Experience in The High-Speed Rail Link in the Netherlands integrated design

I was pleased to accept DHV's invitation to write a foreword to this brochure. Planning a high-speed international rail link is a complex process because of its large scale and the numerous international, transport, macro-economic, business economic, physical, environmental, budgetary and administrative matters which must be considered. An integrated and flexible development process was achieved using the combined knowledge and experience available in the Netherlands. The Dutch Authorities, Dutch Railways, engineering firms and consultants joined forces. It was essential to blend the different cultures and specialized know-how into a cohesive, enthusiastic and innovative team. With DHV's help, this important step has been successful.

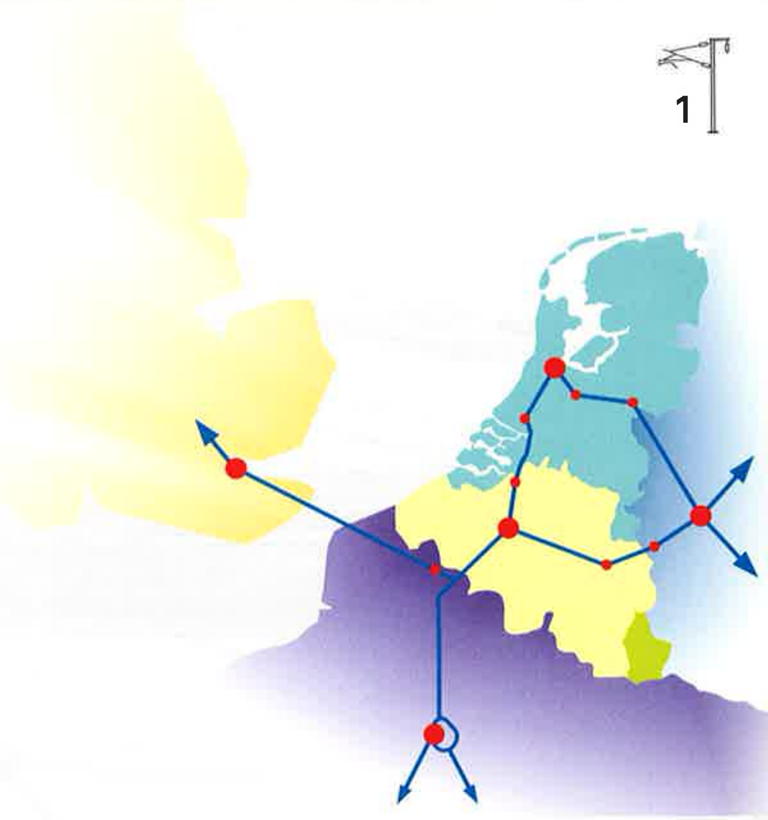
K. H. van Hout

Project Director High Speed Rail Link

Ministry of Transport, the Netherlands

Bookmark

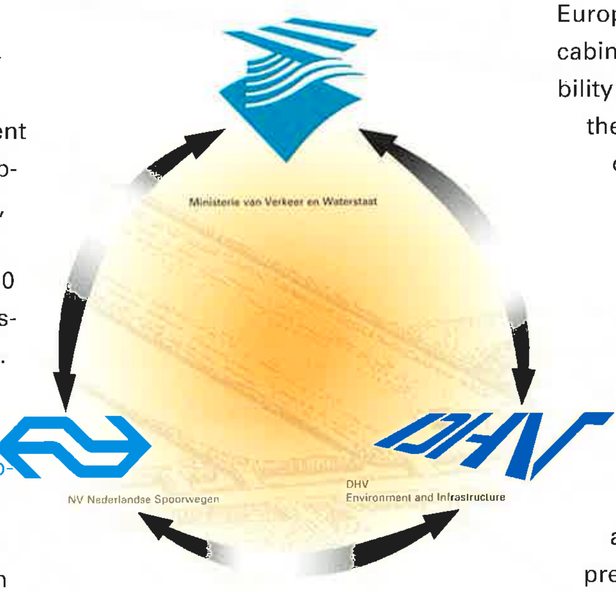
This project description deals with the experience of DHV and with the contributions which it has made to the preparations for a large (inter)national infrastructural project. The description consists of a more general description of the project, the procedures adopted, and of both process management and project management. It also includes a rough summary of the individual contributions made by each participating discipline. The description concludes with a summary of the services and instruments which DHV can offer. The table of contents shown below indicates the numbers of the pages where particular contributions are to be found.



Introduction

New road and rail projects typically require a long development time and once completed, they are used for many decades. However, as soon as the plans leave the drawing board, roads and railroads must be built as quickly as possible. Implementing the design often involves radical changes in the physical, economic and social environment. Sometimes laws and procedures are changed during the lengthy design phase. The only way to cope with these changing circumstances is a flexible planning and design process handled by an efficient project organisation. During the preparation and decision-making phases, 80 to 90 percent of the investment cost estimates are established and 90 percent of the available budget is disbursed when the work is carried out.

Together with other parties involved in the High Speed rail Link (HSL) project, DHV has developed detailed plans for several alternatives for the 80 to 100 kilometres stretch between Amsterdam and the Belgian border. As a result, a total of 1,100 kilometres of new route were evaluated both on or alongside existing rail lines or as totally new routes. This degree of planning was necessitated by the dense population in the western part of the Netherlands, in itself one of the most densely populated countries of the world. The entire complex process was accomplished in only two years due to the combined efforts of a team of about 50 specialists and the use of advanced computer-based tools for design, impact forecasts and presentation.



Part of transeuropean Network

The cabinet feels that The Netherlands should be connected to the European rail network for high-speed trains. It has proposed laying a new track from Amsterdam to Belgium. Amsterdam, Schiphol and Rotterdam will then have a high-speed rail connection with Brussels, London and Paris. The Hague can also be connected directly to this line.

In connecting The Netherlands to the European high-speed rail network the cabinet wishes to improve the accessibility of the Randstad conurbation of the western Netherlands to the rest of Europe. The cabinet also wants to promote the use of the train over that of the car and aeroplane for distances until 500 km's.

Project organisation

The HSL project originated in the Ministry of Transport. Netherlands Railways, involved as the future operator of the HSL, prepared the Key Planning Decision procedures required by Dutch law and the preparation of the HSL Alignment Decree. A joint venture was established between the Ministry of Transport, Netherlands Railways and DHV Environment and Infrastructure.

This joint venture provided the project staff. DHV provided the following expertise:

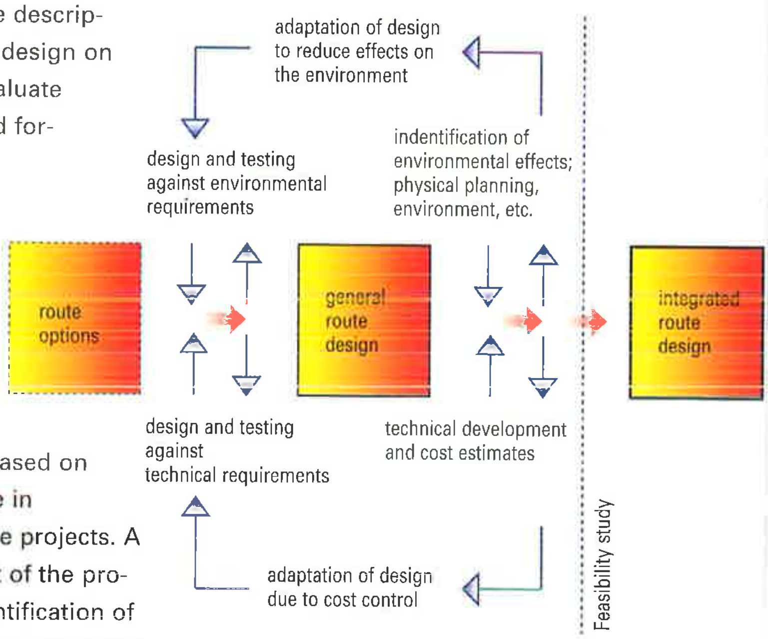
- physical planning
- noise and vibrations control
- environment (landscape, ecology, soil and water)
- route planning
- structural and civil engineering (bridges and tunnels)
- geotechnical aspects
- cost estimates and costing systems
- design methods, impact forecasts and assessments, including policy analysis, Environmental Impact Statements and risk analysis.

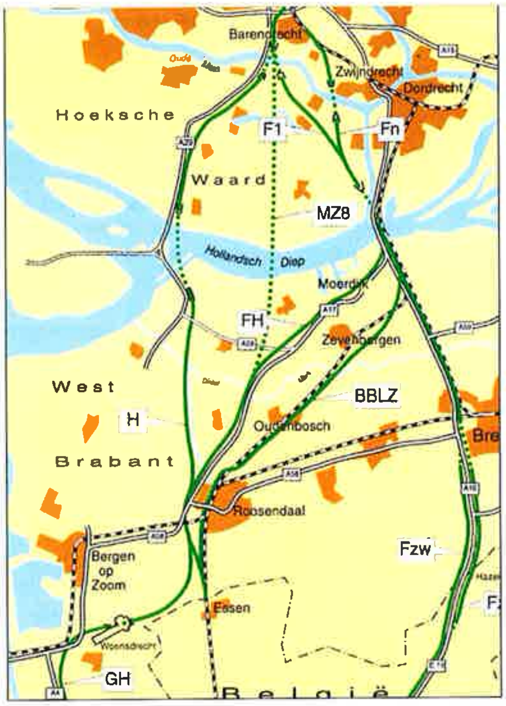
Integrated design process

The HSL Infrastructure Project Bureau's effectiveness was largely due to the exchange of knowledge and experience between the Ministry, Netherlands Railways and DHV. All team members gained a deep insight into the relationship between design and impact on the environment by involving every specialist in the design process.

Decision-making in a project like the HSL is complex and a strong framework must be quickly created to allow the project to be completed on time. Many sensitive decisions are politically charged because of conflicting interests and views. The methodology of managing this huge project and its processes required special attention because of the need to integrate the research performed by various specialists, and to translate policy into technology. An open and verifiable set of procedures was created to generate alternative routes, prepare objective descriptions of effect of design on environment, evaluate these effects, and formulate an assessment method and framework.

It was decided to adopt an integrated design process based on DHV's experience in similar large-scale projects. A fundamental part of the process was the identification of the impact on locations along the potential routes of the new link. The first step was to check viable route options against the environmental and user requirements. Specialists in physical planning, urban development, landscaping and ecology suggested route options in the available space and the landscape. Their findings were correlated and included in several fundamentally different route designs. The effects of the preliminary routes were evaluated in terms of their transport value, impact on the environment, and financial implications.





Route options

The competitiveness of the train on the Amsterdam and Brussels route (via Rotterdam and Antwerp) and beyond will remain vulnerable because of its limited capacity even after the current expansion plans of conventional train services. This situation has called for two strategic scenarios:

- The new lines alternative:
  The building of a completely new rail line (a new route) on which trains could travel at 300 km per hour. Trains could run directly to Antwerp, Brussels, Paris and London throughout the day.
- The combination alternative:
  The laying of a new rail line as close as possible to the existing track, provided with a higher power supply.
  Speeds of 300 km per hour will also be possible. At some locations the speed would be limited due to bends in the route. Trains could run directly to Antwerp, Brussels, Paris and London throughout the day.

Various transport alternatives and infrastructural options were developed for these scenarios. The project bureau developed the alternative routes and evaluated the effects of each objectively.

The next step

Dutch law dictates precise and comprehensive procedures for informing those affected by the proposed plans, giving them an opportunity to express their opinion. The purpose of these procedures is to allow public participation and formal consultations at an early stage, on the basis of which plans can be revised, altered or elaborated if necessary. The final route selection requires parliamentary approval prior to detailed design: this allows municipal authorities time to fit the route plans into their area development schemes. The HSL Infrastructure Project Bureau is now involved in the preparation of parts 3 and 4 (see diagram). The project organisation has been enlarged to over 100 staff members, of whom half were provided by DHV.

Procedures and timetable

	Planning the key decision subject to Environmental Impact Assessment (EIA)	
1994	Part 1	Ministerial intent = design Key Planning Decision = plan (Section 2a, Physical Planning Act) open for public inspection discussion + hearings, recommendations, consultation.
	Part 2	recording of results of discussion, recommendations, consultation
1995	Part 3	Government decision = adoption of Key Planning Decision (plan) proposal submitted to Parliament for approval Parliamentary debate
1996	**Part 4**	**approved Key Planning Decision/plan**
	Alignment subject to Environmental Impact Assessment (EIA)	
1996		**Draft Alignment Plan** open for public inspection (and information of Parliament) discussion, advice consultation (twice if changes have been made), request for planning cooperation
1996		**Alignment Plan** (approval by Minister of Transport, Public Works and Water Management and Minister of Housing, Physical Planning and Environment) announcement

HSL and Physical Planning

Framework

The Dutch government submitted several memoranda to Parliament outlining the physical planning framework for the development of the HSL in the Netherlands.

The memoranda place physical planning in the context of strengthening the position of the Netherlands in Europe. The connection of the North-Western part of the Netherlands to the European high-speed rail network will make a major contribution to this objective.

However, the dense population of the Amsterdam and Rotterdam area puts a severe constraint on the HSL. Space is in high demand for other purposes such as housing, industry, recreation and nature. A balance has to be struck to enable all these uses to develop in harmony.
DHV assisted in clarifying the implications of the large scale infrastructure needed for the HSL, particularly the impact on other physical developments. DHV's physical planning experts have:

- made an inventory of problems and proposed solutions
- assisted in mapping out the route options
- described and assessed the physical impact of the route options.

Statutory physical planning procedures have been refined and translated into requirements to be addressed by the HSL project.

Design

DHV produced an extensive inventory of the physical structure in the area, which may have to be crossed by the HSL, to facilitate plotting of routes. DHV also identified projected physical developments which will shape the face of the area in the near future. The main focus was on the regional development plans, because this is where physical planning policy is usually translated into hard figures like the number of houses and the size of industrial sites for designated areas. Depending on the route selection, the HSL will have a substantial impact on the surroundings. The integration of a national/international rail infrastructure almost invariably conflicts with other objectives pursued at regional and local levels. HSL routes alongside existing rail lines, usually cause problems in urban areas; totally new HSL routes tend to cut through the countryside.
DHV's physical planning experts assessed the effects of the various route options and their design on the present and future physical structure. DHV submitted suggestions aimed at the improved integration of the route options into the overall structure.

Impact

A number of route options have been designed which are considered feasible in terms of physical planning. The impact of each option has been defined and assessed quantitatively and qualitatively to enable a thorough evaluation. The main focus of the assessment is the value of an area for the following functions:

- **living**
- **working**
- **agriculture**
- **recreation**

A special method has been developed to measure quantitative aspects. For each area, DHV gauges the extent to which the present and future physical structure will be impaired according to:

- size and sensitivity of the area the HSL will cross
- manner in which the route cuts through the area (i.e. the horizontal and vertical positioning of the HSL).

The qualitative assessment addresses the physical relationships between these functions and the way they are perceived. For example a route which crosses a "ribbon development" alongside man-made or natural waterways, with only a single row of houses bordering a parallel road. The number of houses expropriated and the loss of agricultural land would be minimal. However, the HSL would have a serious detrimental impact on the living conditions of residents. It would also disrupt the existing urban planning structure because new access roads for motor traffic would be required. Alternatives have been developed.

HSL and Noise Pollution

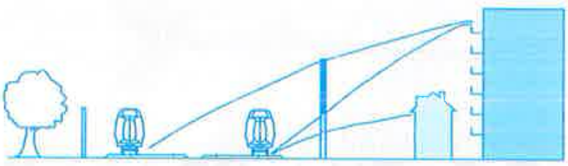
Framework

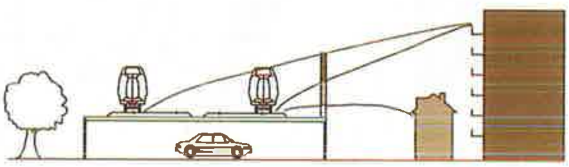
Noise pollution is one of the main causes of concern among people who live along a proposed HSL route. Another major problem is the potential disturbance of areas which are still relatively quiet. The Netherlands is a densely-populated country and consequently has a comprehensive Noise Abatement Act with strict regulations aimed at preventing or reducing noise. There are legally prescribed methods for measuring and calculating the burden on noise-sensitive properties and maximum permissible noise levels. This requires rail designers to plot a route with the least possible noise burden. When it is impossible to keep within the legal limits, the only option is to devise measures which combat noise and/or to install some form of insulation. Even so there may still be a few cases where these measures fail to produce the desired result and houses may have to be expropriated or demolished. This would obviously have a major psychological impact on the occupants and also has considerable financial consequences.

Besides the Noise Abatement Act, the Authorities have other policy instruments which must be considered in addition to the noise pollution of the route options. Vibration caused by the high-speed trains is another potential source of nuisance which must be addressed.

Design

At the outset of the design process it was unclear whether the noise aspect of the HSL could be solved within the existing legal framework because of the highly specific nature of the HSL.

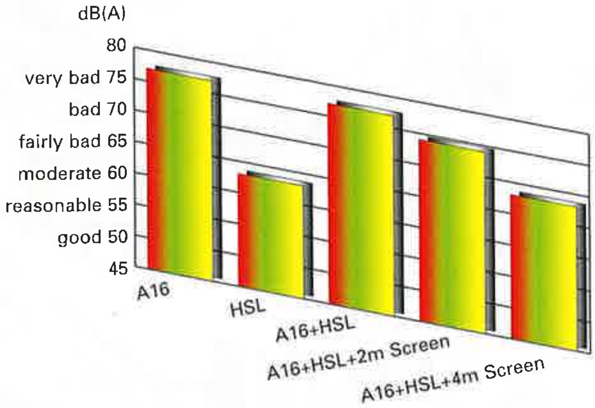




Consequently, the first step was to conduct research to define the nature of the noise, the effectiveness of noise screens and the extent to which people perceived the noise of high-speed trains differently from that of 'normal trains'. Measurements conducted on the TGV-Atlantique in France revealed that the same approach can be adopted as for standard trains when calculating the increase in noise and the effectiveness of noise screens, as long as the right coefficients are entered in calculation models dictated by the Netherlands Railways Noise Pollution Decree.

A main element of the integrated design process was the production of route options. The main consideration was to integrate the HSL in an optimum fashion in the surrounding area within the specified technical criteria and project objectives and with due attention to costs. Consequently, the basic design required a strong emphasis on the abatement of noise. The more obvious ways of reducing noise include constructing the HSL route alongside existing road and rail infrastructures to leave the remaining quiet areas untouched, or to lower the track level of the route over short distances where it passes through urban areas.

A special noise calculation method was devised to help decision-making for an initial route selection. It was based on criteria for residential areas (the number of people affected by noise and vibrations, and the number of houses to be demolished), for tourism areas with overnight accommodation (the number of facilities affected by noise), for the negative effect on quiet areas (in hectares) and for the increase in surface area affected by traffic noise (in hectares).

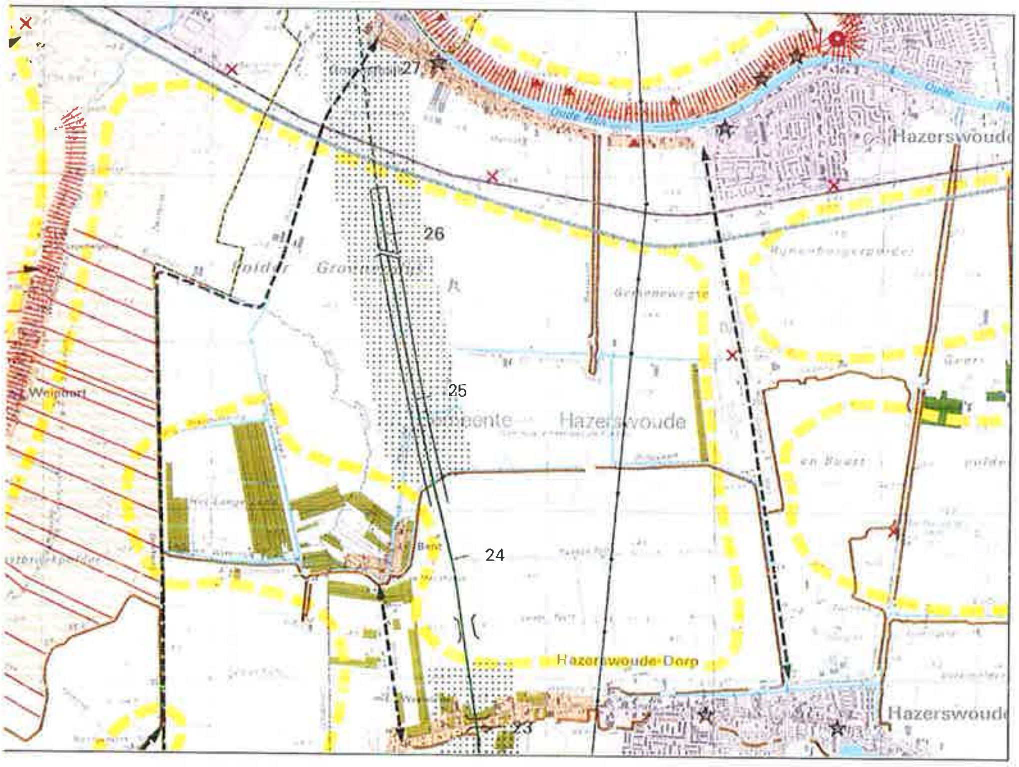


The quantitative evaluation for these criteria for the various routes was determined in an iterative process which calculated contours for different levels of noise, initially without making allowance for any noise-reducing measures. The contours identified the places where measures are necessary because of the proximity of noise-sensitive properties (houses, schools, hospitals, quiet areas). The next step was the re-calculation of the contours but with a different routing and/or noise screens (or barriers) to keep within the limits stated in the Noise Abatement Act. A geographic database was used to count the number of houses affected. The number of people affected by noise was estimated by using relationships established in earlier research and figures for average home occupancy. This contour calculation method could also take into account track elevation, speed, train composition and frequency.

The iterative process was created by integrating Computer Aided Design (3D-CAD) with the Standard Rail Traffic calculation model (SRM-II of the Railways Noise Decree). The process quickly identified the effects of route alterations and noise-reducing measures. The noise contours were then plotted on a topographical background. The system developed for this project has since been marketed under the name of dBMOSS. DHV is using this same system for the planned High Speed Link from Amsterdam to Köln/Frankfurt, and for various road projects.

The environmental quality standard was calculated for the alternatives where the route options are combined with roads and/or rail links already in place. This standard makes it possible to assess the accumulation of noise and the effectiveness of noise-reducing measures for different noise sources in relation to each other. Cost estimates were developed for installing noise-reducing facilities, facade insulation and the expropriation of houses to enable the inclusion of these factors in the final assessment.

HSL and The Natural Environment



Framework
The natural environment comprises flora and fauna, soil and water, and landscape. These elements of our surroundings greatly influence each other and together with man's interventions they form the landscape. The landscape therefore exhibits a variety of structures and patterns.

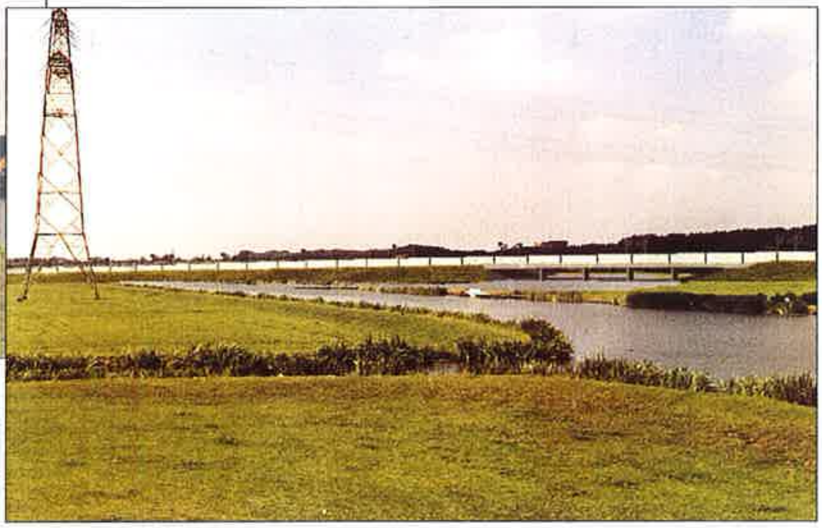
The natural environment is represented by the following elements:

- soil and water (abiotic factors);
- ecology (flora and fauna);
- landscape (visual aspects of the different elements).

These matters play an important role in determining the routing and elevation of the HSL alternatives. The fullest possible allowance has been made for the elements of the natural environment in places where the HSL will cross the countryside.
A method was developed for each of these elements to define and quantify the impact of the HSL on the natural environment as accurately as possible. The aim was to make it easier to compare the proposed routes.
The first step was to produce a complete description of the present situation and of likely independent development of the natural environment between Amsterdam and the Belgian border. The route options served as the basis for applying the method. Special maps were used to set out the data obtained through this inventory process.
The effects of the routes were then defined, quantified and illustrated on the maps. Finally, the impacts of the routes were compared to provide a basis for the decision making proces.

The area affected by the HSL
The area between Amsterdam and the Belgian border has a large variety in landscapes. Certain areas had to be considered separate units on account of their specific combination of soil composition, water management, natural values, human influence and spatial features. Specialists used these features to define values and effects.
The HSL constitutes a huge element of the national/international infrastructure and is highly specialized. It needs a large radius for the rail curvature to meet safety requirements appropriate for the high speeds of the trains. It makes a marked contrast with the present landscape made up mainly of elements of a small scale. The impact of the HSL on the natural environment may be anything from minor to extremely serious, depending on the track concept (ranging from a tunnel to a high embankment) and the selected route.

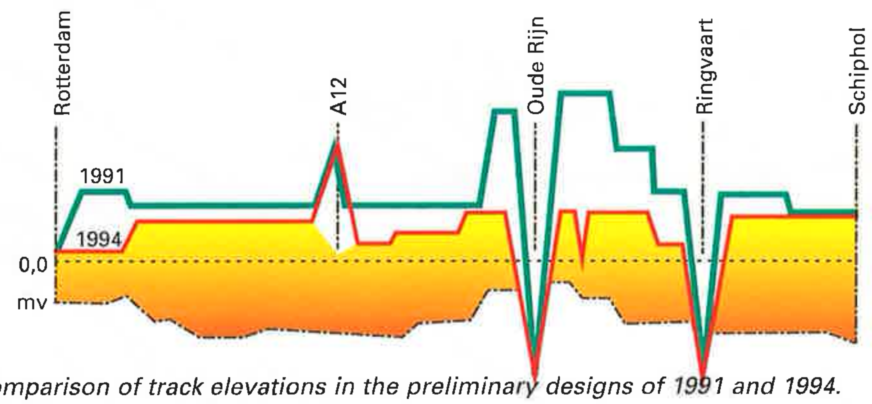
An example of values and effects
To give an example an area is considered, where important values occur for all three elements (Soil and Water, Ecology, Landscape) which are sensitive areas in the construction of the HSL.
The peaty soil in the Northern part of the route contains wide open vistas and has an abundance of water. The high water table attracts a wealth of migrating birds. In addition, some sections in key natural areas are subject to soil conservation regulations, and the open and largely inaccessible peat polders in these areas have been declared quiet areas. Land reclamation projects in previous centuries have left their historical marks on the area in terms of the allotment pattern, preserving the long, narrow lots, development ribbons and windmills of important cultural significance. Because of the sensitivity of the area,



an attempt has been made to position the HSL as low as possible. This is not possible everywhere, however, on account of dike requirements at some essential crossings. Examples are the high walls at the approach to an aqueduct, the high track and viaduct with noise screens at another crossing and the oblique crossing of one of the motorways.
These circumstances and other problems already present will require a careful integration of the HSL. The approach eventually adopted will be worked out by experts in cooperation with relevant authorities.

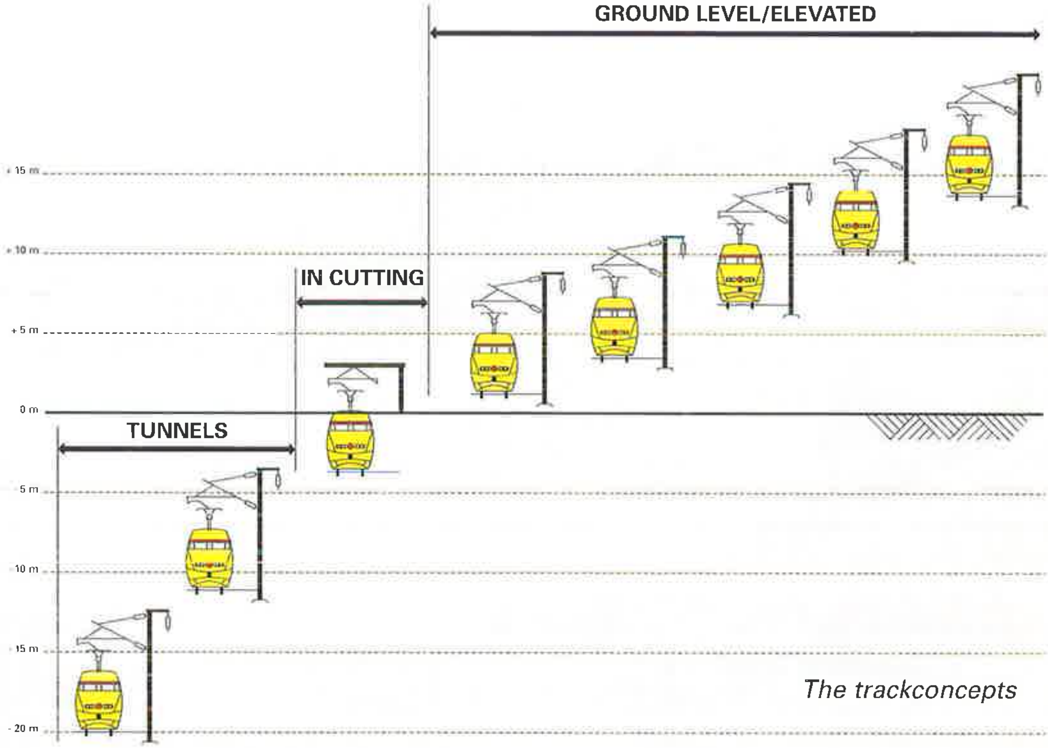
Landscape vision

The Dutch landscape is vulnerable in the case of major alterations. An important principle in the design process is the need to retain a line of sight to the horizon. Ways to achieve this include by positioning the HSL as low as possible in open areas and by constructing spacious underpasses. This approach represents a major change in the earlier HSL design produced in 1991.
It is essential to avoid the repeated adaptation of the HSL to local situations along the route because it would mean losing sight of the project as a whole. Orientation will need to be improved by injecting a recognizable hierarchy into the scale levels of the project. This can be done in various ways. They include giving the HSL its own identity (e.g. uniform design, materials and colours) and by adopting similar solutions in similar situations.
In the follow-up phase, there will be close consultation between experts like urban planners, architects and civil engineers. They will develop a vision for easing the preferred route into place.



Comparison of track elevations in the preliminary designs of 1991 and 1994.

HSL and Civil Engineering

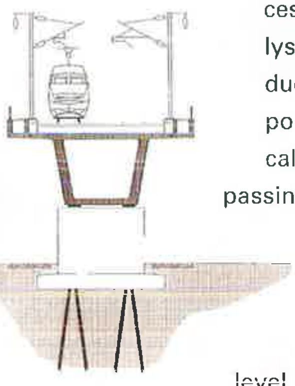


The trackconcepts

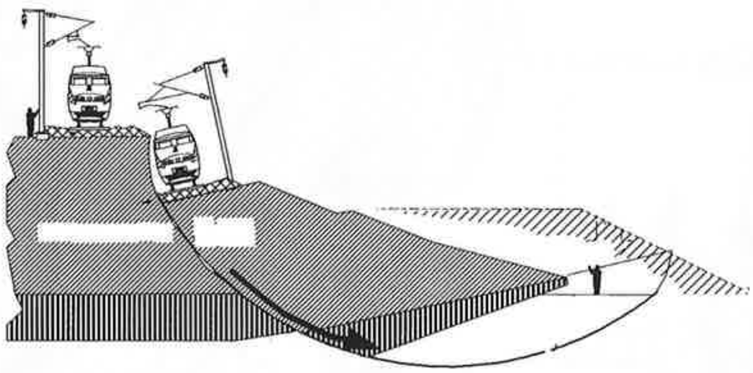
The preliminary civil engineering for HSL will provide an insight into the consequences of designs and will permit taking sound decisions. Under the Dutch Infrastructure (Planning Procedures) Act, it is obligatory to allow for future expansion of civil engineering projects in the designated areas. This presents civil engineers with the challenge of looking one step ahead in their plans. 'Track concepts' were used to form an idea of the possible solutions and their features from the point of view of the different technical aspects involved in the HSL. These are schematic representations of the most likely solutions. Basically, there are four track concepts:

- tunnels
- in cutting
- ground level
- elevated

The integrated design process described earlier was used to determine their feasibility. An inventory was made of almost all essential elements - together with an estimate of costs - with a large degree of detail which enabled a preliminary design to be tailored to each location. The embankments along the route were designed using longitudinal profiles worked out and evaluated on the basis of designs agreed between all relevant experts. This included cross sections for geotechnical and railway engineering purposes. When these plans were taken a step further to include future expansion, it became apparent that the positioning of the route was often determined by constraints related to water management (dikes, clearances). Risk analyses were produced for the possible technical solutions for passing waterways and dikes. The aim was to provide the level of safety expected by the community and to optimise functionality, to minimize disturbance of the surroundings and to reduce costs. As a result some hydraulic solutions were found which considerably improved the design of original route options. All route options cross or influence the existing above ground and underground infrastructures in some manner. Among the factors requiring consideration were alterations to roads and the diversion of roads and cables. In some cases this resulted in an integrated design embracing alterations to the HSL route in combination with road design/reconstruction or a large-scale alteration of a road. The actual performance of work was considered in instances where the construction of the HSL might necessitate major disruption. Attention was focused on innovative solutions like access ramps with noise-absorbing wall cladding, drilled tunnels, the application of geotextiles and so on. Rough working plans were developed for the construction of main elements - mostly tunnels along the routes - to get an idea of the time and costs involved in constructing the HSL.

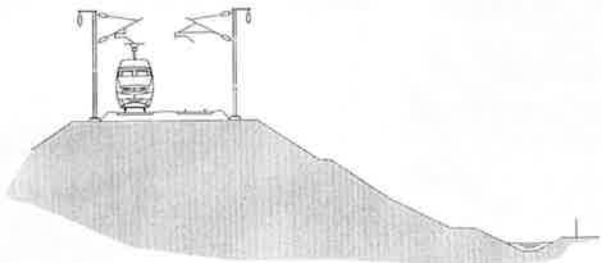


A separate study examined the possible extraction and processing of sea sand for the embankment, subject to mining regulations. The issues which may arise include desalination and the logistics of processing the sea sand. A basic principle for the HSL project is to retain the quality of ground and surface water.



Geotechnical aspects
For reasons of safety and comfort of passengers, a permanent, stable, level track is an essential requirement. The soil in the west of the Netherlands is soft and variable so the optimum interaction is essential between the geotechnical, track and landscape plans. A study of the available soil survey reports resulted in a decision to divide the west of the Netherlands into a small number of characteristic geotechnical areas. For each relevant track concept, the main geotechnical aspects of those areas were examined, to optimise the use of the geological properties of the subsoil. Interpolation techniques were used where necessary and the information was processed in a data base.
This approach quickly produced a picture of the relevant geotechnical aspects of newly submitted route options and a general impression of:

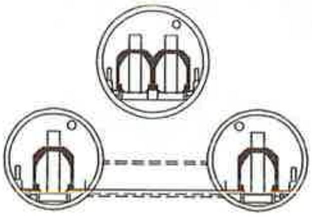
- likely subsidence, consolidation times and subsidence-accelerating techniques
- required cross section (especially slope gradients and possibly toe weights for stability)
- amount of earth movement necessary.



The various foundation possibilities were studied for large structures like tunnels, access ramps, aqueducts and bridges along the routes. Significant attention was devoted to the possibility (and sometimes the impossibility) of drainage on account of environmental requirements.

The drilling of tunnels for the HSL has always been considered to be a realistic possibility. Studies were conducted into the actual tunnel drilling process (including the quality of the removed soil), anticipated subsidence and the effect of drilling on existing (pile) foundations.
The results of these studies formed part of the final comparison of the route options.

HSL and Major Engineering Works

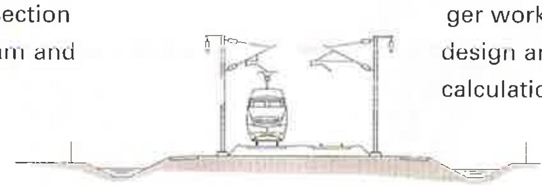


Numerous large-scale engineering works are required to integrate the HSL into the environment by means of low and sunken positions. It was possible to determine the vertical alignment at each location with the help of the overall vertical alignment designed by specialists in railway engineering, environment, physical planning and urban development.

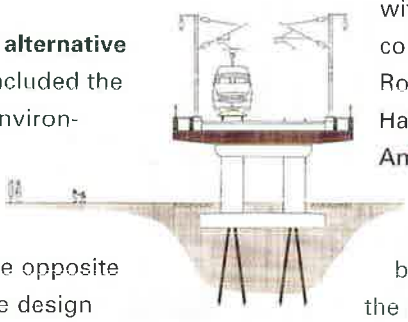
An integrated design method developed by these experts resulted, in many cases, in adaptations of vertical alignments and (engineering) structures.

Most environment friendly alternative

This integrated approach included the development of the most environment friendly route option. Instead of going underground to avoid problems above ground, the opposite approach was adopted. One design was an entirely underground route through a drilled tunnel along the most direct, straightest possible route. The direct project costs were considerably higher than those of a ground level route. To reduce the costs, a study identified the route sections where the HSL could come closer to the surface without encountering too many problems. This could be done by means of a tunnel made in an open excavation, an open trough, an embankment or a viaduct. In the northern portion of each route, this approach turned out to be feasible in some of the polders. The end result was that in the most environment friendly alternative, there would be about 50 percent of underground section between Amsterdam and Rotterdam.

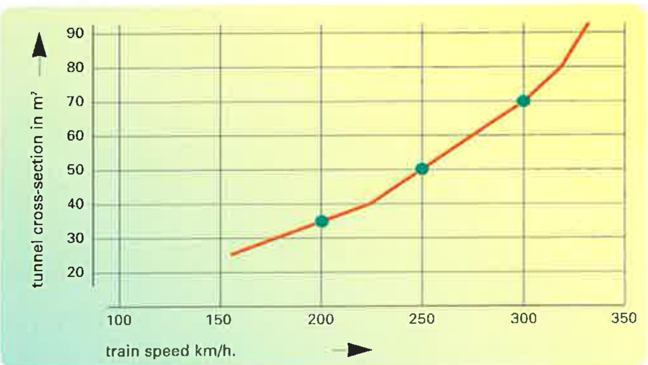


The costs of this solution are roughly the same as the total costs of a route combining the HSL with the existing rail connection between Rotterdam, The Hague and Amsterdam.



This approach has been adopted in the recommendations of the Underground Infrastructure Steering Committee (December 1993).

The speed of trains influences the size and design of the cross sections of closed tunnels and thus the costs. A sensitivity analysis was conducted to identify the consequences for the HSL, and each of the route options contains a variety of engineering works. Larger works like tunnels, open troughs and long viaducts constitute about 50% of the total construction costs. The dominating influence on costs of these larger works called for design and structural calculations commensurate with an estimate of costs sufficiently accurate for this phase of the project. Structural calculations were performed for some basic variants. Important information came from the analysis and interpretation of soil survey reports already available.

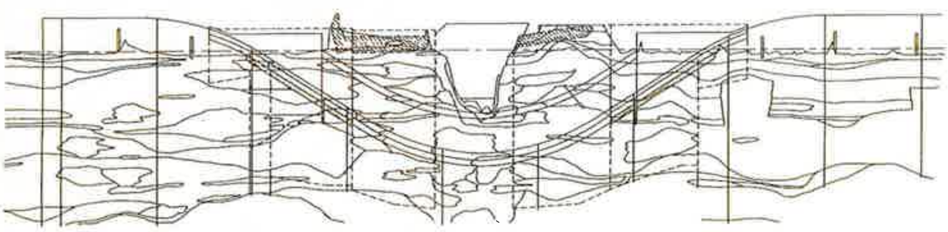


Relationship between train speed and required tunnel cross-section (for a one-track tunnel tube, pressure tightness t =5s).

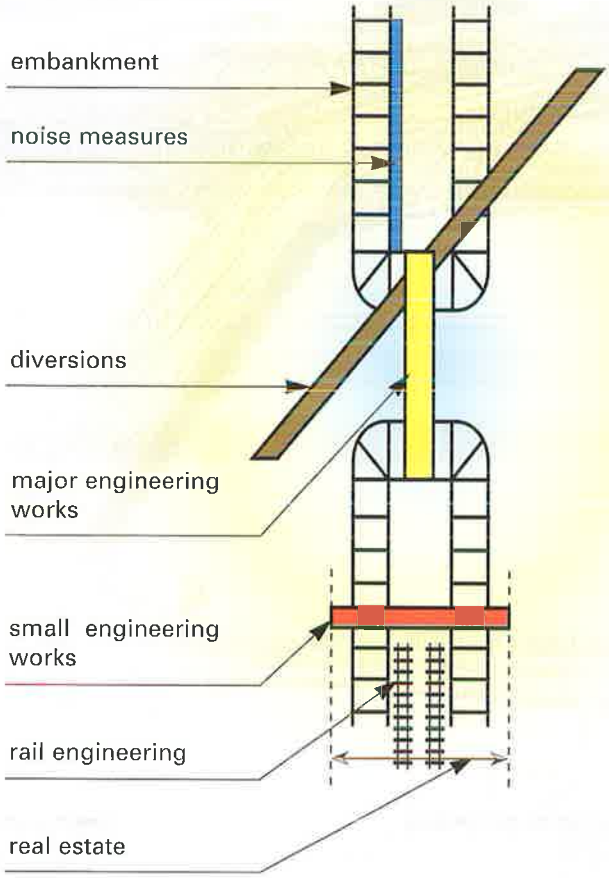
A supplementary soil survey was carried out to examine the crossings of two large waterways. The resulting knowledge and insights were applied in the examination and calculation of the many route options. The possibility of using tunnels to cross polluted water beds by means of a dredged trench was studied and the quantity, removal, transport and storage of polluted mud was examined. Since the influence of ground water is a major factor in estimating the costs of deep constructions underground, the possibility of using underwater concrete and tension piles was maintained because drainage cannot be used in some areas due to potential dehydration of the area.

The eight northern and thirteen southern route options cover a total length of about 1,100 km. There are about 950 engineering works ranging from very small to very large within these route options. The engineers and cost estimators used topographical maps, aerial photographs and field studies to analyse the engineering works needed and to classify them by size.

Some of the structures on the preferred route are impressive in terms of their size. The longest tunnel is about 2,150 metres, with a sunken part of 1,037 metres, while the largest tunnel built in open excavation has a length of 2,500 metres. Numerous open trough constructions were considered, the longest of which is 3,700 metres. In the preferred route there is one aqueduct. There are numerous viaducts, the longest of which is 1,000 metres. The longest bridge in the Delta area south of Rotterdam is 1,085 m.



HSL and Cost Estimates



Estimates were made to determine the most realistic possible picture of the likely costs of each of the HSL route options. The estimates covered preparatory work and all the costs that would be incurred from the time the final decision is taken about the route until the moment the link goes into service. The estimates had to make allowances for the stage of development of the project and the comparability of the routes.

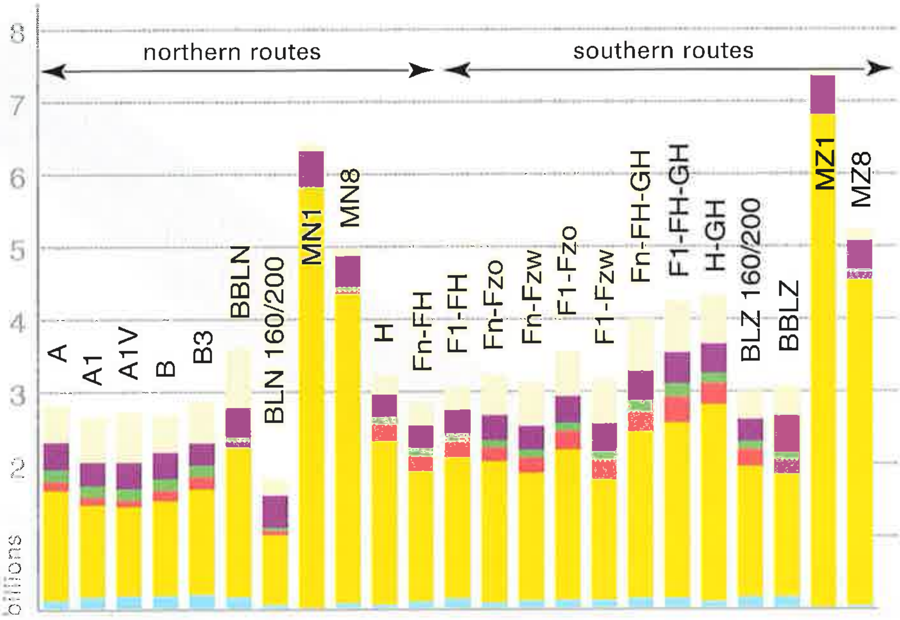
A cost overrun margin was fixed for each of the estimated amounts. The method of the 'Framework for Cost Estimates' of the Ministry of Transport was used as a basis. The following principles were applied:

- recognizability of the method (compared with existing estimation techniques and developments)
- clarity of the method (uniform definition of terms)
- recognizability of the contents (traceability of the basic data and a clear relationship between the estimate, design and list of requirements).

A certain margin of error was assumed in each phase of the project. A statistical approach determined the probability of a cost overrun. It took into account the estimated margin of error of the estimated components individually and as an interdependent whole. Sensitivity analysis examined variations in the basic assumptions and/or design criteria.

The budget was prepared bearing in mind that the project would probably be divided into phases at a later stage so as to make it possible to control, evaluate and analyse the overall project as it moves ahead. The budgets and associated preliminary designs were adapted to this situation. The costs were based on the provisional list of requirements and associated preliminary designs.

The budgets were prepared with the help of the software package IBIS-Calc, which is capable of handling large volumes of data. Each route was divided into a small number of parts and itemized according to the following cost items:



- **embankment**
- **engineering works**
- **environmental measures**
- **railway engineering**
- **track relocations**
- **real estate**

The figures stated for the routes are of the 'feasibility study' level. The main elements of the selected route options have been worked out and budgeted in the form of a 'preliminary design'.

A more general approach was adopted to examine and budget some routes. Consequently, they have wider margins of error.

HSL and Assessment Framework

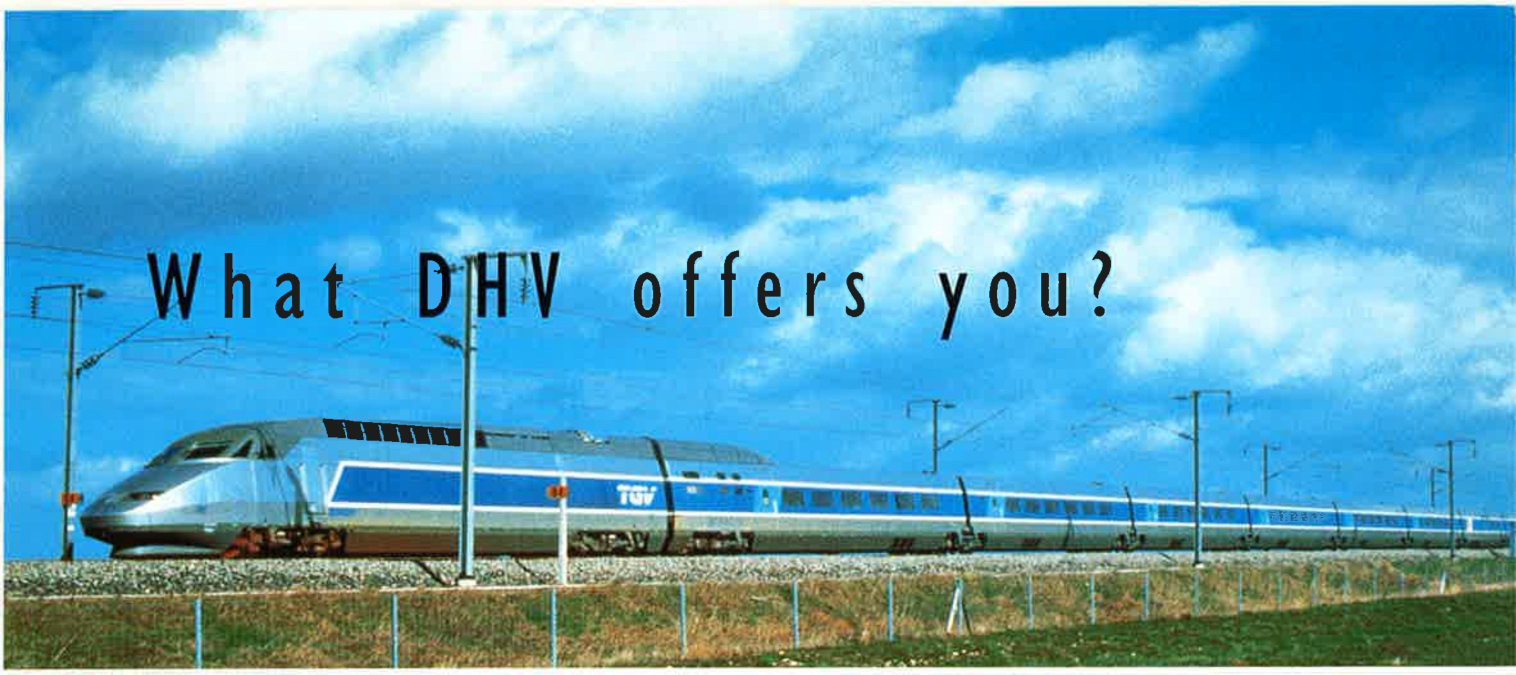
INTEGRAL ROUTE COMPARISON NORTH			0-VAR	BBLN	MN8	A1
NATURAL ENVIRONMENT						
	Landscape	Openness	0	25.5	23.5	49.5
		Small scale	0	3.25	0	2.5
		Orientation	0	8.25	18.25	55
		Cultural values	0	10	0.25	24
		Geological values	0	7	0	0.75
	Ecology	Quantitative biotope loss	0	305.5	56.2	478
		Quantitative biotope loss (disruption)	0	0	150	2009
		Quantitative biotope loss (fragmentation)	0	1.5	12.2	39.5
		Several ecological relations	0	0	4	[illegible]
	Soil & Water	Excavation of soil	0	3	4.[illegible]	
		Soil conservation areas	0	9.1		
		Ground water conservation areas	0	0		
		Sand requirement	0	1		
		Storage of dredged mud	0	[illegible]		
PHYSICAL PLANNING						
	Homes	Existing				
		Future				
	Work	Existing				
		Future				
	Recreation	Existing facilities				
		Future facilities				
		Existing				
	Agriculture					
Li[illegible]						

An 'assessment framework' describes, compares and evaluates the route options systematically and verifiably. The assessment elements were defined where relevant in comparing and evaluating each of the route options.

To describe the effects, several aspects relevant to the comparison of the route options were determined for each subject (natural environment, physical planning, residential environment and living conditions). For the natural environment, for instance, these subjects are landscape, ecology, soil and water. Within each subject, criteria were chosen to quantify the effects where possible. The criteria applied to landscape were openness, orientation, and cultural and geological values. The magnitude and nature of the effects were determined as well: the values were expressed in quantifiable units like the number of houses, disturbance of the surface area and the length of route sections.

Tables were used to compare the effects, i.e. one table with the aggregate of quantitative effects (see example) and another with the derived qualitative values according to a five-point scale (++, +, 0, -, —).

The relevant authorities have to weigh such factors as the international competitive position, added transport value, environmental effects and costs. The memoranda and reports will be used by them as tools to obtain a clear and objective picture of the effects and to demonstrate the implications of decisions, including the uncertainties which exist.



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DHV is active in decision-making processes and strategic consultancy based on its knowledge and experience. Decision-making on complex physical and infrastructural questions in densely populated areas in the 1990s requires thorough preparation based on a sense of reality and on communication with all concerned. DHV provides advice according to a project-based approach emphasizing quality, time and cost control. DHV has continually demonstrated that it works in a problem-solving way through services in:

Transportation Planning, including public transport, traffic planning, traffic safety, forecasts, traffic regulation techniques, logistics and transport economics.
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- traffic models (the North-west European Model, Quo Vadis, Central Netherlands Model)
- noise analysis of road and rail transport (dBMOSS)
- two and three dimensional design packages (Autocad, MOSS)
- geographical and geological information systems (ARC-info, Remote Sensing)
- thematic card production methods
- geotechnical and geohydrological models (PLAXIS, MSTAB, NENGEO, MZET, MICROFEM, MSEEP)
- hydrological and hydrodynamic mathematical models
- soil pollution and distribution models (including BOSS)
- economic instruments
- environment efficiency models (including Primavera)
- cost estimation models (IBIS calq)
- basic land operation calculations
- real estate management models.

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DHV Environment and Infrastructure
Laan 1914, Nr. 35
P.O. Box 1076
3800 BB Amersfoort
The Netherlands
Tel: +31 33 68 27 00
Fax: +31 33 68 28 01

DHV Germany GmbH
Pleikartsförster Straße 99
69124 Heidelberg
P.O. Box 101269, 69002 Heidelberg
Germany
Tel: +49 6221 717-0
Fax: +49 6221 717-289

DHV United Kingdom Ltd.
Priory House, 45/51 High Street
Reigate, Surrey RH2 9RU
United Kingdom
Tel: +44 737240101
Fax: +44 737221502
Telex 942153

DHV CR s.r.o.
Drahobejlova 48
CZ - 190 00 Praha 9 - Liben
Czech Republik
Tel: +42 266037219
Fax: +42 266037207

DHV Magyarország Kft.
(DHV Hungary)
Thököly út 58-60
H -1146 Budapest
Hungary
Tel: +361 268 1728
Fax: +361 268 0830

DHV Polska Spol. zo.o
Dubois Street 9
00-182 Warsaw,
Poland
Tel: +48 26357746
Fax: +48 26356977

DHV España S.L.
C/Arequipa, 1
(Gran Via de Hortaleza)
28043 Madrid
Spain
Tel: +34 1 3815266
Fax: +34 1 3816995

FBO Lda.
Rua Dr. António Loureiro Borges, no. 5
6th Floor/Arquiparque-Miraflores
2795 Linda-a-Velha,
Portugal
Tel: +351 410 88 20
Fax: +351 410 68 30 / 410 68 32

Stewart Scott International (SSI)
2 Norwich Close
Sandown
P.O. Box 784506
Santon
2146 South Africa
Tel: +2711 780-0611
Fax: +2711 883-6789

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