NASA/TM-2018-219750

Current Safety Nets within the U.S. National Airspace System

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October 2017

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October 24, 2017

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Introduction & Motivation

There are over 70,000 flights managed per day in the National Airspace System, with approximately 7,000 aircraft in the air over the United States at any given time. Operators of each of these flights would prefer to fly a user-defined "4D" trajectory (4DT), which includes arrival and departure times; preferred gates and runways at the airport; efficient, wind-optimal routes for departure, cruise and arrival phase of flight; and fuel efficient altitude profiles.

To demonstrate the magnitude of this achievement a single flight from Los Angeles to Baltimore, accesses over 35 shared or "constrained" resources that are managed by roughly 30 air traffic controllers (at towers, approach control and en route sectors); along with traffic managers at 12 facilities, using over 22 different, independent automation system (including TBFM, ERAM, STARS, ASDE-X, FSM, TSD, GPWS, TCAS, etc.).

In addition, dispatchers, ramp controllers and others utilize even more systems to manage each flight's access to operator-managed resources. Flying an ideal 4DT requires successful coordination of all flight constraints among all flights, facilities, operators, pilots and controllers. Additionally, when conditions in the NAS change, the trajectories of one or more aircraft may need to be revised to avoid loss of flight efficiency, predictability, separation or system throughput.

The Aviation Safety Network has released the 2016 airliner accident statistics showing a very low total of 19 fatal airliner accidents, resulting in 325 fatalities[1]. Despite several high profile accidents, the year 2016 turned out to be a very safe year for commercial aviation, Aviation Safety Network data show. Over the year 2016 the Aviation Safety Network recorded a total of 19 fatal airliner accidents [1], resulting in 325 fatalities. This makes 2016 the second safest year ever, both by number of fatal accidents as well as in terms of fatalities. In 2015 ASN recorded 16 accidents while in 2013 a total of 265 lives were lost.

How can we keep it that way and not upset the apple cart by premature insertion of innovative technologies, functions, and procedures?

In aviation, safety nets function as the last system defense against incidents and accidents. Current ground-based and airborne safety nets are well established and development to make them more efficient and reliable continues. Additionally, future air traffic control safety nets may emerge from new operational concepts.

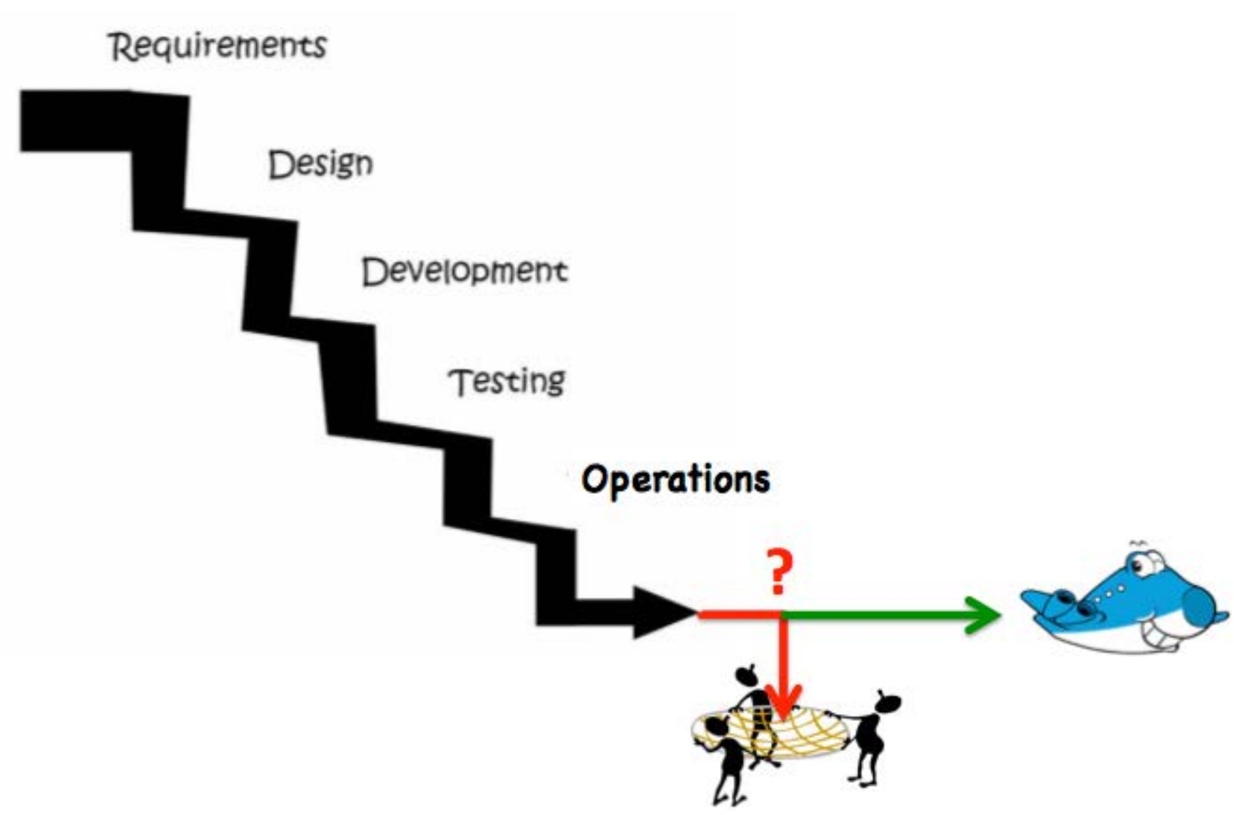
This partial inventory of safety systems and safety nets can be useful in identifying the quality of resilience to adverse conditions and events – those beneficial technologies, functions, and procedures that push the system operating point away from failure. While it may seem counterintuitive because of the current high level of safety in the National Airspace System (NAS), elements of the system occasionally fail or operate in degraded modes. The main reason this does not result in more frequent serious accidents is that components of the system – both technical and human - constantly tweak their performance to achieve adaptive, safe responses. How and why this happens today in the stable, high-reliability organization we call the aviation system is a key reason to foster resilience. Key aspects of the "ecological resilience" of the aviation system include:

- The amount of change the system can undergo and still retain the same controls on function and structure;
- The degree to which the system is capable of self-reorganization; and
- The ability to build and increase the capacity for learning and adaptation

Recovery actions are in many cases evidence of so-called "graceful degradation" from nominal technology and procedural functions as well as organizational processes. Sidney Dekker asserts that

> *"The principles of organization in a living system are unlike those of machines. In contrast to a machine that either works to specification or does not, a living system can be disturbed to any number of degrees. Consequently, its functioning is much less binary, and potentially much more resilient. Such resilience means that failure is not really, or can't even really be, the result of individual or compound component breakage. Instead, it is related to the ability of the system to adapt to, and absorb variations, changes, disturbances, disruptions and surprises. If it adapts well, absorbs effectively, then even compound component breakages may not hamper chances of survival."*[2]

The "living system" we call aviation has taken the overall system reliability of machines from 10^{-5} to 10^{-9}.



Basic Technology Lifecycle Descriptors

Outcomes from the Requirements, Design, Development, and Testing stages can all have positive (+) or negative (-) safety impacts though usually indirect or latent. What this document calls “Safety Nets” come into play in the “Operations” stage.

It is the intention of the authors to publish yearly updates to this safety system/safety net inventory. Readers are invited to suggest corrections and/or additions to this compendium. They can be submitted to: Brian.E.Smith@nasa.gov.

Airborne Safety Nets

Aircraft Communications Addressing and Reporting System (ACARS)

Accident Category (Risk Area)

Excessive crew workload and compromised data integrity

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport, Terminal, TRACON, Enroute & Oceanic

Input Data Required

Radio transmissions between air and ground

Functional Description and Related Warning/Alert Times/Latencies

ACARS is used to send information from the aircraft to ground stations about the conditions of various aircraft systems and sensors in real-time. Maintenance faults and abnormal events are also transmitted to ground stations along with detailed messages, which are used by the airline for monitoring equipment health, and to better plan repair and maintenance activities.

ACARS interfaces with interactive display units in the cockpit, which flight crews can use to send and receive technical messages and reports to or from ground stations, such as a request for weather information or clearances or the status of connecting flights. The response from the ground station is received on the aircraft via ACARS as well. Each airline customizes ACARS to this role to suit its needs.

August 1, 2016: According to ARINC Industry Activities Ku/Ka Band Subcommittee Chairman Peter Lemme, the industry is achieving Internet Protocol (IP) networking today by leaving the historical structure of ACARS in place, while using an ACARS aircraft gateway to take the self-synchronizing ARINC 429 avionics data transfer standard and interfacing that to Internet Protocol, and then using IP to deliver the specified message to the Datalink Service Provider (DSP). Industry has already achieved this capability using Iridium's Short Burst Data (SBD) network transport capability designed for transmitting short data messages between functional equipment and centralized host computer systems. The other new method for operating ACARS over IP, is Inmarsat's SwiftBroadband Safety service.

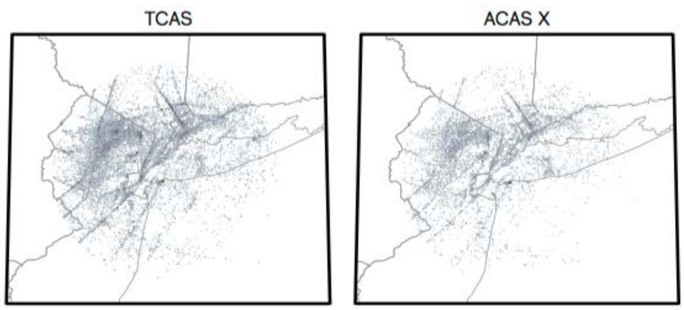
References/Sources

http://www.skybrary.aero/index.php/Aircraft_Communications,_Addressing_and_Reporting_System

http://www.aviationtoday.com/av/issue/feature/88450.html?hq_e=el&hq_m=3286180&hq_l=1&hq_v=6e067cc169

Airborne Collision Avoidance System X (ACAS X)

(Compared with TCAS, ACAS X reduces the number of advisories by half, as shown in these plots of alerts in the greater New York City metropolis taken over a multiyear period.)



ACAS X VARIANTS

ACAS Xa – The general purpose ACAS X that makes active interrogations to detect intruders. ACAS Xa is the baseline system, the successor to TCAS II. The Standards are expected to be ready by 2018.

ACAS Xo – ACAS Xa extensions designed for particular operations, like closely spaced parallel approaches, for which ACAS Xa is less suitable because it might generate a large number of nuisance alerts. The Standards are also expected to ready by 2018.

ACAS Xu – Designed for Remotely Piloted Aircraft Systems (RPAS), incorporating horizontal resolution manoeuvres. Work on Standards will start in 2016.

ACAS Xp – A variant that is expected to solely rely on passive ADS-B data rather than active interrogation to track intruders. It is intended particularly for light aircraft that are not currently required to fit TCAS II. No schedule for the development of Standards yet.

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE165: TCAS Policies and Procedures
SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Will make extensive use of new surveillance sources, especially satellite-based navigation and advanced ADS-B functionality

Functional Description and Related Warning/Alert Times/Latencies

The FAA has funded research and development of a new approach to airborne collision avoidance (provisionally known as ACAS X) since 2008. This new approach takes advantage of recent advances in 'dynamic programming' and other computer science techniques (which were not available when TCAS was first developed) to generate alerts using an off-line optimization of resolution advisories. It is the intention that ACAS X will eventually replace TCAS II (ACAS II). TCAS II has been in operation for many years and has demonstrated its value in preventing mid-air collisions on numerous occasions. In Europe, it is estimated to have reduced the risk of a mid-air collision by a factor of about 5. Two of the key differences between TCAS II and the current concept for ACAS X are the collision avoidance logic and the sources of surveillance data. TCAS II relies exclusively on interrogation mechanisms using transponders on-board aircraft to determine the intruders current and projected future position. If the tracked aircraft is declared a threat and is also TCAS-equipped, the two TCAS II units coordinate complementary advisories. Current TCAS II advisory logic issues alerts against a potential threat on the basis of time of closest approach and projected miss distance. This relies on a fixed set of rules, modelling the spectrum of pilots responses. Instead of using a set of hard-coded rules, ACAS X alerting logic is based upon a numeric lookup table optimized with respect to a probabilistic model of the airspace and a set of safety and operational considerations.

The following benefits are foreseen through the introduction of ACAS X:

Reduction of 'unnecessary' advisories: TCAS II is an effective system operating as designed, but it can issue alerts in situations where aircraft will remain safely separated.

Adaptability to future operational concepts: Both SESAR and NextGen plan to implement new operational concepts which will reduce the spacing between aircraft. TCAS II in its current form is not compatible with such concepts and would alert too frequently to be useful.

Extending collision avoidance to other classes of aircraft: To ensure advisories can be followed, TCAS II is restricted to categories of aircraft capable of achieving specified performance criteria (e.g. minimum rate of climb of 2,500 feet per minute), which excludes the likes of General Aviation (GA) and Unmanned Aircraft Systems (UAS).

Use of future surveillance environment: Both SESAR and NextGen make extensive use of new surveillance sources, especially satellite-based navigation and advanced ADS-B functionality. TCAS however relies solely on transponders on-board aircraft which will limit its flexibility to incorporate these advances.

Safety improvement: It is envisaged that ACAS X will provide an improvement in safety while reducing the unnecessary alert rate.

Minimal changes: ACAS X will use the same hardware (antennas, processors, and displays) as the current TCAS II system and the same range of available RAs will be used. Consequently, pilots and controllers would perceive no change with the transition to the new system, which will be fully compatible with current TCAS II systems.

<u>References/Sources</u>

http://www.skybrary.aero/index.php/ACAS_X

https://www.ll.mit.edu/publications/journal/pdf/vol19_no1/19_1_1_Kochenderfer.pdf

See page 66 of: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Aircraft Condition Monitoring System (ACMS)

Accident Category (Risk Area)

SYSTEM/COMPONENT FAILURE OR MALFUNCTION (NON-POWERPLANT) (SCF–NP)
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (POWERPLANT) (SCF–PP)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE136: Engine Event Recovery Training

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)
:
Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)
:
All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)
:
Terminal, TRACON, Enroute & Oceanic

Input Data Required

Sensors throughout the aircraft

Functional Description and Related Warning/Alert Times/Latencies

Aircraft Condition Monitoring Systems (ACMS) developed by Safran Electronics & Defense collect a wide range of data. As such, ACMSs permits monitoring and control of the status of the onboard systems and equipment, as well as variations to the flight conditions and to the operation of the equipment. ACMSs are fully customizable and can be programmed to anticipate aircraft system failure risks.

Adapted to the specific requirements of the Airbus A320 family, the ED48 FDIMU combines mandatory flight data acquisition and high-performance monitoring capabilities into a single unit. Highly reconfigurable, the ED48 meets the aircraft operators and MROs' needs. In addition to flight data monitoring (FOQA/ MOQA), the ACMS provides troubleshooting for system fault conditions such as electrical power, pitot heater, pneumatic system or engine trim failures.

References/Sources

http://www.safran-electronics-defense.com/aerospace/commercial-aircraft/information-system/aircraft-condition-monitoring-system-acms

ADS-B In/Out

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT JIMDAT Undesired Aircraft State: LOSS OF SEParation

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & high-end GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

Principally, ADS-B signals are only available from equipped aircraft. The ADS-B OUT mandate in Europe is limited to large aircraft. In the USA, ADS-B OUT equipment is mandated for all operations that currently require a Mode-C transponder - which roughly means operations above 10,000ft QNH, in Class B airspace and in and above Class C airspace - from Jan 1st 2020. However, it would be premature to expect ADS-B OUT equipage on all aircraft that carry a Mode-C transponder today due to the cost. Many light aircraft pilots may well decide to stay away from mandated airspace. However, at least in the USA, ADS-B will be the main system support for collision avoidance in the long term (for light aircraft). In some areas of the USA the position of Mode-C equipped aircraft without ADS-B OUT is rebroadcast and can be received by ADS-B IN.

Low Power ADS-B Transceiver (LPAT)
The installation cost for ADS-B OUT is to some extent due to the mandated system requirements for position accuracy and signal integrity etc. Other equipment is targeted below the standard and cost of the ADS-B out mandate. Flight trials are already under way with a Low Power ADS-B

Transceiver (LPAT) being developed by UK NATS and Funke Avionics. This is a light-weight, battery powered carry-on device that is affordable and simple to use and which provides the minimum functionality you need to see and be seen by other traffic. It can also provide warnings against other suitably-equipped aircraft. It could become small enough to be carried also by remotely piloted aviation systems (RPAS).

References/Sources

Automatic Ground Collision Avoidance System (A-GCAS)

Accident Category (Risk Area)

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE001: Terrain Awareness Warning System (TAWS)
SE120: Terrain Awareness and Warning System (TAWS) Improved Functionality
SE184: TAWS - Minimum Vectoring Altitude Reevaluation
SE185: TAWS and RNAV Visual or Other Procedures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Military

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal & Enroute

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

Auto-GCAS continuously compares a prediction of the aircraft's trajectory against a terrain profile generated from onboard terrain elevation data. If the predicted trajectory touches the terrain profile, which is indicated at the 26 sec. mark on the video at the moment when the two chevrons on the HUD come together, the automatic recovery is executed by the Auto GCAS autopilot. The automatic recovery maneuver consists of an abrupt roll-to-upright and a nominal 5-G pull until terrain clearance is assured.

References/Sources

http://aviationweek.com/technology/auto-gcas-saves-unconscious-f-16-pilot-declassified-usaf-footage?utm_rid=CPEN1000000155663&utm_campaign=7051&utm_medium=email&elq2=02905b73606e425cb262ef0ba82a3d40

Central Flow Management Unit (CFMU) Route Validator

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE212: Area Navigation (RNAV) – Equipment and Procedures to Improve Route Entry for RNAV Departures
SE213: Area Navigation (RNAV) – Safe Operating and Design Practices for STARs and RNAV Departures
SE214: Area Navigation (RNAV) – Procedures and Standards to Improve Path Compliance for STARs and RNAV Departures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Pre-flight/Take-off

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

ATC information

Functional Description and Related Warning/Alert Times/Latencies

Within Europe there are as many as 30,000 restrictions in operation at any one time that limit the use of particular airways by days of the week AND by times of day.
This makes generating and preparing an IFR (Instrument) route a complex and lengthy task.
Eurocontrol and CFMU provide several tools including the NOP Portal as a method to validate routes either using a form or cut/paste of the Type B message structure.

References/Sources

https://www.rocketroute.com/blog/validating-fpl-flights-with-cfmu-in-europe
https://www.youtube.com/watch?v=hgrxRfFadKM

Airbus Electronic Centralized Aircraft Monitoring (ECAM)

Accident Category (Risk Area)

SYSTEM/COMPONENT FAILURE OR MALFUNCTION (NON-POWERPLANT) (SCF–NP)
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (POWERPLANT) (SCF–PP)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE136: Engine Event Recovery Training

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Primary engine parameters:
- N1/fan RPM
- EGT
- N2/high pressure turbine RPM
- fuel flow

Other information:
- status of lift augmentation devices
- landing gear position

- hydraulic systems
- electrical systems
- fire suppression
- etc.

Functional Description and Related Warning/Alert Times/Latencies

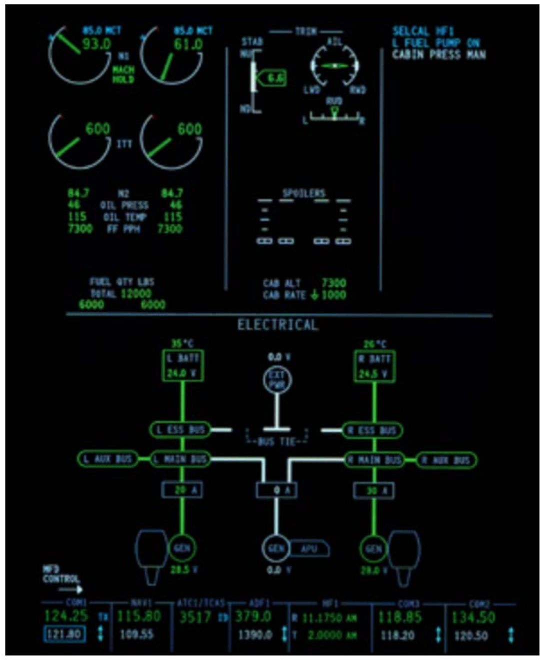
The Electronic Centralized Aircraft Monitor (ECAM) is the Airbus version of an enhanced EICAS system. It presents data on the Engine/Warning Display (E/WD) and the System Display (SD) inclusive of:

- Primary engine indications, fuel quantity, flap and slat position
- Warning and caution alerts, or memos
- Synoptic diagrams of aircraft systems, and status messages
- Permanent flight data

References/Sources

http://www.skybrary.aero/index.php/Electronic_Centralized_Aircraft_Monitor_(ECAM)

Boeing Engine Indication and Crew Alerting System (EICAS)



<u>Accident Category (Risk Area)</u>

SYSTEM/COMPONENT FAILURE OR MALFUNCTION (NON-POWERPLANT) (SCF–NP)
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (POWERPLANT) (SCF–PP)

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE136: Engine Event Recovery Training

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

All

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal, TRACON, Enroute & Oceanic

<u>Input Data Required</u>

EICAS typically includes instrumentation of various engine parameters, including for example revolutions per minute, temperature values, fuel flow and quantity, oil pressure etc. Typical other aircraft systems monitored by EICAS are for example hydraulic, pneumatic, electrical, deicing, environmental and control surface systems.

Functional Description and Related Warning/Alert Times/Latencies

An engine-indicating and crew-alerting system (EICAS)[1] is an integrated system used in modern aircraft to provide aircraft crew with aircraft engines and other systems instrumentation and crew annunciations. On EICAS equipped aircraft the "recommended remedial action" is called a checklist.
EICAS has high connectivity & provides data acquisition and routing.
EICAS is a key function of a glass cockpit system, which replaces all analog gauges with software-driven electronic displays. Most of the display area is used for navigation and orientation displays, but one display or a section of a display is set aside specifically for EICAS.
The crew-alerting system (CAS) is used in place of the annunciator panel on older systems. Rather than signaling a system failure by turning on a light behind a translucent button, failures are shown as a list of messages in a small window near the other EICAS indications.
Time critical warnings alert the crew of a non-normal operational condition requiring immediate crew awareness and corrective action to maintain safe flight.
Time critical warnings are usually associated with primary flight path control. Master warning lights, voice alerts, and ADI indications or stick shakers announce time critical warning conditions.
Aural alerts need to be easily recognized during high workload times, as well as normal operations.
Its crew alerting feature provides Crew Alerting System messaging, flight deck lamp control and aural alerting. Aural alerts can include voice and synthesized tones.
Key Features & Benefits

- Improves reliability through elimination of traditional engine gauges
- Simplifies flight deck through fewer standalone annunciators
- Reduces pilot workload with integrated flight deck and synoptic display of aircraft system status
- Cuts maintenance costs with real-time analysis of aircraft systems
- Reduces and simplifies training through use of easily interpreted synoptics display of major aircraft systems
- Provides redundancy that allows continued operations under most failure conditions

References/Sources

https://en.wikipedia.org/wiki/Engine-indicating_and_crew-alerting_system

https://www.rockwellcollins.com/Data/Products/Integrated_Systems/Flight_Deck/EICAS-5000_Engine_Indication_and_Crew_Alerting_System.aspx

http://craigmiddleton.co.uk/757/Biggles/www.crjresets.ca/z-Mcon/Hard2Find/B757/757_rr/warning_systems/eicas.html

http://ntl.bts.gov/data/letter_nz/tn94_18.pdf

http://www.skybrary.aero/index.php/SE136:_Engine_Event_Recovery_Training

Electronic Pilot Activity and Alertness Monitor (EPAM)

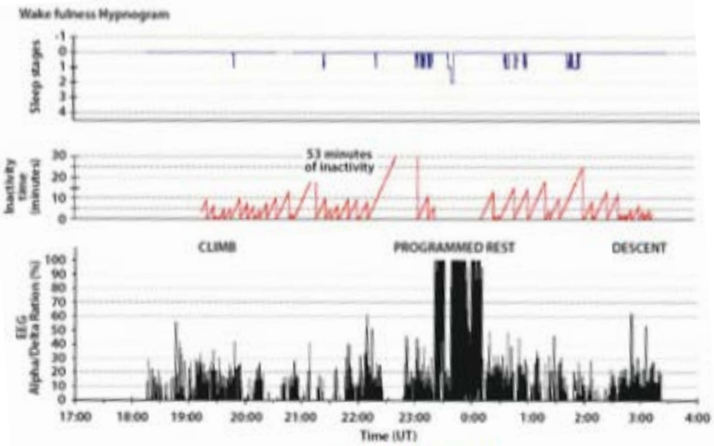


Figure 1. Microsleep occurrences and sleep (A) inactivity time (B), alpha/delta ratio (C) on Atlantic return

<u>Accident Category (Risk Area)</u>

Flight Crew Fatigue

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE199: Airplane State Awareness - Enhanced Crew Resource Management Training

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

All

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal, TRACON, Enroute & Oceanic

<u>Input Data Required</u>

Functional Description and Related Warning/Alert Times/Latencies

Previous studies have shown frequent reductions in aircrew alertness during long-haul flights, even during the critical descent phase. Recommended countermeasures include alternation of crew activity with rest, such as cockpit napping. However, a method of monitoring the alertness level of the active and napping pilots should be considered.

The Electronic Pilot-Activity Monitor (EPAM) continuously monitors the activity of the crew (activity mode) and limits nap duration (timer mode) to prevent sleep inertia effects. The EPAM is currently being validated during actual long-haul flights.

Preliminary results showing that the EPAM can detect some microsleep periods during the flight. However, some microsleeps occurred while the pilot was active. In the timer mode, the EPAM was able to limit sleep duration but some deep sleep was observed.

These results suggest that additional measures (e.g., eye closure duration) should be included to improve the detection of drowsy periods. In addition, the timer mode should be improved to prevent deep sleep in order to prevent subsequent sleep inertia.

References/Sources

http://www.ncbi.nlm.nih.gov/pubmed/12793543

See also Page 51 of HindSight Magazine:
https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Erroneous Flight Instrument Indication Avoidance

Inspection of all pitot heads and static ports during the pre-flight aircraft external inspection.
Use of pitot static heat in accordance with the aircraft's flight manual.
A comprehensive understanding of the relationship between the Air Data systems, Autopilot (AP) and Flight Director (FD) systems and individual AP/FD channels on your aircraft type.
Monitoring of primary flight path parameters (pitch attitude, thrust setting and indicated airspeed) during periods of potential icing encounters.
Awareness of the normal attitudes and power/thrust settings for the various "phases of flight"

Accident Category (Risk Area)

SYSTEM/COMPONENT FAILURE OR MALFUNCTION (NON-POWERPLANT) (SCF–NP)
SYSTEM/COMPONENT FAILURE OR MALFUNCTION (POWERPLANT) (SCF–PP)
loss of/unreliable air data
pilot detection, flagged data?
JIMDAT Undesired Aircraft State:/C: loss of/unreliable air data

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE034: Displays and Alerting Systems

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Recognizing an unusual or suspect indication:

- Keeping control of the airplane with basic pitch and power skills
- Taking inventory of reliable information
- Finding or maintaining favorable flying conditions
- Getting assistance from others

- Using checklists

Functional Description and Related Warning/Alert Times/Latencies

Regardless of the nature of erroneous flight instrument indications, some basic actions are key to survival. The longer erroneous flight instruments are allowed to cause a deviation from the intended flight path, the more difficult recovery will be. Some normal procedures are designed, in part, to detect potential problems with erroneous flight instruments to avoid airplane upsets. Examples are the 80-kn call on takeoff and callouts for bank angle exceedances. In some cases the flight crew may need to recover the airplane from an upset condition: unintentional pitch greater than 25 deg nose high or 10 deg nose low, bank angle in excess of 45 deg, or flying at airspeed inappropriate for conditions. As the condition deteriorates, it becomes more dynamic and stressful. This stress increases the difficulty flight crews experience in determining, believing, and adjusting to using the correct instruments and ignoring the faulty instruments.

The unreliable airspeed procedures supplied in the non-normal section of the QRH have been expanded significantly for the 747-400, 757, and 767 and will eventually be expanded for other current-production models. The procedures contain a reference to indications, which can be individual discrete indications or engine indication and crew alerting system (EICAS) messages that basically point out the evidence of unreliable airspeed/Mach. Other examples of this evidence are provided in the QRH, such as

- Speed or altitude information not consistent with pitch attitude and thrust setting.
- Airspeed/Mach failure flags.
- Blank or fluctuating airspeed displays.
- Variation between captain and first officer airspeed displays.
- Amber line through one or more PFD or ADI flight mode annunciations.
- Overspeed indications.
- Simultaneous overspeed and stall warnings.

References/Sources

http://www.boeing.com/commercial/aeromagazine/aero_08/erroneous_textonly.html

https://www.skybrary.aero/index.php/Unreliable_Airspeed_Indications

http://www.skybrary.aero/index.php/SE034:_Displays_and_Alerting_Systems

FLARM collision avoidance system

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

General Aviation

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON & Enroute

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

FLARM is a traffic awareness and collision avoidance technology for General Aviation, light aircraft, and UAVs. With FLARM installed, pilots are alerted of both traffic and imminent collisions with other aircraft, so they can take action before it is too late. Over 30.000 manned aircraft and many UAVs are already equipped with FLARM and the number is rapidly increasing. FLARM systems are available from several manufacturers for powered airplanes, helicopters, gliders, and UAVs.

The principle is similar to ADS-B, but the alerting logic is specially designed for gliders. Another difference is that FLARM uses frequency-hopping in an open public-use frequency band, which is unprotected. The legal restriction on the use of that band is mainly signal strength.

FLARM works by calculating and broadcasting its own future flight path to nearby aircraft. At the same time, it receives the future flight path from surrounding aircraft. An intelligent motion prediction algorithm calculates a collision risk for each aircraft based on an integrated risk model. When a collision is imminent, the pilots are alerted with the relative position of the intruder, enabling them to avoid a collision.

Each FLARM system determines its position and altitude with a sensitive GPS receiver. Based on speed, acceleration, track, turn radius, wind, altitude, vertical speed, aircraft type, and other parameters, a precise projected flight path can be calculated. The flight path, together with additional information such as a unique identification number, is encoded before being broadcast over an encrypted radio channel twice per second.

Newer FLARM devices which are based on the improved PowerFLARM technology optionally incorporate an ADS-B and transponder (SSR) Mode-C/S receiver. This enables additional aircraft to be included in the collision prediction algorithm.

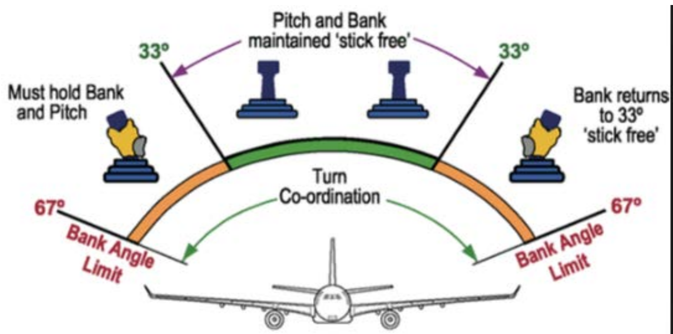
Besides issuing collision warnings, most FLARM systems also show nearby aircraft on a radar screen. This helps pilots to “see and avoid”, before a collision warning becomes necessary.

References/Sources

http://flarm.com

See also page 60 of:
https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Flight Envelope Protection System



Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
JIMDAT Undesired Aircraft States: LoC; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE040: Envelope Protection – New Designs

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

Flight envelope protection is a human machine interface extension of an aircraft's control system that prevents the pilot of an aircraft from making control commands that would force the aircraft to exceed its structural and aerodynamic operating limits. It is used in some form in all modern commercial fly-by-wire aircraft. Its advantage is that it restricts pilots in emergency situations so they can react quickly without endangering the safety of their aircraft.

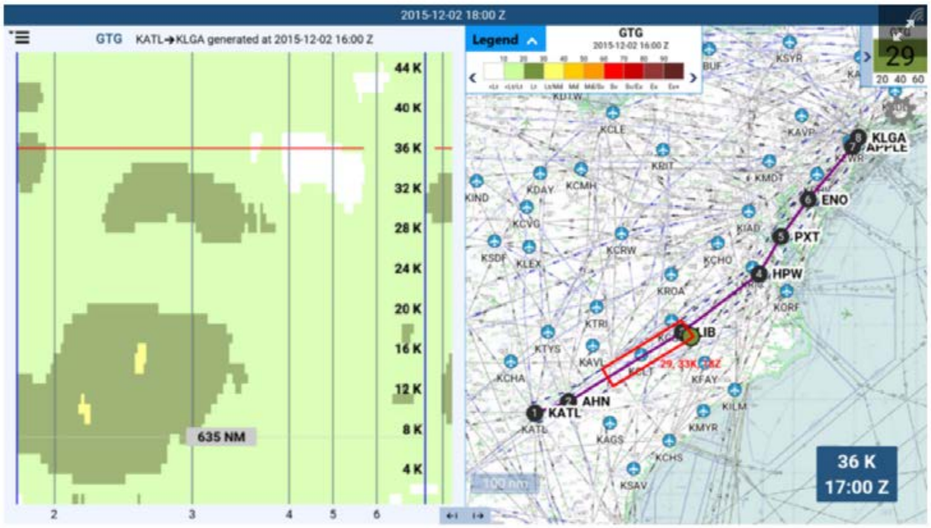
The Airbus A320 was the first commercial aircraft to incorporate full flight-envelope protection into its flight-control software. Former Airbus senior vice president for engineering Bernard Ziegler instigated this. In the Airbus, the flight envelope protection cannot be overridden completely, although the crew can fly beyond flight envelope limits by selecting an alternate "control law". Boeing in the Boeing 777 has taken a different approach by allowing the crew to override flight envelope limits using excessive force on the flight controls.

References/Sources

https://en.wikipedia.org/wiki/Flight_envelope_protection

http://www.airbusdriver.net/airbus_fltlaws.htm

Flight Weather Viewer app (Delta Airlines)



Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
TURBULENCE ENCOUNTER (TURB)
JIMDAT Undesired Aircraft States: LoC; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE078: Turbulence Procedures for Reducing Cabin Injuries

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Using sensors on more than 300 of the airline's aircraft to collect and share data over wireless internet to warn other pilots before they pass through an area where turbulence was recently reported.

Functional Description and Related Warning/Alert Times/Latencies

Delta's Flight Weather Viewer app gives pilots real-time radar readings of air flow patterns and can predict where turbulence will hit–right on the flight deck.

Pilots enter their flight plan data and the app gives them a color-coded map showing where turbulence can be expected–and can help them make more informed decisions on how to avoid it.

Delta Air Lines Inc. pilots are using an in-house app to steer clear of rough air that can unsettle or injure passengers.

Typically, a pilot only has four options: ascend, descend, slow down, or change the route.

The new technology being used to create live turbulence reports and forecasts has been patented and is recognized by the FAA and the National Center for Atmospheric Research.

References/Sources

http://www.travelandleisure.com/travel-tips/airlines-airports/delta-turbulence-app

http://www.bizjournals.com/twincities/news/2016/08/31/delta-turbulence-app-flight-weather-viewer.html

High Energy Approach Monitoring System (HEAMS)

Accident Category (Risk Area)

ABNORMAL RUNWAY CONTACT (ARC)
LOSS OF CONTROL INFLIGHT (LOC-I)
RUNWAY EXCURSION (RE)
unstabilized approach
Flaps (not set by 1000ft), speed (<Vref-5, >Vref+20), glideslope (>1 dot)
JIMDAT Undesired Aircraft State:/Rwy: Runway excursions, Abnormal runway contact, CFIT: Ground Proximity

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE207: Airplane State Awareness - Attitude and Energy State Awareness Technologies (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Aircraft altitude
Predicted specific potential energy
Aircraft speed
Comparison between aircraft position and glideslope

Functional Description and Related Warning/Alert Times/Latencies

High Energy Approach Monitoring Systems are intended to predict the specific aircraft energy state at the touchdown zone of the runway. This predicted energy is compared with predetermined threshold specific energy. An alert is generated when the predicted energy is too high or too low.

The alert by High Energy Approach Monitoring Systems may include a message that is indicative of an aircraft altitude that is higher than a predetermined glide slope when the predicted specific potential energy is at least the predetermined threshold specific potential energy. Also, the alert may include a message that is indicative of an aircraft speed that is faster than a predetermined ground speed when the predicted specific kinetic energy is at least the predetermined threshold specific kinetic energy. Further, the alert may include a message that is indicative of an aircraft altitude that is higher than the predetermined glide slope and an aircraft speed that is faster than the predetermined ground speed when the predicted specific total kinetic energy is at least the predetermined threshold specific total energy.

References/Sources

http://www.skybrary.aero/index.php/High_Energy_Approach_Monitoring_System

Lightning Detection (commercial product)

Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
WIND SHEAR OR THUNDERSTORM (WSTRW)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE039: Basic Airplane Design – Icing
SE078: Turbulence Procedures for Reducing Cabin Injuries

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

L-3's Stormscope¨ system delivers the most current and accurate lightning data in real time, not minutes past the event. No other weather tracking system is as reliable and timely for plotting convective activity and associated hazards, such as turbulence and wind shear. While other systems show you where storms were, Stormscope shows you where they are. Even if you already have datalink weather, adding a Stormscope system to your cockpit gives you the complete weather picture as it's happening.

Stormscope Weather Mapping Systems were the first airborne instruments developed specifically to detect and map thunderstorms by analyzing the radiated signals of electrical discharges from storm cells. During the cumulus stage of a thunderstorm, storm cells are usually precipitation-free, and weather radar is unable to show activity. Stormscope, by detecting the electrical activity already present as the storm builds, provides an accurate view of areas that should be avoided. Stormscope processes both azimuth and range to determine the location and intensity of dangerous thunderstorm cells – then presents the findings in real time.
Stormscope Series Key Features

- Plots lightning as it happens, before the onset of precipitation
- Displays lightning in 25, 50, 100 and 200 nmi ranges
- Pilot selectable cell and strike modes
- 360-degree view, or 120-degree forward looking
- Updates lightning information every second
- Strike Rate indicator details building or dissipating storms
- Integrates with SkyWatch Collision Avoidance Systems

References/Sources

https://www.l-3avionics.com/products/stormscope/

Pilot Activated Recovery System (PARS)

Accident Category (Risk Area)

JIMDAT Undesired Aircraft State:/Gnd Impact; Ground Proximity

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE001: Terrain Awareness Warning System (TAWS)
SE120: Terrain Awareness and Warning System (TAWS) Improved Functionality
SE184: TAWS - Minimum Vectoring Altitude Reevaluation
SE185: TAWS and RNAV Visual or Other Procedures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

General Aviation

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

Pilot-Activated Recovery System (PARS) for a modern fighter aircraft. The PARS is a guidance law that transfers the aircraft from any initial attitude to a wings level, nose-up, recovered flight condition. This system is useful in cases of pilot disorientation.

When the pilot presses a button initiating the PARS, the aircraft's computer will take command of the flight controls and roll until wings level followed by a 5-G pull-up at 4 G's/second until flying straight and level.

This PARS feature is part of the F-16's newest upgrade to avoid mishaps due to controlled flight into terrain (CFIT). The entire fleet of F-16's in the USAF received this important upgrade during the 2014 calendar year. This is incredibly EXCITING news for the fighter pilot community and hopefully will translate into hundreds of lives and billions of dollars saved. CFIT occurs for a variety of reasons and plagues aviation taking the lives of hundreds of military and general aviation pilots each year. Aside from PARS, the other application of this new capability is the Auto-GCAS (Ground Collision Avoidance System). Auto-GCAS provokes inputs to the flight controls similar to the PARS feature described above, but happens automatically without pilot initiation. The technology relies on sophisticated computer software, terrain maps, GPS and predictive algorithms that will 'take the jet' from the pilot when CFIT is predicted to be imminent.

References/Sources

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjfhLLz657PAhWE4yYKHR_6AFMQFggeMAA&url=http%3A%2F%2Fwww.dtic.mil%2Fcgi-bin%2FGetTRDoc%3FAD%3DADA436379&usg=AFQjCNFOVs9aN30RC8yghKBRC4ORH8nVJg&sig2=v-vYwS5KZs80mP-ToL4SRQ://theaviationist.com/2015/02/02/f-16-gcat-explained/

Passive Collision Avoidance Systems (PCAS) for General Aviation

<u>Accident Category (Risk Area)</u>

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

General Aviation

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Climb, Enroute & Approach

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal, TRACON & Enroute

<u>Input Data Required</u>

S Mode transponder signals

Functional Description and Related Warning/Alert Times/Latencies

Passive Collision Avoidance Systems receive (but do not interrogate) active transponders in the vicinity. They must rely on another source to interrogate the intruder's transponder which means that there must be either an SSR (Secondary Surveillance Radar) or a TCAS-equipped aircraft in the vicinity.

These systems display approximate distance (derived solely from signal strength, see photo!), relative altitude and vertical trend and may display the approximate direction of the intruder (like the one on the right side of the picture). Intruders without transponders will not be displayed at all.

References/Sources

See page 60 of: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Predictive Wind Shear (PWS) warning systems

Photo of Research Airborne Predictive Windshear display (NASA)

<u>Accident Category (Risk Area)</u>

LOSS OF CONTROL - INFLIGHT (LOC-I)
ENCOUNTER (TURB)
JIMDAT Undesired Aircraft States: ; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE078: Turbulence Procedures for Reducing Cabin Injuries
SE207: Airplane State Awareness - Attitude and Energy State Awareness Technologies (R-D)

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Climb, Enroute & Approach

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Predictive Wind Shear (PWS) warning systems utilize Doppler weather radar.

Functional Description and Related Warning/Alert Times/Latencies

Airborne wind shear detection and alert system, fitted in an aircraft, detects and alerts the pilot both visually and aurally of a wind shear condition. In case of reactive wind shear detection system, the detection takes place when the aircraft penetrates a wind shear condition of sufficient force, which can pose a hazard to the aircraft. In case of predictive wind shear detection system, the detection takes place, if such wind shear condition is ahead of the aircraft.

Predictive Wind Shear (PWS) warning systems which collect wind velocity data gathered by the weather radar to identify the existence of wind shear. These systems have a short range, and are dependent on the radar picking up velocity data from water and ice particles ahead of the aircraft and, consequently, don't work in dry conditions. However, they are effective, providing the pilot with an opportunity to abort the take-off or carry out a missed approach.

Some versions of terrain awareness warning systems also provide windshear warnings.

PWS provides typically a one-minute advance warning.

Delta's Flight Weather Viewer app gives pilots real-time radar readings of air flow patterns and can predict where turbulence will hit–right on the flight deck.

Pilots enter their flight plan data and the app gives them a color-coded map showing where turbulence can be expected–and can help them make more informed decisions on how to avoid it.

Typically, a pilot only has four options: ascend, descend, slow down, or change the route.
The new technology being used to create live turbulence reports and forecasts has been patented and is recognized by the FAA and the National Center for Atmospheric Research.

References/Sources

http://www.skybrary.aero/index.php/Airborne_Wind_Shear_Warning_Systems

https://www.quora.com/How-does-the-predictive-windshear-system-PWS-work-in-an-aircraft

https://www.ncdc.noaa.gov/data-access/radar-data/tdwr

Pilot Assistants

Accident Category (Risk Area)

Inadequate Pilot Situational Awareness

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

General Aviation

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

"Digital Copilot Designed To Improve Single-pilot Safety" - for GA

The digital copilot concept evolved from work done by the General Aviation Joint Steering Committee's Issues Analysis Team, to identify areas of concern and interest and "issues they wanted addressed," according to Pollack. Industry research also found that accident rates for single pilots flying turbine aircraft are significantly higher than in dual-pilot aircraft. "That helped spur the direction we were headed," Helleberg said.

The digital copilot research focused on the pilot's workload when flying alone, such as weather and traffic awareness and searching for information, all while maintaining control and communicating with controllers.

The idea behind the digital copilot is to create foundational technology that runs on a mobile device, which is easy to bring into any aircraft, rather than software or hardware that must be permanently installed. As a federally funded research and development nonprofit corporation, Mitre doesn't create the end product but develops the concept into something that can be demonstrated, then offers it to industry. An example of this is the Idea lab's work on mobile-device-based software to help prevent runway incursions. App developer ForeFlight used those concepts in its Runway Proximity Advisor, which warns pilots audibly and visually when they are approaching a runway while taxiing and when they enter a runway.

References/Sources

http://www.ainonline.com/aviation-news/business-aviation/2016-09-14/digital-copilot-designed-improve-single-pilot-safety

Radio Altimeter Callouts (optional on Boeing aircraft)

Accident Category (Risk Area)

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)
JIMDAT Undesired Aircraft State:/Gnd Impact; Ground Proximity; unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

radar altimeter

Functional Description and Related Warning/Alert Times/Latencies

Calls can include any of the following: 2500 ("Twenty Five Hundred" or "Radio Altimeter"), 1000, 500, 400, 300, 200, 100, 50, 40, 30, 20, 10 FEET AGL

"Minimums" or "Minimums, Minimums"
"Plus Hundred" when 100 ft above Decision Height (DH)
"Approaching Minimums" when 80 ft above DH
"Approaching Decision Height"
"Decision Height"

Customers can also request special heights, such as 60 ft.

Boeing 777 Flight Management System: ALTERNATE NAVIGATION

If both FMCs fail, initializing alternate navigation does not require any pilot action.

It occurs automatically 2.0 seconds after the last FMC fails. Alternate navigation initializes using the last flight plan and last set of navigation radio frequencies downloaded from the FMC prior to FMC failure.

Alternate lateral guidance is not enabled for an additional 3.0 seconds after alternate navigation initializes. Alternate navigation radio tuning is available as soon as alternate navigation initializes.

References/Sources

taken from Honeywell manual for the B777 FMS system.

Receiver Autonomous Integrity Monitoring (RAIM)

Accident Category (Risk Area)

Various

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE006: Precision-Like Approaches - Area Navigation (RNAV) 3D
SE007: Precision-Like Approaches - Area Navigation (RNAV) Required Navigation Performance (RNP)
SE008: Precision-Like Approaches - Landing Systems (ILS, MLS, GLS)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)
:
Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)
:
All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)
:
All

Input Data Required

aircraft sensors

Functional Description and Related Warning/Alert Times/Latencies

Receiver autonomous integrity monitoring (RAIM) is a technology developed to assess the integrity of global positioning system (GPS) signals in a GPS receiver system. It is of special importance in safety-critical GPS applications, such as in aviation or marine navigation. In application, (RAIM) is considered available worldwide, if 24 GPS satellites or more are operative. If the number of GPS satellites is 23 or less, RAIM availability must be checked using approved ground-based prediction software. RAIM detects faults with redundant GPS pseudo-range measurements. That is, when more satellites are available than needed to produce a position fix, the extra pseudo-ranges should all be consistent with the computed position. A pseudo-range that differs significantly from the expected value (i.e., an outlier) may indicate a fault of the associated satellite or another signal integrity problem (e.g., ionospheric dispersion). Traditional RAIM uses fault detection (FD) only, however newer GPS receivers incorporate fault detection and exclusion (FDE) which enables them to continue to operate in the presence of a GPS failure.

The test statistic used is a function of the pseudo-range measurement residual (the difference between the expected measurement and the observed measurement) and the amount of redundancy. The test statistic is compared with a threshold value, which is determined based on the requirement probability of false alarm (Pfa).

Receiver autonomous integrity monitoring (RAIM) provides integrity monitoring of GPS for aviation applications. In order for a GPS receiver to perform RAIM or fault detection (FD) function, a minimum of five visible satellites with satisfactory geometry must be visible to it. RAIM has various kind of implementations; one of them performs consistency checks between all position solutions obtained with various subsets of the visible satellites. The receiver provides an alert to the pilot if the consistency checks fail.

RAIM availability is an important issue when using such kind of algorithm in safety-critical applications (as the aeronautical ones); in fact, because of geometry and satellite service maintenance, RAIM is not always available at all, meaning that the receiver's antenna could have sometimes fewer than five satellites in view.

Availability is also a performance indicator of the RAIM algorithm. Availability is a function of the geometry of the constellation which is in view and of other environmental conditions. If availability is seen in this way it is clear that it is not an on–off feature meaning that the algorithm could be available but not with the required performance of detecting a failure when it happens. So availability is a performance factor of the algorithm and characterizes each one of the different kinds of RAIM algorithms and methodologies.

References/Sources

https://en.wikipedia.org/wiki/Receiver_autonomous_integrity_monitoring

Runway Overrun Protection Systems (ROPS)

Typical message on Primary Flight Display

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)
UNDERSHOOT/OVERSHOOT (USOS)
off runway (>50kt. @1000ft remaining?)
JIMDAT Undesired Aircraft States: Apt/Rwy: Runway excursions

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE215: Runway Excursion - Landing Distance Assessment
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE220: Runway Excursion - Runway Distance Remaining Signs

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

The system has access to the parameters which affect an aircraft's stop distance, such as:

- Aircraft position
- Aircraft & engine type
- Aircraft weight
- Ground speed
- Outside air temperature
- Slat/Flap configuration
- True and calibrated airspeed
- Wind
- CG

Functional Description and Related Warning/Alert Times/Latencies

Runway Overrun Protection Systems (ROPS) which provide the pilots with a real-time constantly updated picture in the navigation display of where the aircraft will stop on the runway in wet or dry conditions.

ROPS is made up of two sub-functions, ROW and ROP. The ROW function generates alerts which incite the flight crew to perform a Go-Around whereas the ROP function generates alerts which incite the flight crew to apply available deceleration means.
ROW = Runway Overrun Warning ROP = Runway Overrun Protection

ROPS is an Airbus system designed to continuously calculate whether the aircraft can safely stop in the runway length remaining ahead of the aircraft. If at any point the system detects there is a risk of a runway overrun, flight deck alerts are generated to help the crew in their decision making. ROPS is hosted in the aircraft avionics.

On the Airbus A380 and A350, ROPS is integrated with the aircraft flight management and navigation systems and provides pilots with a real-time, constantly updated picture on the navigation display of where the aircraft will stop on the runway in WET or DRY conditions (or pilot selected runway condition for A350).

References/Sources

https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22-rops-active-safety-net.pdf

Reactive Windshear Systems (RWS)

Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
ENCOUNTER (TURB)
JIMDAT Undesired Aircraft States: LoC; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE078: Turbulence Procedures for Reducing Cabin Injuries
SE207: Airplane State Awareness - Attitude and Energy State Awareness Technologies (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Reactive Windshear Systems (RWS) generate alerts based on a comparison between Inertial Reference Unit (IRU) outputs and aerodyanmic data from the aircraft sensor systems.

Functional Description and Related Warning/Alert Times/Latencies

Airborne wind shear detection and alert system, fitted in an aircraft, detects and alerts the pilot both visually and aurally of a wind shear condition. In case of reactive wind shear detection system, the detection takes place when the aircraft penetrates a wind shear condition of sufficient force, which can pose a hazard to the aircraft. In case of predictive wind shear detection system, the detection takes place, if such wind shear condition is ahead of the aircraft.

Predictive Wind Shear (PWS) warning systems which collect wind velocity data gathered by the weather radar to identify the existence of wind shear. These systems have a short range, and are dependent on the radar picking up velocity data from water and ice particles ahead of the aircraft and, consequently, don't work in dry conditions. However, they are effective, providing the pilot with an opportunity to abort the take-off or carry out a missed approach.

Some versions of terrain awareness warning systems also provide windshear warnings.

PWS provides typically a one-minute advance warning.

The Predictive Windshear (PWS) function: (Surveillance system. i.e. WXR) detects windshear:
At least 10 s before a possible encounter
Between 0.5 nm and 5 nm in front of the aircraft
Trigger alerts.
The PWS function can detect and display up to 8 different windshears simultaneously.
The PWS function is available, if the PRED W/S button is set to AUTO, and:
If the WXR is operative, or at takeoff, if the WXR is OFF
In flight, if the aircraft is below 1,500 ft. AGL.

REACTIVE WINDSHEAR DETECTION
A windshear alert triggers, when the aircraft encounters wind gradients during takeoff and landing, which could reduce the margin towards stall.
The windshear alert consists of:
A red windshear message displayed on both PFD.
It flashes during 9 s, then remains steady, as long as the windshear is detected.
An aural WINDSHEAR alert: "Windshear!"
The reactive windshear detection is performed by the primary flight control computers (PRIMs)

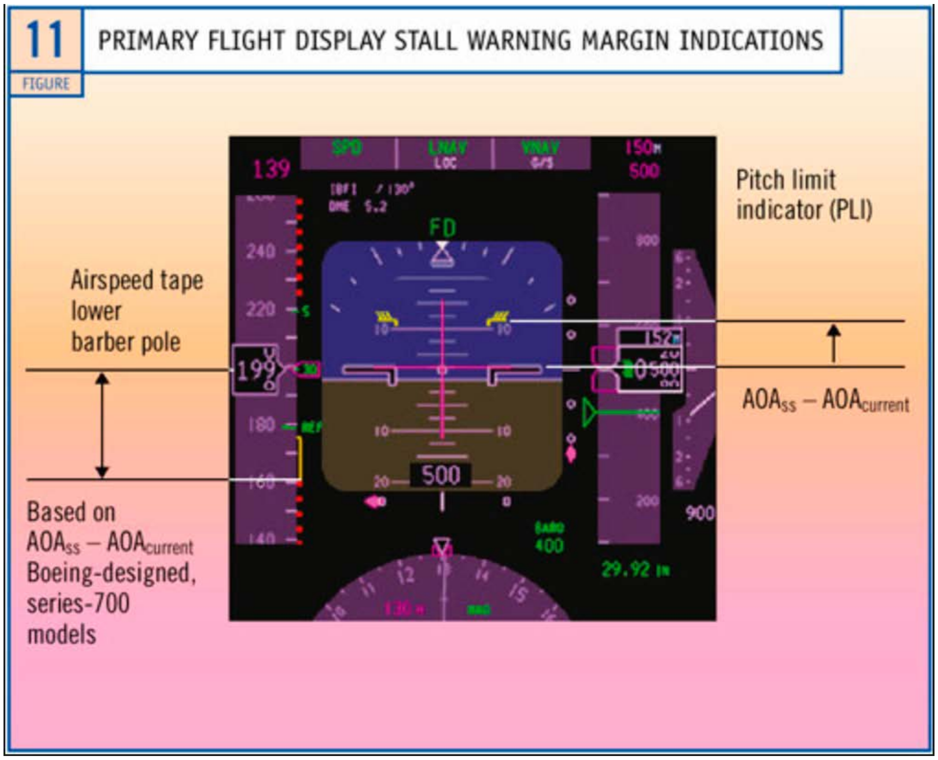
References/Sources

http://www.skybrary.aero/index.php/Airborne_Wind_Shear_Warning_Systems

https://www.ncdc.noaa.gov/data-access/radar-data/tdwr

http://www.pprune.org/tech-log/399223-predictive-reactive-windshear-airbus.html

Stall Warning System



Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
JIMDAT Undesired Aircraft States: LoC; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE085: Vertical Situation Displays
SE192: Airplane State Awareness - Low Airspeed Alerting
SE207: Airplane State Awareness - Attitude and Energy State Awareness Technologies (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Stall warning systems often involve inputs from a broad range of sensors and systems and include a dedicated angle of attack sensor. Static pressure measurement is accomplished using an array of fluch-mounted ports located as far as possible ahead of the wing and other components that could affect the measurement and calibration.

Stall warning vanes electronic processing units & cockpit display

Functional Description and Related Warning/Alert Times/Latencies

Stall Warning System provides the flight crew with advance warning of an impending stall. The stall warning system requirements can be satisfied by the inherent stall characteristics of the aircraft itself or by other appropriate means. Stall warning systems are designed to activate based on the stall characteristics of clean, contamination free surfaces. Airframe contamination can occur both on the ground and during flight. Contamination present whilst still on the ground must be removed by a ground deicing process prior to flight. Should icing conditions be encountered during flight, Ice Protection Systems should be activated. An ice-affected wing will almost certainly stall at a lower angle of attack. Stall warning margins are almost always significantly reduced and the pilot will frequently receive no notice of the impending stall.

Categories:

- Pre-Stall Buffet. In this case, the warning of the impending stall is provided solely by aerodynamic buffet. As the aircraft approaches the stall, the airflow across the upper cambered surface of the wing ceases to flow smoothly, it loses contact with the wing surface and it becomes turbulent. If the turbulent air then flows across the horizontal stabiliser, buffet results. In many aircraft, even some as large as the LOCKHEED AC-130 Spectre, this buffet provides the sole warning of the impending stall.
- Audible Warning. Stall warning is provided by an electronic or mechanical device that sounds an audible warning as the stall speed is approached. The simplest such device is an airframe mounted stall warning horn which sounds when the airflow through it occurs at a specific angle. Slightly more sophisticated audible warning devices consist of either a pressure sensor or a moveable metal tab that actuates a switch as the stall is approached. The switch, in turn, activates an audible warning horn. In some installations, the audible warning is provided by a synthetic voice which helps to reduce warning ambiguity.
- Stick Shaker. A stick shaker is a mechanical device that shakes the control column to warn of the onset of stall. A stick pusher may be installed in association with a stick shaker system in aircraft which are susceptible to the deep stall phenomenon. A deep stall affects certain aircraft designs, most notably those with a T-tail configuration, and results in a substantial reduction or, in some cases, complete loss of elevator authority making normal stall recovery actions ineffective; in many cases, a deep stall might be unrecoverable. The stick pusher is designed to prevent the pilot from allowing the aircraft to enter a stall. In all cases, the stick shaker will activate before the stick pusher.
- Angle of Attack. Stall warning systems often involve inputs from a broad range of sensors and systems and include a dedicated angle of attack sensor. At a predetermined angle of attack, calculated for each possible configuration, the angle of attack sensor triggers the activation of the stick shaker or the audible warning device as appropriate to the aircraft fitment. An angle of attack indicator may or may not be incorporated into the pilot's instrument panel. When installed, the indicator will give a visual indication of the aircraft proximity to the critical angle of attack.

References/Sources

http://www.skybrary.aero/index.php/Stall_Warning_Systems

Synthetic Vision Systems (SVS)

SYNTHETIC VISION OFF SYNTHETIC VISION ON

Accident Category (Risk Area)

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE113: Synthetic Vision Systems (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

The systems combine a high-resolution display with databases of terrain and obstacle data, aeronautical information, data feeds from other aircraft and vehicles, and GPS technology to show pilots exactly where they are and how the aircraft is orientated.

Functional Description and Related Warning/Alert Times/Latencies

Synthetic Vision Systems (SVS) fuse three-dimensional data into intuitive displays that provide unprecedented situational awareness to flight crews.

As technology and data feeds develop, the picture presented may include terrain, weather, the approach path, runway and aerodrome maneuvering areas, and other traffic. SVS display a model of the real world, presenting information to the flight crew in a way that is easy to understand and rapidly assimilated.

The safety challenge for SVS lies in the sophistication and visual clarity of the displayed data. If elements of the data, especially positional data, are incorrect, the picture displayed will not conform to the reality of the situation.

References/Sources

http://www.skybrary.aero/bookshelf/books/3487.pdf

http://www.skybrary.aero/index.php/Synthetic_Vision_Systems

Takeoff Configuration Alerting

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)
high speed Rejected Take Off (RTO)
>100 KIAS (V1?)
JIMDAT Undesired Aircraft State

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE217: Runway Excursion - Takeoff Procedures and Training
SE227: Takeoff Misconfiguration - Air Carrier Procedures for Takeoff Configuration
SE228: Takeoff Misconfiguration - Airplane Design Features to Facilitate Proper Takeoff Configuration
SE229: Takeoff Misconfiguration - Takeoff Configuration Warning System Maintenance and Operational Assurance

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

aircraft and flightdeck sensor systems

Functional Description and Related Warning/Alert Times/Latencies

A take-off warning system or TOWS is a set of warning signals required on most commercial aircraft, designed to alert the pilots of possibly dangerous errors in an aircraft's take-off configuration.

There are numerous systems on board an aircraft that must be set in the proper configuration to allow it to take-off safely. Prior to every flight, the flight officer[s] use a checklist to verify that each of the many systems is operating, and has been configured correctly. However, due to the inevitability of human error, even the checklist procedure can lead to failures to properly configure the aircraft.

Several improper configurations can leave an aircraft completely unable to become airborne– these conditions can easily result in fatal hull loss accidents. In order to reduce this, all major nations now mandate something similar to the US requirement that on (nearly) "all airplanes with a maximum weight more than 6,000 pounds and all jets ... a takeoff warning system must be installed". This system must meet the following requirements:

(a) The system must provide to the pilots an aural warning that is automatically activated during the initial portion of the takeoff roll if the airplane is in a configuration that would not allow a safe takeoff. The warning must continue until–

(1) The configuration is changed to allow safe takeoff, or (2) Action is taken by the pilot to abandon the takeoff roll.

(b) The means used to activate the system must function properly for all authorized takeoff power settings and procedures and throughout the ranges of takeoff weights, altitudes, and temperatures for which certification is requested.[1]
is designed to sound a warning for numerous other dangerous errors in the take-off configuration, such as the flaps and slats not being extended when the throttles are opened while the aircraft is on the ground. The alert is typically in the form of an audible warning horn accompanied by a voice message that indicates the nature of the configuration error.

References/Sources

https://en.wikipedia.org/wiki/Take-off_warning_system

TAWS/GPWS/EGPWS

<u>Accident Category (Risk Area)</u>

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)
ground proximity
TAWS 2.18 threshold
JIMDAT Undesired Aircraft State

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE001: Terrain Awareness Warning System (TAWS)
SE120: Terrain Awareness and Warning System (TAWS) Improved Functionality
SE184: TAWS - Minimum Vectoring Altitude Reevaluation
SE185: TAWS and RNAV Visual or Other Procedures

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Climb, Enroute & Approach

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal, TRACON, Enroute & Oceanic

Input Data Required

EGPWS computer continuously computes clearance envelopes looking down and ahead of the aircraft. Using the terrain database based on the known airplane position derived from either IRS or GPS with the combination of the sensor data inputs from barometric altitude, present track, vertical path, and ground speed, an estimated time to impact can be calculated.

Functional Description and Related Warning/Alert Times/Latencies

The system uses various aircraft inputs and an internal database to predict and warn flight crews of potential conflicts with obstacles or terrain.

In a typical crash, the GPWS sounds for less than 10 seconds prior to impact, while average pilot reaction time to the warning is about 5.5 seconds.

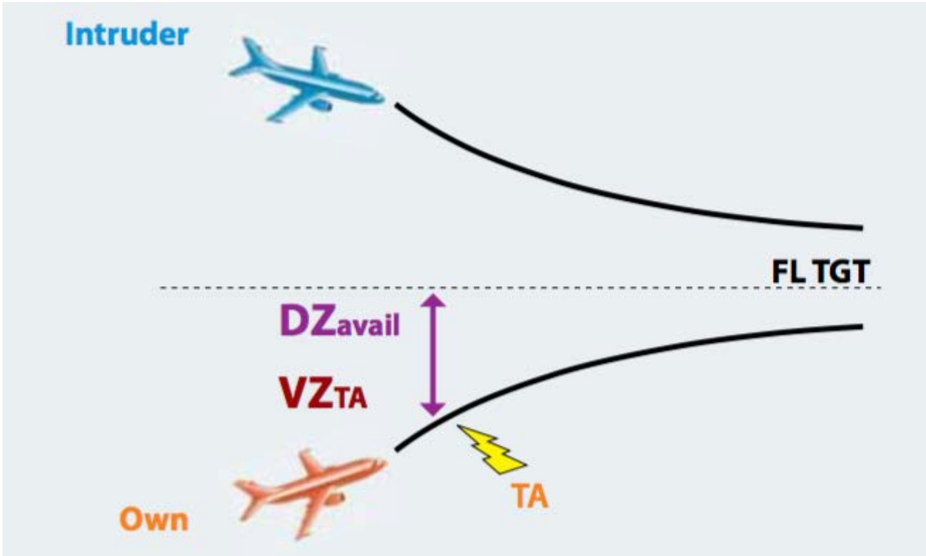
Reaction times to "PULL UP" alerts are generally less than 2 seconds.

Typical terrain depiction on Navigation Display:

References/Sources

https://www.aopa.org/news-and-media/all-news/1997/october/01/gpws-meet-gps://oatao.univ-toulouse.fr/11618/1/causse_11618.pdf

TCAS Alert Prevention (TCAP)



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Upon TCAP activation at TA:
If the aircraft is initially in a vertical guidance mode other than the altitude capture mode (for example in a climb or a descent mode), the vertical mode automatically reverts to the altitude

capture mode (ALT* for Airbus HMI) with the new TCAP altitude control law active (ALT*TCAP control law).

If the vertical mode is initially the altitude capture mode (ALT* with the conventional altitude capture control law active), the vertical mode remains the altitude capture mode but with the new ALT*TCAP control law active. The flight mode annunciator, ‘ALT*’ remains displayed.

Functional Description and Related Warning/Alert Times/Latencies

Airbus has launched the feasibility study of a new system called 'TCAS Alert Prevention' or 'TCAP'.
The objectives of this new 'TCAP' feature are twofold:

1. To reduce the number of undesired TCAS RAs occurring during 1000ft level-off encounters by introducing a new altitude capture law which soften aircraft arrival to an intended altitude when traffic is confirmed in the nearby vicinity.
2. Not to unduly degrade the aircraft performance, in particular in descent, by a premature and excessive reduction of the vertical speed before reaching the altitude target, when it is not justified.

TCAP activation logic is based on the Traffic Advisory (TA) triggered by TCAS system, which clearly confirms the presence of traffic in the aircraft vicinity. This triggering condition is associated to a set of necessary pre-conditions including:

- The Auto Pilot and/or the Flight Di- rector must be engaged,
- The aircraft is converging towards its selected altitude,
- The distance to the selected altitude at the time of the TA is lower than what we called the 'TCAP availability threshold' DZavail (see figure.

The concept of a 'TCAP availability threshold' has been introduced in order to limit TCAP activation to the only TAs corresponding to our targeted encounter geometries, i.e. to the 1000ft level-off encounters. To avoid any TCAP activation upon a TA occurring in other circumstances (e.g. far from selected altitude), TCAP availability threshold DZavail has been defined as the upper distance from the selected altitude where a TA can occur with an intruder capturing the same altitude in the opposite sense (with a 'conventional' altitude capture control law). This DZavail value depends both on the aircraft vertical speed at the time of the TA and on its altitude. What is the difference between TCAS and ACAS?

- TCAS (Traffic Alert and Collision Avoidance System) is a specific implementation of the ACAS (Airborne Collision Avoidance System) concept. TCAS II version 7.0 and 7.1 are currently the only available equipment that is fully compliant with the ACAS II Standards and Recommended Practices (SARPs).
- ACAS II provides "Resolution Advisories" (RA's) in the vertical sense (direction) telling the pilot how to regulate or adjust his vertical speed so as to avoid a collision.
- TCAS II Minimum Operational Performance Specification (MOPS) have been published by RTCA (DO-185B) and EUROCAE (ED-143).
- Mode S EHS DAP enables TCAS Resolution Advisories (RAs) to be downlinked and displayed to ATC.

References/Sources

http://www.skybrary.aero/bookshelf/books/1417.pdf

Traffic Collision Avoidance System (TCAS & TCAS II)

See Airborne Collision Avoidance System (ACAS & ACAS X below)

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE165: TCAS Policies and Procedures
SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems):

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

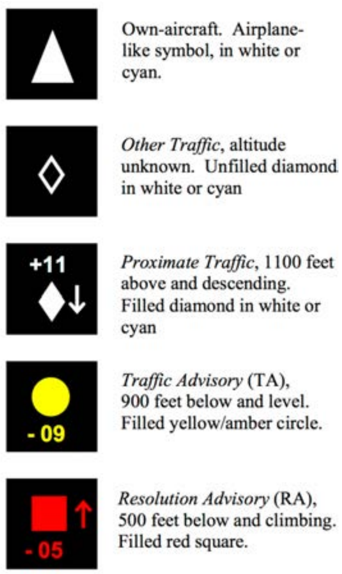
Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

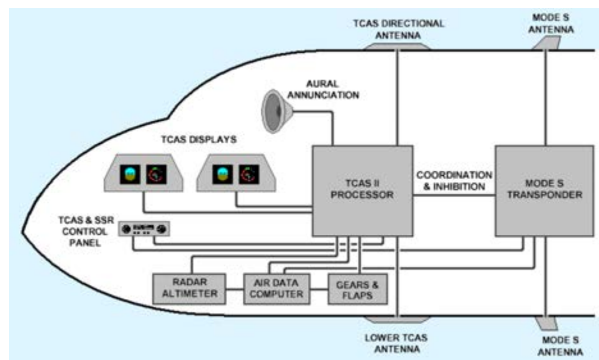
Terminal, TRACON, Enroute & Oceanic

Input Data Required

The TCAS (Traffic Collision Avoidance System) computer receives information:

1. about the pressure altitude through the mode S transponder
2. from the radio-altimeter
3. specific to the airplane configuration
4. from the inertial reference units





Functional Description and Related Warning/Alert Times/Latencies

TCAS protects a small and variable volume of airspace around the aircraft.
This is known as the collision area (an area where a collision is possible).
The threat is determined in terms of time to enter the collision area.
TCAS envelopes vary among equipment manufacturers.

Typical g values for a "CLIMB CLIMB" or DESCEND DESCEND" are 0.25g, aiming for a 1500 ft/min rate of climb or descent. an enhanced RA, "INCREASE CLIMB" or "INCREASE DESCENT" the typical g values are 0.35g, aiming for a 2500 ft/min rate of climb or descent **to be achieved in 2.5 seconds.**

The Airborne Collision Avoidance System (ACAS) is an airborne safety net and an ICAO standard which provides pilots with a system independent of air traffic control to detect the presence of other aircraft which may present a threat of collision. Where the risk of collision is established, the system provides an indication of a vertical maneuver that will reduce the risk of collision. It is often used by the flight crew to improve their situational awareness. (See also: Incorrect Use of TCAS Traffic Display). It serves as a last-resort safety net irrespective of any separation standards.

Because the TAs/RAs are not transmitted to the ground, there is no indication to the controller display in the event of an RA or TA. ATC displays will show a CA (conflict alert) but that is based on computer projections of the flight paths, climb and descent rates, and speeds of the two aircraft involved. It's not based on any information shared in real time between the two aircraft.

TCAS II is required for most airline flights. This is not a requirement for certification, and the TCAS may or may not be on the MEL. However, most flights under part 121 (scheduled airline service, as well as some freight) require TCAS II.

For TCAS:
Aircraft that are assessed as being likely to enter the collision area in between 35 to 48 seconds result in a Traffic Advisory (TA). TA is an audio caution of "TRAFFIC TRAFFIC".
If the time to enter the collision area reduces to 15 to 35 seconds the system will generate a Resolution Advisory (RA). RA is an audio command to Climb or Descend for avoiding the collision.

The pilot reaction time expected by the TCAS II logic is 5 seconds, with the pilot achieving the pull up/push over in three seconds. Pitch change requirements depend on speed. Any subsequent reversal RA must be accomplished within 2.5 seconds.

References/Sources

http://www.theairlinepilots.com/forum/viewtopic.php?t=925&sid=ce62adaadcf26777e950eb530bf3393e

From: https://www.eurocontrol.int/faq/what-difference-between-tcas-and-acas

Taxi Navigation and Situation Awareness (T-NASA; under development)

Credit: Honeywell

Accident Category (Risk Area)

RUNWAY INCURSION (RE)
GROUND COLLISION (GC)
JIMDAT Undesired Aircraft States: /Rwy: Loss of separation

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE181: Taxi and Runway Configuration

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

Integration of:
- Electronic surface (runways/taxiways) map in the research flight deck to provide the pilot with surface information (cleared taxi routes, hold bars, safety warnings, ownship and proximity traffic);
- Differential Global Positioning System (GPS) to accurately position the aircraft on the taxi map;
- ASDE-3 RADAR, and Westinghouse Norden Airport Movement Safety System (AMASS) to provide other traffic and safety warnings;
- ASDE-3 activated transponder-based system for positive vehicle identification on the ground controller's display;
- High speed data link for taxi clearance, proximity, and AMASS warnings.

Functional Description and Related Warning/Alert Times/Latencies

The Taxiway Navigation and Situation Awareness (T-NASA) system is a suite of cockpit displays that provides navigation and situational awareness information to pilots in order to increase the safety and efficiency of airport surface operations. T-NASA consists of three components:
- Taxi Head-Up Display (HUD)
- Electronic Moving Map (EMM)
- 3-D Audio Alerts and Warnings

Three prominent features:
Electronic moving map display
head-up display that projects symbology, correlated with a virtual out-the-window scene
Three-dimensional audio ground collision and warning system that provides auditory warnings that include indication of the direction of approaching aircraft.

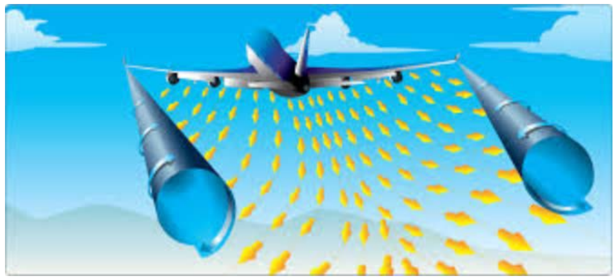
References/Sources

http://human-factors.arc.nasa.gov/groups/HCSL/research/tnasa.php

http://human-factors.arc.nasa.gov/ihi/tnasa/pubs/Foyle_SAE_96_T-NASA.pdf

http://www.skybrary.aero/index.php/SE181:_Taxi_and_Runway_Configuration

Wind Shear / Wake Vortex Detection



Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
ENCOUNTER (TURB)
JIMDAT Undesired Aircraft States: LoC; compromises aircraft controllability, stall warning, unusual attitude, misconfigured A/C, unstabilized approach

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE207: Airplane State Awareness - Attitude and Energy State Awareness Technologies (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Wind Shear / Wake Vortex Detection is accomplished via an ultra-violet band pulse Doppler LIDAR system.

Functional Description and Related Warning/Alert Times/Latencies

Airborne wind shear detection and alert system, fitted in an aircraft, detects and alerts the pilot both visually and aurally of a wind shear condition. In case of reactive wind shear detection system, the detection takes place when the aircraft penetrates a wind shear condition of sufficient force, which can pose a hazard to the aircraft. In case of predictive wind shear detection system, the detection takes place, if such wind shear condition is ahead of the aircraft.

Predictive Wind Shear (PWS) warning systems which collect wind velocity data gathered by the weather radar to identify the existence of wind shear. These systems have a short range, and are dependent on the radar picking up velocity data from water and ice particles ahead of the aircraft and, consequently, don't work in dry conditions. However, they are effective, providing the pilot with an opportunity to abort the take-off or carry out a missed approach.

Some versions of terrain awareness warning systems also provide windshear warnings.

PWS provides typically a one-minute advance warning.

Delta's Flight Weather Viewer app gives pilots real-time radar readings of air flow patterns and can predict where turbulence will hit–right on the flight deck.

Pilots enter their flight plan data and the app gives them a color-coded map showing where turbulence can be expected–and can help them make more informed decisions on how to avoid it.

Typically, a pilot only has four options: ascend, descend, slow down, or change the route.
The new technology being used to create live turbulence reports and forecasts has been patented and is recognized by the FAA and the National Center for Atmospheric Research.

References/Sources

http://www.skybrary.aero/index.php/Airborne_Wind_Shear_Warning_Systems

https://www.ncdc.noaa.gov/data-access/radar-data/tdwr

Hybrid Safety Nets (providing inputs to both flight crew and ATC)

Controller Pilot Data Link Communications (CPDLC)

Accident Category (Risk Area)

Frequency congestion for voice communications; increased chances that one pilot will accidentally override - 'step on' – another

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport, Terminal, TRACON, Enroute & Oceanic

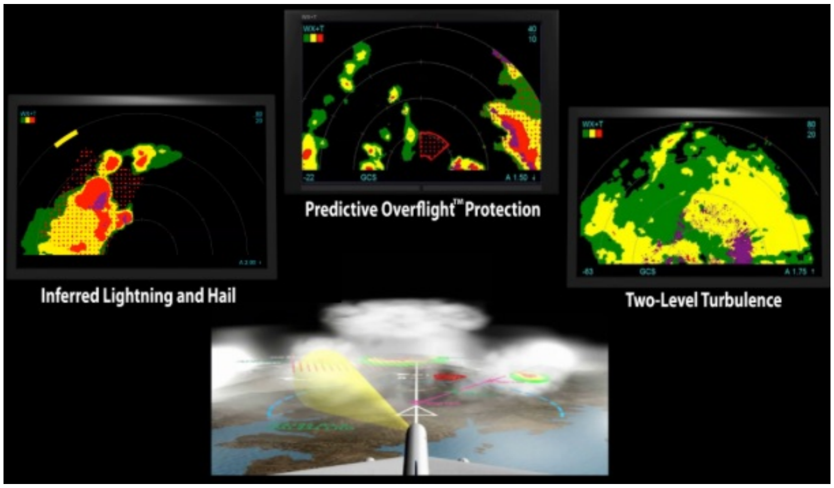
Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwiVio6ek7HTAhUK62MKHeclAj8QFgg2MAE&url=http%3A%2F%2Fwww.skybrary.aero%2Findex.php%2FIntroduction_to_CPDLC_Operations&usg=AFQjCNF--69ttgmBKGDciqYxlvvAzra2BA&sig2=q8q4CID0vQrzZWF6xylkFg

MultiScan ThreatTrack radar



Accident Category (Risk Area)

Weather-related hazards: windshear, turbulence, thunderstorms, etc.

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135?

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute, Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

airborne radar systems

Functional Description and Related Warning/Alert Times/Latencies

MultiScan ThreatTrack weather radar is the first fully certified airborne weather radar with the following capabilities for new Next-Generation Boeing 737s:

Patented Track-While-Scan Technology prioritizes weather threats out to 320 nm by performing dedicated horizontal and vertical scans on developed or fast-growing convective cells that pose an actual threat.

Core Threat Assessment examines thunderstorm cells and increases the displayed colors to better represent the actual thunderstorm threat.

Associated Threat Assessment infers lightning, hail and convective threat potential within and external to a thunderstorm core.

Predictive OverFlight[a] Protection tracks thunderstorm cells ahead and below the aircraft, measures growth rate, predicts bow-wave turbulence and indicates potential threats in aircraft's flight path.

Two-level Enhanced Turbulence Detection detects severe and ride-quality turbulence up to 40 nm ahead of the aircraft.

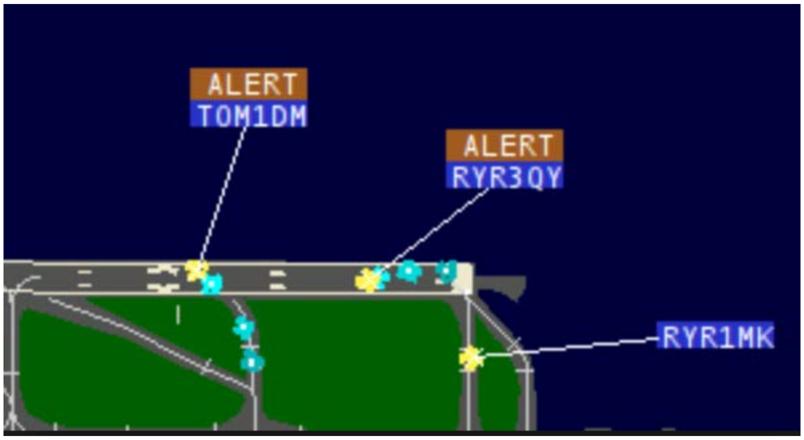
Predictive Windshear Detection with windshear event data recording and retrieval.

Geographic Weather Correlation utilizes a database of geographic and seasonal weather variations that enhance MultiScan ThreatTrack's algorithms to provide accurate worldwide hazard information.

References/Sources

https://www.rockwellcollins.com/Data/News/2014_Cal_Year/CS/FY14CSNR22-ThreatTrack.aspx

Runway Incursion Monitoring and Collision Avoidance Sub-system (RIMCAS)



Accident Category (Risk Area)

GROUND COLLISION (GCOL)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE046: Air Traffic Control Runway Incursion Training
SE060: Pilot Training for Runway Incursion Prevention
SE176: Runway Safety Action Team Evaluations
SE179: Wrong Runway Departures - Scenario-Based Training for Pilots
SE180: Wrong Runway Departures - Scenario-Based Training for Tower Controllers
SE181: Taxi and Runway Configuration
SE182: Wrong Runway Departures - ATC-Clearance Procedure Review
SE183: Wrong Runway Departures - Cockpit Moving Map Display and Runway Awareness System

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

surveillance radar subsystem

Functional Description and Related Warning/Alert Times/Latencies

Surface movement radar system frequently incorporate a Runway Incursion Monitoring and Collision Avoidance Sub-system (RIMCAS). The purpose of RIMCAS is primarily to provide warnings of potential collisions between vehicles and aircraft. It may not be suited to resolving a conflict between two aircraft at high speed.

When an aircraft approaches an arrival runway for landing, a small popup will appear:

The numbers on the left represent the numbers of seconds until the aircraft touches down. If an aircraft is on the runway, and an arrival is 30 seconds or less from landing, the aircraft will be highlighted in the list.

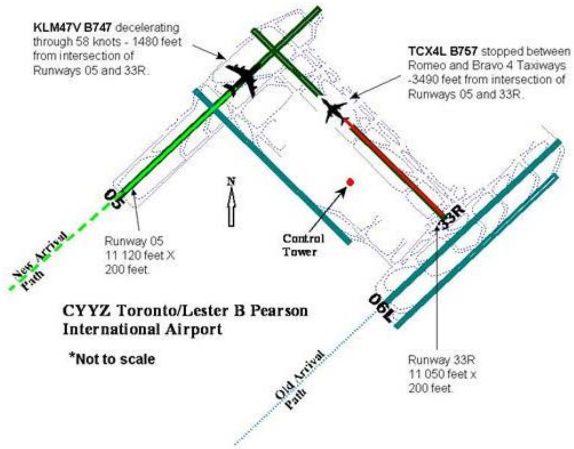
Timely response is critical. A typical short-haul jet takes little more than 30 seconds to get airborne.

References/Sources

http://www.skybrary.aero/index.php/A320/A320,_Zurich_Switzerland,_2011

https://github.com/pierr3/vSMR/wiki/RIMCAS

Runway Occupancy Warning System (ROWSTM)



<u>Accident Category (Risk Area)</u>

RUNWAY EXCURSION (RE)
RUNWAY INCURSION (RI)
runway incursion
crew detection
JIMDAT Undesired Aircraft State

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE046: Air Traffic Control Runway Incursion Training
SE060: Pilot Training for Runway Incursion Prevention
SE176: Runway Safety Action Team Evaluations
SE179: Wrong Runway Departures - Scenario-Based Training for Pilots
SE180: Wrong Runway Departures - Scenario-Based Training for Tower Controllers
SE181: Taxi and Runway Configuration
SE182: Wrong Runway Departures - ATC-Clearance Procedure Review
SE183: Wrong Runway Departures - Cockpit Moving Map Display and Runway Awareness System

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Surface Operations

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Airport

Input Data Required

It is a camera based technology sometimes bundled with the ROWSTM Surveillance system

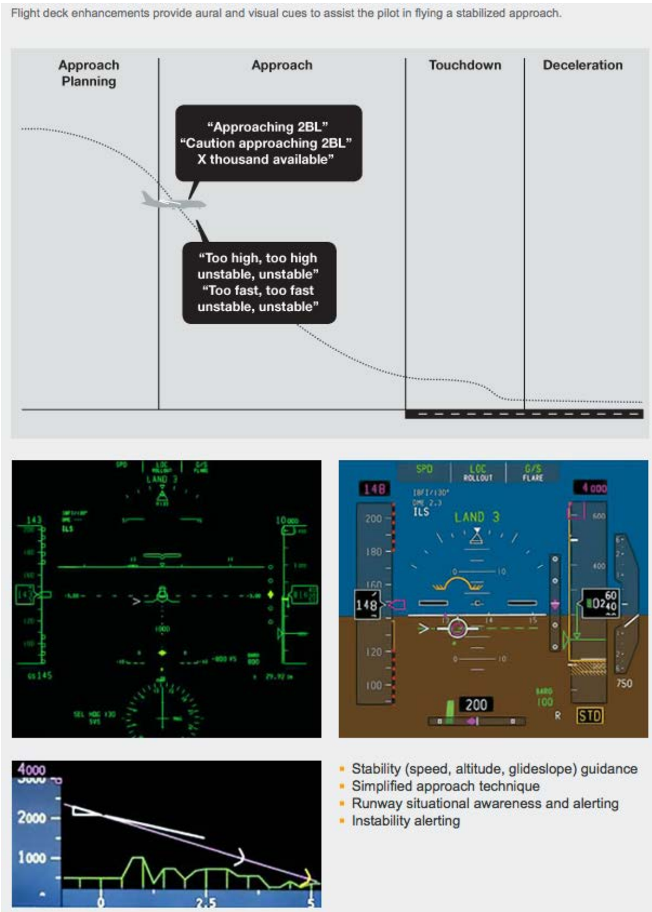
Functional Description and Related Warning/Alert Times/Latencies

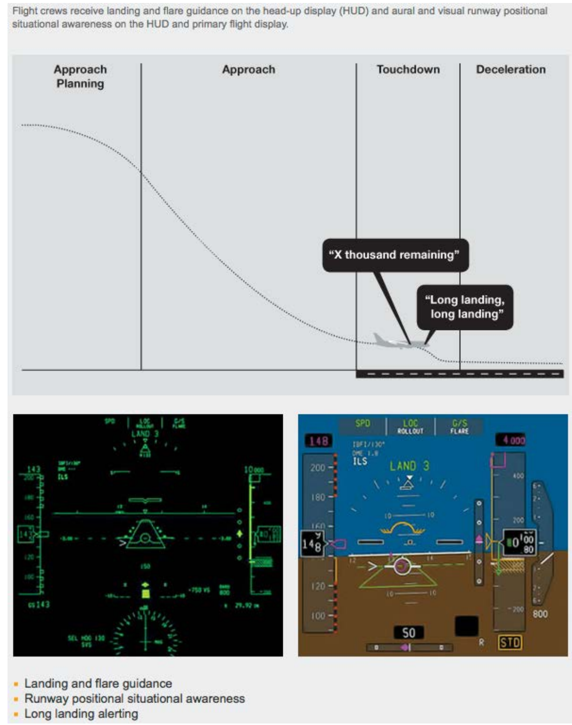
Receiver autonomous integrity monitoring (RAIM) provides integrity monitoring of GPS for aviation applications. In order for a GPS receiver to perform RAIM or fault detection (FD) function, a minimum of five visible satellites with satisfactory geometry must be visible to it. RAIM has various kind of implementations; one of them performs consistency checks between all position solutions obtained with various subsets of the visible satellites. The receiver provides an alert to the pilot if the consistency checks fail.

References/Sources

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiCwJuYpvHOAhXI6CYKHbUXByEQFggeMAA&url=http%3A%2F%2Ftti.tamu.edu%2Fconferences%2Ftac11%2Fprogram%2Fhourin.pdf&usg=AFQjCNHiDRPmYFeIjpCpTiwLSbbzv9r2ig&sig2=0ZFaXqpF0K4br_ie3B81cQ

Boeing Situational Awareness and Alerting for Excursion Reduction (SAAFER)





<u>Accident Category (Risk Area)</u>

Runway Excursion/Runway Overrun

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE215: Runway Excursion - Landing Distance Assessment
SE216: Runway Excursion - Flight Crew Landing Training
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE219: Runway Excursion - Policies, Procedures and Training to Prevent Runway Excursions
SE220: Runway Excursion - Runway Distance Remaining Signs
SE221: Runway Excursion - Policies and Procedures to Mitigate Consequences and Severity
SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

aircraft sensors

Functional Description and Related Warning/Alert Times/Latencies

The Boeing SAAFER strategy implements a combination of procedural and flight deck enhancements along with additional crew education (i.e., training aids) to mitigate runway landing overruns. Components of this approach – procedural enhancements, training aids, and existing flight deck technology – are already available to operators. Boeing recommends implementing these excursion mitigations immediately.

Boeing's runway safety strategy provides flight crews with enhanced awareness, guidance, and alerting tools from the approach-planning phase through landing rollout and deceleration. The strategy's goal is to keep pilots aware and in control of this phase of flight and enable them to make correct and timely decisions that will ensure a safe landing.

This approach is considered a strategy because it encompasses more than just flight deck enhancements. It's designed to improve cognition and pilot decision-making during this high workload phase of flight without overloading the pilot.

References/Sources

http://www.boeing.com/commercial/aeromagazine/articles/2012_q3/3/

Air Traffic Control, Ground-based Safety Nets

A ground based safety net is a functionality within the ATM system that is assigned by the ANSP with the sole purpose of monitoring the environment of operations in order to provide timely alerts of an increased risk to flight safety which may include resolution advice.

Advanced Surface Movement Guidance and Control Systems (ASMGCS)

A visual example of Advanced Surface Movement, Guidance and Control Systems.

<u>Accident Category (Risk Area)</u>

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP, Apt/rwy, Runway incursions

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE046: Air Traffic Control Runway Incursion Training
SE053: Enhanced Airport Surveillance Equipment
SE055: SOPs for Controller Situational Awareness
SE179: Wrong Runway Departures - Scenario-Based Training for Pilots
SE180: Wrong Runway Departures - Scenario-Based Training for Tower Controllers
SE181: Taxi and Runway Configuration
SE182: Wrong Runway Departures - ATC-Clearance Procedure Review

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Surface Operations

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Airport

<u>Input Data Required</u>

airport surveillance radars and aircraft transponder signals

<u>Functional Description and Related Warning/Alert Times/Latencies</u>

Advanced-Surface Movement Guidance and Control Systems (A-SMGCS) comprise a combination of systems that provides services and aids to aircraft and vehicles in order to maintain airport throughput under all local weather conditions, whilst maintaining the required level of safety; they support surface movement operations at an airport based on defined operational procedures.

A-SMGCS provide benefits to Controllers by:
Providing a representation of the actual airport traffic on a display, independent of line-of-sight connection between the Controller and the object.
Anticipating potential conflicts (e.g. hazardous situations between aircraft or between aircraft and vehicles).
Providing alerts.
Maintaining an acceptable level of operational efficiency under reduced aerodrome visibility conditions.
Currently available services

A-SMGCS currently provides two services:
Surveillance service - provides airport traffic situational awareness through the identification, position, and tracking of aircraft and vehicles within a predefined coverage volume via a Human Machine Interface (HMI).
Airport Safety Support service's Runway Monitoring and Conflict Alerting (RMCA) functionality - contributes to operations by preventing hazards/incidents resulting from Controller, Flight Crew or Vehicle Driver operational errors or deviations.
Services in development

The following services are currently being developed by the A-SMGCS community:
Airport Safety Support Service - two new functionalities are being developed and will be added to the support service, including Conflicting ATC Clearances (CATC) and Conformance Monitoring Alerts for Controllers (CMAC).
Routing service – it will automatically generate individual routes for mobiles (aircraft or vehicles) based on known constraints such as standard taxi routes. This service will be a key enabler for functionalities such as the automated switching on/off of AGL (airfield ground lighting) and Route Deviation alerts.
Guidance service – it will help Flight Crew and Vehicle Drivers follow their assigned routes in an unambiguous and reliable way. For example, by automatically switching on and off the taxiway centerline lights and stop bars at a specified distance ahead of individual mobiles whilst taking into account other traffic.

References/Sources

http://www.eurocontrol.int/articles/advanced-surface-movement-guidance-and-control-systems-smgcs

Advanced Technologies for Oceanic Procedures (ATOP)

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Enroute/Oceanic

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Oceanic

Input Data Required

Airspace Management
Optimized sectorization
Fixed RNAV routes
Contingency RNAV routes
Random RNAV routes
Airspace desegregation, flexible use of airspace
Application of RNP
Application of RCP Application of RSP

Air Traffic Services
Trajectory conformance monitoring Minimum safe altitude warning
Conflict prediction
Conflict alert
Conflict resolution advice
Functional integration of ground systems with airborne
Dynamic accommodation of user-preferred flight profiles
Reduced vertical separation
Reduced longitudinal separation
Reduced lateral separation
Independent IFR approaches to closely space runways ATS inter-facility data (AIDC) communications Application of data link

Functional Description and Related Warning/Alert Times/Latencies

Ocean 21 system provides air traffic controllers with state-of-the-art technology that yields significant benefits to airspace users. These benefits include Future Air Navigation Systems (FANS) to support automatic dependent surveillance-contract (ADS-C) position reporting. ADS-C supports reduced separation and the ability for controllers to handle complex traffic situations and grant pilot requests.

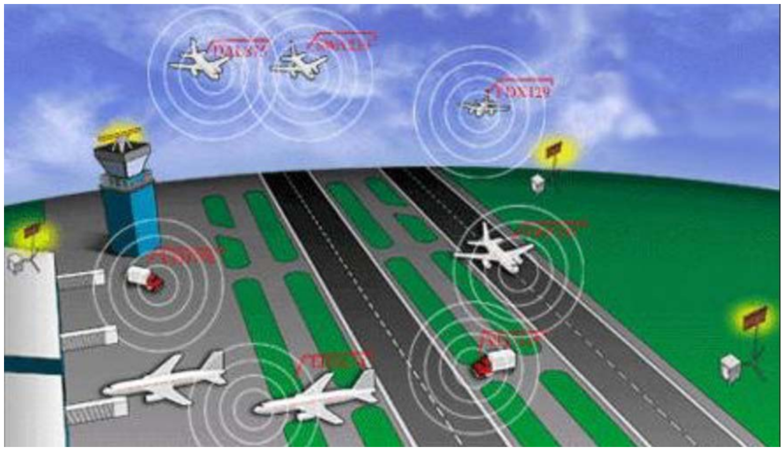
The ATOP system's features include all of the advanced capabilities necessary to modernize air traffic control (ATC) operations to increase capacity, efficiency and safety, while offering a scalable system to meet diverse airspace requirements. These features include automatic conflict probe for aircraft-to-aircraft and aircraft-to-airspace conflicts with conflict resolution advice; incorporation of current wind data into aircraft trajectory modeling; trajectory conformance monitoring; electronic flight data (paperless operations); automatic dependent surveillance contract management; controller pilot data link communications (CPDLC); air traffic services inter-facility data communications (AIDC); integrated presentation of all surveillance information; and traffic load monitoring. These capabilities are packaged in an ultra-high availability architecture specifically designed to support non-interfering hardware and software maintenance.

ATOP capabilities are in some respects out in front of Air Traffic services and safety systems that are available to flights over land.

References/Sources

http://www.lockheedmartin.com/content/dam/lockheed/data/isgs/documents/ATOP%20Brochure.pdf

Airport Movement Area Safety System (AMASS)



Accident Category (Risk Area)

GROUND COLLISION (GCOL)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE046: Air Traffic Control Runway Incursion Training
SE181: Taxi and Runway Configuration

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

Airport Movement Area Safety System (AMASS) provides the following: (a) tracking of ASDE-3 targets; (b) data fusion of ATIDS target data (captured via multilateration or ADS-B) with ASDE-3 track data, and (c) safety logic to detect runway incursions and alert controllers and pilots. [LaRC concept; http://www.cs.odu.edu/~mln/ltrs-pdfs/NASA-98-nav2000-sdy.pdf]

Functional Description and Related Warning/Alert Times/Latencies

AMASS is an enhancement to the Airport Surface Detection Equipment (ASDE-3) radar currently being built. The system will provide automatic conflict alerts (both aural and text) to assist tower controllers in reducing runway accidents.

The system will provide visual and aural alerts involving possible conflicts of aircraft on the runway and on the close approach path with other aircraft, vehicles, or obstacles on or near the runway. The purpose of AMASS is to increase safety on the airport movement area.

As airports become more congested, both the National Transportation Safety Board (NTSB) and the FAA are emphasizing improving safe operations while planes are moving on the ground, that is, as they maneuver from touchdown to an assigned gate and from the time they leave the gate until they are airborne.

During these periods, pilots have a limited range of sight from the cockpit of a large aircraft and air traffic controllers' view of the airport is often restricted by buildings or bad weather.

Average reaction time to alerts is about two seconds.

Further investigation into the automatic onboard detection of runway incursions is justified.

While pilot detection of runway incursions based solely on strict use of a traffic display may be sufficient to catch the majority of incursion situations, this requires close monitoring of the displayed runway on short final approach or departure roll.

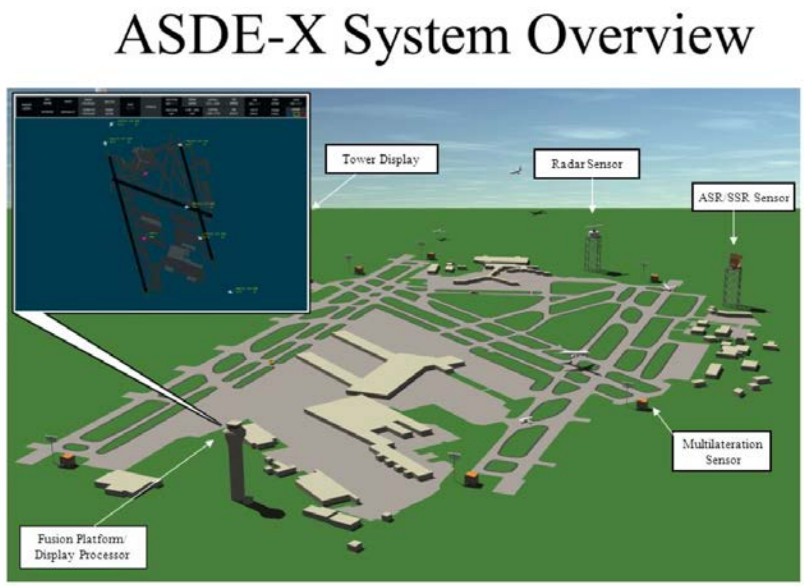
This additional workload and the probability of human error must be traded against a non-zero probability of missed detection and false alarm associated with automatic detection schemes.

References/Sources

http://www.humtech.com/faa/ara/htmls/ht_amass.html

http://worldcat.org/digitalarchive/content/CDM266401.cdmhost.com/CBT/p266401cdi/1209247545644/N20070030080.pdf

Airport Surface Detection Equipment- Model X (ASDE-X)



<u>Accident Category (Risk Area)</u>

GROUND COLLISION (GCOL)

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE053: Enhanced Airport Surveillance Equipment

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Take-off & Landing

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Airport

<u>Input Data Required</u>

Data fusion of multiple sensors:

- surface movement radar
- airport surveillance radar, and

- multilateration inputs

Functional Description and Related Warning/Alert Times/Latencies

ASDE-X uses data that comes from surface movement radar located on the air traffic control tower or remote tower, multilateration sensors, ADS-B (Automatic Dependent Surveillance Broadcast) sensors, the terminal automation system, and from aircraft transponders to determine the position and identification of aircraft and transponder-equipped vehicles on the airport movement area, as well as of aircraft flying within five miles of the airport.

References/Sources

http://www.faa.gov/documentLibrary/media/Order/8200_39D.pdf

Airport Surface Surveillance Capability (ASSC)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Airport Target Identification System (ATIDS)

Accident Category (Risk Area)

GROUND COLLISION (GCOL)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE046: Air Traffic Control Runway Incursion Training
SE181: Taxi and Runway Configuration

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

The Airport Surface Target Identification System (ATIDS) captures position and identity data for aircraft and ground vehicles equipped with ADS-B and/or Mode- S transponders. ATIDS can utilize multiple fixed receiver/transmitters (R/Ts) at an airport. These R/Ts can perform a multilateration function on targets emanating a Mode-S beacon. [LaRC concept]

Functional Description and Related Warning/Alert Times/Latencies

ATIDS is a multi-lateration system designed to track and provide identification information for aircraft and ground vehicles that have operating transponders.

ASDE-3 does not report target identification.

To augment these limitations, an Airport Target Identification System (ATIDS)was developed and installed at certain airports.

Average reaction time to alerts is also expected to be about two seconds.

References/Sources

http://worldcat.org/digitalarchive/content/CDM266401.cdmhost.com/CBT/p266401cdi/1209247545644/N20070030080.pdf

Approach Path Monitor (APM)

Accident Category (Risk Area)

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)
JIMDAT Undesired Aircraft State: CFIT/Gnd impact

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE003: Precision-Like Approaches - Vertical Angles
SE004: Precision-Like Approaches - Vertical Glide Slope Indicators (VSGI)
SE005: Precision-Like Approaches - Distance Measuring Equipment (DME)
SE006: Precision-Like Approaches - Area Navigation (RNAV) 3D
SE007: Precision-Like Approaches - Area Navigation (RNAV) Required Navigation Performance (RNP)
SE008: Precision-Like Approaches - Landing Systems (ILS, MLS, GLS)
SE023: Approach and Landing (ALAR) Flight Crew Training

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Flight plan and terrain and obstacle data

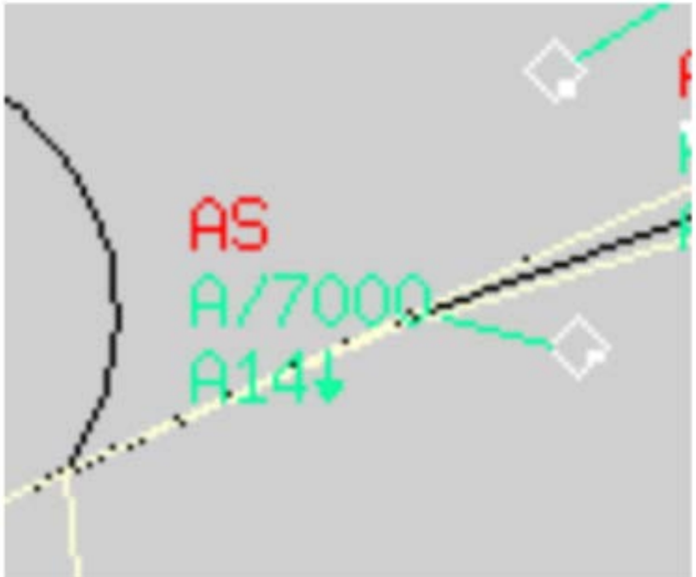
Functional Description and Related Warning/Alert Times/Latencies

Approach Path Monitor (APM), which warns the controller about increased risk of Controlled Flight Into Terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles during final approach.

References/Sources

http://www.skybrary.aero/index.php/Approach_Path_Monitor

Area Proximity Warning (APW)



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Accurate and reliable radar track information

Track Altitude and Track Flight Level

System Tracks from Surveillance Data Processing (SDP). Other data, such as system track ages or accuracy estimates, may be present in the system and these data items may be used by APW to assess the quality of the tracks.

Environment data comprising APW volumes, essential parameters, and where relevant, QNH data and QNH regions, and local air temperature.

Functional Description and Related Warning/Alert Times/Latencies

Area Proximity Warning (APW), which warns the controller about unauthorized penetration of an airspace volume by generating, in a timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume.

When an APW alert is generated, the letters "AS" are shown in the track data block.

At the controller working position and sector that has jurisdiction over the track, "AS" is shown in red, and the controller is able to acknowledge the alert by clicking on the "AS" text.

At other controller working positions the "AS" is shown in yellow, and the alert cannot be acknowledged.

References/Sources

http://www.skybrary.aero/index.php/Safety_Nets

Automated Surface Observing System (ASOS)

Accident Category (Risk Area)

Wx-related hazards: windshear, turbulence, thunderstorms, etc.

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135?

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

meteorological sensors

Functional Description and Related Warning/Alert Times/Latencies

An Automated Weather Observing System, or AWOS, as defined by the FAA, is a suite of weather sensors, which measure, collect and disseminate weather data to help meteorologists, pilots and flight dispatchers prepare and monitor weather forecasts, plan flight routes, and provide necessary information for correct takeoffs and landings.

There are six standard categories of Automated Weather Observing Systems (AWOS), and a limitless number of customized weather stations:

- AWOS I: Wind speed, wind gust, wind direction, variable wind direction, temperature, dew point, altimeter setting, density altitude.
- AWOS II: AWOS I + visibility, and variable visibility.
- AWOS III: AWOS II + sky condition, and cloud height and type.
- AWOS III-P: AWOS III + present weather, and precipitation identification.
- AWOS III-T: AWOS III + thunderstorm and lightning detection.
- AWOS III-P-T: AWOS III + present weather, and lightning detection.

References/Sources

http://www.coastalenvironmental.com/awos.shtml

Automated Electronic Flight Strips (AEFS)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

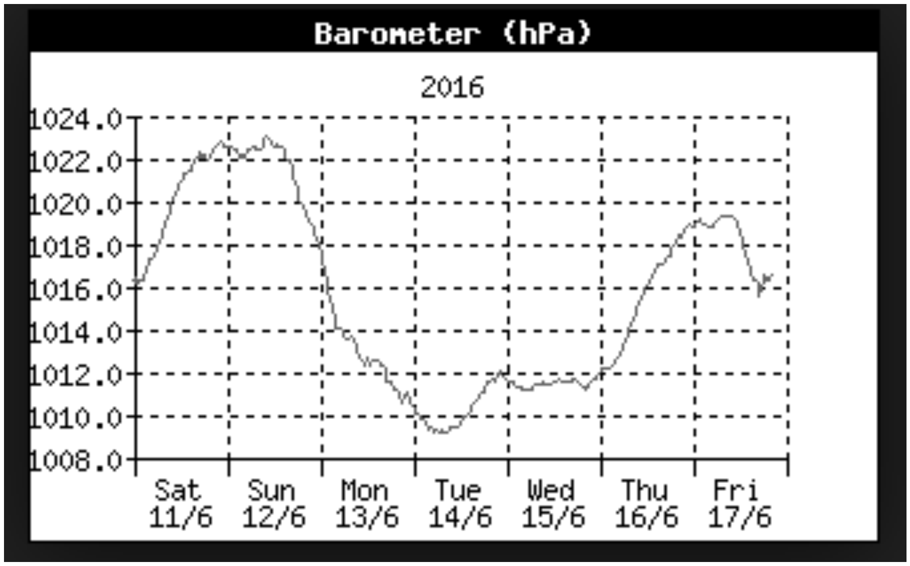
Terminal

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Barometric Pressure Setting Advisory Tool (BAT)



Accident Category (Risk Area)

"CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)
JIMDAT Undesired Aircraft State: CFIT/Gnd impact, Loss of separation

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE034: Displays and Alerting Systems

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

aircraft transponder signals and pressure altimeters

Functional Description and Related Warning/Alert Times/Latencies

The Barometric Pressure Setting Advisory Tool is designed to provide an advisory warning to London Terminal Control Approach controllers where there is a significant difference (greater than 6 hPa) from the prevailing London QNH. The BAT tool applies only to arriving aircraft once they are at or below the transition altitude and works with both multi-radar tracking (MRT) and a single radar information source.

A study conducted by NATS of aircraft flying within the London TMA highlighted some operator anomalies in the setting of flight deck BPS. It found that an overwhelming majority of flight crews change altimeter settings in a timely manner in accordance with ICAO Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS). The risk of level deviations caused by altimeter setting errors is highest when the atmospheric pressure is low and in the case of the London TMA was found to be increased when the QNH being used is less than 996 hPa.

Mode S Enhanced Surveillance (EHS) transponders can automatically provide particular flight management parameters to air traffic control systems which include a Mode S parameter known as Barometric Pressure Setting (BPS).

Mode S BPS data is provided by a large proportion of flights in European terminal airspaces and the NATS study has shown this data to be of a very high integrity in the majority of cases. There are, however, some known problems with data supplied by some aircraft when above the transition altitude, which precludes its use by ATC. Nevertheless, although the provision of Mode S BPS is not mandated, NATS considers that the downlinked data is of sufficient integrity to be used by ATC for aircraft descending below the transition altitude and that this will contribute to the prevention of level busts by inbound aircraft.

The tool is designed to follow these principles of operation:

The Mode S Selected Altitude (SFL) and the current level are compared to confirm that the arriving aircraft crew have set up their aircraft so that it will remain below the Transition Altitude.

Mode S BPS is down-linked from aircraft. The BPS must be 6mb or more different to the London QNH and SFL data must be available.

Other criteria are applied to give flight crews the maximum amount of time to change altimeter settings without unduly risking a nuisance indication of a potential level bust.

References/Sources

http://www.skybrary.aero/index.php/Barometric_Pressure_Setting_Advisory_Tool_(BAT)

https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Conflicting ATC Clearances (CATC)

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

It uses Advanced Surface Movement Guidance and Control System (A-SMGCS) surveillance data

Functional Description and Related Warning/Alert Times/Latencies

Conflicting ATC Clearances (CATC) is the name of a support tool for tower runway controller. The concept of conflicting ATC clearances is based on the Air Traffic Control (ATC) system detecting clearances given to aircraft or vehicles by Air Traffic Control Officers that could lead to rare unsafe situations.

The Conflicting ATC Clearances Safety Net Concept:

Currently the only safety net available to tower runway controllers to avoid runway incursions is the Runway Incursion Monitoring System (RIMS). It uses Advanced Surface Movement Guidance and Control System (A-SMGCS) surveillance data to detect dangerous situations within the runway protection area. Detections and subsequent alerts to controllers are often provided at the very last moment and re- quire immediate reaction.

The new CATC Safety Net will not replace the existing RIMS but is intended as an additional layer of safety. It will give tower runway controller more time to react by detecting conflicting ATC clearances much earlier – typically at the moment when the tower runway controller inputs clearances into the Electronic Flight Strips (EFS), which are already in operational use in many control towers. To do so, it will per- form crosschecks with previous clearances input on the EFS, and in most cases the aircraft position, to check whether one of the situations described in the subsequent paragraphs occurs which could lead to a runway incursion or other hazardous situation.

“Conflicting clearances” based on the one in [5]. We consider 4 types of runway related ATC clearances: Line Up (LUP), Cross (CRS), Take-Off (TOF) and Land (LND).

The detection of CATC will be performed by the ATC system and depending on the situation, some or all of the following data will need to be known by the ATC system:

- The clearances given to the mobiles concerned (Cleared to Land, Cleared to Take Off, Line Up, Enter or Cross. If conditional clearances are used then it will be necessary to be able to input these into the system as well.
- The assigned runway.
- The assigned holding point.
- The route of the mobile/s.
- The position of the mobile/s using A-SMGCS Surveillance data (e.g. position, velocity, track angle...) correlated to flight plans on the mobiles concerned.

References/Sources

http://www.sesarinnovationdays.eu/files/SIDs/2013/SID-2013-56.pdf

Continuous Friction Measurement Equipment (CFME)

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

Various additional sensors include global navigation satellite systems (GNSS), high-speed cameras, temperature sensors for road surface and air, and texture scanners. Texture values are needed to determine values for the international friction index (IFI).

Functional Description and Related Warning/Alert Times/Latencies

CFME is generally mounted on a towed vehicle with a computer-controlled friction device using an electric brake for controlling measured wheel speed. The measure wheel is independent of the other wheels on the friction vehicle.

CFME employ longitudinal force coefficient (LFC) friction testers. they continuously measure friction using a variety of methods, including fixed-slip (skiddometer principle). The longitudinal slip percentage can be set from 1% to 85%.

Runway surface friction/speed characteristics need to be determined under the following circumstances:

- the dry runway case, where only infrequent measurements may be needed in order to assess surface texture, wear and restoration requirements;
- the wet runway case, where only periodical measurements of the runway surface friction characteristics are required to determine that they are above a maintenance planning level and/or minimum acceptable level. In this context, it is to be noted that serious reduction of friction coefficient in terms of viscous aquaplaning can result from contamination of the runway, when wet, by rubber deposits;
- the presence of a significant depth of water on the runway, in which case the need for determination of the aquaplaning tendency must be recognized;
- the slippery runway under unusual conditions, where additional measurements should be made when such conditions occur;
- the snow-, slush-, or ice-covered runway on which there is a requirement for current and adequate assessment of the friction conditions of the runway surface;
- the presence and extent along the runway of a significant depth of slush or wet snow (and even dry snow), in which case the need to allow for contaminant drag must be recognized.

References/Sources

http://www.airport-technology.com/contractors/apron_clean/viatech-airport/

http://moventor.com/about-us/cfme-continuous-friction-measuring-equipment/

Conformance Monitoring Alerts for Controllers (CMAC)

ROUTE DEVIATION	An aircraft deviates from cleared route on a taxiway (RED Alarm if the deviation occurs close to an active runway).
RWY/TWY TYPE	An assigned runway or taxiway is not suitable for the aircraft type e.g. runway is too short.
STATIONARY	A mobile has received a clearance and fails to move within a specified elapsed time.
RWY CLOSED	An assigned runway is closed (RED Alarm if mobile is on the RWY).
TWY CLOSED	The taxi route is planned to go through a closed taxiway (RED Alarm if mobile enters the taxiway).
NO PUSH/TAXI CLR	An aircraft pushes back or taxis without clearance.
NO CONTACT / NO TRANSFER	An aircraft has reached a defined point without being assumed transferred by the controller.
HIGH SPEED	An aircraft exceeds a specified maximum taxi speed.
RWY INCURSION	An unauthorised mobile is in the runway protected area (e.g. NO LINE UP/CROSS/ENTER clearance).
NO TAKE OFF CLR	An aircraft begins take-off without a clearance.
NO LAND CLR	An aircraft is on short finals to a runway without a landing clearance.
STATIONARY IN RPA	An aircraft that has landed and is within the RPA and does not move for 30seconds.
RED STOP BAR CROSSED	A mobile crosses a RED stop bar.

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

ground-based radars

Functional Description and Related Warning/Alert Times/Latencies

When a potentially hazardous situation is detected, the A-SMGCS will provide the controller with the same two types of alert as RIMS, namely 'INFORMATION' and 'ALARM':

- INFORMATION: This means that a potentially hazardous situation may occur. The tower controller can therefore use their skill and experience to resolve the incident without using a drastic action such as issuing a ''go around''. If successful, there will be no alarm; if unsuccessful the alarm will be triggered and be presented on the HMI.
- ALARM: This means that a critical situation exists and that immediate action is necessary. An alarm will also trigger an audio warning (e.g. buzzer) in case the controller is not looking at the HMI at the time.

The alerts can be displayed on the EFS, the radar/track label and in a dedicated alert window on the screen. It is recommended that all alerts are displayed in the alert window until they have been resolved. In the case where more than one alert is triggered for the same mobile it is recommended to display the alert with the highest priority only in the radar/track label and /or EFS, bearing in mind that all the alerts are always being displayed in the Alert Window.

References/Sources

See page 64 of: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Conflict Alerts

Categories of conflict alerts: There are three types of tools used to warn controllers of conflicts:

Short term conflict alert (STCA);
Look ahead time: usually 1-2 minutes.
Input: surveillance data (actual flight level derived from SSR mode C and assumption that the aircraft will maintain its present track). There are some implementations that also include pilot input received via SSR mode S or controller input of CFL.
Used as: safety net (to warn the controller that a separation breach is imminent).

Tactical controller tool (TCT);
Look ahead time: up to 5-8 minutes depending on local implementation.
Used as: conflict resolution and clearance verification tool (to inform the controller if the current clearance results in a separation breach so that it can be corrected if necessary).

Medium term conflict detection (MTCD);
Look ahead time: up to 20-30 minutes depending on local implementation.
Used as: planning tool (to inform the controller of potential conflicts so that a proper plan is made in advance).

<u>Accident Category (Risk Area)</u>

Loss of Separation
JIMDAT Undesired Aircraft State: LOSS OF SEP

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

CAST SEs are those related to TCAS/ACAS listed above

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121, 135, high-end GA

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

<u>Input Data Required</u>

Functional Description and Related Warning/Alert Times/Latencies

A number of ATM safety nets make use of downlink Mode S airborne parameters. This has generated a new capability in ATC to detect errors in altitude setting in the cockpit and correct the error before it becomes a level bust, leading to significant reductions in safety risk. But in certain modes of flight management, the Mode S Selected Level will not always show compliance with step climbs on SIDs or step descents on STARs, as the level information is sourced directly from the selection made on the Mode Control Panel (MCP) and does not take account of other inputs to the Flight Management System (FMS). Unfortunately, the mode of flight most likely to ensure compliance with step climb SID and step descent STAR, where the aircraft automatically follows the vertical profile without the need for pilot intervention, results in the controller only seeing the top altitude of the SID or the bottom altitude of the STAR. We must also ensure that solutions to any mismatch between flight deck and ATC procedures take a 'total system' safety risk viewpoint. "Blind Spot" in air traffic control it refers to the failure to detect a problem (conflict) right in middle of the controller's field of view. Possible Outcome: Loss of separation "Blind Spot" events are typically characterized by the controller not detecting a conflict with the closest aircraft. Such events usually occur after an incorrect descent or climb clearance. Usually there is very little (or no) time to react to such an error and most of the conflicting clearances result in an incident.

The most common triggers for this are:

- Rushed vertical clearance after a pilot request: This scenario trigger occurs when a pilot makes a request for climb/descent. This grabs the attention of the controller whose focus was elsewhere. There is a perceived need to deal with the request as quickly as possible so that the limited attention resource can be returned to other tasks. The controller does not carry out any structured scan for potential conflicts and agrees to the request. The clearance leads to a conflict.
  Instruction to meet constraints: Airspace design for En-Route and TMA sectors has become complex. To accommodate the various constraints, such as the transfer of control, the task is increasingly governed by silent handovers either by standing agreements or individual electronic acceptance. The controller's attention turns to a requirement to climb/descend an aircraft to meet these constraints and does not take into account the potential conflict ahead.
- Clearance not following the horizontal Flight Plan Route: Flight Data Processing (FDP) systems are designed to highlight the planned routing of aircraft. This may be via paper or electronic strips, or by information overlaid onto the radar display. When flights do not tactically follow the pre-planned flight profile, the information gleaned from the FDP system may no longer highlight the potential conflict. This scenario trigger involves instruction or clearance from the controller that result in horizontal deviation from Flight Planned Route. This includes the first clearance and any subsequent clearance before the aircraft re-joins the Flight Planned horizontal route, including the instruction to resume own navigation after vectoring.
- Conflict Resolution Instruction: Solving potential conflict and not detecting the resultant conflict.

References/Sources

http://webstaff.itn.liu.se/~jonlu41/publist/conflict_detection_pre_print.docx.pdf

http://www.skybrary.aero/index.php/Short_Term_Conflict_Alert_(STCA)

http://www.skybrary.aero/index.php/Blind_Spots_–_Inefficient_conflict_detection_with_closest_aircraft

Conflict Probe (part of ERAM)

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Enroute

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

TRACON, Enroute & Oceanic

Input Data Required

ground-based radars

Functional Description and Related Warning/Alert Times/Latencies

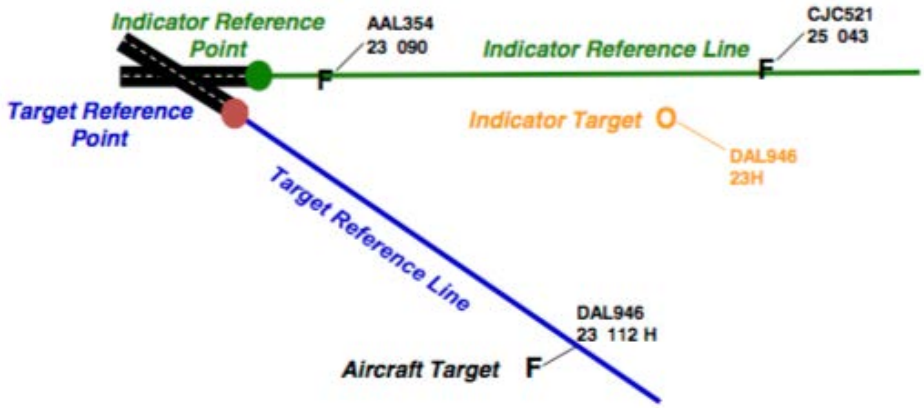
The Federal Aviation Administration (FAA) is currently implementing a number of improvements to the National Airspace System (NAS) in the United States under a multi-agency initiative called the Next Generation Air Transportation System (NextGen) Program. The Separation Management and Modern Procedures Project is a NextGen initiative and its objective is to implement the En Route Automation Modernization (ERAM) strategic conflict probe on the radar controller display utilizing ERAM's Trajectory Modeler (TM) and Conflict Probe (CP) sub-systems.

References/Sources

http://www.tc.faa.gov/its/worldpac/techrpt/tctn13-54.pdf
Billamoria at Ames: https://acy.tc.faa.gov/data/_uploaded/Publications/ICAS_Final_MOD.pdf

Converging Runway Display Aid

Function is to aid controllers in sequencing and separating traffic for arrival at converging runways



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

CAST SEs are those related to Runway topics listed above

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach, Landing & Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

The converging runway display aid (CRDA) is a computer program that can reside on the ARTS III computer used in the terminal area for air traffic control.

The converging runway display aid shows each aircraft on both approach paths by means of a "ghost" image. That is, the position of aircraft number 1 on approach path A is also shown on approach path B as a virtual or ghost representation. Thus the in-trail separation of the aircraft on both paths can be directly observed and adjusted through standard air traffic control procedures in a continuous manner.

Functional Description and Related Warning/Alert Times/Latencies

The Converging Runway Display Aid now allows controllers to use the two diagonal runways again by calculating a safe gap between arriving and departing planes.

It is available at all terminal automation sites.is a passive tool that translates the (x, y) position of an aircraft with respect to a reference point and a reference line onto another reference point and reference line.

It involves no other translation or processing, such as the use of speeds, winds, or times.

Its use for improving safety is at least as compelling as its use for improving efficiency.

"GHOST" aircraft target symbol shown in ORANGE in diagram.

References/Sources

http://www.oharenoise.org/about-oncc/newsroom/34-2015/103-faa-demonstrates-new-converging-runway-display-aid

http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6096051

Digital Automatic Terminal Information Service (D-ATIS)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Approach, & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, & Enroute

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Electronic Flight Strip Transfer System (EFSTS)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Engineered Material Arresting System (EMAS)

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE215: Runway Excursion - Landing Distance Assessment
SE216: Runway Excursion - Flight Crew Landing Training
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE219: Runway Excursion - Policies, Procedures and Training to Prevent Runway Excursions
SE220: Runway Excursion - Runway Distance Remaining Signs
SE221: Runway Excursion - Policies and Procedures to Mitigate Consequences and Severity
SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135?

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

Unlike most safety nets, an EMAS does not analyze and generate streams of data to a computer or relay that information to an air traffic controller, cockpit crew or other responsible party. There are no warnings, surveillance alerts nor advisories.

EMAS is a **passive** system.

Functional Description and Related Warning/Alert Times/Latencies

The EMAS predictably and reliably crushes under the weight of an aircraft, providing deceleration and a safe stop. It is FAA-accepted as an equivalent to a standard Runway End Safety Area (aka Runway Safety Area) and is an acceptable alternative for preventing overrun catastrophes at airports where RESAs/RSAs do not exist or are impractical due to environmental or other issues.

An EMAS bed is designed to stop an overrunning aircraft by exerting predictable deceleration forces on its landing gear as the EMAS material crushes without causing structural failure to the landing gear. The system operates independently of runway friction or braking action because the landing gear gradually sinks into the specially designed crushable material.

An EMAS may literally be the last line of defense against very dire consequences, which makes a very strong case for the system as a “safety net.”

References/Sources

https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Enhanced Short-Term Conflict Alert

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Mode S down-linked aircraft parameters (e.g. Selected Flight Level, Roll angle/Track angle rate)

Functional Description and Related Warning/Alert Times/Latencies

Short-term conflict alerts (STCA) provide controllers with a short-term warning of potential conflicts between aircraft in the same airspace. Enhancing the STCA safety net with information down-linked from the aircraft provides more accurate data on which to base warning signals.

Enhanced algorithms for a Short Term Conflict Alert (STCA) prototype ensures earlier warning and lower false and nuisance alert rates related to steady and maneuvering aircraft, in comparison to existing STCA technology. It improves on the original (Issue 4) specification [51] by adding an additional fine filter designed to predict the lateral path of aircraft holding in stacks. Additionally, it allows downlinked Selected Flight Level (SFL - Mode-S data) information to be used in reducing CAT3-type nuisance alerts and predicting level busts.

Benefits:

- Improves warning times within the en-route Route and TMA airspace leading to increased safety
- Reduces the number of nuisance alarms and maintains the genuine alerts rate
- Increases human performance through a reduced workload for air traffic controllers,

generating a higher level of confidence by staff and an increased trust in the system

References/Sources

https://ore.exeter.ac.uk/repository/bitstream/handle/10036/3154/ReckhouseW.pdf?sequence=1

En Route Automation Modernization (ERAM)

Accident Category (Risk Area)

Enhances safety primarily for the time between wheels up and landing. ERAM is not intended to directly reduce runway excursion/incursion/over-run accidents.

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE047: ATC Tower Controller CRM Training
SE188: TCAS - ATC Procedures and Airspace Design
SE212: Area Navigation (RNAV) – Equipment and Procedures to Improve Route Entry for RNAV Departures
SE213: Area Navigation (RNAV) – Safe Operating and Design Practices for STARs and RNAV Departures
SE214: Area Navigation (RNAV) – Procedures and Standards to Improve Path Compliance for STARs and RNAV Departures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Enroute

Input Data Required

Flight radar data
Real-time electronic aeronautical information including:
- Weather data
- Data feeds from Automatic Dependent Surveillance-Broadcast (ADS-B) and System Wide Information Management (SWIM)
Air traffic control procedures documents
Notices to Airmen (NOTAMs)
Pilot Reports (PIREPs) and other information with the En Route Information Display System (ERIDS)

Functional Description and Related Warning/Alert Times/Latencies

ERAM and STARS enable NextGen capabilities in the NAS and work together to provide greater efficiency and benefits.

The FAA began replacing the legacy system known as the Host with a new, NextGen-enabling system known as En Route Automation, or ERAM.
ERAM provides core functionality for air traffic controllers, and the FAA designed it to support satellite-based systems such as Automatic Dependent Surveillance-Broadcast and data communication technologies. Working together, all of these systems will improve efficiency and enhance safety. The system is now operational at 20 Air Route Traffic Control Centers – also known as en-route centers – throughout the United States and at the FAA Academy in Oklahoma City, Oklahoma. Other FAA air traffic facilities, including Terminal Radar Approach Control facilities and towers, are connected to en-route centers via ERAM. The system also connects with the FAA's Command Center, automated flight service stations, and other agencies, including the Department of Homeland Security, the Department of Defense and U.S. Customs and Border Protection.

ERAM increases capacity and improves efficiency in the nation's skies. It enables en- route controllers at each center to track 1,900 aircraft at a time, while the legacy system could track up to 1,100 aircraft). Coverage extends beyond facility boundaries, enabling controllers to handle additional traffic more efficiently. The system allows controllers to share and coordinate information seamlessly between centers, enabling the use of three-mile (rather than five-mile) separation. ERAM improves flight plan processing and enables automatic transitions between sectors and centers, even when planes divert from their planned course. This improves operational efficiency during bad weather and congestion.

ERAM provides many additional benefits:

- It is a long-term, cost-effective measure. The ERAM program replaces four legacy systems used in today's air traffic control centers, reducing the hardware operating and support costs, as well as the total number of software code lines and the cost of software maintenance.
- It provides more accurate tracking. The ERAM tracking function processes target reports from multiple radars, replacing the single radar tracker in the legacy system. This provides more reliable tracking in areas of partial radar coverage. An independent study the MITRE Corporation performed concluded that the ERAM tracker was more accurate than the legacy system in all cases. The ERAM tracker also processes Automatic Dependent Surveillance-Broadcast (ADS-B) data that is part of NextGen.
- It improves flight plan processing. The ERAM system significantly improves on flight plan processing. ERAM creates a 4-dimensional trajectory (3D plus time) of every flight from take-off to landing. The system uses this information to improve a controller's situational awareness in his or her airspace as well as the surrounding airspace, enabling better decision-making and safer, more efficient routing of aircraft along their flight path. The system can now warn controllers when aircraft are unexpectedly entering their airspace, and provides improved capabilities for handling military aircraft to ensure their training exercises and military missions do not interfere with civilian flights. Improvements in the automation function that transfers

control of a flight from one controller to the next allow ERAM to control flights on fuel-efficient, direct routes in the sky.

- It provides advanced controller tools. ERAM takes advantage of the improved tracking accuracy and flight plan processing to create more accurate controller tools. Like today's system, ERAM detects conflicts between two aircraft, but is more accurate, reducing the number of missed alerts false conflicts. It also adds new capabilities to operate with variable separation standards, allowing the controller to separate aircraft in the most efficient manner possible, increasing airspace capacity. Work is underway to add new controller tools that allow more efficient airborne routing around convective weather, reducing fuel burn and improving airline schedule predictability. Other functions will allow airlines to take advantage of their on-board equipment (RNP/RNAV) to fly fuel-efficient routes, improve airspace safety, and reduce noise and emissions to protect the environment.

En Route Automation Modernization (ERAM) is already in use at all 20 en route centers in the contiguous United States.

<u>References/Sources</u>

https://www.faa.gov/air_traffic/technology/eram/

https://en.wikipedia.org/wiki/ERAM

Final Approach Runway Occupancy Signal (FAROS)

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

CAST SEs are those related to Approach topics listed above

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

The input signal to the FAROS visual signal is provided automatically by the embedded inductive loops which are installed at all runway entry and exit points at certain airports for various operational uses and which are able to detect transiting traffic by the disturbance of the loop magnetic field which it causes. The FAROS system is provided to enhance pilot awareness only. It does not substitute for, or interfere with, existing ATC authority or flight crew procedures, and activation does not affect the validity of an existing ATC Landing Clearance. In many cases, it may be activated on short finals as another aircraft departs from the same runway or an aircraft or vehicle cross it in accordance with their ATC clearances.

Functional Description and Related Warning/Alert Times/Latencies

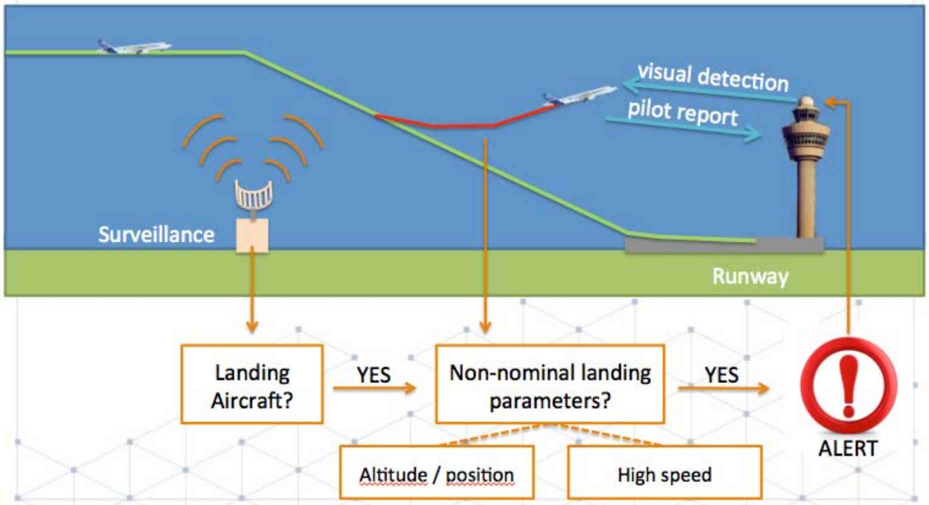
Final Approach Runway Occupancy Signal (FAROS) is an FAA-sponsored concept, which is now being deployed for operational evaluation in the USA, as part of the overall enhancement of safety nets designed to reduce Runway Incursion hazards.

It works by providing a visual signal to aircraft on final approach to land that the runway ahead is occupied by another aircraft or a vehicle. This is done by adapting the PAPI or VASI system to alter from steady lights to flashing mode whilst the identified hazard remains. Externally, the PAPI or VASI system is unaltered and continues to function normally in its primary role as an angle of approach awareness indicator whether or not a FAROS input has temporarily caused the flashing mode to activate.

References/Sources

http://www.skybrary.aero/index.php/Final_Approach_Runway_Occupancy_Signal_(FAROS)

Go-Around Detection System (GARDS)



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
GROUND COLLISION (GC)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE198: Airplane State Awareness - Scenario-Based Training for Go-Around Maneuvers

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal & TRACON

Input Data Required

Surveillance radar

Functional Description and Related Warning/Alert Times/Latencies

Air Traffic Control the Netherlands (LVNL) has built a signal into the air traffic control system for improved safety when an aircraft makes a go-around. This system, which is unique in the world, gives an audio prompt and shows a warning signal on the radar monitor, reducing the risk of an unsafe situation. LVNL continually improves the safety of take-offs, landings and handling of air traffic in Dutch air space. The system correctly captured 459 go-arounds since the launch in May 2015. LVNL project leader Mariska Roerdink presented the Go-Around Detection System at the Eurocontrol Safety Forum in Brussels on June 8.

Antonio Licu, Head of Safety Unit, Eurocontrol: "This is a remarkable piece of technology. I am impressed with the low number of false alerts and the high confidence in the tool by the air traffic controllers."

Go-around

Go-arounds occur regularly and follow a standard procedure. With a go-around, the landing of the aircraft is aborted. There may be various reasons for this, such as exceptional weather or technical conditions, or because the previous aircraft is still on the landing runway. It is also possible that the cabin crew of the aircraft have yet not been able to make all the preparations for landing. Depending on the situation, a go-around may be initiated by the pilot or the air traffic controller.

The air traffic controller issues instructions to aircraft that are landing and taking off from the control tower at Schiphol. In order to provide extra alerts for air traffic controllers in the case of a go-around, an automatic system has been developed, which gives both an audio prompt and makes a warning signal visible on the radar monitor. In the past, situations have occurred in which an air traffic controller has seen an aircraft touch down, yet ultimately, a go-around has nevertheless been made. This has led to high-risk situations.

References/Sources

http://www.skybrary.aero/bookshelf/books/3491.pptx

http://news.lvnl.nl/goarounddetectionsystem

Low-Level Wind Shear Alert System (LLWAS) & Microburst Detection Systems

<u>Accident Category (Risk Area)</u>

LOSS OF CONTROL - INFLIGHT (LOC-I)
WIND SHEAR OR THUNDERSTORM (WSTRW)

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE078: Turbulence Procedures for Reducing Cabin Injuries

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121 & 135

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Take-off, Climb, Approach, Landing

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Terminal

<u>Input Data Required</u>

LLWAS consists of a central wind sensor (sensing wind velocity and direction) and peripheral wind sensors. It enables controllers to warn pilots of existing or impending windshear conditions.

Functional Description and Related Warning/Alert Times/Latencies

The LLWAS provides wind data and software processes to detect the presence of hazardous wind shear and microbursts in the vicinity of an airport.
Controllers will provide this information to pilots by giving the pilot the airport wind followed by the boundary wind

The system senses wind shear occurrences through comparison of reading from the various wind sensors.

LLWAS was fielded in 1988 at 110 airports across the United States

- Many of these systems have been replaced by new TDWR and WSP technology
- Eventually all LLWAS systems will be phased out; however, 39 airports will be upgraded to the LLWAS NE (Network Expansion) system, which employs the very latest software and sensor technology
- The new LLWAS-NE systems will not only provide the controller with wind shear warnings and alerts, including wind shear/microburst detection at the airport wind sensor location, but will also provide the location of the hazards relative to the airport runway(s)
- It will also have the flexibility and capability to grow with the airport as new runways are built
- As many as 32 sensors, strategically located around the airport and in relationship to its runway configuration, can be accommodated by the LLWAS-NE network

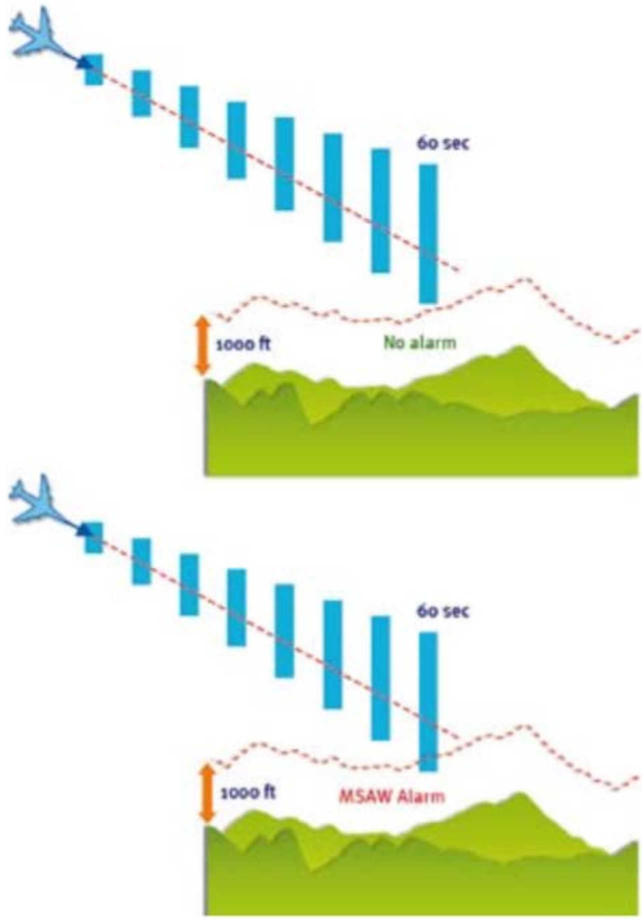
Unfortunately, some microbursts are so small that they can fit between the sensors

Doppler radar has proven effective in detecting microbursts and is being installed at major airports, integrated with the LLWAS

References/Sources

http://www.cfinotebook.net/notebook/weather-and-atmosphere/low-level-wind-sheer-and-microburst-detection-systems

Minimum Safe Altitude Warning System (MSAW)



Accident Category (Risk Area)

CONTROLLED FLIGHT INTO OR TOWARD TERRAIN (CFIT)
JIMDAT Undesired Aircraft State: CFIT/Gnd impact

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE009: Minimum Safe Altitude Warning (MSAW)
SE120: Terrain Awareness and Warning System (TAWS) Improved Functionality

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal & Enroute

Input Data Required

MSAW normally obtains input from the surveillance data processing, the environment data processing and possibly from the flight data processing systems in order to generate alerts. Some examples are presented below:

Surveillance data, including tracked pressure altitude information, can be used to predict hazardous situations;

Flight data can be used in the following manner:
Type/category of flight: to determine the eligibility for alert generation and possibly also the parameters applied;
Concerned sector(s): to address alerts;
Cleared Flight levels: to increase the relevance of alert generation.

Environment data and parameters include:
Terrain and obstacle data;
Alerting parameters;
Additional items (QNH, temperature, etc.).

Functional Description and Related Warning/Alert Times/Latencies

Minimum safe altitude warning (MSAW) is an automated warning system for air traffic controllers (ATCO). It is a ground-based safety net intended to warn the controller about increased risk of controlled flight into terrain accidents by generating, in a timely manner, an alert of aircraft proximity to terrain or obstacles.

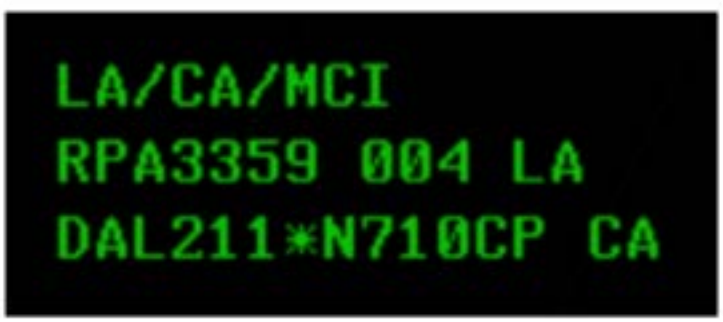
The future position of the aircraft is extrapolated forward from the current track position for a predefined period of time know as the "look-ahead time".
The look-ahead time and MSAW function processing time define the "warning time" – that is, the period available for the ATCO to react to a hazardous situation.

A longer look-ahead time may lead to more false alerts generated by MSAW. A shorter look-ahead time could lead to insufficient warning time for the controller.

An "adequate" warning time is the time which is sufficient for controller's reaction, communication, pilot's reaction and aircraft response and is an indicator for the proper setting of the MSAW function.

The performance of the MSAW function can be described as the best balance between warning time and nuisance alert, taking into account local environment. In this way the air traffic controller would be able to rely on the MSAW during the provision of service.

If a track enters MSAW alert, it will have a red "LA" displayed on the first line of its data block. A tone will also sound. The track will also be added to the LA/CA/MCI list. To acknowledge the alert and silence the tone, slew the track.



LA/CA/MCI list displays tracks in MSAW (Low-Altitude) alert status, Conflict Alert status, or Mode C Intruder status. The example above shows one track in LA status with callsign RPA3359, at 400 feet. Also shown is a conflict alert between DAL211 and N710CP. If one of the targets in a conflict pair is unassociated, it will be displayed as MCI instead of CA, and its reported beacon code will be shown in place of the callsign.

References/Sources

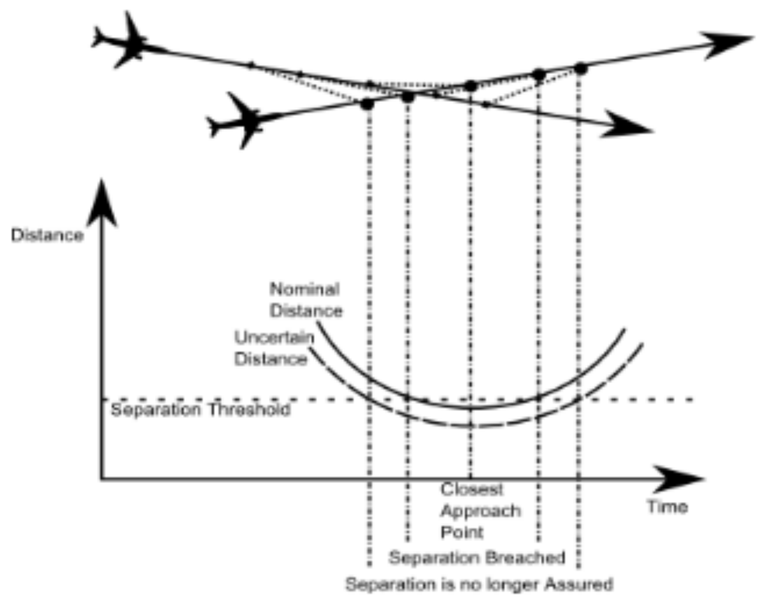
http://www.skybrary.aero/index.php/MSAW

Medium Term Conflict Detection (MTCD)

(European program not yet implemented in the U.S.)

The following clip shows a risk of conflict between two aircraft. It also shows the subsequent electronic entry flight level coordination to avoid the risk.

http://www.eurocontrol.fr/projects/edep/demo/spd/Tools/MTCD%20risk%20and%20level%20coord/MTCD%20risk%20and%20level%20coordination_rendered4.avi



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Flight Data Distribution – flight data is provided to MTCD for all eligible flights;

Trajectory Prediction – the Planned and Tactical Trajectories (see [TP-SPEC]) are provided to MTCD and form the basis upon which the detection of encounters is performed;

Environment Data Distribution – airspace data is provided to MTCD and forms the basis of the detection of aircraft-to-airspace encounters; the airspace configuration and sectorization are used to determine the responsibility of detected encounters, and parameterized operational procedures and letters of agreement define the encounter criteria.

Input: flight plan data and controller input (clearances).

Functional Description and Related Warning/Alert Times/Latencies

Medium-Term Conflict Detection (MTCD) is a flight data processing system designed to warn the controller of potential conflict between flights in his area of responsibility in a time horizon extending up to 20 minutes ahead.

MTCD is an integrated system of predictive tools performing the following functions:

- The detection and notification to the controller of probable loss of the required separation between two aircraft;
- The detection and notification to the controller of aircraft penetrating segregated or otherwise restricted airspace;
- The detection and display to the controller of aircraft-to-aircraft encounters where, although the required separation will be achieved, each aircraft is blocking airspace that might have - been used by the other, e.g. In case of pilot request for an alternative level or when resolving a conflict involving one of the aircraft.

The aim of MTCD is to facilitate a move from the current largely reactive form of air traffic control to more pro-active control, thereby balancing more evenly the workload of tactical and planning tasks, enhancing sector team efficiency and providing an even safer and better service to airspace users. By maximizing the opportunity of pro-actively solving problems during sector planning, it is hoped to reduce tactical workload.

The term MTCD does not refer to a particular piece or collection of equipment, but to any system designed to achieve the above goals.

Within Europe, MTCD was an important component of the First Air Traffic Control Support Tools Implementation (FASTI) programme. Launched in 2005, the FASTI programme supported the development and implementation of controller support tools at control centres across Europe and came to an end in April 2012. Another result of the programme was the development of the Tactical Controller Tool (TCT). This is a feature used as a short term (usually up to 8 minutes ahead) conflict detection and clearance verification tool.

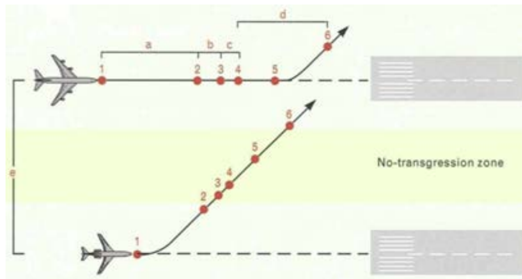
Within the MTCD application several functions are identified at the level of the ground system:

- Trajectory prediction: responsible for creating, in the system, future trajectories for each aircraft/target. (Note: due to performance requirements the system may be required to compute more than one single future trajectory for each aircraft/target);
- Conflict detection: responsible for identifying in the system potentially conflicting trajectories. Potentially conflicting trajectories are those trajectories for which the future position of 2 or more aircraft might fall below specified minima (not necessary the separation minima), given the uncertainty in the prediction;
- Trajectory update: responsible for updating in the system the predicted trajectories whenever this occurs – this functions is performed following an external input (i.e. human intervention) or due to a change in aircraft trajectory and/or automatic integration of detected aircraft position;
- Trajectory edition: responsible for allowing the human interaction with the predicted trajectory of one or more aircraft/targets.

References/Sources

http://www.skybrary.aero/index.php/Medium_Term_Conflict_Detection_(MTCD)

Precision Runway Monitor/Final Monitor Aid
In the event of a deviation, or the predicted penetration of the no-transgression zone, a graded series of alerts are presented in coordinated fashion between the two participating aircraft (the "intruder" and the "evader")



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

CAST SEs are those related to Runway topics listed above

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Approach, Landing & Surface Operations

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

Mode S sensors in the Terminal Area

Functional Description and Related Warning/Alert Times/Latencies

A stand-alone high update monopulse secondary surveillance radar system that employs an electronically scanned phase array antenna and high-resolution CRT monitors.

ATC may authorize simultaneous independent ILS, MLS, or ILS and MLS approaches to parallel dual runways with centerlines separated by at least 3,000 feet with one localizer offset by 2.5 degrees, using a Precision Runway Monitor system with a 1.0 second radar update system, and when centerlines are separated by 3,400 to 4,300 feet when precision runway monitors are utilized with a radar update rate of 2.4 seconds or less.

A high-resolution, color display that is equipped with the controller alert system software/ hardware used in the PRM, PRM-A system, or STARS.

For Simultaneous Independent ILS/ MLS Approaches, a high-resolution color monitor with alert algorithms, such as the Final Monitor Aid or that required in the Precision Monitor Program must be used to monitor approaches where triple parallel runway centerlines are at least 4,300 but less than 5,000 feet apart and the airport field elevation is less than 1,000 feet MSL. (Airfields with higher elevations require an approved FAA aeronautical study.)

Controller lead times should be less than ~7 seconds.

References/Sources

http://www.faa.gov/documentLibrary/media/Order/8200_39D.pdf

https://www.ll.mit.edu/mission/aviation/publications/publication-files/atc-reports/Lind_1993_ATC-190_WW-15318.pdf

Predictive Target Tracking (PTT) for Remote Tower applications

Accident Category (Risk Area)

Unauthorized penetration of transponder equipped movements into unauthorized areas of interest (runways, taxiways, CTR etc.);
Unauthorized penetration of non-cooperative movements into unauthorized areas of interest (runways, taxiways, CTR etc.).

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Climb, Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

An arrangement of cameras, sensors and other specific surveillance devices used to create a 3D view, which would allow visual tracking algorithms to run in the background and track movement, supported by surveillance sensors. The use of an accurate 3D map of the airport environment will enable alarms to be set of at the appropriate time.

Functional Description and Related Warning/Alert Times/Latencies

Predicting aerodrome area incursions is complex and involves many factors such as object behavior modelling. The first stage of development may target low capacity utilization, as was the case for Remote Tower, due to a reduced number of targets and complexity. With faster more accurate algorithms, safety nets based on 3D target tracking may be implemented in more dense, increasingly complex environments. However, such environments also include a higher percentage of cooperative targets so may not always provide the most challenging implementation environment.

Predictive Target Tracking could improve controller confidence and may act as an enabler for Remote Tower operations in a wider range of environments (i.e. larger airports with high traffic density and Multiple Remote Tower applications) and importantly would allow tracking technologies to be used as a form of airport safety net.

References/Sources

See page 57 of: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Required Landing Distance Check

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE215: Runway Excursion - Landing Distance Assessment
SE216: Runway Excursion - Flight Crew Landing Training
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE219: Runway Excursion - Policies, Procedures and Training to Prevent Runway Excursions
SE220: Runway Excursion - Runway Distance Remaining Signs
SE221: Runway Excursion - Policies and Procedures to Mitigate Consequences and Severity
SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

The Landing Distance Required (LDR) depends on a number of factors, principally:

The aircraft landing mass;
The surface wind and temperature;
The runway elevation and slope;
The runway surface conditions (dry, wet or contaminated); and,
The condition of aircraft braking systems.

Functional Description and Related Warning/Alert Times/Latencies

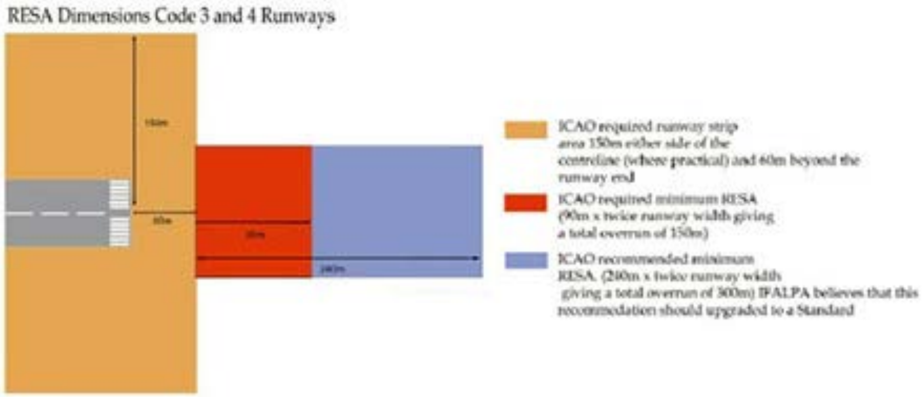
A definition of the Landing Distance Available (LDA) is provided in IR-OPS Annex I - Definitions, as "the length of the runway which is declared available by the appropriate

Authority and is suitable for the ground run of an aeroplane landing"

References/Sources

http://www.skybrary.aero/index.php/Landing_Distances

Runway End Safety Area (RESA)



Source: IFALPA Statement, *Runway End Safety Areas (RESA)*

<u>Accident Category (Risk Area)</u>

RUNWAY EXCURSION (RE)

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE215: Runway Excursion - Landing Distance Assessment
SE216: Runway Excursion - Flight Crew Landing Training
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE219: Runway Excursion - Policies, Procedures and Training to Prevent Runway Excursions
SE220: Runway Excursion - Runway Distance Remaining Signs
SE221: Runway Excursion - Policies and Procedures to Mitigate Consequences and Severity
SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121 & 135?

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Landing

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Airport

<u>Input Data Required</u>

None. RESAs are passive systems similar to EMAS above.

<u>Functional Description and Related Warning/Alert Times/Latencies</u>

Runway End Safety Areas (RESA) are a formal means to limit the consequences when aeroplanes overrun the end of a runway during a landing or a rejected take off, or undershoot the intended landing runway.

They are constructed to provide a cleared and graded area which is, as far as practicable, clear of all but frangible objects. It should have a surface which will enhance the deceleration of aircraft in the overrun case but should not be such as to hinder the movement of rescue and fire fighting vehicles or any other aspect of emergency response activity.

Minor aircraft runway overruns and undershoots are a relatively frequent occurrence. Most data sources point to significant occurrences on average once a week worldwide and suggest that runway excursions overall are the fourth largest cause of airline fatalities. It has been stated by the FAA Airport Design Division that approximately 90% of runway undershoot or overruns are contained within 300 metres of the runway end. The contribution which RESAs can make to a reduction in the consequences of such over-runs has frequently been demonstrated as has the avoidable hazardous outcomes where they have not been present.

ICAO SARPs relating to runways are determined according to runway length using the standard Runway Code categories. Code 1 runways are less than 800 metres long, Code 2 runways are 800-1199 metres long, Code 3 runways are 1200-1799 metres long and Code 4 runways are 1800 metres or more in length.

In all cases, the dimensions of a ‘Runway Strip’ are first defined as it must contain the dimensions of the designated runway surface and it should be flat, firm and free of non-frangible obstructions. For Code 3 and 4 runways, runway strips must extend at least 150 metres either side of the runway centreline and at least 60 metres beyond the end of the runway including any stopway. For Code 1 and 2 runways, the width requirement is reduced to 75 metres and for non-instrument Code 1 Runways, the length requirement is reduced to 30 metres.
ICAO RESA specifications all begin at the limit of the ‘Runway Strip’ not at the limit of the Runway/Stopway surface.

RESA SARPs were revised in 1999 when the then Recommended Practice of a 90 metre RESA was converted into a Standard. The current Requirement is that Code 3 and 4 runways have a RESA which extends a minimum of 90 metres beyond the runway strip and be a minimum of twice the width of the defined runway width. The additional Recommended Practice for these runway codes is that the RESA length is 240 metres or as near to this length as is practicable at a width equal to that of the graded strip. For Code 1 and 2 Runways, the Recommended Practice is for a RESA length of 120 metres with a width equal to the graded strip.

References/Sources

http://www.skybrary.aero/index.php/Runway_End_Safety_Area

Runway Condition Monitoring
Real-Time contaminant measurement and Landing Friction measurements

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

Sensors on survey vehicles

Functional Description and Related Warning/Alert Times/Latencies

Aircraft operations under inclement weather conditions is considered a hazardous operation because these aircraft routinely take off and land on runways that may have contaminants on them. In winter, the contaminants may include snow, ice, wet ice, frost, slush, and liquids. These contaminants significantly reduce the runway surface friction, which affects the ability of the aircraft to stop safely within the runway available length and/or to take off. Of course, this poses potential safety concerns.

For practical application during aircraft operations, measurement of contaminant parameters in aircraft movement surface condition inspection and reporting should meet the following requirements:

- Critical AMS must be monitored, either with adjacent and/or imbedded instrumentation or via inspection vehicle instrumentation or a combination of both of these methods and/or others.
- Sensor accuracy must meet or exceed levels required to confirm presence, spread, distribution, type, and depth of contaminants.
- Instruments must be capable of continuously sampling data in all potential contaminant conditions over long, uninterrupted periods.
- Instrumentation should comply with relevant standards for accuracy, durability, mean-time-between-failure, etc.
- Vehicle based data sampling speeds must be sufficient to sustain a reasonable inspection speed, ostensibly at or above 50 km/h.
- Interpretive software should be capable of averaging the sensed data in real time such that it is of value in estimating aircraft performance during current aircraft operations and is available in real-time in the vehicle.
- Conditions sensing systems should employ sensors and other hardware that are accurate, robust, reliable and cost effective.

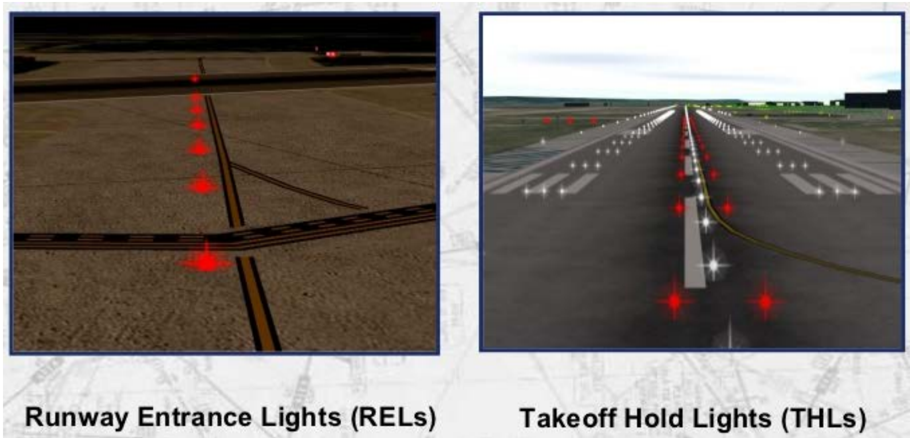
Using aircraft as a friction-measuring device can be a safety enhancement provided the flight crew fully understands what the system is designed to do, how it will do it, how it affects operations and lastly, how the data generated will be used (status of the info etc). Such a system may be part of the solution to the non-standardized friction measuring devices currently operating, and improve the relation between measured braking action and actual deceleration of aircraft, but its implementation should ensure it does not create an additional level of complexity.

References/Sources

https://www.easa.europa.eu/system/files/dfu/Report%20Volume%204%20-%20Operational%20friction%20and%20RCR.pdf

http://www.ifalpa.org/store/14POS09%20-%20Aircraft%20as%20friction%20measuring%20device.pdf

Runway Status Lights (RWSL)



Accident Category (Risk Area)

GROUND COLLISION (GCOL)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE178: Enhanced Surface Marking and Lighting

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport

Input Data Required

The lights are automated based on inputs from terminal and surveillance systems.

Runway Status Lights tell pilots and vehicle operators to stop when runways are not safe. Embedded in the pavement of runways and taxiways, the lights automatically turn red when other traffic makes it dangerous to enter, cross, or begin takeoff. The lights provide direct, immediate alerts and require no input from controllers.

Functional Description and Related Warning/Alert Times/Latencies

RWSL system is a fully automatic, advisory safety system which provides direct alerts to both vehicles and pilots independently of the normal traffic control system operated by ATC. Its objective is to reduce both the number and severity of runway incursions and thereby prevent runway collisions. It is designed to be fully compatible with existing procedures. Early versions of the system had two elements, Runway Entrance Lights (RELs) and Take Off Hold lights (THLs). Runway Intersection Lights (RHLs) were subsequently added and now the intention is to integrate the three RWSL elements with the Final Approach Runway Occupancy Signal (FAROS) system which will provide runway occupancy alerting to aircraft on final approach indicating that it is unsafe to land by automatically changing the PAPIs from a steady illumination to an intermittent one. The FAROS system is described separately.

A graphic of showing a typical application of the three ‘baseline; elements of the RWSL system is at http://www.skybrary.aero/index.php/File:Op-concept-lrg.jpg

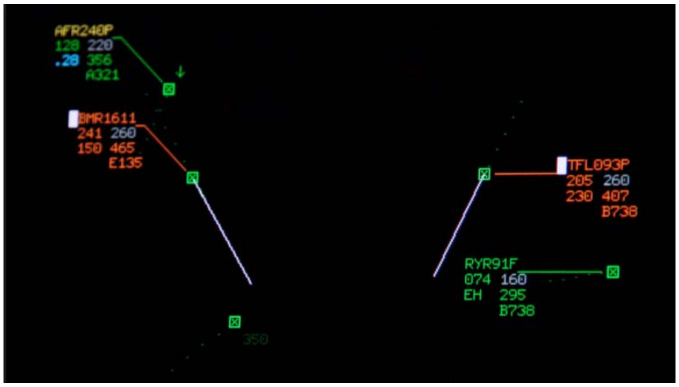
In summary:

- RELs warn that it is unsafe to enter/cross a runway
- THLs warn that it is unsafe to take off from a runway
- RILs warn that it is unsafe to cross a runway intersection

References/Sources

http://www.skybrary.aero/index.php/Runway_Status_Lights_(RWSL)

Short-Term Conflict Alert



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Typical sources of input data:

- radar surveillance data
- flight data
- environment data and parameters

Input: surveillance data (actual flight level derived from SSR mode C and assumption that the aircraft will maintain its present track). There are some implementations that also include pilot input received via SSR mode S or controller input of CFL.

Functional Description and Related Warning/Alert Times/Latencies

Short-term conflict alert (STCA) is an automated warning system for air traffic controllers (ATCO). It is a ground-based safety net intended to assist the controller in preventing collision between aircraft by generating, in a timely manner, an alert of a potential or actual infringement of separation minima.

As an implementation STCA is part of the predictive safety net functions. It uses surveillance information derived from radars, ADS-B or multilateration as well as environmental data and optional flight plan information in order to predict the movement of aircraft.

This process is usually working unnoticeably to the air traffic controller unless a (potential) separation infringement is identified. In this case STCA will generate an alarm to inform the air traffic controller about the hazardous situation identifying the conflicting aircraft.

Due to the uncertainty of trajectory prediction the look ahead time of STCA system is typically limited to approx. 2 minutes.

Extending the look ahead time is not beneficial as more and more nuisance alerts will be generated.

References/Sources

https://en.wikipedia.org/wiki/Short-term_conflict_alert

Standard Terminal Automation Replacement System (STARS)

Accident Category (Risk Area)

Enhances safety primarily for the time between wheels up and landing. STARS detects unsafe proximities between tracked aircraft pairs (Mid-Air Collision) and provides warning if tracked aircraft are detected at a dangerously low altitude (Controlled Flight Into or Toward Terrain). STARS is not intended to directly reduce runway excursion/incursion/over-run accidents.

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE047: ATC Tower Controller CRM Training
SE188: TCAS - ATC Procedures and Airspace Design
SE212: Area Navigation (RNAV) – Equipment and Procedures to Improve Route Entry for RNAV Departures
SE213: Area Navigation (RNAV) – Safe Operating and Design Practices for STARs and RNAV Departures
SE214: Area Navigation (RNAV) – Procedures and Standards to Improve Path Compliance for STARs and RNAV Departures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON

Input Data Required

STARS receives radar data and flight plan information for air traffic controllers at more than 255 radar control facilities and hundreds of airport control towers.
Flight radar data

Real-time electronic aeronautical information including:
- Weather data
- Data feeds from Automatic Dependent Surveillance-Broadcast (ADS-B) and System Wide Information Management (SWIM)

Functional Description and Related Warning/Alert Times/Latencies

STARS and ERAM enable NextGen capabilities in the NAS and work together to provide greater efficiency and benefits.

The Standard Terminal Automation Replacement System (STARS) is now in use at 70 terminal radar approach control (TRACON) facilities, including the "Big 11" TRACONs that control 80 percent of all traffic arriving and departing from U.S. airports. STARS, which replaces multiple outdated automation systems with a single state-of-the-art standardized platform, is being deployed as part of the Terminal Automation Modernization and Replacement program (TAMR). In 2017, the FAA continues to deploy STARS in large, medium, and small TRACONs. By 2019, STARS will be operational at all 255 civil and military TRACONs in the National Airspace System (NAS), thanks in part to a partnership with the Department of Defense.

STARS has new features that will make the system easier for controllers to use than the legacy systems it is replacing. The system provides:

- Weather advisories
- Assistance with terrain avoidance and conflict alerts
- Tracking of aircraft with Automatic Dependent–Broadcast (ADS-B)
- Improved traffic picture with flat-panel LED displays
- Adjustable keyboard backlighting that improves visibility and makes data entry more efficient
- A recall capability so that complex controller workstation settings preferred by an individual controller are now saved for retrieval at the touch of a button
- A highlight capability so a controller can assign a color to an aircraft to make it easier to follow
- A minimum separation capability that enables a controller to select two aircraft and ensure the required separation will be maintained
- A data block feature that automatically lists the number of aircraft in a formation — a function that previously had to be performed manually
- An infrastructure that is easier for technicians to maintain because the same system is being installed at all TRACONs

References/Sources

https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=21034&omniRss=fact_sheetsAoc&cid=103_F_S

https://en.wikipedia.org/wiki/Standard_Terminal_Automation_Replacement_System

Surveillance Target Tracking (STT) for Remote Tower applications

Accident Category (Risk Area)

Unauthorized penetration of transponder equipped movements into unauthorized areas of interest (runways, taxiways, CTR etc.);
Unauthorized penetration of non-cooperative movements into unauthorized areas of interest (runways, taxiways, CTR etc.).

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Climb, Approach & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Airport & Terminal

Input Data Required

An arrangement of cameras, sensors and other specific surveillance devices used to create a 3D view, which would allow visual tracking algorithms to run in the background and track movement, supported by surveillance sensors. The use of an accurate 3D map of the airport environment will enable alarms to be set of at the appropriate time.

Functional Description and Related Warning/Alert Times/Latencies

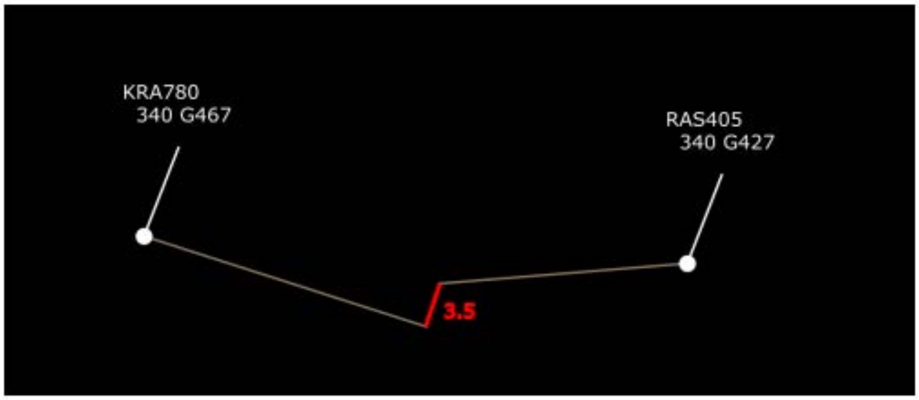
Surveillance Target Tracking (STT)

This refers to the use of positioning sensors, such as an Advanced Surface Movement Guidance and Control System (A-SMGCS), to determine the location of co-operative targets. This feature might prove beneficial for larger airports, where tracks consists mostly of transponder equipped aircraft.

References/Sources

See pg55: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

Tactical Controller Tool (TCT)



Example of TCT implementation. When the function is activated, the speed vectors of both aircraft are extended up to the closest point of approach (CPA) and the minimum distance is calculated based on the current tracks and speeds.

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Climb, Enroute & Approach

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal, TRACON, Enroute & Oceanic

Input Data Required

Input: surveillance and/or FPL data, depending on local implementation.

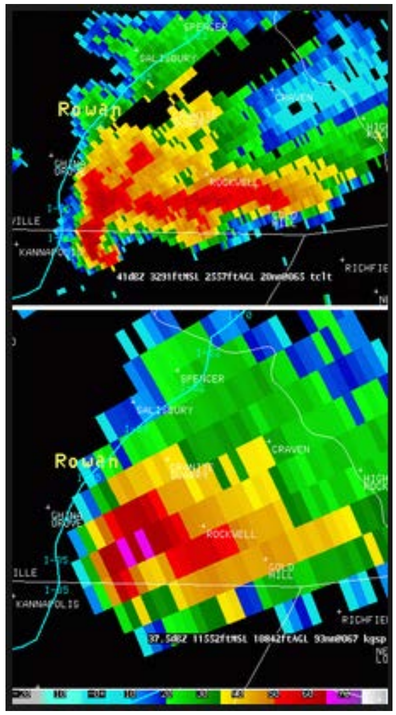
Functional Description and Related Warning/Alert Times/Latencies

Tactical Controller Tool (TCT), operating in both En-Route and TMA, warns the executive (tactical) controller of potential conflicts within the sector. To do this it usually combines current aircraft tracks with an accurate tactical trajectory that reflects the aircraft's current behavior. Some implementations are based only on surveillance data (assuming the aircraft will maintain their tracks, speeds and levels). TCT is primarily a separation assurance aid. It aims to reduce workload per aircraft for the executive (tactical) controller by providing very accurate monitoring and conflict detection. TCT helps not only in detecting problems but also in showing that no problems exist. TCT warnings are usually provided in both the vertical and lateral planes and when no TCT warnings are indicated the controller can be assured that no potential conflicts exist at that time. TCT also indicates when a "critical missed maneuver" could occur, these are situations in which loss of separation would occur if an aircraft failed to make a planned maneuver. TCT is designed to fit with and complement the MTCD sub-system and usually has a look ahead time of five to eight minutes. Depending on local implementation however, the look ahead time may be extended to match the MTCD's. TCT may be activated manually (by selecting the aircraft concerned) or automatically (when the required criteria are met).

References/Sources

http://www.skybrary.aero/index.php/Tactical_Controller_Tool_(TCT)

Terminal Doppler Weather Radar (TDWR)



Accident Category (Risk Area)

LOSS OF CONTROL - INFLIGHT (LOC-I)
WIND SHEAR OR THUNDERSTORM (WSTRW)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE039: Basic Airplane Design – Icing
SE078: Turbulence Procedures for Reducing Cabin Injuries

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Climb, Approach, Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Doppler weather radar, is a type of radar used to locate precipitation, calculate its motion, and estimate its type (rain, snow, hail etc.). Modern weather radars are mostly pulse-Doppler radars, capable of detecting the motion of rain droplets in addition to the intensity of the precipitation.

Functional Description and Related Warning/Alert Times/Latencies

Terminal Doppler Weather Radar (TDWR) is a Doppler weather radar system with a three-dimensional "pencil beam" used primarily for the detection of hazardous wind shear conditions, precipitation, and winds aloft on and near major airports situated in climates with great exposure to thunderstorms in the United States. As of 2011, all were in-service with 45 operational radars, some covering multiple airports in major metropolitan locations, across the United States & Puerto Rico.

Located in near identical locations, a TDWR return (top) and NEXRAD return (bottom) showing the improved resolution in reflectivity, but also showing the attenuation in the TDWR due to absorption from heavy precipitation as a black gap.

Terminal Doppler Weather Radar (TDWR) network is used primarily for the detection of hazardous wind shear conditions, precipitation, and winds aloft on and near major airports situated in climates with great exposure to thunderstorms in the United States. NCEI archives the derived products (called Level III), which are in the same data format as Next Generation Weather Radar (NEXRAD) Level III. NCEI does not archive the base data (called Level II).

TWDR was developed in the early 1990s at Lincoln Laboratory, which is part of the Massachusetts Institute of Technology. The TDWR system was funded by the U.S. Federal Aviation Administration (FAA) to assist air traffic controllers by providing real-time wind shear detection and high-resolution precipitation data.

References/Sources

https://www.ncdc.noaa.gov/data-access/radar-data/tdwr

Tower Data Link System (TDLS)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Approach, & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Traffic Flow Management Convective Forecast (TCF)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Visual Target Tracking (VTT) for Remote Tower applications

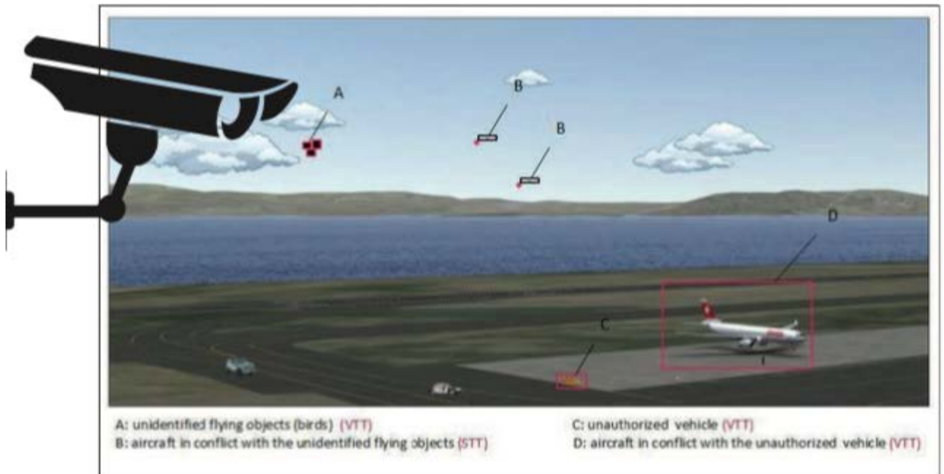


Figure 1: How can Target Tracking act as a safety net?

<u>Accident Category (Risk Area)</u>

Unauthorized penetration of transponder equipped movements into unauthorized areas of interest (runways, taxiways, CTR etc.);
Unauthorized penetration of non-cooperative movements into unauthorized areas of interest (runways, taxiways, CTR etc.).

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

n/a

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Take-off, Climb, Approach & Landing

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

Airport & Terminal

<u>Input Data Required</u>

An arrangement of cameras, sensors and other specific surveillance devices used to create a 3D view, which would allow visual tracking algorithms to run in the background and track movement, supported by surveillance sensors. The use of an accurate 3D map of the airport environment will enable alarms to be set of at the appropriate time.

Functional Description and Related Warning/Alert Times/Latencies

Visual Target Tracking (VTT)

This refers to the technical capability to detect the motion of an object, such as light aircraft and vehicles which may not be equipped with a transponder (non-cooperative targets). In the small rural airports, targeted by the first Remote Tower applications, visual tracking may also be valued for the targeting of birds, large animals, and other moving obstacles.

The information gathered from VTT and STT can be displayed in a number of ways. Above is a basic illustration based on the current HMI used to display tracking information in Remote Tower, although of course this may look very different if integrated into a local tower. We can see how conflicts can be displayed, such as a possible bird strike (see unidentified objects and incoming aircraft), as well as a ground conflict (an unauthorized vehicle on the taxiway). The information coming from Target Tracking could be integrated onto various visual displays or even overlay the control tower windows. Information from the VTT and STT can be combined with labels, text and other visualization in order to keep track of targets.

In its current form Target Tracking is only a controller support tool. Yet with improvements in reliability, it may be possible to integrate such tracking technologies into safety net applications. One such application may be a form of Aerodrome Area Incursion Alarm safety net covering both the aerodrome surface and the airspace in the vicinity. Similar to Area Proximity Warning (APW), a current well-established ground based safety net, Target Tracking could provide controllers with short term notifications of conflict situations within designated areas.

References/Sources

See page 55 of: https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22.pdf

https://www.eurocontrol.int/sites/default/files/publication/Hindsight/hindsight-22-tower-technologies.pdf

Wake Turbulence Mitigation for Departures/Arrivals (WTMD/A)

Accident Category (Risk Area)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

All

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off, Climb, Approach, & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal & TRACON

Input Data Required

Functional Description and Related Warning/Alert Times/Latencies

References/Sources

Safety Systems used by Dispatch (Airline Operations Centers)

Aircraft Situation Display (ASD)

Accident Category (Risk Area)

Disruptions to normal flight operations including weather, airspace alerts, fuel status, etc.

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135?

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

variety of sensors and information sources

Functional Description and Related Warning/Alert Times/Latencies

Aircraft Situation Displays (ASD) are flight-tracking solution providing airlines with the opportunity to improve their operational awareness by tracking, monitoring and analyzing events that can disrupt flight operations. SASDs provides real-time visualization and monitoring of the airline's fleet. The progress of each flight can be observed on an interactive map. Also, aeronautical, geographical and weather data display and organization tools are built into the product making it an ideal solution for both flight dispatch and management users. ASDs alert and advise users in real-time on decisions when specific thresholds are exceeded. The tool significantly increases situational awareness and gives possibility to respond to potential disruptions.

Key features:
Flight tracking (ACARS position reports and ASDI data) including other airlines
Full situational awareness
Integration with all Smart Suite products
Easy access to flight related information and overlays objects:

- Airports
- Runways
- Approach aids
- Airport facilities information
- Navigation aids
- Flight status (airborne, taxi, diverting, emergency, holding etc.)
- Alerts
- Airspace (FIR/UIR, Alert, Danger, Military, etc.)
- Airways/routes
- Timezones
- Weather (METAR, TAF, SIGMET, AIRMET, radar, satellite, volcanic ash, etc.)
- ETOPS information (circles, rules, entry/exit/critical points, etc.)
- Fuel status Information

Decision support
Messaging
Useful toolbars, labels and floating detail windows
Access to all other operational data including:

- Crew/passenger information
- Flight plan
- MEL

References/Sources

http://www.aircraftit.com/Operations/Vendors/Smart-SUITE/Modules/Aircraft-Situation-Display-ASD.aspx

https://www.sabre.com/insights/releases/sabre-introduces-first-real-time-flight-tracking-and-aircraft-situation-display-solutions-for-australian-aviation-market/

Centralized Weight and Balance Tools

<u>Accident Category (Risk Area)</u>

Loading and weight/balance errors

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

SE121: Cargo Loading Training and SOPs

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

Part 121

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

Pre-flight

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

n/a

<u>Input Data Required</u>

aircraft-specific characteristics and loading information for each flight

Functional Description and Related Warning/Alert Times/Latencies

Web-based, visual weight and balance tools are in used by airlines of all sizes. Being integrated with various sources such as flight data, crew data and load information, S4A such tools can support and monitor the airline's whole load planning process. They can support both centralized or de-centralized airline load control models.

General features:

- Centralized load planning
- Optimization of payloads
- Fuel costs reduction
- Personnel training costs reduction
- Improved calculations
- Increased productivity of load control department
- Worldwide access to weight and balance data
- Improved safety by reduction of the error potential
- Cross checks warn personnel of potential problems before they occur
- Efficiency boost through process standardization
- Information provision across a network - the right information on time where it is needed
- Reduced turnaround times
- Optimized fuel tankering scenarios
- Collaborative Decision Making (CDM) in combination with other Smart4Aviation products

References/Sources

https://www.airlinesoftware.net/product/1147/smart-load

Computer Flight Planning Systems (CFP) & Aircraft Routing and Monitoring Tools

Accident Category (Risk Area)

Failure to carry enough reserve fuel for ETOPS and other reserves Required to reach destination airports

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121 & 135

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Airline Operations Center information sources

Functional Description and Related Warning/Alert Times/Latencies

Producing an accurate optimized flight plan requires millions of calculations, so commercial flight planning systems make extensive use of computers (an approximate unoptimized flight plan can be done by hand in an hour or so, but more allowance must be made for unforeseen circumstances). When computer flight planning replaced manual flight planning for eastbound flights across the North Atlantic, the average fuel consumption was reduced by about 1,000 pounds per flight, and the average flight times were reduced by about 5 minutes per flight. [1] Some commercial airlines have their own internal flight planning system, while others employ the services of external planners.

References/Sources

http://www.gao.gov/products/LCD-78-437

https://www.youtube.com/watch?v=k7w1bLbF0vw

Required Landing Distance Check

Accident Category (Risk Area)

RUNWAY EXCURSION (RE)

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE215: Runway Excursion - Landing Distance Assessment
SE216: Runway Excursion - Flight Crew Landing Training
SE217: Runway Excursion - Takeoff Procedures and Training
SE218: Runway Excursion - Overrun Awareness and Alerting Systems
SE219: Runway Excursion - Policies, Procedures and Training to Prevent Runway Excursions
SE220: Runway Excursion - Runway Distance Remaining Signs
SE221: Runway Excursion - Policies and Procedures to Mitigate Consequences and Severity
SE222: Runway Excursion - Airplane-based Runway Friction Measurement and Reporting (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

Take-off & Landing

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

Terminal

Input Data Required

aeronautical information publications

Functional Description and Related Warning/Alert Times/Latencies

A definition of the Landing Distance Available (LDA) is provided in IR-OPS Annex I - Definitions, as "the length of the runway which is declared available by the appropriate Authority and is suitable for the ground run of an aeroplane landing"

References/Sources

http://www.skybrary.aero/index.php/Landing_Distances

Statistical Fuel Analysis (Airline proprietary)

Accident Category (Risk Area)

Failure to carry enough reserve fuel for ETOPS and other reserves Required to reach destination airports but primarily an issue for achieving cost savings for the airlines

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Fuel Managers involved in Dispatch Operations

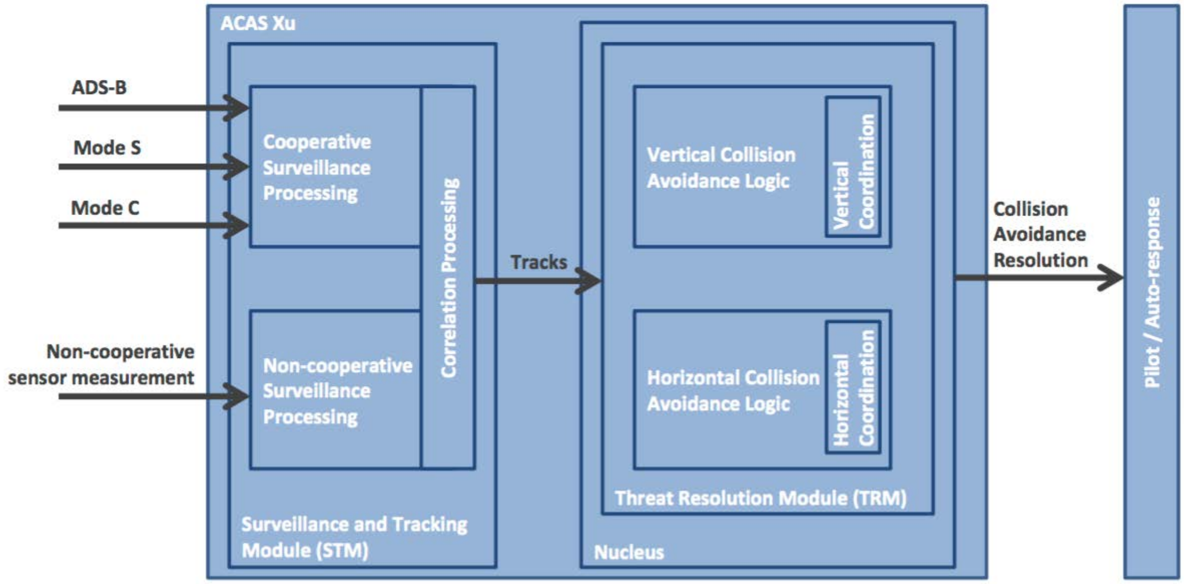
Functional Description and Related Warning/Alert Times/Latencies

References/Sources

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjX0oqelLHTAhUfS2MKHT_VBpEQFggxMAA&url=http%3A%2F%2Fiopscience.iop.org%2F1748-9326%2F10%2F9%2F094002%2Fmedia%2Ferl094002_suppdata.pdf&usg=AFQjCNGKyvCJnPfl2xVmS3lNfkTfgFnQ-w&sig2=RdOXwzpBFXtDYAKeu5ROFQ

Safety Nets related to Unmanned Aerial Vehicles

Airborne Collision Avoidance System (ACAS-Xu)



Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE165: TCAS Policies and Procedures
SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

UAS/UTM

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

all

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

low-altitude airspace

Input Data Required

The ACAS XA system will use the same hardware (antennas and displays) as the current TCAS II system and the same range of RAs – as in TCAS II version 7.1 – will be used.

<u>Functional Description and Related Warning/Alert Times/Latencies</u>

ACAS XU will provide collision avoidance protection for UAS that is interoperable with TCAS II and ACAS X systems per RTCA Special Committee 228

A variant of ACAS X, ACAS Xu (unmanned) is optimized for unmanned aircraft systems (UAS).

ACAS X detects and tracks aircraft by receiving sensor measurements from onboard surveillance systems and estimates the relative position and velocity of nearby aircraft using advanced tracking algorithms. To compensate for imperfect sensors, a surveillance and tracking module explicitly takes measurement and dynamic uncertainty into account by representing relative positions and velocities as a probabilistic state distribution. To assess potential collision risks, ACAS X uses computer-optimized logic lookup tables that capture each possible state in the probabilistic state distribution. Dynamic programming is used to solve Markov decision processes in the creation of these tables, which are used on board an aircraft. The tables provide a cost for each action–no alert, a track advisory alerting pilots about nearby aircraft, or a resolution advisory directing pilots to increase or maintain their existing separation from threat aircraft. This cost is combined with the weighted states to provide a single, optimal action. If a collision avoidance alert is necessary, this information is sent via a data bus to the flight deck displays and aural annunciators to provide pilots with the guidance corresponding to the optimal action.

<u>References/Sources</u>

http://www.rtca.org/Files/Terms%20of%20Reference/SC-147_March_2016_TOR.pdf

Airborne Detect And Avoid (DAA) system

Accident Category (Risk Area)

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE165: TCAS Policies and Procedures
SE186: TCAS Sensitivity Level Command
SE188: TCAS - ATC Procedures and Airspace Design
SE191: New TCAS/Next TCAS Equipment

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

UAS/UTM

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

all

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

low-altitude airspace

Input Data Required

sensors and algorithms aboard UAS

Functional Description and Related Warning/Alert Times/Latencies

Detect and Avoid, also known as Sense and Avoid or Due Regard, uses NanoSAR technology to allow manned or unmanned aircraft to automatically detect other airborne objects and predict potential midair collisions even at night and in low-visibility conditions. If a collision threat exists, the detect-and-avoid radar system alerts the pilot or autopilot so that a new course can be taken, safely avoiding a collision.

NanoSAR detect-and-avoid radar detects the presence of other airborne obstacles and predicts and avoids potential midair collisions. Using radio waves reflected from objects, radar systems naturally obtain information on the distance (range) to those objects. Radio waves from radar systems naturally penetrate visual obstructions such as clouds, fog, smoke, and precipitation, so this same information can be collected even at night and in low-visibility conditions.

HOW DOES DAA WORK?

Detect-and-avoid radar systems use multiple receive antennas to add information on elevation and location of objects to the already available information on range. Using advanced algorithms to compare the signals collected, the system can detect airborne objects and calculate the location and trajectory of those objects. Because the system also knows its own location, it can predict when the trajectory of an airborne object is likely to result in a midair collision.

DETECT

Detect-and-avoid radar systems use multiple receive antennas to add information on elevation and location of objects to the already available information on range. By comparing the signals collected by each of the receive antennas using advanced algorithms, the system can detect airborne objects and calculate the location and trajectory of those objects. Because the system also knows its own location, it can predict when the trajectory of an airborne object is likely to result in a midair collision.

AVOID

Data from the detect-and-avoid radar system can be visually displayed over a map for a manned pilot or sent directly to an autopilot system for manned or unmanned aircraft. When a potential midair collision is predicted by the system, alerts can be sent to pilots or autopilot systems with enough warning to move the aircraft, either manually or automatically, to avoid the midair collision.

IMSAR's detect-and-avoid radar is designed with minimal Size, Weight, and Power (SWaP) to fit on even small Unmanned Aerial Vehicles (UAVs) to allow UAVs and manned aircraft to share the same airspace safely.

References/Sources

http://www.imsar.com/pages/capabilities/daa.php

Dynamic Geo-Fencing

<u>Accident Category (Risk Area)</u>

AIRPROX/TCAS ALERT/LOSS OF SEPARATION/NEAR MIDAIR COLLISIONS/MIDAIR COLLISIONS (MAC)
JIMDAT Undesired Aircraft State: LOSS OF SEP

<u>Related CAST Safety Enhancements</u>
<u>(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)</u>

n/a

<u>Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)</u>

UAS/UTM

<u>Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)</u>

all

<u>Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)</u>

low-altitude airspace

Input Data Required

GPS signals and sensors as well as pre-defined map areas to be avoided by UAS

Functional Description and Related Warning/Alert Times/Latencies

A geo-fence is a virtual perimeter for a real-world geographic area.[1] A geo-fence could be dynamically generated–as in a radius around a store or point location, or a geo-fence can be a predefined set of boundaries, like school attendance zones or neighborhood boundaries.

The use of a geo-fence is called geo-fencing, and one example of usage involves a location-aware device of a location-based service (LBS) user entering or exiting a geo-fence. This activity could trigger an alert to the device's user as well as messaging to the geo-fence operator. This info, which could contain the location of the device, could be sent to a mobile telephone or an email account.

Drone manufacturers should build geofencing constraints into unmanned aerial vehicle navigation systems that would override the commands of the unsophisticated operator, preventing the device from flying into protected airspace.

From: https://www.dji.com/newsroom/news/dji-fly-safe-system

Geospatial Environment Online (GEO) will provide DJI drone users with up-to-date guidance on locations where flight may be restricted by regulation or raise safety concerns. For the first time, drone operators will have, at the time of flight, access to live information on temporary flight restrictions due to forest fires, major stadium events, VIP travel, and other changing circumstances. The GEO system will also include, for the first time, restrictions around locations such as prisons, power plants and other sensitive areas where drone operations raise non-aviation security concerns.

The drone will by default not fly into or take off in, locations that raise safety or security concerns. However, in order to accommodate the vast variety of authorized applications, the new system will also allow users who have verified DJI accounts to temporarily unlock or self-authorize flights in some of those locations. The unlock function will not be available for sensitive national-security locations such as Washington, D.C. or other prohibited areas.

Unlocking will require a DJI user account verified with a credit card, debit card or mobile phone number. DJI will neither collect nor store this information, and the service will be free. The verified account, required only if and when a user chooses to fly in a location that might raise an aviation safety or security concern, provides a measure of accountability in the event that the flight is later investigated by authorities.

References/Sources

https://en.wikipedia.org/wiki/Geo-fence

Human-Factors-related Safety Nets

Pilots and controllers bring significant safety benefits to the aviation system that are not able to be automated. They detect subtle cues and indications that cannot be picked up by equipment alone. Pilots and controllers are also flexible and adaptive and these attributes are very hard to replicate in technical systems; these benefits are often not adequately articulated and can be inadvertently ignored. Therefore, for the foreseeable future, I believe that there is the need for human integration with technology and it is vital that in designing the next ATM system we maximize the beneficial aspects of pilot and controller involvement and use automation to assist and support their task.

Safety nets have a vital part in our future systems but I believe they will be much closer integrated with the core routine. Using the example of automated ground control, it is likely that airports will require a residual controller capability to deal with unique situations and to resolve unusual situations. A fallback capability is also likely to be needed to ensure resilience in case of technical failure. Therefore, an appropriate level of controller skill needs to be maintained to deliver this capability; it might be more appropriate to lower the level of automation so that the controller interacts with the technical system to provide a degree of hands on control, assisted by the automation. The technical capability of the system could then be used to provide medium term conflict alert whilst still allowing controller resolution. However, ultimately if the system detects a safety critical situation then it could step in and put a stop bar to red or not illuminate a certain taxi path. With such a system, we can see that the controller support tool blends with a safety net and we can monitor and measure the alerts generated so we have an indication of emergent controller behavior and potential over reliance on the support tool.

Aviation Safety Action Program (ASAP)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Voluntary, confidential safety reports

Functional Description and Related Warning/Alert Times/Latencies

The goal of the Aviation Safety Action Program (ASAP) is to enhance aviation safety through the prevention of accidents and incidents. Its focus is to encourage voluntary reporting of safety issues and events that come to the attention of employees of certain certificate holders.

To encourage an employee to voluntarily report safety issues even though they may involve an alleged violation of Title 14 of the Code of Federal Regulations (14 CFR), enforcement-related incentives have been designed into the program. An ASAP is based on a safety partnership that will include the Federal Aviation Administration (FAA) and the certificate holder, and may include any third party such as the employee's labor organization.

An ASAP report is created specifically to provide a means for employees to report safety-related events. All individual ASAP reports are clearly labeled as such and must be signed by each employee seeking the enforcement incentives available under an ASAP. Two types of reports are ordinarily submitted under the ASAP:

- Safety-related reports that appear to involve one or more violations of the regulations (e.g., deviating from an Air Traffic Control (ATC)-assigned altitude)
- Reports that identify a general safety concern, but do not appear to involve a violation of the regulations (e.g., flight crewmember concerns that the design of a flight checklist could lead to an error)

Aviation Safety Action Programs (ASAP) implemented by certificate holders are protected from public disclosure in accordance with the provisions of Title 14 of the Code of Federal Regulations (14 CFR) part 193.

ASAP programs are post-hoc incident analysis systems and do not provide near-real-time warnings and alerts.

References/Sources

https://www.faa.gov/about/initiatives/asap/

Aviation Safety Reporting System (ASRS)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Voluntary, confidential safety reports

Functional Description and Related Warning/Alert Times/Latencies

The ASRS is an important facet of the continuing effort by government, industry, and individuals to maintain and improve aviation safety. The ASRS collects voluntarily submitted aviation safety incident/situation reports from pilots, controllers, and others.

The ASRS acts on the information these reports contain. It identifies system deficiencies, and issues alerting messages to persons in a position to correct them. It educates through its newsletter *CALLBACK*, its journal *ASRS Directline* and through its research studies. Its database is a public repository which serves the FAA and NASA's needs and those of other organizations world-wide which are engaged in research and the promotion of safe flight.

Purpose
The ASRS collects, analyzes, and responds to voluntarily submitted aviation safety incident reports in order to lessen the likelihood of aviation accidents.
ASRS data are used to:

- Identify deficiencies and discrepancies in the National Aviation System (NAS) so that these can be remedied by appropriate authorities.
- Support policy formulation and planning for, and improvements to, the NAS.
- Strengthen the foundation of aviation human factors safety research. This is particularly important since it is generally conceded that over two-thirds of all aviation accidents and incidents have their roots in human performance errors.

The ASRS database provides a foundation for specific products and subsequent research addressing a variety of aviation safety issues. ASRS's database includes the narratives submitted by reporters (after they have been sanitized for identifying details). These narratives provide an exceptionally rich source of information for policy development and human factors research. The database also contains coded information from the original report which is used for data retrieval and statistical analyses.

The ASRS is a post-hoc incident analysis system and does not provide near-real-time warnings and alerts.

References/Sources

https://asrs.arc.nasa.gov/overview/summary.html

Crew Resource Management (CRM)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE011: Crew Resource Management (CRM) Training
SE199: Airplane State Awareness - Enhanced Crew Resource Management Training

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

CRM - Crew Resource Management - is the effective use of all available resources for flight crew personnel to assure a safe and efficient operation, reducing error, avoiding stress and increasing efficiency.

CRM was developed as a response to new insights into the causes of aircraft accidents which followed from the introduction of flight data recorders (FDRs) and cockpit voice recorders (CVRs) into modern jet aircraft. Information gathered from these devices has suggested that many accidents do not result from a technical malfunction of the aircraft or its systems, nor from a failure of aircraft handling skills or a lack of technical knowledge on the part of the crew; it appears instead that they are caused by the inability of crews to respond appropriately to the situation in which they find themselves. For example, inadequate communications between crew members and other parties could lead to a loss of situational awareness, a breakdown in teamwork in the aircraft, and, ultimately, to a wrong decision or series of decisions which result in a serious incident or a fatal accident.

The widespread introduction of the dynamic flight simulator as a training aid allowed various new theories about the causes of aircraft accidents to be studied under experimental conditions. On the basis of these results, and in an attempt to remedy the apparent deficiency in crew skills, additional training in flight deck management techniques has been introduced by most airlines. Following a period of experimentation and development, the techniques embraced by the new training became known collectively as CRM. The importance of the CRM concept and the utility of the training in promoting safer and more efficient aircraft operations have now been recognized worldwide.

References/Sources

http://www.skybrary.aero/index.php/Crew_Resource_Management

Fatigue Risk Management System (FRMS)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE211: Airplane State Awareness - Training for Attention Management (R-D)

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

operator on-duty histories and modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

A Fatigue Risk Management System (FRMS) has been defined by ICAO as "a data-driven means of continuously monitoring and maintaining fatigue related safety risks, based upon scientific principles and knowledge as well as operational experience that aims to ensure relevant personnel are performing at adequate levels of alertness".

Description
Historically, the aviation industry has taken a regulatory approach to fatigue prevention through the specification of flight and duty time limitations in a Flight Time Limitations (FTL) Scheme. This is done by limiting the number of hours aircrew can work and specifying the minimum rest time which is required before commencement of each flight duty period. The purpose of an FRMS is to support the safe application of such FTL Schemes by recognizing the need for aircrew be adequately rested before commencing and during flying duties by facilitating both proactive and reactive interventions in relation to the implementation of FTL Schemes.

It has been recognized through research that there are a number of causes of fatigue including:
Lack of adequate sleep within a specified rest period.
Daily body rhythms, known as circadian rhythms, which may impact the quality of sleep and / or affect performance when awake.

A fatigue risk management system allows operators to effectively utilizes their FTL Scheme whilst taking into account the above effects. Fatigue models are may be used to proactively. Demonstrated safety benefits have included increased crew member alertness, better work life balance amongst crews and a reduction in absenteeism attributed to fatigue. In addition to this, an FRMS may facilitate increased productivity and rostering flexibility.

Several examples of successful FRMS are in place today:

New Zealand has the longest experience with the application of FRMS principles to FTL-based rostering. In 1995, New Zealand Civil Aviation Authority Regulations were changed to allow operators to use either a standard FTL scheme or an approved variation on that scheme justified by an assessment and appropriate response to additional factors that might cause fatigue.

Singapore Airlines introduced a FRMS in 2003 after commencement of ultra long haul (ULH) flights between Singapore and New York. The company was allowed to operate these flights as a result of scientific recommendations based on biomathmatical modelling.

easyJet was the first major short haul airline to be issued with a Regulatory dispensation from their FTL Scheme in order to operate a new crew roster pattern which took account of FRMS principles. That roster featured a sequence of 5 early starts, 2 days off, 5 late starts, 4 days off in place of the previous cycle of 3 early starts, 3 late starts, 3 days off).

References/Sources

http://www.skybrary.aero/index.php/Fatigue_Risk_Management_System_(FRMS)

Flight Operations Quality Assurance (FOQA)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Voluntary, confidential safety reports

Functional Description and Related Warning/Alert Times/Latencies

Flight Operations Quality Assurance (FOQA) is a voluntary safety program that is designed to make commercial aviation safer by allowing commercial airlines and pilots to share de-identified aggregate information with the FAA so that the FAA can monitor national trends in aircraft operations and target its resources to address operational risk issues (e.g., flight operations, air traffic control (ATC), airports). Based on the experiences of foreign air carriers, the results of several FAA-sponsored studies, and input received from government/industry safety forums, the FAA concluded that wide implementation of FOQA programs could have significant potential to reduce air carrier accident rates below current levels. A reduction in the already low U.S. airline accident rate is needed to preclude a projected growth in the number of accidents, which is expected to occur due to increased future traffic volume. The value of FOQA programs is the early identification of adverse safety trends that, if uncorrected, could lead to accidents.

The fundamental objective of this new FAA/pilot/carrier partnership is to allow all three parties to identify and reduce or eliminate safety risks, as well as minimize deviations from the regulations. To achieve this objective and obtain valuable safety information, the airlines, pilots, and the FAA are voluntarily agreeing to participate in this program so that all three organizations can achieve a mutual goal of making air travel safer.

A cornerstone of this new program is the understanding that aggregate data that is provided to the FAA will be kept confidential and the identity of reporting pilots or airlines will remain anonymous as allowed by law. Information submitted to the FAA pursuant to this program will be protected as “voluntarily submitted safety related data” under Title 14 of the Code of Federal Regulations (14 CFR) part 193.

FOQA programs include provisions for the identification of safety issues and development and implementation of corrective actions. FOQA can provide objective safety information that is not otherwise obtainable. No aircraft operator is required to have a FOQA program.

FOQA programs are post-hoc analysis system and do not provide near-real-time warnings and alerts.

References/Sources

https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-82.pdf

Line Operations Safety Audit (LOSA)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

data recorded by trained observers and modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

Line Operations Safety Audit (LOSA) is seen as an important way to help develop countermeasures to operational errors. It involves a structured programme of observation of front line activities built around the Threat and Error Management (TEM) concept. It aims to identify threats to operational safety, identify and minimize the risks which are the origin of such threats and implement measures to manage the human error aspects of the residual risk. LOSA provides a way to assess the level of organizational resilience to systemic threats in accordance with the principles of a data-driven approach.

LOSA uses trained observers to collect data about pilot behavior and its situational context on “normal” flights from supernumerary seats on the flight deck. Such monitoring allows the capture of data which can characterize pilot strategies for managing "threats, errors and undesirable states". The audits are conducted under strict no-jeopardy conditions; therefore, flight crews are not held accountable for their actions and errors that are observed. During flights that are being audited, observers record and code:

Potential threats to safety;
How the threats are addressed;
The errors such threats generate;
How flight crews manage these errors;
Specific behaviors that have been known to be associated with accidents and incidents.

The LOSA method is seen as closely linked with Crew Resource Management (CRM) training. A particular strength of LOSA is perceived as the way it identifies examples of "superior" pilot performance that can be provide models for use in training.

References/Sources

https://www.skybrary.aero/index.php/Line_Operations_Safety_Audit_(LOSA)

Line Oriented Flight Training (LOFT)

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

data recorded during flight simulators sessions and modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

Line Oriented Flight Training (LOFT) is carried out in a flight simulator as part of initial or recurrent flight crew training. It involves a detail conducted in real time and representative of line operations but includes special emphasis on abnormal situations which involve communications, management and leadership. The abnormalities which will be encountered are not pre-briefed.

The concept of LOFT was first expounded in ICAO Circular 217 AN/132 'Human Factors Digest No 2' in 1989 which has since been republished in its original form as UK CAA Publication CAP 720 (CRM and LOFT) CAP 720 states in the introduction to Chapter 5 that:
"LOFT can have a significant impact on aviation safety through improved training and validation of operational procedures. LOFT presents to aircrews scenarios of typical daily operations in their airline with reasonable and realistic difficulties and emergencies introduced to provide training and evaluation of proper flight deck management techniques. The result is an appreciation by the air carrier of operational shortcomings on the part of line crews and an evaluation of the adequacy of flight deck procedures and instrumentation, as well as over-all crew training effectiveness."

LOFT scenarios may be developed from many sources, but accident reports provide a realistic and appropriate starting point. A properly conducted LOFT programme can provide great insight into the internal workings of an airline's operations and training programme for the following reasons:

- If similar mistakes seem to be recurring among pilots, it may indicate a potentially serious problem as a result of incorrect procedures, conflicting or incorrect manuals, or other operational aspects.
- It may reveal areas in aircrew training programmes which are weak or which need emphasis.
- It may reveal problems with instrument locations, information being presented to pilots, or other difficulties with the physical layout of a particular flight deck.
- Air carriers can use it to test and verify flight deck operational procedures.

References/Sources

https://www.skybrary.aero/index.php/Line_Oriented_Flight_Training

Operational Use of Flight Path Management Systems

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

SE214: Area Navigation (RNAV) – Procedures and Standards to Improve Path Compliance for STARs and RNAV Departures

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

The Final Report of the Flight Deck Automation Working Group was published by the FAA in the autumn of 2013. It is an extremely thorough evidence-based assessment of the problems which have accompanied the rapid advance in the level of automation. It is also the first comprehensive review of the subject since a 1996 FAA Report on "Interfaces between flight crews and modern flight deck systems".

Underlying themes identified by the Working Group include:

- complexity (in systems and in operations)
- concerns about degradation of pilot knowledge and skills
- integration and interdependence of the components of the aviation system

The Report also notes that since the Working Group completed its data collection and analysis "several accidents have occurred where the investigative reports identified vulnerabilities in the events that are similar to those vulnerabilities identified in this report".

A series of 28 interconnected data-driven findings led to the Group agreeing a total of 18 similarly interconnected Recommendations as follows:

Manual Flight Operations, Autoflight Mode Awareness, Information Automation, FMS Documentation, Design, Training, and Procedures for Operational Use, Verification and Validation for Equipment Design, Flight Deck System Design, Guidance for Flightcrew Procedures for Malfunctions, Design of Flightcrew Procedures, Operational Policy for Flight Path Management, Pilot-Air Traffic Communication and Coordination, Airspace Procedure Design, Flight Deck Design Process and Resources, Pilot Training and Qualification, Instructor/Evaluator Training and Qualification, Regulatory Process and Guidance for Aircraft Certification and Operational Approvals, Flight Deck Equipment Standardization, Monitor Implementation of New Operations and New Technologies, Methods and Recommended Practices for Data Collection, Analysis and Event Investigation That Address Human Performance and Underlying Factors

References/Sources

http://www.skybrary.aero/index.php/Operational_Use_of_Flight_Path_Management_Systems

Normal Operations Safety Survey (NOSS) in ATC

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

data recorded by trained observers and modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

The Normal Operations Safety Survey (NOSS) is a methodology for the collection of safety data during normal air traffic control (ATC) operations. A normal ATC operation is defined as an operation during the course of which no accident, incident or event takes place of which the reporting and/or investigation are required under existing legislation or regulations. Training and check shifts are considered to be outside the scope of normal operations.

By conducting a series of targeted observations of ATC operations over a specific period of time, and the subsequent analysis of the data thus obtained, the organization is provided with an overview of the most pertinent threats, errors and undesired states that air traffic controllers must manage on a daily basis. One feature of NOSS is that it identifies threats, errors and undesired states that are specific to an organization's particular operational context, as well as how those threats, errors and undesired states are managed by air traffic controllers during normal operations. The information thus obtained will enhance the organization's ability to proactively make changes in its safety process without having to experience an incident or accident.

NOSS is designed to complement existing safety data collection sources. Its added value is that it provides data from normal operations (as opposed to abnormal occurrences during operations), and it is not occurrence-driven like most of the existing mechanisms. NOSS can be scheduled at any time that is suitable for the organization, to sample the systemic safety performance in daily operations and to provide an overview of the organizational strengths and weaknesses in the management of threats, errors and undesired states during normal operations. The organization can subsequently act on the outcome of a NOSS before safety issues manifest themselves through occurrences.

References/Sources

http://www.skybrary.aero/index.php/Normal_Operations_Safety_Survey_(NOSS)

Team Resource Management (TRM) in ATC

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

Team Resource Management (TRM) is defined as: Strategies for the best use of all available resources - information, equipment and people - to optimize the safety and efficiency of Air Traffic Services.

By the early 1990's, the corresponding concept of CRM had been embodied in flight crew training by among aircraft operators for many years and there was already good evidence to show that those programmes had been successful in reducing accident and incident rates. TRM was identified as a way of following CRM principles and both, along with the more recent Maintenance Resource Management (MRM), have now been embraced in the wider context of safety management as interventions that defend aircraft operations against common causes of system failure.

Like CRM, TRM was based on the recognition that many operational incidents could be traced back to failures in human performance and teamwork. A EUROCONTROL initiative led to the creation of one of the first TRM training programmes. This prototype included separate modules on Teamwork, Team roles, Communication, Situational Awareness, Decision Making and Stress. Later two additional modules were added to cover the management of error and violation and the impacts of automation.

Effective TRM in ATC requires the best use of all available resources in support of a safe and efficient operation which reduces both the incidence of error and the consequences of residual error. A focus on TRM is especially designed to improve the functioning of air traffic control teams. It does this by increasing the awareness and understanding of interpersonal behavior and human factor capabilities as they are likely to affect operational safety.

There is also evidence to show that CRM principles can be successfully applied to air traffic management. TRM training can reduce teamwork-related incidents and enhanced task efficiency.

The main benefits of TRM are now considered to be:

- Reduced teamwork-related incidents
- Enhanced task efficiency
- Improved use of staff resources
- Enhanced continuity and stability of team work in ATM
- Enhanced sense of working as a part of a larger and more efficient team
- Increased job satisfaction

References/Sources

http://www.skybrary.aero/index.php/Team_Resource_Management_(TRM)

Threat and Error Management (TEM) in ATC

Accident Category (Risk Area)

All

Related CAST Safety Enhancements
(from: http://www.skybrary.aero/index.php/Portal:CAST_SE_Plan)

n/a

Predominant Domain of Use (Part 121, Part 135 (Charter), General Aviation, Military, Rotorcraft, Unmanned Aerial Systems)

Part 121, 135 & GA

Applicable Flight Regime (Take-off, Climb, Enroute, Approach, Landing)

All

Applicable ATC Domain (Terminal, TRACON, Enroute, Oceanic)

All

Input Data Required

Modern best practices in the aerospace human factors community

Functional Description and Related Warning/Alert Times/Latencies

Threat and Error Management (TEM) is an overarching safety concept regarding aviation operations and human performance. TEM is not a revolutionary concept, but one that has evolved gradually, as a consequence of the constant drive to improve the margins of safety in aviation operations through the practical integration of Human Factors knowledge.

TEM was developed as a product of collective aviation industry experience. Such experience fostered the recognition that past studies and, most importantly, operational consideration of human performance in aviation had largely overlooked the most important factor influencing human performance in dynamic work environments: the interaction between people and the operational context (i.e., organizational, regulatory and environmental factors) within which people discharged their operational duties.

There are three basic components in the TEM framework. From the perspective of their users, they have slightly different definitions: threats, errors and undesired (aircraft) states. The framework proposes that threats and errors are part of everyday aviation operations that must be managed by the aviation professionals, since both threats and errors carry the potential to generate undesired states. The undesired states carry the potential for unsafe outcomes thus undesired state management is an essential component of the TEM framework, as important as threat and error management. Undesired state management largely represents the last opportunity to avoid an unsafe outcome and thus maintain safety margins in aviation operations.

Threats - generally defined as events or errors that occur beyond the influence of the line personnel, increase operational complexity, and which must be managed to maintain the margins of safety.

Errors - generally defined as actions or inactions by the line personnel that lead to deviations from organizational or operational intentions or expectations. Unmanaged and/or mis-managed errors frequently lead to undesired states. Errors in the operational context thus tend to reduce the margins of safety and increase the probability of an undesirable event.

Undesired states - generally defined as operational conditions where an unintended situation results in a reduction in margins of safety. Undesired states that result from ineffective threat and/or error management may lead to compromised situations and reduce margins of safety aviation operations. Often considered the last stage before an incident or accident.

References/Sources

http://www.skybrary.aero/index.php/Threat_and_Error_Management_(TEM)

References

1. Preliminary ASN data show 2016 to be one of the safest years in aviation history; https://news.aviation-safety.net/2016/12/29/preliminary-asn-data-show-2016-to-be-one-of-the-safest-years-in-aviation-history/
2. Dekker, Sidney, Hollnagel, Erik, Woods, David, and Cook, Richard, *Resilience Engineering: New directions for measuring and maintaining safety in complex systems*, Final Report, November 2008, Lund University School of Aviation