Runway Excursion
Joint Safety Analysis and Implementation Team

Final Report
Analysis and Recommendations

February 12, 2015

Runway Excursion
Joint Safety Analysis Team
Final Report

Provided to the Commercial Aviation Safety Team

from

The Runway Excursion Joint Safety Analysis Team

February 12, 2015

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OVERVIEW

The Commercial Aviation Safety Team (CAST) chartered the Runway Excursion (RE) Joint Safety Analysis and Implementation Team (JSAIT) in April 2012 to review the findings and recommendations from numerous existing studies on the issue of RE; categorize, organize, and prioritize the recommendations using the CAST safety analysis process; and recommend mitigations using the CAST safety enhancement (SE) process.

Although the worldwide rate of RE accidents has remained relatively steady over the past two decades, RE accidents made up the highest number of accidents and represent the third-highest fatality risk in worldwide operations between 2002 and 2011 (figure 1).

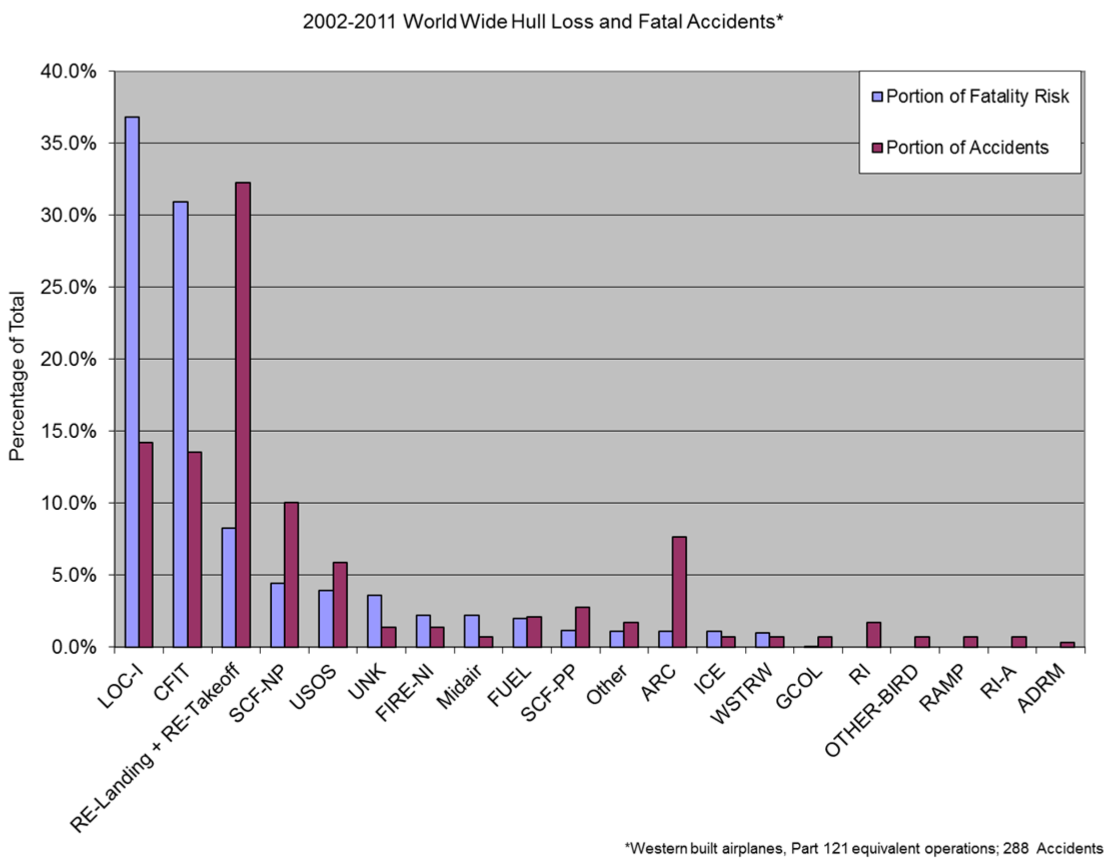

Figure 1. Worldwide Accident Categories and Distribution, 2002–2011

In U.S. 14 CFR part 121 operations between 2004 and 2013, REs made up the highest number of accidents. They represent a similar level of fatality risk as a number of other accident categories, including Loss of Control–Inflight and Fire/Smoke (Non-Impact) (figure 2). The trends in figures 1 and 2 indicate REs represent a significant precursor risk for future fatalities in both U.S. and worldwide operations.

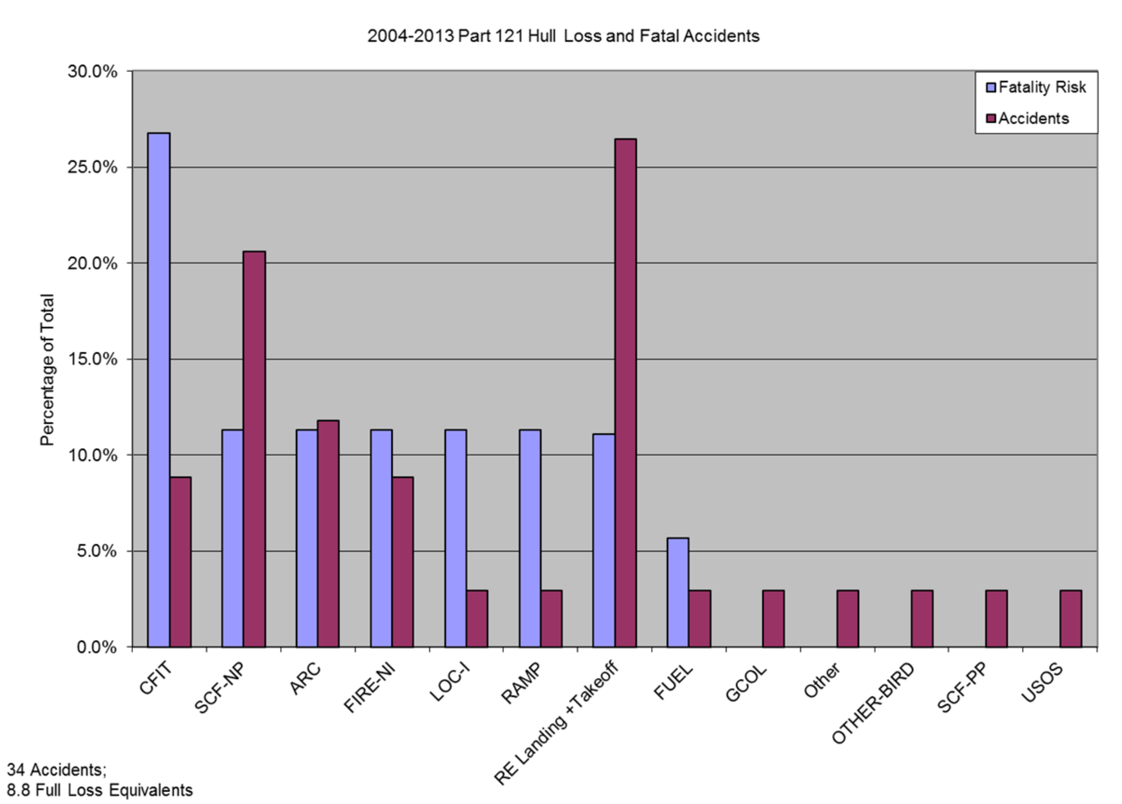

Figure 2. U.S. Part 121 Operations Accident Categories and Distribution, 2004–2013

The RE JSAIT reviewed 15 industry reports from 11 different organizations and authorities. From those reports, the team identified 155 contributing factors and 274 recommendations that were eventually consolidated into 45 Standard Problem Statements (SPS) and 75 Intervention Strategies (IS). The ISs were grouped by affinity into 16 SE Concepts and scored for feasibility and estimated risk reduction against a set of 10 U.S. part 121 RE accidents that occurred between 2002 and 2011. CAST approved all 16 SE Concepts for development in SEs. The RE JSAIT further consolidated the 16 SE Concepts into 7 SEs and 1 research and development (R&D) plan, as shown in table 1 below. For each SE, the RE JSAIT developed detailed implementation plans (DIP), including outputs and actions, responsible organizations, estimated costs, and timelines for completion.

The potential benefits to be gained by preventing future U.S. fatal RE accidents were determined to be $584 million, or an expected value of $5.8 million per 1 percent of estimated risk reduction. Figure 3 below summarizes the cost-benefit comparison for five of those SEs where applicable; additional cost-benefit methodology is available from CAST for SE 218, which is related to implementing onboard overrun awareness and alerting systems. Cost-benefit calculations are not applicable to SE 221 and SE 222.[1]

[1] SE 221 is not included because the benefits are not directly comparable (SE 221 does not presume prevention of the RE event; it only mitigates event severity). SE 222 is not included because it represents research.

Table 1. Summary of RE JSAIT Safety Enhancements

SE	Title	% Risk Reduction	Implementers / Costs ($M)								Flow (mos.)
			Air Carriers	Manufacturers	Regulators	Associations	Labor Orgs	Airports	Others	Total	
215	Landing Distance Assessment	15.0%	$6.8	$0.8	$1.3	$0.5		$2.0		$11.4	28
216	Flight Crew Landing Training	14.0%	$1.6	$0.4		$0.2				$2.2	54
217	Takeoff Procedures and Training	7.4%	$1.6		$0.1	$0.2				$1.9	54
218	Overrun Protection Systems	23.3%†	Vary [1]	$1.2						$1.2	36
219	ATO Policies, Procedures, and Training to Prevent RE	9.2%	$0.3		$1.7	$0.1	$0.2			$2.3	36
220	Runway Distance Remaining Signs	4.0%†				$0.1				$0.1	12
221	Policies & Procedures to Mitigate RE Consequences & Severity	27%			AIP					AIP	54
222	Airplane-based Runway Friction Measurement and Reporting	N/A			$1.2					$1.2	42
	Totals	**48%**	**$10.3**	**$2.4**	**$4.3**	**$1.1**	**$0.2**	**$2.0**	**-**	**$20.3**	**54**

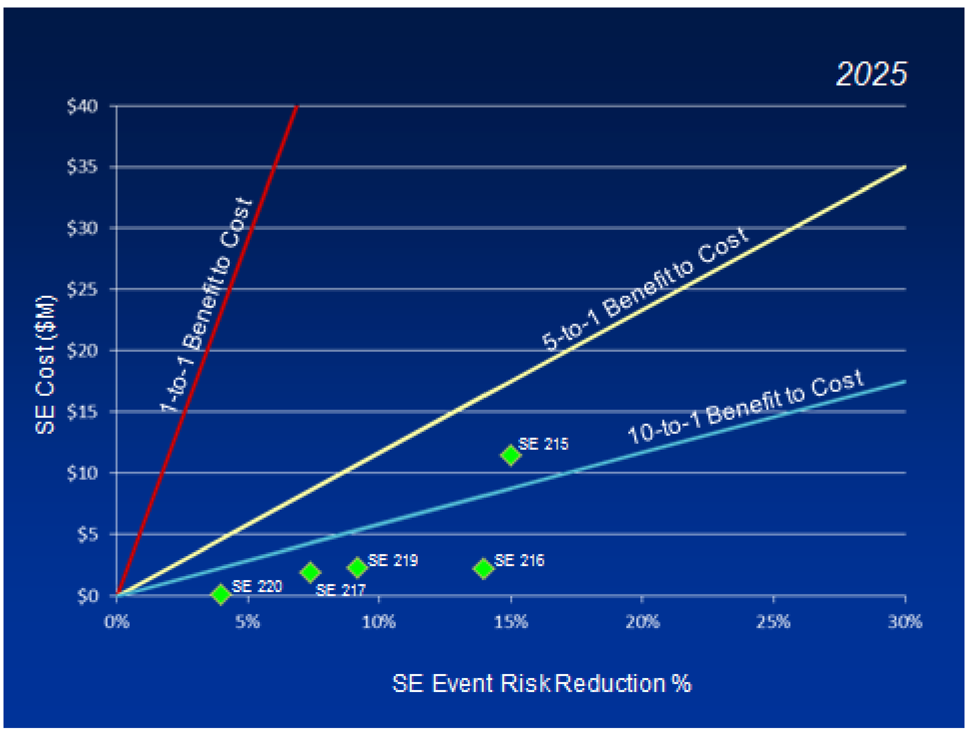

Figure 3. Cost-Benefit Summary of RE JSAIT Safety Enhancements

The RE JSAIT completed its work in March 2014 and forwarded the SEs and R&D study to CAST in April 2014. CAST approved all SEs and the R&D plan in June 2014 and added them to the CAST Safety Plan. CAST recommends adoption of the SEs by all CAST stakeholders and review of the RE SEs by international safety organizations for adaptation to their individual regions.

PROCESS

Pursuant to the RE JSAIT charter, the team followed the process steps shown in figure 4 to complete its tasks.

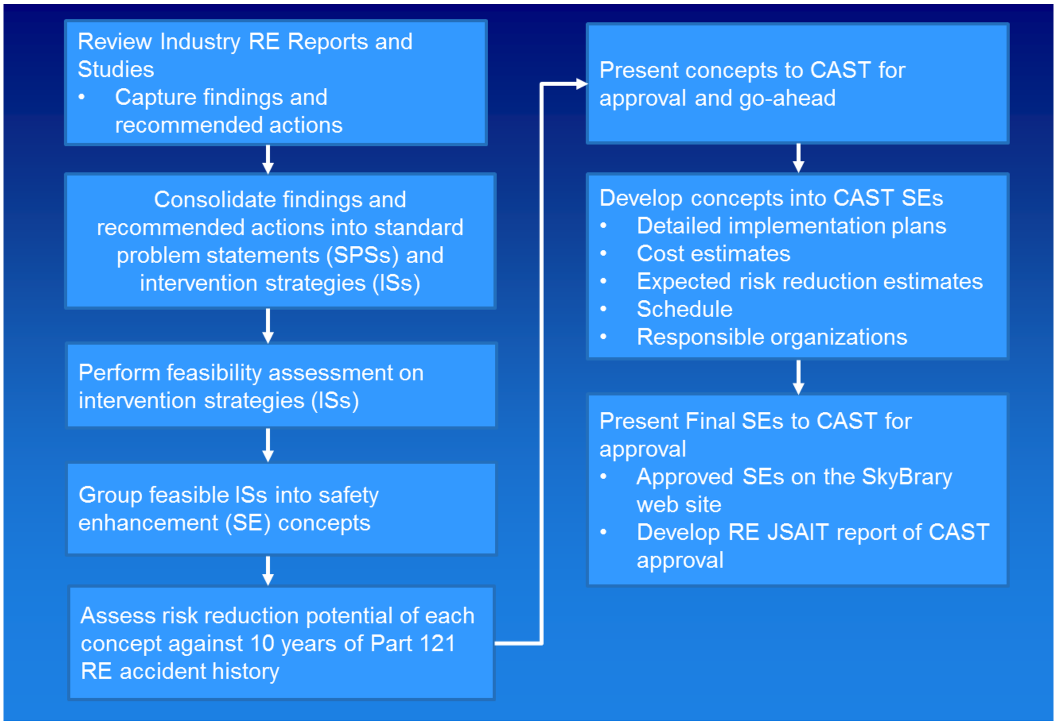

Figure 4. RE JSAIT Process Steps

The key differences between this process and the standard Joint Safety Analysis Team (JSAT) and Joint Safety Implementation Team (JSIT) processes[2] resulted from CAST's recognition that numerous aviation safety organizations and authorities, many of which have a connection to CAST, have studied the contributing factors related to RE during the past decade and made recommendations. Because a large body of analytical work on the subject already existed and was accepted by industry, CAST believed it was unnecessary to conduct formal event sequencing analysis to identify root cause problems, contributing factors, and interventions strategies. To expedite processing, CAST combined both the analysis and implementation phases into a single team activity. This had previously been done for other CAST teams such as Area Navigation (RNAV) Departures, Wrong Runway Departures, and Remaining Risk. In place of event sequencing for RE accidents, the RE JSAIT reviewed 15 reports summarizing the analysis, contributing factors, and recommendations of 11 different organizations (figure 5) with the intent of categorizing, organizing, and prioritizing them into Standard Problem Statements (SPS) and Intervention Strategies (IS) that could then be developed into CAST SEs.

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[2] See the JSAT Process Handbook, revision D, July 2, 2007, and the JSIT Process Handbook, revision B, July 2, 2007, for details of the JSAT and JSIT processes, including event sequencing.

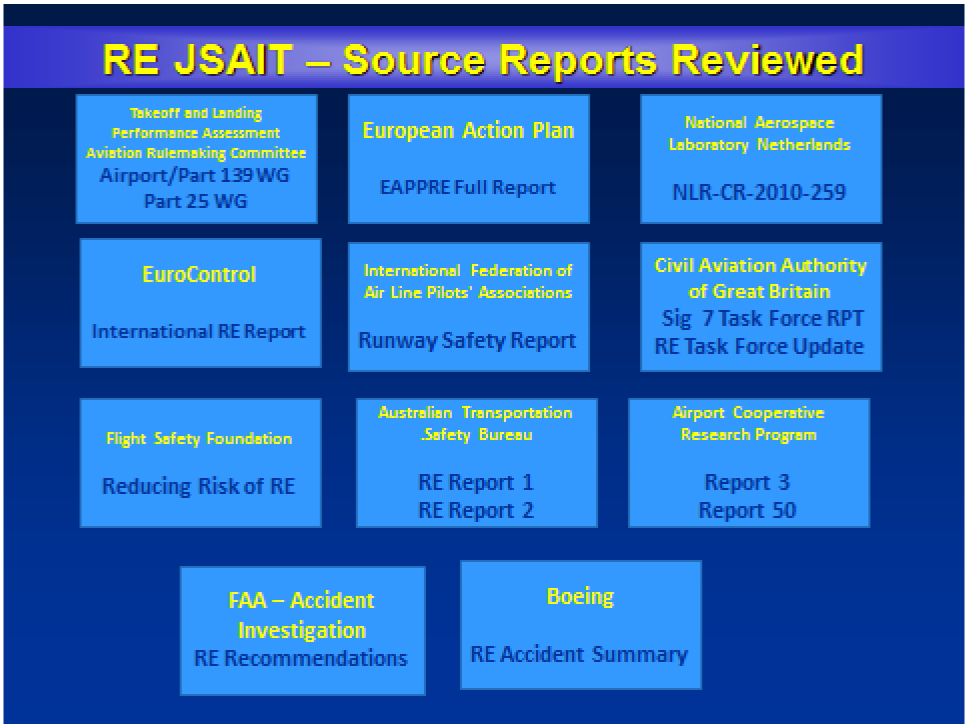

Figure 5. Source Studies and Reports Used in the RE JSAIT

SAFETY ENHANCEMENTS

In June 2013, CAST approved development of the 16 SE Concepts into full SEs. The RE JSAIT agreed to realign the major work items in the SE Concepts to consolidate risk reduction opportunities and to more closely connect the actions in the SEs to the appropriate implementing communities. The team also consolidated a number of separate concepts related to landing assessment and runway conditions into a single SE, as all elements were considered one broad project. Ultimately, the team rearranged the interventions from the 16 SE Concepts into 7 SEs and 1 R&D proposal. The RE JSAIT reevaluated risk reduction scoring for the final SEs and developed costs based on the actions and responsible parties. Table 2 provides a listing of the seven SEs and one R&D proposal, along with estimated costs and risk reduction estimates. Table 3 below shows the mapping of items from the SE Concepts to the final SEs.

Table 2. Summary of Final SEs, Including Cost by Implementer, Expected Risk Reduction, and Schedule Flow Time

SE	Title	% Risk Reduction	Implementers / Costs ($M)								Flow (mos.)
			Air Carriers	Manufacturers	Regulators	Associations	Labor Orgs	Airports	Others	Total	
215	Landing Distance Assessment	15.0%	$6.8	$0.8	$1.3	$0.5		$2.0		$11.4	28
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222	Airplane-based Runway Friction Measurement and Reporting	N/A			$1.2					$1.2	42
	Totals	**48%**	**$10.3**	**$2.4**	**$4.3**	**$1.1**	**$0.2**	**$2.0**	**-**	**$20.3**	**54**

In April 2014, the RE JSAIT presented these 7 SEs (SE 215 through SE 221) and the R&D plan (SE 222) to CAST. Summary pages for all SEs and the R&D plan are provided in appendix H, and the detailed implementation plans (DIP) are provided in appendix I. CAST approved all SEs and the R&D plan in June 2014 and added them to the CAST plan. A brief overview of the major themes addressed is provided in the following sections.

Table 3. Mapping of SE Concepts to Final SEs

#	Concept Description	SE 215	SE 216	SE 217	SE 218	SE 219	SE 220	SE 221	SE 222
1	RE Policies & Procedures	X	X	X		X			
2	Monitoring RE Risk Factors		X						
3	Wind Measurement, Reporting, and Use					X			
4	Standardized, Timely, & Accurate Field Conditions	X							
5	Aircraft-based Measurement & Reporting of Braking Characteristics								X
6	Runway Design, Maintenance, and Closure	X					X		
7	Takeoff Performance Planning & Thrust Setting			X					
8	Takeoff and RTO Considerations			X					
9	Landing Distance Assessment	X							
10	Stabilized Approach, Flare, and Landing		X			X			
11	ATC and Airports Awareness of RE Risk					X			
12	Landing Techniques and Use of Stopping Devices		X						
13	Crosswinds, Tiller Usage, and Asymmetric T/R Deploy		X						
14	Airplane Systems for Runway Overrun Alerting				X				
15	Reduced RE Accident Consequences							X	
16	Touchdown Decision Point						X		

LANDING PERFORMANCE AND TRAINING

Landing performance assessments and flightcrew training recommendations related to the landing phase are addressed in SE 215, RE – Airline Operations and Training – Landing Distance Assessment, and SE 216, RE – Airline Operations and Training – Flight Crew Landing Training. SE 215 combines elements from SE Concepts 1, 4, 6, and 9, consolidating all elements related to recommendations from the Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC) and subsequent actions of the manufacturers and air carriers into a single SE. At the time of SE development, the Federal Aviation Administration (FAA) was pursuing an internal effort to implement as many of the TALPA ARC recommendations as possible without requiring rulemaking. The RE JSAIT aligned the FAA actions of SE 215 with this effort to avoid duplication of effort, coordinate FAA actions with industry actions, and broadly communicate all efforts across the project to all key stakeholders. This resulted in a coordinated plan to develop standardized runway friction reporting criteria and terminology and promote standardized flightcrew and air carrier use of runway friction information in a timely landing distance assessment, using airplane braking performance data for actual braking distance with a 15 percent margin added. The risk reduction estimated for SE 215's combined actions is 15 percent against the RE accident set, presuming an implementation level of 93 percent in U.S. air carrier operations by 2018.[3]

[3] The implementation level of 93 percent for U.S. air carrier operations is based on the estimated number of annual U.S. air carrier operations carried out by airlines represented by one of the three airline industry associations that are CAST members: Airlines for America, the Regional Airlines Association, and the National Air Carriers Association.

SE 216 combines elements from SE Concepts 1, 2, 10, 12, and 13, and addresses flightcrew training recommendations related primarily to three aspects of landing: stabilized approach, flare and touchdown, and proper use of braking and steering devices during rollout. The training recommendations include improving flightcrews' general knowledge of factors that can lead to unstable approaches and long landings, as well as scenario-based training in simulators to practice landing in tailwinds and crosswinds on contaminated runways. The risk reduction estimated for SE 216's combined actions is 14 percent against the RE accident set, presuming an implementation level of 93 percent in U.S. air carrier operations by 2018. The training in SE 216 was also considered to dovetail with training from SE 198, ASA – Training – Scenario-Based Training for Go-Around Maneuvers, which was developed by the Airplane State Awareness JSIT and includes specific training for recovery and go-around from long or bounced landings and from various stages of an unstable approach.

TAKEOFF PERFORMANCE AND TRAINING

Takeoff performance planning and flightcrew training for rejected takeoff (RTO) decisionmaking are addressed in SE 217, RE – Airline Operations and Training – Takeoff Procedures and Training. SE 217 combines elements from SE Concepts 1, 7, and 8, and addresses issues related to proper communication of takeoff performance planning information between all areas at an air carrier, including specific risks associated with the use of electronic flight bags or performance calculators. Flightcrew training for the RTO decision is also incorporated, with general ground training to improve flightcrew knowledge of factors that should and should not be considered in making an RTO. SE 217 also includes recommendations for simulator practice of the RTO decision using various triggers and recommendations for determining whether the crew makes the correct decision per air carrier standard operating procedures. The risk reduction estimated for SE 217's combined actions is 7.4 percent against the RE accident set, presuming an implementation level of 93 percent in U.S. air carrier operations by 2018.

AIRCRAFT DESIGN

Airplane manufacturers and avionics suppliers have developed, and continue to develop, new onboard technologies for the flightdeck to improve flightcrew situational awareness of stable approach criteria exceedances, runway remaining during landing rollout, and alerting of conditions in which the landing distance available or remaining is too short. These systems include the Airbus Runway Overrun Protection System (ROPS), the Boeing Runway Safety Awareness Toolkit (RSAT), and the Honeywell SmartLanding system. At the time of the RE JSAIT's review, these systems are at varying levels of availability and development, but discussion with all three manufacturers indicates the systems will be broadly available both on new airplane designs and as retrofit systems for existing airplane designs.

SE 218, RE – Design – Overrun Awareness and Alerting Systems, is derived directly from SE Concept 14 and includes recommendations for manufacturers to continue developing such systems on all new airplane designs and to develop, as feasible, retrofit options for all existing airplane designs. The SE also recommends air carriers study the feasibility of implementing these systems throughout their fleets, taking into consideration available features, system implementation, crew training requirements, and cost, both for separate retrofit installation and as part of the purchase design for new airplanes. The potential risk reduction estimated from implementing SE 218 is 23.3 percent against the RE accident set, presuming full implementation in all U.S. air carrier fleets by 2025; however, the RE JSAIT recognizes that this represents a theoretical maximum, as it is unlikely that full implementation in all airplanes, especially those nearing retirement, will be cost-beneficial to all air carriers. The RE JSAIT thus developed a specific cost-benefit methodology, summarized in appendix J, to help air carriers make these assessments.

AIR TRAFFIC CONTROL AND AIRPORT INFRASTRUCTURE

Infrastructure issues that contribute to RE accidents include airspace design, air traffic controller procedures and actions, and airport design and maintenance. SE 219, RE – Air Traffic Operations – Policies, Procedures and Training to Prevent Runway Excursions, combines the elements of SE Concepts 1, 3, 10, and 11 to provide recommendations to the FAA Air Traffic Organization (ATO) related to the effects of winds, runway conditions, and stable approaches on RE accident risk. The SE recommends implementing runway selection criteria at all U.S. part 139 airports that limit operations in tailwinds when the runway is wet or contaminated, and also recommends air traffic controllers report winds to flightcrews during takeoff and landing when multiple wind measurement sources are available, consistent with FAA Order 8400.9, National Safety and Operational Criteria for Runway Use Programs. Lastly, the SE recommends general knowledge training for controllers on the effects of winds, runway conditions, and controller practices when staging airplanes during approach. The risk reduction estimated for SE 219 is 9.2 percent, presuming implementation at all part 139 towered airports.[4]

SE 220, RE – Airports – Runway Distance Remaining Signs, combines the elements of SE Concepts 6 and 16 and recommends airport operators and the FAA Airport Improvement Program (AIP) increase, where feasible, the implementation of runway distance remaining signs to improve flightcrew awareness of its position on the runway. SE 220 helps enable elements of SEs 216 and 217 by increasing implementation of infrastructure that flightcrews can use in making go-around decisions from a long or bounced landing and in making RTO decisions. The risk reduction estimated for SE 220 is 4 percent, presuming implementation at all part 139 towered airports.

SE 221, RE – Airports – Policies and Procedures to Mitigate Runway Excursion Consequences & Severity, is unique from the other RE SEs in that it does not directly address problems that cause runway excursions, but instead mitigates the severity of those excursions that do occur. SE 221 implements the elements of SE Concept 15 and recommends airport operators and the FAA AIP carry out the FAA Office of Airport

[4] The RE JSAIT estimated that U.S. air carrier operations at U.S. airports account for approximately 80 percent of all their operations; thus an implementation level of 80 percent was used for SEs 219, 220, and 221.

Safety and Standards plan to align all part 139 airports runway safety areas (RSA) with the recommendations for RSAs in FAA Advisory Circular (AC) 150/5300–13, Airport Design, or else implement Engineered Materials Arresting Systems (EMAS) at runway ends where RSA standards cannot be met. The SE also makes recommendations to airport operators, the FAA ATO, and air carriers on the use of emergency radio frequencies and accident locator grids at each airport in the event of an RE. The estimated reduction in RE accident severity[5] from SE 221 is 27 percent, assuming implementation of the FAA AIP plan for RSAs and EMAS.

RESEARCH AND DEVELOPMENT

The RE JSAIT recommended one R&D study. SE 222, RE – Research – Airplane-based Runway Friction Measurement and Reporting, is derived directly from SE Concept 5, and recommends the FAA complete research currently underway to enable the development, implementation, and certification of onboard aircraft system technologies to assess airplane braking action and provide the data in real time to the pilot, other aircraft crews, air traffic controllers, and airport operators. These characteristics would be calculated from available airplane data sources such as accelerations from the inertial reference system; braking system parameters such as brake pressures, wheel speeds, and brake pedal displacement; and airplane performance data such as airspeed, ground speed, thrust, and configuration (flaps and speedbrakes). As an R&D plan, this SE does not have a direct risk reduction estimate; however, the team estimated the potential risk reduction possible from certain proposed systems at 7.5 percent against the RE accident set, presuming 93 percent implementation in U.S. operations.

[5] Reduction in severity was assessed by determining the likelihood that a fatal or hull-loss RE accident would have been reduced to a non-fatal event involving no more than major (but repairable) damage had suitable RSAs or EMAS been available for the event.

INTEGRATED SAFETY PORTFOLIO

As shown in table 2, the total cost of the RE JSAIT portfolio is estimated at about $20 million. This cost does not include the cost of fully implementing SE 218, which would be determined independently by air carriers for their specific fleets. The cost also does not include the expenditures of the FAA AIP funds, which have already been committed by statute for implementing RSAs and EMAS as recommended in SE 221.

The RE JSAIT estimated the benefits to be gained by reducing RE accidents in the United States using a methodology that accounts for the potential cost of future U.S. fatal and/or hull-loss accidents. Historical data from 1987[6] to present reveal 196 RE fatal and/or hull-loss accidents in worldwide operations and 23 accidents in the United States. As the worldwide data set is broader than the U.S. data, the RE JSAIT used the worldwide severity ratio (percentage of fatalities per accident) of 0.29 in its safety benefit assessment.

At the current U.S. rate of operations, and accounting for the projected growth in operations expected by the U.S. Department of Transportation (DOT) between 2014 and 2025, the RE JSAIT predicts U.S. carriers will likely experience 1.1 fatal hull-loss accidents and 9.7 nonfatal hull-loss accidents during this period, absent further mitigation. Based on U.S. DOT data, the average number of persons onboard each operation over this time frame will be 108; using the 0.29 severity ratio, the number of fatalities expected from a fatal accident is 31. Based on the U.S. DOT current value of a statistical life (VSL) of $9.1 million, the cost of 31 fatalities is $285 million. The additional cost associated with a hull-loss accident includes loss of hull, investigation costs, and site cleanup; this value is approximately $25 million, for a total cost of $310 million for a fatal accident. The expected value of return for preventing 1.1 fatal hull-loss accidents and 9.7 non-fatal hull-loss accidents is $584 million (1.1 * $310 million + 9.7 * $25 million). This equates to a $5.8 million expected value of return for each 1-percent reduction in RE risk.

Using this value, the expected benefit of each SE can be determined using the risk reduction estimates associated with each SE. Figure 6 below presents these benefit values cross-plotted against expected SE costs.

[6] CAST analyses use 1987 as the starting point for historical accident data because the original CAST activity, which began in 1997, used a 10-year previous history of accidents as its analysis set. Thus CAST has a significant amount of information and data on events dating back to this year, making it a suitable cutoff point.

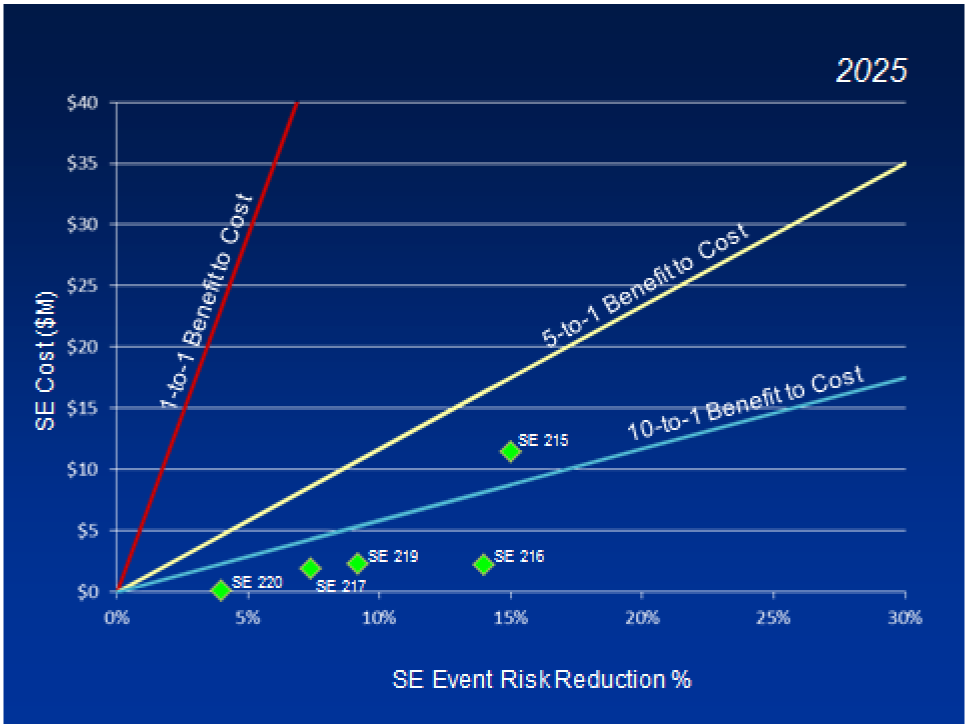

Figure 6. Cost-Benefit Comparison of Individual RE SEs

Cost-benefit relationships are shown for SEs 215, 216, 217, 219, and 220,[7] with lines showing the relationship for 1-to-1, 5-to-1, and 10-to-1 benefit-to-cost ratios. The cost-benefit assessment shows the applicable RE SEs are cost-beneficial by a factor of at least 7-to-1, and most are above a factor of 10-to-1. This indicates resources invested in the CAST RE SEs provide a high return of safety expectation for the amount invested.

[7] SE 218 was not included because a separate cost-benefit methodology was developed for it, as outlined in Appendix J. SE 221 was not included as the benefits are not directly comparable because SE 221 does not presume prevention of the RE event. SE 222 is not included because it represents research.

CONCLUSION AND RECOMMENDATIONS

The RE JSAIT completed its charter in April 2014 by providing seven new SEs and one R&D study to CAST. CAST approved all SEs and the R&D plan in June 2014 and added them to the CAST Safety Plan.

CAST recommends the CAST stakeholder community implement all RE SEs to reduce the future risk and cost of RE accidents in U.S. operations. CAST also recommends international safety organizations review the RE SEs and develop suitable implementation plans for their regions.

Conclusion and Recommendations

APPENDIX A—RE DETAILED IMPLEMENTATION PLANS

This appendix contains brief descriptions of the SEs listed in table 2 above and links to the full detailed implementation plans.

Safety Enhancement SE 215 Runway Excursion – Landing Distance Assessment

Status: Underway

Background

The purpose of this Safety Enhancement is to improve flight crew awareness of their landing distance margin and the factors and variables that can affect it. Flight crews should assess landing performance based on conditions actually existing at time of arrival (rather than the conditions presumed at dispatch), including weather, runway conditions (using standardized terminology), aircraft weight, braking systems, and performance assumptions. To support this assessment, the following should be accomplished:

1. Federal Aviation Administration (FAA) Flight Standards Service (AFS) develops guidance material incorporating Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC) recommendations addressing procedures for conducting a landing performance assessment using actual conditions existing at the time of arrival (including standardizing terms used to report conditions and make landing distance assessments).

2. FAA Office of Airports (ARP) develops guidance material to define terms and format for reporting runway conditions and criteria for clearing or closing runways when friction levels degrade to a level where safe operations are not assured.

3. FAA Aircraft Certification Service (AIR) develops guidance material for how manufacturers should provide airplane landing distance data consistent with TALPA recommendations, including for contaminated surfaces.

4. FAA Air Traffic Organization (ATO) revises their procedures to allow controllers to report timely runway conditions to pilots using TALPA terminology.

5. Airport operators incorporate the guidance material into their runway assessment procedures and report the runway conditions using the new terminology.

6. Manufacturers provide a standardized set of landing distance performance data, which will support the new landing distance calculation standard as defined by guidance material.

7. Air Carriers incorporate the guidance material and manufacturers' landing standardized assessment data into standard operating procedures (SOP) and training to implement landing assessment at time of arrival.

Safety Enhancement SE 216 Runway Excursion – Flight Crew Landing Training

Status: Underway

Background

The purpose of this Safety Enhancement is to reduce runway excursion accidents. Air Carriers should define, publish, and train proper techniques for stabilized approach, flare, touchdown, and use of available airplane stopping devices for the following scenarios:

8. Landing with reduced or minimal landing distance margin resulting from one or more of:
   a. Wet or contaminated conditions;
   b. Tailwind, including gusts; or
   c. Runway closures that reduce available landing distance.
9. Landing with conditions conducive to directional control issues, resulting from one or more of:
   a. Crosswind, including gusts; or
   b. System failures (thrust, brakes, nose gearing steering, etc.) or Minimum Equipment List (MEL) conditions that results in directional asymmetries

Safety Enhancement SE 217 Runway Excursion – Takeoff Procedures and Training

Status: Underway

Background

The purpose of this Safety Enhancement is to reduce runway excursion accidents. Air Carriers should improve takeoff safety through the following actions:

1. Regulators publish guidance material for air carriers on takeoff planning to:
   a. Emphasize timely (i.e., before commencement of taxi) communication and coordination between gate agents, ground crew chiefs, load agents/dispatchers, and flight crews on accurate takeoff weight and balance information.

b. Encourage development and use of software “flags” to alert all air carrier personnel involved in dispatch of aircraft to gross data entry errors.

c. Emphasize the importance for both flight crew members to cross-check takeoff performance data and/or calculations.

d. Provide guidance on training for hazards/risks of incorrect data entry into the Flight Management Systems (FMS), Electronic Flight Bags (EFB), or laptops for takeoff performance calculations.

e. Address proper processing and communication of late changes to passenger/cargo loads, weather and runway conditions, departure runway, or clearance, etc.

f. Address both “paper” information and electronically transmitted information, e.g., Aircraft Communication Addressing and Reporting Systems (ACARS).

2. Air carrier adoption of the guidance material in procedures and training.

3. Air carrier definition and standardization of procedures and training for the rejected takeoff (RTO) decision, utilizing the guidance in the Takeoff Safety Training Aid.

Safety Enhancement SE 218 Runway Excursion – Overrun Awareness and Alerting Systems

Status: Underway

Background

The purpose of this Safety Enhancement is to reduce landing overrun accidents. Manufacturers should develop and manufacturers and operators should implement on-board technologies to reduce or prevent landing overruns on new and existing airplane designs, as applicable and feasible. These technologies should be deployed on new and existing airplanes as follows:

- Manufacturers make systems available on all new type certificate and major derivative, amended type certificate programs involving redesign of flight deck avionics launched after June 1, 2015.
- Manufacturers study the feasibility of providing system on current production, in-development, and out-of-production airplane programs.
- Air Carriers implement on-board technology, as feasible, through purchase on new airplanes and retrofit on existing transport category airplanes.

Safety Enhancement SE 219 Runway Excursion – Policies, Procedures and Training to Prevent Runway Excursions

Status: Underway

Background

The purpose of this Safety Enhancement is to reduce the risk of runway excursion accidents. The Federal Aviation Administration (FAA) Air Traffic Organization (ATO) should develop or modify policies, procedures, and training related to the following factors that contribute to the risk of runway excursions:

1. Airport arrival and departure configuration based on wind conditions;
2. Wind reporting, measurement, and use; and
3. Training of air traffic controllers on factors that contribute to the risk of runway excursion, including wind conditions, runway conditions, and unstable approaches.

Additionally, Air Carriers should review and revise policies to reinforce a culture for flight crews to declare "unable" to Air Traffic Control (ATC) clearances that, in the opinion of the flight crew, could lead to an unstable approach.

Safety Enhancement SE 220 Runway Excursion – Runway Distance Remaining Signs

Status: Underway

Background

The purpose of this Safety Enhancement is to improve flight crew awareness of airplane position on the runway and distance remaining during takeoff roll and landing rollout. Airport operators should add, as feasible, distance remaining signs on runways at Part 139 airports where Part 121 operations are conducted.

Safety Enhancement SE 221 Runway Excursion – Policies and Procedures to Mitigate Consequences and Severity

Status: Underway

Background

The purpose of this Safety Enhancement is to reduce the consequence of runway excursion events. Airport operators and the Federal Aviation Administration (FAA) Office of Airport Safety and Standards (AAS) should modify policies and procedures in regards to the following: 1) Improvement of runway safety areas, including but not limited to implementation of Engineered Materials Arresting System (EMAS), as appropriate. 2) Improved communication between air traffic control, flight crews, and aircraft rescue and fire fighting (ARFF) personnel after occurrence of a runway excursion (RE) event.

Safety Enhancement SE 222 Runway Excursion – Airplane-based Runway Friction Measurement and Reporting

Status: Research & Development Underway

Background

The purpose of this Safety Enhancement is to outline research to be conducted by the aviation community (government, industry and academia) to enable development, implementation, and certification of on-board aircraft system technologies to assess airplane braking action and provide the data in real time to the pilot, other aircraft crews, air traffic controllers, and the airport operators.

APPENDIX B—COST-BENEFIT ASSESSMENT GUIDANCE FOR SE 218

Exposure to an RE accident is related to the number of departure cycles an airplane or fleet accumulates in a given period. The U.S. part 121 operator RE accident rate since 2002 is approximately one RE accident (hull loss and/or fatal) every 12.5 million flight cycles. The predicted number of RE accidents from 2014-2025 (inclusive), absent further mitigation, is 1.1 fatal accidents and 9.7 non-fatal hull losses, representing approximately $584 million in direct accident-related costs to the U.S. industry. Using U.S. DOT predictions for traffic growth between 2014 and 2025, the RE JSAIT calculated the total number of predicted departures between 2014 and 2025, inclusive, as 134 million. Thus the cost per cycle of the predicted RE risk from 2014 to 2025 is $584 million / 134 million cycles, or $4.35 per cycle.

The potential risk reduction of SE 218 systems is 23.3 percent. Applying this to the per-cycle cost of RE risk, the potential per-cycle benefit of SE 218 in terms of accident cost avoided is 23.3 percent * $4.35, or $1.01. This result is useful in determining whether the installation of SE 218 is cost-beneficial on an airplane-by-airplane level. An airplane with an estimated 40,000 cycles remaining before re-sale or retirement would gain $40,400 of potential lifetime benefit from the installation, whereas one with only 10,000 cycles remaining would gain only $10,100 of lifetime benefit. Airline operators, when determining costs for installation of SE 218 systems from manufacturers, can compare per-airplane installation costs against per-airplane potential lifetime benefits and make decisions as to which airplanes or fleets of airplanes should be equipped.

The general equation for determining the projected benefit from avoiding hull loss and/or fatal accidents for any given airplane is as follows:

$$Projected\ Benefit = \frac{Remaining\ hull\ life\ (cycles)}{12{,}500{,}000} \times (RE\ accident\ cost) \times 23.3\%$$

Thus, for example, if an airline's own estimate of an RE accident cost[8] is $50 million, the projected lifetime benefit to be gained for an airplane with 25,000 cycles remaining is:

$$Projected\ Benefit = \frac{25{,}000}{12{,}500{,}000} \times (\$50{,}000{,}000) \times 23.3\% = \$23{,}300$$

The projected benefits thus represent a "break-even" cost per airplane for system installation. In practice, the RE JSAIT presumes operators will likely look at systems on a fleet-wide basis within their particular operation to maintain flight deck commonality and standardized flight crew training requirements. In that case, the values used should reflect fleet averages of cycles remaining, rather than cycles remaining for individual models.

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[8] Airlines may choose, based on their specific experience, to use their own estimates of RE accident costs to account for additional expenses beyond those included in the CAST cost-benefit value. Additional costs may be incurred from loss of use of the airplane, damage to brand or reputation, increased insurance premiums, and costs associated with changes to policy, training, and procedures as a result of an accident.