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THE FUTURE OF SHORT-HAUL AIR TRANSPORT WITHIN WESTERN-EUROPE, WITH EMPHASIS ON THE ROLE OF V/STOL-AIRCRAFT

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Summary

An outline is given on the future of short-haul transport in Western-Europe, mainly based on a study of the Netherlands V/STOL-Working Group. The problems of the existing system using aircraft with conventional take-off and landing techniques (CTOL) to cope with growth in passenger demand, are considered. It is pointed out that the introduction of a new category of aircraft, using improved take-off and landing techniques (RTOL or STOL) can relieve these problems. However, their application is not seen to occur within a new, separate short-haul transport system, but as an extension and supplement to the existing CTOL-system.

1. Introduction

The subject of this paper is the future of short-haul air transport within Western-Europe, with emphasis on the possible role of V/STOL-aircraft. In the last twenty years an enormous amount of literature has been published on V/STOL-aviation and it seems appropriate to indicate firstly some motives for the study from which some thoughts and conclusions are presented.

In 1971 the Ministry for Transports, Hydraulics and Public Works of the Netherlands Government published a brochure on the future of national and international transport for the Netherlands, where all means of transportation were considered (cars, railways, water- and air transport). One of the goals of this study was to stimulate discussions in the Netherlands, which could lead to a more detailed prediction of the development of transport in the future. A fairly large part of the study-known as TP-2000- was devoted to the future of air transport.

Based on the rather optimistic views presented in the literature during the sixties in relation to short-haul air transport, TP-2000 stated: "Major developments in the short- and medium-haul air transport can be expected to come from STOL- and VTOL-aircraft. Some obstacles will have to be overcome, with regard to noise, safety and operating costs. In view of the large efforts, especially in military aviation, it is foreseen that in the eighties civil VTOL-airplanes will become available for regular operation". Moreover, within 5-10 years the use of STOL-aircraft with a capacity of 100-200 passengers was predicted in TP-2000.

To obtain a more thoroughly founded view on the future of short-haul transport in Western-Europe an initiative was taken by one of the Directors of the Civil Aviation Department of the Government to establish a Netherlands V/STOL Working Group. The members of this Group were invited from all civil aviation branches in the Netherlands on a personal membership (fig. 1). This paper is mainly based on the final report of the group, which was published in 1973 (ref. 1); but also some recent information is included.

The results of the study will show to be not at all revolutionary and very much different from the optimistic views on the introduction of V/STOL aircraft, which were given in the sixties. However, they are in agreement with other present views on the subject (e.g. ref. 2 and 3).

2. Growth of short-haul transport; limitations of CTOL-system

The most crucial point in the prediction of the future of air transport is the expectation on growth. It is well-known that during the past decennia the growth in world air transport (in passenger miles) was about 15% per year, that is a doubling every 5 years.

The sudden appearance of the "energy crisis" at the end of 1973 has put forward many questions on future growth problems, but the author believes that the increase of transport is one of the most fundamental issues of our developing world, which will not be changed suddenly due to short-term political events. For Western-Europe a potential for future growth seems available, in case the air transport industry offers more extensive services for the passengers. The reasoning for this potential is based on:

- a. an increase in international activities of the governments, industries, trade companies, banks, etc. which will stimulate business air trips,
- b. growing standard of living, leading to increased time and money for holiday-travels and for private trips over longer distances by air during the whole year,
- c. greater familiarization of the general public with air transport, promoted by charter operations for holiday travel.

When studying the future of air transport all components of the air transportation system has to be considered:

- the aircraft,
- the airport (runway-system and passenger/freight terminals),
- the air traffic control (ATC) system,
- the means of passenger access and egress.

These components of the present CTOL-system have serious limitations which can be expected to hamper the future growth of air transport. As possible limitations are to be considered: noise, congestion, land-use, pollution and fuel-shortage.

At the moment the most serious limitation is the noise-annoyance caused by aircraft to the communities living near airports. Restriction of the number of operations on airports or even closing at night hours, are threatening the expansion of air traffic. Moreover, increased use of secondary airfields, which had up till now very little or no traffic, seems rather impossible due to public opposition. Although this noise problem will stick to aviation during the seventies - maybe the early eighties - because of the use of first and second generation jet-aircraft, it can be expected that the noise problems caused by future aircraft will be greatly reduced. Fig. 2 gives a rough estimate of the noise footprint-areas of future aircraft in comparison with the types now in use. From such data it seems that in the eighties noise problems would not restrict the traffic of CTOL-aircraft on large international airports, located at relative large distances from the city. However, for short-haul operation using airfields nearer to communities, very quiet aircraft could be desirable, which differ from CTOL-types by the use of special engine-types, extreme acoustical treatment and/or steep-gradient flight techniques.

The next important limit for growth seems to be in the area of congestion in the air, on the airport and in ground transport to and from the airport. Without doubt much can be done to increase the capacity of the CTOL/system in the future in these respects. Fig. 3 gives a survey of some possibilities, which are for a large part already under development.

Of course the airport saturation problems can also be much relieved by the construction of new large airports. This possibility is, however, very much restricted by a number of reasons:

1. the use of a large land area, which can hardly be found on reasonable distances from the cities,
2. the vast infrastructure required for transportation of passengers, freight and employees to and from the airport,
3. the large initial costs of the airport and its infrastructure,
4. the heavy public opposition caused by the noise problem of the aircraft of today, the fear for air pollution and the possible effect on natural and/or resort areas.

Some people even believe that the new Paris airport Roissy-en-France will be the last large airport to be constructed in Western-Europe. Although this might be too pessimistic, it is certain that the possibilities to extend the number of large CTOL-airports in this part of the world will be very restricted.

It is at this moment difficult to predict the time of saturation of the CTOL-system in Western-Europe, taking into account the uncertainty of future growth,

the improvements of the system and the building of new airports. However, it seems worthwhile to consider how new aircraft-technology can possibly be used to relieve the CTOL-system. It is the unanimous opinion of the Working Group that long-haul air transport will remain for a long time the domain of CTOL-technology; for short- and medium-haul transport new categories of aircraft could become feasible, as will be indicated in sections 3 and 4.

Atmospheric pollution at low altitudes is not considered as a possible limitation for future growth, because aviation is only a small contributor to the total pollution. Furthermore, actions are already well under way to reduce the pollution content of exhaust gases, in particular for new engines.

In the author's opinion a very comprehensive appraisal on the fuel situation has recently been given by Stamper (ref. 4), which can be summarized as follows:

- a. in the short term no fundamental shortage of fuel will exist,
- b. most important effect of the recent "man-made" crisis is the increase of fuel prices, that will effect aircraft operation and future design-concepts,
- c. kerosine seems the "ideal" fuel for aviation due to the high heating value based on weight and volume; when natural resources run out, aviation will have to rely on synthetic kerosine-type fuel.

This last statement may, however, be altered in the case a world- (or continental-) wide energy-supply based on nuclear/hydrogen technology would develop. Some believe that aviation could have a pioneering role in this development, following in the footsteps of space technology.

3. Prospects of aircraft categories other than CTOL

During the sixties the aircraft industry produced a large number of project studies on STOL- and VTOL-aircraft. In 1971 the Institut du Transport Aérien in Paris - well known under its abbreviation ITA - published a study, which gave details of 21 civil STOL-aircraft designs and 7 civil fixed-wing VTOL-aircraft (ref. 5). In the ITA-bulletin of March 1974 (ref. 6) one can read how little is left of all these projects of the sixties and how little is added on new civil V/STOL-types.

In the author's opinion the exaggerated expectations on V/STOL in the past have been caused by two facts. On the one hand, too optimistic views on the solving of the technical and operational problems and on the funds available for development. On the other hand an underrating of the fact, already mentioned, that the aircraft is only one component of a complete transport system.

A summary of the various categories of aircraft classified according to their take-off and landing performances, is given in fig. 4. Among the aircraft with improved take-off and landing characteristics compared to CTOL, the helicopter and the propeller-driven R- and STOL-aircraft (like the De Havilland Canada DHC-7) are the only types, which can be made available for civil aviation in the near future. Both aircraft categories have limited cruising speed and are of relative small size, which gives them a low productivity in comparison with the CTOL-jets. For Western-Europe, where no immediate need for a supplement to the CTOL-system is required, an introduction of these aircraft on any large scale is not foreseen. Their application is only likely for third-level operations and for low-density traffic in remote areas, but not for medium- and high-density commercial operations.

It was also the strong opinion of the Working Group, that another aircraft category from fig. 5 has to be eliminated for use in the foreseeable future: the fixed-wing civil VTOL-aircraft.

In the past, city-centre to city-centre air transport was considered as an attractive topic for the future, which would demand these VTOL-aircraft. Although the technical and operational problems of vertical (and ultra-short) take-off and landing may be solved by considerable research- and development efforts, it is thought to be unlikely that this type of air transportation will develop on a large scale because of the following reasons:

- a. the inherent large power weight and aircraft complexity will hamper economic operation in comparison to other aircraft categories,
- b. severe public objections against air traffic in densely populated areas because of fear for noise, pollution and accidents,

- c. high prices of real estate in city-centres, which will make VTOL-ports with the necessary extensive facilities for passenger-handling costly,
- d. the passenger origin and destination will quite often not be in the city-centre itself, because the city-oriented activities of the past are spreading to the suburbs, as the living quarters do.

From the considerations above, it follows that the most likely class of aircraft to be used in addition to CTOL-types in the eighties will be in the R- or STOL-category, which at that time will be powered by turbofan-engines.

4. Application of R- and STOL-aircraft in the air transport system

As to the application of R- and STOL-aircraft two possibilities can be distinguished:

- to fulfil a short-haul demand with a new air transport system, which is separated from the existing CTOL-system and connected to this system for feeder purposes only,
- to operate within the existing CTOL-system to relieve some of its problems with regard to noise and/or congestion.

To reduce the door-to-door travel time and to relieve the CTOL-system new, separate STOL-air transport-systems have often been suggested in the past, e.g. using a network of peripheral STOL-ports near the cities (ref. 7). Extensive studies have been published for solving the traffic problems in highly-urbanized regions in the USA by the introduction of such a system, using STOL-aircraft with runway-lengths of 1500-2000 ft (450-600 m), e.g. for the North-East Corridor, Los Angeles - San Francisco area and the Chicago-region. The flexibility of the STOL-system, which allows to fit the network to a changing demand, and the relatively low costs of the infrastructure required, are often quoted as advantages compared to new ground transportation systems. However, such a new air transport system has not materialized, because a vicious circle or "chicken and egg"-problem related to its initiation seems to exist (fig. 5). The aircraft industry, willing to start the development of first generation STOL-aircraft, cannot find customers, because the airlines do not see readily available, profitable demand-markets. These markets cannot develop without some start of the system. Seeing no definite actions by others, the Governments are reluctant to build STOL-ports, to establish separate ATC-facilities and to give the financial support to the aircraft- and engine-industry for development of STOL-aircraft, which closes the circle.

A break-through in this vicious circle can clearly only be brought forward by the execution of a well-defined transportation plan by Governments, which would make available all components of the STOL-system at the same time on a reasonable scale. The experimental STOL-service between Montreal and Ottawa and the development of the De Havilland Canada DHC-7 (ref. 8 and 9) are to be considered as attempts of Canadian aviation to stimulate such a break-through. The state-of the art of STOL-technology will also be improved by the development programs of the two AMST-aircraft in the USA (Advanced Medium STOL Transport: Boeing YC-14 and McDonnell-Douglas YC-15, ref. 10).

Whereas the prospects of a development of a separate STOL-system under governmental lead seems even in the USA still uncertain, this holds the more for the Western-European scene. It is unquestionable that the development of a STOL-system in Western-Europe has to be based on international cooperation, e.g. within the European Economic Community. Neither the political, nor the economical climate, however, seems favourable to expect such a cooperative air transport planning in the seventies for execution in the eighties.

Without a supra-national transportation plan, it is unlikely that a separate R- or STOL-system, which can take a considerable share of the short-haul market, will come into being in Western-Europe.

Recent studies in the USA (ref. 11 and 12) show still the viability of a new short-haul system, however, using RTOL-aircraft ^{*}) with field length of 3000-4000 ft (900-1200 m), instead of 2000 ft (600 m) or less. These larger field lengths are favoured because of the lower aircraft direct operating costs and the availability of runways of sufficient lengths on many existing airfields. With regard of the introduction of such a system, especially from the summary of ref. 11 can be quoted: "Short-haul systems will probably be implemented initially to help relieve congestion at large hubs. As economic feasibility and community acceptance of short-haul is proven, it is expected that the system will expand to secondary airports. The induced market response can be expected to further stimulate the system growth".

It is likely that also in Western-Europe any introduction of aircraft with improved take-off and landing characteristics will be in a gradual way within the CTOL-system to cope with noise and/or congestion problems, that will arise with increased traffic.

The first aircraft type of a new category could be a short-haul, medium size, turbo-fan aircraft, which by careful choice of wing- and thrust loading and the application of sophisticated mechanical high-lift devices, obtains take-off and landing performances in the RTOL-class. This aircraft may have quieter engines with a higher by-pass ratio than comparable CTOL-types and also steeper flight paths in approach and climb-away. To improve their flexibility it may be designed for CTOL-operation at higher take-off weights to increase payload and/or range. This aircraft type might offer the following potentials to expand and supplement the existing CTOL-system:

- a. to increase the capacity of CTOL-airports by the use of separate runways, e.g. in close-parallel operation,
- b. to use secondary airfields near major cities with saturated CTOL-airports,
- c. to expand the aerial network by the use of secondary airfields, existing near many cities, with less environmental impact than caused by CTOL-aircraft,
- d. to prevent closing of existing airports near cities in cases where new large CTOL-airports are built, which are not very suitable for short-haul traffic because of their location at large distances from the cities.

In this scenario jet-aircraft with STOL-performances, requiring powered lift, do not appear as a next generation of short-haul aircraft. This aircraft class, which may become technically and operational feasible during the eighties, might fulfil a transportation task well after 1990, when the CTOL/RTOL-system described above, should need further extension.

From the potentials of RTOL-aircraft mentioned above, especially sub c needs further attention. Up till now the international scheduled air transport in Western-Europe is very much restricted to radially shaped networks with the national capitals as central points. The connections to other European cities are historically mainly "feeder-lines" to attract intercontinental traffic. On the other hand strictly domestic networks exist in most countries. As a result many important industrial and commercial regions in different countries of the Common Market have no direct connections by air. Already in 1965 the late Dutch aviation pioneer from the period after World War 2, Frits Diepen of Fokker-VFW, pointed out the large differences in short-haul air transport between Western-Europe and the USA and showed the large, dormant, possibilities for a denser international network within the countries of the European Economic Community (ref. 8).

A future aim for Western-Europe aviation could be the "regionalization" of the aerial network, which will require, however, a fundamental change in the protective aviation policies of the individual nations. In this respect the recommendations of the European Parliament in 1972 should be remembered. In the author's

*) In ref. 11 and 12 these aircraft are still called "STOL".

opinion the regionalization of air transport is still one of the most interesting challenges for concerted efforts by the West-European aircraft/engine industries, airlines and not in the least the Governments involved.

5. Conclusions

- a. To foster future growth of air transport in Western-Europe measures have to be taken to encounter problems due to noise and congestion.
- b. Besides improvements of all components of the existing CTOL-system (aircraft, airport, ATC and passenger access and egress) an additional potential for future growth can be offered in the eighties by aircraft in the RTOL-category.
- c. A likely development will be the use of short-haul jet-aircraft of medium size without power-lift, but with improved field lengths (RTOL) and improved noise levels in comparison with equivalent CTOL-types.
- d. These RTOL-aircraft offer possibilities to extend the aerial network by using secondary airfields and older airports.
- e. A separate V/STOL-system for city-centre to city-centre air transport is not likely to be developed in Western-Europe in the foreseeable future.

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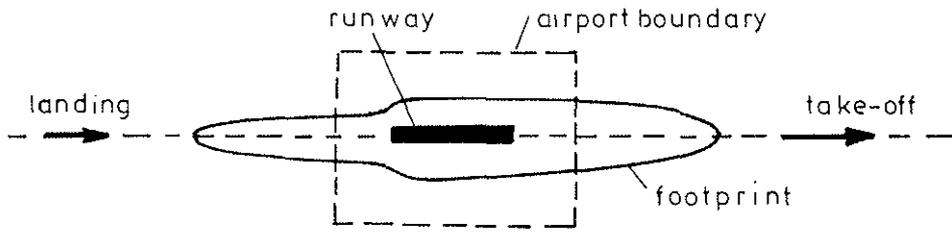
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Members of Netherlands V/STOL Working Group

Experts from:

- Fokker-VFW aircraft industry
- Netherlands Agency for Aerospace programs (NIVR)
- National Aerospace Laboratory (NLR)
- Civil Aviation Department of the Ministry of Transport, Hydraulics and Public Works
- KLM Royal Dutch Airlines
- Schiphol Airport Authority
- Delft University of Technology

Fig. 1: Netherlands V/STOL Working Group



Class	Engine-noise technology	Approach angle	climb-away angle	Footprint (sq.km)	
				90 PNdB	80 PNdB
CTOL	a. 1960	-3°	5°	80	320
	b. 1970 (FAR-36)			25	100
	c. FAR-36 minus 10dB			6	25
RTOL	d. same as c.	-4,5°	8°	4	16
STOL	e. same as c.	-7,5°	13°	2	8

Fig. 2: Foot-print area's for medium-/short-haul aircraft in take-off and landing (qualitative example only).

Component	Aim	Solutions
aircraft	increased transport volume per unit	- larger aircraft size
air traffic control-en-route	higher aircraft density by reduced separations	- improved communication/navigation systems (e.g. area nav.) - computerized traffic control - collision avoidance systems - integration civil/military aviation
TMA and runway-system	increase of aircraft movements/hr	- improved TMA-control - wake turbulence counter measures - high-speed exits and entrances on runways - dual-lane operations - improved landing systems (MLS)
airport terminal	increased passenger flows	- improved lay-out of terminals - improved passenger/luggage handling techniques
passenger access and egress		- improved high-way systems - airport-city connections by train

Fig. 3: Means for increasing the capacity of the CTOL-system

Category	Abbreviation	Runway length	Thrust/weight ratio	High-lift system	Remarks
Conventional take-off and landing	CTOL	$\geq 1500\text{m}$	0.22-0.30	mech. flaps	all current larger civil fixed-wing aircraft
Reduced t.o. and landing	RTOL	900-1200m	0.30-0.35	mech. flaps (evt. BLC)	to be considered as advanced CTOL
Short t.o. and landing	STOL	600m	≥ 0.45	mech. flaps power lift, props power lift, jets	small propeller aircraft only e.g. Breguet 941 e.g. AMST: Boeing YC-14 and McDonnell Douglas YC-15
Vertical t.o. and landing	VTOL	0m	≥ 1	rotor propellers jet-lift	helicopter e.g. tilt-wing concept vectored thrust (Harrier), lift-engines fan in wing

Fig. 4: Aircraft classification

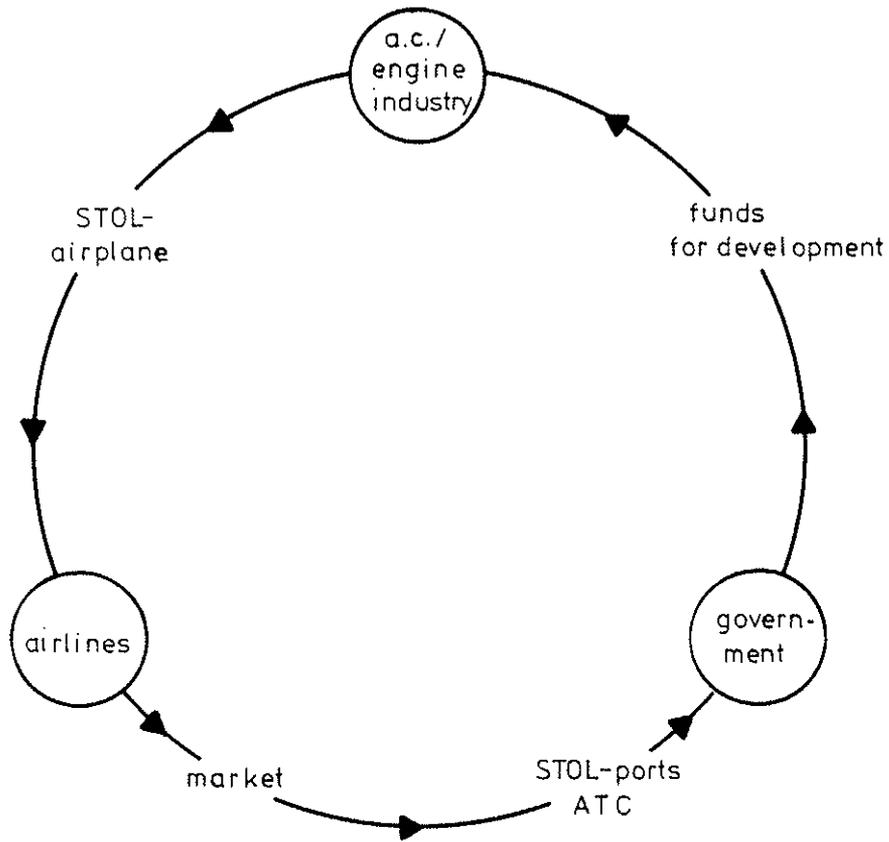


Fig. 5: Vicious circle of STOL