# Runway Incursion Prevention Through The Use of Enhanced Surveillance and Alerting Techniques

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DRAFT DRAFT

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# Objectives

- To suggest unique ADS-B and TIS-B messages that could enhance airport safety with a focus on "Runway Incursion" prevention (e.g., "root cause" risk reduction) and similar incidents involving aircraft, vehicles, and construction equipment on the airport surface—to include both towered and non-towered airports.
- Broadcast data would be made available contemporaneously to nearby aircraft and to ground-based automation for use in alerting algorithms.

# Runway Incursion Review

- Three causes of a runway incursion:
  - Pilot deviations -- The pilot made a mistake
  - Operational Errors -- The controller made a mistake
  - Vehicle / pedestrian deviations -- There was a vehicle or person in the wrong place at the wrong time.
- Runway incursion accidents are the result of a runway incursion. If one prevents the incursion from happening in the first place, one prevents the root cause of the accident.
- ASDE-3 and ASDE-3 / AMASS target runway accident prevention, NOT runway incursion prevention.

# Hypotheses

- ASDE-3 with AMASS, and ASDE-X based on SSR radar and / or primary radar with 1090-based multilateration ALONE will be unable to provide the kind of quality alerting needed to prevent a runway incursion from occurring.
- ADS-B add-on to ASDE-X, with TIS-B and appropriate (new) message set elements, will provide the wherewithal for significant safety improvements. Radar should be an option.
- LASS-like position augmentation for GA (as a broadcast service?) may be needed to enhance surface L-NAC / L-NIC for certain surface movement applications such as A-SMGCS.
- Alerting would be best provided directly to the cockpit.
- Controllers must also have timely alerting.

# Based on Reference Points

- Class A Runway Incursion Incidents (1997-2000)
- Selected Accident Reports (NTSB)
- FAA Order 7110.118 (LAHSO)
- RTCA DO-242 ADS-B MASPS (Appendix E)
- NASA's Runway Incursion Prevention System (RIPS) Program R&D
- Operator Interviews

# Background

- Analysis of Runway Incursion Incidents and Several Surface Accidents - Situational Awareness "Safety" Issues (May '01)
- RTCA SC-193 Airport Mapping Requirements
- Land and Hold Short Operations (LAHSO)
- Surface Management Issues, e.g., FAA's Operational Evolution Plan (OEP)
- ADS-B MASPS DO-242, Appendix E
- ADS-B MASPS (DO-242A) Development
- Related SC-186 ADS-B MASPS Issue Papers

# BASIC ASSUMPTIONS

- **"Key" assumption: Onboard, relevant airport moving map data bases are critical to providing pilots and controllers with advanced alerting. Runway safety areas (RSAs) also would be included in the data base.**
- Enhanced surveillance / ADS-B data link assumed
- Moving map utilized along with a CDTI / MFD.
- Graphical NOTAM overlays highly desirable but optional
- TIS-B data link is a "value added" option
  - ADS-B broadcast messages have re-use functionality via TIS-B, providing 'fused" 1090 multilateration and other data
  - Common denominator
- Aircraft, vehicles and fixed polygons and lines such as RSAs and hold short lines would be geo-referenced
- Variable ADS-B broadcast data rates will conserve bandwidth.

# Human Factors Assumptions

- An airport moving map with CDTI functionality alone may be insufficient to prevent runway incursions in most instances.
- Simply providing a runway “red” alert when occupied is inappropriate, especially at airports with intersecting runways that are “pre-loaded”. A negative training factor.
- Specific alerting features and functions need to be defined.
- Onboard software and ground-based automation will alert pilots in a timely manner resulting in less, not more, workload.

# Supported Surface Movement Applications

- Source: RTCA DO-242, Applications, Appendix E-- Airport Surface Domain:
  - Airport surface situational awareness. (Note: Would also alert crews to non-vehicular obstructions / equipment on closed runways / taxiways)
    - Aircraft
    - Vehicles
    - Controllers
  - Airport surface conflict management
  - Runway incursion prevention
    - Monitoring
    - Alerting
  - Crash, fire and rescue (ARFF) response

# Additional Supported Surface Movement Applications

- Airline / airport surface asset management
- LAHSO risk reduction
- Broadcast of monitored (voice) frequency
- On / off airport noise monitoring
- Surface jet blast avoidance
- Runway excursion risk reduction
- De-ice operations
- Airport and off-airport ELT (via ADS-B) functionality.
  - Emergency priority requests
  - Special handling requests

# Rationale for Alerting

- Systematic analysis of 55 Class A runway incursion incidents indicated lack of awareness by crews. (Analysis conducted May ‘01)
- Several surface accidents also analyzed
- Majority were due to loss of situational awareness
- Some incidents included student pilots
- Many included GA
- Aircraft movement in close proximity to others a factor

# Cockpit Alerts and Warnings

- Cockpit alerts can be aural (voice), visual or tactile (e.g., vibrations).
- Used as a pilot “attention getter”.
- Kinds of alerts:
  - Advisory
  - Caution
  - Warning
  - Time critical warnings
    - Aircraft is OK.
    - No system failure.
    - Immediate pilot reaction required to avert critical situations
    - When multiple alerts occur simultaneously, alert prioritization may be needed.

# Need for "Shared" Controller Alerting

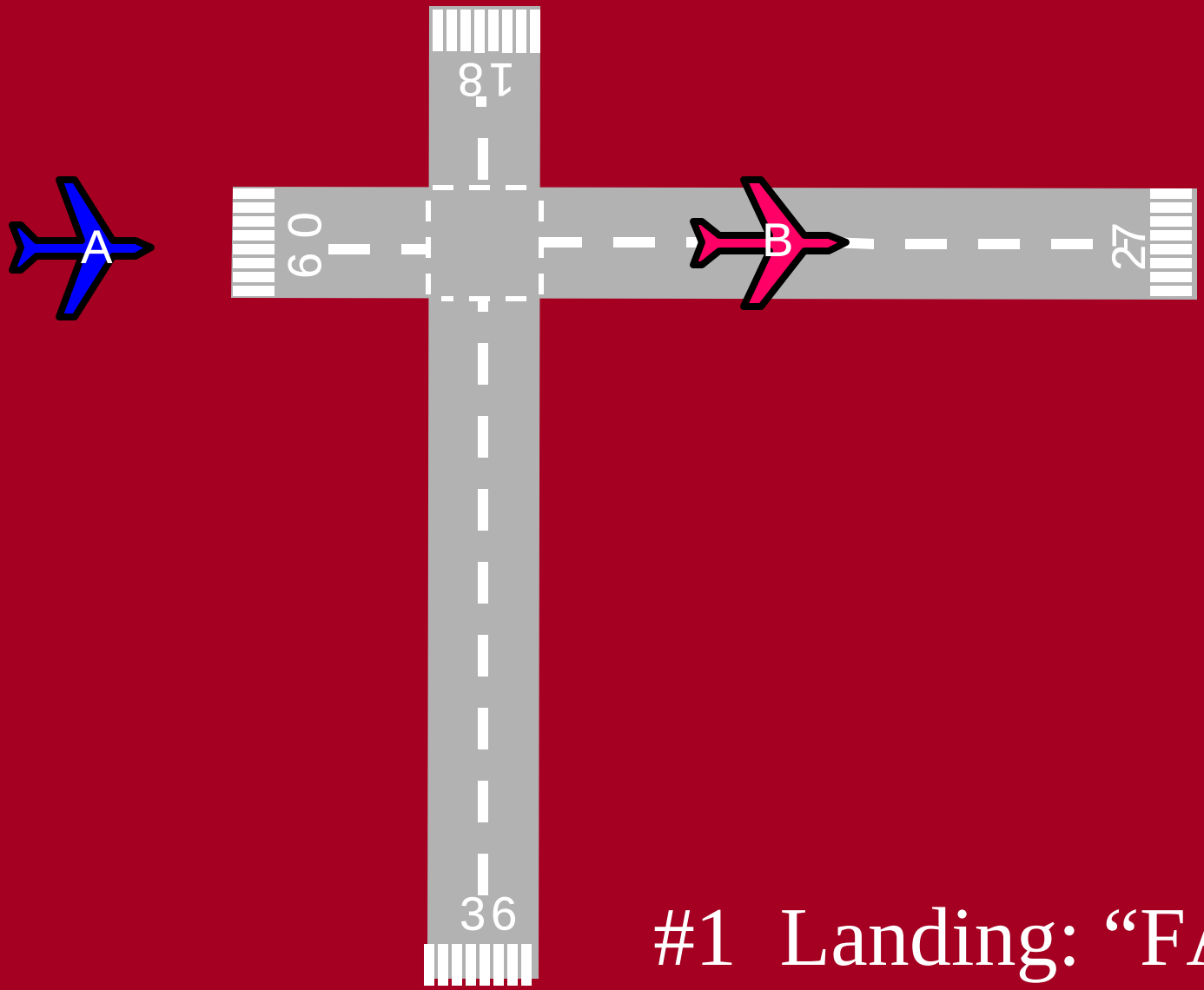
- Controllers also need similar (but perhaps not identical) alerting to that used in the cockpit.
  - Controller support automation may be able to make use of material in this slide set.
- In selecting alerting algorithms for ground-based automation, one must be sensitive that objectives of controller alerting are different than what is needed in the cockpit.
- ADS-B surface automation alerts (for controller use) may also be used to turn on / turn off runway status lights. Runway lights could act as a back-up to cockpit alerting systems.

# Presentation Focus (Repeated)

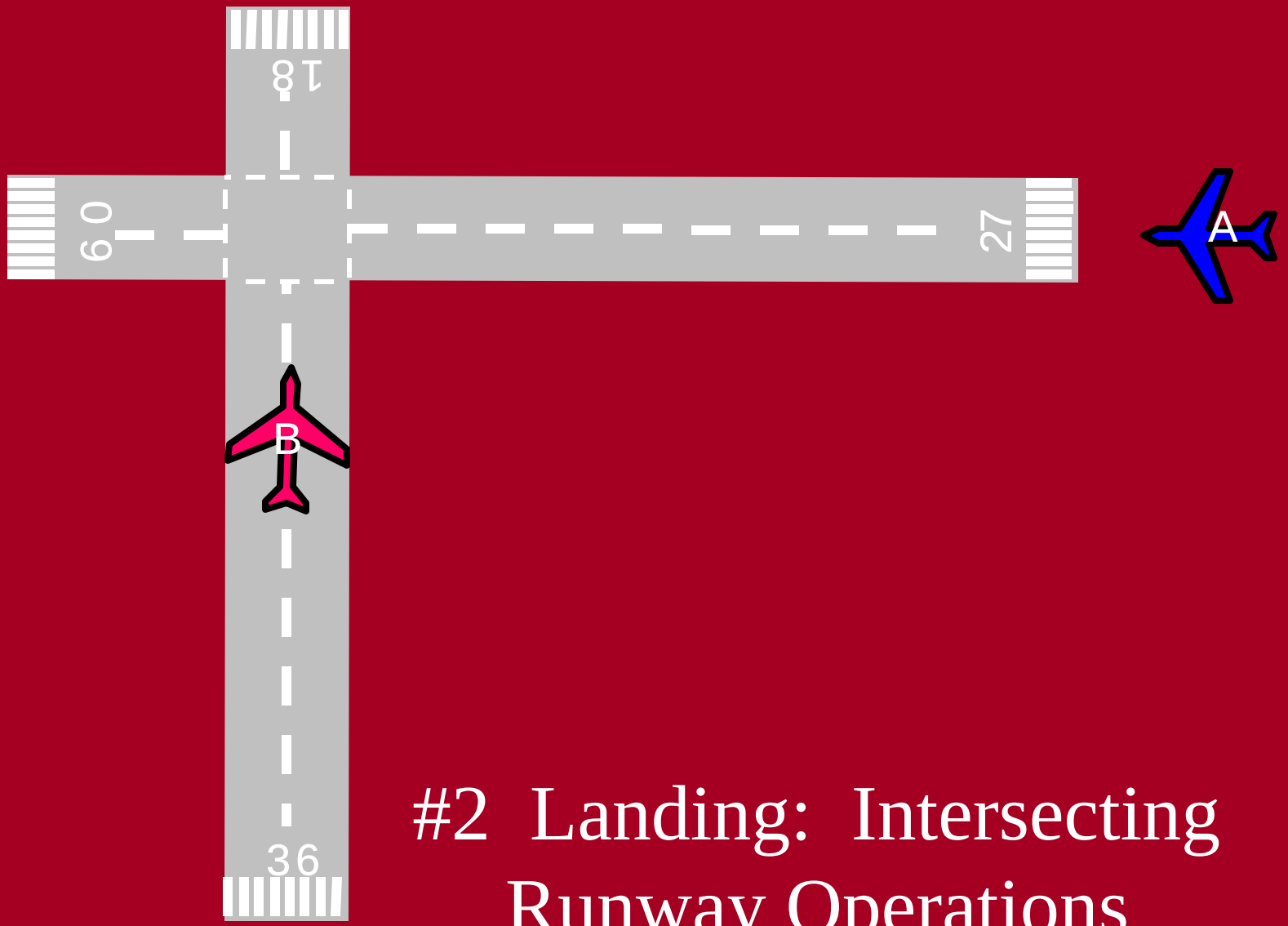
- Intent is to identify possible ADS-B based cockpit-based alerting algorithms that complement a cockpit-based, moving map display.
- These same alerting algorithms may also help controller / ground automation surveillance systems -- "loop delays" would likely limit application to runway incursion accident prevention, not "root cause" incident prevention.
- Suggest surface movement ground architecture based on a low-cost "ASDE-Lite" system, e.g., Capstone / UAT Ground Broadcast Server (GBS), along with 1090 multilateration, and TIS-B. Radar and infrared sensors are optional add-ons.

# APPROACH

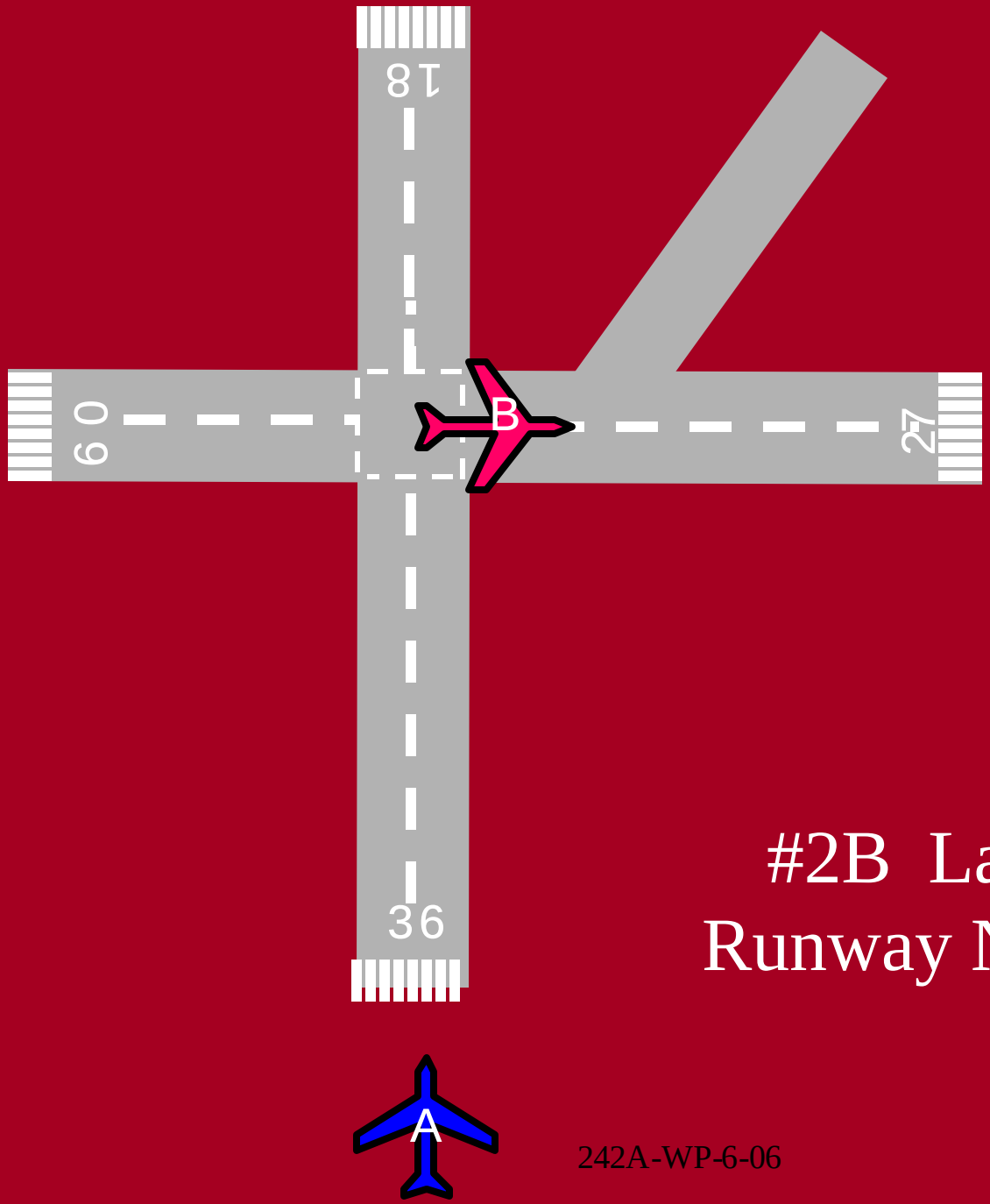
- ADS-B state vector is used as primary alerting source.
- Other alerting message sets are defined in relationship to:
  - State vector
  - Variable broadcast rate
  - Applicable scenario
  - RF transmission link




# #1 Landing: “FAROA”




# #2 Landing: Intersecting Runway Operations




# #2B Landing:
# Runway Not Clear

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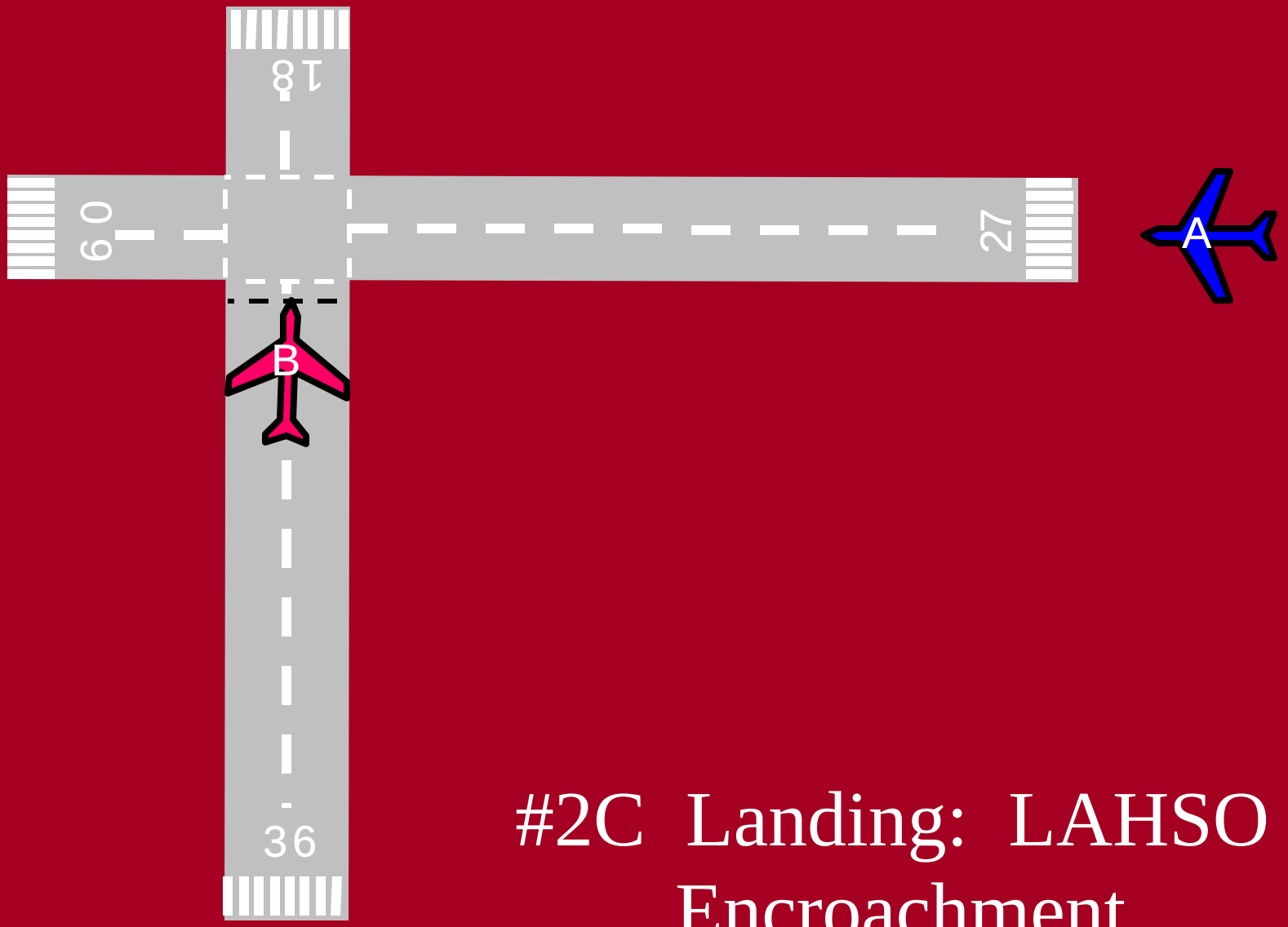


# #2C Landing: LAHSO Encroachment

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# #3 Landing: LAHSO Go-Around

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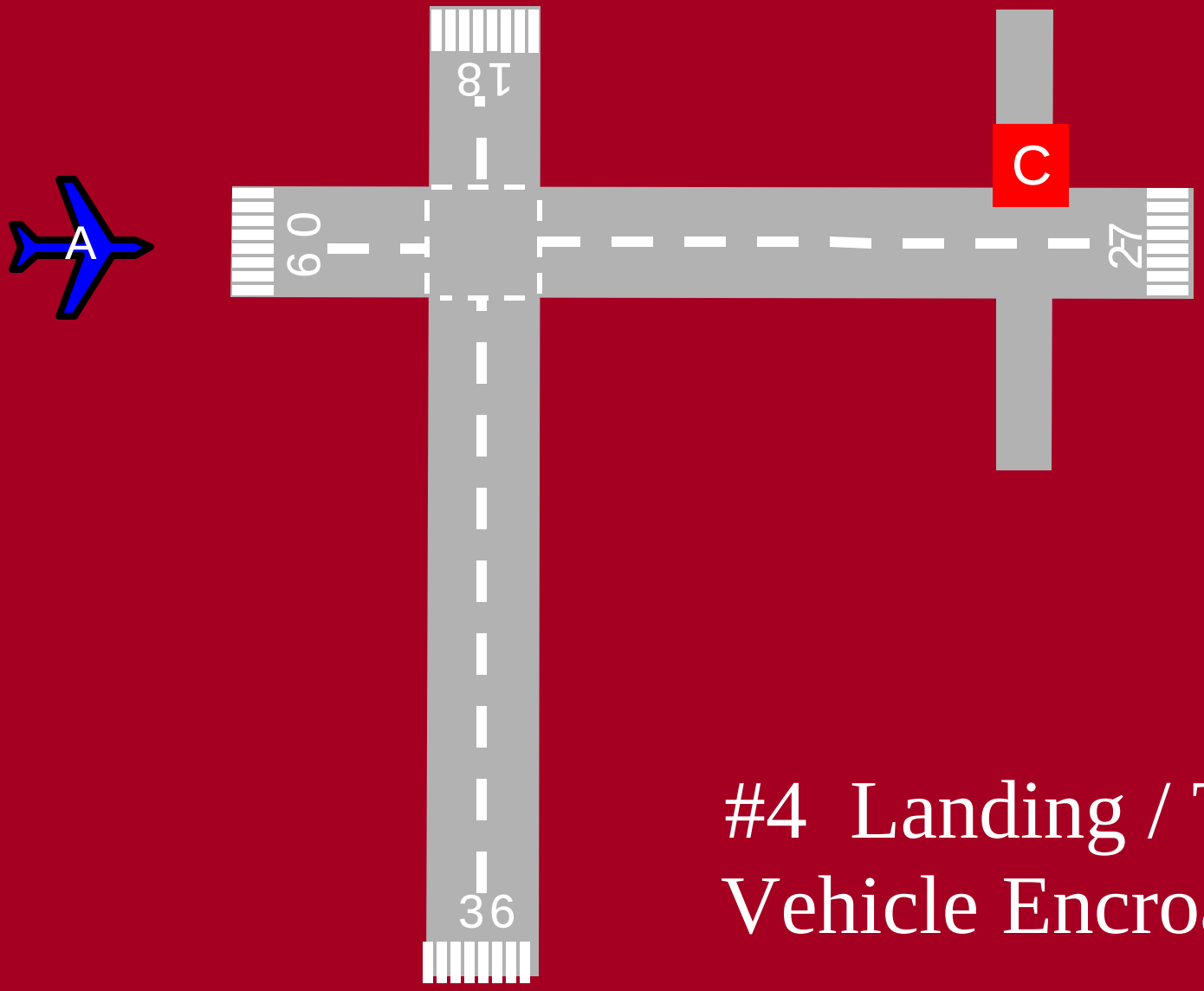
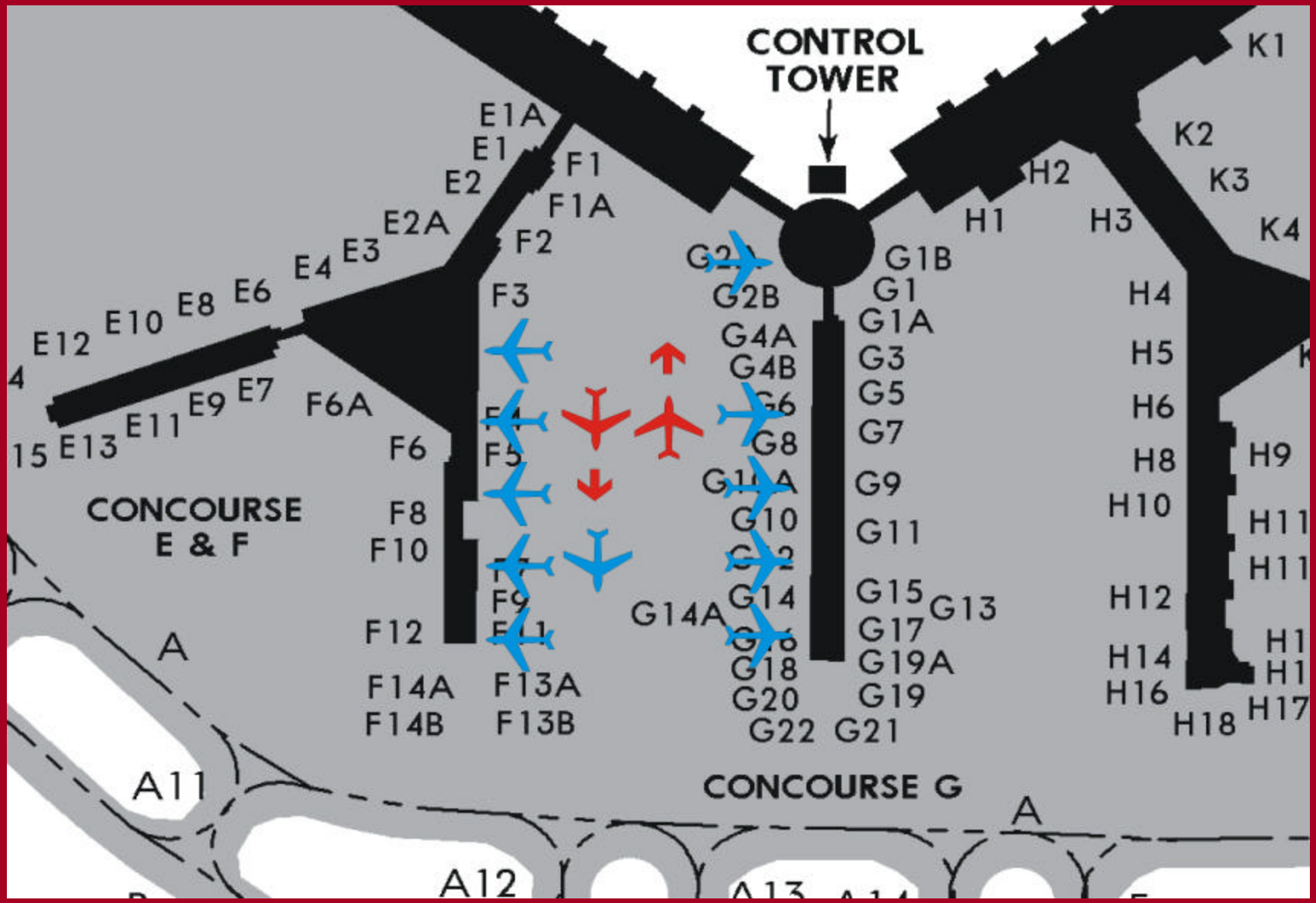
# #3A Take-off: Landing / Go-around on Intersecting Runway




# #4 Landing / Takeoff: Vehicle Encroachment




# # 5 Operations in Close Proximity to Others

| POSSIBLE ADS-B MESSAGE SET ELEMENTS | | | |
|---|---|---|---|
| STATE | BROADCAST RATE | SCENARIO APPLICATION | LINK |
| MAKE AND MODEL | ? | 1, 2, 2B,2C,3,3A, 5 | ADS-B / TIS-B |
| BRAKES ON / OFF | ? | 1,2,2C,3 | ADS-B / TIS-B |
| % POWER | ? | 1,2,2C,3,3A | ADS-B |
| LIGHTS ON/OFF | ? | 1,2,2C,3 | ADS-B |
| COM. FREQ | ? | 1,2,2B,2C,3,3A | ADS-B |
| STUDENT PILOT? | ? | 1,2,2B,2C,3,4,5 | ADS-B / TIS-B |
| HEADING | ? | 1,2,2B,2C,3,3A,5 | ADS-B / TIS-B |
| NAV. CENTER | ? | All | ADS-B / TIS-B |
| VEHICLES ON/UNDER RNWY | ? | ALL | ADS-B /TIS-B |
| AIRBORNE STATUS | ? | 1,2,2C,3,3A | ADS-B / TIS-B |
| ABORT ALERT | ? | All | ADS-B / TIS-B |
| NIC--NAC | ? | All | ADS-B |

# Message Set Selection Process

- ADS-B / TIS-B alerting algorithms would make use of state vectors (e.g., at one second update rate), plus selected additional parameters. See next slide.
- Further discussion and analysis is needed to select / agree upon appropriate message set elements.

# Related Observations / Issues

- LAHSO:
  - Would a runway CPDLC-enabled “Bulls eye” as an overlay on a depiction of a landing runway be value-added?
  - Would the broadcast of own-ship hold-short intentions also be value-added?
  - Would a spacing / ghosting function for intersecting runway missed approaches be helpful?
  - Could TIS-B functionality satisfy this need?
- Role of graphical NOTAM overlays to prevent takeoffs / arrivals on closed runways.
- Would tire predictors help reduce runway excursions?
- Is LAAS functionality needed to reduce small aircraft surface movement flight technical error? Could these GPS correction messages be sent via the UAT?
- Surface vehicles on runway underpasses may trigger false alerts. Runway alerting function needs to be inhibited.
- Could the ADS-B surface automation alerts (for controller use) also be used to turn on / turn off runway status lights?

# Some HF Considerations

- Warnings / alerts and cockpit display “iconology” need to be evaluated, then matured. For example:
  - Display attributes (e.g., color, clutter, information layering, accessibility of information, etc), need to be defined.
  - Labeling conventions / formats for the airport moving map, NOTAM overlays, etc., need to be specifically defined.
  - Prioritization of messages and alerts need simulation / validation.
- Head-up / head-down time needs to be evaluated from a crew / single-pilot workload perspective.
- Usability in each operational scenario also needs to be evaluated.

# Summary: Recommended Actions

- RTCA SC186 WG-1 / WG-4 should reach consensus on:
  - Applications / features / intended functions
  - Minimum alerting required, including required message set elements
  - Clarify role of broadcast versus requested message set data (obtained from stored “register” data)
  - Minimum data broadcast rates, including a possible reduction in aircraft ID and flight number refresh rates
  - Address role of TIS-B to provide LAHSO “end-of-runway” clearance depictions to specific aircraft.
- MASPS Ad Hoc WG should include applications and message sets in planned DO-242A MASPS revision
- Demonstrate functionality as part of future SF-21 OpEvals