Air Reference Velocity Vector
242A-WP-5-13

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Overview

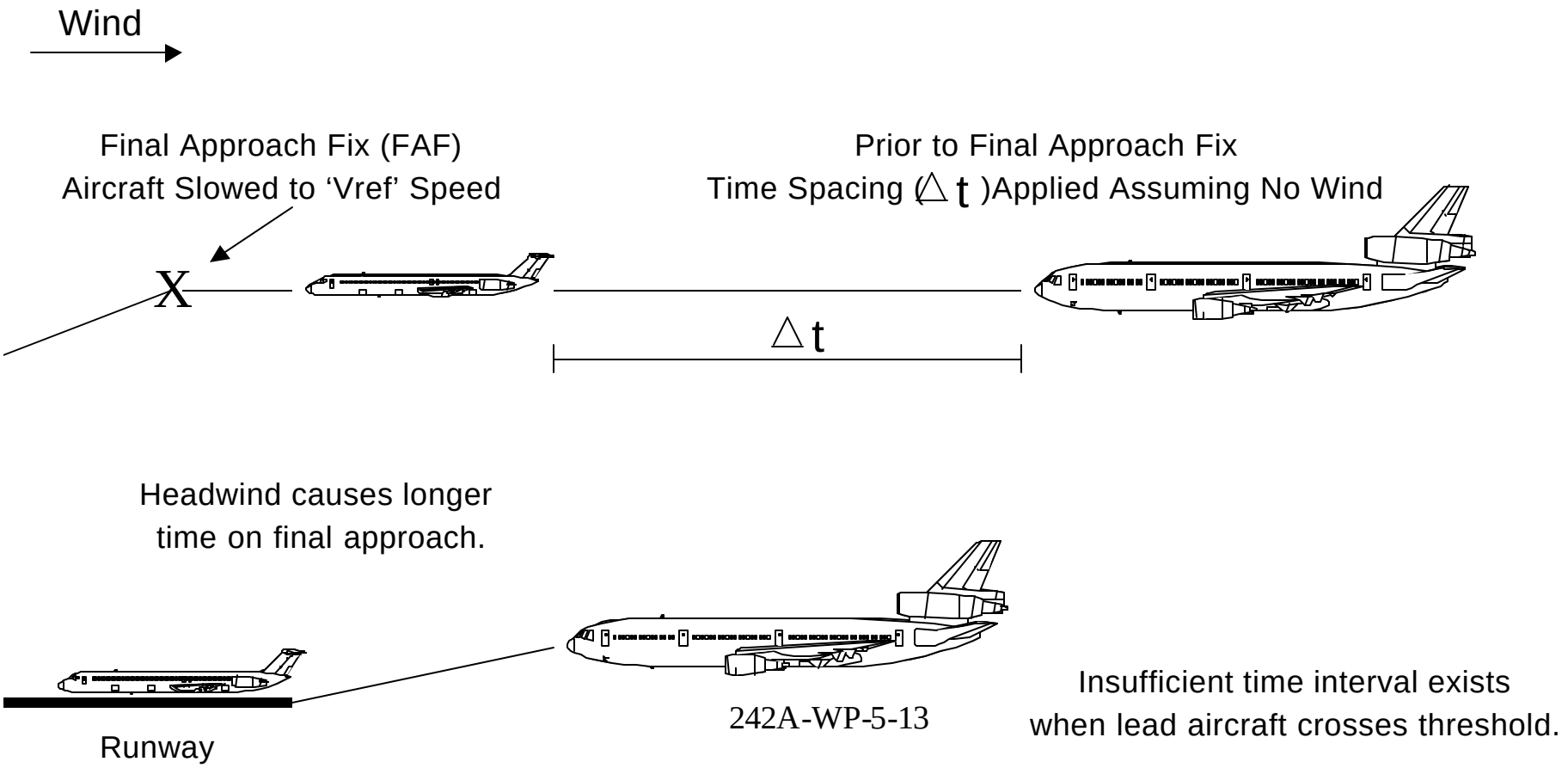
- Current heading and airspeed are valuable information to a variety of applications.
  - Along with ground vector, makes it possible to determine real-time wind encountered by aircraft.
  - Improves conflict detection and prevention when aircraft are not controlled to defined ground track.
  - ATC knowledge of indicated airspeed may improve CTAS trajectory predictions.
- Example applications that would use heading and airspeed information:
  - In-trail spacing approaches.
  - Precision FMS procedures.
  - Conflict detection or prevention following a turn or through a changing wind field.

In-Trail Spacing Approaches

- In-trail spacing approaches aim to achieve a constant threshold crossing interval for a stream of aircraft.
  - Prior to FAF, trailing aircraft maintains specified time spacing behind lead aircraft, consistent with safety.
  - Time spacing based on difference between final approach speeds of both aircraft and wind.
  - Each aircraft slows to its desired approach speed at final approach fix (FAF).
  - Wind affects amount of time in which difference in final approach speeds acts to close or stretch the gap.
- Wind errors lead to increased threshold crossing intervals and lower efficiency.

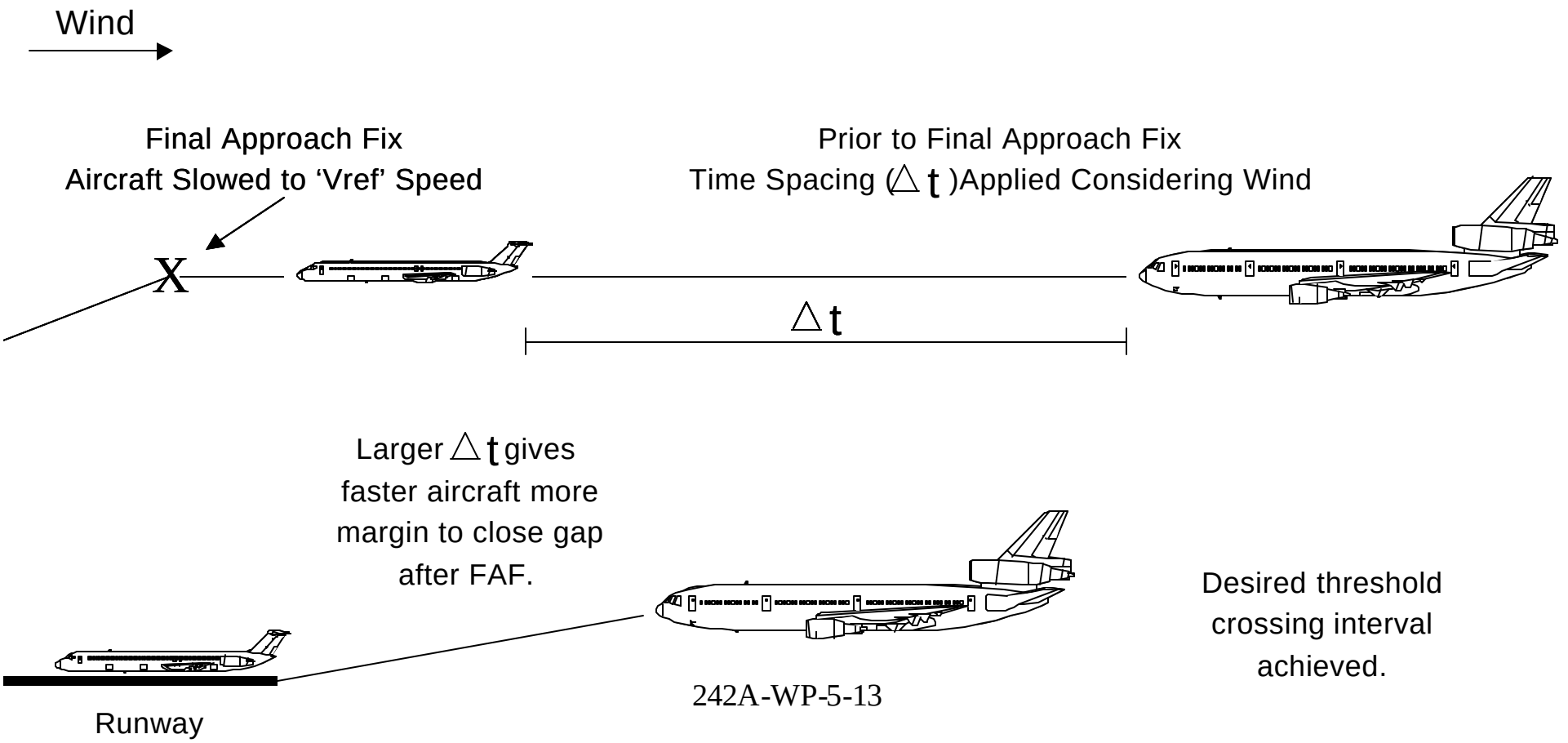
In-Trail Spacing Approaches (cont.)
Headwind Neglected

- Consider example of faster trailing aircraft in unforecasted headwind conditions.



In-Trail Spacing Approaches (cont.)

- Same example, with time spacing adjusted for headwind.



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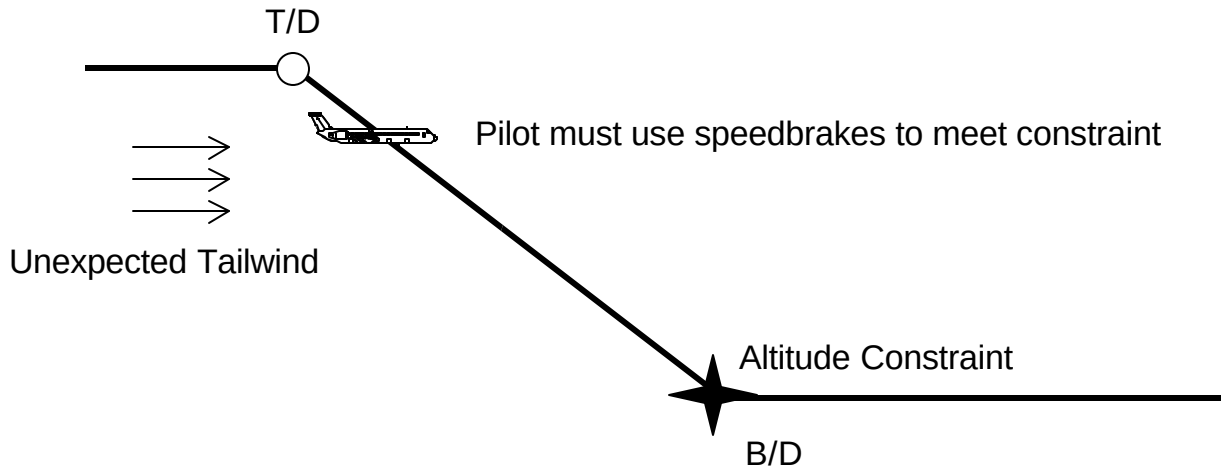
Precision FMS Procedures

- Current air traffic management procedures often impose waypoint speed and altitude restrictions on descending aircraft.
- FMS considers desired speed profile and waypoint restrictions when generating descent path.
  - Current FMS generates idle descent path.
  - Path based primarily on airplane performance and wind.
- Wind information may be locally inaccurate.
- Wind information from nearby aircraft (generated by combination of ground and air vectors) enhances atmospheric models, leading to more accurate path prediction and adherence.

Precision FMS Procedures (cont.)

- Inaccurate wind estimates lead to path that may not meet waypoint constraints without thrust or speedbrake inputs from pilot.
  - Results in higher crew workload and lower fuel efficiency.

Example: Descending Aircraft Encounters Unforecasted Tailwinds



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Precision FMS Procedures (cont.)

- Future ATM procedures likely to require more precise FMS paths.
  - Time constraints applied at waypoints.
  - Fixed radius turns.
  - Vertical tunnels that require path adherence between waypoints (see presentation by Tony Warren).

Conflict Detection for Intruder Aircraft with Non-Controlling Ground Track

- After a turn.
  - Consider intruder aircraft turning in Heading Select mode.
  - Current wind information (calculated by ground and air vectors) allows determination of new ground vector after turn is completed.
    - Assumes commanded heading is also known.
- Changing wind field.
  - Consider intruder aircraft in Heading Hold mode climbing in changing wind field.
  - Extrapolation of current ground vector inaccurate as wind conditions change.

Proposed Air Reference Velocity Vector On-Condition Report

Element #	Contents
1	Participant Address (Section 2.1.2.1.2)
2	Air Speed* (Indicated/True)
3	Heading* (Magnetic/True)
4	Time of Applicability (Section 2.1.1.4)

*Data reference frame is provided in the Mode-status report

Proposal Summary

- Remove references to heading and airspeed data as required elements in state vector report (Table 3-5) and modify accompanying text in Section 3.4.3.1.
- Create requirement for Class A2 and A3 aircraft to be capable of broadcasting heading and airspeed data.
  - Data reference (true/indicated or true/magnetic) must also be provided (could be done in mode status report).
  - Requirement could be met by new on-condition report delegated for heading and airspeed or through state vector.
  - Requirements for broadcast rate and resolution for specific applications are TBD.