Mission Engineering

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This article describes the emerging concept of mission engineering, especially as it is being practiced by the US Department of Defense. Mission engineering is closely associated with systems of systems (SoS) because most missions are accomplished through the coordination and interoperability of multiple systems. The article defines mission engineering and describes the systems engineering activities involved in mission engineering.

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Definition of Mission Engineering

Mission engineering describes the application of systems engineering to the planning, analysis, and designing of missions, where the mission is the system of interest. Mission engineering analyzes the mission goals and thread, analyzes the available as well as emerging operational and system capabilities, and designs a mission architecture to achieve the mission goal (Gold, 2016). Consequently, mission engineering must

simultaneously consider operational, technical, and acquisition issues and their integration in order to design a solution to achieve the mission goal (Van Bossuyt et al. 2019). Lastly, the term “mission” is generally used in the military context, and most mission engineering is for military systems. However, the term, and the process and knowledge it describes, could be applied to space missions or other mission areas.

Missions are almost always conducted by multiple systems coordinating their actions and sharing data. We call these mission-oriented system-of-systems (SoS). Ideally the mission-oriented SoS could be rapidly conceived, assembled, and deployed by operational commanders to react to immediate threats.

Definitions and Principles

A mission describes what the system will do and the purpose of doing it. The mission statement describes Kipling’s “six honest serving-men” – who, what, when, where, why, and sometimes how (Kipling 1902). The mission provides the context for defining measures of effectiveness and for development of the Concept of Operations (CONOPS).

The mission is accomplished by operational nodes completing one or more operational activities. An operational node can be an organization, individual, or system. Operational activities are actions that either transform one or more inputs into outputs or change the state of the system. A system provides capabilities through the execution of operational activities.

Mission Engineering Activities

The following are the main activities of mission engineering:

Mission Capability Analysis and Definition – The engineer analyzes the problem scenario to determine what capabilities are required and to develop a CONOPS for the mission.

Mission Thread Definition – The engineer analyzes the end-to-end set of operational activities. The starting point is modeling the operational activities, their sequencing, and the information flows between them. For military systems, the mission thread is often a kill chain describing the sequence of activities from searching for a threat to engaging a threat.

Tradeoff Analysis – The engineer develops alternatives for accomplishing the mission and conducts trade studies to determine the best alternative given resources and time available.

Mission Architecting – The engineer develops an operational architecture describing the capabilities, the operational activities, operational nodes, and other relevant elements to model the mission.

Requirements Engineering – The engineer determines the functional and non-functional requirements from the capability analysis, CONOPS, and mission threads. The engineer allocates the requirements to the operational nodes. In many cases, the systems in the operational nodes might require engineering to fulfill the requirements.

Interoperability Analysis – The interoperability between systems completing the mission must occur at both the operational and technical levels (Giachetti et al. 2019). Operational interoperability describes the ability of the systems to coordinate their activities to support completion of the mission thread. Technical interoperability describes the ability of the systems to exchange data with considerations for the timeliness and quality of the data. The interoperability analysis generates additional requirements on the systems.

Mission-Oriented SoS Implementation – The mission-oriented SoS must be implemented through designing and developing new systems, modifying existing systems, and/or modifying doctrine, policies, procedures, and other non-materiel means to help achieve the mission.

Mission Verification and Validation – The engineer verifies that the system as delivered satisfies the requirements and validates that the system fulfills the mission purpose and stakeholder needs.

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Additional References

None.

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