# Collective Training Needs Analysis - A New Analytical Framework

**Dr John Huddlestone, Jonathan Pike**
**Cranfield University**
**Cranfield, Bedfordshire, UK, MK43 0AL**
**j.huddlestone@cranfield.ac.uk, j.pike@cranfield.ac.uk**

## ABSTRACT

Collective training lies at the heart of delivering military capability. It is the crucible within which the individual skills of our highly trained and capable soldiers, sailors and airmen are melded together to enable them to deliver winning collective effects. Effective training systems are built upon a foundation of rigorous and robust Training Needs Analysis (TNA), which embraces task analysis, training gap analysis and training options analysis. The TNA process for individual training, as part of the Systems Approach to Training or Instructional Systems Design, is well established in both the literature and in military practice. However the same cannot be said for such a process applied to collective training.

Collective training is inherently more complex than individual training in terms of the tasks being conducted by the trainees, the instructional tasks and the nature of the environment that has to be provided to support the training. In this paper we describe a new analytical framework for collective TNA, which is designed to address these issues. Within this framework, a range of established human factors and systems engineering methods and representational techniques can be utilised to conduct the analysis of both the training task and the instructional task. The synthesis of the analytical outputs facilitates the modelling of the training environment that is required to support these tasks and their associated interactions. The description of the framework is followed by illustrations of some of the techniques that are being explored and developed to facilitate each of the analytical steps.

## ABOUT THE AUTHORS

**John Huddlestone** is a Senior Research Fellow in the Systems Engineering and Human Factors Department at Cranfield University. He leads the research being conducted into Training Needs Analysis and synthetic training under the auspices of the Departments work within the Human Factors Integration Defence Technology Centre. He holds a PhD in Applied Psychology from Cranfield University, an MSc in Computing from Imperial College London and a BEd in Physics from Nottingham Trent University. He is a Member of the British Computer Society and is a Chartered IT Professional. His research interests include simulation, training and task analysis. Prior to joining the University he was a commissioned officer in the Royal Air Force. As a training specialist, he gained extensive experience in training design, aviation training development, flight simulation and the development of computer based training.

**Jonathan Pike** is a visiting Research Fellow in the Systems Engineering and Human Factors Department at Cranfield University and is currently researching Training Needs Analysis methodologies under the auspices of the Departments work within the Human Factors Integration Defence Technology Centre. As a freelance digital learning consultant his experience of e-learning project management, design, development and evaluation spans both the military and civil sectors. His roles have included research, teaching, technical consultancy, instructional design and project management. He holds a BSc in Biology from University College London, an MSc in Applied Computing Technology from Middlesex University and is registered in the PhD programme at Cranfield University. He is a member of the British Computer Society and is a Chartered IT Professional.

# Collective Training Needs Analysis - A New Analytical Framework

**Dr John Huddlestone, Jonathan Pike**
**Cranfield University**
**Cranfield, Bedfordshire, UK, MK43 0AL**
**j.huddlestone@cranfield.ac.uk, j.pike@cranfield.ac.uk**

## INTRODUCTION

Critical analysis of the nature of military collective organizations and the tasks that they undertake in the land sea and air domains, conducted during previous work, has revealed that Training Needs Analysis (TNA) for collective tasks must address issues that do not typically arise in individual training. (Huddlestone and Pike, 2008). Typically, collective tasks are more complex, and factors such as command and control, teamwork, communications and interactions between individuals and teams must all be considered and the cognitive nature of these tasks addressed. Furthermore, as a consequence of the increased task complexity and the larger size of training audience, the instructional task can be significantly more complex. In addition, a larger-scale, more complex training environment has to be constructed and managed.

The extant UK Ministry of Defence (MoD) TNA model has three stages as shown in Figure 1 (MoD, 2007).

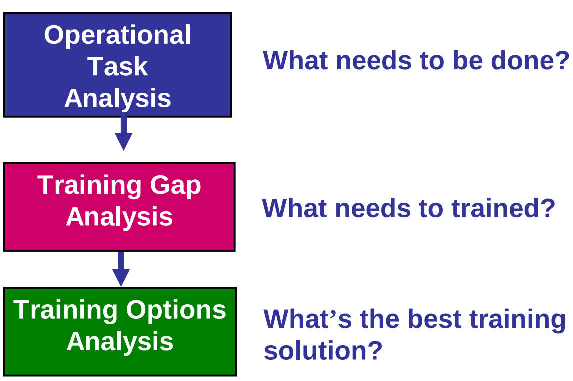


**Figure 1. UK MoD TNA Model**

The logic of the model is that the task to be trained first has to be established. Then the existing capabilities of the training audience are determined. The gap between the required capability and the existing capability of the training audience is the gap that has to be addressed by training. The final stage is to identify feasible training options and select the most suitable option. Whilst this model has proved to be robust in principle and has been used effectively for individual training for many years, it lacks granularity of approach for handling complex task such as collective training and there is relatively little guidance for the generation of training options. Therefore a new analytical framework has been developed by the authors, the TNA Triangle Model.

The concept behind this model is to provide a framework within which new and extant human factors and engineering tools can be used to analyse complex training tasks and generate suitable training options. In this paper the TNA Triangle Model and its theoretical underpinnings are outlined and then illustrations of the use of some of the tools that are being developed and applied within the model are illustrated using collective training examples.

## THE TNA TRIANGLE MODEL

The TNA Triangle Model is based upon an information view of training tasks and the training process. This was described in the individual training context in Pike and Huddlestone (2007). The key points about viewing training tasks from an in formation processing perspective are that training tasks can be characterized by the stimulus and response requirements of the task and by the cognitive processing that is required to determine the appropriate response to the stimulus. The implications of this are twofold. Firstly, the training environment must be capable of supporting the stimulus and response types required for the task. Secondly, there is an instructional requirement to provide the stimuli in such a way that the required cognitive activity is elicited. This leads to a consideration of the nature of instruction itself. Romiszowski (1988) characterized the instructional process as one of two way communication, the significant point being that the instructional environment must support the communications modes that are necessary for instruction of the training task under consideration. Therefore, both the nature of the task itself and the instructional approach impact on the training environment that has to be provided.

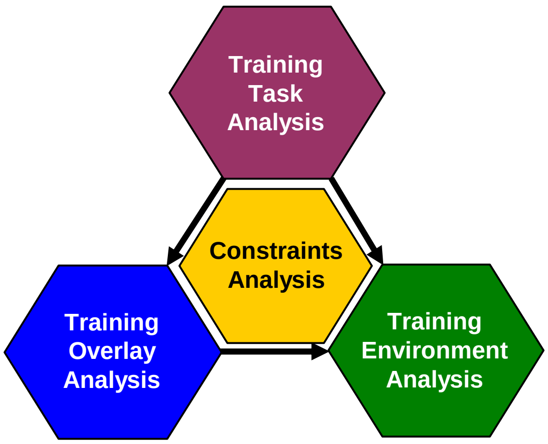


**Figure 2. The TNA Triangle Model**

These relationships are captured in the TNA Triangle Model shown in **Figure 2**. The model identifies four types of analysis that have to be conducted.

The Training Task Analysis component combines operational task analysis and training gap analysis from the extant TNA model, along with their outputs. The significant difference is that the stimulus and response requirements for the training task are explicitly identified at this stage. The arrow from Training Task Analysis to Training Environment Analysis represents the connection between the nature of the task in terms of stimulus and response requirements and the requirement for these to be supported in the Training Environment.

The next component that needs to be considered is Constraints Analysis. There is a wide range of factors to be considered in selecting an appropriate training solution. These include, but are not limited to, the nature of the training task (including such issues as safety), learner characteristics, costs, resource and infrastructure requirements, policy constraints and instructional management (Huddlestone and Pike, 2005, 2006). Early identification of constraints is useful as it saves time being wasted on the formulation and evaluation of training options that are not practically viable.

Training Overlay Analysis consists both of identifying appropriate methods for facilitating the required training along with their stimulus and response requirements, and an analysis of the instructor tasks. The nature of the interactions between instructor and student that will ultimately have to be supported within the training environment are identified. This element has been broken out as a separate area of analysis because of the potential complexity of the instructional task in the context of collective training, as described in the introduction. Task analysis for each of the potential instructor roles may well be necessary, particularly where complex synthetic environments are likely to be used. Without such task analysis, it would be extremely difficult to identify the functionality required for instructors to create scenarios and control the synthetic environment.

Training Environment Analysis focuses on the identification of the elements required in the training environment to support the stimulus and response requirements of both the training task and the training overlay options. This would include the identification of the interfaces that instructors would require to control training devices such as simulators and other tools that they may require to fulfil their role, such as tools to support data capture about student performance during exercises. The Training Environment Model produced at this stage provides a generic map which facilitates the identification of categories of media options that could be used to support the stimulus and response interactions required by the training task and the training overlay.

## TRAINING TASK ANALYSIS

When undertaking task analysis in the individual training context it is common to employ such techniques as hierarchical task analysis and cognitive task analysis. Whilst these techniques are applicable to the collective domain, one of the challenges is dealing with the complexity of a collective task. One approach that has been explored to provide an initial insight into the nature of such complex tasks has been taken from the domain of real time systems design. Ward and Mellor (1985) advocate the use of a context diagram to first capture the entities with which a system has to interact before considering how the system is decomposed into functions which are performed to achieve its purpose. To illustrate the use of the technique, the example of a Maritime One Star Battlestaff is explored.

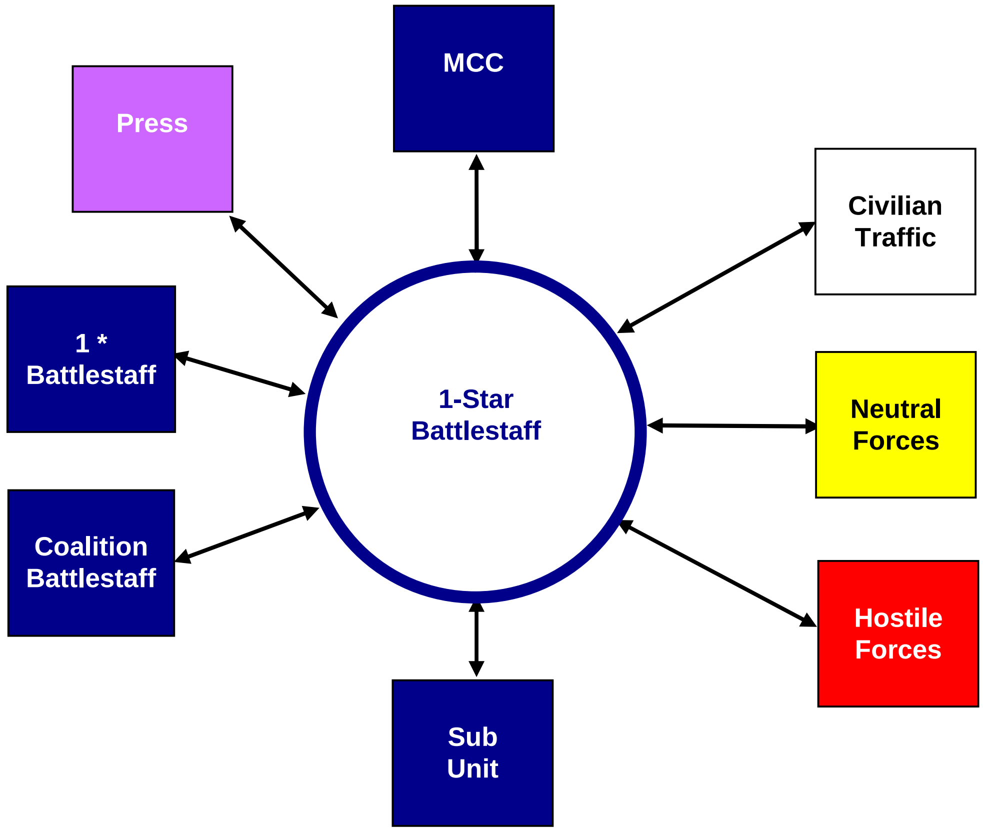


**Figure 3. Battlestaff Context Diagram**

**Table 1 Interaction Table**

| From | To | Content | Mode |
|---|---|---|---|
| MCC | Battlestaff | Commander's Intent | Video Teleconference |
| Battlestaff | MCC | Strategy | Video Teleconference |

A One Star Maritime Battlestaff would typically command a carrier strike group or equivalent sized aggregation of sub units. It would report to a Maritime Component Command and may act in concert with other similar Battle groups. Figure 3 shows a generic context diagram for such a Battlestaff.

The rectangular boxes represent the entities that the Battlestaff has to interact with. These include the superior Maritime Component Command (MCC), subordinate units, hostile and neutral forces, civilian vessels and aircraft, equivalent Battlestaffs that they are collaborating with, and external agencies such as the Press. The arrows show the direction of the interactions. To simplify the diagram in this instance the double headed arrows have been used to show two way interactions. Separate arrows could be used for each type of interaction, however this would make the diagram particularly cluttered, so a single arrow has been used. The nature of the interactions represented by the arrows can then be specified in tabular form as shown in Table 1. The entries in the table capture some of the information that may be exchanged in the daily Video Teleconference typically held between a Battlestaff and its MCC. A fully completed interaction table provides a comprehensive description of the stimuli and responses to and from the Battlestaff. Although this appears to be a simple representation, it is actually a powerful analytical tool and can generate significant insights into the ultimate requirements for the training environment.

.

The significance of two-way interactions with the entities represented, is that the entities process the interaction that they receive and produce a response. Given that the Battlestaff interacts with these entities in the conduct of its task, these entities have to be represented in some way in any training environment that is constructed for the Battlestaff to practise its task. The fact that the entities process the interactions means that they have to have some intelligence associated with them. For example, hostile forces could be represented by ships designated as red forces in the live environment, or by intelligent agents or role players in a simulation. We also need to consider the means through which the interaction takes place. Communication between superior, subordinate and equivalent units is typically through voice communications, chatrooms, the Command Support System (CSS), signals, video teleconference and Link. Press briefings would typically be face-to-face briefs. These mechanisms would need to be supported in the training system.

Perhaps one of the more challenging questions that arises from this analysis is how should subordinate units be represented? This could range from complete warfare teams embarked on a ship, to a role player driving a constructive entity in a simulation. This range of options immediately raises questions of availability of warfare teams to participate in such training events and the viability of using a role player to provide credible responses to the Battlestaff.

The context schema is but one view of the collective task and it has to be supplemented by other views such as those provided by the various forms of task analysis. However, one of its significant attributes is that it enables key issues about the training environment to be elicited at a very early stage of analysis before significant effort is expended on detailed task analysis.

## CONSTRAINTS ANALYSIS

Early identification of the possible constraints on the selection of potential training solutions is valuable, as it prevents effort being wasted on putative solutions that in practice may not be viable. Typical constraints which need to be considered are:

- **Costs** – examples are cost to build, cost to access, cost to run and maintain. Live training such as large scale exercises are constantly under scrutiny because of their high costs.

- **Safety –** safety is a common reason for the selection of synthetic training versus live training, as weapons effects can often only be simulated (shooting at live targets would be unacceptable!).

- **Resource availability** – it is increasingly difficult to get access to exercise areas and other resources due to environmental considerations. Also equipment availability may be an issue, particularly when there is a significant level of operational commitment. Other availability issues include whether the environment is: restricted in terms of location or time; guaranteed available or is availability dependent on specific external conditions (e.g. weather); present for a finite amount of time (e.g. 60 seconds of freefall from 14,500ft for parachuting).

- **Student throughput** – what is the capacity of the training environment, and can it handle the required number of students? Alternatively, is the student throughput going to be sufficient to justify the acquisition of training resources.

- **Support for the Instructional Overlay** – does the environment allow an instructional overlay? Restrictions in this area have some fundamental impacts in that without the instructional overlay one is limited in what one can do to ensure safety. In more extreme examples one ends up building specific instructional environments to get around these restrictions (e.g. building two-seat instructional variants of single seat aircraft).

These are some of the typical constraints that need to be considered. Whilst constraints have to be considered on a case by case basis, future work will explore the development of checklists of the most common constraints in the collective domain.

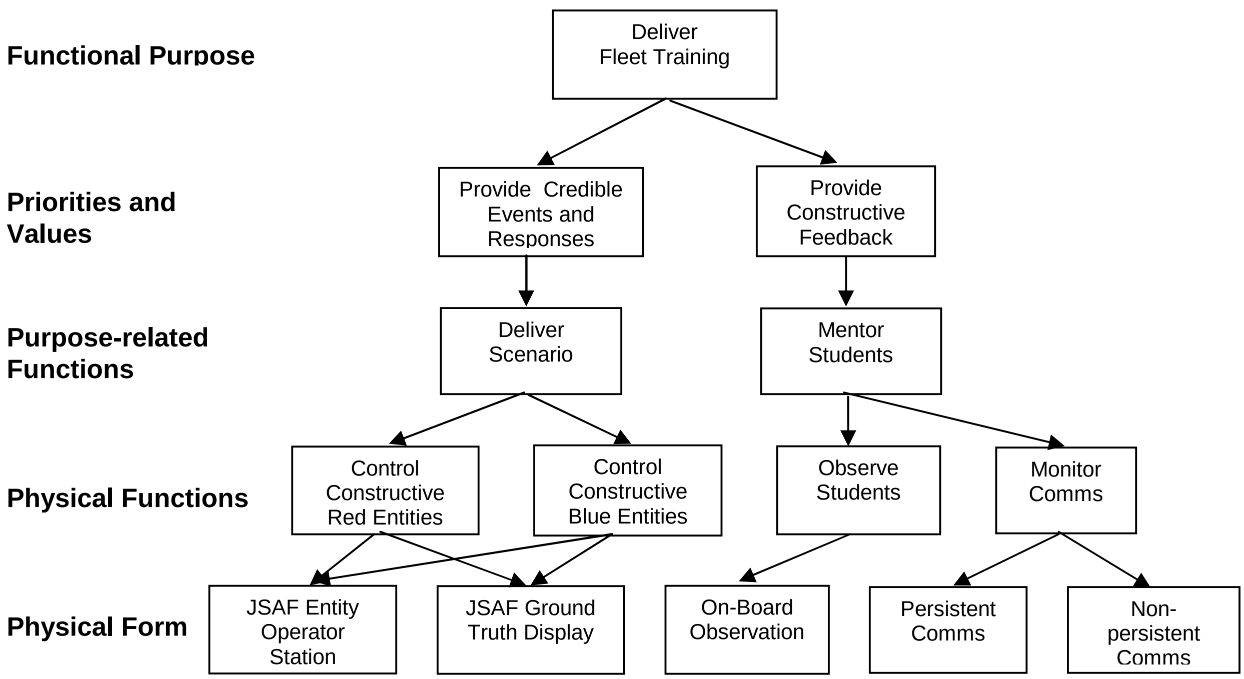


**Figure 4 FST-J White Cell Abstraction Hierarchy Fragment**

## TRAINING OVERLAY ANALYSIS

Typically in TNA the instructor role is not analysed in detail. However, in the collective training domain the scale and complexity of the training demands that the full range of instructor roles and tasks are comprehended in order to ensure that they can be properly supported in the instructional environment. One of the techniques that is currently being explored is the use of abstraction hierarchies. This approach is drawn from Cognitive Work Analysis (Vicente (1999), Jenkins, Stanton, Salmon and Walker (2009)) which has its origins in the analysis and design of complex socio-technical systems.

Figure 4 shows a fragment of an abstraction hierarchy that was developed to capture the white cell (instructional) roles in a US Fleet Synthetic Training Exercise. At the top of the hierarchy is the overall functional purpose that is to be served by the white cell, which in this case was to deliver a fleet training exercise. The next level down identifies the priorities and values associated with this activity by which one can define a successful outcome. Delivering credible scenarios and providing constructive feedback to students are clearly vital if the training mission is to be successful. At the next level the functions that must be carried out to achieve the purpose of the activity are identified. In this case delivering the required scenario and mentoring the students are examples of such functions. The significant feature of these first three levels is that they are technology agnostic. That is to say they hold true regardless of how the task is ultimately implemented. Whilst the particular example that was being investigated was a synthetic training exercise, these functions would hold true for a live exercise at sea.

The lower two levels consider the specific instantiation of these functions in a given environment. In a synthetic environment where red entities and some blue entities are constructive elements in the simulation, the white cell have to control these entities so that they carry out actions in accordance with the scenario design. This requires physical entities to be available to provide the appropriate functionality. The white cell operators require stations at which they can control the simulated entities and also a display of the "ground truth" in the simulation so that they can see all of the entities in play. Similarly, mentors need to be able to observe student actions directly as well as monitor the various communications systems if they are to evaluate student performance and provide effective feedback.

The technology independence of the top three levels of the abstraction hierarchy has significant benefits for the generation of alternative training options, as the higher levels of analysis don't have to be repeated. It simply requires alternative physical functions and forms to be substituted into the framework. The sets of physical forms are elements that have to be present in the instructional environment.

## TRAINING ENVIRONMENT ANALYSIS

Having completed the training task analysis and the training overlay analysis it is possible to conduct the training environment analysis to determine the optimal training environment(s) to support the training task.

The environment in this context is taken to be the domain within which objects, assemblages, processes and events occur. Environments may be:

1) Real environments in the sense that they comprise real vehicles, situations (woodland, desert) or may be proxies for real environments (e.g. swimming pools used for life-raft training). Real environments are experienced directly without mediation through interfaces.

2) Synthetic – synthetic environments exist independently of the means used to represent them to the user (users interacting with synthetic environments always do so through interfaces, different trainees may have different interfaces and so will have different types of information available to them).

3) Communications Environments – these may be persistent (such as chat rooms) or non-persistent (such as radio links).

One of the challenges for the training analyst is to provide visualizations of putative training environments that can be easily comprehended to facilitate comparison. A technique which is being developed to facilitate this is environmental modeling. An example of an environmental model for a Navy Warfare Team onboard at the pierside participating in a Fleet training exercise is shown in Figures 5 and 6.

The environments in this instance are a synthetic theatre of war (provided by JSAF) and persistent and non-persistent communications. Systems onboard the ship provide access to these environments and the Blue cell participants access these systems through the normal interfaces that they use onboad. However, additional components are required to enable the ship's warfare systems to access the synthetic environment, to take information from it, and to feed information to it.. The US Navy uses the Battle Force Tactical Training (BFTT) system. This takes data fed from the synthetic environment and feeds it into the warfare system to produce representative contacts from the sensors, and also takes output from the warfare system and transforms it into data that can be read by the synthetic environment. The BFTT Operator's PC provides a white cell interface into this system. To all intents and purposes, the synthetic environment is transparent to the Blue cell participants, as the displays they get are equivalent to those they would see if they were at sea and the ship was sensing live entities.

In Figure 5 the White cell mentors are also shown. Their interactions are the monitoring of the communications systems and the observation of the Blue cell personnel, as outlined in the abstraction hierarchy shown in Figure 4. This demonstrates how the output of the instructional overlay analysis can be fed into the representation of the training environment.

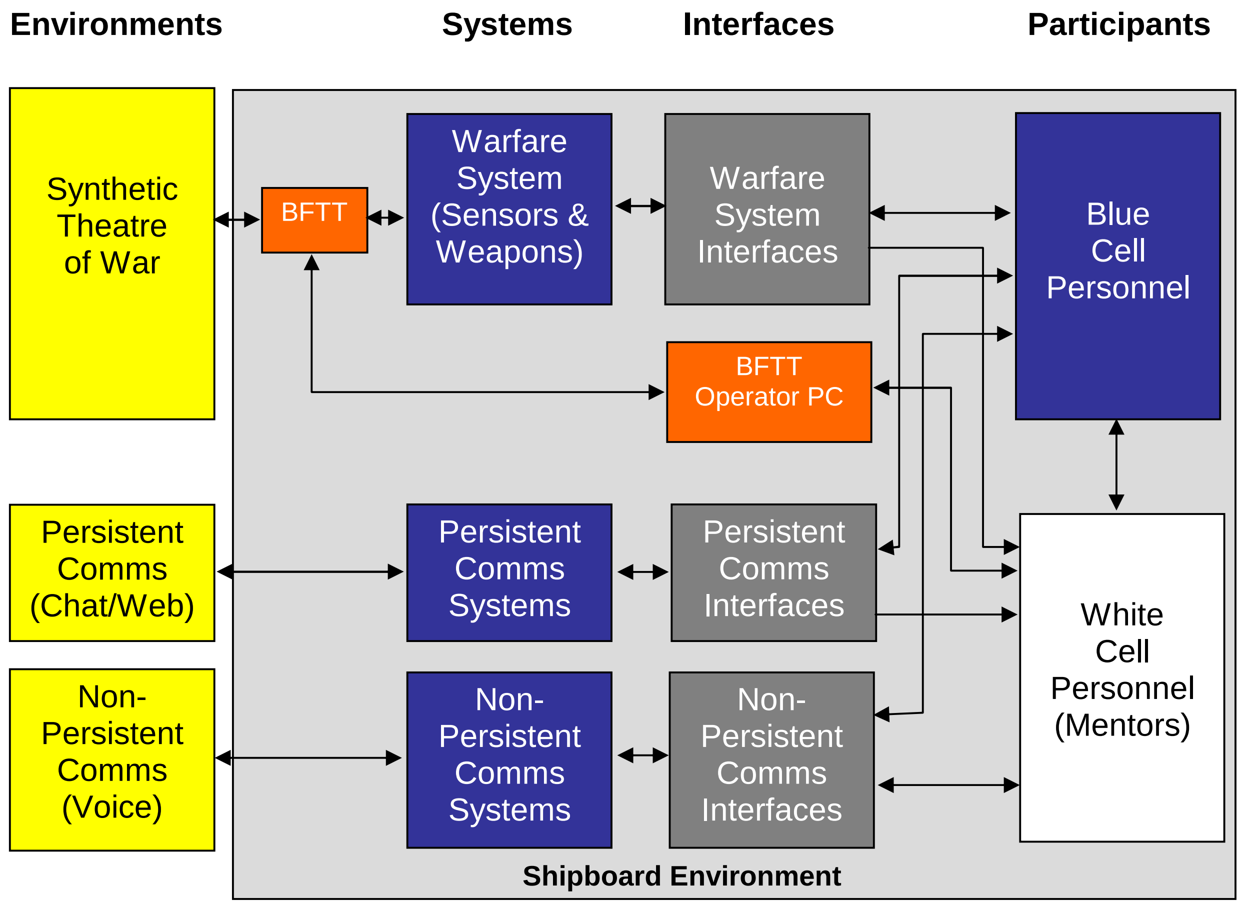


**Figure 5.** Environment Model for On-Board Warfare Team Training at the Pierside

However, there is a significant white cell input required to drive the simulation, including the elements shown in the abstraction hierarchy in Figure 4. The part of the environment in which the majority of the white cell operate is shown in Figure 6. The environments are the same as for the Warfare team, which would be expected as they are driving the environments within which the warfare team are operating. The significant differences are that they interact directly with the synthetic environment in order to control the events occurring, with the interfaces identified in the abstraction hierarchy to view "ground truth" and control constructive entities. They also have access to the communications systems as they provide communications inputs and responses to the Warfare team.

The two diagrams shown in Figures 5 and 6 could be combined into one diagram (which in fact was how it was originally constructed). They are shown separately for ease of presentation in the paper. That said, the full diagram showing the full range of entities that would be derived from a full analysis would quickly become complicated, so splitting such diagrams into cohesive sub-components has been found to be a useful strategy for minimizing complexity without losing coherence.

## CONCLUSIONS

The TNA Triangle model has been developed to provide an theoretically sound analytical framework for use in the collective training domain. To date it has been found to provide sufficient analytical power to facilitate the modeling and analysis of collective training problems as complex as Battlestaff training and for capturing the key properties of training options as complex as US Fleet Synthetic Training (Joint). The analytical techniques presented in the paper have been used in these analyses and have been found to be effective. There remains significant work to be done to provide a complete "toolkit" of

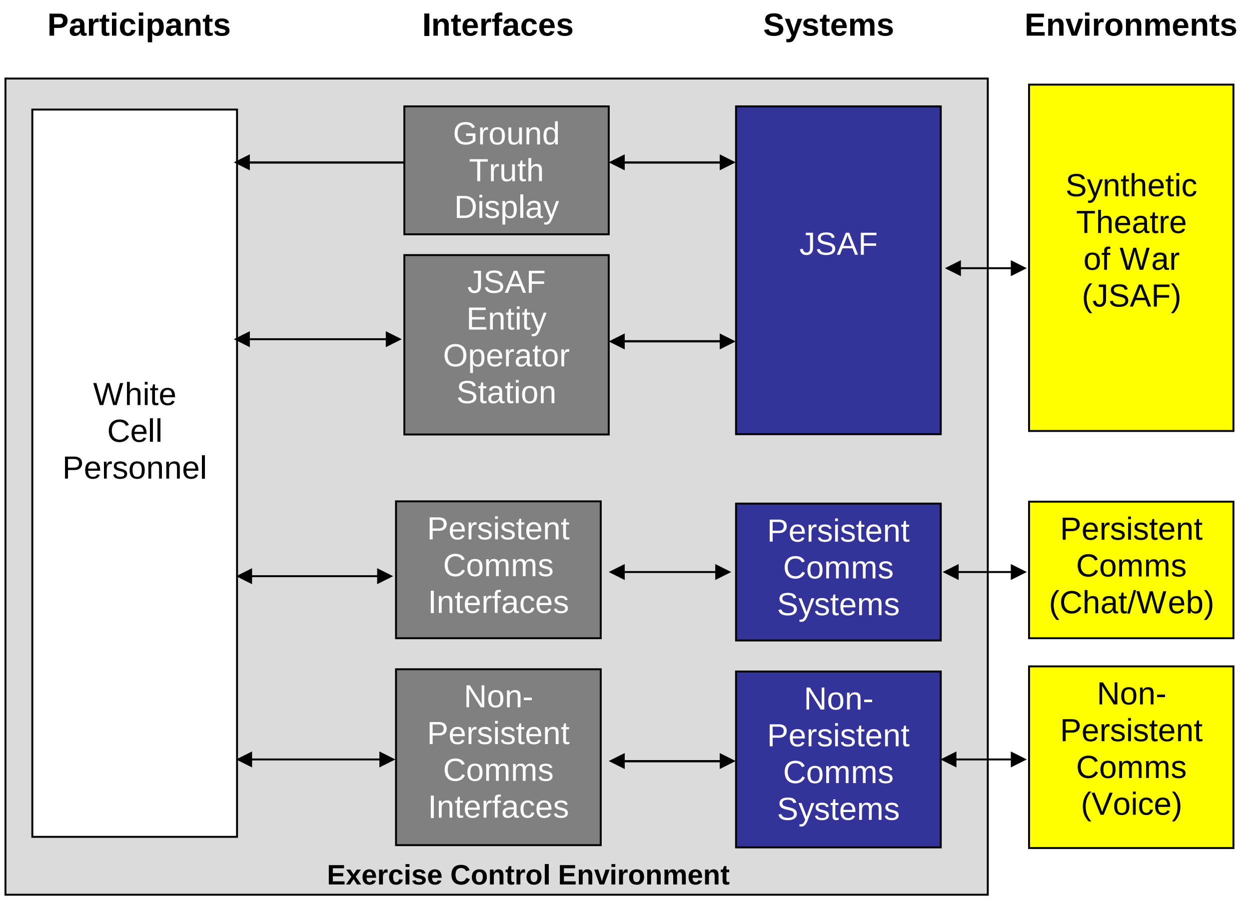


**Figure 6 White Cell Environment for a Fleet Synthetic Exercise**

analytical and representational tools to embrace all aspects of the analyses required within the TNA Triangle Model.

## REFERENCES

Huddlestone, J.A. & Pike, J. (2008) Collective Training – The Training Needs Analysis Challenge

Jenkins D.P, Stanton N.A, Salmon P.M, Walker G.H, (2009) Cognitive Work Analysis: Coping with Complexity, Ashgate, London

Pike, J. & Huddlestone, J.A. (2007) Instructional Environments - Characterising Training Requirements and Solutions to Maintain the Edge, Proceedings of the 29th I/ITSEC Conference, Orlando Fl December.

Romiszowski, A.J. (1988). *The Selection and Use of Instructional Media*, London: Kogan Page.

Ward, P.T. & Mellor, S.J (1985) Structured Development for Real-Time Systems Volume 2: Essential Modelling