The Effect of COVID-19 Staffing Limitations on Physical Security System Performance

Bryce Smith
Sandia National Labs – Albuquerque, NM
brysmit@sandia.gov

Matt Thompson
Sandia National Labs – Albuquerque, NM
mthomp@sandia.gov

Douglas Adams
Sandia National Labs – Albuquerque, NM
dgadams@sandia.gov

Matthew Baitinger
Sterigenics - Oak Brook, IL
mbaitinger@sterigenics.com

ABSTRACT

The COVID-19 pandemic significantly impacted all aspects of society; within the material management domain this resulted from the inability of some personnel to be working on site at their facility during the pandemic. The resulting limitations are hypothesized to have had a cascading effect on many aspects of security system performance. This paper explores the effects of staffing limitations on the critical alarm signal communication aspect of physical security system performance. The analysis contained in this paper was accomplished by applying COVID-19 staffing constraints to a hypothetical facility using a physical security system communication model and evaluating the impact on system performance.

INTRODUCTION

Physical security system management is a complex process with high consequence of failure. To meet the unique set of objectives with the given constraints, each physical protection system is customized to a manner that works best for its facility. Throughout these customizations one aspect remains common; the need for efficient communication across the system in order to translate an alarm signal into an effective response. These communications are often relatively complex messages requiring significant context, and they need to be conveyed through multiple entities over several connections (i.e., system-user, user-monitor, monitor-law enforcement). To complicate the issue further these connections are made over various modalities (i.e., in-person conversation, over the phone, electronic indication, radio). This paper explores the pathways available to communicate messages within a hypothetical facility under various conditions to demonstrate the effects on available communication pathways and their respective communication times. The specific interest of this analysis was to determine the effect of COVID-19 staffing limitations upon the communication networks. The analysis represented a hypothetical facility as a network of communication connections and then allowed or disallowed communication over specific segments of the network based upon constraints and opportunities presented by the following scenarios:

1. Scenario one – Baseline facility “Normal” configuration
2. Scenario two – Facility under COVID-19 staffing restrictions

SAND2021-9387 C
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-NA0003525.

The output of the analysis enumerated the available logical pathways on which the communication could take place, then calculates the time required for a message to traverse the network for each pathway. These scenario results are then compared to determine the changes due to COVID-19.

HYPOTHETICAL FACILITY

The hypothetical facility constructed for this paper represents a business that manages radiological material with a typical physical protection system that is monitored by an offsite alarm monitoring company and supported by a typical law enforcement agency. The hypothetical facilities security system communication network is shown in Figure 1. The entities that send or receive communications within the model include:

- The physical protection system (**System**)
- The onsite staff (**Users**)
- The facility management (**Management**)
- The offsite monitoring (**Monitoring**)
- Law enforcement dispatch (**Dispatch**)
- Local Law Enforcement Agency (**LLEA**)

Within the model, the above-mentioned entities are able to communicate with each other as represented by the interconnections. Within the paper's scenarios, the specific modalities on which the communication takes place (including automated message, phone, SMS text, and in-person conversation) are detailed. It is recognized that this model does not account for threat assessment times or transit times, and it is assumed that upon receiving the message each entity would immediately pass the message to the next party in the pathway. Additionally, the start point is always the alarm being generated by the physical security system, and the end point is the law enforcment response unit being informed of the threat (not arriving on scene).

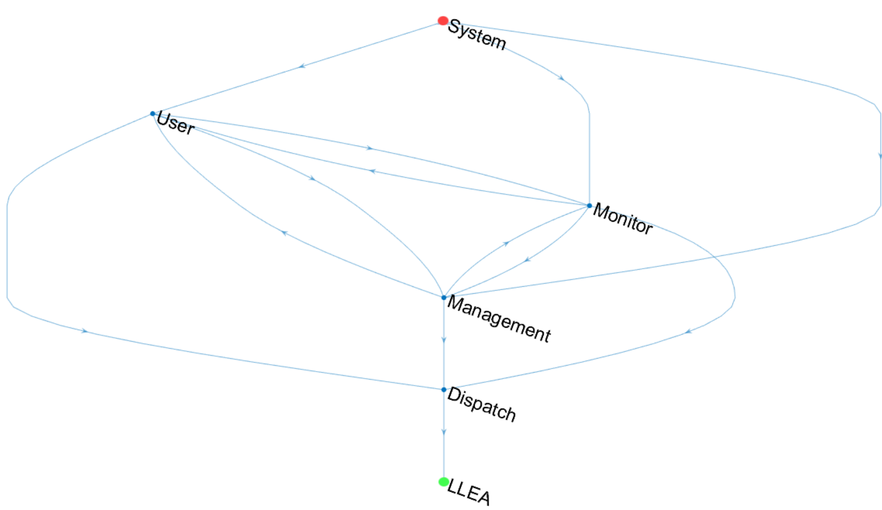

Figure 1. Generalized Network

COVID -19 IMPACTS

COVID-19 has had significant effects on the management of physical security systems; for the purposes of this paper, most notably forcing changes to the number and type of staff that are onsite and thereby types of communications available within the network. It was assumed the onsite staff was minimized to such an extent that the audio/visual alarm indications (sirens, strobes, on-screen alerts, keypad notices) were not effective and the facility staff communication was limited to email or phone.

MODELING METHODOLOGY

In order to analyze the system, a communications model was built where the entities are represented as nodes, and the communications are represented as edges, and, together, they form a network system. After building the generic network as shown in Figure 1, various modalities are then activated/deactivated to represent the different scenarios. Table 1 below outlines the combinations of active edges and nodes for each scenario. The scenario columns indicate each modality's status within the specified scenarios where "1" represents active and "0" represents inactive or unavailable. Additionally the scenario one and scenario two columns are shaded to correspond with the histograms later in the paper.

Table 1. Network Edge/Node Definition Table

Sender	Receiver	Modality	Example	Task Time [s]	Scenario one	Scenario two
System	User	Visual / Audible	Siren, strobe	5	1	0
System	User	Electronic	On screen, SMS	15	1	0
User	Monitor	Electronic	Duress	15	1	0
User	Management	In person	Walk over	120	1	0
Monitor	User	Phone	Emergency call	60	1	0
System	Monitor	Electronic	Alarm signal	15	1	1
System	Management	Electronic	On screen, SMS	15	1	1
User	Monitor	Phone	Emergency call	60	1	1
User	Management	Phone	Emergency call	60	1	1
User	Dispatch	Phone	Emergency call	60	1	1
Monitor	Management	Phone	Emergency call	60	1	1
Monitor	Dispatch	Phone	Emergency call	60	1	1
Management	User	Phone	Emergency call	60	1	1
Management	User	In person	Walk over	120	1	1
Management	Monitor	Phone	Emergency call	60	1	1
Management	Dispatch	Phone	Emergency call	60	1	1
Dispatch	LLEA	Radio	Radio	30	1	1

SCENARIO ONE – BASELINE (PRE COVID)

The communications network from scenario one is shown in Figure 2 where the message is generated at the system node (Red) and needs to be communicated to the LLEA node (green) through the intermediate nodes/edges in their defined direction. Figure 3 below details the pathway times available within this network. There are 34 logical unique pathways available with the most efficient allowing the message to be communicated in approximately 95 seconds. In practice, this would mean this system would have 34 ways to communicate this message and the fastest possible pathway would allow the critical message to reach the LLEA approximately 95 seconds after the alarm was generated.

Beyond the pathway analysis, two observations can be made; first the dispatch node is a potential single-point failure, and, second, the system requires that the message go through at least 3 nodes. Assuming that the likelihood that the message is miscommunicated or that delay increases with the number of times it has to be transferred, this presents a significant risk to the timeliness and success of message communication.

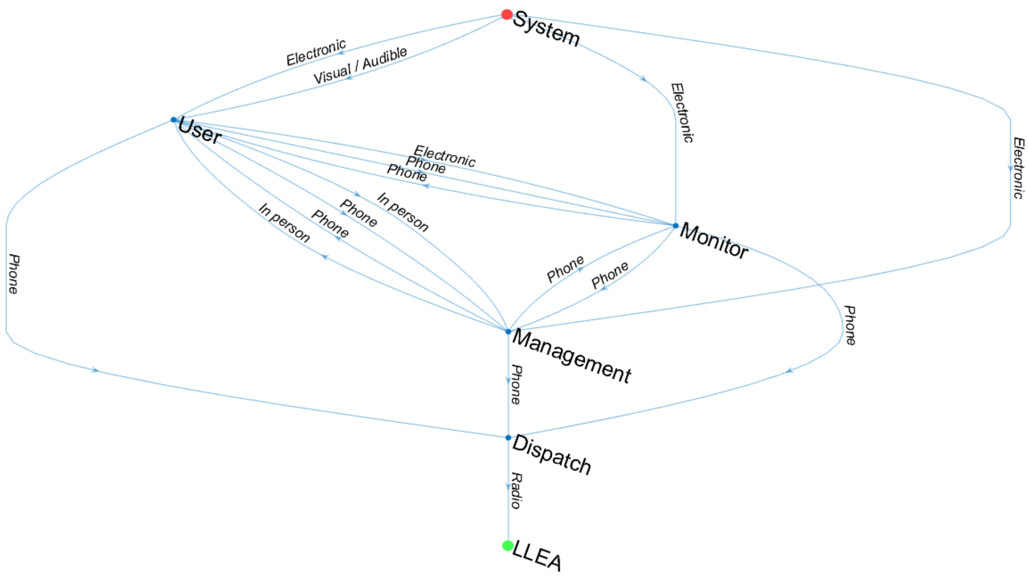

Figure 2. Communications Network for Scenario One

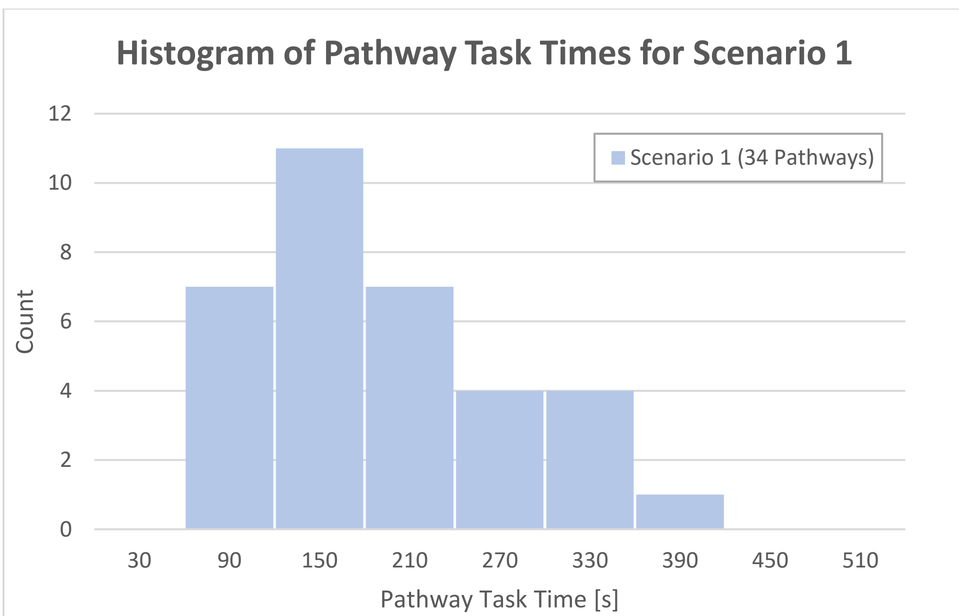

Figure 3. Histogram of Pathway Task Times for Scenario one

SCENARIO TWO – COVID CONSTRAINTS

The communications network resulting from scenario two is represented by Figure 4 where it can be seen that the limitation of reducing onsite staff caused a significant change to the communications structure. Similarly, the histogram of pathway times from scenarios one and two are presented in Figure 5. The overlaid histograms of scenario one (in blue) and scenario two (in orange) demonstrates that there was a large reduction in available pathways; scenario one had 34 where scenario two has only 10. Additionally, the reduction in available pathways was not uniform across the distribution of times, there were more pathways removed from the slower end than from the quicker end. Finally, the most efficient time presented by scenario two is 105 seconds, which is slightly slower than scenario one which had a time of 95 seconds. Overall the changes due to COVID-19 staffing limitations severely decreased the number of pathways available, although the disproportionate elimination of slower pathways over quicker ones allows for efficient message communication with only a slight increase in task time.

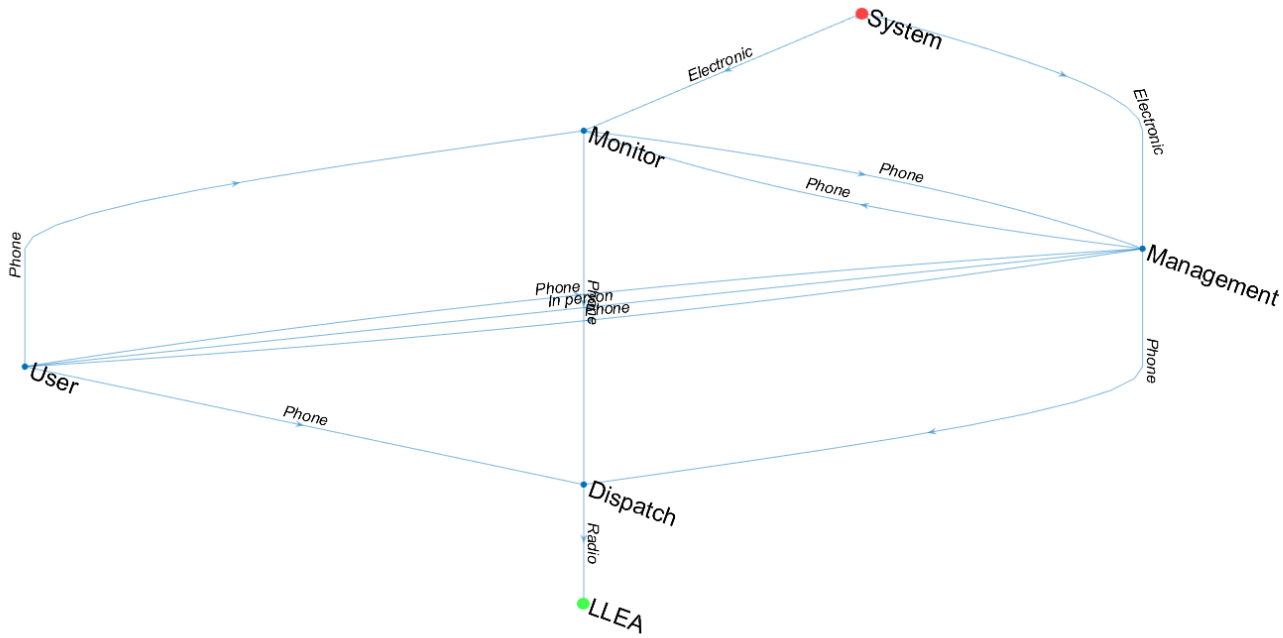

Figure 4. Communications Network for Scenario two

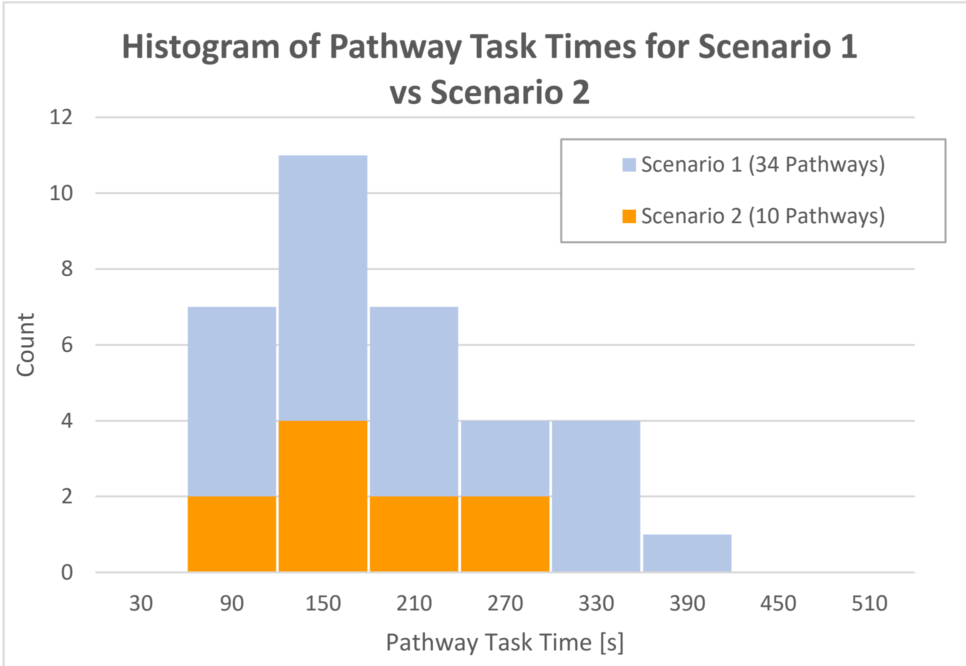

Figure 5. Histogram of Pathway Task Times for Scenario one vs Scenario two

CONCLUSION

The communications networks analyzed demonstrated that there is a robust network in place in the hypothetical facility, and although the restrictions imposed by COVID-19 drastically reduced the available pathways, the ability to communicate a critical message in an relatively efficient manner remains. Quantification of the impact to the security system performance due to the reduction in pathways is a difficult task due to the dynamic nature of interactions and the uniqueness of every individual network. For the purposes of this paper, the quantification will be simplified to a percentage reduction – the COVID-19 staffing restrictions eliminated 71% of the communication pathways. Additionally, the quickest pathway slowed from 95 seconds in scenario one to 105 seconds in scenario two, again concluding an overall effect to the security system is difficult and the quantification will be simplified to a percentage change – the COVID-19 staffing restrictions slowed the quickest communication pathway by 10 seconds, which is 11% slower. It is important to note that the pathways eliminated were not removed uniformly across the distribution as demonstrated by Figure 5, where it can be observed that there was a larger elimination of the longer duration pathways than of the shorter duration pathways. This imbalance in the pathway elimination is likely a result of the affected onsite users existing on a network branch that could be bypassed by other relatively more efficient network branches that were not affected by the restrictions. These results highlight the following: the network was not immune to the staffing restrictions, although based on the observation that the more efficient pathways were less affected by the COVID-19 restrictions. It is concluded that resilience can be achieved through the application of procedures and trainings which direct the communications to occur on the network's more efficient pathways that are preferred not only due to their efficiency, but because they are unaffected by the staffing restrictions.

FOLLOW ON WORK

It is recognized that this analysis technique is limited in that it simply enumerates the pathways available, where more relevant results could be obtained by performing a probabilistic analysis to simulate what pathways would be successful by applying constraints that would emulate procedures and real-world conditions. Additional analysis could be done to calculate the relative importance of each entity and or modality within the network. It is proposed that these tasks be undertaken as a continuation of this work.

REFERENCES

MATLAB Version 2021a. (n.d.). *Computer Software.* The Math Works, Inc.