Rotorcraft Efficient and Safe ProcEdures for Critical Trajectories (RESPECT)

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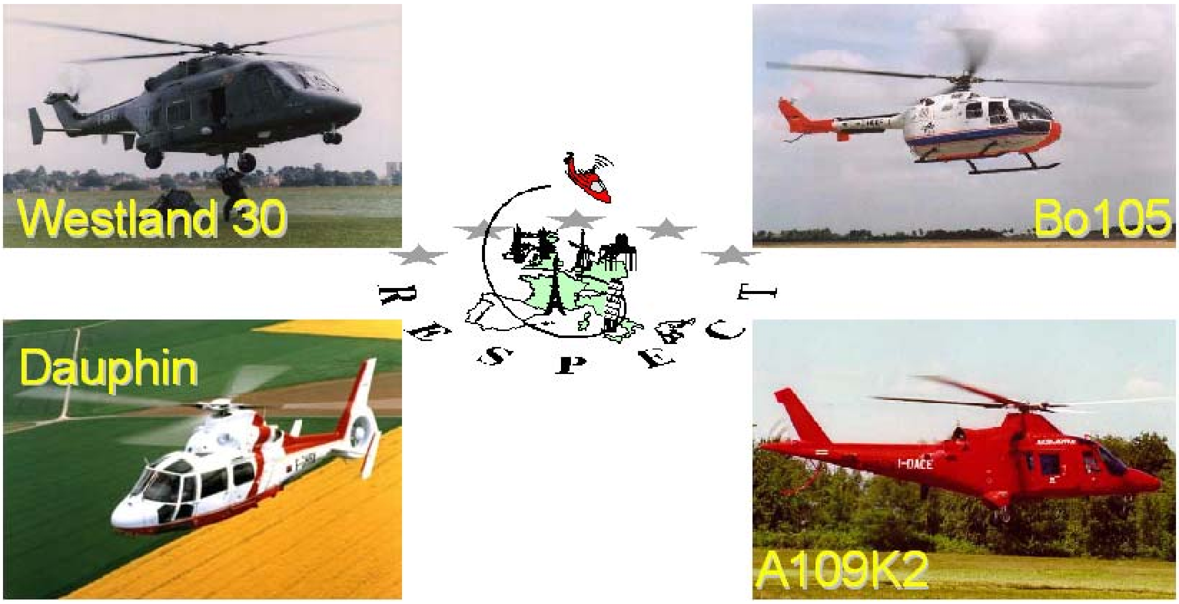

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Abstract

The RESPECT project aims at developing improved rotorcraft terminal procedures and airfield operations (i.e. take-off and landing manoeuvres) for a wide spectrum of field configurations, including, but not limited to, airports (freeing-up valuable runway slots), city centre heliports, and offshore platforms. The project has demonstrated the feasibility and safety of the proposed manoeuvres, with regard to the performance capabilities of existing helicopters, addressing in particular those critical flight conditions during which an engine failure could endanger the passengers and/or the population on the ground.

The approach used to reach this objective is threefold:

- To establish a common performance simulation code and to validate it using flight data.
- To use this code to analytically optimise trajectories and to propose improved manoeuvres.
- To substantiate the practical feasibility and repeatability of these new procedures by means of piloted simulations and demonstration flight tests.

This paper reports on the work done and results obtained during the project.

The outcome of the project will contribute to the development of the public transport helicopter as a dependable and safe vehicle which can effectively complement the existing transportation infrastructure by providing an air link to any medium size city within a range of 150 km of a major airport.

The main benefit will be to ensure a high standard of safety, both for the passengers, and for the people living in the vicinity of heliports.

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1. INTRODUCTION

RESPECT stands for Rotorcraft Efficient and Safe Procedures for Critical Trajectories.

One aim of this project was to critically analyse current helicopter operations and propose validated guidelines for improved methods of operation.

The method developed during the study and proposed as "Improved Methodology for take-off and landing procedures" will be described. The code and some very specific simulator cues will be presented.

The helicopters studied in RESPECT cover a wide technical range of solutions for tail rotor, landing gear, fin, main rotor hub and a large weight envelope for civil transportation.

The RESPECT consortium groups all the major helicopter manufacturers and most of the aerospace research organisations in Europe. In addition some contacts have been taken with operators and airworthiness authorities to inform them about the progress of RESPECT and finally to show the complete results.

2. RESPECT OBJECTIVES

The objectives of RESPECT were :

- To determine how and by how much the terminal manoeuvres can be modified to improve the mission effectiveness with the same level of safety.
- To demonstrate the feasibility of these manoeuvres, taking into account all the practical difficulties.

The manoeuvres dealt with are take-off and landing manoeuvres, considering that an engine failure may occur.

The project was not limited to the improvement of existing procedures or trajectories: it also allows the research to demonstrate the safety issues of the new trajectories or the new type of operations.

To reach these objectives with the best chances of success, a complete methodology has been proposed, with a step by step validation phase. The general method proposed was:

- To develop and validate off-line performance simulation software
- To optimise take-off and landing procedures
- To demonstrate their feasibility by piloted simulations and flight tests

3. METHODOLOGY DESCRIPTION

Figure (1.): RESPECT methodology

The first stage was to look at the current operational procedures and techniques and to find any possible ways of improvement. To improve the efficiency of the consortium it was decided to work with a common off-line code. As such a code did not exist, the project partners agreed developing that tool. A big effort was made about the validation phase. This code was used to analyse flight manual operations to find safety criteria and fields of improvement (fig.(1)).

Using this code for parametric studies or for coupling with numerical optimiser was not a very difficult task and the optimisation process for existing operations or for future uses of helicopters was performed.

Some improved or new techniques were selected and were assessed through piloted simulations. This step gave the opportunity to have "a pilot in the loop" to evaluate new trajectories, including some important points like repeatability, visibility, pilots' workload with and without engine failure and without any danger for the crew or the people on the ground.

For the RESPECT partners, it was the first time that simulators were used for emergency situations and the pilots were really enthusiastic about it.

Then, after checking the pilotability of manoeuvres, some flight tests were performed to validate, in actual flight, the behaviour of helicopters.

Some guidelines and recommendations were issued for improved or innovative procedures.

4. PERFORMANCE SOFTWARE

4.1. Overview

The code developed is called EUROPA for European Rotorcraft Performance Analysis. The code is capable of finding the performance limits of a helicopter at every point in its operating envelope for both steady-state and dynamic performance.
Manoeuvres can be complex (category A operation) and can be evaluated with engine failure, different atmospheric conditions etc...
One additional use of the code is to simulate flight manual procedures to help defining **safety criteria.**

Some optimisation techniques were coupled to easily iterate and find the appropriate manoeuvres (TDP, LDP).

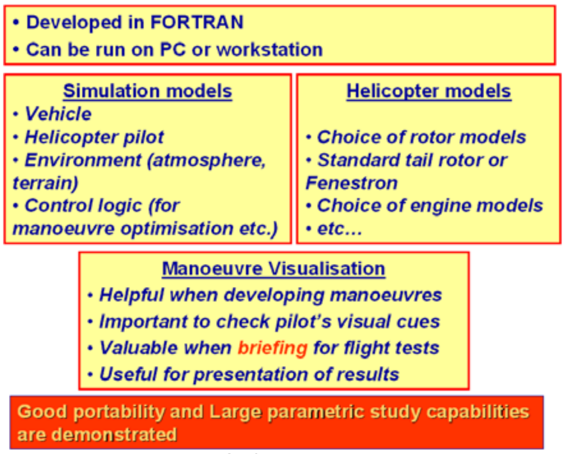

Figure (2.): Software characteristics

Thanks to the very efficient co-operation between the partners, the challenge proposed at the beginning of the project was reached.

A **new code** was developed in common under precise **specifications** for the code architecture and accuracy, together with rules for the **Fortran** development. This code can be run on any kind of platform (fig.(2)).
The contribution of the partners to the development and the modularity of the code gave, as a result, a rather efficient code for **steady and unsteady performance analysis**.
A really big effort was also made about the **code documentation** with the production of detailed manuals for users and developers.

The code includes **simulation models** for vehicle, pilot, environment and control logic.
For some helicopter components, several options can be selected. For **the main rotor**, a blade element integration, an analytical model and a flight test power identification can be selected according to the available aerodynamic data and the constraints on computation time.
A conventional **tail rotor or a "fenestron"** can be used. **Engine models** range from elementary time constant response to a thermodynamic description of engine components.
A specific helicopter model is built by specifying appropriate modelling options as part of the input data files.

Additionally a post processing visualisation software using the VRML language, has been developed. This software provides animated visions of the helicopters and shows the manoeuvres studied. It is helpful for the first visual checking and also to brief pilots before simulation or flight tests.

4.2. Code validation

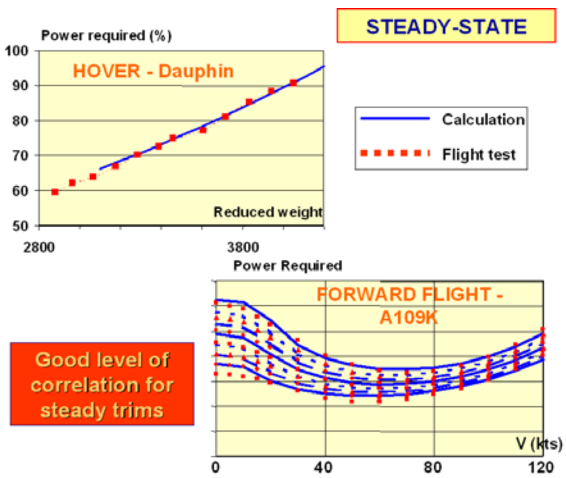

Figure (3.): Steady-state correlation

Because some flight test parameters are not modelled (e.g. variations in vertical air mass motion and wind speed), validation tends not to be an exact science! It is normally necessary to model a number of similar flight test events and look for trends. The performance simulation is deemed to be valid if all of the predicted parameters sit close to the centre of the flight test "scatter".

A sample of results for the steady state is given in fig. (3).

Once the steady state performance of the simulation has been verified, the model is validated for the prediction of manoeuvres. The pilot model and the control logic allow the simulation of **realistic manoeuvres** according to the procedure under study. The effect of pilot reaction delay, pilot abuse, overreaction or the **repeatability of manoeuvres** can be parametrically investigated, making it possible to assess **the safety margins** accurately.

To validate the vehicle model, a “flight test matching” subroutine was created.
The pitch and roll attitude time history from a measured flight test event is used as the "target attitude" to make the performance-simulation follow the measured aircraft attitude traces.
The accuracy of the performance simulation is checked by comparing the "free" simulation parameters with flight test values (fig. (4)).

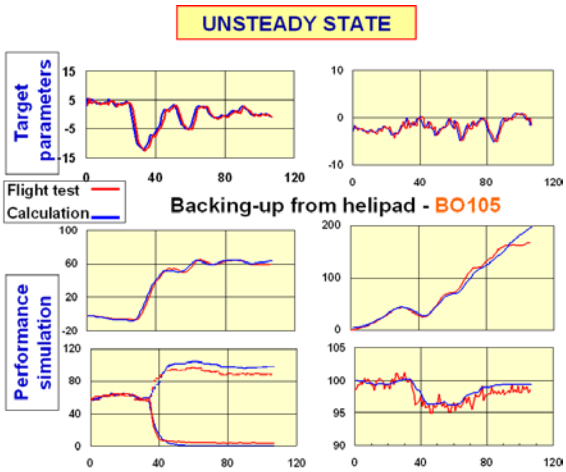

Figure (4.): Unsteady-state correlation

5. PILOTED SIMULATION STEP

After the off-line optimisation step, the RESPECT methodology proposes a piloted simulation phase to present the procedures and have them evaluated by the pilots.

It is evident that those procedures are set up in close co-operation with the test crews but the risks inherent in the flight testing for such procedures call for preliminary evaluation in the simulator, which could also be used as a training platform.

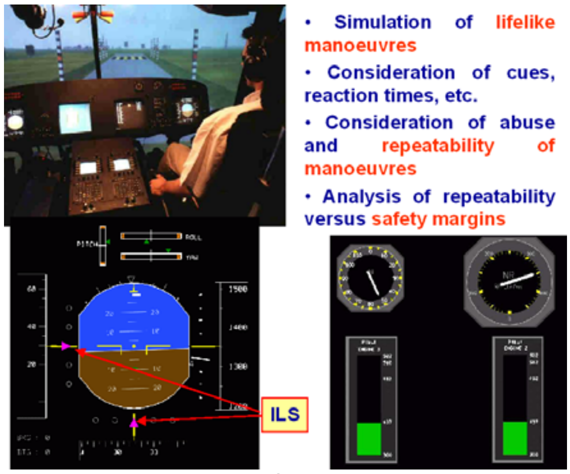

Figure (5.): Simulator cues

The simulation step gives the possibility to simulate life-like manoeuvres, including pilot reaction time, pilot abuse, repeatability, low visibility (clouds, fog, rain…).

It was possible to train the pilot to the manoeuvre and to analyse the repeatability versus safety margins.

6. STUDIED CASES

Figure (6.): Field of application

The RESPECT project has studied 4 different operational theatres.

- Clear heliport – the objective was to reduce noise footprint and to rapidly clear the way.
- Elevated heliport – strong constraint with noise, since a lot of these heliports are close to a city centre or hospital.
- Helideck/offshore operation - performance and take-off weight are a major concern for such long range missions.
- Confined/unprepared area - the pilot does not know the operating site in advance and

the aim is to reduce the space required to operate take-off & landing.

7. Samples of results

2 samples of results will be shown :

- Clear heliport landing
- Helideck take-off

7.1. Clear heliport landing

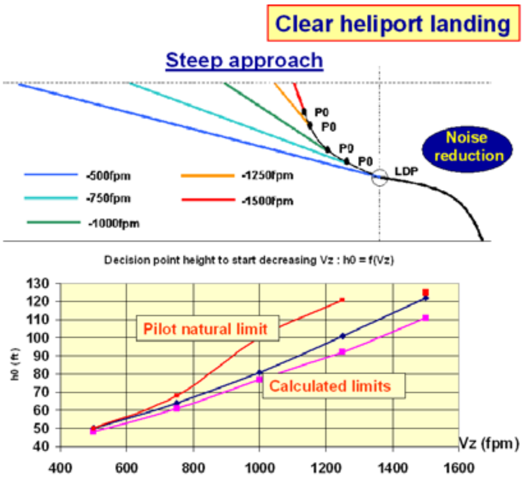

Figure (7.): Clear heliport - Steep approach

For clear heliport landing, steep approach is regarded as a possibility to reduce the noise footprint on ground. Such procedures raise new safety issues. It is necessary to evaluate the impact of such trajectories on the helicopter to allow smooth landing or to keep the capacity to climb in engine failure situations, at any point of the manoeuvre.

RESPECT does not recommend one slope or the other, but shows the capacity to calculate the safe Decision Point versus slope. The TDP (Take-off Decision Point) height is calculated versus slope or weight (fig.(7)).

In the simulator sessions, the pilot could perform the manoeuvres with a calculated limitation. But his visual sensation was quite impressive and he also determined the natural limit with respect to his own visual feeling.

7.2. Helideck take-off.

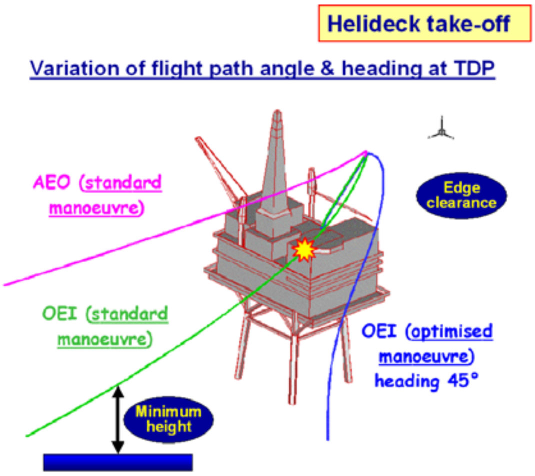

Figure (8.): Helideck operation

For the helideck take-off operation (fig.(8)), the limiting factor is the weight to get the edge clearance and the minimum height with respect to ground (or sea).

A possible solution is a change in heading at the TDP.

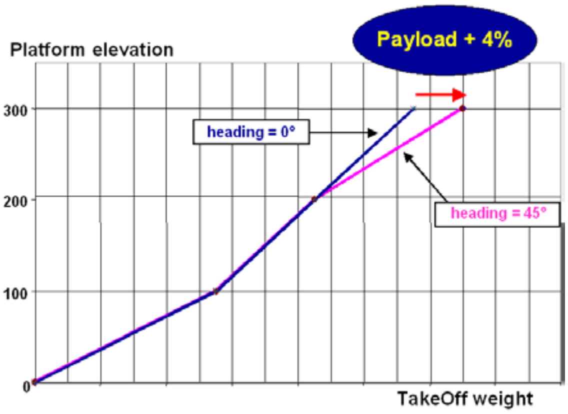

Figure (9.): MTOW versus platform elevation

It was possible to calculate the maximum take-off weight (MTOW) with respect to platform elevation and to demonstrate possible payload gains by changing the take-off technique (fig.(9)).

Some very interesting results were also demonstrated, showing the capability of the method to evaluate dynamic techniques for take-off & landing.

8. CONCLUSIONS

In conclusion the main usable results of the RESPECT project are :

- The common EUROPA **performance tool**. The large field of applicability was demonstrated.
- All the flight tests and the simulation data were dedicated to performance and emergency procedures. This **large data bank** will be used for further code development and validation.
- It was demonstrated that the **piloted simulations** are not only useful for flight mechanics analysis but can also be used for procedure research and pilot training for emergency operations.
- All this step-by-step activity illustrates the **methodology** proposed to help helicopter development, certification and specific operations.
- At the end of the project**, guidelines and recommendations** were issued, which could help operators and authorities to set up new or improved operational rules.

A lot of further possible benefits may emerge in the field of safety and performance, reduction of procedures testing and specifically dangerous ones with engine failure near the ground.

The results show that the method can allow operators to study operations in specific conditions at an acceptable cost.

The helicopter industry as a whole would profit from the market growth triggered by improved flight procedures and by quieter heliport neighbourhoods, if it can be shown that flight safety is preserved or improved without degrading helicopter payload performance data.

The exploitation of results of the time-to-market could take some years since it would be first necessary to convince the helicopter community (operators, airfield authorities, airworthiness authorities) of the advantages offered by the new approach.

Two natural <u>follow-on activities</u> are foreseen.

- One is the collaboration with **authorities and operators** for the research of procedures and the solving of specific problems in order to improve helicopter safety or to open new markets.
- The other one, issued from this fruitful partnership, is the **COMPLICES** proposal. The aim is to apply the tools and the methodology to the Tilt Rotor aircraft for steady and unsteady performance calculations.
  It will give the opportunity to provide performance charts and emergency procedures amended by piloted simulations.
  This first "Computed" flight manual will reduce the development cost and increase the aircraft safety.

9. ACKNOWLEDGEMENT

The authors wish to thank the European Commission for the partial founding of the RESPECT project.

The partnership in this programme led to a gathering of knowledge, competence and expertise, coming from Industry and Research, which allowed to successfully carry out the RESPECT project.

A web site was developed by the RESPECT team for the information of interested organisations.

http://www.nlr.nl/public/hosted-sites/respect/

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