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DESIGNING THE STRUCTURE AND ALIGNMENT OF AN UNDERGROUND LOGISTIC SYSTEM; THE CASE OF THE AMSTERDAM AIRPORT ULS

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Abstract

Amsterdam Airport and its environment are suffering from increasing traffic congestion. It is caused partly by airport related activities which in turn suffer from it. An Underground Logistic System should make a contribution to the solution of these problems.
A definition study was undertaken to define the general characteristics of the system, including the alignment.
The paper describes the process of systematically designing the alignment, parallel to assessing the economic function of the system and choosing its technical characteristics. It sheds light on the criteria to be applied in the various stages of the design process of this type of system.

INTRODUCTION

This a concise report of an adventurous undertaking: finding an appropriate alignment for an underground logistic system (ULS), without a known parallel. It was even more adventurous because the features of the system were only roughly sketched when the study started. It forced us to think continuously about principles of design and to reconsider choices as the system crystallised gradually. First, the background of an ULS and the outline of the 'Definition Study' that included the alignment design are described. Next, the conditions for the alignment and the steps made to develop a specific proposal are analysed in successive sections. Of course these were subject to continuous scrutiny of interested parties inside and outside the project organisation. However important this may be for final decision making, it is not the focus of this paper. Some information on that subject is given in opening and concluding sections.

THE IDEA OF A ULS

Traffic congestion, environmental considerations and a lack of space gave birth to the idea of an underground logistic system for Amsterdam Airport (Schiphol) and its rapidly expanding freight transport. An increased government interest in underground construction and the willingness to finance research into the subject supported the idea.

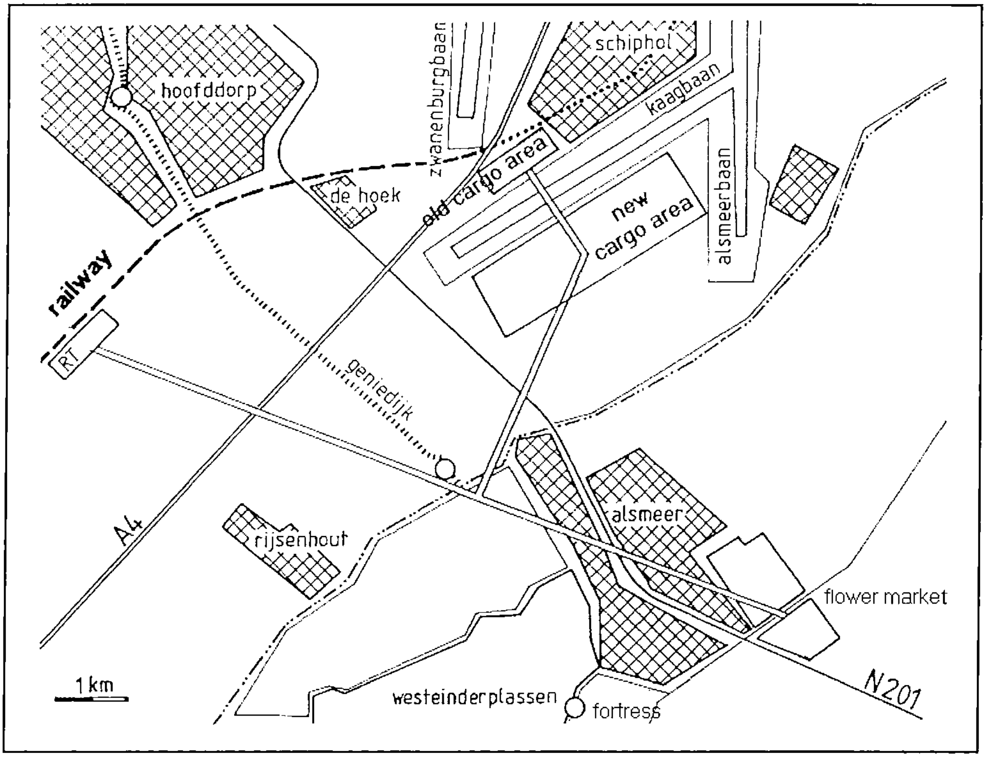
'The Underground' stands for an underground railway system in metropolitan centres, where the street system cannot possibly accommodate the traffic streams. In towns built on weak soil the system is built underneath existing roads if possible. This is the case for the greater part of the Amsterdam and Rotterdam metro systems.
Underground logistic systems are desired by cities that would like to combine a strong retail function in the city centre with a repressive policy towards motorised traffic and wanting to enlarge pedestrianised areas. Urban distribution centres are set up to ban at least heavy lorries from these areas.

Airports too have their collective 'people movers', because no private vehicles are allowed on the air side. London Gatwick and Paris Orly (the OrlyVAL) are two examples only. These can have both an internal (Gatwick) and an external function. The OrlyVAL connects two terminals with the Paris Metro. On airports underground solutions may become necessary when interdependent facilities are located on both sides of a runway. In 1997 a traffic tunnel was built across the most important runway of Schiphol to connect the old freight complex in the central area with a new one.

The Amsterdam Airport ULS is a special case. Here an underground freight transport system is proposed to connect different freight areas, a rail terminal and the Aalsmeer flower market. The idea developed gradually.

The Aalsmeer flower market, or rather auction, is the largest in the world with a multi billion ECU turnover per year. It is still growing fast, especially by exports to Russia. By the nature of its trade, with a 'vase-life' of 10 days, Aalsmeer is dependent on fast and reliable transport. A location less than 10 km from Schiphol is a favourable condition, but the airport is growing even faster. Therefore the road system is becoming more and more congested.
The flower market would love to have better road access to the airport but the government is reluctant to expand the road system for environmental reasons. Public transport to the airport is favoured, for instance rapid bus lanes and a high speed train link are being prepared. Road expansion would

undermine the chances for success of this policy. Therefore the idea of an underground transport system between Aalsmeer and Schiphol was forwarded.
Of course the airport suffers from the same problem. Its expansion is the subject of continuous dispute and it could gain support for the construction of a fifth runway only by developing a large programme for control of environmental impacts, including that of its access routes. Therefore the concept of the 'railway airport' was introduced. The location for a freight terminal could be found only outside the airport proper however, and access to it would be problematic. So the final idea was a system serving both flower market and rail terminal, offering additional congestion-free access for the flower market as well.
The underground dimension of the idea is attractive environmentally and financially. Underground building of infrastructure is promoted in the Netherlands by an extensive study programme and development subsidies for new technology. The first Dutch tunnel bored in soft soil, the 'second Heinenoordtunnel', will be finished in 1998. Several others, both for rail and road, are planned.



Map 1 Study area with configuration 'base line flower market - rail terminal'

THE DEFINITION STUDY

A foundation with the airport and the flower auction as constituents was created to promote and develop the concept.
After an exploratory study by a logistic consultant, Van de Geijn Partners, the concept had taken sufficient shape to try to define the essential characteristics of the system.
During Autumn 1996 a half million ECU definition study was undertaken by this consultant and a number of prestigious institutes: the Netherlands Economic Institute NEI and the TU Delft research

school TRAIL as main contractors and the Dutch Organisation of Applied Technology and the engineering consultant firm Lievense as sub-contractors. The latter sub-contractor had developed a concept of 'Unit Transport per Pipeline' (UTP).

The definition-study for the ULS was of a comprehensive nature : the logistics, the characteristics of demand and the method of tunnelling as well as the spatial lay-out of the system were yet to be determined.
The study was divided in three chapters each with a project group to coach the research.
As a representative of TRAIL the author was responsible for one of the three topics in the study, the general layout of the system: structure and alignment.
The project group for alignment counted representatives of the airport (chair), the flower market, Dutch Rail (NS Cargo), the municipality of Haarlemmermeer (airport location) and Van de Geijn and Lievense.

The study was done in a very short time, four months, predominantly to have it ready in time for acquiring further and larger government subsidies to operationalise the concept, which in fact succeeded. The transport-economic, technological and alignment study had to be executed at the same time, with a continuous exchange of developing insights. It implied that the alignment study had to start without even the most essential information: the exact locations to be connected, the volume and the measures of transport units (cross section!) and the characteristics of the transport system to be accommodated. Therefore it was impossible to work in the traditional trial-and-error fashion as applied to the high speed link from Schiphol to the Belgian border: drawing lines on the basis of a known curve radius, trying to avoid known valued objects and technical difficulties, discussing and adapting these endlessly with regional and local governments.

It implied that we had to apply and partly develop methods to gradually narrow the choices available on the basis of additional information from the other working parties.

THE ALIGNMENT STUDY STEP BY STEP

The alignment study was structured in a series of steps, which are presented here. The most important ones are treated separately in following sections.
For the later steps information from the other studies was necessary and available. The independent start of the alignment study made sure that this information was made available in time.

a. Circumscribing the study area. The area within which to find the alignment was defined by drawing lines from the outer corner of each complex to be served to the other ones. Four of these were given at the start: the flower market, the rail terminal, the old freight area on the airport and the new, developing area. Around these lines ellipses for the alternative detour factors of 1.5 and 1.25 were drawn.
The outer border resulting from the factor of 1.25 was chosen for two reasons:

- the relative ease of underground alignment
- a number of opportunities for alignment manifest after a first fieldtrip and inspection of detailed maps.

b. Designing basic configurations, alternative networks to serve the four complexes, in order not to overlook possibilities, regarding changeable optimisations. A preliminary selection of two configurations served as a reference for following activities.

c. Defining areas to be avoided because of existing values, a 'sieve analysis'. These values are essentially of two kinds:

- economic values
- protected objects or at least locally favoured ones, likely to cause dispute.

The result of this analysis is (should be) a few zones 'of least resistance'.

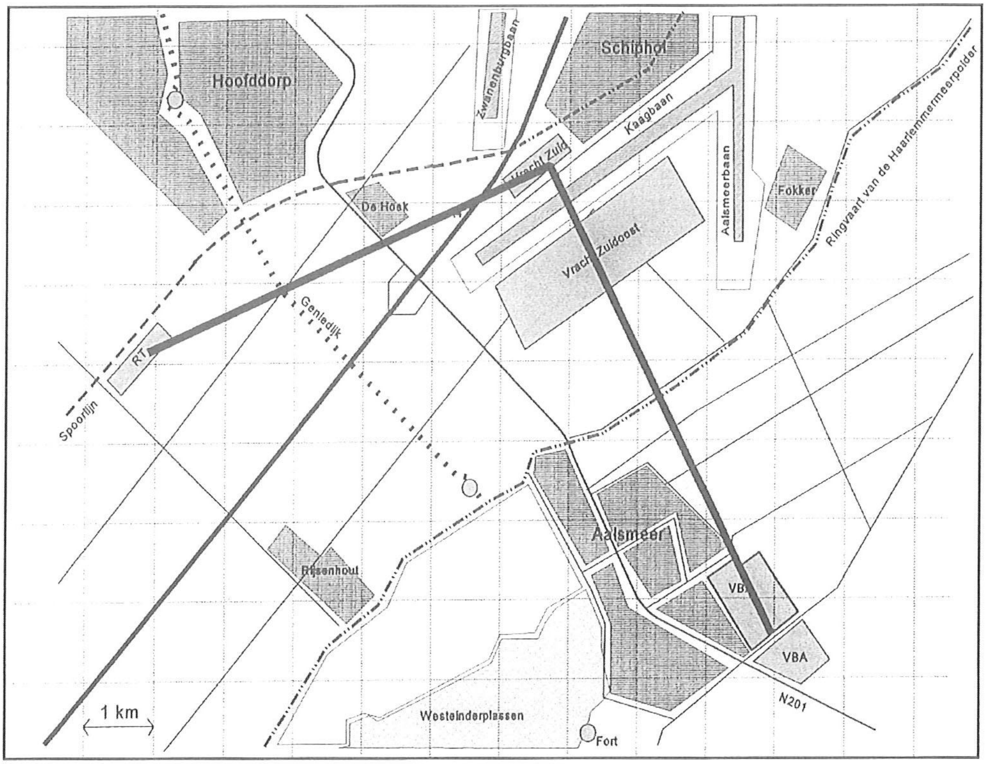
d. Defining attractive areas within in the remaining zones: a potential surface analysis, resulting in corridors for the individual connections.
In this phase the essential characteristics of construction alternatives must be known.

e. Designing alignments with a precision of 25 m within the corridors. Knowledge of terminal locations and geometric features of the transport system are necessary for this step.

f. Assessment of alignments and configurations. This cannot be done without general insight into the relative importance of different transport relationships, construction and environmental cost.

WHAT TO CONNECT AND HOW TO DO IT: DESIGNING BASIC CONFIGURATIONS

At the start there was no indication of the relative importance of different connections. The idea for the ULS was conceived first as a connection between airport and flower market, but how important were in fact the potential flows of both with the rail terminal?



Map 2 Basic configuration 'one continuous line'

The following principles for connecting the four complexes were devised:

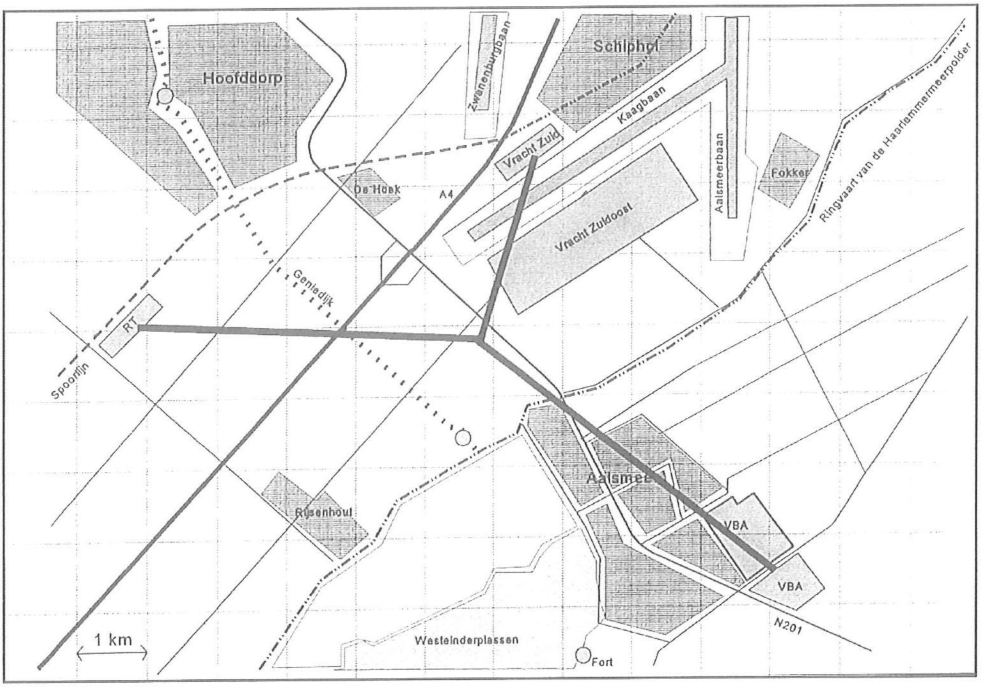
- *one continuous line*, especially one form the rail terminal via the airport to the flower market, implying a large detour between the first and last terminals,
- *an asterism*, conceived either as base with a branch line or as three lines springing from one centre, either one of the complexes or a centre of gravity.
- *a full loop*, offering direct connections between the three institutions at least but implying the greatest length of infrastructure or (in the case of a one way flow) of transport in one direction.

To the first configurations *smaller loops might be added.*

During the study one additional function of the system was suggested: transport between the cargo areas of the airport, because of threatening congestion on internal roads. It made at least two more terminals and a loop on the airport necessary. For the flower market a second terminal in a new extension was thought to be essential.

Two configurations were *selected preliminary.*

- a base from the flower market to the old cargo area and a branch line to the rail terminal with a loop at the junction, roughly similar to the result of the Van de Geijn exploratory study.
- a crooked base line from the flower market to the rail terminal via the south-western corner of the airport territory with a short branch line to the airport loop.



Map 3 Basic configuration 'asterism'

WHERE NOT TO BUILD: A SIEVE ANALYSIS

For most of the study area a sieve analysis was applied. The dominant reason to go underground is the presence of economic values above, and of infrastructure to be crossed over only at high cost (a high bridge in a tall ships route) or not at all (a runway).
An underground location solves the second problem, but not the first one. Even when boring or pressing pipes, damage may be caused to structures above, because of the soft soil.

The criteria used were:

- complex landownership, i.e. lengthy procedures necessary to get 'underpath'
- the presence of overhead constructions, with or without a pile foundation. The latter constitute a bigger problem.
- the presence of underground infrastructure, problematic in a parallel situation, and especially underneath the ULS.

The way from the flower market on old land to the Haarlemmermeerpolder, new land of the 19th century and less intensively used, proved to be the most problematic part of the alternative configurations. A disused railway body, an attractive option with most likely little different owners, was used for different pipes already. Yet on the Aalsmeer side four options were left: through a lake, along a dike, underneath a secondary road (N201) or in the corridor of a future road.

POTENTIAL (SUB)SURFACE ANALYSIS

The next step is to find corridors within the given zones that are best fit for the infrastructure of the system.
Again a number of criteria were devised and applied to compare possibilities:

- the quality of the network: length, location as related to that of terminals,
- he necessity to go underground, a slightly ambiguous one: good for an underground system, bad for cost,
- the possibilities to construct underground structures:
  - the absence of infrastructure above that might be unsettled,
  - the absence of constructions in (stable) infrastructure above: especially bridges on piles constitute a problem,
  - the straightness of routes, essential for no dig construction,
  - the simplicity of underground junctions, important for construction cost,
- the possibility to apply different construction methods, dig- and no-dig,
- availability of locations for construction activities and routes for construction traffic,

Again the airport and its environment, including the route to the rail terminal proved to be unproblematic. For the flower market only two corridors were left. The 'Westeinder' lake caused problems with construction and access, apart from environmental difficulties. The N201 counted several bridges on piles.
It implied that for both configurations one corridor was left for the connection between the flower market and the airport.

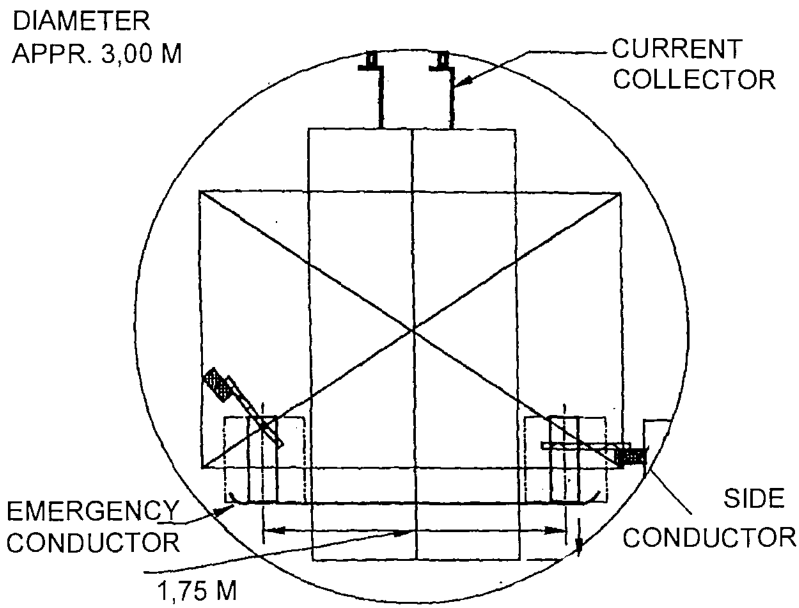
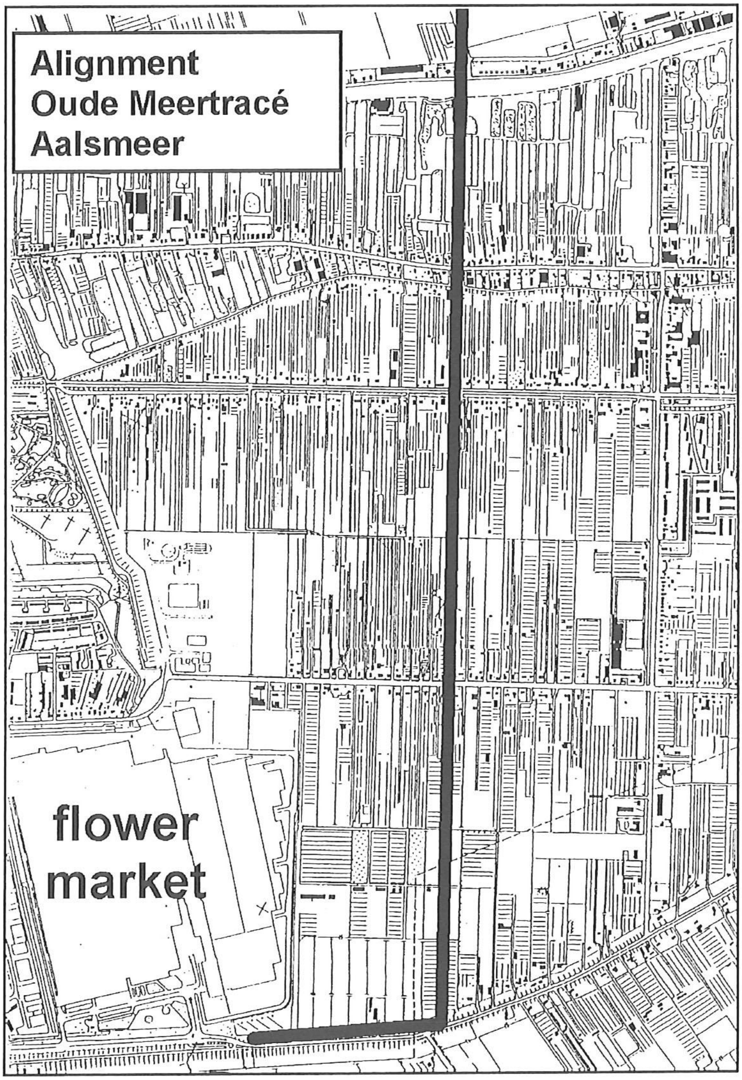


Figure 1 A 3m tube with an indication of vehicle/load sizes, side conducting facilities and current collector provisions

THE ALIGNMENT

After this step by step selection the alignment proved to be hardly any problem. No doubt the traditional strip lotting in the area of Aalsmeer and the rational rectangular development of the Haarlemmermeer contributed to the possibility to draw straight underground lines. This remarkable fact however suggests that solutions at the ground level would be feasible too. The terminals would have to surface anyhow to allow the guided electrical vehicles to enter and leave the system.
The junction for the branch line and the airport loop made some fairly sharp curves necessary. These would have to be built at great cost from the surface, because the junction should have the character of a highway interchange. A design speed of 20 km/h and the combination of terminals and curves where possible minimised this problem.
The alignment has been evaluated with traditional physical planning criteria and the elevation opportunities were assessed on the same basis. It showed that there were only a few stretches where tunnelling would be really necessary: a navigation the Alsmeer and Haarlemmermeer areas and the airside of Schiphol. Simple construction on the surface would be possible on a few stretches, because these were traversing agricultural areas for which there were no development plans. Most of the alternative configurations could put on elevated structures, because an airport environment cannot be called a vulnerable landscape.

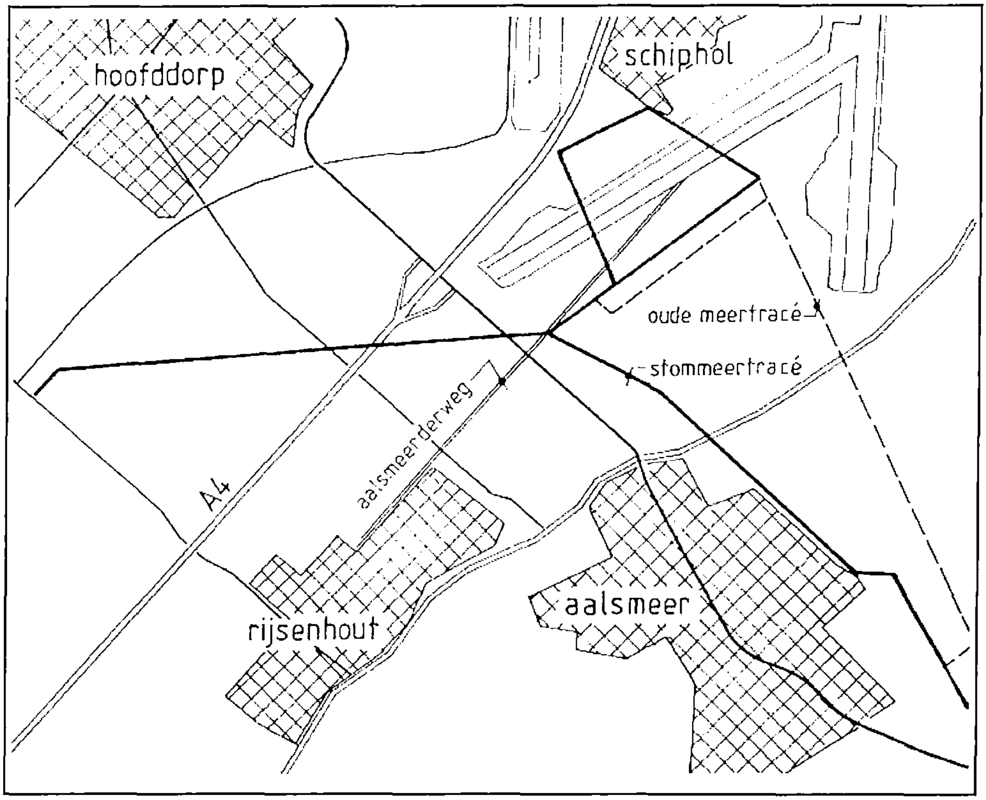


Map 4 Oude Meertracé and strip lotting in Aalsmeer

CHOOSING BETWEEN TWO CONFIGURATIONS

A choice between both configurations could be made only when there was an insight in the transport-economic qualities of the system.
The research calculations of the NEI showed that transport between the flower market and the airport had a considerably smaller volume than potential transport between the flower market and the rail terminal. The stream between airport and rail terminal was estimated to be the largest one.

The configuration with a base line from the flower market to the rail terminal, the 'Stommeer-tracé' was found to be convincingly more attractive from an economic point of view, because it requires less infrastructure. Therefore it was presented as the preferable alternative in the report of the definition study.
The comparison made in table 1 (next page) uses more criteria. For some of these the 'Oude Meertracé' is scoring better. These are predominantly adminstrative and governmental criteria. Procedures are easier in the case of the rejected alignment, because it lies in the more or less reserved zone of a new road the municipality of Aalsmeer and the flower market would love to be built. Governmental support is a related criterion. It is not unlikely that the local enthousiasm for the system is incited by the supposition that it will bring the new road nearer. It would affect the economic viability of the ULS.
In the table different diameters are compared too. There was no agreement on it in the study. The choice of a tube of 3.5 m would be a more profitable one, but this diameter does not allow for the transport of aircraft-pallets, which is of some importance in the relation between airport and flower market. Under pressure of the flower tradesmen the large diameter was chosen. From a logistic point of view this is rather disappointing because it in fact thwarts a policy of standardisation of both containers used and packaging procedures, which certainly is not optimal in air and flower transport.



Map 5 Alternative alignments for ULS

Table 1 Comparison Oude Meertracé and Stommeertracé

	Alignment 'Oude Meertracé'				Alignment 'Stommeertracé'			
	3.5 m tube		5 m tube		3.5 m tube		5 m tube	
	nd	d	nd	d	nd	d	nd	d
building cost	O	-	--	--	+	O	-	-
exploitation cost	O	O	-	-	++	++	+	+
sensitivity to disturbances	-	--	O	-	+	O	++	+
change of land use	3,5	0	++	++	++	-	+	--
procedures	++	0	++	+	-	--	-	--
governmental support	+	++	+	++	O	--	O	--
innovativity	++	--	+	--	0	--	++	--

nd = no dig method
d = dig method
-- = worst score
++ = best score

CONCLUSIONS

The question that remains is whether the alignment of an underground system requires other knowledge and activities than that of a surface system. First of all, the decision to go underground must be made objectively. The ULS Definition Study showed that this decision is in no way self-evident.

Going underground gives a greater freedom of alignment, because double use of space is possible. However, the underground space has been used to quite an extent and this use must be investigated. The land use above cannot be neglected. Not only is consent of landowners likely to be necessary, especially in soft soil there is great risk of impact of the underground system (or at least the constructing of it) on surface activities. Buildings on pile foundations must be avoided unless tunnels are being bored at great depth, which conflicts with surface terminals. It illustrates that elementary knowledge of tunnel construction techniques and their environmental impacts in the widest sense is necessary.

Having to design the alignment of a system that is hardly defined has the advantage of having to work in a fundamental way. It is useful for the normal practice of surface alignment, which often is hardly systematic.

Suspicion of underground motives is quite inspiring for designing alternatives.

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