G9 Safe by design

Workshop report: Escape from the nacelle in the event of a fire

G9 Offshore Wind Health & Safety Association

In partnership with energy institute

G9 SAFE BY DESIGN

WORKSHOP REPORT: ESCAPE FROM THE NACELLE IN THE EVENT OF A FIRE

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1 BACKGROUND AND INTRODUCTION

The G9 Offshore Wind Health and Safety Association (G9) comprises the world's largest offshore wind developers who have come together to form a group that places health and safety at the forefront of all offshore wind activity and development. The primary aim of the G9 is to create and deliver world class health and safety performance across all of its activities in the offshore wind industry. The G9 has partnered with the Energy Institute (EI) to develop materials including good practice guidelines for the offshore wind industry in order to improve health and safety performance. Through sharing and analysis of incident data provided by G9 member companies, an evidence-based understanding of the risks encountered during the development, construction and operational phases of a wind farm project has been developed. This information has been used to identify the health and safety risk profile for the offshore wind industry.

In 2014, the Crown Estate asked the G9 to take over the running and delivery of their Safe by Design workshops. The Crown Estate had run a number of these previously, covering topics such as diving operations, lifting operations, wind turbine design and installation and the safe optimisation of marine operations.

By bringing the Safe by Design workshops into the G9 work programme, the G9 aims to explore industry operations and technologies with a focus on Safe by Design principles. The G9 workshops will examine the current design controls relating to a particular topic, discuss where current design has potentially failed, identify opportunities for improvement and then seek to demonstrate the potential risk reduction to be gained from these new ways of thinking. The outputs from these workshops will be made available on the G9 website in reports to be used as a reference by the industry.

The second workshop was held on 25 March 2015 and covered emergency escape from the nacelle in the event of fire. It explored a number of key topics covering: fire suppression and mitigation; emergency escape equipment and personal protective equipment (PPE), and emergency escape training and competency requirements. The outputs from this workshop are documented in this report.

2 METHOD, AGENDA AND ATTENDANCE

2.1 METHOD

A one-day workshop was held on 25 March 2015 in Oslo, Norway. After opening remarks from Frank Monaghan (Health & Safety Director, ScottishPower Renewables and G9 Focal Group member) the workshop started with the first of three presentations focusing on establishing a wind turbine fire safety case, to demonstrate how the risk of fire to personnel working within an offshore wind turbine has been reduced to the as low as reasonably practicable (ALARP) level.

A second presentation focused on the design characteristics of various types of PPE and emergency escape equipment used in the offshore wind industry, exploring some of the benefits, limitations and characteristics of the different equipment and PPE.

The final presentation focused on emergency escape training and competency requirements, and looked at a particular case study where a G9 member had to review the adequacy of their emergency escape provision after a high potential incident.

After the second presentation, a short exercise was used to communicate the bow tie risk analysis/evaluation method as a tool to demonstrate the links between the potential causes, barriers, controls and consequences of a particular incident (in this case a fire in a turbine). During the breakout sessions, workshop attendees were encouraged to consider the bow tie method for defining the causes of incidents and also the barriers and controls that are currently in use in the offshore wind industry.

There were a total of three breakout groups each facilitated by a G9 member, tasked with looking at different aspects of fire mitigation/suppression/detection technologies, emergency escape equipment and PPE and training and competence of technicians. At the end of the breakout sessions, each group leader presented their main findings and conclusions to all of the attendees in a plenary session and further discussions were held before concluding the workshop.

Feedback forms were also provided to workshop attendees and the results of these are being analysed to inform future workshop topics.

2.2 AGENDA

Workshop opening remarks

Frank Monaghan, Health and Safety Director, ScottishPower Renewables

Presentation 1 – Design characteristics of a nacelle that mitigate the impact of a fire and increase the time for a person to affect an escape

Andy Lidstone, Risktec Solutions and *Mark Jenkins*, EHS Project and Stakeholder Manager, Siemens Energy

Presentation 2 – Overview of different types of escape mechanisms/systems

Dave Thomas, Technical Director, heightec

First exercise – overview of the bow tie risk analysis methodology

Euan Fenelon, Offshore Health and Safety Manager, ScottishPower Renewables

Presentation – Training and competence of technicians in the use of escape mechanisms and equipment

Stu Axcell, Emergency Planning Manager, HFR Solutions and *Mervyn Coldron*, Senior HSEQ Manager – Power Operations, Centrica

Second exercise – breakout group sessions

Group 1 – Fire mitigation: nacelle design characteristics (facilitator: *Euan Fenelon,* ScottishPower Renewables)
Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy)
Group 3 – Training and competence processes (facilitator: *Thomas Eriksen*, Statkraft)

Plenary session – Presentation on key findings/outputs from breakout group discussions

Closing remarks

Frank Monaghan, Health and Safety Director, ScottishPower Renewables

2.3 ATTENDANCE

Name	Company
Mervyn Coldron	Centrica
Peter Villadsen	DONG Energy
Jody Plaister	E.ON
Marcus Peters	E.ON
Garry Bradford	EDF Energy Renewables
John Yorston	EDPR
Andrew Sykes	Energy Institute
Bir Virk	Energy Institute
Claire Smith	Energy Institute
David Thomas	heightec
Stu Axcell	HFR Solutions
Arve Sandve	Lloyd's Register Consulting
Lucia Quintana Alonso	MHI Vestas Offshore Wind
Mark Higgins	MHI Vestas Offshore Wind
Peter Armstrong-Cribb	MHI Vestas Offshore Wind
Philip Merson	Repsol
Andy Lidstone	Risktec
Gareth Ellor	Risktec
Tom Semple	Risktec
Roland Gutbrod	RWE Innogy
Euan Fenelon	ScottishPower Renewables
Frank Monaghan	ScottishPower Renewables
Jan Filip Rasmussen	Siemens Energy
Mark Jenkins	Siemens Energy
David Lange	SP Technical Research Institute of Sweden
Fredrik Rosen	SP Technical Research Institute of Sweden
Stephen Rose	SSE
Peter Brun	Statkraft
Thomas Eriksen	Statkraft
Anne Marit Hansen	Statoil
Jostein Bolstad-Lind	Statoil
Colin Mooney	The Crown Estate
Per Holten-Møller	Vestas

2.4 BREAKOUT GROUP DISCUSSIONS, RESULTS AND CONCLUSIONS

The notes presented in Annex A capture the discussions which occurred during the breakout sessions. They have not been edited post workshop and so capture the essence of the discussions which occurred.

In addition, the bow tie risk assessment in Figure 1 is a high-level illustration of the systems, processes, mitigations and controls that were considered within workshop. Where the workshop focused on the mitigations resulting from a fire in a wind turbine generator (WTG) (more information is provided in this report), the suggested causes and threats of fire in the WTG are also added to provide context. Controls for those threats are also suggested. A more detailed risk assessment would be needed for each threat. For example, within the maintenance threat line, if 'hot work' was being carried out then controls such as physical protection, firewatcher and extra fire-fighting equipment may be required.

Going forward, and in response to some of the comments and suggestions that have been made in these breakout sessions, the G9 will aim to:

– Support and collaborate on research that assesses and quantifies the risk of fire occurring in a WTG.
– Engage with WTG manufacturers and obtain further information on their in-house design/fire risk assessments.
– Encourage research institutes and organisations with specialist fire departments to undertake further research on WTG fire risk.
– Investigate whether it is possible to quantify the 'human factor' and incorporate this into a quantitative risk assessment (QRA) for WTG fire scenarios.
– Review the adequacy of current technician emergency escape equipment and PPE and also the detection and suppression equipment installed in a WTG.

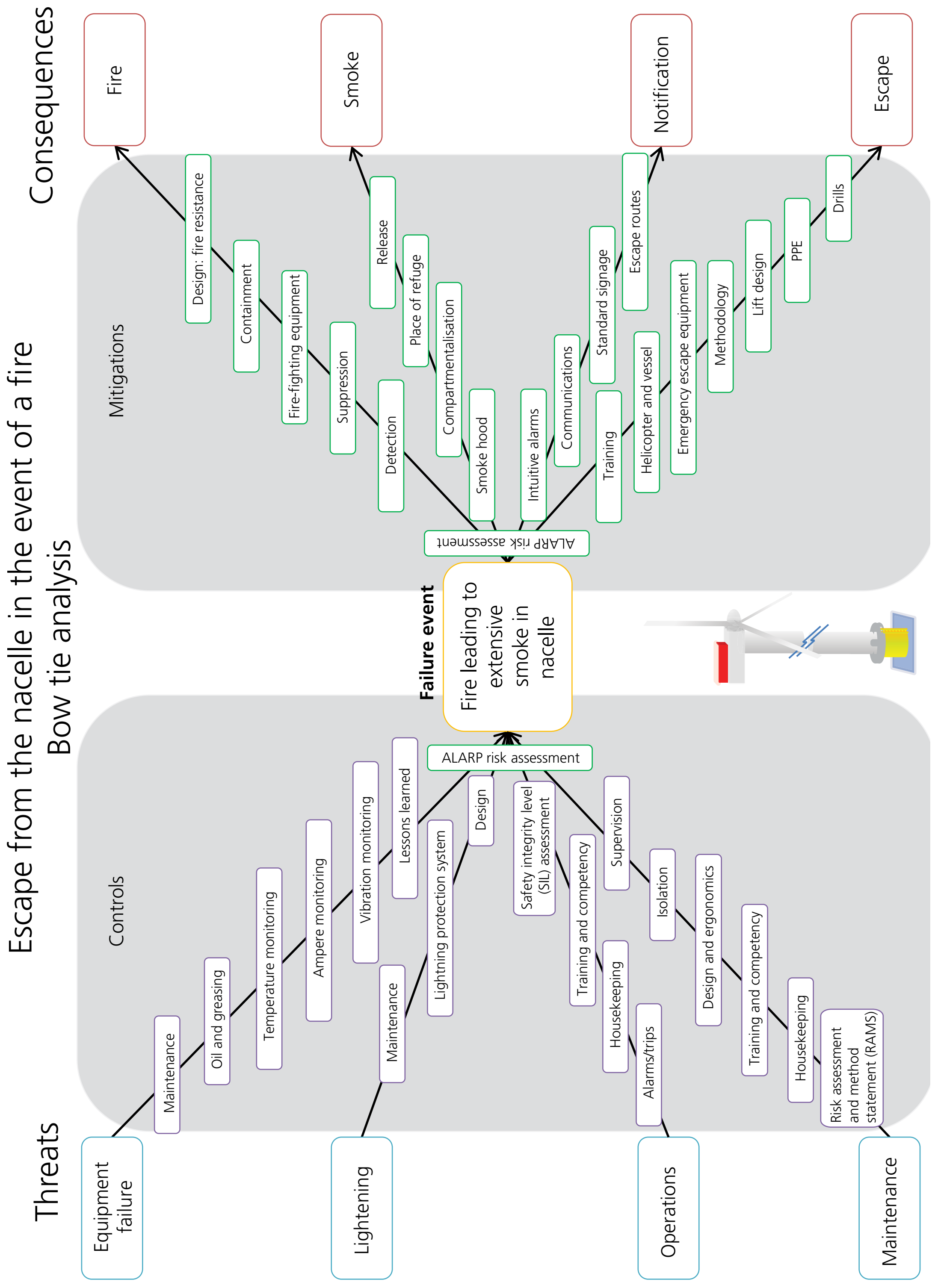

Figure 1: Bow tie analysis – Escape from the nacelle in the event of fire

ANNEX A
WORKSHOP OUTPUTS AND PRESENTATIONS

A.1 BREAKOUT GROUP OUTPUTS

Table 1: Group 1 – Fire mitigation: nacelle design characteristics (facilitator: *Euan Fenelon*, ScottishPower Renewables)

Considered design controls	Potential design controls	Nature of potential risk reduction
Detection	Where are fire detection systems needed in the turbine? Are they needed in the tower and nacelle or can they be focused on particular areas?	Critical knowledge which is needed - where are the fires likely to start? This can then be used to inform where detection systems should be considered/installed.
	It is critical that the appropriate fire detection systems are considered during the design phase of the WTG.	Once a unit has been installed and commissioned, it is much harder and more challenging to initiate a retrofit installation of a detection system. On one site, issues have been identified in the operational phases of a wind farm where a detection system was installed in the foundation and then a new system installed in the tower. Given the time elapsed between the two installations taking place, the systems were not integrated (this could have been addressed in the design phase when specifying the two systems).
	When looking at other industries e.g. aviation, air traffic control towers are designed in such a way that they can withstand severe fires and still function to provide information for flight operations.	
	In the German sector, certification of the fire detection systems is done in line with Allianz standards and processes.	

Table 1: Group 1 – Fire mitigation: nacelle design characteristics (facilitator: *Euan Fenelon*, ScottishPower Renewables) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Detection (continued)	A detection system needs to be clearly audible in all locations where the technician may be working (e.g. in the hub when entering from a nacelle). Fire watchers may also be required dependent upon the type of work being carried out (e.g. work in the foundation/monopile).	Can a detection system accurately pinpoint where a fire is/has occurred and provide this information to the technician who is in the nacelle? Whilst there is an alarm function in turbine controller, in some designs this may not differentiate between types of alarms – there would be benefit in having a fire specific alarm on the turbine controller.
	When an alarm triggers in the control unit, should this indicate 'go to safety' rather than 'go investigate'? When this event is identified as serious should the alarm indicate 'prepare to evacuate'?	Likely that the instruction given will be dependent upon the severity of the incident (from small sparks/smoke all the way to large fires). What is the level of variance in current detection alarm technology? (e.g. light and sound variants, pulsing vs. continuous audio, etc.). What technologies do detection systems employ to detect fire/smoke? (e.g. optical/visual/thermal etc.) and what is the level of standardization across the industry in selecting and using standardized detection equipment?
	Have safety integrated level (SIL) determination and fault chain analyses been undertaken for turbines and nacelles?	The performance level for the turbine can be calculated then this can be used to define the SILs. It is important that client engineers have the necessary competence to ask for and understand any SIL assessment. Other industries (e.g. aviation or rail) are more heavily regulated and consequently have further defined what is safety critical equipment (ref. detection technologies) – it would be beneficial to have a similar/common understanding/agreement within the offshore wind industry on what is considered safety critical equipment.
	Benefit in developing a standard set of industry accepted bow ties.	These can be used to identify what are safety critical equipment/systems.
	It is important that the G9 (representing the collective offshore wind industry) is not seen to be defining what are 'tolerable' risk levels/acceptance.	This is for individual companies to determine based on the context of the risks in their operations.

Table 1: Group 1 – Fire mitigation: nacelle design characteristics (facilitator: *Euan Fenelon*, ScottishPower Renewables) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Suppression	There are various types of suppression systems on the market. Gas suppression systems require airtight buildings in order to be effective. Water misting solutions are available; however, using them will lead to electrical equipment damage.	Competence of technicians and knowledge of the suppression systems is critical – example cited where a crew transfer vessel (CTV) had a FM200 system on board which the technician didn't know how to operate/use. A fire occurred and a dry powder fire extinguisher was used, which resulted in breathing difficulties due to powder inhalation.
	Gas suppression systems can be expensive to install, maintain and replenish once deployed. Also, once the gas is 100 % used, if the ignition source has not been eliminated or removed then the fire will be able to reignite once the gas disperses.	Some G9 members have experience of insurance companies not agreeing on what is best practice for suppression systems in offshore wind turbines.
	There are both advantages and disadvantages to installing automatic manual fire suppression systems. Where automatic systems are installed, there needs to be greater redundancy in the system. Some automatic systems can be stopped for false alarms but cannot be turned off. Fault detections can occur frequently due to detection of brake dust.	If personnel are not present on the turbine or if they have successfully evacuated, controlling and supressing the fire may no longer be required.
	If there was better airtightness between the nacelle and the tower, this could assist in controlling a fire.	
	A fire extinguisher should be considered as an aid to escape rather than a primary means of fire control/ suppression.	

Table 1: Group 1 – Fire mitigation: nacelle design characteristics (facilitator: *Euan Fenelon*, ScottishPower Renewables) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Containment	Would benefit from further consideration during the design stage. Currently turbine towers/nacelles are not designed to be airtight.	Air flow is often required in turbines in order to control condensation formation, and this would not work if airtight principles were adopted. Also, high-powered components generate high levels of heat and air flow can act as cooling on these components.
	Should it be common to close transition piece (TP) doors/hatches when moving in the turbine? Is this a standard practice adopted by all operating companies?	If a fire incident results in personnel injured or burned, do hatches need to open automatically (mechanical process rather than electrical)? In the scenario where the TP door is left open, in the event of a fire then it will burn faster; however, it will also extinguish faster as well.
	Horizontal separation/ compartmentalisation can be designed into buildings to improve fire resistance. Can this also be considered when designing wind turbines?	
	Refuge positions and places of last resort - on offshore substations these would certainly be developed during the design phase; however, would it be feasible to design refuge positions on the actual turbines?	Any place of safe refuge designed into the turbine would need to have a minimum of two exit paths.
	For future designs, there will be a requirement/expectation for manufacturers to advise clients of any limitations for number of people in the nacelle, especially with designs that incorporate more high voltage (HV) switchgear in the base of the tower.	

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 1: Technician in lift 1. Technician in a lift moving downwards (approximation made of 18 m/min). 2. Technicians in the nacelle. 3. Fire at base of tower. 4. Fire alarm sounded, smoke developing. 5. Technician in lift is unsure of location of alarm sounding.	Variations exist in turbine designs: not all turbines have fire alarms and lifts – where possible retrofit with fire alarm/lift if without. Most offshore turbines have a lift (bucket/man rider) and a ladder system. Should the technician stay in the lift or climb?	1. Internal communication between technicians needed to understand where each party is. – Does the communications system work (is there a hardwire telephone in the lift/nacelle)? 2. Communication back to onshore (control room) to gain an understanding of what the indicators are showing – any false alarms? 3. Technician actions in the nacelle depending on information from the control room. Preference for evacuation. Technician in the lift either stays in the lift or starts to climb using the ladder system. – Ultimately this decision depends on the type of lift installed. – The technician's instinct may be to stay in the lift to stay away from any smoke (as less heavy breathing required). – **Safety critical aspects for lift design –** system designed to stop, reset and move. Possible to redesign systems that currently do not meet this functionality? – Service lift working – can go up (unknown – will lift get to the top?) – Lift not working – exit lift and climb. Likelihood not a 'big' fire. **PPE requirement** if lift not working. – Technician has all required equipment on them (apart from a smoke hood). Simple pieces of equipment = lower risk of failure. Climbing kit, twin tail lanyard and harness. – Do not introduce a smoke hood as it offers a false sense of safety/confidence to the technician. – If a smoke hood is already in the turbine/nacelle there is the potential for technicians to waste valuable time searching for it.
		– Design check: pulleys/anchor points able to withstand fire and heat? – **Combustibles in the tower:** cables, diesel fuel in generator, transformer in the base of the tower.

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 2: Technicians in nacelle – need to escape 1. Technician in a lift moving downwards. 2. Technicians in nacelle. 3. Fire at base of tower.	After talking to the onshore control centre: emergency evacuation plan acted out. Technicians are planning for evacuation. Technicians will assemble rescue/ evacuation kit, radio control centre, then discuss when to evacuate. Open nacelle roof to release smoke?	– **Unknown:** how will the technicians know when to evacuate? – Structure is safer than the sea. A fire will likely burn out, it is rare for fire to travel up to the nacelle. Two decks of structural steel are considered 'fairly' safe. – Need to understand the hazard first: only smoke in the nacelle, no fire, then possibility to create a path for smoke to dissipate (e.g. clam shaped roof – quick smoke release when opened). – Choices and decisions are highly dependent on the technicians themselves (the 'human factor' and turbine type in this situation). – **Rescue from helicopter or vessel:** dependent on turbine type. If by helicopter, then the helideck is the safest location on the turbine. – **PPE:** no more than what is being worn, until the technician has reached the nacelle. Life jacket – minimum requirement it is with the technician (not wearing it). Behavioural safety issue exists with carrying life jackets up to the nacelle. – **Different considerations when considering legacy fleet and new turbines.** – **New turbines:** designers need to understand the totality of fire risk. – Turbine manufacturers need to design to ALARP levels. Standard for a turbine should be similarly structured to the car industry, i.e. not up to the customer to ask for protection systems. The question should be if you want to remove this protection?

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 2: Technicians in nacelle – need to escape (continued)		– Customers should be able to increase the safety level on turbines but the minimum standard needs to be designed to ALARP levels. – Potentially, when a turbine manufacturer designs to ALARP levels there is a potential increase in costs, which may make customers consider other WTG manufacturers. – How to verify minimum safety in design? Difficult to set a limit of safety. – Industry standard on PPE? Will be dependent on turbine type. – Fire suppression systems? Risk analysis needed to see if/where necessary. – Historically, turbines have been designed for an onshore environment and modified, never purpose designed for an offshore environment. Current designs cannot be retrofitted in some circumstances (e.g. hatch location). – Future designs for offshore specific turbines will enable better planning to take place. Allow use of similar components and maintenance activities and ensure upfront assessment of safety considerations.
	Evacuation	– Aim is to ensure the technician is able to get to the TP. – Siemens research study – escape through emergency hatches. Chances of landing on the TP or in the sea are roughly 50/50. When escaping from a helibasket it is almost certain that a technician will land in the sea. – **Design:** hatch position and potential to land on a hatch in the sea? – **Unknown:** how will the technician know when to evacuate?

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 2: Technicians in nacelle – need to escape (continued)	Assume technicians land in water – PPE that is needed	– Equipment to get from top of WTG to the sea (e.g. climbing harness). Personal or collective? – Release and get into the sea. – Clipping off – risk scenario dependent on the technician in this situation. – Quick release device still not adequately addressed by the industry. – Suits make it more difficult to disconnect from a carabiner as the technicians body is in the recovery position. In future, more tailored/bespoke equipment will be needed. Discussion between PPE manufacturers and turbine manufacturers is also needed.
	Protection from sea exposure	– Survival suits **compatibility** with escape/sea survival suit required, regardless of sea temperature. – Flotation suit – why are flotation suits not carried? Maintenance of equipment is an issue; wear and tear due to carrying suits, more convenient to have stored in the turbine (take away perception of safety, human barrier). – Flotation suit over vs. survival suit – designed for different purposes. – Additional risks: cold water shock, salt water drowning. – Wear boots when evacuating: extra weight results in restricted swimming capability. – Search and rescue device (personal locator beacon) – may be installed dependent on the turbine model. Maintenance scheme for device necessary. Potential to be very useful. – What if there is a loss of communication with the lift technician or an injury to the lift technician (injured technician not able to disconnect)? What do nacelle technicians do? – **Smoke in nacelle:** put emergency plan at the base of nacelle not in smoke path. Provide airplane-like emergency lighting line on floor to show the escape route.

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 3: Fire burnt out. How do technicians escape? – Go down ladder inside the tower? Not after a fire.	Self-recovery exercise – same PPE as previous scenarios	– Vessel arrives – technicians drop into the sea and get rescued. Potential to adapt vessel rescue to include inspection of TP stability but this is dependent on turbine distance. – There is no guarantee that a helicopter/vessel can rescue people immediately. Use of a life raft – difficulty exists of getting into to a life raft once in the sea. – Evacuating from nacelle into the sea is the last resort, if there is only smoke and no heat then technicians are advised to wait out the fire. – Fire in the nacelle – procedure instructs technicians to go down to TP through the tower. – **Greater concern is regarding the legacy fleet of WTGs as only slight adjustments are providing incremental improvements.** Legacy fleet – extended net, looked into as a possible option. The challenge is to see how much better this would be compared to current industry practice.
	Better designs of new turbines are required to get technicians to the TP?	– Industry is limited by current designs. New turbines are getting larger – there is space for more equipment and the potential to redesign escape solutions.
	PPE/equipment – innovation to land on an external platform	– Guide wire from nacelle to the TP: permanent wire (spinning)? Installed each time work is carried out? Is this considered practical? – Staggered fall nets: life raft at bottom of staggered fall nets, height and space issue as <100 m. Also risk of hitting platform. – Pod: use lift as a heat retardant/safe zone to wait out fire. External lift/pod that can be descended. Potential external corrosion issues. – Life raft lowered down with winch by technicians – through a false floor? – Extend TP platform.

Table 2: Group 2 – Fire mitigation: escape equipment/PPE/WTG escape methodology (facilitator: *Peter Villadsen*, DONG Energy) (continued)

Considered design controls	Potential design controls	Nature of potential risk reduction
Scenario 3: Fire burnt out. How do technicians escape? (continued)		– Helter-skelter or use of nets? – Metal structure in tower to release smoke? – Fireproof pod in nacelle? – Fireproof turbine? Need rethink on functional design to protect life as the priority, and reduce the time needed to spend working on turbines.
	Exit strategies	– Evacuate all in one go: tangle risk but less reliance on other technicians. – Progressive evacuation from a system: heavily reliant on other technicians ahead. **Current scenario** is to always evacuate down, lifting requirements are small. **Potential new scenario:** exit through top of nacelle (via helicopter). A device is needed to rescue up. Knot in standard milan rope, with power drill attached to move upwards. Challenge that is present is the power drill is not made to run flat out for an extended period.
	Use oil and gas expertise - find out what is used and what works well to control fire risk	– Size of turbines compared to oil rigs – a big difference. – Oil and gas – 'human factor' issues. During some major incidents there have been instances where people followed the right procedure and died and where people deviated from the procedure and lived. – Mindset of person in an emergency situation is critical. – In the UK, major changes/improvements made after Piper Alpha incident. – No helideck – escape from hatch, multiple evacuations at the same time. – Design for mass evacuation at one time, to be considered during design phase for new turbines?
	Reducing probability of fire occuring	– Analyse what work is currently being carried out – control of procedures. When on structure, vary the use of electrical components.

Group 3 – Training and competence processes (facilitator: *Thomas Eriksen*, Statkraft)[1]

1. GWO/RenewableUK training

- The current Basic Safety Training every two years is considered sufficient but more drills with the emergency escape equipment that will be used offshore should be undertaken. After training is completed, a technician should be fully proficient in using the emergency escape equipment.
- A refresher course every two years is considered adequate for Basic Safety Training, but there would also be benefit once a quarter having a refresher-type course that is structured and logged for each technician. The refresher frequency will also depend on how often the equipment is being used.
- The current Basic Safety Training provides an understanding of the risks in offshore wind work, but it doesn't necessarily result in a higher skill set being gained by the technician. There is a difference between training courses and drills, and drills are arguably more important for improving skills. This again reinforces the need to have more regular drills.
- The level and frequency of training course certificates to work offshore is at a good level. This has been confirmed within the industry recently.
- Site management may not always prioritise training: technicians are cleared to attend training courses, but when a turbine is down and maintenance work is required the technicians are instead sent to work on the turbine. Technicians need to have support from site management to reduce the number of training course cancellations.

2. Drills in a realistic environment in turbines

- Training complemented by drills
- Potential to have onshore familiarisation and offshore drills.
- Familiarisation can be a fairly simple process.
- More training in dedicated training centres is not necessarily needed as this may increase costs without a justifiable benefit.
- Mocked up clip on/attachment points on site can be used to give some practice/familiarisation of particular systems. Understanding the shift of the loads when clipped on is important. A mock up is a great idea if it can be done in a controlled environment. Can still have a full emergency evacuation drill done using a dummy on the turbine. There is a need to practice these on the turbine, which means the turbine will need to be shut down during the drill.
- Evacuation element in training is more focused around the rescue rather than the evacuation. Can the G9 discuss formally with training providers about mock evacuation situations and available facilities (which are more representative of working offshore)?
- How do incidents influence what the industry should be doing? Drills are important as technicians do not always have time to think about what's going on in a real life situation.

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1 Due to the nature of this topic it was not possible to structure the notes around design/risk controls. Instead, these notes are summarised and presented around the main issues and topics discussed.

- Planning drills
  - Experience has shown from an operational point-of-view that planning drills can be complicated. Lots of planning is involved for a visitor to go on a turbine, visitors need to go with two advance technicians, but this is still thought of as appropriate. There can be a risk of people involved feeling demotivated, and so they need to feel that the drill is worthwhile and beneficial. If operators put in a requirement for people to go on a drill then it needs to be workable within the existing operations.
- How to create realistic drills
  - Demo installation offshore – use this as a live training base? Siemens opinion that this would be valuable as it would allow for e.g. feel of the vessel motion and other 'in the field' experiences.
  - Train realistically, i.e. be exposed to smoke. Smoke hoods may give you more time to escape in a fire scenario. It is rare a technician will experience these conditions, so a mock-up would be sufficient.
  - Risk of panicking is higher in a realistic situation.
- Who will practice drills?
  - Not just about technicians but also need to think about people who go to turbines less regularly.
  - Maybe need to look at requirements for people accompanying technicians.
  - Most people that go on training courses are technicians, they are working on offshore wind farms full time. Zero ambition of incidents? Currently there is a good trend in the industry for the prevention of serious incidents/fatalities.
- When can drills be carried out?
  - If the turbine is shut down for the whole day then multiple drills/exercises can be carried out in the morning and the afternoon.
  - Potential to use no wind days for drills? Cannot run training on these days, so how is this dealt with? Weather days can be days where there is no travel offshore so on these days mock-up facilities onshore could be used.
  - Dependent upon the turbine type and emergency escape plan to get someone down to the TP from the nacelle the whole end-to-end escape path may need reviewing and updating.
  - How does the industry effectively supplement drills with training? Potential to implement a minimum number of drills offshore and then have the training to support and underpin this. Practice and training can take place, but it should always be recognised that this is not a real life situation. Drills should be undertaken in the right environment. Outcomes from drills should be made available to the turbine designer who should be challenged to find solutions to problems experienced. The point is to learn and promote through drills and the windfarm operators should have a certain number of drills planned and the necessary training to back this up.
- Workplace culture
  - Valid training certificates should be provided before sending anyone to work offshore. When not offshore time should be used effectively e.g. team building exercises etc. (to promote a positive safety culture).
  - A culture which recognises the importance of good housekeeping practices and workplace safety will reduce the probability of serious incidents/fatalities.
  - The last barrier to an incident is the person (the ‘human factor’). The risk will still be present if there is a poor safety culture.

- Other industries
  - Strong case to look at other industries and sectors and see what their requirements are for training and drills.

3. Feedback learning to manufacturers/designers

- Need to start looking at emergency escape issues at the turbine design phase and inform designers of these in sufficient time in order to influence future turbine designs.
- Designing and engineering the issues out at the beginning of the turbine design process can greatly assist in ensuring incidents are not repeated.
- Turbine manufacturers do not always fully understand the risks and hazards encountered during wind farm O&M phase: it is in the industry's interest to inform the manufacturers of these issues at the early stages of a turbine design process.

4. Collaboration between manufacturer and the O&M service provider on deciding on drills

- It is possible that a realistic offshore environment can be replicated in a mock-up facility onshore. When a developer plans and builds an O&M facility there should be a budget in this for a mock-up as well.
- Technicians need time to practice on a turbine, which means it needs to be shut down for a period of time. There needs to be an agreement between the windfarm owner/operator and the O&M service provider when planning this shutdown. The operator needs to ensure the turbine is shut down when undertaking drills.

5. Train and drill with the equipment that is used

- How are different types of equipment dealt with? Benefit in standardizing across the industry.
- Some rescue kits are within the nacelle, some have to be taken out by the technicians.
- Examples of different equipment being used when an incident occurred compared to what is used in training meaning technicians have to spend time reading equipment instructions and becoming familiarised with it.
- How drills are carried out will vary and be influenced by the type of turbine operated, although this will not influence the number of drills undertaken.

6. Competency framework

- Should the G9 consider setting key performance indicators (KPIs) for competence and training?
- Currently no plan for the G9 to introduce industry KPIs. In the G9 context there are lagging indicators in the incident data and there is a commitment to produce LTIF and TRIR safety statistics on an annual basis.
- The G9 has already published good practice guidelines for some higher risk activities. There are no KPIs in these; however, the G9 member companies are currently looking to assess the level of implementation of the recommendations in the good practice guidelines.
- How many drills could be done per working hour? Drills can be expensive and complex, but this can be discussed further within the G9.
- Is there a benefit in setting a zero harm 2020 target in the industry?

- The industry is on a journey to develop these tools further and currently it is not as mature as some other industries (e.g. oil and gas).
- There may be an over focus on training type/methodology. Some people are more natural leaders. A company can have a good culture and still pull each other in the wrong direction. The industry should not add more training/syllabus requirements where they are not necessary.
- Competency framework: many elements that can be done offshore and also many at the O&M base. This can be managed by the operator in a number of ways. It is important to train in real world conditions, but there is more risk in doing this when training can be done onshore. Depends on the equipment needed.
- There should be a top-down approach to training and competency within the industry.
- Build on leadership skills which already exist within individual personnel.
- Consider having fixed teams of technicians as it can challenging to have different teams travelling to and working at different sites.

7. Assessing the effectiveness of training

- Vestas have developed a health and safety training questionnaire to assess the effectiveness of training. How else can the industry check that training has been successful?
- There is an obligation to audit training providers. At the end of each course a questionnaire should be given about the course which can be completed by those who attended.
- Whilst all companies have competency matrices these could be supplemented by completing feedback forms on training courses.

8. Contracts

- It should be recognised in tender documents and subsequent service contracts that turbines may require shutting down in order to perform drills and emergency exercises. This could be included in the relevant health and safety sections of any tender/contract documents.

A.2 PRESENTATION INTRODUCTIONS AND SLIDES

Presentation 1: *Andy Lidstone*, Risktec Solutions and *Mark Jenkins*, Siemens Energy: Design characteristics of a nacelle that mitigate the impact of a fire and increase the time for a person to effect an escape

Executive summary

The presentation provides an overview of the recent work performed by Siemens and Risktec in developing fire risk analyses for a number of turbine designs.

The fire analyses form part of a larger safety case project to provide a detailed review of all risks associated with the design, construction, operation and decommissioning of a generic offshore wind farm. The fire analyses comprised a detailed hazard identification to develop a list of all credible fire scenarios from which semi-quantitative bow ties were developed; representing the scenarios, and preventive and recovery controls, in place for the four major risk scenarios.

Detailed computational fluid dynamics modelling was performed to model the scenarios. For example, smoke and heat transport in fire scenarios. The results of which were used to inform escape and evacuation reviews and evaluate the adequacy of the arrangements in place for personnel in an emergency scenario.

The fire risk analyses concluded that there were no intolerable risk scenarios present; however, a number of changes were implemented to the escape and evacuation arrangements for personnel, including new equipment and alternative escape routes.


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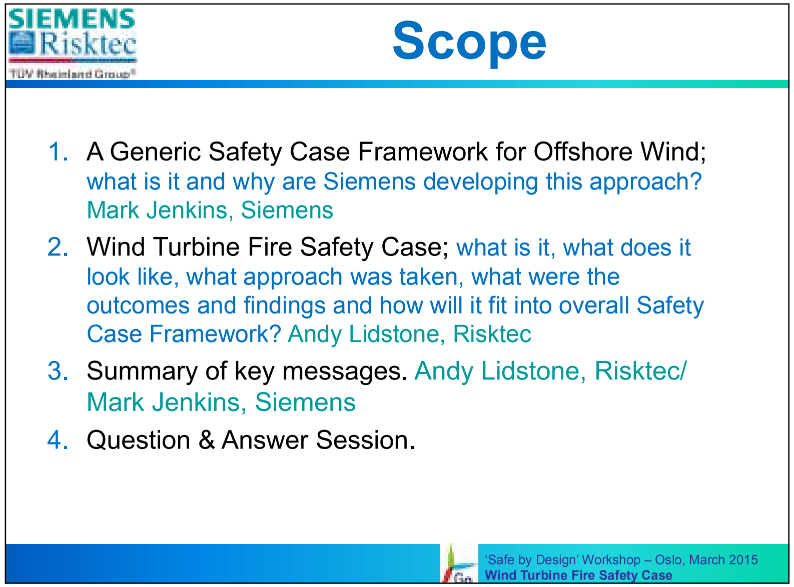
Wind Turbine Fire Safety Case
A holistic approach to ensuring and demonstrating that the risk of fire to personnel working within an offshore wind turbine is reduced As Low As Reasonably Practicable.
G9
'Safe by Design' Workshop – Oslo, March 2015
Wind Turbine Fire Safety Case


SIEMENS
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Scope
1. A Generic Safety Case Framework for Offshore Wind; what is it and why are Siemens developing this approach? Mark Jenkins, Siemens
2. Wind Turbine Fire Safety Case; what is it, what does it look like, what approach was taken, what were the outcomes and findings and how will it fit into overall Safety Case Framework? Andy Lidstone, Risktec
3. Summary of key messages. Andy Lidstone, Risktec/ Mark Jenkins, Siemens
4. Question & Answer Session.
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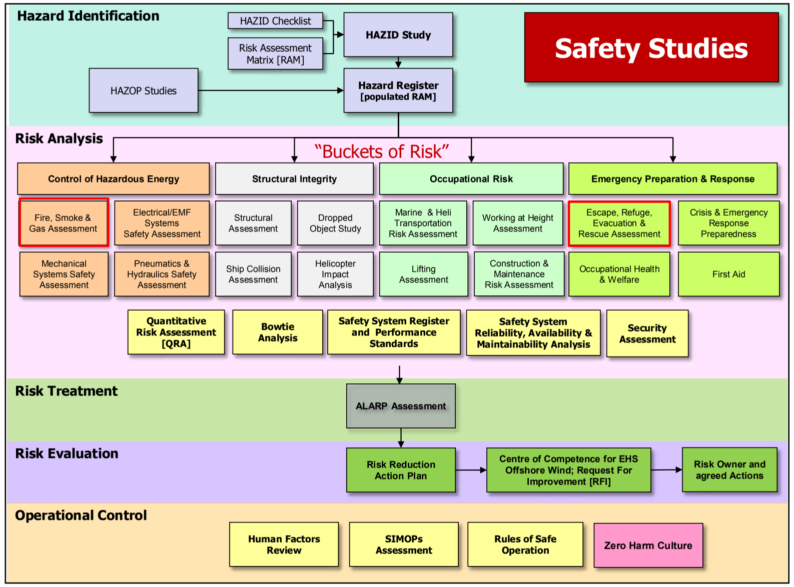
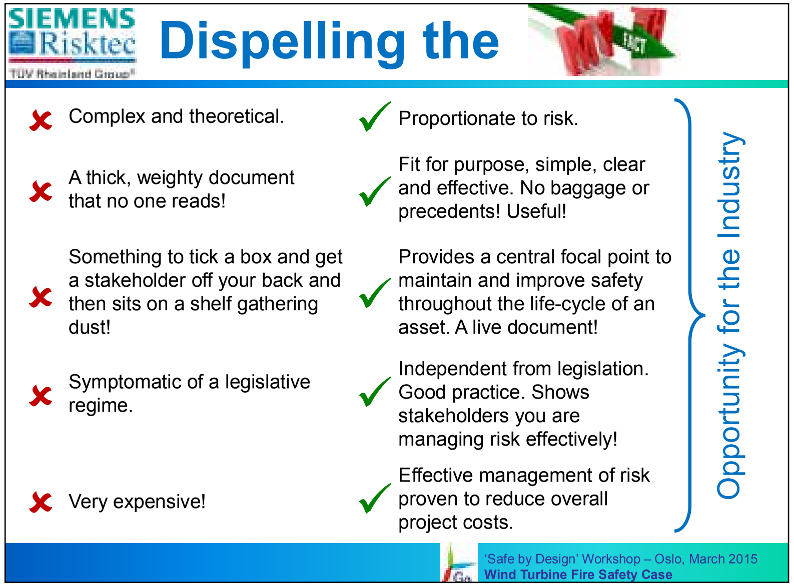

Hazard Identification
HAZID Checklist
Risk Assessment Matrix [RAM]
HAZID Study
HAZOP Studies
Hazard Register [populated RAM]
Safety Studies
Risk Analysis
"Buckets of Risk"
Control of Hazardous Energy
Structural Integrity
Occupational Risk
Emergency Preparation & Response
Fire, Smoke & Gas Assessment
Electrical/EMF Systems Safety Assessment
Structural Assessment
Dropped Object Study
Marine & Heli Transportation Risk Assessment
Working at Height Assessment
Escape, Refuge, Evacuation & Rescue Assessment
Crisis & Emergency Response Preparedness
Mechanical Systems Safety Assessment
Pneumatics & Hydraulics Safety Assessment
Ship Collision Assessment
Helicopter Impact Analysis
Lifting Assessment
Construction & Maintenance Risk Assessment
Occupational Health & Welfare
First Aid
Quantitative Risk Assessment [QRA]
Bowtie Analysis
Safety System Register and Performance Standards
Safety System Reliability, Availability & Maintainability Analysis
Security Assessment
Risk Treatment
ALARP Assessment
Risk Evaluation
Risk Reduction Action Plan
Centre of Competence for EHS Offshore Wind; Request For Improvement [RFI]
Risk Owner and agreed Actions
Operational Control
Human Factors Review
SIMOPs Assessment
Rules of Safe Operation
Zero Harm Culture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Dispelling the MYTH
FACT
Complex and theoretical.
A thick, weighty document that no one reads!
Something to tick a box and get a stakeholder off your back and then sits on a shelf gathering dust!
Symptomatic of a legislative regime.
Very expensive!
Proportionate to risk.
Fit for purpose, simple, clear and effective. No baggage or precedents! Useful!
Provides a central focal point to maintain and improve safety throughout the life-cycle of an asset. A live document!
Independent from legislation. Good practice. Shows stakeholders you are managing risk effectively!
Effective management of risk proven to reduce overall project costs.
Opportunity for the Industry
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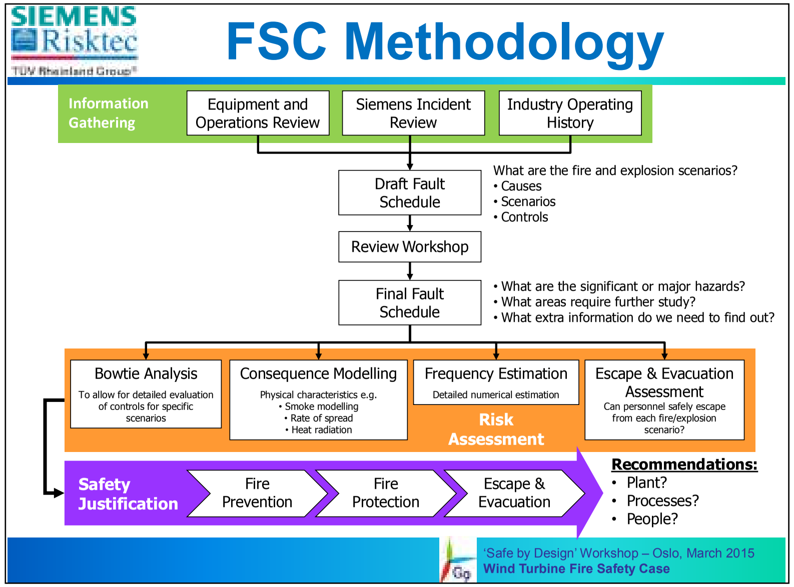
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FSC Methodology
Information Gathering
Equipment and Operations Review
Siemens Incident Review
Industry Operating History
Draft Fault Schedule
What are the fire and explosion scenarios?
• Causes
• Scenarios
• Controls
Review Workshop
Final Fault Schedule
• What are the significant or major hazards?
• What areas require further study?
• What extra information do we need to find out?
Bowtie Analysis
To allow for detailed evaluation of controls for specific scenarios
Consequence Modelling
Physical characteristics e.g.
• Smoke modelling
• Rate of spread
• Heat radiation
Frequency Estimation
Detailed numerical estimation
Escape & Evacuation Assessment
Can personnel safely escape from each fire/explosion scenario?
Risk Assessment
Safety Justification
Fire Prevention
Fire Protection
Escape & Evacuation
Recommendations:
• Plant?
• Processes?
• People?
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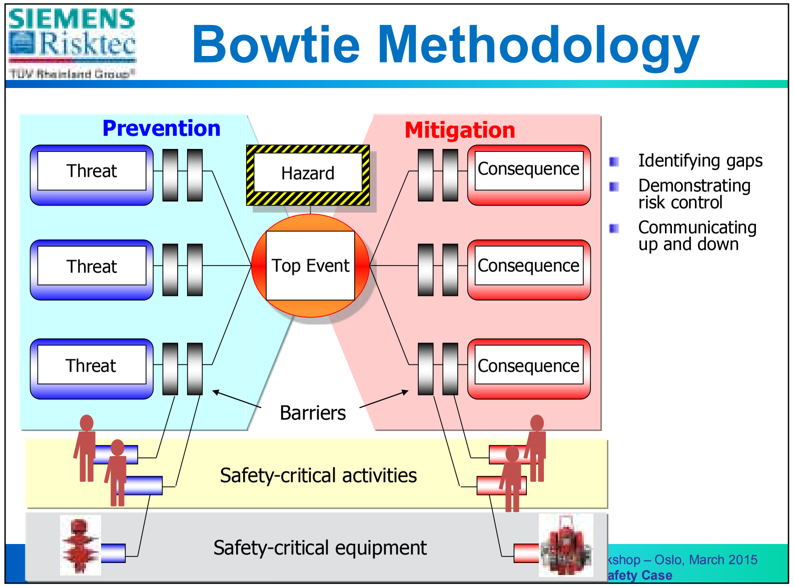
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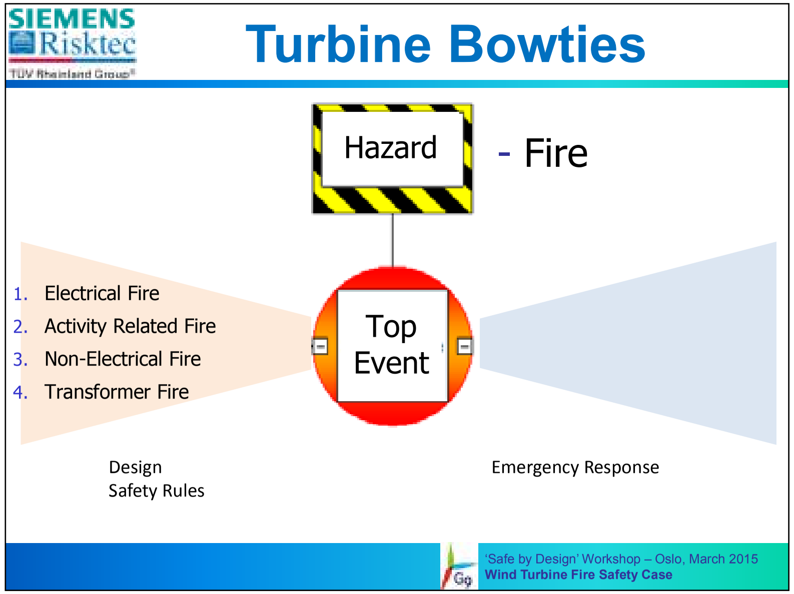
Bowtie Methodology
Prevention
Mitigation
Threat
Threat
Threat
Hazard
Top Event
Consequence
Consequence
Consequence
Barriers
Safety-critical activities
Safety-critical equipment
Identifying gaps
Demonstrating risk control
Communicating up and down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Turbine Bowties
Hazard
- Fire
1. Electrical Fire
2. Activity Related Fire
3. Non-Electrical Fire
4. Transformer Fire
Top Event
Design
Safety Rules
Emergency Response
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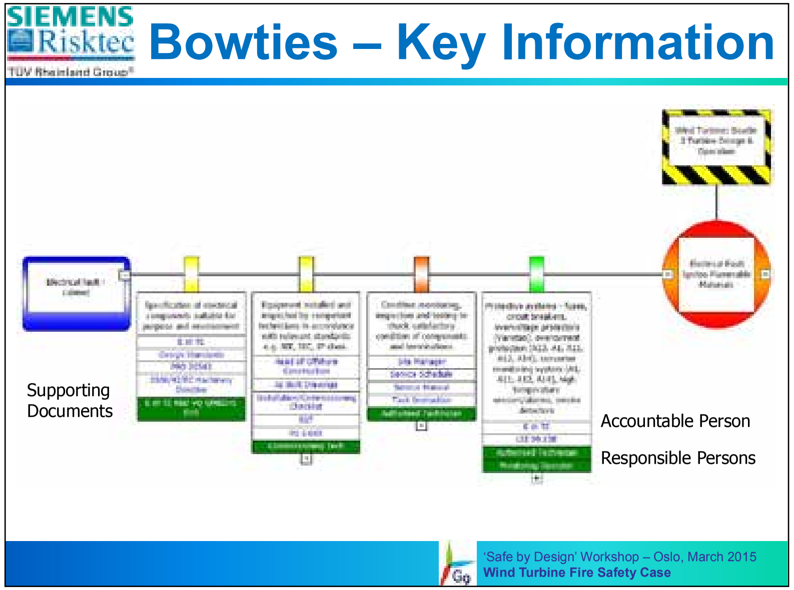
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Bowties – Key Information
Supporting Documents
Accountable Person
Responsible Persons
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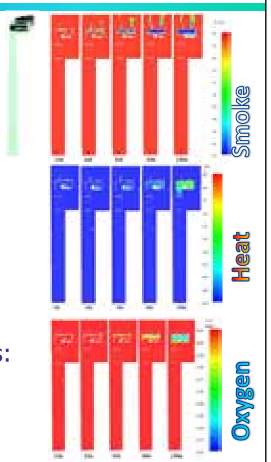
Quantitative Analysis

Frequency analysis:
- Very sparse data available

Detailed fire modelling:
- Locations – Nacelle/Tower
- Ventilation – Sealed/Vented
- External wind – Present/Calm

Consequences modelled:
- Smoke progression
- Heat dissipation
- Oxygen depletion

All modelling used to inform post event actions:
- Escape routes
- Evacuation plans
- Rescue requirements



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Consequence Modelling

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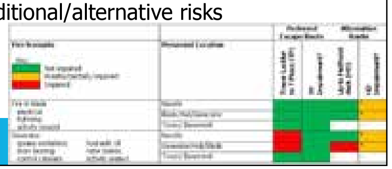
Escape & Evacuation Reviews

Given the consequence modelling results, are the current escape, evacuation and rescue arrangements appropriate?

- For each fire scenario [location and type of fire]
  - How are personnel alerted?
  - How is the fire location determined?
  - Is the primary escape route available?
  - Is there a secondary escape route available?
  - What are the evacuation arrangements?
- Identification of shortfalls
  - Alternative escape route not available
  - Evacuation may present additional/alternative risks



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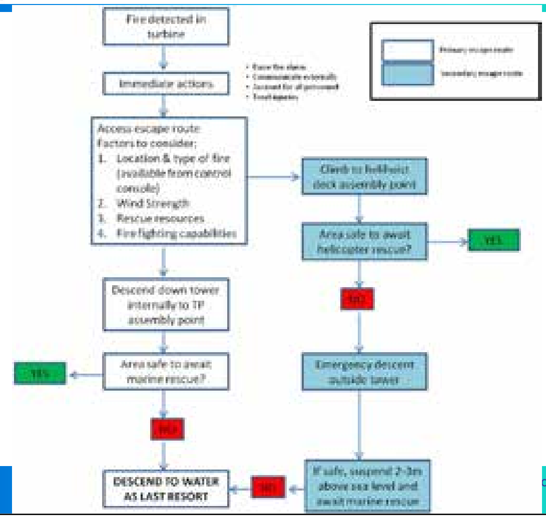
Revised EER Philosophy



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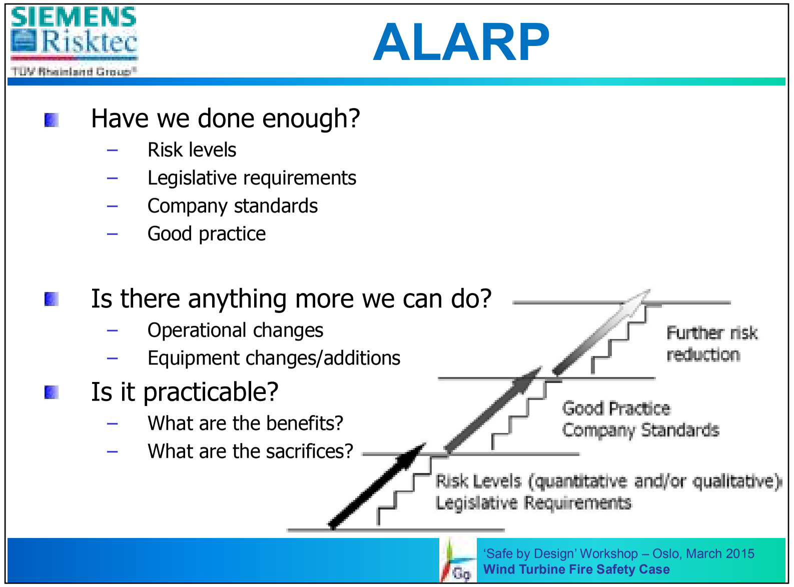
Proof Testing
Both Existing and Revisions
Wind Turbine Fire Safety Case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ALARP
Have we done enough?
– Risk levels
– Legislative requirements
– Company standards
– Good practice
Is there anything more we can do?
– Operational changes
– Equipment changes/additions
Is it practicable?
– What are the benefits?
– What are the sacrifices?
Further risk reduction
Good Practice
Company Standards
Risk Levels (quantitative and/or qualitative)
Legislative Requirements
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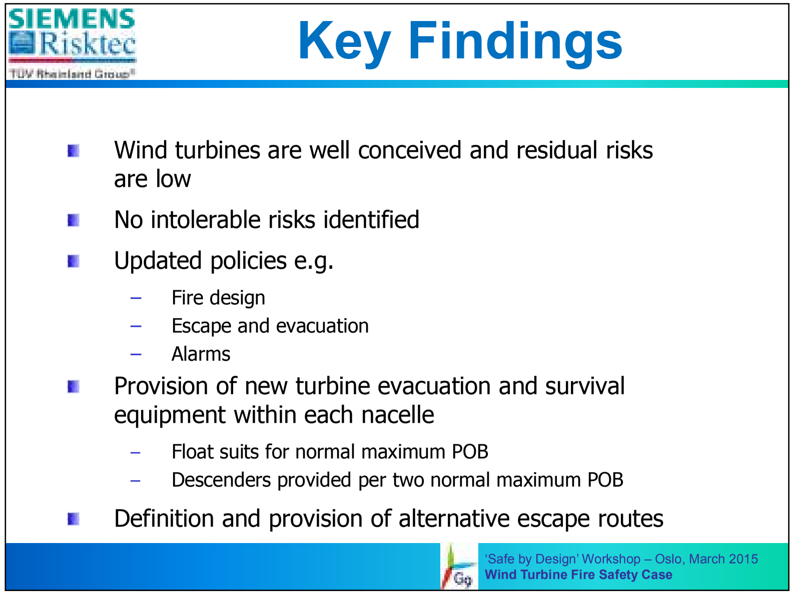
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Key Findings
Wind turbines are well conceived and residual risks are low
No intolerable risks identified
Updated policies e.g.
– Fire design
– Escape and evacuation
– Alarms
Provision of new turbine evacuation and survival equipment within each nacelle
– Float suits for normal maximum POB
– Descenders provided per two normal maximum POB
Definition and provision of alternative escape routes
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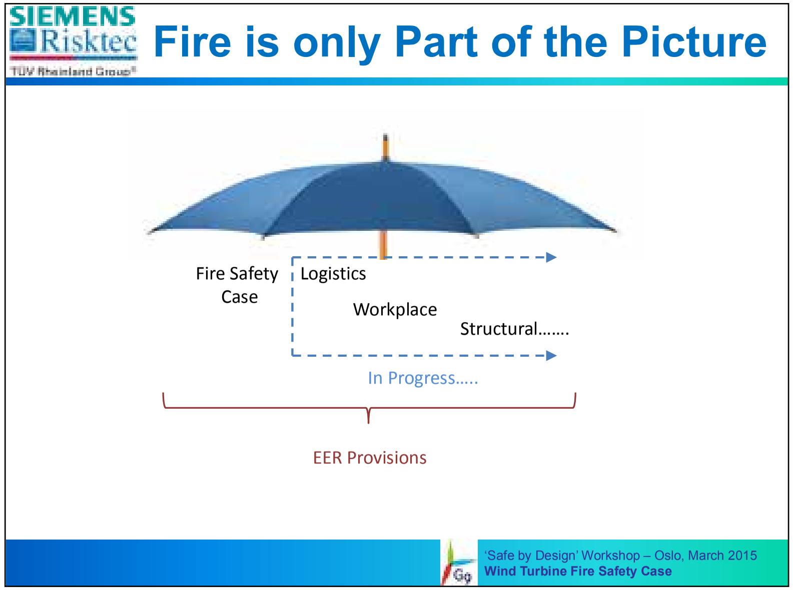
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Fire is only Part of the Picture
Fire Safety Case
Logistics
Workplace
Structural…….
In Progress…..
EER Provisions
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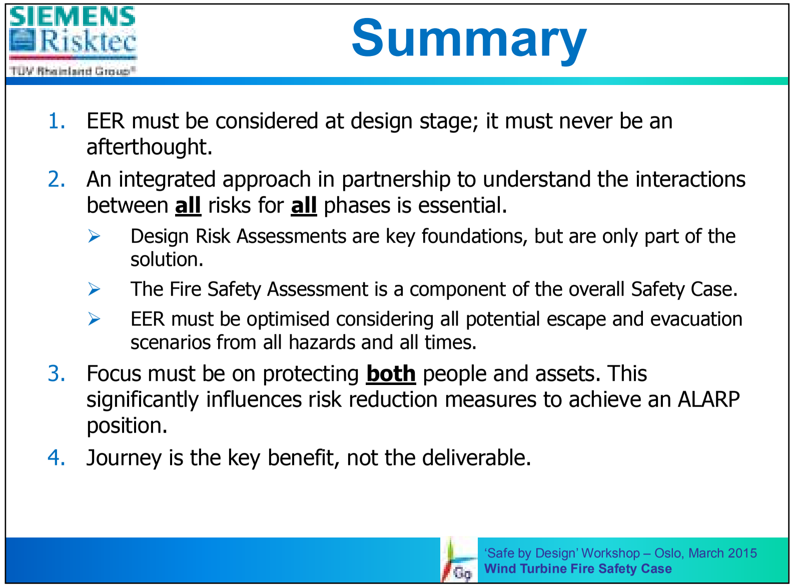
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Summary
1. EER must be considered at design stage; it must never be an afterthought.
2. An integrated approach in partnership to understand the interactions between **all** risks for **all** phases is essential.
➢ Design Risk Assessments are key foundations, but are only part of the solution.
➢ The Fire Safety Assessment is a component of the overall Safety Case.
➢ EER must be optimised considering all potential escape and evacuation scenarios from all hazards and all times.
3. Focus must be on protecting **both** people and assets. This significantly influences risk reduction measures to achieve an ALARP position.
4. Journey is the key benefit, not the deliverable.
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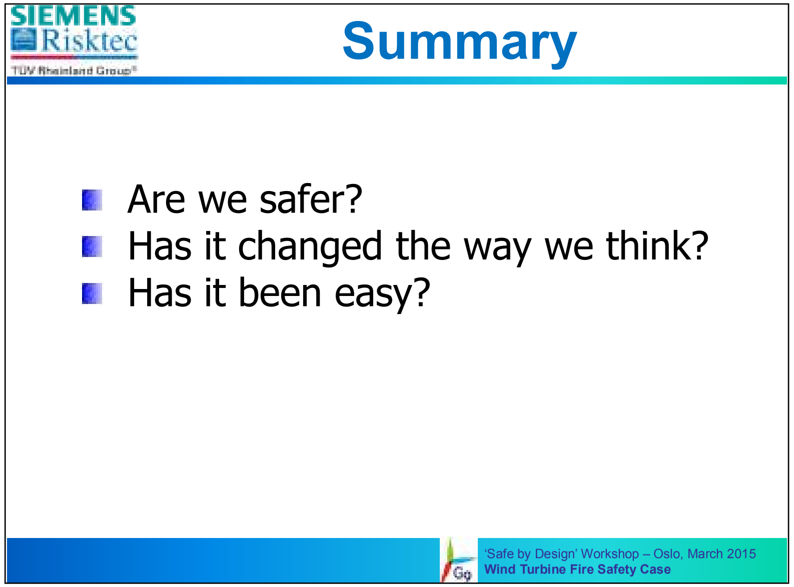
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Summary
Are we safer?
Has it changed the way we think?
Has it been easy?
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Presentation 2 – *David Thomas*, heightec: Overview of different types of escape mechanisms/systems

Executive summary

Wind turbines provide particular challenges for emergency escape in the event of fire, the consequences of which need to be considered. Designers should consider the 'general principles of prevention' (in particular, the need to avoid risk and combat the risks at source) and the 'hierarchy for work at height' (remembering that personal fall protection equipment is a 'last resort').

In selecting equipment, it is important to 'look beyond the standard'. There is often confusion with what is defined as PPE and when a CE mark can be affixed (or not). Product markings should be clear and understood. If unsure, then consult with the manufacturer for advice.

Due account should be taken of the guidance given in G9's *Working at height in the offshore wind industry*, in particular see 3.1 and 5.2. Additionally, rescue plans are not just 'bits of paper'. They should be specific and not 'woolly'; avoid uncertainty and be specific. Make sure that the full evacuation and rescue path has been trialled and ensure that responsibilities are defined and understood.

There are many different types and makes of fall protection equipment: automatic descenders; abseiling kits, and self-evacuation kits. Different kits will be appropriate in different circumstances. Controlled rate descenders (CRDs) require the consideration of many issues: the height of descent (and more); the numbers of users (multi-user); the mass of any users (light and heavy); the number of people that need evacuating (the team size); the speed of descent (that will vary with mass); whether additional friction is required; whether the device can lift and lower; ease of deployment and intuitiveness, etc. Descent energy is important too: standards imply that load and distance are directly proportional; however, this is not the case, and the maximum rated load may not be achieved under the maximum descent height. For information on descent times and the effect of fire on rope, it is important to seek information from the device manufacturer.

A training regime should take account of 'skill fade' and there is a need to distinguish between training, re-training, refreshers, product familiarisation, rescue and evacuation drills, company induction, site induction and task briefings, etc.

G9
Offshore Wind Health & Safety Association

Safe by Design Workshop
Oslo, Norway

Escape from a turbine nacelle in the event of a fire
Personal protective equipment

David Thomas, CEng, FICE, CFIOSH
Technical Director, heightec

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Background

- **Chartered**
  - Civil Engineer (CEng, FICE)
  - Safety and Health Practitioner (CFIOSH)
- **Engineering and management consultancy**
  - Allott and Lomax Ltd (now part of Jacobs)
  - WS Atkins Ltd (now Atkins plc)
- **Health and Safety Executive** (1997 to 2007)
  - Technology Division, Bootle
  - Northern Specialist Group, Manchester
  - Construction Division Technology Unit
- **Contracting and manufacturing**
  - William Hare Ltd
- **Work at height and rescue**
  - heightec
- **Other**
  - Chairman, PH/5, Personal fall protection (BSI)
  - Vice-Chairman, RUK HS&E Strategy Group
  - HSE CONIAC Safety Working Group

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When I was fitter …


Over the top!

GUSTING winds and drizzle did not prevent engineer David Thomas from abseiling off a sheer cliff face in Summerseat to assess the damage to an important stone wall.

Mr Thomas lowered … essary repair work to reinstate Hill Street as a walkway.

BURY Times
25p

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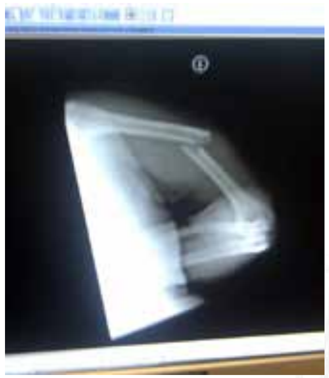
Consequences …



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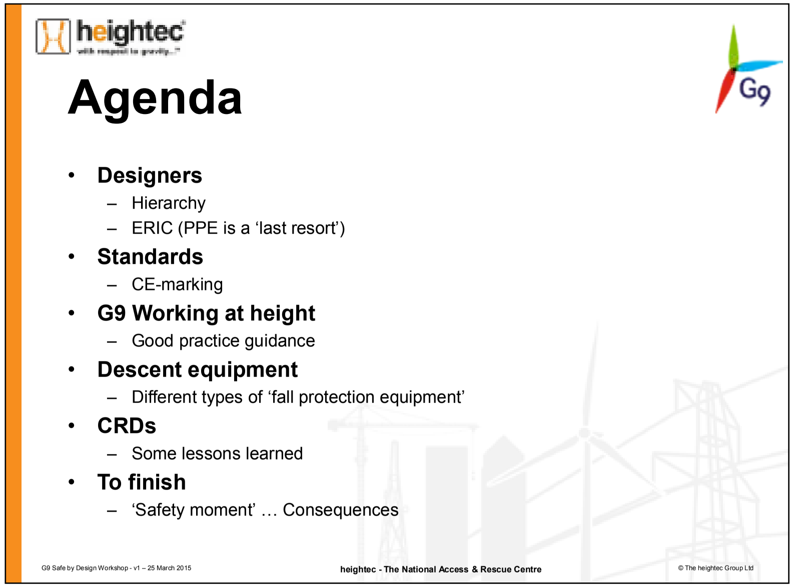
heightec
with respect to gravity...
Agenda
• Designers
– Hierarchy
– ERIC (PPE is a 'last resort')
• Standards
– CE-marking
• G9 Working at height
– Good practice guidance
• Descent equipment
– Different types of 'fall protection equipment'
• CRDs
– Some lessons learned
• To finish
– 'Safety moment' … Consequences
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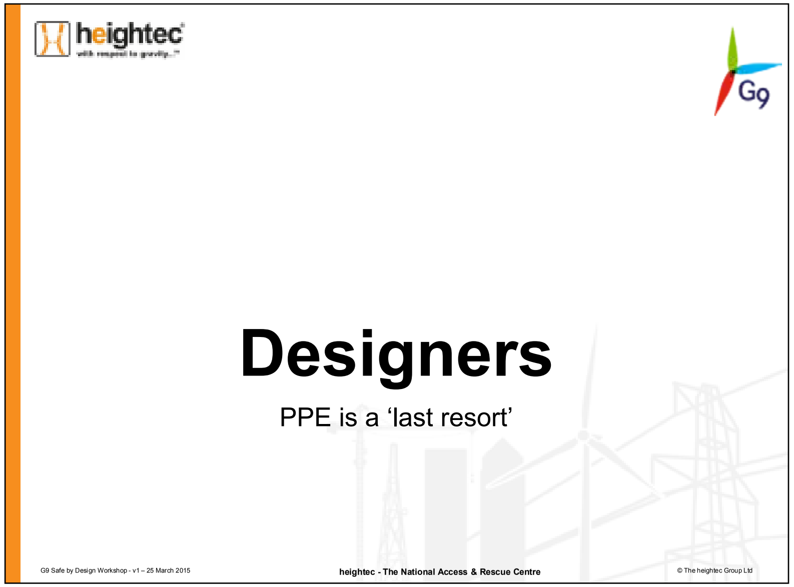
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Designers
PPE is a 'last resort'
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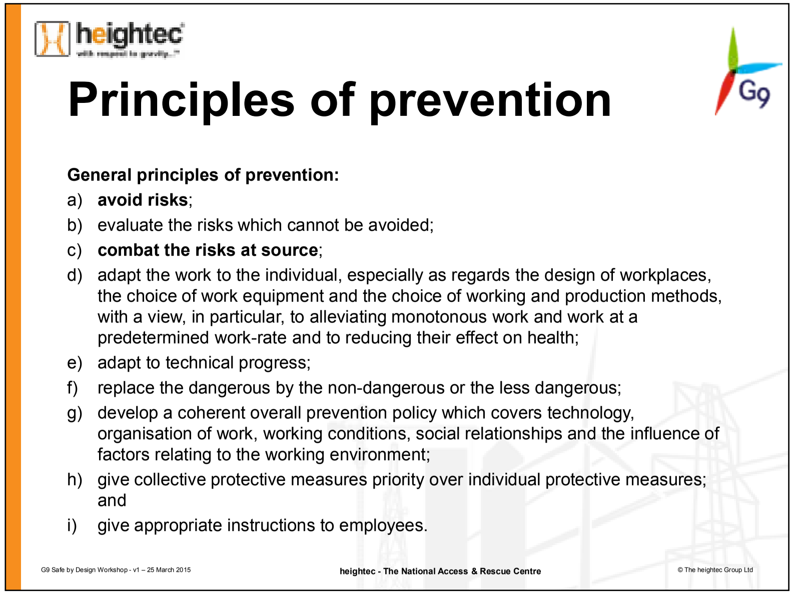
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with respect to gravity...
Principles of prevention
General principles of prevention:
a) avoid risks;
b) evaluate the risks which cannot be avoided;
c) combat the risks at source;
d) adapt the work to the individual, especially as regards the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work and work at a predetermined work-rate and to reducing their effect on health;
e) adapt to technical progress;
f) replace the dangerous by the non-dangerous or the less dangerous;
g) develop a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;
h) give collective protective measures priority over individual protective measures; and
i) give appropriate instructions to employees.
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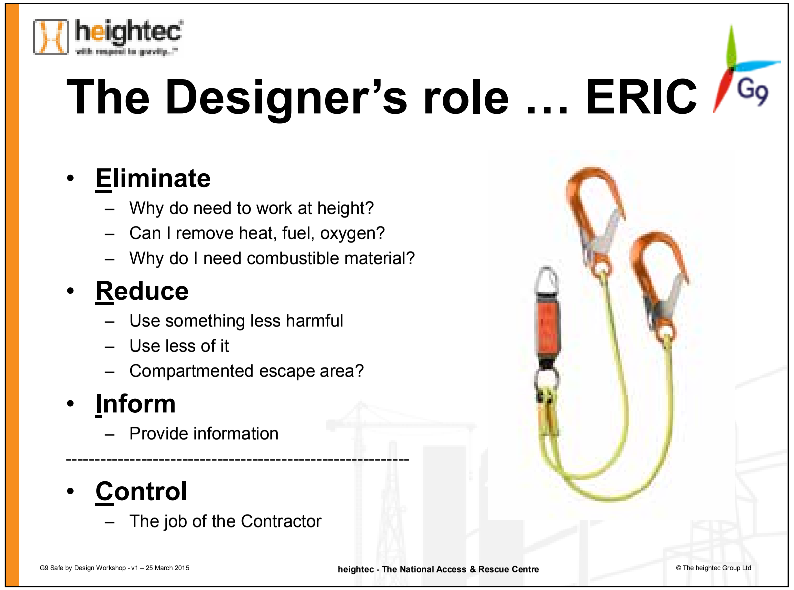
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with respect to gravity...
The Designer's role … ERIC
• Eliminate
– Why do need to work at height?
– Can I remove heat, fuel, oxygen?
– Why do I need combustible material?
• Reduce
– Use something less harmful
– Use less of it
– Compartmented escape area?
• Inform
– Provide information
• Control
– The job of the Contractor
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Standards

Do they help?

Are they 'fit for purpose'?

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To CE-mark … or not

EN 341: 1993

- Scope
  - requirements, test methods, marking and instructions for use for descender devices *used for rescue …*
- Harmonised
  - So, could CE-mark

EN 341: 1996

- Scope
  - … for descender devices as *rescue equipment …*

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- <u>C</u>heck <u>E</u>verything
  - Is equipment suitable for particular risk being considered?
  - Not necessary; testing is limited to lab conditions
- PPE-D 89/686/EEC
  - Basic health and safety requirements (Annex II)
  - Type approval; Category III
  - To be replaced with Regs
- Supply issue
  - Enforced by BIS (UK)

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EN 341: 2011

- Title:
  - Descender devices *for rescue*
- Scope:
  - Requirements, test methods, marking and information … for descender devices … *intended for rescue* and to protect against falls in a recue system …
- <u>Not</u> harmonized
- Not "personal protective equipment" (PPE)
  - 89/686/EEC
  - Just because something is not harmonized does not mean that it is not 'PPE' …

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heightec
with respect to gravity...

PPE Guidelines Blue Book

PPE:

- … any device or appliance designed to be **worn or held** by **an individual** for protection against one or more health and safety hazards
- … Equipment used by a rescuer is not classed as PPE, unless used to protect the rescuer himself …
- … The hazards involved are those which may harm the **equipment user** …

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CE-marking

- **Key points:**
  - Is the equipment "personal protective equipment"
    - "worn" … "held" …
    - "by an individual" …
  - Is the standard harmonised (Annex ZA)
    - provides 'presumption of conformity'
  - Lack of clarity
    - UK:
      PPE Supply is enforced by BIS
      - Not responsive to queries
    - VG11
      - Don't meet often; poor link with TC160

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G9 Working at height

Good practice guidance

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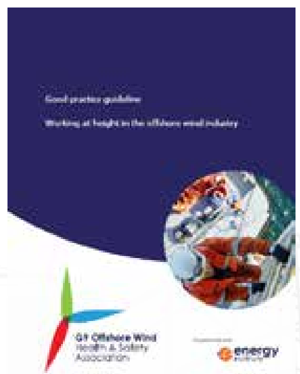
Working at height guidance

- **Design for rescue** (3.1.5.2)
  - Enable foreseeable rescues
    - safely and swiftly
  - Consider:
    - Size of rescue party
    - Suitable fixed and/or moveable anchors
    - Stretcher(s)
  - Equipment
    - Present in offshore asset
    - Carried at all times
    - Available nearby, e.g. vessel
  - Rescue path
    - Size of openings
    - Obstructions
    - Edge protection, e.g. hatches
  - Fire
    - External descent
    - Wind speed; landing platform; vessel recovery



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General points arising

- **Rescue and evacuation**
  - Is training sufficient
    - general ('generic')
    - turbine specific
  - Consider full rescue path
    - moving around vessel
    - vessel to vessel
    - vessel to shore
  - Life jacket buoyancy
    - 275N
  - Cold water protection
    - immersion or survival suit
  - Compatibility issues
    - energy absorbers
      - under lifejacket
    - harness adjustment
      - sizing over other clothing
  - Evacuation time
    - results of fire risk assessment
    - smoke spread
  - Design Reviews
    - Are these undertaken
  - How share best practice
    - Best Practice Forum

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Risk perception

Table 19: Ranking of areas of concern from survey data

Topic group	G9 rank	heightec rank
Design	1	2
Falling object	2	6
Vessel transfer	3	3
Procedure	4	1
Behaviour	5	9
PPE	6	8
Maintenance	7	11
Organisation	8	10
Training	9	7
Rescue	10	5
Other		4

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Rescue plans

- Key points:
  - Full path … Try it!
    - Problems
  - Be specific, not 'woolly'
    - "where required"
    - "at regular intervals"
    - "suitable training"
    - "updated periodically"
    - "if required"
    - "designated members"
- Refreshers …
- Skill fade …
  - Glasgow Caledonian University

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Descent equipment

Evacuation and rescue

Different systems

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Automatic descender

- Evacuation and/or rescue
  - Lifting
  - Controlled lowering
  - Evacuation
- Descent energy
  - Multi-user, e.g. two-person
    - What mass is a 'person'
      - HSE RR342, 116.2 - 122.0 kg
  - Two-way
    - How many people need to get out
- Rope is moving, not fixed
- Use of a steel strop: anchorage

Rotor

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Abseiling kits

- Ready-to-use rescue and evacuation descender
  - Self evacuation
  - Pick-off
- Manually operated
- Rope is stationary
- Not multi-person
  - Powerlock 200kg
- End does not come back up
- Double-braked

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Self evacuation kits

- Configured for immediate descent
- Manually operated
- Small size, traditionally
- Lightweight
  - Micropack can be carried
- Can configure to off-weight
- Double-braked
- Speed control
- Quick release
- Temperature resistance
  - Technora (aramid)

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CRDs

Controlled rate descenders

Some lessons learned

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Equipment selection

Consider:

- Height
  - 80 to 120m
- Number of users
  - 6 No.
- Mass of users
  - Including kit (but how much)
  - What is 'two person'
- Multiple person
  - Two at a time
  - Probability of one or more being 'heavy'
- Number of descents
  - Three
- Ease of deployment
  - Out of the barrel – 'clip and go'
  - Cut with knife; tear
  - Storage ready assembled

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Cont./…

- Speed of descent
  - Varies with mass
  - Controlled
- Inspection and servicing requirements
  - How often and how easy
- Additional friction
  - For lifting and/or lowering
  - Both directions of travel
- Sealed
  - Ingress of dirt and/or moisture
- Ease of use
  - Intuitive
- Lifting <u>and</u> lowering
  - Where else may the kit be required

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Cont./…

- Corrosion resistance
  - Testing shall "… not affect function …"
  - EN: 48 hr exposure
    - "… conformity with this requirement does not imply suitability for use in a marine environment …"
    - Maintenance regime
  - ANSI: 96 hr exposure
    - Orientation of device during testing
- Temperature range
  - Normal operation
    - Hot
    - Cold
- Fire
  - Fire risk assessment
- Escape hatch size
  - How many at once

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Cont./…

- Harness
  - Is operative wearing a harness
  - Is an emergency harness required
- Other uses
  - Is kit required for other rescue(s)
- Changeover
  - Time
  - Person(s) off to person(s) on
- Anchor position
  - High or low
  - Fire propagation; temperature profil
- Handle or wheel
  - Snagging
- Dual approach for 6 No. out?
  - Two CRDs (4)
  - Two personal descenders (2)

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Descent energy (W)

W = m . g . h . n

where
- W is descent energy (J)
- m is descent load (kg)
- g is gravity (9.81m/s)
- h is the descent height (m)
- n is the number of descents

Markings:
- Standard requires:
  - Maximum rated load
  - Minimum rated load
  - Maximum descent height
- May be mutually exclusive
  - i.e. 'maximum rated load' may not be achieved under 'maximum descent height'

- Standards imply that load and distance are directly proportional
  - e.g. half the distance and double the load
- The input *energy* is the same
- Rate of heat dissipation differs
- Heavier load
  - Brake is working harder
  - Performance reduces
  - Speed is quicker
- Does manufacturer provide information on load, speed and distance
  - Are markings clear
  - What additional testing has been undertaken

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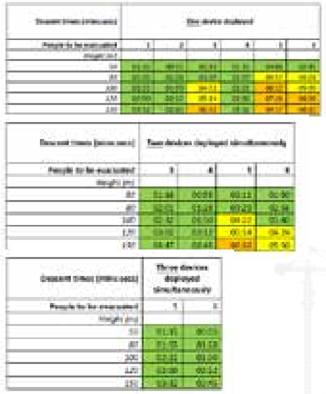
Evacuation time Evidence-based assessment



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In the water

- Compatibility
  - Deployed lifejacket
  - Access to front D-ring
- Ease and method of detaching under load
  - Unclip connector
  - Cut cord
- Next person down delayed!
- What load …
  - Tidal
  - No standard for this
  - No data on which to assess

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Carry your own kit

- 120m of 7mm cord (4.7kg)
- 50m of 7mm cord (2.0kg)

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Risk management

- How lightweight can you get
  - Increased risk; reduction in margins
- Climbers, cavers, etc.
  - accept increased risk
  - use the equipment all the time
- Competence
  - Knowledge, skills, experience
- Refreshers …
  - Distinguish between:
    - Training (and re-training)
    - Equipment familiarisation
    - Refreshers
      - Regular, e.g. drills
      - Periodic, e.g. toolbox talk

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Temperature

- The brake gets very hot when used!
- Heat
  - Radiant, conducted
- Fire
  - Flame
- Testing
  - Lots on aramid cord
  - Survival at these temperatures
  - Aramid sheath: Fire *versus* hot surface
    - Polyester core will melt
- Manufacturer has tested rope after 210ºC for 10mins
  - 10% loss of strength
  - MBL: 2,500kg (10:1 FoS)

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Material properties

Polyamid (Nylon®)

- Melting point
  - 215 ºC
- Water absorption
  - 1 to 7%
- Light resistance
  - Good
- Breaking stretching
  - 16 to 27%
- Resistance to abrasion
  - Very good

Aramid (Technora®)

- Melting point:
  - Chars at 500 ºC
    - Decomposition
- Water absorption
  - 2 to 5%
- Light resistance
  - Bad
- Breaking stretching
  - 2 to 4%
- Resistance to abrasion
  - Adequate

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'Real-life' fire testing (USA)

- Research in progress …..
- Escape from a burning building
  - Assessment of rope heat resistance
- Room temperatures:
  - Ceiling: 517 deg C
  - Window cill: 254 deg C
- While wearing full structural fire fighting kit and BA:
  - 4 people got 1st and 2nd degree burns
  - 5 out of 8 BA cylinder gauges melted
  - 3 fire tunics had small holes burnt in them
  - 1 helmet was destroyed

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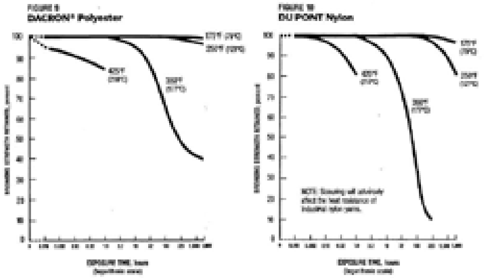
Polyester and Nylon

Synopsis



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Anchor points

- Direction of loading
- Position
- Integrity
  - Strength
  - Standard(s)
  - Testing:
    - initial and periodic
  - Inspection
- Ease of attachment
- Marking
- Anchor slings
  - wire strops
  - rather than fibre

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Skill fade

Is the training regime adequate

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Glasgow Caledonian Uni

Refresher candidates

- "… should undertake rescue and evacuation practice drills between three to six months after acquisition …"

New candidates ('Fresh')

- "… should undergo practice drills within the first three months …"

Observations:

- Need to distinguish more clearly between:
  - Training; Refreshers; Product familiarisation; Rescue and evacuation drills
- Equipment is irregularly seen and used
  - Not necessarily intuitive; Panic in the heat of the moment


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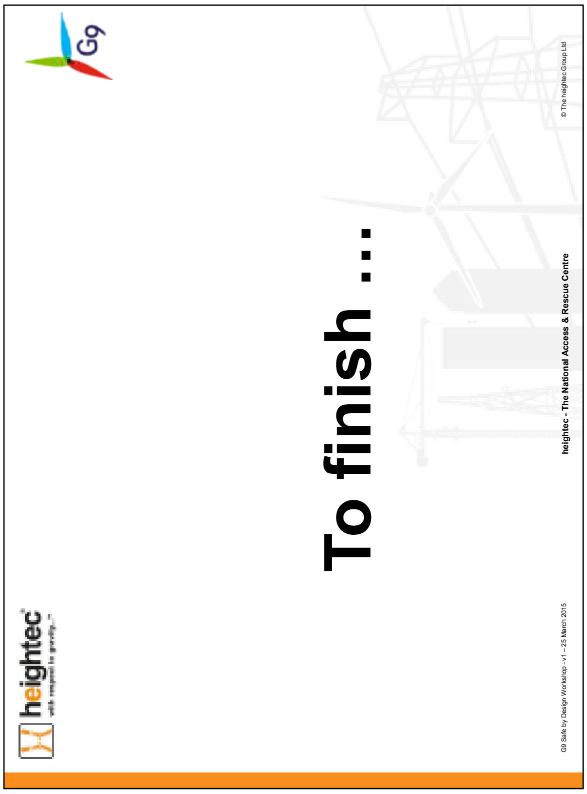
heightec
To finish . . .
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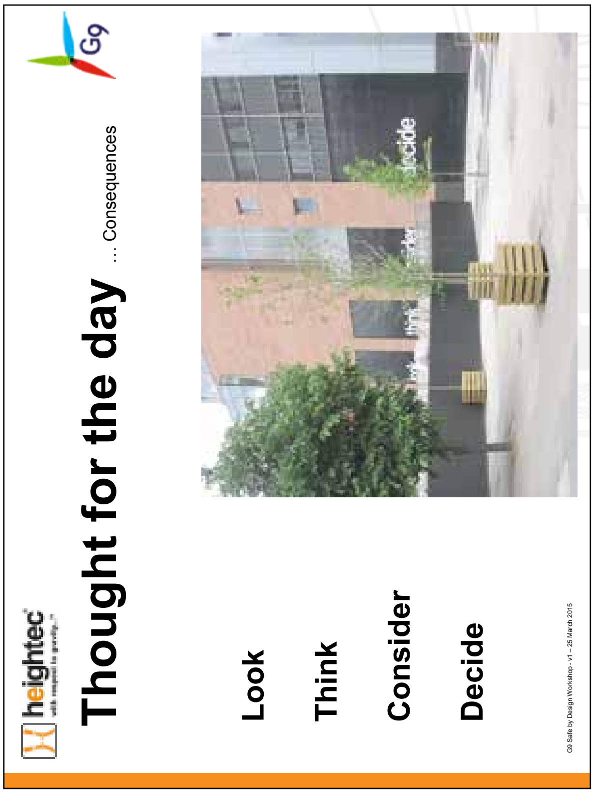

heightec
Thought for the day ... Consequences
Look
Think
Consider
Decide
G9 Safe by Design Workshop - v1 - 25 March 2015

Presentation 3 – ***Stu Axcell*****, HFR Solutions and** ***Mervyn Coldron*****, Centrica: Training and competence of technicians in the use of escape mechanisms and equipment**

Executive summary

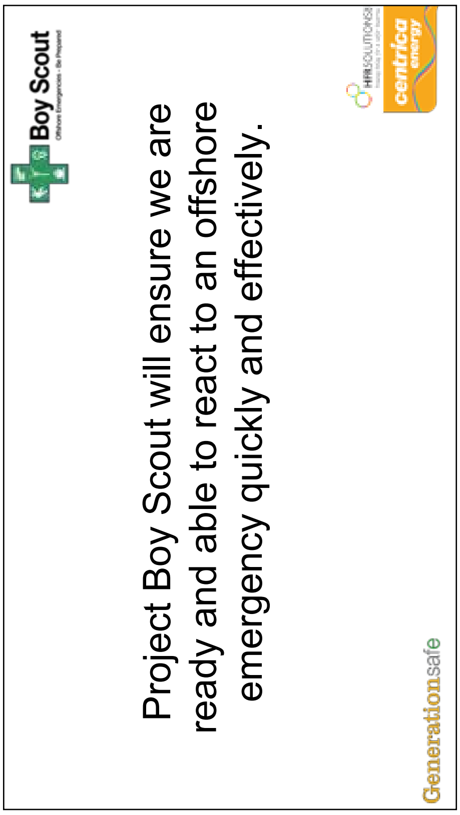
The purpose of the presentation was to provide an overview of the work that Centrica Energy have been doing to improve their emergency response to offshore windfarm installations.

The presentation was broken into two distinct parts; firstly looking at the history and a case study that highlighted potential improvements in response to an emergency. This covered the current status quo in terms of equipment, training and procedures to meet the needs of an offshore incident. The second part of the presentation explained the work currently underway to improve upon the status quo via a project called 'Boy Scout'.

Project 'Boy Scout' is a pioneering project reviewing all areas of emergency preparedness, through a series of focus groups. The intention is that each focus group will critically examine all areas of emergency preparedness and deliver recommendations for improvement. Importantly, a number of recommendations centred around training frequency and the use of no sail days (weather days) have already been implemented; supporting the competence of personnel in the use and execution of first aid and rescue equipment.

A number of other work streams have been introduced as a result of this, including the design and implementation of bespoke confined space training courses and further induction training in collaboration with HFR Solutions. Whilst the project remains work in progress, this G9 Safe by Design workshop provided a platform to share the work being undertaken with the wider industry.


Boy Scout
Project Boy Scout
G9 Introduction
March 2015
HFR SOLUTIONS
centrica energy
Generationsafe


Boy Scout
Project Boy Scout will ensure we are ready and able to react to an offshore emergency quickly and effectively.
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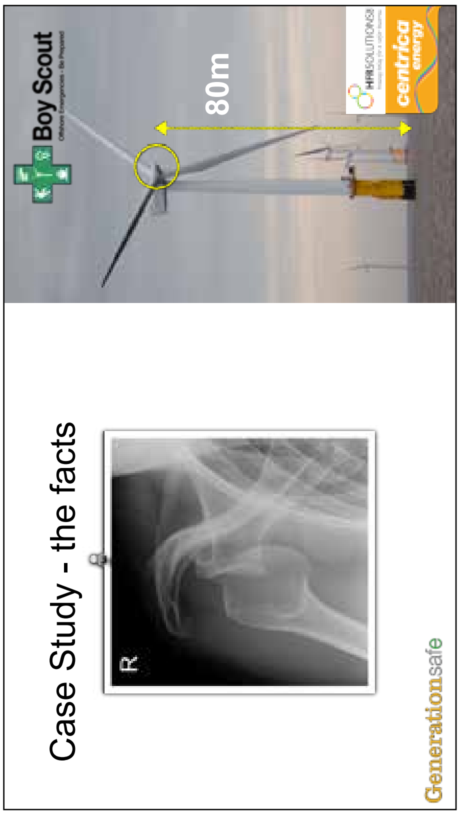
Generationsafe


Case Study - the facts
R
Boy Scout
80m
HFR SOLUTIONS
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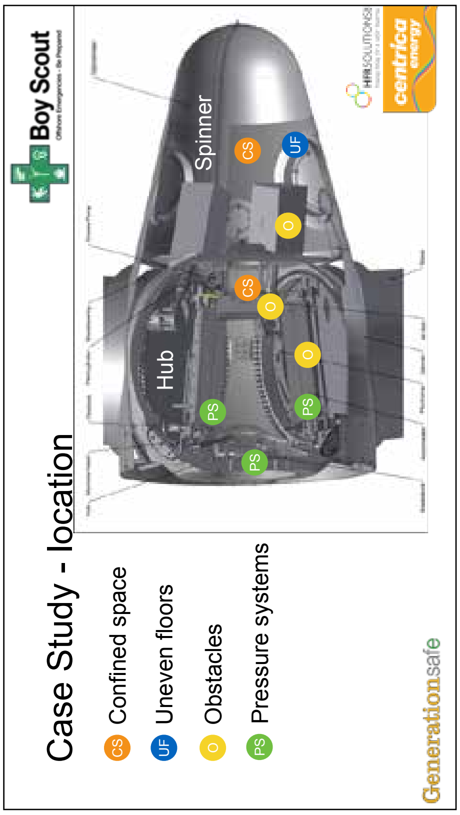
Generationsafe


Boy Scout
Case Study - location
CS Confined space
UF Uneven floors
O Obstacles
PS Pressure systems
Spinner
Hub
HFR SOLUTIONS
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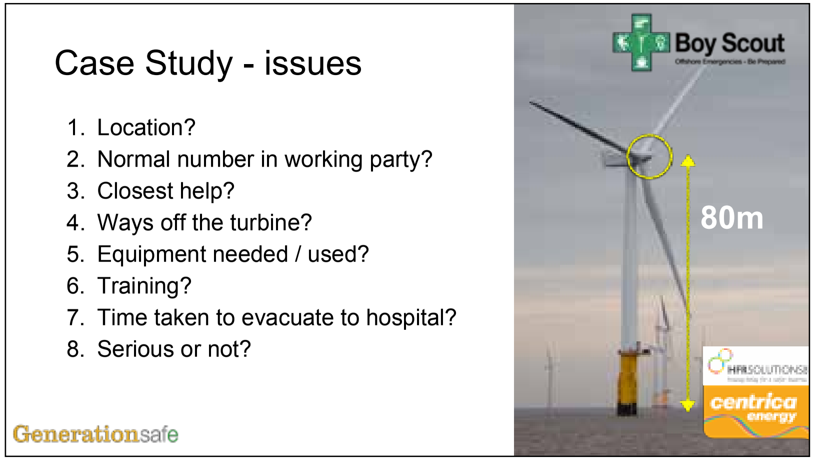
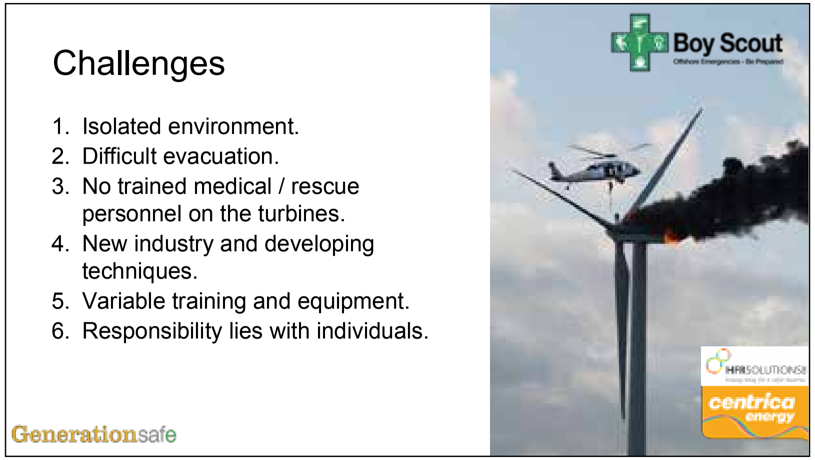
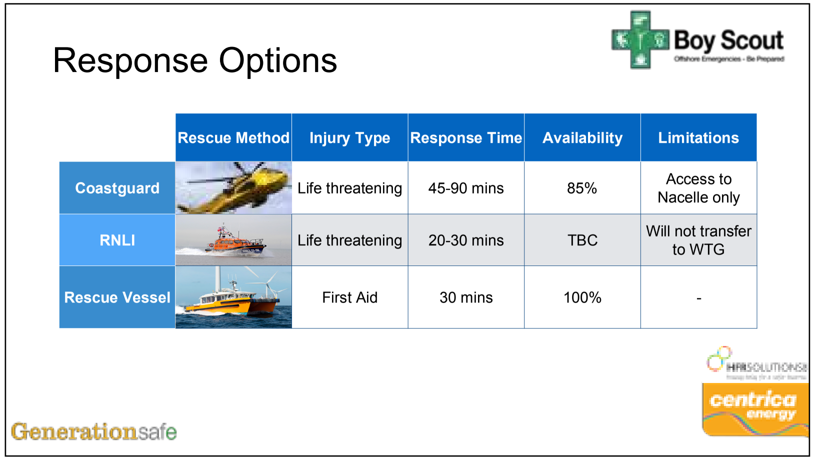
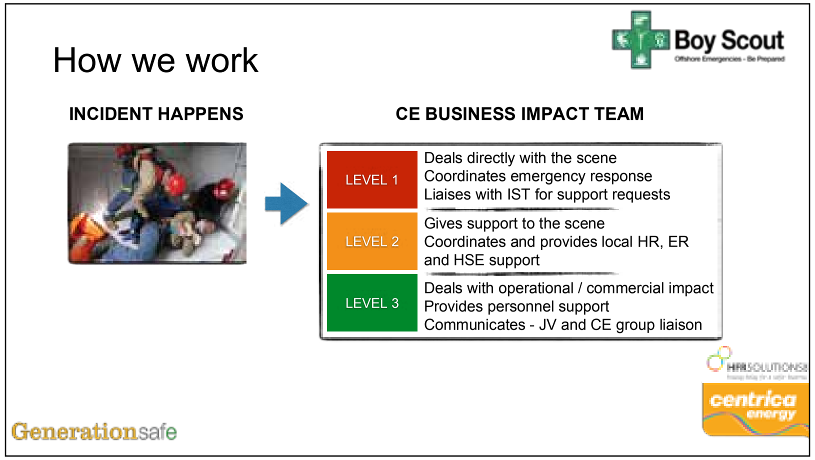
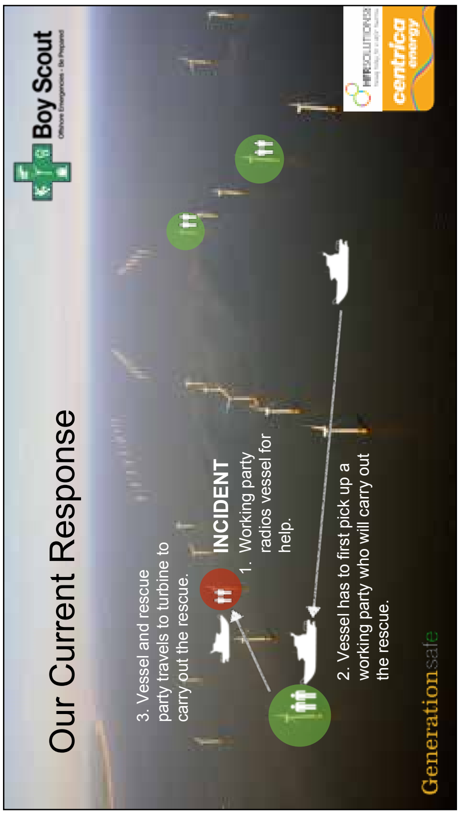






	Rescue Method	Injury Type	Response Time	Availability	Limitations
Coastguard		Life threatening	45-90 mins	85%	Access to Nacelle only
RNLI		Life threatening	20-30 mins	TBC	Will not transfer to WTG
Rescue Vessel		First Aid	30 mins	100%	-




Boy Scout
Our Current Response
INCIDENT
1. Working party radios vessel for help.
2. Vessel has to first pick up a working party who will carry out the rescue.
3. Vessel and rescue party travels to turbine to carry out the rescue.
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Boy Scout
Is this good enough?
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Generationsafe


Boy Scout
Project Boy Scout
The Journey So Far
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Boy Scout
centrica energy
in partnership with
HFRSOLUTIONS
and in collaboration with...
SIEMENS
HM Coastguard
WINDCAT WORKBOATS
COFELY FABRICOM
Lifeboats
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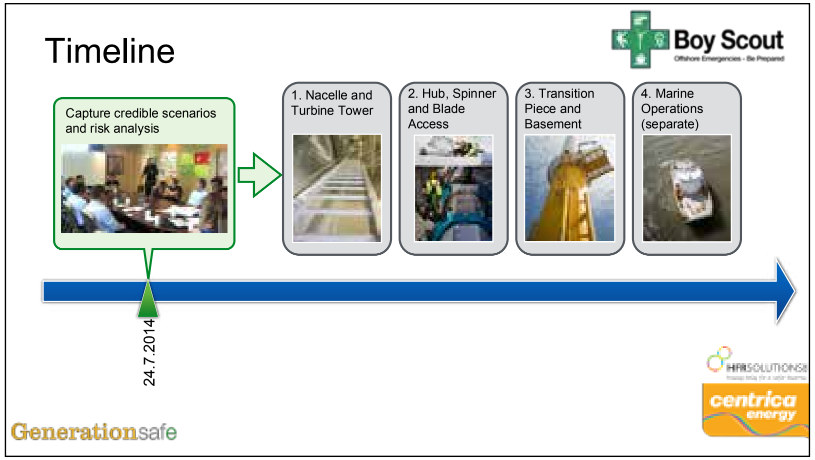
Timeline
Boy Scout
Capture credible scenarios and risk analysis
1. Nacelle and Turbine Tower
2. Hub, Spinner and Blade Access
3. Transition Piece and Basement
4. Marine Operations (separate)
24.7.2014
Generationsafe
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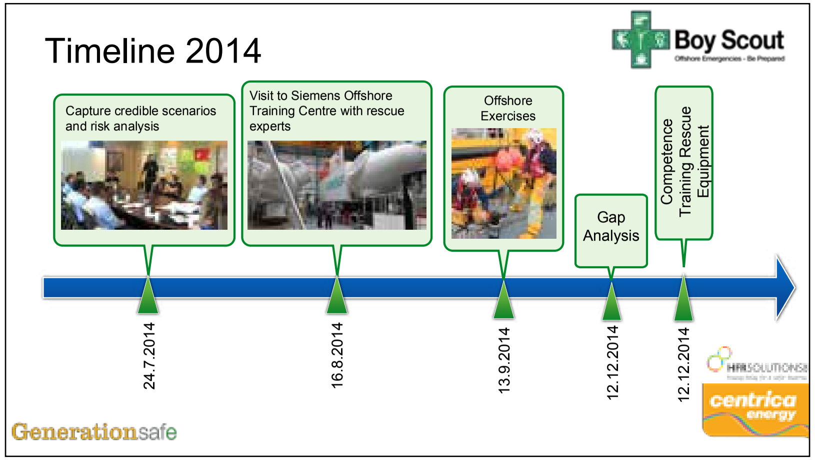
Timeline 2014
Boy Scout
Capture credible scenarios and risk analysis
Visit to Siemens Offshore Training Centre with rescue experts
Offshore Exercises
Gap Analysis
Competence Training Rescue Equipment
24.7.2014
16.8.2014
13.9.2014
12.12.2014
12.12.2014
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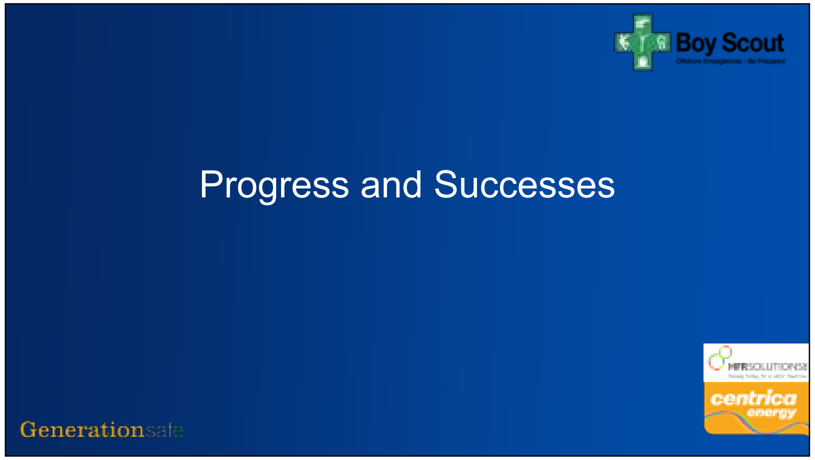
Boy Scout
Progress and Successes
Generationsafe
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Confined Space Training
Boy Scout
• Bespoke confined space training developed by CE and HFR Solutions.
• Course is up and running and awaiting Renewable UK accreditation.
• Already delivered to Siemens and RES Offshore.
• A great example of collaborative working to improve safety offshore.
HATCH
Generationsafe
centrica energy

Induction and Turbine Familiarisation

Our offshore induction includes a six-module video-based course with 'hands-on' practical and field-based training.

Boy Scout Generationsafe

HFR SOLUTIONS centrica energy

Refresher Training

Boy Scout

We are now planning to use weather days for the use of refresher training at HFR Solutions, with groups gaining practical experience of safety equipment, work at height and lifting procedures.

Generationsafe

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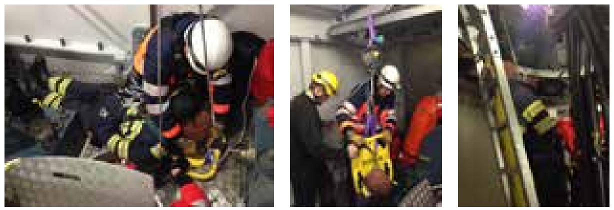
Rescue Plans

Boy Scout

We're in the process of developing bespoke rescue plans for specific areas of the turbinefocussing on techniques, equipment and training requirements.



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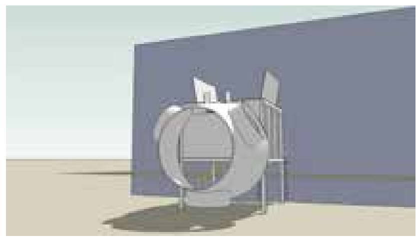
Training Facility Development

Boy Scout

As well as HFR Solutions' work at height tower, we are planning to add full-scale equipment to give hands-on experience of key work areas *onshore* in a safe and controlled environment.



Generationsafe

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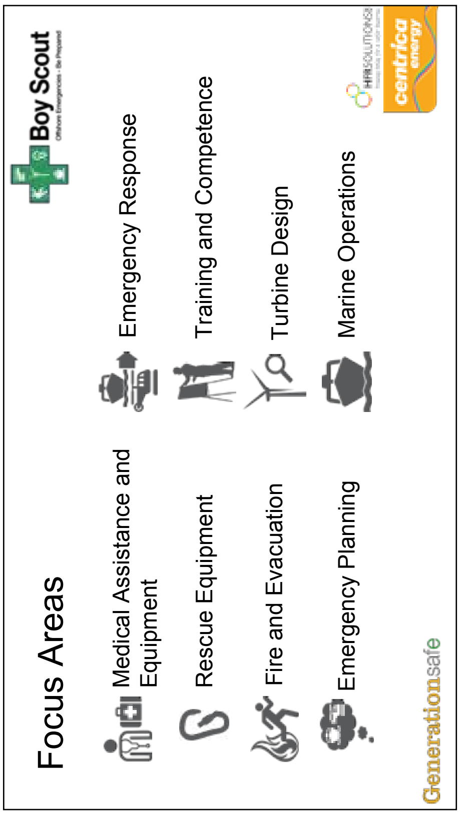
Boy Scout
2015 Work Streams
• Development of Fire Risk Assessment for 3.6MW Turbine
• Emergency plan improvement
• Medical standards and training
• Improvement in offshore response process
• Risk Assessment of Training and Competence Requirements.
Generationsafe
centrica energy


Boy Scout
Focus Areas
Medical Assistance and Equipment
Rescue Equipment
Fire and Evacuation
Emergency Planning
Emergency Response
Training and Competence
Turbine Design
Marine Operations
Generationsafe
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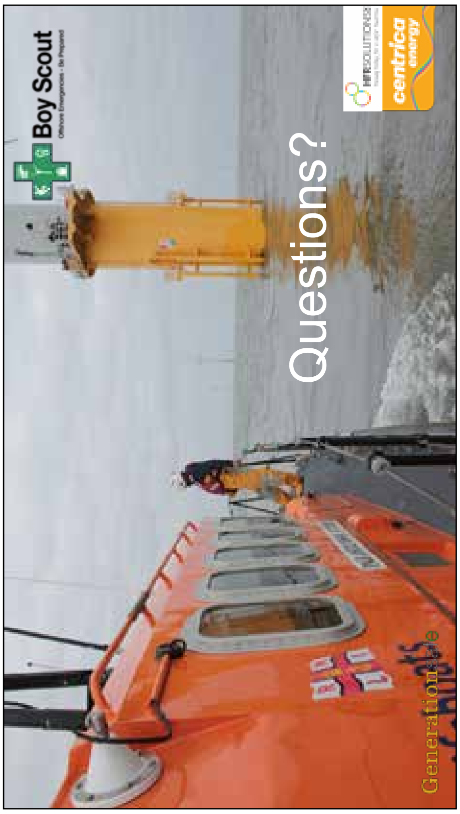
Boy Scout
Questions?
centrica energy

ANNEX B
ABBREVIATIONS AND ACRONYMS

ALARP	as low as reasonably practicable
CE	Conformité Européenne
CDM	construction, design and management
CRD	controlled rate descender
CTV	crew transfer vessel
EI	Energy Institute
G9	G9 Offshore Wind Health and Safety Association
GWO	Global Wind Organisation
HAZID	hazard identification study
HAZOP	hazard and operability study
HSE	Health and Safety Executive
HV	high voltage
KPI	key performance indicator
PPE	personal protective equipment
O&M	operation and maintenance
QRA	quantitative risk assessment
RAM	risk assessment method
RAMS	risk assessment and method statement
SIL	safety integrity level
TP	transition piece
WTG	wind turbine generator

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