This guide to good practice underground space is developed within the framework of the EU-funded INTERREG IIIC project ‘Connected Cities’. It focuses on how a strategic use of underground space can facilitate sustainable modes of transportation and mobility in urban and rural areas. Twelve strategic European projects are evaluated for their good practice in terms of motive, mobility, process, realisation and result. Many of the projects are still under development. For this reason, the guide describes value and meaning in a general sense without too specific or too detailed information. Instead, the guide is intended to provide directions on what aspects and projects to pay attention to in the next couple of years. They may very well represent the shape of things to come.
Connected Cities
Guide to good practice underground space

Connected
Cities

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A joint venture of:
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Connected Cities

During 2004 and 2005, staff from TU Delft (Delft University of Technology) and COB (the Netherlands Knowledge Centre for Underground Construction and Underground Space) developed an idea that evolved into the INTERREG IIIC network called Connected Cities.

This guide to good practice underground space presents a selection of the showcases identified in the course of many meetings, discussions, workshops and conferences held between July 2005 and December 2007. The selection focuses on how a strategic use of underground space can facilitate sustainable modes of transportation and mobility in urban and rural areas.

Over time, we became aware of five recurring aspects. Is there a specific ‘motive’ that characterises the specific showcase? Is the kind of ‘mobility’ a project facilitates innovative or not? Is the decision-making ‘process’ exemplary? Did the ‘realisation’ of the project develop a special construction or design? And finally: Is the ‘result’ genuinely extraordinary? This guide describes these five aspects.

In each of the five chapters, we assess which of the projects stands out in terms of motive, mobility, process, realisation or result.

Many of these projects are still under development. For this reason, the guide describes value and meaning in a general sense. Specific or detailed information tends to be a rapidly ageing snapshot anyway. Instead, the guide is intended to provide directions on what aspects and projects to pay attention to in the next couple of years. They may very well represent the shape of things to come.

Frank van der Hoeven
Delft University of Technology, Lead Partner Connected Cities
There are obvious reasons for carrying out improvements on infrastructure and other mobility projects: people wish to go from A to B. But the reasons for choosing a specific solution are not always clear. The decision to build underground in particular is not always self-evident. However, projects all over Europe demonstrate how this option adds a great deal of value.

Examples include:
- **Arnhem Centraal station, Arnhem** the introduction of the high-speed train resulted in the redevelopment of the station area in Arnhem.
- **The Groene Hart tunnel, The Netherlands** the value of the rural Green Heart in the urban west of The Netherlands gave rise to the construction of a train tunnel • read also Aspect 5.
- **Les Halles, Paris** an outdated underground space in Paris resulted in a new design • read also Aspect 3.
- **Zuidas, Amsterdam** accessibility and further development of the economically valuable southern part of Amsterdam gave rise to large-scale plans for multiple use of space • read also Aspect 5.
The introduction of the high-speed train in Arnhem resulted in the redevelopment of the station area of this Dutch city.

The high-speed train links Arnhem Centraal station directly up to the European rail network. This offers excellent opportunities for the city and the region, where over 700,000 people live. National and international companies are keen to establish their presence near the station because of the excellent accessibility it provides. Developing the areas around high-speed train stations is important for all of The Netherlands. This is why the Dutch government is investing in the redevelopment of the Arnhem station area by designating it as one of the six New Key Projects. Other New Key Projects are: Amsterdam Zuidas, Rotterdam Centraal, Den Haag Nieuw Centraal, Utrecht Stationsgebied and Via Breda.

Right from the start, the use of underground space has been integrated into the design of the station area. In this way the various traffic flows – train, bus, bicycle and car – can be more closely coordinated, so that passengers can transfer from one mode to another as quickly and comfortably as possible. In addition, putting cables and pipes, waste flows and car-parks underground means that above the ground there is more space for the station area’s end-users: passengers and local residents. But also for the companies and shops that are keen to set up business at this location. Underground connections make for an ideal living and working climate above ground.

**Facts & figures**

<table>
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<th>What</th>
<th>Upgrade of the station area, including underground waste transport and a parking garage</th>
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<tr>
<td>Where</td>
<td>Arnhem (150,000 inhabitants), The Netherlands</td>
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<tr>
<td>Status</td>
<td>Work in progress (2004-2010)</td>
</tr>
<tr>
<td>Parties involved</td>
<td>The design of the new public transport terminal and the accompanying parking garage is by UN Studio and has won several awards</td>
</tr>
<tr>
<td>Motive</td>
<td>Economic opportunities for the region by linking up to the European high-speed-train network</td>
</tr>
<tr>
<td>Internet</td>
<td><a href="http://www.arnhemcentraal.arnhem.nl">www.arnhemcentraal.arnhem.nl</a> (in Dutch)</td>
</tr>
<tr>
<td>Internet search strings</td>
<td>Arnhem Centraal, Ben van Berkel, UN studio, nieuwe sleutelprojecten</td>
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The value of the rural Green Heart in the urban west of The Netherlands gave rise to the construction of a train tunnel.

From 2009 the European high-speed-train (HST) network will also run through The Netherlands. The HSL-Zuid will link Amsterdam and Rotterdam to Antwerp, Brussels and Paris. The HST offers a comfortable alternative to driving and flying and brings European cities closer together. This improved accessibility offers economic opportunities for the entire Randstad conurbation, the urban region containing the four major cities in the west of The Netherlands. 

The Groene Hart (Green Heart) is a large open green area within the Randstad conurbation. It is essential for the spatial structure of the Randstad conurbation and as part of spatial policy it is safeguarded against urbanisation and infrastructure changes. When new track was being laid for the HST connection, the value of this area was heavily debated. Did the economic importance outweigh the quality that this green area adds to life in the surrounding urban area? The solution lay underground: thanks to a bored tunnel the area above ground was able to retain its old functions: nature, recreation, agriculture. This was also the reason for boring the tunnel. This kept excavation work down to a minimum so that there was little disruption to life above ground while the construction work was going on.

<table>
<thead>
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<th>Aspect 1</th>
<th>Motive</th>
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<tr>
<td>The Groene Hart tunnel</td>
<td>Protection of green area for nature, recreation and agriculture</td>
</tr>
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</table>

**Facts & figures**

- **What**: Railway tunnel for Amsterdam-Antwerp High-Speed Line
- **Where**: 7-kilometre bored tunnel tube between Amsterdam Schiphol Airport and Rotterdam, The Netherlands
- **Status**: Construction completed (2000–2006), line in use from 2009
- **Internet**: [www.hslzuid.nl](http://www.hslzuid.nl), [www.hslzuid.com](http://www.hslzuid.com)
- **Internet search strings**: Groene Hart tunnel, HSL-Zuid
Paris has the largest underground hub in Europe. After thirty years it is about time to review the original design.

In 1977, the underground RER station of Châtelet-Les Halles opened its doors. It quickly became the busiest passenger station in Europe and the largest underground hub in Europe, with 800,000 passengers a day. Together with the underground shopping centre ‘Forum des Halles’ over one million people use the subterranean facilities at Les Halles every day. The Les Halles district had its up and downs over the last three decades. During the late eighties and the early nineties it was even plagued by crime and drug problems. Now, after thirty years, both the park and the shopping centre feel outdated. Passengers, local residents and businesses asked for the redevelopment of the station, the Forum and the area above. Les Halles is the most important entry in Paris for people arriving from the suburbs. It needs a fundamental upgrade to become more attractive as such. The use of underground space as an integral part of building development continues a long tradition at Les Halles. In the new arrangement the underground complex will become a true gate to Paris. The central square at level minus three will physically and visually link the underground and the city surface. The same level will become the new heart of the Forum where people enter or leave the city in natural light, under a transparent roof, measuring 145 x 145 meters.
Accessibility and further development of the economically valuable southern part of Amsterdam gave rise to large-scale plans for multiple use of space.

Thanks to its ideal location in the southern part of Amsterdam, the Zuidas has great potential to evolve into the most prestigious location in The Netherlands. The area will be on the European high-speed line and has therefore been designated by the Dutch government as a New Key Project. Already, the Zuidas is easily accessible by car, train and metro and, thanks to the proximity of Amsterdam Schiphol Airport, by air as well. The area is close enough to the old Amsterdam town centre to benefit from the city’s economic attractive power. That it is regarded as a prime location not only nationally but also internationally is demonstrated by the businesses that opened up here in the past year, including international banks and firms of lawyers. In addition, the Zuidas, situated between popular residential neighbourhoods and the green outlying districts, is considered an attractive place to live.

Putting the infrastructure – motorway, railway and eventually the HSL line as well – underground frees up valuable construction space above ground. The spatial quality for residents and passers-by is thus improved, since air pollution and noise nuisance remain underground.

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**Aspect 1 • Motive**

**Zuidas**

Amsterdam • The Netherlands

**Facts & figures**

**What**
Redevelopment of outlying district into prime international location for living and working

**Where**
Amsterdam, The Netherlands

**Status**
Area is already being used, completion of underground infrastructure from 2018, the use of space will be further optimised after the tunnel work is finished by building on top of the train and metro infrastructure.

**Motive**
Location of this area offers economic opportunities, the use of underground space contributes to the quality of the living and working environment above ground. A total surface area of 2 million square metres will be realised in a mixed urban environment.

**Internet**
www.zuidas.nl

**Internet search strings**
Zuidas, Amsterdam, nieuwe sleutelprojecten, Pi de Bruijn
Europeans are becoming ever more mobile. And the need for mobility continues to increase. However, the transport models that determined the infrastructure in virtually all European cities are out of date. These old structures can no longer cope with the growth and in addition do not provide sufficient quality and comfort. What is the solution? How do we get cities moving again?

Examples include:
- **A86 tunnel, Paris** • on the Paris ring road, cars and freight traffic are physically separated.
- **Light Rail, Karlsruhe** • for years this German city has had a light rail system running on tram tracks and railway lines • read also Aspect 3.
- **MiniMetro, Perugia** • this Italian city is implementing a transport concept that is a cross between metro and cable car.
- **RandstadRail, The Netherlands** • in the west of The Netherlands train, tram and metro have been merged • read also Aspect 4.
The Paris ring road has a long bored tunnel where cars and freight traffic are physically separated.

The new A86 goes round Paris. The final ten kilometres affect a natural and cultural area of great historical value. This area includes the gardens and palace of Versailles. A long bored tunnel to minimise the impact on the panoramic area seemed too expensive.

The solution lay in the intensive use of space in the tunnel. Instead of dividing traffic in the conventional way between the two tunnel tubes – one for each direction – traffic is divided into passenger transport and freight transport. Trucks and other high-sided vehicles drive on a single-lane road in one tunnel tube, while cars drive one above the other on a three-lane road through the other tunnel tube. This separation is also safer for ordinary traffic: the greatest risk in road tunnels is posed by freight transport.

On the basis of research into driving behaviour, extra modifications were made to the tunnel. The ‘freight tunnel’, for instance, has less steep gradients, while the duplex tunnel for cars has more exits to the surface. To fund the project Paris granted a concession to Cofiroute, the firm that operates toll roads throughout France.

**Facts & figures**
- **What**: Two bored tunnels for the final ten kilometres of the A86 ring road
- **Where**: Paris, France
- **Status**: Tunnels to open 2008–2010.
- **Mobility**: More cars through the same tunnel by stacking second deck inside tunnel tube
- **Internet**: [www.cofiroute.fr/cofiroute.nsf/web/duplex-a86](http://www.cofiroute.fr/cofiroute.nsf/web/duplex-a86) (in French)
- **Internet search strings**: A86 ouest, duplex, tunnel, Cofiroute
For years the German city of Karlsruhe has had a light rail system running on tram tracks and railway lines. What is the difference between a tram and a train? In Karlsruhe there is none. Since the early nineties trams and trains in and around this German city have been fully integrated. Changing from tram to train or vice versa is often annoying for passengers. To make changing more convenient, major German cities such as Munich, Stuttgart and Frankfurt decided to build an S-Bahn. However, the costs of building an underground rail system of this type were excessive. In many German cities the introduction of the U-Bahn (underground) and S-Bahn went hand in hand with the disappearance of the tram. Karlsruhe expressly did not want the classic city tram to disappear. It opted for a different solution. The city decided to link the regional rail network to the tram system, which was working quite well. It invested in light-rail rolling stock that can run on both types of rail. This means that passengers benefit from a fast connection outside the city and a large number of stops in the city centre without having to change. The so-called Stadtbahn was a success and gave rise to considerable growth in the number of passengers. The Karlsruhe concept has often been described as an example of a surface transport system as compared to examples of underground transport systems. However, the city is currently working on an underground variant of this successful concept. Karlsruhe is mainly proof that the modern tram (light rail or tram-train) can be a regional mode of transport that works well.

Aspect 2 • Mobility

Light Rail

Kalsruhe • Germany

For years the German city of Karlsruhe has had a light rail system running on tram tracks and railway lines.

What is the difference between a tram and a train? In Karlsruhe there is none. Since the early nineties trams and trains in and around this German city have been fully integrated. Changing from tram to train or vice versa is often annoying for passengers. To make changing more convenient, major German cities such as Munich, Stuttgart and Frankfurt decided to build an S-Bahn. However, the costs of building an underground rail system of this type were excessive. In many German cities the introduction of the U-Bahn (underground) and S-Bahn went hand in hand with the disappearance of the tram. Karlsruhe expressly did not want the classic city tram to disappear. It opted for a different solution. The city decided to link the regional rail network to the tram system, which was working quite well. It invested in light-rail rolling stock that can run on both types of rail. This means that passengers benefit from a fast connection outside the city and a large number of stops in the city centre without having to change. The so-called Stadtbahn was a success and gave rise to considerable growth in the number of passengers. The Karlsruhe concept has often been described as an example of a surface transport system as compared to examples of underground transport systems. However, the city is currently working on an underground variant of this successful concept. Karlsruhe is mainly proof that the modern tram (light rail or tram-train) can be a regional mode of transport that works well.

Facts & figures

What Regional rail network for seamless public transport into the city centre
Where Karlsruhe, Germany
Status The tram-train was opened in 1992
Mobility A successful integration of train and tram
Internet kvv.de/kvv/der_kvv/karlsruher_modell (in German)
www.kasig.com (in German)
Internet search strings Kombi-lösung, Kasig, KVV, tunnel, Karlsruhe, Kaiserstrasse, Kriegsstrasse, Allmann Sattler Wappner, Zwart Jansma
Aspect 2 • Mobility

MiniMetro

Perugia • Italy
The Italian city of Perugia is implementing a transport concept that is a cross between metro and cable car.

The historical centre of Perugia is on a hill. People who want to get there from the lower outlying districts take the car or bus. But recently a metro has also started running up there as a solution to the environmental and congestion problems of this Italian city.

The new MiniMetro is similar to a cable car. Trains with a capacity of 50 passengers are propelled by a cable at a maximum speed of 25 kilometres per hour. There are virtually no waiting times. The metro calls at the seven different stations with an interval of only 1 minute.

For the 3-kilometre route, a 700-meter tunnel was made in the hill so as to leave the buildings above it intact. A large car-park was built at the start of the line. The French architect Jean Nouvel designed the metro line and the stations, which were opened in early 2008.

### Facts & figures

<table>
<thead>
<tr>
<th>What</th>
<th>New compact, semi-continuous public transport system for the city centre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Perugia, Italy</td>
</tr>
<tr>
<td>Status</td>
<td>In use since early 2008</td>
</tr>
<tr>
<td>Mobility</td>
<td>New system can cope with steep gradients and provides continuous transport at stops</td>
</tr>
<tr>
<td>Internet</td>
<td><a href="http://www.minimetropespa.it">www.minimetropespa.it</a> (in Italian)</td>
</tr>
<tr>
<td>Internet search strings</td>
<td>Minimetro spa, Perugia, Leitner, Jean Nouvel</td>
</tr>
</tbody>
</table>
In the west of The Netherlands, between The Hague and Rotterdam, train, tram and metro have been merged. Following the success of the Stadtbahn in Karlsruhe, the Dutch cities of The Hague and Rotterdam also explored the possibilities of combining metro, tram and train. The result was RandstadRail, a light-rail system linking both cities using different types of track. Crossovers are used to ensure that passengers always get to their destinations quickly without the other traffic in the city being impeded by the high-frequency system. Both in The Hague and in Rotterdam this principle resulted in the construction of tunnels. In The Hague, RandstadRail links up with the tram network, in Rotterdam with the metro network. In The Hague, RandstadRail has a low floor. This improves the accessibility and comfort in the coaches for many user groups.
Major infrastructure projects have an enormous impact. The impact is intended to be a positive one. And yet projects always meet with resistance in the initial stages. What does this mean for the decision-making process? How does support arise for radical solutions involving years of inconvenience for local residents and passengers?

Examples include:

**Light Rail, Karlsruhe** - a referendum was successfully organised, resulting in approval of a combined approach to road and rail mobility - read also Aspect 2.

**Les Halles, Paris** - Parisians were able to express their opinion of the design of the station and the park above it - read also Aspect 1.

**North/South Line, Amsterdam** - Amsterdam communicated actively with local residents to increase support for the construction of a new metro line.

**Stuttgart 21, Stuttgart** - the plans to redevelop the main station and the area around it waited a long time for approval - read also Aspect 4 and Aspect 5.

Aspect 3

Process
Aspect 3 • Process
Light Rail
Karlsruhe • Germany
A referendum was successfully organised, resulting in approval of a combined approach to road and rail mobility.

The Stadtbahn, a combination of tram and train transport, was highly successful in Karlsruhe. In fact, it was so successful that it caused capacity problems in the city centre, where all lines and all passenger flows meet. The result was delays, traffic jams and unclear traffic situations, particularly in Kaiserstrasse.

The most obvious course of action appeared to be to construct the railway lines underground, but this proposal was rejected in a referendum. The citizens thought it was too expensive, too grandiose and too risky for their small city. Usually, a concept is then modified so as to scale down the underground building plans and costs. However, Karlsruhe decided to make the project more complex by including the tunnels under Kriegstrasse in the new plans. Not only would the tram go underground, but a city road would too. Eventually, this combined solution gained sufficient support and was the winner in a second referendum. The city then held an innovative architecture competition for the design of the stations for the Stadtbahn tunnel under Kaiserstrasse.

### Facts & figures

- **What**: Regional rail network for seamless public transport into the city centre
- **Where**: Karlsruhe, Germany
- **Status**: Tunnel is still in planning phase. Start of construction 2009, completion 2017 and 2020
- **Process**: Architectural competition and two referenda, citizen participation resulted in the combined solution.
- **Internet**: [kvv.de/kvv/der_kvv/karlsruher_modell](http://kvv.de/kvv/der_kvv/karlsruher_modell) (in German) or [www.kasig.com](http://www.kasig.com) (in German)
- **Internet search strings**: Kombi-lösung, Kasig, KVV, tunnel, Karlsruhe, Kaiserstrasse, Kriegstrasse, Allmann Sattler Wappner, Zwart Jansma
Parisians were able to express their opinion of the design of the station and the park above it.

In 2004, the mayor of Paris, Bertrand Delanoë, asked four architects to come up with ideas for the redevelopment of the ‘Quartier des Halles’. Les Halles is a district that includes the Châtelet-Les Halles RER-station, the underground shopping mall Forum des Halles and a park on top all of this. The architects invited were Rem Koolhaas (OMA), Winy Maas (MVRDV), Jean Nouvel and David Mangin (SEURA). Delanoë intended the selection process to be more open and democratic than before. The four proposals were exhibited for the duration of six months. Over 125,000 people from Paris, Île-de-France, and the rest of the country, as well as foreigners, came to see the design ideas. All visitors could express their opinions in transparent urns although the ballots were not labelled as votes but merely as “expressions”. The final decision was left to the mayor and his advisers.

Public opinion leaned towards David Mangin’s proposal which, according to the mayor, was the only one that linked Les Halles to the city. In his opinion it embraced both audacity and realism. Delanoë decided to proceed with Mangin’s urban vision and to organise a separate architectural competition for the design of the large roof structure that will cover the entrance to the underground station and shopping mall.
Amsterdam communicated actively with local residents to increase support for the construction of a new metro line.

Amsterdam had a problem with the plans for a new metro line. Opposition to the construction of the first metro line in the city had resulted in serious riots. The outcome of this historic trauma was negative support for all underground plans in the city. The construction of the North/South Line therefore had to meet stringent requirements. For example, there was not allowed to be any demolition work above ground. It was decided to construct the metro tunnel using the tunnel boring method, a no-dig technology. This technology does away with the need to dig up the street for construction work going on for years.

Amsterdam used not only stringent building requirements to try to win support from local residents for the construction of the new metro line. So as to avoid antagonising Amsterdammers, the city organised concrete, visible activities to reduce the nuisance caused by the building work. For instance, local residents received compensation for such things as extra double glazing, hotel accommodation or removal expenses. Simpler, but certainly just as visible: cleaning windows near building excavations. There were two other communication projects in addition to the direct communication with local residents regarding the construction work and the nuisance caused. First, the project organisers explained the results of the construction project. Second, by calling in artists, the building excavations were turned into sources of inspiration.
The plans to redevelop the main station and the area around it waited a long time for approval.

In 1994, Stuttgart presented an ambitious plan. The terminus in the centre of this German city had to be transformed into a modern connecting station. In order to ensure that trains were able to run in two directions, the station would have to be rotated across 90 degrees and the rail infrastructure would have to go underground. Some of the costs of this project could be recouped by redeveloping the 100 hectares of railway above ground into a high-quality urban area.

As so often happens with mega-projects, it was a long time before the parties involved – the national government, the state government, the municipal government and German Railways – officially reached agreement on the financing. The final agreement only came about in 2002. Since then, Stuttgart 21 has been a guiding concept for the redevelopment of station areas in Germany.

### Facts & figures

**What**  Conversion of terminus for through train traffic and redevelopment of station area

**Where**  Stuttgart, Germany

**Status**  Completion of the master plan in 2012

**Process**  Lengthy negotiations about the master plan and the financing, as a result of which the project suffered a four-year delay

**Internet**  [www.stuttgart21.de](http://www.stuttgart21.de) (in German)

**Internet search strings**  Stuttgart 21, Ingenhoven
Aspect 4

Realisation

The success of a construction project depends not only on innovative concepts and project plans. The design and construction phases are at least as important. Does the design provide a space in which users feel at home and is the construction work proceeding smoothly? These are just a couple of examples of the importance of the realisation phase of a project.

Examples include:
- **Crossrail, London**: London is developing a new rail link right through the city. Read also Aspect 5.
- **MetroSur, Madrid**: Madrid was able to build its new metro line remarkably quickly. Read also Aspect 2.
- **RandstadRail, The Netherlands**: the RandstadRail system includes a particularly beautiful underground station in the centre of The Hague. Read also Aspect 2.
- **Stuttgart 21, Stuttgart**: the old, nineteenth-century main station is to be replaced by an architecturally very striking underground station. Read also Aspect 3 and Aspect 5.
London is developing a new connection right through the city which will link railway and the London underground with each other.

Under the name Cross London Rail Links (Crossrail), London and the British government are jointly working on a new rail link through the capital. Crossrail is meant to provide a solution to the overloaded underground system and the expected congestion problems caused by the growth of London by linking railway lines and the London underground with each other. Although the first study into a new connection right through and under London was conducted as long ago as 1974, it was only in the autumn of 2007 that the British government announced that Crossrail had sufficient financial support to allow it to be realised. The cost of constructing Crossrail amounts to €20 billion (over the expected period of construction up to 2017 when the railway opens), will be partially funded by the private sector, which understand that London will receive significant economic benefits from improved railway infrastructure across the capital.
Madrid was able to build its new metro line remarkably quickly. The result is of a high quality.

In the early eighties, Spain was still very much behind other countries. It suffered from a neglected infrastructure and stagnating investment. Surprisingly quickly, however, it has managed to catch up. Characteristic of this speed is the construction of Madrid’s newest metro line, the MetroSur.

South-west of the metropolis are five extensions from the sixties and seventies, where a total of some 900,000 people live. These towns suffer from increasing social problems. People with higher incomes are leaving because of the deterioration of their living environment. The poor connection to Madrid also plays an important part in this. Or it did until the MetroSur arrived. The new metro circle line connects the towns not only with one another, but also with the rest of Madrid’s metro network.

The construction work went at surprising speed. Begun in 1999, it was preceded by just two years’ preparation and the line was opened as early as 2003. Despite this, the result is of a high quality. The 28 new stations have a modern look and a very spacious layout, while the metro trains are also modern and comfortable.
The RandstadRail system includes a particularly beautiful underground station in the centre of The Hague.

The RandstadRail light-rail connection in the city of The Hague includes a tram tunnel of 1,250 metres in length. There are two light-rail stations in the tunnel. A parking garage has been built above it. The architectural design by OMA provides variation in height and width of the tunnel, plenty of daylight and connections to the surface. As a result, passengers can find their way around easily and enjoy a sense of security. The interior design by Lab-Da is of a different nature. The minimal architectural finish of the tunnel walls, where the concrete of the carcass is visible everywhere, is in sharp contrast to the wooden floors on the platforms. Altogether the design gives the impression of an urban reception room, and the tunnel is called the Souterrain.

| What | Tram tunnel with two stations, parking garage and pedestrian area |
| Where | The Hague, The Netherlands |
| Status | In use since 2004 |
| Realisation | Two design offices joined hands to create an ‘urban reception room’ that constitutes a pleasant surprise to passengers |
| Internet | www.randstadrail.nl (in Dutch) or www.connectedcities.eu/guide/randstadrail |
| Internet search strings | RandstadRail, Souterrain, Lab-Da, OMA, Den Haag |
Aspect 4 • Realisation

Stuttgart 21
Stuttgart • Germany
The old, nineteenth-century main station is to be replaced by an architecturally very striking underground station.

The Stuttgart 21 project is already famous for its striking design. The German firm of Ingenhoven Architekten designed an underground station that bears little resemblance to ‘classic’ underground station buildings. The new station features 28 concrete columns supporting the roof and organically flowing into it. The columns support not only the underground structure, but also let in light from the historical gardens above in the centre of Stuttgart. The columns also provide natural ventilation for the station, which is a great benefit, particularly in the event of any smoke development. The smoke can easily exit through the openings in the roof. On top of the station a new type of urban space will emerge.

Facts & figures

| What | Impressive design for new underground station |
| Where | Stuttgart, Germany |
| Status | Completion of the master plan in 2012 |
| Realisation | The German firm of Ingenhoven Architekten created a strikingly light underground station with natural ventilation |
| Internet | www.stuttgart21.de (in German) |
| Internet search strings | Stuttgart 21, Ingenhoven |
All the projects in this book are successful solutions to mobility problems. But is that sufficient? What else can an infrastructure change mean?

**Crossrail, London**  •  from 2017, London will have a rail link relieving the pressure on both the underground and the train  •  read also Aspect 4.

**The Groene Hart tunnel, The Netherlands**  •  the tunnel achieves a dual objective: environmental and economic  •  read also Aspect 1.

**Stuttgart 21, Stuttgart**  •  this German city is not only getting a new underground station, but the above-ground space freed up is also to be redeveloped  •  read also Aspect 3 and Aspect 4.

**Zuidas, Amsterdam**  •  by moving the entire infrastructure underground a completely new business and residential district can rise up above ground  •  read also Aspect 1.
From 2017, London will have a rail link relieving the pressure on both the underground and the train. Crossrail is very similar to the famous RER system that connects the train and metro with one another in Paris. Crossrail links London Underground, National Rail and the regional Docklands Light Railway. The new east/west line will run right through London and, near Heathrow Airport and through the centre, will go underground for a distance of 7 kilometres and 21 kilometres respectively. Crossrail will also feature nine new underground stations. When the line is completed in 2017, trains are intended to run on it at high frequencies so as to relieve the pressure on the existing rail and underground lines. This will increase the capacity of London’s public transport by 10 percent. In addition, Crossrail should give London an economic boost. The idea is that business centres such as the City of London and Canary Wharf will continue to be attractive as locations for multinationals due to the new connection. It is even expected that, in approximately 20 years, Crossrail will create 30,000 additional jobs in the city centre. Transport for London estimates that the overall benefit of Crossrail to the UK economy is €38 billion.

**Facts & figures**

**What**
A high frequency, partially underground east to west railway

**Where**
London, United Kingdom

**Status**
Completion in 2017

**Result**
30,000 additional jobs, €38 billion overall benefit to the UK economy

**Internet**
www.crossrail.co.uk

**Internet search strings**
Crossrail, Transport for London
Aspect 5 • Result
The Groene Hart tunnel
The Netherlands
The Groene Hart tunnel is in the open, rural area at the heart of the Randstad. It achieves a dual objective: environmental and economic.

The Randstad conurbation is the urbanised area in the west of The Netherlands. Cities such as Amsterdam, Rotterdam, The Hague and Utrecht are located here in a circular arrangement. There is, however, a sparsely populated, open, rural area at the heart of the Randstad conurbation: the Groene Hart (Green Heart). This green area plays an important part for the surrounding cities in providing space for nature, agriculture and recreation. Although the pressure on the use of space from the cities is high, the area is being kept as rural as possible. So when the high-speed line from Amsterdam to Antwerp via Rotterdam was being built, it was decided to construct a tunnel underneath the Groene Hart area.

The 7-kilometre bored tunnel is a prime example of the so-called dual objective concept. During the nineties, people in The Netherlands were convinced that the economy and the environment could be developed at the same time without having to choose between them. In the case of The Groene Hart tunnel, the central green area has remained an open space and Amsterdam, Schiphol Airport and Rotterdam have acquired a rapid connection to the major economic centres in Europe.
Stuttgart is not only getting a new underground station, but the above-ground space freed up is also to be redeveloped.

Stuttgart’s new underground station provides more efficient train transport. The station, which has always been a terminus, is to be converted into a through station. This means that journeys using regional transport or the high-speed line can be shortened by as much as 30 to 40 minutes. But Stuttgart 21 is more than a mobility project. It also shows what the redevelopment of a station area can mean for inner cities. The new station gives Stuttgart the leeway to build a completely new centre in ten to twenty years. The 100 hectares that are currently used by the station railway yards are to be transformed into a high-quality urban area. The project also adds value to the ‘castle gardens’ above the station as the green heart of the developing city centre. The historical Bonatz building next to it will function as a loggia in the station area.

<table>
<thead>
<tr>
<th>What</th>
<th>Conversion of terminus into through station and redevelopment of station area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Stuttgart, Germany</td>
</tr>
<tr>
<td>Status</td>
<td>Completion of the master plan in 2012</td>
</tr>
<tr>
<td>Result</td>
<td>Striking new central station and a 1.4 million square meters floor space mixed-use development</td>
</tr>
<tr>
<td>Internet</td>
<td><a href="http://www.stuttgart21.de">www.stuttgart21.de</a> (in German)</td>
</tr>
<tr>
<td>Internet search string</td>
<td>Stuttgart 21, Ingenhoven</td>
</tr>
</tbody>
</table>
By moving the entire infrastructure underground a completely new business and residential district can rise up above ground.

The results of the Amsterdam Zuidas area development are not entirely visible as yet. The tunnel will not be completed until 2018, with the entire infrastructure being underneath this international business centre. Only then will companies and residents be able to benefit fully from the infrastructure that makes this location so accessible. Less than six minutes to the airport by train, a few minutes to the old heart of the city on the North/South metro line. Eventually the high-speed train will also stop here, taking three hours to get to Paris or speeding to Germany at 300 kilometres an hour.

By routing all the arterial routes underneath the Zuidas, 24 hectares of building space are freed up above ground. Business premises are to be built here that are in great demand by the top players in business services. These companies in turn add nicely to the mix of functions in the area. In addition to the 9,000 homes that are to be built, education already plays an important part due to the presence of one of Amsterdam’s universities and the Rietveld art academy.
All efforts have been made to identify the interested parties. Anyone wishing to assert his or her rights is kindly requested to contact the publisher (info@cob.nl).

Aspect 1 • Motive

- Arnhem Centraal station, Arnhem • artist impressions by UN Studio (page 8, 10, 11, 12, 13)
- The Groene Hart tunnel, The Netherlands • photos by Rijkswaterstaat HSL-Zuid / Aeroview B.V. - Rotterdam • artist impressions by Holland Railconsult (page 8, 14, 15)
- Les Halles, Paris • photos and artist impressions by SEURA - Société d’Etudes d’Urbanisme et d’Architecture (page 8, 16, 17)
- Zuidas, Amsterdam • (page 8, 18, 19)

Aspect 2 • Mobility

- A86 tunnel, Paris • artist impressions by Cofiroute (page 20, 22, 23)
- Light Rail, Karlsruhe • photos and artist impressions by KASIG - Karlsruher Schieneninfrastruktur-Gesellschaft mbH • artist impressions by Zwarts & Jansma Architecten (page 20, 24, 25)
- Minimetro, Perugia • photos and artist impressions by Minimetro S.p.A. (page 20, 26, 27, 28, 29)
- RandstadRail, The Netherlands • photos by projectorganisation RandstadRail (page 20, 30, 31)

Aspect 3 • Process

- Light Rail, Karlsruhe • photos and artist impressions by KASIG - Karlsruher Schieneninfrastruktur-Gesellschaft mbH (page 32, 34, 35, 36, 37)
- North/South Line, Amsterdam • photos by Gé Dubbelman • artist impressions by Benthem Crouwel architecten (page 32, 40, 41)
- Stuttgart 21, Stuttgart • Landeshauptstadt Stuttgart, Ingenhoven Architekten (page 32, 42, 43)

Aspect 4 • Realisation

- Crossrail, London • photos and artist impressions by Crossrail (page 44, 46, 47)
- MetroSur, Madrid • Theo Dole, Rutten Communicatie-advies Amsterdam (page 44, 48, 49)
- RandstadRail, The Netherlands • photos by Gemeente Den Haag, Dienst Siedelijke Ontwikkeling, afdeling communicatie (page 44, 50, 51)
- Stuttgart 21, Stuttgart • Landeshauptstadt Stuttgart, Ingenhoven Architekten (page 44, 52, 53, 54, 55)

Aspect 5 • Result

- Crossrail, London • photos and artist impressions by Crossrail (page 56, 58, 59)
- The Groene Hart tunnel, The Netherlands • photos by Rijkswaterstaat HSL-Zuid / Aeroview B.V. - Rotterdam and Ton Poortvliet • artist impressions by DPI (page 56, 60, 61, 62, 63)
- Stuttgart 21, Stuttgart • Landeshauptstadt Stuttgart, Ingenhoven Architekten (page 56, 64, 65)
- Zuidas, Amsterdam • CIIID projectbureau Zuidas (page 56, 66, 67)
Underground use of space is becoming a more important aspect of spatial development in the Netherlands. COB considers it her mission to contribute, through co-operation, in a lasting and sustainable way to a responsible development, construction and management of underground spaces. COB wants to do this through preserving already developed knowledge, creating new knowledge, and in a more broad sense providing a positive development climate for innovative ways of underground use of space. Based on this mission, COB makes clear choices. COB aims at tangible, practical research on current issues with social relevance. In this way, COB wants to promote the common interest as well as its participants interests. • www.cob.nl

Project part-financed by the European Union

INTERREG is an EU-funded programme that helps Europe’s regions form partnerships to work together on common projects. By sharing knowledge and experience, these partnerships enable the regions involved to develop new solutions to economic, social and environmental challenges.

Connected Cities is about sustainable mobility and spatial development. As EU-sponsored Interreg IIIC network it focuses on high quality public transport and transport development areas, aimed at improving mobility and quality of life in urban and rural areas. The network activities continued until the end of 2007. • www.connectedcities.eu
This guide to good practice underground space is developed within the framework of the EU-funded INTERREG IIIC project 'Connected Cities'. It focuses on how a strategic use of underground space can facilitate sustainable modes of transportation and mobility in urban and rural areas. Twelve strategic European projects are evaluated for their good practice in terms of motive, mobility, process, realisation and result. Many of the projects are still under development. For this reason, the guide describes value and meaning in a general sense without too specific or too detailed information. Instead, the guide is intended to provide directions on what aspects and projects to pay attention to in the next couple of years. They may very well represent the shape of things to come.