Executive Summary:

BACKGROUND: Whilst witnessing in recent years a range of disasters in Europe the following questions about human behavior in crisis situations gain importance: How do people react in an emergency, and does culture have an impact on emergency behavior? More significantly, could a better understanding of cultural response to crisis situations assist in developing better emergency procedures?

THE PROJECT: BESECU (Behavior, Security and Culture) was an investigation of cross-cultural differences of human behavior in crisis situations in order to better tailor security-related communication, instructions and procedures. The BESECU consortium includes researchers and SMEs, as well as first responder organisations from eight different countries.

METHODS: As part of the largest, multi-stage simultaneous field study on human response to crisis and evacuation, expert and survivor focus groups and a cross cultural field study with 1130 survivors and 3011 first responders were conducted in eight European countries with diverse cultural background. In addition as part of the experimental component of project BESECU three unannounced building evacuations were conducted in the Czech Republic, Turkey and Poland resulting in the generation of response phase data from 70, 51 and 192 people from each of the respective countries. This data was then compared with data from 104 individuals generated from a similar evacuation conducted previously in the UK.

RESULTS:

1. Study data enable analysis of whether culturally appropriate evacuation processes and security related communication are required.

2. Study showed where information of occupants is necessary.

3. Information about the situation itself is crucial for occupants in order to initiate an emergency response.

4. The study produced scientifically sound and cross-culturally validated instruments to assess human behavior in security-relevant crisis situations across cultures of survivors of disasters (BESECU-S)

5. The study produced scientifically sound and cross-culturally validated instruments to assess attitudes and reactions of first responders concerning individual communication with disaster survivors (BESECU-FR).

6. Two comprehensive evacuation model validation data sets were developed from the Turkish and Polish evacuation trials.

7. A set of behaviors and cognitions which are unique or differ across cultures was identified, however indices for cross-culturally differences were identified, e.g. in prevention knowledge and safety culture habits

8. The results from the experimental programme demonstrate that there are significant differences in response time distributions and differences in Response Phase parameters between all four populations.

9. BESECU has gathered first evidence on non-verbal communication by first responders.

CONCLUSIONS: The significant findings from BESECU will inform future research and developments that aim to improve communication and evacuation. The results from the BESECU evacuation trials suggest that the observed differences in human behavior are the result of cultural influences on Response Phase behavior. However, further work is required before a definitive link between social culture and evacuation behavior can be established.

Project Context and Objectives:

How will people from different cultures and societies respond to the call to evacuate and behave during an evacuation? Most field study data and experiments conducted in this area focus on subjects from the USA, Canada or Australia. It can be argued that these societies are quite similar with similar cultures. A Common perception is that differences in culture (both the social and fire cultures) influence response behaviors as well as response times. If that is true, it may have a profound impact on the way we plan procedures for large scale evacuation, understand and model human behavior. Furthermore it influences the applicability of existing models to different societies and cultures. The aim of the BESECU project was to investigate cross-cultural and ethnic differences of behavioral reactions in situations requiring evacuation, response times in evacuation and perceived experiences in different crisis situations in order to better tailor security related communication, instructions and procedures with a view to improving evacuation and protection. The central components of BESECU are two studies that ran parallel:

(A) A social scientific study across a wide range of target groups and types of crisis situations, and

(B) An experimental study on human behavior in evacuation of buildings.

These studies were both conceptually linked to each other as well as through a number of methodological steps.

Within the project the following objectives were achieved:

The first steps within the project were the identification of important stakeholders and the conduction of an expert review in each centre in order to identify research settings and scenarios. Furthermore national and international evidence in respect to human behavior in crisis situations was reviewed with a particular focus on evacuation behavior from a cross-cultural perspective in order to identify key components that needed to be addressed in the two research arms. An international workshop was held in order to receive feedback on the proposed conceptual framework.

Focus groups and face-to face interviews across all participating centers with 132 native and migrant survivors of different crisis situations and 54 emergency personnel (fire fighters, paramedics, physicians etc.) and key representatives (counselors, journalists, NGOs, politicians etc.) were conducted and analyzed.

The main objective of the research activity was to assess cultural differences in objective and subjective measures of human responses, and to develop evidence on human behaviour in crisis situations. A research tool to assess human response in different cultures as well as their application across cultures is a challenge for researchers. Cross-cultural research on human behavior in crises situation denotes an additional collaborative and comparative effort by using the same study approaches and measurement instruments across cultures. The BESECU group has taken the first international effort in this regard. In order to address these aims, two standardized international instruments have been developed on the basis of focus groups, interviews, expert consultations and literature research:

1. A cross-culturally developed and standardized instrument to assess human behaviour in security-relevant crisis situations across cultures of survivors of disasters (BESECU-S)

2. A cross-culturally developed and standardized instrument to assess attitudes and reactions of first responders concerning individual communication with disaster survivors (BESECU-FR).

BESECU-S assesses human behavior in different crisis situations across cultures and BESECU-FR was developed in order to assess attitudes and reactions of first responders. These two instruments were then pilot tested in order to determine feasibility, practicability, the difficulty of items and scales as well as their psychometric performance. Pilot data analyses and individual feedback of participants concerning the two instruments were integrated and produced the field study versions of the two BESECU instruments.

As a next step the field study in all eight European countries was conducted with people that experienced a domestic fire, a public fire, a flood, an earthquake or a terrorist attack as well as with fire fighters. Field study data were then analyzed in detail and tested for cross-cultural differences in both the experimental trial and the field study. Findings are evaluated in terms of end-user who might benefit from findings, and in terms of the implications of findings in specific areas. As a first result general recommendations for different type of end-users of research findings were established. In addition an educational module for professionals responsible in crisis situations was developed.

Furthermore communication guidelines for culture-sensitive communication regarding security interventions were derived from the results of field study and field trials. As another innovative research field, non-verbal signals were developed and tested as a communication standard in evacuation in a cross-cultural experiment. Experimental field trials with standardized settings were conducted in U.K., Poland, Czech Republic and Turkey. Objective measurements were made such as total response time and pre-evacuation time. Furthermore the evacuation behavior of the participants was video-taped.

The cross-cultural findings will be implemented in various settings on both a European and a national level. Findings will probably be embedded in the educational program of first responders (e.g. firefighters). Furthermore the results will be useful for designer of various building as well as designer of operating procedures of buildings and policy-makers.

To investigate potential cultural differences in human behavior in crisis situations, three unannounced evacuation experiments were undertaken in three European countries, Czech Republic, Poland and Turkey. The purpose of these experiments is to explore the differences and similarities in observed emergent behaviors (during the response phase) of the test populations under emergency evacuation situations. Thus the unannounced nature of these trials is essential as this will instil in the test population a feeling that this could be a real situation requiring evacuation.

In order to expand the set of useful data, the data derived from the BESECU trials is compared with data collected from an evacuation trial conducted in the UK by the Fire Safety Engineering Group (FSEG) of the University of Greenwich [9-11]. The FSEG trial was conducted in a university library building and so to maintain a basis for comparison, the BESECU trials are all conducted in university library buildings. There are a number of

advantages in using library buildings as the selected target structure for this cross-cultural study. These include:

- The nature of the target population found in university libraries is similar across different countries.

- The nature of university library buildings is similar across different countries.

- University library buildings are relatively straight forward to evacuate and do not involve any essential service or business disruption.

- As the library building is administered by a single authority, it is relatively easy to obtain permission to evacuate such buildings.

- There are fewer ethical issues as the target population is not generally considered at risk, vulnerable or involving minors.

- The project already has access to a UK data set for this type of building which can be used as a basis for comparison.

The research question addressed by these trials is, is it possible to identify similarities or differences between cultures in response to emergency evacuation situations. In order to investigate this issue, data was collected in several forms, including manual measurements with stop watches, video recording and post evacuation questionnaires. This range of data collection techniques enable:

- Objective measurements made through systematic analysis of video footage and manual measurements.

- Subjective experiences captured through post evacuation questionnaire analysis.

- Behavioral observations made through analysis of video footage.

The data derived from these various sources was then compared to identify similarities and differences in:

- The range of occupant response times.

- Nature (shape) of response time distributions.

- Type and frequency of response phase behaviors.

- Response to authority figures during response phase.

In addition, data suitable for the validation of evacuation models was collected from the trials. This involved:

- Full building evacuation data

- Component data such as: exit flow rates, crowd densities as a function of time, exit times, etc.

Cross-cultural findings are and will further be implemented on both a European and national level in various settings, including educational centers for first responders, designer of various building as well as designer of operating procedures of buildings and policy-makers.

Publication and dissemination of the field trial results of BESECU project more widely (through association with various European groups) in refereed journals, at conferences, to policy and service groups, and to users is has already happened and is still in process. The results are used to inform security policy and practice in relation to human behaviour in crisis situations and the development of security-related research and policy strategies within the European Community. With help of peer-reviewed publications and other dissemination activities BESECU results contribute to the knowledge base on human behaviour research.

Project Results:

The BESECU field study ended April 30th 2011 with a total of 4141 participants (1130 survivors and 3011 first responders). 594 survivors of a domestic fire, 180 survivors from a fire in a public building, 127 earthquake survivors, 175 flood survivors as well as 54 survivors of terroristic attacks could be included in the field study analysis. As a next step a detailed data analyses followed which provide information relating to cross-cultural comparisons, the impact of the type of disaster or other factors on behavioral responses. The next sections comprise the main findings of the field study and the experimental trials as reported in the corresponding deliverables.

3.1 Core Recommendations and applications for different types of End-user

1. Response time data for library buildings in Turkey, Poland, Czech Republic and UK

End-Users: Design engineers, Regulators.

The data collected for Turkey, Poland and the Czech Republic is the first of its kind. This data will be of great use to design engineers who have up until this time had to make assumptions for response time data for use in these type of structures. Response time data of any kind, for Turkey and Czech Republic has never been published prior to this work.

2. Cultural Component to Evacuation Behaviour.

End-Users: Design Engineers, Regulators, Model Developers, Evacuation Behaviour Research Community

Results from the 4 evacuation trials suggest that the response phase behaviour may be strongly culturally dependent. This has important implications to the Design Engineers and Regulators in so far as it suggests that evacuation data used to define evacuation scenarios may not be universally applicable i.e. data derived from trials in one country may not be strictly relevant for another country. This is also of importance to model developers who must be careful how they specify default data within their models. It is also of importance to the evacuation research community as it opens a new area of research and suggests that it is important to collect data from other countries.

3. Evacuation model validation data based on Turkey and Poland evacuation trials.

End-Users: Design engineers, Regulators, evacuation model developers.

Detailed evacuation model validation data was collected for the first time that provides precise information for model validation, detailing starting position, exits used and response times and exit time histories (Turkey data set) and detailed crowd densities and exit time histories (Poland data set). This data is unique and provides an excellent basis to perform detailed validation of evacuation models. This will be of great benefit to model developers who can assess their models for the first time, Regulators who will be able to assess the capability and accuracy of evacuation models and Design Engineers who will be able to better select appropriate evacuation models for their design applications.

4. Empirically based Response time predictive model.

End-Users: Design Engineers, Evacuation Behavior Research community.

An empirical model has been developed which can be used to predict mean response times. The model is based on key parameters which define a particular evacuation such as the average number and duration of likely Action and Information tasks undertaken by the participants. This model allows likely response times to be predicted and has been tested against results generated from the 4 evacuation trials. This is particularly useful for Design Engineers who can use the approach to produce meaningful estimates of likely response times for evacuation analysis. This is also useful for the human behaviour research community as it indicates key influencing factors which determine the response phase behavior within an evacuation.

3.1.1 Fire emergency recommendations

1. The knowledge level of the participants is not very high in general. The mean knowledge level regarding first aid knowledge and taking part in fire drills is estimated around 2-2,5 on a scale from 1 (not at all) to 5 (extremely). About 30 % had never participated in fire drills at school, and about 40 % had never participated in fire drills at work.

2. The results indicate that a higher level of previous knowledge, as well as a higher level of prior experience, leads to less strong negative feelings (nervous, scared, upset, and stressed) in an emergency situation. The results also indicate that people who have a higher level of previous knowledge regarding emergency situations experience a higher level of control in the emergency situation. These results show that knowledge as well as practical experience seems to help people stay calm and in control in an emergency situation.

3. The most common way to become aware of a domestic fire seems to be sensing environmental cues (such as smell and smoke), which alerted 90 % of the people who experienced a domestic fire. Noticing others reactions and being specifically informed by someone (most often family, friends or neighbors) alerted 70 % and 65 % respectively. These results mean that more than 30 % was not specifically informed about the incident by anyone.

4. However the majority, more that 80%, of the participants understood immediately that it was a fire. This is probably due to the fact that fire causes smoke and smell which in a normal situation can be perceived by most people.

5. About one fifth of the participants actively sought information when they understood that something was happening.

6. Quite a large percentage, 37 %, of the people experiencing a domestic fire would have needed more information to help them respond, though there were quite large differences between the countries. Most people needed information about what they should do. The nature of the incident, or the type of threat the incident posed to them. A majority would have needed this information from the emergency services.

7. A majority of the participants in this study, more than 70 %, communicated with the emergency services during the incident, and this communication is most often verbal.

8. The trust for medical service, police and fire service was a little lower after the incident than before, for the sample as a whole. However, there were variations between the countries. The reason for the difference in trust before and after the incident is not clear. The difference found in this study is however small.

3.1.2 Recommendations for emergency communication

(1) People should be given education, theoretical as well as practical (drills), on how to manage an emergency situation. Training programs, e.g. held by emergency services, should be given in schools, pre-schools and workplaces.

(2) People should be given the available information during an emergency. People have a need to know about what they are expected do, about the nature of the incident, and about the type of threat the incident pose to them.

3.1.3 Future prospects

Within the BESECU project an exploratory approach was used in order to get more knowledge on the communication and information as well as on behaviours, emotions, reactions and actions in an emergency situation in a cross cultural perspective. Few studies have been carried out in this area and more work is needed. Some suggestions for further work are:

(1) A study on how theoretical and practical emergency knowledge could be given to inhabitants in the best way, and what elements should be included in this education and training.

(2) A study on how to improve communication at the scene of the emergency to people involved in an emergency.

(3) Design of communication guidelines adapted to specific countries. This work could for example include guidelines on what can be applied as a standard across countries and also to identify if there are specific needs for certain countries.

3.2 Survivors

The following section gives an overview over the preliminary results of which the effects of socio demographic differences as well as other factors still needs to be determined. Table I shows prior experiences of the BESECU survivors in respect to emergency situations. There are small country difference effects regarding all incidents except for earthquake (medium effect). In total 41.1% of the BESECU participants had not experienced another incident before the one in question. Compared to the data of a representative study in Germany there are differences regarding domestic fire, flood and terrorist attack.

Compared to the data of a representative German study, there are also large differences in risk perception concerning all incidents between the BESECU Sample and the representative Sample. These differences might be a hind for the profound impact of disaster experience on risk perception with an elevated risk perception of people with prior disaster experiences.

 The graph shows the risk perception (in percent) depending on the number of prior experiences of the BESECU survivors. The red line represents all participants that experienced only one of the events in question and had not experienced any event before. The purple line on the other hand represents participants that experienced at least three of the events in question in their lifetime. Experiencing more than just one incident increases risk perception for becoming a victim in the future.

Prevention knowledge

 In respect to first aid knowledge Germany is leading with people in general having a little more than moderate knowledge in first aid which can help them in an emergency situation. People from Turkey seem to have more professional emergency knowledge and people from the U.K. have had many fire drills at work compared to people from Italy.

Initial interpretation of the event

Table II shows the percentages of a correct initial interpretation of the event depending on the presence or absence of environmental cues (e.g. unusual smell, power outage, explosion/vibration, smoke flames fire or rising water). If environmental cues are present more people interpret the situations fire, flood and earthquake correctly whereas the terrorist attack remains a very ambiguous situation for the initial interpretation.

Behavior at realization

Participants from Poland were more emotionally distressed by the incident than participants from Sweden or Germany.

People from Poland experienced a mean number of 2.49 symptoms during the incident whereas people from Sweden only experienced 1.15 symptoms. In a terrorist attack people tended to have more panic like symptoms than survivors who experienced a fire in a public building (2.84 vs. 1.13).

In total 51% used a specific exit because it was habit and they usually use this exit. Interestingly these results largely differ in respect to the incident itself. Table V displays these choices in respect to the different disasters. Using the exit because it is habit is the first choice in flood, earthquake and fire incidents. In terrorist attacks on the other hand more than 70% of all participants followed other people or were directed/forced into using a specific exit.

3.3 First Responders

A convenience sample of 3011 firefighters was drawn (Czech Republic [n = 302], Germany [n = 701], Italy [n = 623], Poland [n = 375], Spain [n = 163], Sweden [n = 181], Turkey [n = 468], UK [n = 198]).

In general fire fighters assessed that it is more likely that they will become a victim of a domestic fire while they are on duty compared to not on duty. The biggest difference between these estimates - on duty vs. not on duty - is in the Czech, Spanish and Turkish sample. In general the Turkish sample scored very high.

Additionally, in general fire fighters assessed that it is more likely that they will become a victim of a traffic accident while they are not on duty compared to on duty.

The last slide shows that Turkish fire fighters assessed the likelihood of becoming a victim of a terrorist attack very high compared to the other firefighters. The largest difference between the estimates - on duty vs. not on duty - is in the Italian sample.

They sometimes use body language and hand signals;often they communicate verbal face-to-face. The largest difference between the countries is in respect to Telecommunication (e.g.

phone calls). Italian, Spanish and Turkish fire fighters use more often Telecommunica-tions compared to for example German fire fighters.

3.4 Sign language

The Main School of Fire Service (SGSP) has done research on existing hand signals/non-verbal signs for communication. At present an actual application is rare. The goal of developing and establishing a set of signs/hand signals is an enhancement and possible improvement of communication between survivors and first responders independent of nationality or ethical background. A set of hand signals was elaborated and further analyzed. On that basis 16 hand signals were established as a way of non-verbal communication. In order to further test the applicability of these signals in a European survey, video films demonstrating these signs were produced.

The following 12 handsignals have been identified in the international survey to be understandable across cultures. 1. Stop; 2. Follow me; 3. Run, Hurry up; 4. Go this way; 5. Calm down; 6. Come to me; 7. Move back; 8. Crawl; 9. Jump down; 10. Lay on the floor; 11. Help me; 12. Do not do it

3.5 Experimental programme

The aim of the experimental component of project BESECU was to study how people react in an emergency, and to determine whether social culture impacts emergency behavior. As part of project BESECU, three unannounced library evacuations were conducted in the Czech Republic, Turkey and Poland. In addition, the data from these trials was compared with data generated from a similar evacuation conducted previously in the UK. The main purpose of these trials was to examine if social culture influences the manner in which people respond to the call to evacuate. Thus the experimental component of BESECU focused on the Response Phase of the evacuation process. A secondary aim of the experimental component of project BESECU was to develop evacuation data sets which may be useful to validate evacuation models.

(a) Czech Republic (b) Turkey (c) Poland

The three evacuations that were conducted as part of this project generated detailed Response Phase behaviors for 373 individuals. Combined with the data analysed from the UK evacuation, the Response Phase data set studied in BESECU comprised of 477 individuals, 192 from Poland, 51 from Turkey, 70 from the Czech Republic and 104 from the UK. Two comprehensive evacuation model validation data sets were also developed from the Turkish and Polish evacuation trials. The key developments and findings resulting from this work are set out below.

Response Phase Descriptive Framework

The comparative studies of evacuation behavior were based not simply on response times but on a framework, developed as part of project BESECU, to describe Response Phase behaviors. The framework not only provides a consistent method for describing Response Phase behavior, but also provides a systematic means for classifying and quantifying the Response Phase other than simply using the overall response time. By understanding and

quantifying the factors which influence and ultimately determine the Response Phase we are better able to compare and contrast different evacuation situations.

Based on the Response Phase Behavioral Framework, key parameters that define the Response Phase for each member of the population are:

-Response Time (sec).

-Notification Time (sec).

-Number of Action Tasks undertaken.

-Number of Information Tasks undertaken.

-Action Task duration (sec).

-Information Task duration (sec).

From these individual parameters a parameter set representative of the population as a whole can be determined by taking the average for each individual parameter. In this way the Response Phase for a particular evacuation can be defined by specifying the average duration of the Notification stage (NT), the average number of Action Tasks (AT) undertaken, the average number of Information Tasks (IT) undertaken, the average duration of an Action Task (ATT), the average duration of an Information and Task (ITT) and the average Response Time (RT).

For a common group of buildings and their populations defined by; building type, nature of notification system, population demographics and levels of population structural familiarity and training, the Response Phase parameter set (i.e. NT, AT, IT, ITT and ATT), and hence the response time distribution, can be expected to be similar for different examples within the group. However, if the Response Phase parameter set and hence the response time distribution are also dependent on culture, it is possible that the response time distributions and Response Phase parameter sets will be different even for buildings from the same group located in different countries.

In addition, the Response Phase Behavioral Framework provides an empirical means of predicting population average response time based on average number of Information/Action tasks, average task duration and average notification time.

Differences in Response Phase Behaviors

For the four library evacuations conducted in four different countries, differences were noted in the relative trends between Response Phase parameters (NAT, NIT, ATT, ITT and NT) defining the Response Phase parameter set.

Of the four countries, the UK (alarm only) population was the only one of the four national groups whose trends in Response Phase characteristics matches the trends of the national average population. These trends are that the population undertakes more Action than Information tasks and the average duration of an Information Task is greater than the average duration of an Action Task. The Polish and Czech (alarm only) populations match different

aspects of the average trend, with the Polish population matching trends in the number of tasks, while the Czech (alarm only) population matches trends in the average duration of the tasks. The Turkish population behaves in a way which is opposite to the national average trends.

Furthermore, trends in the number and duration of Response Phase tasks also differ between the national groups. Consider the country with the longest response times (Czech Republic) and the country with the shortest response times (Turkey). Virtually all the Response Phase parameters for the Czech (alarm only) group are greater than or significantly greater than the national group averages, indicating that this group will take considerably longer in the Response Phase than the national average, and is likely to have the longest response time. For the Turkish group, both the NT and the number of Action Tasks are smaller than the national average and the average duration of both Action and Information Tasks are less than the national group averages. This suggests that the Turkish population is likely to have a shorter Response Phase than the national average, and is likely to have the shortest Response Phase.

Differences in Response Time Distributions

Statistically significant differences (at the 5% level) were observed in the response time distributions for the four library evacuations conducted in four different countries.

The UK (alarm only) response time data is:

-quicker on average than the Czech Rep (alarm only) response time data.

-slower on average than the Poland response time data.

-slower on average than the Turkey response time data.

The Poland response time data is:

-quicker on average than the Czech Rep (alarm only) response time data.

-slower on average than the Turkey response time data.

The Turkey response time data is:

-quicker on average than the Czech Rep (alarm only) response time data.

On average, the population with the quickest to the slowest response times are: Turkey, Poland, UK and Czech Republic.

Is Response Phase Behaviour Dependent on Social Culture?

The response time distributions for each of the four libraries have been shown to be statistically significantly different. In addition, trends in and values of the Response Phase parameter sets for the four evacuations have been shown to be different. Furthermore, every effort was made to ensure that the conditions for each evacuation were as similar as possible. This is essential to ensure that as far as possible the main variable that may influence

evacuation performance is social cultural. As these trials were full-scale and unannounced, as opposed to laboratory based trials, it is virtually impossible to ensure that conditions are exactly identical in each trial. However, the age, gender and evacuation experience of each population was very similar.

The building type across all three trials was also identical (a library) so as to ensure that the population were involved in similar activities. To a certain extent this was achieved with the majority of people (over 69%) in each library involved in work related activities. However in one case (Polish library), a relatively small proportion of the population (a quarter) was involved in computer work related activities at the time of the alarm compared to the other populations (which had about a half). This may explain why the Polish population had the shortest average notification time. However, the Polish population did not have the shortest average response time and so the differences in the number of people engaged in computer work related activities is not considered significant. While only a single evacuation trial was conducted at each library, this is not considered to be significant as there is some evidence to suggest that response time distributions derived from one trial can be expected to be representative of the scenario (defined by building type, notification system and population) being considered. However, of more significance is the fact that a different notification system (alarm) was used it the UK trial compared to the other three trials. As the nature of the alarm system is expected to have a significant impact on the response time distribution, it can be argued that the UK data set should be excluded from the cross-cultural comparison.

Given that the parameters that influence Response Phase behavior and performance (e.g. population: level of familiarity and training, age distribution and gender mix and type of structure) were reasonably controlled, it is possible that the observed significant differences in response time distributions and the differences in Response Phase parameters are the result of cultural influences on Response Phase behavior. This conclusion is valid for the three BESECU libraries (Turkey, Czech Republic and Poland) and may also be valid for the fourth library (UK). Further work is required before a definitive link between social culture and evacuation behaviour can be established.

Impact of Different National Response Time Data on Evacuation

While the response time distributions for the four national groups have been shown to be statistically significantly different it is not clear what impact these differences would have on an evacuation simulation. In order to assess the impact of these different response time distributions they were each applied in turn to the Turkish library evacuation and the buildingEXODUS evacuation simulation software was used to gauge the impact these different response time distributions would have on the evacuation.

The four evacuation simulations produced using the four national response time distributions resulted in very different evacuation predictions. Even in the best case (comparing the Turkish prediction with the Polish prediction), differences in evacuation times can be between 2% to 28%. In the worst case, (comparing the Turkish prediction with the Czech prediction), differences in evacuation times can be as much as 66% to 93%. Thus if significant differences in national representative response time distributions exist, they can lead to very different

evacuation outcomes. It is thus important to ensure that the response time distribution used in computer egress simulations in different countries are representative of that national group.

Predictive Response Time Model

An empirical response time model, based on the Response Phase parameter set (NAT, NIT, ATT, ITT and NT) was developed and applied to the evacuation trial data. For four different evacuations in four different countries the predictive response time model was able to predict the measured average response time within: 1.6% in the Czech Republic evacuation trial, 11.3% in the Turkey evacuation trial, 3.0% in the Poland evacuation trial and 3.9% within the UK evacuation trial. The average error across all four trials is 5.0%.

Thus the constants used in the empirical response time model appear to be reasonably robust, providing a good level of agreement for four evacuation trials conducted in four different libraries in four different countries. Of more importance is the insight it provides into the behavioral factors driving the response time. Using this approach it should be possible to estimate the impact of introducing technical or procedural measures to address various behavioral determinants of response time such as the duration of the average Information Task, or the number of Information Tasks that are performed by a population.

Validation Data Sets

Two evacuation data sets, based on the Turkish and Polish library evacuations, suitable for the validation of evacuation models have been developed. The Turkish validation data set involves the evacuation of the entire library and consists of exit flow data for each of the two exits. The Polish validation data set involves a sub-set of the full library evacuation incorporating the portion of the library just in front of the library main exit, between the base of the main entrance stairs and the main exit and consists of exit flow data and the transient change in the population density just ahead of the exit.

Both validation data sets are unique in their own way. Unlike most evacuation model validation data sets, the Turkish data set incorporates regional information relating to the starting locations of the population and regional response times for the population. Most evacuation validation data sets lack these essential details allowing modellers the opportunity to tune their predictions in order to obtain the best fit to the experimental results. Furthermore, most evacuation model validation data sets only test model predictions of exit flows, whereas the Polish data set provides data describing the transient variation of population densities, allowing a more detailed analysis of model predictions.

The Turkish evacuation data set provides a comprehensive validation data set, uniquely including regional starting locations and response time distributions for the population, for a complex multi-floor building. As such, the data set is an important contribution to the development of evacuation models. The simulations of the Turkish evacuation using the buildingEXODUS software demonstrate that this evacuation modeling tool is capable of reproducing the measured results of the evacuation with a high degree of accuracy.

The Polish evacuation data provides a validation data set for evacuation models which includes transient density measurements along with the standard exit curve. While the geometry of the validation data set is small it uniquely provides a means of gauging the ability of evacuation simulation software to predict transient population density variations in the exit flow. As such, the data set is an important contribution to the development of evacuation models. The simulations of the Polish evacuation using the buildingEXODUS software demonstrate that this evacuation modeling tool is capable of reproducing the measured exiting times to within 5.8% and is capable of predicting the transient density variations to a good degree of accuracy. This indicates that the software is capable of resolving the crowd dynamics associated with congestion in the flow domain and the exiting behavior.

Observations Relating to the Response Phase

The detailed analysis of the BESECU and related evacuation data allowed a number of important observations to be made concerning evacuation behavior. These include:

-Average Response Phase behaviors

Taken across all four evacuations, on average university library populations:

-Have an average notification time of 10.4 s.

-Undertakes on average 4.2 Information Tasks.

-Undertakes on average 5.4 Action Tasks.

-Requires on average 6.4 s to complete an Action Task.

-Requires on average 7.1 s to complete an Information Task.

-Has an average response time of 79.6 s.

-Impact of pre-alarm activity on Notification Time

Across all four evacuation trials it was noted that occupants engaged in computer related work activities incur longer delays in disengaging from work related activities on the sounding of the alarm than those engaged in other types of work activities. Hence being engaged in computer activities may lead to longer notification times and hence longer response times. Notification times for those engaged in computer related work are between 14% and 175% longer than those involved in other work related activities.

-Alarm Vs Staff Intervention

In the Czech evacuation part of the population was exposed only to a voice alarm and part only to staff intervention. This provided a good opportunity to compare and contrast the response behaviors of the two populations. Compared to the staff intervention population, the alarm only population:

-Take 12.3X longer to disengage from their pre-alarm activities,

-Undertake 2.3X more tasks,

-Undertake 3.7X more Information Tasks and

-Take 1.5X longer in information exchange.

All of this explains why the alarm only population has an average response time 4.5X greater than the staff intervention population. The results for the Czech population confirm the commonly held belief that relative response times for populations exposed to staff intervention will be shorter than those exposed to an alarm only. However, it must be noted that the response times reported here do not include the time required for the staff member to respond to the alarm and travel to the population location. If these times are taken into consideration, the absolute response time for the population exposed to staff intervention may be greater than that for the population exposed only to the alarm.

-Alarm and Staff Intervention

In the UK evacuation some of the population was exposed to both the alarm and staff intervention. In such cases, staff intervention is intended to shorten the response phase of those individuals that may take excessive time responding. The staff intervention process achieves this by reducing the targeted occupants Notification stage or Activity stage or both stages. Evidence supporting this view was collected from the UK evacuation trial. In this trial the staff intervention population consisted of two distinct sub-groups.

The first sub-group had exceptionally long Notification times, the group effectively ignoring the alarm. However, this sub-group disengaged from their pre-alarm activities shortly after staff intervention. Clearly, this sub-group was intent on completing their pre-alarm activities. However, without staff intervention, these individuals may have incurred even longer Notification times. So staff intervention may have resulted in these individuals completing the Notification stage sooner than would otherwise have occurred. The response time for this sub-group was significantly longer than that for the alarm only group, but may have been even longer without the staff intervention. For this group, staff intervention potentially reduced what are exceptionally long Notification times from being even longer and reduced the duration of the Activity stage. Had the staff intervention occurred earlier, the notification time may have been even shorter.

The second sub-group had completed the Notification stage and commenced the Activity stage well before any staff members appeared. For this group the Notification time was extremely short and was not influenced by the staff intervention. However, this sub-group undertook more tasks during the Activity stage (10.7) than the alarm only population (8.8). It is possible that the staff intervention prevented even more tasks from being undertaken during the Activity Stage, preventing the Activity stage from taking even longer. The response time for this group was marginally longer than that for the alarm only group (92 sec). For this group, staff intervention potentially reduced the duration of the Activity stage.

- Group Behavior

From the Turkish and Polish evacuation, the response to the questionnaires suggests that when first alerted by the alarm about half the population were in groups of friends, a third

were alone and about a fifth were in groups of strangers. If you were in a group of friends prior to the alarm, it was likely that you evacuated in a group and that you exited in a group whereas if you were in a group of strangers, it is likely that you separated from the group and evacuated alone. Thus the bond between groups of friends is seen to be much stronger than the group bond between strangers during the evacuation. Furthermore, if you were alone prior to the alarm, you were very likely to evacuate alone. Clearly group behavior is an important aspect of evacuation and requires further research.

-How representative is a response time distribution derived from a single trial?

It is conjectured that repeat evacuation trials in a given structure with a different but similar population (i.e. a population that has similar demographics and key characteristics) will produce similar response time distributions. Evidence to support this view was presented from the EF FP7 SAFEGUARD project which involved two evacuation trials on a large passenger ferry involving a range of accommodation including; business and traveller class seating areas (airline style seating), large retail and restaurant/catering areas, bar areas, indoor and out-door general seating areas and general circulation spaces. The trials were conducted on two days with two different but similar populations. The two response time distributions were made up from 533 and 470 individual response times respectively. Mann-Whitney testing performed on the pair of data sets revealed that there is not a significant difference between the pair of response time distributions at the 5% significance level. As the response time distribution is a statistical construct - unlike the evacuation exit curve- it is more likely to be invariant with respect to repeat trials.

- The impact on validation simulations of uncertainties in occupant response time distributions and starting locations.

The sensitivity of evacuation model predictions with respect to uncertainties in occupant response times and starting locations was assessed using the Turkish library validation data set. This data set consisted of an unannounced evacuation from a two floor structure consisting of two staircases, two exits and 100 occupants. Analysis suggested that using a global rather than a local response time distribution can introduce sizeable discrepancies (between 2% and 22%) in the numerical predictions. Greater discrepancies (between 3% and 33%) are introduced when the starting locations of the agents are randomised and the global response time distributions are used. Perhaps of greater concern, by randomising the starting locations of the population within the simulation, the exits and hence exit paths taken by the agents are different to those in the evacuation experiment, and so even the evacuation dynamics within this simulation are potentially different to that of the experiment.

Furthermore, the differences in apparent accuracy of the predictions are generated by the same software tool simply by introducing uncertainties in the initial conditions. Thus it is possible to come to different conclusions on the suitability of the evacuation software in reproducing the trial data based on the quality of the initial scenario specification data. To truly gauge the ability of an evacuation model to accurately predict the outcome of an evacuation, validation data sets should include accurate information relating to the starting locations of the population and individual response time data, or at the least, regional response time and starting location data. Without this type of information uncertainties of between 3% and 33% or greater are possible even if the software is capable of producing perfect agreement with the experimental data.

- Impact of fire culture on evacuation performance

In the BESECU evacuation trials, the impact of fire culture on the outcome of Response Phase and evacuation performance was controlled, for the most part, through the intervention of the FSEG research team. However, in the event of a real emergency, the noted deficiencies in fire culture could be expected to adversely contribute to evacuation performance. Noted short comings in fire culture included:

-Failure of the alarm system to operate in the Czech trial. If regular testing was required by regulation and undertaken, this could have been avoided.

-Nature of the alarm message was too long and complex in the Czech trail. Regulatory guidance should be provided regarding the effective use of a voice alarm system.

-Exits were locked and chained shut in the Czech trial. Fire regulations should prevent exits from being unusable and fire safety inspections should detect when this occurs.

-No evacuation drill had ever been conducted in the Turkish library. Fire regulations should make some form of fire drills mandatory.

-The fire alarm had never been tested in the Turkish library. Fire regulations should make it mandatory to have regular tests of the fire alarm system.

-The alarm message was not in the native language of the building users in the Turkish library. Regulatory guidance should be provided regarding the effective use of a voice alarm system.

-There were no evacuation plans for the Turkish library. Fire regulations and safety regulations should make it mandatory for some form of emergency evacuation plans for public buildings.

-The emergency exit was locked and the emergency signage changed in the Turkish library. Fire regulations should prevent emergency exits from being unusable and fire safety inspections should detect when this occurs.

-In the Polish trial, while the emergency exits were well designed and positioned around the library, the immediate access area just outside some of the emergency exits were not appropriate. Building fire regulations should extend to the outside of the building and to the assembly of the occupants and fire safety inspections should enforce these regulations.

Potential Impact:

4.1 Impact within the project

The wider socio-economic impact is based on the fact that BESECU improves the understanding of evacuation from a cultural perspective. It is the first field study trial which was simultaneously cross-culturally designed and provides evidence for both cultural effects on the one hand and unique reactions which are invariant across cultures on the other hand. While we are able to quantify some of the response indicators, however, it is also the systematization of phenomena which is a core result in terms of future improvement of the understanding of first response by civil protection organizations.

In Germany, first responders from all 16 regions took part and were informed about the study. In the UK 52 different fire and rescue services confirmed their participation. First responders in Poland came from 14 out of 16 different regions, in the Czech Republic 12 out of 14 regions were reached and in Italy 18 out of 20 different geographical regions were included in the BESECU field study for first responders. In Turkey first responders from at least one province in each main region (i.e. Aegean Region, Black Sea Region, Central Anatolia, Eastern Anatolia Region, Marmara Region, Mediterranean Region and Southeastern Anatolia Region) took part in the field study. In Sweden 41 different rescue services from 28 different cities/regions contributed to the results of the field study whereas in Spain 9 out of 17 regions were addressed. All in all first responders in a great variety of different regions were involved and also eager for results and implementation of results. Main impacts for these different organizations are the following:

(1) Evacuation procedures can be improved on the basis of the findings of the BESECU evacuation trail. While at this stage it is difficult to quantify the long-term impact of the project, it is estimable that the impact will be considerable since new equations will go into evacuation procedure planning.

(2) Crowd managers and evacuation managers, as well as other first responders can integrate key findings into their educational programs. These results are shown in the deliverable (communication standards, education silent evacuation).

4.2 Examples for demonstrating long lasting impact

BESECU findings have a long lasting impact outside the project. In addition to the fact that-so far- BESECU findings have already been used in three European projects (and further will follow), most national partners have initiated activities that will directly impact first responders education as well as projects. Beyond to the education modules described in Deliverables, there are some national project activities which directly influence first responders work and consequently citizens. To give 1 example.

a) The project Rescue, Aid and Culture Project (Project full title: Intercultural Competence in Civil Protection) which is commissioned by the Federal Office of Civil Protection and Disaster Assistance (BBK) is one example. Within the project a large sample of people with emergency experience and migration background will be interviewed and surveyed. The focus will be on Turkish and Turkish-born and Russian-born /-speaking population. Main goal is the development of an intercultural curriculum for first responders which implements the experiences and needs of Migrants as well as non-Migrants.

In addition to that many further projects will be influenced by the results of the BESECU study.

4.3 Main dissemination activities and exploitation of results

The BESECU project involves researcher from different fields as well as end-users. All project partners were able to use different strategies in order to address different audiences. In addition to the interdisciplinary BESECU team, national and international experts from fields of security research and emergency evacuation supported the project as members of an international advisory group.

4.3.1 Civil society:

The main challenge in the BESECU study was to identify and contact people who experienced one of the crisis situations. In several kinds of crisis situations, the people involved were only transient 'occupants' (e.g. hotel guests, short-stay hospital patients, commuters) thus making them hard to trace. In order to reach a great number of possible participants, various strategies have been applied in the course of the study.

Web: One strategy to reach as many people as possible nationwide is the recruiting and informing civil society via online advertisement. A large variety of portals was including social media like Twitter or Facebook. A facebook page was created which included all relevant information about the project and a link to the BESECU website. Furthermore existing groups regarding relevant emergency situations have been linked to the BESECU page, so that people with these experiences were informed about the study. Besides the special groups regarding flood and fire other communities like university groups were used to inform a broad audience. By using this method more than 1000 people were informed about the project at once. Furthermore all partners provided a link on their website to the BESECU website. The BESECU website was updated continuously and available in all languages of each participating country. Furthermore the website enabled people to take part in the field study or provided contact information for each country.

Media:

Impressions from a BESECU workshop were broadcasted at a local German TV station. In addition radio interviews as well as TV interviews were held in the countries of different partners. Especially radio interviews or radio spotlights were broadcasted not just once but several times and therefore reached a broad audience from different fields.

Press-releases:

Short articles or calls were published in regional, local and national newspapers. Especially in areas affected by flooding or earthquakes announcements in local gazettes published by the citizen office were one very effective way to reach the inhabitants.

4.3.2 Scientific Community, Research:

Publications:

In order to reach and inform the scientific audience numerous publication activities took place in the course of the project. The following six scientific articles have already been published in scientific journals and books:

1. Schmidt, S., Knuth, D., & Doris, K. (2011). Human behavior in crisis situations: A field study of firefighters and survivors across different types of disaster situations. In W. Jasklowski and P. Kepka (Eds.), Emergency Evacuation Behavior of people from buildings. Warszawa: BEL Studio.

2. Preiss, M., Sotolarova, M., & Holubova, M. (2011). Trauma and Stress in 6 Years After Floods in 2002 - Experiences From the Focus Groups. Psychiatrie, 15(2), 64 - 70.

3. Kepka, P. (2011). Non-verbal evacuation - to provide efficient evacuation of people. In W. Jasklowski & P. Kepka (Eds.), Emergency Evacuation Behavior of people from buildings. Warszawa: BEL Studio.

4. Galea, E. R., Sauter, M., Deere, S. J., & Filippidis, L. (2011). Investigating the Impact of Culture on Evacuation Behavior - A Turkish Data-Set. Fire Safety Science 10, 709 - 722.

5. Freitag, S., Grimm, A., & Schmidt, S. (2011). Talking about traumatic events - A cross-cultural investigation. Europe's Journal of Psychology, 7(1), 40-61.

6. Galea, E. R., Deere, S., Sharp, G., Filippidis, L., & Hulse, L. (2010). Investigating the Impact of Culture on Evacuation Behavior. Paper presented at the 12th International Fire Science & Engineering Conference, University of Nottingham.

In addition seven articles have already been submitted to peer-reviewed journals:

7. Prati, G., Pietrantoni, L., Saccinto, E., Kehl, D., Knuth, D., & Schmidt, S. Risk perception of different emergency situations in a sample of European firefighters

8. Knuth, D., Kehl, D., Galea, E., Hulse, L., Sans, J., Valles, L., et al. Development of the BESECU-S - A self-report instrument for survivors of emergency situations.

9. Kehl, D., Knuth, D., Galea, E., Hulse, L., Sans, J., Valles, L., et al. Development of the BESECU-FR - A self-report questionnaire for firefighters

10. Kehl, D., Knuth, D., Hulse, L., & Schmidt, S.. Predictors of symptomatic stress reactions and posttraumatic growth among fire fighters after work-related critical emergencies - a cross cultural study

11. Knuth, D., Kehl, D., Spangenberg, L., Hulse, L., Brahler, E., Schmidt S. Risk perception and disaster experience: comparing a representative German sample with German disaster survivors.

12. Grimm, A., Hulse, L., & Schmidt, S. Cross-cultural pilot study on peritraumatic emotions, perceived threat and control beliefs in disasters

13. Grimm, A., Hulse, L., Preiss, M., & Schmidt, S. Behavioural, emotional and cognitive responses in European disasters: Results of survivor interviews

Further publications regarding risk perceptions, posttraumatic stress and posttraumatic growth of fire fighter and survivors, the developed evacuation sign language and numerous other topics will follow. Further national and international comparisons will be realized in cooperation with each partner.

Web, conferences and seminars:

The official website of BESECU also served as the main contact point for scientific community. In addition numerous psychology websites and universities were contacted and included information about the BESECU study on their website. An important way to disseminate information and first results of the BESECU study are presentations and conferences. I many cases these approaches did not only reach the scientific community but also several end-users and fire fighters. Speeches were held at European Congress on Civil Protection and Disaster Management in 2009 and 2010, the International Scientific and Technical Conference "Emergency Evacuation of People from Buildings" (EMEVAC) in 2011, the 12th international Interflam conference on fire science and engineering and the Conference "Normativa de Prevenció I Protecció d'Accidents in 2011. At the universities of Greifswald, Greenwich and Bologna the BESECU study was also part of various seminars and lectures. Further seminars and lectures were held during security research meetings within the business sector and safety networks.

4.3.3 End-users, First responders, Fire safety Professionals:

The aim of the BESECU study was to provide an evidence base that is useful on a national and European agenda. It is important that research and research results are available for end-users as well. Therefore first responders and end-users were another audience that was the target of dissemination activities.

BESECU has included end-users not only in the consortium but also in the international advisory group. In the process of recruitment a great variety of recruitment strategies was used in order to inform first responders about the study and its goals.

Direct contact:

The most commonly strategy used in all countries was direct contact with fire stations. Therefore personal visits, emailing and calling of regional, provincial and volunteer fire brigades and fire departments were carried out. In addition small presentations and seminars were carried out.

The map illustrates the regions of first brigades which actively supported the BESECU study by taking part in the field study.

As can be seen in the map, the BESECU consortium was able to reach first responders in all eight European countries and in numerous regions of each individual country.

The online availability of the questionnaire and the BESECU homepage led to an overwhelming number of interested persons. 4928 persons visited the page of the questionnaire within the 10 months.

Web:

Due to the fact that many fire brigades also have a website or even a Facebook page, the dissemination activities were enlarged. The BESECU project was announced on numerous first responder websites, newsletter, pages and special forums. The announcements included information about the project, information about the people we are looking for, a link of the BESECU website and therefore to the online questionnaires and contact details (e.g. Name, address, telephone number and email address). In addition all project partners included information about the BESECU study on their website.

Presentations and press-releases:

Additionally to the online presence of the BESECU study, announcements were also published in fire fighter magazines and newsletter. Furthermore presentations at the fire station were held in order to inform first responders and give them the possibility to ask questions about the study. In this context information sessions were also held with fire fighter trainers as well as psychologists of the rescue service.

List of Websites:

http://www.besecu.de

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