Underground Space Development: Setting Modern Strategies

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“...evidence of tunnel construction works reflects the cultural developments of civilizations and particularly the growth of technical and economic strength”

G.E. Sandstrom
Scene of traffic congestion, *Wood engraving*
The first Athens metro line

Excavations for the underground extension of the first Athens Metro line
### Annual passenger trips in major metro systems

<table>
<thead>
<tr>
<th>Metro</th>
<th>Passengers</th>
</tr>
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<tbody>
<tr>
<td>Tokyo Subway</td>
<td>2.646 billion</td>
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<tr>
<td>Moscow Metro</td>
<td>2.475 billion</td>
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<tr>
<td>New York City Subway</td>
<td>1.850 billion</td>
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<tr>
<td>Seoul Subway</td>
<td>1.654 billion</td>
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<tr>
<td>Mexico City Metro</td>
<td>1.442 billion</td>
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<tr>
<td>Paris Métro</td>
<td>1.336 billion</td>
</tr>
<tr>
<td>London Underground</td>
<td>1.094 billion</td>
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<tr>
<td>Osaka Municipal Subway</td>
<td>912 million</td>
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<tr>
<td>Hong Kong MTR</td>
<td>867 million</td>
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<tr>
<td>São Paulo Metro</td>
<td>774 million</td>
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<tr>
<td>Beijing Metro</td>
<td>765 million</td>
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<tr>
<td>Cairo Metro</td>
<td>750 million</td>
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<tr>
<td>Santiago Metro</td>
<td>680 million</td>
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<tr>
<td>Shanghai Metro</td>
<td>649 million</td>
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<tr>
<td>Madrid Metro</td>
<td>647 million</td>
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<tr>
<td>Saint Petersburg Metro</td>
<td>602 million</td>
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<tr>
<td>Prague Metro</td>
<td>531 million</td>
</tr>
<tr>
<td>Buenos Aires Metro</td>
<td>476 million</td>
</tr>
<tr>
<td>Berlin U-Bahn</td>
<td>475 million</td>
</tr>
<tr>
<td>Vienna U-Bahn</td>
<td>427.4 million</td>
</tr>
</tbody>
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*Underground Spaces 2008*
Lidabashi Station: a major interchange station in Tokyo, connecting four major underground lines and one above ground line.
Minato Mirai: The harbour of the future

Natural lighting, even at the fourth level underground
Athens metro

Monastiraki station  Dafni station
The automobile empire
“Big Dig”: The biggest underground project:

- Total excavation: 12.5 million m³
- Total cost: 14.6 billion U.S. $
- 10 underground lanes
The SMART PROJECT - Kuala Lumpur:

- A motorway used, also, as a flood discharging system
- Total Storage Capacity: 3 million m³
La Pedrera

Barcelona, Spain

Designed by Antoni Gaudí
and built in the years 1905–1907
Estienne d'Orves square - Marseille
Montreal: « The city under the city »
Underground Shopping Malls: Moscow
Underground Shopping Malls: Shinjuku
- More than 450,000 m² of used underground space.
- More than 50 companies, with 1300 employees
Subtropolis complex

- Low lease rates: 30-50% less than above ground facilities
- Low utility costs: 50-70% savings in total energy costs
- Almost constant temperature
Sewage treatment plants

Viikinmaki, Finland
Sewage treatment plants

Kakolanmäki, Finland

Underground Spaces 2008
Itakeskus underground swimming pool, Helsinki

More than 400,000 visitors every year

Underground Spaces 2008
Zhongguancun center: The “Silicon Valley of China”
The Super K, located 1000 m underground in the Mozumi Mine, Japan
Why are we involved in underground development?
Athens: a Metropolis of 4.5 million inhabitants in 3,500 sq. km
The contribution of LMET in underground development
The contribution of LMET in underground development

Perama
The contribution of LMET in underground development
The contribution of LMET in underground development
Can the IT revolution change the current trend?
In the last 50 years the world population has grown by 256%, while the urban population has grown threefold.

Almost 50% of the world population resides in urban areas.

Today there are 21 megacities with more than 10 million inhabitants in the world.

1950: Global pop: 2.5 billions
83 cities > 1 million
2 cities > 10 millions

2006: Global pop: 6.5 billions
387 cities > 1 million
21 cities > 10 millions
Forecasts for urban population for 2030

- The global population will exceed 8 billion people
- More than 60% will be urban population. This percentage will be 80% for Europe and North America
Price of urban land

Supply of urban land

P1'

D1

S1
Space scarcity: two ways out:

To maximize the utilization of the urban surface land (e.g. build skyscrapers)

or

To utilize the urban underground space
Underground space: a “strange” commodity

- A non-renewable resource ...
- Free or private good?
- Need to implement environmental economics

The “spaghetti subsurface problem”
The mining sector

- 7 billion tons/year extracted by underground mining
- 35 million people working in mining
- 450 billion US $, the total value of annual mined production
Room-and-Pillar mining

Using mining methods...

Hunt Midwest (Subtropolis)
Lavera oil storage facility (France)

Total capacity: 400,000 m$^3$
Oil storage facility (S.Korea)

Total capacity:

4,600,000 m³ (1985)
+ 1,900,000 m³ (1997)
+ 800,000 m³ (2006)
Natural gas storage in salt domes

Manosque (S. France)
Natural gas: $300 \times 10^6 \text{ m}^3$, Oil products: $6.5 \times 10^6 \text{ m}^3$
Natural gas storage in salt domes

Typical Dimensions:
- 500-600 m height
- 100-150 m diameter

Capacity:
$500 \times 10^3$ m$^3$
Underground space in urban environment can be thought as "the modern ore"

**Things to do:**

- Modify typical mining techniques to adopt all modern requirements
- Cultivate a new philosophy in the mining sector by first changing the curricula of the mining schools

**Bauxite:** 70 $ per m³ of extracted underground space

**Underground parking space in Athens’ centre:** 600 $ per m³ of extracted underground space
Underground development will continuously come in the spotlight!

WE WILL BE THERE!