ANNEX 3-51 ELECTROMAGNETIC WARFARE AND ELECTROMAGNETIC SPECTRUM OPERATIONS

ELECTROMAGNETIC SPECTRUM SUPPORT ACTIVITIES

Last Updated: 30 July 2019

Electromagnetic Spectrum Operations (EMSO) require a solid foundation from which to launch operations in the electromagnetic spectrum (EMS). To achieve successful operations spanning the range of military operations (ROMO) in the EMS, continued investments in numerous mission areas are made during peace and wartime. Cementing the base of joint EMS capability is a dedication to the **education** and **training** of the whole force and the **staffing** of a dedicated professional force fluent in EMS operations. A joint electromagnetic warfare[23] (EW) strategy is driven by persistent national and combatant command (CCMD)-derived **intelligence** to monitor our adversaries and understand their use of the EMS. **Coordination** within the Department of Defense (DOD) and across the Air Force will ensure streamlined and responsive acquisitions processes and resource allocations under a unified effort. Lastly, a dedication to **testing** and **programming or reprogramming** efforts ensure the Air Force is postured to best sense, protect, and respond effectively to any threat in the EMS.

A thorough knowledge of adversary capabilities derived from near real time (NRT) information is a critical enabler of successful military operations, focused for the operational commander, as well as baseline operational, scientific, and technical intelligence information gathered over time. Accurate intelligence is needed to gauge the intent of an adversary, and this intelligence should be transmitted to the users in a timely manner. Intelligence, surveillance, and reconnaissance (ISR) is a critical force multiplier when applying lethal as well as nonlethal effects of electromagnetic warfare, and cyberspace warfare.

Under Secretary of Defense for Intelligence (USD-I) serves as the principle staff assistant to the Secretary of Defense (SecDef) and Deputy SecDef regarding intelligence support to the DOD and exercises the SecDef's authority, direction, and control over combat support agencies (CSAs). These include the National Security Agency (NSA) / Central Security Service (CSS), Defense Intelligence Agency, National Geospatial Intelligence Agency, and the National Reconnaissance Office. These CSAs

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[23] For the reason these terms have been changed from "electronic" to "electromagnetic," see "Note on the Terms 'Electronic' vs. 'Electromagnetic'" in, "Introduction to Electromagnetic Spectrum Operations," this annex.

are required to support DOD activities. There are many types of support these agencies provide the DOD and specifically to EW. These include foundational intelligence, technology support, signals intelligence (SIGINT), cryptologic support, foreign military orders of battle (to include electromagnetic order of battle), global intelligence analysis through open source intelligence, integration of foreign partner intelligence capability, access to denied areas, and the planning and execution of military operations.

The Service intelligence organizations provide intelligence support for DOD missions related to military systems, equipment, training, and national intelligence activities. The Deputy Chief of Staff of the Air Force for Intelligence, Surveillance, Reconnaissance, and Cyber Effects Operations (AF/A2) is responsible for policy, formulation, planning, evaluation, oversight, and leadership of Air Force global integrated intelligence, surveillance, and reconnaissance (GIISR) capabilities, which support and feed EW, specifically EW support[24] (ES). The 25th Air Force (25 AF), a subordinate to Air Combat Command (ACC), is responsible for executing AF/A2s GIISR responsibilities. ACC and 25 AF organizes, trains, equips, and presents assigned forces and integrates their all-source intelligence capabilities within the Air Force, combatant commands (CCMDs), and CSAs.[25]

Additionally, ACC, via 25 AF, is responsible for prioritizing and acquiring capabilities to support the CCMDs and their priority EW and EMSO effects. As adversaries continue to advance their capabilities to including complex signals and cognitive / artificial intelligence capabilities, a strong link between EW capabilities and their intelligence support activities is necessary to maintain the advantage in a contested battlespace.

Intelligence, Surveillance, and Reconnaissance Support

Accurate and timely ISR is the foundation for effective EW planning and employment. ISR supports EW through several functions. First, constant analysis by various scientific and technical centers guards against hostile technical surprise. Second, indications and warning centers provide tactical, operational, and strategic warning to friendly forces. Third, ISR continually monitors threat systems to support programming and reprogramming of all systems. Fourth, intelligence supports mission planning.

✪ **Signals Intelligence** (SIGINT) is a category of intelligence comprising either individually or in combination with all communications intelligence, electromagnetic intelligence and foreign instrumentation SIGINT, however transmitted. SIGINT collection and dissemination are highly dependent on the EMS. SIGINT provides the basis for characterizing the electromagnetic environment (EME) to include those frequencies associated with radio, radar, infrared equipment, and directed energy systems. Intelligence preparation of the operational environment analysts evaluate how the EME will affect military operations in a specific operational area (OA) and

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[25] Note that 25 AF is in the process of reorganizing and combining with 24th Air Force (Air Forces Cyber), which is also subordinate to ACC. The full implications of this change have yet to be determined.

collaborate with intelligence planners to deliver tailored EMS operations mission support products

- ✪ **Electromagnetic Warfare Support** refers to the division of EW involving actions tasked by, or under direct control of, an operational commander to search for, intercept, identify, and locate or localize sources of intentional and unintentional EM radiation for the purpose of immediate threat recognition, targeting, planning, and conduct of future operations. ES is closely related to, but separate from, SIGINT, based primarily on the intent for which the data or information is to be used. The Non-kinetic Operations Coordination Cell in the air operations center synchronizes and integrates the planning and operational use of ES sensors, assets, and processes within a specific OA should be integrated and synchronized to reduce uncertainties concerning the adversary, environment, time, and terrain. ES data can be used to produce SIGINT, provide targeting for electromagnetic attack[26]or other fires, and produce measurement and SIGINT.

- ✪ **ES and SIGINT.** ES and SIGINT are differentiated by purpose, scope, and context. ES assets are tasked by operational commanders to search for, intercept, identify, and locate sources of intentional or unintentional EM radiation. In contrast, SIGINT assets are tasked by Director, NSA (Chief, CSS), or by an operational commander under SIGINT operational tasking authority delegated by the Director, NSA. The purpose of ES tasking is immediate threat recognition, planning, and conduct of future operations, and other tactical actions such as threat avoidance, targeting, and homing. ES is intended to respond to an immediate operational requirement. ES and SIGINT operations often share the same or similar assets and resources and may be tasked to simultaneously collect information that meets both requirements. For example, data collected for intelligence purposes can meet immediate operational requirements, just as data collected for ES purposes can be processed by the intelligence community (IC) for further exploitation after the operational commander's ES requirements are met. For further information on the SIGINT and ES relationship, see Joint Publication (JP), 3-13.1, *Electronic Warfare*, and Chairman of the Joint Chiefs of Staff Instruction 3210.03C, *Joint Electronic Warfare Policy,* for a more in-depth discussion of the relationship and distinction between ES and SIGINT.

- ✪ **Sensitive reconnaissance operations** support constant analysis by various scientific and technical centers, which guards against hostile technical surprise. While preventing surprise, intelligence guides EW strategy and critical technology research and acquisition decisions. Constant analysis establishes and maintains comprehensive support databases as well as examination of scientific and technical intelligence and general military intelligence capabilities. Clearly defined intelligence requirements are necessary to ensure resulting intelligence information meets the needs of EW planners and decision makers are not overloaded with excessive or meaningless data.

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✪ **Indications and warnings**-capable assets, executing the ES role provide tactical and operational threat warning to joint and coalition forces.

✪ ISR continually monitors threat systems to support reprogramming of all systems.

✪ ISR-derived intelligence supports mission planning in the tasking cycle.

✪ ISR provides NRT measures of effectiveness and measures of performance data to assessors for effective electromagnetic battle management.

Specifically, ISR supports EW by providing technical threat descriptions and tailored threat environment descriptions. EW planning requires parametric and employment data, modeling and simulation tools, and mission planning tools to prioritize targets and defense tasks. ISR assets are required to support both offensive and defensive EW planning. To be of value, these assets should provide timely intelligence and be responsive to the commander's needs. Intelligence support includes establishing and maintaining comprehensive support databases as well as looking at scientific and technical intelligence and general military intelligence capabilities. Clearly defined intelligence requirements are necessary to ensure resulting intelligence information meets the needs of EW planners and decision makers are not overloaded with excessive or meaningless data.

Electromagnetic Warfare Wings

The Air Force has numerous ISR wings that provide EMSO support with EA platforms and ISR-enabled ES platforms, which deploy in support of geographic combatant commands. Currently, the 55th Wing provides both ES ISR and electromagnetic attack[27] (EA) assets, while the 480th ISR and 70th ISR Wings provide global distributed and reach-back ISR capabilities. The 70th ISR Wing works closely with the NSA/CSS, leveraging the net-centric capabilities of a world-wide cryptologic enterprise. The 480th ISR Wing capabilities include national cryptologic, information technology, cyberspace ISR, tactical analysis, joint force air component commander support, and SIGINT integration. Finally, the 363d ISR Wing provides targeting-related intelligence to air component forces, to include non-kinetic targeting support. All of these wings and support activities are vital to EW and EMS operations, and are foundational capabilities that allow the CCDR to bring EW and EMSO to bear in the battlespace.

Additionally, integration of organizations and forces that conduct EW and ISR is crucial to effectively integrate an EW and EMS operations plan. Efforts should be taken to ensure priority EA targets and collection requirements are integrated and not just deconflicted. Designing a purposeful plan that maximizes the spectrum is critical to gaining and maintaining the desired degree of EMS control. At the strategic and operational levels, some EW and EMS capabilities may need to be coordinated with the

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NSA and other IC organizations to ensure that an assessment of intelligence gain or loss is accomplished, and the effects are incorporated into the combatant commander's strategy.

Education and Training Support

Today's Airmen are digital natives, fluently using information technologies and smart devices throughout every aspect of their lives. A common understanding of how the spectrum is utilized and how the Air Force conducts operations throughout the EMS should be paired with this personal digital fluency across the force to produce synergistic battlespace effects.

Beyond a baseline knowledge and lexicon in the force, the Deputy Chief of Staff of the Air Force for Operations (AF/A3) ensures EW professionals receive focused training at initial, operational, and senior staff levels. While initial training is required to operate at the tactical level, operational and senior staff education builds integration and strategic knowledge sets that contribute to the joint EMSO campaign. With the continued cat-and-mouse nature of EW spiraling ever faster in the 21st Century, deliberate developmental education is critical for EW professionals. Deliberate education enables our professionals to maintain their own knowledge base while developing a strategy to counter future threats.

To best train for warfare in the EMS, simulator-based training is essential for Airmen. Simulators allow Airmen to train in a congested and contested EMS environment while not exposing sensitive capabilities to our adversaries.

Functional Coordination and Synchronization

Proper coordination of the Air Force EW and EMSO mission ensures that unity of effort is achieved in all organize, train, and equip (OT&E) decisions, which is accomplished by Headquarters Air Force Electronic Warfare Division (AF/A5RE). To properly align its efforts, the DOD established the **Electronic Warfare Executive Committee (EW EXCOM)**. EW EXCOM serves as the senior executive focal point for the DOD's EW enterprise in all capability and capacity decisions. Aligned under the EXCOM's priorities, the Air Force ensures that it coordinates manning, training, and acquisition decisions. For example, in radar warning receiver (RWR) acquisitions, EW system requirements and procurements could be standardized to ensure that fewer and more capable RWRs are implemented. This improves upon the current model whereby each major weapon system program procures their own RWR, suffering higher cost and implementation times as well as slower reprogramming due to the numerous models currently fielded.

Basic Research Support

Air Force Research Lab (AFRL) is responsible for discovery, development, and integration of warfighting technology. Basic and applied research enables future capabilities in the Air Force. Basic research is required to enable future concepts such

as cognitive EA and adaptable waveforms. The research that is done in AFRL feeds into the CCMD requirements process as well as ACC's and Air Force Space Command's (AFSPC's) organize, train, and equip responsibility. By ensuring that research advances are shared across functional communities, the Air Force can more confidently ensure that major developments do not allow strategic surprise and place the Air Force at a disadvantage in a near-peer conflict. While these functions occur across the Air Force, direct connections and integration should occur for EW and EMSO just the same.

Weapons and Tactics Program Support

The weapons and tactics program includes the tactics improvement proposal (TIP)-to-test process in which the combat Air Force (CAF) identifies tactics, techniques, and procedures (TTPs) across the Air Force which need testing. This process takes existing capability and tests the utility of using that existing capability in a new way. The TIP-to-test process feeds directly into the CAF test priority list (TPL) and those tests are approved by the major command (MAJCOM) commander for test. The test results are published and incorporated into the 3-1 series of Air Force TTPs. EW and EMSO capabilities are a part of the TIP-to-test process as any other weapon system or mission design series.

Operational Testing Support

The Air Force performs developmental testing and operational testing for all weapon systems. The 53rd Wing is responsible for operational testing and evaluation for the combat air forces. Testing is conducted for EW and EMSO capabilities within the 53d Electronic Warfare Group (EWG). In addition to testing an EW or EMSO weapon against a certain threat, the 53rd Test and Evaluation Group (TEG) also considers electromagnetic interference (EMI) and interoperability with other blue force weapon systems. Considering EMI and interoperability across the range of EW and all EMSO, to include weapons such as air-to-air missiles, air-to-ground weapons, and other systems, is critical to successful integration in the battlespace. It is critical when testing weapons that EMSO considerations are accounted for in those TIPs and test plans. If a weapon requires the use of the EMS, then an element of that test should include EMSO. **Specifically the EP features of the weapon or system being tested should be accounted for in all test plans.** Contested, degraded, and operationally limited impacts by the adversary should also be considered. Currently, the 53rd Wing also conducts COMBAT SHIELD exercises that test the actual EW effectiveness of CAF units' equipment. Further, the Joint Electromagnetic Preparedness for Advanced Combat capabilities are used to simulate "red" (enemy) EW forces, to assist in development of tactics.

Modeling, Simulation, and Analysis (MS&A) Support

Effective and representative MS&A is critical to understanding the impact that EW and

EMSO activities have in the battlespace. The Air Force should ensure that capabilities like Advanced Framework for Simulation, Integration and Modeling (AFSIM), and other simulation capabilities, are able to replicate accurately the adversary's environment and that EW and EMSO capabilities are represented to the highest fidelity. Without access to every adversary capability for testing, MS&A is the one way that EW and EMSO capabilities can be tested and validated. Specifically MS&A beyond a 1v1 scenario (a single "blue" weapon vs a single "red" weapon) is a requirement. The ability to understand second-order effects, electromagnetic interference (EMI), and how EW and EMSO capabilities integrate with other weapon systems should be incorporated into MS&A. The impact of not fully modeling and simulating EW and EMSO capabilities is that effects in the EMS may be negated or have reduced effectiveness unknowingly. A synchronized plan, including all EW and EMSO capabilities, focused on critical nodes and targets based on intelligence is necessary to maintain high standards and readiness.

Requirements Support

Combatant command EW and EMSO requirements for operation plans are identified and communicated to component MAJCOMs and fulfilled by Air Staff and the major commands (e.g., Air Combat Command, Air Force Space Command, and Air Force Global Strike Command). Periodic CCMD review and updates are required to ensure adversary capability changes and TTPs are incorporated throughout every level of acquisition and planning process. Specific EW and EMSO requirements are routed through Joint Urgent Operational Need (JUON) and Urgent Operational Need (UON) statements. However, JUONs and UONs should not be the "requirements process." The requirements process is an iterative and strategic outlook that stays ahead of the adversary and works to identify and build EW and EMSO capability required to execute future operations.

EW and EMSO requirements do not always have to be hardware or new systems. With an open architecture and software standards, requirements may be as simple as a software or application change. In the future, flexibility within EW and EMSO will be enabled by standards that allow for a streamlined requirements process. Clear communication between the joint level, the CCMD, typically the CMD EWO and Spectrum Operations, to the component MAJCOM and to Air Staff enables efficient and effective planning.

Acquisition Support

"Our decades long acquisition upgrades cannot counter the global proliferation of threats" (DOD *Electronic Warfare Strategy, 2017)*. The intelligence process is critical to the acquisition process. As new targets are identified and complex targets continue to evolve, the acquisition process should be flexible and agile in order to maintain pace with the adversary. In order to maintain pace, EW and EMSO requirements must include standards and a common open architecture. The commercial world has outpaced the DOD in many areas and technology interoperability being one area that directly impacts EW and spectrum operations. Adversaries have access to more

capability and technology than ever before, at low cost. The need to rapidly detect, design build, and field capability has reached a revisit rate far faster than any other time in history. The approach taken in the Air Force EW and EMSO acquisition process should incorporate lessons learned from history, but also look to the future, more closely aligning the Air Force's doctrinal functions that enable required combat capability. A common example is the Android operating system (OS). Developers can create applications for the Android OS and they will be compatible and executable. The value of this is that it reduces development time and cost, while increasing capability. The process that allows this to occur is a user need (the requirement), foundational information about the capability (the intelligence), and a set of standards and procurement vehicles that enable rapid acquisition of capability.

Doctrinally these functions exist in the DOD and Air Force; however, they should be synchronized to enable cost effective and relevant EW and EMSO capabilities.
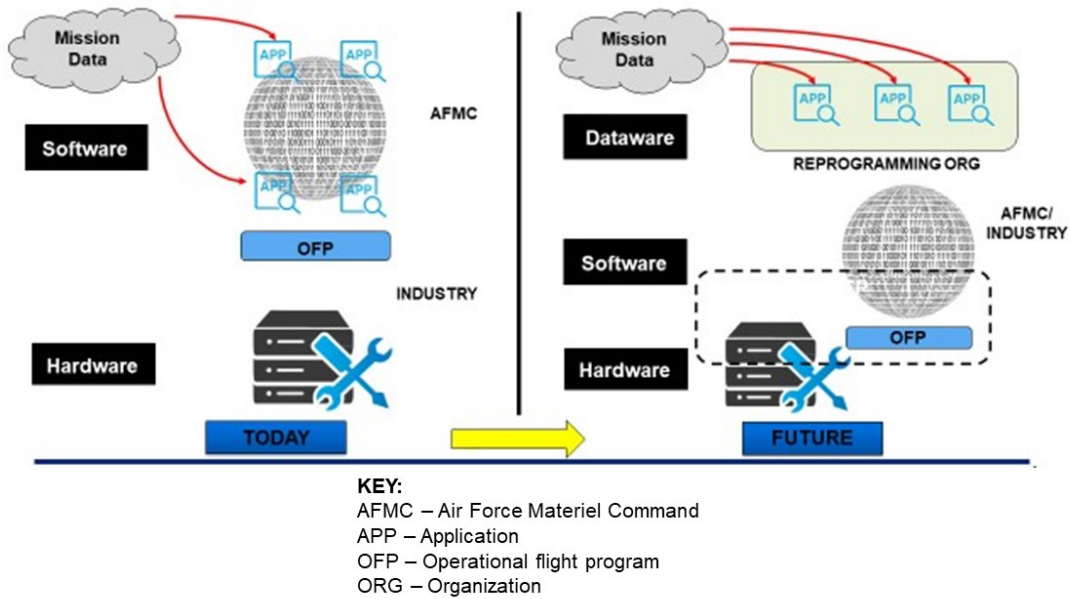
Logistics Support

Readiness and sustainability of electromagnetic assets are directly related to the quality of logistics planning. EW logistics programs should be in balance with modernization efforts and the operating capability each category of resources provides. Emphasis should be on total effectiveness to maximize EW capabilities.

Operational Mission Data File Programming and Reprogramming Support

Operational mission data programming and reprograming takes advantage of the Electronic Warfare Integrated Reprogramming (EWIR) process defined in Air Force Instruction (AFI) 10-703, *Electronic Warfare (EW) Integrated Reprogramming*. The EWIR process uses a suite of software-definable tools that enables aircrew survivability and mission success while operating in an environment characterized by friendly, neutral, and hostile threat systems that use the EMS. EWIR provides a capability to characterize the EM emissions of hostile and other systems, analyze and model their impact on operations, and incorporate these characteristics to enable rapid detection, accurate identification and appropriate response within the EM spectrum. The 53 EWG is the Operational Reprogramming Center for the CAF, Combat Search and Rescue, and selected foreign military sales-supported aircraft. For more information on EWIR, see AFI 10-703.

53 EWG provides operational mission data production though the use of the Specialized Electromagnetic Combat Tools and Reprogramming Environment (SPECTRE) enterprise. SPECTRE is a suite of software definable tools to support the automation, centralization and standardization of all 53 EWG reprogramming activities for the CAF in accordance with AFI 10-703. This process should continue to be agile and adaptive to ensure the DOD maintains advantage within the EMS as the Air Force consolidates and modernizes the EW reprogramming enterprise.

KEY:
AFMC – Air Force Materiel Command
APP – Application
OFP – Operational flight program
ORG – Organization

SPECTRE Model-Based Systems Engineering Environment

SPECTRE provides a full web-based collaborative environment where mission data can be developed and tested in a model-based systems engineering environment (MBSE) (see figure, "SPECTRE Model-Based Systems Engineering Environment) will enable the operational reprogramming center to meet associated timelines to meet the warfighter needs.

SPECTRE is designed to allow machine-to-machine transfer of intelligence data and programming information into mission data generator tools. SPECTRE has modules to support all current CAF platforms and has the organic capability to expand into emerging Air Force and joint force airborne operational mission data software reprograming needs. (See figure, "SPECTRE Process".)

The 53 EWG organic, integrated suite of software modules for MD programming
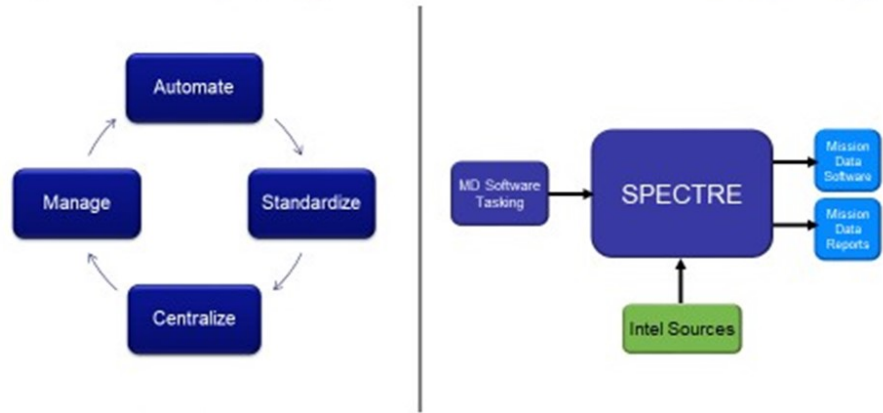
SPECTRE is not just a product, it is a continuous innovation process to maximize "People, Process, and Technology"!

KEY:
EWG – Electromagnetic warfare group
MD – Mission data
SPECTRE – Specialized Electromagnetic Combat
Tools and Reprogramming Environment

SPECTRE Process

To meet emerging capabilities, a single Air Force Multidomain Operational Reprogramming Center is responsible for programming and reprogramming EMS and EW systems, and providing sensor engineering for all Air Force and joint platforms. To enable an advantage or achieve localized superiority within the EMS, we should integrate concepts such as artificial intelligence, human-in-the-loop machine learning, and software-centric EW capabilities into Air Force operational mission data production to meet the warfighters' air tasking order timelines. In the near term, software centric EW will require experts to develop, test, and characterize machine algorithms to take advantage of a decade's worth of radio frequency data. The Air Force should move toward agile, software definable capabilities in which new mission data will enable greater capability through software interfaces, as well as develop new programming schemes for emerging space systems that should be thoroughly integrated into the current construct.

Integrating cross-platform data will increase efficiencies not previously encountered by enabling more rapid and agile MD updates. Taking advantage of the systems-of-systems concept is the vehicle through which the capability will emerge. We will continue to build and adapt the SPECTRE open and common architecture to allow transparent system-of-systems integration to enable greater efficiencies.
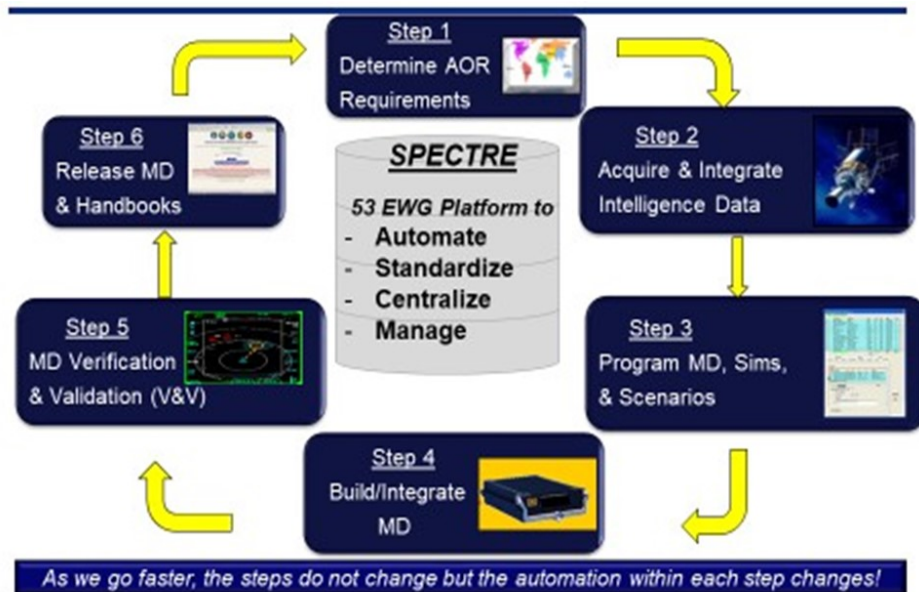
KEY:
AOR – Area of responsibility
EWG – Electromagnetic Warfare group
MD – Mission data

Mission Data File Process

The figure, "Mission Data File Process" shows the six-step process that all mission data files undergo. This process ensures the most up-to-date intelligence data is incorporated into the output along with a complete verification and validation in a simulated environment. The commander, Air Force forces' A3 staff should work with MAJCOM wing's weapons shops to collect EW programming and reprogramming requirements. Based on the current timeline, the urgency of the warfighters' need will drive the routine, urgent, or emergency (yearly, 72 hours, 24 hours) binning of the request. However, by increasing our technological capability, the Air Force's timeline to program and reprogram new mission data updates and releases will be significantly reduced.