COLLECTIVE TRAINING NEEDS ANALYSIS REVIEW

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LIST OF ACRONYMS AND DEFINITIONS

AAR	AFTER ACTION REVIEW
ADDIE	ANALYZE, DESIGN, DEVELOP, IMPLEMENT AND EVALUATE
ADDP	AUSTRALIAN DEFENCE DOCTRINE PUBLICATION
ADL	ADVANCED DISTRIBUTED LEARNING
ALPS	ARMY LEARNING POLICY AND SYSTEMS
API	APPLICATION PRODUCT INTERFACE
ARI	ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
ASAT	AUTOMATED SYSTEMS APPROACH TO TRAINING
AWACS	AIRBORNE WARNING AND CONTROL SYSTEM
BF	BATTLE FUNCTION
BF ANALYSIS	BATTLEFIELD FUNCTIONAL ANALYSIS
BG	BATTLE GROUP
BDE	BRIGADE
BN	BATTALION
BOS	BATTLE OPERATING SYSTEMS
C2	COMMAND AND CONTROL
CA	CANADIAN ARMY
CAE	CAE DEFENCE AND SECURITY CANADA
CAF	CANADIAN ARMED FORCES
CARO	CONSTRAINTS, ASSUMPTIONS, RISKS AND OPPORTUNITIES
CAX	COMPUTER AIDED EXERCISE
CCF	CRITICAL COMBAT FUNCTIONS
CDS	CHIEF OF THE DEFENCE STAFF
CEB	CUSTOMER EXECUTIVE BOARD
CFITES	CANADIAN FORCES INDIVIDUAL TRAINING AND EDUCATION SYSTEM
CFNOS	CANADIAN FORCES NAVAL OPERATIONS SCHOOL
CFPDS	CANADIAN FORCES PROFESSIONAL DEVELOPMENT SYSTEM
CMP	CHIEF OF MILITARY PERSONNEL
COMMAND	COMPREHENSIVE MISSION NEEDS ANALYSIS AND DETERMINATION
CPX	COMMAND POST EXERCISE
CTEG	COLLECTIVE TRAINING AND EXERCISE GUIDANCE
DHCSTC	DEFENCE HUMAN CAPABILITY SCIENCE AND TECHNOLOGY CENTRE
DIF	DIFFICULTY, IMPORTANCE, FREQUENCY
DRDC	DEFENCE RESEARCH AND DEVELOPMENT CANADA
DSAT	DEFENCE SYSTEMS APPROACH TO TRAINING
DSTL	DEFENCE SCIENCE AND TECHNOLOGY LABORATORY
DTSM	DEFENCE TRAINING SUPPORT MANUAL
EDO	EDUCATIONAL OBJECTIVES
EO	ENABLING OBJECTIVES

FM	**FIELD MANUAL**
FSO	**FOREIGN SERVICE OPERATIONS**
GP	**GROUPS**
GS	**GENERAL SPECIFICATIONS**
HF	**HUMAN FACTORS**
HFE	**HUMAN FACTORS ENGINEERING**
HFI	**HUMAN FACTORS INTEGRATION**
HFI DTC	**HUMAN FACTORS INTEGRATION DEFENCE TECHNOLOGY CENTRE**
HSI	**HUMAN SYSTEMS INTEGRATION**
IOS	**INTEGRATED OCCUPATIONAL SPECIFICATIONS**
ISD	**INSTRUCTIONAL SYSTEMS DESIGN**
IT&E	**INDIVIDUAL TRAINING AND EDUCATION**
ITP	**INTEGRATED TRAINING PLAN**
JBOS	**JOB BASED SPECIFICATIONS**
JIMP	**JOINT INTERAGENCY MULTINATIONAL PUBLIC**
JSP	**JOINT SERVICE PUBLICATION**
JTAR	**JOB-TASK ANALYSIS REPORT**
KSA	**KNOWLEDGE SKILLS ATTITUDES**
LMS	**LEARNING MANAGEMENT SYSTEM**
LRS	**LEARNING RECORD SYSTEM**
MA	**MANAGING AUTHORITY**
MANPRINT	**MANPOWER AND PERSONNEL INTEGRATION**
MEC	**MISSION ESSENTIAL COMPETENCIES**
METL	**MISSION ESSENTIAL TASK LIST**
MOD	**MINISTRY OF DEFENSE**
MTS	**MANAGEMENT OF TRAINING SYSTEMS**
NGO	**NON-GOVERNMENTAL ORGANISATIONS**
OA	**OCCUPATIONAL ANALYSIS**
OGD	**OTHER GOVERNMENT DEPARTMENTS**
OS	**OCCUPATIONAL SPECIFICATIONS**
OSD	**OPERATIONAL SEQUENCE DIAGRAMS**
OSIP	**OCCUPATIONAL STRUCTURE IMPLEMENTATION PLAN**
OSS	**OCCUPATIONAL SPECIALTY SPECIFICATIONS**
OTP	**ORGANISATION-TASK-PERSON**
PO	**PERFORMANCE OBJECTIVES**

QS	QUALIFICATION STANDARD
QSWB	QUALIFICATION STANDARD WRITING BOARD
RCAF	ROYAL CANADIAN AIR FORCE
RCN	ROYAL CANADIAN NAVY
RDF	RESOURCE DESCRIPTION FRAMEWORK
REST	REPRESENTATIONAL STATE TRANSFER
SAM	SUCCESSIVE APPROXIMATION METHOD
SAT	SYSTEMS APPROACH TO TRAINING
SME	SUBJECT MATTER EXPERT
SOP	STANDARD OPERATING PROCEDURE
TA	TECHNICAL AUTHORITY
TCTNA	TEAM COLLECTIVE TRAINING NEEDS ANALYSIS
TDO	TRAINING AND DEVELOPMENT OFFICER
TE	TRAINING ESTABLISHMENT
TNA	TRAINING NEEDS ANALYSIS
TNASG	TRAINING NEEDS ANALYSIS STEERING GROUP
TO	TRAINING OBJECTIVES
ToR	TERMS OF REFERENCE
TrAD	TRAINING AUTHORISATION DOCUMENT
TRADOC	TRAINING AND DOCTRINE COMMAND
UJTL	UNIVERSAL JOINT TASK LIST
UK	UNITED KINGDOM
USAF	US AIR FORCE

EXECUTIVE SUMMARY

Historically, training has focused on the needs of the individual. More recently, institutions have recognised that individuals seldom work in isolation, and that training for teams is necessary for these institutions to meet their objectives in the most effective manner possible. This recognition is particular true in the Canadian Armed Forces (CAF), in which a large workforce must come together to meet objectives at the tactical, operational and strategic levels. Therefore, training must align with both the organisational structure as well as the strategic framework within which the collective operates.

Defence Research and Development Canada (DRDC) is mandated to carry out scientific investigation to support the CAF. DRDC have been tasked with supporting the development of training approaches to support the CAF into the future, and an integral part of these investigations is the development of a training lifecycle approach that supports collective training. The objective of the work described in this report was to review a number of team or collective Training Needs Analysis (TNA) methods. The resulting information will be used by DRDC to progress their support to the CAF.

The Technical Authority (TA) for this task provided a list of evaluation questions to be considered for each method. Additional evaluation questions and criteria were developed and added to the review following discussion with the TA and consideration of the problem space. Each TNA method was described and evaluated according to the following criteria:

- Background to the method;

- training lifecycle stage addressed;

- alignment with strategic framework;

- governance;

- applicability to individual and/or collective training;

- prescriptiveness of analysis elements; and

- usability.

A total of nine methods were reviewed:

1. Canadian Forces Individual Training and Education System (CFITES);

2. Battlefield Functional Analysis;

3. MANPRINT/Human Systems Integration (HSI);

4.   Mission Essential Competencies (MEC);

5.   Successive Approximation Method (SAM);

6.   Team Collective Training Needs Analysis (TCTNA);

7.   Team Training Needs Analysis (Team TNA);

8.   UK Ministry of Defence Joint Service Publication 822 (JSP822); and

9.   Experience Application Product Interface (xAPI).

Using CFITES as the benchmark, each method was evaluated and judged against the criteria listed above. Only JSP822 was judged to be the equal or better of CFITES. Other methods, notably MECs and Battlefield Functional Analysis, were judged to be equivalent or better to CFITES for one or two criteria, indicating that there are specific elements of those methods that might improve upon specific elements of CFITES (these elements are not necessarily identified as shortcomings).

On the basis of this review, it is recommended that JSP822 be used as a model with which to improve the analysis of collective training needs in the CAF. In order to facilitate this process, it may be expedient to use TCTNA as an exemplar since it is the foundation of JSP822 without associated governance or strategic framework. Additionally, other methods such as MECs and Battlefield Functional Analysis should also be considered for how they might be leveraged to result in a reliable and valid collective TNA approach for the CAF.

1   INTRODUCTION

Defence Research and Development Canada (DRDC) – Toronto Research Centre undertakes a range of research and development activities to support the Canadian Armed Forces (CAF). As part of this remit, DRDC Toronto engages industry to provide specialist support. The contract for support is awarded through a competitive process and may be limited to a specific short-term need or may be a Standing Offer under which multiple instances of support can be secured without needing to go through a competitive process, within a predetermined period of time and funding envelope. This report represents Task 9 under Standing Offer W7719-155268, awarded to CAE Defence and Security Canada (CAE) for the purposes of providing Human Factors (HF) support to Modelling and Simulation. The Technical Authority (TA) for this task is Dr. Blake Martin.

1.1   Background

As the science of training analysis and design has evolved, organisations, particularly the military, are increasingly recognising that much work is carried out by teams, rather than individuals. It is no longer sufficient to simply consider individual training and evaluation; training systems must now also ensure that the trained individual can contribute effectively to the efforts of the team or collective. This requirement is defined in various policy documents by the CAF (DAOD 8015-0) as well as the component commands: The Canadian Army (CA; B-GL-300-008/FP-001), the Royal Canadian Air Force (RCAF; RCAF Modeling & Simulation Strategy and Roadmap 2025) and the Royal Canadian Navy (RCN; NAVORD 4500-0). Additionally, Canada's closest allies have issued policy directives emphasizing the need for team and collective training: the United Kingdom (UK) Ministry of Defence (MOD; JSP822), the United States (US) Army Training and Doctrine Command (TRADOC; Department of the Army, 2012, the New Zealand Army (NZ Army, 2015) and the Australian Defence Force (Australian Defence Doctrine Publication (ADDP) 7.0 Doctrine and Training).

Collective training policy and global practice affords the CAF the opportunity to 'benchmark' their collective training policy and approaches and either incorporate beneficial elements not already part of the Canadian approach, or support the assertion that the Canadian approach employs the current state of the art. For instance, the Army of Bosnia-Herzegovina has a policy and approach on individual and collective training that emphasizes the importance of a Mission Essential Task List (METL) and its linkages to individual leader and soldier tasks underpinning collective performance (UK Ministry of Defence, 2016). Policy is a significant step towards the implementation of an effective training system that addresses individual and collective training needs. Policy shows a willingness, at the highest levels, to invest in the development of a capability. Policy must, however, be supported by a deliberate programme of analysis to ensure the capability stands the greatest chances of success.

DRDC Toronto is involved in training research to support the CAF. Such research (for instance, Matthews and Lamoureux, 2003; Zobarich, Lamoureux and Martin, 2007) has examined training analysis and development approaches from other countries to consider their applicability and application to Canada. Most recently, DRDC Toronto has supported the RCAF in the

development of collective training for the Joint Terminal Attack Controller role (Martin, 2016). The role involves teamwork between ground and air-based teams to concentrate an effect (often kinetic) on a target. This work involved comparing the Canadian Forces' Individual Training and Education System with the US Mission Essential Competencies for the degree to which they can be used to define training objectives and curriculum content (Martin, 2016).

A training need does not arise in a vacuum. It is usually identified through an observation of a performance deficiency or some change to procedures or technology associated with a task. The deficiency or change has an effect on the organisation's ability to achieve its mission, therefore the organisation authorises that training be re-evaluated to address the deficiency or change. Training must fit within the strategic goals and direction of the organisation.

The RCAF Simulation Strategy (RCAF, 2015) identifies ten strategic training requirements necessary to achieve a simulation-focused training approach by 2025. The first four relate directly to developing appropriate training that will address and support the strategic mandate of the RCAF, specifically:

1. **Force Structure Traced to Strategic Guidance:** All elements of the RCAF force structure must be traceable to strategic guidance at an equivalent level of granularity;

2. **Training Requirements Traced to Force Structure:** All training must be supported by specific individual and collective training requirements that can generate the necessary force structure;

3. **Device Options Traced to Training Requirements:** Device recommendation options must be generated through a training method and media analysis of specific individual and collective training requirements; and

4. **Device Options Rationalized into System Requirements:** Device options must be rationalized into system requirements for one or more training devices based on financial and logistical constraints.

Figure 1-1 illustrates the four aforementioned RCAF training requirements, overlaid with a summary of how the RCAF's strategic training requirements frame the development of training. The hierarchical organization of the figure implies the critical role of training analysis in the development of effective training should support the strategic objectives of an organisation.

All elements of the RCAF force structure must be traceable to strategic guidance at an equivalent level of granularity.

Force Structure Traced to Strategic Guidance

Strategic Framework Surrounding Training

All training must be supported by specific individual and collective training requirements that can generate the necessary force structure.

Training Requirements Traced to Force Structure

Context for Training Analysis

Device recommendation options must be generated through a training method and media analysis of specific individual and collective training requirements.

Device Options Traced to Training Requirements

Training Design

Device options must be rationalized into system requirements for one or more training devices based on financial and logistical constraints.

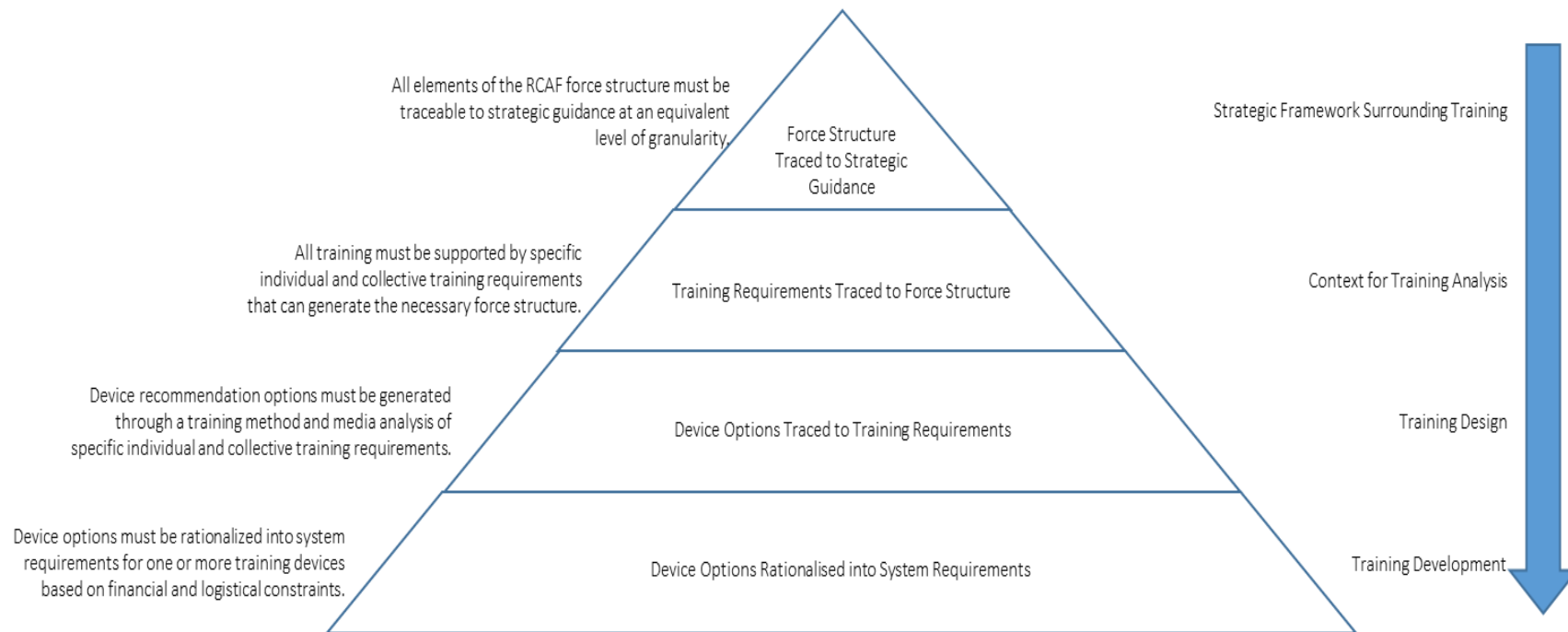Device Options Rationalised into System Requirements

Training Development

Figure 1-1: RCAF Simulation Strategy Strategic Training Requirements

The RCAF training requirements cannot be met without a careful examination of RCAF training needs. Training Needs Analysis (TNA) is used to determine the gap between an incoming trainee's current knowledge and skill proficiency, and that required to perform a specific role to a given standard in a particular environment. Note that an 'incoming trainee' does not necessarily refer to an ab initio; incoming trainees may be experienced personnel who are changing their role, being presented with new technology or systems, or other situations wherein their existing knowledge and skills are no longer sufficient. Typically, such analysis determines the tasks or situations demanded by the role, and suggests or stipulates appropriate training activities. Currently, the CAF uses the Canadian Forces Individual Training and Education System (CFITES), which is a derivative of the Analyze, Design, Develop, Implement and Evaluate (ADDIE) model. The TNA aspects of CFITES are only part of a comprehensive education management system.

TNA is a general term to encompass a variety of approaches purporting to progress an identified training need to a set of requirements on the basis of which an effective training solution can be designed and built. Many TNA methodologies explicitly focus on the individual, however team and collective training forms an important part of military force generation since much operational activity involves the behaviour of "a number of persons constituting a work group, assembled together for the purpose of joint action" (Huddlestone & Pike, 2016, p. 51). As the Canadian Forces education management system evolves, it will increasingly comprehend team and collective training, and continue to look for efficiencies, as well as means to increase the impact of training. It is therefore important to continually review alternative TNA models that may offer the CAF distinct advantages and opportunities for considering team and collective training needs.

DRDC recognizes the lack of research directly comparing the effectiveness of one TNA method relative to another (Martin, 2016). The current work therefore evaluates a selection of different methods, some proposed by DRDC and some identified during the course of this work, according to a number of different criteria introduced in Section 2:

- the usability of the method for team and collective training needs;

- the extent to which the method derives training requirements from strategic guidance, or can directly link training requirements to force structure and strategic guidance, and

- the validity of the outputs of the method.

This report presents a summary of an analysis conducted on selected TNA approaches to identify elements or methods appropriate for collective/team TNA. The results are used to make recommendations to the CAF regarding the use of valid, reliable and effective team/collective TNA methods to support the CAF training system.

1.2 Objectives

The overall objective of this work was to review selected approaches to team/collective TNA and make recommendations on how to improve the CAF approach to team/collective TNA. The

review was supported, in part, by a TNA summary spreadsheet provided by the TA. The experience of using the spreadsheet was also used to suggest enhancements to the spreadsheet intended to increase its utility for the TA and others with an interest in TNA methods. This was undertaken in collaboration with the TA and is contained in Annex A.

The main project objective was organized into a framework that systematically bound the training system problem space as three specific questions:

1. What elements of TNA will enhance the extant TNA approach described in Volume 3 of CFITES, specifically in the area of team/collective training?

2. Considering TNA in an organisational context, how can training be better integrated with the organisational framework, force structure and strategic guidance provided by higher authorities to derive training requirements and traceable training requirements?

3. What desirable usability characteristics of TNA methods may be incorporated to enhance the validity (i.e., method capture intended content) and reliability (i.e., repeatability of method) of the TNA approach employed by the CAF?

These questions were answered by integrating the TNA summary spreadsheet to develop a list of criteria for comparison (that will be presented in Table 2-3) and considering each method with respect to these criteria. CFITES, as the incumbent method of the CAF, is presented first (Section 3.1), as the benchmark against which to compare and contrast all other methods according to the criteria. Recommendations for improving team/collective TNA in the CAF stem from these questions and the comparison with CFITES.

1.3   This Document

This document presents the outputs from the review of a variety of team/collective TNA methods. The document is organised as follows:

- Section 1: Introduction: This section introduces the contracting mechanism and the topic area before outlining the objectives.

- Section 2: The Training 'Landscape' and Criteria for Comparison: This section explains the criteria for comparison on which the analysis of TNA methods was founded.

- Section 3: TNA Comparison Results: This section provides a description and review of nine TNA methods selected by the TA and CAE.

- Section 4: Discussion: This section considers the review from a holistic perspective and attempts to compare and contrast the different methods and understand what they offer to the Canadian experience.

- Section 5: Conclusions and Recommendations: This section summarises the conclusions and recommendations made in the course of writing this document.

- Section 6: References: This section lists the references used when writing this document.

2 THE TRAINING 'LANDSCAPE' AND CRITERIA FOR COMPARISON

The current work reviews a number of approaches to TNA. Pursuant to this review, the TA provided a spreadsheet with questions intended to facilitate comparison of different TNA methods. CAE built upon these questions to provide additional information on:

- enhancing the TNA component of the CAF training lifecycle management system,

- accommodating needs analysis for team and collective training and investigating ways to ensure direct linkages between training and strategic guidance, and

- insights into the organisational framework and force structure.

Accordingly, a number of additional criteria for comparison were developed. These incorporated the intent of the questions from the spreadsheet but in addition represent distinctive dimensions of comparison to permit identification of those methods and their features from which the CAF can enhance their own training lifecycle management system.

This section begins by defining TNA before describing the criteria for comparison, how the criteria will be used to contrast the different methods discussed in this report and how they should lead to recommendations for future versions of a CAF training lifecycle management system. The final section describes the comparison approach itself.

2.1 Training Needs Analysis

A TNA is a systematic analysis to identify a training need and to define the subsequent training requirements in terms of tasks, skills, knowledge, aptitudes and attitudes[1]. The training need may have arisen out of some organisational change, change to policy, legislation or doctrine, or acquisition of new equipment (MOD, 2016; p.14). TNA is a flexible approach that, depending on the complexity of the training requirement, encompasses many different component activities. While the specific approach may vary, the intent is always to obtain a comprehensive understanding of the information required to develop training. Opinions will vary between analysts as to what information is required, but a comprehensive TNA will result in detailed descriptions of the training need in terms of the job, job context, personnel, and the organisation supporting the job and the job holder. In addition, it will define the level of competence that must be demonstrated (i.e. performance standard to be attained) and the knowledge, skills and attitudes required to achieve this competence.

Although TNA has been discussed in the literature for more than 50 years, there are few authoritative methodologies. Until the last 20 years it seems that there have been two schools of thought regarding TNA: The Organisation-Task-Person (OTP) model (McGehee and Thayer, 1961) and the Performance Analysis model (Mager and Pipe, 1984). These two models have

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[1] A key model in training is that of 'Knowledge, Skills and Attitudes' (KSA). The reader may find other expansions of this acronym variously describing the 'A' as 'Attributes', 'Aptitudes' and 'Abilities'. For the purposes of this report we have used 'Attitudes', in keeping with military usage (e.g. MIL-HDBK-29612-2A)

been used as convenient groupings under which to categorise emerging TNA methods. A short description of each model is merited.

The OTP model (McGehee and Thayer, 1961) considers:

- the organisation's objectives and goals, resource needs and measures of efficiency;

- the performance standards required in task performance, what tasks must be performed, and the required knowledge and skills necessary to perform the tasks; and

- the people in the organisation who should receive the training, but establishing the level at which each employee is performing relative to performance standards, as measured through performance appraisals or proficiency tests.

The Performance Analysis model is concerned primarily with identifying and determining the causes of discrepancies between required and observed performance, or between expert and average performers. A training need therefore only exists when a performance discrepancy exists due to a lack of knowledge or skills rather than remuneration, organisational culture and policies, or general lack of support. The Performance Analysis model posits that much training has little or no effect on job performance since performance discrepancies are often better addressed by changes in the work environment (Mager and Pipe, 1984).

Neither the OTP model nor the Performance Analysis model make specific mention of individual or team tasks. Subsequent authors (Taylor, O'Driscoll and Binning, 1998) have integrated and extended the OTP and Performance Analysis models and noted the need to conduct analyses at a variety of levels (individual, group/organisational, inter-organisational) but they, too, have not explicitly mentioned team/collective tasks or training.

2.2   Criteria 1: Training Lifecycle Stage Addressed

The training lifecycle encompasses the entire 'life' of a training solution, from the initial identification of a need to the point where the training solution is replaced or deemed no longer necessary. In Instructional Systems Design (ISD), otherwise referred to as the Systems Approach to Training (SAT), the most common training lifecycle model is the ADDIE model (Branson, Rayner, Cox, Furman, King & Hannum, 1975). CFITES is built upon this model. Figure 2-1 graphically depicts the ADDIE model.
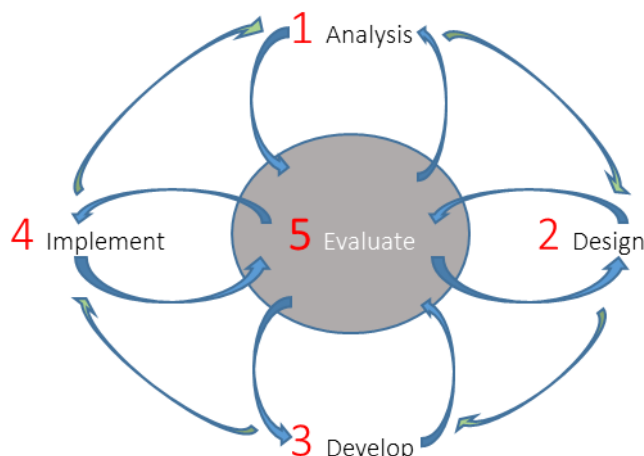
Figure 2-1: The ADDIE Model (adapted from Crawford, 2011)

The five phases in the ADDIE model include the following elements:

1. **Analysis:** clarification of the instructional problem, goals and objectives; understanding of the learning environment and the learners existing knowledge and skills as well as required knowledge, skills and attitudes.

2. **Design:** results in detailed plans for the training solution, including development of Performance Objectives (PO), Educational Objectives (EdO) and Enabling Objectives (EO)[2]; development of learner assessment tools and approaches; development of exercises, content, lesson plans; media selection; creation of documentation concerning framework and guidelines for the training solution.

3. **Develop:** based on the solution architected during the design phase, this phase concerns creating and assembling the content, building the devices, integrating technology, and ensuring the training solution is ready for deployment.

4. **Implementation:** train the trainers with respect to the course curriculum, expected learning outcomes, media to be used and testing procedures. The training solution is then presented to learners.

5. **Evaluation:** there are two sorts of evaluation; of the learners and of the training solution itself. Learner evaluation concerns the retention of information, its accuracy and the ability of learners to apply the information. Training solution evaluation concerns the success of the training system to produce trainees who are able to perform the job role for which they have been trained. In this sense, evaluation is used to validate the training system. If learners are evaluated as successful, and yet they are not competent to perform their job role, then the training solution must be re-evaluated. CFITES, however, makes a distinction

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[2] Note that CFITES includes PO, EdO and EO as part of the Analysis phase.

between evaluation and validation. Evaluation includes consideration of student learning progress in the context of the training system, as well as consideration of the ability of the training system to convey information to the student. Validation is a distinct and separate phase that concerns the degree to which the training system addresses institutional objectives. The consideration of the training system within institutional context marks an elaboration of the traditional ADDIE model to meet the specific needs of the CAF.

Although the ADDIE model can be considered linear, with one phase following another, it is an iterative process where each phase involves an evaluative loop to ensure continuous improvement, as indicated in Figure 2-1. Nevertheless, military (and, more generally, government) acquisitions prefer to adopt the linear approach, where each step is completed before moving to the next step. This is referred to as the Waterfall approach (Royce, 1970). Organisations with public accountability seem to share a preference for the Waterfall approach since it permits better prediction of the likely costs associated with an acquisition.

The ADDIE model will be used as one dimension against which to differentiate the methods reviewed in this document. Specifically, methods will be 'plotted' along the training lifecycle described by ADDIE. Although this review focuses on TNA part of the analysis phase, by plotting methods along the training lifecycle it will be clearer whether they could contribute to the CAF collective/team TNA method, how they compare to other methods with respect to the role they play and whether they might serve the CAF at other phases in the training lifecycle[3].

2.3   Criteria 2: Alignment with Strategic Framework

As noted in the Background (Section 1.1), the CAF as well as each of its three branches of the military have policy statements regarding collective training. DAOD 8015-0 is approved by the Chief of the Defence Staff (CDS) and applies to all officers and non-commissioned members of both the regular force and the reserve. DAOD 8015-0 states:

> *"The CAF is committed to using Collective Training as a fundamental method of providing CAF members, operational units and formations with the experience, confidence and training necessary to carry out their assigned missions."*

This policy is embodied in the CAF Collective Training and Exercise Guidance (CTEG) which is issued annually to provide strategic-level guidance from the CDS concerning collective training activities for the year. This is elaborated by the CAF Integrated Training Plan (ITP) which is also issued annually and provides detailed resource allocations to support the programming, planning and conduct of joint, interagency and combined training and exercises. The ITP is part of the Collective Training Management Framework[4].

Collective training is one means by which the CAF achieves the capabilities required by the CDS and operational level commanders. Environmental chiefs of staff are responsible for creating opportunities for collective training. Collective training is intended to facilitate

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[3] Note that CFITES has been designed to address all phases of the training lifecycle. Other methods, for instance JSP822, also address all ADDIE phases.

[4] Document was not found during this review.

achievement of capabilities identified by the CDS and operational level commanders and generated by the environmental chiefs of staff. Thus, strategic policies such as the RCAF Simulation Strategy discusses a force structure that is traceable to strategic guidance and training that is traceable to the force structure. Likewise, the RCN policy on collective training notes from the outset that they must develop and provide mission capable units to force employers and that, within this mandate; they must train forces to sufficient competency to operate independently or as part of a coalition anywhere in the world.

For the purposes of comparing a TNA method's alignment with the strategic framework, the guidance should make it clear that the TNA method places the job role in two specific contexts: the organisational and the mission. The organisational context should result in training to enhance integration with other individuals to form a team, and integration with other teams to form a collective. The mission context should result in training that contributes to or enables the achievement of operational objectives by the team and the collective and, by implication, the organisation. The mission context should be traceable and map directly to training requirements. If a TNA method does not specifically direct an analyst to incorporate these perspectives, then the linkage between the strategic guidance and the collective training may be weak.

Training requirements arising from the analysis should be demonstrably connected to the organisational framework, the force structure and the strategic guidance. Training outcomes should be linked to the training requirements and thereby linked to the organisational framework, the force structure and the strategic guidance.

2.4   Criteria 3: Governance

Review of the literature revealed that the TNA methods described by the military and those by the civilian domain differed regarding the application of governance. This speaks to one of the objectives of this work: to tighten the linkage between TNA, the organisational and strategic frameworks, and guidance in which the training solution exists. Military organisations build strategic alignment into their TNA methods very deliberately. Governance can include requiring command authorisation to begin a TNA, the existence and composition of a TNA steering group, and the manner in which training requirements, POs, EdOs and EOs are written and agreed upon; governance is built into military TNA methods from the beginning. Too much governance, however, can unnecessarily inhibit progress towards a new training solution.

When evaluating governance in the context of TNA, CAE considered the following factors to form a judgement on the criteria:

- Do the method and its output require oversight and approval from those in positions of authority and those with domain expertise (e.g., a working or steering group)?

- Does the method require a group of people with diverse backgrounds and skill-sets to collaborate and carry out the associated TNA activities, thereby potentially applying some amount of self-governance?

- Are the roles and responsibilities of the members of the group well defined with respect to governance of the TNA activities?

- Do steering group members have sufficient authority to remove obstacles?

- Do steering group members have appropriate knowledge to make quick and intelligent decisions?

- Does the organisation prioritize the availability of steering group members?

- Does the method specify that analysts be given the time to do the work in a consolidated and timely fashion?

- Does the method dictate outputs that can be read and understood quickly?

- Does the method include submission templates to steering group and others for their review and approval?

- Does the method include prescribed outputs that clearly indicate what the need is, what its component parts are, and how they are satisfied by the training requirements?

- Does the method mandate a sufficiently rapid pace of milestones and deliverables to maintain momentum and progress in the development of a new set of training needs?

2.5 Criteria 4: Applicability to Individual, Team and/or Collective Training

Training analysis has traditionally focused on the needs of the individual but it is increasingly recognised that tasks are often performed as part of a team. Team or collective performance is therefore a necessary precursor to mission achievement. Although an accepted standard to team/collective TNA may not yet be recognized, the RCN provides the following definitions of individual and collective training.

Individual training is defined as "the instructional activities for individual members that provide the skills, knowledge and attitudes required in the performance of assigned duties" (RCN Collective Training Strategy Policy and Guidance, 2016).

Collective training is defined as "training, other than Individual Training and Education, designed to prepare sub-teams, teams and units to perform military tasks in accordance with defined standards. Collective training includes procedural drill and the practical application of doctrine, plans and procedures to acquire and maintain tactical, operational and strategic capabilities" (RCN Collective Training Strategy Policy and Guidance, 2016).

This definition of collective training is almost indistinguishable from that of the RCAF: "Collective training is not Individual Training & Education (IT&E). This training is designed to prepare teams, crews, units and other elements to work together effectively to perform

assigned tasks. Joint, Combined, Tactical, Strategic and Operational Training are all examples of collective training: (National Defence, 2015a, p. 2/15).

Both the RCN and the RCAF should be contrasted with that of the CA: "Collective Training is the mechanism by which a commander takes a full complement of qualified soldiers – combined with time, resources, and applied Tactics, Techniques and Procedures – to produce competent, cohesive and disciplined organizations that are operationally deployable within realistic readiness timeframes. Collective Training for land operations will, as much as possible, be progressive and conducted in an all-arms environment, building upon individual knowledge and skills. While Individual Training and Professional Military Education are important to the acquisition of knowledge and skills in each Developmental Period, the experience gained by individuals during collective training events exposes soldiers to more complex concepts and conditions. Exposure to collective training provides the broad base of experience needed to progress to the next Developmental Period" (National Defence, 2014, p. 6.1.1).

The CA definition provides parameters which collective training must meet or work within and clearly differentiates collective training from individual training. Those carrying out training needs analysis for the CA would be better able to focus their efforts toward the development of collective training, based on this definition, than would their peers in the RCN or RCAF.

The spectrum of individual to collective training is provided at several levels corresponding to increasing complexity. Table 2-1 compares the various levels of individual, sub-team, team-level, unit, Task Group and task Force level training for the RCN, the RCAF, the CA and the UK MOD. This serves to reinforce that most militaries recognise different scales of collective training, even if the lexicon is different.

Table 2-1: Comparing Levels of Individual and Collective Training

RCN	CA	RCAF	UK MOD
Individual training	Individual Training		Tier 0: prepares individuals to operate as teams below Unit level.
Level 1: Sub-Team Level Training e.g. Underwater Warfare team, Damage Control Team	Section Level Training	Sub-Unit and Unit (collectively referred to as Unit-Level) Level Training e.g. Crew, Section, Team, Flight, Squadron	Tier 1 prepares units and sub-units to take their place within a tactical formation or Combined/Joint Force Component.
Level 2: Team Level Training e.g. Combat Department, Engineering Department, Deck Department	Platoon Level Training		Tier 2 prepares tactical formations operating below the Combined/Joint Force Component level for operational deployment.

RCN	CA	RCAF	UK MOD
Level 3: Unit Level Training e.g. the ship	Company Level Training	Formation Level training e.g. tactical level formations (Wing) and operational level formations (Air Division)	Tier 2(+) prepares one or more Combined/Joint Components for operational deployment, in combined or joint contexts on a UK, NATO or Coalition framework basis.
Level 4: Task Group Level Training e.g. Task Group Staff, multiple force elements, national or combined	Battle Group Level Training		Tier 3 prepares a Combined/Joint Task Force for operational deployment or Permanent Joint Overseas Base, in combined or joint contexts on a UK, NATO or Coalition framework basis.
Level 5: Task Force Level Training e.g. Joint Task Force Staff, two or more environments, coalition	National Joint Multi Unit International (Coalition) Joint Multi-Unit	Command Level training e.g. strategic commands, the whole RCAF	Tier 4 is undertaken at the strategic level and concerns political-military action involving Other Government Departments (OGD)/Non-Governmental Organisations (NGO).

As can be seen from Table 2-1 there is a reasonable mapping between military organisations. The addition of strategic-level training (Tier 4) for the UK model may reflect the extent of their military commitments and the different mission sets given to the UK MOD. Elaborating on the levels of collective training, the CA substantively differentiates between the types of training it pursues at each level. Table 2-2 expands upon the information in column two of Table 2-1 (i.e. the CA) and maps the levels of collective training to the formation name and describes the type of training to be undertaken.

Table 2-2: Canadian Army Collective Training at Each Formation Level (from DND, 2014: Training for Land Operations, Appendix 3: Levels of Collective Training)

Level	Formation	Remarks
Level 7	Formation (brigade group)	1. Training at this level may be multinational and may include a requirement to understand higher-level coalition operations. 2. Increased emphasis will be placed on Foreign Service Operations (FSO) within a Joint Interagency Multinational Public (JIMP) context.
Level 6	Unit and combined arms unit (battle group (BG)/ battalion group (Bn gp))	1. This includes unit training in non-manoeuvre units prior to incorporation into another unit or formation. 2. Level 6 Computer Aided Exercise (CAX) and Command Post Exercises (CPXs) should be used for command and staff training, in both FSO and domestic operations (domestic operations) scenarios.

Level	Formation	Remarks
		3. Level 6 field training will generally be limited to training for high readiness and will be confirmed by force-on-force training. 4. All Level 6 training will generally take place in a joint and combined context.
Level 5	Combined arms sub-unit	1. Level 5 training is the CA's vital ground in terms of collective training. During training for high readiness, Level 5 training shall include live fire training. 2. Level 5 training is conducted by combat teams (combat teams), company groups (coy groups) or other multi-disciplinary sub-unit organizations (i.e., an All-Source Intelligence Centre, a forward support group or a field artillery battery). 3. Enhanced Level 3 may be used to describe combined arms operations at the sub‑sub-unit level, in a Level 5 context. 4. It is at this level that the synchronization of arms and services becomes critical.
Level 4	Sub-unit (squadron (sqn)/ coy)	1. Similar to Level 3, focused on Tactics, Techniques and Procedures training. 2. Training a sub-unit to this level will generally be required by a force generation unit prior to forming a combined arms unit or joint task force.
Level 3	Sub-sub-unit (troop (tp) / platoon (pl))	1. Increased command and control challenges. 2. Tactical situations should be less predictable than Level 2, and battle drills should be less detailed.
Level 2	Section (sect)/ crew/det	1. Generally, battle drills, aimed at executing battlefield tasks to a high standard. 2. Combat battle tasks training should generally culminate in a Level 2 live fire event (stand or FTX).

There are differences in the content of a training analysis conducted at the sub-team level versus one done at the higher team/collective levels, not the least of which begins the scale of the tasks to be trained. This may be managed practically during the analysis by 'stopping' the analysis at less granular levels of decomposition, i.e. focusing on the activities that are unique to the team/collective level of training, and presuming that activities that appear at lower team/collective levels of training have been learned[5]. Thus, one may assume that the TNA *method* may be common at all levels of personnel aggregation (i.e. individual to team to Joint)

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[5] This statement assumes that training progresses in a linear fashion, i.e. which advanced training is built on the successful achievement of intermediate and basic training. This is not necessarily the case though. Training that is provided early in a person's development may be revisited repeatedly and applied for different purposes and in different contexts. Thus, stopping analysis at less granular levels may not be a satisfactory way of repurposing individual TNA approaches to the problem of collective TNA.

but the TNA *content* (complexity, types of tasks, etc.) will differ from one level to the next. Nevertheless, as soon as training moves from individual to a small team, the focus will likely be on integrating the activities and outputs of two or more people.

Ultimately, mission effectiveness for any collective relies on activities and outputs that are based on a group of people acting with common purpose, not the discrete actions of individuals. This scaling continues ad infinitum. With this in mind, for the remainder of the document the terms 'team' and 'collective' will be used interchangeably and the reader should not infer any difference between the two terms unless specifically directed to do so in the associated text.

The collective training criteria evaluate how well suited each TNA method is for collective training. The TNA Collective training analysis criteria considers the following information where available:

- Does the method result in a mapping of team and collective communication links, interdependencies, and joint decision-making activities?

- Is the method for collective TNA fundamentally different from associated methods for individual TNA?

- Does the method specify the unit levels that can be addressed (i.e., Level 1 -individual, Level 2 - section or crew, Level 3 - troop or platoon, Level 4 - squadron or company, Level 5 - combined arms sub-unit, Level 6 - battle group, Level 7 - formation or brigade)?

2.6   Criteria 5: Prescriptiveness of Analysis Elements

When carrying out an organisational or job task analysis, it is difficult to prescribe what should be captured, how it should be captured and what elaborating information should accompany it. Many factors will influence the level of granularity captured by the analyst which, in turn, will impact the outcome of the analysis. Since each job context is different, however, the method should not unnecessarily constrain the analyst. This activity can be assisted by developing a lexicon by which analysts can describe an organisation, a task or a job-holder. Further, it may be possible to prescribe the mappings from one step of a TNA analysis to the next (i.e. the transition). For instance, it may be possible to map, a priori, the skills, knowledge and attitudes associated with a specific type of task. The analyst, in describing a job can choose the type of task to be performed and be led to the corresponding skills, knowledge and attitudes. These, in turn, could have preferred approaches to instructional delivery.

The remaining analysis can concentrate on ensuring that the characteristics of the task that are unique to the job environment are reflected in the PO, EdO[6] and EO. This would be an example of a prescriptive TNA method. The converse of a prescriptive method would be an 'open' method, in which the analyst is given very little guidance to carry out the TNA. Another

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[6] Note that EdO are individual in nature and are therefore not germane to discussion in this report. Further, while CFITES makes provision for them, EdO have been specified inconsistently in the past in accordance with the perspectives of the organizational leadership at the time.

way of characterising this dichotomy is as 'science' versus 'art', where science endeavours to uncover the mechanisms by which the whole process works to understand and recreate it, whereas art is left to inspiration and embraces the variety of outcomes that can arise from the same context.

The prescriptiveness of the TNA approach considers the following factors where described:

- the personnel required to employ the method in terms of their education, operational experience, and time requirements;

- the guidance to enable analysts to understand how to carry out each part of the analysis;

- the tools, aides, checklists and the like to enable application of the method in a consistent and efficient manner;

- whether the terminology and outputs that are consistent across applications (e.g., a taxonomy of skill types that are applicable across military tasks);

- whether the method leverages structured descriptions of the work, such as a task list;

- whether the method leverages structured descriptions (e.g., knowledge, skills, competencies, etc.) of what needs to be learned;

- whether the method clearly and effectively identifies training gaps;

- whether the method produces a report on the difficulty, frequency, and importance of tasks;

- the specificity of resulting training objectives; and

- whether the method results in an estimation on the amount and frequency of training required to acquire and maintain the required level of performance.

2.7   Criteria 6: Usability

In the context of discussions of collective TNA, usability refers to the ease with which an analyst, or team of analysts can comprehend the method and apply it in a manner that ensures they will get usable outputs that do not differ appreciably from another analyst, irrespective of their background or experience in doing TNA. To this end, usability refers to the face validity of the output (i.e. does it represent what it purports to represent?), the reliability of the method (i.e. given the same inputs will the method result in the same outputs every time?), the ease of use of the method and the utility of the output.

The ease of use of the method implies that, whatever the scientific background of the method, the instructions to carry out the TNA should be clear and simple. In the military, analysts may come from a variety of backgrounds and may only be assigned to a particular area for a short period of time. A TNA method that requires significant training and experience will be ignored.

Further, the educational background and affinity of analysts may also be highly variable and it should be assumed that the analyst does not have the time or inclination to learn a complicated TNA method.

Another consideration when selecting a TNA method is its utility. The utility of the method refers to how accurate and how directly the output from the TNA can be used to design, develop, implement and evaluate a training solution. A prescriptive method should lead to useful outputs since it would be based on a theoretical and practical background, although being prescriptive is not a guarantee that it is usable.

Assuming the standard level of knowledge and expertise of the military training analyst, the TNA usability criteria considers the following information where available:

- the estimated reliability of the method;

- the face validity of the method;

- the ease of use of the method;

- the overall utility of the method;

- the type and necessity of background materials, such as concepts of operations, training curricula, etc., to employ the method; and

- the events, tools, infrastructure and other materials needed to employ the method.

2.8   TNA Comparison Approach

The preceding sections have described a number of criteria to differentiate between the TNA methods reviewed to identify those that:

- add a 'collective' element to TNA;

- enhance the linkage between TNA and strategic guidance; and

- be sufficiently usable for the purposes of the CAF.

Given that the current approach to TNA is governed by CFITES, the CFITES approach was used a benchmark against which to compare the other methods. In Section 3 each TNA method is described in general terms before being discussed in terms of the six criteria. At the conclusion of each criteria section, each method is compared to CFITES and judged to be better, worse or equal in terms of adequately addressing that criteria[7]. A simple table is provided at the conclusion of each TNA method's section summarising the criteria-based comparison with CFITES. Better is indicated by a '+' and green-filled cell; worse is indicated by

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[7] These judgements were chosen because no scale exists to judge the criteria, nor could a bespoke scale be used reliably between analysts.

a '-' and a red-filled cell; and equal is indicated by a '=' and no colour to the cell. These simple tables are aggregated to provide an overview in Section 3.8. The resulting table is presented twice: once in Section 3 (Table 3-1) to provide the reader with an overview prior to reading details of each method, and again in Section 3.8 (Table 4-1).

Additionally, the TNA methods were used to complete the "Collective and team TNA evaluation questions" spreadsheet provided by the TA. The completed spreadsheet was provided as a separate deliverable. The spreadsheet questions have been aggregated with any additional factors described under the comparison criteria above and the completed summary of factors to be considered for each TNA method is provided in Table 2-3.

A former CAF Training and Development Officer (TDO) reviewed the inputs to the spreadsheet to provide final assessment of utility, validity and reliability of the information captured, as well as the overall usability of the TNA methods themselves.

Table 2-3: Summary of Factors Considered when Evaluating TNA Methods

Summary of Factors Considered when Evaluating TNA Methods
Background
• Summarize the method. • Who are the developers of the method? Identify the institutional affiliation of the developers and the programmatic motivation for development of the method. In the case of training analysts, make reference to the capability of military training development officers. • What is the underlying scientific theory or theories that support the method?
Training Lifecycle Stage Addressed

• Based on ADDIE, which of the following does the TNA method address:
   o Analysis;
   o Design;
   o Development;
   o Implementation; or,
   o Evaluation?
• Note: Evaluation is distinct from the validation stage in CFITES.
• Does the analysis provide tools and instruments to gather data about trainee performance?
• Are the analyses, its tools and instruments sufficient to provide guidance on amending and improving the training program?

Alignment with Strategic Framework
• Does the analysis clearly and explicitly accommodate the organisational framework in its output (i.e. training requirements)? • Does the analysis clearly and explicitly accommodate the mission context in its output (i.e. training requirements)?
Governance
• Do the method and its output require oversight and approval from those in positions of authority and those with domain expertise (e.g. a working or steering group)?

Summary of Factors Considered when Evaluating TNA Methods

- Does the method require a group of people with diverse backgrounds and skill-sets to collaborate to carry out the associated TNA activities, thereby potentially applying some amount of self-governance?
- Are the roles and responsibilities of the members of the group well defined with respect to governance of the TNA activities?
- Do steering group members have sufficient authority to remove obstacles?
- Do steering group members have appropriate knowledge to make quick and intelligent decisions?
- Does organisation prioritize availability of steering group members?
- Does the method specific that analysts be given the time to do the work in a consolidated and timely fashion, which is supported by the organization?
- Does the method dictate outputs that can be read and understood quickly?
- Does the method include submission templates to steering group and others for their review and approval?
- Does the method include prescribed outputs that clearly indicate what the need is, what its component parts are, and how they are satisfied by the training requirements?
- Does the method mandate a sufficiently rapid pace of milestones and deliverables to maintain momentum and progress in the development of a new set of training needs?

Applicability to Individual, Team and/or Collective Training

- Does the method enable organizational objectives (e.g. air power missions, mission task lists/capability needs) to be mapped soundly and logically to team and collective mission capability needs?
- Does the method provide or use a framework allowing connection of team and collective outcomes to overall organizational objectives?
- Does the method map out team and collective communication links, interdependencies, joint decision making activities?
- How does the method differ from individual training analyses performed on members of the collective?
- What unit levels have and can be addressed using the method (Level 1 -individual, Level 2 - section or crew, Level 3 - troop or platoon, Level 4 - squadron or company, Level 5 - combined arms sub-unit, Level 6 - battle group, Level 7 - formation or brigade)?
- Does the method provide training activities, scenarios or experiences to overcome training gaps?
- Does the method provide a logical link between training requirements and appropriate instructional media?

Prescriptiveness of Analysis Elements

- Does the method provide a structured description of the work, such as a task list?
- Does the method provide a structured description (e.g. knowledge, skills, competencies, etc.) of what needs to be learned?
- Does the method clearly and effectively identify training gaps?
- Does the method produce a report on the difficulty, frequency, and importance of tasks?
- Does the method provide specific training objectives?
- Does the method produce estimates of the amount and frequency of training required to acquire and maintain the required level of performance?
- Does the method explain how to use its products as inputs to the derivation of training requirements (i.e. the process by which the products are used and combined to lead directly and traceably to requirements)?

Summary of Factors Considered when Evaluating TNA Methods
• Does the method describe the personnel required to employ the method in terms of their education, operational experience, and time requirements?
• Does the method provide sufficient guidance to enable analysts to understand how to carry out each part of the analysis?
• Does the method include the tools, aides, checklists and the like to enable application of the method in a consistent and efficient manner?
• Are the terminology and outputs that are consistent across applications (e.g. a taxonomy of skill types that are applicable across military tasks)?
Usability
• Describe the type and necessity of background materials, such as concepts of operations, training curricula, etc., to employ the method.
• Describe the events, tools, infrastructure and other materials needed to employ the method.
• Estimate the reliability of the method.
• Evaluate the face validity of the method.
• Estimate the ease of use of the method.
• Estimate the overall utility of the method.

Judgements made concerning the different methods are based on consideration of the material available in the public domain and none of the methods were applied to a training need in order to obtain greater insight. Although CAE's TDO brings a user's perspective to the consideration, his insights are also primarily based on the published material.

3 TNA COMPARISON RESULTS

This section contains the detailed results of the TNA analysis. Each TNA method is contained within its own sub-section and discussed in terms of the TNA comparison criteria presented in Section 2. CFITES is presented first as the baseline for Canadian Military and the benchmark by which the other TNA methods will be judged. The remaining TNA methods are presented in alphabetical order. Additionally, Table 3-1 presents the reader an overview of the relative strengths and weakness of the methods against each criterion in comparison to CFITES. Note that if a method is weaker than CFITES for a particular criterion, the corresponding cell will be coloured red, while if a method is stronger than CFITES for a particular criterion, the corresponding cell will be coloured green.

Table 3-1: TNA Method Criteria Comparison Table

+ (better) - (worse) = (same) =/+ (equal or greater to)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
CFITES	=	=	=	=	=	=
BF analysis	-	=	=	-	=	=
MANPRINT/HSI	-	-	-	-	-	-
MEC	-	=	=	=	-	+
SAM	=	-	-	-	-	+
TCTNA	-	+	=	-	+	=/+
Team TNA	=	-	-	-	-	-
UK MOD JSP822	=	+	=/+	=/+	=/+	=/+
xAPI	-	=	-	-	+	-

3.1 CFITES

3.1.1 Background

CFITES is a management system to optimize the quality and quantity of IT&E for Canadian Forces personnel, while minimizing the resources dedicated to training programmes. The manner in which CFITES fits into the strategic framework of the CAF is depicted in Figure 3-1, with CFITES specifically represented by the 'bubble' on the right side of the figure. For the purpose of this report, the TNA review and comparative analysis focused on the Quality Control system, a six-phase instructional design process, and specifically, the analysis phase.
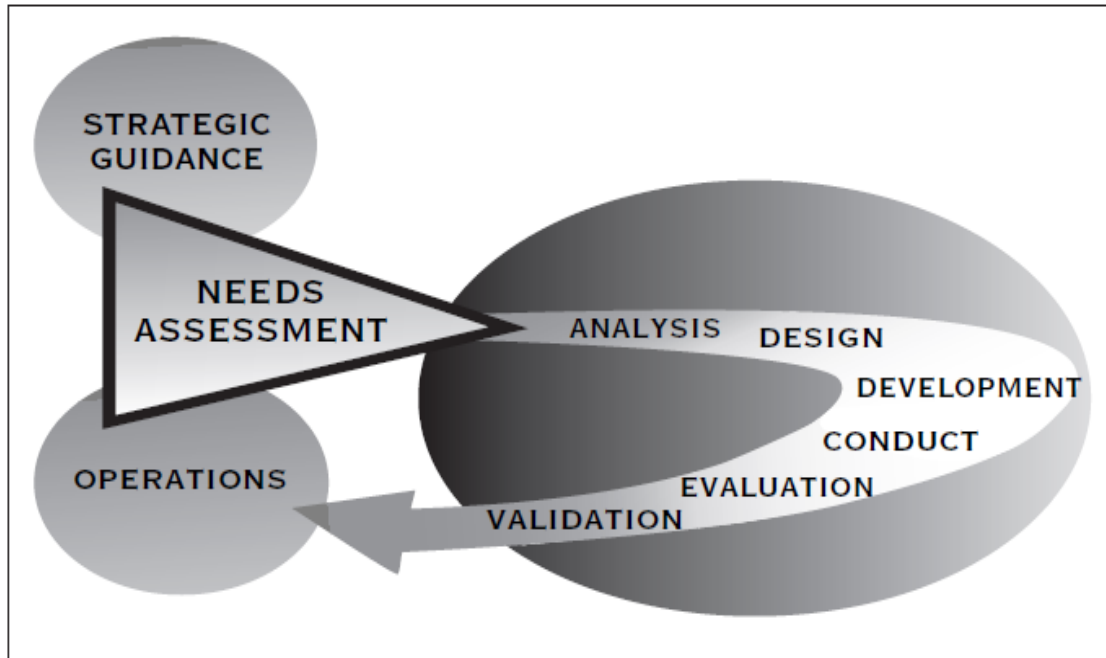
**Figure 3-1: Strategic Overview of Training in CAF, Showing CFITES 6 Phases (on right)
(from CFITES, Vol. 3, Figure 1, p. 1)**

The objective of the analysis phase is to specify the training and education outcomes required, in terms of on-the-job performance. Analysis is undertaken when either a needs assessment or operational requirements has determined that an instructional programme is required to address a performance deficiency. This need might be a result of adjustments to strategic guidance or departmental objectives and goals, or the implementation of new operational equipment. As well, analysis might be triggered by an occupational analysis or feedback from the validation phase of CFITES.

Input to the analysis may include: needs assessment, departmental direction, lessons learned/after action reports, branch/corps advisor input, validation report, occupational analysis, or approved revised specifications (including General specifications (GS), Occupational Specifications (OS: Integrated Occupational Specifications - IOS, or Job Based specifications - JBOS), and Occupational Specialty Specifications (OSS).

CFITES was developed by the Canadian Forces as part of the Canadian Forces Professional Development System (CFPDS), a comprehensive and sequential process that implements a continuous development programme for CF personnel. There are no underlying scientific theories cited in CFITES documentation; however, the CFITES Quality Control System is predicated on the ADDIE model, a systematic process used by instructional designers for developing effective instructional materials.

Although CFITES does not identify the scientific theories on which it is based, CFITES clearly incorporates learning and instructional theories to inform the processes and activities. Theories

that affect the way instructional content is designed include the three primary learning theories of behaviourism, cognitivism, and constructivism, as well as adult learning theories (androgogy and self-directed learning), cognitive load theory, and multimedia theory. Broader frameworks such as ISD and ADDIE are also apparent in CFITES.

3.1.2 Training Lifecycle Stage Addressed

As noted above, CFITES is a management system that addresses all stages of the ADDIE training lifecycle. For the purposes of this review, however, only Volume 3 concerning analysis of training needs was considered.

3.1.3 Alignment with Strategic Framework

CFITES is part of the CFPDS, a management model that defines professional development for all members of the CF. CFPDS is a comprehensive framework consisting of four pillars: training, education, self-development, and work experience. Its objective is to develop effective "warfighters" who are able to apply their craft in multiple and changing operational contexts.

CFITES explicitly supports the development of IT&E and it aligns with CF strategic objectives in terms of organizational and mission contexts, to varying degrees. From an organizational context, training is focused on developing individual skills that can be applied within a team or collective context.

With respect to addressing collective training, CFITES is weak. Nevertheless, there are instances in which individual training programs are 'enhanced', often by conducting some of the individual training in a simulated operational context with others undergoing different individual training but where team performance is a necessary precursor to success. For instance, the RCN conducts a "MEGA" phase at the Canadian Forces Naval Operations School (CFNOS) in Halifax, NS that brings several individual training programs for multiple occupations into an Operations Room simulator to develop the individual skills in the operational context which is, itself, characterised by significant collaboration, coordination and communication. As well, the CA has been integrating game-based training in individual training programs to place the individual in a virtual operational context that permits the trainee to apply their individual skills in a team context. While the placement of a trainee in a team context does not necessarily mean collective training is taking place, if team performance is necessary to succeed at the training, there is likely to be some collective training occurring (even if it is not particularly effective).

From a mission context, CFITES ensures that the operational context is the foundation for the development of IT&E, by including SMEs with operational experience in the Qualification Standard Writing Board (QSWB).

Given the above considerations, due to the lack of explicit guidance for the collective domain, CFITES has a weak alignment with strategic objectives in terms of the organizational context, but a strong alignment from a mission perspective; however, as a whole, CFITES supports CF strategic objectives by linking the training objectives to the operational context and the strategic guidance.

3.1.4 Governance

DAOD 5031-2 addresses the first three pillars of the CFPDS (training, education, and professional development). It defines the organizational framework for the delivery of IT&E, and provides direction on training development processes, areas of responsibility, and steering group construct.

The IT&E governance hierarchy in the CAF is as follows:

1. Chief of Military Personnel (CMP) is overall responsible for IT&E and professional development.

2. The Training Authority is responsible for IT&E for a specific military occupation or branch.

3. The Training Establishment (TE) is responsible for the delivery of IT&E within their particular domain of expertise[8].

In terms of the Analysis phase of CFITES, the Managing Authority (MA) is responsible for development of the organizational training control documents, including the Qualification Standard (QS) and the Job-Task Analysis Report (JTAR), the overarching document that defines the complete list of tasks, skills, knowledge, and attitudes for the occupational role in question. It is an organization consisting of training development specialists and SMEs. When the requirement exists, the MA will initiate the CFITES Quality Control system by convening a QSWB and provide a representative to ensure that the outcome meets the needs of the occupational role.

In addition, CFITES guidance is laid out in a series of manuals (A-P9 series) that address all phases of the CFITES Quality Control process. It describes the processes and outputs of each of the phases. As it relates to training needs, CFITES Volume 3 provides the guidance on analysis of training within the CF, and details the controlling document, the QS, which describes the scope of the training as well as training management and trainee assessment details. In addition, this manual describes the composition of the steering group, the QSWB, the various activities of the analysis phase, and a checklist (Annex H to CFITES Volume 3) to confirm that all activities have been completed.

The outcome of the analysis phase, the QS, is then presented to the MA for review and approval. Once the QS has been approved, the Design phase can begin, from which the training will be designed. Based on the guidance provided in DAOD 5031-2 and the CFITES manuals, as well as the involvement of the MA in the analysis process, there is a high level of governance within the CF in the application of the CFITES.

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[8] A particular trade or occupation will require several different skills of its members. These skills may be trained by different training establishments. Therefore, the TA is concerned with the IT&E for the entirety of an occupation while a TE is concerned with the skills within their domain of expertise. An occupation may receive IT&E from several different TE to meet the requirements of their occupation.

3.1.5   Applicability to Individual and/or Collective Training

CFITES was developed as a model for the individual training and education context. It identifies relationships between tasks, skills, knowledge, and attitudes required for a given job; however, it does not explicitly provide guidance for implementation in the team and collective training context. The analyst may review documentation concerning organisational objectives and integrate the IT&E within the organisational objectives framework; however, no deliberate or systematic mapping from IT&E to organisational direction is found in CFITES.

Despite this lack of explicit modeling for team and/or collective training, the instructional analysis process includes a review of relevant documentation, including organisational objectives and strategic guidance, and integrates the IT&E with the organisational objectives. In addition, the analysis phase of CFITES does provide a structured approach to training needs analysis with guidance for processes and tools that support the methodology and has a high level of potential for application within the team and/or collective training domain. As noted in Section 2.5, it may be possible to use existing TNA methods, developed for individual training, for the purposes of collective TNA by refocusing the content of the outputs toward collective training and performance requirements. In this way, CFITES can be considered agnostic to whether training is individual or collective.

3.1.6   Prescriptiveness of Analysis Elements

CFITES can be viewed as both a science and an art. From a science perspective, CFITES guidance is defined within the CFITES manuals. They provide detailed instructions on the implementation of the CFITES Quality Control system, including personnel required for its application, processes and activities for each phase, and tools for use during each of these activities. In addition, the structured output is described in detail with supporting examples provided throughout the documentation.

From an art perspective, the various operational commands will have their "own perspective" on the process and output and the construct of the QSWB will vary depending on the operational domain. As such, there will be minor differences in the overall application of the processes and the output, however, guidance is robust enough to ensure that the training programs developed across operational domains will be such that an individual will be able to step from one operational domain to another and apply the processes in a consistent manner.

Individual training specialists and analysts, however, are not provided with particularly detailed or prescriptive guidance for carrying out the analysis activities. This allows each analyst flexibility in the way they carry out their analysis, permitting differences in domains, data availability, tool applicability, etc. to be accommodated, but can lead to random variation between training analyses.

There is a high level of prescription in CFITES with respect to the high-level process. The process is defined in enough detail that its application is consistent in terms of accuracy of instructional requirements and consistency of its application across domains. For instance, proficiency levels that must be attained and demonstrated by trainees, are defined in terms of the task and the knowledge components (see Figure 3-2). In addition, the training specialists

responsible for guiding the process have the requisite skill, knowledge and experience to ensure that the process is consistently implemented. That said, the process is not prescriptive at the level of specific analyses, meaning that while CFITES will be applied consistently, it may not result in outputs that would be considered statistically reliable.

3.1.7 Usability

The processes and activities of the CFITES Quality Control system require the involvement of the following personnel:

- TDOs/instructional designers for the analysis of training needs, design of instructional material, and evaluation/validation of training efficiency and effectiveness;

- instructional developers for development of instructional material;

- multimedia developers for development of instructional media; and

- end-users and SMEs with operational experience to deconstruct of the job and identify instructional requirements (tasks, skills, knowledge, and attitudes).

TASKS/SKILLS		KNOWLEDGE
DEFINITION	**PROFICIENCY LEVELS**	**DEFINITION**
The level of proficiency required to perform parts or elements of duties and tasks under continuous supervision.	1	An awareness of the basic definitions and concepts associated with a topic or a body of knowledge.
The level of proficiency normally required to perform duties and tasks under supervision.	2	The level of understanding of definitions and basic concepts which enables the relating of this knowledge to job requirements.
The level of proficiency required to independently and correctly perform duties and tasks.	3	The level of understanding of theory and principles of a topic or body of knowledge which enables critical thought and independent performance and is usually gained through formal training and job experience.
The level of proficiency which usually can be acquired by considerable training and extensive practical job experience.	4	The level of knowledge which enables the synthesis or integration of theory facts and practical lessons learned to support the identification of knowledge solutions to non-routine problems. This is gained from formal training and education and considerable job experience.
The level of proficiency indicated by a mastery of techniques and expert application of procedures.	5	A recognized level of expertise, which includes a mastery of theory and application, related to a given body of knowledge.

Figure 3-2: CFITES Prescription of Proficiency Levels (from CFITES Vol 3, Table 9, p. 16)

During the analysis phase, a QSWB consisting of a TDO, SMEs, and a representative of the MA is convened to determine operational performance requirements for the given occupation. The members of the board will (1) review relevant documentation, (2) analyse the tasks, (3) specify the performance/education objectives and (4) prepare qualification standards. Each of these processes is explained in more detail below:

1. During the documentation review process, the QSWB examines relevant documentation, such as the performance specification, the needs assessment, and the occupational

analysis (OA) to identify performance requirements. The QSWB validates the IT&E requirement that arises from the needs assessment. In particular, the needs assessment may identify methods other than IT&E. Other documentation to be reviewed may include Occupational Specifications, Occupational Structure Implementation Plan (OSIP), technical manuals, policy documents, human factors engineering studies, training evaluation or validation reports, and learner feedback. By the end of the document review process, the QSWB should know why an instructional programme is required, what duties and tasks are included in the performance requirement, what fundamental skills, knowledge and attitudes enable performance of the duties and tasks, and when the skills, knowledge and attitudes will be required.

2. During the task analysis, the QSWB will review available information to identify tasks required in the performance of the job and determine which tasks will require training using either the Criterion Approach or Difficulty, Importance, Frequency (DIF) analysis:

   a. The criterion approach involves the establishment of lists of criteria for each task on which to base the decision. Some criteria might include: entry level (skills knowledge and attitudes) of trainees, percent of job incumbents performing the task, Percent of time spent performing the tasks, consequences of inadequate performance, task delay tolerance, frequency of task performance, task performance difficulty, and time between job entry and performance. This list is not exhaustive.

   b. The DIF analysis is a decision-making flow chart wherein each task is submitted to yes/no questions for difficulty, then importance, and finally frequency. Depending upon the outcome, tasks are either rejected, or selected, with a highly difficult, highly important, infrequent task being highest priority. Prioritisation can be further elaborated by making the importance and frequency answers ""low, medium, or high"".

   c. The QSWB will then organise the selected tasks to understand the links between tasks and what must be trained first as a precursor to other tasks. These tasks may be organised on a timeline (scalar). The outputs of the task analysis are a prioritised list of tasks and a schematic representation (the timeline) of the IT&E requirement.

   d. The tasks will then be analyzed to identify supporting skill (mental or physical activity requiring a degree of proficiency achieved through practice), knowledge (theoretical or practical understanding of a subject that enables performance) and attitude (deeply held opinion or conviction which underlies or motivates behaviour) components that are required to complete the task.

3. The resultant Tasks and KSAs are constructed into Performance, Enabling and Educational Objectives. POs are statements comprising a performance statement (described below), the conditions under which the task must be completed, and the standard to which it must be performed. There may also be links to a reference number/material, specification numbers (task and knowledge), and any remarks or limitations. Performance statements contain a verb, an object, and any necessary qualifier(s). Condition statements often describe tools and equipment to be used, job aids, reference manuals and materials,

supervision applied, assistance available, special physical or psychological demands, the environment, and any cues.

4. The QSWB then prepares the qualification standard for publication. Different formats are preferred by different groups but, at a minimum, a QS should consist of a statement of purpose, PO and/or EOs with supporting detail and limitations, a task list, including tasks that do not require training ("No-Train") and a scalar (a graphical representation of a task flow), and main references and supplementary information as appropriate. The QSWB should also publish a record of proceedings."

A lack of objective evidence exists on usability as defined by ease-of use for a particular user within a specified context of use. The subjective opinion of the project's TDO is that CFITES has a high level of usability, as demonstrated by the historic application and effectiveness of the system within the CF. The guidance provided within the CFITES manuals promotes a consistent application across occupational domains. Despite this endorsement, the authors acknowledge that the frequency of use of this method does not relate to its usability.

3.1.8   Summary

CFITES addresses all phases of the training lifecycle. CFITEs possesses a high degree of prescriptiveness and aligns closely with governance and strategic directives. Although initially developed for individual training development, it is robust enough to allow for use in team and/or collective TNA contents. It would require some modification of the analysis tools in order to address the more complex team and collective training context; however, the training specialists within the CF organization responsible for IT&E have the knowledge and experience to affect these changes and implement the modified processes.

Table 3-2 provides the criteria evaluation for CFITES used to compare between methods. Given that CFITES is the benchmark by which the other methods are judged, all criteria are deemed equivalent.

Table 3-2: Criteria Evaluation for CFITES

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
CFITES	=	=	=	=	=	=

3.2 Battlefield Functional Analysis

3.2.1 Background

BF analysis is essentially a function-based task analysis applied by the US Army to understand a given mission through the systematic decomposition and contextualization of the tasks, involved participants, and information requirements for a set of unit-based *battlefield functions (BF;* Love, 1998). BFs are defined as "processes or activities occurring over time that must be performed to accomplish supporting critical mission tasks (Fields et al., 1997, p. 2). Prior to 1996, BFs were referred to as Critical Combat Functions (CCFs); the term BF was adopted by US Army TRADOC in September of that year (McIlroy, 1997). At that same time TRADOC also renamed tasks analysis to function analysis, hence the name for BF analysis (Fields et al, 1998).

At the Army training level, BF analysis (and BFs) were designed to be compatible with TRADOC's "Blueprint of the Battlefield" (Gibbings, Wagner, Morey and Grubb, 1992). Blueprint of the Battlefield was one of two techniques recommended by TRADOC in the early 1990s to identify collective tasks as part of a systems approach to training (Department of the Army, 1990). Blueprint of the Battle field is a "comprehensive, hierarchical listing of Army functions performed in support of the battlefield and their definitions; collectively includes three blueprints – one for each level of war: strategic, operational, and tactical" (Department of the Army, 1991). This multilevel *Blueprint* was developed through iterative SME input to provide a common reference system for Army requirements organized by the major functions, called operating systems. Operating systems in the Tactical (i.e., Battlefield) Blueprint are therefore called Battle Operating Systems (BOS; Gibbings et al., 1992).

The Blueprint describes seven hierarchically organized BOSs that must be performed by the force to successfully execute a given mission (Department of the Army, 1990). The seven BOS are: Maneuver, Fire Support, Air Defense, Command and Control, Intelligence, Mobility & Survivability, and Combat Service Support (each are defined in detail in Gibbings et al., 1992). The level of detail regarding what the force must do to accomplish a mission increases as the levels progress down through the BOSs, BFs and tasks. As shown in Figure 3-3, BFs represent the high-level groupings of mission sub-functions.

BF analysis was developed by the US Army Research Institute for the Behavioral and Social Sciences (ARI; Love, 1998), which conducts research on how to design unit training strategies and methods (Mirabella, 1997). Published work prior to 1996 described task analyses, later renamed Functional Analysis, for the Blueprint of the Battlefield and various CCRs (i.e., BFs) within the Functional Approach to Training (e.g., Mellin, Stroud & Geohegan, 1993; McIlroy, 1995). The BF analysis method was deemed complimentary to the collective task identification procedures used by the US Army TRADOC as a sources of data build applications such as assessment tool (McIlroy, 1997).
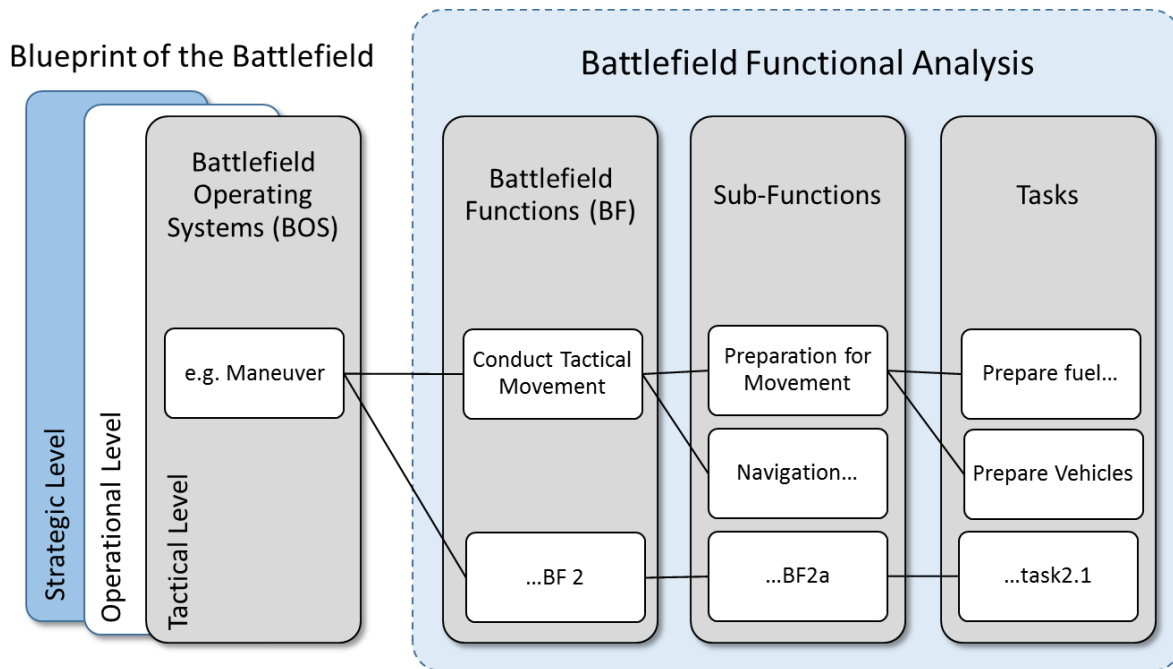
Figure 3-3: Hierarchy of BF Analysis Components

Subsequent work conducted analyses under the name BF analysis to generate BFs, or to produce detailed information about related BFs belonging to specific operations (McIlroy, Mullen, Dressel & Moses, 1996; McIlroy, 1997). Other research directly targeted a single BF such as directing and leading units during the preparation for battle (McIlroy, 1995), or coordinating synchronizing, integrating Joint Task Force fire support (Fields, Taylor, Moore, Mullen & Moses, 1997) and the analysis of Command and Control (C2) BF by an Armored Brigade (Ford, Mullet & Keesling, 1997). These projects are collectively associated with the BF analysis method, and the production of numerous BFs.

The current status or relevance of BF analysis is unclear as no published research using BF analysis or Blueprint of the Battlefield was located after the year 1998. One exception was the unintentional discovery that BOS has been replaced by *Combat Power*. Combat Power is defined in the Operations Field Manual as "the total means of destructive, constructive, and information capabilities that a military unit or formation can apply …by converting potential into effective action" (FM 3-0, C1, 2011, p. 4-1). Combat Power contains nearly the same levels as BOS but organized as eight total categories. The Mission Command (i.e., C2) applies five warfighting functions (i.e., Movement & Maneuver, Fires, Intelligence, and Protection) through Leadership supported by relevant Information, as depicted in Figure 3-4.
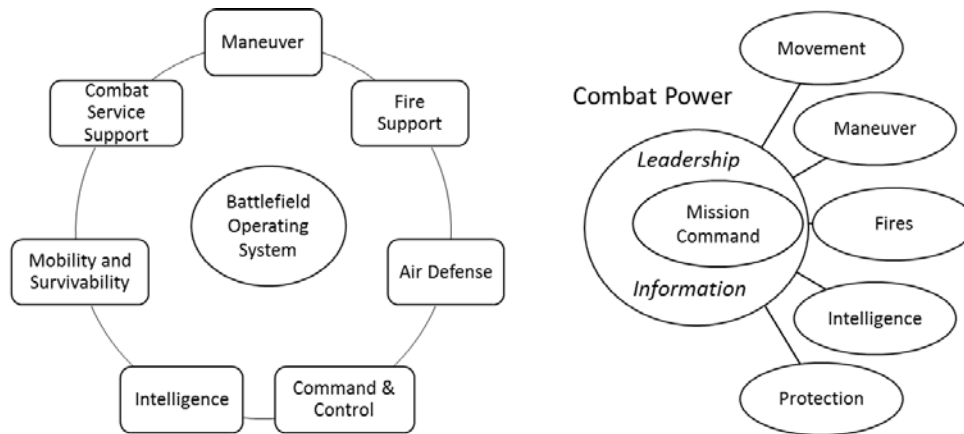
Figure 3-4: Elements of BOS (left) and Command Power (right)9

The relationship between BF analysis as a relevant methodology to Combat Power (rather than BOS or BF) is also unclear. Between the years 1998 and 2010, there appears to be a gap in published literature making any reference to BF analysis or BOS at all. It is not until 2011 where the Preface of the US Army Operations Field Manual 3-0 Change 1 briefly states the replacement of BOS by the term 'Combat Power' (FM 3-0, C1, 2011). While a seemingly related term, Combat Power analysis, is discussed as part of Course of Action Development in the Operational Planning Process, this is a completely different concept than BF analysis. It is possible that the relevance of BF analysis was dependent on a limited life expectancy of the particular funding vehicle within the ARI.

Whereas detailed references are made to Blueprint of the Battlefield and BOSs as a technique for collective task analysis within the 1990 version of TRADOCs current System Approach to Training (Department of the Army, 1990), there is no specific mention of any BF analysis-related terms within the 2004 version (Department of the Army, 2004). TRADOC Pamphlet 350-70-6 provides guidance on the Systems Approach to conducting five types of training analyses: needs, mission, collective task, job, and individual task analysis (Department of the Army, 2004). The pamphlet is only one of many detailed instructional guidance documents openly available on TRADOC's Training Development and Delivery Directorate website[10].

3.2.2 Training Life Cycle Stage

BF analysis primarily addresses the Analysis stage of the ADDIE model, as it is the equivalent of task analysis, branded for the battlefield. However, in line with US ARI's goal to develop training material requirements traceable to how soldiers accomplish their missions, BF analysis results *can* be used to inform the design and development of training content. The hierarchical structure of operating systems derived from the Blueprint of the Battlefield (i.e., BOS) link to generic BF, which are then analyzed (using BF analysis) within the context of a mission to produce tactical level information. These more specific task level requirements and associated

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[9] Adapted from McIlroy (1995) & FM 3-0, C1, 2011

[10] TRADOC pamphlets available at: http://www-dcst.monroe.army.mil/tdaa

information products can be used for training development, as part of training Design (Fields et al., 1998) and even performance assessment packages (Mullen, Elder & Kemper, 1998).

On the other hand, while BOSs can be used to provide comprehensive data bases to facilitate the development of training strategies through a BF analysis (Mullen, Elder, & Kemper, 1998), they appear to rarely be used as such. The method's own developers noted that tasks are often narrowly described within the isolation of "single BOS element within one echelon. What have been lacking are function analyses along with task descriptions that have a broader BOS perspective; one which focuses not only on intra-BOS relationships, but also the relationships of that BOS with other BOSs in accomplishing the overall mission" (Mullen, Elder, & Kemper, 1998, p. v). The authors point out that the lack of consideration for the multifaceted BOS relationships presents obstacles to defining training requirements and strategies for combined arms.

3.2.3   Alignment with Strategic Framework

BF analysis closely aligns with the identification of collective tasks within the US Army's TRADOC's SAT. This suggests that BF analysis was developed to follow strategic direction and support organisational objectives. At its inception, BF analysis was tightly coupled with the US Army's Blueprint of the Battlefield, which could be considered a strategic framework in that it is a standardized ontology to describe military operations. Within the Blueprint, the tactical level BOSs are not mission specific, but rather are organized by functions to facilitate examination of operations in terms of the same basic elements. These BFs stipulate "what the force does on the battlefield rather than how the force does it, or when" (Gibbings et al., 1992).

As shown in Figure 3-5, BF in the BOS can be further decomposed into generic tactical tasks. Tasks can then be designated to responsible units, weapons system, or soldiers by particular branches or proponents (Gibbings et al., 1992). Given the lack of recent work connecting BF analysis specifically with TRADOC, it is unclear whether the method is no longer used, or has simply adopted a new name.

3.2.4   Governance

BF analysis is not described as having any specific governance structure (e.g. steering committee) per se, however the functional analysis components are aligned to Blueprint of the Battlefield, described in the previous section. If BF analysis has been folded into the US Army TRADOC SAT (albeit under some other name) it could be subject to some form of governance.
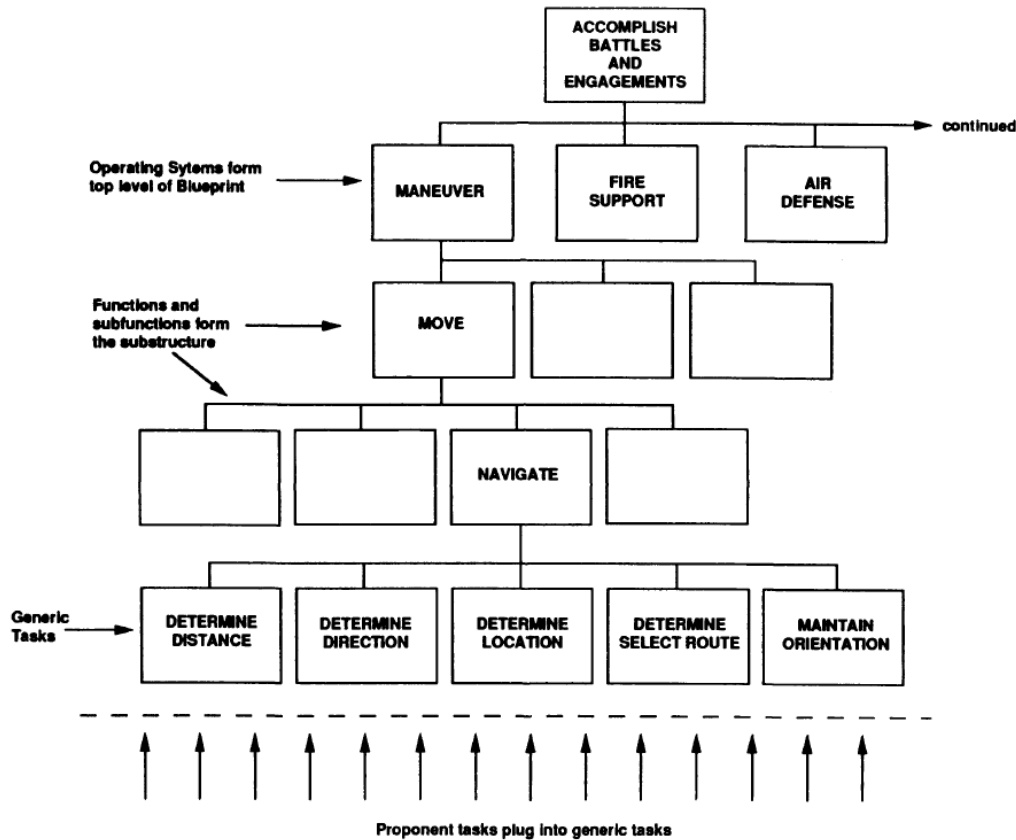
Figure 3-5: Relationship between Functions and Tasks in the Blueprint of the Battlefield (Gibbings et al., 1992, p. 507)

3.2.5 Applicability to Individual and/or Collective Training

Using the Blueprint of the Battlefield and BOS hierarchical organization, which are aligned with larger US Army databases (UJTL and METL), BF analysis would enable organizational objectives to be mapped soundly and logically to team and collective mission capability needs. Ford, Mullen and Keesling (1997) downplay the role of the higher-level functions in BOS for specific assessment. Instead, the authors suggest that BOS should be used as a guide to the "commander's assessment of the METL…and as a tool to organize battle tasks" (p. 5).

One of the outputs particularly relevant to collective training is how BF analysis defines those tasks occurring either sequentially or in parallel using Operational Sequence Diagrams (OSD). OSDs are well-suited for team analysis in terms of providing a means to visualize information requirements and communication links among groups of people in related tasks. An OSD provides a graphic schema to visualize various information requirements about mission tasks such as sequence, functional relationships and information requirements (Brooks, 1960). The main objective is to depict task flow, which may occur in parallel or simultaneously to other temporally proximal tasks (Fields et al., 1997). This style of analysis can be useful for the

assessment or manipulation of the order of tasks within a particular function. The OSD components are described in detail by Fields et al. (1997).

Because BF analysis is conducted at the functional level, there were no previous reports specifically focused on individual task training. However, the roll-up of tasks to functions could be used to derive individual training requirements. Previous work (accessible and published) has conducted BF analysis for the following unit types:

- Battalion task force (McIlroy, 1995);

- Brigade Combat Team (McIlroy et al, 1996);

- Army Corps acting as a Joint Task Force (Fields et al, 1997);

- Armored Brigade (Ford, Mullen & Keesling, 1997); and

- Direct Support Field Artillery Battalion (Mullen, Elder & Kemper, 1998).

These reports did not however contain training outputs, but rather suggested uses for training material based on the links from the BF analysis and other Army task databases.

3.2.6   Prescriptiveness of Analysis Elements

The BF analysis method results in a structured description of the work in the task list, task list summary and OSD outputs. BF analysis does not specifically provide a structured description of the knowledge, skills and competencies to be learned; however, these could be identified by joining the BFs to a larger databased such as the METL or the UJTL. While BF analysis products can be used to inform training design, it does not offer a means to clearly and effectively identify training gaps. BF analysis does not produce a report on the difficulty, frequency, and importance of tasks.

Review of the available (but somewhat disjointed) literature suggests the focus is on providing a comprehensive BF inventory rather than promoting BF analysis as a method. Most of the located published literature contains rather detailed descriptions of the included BF analysis sections and activities conducted as part of their analyses (e.g. Fields et al.,1997). However, these sections are in support of the analysis outputs – the BFs. This format is comparable to a method section description in a research paper. The methodology allows the reader to understand the process taken by the researchers, which adds context to the results, but it is not intended to promote a generalizable technique such as would be found in a methodological paper.

The inherent structure of BF analysis purports that each task and BF is traceable to an element of Combat Power/BOS (McIlroy, 1997), as shown in Figure 3-4 and Figure 3-5. Again, like standard Task Analysis, the BFs represent a roll-up of related functional elements including lower-level functions, sub functions, and tasks. It is up to the analyst to decide at what level of granularity to stop, but generally, tasks contain the highest degree of detail and are not further

subdivided. Functions and tasks are discrete, meaning that no function or task appears in more than one place in the BOS (Gibbings et al.,1992).

The specific outcomes of the analysis are dependent on the way in which the analysis is applied; therefore, the envisioned application should drive the specificity and number of analysis components (McIlroy, 1997). BF analysis along with its related products (e.g. OSD) is designed to couple with other task analysis-based methods to support training development and management (Love, 1998). Some of the reviewed literature has linked BF to various training objectives, such as attempting (with moderate success) to merge BFs into automated relational databases (McIlroy & Mullen, 1997). Another project used the BF analysis to link Fire Support to a universal Joint Task List from which to construct a joint METL (Fields et al., 1997). The UJTL is a menu of capabilities (mission-derived tasks, with associated conditions and standards, i.e. the tools) a joint force commander selects to accomplish the assigned mission. Once identified as essential to mission accomplishment, the tasks are reflected within the command joint METL (Department of the Army, 2004).

The only "true" instructions located in the literature review to apply BF analysis for training were described by Love (1998). The following steps are summarized from Love (1998) and assume the analyst is applying the outcome from a previously conducted BF analysis to training development. Each instruction is described along with the required information inputs and resulting information product output, as follows (as well as illustrated in Figure 3-6):

1. Identify relevant personnel (i.e. who should be trained) with respect to each BF Task List:

    a. Input: previously conducted BF analysis, SME analysis; and

    b. Output: a list of personnel linked to BF tasks.

2. Define roles and responsibilities:

    a. Input: doctrinal publications, unit SOPs, and training guides/manuals, and produce the additional resources needed by those key staff sections, SME input; and

    b. Output: a detailed and comprehensive set of responsibilities and tasks, displayed in an OSD for each of the key staff sections.

3. Develop overall training objective, task and standards:

    a. Input: the Purposes and Outcomes section of the BF (which provides the start point for this refinement process), SME input on critical tasks and corresponding standards; and

    b. Output: defined responsibilities and tasks for the staff sections.

4. Develop performance assessment tools:

    a. Input: SME input combined with the overall training objective, and tasks within context of the BFs; and

b. Output: a Self-Assessment Tool to be used by the chief of each key staff section to conduct a 10-15-minute mini-AAR (after action review) at the conclusion of each iteration or phase of its operations to consider how personnel performed each of the detailed tasks contained in their set of responsibilities and tasks.

5. Document performance and lessons learned:

a. Input: results of the self-assessment tool and AAR; and

b. Output: the AAR provides a record and feedback on performance and specifies where additional training is required, and potential improvements for the next iteration.

Figure 3-6: Summary of Love's (1998) BF Analysis to Training Instructions

Love (1998) suggests that the key to using BFs to develop training guides is to determine who the training audience is and then to extract the detailed information from the outputs of the BF analysis most appropriate for that audience. However, given that the procedures for developing BF analysis draw heavily on the SME expertise, the outcome directly applicable to training may be highly subjective.

3.2.7   Usability

Given the lack of recent literature on the BF analysis, it is difficult to comment on its usability relative to similar methods found in modern training research. Common to most task analyses, the process is likely to be labour intensive and require substantial analysis time and external validation. However, the use of the pre-defined BOS functions does offer some heuristic advantages in that the user is not forced to identify all levels of the analysis from scratch. On the other hand, it is possible that the inherent foundation of the Blueprints and BOSs caused the BF analysis to be overly project specific (for e.g. useful only to the ARI). Such a high degree of specificity may have decreased the usability for other domains or purposes. Equally,

if the method was seen as too resource intensive, this may have contributed to the decreased use and eventual apparent extinction.

Subjectively, BF analysis has been described as a high-utility tool (Love, 1998). Love (1998, p.3) comments positively on "the input/output charts and the linkages of tasks to doctrinal references… in the absence of joint how-to manuals, BFs analyses provide sets of comprehensive and detailed tasks (including the how-to, arranged in logical combat operational sequences for the missions and functions involved. It is these sets of tasks that are most beneficial in developing joint training guides". The TRADOC documents related to the Blueprint of the Battlefield provided the most detailed instructions on the conduct of the BOS analysis phase (Department of the Army, 1990). However, these instructions were more at the general task identification level, rather than any specific direction for BF analysis.

Some degree of usability could be implied from the detailed descriptions of the various BF analysis components. The outcomes of a BF analysis encountered during the literature review were presented in report format. The related information products were therefore sections of the report. Similar to most task analysis style reports, there were slight variations in the organization and nomenclature of section headings and content across BF analysis (e.g., between shift from CCF to BF). Akin to a task analysis method, there are a number of information output products that can be derived from a BF analysis, depending on the intended use. The need for each BF analysis product should therefore determine the level of detail and selected analysis components (McIlroy, 1997).

The following list provides an overview of the most useful BF analysis section/products encountered during the literature review would be expected to contribute to usability. A detailed description of typical report sections (e.g. overview, lessons learned etc.) is provided in McIlroy (1997).

- User's Guide: the user's guide prefaces the BF analysis with recommendations for how the specific information contained in the report should best be used, for example by training developers to develop training material. This section may include additional context such as descriptions of the component relationships and specific examples of how the information can be applied to reach an end-goal. This section could help the reader more easily identify the relevance to training development.

- Task List Summary & Task List: the task list summary provides a condensed overview of all the BF and related tasks (organized by BF) that are included in the report as part of the BF analysis. The task list provides more detailed descriptions about each task such as the primary participants involved, and references for each task (e.g. doctrine). This additional information should help the user identify the training audience and any relevant documentation required for a training event.

- Outcomes and Purpose: this section is also in list format, but provides a higher-level description of the overall intent of each BF analyzed (purpose) as well as more detailed summaries of what other tasks or goals will have been achieved once the BF is executed. For example, in one analysis of the BF - Direct and Lead Unit during Preparation for the Battle – the purpose is to "provide leadership, direction, command and control during

preparation for the battle". There are six listed objectives, one of which is "The Task Force Commander is able to appraise his plan based on the current situation so as to determine that the plan remains valid or has become invalid" (McIlroy, 1995, p.11).

- Operational Sequence Diagram: this section provides a schematic depiction of the task list, organized in a relative linear matter. The OSD illustrates those tasks occurring either sequentially or in parallel using standardized flow charts and swim lanes. OSDs are described (and illustrated with an example) in more detail in Section 3.2.5.

- Key Inputs and Outputs: related to the OSD output, this section provides the information exchange requirements for participants to successfully accomplish the BF. Key input information can be used to inform training exercises, while Key Outputs can be used to shape the development of performance assessment measures for each BF.

- Task Linkages to Other BFs/Units: This section provides a mean to associate the tasks from the BF analysis with other BFs or with relevant databases. For example, Fields et al. (1997) linked BF tasks to UJTL with the aim of supporting training development of related tasks.

3.2.8   Summary

BF analysis is a function-based approach to task analysis of the US Army Battlefield that focuses on task descriptions and role allocation. The paucity of literature suggests that BF analysis within current training development may no longer be relevant as-is. There is no official guidance on using the task descriptions to develop training products other than some descriptive literature (Love, 1998). BF analysis was developed specifically for the military and aligns with the operational and tactical level force structure for the US Army through Blueprint of the Battlefield. While it does not refer to any theoretical underpinnings or governance, the Blueprint of the Battlefield was at one time aligned with TRADOC. BF analysis itself however, does not seem to have been formalised as a standard US Army process. Like any task analysis, the completion of a full BF analysis is labour intensive and requires substantial SME input. However, given the detailed instructions on each output, which align to other task databases (e.g. UJTL), the BF analysis appears reasonably usable. In other words, while the process may be difficult, but not necessarily complex, the highly contextualized application to the Army domain may have limited its succession into modern training literature.

Table 3-3 shows the comparison of BF analysis and the CFITES baseline.

Table 3-3: Criteria Evaluation for BF Analysis

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
BF analysis	-	=	=	-	=	=

3.3 MANPRINT and HSI

Manpower and Personnel Integration (MANPRINT) is a systems engineering approach intended to coordinate the activities and outputs of different disciplines concerned with the role of humans in a system: Training, Manpower/Personnel, System Safety, Health Hazard Assessment and Human Factors. More recently, the term 'MANPRINT' has been overtaken by Human Systems Integration (HSI; or Human Factors Integration (HFI) in the UK). Because HSI is primarily concerned with coordinating the outputs of a variety of disciplines it does not necessarily focus on the specific tools or techniques of the constituent disciplines, leaving this to experts in the respective disciplines. Nevertheless, a number of edited collections, in particular Booher (1990; 2003), have included chapters that discuss the training lifecycle within the HSI framework. This section attempts to distill the insights and guidance concerning collective TNA from these sources.

3.3.1 Background

Hettinger (2003) uses the definition of team provided by Swezey & Salas (1992): "Team is defined as a set of two or more individuals who must interact and adapt to achieve specified, shared and valued objectives". Hettinger notes that there are very few roles in complex systems (e.g. command and control systems, military manoeuvre units) that occur outside of a team context, with the attendant collaboration required to achieve the team's goals. With this in mind, Hettinger (2003) provides a short section on individual versus team training.

Hettinger (2003) observed that research in team training proceeds from the belief that team performance will be improved when team members share a mental model. This shared mental model is comprised of a number of factors, including knowledge of the tasks to be performed, the bounds of acceptable or required performance, the overall goals and their respective sub-serving nearer-term goals that must be satisfied to achieve the overall goal. Collectively, team members also need to possess the skills to achieve the team's objectives. Note that the use of the term 'collectively' here implies that team members need the skills that are relevant to their assigned role in the team, but not that all team members need competence in all skills. Team members need to accurately understand the current state of team performance and their role in the team, as well as accurately anticipate the state of operations in the near future. Within the HSI community, Hettinger (2003) considers the main topics of research to be the identification of team-based KSAs and methods to develop them through training, the utility of shared mental

models and the role of team coordination in accidents. Although there is research into the identification of team-based KSAs, there is no mention of research into standardised methods of collective TNA. While the KSAs form a key component of a TNA, the specific identification of KSAs for a particular collective training application and the translation of those KSAs into EOs and POs are not described, nor were uncovered through a broader search for evidence of TNA methods referenced by Hettinger (2003).

The main approach to identifying team-based KSAs is to carry out task analysis, based on observation of work and SME interviews, resulting in comprehensive human-centred descriptions of the work to be done, the context of the work and the factors affecting performance. Further analysis is then undertaken to determine which work is most critical, the cognitive, physical and perceptual features of the work and the standards of performance that must be achieved, both to demonstrate competency and to demonstrate mastery. Cognitive Work Analysis (Vicente, 1999) and Cognitive Task Analysis (Schraagen, Chipman & Shalin, 2000) can also be applied, as can knowledge or concept mapping, to delineate the possible connections between events, costs and constraints of the task environment and the operator's (and, through further analysis, the team's) related cognitive and perceptual tasks.

MANPRINT includes a chapter on training systems and analysis. Pertaining to TNA, it describes a MANPRINT Analysis for the Training system. The analysis assumes that a general training requirement has already been identified by the environmental commander and passed to the training authority to develop a training curriculum. The training analysis is one of the first steps in a longer cycle of analysis, design, development, implementation and evaluation (i.e. ADDIE) that accords with the US Army's SAT. The main stages in the training analysis are: 1) identification of a training deficiency 2a) carrying out job, task and skill analyses 2b) performance of a media analysis 3a) development of training concept/macro and micro strategy 3b) identification of training alternatives and 4) carrying out a training effectiveness analysis. Data from these analyses are used as inputs to trade-off studies that contribute to a range of options to be selected for implementation by the training authority and relevant stakeholders.

In interpreting the MANPRINT training system analysis guidance it is important to note that these 4 stages of analysis are done for each of the MANPRINT domains: Manpower and Personnel, Training, Human Factors Engineering, and Safety and Health Hazards.

- Manpower (or "Workforce") and Personnel analyses are concerned with determining the numbers and types of personnel required to operate and maintain the system. Additionally, workforce and personnel analyses are intended to identify the attributes of those selected to use the system. With respect to the design of a training system, these analyses will be concerned with those that will be delivering training and maintaining the training system. Workforce and personnel analyses concerning the trainees would be undertaken in support of operational system development.

- Training analyses are concerned with the type of training operators and maintainers will require to use the system in an operational context and ensure it is fully functional and maximally available. Within the context of training system development, training analysis is intended to develop 'train the trainer' approaches to ensure that instructors and curriculum

developers are able to develop and deliver training that is effective at producing competent operators. Similarly, training analyses will result in training objectives to assist maintainers achieve their objectives for training system availability.

- Human Factors Engineering (HFE) analyses are concerned with the trainee's ability to function within the training system, the instructor's ability to use the training systems and the maintainer's ability to keep the training systems available. HFE analyses ultimately become the basis for test and evaluation plans for acceptance of the training system and, in more enlightened programmes, a significant contribution to the development of the instructional curriculum itself.

- Safety and Health Hazard analyses are concerned with both the operational system as well as the training system and the possibility that they may pose a danger for the trainee, or that the trainee may cause damage to the real system when they move on from training. In particular, with embedded training systems, the opportunity for interference between the training system and the operational system must be considered.

3.3.2 Training Lifecycle Stage Addressed

Oneal (1990) and Hettinger (2003) describe the applicability of MANPRINT and HSI (respectively) across the entirety of the training lifecycle (i.e. initial analysis, design, development, implementation and evaluation). Attempts were made to find additional literature that used Oneal or Hettinger as a primary reference but these were unsuccessful. This has led to the conclusion that, although MANPRINT and HSI remain influential models by which military systems are developed, the theoretical bases which they provide are passed over in favour of more elemental work in the training field by Salas et al. (2009), Patrick (1992), Kirkpatrick (1994) and Bloom's taxonomy (see Anderson & Krathwohl, 2001).

3.3.3 Alignment with Strategic Framework

The model adopted in HSI is human-centric and not organisation-centric. Neither author notes or emphasizes the need to be aligned with strategic objectives. However, since HSI is a military concept, it is expected that any application of the outline TNA method would fit within the strategic guidance, organisational framework and force structure. Oneal (1990) in particular seems to write with specific organisational imperatives in mind. The use of specific terms for deliverables, such as "Concept Formulation Package" or "Required Operational Capability" imply formalisation within the organisational procedures, and the flow charts provided to describe the training system indicate effort to integrate with a broader set of processes. Without a wider specific analysis of (in Oneal's case) the US Army processes and a comparison with the approach to training analysis, it is difficult o draw firm conclusions about how well MANPRINT or HSI has been integrated within different organisations.

3.3.4 Governance

No mention of any governance mechanisms was made.

3.3.5 Applicability to Individual and/or Collective Training

The discussion of training analysis was largely agnostic to the notion of team or individual. It is assumed that the authors generally had individual training in mind when discussing training analysis.

3.3.6 Prescriptiveness of Analysis Elements

There is very little guidance provided regarding how to carry out TNA.

3.3.7 Usability

There is little indication of the potential usability of a TNA method. Oneal (1990) and Hettinger (2003) describe the applicability of MANPRINT and HSI (respectively) across the entirety of the training lifecycle, but neither describes training analysis in much detail. A novice analyst would be unable to use the descriptions of training analysis without doing a significant amount of additional reading and experienced analysts would almost certainly carry it out in different ways.

3.3.8 Summary

MANPRINT and HSI provide a conceptual framework within which training analysis activities can be undertaken, but provide little specific guidance concerning the actual execution of a training analysis study, the development of analysis outputs and the use of these outputs to drive training system design. MANPRINT and HSI have not clearly been integrated into the organisational or strategic frameworks within which they are intended to be used. It may be that existing training studies were reverse-engineered by Oneal (1990) and Hettinger (2003) to fit the MANPRINT/HSI paradigms. Some specific mention of team training is made in Hettinger (2003), reflecting a growing recognition of the issue across the military domain but again, few specific differences were highlighted, and none were mentioned where analysis methods are concerned.

Table 3-4 provides the criteria evaluation for MANPRINT/HSI that is used to compare between methods.

Table 3-4: Criteria Evaluation for MANPRINT/HIS

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
MANPRINT/HSI	-	-	-	-	-	-

3.4 Mission-Essential Competencies

3.4.1 Background

Mission Essential Competencies (MEC) is a trademarked process model of competency-based training within the US Air force (USAF; Alliger et al., 2013). The MEC methodology was conceived in the early 2000's from a research partnership between the Commander of the Air Combat Command and the Air Force Research Laboratory's Warfighter Readiness Research Division, who sought to enhance the use of advanced simulation in aircrew training programs (Colegrove & Alliger, 2002, as cited in Colegrove & Bennett, 2006).

MEC was founded as part of the USAF's objective to develop Command and Control (C2) metrics that could 1) identify process and collaboration-focused training requirements rather than platform-specific standard operating procedures, 2) determine behaviorally-anchored performance measurement criteria, and 3) develop team training methods and systems (Tossel et al., n.d.).

MEC is twofold: MECs as a series of related subcomponents that describe performance, and the MEC process as a development method to identify MECs (Alliger et al., 2007). The MEC components consist of MEC elements, the Supporting MEC Competencies, MEC Knowledge and Skills, and MEC Developmental Experiences.[11] Figure 3-7 graphically depicts the relationship among all MEC components.

MECs are formally defined as "higher-order individual, team, and inter-team competencies that a fully prepared pilot, crew, flight, operator, or team requires for successful mission completion under adverse conditions and in a non-permissive environment" (Alliger et al., 2007, p.14). Similar to BFs described earlier, MEC elements represent high-level functions. MECs are developed for and situated within a given mission (e.g. Air-to-Air), meaning they are more specific than what might be found in general industry competencies such as leadership skills (Colegrove & Alliger, 1992 as cited in Alliger et al., 2013).
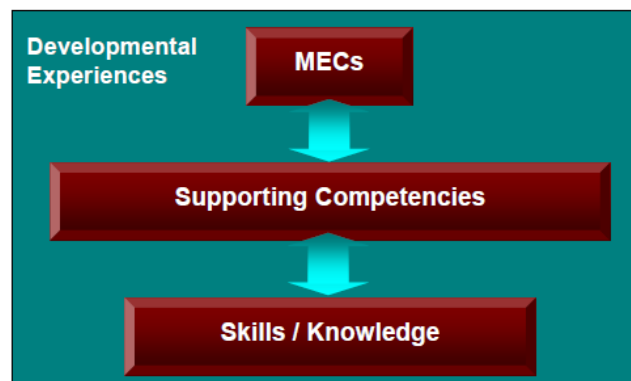
Figure 3-7: Relationship among MEC Components (Colegrove & Bennett, 2006, p. 8)

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[11] The term 'Developmental' appears to have been dropped from Experiences in later publications.

MECs are structured as short action-oriented statements that describe various components of the conducted work, each elucidated by descriptor text and framed by a start, an end and a purpose statement (Alliger et al., 2006; 2013). Table 3-5 provides an example MEC for Airborne Warning and Control System (AWACS) (adapted from Alliger et al., 2013, p. 219).

Table 3-5: Example MEC for AWACS

MEC Statement	Start	Stop	Purpose
Detects entities in area of interest— includes all air and surface tracks, and emitters of interest.	When systems operational	When systems powered down	Assist in contributing entities to Single Integrated Operational Picture (SIOP; e.g., using onboard and off board sensors).

Supporting Competencies are the "broad, high-level skills and knowledge that underlie the successful development and performance of the MECs" (Alliger et al., 2013, p. 220). Supporting competencies include generalizable competencies typically seen in industry and human performance literature, such as Leadership, Situation Awareness, Decision Making and Adaptability (Alliger et al., 2007; 2013).

Knowledge and Skills is defined in two parts; knowledge is the "information or facts that can be accessed quickly under stress [i.e., under combat conditions]", and a skill can be defined as "a compiled sequence of actions that can be carried out successfully under stress" (Alliger et al., 2013, p. 220). Examples of Knowledge and Skill statements from AWACS are provided in Table 3-6 (adapted from Alliger et al., 2007, p. 17). Again, a position-by-Knowledge and Skill matrix can be used in cases where not every knowledge or skill applies to every position.

Table 3-6: Example Knowledge and Skills

Knowledge / Skill	Description
Knowledge: Environment Effects	Understands the effects of environmental factors on the mission (e.g. terrain, smoke, vegetation)
Skill: Identifies Targets/ Threats	Interprets the visual cues/system indicators that identify various targets/threats

Developmental Experiences are mission-related occasions identified by SMEs believed to facilitate combat mission readiness. Experiences are captured during the MEC process to describe "developmental events that occurs during training and at various times across the career of a warfighter necessary to learn a Knowledge or Skill, or practice a MEC or SC under operational conditions" (Alliger et al., 2013, p. 220). Experiences can be one of three types of MEC related situations.

1. an event that occurs to or is encountered by the subject (e.g. fatigue during a task);

2. an action that is performed (e.g. live weapon employment); or

3. an operation that may be useful in achieving the required mission competencies under adverse conditions (e.g. ground adversary jamming) (Alliger et al, 2013).

MECs and their related content are developed through a series of iterative SME workshops and surveys led by a trained MEC expert. If multiple weapon systems are part of the same mission the corresponding SMEs must be represented (Alliger et al., 2013). The main steps to developing the elements of the MEC model are summarized from Alliger et al. (2007, p. 21):

1. Workshop 1 (Mission Review, Task Identification, KS and SC Generation): The first workshop produces an initial set of MECs drafted by SMEs identified by the operational customers. This workshop operates in part as a task analysis, where SMEs provide information about the structure of their unit, missions and tasks performed, Knowledge and Skills, and Supporting Competencies. The MEC facilitators collect and analyze to create the draft list of MECs, Knowledge and Skills.

2. Workshop 2 (Confirmation/Revision of MECs and Workshop 1 Outcomes, Generation of Experiences): Using the collected data from workshop 1, the second workshop validates the MECs and Secondary Competencies, which allows the facilitators to elicit further Knowledge/Skills and also add Experiences, resulting in a database of expert knowledge.

3. Operational Surveys: The collection of data from the second workshop is presented to the broader operational community via custom surveys (relative to each weapon system's MECs, Knowledge and Skills, Supporting Competencies, and Experiences). The data are summarized in a series of reports for operational personnel to review and interpret the data to identify training gaps. Refer to Alliger et al (2006 and 2013) for detailed survey examples.

4. Comprehensive Mission Needs Analysis and Determination (COMMAND) Workshop: In the final workshop, SMEs review the survey results to identify training gaps. This involves a comprehensive analysis of the weapon system and associated career field training status, and may also include linking knowledge and skills to experiences. This data is entered into the COMMAND worksheet.

Martin (2016) describes two report products developed as part of the MEC process: the MEC Summary report and the MEC COMMAND worksheet.

1. **The MEC Summary Report:** report provides a list of MECs, their Supporting Competencies, Knowledge and Skills, as well a list of experiences deemed necessary and sufficient to develop the identified training requirements. Further, the report offers a determination of whether an item represents a gap, and the level of priority for training, as well as the required level of proficiency (Martin, 2016).

2. **MEC COMMAND Worksheet/Summary**: The survey results from the operational community are formatted into a customized digital spreadsheet that is projected to facilitate group discussion. The final worksheet is transferred to a COMMAND Summary sheet,

which amalgamates results into a database of MEC proficiency data to show the number of training gaps. The sort and filter functions enable the worksheet to be sorted by proficiency, nature of the gap, and experience. Examples of the COMMAND worksheet are shown in Alliger et al. (2007, p. 28 & 30).

3.4.2 Training Life Cycle Stage Addressed

MEC as a process is representative of the Analysis phase of the ADDIE model, while MECs as an outcome could be considered a blend of design of training phases. MECs answer the question, "What do we measure?" (Colegrove & Bennett, 2005, p.3).

From the analysis perspective, the MEC process is largely an SME-oriented tasks analysis that results in several outcomes: the MEC statements the Supporting Competencies, statements of Knowledge and Skills, and Developmental Experiences. From the design perspective, The MEC model offers a structured set of competencies (and Supporting Competencies) and related components (such as Knowledge and Skill statements) that can be used in various ways to build a competency-based training program. For example, Bennett et al. (2006) describe how MEC definitions have been used as simulator input to validate training requirements and assessment needs identified with the MEC process. Martin (2016) argues that the Developmental Experiences are ideally suited for the Design phase. In essence, the very nature of a MEC experience suggests to the TDOs the precise requirements for a trainee to develop the necessary skills and knowledge to achieve the competencies for a given mission.

3.4.3 Alignment with Strategic Framework

Given that MEC was developed by the USAF, the MEC framework is presumed to be aligned with the USAF strategic framework. However, a direct link was not apparent in the reviewed literature. Alternatively, an indirect association may be assumed. Martin (2016, p.20) suggests that MEC's "grass-roots development… process may implicitly, rather than explicitly… invoke… strategic guidance as understood and interpreted by those being directed, as opposed to by those providing direction".

3.4.4 Governance

There is no defined governance for MECs. However, the detailed process, descriptions and survey tools available for the SME workshops (e.g. Alliger et al., 2007; Colegrove & Bennett, 2006) provide a framework upon which users can impose their own governance structure within their organization. The MECs development process produces a large database of MECs proficiencies that are stored in the COMMAND worksheets. Detailed reports produced from the COMMAND summaries highlighting training gaps linked to MEC components could be used for consideration by other stakeholders in the organisation. These outputs would enable the authoritative bodies in a given organization to oversee the planned training within the context of the desired strategic direction.

The service mark Mission Essential Competencies and its process is proprietary, jointly owned by the Air Combat Command, the 711 HPW/RHA (AFRL), The Group for Organizational

Effectiveness, Inc. & Aptima, Inc. The governance of the process is clearly defined and highly structured within their organizations, and only personnel trained in the delivery of the method may guide it.

3.4.5 Applicability to Individual and/or Collective Training

Although the MEC literature suggests that MECs are "scalable in application from the individual to multi-team collective training" (Colegrove & Bennett, 2006, p.8), there is no specific guidance for how this is achieved, and whether any special considerations are made. One exception is that when more than one weapon platform is cooperating on a mission, both must be analyzed. Despite this lack of explicit guidance for collective training, the MEC analysis provides a structured approach to TNA, including gap analysis within the COMMAND workshop. As such, with additional guidance to include collective tasks within the SME workshops, MEC could be applied to a team and/or collective training domain.

3.4.6 Prescriptiveness of Analysis Elements

The MEC analysis process is prescriptive in the sense that it provides explicit detailed instructions and guided examples for the MECs development workshops, survey structures and report content. In particular, instructions for the COMMAND workshop and summary worksheet are highly structured. For example, official MEC workshops can only be led by a trained MEC specialist who leads SMEs through the process in a structured manner.

There is also detailed guidance on how to translate the MECs into training requirements. Tossell et al. (n.d.) describes an example of three approaches from which training developers can use the relationship among the various MEC components model to develop training:

1. Approach 1: Using MEC proficiencies. Using a deductive approach, the analyst works backwards from the highest level of MECs to determine training needs, including which competencies require training to the associated Knowledge, Skills and Experience that could be embedded into scenarios.

2. Approach 2: Using Comprehensive MEC Analysis and Needs Determination (i.e., COMMAND) process: Here, Developmental Experiences are reviewed in sequence, adhering to the following format: Within an given division, for each Developmental Experience, three questions are asked of SMEs, with survey data being presented for each on the importance, utility and personal experience related to each MEC.

3. Approach 3: Knowledge and Skill Inventory: individuals complete a Knowledge and Skill inventory to assess their current proficiency against the developed MEC standard. These results are then analyzed to understand training needs in relation to specific KSs (e.g., if most operators at a given position for a particular Knowledge or Skill report a Basic level when an Intermediate level is required).

The MEC process yields a set of complex, interactive tools (i.e., COMMANDS, Knowledge/Skills/Experience Mapping tool) that can be used to generate training opportunities in and of themselves. Conceivably, a training officer or commanding officer could analyze an

upcoming mission, select developmental experiences from the list, and train his subordinates. Similarly, based on failures on previous missions or identified training gaps across the training community, he or she could select one or more developmental experiences that would address the gap.

3.4.7   Usability

While existing MECs are mainly relevant to air operations, the general MEC development process of iterative workshops could be applied to any training strategy, given access to the appropriate SMEs. The fact that MEC is proprietary is the main limiting factor for utility, in that it cannot be conducted by a layperson. However, if an agency is willing to fund this particular effort, MEC appears usable primarily in the sense that the entire process would be guided by an MEC expert. As such, the average person would need not be concerned with the relative usability of the method – unless they wished to become trained themselves. Under this assumption, the MEC process seems useful for analyzing training requirements. Bennett et al. (2006, p. 2) state that MECs "generalize across many of the missions conducted in coalition operations that follow traditional doctrine and concepts of operation (e.g., air to air operations, air to ground/combat strike operations, air battle management)". In this context, the identified knowledge and skills, and the experiences associated with MECs proficiency could be transferable from one mission to another.

The MEC outcomes may be presumed to have content validity due to the systematic method in which MECs are constructed (Tossel et al., n.d.). Alliger et al (2013) further tested this concept through examination of survey data from different target populations, finding MEC measures reliable (performed in a way that valid measures would be expected to perform). The MECs examined demonstrated appropriate expert/novice differences in MEC proficiency ratings, expected relationships between general competencies and MECs, and reasonable relationships between job tenure and knowledge/skill.

3.4.8   Summary

MEC originated as a list of constituent elements that must be successfully carried out to achieve an air force mission. The success of the framework led the originators to recommend the framework be adopted by other military organisations and be developed into a method by which to derive the constituent elements. Similarly to BF analysis, MEC serves to describe training gaps, but do not necessarily direct the user how to train. Further TNA research could use MEC processes to define performance metrics used to assess the proficiency of MECs, supporting competencies, knowledge and skills, however details for collective training are lacking. It is possible that withholding of such information is an deliberate means to maintain control of the MEC process.

Table 3-7 shows the comparison of MECs to the CFITES baseline.

Table 3-7: Criteria Evaluation for MECs

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
MEC	-	=	=	=	-	+

3.5   Successive Approximation Model

3.5.1   Background

Successive Approximation Method (SAM) is based on the Agile software development process[12] and foregoes the linear, Waterfall approach of ADDIE in favour of many short iterations consisting of design/develop – prototype/implement – review/evaluate. Nevertheless, SAM is based on ISD and maps to ADDIE. Indeed, the developer notes that SAM is offered as an alternative to ADDIE, if ADDIE is not delivering effective training outcomes (Allen, 2012). Retain ADDIE if it is successful within the organisation (Allen, 2012).

In SAM, the preparation phase is meant to be a quick phase wherein information and background knowledge is gathered. In ADDIE the analysis phase might last for a significant period of time. SAM emphasises feedback on design to narrow in on training needs, rather than formal preliminary analysis. The end result of a SAM iteration is a completed, useable product. Successive iterations would add functionality to that product, with each cycle, again, resulting in an improved, useable product.

SAM was developed by Michael Allen, and there are two books on the method (Allen, 2012; Sites & Green, 2014). These books include guidelines and templates for new and experienced users. Apart from these two books, there is very little in the public domain concerning SAM. What does exist are brief descriptions of the method with no indication of where the method has been used.

3.5.2   Training Lifecycle Stage Addressed

SAM is presented as a solution for all stages in the ADDIE lifecycle, including analysis. It is unlikely, however, that SAM adequately deals with learner and program evaluation, focusing

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[12] Agile software development refers to a process by which requirements and designs for software projects evolve iteratively through rapid cycles of specify-design-develop-test. The Agile approach is characterized by a great deal of collaboration and responsiveness to emerging needs. Agile is contrasted to the traditional Waterfall approach to software development, which delivers a product to meet requirements that are agreed at the outset of the work and are unlikely to change. Typical military systems development (indeed, government acquisitions in general) follow a Waterfall approach.

instead on iterative evaluation of component pieces of the training solution. There is no evidence that this sort of evaluation necessarily scales to the whole training solution.

3.5.3   Alignment with Strategic Framework

SAM was developed to overcome perceived barriers common in development work (quality, timelines, budgets, managing SMEs) and to enhance the creation of performance-driven learning. It is unlikely that SAM, with such an objective, fits well within a strategic framework. Further, the AGILE process is very focused on the user, rather than the organisation. Following on from the observations in Section 2.2 concerning the Waterfall approach, larger organisations require predictable outcomes to overcome the organisational distance between the work being done and those setting the strategic direction for the organisation. SAM's rapid progression from nothing to a usable product may result in an unpredictable outcome where the organisation is concerned. This may, however, be well-suited to an urgent operational need (for instance, in theatre) where SAM may be able to provide 'just-in-time' training to a specific, and unforeseen, problem. Thereafter, the just-in-time training, as well as the subsequent performance, could be considered within a more formal training development process.

3.5.4   Governance

SAM attempts to circumvent the formality of governance in favour of creativity and innovation. Although the development process is managed and approved, unexpected solutions are acceptable because they may lead to a successful solution. In the Agile framework, however, development teams are self-organising and self-regulating, which also indicates a disconnect from governance.

3.5.5   Applicability to Individual and/or Collective Training

The method does not specify whether it is applicable to individual or collective training. It is expected that the developers of the method would state that it is applicable to collective training at any and all levels. There does not seem to be any aspect of the method that is specific to collective rather than individual training analysis and nothing to indicate that SAM would adopt a different framework to be applicable to collective training problems.

3.5.6   Prescriptiveness of Analysis Elements

As noted above, guidance and templates are available. In the interests of creativity, however, such guidance is unlikely to be prescriptive; more a framework within which to work. There are not any task lists or structured descriptions associated with the method, nor are there specific training objectives. These would vary according to the domain of application and, therefore, would need to be provided a priori to the analyst, as with MEC or METL examples.

3.5.7   Usability

While analysts may find SAM simple to wield, it is unlikely that the approach will exhibit much reliability. However, because of the iterative cycle of analyse, design, build and test, it is likely that training solutions developed through SAM will exhibit good validity for the specific problem

that they are addressing. This may scale upwards to training solutions intended for the full range of job tasks, and may also scale to collective training, but it is unclear from the available material whether problems of greater scale have been addressed.

Despite the existence of two books on SAM with associated templates, as well as occasional two-day user 'mega-workshops' in the method, it was not possible to find any opinions in the public domain on the usability or success of SAM. Thus, there is still no guarantee that the method is in fact useable.

3.5.8   Summary

SAM addresses all phases of the training lifecycle, although it offers less with respect to formal assessments of learners and the training solution. The method's usability may exceed that of CFITES but this is likely (at least in part) due to SAM's lack of prescriptiveness, its loose governance and its loose coupling with strategic objectives. It is unclear from the material reviewed whether SAM would be effective in TNA for collective activities. CFITES may be able to leverage some of the AGILE aspects of SAM but it is unlikely to offer much more to enhance CFITES ability to deliver Collective TNA or a tighter coupling with strategic objectives.

Table 3-8 shows the comparison of SAM to the CFITES baseline.

Table 3-8: Criteria Evaluation for SAM

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
SAM	=	-	-	-	-	+

3.6   Team Collective Training Needs Analysis

3.6.1   Background

Huddlestone and Pike developed and refined Team Collective Training Needs Analysis (TCTNA) over the course of 10 years. From 2005 to 2015 the authors conducted numerous individual and collective TNA research projects at Human Factors Integration Defence Technology Centre (HFI DTC) and Cranfield University (now the Defence Human Capability Science and Technology Centre [DHCSTC]) on behalf of the Defence Science and Technology Laboratory (DSTL), UK MOD[13]. A notable outcome from this decade was the Triangle Model of TNA, upon which the TCTNA method is based. The Triangle model contains a training task analysis, training overlay analysis, training environment analysis all centered around

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[13] https://www.defencehumancapability.com/HFIDTCLegacy.aspx

constraints analysis (Huddleston and Pike, 2009). These components represent some, but not all of the TCTNA components.

TCTNA was officially developed in 2011 to supplement the task analysis and TNA guidance provided in JSP822 (Pike and Huddlestone, 2011). The 2011 publication was in response to a request by the Royal Navy to provide TNA guidance for Collective Training for the Queen Elizabeth Class Aircraft Carriers (Pike and Huddlestone, 2011). In 2014, a TCTNA methodology update and user guide was published by DHCSTC, which included a team/collective tasks analysis and elaboration on the constraints analysis to include additional assumptions, risks and opportunities analysis (Huddlestone and Pike, 2014). The most recent TCTNA found in Huddlestone and Pike's (2016) hardcover guide. Part one of the book explains the underpinning TCTNA models while Part two explains the analytical approaches exemplified through detailed case studies.

TCTNA is an integrated framework for collective training developed by authors Huddleston and Pike for the DHCSTC. TCTNA was designed to extend and amplify the extant guidance on TNA provided in JSP822 (discussed in Section 3.8). The Defence Training Support Manual (DTSM. summarized in Huddlestone & Pike, 2014) provides a systematic approach for TNA grouped as three overall phases:

1. Phase 1 is the TNA scoping study which identifies project management details including risk, resourcing, assumptions etc.;

2. Phase 2 is the TNA development which designs the training through the conduct of operational and business task analysis, gap analysis, fidelity analysis, and training options analysis; and

3. Phase 3 is the TNA post project evaluation which reports on the effectiveness of the overall training solution.

Huddlestone and Pike (2014) point out that although the DTSM alludes to team and collective training, the TNA analytical techniques (at least at the time) were developed for individual training and not easily transposable to the team and collective level. Further, the team training itself must be scalable from a small team of two individuals, up to a Joint Task Force operating in a multinational context (Huddleston & Pike, 2014). TCTNA was therefore developed to address team and collective training gaps through the provision of additional analyses (and their relationships) within the first and second TNA phases. These analyses address the complexity of team and collective training needs through consideration of the relationship of "individual and team tasks, teamwork, command and control, task and training environments, scenario definition, instructional strategy, team training approaches, instructional strategy, and wide-ranging organisational and procurement considerations" (Huddlestone & Pike, 2016, p. xxii).

To address the areas of complexity posed by team and collective training, the TCTNA is composed of a set of analytical tools to be used by the researcher, which are based on a set of inter-related models. As illustrated in Figure 3-8, the analyses include the Team/Collective Task analysis, the Training Environment Analysis, the Training Overlay Analysis, the

Constraints Analysis and the Training Options Analysis. The Team Training Model presents a system of models relevant to each analysis process. These include the Team Performance model, consisting of the Team and Collective Task Model and the Training Environment Model, and the Training Overlay Model.
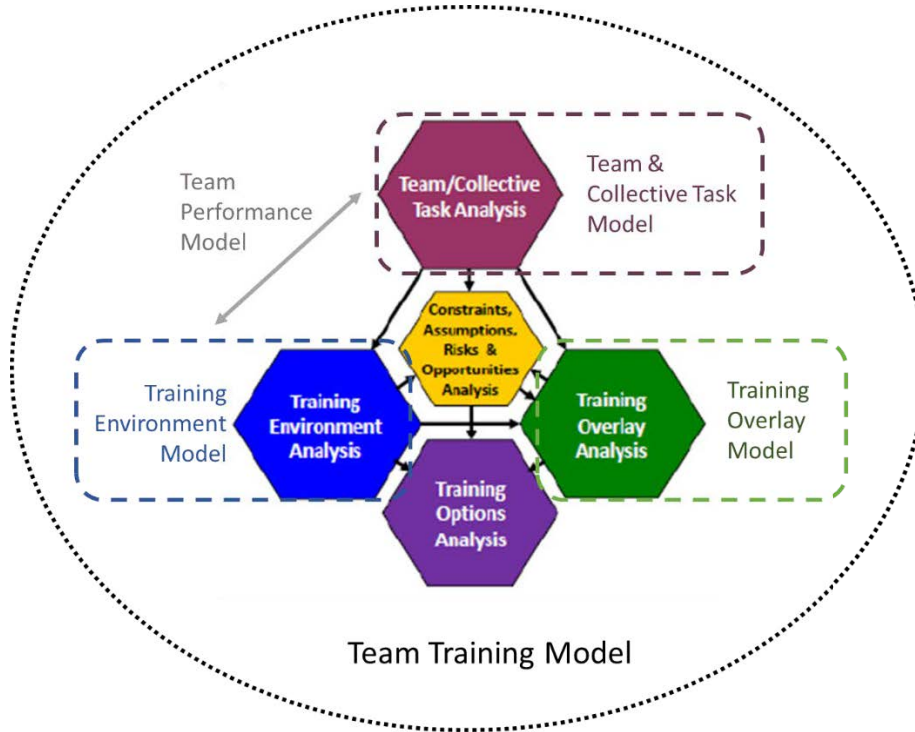
Figure 3-8: TCTNA Analysis Components and Related Models (adapted from Huddlestone and Pike, 2014, p.9)

The following section present the TCTNA analysis followed their relevant models.

3.6.1.1   TCTNA Analyses

TCTNA prescribes a framework of interdependent analytical processes (Figure 3-9) intended to systematically identify the most optimal collective training options. Through an iterative process of developing team/collective training requirements, taking into consideration the environmental context, the supporting training overlay and constraints, assumptions, risks and opportunities among them, the respective training options can be identified and valuated (Huddlestone & Pike 2014; 2016).

The following summarizes Huddlestone and Pike's (2014; 2016) TCTNA analysis components (refer to Figure 3-9):

- The Project Initiation is not an analysis component but is the first phase in the overall process of conducting a TCTNA where typical project management activities such as objectives, risks, timelines and required outputs are defined.

- The Team/Collective Task Analysis is first conducted to identify the key task conditions, including team and sub-team descriptions, the task processes, team interactions, the intermediate outputs of the task, the evaluation criteria for both the processes and the outputs. The products of this analysis serve as the starting points for the subsequent Training Environment and Training Overlay Analysis processes.

- The Constraints, Assumptions, Risks and Opportunities (CARO) Analysis which captures all of the factors which impact on the development of a suitable training strategy and the viability and suitability of alternative training options. The CARO is most often known in the early planning stages, but can be elaborated through the task, environment and training overlay analyses.

- The Training Environment Analysis takes into account information gathered from the team/collective task analysis to identify the environmental context pertinent to all elements within the training, including fidelity requirements.

- The Training Overlay Analysis is used to specify the training strategy in consideration of the assumptions, constraints, opportunities and risks identified as part of the CARO, as well as the task structure, assessment requirements and task conditions identified within the Team/Collective Task Analysis. The training strategy includes specific aims such as training objectives, priorities, staff requirements, duration and system capacity. Finally, the training overlay analysis defines interactions with the strategy and training environment.

- Training Options Analysis determines the range of alternative training alternatives (e.g. media) that are aligned with outcomes from the Environmental Analysis, the Overlay Analysis (i.e., the strategy) and the CARO.

A schematic overview of the TCTNA process is shown in Figure 3-8. From a top-down perspective, the diagram depicts a linear as well as iterative process sequence, including the relationships between processes. The products from each process are included in the respective coloured boxes, and also summarized (for readability) in Table 3-9. Detailed descriptions and examples of all TCTNA products are provided in Huddlestone and Pike (2014 & 2016).

1 Project Initiation

TCTNA Initiation Document to include: Aim, context, scope, links to other analyses, required outputs, key project data, management structure and process, methodology, data sources and points of contact, resources, plan and timescales, risks, assumptions, constraints and opportunities

Analysis

CARO known at the planning stage

2 Team/Collective Task Analysis

Conditions table, team organisation description, task decomposition (task network diagram and description table), team knowledge

3 Constraints, Assumptions, Risks & Opportunities (CARO) Analysis

Constraints table, Assumptions table, Risk register, Opportunities table.

Whilst CARO can best be evaluated once the task has been understood, some may be well known at project start-up (hence the link from 1). Analysis of the environment and overlay may also highlight other CARO (hence the links from 4 and 5)

CARO impact on training strategy development and training option selection

Task conditions, cues and outputs, team composition, non-team actors

Task structure, assessment requirements and task conditions

4 Training Environment Analysis

Training environment diagram, Training environment specification tables (includes fidelity requirements)

Environment elements

5 Training Overlay Analysis

Training Strategy : priorities, training objectives, throughput, structure and sequence, duration, system capacity

Detailed Overlay Requirements: Staff requirements, overlay interfaces to the training environment (set-up and control)

Environment specification

Overlay specification

6 Training Options Analysis

Training Option Definition: Identification of options, option description, costs
Option Evaluation: development of criteria, option comparison

Figure 3-9: TCTNA Process Sequence/Aide Memoire (Huddlestone & Pike, 2012, p. 11)

Table 3-9: Summary of TCTNA Products [14]

TCTNA Analysis	Products
Project Initiation	• Project Initiation Document
Team/Collective Task Analysis	• Task Scope Description • Team/Collective Organization Description • Task Conditions Table • Task Network Diagram • Task Description Table • Team Knowledge Table
CARO Analysis	• Constraints Table • Assumptions Table • Risk Register • Opportunities Table
Training Environment Analysis	• Training Environment Diagram(s) • Training Environment Specification Tables
Training Overlay Analysis	• Training Strategy • Detailed Training Overlay Requirements
Training Options Analysis	• Option Descriptions • Selection Criteria Definition • Option Evaluation Table • Training Options Recommendations

3.6.1.2   TCTNA Models

The analytical processes described above within the TCTNA methodology are connected by a system of interwoven models within an integrated Team Training Model. Pike and Huddlestone (2011) developed the Team Training Model from a comprehensive review of existing teamwork

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[14] See pages 12-13, and Appendixes A to F of Huddlestone and Pike (2014) for detailed descriptions/ examples.

and team performance models synthesized to describe the TCTNA process. The Team Training model illustrated in Figure 3-10 is comprised of five interrelated models that directly support the TCTNA analysis processes.

A series of detailed model component descriptions are provided within Huddlestone and Pike (2014; 2016). The following summarizes the TCTNA model components (see also Figure 3-10):

- The Team and Collective Task Model guides the users on decomposing team and collective tasks within the tasks analysis process - not only with the decomposition of the task, but also with the identification of assessment criteria for both the tasks processes and their products.

- The Training Environment Model, which is part of the Team and Collective Task Model, prescribes a method for analysing training environment into fidelity requirements to replicate the task environment for training purposes. Both of these support the Team Performance model.

- The Team Performance Model considers team processes to generate outcomes that affect Team and Collective Task Analysis in terms of the significance of the properties of the team members and the properties of the overall team on the execution of team tasks, which transform the environment. All aspects of the Team Performance Model feed into the Training Overlay Model.

- The Training Overlay Model provides a detailed breakdown of all of the elements of the training strategy in terms of tasks and resources that are required for training to be delivered effectively.

- The Team training model is simply the comprehensive view of the team performance model and the training overlay model. The full Team Training Model (p. 26 of Huddlestone and Pike, 2014) provides the most detailed schematic of the various types of data that are captured across the whole of the TCTNA process.
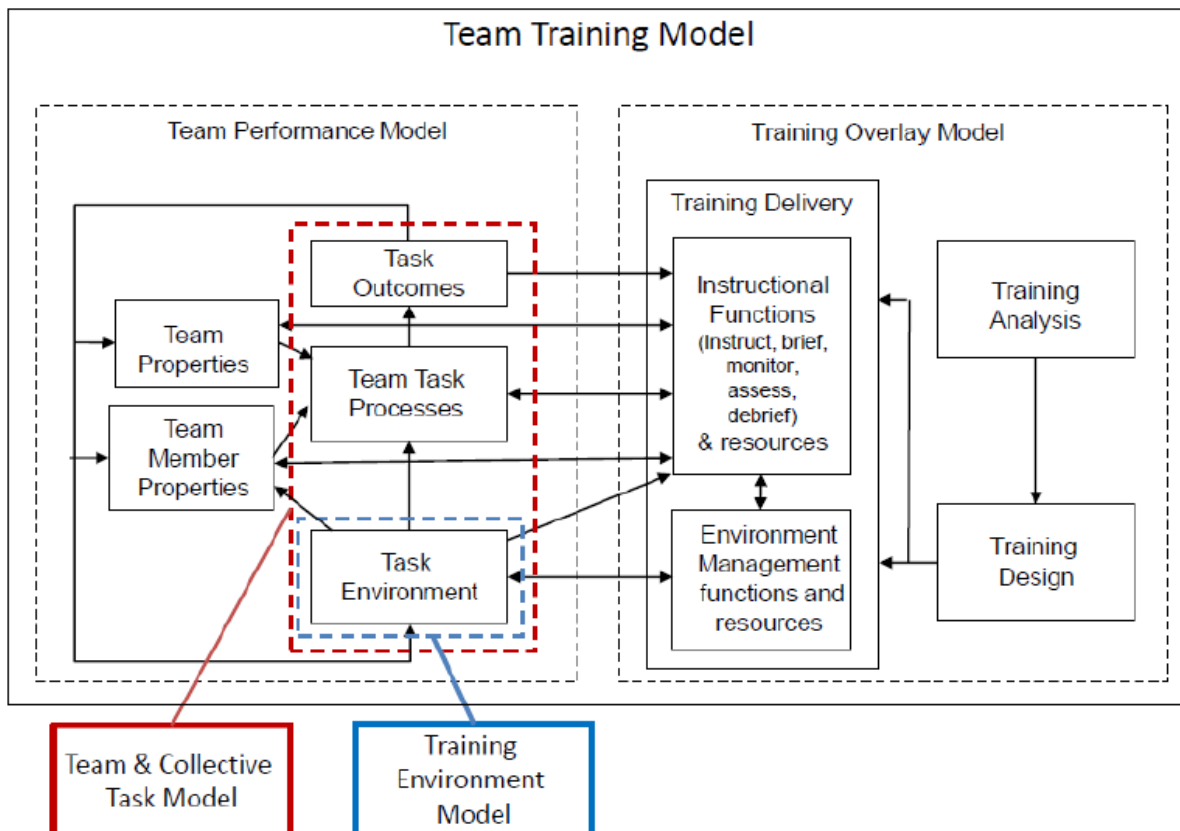
Figure 3-10: Models underpinning the TCTNA Method (Huddlestone & Pike, 2014, p.15)

3.6.2   Training Life Cycle Stage Addressed

As illustrated in Figure 3-9, the TCTNA only describes the Analysis stage of the ADDIE model. Analysis is the driving factor behind all major TCTNA process: Team/Collective Task Analysis, Training Environment Analysis, Training Overlay Analysis, and Training Options Analysis. As with the TNA, TCTNA is considered an up-front analysis used to define the nature and extend of training required. The method does not provide specific guidance on how to develop or evaluate that training.

3.6.3   Alignment with Strategic Framework

TCTNA was developed as part of a coherent strategy of Human Factors research for the HFI DTC. TCTNA was originally developed to supplement the guidance in the Joint Service Publication concerning individual training by extending training analysis to encompass collective training. Thus, TCTNA can be said to fit within a strategic framework, although it was developed deliberately to avoid being beholden to any strategic framework. In other words, TCTNA should be amenable to adoption by, and integration within, any strategic framework.

3.6.4   Governance

TCTNA is not governed by a particular body and therefore has no governance processes or organisation associated with it. The detailed user guides in Huddlestone and Pike (2014; 2016) instead provide a framework upon which users can impose their own governance structure that suits their organization. The most governance-like direction comes from the development of the project initiation document; "when endorsed it forms the Terms of Reference for the analysis team" (Huddlestone and Pike, 2014, p. 27). Each analysis phase of the TCTNA produces a number of products (see Table 3-9) for consideration by other stakeholders in the organisation. These outputs would enable the authoritative bodies in a given organization to oversee the planned training within the context of the desired strategic direction.

3.6.5   Applicability to Individual and/or Collective

TCTNA is fully dedicated to collective TNA, but could also be used for individual training needs. The outputs are equivalent output to that of individual TNA but with additional information pertinent to the team and collective context.   A key difference between the TCTNA approach and the analysis approach for individual training is that there is not a separate analytical approach recommended for conducting scoping studies. Within the TCTNA approach the analysis stages are applied iteratively as required.

There are a number of team and collective training outputs that are useful for analysing team activities described as part of the team/collective tasks analysis. The two most relevant products to team communication networks are the task network diagram and the Team Knowledge table, summarized from Huddlestone and Pike (2014) below:

- A Task Network Diagram (see Figure 3-11) illustrates the sequence of actions undertaken and intermediate outcomes that are generated as a result. The use of a task diagram may assist task decomposition and facilitate SME discussions by validating task sequences and activity phases within the team. An accompanying task description table details each sub-task identified in the task network diagram (e.g. participants, inputs, processes) including team interactions, relevant task conditions, and systems used by the team.

- A Team Knowledge Table captures the underpinning Knowledge Skills and Attitudes required by team members to form appropriate task execution mental models. This information needs to specified by the analyst, but is used to inform the development of knowledge-related training objectives in the Training Overlay Analysis. Limited guidance was provided for this product.
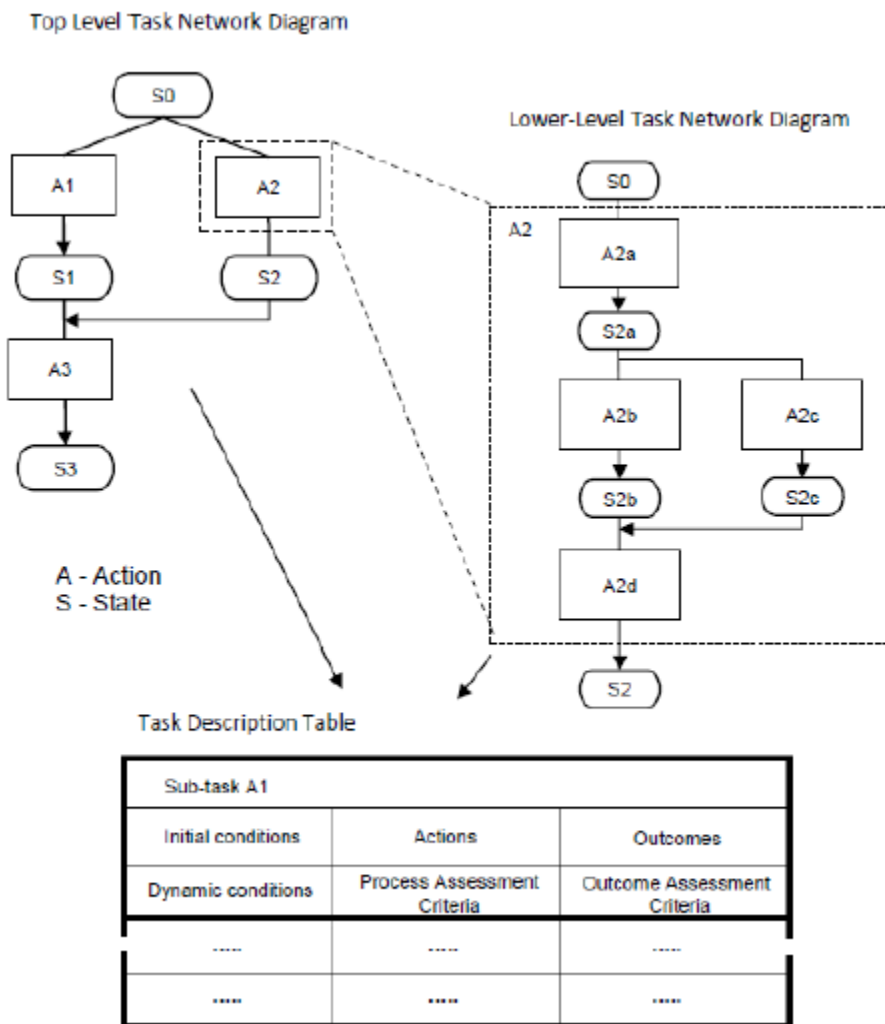
Figure 3-11: Overview of Task Network Diagrams and Task Description Table (from Huddlestone and Pike, 2014, p. 40)

3.6.6   Prescriptiveness of Analysis Elements

TCTNA is quite prescriptive in that provides detailed instructions and guided examples for every analysis type. The user guide in Huddlestone and Pike (2014; 2016) contains dedication sections for each of the five analyses including the project initiation. The guides describe the following phases:

1. purpose of the analysis (and context within the TCTNA model);

2. an overview of the process of how to conduct the analysis;

3. descriptions and examples of the associated products;

4. suggested information sources that can be used to complete the analyses;

5. criteria used to assess the analysis quality; and

6. specific analysis guidance for each step (e.g. how to establish scope, describing the training audience.

The Appendices of Huddlestone and Pike (2014), Part 2 of Huddlestone, and Pike (2016) flesh out the entire TCTNA process using detailed case studies.

3.6.7   Usability

Given the high level of prescriptiveness as well as significant cross-referencing from the analysis sections, models and analytical tools, the TCTNA could be expected to be used with a reasonable degree of reliability and validity.

The user is guided by indexed chapters linked to the TCTNA diagram (see Figure 3-9) on how to selectively use the TCTNA method for various analyses. As mentioned in the previous section, the TCTNA user guides contain detailed examples of completed TCTNAs in various domains to assist the reader's understanding (Huddlestone & Pike, 2016). Within each analysis section, there are a number of tools described and presented for use during conduct of the TCTNA framework, including process flow charts, relational diagrams and tables. These help to organize the data. Selection of appropriate tools is dependent on the complexity of the task/mission being deconstructed.

Within the user guides, the authors provide a number of guidelines and suggestions for ways to conduct the analysis and validate the quality of the results. For instance, it is well known that for any task analysis, the level of detail depends on the purpose of the analysis. To assist the users, the authors describe "stopping rules" for task decomposition and a task diagram in the detailed instructions for how to complete team/collective tasks analyses.

This view is supported by a number of subjective reviews available online.[15] Several quoted examples from the review of Huddleston and Pike (2016) guide are provided below:

> '[TCTNA]… provides processes on the elements of team and collective training analysis, gives a toolkit for those involved with the acquisition of related training systems and, more importantly, is an essential guide for those who want to make their training better.' Commander Paul Pine, Royal Navy (Maritime Training Acquisition Organization)

> 'This is an exceptionally comprehensive look at team and collective training. It provides a rare insight into the methodology of training needs analysis and how it can address the complexities beyond the individual level. The author's credentials are apparent and amply demonstrated in the worked examples and

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[15] https://www.amazon.ca/Team-Collective-Training-Needs-Analysis/dp/1409453863

case studies.' Lt Col (Retd) Guy Wallis, Principal Analyst, Defence Science and Technology Laboratory.

Nevertheless, the consistency of efficiency of output will also depend on the skill and experience level of the analyst which would need to incorporate experience in training development, human factors and domain expertise. The TCTNA could be considered difficult in that multilayers of analysis make it time consuming and labour intensive, but not necessarily reflective as poor usability. Time-wise, the TCTNA represents a significant organizational undertaking reflecting the complexity of team and collective tasks (Huddlestone & Pike, 2016), which could perhaps be weighed against the time and cost of a poorly performed analysis. The authors themselves describe it as a likely complex task that needs to be set up correctly from project initiation. However, given that TCTNA was developed to address the failure to consider complexity in other TNA methods, it would seem that some degree of complexity within the analysis should be expected by the analyst.

3.6.8   Summary

TCTNA is primarily an analysis method, based on the current state of the art and is arguably the only TNA method directed specifically toward collective training needs. The method was developed to be generic so it is not necessarily tightly coupled to any strategic framework, nor does it have governance mechanisms built in but, as will be seen in Section 3.8, such alignment and mechanisms can be added. The TCTNA method is prescriptive without being overly rigid and is usable for novice or inexperienced analysts. Difficulty in applying the method stems from its inherent design to consider the complex nature of collective training, as well as the high dependence on SME involvement and analyst expertise.

Table 3-10 shows the comparison of TCTNA to the CFITES baseline.

Table 3-10: Criteria Evaluation for TCTNA

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
TCTNA	-	+	=	-	+	=/+

3.7   Team Training Needs Analysis

3.7.1   Background

A leader in the field of Human Factors and training, Eduardo Salas has a long list of publications. In particular, Salas has been involved in research concerning simulation-based training and team work. Salas and his collaborators compiled the key conceptual findings of

this research history in a book describing team training essentials (Salas, Benishek, Coultas, Dietz, Grossman, Lazzara and Oglesby, 2015).

Salas' book is intended to be a simple-to-use guide for training professionals and uses approaches to assist the reader to organise and retain the information being presented. Salas et al (2015) do this by organising the information into five pillars. Each of these pillars is broken down into two or more principles. Principles are then broken down into guidelines all of which are supported by specific tips and advice that take the guide from research-based theory to practical application. The numerous tips and advice are quite specific and therefore are not described in detail here; except to say that they support the use of the corresponding guideline when put into practice. Principles and guidelines are numbered contiguously across pillars and principles. Salas et al describe a Team TNA method in Chapter two, which concerns pillar one: Ensuring the need for teamwork behaviours and team training. Pillar one is comprised of two principles, described further below.

Principle one of pillar one is to systematically identify characteristics of the organisation, team tasks and individual team members. Principle one consists of three guidelines. Guideline one recommends that training analysts determine how organisational factors (e.g. culture, climate, strategic goals) may facilitate or hinder teamwork. This guideline implies that an organisational analysis should be performed, in particular to determine how and whether stated training objectives are supported by and supportive of organisational factors. This activity should involve interviews, documentation review, and consideration of existing team training materials.

Guideline two recommends that the training analyst defines the team's purpose and what teamwork competencies (i.e., KSAs) are required to achieve team goals. This step requires that a team task analysis be carried out. This identifies the operational tasks (taskwork) and the teamwork (communications, coordination, cooperation) behaviours required for effective team performance. Both elements of performance (i.e. taskwork and teamwork) are necessary precursors for effective team performance; one or the other will not suffice. The Team task analysis will inform what needs to be trained as well as how to evaluate team training success. These steps are discussed under pillar three and pillar four respectively. The first step is to specify the jobs that require teamwork, describe their essential components (work functions, resources required) and then identify the key task requirements (i.e. task and teamwork KSAs). Finally, task specifications (job conditions, quality/performance expectations) should be identified. This all answers the what, the who and the how much. Appendix 1 of the Salas et al (2015) lists potential teamwork KSAs.

Guideline 3 is used to understand the individual characteristics likely to impact teamwork and team training. This "person analysis" also helps identify which personnel will most benefit from team training, and which personnel already have the necessary KSAs for team tasks. This can help prioritise training in the event that resources, opportunities or funds are restricted. Individual characteristics such as motivation and learning preferences can also influence the success of team training and not all learners will benefit equally from training opportunities. Information such as cognitive ability, age, self-efficacy and personality (Salas et al, 2015) will affect the design of team training.

Pillar one includes a second principle. Principle two recommends that the training analyst evaluate whether the organisation is ready to receive team training. This involves determining whether teamwork deficiencies are the root cause of organisational problems, confirming that team training is the most appropriate solution and ensuring the organisation can support team training activities.

Guideline four recommends that the training analyst analyse the cause of performance deficiencies and consider appropriate improvement strategies. If analysis shows that the performance deficiency is traceable back to an individual KSA, then team training might not be the most effective solution. Likewise, implementation of job aids may be a more effective solution than training. Determining the nature of the deficient KSA will guide whether the organisation should offer team training, improve the nature or availability of job aids or provide some other intervention.

Guideline five recommends that the training analyst determine whether the organisation can adequately support team training. Salas et al. (2015) conceptualise it as an extension of guideline 1 and 3. Factors in the workplace that might influence training effectiveness include a supportive work environment, whether systems are in place to prepare and motivate the learner, logistical arrangements, and so on. Tips and advice are given.

As noted above, the specification of what needs to be trained (i.e. EOs and POs) is discussed by Salas et al (2015) under pillar three: design team training for maximum accessibility, usability and learnability. While this pillar deals primarily with design of the training system, principle six (systematically design team training based on what is scientifically shown to be effective), guideline 16 deals with the definition of learning objectives. Salas et al (2015) recommend that the training analyst define the learning objectives prior to beginning design and development work. The learning objectives should be action-oriented, specific and measurable (Salas et al, 2015). Salas et al (2015) adapt the team competency model of Cannon-Bowers et al. (1995) depicted in Figure 3-12.
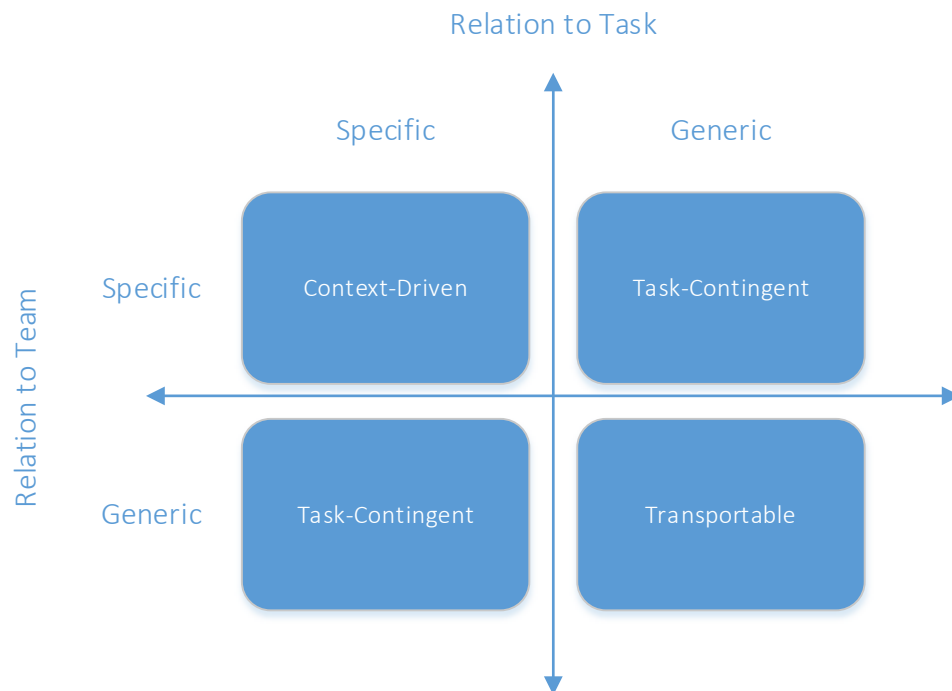
Figure 3-12: Types of Team Competencies (adapted from Cannon-Bowers et al, 1995)

Cannon-Bowers et al (1995) describe the four team competencies (i.e., quadrants) in the model as follows:

- Task-Contingent: relevant to specific team tasks only;

- Team-Contingent: relevant to a specific team only;

- Context-Driven: relevant to a particular combination of team and task; and

- Transportable: broadly relevant in a wide variety of team or task contexts.

Salas et al (2015) also offer guideline 17, which advocates selecting the specific teamwork KSAs to be targeted by team training. KSAs are considered more granular and specific than the learning objectives discussed in guideline 16 and should be defined accordingly. These KSAs should also be amenable to measurement by measurement defined method. As noted above, a list of potential KSAs is provided by Salas et al (2015) in an appendix, but these are neither applicable to all contexts, nor are they exhaustive.

Salas et al (2015) also offer some guidance on how to develop approaches to assess team training. This is the subject of pillar four: evaluate the team training programme. Salas et al. (2015) take a broad view of this and provide principles and guidelines to address the assessment of both the learner and the training programme.

Although Salas et al. (2015) provides extensive guidance for the full training lifecycle, most of the guidance is at the conceptual level. The exception to this is the provided tips and advice but, ironically, these are pitched a level below where a novice training analyst would need prescriptive guidance.

3.7.2 Training Lifecycle Stage Addressed

Salas et al. (2015) present a method that covers the entirety of the training lifecycle but for this review only the analysis phase was considered. In comparison to CFITES, the specification of EOs and POs is moved to the training design phase from the analysis phase, and development of evaluation measures (of trainee performance) is moved to an evaluation phase from the analysis phase. Nevertheless, Salas et al (2015) have addressed the full training lifecycle described by the ADDIE model. The expertise also seems to reside in analysis of the team work context, rather than in the implementation of the training system, in keeping with their background as a research organisation rather than a development organisation.

3.7.3 Alignment with Strategic Framework

Salas et al. (2015) note the importance of setting the Team TNA within the organisational context but provide no advice about how this should be done. For example, their tips and advice include: "Define the organisation's goals, structure, operational environment, and strategic objectives." This speaks to the intent for the Team TNA to be set within the organisational framework and to take deliberate account of the mission context, but indicates that their method was not developed for a specific organisation, nor has it been altered or applied to support an actual institutional application (as opposed to carrying out training analysis in an academic context).

3.7.4 Governance

Salas et al. (2015) do not make any mention of governance mechanisms. Specifically, there is no mention of a steering group or oversight by any individual or group. There is no discussion of the specific analysis team members or their roles and responsibilities. There are no reporting requirements and no reporting formats mentioned, and there is no timeline in which the analysis should be carried out. Finally, there is no discussion of the level of authority that individuals involved with the training analysis should wield (i.e. to overcome obstacles to the training analysis).

3.7.5 Applicability to Individual and/or Collective Training

The Team TNA method is based on the extensive experience of Salas and his collaborators in the field of teamwork. The Team TNA method is intended to address team training; however it exhibits very few differences from a standard individual TNA. Salas et al (2015) also do not make any reference to the levels of collective training or specific organisational groupings (e.g. Squadron or Wing) that might indicate specifically what level of training their method targets.

3.7.6   Prescriptiveness of Analysis Elements

There is very little prescription in the method described in Salas et al. (2015). As noted above, most of the information is at the conceptual level, and the tips and advice seem to bypass the practical level of guidance that a novice analyst would require in order to carry out a training analysis and produce output that is comparable to another trained analyst. There are no task lists or structured descriptions of learning objectives, nor is there any guidance on how to move from analysis data to analysis outcomes (i.e. training objectives and requirements).

The book does, however, provide a list of KSAs in the appendix. This would be useful to a novice or inexperienced training analyst. These KSAs are named, described and associated with example behavioural markers. Representative reference sources are also listed with an indication of whether there is significant or moderate empirical evidence for the existence of the KSA. The KSAs are grouped as attitudes, behaviours and cognitions, but are not differentiated according to whether they represent knowledge or skill. The KSAs are presented in general terms and are thus broadly applicable across the range of potential team work context. They are not otherwise related to the training analysis process described by Salas et al (2015). The KSA list was originally presented in Salas, Rosen, Burke & Goodwin (2009).

3.7.7   Usability

There is no indication of the usability of the Team TNA method. Salas et al (2015) note that background materials are required to carry out the analysis, but they do not make reference to specific material. Likewise, Salas and his colleagues do not describe any events, tools or infrastructure that assist in the training analysis. On the basis of the information given, it is not possible to judge the likely reliability and validity of training analysis outcomes beyond stating that they are unlikely to be good, given the lack of instructions on how to carry out each analysis element. This would make the method difficult to use, since an analyst would effectively have to develop this level of understanding them self. This calls into question the overall utility of the approach.

3.7.8   Summary

Team TNA addresses all phases of the training lifecycle but focuses more on the research and theories behind teamwork and training than on the practicalities of analysing, developing, delivering and evaluating training. There is very little guidance on how to perform a Team TNA and no effective governance mechanisms or alignment with strategic objectives. The Team TNA description does, however, include a list of KSAs in the appendix to the book which might be helpful to standardise training analysis for collective tasks.

Table 3-11 provides the criteria evaluation for Team TNA that is used to compare between methods.

Table 3-11: Criteria Evaluation for Team TNA

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
Team TNA	=	-	-	-	-	-

3.8   UK Ministry of Defence JSP822

3.8.1   Background

Joint Service Publication (JSP) 822 is the authoritative policy and guidance document for the UK MOD to support assurance that defence training and education is appropriate, efficient, effective and safe. JSP822 represents the practical implementation of the research-based Defence Systems Approach to Training (DSAT), which provides a structured conceptual framework within which JSP822 is based. JSP822 is in two parts: a directive (Part 1) and guidance (Part 2). Part 2 assists staff to comply with Part 1.

DSAT has four stages (elements): analysis, design, delivery, and assurance (see Figure 3-13) with feedback loops from assurance to the preceding stages (for continuous improvement of the training system, similar to the ADDIE model portrayed in Figure 2-1). DSAT is part of the Management of Training Systems (MTS), which further includes management and governance.

Historically, JSP822 was focused on individual training. However, it became increasingly clear that training was conducted in Pan-Defence and Joint environments. Therefore, it was decided all training, even at the earliest points, should incorporate collective aspects and collective training should incorporate elements of individual training. Individual training provides the building blocks of collective performance, which in turn is a necessary element of delivering a defence effect. Thus, individual and collective training must be considered together.

JSP822 Part 1 includes terms of reference for a Collective Training Customer Executive Board (CEB, effectively the recipient of the outputs from a QSWB in the CFITES model) including accountability, membership, responsibilities, authority and frequency of meetings, and a section on collective training itself. Figure 3-14 outlines the activities associated with the individual and collective training analyses in JSP822.

Element 1. What is the requirement; is a new training activity needed; and, if so, what kind?

ANALYSIS

Statement of Requirement (SOR)
TNA Steering Group (TNASG)
Stage 1: Scoping Exercise Report
Raise Training Authorisation Document (TrAD)
Role Analysis (RA)   Team/Collective Task Analysis (TCTA)
Role Performance Statement (Role PS)   Team Performance Statement (Team PS)
Stage 2: Training Gap Analysis (TGA)   Overlay Analysis (OA)
Draft Training Objectives (TOs)   Draft Collective Training Objectives (CTOs)
Training Options Analysis (TOA)   Environment Analysis (EA)
Training Needs Report
Risk/Assumption Management
Pipeline Management
Statement of Trained Requirement (SOTR)

Element 2. What should the training activity look like; who will deliver it, and with what resources?

DESIGN

Trained Output Requirement Review
Stage 1: Individual/Collective Training Objectives (TOs/CTOs)
Formal Training Statement (FTS)
Enabling Objectives (EOs) / Key Learning Points (KLPs)
Stage 2: Assessment Strategy
Selection of Methods & Media
Stage 3: Learning Scalar / Learning Specification (LSpec)
Collective Training Trainer Tasks
Risk/Assumption Management
Training Design Review
Training Authorisation Document (TrAD)

Element 3. The training activity is delivered.

DELIVERY

Statement of Training Task (SOTT)
Defence Trainer Capability (DTC)
Preparing Training
Programming, Scheduling and Resourcing of Training
Piloting of Training Activity
Management of Training Deficiency
Commander's Risk Assessment (CRA)
Collective Training Risk Management
Training Quality Manual (TQM)
Trainee and Trainer Management

Element 4. Is the training activity being delivered correctly and does it meet the requirement? Is the whole Training System fit for purpose?

ASSURANCE

Stage 3: Training Needs Evaluation (TNE)
Continuous Improvement (CI)
3* - DPTB / JCSSG
2* - Training Policy Group / DJCTEC
1* - TESRR PAG / JCTWG
Customer Executive Board (CEB)
Working Groups/Steering Groups (WGs/SGs)
Evaluation Strategy plus InVal and ExVal
1st Party Audit and Inspection
2nd Party Audit and Inspection
3rd Party Audit and Inspection

Figure 3-13: Four elements of DSAT (from MOD, 2016, Part 2, p. 3)

The individual training section in JSP822 mandates the following activities:

- Analysis:

  - scoping exercise report;

  - role analysis;

  - training gap analysis;

  - draft training objectives;

  - training options analysis; and

- training needs report.

- Design:

  - individual Training Objectives (TOs);

  - formal training statement;

  - enabling objectives;

  - assessment strategy;

  - selection of methods and media; and

  - learning scalar/learning specification.

- Delivery:

  - adherence to Defence Technology Centre policy;

  - preparing training;

  - programming;

  - scheduling and resourcing of training; and

  - management of training deficiency.

There is also a great deal of guidance concerning the manner in which individual trainees are dealt with on an interpersonal level to ensure that different maturities are managed correctly.

The section describing collective training policy does not enumerate the different analysis, design and delivery activities; although it specifically states that it extends existing policy on individual training. Guidance concerning outputs, processes and products is provided in Part 2. The directive defines Tier 0 through Tier 4 (0: sub-unit, 1: unit, 2: tactical formation, 2+: component level joint, 3: combined/joint and 4: strategic). The directive also defines a continuum of collective training from integration, core adaptive, joint competency, coalition competency to In-theatre training. The directive states that collective training consists of four components: supportive information, part-task practice, just-in-time information, and whole training tasks followed by evaluation, validation and certification. The inclusion of whole tasks minimises the risk of collective tasks being completed successfully despite performance being poor on component parts of the tasks. In other words, training should not be deemed successful because trainees accidentally succeeded with no corresponding learning or insight into their performance.

In Part 2 the most significant differences between the approach to individual and collective training in the DSAT exists during the analysis phase. In both cases the process begins with

the formation of a TNA Steering Group (TNASG) followed by a Scoping Exercise Report. The Raise Training Authorisation Document (TrAD) step marks the deviation between individual and collective training:

- Individual training proceeds through:

  - Role Analysis;

  - Training Gap Analysis;

  - Draft Training Objectives; and

  - Training Options Analysis.

- Team/Collective training proceeds through:

  - Team/Collective Task Analysis;

  - Overlay Analysis;

  - Draft Collective Training Objectives; and

  - Environment Analysis.

Both individual and collective training analyses are documented in a Training Needs report. Then the analysis phase is concluded with Risk/Assumption Management, Pipeline Management and a Statement of the Trained Requirement. This information is then passed forward to the training design activity during which the training objectives and enabling objectives are identified (unlike CFITES which includes these as part of the analysis phase).

JSP822 Part 2 explicitly describes the governance to be applied. This increases the likelihood that the training integrates with and fits within a strategic framework provided by organisation objectives. The JSP822 approach to individual and collective training analysis (i.e. not the alignment with the strategic direction nor the governance structure) is based wholly on the method developed by Huddlestone and Pike (2016) under the auspices of the HFI DTC.
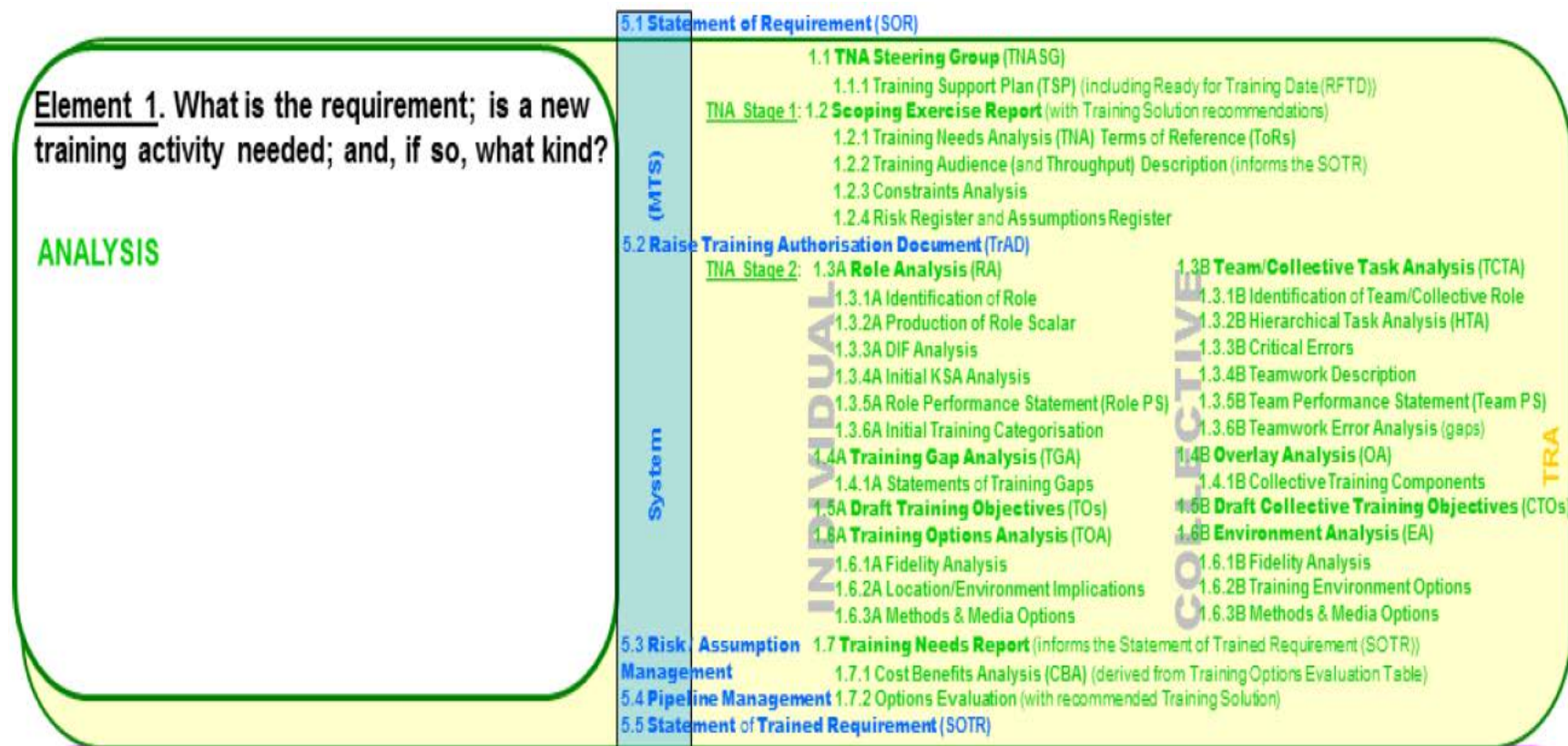
.

Figure 3-14: Training Analysis Phase of DSAT (from MOD, 2016, Part 2, p. 14)

3.8.2   Training Lifecycle Stage Addressed

JSP822 addresses all phases of the training lifecycle, although uses a slightly different model to ADDIE. Table 3-12 compares the ADDIE phases with outlined in JSP822.

Table 3-12: Comparison of ADDIE and JSP822 Training Phases

ADDIE	JSP822
Analysis	Analysis
Design	Design
Develop	
Implement	Delivery
Evaluate	Assurance

JSP822 has specific guidance for all phases including, of particular relevance to this work, the Analysis phase. Many of the initiating inputs to the Analysis phase are analogous to those in CFITES, as are the outputs. PO and EO, however, are not developed until the Design phase, unlike CFITES in which they comprise part of the Analysis phase.

3.8.3   Alignment with Strategic Framework

JSP822 is the authoritative policy document covering training in the MOD. As part of JSP822, the collective TNA methodology must be assumed to be fully aligned with the strategic framework of the MOD as a whole, as well as the environmental commands (i.e. the Army, the Royal Navy, the Royal Air Force and the Royal Marines). JSP822 also ties into MST and includes a CEB in its guidance, further strengthening the link with strategic guidance, the organisational framework and force structure. Continuing in this vein, the Analysis phase results in a Pipeline Management report to communicate the implications of the analysis to those managing force structure. This is not meant to imply that a training analysis influences force structure; rather, this is a checkpoint to ensure the training analysis matches the demands imposed by force structure. If JSP822 were to be used as a model on which to base a revision to CFITES (i.e. to explicitly accommodate collective training) all elements that are based on the framework provided by the MOD's organisation and strategic guidance would have to be identified and revised to match DND. This same review would also have to be carried out for governance processes.

3.8.4   Governance

As mentioned above, JSP822 includes Terms of Reference (ToRs) for CEB and produces a number of outputs for consideration by other stakeholders in the organisation. These outputs include scoping exercise report, training authorisation document, team/collective task analysis, overlay analysis, draft collective training objectives, environment analysis, training needs report, risk assumption management, pipeline management and a statement of the trained requirement; see Figure 3-14). These outputs permit those in authority to exercise oversight

and ensure that the broader perspective afforded by strategic direction, the organisational framework and force structure is included in the training analysis. This will help to ensure the training contributes effectively to the development and maintenance of the overall capability, thus reinforcing the validity of the method in use.

3.8.5   Applicability to Individual and/or Collective Training

JSP822 specifically deals with collective training, presenting two different sets of analysis activities to cater to the different demands of both individual and collective training. The collective training method is adapted from the HFI DTC research programme (Huddlestone and Pike, 2016) which builds upon the collected body of research in the fields of Human Factors and training. As noted above, JSP822 also defines collective training at a variety of levels: Tier 0 through Tier 4 (0: sub-unit, 1: unit, 2: tactical formation, 2+: component level joint, 3: combined/joint and 4: strategic).

The directive also defines a continuum of collective training from integration, core adaptive, joint competency, coalition competency to In-theatre training.

* Integration training: individual units provide training to individuals to work individually and within teams and sub-units. This training is not considered collective training in JSP822 and addresses Tier 0.

* Core adaptive training: units and tactical formations are trained to ensure they are competent to be deployed if necessary (i.e. they are held in reserve rather than the primary force). This is the first level of collective training and addresses Tiers 1 and 2.

* Joint competency training: joint training (i.e. land, sea, air, marines or some combination of two or three) is carried out at the component level, usually sponsored and directed by a joint headquarters. This level of collective training addresses Tier 2+.

* Coalition competency training: this training concerns the effective involvement of the joint force in a coalition mission. Again, a joint force headquarters or similar would be responsible for sponsoring and directing this training. This level of collective training addresses Tier 3.

* In-theatre training: carried out during a deployment to maintain existing skills, develop new skills and capabilities, carry out mission rehearsal or otherwise adapt to some change in personnel or organisation. This level of training need not be collective and can address any of the tiers.

This organisation maps to the MOD's tiered description of training levels, presented in Table 2-1.

3.8.6   Prescriptiveness of Analysis Elements

JSP822 is very prescriptive, on a par if not exceeding the degree of prescription in CFITES. In common with CFITES, JSP822 includes suggested content for the various reports and provides

some guidance regarding the contextual considerations a training analyst should make for each analysis activity. For instance, JSP822 shows the reader how to lay out and number a role scalar (Part 2: p. 33-35) and associate tasks in the role scalar with Difficulty-Importance-Frequency (DIF) and KSA information (Part 2: p. 35-36; both of which are important when determining how to structure the training and identifying corresponding EO and PO). JSP822 provides the analyst with methods of assessment that are specific to the evaluation of a Knowledge element, a Skill element and an Attitude element (Part 2: p. 36-38). JSP822 also includes some guidance on combining outputs from two or more analysis activities to directly inform the evolving training solution (Part 2: p. 59-61).

JSP822 offers further specific guidance for carrying out its collective TNA components. This begins with how to carry out the task analysis to capture the contextual and mission elements that are missing in an individual task analysis. The guidance then explains how to incorporate role information before combining the various task information into a hierarchical task analysis. Using the hierarchical task analysis as a structure, the analyst then describes critical errors for each task and teamwork that is implicated in those critical errors. This is supplemented by guidance on how to perform a teamwork error analysis (Part 2: pp. 52 – 53). JSP822 also provides a task description table (Part 2: p. 51) as a recommended format to further describe the important aspects of a task, including the teamwork elements, teamwork stressors and any metrics that could or are used to evaluate the task.

Continuing with the collective training analysis, guidance on how to carry out the Overlay Analysis is provided (Part 2: p. 53 – 54), followed by guidance on how to carry out the Environment Analysis (Part 2: p. 54 – 58). The output from the Environment Analysis is particularly useful since it matches a Training Media Analysis. The Environment Analysis considers the fidelity required for effective training in five dimensions with respect to physical fidelity and psychological fidelity:

- System Fidelity: how closely does the training system match the operational system?

- Resource Fidelity: how closely do the supporting activities, such as logistics, equipment or ammunition load, need to match real-life?

- Human Fidelity: how closely do interactions with other humans, either members of the team or external parties, need to match the operational reality?

- Manned System Fidelity: how closely do other weapons systems in the training environment, controlled by instructors, role-players or interactors, have to match reality?

- Physical Environment Fidelity: how realistically do static and dynamic environmental elements (e.g. ground, forest, water, waves, clouds) have to be?

This analysis leads to the consideration of the training environment as live or synthetic and, if synthetic, whether it is virtual or constructive. This will result in a training environment specification which will feed a consideration of the method and media options for training.

In summary, there is a great deal of guidance in JSP822 that would be immediately useful to the CAF to support current training development activities, irrespective of the organisational framework and governance regime that must be employed.

3.8.7 Usability

Given the degree of prescription in JSP822, as well as the cross-referencing to references and templates, a user should be able to apply JSP822 with a reasonable degree of reliability and validity, in particular if governance includes an element of corporate legacy knowledge (what has been done before, how it is done for analogous job roles, etc.).

3.8.8 Summary

JSP822 addresses all phases of the training lifecycle. The usability of JSP822 is likely equal to, if not better than, CFITES. JSP822, developed as it was for the MOD, is well aligned with strategic direction, the organisational framework and force structure. JSP822 was deliberately developed to incorporate specific governance procedures, and this serves to strengthen the alignment with the organisation and objectives of the parent entity (i.e. the MOD). Further, its origins in research carried out by the HFI DTC (Huddlestone and Pike, 2016) ensure that the outputs, while difficult to establish rigorously, are likely to be amongst the most reliable and the most valid, assisted by the level of prescription in the guidance material. Finally, JSP822 has been developed to explicitly address collective training with analysis activities that differ from those intended to support training analysis for individual roles.

Table 3-13 provides the criteria evaluation for JSP822 that is used to compare between methods. Note that JSP822 has been judged equal to, or better, than CFITES on several categories and thus also highlighted in green. The reader should not consider these equivocations representative of significant advantages on the part of JSP822 over CFITES.

Table 3-13: Criteria Evaluation for JSP822

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
JSP822	=	+	=/+	=/+	=/+	=/+

3.9 xAPI

3.9.1 Background

xAPI was originally known as Tin Can API and was developed by Rustici Software (tincanapi.com) as part of a research project commissioned by Advanced Distributed Learning

(ADL; adlnet.gov). ADL is a US government initiative reporting to the Deputy Assistant Secretary of Defense for Force Education and Training, under the Office of the Assistant Secretary of Defense for Readiness.

xAPI is a de facto software design standard for development of training systems that permit extensive data recording, performance measurement and analysis. xAPI describes a Representational State Transfer (REST) based Application Product Interface (API) used to store and retrieve a learner's activity data, and a Resource Description Framework (RDF) based data model where restrictions among data are specified in natural language. xAPI facilitates the interoperability between the trainee's learning device, a Learning Management System (LMS) and a Learning Record System (LRS). xAPI is the de facto standard due to the number of vendors who have adopted it, which is due to the simple data model.

Software "statements" form the basis for xAPI. A variety of ontologies are proposed for xAPI wherein the statements are formalised. A statement consists of the Actor (Agent or Group), a Verb, and an Object (Activity, Agent, Group or Statement). Statements can also describe the outcome of the event and conditions under which the event was performed via the Result and Context properties. Statements can also have associated Attachments. A statement will be made by someone or something (Authority) and has properties of a user ID, time of the event (Timestamp), time that it was stored in the LRS (Stored) and the version of xAPI (Version).

Using xAPI permits a training developer to record almost any activity, link different LRS' to share data and move it around, record training performance from any enabled device, and draw from any tracking event (not just those mediated by a LMS).

xAPI can be applied retrospectively to improve training content and delivery, or in real-time to adapt training delivery to the needs of individual student(s).

3.9.2   Training Lifecycle Stage Addressed

xAPI records actual trainee performance data from an existing training device (e.g. a simulator or an eLearning application). This data can be used by analysis software to feed back an evaluation to the trainee or be stored for later analysis. Because xAPI requires a training system to already be in place, it does not directly address the analysis, design or develop phases of the ADDIE framework. xAPI is active during the implementation phase, but primarily addresses the evaluation phase of the ADDIE framework. This is not to say, however, that xAPI does not contribute to the analysis phase. The data can be used to support a TNA by highlighting aspects of performance with which trainees have the most difficulty, including those related to teamwork. Thus, xAPI could be a useful contribution as a data source and reference when carrying out a collective TNA.

3.9.3   Alignment with Strategic Framework

xAPI represents a tool with which to capture data. This data can then be used to assist in the evaluation of training effectiveness and to specify subsequent adaptations or improvements to the training system. As such it is not so much 'aligned' with the strategic framework as 'serving' the strategic framework. Strategic direction may require that deep evaluation of training take

place; deployment of xAPI is a solution decision taken by those charged with implementing the strategic direction rather than being something itself that needs to be adapted to align with the strategic direction.

Concerning alignment with the mission context, xAPI takes whatever data is produced by the training device and, as such, is agnostic of the mission context. This is not to say that xAPI would not support analysis of mission-specific parameters; just that this would not be an intrinsic function of xAPI.

3.9.4   Governance

There is no governance applied to xAPI since it is a tool. However, governance would need to be applied to the data records produced by xAPI, since these concern personal data and must be handled accordingly.

Concerning the specific criteria listed in Section 2.4, the xAPI methodology does not mention specific oversight requirements or a steering group, nor the need for a particular team composition. Any such governance would be specified by the organisation for which xAPI is being used. Likewise, the specific governance processes listed in Section 2 would also be dictated by the leadership of the sponsoring organisation.

3.9.5   Applicability to Individual and/or Collective Training

As noted above, xAPI is used to record trainee performance data and store it for analysis, including the rapid provision of feedback to the trainee on their performance. Because xAPI is an interface between a training device, and LMS and an LRS, the type of data that can be recorded is effectively limitless. xAPI would therefore be applicable equally to individual and collective training. It is up to the software developer to determine how to use xAPI to capture the desired data.

3.9.6   Prescriptiveness of Analysis Elements

Software must be coded correctly in order to function as intended. The logic that governs software behaviour dictates that all inputs and outputs must be known and defined precisely. These aspects of software require that an application is developed according to a rigid set of rules, and any interface between software elements must conform to this set of rules. As a software specification, xAPI must also follow the logic and definitions associated with the devices in use and is therefore prescriptive. Therefore, it is likely that most applications of xAPI will be equally precise in their development and be interoperable with each other with minimal additional work.

Concerning the specific factors described in Section 2.6, xAPI does not result in task lists or learning objectives without supplemental analysis. Task lists in particular would likely be an input to xAPI development work. There are no prescribed analyses to be performed to support xAPI; as it is more likely to provide input to other analyses. There are, however, a number of xAPI user groups online where a developer can search and find solutions to problems that are

encountered. The first two user groups found using a Google search http://xapiquarterly.com/ and https://groups.google.com/a/adlnet.gov/forum/#!forum/xapi-design.

3.9.7   Usability

To be applied successfully xAPI requires specific knowledge and training beyond that which a training analyst would reasonably be expected to possess, as well as the appropriate development environments and facilities for integration with other software and hardware elements. The anticipated training analyst is unlikely to be able to use xAPI successfully, although they could effectively specify its use in a training solution. This specification could then be used by software developers to build xAPI into the training solution.

xAPI, because it is a software method, exhibits good reliability and validity, based on the manner in which it is implemented and the data which is made available to it. To sufficiently trained and experienced developers, xAPI is easy to implement and, internally at CAE, xAPI is being used successfully on a variety of training devices.

3.9.8   Summary

xAPI is not particularly well-suited to inform the CAF regarding collective training, alignment with strategic guidance or usability. Rather, xAPI is a tool by which to generate data on which analysis can be performed. This analysis can be directed toward a variety of objectives, including the general review of a training programme or the specific review of identified training components (e.g. that trainees are having difficulty with). The outputs from analysis of data collected through xAPI can be used to assist in training improvement.

Table 3-14 provides the criteria evaluation for xAPI that is used to compare between methods.

Table 3-14: Criteria Evaluation for xAPI

+ (better) - (worse) = (same)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
xAPI	-	=	-	-	+	-

4   DISCUSSION

4.1   Comparison of Collective TNA Methods

With the exception of JSP822 and TCTNA, Few TNA methods reviewed in this work were deliberately developed to address team or collective training needs. This is not to say that existing TNA methods are not suitable for team or collective requirements. It is possible that the TNA method can remain the same while the content or perspective of the analysis will change to focus on team issues; this is likely to be the case with CFITES. Presuming a motivated analyst who remains aware of the needed perspective, CFITES could reasonably be used effectively for collective TNA with minimal modification. However, the UK has devoted a great deal of effort in developing a collective TNA method and it would be instructive to consider what their method can offer to the CAF.

In comparison to other methodologies, (Table 4-1) CFITES is deficient with respect to usability. This diagnosis is based on two features: (1) the need for clearer guidance concerning the constituent TNA activities and (2) the need for better standardisation due to the provision of vetted descriptions and mappings from which the analyst can choose.

Table 4-1: TNA Method Criteria Comparison Table

+ (better) - (worse) = (same) =/+ (equal or greater to)	Training Lifecycle	Collective Training	Strategic Objectives	Governance	Prescriptiveness	Usability
CFITES	=	=	=	=	=	=
BF analysis	-	=	=	-	=	=
MANPRINT/HSI	-	-	-	-	-	-
MEC	-	=	=	=	-	+
SAM	=	-	-	-	-	+
TCTNA	-	+	=	-	+	=/+
Team TNA	=	-	-	-	-	-
UK MOD JSP822	=	+	=/+	=/+	=/+	=/+
xAPI	-	=	-	-	+	-

Two other criteria stand out as having slightly more favourable judgements for TNA methods when compared to CFITES: Collective Training and Prescriptiveness. However, a closer look at these two criteria reveals that TCTNA and JSP822 are both judged better than CFITES, thus

accounting for the bulk of the positive judgements. That TCTNA and JSP822 are afforded the same judgement is not surprising, since JSP822 is based on TCTNA, with the addition of specific elements for strategic alignment and governance. xAPI is judged to be better with respect to prescriptiveness because it is a software specification.

Reading across the rows instead of down the columns, it is clear that one TNA method compares favourably with CFITES: JSP822. This is not a surprise; JSP822 has been developed to address individual and collective training, and has been updated frequently in the last two years. Further, it is based on a significant collaborative effort by academia, industry, and defence science organisations to leverage the most recent theories and approaches concerning learning and training to develop a training analysis approach that is effective for both individuals and teams. This effort is represented by the TCTNA method which was the second-most favourably judged method (and on which JSP822 was based), only faltering on strategic alignment and governance because it was deliberately developed to be agnostic of specific organisational structures and processes.

4.2   Incorporation of Collective Training Analysis in CFITES

Although JSP822 has been judged to be equal and/or better than CFITES in most categories, it is not possible to judge whether it is equal or better than CFITES overall. The analysis is equivocal because, within the scope of this review, it has not been possible to determine between the two which offers the best strategic alignment, governance, prescriptiveness or usability. Both explicitly refer to training existing within the framework afforded by strategic guidance, organisational framework and force structure. Both have explicit requirements for governance that include regular meetings of qualified participants with appropriate authority. Both provide a great deal of direction and assistance to analysts carrying out a TNA but it is unclear whether a resulting TNA from either would be more valid, reliable or useful. That said, the origins of JSP822 in academia, as well as the amount of guidance available to analysts (chiefly via the TCTNA book [Huddlestone and Pike, 2016)] on which JSP822 is based), would suggest JSP822 is likely to be more prescriptive but in a usable way.

The fact that TCTNA has not been judged quite so favourably as JSP822 is not necessarily a negative thing. If DND is looking for an example on which to base the next incarnation of CFITES, it might be preferable to consider a comprehensive method that does not bring existing assumptions concerning governance and strategic frameworks. Since TCTNA is at the heart of JSP822, it is likely that it can serve the same role for a CAF training system solution.BF Analysis could potentially also serve this role since it is used as the basis for the US Army approach to collective training analysis. However, as discussed the current status of BF analysis within the US Army is unclear. TRADOC's systems approach to training, with its detailed guidance on collective tasks analysis for training development is likely a more promising avenue (from which the BF Analysis was based in an older version).

Why has this review not clearly identified methods that represent improvements over what is currently offered by CFITES? There a number of possible explanations: CFITES is either already well designed, nothing has been developed that improves upon CFITES, no formal comparisons have been made or no one method is better or worse than CFITES in all

evaluation categories. In the first case, CFITES already makes explicit provision for strategic alignment and governance, although these may be poorly applied in practice. Governance should satisfy the need for both the development of high quality training outputs and the alignment with the organisational framework. Further development work might be possible to strengthen strategic alignment and governance, but this would be based on detailed consideration of actual CAF TNAs in the strategic/organisational/force context, rather than adopting best practices of other organisations.

In the second case, that nothing better has been developed yet, it is clear that CFITES is not designed deliberately to deal with collective training. Notwithstanding that many of the TNA activities can be applied with a different perspective to cover collective training, this review has identified some methods that offer advantages over CFITES. MEC and TCTNA/JSP822 (since JSP822 is based on TCTNA they are treated as one method from this point) both provide some improvements over CFITES.

In the third case, that no formal comparisons have been made, this is not entirely true. Martin (2016) has compared CFITES and MECs. In the case of TCTNA and JSP822, however, there has been no formal comparison with CFITES and it is difficult to state categorically that they improve upon what is already offered by CFITES.

The final explanation returns to something introduced above: that some methods do offer advantages over CFITES, in particular MECs and TCTNA/JSP822. These methods are not universally better than CFITES in all categories; rather, they have advantages in certain of the categories and, at an even more granular level, in certain elements of specific categories. These advantages should be considered for how they might be used to strengthen CFITES' treatment of collective training and its alignment with the strategic framework.

MEC is comprised of a database of competencies that have been deemed, through analysis and SME judgement, to be essential to mission success. This provides two specific advantages for the operational commander: the MECs facilitate the process of specifying training because competencies are standardised, described and published, and the MECs ensure that all participants in training understand their contribution so all participants receive effective training. While the development of the training curriculum itself is not dealt with by MECs, the strategic framework within which a training need is identified is based on a common language shared and understood by all training sponsors (i.e. operational commanders).

The method by which the training curriculum is developed is dealt with, at least in large part, by TCTNA/JSP822. TCTNA can be used to analyse a set of MECs in order to derive the training requirements, objectives, KSAs and performance metrics. TCTNA is chosen over CFITES for the analysis process because it has been developed to address collective training. Particularly notable is TCTNA's Team Performance as a precursor to the Team Overlay model. The former specifies the properties, processes, outcomes and environment of the team, which is distinctive from all other methodologies. Similarly, Hettinger's (2003) "shared mental model" as well as Salas et al.'s (2015) differentiation between taskwork and teamwork allude to the notion of distinctiveness of training needs for teams as opposed to individuals.

4.3   Validity and Reliability of TNA Methods

Of note throughout this review is that none of the methods reviewed have been formally[16] assessed for their validity or reliability. All, presumably, are felt by their developers and users to have reasonable qualitative or face validity and reliability but there have been no quantitative, numerical, statistical assessments of validity or reliability. This is understandable: many of the outcomes from training analysis are not easily amenable to simple and unequivocal quantification, due to the complexity of the mission context and the difficulty of establishing causality from training to mission success. Further, it is very difficult to ensure that different analysts employ the same input data, in particular the overriding objective for carrying out the training analysis. Each time a training analysis is carried out, it is for the specific purposes of the analyst(s) at that point in time, making it difficult to compare analysis methods over time. The success of the training program is also difficult to attribute solely to the training analysis, since there are many other variables implicated in training success. To the best of our knowledge, there has been no 'simulated' training need developed, wherein all analysts carry out the training analysis with the same direction and within the same frameworks, and receive the same input information. This would be one way to investigate validity and reliability in a more rigorous manner.

4.4   Strengthening the Strategic Alignment of CFITES

Returning to the desire to tighten the linkage between the TNA method used by CAF and strategic guidance, the organisational framework and force structure, it would be insightful to audit some completed training analyses. This audit would consider two things: whether the steps outlined in CFITES were followed precisely and how well the training analysis and its outputs matched the strategic context. This would require the development of an audit method that addressed both CFITES processes and the nature of the strategic context. Then training analyses could be compared with these instruments. Recognising that CFITES is designed to be flexible and it is likely that not all steps would be applied in all situations, the ultimate objective of the audit would be to identify the minimum steps in CFITES that must be applied to support an effective training analysis.

Perhaps further than this, and given that JSP822 may offer enhancements to CFITES with respect to strategic alignment, the audit approach could also be carried out on training analyses developed under the auspices of JSP822. The results could be considered and, where appropriate, any improved elements of strategic alignment and governance uncovered from JSP822 could be considered for incorporation within the CAF TNA approach.

A clearer direction regarding how a CAF training analysis method for collective training could be constructed through the application of JSP822 to a CAF training analysis. Ideally, this application would be for a collective training requirement, but could be for individual training if the opportunity does not arise. This should be done alongside a CFITES analysis but by

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[16] "Formally" means the statistical calculation of validity (the extent to which a tool describes what it purports to describe) and reliability (the likelihood that a tool, presented with the same input data, will deliver the same output) metrics.

separate analysts to compare the outputs in terms of the ease of their production and the subjective validity and utility of the outputs.

5 CONCLUSIONS AND RECOMMENDATIONS

This review has shown that there are very few specific methods developed to support collective TNA. If TCTNA and JSP822 are combined as being, in essence, the same method, then only one collective TNA method was found. This is not to say that analysis activities currently in use could not be reoriented to address collective training. TCTNA/JSP822, however, have been developed on the basis of the latest theory and practice to specifically address the unique aspects of collective training that make it different from individual training. CAF should consider using the TCTNA method as a basis for developing a collective TNA process that is complementary to the CFITES analysis phase. Further, the CAF should consider investigating the potential benefits of leveraging specific elements of other methods, in particular MECs and Battlefield Functional analysis, to result in a valid and reliable method for collective training needs analysis.

Considering JSP822 specifically, because it has been developed for a military training system it may have a tighter alignment with strategic guidance, its organisational framework and force structure than CFITES. CFITES, however, also exhibits good strategic alignment and active governance, so it is debatable whether JSP822 can be drawn from to improve the CAF training analysis process, at least with respect to strategic alignment. However, since JSP822 was specifically developed on a theoretical foundation, supported by practical experience, to deliberately accommodate team and collective processes and tasks, it is reasonable to presume JSP822 can offer improvements over CFITES with respect to team and collective TNA.

Based upon these conclusions, we recommend that both CFITES and JSP822 be audited to assess which method offers the best strategic alignment and governance. We also recommend that the CFITES training analysis method and the TCTNA method be used to carry out a training analysis on the same training problem. The results should be compared to determine the advantages and disadvantages of each in a traceable and quantifiable way.

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