Designation: F3586 − 22

Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation 14 CFR Part 89[1]

This standard is issued under the fixed designation F3586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice provides a Means of Compliance (MOC) that gives sufficient clarity to the Unmanned Aircraft System (UAS) or Broadcast Module manufacturers to produce a compliant Remote ID (RID) System (RIDS) such that submitting a Declaration of Compliance[2] (DOC) to this MOC will satisfy the requirements of the Federal Aviation Administration (FAA) 14 CFR Part 89 (Part 89) rule.[3] This practice also explains what to expect from aircraft operating in compliance to this MOC.

1.2 The FAA provided three options to comply with the Remote ID regulations: Standard Remote ID UAS, Remote ID Broadcast Modules, and FAA-recognized identification areas (FRIAs). The scope of this MOC is to cover both Standard RID and RID Broadcast Modules.

1.3 The FRIA portion of the rule is out of scope since it provides a means to avoid the technical RID requirements by operating within administrative boundaries.

1.4 Both SI and non-SI units are used in this document. Since this is an aviation standard and it addresses FAA rules, some units are used in preference of being consistent with industry and regulatory norms.

1.5 *Table of Contents:*

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standard:*[4]

F3411 Specification for Remote ID and Tracking

2.2 *Other Documents:*

14 CFR Part 89 Remote Identification of Unmanned Aircraft[3]

47 CFR Part 15 Radio Frequency Devices[5]

Advisory Circular AC 89-2 Declaration of Compliance Process for Remote Identification of Unmanned Aircraft[2]

ANSI/CTA-2063-A Small Unmanned Aerial Systems Serial Numbers[6]

Technical Standard Order TSO-C199 Traffic Awareness Beacon System (TABS)[7]

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[1] This practice is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.02 on Flight Operations.

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[2] See FAA Advisory Circular 89-2, https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_89-2.pdf.

[3] Available from https://www.federalregister.gov/documents/2021/01/15/2020-28948/remote-identification-of-unmanned-aircraft. Portions of Part 89 are reproduced (in italics) in Section 7 and Appendix X1.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[5] Available from https://www.ecfr.gov/current/title-47/chapter-I/subchapter-A/part-15.

[6] Available from Consumer Technology Association, 1919 S. Eads Street, Arlington, VA 22202, https://www.cta.tech/.

[7] Available from https://rgl.faa.gov/Regulatory_and_Guidance_Library/rgTSO.nsf/0/1600df588a6f53ae86257d710070d105/$FILE/TSO-C199.pdf.

WGS-84 World Geodetic System[8]

3. Significance and Use

3.1 The general approach to this practice is to serve as an "overlay" of requirements to the ASTM F3411-22a Standard Specification for Remote ID and Tracking by identifying mandatory portions, substituting values as needed, overriding items that may be optional, and providing additional requirements that are beyond the scope of Specification F3411, yet are necessary to provide proper guidance to meet the requirements set forth in Part 89.

3.2 Furthermore, this practice provides additional details on minimal testing requirements for those submitting a DOC based on this MOC.

4. Subset of Options in the F3411 Specification Considered

4.1 The F3411 Specification provides four broadcast methods and one network method to implement RID:

4.1.1 Bluetooth[9] Legacy Advertising (also known as the "Bluetooth 4" method): Specification F3411, Subsection 5.4.6.

4.1.2 Bluetooth 5 Long Range + Extended Advertising (also known as the "Bluetooth 5" method), Specification F3411, Subsection 5.4.7: this includes the requirement to implement Bluetooth Legacy, Specification F3411, Subsection 5.4.6.

4.1.3 Wi-Fi[10] Neighbor Awareness Networking (NAN): Specification F3411, Subsection 5.4.8.

4.1.4 Wi-Fi Beacon: Specification F3411, Subsection 5.4.9.

4.1.5 Network RID with Service Suppliers, Display Providers, and Discovery and Synchronization Service (DSS): Specification F3411, Subsection 5.5.

4.2 To meet the "broadcast," "error correction," and "maximum range" requirements of Part 89, and to converge on better interoperability, this MOC requires broadcasting using methods 4.1.2 or 4.1.4.

5. Requirements and Exceptions from the F3411 Specification

5.1 The requirements in this MOC are design requirements of UAS Remote ID. They are not operational requirements. Although a UAS may be designed to these requirements, there may be times when, operationally, certain information cannot perform to the intended requirements. For example, Global Navigation Satellite Systems (GNSS) may have limited reception in certain environments (such as indoors). These requirements do not seek to remedy those conditions. Both Standard RID and Broadcast Modules shall implement all mandatory requirements in the following sections of the F3411 Specification:

5.1.1 Subsections 5.1 through 5.4.5.

5.1.2 Either (or both) of the following:

5.1.2.1 If Implementing Bluetooth, all of Subsection 5.4.6 and all of Subsection 5.4.7 (includes both Bluetooth 5 and Bluetooth 4).

5.1.2.2 If Implementing Wi-Fi Beacon, all of Subsection 5.4.9.

5.1.3 The following FAA requirements take precedence over certain requirements, options, and values in the F3411 Specification.

5.1.3.1 Specification F3411, Subsection 5.4.3, only Wave Law "Type 1" in Tables A3.2 and A3.3 shall apply.

5.1.3.2 Specification F3411, Subsection 5.4.5.6, for Standard RID, the Basic ID message shall include either:

(1) The Unmanned Aircraft (UA) serial number in the format required by the F3411 Specification (in the format of ANSI/CTA-2063-A); or

(2) A unique Session ID (UTM Assigned universally unique identifier (UUID) or Specific Session ID) as described in Specification F3411, Table 1 and Subsection 5.4.5.6, which can be resolved to the corresponding serial number, with access limited to authorized parties only, through a system and process accepted by the FAA.

For Broadcast Modules, the Basic ID message shall be the broadcast module's serial number in the format required by the F3411 Specification (which requires the format of ANSI/CTA-2063-A).

5.1.3.3 Specification F3411, Subsection 5.4.5.18, The System Message is required.

5.1.3.4 In the System Message, the following fields are required (the remaining fields in the System Message can be filled with default values when not used):

(1) Operator Location/Altitude Type
(2) Operator Latitude
(3) Operator Longitude
(4) Operator Altitude
(5) Timestamp

5.1.3.5 For Standard Remote ID, the Operational Status field (Specification F3411, Subsection 5.4.5.7) in the Location/Vector Message is required.

5.1.3.6 For Standard Remote ID, the Operator Location/Altitude Type (Specification F3411, Subsections 5.4.5.18–5.4.5.19) in the System Message shall be either "1. Dynamic" and use a system that accurately (as described in MOC 7.1) reports the location of the ground control station (GCS); or "2. Fixed" where the location is automatically programmed into the UAS based on the actual location of the GCS within the accuracy requirements of Part 89 (as described in MOC 7.1). The GCS location must correspond with the location of the operator.

NOTE 1—UAS designers and producers may determine which part or element of the control station represents the location to be incorporated into "System Message" if it corresponds to the actual operator's location.

5.1.3.7 For Broadcast Modules, the Operator Location/Altitude Type (F3411, Subsection 5.4.5.18) in the System Message shall be "0. Take Off." The source of the "operator location" shall be based on the location of take off within the accuracy requirements of Part 89 (as described in 7.1).

[8] Available from International Civil Aviation Organization (ICAO), 999 Robert-Bourassa Boulevard, Montréal, Quebec, Canada H3C 5H7, https://www.icao.int/safety/pbn/Documentation/EUROCONTROL/Eurocontrol%20WGS%2084%20Implementation%20Manual.pdf.

[9] Used throughout the practice, Bluetooth is a registered trademark of Bluetooth SIG, Inc., 5209 Lake Washington Blvd. NE, Suite 350, Kirkland, WA 98033.

[10] Used throughout the practice, Wi-Fi is a registered trademark of Wi-Fi Alliance, 10900-B Stonelake Boulevard, Suite 126, Austin, TX 78759.

5.1.3.8 The following value in Specification F3411, Table A3.1, shall be overridden to the following: BcMinStaticRefreshRate = 1 Second. This shall be the minimum period within which all required data elements are regularly broadcast.

5.1.3.9 Although the term "Geometric Altitude" is used in the rule, the F3411 Specification uses the term "Geodetic Altitude" based on the WGS 84 Height Above Ellipsoid standard, which is a form of Geometric Altitude and thus satisfies the requirement of this term within Part 89.

5.1.4 For physical add-on Remote ID Modules, the user instructions shall include the following:

5.1.4.1 Instructions on how to install the module on an aircraft in a way that ensures the location source hardware can acquire the aircraft location and ground-based receivers are able to receive the RID broadcasts at an optimal range in any direction.

5.1.4.2 Limitations that may prevent the module from:

(1) Determining the aircraft location.

(2) Transmitting in an omni-directional manner.

6. Alternative Applications of Specification F3411 to Meet Part 89 Requirements

6.1 *Message Synchronization:*

6.1.1 The rule also requires the following:

89.310(b) Time mark. The time mark message element must be synchronized with all other remote identification message elements.

6.1.2 The F3411 Specification presents the required data elements spread across three messages (1. Basic ID, 2. Location/Vector, 3. System). The Timestamp shall be incorporated into the System message as described in Specification F3411, Table 11.

6.1.3 When the receiver receives position updates, that data is merged with the most recently received static data to present a synchronized data element record with the time mark being set by the most recent aircraft position update. Additionally, the requirement in MOC 5.1.3.8, following Part 89, effectively mandates that all three required messages are transmitted within 1 second, with this method resulting in the system timestamp being associated with all required data elements is never older than 1 second. Therefore, this MOC submits that the Specification F3411 implementation of Timestamp satisfies the intent of Part 89.305(b).

6.2 *Error Correction:*

6.2.1 By requiring either the Bluetooth 5 Long Range or Wi-Fi in MOC 5.1.2, forward error correction (FEC) is inherently required as it is built into both transport protocols. Therefore, this MOC satisfies the "error correction" requirement of Part 89.

7. MOC Requirements Not Covered by the Practice

7.1 *Location Accuracy Requirements of Broadcasted Location Information:*

7.1.1 *Standard Remote ID*—Standard Remote ID products (both aircraft and GCS) shall meet the Part 89 accuracy requirements through either of the following three methods:

7.1.1.1 Design specification (aircraft or GCS):

(1) Aircraft—The aircraft is designed with an integrated GNSS system that, at a minimum, uses Global Positioning System (GPS) with Satellite-based Augmentation System (SBAS) (Wide Area Augmentation System (WAAS)) augmentation as its location source.

(2) GCS—The GCS is designed with an integrated GNSS system that, at a minimum, uses GPS with SBAS (WAAS) augmentation as its location source.

7.1.1.2 Design specification (GCS Only)—GCS uses an external device with either of the following characteristics as its location source:

(1) External device uses GPS with SBAS (WAAS), or

(2) Federal Communications Commission (FCC)-certified external personal wireless device with integrated GNSS (See Appendix X1 for justification). The UAS user instructions shall minimally include the following text:

"The [device description] connected to the ground control station must minimally be one of the following:

1) FCC Certified personal wireless device that uses GPS with SBAS (WAAS) for location services; or

2) FCC Certified personal wireless device with integrated GNSS.

Also, the [device description] must be operated in a way that does not interfere with the location reported and its correlation to the operator location."

NOTE 2—Example "device description": "Cell Phone or Tablet".

7.1.1.3 Test demonstration (aircraft or GCS):

(1) Aircraft—If the aircraft does not satisfy method 7.1.1.1 requirements, then the test demonstration method outlined in 8.9.3 or 8.9.4 shall be used to satisfy the location accuracy requirements.

(2) GCS—If the GCS does not satisfy method 7.1.1.1 or 7.1.1.2 requirements, then the test demonstration method outlined in 8.9.3 or 8.9.4 shall be used to satisfy the location accuracy requirements. If the GCS relies on a separate device as its location source, a representative device shall be used in the testing.

7.1.2 *Broadcast Modules:*

7.1.2.1 Broadcast modules shall use the take-off location to represent the location (horizontally and vertically) of the operator.

7.1.2.2 The same requirements in 7.1.1, methods 7.1.1.1 or 7.1.1.3*(1)*, shall be used to satisfy the aircraft and take-off location accuracy requirements.

7.2 *Pre-flight Self-Test (PFST):*

7.2.1 Part 89 requires:

89.310(c)(1) [standard] Prior to take off, the unmanned aircraft must automatically test the remote identification functionality and notify the person manipulating the flight controls of the unmanned aircraft system of the result of the test.

89.320(c)(1) [broadcast modules] Prior to take off, the remote identification broadcast module must automatically test the remote identification functionality and notify the person manipulating the flight controls of the unmanned aircraft system of the result of the test.

7.2.2 To meet this requirement, the RID system, whether integrated into the UAS or as a separate broadcast module, shall automatically initiate a PFST, and the user instructions of the product shall document the PFST usage and limitations. It is not necessary for the UAS to perform the PFST again prior to power off.

7.2.3 The RID system or UAS shall have a documented unique indicator, either visual (light emissive), audible, or using some other user interface that informs the operator of the result of the PFST. The documentation shall include how to interpret a pass or fail of the PFST. The components and functions tested shall include the following:

7.2.3.1 Location source hardware and software are functioning properly, and the required parameter values are set.

7.2.3.2 Transmitter radio hardware and software are functioning properly, transmitting and the required parameter values are set.

NOTE 3—Although the aircraft and GCS must be designed to meet certain accuracy requirements, the PFST of these specific hardware/software functions does not require establishing a location fix or specific accuracy.

7.3 *Monitoring:*

7.3.1 Part 89 Requires:

89.310(c)(3) [standard]: The unmanned aircraft must continuously monitor the remote identification functionality from take off to shutdown and must provide notification of malfunction or failure to the person manipulating the flight controls of the unmanned aircraft system.

89.310(c)(3) [broadcast modules]: The remote identification broadcast module must continuously monitor the remote identification functionality from take off to shutdown and must provide notification of malfunction or failure to the person manipulating the flight controls of the unmanned aircraft system.

7.3.2 To meet this requirement, the RID system, whether integrated into the UAS or implemented as a separate broadcast module, shall have a documented indicator that communicates a malfunction or failure of the RID system to the operator. The functions monitored shall include the following:

7.3.2.1 RID-required data source hardware and software are functioning properly.

7.3.2.2 Transmitter radio hardware and software are functioning properly.

NOTE 4—Monitoring these hardware/software functions does not require establishing a location fix or specific accuracy, nor does it (necessarily) require a "closed-loop" RID receiver function.

7.3.3 The indicator could be displayed in the GCS, an RID receiver, mobile application, or other means with software logic to detect a failure and inform the operator.

7.3.4 The monitoring system shall start prior to take off and continue to run at least until shutdown.

NOTE 5—Shutdown does not necessarily imply power down. Shutdown will be aircraft and operator specific, but generally corresponds to a situation where the UAS is not available for flight.

7.3.5 Documentation of the functionality, possible software installation, and usage instructions for this monitoring system, shall be provided together with the RID system.

7.4 *Take-off Prevention When Not Broadcasting RID (Standard RID Only):*

7.4.1 Part 89 Requires:

89.310(c)(2): The unmanned aircraft must not be able to take off if the remote identification equipment is not functional.

7.4.2 For standard RID systems, after power on, until the PFST passes, and all required RID message elements are being transmitted, taking flight shall be prevented by the control system of the UAS.

NOTE 6—As stated in Note 3, the PFST does not require establishing a location fix or specific accuracy to pass. Under certain conditions (indoors, or GNSS "canyon"), this may not be possible.

7.5 *Tamper Resistance:*

7.5.1 Part 89 Requires:

89.310(d) [standard]: The unmanned aircraft must be designed and produced in a way that reduces the ability of a person to tamper with the remote identification functionality.

89.320(d) [broadcast modules]: The remote identification broadcast module must be designed and produced in a way that reduces the ability of a person to tamper with the remote identification functionality.

7.5.2 The Remote ID system shall protect Part 89 required broadcasted message elements from being altered through the end-user interface(s) of the system by masking the items from user input. The following message elements are an exception to this requirement:

7.5.2.1 Emergency Status Indicator.

7.5.2.2 ID mode selection of Serial Number or Session ID.

NOTE 7—End-user interfaces include the following: External Buttons, screens, add-on devices (such as cell phones/apps), external wiring interfaces + supporting software.

7.5.3 For Standard RID, as required in 7.2.2, the RID system must perform a PFST. If the aircraft RID location source hardware and software or RID transmit hardware and software are detected not functional as described in 7.2.3, due to tampering or other failure, then taking flight shall be prevented by the control system. This take-off prevention feature shall be protected from being altered through the end-user interface(s) of the system.

7.6 *Interference Considerations:*

7.6.1 Part 89 Requires:

89.310(f) Interference considerations. The remote identification equipment must not interfere with other systems or equipment installed on the unmanned aircraft, and other systems or equipment installed on the unmanned aircraft must not interfere with the remote identification equipment.

7.6.2 The RID system shall not degrade the flight-critical radio communications to the extent where the aircraft cannot be safely controlled.

7.6.3 The RID system shall not degrade the other Radio Frequency (RF) sensitive systems, for example: GNSS such that the data elements transmitted are unable to meet the performance and periodicity requirements of this MOC.

7.6.4 Other radio systems on the aircraft shall not interfere with the Remote ID equipment in a way that prevents Remote ID from functioning as intended.

7.7 *Emergency Status Indicator:*

7.7.1 For standard RID, the emergency status indicator shall be satisfied using either (or both) of the following methods:

7.7.1.1 The system shall provide a mechanism for the operator to manually assert the emergency status and document this function in the user instructions. If a manual assert mechanism is used, it shall be available to use at the operator's discretion.

7.7.1.2 The system shall automatically assert the emergency status at least under the two following conditions:

(1) UAS unable to recover from an uncontrolled descent.

(2) UAS unable to recover from loss of control of the flight trajectory.

7.7.2 In the event of an emergency status assertion, the RID system shall transmit the Operational Status of "Emergency" (3) as described in Specification F3411, Tables 1, 2, and 6. The RID system may optionally fill in the "Self ID" message (Specification F3411, Subsections 5.4.5.16–5.4.5.17) with a short description of the emergency condition. When implementing the Self ID message for this purpose, it shall set the Description Type to "Emergency Description" (1).

7.8 *Designed to Maximize Range*—The rule requirement, Part 89.310(g)(2), "…designed to maximize the range at which the broadcast can be received…" is met in the F3411 Specification by balancing the general available electronics that can be used for this purpose and prescribing the minimum power, periodicity, radiation pattern, and technique.

7.8.1 *Power:*

7.8.1.1 The solution (whether standard RID or broadcast module) shall conform to the requirements specified in Specification F3411, Subsection 5.4.3 (which specifies power and radiation pattern), and the associated values in Tables A3.1, A3.2, A3.3 (Wave Law Type 1). See rationale in Appendix X2.

7.8.1.2 This requirement reflects the capabilities of commonly available commodity radio parts.

7.8.1.3 Although the Bluetooth power level requirements are lower than Wi-Fi, to implement the Bluetooth solution, both Long Range and Legacy advertising modes shall be implemented. The Long Range mode transmits at a much lower rate (than Legacy advertising mode—125 kbps rather than 1 Mbps) and uses FEC, which both will serve to extend the range. Requiring Legacy mode enhances compatibility across nearly all handheld devices.

7.8.2 *Periodicity*—The rule requires all required data elements to be transmitted at least once per second. Therefore, when sending the data across multiple messages, all messages containing the Part 89 required data elements (Basic ID, Location/Vector, System messages) shall be sent at least every 1 second.

7.8.3 *Radiation Pattern*—The F3411 Specification, Subsection 5.4.3, requires the minimum average EIRP power and a maximum "peak to average" around the horizontal plane. The most common implementation of this requirement will likely result in a horizontal toroid (donut) shape radiation pattern that optimizes for horizontal range.

7.8.4 *Technique*—As specified in 5.1 of this MOC, requiring either Wi-Fi or Bluetooth Long Range (+ Bluetooth Legacy), given the constraints of handheld device compatibilities, allowing only this subset contributes toward "designing for maximum range."

TABLE 1 System Properties

Item	Value	Notes
Product Make		
Product Model #		
Product RID Serial #		
Software Stack Version		
Hardware Version		
Broadcast Method(s)	"Bluetooth" or "Wi-Fi," or both	
Broadcast Rate	x Hz	How often are packets sent
Msg Update Rate	x Hz	How often are messages updated
RID Monitor Indication Method		GCS indicator, App (Name), Other (describe)
Implemented Optional Emergency Status Description	Y/N	

8. Test Methods

8.1 *Scope*—This section includes testing that shall be performed to declare a product design compliant to this MOC. It is not intended to be comprehensive of all testing that may be required for a product.

8.2 *Significance and Use*—This test series serves as a design validation of a compliant make and model. In addition to meeting all requirements in Sections 5, 6, and 7 of this MOC, all items in this section shall achieve a result of "PASS" for a Standard RID UAS or RID Broadcast Module (as appropriate) to be compliant to this MOC. (Portions sourced from ASD-STAN.[11])

8.3 *Hazards:*

8.3.1 Ensure that UAS are configured as to not cause harm to individual(s) conducting the test or third parties.

8.3.2 UAS that are powered or operational can present hazards. Ensure that propellers are removed or caged during laboratory testing.

8.3.3 Field testing of UAS can present hazards. Take appropriate safety precautions when field testing UAS.

8.3.4 When testing UAS with power plants or lithium batteries, or both, an appropriate fire extinguisher for each application should be within reach. Participants should be made aware of the hazards of lithium batteries or flammable fuels, or both, and which fire extinguishers are appropriate for lithium or flammable fuel-based fires, or both.

8.4 *Procedure*—A unit representative of the make and model that will be submitted in the DOC shall be used in all applicable tests in this section. When performing all the tests required in Section 8 and assessing that all requirements stated in this MOC are met, Table 3 shall be filled in and recorded as a checklist and shall be archived as a part of the "supporting data" to show compliance to this MOC.

8.5 *Required System Documentation for Performing the Test*—Table 1 shall be filled and maintained in compliance records in support of the testing process.

[11] Copyright CEN, reproduced with permission; ASD-STAN prEN 4709-002 P1, Aerospace series - Unmanned Aircraft Systems - Part 002: Direct Remote Identification, http://asd-stan.org/downloads/asd-stan-pren-4709-002-p1/.

8.6 *Broadcast Protocol, Message Elements, and Periodicity Testing:*

8.6.1 *General Test Setup*—The test requires a computer, laptop, or other device with packet capturing software installed and a wireless network device with a "sniffing" function capable of capturing and logging the underlying raw data and timing information (at least to 10 ms accuracy) transmitted by the UA or broadcast module. See Fig. 1.

8.6.2 *Measurement Procedure:*

8.6.2.1 *Step 1*—Set the UA or Broadcast Module to power on, and to the point where the RID System (RIDS) is in its nominal state of periodically broadcasting data.

8.6.2.2 *Step 2*—Start the packet capturing software to capture at least 10 seconds of broadcast data.

8.6.2.3 *Step 3*—Use the packet capture software to filter out the required data, check whether the captured packets contain periodic RID-required data (Sections 5.1.3.2 – 5.1.3.9) as appropriate for Standard Remote ID or broadcast modules. Calculate the interval between multiple frames by taking the difference of the received timestamps logged in the sniffing software. By analyzing the message types carried in the frames, the transmitting intervals of the messages can be calculated. When all required messages are encapsulated in a single message pack, the interval between two frames shall be less than or equal to the transmission interval of dynamic messages (1 second).

8.6.2.4 *Pass Criteria*—For each message type, the time interval between two messages is calculated, and the interval is compared against the maximum as specified in Specification F3411, Subsection 5.4.4.1, and as amended by MOC 5.1.3.8. The interval shall be less than or equal to the allowed time (1 second). In summary, all fields in Table 2 shall be received at least every second.

8.7 *Flight Testing Setup:*

8.7.1 The setup shall be performed outdoors using the final version of the RIDS product intended for use in the airspace. A mobile device with a receiver app (or other receiving device) that is compatible with the transmitting device and capable of displaying all required message elements shall be used to validate the tests in 8.8 and 8.9.

8.8 *Power On and Pre-flight:*

8.8.1 *Nominal Operation Test:*

8.8.1.1 *Step 0 (setup):*

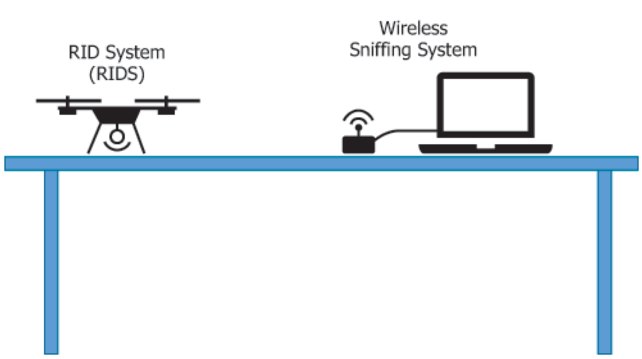


FIG. 1 General Test Setup

TABLE 2 Received Data Elements

Field	Received/ Correct
1. Properly assigned serial number or session ID, or if broadcast module, the properly assigned serial number of the broadcast module	
2. Latitude and longitude of the GCS, or if broadcast module, the take-off position of the UA	
3. Geometric altitude of the GCS, or if broadcast module, the take-off altitude of the UA	
4. Latitude and longitude of the UA	
5. Geometric altitude of the UA	
6. Velocity of the UA expressed as:	
a. Track direction	
b. (Horizontal) speed	
c. Vertical speed	
7. Coordinated Universal Time (UTC) time of applicability of the position data	
8. Operational (or emergency) status of the UA (standard RID only)	

(1) (Broadcast Modules only) Follow the user instructions to install the module on the UA and turn on the module.

(2) Follow the UAS user instructions on the power-on procedure and wait the required amount of time or the indication of when the system is ready to take flight.

(3) Power on the compatible receiver app.

8.8.1.2 *Step 1:*

(1) Observe the result of the PFST as documented.

(2) Observe the data on the receiver app.

(3) Perform a brief take-off operation.

(4) Land.

8.8.1.3 *Pass Criteria:*

(1) PFST result is observable by the Pilot In Command (PIC) as documented.

(2) All required data elements (see 8.9.1) are shown.

(3) Successful Take off/Landing.

8.8.2 *Failure Mode Operational Test:*

8.8.2.1 *Step 1:*

(1) Induce a failure in one of the required components to be functional in MOC 7.2.3.

(2) Attempt Take off (Standard Remote ID only).

(3) Repeat separately for each required functional component in MOC 7.2.3.

(4) Disable broadcasting of Remote ID, repeat test.

8.8.2.2 *Pass Criteria (Standard Remote ID):*

(1) The PIC is notified of the PFST failure through the documented monitor interface defined in 7.3.

(2) The aircraft will not commence take off when it is attempted during this failure condition.

8.8.2.3 *Pass Criteria (Broadcast Module):*

(1) PIC is notified of the PFST failure through the documented monitor interface defined in 7.3.

8.9 *Flight Test:*

8.9.1 *Nominal Operations:*

8.9.1.1 *Step 1*—Perform take off of the RIDS UA and fly to a height above the surface of 10 m (either to a fixed position, or into a continuous pattern).

8.9.1.2 *Pass Criteria*—After take off, verify on the RID receiver application that the following fields are received and correct. Table 2 shall be filled and archived with compliance records.

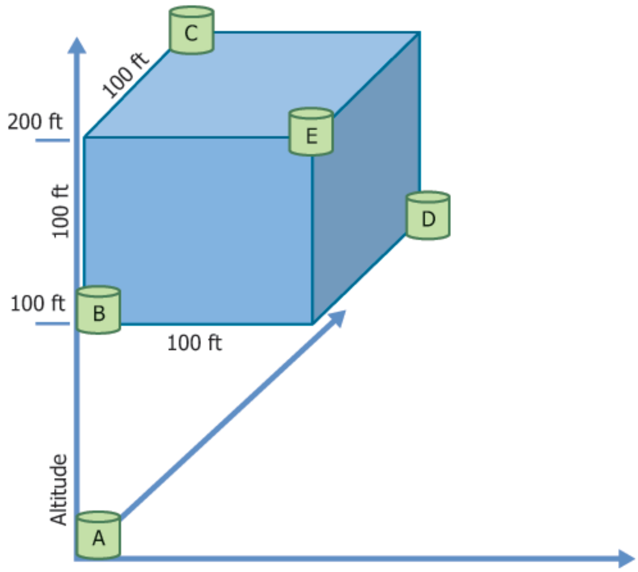


FIG. 2 Multirotor-UA Test Procedure

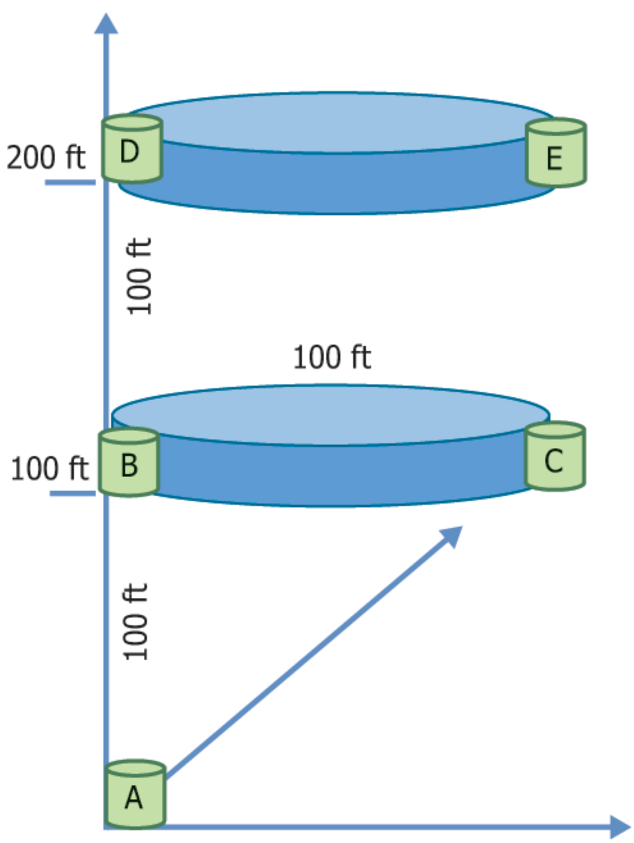


FIG. 3 Fixed Wing UA Test Procedure

8.9.1.3 *Step 2:*

(1) Multirotor-UA (with or without Broadcast Module)—Start flying the test procedure in accordance with Fig. 2, from Point B to E, D, C and then back to Point B, hovering minimum 5 seconds on every position.

(2) Fixed Wing UA (with or without Broadcast Module)—Start flying the test procedure as illustrated (or similar) in Fig. 3, from Point B and then back to Point B, loitering minimum for 60 seconds or three orbits on every altitude (between B and C and between D and E). The climb and descent phases will allow observing different speeds. It is not necessary to match the dimensions in Fig. 3, but to roughly match the pattern and verify that the received data matches the position(s) of the aircraft. For example, the flight legs may be extended to simplify the test.

8.9.1.4 *Pass Criteria*—Verify on the RID receiver mobile device application if the received RID information on all mandatory fields is correctly displaying the current UAS flight status. For example:

(1) Correct Operational Status (non-Emergency).

(2) Correct serial number (or Session ID as appropriate), timestamp, position and altitude, horizontal and vertical speed, direction.

(3) Correct remote pilot location or take-off position information as required.

8.9.1.5 *Step 3*—Check Remote Pilot position or Take-Off position. Remote pilot shall change the position and move 30 ft into any direction and then move back to point A.

8.9.1.6 *Pass Criteria*—For Standard RID, verify the new position of the Remote Pilot is correctly displayed on the receiver app. For Broadcast Module, and when no "live" pilot position is available, verify the UA take-off point is correctly displayed on the receiver app.

8.9.2 *Emergency Status (Standard RID only):*

8.9.2.1 *Step 1*—If the UAS implements automatic emergency detection as described in 7.7.1.2, induce or simulate each automated emergency condition enumerated in MOC 7.7.1.2.

8.9.2.2 *Pass Criteria*—Observe the Emergency Status indication (Operational Status type 3) for each induced condition through the Remote ID Receiver. If the system implements emergency status descriptions (7.7.2), observe the emergency status description(s) in the Self ID message (description type 1).

8.9.2.3 *Step 2*—If the UAS implements manual emergency assertion as described in 7.7.1.1, manually assert an emergency through the user interface.

8.9.2.4 *Pass Criteria*—Observe the Emergency Status indication through the Remote ID Receiver.

8.9.3 *Single (known/surveyed) Point Accuracy Measurement:*

NOTE 8—This test is only required if the Aircraft or GCS is not compliant using methods in 7.1.1.1 or 7.1.1.2.

8.9.3.1 *Step 1:*

(1) Select a known surveyed physical position that would be representative of a typical operating environment for the UAS design as a reference point. Optionally, measure an offset from this position to use as a test reference point. Place the device under test at this position on the ground, table, or other holding device such as a tripod. Power the system on and wait until the PFST has passed and the location system has established a fix within the accuracy requirements of Part 89.

(2) This is the beginning of the sample test period. The testing may be performed in a single period of at least 12 hours or using the following segmented capture method: capture at least 150 position samples (at least one sample every 4 seconds) over a time period of at least 10 minutes.

(3) This is the end (beginning +10 min) of the sample test period. Repeat this capture at least 6 times, with a minimum of 2 hours difference in the time of day of each capture session. If the GCS relies on a separate device as its location source, a representative device shall be used for testing.

8.9.3.2 *Pass Criteria*—Reported position and altitude of aircraft or module (and for Standard RID, position and altitude of GCS) is within the Part 89-required accuracy tolerance of the reference point for 95 % of the samples within the sample test period(s).

8.9.4 *Accuracy Test Using Simulation Option*—An alternative to applying the test method of 8.9.3 is to use the simulation method described in Annex A1.

8.9.5 *Broadcast Module and Standard Omni-directional Test:*

8.9.5.1 *Step 1:*

(1) If Broadcast Module, it shall first be integrated onto a representative aircraft.

(2) Move aircraft (or receiver) to 100 m distance between aircraft and receiver.

(3) Turn aircraft (or move receiver) to where the transmitter changes 9 degrees (±1 degree) of aspect to the receiver.

(4) Repeat for every 9 degree increment of 360 degrees.

NOTE 9—The Aircraft does not necessarily need to fly during this test. It could be on a fixed "tripod" or other stand, at least 1.5 m high, and either the aircraft could be rotated, or the receiver could be moved to accomplish the aspect angle. The receiver shall be at a lower elevation than the aircraft. Note, this is not a range test, but rather a validation on the omni-direction capability as an integrated system. Also, the "receiver" does not necessarily need to be a handheld device, and optimally, it should be the sniffer setup described in 8.6.1.

8.9.5.2 *Pass Criteria*—Each increment shall receive the required messages at least every second for 9 seconds out of 10 seconds and no more than four increments may fail this ratio, and no two failures may be adjacent to one another.

8.9.6 *Failure Mode (monitoring) Operational Test During Flight:*

8.9.6.1 *Step 1:*

(1) Induce a failure (or simulation of a failure) in one of the required components to be functional in MOC 7.2.3.

(2) Observe failure indication as documented in the "user instructions."

(3) Repeat separately for each required functional component in MOC 7.2.3.

8.9.6.2 *Pass Criteria (Standard RID and Broadcast Module)*—The PIC is notified of the failure through the documented monitor interface defined in 7.3.

8.10 *Model to Model Considerations*—If a revision to the model of a Standard RID UAS or Broadcast Module affects the following systems, it shall be retested in accordance with the applicable affected functions in Section 8, and add results to compliance records as described in Section 10.

8.10.1 Integrated Remote ID location source hardware or software.

NOTE 10—End user provided external location source devices are not in scope for this requirement.

8.10.2 Remote ID software or logic.

8.10.3 Remote ID Transmitter radio or antenna hardware or software.

8.11 *Compliance through "Inspection"*—For items in Table 3 that show a "Test Method" as "Inspection," analyze the design in accordance with the requirements and ensure that the product is compliant.

9. Precision and Bias

9.1 All requirements that have necessary precision attributes have the required precision stated within the requirement itself. Otherwise, the stated numerical requirements must be met to a precision of 95 % and met 95 % of the time. No information can be presented on the bias of the test methods in this practice because no such requirements have an accepted reference value available.

10. Satisfaction of Rule Requirements

10.1 The intent of this section is to present an accounting of the requirements of the rule and how each item is addressed in this MOC or the F3411 Specification, or both.

10.2 In addition to filling the appropriate checklists in Tables 21, 22, 23, 24, 25 in the F3411 Specification, Table 3 shall be filled and recorded in the compliance records that must be available upon request from the FAA.

10.3 For each test performed in Section 8, a description of the tools used to perform the testing, the data collected, and the results of each test shall be included in the compliance records.

11. Keywords

11.1 ASTM; broadcast; F3411; MOC; remote ID

TABLE 3 Requirements for Standard Remote Identification Unmanned Aircraft and Remote Identification Broadcast Modules

Rule	Document Section	Test Method	Pass? Y/N
Subpart D—Requirements for Standard Remote Identification Unmanned Aircraft and Remote Identification Broadcast Modules			
§ 89.301 Applicability. This subpart prescribes the minimum message element set and minimum performance requirements for standard remote identification unmanned aircraft and remote identification broadcast modules.			
§ 89.305 Minimum message elements broadcast by standard remote identification unmanned aircraft. A standard remote identification unmanned aircraft must be capable of broadcasting the following remote identification message elements:			
(a) The identity of the unmanned aircraft, consisting of:			
(1) A serial number assigned to the unmanned aircraft by the person responsible for the production of the standard remote identification unmanned aircraft; or	F3411: Table 1 (UAS ID), 5.4.5.5, 5.4.5.6 MOC: 5.1.3.2*(1)*	MOC: 8.9.1	
(2) A session ID.	F3411: Table 1 (UAS ID), 5.4.5.5, 5.4.5.6 MOC: 5.1.3.2*(2)*	MOC: 8.9.1	
(b) An indication of the latitude and longitude of the control station.	F3411: 5.4.5.18, 5.4.5.19 MOC: 5.1.3.4	MOC: 8.9.1	
(c) An indication of the geometric altitude of the control station.	F3411: 5.4.5.18, 5.4.5.19 MOC: 5.1.3.4	MOC: 8.9.1	
(d) An indication of the latitude and longitude of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(e) An indication of the geometric altitude of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(f) An indication of the velocity of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(g) A time mark identifying the Coordinated Universal Time (UTC) time of applicability of a position source output.	F3411: 5.4.5.18, 5.4.5.19 MOC: 5.1.3.4	MOC: 8.9.1	
(h) An indication of the emergency status of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 7.7	MOC: 8.9.2	
§ 89.310 Minimum performance requirements for standard remote identification unmanned aircraft. A standard remote identification unmanned aircraft must meet the following minimum performance requirements:			
(a) Control station location. The location of the control station of the unmanned aircraft must be generated and encoded into the message elements and must correspond to the location of the person manipulating the flight controls of the unmanned aircraft system.	MOC: 5.1.3.4, 5.1.3.6	MOC: 8.9.1	
(b) Time mark. The time mark message element must be synchronized with all other remote identification message elements.	MOC: 6.1	MOC: 8.9.1	
(c) Self-Testing and monitoring.			
(1) Prior to take off, the unmanned aircraft must automatically test the remote identification functionality and notify the person manipulating the flight controls of the unmanned aircraft system of the result of the test.	MOC: 7.2	MOC: 8.8	
(2) The unmanned aircraft must not be able to take off if the remote identification equipment is not functional.	MOC: 7.4	MOC: 8.8.2	
(3) The unmanned aircraft must continuously monitor the remote identification functionality from take off to shutdown and must provide notification of malfunction or failure to the person manipulating the flight controls of the unmanned aircraft system.	MOC: 7.3	MOC: 8.9.6	
(d) Tamper resistance. The unmanned aircraft must be designed and produced in a way that reduces the ability of a person to tamper with the remote identification functionality.	MOC: 7.5	Inspection	
(e) Error correction. The remote identification equipment must incorporate error correction in the broadcast of the message elements in § 89.305.	F3411: 5.4.7.1, 5.4.8.2, 5.4.9.2 MOC: 5.1.2, 6.2	Inspection	
(f) Interference considerations. The remote identification equipment must not interfere with other systems or equipment installed on the unmanned aircraft, and other systems or equipment installed on the unmanned aircraft must not interfere with the remote identification equipment.	MOC: 7.6	MOC: 8.9	
(g) Message broadcast.			
(1) The unmanned aircraft must be capable of broadcasting the message elements in § 89.305 using a non-proprietary broadcast specification and using radio frequency spectrum compatible with personal wireless devices in accordance with part 15 of title 47, Code of Federal Regulations, where operations may occur without an FCC individual license.	F3411: 5.4 MOC: 5.1.2, 5.1.3	Inspection	
(2) Any broadcasting device used to meet the requirements of this section must be integrated into the unmanned aircraft without modification to its authorized radio frequency parameters and designed to maximize the range at which the broadcast can be received, while complying with 47 CFR part 15 and any other applicable laws in effect as of the date the declaration of compliance is submitted to the FAA for acceptance.	MOC: 7.8	Inspection	
(h) Message elements performance requirements.			
(1) The reported geometric position of the unmanned aircraft and the control station must be accurate to within 100 ft of the true position, with 95 % probability.	MOC: 7.1	MOC: 8.9.3, 8.9.4, Inspection	

TABLE 3 *Continued*

Rule	Document Section	Test Method	Pass? Y/N
(2) The reported geometric altitude of the control station must be accurate to within 15 ft of the true geometric altitude, with 95 % probability.	MOC: 7.1	MOC: 8.9.3, 8.9.4, Inspection	
(3) The reported geometric altitude of the unmanned aircraft must be accurate to within 150 ft of the true geometric altitude, with 95 % probability.	MOC: 7.1	MOC: 8.9.3, 8.9.4, Inspection	
(4) The unmanned aircraft must broadcast the latitude, longitude, and geometric altitude of the unmanned aircraft and its control station no later than 1.0 seconds from the time of measurement to the time of broadcast.	F3411: 5.4.4, Table A3.1 (BCMax-DataAge) MOC: 5.1.1	MOC: 8.6	
(5) The unmanned aircraft must broadcast the message elements at a rate of at least 1 message per second.	MOC: 5.1.3.8, 7.8.2	MOC: 8.6	
(i) Take-off limitation. The unmanned aircraft must not be able to take off unless it is broadcasting the message elements in § 89.305.	MOC: 7.4	MOC: 8.8.2	
§ 89.315 Minimum message elements broadcast by remote identification broadcast modules. Remote identification broadcast modules must be capable of broadcasting the following remote identification message elements:			
(a) The identity of the unmanned aircraft, consisting of the serial number assigned to the remote identification broadcast module by the person responsible for the production of the remote identification broadcast module.	F3411: Table 1 (UAS ID), 5.4.5.5, 5.4.5.6 MOC: 5.1.3.2*(1)*	MOC: 8.9.1	
(b) An indication of the latitude and longitude of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(c) An indication of the geometric altitude of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(d) An indication of the velocity of the unmanned aircraft.	F3411: 5.4.5.7, 5.4.5.8 MOC: 5.1.1	MOC: 8.9.1	
(e) An indication of the latitude and longitude of the take-off location of the unmanned aircraft.	F3411: 5.4.5.18, 5.4.5.19 MOC: 5.1.3.4	MOC: 8.9.1	
(f) An indication of the geometric altitude of the take-off location of the unmanned aircraft.	F3411: 5.4.5.18 MOC: 5.1.3.4, 5.1.3.7	MOC: 8.9.1	
(g) A time mark identifying the Coordinated Universal Time (UTC) time of applicability of a position source output.	F3411: 5.4.5.18 MOC: 5.1.3.4	MOC: 8.9.1	
§ 89.320 Minimum performance requirements for remote identification broadcast modules. Remote identification broadcast modules must meet the following minimum performance requirements:			
(a) Take-off location. The remote identification broadcast module must be capable of determining the take-off location of the unmanned aircraft.	MOC: 5.1.3.7	MOC: 8.9.1	
(b) Time mark. The time mark message element must be synchronized with all other remote identification message elements.	MOC: 5.1, 5.1.3.4	MOC: 8.9.1	
(c) Self-Testing and monitoring.			
(1) Prior to take off, the remote identification broadcast module must automatically test the remote identification functionality and notify the person manipulating the flight controls of the unmanned aircraft system of the result of the test.	MOC: 7.2	MOC: 8.8	
(2) The remote identification broadcast module must continuously monitor the remote identification functionality from take off to shutdown and must provide notification of malfunction or failure to the person manipulating the flight controls of the unmanned aircraft system.	MOC: 7.3	MOC: 8.9.6	
(d) Tamper resistance. The remote identification broadcast module must be designed and produced in a way that reduces the ability of a person to tamper with the remote identification functionality.	MOC: 7.5	Inspection	
(e) Error correction. The remote identification broadcast module must incorporate error correction in the broadcast of the message elements in § 89.315.	F3411: 5.4.7.1, 5.4.8.2, 5.4.9.2 MOC: 5.1.2, 6.2	Inspection	
(f) Interference considerations. The remote identification broadcast module must not interfere with other systems or equipment installed on compatible unmanned aircraft, and other systems or equipment installed on compatible unmanned aircraft must not interfere with the remote identification equipment.	MOC: 7.6	MOC: 8.9	
(g) Message broadcast.			
(1) The remote identification broadcast module must be capable of broadcasting the message elements in § 89.315 using a non-proprietary broadcast specification and using radio frequency spectrum compatible with personal wireless devices in accordance with part 15 of title 47, Code of Federal Regulations, where operations may occur without an FCC individual license.	F3411: 5.4 MOC: 5.1.2, 5.1.3	Inspection	
(2) The remote identification broadcast module must be designed to maximize the range at which the broadcast can be received, while complying with 47 CFR part 15 and any other applicable laws in effect as of the date the declaration of compliance is submitted to the FAA for acceptance.	MOC: 7.8	Inspection	
(h) Message elements performance requirements.			

TABLE 3 *Continued*

Rule	Document Section	Test Method	Pass? Y/N
(1) The reported geometric position of the unmanned aircraft must be accurate to within 100 ft of the true position, with 95 % probability.	MOC: 7.1	MOC: 8.9.3, 8.9.4, Inspection	
(2) The reported geometric altitude of the unmanned aircraft must be accurate to within 150 ft of the true geometric altitude, with 95 % probability.	MOC: 7.1.1	MOC: 8.9.3, 8.9.4, Inspection	
(3) The reported geometric position of the take-off location must be accurate to within 100 ft of the true geometric position, with 95 % probability.	MOC: 7.1.2	MOC: 8.9.3, 8.9.4, Inspection	
(4) The reported geometric altitude of the take-off location must be accurate to within 150 ft of the true geometric altitude, with 95 % probability.	MOC: 7.1	MOC: 8.9.3, 8.9.4, Inspection	
(5) The remote identification broadcast module must broadcast the latitude, longitude, and geometric altitude of the unmanned aircraft no later than 1.0 seconds from the time of measurement to the time of broadcast.	F3411: 5.4.4, Table A3.1 (BCMaxDataAge), MOC: 5.1.1	MOC: 8.9.3	
(6) The remote identification broadcast module must broadcast the message elements at a rate of at least 1 message per second.	MOC: 7.8.2	MOC: 8.6	

ANNEX

(Mandatory Information)

A1. SIMULATION OPTION FOR ACCURACY TESTING

A1.1 *Simulation Testing*—The following section is a direct excerpt from Annex A2 of FAA's TSO-C199. The MOCs approach to simulation testing is to adopt the static simulation portions from TSO-C199. The text in Fig. A1.1 is a direct quote from TSO-C199 (with modification indicated in red and strikethroughs), and therefore the section numbers of the original TSO are preserved for reference purposes. The text in Fig. A1.1 is intended to be treated as quoted/modified rather than directly represent ASTM Standard section numbers.

A2.2.6.3.3 GPS Simulator-based Accuracy Tests.

A2.2.6.3.3.1 The equipment SHALL be tested using a GPS simulator scenario~~. that includes both static and dynamic aircraft maneuvers.~~ The horizontal and vertical position errors SHALL be computed for each position estimate output by the equipment.

A2.2.6.3.3.2 Monitor the sensor provided HFOM and VFOM, or HFOM and VFOM derived from the sensor provided HDOP and VDOP per paragraphs A1.2.5.8 and A1.2.5.10. In order to pass the test, the horizontal position error must be less than ~~30 meters~~ 100 feet for Aircraft and GCS for at least 95% of the samples and the horizontal accuracy reported must be greater than the actual position error for at least 95% of the samples. In order to pass the test, the vertical position error must be less than 150 feet for aircraft and 15 feet for GCS ~~45 meters~~ for at least 95% of the samples and the vertical accuracy reported must be greater than the actual position error for at least 95% of the samples.

A2.2.6.3.3.3 The horizontal position error SHALL not exceed 0.5 NM at any time during the test.

A2.2.6.3.3.4 Simulator Scenario Details

A2.2.6.3.3.4.1 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. In order to pass the test, 99.9% of the position outputs must be reported as valid, excluding those position reports prior to the first position fix.

A2.2.6.3.3.4.2 The simulator scenario SHALL use the standard 24 satellite constellation in RTCA/DO-229D Appendix B. Additionally, any other FCC certified constellations may be used such as Galileo E1 and E5. The initial position and time should be chosen to ensure the satellite geometry supports the test Pass/Fail criteria and the HDOP is close to 2.5 and VDOP is close to 3.7.

~~A2.2.6.3.3.4.3 The simulation SHALL include both stationary and dynamic portions, as follows:~~

A2.2.6.3.3.4.3.1 At least 10 minutes of stationary position.

~~A2.2.6.3.3.4.3.2 A sequence of different maneuvers, including acceleration to a constant velocity, climbs, descents, and turns.~~

~~A2.2.6.3.3.4.3.2.1 A series of turns should be included to ensure a constantly changing velocity to expose any effects of filtering on the position output.~~

~~A2.2.6.3.3.4.3.3 At least 10 minutes of accelerated maneuvers SHALL be simulated.~~

~~A2.2.6.3.3.4.3.4 Aircraft dynamics are as follows: ground speed = 200kt, horizontal acceleration = 0.58g, vertical acceleration of 0.5g.~~

A2.2.6.3.3.4.4 The simulated satellite signals SHALL be set to -134 dBm while position measurements are taken. Signal powers may be increased at the beginning of the scenario to allow for initial acquisition.

A2.2.6.3.3.4.5 Simulated signals SHALL include ranging errors for atmospheric effects (troposphere and ionosphere) that adhere to approved models. Refer to DO-229D Appendix A Section A.4.2.4 and IS-GPS-200G dated September 5, 2012.

A2.2.6.3.3.4.6 No interference needs to be simulated.

A2.2.6.4 Verification of Step Detector

A2.2.6.4.1 The step detector SHALL be tested under static ~~and dynamic~~ conditions to successfully demonstrate the requirement in A2.2.6.4 is met. If the manufacturer can show by inspection that its equipment's step detection mechanism is insensitive to the type of step (a change in navigation data or a sudden change in code phase), only one type of step need be tested. Nominal satellite signal power (-128 dBm) may be used during these tests.

A2.2.6.4.2 Static Test.

A2.2.6.4.2.1 The step detector test in RTCA/DO-229D section 2.5.3.1 SHALL be performed, with the following exceptions:

A2.2.6.4.2.2 In order to pass the test, the satellite with the step error should be removed from the position solution within 10 seconds of introducing the pseudorange step AND the horizontal position error of all the valid positions is not to exceed 200 meters throughout the entire test.

A2.2.6.4.2.3 Instead of introducing a step error on the hardest-to-detect satellite, the test must be performed by introducing a step error on each satellite individually. The pass criteria should be met for each case.

FIG. A1.1 Excerpt from Annex A2 of FAA's TSO-C199

~~A2.2.6.4.3 Dynamic Test.~~
~~A2.2.6.4.3.1 Repeat the Static Test using nominal aircraft dynamics. Nominal aircraft dynamics are defined to be ground speed = 200 kt and horizontal acceleration = 0.58 g. These dynamics can be simulated as a series of turns. The pass criteria from the static test SHALL be used.~~
~~A2.2.6.5 Velocity Accuracy Tests.~~
~~A2.2.6.5.1 The velocity accuracy tests specified AC 20-138D Appendix 4, sections 4-2, 4-3 and 4-4 SHALL be performed per the requirement in A1.2.6.5 and show the unit provides an accuracy of 10 m/s or less, at least 95% of the time. It is assumed that the GPS position source does not provide a velocity accuracy output and the TABS will broadcast NACv = 1. Only the tests required to demonstrate a NACv = 1 need be run.~~
A2.2.6.6 Interference Tests.
A2.2.6.6.1 The equipment SHALL be tested using simulated GPS signals mixed with an interfering signal of gradually increasing power until the equipment loses position to verify the requirement outlined in para A1.2.6.6. The horizontal position accuracy will be evaluated.
A2.2.6.6.2 Simulator Scenario Details.
A2.2.6.6.2.1 Use the same simulator scenario set up found in A2.2.6.3.3.4 with the following exceptions:
A2.2.6.6.2.2 The interfering signal SHALL be broadband noise with bandwidth of 20 MHz centered on 1575.42 MHz. The initial power spectral density SHALL be -170.5 dBm/Hz (-97.5 dBm total power).
A2.2.6.6.2.3 The scenario may to be extended to allow sufficient time for increasing interference power.
A2.2.6.6.3 Test Procedure
A2.2.6.6.3.1 Step 1 The interfering signal SHALL initially be turned off.
A2.2.6.6.3.2 Step 2 The simulator scenario SHALL be engaged and the satellites' RF SHALL be turned on.
A2.2.6.6.3.3 Step 3 The equipment SHALL be powered on and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.
A2.2.6.6.3.4 Step 4 The receiver SHALL be allowed to reach steady state. When the receiver has reached steady state, an interfering broadband noise signal of -170.5 dBm/Hz SHALL be applied.
A2.2.6.6.3.5 Step 5 The interference power SHALL be maintained until the accuracy has reached steady-state. Position measurements and validity indications SHALL be recorded during this interval.
A2.2.6.6.3.6 Step 6 The power of the interfering signal SHALL be increased by 2 dB and maintained for 200 seconds.
A2.2.6.6.3.7 Step 7 Go to Step 5 and repeat until the receiver is unable to maintain a position fix.
A2.2.6.6.4 Pass/Fail Criteria
A2.2.6.6.4.1 The horizontal position errors SHALL be computed for each position estimate output by the equipment.
A2.2.6.6.4.2 The horizontal position error SHALL not exceed ~~0.5 NM~~ 100 feet for Aircraft and GCS at any time during the test.
A2.2.6.6.4.3 Only those position outputs that are reported as valid by the equipment need to be considered for the accuracy evaluation. There is no minimum interference rejection requirement for TABS equipment and loss of position in the presence of interference is acceptable behavior.

FIG. A1.1 Excerpt from Annex A2 of FAA's TSO-C199 *(continued)*

APPENDIXES

(Nonmandatory Information)

X1. EXTERNAL DEVICE FOR GCS LOCATION SOURCE RATIONALE

X1.1 In the Final Rule Preamble, Section XIII.C.2.I

The FAA proposed positional accuracy requirements that are compatible with commercial off the shelf position sources, such as GPS receivers integrated into many existing UAS, smart phones, or other smart devices.

X1.2 Section XIII.C.3.I

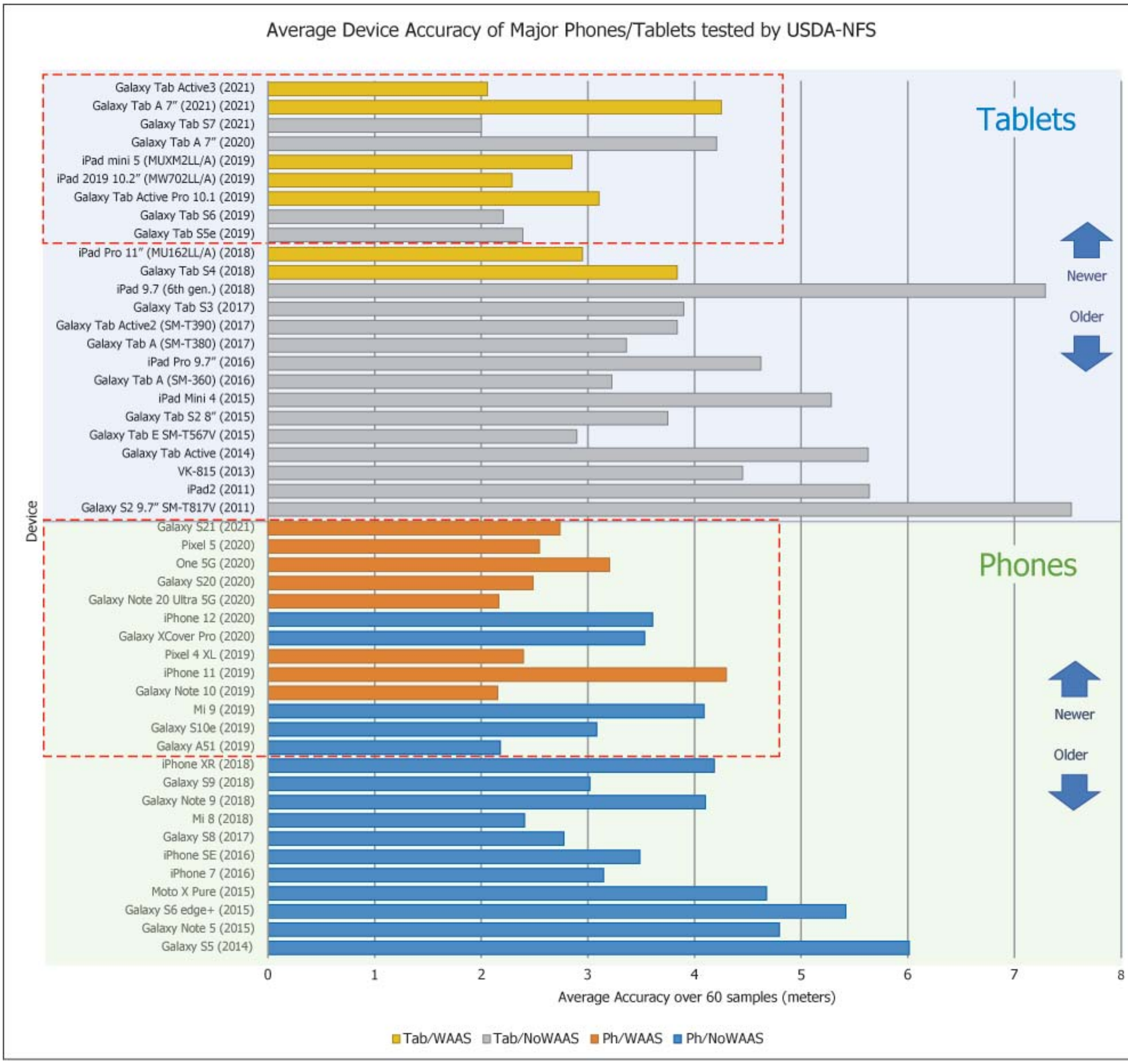
The FAA anticipates that most standard remote identification unmanned aircraft will be designed to be paired with an existing smart phone or smart device to provide the control station location information.

X1.3 The USDA Forest Service performed GPS accuracy testing of a wide variety of devices primarily to determine the impact of tree canopies to GPS performance.[12] In doing this testing, many common cell phones and tablets were tested.

X1.3.1 When reviewing the data taken with 60 samples for each device without canopy incursions, it is observable that for devices newer than 2019, the average (horizontal) accuracy of tablets without WAAS performed slightly better (about 8 %) than tablets with WAAS. For phones, there are also several overlapping results but, on average, the phones without WAAS performed within about 17 % (or just under 0.55 m) of the phones with WAAS. This data is based on averaging 60 samples of each device in a clear area (see Fig. X1.1). Since the FAA policy[13] accepts devices that use WAAS-based GPS as a location source, and given the intended use cases outlined in the rule preamble, sections XIII.C.2.l and XIII.C.3.l, this MOC submits that any FCC-certified personal wireless device with GNSS location services should be acceptable for the accuracy requirements of Part 89.

[12] NTDP GPS Receiver Horizontal Accuracy Reports, https://www.fs.fed.us/database/gps/mtdcrept/accuracy/index.htm.

[13] Policy Statement for the Reported Geometric Altitude of the Control Station of a Standard Remote Identification Unmanned Aircraft, https://www.federalregister.gov/documents/2021/11/22/2021-25366/policy-statement-for-the-reported-geometric-altitude-of-the-control-station-of-a-standard-remote.



Source: https://www.fs.fed.us/database/gps/mtdcrept/accuracy/index.htm

FIG. X1.1 Average Device Accuracy of Major Phones/Tablets Tested by USDA-NFS

X2. POWER LEVEL RATIONALE

X2.1 The text in the F3411 Specification is shown in Fig. X2.1.

X2.2 *Explanation*—For Wi-Fi, the minimum average EIRP of 13 dBm is calculated by taking the minimum reference conducted power (17 dBm) from the radio, adding the common cable/connector losses (–2 dB), and adding the (required) minimum average gain of the antenna system (–2 dBi) around the 360 degree horizontal plane. See Fig. X2.2 and Fig. X2.3.

X2.2.1 An alternative method is to use an absolute minimum EIRP of 11 dBm, which is calculated by taking the minimum reference conducted power (17 dBm) from the radio, adding the common cable/connector losses (–2 dB), and adding a ("absolute" rather than "average") minimum gain of the antenna system (–4 dBi) around the 360 degree horizontal plane. See Fig. X2.4 and Fig. X2.5.

X2.3 *Power Level Choices*—The workgroup analyzed the available products in the market and chose a minimum reference power level that reflects a wide diversity of suppliers and component availability. As such, the workgroup determined that for Wi-Fi, the market reference minimal power level should be 17 dBm, and for Bluetooth, 5 dBm. Fig. X2.6 and Fig. X2.7 represent a distribution of suppliers for Wi-Fi and Bluetooth products and various power levels. The source for this data comes from a leading component distributor

5.4.3 Output Power and Pattern—For output power and pattern, the requirement (BPW0010) seeks to provide a sufficiently high power transmission that generally emits in an omni-directional pattern using commonly available components. This can be accomplished using either of the following two options:

a) The average Effective Isotropic Radiated Power (EIRP) around the horizontal plane of the antenna system shall be at least [BcMinAvgEIRP] and the Peak to Average gain around the horizontal plane of the antenna system shall be no more than [BcMaxPeakToAvg]. The average EIRP is calculated by adding the conducted power into the antenna system to the average gain of the antenna system in the horizontal plane; or

b) The minimum EIRP around the entire horizontal plane of the antenna system shall be at least [BcMinEIRP]. The minimum EIRP is calculated by adding the conducted power into the antenna system to the minimum gain of the antenna system in the horizontal plane.

These options are intended to allow for use of manufacturer data sheets to demonstrate compliance. The Horizontal Plane is defined as a plane of the transmission pattern that approximately corresponds to the horizontal plane during the most common average orientation of the vehicle when flying. The UAS should be mechanically designed in a way to minimize radio pattern distortion of Remote ID.

TABLE A3.1 Broadcast Values

Value Name	Value	UoM	Req Ref	Section Ref
BcMinAvgEIRP	Use Table A3.2	dBm	BPW0010	5.4.3
BcMaxPeakToAvg	4	dB	BPW0010	5.4.3
BcMinEIRP	Use Table A3.3	dBm	BPW0010	5.4.3
BCMinUasLocRefreshRate	1	Seconds	BUR0010	5.4.4
BCMinStaticRefreshRate	3	Seconds	BUR0020	5.4.4
BCMaxDataAge	1	Seconds	BUR0030	5.4.4

TABLE A3.2 BCMinAvgEIRP Values

BCMinAvgEIRP - Minimum Average Tx EIRP in Horizontal Plane			
Wave Law	2.4 GHz Wi-Fi	2.4 GHz Bluetooth	5 GHz Wi-Fi
Type 1 (for example, USA)	+13 dBm	+3 dBm	+13 dBm
Type 2 (for example, China)	+11 dBm	+3 dBm	+11 dBm
Type 3 (for example, EU, Japan, Korea)	+11 dBm	+3 dBm	+4 dBm

TABLE A3.3 BCMinEIRP Values

BCMinEIRP - Minimum Tx EIRP in Horizontal Plane			
Wave Law	2.4 GHz Wi-Fi	2.4 GHz Bluetooth	5 GHz Wi-Fi
Type 1 (for example, USA)	+11 dBm	+3 dBm	+11 dBm
Type 2 (for example, China)	+9 dBm	+3 dBm	+9 dBm
Type 3 (for example, EU, Japan, Korea)	+9 dBm	+3 dBm	+4 dBm

FIG. X2.1 Specification F3411 Text

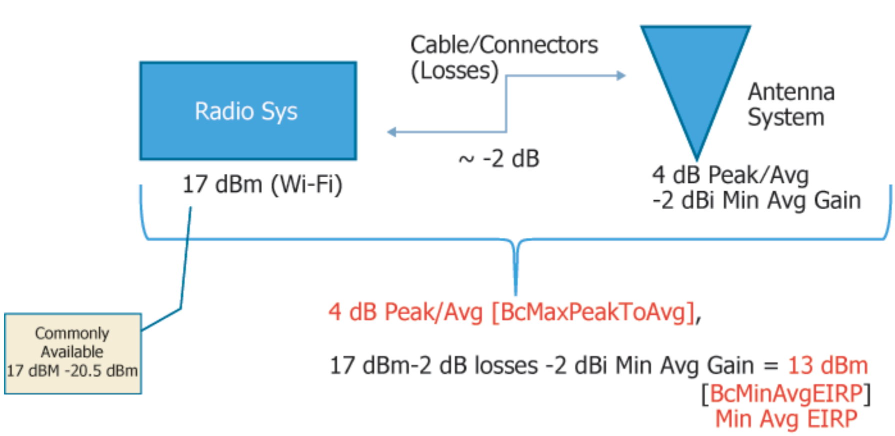


FIG. X2.2 Minimum Average EIRP Calculation

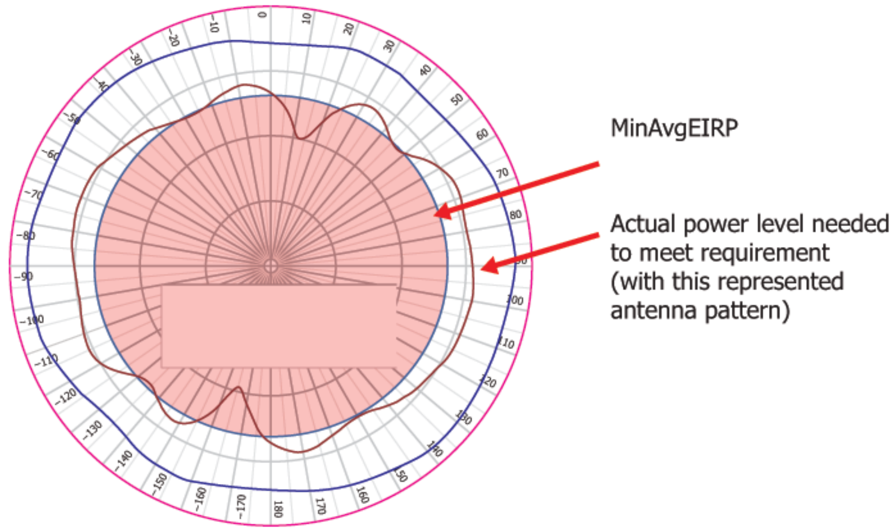


FIG. X2.3 Minimum Average EIRP Illustration

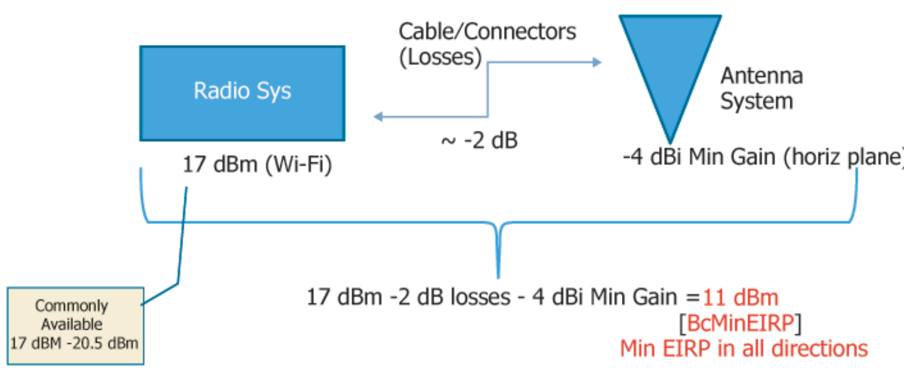


FIG. X2.4 Minimum EIRP Calculation

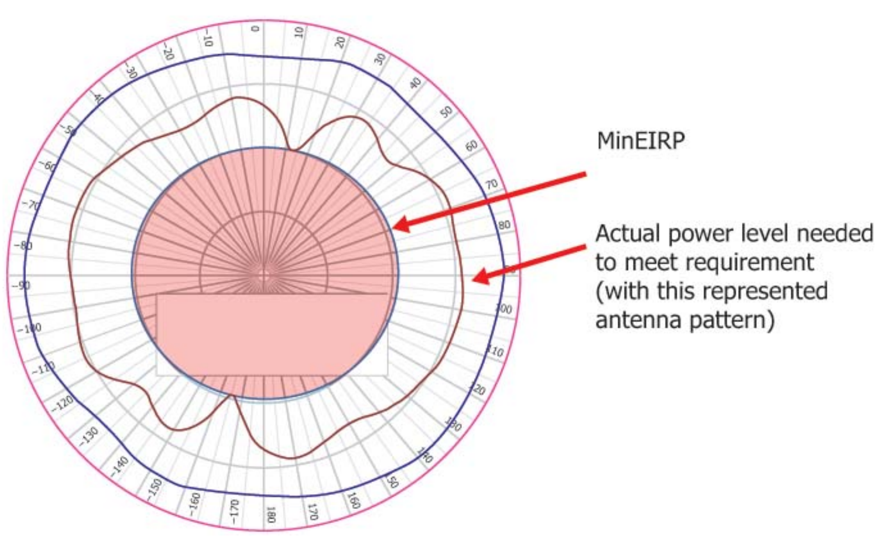


FIG. X2.5 Minimum EIRP Illustration

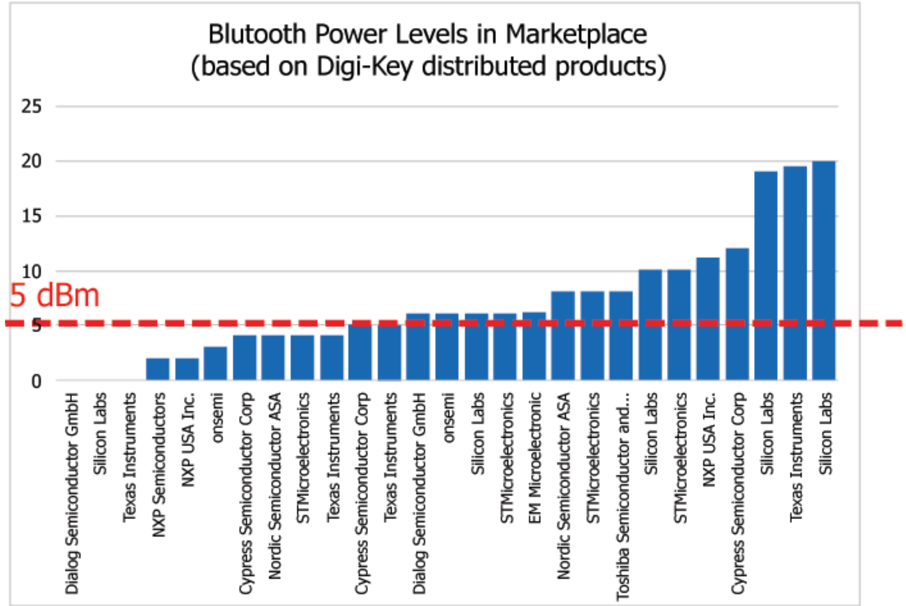


FIG. X2.6 Bluetooth Power Levels

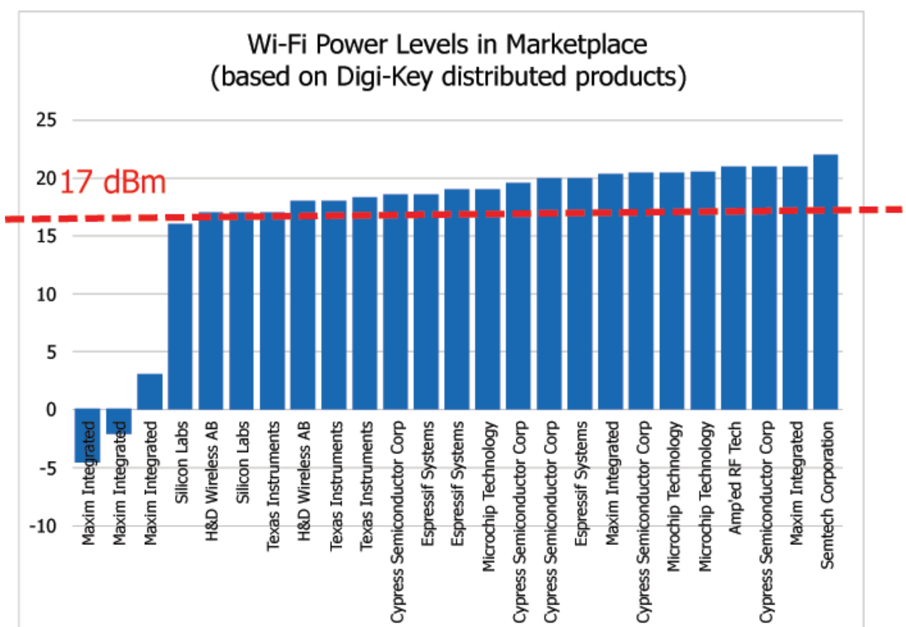


FIG. X2.7 Wi-Fi Power Levels

(Digi-Key) with an exportable table of products.[14]

X2.3.1 *Bluetooth*—Although the power level requirement for Bluetooth is lower than Wi-Fi, Bluetooth has the following capabilities that result in a lower receive sensitivity (which provide for a longer range):

X2.3.1.1 *Narrow Band*—The range of Industrial, Scientific, and Medical (ISM) radio technologies is highly affected by interference of competing transmissions and other radio noise.

[14] Digi-Key (a registered trademark of Digi-Key Corporation, Thief River Falls, MN) Wi-Fi and Bluetooth 5 and 5.1 products, https://www.digikey.com/en/products/filter/rf-transceiver-modules-and-modems/872?s=N4IgjCBcoKwOwA4qgMZQGYEMA2BnApgDQgD2UA2iAMwBMADHGHCMbQzQCwsg0IBsfOMwC6xAA4AXKCADKEgE4BLAHYBzEAF8NxGhRAB3RfPzZ8uXCGEagA.

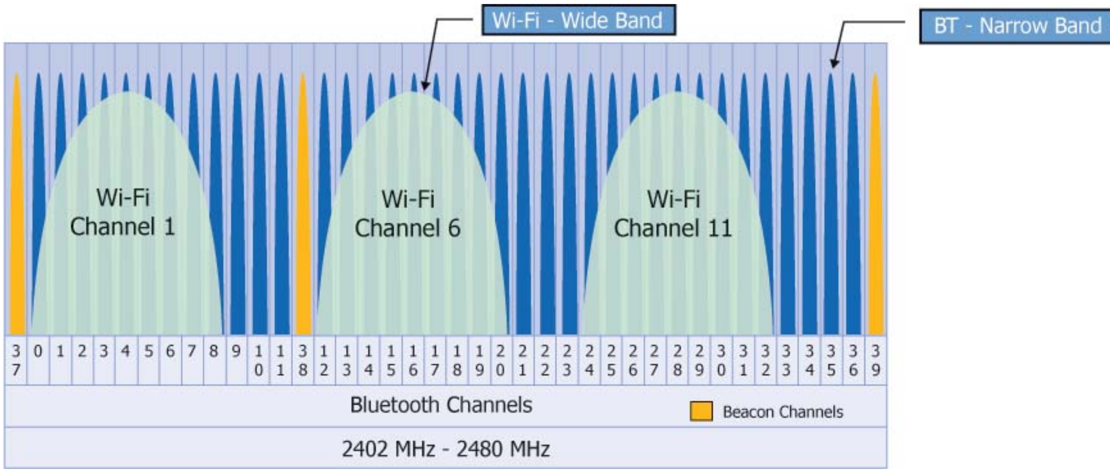


FIG. X2.8 Narrow Band

This narrow band helps to limit the potential for radio interference, therefore, enhancing the range. Also, with a narrow band, with frequency hopping, there are many more places on the spectrum to where the broadcasting can move to avoid interference. See Fig. X2.8.

X2.3.1.2 *Slow Data Rate:*

(1) Since Bluetooth (Long Range) runs at 125 kbps, it provides a longer "symbol time" that allows for better receiver sensitivity and, thus, enhances range.

(2) Given the power levels generally available on the mainstream market for consumer products and keeping some attention to having a healthy diversity of suppliers available for Remote ID radio components, the workgroup submits that the choices made for the reference and power level requirements address "maximize range" requirement for the power level component of "range."