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THE ECOLIFTER: A NEW CONCEPT FOR A DEDICATED ADVANCED CARGO TRANSPORT

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Abstract

The development of the European economy requires an efficient transportation system. This does exist in Europe by a mix of motorways, railway-lines and numerous well developed air-ports. For passenger transportation the contenders are offering reasonable alternatives, depending on the distance to be covered. The picture changes with respect to the transportation of goods and freight. The increasing demand (roughly 7% growth p.a.) is mainly absorbed by trucks. In consequence, an enormous amount of additional traffic is generated on roads, blocking motorways and increasing emissions and risks. This paper will start with a description of the current cargo transport system in Europe and a comparison of road, rail and air will be given with respect to energy consumption, land resources required, flexibility, time and cost of transportation. In the second part, a scenario for an innovative air cargo transport system will be developed. This will include the infrastructure necessary on the ground as well as the technical and operational requirements for a future dedicated civil cargo aircraft, capable to compete successfully with land transport and offering significant advantages in respect of capital investment, flexibility and safety. Finally a family of aircraft dubbed „The Ecolifter", covering the 200 to 400 tonnes payload bracket with significant range potential will be presented and discussed.

Introduction

The establishment of the European Economic Community in the 50-ies has been at the origin of an unprecedented development of welfare in its member-countries. The free access to all national markets in combination with an increasing separation of labour and production into new "low cost" regions lead to an unpredictable demand for traffic capacity in Europe. The end of the cold war and opening of the borders of the eastern countries has further increased the demand for transport capacity in Europe. This trend will continue most certainly at a higher rate with the further development of eastern European markets and their future integration into the European Union.

The major part of freight traffic is handled by trucks, but road capacity is reaching its limits. A considerable reduction in traffic flow due to increasing congestion has a negative impact on the efficiency of the road transport system. In addition, passenger traffic is increasing. Many regions in Europe suffer from incredible noise levels, strong emissions of toxic gases, endless queues of vehicles and numerous victims of traffic accidents.

The political and public discussion is mainly focused, how cargo can be transferred to rail; but despite major investments by several governments and the European Community, no major effect has been realised.

Due to the very dense population in central Europe, all new efforts to build new motorways and High-speed-train tracks are confronted with major manifestations and resistance from the public. Air Cargo transport in Europe with its share of less than 1% and despite its growth rates of about 7% cannot be seen as a significant element in the European transport system today.

Traffic Situation in Europe

The following two examples are highlighting the dramatic situation in Europe:

1. In the north-south direction, 18.8 million tonnes have been transported in the year 1990 over the Brenner pass requiring 1.1 million truck movements. This means a truck every 20 seconds by day and by night. The traffic forecast is expecting a minimum of 25 million tonnes for the year 2000 (see Figure 1).

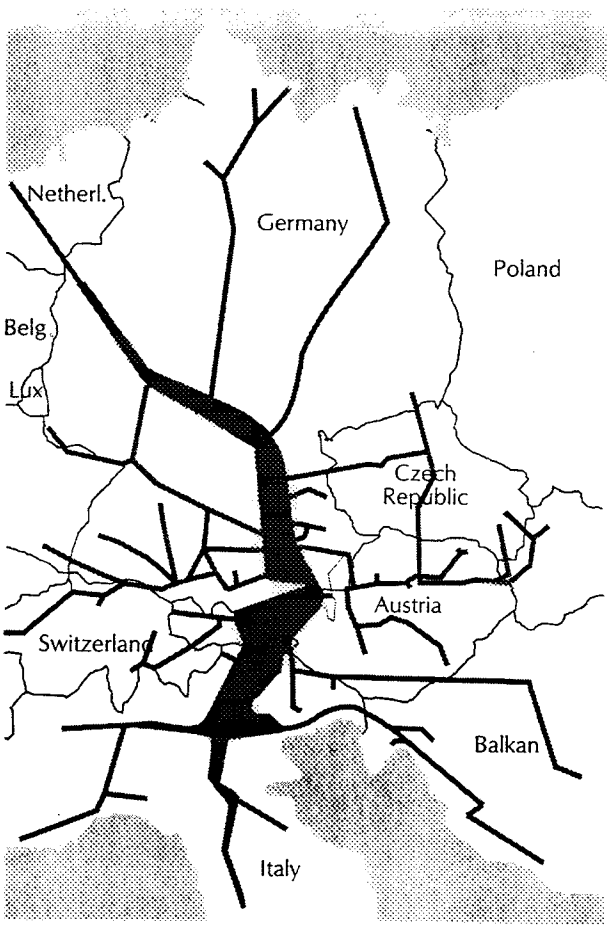

FIGURE 1 – North / South Cargo Flow – Brenner Tunnel Bottleneck

2. Since the fall of the Iron curtain between east and west, a dramatic growth in east-west traffic of more than 14% per year is registered. In the year 2000, one million truck movements across the east German border are expected. The number of roads is limited. At the A12, the main motorway between Germany and Poland, transit delays between 1 and 2 days are not unusual.

These are only 2 examples which are indicating the future traffic collapse in this areas.

The critical traffic flows through Europe can be visualised in a "hot pentagon" (see Figure 2) [6]. In this "hot pentagon" traffic congestion and collapses especially at the "Brenner-route", the motorway A12 between Germany and Poland and the French "autoroute du Sud" leading to Spain are already normal. Other routes will follow in the near future.

It is clear, something has to happen, actions are necessary! But which solutions are feasible and economically and ecologically acceptable?

The obvious solutions in the public discussions are:

- Duplication of motorways and big investments in new tunnels and bridges!
- Transfer of cargo from road to rail!

Let us first examine road transport today.

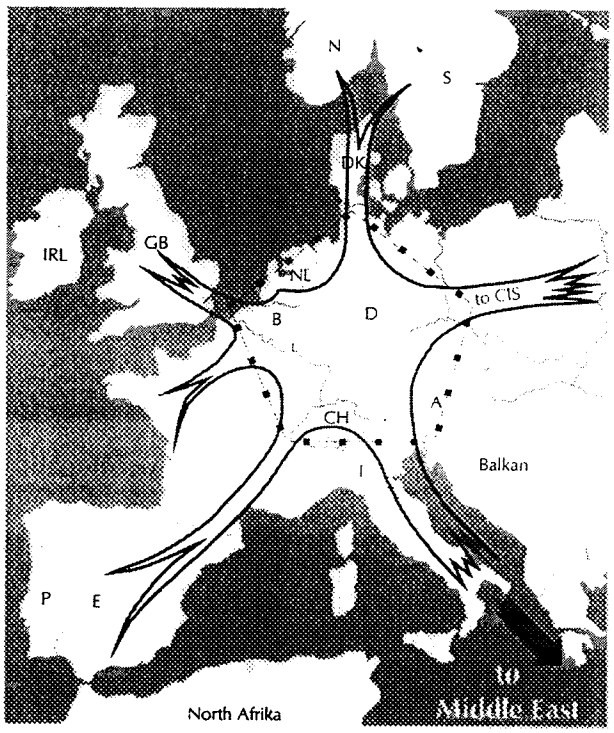

FIGURE 2 - The Hot Pentagon

Cargo Transportation by Road

It is sometimes difficult to get a consistent set of data from the same source and gathered in the same way and with the same methodology. Instead of showing the data for cargo traffic in Europe, I will present the data for Cargo traffic in Germany (see Figure 3). As Germany is right in the middle of the a.m. "hot pentagon", these data are a fairly good indicator of the European cargo traffic shares [1].

Road traffic is divided in short range and long range traffic. The short range traffic on road is without any alternative. No substitute is seen, to replace this cargo traffic economically. The long range traffic is the critical component, which is raising concern in the public debate and here are several alternatives possible: rail- and air-transport!

Cargo traffic in total increased in Germany from 1980 to 1996 by 73 % [1] (see Figure 3).

This increase in traffic demand was mainly taken up by long range trucks, which increased their share in this period by nearly 270%!

Rail transport increased in this period by only 5%. The overall share of rail fell from 25% in 1980 to only 15% in 1996. These figures are showing clearly, that trucking is the most flexible, fastest and most economical option for surface transport.

It consequently must be the yardstick for any alternative solution.

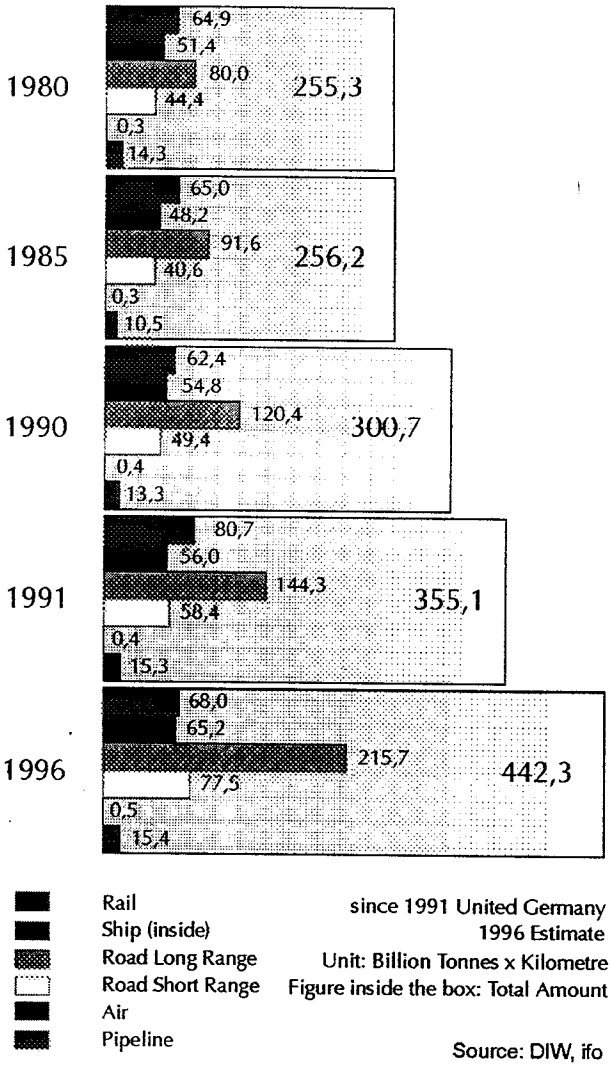

FIGURE 3 - Cargo Statistics for Central Europe

Diversion of Cargo Transportation to Rail

In the public discussion, all the political effort is directed, how the rail system can be supported to be more competitive. In 1995 for example, the government in Germany invested 3 times more for rail than for road transport! If now a transfer from road to rail is politically envisaged, a simple but illustrative example is given in [7] (see Figure 4). If only 10 % of the long range road traffic should be substituted by rail, this would require an increase in rail transport by about 30 %. As rail transport does not have the flexibility to bring the goods from the source point to the final destination, a "combined traffic system" (intermodality) is required. The combined traffic therefore has to increase by 170% from today's figures just to reduce the long range traffic on roads by 10%.

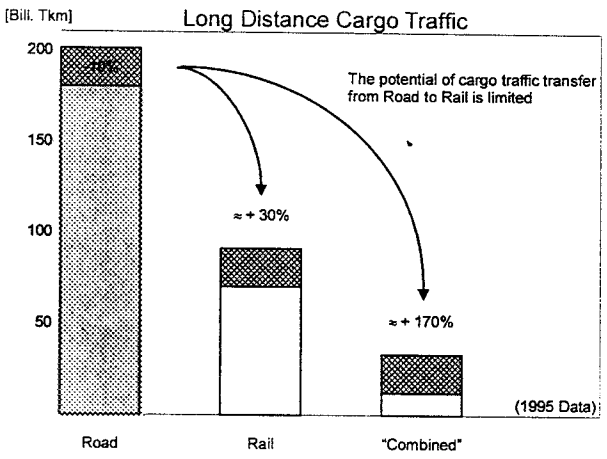

FIGURE 4 - Diversion of Freight Capacity from Road to Rail

Between Northern and Southern Europe the market share of rail in the 1970 to1992 period dropped from 80% to 46%.

In central Europe the market share of rail in the 1980 to 1996 period dropped from 45% to 24%.

In Germany the overall load factor of trains has been less than 50%.

The advocates of rail believe in a reversal of this trend but as the above figures show, this wishful thinking and hoping is not shared by the market!

The main problems of rail are:

- cost (particularly capital and system maintenance);
- high block time (up to two weeks from southern France to Sweden for example);
- inflexibility;
- lack of interoperability;
- matching of freight and passenger traffic on same tracks;
- national rail cartels.

Future Transport Development

As can be seen in Figure 5, an increase in growth national product is linked with a parallel increase in revenue passenger miles or more generally with an increase in demand for transport capacity. On top of the increase in GDP in Europe, the further globalisation of the industrial production will demand additional freight transport capacity.

If transport demand further increases by about 6 % per year in Europe [4], this increase can not be handled just by putting more trucks or trains on the existing road- or rail-systems.

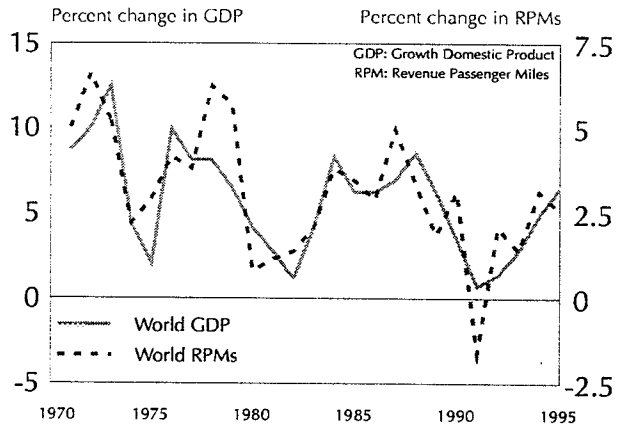

FIGURE 5 – Welfare and Traffic Demand

The consequences of the overburdened road traffic are:

- Traffic jams and accident risks;
- Degraded efficiency of transport (including personal traffic and public acceptance);
- Loss of punctuality;
- High road/rail maintenance/repair costs;
- Major investments for additional tracks (road or rail);
- More land required;
- Environmental opposition due to increase in noise and pollution.

Road congestion is currently estimated to waste up to 150 billion US-$ a year in lost time and fuel within the EU!

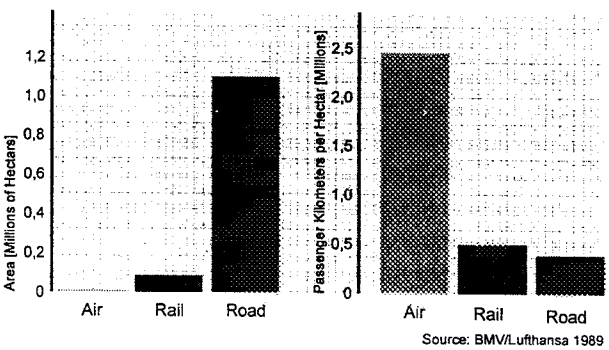

FIGURE 6 - Comparison of Land Consumption

Costs for the proposed new Brenner tunnel between Munich and Verona are estimated to be in the order of 80 billion US-$; a fairly simple new highway project between Berlin and Moscow is estimated to cost about 12 billion US-$. But this is only one new track. All other tracks have to be upgraded consistently to cope with the increase in traffic, a multibillion $ exercise. The enormous landmass consumption to increase land transport capacity will not be easily accepted by the population. Surface transport requires a very high amount of land, compared to air transport (see Figure 6).

Environmental impacts are equally dramatic.

Cargo Transportation by Air

Cargo transport by air is hardly visible in Europe compared to that of other transport means (about 0.3%). In none of the public discussions, an increase in air cargo is seen as a means to alleviate the surface transport system. Main arguments against air cargo are:

- energy consumption is too high;
- cost are not competitive;
- only old aircraft are cost efficient but not environment friendly.

But, the obvious advantages of air freighting among others are:

- high transport speed (low block time);
- flexible route structure and independence of topography;
- wide range spectrum;
- no direct en-route noise and emission impact on the population;
- small land requirement (1/5 compared to rail and 1/6 compared to road, see Figure 6);
- reduced traffic jams and accident risks;
- reduced financial investments (about 1/15 compared to land transport).

Comparison of Energy Consumption and Cost

There is only limited literature available, which allows a comparison of energy consumption for different transport means [8],[9]. In [8] a methodology is outlined, based on the aerodynamic efficiency L/D = 1/e, which allows in a consistent manner to compare the specific primary energy consumption for different transport means. Starting from the energy the transport vehicle is consuming per passenger and kilometre, several efficiency factors are introduced like loadfactor, propulsion-system-efficiency-factor, geographical-detour factor, construction factor (relation of payload to max. vehicle weight), etc.. Figure 7 is showing that the aircraft is very efficient for transportation of passengers, always comparable and often better than car, rail and high-speed-trains.

For cargo transportation the picture will slightly change, the truck being the yardstick for all other transport means. Its higher transport capacity

compared to the private car is increasing its transport efficiency considerably!

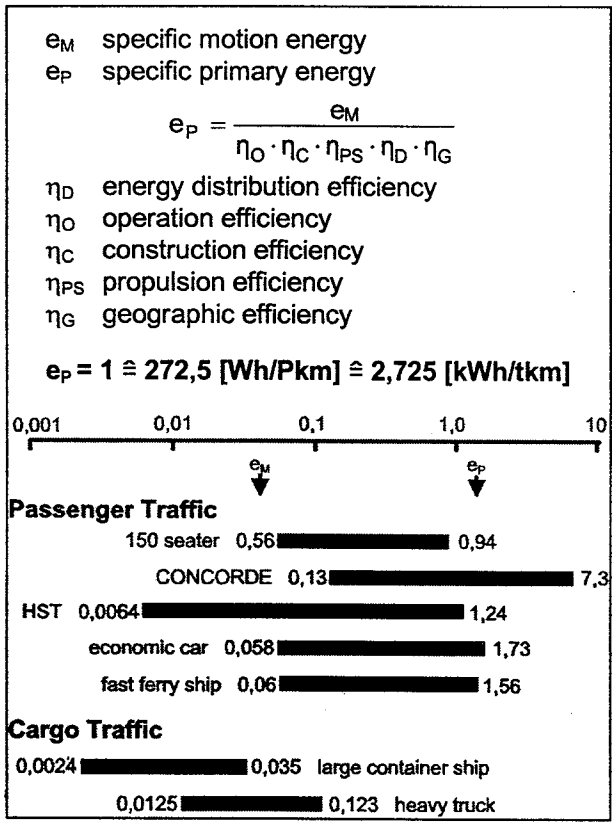

FIGURE 7 - Comparison of Specific Primary Energy Consumption

Primary energy consumption is however only one factor out of several others. A direct operating cost method is needed, where in addition to energy consumption (fuel consumption) also maintenance, depreciation, interest rates, insurance, route fees, taxes and personal costs (crew) are included. As the realities of today's cargo market show, the low cost of trucks and their flexibility to carry goods directly from A to B without any transfer or reloading is one of the attractions of long range cargo transport on road!

But there are some other parameters like transport speed (block time), landmass consumption, noise and emissions, where road transport is stalling.

Some advantages for the air cargo transport are obvious:

- there is a clear time benefit, which makes it attractive;
- geographic hurdles like mountains, rivers, seas or oceans are not obstacles;
- in the air is no need for fixed tracks, there are only "soft tracks".

As can be seen by the success stories of FedEx, UPS, DHL and other so called "integrators", the fast and in-time delivery of parcels and goods all over the world is a very attractive product and fulfils a market demand. This shows that the cargo aircraft may have a big future, if its positive aspects can be put into an integrated transport system.

A New Air Cargo System

Most of the Cargo aircraft flying today are modified former passenger aircraft [3],[4],[5]. There are some attempts mainly for outsized cargo, to build specific transport aircraft like the A300-600 ST Beluga from Airbus [10]. But this are special purpose developments instead of developments for the general air cargo market.

If the air cargo transport system in Europe should be successfully installed, some new features have to be considered.

Air traffic congestion is a limiting factor today in the vicinity of major European hubs. If in addition to the further increasing number of passenger aircraft airports will have to cope with an increasing number of freighter aircraft, the system will collapse. A basic assumption will be: The passenger and the cargo transport have to be separated. A tendency in this direction is already visible. Major operators like Lufthansa, KLM and BA have separated responsibilities (business units) for their passenger and cargo operations to better cope with the specific demand in each sector. In the long term this trend will continue.

Therefore air cargo should be handled at specific airports, where only little or no passenger movements will take place. These cargo airports need a normal runway and a cargo terminal area. The investment in cargo terminals and loading devices will be considerably less compared to passenger handling. In each major European country about three to four specific cargo airports will be needed. New cargo airports could be transformed from abandoned military airfields. So some elements like runway and terminal areas would already exist. In Germany for example the three cargo airports could for example be located in Manching (close to the Munich area), in Hahn (close to Frankfurt and Cologne) and in Parchim (between Hamburg and Berlin). So the major economic areas could be served.

The basic requirements for the new cargo airports are:

- within 100 km of a major economic region / centre;
- no restrictions for night operations;
- direct access to the motorway system;

- direct access to the railway system;

The separation between cargo and passenger transport alleviates airport congestion. The airspace in Europe can still handle additional flight movements, especially by using new technologies like GPS and the envisaged "reduced separation minima".

In the interim phase, till the new cargo airport system will be operational, the existing airports would still handle both, passenger and cargo.

Requirements for Future Dedicated Civil Cargo Aircraft

As mentioned earlier, all current cargo aircraft are developed from either military transports (C130, An 124, etc.) or from passenger aircrafts (B747, A300, MD11 etc.)[5]. The example of the Beluga indicates, that requirements for an optimised cargo aircraft are different from passenger aircraft.

- Cruise Mach number: not less than M = 0.7;
- Range: not less than 3500 km (1900 nm) for Intra Europe and 7500 km (4050 nm) for worldwide operations;
- Payload: not less than 250 tonnes with development potential to at least 400 tonnes. Load to be carried normally in 8ft wide intermodal containers compatible with road and rail transport;
- Airfield: standard runway length (between 3000 and 4000 m); ACN flexible Cat. B, 66 Rigid Cat. B;
- Noise: Reduced noise configuration to allow 24h operations;
- Turnaround: quick loading- and unloading-configuration; i.e. front end loading, advanced container loading system;
- **Economy:** is the driver for the aircraft configuration;
- Systems: adapted air conditioning requirements for cargo hold;
- Pressurisation limited to cockpit section;
- Technology: only cost effective, advanced technology, covering also maintenance and ground operation issues;
- Engines: available and proven advanced turbofan engines.

The ECOLIFTER Concept

Much more work is required to establish a proposal for a future air cargo transport system for Europe and develop from the market needs and market forecasts the requirements for a dedicated, optimised Cargo Transport Aircraft that also must fit the global market. An aircraft concept has to be developed, not neglecting "unconventional configurations" like:

- Flying wing;
- Blended wing body;
- Three surface concept / canard configuration;
- Twin fuselage layout;
- etc.

which will have to be examined. But to start the analysis a well established reference vehicle is needed. Hans A. Nietzballa, a physicist, is at the beginning of the ECOLIFTER idea. In 1991 he prepared a study about the potential use of an Ultra High Capacity Aircraft and its benefits compared to cargo transport on road or rail. The idea has been taken up by two former aircraft design experts from Airbus – Jean Roeder and Bernard Davey – who have developed a reference aircraft configuration[6]. Since about one year, the aeronautical departments of three major European Universities (ENSICA in Toulouse, France; Cranfield University in Cranfield, UK and Lehrstuhl für Luftfahrttechnik at Technische Universität München, Germany) have agreed an MoU to further promote air cargo research and the ECOLIFTER concept and have created an "Air Cargo Research Team". In this context the ECOLIFTER concept will be further investigated, alternative configurations will be examined, and evaluation of performance and cost of each concept to consistent standards will be done.

The ECOLIFTER baseline configuration, as it stands today, is based on a fuselage cross section, which can load four standard container (8 feet wide, two side by side – see Figure 8). The side view is shown in Figure 9 and has the following characteristics:

- 250 t payload capability with development potential to 400 tonnes;
- fuselage cross section for four longitudinal rows of 8ft wide intermodal containers;
- low wing position;
- low cockpit position as proven in the A300-600 ST Beluga to allow front loading (see Figure 11);

- engine installation to allow a high degree of noise shielding;
- reduced air conditioning required for cargo holds, which remain unpressurised;
- acceptable field performance;
- dual main landing gear configuration;
- longitudinal and lateral stretch capability (twin body, Figure 10).

The ECOLIFTER concept is still a relatively conservative design. This allows to have a fairly well established weight breakdown and a well proven reference configuration.

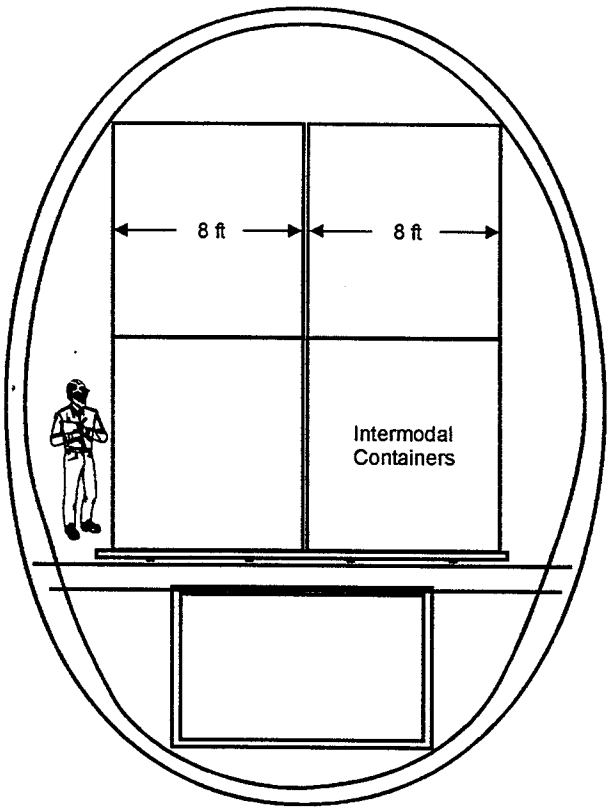

FIGURE 8 - ECOLIFTER – Cross Section

Figure 8 shows the fuselage cross section, Figure 9 the general arrangement and Figure 10 shows the proposed family concept, which can be developed up to 500t payload. Due to the big wing, a range extension can fairly easily be developed.

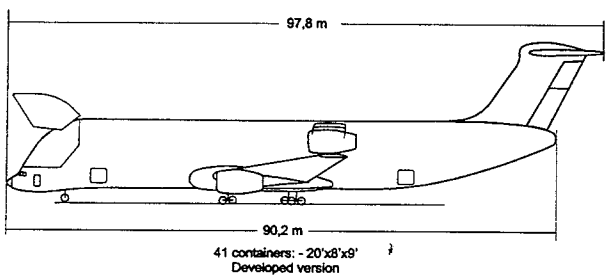

FIGURE 9 - ECOLIFTER – Baseline Configuration

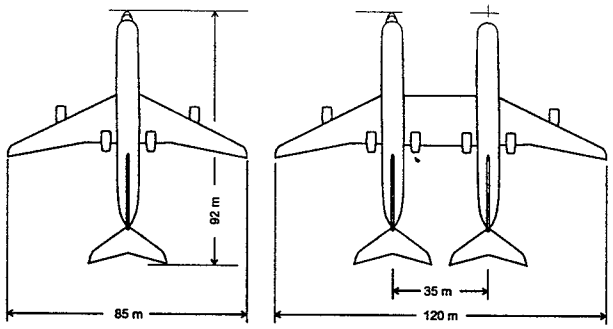

FIGURE 10 - ECOLIFTER – Family Concept

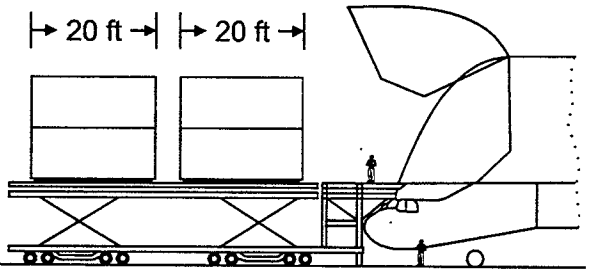

FIGURE 11 - Front Loading Concept

Several students and student teams are working at different aspects of this configuration.

Conclusions

The liberalisation of trade in Europe in addition to the opening of the eastern European countries is creating a huge demand for freight traffic. The well developed road and rail system can however no longer cope with the steadily growing traffic. Huge investments for new transport capacities – building new tracks for road or rail, costly tunnels and bridges as well as terminals – have to be made, if just an extension of the existing system is envisaged. The very low energy consumption of modern passenger aircraft in combination with the speed advantage and the growth potential of future cargo aircraft have led to the idea of a new Air Cargo Transport system for Europe. Part of this system is the development of an optimised dedicated, large Cargo transport aircraft, called ECOLIFTER. Several Aeronautical Institutes have jointly created an Air Cargo Research Team to further promote the investigations on market, logistical and technical aspects of a future Air Cargo transport system. This paper presents just the beginnings and some of the basic aspects of this initiative.

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