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ROTORBLATT

Testing PAVE procedures in the DLR EC 135 ground simulator

Pilot Assistant in the Vicinity of Helipads

Predicted trajectory in a virtual landscape

Virtual runway: integration of rotary-wing at aerodromes

A Research Project of the German Aerospace Center (DLR) and ONERA

PAVE

... heißt ein DLR-Projekt, dessen Ziel es ist, einen Hubschrauber-Pilotenassistenten zu entwickeln, der die Crew in die Lage versetzt, den Helikopter jederzeit, bei schlechtem Wetter und schwierigen Flugbedingungen sicher zu starten, zu führen und zu landen. Erste Schwerpunkte sind die An- und Abflugverfahren sowie die Verringerung von Lärmemissionen. Hier hat das DLR bereits Versuche mit dem FHS-Forschungshubschrauber (EC 135, Foto unten) absolviert.

Der Assistent ermöglicht eine präzise Flugführung, soll Kollisionen mit dem Gelände und anderen Luftfahrzeugen vermeiden und insbesondere bei neu entwickelten komplexen Helikopter-Anflügen unterstützen. Voraussetzungen: 4-Achsen Autopilot, (Bord-)Sensoren wie GPS, Hindernis- und Kollisionswarnsysteme, Datenbanken mit Leistungsparametern, Gelände- (Topographie) und Luftraumdarstellung etc.

Eine wichtige Vorgabe ist die Anpassung der Schnittstellen an eine einsatzorientierte, intuitive Bedienerführung. Der Assistent plant den kompletten Flug auf der Basis aller gespeicherten Profile.

Weitere Flugversuche beginnen in 2005. Das DLR legt großen Wert auf einen fortlaufenden Erfahrungsaustausch mit Piloten und Betreibern, um so alle Verbesserungen zu integrieren. Beteiligt ist auch die französische Forschungseinrichtung ONERA.

Measuring the noise pattern: Flight campaign with FHS

Pilot Assistant
The Next-Generation Helicopter Cockpit

Improvements in the field of Communication, Navigation, Surveillance (CNS) Technologies are finding their way into helicopter cockpits. The next step after the introduction of the glass cockpit, flight control systems with full authority, and flight management systems is the invention of the helicopter pilot assistant. Research is under way to give the pilot sophisticated computer assistance at hand.

The driving force is not only to reduce workload by delegating routine tasks in order to free capacities to concentrate on mission related issues. The addition of a Pilot Assistant can overcome current restrictions in helicopter operation and may be an enabler of new flight procedures and missions which cannot be performed by the pilot today.

The vision is to enable safe and efficient helicopter operation around the clock in all weather conditions and to use the full potential of the helicopter capabilities in the future to further expand the envelope of helicopter operation.

The next generation helicopter cockpit will have access to more detailed, more accurate, and up-to-date information provided by onboard databases, datalinks or sensors, e.g. digital terrain-databases or actual weather and traffic information. The Pilot Assistant will manage the information gathering process, prioritize information and present information suitable for the given flight situation. The flight or mission planning capability onboard will drastically improve in terms of accuracy and complexity. The assistant will use it to detect and resolve conflicts, and to avoid terrain, traffic and obstacles. Even fully automatic flight execution along preplanned trajectories will be feasible.

The pilot is in command and delegates tasks to the assistant, which should be designed to be operated in an intuitively understandable way. Such an integrated single system with a human-centered design offers many benefits compared to the various different task-oriented systems currently spread over the instrument panel. The benefits are ease of use, less training hours, and less workload to mention only a few.

Applied Research in Helicopter-Pilot Assistance

The German Aerospace Center (DLR) together with its French counterpart organization ONERA is conducting applied research in the field of helicopter pilot-assistance. A joint project entitled PAVE (Pilot Assistant in the Vicinity of Helipads) was launched under the management of the DLR Institute of Flight Guidance in Braunschweig.

PAVE concentrates on approach to and departure from helipads and is to enable safe takeoffs and landings even under minimal visual conditions. The project covers today's standard procedures and emergency procedures in case of an engine failure. Research is also being done to define noise-abatement procedures and time based procedures required for future Air Traffic Management applications.

The pilot assistant PAVE is a functional prototype and will be integrated into DLR's research helicopter Flying Helicopter Simulation (FHS) with first flight trials starting in 2005. The FHS, a Eurocopter EC 135, is a fly-by-light helicopter with a modified cockpit. The cockpit features a large freely configurable display on the right hand side for the test pilot and conventional glass-cockpit instruments on the left side for the safety pilot, who can take control of the helicopter if necessary. This permits testing of new control laws, flight-guidance and display concepts under realistic flight conditions without risk.

In the first stage of the PAVE project the main focus is to increase situational awareness of the pilot, to improve onboard planning capabilities and to support flight execution. The assistant is even able to guide the helicopter automatically along a preplanned trajectory.

Realtime onboard planning

One of the main features of the assistant system is its capability to compute the optimal plan according to constraints set by the pilot and to calculate and predict the flight path accurately. The DLR Institute of Flight Guidance has developed a highly accurate 4D trajectory-planner for helicopter application. The Pilot Assistant PAVE generates a 4D trajectory with time being the fourth dimension. The trajectory is based on the helicopter performance-data, helicopter state, actual weather and the helicopter's flight envelope. The assistant simulates the entire flight along the defined route, and according to the helicopter flight-procedures (altitude and speed profile). It modifies flight parameters until the constraints are satisfied. For example, speed will be increased if the helicopter is late at a waypoint with a fixed time of arrival.

The pilot is able to set waypoints, altitude and speed restrictions, and to define times of arrival at waypoints. Conflict detection with terrain is made during the simulation process and the assistant proposes a solution in case of conflict.

The trajectory has a high level of detail and covers typical helicopter maneuvers, e. g. backwards flight, turns, etc. An accurate flight path is a prerequisite for time based flight guidance and for conflict detection with obstacles, terrain, other aircraft and helicopter flight envelope limits. The trajectory reflects the flight intention and is the core information for further assistant driven processing like operator communication, Air Traffic Control by datalink, and flight-progress monitoring. The computer is powerful enough to cope with the realtime requirement of a maximum of 1 to 2 seconds for the planning process.

Human-Machine Interaction

Special attention is paid to finding ways to simplify constraint setting by the pilot.

A prototype navigation display is used which allows rapid investigation of new solutions by using soft keys and a cursor device. The pilot can set waypoints directly on the moving map by just clicking on the chart. Graphical constraint setting is considered with or without numerical settings. Another option under investigation is Direct Voice Input (DVI). All interface solutions have to be considered in the light of the challenging environment of the helicopter cockpit which can be noisy and vibrating, and offer only restricted space for additional devices and large size screens.

The assistant is designed to limit the necessary inputs to a minimum. It can construct flight plans from the navigation database or reuse pilot defined flight plans stored in the system or upload flight plans generated on the ground prior to the flight. In the simplest case only the destination point has to be inserted by the pilot to get a flyable trajectory.

Electronic charts are available onboard for flight preparation. Helipad Images are stored to increase situational awareness. The photo may be overlaid with additional information to highlight obstacles or preferable approach sectors.

Another important question is how to present the planned trajectory to the pilot. Today, it is possible to present some information on a moving map, vertical displays are not standard, and 3D presentations are just emerging. In the PAVE project DLR investigates visualizing the predicted trajectory in a virtual landscape.

High-Accuracy Terrain Data and Virtual Landscape

Realistic visualization of the helicopter flight along the planned trajectory is based upon data acquired with the High Resolution Stereo Camera (HRSC) shown below.

The HRSC camera was originally developed for Mars missions by the DLR Institute of Planetary Exploration in Berlin. The imaging system provides image data for the generation of digital ortho-images and digital surface models with an accuracy of 10 to 20 cm. Since the first experiments with an airborne version of this camera were carried out in 1997, coverage of more than 150 cities and large areas has been acquired and processed in Europe and the USA.

In 2004, a HRSC flight campaign was conducted exclusively for PAVE to cover the Braunschweig flight-test area. The resulting highly accurate terrain and image database is used by the pilot assistant to detect conflicts with terrain during the trajectory prediction process. Additionally, DLR is exploring the virtual landscape as a means to enhance situational awareness.

Autonomous Flight

Under investigation in PAVE is the pilot's option to delegate the entire task of flying the helicopter to the assistant. The assistant guides the helicopter along a preplanned trajectory by switching autopilot modes. The Institute of Flight Systems is developing a model-following control system with full authority for the FHS. The assistant enables an autonomous flight mode and provides adaptive flight-control laws to improve handling qualities in degraded visual conditions for the manual flight mode.

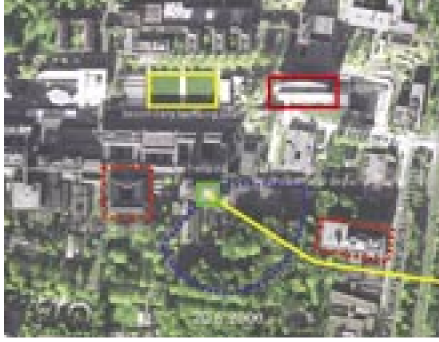
New Approach and Departure Procedures

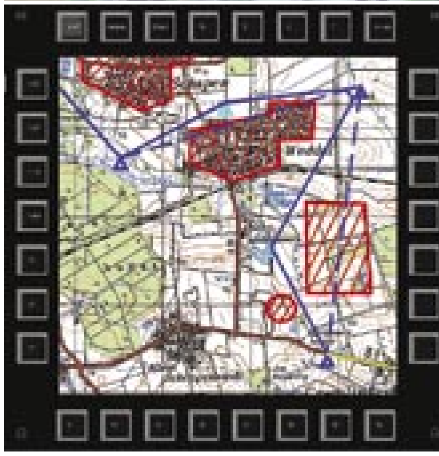
Today, helicopters are noisy during approach and landing, and, at busy airports, have to follow flight procedures designed for fixed wing aircraft. These procedures may change in the future.

The idea behind noise-abatement procedures is to fly the helicopter in those regimes of the flight envelope which produce less noise than others. Having a pilot assistant at hand, segmented approaches with precise descent and deceleration maneuvers may be realized without confronting the pilot with a high workload in an already demanding flight phase.

DLR flew its helicopters, the BO 105 and the EC 135, extensively above a wide area microphone array in 2004 to measure the noise pattern on the ground for different flight parameters. The Institute of Aerodynamics installed 40 microphones to cover an area of 800 x 800 m. The flight campaign was done in the framework of the PAVE project and took place at the closed down airport Cochstedt, Germany with no background noise of other aircraft. From the gigabytes of data the acoustics experts are now identifying an acoustic reference-model . Noise-abatement procedures flyable with conventionally equipped helicopters and for use in combination with a pilot assistant are being defined. The new procedures will be validated in additional flight tests later on in the project.

Another objective is to fly helicopter specific procedures at airports. Time based flying and separation of rotorcraft and fixed-wing traffic flow are envisaged to meet the demands of high capacity in future Air Traffic Management scenarios. The





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Fotos: DLR; Wenske, RB

Institute of Flight Guidance will define and demonstrate such helicopter specific procedures as part of the EU-project OPTIMAL in 2006.

Summary

The article gives a short overview of the DLR research in the complex field of helicopter pilot assistance. PAVE flight trials start in 2005. All the ideas of the researchers will be discussed with helicopter pilots, and many improvements will evolve from these discussions and will be integrated in the research prototype.

Ralf Kohrs; DLR

The DLR Institute of Flight Guidance in Braunschweig, Germany, has a long standing tradition in research on aircraft guidance and air traffic management. Its main areas of research are the optimum co-operation of human operators and automatic systems, and the design of support systems for pilots and controllers. It operates flight-simulation, air-traffic-simulation and ground-movement-simulation facilities including cockpits for transport aircraft and helicopters. (www.dlr.de)

The Virtual Runway

After the economic slump in aviation following 9-11, business is picking up pace again. Annual growth rates of 5 % and more at the airports prove this. But with this positive trend other problems returned to the international airports: capacities are at their limits, and at "rush hours", air-traffic controllers work at their limits. Effective use of airspace is almost constantly improved, but this is no help as long as the airports do not have the capacities to actually bring all the airliners in.

Part of the problem is General Air Traffic (GAT): shuttle and commuter flights as well as business aircraft that depend on the same runways as the big airliners. De-concentration seems to be the magic word to solve the problems. The simple solution is, just do not let GAT into the big airports and ban them – preferably to far away airfields. Naturally this is unacceptable especially to those, who are to no small percentage providing the airlines' income – by flying with them – and for whom "time is money".

Enter the vertical lift aircraft, be it the helicopter or a tilt rotor. Neither requires a runway, or needs to interact with fixed-wing aircraft in the approach sector, as they could approach at a 90 ° angle to it. This sounds optimistic and as if it were easy, but it is not.

What are we forgetting? What is the problem?

Currently, helicopters flying a perpendicular approach (e. g. approaching from the south/north to a west/east runway) can do this only under visual meteorological conditions (VMC), and when they do so, they usually worry most air traffic controllers. To permit these approaches under IFR in instrument meteorological conditions (IMC) blows all existing separation criteria to pieces and cannot be managed any longer even by the best controller.

However, there is a solution: integration of rotary-wing air traffic into the departing and arriving traffic.

Procedures for the approach could be to use a dedicated low-level helicopter flight-system; vertical separation up to entering into the approach sector; parallel approaches to existing runways adhering to existing separation criteria. Airline aircraft follow these procedures every day, approaching parallel runways, thousands of meters long.

The helicopter's or tilt rotor's advantage is that it does not need that long runway. A virtual runway would do, a small helipad connected to runways and taxiways. This simple solution could open capacities in the air spaces of airports, without the need for additional real runways.

It does require the adaptation of air traffic regulations to the special possibilities of the rotary-wing aircraft. It requires a restructuring of the air space, taking reduced obstacle clearance limits and steeper glide paths into consideration. Pilot-assistance systems like PAVE will allow rotorcraft specific instrument flights and further add the options for:

- noise reduction,
- flexible glide path settings,
- reduction of the work load for the crew.

Guido Ziese

Die virtuelle Runway

Nach den Einbrüchen in der Luftfahrt als Folge des 11. September 2001 nimmt die Branche wieder Fahrt auf. Das beweisen die Zuwachsraten an den Airports von durchschnittlich 5% jährlich. Mit diesem positiven Trend wachsen aber auch wieder die Probleme an den großen internationalen Flughäfen. Die Kapazitäten bewegen sich schon heute entlang der Obergrenzen; die Fluglotsen arbeiten in den Hauptverkehrszeiten am Limit. Es gibt laufend Verbesserungen zur optimalen Nutzung des Luftraums, doch was nutzt diese bessere Auslastung, wenn man die Airliner nicht zeitgerecht herunterbringt, wenn es dem Flugplatz an Kapazitäten fehlt?

Einen Teil dieser Probleme verursacht der General Air Traffic (GAT): Zubringerflüge und Geschäftsliner, die genau wie die großen Airliner auf die Piste angewiesen sind. Entflechtung heißt das Zauberwort, das nun die Probleme lösen soll. Vereinfacht heißt das: Man lässt den GAT erst gar nicht mehr herein und verbannt ihn – nach Möglichkeit weit weg. Eine erhebliche Erschwernis gerade für die Klientel, welche die Luftfahrt zu einem großen Teil mitträgt und für die das Motto „Zeit ist Geld" in hohem Maße zutrifft.

Dies bringt nun wieder den Senkrechtstarter – als Drehflügler oder Kipprotor – ins Gespräch. Der benötigt keine Piste und stört nicht im Anflugsektor, da er ja quer zum Platz anfliegen kann. Das klingt optimistisch und hört sich einfach an – ist es aber nicht.

Was wird vergessen? Wo liegt das Problem?

Hubschrauber, die quer anfliegen – z. B. bei einer Ost-West-Piste von Norden oder Süden – können das nur unter Sichtflugbedingungen (VMC) und bereiten manchem Lotsen auch jetzt schon einige Probleme. Diese Anflüge zusätzlich unter Instrumentenflugbedingungen und -regeln (IFR) freizugeben, sprengt alle Staffelungskriterien und ist für den besten Fluglotsen nicht kontrollierbar.

Es gibt eine Lösung: Integration der Drehflügler in den An- und Abflug-Verkehr.

Beim Anflug wäre folgendes Verfahren denkbar: Benutzung eines eigenen, niedrigen Höhenbandes. Vertikale Staffelung bis zum Einflug in die Anflugsektoren. Parallelanflüge zu getrennten Pisten, die nach Abstand und Lage die vorgeschriebenen Staffelungskriterien erfüllen. Diese Verfahren werden Tag für Tag von Airlinern geflogen, nebeneinander zu parallelen, kilometerlangen Pisten.

Der Vorteil für den Hubschrauber oder Kipprotor: Er benötigt keine kilometerlange Piste. Eine virtuelle Runway reicht; ein kleiner Heliport mit einer Anbindung an das Rollfeld. Auf diese Weise werden Kapazitäten von und zu Flughäfen gewonnen, ohne die Umwelt durch den Neubau zusätzlicher Pisten zu belasten.

Dazu notwendig ist eine Anpassung der Flugsicherungsvorschriften an das besondere Einsatzspektrum des Drehflüglers. Dies erfordert eine Änderung der Luftraumstruktur unter Berücksichtigung reduzierter Hindernisabstände und steilerer Anflugwinkel. Pilotenassistenzsysteme wie PAVE ermöglichen hubschrauberspezifische Instrumentenflüge mit den Optionen der

- Lärmreduzierung
- flexiblen Flugwegführung und Anflugwinkelanpassung
- (Arbeits-)Entlastung für die Crew im Cockpit.

Guido Ziese