Chapter 5 – T&E ASPECTS OF EW SYSTEM ARCHITECTURE

5.1 INTRODUCTION

The approach to testing any specific EW system or function depends on its architecture. Testing and the subsequent evaluation of standalone systems are relatively straightforward. When the EW system is combined with other systems and sub-systems on a single platform, both the quantity and nature of interactions which must be considered grow substantially. This chapter focuses on testing federations of equipment and systems, and integrated systems.

The even more complex case of Multi-Platform Geo-Location using RWR/ESM as a threat Emitter Location System (ELS) is not explicitly covered in this Handbook. Many of the considerations are similar to the single platform integrated EW system, but with the added complication of data links between the platforms concerned. Other information is available to the interested reader. [1]

5.2 STANDALONE EW SYSTEMS

The simplest category of EW systems, from a T&E point of view, are those having minimal interaction with other systems on the same platform. These standalone systems can usually be evaluated without a rigorous evaluation of the performance of other aircraft functions. Of course, interoperability and EMI issues must be considered for standalone systems.

5.2.1 Standalone System Description

Standalone EW systems are those systems that do not depend on data, information, cueing, or other functions from other EW or avionics systems on the platform. These systems generally have a specific single function such as radar warning, jamming, or chaff dispensing. Standalone system testing is relatively simple; the system is exposed to the expected threat environment and observed for the correct response.

5.2.2 Standalone System Testing

A standalone RWR is designed to provide the pilot with visual and audio warnings when the aircraft is illuminated by one or more threat radar systems. As discussed in Chapter 2, specific tests are performed in both ground and flight environments to measure and establish the performance of each major functional element of the RWR. The antennas are characterised individually and in their installed configuration to verify their frequency, spatial coverage and gain performance. Receiver tests are conducted to determine sensitivity, selectivity, and other key parameters. The signal processing function is tested to ensure that all threat signals specified for the system are properly categorised. Finally, the Man-Machine Interfaces (MMIs) are evaluated for correct operation. While this overall process may require hundreds of individual tests, the evaluation of results remains relatively simple and the test conditions can be easily achieved. Each element of the system either functions as specified, or not; each test condition is discrete and has little or no dependence on other test conditions.

5.3 FEDERATED EW SYSTEMS

Federated systems represent present an increased level of complexity. Additional interfaces have to be considered in the design of the test program. A depiction of this architecture is shown in Figure 5-1.

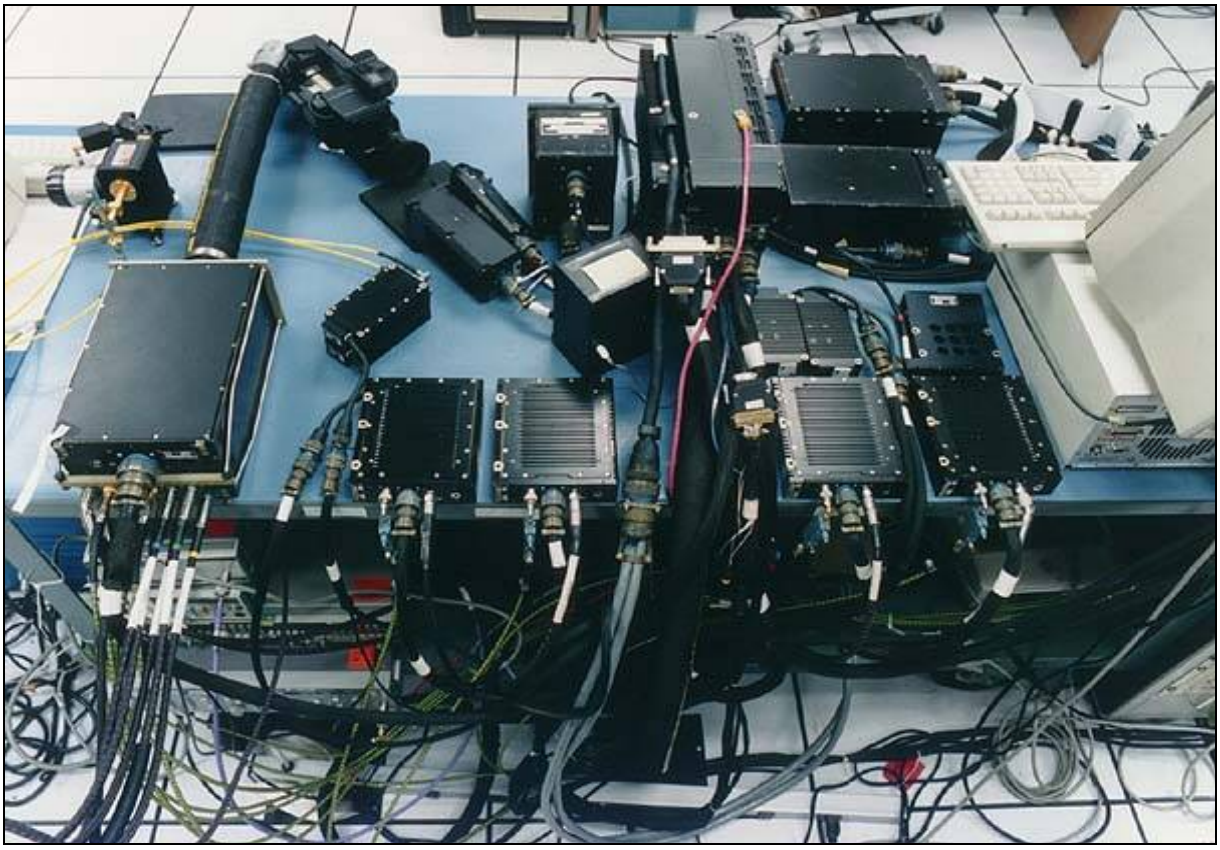

Figure 5-1: Federated System in HITL Test at ECSEL Facility, Pt. Mugu, California.

5.3.1 Federated System Description

Federated systems are those systems which maintain their own functional identities or boundaries, but are dependent on data, information, cueing, or other functions from other systems outside of those boundaries. Most avionics and EW systems of the late 1970s through the early 1990s have exhibited this characteristic.

The testing of such systems is considerably more complex than the standalone case previously discussed. The causes of this complexity are best understood by reviewing an example test process for a federated RWR and RF jamming system. Generally, such systems still have their own control panel and displays.

5.3.2 Federated System Testing

For this example, consider that the RWR and jammer are installed on the same platform and designed to work against the same set of threats. They share a common threat database or MDF. When the RWR detects a threat it will be displayed on either a dedicated system display or on a MFD in the cockpit. The display will show a unique symbol representing the threat type, azimuth, and estimated lethality. The pilot also receives a warning tone in his headset. Upon command from the pilot, the threat identification and location data are passed to the jammer sub-system. The jammer determines the optimum jamming response for the detected threat, tunes a receiver to the proper frequency, and emits the necessary RF energy. If the jamming is effective, the RWR will detect that the radar is no longer tracking the aircraft. From this scenario the example test program can begin to be structured, the test resource requirements determined, and an evaluation process planned.

Two common MOPs for the example system are:

- Response time for the RWR to detect each threat signal in the MDF.
- Response time to initiate the optimum jamming waveform.

Many other MOPs apply to this type of testing, but these two serve to illustrate the point. While the first MOP appears to focus on the RWR standalone performance, there is a potential for interaction with the jammer through the MDF. If both the jammer and the RWR attempt to access the MDF simultaneously, there may be a delay in the data needed by the RWR. Consequently, testing must be structured to acquire data under various operating conditions for both the RWR and the jammer. The data collected must be categorised to reflect the operating conditions to determine if there is a significant delay imposed by multiple systems sharing a common MDF. The system specification requirement identifies how much delay acceptable. Certainly, the standalone performance of the RWR will be a dominant factor in this objective, but additional testing to ascertain the overall performance of the federated system is of paramount importance to the military end user.

The second MOP clearly implies evaluation of the fully federated system. The RWR, jammer, shared MDF, displays, and the pilot all play an important role in overall system performance and effectiveness. To fully analyse and evaluate the results of this test, insight into the performance of each individual component of the system is necessary. The evaluation should not just assess if improvements are needed, but if so, which part of the system is the best candidate for improvement. This MOP also brings into play the human operator; a component with a high degree of variability. In order to appreciate the operator's effect on overall system performance, data will need to be collected under a wide range of operational conditions, and with a range of operators.

All of this leads to the conclusion that test of federated systems brings about an increased burden on the test planning and analysis processes over that of the standalone systems test. The same facilities will be used, but the number of test runs or flights may increase significantly as the system complexity grows.

5.4 INTEGRATED EW SYSTEMS

Some combat aircraft designs from the late 1990s onward have moved from the relatively simple federated approach to an extensive integration of EW and avionics functions. The U.S. Air Force F-22, shown in Figure 5-2, is an example of this integrated approach. Functional integration offers numerous advantages to system designers while creating complex challenges to testers.

Figure 5-2: F-22 Employs a Fully Integrated Avionics and EW Suite – (USAF Photo).

The Eurofighter Typhoon also has an integrated DAS, comprising EuroDASS 'Praetorian' (ESM-ECM, TRD, MWS and LWS), as shown in Figure 5-3, Defensive Aids Computer, and flare and chaff dispensers.

Figure 5-3: Praetorian Components – (© SELEX Galileo 2008).

5.4.1 Integrated System Description

Integrated EW systems are not just a combination of standalone systems linked together as is the case with the federated approach. Rather, integrated systems tend to have a homogeneous functional identity. There is no discernible boundary between sub-functions such as radar warning, missile warning, jamming, or other EW activities. Most, if not all, components in the system may be shared between the sub-functions on the basis of complex scheduling and resource control algorithms.

Modern highly integrated systems employ a number of apertures, e.g., antennas and IR detectors, to perform a variety of functions. EW and non-EW system designers no longer necessarily treat these apertures as dedicated to a single sub-system. An antenna on a modern fighter aircraft FCR will generally be a high-gain, electronically steered, phased array that can be tasked to support sensing functions for other onboard systems.

5.4.2 Testing Integrated EW Systems

Testing of isolated functionality becomes difficult, if not impossible, with the operational software[1] in place. Flight tests will reveal little of the source of performance problems with integrated systems. ISTF and HITL test facilities that can make large numbers of test runs with precisely controlled conditions and extensive instrumentation are essential to the T&E of integrated systems.

The OAR remains useful in establishing the overall effectiveness of integrated EW systems, as discussed in Section 6.8. However, in order to evaluate the system effectiveness in conditions outside that which can be demonstrated with OAR resources, the tester must rely on digital M&S and ground-based resources. The current trend is to combine digital models with hardware threat and environment simulations to provide controllable, repeatable stimulation of the entire test aircraft in an ISTF.

This capability to immerse the entire aircraft in a controlled and representative EW environment requires that all signals of interest (RF, IR, UV) be simultaneously generated in a coherent manner. Information content must be consistent among and between emissions from both the SUT and the simulated environment. All objects used in the test scenario must appear to exist at the right time and place; that is, coherency must exist in all domains detectable by the SUT.

These requirements drive ISTF signal and scene generation and scenario control software to the far extreme of current technical capability. A simple example serves to help understand this demand on test resources. Assume the integrated EW system being tested can sense RF and IR emissions from a potential threat aircraft and correlate this sensor data with its own radar detections and tracks. The test facility will then be required to generate a radar return representative of the threat aircraft's RCS, an IR scene, and other RF emissions all coming from the intended target position. Looking at this requirement in the time domain, all simulations must present realistic target motion and the resulting changes in physical characteristics of each signal. Radar target returns must be modulated with the correct Doppler, scintillation, and other characteristics to permit a viable test of a coherent processing AI radar.

If, due to minor time or space positioning errors in the simulation, the IR emissions from the target were displaced from the radar target simulation, then the SUT may declare two targets rather than one. Clearly, the eventual outcome of a one-versus-one engagement should be different than a one-versus-two engagement. This difference would invalidate the planned test.

For ISTF testing of modern integrated EW systems, this simple example must be replicated many times to represent realistic threat densities. Very sophisticated and costly threat and signal generation systems, scenario control software, digital models, and instrumentation are needed to accomplish these high-

[1] Operational software in this usage means the OFP and the MDF. The terminology varies with Nations and services.

density, high-fidelity simulations. However, in spite of the cost and complexity involved, such test capabilities can pay great dividends in understanding the behaviour of integrated EW systems and isolating hardware and software failures, prior to flight test and combat use.

5.5 REFERENCES

[1] NATO Industrial Advisory Group, Study Group SG-79 'Emitter Location and Data Links to facilitate Suppression of Enemy Air Defence': Final Report. NIAG-D(2006)0009. February 2006.

5.6 FURTHER READING

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