ADDRESSING THE UNMANNED AIRCRAFT SYSTEMS (UAS) NAVIGATION STANDARDS GAP

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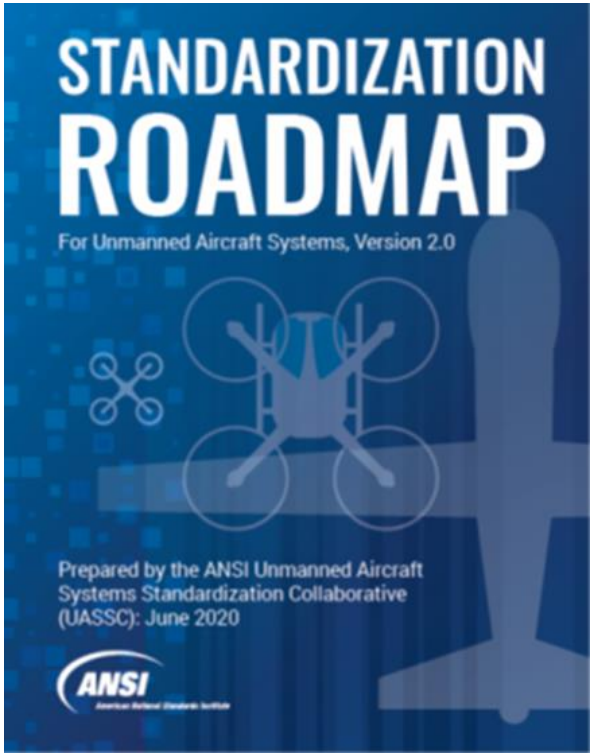
SAE INTERNATIONAL

Gap A7: UAS Navigation Systems

- ANSI Standardization Roadmap for UAS Version 2.0:
  - Identified a gap (A7) in standards for UAS Navigation Systems
  - Prioritized this gap as:
    - High (Tier 1)
    - Most Critical
  - The SAE PNT Committee is committed to supporting UAS standardization efforts and filling the A7 gap



The Need for UAS Navigation Standards

CROWDING in AIR
NEAR MISS

ATM Hazards Ahead

CROWDING on GROUND
RUNWAY INCURSIONS

Essential Improvements

- Positioning
- Position-*dependent measurements*
- Modern estimation: > 60 years old
- Unequal accuracies, correlations, …
- Tight coupling, integrity, differential
- “Measurements, not Coordinates”
  - IoN Journal v4 n (Autumn 199, pp. 203 -216)
  - IoN Newsletter v26 n (Summer 2016, pp. 14-15)
- *Future* position – at closest approach

Importance of Dynamics

- 100 sec to closet approach
- 1-cm/sec x 100 sec = 1 meter

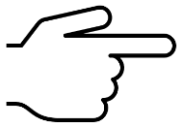
  Validated in flight: IoN Journal v60, n3

  See also:

  https://www.youtube.com/watch?v=DQcvAx0GYGk

  https://www.youtube.com/watch?v=2X88s4o74c4

ADS-B 10 m/sec x 100 sec = 1000 m

1000 x 1000  uncertainty *area* x 1 million

Collision Avoidance by Speed Change

- [Coordinates : A resource on positioning, navigation and beyond » Blog Archive » Collision avoidance by speed change (mycoordinates.org)]
- [IJUSEng1.pdf (jameslfarrell.com)]

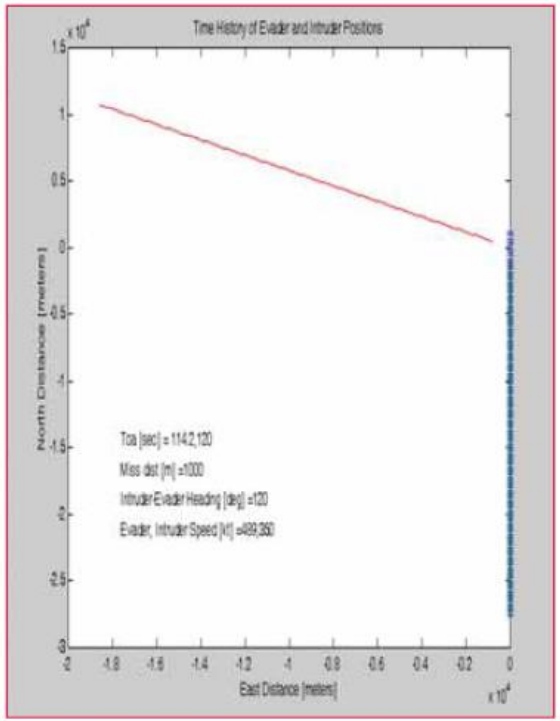


Figure 1: Speed Increase Scenario

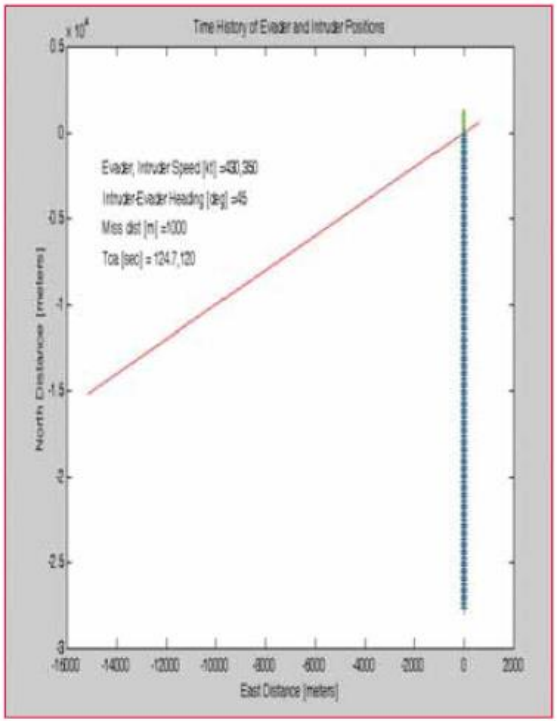
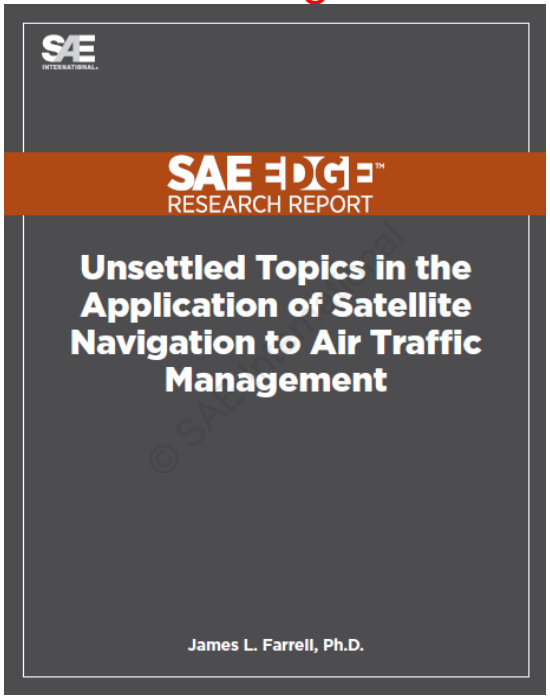


Figure 2: Speed Reduction Scenario

2½ – Minute Video

https://www.youtube.com/watch?v=84De8EM8S0U

Gradual change well in advance



Wide separation 2 minutes later

EDGE DEVELOPMENT TEAM

- Dorota Brzezinska, Associate Dean for Research, Ohio State University College of Engineering
- Dana A Goward, President, Resilient Navigation & Timing Foundation
- Jade Morton, Professor, Aerospace Engineering Sciences Department at the University of Colorado
- Tim Murphy, Senior Technical Fellow – Boeing
- Ron Ogan, Captain, Civil Air Patrol (USAF auxiliary)
- Logan Scott, Logan Scott Consulting
- Doug Taggart President, Overlook Systems Technologies, Inc.
- Erik Theunissen, Professor, Netherlands Defence Academy
- Maarten Uijt de Haag, Professor at TU Berlin
- William Woodward, Chairman, SAE Intl Aerospace Avionics Systems Div.

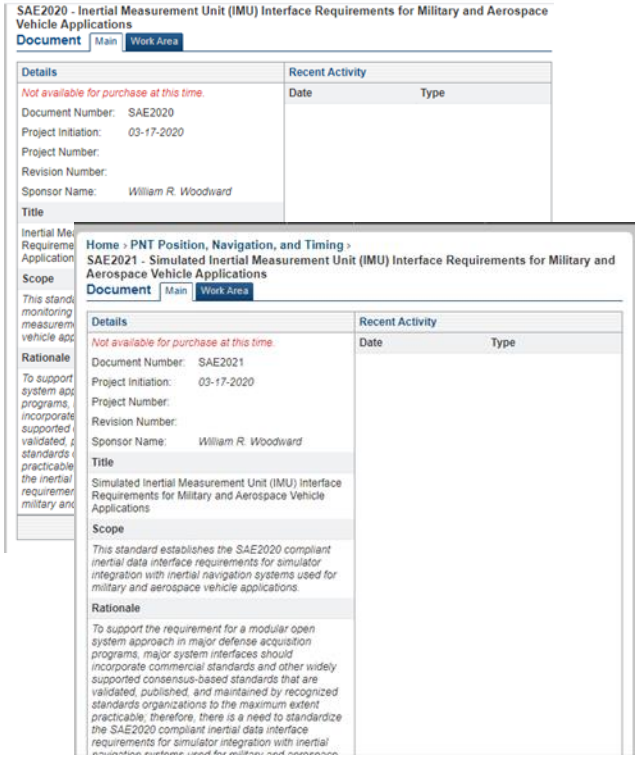
Inputs From

- Civil Air Patrol
- Authentication
  - bandwidth
- F-16 auto pullup

Software Will Take Effect If:

- implanted in *HARD*ware
- reliably installed
- all data communicated to hardware
- with precise timing
  - from multiple sources
  - unified time base constructed
- guided by operational experience

UAS Navigation Systems Standards


SAE2020 - Inertial Measurement Unit (IMU) Interface Requirements for Military and Aerospace Vehicle Applications

Document | Main | Work Area

Details	Recent Activity
Not available for purchase at this time.	Date Type
Document Number: SAE2020	
Project Initiation: 03-17-2020	
Project Number:	
Revision Number:	
Sponsor Name: William R. Woodward	

Title

Scope

Rationale

Home › PNT Position, Navigation, and Timing ›

SAE2021 - Simulated Inertial Measurement Unit (IMU) Interface Requirements for Military and Aerospace Vehicle Applications

Document | Main | Work Area

Details	Recent Activity
Not available for purchase at this time.	Date Type
Document Number: SAE2021	
Project Initiation: 03-17-2020	
Project Number:	
Revision Number:	
Sponsor Name: William R. Woodward	

Title

Simulated Inertial Measurement Unit (IMU) Interface Requirements for Military and Aerospace Vehicle Applications

Scope

This standard establishes the SAE2020 compliant inertial data interface requirements for simulator integration with inertial navigation systems used for military and aerospace vehicle applications.

Rationale

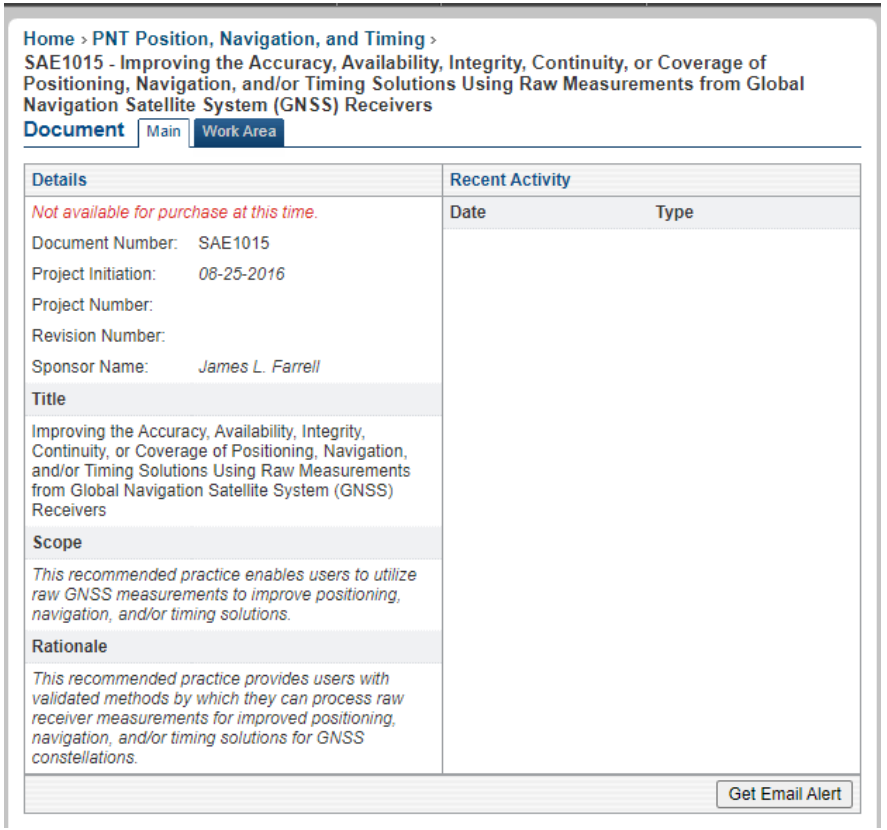
To support the requirement for a modular open system approach in major defense acquisition programs, major system interfaces should incorporate commercial standards and other widely supported consensus-based standards that are validated, published, and maintained by recognized standards organizations to the maximum extent practicable; therefore, there is a need to standardize the SAE2020 compliant inertial data interface requirements for simulator integration with inertial

UAS navigation systems need definition to include:

- Inertial sensors - IMU
  - Interface
  - Performance
- Navigation processor – INS
  - Interfaces
    - IMU
    - Aiding sensors
    - Users
- Clock – Timing architecture
  - Timestamps
  - Synchronization
  - Loss of GPS/GNSS

UAS Navigation Systems Standards

- UAS navigation systems integrators need technical guidance in the form of:
  - Recommended practices
  - Information reports
- For the best use of:
  - Inertial data
  - GPS/GNSS data
  - Aiding data (non-GPS/GNSS)
  - Timing



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SAE1015 - Improving the Accuracy, Availability, Integrity, Continuity, or Coverage of Positioning, Navigation, and/or Timing Solutions Using Raw Measurements from Global Navigation Satellite System (GNSS) Receivers

Document | Main | Work Area

Details

Not available for purchase at this time.

Document Number: SAE1015

Project Initiation: *08-25-2016*

Project Number:

Revision Number:

Sponsor Name: *James L. Farrell*

Title

Improving the Accuracy, Availability, Integrity, Continuity, or Coverage of Positioning, Navigation, and/or Timing Solutions Using Raw Measurements from Global Navigation Satellite System (GNSS) Receivers

Scope

This recommended practice enables users to utilize raw GNSS measurements to improve positioning, navigation, and/or timing solutions.

Rationale

This recommended practice provides users with validated methods by which they can process raw receiver measurements for improved positioning, navigation, and/or timing solutions for GNSS constellations.

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UAS Navigation Systems Standards

- Our approach:
  - Based on decades of experience interfacing new technology with legacy systems
  - Defines what you need and explains how to use it
  - Non-proprietary
  - OEM friendly
  - Aligns with Open System Approaches/Architectures
  - Aligns with Digital Engineering approaches
- Allows for:
  - All technologies (RLG, FOG, MEMS, etc.)
  - New sensors
  - New capabilities
  - Local UAS data sharing
  - Integration with other systems and/or networks
  - Open competition
- Includes “UAS” in the title of each standard
- Almost sounds too good to be true, but we believe it is possible

UAS Navigation Systems Standards

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