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THREE-DIMENSIONAL COMPUTER AIDED DESIGN SYSTEMS – IMPACTS ON FUTURE HELICOPTER DESIGN WORK

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THREE-DIMENSIONAL COMPUTER AIDED DESIGN SYSTEMS – IMPACTS ON FUTURE HELICOPTER DESIGN WORK

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Abstract

At MBB, the use of 3-D Computer Aided Design system in HC preliminary design has increased rapidly since it's installation to 30% to 40% of total draft work. Consequently a variety of new options such as surface generation, spatial integration, kinematic calculation and analysis, enable the engineer to develop new methods and new approaches to design problems. In addition, a great time saving is achieved in usual draft work. Typical applications of 3-D systems in preliminary design include the generation of HC geometry, subsystem integration, cockpit layout and kinematic investigations.

The data base capability of the 3-D system allows the user to connect interface programs for further investigative versatility. Thus, the extensive application of 3-D systems will evolve the design of helicopters to an optimization process during the early design phase.

1. Introduction

The growing requirements of both the civil and military helicopter markets in the areas of performance and efficiency of next generation helicopters create the necessity of a optimization process in the early preliminary design phase. Significant improvements in that area are reached by means of Computer Aided Design systems (CAD).
Table 1 shows a general overview of the history of CAD systems at MBB.

1966	1st Investigations	
1970	1st Application of Surface Defining System	
1977	Studies of MBB/IBM for a Graphic, Interactive System	
1979	Installation of 2-D System **'CADAM'**	
1981	Test Installation of 3-D System **'CATIA'**	
1983	1st Application of 3-D System	
1984	Begin 3-D-NC-Milling	
MBB total:	300	Graphic, Interactive Work Stations
	30	Plotter
	2100	Trained Personel
HC Division:	29	Stations
	3	Plotter
	250	Trained Personel

Table 1

Two-dimensional CAD systems were the first step to significant improvements. While 2-D systems don't essentially change the helicopter design process, 3-D systems offer a wide variety of abilities, which have a great impact on the aircraft design process.

2. Growing Applications of CAD Systems

Since the CAD systems have been installed, their application has increased steadily. Today, most preliminary and production drawings are developed on CAD systems.

Especially in the preliminary design group, more and more drafts and investigations are made by means of 3-D systems.

Figure 2 shows the degree of penetration of 2-D and 3-D drafting into the preliminary design group.

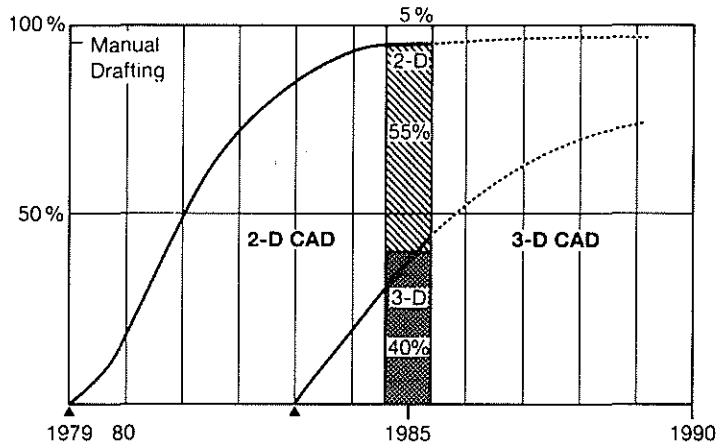


Fig. 2

About 95 % of drawings are made with CAD systems, up to 40 % on 3-D systems, replacing 2-D work.

3. Advantages of 3-D Systems

By means of 3-D systems, a dramatic reduction in manhours is possible compared with manual methods and, in many instance, with 2-D systems. Figure 3 shows the times needed for generating and defining the surface geometry of a typical small helicopter. Using a 3-D system, the manhours can be reduced to about 10 % compared with that of manual methods.

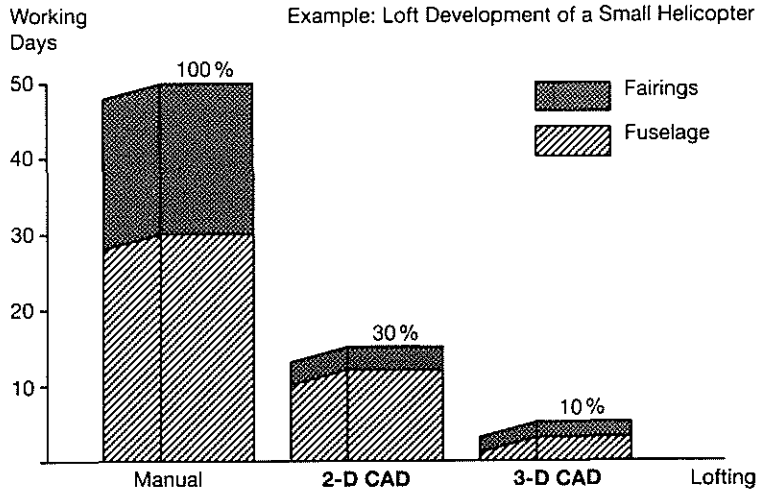


Fig. 3

In addition, the 3-D system offers a selection of new options for designing, analysing or visualizing, i.e. spatial integration, cockpit layouts and kinematic investigations can easily be done.

Both the time saving in replacing manual or 2-D drafting and the tremendous extension of design alternatives of a 3-D system enable the designer to consider more requirements in the early design phase and to develop multiple approaches in HC design.

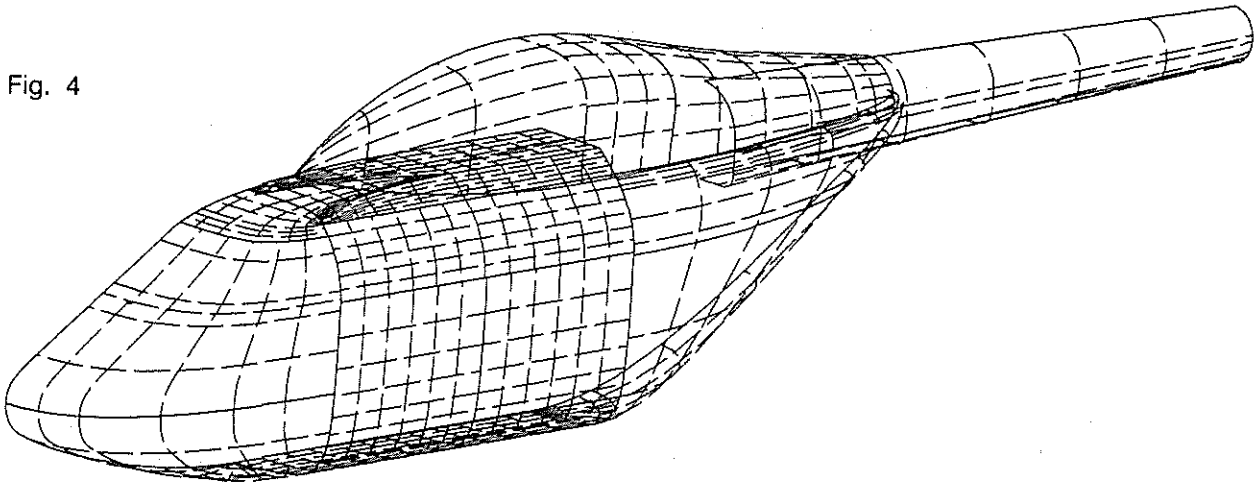
In addition, once the geometric data are generated, they exist as a data base for further investigations, detailed design and analysis, leading to further reduction of manhours in other disciplines. Cross sections, contours, views and angle of sight diagrams can easiliy be derived. Important for future design process will be the possibility of aerodynamic analysis based on the generated geometric data, allowing the designer to optimize the geometry of a HC in the preliminary design phase.

Further applications of the data base properties are possible in areas such as geometric analysis, scaling for wind tunnel models, Finite Element Analysis (FEM) or later Computer Aided Manufacturing (CAM).

4. Typical Applications of 3-D System in Preliminary Design

A basic work in preliminary design is the development of the outer dimensions, contours and the loft of helicopters, corresponding to a myriad of requirements. Figure 4 shows the loft of a light helicopter, generated on 3-D CAD system.

Fig. 4



Here, each point on the HC surface is exactly defined. Isoparametric lines on the surfaces give an impression and provide feed back to the designer in the first iterative step to optimize the loft. Aerodynamic requirements can be considered as well as geometric requirements, such as flat or simple curved windows.

The next stage in HC design is the integration of subsystems. A similar task is the integration of new components into existing HC. Figure 5 shows the integration of a new engine type into a light twin helicopter.

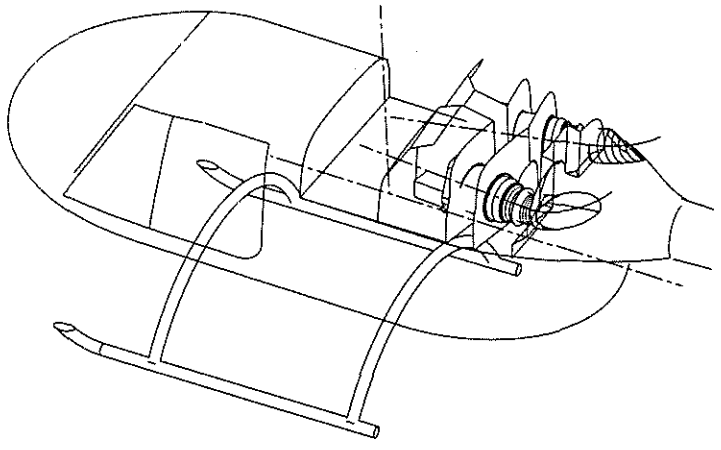


Fig. 5

By this, the general arrangement of engines, transmission and other subsystems can be studied as well as alternative air inlet systems, including fire wall layout or exhaust pipe arrangement. With the 3-D system mayor components can be generated as solids with optional colour shading, which enables the designer to readily visualize the actual installation.

A difficult subject for simulation and predictions is cockpit design. A 2-D cockpit layout has to be realized often in several simple and more detailed mock-ups. Using a 3-D system, the designer has options which enable him to develop with precision and to iteratively solidify this design before it is realized in a mock-up. Figure 6 shows a 3-D cockpit layout for a military helicopter.

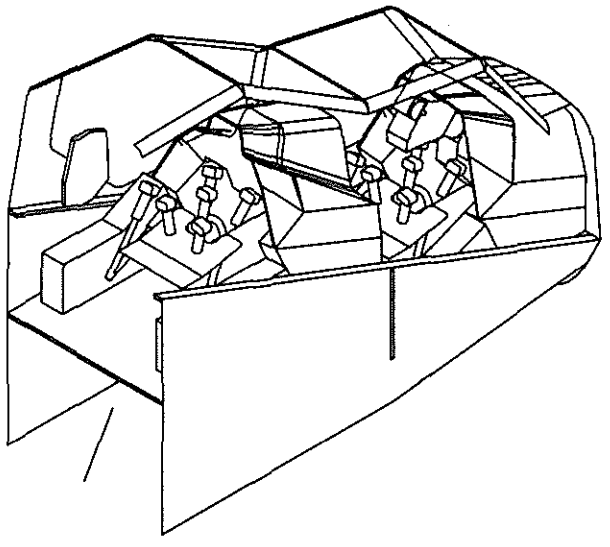


Fig. 6

Instrument panels, side panels and glare shields are designed corresponding to sight aspects and reachable areas of the pilot. The geometry of panels and glare shield contours are designed in line with the window and windshield contour, looking from the left and right eye point, respectively.

To check the design, the 3-D system offers the possibility of a conic view which will simulate a real view *from any point in any direction as opposed to the usual projection which is a normal projection.* Figure 7 shows a conic view from the rear seated crewmember's eyepoint looking straight forward.

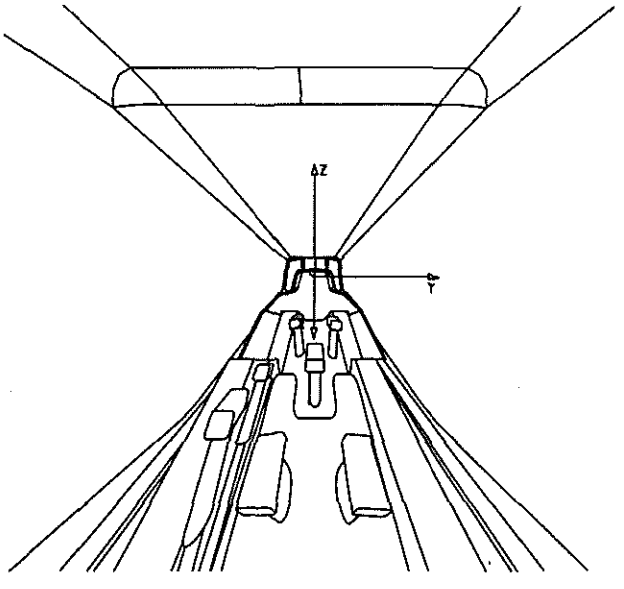


Fig. 7

This option enables the designer to get a perception of sitting inside the cockpit. This provides obvious advantages for the analysis of sight quality.

Kinematic analysis, such as cockpit, sliding or clamshell door movements, are problems, which cannot be solved efficiently with 2-D systems. The 3-D system is able to calculate combined kinematics, consisting of several moving parts. Examples are given in Figures 8 and 9.

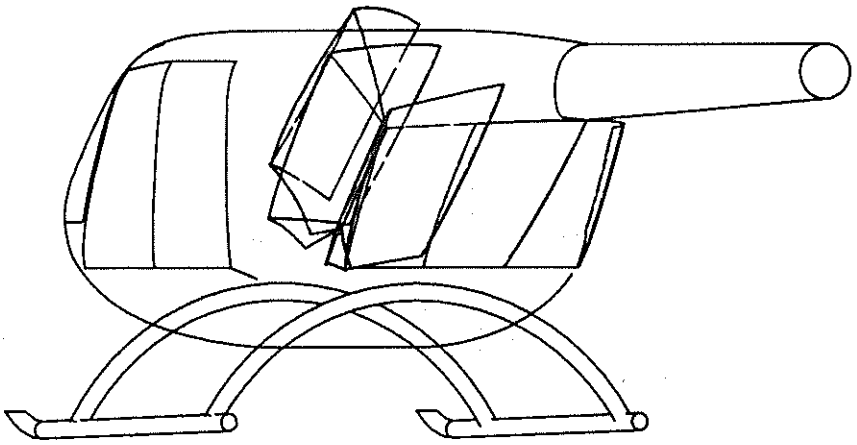


Fig. 8

Figure 8 shows a BK117 type clamshell door, which is foldable.

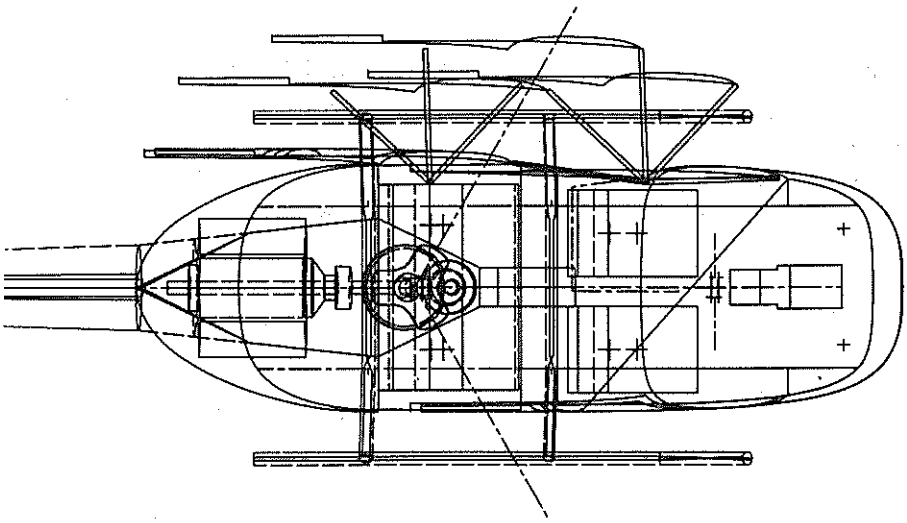


Fig. 9

Figure 9 shows the door of a small helicopter, which is hinged to the fuselage by three lever rods. The movements of the several parts are directly visible on the screen through certain steps, which can be determined by the user.

The loci of a moving reference can be generated during the kinematic calculation. The clearance of moving parts to other parts can be subsequently analyzed. In short time, different kinematic solutions can be efficiently investigated.

The basic arrangement of next generation helicopters will be generated totally in the 3-D system. Figure 10 shows a new, small helicopter project with the major components and the structure system, generated in the 3-D system.

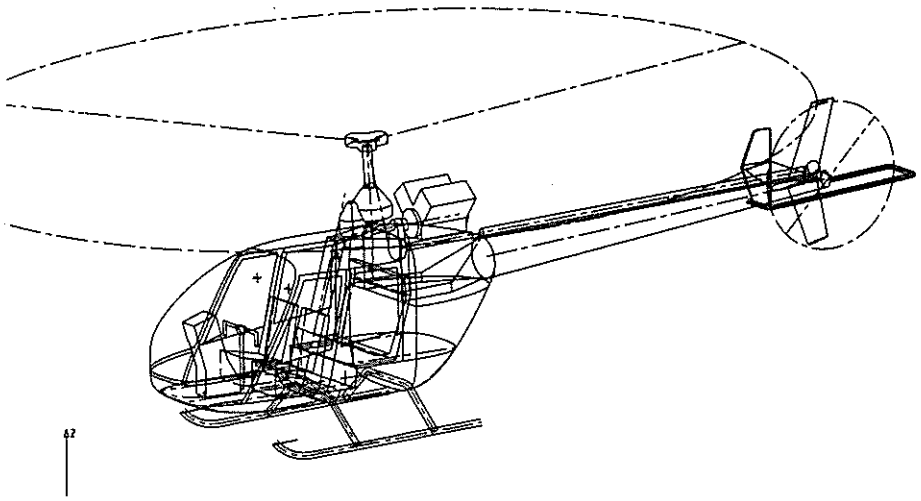


Fig. 10

The formulated data base allows the recall or generation of details for further design, such as normal and oblique sections or contours of structure components within a few minutes, which historically would have taken hours using manual methods. Volume and surface area calculation, which are the bases for first weight and cost estimations can be easily done using the geometric analysis capability of the 3-D system.

Further, the data in the 3-D system can be retrieved by external interface programs. An example is given in Figure 11. An interface program uses the data of the window contours, which are generated as wire frames, and calculates angle of sight diagram data. Out of these data the program generates a 2-D drawing of the angle of sight diagram. Compared with manual methods, the time necessary for generating an angle of sight diagram is reduced from hours to some minutes.

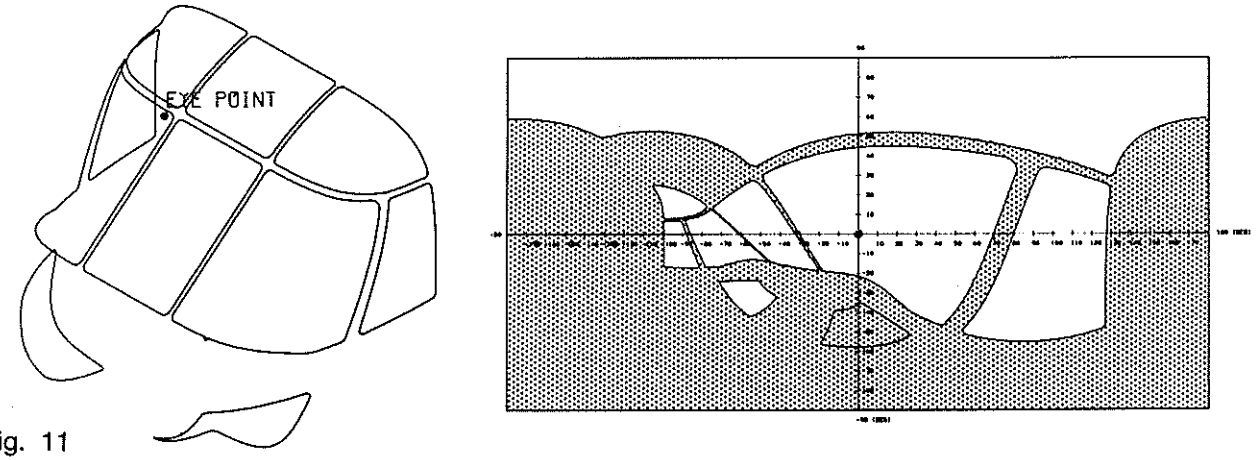


Fig. 11

The consideration of aerodynamic and flight quality requirements demand greater emphasis during the early design phase of HC's. Experience shows, that modifications on the basic geometry of a helicopter during the detailed design phase because of aerodynamic or flight dynamic reasons are very time consuming and expensive. To minimize redesign, MBB is developing the interaction of aerodynamic calculation methods with the data base of the 3-D system. The outside geometry of the helicopter is then transformed to a panel model, Figure 12. Thus, the theoretical speed and pressure distribution on and in any distance from the HC surface can be calculated.

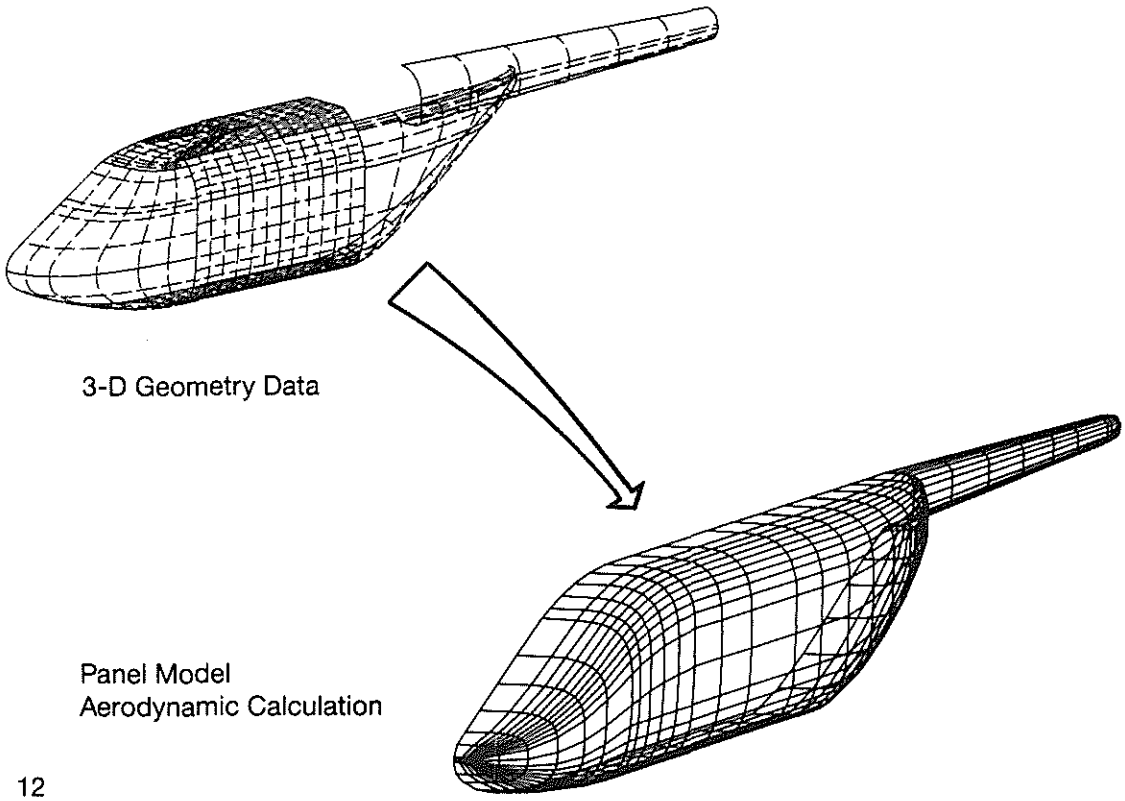


Fig. 12

The result is another input for the development work. The extensive use of both these numerical methods and 3-D graphic systems will lead to the possibility of a optimization process in the early design phase.

CONCLUSION

The application of 3-D systems will continue to grow. Their capabilities will ultimately include tasks that, with todays systems are more easily handled and better suited with 2-D options. Although initial training time of about two weeks is required for learning the 3-D system operation, the designer overall productivity is unquestionably enhanced with his ability to effect multiple solutions and innovate approaches in a fraction of the time.

Numerical codes can share the 3-D information data base and make further calculation and investigations. The design process is now evolving into an optimization process, which will yield designs of high performance, cost effective military and civil helicopters.