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# Combat Situation Awareness (CSA) Model-Based Characterizations of Marine Corps Training and Operations

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# EXECUTIVE SUMMARY

A model for characterizing situation awareness (SA) was tested by applying its elements to performance data gathered on Marine Corps Infantrymen from both training and operational deployment. The objective was to determine whether model-based factors of SA could be discerned strictly from operational settings, as contrasted with controlled laboratory conditions. The method involved the collection of "critical incident" reports of serious military failures, gathered from training and operations, which could be attributed to decision-making breakdowns. Reports were examined for instances of model-relevant features and results were analyzed as frequency plots. Such an empirical approach to performance analysis has the benefits of strong contextual validity (data gathered amid free-running mission activities) and clearly documented military consequences. Initial results showed interpretable differences in the type of SA breakdowns that could account for these incidents, categorized by level of leadership, mission, setting (i.e., training or operations), and other contributing factors.

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# BACKGROUND

Understanding and responding appropriately to chaotic events, and anticipating their consequences in real time, are essential skills to military success and survival. These skills require situation awareness (SA): the capability of the warfighter to apply the proper action at the proper time for both tactical and strategic advantage. Situation awareness is an active topic of analysis for military operations support. The assumption is that superior SA will increase the probability (although not the certainty) of victory through improved assessment of, and response to, combat events.

Although SA has been examined from a variety of perspectives (e.g., Dominguez, 1994; Fracker, 1998), the practical foundation of SA as a research construct is largely credited to the original work of Mica Endsley, who provided both a formal model and a set of analytical methods (e.g., Endsley, 1987, 1990, 1995) relevant to evaluating warfighting performance.

The value of good SA to warfighter viability is hard to question. As stated by Endsley and others, situation awareness is "knowing what is going on around you," a description familiar to anyone in the military. The Endsley model (e.g., Endsley, 1993) proposes three levels of SA: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." These characteristics are more formally labeled as Level 1 (Perception), Level 2 (Comprehension), and Level 3 (Projection), respectively (Endsley, 2000). These model elements can characterize both experience (e.g., from simply perceiving basic stimuli by the new soldier to the rapid and complex field assessments of the combat veteran) and native ability. .

Good SA cannot guarantee good decision performance, of course. Errors can occur because of procedural constraints (such as tactics or rules of engagement) or poor execution of an appropriate response. Furthermore, SA is influenced by the time that an individual has to process information and the fact that most military situations are dynamic, which means that SA must continually adapt. Nevertheless, although poor SA does not preclude good outcomes (e.g., the luck encountered in the "fog of war"), it is reasonable to believe that good SA improves the likelihood of good operational decision making (Adams, Tenney, and Pew, 1995; Smith and Hancock, 1994).

## SITUATION AWARENESS RESEARCH APPROACH

Most early SA studies involved aviation tasks (Endsley, 1987, 1993; Fracker, 1988; Hartman and Secrist, 1991; Sarter and Woods, 1991; Taylor, 1990), although examination of ground warfighter performance, and development of measurement methods to address it, has also been conducted by the Army (e.g., Endsley, et al., 1999; Matthews and Beal, 2002). Such studies have focused on SA for medium and large-size (e.g., platoon, company, brigade) forces and on officer level leadership (e.g., Strater, et al., 2001; Strater, Jones, and Endsley, 2001; Matthews, et al.Strater, and Endsley, 2004; Warner, et al.Finklaire, and Pacey, 2001). While this work has generated important insights into SA measurement and understanding, certain limitations of the research model and its focus need to be highlighted to place current knowledge into context:

- Tasks related to platoon-level operations (and above) typically involve the aggressive use of information technologies for intelligence gathering, communication, etc. and—because these technologies are the fundamental tools for developing combat situation awareness (CSA)—the content of such technologies have dominated SA investigations (e.g., Bolstad and Endsley, 2000; Farrell, Jameson, and Stoneking, 2003; Jameson, 2001).
- Most SA research involving ground forces has relied on simulations or other structured exercises for experimental control of conditions and manipulations (e.g., Matthews, et al., 2000; Strater, et al., 2001).

- The primary SA data collection method, and most of its variants, requires some form of intrusion into the test environment. Typically, SA experiment design involves interruption of the mission under study (e.g., "freezing" a simulation) and administration of a set of questions regarding participants' knowledge of tactical conditions. Interruptions are made at multiple random points during an experiment session in order to generate the performance data set (e.g., Endsley, et al.., 1999; Matthews, et al.., 2000). The validity and scientific impact of results obtained in this way may be limited, as such "clean" conditions are never obtainable in the field, and the temporal dynamic of operational missions is fundamentally different from simulations marked by periodic interruptions.

## MILITARY APPLICATION OF SA RESEARCH

SA research has proven valuable to the military command levels to which it has been applied. SA is important both strategically and tactically, however, and studies of SA at the individual—especially junior officer and enlisted—level are no less critical, especially since the brunt of current military operations involve small units and small unit leaders. This form of combat relies more on raw sensory experience as input, with less use of technology and information systems. It is characterized by shorter response times, more immediate feedback, and more rapid fluctuations in relevant conditions.

The work reported here was motivated by the lack of significant SA analyses in the literature regarding Marine Corps units at a time when Marine operations are both protracted and intense. The decision-making performance of the patrolling Marine is highly dependent on SA (e.g., USMC, 2005**)**, so SA research focused on this population and its missions could improve combat effectiveness and save lives. Furthermore, the Marine Corps continues to evaluate a doctrine of "distributed operations" (Goulding, 2005) that will place more decision-making responsibility on lower enlisted ranks—individuals with the least technology support and the most unpredictable operating environments. The current work therefore focused on small unit missions and junior leaders for reasons of relevance to both current and projected Marine Corps operations.

## MOTIVATION FOR THE CURRENT STUDY

Discussions with U.S. Army researchers and testing agencies revealed anecdotal reports about the limited utility of current SA measurement methods (i.e., structured environments and scenario interruptions) when applied to deployed operations or field training. Such reports tend to call into question the applicability of current SA experiment designs to practical operations. It is reasonable, however, to expect that a model of human performance—that is, one useful for both explaining observed phenomena and predicting future phenomena—should find instantiation in real-world environments. A key requirement of the current study, therefore, was to examine only continuous, "free play" mission activities that had observable, negative outcomes, to ensure military relevance. In other words, this study focused on SA problems that occur during actual mission performance, rather than on problems more typically generated through structured scenario control in research settings.

An alternate method to scenario interruption for performance measurement can be found through critical incident reporting (e.g., Klein, et al.Calderwood, and Macgregor, 1989) used in the Aviation Safety Reporting System (NASA; 2006). The Aviation Safety Reporting System (ASRS) is a data collection tool and database that utilizes anonymous pilot self-reporting of flight incidents (e.g., hazards that did not result in overt mishaps) to help identify problematic characteristics of the aviation environment. Analysis of the ASRS database is used to guide structured research of specific issues, to change aviation policy, and to refine pilot training. This study utilizes a similar incident reporting technique in support of Marine decision-making research. A useful feature of this performance measurement approach is that it can be applied to both training and operational activities without modification. An incident reporting technique is used to extract SA data from operational events, and to evaluate the potential of such an approach as an SA investigation tool to supplement the results of more structured research. The three goals of the study reported here were to:

- Characterize and quantify the SA performance of small unit leaders for current combat missions (i.e., CSA) conducted by the Marine Corps
- Utilize an incident report approach, developed for this purpose, to CSA performance measurement
- Compare SA error profiles from both training and operational deployment settings

## MARINE CORPS MISSION TRAINING

The Marine Corps conducts mission-specific weapons and tactics training for all units prior to operational deployment. Data collection for this study was initiated in 2005 during Stability and Security Operations (SASO) training conducted at March Air Reserve Base, and continued as this training was transitioned to the Marine Air Ground Combat Center (MAGCC), Twentynine Palms, CA, in 2007, as part of the Mojave Viper training syllabus.

SASO included missions and tactics required of small units operating among civilian populations (specifically, Operation Iraqi Freedom). The Marine Corps scheduled SASO training for battalions just prior to their operational deployment. The syllabus focused on small units, operating on the move in ill-defined or rapidly changing circumstances, and typically far from other assistance. The environment was designed to be representative of operating conditions in Iraq.

A major benefit of data collected from SASO and, later, Mojave Viper, was that training activities were divided into mission-specific events that aided focused performance measurement. The high instructor-to-student ratio also offered a wealth of operationally experienced observers and subject matter experts (SMEs) to provide performance assessment. SASO training missions consisted of:

- Patrol (on foot)
- Mounted Patrol (which included mechanized patrol)
- Cordon and Knock – an organized effort to surround and secure a building, and then to control, search, or question the building occupants
- Urban Assault – securing and occupying a building or area by force, when occupied by hostile forces. This is the only mission with an a priori offensive orientation, i.e., the intent is one of engaging and prevailing over a hostile threat
- Checkpoint Operations – intended to set up vehicle "stop and inspect" security stations
- Convoy – multi-vehicle movement of personnel and materiel, often through uncontrolled or hostile areas
- Firm Base – events occurring for the defense and operation of a fixed secure area, from which patrols and other missions are then deployed
- FEX – a final exercise involving a full range of missions and problems lasting over 72 continuous hours

To establish a common basis for evaluation, all component training missions used for this study (including operational reports provided from Iraq) were mapped to the original SASO syllabus structure.

# METHOD

The study relied primarily on instructor evaluations of SA performance, gathered as part of their normal training observation duties. Instructors were used as the data collection source because they best understood what constituted militarily meaningful decision-making “errors.” Equally important, they understood what mistakes were not important. The instructor cadre therefore provided an effective, operationally relevant filter for performance measurement, superior in relevance and validity to the judgment of untrained researchers. The data set was supplemented by reports solicited from Marines on deployment in Iraq, under sponsorship of the Marine Corps Training and Education Command (TECOM).

## DATA SOURCES

A CSA incident report form was developed specifically for the research study, to be completed whenever an instructor observed a decision-making problem of significance to mission performance or safety, and was designed to be short enough for on-the-spot completion. The incident report (Appendix A) provided space for the observer to enter a brief narrative description of the event, as well as to specify characterizing data such as leadership level or mission, and contributing factors such as fatigue, training, or equipment condition. Experience with the incident report form led to a parallel effort to distribute the form to units deployed to Iraq. Introduction letters and completion instructions were included with each form, which could be returned voluntarily and anonymously by prepaid mail.

The Marine training staffs also utilized an evaluation form of their own. These forms were completed as part of their instructor duties and addressed critical factors of planning, preparation, and execution for each mission, with space for additional instructor comments as needed. To supplement the final data set, these forms were reviewed and scored with the same protocol used for evaluation of the incident report forms.

## PROCEDURE

Command leadership was first briefed regarding the purpose of the experiment and the desired data collection procedures. After official endorsement was obtained for the study, the staff was briefed on the specific data collection method. The incident report form was explained in detail, including the importance of anonymity for the people under observation. Instructors with operational experience were also encouraged to complete incident reports, as time permitted, pertaining to recollections of SA performance errors or other decision-making problems observed during their own deployments. After all questions were answered, a supply of incident report forms was left with the command, and the training staff went on to conduct their normal duties.

At the conclusion of each unit training cycle (approximately every 2 weeks), the experimenters returned to collect the incident report forms, including duplicates of available instructor training evaluation forms. Reports that contained irrelevant or uninterpretable events were first discarded. Remaining forms were then checked to remove any personally identifiable information, and collated to remove any redundant reports (i.e., multiple sources reporting on the same incident). Forms returned from Iraq were scored as received, until the end of the data collection period. Finally, all data were entered into an Excel spreadsheet for analysis.

Each incident was then classified according to the consensus judgment of the research team as primarily representing SA Level 1, 2, or 3 characteristics, using the Endsley model. Although many reports contained elements that could legitimately reflect more than one SA category, only a single classification was assigned to each incident for this initial analysis. In addition, data from special response fields were extracted from each report, as follows:

- Source – Training or operational Deployment
- Mission, using the SASO model, above
- Leadership Level – the individual most responsible (or involved) in the incident, including Fire Team Leader, Squad Leader, Platoon Leader, and Company Commander
- Contributing Factors – conditions or items that were involved in the incident, which were further parsed into
    - Standing Conditions, involving characteristics that were fixed or that did not change significantly during operations, such as experience, pre-existing training or skill levels, equipment, and communications support
    - Acute Conditions, involving characteristics that could fluctuate during operations, such as daily fatigue or sleep, stress or overload, and level of inattention or complacency

## PERSONNEL

Reports were gathered from units completing SASO training, Mojave Viper training, or on deployment in Iraq between May 2005 and September 2008.

## ANALYSIS

This study was conducted to explore the potential of applying a theoretical model of situation awareness to a collection of operational events. Data were presented in terms of bar charts and frequency tables to reveal SA patterns across the two primary factors of interest—Leadership Level and Mission. Analyses for this initial study were primarily descriptive.

Inferential statistical analysis was not applied to the data set because of the disparity in numbers of reports from Training and Deployed sources and the small sample sizes that resulted from even basic partitioning of the data set. Analytical approaches for future data collection efforts are presented in the Discussion.

# RESULTS

A total of 79 reports were obtained from the training environment and 22 reports were obtained from operational deployments to Iraq at the conclusion of the data collection period, yielding a total of 101 distinct incidents.

## GENERAL

Figure 1 shows the breakdown of reports according to the Endsley model, sorted by Source. All three data sets—Training, Deployed, and Combined—show the same step-wise structure, i.e., Level 1 errors > Level 2 errors > Level 3 errors. Based on these results, the majority of incidents were attributable to a failure to perceive important features of the environment or situation.

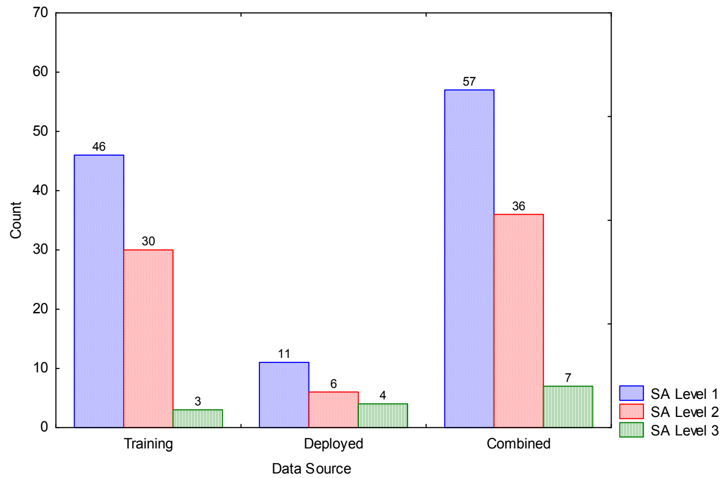



Figure 1. Data Source x SA Level.

Table 1 shows the breakdown of reports by Mission. Most reports came from Urban Assault, Patrol, and Checkpoint Operations. It is possible, but not conclusive, that relative numbers of incident reports reflect characteristics of the missions themselves (such as exposure to hazards for a protracted period, activities performed while dismounted, etc.) and therefore provide an ordinal predictor of mission complexity.

Table 1. Data Source x Mission.

| Mission | Source | | |
|---|---|---|---|
| | Training | Deployed | Combined |
| Patrol | 22 5 | | 27 |
| Mounted Patrol | 8 2 | | 10 |
| Cordon / Knock | 13 0 | | 13 |
| Urban Assault | 19 9 | | 28 |
| Checkpoint | 14 4 | | 18 |
| Convoy | 0 1 | | 1 |
| Unknown | 0 1 | | 1 |
| FEX | 2 0 | | 2 |
| Firm Base | 1 0 | | 1 |

The same three missions—Urban Assault, Patrol, and Checkpoint Operations—dominated the data set when expressed as proportions (Figure 2), with Urban Assault (planned and executed as an offensive operation) accounting for the most Deployed incidents.

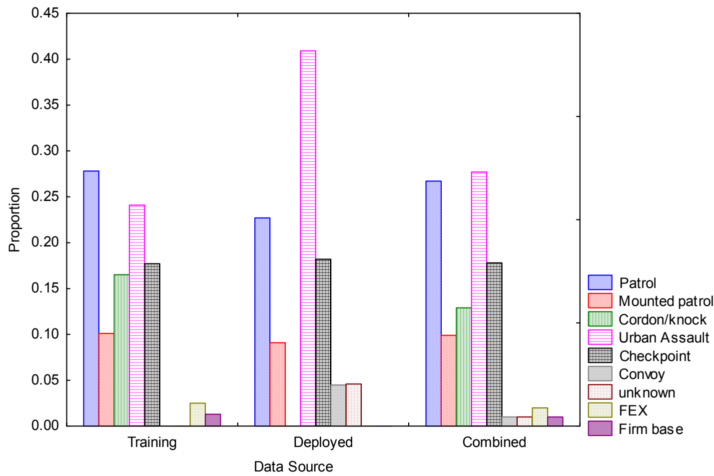



Figure 2. Data Source x Mission.

In the results that follow, combined sources are presented first, followed by results from Training and results from Deployment settings. The analysis of Contributing Factors is presented last. In addition, each analysis is shown from two complementary perspectives to reflect the potential understanding to be gained from this approach to performance modeling:

- The pattern of SA error frequencies across a factor (e.g., the relative proportion of SA Level 1, 2, and 3 errors for Leadership Level), and
- The pattern of SA error frequencies within each level of the factor (e.g., the relative proportion of SA Level1, 2, and 3errors for the Fire Team Leader, for the Squad Leader, for the Platoon Leader, and for the Company Commander).

Because small sample sizes in many categories yielded dramatic differences in raw data counts, subsequent analyses are presented in terms of <u>relative proportions</u> within each category (i.e., the approach of Figure 2), which appeared to provide more stable and interpretable results.

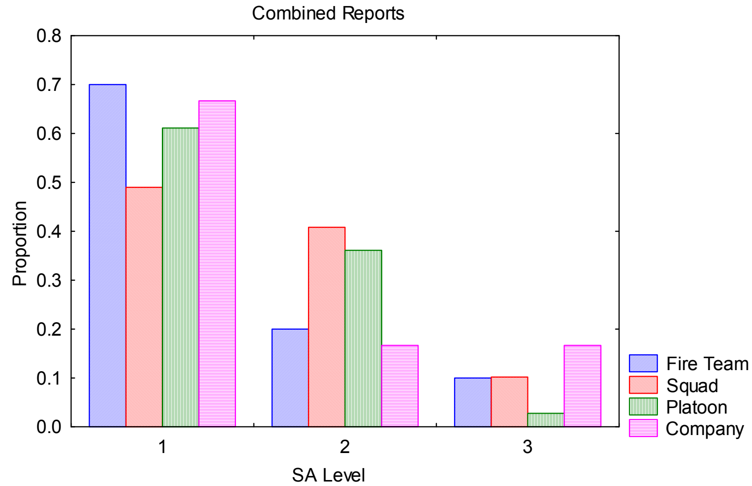
## PART I – LEADERSHIP LEVEL

Distributed operations (DO) doctrine places more reliability on junior leaders to execute decision-making tasks formerly conducted by more senior leaders. It was useful, therefore, to investigate SA incidents at different levels of leadership in order to characterize current performance levels and the direction that future DO training may need to take.

### Combined Results

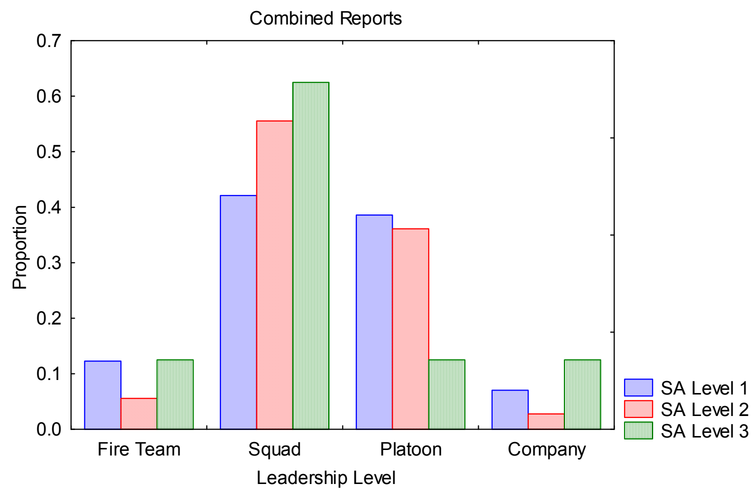
As shown in Figure 3a, the highest proportion of errors occurred at SA Level 1 (Perception), in keeping with earlier data depictions. The data transposition of Figure 4 shows that the highest error rates were observed among Squad and Platoon Leaders at all three SA levels. This may reflect the relative responsibilities of these leadership levels or may indicate that Fire Team Leaders do not have the decision-making duties that would lead to the type of incidents that triggered the reports of this data set. The result for Company Commander is more difficult to interpret; it is possible that this leadership role has sufficient time for decision making, or access to information support resources, that resulted in relatively few reported errors.

Figure 3b shows an interesting pattern of SA errors for the Squad Leader, with most errors occurring at Level 3 (Projection). This is contrasted with the pattern of Figure 1, which showed a generally decreasing frequency of errors with higher SA levels, and may be indicative of the challenges faced by this junior, yet pivotal leadership position.




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fire Team** | 7 2 | | 1 | 10 |
| **Squad** | 24 | 20 | 5 | 49 |
| **Platoon** | 22 13 | | 1 | 36 |
| **Company** | 4 1 | | 1 | 6 |

(a) Leadership Level x SA Errors – Combined




| | Fire Team | Squad | Platoon | Company | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 7 24 | | 22 | 4 | 57 |
| **SA Level 2** | 2 20 | | 13 | 1 | 36 |
| **SA Level 3** | 1 5 | | 1 | 1 | 8 |

(b) Leadership Level x SA Errors – Combined

Figure 3. SA Errors: Different Levels of Leadership – Combined.

### Training Results

The pattern of SA errors observed from Training (Figure 4a), and their breakdown by Leadership Level, essentially matches those of the Combined reports presented in Figure 1—the vast majority of reported errors occurred at SA Level 1. The predominance of perception errors (i.e., detecting elements of the environment) is possibly due to the fact that Training reports made up the majority of the data set and Marines are still mastering tactical skills at this stage of their development.

Figure 4b also shows the same reversed pattern for squad leader performance found earlier, again probably due to the major contribution of Training reports to the data set.


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fire Team** | 4 0 | | 0 | 4 |
| **Squad** | 22 | 17 | 2 | 41 |
| **Platoon** | 16 12 | | 1 | 29 |
| **Company** | 4 1 | | 0 | 5 |

(a) Leadership Level x SA Errors – Training


| | Fire Team | Squad | Platoon | Company | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 4 22 | | 16 | 4 | 46 |
| **SA Level 2** | 0 | 17 | 12 | 1 | 30 |
| **SA Level 3** | 0 2 | | 1 | 0 | 3 |

(b) SA Errors X Leadership level – Training

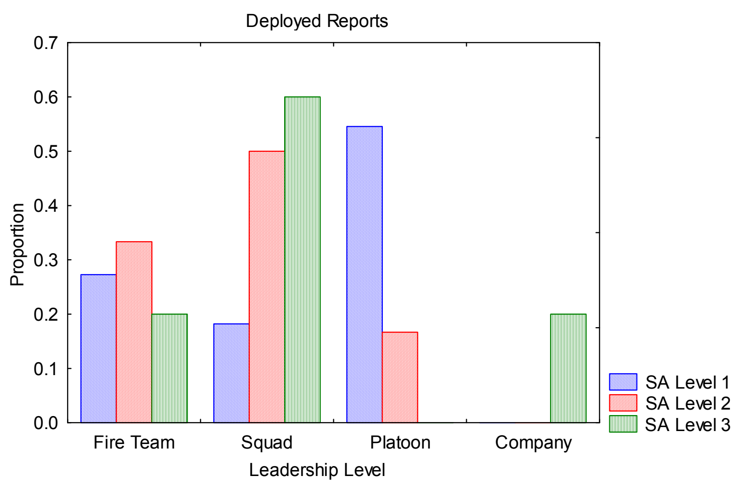
Figure 4. SA Errors: Different Levels of Leadership – Training.

## Deployment Results

Differences in error patterns between Deployment and Training data (Figures 4 and 5) may be due to the disparity in numbers of reports received from these sources. Deployment data were relatively sparse and, therefore, frequency counts were probably less stable. Figure 5b, however, also shows the reversed pattern of SA errors for the Squad Leader role.


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fire Team** | 3 2 | | 1 | 6 |
| **Squad** | 2 | 3 | 3 | 8 |
| **Platoon** | 6 1 | | 0 | 7 |
| **Company** | 0 0 | | 1 | 1 |

(a) Leadership Level x SA Errors – Deployed




| | Fire Team | Squad | Platoon | Company | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 3 2 | | 6 | 0 | 11 |
| **SA Level 2** | 2 | 3 | 1 | 0 | 6 |
| **SA Level 3** | 1 3 | | 0 | 1 | 5 |

(b) SA Errors x Leadership level – Deployed

Figure 5. SA Errors: Different Levels of Leadership – Deployed.

In summary, results for analyses of Leadership Level indicate that:

- SA error frequencies follow an overall pattern, with more Level 1 than Level 2 errors, and more Level 2 than Level 3 errors. The predominance of this effect in the Training data may indicate that experience may account for much of this SA error category.
- Most incidents involved the Squad Leader, followed by the Platoon Leader, the Fire Team leader and Company Commander, respectively.
- The pattern of SA errors was reversed for the Squad Leader, compared with the data set as a whole, with more Level 3 (Projection) errors than Level 1 (Perception) errors, and may indicate special conditions of this position.

## PART II – MISSION

Each SASO mission reflects different degrees of complexity and hazard, depending on the amount of time spent in a hostile area, the number of people involved (i.e., military and civilian, friendly, and hostile), the availability of protective cover, and the clarity of task objectives. Data evaluation must therefore include such contextual factors.

Note that one report, obtained from a SASO instructor regarding a deployment experience, contained valuable and relevant data regarding SA performance. Unfortunately, the specific mission was not listed on the report. Rather than delete the incident, an "Unknown" category was included in the results, below, although little could be gleaned from the report.

### Combined Results

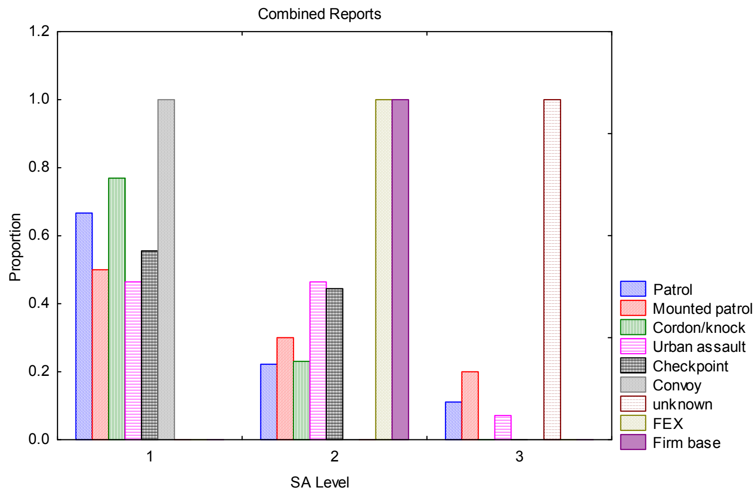
As noted earlier, the Urban Assault, Patrol, and Checkpoint missions accounted for most of the incident reports, and that these missions broke down across the three SA levels in a stepwise fashion. Figure 6a completes the picture of relative error frequencies for all mission types and all SA levels.

While the stepwise relationship in error frequency across Level 1, Level 2, and Level 3 is roughly maintained in this breakdown, it is apparent in both Figure 6a and 6b that some missions showed widely differing effects in this regard, likely due to the instability of very low frequency counts (e.g., Firm Base), which influenced the proportions shown in the bar graphs. Relationships across SA levels are easier to see in the accompanying table of each figure.

Note that Convoy, Firm Base, and FEX differed markedly from other missions in the number of incident reports collected. Certainly, the FEX mission is unique to Training, and low report numbers are explainable on that basis, while the Firm Base mission may be approached differently during deployment. Further analysis and/or data collection is necessary, however, to resolve whether the Convoy disparity is due to the characteristics of the mission (e.g., greater team cooperation, more structured event sequences, etc.), to its relative frequency of occurrence in training syllabi or deployed assignments, or to some other factor.

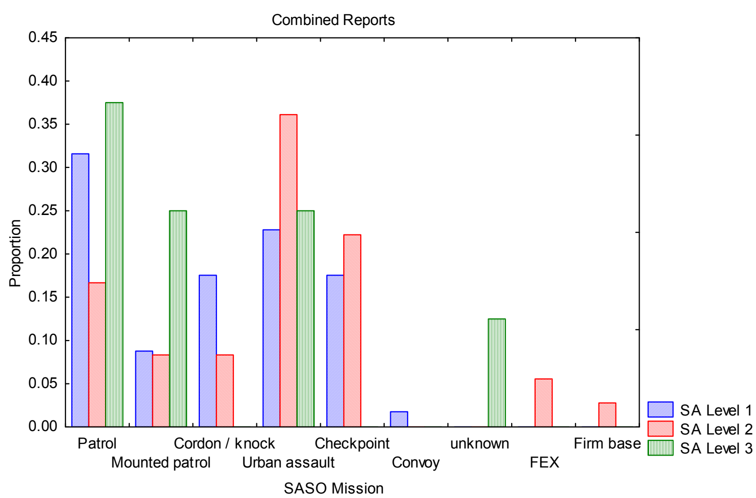
### Training Results

Although the relative pattern of SA errors (Level 1 > Level 2 > Level 3) can still be seen across missions where reports were provided (Figure 7a), these patterns vary dramatically by Mission (Figure 7b). No reports, or extremely small numbers of reports, were received for several missions (as discussed for Combined results, above), making interpretation problematic. Again, the breakdown of SA errors recorded from training events is easier to see in the frequency tables of Figure 7 than from the bar graphs.




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Patrol** | 18 6 | | 3 | 27 |
| **Mounted Patrol** | 5 3 | | 2 | 10 |
| **Cordon / Knock** | 10 3 | | 0 | 13 |
| **Urban Assault** | 13 13 | | 2 | 28 |
| **Checkpoint** | 10 8 | | 0 | 18 |
| **Convoy** | 1 0 | | 0 | 1 |
| **Unknown** | 0 0 | | 1 | 1 |
| **FEX** | 0 2 | | 0 | 2 |
| **Firm Base** | 0 1 | | 0 | 1 |

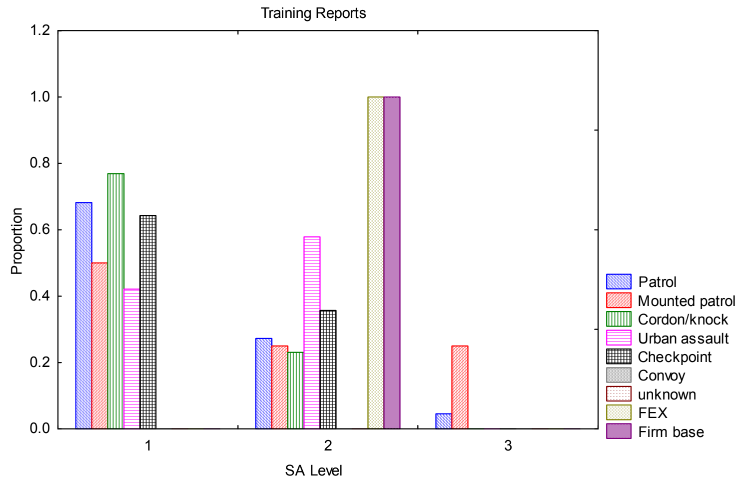
(a) Mission Type x SA Errors – Combined




| | Patrol | Mounted Patrol | Cordon / Knock | Urban Assault | Checkpoint | Convoy | Unknown | FEX | Firm Base | ∑ |
|---|---|---|---|---|---|---|---|---|---|---|
| **SA Level 1** | 18 | 5 10 | | 13 10 | | 1 | 0 | 0 | 0 | 57 |
| **SA Level 2** | 6 | 3 3 | | 13 8 | | 0 | 0 | 2 | 1 | 36 |
| **SA Level 3** | 3 2 | | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 8 |

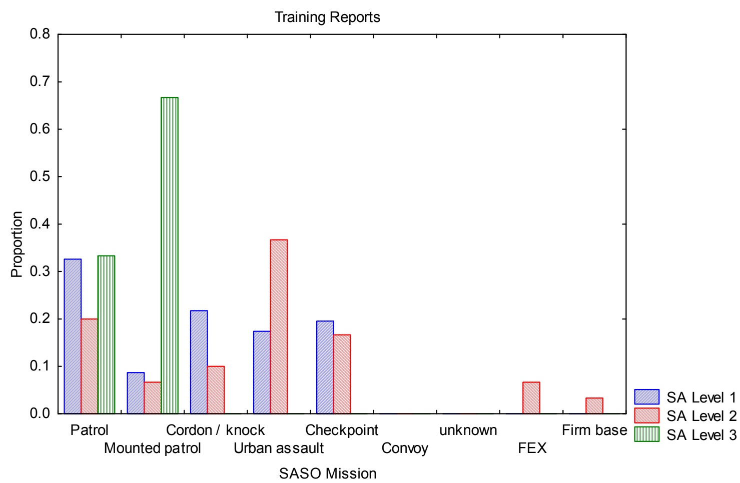
(b) SA Errors x Mission Type – Combined

Figure 6. SA Errors: Mission Type – Combined.




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Patrol** | 15 6 | | 1 | 22 |
| **Mounted Patrol** | 4 2 | | 2 | 8 |
| **Cordon / Knock** | 10 3 | | 0 | 13 |
| **Urban Assault** | 8 1 | 1 | 0 | 19 |
| **Checkpoint** | 9 5 | | 0 | 14 |
| **Convoy** | 0 0 | | 0 | 0 |
| **Unknown** | 0 0 | | 0 | 0 |
| **FEX** | 0 2 | | 0 | 2 |
| **Firm Base** | 0 1 | | 0 | 1 |

(a) Mission Type x SA Errors – Training



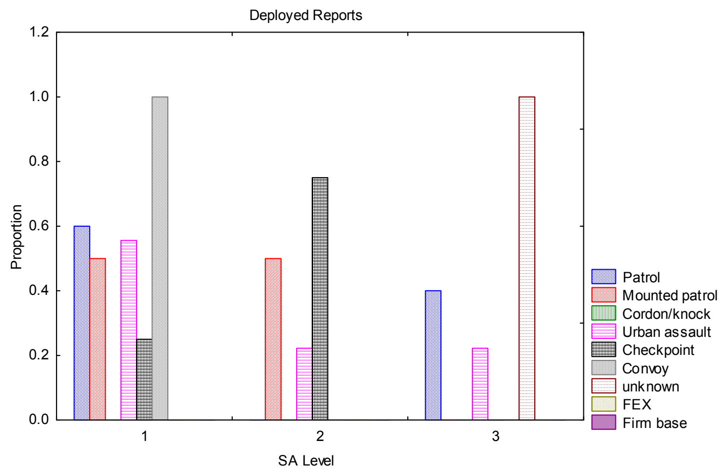

| | Patrol | Mounted Patrol | Cordon / Knock | Urban Assault | Checkpoint | Convoy | Unknown | FEX | Firm Base | ∑ |
|---|---|---|---|---|---|---|---|---|---|---|
| **SA Level 1** | 15 4 | | 10 | 8 | 9 | 0 | 0 | 0 | 0 | 46 |
| **SA Level 2** | 6 2 | | 3 | 11 | 5 | 0 | 0 | 2 | 1 | 30 |
| **SA Level 3** | 1 2 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |

(a) SA Errors x Mission Type – Training

Figure 7. SA Errors: Mission Type – Training.

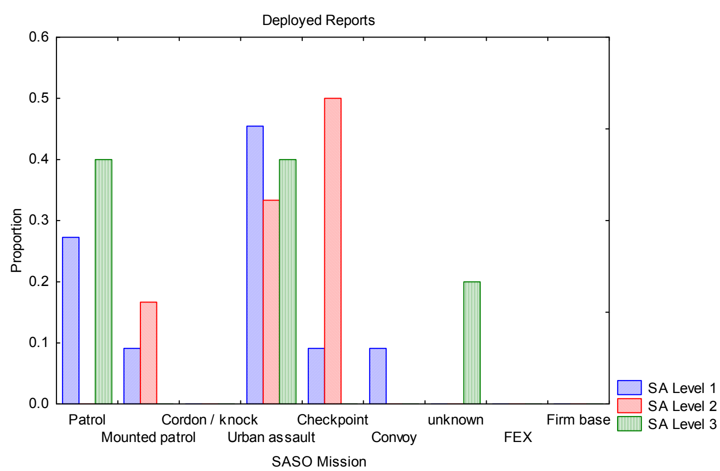
## Deployment Results

The low numbers of reports from deployment, shown In Figure 8, give caution to any interpretation. While the characteristic relationship across SA levels was again found for the mission with the highest report count (Urban Assault), other mission data were too sparse to support further conclusions.




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Patrol** | 3 0 | | 2 | 6 |
| **Mounted Patrol** | 1 1 | | 0 | 2 |
| **Cordon / Knock** | 0 0 | | 0 | 0 |
| **Urban Assault** | 5 2 | | 2 | 9 |
| **Checkpoint** | 1 3 | | 0 | 4 |
| **Convoy** | 1 0 | | 0 | 1 |
| **Unknown** | 0 0 | | 1 | 1 |
| **FEX** | 0 0 | | 0 | 0 |
| **Firm Base** | 0 0 | | 0 | 0 |

(a) Mission Type x SA Errors – Deployed




| | Patrol | Mounted Patrol | Cordon / Knock | Urban Assault | Checkpoint | Convoy | Unknown | FEX | Firm Base | ∑ |
|---|---|---|---|---|---|---|---|---|---|---|
| **SA Level 1** | 3 1 | | 0 | 5 | 1 | 1 | 0 | 0 | 0 | 11 |
| **SA Level 2** | 0 1 | | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 6 |
| **SA Level 3** | 2 0 | | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 5 |

(b) SA Errors x Mission Type – Deployed

Figure 8. SA Errors: Mission Type – Deployed.

In summary, examination of SA error distributions by Mission indicated that:

- The Urban Assault, Patrol, and Checkpoint Operations missions accounted for most of the SA errors. This may be due to the inherent characteristics of these mission, e.g., complexity, duration, or hazard, but the causal factors could not be resolved solely from these data.
- The parsing of such a limited data set into such a large number of missions meant that most Mission categories were represented by extremely low numbers of reports, or none at all. Clearly, a limit is reached for the number of groups that can be analyzed with the size of the current data set.

## PART III – CONTRIBUTING FACTORS

Because operational performance is a function of multiple factors, the incident report forms used for this study included response items for denoting some typical influences on military decision making. The objective was to amplify the narrative of an incident and to place it in a larger military context; characterizing the impact of contributing factors to SA can provide an enhanced foundation for directing improvement interventions. Two classes of conditions were addressed: Standing and Acute.

Standing conditions were defined as major elements of the Marine environment that were brought to a mission such as Equipment, Communications, and Training. Note that formal training was equated with skill level for this study, and were distinguished from Experience, which could be accumulated independently from Training. This distinction is important to evaluation of the results, and may require reconsideration in future data collection efforts.

Acute conditions fluctuate at shorter time scales and include such factors as Fatigue, lack of sleep, Stress, overload, Inattention, and complacency. Acute conditions are often under more individual or unit leader control. The design of the incident report form involved factor combinations, i.e., Fatigue / Sleep, Stress / Overload, and Inattention / Complacency, which may have sacrificed definitional precision for speed and convenience in completing the form, and which may also require reconsideration in future studies.

*Note that factor counts can exceed total incident report counts, as more than one factor could be listed for each incident.*

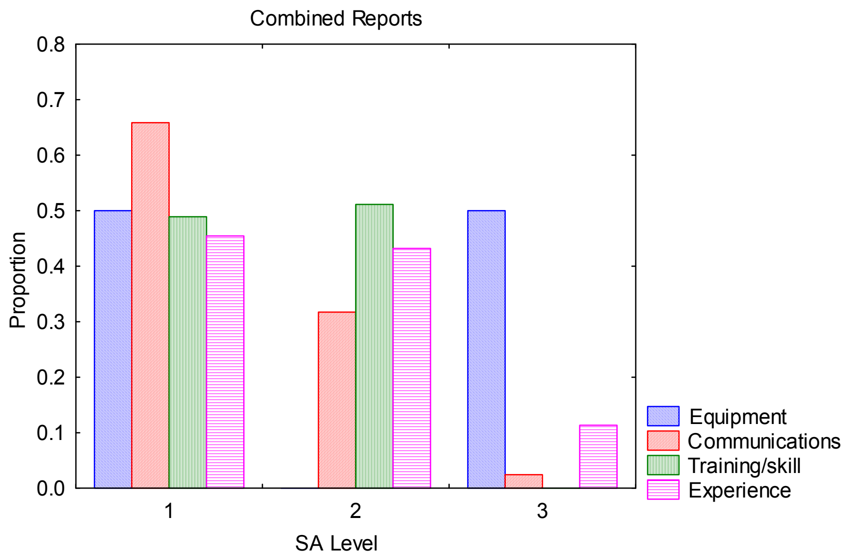
### Standing Conditions

#### *Combined Results*

As shown in Figure 9, all factors except Equipment showed stable (and roughly equivalent) patterns of SA errors. Equipment reports represented only 2% of all data, but most reports were collected from the training environment where equipment resources were either not taxed or equipment was not available (and could not, therefore, be a factor in SA incidents).

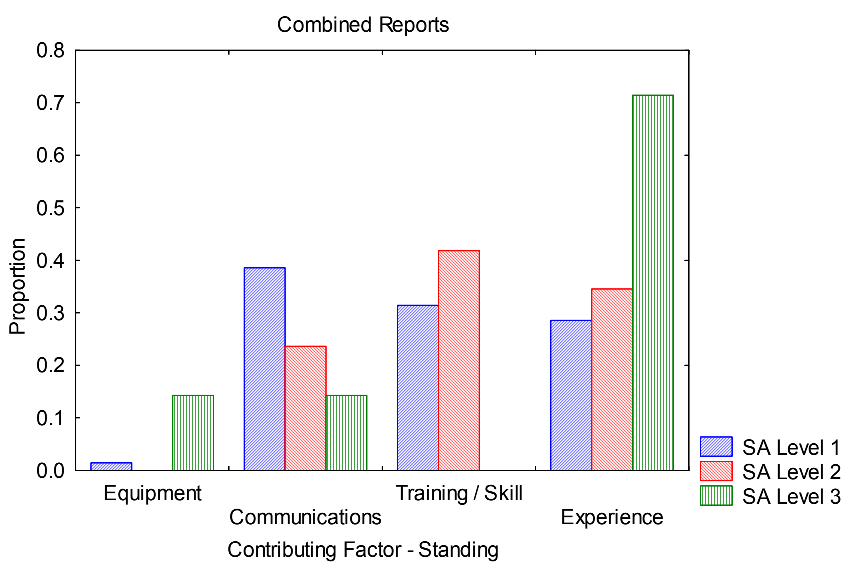
Virtually all Communications reports involved verbal interactions, i.e., close-range or face-to-face commands. Nevertheless, the role of such communications in supporting or impeding good SA illuminates similar issues with radio and other IT communications systems. Note the heavy involvement of Communications as a factor in SA Level 1 (Perception) errors. The consistent trend regarding the Level 1 – Level 2 – Level 3 relationship is maintained throughout this analysis, as well.

Experience showed the highest proportion of Level 3 (Projection) errors for all of the conditions, which may indicate a significant role for experience in making effective decisions or in establishing deeper levels of situation awareness.




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Equipment** | 1 0 | | 1 | 2 |
| **Communications** | 27 | 13 | 1 | 41 |
| **Training** | 22 23 | | 0 | 45 |
| **Experience** | 20 19 | | 5 | 44 |

(a) Standing Condition x SA Errors – Combined




| | Equipment | Communications | Training / Skill | Experience | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 1 27 | | 22 | 20 | 70 |
| **SA Level 2** | 0 13 | | 23 | 19 | 55 |
| **SA Level 3** | 1 1 | | 19 | 5 | 26 |

(b) SA Errors x Standing Condition – Combined

Figure 9. SA Errors: Standing Conditions – Combined.

### *Training Results*

Training data results (Figure 10) showed few differences from the Combined data results. Again, no equipment-related incidents were found during Training, which is most likely a function of the controlled nature of the syllabus (i.e., where resources were either prepared in advance of the training event or were not used at all).


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Equipment** | 0 0 | | 0 | 0 |
| **Communications** | 21 | 11 | 1 | 33 |
| **Training / Skill** | 19 2 | 0 | 0 | 39 |
| **Experience** | 17 1 | 6 | 2 | 35 |

(a) Standing Condition x SA Errors


| | Equipment | Communications | Training / Skill | Experience | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 0 21 | | 19 | 17 | 57 |
| **SA Level 2** | 0 11 | | 20 | 16 | 47 |
| **SA Level 3** | 0 1 | | 0 | 2 | 3 |

(b) SA Errors x Standing Condition – Training

Figure 10. SA Errors: Standing Conditions – Training.

Note that Communications contributed most strongly to SA Level 1 (Perception) errors, indicating the critical nature of basic information exchange to an awareness of the environment. In addition, Experience played a very small role in SA Level 3 (Projection) errors, which could indicate a ceiling effect of experience on performance under Training conditions (i.e., which may not require significant application of SA Level 3 (Projection) performance), or a relative paucity of experience among Marines at this stage of development (i.e., in which case it would not represent a significant basis for performance assessment).

### *Deployment Results*

The Deployment data shown in Figure 11 are consistent with the patterns found for Training data. Note the consistent role of Experience at each level of SA for this data source, with increased involvement of Level 3 SA. While it is tempting to attribute the importance of Experience to the demands of deployed operations, the sample numbers are too low to draw such firm conclusions.

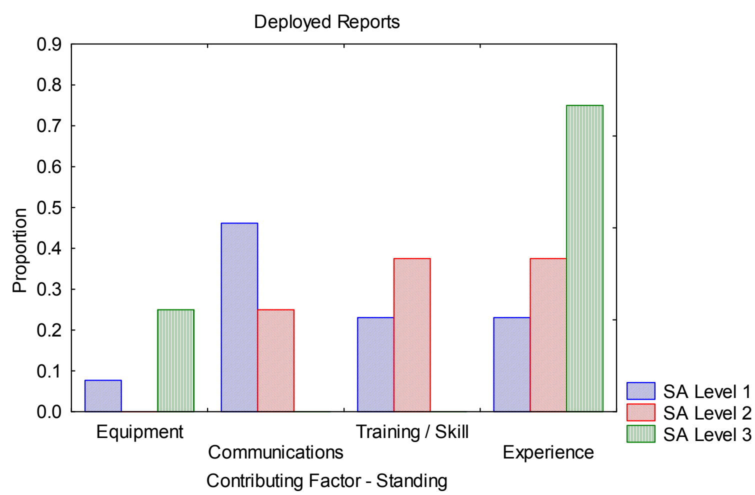
Figure 11 also shows the relative greater contribution of Standing Conditions to SA Level 1 (Perception) errors in the Deployed environment, when compared with Training results.

A review of Standing factors associated with the data set indicated that:

- Experience was a prominent factor in SA errors, especially in the reports gathered from the Deployed environment, with SA Level 3 errors accounting for a larger proportion of incidents compared to the Training environment. Although this result may show an interesting feature of an SA modeling approach to empirical data, respondents may have also interpreted “experience” in a broad way. This observation therefore remains tentative, pending further data collection.
- Standing Conditions contributed primarily to SA Level 1 errors; this proportion was greater in the Deployed setting than in the Training setting.
- Equipment factors played almost no role in SA performance in the Training setting, possibly due to controlled conditions unique to that environment.


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Equipment** | 1 0 | | 1 | 2 |
| **Communications** | 6 2 | | 0 | 8 |
| **Training / Skill** | 3 3 | | 0 | 6 |
| **Experience** | 3 3 | | 3 | 9 |

(a) Standing Condition x SA Errors – Deployed




| | Equipment | Communications | Training / Skill | Experience | ∑ |
|---|---|---|---|---|---|
| **SA Level 1** | 1 6 | | 3 | 3 | 13 |
| **SA Level 2** | 0 2 | | 3 | 3 | 7 |
| **SA Level 3** | 1 0 | | 0 | 3 | 4 |

(b) SA Errors x Standing Condition – Deployed

Figure 11. SA Errors: Standing Conditions – Deployed.

## Acute Conditions

### *Combined Results*

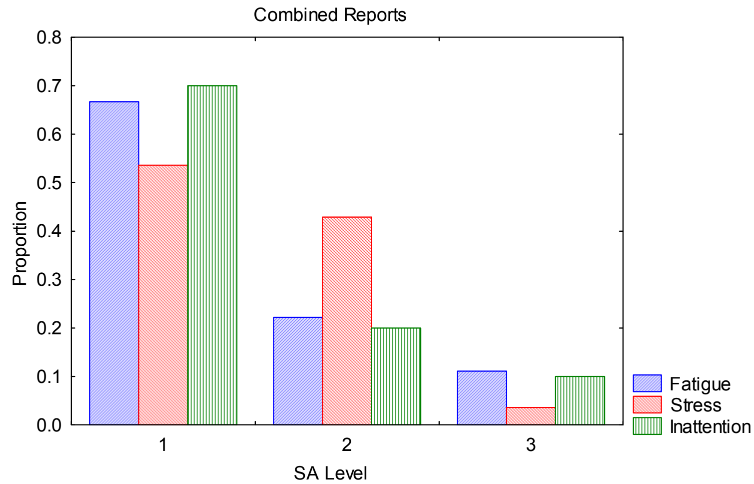
The tables in Figure 12 illustrate that the major factors involved in SA incidents were Stress / Overload and Inattention / Complacency. The relatively short 2-week duration of the training syllabus for SASO or Mojave Viper may account for the relatively mild impact of Fatigue / Sleep. Of these factors, Inattention / Complacency was associated most prominently with SA Level 1, while Stress / Overload was most associated with SA Level 2.

Characteristic patterns of SA ratios (i.e., Level 1 > Level 2 > Level 3) can again be seen in Figure 12 for Acute Conditions, i.e., with primary influence of these factors found for SA Level 1.

### *Training Results*

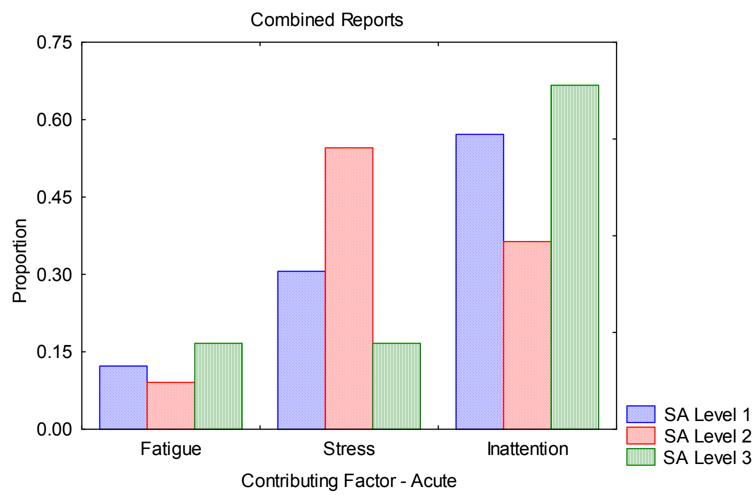
The minor role of Fatigue / Sleep on incidents from the Training environment can again be seen in Figure 13. The effects of Stress / Overload on both Level 1 and Level 2 SA incidents can also be seen in the figure, which indicates that this factor influenced both Perception and Comprehension performance in the incident reports.

It is noteworthy that 62% (21 of 34) of Level 1 errors were attributed to Inattention / Complacency, compared with only 33% (11 of 34) attributed to Stress / Overload. This condition is reversed for Level 2 errors, however—5 of 17 (29%) and 11 of 17 (65%), respectively—implying a stronger contribution of Inattention / Complacency to Level 1 errors (the perception of elements in the environment) and a stronger contribution of Stress / Overload to Level 2 errors (the comprehension of their meaning).




| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fatigue / Sleep** | 6 2 | | 1 | 9 |
| **Stress / Overload** | 15 12 | | 1 | 28 |
| **Inattention / Complacency** | 28 8 | | 4 | 40 |

(a) Acute Condition x SA Errors Combined



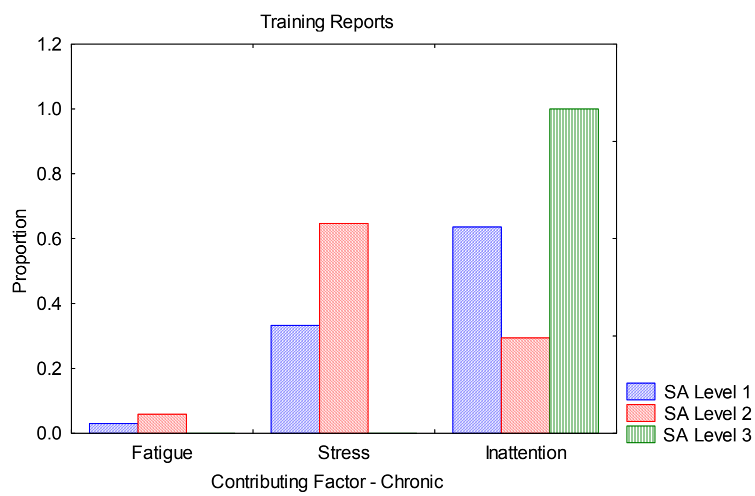

| | Fatigue / Sleep | Stress / Overload | Inattention / Complacency | ∑ |
|---|---|---|---|---|
| **SA Level 1** | 6 15 | | 28 | 49 |
| **SA Level 2** | 2 12 | | 8 | 22 |
| **SA Level 3** | 1 1 | | 4 | 6 |

(b) SA Errors x Acute Condition Combined

Figure 12. SA Errors: Acute Conditions – Combined.


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fatigue / Sleep** | 1 1 | | 0 | 2 |
| **Stress / Overload** | 11 11 | | 0 | 22 |
| **Inattention / Complacency** | 21 5 | | 2 | 28 |

(a) Acute Condition x SA Errors – Training




| | Fatigue / Sleep | Stress / Overload | Inattention / Complacency | ∑ |
|---|---|---|---|---|
| **SA Level 1** | 1 11 | | 21 | 34 |
| **SA Level 2** | 1 11 | | 5 | 17 |
| **SA Level 3** | 0 0 | | 2 | 2 |

(b) SA Errors x Acute Condition – Training

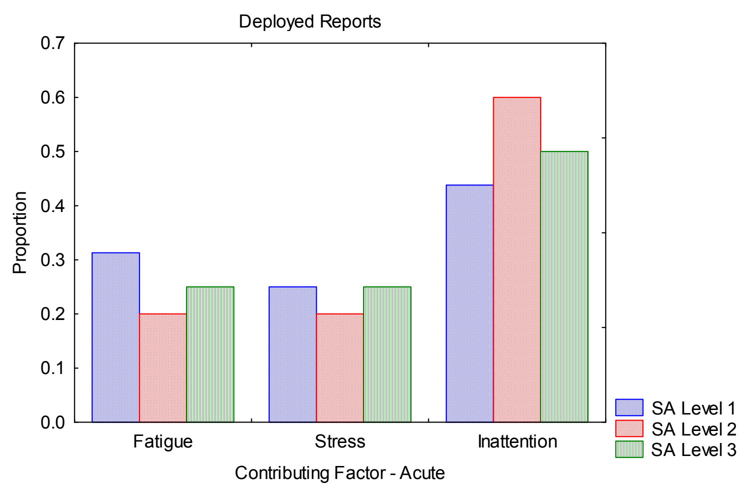
Figure 13. SA Errors: Acute Conditions – Training.

### ***Deployment Results***

SA patterns were more difficult to detect in the Deployed data, shown in Figure 14, although Inattention / Complacency was associated with more SA incidents than Fatigue / Sleep or Stress / Overload.


| | SA Level 1 | SA Level 2 | SA Level 3 | ∑ |
|---|---|---|---|---|
| **Fatigue / Sleep** | 5 1 | | 1 | 7 |
| **Stress / Overload** | 4 1 | | 1 | 6 |
| **Inattention / Complacency** | 7 3 | | 2 | 12 |

(a) Acute Condition x SA Errors – Deployed




| | Fatigue / Sleep | Stress / Overload | Inattention / Complacency | ∑ |
|---|---|---|---|---|
| **SA Level 1** | 5 4 | | 7 | 16 |
| **SA Level 2** | 1 1 | | 3 | 5 |
| **SA Level 3** | 1 1 | | 2 | 4 |

(b) SA Errors x Acute Condition – Deployed

Figure 14. SA Errors: Acute Conditions – Deployed.

Although the number of reports was low for this evaluation, the figure shows the primary locus (Level 1) for associations with these Acute Conditions in reports gathered from deployed forces. Overall, evaluation of Acute Conditions revealed that:

- Inattention / Complacency was most associated with Level 1 (Perception) SA errors, and played the largest role in both Training and Deployed settings
- Stress / Overload was associated with both SA Level 1 and Level 2 errors, at least in the Training setting
- Fatigue / Sleep did not play a significant role in performance from the Training environment, probably because of the brief (e.g., 2-week) duration of the syllabus

# DISCUSSION

While the work reported here was only exploratory, this first-generation incident report appeared to be effective as a data collection tool that could be used with little training by both expert evaluators and operational Marines, as part of their normal duties. While incident report data from operational settings are essential for comparison with training data, a more systematic approach to the collection of such field data is required in the future. Certainly, greater equivalence in the numbers of reports collected from operational and training environments is essential to reliable analysis. Furthermore, although retrospective reports from operational deployments proved useful to this study, the lack of control over what was provided, the varying amounts of time since the events occurred, and the motivations of the people who furnished these reports left open the issue of survey rigor. Finally, the incident report form itself could benefit from a more considered selection of contributing factors to ensure that more precisely defined information is gathered.

The SA scoring assignment procedure used for this study (i.e., Level 1, Level 2, or Level 3) was a single classification decision made for each incident report. A method for accommodating the inputs of multiple evaluators, however, (i.e., beyond the consensus approach employed here) would provide the data variance that could support inferential statistical analysis. Experience with the scoring process also showed that many reports contained descriptions of multiple activities that contributed to the final event outcome. A procedure to integrate these various activities into a common theoretical rubric was not developed in this study. It is likely that a more comprehensive scoring protocol that includes the sequence and timing of these activities will be necessary, however, to support rigorous SA evaluations of real world incidents such as those used in this study.

The experience gained from this study has also shown that both the incident report content and the theoretical perspective could benefit from further development. Consideration of more precise factor definitions (e.g., between Fatigue and Sleep), for example, and comparative evaluations of alternative SA models such as the OODA loop (e.g., Brehmer, 2004), could further enhance both the methods and the knowledge needed to enhance Marine Corps training. Both of these efforts could be readily achieved by reviews of existing data bases (e.g., those maintained by the Marine Corps Center for Lessons Learned), to generate the kinds of factor analysis dimensions that could refine the items of interest during future field research.

A theoretical weakness of the critical incident approach is time. The data reported here were collected over a period of years. Operational demands, political conditions, and military doctrine, however, can change relatively rapidly. An analysis approach based only on collection of empirical field data contains the risk of being rendered irrelevant by the time results are processed and available for use. By comparison, the Aviation Safety Reporting System (ASRS), which was earlier used as a conceptual guide for the critical incident method, is concerned with the relatively slow-changing domain of civil aviation operations. A solution to this situation is to maintain a data collection program on a continuing basis, which would then better track such operational shifts by reducing response latencies, as the most current data would be continually available for analysis.

# CONCLUSIONS

The primary goal of this study was determine whether useful, coherent, and model-based information could be extracted from observations of real-world events. More specifically, the objective was to characterize situation awareness (SA) errors of small unit leaders under realistic conditions, where such errors led to observably bad outcomes, and to determine the relationships of leadership level, tactical mission, and other contributing factors to those errors. We sought to structure SA performance reports according to the Endsley model, using field reports from both training and deployed settings. While the number of incident reports was small, the results demonstrated that it is possible to unobtrusively capture systematic performance data that are meaningful to both Marines and researchers. Based on these results, it appears that such data—in larger quantities—can support the generation of interpretable, quantitative patterns of SA performance that could be used to guide interventions in training, technology support, and tactics. More importantly, the use of event reporting as a research tool ensures that modeling and design efforts can be placed on a foundation of empirically documented problem factors, rather than only on an extrapolation of structured research studies.

Based on the data collected to this point, it appears that:

1. Interpretable (i.e., theory-related) dimensions of SA can be characterized through the incident report method, but large amounts of data are required for stability of the results.
2. The Endsley model of situation awareness appeared to provide useful dimensions for evaluating performance across a wide variety of missions and leadership levels (although other models should be explored, as well).
3. Although small, differences between Training and Deployed settings were found, further data collection may yet uncover important differences in SA patterns between these two environments that may provide important guidance for training improvement. Data collection from both settings, therefore, should continue.

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# APPENDIX A: INCIDENT REPORT

## CSA Incident Report

**Who?** (*Instructors asked to identify only the leadership level of the person responsible for the incident, i.e., no personally-identifiable information*)

**What happened?** (*Instructors asked to provide brief narration of event and its outcome*)

**When (in the timeline)?** (*Instructors asked to state whether incident occurred during planning, execution, etc.*)

**Why did it happen?** (*Instructors asked to provide their own opinions about the causes or event-sequence that led to the incident*)

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**14. ABSTRACT**
A model for characterizing situation awareness (SA) was tested by applying its elements to performance data gathered on Marine Corps Infantrymen from both training and operational deployment. The objective was to determine whether model-based factors of SA could be discerned strictly from operational settings, as contrasted with controlled laboratory conditions. The method involved the collection of "critical incident" reports of serious military failures, gathered from training and operations, which could be attributed to decision-making breakdowns. Reports were examined for instances of model-relevant features and results were analyzed as frequency plots. Such an empirical approach to performance analysis has the benefits of strong contextual validity (data gathered amid free-running mission activities) and clearly-documented military consequences. Initial results showed interpretable differences in the type of SA breakdowns that could account for these incidents, categorized by level of leadership, mission, setting (i.e., training or operations), and other contributing factors.

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