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*Customer Success Is Our Mission*

# Mode 5 Level 2 – Broadcast (M5L2-B)

## *Securing ADS-B with Mode 5 Level 2 for Air Traffic Management and Single Integrated Air Picture*

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# Agenda

- Automatic Dependent Surveillance-Broadcast (ADS-B) Background
- Mode 5 Level 2 – Broadcast (M5L2-B) Rationale
- M5L2-B Functional Diagram
- Data Mapping
- Accuracy and Integrity
- Position Extrapolation for Tracking
- Tracking Advantages Summary
- Platform Considerations
- Summary

# ADS-B: Position Broadcasts for Situational Awareness

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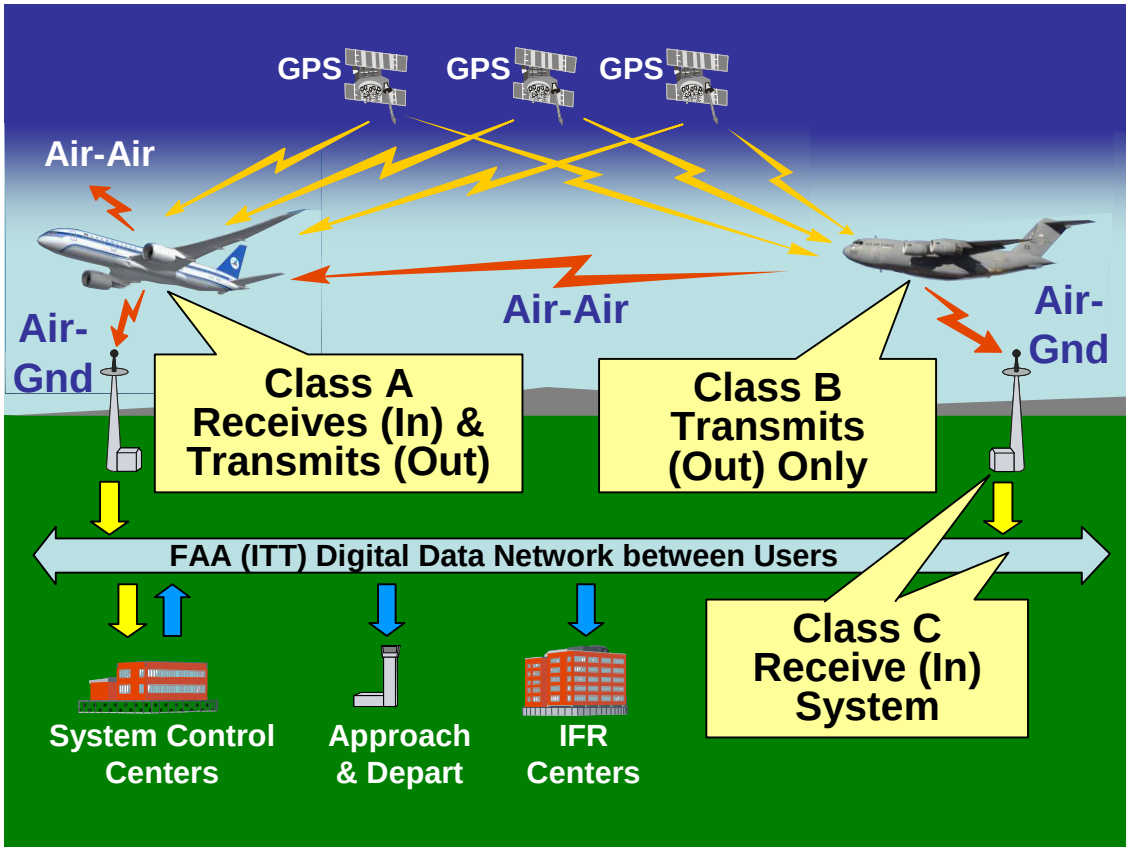
- Automatic, common data exchanges for network-centric air traffic management (ATM)
- Provides common cockpit and ATM situational awareness for air to air conflict avoidance
- Allows reduced separation for increased capacity and scheduling




**Significant shift from active interrogating to platform self-reporting**

# Why Mode 5 Level 2-B (M5L2-B)?

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- **ADS-B** is the basis for future world-wide air traffic management (ATM)
  - FAA mandate target is 2020 (draft NPRM)
  - European mandate recently accelerated to 2015
  - Hudson Bay (Canada) mandated now
  - Open access to platform position and intent data, not secure
- **Mode 5 Level 2-B (M5L2-B)**
  - Secures ADS-B data through direct mapping into Mode 5 Level 2 reports
  - Enhances "one track per aircraft" for Single Integrated Air Picture (SIAP)
    - Predictive tracking simplified with both velocity and position data provided by the airborne platform
  - Enables platform self awareness for sense and avoid capability in a secured military environment (i.e. UAVs in lower airspace)
- **M5L2-B** uses existing Mode 5 Level 2 functionality in Mode 5 transponders

**An opportunity for DoD to leverage civil investments**

# M5L2-B Functional Integration

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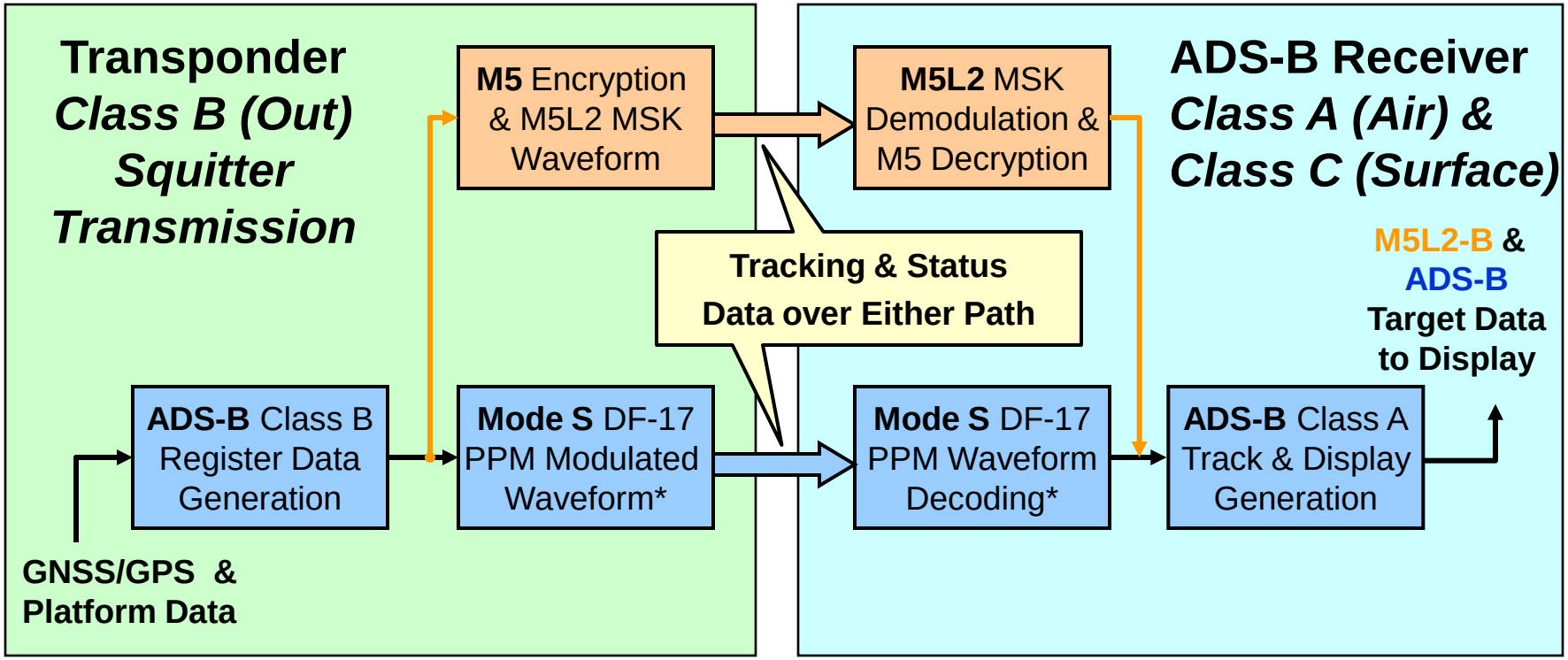
- Mode 5 transponders already support Mode 5 Level 2
- ADS-B data ‘fits’ into Mode 5 Level 2 messages




**Existing Mode 5 Level 2 systems support M5L2-B**

# M5L2-B Data Mapping: Position Message Example

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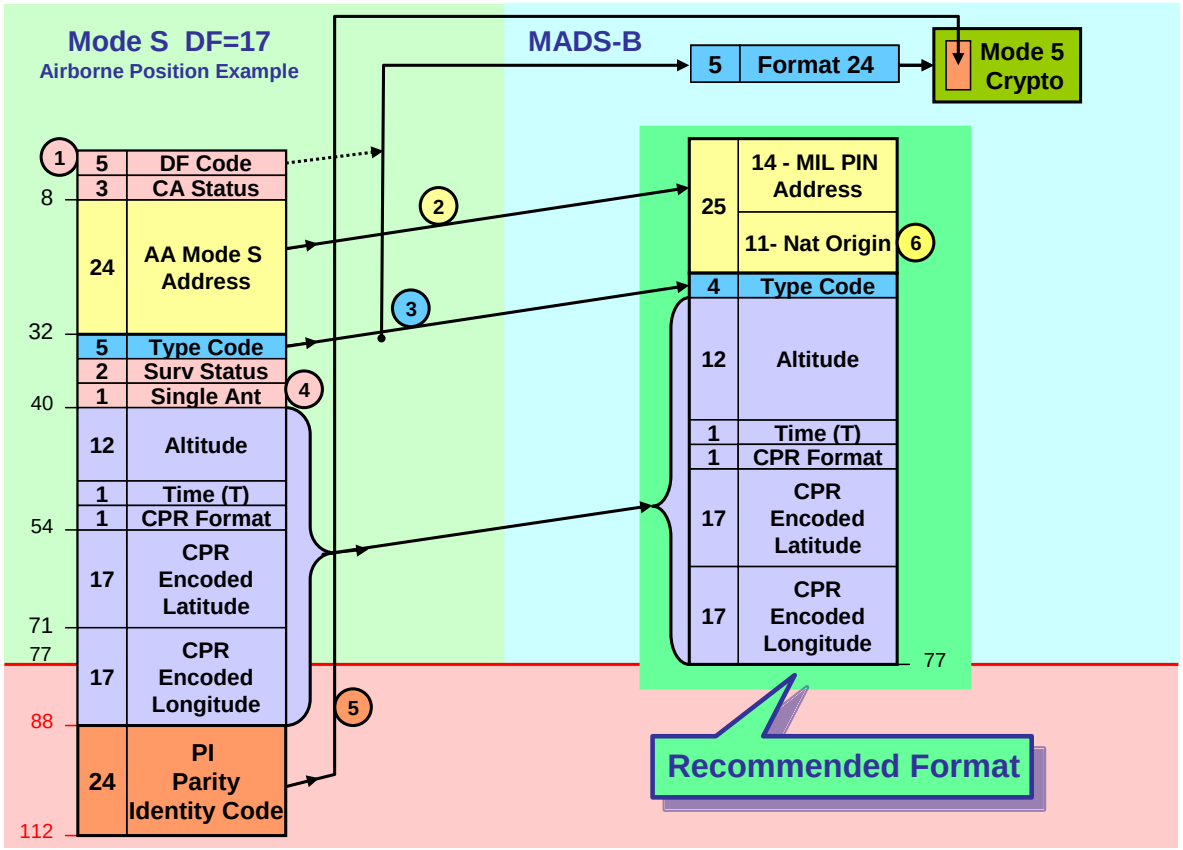
- Uses Mode 5 Level 2 formats 24 to 28 that were unused
- Direct mapping of key ADS-B data fields to eliminate data conversion issues




**Mapping is published in DoD AIMS 03-1000 change proposal**

# Accuracy and Integrity: Mode 5 Level 2 FOM

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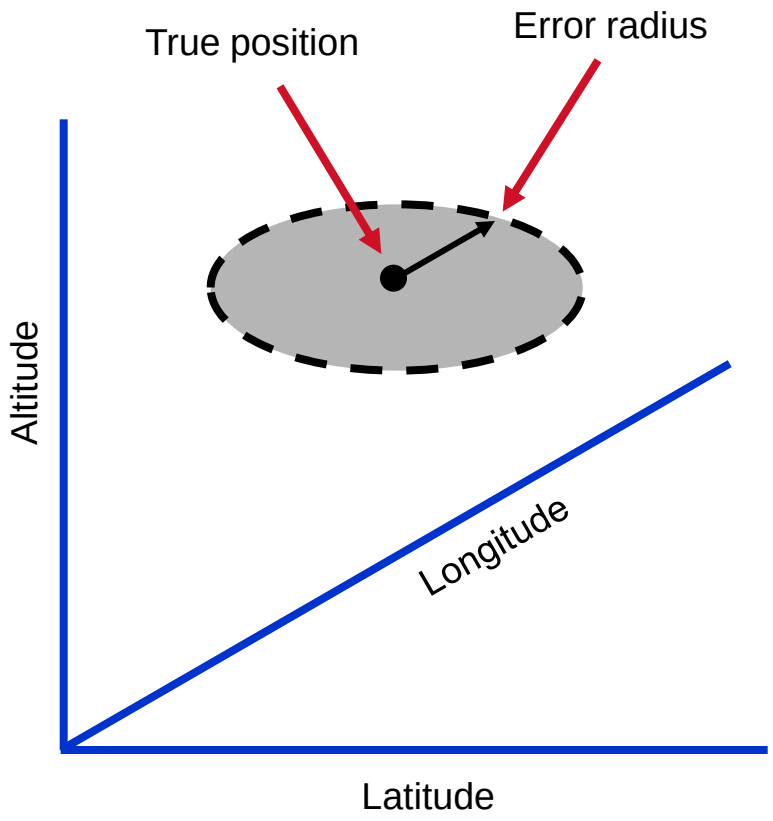
**Figure of Merit (FOM)** should represent the best estimate of the platform position accuracy inclusive of platform movement and latency at the time of transmission (DoD AIMS 03-1000A)

| FOM | Estimated Position Error (meters) |
|---|---|
| 1 | ≤ 25 |
| 2 | >25 and ≤ 50 |
| 3 | >50 and ≤ 75 |
| 4 | >75 and ≤ 100 |
| 5 | >100 and ≤ 200 |
| 6 | >200 (and ≤ 500) |




**M5L2 High Res PIN Report has horizontal position accuracy FOM**

# Accuracy and Integrity: ADS-B NACp

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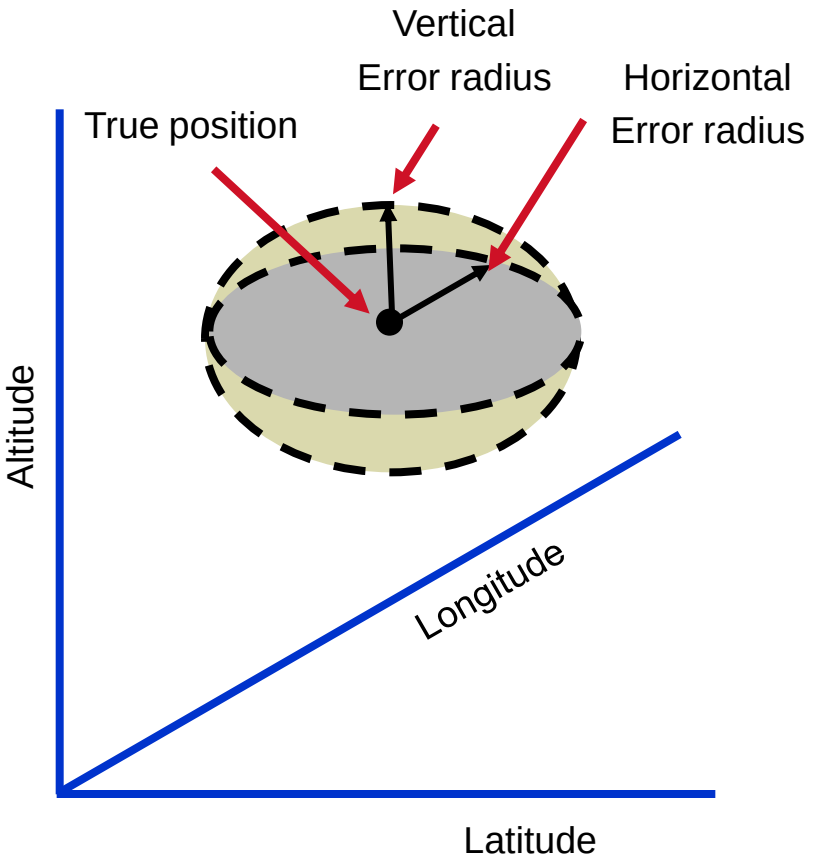
**Navigation Accuracy Category for Position (NACp)** specifies with 95 percent probability that the GNSS provided information is correct within an associated allowance

| $NAC_P$ | 95% Horizontal and Vertical Accuracy Bounds (EPU and VEPU) | Comment |
|---|---|---|
| 0 | EPU ≥ 18.52 km (10 NM) | Unknown accuracy |
| 1 | EPU < 18.52 km (10 NM) | RNP-10 accuracy |
| 2 | EPU < 7.408 km (4 NM) | RNP-4 accuracy |
| 3 | EPU < 3.704 km (2 NM) | RNP-2 accuracy |
| 4 | EPU < 1852 m (1NM) | RNP-1 accuracy |
| 5 | EPU < 926 m (0.5 NM) | RNP-0.5 accuracy |
| 6 | EPU < 555.6 m ( 0.3 NM) | RNP-0.3 accuracy |
| 7 | EPU < 185.2 m (0.1 NM) | RNP-0.1 accuracy |
| 8 | EPU < 92.6 m (0.05 NM) | e.g., GPS (with SA) |
| 9 | EPU < 30 m and VEPU < 45 m | e.g., GPS (SA off) |
| 10 | EPU < 10 m and VEPU < 15 m | e.g., WAAS |
| 11 | EPU < 3 m and VEPU < 4 m | e.g., LAAS |

**FAA NPRM threshold**




**ADS-B NACp has horizontal and vertical position accuracy bounds**

# Accuracy and Integrity: M5L2 FOM vs ADS-B NACp

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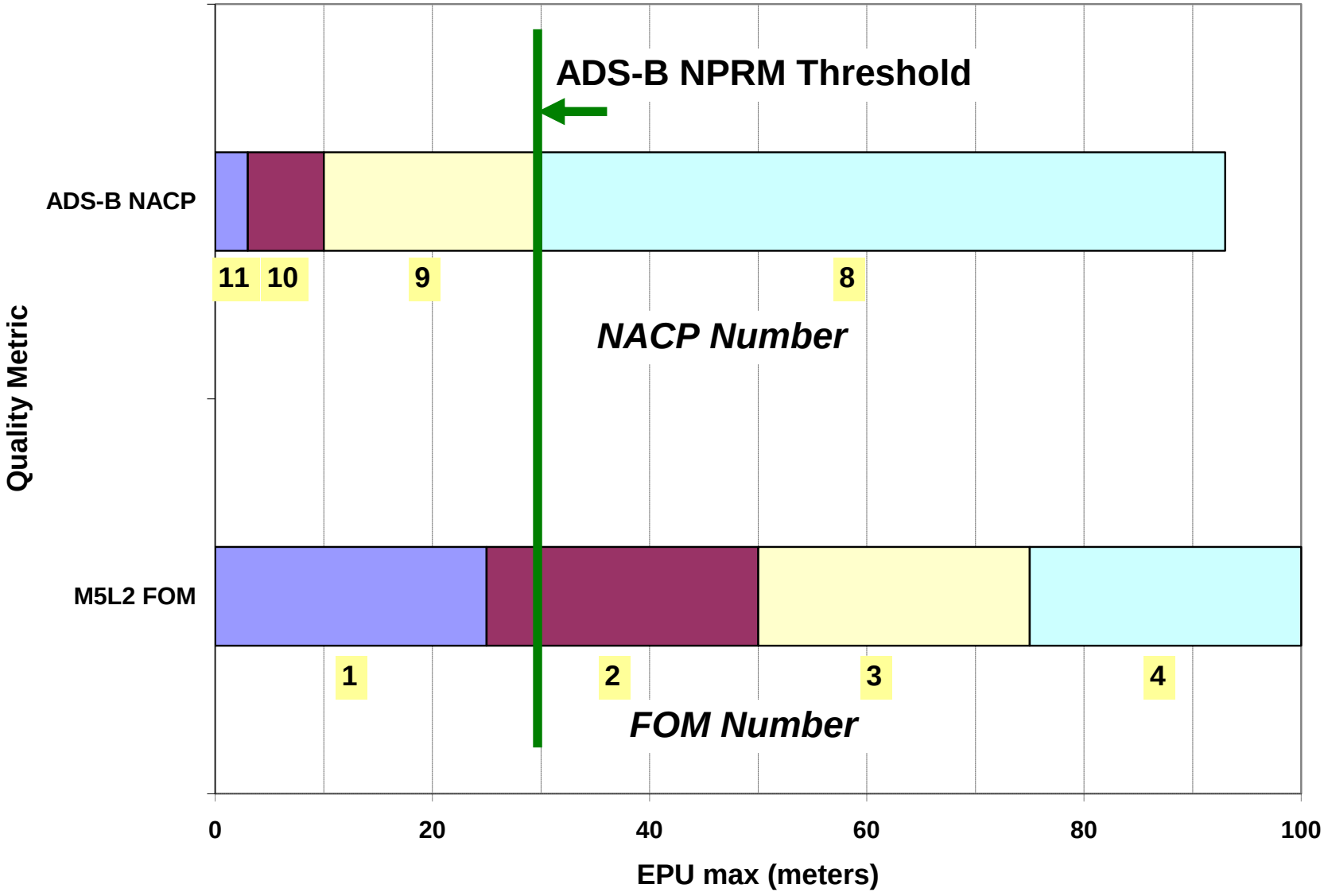

# Accuracy and Integrity: ADS-B NACv

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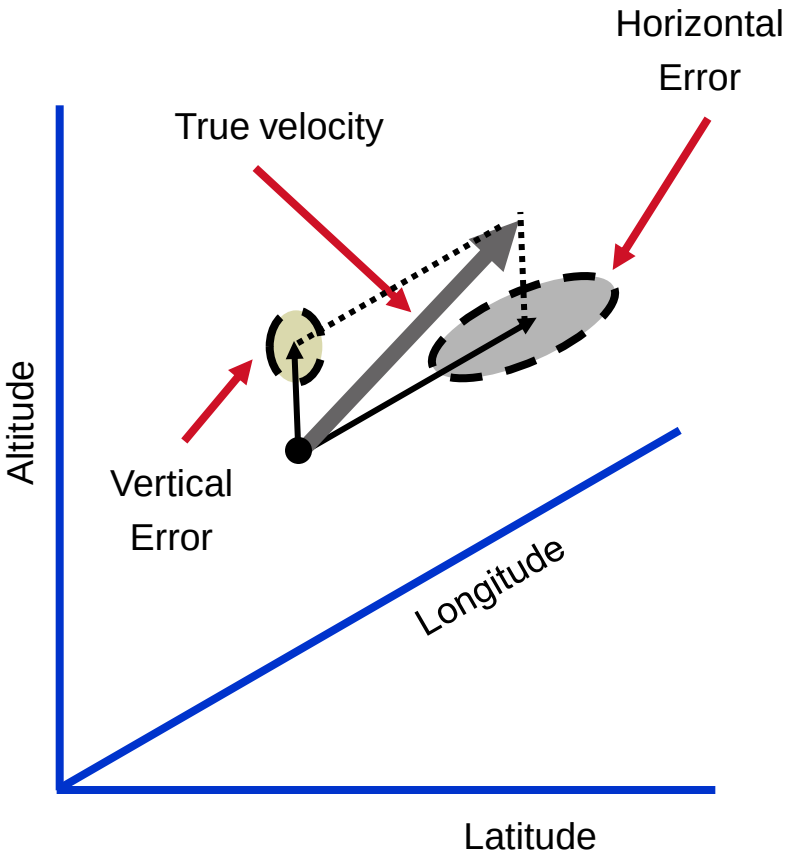
**Navigation Accuracy Category for Velocity (NACv)** is a measured value similar to the NACp except that it applies to the computed velocity derived from navigation position sensor or navigation system

| $NAC_V$ | Horizontal Velocity Error (95%) | Vertical Geometric Velocity Error (95%) |
|---|---|---|
| 0 | Unknown or ≥ 10 m/s | Unknown or ≥ 50 feet (15.24 m) per second |
| 1 | < 10 m/s | < 50 feet (15.24 m) per second |
| 2 | < 3 m/s | < 15 feet (4.57 m) per second |
| 3 | < 1 m/s | < 5 feet (1.52 m) per second |
| 4 | < 0.3 m/s | < 1.5 feet (0.46 m) per second |

**FAA NPRM threshold**




**ADS-B includes horizontal and vertical velocity accuracy bounds**

# Accuracy and Integrity: ADS-B NIC

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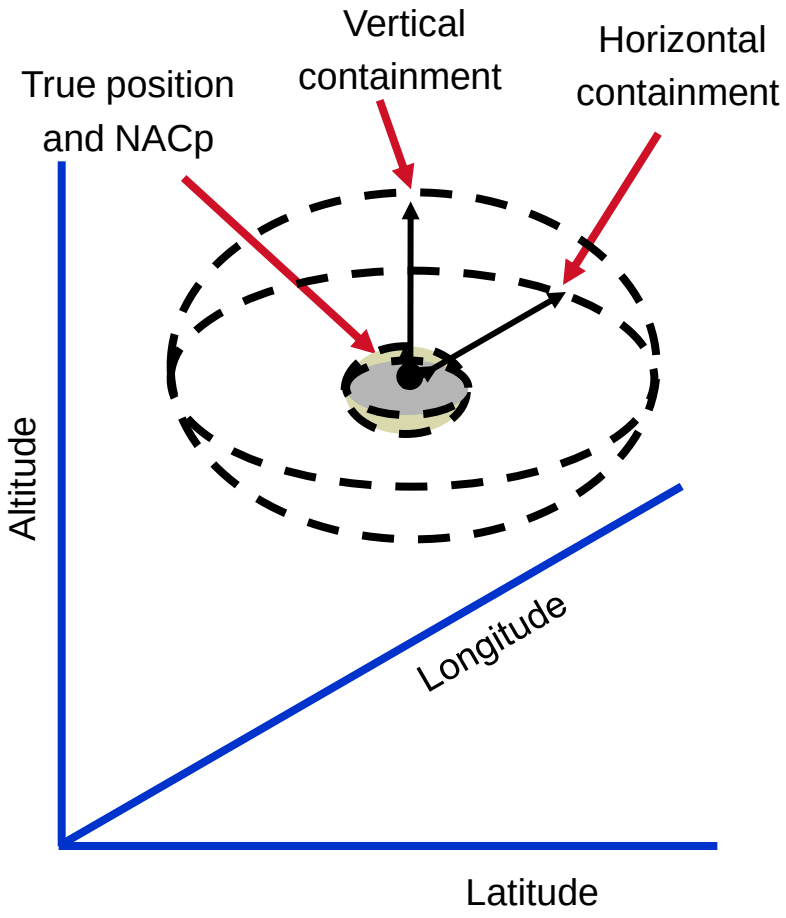
**Navigation Integrity Category (NIC)** differs from NAC in that a NIC value specifies aircraft integrity containment often referred to as 'containment radius' which is the maximum error for the broadcast position

| NIC (Notes 1, 2) | Horizontal and Vertical Containment Bounds | Comment |
|---|---|---|
| 0 | $R_C \geq 37.04$ km (20 NM) | Unknown Integrity |
| 1 | $R_C < 37.04$ km (20 NM) | RNP-10 containment radius |
| 2 | $R_C < 14.816$ km (8 NM) | RNP-4 containment radius |
| 3 | $R_C < 7.408$ km (4 NM) | RNP-2 containment radius |
| 4 | $R_C < 3.704$ km (2 NM) | RNP-1 containment radius |
| 5 | $R_C < 1852$ m (1 NM) | RNP-0.5 containment radius |
| 6 | $R_C < 1111.2$ m (0.6 NM) | RNP-0.3 containment radius |
| 7 | $R_C < 370.4$ m (0.2 NM) | RNP-0.1 containment radius |
| 8 | $R_C < 185.2$ m (0.1 NM) | NP-0.05 containment radius |
| 9 | $R_C < 75$ m and VPL < 112 m | e.g., WAAS HPL, VPL |
| 10 | $R_C < 25$ m and VPL < 37.5 m | e.g., WAAS HPL, VPL |
| 11 | $R_C < 7.5$ m and VPL < 11 m | e.g., LAAS HPL, VPL |

**FAA NPRM threshold**




**Navigation integrity enables reduced flight separation**

# Accuracy and Integrity: ADS-B SIL

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**Surveillance Integrity Level (SIL)** specifies the avionics integrity level and the probability that the position error may be larger than the reported NIC

| SIL | Probability of Exceeding the $R_C$ Integrity Containment Radius Without Detection | Comment |
|---|---|---|
| 0 | Unknown | "No Hazard Level" Navigation Source |
| 1 | $1 \times 10^{-3}$ per flight hour or per operation | "Minor Hazard Level" Navigation Source |
| 2 | $1 \times 10^{-5}$ per flight hour or per operation | "Major Hazard Level" Navigation Source |
| 3 | $1 \times 10^{-7}$ per flight hour or per operation | "Severe Major Hazard Level" Navigation Source |

**FAA NPRM threshold**

The minimum SIL value of 2 would provide integrity assurance that meets a failure rate probability of 99.999 per flight hour

[19] ADS–B Out avionics design assurance is dependent on both the hardware and software levels. There are 5 hardware design assurance failure classifications; (1) Catastrophic, (2) Hazardous/Severe-Major, (3) Major, (4) Minor, and (5) No Safety Effect. RTCA/DO–178B ''Software Considerations in Airborne Systems and Equipment Certification'' software classifications are; (1) Level A, (2) Level B, (3) Level C, (4) Level D, and (5) Level E which directly map to the hardware design assurance failure classifications. The minimum requirement for systems development assurance for ADS–B Out is a hardware design assurance (failure classification) of ''major'' dependent upon RTCA/DO–178B Level ''C'' software.

**FAA NPRM excerpt**

# Position Extrapolation for Tracking
# M5L2 vs. M5L2-B (ADS-B)

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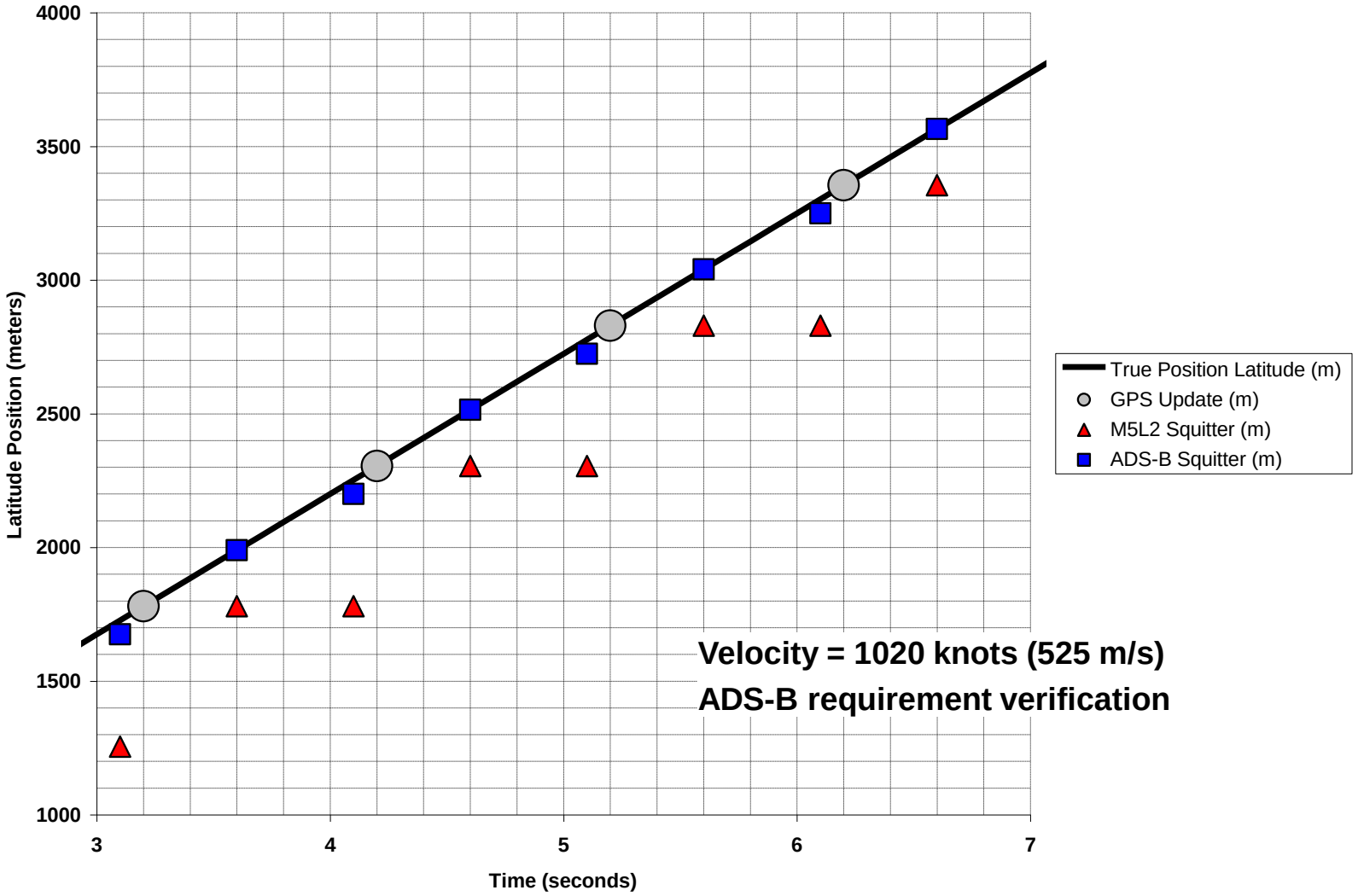


**ADS-B has well defined framework for precision tracking**

# Tracking Advantages Summary

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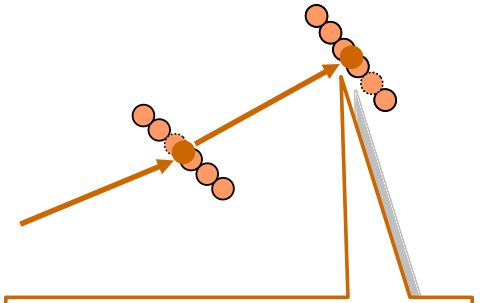
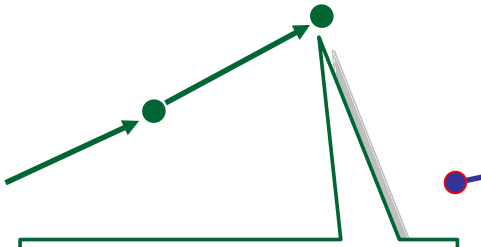
**1 Traditional and M5L1 Q&A**



**Provides Track *History***

- **Interrogator determines track from past & current position reports**

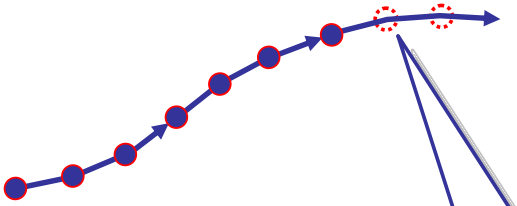
**2 M5L2 with GPS Position Reports**



**Provides more Accurate Track *History***

- **Interrogator still tracks from history data**

**3 M5L2-B Provides Position & Velocity Reports + Status Data**



**Provides Accurate Predicted Track from Aircraft NAV System – Best data source!**

- **Receiver tracker minimal!**

- The ADS-B/M5L2-B 'Track File' is universal based on ID indexed position and status data for Single Integrated Air Picture (SIAP) integration
- Complex geo-registration issues in networked command and control systems resolved with calibrating truth data from self reporting airborne friends
- Enables cockpit display of traffic information (CDTI) for sense and avoid systems in a secured military environment using common civil/military procedures

**M5L2-B enhances predictive tracking with position and velocity data**

# Platform Considerations

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- ADS-B (Class B) implementation for transponders
  - Platform needs to route GPS data (position, velocity, and time) to transponder
- M5L2-B (Class B) for transponders
  - Assuming platform is configured for ADS-B, as noted above no further platform impact/changes
- Interrogators are a case by case review process
  - Retain active interrogation capability
  - Passive reception of ADS-B/M5L2-B data is platform dependent

**Negligible platform impact to implement secure ADS-B capability**

# Summary

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- ADS-B mandated for civil airspace interoperability
- ADS-B performance requirements are being vetted worldwide through civil investments
- M5L2-B provides operational security for ADS-B in military operations (enhances SIAP)
- M5L2-B approach takes full advantage of current Mode 5 Level 2 design in the transponders
- Uniquely satisfies joint civil and military needs