MODERN HELICOPTER TECHNOLOGIES AT MBB AND THE APPLICATION IN FUTURE PROGRAMMES

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Abstract

As an introduction, the history of the German helicopter activities is described.

After a short definition of the market needs for the Helicopter Technologies, based on civil and military use, the current activities at MBB are described. The most important technology programmes covering rotor technology, vibration suppression, advanced composite airframes, avionics/cockpits and flight controls are presented. A further main topic is the description of the present and future Helicopter projects like BO108, PAH2, NH90 and ALH.

In the concluding chapter an outlook concerning MBB-Helicopter activities is given.

History of German Helicopter Technology

Phase of the Pioneers

The sincere desire of mankind to take off into the sky like birds led to a variety of different ideas and trials to make this dream come true. Already amongst the first known proposals we find concepts for machines for vertical take off and landing. But, finally, beside the balloons, the fixed wing solutions were the first to realize real flying capabilities early this century, the helicopters being still in a stage where the pure feasibility to build a machine which can take off was the driving factor.

The first really sucessfull helicopter with official type certificate, the German FW61 designed by Prof. Focke, made its maiden flight in 1936, showing a lack of approx. 20 years behind the fixed wing technology (Fig.1). Noteworthy seems the fact that the design of the FW61 was not only based on intensive theoretical work but also on trials with flying models and wind tunnel tests.

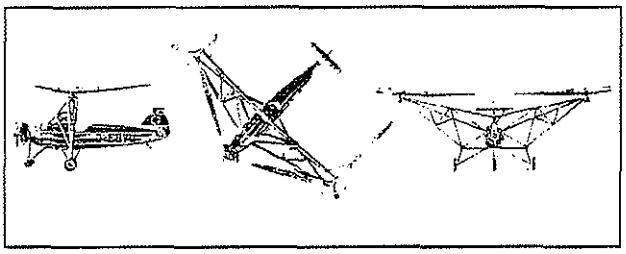

Fig. 1 Focke Wulf FW61 (1936)

The basis for this success was built by numerous pioneers of different nations to overcome the main barriers of vertical take off and landing like the power to weight ratio, strength and stability, controlability and unsymmetry of rotors. It is therefore not surprising, that the development of helicopters took a roundabout via autogiros with the famous de la Cierva inventing hinged rotor systems.

In this period until the end of the second world war the helicopter technology in Germany further envolved to provide payload capacities which lead to practical use also for military tasks. Only some names representative for the leading german pioneers of that period are called back in your memory: Flettner, Focke, Achgelis, Hohenemser, Sissingh, von Doblhoff, Laufer, Hoffmann, Rohlfs, Hanna Reitsch and Bode, developing technologies, among others, like tandem rotors, intermeshing rotors, jet propulsion rotors including hingeless rotors.

This productive and innvative period was interrupted -as you all know- at the end of the second world war untill mid of the 50ies when actions in the aerospace field didn't take place in Germany nearly at all.

After this gap of 10 years, especially the German helicopter Industry had to make a lot of efforts to come into business again. A driving factor were the requirements of the German Armed forces after the acceptance of the Fede-

ral Republic of Germany as a partner in the NATO. The army, airforce and navy were equipped, at the beginning, with American, French and British helicopters and the German industry started to participate in the fields of licence production, maintenance, repair and overhaul.

In the period of the late 50ies, early 60ies, the helicopter industry, with Bölkow amongst the most important companies, began with own developments. Obviously the market of at that time „conventional" helicopters were dominated by the big American, French and British companies. Therefore innovative ideas growing on the grounds of the period of forced inactivity were worked on and tested in Germany and so at Bölkow/MBB starting from the small one man helicopter project BO103 with the first composite rotor blades, the high speed helicopter BO46 featuring the Derschmidt swivelling main rotor designed for speeds up to 450 km/h, the heavy lift helicopter project resulting in tests with a 31 m diameter „Heidelberg"-rotor providing up to 36 tons thrust and, among others, the light helicopter called BO105.

Compared to the fore-mentioned ideas, the „only" differences of the BO105 to its competitors were features like the twin engine layout or the hingeless rotor in combination with glass fibre blades. But thanks to this, the BO105 really found a market and became the first commercially successfull German helicopter, followed by the BK117 and BO105 LS programmes.

Current Helicopter Activities in Germany

Fig. 2 shows the most important helicopter types operated in Germany.

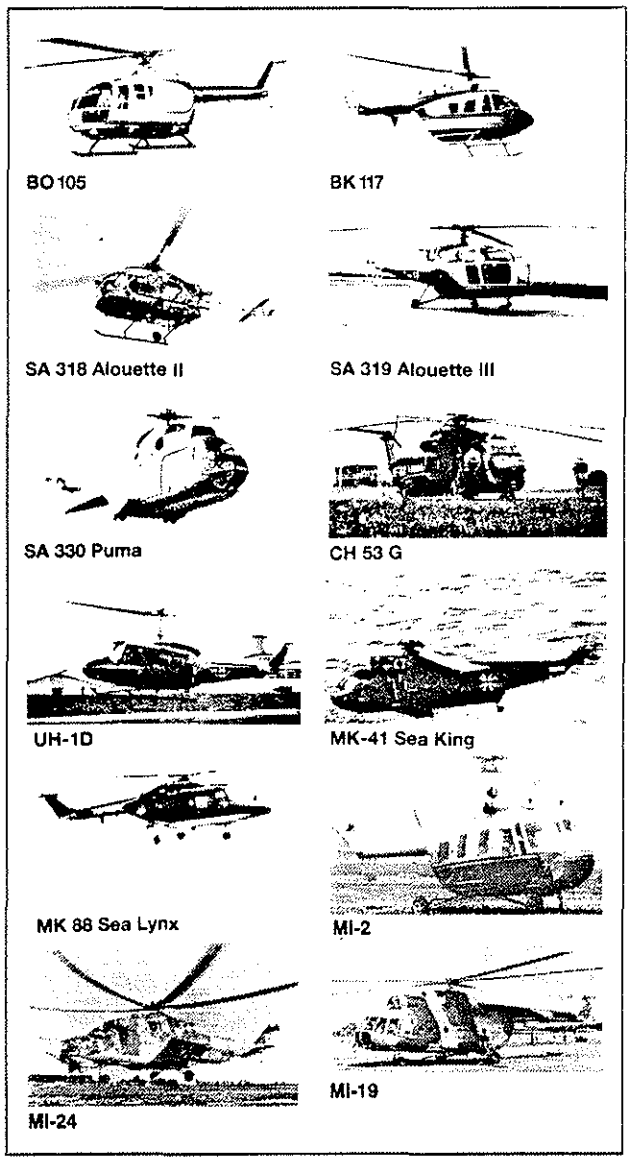

Fig. 2 Helicopter Types Operated in Germany

The driving mission within the public operated helicopters forms the Emergency medical service, served by helicopters operated by the German Border Police, the Allgemeine Deutsche Automobilclub ADAC and the Deutsche Rettungsflugwacht DRF. Since 1970, pioneered by the ADAC with one BO105 in Munich, a close network of rescue helicopter stations distributed throughout Germany has been established. Including privately operated medical transportation tasks, about 70 helicopters in Germany are performing medical mission services.

The following facts are noticeable:

- Nearly 70% of the total number of the around 1500 helicopters are under military use, 30% under public and civil operations.
- 37% of the non military helicopters are operated by public authorities or establishments.
- Only 19% or 290 units out of the total number of helicopters are operated by private establishments, as a result of the restrective laws in Germany concerning VTOL operations.

In fig. 3, the different types of missions in Germany are presented, divided into the three groups of operators, the military users, the public and EMS operations and the private operators, performing the various general civil missions, including the respective number of helicopters.

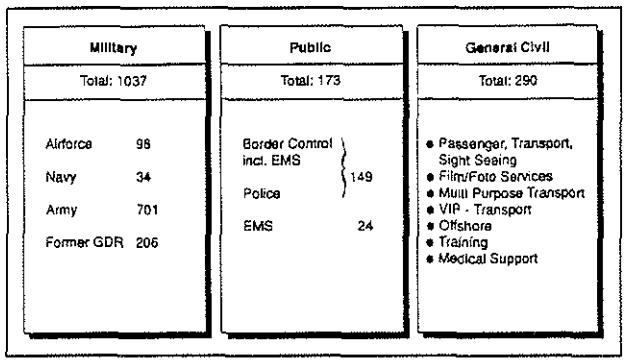

Fig. 3 Helicopter Missions in Germany

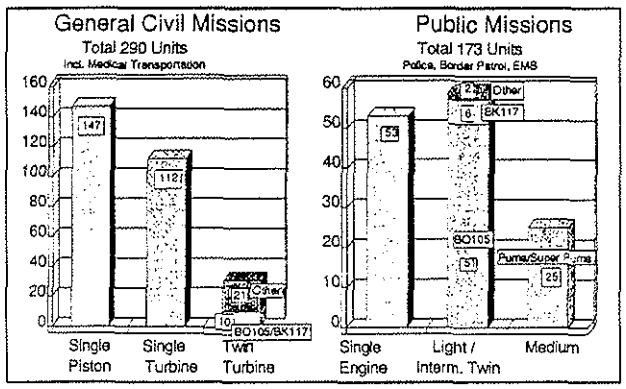

Fig. 4 Civil and Public Missions in Germany

Fig. 4 presents a further analysis of the civil operated helicopters in Germany with the following interesting results:

- Within the privately operated helicopters performing general civil missions, about 50% are piston engined helicopters. Obviously the german designs are of minor importance within this sector.
- Within the public operated helicopters, we find a high standard compared with other nations, but still about 30% are single engine helicopters. The biggest group is formed by the light twins with a majority of BO105/BK117's.

Fig. 5 contains a summary table of all helicopter types being operated in Germany, including the Sovjet Union built machines which have been used in the former German Democratic Republic. A close view to this table tells us that there still exist a considerable number of old designs and a wide variety of different types. The german designs only hold a share of about 26% in terms of numbers, in terms of value the share is even much lower.

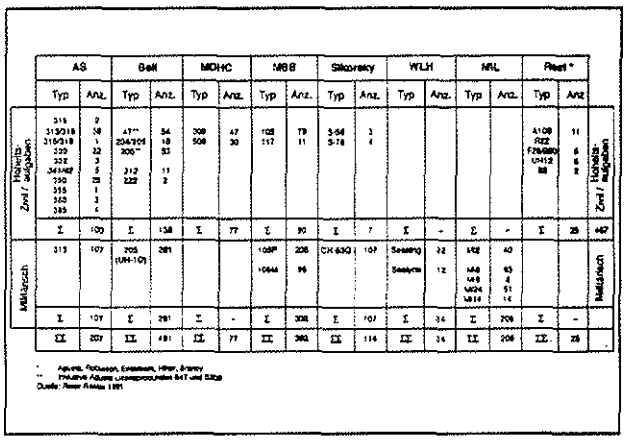

Fig. 5 Helicopter Related Establishments in Germany

Nevertheless, a wide variety of establishments in Germany are related to helicopters, a summary of which is shown in fig. 6.

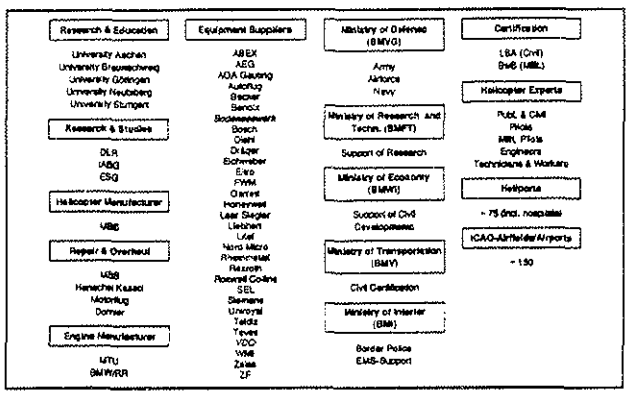

Fig. 6 Number of HC-Types Operated in Germany

Todays Market and Environment

The Helicopter industry is facing today an environment with a lot of difficulties, for example:

- Fundamental change in the security environment
- Shrinking military budgets
- Strong competition in the civil market

and therefore we are confronted in an increasing Industrial Integration process resulting in internationalisation of R&D-work and collaboration between the helicopter manufacturer.

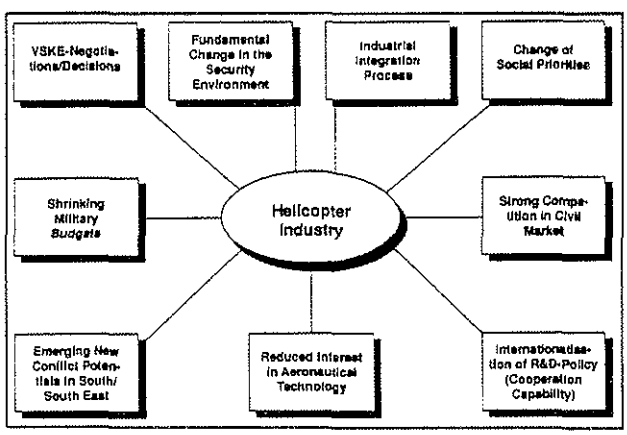

Fig. 7 Today's Environment

The Helicopter Manufacturer are driven by the following main elements:

- The User is looking for safety and comfort
- The Operator is looking for DOC, Payload, Flexibility
- The Environment is sensitive for Pollution, external noise, etc.

All the requirement coming out of these elements has to be matched and incorporated in the business strategy of the HC-Manufacturer. Having this in mind and taking the own business objectives like

- shorten the development time
- reduction of development cost
- minimizing the production cost
- improving quality and reliability

the helicopter manufacturer needs a long term technology strategy to fulfill all this different requirements and take a technical/economical compromise in the future products (fig. 8).

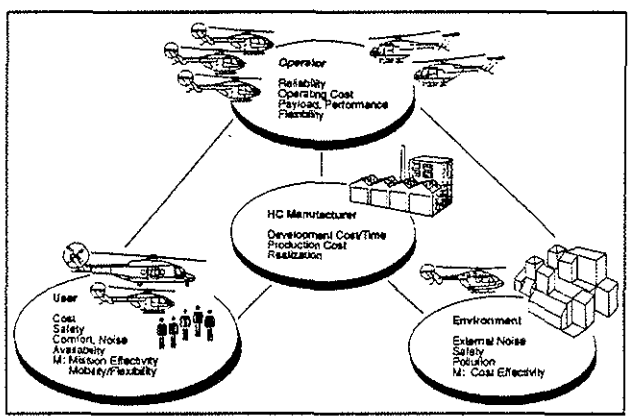

Fig. 8 Helicopter Market Environment - Requirements

The key technologies on which we are working today and creating the products of the year 2000 has to be reviewed according to these market needs and environmental requirements having also the future traffic szenario in mind. In a very early stage of the definition phase of a new project, we have to focus the technology activities to lead concepts and compare it to the future requirements to reduce the risk of the investment. The lead concepts consist of key technologies for Rotors, Airframe, Avionics etc (fig. 9).

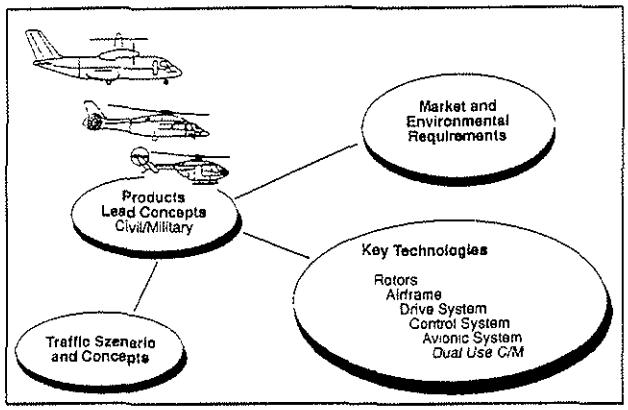

Fig. 9 Helicopter Technology Strategy

Technology Basis in Germany

Since the early 1960s, when Bölkow Company, now MBB, became a member of the helicopter community, the work at MBB has always been centered around technology advancements. Active work on new technology has continued till today and will play an even more pronounced role in the future. In the following paragraphs some of our recent R&T projects are reviewed.

New Rotor Systems

The main rotor -as the heart of the helicopter- has since long been the subject of intensive R&D work at MBB. The early design and development of the successfull BO105 „Hingeless Rotor System" with titanium hub and full composite rotor blades, was a breakthrough in rotor systems technology in the 1960s (fig.10).

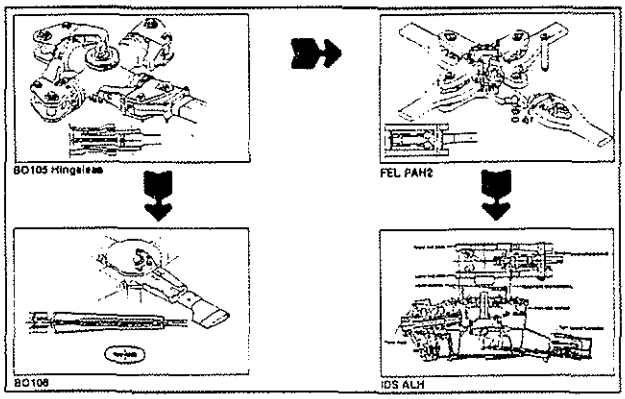

Fig. 10 Development of Rotor Concepts

Further progress in the application of new composite materials allowed new concepts, providing more simple, long lasting, low weight and low cost rotor designs. One promising direction is seen in the „FEL"-Main Rotor concept, which is basically a new version of the original BO105 hingeless rotor, replacing titanium material by carbon composites, and oil lubricated bearings by maintenance-free elastomeric bearings (figures 10,11). The four-bladed FEL-rotor , having a 10% „equivalent flap hinge" offset, was developed for and is now flying on the Franco-German TIGER armed helicopter.

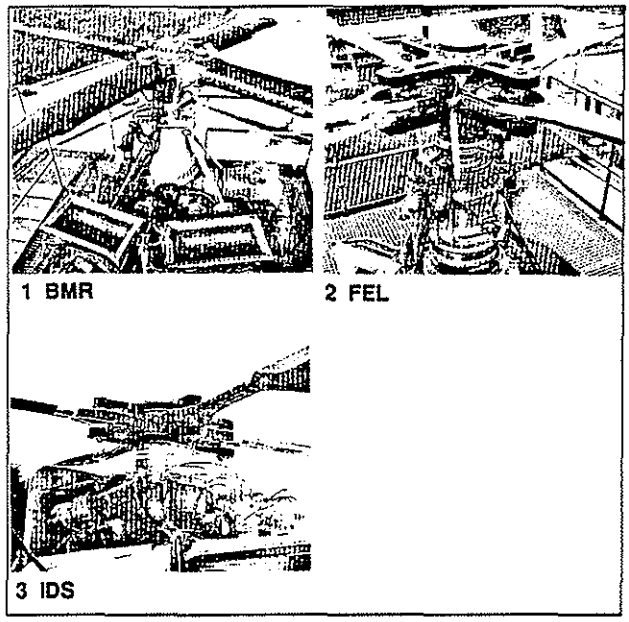

Fig. 11 Advanced Rotor Concept Technologies

Based on the FEL-Rotorhub concept, an increased level of integration was achieved in the socalled Integrated Dynamic System, IDS (fig.10 bottom right). The system is currently in the final stage of ground testing in the Indian ALH prototype. The IDS integrates the rotor hub, the main gearbox, the upper control unit and the servohydraulics in one unit. The obvious benefits are compactness, protection against sand and dust, low vulnerability and significant weight reduction.

As a final step forward, the application of advanced fiber composites has made it feasibility to develop fully bearingless rotors (fig. 10 and 11). The basic feature of this concept is the utilization of a flexbeam structure at the inboard section, to replace the mechanical elements and to provide the blade motions by pure bending and twisting of the structure. The rotor shows 20% weight reduction and 40% less parts count, when comparing to the BO105 hingeless rotor. The rotor is flying on our BO108 prototypes, demonstrating exceptional handling qualities, high aeromechanical stability and full structural integrity.

Full composite technology application is particularly attractive also for tail rotors, since maintenance and life-time of tail rotor has been a problem for nearly all helicopters. Systems designed and successfully flight tested at MBB are shown in fig. 12. The results confirmed high aerolastic stability and, as expected, low bending and torsional shear stresses in all critical elements. As the latest development, a new version of a four-bladed full composite tail rotor is currently ground tested for the application on the Indian ALH-Helicopter-Project (fig. 13).

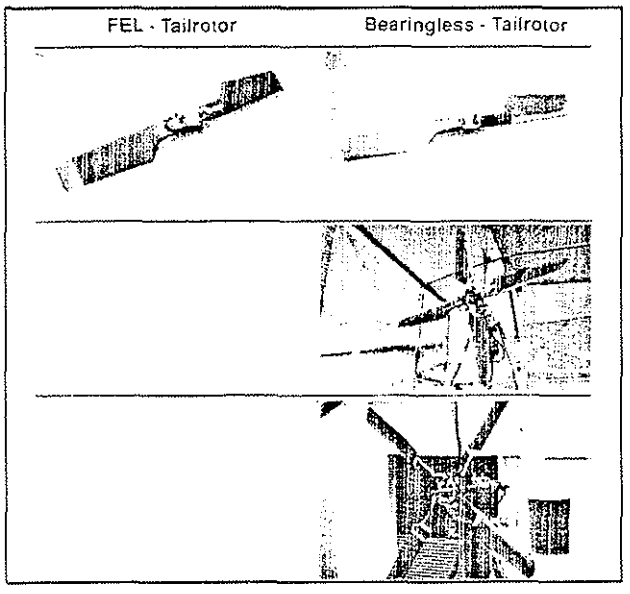

Fig. 12 Composite Tailrotor Developments

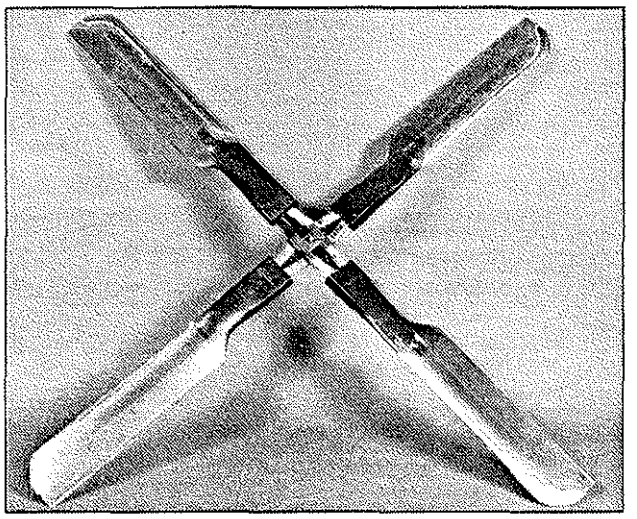

Fig. 13 Four-Bladed Composite Tailrotor (ALH)

Anti-Vibration Technology

Increasing requirements on comfort and vibration levels of future helicopters have led to intensive work on vibration reduction at MBB during the past 20 years. The work included several techniques, like blade dynamic tuning, matching of airframe structures, application of dynamic absorbers, passive rotor-to-fuselage isolation, and active control techniques, like higher harmonic control (HHC)

As it looks, vibration control by use of passive isolation elements is one of the most promising methods of today. The principle and mode of operation of the socalled anti-resonance-systems (ARIS) can be seen in fig. 14. The input forces from the rotor (upper curve) are counter-acted by the out-of-phase forces of the isolator mass, resulting in perfect zero force waveforms of the fuselage.

Several Vibration Isolation Systems were developed at MBB (fig. 15), including mechnical elements and elements with a hydraulic transmission of the forces. These elements were flight tested in the BK117 and the BO108 helicopter,with excellent isolation efficiency (98% transmissibility) and vibration levels in the aircraft well below 0.1 g´s.

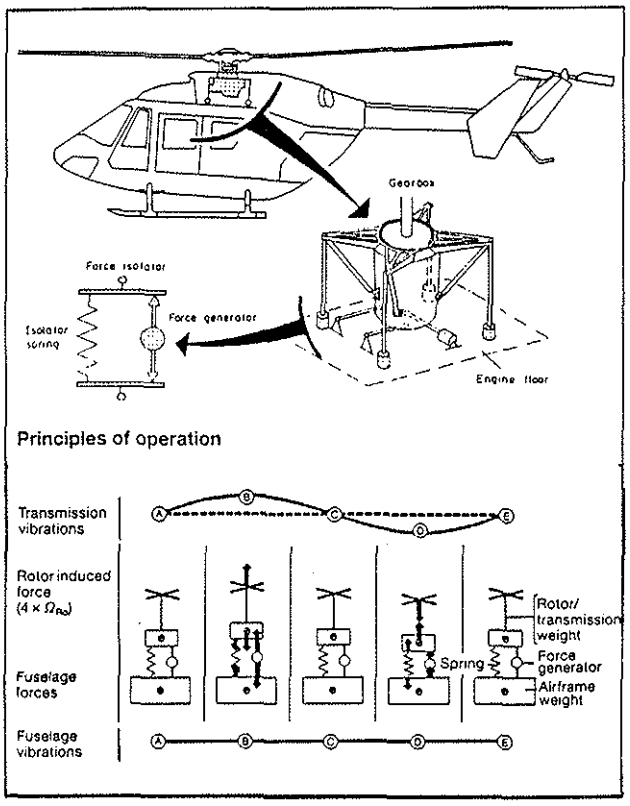

Fig. 14 Mode of Operation of Anti-Resonance

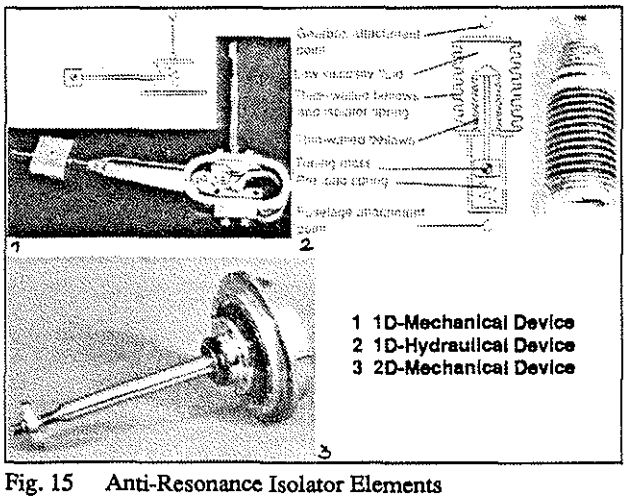

Fig. 15 Anti-Resonance Isolator Elements

The latest development is shown in fig. 15 (bottom left), showing 2-axis isolator elements, which will allow complete 6-axis rotor isolation with only four elements installed. The systems has been developed for the Indian ALH-Program.

Higher Harmonic Blade Control

Main work in Germany in the recent years was also concentrating on the development and demonstration of the active control technology using Higher Harmonic Blade Control, HHC. Cooperative pograms with German DLR and HFW included very successful open and closed loop tests on a model rotor in the DNW -Wind-Tunnel, and flight testing of HHC-actuators in the rotating pitch ink, fig.16.

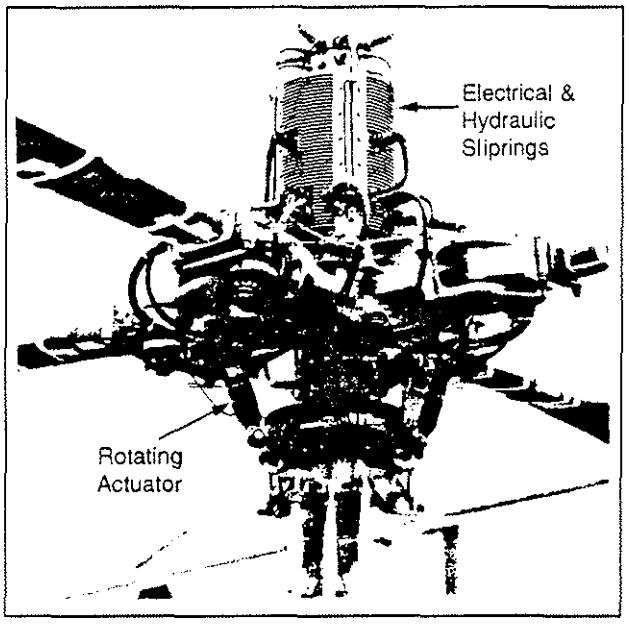

Fig. 16 IBC-Blade Actuators (Rotating System)

Another important step was testing of the influences of HHC on blade impulsive noise. The tests in the DNW-tunnel showed very encouraging results, fig.17. Measurements under the rotor disk (Z/R=1,2) indicate local noise level reductions up to 4 dB´s. The way it looks today, such systems, combined with the progress in electronics, could enable significant improvements in vibrations and noise, and could open the door to a substantial expansion of today´s flight envelope limitations.

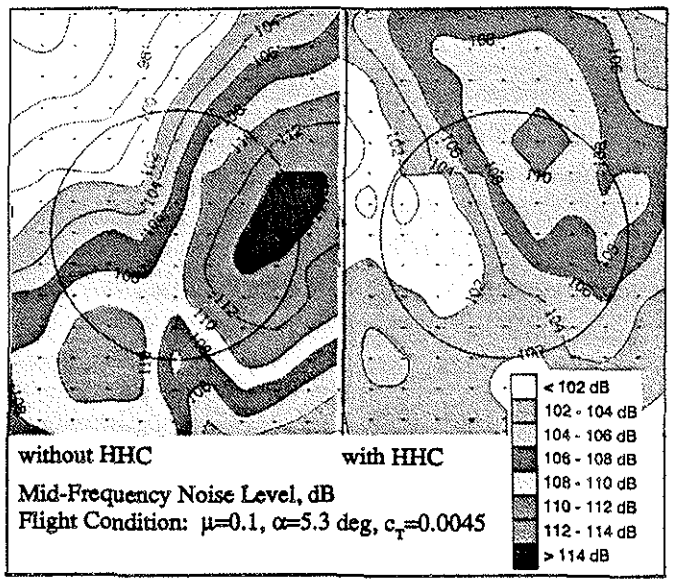

Fig. 17 Noise Reduction by HHC (DNW-Windtunnel Test)

Composite Structures Technology

For many years, the governing factor in aeronautical technology has been materials, and here especially the application of fiber composites. A fore-runner has been the rotor blades technology, which made the introduction of glass-fiber reinforced plastic blades into service helicopters possible about 20 years ago. The development of modern bearingless rotor systems became feasible only by application of advanced fiber composites, as mentioned before.

The logical evolution was then to use composite materials also in the design of primary airframe structures. A significant step forward at MBB was achieved through a composite airframe program, using a BK117 as a flying demonstrator (fig.18). As an overall result, the program explored the possible weight savings (25%), the reduction of number of parts (80%) and gave valuable insight into manufacturing cost, reliability and energy absorption capabilities of composite airframe structures.

Fig. 18 BK117 Composite Fuselage Demonstrator

The design procedures and experiences from this technology program were transfered to the airframe structure of the TIGER-prototype (fig.19), 80% of which is made of composite materials. Some features of the structure are: self-stabilized sandwich panels composed of carbon and Kevlar skins with Nomex honeycomb, and underfloor structure with high energy absorption panels for crash protection.

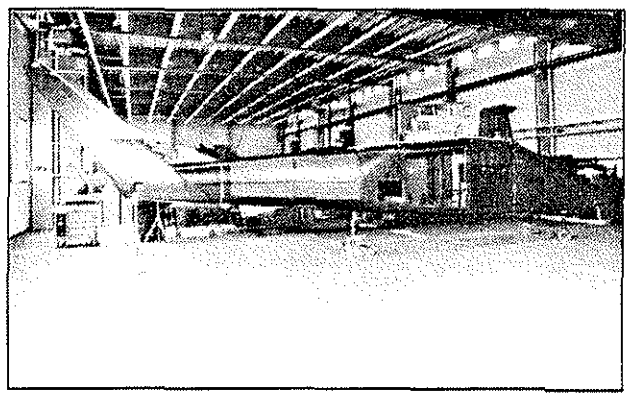

Fig. 19 TIGER Composite Fuselage

New Avionic Systems and Cockpit

One area where electronics and optronics will have a major impact, is in the avionics and cockpit field. New sensor-technologies and display techniques are particularly important, not only for military missions, but also for civil application to extend flight capabilities during night and bad weather. Lack of such capabilities is one of the most significant drawbacks of most of the todays helicopters.

As an early program (1980), MBB established a „Flying Laboratory" (FLAB) Program, which concentrated on the integration of new visual aids, advanced cockpit displays, and mast-mounted and various types of Helmet-Mounted sight systems. The development of flat, light weight colored displays is in rapid progress and their application in helicopter cockpits is under full development. Figure 20 gives an impression of a display-integration program, including 5 1/4 x 5 1/4 inches LC flat panels for flight displays. The system is currently under development for application on the BO108 helicopter.

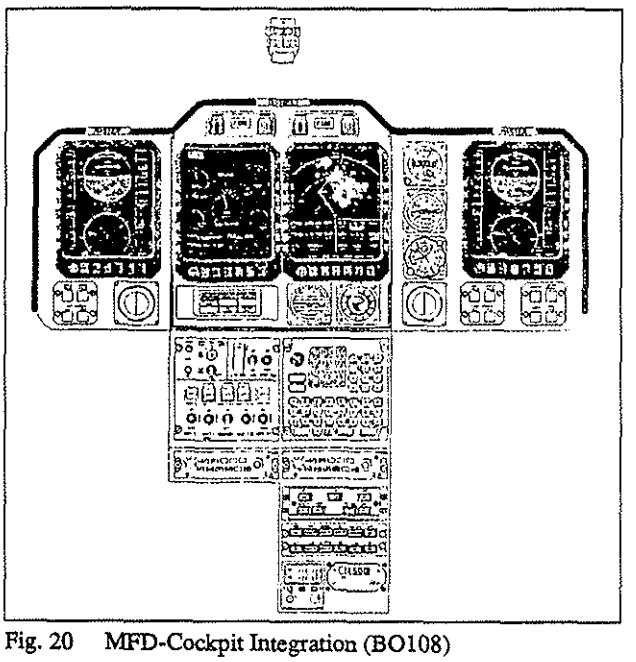

Fig. 20 MFD-Cockpit Integration (BO108)

A major thrust in man-machine interface technology is currently taking place within the TIGER-Program. The 2-crew tandem cockpit (fig.21) is based on the extensive use of coulour MFD´s, two per crew station, to display all required system, flight and sensor information, and one CDU per crew to control avionic systems and com/nav data. The system is completed by Helmet-Mounted Sight and Displays that present flight symbology overlayed on a FLIR image.

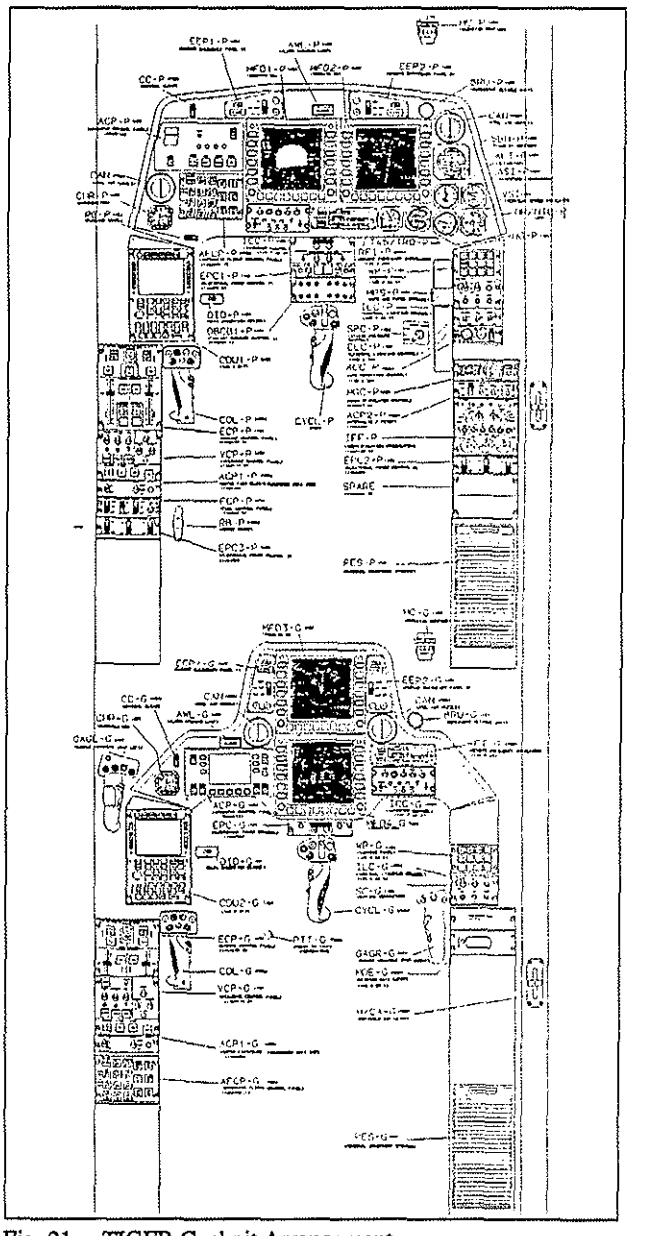

Fig. 21 TIGER Cockpit Arrangement

Advanced Flight Control Systems

The enormous advances in electronics and micro-processor computing will also dominate the technology of future flight controls systems. Early work on digital fly-by-wire systems at MBB was conducted in the 1970s, using a BO105 flying simulator. Having been convinced of the inherent advantages of electro-optic components technology, MBB started a Fly-by-Light technology program, called OPST-Program (fig.22). The object of this program was to gain practical experience of optical control systems technologies at minimum cost and risk, technical as well as flight safety risk.

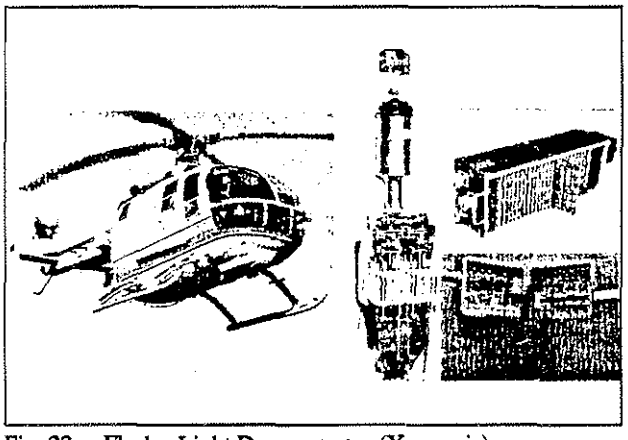

Fig. 22 Fly-by-Light Demonstrator (Yaw-axis)

A very straight forward architecture was choosen for the demonstrator aircraft: The yaw-axis system consisted of triplex „semi-smart" pedal and collective transducers, triplex yaw-rate gyro, triplex FCCs and duo-duplex „smart" electro-hydraulic actuators (developed by LAT). A total of 40 hours of flying was completed with the DLR without any hardware malfunction. The flight trials generally received favourable comments.

Further experience gained was an inherent immunity to EMI, extremely high data transmission capability, and mass savings, as no special shielding is required. A complete 4-axis Fbl program is on the way to be launched. In our conclusion, Fbl-technology is here to stay and will establish itself as the leading technology.

R&D Tools and Facilities

Rotary-wing research and development is a complex, interrelated challenge. During the various phases of definition, development and testing, various tools are necessary in order to support design work and to reduce cost and risk of the development process. MBB has always been active to develop and improve these tools on a broad front, both by in-house and public funded efforts.

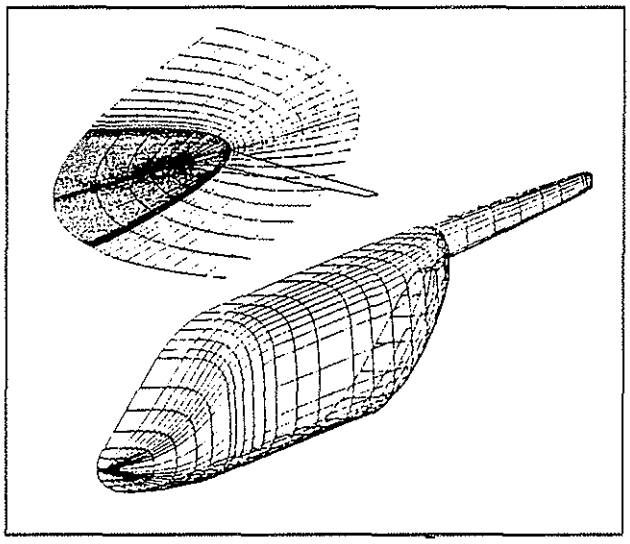

Fig. 23 Advanced Computational Analysis

Advanced computational fluid dynamics (CFD-codes and FEM-Analyses are the basis for the physical understanding of the complex aerodynamic and structural elastic phenomena (fig.23). Multi-disciplinary, comprehensive helicopter programmes (STAN, SACRA) model the complete rotor aerodynamics, aeroelastics, fuselage aerodynamics and provide results on loads, trim, stability and control response behaviour of the aircraft.

Experimental work in the windtunnel plays an increasing role. MBB and DLR operate a powerfull facility, a fully modular test-rig (fig. 24) with high power installation for the operation in the Dutch-German windtunnel (DNW). Work with this model concentrates on both basic phenomena research, as well as on rotor and advanced vehicle configurational development.

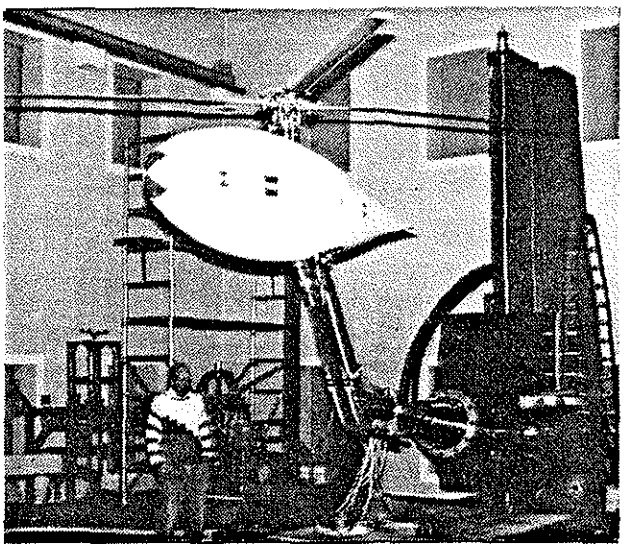

Fig. 24 Modular Windtunnel Test Rig

A revolutionary impact in helicopter system development comes from the use of modern man-in-the-loop simulation during the design process. MBB has built a modern simulation - 30 ft diameter - dome facility within its Helicopter and Military Aircraft Group in Ottobrunn. It comprises a computer-generated-image system (Compu-Scene IV, 140° x 120° FOV), interchangeable cockpit and fully nonlinear helicopter mathematical modelling. This simulation facility is integrated in the laboratory and system integration environment and can be used to support the full range of research and engineering services. As a special tool for MMI-Investigations and cockpit simulations, a new simulator cockpit (SIMCO), fig.25, was established, which is used for MMI and System simulation within the TIGER-program.

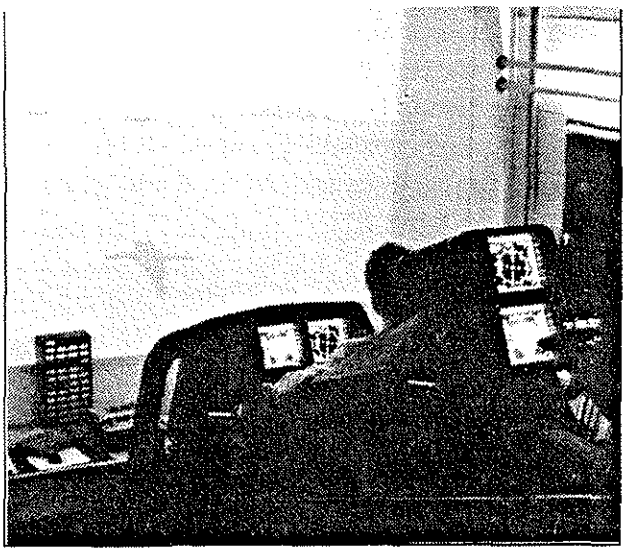

Fig. 25 TIGER Simulation Cockpit (SIMCO)

Finally, for the demonstration of new system technology, the flying simulator BO105-S3 is a highly valuable tool. Flying simulators are key tools for future inflight demonstrations and for the development of advanced flight control systems, new control strategies and novel crew station arrangements. The S3-flying simulator is operated in close cooperation with the DLR. A new BK117-Flying Simulator Aircraft on Fly-by-Light basis is in the conceptual phase.

National Cooperation

Cooperation of the Helicopter Industry, Research Institutes and Universities plays a vital role in Germany's helicopter technology work. Since many years, DLR has established a systematic Helicopter Technology Program, which is clearly defined and oriented to actual market needs, under full harmonization with the helicopter manufacturer and equipment industry. Valuable contributions in the recent years were achieved in the area of new rotor blade airfoils, active rotor control (HHC), rotor test methodology in the wind-tunnel, guidance and control, and structural crash characteristics.

As a global frame, all german helicopter technology activities are coordinated by a national Working Group (AKH), which combines both national ministries and agencies, research institutes, universities and the national helicopter industry (fig.26).

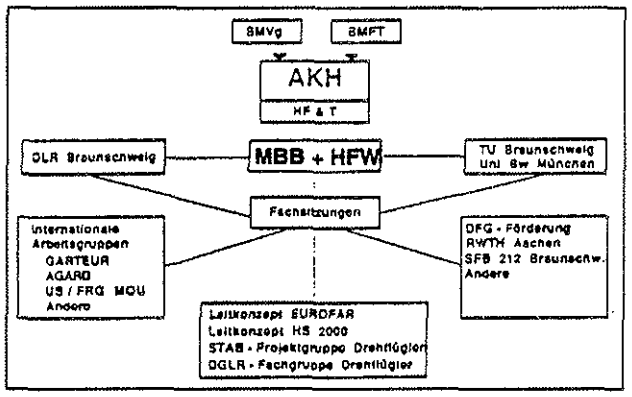

Fig. 26 German Helicopter Technology Grouping

Main Programme Activities at MBB

Flying Fleet BO105/BK117

The technology described here does not constitute an end itself; rather, its purpose is to result in series applications with ongoing programmes. With these technologies we have various options to improve the flying fleet BO105, BO105 LS and BK117 (fig. 27, 28).

Fig. 27 BO105

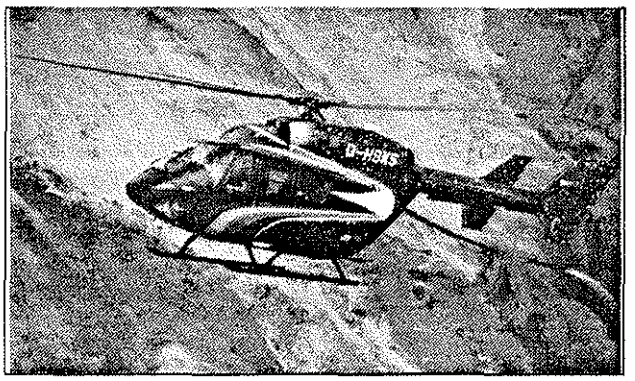

Fig. 28 BK117

The possible improvements will concentrate mainly on

- reduction in operating expenses
- decreasing of the production costs
- improving of the passenger comfort.

An improvement on performance can be done on special customer request. Since all improvements involve considerable development, the market will decide just how far we will actually go.

In the class of the BO105 we will give all additional benefits coming out of the technology work to our new helicopter BO108. For the BO105 German Antitank Heliocpter PAH-1 the German Ministry of Defence issued in december 1987 a tactical requirement for improved performance, growth potential and, in a second phase, for night fighting capability. A contract for the phase I was signed in November 1989 for development and adaption of the light-weight digitized HOT firing installation, as well as the new rotor blades and the improved oil cooling system. With the applied measures a gross weight increase to 2500 kg, a reduction of the empty weight by 60kg, a better manoeuverability and reduced pilot work load were achieved. Type certification was issued on March 28, 1991 and a first retrofitted PAH-1 was delivered at the end of May 1991 (fig. 29).

Fig. 29 PAH-1 KWS

Under the planned phase II improvement package the PAH-1 will have night flying and night fighting capability. Due to the defense budget situation we have to look to a less expensive solution like reducing the night capability to night flying but improving the defense capability with radar - and laser warning receivers. In addition to the PAH-1 upgrade, 52 helicopters out of the present PAH-1 fleet will be converted to an escort configuraiton (BSH-1) with General Dynamic´s air-to-air Stinger missiles.

For the BK117 (fig. 28), with more than 300 HC world-wide in operation, a MTOW upgrade to 3350 kg with increased C.G. and control limits, keeping the present empty weight that means full benefit of add. 150 kg useful load, is planned for delivery in 1992.

For improving the flight comfort, an installation of the Anti-Resonance Vibration Isolation System (ARIS) will be offered as optional equipment. With the new Arriel-equipped BK117 C-1 Version MBB meets future market requirements and specific customer needs, offering operators more flexibility in their engine selection. Studies for a new I-Panel including EFIS, and a new front nose shape, increasing of the mainrotor transmission power and tailrotor improvements are under way.

PAH-2/HAP/HAC -TIGER Program

Only 3 years after full scale development go ahead for the TIGER program, the prototype No 1 of this French-German Antitank and Combat Support Helicopter took off for its maiden flight from Aerospatiale´s Marignane Heliport on 27. April 1991 (fig. 30).

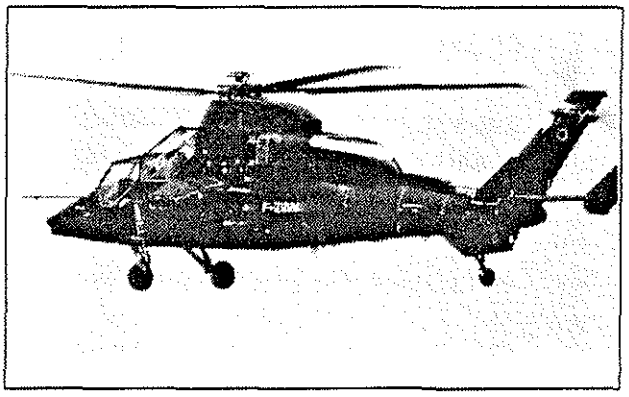

Fig. 30 TIGER

The flight envelope covered up to now with the PT1 is shown in fig. 31.

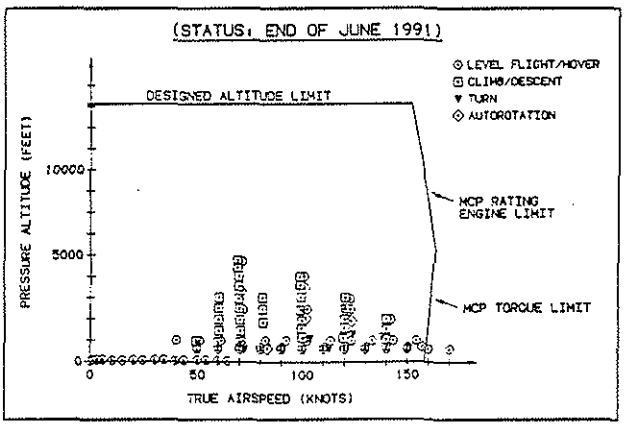

Fig. 31 TIGER Flight Test Envelope

The most important technological characteristic of this program, which is specialized to an anti tank helicopter features in:

- narrow front silhouette through tandem cockpit
- tricycle landing gear with high energy-absorption capability
- low optical, radar and IR signatures

- Mast Mounted Gunner/Co-Pilot Sight (infrared-, TV-Channel, Laser range finder) gyro-stabilized, for target detection, identification and aquisition
- Infrared, nose mounted Pilot Sight
- 8 anti tank missiles (HOT2 and/or PARS3)
- 4 infrared self defense air-to-air missiles (Stinger for Germany, Mistral for France)
- high tolerance against ballistic impact through selected construction methods, armoring, system redundancies and two engines.

The Tiger project features the following technologies:

- FEL-Rotor with optimized aerodynamic profiles
- full composite fuselage
- redundant data bus acc. to MIL-STD-1553 B
- modern glass cockpit
- advanced weaponary
- advanced maintenance system with integrated monitoring and checkout system.

One major part in the development of the TIGER are the avionic system activities. For the basic avionic all equipments are under development and some models are delivered for rig testing. For the man-machine interface a first simulation campagne of the glass cockpit and with the pilot in the loop was performed. Various sessions to optimize the ergonomy in the cockpit were done. The SW-development based on SW requirement specification is in progress. First SW-Prototype elements running on host and target computer. The Euromep basic development activities are running in the standard programmes HOT and TRIGAT.

The main contractor for the TIGER program is Eurocopter, the leading European Helicopter Manufacturer formed by Aerospatiale of France and Messerschmitt-Bölkow-Blohm of Germany. On the customer side, the program is controlled by the joint German-French Helicopter Program Office (DFHB/Deutsch-Französisches Hubschrauber-Büro) located at Koblenz, Germany.

The German Army requires a total of 212 TIGER anti-tank helicopters. The French requirement amounts up to 140 anti-tank helicopters. Series delivery of TIGER will begin in 1997/1998, so this is currently MBB´s most important helicopter program.

NH90

The NH90, a joint European Helicopter in the 8000kg to 9000kg class (depending on mission and equipment) will have two variants, the TTH (Tactical Transport Helicopter) for the airforce (fig. 32) and the army and the NFH (NATO Frigate Helicopter) for the Navy (fig. 33).

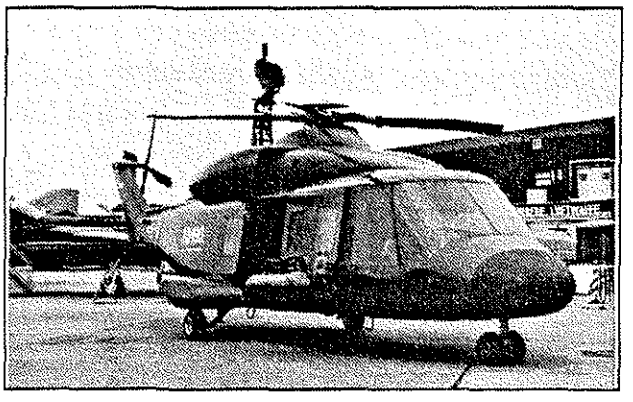

Fig. 32 Tactical Transport Helicopter (TTH)

Fig. 33 NATO Frigate Helicopter (NFH)

The main tasks of NH90 are air transportation, SAR (Search and Rescue) airmobile support, provisioning troops, antisubmarine and vessel-engagement missions. The TTH version for the airforce and army is designed for defensive weapon equipment (capacity appr. 2000 kg) with possible variants for transporting light tactical vehicles in the cargo bay. The TTH will have a top speed of about 160 kts with cruising speed of 140 kts and an endurance of appr. 2.5 hrs. The NFH naval version offers complete autonomy in submarine engagement and is especially designed for all-weather and ship based operations. The NFH will have a top speed of 120 kts and an endurance of appr. 4 hrs. The NH90 is powered by two gas turbines (RTM322 or GE-T700) and has a standard range of 700 km which can be doubled by using auxiliary tanks.

In this program most of the technology mentioned earlier will be utilized for e.g.

- modern rotor technologies
- full composite fuselage
- Higher harmonic control
- fly-by-wire
- modern electrical bus system
- aircraft management computer
- Health and Usage monitoring
- advanced cockpit with displays
- design philosophy according damage tolerance and crash resistance.

The mission equipment packages (MEP) will vary according the mission task, like

- Electronic Warfare System (EWS)
- Anti Submarine Warfare (ASW) dip Sonar
- Sono Buoys
- Torpedos
- Antiship Missiles
- Mines
- Air to Air self defence capability.

This program is arranged with four European partners France (43,4%), Italy (26,4%), Germany (23,6%) and Netherlands (6,6%). The participating nations signed by end of 1990 the D&D-MOU and the official program launch by the governments is to be expected by the end of 1991. The total requirements of the four countries amounts to approximately 620 Helicopters. An export potential of additional 400-600 helicopters has been defined.

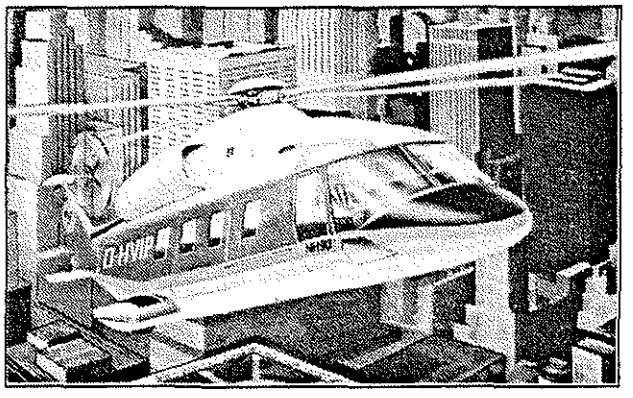

Fig. 34 NH90 VIP - Version

BO108

The BO108 incorporates the most modern helicopter technologies of MBB. New Systems were being tested at MBB over the past four years, using either the BO105 or the BK117 as test vehicles. In order to fully utilise today's technical capabilities, however, it was decided to integrate all these new technologies into the

BO108. One of the most significant technological developments for the BO108 is the Bearingless Main Rotor System. This technology is also selected for one of the most important US-Military Helicopter Program RAH-66 Comanche. The main Design and Technology features for the BO108 (fig. 35) are listed below:

- Bearingless Main Rotor System (BMR)
- BTR or FEL - Tailrotor System
- passive Anti-Resonance-Vibration-Isolation System (ARIS)
- Two stage, flat profile, light weight, main transmission
- Modern interior cockpit with ergonomically designed controls and seats
- Modern cockpit instruments considering also LC flat panel technology
- Airframe Structure with a high percentage of composite
- Special Cabin interior noise treatment
- Modern Engines with FADEC-Engine Control System (TM319 or PW206)
- Three axis duplex hydraulic system with electrical control inputs.

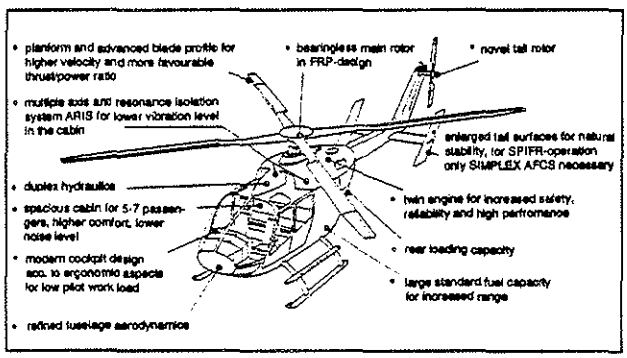

Fig. 35 BO108 Technology

With these technologies applied, MBB believes to achieve the main objective in the BO108-conception to make this future helicopter more economical, for instance by simplifying maintenance procedures and reducing direct operating cost and life cycle cost whilst increasing performance at the same time (fig. 36).

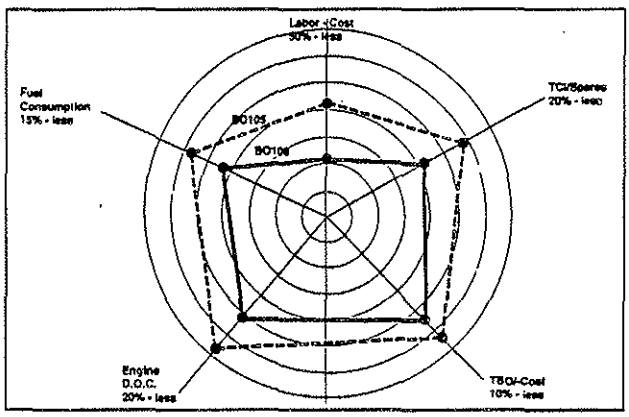

Fig. 36 BO108 Economic - Objectives

The prototyp No 1 has accumulated in meantime appr. 200 flight test hours with successfully exploring the basic flight envelope (fig. 37). The aircraft has been flown at weight level up to 5400 lbs and has been tested up to the maximum altitude permitted by the engines of 20.000 ft. Flight speeds of 165 kts in dives and a maximum rate of climb of 1900 ft/min were achieved. A service ceiling of more than 10000 ft was demonstrated under one-engine-off (OEI) condition.

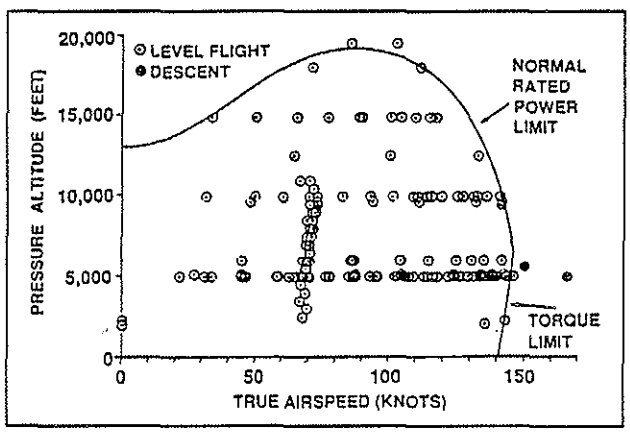

Fig. 37 BO108 Flight Envelope

In meantime the prototyp No 2 in a 6-Seater configuration powered by TM319-Engine has performed its first flight on 5. June 1991 at MBB/Ottobrunn (fig. 38).

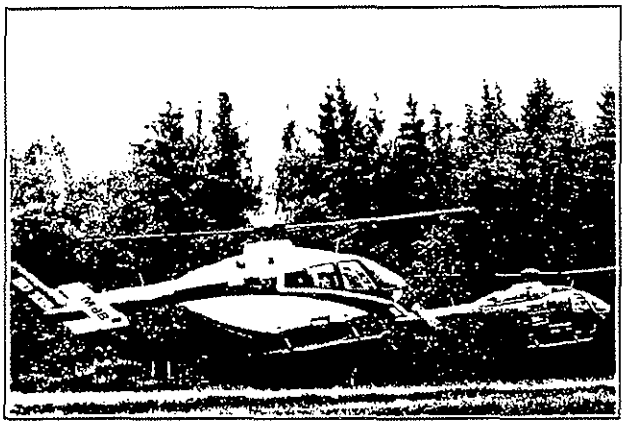

Fig. 38 BO108 S01 and S02

The design work for the pre production helicopter S01, powered by TM319 and S02, powered by PW206B is ongoing. Also some feasibility studies using the BO108 as a military helicopter have been performed. The selected BO108 configuration offers also good possibilities in terms of sensor installations, carriage of weapons and is very capable for installation of equipment due to its internal volume. Possible future roles for such an helicopter could be the observation and light SCOUT-mission, special tasks in training, medical support, ECM/ECCM and for battlefield surveillance, for example (fig. 39).

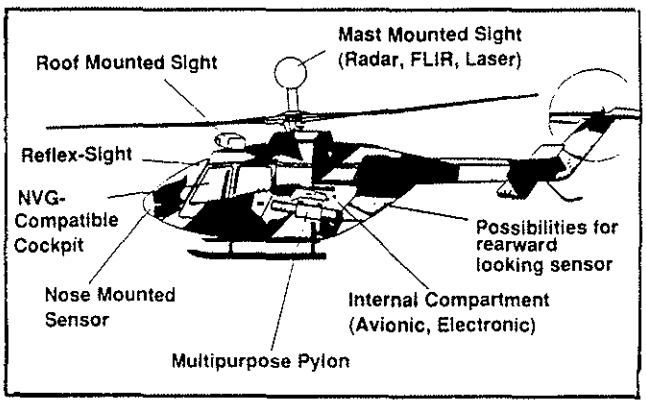

Fig. 39 Potential Military Application

The future BO108 program activities show final development flight testing and certification flights with the S01 at MBB/OTN and with the S02 at MCL/Canada achieving certification for VFR/IFR in 1994/1995.

ALH

In July 1984 MBB signed a contract with the Indian government to support India in developing a multipurpose transport helicopter of the 5 t class. The Advanced Light Helicopter (ALH) is designed for multirole application in both, civil and defence operations (fig. 40). The helicopter has a hingeless main- and tail-rotor. Main transmission and main rotor head are combined in an integrated module called Integrated Dynamic System (IDS).

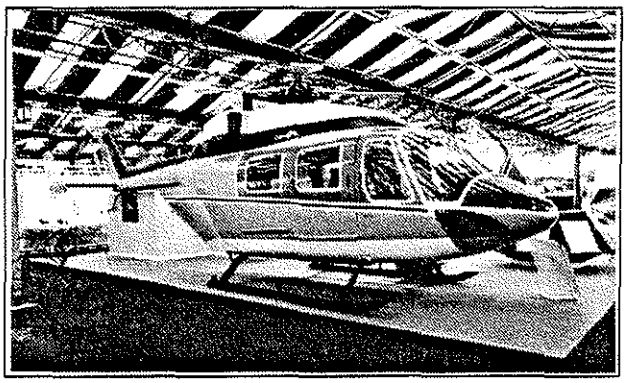

Fig. 40 Advanced Light Helicopter (Mock-up)

The Anti Resonance Vibration Isolation System (ARIS) used in this helicopter permits with 4 isolation units a 6-axis isolation. The units are designed according to fail safe criterias and are maintenance free. The fuselage shows an extensive use of composite materials, appr. 60% of the surface area. The cabin offers a big internal volume, in the basic version the ALH offers a seating capacity for a crew of 2 persons and 11 passengers. A major design requirement for the power plant and dynamic system was an excellent performance in hot- and high-condition also under OEI-condition.

Since december 1990 the Ground Test Vehicle (GTV) is in operation in Bangalore to carry out dynamic tests on engines, transmission systems, rotors etc (fig. 41). The maiden flight

will take place in the near future. MBB has not yet decided to proceed with an own version of the ALH.

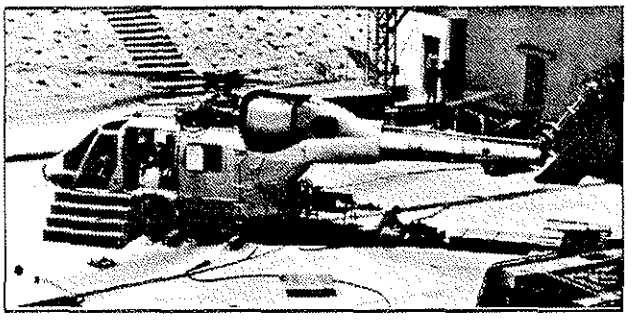

Fig. 41 Ground Test Vehicle (GTV)

Next Helicopter Generation

Although substantial technical gains have been achieved in the past, the current state-of-the-art still presents some obstacles to a full acceptance of rotorcraft by operators, passengers and communities.

In the civil field, the critical technologies are more or less identified, where improvements must be achieved, i.e.

- Economics of acquisition and operation
- External and internal noise
- Vibration and comfort
- Safety of vehicle and operation
- Air-Traffic-Integration for all-weather

In the military field, the substantial changes in the threat scenarios have also led to new requirements, such as

- increased air-mobility
- air-to-air combat capability
- sophisticated sensor/reconnaisance capabilities
- control/communication/coordination capabilities
- versatility of operation

As outlined before, the technology basis for fulfilling such new requirements -both civil and military- is under preparation. We have to concentrate our capabilities and to focus our ressources to these goals. Studies at MBB are concentrating on new concepts for the "Helicopter 2000" (Fig. 42), and the payoff of new technologies applications is under investigation.

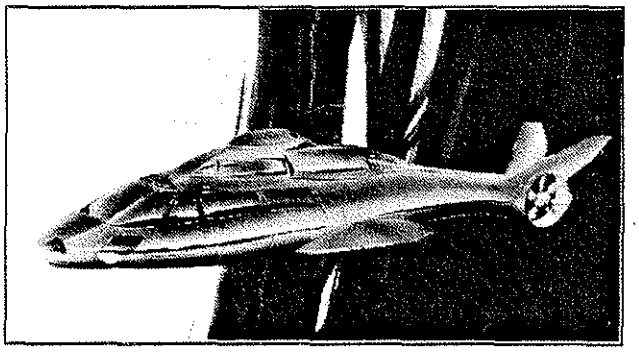

Fig. 42 Helicopter 2000 Project Study

The motivation for new forms of rotorcraft is also increasing today and the next generation of rotorcraft will probably look different from today's vehicles. The Tilt-Rotor technology has been taken up within the European Collaborative EUROFAR-project (Fig.43), aimed to offer a european tilt-rotor aircraft by the year 2010.

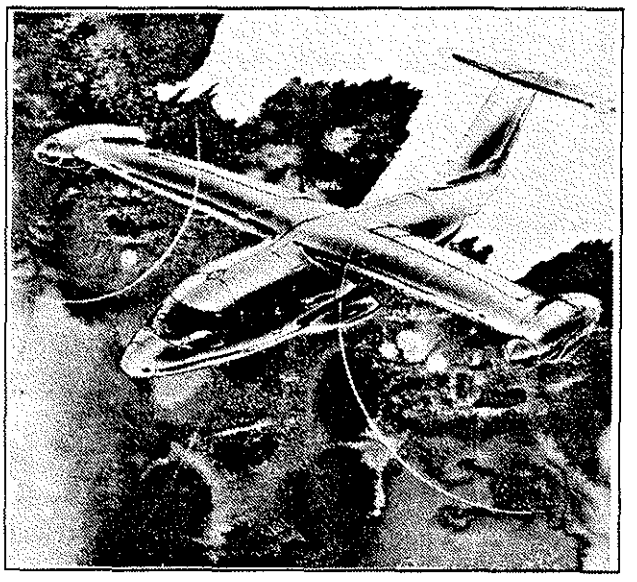

Fig. 43 EUROFAR Tiltrotor Aircraft Project

Outlook for the German Helicopter Activities

A key element for the German helicopter industry is the German civil and military home market. And if we compare the present numbers to the market volume what we had in the past excluding the MI-Helicopters, than we have a market volume which was relatively constant. Now to predict the future, how the German helicopter market will develop is a very ambitious task and can not be seperated of the environmental conditions like world-market, political situation etc. But we are all part of the Helicopter business, therefore it is our duty to do some assumption about the future helicopter business. I will try to formulate some perspectives, but having in mind that we are normally too optimistic in the near future and we are too pessimistic in a more distant future.

Military Helicopters

The military helicopters has achieved due to the IRAK-War, a positive image. The helicopter operated in this conflict have shown evidence that they can do for what they are designed. Also they have shown that the helicopter can play an important task within the global conflict szenario.

Therefore I believe that the prospects for the military helicopters in Germany are good. The main programmes in the future are PAH-2 and NH90. The necessary tasks for PAH-1 upgrate, UH-1D life time extension program and the BSH-1 Escort helicopter are clearly formulated and these programmes are more or less confirmed in the relevant mid term military plannings.

Although not yet formulated officially, but taking the future requirement into account, it seems to be a demand in a specialized Escort Helicopter called BSH-2. Also the missions reconnaissance and battle field guidance and control are getting more important in the future as a helicopter task.

Civil Helicopters

The most difficult and demanding activities are civil helicopter activities because the market shows

- still depressed sales
- second hand products out of military use
- too many products
- intensive competition

Of course MBB is also hit by this situation. Because the fleet of German civil helicopters is relatively small, our operators do not have the same magnitude of problems than the big operators. Giving up civil business and concentrating only on military helicopters is in my opinion not a solution. The German helicopter industry needs both activities in the future to be in long term competitive. Maybe a small growth for Helicopter doing some public tasks can be assumed. Perhaps new tasks like environment control, EMS during night and under bad weather condition can create some positive impacts.

Consequences for the German Helicopter Industry

The governments, users and industry have invested a lot in what we have established as a Helicopter Industry in Germany and also a significant amount of money for the future -as I hopefully could demonstrate a little bit- is necessary to keep this industry alive and now of course we want a return of investment in form of a bigger share of our home market and

what is much more important in the world market. It is my opinion that we can achieve this objective only, if we collaborate within our industry to be more efficient with our investments and to create larger military markets. Germany, especially DASA has very clear-ly demonstrated that we are going the way of international cooperation in the field of aerospace and in our case helicopter. Only those companies which arrange their business in such a manner and are prepared to cooperate on an international basis will be able to survive.

Aerospatiale and MBB who already cooperate in the German-France „TIGER" program as well as in the NH90 program have decided to coordinate their helicopter activities immediately with the aim of establishing a common holding company Eurocopter SA. Eurocopter will be established within 1991 and will be open to other helicopter companies to strengthen and concentrate the performance of the European helicopter industry.

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