Emergency management training: R-statistics for debriefing

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Abstract:

This paper presents data from an emergency management training exercise conducted at Stiklestad, Norway in May 2011, with participants from emergency teams from three counties in the middle part of Norway and Sweden (Trøndelag and Jämtland). The exercise was conducted as part of the Interreg project GSS[1] – (Grenseoverskridende samarbeid for sikkerhet / Cross-border cooperation for security). The training exercise was facilitated as a tabletop exercise with computer supported presentation of the events of the emergency scenario and detailed recording of the communication among the teams both within and between the two countries. The data consisted of individual communication messages that were aggregated up to the level of the role of the participants in the emergency teams in order to present data on who communicated with whom, how often and whether the communication messages provided or asked for more information about the emergency event. The R-statistics open source package allowed on-the-fly analysis and graphical presentation of the data for immediate use during the debriefing session following the training session.

Key Words: *Emergency Management Training, Risk Management,Cross-Border Communication, Statistical Analysis, R-Statistics Package*

Introduction

This paper explores the use of an open source statistical tool integrated in a disaster management simulation. The purpose of the integrated tool is to provide an on-the-fly analysis of simulation data for the debriefing session immediately following a disaster management simulation. A prototype of such a tool has been developed and tested with computer generated data on communication among simulation participants, media handling agility of the participants as well as individual and organisational learning effects.

Literature on the key role of debriefing in simulations is extensive. Debriefing is considered to be as important as the design of the simulation itself. Providing a sense of closure and collective insights that otherwise might get lost on individual participants are central concerns in the debriefing process. Playback of selected simulation situations is also an important tool in computerized simulations and role-playing. (Fanning and Gaba, 2007; Jenvald and Morin, 2004).

Simulations of response patterns to disaster situations also have a long tradition in the literature. Jenvald and Morin (2004) show how the recording of data during a training scenario come to play a central role in the debriefing, both in terms of a "after-action review" or playback of situations, and as a resource of data which may be analysed in a "diagram view" during the debriefing. The connection between the simulation design, cultural variation and patterns of communication may be represented by the following model:
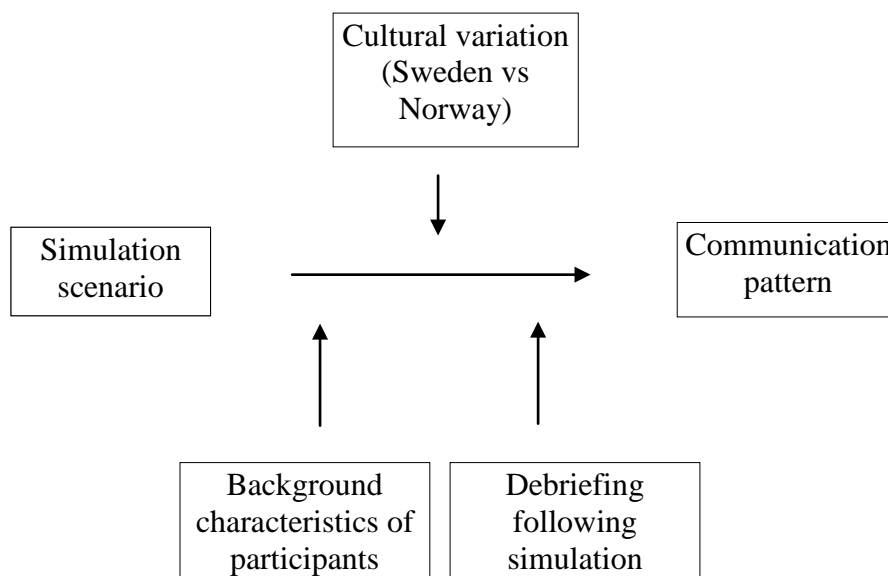

Figure 1: Model of interplay of simulation design, cultural variation and communication patterns.

The R Project for Statistical Computing (R-project, 2009a) is an open source statistical program used extensively in academic settings. R is ".. an integrated suite of software facilities for data manipulation, calculation and graphical display." The maintenance of the package is under the guidance of the R Foundation which includes major benefactors and supporting institutions providing necessary funds for updates of the R statistics package.

Documentation of the R statistical package is provided by a multitude of online material. The

Personality-project.org (2009) is an example of such online material, providing a comparison with SPSS/SAS.

The online material from the R-project now includes their own R Wiki (R-project, 2009b). The R Wiki provides links to the online R docucmentation manuals. The R Wiki presents 20 textbooks published in 2009 on the use of R in various settings, among them an introductory text by Zuur et. al. (2009).

Data acquisition from the tabletop exersise

The GSS project (Grenseoverskridende samarbeid for sikkerhet / Security Cooperation across Borders) is funded by Interreg and the European Regional Development Fund (ERDF) from 2010 – 2013, and provides emergency management training during computerized / table top exercises. The project is coordinated by the Mid Sweden University and Nord-Trøndelag University College, and includes external supporting partners in the local police, fire and ambulance emergency organizations. The project plans and implements leadership training exercises during May of each year from 2011 to 2013. In 2011 the emergency training simulation took place at Stiklestad May 18 and 19 during the annual meeting of the Border Rescue Council (Grenseredningsrådet).

The scenario for the 2011 emergency training event was that of a severe Winter storm during the New Year holiday in the border region between mid-Sweden and Mid-Norway. The scenario consisted of 13 emergency incidents/events of varied severity that was presented during a 3 hour simulation / role playing session. The participants gathered in two rooms at the Stiklestad hotel – a Swedish and a Norwegian room. The participants gathered around tables with their respective professional unit (police, fire, ambulance, county preparedness agencies, municipality officials and the Swedish 911 agency (SOSalarm).

Display 1: Police and municipality officials (Sweden)

A moderator in each of the two rooms guided the participants through the 4 hour training session, calling on the participants to respond to the various events presented on their computer laptops. A central database distributed the updates of the scenario under the control of a "master" moderator making sure that all participants had completed debate and recording of actions of communication and decisions made following an individual event. The participants recorded which rescue organization they wanted to contact regarding an exchange of information (requesting or providing information).

A given event during the simulation / role playing session would trigger an amount of discussion among the representatives of the various professional organizations participating. In that process, the participants would use the web-based computer simulation tool to indicate that they needed more information or wanted to share information with another rescue group – either in Norway or Sweden. Figure 2 displays the user interface for recording the exchange of information with other participant groups and decisions made during the discussion of a given event during the simulated emergency.

Each participant group recorded anywhere from zero to 6-8 information exchange actions during each of the 13 events of the simulated emergency. Thus it is an asymmetrical database in which some participants were very active while others recorded no or little exchange of information with other groups.

Figure 2 shows the interface of a participant, in which the text of the warning is presented, and a communications panel is available to share information or ask for information from other groups, as well as recording decisions made in the discussion following the event.

Figure 2. Simulated emergency: user interface for recording communication with others

In figure 2 the participant (police in Norway) requests information (1) from the police in Sweden. Optionally, the police may have offered information (2) to the county, Swedish 911 (SOSalarm) or other groups on either side of the border.
The interface also displayed the last 5 actions taken in this role.

Figure 3 shows the interface of the administrator (super-moderator) guiding the progress of the events of the simulated emergency situation. The cumulative number of messages transmitted is also presented to the administrator – her at the end of the simulation, at event 12.
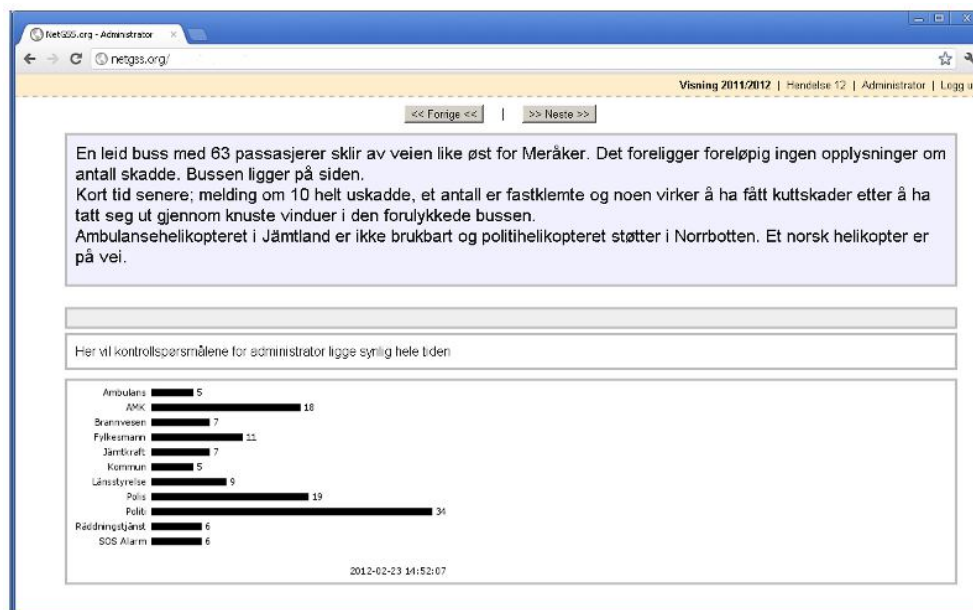
Figure 3. Simulated emergency event: user interface for administrator

In order to provide summaries of data from the simulation during the debriefing session taking place shortly after the completion of the emergency training session, the project used an open source statistics package (R Project) available on the simulation engine server. The data from the emergency management exercise was aggregated and prepared for graphical analysis using a sequence of programming tools (php programming and R statistics batch scripts).

Data analysis

The data analysis first presents a box-and-whiskers plot and an analysis of variance in order to visualize the differences between the various groups participating in the simulation.
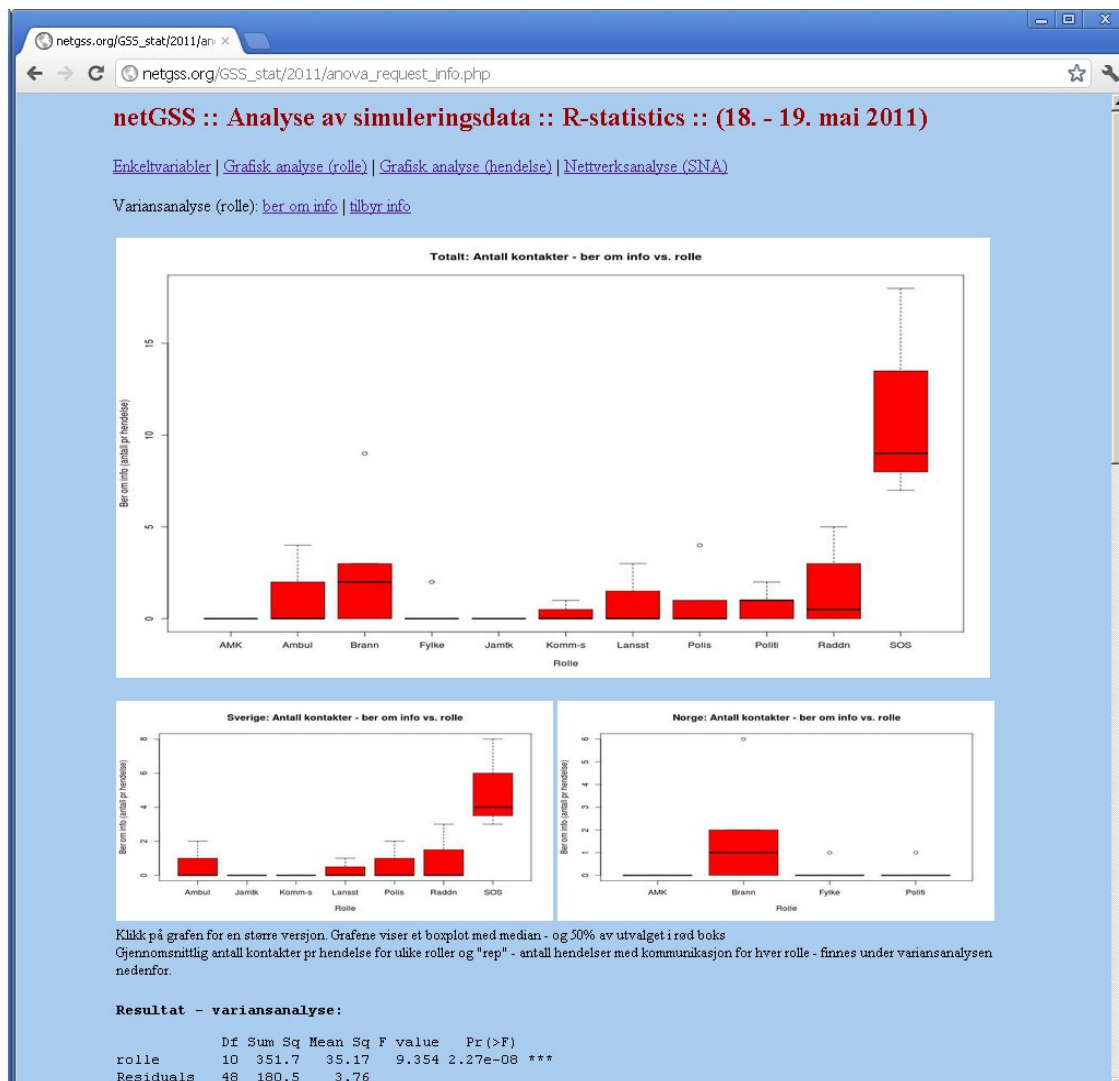
Figure 4. Frequency of communications by role (all participants at top, Swedish and Norwegian participants respectively, bottom graphs)

Figure 4 shows the box-and-whiskers plot and analysis of variance of the variable communication initiated by role in simulation. The emergency management exercise in May 2011 was not successful in convincing all participants to indicate who they wanted to communicate with – consequently there was little directed communication from AMK (ambulance), Jamtkraft (power company) and kommune (municipality).

The R command-driven language required for producing the graphs and statistical output in figure 4 is given in table 1, below:

```
sim_data <- read.table("gss_actions.txt",header=TRUE)
hendelse <- sim_data$Hendelse
rolle<- sim_data$Gruppe
land <- sim_data$Land

sim_agg <- aggregate(sim_data[,5:32], by=list(rolle,land,hendelse),FUN=sum)
sim_agg_sv <- subset(sim_agg, land=='Sverige', select=Group.1:xMedia, drop=TRUE)
sim_agg_no <- subset(sim_agg, land=="Norge", select=Group.1:xMedia, drop=TRUE)

anova.dat = aov(sum_ber_om_info~rolle)
summary(anova.dat)

jpeg("plot_anova_request_info.jpg", width=1000, height=700)
mai=c(1,1,1,0)
boxplot(sum_ber_om_info~rolle,xlab="Rolle",ylab="Ber om info (antall pr
hendelse)",data=sim_agg,main='Totalt: Antall kontakter - ber om info vs.
rolle',col=2,drop.unused.levels=TRUE)

dev.off()
```

Table 1: Set of commands in R statistics package for producing histograms in figure 4
(boxplot and analysis of variance).

The php language execution of the R statistics commands in table 2 is shown below with a
transfer (piping) of the univariate commands as a text file into the R statistics program
(located in /usr/bin/R), utilising the "plain vanilla" design of R (Jocker, 2009).

```
<?php
$exec_result = exec ("cat rC_anova_request_info.txt | /usr/bin/R --vanilla",$result,$error);
?>
<a href="plot_anova_request_info.jpg", target="_blank">
<img src="plot_anova_request_info.jpg" width=800 height=400></a>
<br>
<p>
<a href="plot_anova_request_info_sv.jpg", target="_blank">
<img src="plot_anova_request_info_sv.jpg" width=400 height=200></a>

<a href="plot_anova_request_info_no.jpg", target="_blank">
<img src="plot_anova_request_info_no.jpg" width=400 height=200></a>
<br><small>
<?php
print ('<pre>');
print ('<br><b>Resultat - variansanalyse:</b><p>');
for ($k=0; $k<=sizeof($result); $k++)
  {
    $result_line=$result[$k];
  }
?>
```

Table 2: Executing (in php) the set of commands in R statistics package in table 1 (displaying
figure 4)

The R-project statistics package was used to perform a Social Network Analysis (SNA) of the simulation data from May 2011. John Scott (1987) and Francesco Martino & Andrea Spoto (2006) provide a thorough review of Social Network Analysis, and the use of R-statistics for data analysis in general and for SNA analysis in particular is well documented (Ekker, 2009; Handcock et.al. 2008).

Here are the graphs from the SNA – figure 5 presenting the communication pattern early in the simulation, figure 6 presents the communication pattern mid-way in the simulation – and figure 7 the pattern towards the end of the simulation.
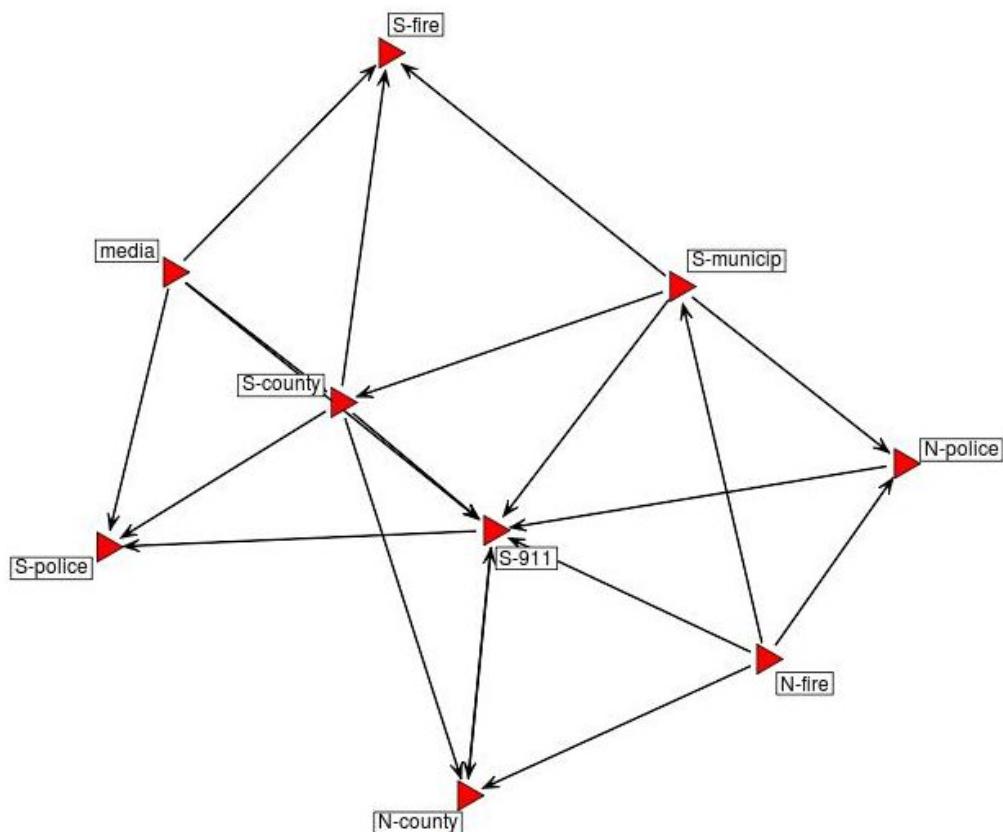

Figure 5. Communications (offering info) by role - early in simulation
(arrows point towards organization offering information)

In figure 5 we see that the S-911 (SOSalarm in Sweden) is a center of the graph as the organization with the largest number of communication messages offering information to other organizations in the early part of the simulation. Arrows point to the organization offering information to others, and an arrow pointing both directions – as in the S-911 and N-county communication in figure 5 indicates two communication messages between these two organizations. Table 3 shows that the proportion of messages crossing the border is 0,35 in the early part of the simulation (figure 5), 7 out of a total of 20 communication messages. The detailed matrix of communication patterns is found here:

Figure 6. Communications (offering info) by role – mid-way in simulation
    (arrows point towards organization offering information)

Figure 6 presents the communications pattern mid-way through the simulation, and at this point in the simulation it is the police in Norway (N-police) that is the center of the social network. Table 3 indicates an increase in the cross-border communications in this period, with a proportion of cross-border communications reaching 0,55, i.e. 6 out of a total of 11 communication messages targeted an organization across the border.
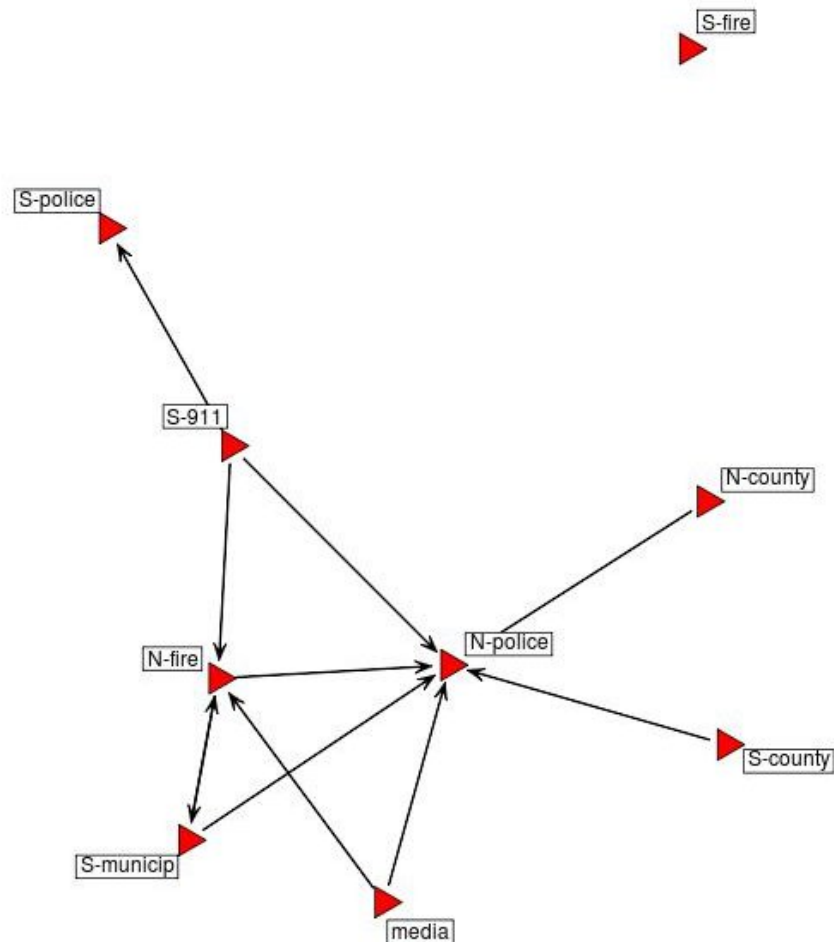
Figure 7. Communications (offering info) by role–towards end of simulation
(arrows point towards organization offering information)

In figure 7 we see that the Swedish SOSalarm (S-911) and the Norwegian fire department (N-fire) are the two centers of the social network graph towards the end of the simulation. The total number of communication messages have increased to 19, and the proportion of messages crossing the border is 0,42 – quite a bit lower than during the middle of the simulation when the proportion was 0,55 (table 3).

Early in simulation:			
	frequency	Total number:	20
Norway (internal communication):	2		
Sweden (internal communication):	11	Across border:	7
Norway – Sweden	4		
Sweden – Norway	3	Proportion across border:	0,35
Mid-way through simulation			
	frequency	Total number:	11
Norway (internal communication):	4		
Sweden (internal communication):	1	Across border:	6
Norway – Sweden	5		
Sweden – Norway	1	Proportion across border:	0,55
Towards the end of the simulation			
	frequency	Total number:	19
Norway (internal communication):	5		
Sweden (internal communication):	6	Across border:	8
Norway – Sweden	4		
Sweden – Norway	4	Proportion across border:	0,42

Table 3. Communication messages (offering info), total number and proportion across border (Source: GSS project output (R-statistics Social Network Analysis): http://netgss.org/GSS_stat/2011/eng/SNN_graph_give_segments.php)

Conclusion

The content of the messages during the early part of the simulation was of a more general nature regarding the threat of severe weather during the New Years weekend. The last message in this early part of the simulation was directed only to the Swedish participants, and informed of the closing of a major road on the Swedish side of the border. This may account for the large number of messages among the Swedish participants (11 contacts with other Swedish participants) compared to 2 among the Norwegian participants.

During the middle part of the simulation the messages became more directed, including a graphic presentation of a car stuck in a snowdrift and a cell phone message referring to a family seeking refuge in a cabin on the Swedish side of the border, while the phone message was picked up by Norwegian authorities. The last message during the middle part of the simulation included a cell phone emergency message from three individuals being lost in the mountains with injuries to one of the individuals. These messages produced fewer acts of communication among the participants, but more communication across the border (6 out of a total of 11 messages). The fact that messages from the Swedish side of the border were picked up by the Norwegian side may account for an increased proportion of messages (0,55) reaching across the border to participants in the neighboring country.

During the last part of the simulation, the messages presents an increasingly threatening situation in the border region. Temperatures are dropping, wet snow threatens the electric power grid and a bus with 63 passengers is in the ditch just west of the border and a helicopter from the power company has crashed on the Swedish side of the border. The number of messages between the emergency agencies within each country increases to a total of 19, but the proportion of messages across the border drops to 0,42 (table 3). At this point in the emergency simulation the events presented are more clearly delineated as being either on the Swedish or the Norwegian side of the border. As more information becomes available, the need for cross border communications is reduced - the emergency teams coordinate actions among themselves on either side of the border.

Literature

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