SAFEGUARD
THE NEWSLETTER

Issue: 1, June 2011

WELCOME TO SAFEGUARD: THE NEWSLETTER

We report on project progress ...

Jenny Gyngell,
BMT Group Ltd

Do we really know that a ship can safely evacuate passengers in an emergency? Can we be certain that the software on the market to test ship evacuation is realistic?

Passenger response time data is fundamental to ship based evacuation analysis and is a key parameter specified in the IMO protocol MSC Circ 1033 and its successor MSC Circ 1238. But research conducted under the EU project FIRE EXIT (G3RD-CT-2002-00824), concluded that the response time data currently used in MSC Circ 1033 was not robust enough to accurately represent what really happens. That, in turn, meant it was not a suitable basis for use in evacuation simulation programs to validate protocols.

The SAFEGUARD project is a major exercise to collect human performance data in full scale ship trials,providing the evidence for calibration and validation data of ship based evacuation models. It's also investigating additional benchmark scenarios to be used in certification analysis.

A large corpus of sea based data on passenger response times is being acquired as well as assembly times during ship evacuations; all of which is of a sufficient size and richness to calibrate response time distributions and validate assembly process evacuation models.

Our main objective is to provide strong, sound data to serve as the basis for improved evacuation analysis protocols beyond MSC Circ 1238.

**For more information on the SAFEGUARD project please contact Mrs Jenny Gyngell,
Senior Project Manager – BMT Group Ltd
safeguard-PM@bmtproject.net
or visit the project website
www.safeguardproject.info**

MOST COMPREHENSIVE PASSENGER EVACUATION DATA EVER COLLECTED

Professor Ed Galea of the University of Greenwich's Fire Safety Engineering Group, tells the story of three passenger ships, five semi unannounced assembly trials at sea, 5,600 passengers successfully and safely assembled, 5,000 infra-red tags issued, plus 100 Gb of video data and information from over 3,000 passenger questionnaires which collected the most comprehensive passenger evacuation data ever. This is project SAFEGUARD!

The data underpinning IMO MSC Circ 1238, relating to current international ship evacuation analysis guidelines, needs improving and the SAFEGUARD project is designed to amass sufficient analysis of passenger behaviour to do just that. Passenger ship evacuation modelling also lacks a comprehensive data set with which to test and validate ship based evacuation models.

The Fire Safety Engineering Group (FSEG) of the University of Greenwich, in collaboration with Marine Institute's Offshore Safety and Survival Centre (OSSC) and the SAFEGUARD consortium, has conducted five full-scale semi-unannounced assembly trials at sea. These trials used the largest number of people ever put together to monitor behaviour patterns in a detailed and systematic way. 4,308 passengers out of a total of 5,594 passengers actively took part in them.

Three ships of different designs were selected to generate differing passenger response behaviours. The Royal Caribbean International vessel, "Jewel of the Seas" was the first and that trial, involving 2,304 passengers alone, made it the largest fully monitored assembly trial ever conducted at sea. The other two chosen were the ColorLine RO-PAX SuperSpeed 1, without passenger cabins, and the Minoan Lines RO-PAX Olympia Palace, with these. >> ***Continues on pages 2-3***

Figure 2 – The Minoan 'Olympia Palace'

Figure 3 – The Royal Caribbean 'Jewel of the Sea'

Figure 4a - Mounting equipment with camera

MOST COMPREHENSIVE PASSENGER EVACUATION DATA EVER COLLECTED

Continued from
Front page >>

Each trial collected three data sets. The first was passenger response time, recorded on video cameras positioned throughout each vessel. An innovative network of Infra-Red (IR) beacons, positioned throughout each vessel, and IR tags worn by each passenger was the second collating validation data about starting locations of passengers, arrival time at the designated assembly areas and the paths they took to get from one to the other.

Lastly, in a specially designed questionnaire, we sought more information from the passengers, following the evacuation exercise, to help us analyse behavioural traits.

DATA ON FILM

Video cameras were used to record passenger response to the call to assemble (see figure 4). A total of 80 hours of video footage was collected over the five trials from 246 video cameras, generating a massive 100 Gb of video data. A team of three research staff from FSEG and OSSC are busy analyzing this data, generating response time data for the three different types of vessel. This will be taken to suggest improved passenger response time distributions for use in computer based evacuation modelling of the type conducted using the current IMO MSC Circ 1238 guidelines.

In addition to the video data, a comprehensive set of passenger movement data was collected from each trial. This was collected using a novel Infra Red (IR) tracking technology developed as part of project SAFEGUARD (see Newsletter 1 for details). The passenger ship evacuation modelling community lacks a comprehensive data set with which they can test and validate ship based evacuation models. Part of the difficulty is that the ship assembly process is complicated, in turn resulting in complex routes passengers take as they move to the assembly stations. Unlike in the built environment, where the movement of people is essentially unidirectional, onboard ships passengers can move down to the assembly station or up to one and there can be any number of assembly stations distributed throughout the vessel, potentially on more than one deck. Also, passengers can come from any part of the vessel, from cabins, bars, restaurants, shops, casinos, swimming pools, cinemas, outer decks, etc. This makes identifying starting locations and routes taken by individuals extremely difficult. Furthermore, use of video cameras, the standard method of recording movement of people in evacuation research, requires the use of dozens of video cameras.

Figure 5 - IR field generating beacon (top) and IR logging tag (bottom)

Figure 4b - Example video camera mounting location

Passengers during the assembly trials

Passengers on the SuperSpeed during the assembly trial clearly wearing their IR tags. Passengers on the Jewel of the Seas during the assembly trial clearly wearing their IR tags

Passengers on the Olympia Palace during the assembly trial, walking along corridors and entering the assembly station, all clearly wearing their IR tags.

"The wealth of data that has been collected is being analysed and will eventually contribute to improving safety at sea."

Furthermore, tracking the movement of hundreds or thousands of people across these is an extremely difficult, if not impossible task. In an attempt to address this problem FSEG and OSSC have developed IR tracking technology in collaboration with the RFID Centre Ltd UK.

TAGGED

The system relies on the passengers agreeing to wear an IR tag (see Figure 5) for the purposes of the trial. As the trial may take place at any time, the passengers must be prepared to wear the tag for an extended period (possibly all day/night) and so it must not interfere with normal activities, be comfortable, and, if possible, blend in with their normal attire. A number of IR beacons are setup at key locations throughout the vessel.

As a tagged passenger passes through the field, IR light sensors in the tag detect the IR light and log its ID and the time at which it was detected in the tag's own internal memory. Following the test, tags must be retrieved, and using software developed by FSEG, the passenger's route from their starting location to the assembly station can be determined. In addition to the actual route taken, the time they left their starting location, the time they arrived at the assembly station and the time they crossed other key locations enroute can be determined. Using this information a comprehensive data set can be assembled describing the details of the assembly process which can be used for evacuation model validation purposes. Across the five trials, some 5039 IR tags were distributed and 338 (7%) were lost. The largest single trial involved 2304 IR tags.

The first validation dataset, based on the SuperSpeed trials, has been assembled and is currently being used to test three of the leading ship evacuation software tools; *maritimeEXODUS, EVI* and *ODIGO*. It is hoped that two more validation datasets will be produced from the data collected.

It is intended that these validation datasets will be incorporated within an updated version of IMO MSC Circ 1238 guidelines, allowing the accuracy of ship based evacuation models to be assessed for the first time.

QUALITATIVE QUESTIONNAIRES

Finally, a passenger questionnaire, developed by FSEG and OSSC, was used to capture key aspects of the passengers' behaviour that could not be identified via the video cameras or the IR system. 24 questions provided information regarding the demographics of the passengers, their familiarity with the vessel and their experience of other assembly exercises. In particular, the questionnaire allows participants to describe what they did and why, as well as helping identify where passengers were when the alarm sounded and how they reacted to it. Questions also probe whether or not the participants knew what to do, where to go and how they navigated towards the assembly stations. In total, some 3648 questionnaires, produced in six languages, were completed, 85% of the number distributed. English, German, Norwegian (SuperSpeed trials), English, Spanish (Jewel of the Seas trial) and English, Greek, Italian, German (Minoan trials) were the languages used to cover all likely participants in the trial ships.

Now that the trials have been successfully completed, the second phase of the project begins in earnest. The wealth of data that has been collected is being analysed and will eventually contribute to improving safety at sea.

Figure 8 - Paths taken by three passengers during the SuperSpeed trial recreated using IR tag information

Evacuation Analysis

By Antoine Breuillard, Bureau Veritas, Marine Division, Research Department

As its part in the project, Bureau Veritas has been analysing past accidents. The research included quantitative study of accident databases and qualitative assessment of accident reports and professional mariners' feedback.

CAUSES OF ABANDONMENT

Casualty Basic Retrieval Group	*Abandon at sea (by any means)*	*Disembark at berth*	*Total*
Collision	1%	10%	11%
Contact	2%	11%	13%
Fire / Explosion	12%	13%	25%
Foundered	4%	0%	4%
Hull / Machinery damage	2%	15%	17%
Wrecked / Stranded	21%	8%	30%
Total	**45%**	**55%**	**100%**

As its part in the project, Bureau Veritas has been analysing past accidents. The research included quantitative study of accident databases and qualitative assessment of accident reports and professional mariners' feedback. For the quantitative study, 135 relevant accidents from over the past 10 years were studied. Factors to emerge included that 20% of evacuations happened in listing conditions and 12% with smoke having spread in the ship super-structure. 50% of abandonments were at sea, the other 50% took place in port (of origin, destination, or transit). One third of these disembarkations at berth probably happened in hazardous conditions.

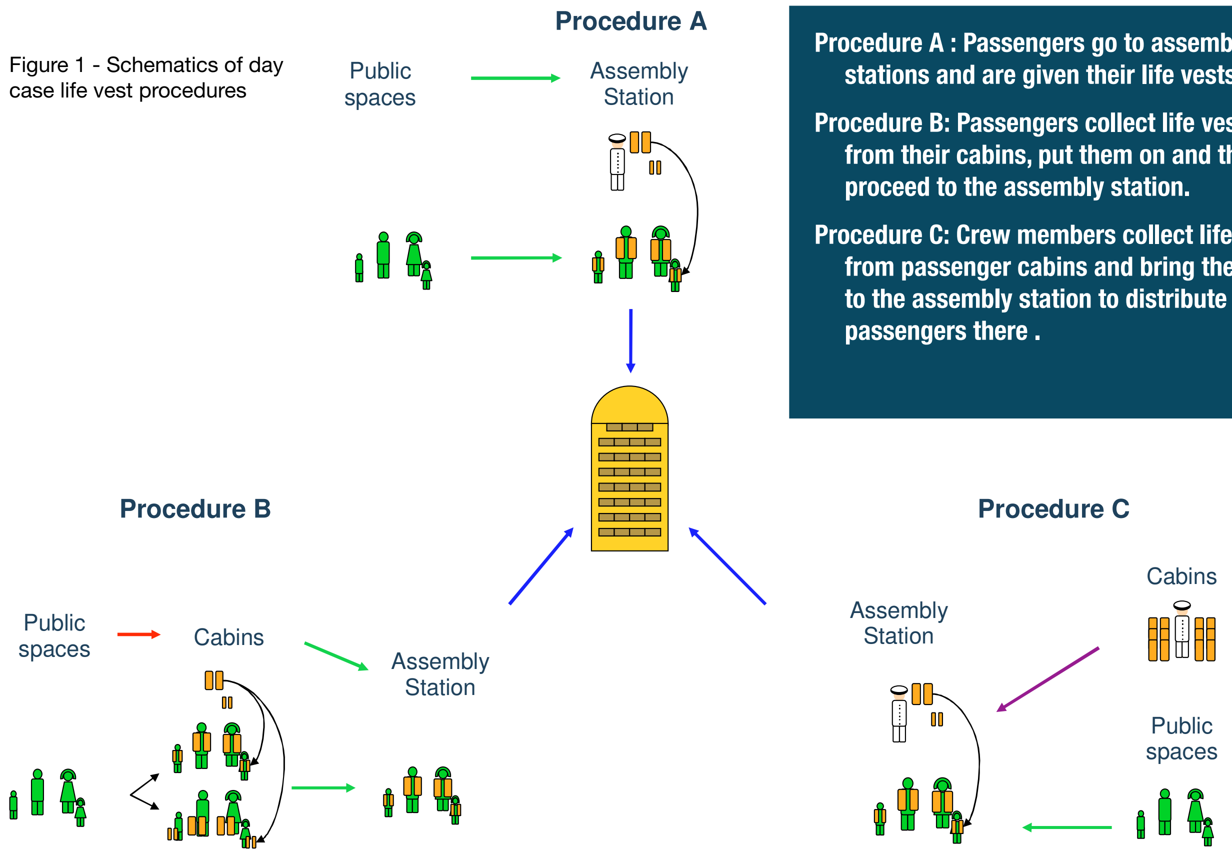

Figure 1 - Schematics of day case life vest procedures

Procedure A : Passengers go to assembly stations and are given their life vests there

Procedure B: Passengers collect life vests from their cabins, put them on and then proceed to the assembly station.

Procedure C: Crew members collect life vests from passenger cabins and bring them to the assembly station to distribute to passengers there .

ENHANCED SCENARIOS

AAccident reports and testimonies also provided excellent details on past incidents. It revealed, for example that in addition to accidents, passenger assembly occurs for 'man overboard' or security alerts as well.

From a procedural point of view we highlighted that the evacuation process on Ro-pax and cruise ships differ and we showed the impact on the different phases of an evacuation process. Another factor to emerge was that the evacuation procedures on cruise ships can vary considerably from one ship to another. This information was gathered to identify areas for improvement and then specialist knowledge applied to recommend safety enhancements to tackle these. Recommendations were also made for advanced evacuation calculation methods. We discussed whether our proposals should take into account that Circ 1238 is used for purposes other than standard evacuation, such as alternative design for fire safety and alternative design for life saving appliances.

We have listed current evacuation scenarios but added other possible alternatives to be considered. Our initial study looked at the enhancement of existing cases.

- Adding Congestion as a performance criterion.
- Locating some passengers on public open decks for day cases.
- Realigning existing cases 3 and 4 so that they would now be consistent with the Safe Return to Port concept where the casualty threshold is exceeded in some critical main vertical zones (MVZ).

These critical zones would be the longest to evacuate and the most populated. Our view is that only these worst case scenarios should be evaluated in degraded conditions. These would be evacuated using secondary routes, and with people redirected to assembly stations other than those in the damaged MVZ. This would enable us to evaluate the flexibility of evacuation routes throughout the ship.

We also included one additional case:

- Setting up a hybrid of night and day cases where 50% of passengers are in cabins and 50% in public area. This can then be tested to see how it compares to the current day and night case. We can then identify possible cross flows that might happen in a hybrid case.

FURTHER RESEARCH

We have also identified four areas needing further research as data is not yet available to make recommendations to modify the Circular. These are:

- Establishing a disembarkation to shore case where people start from the assembly station and evacuate through gangways/ footbridge. We do not have sufficient date to model flows on gangways or footbridges.
- Simulating life vest recovery in the day case for cruise ships Models for life vest recovery procedures are presented above (see figure 1) but while they cover all the known procedures onboard, not enough information is available about the time taken to find and put on lifejackets. Neither do we know enough about how muchwearing a life jacket slows people down during evacuation.
- Finding more demographic data specific to Ro-pax. The current population's composition assumed in the MSC/Circ.1238 is shown in Figure 2.
- Establishing a complete evacuation performance standard including abandonment. This case has been developed in SAFEGUARD. Our proposals would keep the methodology for analysing just the assembly phase, as set out in the current circular, within a timescale of a 30 minutes abandonment. Now we have identified additional features for designers to include when calculating abandonment times. This includes grouping at the assembly station, the time taken for passengers to travel from the assembly station to the embarkation points, and the embarkation time in the lifecrafts. This will require defining of new time variables for individuals (grouping, travelling to embarkation, embarking and launching) so that the whole procedure onboard can be modelled. In this way different options of evacuation strategies can be selected by the designer and the owner (in Figure 3 the procedure waits the captain signal before sending groups to embarkation, in Figure 4 the procedure allows the survival craft groups to go to embarkations immediately after having been constituted).

The methodology needs several 'allocation' tables to map where people or groups of people ought to go during the different phases of evacuation. The performance standard for the current circular is 60 or 80 minutes However, more data is necessary to model the group behaviour over all phases of evacuation.

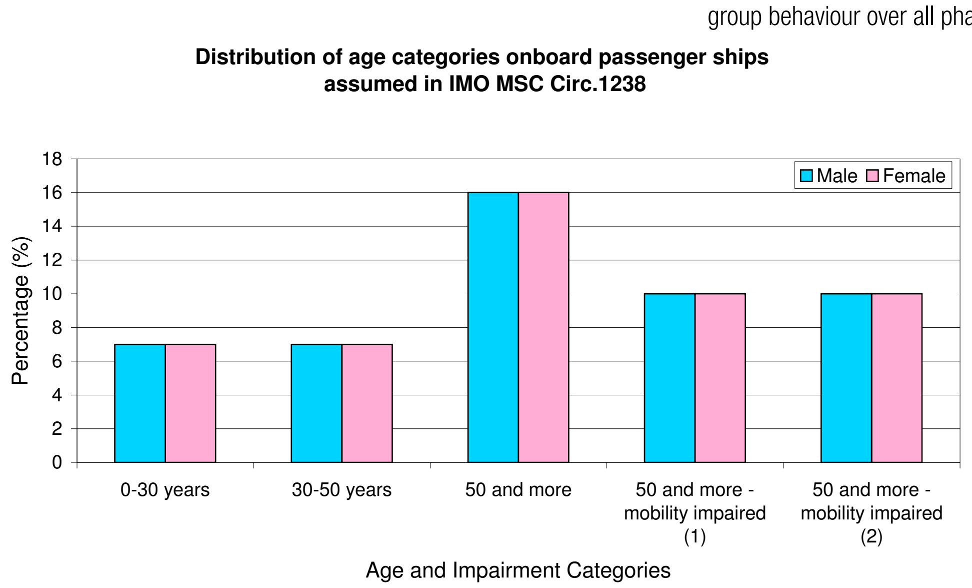

Figure 2 - Current Population's composition (age and impairment) in the MSC/Circ.1238

SCENARIO TESTING

Most of these enhanced scenarios and additional scenarios are currently being developed and tested in a work package lead by S@S and in which BMT, BV, PRINCIPIA, S@S and UoG are involved. Final recommendations will be made to IMO in an information paper next year.

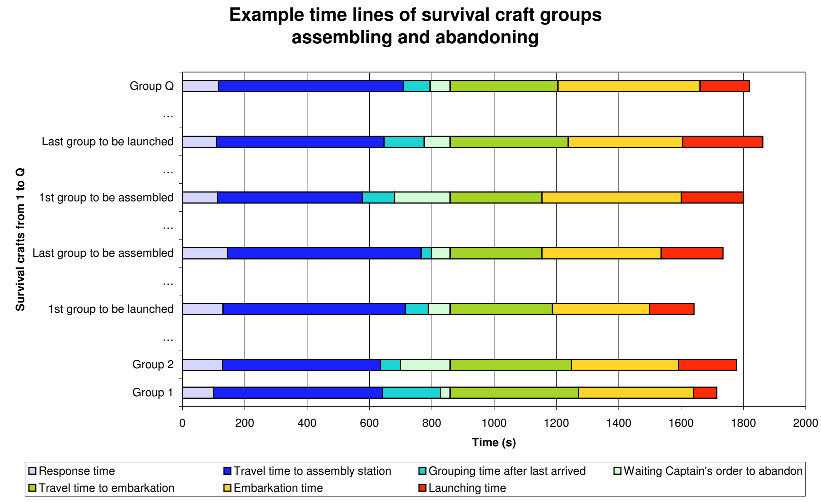

Figure 3 - Example time line of survival craft groups assembling and abandoning after Captain's signal (at t=860 s)

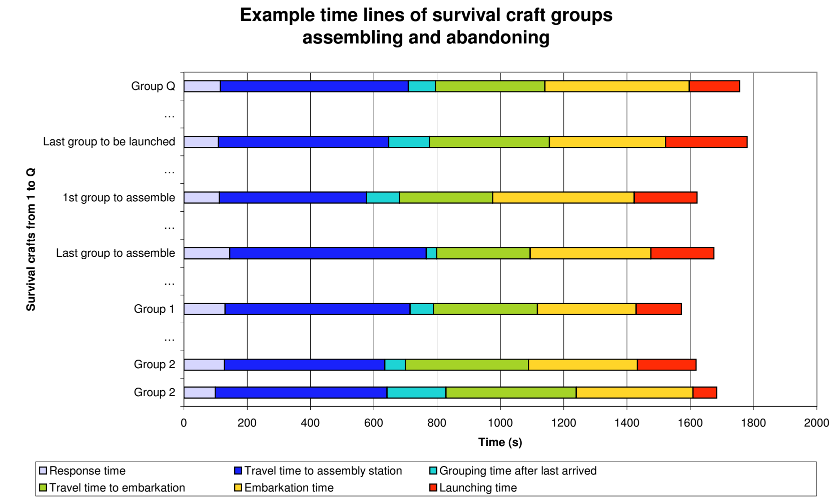

Figure 4 - Example time line of survival craft groups assembling and abandoning immediately. Same segments as in Figure 3 : No interaction with assembly phase, eg if routes are independent.

The SAFEGUARD Heel Case

By Ian Nicholls, Safety at Sea Ltd (S@S)

Currently heel and its effect is not explicitly considered in the IMO Guidelines for Evacuation Analysis. Working with partners on the SAFEGUARD team, S@S was tasked to explore the possibility of additional benchmark scenarios relating to heel.

During an evacuation, heel is often only one of numerous issues that may affect the behaviour of the ship's occupants and the ship itself. To ensure all aspects were considered comprehensively, a review of 109 accidents related to flooding events (e.g. collisions, groundings, water ingress) and involving over 150 vessels was undertaken. From this casualty data, the resulting extent of heel, trim, vessel motions, flooding extent, non – availability of systems, and blackout was evaluated.

As a result of this work, some of the flooding effects identified could be discounted; one example of this being the extent of flooding, which was found not to have any significant impact on occupants during evacuations following flooding due to collisions and/or groundings. In such cases, flooding rarely extends above the bulkhead deck - the highest continuous deck the watertight subdivision extents to. Therefore the main escape routes and assembly stations for passengers are not affected.

REVIEWING LEGISLATION

Subsequently, a review of relevant statutory legislation was undertaken. Aspects of SOLAS Chapter II deal, in part with electrical installation; within this, Regulation 42 requires emergency lighting to be available and that muster and embarkation areas are sufficiently lit for 36 hours to enable abandonment. Regulations within SOLAS chapter III, dealing with provision for stowage and launching of survival craft, among other items, require vessels to be able to be abandoned with a heel angle of up to 20° and a trim angle of up to 10°. EC regulations (EC Directive 2009/45/EC) require that watertight doors on board passenger ships must be able to be closed automatically when the vessel has an adverse list of 15°. Watertight doors however, are not considered part of primary escape routes. Considering the current requirements, we can infer that all systems necessary to support escape, mustering and abandonment are expected to be operational for heel angles of up to 20°.

Finally, data from damage stability calculations comprising over 50 passenger vessels was reviewed to gain information on expected heel and trim angles as well as ship motions for design scenarios associated with flooding.

To understand dynamic motions in damaged conditions, S@S reviewed the outcome of physical model testing of over 40 passenger ferries in damaged conditions including flooding to one and two adjacent watertight compartments. The ferries were assessed in a range of significant wave heights from 1.9 to 4m and wave periods, and were tested between 1997 to present as part of the implementation of the Stockholm Agreement in the North of Europe.

Based on the broad spectrum of sources discussed, representative scenarios, reflecting as far as was possible the likely behaviour of damaged passenger ships, have been proposed. A vessel heeled at 20° and another with the vessel trimmed to 10° will be taken forward to the next stage of SAFEGUARD where the quantification of the effect of these scenarios on the evacuation will be carried out. From this, recommendations on including heel within the guidelines will be made.

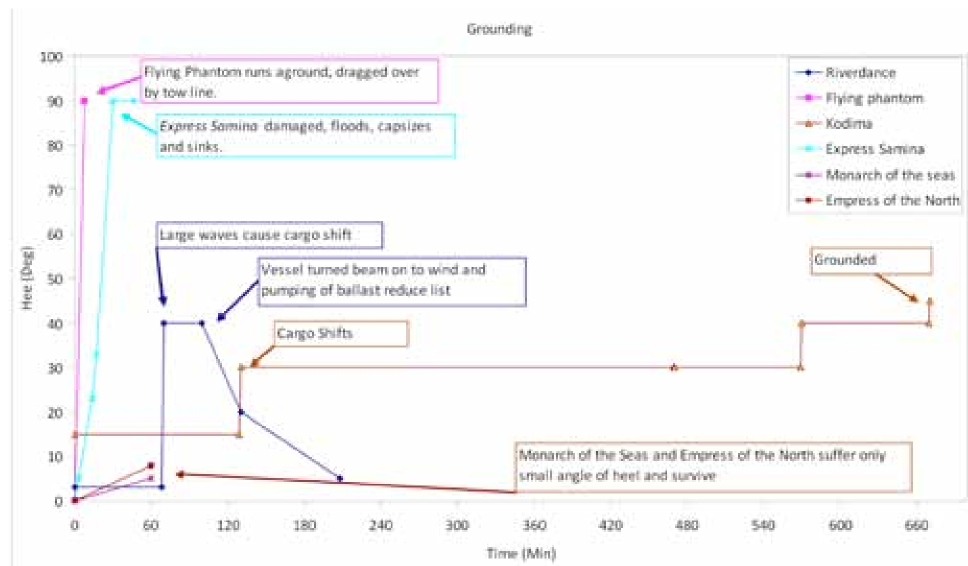

Figure 1 Estimated evolution of heel angle for grounding incidents – data inferred from publicly available accident investigation reports.

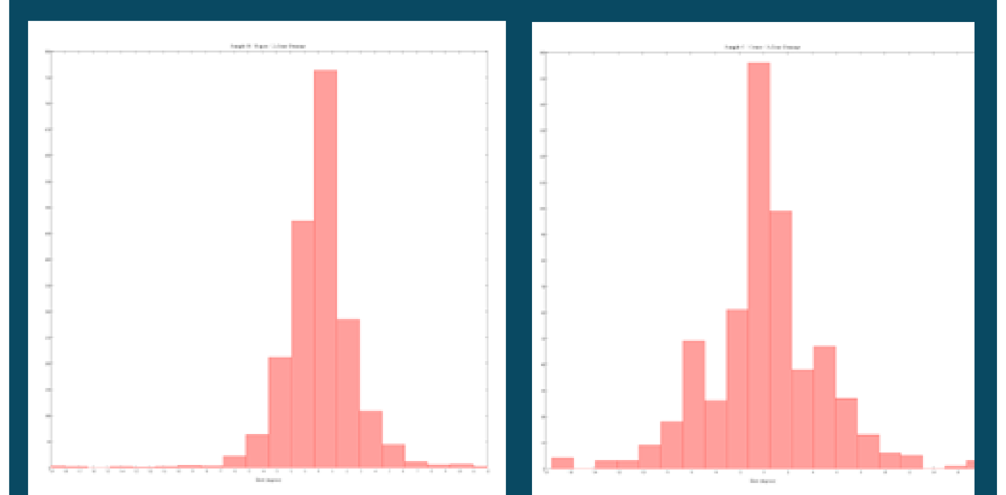

Figure 2 - Two histograms showing angles of heel for ropax and cruise vessels subjected to 2 and 3-zone damage respectively. Most ropax vessels in sample B (left) were not designed to meet current (SOLAS 2010) damage stability requirements.

The SAFEGUARD Fire Case

Introducing the Impact of Fire into Evacuation Analysis in MSC Circ 1238

By Prof Ed Galea, Fire Safety Engineering Group, University of Greenwich

In the present IMO Guidelines, fire is not considered to explicitly impact passenger or crew performance. While evacuation scenarios 3 and 4 in MSC Circ 1238 are intended to represent a damage situation – including a potential fire – neither include the impact of the fire on evacuees. In these scenarios, the "fire" is only considered to force the passengers in the affected vertical fire zone to move into the neighbouring fire zones. One of SAFEGUARD's aims is to include some representation within these of the likely effects of the fire on movement of the passengers in the affected fire zone.

There are several ways that fire analysis could be introduced into the IMO Circ 1238 scenarios:

1) Undertake Computational Fluid Dynamics (CFD) fire simulations for the proposed ship layout based on a single or a set of fire scenarios.

2) Impose a representative reduction in passenger travel speeds resulting from possible fire hazards

In the first option, the hazard distribution resulting from each simulated fire scenario using a CFD model would be linked to an evacuation simulation determining the impact of the fire on the evacuating population. But as the fire simulation would be specific to each vessel's layout, although the first option provides the most reliable method of determining the impact of the fire on passengers. it would be prohibitively expensive to run using current fire modelling technology. Neither can all ship evaluation models be linked to fire simulation data, so for both these reasons, this is inappropriate for application to a modified form of MSC Circ 1238.

REDUCED SPEEDS

Using the second option, a representative set of reduced passenger travel speeds must be determined. Fire hazard data will not be used. Given that MSC Circ 1238 specifies "normal" maximum passenger travel speeds, defining a travel speed reduction is consistent with it.

As only a reduced travel speed is required for the modified evacuation scenario such changes will be relatively simple to program into ship evacuation modelling software currently used for MSC Circ 1238 analysis. The proposed introduction of the fire into MSC Circ 1238 is only intended to make the evacuation analysis in secanarios 3 and 4 more representative of a severe fire case. It cannot assess the vessels' fire safety provision, nor likely fatalities or injuries resulting from the fire/evacuation scenario. A separate fire analysis will have been undertaken to establish compliance with IMO fire safety requirements.

TEST FIRE

To establish travel speed reduction factors a test fire was simulated, typical of severe fires likely to occur on passenger ships. To examine the impact of fire on a hypothetical vertical fire zone, experimental data (Heat Release Rate (HRR) and smoke and toxic species yields) relating to passenger ship fires was needed, although there is very little data currently which provides the level of detail required. The data set adopted is derived from a series of test fires conducted by SP Fire Technology[1], a leading fire research institute based in Sweden. The SP test case involved a mockup of a cabin and a short length of ship corridor (see Figure 1). Materials typically found in cabins - bed, linen, dressing table, wardrobe, flooring, etc - were included while much of the cabin was made from new composite materials.

The selected fire case represented a significant risk to life in which a 'flash over'' occurred. The experiment initially used SMARTFIRE CFD fire simulation software developed by FSEG; these simulations demonstrated that this could producing good correlation with the experimental data.

The 'mass loss' rates and 'species generation' rates were then used in a computer simulation of a cabin fire within a generic cruise ship vertical fire zone (see Figure 2), containing five decks. This was a worst case, where the door of the cabin where the fire originated is left open and fire suppression fails. Cases where fire suppression in the corridors also fails are considered. The doors to the stairs in the vertical fire zone are assumed open, allowing smoke and hot gases to spread through the vertical fire zone.

The fire is initially located within a cabin on the bottom deck (see Figure 3) however, fire scenarios involving positioning the fire on another deck within the vertical fire zone are also considered. But to keep the number of fire simulations manageable, it was decided to locate the fire in the middle cabin. Two deck locations were considered, one on the bottom deck and the second on the middle deck. In addition, scenarios in which the fire suppression system (water mist) within the corridors is activated were also investigated. Each simulation required in excess of 10 days of processing to complete. completion.

IMPACT ASSESSED

We are now using these to determine possible spread of fire effluent (heat, smoke and toxic gases) throughout the vertical fire zone used for the various fire scenarios. By coupling the fire effluent spread to an evacuation analysis using the maritimeEXODUS software, the impact that the fire has on the movement rates of passengers within the vertical fire zone is being assessed. This in turn will be used to suggest several plausible travel speed reduction factors to impose on a simplified fire-evacuation analysis i.e. one in which the fire is not directly simulated but the evacuation is using a model. The various Fire Degraded Travel Speed Models (FDSM) suggested by this analysis will be assessed by comparing the predictions of assembly and deck clearance times derived with that of the full fire-evacuation analysis. Finally, the best FDSM will be applied to an evacuation analysis of an entire passenger ship to determine the impact of imposing the it on the assembly time.

FSEG expect to complete this analysis early in the second half of 2011. The results from this will be used by SAFEGUARD to suggest a modification to scenarios 3 and 4 of IMO MSC Circ 1238 which will include the impact of fire on the assembly analysis.

Figure 1 - Cabin material in SP cabin fire test

1: Figure reproduced from Arvidson, M., Axelsson, J., and Hertzberg, T. (2008) Large-scale fire tests in a passenger cabin, SP Report 2008:33, SP Technical Research Institute of Sweden.

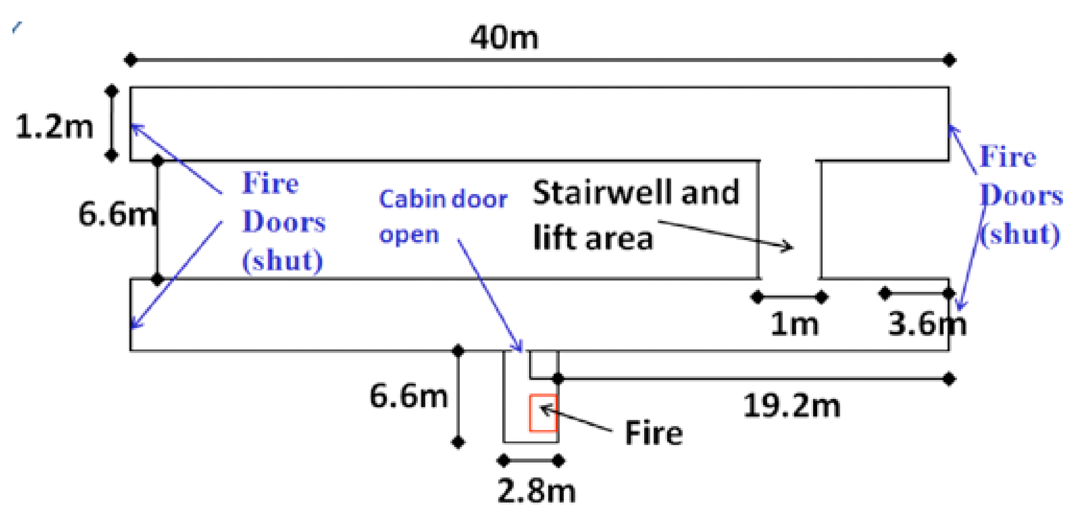

Figure 2- Deck layout for hypothetical vertical fire zone containing fire.

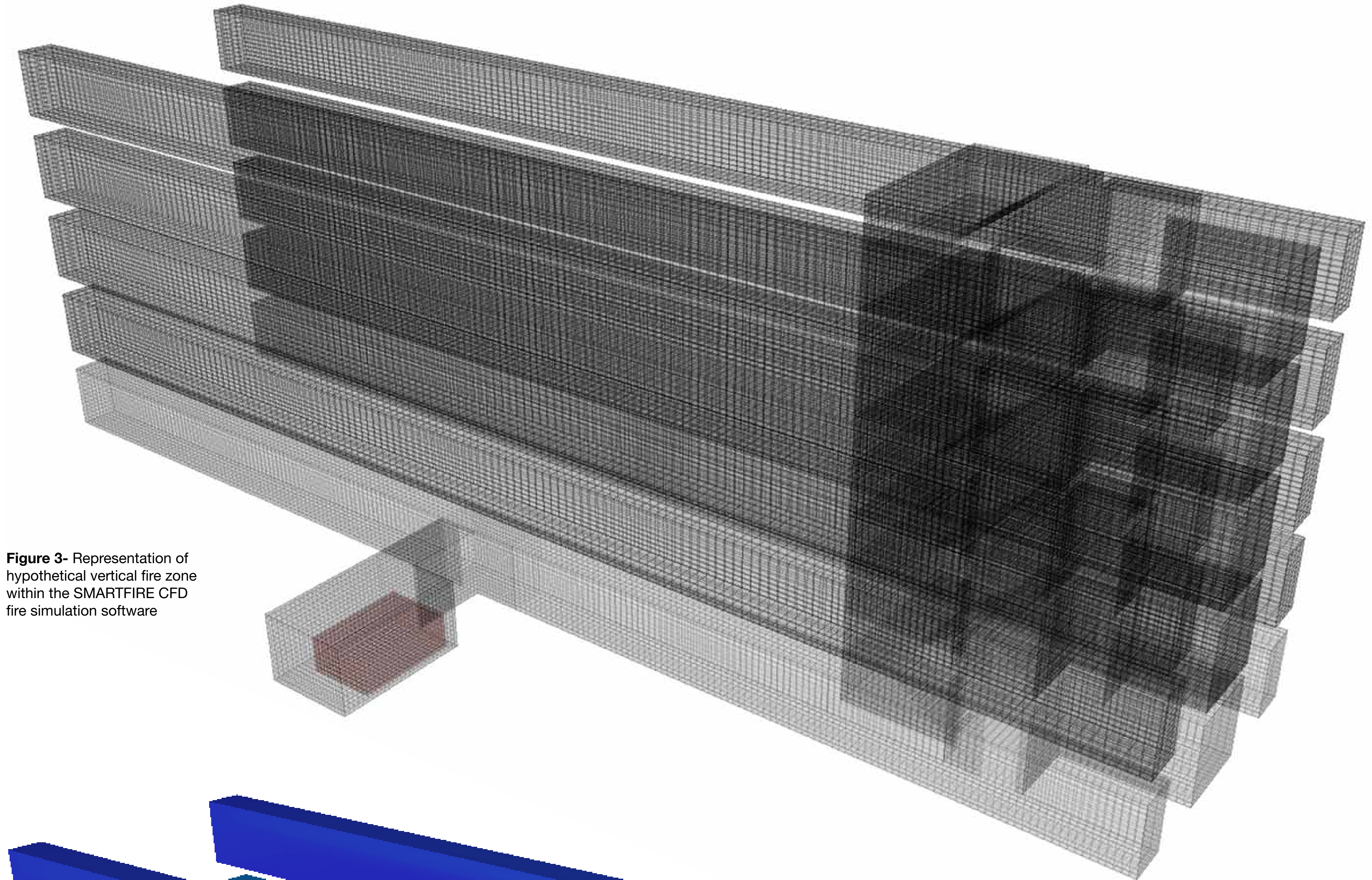

Figure 3- Representation of hypothetical vertical fire zone within the SMARTFIRE CFD fire simulation software

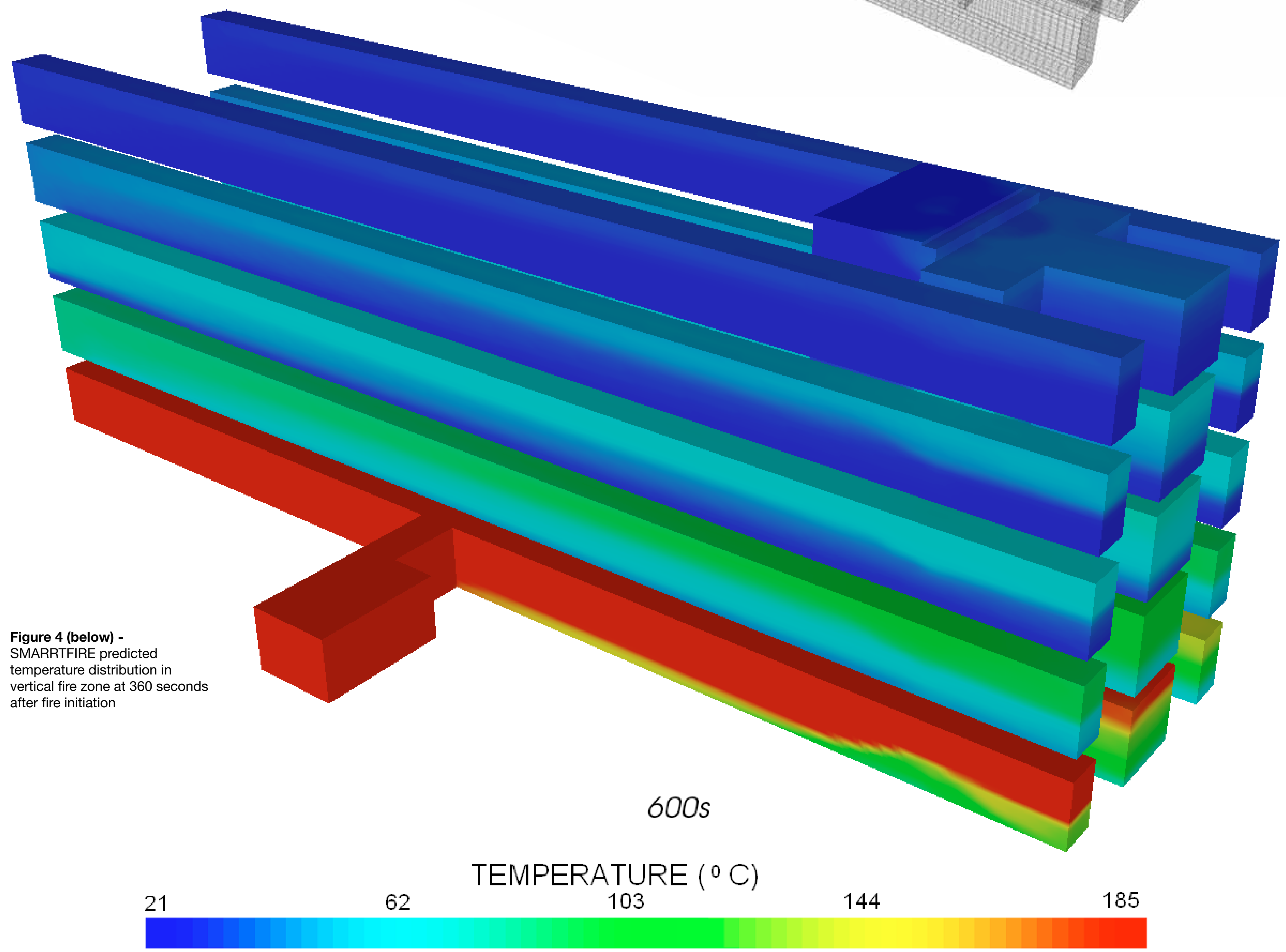

Figure 4 (below) - SMARRTFIRE predicted temperature distribution in vertical fire zone at 360 seconds after fire initiation

Geometry modelling for advanced evacuation analyses

By Nicolas Besnard, Principia

IMO Regulations specify "a computer-based simulation that represents each occupant as an individual that has a detailed representation of the layout of a ship and represents the interaction between the occupants and the layout" (MSC./1/Circ.1238).

To meet this requirement, software providers have been developing modern tools based on a 3D model of the ship, and a spatial spotting of the occupants within this. In most of advanced simulation tools, the occupants are simulated as 3D agents free to move within the ship model. Collision detection is part of the simulation engine, and allows addressing guiding agents through the model (agent/geometry interaction), as well as agent/agent collisions.

The ship model represents free spaces (zones, corridors) linked together, and takes into account obstacles that can affect occupants' motions such as doors or furniture, etc. Stairwells are key to evacuation analyses, and are necessarily represented. The scenarios specified by the IMO regulation implies that the zones are distinguished by their type: public spaces, restaurants, theatre etc., while passenger and crew zones are also identified. The geometry of the model must be defined as close to reality as possible, as it can have a great impact on the flow rates of moving occupants, and on the build up of congestion.

Three advanced simulation software tools are implemented in SAFEGUARD: EVI, EXODUS and ODIGO, each used by one partner of the project. Color Line "Superspeed" ferry, Royal Caribbean "Jewel of the Seas" cruise ship, and Minoan "Europa Palace" ferry are being modelled into each of the three software tools. At the moment, the Superspeed and Jewel of the Seas models are completed.

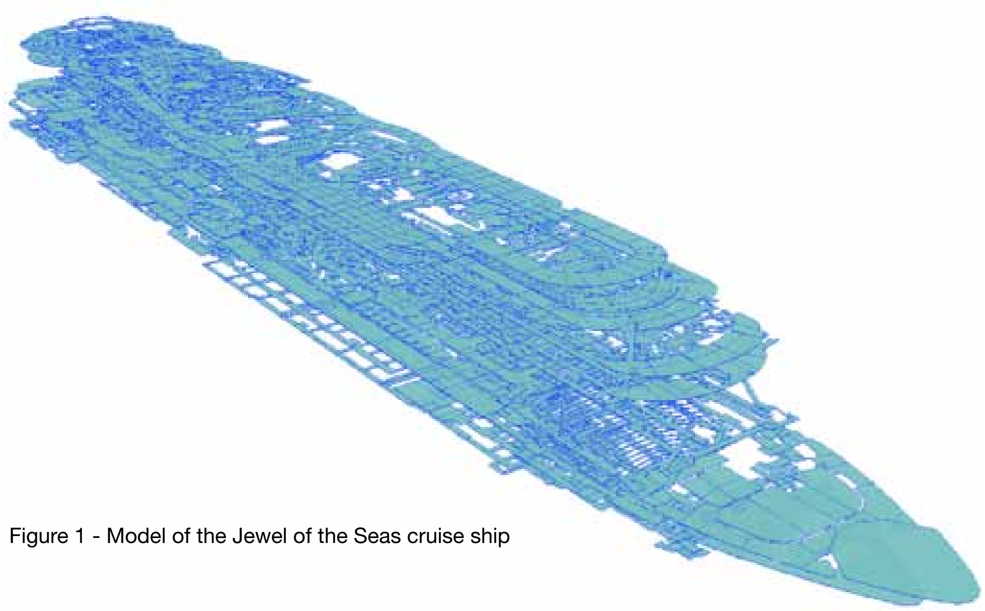

Figure 1 - Model of the Jewel of the Seas cruise ship

LIST OF PUBLICATIONS PRODUCED SO FAR

1) "The SAFEGUARD Project: Collection and Preliminary Analysis of Assembly Data for Large Passenger Vessels at Sea", Galea, E.R., Brown, R.C., Filippidis. L., and Deere. S., Proceedings, COMPIT'10, 9th International Conference on Computer and IT Applications in the Maritime Industries, Gubbio, 12-14 April 2010, pp 424-433, 2010.

2) "Collection of Evacuation Data for Large Passenger Vessels at Sea", Galea, E.R., Brown, R.C., Filippidis. L., and Deere. S., Pedestrian and Evacuation Dynamics 2010. 5th International Conference. Proceedings. March 8-10, 2010, Springer, New York, NY, Peacock, R.D., Kuligowski, E.D., and Averill, J.D., Editor(s), pp 163-172, 2011.

Our partners

SAFEGUARD has nine project partners based in the UK, France, Canada, Norway and Greece

BMT Group Ltd is a leading international multi-disciplinary engineering, science and technology consultancy offering a broad range of services, particularly in the defence, energy, environment, shipping and ports and logistics sectors. BMT will conduction the SAFEGUARD ship trials, lead exploitation and dissemination of results and will coordinate the project.

University of Greenwich, Fire Safety Engineering Group is the largest academic fire-safety modelling group in Europe and has considerable experience in the development of evacuation modelling software and fire modelling software and their use in a variety of practical engineering applications in the aviation, building, marine and rail industries. FSEG's main SAFEGUARD tasks are: designing and running the ship evacuation trials, analysis of ship evacuation data, production of the validation data sets and development of the "Fire Benchmark Case" using the SMARTFIRE fire simulation tool.

Bureau Veritas is a service company specializing in QHSE management (Quality, Health, Safety and Environment) and Social Accountability offering an extensive range of technical services and solutions in the fields of certification, conformity assessment, consulting and training. In SAFEGUARD BV's main task is aaccident analysis and the enrichment of present evacuation scenarios.

PRINCIPIA provides scientific engineering support to shipyards, classification societies, suppliers, ship-owners, navies, oil and gas companies, offshore and other maritime industries with expertise in structural mechanics, fluid and thermal mechanics, CFD, naval architecture, operations and safety. In SAFEGUARD PRINCIPIA will use the ODIGO ship evacuation software and trial data to develop new scenarios.

Safety @ Sea Ltd is an engineering consultancy specialising in stability of ships and advanced marine vehicles operating in partnership with the Ship Stability Research Centre (SSRC) of the Universities of Glasgow and Strathclyde, a world-leading centre of excellence on ship safety. In SAFEGUARD their task will be the verification of additional Scenarios and creation of a 'Heel Benchmark' using the PROTEUS dynamic stability analysis tool.

Marine Institute Offshore Safety and Survival Centre at the Memorial University of Newfoundland undertakes training and research to improve marine safety standards using facilities in St. John's Harbour and at a purpose built training centre. The facility is equipped with a survival tank complete with an underwater escape trainer, a simulated ship structure for use in firefighter training, a structure from which to lower life saving devices, and dedicated training vessels.

Color Line Marine AS is a ship management company situated in Sandefjord, Norway owned by the Norwegian cruise ferry company Color Line AS. In 2006 approx. 4,3 million passengers travelled onboard the vessels and approx. 194,000 freight units (12m) were transported by Color Lines ships. The company have approx. 3500 employees and is responsible for the building of the world's largest and most modern cruise ship with car deck, and two ultra-modern SuperSpeed vessels at the Aker Yards in Rauma in Finland. Color Line are providing passenger vessels for the sea trials.

Royal Caribbean International began in the late 1960's as a consortium of Norwegian ship owners and prides itself on introducing new shipboard innovations. Royal Caribbean International operates a fleet of 21 cruise liners with 2 ships in construction on voyages that include Alaska, Asia, Australia/New Zealand, Bahamas, Bermuda, Canada/New England, the Caribbean, Dubai/Emirates, Europe, Hawaii, Mexico, Pacific Northwest, the Panama Canal, South America and Transatlantic destinations. Royal Caribbean are providing the passenger vessels for the sea trials.

Minoan Lines Shipping SA is a leading provider of passenger and vehicle ferry services in Greece with a history of 34 years of expanding operations. It is also active the last 25 years in the Adriatic Sea linking Greek and Italian ports with safety and comfort. The company owns a very modern fleet of 7 high-speed ferries with an average age of 4.9 years and a combined carrying capacity of 12,454 passengers and 5,230 vehicles. Minoan are providing the passenger vessels for the sea trials.