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Adoption of New Transport Technology:
a Quick **Scan** Approach

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Research Memorandum 1995-27

**ADOPTION OF NEW TRANSPORT TECHNOLOGY:
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Research Memorandum 1995 • 27

ADOPTION OF NEW TRANSPORT TECHNOLOGY:
A QUICK SCAN APPROACH

DRAFT VERSION

JULY 1995

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Abstract

Quick **scan** methods aim at a fast and transparent analysis of alternative solutions to planning problems in a situation of shortage of information. They **generate** new knowledge about solutions in early stages of decision **making** and in 'creative experiments' in scenario analysis. The **importance** of quick **scan** methods is growing within the trend toward more flexible and **interactive** approaches in decision **making** in policy and planning.

This article presents a quick **scan** of alternative technology options to transport problems, in view of their adoption in the market. The **technologies** involved represent good efforts to **contribute** to energy efficiency and a reduction of air pollutants. The perspective used in this quick **scan** is spatial by emphasizing the influence of spatial settlement patterns in scenario thinking on future transport.

Key Words: Quick **Scan**, Multicriteria Analysis, Transport Technology, Urbanization Pattern.

1. PROBLEM FIELD

In the past decades, transport has **continued** to increase its consumption of non renewable energy sources, to lead to increasingly **higher** levels of congestion, and to emit substantial levels of **gases** (including greenhouse **gases**).

Major **allies** in coping with transport pollution and energy use are usually expected to be in behavioral changes (e.g. mobility and life style patterns), and changes in geographical patterns of living, working and recreating [1, 2, 3]. In addition, technological progress is usually considered an important **means** in coping with the problems. Therefore, a **systematic** assessment of the opportunities offered by new transport technologies **may** bring to light new policy perspectives. This article **will address** the potential of **such** new technologies by **means** of a quick **scan** approach.

The technologies in this quick **scan** procedure exemplify good efforts to **contribute** to a sustainable passenger transport, in terms of energy **efficiency** and emission of greenhouse **gases** (Table 1) [4]. Their potential use is on different spatial **scale**. In addition, both foreseeable developments with a relatively short lead **time** (conventional systems) and developments further away (advanced systems) are taken into account. Of course, the list of technologies is not exhaustive but mainly **indicative**.

Table 1 Transport **technologies and spatial scale**

The need for transport emerges **where** functionally dependent **human** activities are separated in **space**. In the 1960s and **1970s**, the spatial separation of working and living was enlarged to an unprecedented degree. This suburbanization was primarily residential and **caused** therefore, a focused patten of longdistance commuting from suburbs and outer **areas** to central cities. Later developments were considerably more complex because the sprawl of living quarters was **coupled** with a substantial suburbanization of employment, leading to an increased cross-commuting as **well** as relatively shortdistance intra-suburban commuting trips. Aside from living and working, **also** a separation of living and recreation took **place** in the past decades.

Spatial planning for a reduction of transport is still limited in scope, because there is a shortage of knowledge on the underlying **principles** [5, 6]. **Much** research has focused on the relationship between urban form (**size** and density) and passenger transport. One of the major conclusions so far is that larger, dense cities are associated with a high use of public transport and with a low gasoline consumption [7]. What **however, also** matters is **where** the interdependent workplaces, service centers and houses are located within the metropolitan area, particularly **also where** populations with different life styles are living. In other words, the socio-economic composition of the city seems to be a further important element in the generation of passenger transport flows.

One particular planning concept is important here, namely the 'compact' city. **Such** a city is suggested to **provide** highdensity housing and a concentration of employment in the central city-area and subcentres [8, 9]. The compact city is currently adopted in Europe as a leading **principle** in urban planning [10, 11], under the assumption of two major **merits** in terms of sustainable transport, namely short private journey lengths and good **prospects** for public transport. In a decentralized city, **however**, jobs and houses tend to disperse further in and beyond the metropolitan area (a **process** named counter-urbanization), causing larger and more **diffuse** traffic **flows** [10]. Uncertainty about these developments will be dealt **with** in the quick **scan** procedure **here**.

2. INFLUENCES ON ADOPTION

Three types of **factors influence the prospects** for adoption of new transport technology **from** a spatial point of view:

- (1) spatial **inertia**
- (2) the technology's critical system features
- (3) future urbanization patterns.

The most important barrier to adoption of new transport **technologies** seems to be **spatial inertia**. **Once traffic infrastructure** and other **artefacts** of **human** activity (**such** as houses, industrial premises and buildings) have been established, it **will** be used for a long

time, at least **the time** needed to **generate** a **sufficient** return on investment. Spatial **inertia holds** particularly for historical buildings and structures in inner city **areas**.

Critical system features are the set of **specific** attributes of a transport technology which determines the spatial conditions for implementation as **well** as (un)desired impacts of this implementation. For example, a critical system feature of public transport modes is the need for a minimum amount of travel **demand** (threshold level) in an area. Barriers to adoption arise **when** threshold levels of **demand** for the **advocated** technology are not reached, due to a low population density. In addition, **upper** levels are concerned with the maximum distance which particular vehicles **can** bridge. Accordingly, barriers **may** arise **when** distances in transport **needs** exceed the **upper level** of spatial **reach**. This barrier **holds**, for example, for particular types of electric **car**.

Different critical system features of transport **technologies also cause** a differentiation in the spatial impacts of these **technologies**. The most common negative impacts are noise, emission of gas, danger of **accidents** (crashes) and vibration. These **may constitute** a barrier to adoption **when** an **accepted** maximum level of inconvenience is exceeded. New transport technology **may, however, also cause** various positive impacts, **such** as a fluid **traffic** instead of congestion, and potential creation of emission-free zones.

The way in which critical system features **influence** adoption, is **very much** dependent on the **urbanization pattern** that **will** develop in next decades. Future patterns of urbanization **will** therefore, be given particular attention in the current quick **scan** procedure.

At the metropolitan **scale** we take into account the previously **discussed** compact city and as a contrasting perspective, the **decentralized** city (Table 2). At the **(inter)national scale**, we **will** consider two contrasting perspectives designed by the Physical Planning Agency in the Netherlands [12], named (1) specialization and **concentration** and (2) chains and zones. The former **articulates** an ongoing concentration of population as a **result** of the location of leading **economic** (world) **functions** in leading (large) cities. This **process will enforce** a hierarchy of functions and a hierarchy of locations (including metropolises at the top, followed by europolises and smaller cities) which is likely to be associated with a hierarchy of transportation systems. Accordingly, metropolises are the center of a radial system (mainports) **that connects them** with europolises, and the europolises are the center of a radial system that **connects them with** smaller cities, etc. In contrast with this, the **chains** and zones pattern is **weakly oriented** toward a hierarchy of **functions**. **Companies** are **increasingly footloose** in

such a way that the concomitant spatial processes lead towards dispersion on various **scales**. This pattern is associated with a criss-cross character of **main traffic** and transport **relationships**, whereas (national) spatial strategies tend to focus on the bundling of these relationships (in chains).

Table 2 Future urbanization patterns

3. METHODOLOGY

Scenario analysis has increased in **importance** in the past few years. Particularly for complex problems with a relatively long **time** horizon and concomitant shortage of information, scenario analysis has moved towards '**creative** learning' processes including various 'cycles' of activities to **discuss, evaluate**, register, **synthesize** and present information on potential development processes [13]. Within this framework, quick **scans** intend to bring new information to light which **can** be used in starting and restarting 'cycles' of scenario activity . Due to their simple and transparent character, they **also allow** for a more **interactive** participation of various stakeholders in policy processes. An essential component of quick **scans** is **sensitivity analysis**, in view of different policy assumptions (e.g. diverse community **interests**) and assumptions on developments which are beyond **control** (e.g. macro-economic conditions, urbanization patterns). Thus, by **means** of sensitivity analysis the stability of quick **scan** outcomes under different assumptions **can** be made **clear**.

A quick **scan** approach is used here in order to **assess** the **chance** for adoption of new transport **technologies**. It **needs** to be emphasized that there are three **specific** circumstances in this quick **scan** procedure. First, the alternative **technologies will** not be '**scanned**' on their effectiveness in reaching sustainability aims in terms of energy use and air pollution. This is taken for granted [4]. Secondly, among a set of **further** conditions to adoption only **spatial** criteria **will** be explored. As a **consequence, economic (cost)** criteria and behavioral (**attitudinal**) criteria are excluded from the analysis. Third, only circumstances in the stage of exploitation of the technology will be taken into account (leaving most of the construction stage aside). We distinguish **six** spatial evaluation criteria as follows:

- (1) **Spatial connection and range:** the better the technology in terms of bridging distances in a fast (smooth) way, the larger the chance for adoption.
- (2) **Spatial demand:** the **higher** the threshold **level** of **demand**, the smaller the chance for adoption.
- (3) **Infrastructure needs (spatial inertia):** the smaller the **needs** for new (additional) **infrastructure**, the better **the** chance for adoption.
- (4) **Efficiency of land use:** the more **efficient** land (road) use, the larger the chance for adoption.
- (5) **Local positive/negative impacts on surrounding land:** the less negative impacts (**such** as noise, vibration, danger for crashes), the larger the chance for adoption.
- (6) **Landscape impairment:** the **less** impairment, the larger the chance for adoption.

In the current quick **scan**, scores **will** be assigned to **each** of the above criteria by using a five point rank scale, running from **very** positive conditions for adoption (5) to **very** negative conditions (1). The **results** will be **processed** by **means** of multi-criteria analysis (MCA), **merely** for **illustration** purposes.

The assignment of scores of the transport **technologies** on the above **evaluation** criteria is based **upon** a concise study of the literature. The head lines of this study are the subject matter of the next two sections.

4. CONVENTIONAL TRANSPORT SYSTEMS

This section will discuss three transport **technologies** which are **already** adopted on a small scale and **may** be **further** adopted on the short term, i.e. High Speed (**HS**) Train, Maglev, and Improved **Car**.

The most important designs of HS Trains are the French TGV, the German ICE and the Japanese **Shinkansen** [14, 15, 16, 17]. Less **mature** systems are the Italian Pendolino **ETR450** and the British **IC225**. In densely populated **areas** in Europe and Japan, HS train systems **can very well compete** with **cars** and jet aircraft between cities roughly 160 to 800 km apart.

The major positive feature of HS trains (in relation to adoption) is their smooth **connecting** of large metropolitan **areas**. At the same **time**, HS train is a transport mode with

a relatively high threshold **level** of **demand**, i.e. the urban centers to be **connected** **should** be sufficiently large and sufficiently interdependent. A strongly positive feature of HS train operation is its compatibility with existing rail systems, and its smooth **integration** into conventional hierarchical systems. The voltage (in e.g. **TGV**) is **however**, **higher** than provided on most conventional tracks causing the need for a separate track (which cannot be used by other **trains**) or an adaptation of the power train. Further negative features include noise, vibration, and landscape damage in the case of completely new infrastructure.

When (inter)national urbanization patterns develop according to the chains and zones model, the interdependent metropolitan **areas** need to be sufficiently large (around a few million inhabitants) and the distance in-between **needs** to be **sufficiently** long to take advantage of the high speed. **When** urbanization patterns develop according to **the** specialization and concentration model, there seems no restriction to adoption.

Maglev systems make **use** of magnetic levitation (either through electromagnetic or electrodynamic suspension) while propulsion of **the** trains is realized by **means** of a linear induction motor. Presently, there is one High Speed Maglev system available for commercialization, i.e. the German Transrapid 07 [18]. Low Speed Maglev systems have been developed in Japan, Great Britain (Maglev People **Mover**) and Germany (M-Bahn). Like HS train, HS Maglev has clearly the positive feature of connecting city-centers of densely populated metropolitan **areas** in a fast and smooth way. Due to investment levels associated with a completely new infrastructure, it **can** **however**, only **operate** **when** there is a **very** high **demand** for transport, **such** as in Japan between Tokyo and Osaka [19]. A strongly negative feature of (high and low speed) Maglev **systems** is **the** need for a **completely new infrastructure** for accommodating trains, which is totally incompatible **with** existing rail systems. A further negative characteristic is **the** need of the new infrastructure to penetrate deeply into the city-hearts in order to be **effective**. There are **also** some unfavorable local impacts foreseen, **such** as aerodynamic noise (at high speed) and landscape impairment.

When urbanization develops according to the chains and zones pattern, the interlinked metropolitan centers need to be **sufficiently** large and **the** distance in-between **needs** to be **sufficiently** long to take advantage of the high speed. Adoption **may** be further hindered **when** the corridors between the metropolitan centers **lack** easy available land for a new infrastructure. **When** urbanization patterns develop according to the specialization and concentration model, adoption **seems** only realistic **when** there is a **sufficiently** large **interde-**

pendency between the top metropolitan centers of a country. Similarly, the adoption of LS Maglev is dependent **upon** a relatively high **demand** for transport. On the scale of the metropolitan area (region) therefore, adoption seems only to be realistic under conditions of a high-density compact city. **However**, here **comes** a further complication because land for new infrastructure **will** not be easily available in densely populated **areas**.

The last conventional transport technology to be **discussed** here is Improved **Car**. A major example is the electric **car** based **upon** various energy **devices** such as **an** electric battery, a hybrid system and fuel **cells** [20]. Battery-electric **cars** **will** soon be **introduced** to the market in a number of **niches**. The technology has the positive critical feature of contributing to emission-free zones, provided that **also** regulatory measures are taken. The range of battery-electric vehicles (**BEVS**) is, **however**, still limited to 70 to 100 km, whereas the top speed is about 100 **km/h**. The use of BEVS **will** therefore, mainly focus on urban **traffic**. Furthermore, a large scale introduction of BEVS **makes** the establishment of public charging stations necessary, including investment in grid and facilities. Hybridelectric vehicles (**HEVS**) **may** combine various **benefits** of electric contraction with the **longer** range, better performance and fast fuelling characteristics of conventional **cars**. A further type, **fuel-cell** powered vehicles, is similar to HEVS in that they **also** have **an** electric drive train combined with **an** on-board power source. The power source in this case is a fuel-cell, i.e. **an** electro-chemical **device** which directly **converts** chemical energy from **fuel** into electrical energy .

Except for the hybrid-electric (and perhaps **also** the fuel-cell vehicle), the most negative feature in view of adoption is **the** small maximum distance which **can** be bridged. **When** urbanization on the metropolitan scale develops according to the decentralized city, the option of improved **cars** with a **short** range seems hardly feasible. In the compact city, land use and transport planning largely favor public transport. **When however, specific** attention is given to road infrastructure and parking facilities at employment sites, the option of improved (**small** distance) **cars may well** be feasible in **the** compact city.

5. ADVANCED TRANSPORT SYSTEMS

This **section will discuss** three transport options of which market adoption **may** only

occur **merely** on the **longer** term, i.e. Subterranean Systems, Hydrogen Aircraft and Guided Vehicles.

Advanced Subterranean Systems are different from **all** other modes in that they aim at a **drastic** reduction in both environmental and energy **cost**, due to their **(almost) vacuum** tubes. There are currently two designs of **such** systems available, i.e. the Dutch High Speed Tunnel Transport System (**HSTT**) [21] and the Swissmetro Project [22]. The Dutch concept of HSTT includes a network of tunnels in which a bullet-shaped vehicle is propelled by a linear motor. The maximum speed amounts to 500 **km/h**, while energy use **will** be extremely low. The HSTT system is designed for **both** passengers and freight transport, and is intended to **compete** with air and rail transport over distances exceeding a few hundred kilometers. A complementary **feeder** system ensures an **efficient** linkage with existing transport **infrastructure**. The Swissmetro Project is intended to connect the major Swiss cities, but different from the HSTT, it is only designed for passenger transport.

Subterranean Systems have the potential of connecting major cities in a **very** fast and smooth way. In addition, land use is typically **very** small witness the need for land only for **entrance** and exit, and stations for **air-conditioning**. Investment **costs** are certainly **very** high so that the technology is restricted to heavily **populated areas** and corridors of **very** dense good transport. As a **consequence**, Subterranean Systems **will** be feasible on the interurban (national) and international level **when** the trajectories include a **considerable** number of large and strongly interdependent population and **industrial** centers. The presence of natural barriers, including water, mountains and **valuable nature** reserve area, **may also** justify **long-distance tunneling**. Unlike High Speed Train and Maglev it is **difficult** to assess the **influence** of future urbanization patterns on adoption of Subterranean Systems. The ideas about the spatial **scale** of the systems, density of terminals, etc. are still too **much speculative** at present.

Our second example of advanced transport technology is Hydrogen Aircraft. Although aviation is currently responsible for a small share in the world's carbon dioxide emission (**3%**), it **needs** to be realized that this mode is **very** fast growing. The use of hydrogen is one of the **very** few options for reducing emission of carbon dioxide [20]. A negative critical feature of Hydrogen Aircraft is the need for construction of a completely new hydrogen production, storage and distribution **infrastructure**, which is incompatible with the existing **infrastructure** of kerosene. Because the **life-time** of airplanes is roughly 25 years, the **pene-**

tration of the Hydrogen Aircraft **will** be slow. As a **consequence**, both kerosene and hydrogen fuel systems **will** have to be in operation simultaneously for a certain 'transition' **period**. **This** requirement **may** put a heavy pressure on land in and around airports. At the same **time**, strong **safety** measures for distribution and storage seem to be necessary on a permanent basis, which **may** ask for additional use of land.

With **regard** to future urbanization patterns, it seems reasonable to assume that the high investment **level** associated with the new fuel system is only **justified** at mainports of **very** large cities, emerging particularly in the specialization and concentration pattern of urbanization.

The last advanced transport technology to be **discussed** is Guided Vehicles. This mode embraces two different systems, namely physically guided vehicles and electronically guided autonomous road vehicles. Physically guided systems work by **means** of mechanical interaction (rails) or electromagnetic energy (Maglev). There are two **variants**, namely systems of inseparable vehicles and guide-ways, and systems in which the guided vehicles **can** also drive like **normal** passenger **cars**.

A major example of the inseparable system is TAXI 2000 [23]. This urban transportation system operates under **automatic control** between stations in a network of narrow, unobtrusive guide-ways. Empty vehicles **can** be ordered **continually** so that they **can anticipate demand** and wait for people. **Both** passenger and **freight** vehicles **may operate** on the same network. A positive feature of this type of guided vehicles is the relatively small use of land. At the same **time**, it is associated with two negative **factors** for adoption, namely a limited **reach** and a high **level** of **demand**. Accordingly, **when** cities develop in a 'compact' way the inseparable system **may** be feasible on particular high-density trajectories. Its use seems to be unrealistic in decentralized cities and (on **higher** spatial **scales**) in urbanization patterns **where** passenger flows are **rather diffuse**.

Systems of electronically guided autonomous vehicles (navigation) **may** range from route information systems to **fully** automated route guidance [23, 24, 25, 26]. Developments in **electronic** guidance are **already taking place**, for example in Europe in **the** DRIVE program. **When all** vehicles are centrally **controlled**, distances between them **can** decrease **and speed can increase**, leading to an avoidance of congestion. **Electronic** guidance systems **contribute** significantly to an **efficient** road use through the enforcement of **rational** driving **behavior and efficient** route selection. In addition, these systems claim a small **amount** of

extra land for **infrastructure**. From this point of view therefore, **no** restriction for adoption seems to be at work. **When** we **come** to the future pattern of urbanization on various **scales**, **all** patterns which **generate traffic** in relatively dense bundles **may** be subject to a fast introduction. On the metropolitan level, this **means** that compact cities have a **higher** chance for (a fast) introduction than decentralized cities.

The above insights serve as the **principal** basis for the assignment of scores on the evaluation criteria. For simplicity reasons, no priorities **will** be expressed for evaluation criteria (equal weighting). The associated **evaluation** matrices **will** be **discussed** in the next **section**.

6. QUICK SCAN RESULTS

The assignment of scores aims to be consistent between the **three** sets of alternative **technologies** (Table 3) although the amount of speculation is inevitably larger for advanced systems compared with conventional systems. A particular aim of our quick **scan** is to investigate the sensitivity of the outcomes to variation in **future** urbanization. The scores **under** the assumption of two different urbanization patterns are given in Table 4. The matrices show large differences in scores only on **selected** criteria. For example, we assume that the major **difference** in chance for adoption of Low Speed Maglev is based on spatial **demand factors** (criterion 2). In the compact city, a high level of **demand will contribute** to the adoption of this technology (score of 4) while in **the** decentralized city a low (diffuse) **demand** will clearly **hamper such** development (score of 1). Although score differences like these are realistic and **can** be argued, there is nevertheless a **certain** amount of arbitrariness involved.

Table 3 Evaluation matrices

Table 4 Evaluation matrices from **an** urbanization perspective

To **summarize** the matrices a **concordance** analysis [27] is used. This method deals

with qualitative (ordinal) measurement scales and is **very** simple to apply. It is based on a pairwise comparison of **all** alternative options, and subsequent subtractive summation. Various more advanced techniques are available, but not strictly necessary in view of quick and transparent procedures [27, 28, 29].

The results of the quick **scan can** be summarized as follows (Table 5). With respect to conventional technologies and metropolitan scale, Improved **Car** has clearly better opportunities for adoption than LS Maglev. On **higher** spatial scales, again Improved **Car** (hybrid types with long range) has the best outlook for adoption, closely followed by HS Train. Regarding advanced transport systems, the best **chance** for adoption is clearly for Subterranean Systems, leaving Hydrogen Aircraft and Guided Vehicles far behind.

Table 5 Results of quick scan

Regarding the metropolitan scale, it appears **that** future urbanization patterns do not lead to fundamental shifts in results. In both compact cities and decentralized cities, the outlook for adoption is better for Improved **Car**. With respect to **higher** scale levels, one **can** observe a **basic difference** in outcomes between **the** specialization and concentration pattern and the chains and zones pattern. HS Train appears to be superior in the former (albeit with small **difference**) while Improved **Car** (long range) has clearly the best outlook on adoption in the **latter**. At the same **time** the results for HS Maglev are similar under **all** conditions. It **can** thus be concluded that the current quick **scan** results are **sensitive** to future urbanization to a limited degree and only for **higher** spatial scale levels.

Quick **scan** results need to be visualized clearly in view of **an efficient** interpretation by policy makers, future users of transport, and other **consultants** and experts in scenario writing. The ‘spiders’ used here (Figure 1) express the previously given **evaluation** scores for four separate technologies, under the assumption of different patterns of urbanization. **Each** axis represents one **evaluation** criterion and is accordingly scaled 1 to 5. The **figure** shows for example, **the** superiority of Improved **Car** over Low Speed Maglev, particularly a large score **difference** on spatial **demand factors** (decentralized city), local impact **factors** (**particularly** compact city) and **infrastructure needs** (**both** urbanization patterns). The visualization by **means** of ‘spiders’ **makes** the following information readily available:

- (1) **the overall outlook** on adoption: **the** larger the ‘web’ the **higher** the chance for adoption.
- (2) the **dominance of certain** classes of criteria: an orientation (high scores) towards the **left-hand side** in the **figure means** a favourable outlook on adoption based **upon** ecological (quality of life) criteria.

Figure 1 Transport technology **and** chance for adoption

7. CONCLUDING REMARKS

Quick **scan** methods are helpful in early stages of planning by providing new knowledge on alternative solutions in a simple, flexible and transparent way. There is a growing need for **such** methods within the trend for participatory approaches in decision **making**. Quick **scan** methods enable decision makers and other stakeholders to **participate** interactively in the **process** of **identifying** alternative solutions to planning problems, and identifying pros and **cons** of these solutions from different perspectives.

The quick **scan** in this article aimed to explore the adoption of **selected** new modes of passenger transport from a spatial perspective. With **regard** to conventional technology, Improved **Car** appeared to have the best opportunities on various spatial **scales**. Particularly on **higher scales**, High Speed Train **also** offers good outlooks for adoption. Regarding advanced technology, Subterranean Systems appeared to have **the** best **prospects** from a spatial point of view.

The front position of quick **scans** in scenario experiments clearly **causes** a need to ‘test’ the outcomes on stability while using different assumptions. Accordingly, the quick **scan results** here have been explored on the **influence** of different future patterns of urbanization. It appeared that our **results** are sensitive to future urbanization to a small degree and only for **higher** spatial **scales**. On the **latter scales** different outcomes could be observed for Improved **Car** (long range) and High Speed Train. In **general**, the role of different assumptions **may also** be explored by assigning different priorities (and concomitant weights) to the **evaluation** criteria.

Now two questions need to be **answered**, namely (1) is the quick **scan used** here

transferable to other policy situations, and (2) what is the validity of the achieved results? As to the **first** question, it **seems** to be that quick **scans** are **useful** in **all** policy situations **where** there is a need for a fast exploration of alternative options based on small **information**. One example is the front stage in Environmental Impact Assessment [30]. In **such** situations, data **may** be of a mixed qualitative and quantitative type (instead of one type in the current analysis). Multi-criteria analysis **however**, offers various ways to handle **such** data situations [28]. As to the **second** question, it **needs** to be emphasized that a certain amount of arbitrariness is evident in all steps of the procedure **where** choices are at hand, i.e. the **precise** assignment of scores, the expression of priorities, and the selection of the processing technique. In **fact**, for **all** of these **aspects** the robustness of results should be ensured. **However**, in quick **scan** procedures a balance **needs** to be **found** between the speed (and transparency) of achieved results and the robustness of these results. **Because** the **balance** **needs** to be in favour of the former, the best thing that **can** be done is to make arbitrariness explicit.

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Figure 1 Transport **technology** and **chance** for adoption

Evaluation criteria

- (1) Spatial **reach** and connection
- (2) **Demand**
- (3) Need for new **infrastructure**
- (4) Land **use**
- (5) Local impacts
- (6) Landscape.

URBANIZATIONc+z **chains and zones**

S+C specialization and concentration

DC **decentralized** city

CC compact city

(INTER)NATIONAL

— = C+Z model

--- = S+C model

High Speed Train

Maglev High Speed

METROPOLITAN

— = DC

--- = CC

Maglev Low Speed

Improved Cars

Table 1 Transport technologies and spatial scale

Technology	Metropolitan	Interurban/ National	International
Conventional			
High-Speed Train		x	x
Maglev Low-Speed	x		
Maglev High-Speed		x	
Improved Cars	x	x	
Advanced			
Subterranean Systems		x	x
Hydrogen Aircraft			x
Guided Vehicles	x	x	

Table 2 Future **urbanization patterns**

<i>Metropolitan</i>	<i>COMPACT CITY</i>	<i>DECENTRALIZED CITY</i>
Process	High density living and jobs close to public transport infrastructure	Ongoing suburbanization
Functional Structure	Strong mix of living and working Hierarchy of (sub)centres	Separation of living and working Flat structure
Traffic Pattern	Short and dense	Criss-cross
<i>(Inter)national</i>	<i>SPECIALIZATION AND CONCENTRATION</i>	<i>CHAINS AND ZONES</i>
Process	Specialization and concentration in large urban centres	Spread over urban regions (potentially some self-supporting)
Functional structure	Hierarchy of functions and hierarchy of cities	Flat structure based on increased footlooseness
Traffic Pattern	Hierarchical radial	Criss-cross (potentially bundled)

Table 4 Evaluation matrices from an urbanization perspective

Set of alternatives	Evaluation Criteria (a)					
	(1)	(2)	(3)	(4)	(5)	(6)
<hr/>						
<i>Conventional, Metropolitan</i>						
Compact city						
▪ LS Maglev	5	4	1	1	1	2
▪ Improved Car	3	4	3	1	5	3
Decentralized city						
▪ LS Maglev	4	1	1	2	2	2
▪ Improved Car	2	4	3	3	4	3
<hr/>						
<i>Conventional, High Scales</i>						
Specialization-concentration						
▪ HS Train	5	4	4	3	2	2
▪ HS Maglev	5	3	1	2	2	2
▪ Improved Car	3	4	3	3	5	3
Chains and zones						
▪ HS Train	5	2	4	3	2	2
▪ HS Maglev	5	1	1	2	2	2
▪ Improved Car	2	4	3	3	4	3
<hr/>						

(a) See Table 3.

Table 5 **Results of quick scan**

Sets of alternatives	General	Urbanization Patten (a)	
Conventional, Metropolitan -----		cc	DC -----
Low Speed Maglev	-4	-2	-4
Improved Car (short range)	4	2	4
Conventional, High Scales -----		s + c	c + z -----
High Speed Train	3	4	2
High Speed Maglev	-7	-7	-7
Improved Car (long range)	4	3	5
Advanced, High Scales -----			
Subterranean Systems	6		
Hydrogen Aircraft	-5		
Guided Vehicles	-1		

(a) CC = Compact city; DC = Decentralized city
 s + c = **Specialization** and concentration
 C+Z = **Chains** and zones