Smart belt design for monitoring falls, posture and basic physiological parameters in the community

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Background

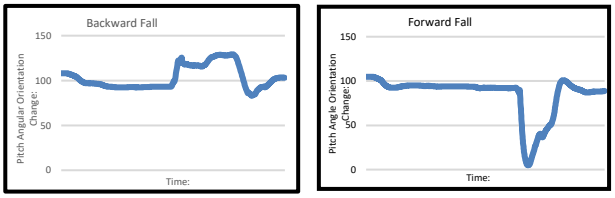
Aging population is a major concern for healthcare providers. There is a growing need to monitor people's health in the community to relieve pressure on acute service providers. The use of wearable devices in the community has gained significant attention in recent years due to rapid advances in technology. Research in the area shows that such devices can offer significant improvement to the general health and quality of life in elderly people. The adoption and uptake of this technology however remains relatively low due to the way people interact with the technology. The aim of this project is to design a practical, simple-to-use device that can be easily integrated into everyday life.

Method

The prototype incorporated the use of an accelerometer, gyroscope and digital motion processor on a single chip, the size of a 10-pence coin. The device communicates via fast I2C protocol with minimal hardware requirements. An Arduino Nano Every microcontroller was used in this prototype with a 20MHz clock and a 48KB on-board flash memory. The Arduino unit communicates to nearby devices such as laptops or mobile phones via a Bluetooth plugin module. A graphical user interface (GUI) was developed in C# using the Unity Game Engine Integrated Development Environment (IDE). The prototype also incorporated a respiratory rate monitor using a conductive rubber stretch sensor, and a heart rate monitor using an integrated signal conditioning chip. The whole device was powered using a 9V battery and the cost of the components was less than £50. In order to test the performance of the device, simulation experiments were carried out using a test object and a human volunteer. Various digital filters were used to remove noise and correct for drift.

Results

The linear quadratic estimation (LQE) filter performed best in removing noise and providing long-term stability for the posture/fall detector sensor. Simulation results showed that the sensor was successful in detecting falls as shown on the right. Respiratory and heart rate monitors also performed reliably with basic signal processing techniques.



Discussion and Conclusions

Current state-of-the-art in microchip sensor technology and digital signal processing makes the development and utilisation of wearable devices solutions cheap and reliable. Future work is needed on data security and protection, data storage, power conservation and sustainability.

Keywords: Wearable devices, fall detection, posture, home monitoring

Enhancing Medical Physics Operations with ChatGPT 4.0 Today: Capabilities and Considerations

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Abstract – Case study of experience no more than 1 page in Arial 11 point, presenting speaker underlined

Abstract: Enhancing Medical Physics Operations with ChatGPT 4.0 Today: Capabilities and Considerations

The adoption of artificial intelligence tools like ChatGPT 4.0 in medical physics departments represents a forward step in refining operational processes and data analysis and generating major efficiency savings. This presentation will explore the application of ChatGPT 4.0 as an adjunctive resource across a spectrum of tasks within medical physics. Key focus areas include data processing & visualisation, workflow optimisation, and quality assurance measures, with specific examples such as gamma analysis, DICOM handling, and analysis of (anonymised) patient pathway data. Some current limitations of ChatGPT will also be discussed, underlining the importance of human oversight and the caution required in an environment with medical devices.

Furthermore, we will examine the utility of ChatGPT 4.0 in routine departmental activities such as project planning, minuting meetings, and code generation & debugging. The discussion aims to underscore ChatGPT's function as a collaborative tool, which supports medical physics professionals by automating routine tasks, thereby reallocating focus towards direct patient care and research.

The talk aims to showcase the potential of ChatGPT to contribute to departmental efficiency and innovation, all the while advocating for the indispensable nature of human expertise and the irreplaceable role of traditional medical devices.

Is there a role for non-UKCA marked smart technology in the modern NHS?

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Background: Smartwatches have experienced a surge in popularity within the general population in recent years. It was predicted that 109.2 million devices will be sold globally by 2023 (Siepmann and Kowalczuk, 2021). Many of these devices use photoplethysmography to track physiological data, making them an important tool for health monitoring. The objective of this project was to investigate potential differences in accuracy between smartwatches that are registered as medical devices and those that are not.

Method: The heartrate measurement taken by the watch was compared with those taken by a Philips MX450 monitoring system which is used in a clinical setting for measuring SpO2 and heart rate using photoplethysmography. 15 participants [60% male] were asked to sit at rest for 10 minutes before engaging in a 3-minute exercise session. Heart rate data was collected from both the patient monitor and the smartwatch at 30-second intervals. Participants were classified according to their Fitzpatrick skin tone, age, and BMI to examine the potential impact of these variables on the results.

Results: This study revealed significant variations in accuracy among different smartwatches. During exercise, the difference in readings between the patient monitoring system and all smartwatches were much greater than during rest This discrepancy was attributed to artefacts present on both the patient monitoring system and the smartwatches, with sweat likely being the primary culprit for these inaccuracies. Figure 1 and Figure 2 show that when the Samsung Galaxy Watch4 and Google Pixel Watch were compared to the patient monitoring system, the Samsung Galaxy Watch4 showed greater accuracy as the confidence intervals were significantly smaller. This watch is UKCA marked for it's blood pressure monitoring feature which uses the same photoplethysmography hardware as the heart rate function, whereas the Google Pixel Watch is not UKCA marked as a medical device.

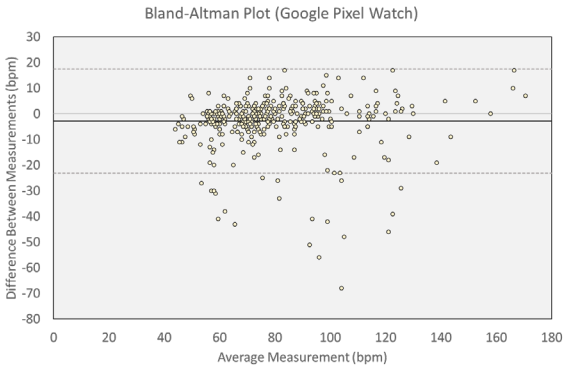

Figure 1 Bland-Altman Plot for Google Pixel Watch

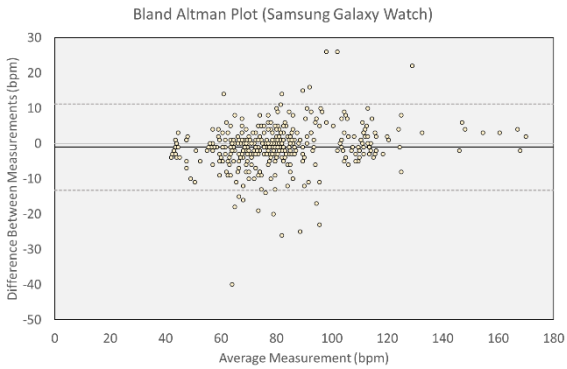

Figure 2 Bland-Altman Plot for the Samsung Galaxy Watch4

Discussions and Conclusions: Whilst there is more work to be done, early stage results indicate that there is a difference in the accuracy of smart devices with a component UKCA marked as medical devices when compared to those that are not UKCA marked. This suggests that it may be reasonable to use the measurements from these devices in the diagnostic process in the future assuming differences of ±10 bpm are clinically acceptable.

Keywords: smart devices, pulse oximetry, CE marking, medical devices, physiological measurements

References: Siepmann, C. & Kowalczuk, P. (2021) Understanding continued smartwatch usage: the role of emotional as well as health and fitness factors. *Electronic Markets*. [Online] 31 (4), 795–809.

Analysis of independent dose calculation and measurement systems in clinical use for patient specific quality assurance.

Background: Patient specific quality assurance (PSQA) is an essential part of a comprehensive QA program. It is therefore imperative that the limitations of the independent dose calculation and measuring systems used for PSQA are well understood. In this project, we will investigate the dosimetric differences between the PSQA systems currently in clinical use in Bristol Haematology and Oncology Centre (BHOC). We will also evaluate the sensitivity of the measuring systems in detecting errors in the treatment plans.

Independent verification of the treatment planning system (TPS) dose is recommended in numerous publications including IPEM Report 81 [1], Towards safer radiotherapy [2], AAPM task group 219 [3] and the NHS service specification for external beam radiotherapy.

In BHOC, independent dose calculation of treatment plans is performed using two different pieces of software: one which utilizes a collapsed cone convolution (CCC) algorithm namely Compass, and a novel system which utilizes concepts of virtual Monte-Carlo codes namely myQAion. Both systems compare the TPS dose against the independently calculated one by performing gamma analysis with predefined gamma criteria.

If a plan fails the gamma analysis, then the next step is to deliver the plans to a radiation detector to investigate its deliverability. Two different types of detectors are used in BHOC, an ion chamber array detector (MatrixX, IBA) and a novel CMOS (complementary metal oxide semiconductor) detector (SRS detector, IBA).

This process can be time consuming, taking between 20 minutes and several hours. Moreover, literature is conflicting about the benefit of plan measurement for certain patients. McKenzie *et.al.* compared the performance of PSQA detectors and concluded that some of them could not distinguish between acceptable and unacceptable plans [4]. Additionally, Han *et.al.* observed dosimetric and gamma passing rate differences between measurement-based and independent dose calculation based PSQA and concluded that care must be taken when considering replacing the former by the latter [5]. It becomes apparent that there is no unanimous consensus as to what method of PSQA is most appropriate for each treatment plan which can lead to delays in the patient pathway.

Methods. SABR clinical plans of high complexity will be computed using the same calculation parameters in the treatment planning system (TPS) Raystation and in the independent dose calculation systems Compass and myQAion. Plans will be validated by measurements performed on the MatrixX and the SRS detector. The results will be analysed in the following way:

- The Raystation, Compass and myQAion doses will be compared to each other by means of gamma analysis and volume dose differences. The gamma analysis will be performed in the Compass and myQAion systems and independently in another dose evaluation system (myQApatients).
- The calculated doses will be compared against the dose distributions measured by the two detectors, via means of gamma analysis.
- The sensitivity of each detector will be evaluated by their ability to identify errors which will be introduced in clinical plans (i.e. MLC position errors).
- The complexity indexes calculated by myQAion will be analysed against the measurement results for each plan with the aim of establishing whether there is a statistically significant correlation between them which would allow us to use them as a predictive tool for plan measurement.

Results. This is an STP Master's project with full results expected May 2024. Preliminary results for the independent dose calculation systems show that there is a statistically significant difference in the doses calculated by them, but further analysis is needed before any concrete conclusions can be reached.

myQAion	Compass

Mean PTV dose difference (%)	Standard deviation of PTV dose difference	Mean PTV dose difference (%)	Standard deviation of PTV dose difference
0.59	0.85	3.18	1.17

Conclusion. The results of this project hope to help streamline the PSQA process in our department thus making it less time consuming and more reliable so that we can provide the best possible quality of care to our patients.

Key references.

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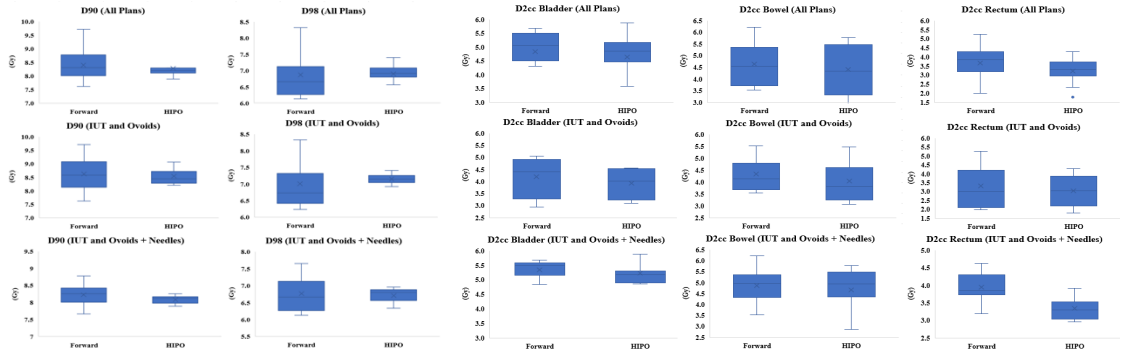
A Comparison Study: Can Cervical Plans in Brachytherapy be Improved Using HIPO Over Forward Techniques?

Kay Pile

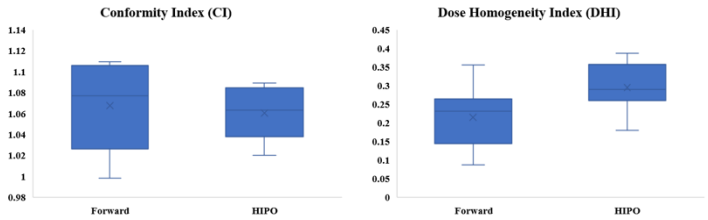
Aims. The overarching aim of this study is to investigate the feasibility of adopting inverse planning using HIPO (Hybrid Inverse Planning Optimisation) within our HDR (high-dose rate) brachytherapy clinic at the Exeter Oncology Centre. The primary focus is on evaluating the dosimetric differences of HIPO against GRO (graphical optimisation) and manual source dwell placement that is currently performed as part our department's forward planning procedure for cervical plans, to help guide whether it would be beneficial to integrate as an option within the planning workflow.

Methods. A cohort of nine historical patients who underwent a boost of HDR cervical brachytherapy were selected for this study that satisfied the case inclusion criteria of being image guided HDR plans. These plans were delivered with a standard prescription to Manchester point-A of 7 Gy over four fractions in three days. The plans consist of applicator setups consisting of just the IUT and ovoids, and those with needles. The HIPO license was activated on Oncentra Brachy and used to inversely optimise these plans. The dosimetric indices, D90 and D98 to the target and D2cc to the organs at risk were evaluated against the recommended GYN-ESTRO EMBRACE II guidelines [1]. Conformity and homogeneity indexes were determined, as well as the radiobiological parameters tumour control probability (TCP) and normal tissue complication probabilities (NTCP). The source-dwell times were summed within the intrauterine tube (IUT), ovoids and needles.

Results and Discussion. Overall, the D90 and D98 to the HR-CTV were comparable between the forward and inverse HIPO plans, with no statistically significant differences ($p>0.05$) observed between treatment configurations either with or without needles. The D90 and D98 also satisfied the minimum plan coverage aims in all cases as recommended by GYN GEC-ESTRO II protocol. As demonstrated visually by the boxplots, less variation in the HR-CTV coverage (in terms of D90 and D98) was observed with the HIPO plans. Only the rectum saw a significant increase in its D2cc in the HIPO plans ($p=0.017$).



There was no remarkable change in the mean conformity index in the HIPO plans than in forward planning. The mean dose homogeneity index was significantly higher by 38% across the HIPO generated plans ($p = 0.012$) than in the forward generated plans. This reflects that the algorithm covers the HR-CTV more uniformly in the 100% to 150 % prescription dose range.



There was a significant increase ($p=0.048$) in the TCP in the HIPO generated plans compared to the forward plans. The NTCP for all the OARs saw a decrease, 1.54 % for the bladder, 1.52 % for the bowel and 0.17 % for the rectum, however this was not statistically significant. The mean overall loading times were significantly reduced ($p < 0.05$) in the HIPO plans for both the plans without ($p = 0.002$) and with interstitial needles ($p=0.028$). For the IUT and ovoid setup, the total mean loading time decreased by 55 seconds, and with interstitial needles was decreased by 62

seconds. The IUT and ovoid mean loading times were both also significantly ($p < 0.05$) reduced in the plans containing needles, which was accompanied by an increase in the mean loading time within the needles. This suggests that HIPO tends towards dwelling the source for longer in the peripheral needles rather than in the IUT and ovoids.

Conclusion. Inverse planning with HIPO presents an option for optimising HDR cervical treatment plans. Through comparing the dosimetric parameters between the forward and inverse plans, only the D2cc to the rectum saw a significant reduction in the HIPO plans. Whilst the conformity indexes were similar, there was a significant increase in the dose homogeneity index. The loading time results express that the relative catheter weightings in the channels deviated greatly from local protocol, which may require the delineation of extra optimisation structures.

Key Words: For example: *HDR Brachytherapy, HIPO, Inverse Planning, Cervical*

Key references.

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Title of Study Development of phantoms and a quality assurance protocol for a multi-centre abbreviated magnetic resonance imaging breast study.

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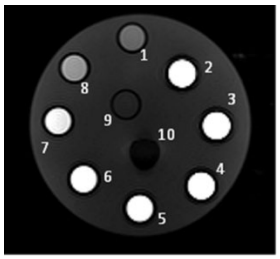
[1] University Hospitals Bristol and Weston NHS Foundation Trust, [2] University of Oxford, [3] St George's University Hospitals Foundation Trust, [4] North Bristol NHS Trust,[5] Retired -Royal Marsden NHS Foundation Trust and Institute of Cancer Research,[6] Royal Surrey County Hospital NHS Foundation Trust, [7] Gloucestershire Hospitals NHS Foundation Trust

Background: Previous studies have indicated that aggressive cancers, not well visualised on mammograms, can be identified on an abbreviated magnetic resonance imaging (MRI) breast protocol called FAST MRI [1-5].

The aim of this study was to design and develop prototype phantoms for contrast-weighting and geometric evaluation of abbreviated breast MRI sequences. The phantoms form the basis for standardised quality assurance (QA) testing in a multi-centre FAST MRI study.

Methods: A contrast phantom was developed by testing the responsiveness of MRI contrast agents to small changes in clinical sequence parameters and assessing their stability and reproducibility (Figure 1a and 1b). A geometric phantom was developed by investigating different construction methods and target designs with comparison to expected clinical scan parameters (Figure 1c). The phantoms were assessed on clinical MRI scanners used in the NHS breast screening programme for women at high risk and used to develop a FAST MRI QA protocol.



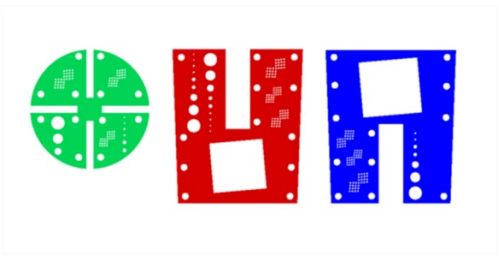
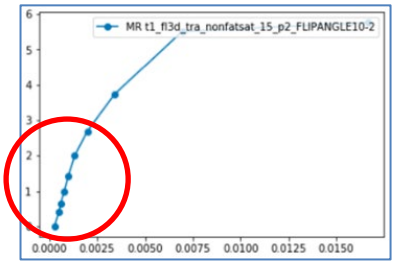


Figure 1a Contrast phantom **Figure 1b**T1W MRI image **Figure 1c** Geometric phantom design

Results: For the contrast phantom measured T1 values agreed with the literature for Gadolinium and Nickel Chloride solutions and signal enhancement showed strong sensitivity to changes in clinical sequence parameters (Figure 2a). For the geometry phantom a design was chosen which included a range of resolution test targets to allow swift visual evaluation and in-depth analysis and performance tracking (Figure 2b). Visual inspection and analysis of the MR images indicate the phantoms are suitable for use in a FAST MRI QA protocol to assess contrast-weighting and geometry.



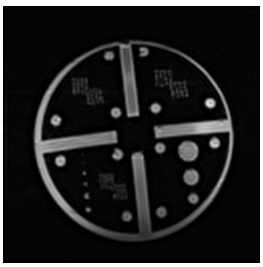


Figure 2a Signal enhancement vs 1/T1 **Figure 2b** T1W image of geometric phantom

Discussion: The phantoms are relatively inexpensive, easy to set up, fit inside a standard breast MRI coil and are suitable for MRI radiographer-led QA.

Conclusion: Two dedicated phantoms and a standardised QA protocol were designed and developed as part of the QA programme for the FAST MRI study. The phantoms and QA protocol have the potential to be incorporated into NHSBSP technical guidance for MRI equipment quality assurance testing.

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Key Words: abbreviated MRI, phantoms, quality assurance, breast screening, FAST MRI

Optimising bone scans using SwiftScan technology

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Background

The need for optimisation of patient dose is set out internationally as a fundamental of radiation protection by ICRP [1], and in UK legislation within IR(ME)R [2]. To comply with this, the acquisition of a new NM/CT Discovery 870 gamma camera within Gloucester Hospitals NHS Foundation Trust provided the perfect opportunity for optimisation as it came with SwiftScan technology. SwiftScan has been shown to optimise patient outcome by allowing a reduction in imaging time or dose whilst maintaining an appropriate image quality [3, 4]. The possibility of reducing acquisition time without compromising image quality is of particular importance within bone scintigraphy, as it is one of the most commonly undertaken scans within nuclear medicine departments and hence represents a significant proportion of the clinical workload [5, 6]. Therefore, being able to reduce the time per scan can have a large time benefit to a department, making it the perfect candidate for optimisation, and the focus of this research.

Methods.

Initial results were collected using nuclear medicine quality assurance phantoms to investigate the impact of changing acquisition time and applying SwiftScan technology on final image quality. The images collected were assessed qualitatively, and then quantitatively looking at the change in CNR and coefficient of variance. These results were used to support a set of new parameters to be applied clinically. Two case studies were chosen for this research. These patients had images taken initially using the standard bone scan protocol at use at GHNHSFT. The new protocols were then applied and the patient imaged again. The set of images for each patient were compared against each other as a direct comparison between old and “optimised” settings. This evaluation was done quantitatively by a physicist and then qualitatively by a reporting radiologist. A final image optimisation team consisting of physicists, radiologists, and radiographers then met to discuss the results and formulate an optimised protocol for bone scan patients to be used within GHNHSFT.

Results

There are no final results for this research project as it is still in progress with a completion date of early May 2024.

Key references

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Refinement of IRAT2 – 'Up Sewage Works Creek'

Aims and background

The Royal Cornwall Hospital discharges via a sewage works on a tidal river.

A proposed change to our discharge limits was evaluated using the Initial Radiological Assessment Tool 2 (IRAT2). This indicated annual doses to Anglers in the region of 1200 µSv (well above the screening criterion of 20 µSv per year) and a sewage treatment works (STW) worker dose of 33 µSv per year. The model needed to be refined to fit reality and ensure that doses to exposed persons were actually (as common sense suggested) below the screening threshold.

Methods:

The aqueous discharge of P-32 (the main culprit) was reduced by three quarters through the use of annual (as opposed to monthly) discharge limits, but the dose to Anglers was still high at 470 µSv per year.

The model was refined for river flow rate, fish consumption and working behaviour of sewage treatment workers. The first of these involved investigation of the tidal patterns at the discharge point of the STW and conversations with CEFAS (Centre for Environment, Fisheries and Aquaculture Science). IFCA (Inshore Fisheries and Conservation Authority) advised on the consumption of fish by local anglers and finally South West Water kindly engaged with the physics team regarding working habits of their employees. This work also involved various site visits to the picturesque rivers and shorelines (and STW) of Cornwall.

This information was used with the Environment Agency (EA) guidance on IRAT2[(a)] to tailor the calculation model for the specifics of the discharges from the Royal Cornwall Hospital.

Results:

After extensive finessing, the maximum dose to any person of interest was below the screening criterion of 20 µSv per year.

Discussion:

IRAT2 is a screening tool and as such is designed to provide a conservative assessment. Making changes to the model is sometimes necessary, however this is not a straightforward process.

Conclusion:

Awaiting verdict from EA.

Key words:

Initial radiological assessment tool, IRAT, Environment Agency, Permit amendment

(a) *Initial Radiological Assessment Tool 2: part 2 methods and input data, EA 2022 https://assets.publishing.service.gov.uk/media/63528573d3bf7f1943006c60/Initial_radiological_assessment_tool_2_-_part_2_methods_and_input_data.pdf accessed March 24*

Chloe Trevail 2024

Reviewing a Major Incident Plan for Contaminated Casualties from a Naval Base arriving at an NHS Hospital, and Liaison between NHS, MoD and Babcock physicists

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Background: HM Naval Base Devonport and Babcock International's Devonport Royal Dockyard jointly form the largest naval support site in Western Europe. Babcock's facilities include the UK's only licensed site for refitting and refuel of nuclear-powered submarines, including Trafalgar and Vanguard-class submarines. Derriford Hospital in Plymouth would be the receiving trauma centre for any contaminated casualties in the event of an incident at Devonport. Derriford has a Major Incident Plan for receiving potentially contaminated casualties should such an incident occur. Ownership of this is held by the Clinical & Radiation Physics (C&RP) group, with oversight from clinical scientists/RPAs/RWAs within Nuclear Medicine.

The Babcock International Emergency Planning Group based at Devonport has an extensive emergency responder call out list, with certain roles requiring a 24/7 presence on site. Physical resources include dedicated emergency response facilities, vans equipped with monitors and the capability for the decontamination of personnel . By contrast, the C&RP Emergency Call Out list consists of eight people, half of whom do not live in Plymouth, and typical monitoring equipment for a hospital Nuclear Medicine department.

Processes: A strong working relationship has built up over time between C&RP and the Devonport Emergency Planning Group. With staff turnover and periodic reviews of practices, we felt that it was important to build stronger links, better communication and greater understanding of each other's procedures. The Derriford contingency arrangements are reviewed and updated every two years. At the latest review, the receiving medical theatre was in the process of being demolished, therefore part of this review involved the designation of a suitable theatre to receive a critically injured contaminated patient, whilst reducing the impact to the rest of the hospital. We further considered the likely support available from medical physics personnel in the event of an incident, and how skills from different staff groups could be best utilised to support monitoring, decontamination and limiting contamination spread.

Lessons Learned: We considered security implications and realistic staffing scenarios for out of hours incidents. We walked through areas of ED and Theatres with local staff to ensure viability of plans. We sought help from the Babcock Emergency Planning Group to discuss handover arrangements for contaminated casualties and likely scenarios.

Best Practice: Several familiarisation visits took place, both for hospital staff to visit the Naval Base and vice versa. Babcock/MoD staff were taken on tours of relevant areas of the hospital to better envisage realistic enactment of the plans. UHP staff visited the Devonport site and watched contingency plan rehearsals. Additionally, we set up a secondment placement scheme for a Babcock Health Physics trainee at Derriford Hospital to help us review our plans and provide insight into what would be expected from an incident at Devonport.

Conclusion: This presentation will discuss an outline of the actions involved when enacting the plan, and how the Derriford Hospital physicists has learned from Babcock and MoD colleagues. A particular highlight was the secondment placement scheme which we hope to run in the future.