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SUBSURFACE PLANNING AND GEO-MAPPING – An Overview

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ABSTRACT: During the last years, many nations have put focus on the need for good and professional planning of underground space. By co-ordinating the different interests and needs for building under our cities and by improving the legislative and administrative framework, development of underground space can be facilitated. This paper will present the experiences of 9 ITA member states as compiled by the author in a report published by the Working group No. 4 within the International Tunnelling Association, ITA.

1 BACKGROUND

National legislation and local authorities can either facilitate or restrain the use of underground development. Legislation is often more coherent and clear for surface solutions than is the case for building underground. The lack of clear rules and routines or standards for underground construction may delay the legal procedures thus prolonging projects and increasing their costs. It is not unusual that these procedures take longer time than what it takes to construct the facility. On the other hand, underground construction has in most countries been less regulated than surface construction. The increasing demands for underground solutions emphasises the need for a better co-ordination of the utilisation of underground space.

Within the International Tunnelling Association, Working group 4 ("Subsurface Planning") is responsible for dealing with these topics. Already in 1990 a first study on the subject of legal and administrative Issues in Underground Space Use was compiled by Ray Sterling, at that time director of the University of Minnesota, USA[1].

Since then, and with an increasing utilisation of the subsurface, the lack of legislation, administrative routines and knowledge about the peticularities of underground space among those dealing with these issues has become more and more evident.

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In 1995 the Working Group decided to ask its member nations to do reports on their experiences on the Planning and Mapping of Subsurface Space. Nine member nations presented contributions to the work. We can conclude that during the last couple of years, many nations have undertaken to make very comprehensive studies, which have and are being presented to politicians and decision makers to focus on the problems, to suggest improvements in legislation and to introduce a number of possible, infrastructural solutions underground. As a result, the planning authorities in some major cities have recognised the potential of underground space to be considered in future developments of the city. The national contributions, many of them very comprehensive, clearly show that there are some common international problems regarding planning and mapping of underground space.

The reports are of varying length and contents. Some of the countries have presented extensive reports and summaries of extensive research programmes within this field. Others have presented short summaries of the present state of legislation in their countries. Almost all contributions deal with the question why the use of underground space is increasing and what future uses that seem to be in the pipe.

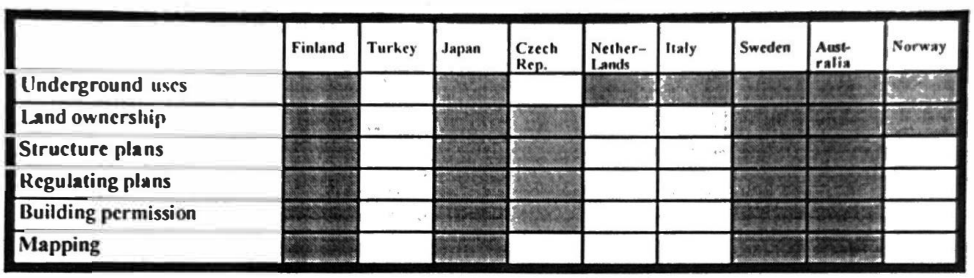

Fig 1. An overview of the issues dealt with in the national contributions to this report (dark colour indicates more extensive coverage of topic).

This short overview of the summary can by no means review everything presented in the nine national contributions. The aim has instead been to summarise the main points stressed in the contributions and also include some of the presented examples. In some cases recommendations for future action have been pointed out. These recommendations are presented in the report and are definitely of value for the ITA and its future work within this field. A summary of the report has also been published in Tunnelling and Underground Space Technology [2]

2. UNDERGROUND SPACE IS BECOMING MORE AND MORE ATTRACTIVE

All of the contributions stated that use of underground space is becoming more and more attractive for development. One general and major point is that use of underground space is a means for achieving quality aspects such as an improved environment. In many cases the choice of an underground solution is a choice between the underground solution and no solution at all. This because of the environmental concerns.

There are also a number of possible impediments to the utilisation of underground space. In the Dutch study [3] these have been analysed and are presented in the tables below:

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Impediments		Nuances/ possible solutions	
I	**Legal aspects** - Unclear legislation and regulation concerning decision-taking on (major) projects - Unclear public and private law provisions concerning underground construction	-	Harmonization and synchronization of legal procedures concerning decision-taking on (major) projects is under study - Legislation and regulation concerning underground construction should be transparently presented and if necessary allowed to be amended.
II	**Spatial planning aspects and zoning plan** - Spatial planning schemes and planning policy are entirely focused on above-ground activities	-	Develop an integrated spatial planning vision on the use of both above-ground and underground space - Possible solution by amending the Spatial Planning Act
III	**Lack of a (dynamic) integrated assessment framework** - Underground options are often not - or not seriously - incorporated in the decision-taking procedure. - Lack of a good method for comparison of differing underground and above-ground options.	-	Development of a (dynamic) integrated assessment framework, to ensure that all the relevant aspects and options are considered at each stage of the assessment process.
IV	**Lack of integrated decision-taking procedures** - Major projects feature an unclear and unmanageable decision-taking process, yielding a frequently suboptimal outcome with regard to utilization of underground space	-	Well-designed integrated decision-taking procedures can improve the manageability of the assessment process between various option, and can optimize the outcome.
V	**Unfamiliarity with the possibilities of underground construction** - Utilization of underground space is a relatively new concept in the Netherlands, and many possibilities are still unknown.	-	To ensure optimized utilization of the possibilities of underground construction, certain actors must possess certain know-how, information strategies can be formulated with that objective.

Fig 2. Possible impediments related to enabling factors as described in the Dutch report.

2.1 WHO OWNS THE SUB-SURFACE?

The most common maxim applied to the definition of limits of surface property ownership is from Roman law "Cujus est solum ejus est usque ad coelum et ad infernos" meaning " The owner of the surface also owns to the sky and to the depths". In the ITA survey "Legal and administrative issues in underground space use, four main conditions appeared to exist in relation to the limits of surface property ownership:

1. the surface owner owns to the centre of earth
2. the surface owner owns as far as reasonable interest exists
3. the surface owner owns only to a limited depth beneath the land surface (as little as 6 metres)
4. private land ownership is non-existent

Ownership does not necessarily give the right to use the land or the underground space. The right to use the underground space is often restricted in some way either through land-use plans or legal praxis neither does the ownership of land necessarily give the right to opposite activities of other users under the surface.

In most of the contributions to this overview the legal framework related to ownership of subsurface space is regarded as a problem.

Since 3-dimensional real-estate not yet is a possibility, the right to build a tunnel or a

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cavern must be obtained by other means. The most common way to do this is by some kind of easement. Easements can for example be established to define security zones protecting a tunnel from other projects that could harm the structure.

Even though this possibility exists there are problems that cannot be solved without making 3-dimensional real-estate possible.

2.2. Make 3-dimensional real-estate possible!

Some of the contributions propose the idea of creating 3-dimensional real-estate.

By updating the land title legislation the ability to subdivide land into strata could be enhanced. This could be done by defining "land" in the current legislation as being expressly three dimensional with ownership expressed to include the vertical as well as the horizontal. The legislation should also be amended so that it makes zoning in three dimensions possible.

The liability issues related to subsidence above underground projects and removal of lateral support to adjacent properties however may become more complicated when land ownership is subdivided vertically as well as horizontally.

It is important that national governments look over the legal framework related to ownership of subsurface space so that the legal responsibilities between owners of underground space and other affected parties are clearly defined. This can be done either by making 3-dimension property possible or by other amendments of existing legislation, so that development of urban underground infrastructure is facilitated.

3. STRATEGIC PLANNING OF UNDERGROUND SPACE

3.1. The need for a better co-ordination of different uses

Strategic land-use planning (also referred to as master or general planning) is used in most countries as a way of obtaining a broader perspective and understanding to assist in the land-use decision making process. In some countries this form of planning is compulsory, in others it is done on a voluntary basis. In some countries the master plans are binding for detailed plans, in other countries not. What the strategic land-use plans have in common is that they:

1. help establish visions and objectives for the development or conservation of certain areas
2. establish strategies to achieve the visions
3. often are comprehensive thus taking into account different demands for the use of the land and also addressing issues that reach beyond land-use aspects
4. in many cases are drawn up incorporating a strong degree of government agency and public participation

Strategic planning for the use of underground space is not common. In most countries decisions regarding underground space use have been on a piecemeal basis and as long as underground space is only used for a few tunnels in these cities this is no problem. The difficulties arise when underground space becomes attractive for different needs and when the co-ordination of these needs become evident.

As stated earlier in this report development of underground space is becoming more and more interesting. Increases in the use of the underground for major transport projects and

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the rise in the number of private utility providers highlights the importance of underground planning for cities and urban areas. It is obvious that underground space is not an infinite resource and its use must be managed carefully and professionally.

Many of the contributions to this report therefore recommend that strategic planning should to a greater extent be applied to underground space.

3.2 Examples of strategic plans

It is not uncommon that tunnels are included in the strategic plans for cities. Less common are strategic plans for underground space co-ordinating different needs for future development. A few examples have been identified through this survey.

The *City of Sydney's* planning department has initiated a discussion on the preparation of a strategic plan of the city's underground to provide a policy framework for decisions relating to the future uses of this area [4].

The *City of Helsinki* has a space allocation plan of underground activities since 1984. The main purpose of this system is to co-ordinate the underground plans of various municipal authorities and private construction projects[5].

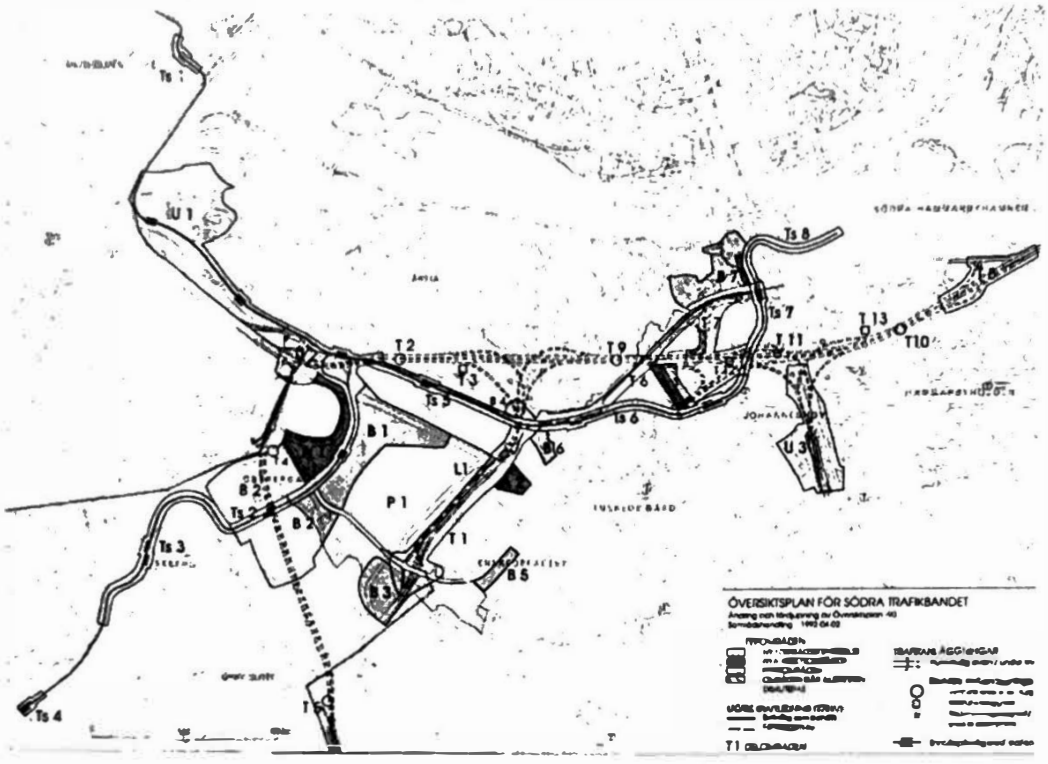

Fig 3. This strategic land-use plan for the southern part of *Stockholm*[6,7] includes both the planning of the Southern Link of Stockholm's ring-road, the new Light rail-system and the planned development of the land use.

4. DETAILED PLANNING

Detailed development plans (sometimes referred to as zoning plans or town plans) are normally legally binding. The plan consists of a map with regulations concerning the use of the land, restrictions and specific requirements on the permitted development.

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COUNTRY	Are detailed development plans that only deal with the subsurface possible by law?	Are tunnels and caverns regulated in detailed development plans?
FINLAND	No, the regulations apply both to the surface and the underground	In some cases especially in Helsinki
TURKEY	No, the regulations apply both to the surface and the underground	In some cases especially in larger cities.
JAPAN	No, the regulations apply both to the surface and the underground.	In some cases.
CZECH REP.	?	?
NETHERLANDS	Plans only dealing with the surface do not exist. By law consequences for the surface have to be included.	Tunnels and underground structures are regulated in development plans.
ITALY	?	?
SWEDEN	No, the regulations apply both to the surface and the underground	In some cases especially in larger cities.
AUSTRALIA	?	?
NORWAY	No	In some cases.

Fig. 4 The legal requirements and possibilities vary from country to country. The figure above attempts to summarise the situation in the countries participating in the survey.

The matters that can be regulated in detailed development plans vary between the countries. Common issues dealt with in the plans are for example:

1. Regulations related to depth, such as safety zones to protect the caverns from development on the surface
2. definition of permitted building volume
3. regulations concerning the quality of underground space
4. visual and functional aspects of the space such as compatibility with the townscape
5. regulations concerning environmental impacts such as vibrations from the use of rail or road tunnels, effects on the ground-water table etc.
6. Functional regulations which concern underground work spaces'
7. regulations related to the built environment above ground level such as entrances and their location, vertical shafts and their location, ventilation ducts and their location.

5. BUILDING PERMISSION

Before construction work can start building permissions are required in most countries.

COUNTRY	Is building permission required by law for tunnels and caverns?
Finland	is required when people are to live or work in the cavern
Turkey	is required
Japan	is required
Czech Rep.	is required
Netherlands	is always required
Italy	is required
Sweden	is required except for mines and metro-systems
Australia	?
Norway	is required

Fig 5. The table illustrates the requirements for building permission in the studied countries

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6 RECOMMENDATIONS FOR SUBSURFACE PLANNING AND MAPPING

According to this survey, it has been established that the legal framework for planning the use of subsurface space is in many nations insufficient or even non-existent. It can also be agreed that underground development must be viewed as a means of achieving strategic objectives of a community and/or government. In order to accomplish this, the following basic requirements may be suggested for the planning and mapping of underground installations.

State governments should look at underground space use in major urban areas as a way of reinforcing strategic objectives and enhancing the environmental quality of urban centres and helping maintain its street life – not as pulling the urban life below ground-". There are many ways of stimulating the use of underground space.

State governments may foster visions exemplifying the benefits of the underground including reports on environmental, institutional and economical feasibility.

State governments and the private sector should pursue technological development aimed at facilitating cheaper and more risk-free underground construction, as cost is a major barrier to greater use of underground infrastructure solutions.

5.1. Reform the legislation concerning underground planning

Some countries express that state governments should regulate the legal framework for underground construction. In most countries involved in the ITA-survey, increased planning of underground space was called for. The main reason for this is the need to better co-ordinate between different needs in urban areas. Municipalities should reserve corridors for future transport tunnels as done for surface routes. They should also include the possibilities of underground space in cities and major urban areas in their conceptional planning and provide for reservation of this space in their strategic plans. Systems for planning, zoning, reserving and regulating underground space should be developed as well as codes of best practice for layout of transport and utility infrastructure. It has also been pointed out that state governments should check and modify building codes where appropriate so that they do not unnecessarily inhibit underground use.

It is recommended that general national rules or recommendations are established for the protection of the environment, maintenance of groundwater levels etc. In sensitive areas (e.g. archaeological) special directions would be called for.

5.2. Local authorities (cities, communities, municipalities)

Many of the national contributions focus the need for a better co-ordination and planning of the use of the space below our cities. In some cities, the extensive use of the underground has led to a growing congestion below the surface similar to the congestion already existing on the surface. As stated earlier in this report development of underground space is becoming more and more interesting. Increases in the use of the underground for major transport projects and the rise in the number of private utility providers highlights the importance of underground planning for cities and urban areas. It is obvious that underground space is not an infinite resource and its use must be managed carefully and professionally. Local authorities should therefore better co-ordinate the different uses and needs of underground space in viewing it as a means to improve the infrastructure in a long-term planning.

Local authorities may adopt a plan for underground space that covers the whole municipality – a strategic plan of the underground – to provide a policy framework for decisions relating to the future subsurface use of the area.

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Local authorities should collect and collate information on underground geological conditions, existing underground structures and available underground space and interpret this information for use in short and long range urban planning to be consulted when new underground installations in the area are being discussed.

Different cities have different procedures for the permission procedures. There is a need for a greater consistency. A single set of guidelines and recommendations is called for.

5.3. *Specific Items in Planning an Underground Installation*

Particularly in a major underground project, decision-making may often be divided on many hands (public/local authorities, clients, owners etc.). To achieve harmonisation and synchronisation of legal procedures concerning decision-taking it is recommended that a detailed Organisation Scheme is developed at the early phase of the project with representatives from the parties concerned. This would mean shorter 'communication-ways' for a decision and - if necessary - facilitate any amendments that are called for in the regulations for the implementation of the project.

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