The quest for the ring: Designing submarine control room work using ComTET

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THE WORK IN CONTEXT

Research and development for new operational capability in submarines comprises research into human centred design of new capability (where the Command Team-work Experimental Testbed (ComTET) resides), procurement of new capability training capability, and operational evaluation of capability and lessons learnt. The research is given impetus from lessons learnt at sea as well as horizon scanning for technological capability by Defence Science and Technology Laboratory (Dstl). This is fed into the design challenge, which is presented to the ComTET Team, who undertake the research. The ComTET team work with submarine trainers to review current operations and new ways of working. Experiments conducted using the ComTET facilities with serving submariners are able to test and evaluate new technologies and new ways of working. The refined concepts may be taken into the simulators to further refine and test. Once the new operational capabilities have been shown to deliver benefit in ComTET facilities, and the simulators, then they may enter the procurement process. When the new capability enters service on operational platforms, then full evaluation in-service may begin. Any lessons learnt during service may then be fed back into the research cycle. The ComTET team have delivered a guidance document reviewing simulator fidelity, validity and transfer of training to underpin understanding of facility requirements across the different phases of testing.

KEYWORDS

Control room, command and control, teamwork, EAST

A brief outline of the work carried out

Over the past six years, the team at the University of Southampton designed and developed the Command Teamwork Experimental Test-bed (ComTET) laboratory to examine the performance of command teams during ‘return to periscope depth’ (RTPD), ‘dived tracking’ (DT), and ‘inshore operations’ (INSO) (Stanton and Roberts, 2018; Stanton et al., 2018; Roberts et al., 2017, 2018). The aim of ComTET is to use the Event Analysis of Teamwork (EAST) (Stanton et al., 2008, 2019) method to better understand submarine command team working across different operation types and levels of demand. The descriptive power of EAST facilitated an understanding of what information is utilised by command team operators and how this information flows around the control room. All experimental manipulations (combined control room, reduced crewing and ring control room) were compared to a baseline control room configuration representative of an operational Royal Navy submarine. Ten teams have been tested in each manipulation (240 participants in total), including multiple expert teams comprised of qualified submariners (as the gold standard).

A representative submarine control room simulator was developed. A set of three unclassified scenarios (RTPD, DT and INSO) all in high and low demand, were designed to capture the widest range of operations submarines routinely complete. An eight hour training package was designed to train non-expert operators to be representative of a submarine command team. This included the basics of submarine operation, the development of a tactical picture, optimal communication structure and specific workstation operation (for example a sonar tutorial and periscope operator tutorial). A large number of novice participants (drawn from industry as well as the university studentship) were recruited for each study (ten teams of eight individuals (baseline) and ten teams of seven individuals (manipulations)), providing high statistical power. To provide a point of reference, one of the teams recruited from each study was made up of currently operational submariners, used as the ‘gold-standard’ comparator.

The analysis used was a new shortened form of EAST (Stanton, 2014). EAST models complex collaborative sociotechnical systems through a network approach. The networks are based on transcriptions of all of the communications in the sound and control rooms, for each of the six scenarios. Specifically, three networks are considered: task, social, and information. Relevant statistical analyses were conducted on the metrics derived from the building of the different networks. Typically, the analysis involved 3 x 2 x 9 mixed analysis of variance (ANOVA) with the completion of relevant post hoc comparisons for the investigation of statistically significant main effects. A total of eight studies have been conducted, the studies were conducted in an iterative fashion, with input from subject matter experts (human factors, Royal Navy, industry) guiding the investigative process.

Findings/solutions (the outcome)

In the baseline studies, a number of potential shortfalls in the current command team working under some circumstances were identified that provided the platform of investigation for the future studies. A communication bottleneck between the operations officer (OPSO) and the sonar controller (SOC) was observed. The communication between these operators was critical in terms of connecting the sound room and control room. This resulted in a delay of critical information being passed from the sound room (for example, a new contact detection) or a backlog of information. The distance between the sonar operations (SOPs) and the target motion analysis operators (TMAs) was the largest observed in terms of network composition (the largest number of hops to connect these ‘nodes’). Yet these operators rely most heavily on each other for task completion (for example, feeding speed estimates into solution). The officer of the watch (OOW) had to seek and frequently request information, pulling information out of the system rather than the information being pushed to them. The OPSO is often extremely overloaded in terms of information brokering (for example, for the OOW), quality checking (for example, for the TMAs) information fusion (for example, sonar and periscope) and prioritising (for example, with the SOC). An environment was created that facilitated the conditions for engineered social loafing (Stanton and Roberts, 2019). The configuration means that operators (for example, the SOPs) cannot always pass or receive relevant information (as only one operator can talk to the SOC at any time). In this situation, conditions are met for social loafing, resulting in capacity reduction. There was a clear lack of sensor information alignment resulting in disparate information availability (for example, bearing might be provided by sonar and/or periscope) with this requiring operator intensive decision based integration. This was compounded by a difficulty in assessing operator workload and task understanding, due to outward facing workstations.

The ComTET program has demonstrated that it is possible to build a low-cost mid-fidelity simulator and conduct a series of studies with high statistical power to provide evidence for how submarine control room operations of the future might be improved. The key findings highlight that co-location of operators highly dependent on each other for task completion creates greater efficiency in terms of information flow and increases command team capacity. Having operators facing inwards in a ring format creates conditions for much better situation awareness between the command team. Placing the OOW in the centre of the command team leads to a more efficient tactical picture generation. The testing program has also provided early insights into the potential for sensor information integration, role merging, optimal integration of future sensor information/operation and where automation of tasks might best be focused. It is acknowledged that the current work has limitations: most notably that full sensor capabilities or operator numbers were not included in the testing program. Nevertheless, the large sample size attained (over 240 participants in the ComTET studies) has provided a body of evidence with high statistical power and excellent relative fidelity.

Impact

The ComTET team recognises the importance of generating outputs that provide practical solutions for designing ways of working for command teams in current and future platforms. The ComTET team have established strong links with the trainers. This has enabled the ComTET team to build upon a strong track record of understanding command team operations in submarines (we have already conducted studies on simulators in the UK). The research of ComTET was initially aimed at the design of future platforms, however currently operational command teams are already testing the outputs of the studies in the most recent project work. The impact of this work has been wide reaching.

The ComTET team have always strived to ensure the impact of the work is wide reaching by hosting quarterly steering committee meetings. The meetings have routinely been attended by representatives from the Royal Navy, industry partners involved in the design and construction of submarines and relevant Ministry of Defence agencies included in the provision of requirements for future systems and procurement of such systems. The success of the project has fuelled attendance at the facility of senior representatives at the highest level from the Royal Navy and Ministry of Defence.

The research has also been written up into reports to Dstl (20 in total) and is undergoing approvals for publication in the peer-reviewed literature (all research is subjected to a strict permission-to-publish approval process). Publication of the research in peer-reviewed journals is one way of demonstrating that this research is world leading. So far, the ComTET project has published 12 journal papers.

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