Notice of Proposed Amendment 2013-09

Reduction of Runway Excursions

RMT.0047 (25.027), RMT.0569 and RMT.0570 — 10/05/2013

EXECUTIVE SUMMARY

The scope of this rulemaking activity is outlined in the Terms of Reference (ToR) RMT.0047 (25.027), RMT.0569 and RMT.0570, Issue 1 of 9 October 2012.

For the last decades, runway excursions at landing (and in particular runway overruns) have been recognised as a major contributor to accidents worldwide and as an important risk to aviation safety.

Based on the analysis of these events, safety review reports, safety recommendations, and the recent development of on-board protective systems that can help to reduce the number of runway overruns at landing, this NPA proposes:

— a draft Decision for amending CS-25 (RMT.0047 (25.027)) for the certification standards of Runway Overrun Awareness and Avoidance Systems (ROAAS) for new designs; and

— a draft Opinion amending Part-26 (RMT.0569) and a draft Decision amending CS-26 (RMT.0570) for the mandatory installation of ROAAS into large aeroplanes produced after a certain date and operated by European commercial air transport operators.

Applicability		Process map	
Affected regulations and decisions:	CS-25, CS-26, Part-26	Concept Paper:	No
Affected stakeholders:	Large Aeroplane TC holders and applicants for TC/STC Large aeroplane operators Flight crew and Training Organisations	Terms of Reference:	09/10/2012
Driver/origin:	Safety	Rulemaking group:	No
Reference:	See Pre-RIA	RIA type:	Full
		Technical consultation during NPA drafting:	Yes
		Duration of NPA consultation:	3 months
		Review group:	TBD
		Focussed consultation:	TBD
		Publication date of the Opinion:	2013/Q4
		Publication date of the Decision:	2013/Q4: CS-25 2014/Q1: CS-26

Table of contents

1. Procedural information

1.1. The rule development procedure

The European Aviation Safety Agency (hereinafter referred to as the 'Agency') developed this Notice of Proposed Amendment (NPA) in line with Regulation (EC) No 216/2008[1] (hereinafter referred to as the 'Basic Regulation') and the Rulemaking Procedure[2].

This rulemaking activity is included in the Agency's Rulemaking Programme 2013-2016 in ToR RMT.0047 (25.027) (for a Decision), RMT.0569 (for an Opinion) and RMT.0570 (for a Decision), Issue 1 of 9 October 2012[3].

The text of this NPA has been developed by the Agency. It is hereby submitted for consultation of all interested parties[4].

The process map on the title page contains the major milestones of this rulemaking activity to date and provides an outlook of the timescale of the next steps.

1.2. The structure of this NPA and related documents

Chapter 1 of this NPA contains the procedural information related to this task. Chapter 2 (Explanatory Note) explains the core technical content. Chapter 3 contains the proposed text for the new requirements. Chapter 4 contains the Regulatory Impact Assessment showing which options were considered and what impacts were identified, thereby providing the detailed justification for this NPA.

1.3. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at **http://hub.easa.europa.eu/crt/**[5].

The deadline for submission of comments is **12 August 2013.**

1.4. The next steps in the procedure

Following the closing of the NPA public consultation period, the Agency will review all comments and, if necessary, perform a focussed consultation which can consist of a technical workshop, meeting, conference or consultation via CRT.

The outcome of the NPA public consultation will be reflected in the respective Comment-Response Document (CRD).

The Agency will publish the CRD with the Opinion on Part-26 and Decision on CS-25.

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1 Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1), as last amended by Commission Regulation (EU) No 6/2013 of 8 January 2013 (OJ L 4, 9.1.2013, p. 34).

2 The Agency is bound to follow a structured rulemaking process as required by Article 52(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as the 'Rulemaking Procedure'. See Management Board Decision concerning the procedure to be applied by the Agency for the issuing of Opinions, Certification Specifications and Guidance Material (Rulemaking Procedure), EASA MB Decision No 01-2012 of 13 March 2012.

3 http://easa.europa.eu/rulemaking/terms-of-reference-and-group-composition.php.

4 In accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

5 In case of technical problems, please contact the CRT webmaster (crt@easa.europa.eu).

The Opinion contains proposed changes to EU regulations and it is addressed to the European Commission, which uses it as a technical basis to prepare a legislative proposal.

The Decisions contain Certification Specification (CS), Acceptable Means of Compliance (AMC) and Guidance Material (GM).

The Decision on CS-26 will be published by the Agency when the related Implementing Ruleis adopted by the Commission.

2. Explanatory Note

2.1. Overview of the issues to be addressed

For the last decades, runway excursions have been recognised as a major contributor to accidents worldwide and as an important risk to aviation safety. Recently, on-board systems that are able to significantly contribute to the reduction of those events, and in particular those occurring longitudinally at landing (statistically around 80% of reported runway excursions occur at landing), have been developed and can be installed into new types of large aeroplanes, but also into newly produced large aeroplanes.

These systems typically integrate an awareness function, which applies in flight and aims at triggering a timely go-around action, and an avoidance function, which applies on ground and optimises available deceleration means to stop the aeroplane.

This NPA proposes certification standards for these systems and their mandatory installation into new designs and all newly produced large aeroplanes to be operated in commercial air transport.

For more detailed analysis of the issues addressed by this proposal, please refer to the RIA section 4.1. 'Issues to be addressed'.

2.2. Objectives

The overall objectives of the EASA system are defined in Article 2 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Chapter 2 of this NPA.

The specific objective of this proposal is to increase the level of safety by reducing the number of runway excursions through mandating existing technologies on large aeroplanes (new designs and newly produced) to be operated in commercial air transport.

2.3. Summary of the Regulatory Impact Assessment (RIA)

<u>Proposed new certification standards and installation requirements for ROAAS</u>

Today, some systems have been developed, certified, and put into service on large aeroplanes to protect against the risk of runway excursion at landing. Such systems are available and can also be installed retroactively on already type-certificated aeroplanes.
The key questions for the Regulatory Impact Assessment (RIA) was to determine how many of the above-mentioned accidents and fatalities could be prevented by ROAAS and at what costs.

Based on the RIA, the Agency decided that a regulatory framework for the implementation of those innovative runway safety solutions should be proposed.

To this end, three options were evaluated in the RIA (see section 4.) requiring the installation of ROAAS:

(1) on new types only,

(2) on new types and all new deliveries, or

(3) on new types, all new deliveries, and all in-service aeroplanes.

The Agency proposes Option 2 as this would be the most cost-effective way to introduce ROAAS in the European fleet and decrease runway excursions.

2.4. Overview of the proposed amendments

<u>The envisaged regulation changes are:</u>

In CS-25 Book 1, SUBPART D, add a new CS 25.705.

In CS-25 Book 2, GENERAL ACCEPTABLE MEANS OF COMPLIANCE — AMC, add a new AMC 25.705.

In Part-26, add a new section 26.205.

In CS-26, add a new CS 26.205.

Review of events and lessons learned

The EASA Annual Safety Review 2011 identifies runway excursions as the fourth most frequent accident category which involved EASA Member State operated aeroplanes (2002–2011). Runway excursions ranked 11th for fatal accidents.

Between 1991 and 2010, EASA Member State operators had on average close to 1 fatality per year due to runway excursions at landing (see *4. Regulatory Impact Assessment* section 1.1. for more details). The average value of aircraft damage is estimated to amount to EUR 11 million[6] per accident, more than EUR 253 million over the last 20-year period. Airport delay and diversion costs are estimated to be EUR 1.76 million per accident, which meant additional costs of EUR 40.4 million for the industry.

The number of these occurrences has increased in line with the growth in traffic.

According to IATA's 2010 Safety Report, runway excursions represented 26% of all accidents that occurred in 2009. The subject is also identified as an operational issue in the European Aviation Safety Plan (EASP) 2012–2015[7].

In the advisory circular (AC) No: 91-79 'Runway Overrun Prevention'[8] released on 6 November 2007, the FAA highlighted that:

(1) 'well-developed Standard Operating Procedures (SOPs) are the primary risk mitigation tools used to prevent runway overruns; these procedures must be relevant and focused on the end user—the flight crew',

(2) 'an effective training program is a secondary tool that provides academic knowledge about the subjects related to landing performance' and

(3) 'effective checking that emphasizes the subject of aircraft landing performance is an essential tool in preventing runway overruns'.

This AC No: 91-79 put also emphasis on the need to reassess landing distance at the time of arrival based on actual conditions.
Experience shows that training and procedures need to be supplemented by on-board means to help the flight crew know during short, final and landing roll, if their real-time landing/stopping distance and trajectory are compatible with the available/remaining runway distance and conditions (ie. dry or wet runway).
As demonstrated in numerous investigation reports, rapidly changing conditions are key contributors to overrun events, particularly when the flight crew is primarily focused on their landing and is no longer in a position to reassess their landing distance.
In such a situation, on-board means should be capable of performing real-time calculation in order to assess the real-time runway overrun risk and aid the flight crew awareness and subsequent decision making. Moreover, the enhanced awareness provided by such on-board means should allow to develop effective avoidance on-board capability in order to help the flight crew to use all required and available deceleration means in a timely manner.
In 2011, acknowledging these facts, the National Transportation Safety Board (NTSB) issued recommendation A-11-28 to the FAA, to 'actively pursue with aircraft and avionics

6 Landing overrun occurrences resulting in major or total loss in the 1993–2012 20-year period. Source: Ascend Aviation.

7 http://www.easa.europa.eu/sms/docs/European%20Aviation%20Safety%20Plan%20(EASp)%202012-2015%20-v1.0%20FINAL.pdf.

8 http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/list/AC%2091-79/$FILE/AC_91_79.pdf.

manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed'[9].
One of the results of the combined and sustained efforts of authorities and industry organisations to prevent runway excursions is the European Action Plan for Prevention of Runway Excursions[10] (EAPPRE) (Edition 1.0 - January 2013). The document provides recommendations on the use of 'all practicable means available ranging from the design of aircraft, airspace, procedures and technologies, to relevant training for operational staff associated with runway excursion prevention.'

These recommendations are addressed to Aerodromes Operators, Air Navigation Service Providers, Aircraft Operators and Manufacturers, Professional Associations, the EASA and National Aviation Safety Authorities. Among the recommendations, the following were issued:

— Ref. 3.5.3 (for aircraft manufacturers):

'On-board real-time performance monitoring and alerting systems that will assist the flight crew with the land/go-around decision and warn when more deceleration force is needed should be made widely available.'

— Ref. 3.7.11 (for EASA):

'Develop rulemaking for the approval of on-board real-time crew alerting systems that make energy based assessments of predicted stopping distance versus landing distance available, and mandate the installation of such systems'.

The follow-up have been included in the European Aviation Safety Plan.

<u>Current regulatory status</u>

<u>ICAO Annex 6, Operation of Aircraft</u>

Part I, International Commercial Air Transport – Aeroplanes

Chapter 5 addresses aeroplane performance limitations.

Chapter 6, Aeroplane instruments, equipment and flight documents, does not require ROAAS.

<u>EASA Certification Specifications – CS-25</u>

CS 25.125 addresses landing performance.

Although there is no specific requirement about ROAAS, some requirements in Subparts D – Design and Construction, F – Equipment and G – Operating limitations and information, would be applicable to these systems.

<u>FAA regulations</u>

Like the EASA regulations, the current Part 25 and Part 121 do not explicitly address or require ROAAS.

The Take-off and Landing Performance Assessment Aviation Rulemaking Committee (TALPA-ARC) was chartered by the FAA to address time of arrival landing performance assessments (and take-off and landing operations on contaminated runways), and delivered its recommendations to the FAA.

<u>EASA mitigation actions</u>

The Agency has issued Certification Review Items (CRIs) providing Acceptable Means of Compliance and interpretative material for the certification of ROAAS installed in new or in-service large aeroplane types on a voluntary basis.

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9 http://www.ntsb.gov/doclib/reports/2011/AAR1101.pdf (p. 105).

10 http://www.skybrary.aero/bookshelf/books/2053.pdf.

In order to implement the preferred option, the following changes are envisaged:

Commission Regulation on Additional Airworthiness Requirements for Operations (still draft, see NPA 2012-13[11]).

In Subpart B, introduction of a new section 26.205 which would require installation of a ROAAS on newly produced large aeroplanes operated by European commercial air transport operators three years after the publication of the rule.

Decision of the Executivee Director of the European Aviation Safety Agency for Additional Airworthiness Specifications for Operations (CS-26) (still draft, see NPA 2012-13).

In Subpart B, introduction of a new paragraph CS 26.205 which would specify the certification standards for the installation of ROAAS into already type-certificated aeroplanes.

CS-25:

In Book 1 SUBPART D, introduction of a new paragraph CS 25.705 which would specify the certification standards for the installation of ROAAS into new designs.

In Book 2 SUBPART D, introduction of a new AMC 25.705. This AMC lists the CS-25 paragraphs that are to be considered for the certification of ROAAS, and provides generic Acceptable Means of Compliance and guidance for the content of the Aeroplane Flight Manual, Human factors considerations and integrity of the used on-board runway data.

11 http://easa.europa.eu/rulemaking/docs/npa/2012/NPA%202012-13.pdf.

3. Proposed amendments

The text of the amendment is arranged to show deleted text, new or amended text as shown below:

(a) deleted text is marked with ~~strike through~~;

(b) new or amended text is highlighted in grey;

(c) an ellipsis (…) indicates that the remaining text is unchanged in front of or following the reflected amendment.

3.1. Draft Regulation (Draft EASA Opinion)

3.1.1 Draft Opinion Part-26

26.205 Runway Overrun Awareness and Avoidance System (ROAAS)

Operators of large aeroplanes used in commercial air transport shall ensure that:

(a) aeroplanes first issued with an individual Certificate of Airworthiness on or after (three years after the entry into force of this regulation) is equipped with a real-time crew alerting system that makes energy based assessments of predicted stopping distance versus landing distance available. The system shall provide the flight crew with:

(1) timely in-flight predictive alert of runway overrun risk, and

(2) on ground predictive alert or automated means for runway overrun protection during landing.

3.2. Draft Certification Specifications (Draft EASA Decision)

3.2.1 Draft Decision CS-26

Book 1

SUBPART B — Large Aeroplanes

CS 26.205 Runway Overrun Awareness and Avoidance System (ROAAS)

Compliance with Part 26.205 is demonstrated by complying with CS 25.705.

3.2.2 Draft Decision CS-25

Book 1

SUBPART D — Design and Construction

CS 25.705 Runway Overrun Awareness and Avoidance System (ROAAS)

(See AMC 25.705)

A ROAAS must be installed.

The ROASS must be a real-time crew alerting system that makes energy based assessments of predicted stopping distance versus landing distance available, and meets the following requirements:

(a) The system must provide the crew with timely in-flight predictive alert of runway overrun risk; and

(b) The system must provide the crew with:

(1) on-ground predictive alert, or

(2) automated means for runway overrun protection during landing

Book 2

AMC 25.705 Runway Overrun Awareness and Avoidance System (ROAAS)

1. Purpose

This AMC provides guidance for the certification of ROAAS installed in large aeroplanes.

2. Related Certification Specifications

CS 25.705 Runway Overrun Awareness and Avoidance Systems

CS 25.101 (Performance) General

CS 25.125 Landing

CS 25.735 Brakes and braking systems

CS 25.1301 Function and installation

CS 25.1302 Installed systems and equipment for use by the flight crew

CS 25.1309 Equipment, systems and installation

CS 25.1322 Flight crew alerting

CS 25.1581 (Aeroplane flight manual) General

CS 25.1583 Operating limitations

CS 25.1585 Operating procedures

3. Related material

(a) Federal Aviation Administration and EASA documents

(1) Advisory circular 120-28[12], Criteria for approval of category III weather minima for takeoff, landing, and rollout

(2) EASA AMC 25.1302 Installed systems and equipment for use by the flight crew

(3) EASA AMC 25.1322 Alerting Systems

(4) EASA AMC 25-11 Electronic Display Systems

(5) EASA AMC 25.1309 System Design and Analysis

(6) EASA AMC 20-115…Software Considerations for Airborne Systems and Equipment Certification

4. Definition of terms

The following definitions should be used when showing compliance with CS 25.705:

a. 'Automated' means that the system functions without any input from the flight crew.

b. 'Runway overrun risk' means a probability that the aeroplane cannot be stopped on the available landing distance.

c. 'Predictive alert' means that the alert is provided before a problem arises and not during the landing roll, with appropriate consideration of the aeroplane configuration, the runway characteristics and the prevailing environmental conditions (e.g. dry or wet runway).

d. 'Timely' means that the alert is provided at a time at which corrective action (e.g go-around) is still possible.

12 http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/bbada17da0d0bbd1862569ba006f64d0/$FILE/AC120-28D.pdf.

5. Background

The intent of this AMC is to address generic certification issues related to ROAAS. Various systems may satisfy the requirements of providing protection against runway excursion. Therefore, the specific design features of each system will be addressed during the certification process.

6. Terminology and acronyms

For the purposes of this AMC, the following generic designations and acronyms are used:

— 'ROAAS' designates the whole runway overrun awareness and avoidance system, including the awareness function and the avoidance function;

— 'Awareness function' designates the function providing the flight crew with in-flight and on-ground alerting of runway overrun risk; and

— 'Avoidance function' designates the function providing the flight crew with on-ground guidance or automated means for runway overrun avoidance during landing.

7. Human Factors considerations

It should be demonstrated that ROAAS Human Machine Interfaces comply with CS 25.1302. Special attention should be paid to the following criteria:

(a) Legibility of text and symbols;

(b) Consistency with other flight deck systems, applications, and crew alerting philosophy;

(c) Colour coding;

(d) Flight crew workload; and

(e) Crew error detection and management.

8. Aeroplane Flight Manual (AFM) content

The limiting conditions and availability of ROAAS should be stated in the AFM as follows:

(a) The AFM should state all limitations and parameters (for instance the landing configurations, the landing weight range, the runway characteristics (slope, surface), and environmental conditions) for which ROAAS performance is demonstrated. In case an aeroplane operation is allowed outside this ROAAS validity domain but still within the certified AFM domain, it shall be demonstrated that no alerts from the awareness function will be unduly triggered, taking into account specific non-normal procedures.

(b) The AFM should provide approved procedures essential to safe operation, including unambiguous procedures to be applied by the crew in case of ROAAS alert triggering.

9. Production process, accuracy and integrity of used on-board runway data

To ensure that ROAAS is properly working on the actual landing runway, it should be demonstrated that on-board runway data used by ROAAS are produced and updated in accordance with acceptable processes, resulting in adequate level of accuracy and integrity to allow real-time performance calculation and not mislead the flight crew.

4. Regulatory Impact Assessment (RIA)

4.1. Issues to be addressed

The EASA Annual Safety Review 2011 identifies runway excursions as the fourth most frequent accident category in commercial air transport for EASA Member States operated aeroplanes (2002−2011). Runway excursions ranked 11th in the causes of fatal accidents.

Between 1991 and 2010, for EASA Member State operators, there were on average close to 1 fatality per year due to runway excursions at landing (see section 1.1. for more details). The average number of fatality and injuries per accident were 0.7 and 6.2 respectively. The average value of aircraft damage is estimated to amount to EUR 11 million[13] per accident, more than EUR 253 million over the last 20-year period. Airport delay, cancellation and diversion costs are estimated to be EUR 1.76 million per accident, which meant additional costs of EUR 40.4 million for the industry. The number of runway excursion occurrences at landing has increased in line with the growth in traffic.

As aviation traffic is expected to continue to grow worldwide as well as in Europe (albeit at a lower rate)[14], the number of runway excursions can also be expected to increase further.[15]

This situation drove aviation stakeholders worldwide to cooperate towards solutions addressing this risk. In particular, runway excursion prevention is one of the topics under scrutiny within the European Commercial Aviation Safety Team, part of the European Strategic Safety Initiative. Furthermore, the European Aviation Safety Plan 2012-2015[16] (pages 18-20), while recognising some achievements in runway excursion prevention, calls European partners to take an active part in the global effort to improve runway safety, especially by helping ICAO to promote and encourage the implementation of new runway safety solutions. This was recognised at the ICAO Global Runway Safety Symposium held in Montreal on May 2011 and, in particular, during all ongoing ICAO Regional Runway Safety Seminars.

In addition to their involvement in the development of operational and training solutions, some aeroplane and equipment manufacturers have developed or are developing systems for the avoidance of runway overrun at landing (ROAAS). These systems typically integrate an awareness function, which is applied in flight and aims at triggering a timely go-around action and an avoidance function, which applies on ground and optimises the using of available deceleration means to stop the aeroplane. These systems may be installed on new aeroplane types, and are proposed as well in production or for retrofit on existing aeroplane types.

These ROAAS are expected to be effective for the most important factors triggering runway excursions at landing as shown in Table 1[17].

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13 Landing overrun accidents of EASA Member State operators in the 1991–2010 20-year period. Source: Ascend Aviation.

14 ECTL Long term forecast.

15 Eurocontrol (2010): A Study of Runway Excursions from a European Perspective. NLR Air Transport Safety Institute, G.W.H. van Es. May 2010, p16.

16 http://www.easa.europa.eu/sms/docs/European%20Aviation%20Safety%20Plan%20(EASp)%202012-2015%20-v1.0%20FINAL.pdf.

17 Eurocontrol (2010): A Study of Runway Excursions from a European Perspective. NLR Air Transport Safety Institute, G.W.H. van Es. May 2010, p16.

Table 1: Most important causal factors for landing overruns

Factor	Europe	Outside Europe
Wet/contaminated runway	38.0%	66.7%
Long landing	24.0%	44.5%
Incorrect decision to land	14.9%	16.8%
Speed too high	14.0%	22.1%
Late/incorrect use of brakes	14.0%	10.3%
Late/incorrect use of reverse thrust	14.0%	10.0%
Aquaplaning	7.4%	16.2%
Tailwind	7.4%	15.9%
Too high on approach	3.3%	7.2%

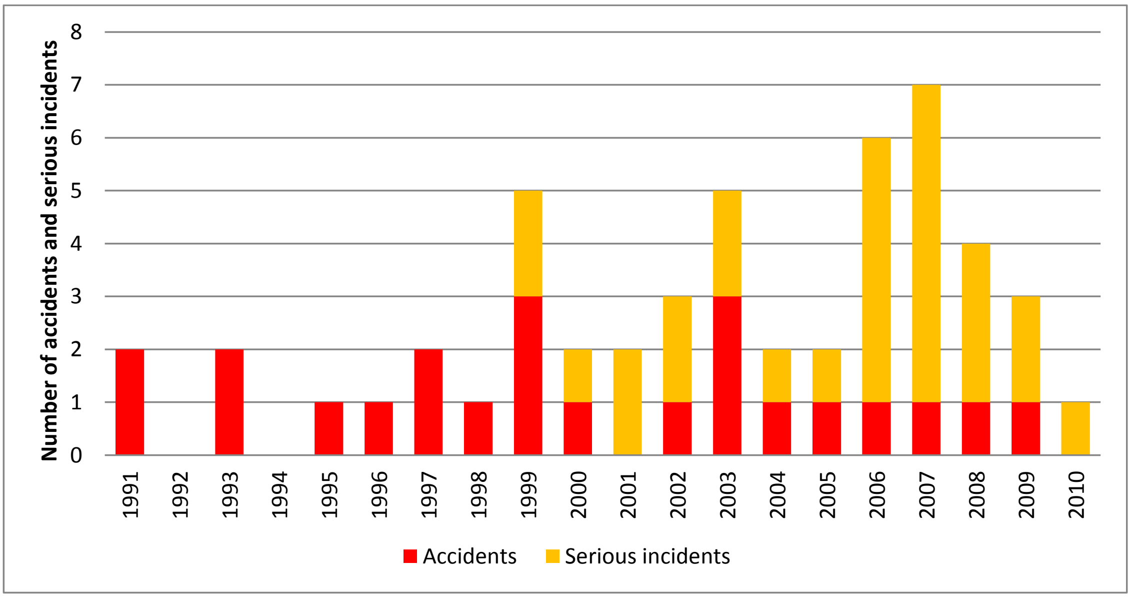
The Agency has issued CRIs providing AMC and interpretative material for the certification of ROAAS to be installed in new or in-service large aeroplane types on a voluntary basis.

4.1.1. Safety risk assessment

For operators certified in an EASA Member State, runway excursion is the fourth most frequent accident category (roughly 1.2 accidents and 1.4 serious incidents per year on average).

As Figure 1 shows, there is also an increasing trend when looking at accidents and serious incidents although the last three years show a sign of improvement.

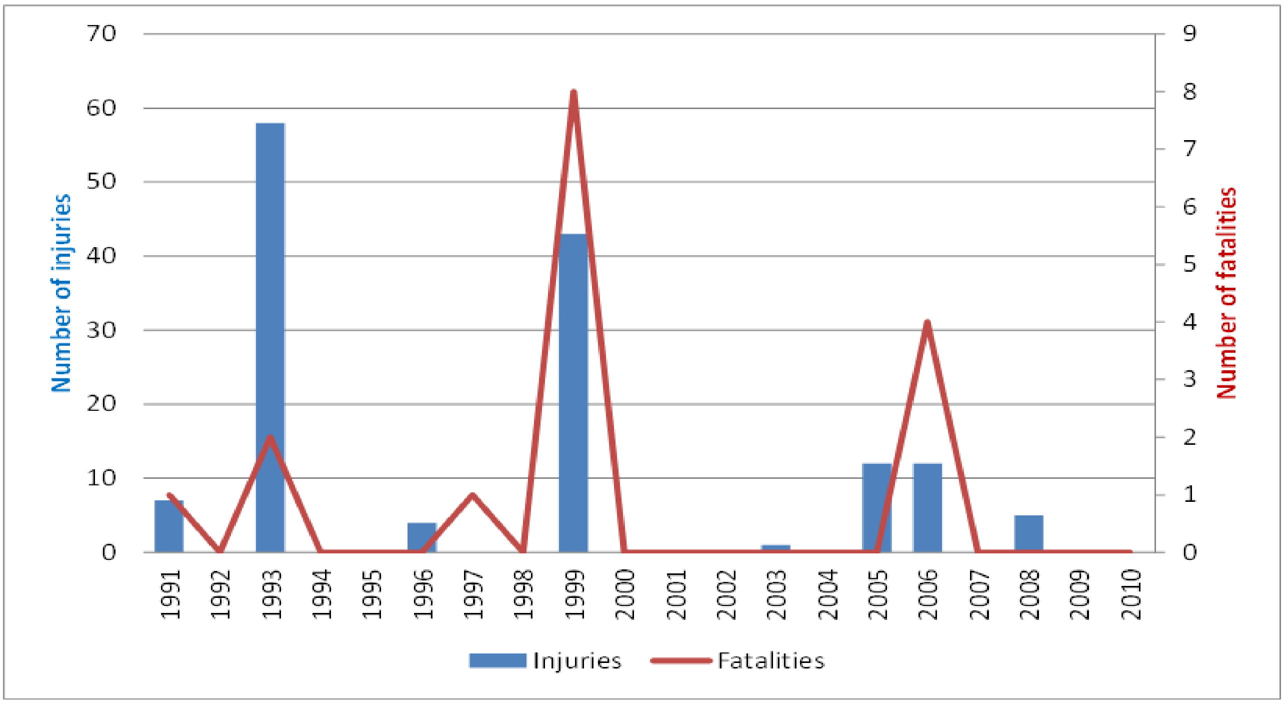
Figure 1: Runway excursion accidents and serious incidents at landing (EASA MS)



On the other hand, runway excursion ranks only 11th among the categories for fatal accidents.

Figure **2** shows that there is no obvious trend in casualties in the past two decades. Since the early 90s, the number of fatalities and injuries appears to remain at a comparable level and frequency. Overall, EASA Member State operators had 51 longitudinal runway excursions, 23 accidents and 28 serious incidents between 1991 and 2010.

Figure 2: Fatalities and injuries during runway excursions at landing[18], 1991–2010[19]



A 2010 Eurocontrol study on runway excursions[20] came to the following main conclusions:

— The runway excursions rate did not show a significant improvement during the study period 1980–2008;

— Runway excursions that occurred in Europe have very similar causal factors as excursions that occurred elsewhere;

— The four types of runway excursions (take-off overrun; take-off veeroff; landing overrun; landing veeroff) show a very similar frequency of occurrence for Europe compared to the rest of the world;

— Landing overruns and veeroffs are the most common type of runway excursions accounting for more than 77% of all excursions.

4.1.2. Who is affected?

Primarily affected stakeholders

— Large aeroplane manufacturers, some equipment manufacturers, and possibly other organisations wishing to install ROAAS since they design, produce, and install those systems;

— European operators of large aeroplanes used for commercial air transport (close to 1 000) since they would have to ensure that their fleet is equipped in due time.

Secondarily affected stakeholders

— Approved Training Organisations (ATOs) and holders of Flight Simulator Training Devices (FSTD) qualifications (more than 600).

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18 Veeroffs included.

19 EASA MS operated aircraft with a mass group above 5700 kg.

20 Eurocontrol (2010): *A Study of Runway Excursions from a European Perspective.* NLR Air Transport Safety Institute, G.W.H. van Es. May 2010, p5.

4.1.3. How could the issue/problem evolve?

If one were to predict future fatalities and injuries based on the data available, one would need to take into consideration that runway excursions are proportionate to the number of movements. Based on a 3.9% average annual increase in traffic, Table 2 provides an estimate of the fatalities and injuries to be expected.

Table 2: Future expected landing overrun fatalities and injuries European operators in a no regulatory change scenario (Option 0)[21], [22]

Year	Accidents	Fatalities	Injuries
2012	1.2	0.9	7.7
2013	1.3	0.9	8.0
2014	1.3	0.9	8.3
2015	1.4	1.0	8.6
2016	1.4	1.0	8.9
2017	1.5	1.0	9.3
2018	1.6	1.1	9.6
2019	1.6	1.1	10.0
2020	1.7	1.2	10.4
2021	1.8	1.2	10.8
2022	1.8	1.3	11.2
2023	1.9	1.3	11.7
2024	2.0	1.4	12.1
2025	2.0	1.4	12.6
2026	2.1	1.5	13.1
2027	2.2	1.5	13.6
2028	2.3	1.6	14.1
2029	2.4	1.7	14.7
2030	2.5	1.7	15.3
2031	2.6	1.8	15.9
2032	2.7	1.9	16.5
Total	39.3	27.3	242.4

Based on the above analysis, the likelihood of runway excursions is considered improbable[23]. The severity of the occurrence can be catastrophic[24]. Therefore, the combined runway overrun risk is considered to be of high significance. The following section will define the objectives based on this safety issue and section 4.3 will identify design options to address the issue.

[21] In real life the number of accidents, fatalities or injuries can only be a whole number and not a fraction (either an accident occurs or it doesn't). However, using whole numbers for infrequent events could lead to significantly misleading results, therefore it is appropriate to use fractions for greater accuracy.

[22] Annual results are shown as rounded to one decimal, the calculation of the totals are made without rounding, therefore the total numbers might differ slightly from the sum of the years.

[23] Very unlikely to occur.

[24] Catastrophic occurrence means multiple deaths and equipment destroyed.

4.2. Objectives

The overall objectives of the Agency are defined in Article 2 of the Basic Regulation. This proposal will contribute to the overall objectives by addressing the issues outlined in section 4.1 above.

The specific objective of this proposal is:

- to significantly reduce the number of runway overrun events at landing.

4.3. Policy options

Option No	Description
0	**Baseline option**: No change to existing regulations; the Agency would, nevertheless, continue to use the CRI process for approving the installation of ROAAS offered as an option to airline operators.
1	**New types only:** Update CS-25 to provide certification standards and generic AMC and guidance requiring the installation of ROAAS on new designs.
2	**New types and all new deliveries:** Implement Option 1, and in addition introduce a requirement into Part-26, for the mandatory installation of ROAAS into large aeroplanes operated by European commercial air transport operators produced after a certain date, and update CS-26 to define the certification standards of such systems for already type certificated aeroplanes.
3	**All new deliveries and full retrofit:** Implement Option 2, and in addition require installation of ROAAS into in-service large aeroplanes operated by European commercial air transport operators before a certain date.

4.4. Methodology and data (only for a full RIA)

4.4.1. Applied methodology

The benefits and costs of the options identified in the previous sections mainly depend on the unit costs for the various ROAAS as well as the speed at which these systems will be introduced into the fleet.

4.4.2. Data collection

The unit costs estimated in this RIA are based on information provided by aeroplane and equipment manufacturers.

The fleet evolution in 6.1 for the different options is generated based on:

— ASCEND/AIRCLAIMS fleet data base;

— Fleet forecasts from manufacturers;

— Long term traffic forecast by EUROCONTROL;

— Large aeroplane retirement curves generated from ASCEND data; and

— Assumptions on new Type Certificates based on historic data.

As far as the safety impact is concerned, it is assumed that the rate at which the ROAAS are introduced in the fleet determines the safety impact of a particular option.

In the comparison of options, we used cost-effectiveness analysis to calculate the cost needed to avoid one fatality. [25] Cost-effectiveness analysis ranks regulatory options based on 'cost per unit of effectiveness', i.e. cost per fatalities avoided.

In order to avoid a result that concentrates only on a single type of benefit (i.e. the number of fatalities avoided), the net cost of each option was calculated, which takes into account the benefit of avoided aeroplane damage and airport delays and diversions.

For reasons of comparability, all monetary values are expressed in 2012 euros. For future costs and benefits we applied a standard discount rate of 4%, and we also inflated past costs with the same value.[26]

4.5. Analysis of impacts

Fleet evolution and ROAAS introduction

The three options identified result in different speeds at which the ROAAS technology is introduced in the fleet. In order to analyse these different speeds, the fleet evolution is analysed. Industry forecasts[27] on average expect a 3.2 % annual increase of the fleet in Europe until 2032. In absolute numbers, the fleet would thus increase from 7 400 airframes in 2012 to 13 400 by 2032 (see Table 9, page 26). The following analysis estimates the share of this fleet which would be equipped with ROAAS in the different options.

Option 0 is the reference option as described in the issue analysis in section 1. As the technology is available and can be certified based on CRIs, it can be assumed that the technology will be introduced at a very limited to negligible rate into the fleet.

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[25] See p. 46 of the European Commission Impact Assessment Guidelines (SEC(2009) 92).

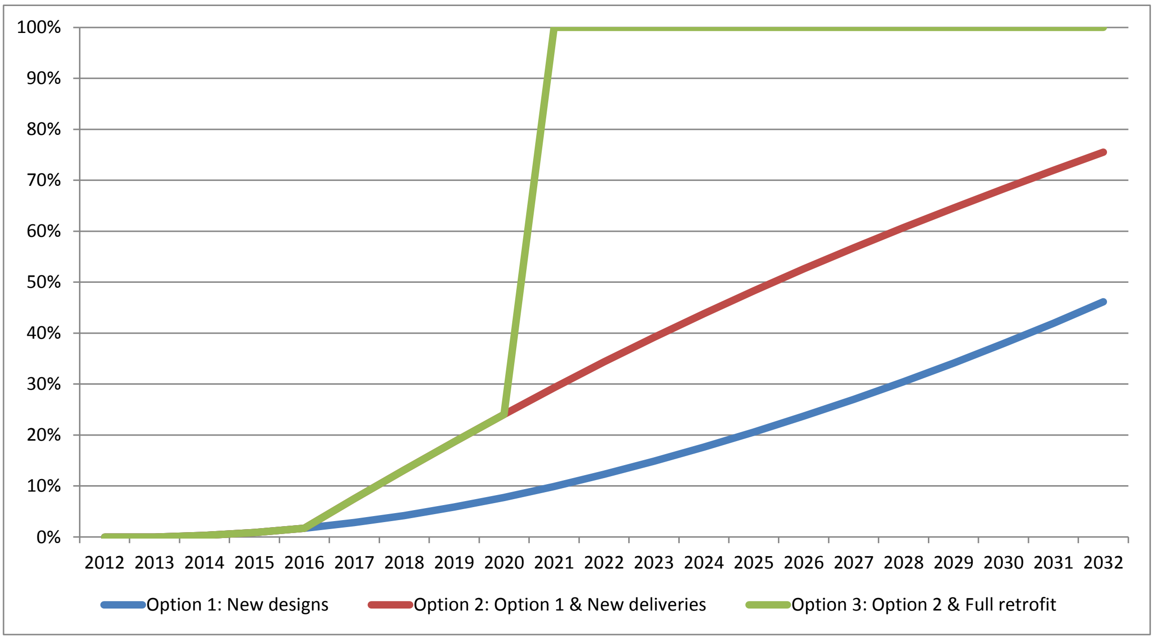
[26] The number of accidents, fatalities and injuries prevented are not discounted. While economic theory suggests a time preference also for non-monetary benefits, discounting the number of fatalities prevented does not change the relative cost-effectiveness of the options compared to each other. The final recommendation of the RIA is not sensitive to discounting.

[27] Airbus Global Market Forecast 2012–2031, Boeing Current Market Outlook 2012–2031, Bombardier Commercial Aircraft Market Forecast 2012–2031.

Option 1 is requiring only new types as of 2014 (date of publication of the new certification standards) to have the ROAAS technology installed. Based on data analysis, it is assumed that every year 1.2 new types are certified on average. An even distribution of deliveries per type is assumed, so e.g. if there are 20 types then each type has 5% share in the total deliveries. As the number of new deliveries and thereof the share of new types increase every year, so does the number of deliveries per new type.

As Figure 3 shows, by 2032 less than 50% of the fleet would be equipped with the technology.

Figure 3: Share of ROAAS in the EASA operators fleet by option



Option 2 mandates the installation of ROAAS on new types and all newly delivered aeroplanes to be operated by European commercial air transport operators from 2017. Consequently roughly 75% of the fleet would be equipped with the technology by 2032.

Option 3 mandates systems installation on all new deliveries and on all in-service aeroplanes (in-production and full retrofit), i.e. all the fleet would need to be equipped with the system by 2021. Thus, in that year (at the latest) the whole of the EASA fleet would be equipped with the ROAAS technology. Note that the graph in Figure 3 assumes that the equipment would be installed right in the implementation year. In reality, it is likely that the introduction will be carried out gradually as of the announcement date of the new rule. Thus the associated costs and benefits are likely to occur earlier.

4.5.1. Safety impact

Firstly, as outlined above, the safety impacts of the different options depend on the speed at which the new technology is introduced into the fleet. They are, thus, assumed to be directly proportionate to the rates shown in Figure 3.

Secondly, the safety impacts depend on how many of the observed accidents the system could prevent. A thorough analysis of the past events for European operators indicated that around half of the observed 51 serious incidents and accidents shown in table 3 could have been prevented by a ROAAS system.

Table 3: Number of runway excursions at landing of EASA operators

Year	Total number of		Thereof			
			Preventable		Non-preventable	
	Accidents	Serious incidents	Accidents	Serious incidents	Accidents	Serious incidents
1991	2		2			
1992						
1993	2				2	
1994						
1995	1				1	
1996	1		1			
1997	2		2			
1998	1				1	
1999	3	2	1	1	2	1
2000	1	1	1	1		
2001		2		1		1
2002		2		1		1
2003	4	2	1	1	3	1
2004	1	1		1	1	
2005	1	1	1	1		
2006	1	5		2	1	3
2007	1	6		3	1	3
2008	1	3	1	3		
2009	1	2	1	1		1
2010		1		1		
Total	23	28	11	17	12	11

In this analysis, all the existing contributing factors to the runway overrun (weather, runway condition, aeroplane configuration, etc.) were taken into account.

It was considered that if installed, a ROAAS could not have prevented an event where a mechanical failure was the major contributing factor to the runway overrun, or if the landing was obviously performed in weather conditions outside the aeroplane limitations.

An installed ROAAS was given a lower, 50% credit, for instance in the case where the system would have informed the flight crew of the risk of long landing/runway overrun (and proposed a go-around) but where at the same time a braking action lower than expected (runway reported wet instead of contaminated) contributed to the overrun.

Finally, a 100% credit was given to the ROAAS, if installed, for events which occurred on a perfectly airworthy[28] aeroplane and in normal weather and runway conditions (e.g. a long/fast landing on a dry runway).

Out of 11 preventable accidents, there are two with the lower, 50% credit, while among serious incidents, there are 9 cases out of 17 where the most probable efficacy of ROAAS was estimated to be less than 100%.

The following table (Table 4) shows the estimated number of fatalities and injuries that could be avoided in future in EASA Member States by the introduction of the ROAAS technology, based on the safety data provided in section 1.1. and the expected level of installation of the system in the fleet, for each option. The estimate is based on the

[28] No failure affecting the landing performances.

forecasted number of future accidents and fatalities as provided in Table 2 and the share of the fleet that is equipped by the new technology as shown in Figure 3.

It is assumed that the ROAAS can help reduce significantly the number of accidents and fatalities/injuries if installed and performing its intended function. Therefore an unjustified increase of Go-Around rate is not expected. In order to estimate the safety benefits, we forecasted the number of future accidents based on historical data and the expected increase in the traffic of EASA Member State airlines. Based on data analyis, we assumed 0.7 fatalities and 6.2 injuries per accident.

Table 4: Statistical safety benefits of ROAAS over the 20 year analysis period (avoided casualties)[29],[30]

Year	Option 1: New TCs			Option 2: New Deliveries			Option 3: Full retrofit		
	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries	Accidents	Fatalities	Injuries
2012	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1
2016	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.2
2017	0.0	0.0	0.3	0.1	0.1	0.7	0.1	0.1	0.7
2018	0.1	0.0	0.4	0.2	0.1	1.3	0.2	0.1	1.3
2019	0.1	0.1	0.6	0.3	0.2	1.9	0.3	0.2	1.9
2020	0.1	0.1	0.8	0.4	0.3	2.5	0.4	0.3	2.5
2021	0.2	0.1	1.1	0.5	0.4	3.2	1.8	1.2	10.8
2022	0.2	0.2	1.4	0.6	0.4	3.9	1.8	1.3	11.2
2023	0.3	0.2	1.7	0.7	0.5	4.6	1.9	1.3	11.7
2024	0.3	0.2	2.1	0.9	0.6	5.3	2.0	1.4	12.1
2025	0.4	0.3	2.6	1.0	0.7	6.1	2.0	1.4	12.6
2026	0.5	0.3	3.1	1.1	0.8	6.9	2.1	1.5	13.1
2027	0.6	0.4	3.7	1.2	0.9	7.7	2.2	1.5	13.6
2028	0.7	0.5	4.3	1.4	1.0	8.6	2.3	1.6	14.1
2029	0.8	0.6	5.0	1.5	1.1	9.5	2.4	1.7	14.7
2030	0.9	0.7	5.8	1.7	1.2	10.4	2.5	1.7	15.3
2031	1.1	0.7	6.7	1.8	1.3	11.4	2.6	1.8	15.9
2032	1.2	0.9	7.6	2.0	1.4	12.4	2.7	1.9	16.5
Total	7.7	5.3	47.4	15.6	10.9	96.5	27.2	18.9	168.2

4.5.1.1. Aircraft damage avoided

As far as equipment damage is concerned, Table 6 gives an estimate of the future damage that could be avoided. The estimate is based on the historical values of the 1991-2010 period, where 11 out of the 23 runway excursion accidents could have been prevented by the ROAAS. The 1.15 average annual number of accidents is expected to increase in the future in line with the predicted traffic increase of 3.9 % annually. Using the average cost per accident of EUR 11.1 million[31], the total figures are estimated for the 20 year analysis period. Option 3 forces a full retrofit by 2021 and thus creates the highest benefit in terms of the present value of avoided equipment damage or loss, amounting to an estimated EUR 159 million.

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29 In real life the number of accidents, fatalities or injuries can only be a whole number and not a fraction (either an accident occurs or it doesn’t). However, using whole numbers for infrequent events could lead to significantly misleading results, therefore it is appropriate to use fractions for greater accuracy.

30 Annual results are shown as rounded to one decimal, the calculation of the totals are made without rounding, therefore the total numbers might differ slightly from the sum of the years.

31 The average value of aircraft damage per runway excursion accident is based on historical data of European operators obtained from the Ascend database. In the 1991-2010 period there were 11 accidents that could have been prevented by ROAAS. These accidents all resulted in substantially damaged or completely destroyed aircraft.

This level of hull loss and liability claims is also affecting significantly the amount of hull and liability insurance paid on a yearly basis by aeroplane operators.

4.5.1.2 Diversion, delay, and cancellation costs avoided

The costs of a runway excursion accident is not limited to equipment damage, but also includes costs for operational disruptions. To account for this, it is assumed that after an excursion the runway is closed for a duration of ten hours on average, and the number of affected movements is 10 per hour. On a smaller airport with one runway, this can mean a closure of the whole airport causing diversions, cancellations and delays. Although on a larger airport there might be operational runway(s) left, the number of affected flights is expected to be similar because of the proportionally heavier traffic.

Delays, cancellations and diversions were monetised using values based on Eurocontrol recommendations. The average cost to the airline of a ground delay of a passenger air transport aeroplane is EUR 7 900 per hour, and the average cost of a diversion to another airport then planned for a commercial scheduled flight is EUR 13 900, and the average cost of a cancellation on the day of operation is EUR 33 100. During the 10-hour period while the runway is closed we expect 15 arrivals to be diverted, 20 arrivals to be cancelled and 15 arrivals to be delayed. Among the 50 planned departures 35 are assumed to be cancelled and 15 are expected to be delayed.

Based on the above assumptions, a runway excursion accident is estimated to cause EUR 208 500 diversion, EUR 355 500 delay and EUR 1 820 500 cancellation costs. The present values of avoiding 7.7, 15.6 and 27.2 accidents (Options 1, 2 and 3, respectively) are EUR 9.2, 19.2 and 34.3 million (see Table 5 and Table 6).

Table 5: Estimation of diversion, cancellation and delay costs[32]

Time after accident (hour)	Average delay (hours)	Arrivals				Departures				Total
		Diversions (aircraft)	Cancellations (aircraft)	Delays (aircraft)	Value	Diversions (aircraft)	Cancellations (aircraft)	Delays (aircraft)	Value	
0–1	9.5	5			€ 69 500		5		€ 165 500	€ 235 000
1–2	8.5	5			€ 69 500		5		€ 165 500	€ 235 000
2–3	7.5	5			€ 69 500		5		€ 165 500	€ 235 000
3–4	6.5		5		€ 165 500		5		€ 165 500	€ 331 000
4–5	5.5		5		€ 165 500		5		€ 165 500	€ 331 000
5–6	4.5		5		€ 165 500		5		€ 165 500	€ 331 000
6–7	3.5		5		€ 165 500		5		€ 165 500	€ 331 000
7–8	2.5			5	€ 98 750			5	€ 98 750	€ 197 500
8–9	1.5			5	€ 59 250			5	€ 59 250	€ 118 500
9–10	0.5			5	€ 19 750			5	€ 19 750	€ 39 500
0–10		15	20	15	€ 1 048 250	0	35	15	€ 1 336 250	€ 2 384 500

32 Assuming a 6-hour duration with 8 arrivals and 8 departures per hour.

Table 6: Statistical safety benefits of ROAAS over the 20 year analysis period (avoided aircraft damage and delay/diversion costs) [33], [34], [35]

Year	Option 1: New TCs			Option 2: New Deliveries			Option 3: Full retrofit		
	Accidents	Aircraft damage	Delay and diversion	Accidents	Aircraft damage	Delay and diversion	Accidents	Aircraft damage	Delay and diversion
2012	0.0	€ 0	€ 0	0	€ 0	€ 0	0	€ 0	€ 0
2013	0.0	€ 0	€ 0	0	€ 0	€ 0	0	€ 0	€ 0
2014	0.0	€ 37 078	€ 7 982	0.0	€ 37 078	€ 7 982	0.0	€ 37 078	€ 7 982
2015	0.0	€ 110 807	€ 23 855	0.0	€ 110 807	€ 23 855	0.0	€ 110 807	€ 23 855
2016	0.0	€ 217 569	€ 46 839	0.0	€ 217 569	€ 46 839	0.0	€ 217 569	€ 46 839
2017	0.0	€ 359 797	€ 77 459	0.1	€ 953 610	€ 205 298	0.1	€ 953 610	€ 205 298
2018	0.1	€ 533 806	€ 114 921	0.2	€ 1 666 551	€ 358 784	0.2	€ 1 666 551	€ 358 784
2019	0.1	€ 741 569	€ 159 649	0.3	€ 2 363 153	€ 508 752	0.3	€ 2 363 153	€ 508 752
2020	0.1	€ 980 659	€ 211 121	0.4	€ 3 040 175	€ 654 505	0.4	€ 3 040 175	€ 654 505
2021	0.2	€ 1 251 198	€ 269 365	0.5	€ 3 697 072	€ 795 925	1.8	€ 12 627 596	€ 2 718 536
2022	0.2	€ 1 549 419	€ 333 567	0.6	€ 4 331 161	€ 932 435	1.8	€ 12 615 454	€ 2 715 922
2023	0.3	€ 1 873 223	€ 403 277	0.7	€ 4 938 278	€ 1 063 139	1.9	€ 12 603 323	€ 2 713 310
2024	0.3	€ 2 218 961	€ 477 710	0.9	€ 5 517 101	€ 1 187 751	2.0	€ 12 591 205	€ 2 710 701
2025	0.4	€ 2 589 383	€ 557 456	1.0	€ 6 076 870	€ 1 308 261	2.0	€ 12 579 098	€ 2 708 095
2026	0.5	€ 2 980 908	€ 641 746	1.1	€ 6 611 740	€ 1 423 410	2.1	€ 12 567 003	€ 2 705 491
2027	0.6	€ 3 389 363	€ 729 680	1.2	€ 7 120 306	€ 1 532 897	2.2	€ 12 554 919	€ 2 702 889
2028	0.7	€ 3 821 217	€ 822 652	1.4	€ 7 612 740	€ 1 638 911	2.3	€ 12 542 847	€ 2 700 291
2029	0.8	€ 4 275 396	€ 920 430	1.5	€ 8 089 846	€ 1 741 625	2.4	€ 12 530 786	€ 2 697 694
2030	0.9	€ 4 750 307	€ 1 022 671	1.7	€ 8 550 552	€ 1 840 808	2.5	€ 12 518 738	€ 2 695 100
2031	1.1	€ 5 247 203	€ 1 129 646	1.8	€ 8 998 655	€ 1 937 278	2.6	€ 12 506 700	€ 2 692 509
2032	1.2	€ 5 765 735	€ 1 241 278	2.0	€ 9 433 286	€ 2 030 848	2.7	€ 12 494 675	€ 2 689 920
Total	7.7	€ 42 693 598	€ 9 191 304	15.6	€ 89 366 550	€ 19 239 305	27.2	€ 159 121 285	€ 34 256 474

4.5.1.3 Other costs avoided

Runway excursion accidents have other direct and indirect costs that were not included in the calculation of economic benefits. These include:

— Rescue costs of the accident

— Repair costs for the runway

— Accident investigation costs

The monetary values for the economic benefits are considered to be very cautious since they do not include the above 'other costs' and also do not include the cost of incidents and serious incidents.

4.5.2. Environmental impact

Not applicable.

4.5.3. Social impact

Not applicable.

4.5.4. Economic impact

4.5.4.1 Costs

[33] In real life the number of accidents, fatalities or injuries can only be a whole number and not a fraction (either an accident occurs or it doesn't). However, using whole numbers for infrequent events could lead to significantly misleading results, therefore it is appropriate to use fractions for greater accuracy.

[34] The annual numbers of accidents are shown as rounded to one decimal, the calculation of the totals are made without rounding, therefore the total numbers might differ slightly from the sum of the years.

[35] Equipment damage values are present values, discounted with a 4% rate to 2012.

The unit costs for the introduction of ROAAS is estimated to range from EUR 17 000 to EUR 39 000 per airframe. The low estimate uses EUR 17 000 for new aircraft and EUR 29 000 for retrofit, while the high estimate calculates with EUR 23 000 for new aircraft and EUR 39 000 for retrofit. The analysis is based on the assumption that the technical requirements for this safety standard are sufficiently generic so that they can be met by different airframe and equipment manufacturers. These figures are used as lower and upper estimates for further cost analysis. Stakeholders are invited to comment in particular on these figures.

4.5.4.2 Others costs

The introduction of ROAAS have other direct and indirect costs that were not included in the calculation. These include:

- Adaptation of SOPs/checklists
- Adaptation of training crew
- Additional functional checks

Table 7: Cost estimate for European operators for the ROAAS rules by option (in 2012 EUR)

Year	Low estimate			High estimate		
	Option 1 New TCs	Option 2 New Deliveries	Option 3 Full retrofit	Option 1 New TCs	Option 2 New Deliveries	Option 3 Full retrofit
2012	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
2013	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
2014	€ 361 501	€ 361 501	€ 361 501	€ 489 090	€ 489 090	€ 489 090
2015	€ 725 421	€ 725 421	€ 725 421	€ 981 452	€ 981 452	€ 981 452
2016	€ 1 060 812	€ 1 060 812	€ 1 060 812	€ 1 435 216	€ 1 435 216	€ 1 435 216
2017	€ 1 425 222	€ 9 110 240	€ 9 110 240	€ 1 928 241	€ 12 325 619	€ 12 325 619
2018	€ 1 760 030	€ 7 053 557	€ 7 053 557	€ 2 381 218	€ 9 543 048	€ 9 543 048
2019	€ 2 118 651	€ 7 066 476	€ 7 066 476	€ 2 866 410	€ 9 560 526	€ 9 560 526
2020	€ 2 459 503	€ 7 043 123	€ 7 043 123	€ 3 327 563	€ 9 528 931	€ 9 528 931
2021	€ 2 806 834	€ 7 011 113	€ 147 392 861	€ 3 797 481	€ 9 485 624	€ 198 217 985
2022	€ 3 123 809	€ 6 948 177	€ 3 502 800	€ 4 226 329	€ 9 400 475	€ 4 739 083
2023	€ 3 423 292	€ 6 835 540	€ 3 478 506	€ 4 631 512	€ 9 248 084	€ 4 706 214
2024	€ 3 695 116	€ 6 710 671	€ 3 440 281	€ 4 999 275	€ 9 079 143	€ 4 654 497
2025	€ 3 992 016	€ 6 656 763	€ 3 420 269	€ 5 400 963	€ 9 006 209	€ 4 627 423
2026	€ 4 260 611	€ 6 547 990	€ 3 386 891	€ 5 764 356	€ 8 859 045	€ 4 582 265
2027	€ 4 493 200	€ 6 418 858	€ 3 360 461	€ 6 079 036	€ 8 684 337	€ 4 546 506
2028	€ 4 783 283	€ 6 371 660	€ 3 331 053	€ 6 471 501	€ 8 620 481	€ 4 506 719
2029	€ 5 070 588	€ 6 336 053	€ 3 298 936	€ 6 860 207	€ 8 572 306	€ 4 463 267
2030	€ 5 345 499	€ 6 285 367	€ 3 281 146	€ 7 232 146	€ 8 503 732	€ 4 439 198
2031	€ 5 632 107	€ 6 261 483	€ 3 259 844	€ 7 619 909	€ 8 471 418	€ 4 410 377
2032	€ 5 919 795	€ 6 230 138	€ 3 235 327	€ 8 009 135	€ 8 429 011	€ 4 377 207
Total	€ 62 457 290	€ 111 034 943	€ 216 809 506	€ 84 501 040	€ 150 223 747	€ 292 134 623

The cost estimates in Table 7 illustrate the costs associated with the three options. Option 1 is the least costly (EUR 62 million to EUR 84 million for the low and high estimates respectively) as it applies only to newly certified types. This leaves manufacturers and operators the longest period to adjust and applies in the early years of implementation only to a small fraction of the fleet.

For Option 2, all newly delivered aeroplanes as of 2017 have to be equipped with a ROAAS. This leads to higher overall costs (EUR 111 million to EUR 150 million) as a higher share of the fleet needs to be equipped.

Option 3 mandates, in addition to Options 1 and 2, a full retrofit, i.e. as of 2021 all existing fleet and new deliveries have to be equipped with the new system. This generates the highest costs, between EUR 217 million and EUR 292 million EUR. In the analysis all of the retrofit cost is booked in the implementation year 2021. This is a simplification as in reality it can be expected that the fleet is gradually fitted with the equipment to meet the standard by 2021. However, for the overall results and comparison of options this is negligible.

4.5.5. General aviation and proportionality issues

The proposed amendments to CS-25 and CS-26 would ensure a level playing field between all applicants for approval of ROAAS.

4.5.6. Impact on "Better Regulation" and harmonisation

ICAO is considering the development of international standards and recommended practices for the prevention of runway excursions, and in particular the installation of on-board systems, such as that proposed by this NPA.

4.6. Comparison and conclusion

Comparison of options in **Table 8** gives an overview of the impacts expected from the options considered.

The results of this RIA suggest that Option 2 is the most cost-effective. It creates a significant safety benefit, with an estimated 16 accidents avoided; 11 fatalities and 97 injuries prevented and avoided accident costs in the order of EUR 100 million[36]. The costs for implementing this option are estimated to range between EUR 111 and 150 million, depending on the unit cost assumptions.

To support the decision-making a key cost-effectiveness indicator[37] was calculated: net costs per casualty prevented. According to this indicator Option 2 is the most cost-effective at EUR 220.000 to EUR 3.8 million per casualty prevented.

As regards Option 1 the safety benefits are low compared to costs due to the slow introduction of the system to the fleet (new types only). As regards Option 3, the mandatory retrofit for aircraft already flying increases the costs per prevented fatality over proportionally.

Thus, the Agency proposes option 2 as it is the most cost-effective option.

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[36] 2012 euros, discount rate 4%.

[37] European Commission Impact Assessment Guidelines (SEC (2009) 92), p46.

Table 8: Summary of impacts and cost-effectiveness assessment (2012–2032, 2012 EUR)

	Option 1 New TCs	Option 2 New Deliveries	Option 3 Full retrofit
BENEFITS			
Number of accidents prevented	7.7	15.6	27.2
Casualties prevented			
Fatalities prevented	5.3	10.9	18.9
Injuries prevented	47.4	96.5	168.2
Avoided costs			
Aircraft damage avoided	€ 42 693 598	€ 89 366 550	€ 159 121 285
Diversions, delays and cancellations	€ 9 191 304	€ 19 239 305	€ 34 256 474
Total avoided costs	€ 51 884 902	€ 108 605 855	€ 193 377 759
COSTS			
Equipment (implementation costs)			
Low estimate	€ 62 457 290	€ 111 034 943	€ 216 809 506
High estimate	€ 84 501 040	€ 150 223 747	€ 292 134 623
COST EFFECTIVENESS			
Net costs (Gross costs - Avoided costs)			
Low estimate	€ 10 572 388	€ 2 429 088	€ 23 431 747
High estimate	€ 32 616 138	€ 41 617 892	€ 98 756 865
Net cost per fatality prevented			
Low estimate	€ 1 980 441	€ 223 321	€ 1 236 584
High estimate	€ 6 109 722	€ 3 826 196	€ 5 211 782

4.7. Annex A: Supporting tables

Table 9: Fleet evolution

Year	Total fleet	Thereof aircraft with ROAAS					
		Option 1		Option 2		Option 3	
2012	7 404	0	0.0%	0	0.0%	0	0.0%
2013	7 641	0	0.0%	0	0.0%	0	0.0%
2014	7 886	23	0.3%	23	0.3%	23	0.3%
2015	8 138	71	0.9%	71	0.9%	71	0.9%
2016	8 398	144	1.7%	144	1.7%	144	1.7%
2017	8 667	246	2.8%	652	7.5%	652	7.5%
2018	8 944	377	4.2%	1 177	13.2%	1 177	13.2%
2019	9 230	541	5.9%	1 724	18.7%	1 724	18.7%
2020	9 525	739	7.8%	2 291	24.1%	2 291	24.1%
2021	9 830	974	9.9%	2 878	29.3%	9 830	100.0%
2022	10 145	1 246	12.3%	3 483	34.3%	10 145	100.0%
2023	10 469	1 556	14.9%	4 102	39.2%	10 469	100.0%
2024	10 804	1 904	17.6%	4 734	43.8%	10 804	100.0%
2025	11 149	2 295	20.6%	5 386	48.3%	11 149	100.0%
2026	11 505	2 729	23.7%	6 053	52.6%	11 505	100.0%
2027	11 872	3 205	27.0%	6 733	56.7%	11 872	100.0%
2028	12 250	3 732	30.5%	7 435	60.7%	12 250	100.0%
2029	12 641	4 313	34.1%	8 161	64.6%	12 641	100.0%
2030	13 045	4 950	37.9%	8 910	68.3%	13 045	100.0%
2031	13 462	5 648	42.0%	9 686	72.0%	13 462	100.0%
2032	13 893	6 411	46.1%	10 489	75.5%	13 893	100.0%

5. References

5.1. Affected regulations

- Commission Regulation on Additional Airworthiness Requirements for Operations (still draft, see NPA 2012-13)[38]

5.2. Affected CS, AMC and GM

- Decision of the Executivee Director of the European Aviation Safety Agency for Additional Airworthiness Specifications for Operations (CS-26) (still draft, see NPA 2012-13)
- Decision 2003/2/RM of the Executive Director of the European Aviation Safety Agency of 17 October 2003 on Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance, for large aeroplanes ('CS-25')

5.3. Reference documents

European Aviation Safety Plan 2012-2015

European Action Plan for Prevention of Runway Excursions Edition 1.0

[38] http://easa.europa.eu/rulemaking/docs/npa/2012/NPA%202012-13.pdf.