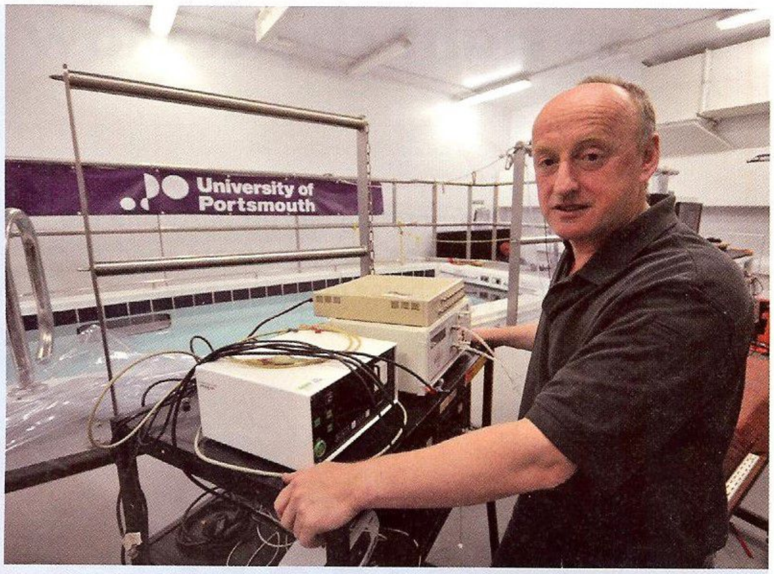
FLOOD: RESPONSE & SURVIVAL

ONE-DAY CONFERENCE *FLOODFIGHTERS – SAR TO RESUSCITATION* TOOK PLACE 26 MARCH IN POOLE, UK, BRINGING A RICH FEAST OF CUTTING-EDGE KNOWLEDGE TO AN EXPERT AUDIENCE. JOSE SANCHEZ DE MUNIAIN PRESENTS SUMMARIES OF FOUR OF THE PRESENTATIONS.

SLS GB (Surf Life Saving GB) Commissioner Adrian Mayhew welcomed the audience and reminded them why they were here. 'We need to share ideas about saving lives. The key driver is understanding what happens in tactical and medical configurations and we hope today will go from top level down to tactical level, because floods are not going away. We have all been affected by floods in the UK, and we know in Europe it has been massive too. We know the problem is getting worse so we need to ensure we keep on sharing.'

Deputy Chief Jeff Dulin from the Charlotte Fire Department (NC, USA) – chair for the conference – highlighted the special relationship between Charlotte Fire Department and UK Fire and Rescue Services that goes back 16 years as regards flood and water response. 'A lot of the information in this conference pertains to what has happened recently here in the UK. We are at a crossroads in this country in terms of developing assets to deploy, and how to prevent drownings when they do occur. The theme for today is a full-frontal [response] to that.'



Michael J Tipton, Professor of Human and Applied Physiology, Extreme Environments Laboratory, Department of Sport & Exercise Science, University of Portsmouth, UK.

'Rescue and resuscitation – the dilemmas of search and rescue efforts in drowning incidents', Professor Michael J Tipton, SLS GB Technical advisor, University of Portsmouth

Humans have dramatic physiological responses ('cold shock') when they are immersed in water and Professor Tipton began by showing what happened when a student wearing heavy clothing was lowered to 10 °C water (not submerged completely) and asked to hold his breath as long as possible. He managed five seconds before needing to take another breath. 'It's that piece of video by the way that made people appreciate for the first time the need for some form of emergency breathing system for those flying around in the North Sea, because at the time the protection was a "shorty" wetsuit called a shuttle jacket – for when shuttling back and froth from the rig and the accommodation platform. And it gave you good protection from hypothermia – but only one extra second of breath hold.'

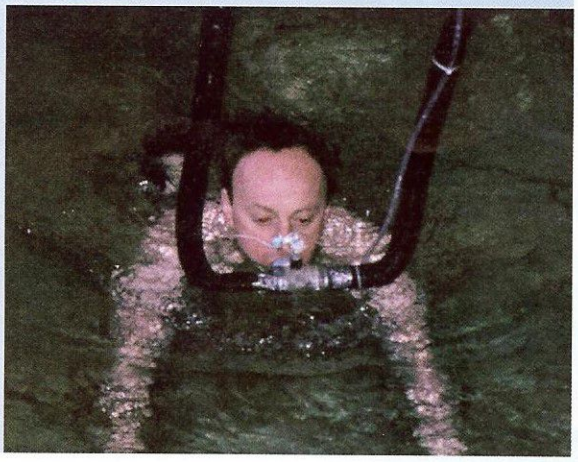
Pre-immersion heart beat of the student was 96 bpm, shooting up to 156 bpm during immersion. 'He's sitting still, breathing 66 breaths per minute, shifting 114 litres out per lung. You need to put that 114 litres in context of the lethal dose of drowning, which is about 1.5 litres of salt water or 3 litres of fresh water for the average individual.'

Over the first 70 seconds of immersion the heightened respiratory response takes place. If water is breathed in, it takes about two minutes to drown. For two minutes the heart continues to beat and thereafter respiratory and cardiac arrest takes place.

The physiological response is different, however, when someone is submerged in water or exposed to periodic wave splash in the face.

The 'diving response' is the response that diving mammals rely on to enable them to go under water for up to 90 minutes. It is initiated by receptors around the oral and nasal region, and it has the opposite effect on the heart – it slows it down. 'It tries to turn you into a heart-lung-brain machine, minimising the

Professor Tipton in one of his own experiments to see how the body reacts as it is exposed to cold water.



The conference took part at Pool Ferry Terminal, in Brittany Ferries' offices.

amount of oxygen you use to allow you to stay under water for a long time and assist you in breath holding.'

The cold shock and diving response can occur simultaneously when people go under water (or have wave-splash). The cold shock response tries to accelerate the heart rate, stimulated by cold receptors on the surface of the skin (hence why fat doesn't protect against this response) – this is a response mediated by the sympathetic division of the Autonomic Nervous System (ANS). The diving response – is mediated by the parasympathetic division of the ANS – it tries to slow down the heart rate.

Normally these two arms of the ANS work reciprocally (when one goes up the other goes down) – but in a few unusual circumstances (such as cold water immersion) both sides are stimulated. 'Of all the emotions anger does the same thing. It holds the parasympathetic system and stimulates the sympathetic system, which is one of the reasons anger is the emotion people most report to have had prior to being admitted to the cardiac ward.'

The situation changes when the cold receptors on the skin are covered with clothing, which diminishes the cold shock response, and heightens the diving response. An experiment showed a person underwater, wearing head to toe protective clothing, exercising back and forth in 5 °C water. His heart rate was 33 beats per minute, 'low enough to have a flat line across your ECG screen on one sweep!'

It is the balance between sympathetic and parasympathetic responses that produces different ECG readings in different people, according to how their hearts are wired. Some hearts can descend into a form of fatal arrhythmia – sudden death – as a consequence of the autonomic conflict. 'We think this explains what is called "dry drowning", but once you've become incapacitated by this type of response the chances of taking in water are significantly increased and drowning is then diagnosed. The important thing is that it will not be picked up later, because it is due to an electrical problem of the heart. When you look at the heart at post mortem, it looks fine.'

Professor Tipton then moved on to a more 'uplifting' subject, namely time under water and survival – and how this can influence rescue policy.

How long after drowning can someone be resuscitated? 'If you are young, in fresh water, and cool very quickly, there is a possibility that you will have a long period where you might be able to be resuscitated. If you are old, in salt water, and its warm, the probability falls and the time falls.'

A seven to ten-minute rescue window following cardiac arrest due to drowning is well established, with a diminishing probability of resuscitation depending on a number of variables. A dramatic video was then shown which highlighted these variables. The video showed a four-year-old child pulled out from under ice water in Lake Michigan. The child had been under water for over 15 minutes before SCBA divers turned up. The child had been under water for around half an hour when rescued but he made a full recovery with no neurological problems.

To try and explain this, Professor Tipton and his team looked for similar cases and concluded that these survival cases occurred due to the twin-edged sword that is hypothermia. 'It can kill you when the core temperature falls below around 25 °C – an important number that came out of Dachau, where sadly a lot of people died to get to that number. It is, in general, the lethal body temperature of hypothermia.'

Hypothermia reduces the body's requirement for oxygen and increases the time that tissues (including the brain) can spend without oxygen. For that to protect against brain damage during drowning, fast cooling is required. 'If the brain is without oxygen for 10 minutes you get irreversible damage. If you lower its temperature from 37 to 30, you double that window. If the brain temperature goes to about 22 °C, you have about an hour.'

The child in Lake Michigan was in cardiac arrest, respiratory arrest and to all intents and purposes drowned, but not at that stage fatally.

The gastrointestinal tract is the largest surface area in the body exposed to the environment, followed by lungs and skin. 'We've always taught that cold shock response, uncontrolled hyperventilation, loss of control of breathing, leads to drowning. However, if you have that response and you are under ice cold water, you will flush water in and out of the lung, that can cool the heart, and thereby the blood supply going to the brain.'

Research suggests that if a child goes under water, their cold response will pump water in and out of the lung for a minute, after which the heart will keep on beating for another minute, and this is sufficient to lower the temperature of the brain enough to extend survival time under the water.

'What is the rescue dilemma that comes from this?' asked Professor Tipton, 'When should search and rescue change to body recovery?' Matters are complicated by the additional factor of risk to the rescuer, and a number of cases were then shown including the case of a two-and-a-half year old female in Salt Lake City, who survived 66 minutes of submersion and made a complete recovery.

'We are unable to substantiate any cases of survival for longer than 30 minutes in water warmer than 6 °C. And that's not because we didn't look for them, it's because they don't occur.'

Prof. Tipton's recommendation for rescuers was to start the clock on arrival at the scene and not rely on bystanders for estimations of time. If the water were warmer than 6 °C, survival would be unlikely if submerged longer than 30 minutes. If not, then he recommended rescuers continue to search for 90 minutes, bearing in mind 66 minutes was the record.

'We want all the different agencies to come in line and follow the same protocol so we don't get scenarios where people are starting to be resuscitated and the process stops and starts again. I think you'll see that enshrined in the Fire and Rescue Services' Survivability of Water Manual which will shortly be published.' Finishing his presentation, Prof. Tipton remarked that he was always asked whether, if one went under cold water, should one breathe in and out as much as possible in order to increase chance of survival? 'The answer to that is that it takes a braver man than me to say "yes". But you would need to be a very small adult, or a child. You'd need to be in icy water, and fresh, and then possibly yes. But I'm not putting that forward as policy.'

In the Thames Valley in February there was no pre-deployment of mutual aid in response to flood warnings. Picture credit: Surrey Police, Flickr.

'2013, 60 years on from 1953 – lethal storms and sea surge, how are we doing in flood rescue response?' Deputy Chief Fire Officer Roy Harold, Norfolk FRS

In 1953, a devastating storm surge flooded wide areas along the low lying coastlines surrounding the North Sea. Many hundreds were killed in the UK, Netherlands, Germany and Belgium, and there was substantial damage to infrastructure and industry. There was no prior notice, and national governments did not become aware of the disaster until the rescue operation was well underway.

In 2007, a similar storm surge was forecast 48 hours in advance, and warnings were circulated along the East coast of England. CFOA's national flood support team coordinated mutual aid from across the UK, and 40 flood rescue teams were deployed into the risk area before the tidal peak hit the coast.

Following the 2007 floods, Sir Michael Pitt's review set out a list of recommended actions at national and local levels. Some, but not all, of these recommendations have been put in place. The Flood Forecasting Centre, jointly established by the Met Office and the Environment Agency, now provides world-leading predictive information on severe weather impacts, giving reliable flood assessments 2-4 days ahead of time to an accuracy of 1 km^2. DEFRA, as lead government department for flooding, has sponsored joint work by CFOA (Chief Fire Officers Association) and the RNLI (Royal National Lifeboat Institution) to produce a Flood Rescue Concept of Operations, and provided grant funding which has seen the number of flood rescue teams available for national deployment more than trebled, and provided over 50 flood rescue tactical advisors on call to assist local responders. So, we now have some of the best early warning systems in the world, and far more tools in our flood response toolbox.

However, one key recommendation from Sir Michael Pitt has still not been implemented – Number 39: **'The Government should urgently put in place a fully funded national capability for flood rescue, with Fire and Rescue Authorities playing a leading role, underpinned as necessary by a statutory duty.'**

No progress has been made on implementing this recommendation in England. No single agency has responsibility for flood rescue. This contrasts with the positions in the devolved administrations, were the role is now clearly placed with the Fire & Rescue Service. In the absence of a clearly stated national position, local resilience forums across England have made their own determination of who will do what in their own local areas. Whilst this locally determined position for managing emergencies works adequately for a single incident which falls within the boundaries of an individual Local Resilience Forum (LRF), it is a recipe for confusion for wide area, long duration incidents, which affect multiple LRFs and pay no heed to administrative boundaries. In such circumstances, a coordinating function needs to sit between COBR and local Strategic Coordinating Groups, to collate forecasting information, consider threat assessments, and balance requests for mutual aid against available resources.

This requirement is not unique to floods in England – indeed, DEFRA sponsored the author to visit the Federal Emergency Management Agency in Washington DC in 2011, to review lessons identified in the United States after Hurricane Irene. There, the pre-existing arrangements for national coordination, which involved a volunteer rota of civil servants standing up an emergency room, where found to have failed in the face of a long duration incident covering a wide area – the volunteers simply could not sustain the tempo of demands for technical information and support. As a result, the US established Incident Management Assistance Teams (IMAT's), made of a permanent staff of professional emergency managers, who are trained and equipped to provide specific gap-filling support to assist and augment local emergency managers, who retain responsibility for resolving emergencies through the same principles of devolved command (AKA 'subsidiarity') found in England.

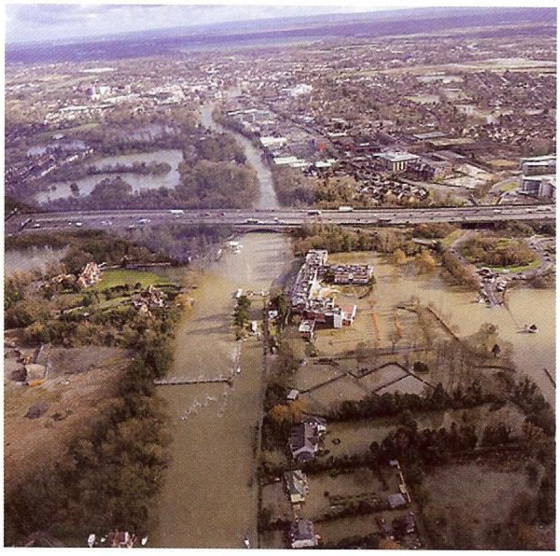
Government guidance on flooding, published in 2013, followed up on the IMAT principle by setting out procedures to establish an operations and logistics cell to support central government contingency planning in the event of a wide area flood. However, during the 2013/14 winter floods, this cell was not established. As a result, there was no single place nationally where forecasting information could be brought together with information on population and infrastructure threats, and technical expertise on available flood rescue resources. Mutual aid resource requirements were raised at LRF level, escalated to DCLG's (Department for Communities and Local Government) Emergency Room, and authorised for deployment via the Fire & Rescue Service National Coordination Centre. But in the absence of a single 'information hub', those local requirements were met on a first-come, first-served basis, with no matching to national strategic requirements, or oversight to compare and align local and national perceptions of risks and resources.

What this meant in practice was that in December, East

Sea wall under the main rail line collapses in Dawlish, Devon, February 5. Right: an aerial view of flooding on the Somerset levels on February 2. Picture credits: Met Office.

Coast LRFs that have long practiced together under the auspices of the DEFRA (Department for Food, Environment and Rural Affairs) East Coast Flood Group enacted their contingency plans on receipt of the flood forecast. Predeployment of mutual aid was requested and actioned, with teams in place ahead of time from Humberside to Suffolk. However, available resources had been used up by the time Essex and Kent requested mutual aid, which meant that Essex got some of what it asked for, and Kent got nothing. This reflects the assessments of likely resource requirements that have been undertaken on behalf of DEFRA, which indicate that a full blown East Coast tidal surge would need more than 500 specialist flood rescue teams – the national flood rescue asset register currently has around 130 teams listed. There are not enough resources to deal with an East Coast tidal surge. Therefore, those resources that are available have to be rationed carefully against national rather than local priorities.

In the Thames Valley in February, there was no predeployment of mutual aid in response to flood warnings. National flood rescue resources were only requested after the flooding was already extensive, and then only in small numbers. Whilst support was brought in through local bilateral arrangements, and in large numbers from the military, at no time were more than a minority of available specialist flood rescue teams called upon. This contrasts strongly with the situation for high volume pumps (HVPs), which are unequivocally a fire and rescue service national resilience responsibility. Every single HVP in the country was deployed, at the same time as the great majority of flood rescue teams were standing idle. That those teams were needed was indicated by a request to supply drysuits to the military for the use of troops wading through cold, heavily contaminated flood water – it is hard to understand the reasoning behind wanting to take equipment from trained flood responders to give to untrained military personnel, so that they can do tasks which the flood responders have declared they are available to do on a national basis. Although the majority of flood rescue teams declared to the national asset register are from Fire & Rescue Services, a significant number come from the voluntary sector, in what is very much a multi-agency collaborative model. It was particularly disheartening for those volunteers, who have given up much of their own time and energy to provide a resource, to then not be called upon, whilst being bombarded by media images of ill-equipped and apparently adhoc efforts



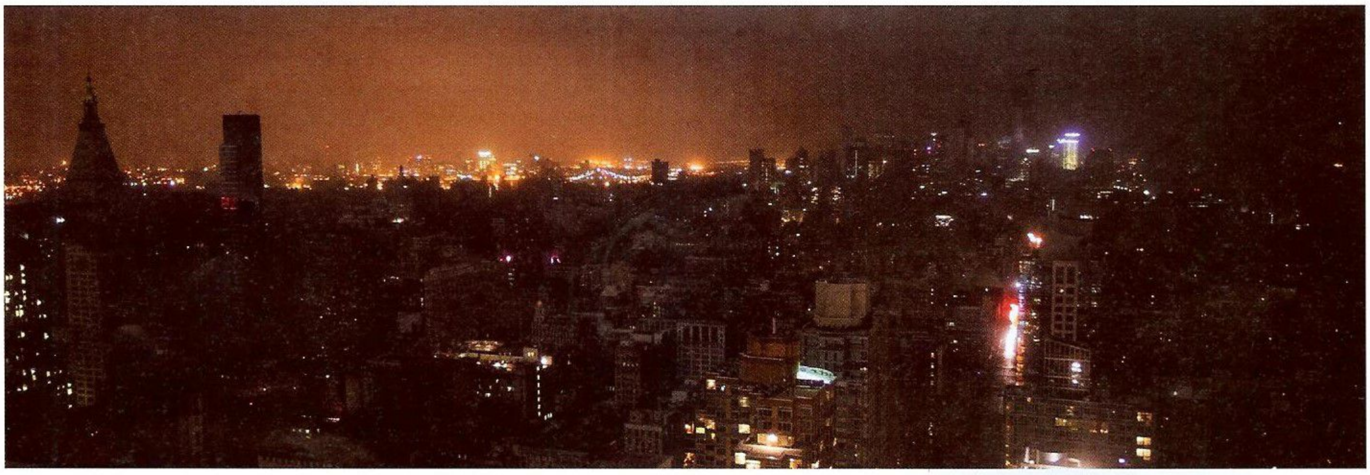
Not through their own choice, the majority of the UK's flood rescue teams stood idle during the wide area flooding that took place in February.
Picture credit: Surrey Police, Flickr.

to reduce the impact of flooding.

So, how to resolve these concerns? Fortunately, the principles are already well established, and the resources exist, albeit in limited numbers. Wide area floods are long duration events that transcend Local Resilience Forum boundaries. They are not 'no-notice' events, and nobody in the UK should ever be surprised by a flood. We do not currently have enough response resources to cover every request, so will have to ration what is available to the highest priorities. Those requests will not just be for rescue, but will extend to protection of infrastructure and resupply of stranded communities. To deal with those requests, we have a toolbox made up of a multi-agency group of trained flood responders, and a cadre of specialist tactical advisors. We also have a ready made national coordination function to provide command and control facilities, in the shape of the CFOA National Resilience Team (NRAT) and the FRS National Coordination Centre. All that we lack is the clear strategic intent in Whitehall [metonym for British Government] as to what to do with these resources. We have a box of tools, but no clear idea of what we want to do with them.

Three simple steps would transform our national ability to manage wide area floods:

1. **DCLG's Emergency Room should be run by professional emergency managers, led by the Chief Fire & Rescue Advisor. The NRAT team are a standing resource that could and should provide a UK equivalent to the FEMA IMAT.**
2. **Trained flood advisors provide a critical support function, and should be automatically embedded into national and strategic coordinating groups, not restricted solely to tactical level command support. Without their expertise, well meaning but ill-advised proposals, such as that exemplified by the drysuit request, will continue to appear and circulate.**
3. **The government's guidance on flooding should be followed by the government – the operations and logistics cell is a vital information hub that needs to be established as a functioning reality, not just a concept.**



'Hurricane "Superstorm" Sandy, the deadliest and most destructive of the 2012 Atlantic hurricane season, the lessons for the future, a case study', Deputy Chief John Esposito, Fire Department, City of New York, USA

The storm struck the East Coast of the US on Monday the 29th of October. FDNY usually has a seven to 10 day warning that a hurricane is going to hit so it was well aware the storm was coming. Four days before – at 5pm on the Friday – the preplans were launched. 'We are firm believers in preplanning – it is very effective. One of the first things we did was activate our incident management team, which is intended to run large scale events in parallel to every-day operations.'

Sandy's trail of chaos. Above: power outage in Manhattan. Right: houses burned down in Long Island. Opposite: crane collapse in midtown Manhattan.

The preplans involve checklists – ensuring sufficient fuel for apparatus, radio batteries charged etc ('again, very effective'). 'We have preplans for four days out, three days out, two days out etc.'

Homebound evacuation began on the Friday, but Mayor Michael Bloomberg decided not to order a door-to-door evacuation – in Esposito's view there would not have been enough resources to enforce a door to door evacuation. However, it was 'highly suggested' people evacuated flood zone A, which contained around 375,000 people, where shelters only had space for 70,000.

The Homebound Evacuation during Hurricane Irene in 2011 had highlighted the situation where people had wanted to evacuate but didn't have the means to do so or the time, so for Sandy the evacuation began earlier, consisting of a school bus manned by two firefighters that would pick people up and take them (within reason) to where they wanted to go. 'This was pretty effective, and all people had to do is ring 311, the New York City number for city information.'

DC Esposito highlighted some of the challenges faced by FDNY, including a number of incidents that individually – and on a normal day – would have warranted front-page exposure in the daily newspapers, such as a crane collapse in midtown Manhattan as well as a 27-building fire. 'The fact that nobody knows this happened is the incredible part – and it wasn't the biggest fire of the night.' One fire in the far west end of Rockaway took out 115 buildings.

Several EMS and fire houses were flooded but only one front-line apparatus (a brand new 100 ft aerial ladder) was destroyed, and this in Rockaway.

As expected, power loss was experienced at a number of locations – including one power loss at the request of FDNY. 'We noticed that as water levels rose the number of structural fires were going through the roof. The Queens' Commander requested the utility company cut the power, and immediately we saw the number of calls stopped going up.'

Other complications involved hospital evacuations. Hospitals were prepared and had back-up power, but one hospital's power generators were in the basement so once it was flooded an evacuation was necessary. Bellevue Hospital was evacuated two days after the storm because its back-up power had not been designed to function for such a protracted length of time.

DC Esposito highlighted some of the lessons learned from 9/11 that were successfully implemented during Hurricane Sandy. One was the instigation of a decentralised command system during a multiple-incident situation. 'Everything cannot be run from the command centre in headquarters, so as part of the preplans each borough had to follow a borough command control model. Each borough turned into a different fire department, with each borough commander in charge.'

The next lesson, said Esposito, was about 'letting people go': 'It is not the time to micromanage. All that time prior to an incident is about training and education and making sure your people know what to do – so when it gets bad they have to go out there and do it.'

As part of New York's citywide incident management system (CIMS) the FDNY is bound to list all the core competencies of its fire departments (eg SAR, pre-hospital care). 'During the incident we had people responding to normal incidents lacking the normal supervision, assistance and relief. We had people operating for way too long but these were special circumstances.'

Many firefighters lost their homes during Sandy, which created a long-term – and still an ongoing – problem. 'They were able to switch vacation time around and take time off. We set up a fund for members to donate towards those that had lost their homes, sanctioned by the fire department.' Another initiative involved off-duty firefighters donating their own time to gut flooded houses and pump out the water.

Gasoline supply was identified as a problem and in future ensuring there is an in-house supply will be added to the preplans' list of check boxes: 'We don't need our own people waiting in line to get gasoline to run generators and chainsaws.'

Concluding his presentation, DC Esposito commented that overall the response of FDNY went very well. The lessons from 9/11 had been learned the hard way, when so much was lost. 'We paid a heavy price to learn and had to change.'

'Accidental hypothermia – a survival from accidental hypothermia of 13.7 °C', Dr Anna Bågenholm and colleague Dr Torvind Næsheim

The presentation kicked off with a short clip from popular TV series The X-Files, with FBI Special Agent Fox Mulder speaking to colleague Dana Scully: 'You asked how the impossible can be possible. In Norway a woman was at the bottom of an icy lake for an hour, no heartbeat, body temp 58 degrees, made full and complete recovery.'

That woman was Dr Anna Bågenholm from Sweden, who 15 years on from the accident proceeded to tell her remarkable story of survival. On the afternoon of May 20th 1999 she and fellow junior doctors Torvind Næsheim and Marie Falkenberg were skiing down a steep gulley in the mountains outside of Narvik, when she lost control and fell on her back, sliding head first along the ice on a frozen stream. A hole opened up in the ice, her head and torso were pulled in and icy water filled her clothes. When Dr Næsheim found her, only her feet and skis were above the ice: 'We thought she would just get wet and we thought it was funny at first. But it was steep and the current so strong we couldn't get her out,' remembered Dr Næsheim. They called for help after seven minutes, 'She was moving but after around 30 minutes she stopped moving. This was the first point where she could have suffered cardiac arrest.'

Dr Bågenholm recalled how rescuers arrived from the city and tried to drag her out, but this was not possible. 'Then another rescuer arrived. He had been working in his garden when the call came in and he happened to have brought his pointed shovel with him on the rescue, and managed to dig a hole in the ice with it.' Dr Bågenholm had been in the water for 80 minutes at this point.

Once out of the ice Dr Næsheim began cardiopulmonary resuscitation. 'A Sea King helicopter arrived four minutes after she was pulled out of the ice. I was doing CPR and didn't hear it arrive at all. The helidoctor came in wearing his orange overalls and I couldn't figure out how he'd got there,' remembers Dr Næsheim.

The question was then whether to take Dr Bågenholm to the nearest hospital, only three minutes away, or travel further to Tromsø University Hospital, an hour away. The latter option was decided on. 'They have a saying in Norway that if you think someone has had cardiac arrest from hypothermia, they should be taken to a hospital that can rewarm. At Tromsø they had done this a number of times before and succeeded,' said Dr Næsheim.

By the time Dr Bågenholm arrived in hospital, CPR had been carried out for one and a half hours, and total time without cardiac was two hours 45 minutes.

'She was a standard dead person. No respiration, no pulse, dilated pupils. But she had above normal level of oxygen in the blood and above normal CO_2, which was good,' said Dr Næsheim. Dr Bågenholm's body temperature on arrival was 13.7 °C, at the time the lowest survived body temperature ever recorded in a human with accidental hypothermia. 'I think there is one girl, now 13, who has the record,' [fellow Swede Stella, 7 years old, survived 13 °C at Christmas 2010] remarked Dr Bågenholm.

In a state of hypothermia cell function deteriorates but metabolism also reduces, which leads to less oxygen demand, explained Dr Næsheim. 'And if the balance between oxygen supply and demand is out, and you use more oxygen than you gain, then you have cellular damage.'

When a 'warm' patient is in cardiac arrest, there are only a few minutes before the brain begins to deteriorate. 'However, if you can cool that patient down by some 10 degrees then you have a larger window for rescue, CPR, cardiac bypass etc, without the brain getting damaged,' said Dr Næsheim. Currently the time limit for carrying out CPR in these situations is unknown, but the key is to continue to carry out CPR without raising the temperature and therefore raising the metabolism. 'But if the patient has circulation, then you want to warm. So either CPR or warming, but never at the same time.'

Patients with cardiac arrest as a result of hypothermia should be taken to the nearest hospital with cardiopulmonary bypass facilities: 'Transport distance makes no difference to survival, because we can sustain oxygenation so well at those low temperatures, that patients have the same chance of survival,' said Dr Næsheim.

Warming can either be carried out externally via the skin, or by taking the blood out, oxygenating it, warming it, and pumping it back in.

On arrival at hospital Dr Bågenholm was taken straight to the operating room, CPR being carried out until she was connected to the cardiopulmonary bypass machine. 'When my heart was 31 °C it started beating again. I was in the operating room for nine hours.

'I was on a smaller bypass machine for an additional six days, and on a respirator for four weeks. When I woke up I couldn't feel anything from the neck down.' Although Dr Bågenholm's brain had survived intact, many of her nerve endings had died and it took another two years until these never endings had fully regrown. 'I was going to be a surgeon but now I'm a radiologist. I do do some things with my hands, but I'm bad at certain things like peeling potatoes.'

Concluding the retelling of her incredible experience, Dr Bågenholm said; 'Maybe after hearing my story you will be able to save people – so remember, don't declare people dead on the scene.'

Right: Dr Naesheim shows how he attempted to pull Dr Anna Bågenholm (pictured top) from under the ice.