Human Reliability Considerations from the Hawaii Ballistic Missile Alert Event

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Abstract: Rarely do two clicks of a computer mouse incite widespread panic and create international news. The incorrect assumption of a Hawaiian Emergency Management Agency warning officer on January 13, 2018, led that officer to select an actual ballistic missile alert rather than a test alert option from the agency's computer interface dropdown menu. Further, presented with the option to confirm his selection, said officer validated his choice. His actions would set in motion a chain of events impacted drastically by heightened tension regarding U.S. relations with North Korea. This paper applies the Standardized Plant Analysis Risk-Human Reliability Analysis (SPAR-H) method to the Hawaii ballistic missile alert (BMA) event, aligning the individual components of the event, obtained from the Hawaii Department of Defense report, with the respective performance shaping factors detailed within the SPAR-H method framework.

Keywords: HRA, SPAR-H, Ballistic Missile Alert.

1. INTRODUCTION

Hawaiian residents were quickly warned of an incoming ballistic missile threat to Hawaii and advised to seek shelter by one of three alert systems and two social media platforms. Despite subsequent Facebook and Twitter announcements declaring the alert to be a false alarm, a period of 38 minutes elapsed before the agency issued a false alarm alert. Investigations by the Hawaii Department of Defense (HI-DOD) and the Federal Communications Commission (FCC), begun in the early days following the incident, reported a history of reported workplace concerns regarding the warning officer who issued the alarm [1, 2] as well as insufficient training, inadequate training records, and agency operation failures.

2. BACKGROUND

Hawaii is the only state in the nation with a pre-programmed alert that can be quickly sent to wireless devices in the event of a ballistic missile attack (BMA) heading toward the United States. Given anxiety and uncertainty over U.S. relations with North Korea, the State of Hawaii had established a new series of BMA drills through the Hawaii Emergency Management Agency (HI-EMA) in September, 2017. HI-EMA crew shifts were tasked with creating a simulated incident and executing a corresponding drill at a minimum of three times during the week [2]. These BMA drills were carried out successfully 26 times. On the day the false BMA was issued, a crew of six HI-EMA employees—four warning officers and two supervisors—were in the building within the HI-EMA bunker in the Diamondhead crater on the Hawaiian island of Oahu.

For this paper, the research team analyzed the initial investigation documents, identified the individual factors contributing to the failures and employed the Standardize Plant Analysis Risk-Human (SPAR-H) human reliability analysis (HRA) method [3] to quantify the probability of these factors occurring together to produce the overall event. SPAR-H works by assigning human error multipliers to the levels of different performance shaping factors (PSFs). Though originally developed for use in the nuclear industry, SPAR-H may be used for accident investigation and system redesign as well. The January, 2018, Hawaii event affords the opportunity for researchers to apply SPAR-H to a non-nuclear setting.

3. EVENT DETAILS

At 8:00am on January 13, 2018, a "non-planned" or spontaneous drill was initiated at shift change at the State Warning Point (SWP) location of the HI-EMA employee. While other warning officers participating in the drill reported later that they fully understood this to be a drill, one warning officer claimed to believe that this was a real emergency. The officer responded accordingly, selecting and clicking a live alert from a dropdown menu, then clicking on a button labelled "yes" when prompted, "Are you sure you want to send this Alert?" Thus, a live incoming BMA was issued and transmitted from HI-EMA at 8:08am via the Emergency Management Systems (EMS), Commercial Mobile Alert (CMA), and Wireless Emergency Alert (WEA) systems as well as Twitter and Facebook social platforms [2]. The alerts were received over television, radio, and cellphones in Hawaii almost immediately, with the message stating that there was an incoming ballistic missile threat to Hawaii, advising residents to seek shelter with emphasis that the message was not a drill. Within a few short minutes it was communicated across Facebook and Twitter that the alert was a false alarm with no threat of a missile attack. However, it would be another 38 minutes before a second message was sent out from HI-EMA denouncing the first alert. Table 1 displays the timeline of events from the initial alert to the false alarm alert as reported in [2].

Table 1: Timeline of Events for Hawaii Ballistic Missile False Alarm [2].

0800	• HI-EMA's midnight shift supervisor begins a no-notice ballistic missile defense drill at a shift change by placing a call, pretending to be U.S. Pacific Command, to the day shift warning officers.
0805	• The midnight shift supervisor plays a recording over the phone that properly includes the drill language "EXERCISE, EXERCISE, EXERCISE," but also erroneously contains the text of an EAS message for a live ballistic missile alert, including the language, "THIS IS NOT A DRILL." The recording does not follow the script contained in HI-EMA's standard operating procedure for this drill. • The day shift warning officers receive this recorded message on speakerphone. • While other warning officers understand that this is a drill, the warning officer at the alert origination terminal claimed to believe, in a written statement provided to HI-EMA that this was a real emergency, not a drill. • This day shift warning officer responds, as trained for a real event, by transmitting a live incoming ballistic missile alert to the State of Hawaii.
0807	• In doing so, the day shift warning officer selects the template for a live alert from a drop-down menu, and clicks, "yes" in response to a prompt that reads, " Are you sure that you want to send this Alert?"
0808	• Day shift warning officer receives false WEA on mobile device
0809	• HI-EMA notifies Hawaii Govemor of false alert
0810	• HI-EMA to U.S. Pacific Command and Honolulu PD: No Missile Launch
0812	• HI-EMA issues a cancellation, ceasing retransmission over EAS, WEA
0813	• HI-EMA begins outreach, but its phone lines become congested
0820	• HI-EMA posts on Facebook, Twitter – "NO missile threat to Hawaii"
0824	• Hawaii governor retweets notice that there is no missile threat
0827	• HI-EMA determines that an EAS, WEA Civil Emergency Message (CEM) is the best vehicle for correction
0830	• FEMA confirms HI-EMA's view on CEM; Hawaii Governor posts correction on Facebook.
0831	• HI-EMA supervisor logs into alert system, begins to create false alert correction
0845	• HI-EMA issues correction through EAS and WEA that there is no missile threat

Prior to the incident, little was communicated regarding the operations conducted within HI-EMA, nor was there adequate insight into the relationship the agency shared with the Federal Emergency Management Agency (FEMA). Following the events of January 13, the HI-DOD conducted a brief preliminary investigation into the incident and released the following findings:

- HI-EMA did not maintain comprehensive training records.
- Despite replacing the software program in December, 2017, HI-EMA did not provide technical training for SWP employees. Employees felt basic training provided was inadequate.
- The BMA Checklist was characterized as vague, allowing workers to interpret the steps they should follow differently.
- On January 13, 2018, HI-EMA conducted the drill at change of shift, creating confusion regarding who was in charge and which shift was responsible for carrying out the checklist.

- HI-EMA policy did not require a second person to sign off on alerts before they were sent.
- HI-EMA lacked any preparation for how to correct a false warning, as it was not included within the checklist.
- HI-EMA Management had been aware for years that the employee who issued the BMA had difficulties performing his job.
- In the past, this same employee had mistakenly believed drills for tsunami and fire warnings were actual events.
- Colleagues had voiced concerns that they were not comfortable working with the employee.
- HI-EMA Management supervisors counseled the employee, but he remained for a decade in a position that had to be renewed each year.
- HI-EMA was unaware of jurisdiction regarding alerts, specifically, that confirmation from FEMA was not necessary prior to HI-EMA issuing a second "All Clear" alert.

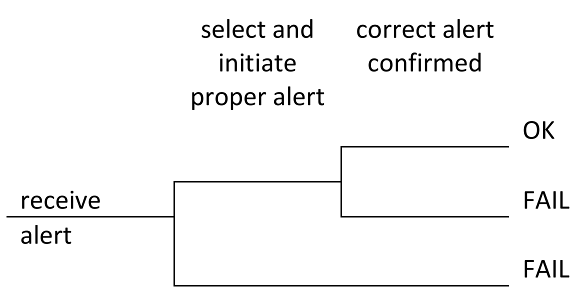
Note that these findings should be considered as preliminary, since additional investigations are ongoing. Initial media reports suggested that the event may have been the result of poor usability in the alerting system. The HI-DOD's internal report shifts the cause much more to individual culpability. Such findings, which strongly point to a single individual, should be validated by external sources to ensure the individual has not served as a scapegoat for more systemic problems in the organization and process.

4. HUMAN RELIABILITY ANALYSIS OF EVENT

Humans are imperfect, and human error is an inevitable occurrence. Of course, not every human error is consequential, but the potential for risk significant human errors must be considered. Human reliability analysis (HRA) provides a means for identifying human failure events (HFEs) and quantifying the probability of the events occurring as human error probabilities (HEPs). The retrospective HRA detailed in this paper considers the likelihood that such an event would have occurred or could occur again given similar context. The actual probability of the event is, of course, 100%, since it did occur, but that does not address the likelihood of future events.

We begin with the consideration of the major tasks or steps involved in this event. The simplified event tree in Figure 1 below illustrates the three essential steps for an alert to be issued. First the operator must receive the signal to initiate an alert. Second, the operator then initiates the event through software, and third the software queries the operator to confirm the issuance of the event and, if confirmed, the alert is sent.

Figure 1: Simplified Event Tree for Sending Drill Alert.



As designed and from a human factors perspective, this is a very straight-forward process. Essentially the operator needs to perceive the instruction/command that an alert signal should be sent, and then send the correct alert signal. The confirmation step is actually a recovery step where, if the alert initiation was made inadvertently, it could be stopped. However, as presented in the HI-DOD preliminary investigation, substantial evidence exists for less than adequate PSFs for the essential steps.

The next step in the process is to quantify the probability of each of the steps in the event tree. The HRA quantification method employed, the SPAR-H method [3], is an approach developed to support plant-specific probabilistic risk assessment (PRA) models for the U.S. Nuclear Regulatory Commission (NRC).

The SPAR-H method was originally used by the U.S. NRC as a tool to carry out post-event analysis. Dissecting the Hawaii event similarly affords the opportunity to create a model of the system from a failure perspective that can inform improvements to the process including models of recovery. It can also serve to inform as to where the weak links are in such human machine systems that can be corrected. In the next section we will illustrate quantification using SPAR-H. We will begin with a brief explanation of the SPAR-H method.

Table 2: Definitions of the SPAR-H PSFs (Summarized from [3])

- *Available Time*: the amount of time that an operator or a crew has to diagnose and act upon an abnormal event.
- *Stress and Stressors*: negative as well as positive motivating forces of human performance that impede the operator or crew from completing a task.
- *Experience and Training*: the experience and training of the operator(s) involved in the task and experience of the individual or crew.
- *Complexity*: the difficulty of the task to be performed in the given context.
- *Ergonomics (including the Human-Machine Interface):* the equipment, displays and controls, layout, quality and quantity of information available from instrumentation, and the interaction of the operator/crew with the equipment to carry out tasks.
- *Procedures*: the existence, use and quality of formal operating procedures for the tasks under consideration.
- *Fitness for Duty*: whether or not the individual performing the task is physically and mentally fit to perform the task at the time.
- *Work Processes*: aspects of doing work, including inter-organizational, safety culture, work planning, communication, and management support and policies.

5. HUMAN ERROR AND SPAR-H BASICS

A SPAR-H analysis is carried out in the following manner:

- A determination is made if the situation represents an “At Power” or “Low Power and Shutdown” event. This delineation is only applicable to nuclear power scenarios, and most non-nuclear activities, including the present analysis, would assume the equivalent of “At Power” activities and use the corresponding SPAR-H worksheet.
- A determination is made whether the activity is Diagnosis and/or Action, which provides nominal (i.e., default) HEPs. Diagnosis refers to cognitively engaging activities like checking monitors or making decisions. Action refers to those activities involving some form of physical activity like pushing a button. The nominal HEP for diagnosis is 0.01, and the nominal HEP for action is 0.001. When there is the influence of both Diagnosis and Action, the individual HEPs are summed.
- The influence of PSFs is determined and the appropriate level assigned. PSFs can have negative, neutral, and positive influences. A negative influence has a multiplier greater than 1,

which increases the HEP from the nominal value. A neutral influence has a multiplier equal to 1, which does not change the HEP. A positive influence has a multiplier less than 1, which decreases the HEP. SPAR-H considers eight PSFs, shown in Table 2. More complete definitions of each factor and levels may be found in [3]. The product of all eight PSFs is multiplied by the nominal HEP to produce the basic HEP.

- Where applicable, the basic HEP is corrected for dependency between successive HFEs. The dependency concept is that an initial error increases the likelihood of subsequent errors. Where dependency exists, it is treated as a mathematical anchor to increase the HEP for successive errors.

6. SPAR-H ANALYSIS OF EVENTS

Crucial to this analysis is the assessment of the PSFs for each of the events and tasks. Table 3 displays the information provided by HI-EMA as it aligns with the eight PSFs of SPAR-H. This information was then used to determine the level of each PSF for each the three tasks in the event tree.

Next, quantification was completed using the SPAR-H worksheet for each of the steps in the event tree. The "Alert initiation" and the "Alert confirmation" steps are each composed of both SPAR-H task types—a diagnosis/decision component and an action component—so each of those steps requires two SPAR-H worksheets. The "Alert signal received" step only has the action worksheet. The completed worksheets are not included in this paper due to space constraints, but Table 4 below shows the assigned PSF multiplier values by action and final failure probabilities. Note that a multiplier of 1 suggests that there is no documented effect for that PSF.

Of particular interest in Table 4 are the PSFs and weights for experience/training, procedures, and ergonomics/human-machine interface (HMI). The information provided by the HI-DOD investigation clearly presented a picture where the training was poor, the particular operator involved had a history of error, there were poor procedures, and the HMI actually presented conflicting information regarding whether it was a drill or not, not to mention the poorly designed interface itself. Essentially it is a worst case scenario.

Obviously if we were not modeling this specific event and operator the overall failure rate would be lower, as we would not have specific knowledge about the operator's poor performance record; however, we would have the information regarding the lack of clear procedures, no signoffs for checks and balances, and a poorly designed interface that could lead to inadvertent error. Of critical importance here is the fact that the operator did receive some conflicting information, ostensibly did not perceive that this was in-fact a drill, and there was an insufficient recovery mechanism. The recovery mechanism, as designed, did present the opportunity for the operator to cancel the alert, but there were no second eyes or supervisory involvement to ensure a reconsideration of the decision. Somewhat unique to this incident is the world political environment with the high tension at the time between North Korea and the U.S. that may have increased the stress level as well as contributing to the believability that an actual attack was occurring. Also recent changes in the operations regarding the interface with no substantive training impacted the usability of the HMI.

7. CONSIDERATION OF TEAM FACTORS

The majority of widely used HRA methods including SPAR-H model human errors carried out by individuals or crews acting as a single entity, rather than within the context of those working in teams. Additionally, HRA models focus mainly on PSFs that affect the individual's cognition (stress, procedures, etc.) with little work centered on teamwork (leadership, perceptions and actions of other team members, etc.), team challenges and how these affect the quantification of HEPs. The Hawaii incident is a good example of how lack of mutual awareness, defined as "knowledge of what other team members are doing, how they are doing it, as well as how and when they can affect each other's activities" [4] can create opportunities for team errors.

Table 3: PSFs Aligned with Reported HI-DOD Issues

PSFs	HI-DOD Issues
Stress or stressors	● Stress and anxiety created by recent North Korea nuclear attack concerns. ● Drills were a recently added training exercise. ● Drills were administered spontaneously.
Experience and training	● Employee was a 10-year veteran of the agency and a supervisor. ● Standard practice test conducted during each shift change three times a day were not yet routine enough to be predictable, but they were not entirely new. ● Employees had not been trained on the new FEMA software currently being used. ● No records maintained for employee training and to what degree.
Ergonomics or HMI	● Interfaces had not been updated. ● File names were very similar with little distinction between the test missile alert and the genuine missile alert.
Procedures	● The recording does not follow the script contained in HI-EMA's standard operating procedure for this drill. ● Recorded message was incorrectly interpreted as part of an unscheduled drill. ● "The day-shift manager was not prepared to supervise the morning test," the FCC said. ● Following standard procedures, the night-shift supervisor posing as Pacific Command played a recorded message to the emergency workers warning them of the fake threat. The message included the phrase "Exercise, exercise, exercise." But the message inaccurately included the phrase "This is not a drill."
Fitness for duty	● Reports stated that Hawaii emergency management officials knew for years that the employee had problems performing his job. ● In the past, the employee in question had mistakenly believed drills for tsunami and fire warnings were actual events. ● Colleagues reported not feeling comfortable working with the individual. ● Supervisors had counselled the employee repeatedly, yet retained him for a decade in a position that had to be renewed each year. ● During the drill, the employee reported that he did not hear the word "exercise" repeated six times. All of the fellow officers participating in the drill confirmed that they had clearly heard the word "exercise" during the drill.
Work processes	● FEMA and HI-EMA did not have clear policies for issuing alerts. HI-EMA waited for permission to issue a second alert stating that the first alert was a false alarm. According to FEMA, this was not a requirement. ● The agency had a vague checklist for missile alerts, allowing workers to interpret the steps they should follow differently. ● HI-EMA Managers didn't require a second person to sign off on alerts before they were sent. ● The agency lacked any preparation on how to correct a false warning. ● New computer software programs had been added to the agency's computers but no training had been conducted to teach officers how to apply it.

Table 4: PSF Values per Action and Final Failure Probabilities

PSF	PSF Multiplier by Step and Task Type					Supporting information
	Receive Drill Alert Signal Action	**Select & Initiate Proper Alert Diagnosis**	**Select & Initiate Proper Alert Action**	**Correct Alert Confirmed/ Disconfirmed Diagnosis**	**Correct Alert Confirmed/ Disconfirmed Action**	
Available time	1	1	1	1	1	Time assessed to be nominal—enough to execute task
Stress/ Stressors	2	2	2	2	2	Stress was assessed as high—due to level of perceived threat and error consequence
Complexity	1	1	1	1	1	Complexity was assessed as nominal—task is straight-forward
Experience/ Training	3	10	3	10	3	Low—no comprehensive record of training, prior similar errors, no training on software
Procedures	5	20	5	20	5	Incomplete—checklist was characterized as vague, no sign-offs
Ergonomics/ HMI	10	50	10	50	10	Poor—poorly designed system and no training for alert signal, and actions for alert initiation and confirmation—for diagnosis, information providing was conflicting, making it misleading
Fitness for Duty	1	1	1	1	1	Nominal—insufficient information to judge operator condition
Work Processes	5	2	5	2	5	Poor—job performance issues not dealt with, no shift turnover protocol`
Failure Probabilities	**.43**	**.99**	**.43**	**.99**	**.43**	

Team and teamwork/communication errors are distinct from individual human errors since they can be affected by mutual awareness, dependency of individuals on each other, as well as information transmitted within team members due to the complex and dynamic nature of the environment. The HI-DOD investigation described the employee who sent out a false alert as not showing initiative and mentioned that there were issues related to morale and poor performance evaluations for some of the employees including the officer who issued the false alert. Poor team dynamics can affect individual and team performance. During the Hawaii incident, the officer identified earlier incorrectly diagnosed the situation from the available information and arrived at a different conclusion than his crewmembers. As a result, he failed to resolve the differences and failed to communicate both his decision-making and his subsequent intentions, leading to error—the elicitation of the false alert. Lack of training and detailed procedures as well as a complex event also caused the crew to address the issue incorrectly.

The success or failure to perform the drill depended on the crew's diagnoses, actions and their ability to work as a team. This is important for efficient and effective utilization of their experience and training to address the issue and mitigate the team errors that could contribute to the risk. HRA methods are not able to account for team performance in the modeling and quantification of the HEPs, which affects the validity and accuracy of the estimations.

The Hawaii incident provides an opportunity to examine human error from a team rather than an individual perspective. Further information examining the impact mutual awareness has on team operations is forthcoming.

8. CONCLUSION

The events which occurred in Hawaii in January, 2018, provide another clear example of how failures occur in complex technological systems. This paper provides a unique perspective and analysis of the events contributing to the BMA false alarm. As demonstrated within this paper, the SPAR-H method has far reaching applications beyond its initial nuclear power plant origins. Information obtained within the HI-DOD report was aligned with the eight PSFs of SPAR-H. Relying upon the SPAR-H capabilities for identifying and quantifying failure probabilities, SPAR-H catalogued the key contributing factors to the incident and weighted the event as high likelihood given the context.

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