Use of Digital Modeling, Simulation, and Analysis to evaluate EW Missions

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Abstract — The dramatic increase in complexity of the missions, systems, and processes, coupled with the delivery timeline compression directly affects the mission responsiveness and the delivery capability. A situation like that requires a revolutionary improvement and not incremental. The usage of digital modeling, simulation, and analysis, using AGI STK – Systems Tool Kit physics-based and multi-domain engineering software, incorporates the operational environment and allows a better evaluation of the mission outcomes at every phase of the lifecycle. Detailed digital models can be defined to include all subsystems, platforms and components to evaluate the system performance for individual systems, and when integrated into a common simulated environment, the mission effectiveness can be dynamic measured through analytical graphs, reports and visualized in 2D and 3D. A study and evaluation of these techniques and methods were applied into an electronic warfare mission scenario.

I. INTRODUCTION

New emerging technologies and processes in the component, subsystem and system level are considerable increasing the complexity of the missions. The systems that are utilized to execute missions and the processes that are used to engineer and deliver the systems and capabilities for those missions are becoming more complicated. Then the effort and the time required are increasing to deliver the same capabilities [1]. In the other hand, the demand for the responsiveness are being significantly compressed and the time to identify the need for the mission objective and the definition around that has gotten shorter, as shown in Figure 1.

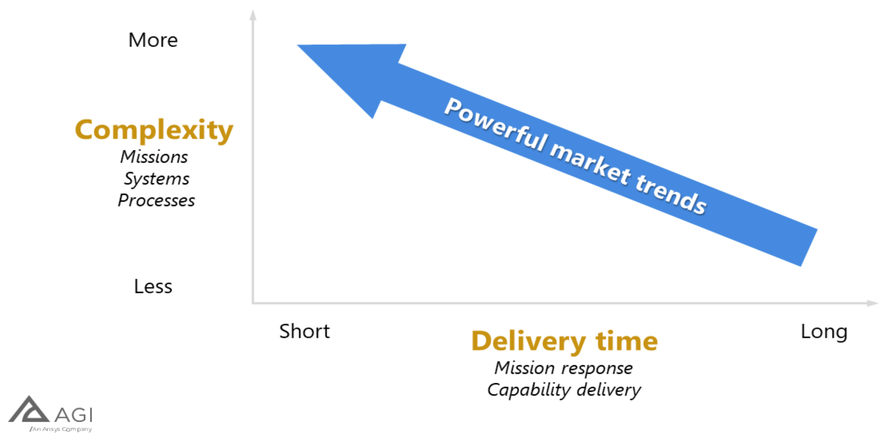

Figure 1 – Mission Complexity and Delivery Time.

II. THE LIFECYCLE PERSPECTIVE

The mission's lifecycles are increasingly moving from the standard “engineering V” to a more cycle perspective, where the mission is the center of attention and linked to every decision at every stage of the mission process [1]. There are multiple forms of information around this process, from concept development to operations and sustainment. The Figure 2 shows how the process are all tied together, allowing proper iteration at each phase and securing individual and mission-level outcome evaluation.

In a Electronic Warfare (EW) mission scenario, we can split the models into three levels, The Component/Sub-system Models, The System Models, and The Mission Model. The model, simulation and analysis methods presented was performed based on AGI – Systems Tool Kit Software.

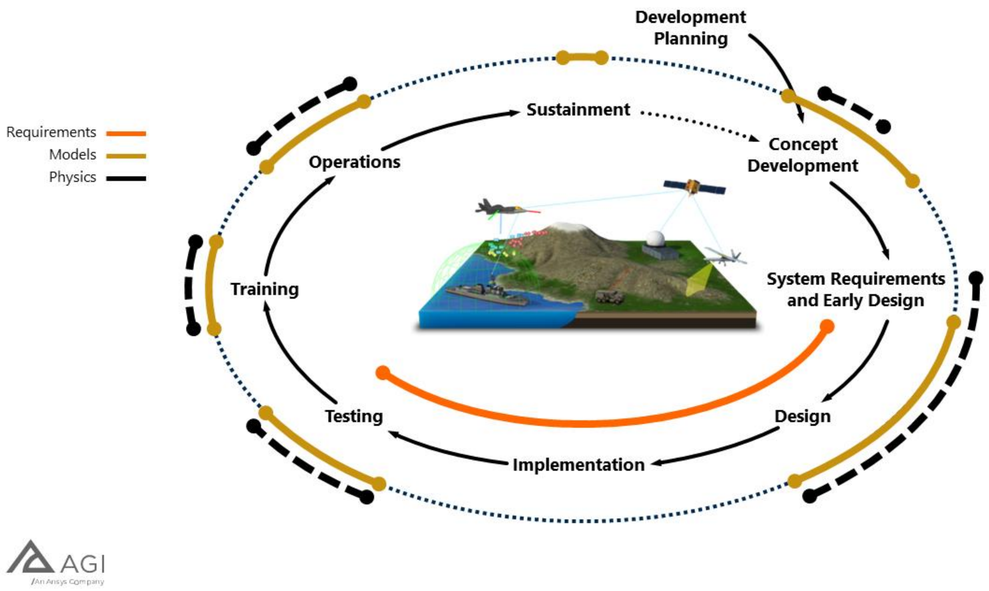

Figure 2 – Mission Lifecycle Model.

III. COMPONENT/SUB-SYSTEM MODELS

Describes detailed Models of each element defined and configured, updating to these models are necessary and required during entire lifecycle, and shall include all subsystem, platforms and components [2].

- **Antenna Characterization:** Different antenna types and Phased Array characterization (element configuration, back lobe suppression methods, isotropic elements and minimum redundant linear arrays).
- **Propagation Channel:** RF Environment, including Rain/Cloud/Fog, atmospheric absorption, Terrain and Urban effects, tropospheric scintillation and radar clutter.
- **Transmitter & Receiver:** Frequency, Power, Data Rate, Modulation, Filters, PSD, Polarizations, Gains/Losses, Bandwidth, System Noise Temperature.
- **Radar:** Monostatic and bistatic radar systems with operations in Synthetic Aperture Radar (SAR) and/or Search/Track modes (Identify jammers and interference sources, clutter algorithms for geometry model plugin, and multiple frequency dependent radar cross sections - RCS)

IV. SYSTEM MODELS

The System Models links the underlying Component/Sub-system Models into a System level Models, defining outcomes and measure of system performance for individual systems.

- **Communication Link Modelling:** Performance prediction, LOS, EIRP, RIP, Gains, Losses, Flux Density, C/No, Eb/No, BER.
- **Radar Modeling:** Integrated Probability of Detection, Integrated Time and SNR, Number of Pulses to goal-SNR, RCS Aspect to Target.
- **Mask & Attenuation:** Body Mask Attenuation based on 3D models and antenna placement.
- **Jamming Models:** Theoretical Jammers, Signal Degradation, Filtering, and Spectrum Analysis.

V. MISSION MODEL

Integrates system models into a common simulated physics based environment to evaluate Mission effectiveness.

- **Electronic Support:** Provides situational awareness and understanding of the electromagnetic battlespace, including signal mapping, type of signal, sources and identify friendly or foe signals.
- **Electronic Protection:** Involves actions taken to protect friendly forces (personnel, facilities, and equipment) from any effects of friendly or enemy use of the electromagnetic spectrum that degrade, neutralize or destroy friendly combat capability.
- **Electronic Attack:** The use of electromagnetic or directed energy to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability.

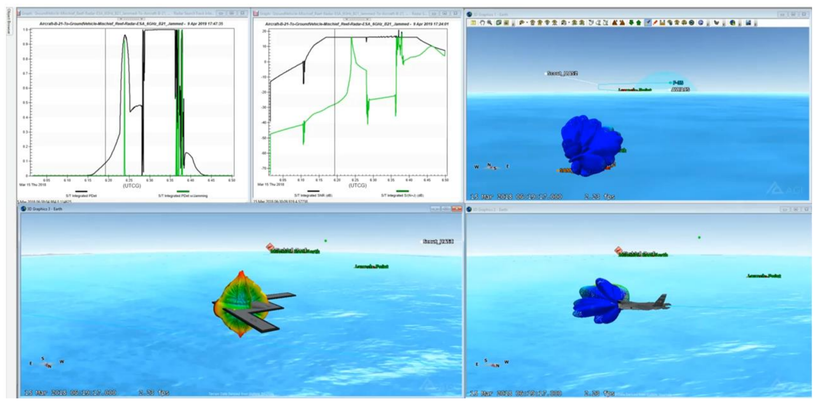

Figure 3 – Analytical Results and 3D Visualization.

VI. CONCLUSION

Using AGI STK – Systems Tool Kit in addition to the techniques throughout the engineering life cycle, it was possible to perform digital modeling, simulation, and analysis of a generic Electronic Warfare Mission scenario in common simulated environment. The Mission outcome evaluation was done based on the metrics for Electronic Support, Protection, and Attack using dynamic analytical reports, graphs and 3D visualization.

REFERENCES

1. K. Flood “Introduction to Digital Mission Engineering”, Phoenix Integration DME, June 2020.
2. L. Oltrogge, H.Rashid, G. Yamato “Addressing Small Satellite Communications Issues”,IAA-BR-18.