FOURTEENTH EUROPEAN ROTORCRAFT FORUM

Paper No. 22

EUROFAR
STATUS OF THE EUROPEAN TILT-ROTOR PROJECT

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ABSTRACT

In 1986, a joint activity between Europe's helicopter and fixed-wing manufacturers was started, to investigate the feasibility of an European tilt-rotor aircraft for the years 2000.
The EUROFAR (European Future Advanced Rotorcraft) Project, sponsored by the European "EUREKA" R & D initiative, is a cooperative five-nations, six-companies program. Following the go-ahead decision (Sept. 87), the partner companies are currently working on a 3-year phase to study specific tilt-rotor component technologies, investigate certification and infrastructure, air traffic control problems and to conduct market survey for a commercial product.

The reference aircraft configuration, on which current technical studies are based, is aimed at a maximum take-off weight of 13.000 Kg, fuselage length of 19 meters, wing span of 15 meters and a rotor diameter of 11 meters. The aircraft will fulfil a basic mission to transport 30 passengers over 1000 Km at a cruise speed of 300 knots and at an altitude of 7500 m ISA.
The main technical issues, currently under investigation, are to design a safe, reliable and minimum-weight rotor system, digital fly-by-wire control systems, advanced transmission systems and composite fuselage structures. Aerodynamic and dynamic wind tunnel models will be tested to support the technical definition of the aircraft.

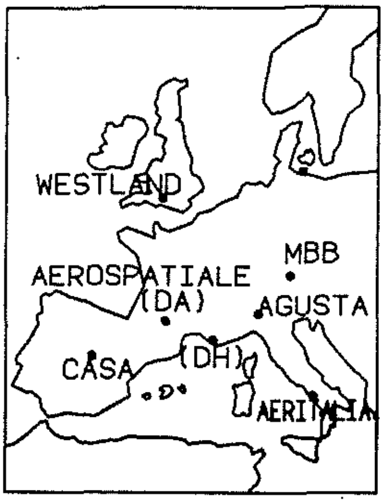
This paper gives an overview of the program schedules, the industrial organisation, the aircraft configuration, the technology studies and the current status of the envisaged technological solutions. Impacts on the aircraft layout from infrastructure, air traffic control, marketing, and certification aspects will also be discussed.

1. INTRODUCTION

The major European aerospace groups, which have acquired in the present century considerable expertise in the field of helicopters, airplanes, engines and equipments as a result of their own action or by their participation to major European programs, decided in 1986 to conduct joint activity to advance the level of the tilt rotor technology in Europe and to maintain competitiveness in this new field of future aerospace communication systems.

AERITALIA (AIT), AEROSPATIALE (AS), AGUSTA (AG), CASA, MBB and WESTLAND (WHL) jointly submitted in 1987 the EUROFAR project to the approval of European Governments participating in the EUREKA program (Fig.1).

Fig.1 EUROFAR PARTNER COMPANIES



2. OVERALL PROGRAM SCHEDULES

The overall program includes three phases (Fig.2):

<u>Preliminary Phase</u> mainly dedicated to:

- Research and Design activities to elaborate a technical definition of a tilt rotor demonstrator.
- Marketing Research and Cost Effectiveness, considering the Eurofar both as a competitor for existing traffic and, due to its unique characteristics, as a generator of new traffic.
- Infrastructure Studies considering the important inter-relationship with the urban environment problems concerning operations, logistics, public acceptance and ground system support.
- Certification Rules and Procedures considering the future regulations applicable to Tilt Rotors as agreed by National Authorities, ATC Organizations and potential operators.

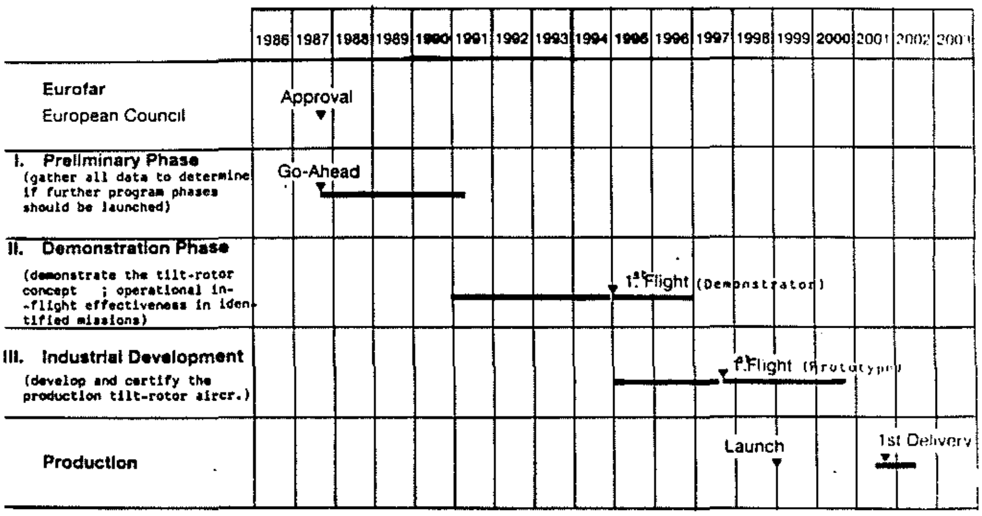
Technological Development and Demonstration Phase mainly dedicated to:

. demonstrate operational in flight effectiveness of the Tilt-Rotor concept in the identified missions.

Industrial Development Phase mainly dedicated to:

. develop and certify the production aircraft.

Fig.2 - EUROFAR OVERALL PROGRAM SCHEDULE



In September '87 a go-ahead decision was taken by the EUREKA representatives to support the Preliminary Phase for a three years period (1988÷1990). The project is being supported by governmental agencies.

3. THE INDUSTRIAL ORGANIZATION

The organizational structure is derived from previous industrial collaboration experience during which its effectiveness was fully demonstrated (Fig.3).

It is essentially structured on three levels:

A) INDUSTRIAL MANAGEMENT COMMITTEE (IMC)
with the responsibility for decisions concerning the industrial management of the program as well as the arbitration of conflicts at the IPG level.

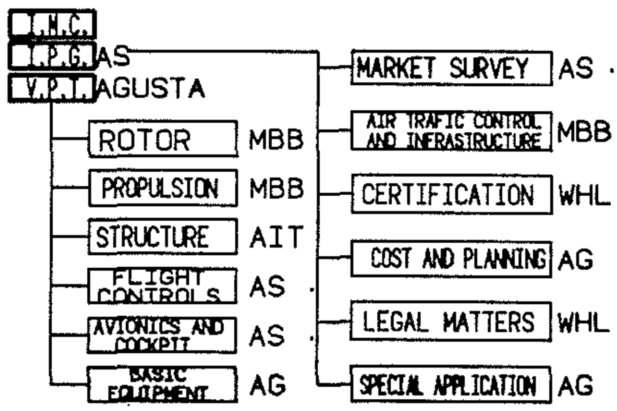
B) INDUSTRIAL PROGRAM GROUP (IPG)
with the responsibility for all the operational aspects of the program (integration of other groups, selection of main technologies, management of the program costs) as well as arbitration of conflicts at working group level.

C) WORKING GROUPS (W.G.)
with the responsibility to explore all the technical, marketing, infrastructure and certification problems prior to taking up the specific design aspects of the aircraft.

In addition the VEHICLE PROJECT TEAM (VPT) is responsible for the integrated technical decision as they result from the detailed recommendations made by the expert teams reporting to the V.P.T.

Each team is headed by one of the companies participating in the program.

Fig.3 - PHASE 1 - INDUSTRIAL ORGANIZATION



Work shares in the program are divided among the participating companies as indicated in Figure 4.
The airplane divisions of Aerospatiale and MBB are adding their technical and financial support to the program within the amount of sharing indicated in the table.

Fig.4 - EUROFAR WORK SHARING DURING PREL. PHASE

FRANCE	AEROSPATIALE	29%
ITALY	AGUSTA 20.3% AERITALIA 8.7%	29%
GERMANY	MBB	29%
GREAT BRITAIN	WESTLAND	6.5%
SPAIN	CASA	6.5%

4. GENERAL DESIGN REQUIREMENTS

The objective for the EUROFAR Preliminary Phase is to define the characteristics of a tilt-rotor vehicle mainly meeting the requirement specification derived from marketing survey. The technical groups are at the present referring to a primary civil application as indicated in Figure 5.

Fig.5 - CIVIL APPLICATION

- OFFSHORE
- CORPORATE/EXECUTIVE
- PUBLIC SERVICE
- RESOURCE DEVELOPMENT
- COMMUTER/PASSENGER
  - High Density
  - Regional
- DEVELOPING REGIONS

Principle studies on military missions are also conducted to define the potential for military applications (Fig.6).

Fig.6 - POTENTIAL FOR MILITARY APPLICATIONS

- TACTICAL TRANSPORT
- RAPID REINFORCEMENT AND RESUPPLY
- SHIP BASED, OPERATIONS
- COMBAT AIR ASSAULT
- AIR MOBILITY
- COMBAT SEARCH AND RESCUE
- WORLDWIDE SELF-DEPLOYABILITY

There are possibilities that future marketing results could alter the present reference target.

A decision has been taken to investigate the design requirements of a reference vehicle, enabling trade-off studies to be undertaken.

The main design parameters of this reference vehicle are shown in Figure 7.

Fig. 7 - GENERAL DESIGN REQUIREMENTS

- 30 PASSENGERS AT 90 Kg
- 2 CREWS AND 1 FLIGHT ATTENDANT
- RANGE 600 nm (2 x 300 nm)
- FUEL RESERVES: 87 nm at Long Range Speed
  45 min at V_{BE} at 5000 ft
- CRUISE ALTITUDE: about 7500 m
- CRUISE SPEED: 300 kts
- CAT. A CAPABILITY
- COST EFFECTIVE: Fuel efficient
- COMFORTABLE INTERIOR
- LOW EXTERIOR NOISE LEVEL
- HIGH SAFETY LEVELS
- HIGH PERFORMANCE
- AUTOROTATION
- EMERGENCY LANDING AC-MODE
- BLADE FOLDING
- DEICING
- LIGHTNING
- PRESSURIZED FUSELAGE
- RAMP SELF-SUFFICIENCY
- ADVANCED TECHNOLOGIES:
  - Extensive use of composite
  - "Fly By" technology
  - Advanced cockpit design with side arm controllers

5. PRESENT AIRCRAFT CONFIGURATION (Main Features)

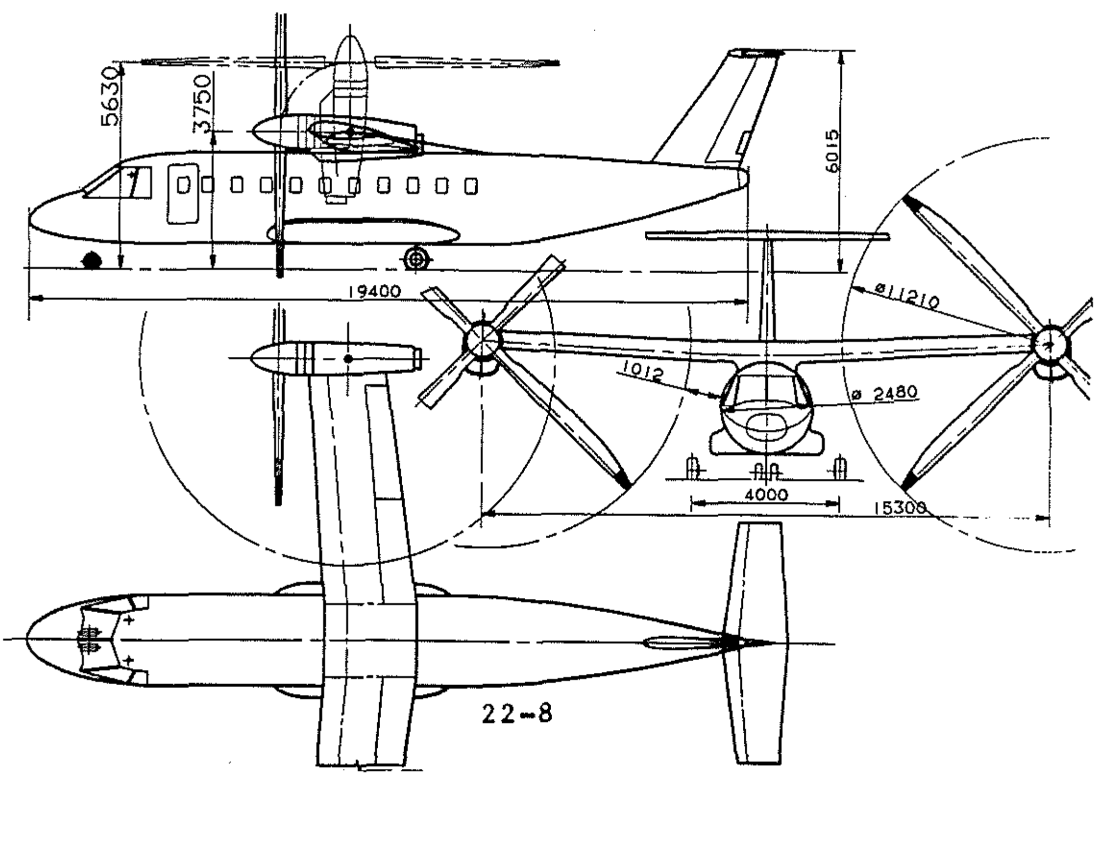
The reference vehicle is a 13 tons tilt-rotor aircraft which will fulfil basic mission to transport 30 passengers over 600 nm at a cruise speed of 300 Kts and at an altitude of 7500 m ISA (Fig.8).

Fig. 8 - CHARACTERISTIC DATA

• MAXIMUM AUW	13650 Kg
• EMPTY MASS (FULLY EQUIPPED)	8750 Kg
• EMPTY MASS/MAX.AUW	64.1 %
• CRUISE SPEED	300 Kts
• CRUISE CONDITIONS	7500 m/ISA
• WING SPAN	14.7 m
• FUSELAGE LENGTH	19.4 m
• ROTOR DIAMETER	11.21 m
• ENGINES: MCR at SL/ISA	2570 KW

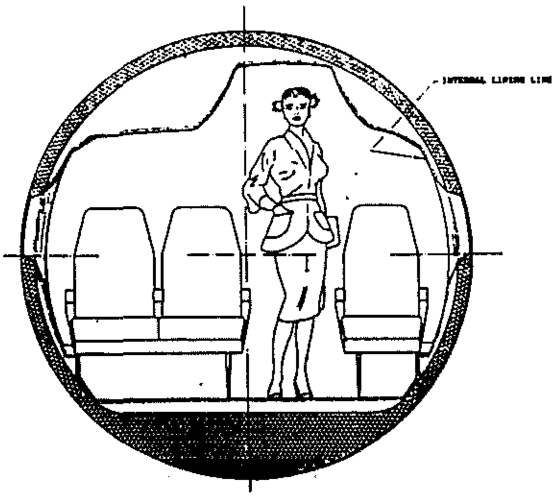
The baseline configuration is similar to a typical airplane fuselage with a low-aspect-ratio fixed-wings with wingtip mounted tilting rotors of about 11 meters diameter. The wing (35 m^2) will probably be high mounted at the top of the fuselage and may have both trailing-edge slats and flaps; its span is estimated at 14,7 m. The wing will be tapered with a forward sweep angle and small dihedral angle too (Figure 9).

Fig. 9 - THREE VIEW DRAWINGS (BASELINE CONFIGURATION)



A fuselage with an outer diameter of 2,5 m will accomodate a double seat of 102 cm. (40 in.) plus a single seat of 51 cm. (20 in.) with an aisle width of 46 cm. (18 in.) (Figure 10).
The minimum seat pitch will be 78 cm. (31 in.)
The fuselage length will be of 19,4 m with the capability to carry LD3 containers.

Fig.10 - EUROFAR INTERNAL FUSELAGE ACCOMODATION



- OUTER DIAMETER 2480 MM
- DOUBLE SEAT WIDTH 40 IN (1016 MM)
- SINGLE SEAT WIDTH 20 IN (508 MM)
- AISLE WIDTH 18 IN (457 MM)
- HEIGHT INTERNAL CABIN 73.2 IN (1860 MM)
- WIDTH ABOVE CABIN FLOOR 64.5 IN (1638 MM)
- SEAT PITCH MIN. 31 IN (787 MM)
- CAPABILITY TO CARRY A LD3-CONTAINER

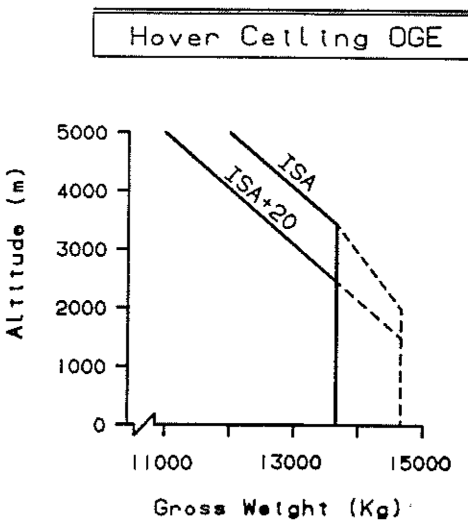
The tail cone will be a standard airplane configuration with a vertical fin and a horizontal tailplane whose position (on the top or on the bottom) is in definition.

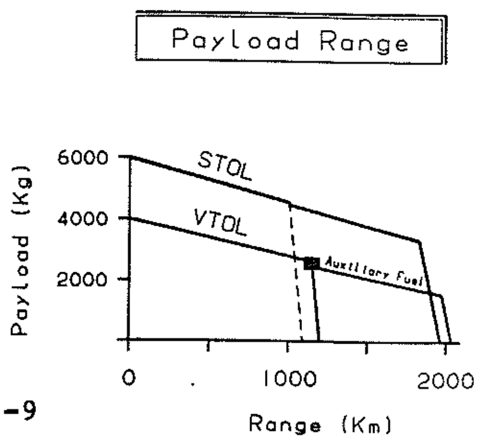
A wind tunnel solution with an H tail configuration will also be tested.

Two configurations of the rotor drive system (tilting of the complete engine-nacelle or tilting the rotor with stationary engine) are presently in evaluation for selection of the better solution.

Main performance data are as follows:

Fig.11 - EUROFAR MAIN PERFORMANCE





6. TECHNOLOGY AND AIRCRAFT STUDIES

Rotors

The Rotor's work comprise up to now three major interdipendent parts:

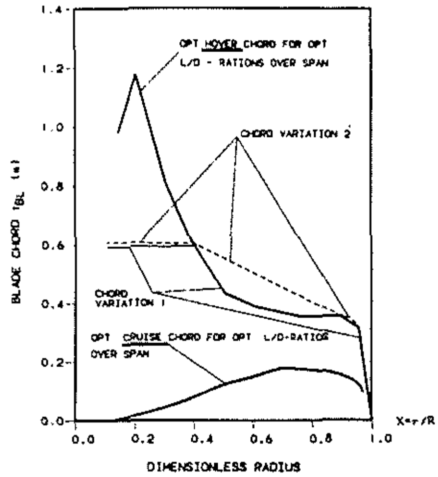
- basic technological studies, which will result in preliminary requirements and assessment criteria
- basic design studies, investigating the dynamic feasibility and functionality of blades, hub and controls.
- definition of wind tunnel models and tests for rotor performance and system dynamics experiments in the year 1990.

For a 30 PAX aircraft, a rotor with the data in Figure 12 can be proposed. The aerodynamic relevant geometry is a compromise between optimum in hover and cruise. Fig. 13 shows the different requirements of hover and cruise for the blade chord. Chord and twist selection has to take into account "excellent" aerodynamic efficiencies in both flight regimes as well "enough" thrust capacity to stand gusts and manoeuvres in the very low speed range of the aircraft. Fig. 13 shows also the sensitivity of Figure of MERIT versus twist variations. The airfoils and their radial arrangement require for the inboard sections up to 50% R a high L/D-ratio and high zero lift angles-of-attack. For the outboard sections (50-100% R) modern helicopter airfoils like the German DMH or the French OA series can fulfil the requirements of low drag, high drag divergence number and low pitching moment coefficient.

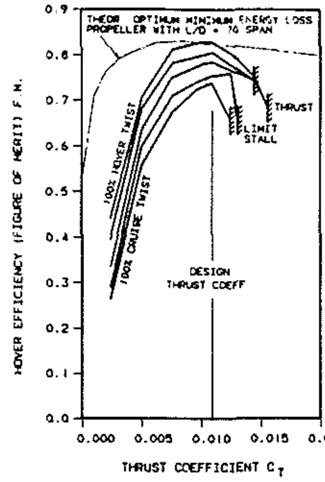
FIG.12 - EUROFAR 30 PAX: ROTOR CHARACTERISTICS

NUMBER OF BLADES:	4
RADIUS:	5.6 M
CHORD (10/40/91% R):	0.6/0.6/0.36 M
TWIST (30/50/100% R):	-18/-29/-45 DEG
THICKNESS (20/50/75/100% R):	28/18/12/9% CHORD
AIRFOILS (10-50% R):	HIGH L/D, HIGH α_0/
(50-100% R):	ADVANCED HELICOPTER OUTBOARD AIRFOILS (DMH OR OA SERIES)
GEOM. SOLIDITY:	0.095
THRUST COEFFICIENTS (HOVER/CRUISE C_T):	0.0117 / 0.0038
EFFICIENCIES (HOVER/CRUISE):	0.80 / 0.84
TIP SPEED (HOVER/CRUISE):	220 / 176 M/S
DISK LOADING (HOVER):	735 N/M^2
BLADE LOCK NUMBER:	6
APPROX. BLADE MASS:	60 KG GFRP/CFRP (GLASS FIBER REINFORCED PLASTICS/CARBON FIBER REINFORCED PLASTIC) - COMPOSITE STRUCTURE

Fig. 13 - ROTOR AERODYNAMIC TRADE OFFS



CHORD VARIATIONS IN THE NEIGHBOURHOOD OF THE OPTIMUM HOVER CHORD.



HOVER FIGURE OF MERIT VS THRUST COEFFICIENT DUE TO TWIST VARIATIONS

Three different dynamic functional rotor concepts are under consideration for EUROFAR:

- hingeless-bearingless, with the design challenge of low equivalent flapping hinge offset and sufficient lead-lag damping for a soft inplane option.

- articulated, with low hinge offset

- gimballed, aiming for a good design solution for the constant velocity torque transfer element.

Key design parameters (last not least the number of blades) shall be determined by intensive studies of loads trends and aeroelastic stability of the coupled system wing/rotor.

Two windtunnel (WT) models will substantiate in 1990/91 the findings of performance and dynamic relevant parameters of the rotor with respect to the coupled system rotor/wing/fuselage/controls.

Included in the EUROFAR series of 3 WT-models, N°2 is a large scale, MACH scaled, isolated rotor model (See Fig.14), which mainly serves to prove performance and helps to understand the aerodynamic peculiarities of the highly loaded prop-rotor. A special new tilt rotor test stand commissioned for the end of 1989, (see Fig. 15), in the ONERA S1MA windtunnel, will provide the required tilting capability and power.

Fig.14 - INFORMATION ON THE EUROFAR ISOLATED ROTOR (MODEL N°2)

<u>OBJECTIVES / TEST ITEMS</u>
- PROOF OF PERFORMANCE
- INDUCED VELOCITIES
- WING/ROTOR INTERFERENCE
- STATIC CONTROL LAWS FOR CONVERSION
- ROTOR NOISE
- ROTOR LOADS

<u>SCHEDULED TESTS</u>
- MODEL COMMISSIONING AND HOVER TESTS AT AEROSPATIALE, MARIGNANE FRANCE 1990
- CONVERSION AND HIGH SPEED SPEED TESTS IN ONERA WINDTUNNEL S1MA MODANE--AVRIEUX, FRANCE 1990

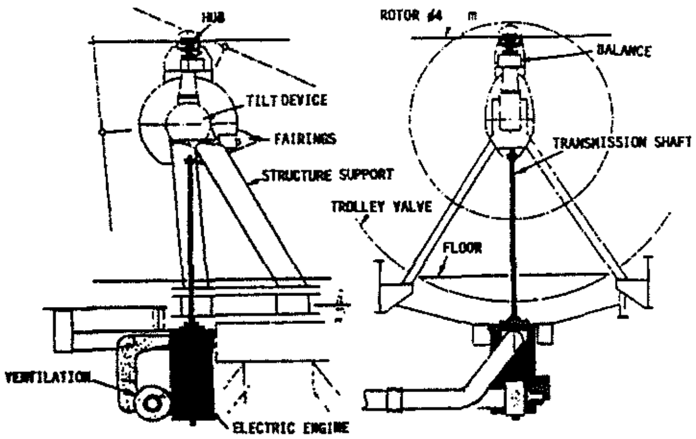
<u>MODEL CONFIGURATION</u>
- ARTICULATED, CONVENTIONAL HUB WITH APPROX. SIMILAR DYNAMICAL CHARACTERISTICS
- BLADES AS GF/CFRP-STRUCTURES
- SEPARATE WING MODULE

<u>FEATURES OF ONERA S1MA WINDTUNNEL</u>
- TEST SECTION DIAM.: 8 M
- MAX TUNNEL SPEED AND POWER MACH 1 / 88 MW

<u>FEATURES OF TILT ROTOR TEST STAND IN S1MA</u>
- DRIVE POWER: 500 KW
- TORQUE: 7000 NM AT 680 RPM
- STIFF SUPPORT > 20 Hz
- ROTOR AXIS TILT RANGE: 120 DEG
- SPEED STABILITY: 0,2%

<u>MODEL FEATURES AND DATA</u>
- GEOMETRIC SCALE: 1/2,8
- MACH SCALING
- RADIUS: 2 M
- MEAN CHORD 0,161 M (4 BLADES)
- POWER (EQUIV. SL/ISA)
  - HOVER: 240 KW
  - CRUISE: 357 KW
- REYNOLDS NUMBERS:
  - HOVER: 2.900.000
  - CRUISE: 1.900.000
- APPROX. BLADE MASS: 2,73 KG
- NUMBER OF MEAS. AND CTRL. SIGNALS: APPROX. 60

Fig. 15 - MODEL 2 ROTOR TESTING



TILT ROTOR TEST STAND (500 kW) IN TROLLEY #3 OF ONERA WINDTUNNEL S1MA IN MODANE-AVRIEUX FRANCE

The third EUROFAR model is dedicated to investigations of tilt rotor aeroelastics. Its modular design allows carefull monitoring and extensive experimental investigations of the isolated rotor, of the rotor and wing system and at last of the full span aircraft (see information in Fig. 16).

Fig.16 - INFORMATION ON THE EUROFAR AEROELASTIC MODEL (MODEL N°3)

OBJECTIVES / TEST ITEMS
- FIND FLIGHT BOUNDARIES OF DYNAMIC STABILITY
- VALIDATE MATH. MODELS
- WHIRL FLUTTER STABILITY
- BLADE FLAP-LAG-TORSION STABILITY
- FLT. MECH. STABILITY
- LOADS

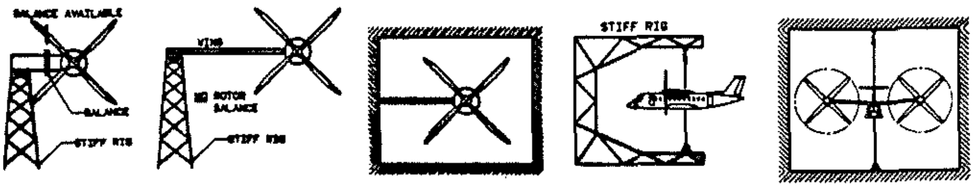
SCHEDULED TESTS
- WING/ROTOR IN GERMAN-DUTCH-WINDTUNNEL (DNW) VOLLENHOFE, NETHERLANDS 1990
- FULL SPAN MODEL IN DNW 1991

MODEL CONFIGURATION
- MODULAR DESIGN
- SCALED BEAM STRUCTURES WITH AERODYNAMIC FAIRINGS
- POWERED NACELLES
- D.O.F. OF FULL SPAN MODEL: VERTICAL, ROLL, PITCH, YAW

FEATURES OF DNW-TUNNEL
- TEST SECTION SIZE: 8 x 6 M^2
- MAX SPEED: 110 M/s

MODEL FEATURES AND DATA

- GEOMETRIC SCALE:	1/4.5
- FROUDE SCALING	
- FUSELAGE LENGTH:	4.31 M
- WING SPAN:	3.27 M
- ROTOR DIAMETER:	2.5 M
- MAX LATERAL DIM.:	5.76 M
- MAX VELOCITY:	67 M/s
- POWER (SL/ISA)	2 x 13 KW
- TOTAL MASS:	150 KG
- TOTAL NUMBER OF MEAS. AND CTRL SIGNALS:	80

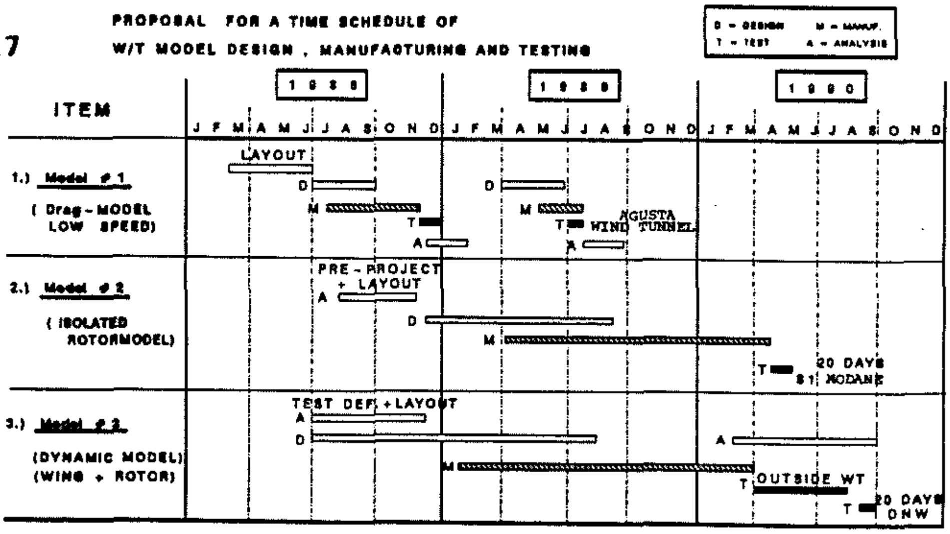


Vehicle aerodynamics

Theoretical models and a complete wind tunnel model (in a later phase with working rotors) will be prepared to assist in aerodynamic design studies, to assess and optimize drag and overall aerodynamic behavior and to produce a first estimation of aircraft performances.

Figure 17. presents the time schedule of all the wind tunnel models mentioned: the drag model, the isolated model, the dynamic/aeroelastic model.

Fig.17



In order to provide the aerodynamic characteristics and allow configuration development of the EUROFAR airframe, a wind tunnel test series will be conducted on a complete non-powered modular model at 1/12,5th scale. After a first series of tests, provision is made for refinement of the model to the proposed configuration.

Figure 18 indicates the main objectives of the drag model supporting the aerodynamic studies and Figure 19 shows the modularity of the model with all the components and combination of components to be tested.

Fig.18 - WIND TUNNEL TEST: DRAG MODEL

OBJECTIVES

- -VEHICLE CONFIGURATION INVESTIGATIONS
- -AERODYNAMIC CONTOUR OPTIMIZATION
- -DRAG AND STABILITY

W. T. TEST

FIRST PHASE:

- -W.T. : "MEAN" SIZE
  MODERATE SPEED
  AVAILABILITY,FLEXIBILITY,"LOW"COST
- -MEASUREMENT OF AERODYNAMIC GLOBAL COEFFICIENTS (LOW ANGLES)
- -STATIC DERIVATIVES
- -FLOW VISUALIZATION (SURFACE)
- -PARAMETRIC STUDY

FOLLOWING PHASES:

- -GLOBAL COEFFICIENTS IN CRUISE FLIGHT (ROTOR WAKES INTERACTION)

MODELS

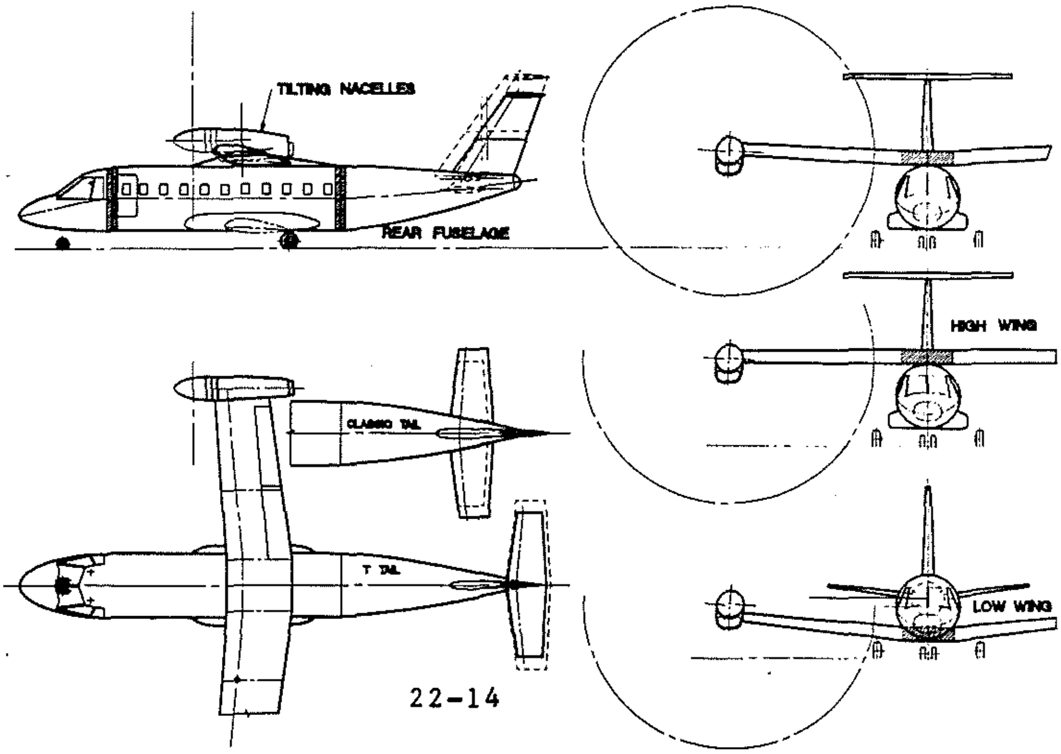
SCALE = 1:12.5 (8%)

1 A-FUSELAGE MODEL WITHOUT ROTORS
-MODULAR DESIGN
-ADJUSTABLE CONTROL SURFACES/NACELLE ANGLE

1 B-POWERED MODEL (AERODYNAMIC COMPLETE MODEL)
(SCALE MAY BE INCREASED)

1 C-ROTOR/WING AERODYNAMIC INTERACTION
(PARTIAL MODEL)

Fig.19 - DRAG MODEL: CONFIGURATIONS TO BE TESTED



Other five Expert Teams have recently been set up, in addition to the Rotors Team which has now been working for more than 12 months. Their early work has involved planning and definition of the main architectures and technical trade-off studies based upon the 30 passengers reference vehicle. During the three years Preliminary Phase the studies will be refined to produce a basic definition of the Demonstrator Vehicle.

Structure

The structural configuration and design load cases are being formulated from the vehicle performance, Certification and Airworthiness requirements. To reduce the empty weight as much as possible, composite materials will be used wherever applicable: the problem associated with a pressurized composite fuselage will therefore have to be addressed. Preliminary studies have also been made on wing span design against strength and aeroelastic stability requirements.

Flight Control

A flight control moding and operating concept has to be developed to cover control of the aircraft in the various configurations/flight phases, i.e. take-off and landing, hover transition to/from airplane mode, and cruise.
This includes design considerations with respect to system structure, cockpit controls and displays concept, control laws and mode and failure management. The hardware technology to be applied will be digital fly-by-wire/fly-by--light to provide the flexibility required for performing the complex control and monitoring tasks, to achieve the required safety and reliability levels, and to save weight.

Propulsion

This team is responsible for the drive system and its integration with the rotors and engines. Preliminary estimated for engine gearbox and performance are shown in Fig.20.

The main problem to be addressed by this team is trade-off studies of the transmission system for tilting and non-tilting engines, which will at a later date involve engine manufacturers.

One of the critical aspects of the transmission system is safety. The system must be much safer than current helicopter transmissions if the target of producing a vehicle which has safety levels comparable with fixed wing aircraft is to be met. This will inevitably require innovative design and use of health and usage monitoring systems.

Fig. 20 - ESTIMATED ENGINE AND GEAR BOX PERFORMANCE

Condition for 30 PAX/D	Power Setting	Power Required (installed)	% of rated power	Rotor Speed $-n_2$	Torque
Cruise 7500m/ISA 300 KTAS	max. cruise	2 x 1369 kW	97%	80%	2 x 40800 Nm
HOGE 500m/ISA+20	take off	2 x 1781 kW	76%	100%	2 x 42500 Nm
OEI * 500m/ ISA+10	OEI 30s (better: 2.5min)	1 x 3172 kW	100%	100%	1 x 75700 Nm (short time only)

* OEI is simulated with 90% of HOGE power!

Minimum Engine Performance

- at SL/ISA/ static / 100% n_2
- max. cruise: 2 x 2570 kW
- OEI 30s or better : 1 x 3600 kW appr. OEI 2.5min

Minimum Gear Box Limits

- Continuous : 2 x 2000 kW (i.e. 2x50000Nm at 100% n_2)
- OEI -short time: 1 x 3200 kW
- OEI continuous: 1 x 2500 kW

Cockpit and Avionics

At present, one expert team is responsible for cockpit design and avionics, but may at a later date be separated into two teams. The primary activities of the team will include an analysis of layout existing requirements for visibility, accessibility, instruments and certification. A mission analysis of the envisaged flight profile will be made, resulting in a crew concept (number of crew) and an assessment of crew task and workload. This will lead to a general specification of the cockpit, following which detailed design will begin involving panel layout, seat design and control layout. From this design, a mock-up will be built and assessed, producing some of the requirements for the simulation activity. Trade-off studies will be made involving flat panel displays, direct voice outputs/inputs etc.

An analysis of applicable standards and requirements will be made leading to a general specification for the avionics. The group will also undertake a review of state-of-the-art technologies and make a trade-off study to assess the applicability of new technologies (fiber-optic data bus,high speed data bus and distributed architectures).

Basic Equipment

This team has the task of defining the hydraulic, electric, pressurization and air conditioning systems deicing and anti-icing systems, and the design of the undercarriage.

7. MARKETING STUDIES

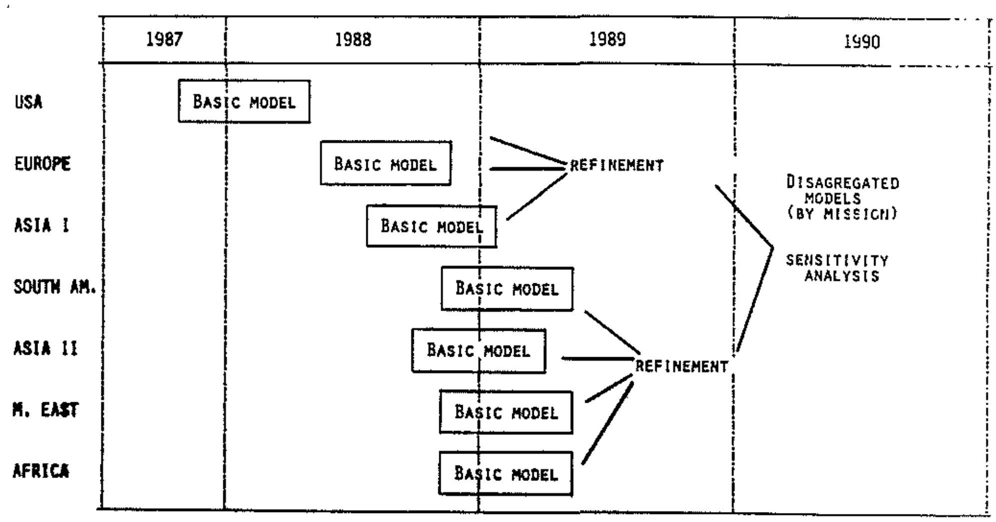
The objectives of the marketing studies are to develop the capability to forecast the sales potential of the tilt rotor aircraft, to validate this capability, and assess the commercial viability of the tilt rotor.

On consequence the studies will be addressed to investigate the tilt rotor's practicality and to demonstrate its economic advantages over conventional helicopters. The studies are focused on operating cost, safety, range and speed performances, piloting and operational procedures, operational limits, integration into air traffic patterns, and in-city penetration capability.

The objectives of the marketing studies, planned as in Figure 21, are to:

- develop a capability to forecast the sales of the tilt rotor aircraft under a range of assumptions
  - . tilt rotor performance, convenience comfort, costs, availability
  - . competitive situation in transportation markets
  - . macro-economic and regulatory conditions
- apply this capability to an important regional market
  - . with validation of the approach
  - . with requirement from initial experience
  - . with training, and transfer of analysis technology
- produce analysis results which indicate commercial viability of the tilt-rotor
  - . basic sales forecast
  - . effects of tilt rotor design parameters on sales
  - . identification of other sensitive factors
  - . timing the window of opportunity

FIG.21 - EUROFAR MARKETING STUDY PLANNING



8. INFRASTRUCTURES AND AIR TRAFFIC CONTROL

The infrastructures are one of the other key points of this phase.

The implementation of this communication system will imply equipping heliports and their surroundings, especially in urban areas, with relatively moderate cost infra-structures, provided with high performance characteristics made possible by modern technology.

Eurofar will permit all weather flight and IMC approaches in an urban environment.

The tilt rotor can use infrastructures which does not require big fundamental changes in actual architectures and city planning. New steep approach techniques allow the clear space around them to be even further reduced.
Arrangements could also be considered to enhance the continuity along the various transportation systems, for example: the tilt-rotor could enter the cities along railways lines (which are clear right-of-way paths generally leading downtown) and then land at a heliport near the station or on a roof top helipad.

This will simplify connections with ground transportation systems (train, subway, bus, taxi, car).

The new system needs electronic flight aids such as MLS (Microwave Landing System), GPS (Global Positioning System) and AWOS (Automated Weather Observation System) that will permit a steep descent path and automatic guidance till the final touchdown.

Figures 22 and 23 present a comparison between the typical ILS system now utilized for fixed wing aircraft and the MLS system as it will be probably used for a tilt rotor aircraft.

Fig.22 - COMPARISON BETWEEN ILS AND MLS

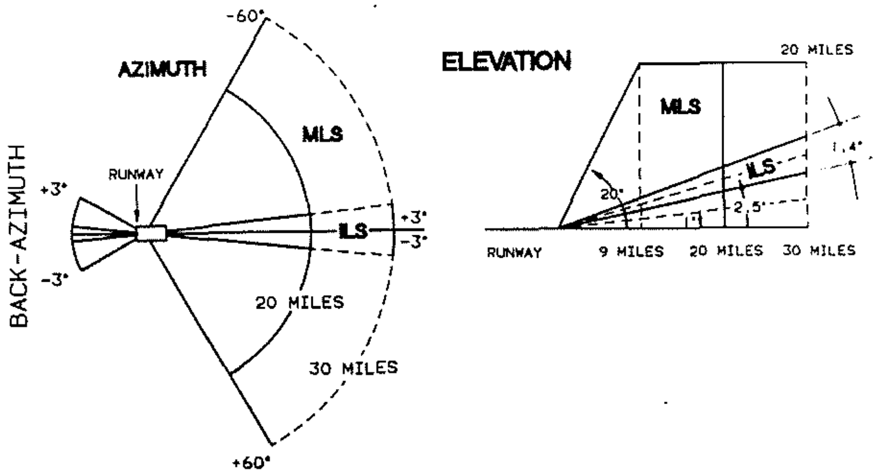
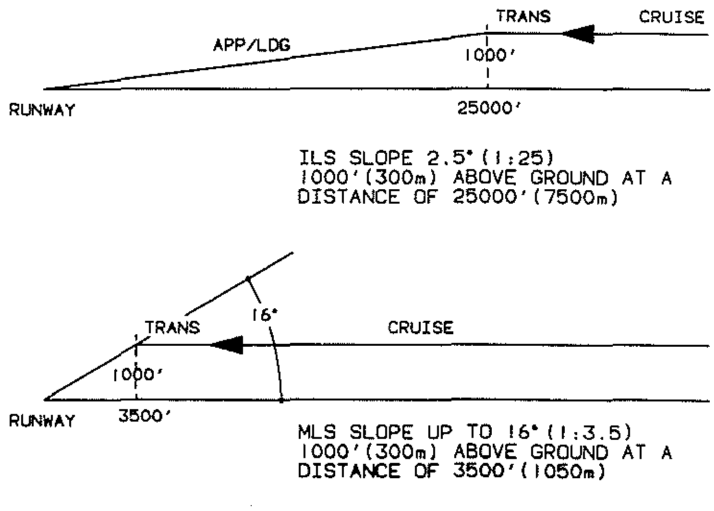


Fig.23 - COMPARISON BETWEEN ILS AND MLS



9. CERTIFICATION

Both the FAA and European Authorities have publically stated that powered lift aircraft will be expected to adhere to the same safety levels as those presently achieved by fixed wing aircraft.
The tilt rotor concept will be expected to reach levels of safety hitherto unattained by rotor lifted vehicles.
If the vehicle has to achieve commercial success in operation from urban centres, safety and the public's perception of safety must be a major consideration in the formulation of the design.

The basic safety criteria for commercial aircraft are contained in various national and international Civil Airworthiness Requirements. For the tilt rotor no defined Code of Requirements yet exists, and those draft criteria which have been written are intended to encompass the entire range of powered lift concept (except helicopters).
Therefore, at this present stage of the tilt rotor project, it is not possible to give a precise statement of applicable rules, but rather an interpretation of the undergoing aims.

In the United Stated, the FAA (Southwest Region) has issued a set of Draft Interim Airworthiness Criteria which have been circulated for comment within the US and Europe.
The EUROFAR Certification Group is active in the comment process on behalf of AECMA. In Europe the regulatory activity has not really commenced. The European Authorities work to date has been to comment separately the FAA criteria.
Nevertheless, the current moves towards a single certification action within Europe and ultimately towards an European Airworthiness Authority are forcing them to be together and create a Powered Lift Joint Airworthiness Requirement (JAR).

At this stage in the EUROFAR project it is important for the Certification and Design groups to consider the undergoing principles behind the airworthiness requirements. These principles may be defined as safety target. The commonly held belief is that helicopters are at least an order of probability less safe than fixed wing aircraft and this is largely due to the presence of the rotor and transmission systems. The problem here is complexity and in the tilt rotor the aim must be to produce a simple system and carefully examine the design by a failure analysis.
Health and usage monitoring systems should be installed in gearboxes and damage tolerant material and design concepts used wherever possible.

A full damage tolerance (fail-safe) approach will be used wherever possible throughout the aircraft, considering such factors as redundancy of load paths, damage tolerant materials, design technologies. Damage due to discrete sources has to be considered such as bird impact and uncontained engine failure.

Other issues to be considered in the design from the certification point of view include icing, lightning protection, fire, smoke and toxicity etc.

Other issues of certification involve the vehicle's performance. Autorotation is an important topic. Under present airworthiness requirements, fixed wing airplanes are required only to maintain control following total power failure, whereas the helicopters have to demonstrate the capability to perform a landing on a prepared surface. Whatever the actual requirements may say, the undergoing intent is that it should be possible to return to the ground safely following total power failure. This can be achieved by two methods: run-on landing or autorotation; either methods will introduce factors which have to be considered in the design. However autorotation is seen as the desired aim.

In addition to the inputs to the technical teams, the Certification Group has taken a wider role in developing close relationships with the FAA and European Authorities and is playing an active role in the development of certification requirements.

10. CONCLUSIONS

The unique operational capabilities of the TILT ROTOR offer the potential of an entirely new transportation system.

Applications such as commuter, executive or corporate transport, emergency medical service, police support, fire support, search and rescue, drug interdiction, servicing deep-water oil rigs, small package delivery, are well suited to this new form of transportation.

With the speed and fuel efficiency of a turboprop aircraft and the ability to operate like a helicopter, the tilt rotor can do almost all the things that both types can do and will give us a new opportunity in flight.

The European Partners with their active collaboration in the EUROFAR PROGRAM are realizing this new opportunity.

We are certain that less than ten years from now the EUROFAR will be of tremendous benefit to our society and will open a new era in the transportation system throughout the world.