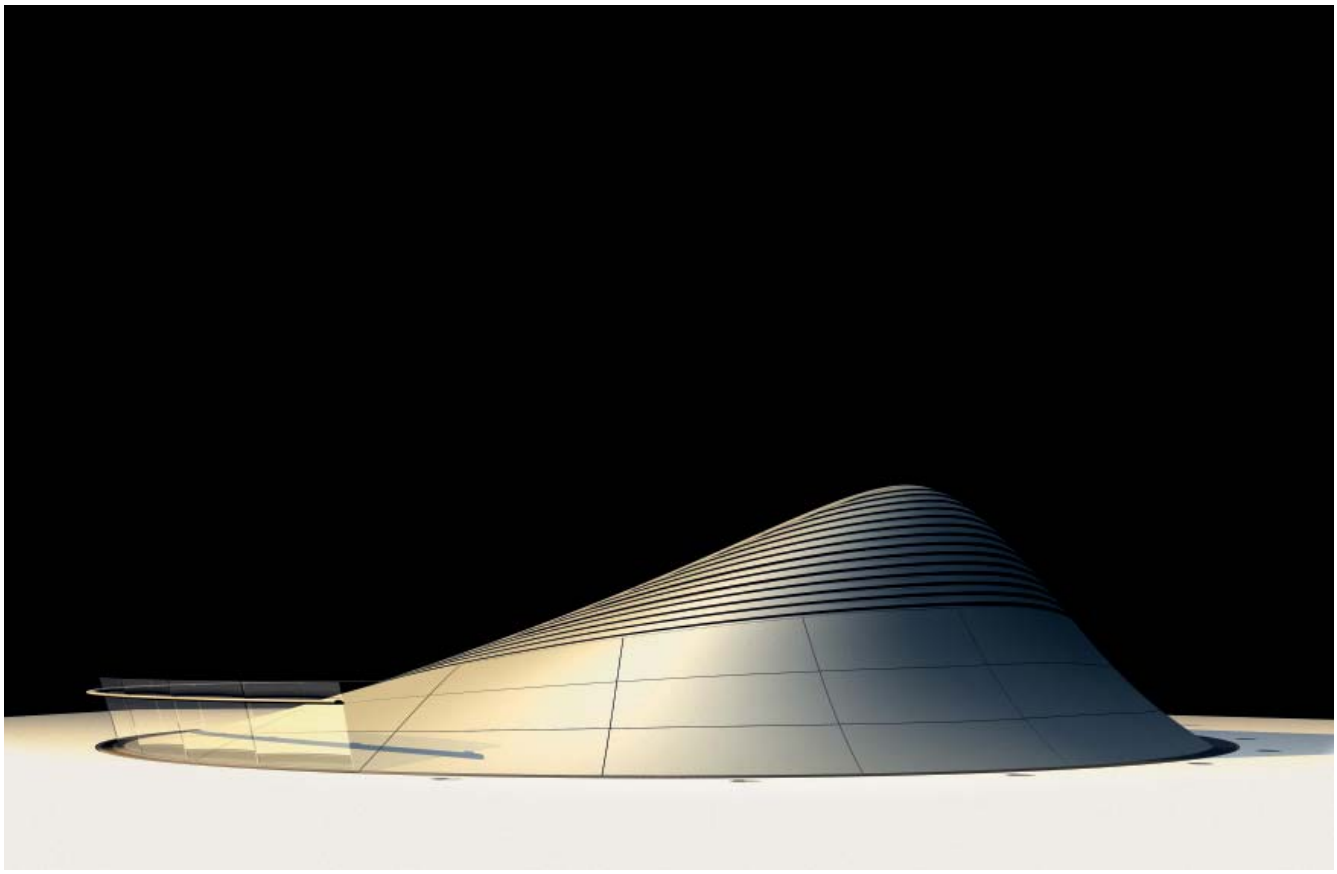

Global Holcim Awards

Main Station Stuttgart - Zero Energy Station
Ingenhoven Architects, Düsseldorf

Project Booklet

Author

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Project Description

Main Station Stuttgart - A new generation of zero energy stations

The heyday of railway stations in the 19th century saw bold engineering feats for the new halls for train terminals in all major European cities. The stations were erected in the expansion areas of the historic cities, which continued to grow around them. Many years later, of course, the rail tracks would become a hindrance to further urban development.

Stuttgart is a particular case in point. The city lies in a valley, a geographic cul-de-sac, and the central station built by Paul Bonatz blocks any expansion of the narrow city centre. Moreover, Stuttgart station is a terminus, which makes it difficult to link the city to the high-speed rail network that is being developed throughout Europe. The new station design should go beyond breathing new life into the structures built during that earlier era with modern means and lead to the emergence of a new generation of railway stations. The Deutsche Bahn has planned to add a new high-speed line for this city in the coming years, laid out in an underground tunnel at a right angle to the existing tracks. This will free up development space for a vast new urban quarter. The project is called "Stuttgart 21" and the concept envisions the new tracks in a tunnel some 12 metres below the old terminus.

The design proposes to stretch the park which is adjacent to the existing station over top of the new subterranean tracks and platforms with a monumental and continuous station hall illuminated by natural light that will fall into the space through large circular "light eyes". The design aims to go beyond mere functional purpose by translating the new era in rail transportation into a contemporary form. An ecological approach to building was thus an important concern. The construction depth of the efficient shell structure was able to be reduced to one hundredth of span, resulting in the use of much less material. The station will operate without supplied energy. The "zero-energy station" requires no heating, cooling or mechanical ventilation.

The new station will give Stuttgart a new centre. In 10 to 20 years hence, the old tracks may well be replaced by a new urban district. The castle gardens are Stuttgart's lungs and will only gain in importance as the city expands. The park will be extended from the edge of the downtown core across the underground railway station. The "light eyes" will establish an experiential sense of the subterranean station even to passers by above ground. The historic building and the new station link the old and new sections of the city. The plan creates a station square with clear contours: here the Cannstatter Promenade, an extension to the Königstraße, will provide access to the new quarter. The large booking hall of the Bonatz building is the section of the station that is closest to the city. The concept transforms the old station into a meeting place with restaurants and shops, opening the floor of the existing station hall in order to interconnect all levels of new station and to integrate the historic fabric into the new design.

The approval process is completed after nearly three years period in 2005. Currently there is only one single administrative appeal, that will be dismissed most likely. The tender procedure for the construction work will be announced Europe-wide.

Project Data

Project title:	Main Station Stuttgart
Competition:	International Competition 1997, 1st Prize
City:	Stuttgart
Country:	Germany
Project type:	Transport Infrastructure
Status of planning:	Final Design and Construction Document Stage
Status of formal Permission:	approved
Start of construction:	May 2007
Client:	Deutsche Bahn AG, Berlin; represented by DB Projekt Bau GmbH Niederlassung Südwest, Projektzentrum Stuttgart 21
GFA:	185.000 m²
Building Costs:	250 Mio. Euro
Completion:	2007 - 2013
General planning	Ingenhoven Architekten GmbH, Düsseldorf
Architects:	Ingenhoven Architects, Düsseldorf
Client	Deutsche Bahn AG, Berlin represented by DB ProjektBau GmbH Niederlassung Südwest, Projektzentrum Stuttgart 21
Project Management:	Drees & Sommer Infra Consult & Management GmbH, Stuttgart
Structural Engineering:	Ingenieurarbeitsgemeinschaft Tragwerksplanung S21 Hauptbahnhof GbR Leonhardt, Andrä und Partner, Stuttgart with Happold Ingenieurbüro GmbH, Berlin
Advice Structural Form:	Frei Otto, Leonberg with SL-Sonderkonstruktion und Leichtbau, Leinfelden
Building Services:	NEK Ingenieure, Frankfurt/Main
Building Physics:	DS-Plan GmbH, Stuttgart
Facade Planning:	DS-Plan GmbH, Stuttgart
Ventilation Analysis:	IFI Institut für Industrieaerodynamik, Aachen
Transportation Planning:	Ingenieurgruppe für Verkehrsplanung und Verfahrenstechnik, Aachen
Fire Protection:	BPK Brandschutz Planung Klingsch GmbH, Düsseldorf
Lighting:	Tropp Lighting Design, Feldafing
Landscape Architecture:	Ingenhoven Architects, Düsseldorf with WKM Weber Klein Maas Landschaftsarchitekten, Meerbusch

1. Quantum change and transferability - Minimised Construction

The continuous form of the shell-type concrete roof creates a highly effi cient load-bearing structure which is only subject to pressure load and has a structural height which is as little as 1/100 of the span. The use of advanced high-strength concrete and cement grades means that the material properties can be selected, so that the durable exposed concrete surfaces form the fi nished building.

1.1 An integrated ecological concept with contributions to all disciplinces

1.1.1 An ecological and sustainable concept

The new Stuttgart main station will mark the realisation of a transport concept to link southern Germany to the European high-speed rail network. The project takes into account all aspects of ecological, resource-saving and sustainable building. Expansion of local public passenger rail services makes ecological sense, and this is reflected in the unique building concept, which involves no land use and uses building materials in a resource-saving way.

The construction of Stuttgart's new main station is extremely efficient in terms of materials, with an absolutely minimal use of primary energy. The concrete structure is always in compression, which means that only a very small amount of structural steel is required. The amount of concrete used was similarly reduced further by optimising the thin shell of the structure.

The interplay between different scenic, infrastructural, urban planning and architectonic features, the transparency of the legal planning procedure and the optimised design, construction and logistics employed in realising the project are its outstanding features. The new Stuttgart main station building is not only an example of the correspondence between space and design. More than this it is a complex functional system, which makes intelligent use of the existing natural energy resources to operate the building and to improve the comfort of the people using it; at the same time, CO2 emissions are cut by a significant amount – a smart zero-energy concept.

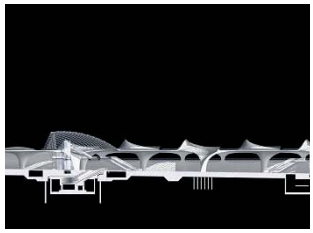
All parameters and phases of the project are documented in comprehensive detail, which means that its findings and expertise can be relayed to other, comparable infrastructure projects such as railway stations, airports or terminals, or other urban planning projects.

1.2 An innovative sustainable building and urban landscape project generated from local conditions

1.2.1 Developed on the basis of local conditions

In 1997, a competition was announced for the Stuttgart main station hall. The design objective was to replace the existing terminus with a new, low-level through station and create a new municipal district on the land freed up by removing the existing railway lines. It seemed inevitable for the function of the terminus to ruin the castle gardens. The key challenge was therefore to cross the valley and the park leaving the castle gardens intact.

The difference in height between the existing park level and the planned railway tracks is approx. 10-12 metres, enough for the requisite vehicle clearance for high-speed trains and for construction of a spacious station hall. This called for development of a structure of minimal height which would give a maximum amount of space to both the station hall and the park overhead.



1.2.2 "Schlossgarten" castle gardens – an open space

The castle gardens form a coherent scenic area of major historic, ecological and urban significance. As the main area of open space in the city, the gardens connect Stuttgart city centre with the Neckar river. The aspect of preserving and enhancing this particular area was the starting point for tackling the project as a whole. The castle gardens remain the „green heart" of Stuttgart, and the new main station gives more castle gardens back to the city.

1.2.3 Unique space

In collaboration with Frei Otto and a team of structural engineers led by Ted Happold's partner Michael Dickson and Leonhard, Andrä und Partner, a structure was developed which can span 36 metres with a shell thickness of around 35 centimetres. What emerged was a new kind of three-dimensional continuum of space with a reinforced concrete compression structure.

1.2.4 Developing the form of the new station hall

The structure of the roof of the station hall was developed in an integrative process, involving many planning experts and procedures. The goal was to minimise the structural height of the roof construction whilst maximising the internal headroom of the station hall. Development of the roof form incorporated the results of work in progress since 1963 at Stuttgart University's Institut für leichte Flächentragwerke (Institute for Lightweight Shell Structures).

Soap film membranes were used to develop forms with a completely even distribution of tensile stress, which are often referred to as minimum area surfaces. If the form created in this way is inverted by 180 °, the resulting vaulted reinforced shell structure purely bears compression stresses. The result is a pure compression shell structure of minimal structural height. A funnel-like chalice with a "light eye" is derived from the loop-like eye of the soap film model in the shell structure. The experimental approach to developing the individual element (light eye) and the continuum of connected chalice supports and trough walls further took place on real suspended chain models.

The form finding process progressed in parallel using digital CAD-based minimum area surface programs. The results of the real and digital models were compared. The results are the basis of the full three-dimensional volume model of the complete station hall.

1.2.5 Zero energy station

The design for the new low-resource and low-energy Stuttgart main station is an integrated concept developed on the basis of the natural conditions and situation of the site. Stuttgart station is the prototype of a new generation of railway stations that give priority to passenger comfort. The basic ecological concept makes use of natural physical cold and heat storage mechanisms of the earth, making heating and air conditioning systems superfluous. Ventilation of the station is through the

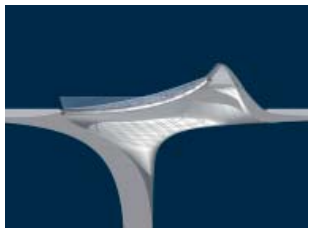
tunnels in conjunction with the light eyes, which can be opened. Thanks to the intelligent use of natural energy resources, there are no CO2 emissions.

The light eyes are evenly distributed above the platforms, guaranteeing that the station hall has an adequate supply of natural light for up to 14 hours a day.
The vaults and openings in the hall permit an even distribution of natural light. Light surfaces ensure that the hall is pleasantly lit even in dull weather. The results of lighting model studies performed to date have been incorporated into the form finding process. At night, the underside of the shell structure is used to reflect the artificial lighting. To reduce CO2 emissions, the station lighting is powered by the eco-electricity supplied by the utility provider or via photovoltaic cells located on the northern station building.

1.3 An outstanding approach regarding a sophisticated and highly optimised loadbearing construction.

1.3.1 Optimising structural behaviour

As development of the three-dimensional volume model progressed, the first finite element models of the chalice supports emerged to demonstrate the structural feasibility of the design and optimise the geometry. The results were then applied for further development of the form to a partial section of several chalice supports and finally to a full finite element model of the station roof.



The supporting structure of the station hall is a vaulted, seamless concrete shell structure. The vault system is divided into 28 equal modular elements, the chalice supports, between the four platforms and the long outside walls. Each chalice support is hexagonal in plan. The corner points lie in a 40-metre circle. The upper surface of the shell roof is even, while underneath the surface is curved throughout following the flow of forces. The surface flows are such that the central surface of the shell is inclined overall. This ensures that the vertical loads in the shell structure as a whole are transferred via membrane forces and bending.

The geometry of the chalice supports has been developed and continuously optimised using three-dimensional methods so that all standard chalices are produced with one form. Given the double curvature of the geometry, which makes counter formwork necessary, and to make it possible to reuse the formwork panels, the surfaces of the formwork are made of stainless steel. As a result of various feasibility studies relating to the technical requirements, the quality of the surface and the colour, the shell structure will be made of self-compacting concrete.

1.4 Accompanyed by a comprehensive dissemination of knowledge.

1.4.1 Communication and the public

An information centre on around 500 square metres of floor space has been open to the public at Stuttgart main station on a daily basis for over 10 years.
The information available here is supplemented by a website for the project and numerous publications from the project company.

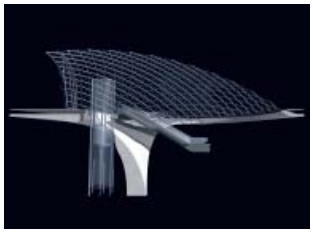
2. Ethical standards and social equity - open public space

The station as a whole, with its exterior plazas, walkways and platforms, forms a new central urban public space and a social meeting point which creates a pedestrian link between the "Stuttgart 21" development and the present city centre. The listed historical Bonatz building is integrated into the functions of the new Stuttgart main station.

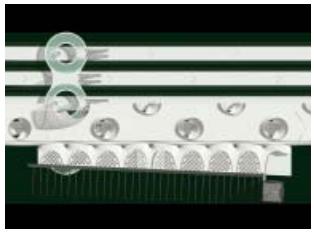
2.1 Adherence to a public and handicapped accessible building in all phases

2.1.1 Public Building

The station as a whole, with its exterior plazas, walkways and platforms, forms a new central urban public space and a social meeting point which creates a pedestrian link between the Stuttgart 21 development and the present city centre. The main station itself is a public space, offering unrestricted access to the public at any time of the day or night.

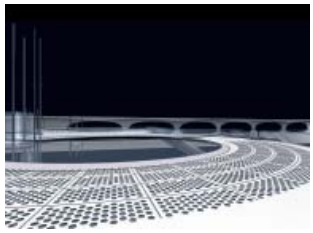


Delicate glass shell structures show visitors the way into the station from all four directions and provide a link to all parts of the city. Set back from the surrounding streets, they clearly mark the position of the new station hall between Straßburger Platz and Schlossgarten (castle gardens). As many as 250,000 people will use the transport system at the new station, on trains, trams and buses, every day. Access and standards for the disabled are provided throughout.



2.1.2 A handicapped accessible building

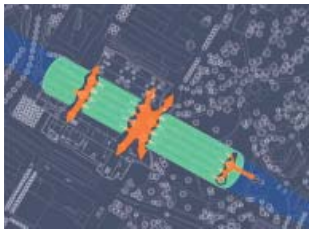
Stuttgart main station has been planned in its entirety with consideration of the needs of people with restricted mobility. It offers barrier-free access on every level. This includes access to other transport services such as the underground and tram systems and to the bus station. The needs of blind and partially sighted passengers or passengers with a hearing disability were also taken into consideration



2.2 Engineering the flow and contributing socially viable environments.

2.2.1 Engineering the flow

With an entrance on every side, the station hall is closely woven into the urban fabric of Stuttgart. The station hall not only connects the city with the high-speed rail network; it is also an important link between the historic city centre and the new Stuttgart 21 district.



In this way, the station is the key to future development of the city, resocialisation of the city centre and urban planning agglomeration of the Stuttgart basin as a whole.

2.3 Participation of stakeholders and the public during the complete process.

2.3.1 The public and information

At the time of the first preliminary studies on the project by the client and the planners, the public, the political committees and the institutional lobbies were incorporated into the planning and approval procedures for Stuttgart main station. A public information centre at the main station was opened over 10 years ago. The permanent exhibition extends over three levels, showing the newest plans and models for the building project. The approval procedure takes place in several stages. At each stage, the results of planning are disclosed openly and to the public, i.e. people who are directly affected by the project and others with an interest in it have the opportunity to submit any doubts or suggestions they may have with regard to the planning. The project was divided into seven stages of planning permission for detailed expert examination with regard to ecological, technical and public law considerations.

By considering various different proposals, a solution was found that raised the least number of possible issues. Institutional lobbies and political committees additionally receive information on an ongoing basis throughout planning to enable their suggestions or doubts to flow directly into the planning process.

2.4 Outstanding interdisciplinary and teamorientated working conditions.

2.4.1 Teamorientated interdisciplinary working conditions

Determining idea of the design process is the overall approach according to criteria of ecological responsibility for the environment, economy of resource usage, technical progress, logical construction and sustainability for the buildings long-term lifecycles. The project demonstrates innovation to increase technical and aesthetic visions in comparison to conventional procedures. Therefore all planning phasesare elaborated throughout the whole design process closely with engineers and consultants.

2.4.2 Health and safety standards

Legal requirements relating to health and safety at work are observed during all phases of the project, particularly in building site operations and during the start-up phase of the station. Government bodies regularly monitor that the rules and regulations are being upheld.

2.4.3 Protection against discrimination

Germany's law protecting against discrimination, the Antidiscrimination Act (Antidiskriminierungsgesetz, ADG), protects minorities with regard to matters of labour law and civil law. To this end, those belonging to the groups of people protected by the law are granted certain legal rights in relation to the employer and private individuals acting in a legally sanctioned manner in relation to the protected person.

2.5 A political correct and transparent proceeding in all phases.

2.5.1 Transparency

The aim behind the planning and approval procedure as set down by law is to find the solution to the planning objective that raises the least possible number of issues. It sets out to achieve a detailed expert examination of the project with regard to aspects of ecology, technology and public law. In each planning phase, different versions of solutions are developed, and those which raise the least issues after consideration of all aspects are pursued and developed to further stages. The procedure provides for public involvement at every stage of the approval process. A public debate is held over several days at which any objections can be aired and discussed with all affected and interested parties under the supervision of independent institutions. Information is also provided in advance.

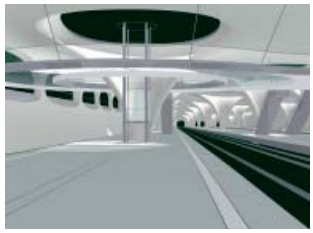
The affected parties may appeal to the courts with regard to the outcome of the approval procedure at any stage of the process. Decisions are made exclusively by elected representatives and political committees. The committees involved in the process are independent, freely elected parliaments at local, regional and national level.

3. Ecological quality and energy saving - zero energy station

A high level of visual and thermal comfort is achieved with hardly any consumption of primary energy. The natural ventilation and air extraction system uses natural draughts in conjunction with thermal air flow without any addition of thermal energy.

3.1 Highly convenient indoor qualities due to energy and material effi ciency.

3.1.1 Comfort and the quality of the surroundings



Thanks to the intelligent use of natural energy resources, a high general level of visual and thermal comfort is achieved without the use of primary energy. The station, which is lit with natural light and has an average daylight quota of over 4 %, is equipped with an auxiliary system to back up the natural light.

A maximum specific connected load of 3 – 9 W/m² is achieved by varying the ratio of direct and indirect input. The natural ventilation provided by train-induced flow in connection with thermal flows creates a maximum air velocity of 1.0 – 1.5 m/sec. on the platforms. The high level of thermal comfort, which is achieved without any input of thermal energy, is reflected in the average perceived temperatures on the platforms of 20 – 22 ° C in summer and 5 – 8 ° C in winter. By cutting back to what is necessary, a high level of comfort was achieved for an extremely low primary energy consumption.

The temperatures expected in the tunnels vary in the course of the year by an average of +10° C and, given the flow conditions, rarely reach temperatures above +20°C in summer or 0° C in winter. Computational Fluid Dynamics (CFD) were used to solve technical problems in connection with flows in order to demonstrate the air velocity and temperature profiles through the year.

3.1.2 Low primary energy requirements

The cumulative primary energy consumption of the building materials selected for construction of the station hall during manufacture is very low. Concrete has a primary energy factor of approx. 400 kwh/m³.

The reinforcing part of the reinforcing steel has been reduced to the structural minimum, with the result that the concrete shell of the station roof has a primary energy factor of around 200 kwh/m². By comparison, a theoretical alternative structure for a station hall made of steel and glass would have a primary energy factor of approx. 5,000 kwh/m² , i.e. energy consumption would be around 25 times higher.

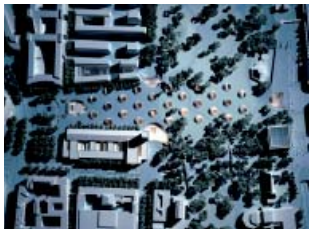
3.2 Low energy consumption by using energy saving technologies.

3.2.1 Low energy material

Concrete is the second most used resource in the world after water. Currently there is no practical substitute for this versatile and durable product for most purposes. As the chief ingredient in concrete, cement is therefore a key requirement of modern society, but its manufacture is a resource- and energy-intensive process. Therefore, although CO2 emissions per tonne of cement are approx. 0.8, they are only approx. 0.08 per tonne of concrete, which compares favorably with CO2 emissions from other building materials and industrial commodities. Total emissions from cement production amount to around 5% of man-made CO2 emissions.

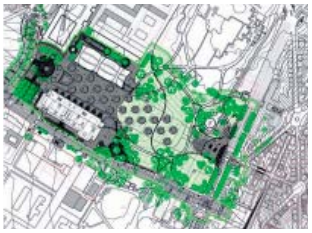
3.3 A long-term nature protecting and land use effi cient project.

3.3.1 Protecting the countryside



The „Schlossgarten" castle gardens follow the line of the Nesenbach to create a coherent scenic area of great historic, ecological and urban significance. The aspect of preserving and enhancing this particular area was the starting point for tackling the project as a whole.

3.3.2 No land use



The new Stuttgart station is an underground structure. With the removal of the overground railway lines belonging to the former terminus, the city will benefit from an additional green space of around 42,000 m² on the roof of the new station.

3.33 Brownfield redevelopment

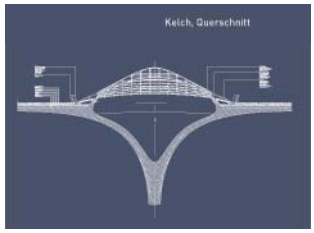
The overground railway lines from the old terminus will be removed and the new Stuttgart 21 district will be built in their place. This will help to prevent other expansion and urbanisation into the surrounding countryside. The northern building will be built on this designated land.

3.4 A project reducing environmental impacts to a minimum.

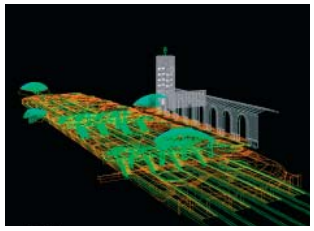
3.4.1 Reducing negative environmental impact

The project for Stuttgart main station incorporates aspects of sustainability and the reduction of negative environmental impact in many ways. The chosen location uses developed areas as space for conversion. Alternative modes of transport, i.e. rail services, are given long-term support and public spaces are maximised. Increasing the share of public transport services reduces the negative impact of traffic on the climate, on the quality of the air and on the quality of life.

3.4.2 Environmental compatibility



To sustain the quality of life in Stuttgart into the future, the city commissioned a variety of comprehensive studies on the environmental compatibility of the project prior to implementation of the planned measures. These included studies on climate, air, noise, hydrogeology, mineral water, contaminated sites, fauna and flora, and energy. The findings of these extensive investigations are incorporated in the building plans and are developed and elaborated on an ongoing basis.



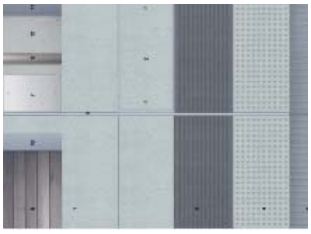
A further important consideration is protection of mineral water and groundwater. Here, adverse effects can be minimised by using the appropriate building technology and careful compliance with the demands of water supply and distribution.

The full surface of the concrete shell roof of the station hall will be covered with a structure of earth and substrate, helping to prevent urban heat islands in the city. Rainwater will be able to seep away naturally. The underground station with its 28 light eyes also reduces light pollution during the night. Low emitting materials only will be used throughout.

3.4.3 Integrating the fabric of existing buildings

Alongside the planned new station hall, parts of the existing station passenger building, the Bonatz building, will be preserved for station functions. The fabric of this listed building will be preserved and extended. It will be used as part of the new station to house administration and in particular services and retail.

3.5 Using durable products and robust technologies.



The volume of the building is reduced to the minimum. The reusability of the formwork elements and the prefabrication of modular components facilitated the efficient and profitable planning of the construction process. The functional requirements of the station were met by modular and replaceable finishing elements. This ensured a long service life for the building.

4. Economic performance and compatibility

A solid and well balanced fi nancing is based on increase of future-orientated public transport system capacities and sales revenue of former rail track areas. This ensures a long-term feasibility of the projects economic.

4.1 An outstanding infrastructure project with innovative financing models.

4.1.1 An outstanding infrastructure project

Stuttgart 21 is an outstanding infrastructure project. With a 30 km stretch of the high-speed Paris to Bratislava line as part of the European Magistrale passing through the city, and a further 30 km of urban connections into the new central through station, Stuttgart rail junction will undergo complete restructuring. At the same time, Stuttgart 21 also offers the state capital an opportunity for urban redevelopment of 100 hectares of freed-up railway land in a top city-centre location.

Several partners are therefore contributing to the financing of Stuttgart 21 and its 2.8 billion Euro volume of investment. The partners are: the Federal Republic of Germany, the state of Baden-Württemberg, the state capital Stuttgart itself and Deutsche Bahn AG. In 2001, all project partners agreed to set about the task of realising the Stuttgart 21 project. The financing agreement has a number of special features. For example, the state of Baden-Württemberg has agreed to pre-finance the federal government share up to 2011, while Stuttgart as the state capital purchased the freed-up railway land from Deutsche Bahn AG back in 2001. The European Union will also make a major contribution to financing Stuttgart 21 with its programme for expansion of east-west links to promote integration of the new partner states.

4.2 The tremendous impetus for business ensures a positive regional impact.

4.2.1 Tremendous impetus for business

With sustained improvement of the rail infrastructure, journey times on long-distance routes, i.e. in conjunction with the new railway line between Wendlingen and Ulm, and also on local routes in the Stuttgart area can be reduced considerably. Under Stuttgart 21, it will be possible to reach Stuttgart airport and the Neue Messe exhibition centre in just 8 minutes from Stuttgart city centre. Thanks to these highly attractive rail links, the volume of passengers is expected to increase on long-distance and local routes by up to 50 % by the year 2015.

The European Union is keen to expand the high-speed rail links in east-west corridors and will support projects with appropriate funding rates. Three contiguous projects are part of the Paris-Bratislava railway line. Stuttgart 21 and the new Wendlingen-Ulm line are currently in the approval phase, while Neu-Ulm 21 is already underway and will come on line in 2008.

Stuttgart 21 gives tremendous impetus to Stuttgart as a location for business. During the planning and realisation phase, 4,200 jobs will be created per year. Production services and effects on supplier industries are currently estimated at 3.6 billion EURO. Once the former railway land has been redeveloped, the city centre will no longer be split in two by the tracks. These 100 hectares of land will be turned into a new residential, shopping and service district, offering living space for up to 11,000

people and 24,000 jobs, which will be characterised by the high quality of the location and an optimal transport infrastructure.

Stuttgart 21 is also a very ecological project. The city centre park will be extended by 20 hectares, and it is anticipated that the improvement in the available transport services will encourage people to switch from road to rail. The reduction in the volume of road traffic is currently estimated at around 350 million car-km/year.

At the heart of the city expansion lies a piece of land measuring around 29 ha and situated next to the current station in a northerly direction. It is a premium city centre location: urban, central, close to the station and very well developed. Around 20 % of the area is earmarked for housing. Beyond that around 465,000 square metres of the space will be used for trade, business, administration and culture.

Stuttgart 21 not only benefits long and short-distance rail passengers, but everyone in the region. During the construction period for the station, tunnels and new railway line installations, 4,200 people will be able to earn their living – for close on a whole decade. Experts have calculated that the building work on the rail system will give a major boost to manufacturing activities. In other words: Stuttgart 21 creates additional billions worth of sales volume, from which the building and construction trade, electrical, steel and mechanical engineering industries, and above all the regional trades, will naturally profit.

More jobs will be created through development of the freed-up land. According to calculations by the Regional Statistical Office (Statistisches Landesamt), this measure will secure some 1,600 jobs and create more up to the year 2030. A significant number of indirect follow-up jobs can be added to the total. Up to four billion Euros of investments are expected in structural engineering. And the new sections of the city will not only create a new standard of living for 110,000 people in the city centre but also offer scope for 24,000 long-term jobs.

4.3 A forward looking station and urban redevelopment project with regard to future changes.

4.3.1 A forward-looking station

The existing Stuttgart terminus has reached its capacity limit. All studies have indicated that optimisation of the terminus is possible but, because of the topographical situation of the station in the Stuttgart basin and the steep approaches, would prove very costly and fail to bring about any sustainable improvement in capacity.

The new station will be turned by 90° in relation to the existing main station and built at underground level, with completely redesigned, fast approaches. These measures will give Stuttgart station the capacity it needs, which is double the current level. Flexibility will also be a feature of the new central station. Long mainline trains, or two short local trains, can be dispatched from one platform. Given the pace of development in signalling technology, trains will be able to arrive and depart in much quicker succession in future, which means that more increases in capacity will be possible. This is why the forward-looking Stuttgart 21 project will improve the attractiveness of the Stuttgart region within the European high-speed rail network.

4.4 The increase of passengers effects robustness to economic developments and conditions.

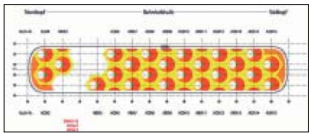
4.4.1 Robustness to economic conditions

The financing behind the Stuttgart 21 project is not affected by fluctuating business and economic conditions. In addition to the income from the sale of freed-up railway land, increasing the capacity of rail operations will also make a major contribution to financing efforts.

All completed new railway lines show a significant increase in passenger numbers. With no let-up in the demand for mobility, fast and attractive alternatives to chronically overloaded roads are essential. The diversity of the Stuttgart 21 project makes it possible to improve not only long-distance but also local transport services. The high number of commuters travelling into the state capital every day by car can be reduced significantly as a result.

4.5 The integrated project follows a high level of economic resources usage.

4.5.1 Economy of resources deployed in construction.



The trough construction of the station hall will be erected in three sections, both for water supply and distribution reasons, and others. Construction of the shell roof structure will follow that of the trough structure, likewise in sections, beginning from the southern end of the station.Each chalice element will be covered with concrete in one form over the full length up to the top edge.

The form made of stainless steel sheet with ribbed reinforcement comprises a lower and an upper part. The self-compacting concrete is poured in from above through permanently installed channels, which will remain in the structural element. Construction proceeds with two forms so that in axis A4 one of the four entrance shells is horizontally connected to the suburban rail line (S-Bahn), which runs at a right angle. In front of this horizontal interface, building work will proceed in parallel at the northern end of the station.

5. Contextual response and aesthetic impact - woven into urban fabric

The unmistakeable identity of the nature-like structure creates a long-lasting aesthetic elegance. The interlinking of the public pedestrian paths in the station and the "concealed" building structure correspond to the simple urban spatial setting.

5.1 Improvement and preservation of the existing distinctive topography.

5.1.1 Preserving and enhancing this particular area

The valley basin is one of the special features of Stuttgart compared with other cities. Given the high frequency of winds parallel to the valley, the Nesenbach valley along the castle gardens acts as the main ventilation channel for Stuttgart city centre. Cold air flows at night provide for pleasant cooling and ventilation. Preserving this function was one of the central points of the climatic research for the design of the new interregional station.

Following the line of the Nesenbach, the castle gardens form a coherent scenic area of major historic, ecological and urban significance. As the main area of open space in the city, the gardens connect Stuttgart city centre with the Neckar river. The aspect of preserving and enhancing this particular area was the starting point for tackling the project as a whole.

Measurements in a wind tunnel Night-time currents of cold air Stuttgart's valley basin situation. In the wind tunnel, the urban planning model demonstrates how the cold air can flow unhindered given an optimised structural form and height and street width. Higher buildings are only planned for suitable locations. Landscaped roofs, spacious green areas and trees improve the microclimate.

5.2 An interwoven contextual project corresponding to the interdependecies of the urban fabric.

5.2.1 A new city centre

The new station will give Stuttgart a new centre. In 10 to 20 years hence, the old tracks may well be replaced by a new urban district. The castle gardens are Stuttgart's lungs and will only gain in importance as the city expands. The park will be extended from the edge of the downtown core across the underground railway station. The "light eyes" will establish an experiential sense of the subterranean station even to passers by above ground. The historic building and the new station link the old and new sections of the city. The plan creates a station square with clear contours: here the Cannstatter Promenade, an extension to the Königstraße, will provide access to the new quarter. The large booking hall of the Bonatz building is the section of the station that is closest to the city. The concept transforms the old station into a meeting place with restaurants and shops, opening the floor of the existing station hall in order to interconnect all levels of new station and to integrate the historic fabric into the new design.

5.3 A future orientated public transportation system with cautious restoration of the built environment.

5.3.1 Evolution of rail transport

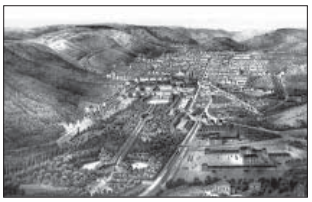
Towards the end of the 19th century, Stuttgart's first station, which was built in 1846, had achieved its final form after decades of expansion. Yet by around 1900 the station was still under strain, serving more than 7 million passengers a year.
In 1910 a competition was announced for a new terminus on Schillerstraße. The winners of the competition were Stuttgart-based architects Paul Bonatz and Friedrich Eugen Scholer, with a design they had codenamed – as was the tradition at the time – umbilicus sueviae, the hub of Swabia.

After a construction period spanning a total of eight years, from 1914 to 1922, the southern section of the station with tracks 9 to 16 was inaugurated. The station was finally completed in 1927.

The development of the high speed railway network requires renovation of Stuttgart's existing main railway station and its development as a through station below ground level. It is southern Germany's biggest town planning infrastructure project and the first part of the greater "Stuttgart 21" programme which foresees new inner city development over the buried tracks. A minimalistic concrete shell construction will span the 420 metre long railway platforms and connect inner city pedestrian zones with the historic Schlossgarten park. Structural geometry has been developed together with Frei Otto. Altogether 28 eyelets will bring daylight and natural ventilation into the underground station. For heating, cooling and lighting no energy is required, therefore the station is a zero energy building.

5.3.2 Castle gardens

Around 1855 the castle gardens were a central royal garden with avenues strictly bearing towards the royal residence. The castle gardens were reorganised in 1961 for the National Garden Exhibition (Bundesgartenschau). In line with the thinking in this era, the castle gardens were turned into a public garden and the axial reference to the royal residence done away with.
The urban planning and landscaping concept for the open spaces and castle gardens, which won the international competition and is now being implemented, follows the natural topography and creates a spacious crossing through the valley from Kriegsberg in the east to Uhlandhöhe in the west. The new spatial composition restores the characteristic scenery between the hills and the parkland.



5.4 The station is a flexible, reversible and sustainable building.

5.4.1 Attractive rail services for the long term

Connecting Stuttgart at underground level to the European high-speed rail network and its new generation of trains is an idea that can only be turned into reality with an extraordinary and extremely efficient design. The hall, with its 420 m long platforms, opens up possibilities for maximum flexibility.

All known passenger trains can stop in any position. Any combination of long-distance and local services is possible, which will help to sustain rail services in the future. The media technology of the supply and installation channels is equipped to permit retrofits and subsequent installations as needed.

5.5 Main Station Stuttgart, with its unique and signifant continuum, refl ects a high level of ingenious and architectural qualities.

5.5.1 An unique significance

The unmistakeable identity of the nature-like structure creates a long-lasting aesthetic elegance of the load-bearing structure. The interlinking of the public pedestrian paths in the station and the „concealed" building structure correspond to the simple urban spatial setting with its subtle lines of sight. The constructive implications for the future life of the city of Stuttgart, and the increase in development values they imply, make the scheme of unusual significance.

5.5.2 Interdisciplinary design virtues

Main Station Stuttgart is an ingenious space for high speed trains. The goal was achieved not by striving for a high-impact image, but by taking a completely different approach. Opimisation, minimisation, effi cience and finesse in all technical and structural aspects - in other words: the qualities of interdisciplinary engineering and design virtues helped to show the way.