a little in the cold Finnish winter. More examples are storages for coal and snow, which is no longer allowed to be dumped into the sea.

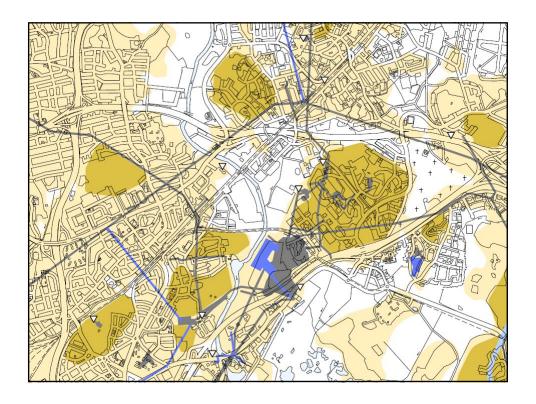




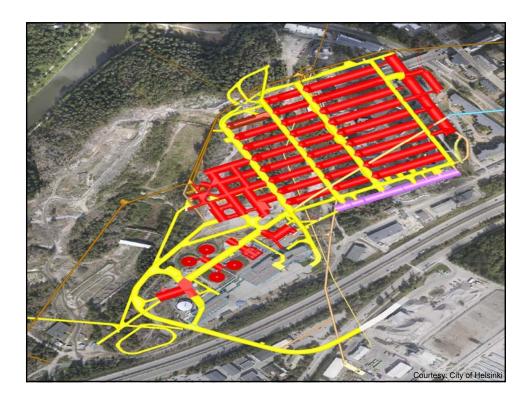
## Lesson 2: Planning for Use of Underground Space in Helsinki

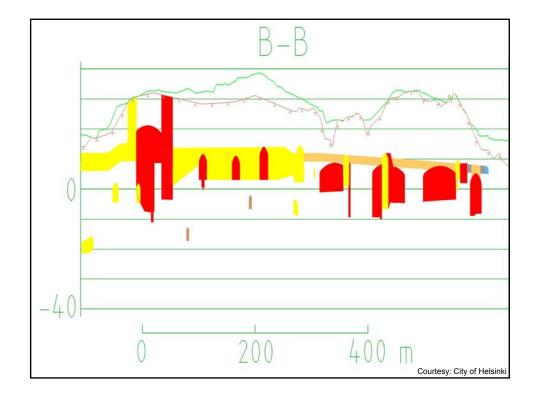
Ilkka VÄHÄAHO, Head of Geotechnical Division Helsinki City Real Estate Department, Finland

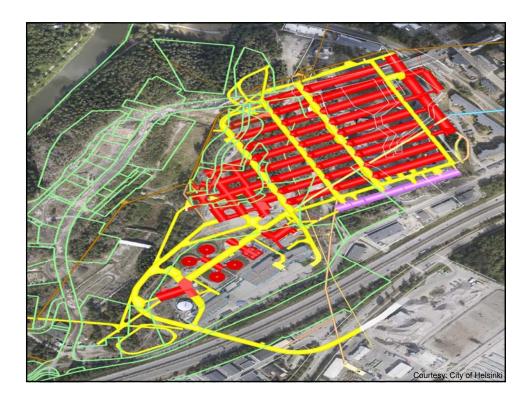


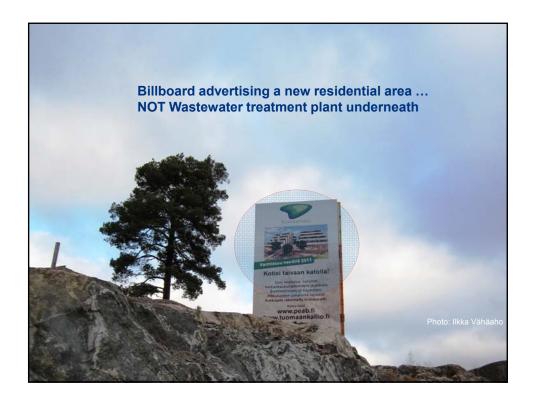














# Lessons Learned from Viikinmäki Case

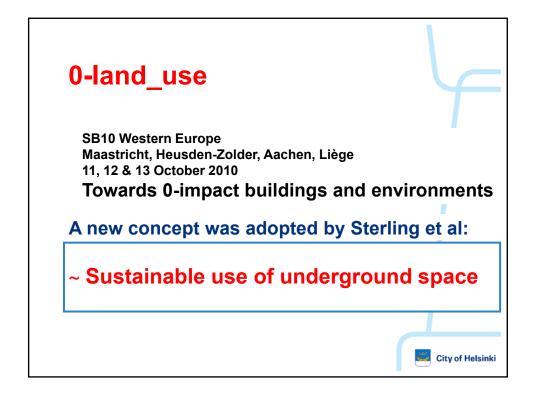
- Viikinmäki waste water treatment plant is the central plant for treating wastewater from six towns and cities
- It is less than 10 km from the centre of Helsinki
- The plant treats 280,000 m<sup>3</sup> of wastewater from about 750,000 people every day
- Completed at a cost of €180 million, the treatment plant began operating in 1994
- It replaced more than 10 smaller treatment plants, all above ground, allowing these sites to be zoned for more valuable uses
- The construction of the underground wastewater treatment plant took place simultaneously with the construction of ground-level infrastructure and residential buildings

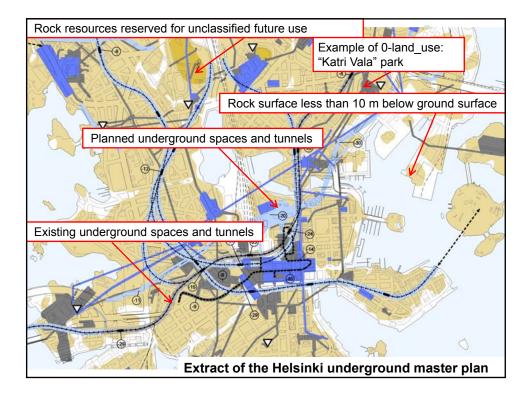


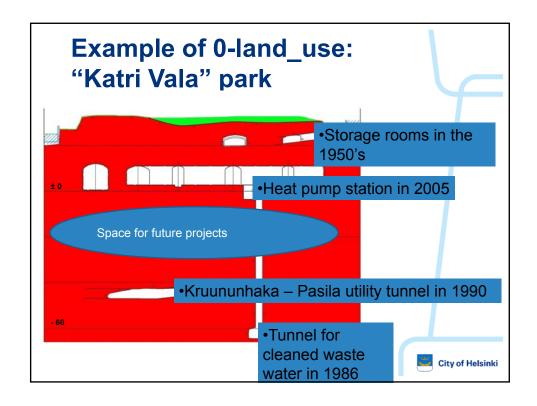
# **Examples of Future UG Planning**

Underground master plan of Helsinki is an example of a new 0-land use thinking

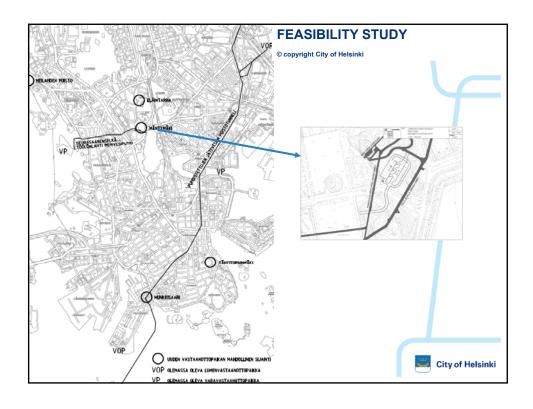


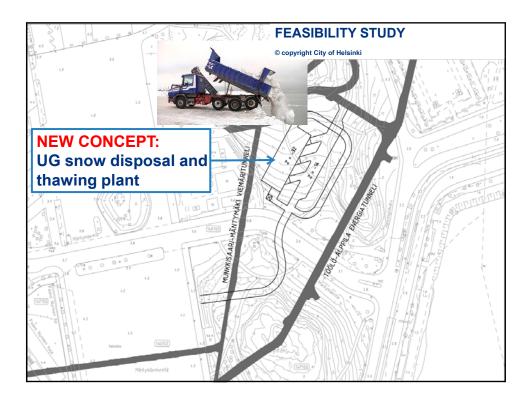














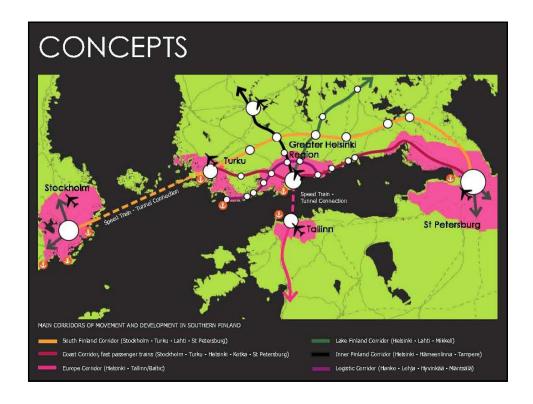
## **Helsinki Conditions**

- Helsinki is the capital city with 591,000 inhabitants
- Altogether 1.3 million people, approximately one in four Finns, live in the Greater Helsinki area
- Surface area of Helsinki is only 215 km²
- Average size of municipalities in Finland is 585 km<sup>2</sup>
- Finland has 336 independent municipalities







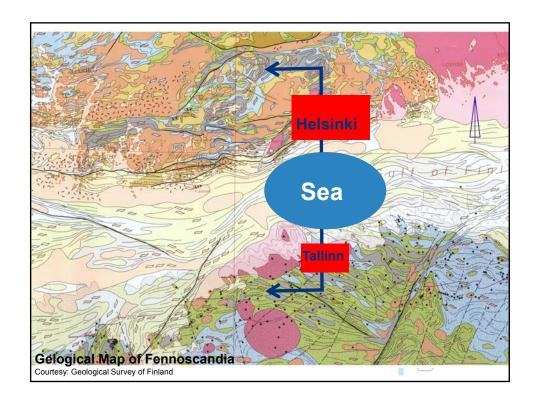


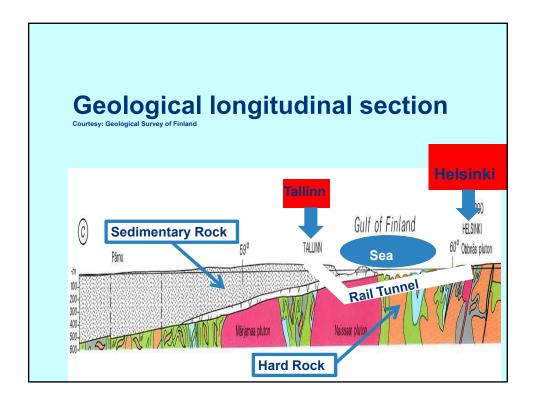


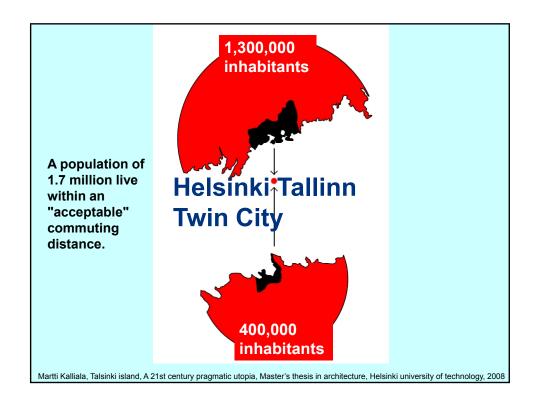
## **Tunnel from Helsinki to Tallinn**

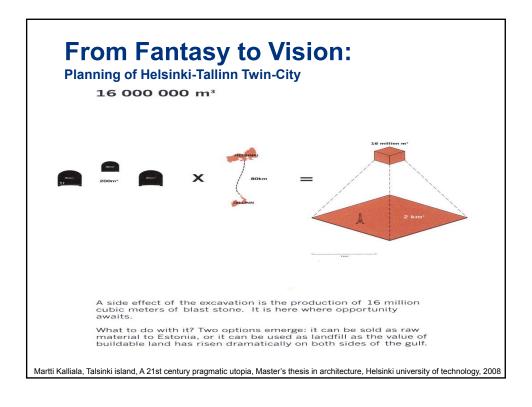
- The route of the proposed undersea tunnel from Helsinki (in Finland) to Tallinn (in Estonia)
- At present fast surface vessels can cover the 82 km in about an hour and a half









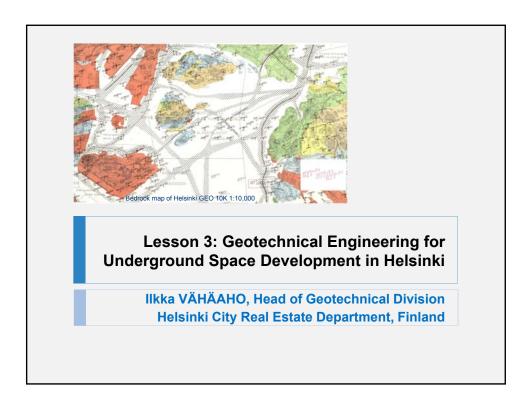




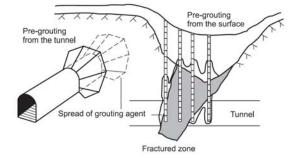


## Conclusions of Lessons 1 & 2

- It is most important to educate planners and decision makers about the usefulness of underground (UG) resources
- Cooperation of technical departments and commercial enterprises in UG construction of Helsinki is already a worldwide model
- Finnish Tunnelling Association has produced and promoted a series of books, theses and videos that visually demonstrate the potential attractiveness of the underground

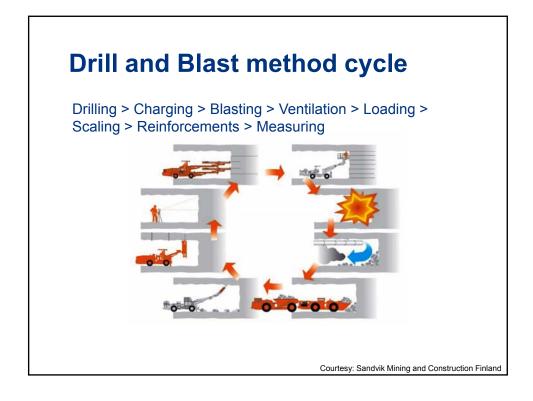




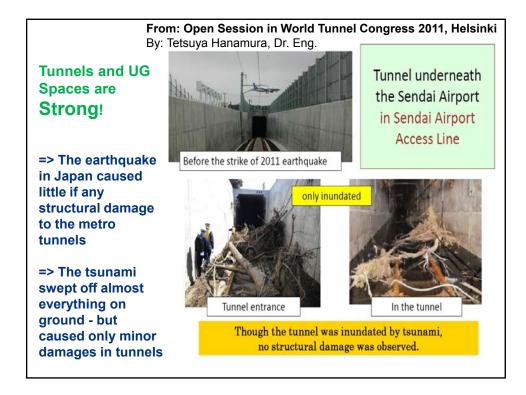


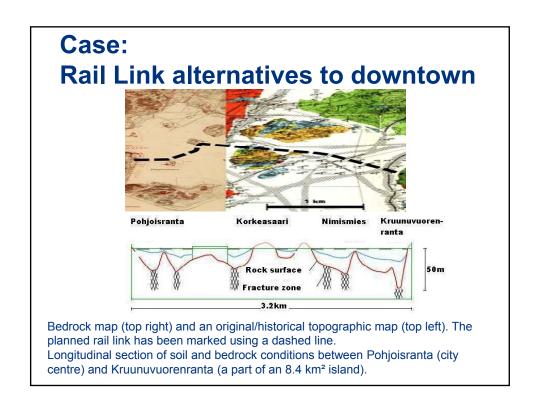
Two alternatives: From the tunnel or from the surface

Courtesy: Sandvik Mining and Construction Finland









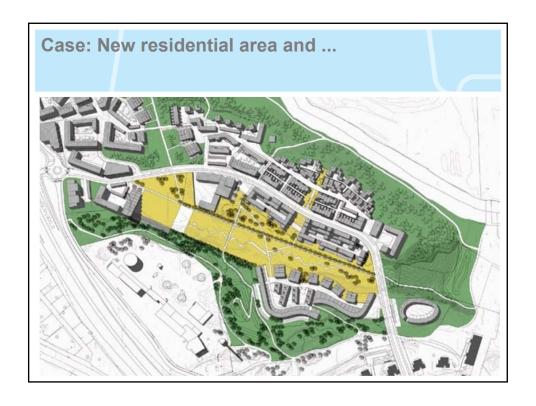


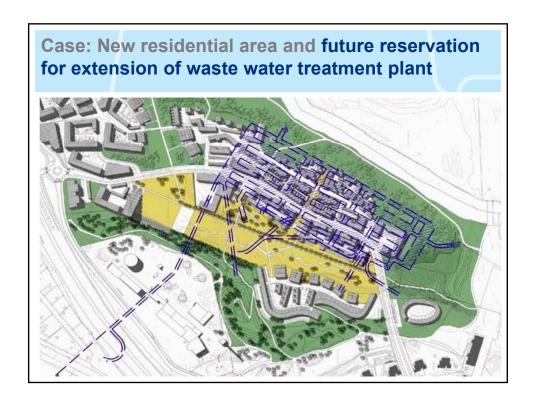
### **Public Transport alternatives**

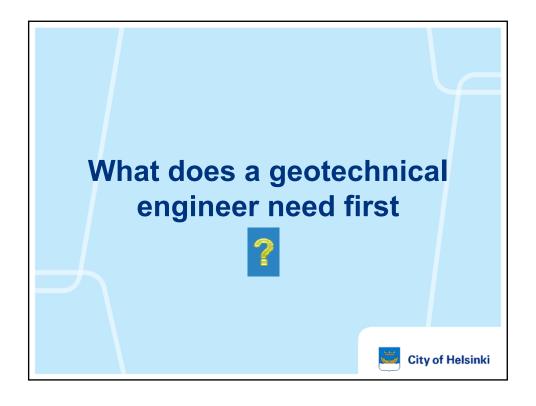
- Rock Tunnel Too deep and expensive
- 2. Immersed Tunnel Expensive and uncomfortable
- 3. Bridge ? Aesthetics and price
- 4. Cable Car ? Cheaper but does it work
- 5. Ferry ? Weather and winter

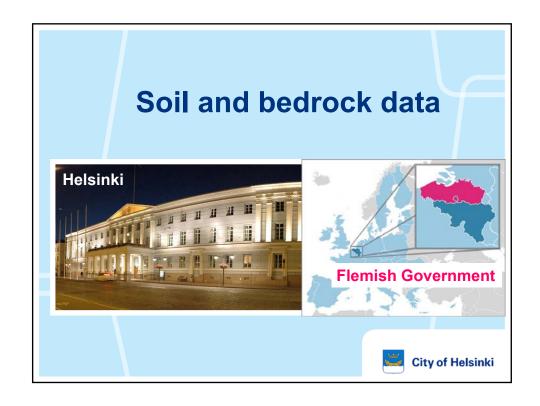
My proposal in this case is: High standard and economical bridge











# The best soil and bedrock databases

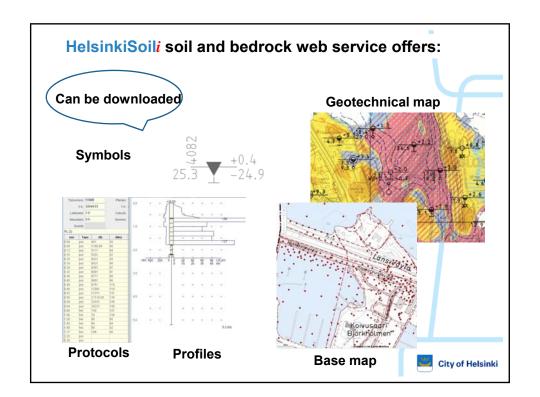
Geotechnical and geological data management in urban underground (UG) areas \*)

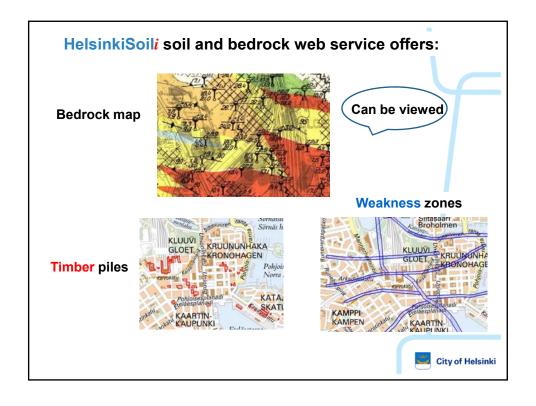
Geotechnical Division, Real Estate Department, City of Helsinki, Finland *Mr. Ilkka Vähäaho, Mr. Juha Korpi, Dr. Ilkka Satola* 

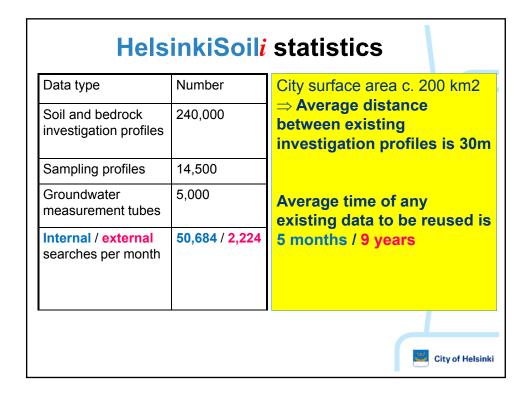
Geotechnics Division, Flemish government, Belgium

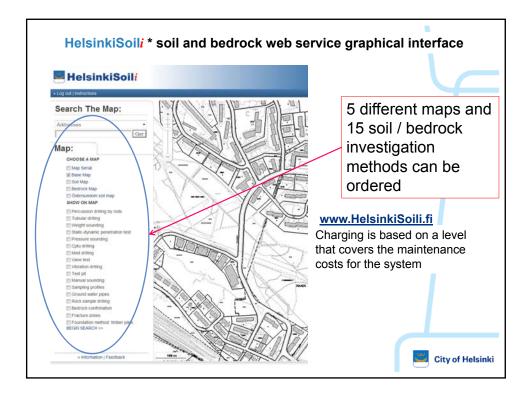
Mr. Gauthier Van Alboom, Ms. Ilse Vergauwen

\*) Paper was presented in the World Tunnel Congress 2011 and is released in the proceedings (see: <a href="https://www.wtc11.org">www.wtc11.org</a>)





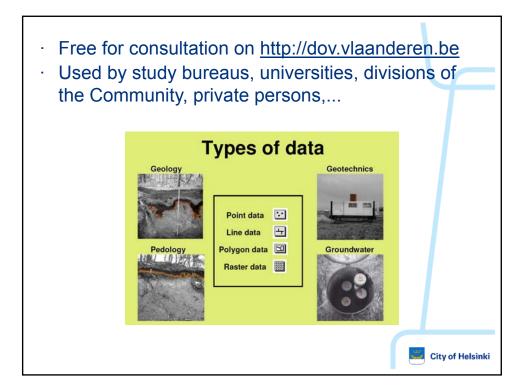


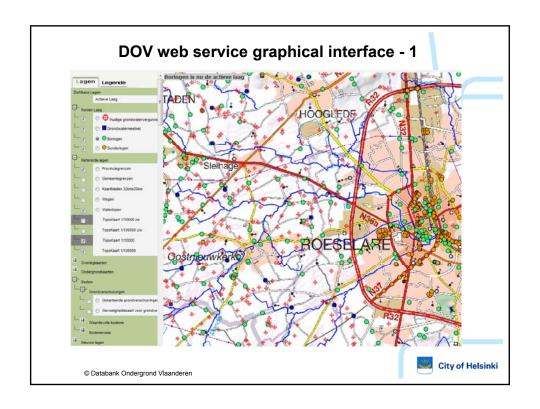


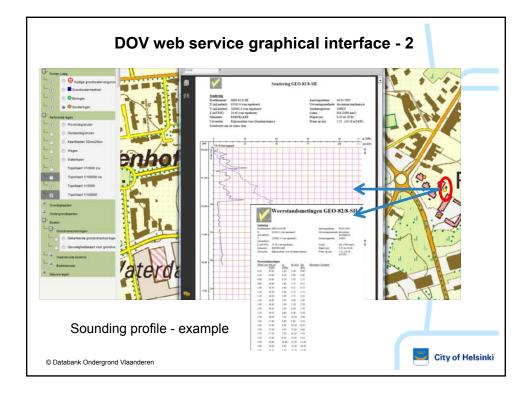
### Database of the subsoil of Flanders (DOV) in Belgium since 1996

- DOV is a co-operation of three divisions of the Flemish government
- DOV is the overall database of all subsoil information of Flanders
- DOV has two types of data:
  - alphanumeric and
  - cartographic data









# Successful Geotechnical Engineering in Helsinki has needed:

- Reliable site specific facts on:
  - ✓ Ground, bedrock, existing UG devices and structures and future plans (= GIS Database)
- Competent and experienced designers
- Capable (land)owners and developers
- Reliable authorities
- Competitive contractors
- Cooperation with neighbours
- Good references from previous projects



### **Typical Construction Case**

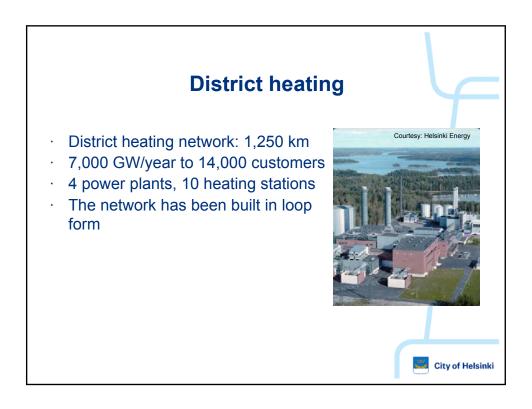
- ☐ Tunnel: 6.5 m x 5.5 m
- ☐ Drill & blast
- □ Pre-grouting
  - Allowed water leakage: 4 l/min/100 m
- Reinforcement:
  - Bolting and
  - Sprayed concrete











### **District cooling**

- · Eco-efficient energy.
- 80 % of production based on resources which otherwise would be wasted
- Renewable energy sources such as seawater
- · Length of the network 30 km
- · Output 100 MW
- · Clients: 170

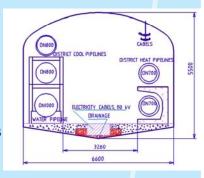




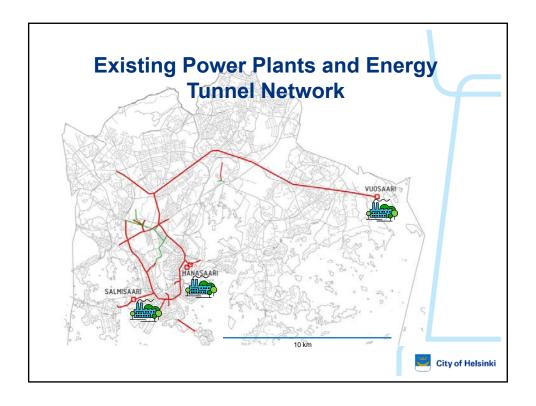
City of Helsinki

### **Energy tunnel**

- Energy tunnel = utility tunnel
  - · District cooling,
  - · district heating,
  - · fresh water,
  - electricity cables and telecommunication cables
- · Over 200 km of technical tunnels
- 60 km of energy tunnels used by a number of operators







### Katri Vala underground heat pump plant

- The world's largest underground heat pump plant
- The cave is 7,000 m<sup>2</sup> at a depth of 25 metres.
- · The location is ideal:
  - outfall tunnel and utility tunnel are under the plant
  - · Close to the city centre
- · The production output:
  - 90 MW of district heat and 60 MW of cooling output



### Construction below the city area

- · Challenges:
  - accesses up to surfaces in built-up area (driving accesses, emergency exits, ventilation shafts, etc.),
  - drilling and blasting disturbances in city area,
  - drilling and blasting nearby existing underground spaces and
  - breakthrough to other utility tunnels





### Main advantages in placing different technical facilities underground

- · Pipelines are straighter savings
- · Expenses are shared by several users
- · Later construction on the surface not impaired
- · The land released for other purposes
- · Minimum interference with normal life
- Rock tunnels / spaces do not affect the environment
- Rock tunnels / spaces are safe



The City of Helsinki has an excellent experience in Geotechnical Data Management in urban underground areas and in placing different facilities underground!

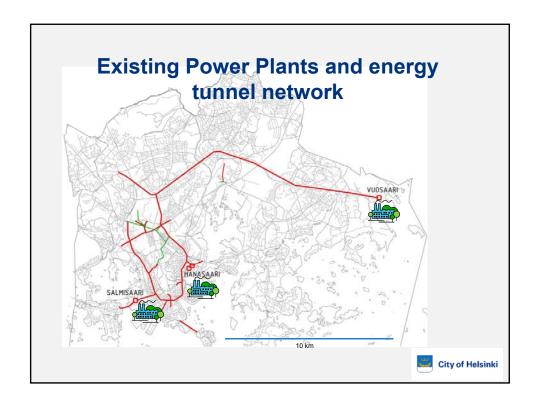
A lot of advantages have been achieved during planning, construction and operation.





**Lesson 4:** Non-geotechnical Engineering for Underground Space Development in Helsinki

Ilkka VÄHÄAHO, Head of Geotechnical Division Helsinki City Real Estate Department, Finland



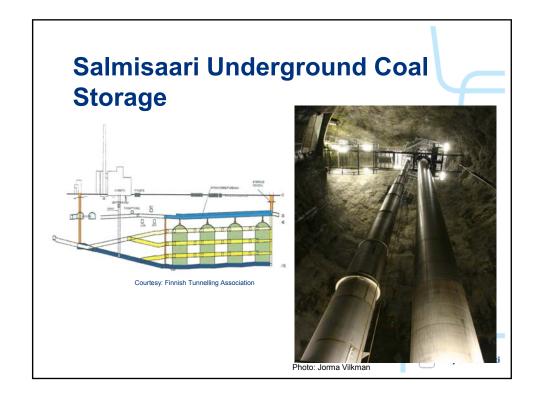


# Case Salmisaari power plant's Coal heap



The new 400,000 m³ coal stock silos of the Salmisaari power plant were built (2002-2004) into the bedrock. Left hand photo (2003) with a pile of coal and a pile of quarried rock. Right hand photo (2010) the same area with a number of headquarters of some most remarkable companies in Finland.





### Salmisaari area before and after Underground Coal Storage





Coal Storage Silos in bedrock were built with the price that the City of Helsinki got by selling the former Coal heap area for building ground to private companies

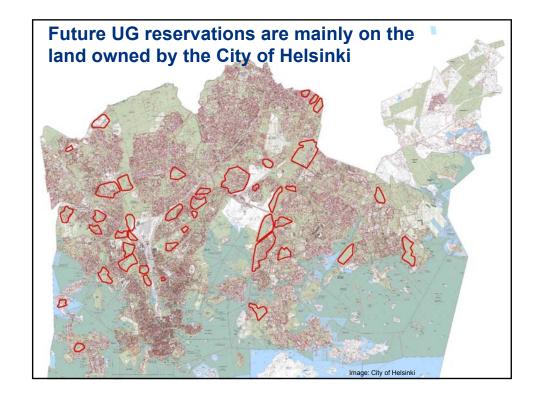
City of Helsinki

# Map of Helsinki The green areas of land are owned by the City of Helsinki and the white areas are owned by others Image: City of Helsinki The City of Helsinki consists of 215 km2 of land and 500 km2 of sea The City of Helsinki owns 65% of its land

# Land Ownership Strategy of the City of Helsinki

- The city tries to buy the needed land areas as greenfield land before zoning
- Today the city is facing more and more redevelopment of brownfields especially when developing waterfront areas
- Easier to develop underground resources under your own real estate





## The means of getting hold of land in Helsinki 1(3)

- Buy the land needed for zoning by voluntary transactions (purchases or land switches) before the zoning begins
  - ➤ The value increase of the zoning is fully usable for the carrying out of the town plan; i.e. building streets, parks, communal service properties such as schools, playgrounds etc
  - Owning the land gives the city the power to decide on the timetable of developing



# The means of land acquisition in Helsinki 2(3)

- The Finnish legislation allows the city to "take" the land if the voluntary negotiations fail
  - > Helsinki has been reluctant to use this possibility

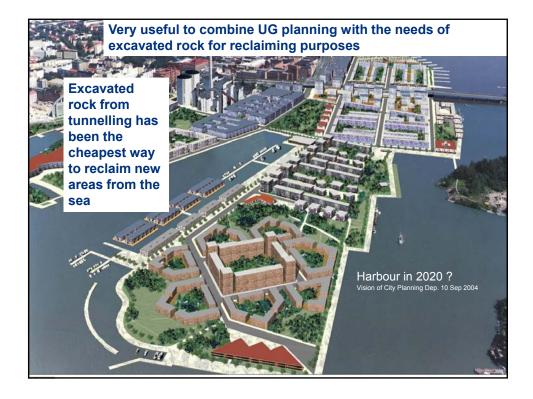


# The means of land acquisition in Helsinki 3(3)

- When rezoning private land, the city also negotiates zoning agreements with the land owners involved
  - Agreements specify how much of the public rezoning implementation costs are to be paid by the land owner
  - The payment is linked to the land value increase generated by the new town plan



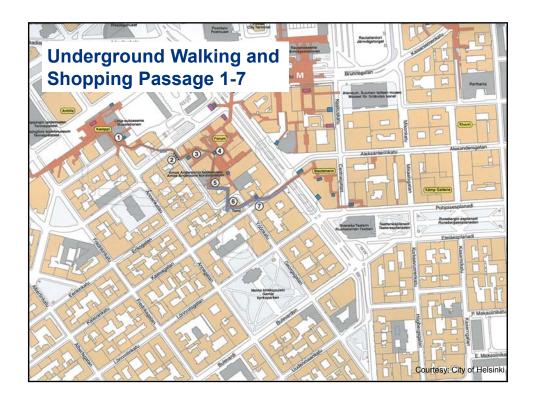




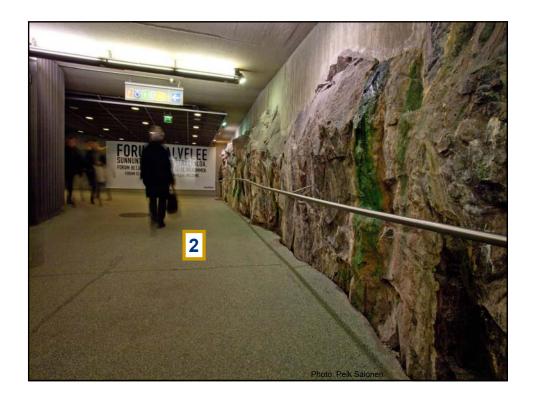
# **Dilemmas** Facing Underground Planning

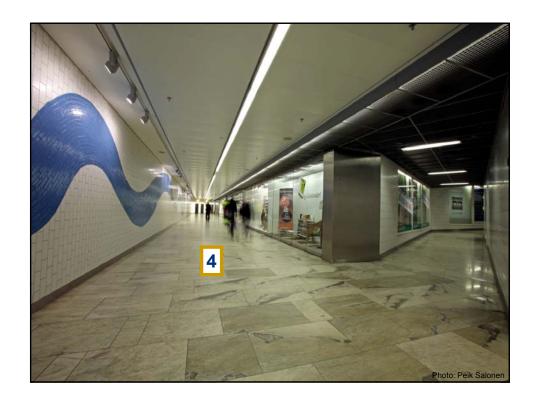
- According to the law (in Finland), the owner of a property has control over the underground part of the property
- The vertical extent of ownership is not specifically defined in legislation
- When interpreting the extent of ownership, the lower boundary of a property has been limited to the depth where it can be technically utilised; in practice this means the depth of 6 m
- City of Helsinki charges also those companies using underground space, but the rent is only c. 50% of the corresponding ground-level rent
- Anyone constructing facilities underground must obtain agreement on the right to use the underground construction site
- Ownership can be established through voluntary transactions, agreements or compulsory purchases based on legislation
- The precondition for obtaining a building permit is that the applicant has control over the construction site

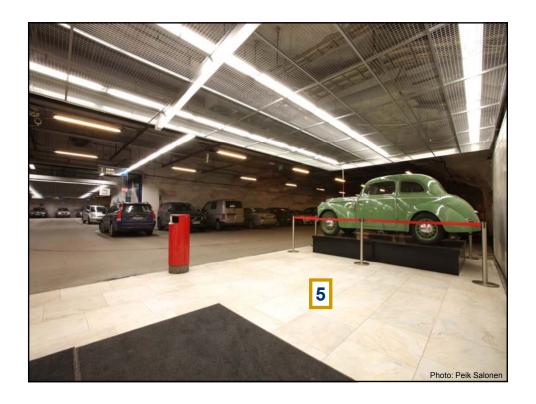
# **Underground Architecture & Shopping**













### **Conclusions of Lessons 3 & 4**

- Up-to-date soil and bedrock databases are of high value
- Placing different facilities underground is a safe and economical investment of today and even more in the future
- Owning the land donates the city the value increase of zoning and the power to decide on the timetable of development projects
- Aesthetic aspects are important and they call for skilled architects

### **Conclusions of the Workshop**

- Important to educate planners and decision makers about the usefulness of UG resources
- Placing different facilities UG is a safe and economical investment
- Owning the land donates the city the value increase of zoning and helps UG Planning





# Message to the Government of Hong Kong from ITA Committee on Underground Space - ITACUS

# International Tunnelling and Underground Space Association ITA



**Better and Resilient Cities** 

## Hong Kong is welcome to ITA Global Perspective programme

- The programme aims to identify how underground space use can be beneficial in terms of rapid urbanisation and in terms of making cities more resilient to natural disasters and the effects of climate change
- Bringing municipal engineers, urban planners and local government decision makers together to help them understand the benefits of underground space use

### How can you join?

- At international activities like:
  - ✓ ISOCARP (The International Society of City and Regional Planners ) World Congress 2011 in Wuhan (www.isocarp.org)
  - ✓ IFME (The International Federation of Municipal Engineering) World Congress 2012 in Helsinki (www.ifme2012.com)
  - ✓ ITA World Tunnelling and Underground Space Congress 2012 in Bangkok (<u>www.ita-aites.org</u>)
  - ✓ ACUUS (Associated research Centers for the Urban Underground Space) Conference 2012 in Singapore (www.acuus2012.com)