National Aeronautics and Space Administration

Airport Safety Research

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Airport Safety

Goal: Prevent collisions in the terminal maneuvering area in any visibility condition through technologies that enhance situational awareness, navigation, and alerting for the pilot.

Avoidance – Ability of pilots to reduce the likelihood of getting into a potential conflict situation.

- Own-ship position awareness
- Traffic position awareness
- Route awareness
- Route deviation detection

Detection – Ability to become aware that a potential conflict situation has occurred so that action can be taken if necessary to avoid the conflict.

- Timely alerting to flight crew and ATC

Airport Safety Technology

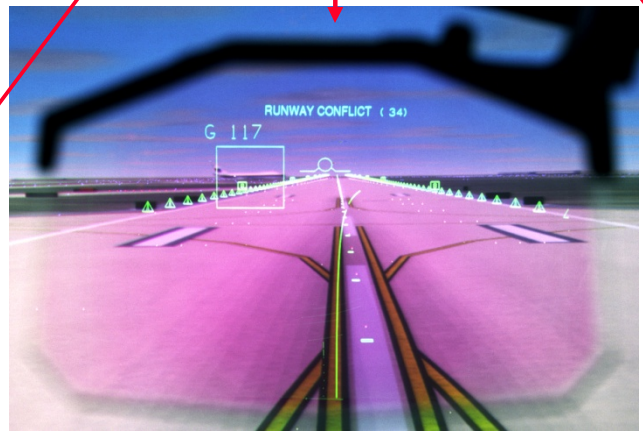
Avoidance

II. Know where others are
Traffic position awareness
(ADS-B or TIS-B data link)

I. Know where you are
Own-ship position awareness
(GPS & airport database)

III. Know where to go
Route awareness
(Taxi route from ATC)

Approach Surface Map



HUD Guidance

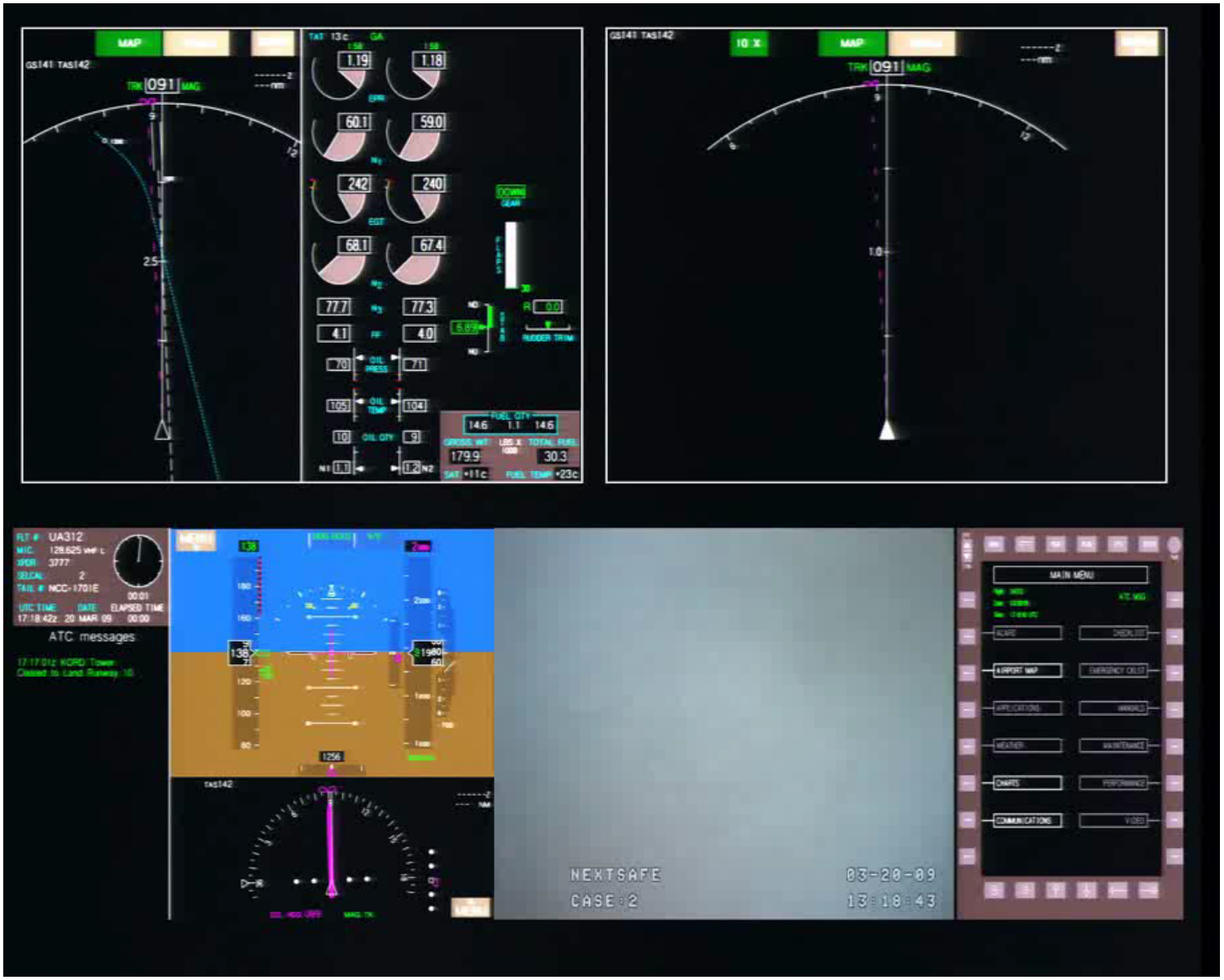
"Warning, Traffic 34R"
"Caution, Traffic Departing 25"
"Crossing Hold"
"Off Route"

Taxi Surface Map

Detection

IV. Know when a mistake occurs
(Immediately alert flight crew & ATC)

Indication and Alert on Approach



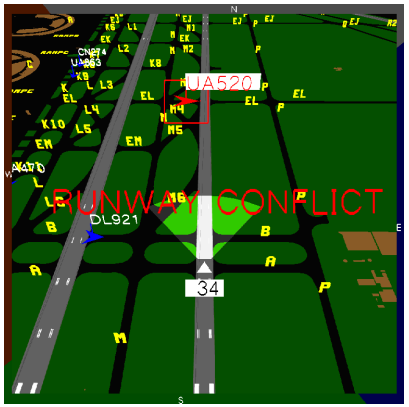
Airport Safety Research Evolution

Runway Incursion Avoidance

Runway Incursion Detection

Terminal Area Conflict Detection

Airport surface situation awareness and enabling technology research

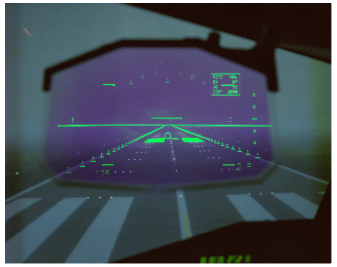


Commercial - intersecting runway incursion prevention

FAA announces nationwide ADS-B deployment

Terminal area conflict detection, alerting & resolution

1990 | 2000 | 2010



Commercial - single runway incursion prevention

General aviation incursion prevention

Electronic Flight Bag Guidelines Published AC 120-76(A)

Prior Research

Runway Incursion Avoidance (1993 – 1998)

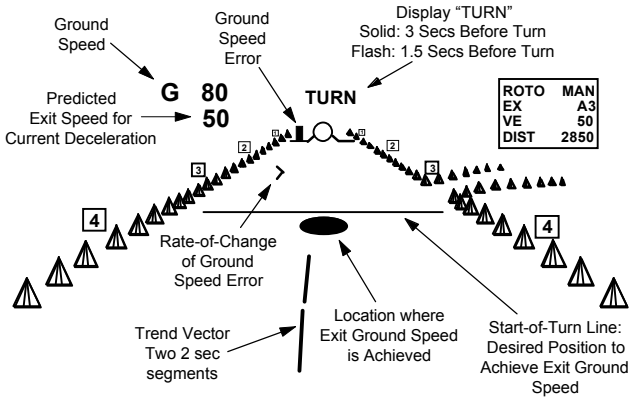
Terminal Area Productivity (TAP) Program

Low Visibility Landing and Surface Operations (LVLASO) Project

Goal: Safely achieve clear-weather runway and taxiway capacity during instrument weather conditions

- *Taxi-Navigation and Situation Awareness (T-NASA)* (ARC) to achieve safe and efficient taxi operations in low visibility

- *Roll-out Turn-off (ROTO)* to assist crew in safely reducing runway occupancy time in low visibility by providing deceleration profile to chosen exit



Prior Research

Runway Incursion Avoidance (1993 – 1998)

- Simulation studies
  (LaRC and ARC)
- 1995, B-737 flight testing at FAA Technical Center, Atlantic City, NJ
- 1997, B-757 flight testing at Hartsfield Atlanta International Airport

System concept installed in Flight Simulation Facility (ATC interface not shown)

Prior Research

Runway Incursion Avoidance (1993 – 1998)

LVLASO simulation and flight tests have shown:

- Feasibility of concept in operational environment
- Taxi efficiency and safety are improved
  - Increased taxi speeds
  - Elimination of off-route navigation errors
- Runway occupancy time can be maintained in low visibility conditions
- Pilots have greater confidence regarding aircraft position and airport state

Prior Research

Runway Incursion Detection (1999 – 2006)

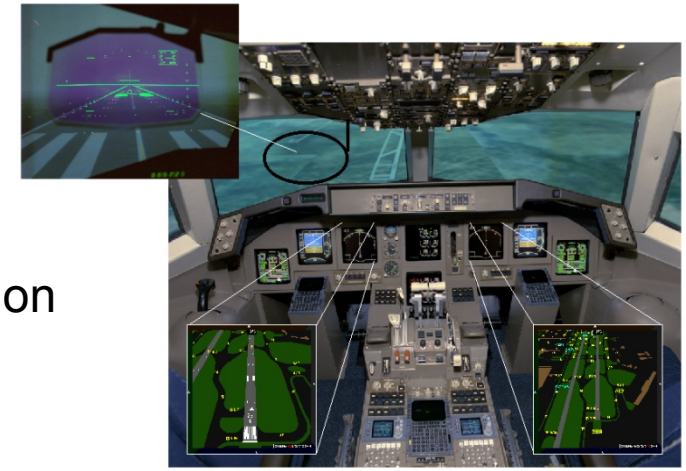
Aviation Safety (AvSP) Program Synthetic Vision Systems (SVS) Project

B-757 Flight Test at DFW Airport (2000)

- Both airborne and ground-based detection
- FAA surveillance system
- Single runway scenarios

HUD Guidance

Electronic Moving Map



Full Mission Simulation Study (2002)

- Detection algorithm and display concept evaluation
- Single runway scenarios
- Crew evaluation

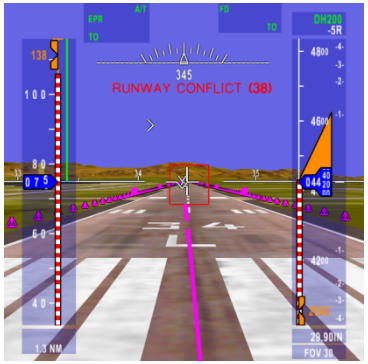
Prior Research

Runway Incursion Detection (1999 – 2006)

Aviation Safety (AvSP) Program Synthetic Vision Systems (SVS) Project

Gulfstream-V Flight Test at Reno and Wallops (2004)

- RIPS integrated with Synthetic Vision System
- Intersecting runway scenarios



General Aviation (GA) Simulation Study (2005)

- Detection algorithm, display concepts, and pilot performance evaluation
- GA test subjects

Prior Research

Runway Incursion Detection (1999 – 2006)

Commercial operations research has shown:

- Feasibility of onboard detection and alerting
- Onboard detection and alerting increased safety margins and likelihood of incursion prevention
- Onboard alerts more timely for crew than ground-generated alerts
- Aural alert provides first awareness of incursion
- On departure, abort conducted sooner with alerting
- Surface map with traffic effective in preventing taxi incursions and provided increased situation awareness for surface operations

General aviation operations research has shown:

- Severe risk of collision occurred with traffic shown on surface map
- Traffic presentation marginally beneficial unless alerting provided
- Alerts provided sufficient time to avoid potential conflict
  - On approach: Caution 35 sec., Warnings 25 sec. from traffic
- Alerting provided greater safety margins on departure
  - Aborted sooner, 2 to 6 seconds
- Audible alert minimum required, alert with map and traffic optimal

Pilots prefer:
- Earlier alerting on approach with caution and warning alerts
- Simple, quick alerting for departure and taxi
- Descriptive alert with location and maneuver guidance

Current & Future Research

Objectives

Continue and expand research in aircraft-based conflict detection and resolution (CD & R) concepts to ensure safe terminal/surface area operations for current and future NAS operations.

Surface collision avoidance flight deck technologies

- Crew/vehicle interface concepts
- NextGen operations requirements
- Mixed fleet equipage and operations
- ATC interactions
- Complementary airborne and ground conflict detection and alerting

Aircraft-based airport traffic collision avoidance algorithms

- Runway, taxi, and low altitude conflict detection and alerting
- Directive alert feasibility
- Traffic intent data

Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (ATSA SURF IA)

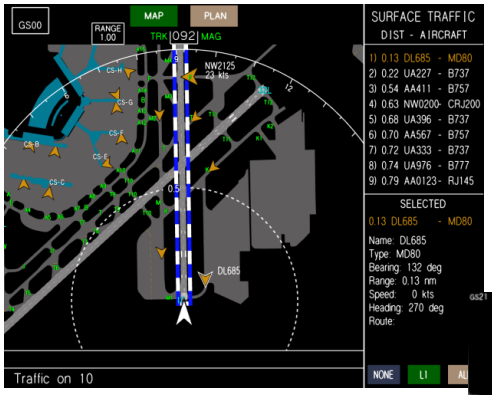
- Safety, Performance and Interoperability Requirements Document (SPR) for aircraft-based conflict detection and alerting developed
- SPR approved by RTCA December 2010, DO-323
- NASA participation on SURF IA committee since its inception
- NASA research conducted and results provided to committee to support SURF IA activities

RTCA SC-186, WG1

Piloted Simulation (spring 2009)

Evaluate

- Concepts and criteria for indications and alerts of potential airport traffic conflicts during low altitude air-to-air, taxiway, and runway operations
  - NASA and SURF IA alerting criteria
- Indication and alerting display concepts
- Directive alert concepts



Experiment Overview

- 6 runway, 5 taxi, 2 low altitude scenarios
- 12 flight crews, 24 test runs per crew
- High-fidelity simulator, ORD airport

Results

- Indications beneficial and provided additional runway safety information, method of presentation confusing
- NASA and SURF IA alerts adequate for pilot response to runway conflict
- NASA alerting criteria preferred and rated earlier, providing more time to proactively avoid conflict situations
- Directive alerts desired for runway and low altitude operations, but not for taxi operations

Piloted Simulation (fall 2009)

Evaluate

- Pilot reaction to off nominal conflict events
- Various conflict alert timings (Early, Mid, Late)
- Directive alert concepts
- Indication and alerting display concepts

Method

- ORD, 1200’ RVR, day, 18 flight crews
- Runway, taxiway, and low altitude air-to-air conflict scenarios

Results

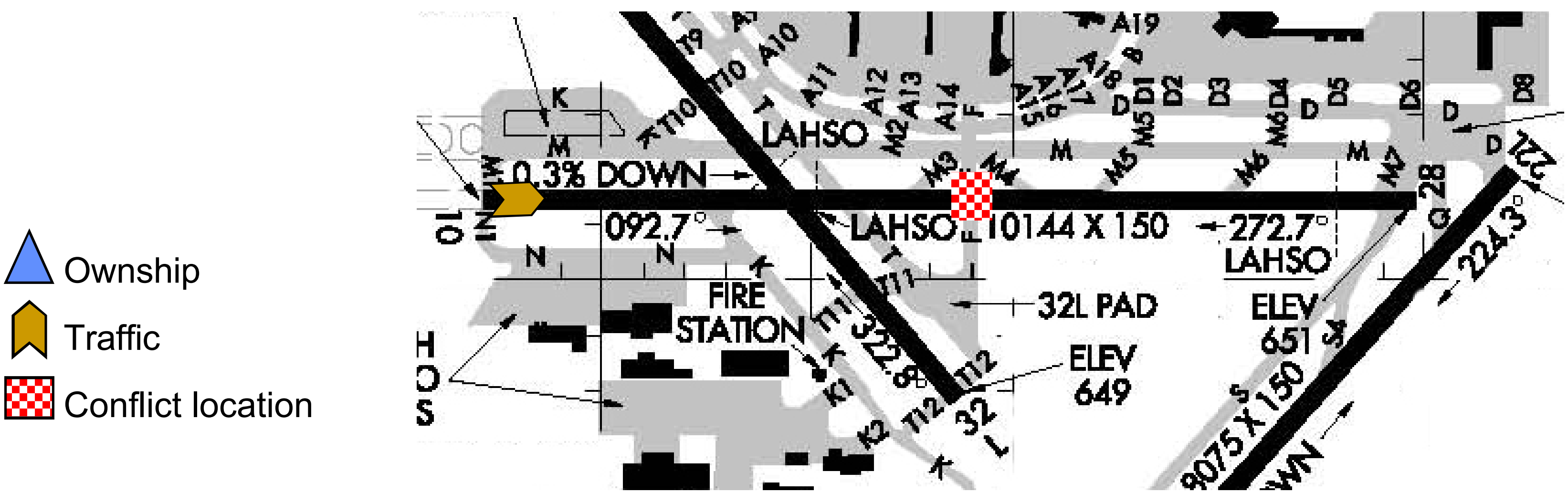
- Indications beneficial and provided additional runway safety information, more research necessary to determine most effective presentation method
- Alerts more effective in preventing conflicts than surface map alone in most scenarios evaluated
- Pilots prone to act upon alert without confirmation, low nuisance alert rate critical
- ‘Early’ alerting preferred in most scenarios evaluated, more research necessary to determine nuisance and missed alert rate with earlier alerting
- Directive alerts shown to be beneficial, more research necessary

Taxi / Departure Scenario Results

	Distance from Hold Line (feet)	Timeliness Preference (mean \ st dev)	Timeliness for Avoidance (mean \ st dev)	Usefulness (mean \ st dev)
TI	630	4.0 \ 0.3	N/A	6.8 \ 0.5
RSI	86	4.3 \ 0.5	N/A	6.7 \ 0.7
Warning - Early	149	4.2 \ 0.4	4.1 \ 0.3	6.9 \ 0.3
Warning - Mid	-15	5.5 \ 0.8	5.2 \ 0.7	6.5 \ 1.1
Warning - Late	-113	6.7 \ 0.5	6.3 \ 0.9	4.1 \ 2.3

Timeliness: 1 = too early, 4 = just right, 7 = too late   Usefulness: 1 = completely useless, 7 = completely useful

- Late warning considered way too late and marginally useful (6 crews crossed rwy)
- Mid warning rated slightly late but still useful (4 crews crossed runway)
- Early warning statistically preferred for timeliness and usefulness
- Early condition provides predictive alerting, before crossing hold line if speed > 8 kt



Fast-time Simulation (1Q CY2011)

Evaluate

- Aircraft-based conflict detection and resolution (CD&R) algorithms during airport terminal area operations
  - NASA and SURF IA algorithms
  - 12 scenario types – 7 runway, 3 taxi, 2 low altitude air-to-air
- Effect of position accuracy
  - NACp 8, 9, 10, 11 and truth
- Multiple levels of CD&R equipage
  - Ownship and traffic equipped
  - Ownship or traffic equipped
  - Neither aircraft equipped
- Directive alerting

Metrics

- Nuisance indications and alerts and missed detections
- Collision / near collision
- Closest separation (horizontal, vertical, slant range)
- Distance and time to impact and traffic at indication / alert