Analysis of urban search and rescue markings applied following the 22 February 2011 Christchurch earthquake

Stephen Glassey MEmergMgt, NCUSAR, CEM®, MEPS
Institute of Risk, Resilience & Renewal, University of Canterbury
Email steve.glassey@canterbury.ac.nz

Abstract

In one of New Zealand's worst disasters, international rescue teams from around the world responded to the Christchurch earthquake. To ensure interoperability and effectiveness of such global rescue responses, an international body under the auspices of the United Nations has established guidelines for these rescue teams, including a standardised search marking system for damaged and collapsed structures. The aim of this research was to evaluate whether responding teams adhered to the guideline when applying such markings. From hundreds of photographs, 153 images were visually analysed using a novel qualitative evaluation tool known as the Search Marking Adherence Score (SMAS). An online survey of responders (n=68) gathered further qualitative and further quantitative data. It was found that search markings were generally well applied but some team types performed better than others. New Zealand Response Teams scored the highest, followed by International teams, then New Zealand Task Forces. The analysis also leads to several practical recommendations to enhance the search marking specifications within the international guideline.

KEY WORDS: *Christchurch, earthquake, urban search and rescue, INSARAG, SMAS, markings, New Zealand.*

Introduction

At 12:51pm on Monday 22 February 2011, a shallow magnitude 6.3 earthquake struck at the heart of the Christchurch, leading to 182 fatalities, hundreds of injured (Royal Commission of Inquiry: Canterbury Earthquakes, 2011), over 156,000 insurance claims and damages in excess of NZ$5bn (Murdoch & Fraser, 2011) making it one of New Zealand's worst disasters in history. The earthquake left hundreds of buildings severely damaged with people trapped inside. This led to New Zealand's first national state of emergency being declared (Carter, 2011) and prompting a massive international urban search and rescue effort with teams afar as the United Kingdom, United States of America, Japan, China, Taiwan, Singapore and Australia deploying to assist (Figure 1).

Figure 1: Map of countries that deployed international rescue teams to Christchurch earthquake (Map source: Google).

The formal global mechanism to standardise such response efforts is provided by the United Nations through guidelines established by the International Search and Rescue Advisory Group (INSARAG) under the authority of United Nations General Assembly Resolution 57/150 (United Nations General Assembly, 2002b) of which New Zealand was in favour of (United Nations General Assembly, 2002a). INSARAG published guidelines include capacity development, standardised tactics, search methodology, team classification and search marking systems. In 2001, New Zealand formally established the national urban search and rescue project (National Urban Search & Rescue Steering Committee, 2008) which gave effect to the resolution. The multi-agency Steering Committee included officials from the Ministry of Civil Defence & Emergency Management, New Zealand Fire Service and local government. Over the following years, urban search and rescue task forces were established (NZTF1 in Palmerston North, NZTF2 in Christchurch and NZTF3 in Auckland) by the New Zealand Fire Service. These taskforces were augmented by the development of locally based volunteer civil defence rescue teams nationally audited and registered as New Zealand Response Teams. Following the February 2011 earthquake all three task forces and eighteen response teams were deployed to the affected area, making it the largest national disaster rescue deployment in New Zealand history. The central business district was one of the worst affected areas and became the focal point for rescue personnel to search some 4,000 buildings in the cordoned zone, later to be known as the *Red Zone*. In accordance with the INSARAG Guidelines and Methodology (herein the guidelines) a structural marking (figure 2) is applied to collapsed structures (United Nations, 2011, p. 95). This marking is different to the disaster rescue markings (figures 3 and 4) used in the United States of America as specified by the Federal Emergency Management Agency (2003b). The guideline has been continually updated through input at annual INSARAG Team Leader Meetings and prior to the February earthquake the Victim Marking system (figure 5) was removed (T. Skavdal, INSARAG Secretariat, personal communication, October 2011). Indeed the victim marking concept was not

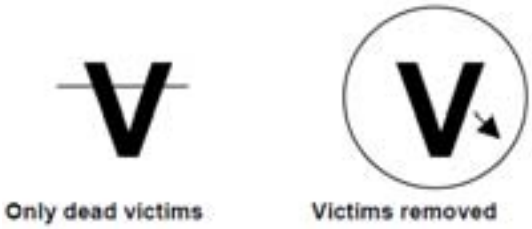
included since the July 2006 edition of the guideline, but published in the General Rescue Manual of March 2006 (Ministry of Civil Defence & Emergency Management, p. 33). The purpose of the marking systems is to provide a standardised method to indicate search progress and to clearly indicate whether potential or actual victims remain inside the collapsed structure to avoid duplication of search effort and prevent heavy machinery being accidentally used where casualties remain. It is important that all responding agencies understand the marking system along with other protocols outlined in the guideline to avoid confusion. Beyond the work of Morris (2007), there is a void of empirical research relating to INSARAG activities. No empirical research could be found relating to the FEMA marking system either. This study explores the application of the INSARAG structural markings used following the February earthquake through evaluating quantitatively the adherence to the guideline using a newly developed tool, evaluating qualitatively the rationale for adherence variation by responders through an online survey and offers an appraisal and recommendation for future application of disaster search markings.

Figure 2: INSARAG Structural Marking

Figure 3: FEMA Structure/Hazards Evaluation Marking

Figure 4: FEMA Search Assessment Marking

Figure 5: INSARAG Victim Marking (discontinued)



Method

A sample of images (n=153) containing search markings applied within the following ten days of the 22 February earthquake were finalised from several hundred photographs supplied by social media and other network requests, along with images from the internet. The majority were geotagged or displayed adequate building features to allow confirmation that they were from the affected central

business district. According to the Canterbury Earthquake Recovery Authority (CERA), there are approximately 4,000 buildings in the central business district. Images were visually assessed and given a Search Marking Adherence Score (SMAS) and additional data was also captured. The qualitative data results have a margin of ±7.77% at the 95% confidence level based on the sample (n=153) and population (n=4,000) sizes. Following the analysis of SMAS data, an online survey was completed.

Search Marking Adherence Score

A simple quantitative grading system was developed as part of this research project to enable comparative analysis of search markings applied following the February earthquake. The common characteristics of search markings between the INSARAG structural assessment and the FEMA markings (Structural/Hazard Evaluation Marking when used in conjunction with the Search Assessment marking) were identified (table 1). Based on these common characteristics, the Search Marking Adherence Score (SMAS) (table 2) is then applied to images of search markings. The simplicity of the tool enables benchmarking of search markings to occur. In operating the tool, SMAS is converted to percentage, excluding criteria unable to be evaluated. Fields that are unable to be evaluated are counted and noted next to the percentage as the adjustment factor in superscript i.e. "SMAS: 85%^{2}"

Characteristics	**FEMA**	**INSARAG**
Colour	International Orange	International Orange
Size	2'x2' (0.6m x 0.6m)	1m x1m
Placement/Positioning	SHE specified only	Near point of entry
Usage	FEMA teams	USAR teams
Entry Recommendation	SHE	Go or No Go
Reporting	Yes - To local ICP	Yes to OSOCC
Team ID	Yes (US as per FOG)	Yes
Date/Time Start	Time	Yes
Date/Time Finish	Yes	Yes
Hazard Info	Yes	Yes
Missing Persons	Yes	Yes
Live Victims Rescued	Living – only still inside	Yes
Dead Victims Extricated	Dead – only still inside	Yes
Completed to Capacity		Circle around entire marking
Confirmed as Clear		Horizontal Line

Table 1: Common characteristics of search marking systems

The Search Marking Adherence Score (SMAS) was peer reviewed then piloted and refined with a small sample (n=20/13%) before being applied to the entire sample.

Criteria	Major Non Adherence (1)	Minor Non Adherence (2)	Adherent (3)	*Example*
1. Colour (compulsory)	Difficult to read	Colour choice able to read	International Orange	*3 (International Orange)*
2. Size (compulsory)	<20% 1x1m UN 2'x2' FEMA Or no box	±5-20% 1x1m UN 2'x2' FEMA	>5% 1x1m UN 2'x2' FEMA	*2 (1.2x1.2m)*
3. Placement/Positioning	Not on Structure	On Structure	Front of Structure	*2 (side of structure)*
4. Entry Recommendation	Well outside specification or Incorrect location or not included	Correct location and near specification (N or NG)	Correct location and within specification	*2 (NG, rather than No Go)*
5. Reporting	Not reported	Reported outside parameters (delayed)	Reported within parameters	*- (Blank/unable to verify)*
6. Team Identification	Unable to Identify country or team	Difficult to Identify country or team	Easy to Identify country or team	*3 (NZ-RT23)*
7. Entry Time	Well outside specification or not given	Near specification	Within specification	*1*
8. Exit Time	Well outside specification or not given or unable to read	Near specification	Within specification	*3 (Date given 22FEB 13:15)*
9. Hazard Info	Well outside specification or unable to read	Near specification	Within specification (including Null)	*- (Blank)*
10. Victim Data	Well outside specification or unable to read	Near specification	Within specification (including Null)	*3 (0 on left and right of box)*
11. Completed to Capacity	Well outside specification	Near specification	Within specification	*3 Box circled*
12. Confirmed as Clear	Well outside specification but noted otherwise	Near specification	Within specification	*3 Line through box*

Table 2: Search Marking Adherence Score (SMAS)

Limitations

The SMAS is limited to generating quantifiable data on the adherence to either the FEMA or INSARAG marking system. It is not capable to measure rationale for deviation, so therefore it

provides a score solely on adherence to the criteria, as opposed to acknowledging the operational demands may require such non-adherence. To capture the rationale for non-adherence, an online survey was undertaken to ascertain the rationale for deviation from the guideline. The sample size when viewed collective provides a fair margin of error. The population size is likely to be exaggerated in this study as not all buildings within the Central Business District would require a search marking under the guideline and by doing so the results may have a lower margin of error accordingly. There are however limitations with the data; in particular low daily samples at the beginning and end of the date range in particular days 1 (n=2), 2 (n=3), 9 (n=5) and 10 (n=1). Individual teams or countries were unable to be negatively identified as part of the ethical requirements for this study, consequently a number of images have their team identification removed. This limits segregation of results to allow comparison between individual teams and data is based on three team types, rather than specific entities.

Results

General Observations

Of the sample population (n=153), 66.01% of the markings were applied by International Teams, 24.84% by NZ Task Forces and the remaining 9.15% were applied by NZ Response Teams. No markings by other team types such as New Zealand Fire Service (Non-USAR), Red Cross or Land Search and Rescue were observed. Only 1 (0.65%) marking was identified to have followed the FEMA marking system, which was applied by a NZ Task Force. 24.84% (n=38) used the figure zero to indicate a null field (figure 8).

Search Marking Adherence Score

There was an overall trend of improvement of search marking adherence as the incident progressed (figure 6). The Quantitative data in isolation does not provide any valid explanation for the minor increase in the scoring trend. Results from the survey shall be used to in conjunction with this data to make an informed analysis.

Figure 6: SMAS trends

SMAS Criteria comparison by Team Type

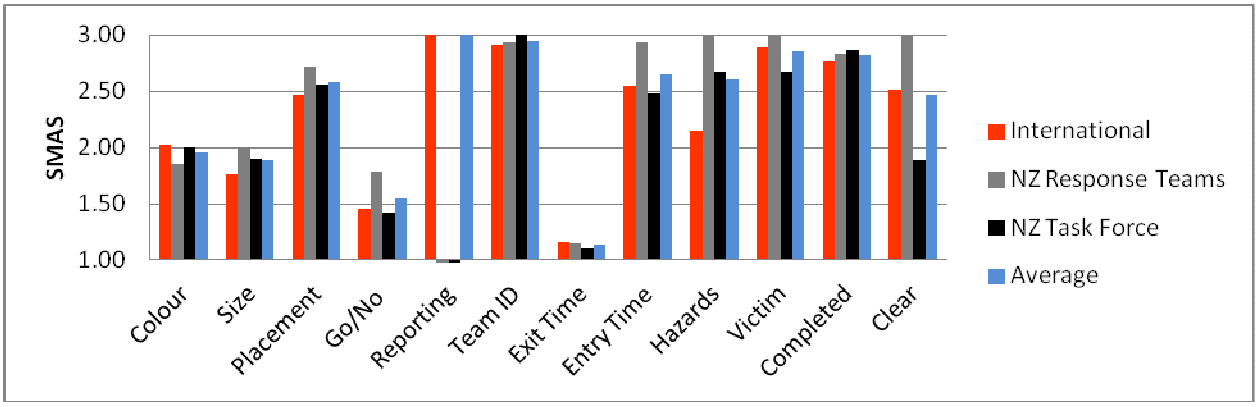


Figure 7: SMAS average by team type

In analysing the colour application of the sample, only 4% (n=6) used the specified *international orange* colour to apply the search marking. The next prevalent colour selected was other shades of orange, including fluorescent types (40%, n=61) meaning 44% (n=67) of all search markings were a shade of orange. Following orange types, pink (39%, n=59) appeared to be the closest rival. Other colours included yellow (8%, n=13), red (5%, n=8) or green (4%, n=6). No other colours were observed in the sample. In respect to the SMAS *colour* criteria (figure 7), international teams averaged 2.02, NZ Task Forces 2.00, NZ Response Teams 1.86, with an overall average of 1.96.

In the scoring of *size* (figure 7), the international teams slightly under performed under these criteria (1.76) against their NZ Task Force (1.89) and NZ Response Team counterparts (2.00) with an overall average of 2.00. An illustration of a marking being oversized is provided in figure 10.

Placement scores also hard marginal variation with NZ Response Teams having a high adherence to the guideline (2.71). Remaining team types followed with NZ Task Forces (2.55), International Teams (2.47) and an overall average of 2.58. In application of the markings, 80.39% (n=123) were applied on the collapsed structure near the point of entry in accordance with the INSARAG guideline. The remaining markings were applied to the fence 6.54% (n=10), footpath 10.46% (n=16) (figure 11) or on a sheet or similar non structural element 2.61% (n=4).

Scoring of *Go/No Go* criteria showed a distinctive variance between NZ Response Teams (1.79) and International Teams (1.45) and NZ Task Forces (1.42), with an overall average of (1.55). The guideline requirements specified in F13.6 (United Nations, 2011, pp. 95-96) both in the text descriptor and example illustration clearly prescribe “Go” or “No Go”, however International and NZ Task Force team types were more prone to abbreviate these to “N” or “NG” (figure 9).

Reporting was difficult to accurately score as it was not possible to interview each person responsible for the sampled marking to ascertain whether the assessment result was reported immediately to the

OSOCC as specified in the guideline (United Nations, 2011, p. 95). Only one confirmed instance of reporting assessment result from the image sample population was available. Although the SMAS does take into consideration all criteria of the INSARAG structural marking, this criteria was omitted under the Adjustment Factor in close to all instances (99.34%) under this analysis.

All team types consistently scored high under the *Team Identification* criteria. NZ Task Forces scored the maximum average of 3.00, followed by NZ Response Teams (2.93) and International Teams (2.91) with an overall average of (2.95) making it the most highly scored criteria across SMAS analysis. There appeared to be no major issues with identifying the team whom applied the search marking.

Entry and *Exit Times* were problematic with discrepancies within the guideline. The guideline requires a start (entry) date and time under F.13.6(3.4) and a finish (exit) date and time under F.13.6(3.5), however the example illustration only provides for start time/date, no finish date/time is provided (United Nations, 2011, p. 96). Based on example illustration within the guideline, where only one date/time was provided, it has been assumed as the *start* date and/or time. Due to this there was significant underperformance of *exit* criteria across all team types (International 1.16, NZ Response Teams 1.14 and NZ Task Forces 1.11) with an average of 1.14. In contrast, the use of at least an *entry* date or time in the image sample was very high (average 2.65) with NZ Response Teams being scoring highly (2.93). International Teams (2.54) and NZ Task Forces (2.47) following behind. 10.46% (n=16) of markings used the US date format system (figure 8) contrary to local format and all of the US date formats were applied by International Teams.

Hazard information scores varied considerably from 3.00 (NZ Response Teams), 2.67 (NZ Task Forces) and 2.14 (International Teams), average 2.60. Figure 10 illustrates on example of incorrect placement of “water basement” hazard information which should have been outside the box at the top if to applied in accordance with the guideline (United Nations, 2011, p. 96).

Figure 8 (International Team): *Example of foreign date format. The size and location of the date is also non-compliant. Zero fields for victim information are also applied. Photo by Stuart Fraser.*

Figure 9 (NZ Task Force): *Example of abbreviated Go/No Go, correct placement of hazard information, limited date/time, and incorrect indication of "clear" (line through marking not applied). Photo by Stuart Fraser.*

Figure 10 (International Team): *Marking that misplaces and abbreviates "No Go". Incorrect placement of "water basement" hazard. Zero fields for victim identification are also applied. Photo by Peter Seager.*

Figure 11 (NZ Response Team): *Marking applied not on the structure, abbreviated "Go" and oversized. Note use of letters to denote month to avoid confusion with foreign date format. Horizontal line drawn through marking to mark as clear. Photo by Alan Keeber.*

Victim Data adherence scored well with an overall average of 2.85 (NZ Response Teams 3.0, International Teams 2.89, NZ Task Forces 2.67). The use of the figure zero used (24.84%, n=38) to indicate a null field was mainly used by international teams and predominantly for victim data (figures 8 and 10). Despite the removal of victim markings (figure 4) from the guideline prior to 2006, there appeared to be a trend for some teams, both domestic and foreign to still apply these (Figures 12 and 13).

Figure 12. *Victim marking. Photo by NZ Defence Force.*

Figure 13: *Victim marking. Photo by Phil Parker.*

All team types generally adhered to the guide to mark a structure as *Completed* (NZ Task Forces 2.87, NZ Response Teams 2.83, International Teams 2.76. Overall average 2.82). Again between 2002 and 2006, there appeared to be another change to the guideline introducing a horizontal line to indicate as *Clear*. The difference being that *Completed* was to indicate that the structured had been searched to the team's capacity and indicated by a circle being drawn around the entire marking (United Nations, 2006, p. 96). The new marking to confirmed no more victims remain (or *Clear*) was the addition of a horizontal line through the entire marking (United Nations, 2006, p. 96). There appeared to be significant variation in adherence to the guideline by teams marking a structure as *Clear*. NZ Response Teams showed high adherence to the guideline for confirming a structure had no more victims remaining (3.00), followed by International Teams (2.52) and NZ Task Forces (1.89).

Although the research will not negatively identify specific task forces, during the analysis of pictures it was observed that the Singaporean and Australian international teams scored very high in their adherence to the INSARAG guideline.

Overall, NZ Response Teams had the highest adherence to the guideline with an average SMAS of 77.46%[3.36], followed by International Teams 71.55%[3.38] and least adherent was NZ Task Forces 69.87%[3.32] (SMAS Average across all team types 73.00%[3.35],n=153).

Survey

An online survey was then undertaken to address areas that required further clarity arising from the SMAS evaluation. Responding teams were approached via direct email and social media channels, with all foreign INSARAG teams being approached to participate through their respective country focal points. There were a total of 68 responses to the online survey from an estimated population of 600 responders (both domestic and international) providing a margin of error ±11.1% at the 95% confidence level. Non-accredited responders were not solicited as part of the survey.

Team Origin

The survey respondents comprised of New Zealand Task Forces (4.7%, n=3), New Zealand Response Team (18.8%, n=12), New Zealander Other (7.8%, n=5) and International (68.8%, n=44). The majority of the International team origins were Australian. The lack of New Zealand Task Force participation could be attributed to ongoing industrial action including prohibition of union members to use computers.

Experience and Qualification

The majority of respondents deemed their level of training to be certified to INSARAG Heavy (60%, n=33), followed by NZUSAR Responder (30.9%, n=17). Other respondents selected nil (1.8%), NZUSAR Awareness (1.8%), NZUSAR Technician (3.6%), INSARAG Light (1.8%) and INSARAG Medium (3.6%). This data is consistent to the team origin data above. The experience base within the sample population was high with the majority indicated they had more than five years experience (74.2%, n=49), including 27 that had more than ten years experience (40.9%). In respect of the actual response to major structural collapses, the majority had no experience (40.9%, n=27), only 1-0 days (40.9%, n=27) and only (18.1%, n=12) having 11 or more days experience at such events. In correlation with the experience base, it would appear that the majority of USAR operatives who deployed to Christchurch generally have minimal operational experience in structural collapse operations which is likely to be attributed to the fact that urban search and rescue is relatively new within Australasia with most capacities only formally established within the last decade.

Familiarity with and importance of INSARAG Guidelines

Despite the expectations laid out in United Nations General Assembly Resolution 57/150 (2002b), respondents largely appeared unfamiliar with the “INSARAG Guidelines & Methodology”, with 24.2% (n=16) never heard of the document, 19.7% (n=13) aware of its existence but never read the document, with the majority having read it (entirely or in part) only 1-2 times (34.8%, n=23). It could be argued that national documents such as training packages disseminate the core information such as search marking systems, however the SMAS analysis and later surveyed questioning around guideline version updates would suggest otherwise. When asked how important it is for teams to

apply the INSARAG markings in accordance with the guideline, 98.3% (n=57) indicated compliance was moderately to extremely important (66.7 % extremely important, 29.8% very important, 1.8% moderately important).

Perceived practicality of INSARAG search markings

It has long been of concern by some practitioners that the INSARAG marking's size and colour was impractical. The earlier SMAS analysis indicated only 4% of the sample pictures used the prescribed international orange colour (figure 7). Respondents were asked how practical was the use of the colour "international orange" for search markings applied during the response to the Christchurch earthquake. 64.9% (n=37) indicated this colour was practical or highly practical; 29.8% (n=17) indicated it was not practical or highly unpractical. Many respondents also commented that the colour selection itself was not the issue, but the lack of availability of the prescribed colour in sufficient quantities in the initial phase of response. The one by one metre box used as part of the structural marking (figure 2) was also evaluated for perceived practicality. 61.4% (n=35) indicated the box size was practical or highly practical. 31.6% (n=18) indicated it was not practical or highly unpractical. As the INSARAG guideline has an international audience, the impact of varying date formats was also surveyed. 42.1% of respondents (n=24) indicated that the varying date formats (i.e. 2/21, 21/2, 21 FEB etc) by international teams was problematic. It could be assumed that under the guidelines, international teams need to respect local traditions and customs, including adopting the local country's date formatting convention – this however was not always the case.

Awareness of changes to INSARAG search markings

Respondents (n=57) were asked to best describe how to illustrate that all work has been completed and no victims (live or deceased) remain on an INSARAG structural marking. 47.4% (n=27) correctly identified the correct action, that being to draw a horizontal line through the box. 40.4% (n=23) chose to draw a circle around the box, which used to be the correct answer prior to the 2006 edition of the guideline. 12.3% (n=7) also gave incorrect answers, choosing writing "clear" or "0" underneath the box. This supports the earlier SMAS analysis which suggests significant misunderstanding of the completion to capacity and final clearance markings. Ironically, it is the New Zealand Response Teams who are not linked into the INSARAG arrangements that scored the highest SMAS scores and understanding of the current version's requirements in the survey results. Additionally, some respondents also noted that the horizontal line should also be changed to indicate that not only has the building been cleared, but there should be no need for rescue personnel to re-enter the structure.

General Comments

Respondents also commented on the comparison between the FEMA and INSARAG marking systems. Users including those who were familiar and experienced with the FEMA marking, indicated a preference for the INSARAG structural marking as it provided for more information, although the prescribed size is too small to be useful. There was also demand for a rapid clearance marking that

could be applied quickly to non-structural search areas such as vehicles, boats, caravans, collapsed walls and sheds by first responders. This was reflected by one respondents comment:

> *"I believe they [the marking systems] are in need of urgent review and possible reworking. There needs to be a simple system, for example when checking a single car for victims. To spray an entire USAR TF marking on each car is not practicable but the word CLEAR is not UN approved".*

Another area of concern raised by respondents was the damage to property from the marking system, especially to structures that were not damaged but had to be searched. In response to this dilemma, some teams opted to not conform to the guideline and spray paint the footpath or the glass frontage. One respondent noted:

> *"We were on 23rd/24th/25th Feb directed to no mark any buildings, use only the foot path with a limited marking, not INSARAG format. Later markings still mixture of clear with team name, date. spray paint varied due to availability, one point the replacement paint was bike repair paint in browns, off yellows and greens which proved useless".*

The issue of damage to property caused by spray paint was also highlighted in the National Commanders Inquiry Report (New Zealand Fire Service, 2011, p. 17). It is agreed the teams were following the guideline and that markings may be applied pursuant to section 92 of the Civil Defence Emergency Management Act 2002. Additional protection from liability is also found within the Fire Service Act 1975 (s.43) and Civil Defence Emergency Management Act 2002 (s.110) which were applicable to the urban search and rescue response in Christchurch.

Finally, some respondents made note that due to no markings being used or incorrect markings being applied, many structures were subsequently searched again unnecessarily, wasting time and placing personnel at risk.

Literature Review

Despite the significant costs associated with deploying international search and rescue teams, the literature is scarce of proving their effectiveness, with some arguing that the cost of deployment would save more lives if allocated pre-event in disaster risk reduction and mitigation programmes. Others retort that the saving of even one life can not have a tangible price placed upon it. Some would also suggest that the extension of international rescue teams is more of a political gesture than based on humanitarian needs alone, such as the deployment of the New Zealand Task Force to Japan following the devastating Tsunami in March, 2011, in which the mission saved no lives. The politics of international search and rescue can be seen at all levels. The General Assembly Resolution and INSARAG Guideline expect any internationally responding team is accredited at the Medium or Heavy classification. The New Zealand Task Force remains unaccredited to any level according to the INSARAG directory (INSARAG, 2011). It could be argued that it was hypocritical that the New

Zealand Government declined to accept unaccredited teams into Christchurch following the February 2011 earthquake (Field, 2011), yet deployed it's unaccredited team to Japan. Others may view this exchange as a practical means to demonstrate the government's genuine compassion and moral obligation to reciprocate.

In review of available post-mission reports on the Virtual OSOCC, it would appear only the Australian teams have uploaded these (OCHA, 2011), despite the requirements to provide such a report under the guideline. Though not focused specifically at urban search and rescue operations, the New Zealand Fire Service National Commander commissioned a internal inquiry did make some remarks concerning the application of search markings (New Zealand Fire Service, 2011, p. 17):

> *The United Nations Office for the Coordination of Humanitarian Affairs field support section International Search and Rescue Advisory Group (INSARAG), of which New Zealand is a member, has devised guidelines for building markings in order to ensure optimal coordination on a work site by USAR teams. These markings are not widely known by those NZFS personnel not in USAR. We were also advised that these markings were not always used consistently by international USAR teams during the search and rescue operation which caused further confusion.*
>
> *Another issue raised with us was that the spray painted markings on certain surfaces and motor vehicles had resulted in considerable rectification expense. While we can understand the concern expressed we note that USAR crews followed the INSARAG guidelines.*

These comments are of interest. Firstly, the New Zealand Fire Service is the Lead Agency for USAR in New Zealand pursuant to the National Civil Defence Emergency Management Plan. Changes in the USAR organisation from 2005, has lead to a deterioration of relationship between New Zealand USAR Task Forces and New Zealand Response Teams, more so at the strategic level (personal observation). Some senior officials within the New Zealand Fire Service have argued there is no need for (volunteer) light rescue teams as their service was to train all of its members to and beyond USAR Category 1 Awareness (personal observation). Despite such intentions, no such capability has been developed significantly beyond the three task forces, a point well proved by the National Commander's report admitting the lack of awareness by their operational staff of a marking system which is seen by both domestic and international USAR practitioners as important (98.3%, n=57, indicated search marking compliance was moderately to extremely important). The report also purports that international USAR teams inconsistently applied search markings (causing confusion), yet the SMAS and survey results suggest the exact opposite. New Zealand Task Force (NZ Fire Service) teams actually scored the lowest in applying the INSARAG marking systems correctly.

Discussion and Implications

General

The INSARAG marking system proved to be a useful tool in the aftermath of the Christchurch earthquake. Although there was variation across the team types and country of origin, the system worked reasonably well when applied correctly. The INSARAG marking system appeared to be favoured over the FEMA marking system as it allowed for more information to be illustrated and is less codified. There did however seem to be a general theme that many teams were not aware of the revised structural marking and the removal of the victim markings from the guideline. Almost unanimously (98.2%), surveyed respondents indicated that it was important that USAR search markings be applied correctly in accordance with the INSARAG standard. The standardisation and consequential correct interpretation of search makings should lead to a more effective rescue response through minimising duplication of search efforts, safer working environment for rescuers, improved detection and retrieval rates of victims, improving international interoperability across rescue teams, which all lead for better outcomes for the affected community.

Application performance

There was a slight increase in adherence scores in the days following and this is likely to be attributed to verbal pollination of the guideline's understanding between team members. New Zealand Response Teams scored the highest in their application of search markings, even above the average of internationally accredited INSARAG teams. This is likely to be contributed to by their culture of regular USAR specific training as volunteers (albeit at a light level) and an autonomous interest to follow changes of the guideline regardless of the lack of information or updates from the country's focal points. International teams were second in their adherence scoring, reflective of the need to ensure all operational members are familiar with the guideline as part of their accreditation. The New Zealand Task Forces scored the lowest which may be caused by a lack of regular ongoing training and exercising in comparison to the other team types and lack of information or updates from the country's focal point (such as changes to the guideline).

Key recommendations

Structural Markings

The guideline for the structural marking should be revised as follows:

1. Clarify that the size and colour of the marking is only a recommendation.
2. Recommend that a universal date format being adopted (i.e. 22 FEB 2011).
3. That only one time (entry or exit) is listed to decrease paint consumption.
4. Placement of the marking ideally should be on the front of the structure; however other options including on the structure's footpath or fence may be less preferred alternatives, noting that liquefaction and traffic may affect the survivability of footpath placed markings.

5. That the structural assessment (Go or No Go) should be abbreviated (to G or N) to decrease paint consumption and reduce encouragement of public to re-enter buildings safe for rescuers, but not safe for public.
6. Consider standardised international team naming conventions to allow for country and level to be included. For example NZ1M (New Zealand Team 1 – Medium), US2H (USA Team 2 – Heavy), FJ3F (Fiji Team 3 First Responder). This would allow the "completed to team capacity" circle marking to be better understood in context to the team's level of capability (First Responder, Light, Medium and Heavy).
7. That null values (such as victim data) not be used to decrease paint consumption
8. The horizontal line is the indication of clear and once applied the structure should not be re-entered by rescue personnel.

Training and Competency

9. The guideline and in-country training guidelines for urban search and rescue should mandate periodic search marking competency tests for rescue personnel.

Information Sharing

10. The guideline should include Terms of Reference (TOR) and for INSARAG country focal points (political and operational) and develop a mechanism to ensure guideline updates and other relevant information resources and opportunities are promulgated to all stakeholders (accredited and non-accredited actors).

Rapid Clearance Mark (RCM)

11. The guideline needs to include a simple marking able to be used by non-USAR first responder to mark buildings as clear. This could also be used by USAR practitioners to note that non-structural search areas (vehicles, caravans, boats, small sheds, collapsed walls etc) have been cleared. To distinguish this from property owners or occupiers, a circle with a horizontal line could be used (i.e. ~~O~~) as suggested by one respondent. The marking of "clear" could be left as a common sense application for use by property owners and lay-persons.

Low Damage Search Marking (LDSM)

In particular when searching suburbs with minimal damage, consideration should be given to an alternative means to mark the structure other than spray paint. Several options have been put forward by the sample group including coloured card and waterproof paper, stapled to the fence with the search assessment marking applied using a permanent marker. Such a placard based system (figure 14) has already been used, including following the Bastrop Fire (E. Macaluso, personal communication).

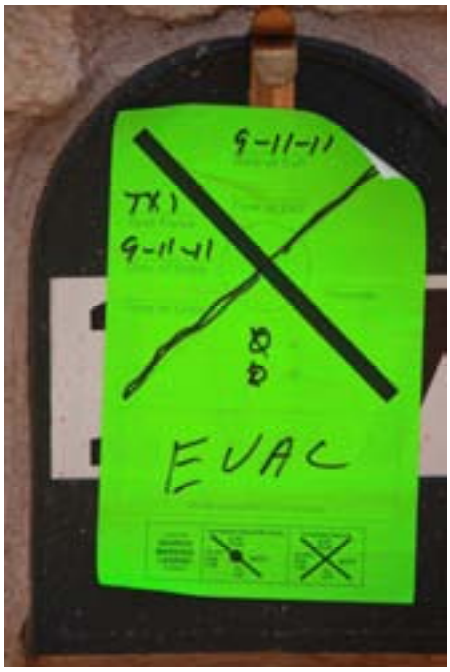


Figure 14: FEMA search assessment marking in use by Texas Task Force 1, Bastrop Fire, 2011.

Some countries have developed post-response building evaluation systems that include the use of coloured card (New Zealand Society for Earthquake Engineering, 2009). However, the use of coloured card as a search marking may be problematic given potential conflict with such engineering assessment placards systems.

12. The INSARAG guideline should suggest the use of waterproof paper (A4 or Letter size) being affixed to the structure or fence seems with the structural marking information being written on in permanent marker. The structure's address should also be placed on the header in case the marking sheet separates from the structure.

These sheets could be pre-printed with base information (i.e. box and team identification, as per Figure 14) to expedite search operations. One respondent indicated a potential problem of using a smaller card option, that being it would be difficult to read whilst driving in comparison to the traditional one metre square spray painted box. However should a building be collapsed or damaged, the standard (spray painted) structural marking should be used instead making the property easy to identify.

Victim Markings

There was a lack of data pertaining to victim markings which were used following the Christchurch earthquake, despite the victim marking system being removed from the INSARAG Guideline. The victim marking system has been revised and included in the current FEMA USAR Task Force Field Operations Guide (Federal Emergency Management Agency, 2003a).

13. The INSARAG guideline should include the revised victim markings or at least provide commentary and reference resources in which personnel can refer to in order to decode such markings if deployed to countries which domestically use these.

Conclusion

The evolution of the INSARAG guidelines appears to give good effect to standardise operational methodology including search marking systems within the international community. It will always be important that end user practitioners are involved in the review of such systems and more importantly, the changes being promulgated effectively. The evaluation of search marking adherence to the INSARAG guideline in this article is not necessarily a reflection of the actual effectiveness of search and rescue operations following the 22 February 2011 Christchurch earthquake. Further consideration is needed around the interpretation, application and adjustment of the INSARAG structural assessment marking by the international working groups responsible. Some team types need to spend more attention to ensuring basic markings are understood and applied in accordance with current guidelines to ensure an improved level of response in the future. Further research is needed and should focus on the effectives of international search and rescue programmes (in particular their benefit in comparison to local capacity building and risk reduction programmes), effectiveness of victim markings and changes to the markings (such as LDSM and RCM suggestions).

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About the author

Steve Glassey is the Deputy Director of the Institute for Risk, Resilience & Renewal at the University of Canterbury, Christchurch, New Zealand. In his former role with the New Zealand Fire Service (National Headquarters), he was seconded to the National USAR Project to develop several elements, including national training, response team registration, incident ground certification and canine search. He is a former Technician (CATII) with New Zealand Task Force 1 and holds National Certificates in Urban Search & Rescue (Response Leader, Response Medic, Training, Rope Specialist and Technician strands). He has been deployed to several USAR incidents including Bryans Beach (2004), Gisborne Earthquake (2007) and Christchurch Earthquake (2011), some of these in command roles. He is an active Instructor Trainer with Rescue 3 International and teaches NFPA1670 and 1006 compliant rope and water technical rescue programmes internationally. In 2005, he was presented with an award for his dedicated contribution to the National USAR Programme by the National USAR Steering Committee. Steve is also an Associate Lecturer in Technical Rescue for the University of Central Lancashire and an External Research Affiliate with the Joint Centre for Disaster Research.

Abbreviations

CDEM	Civil Defence Emergency Management
FEMA	Federal Emergency Management Agency (US)
FOG	Field Operations Guide
ICP	Incident Control Point (aka Incident Command Post)
IEC	INSARAG External Classification
INSARAG	International Search and Rescue Advisory Group
LDSM	Low Damage Structural Marking
MCDEM	Ministry of Civil Defence & Emergency Management
NDMO	National Disaster Management Office
OCHA	Office for the Coordination of Humanitarian Affairs
OSOCC	On Site Operations Coordination Centre
NZ	New Zealand
NZFS	New Zealand Fire Service
NZRT	New Zealand Response Team (Registered)
NZTF	New Zealand Task Force (part of New Zealand Fire Service)
RCM	Rapid Clearance Marking
SHE	Structural/Hazard Elevation
SAM	Search Assessment Marking (FEMA)
SMAS	Search Marking Adherence Score (Glassey, 2011)

TOR	Terms of Reference
UN	United Nations
UNDAC	United Nations Disaster Assessment Coordination
USAR	Urban Search and Rescue

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