Power failures in single engine helicopters

Establishment of the case for/against enhancing certification requirements on pilot intervention times

Customer

National Aerospace Laboratory NLR

NLR-TP-2014-061 - April 2014

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EXECUTIVE SUMMARY

Power failures in single engine helicopters

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[Picture source: Ref. 1]

Report no.
NLR-TP-2014-061

Author(s)
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Knowledge area(s)
Helikoptertechnologie

Descriptor(s)
Helicopters
Flight Safety
Autorotation
Engine Failure
Safety Regulation

Problem area

The entry into autorotative flight following loss of power in a single-engine helicopter is a time critical event. It requires immediate recognition and response by the pilot to avoid the rotor speed decaying to a point where the rotor enters an unrecoverable stalled condition. Safe entry into autorotative flight is therefore dependent on the allowable response time (response time available) matching or exceeding the actual (pilot) response time. EASA's future rulemaking is looking to increase the allowable pilot response times.

Description of work

Ecorys and NLR have carried out a Regulatory Impact Assessment (RIA) study, with the aim to support future rulemaking on single-

This report is based on a presentation held at the 7th EASA Rotorcraft Symposium, Cologne [Germany], December 4-5, 2013.

engine helicopters with increased pilot intervention times following power failure. The specific objective was: "the establishment of the case for/against enhancing certification requirements in the area of pilot intervention time following power failure in single-engine helicopters".

The study started with a literature search, with two objectives:

1. Establish an optimum or range of pilot response times for single-engine helicopter loss of power events;
2. Identify existing or emerging technologies that could reduce or delay the loss of rotor speed following engine failure to increase the allowable response time.

Next an analysis of the safety impact was made in order to quantify the maximum safety benefit that could be achieved if safe entry into autorotation following engine failure in a single-engine helicopter was assured.

The study then attempted to determine the impacts on helicopter design and operation as a result of increasing the allowable response times. Several technological solutions that can increase the allowable response time have been investigated. From the simulations that have been performed, it is apparent that these solutions are capable of increasing the time available, but they come with a mass and/or cost increase.

Results and conclusions

The Regulatory Impact Assessment indicates that the policy options to impose mandatory requirements to manufacturers to increase the allowable response time following engine power failure to 2 seconds for all flight phases do not show a positive case if the safety impacts are compared with the economic, environmental and social impacts. The option to provide non-mandatory information however does provide a positive case.

Applicability

The results of the Regulatory Impact Assessment can be directly used by EASA to support their future rulemaking on single-engine helicopters.

The results can also be used to promote research in close cooperation with the industry in order to try and materialise the significant safety benefits that are there, while trying to avoid the negative impacts (mass and/or cost) as addressed in the study. EASA could for example open a Research Program to encourage European companies to stay on top of global innovation in this area.

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The contents of this report may be cited on condition that full credit is given to NLR and the authors.

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Summary

Single-engine helicopter certification requirements for entry into autorotation take into account allowable pilot response times of 1 second for cruise and 0.3 second for other flight phases. To support EASA's future rulemaking on increased pilot intervention times following power failure on single-engine helicopters, a Regulatory Impact Assessment has been carried out.

First, a literature search indicated that the actual pilot response time to enter into autorotation can be up to 3 seconds (for twin-engine helicopters). This response time can be decreased by warning cues as well as by active systems that automatically perform the corrective action. There are also a number of technological options that can increase the allowable response time, like tip jets, a flywheel, an auxiliary turbine or an electric motor. But also passive systems like added tip weights or increased rotor speed can increase that time. Against the background of the safety impact analysis it is assumed that an increase in available allowable response time to 2 seconds for all flight phases will avoid, as a maximum, 80% of the accidents caused by a "late response to start autorotation".

The effect of several technological solutions on the allowable time has been investigated through computer simulations. From that it is apparent that these solutions are capable of increasing the allowable time, but they come with a mass and/or cost increase, and thus a reduction in payload capacity.

The Regulatory Impact Assessment indicates that the policy options to impose mandatory requirements to the manufacturers to increase the allowable response time following power failure to 2 seconds for all flight phases do not show a positive case if the safety impacts are compared with the economic, environmental and social impacts. The option to provide non-mandatory information however does provide a positive case


KLM

Content

Abbreviations

Acronym	Description
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CS	Certification Specifications
EASA	European Aviation Safety Agency
EMPRESS	Energy Method for Power Required EStimateS
EUROPA	EUropean ROtorcraft Performance Analysis
MCA	Multi-Criteria Analysis
MTOM	Maximum Take-Off Mass
RIA	Regulatory Impact Assessment
RMT	Rule Making Task
SME	Small and Medium size Enterprises
SPEAR	SPEcification Analysis of Rotorcraft
VLR	Very Light Rotorcraft

Definitions

Allowable response time (response time available)	The period between the failure occurring and the pilot having to make an input in order that the rotor speed does not fall below its minimum transient limit.
Actual (pilot) response time	The combination of the decision time plus the reaction time.
Decision time	The time needed by the pilot to recognise and interpret cues and warnings to identify the problem and to decide on the appropriate corrective action.
Reaction time	The time taken by the pilot after the decision on the appropriate corrective action until commencement of the recovery action.

1 Introduction

Remark

This report is based on a presentation held at the 7th EASA Rotorcraft Symposium, Cologne, 4-5 December 2013. The hand-out material for this Symposium is limited to the presented slides, and therefore no paper needed to be drafted. To limit the effort required to draft this report, the body of the report (chapter 2) only contains a summarized overview of the work carried out, and is based on Ref. 2. Chapter 3 provides the conclusions. All slides presented at the Symposium are provided in the appendix.

2 Overview of the study

2.1 Study objective

The entry into autorotative flight following loss of power in a single-engine helicopter is a time critical event. It requires immediate recognition and response by the pilot to avoid the rotor speed decaying to a point where the rotor enters an unrecoverable stalled condition. Safe entry into autorotative flight is therefore dependent on the allowable response time (response time available) matching or exceeding the actual (pilot) response time. Normal certification practice assumes time delays of 1 second during the cruise phase and 0.3 seconds during all other flight phases. EASA's future rulemaking is looking to increase the allowable pilot response times.

The presentation describes the Regulatory Impact Assessment (RIA) to support future rulemaking on single-engine helicopters with increased pilot intervention times following power failure. It is developed to support EASA in its rulemaking task RMT.0246 (MDM.050), see Ref. 3. The specific objective is: "the establishment of the case for/against enhancing certification requirements in the area of pilot intervention time following power failure in single-engine helicopters". The RIA has been carried out by Ecorys and NLR.

2.2 Literature study

The study on which the RIA is based started with a literature search with twin objectives:

1. Establishing an optimum or range of pilot response times for single-engine helicopter loss of power events that was commensurate with known human performance;

2. Identifying existing or emerging technologies that could reduce or delay the loss of rotor speed following engine failure to increase the allowable response time to the pilot to successfully enter autorotation.

From the literature search it can be concluded that the allowable response time depends on the type of aircraft and its characteristics (weight, rotor inertia, etc.) but even more on the phase of flight. In hover or climbing flight the allowable response time is at its lowest, around 0.3 seconds, and in forward flight is increased to in general 3 to 5 seconds. The actual response times found in the literature search indicate that the actual pilot response time to enter autorotation can be up to 3 seconds (90th-percentile value for twin-engine helicopters). As no actual response times were found for single-engine helicopters, this value has been used as an indication for possible actual response times for single-engine helicopters. It is however recommended to continue research in this field with a focus on single-engine helicopters.

The allowable response time can be increased by active systems such as tip jets, a flywheel, an auxiliary turbine or an electric motor. Also passive systems in the form of added tip weights or increased rotor speed can increase the allowable response time. The actual response time can be decreased by visual or other warning cues provided in advance as well as active systems that detect low rotor speed and automatically perform the corrective action.

Based on the outcomes of the literature search it appears that the currently applied normal certification practice to assume a 1 second time delay for the cruise phase and 0.3 seconds for other flight phases may not be sufficient to adequately embody normal pilot performance. Increasing the corrective action time delay for power failure in the certification specification to reflect the ability of the 90th-percentile pilot would be desirable.

2.3 Safety impact analysis

Next an analysis of the safety impact was made in order to quantify the maximum safety benefit that could be achieved if safe entry into autorotation following engine failure in a single-engine helicopter was assured. For this all accidents with single engine helicopters that occurred in an EASA member state during 2000-2011 were collected, totalling 886 accidents. A total of 151 of these accidents were related to engine failure, and for 99 it was determined that a successful autorotation would have been possible. Analysis of these cases determined that the maximum safety benefit that could be expected would be that 20% of all engine failure related accidents with single-engine helicopters, in which an autorotation is possible, could be avoided. The maximum safety benefit attainable equates to an estimated reduction of approximately 22 accidents during the period of 2000-2011 (2 accidents per year), saving the lives of about 13 people (1 person per year).

2.4 Computer simulations

The study then attempted to determine the impacts on helicopter design and operation as a result of increasing allowable response times to accommodate the range of pilot response times established from the literature search. This was determined by performing a (parametric) study using a combination of analysis, simulation and engineering judgment. Technologies identified in the literature search have then been incorporated in the helicopter design so as to sufficiently increase the time available to the pilot to successfully enter autorotation following a (complete) power failure.

Several technological solutions that can increase the allowable response time have been investigated (adding an emergency power source, increasing the rotating system inertia and automatic lowering of collective control). Three computer codes have been used:

- Energy Method for Power Required EStimateS (EMPRESS), used to assess the impact on the steady state flight performance, including power required and fuel consumption;
- EUropean ROtorcraft Performance Analysis (EUROPA), used to assess the impact of the pilot response times and the technologies on the rotor speed decay after power failure during various operational conditions;
- SPEcification Analysis of Rotorcraft (SPEAR), used to assess the impact of selected technologies on the helicopter design, including weight penalties; the tool establishes feasible helicopter dimensions (expressed in size and mass) based on a set of flight performance requirements and a set of operational (mission) profiles.

Computer simulations have been made for four helicopter types of various classes, capturing the range of single-engine helicopters:

- HeliSport CH-7 Kompress (piston engine, MTOM 450 kg);
- Robinson R44 Raven I (piston engine, MTOM 1089 kg);
- Bell 206B-3 JetRanger III (turbine engine, MTOM 1452 kg);
- Aerospatiale AS350B2 Ecureuil (turbine engine, MTOM 2250 kg).

The simulations have been performed for various pilot response times and flight conditions, and at maximum take-off mass and instantaneous power failure (worst case situation). From the moment of complete power failure to the moment of recovery the rotor speed will drop, and the helicopter will roll, pitch and yaw to various degrees. After a delay (the pilot response time) the pilot responds to the engine failure by lowering the collective. The Rotorcraft Flight Manuals for the 4 helicopter types under consideration provide values for the minimum power-off rotor speed. However, it is to be noted that none of these Flight Manuals provides a value for a transient minimum power-off rotor speed, and therefore the minimum power-off rotor speed is considered to be the minimum allowable value. The rate of rotor speed decay varies with the level of the power required before failure, and will be highest in conditions of high power demands (like hover or high speed at high mass). The time to reach the minimum rpm after engine failure ranges from 0.5 s for the CH7 to 1.2 s for the AS350B2

Next the likelihood of recovery after a complete power failure at various flight speeds and pilot response times has been investigated for the 4 helicopter types. The following definitions are used:

- ‘Likely’ denotes a situation in which recovery is possible with rotor rpm staying within limits or temporarily dropping slightly below the limit;
- ‘Probable’ denotes a situation in which recovery seems to be possible, but in which the rotor rpm drops below the minimum allowable value by 5-10%;
- ‘Unlikely’ denotes a situation in which rotor rpm drops far below the minimum allowable rpm, or the fuselage pitch/roll attitudes exceed limitations.

Summarizing the simulation results it is concluded that the following values of pilot response times will potentially lead to a safe recovery after a complete power failure (cells labelled ‘likely’ and ‘probable’):

- up to 0.5 seconds in hover for all 4 helicopter types;
- up to 2 seconds at bucket speed for all types but the B206B3;
- up to 1 second at cruise speed for all types but the CH7.

These values are in line with the certification requirements (1 second for cruise phase and 0.3 seconds for other flight phases). But they are not in line with actual pilot response times. Therefore technological solutions will be required to bridge the gap between allowable response times and actual response times.

2.5 Technological solutions

With the conclusions from the simulation results several technological solutions have been investigated. These can be grouped in three systems:

- adding emergency power source;
- increasing rotating system inertia;
- automatic lowering of collective control.

The objective of implementing these systems is to increase the time available to the pilot to successfully enter autorotation following a complete power failure. Simulations have been made for various pilot response times and mainly for the hover OGE case (being the most critical flight phase). Solutions that will increase the available pilot response time to 2 seconds are deemed feasible. This is in line with the British Def Stan 00-970, which stipulates a 2 s delay from any flight condition, as did BCAR Section G. From the simulations that have been performed it is apparent that these solutions are capable of increasing the time available, but they come with a considerable mass and/or cost penalty. Increasing the allowable response time to more than 2 seconds is not deemed realistic.

2.6 Regulatory Impact Assessment

The Regulatory Impact Assessment (RIA) aims at establishing which option would best achieve rulemaking objective while simultaneously minimising potential negative impacts. Against the background of the safety impact analysis, it is assumed that an increase in time available to 2 seconds for all flight phases will achieve 80% of the maximum safety benefit available. This assumption is based on the fact that on the one hand there remains a shortfall between allowable response time and the demonstrated actual response times, and on the other hand the types of helicopters under investigation are for a large part flown in an active, hands-on way, providing the lower range of actual response times.

Three main policy options were identified for the RIA:

- Option 0 – “Do nothing scenario”;
- Option 1 – Mandatory certification of new single-engine helicopter models – Increase the allowable response time for pilot intervention following engine power failure, from 1 second for the cruise phase and 0.3 seconds for other flight phases to 2 seconds for all flight phases; This option is split further to variants 1A and 1B representing the complexity of the technological solutions that can be applied to achieve this target:
    - Option 1A – Increasing rotating system inertia by placing tip weights on rotor blades;
    - Option 1B – Application of auxiliary systems (emergency power supply, automatic lowering of collective control).
- Option 2: - Mandatory certification of new single-engine helicopter models – Increase of the allowable response time from 1 second for the cruise phase and 0.3 seconds for all other flight phases to above 2 seconds for all flight phases;
- Option 3: Additional non-mandatory information provided to manufacturers regarding the safety benefit gains by increased allowable response times.

Option 2 has been excluded from further analysis as this option is not deemed realistic from a technological point of view.
This RIA, affecting the single-engine helicopter sector, considers in particular the following assessment criteria (weight values have been assigned to each one):

- Safety weight 3;
- Economics weight 2;
- Social weight 2;
- Environment weight 2;
- Proportionality issues weight 2;
- Regulatory harmonisation weight 1.

The analysis of the impacts of the options for each of these criteria should be done in line with the scale of the issue considered as well as based on the availability of data. Different methodologies exist for the execution of a RIA, e.g. a Cost-Benefit Analysis (CBA), a Cost-Effectiveness Analysis (CEA) or a Multi-Criteria Analysis (MCA). Taking into account the limited data available for the single-engine helicopter market as well as the fact that the existing data is a mix of quantitative and qualitative information, the MCA was selected for the assessment of the proposed options. For the assessment of the effects a standardised rating scale has been used (range -5 to +5). To arrive at the final ranking of the options, the standardized scores are multiplied by the weights and then summed for each alternative.

2.7 Outcome of RIA

Option 1A yields a clear positive safety impact. However, the impacts on economic, social, and environmental elements are moderately negative. Despite the possible safety gain, the negative impact on most of the other impact areas produces an overall slightly negative impact.

Option 1B also yields a clear positive safety impact. However, the economic, social and environmental impacts of adopting this policy option were found to be negative. Specifically regarding the case of economic impacts, option 1B shows a more negative impact than option 1A, as the development and price costs have been assessed to be higher for the development of those new auxiliary systems.

Option 3 produces a marginal safety benefit. This option also shows a slightly positive impact in the social area of impact, which together offsets a slightly negative economic and environmental impact. Therefore this is the only option that produces a positive case overall.

When comparing the summarized impacts of Options 1A, 1B and 3 it becomes apparent that all options show a clear safety benefit combined with a negative economic impact. Next we zoom in into the safety and economic impacts, both expressed in costs. The costs of the safety impact are due to the costs of prevented accidents, fatalities and injuries. The economic costs are dominated by the cost of additional fuel due to the higher mass. The overall costs results clearly show that the safety benefits and additional fuel cost figures are by large unbalanced.

The RIA indicates that the policy options to impose mandatory requirements to manufacturers to increase the allowable response time following engine power failure (options 1A and 1B) do not show a positive case if the safety impacts are compared with the economic, environmental and social impacts. The option to provide non-mandatory information (option 3) however does provide a positive case.

3 Conclusions

Safety is one of the factors helicopter operators take into account when deciding to invest in a single-engine helicopter. It is an important factor, however, it is not the only one. Safety measures are likely to influence the sales price and recurring costs of helicopter operation. In that sense, any regulation imposed should be very deliberate in addressing economic impacts it might cause.

The literature search undertaken in this study indicates that the actual pilot response time to enter autorotation can be up to 3 seconds (for twin-engine helicopters), while certification requirements take into account an allowable response time of 1 second for cruise and 0.3 second for other flight phases. This study has identified a number of technological options that could increase the allowable response time available to the pilot. However, the study also indicates that these technological solutions could bridge the gap between the actual response time and available response time only to some extent and not entirely. All technological solutions examined will lead to weight increases with consequences on helicopter prices. This is likely to affect market demand, although this depends on several factors. Nevertheless, against the background of the safety impact analysis it is assumed that an increase in allowable response time to 2 seconds for all flight phases will avoid, as a maximum, 80% of the accidents caused by a “late response to start autorotation”. This leads to annual safety benefits, which are around € 4 million per year for Europe. While this number is substantial in absolute terms, relative to the total potential safety benefits from addressing all helicopter safety issues, they are relatively modest.

Economically speaking, the impact on the recurring costs for operators, stemming from increased fuel burn as a result from the option's weight increase, is also important. Again this increase is relatively low in terms of the overall operating costs (as the safety benefits are relatively low compared to the overall potential safety benefits from helicopter safety), but the absolute increase in recurring costs does seem to outweigh the safety benefits on an annual basis. Nevertheless, as successful examples of integrating increased safety standards may come along and the supporting technologies are getting more fine-tuned, the case might be that, in the not too distant future, conditions may become mature to implement the suggested regulation change.

All together, the regulatory impact assessment indicates that the policy options to impose mandatory requirements to manufacturers to increase the allowable response time following engine power failure to 2 seconds for all flight phases do not show a positive case if the safety impacts are compared with the economic, environmental and social impacts. The option to provide non-mandatory information however does provide a positive case.

It is recommended to issue a recommendation to the manufacturers of helicopters to increase the allowable response time following engine power failure, to 2 seconds for all flight phases.

Furthermore it is recommended to continue research in close cooperation with the industry in this area in order to try and materialise the significant safety benefits that are there, while trying to avoid the negative impacts (mass and/or cost) as addressed in this study. EASA could for example open a Research Program to encourage European companies to stay on top of global innovation in this area.

4 References

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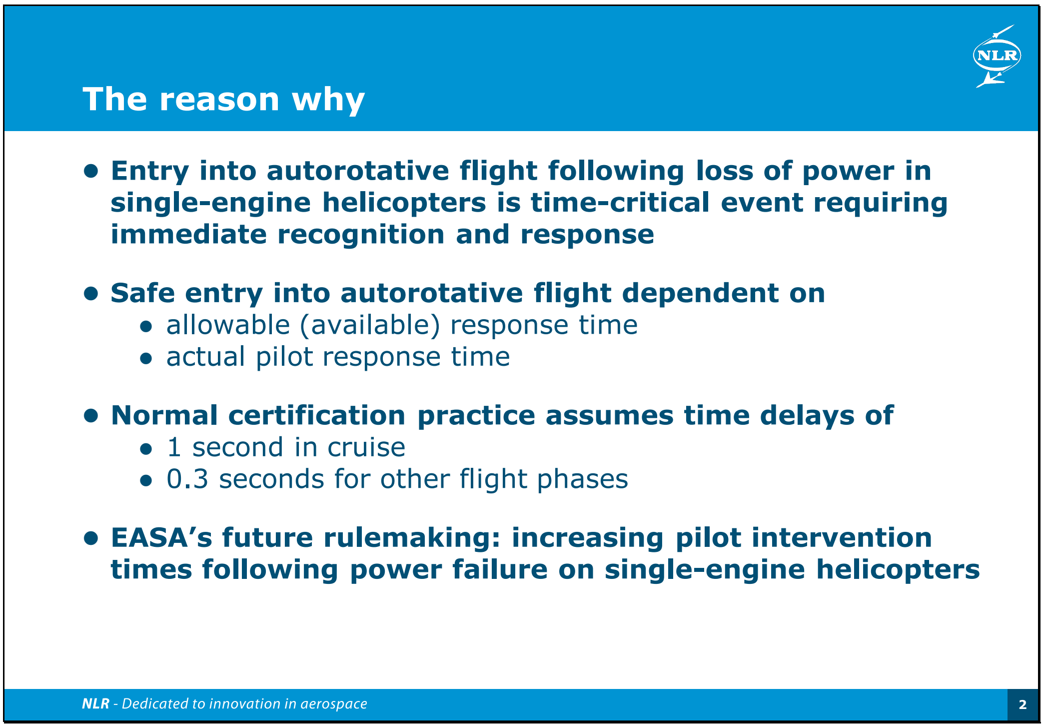
2. *RIA to support future rulemaking on single engine helicopters with increased pilot intervention times following power failure,* Ecorys and NLR, August 2013.
3. *Annex IV to the ED Decision 2013/029/R, Revised 4-year Rulemaking Programme 2014-2017 - Detailed view,* https://easa.europa.eu/agency-measures/docs/agency-decisions/2013/2013-029-R/Revised%204-year%20RMP%20(2014-2017)%20-%20Detailed%20view.pdf.

Appendix A Presented slides

Slide 1

Slide 2



Slide 3

Contents

- Study objective
- Literature study
- Safety impact analysis
- Computer simulations
- Technological solutions
- Regulatory Impact Assessment
- Outcome of RIA
- Conclusions

Picture: Nicole Garmston
Source: Sunday Herald Sun

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Slide 4

Study objective

- Support EASA's future rulemaking on increased pilot intervention times following power failure on single-engine helicopters
- Specific objective of study is
  - *"the establishment of the case for/against enhancing certification requirements in the area of pilot intervention time following power failure in single-engine helicopters"*
- NLR & ECORYS performed Regulatory Impact Assessment

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Slide 5

Literature study -1-

- **Goal to identify**
  - range of pilot response times (allowable and actual) for single-engine helicopter loss of power events
  - existing or emerging technologies that could increase time available to successfully enter autorotation
- **Response times**
  - depend on rotorcraft type and characteristics (rotor inertia, weight, etc.), but even more on flight phase
  - allowable (available) response time
    - 0.3 seconds in hover
    - 3 to 5 seconds in forward flight (MTOM > 4300 kg)
  - actual response times (90th percentile)
    - 2 to 3 seconds (twin-engine helicopters only)

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Literature study -2-

- **Identify technologies**
  - increasing allowable response time
    - active technologies
      - additional power source
      - tip jets
      - flywheel
    - passive technologies
      - additional blade inertia
      - increased rotor RPM
  - decreasing actual response time
    - additional cues (visual, aural, etc.): not beneficial
    - advance warnings: may reduce times by 0.5 to 1.4s
    - automated system performing corrective action

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Safety impact analysis

- **Quantification of the maximum safety benefit**
- **NLR dataset of 886 single engine h/c accidents (EASA member states, years 2000-2011)**
- **151 accidents related to engine failure**
  - for 99 accidents a successful autorotation was deemed possible, but landing was unsuccessful
  - max. 22 of these (caused by "late response to start autorotation") could have been avoided, saving 13 lives
  - increasing time available to 2 seconds (for all flight phases) could have avoided 18 of these 22 (80%), saving 10 lives

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Computer simulations -1-

- **Three NLR computer simulation codes used**
  - 'EMPRESS' for steady state flight performance
  - 'EUROPA' for engine failure simulations
  - 'SPEAR' to asses impact of technologies on design/mass
- **About 30 single engine helicopter types**
  - MTOW 450 to 3000 kg
  - piston and turbine engine
- **Four selected for computer analysis**
  - HeliSport CH-7 Kompress (450 kg)
  - Robinson R44 Raven I (1089 kg)
  - Bell 206B-3 JetRanger III (1452 kg)
  - Aerospatiale AS350B2 Ecureuil (2250 kg)

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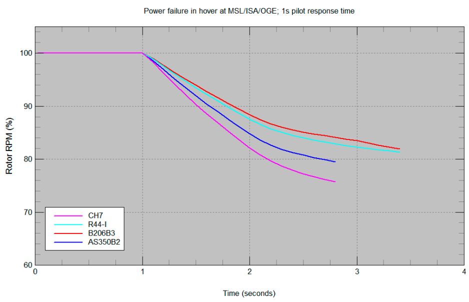
Computer simulations -2-

- **Instantaneous engine failure**
- **Variation of pilot response times after engine failure**
  - ranging from 0.5s to 4s
- **Variation of flight conditions**
  - air speed
  - level flight
  - climbing flight



- **In hover, minimum allowable rotor rpm reached**
  - CH7 after 0.5 s (min. allowed RPM 90%)
  - R44-I after 0.75 s (min. allowed RPM 90%)
  - B206B3 after 0.8 s (min. allowed RPM 90%)
  - AS350B2 after 1.2 s (min. allowed RPM 82%)

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Computer simulations -3-

- **Likelihood of recovery after complete power failure**
  - current situation (no changes)

		AS350B2	B206B3	R44-I	CH7
Recovery after 0.5s pilot response time	hover OGE	likely	probable	probable	probable
	bucket speed	likely	likely	likely	likely
	cruise speed	likely	probable	probable	probable
Recovery after 1s pilot response time	hover OGE	probable	unlikely	unlikely	unlikely
	bucket speed	likely	likely	likely	probable
	cruise speed	likely	probable	likely	unlikely
	climb VBROC	probable	unlikely	unlikely	unlikely
Recovery after 2s pilot response time	hover OGE	unlikely	unlikely	unlikely	unlikely
	bucket speed	likely	probable	probable	probable
	cruise speed	unlikely	unlikely	unlikely	unlikely
	climb VBROC	unlikely	unlikely	unlikely	unlikely

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Technological solutions -1-

- **Available response time to recover after complete power failure very limited**
- **For 3 out of 4 investigated helicopter types available response times 'meet' certification requirements**
- **Actual pilot response times longer than available times**
- **Technological solutions can improve available times**
- **Three types investigated**
  - adding emergency power source
  - increasing rotating system inertia
  - automatic lowering of collective control

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Technological solutions -2-

- **Mass impact of installing solutions allowing 2 second pilot response time in hover**

	AS350B2	B206B3	R44-I	CH7
Max. take-off mass	2250 kg	1452 kg	1089 kg	450 kg
Installed MCP	466 kW	236 kW	175 kW	73.5 kW
Additional power required to keep rotor rpm above minimum allowable	120 kW	120 kW	90 kW	39 kW
Total delta mass at equal payload and range	95 kg	110 kg	81 kg	50 kg
Increase in rotor inertia required to keep rotor rpm above minimum allowable	100 %	150 %	150 %	200 %
Total delta mass at equal payload and range	94 kg	120 kg	70 kg	41 kg

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Slide 13

Regulatory Impact Assessment -1-

- **RIA aims at establishing which option would best achieve rulemaking objective while simultaneously minimising potential negative impacts**
- **Four options considered**
  - Option 0 – "Do nothing scenario"
  - Option 1 – Mandatory certification of new single-engine h/c's with allowable response time increased to 2 seconds for all flight phases (1A extra inertia, 1B extra power)
  - ~~Option 2: - Mandatory certification of new single-engine h/c's with allowable response time increased to above 2 seconds for all flight phases~~
  - Option 3: Additional non-mandatory information to manufacturers w.r.t. safety benefit gains by increasing allowable response times (up to 2 seconds)

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Regulatory Impact Assessment -2-

- **Items considered for RIA**

Assessment criteria	Weight
Safety	3
Economics	2
Social (e.g. employment in Industry)	2
Environment	2
Proportionality issues (proportional throughout Industry)	2
Regulatory harmonisation	1

- **Impact assessed through Multi-Criteria Analysis, either quantitatively or qualitatively**
- **Using standardised rating scale for assessment of effects (range -5 to +5)**

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Outcome of RIA -1-

- **Summary of impacts**

Impact assessment area	Weighted score option 1A	Weighted score option 1B	Weighted score option 3
Safety	6	6	3
Economic	-3.5	-4.5	-1.5
Social	-2	-2	1
Environment	-2	-2	-1
Proportionality	0	0	0
Regulatory	0	0	0
Total impact	**-1.5**	**-2.5**	**1.5**

- **Option 3 ("non-mandatory request to manufacturers") produces positive case overall**

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Slide 16

Outcome of RIA -2-

- **Safety impact**
  - cost savings due to prevented accidents/fatalities/injuries
- **Economic impact (expenditures)**
  - one-off costs (development, certification, production)
  - recurring costs (fuel, training, maintenance, airworthiness)
  - others (selling price, market impact)

	Option 1	Option 3*
Safety benefit / year	€ 3.9 million	€ 0.47 million
Additional fuel cost / year	€ 6.7 million	€ 0.80 million

* assuming 12% market penetration

- **Safety benefit and fuel cost figures unbalanced**

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Conclusions

- Certification practice not in line with human performance
- Study proposes to use 2 second time delay for all flight phases (in line with Def Stan 00-970)
- Technologies can help, but with mass and cost impact
- Safety and economic cost figures unbalanced (safety benefit €3.9M/year, extra fuel costs €6.7M/year)
- Very few accidents attributed to failure to enter autorotation (~2 accidents/year & 1 fatality/year)

→ Recommend manufacturers to increase allowable response time to 2 seconds

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WHAT IS NLR?

The NLR is a Dutch organisation that identifies, develops and applies high-tech knowledge in the aerospace sector. The NLR's activities are socially relevant, market-orientated, and conducted not-for-profit. In this, the NLR serves to bolster the government's innovative capabilities, while also promoting the innovative and competitive capacities of its partner companies.

The NLR, renowned for its leading expertise, professional approach and independent consultancy, is staffed by client-orientated personnel who are not only highly skilled and educated, but also continuously strive to develop and improve their competencies. The NLR moreover possesses an impressive array of high quality research facilities.

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