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NATO IFF TEST REQUIREMENTS – TRANSPONDER FLIGHT MARK XIIA AND MODE S

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NATO LETTER OF PROMULGATION

26 September 2019

1. The enclosed Allied Electronic Publication AEtP-12.4, Edition A, Version 1, NATO IFF TEST REQUIREMENTS – TRANSPONDER FLIGHT MARK XIIA AND MODE S, which has been approved by the nations in the Consultation Command and Control (C3) Board, is promulgated herewith. The recommendation of nations to use this publication is recorded in STANREC 5647.

2. AEtP-12.4, Edition A, Version 1, is effective upon receipt.

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4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

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1. General

1.1. Introduction

These test requirements have been prepared by the North Atlantic Treaty Organization (NATO) Identification Friend or Foe (IFF) Capability Team (CaT). These test requirements were developed in order to assist with flight test planning for installed transponders in accordance with STANAG 4193 Edition 3.

1.2. Objective

The purpose of these test requirements is to evaluate transponder compliance with the STANAG 4193 Edition 3 requirements specification at a platform level. Successful completion of these tests provides an acceptable confidence level of proper operation or identifies areas of needed improvement.

The tests will verify:

a. Mark XIIA system performance

b. Mode Select (Mode S) system performance

c. Automatic Dependent Surveillance-Broadcast (ADS-B) Out system performance (if necessary as ADS-B is not required in STANAG 4193 Edition 3)

1.3. Scope

Testing will be conducted to obtain transponder data in the operational environment of the platform under test. The operational environment includes normal mission avionics, which will be enabled. The transponder will be interrogated in Selective Identification Feature (SIF), Mode 4, Mode 5 Level 1, and Mode S. Mode 5 Level 2 and ADS-B data will also be collected (if required). Prior to each testing event, a flight line check will be performed on the transponder to verify correct operation.

The described methods in this document are only examples of performing the tests. The platform testing coordinator may develop other methods to obtain the required data.

1.4. Acronyms and Abbreviations

ADS-B	Automatic Dependent Surveillance-Broadcast
CaT	Capability Team
EHS	Enhanced Surveillance
ELS	Elementary Surveillance
EIRP	Equivalent Isotropically Radiated Power
FCU	Flight Control Unit
FMS	Flight Management System
FOM	Figure of Merit
GNSS	Global Navigation Satellite System
ID	Identification
IFF	Identification Friend or Foe
I/P	Identification of Position

KIAS	Knots Indicated Air Speed
LOS	Line Of Sight
MCP	Mode Control Panel
Mode S	Mode Select
NATO	North Atlantic Treaty Organization
PID	Probability of ID
RF	Radio Frequency
SIF	Selective Identification Feature
TSPI	Time, Space, and Position Information

1.5. References

1) STANAG 4193 Edition 3
   Technical Characteristics of the IFF Mk XIIA System

2. Test Preparation

2.1. Instrumentation

It is highly recommended that the transponder be instrumented for any flight test conducted. Replies (to Mode 5 at a minimum) should be logged and time stamped with the highest accuracy achievable. The ability to compare replies sent by the transponder to replies received by the interrogator is quite valuable in the data analysis effort. Time, Space, and Position Information (TSPI) should also be collected on the platform and at the interrogator (if applicable). Additionally, any data being sent to and from the transponder should be recorded if possible. Mode 5 Level 2 and Mode S Enhanced Surveillance (EHS) cannot be properly evaluated without this data.

2.2. Authorizations

It must be ensured that proper authorizations are received for the use of the airspace needed, radiation of the transponder, radiation of the interrogator, and radiation of any test equipment.

2.3. Key Usage

Care should be taken to ensure that only authorized Mode 4 and Mode 5 keys are loaded and radiated. Mode 4 and Mode 5 test keys shall be used for flight testing. Mode 5 operational key may be used only when specifically authorized, in accordance with the NATO Mk XIIA Mode 4 / Mode 5 Key Management Plan.

3. Test Events

Note that multiple test events may be combined into a single flight test. It should be ensured that all testing is conducted at operationally representative altitudes within Line Of Sight (LOS) of the transponder platform and within the maximum range capability of the interrogator system. (An exception to this is the Performance over the Operational Range profile which intentionally flies past the LOS or maximum range). Maximum range may be limited by the Equivalent Isotropically Radiated Power (EIRP) of the interrogator system, the range decoded by the processor, or the data presented to the operator.

$$LOS\ (nmi) = 1.23(\sqrt{\text{interrogator height (ft)}} + \sqrt{\text{transponder height (ft)}})$$

Flight testing is not required for surface or subsurface platforms.

3.1. Antenna Coverage

STANAG 4193 Ed 3: Part III Annex A 3.3.1; Part III Annex A 3.4.1

3.1.1. Data Needed

Probability of Identification (ID) (PID) data must be provided to show adequate antenna coverage. The flight data will be used in conjunction with the antenna data from AEtP-12.8, the NATO IFF Test Requirements – Interrogator Platform Integration Mk XIIA and Mode S.

3.1.2. Method of Test

A flight should be conducted which presents all azimuth aspects of the aircraft to the test interrogator; a figure 8 pattern is recommended. At least one hour of data should be collected.

In order to verify adequate antenna coverage it is important to conduct this test using the proper link budget.

$$Int_{transmitter\ power} = XP_{receiver\ MTL} + XP_{feeder\ loss} + \text{Free Space Loss} + \text{Atmospheric Attenuation} + M_{factor} - INT_{ant\ gain} + INT_{feeder\ loss} + \text{Margin}$$

Where:

- $XP_{receiver\ MTL}$ = direct connect value taken from AEtP-12.8, the NATO IFF Test Requirements – Interrogator Platform Integration Mk XIIA and Mode S
- $XP_{feeder\ loss}$ = measured value from AEtP-12.8, the NATO IFF Test Requirements – Interrogator Platform Integration Mk XIIA and Mode S
- Free Space Loss = 98.058 dB + 20 log D_{nmi}
- Atmospheric Attenuation = 1.3 dB
- M_{factor} = 3 dB (to account for tropospheric scattering, fluctuation loss, polarization loss, signal processing losses, and system accuracies)
- $INT_{ant\ gain}$ = the interrogator antenna gain at the point for which the beamwidth is sufficient to produce an acceptable quantity of replies to meet the system's probability of identification requirements (typically at the −3 dB beamwidth). [For example, if the peak antenna gain is 21 dB, but the interrogator is required to detect a transponder across the full beamwidth that is 3 dB down from the peak antenna gain, the $INT_{ant\ gain}$ will be 18 dB]
- $INT_{feeder\ losses}$ = the total transmission system loss from interrogator to antenna (includes losses from RF cables and connectors; and any installed Radio Frequency (RF) filters, diplexers, rotary joints, and RF switches (if external to the interrogator or antenna)).
- Margin = 9 – 12 dB for the purposes of this test

The test should be conducted in a location with negligible multipath. If that is not achievable, account for the multipath in the link budget equation. In order to balance the equation, the distance the test aircraft is from the interrogator will need to be adjusted and/or an attenuator will need to

be placed in-line with the interrogator. DO NOT place an attenuator in-line with the transponder under test.

3.2. Performance over the Operational Range

3.2.1. Data Needed

Data must be provided which proves that the platform under test can produce an acceptable PID. Interrogator target report data should be collected in SIF, Mode 4, Mode 5, and Mode S Elementary Surveillance (ELS). Successful and unsuccessful ID attempts should be presented in a range vs. time plot. The overall PID should be calculated, removing any period of time when the platform is beyond LOS / maximum range or in a known multipath null. While there are no pass / fail criteria for PID, any significant drop-outs which do not correspond with known multipath nulls must be investigated.

3.2.2. Method of Test

Separate testing should be conducted for SIF, Mode 4, Mode 5, and Mode S ELS. Interrogation modes may be alternated between interrogation attempts, but Mode 5 supermode interrogations should not be used to evaluate performance in SIF or Mode 4 as the number of interrogation attempts is degraded by Mode 5 supermode. Mode 5 data should be prioritized and should be provided for a complete radial (outbound and inbound). SIF, Mode 4, and Mode S data should be collected as time permits.

The transponder platform should fly a radial starting no less than 5 nmi from the interrogator and ending just past the calculated LOS. The transponder platform should return on the same radial. The platform should fly at an operationally representative altitude and airspeed. Multiple radials should be conducted depending on time available.

3.3. Mode S EHS

3.3.1. Data Needed

Data must be provided which shows that the platform under test can correctly report the data required by Mode S EHS. Data received by the interrogator should be compared with data taken from the transponder platform. The following data should be analysed: selected altitude (Mode Control Panel (MCP)/Flight Control Unit (FCU) is required; however, if Flight Management System (FMS) is integrated it should also be analysed), roll angle, true track angle, ground speed, track angle rate, true airspeed, magnetic heading, indicated airspeed, barometric altitude rate, and Mach. If the platform transmits inertial vertical velocity it should also be analysed. If the platform uses the mode/status bits in register 40_{16} and 62_{16}, those should also be analysed. It is highly recommended that the platform be instrumented to record all of the needed data for comparison. However, the interrogator data can be compared with detailed notes taken by the test conductor and/or operator(s) if instrumentation is not available. Any discrepancy between the platform data (or notes) and the interrogator data must be investigated.

3.3.2. Method of Test

To verify Mode S EHS performance, the platform must fly with varying headings, airspeeds, angles-of-bank, and climb rates. All values chosen should be well within flight limits, but different enough to easily distinguish the different values in the data. If there are multiple autopilot modes,

it is suggested that they be exercised at least once each during the flight(s). Two profiles are suggested to collect the necessary data.

3.3.2.1. Track and Turn

The aircraft should conduct eight 360 degree orbits at various airspeeds and angles-of-bank. The orbit parameters are defined in the table below.

Direction of Orbit	Angle-of-Bank (deg)	Airspeed (KIAS)
Clockwise	X	A
Clockwise	Y	A
Clockwise	X	B
Clockwise	Y	B
Counter-Clockwise	X	A
Counter-Clockwise	Y	A
Counter-Clockwise	X	B
Counter-Clockwise	Y	B

3.3.2.2. Heading and Speed

The aircraft will conduct six 360 degree orbits using a standard rate of turn at various airspeeds, climbs, and descents. The orbit parameters are defined in the table below.

Direction of Orbit	Climb / Descent (fpm)	Airspeed (KIAS)
Clockwise	0	A
Counter-Clockwise	0	B
Clockwise	+X	A
Counter-Clockwise	-X	A
Clockwise	+Y	B
Counter-Clockwise	-Y	B

3.4. Mode 5 Level 2

3.4.1. Data Needed

The accuracy of the position (latitude, longitude, and Global Navigation Satellite System (GNSS) altitude) reported by the transponder platform along with the accuracy of the reported Figure of Merit (FOM) must be verified. The data received from the system under test must be compared with an independent source in order to determine the accuracy. The accuracy of the truth source, including any potential latency, must be taken into account when calculating the errors.

3.4.2. Method of Test

It is not possible to fully test the Level 2 system in controlled flight testing; the data collected will be evaluated along the data required from AEtP-12.8, the NATO IFF Test Requirements – Interrogator Platform Integration Mk XIIA and Mode S.

Mode 5 Level 2 squitters should be collected during all flight testing conducted for analysis. If an omnidirectional antenna is available to collect squitters, no interrogations are needed in Mode 5 Level 2. However, if only a directional antenna is used, it is likely that only a small sample of squittered reports will be received. In that case, it is recommended to interrogate Mode 5 Level 2 for at least 20 minutes during a profile consisting of heading, altitude, and velocity changes. At a minimum format 20 should be interrogated; other formats may be interlaced as desired.

3.5. ADS-B (not required by STANAG 4193 Edition 3)

3.5.1. Data Needed

3.5.1.1. Flight Testing

Verification is needed to confirm that the platform under test can correctly report the data required. Ensure all data associated with the track is consistent, such as position, 24-bit address, velocity, flight ID, barometric altitude, Mode 3/A code, emitter category, and geometric altitude. There are no specific tolerances for the comparison; the data must be qualitatively analysed to evaluate whether the results are consistent with what is expected. Analyse the data to determine if there were any unexpected data dropouts that might be caused by intermittent wiring interfaces or interface incompatibility, and to ensure the installed system meets its stated accuracy and integrity performance under flight conditions. It is recommended that a GNSS performance prediction for the applicable time of the test is done to establish the predicted performance.

3.5.1.2. Taxiing Testing

Verification is needed to confirm that the platform under test can correctly report the data required while taxiing. The latitude, longitude, ground speed, and ground track angle / heading (whichever is provided) should be compared to an independent source. If no independent source is available, the data must be qualitatively analysed to evaluate whether the results are consistent with what is expected.

3.5.2. Method of Test

3.5.2.1. Flight Testing

There are no specific profiles that must be flown, but note that the flight must be conducted within the ADS-B ground station coverage. It is recommended that at least one hour of data be collected which includes heading, altitude, and velocity changes (collecting data during the Mode S EHS profiles is preferred). Flight parameters should be within the platform norms for civilian airspace.

To assist with data review, it is very helpful to have the operator log the following events with the time that they occur: Mode 3/A code change, Identification of Position (I/P) initiated, and baro setting change.

3.5.2.2. Taxiing Testing

As ADS-B transmits unique information while on the ground, the accuracy of this information must also be verified. It is suggested that ADS-B squitters be decoded while the aircraft is taxiing in preparation for flight testing. If it is impractical to collect the ADS-B squitters of the taxiing aircraft, a simulation conducted in a test integration lab is also acceptable.

3.6. Other Considerations

All anomalies observed during testing should be well documented. Items of interest include, but are not limited to:

- False targets, especially occurrences of the target of interest at an incorrect azimuth or range
- Caution events (ideally the caution indicator would be instrumented, but if not, make sure that the operator is requested to report any caution events)
- Built-in-test faults (transponder, GNSS source, air data computer, etc.)
- Unexpected behaviour by any other IFF indicator (reply, lethal, etc.)
- Any anomalies associated with the testing interrogator
- ADS-B function fail
- ADS-B position source fail

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