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NAVIGATION MAP DISPLAY FOR HELICOPTERS

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BODENSEEWERK

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Abstract

This presentation describes the experimental system of a" Navigation Map Display for Helicopters", which was especially designed with respect to ergonomic aspects such as space in the cockpit, easy handling, minimum concentration effort for operation, low weight, small size and use of the pilot's "personal" navigation map. The unit can be operated together with any navigation system on board.

In order to understand the function and performance of the unit, information are given on history, main requirements, function, performance and set up of the map display.

The paragraph dealing with "Prospects" shows the varions possibilities of communicating with advanced bus systems (MIL-Bus 1553B), of monitoring flight paths during SAR missions, of an automatic updating of the respective airborne navigation systems and of using the unit on land vehicle navigation systems.

NAVIGATION MAP DISPLAY FOR HELICOPTERS

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Ladies and Gentlemen,

let me tell you something about a "Navigation map display for Helicopters" placing the emphasis on the ergonomic aspec please have a first look to the

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1. Why map displays?

This question is as old as flying on an aircraft. Man always wanted and still wants to know the actual position of the aircraft at any time and any state. Knowing the actual position makes him feel safe, it confirms of the performance supplied and allows a safe planning of the forthcoming missions.

Today there are suitable means to achieve this goal in modern navigation with a considerable degree of safety, for instance radio navigation systems, inertial navigation systems, Doppler navigation systems and global positioning systems. But all these systems still have one common disadvantage: the actual position is indicated in a digital form. Man, however, as an analog-thinking being needs some kind of "translation aids" to finally identify the position on a map.

The navigation map display is such a "translation aid" from digital to analog; it automatically transmits the coordinates of a navigation system in due time and without making any error to the mission map. Very often it is of major importance that this is not a synthetic representation but actually the "own" pilot's personal map, where manual entries are possible, too.

2. Why operational map displays only as late as today?

This question is legitimate. The desire to represent the actual position on a map and the possibilities to do this exist for a long time already. As an example I only want to mention the more than 25 years of research activities done by the "Institut für Flugnavigation" at the university of Stuttgart.

The decisive break through in this field of avionics was done when the microprocessor technique was introduced. This technology then allowed the design of complex systems which were easy to handle. With respect to weight and volume these instruments no longer represented a problem when they were integrated in the cockpit of a helicopter or other aircraft.

And the additional advantages offered by the digital technique could also be used, such as:

- higher flexibility when using the map display because of accelerated processing speed and increased storage possibilities
- better adaptiveness to existing navigation systems. This is sometimes possible by only modifying of the software
- enlarged modes of map displays, for instance switching to different map scales, moving to target points independent of the basic navigation system, interrogating of storage contents, possibilities for testing and selftesting.

3. History

1977:	unofficial inquiry of the German Army pilots for an automatic navigation map display to be used on a helicopter
1978/79:	modification of an existing navigation map display for land vehicles in cooperation with the "Institut für Flugnavigation" at the University of Stuttgart. Creation of a flying experimental version of HKG 5 (Hubschrauber-Karten-Gerät)
Nov. 1979:	First flight of a HKG 5 on a CH 53 helicopter
1981/82/83:	Various tests to demonstrate whether the HKG 5.2 could be accomodated on the following aircraft. Namely the helicopters type BO 105/PAH 1, VBH and Bell UH-1D all used by German Army pilots. These tests showed positive results.
1983:	Completion of the tactical requirement in Germany: for helicopter night missions the HKG 5.2 is considered to be absolutely necessary.

4. Presentation of the Unit

4.1 Principal functions

The display gets the digital position information from the navigation system via a screened cable. It will process the data by the microprocessor, and will control two stepper motors via an amplifier device. The stepper motors are moving a lamp with a lens system in x and y direction via a spindle. This lamp illuminates the cover glass and the map placed on it, thus showing the geographic position of the helicopter as a bright light spot on the map.

4.2 Operation

The normal operational position of the display is "NAV". When switching to "NAV" an automatic adjustment process will be carried out, moving the light spot on the map area in diagonal direction. Thus, the microprocessor is informed about correct function of the stepper motors and their zero position.

The experience gained during the flight tests showed that the position "NAV" is maintained for more than 90 to 95 % of the mission time. This is already a first indication for the fact that the display can be operated with minimum effort. During flight different map scales can be used. If we take for instance this HKG 5.2, the scales 1 : 50.000, 1 : 250.000, 1 : 500.000 are used according to the main requirements of the German Army pilots.

If the helicopter is mainly flying in South direction, the map may be rotated by 180°, it is then south-oriented. For doing so the ▼N switch has to be activated making the light spot moving to the real position. This movement is symmetrical.

When the switch is in "Ziel" (Target) position any target point may be manually selected by activating the four push-buttons according to their directional markers. The East-North coordinates can thus be read on the display panel and can be transmitted by radio to the competent head office for instance.

This mode also allows an updating of the navigation system. When passing a prominent landmark, the navigation system has to be set to "Hold". Then the light spot can be slewed to this landmark on the map and the East-North can be read on the display panel.

Then the coordinates are entered into the navigation computer. After pushing the "ENTER" key on the computer keyboard and after transition to normal navigation mode, the distance flown in the meantime will be added, giving the real position.

In "Memory" mode the characteristic map data, such as the center coordinates and the selected map number of the various navigation maps will be stored. It is suitable to do this before the missions are started as the battery buffered RAMs will keep these data, even when the unit is switched off. In future we will, however, use non-volatile memories.

In order to key in the map sheet characteristics, the two horizontal push buttons (◄— —►) are actuated to select the relevant digit and to make it blinking. The two vertical push buttons (↑ ↓) then serve for the determination of the contents of the digit by counting up or down (A - Z, 0 - 9).

When a data record has been fed-in and checked, it is transferred to the memory by pressing the "IN" - key. The contents of the memory may be overwritten or cancelled.

If for some reason the perfect operation of the navigation system is doubted, the switch is set to "T" (Test). If the light spot moves to the map center, it is clear that the map display operates properly. In this case the failure must be caused by the navigation system.

This setting (T) also allows checking of the memory contents by pushing the vertical push buttons (↑↓) for each scale. An empty memory is indicated by a dash.

By means of the left switch on our viewgraph the illumination of the map window can be dimmed and the switch on the right is used to dim both the brightness of the light spot and the characters in the window.

4.3 Display panel

The head end of the map display is provided with the display panel. The present version still uses LEDs. Future units will have LCDs for the indication.

The number of the map to be placed on is shown in the respective display segment. The rectangle (☐) shows the two identification characters of the 100 km square of the UTM map system (e. g. NV). This is followed by the digital display of the East and North values. Generally the primary navigation system is also provided with this digital display for Eastings and Northings.

4.4 Technical data

Possible Map Scales:	1:50.000	1:250.000	1:500.000
Obtainable indication accuracy:	10 m	50 m	100 m
Accuracy, absolute:	± 0,2 mm		
Weight:	1,95 kg		
Dimensions:	200 mm x 350 mm x 45 mm		
Display size:	160 mm x 240 mm		
Stepwise movement of the luminous dot:	0,2 mm		
Map illumination:	steplessly variable		
Brightness of the luminous dot:	steplessly variable		
LED/LCD-Indication:	steplessly variable (additional illumination)		
Power supply:	28 VDC		
Power consumption:	20 W normally 25 W max.		

4.5 Interface

At present the experimental map displays HKG 5.2 are provided with the following interfaces:

- Data input ARINC 575
- Data input of two Doppler-manufacturers, factory standard
- Data input of a land vehicle navigation system, factory standard

Options:

- Data output ARINC 575 (in preparation)
- MIL Bus 1553 B, bidirectional (in preparation)

4.6 Set up of the map display

For maintenance reasons the unit is devided into two parts. After unscrewing of four screws, the inner sections are easily accessible. Flexible cables ensure full function even in this constellation.

The navigation map display housing is made of high quality aluminium alloy. It can be screwed in such a way that it is waterproof in accordance with the MIL standards.

The upper part of the housing is provided with integrated shaped parts for the display and control panel and the window on which the map is placed. The window frame is provided with holding magnets and two locating pins for adjusting the map.

In addition the stepper motors, the guide rails, and the high-precision spindles for moving the light spot are also housed here. The light spot is produced by means of a lamp, a lens and a pinhole mask.

The bottom part of the housing consists of a solid base plate accommodating the electronics card, the switches and controls and the LEDs (LCDs). The electronics card is provided with the microprocessor (8 bit), the RAMs, the EPROMs and the power supply.

5. Ergonomic aspects

Though the navigation map display for helicopters is an avionic instrument, it is not stowed away as a "black box" somewhere in a bay. As you can see in the viewgraph it has to be within the operator's reach. By this characteristic it is exceptional among all other avionics. It could even be possible that it will belong to the pilot's personal outfit.

And this was the reason why - right from the beginning of the design - special attention was paid to the ergonomic aspects of the map display.

And very soon the following problems appeared:

- to find space for the unit in the mostly very narrow helicopter cockpits
- a minimum concentration effort required to operate and control the display
- easy operation and clear display of data
- low weight and small size
- and special requirement by the pilots: they wanted to use their personal navigation or mission maps.

5.1 Operational aspects

The map display should not be too highly sophisticated and should be easy to handle. It should in fact only replace the well-known pilot's knee-board, with the additional requirement to automatically find and indicate the actual position. Therefore it is essential that the pilot may put the display aside if it is not needed. If it is switched on again it will automatically display the map number required for the selected scale. Thus, the position is found by a minimum effort of the pilot: reading of the map number - taking the map out of a file - placing the map on the map display unit.

The possibility to switch over to North-South and then to turn the map to flight direction satisfy the requirements expressed by a great number of pilots.

The illumination devices of the map display must be adaptable to the environmental conditions, as especially by night the pilot's orientation is complicated. Therefore he very much relies on the map display. Military test flights showed that the pilots drew wrong conclusion from the changed skylines when wearing night goggles; they relatively often took the wrong way even in a well-known surrounding. Therefore the use of a navigation map display when wearing night goggles became even a military requirement in Germany.

5.2 Map management

When flying the pilot does not want to be loaded with extra work by using the map display. Right from the beginning it was therefore stressed that the map management can be fully prepared before flight. In case of the HKG 5.2 the maps are systematically numbered, cut to size, put in plastic jackets with metalic strips and their center coordinates are entered into the RAM. All this is done outside the helicopter. The maps may be used for many years, at least until new navigation maps are available.

During flight the map can be placed on the display with only one hand and can be adjusted by means of small adjustment pins. This does not require much effort by the pilot and therefore one can say the present HKG 5.2 is nearly an "automatic" navigation map display.

5.3 Use in the cockpit

Up to now, this aspect required the most extensive ergonomic studies. As previous applications represented typical retrofit applications, several studies were made to investigate on the use of the map display as a kneeboard. These are several versions which were used for installation tests or tests with sitting persons. The result is the present design of the HKG 5.2. The external dimensions are: 200 x 350 x 45 mm and it is used as a pilot's kneeboard. This is a possibility to attach the unit on the thigh.

We also studied the possibility of mounting the map display in the cockpit, but this depends on the type of helicopter. It can be screwed to a suitable structure or panel section.

This support is another solution and a special development for the use on the BO 105/PAH 1/VBH of the German Army, and it has been built as an experimental sample, as space problems are extremely critical on this specific helicopter. The reason for this version was that we had asked the pilots what they thought about the installed possibility. They had considered it to be a real alternative to the kneeboard version. A final decision on this is still pending.

5.4 Reliability / Confidence in the map display

As the pilot very much relies on the map display, he must have a sound confidence in it. Therefore the introduction of the "Test-mode" was of vital importance. Although this is a mere classic "go - nogo" test, it can absolutely back up the feeling of confidence.

6. Prospects

At present considerations are made on the extension of the functions up to a central airborne navigation system. The fact that the system can communicate with advanced bus systems (MIL - Bus 1553 B) is also taken into account in this connection.

As far as the operational side is concerned the use during SAR missions above sea would be important. Given flight paths can be drawn on foils like a net or grid and can then be placed on the mission map. By means of the light spot the flight path could always be monitored, and this is most useful because of the missing reference markers on the open sea.

The map display can be developed for an automatic updating of the respective airborne navigation system. As any position is available by manually moving the light spot on it, the manufacturer of the navigation system should provide for the possibility to process these data in the computer for automatic updating purposes.

And this is an example for using the map display together with a land navigation system.

7. Summary

The navigation map display HKG 5.2 is an experimental instrument which has developed to a typical retrofit unit. On board it is something like the pilot's "right hand". Therefore special attention was paid to the ergonomic aspects of the design.

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The map display is a valuable navigation aid for the pilot, especially in critical flight phases, such as bad weather, in twilight, at night and in case of extremely difficult missions. It is able to automatically indicate the actual position of the helicopter at any time and without error.

The map display helps the pilot to feel more safe and thus it helps to make air traffic more safe, too.

Ladies and Gentlemen, I thank you for your kind attention.