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Applying Systems Design to Improve Emergency Operations Center Performance

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Abstract: The West Point Emergency Operations Center (EOC) is considering an infrastructure and systems upgrade to improve its ability to respond to emergencies in the West Point area. This research project used the Systems Design Process and leveraged literature reviews, stakeholder interviews, site visits to multiple operations centers, and observation of the West Point EOC in action. Using a multi-objective value model and Zwicky's morphology, three distinct strategies were evaluated. The team found that a mixed technological approach, rather than an EOC-specific software tool, and a more open layout could improve cross-organizational information sharing and real-time situation tracking. The West Point EOC can use these recommendations in a pilot program to confirm the project's findings and identify specific software solutions prior to committing and funding a major upgrade.

Keywords: Common Operating Picture, Emergency Operations Center, Systems Design Process

1. Introduction

Emergency Operation Centers (EOC) serve as the core coordination hubs for managing "information and resources to support incident activities", and act as command and communication centers within emergency management systems (Federal Emergency Management Agency, 2017). As the epicenter responsible for collecting, analyzing, and disseminating data, they support unified decision-making across multiple jurisdictions, agencies, and disciplines (Emergency Information Infrastructure Partnership, 2007). Additionally, EOCs must adapt as they often serve in a multitude of facets, including managing the execution of large-scale special events, controlling the response and relief efforts during severe weather and natural disasters, and responding to security threats or attacks.

The West Point EOC is seeking to improve its ability to seamlessly monitor and display critical information, support timely decision-making, and effectively coordinate across stakeholders during a wide range of dynamic events. The EOC currently possesses a range of resources and communication tools, but has identified the need for improved communication flow, unified situation awareness, and cross-organizational coordination. For example, one unique challenge is the need to more effectively coordinate between West Point (a federal entity) and local and state entities, who have different command structures, information technology (IT) systems, and administrative policies.

2. Methodology

The research team used the first three phases of the Systems Decision Process (SDP) as a framework for this research project. Problem Definition leveraged literature reviews, stakeholder interviews, site visits to multiple operations centers, and observation of the EOC in action to understand the EOC's true functional requirements and values. The Solution Design and Decision-Making Phases leveraged Zwicky's morphology to develop and evaluate potential recommendations for change. Solution Implementation was considered outside the scope of this project.

2.1 Problem Definition

The Problem Definition Phase began with a literature review which helped frame the problem for the team. Site Visits then gave the team an understanding of what a highly functioning EOC looked like and how they operate. The team then developed communication network diagrams to better understand the EOC's capabilities and how key stakeholders communicated, as well as a value model for the client's objectives.

2.1.1 Literature Review

Federal doctrine, particularly the National Incident Management System (NIMS) and the National Response Framework (NRF), establishes a standardized structure for coordination across jurisdictions and agencies, emphasizing shared situational awareness and unity of effort during emergency response operations. While these frameworks provide a common structure, research consistently showed that the effectiveness of EOCs depends largely on how well these principles are implemented at the operational level (Federal Emergency Management Agency, 2017; Federal Emergency Management Agency, 2019).

A recurring theme from the literature review was that communication and interoperability are the most critical determinants of EOC performance. Effective emergency coordination requires agencies to share information quickly and reliably across organizational and technological boundaries. Studies of emergency response networks demonstrate that interoperable communication systems and clearly defined liaison relationships reduce information latency and improve coordination during complex incidents. When agencies rely on multiple disconnected systems or inconsistent communication channels, coordination becomes fragmented and can slow decision-making during time-sensitive events (Kapucu, 2006; Comfort, 2007).

Research on organizational structure further highlights the importance of adaptable coordination mechanisms within EOCs. Highly centralized structures can provide clear authority but may limit flexibility during dynamic incidents, while more networked or hybrid structures enable faster information sharing and collaboration across agencies. High-performing EOCs, therefore, function less as traditional command centers and more as information integration hubs, collecting data from multiple sources and disseminating a shared Common Operating Picture (COP) that supports coordinated action across stakeholders and incident commanders (Moynihan, 2009).

Lessons from previous emergency responses reinforce these findings. After-action reports (AAR) from large-scale incidents consistently identified breakdowns in communication, resource visibility, and information sharing as key contributors to ineffective response operations. These AARs emphasized that improving situational awareness through integrated information systems, real-time visualization tools, and strong interagency communication practices can significantly enhance the effectiveness of emergency coordination (Constant Associates, Inc., 2022; County of Sonoma, 2018).

Collectively, the literature review characterizes the EOC as a coordination system in which technology, organizational structure, and communication practices must function together to support effective emergency response. These insights informed the research team's focus on interoperability, communication pathways, and COP design when evaluating the West Point Emergency Operations Center.

2.1.2 Stakeholder Analysis

West Point's EOC is responsible for coordinating responses during natural disasters and emergencies as well as security threats and incidents. West Point is also unique in that it is a military installation, historic site, and university. West Point hosts a range of collegiate activities and large-scale special events (e.g., graduation with distinguished visitors, football games, etc.). As a historical landmark and active tourist destination, West Point must also accommodate significant civilian visitation. This creates a unique challenge of maintaining the security requirements of a restricted military installation while enabling controlled public access for tourism and high-attendance events.

The research team conducted stakeholder interviews and observational visits to better understand the operational challenges that EOCs face and how interoperability, communication, and situational awareness function within a multi-agency environment. Discussions with West Point stakeholders, like the Keller Army Community Hospital, revealed interoperability and information flow challenges. For example, much of the critical information is transmitted via phone, email, or messaging, and then manually entered into West Point's current EOC-specific software system for situational awareness. Engagement with the Orange County EOC provided a comparative model of large-scale coordination, where centralized dashboards displaying real-time geospatial data improved situational awareness and demonstrated the importance of strong communication pathways between stakeholders. Observation of the U.S. Secret Service Multi-Agency Communication Center illustrated how operations centers function primarily as hubs for information aggregation and dissemination, rather than a centralized decision-making

node, with a common operating picture (COP) enabling real-time information sharing among partner agencies. Finally, discussions with the USMA Chief Information Officer clarified information technology constraints within the installation, particularly the administrative and security considerations involved with operating various government and commercial networks.

2.1.3 Communication

The Research Team next developed communication network diagrams to visualize the information flow between key stakeholders during EOC operations. Figure 1 and Figure 2 show examples of the communication network diagrams developed (not the actual network diagrams developed). Of note, the "Point-to-Point" label in Figure 1 denotes phone or email. In Figure 2, the colored circles indicate which systems each position has direct access to. The diagrams highlighted that communication is not conducted through a single standardized platform, but instead through multiple channels which require information to be manually transferred or relayed by the individuals in the EOC. Moreover, the diagrams revealed that the EOC was the only entity that had access to every communication system and direct access to every key stakeholder (either through its assigned personnel or liaison officers). Liaison officers (LNO) are a vital aspect of any EOC, as the loss of an LNO (particularly from an external organization) could deprive an EOC of direct access to a key communication system.

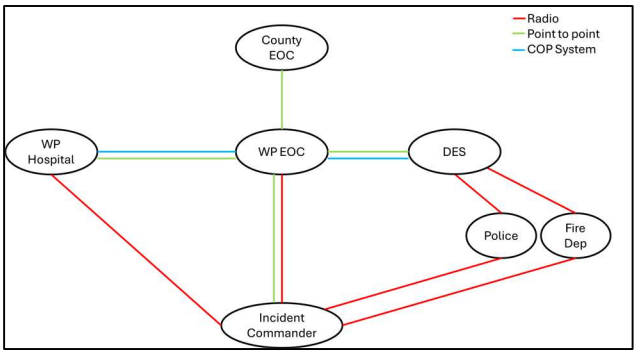

Figure 1. Simplified Example of a Macro Communication Network Diagram

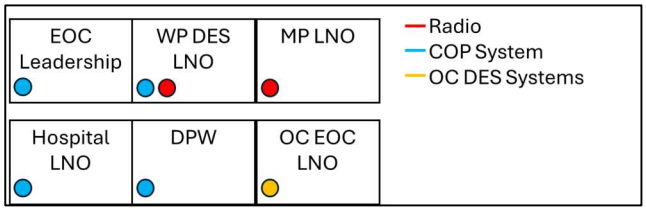

Figure 2. Simplified Example of an Internal Communication Network Diagram

2.1.4 Value Modeling

Incorporating the information gained from the literature review, stakeholder meetings, site visits, and client objectives, the team built the value model shown in Figure 3. The fundamental objective is a well-functioning EOC that has an accurate understanding of any situation and can effectively coordinate a response in a timely manner. To achieve this, the four major objectives are: Manage Situational Information, Display Information, Share Information, and Communicate & Brief Information. The team then identified six value measures for these objectives. Event Mapping uses a 1-10 constructed scale to evaluate how well a potential solution accurately captures and visually displays the current situation (i.e., a common operating picture). Event Tracking uses a 1-10 constructed scale to evaluate how well a potential solution can capture and log key information and situation updates. For simultaneous displays, a "display" is considered the ability to project an individual computer system screen (not multiple windows from a single system). An "air gap" is defined as the transferring of information

from one system to another system by a human. For example, receiving information updates from a radio and then typing that information into the event log is considered one air gap. Intra-EOC communication uses a 1-10 constructed scale to evaluate the ability of EOC personnel to share information and collaborate. Finally, Command Briefing Ability uses a 1-10 constructed scale to evaluate the EOC's ability to host specialized briefings or planning sessions separate from regular EOC operations. Finally, the team developed value functions and swing weights for each value measure with the West Point EOC Leadership.

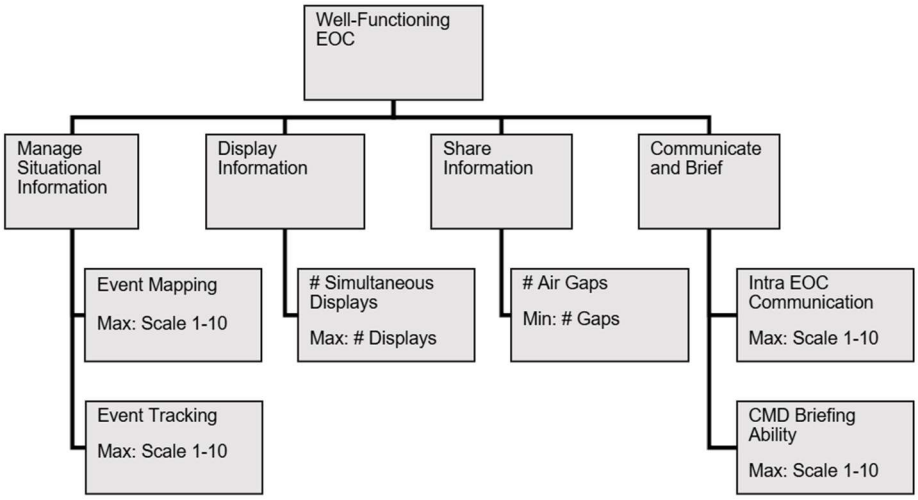

Figure 3. Value Model

2.2 Solution Design

The team used Zwicky's morphology to develop potential solutions for an upgraded EOC design. The team chose a morphological analysis because multiple parameters were identified with no obvious optimal configuration. The team identified key parameters that would be critical to any EOC upgrade: Visual COP system, Event Tracking Log, Instant Messaging System, Room Layout, Break-Out/Collaboration Spaces, and Independent Displays. Both the stakeholders and the literature review identified Instant Messaging as a critical method for secure communication between organizations and individuals during a crisis. Room layout refers to the general configuration of desks and stations in the EOC room. The number of independent screens is the number of screens that can be used simultaneously by different people/computer systems. The team then developed potential solution designs based on three strategies: Simplicity, Communication Maximization, and Briefing Maximization. Simplicity seeks to minimize the number and complexity of the EOC software platforms. Communication Maximization seeks to maximize intra-EOC and external communication. Briefing maximization seeks to maximize the EOC's ability to hold separate tailored briefings and planning sessions in addition to the regular EOC operations.

Table 1. Zwicky's Morphology Table.

	Strategy		
Parameters	**Briefing Maximization**	**Communication Maximization**	**Simplicity**
COP	GIS Software	GIS Software	Current System
Event Tracking Log	Current System	A365	Current System
Instant Messaging	U365	A365	Commercial App
Room Layout	Row	Row	Current Shape T-Shape
B-O Room	2	1	1
# of Independent Screens	3	5	3

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3. Conclusion and Recommendations

The team then scored each strategy using the developed value model. Table 2 shows a completed Value Model, but with altered scores and weights for this publication. The Communication Maximization strategy had the highest total score.

Table 2. Example of the Scoring Table.

	Event Mapping	Event tracking	# Simultaneous Displays	# Air Gaps	Intra-EOC Communication	Briefing Ability	Weighted Total Score
Briefing	70	65	70	85	75	90	75.31
Communication	80	80	75	90	70	70	77.98
Simplicity	60	60	50	95	65	80	67.64
Current	60	60	25	70	90	70	60.14

Based on the value scoring results, the team recommends piloting the communications maximization strategy, which emphasizes the use of GIS software as the primary COP, enabling real-time spatial visualization of incidents, resources, and operational areas. Event tracking and logging, instant messaging, and cloud-based document management would be managed through the A365 software platform, giving the EOC personnel to maintain shared documentation and incident tracking across multiple organizations. Communication between stakeholders would also be supported through the A365 software platform, consolidating messaging and information exchange within a unified digital workspace. With the use of the A365 platform, Orange County will not have direct access to the A365 platform, so a liaison inside the EOC will be necessary to reduce risk of information delays or inaccurate information. The row-style layout has become an industry standard, used by many EOCs and military tactical operation centers. Figure 4 shows an example of a row-style EOC Layout that could be used for a pilot test in the West Point EOC.

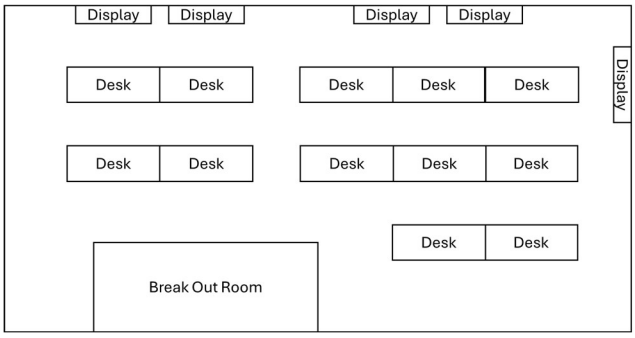

Figure 4. Example of a Row-Style EOC Layout

A pilot program is recommended because four of the value measures were scored on a constructed scale, in which scores were determined based on discussions with stakeholders or subject matter experts. The full strategy configuration has not been tested formally. Luckily, the West Point EOC has the ability to test this configuration with little to no cost. Formal testing will allow the EOC to validate the current value scores and identify any unforeseen secondary/tertiary effects prior to committing to permanent upgrades and upgrade costs. The EOC can begin with a tabletop exercise prior to piloting the concept during an actual special event at West Point. Planned events, like concerts or sporting events, provide an opportunity to exercise the full EOC in a real, but still mostly predictable, situation. The team has identified two options for a COP, though others may exist. The West Point EOC can test ArcGIS and a Power BI mapping visualization tool. ArcGIS provides more robust capabilities, but Power BI can be combined with a tailored dashboard. Finally, a pilot program will help ensure the identified solution is suitable and usable by all key stakeholders, including West Point Emergency Services, the West Point Hospital,

Orange County EOC, and other key external stakeholders. Together, the approach will strengthen the EOC's ability to integrate information, reduce communication fragmentation, and support faster decision-making during incidents.

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