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Scenarios for Examining Civil Aviation Infrastructure Options in the Netherlands

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PREFACE

This report summarizes the results of one of the subtasks of a policy analysis study that was performed by the European-American Center for Policy Analysis (EAC), which is a part of RAND. The study was performed for the Netherlands Ministry of Transport, Public Works and Water Management (V&W), Ministry of Housing, Spatial Planning and Environment (VROM), and Ministry of Economic Affairs (EZ), in support of the project called '*Toekomstige Nederlandse Luchtvaart Infrastructuur*' (TNLI) [Future of Dutch Civil Aviation Infrastructure]. The entire study had the following task description: *Assuming the Netherlands chooses to accommodate future air transport demands, assess infrastructure options for accommodating the demand, identify their positive and negative attributes, and draw conclusions about them.*

The subtask reported on in this document is the specification of the scenarios that were used in the remainder of the study as the possible future worlds in which the infrastructure options might have to function.

In addition to this document, the study has produced three written products:

- A Research Brief, which is a brief description of the primary findings of the project.
- A summary of the analysis of the infrastructure options [*A Policy Analysis of Civil Aviation Infrastructure Options in the Netherlands*, EAC DRU-1512-VW/VROM/EZ, January 1997].
- A framework for an adaptive policymaking process, which can be used to devise a policy for civil aviation that addresses the high levels of uncertainty confronting civil aviation policymakers [Adaptive Policies, Policy Analysis, and Civil Aviation Policymaking, EAC DRU-1514-VW/VROM/EZ, January 1997].

The information presented in this document should be of direct help to the TNLI project team in its preparation of a *Perspectieven Nota*, which is designed to help the Dutch Cabinet develop a view on an integral policy vision for the entire civil aviation system of the Netherlands. It should also be of interest to stakeholders who will be participating in the forthcoming public debate on the future of the Dutch civil aviation system. The scenarios themselves should be of use to policymakers who have

to develop a civil aviation policy for the Netherlands in the face of enormous uncertainties.

The EAC, an independently-chartered European unit of RAND, is located in Delft, the Netherlands. It operates as a foundation (Stichting), chartered in The Hague under Dutch law. The mission of the EAC is to conduct interdisciplinary analyses of public policy problems facing Europe and North America; to convey the results of these analyses to the policymaking community, the research community, and the public at large; and to foster cooperation among researchers in all parts of Europe and North America. The EAC seeks to accomplish its mission through research projects of interest to governments and society as a whole. EAC research is conducted alone, in conjunction with individuals and research organizations in the Netherlands and throughout Europe, and through close cooperation with other RAND sites.

For further information about the RAND/EAC project, please contact its project leader:

Dr. Warren E. Walker
European-American Center for Policy Analysis
c/o TU Delft
Landbergstraat 6
2628 CE Delft, The Netherlands
Tel: +31-15-2785411
E-mail: Warren_Walker@rand.org

For information about the TNLI project, contact its project leader:

mw. drs. Nelleke Don
Ministry of Transport, Public Works and Water Management
P.O. Box 20901
2500 EX Den Haag, The Netherlands
Tel: +31-70-3516960

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We are grateful to the Ministry of Transport, Public Works and Water Management (V&W), Housing, Spatial Planning and the Environment (VROM), Economic Affairs (EZ), and the Central Planning Bureau (CPB) for allowing us to make generous use of the time of several of their staff members.

We would also like to thank the CPB for providing us with facilities for meetings of the Analytic Support Group for a period of three weeks.

1. INTRODUCTION

1.1 BACKGROUND

The evaluation of alternative infrastructure options for the Dutch civil aviation system should take place in the context of the future world in which they will have to function. But, the future is uncertain. One way to deal with this uncertainty is to construct several scenarios and examine the way that the different options perform in each of them.

A scenario is a description of a hypothetical future state of the world, including a consideration of the major uncertainties encountered in moving far into the future. The scenario pays attention to developments within the system and to developments outside the system that affect the system, excluding the policy options to be examined.

Five scenarios were developed for the TNLI project. The scenarios have not been named. They are referred to as Scenario 1, Scenario 2, Scenario 3, Scenario 4, and Scenario 5. The scenarios focus on two things: (1) the world of civil aviation, and (2) changes -- both inside and outside the civil aviation system -- that are relevant for making policy decisions about investments in civil aviation related infrastructure in the Netherlands.

These scenarios were specifically developed to explore future developments that could be relevant for policy decisions about the Dutch civil aviation system. They are not predictions or forecasts about the future, nor do they represent the most likely future developments. They are not an inventory of all the changes affecting civil aviation that can occur in the future -- encompassing all possible changes in five scenarios is impossible. The scenarios do not tell us *what will happen* in the future, rather they tell us *what can happen*. In order to do this, they categorize the changes into five groups. The changes within a group are intended to have similar implications for policies concerning the capacity of civil aviation infrastructure in the Netherlands. Each individual scenario, although a single point by itself, represents a much larger family of changes that fall within the category represented by the scenario.

1.2 SCENARIO ELEMENTS

Each scenario consists of a set of plausible and possible developments, which are divided into two categories: elements that are predetermined and elements that are uncertain. What makes some elements predetermined and others uncertain is their likelihood of occurrence. The developments in the predetermined category are more likely compared to developments in the uncertain category. However, it is worth emphasizing that *there are no guarantees that the developments in the predetermined category will take place in the future.*

The developments included in the predetermined category are common to all five scenarios and provide the general context for the five scenarios. These predetermined elements describe developments in the civil aviation world, as well as developments in the world outside of civil aviation. The macroeconomic environment and the development of alternatives to air transport are examples of predetermined elements that are outside the civil aviation system as defined in this study. The capacity of European airspace is an example of a predetermined element that is part of the civil aviation world in this study.

All five scenarios have exactly the same assumptions about the predetermined elements. This holds, for example, for the pace of economic growth and the mobility that it generates. What makes them differ from each other are the assumptions they make about developments in the uncertain category. For example, there is a great deal of uncertainty about what the European airline industry will look like in the future -- the number of airlines, the type of airlines, and their route networks. There is uncertainty about whether there will be a few large airlines or many smaller airlines, whether these airlines will have linear route networks or hub-and-spoke networks. It is also uncertain whether long distance mobility will be satisfied by air or by train. These factors, although uncertain, have major implications for the choice of a civil aviation policy.

The picture of what the future will look like depends on the assumptions that are made about the uncertain elements. It is difficult to argue that any given set of assumptions is the correct one. Lacking the information that would allow a distinction to be

made about the "correctness" of different sets of assumptions, a different set of assumptions are made about the uncertain elements in each scenario.

The remainder of this document is divided into four sections. Section 2 describes the process that was used to develop the scenarios; Section 3 discusses the predetermined elements; Section 4 discusses the major structural uncertainties in the world of civil aviation; and Section 5 describes each of the five scenarios.

2. THE SCENARIO DEVELOPMENT PROCESS

The process that we used in developing the five scenarios is shown graphically in Fig. 1. One of the key features of this process was the involvement of many individuals with a wide range of technical expertise and perspectives. Members from different parts of the Ministry of Transport, Public Works and Water Management (V&W), Ministry of Housing, Spatial Planning and the Environment (VROM), Ministry of Economic Affairs (EZ), and Central Planning Bureau (CPB) were intimately involved in the development of these scenarios. In addition to the involvement of these individuals, we also interviewed several technical experts in a variety of topics related to the development of civil aviation. For example, we interviewed experts in airline and airport economics, logistics, and high speed trains, to name a few. A list of the individuals involved with and interviewed in the course of developing these scenarios is provided in Appendix A.

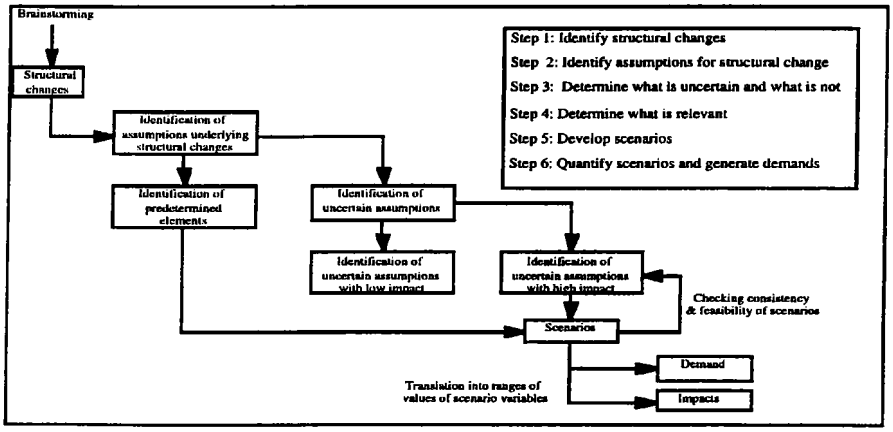

Figure 1-The scenario development process

Step 1: Identify structural changes

A structural change is a change in the structure of the civil aviation system. Changes within the subsystems making up the larger system, the relationships among the subsystems, or the relationship of the system to its environment can all be structural changes. For the purpose of developing scenarios, the civil aviation system was viewed as being made up of three smaller subsystems: the demand

subsystem (which produces the passengers and cargo to be transported), the supply subsystem (which provides the capacity for servicing the demand), and the operational environment in which the civil aviation system operates. The three subsystems are all equally important, and all three were included in the scenario development exercise.

Whether or not a particular change was labeled as a structural change depends on the magnitude of the change and its implications for the behavior of the system. To qualify as a structural change, the magnitude of this change has to be large and it has to have important implications for changing the way the system works.

There are many judgments involved in defining the system under consideration, the relationships among the subsystems, and the definition of what is "large." Thus, the determination of what constitutes a structural change is necessarily subjective.

Structural changes were identified by conducting a series of brainstorming sessions. This step produced a list of structural changes in the civil aviation system, which are presented in the Appendix B.

Step 2: Identify assumptions underlying the structural changes

The next step was to identify the assumptions underlying each of the structural changes. An assumption can be defined as an assertion about some characteristic about the structure or behavior of the system that underlies the structural change. For example, the use of hub-and-spoke networks by European airlines in the future is one important structural change. However, for European airlines to be able to successfully restructure their route networks as hub-and-spoke networks, several things are required. For example, airports that are to serve as hubs for airline operations have to have adequate peak hour capacity for accommodating the bank system of flight scheduling that characterizes hub-and-spoke operations. Thus, the availability of adequate airport capacity is an assumption that has to be made if a hub-and-spoke system is predicted for the future.

In the above example only one assumption was mentioned. However, the occurrence of each structural change is usually contingent on the validity of several assumptions. That these assumptions are valid is often uncertain. In this step we specified, for each of the

structural changes identified in Step 1, the assumptions on which the structural change is contingent.

Step 3: Categorize assumptions as predetermined or uncertain

The assumptions from Step 2 were placed into one of two categories, predetermined or uncertain (see Fig. 2). Assumptions about which we were fairly certain were placed into the predetermined category. The remaining assumptions were placed into the uncertain category. The assumptions in the predetermined category were included in all the scenarios. The uncertain assumptions were used to identify the most important and relevant structural uncertainties that have to be taken into account.

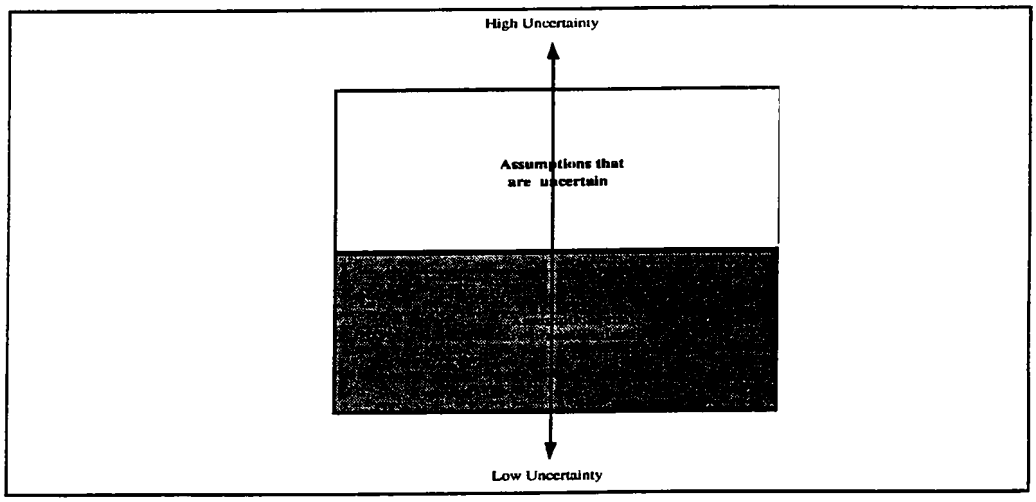

Figure 2-Identifying the assumptions that are predetermined

Step 4: Assess the impact of uncertain assumptions

We want to focus on the uncertain assumptions that are most important in determining future demand. To identify such assumptions, we considered the impact of each uncertain assumption on demand. Based on the estimated impact that each assumption has on demand, it was placed in either a high or low impact category (see Fig. 3). The uncertain assumptions in the low impact category were dropped from further consideration. The uncertain assumptions in the high impact category, along with the predetermined elements, formed the basis for the scenarios.

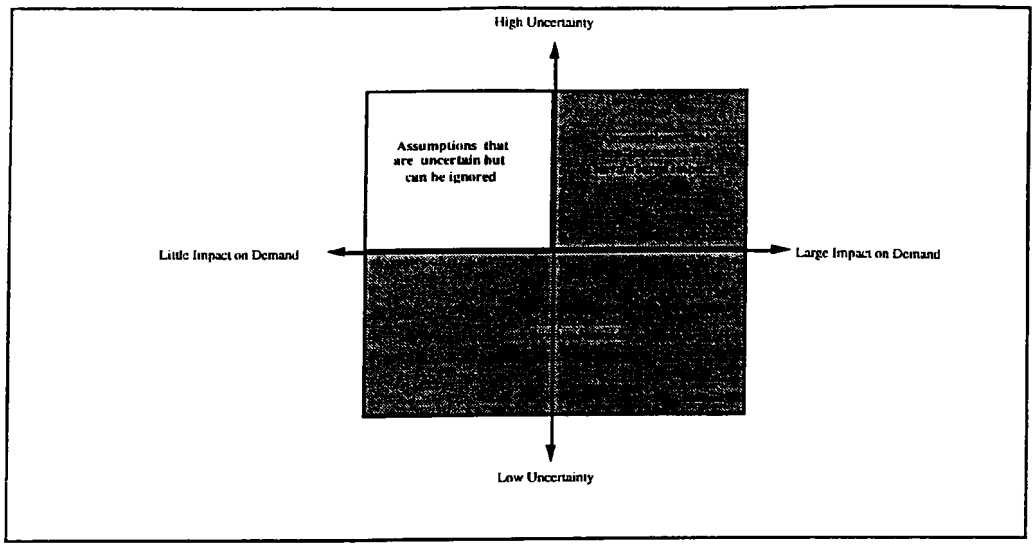

Figure 3-Identifying uncertain assumptions with a large impact on demand for air transport

Step 5: Develop scenarios

A scenario includes four things: (1) the assumptions that were placed into the predetermined category in Step 2 (all scenarios include the same predetermined elements); (2) the logic relating the assumptions to the structural changes; (3) the logic relating the structural changes to demand and impacts; and (4) a quantification of the scenario assumptions into numbers that can be used by the demand generation and impact models.

The number of possible scenarios, depending on the number of uncertain high-impact assumptions, can be large. Every combination of these assumptions cannot be considered. The number of combinations has to be reduced. To do this, we created four families of scenarios, placed each scenario in one of these four families, and selected one representative scenario from each family.

In terms of providing infrastructure to meet future needs, it is important to know the volume of passengers, cargo, and aircraft -- this is, the volume of demand. However, it is also important to know the type of aircraft, number of business versus tourist passengers, number of terminus versus transfer passengers, type of cargo, etc. -- these make up the nature and volume of demand. In the future, there can be big or small changes in nature and volume. The families of

scenarios differ in the changes that we expect in each of these two dimensions. Figure 4 shows the four families of scenarios.

Some mention needs to be made about the surprise-free scenario. The surprise-free scenario, as the name suggests, portrays a future world in which nothing unexpected happens. Large changes can be part of a surprise-free future world, as long as they are expected by the people who are going to use these scenarios. For example, most observers of civil aviation in Europe expect large changes in the volume, nature, and spatial distribution of demand for air transport in response to deregulation and liberalization of air travel in Europe. A surprise-free scenario would include these expected future developments in civil aviation in Europe.

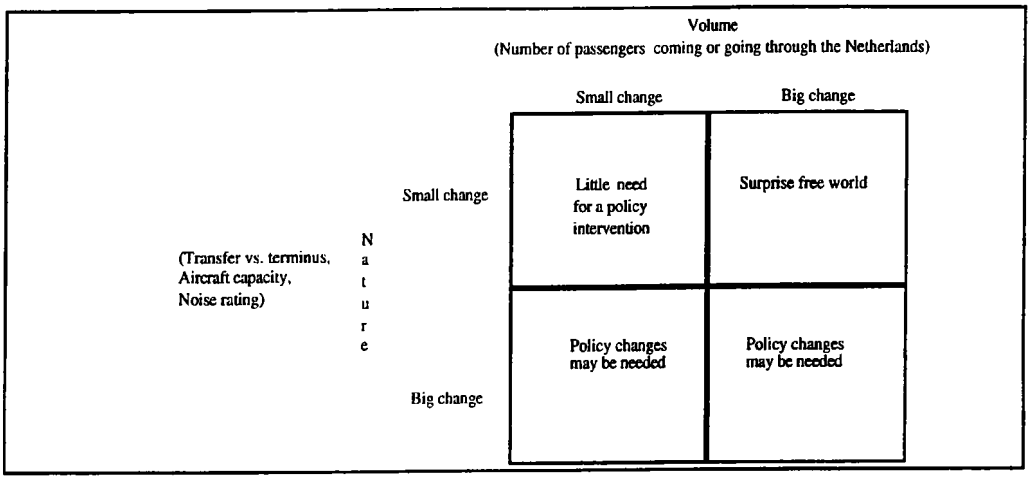

Figure 4-Families of scenarios

Step 6: Quantify the scenarios

The impacts of the assumptions determined in the previous steps were converted into inputs that were then used by the demand and impact models. This was necessary so that we could use these models to produce outputs that formed the basis for the subsequent assessment of infrastructure options.

3. PREDETERMINED ELEMENTS

Predetermined elements are assumptions about developments that could affect the civil aviation system -- ***assumptions whose likelihood of occurrence is high enough to treat them as certain or near certain***. These elements are included in all five scenarios.

Assumptions about future developments that are considered likely were grouped into the following nine categories of predetermined elements: (1) economic environment; (2) oil prices; (3) high speed trains; (4) telematics; (5) land use; (6) airports; (7) airspace; and (8) aircraft technology. We discuss each of these in the following subsections. Table 1 contains the complete list of predetermined elements.

3.1 ECONOMIC ENVIRONMENT

For the purposes of this study we divided the world into four regions: Europe, North America, the Far East, and Other. Europe includes the EU countries, countries of the former Soviet Union, and East European countries. North America includes the United States, Canada, and Mexico. The Far East includes China, Japan, Singapore, Taiwan, South Korea, Indonesia, Malaysia, Philippines, and Thailand. The category Other includes all remaining countries. Although the number of countries in the Other category is large, their economic significance is small. In 1991, the countries included in the Other category (excluding the CIS) contributed less than 20% of the world's GNP.[1] Further, not only do these countries contribute a small share of the global GNP, but the populations of countries in the Other category is very large. This means that the per capita GNP in these countries is small. From the point of view of air travel, low per capita GNP means that these countries are not very important. Thus, the focus of the scenarios in this study was on three regions: Europe, North America, and the Far East.

[1] Pavaux (1995).

Table 1

Pre-determined Scenario Elements
(Elements common to all five scenarios)

Economic Environment:
Stable global macroeconomic environment
Greater economic parity between countries in Europe, Far East, and North America
Economic growth in Europe is fueled by southern and east European countries.
Trade within and between regions will increase significantly.
Flexible labor markets

Oil Prices:
Oil price increases will not have a significant impact on the demand for air travel.

High Speed Trains (HST):
HST network linking Paris, Brussels, Cologne, Amsterdam, and London.
HST network in Italy and Spain
French and German HST networks are linked to each other.
HST speeds of up to 300 km/hour.

Telematics:
30% Reduction in the demand for business travel

Land Use:
Availability of land for building new airports or expanding existing airports will be limited.

Developments at Airports:
Microwave Landing Systems and Global Positioning Systems will be in use.
Night time flights will be restricted in one way or another at most West European airports.

Developments to Increase Airspace Capacity:
Unified European Air Traffic Management System will be in place.

Developments in Aircraft Technology:
Mega-jumbos will be in operation.
Technological developments will result in small incremental improvements to make aircraft engines quieter, cleaner, and more fuel efficient.
No breakthrough technological developments (for example, developments that will reduce aircraft noise by 50%) are expected.

3.1.1 Economic Growth

The global macroeconomic environment is assumed to be stable. There will be the usual economic cycles. However, there will not be any large scale structural macroeconomic instability in the European, North American, or Far Eastern economies. The rate of GNP growth for individual countries within the three regions will vary. No assumptions are being made about what the variation in economic

growth rates of countries within a region will be. What is being assumed is that the economies will grow, even if they do so slowly. The possibility of hyperinflation or a depression has explicitly been ruled out.

Of the three regions, economic growth in the Far Eastern economies will be higher than in the European and North American economies. Studies carried out by the OECD clearly show just how important the Far Eastern economies will be in the future. According to the OECD, the share of total world output of the Far Eastern region as a whole will rise from the current 25% to more than 50% in 2040. These Far Eastern economies will not, however, experience the extraordinarily high growth rates for the entire 30-40 year time period. As the economies of countries in the Far East mature, their economic growth will also slow down. The net effect of differential economic growth rates in the three regions will be greater economic parity among them. To illustrate what these developments could mean, consider the case of China. If thirty years from now the Chinese were to fly as much as North Americans do today, the Chinese alone would generate more air traffic than the entire world has today.[2]

In the European region, economic growth will be fueled by growth in the Southern (Spain, Greece, Portugal, Italy) and East European (Hungary, Poland, Czech Republic, Slovakia, the Baltic states, and Russia) economies. Thus, there will also be greater economic parity than there is currently within Europe.

3.1.2 Growth and Composition of International Trade

An important implication of economic parity within and between regions is that there will be a significant increase in both intra- and inter-regional trade. Additionally, the composition of this trade is also expected to change. The expectation is that trade between and within these regions will increasingly be made up of high-value items, not bulk items or raw materials. High-value items are items with a high average value per unit of weight. In 1994, the top five categories for items imported into the US by air were:

1. personal computers and equipment,
2. sound recording equipment,

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[2]Ibid.

3. footwear,
4. photocopying equipment, and
5. apparel.[3]

Also in 1994, the top five categories for items exported from the US by air were:

1. engines/motors,
2. personal computers,
3. measuring and technical instrumentation,
4. telecommunications equipment, and
5. tractor parts.[4]

In 1994, about 50% of total imports carried into the US by air had a value of over $16 per kilogram, and 47% of all exports from the US that were carried by air has a value of over $16 per kilogram.[5] This information suggests that high-value items are quite likely to be transported by air. This segment of international trade (over $16 value per kilogram) is expected to grow more rapidly than other segments, and for the past decade has grown twice as fast as air traffic. Thus, growth in the trade of high value items offers significant new possibilities for air transport.

Another aspect of international trade also needs to be pointed out. Because the value per unit weight is frequently used to identify potential markets for air cargo, it might be assumed that the market for air cargo is limited to high value items. This is not necessarily true. Although close to 50% of all US imports and exports carried by air in 1994 had an average value of $16 or more per kilogram, almost 20% of all US exports and important carried by air in the same year had a value of less than $4 per kilogram.[6] This suggests that the choice of mode for transport of cargo may be based not only on the average value per unit weight of an item, but on other factors as well -- factors such as the characteristics of the item itself and business practices such as just in time manufacturing.

A number of recent political developments, largely institutional and organizational, are expected to significantly boost trade by

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[3]Boeing Commercial Airplane Group (1995), p. 69.
[4]Ibid.
[5]Ibid.
[6]Ibid.

creating an environment conducive to trade. Among these developments are the creation of the World Trade Organization, multi-lateral agreements for the establishment of intellectual property rights in emerging markets, the General Agreement on Trade and Tariffs (GATT), lowering of trade barriers, and the removal of restrictions on the movement of goods.

Within Europe, the volume of intra-European trade will increase significantly. Already, the benefits of European integration in terms of increased trade are becoming visible. In the last decade, intra-EC trade has exceeded extra-EC trade by an increasing margin. Despite these increases, intra-EC trade still has considerable potential for growth. The level of trade among EU member states is very small compared to the level of trade among states in the USA. [7] Clearly, there is plenty of room for intra-European trade to expand significantly. How much air transport will benefit from intra EU trade is difficult to say. However, if the value of time increases and the growth in EU trade comes from trade in high value items, air transport will benefit from the growth in intra-EU trade.

3.1.3 Other Developments

The European labor market will become more flexible; labor laws will become less restrictive and constraining for employers. In Europe, labor will be more willing to move from one location to another and across borders. There will be a greater tendency for piecemeal and contract labor. As a result of such developments, it will be possible for airlines to use crews from countries with the lowest labor costs; airlines will also be able to move their maintenance operations to the countries offering the best combination of low costs and high service standards.

Greater mobility, willingness to travel, and prosperity will all combine to increase the number of people traveling by air. A shorter work week, and greater flexibility in determining when and how people take vacations will contribute to higher mobility in the population. Currently, the US population travels further and more often than the population of European or Far Eastern countries. In both Europe and the Far East, the number of people who travel by air and the number

[7] EC DG XIII (1993).

of trips these people make are significantly lower than in the US. While some of these differences can be attributed to the geographical differences among the three regions, it seems reasonable to assume that passenger air transport still has lots of room to grow in Europe and the Far East.

Finally, in Western Europe there will not be a significant increase in population. However, the population in Europe will have a higher proportion of elderly than it has today.

3.2 OIL PRICES

In the TNLI project we are interested not in the price of oil 30 years from today, but in the impact of higher oil prices on the demand for air transport. Higher oil prices will reduce the demand for transport by increasing the cost of transport. However, higher oil prices will not affect all transport modes to the same extent, or in the same way. For example, higher oil prices may reduce the demand for short distance (less than 600 miles) air travel while increasing the demand for train travel. The differential impacts of higher oil prices on the demand for different transport modes has to do with the relative characteristics of the transport modes, characteristics such as energy efficiency, speed, and convenience. Thus, it seems reasonable to begin to consider the impact of higher oil prices on air transport by considering the alternatives to air transport.

3.2.1 Substitution of Air Transport Due to Higher Oil Prices

What makes air transport different from other transport modes is its speed; nothing comes close to matching the speed of modern day jet aircraft. Having said this, let us consider the alternatives to air transport. For passenger transport over short distances (less than 600 miles), air transport faces competition from cars, buses, trains, and (possibly) ships; on longer distances, air transport has no real competitor. The greater the distance, the greater the time savings resulting from flying, and the greater the attractiveness of air transport. It seems reasonable to assume that, if there is to be substitution away from air travel, it will be mostly on short distance routes within Europe. However, even within Europe, it seems unrealistic to think that <u>all</u> intra-European routes will be affected equally. Some routes will have better developed alternatives to air

travel than other routes. Thus, even if oil prices rise significantly, it is difficult to imagine that all intra-European air travel will be substituted for by other transport modes. With regard to intercontinental air travel, there are no real substitutes and none are expected to be developed within the next 30-40 years. It seems difficult to imagine that large numbers of intercontinental passengers will travel by ship. Thus, it seems that regardless of the price of oil, intercontinental air travel is here to stay.

Passenger air travel will be affected by higher fares resulting from higher oil prices. The extent of substitution away from air travel is uncertain. In one of the scenarios (Scenario 4), we consider the possibility of dramatically reduced intra-European air travel. Although the reduction in air travel is postulated as coming about for reasons other than higher oil prices, the effect on the level of air travel is the same. For a policymaker contemplating infrastructure investments, it is not important why there is a significant decline in demand. It is more important to recognize the possibility of a significant decline in demand and an appreciation of what this decline would mean for the planned investments in civil aviation related infrastructure. If demand were to decline significantly, or not increase as much as expected, future investments in civil aviation infrastructure would not be necessary.

Now consider the case of air cargo. As was mentioned earlier, high value items are better candidates for transport by air than are low value items.[8] However, it was also pointed out that low value items are also increasingly being shipped by air. This trend, of shipping low value items by air, can be explained by three developments. First, over the years, the price of air transport has declined. Second, the importance of business practices such as just-in-time delivery and distributed manufacturing has grown. And third, the cost of maintaining inventories has increased.[9] These developments have reduced air transportation costs as a percentage of total costs to the point where items that were usually not shipped by air are now shipped by air. If oil prices increase, they will increase air transportation costs. All other things being the same,

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[6]Boeing Commercial Airplane Group (1995).
[9]Klapwijk (1996)

the share of air transport's costs of the total cost of an item will also increase. The extent to which higher oil prices increase the share of air transportation costs as a proportion of total costs increases will determine whether or not a particular item is shipped by air. It stands to reason that the increase in the share of transportation costs as a proportion of total costs will be smaller for high value items than for low value items. Another way of saying this is that the price elasticity of demand for low value air cargo is higher than the price elasticity of demand for high value cargo. Thus, if oil prices increase, it would seem reasonable to assume that the low value items will be the first to be transported by substitutes to air cargo.

Now consider the possibilities for substituting air cargo with a competing transport mode. Most intra-European cargo is already transported by trucks and trains; most bulk cargo on intercontinental routes is transported by ship. Air cargo consists mostly of freight with high value; items such as computer ships, and flowers, are typical examples of what is transported by air. Some of these items could be transported by ship; however, other items such as flowers could not. Thus, even for air cargo, the possibilities for substitution are limited.

The preceding discussion about oil prices is not intended to suggest that oil prices are unimportant for the aviation sector. Oil prices are important. Airlines care a great deal about the price of fuel. Currently, fuel costs are about 12-15% of total airline costs.[10] Depending on the price of oil, the share can change. For example, during the 1981 oil crisis, this share increased to almost 30%.[11] However, the issue here is not whether oil prices will change or not; it is certain that oil prices will change. The real issue is what effect higher oil prices will have on the demand for air transport. According to some estimates, if the price of oil were to increase by 50%, it would lead to only a 5-7% reduction in the demand for air travel depending on the elasticity used.[12]

Given the above discussion, it should be clear that higher oil prices are likely to have a limited impact on air transport.

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[10]Lesage (1995).
[11]Ibid.
[12]Ibid.

However, the implicit assumption in all this is that, although in the distant future (30-40 years from now) oil prices will be higher than what they are today, they will not be so much higher that they will hinder global economic growth. If oil prices rise to the point where they hinder global economic growth, it is safe to say that there will be large structural changes in the global economy while it adjusts to the higher oil prices. Next, we consider the possibility of oil prices increasing to the point where high oil prices hinder global economic growth.

3.2.2 The Possibility of Oil Price Increases Hindering Global Economic Growth

If the demand for oil is greater than the supply of oil, prices will rise. The future supply of oil is measured by the reserves to production ratio (the production ratio is calculated by dividing the level of proven reserves by current production levels). In 1990, the ratio of reserves to production was 40; this means that at current production levels there are adequate reserves for meeting the demand for oil for the next 40 years.[13] However, the demand for oil is expected to increase in the coming 40 years, so the proven oil reserves will probably be adequate for less than 40 years. If the demand for oil outstrips the supply of oil, oil prices will certainly start to rise. Depending on how much oil prices rise, the following four developments reducing the demand for oil can be expected:

1. Oil reserves that are currently too expensive to exploit will be exploited,
2. There will be investments in more fuel-efficient production technologies,
3. There will be substitution away from oil to non-oil-based energy sources, and
4. There will be investments in R&D to develop artificial substitutes for oil.

For oil prices to rise significantly, we must assume that none of these four developments will take place. Additionally, we must also assume that no new oil reserves will be discovered. The simultaneous occurrence of all five of these developments is unlikely

[13]World Energy Council (1993).

enough to rule out oil prices that are high enough to hinder the growth of the global economy.

For example, consider the market for natural rubber in the earlier half of this century. This example provides a good illustration of how market forces work to restrain the price of a commodity. With the advent of the motor car, natural rubber became a very valuable commodity. Although, a renewable resource, the supply of natural rubber was limited and this supply was too small to meet the demand for rubber for making car tires. The price of natural rubber did rise. However, as the price of natural rubber increased, the search for the development of a substitute also intensified and eventually led to the development of synthetic rubber. The market and the price for natural rubber collapsed as a result of this development, and today most of the demand for rubber is met by synthetic rubber. There is little reason to expect that the same could not happen with oil.

3.3 HIGH SPEED TRAINS

A high speed train (HST) is a train that runs at speeds of at least 300 km/hour on new tracks and 250 km/hour on upgraded tracks. The average speed of the HST is assumed to be 300 km/hour. Although higher speeds are possible, the energy requirements of running conventional HST make it unlikely that HST would operate at speeds much higher than 300 km/hour.[14] There are also significant maintenance problems associated with operating HST at speeds over 300 km/hour.[15] These two factors make it very unlikely that HST will operate at speeds much above 300 km/hour. Further increases in the speed of trains will have to come from new technology.

The magnetic levitation technology is one technology for increasing the speed of HST well above the 300 km/hour that is possible with conventional HST technology. However, the widespread adoption of completely new HST technology such as magnetic levitation (maglev) technology for trains has been ruled out. The reason for this is that maglev trains will require completely new infrastructure; they cannot make use of existing rail infrastructure. Also, conventional trains cannot use the infrastructure that is

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[14]ICAO (1995)
[15]Personal communication with Dr. Jacques Pavaux

needed for maglev trains. The investments that would be required to replace conventional infrastructure and rolling stock are so large as to rule out the widespread adoption of maglev technology in the near future.

3.3.1 European HST Network

An extensive European HST network is planned. The EC has plans for about 9000 km of new track and 15000 km of upgraded tracks sometime in the next few decades.[16] However, it should be emphasized that these plans are little more than a statement of desired goals. These plans omit any discussion of how this extensive HST network will be financed. The infrastructure needed for the operation of the HST is very expensive. Most plans about the HST network assume that somehow the finances for this comprehensive European HST network will be forthcoming. Thus, instead of assuming the existence of an extensive HST network in all five scenarios, the existence of a minimum HST network is assumed. In addition, an extensive HST network is assumed in Scenarios 4 and 5.

The following minimum network is assumed to exist in all scenarios; the internal network in France and Germany, and HST links between Paris, Brussels, Cologne, Amsterdam, and London (PBKAL). It is also assumed that the French and German HST systems are linked. In addition, there are HST links in Italy and Spain. The Italian and Spanish networks will probably be extended in the coming years and they may also link up with the French HST network. However, from the perspective of the TNLI project, the Italian and Spanish HST networks and their links with the French HST network are not nearly as important as the PBKAL HST network.

3.3.2 HST and Air Transport

Another important assumption about HST is the level of integration of HST with air transport. In terms of the integration of the two modes, it is assumed that the HST stations in European cities will be at the airports serving these cities and that the HST service to the airports will be fully integrated into the larger HST network. Other developments such as integrated ticketing for journeys involving both air and HST travel, coordination of schedules, and

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[16] ICAO (1995).

reservations are also assumed. Thus, the penalty, in terms of time and inconvenience, for multi-modal travel will be significantly less than what it is now. The only thing that is not assumed to be predetermined is integrated baggage handling for HST and air. Integrated baggage handling for the two modes would mean that passengers could arrive at a HST station, check their baggage at the station, and retrieve their baggage on reaching their final destination. Currently, this is not possible. The factors affecting this are considered next.

According to representatives of the Dutch HST company, the Hogsnelheidstrein Vervoers Exploitatie Maatschappij NV (VEM), the development of baggage handling facilities allowing a seamless transfer of baggage from planes to the HST will be very expensive. Such an investment could not be justified for the number of passengers VEM expects to transfer from aircraft to HST by 2003. The number of passengers transferring from air to HST at the airport would have to increase significantly before investments in integrated baggage handling can be justified on economic grounds. The VEM expects to carry 6.6 million passengers on the Amsterdam, Brussels, Paris, London route in 2003.[17] Of this 6.6 million, VEM expects that roughly 30%, or about 2 million, will be passengers who would have traveled by air.[18] Of these, about 600,000 are expected to be transfer passengers (passengers transferring from air to HST at the airport); the remaining 1,400,000 are origin/destination passengers.[19] For purposes of integrated baggage handling, it is the transfer passengers that matter. What this suggests is that, before baggage handling can become fully integrated, more than 600,000 transfer passengers are needed. What this also says is that, for integrated baggage handling, the feeder role of HST would have to increase significantly.

The HST is not going to be a significant competitor to air cargo in most segments of the air cargo market. The most straightforward reason for this is that most intra-European air cargo is already carried on trucks. Additionally, the HST technology is not well suited for carrying heavy cargo. The track requirements for a heavy

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[17]VEM Report.
[18]Ibid.
[19]Ibid.

HST make it very expensive. In Germany, the HST tracks have been built so that cargo can be carried on the ICE line linking the northern and southern parts of Germany. However, the cost of building and maintaining this track have turned out to be so high that the Germans have abandoned the concept of carrying cargo on their HST lines. The only segment of the cargo market in which competition between the HST and air is realistic is the intra-European express cargo market. Although it is not clear what proportion of the express cargo is really carried by air, it should be pointed out that intra-European express cargo market is not where air cargo growth is expected in the coming years. The highest growth rates for air cargo are expected on routes between Europe and the Far East, and on these routes the HST cannot compete with air.

The importance of HST in this study comes from HST being able to compete with air transport in ways and over distances that conventional trains and cars cannot. To illustrate the impact of the HST on air transport we first provide a framework for evaluating the effect of HST on air transport, some examples of the impacts of HST on air transport, and some estimates about the likely effects of HST on passenger air travel.

The two most important effects of HST are the substitution effect and the feeder effect. The size of the substitution effect of the HST depends on how well HST is able to compete with air travel. The size of the feeder effect depends on the level of integration of the air and HST networks. These two effects are described in some detail below.

3.3.2.1 *Substitution effect of HST*

HST is a genuinely new transport mode that can effectively compete with continental air traffic. However, competition is not possible on all continental routes. For one, the cities in question have to be connected by a HST link. We have already mentioned that HST infrastructure is expensive. Thus, the HST network cannot, in the next 30-40 years, be a very extensive network covering a very large proportion of European cities. Additionally, we can also rule out routes that require new tunnels for crossing mountains or bodies of water. Building new tunnels for the HST would make it even more expensive. Finally, given its speed, it will be difficult for the

HST to compete with airplanes over long distance routes (on routes longer than 600 nautical miles or 1000 km).[20] Thus, while there is agreement that the HST will be most competitive with air travel over short distances, there is less agreement on what exactly this means and the extent of substitution that is possible.

A survey carried out by VEM suggests that total trip time (time it takes to complete a journey) is one of the most important determinants in choosing a mode of transport; service frequency and quality play a smaller role. According to this VEM survey, the HST will provide a good alternative to air and car transport on medium-range distances, that is roughly between 200 and 600 km.

A report produced by the Institute of Air Transport (ITA, 1991) reaches roughly the same conclusion; the HST has a clear advantage over the airplane on short routes (< 350 km) while the airplane retains its advantage on the longer routes (> 1000 km). The longer the route the greater the advantage the airplane has over the HST. Between 350 km and 1000 km, HST and the airplane are competitors.

In the range of 350-1000 km, the choice between these two modes is determined by total trip time and the prices of the two modes. Assuming that passengers trade off the time-savings from flying for the lower costs of the HST, the ITA report concludes that the modal split is in favor of HST between 350 km and 600 km and in favor of the airplane between 600 km and 1000 km. Thus, both the VEM and ITA reports agree that HST can have a large substitution effect on distances up to 600 km. A report produced by the International Civil Aviation Organization (ICAO, 1995) states that, depending on the speed of the HST and market size, significant substitution possibilities exist for distances up to 1000 kilometers. Varlet (1992) states that HST will be able to compete effectively with air travel up to distances of 900 km.[21] Thus, an upper limit of 1000 km on routes over which HST can compete with air travel seems to be reasonable. Some examples of HST operation and their impact on air travel are provided next.

A HST link was established between Paris and Lyon in 1981, which reduced total trip time on the Paris-Lyon route from four hours to

[20]ITA (1991), ICAO (1995).
[21]Varlet (1992).

two hours. The introduction of this link led to a 50% decrease in air traffic between 1980 and 1985. Taking into account the natural market growth, the total substitution effect was estimated at about 70%.[22]

After observing the success of the French HST, several European countries introduced a HST service. In Sweden, a HST service was started between Stockholm and Gothenburg in 1990. In 1990, the Stockholm-Gothenburg route was the densest air service route within Sweden; each year more than one million passengers were transported by air on this route. When the Stockholm-Gothenburg HST link was started, there were only two daily HST departures in each direction, total trip time was slightly less than with conventional trains, and delays were common. Over time, the Swedish State Railways upgraded the HST track, increased the number of services, and improved the punctuality. Given these improvements, it would be reasonable to expect significant substitution to the HST on the Stockholm-Gothenburg route. However, the substitution away from air to HST was on the order of 3%.[23] This small substitution effect has been attributed to a number of factors, namely:

1. the conventional trains were already quite good and the HST provided only slightly higher speeds;
2. the HST was still slow compared to air; and
3. the HST fares were not low enough to attract passengers away from air travel.[24]

Of these three factors, the last factor is particularly important in considering the future impact of HST on air travel. It is important to understand that the substitution effect depends not only the HST fares, but also on the air fares. It seems unreasonable to assume that airlines will not reduce air fares when faced with competition from the HST. To the contrary, there is evidence to suggest that airlines will reduce air fares when faced with competition from other transport modes.

What these two examples show is that HST can be successful on routes between 200 and 600 kilometers, but that the success of the HST is not guaranteed. These examples also show that distance is not

[22]Ibid.
[23]ICAO (1995).
[24]Ibid.

the only factor determining the size of the substitution away from air travel to HST. Finally, and contrary to results of the survey conducted by VEM, reliable and high frequency services are important for the success of HST in its competition with air travel. It should be clear by now that there are several factors that have to be considered in evaluating the size of the substitution effect of HST. The ITA report gives a framework for evaluating the substitution potential of HST.

Both the ITA and VEM reports state that price and time (including costs and time it takes to get to and from the airport or train station) are important factors for choosing between air and HST. However, as the above examples make clear, the modal split between HST and airplanes depends not only on price and travel time. It is also a function of the schedules, service frequency, reasons for travel, and availability of substitutes on individual routes.

Two modes are competitors when they are substitutes for each other, or when they can satisfy the same needs. On distances between 350 - 1000 km, the traffic is divided between the HST and the airplane based on relative travel times and prices. The time savings of the airplane are offset by the lower costs of the HST. To make the tradeoff between air and HST traffic, it is necessary to know the value of time to passengers. One way to estimate the value of time to a passenger is to determine the point at which a passenger is indifferent to the choice between air and HST. This value can be calculated as follows:

$$v_o = \frac{p_{airplane} - p_{train}}{t_{train} - t_{airplane}}$$

where,

v_o = value of time for which the passenger is indifferent between air and HST travel,
p = price of the ticket,
t = travel time.[25]

If the value of time for a passenger is higher than v_o, the passenger will choose the airplane over the HST, and vice versa. The Varlet report calculated the above value for 72 city pairs to examine the possibilities for substitution to HST from air.

[25]Varlet (1992).

Based on the above calculation, the Varlet report identified eight routes on which the HST is most likely to have a large negative impact on air travel. On these eight routes, a passenger will only choose to take the airplane if he or she is willing to pay at least 180 ECU (for business traffic) or 66 ECU (for traffic for personal reasons) per hour of time saved (in comparison with the rail journey). Apparently, this sum of money is sufficiently large to conclude that the HST will have a large substitution effect on these routes.

Table 2

Routes with High Substitution Possibilities to HST (Varlet Report)

Route	Distance (km)
Amsterdam - Brussels	158
Barcelona - Toulouse	263
Brussels - Paris	270
Lyon - Milan	310
Barcelona - Marseilles	350
Paris - Stuttgart	489
Barcelona - Lyon	543
Brussels - Lyon	575

The calculations and the resulting selection of the eight routes in Table 2 is valid for routes on which the HST and air travel compete for origin destination passengers, and on routes where the HST is running on completely new tracks for the full length of the journey. This comparison was based on air fares prevailing at the end of the 1980s and estimated future fares for HST. Finally, this ITA analysis is based on a comparison of only the prices and travel times for HST and air travel.

The ICAO report considers an additional factor, market size, in considering the possibilities for substitution between HST and air. The ICAO report uses two criteria for selecting city pairs on which competition is possible. First, the cities have to be less than 600 km (as the crow flies) apart and the route should have at least 25000 seats per week. Using these two criteria, the ICAO report selected

ten city pairs as having possibly large substitution effects (see Table 3).

Table 3

Routes with High Substitution Possibilities to HST (ICAO Report)

Route	Distance (km)	Weekly Market Size
London - Paris	214	85192
Madrid - Barcelona	300	65198
Rome - Milan	291	54336
Amsterdam - London	229	49031
Paris - Nice	418	46298
London - Edinburgh	331	40428
London - Frankfurt	405	39330
London - Glasgow	344	38504
Frankfurt - Berlin	268	37593
London - Brussels	217	35512

The list of city pairs in Table 2 is very different from the list in Table 3. The most striking difference is that the ITA study did not select any routes that included London. This may be simply because the ITA report's results are based on existing HST routes and London does not have a HST connection as yet.

However, there are also some interesting similarities between the results of the two reports. First, the distances between the city pairs are all well below 600 km. Second, both reports stress the desirability of the Amsterdam - Brussels - Paris HST link. In addition, the VEM plans also stress the importance of the Amsterdam - Brussels - Paris route. The VEM report says, "The HST's position on the Amsterdam - Paris route will be very strong, in terms of both travel time and price, compared to the competition from air and road." On the Amsterdam - Brussels - Paris route, door-to-door travel times via HST will be almost as short as by air. However, despite the parity in travel time and lower HST fares, HST is expected to attract only two-thirds of the airline passengers on the Amsterdam - Paris route. This can only mean that there will always be some passengers who place a high enough value on their time to

choose the airplane over the HST. What this suggests is that HST will have a smaller than expected substitution effect if air fares decline. In the future, air fares are expected to decline significantly. For example, recently a new airline operating from Schiphol offered a round trip air fare to London for NLG 198.[26] Thus, it is clear that the airlines will not easily give up their share of passengers to HST.

What the preceding discussion should make clear is that the size of the substitution effect is a function of factors in addition to the distance between city pairs. What should also be clear is that the success of HST as a substitute for air travel is not a given. Given the infrastructure costs for HST, the HST will not always be a cost-effective alternative to air transport. Thus, it seems reasonable to conclude that on a few dense routes HST will take away a significant share of the traffic from airlines. However, on a Europe wide basis, the substitution effect of HST on air travel will be small.

3.3.2.2 *Complementarity of air and rail traffic: the feeder effect*

HST and air travel can also be complementary modes of transport, i.e., their successive utilization is either necessary or preferred to the utilization of a single transport mode for the entire journey between two cities. The HST has an advantage over the airplane on short routes with dense traffic; the airplane has the advantage on long routes. The complementarity of these two modes will be greatest when the use of HST and air is combined on successive segments, a short segment and a long segment. The logic of HST/air complementarity is such that it makes sense to use the HST to feed traffic from second-tier cities to the airports. In the past, however, there have been few attempts to use trains to feed traffic to airports. Use of trains as a feeder has been seriously attempted only in Germany and Switzerland. Although both these countries used conventional trains, they provide some useful insights into the potential HST/air complementarities.

In Germany, Lufthansa operates an "Airport Express" train between Düsseldorf, Köln, Frankfurt and Stuttgart. This train serves

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[26]Financial Times (2 August 1996).

the airports at Frankfurt and Düsseldorf. This train has Lufthansa cabin crew, offers integrated baggage handling, and the quality of service in this train is comparable to service in Lufthansa airplanes. More than 200,000 passengers a year use this train. The Frankfurt - Mannheim - Stuttgart route which is currently in preparation is expected to attract another 100,000 passengers. The train's share of total traffic between Frankfurt, Düsseldorf, and Köln has increased from 24% in 1982 to 33% in 1989.

In Switzerland the "Rail & Fly service" resembles the German "Airport Express". The only difference is that the Swiss train service is operated by the railway company instead of by an airline and in Switzerland the baggage check service is offered at many more stations than in Germany. The German and Swiss experience tells us that the following would promote the complementarity between air and HST:

1. *Excellent interconnection between the rail and air networks*: An interconnection is the linking of at least two different modes of transport in a way that will allow passengers to transfer from one mode to another quickly and easy. Interconnections are necessary because air and railway (conventional and high speed) networks are complementary transport systems. An airport is a natural location for making this connection since it is usually already well connected to the motorway system.

2. *Baggage can be checked in from the origin to the final destination*: To make a transfer from train to airplane more comfortable for the passengers, a service to check baggage at the departure train station through to their final destination would make a journey combing air and HST segments less inconvenient and more attractive.

3. *Commercial cooperation between the railway companies and the airlines:* Cooperation between railway companies is necessary to make combined air/rail travel more comfortable for passengers. Cooperation is also needed in the areas of schedule integration, ticketing, and linked reservation systems. There are also other areas in which the railway companies and the airlines can mutually benefit from

cooperating with each other -- for example, in the areas of yield management and joint promotion.

The ITA report studied the possibility of HST/air complementarity using the Paris airport. This report looked at three types of services: nonstop air service between two points, an air/air service with a transfer in Paris, and a HST/air service with also with connections in Paris. These three types of service were studied for four routes, Nantes - Paris - Rome, Nantes - Paris - Milan, Rennes - Paris - Rome, and Rennes - Paris - Milan. Each of these four routes combines a short segment between a secondary city (Nantes or Rennes) and a connection hub (Paris) and a longer segment between this hub and another hub (Rome or Milan[27]) in Italy. For each route and each service type, the ITA report calculated travel times from city center to city center, frequency of departures, total price and total cost of the journey, energy consumption, and frequency of delays.

In the case of Nantes - Milan, nonstop air service was slightly more than twice as expensive as the air/air service, and three times as expensive as the rail/air service. This was true for the other three routes as well. If conventional rail service is replace by HST service on the short segment, the total cost of HST/air service is, depending on the case, 10 to 25% lower than the total cost of air/air service. However, the HST/air service results in much lower energy consumption. This suggests that HST/air service is competitive with air/air service based on price, as well as energy consumption. If we base the comparison on travel time alone, the air/air service wins. Air/air service is slightly faster (15 to 55 minutes), while nonstop air service is 2 to 3 hours faster than the HST/airplane service. However, using the HST as a feeder can free up aircraft gates at airports, an important consideration at crowded European airports. The complementarity between air and HST, if properly exploited, can have several advantages. These are:

1. *A better balance of price and time.* The ITA report concludes: "The markets for which the two modes are

[27]The catchment area of Rome is Perugia, Napoli, Foggia, and Bari. The catchment area of Milan is Genova, Verona, Padova, and Venezia.

complementary are markets consisting of one or two segments on which the train is at least as fast but not as expensive as the airplane and another, longer segment on which the airplane is faster than the HST. By using both modes to make a journey, a passenger benefits from their complementarity by achieving an optimal balance of price and time." The examples in the ITA report show that, on routes between a medium-sized city located less than two hours from a major airline hub and a large city, a solution combining the train and airplane is much less costly than nonstop air service.

2. *Combined train/airplane service is economical in terms of energy consumption.* The major advantage of HST over the airplane is its low energy consumption. Even on long distances with the latest technology, on a per seat basis, aircraft use at least twice as much energy as trains running at 300 km/hr. Over shorter distances, in comparison with less-efficient aircraft, HST uses one-fourth to one-fifth as much energy per passenger.

3. *Combined train/airplane service frees time slots at airports.* In principle, the nonstop air routes between second tier cities with HST connections and airports with major airline hubs can be replaced by HST links.

4. *High speed trains could even be used to gain market advantages for airlines in long haul flights.* Substitution of short haul operations with small aircraft and high frequencies by HST will increase the long haul share of airline traffic.

Using HST as a feeder is a viable alternative to feeder flights. In general, if a good HST link exists between two cities that are not too far apart, there is little need for flights between the two cities. However, linking cities via HST links is constrained by the lack of demand on most European routes. A HST link is profitable and economically justifiable only on the dense intra-European routes. The number of such routes is quite limited. Certain conditions, like low prices, rapid transport, and high frequency of departures will have to be met in order for HST to have a significant impact on air

travel. As has already been said, price, time and service frequency of HST are important factors affecting the impact of HST on air travel. However, quality of service, availability of clear information, and possibilities for direct links and connections should not be ignored.

Finally, there are a number of additional developments that can influence the modal split between HST and air. These developments include:

1. *Government policies regarding passenger transport.* For example, governments could exempt HST tickets from Value Added Tax (VAT) (at the moment, train tickets carry VAT while air tickets do not). Another policy option would be to tax aviation fuel.
2. *Change in consumer preferences and attitudes.* Increasing environmental consciousness could lead to changes in government policy and changes in consumer mode choice. People may choose to take trains rather than airplanes despite the trains taking more time and not being much cheaper than airplanes.
3. *Increasing congestion in skies over Europe.* Although airplanes are faster than trains, crowded skies can still lead to total trip times being the same for airplanes and trains on shorter routes.
4. *Liberalization of air travel in Europe.* The deregulation of air travel within Europe gives airlines much greater flexibility in setting fares, selecting routes, and in determining service frequency on a route. As a result, the price of air travel within Europe is expected to drop significantly. Surface transport modes could find it difficult to compete with fast, frequent, and inexpensive air travel.

Based on the preceding discussion, it is clear that the HST will not be able to compete with air travel on all intra-European routes. The HST will be most competitive with air travel on short distance routes (less than 1000 kilometers). In addition, this competition will mostly be for passengers traveling directly between two cities

having both direct air service and HST links. The estimated size of the substitution effect is expected to be in the range of 10-25%. There are no estimates, that we know of, for the size of the feeder effect.

What this discussion tells us is that the effects of HST on intra-European air travel are quite uncertain. This then begs the question of why we view the impact of HST as a predetermined element and not as an uncertainty to be included in the scenarios. The reasoning behind this is simple. The minimum HST network we have assumed already exists. In the future, HST will become more, not less, competitive with air travel. Thus, by assuming the maximum possible substitution effect of HST on routes that affect the Netherlands we can avoid being overly optimistic about the number of passengers who will choose the airplane over the HST. For the purposes of the TNLI study, it is better, in our view, to overestimate the impact of HST on air travel.

3.4 TELEMATICS

Telematics refers to a wide spectrum of technologies that can be used for communication purposes. The possibilities for communication include exchange of data and information, video conferencing, etc. There is a great deal of debate about the potential effect of these technologies on the demand for travel in general and air travel in particular. The central question seems to be whether telematics will substitute for air travel, and the magnitude of this substitution effect. In addition, telematics is expected to generate new demand for air travel. The answers to these questions vary. Boeing, the US airplane manufacturer, regularly produces forecasts of what future demand will be. According to Boeing, telematics will have a substitution effect on the order of 3-5% in the year 2015.[28] The largest estimate that we could find for the substitution of air travel (for both business and leisure) by telematics was 25%.[29] In these scenarios we are assuming that telematics will lead to a 30%

[28]Boeing Commercial Airplane Group (1995).

[29]Apogee Research, in a study for the U.S. Transportation Research Board, concluded that telematics could substitute for between 2-10% of business air travel. Arthur D. Little, in a study for Airports Council International (ACI), concluded that videoconferencing could substitute for about 15% of business air travel (See STRATEGEM (1995) and ITA (1991)).

reduction in demand for business travel (as an upper bound on the possible effect of telematics in the next 30-40 years).

We assume that this substitution effect (of telematics) is limited to business travelers. It also seems reasonable to assume that the substitution effect will be larger for intra-company travel than for inter-company travel. It seems reasonable to assume that people in different locations, but in the same company, are better able to communicate with each other using these new technologies, compared to people in different companies. It also stands to reason that leisure passengers are unlikely to replace their trips to a holiday destination with a cyber vacation. We are assuming that telematics will not have any effect on leisure travel.

Next, there is the issue of how much additional travel telematics will generate. For these scenarios, we assume that the generation effect from telematics will be negligible.

Estimating the size of the direct substitution and generation effects of telematics on air travel has been the focus of much attention. However, telematics can have another potentially important effect that has not been discussed as much. Telematics includes technologies that can be used for traffic management systems, traffic information systems, and smart highways. These systems can help to reduce congestion and bottlenecks on the roads. As a result, car travel could become more reliable in terms of the time it takes to travel between two points, and it could take less time.

Total trip time is often used for comparing the competitiveness of air travel with other modes on a given route. The time actually spent traveling is obviously much less for air travel than for any surface transport mode. However, the time it takes to get to and from an airport is often as much as the time actually spent flying. Among other things, passengers compare the total trip time for each mode. Currently, one of the problems associated with air travel is actually getting to and from the airport. Not only does it take a long time to get to the airport, but the actual amount of time that this takes is highly unpredictable. The introduction of advanced technologies to reduce road congestion will reduce the time it takes to get to the airport. Thus, it can help to improve the competitive position of air transport with respect to other surface transport modes. In these scenarios we assume that telematics will not remove the problem of

congestion on roads, but that it will keep the problem from getting worse.

3.5 LAND USE

One of the factors currently restricting the growth of civil aviation in Europe is the availability of airport capacity at European airports. Most major European airports (for example: Heathrow, Gatwick, Frankfurt, Schiphol, and Copenhagen) are operating at or near the limit of their capacity and the need for new European airports is well recognized.[30] However, the expansion of existing airports, or the construction of new airports requires large tracts of land. Looking at a map of Europe, it seems that there is plenty of land available for expanding or building airports. However, this is misleading.

The land used by an airport includes not only the land that is used for the runways, buildings, and other airport related infrastructure. The land used by an airport also includes the land that cannot be used for other purposes because of the noise generated by the airport, or because it is needed for infrastructure linking the airport to surface transport.[31] For these reasons, the amount of land needed for airports is much larger than what is covered by the physical infrastructure of the airport itself.

Historically, airports have been located close to larger population and/or economic centers. While proximity to urban/economic centers provides quick access to the airport, it can limit opportunities for expansion. Consider the example of National airport in Washington D.C. The trip from the city to National airport is a short one because the airport is located more or less within the city. However, National airport has limited runway capacity and cannot expand because there is no more land available. In order to grow, National airport can only make more efficient and intensive use of its existing resources. In order to accommodate future demand for

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[30]This capacity is not necessarily the capacity at which an airport can potentially operate; rather it is the capacity at which an airport is allowed to operate (ECAC, 1992).

[31]For example, in the Netherlands, the *vrijwaringszone* (the protected zone around Schiphol Airport in which no new houses may be built because of aircraft noise and safety considerations) has an area almost ten times the size of the area physically occupied by the airport itself.

air travel to and from Washington DC, a new airport was built outside the city limits. This new airport, Dulles International Airport, was underutilized for a very long time after it was completed. This, despite the best efforts of the aviation authorities to get airlines to use Dulles instead of National. Given that the facilities at Dulles are better than the facilities at National, from the airline's perspective it would be better to use Dulles, however, but from the air traveler's perspective, National airport has a better location than Dulles.[32]

What the above discussion suggests is that it is not realistic to suggest that airports be located in remote areas, far away from the major population/economic centers. The question then becomes, how far is far? The time it takes to reach the airport from a city center is more relevant for answering this question rather than the physical distance of an airport from the city center. In principle, an airport could be built in a remote unpopulated area as long as it was well connected to the population centers falling within its catchment area. However, the issue here is cost, the further an airport is from the population centers, the more it will add to the cost of the infrastructure that is needed to link the airport to the population/economic centers it serves. A related issue is how much time people are willing to spend to reach the airport.[33] None of these questions can be answered with any degree of certainty. However, conventional wisdom says that most people are unwilling to travel for longer than two hours to get to an airport. Thus, an airport cannot be located too far away from the population centers it serves or plans to serve.[34]

Given the large area needed for an airport and the need for an airport to be located not too far from the population/economic

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[32]One could argue that, if Dulles Airport were connected to the Metro system, many more people would use it.

[33]Narita airport in Tokyo is an example of an airport built very far away (almost 400 km) from the city center. However, Narita is linked to Tokyo by a bullet train that takes slightly over an hour to complete the trip from Narita to the city center.

[34]In this regard, it is interesting to note the impact of the high speed train on the catchment area of an airport. The HST linking Amsterdam and Paris, when fully operational, will reduce travel time to just under three hours. This means that it will be faster to reach Schiphol from Paris than from points that are within the Netherlands and that are much closer to Schiphol in terms of spatial distance.

centers it serves, the availability of land for expanding or building airports is greatly reduced. Thus, it is reasonable to assume that the availability of land for expanding or building airports will be limited.

3.6 AVAILABILITY OF LAND IN THE NETHERLANDS

The Netherlands is one of the most densely populated countries in the world with a population density of about 434 inhabitants per square kilometer. Current expectations are that the Dutch population will continue to grow at least until the year 2000, further increasing the pressure to use land more efficiently[35]. There are four primary functions for land: 1) housing, 2) industrial, 3) agricultural, and 4) nature. These four functions often come into conflict with each other. For example, expanding the amount of land used for housing reduces the amount of land available for the other functions. This conflict is also evident in the case of Schiphol. Expanding the level of operations at Schiphol would mean more noise, emissions, and road congestion for the people living in the vicinity of Schiphol.

In the future, the demand for land for housing and industry is expected to increase. The land area set aside in the form of nature or wilderness reserves is already quite small in the Netherlands. It is very difficult to see any encroachment of areas that are presently being used as nature or wilderness areas. Finally, the land under agriculture will probably not increase or decrease by much[36]. A stagnant European market for agricultural and dairy products along with the EU's agricultural and environmental policies rules out an expansion of the area devoted to arable and dairy farming.[37] However, glass house horticulture is booming in the Netherlands and this will generate demand for more land[38]. Thus, the overall demand for land is expected to grow and grow quite significantly in the coming years.

3.7 DEVELOPMENTS AT AIRPORTS

We assume that European airports will be using Microwave Landing Systems (MLS) or the Global Positioning System (GPS) for guiding

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[35]Sanders (1989)

[36]Stuurgroep Groene Hart (1992)

[37]Central Planning Bureau of the Netherlands (1992).

[38]Spaans (1992)

aircraft coming in to land. The advantage of these systems is that they permit approaching aircraft to engage in complex maneuvers as they come in to land and take off. By engaging in these maneuvers, the aircraft are better able to avoid having to overfly densely populated areas. In addition, these systems allow reduced aircraft separations on final approaches without compromising safety. Thus, new landing systems will reduce the noise annoyance from aircraft and reduced aircraft separations will increase airport capacity.

New operational standards that increase the capacity of an airport will also be used at all European airports. For example, reduction of radar separation on final approach, reduction of diagonal separation on final approach, reduced runway separation on same runway, simultaneous operations on intersecting/converging runways etc., will become standard at European airports. In addition, new technologies that are needed to support some of these procedures will be in place. For example, the Converging Runway Display Aid System (CRDAS) is needed for simultaneous operations on intersecting or converging runways.

The European, US, and Far East Asian aircraft fleets will have all-weather operational capability. Aircraft and ground communications will be handled using satellite-based communication systems, which, for all practical purposes, have unlimited capacity. Thus, there will be no limitations on the level of communications between aircraft and ground control.

Passenger and freight handling times at European airports will be reduced considerably. A lot of the paperwork currently required for passengers and cargo will be eliminated; many tasks will be automated.

Most West European airports will have a night curfew in effect during the hours between 2300 and 0600 hours. Some West European airports will use market mechanisms (for example, significantly higher landing fees and airport use charges during the night hours) to reduce night flights. Aircraft emissions around airports will be monitored and controlled in much the same way that noise has been. Noise and emissions from aircraft will be on the order of 15-20% lower than before; however, there will not be any dramatic reductions in aircraft noise and emissions leading to significant jumps. There

will be stringent noise regulations, with strict monitoring of aircraft noise and approaches for landing and take-off.

Finally, land use zoning will be in place around airports. Land around airports will not be used for residential purposes. It will be used mostly for industrial and business purposes.

3.8 DEVELOPMENTS TO INCREASE AIRSPACE CAPACITY[39]

The Air Traffic Management (ATM) systems that are in use today were not designed to handle the volume of air traffic that is being handled today. As a result, ATM systems all over the world are stretched to the limit. This is undesirable from several points of view. First, and perhaps most important, it can result in air travel becoming less safe. And second, it results in the inefficient use of increasingly crowded airspace.

If air traffic grows as forecast, it is quite clear that current Air Traffic Control (ATC) systems cannot handle this traffic without compromising safety or causing severe flight delays. Thus, the need for change is becoming ever more urgent. As a result of this urgency, several efforts are currently underway to address these problems. Several of the major efforts currently underway to increase the capacity of ATC system are described below (most of these efforts, it is expected, will be completed in the course of the next decade).

There are two types of airspace capacity, enroute airspace capacity and the airspace over an airport (also referred to as the Terminal Management Area (TMA)). Both are discussed in this section. Currently, everyone agrees, there is serious congestion in the skies over Europe. One of the primary reasons for this congestion is that Europe does not have a unified air traffic control system designed to serve the entire region. Instead, there are a patchwork of over two dozen air traffic control systems operating out of over forty ATC centers. This patchwork quilt of ATC centers reflects political rather than operational considerations. In the scenarios, we assume that the current system of ATC will be rationalized along operational considerations in the future. Since airspace is an essential

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[39]This section is based on the following documents: Federal Aviation Administration (1995), EUROCONTROL (1995a), EUROCONTROL (1995b), EUROCONTROL (1993), German Airspace Users Association.

requirement for air traffic, this assumption is discussed in more detail.

The following reasons have been given for the current air traffic control crisis in Europe:

1. European airspace is highly fragmented. Each country, however small, has its own separate ATC authority.

2. There is a lack of common standards among the European ATC centers.

3. Different minimum separation standards are used in different countries, which results in bottlenecks.

4. Large amounts of airspace are reserved for exclusively military use; commercial air traffic must fly around this restricted airspace.

5. There is an inflexible sectorization of airspace.

6. There is a lack of adequate airport capacity.

In the scenarios, we are assuming that most of these problems will be solved in the next 10-15 years. Most of the technology that is needed for solving these problems is already here.[40] Technology for reducing radar separations, and air traffic controller workloads, etc., already exists. However, there are two constraining factors that could prevent the ATC problem from being solved. First, there are several institutional problems, European countries have to agree to hand over control of their airspace to a common European authority, they have to agree on common standards and procedures for ATM. Second, a unified European air traffic control system will require significant funds, the availability of which is by no means guaranteed.

On April 24, 1990, the transport ministers representing the member states of the European Civil Aviation Conference (ECAC) adopted a plan that outlined a four-phase strategy for increasing the capacity of airspace in ECAC member states. This plan is called the

[40]The United States Federal Aviation Administration (FAA) has already begun introducing a free flight regime to replace the current system of air traffic corridors. The free flight regime greatly increases the airspace capacity without compromising safety. In addition, there are significant economic benefits to airlines from being able to choose the shortest routes between two points. Thus, there are no technological constraints and there exist significant economic incentives to adopt such a system in Europe.

European Air Traffic Control Harmonization and Integration Program (EATCHIP). Phase 1 and Phase 2 of this strategy call for the harmonization and integration of ATC systems and procedures in ECAC member states. The later phases call for the development of a completely new ATC system, which is called the European Air Traffic Management System (EATMS). EATMS has been designed to accommodate double the current level of traffic in the air space of ECAC member states without compromising safety and, according to the plan, should be operational in ECAC member states by 2003.

Despite these two potential constraints, we believe that Europe's ATC problems will be solved. First, the creation of institutions for managing a unified European ATC system has already begun. A European agency, EUROCONTROL, has been set up for this purpose. Regarding the financing of a European ATC system, we assume that the needed finances will become available. We make this assumption based on the estimates of the opportunity costs of ATM congestion for airlines, airports, and passengers. Some sources estimate the annual cost to airlines of ATC-related delays to be almost $5 billion at present. Given that air travel in Europe is expected to grow significantly in the future, the opportunity costs associated with not solving the ATM problem in the skies over Europe will only become larger.

The problems of air traffic control can be traced to one of three sources: (1) obsolete equipment; (2) controller overload; and (3) lack of adequate standards. For example, the resolution of new radar is much higher than that of older radar. The latest generation of radar can provide much more precise aircraft position information than what used to be possible. However, the radar technology in use varies widely by country and region. This means that sectors using old radar technology have less capacity than sectors using advanced radar technology. This results in bottlenecks and uneven flow of traffic throughout the regional airspace. The work load of controllers is another factor limiting the use of airspace. The current sectorization of airspace was carried out when the level of air traffic was much less than what it is today and aircraft flew much slower than modern jet aircraft. As a result, controller workload has increased and reaction times available to controllers for resolving potential conflicts has decreased. In order to maintain

safety standards, air traffic controllers have been forced to increase aircraft separations, resulting in the inefficient use of air space. Finally, there is the problem that equipment, technical standards, and traffic control procedures vary widely by country and region. Differences in all these things means that coordination between ATC centers in different countries or regions is that much harder.

3.8.1 En-Route ATM

A collection of technologies are being developed to support ATC personnel in aircraft conflict detection and resolution of problems along its flight path in coordination with air traffic flow management control. These technologies, once operational, will help reduce controller workload and thereby increase airspace capacity.

Currently, oceanic ATC is mostly manual and is based on little information. Aircraft transmit their position over the ocean on an hourly basis using High Frequency (HF) transmissions. Because aircraft position information is not always current and subject to interference there is a lot of uncertainty about the exact position of aircraft flying on oceanic routes at any given moment in time. As a result, the spacing between aircraft on these routes is quite large. These large separations restrict airspace capacity and require aircraft to fly on non-optimal routes. The Oceanic automation program offers the potential to dramatically improve this situation. Navigation equipment on board the aircraft is relayed to the Automatic Dependent Surveillance (ADS) system via a satellite data link to ATC facilities. The position of the aircraft is displayed to the ATC in almost real time without any interference.

3.8.2 Communications and Satellite Navigation

Technological developments in Communications, Navigation and Surveillance (CNS) systems provides the potential for improving ATM system performance, safety, capacity and efficiency. Currently, most links between aircraft and ATC control at airports and en-route use voice communication. Several data link applications have been developed for communications between aircraft and ATC. These applications allow data to be provided without voice communication. Data that are currently provided via voice communication,

meteorological data, en-route information, terminal and tower ATC communications, and other aeronautical services can be provided via these data links. A particularly important application is the Aeronautical Telecommunication Network (ATN). The ATN supports the use of many different data links such as satellite, Mode S, and VHF.

Currently efforts are also underway to augment the signals of the US Global Positioning System (GPS) to enable use of GPS for civil aviation navigation requirements. A variety of procedures are being developed to allow use of GPS for oceanic and overland en-route, terminal non-precision approaches, precision approaches, and airport surface navigation. Satellite signals provide three dimensional positioning information which will allow aircraft to fly more direct routes and not be confined to air traffic corridors, thereby increasing the capacity of airspace. GPS will also increase capacity by reducing minimum separations between aircraft and can also provide precise positioning information for aircraft without the need for surveillance.

3.8.3 Developments in Terminal Management Area (TMA) Air Traffic Control (ATC)

The terminal areas of major airports are very complex and dense environments for ATC. Arrivals approach from as many as eight different directions with jet traffic descending from high altitudes and other traffic entering the terminal area from lower altitudes. The variety of different approach paths and the different altitudes at which the traffic enters the terminal area makes it difficult for air traffic controllers to foresee how one approach path will interact with another approach path. This usually leads to a bunching of traffic and increasing the workload for controllers, increased fuel burn due to the need to maintain separations. Speed and space restrictions in the terminal area add to the difficulty of maintaining and orderly flow of traffic to the runways. Visibility, wind shifts, variations in aircraft mix, wake vortex problems, missed approaches, runways changes or closings, all add to the difficulty of controlling traffic efficiently and safely in the terminal airspace.

A number of different technologies provide the potential for significantly increasing the capacity of terminal airspace without compromising safety. These technologies include:

1. automation of ATC in the terminal airspace around an airport
2. precision runway monitor
3. precision approach and landing systems
4. collision avoidance systems
5. wake vortex detection and measurement systems
6. terminal area surface surveillance systems

3.8.3.1 *Automation of ATC in the terminal airspace around an airport*

The purpose of automating terminal ATC is to assist air traffic controllers in improving the terminal area ATM process. There are two developments that are particularly important for increasing terminal air space capacity are: the Converging Runway Display Aid (CRDA)/Controller Automated Spacing Aid (CASA) and the Center Terminal Radar Approach Control.

The CRDA is designed to display the actual location of an airport while simultaneously displaying the aircraft's image at another location on the air traffic controllers radar scope. This system assists the controller in assessing the relative position of aircraft approaching on different but converging approaches. CRDA increases airport capacity by allowing simultaneous use of multiple runways under IFR rules. Tests using CRDA on dependent precision converging approaches in near Category I minimums have yielded capacity increases up to 33%.

The CASA system is designed to support the synchronization of aircraft in different traffic streams. The benefits from CASA range from allowing a more effective merging of aircraft in the terminal area prior to the approach phase to taking fuller advantage of available runway geometry using asymmetrical staggered approaches.

Center-TRACON (Terminal Radar Approach Control) Automation System is a collection of systems that are designed to improve overall system performance while maintaining a certain level of safety by helping controllers smooth and coordinate traffic flows more smoothly and efficiently. The three system making up Center TRACON are: Traffic Management Advisor (TMA), Final Approach Spacing Tool (FAST), a Descent Advisor (DA), and the Expedited Departure Path (EDP). The TMA determines the optimum spacing and schedule for arriving traffic. FAST helps controllers merge arriving traffic into an efficient flow to the final approach and also helps controllers

merge missed approaches and pop up traffic into the final approach stream. DA assists controllers in meeting TMA arrival times while maintaining separations. Finally, EDP will help controllers weave departing aircraft into the existing low of en route traffic.

3.8.3.2 *Precision runway monitor*

Capacity can be significantly increased at airports with closely spaced parallel runways if the allowable runway spacing for conducting independent parallel instrument approaches can be reduced. The current allowable runway spacing for conducting such operations uses standards based on the surveillance update rate, the accuracy of airport surveillance radar, and the capabilities of the terminal area radar systems. If the surveillance rate and the accuracy of the radar could be improved, the allowable runway spacing for conducting independent parallel instrument approaches could be reduced.

The Precision Runway Monitor (PRM) has an improved antenna system that provides a higher azimuth and range accuracy, and higher update rates than current terminal radar systems. The E-scan radar used by the PRM is capable of updating an aircraft's position every half second. This update rate is orders of magnitude higher than what is possible using current terminal radar systems. Additionally, the PRM system also has a monitoring system that monitors parallel approaches on a high resolution display system and automatically alerts controllers when an aircraft appears to be entering the no-transgression zone between the runways.

3.8.3.3 *Precision approach and landing systems*

One of the problems associated with an instrument landing system (ILS) is the long straight-in-flight path that is necessary. This sometimes can become a problem in congested air space when two or more airports are located close to each other because flight paths crisscross in ways that preclude separation by altitude. In these configurations the airports become interdependent. The curved approach capability provided by MLS and GPS will provide a solution to this problem.

The use of satellite based navigation systems can provide greater flexibility in use of terminal area air space by shortening flight paths, segregating aircraft by type, reducing arrival and

departure gaps, and avoiding noise sensitive areas. Additionally, GPS will also permit precision approaches to runways where ILS could not be used because of ILS localize frequency-band congestion or interference with FM radio broadcasts.

GPS will also help in reducing aircraft separations and in relieving surface congestion that results from restrictions due to ILS critical area sensitivity to reflecting surfaces, such as taxiing and departing aircraft.

3.8.3.4 *Traffic alert and collision avoidance system applications*

Traffic Collision Avoidance System is an airborne system that operates independently of ground-based ATC radar to surveil nearby transponder-equipped aircraft and provide relative position and altitude information to the pilot.

Although the primary role of TCAS is collision avoidance, the capabilities inherent in its design offer the potential to improve the overall efficiency and safety of the system.

3.8.3.5 *Wake vortex detection and measurement systems*

Wake vortex problems require certain minimum separations between aircraft. Current ICAO separation standards are based on pragmatic experience rather than on research. Data from several wake vortex detection and measurement systems deployed at several airports will be used to revise separations under specific conditions. Revised wake vortex procedures can increase airport capacity by 12-15% in instrument meteorological conditions, thereby enhancing airspace capacity and decreasing delays.

3.8.3.6 *Terminal area surface surveillance systems*

Airport surface operations are often the cause of flight delays. Taxiway interference, separation at intersections, and departure sequencing are some of the causes of surface-related flight delays. These delays arise because of the problems associated with controlling and coordinating the movement of aircraft and a variety of other vehicles on the surface. Controllers often rely on visual contact to guide the surface operations at an airport. Thus, in addition to inadequate capacity, surface-related flight delays are further exacerbated by low visibility conditions. The ICAO panel on

all weather surface operations is developing the operational requirements that will be needed to support advanced concepts and automation for supporting airport surface movement. The ICAO effort is expected to result in system performance requirements for automation, communication, navigation, and surveillance.

There are five elements that are currently being worked on to improve the safety and efficiency of airport surface movements: a runway status light system, a surveillance data link, oral and visual warnings, data tags, and a traffic planner. The technologies making up these elements are being combined by the United States Federal Aviation Administration, in close cooperation with the ICAO panel on all weather surface operations, into a single program called the Airport Surface Traffic Automation Program (ASTA). The ASTA is developing an enhanced surface safety system using the Airport Surface Detection Equipment primary ground sensor radar, Automated Radar Terminal System (ARTS), Global Positioning System (GPS), Airport Movement Area Safety System (AMASS), and other technologies.

ASTA will provide controllers with automatically generated warnings and cautions as well as attach data tags to all aircraft and airport vehicles for identification purposes in all weather conditions. ASTA also includes a traffic planner for improving the routing of aircraft on the taxiways.

The AMASS is an automation enhancement of the ASDE-3 primary ground sensor radar that provides an initial safety capability on runways and connecting taxiways. The AMASS uses the signals from a group of ASDE-3 radar returns to determine a target, and then analyzes the targets position and motions with respect to other targets and the airport's defined configuration to determine if there are any conflicts among the targets or with the defined operations. In case there is a conflict, the system provides the controller with both a visual and an oral warning. The AMASS also has a link with the Automated Radar Terminal System in order to include airborne aircraft on final approach to determine in the check for conflicting target operations on the airport's surface.

The ASTA program also shares information with the Terminal Air Traffic Control to create an interrelated runway incursion prevention and surface traffic management system. Once completed, the ASTA

program will provide an all weather, automated capability permitting safer, higher capacity airport operations.

3.9 DEVELOPMENTS IN AIRCRAFT TECHNOLOGY

A general rule that has been used in these scenarios is that technology by itself will not be a constraint. The availability of new technology is seen to be a function of market needs and economic viability. We assume that any new aircraft that is introduced will have to meet at least the following minimum conditions. It must reduce operating costs by at least 15%, it must be able to meet the current ICAO Chapter III (and possibly Chapter IV) noise regulations, it must be as safe as the aircraft currently flying, and it should not necessitate a complete redesign of airports.

3.9.1 Developments in Aircraft Engine Technology

Emissions from aircraft engines contribute to environmental problems included in three environmental themes used in Dutch environmental policy documents. These three themes are: 1) climate change; 2) acidification; and 3) disturbance. The climate change theme includes the problems of the greenhouse effects and the depletion of stratospheric ozone. The acidification theme is concerned with the prevention of damage to forests and natural parklands caused by the deposition of sulfur, nitrogen, and ozone in the atmosphere. The disturbance theme has to do with maintaining a satisfactory standard living environment in relation to noise, odor, vibration, safety, and air quality.

The main aircraft emissions resulting from the combustion of aviation fuels are carbon dioxide (CO2), water vapor, and oxides of sulfur (SOx). Despite the high efficiency of modern day aircraft engines, combustion is not complete leading to the generation of a number of products. The most important products of incomplete combustion are carbon monoxide (CO), volatile organic compounds (VOC), and particulates. In addition, the high temperatures in the combustion chambers leads to the formation of oxides of nitrogen (NOx). Finally, aircraft engines also emit unburned hydrocarbons (UHC), nitrous oxide, and methane. The contribution of each of these emissions to the environmental themes is shown in Table 4. In Table 4, Column 1 identifies the environmental theme or problem, Column 2

lists the compounds that are considered to be particularly important for each theme, Column 3 lists the compounds that are linked to the theme, but are not considered to be important, and Column 4 lists the compounds whose links to the theme are still uncertain.

Table 4

Current Estimates of the Link Between Aircraft Emissions and Environmental Problems

Environmental Theme	Important	Unimportant	Uncertain
Ozone depletion	NOx	CO2, VOC, CO	SO2, water vapor, particulates
Greenhouse effect	CO2, NOx	VOC, CO	SO2, water vapor, particulates
Acidification	NOx	CO2, SO2, Water vapor, VOC, CO, particulates	
Local air quality	VOC, CO, SO2, NOx, particulates, odors	CO2, water vapor	

Source: Dutch Ministry of Housing, Spatial Planning and the Environment, 1995

Three types of technological developments can reduce emissions from aircraft engines. These are changes in the: (1) design of aircraft engines; (2) design of aircraft; and (3) type of aviation fuels that are used.

Emissions can be reduced by making the aircraft engine more efficient. Increase in the efficiency will as a rule lead to a lowering of per unit emissions of CO2, water vapor, CO, VOC, and SO2. However, as the efficiency of an engine increases, the temperature and pressure in the combustion chamber rises. Since, NOx is formed as a function of the temperature in the combustion chamber, as engine efficiency increases, NOx emissions will also increase. Thus, there is a tradeoff in making aircraft engines more fuel efficient and reducing NOx emissions.

Currently, the aviation industry is researching the possibility of using the so-called propfan engine. The propfan engine has one or two large propellers driven by a gas turbine. The estimated efficiency gain from the use of this technology is about 20% over the efficiency of current day jet engines[41]. However, there is still a

[41] Energie Centrum Nederlands (1994).

lot of uncertainty about when this technology will be ready for commercial use.

Another line of research aimed at reducing aircraft emissions is aimed at developing techniques for improving the efficiency of the combustion process in the combustion chamber of aircraft engines. This research is primarily aimed at reducing the emissions of NOx, CO, and VOC. Examples of such techniques include better fuel-air mixing, adjustable air slots, lean-burn and staged combustion techniques. It was estimated that the GE90 engine using staged combustion techniques would provide up to a 35% reduction in NOx emissions. However, information collected from tests of the first version of the General Electric GE90 engine indicates that actual NOx reductions will be less than what was anticipated.

Another engine manufacturer, Rolls Royce, has developed an engine that produces significant NOx reductions without using staged combustion technology. In a test conducted by Rolls Royce, a Boeing 777 powered by the Rolls Royce Trent 800 engine produced 45% of the NOx per passenger compared to the Lockheed Tristar powered by the RB211 engine over a 3000 nautical mile mission.[42] However, Rolls Royce and another engine manufacturer, Pratt & Whitney, are also engaged in the development of their own engines using staged combustion technology.

Ultra low NOx combustion technology that can reduce NOx emissions by a factor of 10 has also been demonstrated in the laboratory. It is thought that the ultra low NOx emission technology may be mature enough for commercial adoption by the year 2010-2015.

Unburned hydrocarbons and carbon monoxide are the result of incomplete fuel burn. However, modern aircraft have almost 100% combustion efficiency over most of the flight cycle. However, at ground level and in the time it takes to reach ideal cruising altitude and speed, small amounts of unburned hydrocarbons and carbon monoxide are emitted. For example, the Rolls Royce Trent 800 engine produces only 20% of the carbon dioxide and 2% of the unburned hydrocarbons that were produced over a LTO cycle by the original Rolls Royce RB211-22B engine. The levels of CO and UHC emission from

[42]Memorandum submitted by Rolls Royce PLC to the UK House of Commons, Transport Committee, Session 1995-96 on UK Airport Capacity, which is reprinted in (Transport Committee, House of Commons, 1996, p. 401).

modern aircraft emissions is so low that future reductions are not feasible.

Oxides of sulfur result from the presence of sulfur in aviation fuel. International standards restrict the level of sulfur in aviation fuels to 0.3%. Given the already low sulfur content of aviation fuel, the increasing efficiency of aircraft engines, and the role of sulfur as a lubricant there is little reason to further reduce the emissions of oxides of sulfur from aircraft engines.[43]

Besides changes in the design of aircraft engines, changes in the design of aircraft are also important in reducing emissions. Aircraft designs are constantly being modified to reduce the weight and drag of aircraft. This reduces fuel consumption and thereby reduces emissions. Another important technological trend is the increasing power and reliability of aircraft engines. Aircraft engines have steadily become more powerful and reliable, so it is now possible to use only two engines instead of the three or four engines that were used on large aircraft like the Boeing 747.

We expect incremental technological developments in quieter, cleaner, and more efficient engines, more aerodynamic and lighter airframes, navigation, cockpit, and flight management systems, and radar. However, in the coming three decades, no breakthrough technological developments, such as aircraft engines that are twice as quiet or fuel efficient than engines in use today, are expected.

3.9.2 Development of New Aircraft Types

The development of the following new aircraft types can have a significant impact on the airline industry. The development of a 250-350 seat twin jet aircraft capable of flying long haul routes, a 200-400 seat supersonic transport (SST), and a 800-1000 seat aircraft. Boeing has already introduced the Boeing 777, a 250-350 twin jet aircraft. NASA has announced plans to cooperate with the Russian aircraft manufacturer Tupolev to build a large SST. Both Boeing and Airbus have announced plans to build a 800-1000 seat aircraft. The Boeing 777 is already in service and the large SST is already in the prototype testing phase. The mega-jumbo is still on the drawing

[43] Ibid.

boards. The factors that could affect the development of both aircraft types are considered next.

We assume that a completely new SST will not be in operation in significant numbers (600-1000 aircraft worldwide) in the next 30-40 years. SSTs have the obvious advantage of higher speed and shorter travel times. The disadvantage is that SSTs are noisy, use a lot of fuel, and there is concern about the possible impact of a large fleet of SSTs on the ozone layer. The impact that a fleet of SSTs would have on the ozone layer is particularly important. There is considerable disagreement about what effect such an aircraft would have. Some say that 300 SSTs would destroy as much ozone as all the aerosols in the world; others say such a claim is baseless.[44] Regardless of what the reality is, airlines and aircraft manufacturers are unlikely to be willing to risk investing large sums of money in SST technology until there is more precise information about the impacts of aircraft emissions on the ozone layer. However, there are also other reasons why the SST is not considered to be economically viable.

Consider the market potential for the SST. Given the high speed of a SST, a large SST would be well suited for operating on long distance routes. The SST is not as well suited for short or medium haul routes. Most of the flight legs in the European and domestic US market are under three hours flying time (using subsonic aircraft). The reduction in travel time on these routes by operating an SST would be small. Furthermore, it is unlikely that the SST would even be allowed to fly at supersonic speeds over populated land routes because of concerns about noise from sonic booms. Thus, the potential market for the SST consists of routes between North America, Europe, and the Far East. These routes are heavily traveled routes and are expected to grow in the future. However, they form a fairly small portion of the total market for civil aviation. Additionally, an airline would prefer to invest in aircraft that can operate on a multiplicity of routes rather than in aircraft that can operate on a single route.

So far, nothing has been said about the operating costs of a SST. The operating costs of an aircraft can be divided into the following

[44]Thebault (1995).

categories: ownership costs, fuel costs, maintenance, and crew. Ownership costs are the largest component of aircraft operating costs (about 45% for an Airbus A320-200), and are directly related to the development cost of an aircraft and the size of the market (which we have noted is not very large for the SST). The next largest cost category, and the most variable cost category, is for fuel (about 19% for Airbus A320-200). The maintenance and crew costs are the two smallest cost categories, they do not vary much, and cannot be reduced significantly. Thus, not surprisingly, aircraft developers focus their efforts on minimizing development costs and maximizing fuel efficiency. Both of these are considered next.

Over the years, aircraft development costs of new aircraft have been increasing. Every new aircraft costs more to develop than the aircraft it replaces. However, the development costs for the SST are expected to be especially large.[45] The primary reason for the high development costs of an SST is a new propulsion system is needed. The propulsion system of the SST will have to satisfy two criteria. The SST has to be able to meet applicable noise standards for takeoff and landing, and performance must be optimized at supersonic speeds. Reducing noise would mean that the SST could not use its afterburners on takeoff and would require an engine with dual-flow technology. Optimizing performance at supersonic speeds calls for an engine with a low bypass ratio and excludes the use of afterburners to reach supersonic speeds. Engines capable of meeting these two requirement are under development, but no prototypes exist as yet. The development costs for this new propulsion system are expected to significantly increase the development costs of the SST.

Estimates of the development costs for a new SST have been placed at around US $ 20 billion, roughly four times that of conventional wide body jets, and twice as much as that of a mega jumbo.[46] If we use the ratio of the investment to the cost price for a subsonic aircraft for the SST to determine its break-even point, we have a figure of 2400 aircraft. Even the most optimistic estimates of demand for an SST do not come close to this number. In fact, even a market for 1000 such aircraft is considered unrealistic. Assuming a

[45]Ibid.
[46]Ibid.

more realistic number of about 500 aircraft, we have an amortization cost of US $ 40 million per SST, four times that of a widebody subsonic airliner. The production costs of an SST are also higher than that of subsonic airlines. Assuming production costs equivalent to those of current subsonic wide body aircraft, the price of an SST would be about US $ 170 million compared to US $ 140 million for a B-747-400. It is clear that the development and production costs of an SST will be significantly higher than any conventional subsonic airliner. How much higher these costs are will be determined by the size of the market for the SST. The estimates of the market for the SST vary, but even the more optimistic estimates are relatively small. We therefore assumed that a 200-300 seat SST will not come into operation in the next 30-40 years.

A similar analysis for the mega-jumbo shows that, on a per seat basis, the mega-jumbo costs about half of what the SST costs. Thus, it would seem reasonable to assume that it is more likely that the mega-jumbo will come in service before the SST does. Not insignificantly, no Western aircraft manufacturer has announced plans to develop an SST, while both Boeing and Airbus are now proceeding with the development of the mega-jumbo. In addition to having low per seat operating costs, the mega-jumbo is also attractive to airlines because of the increasing congestion at airports. The only way to accommodate the expected growth in air travel at many airports is by increasing the average aircraft size. As a result, we have assumed that mega-jumbos will be in operation sometime in the next 30-40 years.

4. UNCERTAIN ELEMENTS

Uncertain elements are assumptions about developments that could have a significant affect on the civil aviation system -- **assumptions whose likelihood of occurrence is not high enough to treat them as certain or near certain.**

The major uncertainties concerning the future of civil aviation in Europe come from the deregulation of the airline industry, technological developments, and a trend towards the globalization of the airline industry. The number of airlines that will survive, what their route networks will look like, the extent of government subsidy to airlines, availability of airport capacity, and aeropolitical restrictions all contribute to uncertainty about the future. In developing the scenarios, we considered all these uncertainties and many more. However, three of these uncertainties were viewed as being particularly important and relevant for the TNLI project. These three uncertainties directly affect the policy decision(s) being considered in the TNLI project -- whether or not there should be investments in civil aviation related infrastructure in the Netherlands, and the extent of these investments.

The three most important uncertainties concern:

1. The structure of the European airline industry, and the Netherlands' role in it;
2. The preferences and behavior of passengers;
3. The health of the global civil aviation industry.

4.1 THE EUROPEAN AIRLINE INDUSTRY

The discussion about the European airline industry has two objectives. First, it outlines the logic of why a significant reorganization and consolidation of the airline industry is expected. And second, it points out the assumptions that are implicit in this logic. The number of existing airlines that will survive, new airlines that could enter the market, and the route networks of these airlines will be discussed. It is the uncertainty about these underlying assumptions that creates uncertainty about the extent and nature of the reorganization in the European airline industry.

In the past, civil aviation in Europe has been a highly regulated business. The provision of air services among countries was governed by a complex system of bilateral agreements between pairs of countries. These agreements specified in great detail the air services that could be provided, the airports that could be served, the frequency of flights, the airlines that were permitted to provide these services, and the fares to be charged on various routes.

The regulatory environment of European civil aviation has been significantly liberalized in the past few years. One of the main objectives of this liberalization has been to create conditions for more competition in the European airline industry. The liberalization measures include the opening up of protected home markets and the elimination of government subsidies, restrictions on capacity, service frequency, and restrictions on airline fares. The objective in liberalizing the provision of air transport is to make the European airline industry an efficient, profitable, and competitive industry.[47]

One of the ways in which the above transformation of the airline industry is expected to come about is via a consolidation of the airline industry -- there will be fewer airlines than there are now. The inefficient airlines, and the airlines getting state subsidies are expected to be unable to continue as independent entities in the future. Without government subsidies, most flag-carrying airlines (Air France, Iberia, TAP, Sabena, Austrian Airways, Finnair, Alitalia, Olympic Airways, Aer Lingus) are not expected to be able to survive in the face of increased price based competition from other more efficient European carriers (British Airways, Lufthansa, KLM, SAS, Swissair), US, and Far Eastern carriers.

If a consolidation of the European airline industry takes place, a large scale reorientation of the route networks is inevitable. Currently, the flag carrier of a given country has a base of operations located in the capital city of that country. The flag carrier provides flights to various European and intercontinental

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[47]The efficiency, profitability, and competitiveness refer to the European airline industry as a whole, not to an individual airline. Clearly, there are European airlines that are all of the above. However, the majority of European airlines are not. Also, the competitive position of European airlines is weak compared with US and Far Eastern carriers.

destinations from its home base. Thus, in some sense, the current route network of most European airlines is already a hub-and-spoke network. However, these hubs are not true hubs because the characteristic bank system for scheduling flights is not widely used at these airports.[48] The airline's intra-European network acts as feeder for the intercontinental network and vice-versa. The problem, however, is that currently there are far too many hubs in Europe to fully realize the economies of scale and scope that are possible with a larger hub-and-spoke operation. Thus, along with a reduction in the number of airlines, there is likely to be a reduction in the number of hub airports in Europe.

In a competitive airline industry, only the most efficient airlines will survive. The route network is an important factor in determining the efficiency of airlines. From a theoretical point of view, a hub-and-spoke network is the most efficient route network. Given the economic logic of hub-and-spoke networks, it is clear that some of the present hubs will not be viable in the future. Some of them will gain in importance, while others will lose in importance. Thus, some airports will become larger and some will become smaller. The airports that become larger will be airports that are used by one of the surviving European (or other) airlines as a base for their hub operations.

The above sketch of the future is based mostly on economic theory and the experience of airlines in the United States. Now we turn to the underlying assumptions that would have to be true in order for this logic to become operational.

4.1.1 Elimination of Government Subsidies

It is clear that the European Commission wants to promote competition in the European airline industry. However, the extent to which competition will be promoted, and the nature of competition that will result is not clear. The European Commission wants to do away with government subsidies for airlines. Presumably, the national governments also want to do away with these subsidies. However, it is not clear that they can. The implications of eliminating subsidies in

[48]Airlines schedule flights arriving and departing from their connecting hubs in *banks*. Each bank consists of a large number of arriving or departing flights within a short period of time.

terms of lost jobs, other economic impacts, and national prestige are quite large. As a result, the elimination of subsidies to national airlines is not just an economic issue but it is a difficult political issue. Given recent events, doubts about the EC's willingness and ability to stand up to national governments on the issue of government subsidies to airlines would be justified.

The EC's liberalization packages are very clear on the issue of subsidies -- state subsidies have to be eliminated. However, in face of the opposition and unwillingness of national governments, the EC has been forced to come up with an alternative. The EC now says that it will view government decisions to provide subsidies to airlines as it would view any other investor investing in the airline. Now suppose that the airline requires an infusion of capital to continue operating. In the view of the EC, the national government can provide this infusion of capital as long as this is something that other investors would also do. This is a reasonable argument. However, it is unclear whether a government can be equated with other investors. It also begs the question of why the airline in question cannot raise the money from the usual sources of capital like banks. Using this criterion it would be difficult to deny the infusion of capital to an airline. The point of this extended discussion is to make clear the uncertainty about even something that seems quite straightforward -- the elimination of government subsidies to airlines.

4.1.2 Multilateral Negotiation of Air Traffic Agreements

Another significant factor in the reorientation of the route networks is the relationship between the EU and other countries. Currently, air traffic rights are negotiated by national governments on behalf of their carriers. These agreements, called bilateral general service agreements (GSAs), determine which airlines can fly passengers and cargo between the two countries, how many times they can fly, and the points in each country to which service can be provided. The Netherlands, for example, has a special bilateral agreement with the United States called an open skies agreement. According to the terms of this agreement, a Dutch airline can fly as many times as it likes to any point in the US. However, Dutch airlines cannot fly to points in the US from points outside the

Netherlands. If , for example, a Dutch airline were to locate an intercontinental hub outside the Netherlands, the Netherlands would have to renegotiate its bilateral agreements so that Dutch airlines could fly from points outside Europe to countries outside the EU. The successful renegotiation of bilaterals so that Dutch airlines can operate to points outside the EU from outside the Netherlands is very unlikely. This can only happen if the current system of negotiating bilateral agreements is replaced by a multilateral agreement negotiated by the EU on behalf of its member states.

4.1.3 Airport Capacity

The nature of a hub-and-spoke network operation is such that the airport serving as the hub in this network has to be able to handle large numbers of aircraft and passengers in short periods of time. For example, an airport able to handle 90 aircraft movements an hour will be preferred by an airline over another airport that can handle only 60 aircraft movements every hour, all other things being equal. Thus, an airport with a large peak hour capacity is very important for the success of a hub-and-spoke operation.

The development of hub-and-spoke networks will lead to the airports chosen as hubs by the surviving airlines becoming much larger than their current size. Most of the major airports in Western Europe are currently operating at maximum or near maximum capacity. However, use of new systems such as MLS and GPS, CRDAS, and reduced radar separations can significantly increase an airport's capacity. We assume that all possible measures will be taken to increase the capacity of congested airports and that airport capacity will not be a constraint.

It should also be pointed out that we do not expect regional airports to play a significant role in the future route networks of European mega-carriers. Currently, regional airports have a small role in commercial civil aviation in Europe. These regional airports cater to small niche markets served by small airlines. For example, regional airports often cater to charter traffic during the summer months, or focus on providing direct flights for business passengers. In the future, we expect little change in this pattern.

4.1.4 Number and Type of Airlines

It is clear that most of the state supported airlines will not be able to survive without state subsidies. What is not clear is how many airlines will be able to survive as major players in what is now the global game of civil aviation.

The number of state supported airlines will decline. However, a growing and profitable air travel market will also attract new entrants. The question is what these entrants will look like. For example, British Midlands (BM), one of the few completely private European airlines, is also a highly profitable airline. However, BM only serves European markets; it does not operate any routes outside Europe. According to conventional wisdom, BM should not be able to survive with a purely European network. It seems (and this is borne out by the example of Pan American Airlines), that airlines with only a domestic, or only an international network, cannot survive in the world of hub-and-spoke networks. BM is cognizant of this. A key feature of the BM strategy is code sharing agreements; BM has eleven such agreements with international airlines. Thus, even without having an international network, BM can survive because it is able to collect passengers from all over the world at its London hub and fly them to their final European destinations, and vice versa.

There is also the possibility of airlines providing only direct point to point services on dense intra-European routes. These airlines are described by what is called the Southwest Airlines model. An example of an airline provides point to point service on intra-European routes is the Dutch charter carrier Transavia. The official policy of Transavia states that its strategy consists of providing non-stop point to point service. Airlines such as Transavia, are able to provide service at a lower cost than larger airlines. In fact, KLM leases capacity from Transavia to provide service on several intra-European routes.

If the US experience is any guide, charter operations will decline and will be replaced by scheduled operations. If this happens, it is unclear whether charter carriers will expand their services to provide scheduled service, or whether these carriers will be taken over by the larger European or other carriers. No one knows the degree to which the charter and scheduled airline industry will merge, or what role charter carriers will have in the future. What

is clear, however, is that the difference between these carriers will be much smaller than what it is today.

Then there are the low cost no-frills airlines. These airlines survive based on their ability to under price their competitors. In the US during the 1980s, a large number of no frills airlines emerged. These airlines were, however, taken over by the larger airlines. One conclusion that could be reached based on the US experience is that low cost competitors cannot, in the long run, compete with the established carriers. Interestingly, however, the US airline industry has recently seen a number of new entrants offering low cost point to point service between various cities. Similar low cost airlines have already made their appearance in the skies over Europe. The important aspect about this development is not the market share that these new entrants will be able to get; rather, it is the effect they will have on the fares offered by the larger carriers.

4.1.5 Continued Existence of the EU

At the risk of stating the obvious, it should also be pointed out that the above discussion is predicated on the continued existence and development of the European Union as currently laid out. There are good reasons to believe that the collapse of the European Union, while improbable, is not impossible. Variation among countries in economic performance, political, institutional, and cultural beliefs are all factors that can individually or collectively lead to the collapse of the EU as currently planned.

4.2 BEHAVIOR OF PASSENGERS

One of the large unknowns about the future is the behavior of passengers. From the perspective of the airlines, a hub-and-spoke network is a good thing -- it allows them to lower costs. However, from the perspective of passengers, a hub-and-spoke network is not as desirable as a direct flight -- it requires changing aircraft at the hub, which results in longer travel times and greater inconvenience. Thus, passengers have to decide whether the inconvenience of flying through a hub is worth the lower fares.

There is little empirical evidence about how much more airline passengers are willing to pay for direct flights between their origin and destination. The only real evidence of this (and this too is

indirect) comes from the United States. Apparently, the number of airline passengers increased significantly after the deregulation of the airline industry. One of the major reasons for this boom in air travel was the significantly lower fares US airlines were able to offer as a result of realigning their route networks; many more people were able to fly than ever before. One could, arguably, conclude from this that airline passengers in the US opted for lower fares and were willing to put up with longer travel times and greater inconvenience.

However, the experience of the US airline industry and the behavior of US passengers cannot necessarily be generalized to Europe. The most important reason for this is that flights in Europe are much shorter than they are in the US. Most flights in the US last over two hours. In Europe, most intra-European flights are under two hours. In principle, the longer the flight time, the less important the connect time (the extra time spent in connecting at a hub) becomes. The implication is obvious. Airline passengers are more likely to complain if a flight of 45 minutes (a direct flight) is replaced by a flight (through a hub) that takes an extra 30 minutes than if a 180 minute direct flight is replaced by a flight through a hub that takes an extra 30 minutes.

4.3 HEALTH OF THE CIVIL AVIATION INDUSTRY

Two factors define the health of the civil aviation industry: growth and profitability. If civil aviation is a growing and profitable industry, it is healthy. If civil aviation is shrinking and is an unprofitable business, it is unhealthy.

Growth of the civil aviation industry means an increase in the number of passengers, volume of cargo, and the number of aircraft in the fleet of commercial airlines. Profitability is defined in the usual manner, revenues minus costs. The larger the positive difference between the two, the higher the profitability of the airline industry.

From the perspective of the TNLI project, both growth and profitability are important factors when considering the health of the civil aviation industry. Growth of civil aviation is important because it directly affects decisions relating to investments in civil aviation infrastructure. If the number of people traveling to

and from the Netherlands increases significantly, new facilities will be needed. For example, the passenger ship industry lost much of its importance with the advent of cheap, fast, and safe commercial aviation services. As this industry became less important, investments in infrastructure for passenger ships also declined. If for some reason the civil aviation industry follows a similar route as that followed by the passenger ship industry, future investments in civil aviation infrastructure are not likely to be needed.

The profitability of the industry determines the extent to which investments in new infrastructure can be made. The more profitable an industry is, the easier it will be to justify investing in new infrastructure.

Given the above, if civil aviation is a healthy industry in the future, it is likely that problems presently associated with civil aviation (for example, congestion at airports, aircraft noise) will be exacerbated, and there will be new problems (aircraft emissions contributing to global climate change) about which we know little. Dealing with these problems will in all probability require new investments in aviation related infrastructure. Conversely, if civil aviation is an unhealthy industry, it seems unlikely that aviation will continue to present the sorts of problems it currently poses. Thus, it is unlikely that new investments in infrastructure will be needed. However, it should be clear that the state of civil aviation will clearly affect the needs that have to be met.

5. DESCRIPTION OF SCENARIOS

This chapter describes the five scenarios that were developed based on a consideration of the predetermined and uncertain elements. For each of the five scenarios, the major structural uncertainties, and the implications of making certain assumptions about these uncertainties are described in six subsections:

1. Worldwide growth of civil aviation
2. Configuration of European civil aviation system
3. European civil aviation policies
4. Other transportation systems and substitutes
5. Airport capacity in Europe
6. Aircraft technology

The major structural uncertainties and the assumptions about each of these uncertainties that are included in the five scenarios are summarized in Table 5.

5.1 SCENARIO 1

5.1.1 Worldwide Growth of Civil Aviation

Air travel is growing, more people and cargo are flying than ever before. The airline industry is profitable.

Worldwide, there is heavy traffic between the US and Europe, as well as long-haul flights between Europe and the Far East. The number of European destinations with air service has increased. The frequency of service to the smaller European cities has also increased. Regional air service has also increased significantly.

Cargo traffic is expected to grow faster than passenger traffic. Worldwide growth in passenger flights is 6% per year, and growth in cargo air transport is 7%. The growth in passenger traffic comes from greater prosperity in the three regions (Europe, North America, and the Far East), more leisure travel, and lower air fares. The growth in air cargo comes from an expansion of express mail services and the changing composition of trade among the three regions, notably between the Far East and the other two regions. More trade in high value goods has increased the volume of cargo being shipped by air.

Table 5

Uncertain Elements in the Five Scenarios

Uncertain Element	Scenario 1	2	3	4	5
Worldwide Growth of Civil Aviation	High	High	Moderate	Decline	Decline
Configuration of European Civil Aviation System					
Number of European hubs/intercontinental gateways	6	6	10	3	3
Number of European airlines	6	6	10	3	3
Ownership of airlines	Private	Private	Govt./ private	Private	Private
Competition in airline industry	High	High	Low	High	High
Airline route networks	hub-and-spoke	hub-and-spoke	hubs and O/D networks	O/D networks	O/D networks
Hub or ICA gateway in the Netherlands	Yes	No	Yes	Yes	No
Presence of European mega-carrier in NL	Yes	No	Yes	Yes	No
European Civil Aviation Policies					
Elimination of government subsidies to aviation	Yes	Yes	No	Yes	Yes
Existence of multilateral air traffic agreements	Yes	Yes	No	Yes	Yes
Substitute Transportation Modes					
Competition between HST and air transport	Medium	Medium	High	Low	Low
Feeder role of HST	Low-	Low	Medium	Large	Large
Airport Capacity in Europe					
Availability of airport capacity in Europe	Yes	Yes	No	Yes	Yes
Aircraft Technology					
Proportion of mega-jumbos in aircraft fleet	Moderate	Moderate	Small	High	High

In Scenario 1 it is assumed that the fuel prices will remain stable. (A distinction needs to be made between oil prices and fuel prices. Oil price is the price of crude on the spot market. Oil prices are assumed to be stable and are one of the predetermined elements. Fuel prices include taxes and any other charges that may be relevant. This is the cost of aviation fuel to airlines.)

5.1.2 Configuration of European Civil Aviation System

There has been considerable consolidation of the airline industry. Only a few carriers survived the deregulation. The national carriers went out of business or were taken over by other more healthy airlines. The surviving carriers are mostly privatized carriers. The intercontinental services are provided almost exclusively by the large carriers operating out of European hubs. The large European carriers have developed close ties with regional carriers to provide regional air service to a larger number of smaller European cities than before. The frequency of service to all destinations has increased many fold.

On some of the high density intra-European routes there is intense competition between the airlines. Some niche players have also entered the market, offering low cost services to the non hub airports. However, none of these niche players survives for any significant length of time. This segment of the market is characterized by frequent entry and exit of airline operators.

Another important development has been the growth of global airline systems. The consolidation of the airline industry has taken place in other parts of the world as well. Thus, there are a few mega carriers, that in cooperation with each other, provide service to points all over the globe.

Charter operations have ceased. The charter carriers have either been taken over, merged, or operate in close cooperation with the larger hub carriers.

The nature of competition among airlines has changed. First, the competition is almost exclusively based on price. Competition based on quality is a thing of the past. Second, competition has been globalized. Airlines are competing for passengers not only on routes but over the entire network. Thus, a Dutch airline in cooperation with a Far Eastern carrier could compete for passengers wanting to

fly from origins in the Far East to destinations all over Europe, not just the Netherlands. This is an important difference. Currently, airlines compete with each other on specific routes. For example, there is heavily traveled London New York route. The belief is that the more carriers that provide service on a route, the lower the air fares will be. However, in the world of a hub-and-spoke system, a Dutch carrier can compete on the London-New York route without offering a direct flight between these two points. It can compete by offering a service from London to its hub in the Netherlands, and from the Netherlands to New York.

There is a very well developed hub-and-spoke network in Europe, with six hubs. One of these hubs is located in the Netherlands.[49] Each hub is dominated by one or at most two airlines that use the airport as their base of operations. The proportion of transfer passengers going through these airports has increased significantly compared to today. Except when traveling between two hubs, or when travel originates at a hub, it is difficult to travel from one point to another without transferring. The distribution of traffic between points is shown in Table 6.

Table 6

Proportion of Direct versus Transfer Passengers Between Points in Scenario 1

Route	Direct	Transfer
Hub - hub	100%	0%
Hub - nonhub	80%	20%
Nonhub - nonhub	20%	80%

The combination of the hub-and-spoke systems and the elimination of inefficient airlines has led to significantly lower air fares. The low air fares and the demand for intercontinental travel have generated significant new demand for intra-European air travel.

[49] The demand model required that the location of these six hubs be specified. In addition to assuming that there was a hub in the Netherlands, we assumed that there would be hubs in Frankfurt, London, Madrid, Prague, and Paris.

5.1.3 European Civil Aviation Policies

The domestic markets of all EU countries are completely open to carriers from other EU countries. Restrictions on tariffs, capacities, entry and exit have been dismantled. All government subsidies to airlines have been eliminated.

The system of bilateral general service agreements between countries has been replaced by a multilateral open skies regime between the EU and the United States as well as most of the countries in the Far East. This means that any EU carrier can fly to any point in the United States, or to point in the Far East from any point of origin within the EU.

All countries have harmonized their laws relating to the environment, so there is no policy competition in the environmental domain. What this means is that, within the EU, government policies with regard to matters such as taxes on aviation fuel, night curfews on flights, and restrictions on aircraft noise and emission have been standardized. Thus, airlines have no reason to move from one airport to another because of differences in restrictions on their operations. Instead, these decisions are based purely on a consideration of airline needs and what an airport has to offer the airline.

5.1.4 Other Transportation Systems and Substitutes

The major competitor to aircraft traffic comes from the high speed train. This competition is limited to the intra-European trunk routes. There is substitution away from air to the high speed train on routes connecting the large European cities with hub airports. The extent of substitution is not as high as what was expected. The reason for this is that airlines have reduced their fares significantly in response to the threat of competition from the HST. If airlines were unable to, or did not reduce fares for any reason on routes where the HST was a competitor, the extent of substitution away from air travel would be much higher. On some routes, however, the substitution will be massive regardless of how much airlines reduce their fares. This substitution will be because of the sheer convenience of the HST, which takes passengers from one city center to another. For example, the high speed train almost completely replaces air travel between Paris and Amsterdam. However, for people

traveling from, say, Amsterdam to London, the substitution effect will be smaller.

Another important effect of the HST will be to expand the existing catchment areas of airports. According to conventional wisdom, passengers are not willing to travel more than two hours to an airport to catch a flight. The HST will reduce the travel time between city pairs connected by HST. Thus, intercontinental passengers, for example, in Paris will have a real choice as to which airport they want to leave from. Passengers from Paris could just as easily fly out of London or Amsterdam. Thus, airlines located at these airports are going to compete for passengers from each others' catchment areas, something that has not been seen on a wide scale so far.

5.1.5 Airport Capacity in Europe

Adequate airport capacity exists at European airports and at American and Far Eastern points of origin. Airport capacity includes the capacity with regard to all parts of the airport -- the runways, aprons, taxiways, gates, and terminal buildings.

Currently, most of the major European airports have constraints on runway capacity. Significant increases in runway capacity can come about as a result of new technology, operating procedures, and standards. However, the capacity increases that are possible using these measures will probably be inadequate. At some point, new runways will be needed to alleviate congestion at these airports. The assumption is that these runways will become available.

5.1.6 Aircraft Technology

Mega-jumbo jets are in operation. The increased demand for air travel and the higher frequency of flights, combined with the capacity limitations of airports has made it necessary to introduce larger aircraft in order to accommodate the increased number of aircraft movements.

5.2 SCENARIO 2

5.2.1 Worldwide Growth of Civil Aviation

Air travel is growing, more people and cargo are flying than ever before. The airline industry is profitable.

Worldwide, there is heavy traffic between the US and Europe, as well as long-haul flights between Europe and the Far East. The number of European destinations with air service has increased. The frequency of service to the smaller European cities has increased. Regional air service has increased significantly.

Cargo traffic is expected to grow faster than passenger traffic. Worldwide growth in passenger flights is 6% per year, and growth in cargo air transport is 7%. The growth in passenger traffic comes from greater prosperity in the three regions (Europe, North America, and the Far East), more leisure travel, and lower air fares. The growth in air cargo comes from an expansion of express mail services and the changing composition of trade among the three regions, notably between the Far East and the other two regions. More trade in high value goods has increased the volume of cargo being shipped by air.

It is assumed that the fuel prices will remain stable. (A distinction needs to be made between oil prices and fuel prices. Oil price is the price of crude on the spot market. Oil prices are assumed to be stable and are one of the predetermined elements. Fuel prices include taxes and any other charges that may be relevant. This is the cost of aviation fuel to airlines.)

5.2.2 Configuration of European Civil Aviation System

There has been considerable consolidation of the airline industry. Only a few carriers survived the deregulation. The national carriers went out of business or were taken over by other more healthy airlines. The surviving carriers are mostly privatized carriers. The intercontinental services are provided almost exclusively by the large carriers operating out of European hubs. The large European carriers have developed close ties with regional carriers to provide regional air service to a larger number of smaller European cities than before. The frequency of service to all destinations has increased many fold.

On some of the high density intra-European routes there is intense competition between the airlines. Some niche players have also entered the market, offering low cost services to the non hub airports. However, none of these niche players survives for any significant length of time. This segment of the market is characterized by frequent entry and exit of airline operators.

Another important development has been the growth of global airline systems. The consolidation of the airline industry has taken place in other parts of the world as well. Thus, there are a few mega-carriers that, in cooperation with each other, provide service to points all over the globe.

Charter operations have ceased. The charter carriers have either been taken over, merged, or operate in close cooperation with the larger hub carriers.

The nature of competition among airlines has changed. First, the competition is almost exclusively based on price. Competition based on quality is a thing of the past. Second, competition has been globalized. Airlines are competing for passengers not only on routes but over the entire network. Thus, a Dutch airline in cooperation with a Far Eastern carrier could compete for passengers wanting to fly from origins in the Far East to destinations all over Europe, not just the Netherlands. This is an important difference. Currently, airlines compete with each other on specific routes. For example, there is heavily traveled London-New York route. The belief is that the more carriers that provide service on a route, the lower the air fares will be. However, in the world of a hub-and-spoke system, a Dutch carrier can compete on the London-New York route without offering a direct flight between these two points. It can compete by offering a service from London to its hub in the Netherlands, and from the Netherlands to New York.

There is a very well developed hub-and-spoke network in Europe, with six hubs.[50] It should be noted that there is no airline hub in the Netherlands. The reason why there is no hub in the Netherlands is discussed a little later.

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[50] These six hubs are located in London, Madrid, Paris, Berlin, Warsaw, and Prague.

Each of the six hubs is dominated by one or at most two airlines that use the airport as their base of operations. The proportion of transfer passengers going through these airports has increased significantly compared to today. Except when traveling between two hubs, or when travel originates at a hub, it is difficult to travel from one point to another without transferring. The distribution of traffic between points is shown in Table 7.

Table 7

Proportion of Direct versus Transfer Passengers Between Points in Scenario 2

Route	Direct	Transfer
Hub - hub	100%	0%
Hub - nonhub	80%	20%
Nonhub - nonhub	20%	80%

The combination of the hub-and-spoke systems, elimination of inefficient airlines, entry of US carriers in Europe, and the emergence of East European carriers has led to much lower air fares. The low air fares, and the demand for intercontinental travel have generated significant new demand for intra-European air travel.

There can be two possible non-strategy related reasons for why there is no hub in the Netherlands. However, regardless of the reason, the effect for the Netherlands is the same -- no hub airport. The first reason for the lack of a hub in the Netherlands is that no Dutch airline was able to survive as a major player in the world of global civil aviation. The major Dutch airline carrier had difficulties with its US partner. The US partner experienced serious financial difficulties and was taken over by another US carrier that already had an alliance with some other non-Dutch European airline. This non-Dutch European airline already had a hub outside Europe. From the US airline's perspective, it made little sense to enter into an alliance with a second European carrier. Thus, the US carrier terminated its relationship with the Dutch airline. Partnership with a US carrier was an important part of the strategy of the Dutch carrier. Unable to find another US airline with which to enter into an alliance, the Dutch carrier went out of business.

The second reason for the Netherlands not having a hub is similar to the first but slightly different. Compared to other European and US carriers, Dutch carriers are relatively small. In a world of global competition, declining airline yields, and hub-and-spoke systems, small carriers cannot survive except in partnership with larger carriers. This partnership provides the smaller carriers with access to passengers that they otherwise would not have. The small Dutch carrier recognizing this fact agrees to be taken over by a larger European airline. The larger airline benefits from this takeover because it no longer has to compete with the Dutch carrier.

It should be pointed out, however, that not having a hub airport does not mean that the Netherlands has no air connections with the outside world. What it does mean is that Dutch airports are destinations at the end of spokes connected to the major European hubs. From the perspective of a passenger this means that it is now more difficult than before to travel to destinations without first transferring at one of the hub airports.

The economic center of gravity has shifted toward the east as the EU has expanded. What this means is that air service can be provided to all points within Europe from points in Eastern Europe. Another important point to note is that the costs of operating out of Eastern European airports are less than the cost of operating out of airports in Western Europe.

The eastward expansion of the EU has brought about the entry of US carriers in Europe. US carriers are already present in Europe. However, in this scenario it is hypothesized that US carriers are able to compete even on domestic intra-European routes via a system of code sharing alliances and takeovers. At least one US carrier has formed an alliance with an East European carrier and is using this carrier to transfer passengers arriving from the United States to various points within Europe. Although the travel times involved are somewhat longer than what they would via other more centrally located hubs, the differences in costs, and more or less unrestricted capacity at the East European airports make it possible for this US carrier to offer much lower fares to European destinations. Thus, there is intense price competition in the European airline industry.

5.2.3 European Civil Aviation Policies

The domestic markets of all EU countries are completely open to carriers from other EU countries. Restrictions on tariffs, capacities, entry and exit have been dismantled. All government subsidies to airlines have been eliminated.

The system of bilateral general service agreements between countries has been replaced by a multilateral open skies regime between the EU and the United States as well as most of the countries in the Far East. This means that any EU carrier can fly to any point in the United States, or to point in the Far East from any point of origin within the EU.

All West European countries have harmonized their laws relating to the environment, so there is no policy competition in the environmental domain. What this means is that Western European government policies with regard to matters such as taxes on aviation fuel, night curfews on flights, and restrictions on aircraft noise and emissions have been standardized.

However, there are differences in policies between the Eastern and Western European countries. This means that an airline, while less willing to move from a West European airport to another West European airport, could be willing to move to a East European airport. What this also means is that there is more capacity in the European aviation system, since most of the East European airports are new with large capacities.

5.2.4 Other Transportation Systems and Substitutes

The major competitor to aircraft traffic comes from the high speed train. This competition is limited to the intra-European trunk routes. There is substitution away from air to the high speed train on routes connecting the large European cities with hub airports. The extent of substitution is not as high as what was expected. The reason for this is that airlines have reduced their fares significantly in response to the threat of competition from the HST. If airlines were unable to, or did not reduce fares for any reason on routes where the HST was a competitor, the extent of substitution away from air travel would be much higher. On some routes, however, the substitution will be massive regardless of how much airlines reduce their fares. This substitution will be because of the sheer

convenience of the HST, which takes passengers from one city center to another. For example, the high speed train almost completely replaces air travel between Amsterdam and Paris. However, for people traveling from say Amsterdam to London, the substitution effect will be smaller.

Another important effect of the HST will be to expand the existing catchment areas of airports. According to conventional wisdom, passengers are not willing to travel more than two hours to an airport to catch a flight. The HST will reduce the travel time between city pairs connected by HST. Thus, intercontinental passengers, for example, in Paris will have a real choice as to which airport they want to leave from. Passengers from Paris could just as easily fly out of London or Amsterdam. Thus airlines located at these airports are going to compete for passengers from each others' catchment areas, something that has not been seen on a wide scale so far.

5.2.5 Airport Capacity in Europe

Adequate airport capacity exists at European airports and at American and Far Eastern points of origin. Airport capacity includes the capacity with regard to all parts of the airport, the runways, aprons, taxiways, gates, and terminal buildings.

Currently, most of the major European airports have constraints on runway capacity. Significant increases in runway capacity can come about as a result of new technology, operating procedures, and standards. However, the capacity increases that are possible using these measures will probably be inadequate. At some point new runways will be needed to alleviate congestion at these airports. The assumption is that these runways will become available.

A significant development has been the construction of a very large new airport in Paris. The two existing airports have been closed. Given the central geographic location of Paris, large passenger flows into Paris, a large catchment area, and good connections with the high speed trains make Paris the preferred choice for traveling into and out of Europe.

5.2.6 Aircraft Technology

Mega-jumbos jets are in operation. The increased demand for air travel and the higher frequency of flights, combined with the

capacity limitations of airports has made it necessary to introduce larger aircraft in order to accommodate the increased number of aircraft movements.

5.3 SCENARIO 3

5.3.1 Worldwide Growth of Civil Aviation

Air travel is growing, more people and cargo are flying than ever before. The airline industry is profitable.

Worldwide, there is heavy traffic between the US and Europe, as well as long-haul flights between Europe and the Far East. The number of European destinations with air service has increased, but not as much as in the previous two scenarios. The frequency of service to the smaller European cities has also increased, but again not as much as in the previous two scenarios. Regional air services have not increased as much.

Cargo traffic is expected to grow faster than passenger traffic. Growth in passenger flights is 6% per year; growth in cargo air transport is 7%. The growth in passenger traffic comes from greater prosperity in the three regions (Europe, North America, and the Far East), more leisure travel, and lower air fares. The growth in air cargo comes from an expansion of express mail services and the changing composition of trade among the three regions, notably between the Far East and the other two regions. More trade in high value goods has increased the volume of cargo being shipped by air.

Although there has been considerable growth of civil aviation at the global level, intra-European air travel has not increased as much as on the intercontinental routes. The reason for this is that European unification has not progressed as smoothly or as far as expected. The airline industry has also not undergone restructuring on as large a scale as in the previous two scenarios. The airline industry still has inefficiencies, which are reflected in higher fares. The higher fares have restricted demand to levels lower than what it would be if the airline industry were more competitive.

It is assumed that the fuel prices will remain stable. (A distinction needs to be made between oil prices and fuel prices. Oil price is the price of crude on the spot market. Oil prices are assumed to be stable and are one of the predetermined elements. Fuel prices include taxes and any other charges that may be relevant. This is the cost of aviation fuel to airlines.)

The Netherlands is able to maintain its position in the world of civil aviation.

There is strong economic growth in Eastern and Southern Europe, but the EU has not expanded.

5.3.2 Configuration of European Civil Aviation System

The level of consolidation in the aviation industry is low to moderate. There are large numbers of airlines, including regional airlines and niche players.

The aviation market is not fully competitive.

The route network consists of several small hubs and many O/D connections.

There are European hubs in ten European cities, including a hub in the Netherlands.[51]

There are O/D connections between smaller European airports (airports that are not connecting hubs for one of the surviving European carriers).

5.3.3 European Civil Aviation Policies

European unification has not progressed as far as planned or as smoothly as had been expected.

Subsidies to some airlines continue.

There are no multi-lateral open skies treaties between EU and the US or the Far East.

There has been no expansion of bilateral open-skies agreements between countries.

Policy competition among countries is high.

5.3.4 Other Transportation Systems and Substitutes

HST serves as a feeder to flights from the air hubs.

HST is a strong competitor to air on highly traveled trunk routes.

5.3.5 Airport Capacity in Europe

No major European airport has excess capacity.

5.3.6 Aircraft Technology

Mega-jumbo jets are in operation.

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[51] The cities with hubs are London, Frankfurt, Paris, the Netherlands, Zurich, Copenhagen, Madrid, Milan, Berlin, and Prague.

5.4 SCENARIO 4

5.4.1 Worldwide Growth of Civil Aviation

New information linking aircraft emissions to global environmental changes and harmful health effects becomes available. This new information suggests that there is an urgent need for governments to act to reduce the level of air transport. Given the urgency of the situation, governments are forced to act quickly and agree on a joint policy for dealing with this problem. Since the harmful environmental impacts of aviation have to be dealt with on a global scale, the new aviation policy has to be agreed to by all countries. The International Civil Aviation Organization (ICAO) provides the forum for determining and implementing the policy. The new policy does three things. First, it recognizes that air transport cannot be entirely eliminated until equally fast and economical substitutes become available. In particular, intercontinental passenger transport cannot easily be substituted for by other transport modes. Second, it is agreed that air transport as a sector will not be subsidized in any form whatsoever by governments. Finally, it is agreed that aviation will be taxed so that prices fully reflect the environmental costs imposed by air transport.

As a result of this new policy, the prices for air travel increase significantly as subsidies are eliminated and aviation fuel prices increase. Higher prices have several effects. First, the higher prices result in a global downturn in demand for air transport. Second, there is considerable substitution of other transport modes for air transport. In particular, the volume of air cargo (even intercontinental air cargo) declines dramatically, due to shifts to other transport modes and greater regionalization of production centers.

5.4.2 Configuration of European Civil Aviation System

As a result of the elimination of government subsidies, airlines have had to compete with each other on the basis of costs. This combined with the decline in demand for air transport has resulted in a shake-out in the airline industry. Inefficient airlines have gone

out of business and there are far fewer surviving airlines than there were before. There are only three surviving European airlines.

The surviving airlines primarily serve the intercontinental market. The air cargo market has declined even more than the demand for passenger transport; only the most valuable cargo is now transported by air.

Each one of the three surviving airlines has concentrated all its operations at a single airport. Thus, there are three major aviation gateways in Europe.[52] One of these gateways is in the Netherlands.

5.4.3 European Civil Aviation Policies

Taxes are much higher, and there is more regulation of air transport. Passengers are required to pay higher airport taxes. Also, there has been an agreement on an accelerated schedule for phasing out older aircraft types. Finally, all short and medium haul flights have been eliminated.

All subsidies to airlines, airports, and other operators have been eliminated.

5.4.4 Other Transportation Systems and Substitutes

There has been a massive substitution of HST for air transport. The HST also serves as a feeder for airlines by linking large population centers to the three European gateways. Most people use the HST to travel between their origin or destination and one of the intercontinental European gateways. As a result of the increased numbers of people traveling by HST, the extent of the HST network has also increased, with links to and within Scandinavia, southern Europe, and the United Kingdom.

5.4.5 Airport Capacity in Europe

Although air traffic is concentrated at three European gateways, these airports have adequate capacity. The capacity is adequate for several reasons. First, short distance, intra-European, and commuter flights have been almost entirely removed from these airports. Second, the average aircraft size has increased significantly, since most of the flights to and from the gateways are long distance

[52] The three gateways are in the Netherlands, Berlin, and Paris.

intercontinental flights. Third, load factors have also increased dramatically. Larger aircraft and higher load factors mean that more passengers are carried per flight. Fourth, the demand for air transport has declined due to the high prices. And finally, since airlines no longer use hub-and-spoke networks, airports can spread the demand more uniformly over the day. With hub-and-spoke networks, airlines required a large capacity during peak hours. At other times of the day, the airport's capacity was not used very much. Now, airports can make use of their capacity throughout the day rather than only during the peak hours. For all these reasons, the three European gateways have been able to accommodate the traffic despite the concentration that has taken place.

5.4.6 Aircraft Technology

Mega-jumbo jets are in operation. It might seem contradictory to assume that a new, expensive type of aircraft would be developed in the face of declining worldwide demand. However, there are several reasons why mega-jumbos might still be developed despite declining demand. First, mega-jumbos are attractive to airlines because they have lower operating costs (crew, fuel, etc.) than smaller aircraft. The few surviving airlines are flying only long-haul routes and want to reduce their costs as much as possible. Operating mega-jumbos is a way for airlines to lower costs. This serves to increase the demand for mega-jumbos. Second, although demand for air transport has declined, prices for air travel have increased significantly and the airline industry has fewer players. This has resulted in the surviving airlines becoming large and profitable. Thus, these airlines have the money to pay for the development and purchase of the new mega-jumbos. Third, airlines no longer use small- and medium-size aircraft, since the short- and medium-haul routes on which these aircraft used to operate are no longer served. For aircraft manufacturers this means that they cannot stay in business without developing new aircraft types (in this case mega-jumbos) to replace their small- and medium-size aircraft. Thus, aircraft manufacturers are left with no option but to develop this new aircraft type.

5.5 SCENARIO 5

5.5.1 Worldwide Growth of Civil Aviation

New information linking aircraft emissions to global environmental changes and harmful health effects becomes available. This new information suggests that there is an urgent need for governments to act to reduce the level of air transport. Given the urgency of the situation, governments are forced to act quickly and agree on a joint policy for dealing with this problem. Since the harmful environmental impacts of aviation have to be dealt with on a global scale, the new aviation policy has to be agreed to by all countries. The International Civil Aviation Organization (ICAO) provides the forum for determining and implementing the policy. The new policy does three things. First, it recognizes that air transport cannot be entirely eliminated until equally fast and economical substitutes become available. In particular, intercontinental passenger transport cannot easily be substituted for by other transport modes. Second, it is agreed that air transport as a sector will not be subsidized in any form whatsoever by governments. Finally, it is agreed that aviation will be taxed so that prices fully reflect the environmental costs imposed by air transport.

As a result of this new policy, the prices for air travel increase significantly as subsidies are eliminated and aviation fuel prices increase. Higher prices have several effects. First, the higher prices result in a global downturn in demand for air transport. Second, there is considerable substitution of other transport modes for air transport. In particular, the volume of air cargo (even intercontinental air cargo) declines dramatically, due to shifts to other transport modes and greater regionalization of production centers.

5.5.2 Configuration of European Civil Aviation System

As a result of the elimination of government subsidies, airlines have had to compete with each other on the basis of costs. This combined with the decline in demand for air transport has resulted in a shake-out in the airline industry. Inefficient airlines have gone

out of business and there are far fewer surviving airlines than there were before. There are only three surviving European airlines.

The surviving airlines primarily serve the intercontinental market. The air cargo market has declined even more than the demand for passenger transport; only the most valuable cargo is now transported by air.

Each one of the three surviving airlines has concentrated all its operations at a single airport. Thus, there are three major aviation gateways in Europe.[53] None of these gateways is in the Netherlands.

5.5.3 European Civil Aviation Policies

Taxes are much higher, and there is more regulation of air transport. Passengers are required to pay higher airport taxes. Also, there has been an agreement on an accelerated schedule for phasing out older aircraft types. Finally, all short and medium haul flights have been eliminated.

All subsidies to airlines, airports, and other operators have been eliminated.

5.5.4 Other Transportation Systems and Substitutes

There has been a massive substitution of HST for air transport. The HST also serves as a feeder for airlines by linking large population centers to the three European gateways. Most people use the HST to travel between their origin or destination and one of the intercontinental European gateways. As a result of the increased numbers of people traveling by HST, the extent of the HST network has also increased, with links to and within Scandinavia, southern Europe, and the United Kingdom.

5.5.5 Airport Capacity in Europe

Although air traffic is concentrated at three European gateways, these airports have adequate capacity. The capacity is adequate for several reasons. First, short distance, intra-European, and commuter flights have been almost entirely removed from these airports. Second, the average aircraft size has increased significantly, since most of the flights to and from the gateways are

[53] The three gateways are Prague, Berlin, and Paris.

long distance intercontinental flights. Third, load factors have also increased dramatically. Larger aircraft and higher load factors mean that more passengers are carried per flight. Fourth, the demand for air transport has declined due to the high prices. And finally, since airlines no longer use hub-and-spoke networks, airports can spread the demand more uniformly over the day. With hub-and-spoke networks, airlines required a large capacity during peak hours. At other times of the day, the airport's capacity was not used very much. Now, airports can make use of their capacity throughout the day rather than only during the peak hours. For all these reasons, the three European gateways have been able to accommodate the traffic despite the concentration that has taken place.

5.5.6 Aircraft Technology

Mega-jumbo jets are in operation. It might seem contradictory to assume that a new, expensive type of aircraft would be developed in the face of declining worldwide demand. However, there are several reasons why mega-jumbos might still be developed despite declining demand. First, mega-jumbos are attractive to airlines because they have lower operating costs (crew, fuel, etc.) than smaller aircraft. The few surviving airlines are flying only long-haul routes and want to reduce their costs as much as possible. Operating mega-jumbos is a way for airlines to lower costs. This serves to increase the demand for mega-jumbos. Second, although demand for air transport has declined, prices for air travel have increased significantly and the airline industry has fewer players. This has resulted in the surviving airlines becoming large and profitable. Thus, these airlines have the money to pay for the development and purchase of the new mega-jumbos. Third, airlines no longer use small- and medium-size aircraft, since the short- and medium-haul routes on which these aircraft used to operate are no longer served. For aircraft manufacturers this means that they cannot stay in business without developing new aircraft types (in this case mega-jumbos) to replace their small- and medium-size aircraft. Thus, aircraft manufacturers are left with no option but to develop this new aircraft type.

APPENDIX A

PERSONS INVOLVED IN SCENARIO DEVELOPMENT

Scenario Development Support Group

Drs. J.G. Veldhuis, Ministry of Transport, Public Works and Water Management (V&W), Airport Economics and Research Section, Air Transport and Infrastructure Policy Directorate.

Drs. P.J. Uitenbogaart, Ministry of Transport, Public Works and Water Management (V&W), Airport Economics and Research Section, Air Transport and Infrastructure Policy Directorate.

Ir. H.C. van Evert, Ministry of Transport, Public Works and Water Management (V&W), Transport Research Center (AVV), Strategic Studies Division.

Ing. H. van Vliet, Ministry of Transport, Public Works and Water Management (V&W), Transport Research Center (AVV), Strategic Studies Division.

Mr. ir. J.P. Jonges, Ministry of Transport, Public Works and Water Management (V&W), Transport Research Center (AVV), Program Supervisor - Strategic Studies Division.

Dhr. P. Dingemanse, Ministry of Housing, Spatial Planning and Environment (VROM), Planning, Rijksplanlogische Dienst.

Drs. K. A. Heineken, Ministry of Housing, Spatial Planning and Environment (VROM), Hoofdafdeling Economische Beleids Advisering, Centrale Directie Financiele en Economische Zaken.

Drs. M. A. Koning, Traffic and Transport Section, Central Planning Bureau

Persons Interviewed

Airlines:

Drs. B. Veldman, STRATEGEM, Managing Director

Dhr. J.W. Kerckhoff, KLM, Director - Corporate Strategy and Planning

Dhr L. van der Weijr, KLM, Director - Corporate Strategy and Planning

Dhr. B. Grin, KLM, Director - Cargo Development

Dhr. I. Dale, British Airways, Senior Strategist - Corporate Strategy

Dhr. P. Rhijnsburger, Transavia Airlines, Deputy Director - External Affairs

Mw. B. Houben, British Midlands, Marketing Executive

Airports:
Prof. drs. J.G. de Wit, Ministry of Transport, Public Works and Water Management (V&W), Directorate General for Civil Aviation, Head - Airport Economics and Research Section

Ir. Jurek Keur, Amsterdam Airport Schiphol, Head - Airside Environment and Strategy

Dhr. F.S. Bisschop, Amsterdam Airport Schiphol, Director - Cargo

Mr. P. Kraaijeveld, Amsterdam Airport Schiphol, Manager Cargo Research

Dhr. A. McDermid, British Airports Authority (BAA), Head - Airport Strategy

Dhr. B. Korsgaard Pederson, Copenhagen Airport, Project Manager - Planning Department

Ir. H.J. Simonsen, Copenhagen Airport, Project Engineer - Aircraft Related Design

Drs. R.J.V.M. Buck, Buck Consultants International, President

Airport and Airspace Capacity:
Dhr. B. Miallier, EUROCONTROL, EATCHIP Development Directorate, Head - User Requirements and Concept Definition Section

Ir. H.J. Kamphuis, Air Traffic Control (at Schiphol), Head - Navigation and Airport Strategy

Dhr. H.J. Klumper, Ministry of Transport, Public Works and Water Management (V&W), Aeronautical Inspection Directorate

Drs. S. Jonkhart, National Aerospace Laboratory (NLR), Environmental Research Engineer, Flight Division

Ing. P. Frankena, National Aerospace Laboratory (NLR), Project Engineer aircraft noise, Flight Division

Dhr. N. Solat, United States Federal Aviation Administration, International Technical Program Manager

Airport Costs:
Ir. H.A. Brockmeier, Netherlands Airport Consultants B.V., Managing Director

Ir. F. Kamerling, Netherlands Airport Consultants B.V.

Ir. M.V. Julius, Netherlands Airport Consultants B.V.

Future Demand for Air Transport:
Dhr. G. Dallery, Airbus Industrie, Strategic Planning Manager - Forecasting

Dhr. C. Vandenberghe, EUROCONTROL, Head - Air Traffic and Statistics Section

High Speed Train:
Ir. J. Griep, Ministry of Transport, Public Works and Water Management (V&W), Projectbureau HST

Prof. ir. J. Pavaux, Institute of Air Transport, Director General

Dhr. M. O'Hanrahan, Institute of Air Transport, Editor in Chief (ITA-Press)

Dhr. J. Braber, Hogesnelheidstrein Vervoers Esploitatie Maatschappij (HST-VEM), Marketing and Sales

Dhr. R. Umans, Hogesnelheidstrein Vervoers Esploitatie Maatschappij (HST-VEM), Controller

Dhr. K. McMillan, Editor - Avmark Aviation Economist

Surface Transportation:
Ir. J.W. van Ammers, DHV, Managing Director - Transportation Planning Department

Ing. H.B. Waller, DHV, Projectleader - Logistics and Transport Sector

Societal Developments:
Prof. P. Nijkamp, Vrije Universiteit Amsterdam, Department of Regional Economics

Prof. P. Rietveld, Vrije Universiteit Amsterdam, Department of Spatial Economics

Prof. A. Faludi, University of Amsterdam, Amsterdam Study Centre for the Metropolitan Environment

Scenario Development Methodology:
Ir. E.J. Verroen, TNO Institute for Policy Studies, Centre for Infrastructure, Transport and Regional Development

Dhr. J. Leemhuis, Global Business Network (GBN)

Miscellaneous:
Dhr. K. den Braven, Ministry of Transport, Public Works and Water Management (V&W), Directorate General for Civil Aviation, Head - Air Transport Policy Division

Dhr. F. Sorensen, Commission of the European Communities, Directorate General for Transport, Air Transport Policy

Ir. J. Franssen, Stichting Natuur and Milieu, Traffic and Transport

Dhr. R. Fennes, Ministry of Transport, Public Works and Water Management (V&W), Directorate General for Civil Aviation, Senior Air Policy Officer

APPENDIX B

STRUCTURAL CHANGES TO THE CIVIL AVIATION SYSTEM

Structural Changes Affecting Supply

1. Fragmentation versus harmonization of European airspace
2. Satellite-based versus radio-based navigation, control, and surveillance systems
3. Constrained versus unconstrained availability of land
4. Public versus private ownership of airport and other infrastructure
5. Centralization versus decentralization of ATC providers within Europe
6. Opening military airspace for civilian use versus keeping it closed
7. Centralized versus decentralized ownership of airports
8. National versus foreign ownership of airports
9. Harmonization versus policy competitiveness of EU environmental regulations and norms
10. Dispersion versus integration of air transport facilities/functions

Structural Changes Affecting Demand and Mode Choice

1. Green behavior versus despoliation
2. Transportation versus recreational role of air transport
3. Short versus long distance vacation trips
4. Eastward expansion versus status quo of EU
5. Ground transport versus air transport
6. Telematics as complementing versus competing with air transport

Structural Changes Affecting the Operational Environment

1. Non-integrated versus integrated door-to-door transport network, services (including information services), and providers
2. Integration versus separation of local and enroute ATC

3. Vertical integration versus specialization of airport service providers

4. Consolidation and concentration versus fragmentation of the airline industry

5. Specialization versus diversification of the functions provided by airlines

6. Conventional versus space age construction materials

7. Pure transport versus value added activities on board the aircraft

Structural Changes Affecting Many Parts of CA System

1. Instrument Landing Systems (ILS) versus Microwave Landing Systems (MLS)

2. Diversification versus specialization of non air transport activities

3. Mega-planes versus small aircraft for long distance air travel

4. Conventional versus VTOL take off/landing

5. Conventional speed versus supersonic speed

6. Conventional fuels versus hydrogen-based fuel

7. Conventional planes versus low-noise planes

8. Open skies versus restricted competitive environment for airlines

9. Multilateral versus bilateral negotiations of general service agreements (GSAs)

10. Private versus state ownership of airlines

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