Role-Focused Training and Education in the UK Defense Nuclear Enterprise

Kirk D. Atkinson, Alice M. Darbyshire, Farkhanda Kauser, Rizgar Mella, Martyn D. Kendrick, James R. Bratt

Defence Academy of the United Kingdom, HMS Sultan, Military Road, Gosport, Hampshire, PO12 3BY, United Kingdom
kirk.atkinson957@mod.gov.uk

INTRODUCTION

Founded in 1959 as the Department of Nuclear Science and Technology (DNST) at the Royal Naval College in Greenwich, the present day Nuclear Department (ND), part of the Defence Academy of the United Kingdom, provides academic training and education (T&E) for Royal Navy (RN) and civilian personnel appointed to posts within the UK's Naval Nuclear Propulsion Programme (NNPP).

Conceived at the start of the UK NNPP and modelled on United States Department of Energy reactor operator training requirements, the ND's Nuclear Reactor Course (NRC) has been running continuously for almost sixty years. The NRC is a six-month graduate-level T&E package for new-entry Marine Engineering (Submarine) Officers which culminates in the award of a postgraduate diploma (PgDip) in Nuclear Reactor Technology from Cranfield University, the Defence Academy's academic partner. All RN Marine Engineering (Submarine) Officers, present or past, have completed the NRC. To cater for more experienced officers taking up desk officer posts and their civilian counterparts in the Ministry of Defence (MOD) and Rolls-Royce, a twelve-month graduate-level T&E package, the Nuclear Advanced Course (NAC), was created. This course culminates with the award of a Master of Science (MSc) in Nuclear Technology and Safety Management.

Traditionally, for each post type within the UK NNPP, a bespoke course was created to satisfy its T&E needs. Ignoring many low-level courses, this included the Nuclear Radiological Protection Course for health physics personnel, the Nuclear System Designers Course for engineers working on new plant development, the Nuclear Systems Support Course (NSSC) for technical specialists in procurement and assurance, the Nuclear Warship Support Course (NWSC) for dockyard personnel and engineering managers, the Nuclear General Course for submarine executive and warfare officers, and the Nuclear Technical Personnel Course for Rolls-Royce reactor operators. Despite major similarities between some of these courses, as they are delivered independently of each other, they make inefficient use of academic staff resources and create difficulties in keeping course content up-to-date. Recent organizational and structural changes within the UK Defence Nuclear Enterprise (DNE) provided an opportunity to rectify this situation. Following a fit-for-purpose review of existing courses, this paper outlines the realized and proposed changes to defence nuclear civilian T&E in the UK.

ROLE-FOCUSED TRAINING AND EDUCATION

Training and education within the UK DNE must comply with the MOD's Defence Systems Approach to Training (DSAT) [1, 2]. The four stages of the DSAT process include requirements analysis, T&E design, T&E delivery, and assurance that the T&E meets the requirement. The Training Requirements Authority (TRA) that represents the end-user of trained or educated personnel, sets the T&E requirements and assures that they a met. The Training Delivery Authority (TDA) is responsible for the design and delivery of T&E whilst the Training Provider (TP) is responsible for the actual teaching and assessment. The ND is both the TDA and the TP within the UK DNE.

Elsewhere within defence, TRA's fully adopt the DSAT process and define Role Performance Statements (Role PS) outlining the performance indicators for, and the knowledge and understanding expected of, an individual fulfilling a given role. The DNE has not embraced this approach in its entirety but has instead developed a Nuclear Competency Framework (NCF) [3] for all civilian posts to map against. Given there are several thousand civilian posts within the DNE (if contractors are included), although the NCF is useful for assessing general levels of nuclear Suitably Qualified and Experienced Personnel (SQEP), e.g. level 0 awareness, level 1 practitioner, level 2 supervisor/senior practitioner and level 3 expert, it is too granular to facilitate identification of T&E requirements for individual posts.

After undertaking a review of the NSSC course it was recognized that the NCF provided no guidance as to whether the content of the course was appropriate for the audience, or indeed whether the audience was appropriate for the content. To determine performance indicators from which a set of Training Objectives (TO) could be derived, role analysis was conducted on a subset of posts from the UK's Submarine Delivery Agency. Each post was deconstructed into a set of constituent roles and then, for each role, its component tasks, sub-tasks and task elements were identified. Using this information, Role PS's were produced.

For example, a technical specialist working in the reactor pressure vessel section would need to understand and apply fundamental concepts of materials science, radiation physics, and safety, along with more specialist knowledge of applied structural integrity and manufacturing. Bringing the elements together, a task required of this individual might be to judge the accuracy of a structural mechanics calculation presented in a technical report, which itself might require interpretation of some non-destructive testing data. Similarly, a technical specialist working in the core design section will also need to understand and apply fundamental concepts of materials science, radiation physics, and safety, along with a specialist

knowledge of reactor physics and thermal hydraulics. A task required of this individual might be to judge the uncertainty in results from a deterministic neutron transport calculation. In both cases, whilst the individuals are in different posts wherein they undertake tasks that make use of specialist skills or knowledge, they also make use of the same core skills and knowledge. In essence, it could be said that they have two roles: a general technical role and a technical specialist role. Extrapolating this across the entire DNE, almost all posts were found to have a general role in addition to at least one specialist role.

FLEXIBLE THROUGH-CAREER T&E PATHWAYS

Further analysis of posts within the DNE showed that, whilst all posts consisted of general and specialist roles, these roles exist at one of two academic levels. Technical specialist posts typically have roles at a higher academic level because post holders are required to develop solutions to engineering or science problems and/or have technical accountability with significant levels of risk. It is expected that persons whose posts contain these roles will be graduate engineers or scientists with, or working towards, chartered engineer status (professional engineer in the US). Engineering manager and technician posts typically have roles at a lower academic level. Post holders with these roles are typically high-school graduates, career-changers, or individuals preferring a more hands-on, vocational occupation wherein they maintain and manage applications, repairs or operations, or are directly involved in such activities.

To address the requirement for T&E at higher and lower academic levels, we have developed two pathways which are sufficiently flexible to accommodate frequent post-rotation. Within the DNE it is common for personnel to undertake posts of 2-5 years duration after which they move on to new posts with different roles requiring different knowledge and skills. As some extant posts mandate completion of either the NSSC, or the NWSC, both courses have been retained and revised to provide the required T&E for the general technical role at either the higher or lower academic level. These are followed by role specialism streams, also pitched at higher or lower academic levels, made up of short courses. As an individuals' career develops, they can build on their general role knowledge, adding role specific skills and knowledge without repetition, as they require it.

Level 7 Pathway

The higher academic level T&E pathway is pitched at Regulated Qualification Framework (RQF) level 7 for which Postgraduate Certificate (PgCert), Postgraduate Diploma (PgDip), or Master's degrees (MSc) are awarded. T&E at this level is necessary for graduate engineers and scientists in nuclear posts as they require enhanced problem solving and analytical skills so they can effectively evaluate and judge technical outputs from other teams and contractors involved in plant design and through-life support.

As mentioned above, the NSSC has been retained in a revised form and forms the common core of the pathway. It is comprised of three, 10-credit modules: Nuclear Science and Engineering (which includes nuclear and radiation science, materials science and chemistry); Core Performance (which includes reactor principles, thermal hydraulics and dynamics); and Radiation Protection and Nuclear Safety. Each module lasts two weeks and each credit is equivalent to ten study hours. If all three modules are completed the student is awarded an NSSC certificate. One of the key aims of the NSSC is to provide system-level contextual awareness to the science and engineering principles presented and a common language for improved communication between teams.

As no post consists purely of a general role, in addition to the NSSC, and depending on the post, students also take a role specific stream comprised of a three, 10-credit short courses, each of two weeks duration. Currently role-specific streams have been developed for personnel working in core design, structural integrity, EC&I, health physics and nuclear safety. Once 60 credits have been successfully completed a PgCert in Naval Nuclear Reactor Technology (NNRT) is awarded. This award point is shown in Fig. 1.

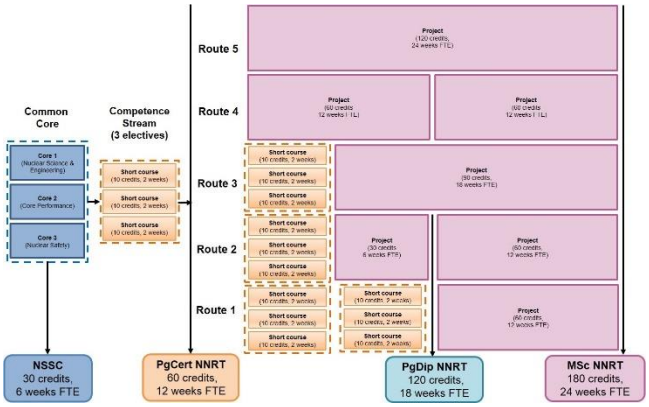

Fig. 1. Level 7 T&E pathway from NSSC to MSc in Naval Nuclear Reactor Technology (NNRT).

Completion of further role-specific streams, e.g. after an individual undertakes the T&E necessary to fulfill their new role, allows further awards to be made. To allow credit for work-based learning, projects of varying durations (from 6 to 24 weeks) can be undertaken. This option is highly beneficial for entry-level graduates on the MOD Defence Science and Engineering Group (DESG) training scheme as they are required to complete a range of projects whilst on placements (internships) to other teams and contractors. It is also highly beneficial for personnel from contractor organizations as they can gain credit for technical work conducted during their day job.

The level 7 T&E pathway maps neatly onto the MOD core career grade structure. Graduate engineers and scientists

enter at grade 1, undertaking the NSSC before promotion into a grade 2 (specialist) post. At grade 2, the incumbent will take a role-specific package such that they can function effectively in a grade 3 (senior specialist) post. Whilst working at grade 3 they will complete one, or more, T&E packages for other roles with the scope of a technical section or group such that they can function as its section head or group manager (grade 4) wherein they may need to work with analysis provided by a range of specialists under their line management.

Level 4-5-6 Pathway

The lower academic level T&E pathway is pitched at Regulated Qualification Framework (RQF) levels 4, 5 and 6 which equates to a Higher National Certificate, Higher National Diploma/Foundation degree (FdSc) and Bachelor's Degree (BEng/BSc), respectively. People on this pathway are typically in posts where roles are more practical or vocational (e.g. dockyard workers or nuclear welders), or where a high-school education is sufficient. Like the level 7 T&E pathway described above, one of the ND's original courses, in this case the NWSC, has been retained and revised to provide the general role T&E requirement.

The NWSC comprises three, 10-credit, level 4 modules: Nuclear Science and Engineering, Radiation Protection and Nuclear Safety, and a choice of Manufacture, In-Service or Disposal. Each module last two weeks, is scenario based, and is more qualitative than the similarly named level 7 module. Each credit is equivalent to ten study hours. If the three modules are successfully completed the student is awarded an NWSC certificate. Whilst this is sufficient for many individuals, some might aspire for higher qualifications, or might post-rotate between teams, acquiring additional skills or knowledge in the process. Mirroring the level 7 pathway, short courses at levels 4, 5 and 6 are available, for example the level 5 Nuclear Instrument Calibration Course could be credited towards an undergraduate qualification.

As an individuals' career develops it is expected that they progressively develop and display learning attributes from simple understanding (level 4), through application of knowledge (level 5), to analysis of problems (level 6). Level 6 skills and knowledge can be assessed through work-based projects totaling 12-months full time equivalent (FTE).

In addition to the level 4-5-6 T&E pathway described, a Nuclear Science and Engineering Degree Apprentice Scheme (NSEDA) is also available. Following the UK Government policy of increasing the number of apprentices trained nationally by charging medium-to-large businesses a levy, the ND, together with the University of the West of England (UWE) offers a BEng Mechatronics. Whilst the course itself is predominantly mechanical and electrical engineering, personnel undertake two week nuclear science and engineering and safety modules, annually in years 2, 3 and 4 of the programme, and to build experience, undertake placements throughout in various teams across the DNE. In the final year of the apprenticeship, in order to be awarded the degree, they undertake a 12-month project in a nuclear engineering subject.

CONCLUSIONS

The Defence Nuclear Enterprise faces constant challenges in sustaining a suitably qualified and experienced workforce. With a resurgent civil new build and pressure on public sector finances, personnel have many opportunities outside defence. To mitigate this risk the DNE provides the opportunity for personnel to gain real-world qualifications up to MSc-level hence simultaneously providing a disincentive to leaving and an improvement in SQEP.

In this paper we have presented two T&E pathways for civilian nuclear personnel that reduce through-life training time and duplication, or divergence, of learning. In providing T&E by role rather than post, T&E is targeted and delivered just-in-time. Once the pathways are fully developed, given they both use common core frameworks, further work will investigate whether other ND courses, such as the NRC and NAC, could be absorbed within them. Civilian and service personnel receiving the same core T&E would be a demonstration of a successful whole force concept. Finally, given the large varied workforce within the DNE, self-identification of roles to reverse engineer the nuclear competency framework through course selection will be investigated.

REFERENCES

1. MINISTRY OF DEFENCE, "JSP 822 Defence Direction and Guidance for Training and Education Part 1: Directive," *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/600177/20170317-JSP_822_Part_1-Final.pdf* (2017).

2. MINISTRY OF DEFENCE, "JSP 822 Defence Direction and Guidance for Training and Education Part 2: Guidance," *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/607717/20170404-JSP_822_Part_2-Final-O.pdf* (2017).

3. MINISTRY OF DEFENCE, "Nuclear Competence Framework," Version 1.0 (2012).