Methods for Transitioning from Soft Systems Methodology (SSM) Models to Object Oriented Analysis (OOA), developed to support the Army Operational Architecture (AOA) and an Example of its Application

Mr Charles Lane
Hi-Q Systems Ltd
The Barn
Micheldever Station
Winchester, SO21 3AR
United Kingdom

Major Kevin Galvin
Director General Development and Doctrine
DGD&D
Room 1314/1316
Ministry of Defence
Main Building, Whitehall
London, SW1 2HB
United Kingdom

Abstract

In May 1998 the UK's AOA Version 1.0 was released. A follow on study into methods for transition from SSM activity models into Object Oriented (OO) products in a form which would support effective development of appropriate computer applications was completed. Hi-Q Systems was invited by the Ministry of Defence (MoD) to conduct the study as they were actively engaged in both SSM and OOA work in general.

The core problem with moving from SSM to OOA is that the two methodologies operate with different paradigms making information captured in one model difficult to place directly into the other. SSM models the business domain in terms of conceptual activities (verb based processes), while OOA models the domain with real world objects (noun based entities). The study identified 4 potential methods of transitioning, their advantages and disadvantages and completed an indirect fire example.

The transition study recommended that the preferred method "Consensus Primary Task Model to Use Case Transition" be applied to a more mature example using the SSM activity model and its information requirements that had been built during the analysis of Short Range Air Defence (SHORAD) digitization requirements.

This paper describes the transition methods and shows two examples that use the preferred method of transition:

- AOA High Intensity Conflict (HIC) view, use of indirect fire
- SHORAD degree of protection

1. **Introduction**

1.1 *Study Background*

SSM has already been employed for business analysis in support of information system development within the AOA and Statement of User Needs (SUN) in the UK Digitization of the Battlespace (Land) (DBL) programme. The use of SSM modelling is being adopted increasingly during further analysis of the Army's business. Much effort has therefore already been invested in developing and exploiting this methodology.

OO technology is recognised by the MoD Digitization Co-ordination Office (DCO) and Applied Research Programme (ARP) 19e as the probable basis for a component-based architecture within the DBL programme. It would therefore be both desirable and cost-effective to have a mechanism to migrate SSM models into OOA. The identification of an effective transition process would permit component-based software systems to be designed directly from supporting SSM domain analysis. Furthermore, if a suitable transition could be identified the business analysis of future SSM studies will directly support the development of supporting IT.

1.2 *Relationship of the Transition Study to the Single Army Activity Model (SAAM)*

The transition study recommended that as the AOA is to be used as the basis for the future development of IT systems to support the needs of the army:

- The AOA be developed further to produce a CPTM that incorporates the High Intensity Conflict and Peace Support Operations views of the Army, which are currently modelled as individual CMs.

- An organisational mapping be performed on the derived CPTM. This will assist in identifying the domain experts that should be consulted in the Use Case analysis.

- The information requirements are identified for each activity within the AOA CPTM. This should assist in the identification of the key information services that the OM should provide.

These recommendations were undertaken in the development of a SAAM that re-used the lower level AOA activities. The SAAM provides a single consensus view of the Army enterprise, based on four principal activities principally delivery and maintenance of capability, strategic and operational planning, command and control the execution of a specific operation and the overall management and control of the Army. The Information Systems Methodology (ISM) utilised in the SAAM has provided an initial Information Architecture (IA). The IA defines, for each activity in the model, three categories of information: that required for the activity to take place; that produced as an output of the activity; that required as a measure of performance of the activity. From this the sources and sinks of information can be identified. This "ideal" view of what the Army/Land Component should do can now be used to move the SAAM towards OOA/Design (OOA/D) via an appropriate transition method by its comparison with "real" world organisations, information requirements, systems and Standard Operating Procedures (SOPs).

1.3 *Content*

The paper is structured as follows:

- Section 2 compares and contrasts SSM and OOA in order to deduce the various transition points between the two methodologies. This leads to the identification of four potential transition methods.
- Section 3 describes the methods and their relative advantage assessed.
- Section 4 demonstrates the use of the preferred method to make the transition from SSM activities within the AOA version 1.0 HIC view, based on the conduct of indirect fire engagements, to candidate OO objects. The effectiveness of the transition has been limited by the extent of the analysis completed within SSM using ISM and OOA using "Use Cases".
- Section 5 provides a more complete example of the transition process based on a SHORAD application. Many more techniques are used to help with the transition; these are described.
- Section 6 concludes.

2. A Comparison of the SSM and OOA Techniques

2.1 *SSM*

2.1.1 *Overview of SSM*

SSM is a means of investigating systems of purposeful human activity [Wilson, 1992]. SSM modelling uses the technique of functional decomposition to build a conceptual representation of the system of interest in terms of the ideal set of activities and the logical dependencies between them. Specifically, SSM provides a set of techniques for generating a defensible description of an operational ("business") domain. SSM advocates building models in terms of activities (i.e. verbs describing processes). These models can then be used, *inter alia,* to extract the information support requirements for the activities identified. Hence SSM business modelling flows readily into the design of supporting, activity based (functionally structured) software systems (i.e. software modules that perform specific functions and require/generate specific inputs/out puts), where software development is based on highly procedural lines.

2.1.2 *Why use SSM?*

SSM is particularly relevant where the domain is complicated and various stakeholders embrace differing viewpoints. In such situations SSM is an excellent methodology for analysis as it facilitates the construction of a defendable consensus model to which the stakeholders can relate.

2.2 *OOA*

2.2.1 *Overview of OOA*

OOA is a method in which requirements are examined from the perspective of the objects found in the vocabulary of the real-world problem domain. Thus OOA requires an understanding the problem, the business rules and the vocabulary. OO modelling is a means of building IT systems

based on a representation of the real world in terms of these objects. A business object describes an integrated collection of business capabilities that focus upon something of interest to the business[1]. Objects encapsulate two kinds of properties:

- Behavioural: An object provides a collection of **services**. These constitute the entire description of what the object is capable of doing.
- Information: An object includes a collection of information elements, **attributes**. These constitute the knowledge needed by an object in order to fulfil its behavioural properties.

Objects common to a domain can be grouped together and associated with one another. The set of objects that call each other's services, in order to perform the business activities is called a BOM. Achieving a well-structured BOM with objects that fully encapsulate their area of responsibility and only that area, is vital for the long-term development of the IT support system.

OOA encompasses and facilitates the following techniques:

- **Abstraction** is where an entity (e.g. an object) is dealt with at a fixed level of detail, while ignoring the lower level details (e.g. a house is an abstraction of bricks, cement, wood, nails, glass etc arranged in to a particular form)

- **Encapsulation** is the binding of data (attributes) and functionality (services) within objects, with only pertinent services being made available to the 'outside world' (e.g. every house provides a service to facilitate entry into and out of the house). Encapsulation serves to separate the contractual interface of an object from its internal implementation. This aids the preservation of integrity of information.

- **Inheritance** allows a new type of object to be derived from a previously specified entity. Only the differences from the parent object are explicitly detailed within the child object and the rest is inherited from the parent (e.g. a house is a special type of building).

2.2.2 *Use Cases and Actors*

Use Case analysis is a technique that may be employed by the OO analyst to embark upon OOA in a structured manner. Use Cases describe specific activities performed within a system. The people, organisations, or devices that participate in the activity are known as Actors. The identified Actors within the system are mapped to the appropriate Use Cases. The analyst investigates the business domain, taking a top-down approach. Then, the Use Cases are decomposed into a series of steps that are performed in order to carry out the activity. Performing a Use Case study forms a framework for the OO analyst to gather information on the problem domain and replaces the requirements specification that is typically performed early in a software development project.

2.2.3 *Unified Software Development Process*

Booch and Jackobsen [Booch, *et al.,* 1999] have produced a unified process for the development of software using OO techniques from their former individual work that considers Use Case

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[1] The definition of a business object is taken from Modular Object Oriented Development - Software suite produced by MooD International Limited and used to record the SAAM

analysis an integral part of system analysis. They argue that information systems analysis can not be based on the Unified Modelling Language (UML) technique of Use Case analysis alone as consideration of architectural aspects is crucial. The architecture of a software intensive system can best be described using five interlocking views (see Figure 1). Each view is a projection into the organisation and structure of the system. The Use Case view describes the behaviour of the system as seen by analysts and end-users. The static aspects are captured in Use Case diagrams; the dynamics in interaction, state-chart and activity diagrams. The design view encompasses the classes, interfaces and collaborations that form the vocabulary of the problem and its situation. This view primarily supports the Functional Requirements (FRs) of the system, meaning the services that the system should provide to its end-users.   The process view addresses the performance, scalability and throughput of the system and supports the Non-Functional Requirements (NFRs) of the system
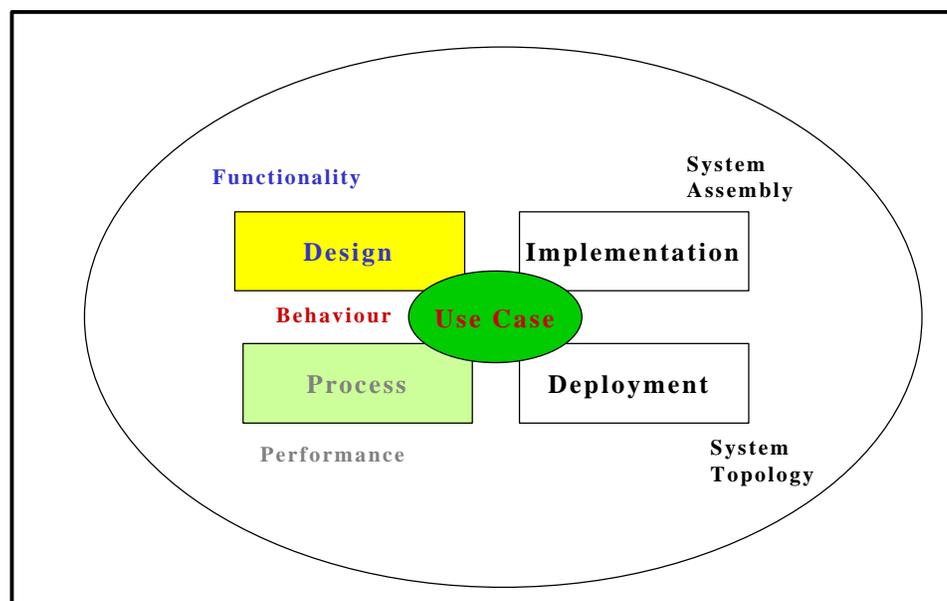

Figure 1. Modelling a System's Architecture

A Use Case alone can only support the development of an object model that meets the current FRs whereas an architectural view based on the business structure with emphasis on long term maintainability leads to a BOM which embodies future FRs and NFRs.

2.2.4 *Why use OOA?*

OO is radically different from structured functional decomposition and possesses a number of significant advantages when it comes to constructing software systems.   These advantages include:

- From abstraction allowing consideration of an entity (object) without having to be concerned about complicated and irrelevant details in it's underlying form;
- From encapsulation aiding information integrity and prevents clients of the object from being exposed to the lower level detail;

- From inheritance ensuring that only the differences from the parent object need be explicitly detailed within the child object, with all common functionality being inherited.

OOA can claim to be modular, readily extensible and suited to reusable component-based systems. Component software system development, based on OO techniques, is thus desirable when it comes to designing and building complex IT systems.

2.3 *Comparison between SSM and OOA*

2.3.1 *SSM and OOA Common Features*

Common features between the techniques of the two methodologies exist that improve the likelihood of a direct transition i.e. without specific new analysis in order to commence OOA.

- The "What's" of SSM and the "desired behaviour" of the OOA Use Cases.
- The possible similarity between the technique of information category analysis within ISM based on SSM business analysis and the Unified Software Development Process concept of an architectural approach that considers Use Case and design views simultaneously to provide the business analysis

2.3.2 *SSM and OOA Contrasting Features*

Contrasting features lead to the prospect of an indirect transition, for example:
- The conflict that exists between the SSM "conceptual" and the OOA "real" world perspectives.
- The disparity between the SSM examination of the system as it is intended "to be" and the OOA examination of the system "as is". SSM aims to analyse the business with a view to primarily changing the business, its objectives, processes, organisation etc., whereas OOA (like ISM) analyses the IT to support the business

2.3.3 *Transition Point Deductions*
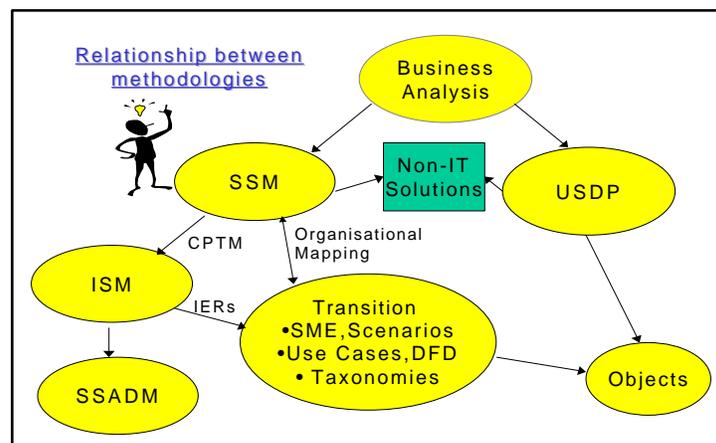
Figure 2. Relationship between Methodologies

Figure 2 shows the relationship between the methodologies and techniques used in the production of operational architectures. ISM leads naturally into the development of functionally-based IT systems, through identifying information flows into and out of activities that can be recorded on a Maltese cross. Activity information requirements can then be compared with existing IT support and recommendations made for the development of new IT using Structured System Analysis and Design Method (SSADM). However the use of structured analysis as a front end to OO design is not desirable. [Booch, 1994] strongly discourages this approach, but acknowledges that, for some organisations, it is the only pragmatic option due to prior investment in structured analysis (and not OOA). Experience has shown that using structured analysis as a front end to object-orientated design often fails due to the limitations of the "structured-design mindset". Thus the transition from SSM to OOA should be performed prior to the point where SSM reaches the transition into structured IT analysis.

OOA, through the Use Case technique, is performed on areas of the SSM business analysis where IT could improve the effectiveness of the business. Assuming that an initial SSM analysis phase is to be performed then the route to an OO IT system should progress through the following stages:

Business Analysis (e.g. SSM, Use Case) → **Software Analysis** (e.g Production of a BOM) → **Software Design** → **Implementation** → **IT System**.

The journey along this path is iterative and will require revisiting earlier stages when omissions or 'mistakes' are discovered (See Figure 3).
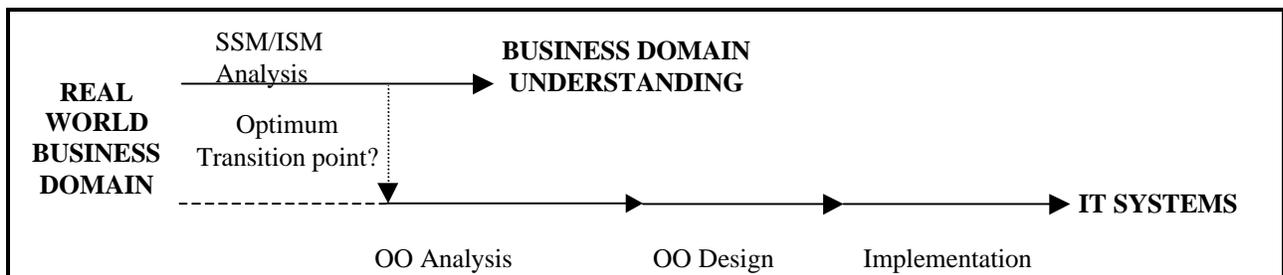
Figure 3. SSM to OOA Path

Since SSM consists of a collection of techniques through which the business domain can be explored it would be beneficial to know which of these techniques support OOA and which add little or nothing. This should help to determine at which point the transition from SSM to OOA should be made.

SSM and OOA business analysis adopt a top down approach in exploring and analysing the domain. This gives rise to the question of the appropriate level of detail the modelling should reach prior to switching from SSM to OOA. The more SSM is utilised the easier it is to specify the Use Case Descriptions, yet the more time consuming the analysis.

2.4 *IDEF*

2.4.1 *US Force XX1 Operational Architecture*

The US is developing an operational architecture for the US Army documenting the future requirements for connectivity, the information to be exchanged and the responsibility for processing between elements of the experimental Digitization Force XX1 and the IS required. The OA is predicated on the users' desire to integrate combat, combat support (CS) and combat service support (CSS) functions in order to increase synchronisation of operations. The OA will be used to support the development of the following products:

- Procurement Plan to generate future equipment requirements
- Business Process Re-engineering of tactical units through the Force XX1 experiment to identify more efficient ways to complete the mission
- An understanding of formation C2 processes in terms of functionality required and associated relationships to be used in subsequent IT analysis and design

2.4.2 *Methodology*

Initial activity models were constructed using the material from the Force XX1 doctrinal publications, equipment and organisation tables training reports and discussions with subject matter experts. For example, in the case of air defence (AD), the model explores C2 of the divisional AD battalion. The Force XX1 AD battalion is designed, equipped and trained to meet the demands of the 21st century. Where applicable unit functional and organisational changes made as a result of the Force XX1 experiments were incorporated into the model. The modelling results show how the AD units will be required to function in the 21st century.

2.4.3 *IDEF Modelling*

Integration definition (IDEF) modelling takes a top-down activity-based approach. The main technique is to conduct a hierarchical functional decomposition graphically representing the results using information exchange matrices, decomposition diagrams and node trees. IDEF is used to capture information about activities in order to provide:

- An understanding of how processes are conducted in the "as-is" operational environment.
- Identification of system integration requirements.
- A framework for scoped operations.
- The path for process change.

Equipped with this information it will be possible to identify both how force elements will function in the future and the development requirements of systems to support them.

2.4.4 *Implications for UK Transition Method from SSM to OOA*

IDEF activities are described as verbs or verb phrases, much like SSM activity models.

IDEF activity relationships (ICOMs) are described as nouns or noun phrases:

- Input (I) - data used to produce an output
- Control (C) - data that constrains or regulates the activity
- Output (O) - data produced by the activity
- Mechanism (M) - people or systems that perform the activity

The activity relationships are expressed in a similar manner to ISM in that ISM identifies (I/C/O) as Information Categories, although the nature rather than actual data is considered. OOA identifies (M) as Actors in the Use Cases.

The similarity between the IDEF and SSM/OOA methods suggests that the UK preferred transition method could be used to derive the US object model. The real strength of the US operational architecture is that the results of the Force XX1 experiments have been used in the development of the concepts and processes required for conducting operations that exploit the digitization principles of tempo, simultaneity and lethality. Conversely the US operational architecture is unlikely to have been developed from identifying the logical set of activities and their dependencies necessary to exploit digitization, as would be produced using SSM. Instead, it seems to have structured Force XX1 functionality on existing organisations and user aspirations not capability statements. This would suggest different start points; the UK has built an activity model independent of real world organisations, structures and equipment whereas the US has based their activity model on current investments.

3. The Possible Transition Methods

3.1 *Background*

The steps described in the possible transition methods are generic. However, the advantages and disadvantages attached to each method are consequent only on the nature of the AOA SSM analysis.

3.2 *Object Model (OM) from Conceptual Primary Task Model (CPTM)*

3.2.1 *Stages*

This method starts with the SSM CPTM and identifies potential objects by extracting the nouns from the activities. The following steps are performed:

- STEP 1 –Scope activities within the CPTM to be investigated for possible IT support (and hence OOA).
- STEP 2 – Taking each activity in turn, identify the nouns in the CPTM activity bubbles; these nouns become the candidate objects for the object model.
- STEP 3 – Examine the list of nouns and remove any duplicates or any nouns, which represent the same entity.
- STEP 4 – By examining the root definition, the logical dependencies and information requirements within the CPTM, make the appropriate associations between the objects to form a first pass OM.

- STEP 5 – Continue analysis employing conventional OOA techniques. The OOA can now be continued using a suitable OO methodology and notation (e.g. OMT with UML notation).

3.2.2 *Advantage*

- The method delivers a relatively simple solution by direct transition. It is quick to apply and requires no further investigation into the business domain as the OM is based purely upon the CPTM and supporting root definitions.

3.2.3 *Disadvantages*

- The OM is produced at the same level as the Conceptual Model (CM). Unless the SSM analysis has been carried out to a detailed level, the resulting OM may not be sufficiently comprehensive. The resulting OM may not be suitable for development into a BOM that directly supports IT application development.
- There is a danger that the OM will be distorted due to direct linkage to the CM. The CM is based upon a conceptual view of the word and hence the resulting OM is likely to adopt this view as opposed to being based directly upon the real world.

3.2.4 *Assessment*

This method may be useful where a detailed SSM CPTM has been produced and IT support is to be defined at a very high level. It may also be useful for the analyst to use this method to develop a high level BOM prior to applying some other method to launch into more detailed OOA.

3.3 *Identify Objects from CM Activity Information Requirements*

3.3.1 *Stages*

This method starts like the previous method in that it considers the activities of the SSM CPTM and identifies potential objects by extracting the nouns. The following steps are performed:

- STEP 1 – Scope activities within the CPTM to be investigated for possible IT support (and hence OOA).
- STEP 2 – Examine all the information requirements for the activities within scope and identify the services that the OM should possess in order to deliver this information
- STEP 3 – Group together related services and identify the objects that could provide these services
- STEP 4 – Analyse the behaviour of these objects in order to firm up the OM. Scenarios and sequence diagrams could be employed based upon the activities specified in the CM.
- STEP 5 – Continue analysis by employing conventional OOA techniques. The OOA can now be continued using a suitable OO methodology and notation (e.g. OMT with UML notation).

3.3.2 *Advantage*

The method is relatively simple and by virtue of being a direct transition, is quick to perform. As with the previous method, no further decomposition of the system is required and no potentially time consuming Use Case analysis to be performed.

3.3.3 *Disadvantages*

- The OM is produced at the level of CM and suffers the same limitations
- There is a danger of distortion in the OM due to direct linkage to the CM. In this case, the method may distort the OM through the emphasis given to the identification of services followed by the derivation of objects to hold them.
- Full SSM information requirements analysis is a pre-requisite. A substantial amount of SSM analysis needs to be performed prior to moving across to OOA. If this level of SSM analysis already exists, this is no longer a disadvantage.

3.3.4 *Assessment*

It seems unlikely that this method will be able to stand-alone.   The AOA information requirements have matured recently due to the SAAM project. Further investigation of this technique through an illustrative worked example based upon the AOA is now thought to be practical.

3.4 *Identify Use Cases from Root Definition*

3.4.1 *Stages*

Identifying objects directly from the root definition would yield too few objects to build a worthwhile OM. However the root definition could be used as starting point for domain analysis within an OO framework by performing the following steps:

- STEP 1 – The root definitions are used as a starting point to identify the main use of the system and hence form the starting point for the development of a set of high level Use Cases.
- STEP 2 – Domain experts are involved to develop the Use Cases.
- STEP 3 –Analysis is continued through conventional OOA techniques. The OOA can now be continued using a suitable OO methodology and notation (e.g. OMT with UML notation).

3.4.2 *Advantages*

- The OO analyst requires minimal SSM understanding. This method draws purely upon the English language root definitions which are developed early within an SSM study
- The use of Use Cases adds real-world detail and
  - Avoids distorting the OO model.
  - Results in appropriately detailed OM.

3.4.3 *Disadvantages*

- The method is an indirect transition from SSM. It requires a Use Case analysis to gain detailed real-world understanding. It is not as quick to employ as the direct transition methods above.
- Use Cases may not be directly apparent from the root definition. The Use Cases may start at a very high level and the analyst will need to either make assumptions as to how the system achieves its purpose or carry out further investigations to obtain clarification.
- Root definition imparts little domain knowledge. This method relies upon an all-encompassing root definition that describes fully the system being modelled.
- A CM is still required to check/develop the root definition. The construction of a sound Root Definition is an iterative process that goes hand in hand with building a CM.

3.4.4 *Assessment*

The advantages are not significant enough to offset the disadvantages. This method is not appropriate and should not be employed.

3.5 *Derive Use Cases from the activities within the SSM CPTM*

3.5.1 *Stages*

- STEP 1 – <u>Identify Focus</u>. Scope and prioritise AOA activities to be investigated for possible IT support (and hence OOA).
- STEP 2 – <u>Identify Scope of OOA</u>. Determine which of the selected low-level activities are likely candidates for IT support which may require decomposition of some specific activities, for which the possible use of IT is unclear.
- STEP 3 – <u>Identify Actors</u>. For each of the low-level activities identify the Actors (roles, organisations, devices, systems) that perform the activity. The organisational mapping performed onto the CPTM can be used to assist.
- STEP 4 – <u>Develop Top Level Use Cases</u>. Take each of the identified low-level activities as the name of a Use Case. Involve the relevant Actors and/or domain experts in order to write these top level Use Cases. Once again the organisational mapping performed onto the CPTM may help the analyst in determining specific users who should be consulted during the OOA.
- STEP 5 – <u>Develop multi-level Use Cases</u>. Decompose the top-level Use Cases to an appropriate number of levels (probably three or four). The analyst should continue to involve the relevant Actors/domain experts in order to derive and validate the Use Cases.
- STEP 6 – Identify (High-Level) Objects. Identify objects from the Use Cases (by extracting the nouns), duplicate objects are removed and associates are made between the objects to express their relationships.
- STEP 7 – Map required (High-Level) Services onto Objects. Determine the high-level services from the SSM CM Activity Information requirements and map them onto the objects. If there is not a complete mapping then missing objects can be identified.
- STEP 8 – Continue Analysis Employing Conventional OOA/D Techniques. Continue the OOA using a suitable OO methodology and notation (e.g. OMT with UML notation).

3.5.2 *Advantages*

- The use of Use Cases adds real-world detail and hence:
    - Avoids distorting the OO model
    - Results in appropriately detailed OMs
- There is no paradigm shift in the modelling language; the CM is built from activities while Use Cases describe activities. This therefore seems to be the most natural transition.
- The transition utilises the detailed elements of the SSM analysis (the CM and the information requirements of each activity) and hence draws upon the understanding gained through the SSM analysis to support the OOA.
- The CM provides a uniform framework across the domain from which to start developing the Use Cases. This will prove beneficial when developing separate IT systems that will be required to inter-operate.

3.5.3 *Disadvantage*

- This is an indirect transition from SSM. It requires a Use Case analysis to gain detailed real-world understanding. It is not as quick to employ as the direct transition methods.

3.5.4 *Selected Method*

The fundamental measure of a transition method's suitability is the resultant quality of the OM. The CPTM is the best model to use as it encompasses, by definition, all the relevant stakeholder view points. Although the same techniques could be applied to an individual CM, the IT system would be based on one particular view of the system and would not align with IT systems developed from competing views of the problem domain.

The recommended transition method is from SSM CPTM to OOA Use Cases.

4. **Indirect Fire Example- CPTM to Use Case Transition**

4.1 *Overview*

By applying the recommended method identified above objects were identified. Limited study time precluded forming these into a first pass object model.

These specific steps were performed:

- For each of the in-scope level 3 activities within the CM, consulting a domain expert identified the actors.
- First pass top level Use Cases were developed by consultation with a domain expert.
- Objects were identified from the Use Cases (by extracting the nouns); duplicate objects were removed to form the candidate object list.

4.2 *Step 1 and 2 – Identify Focus and Scope of Analysis Area*

A domain expert was consulted to identify the Actors and help develop the Use Cases. In order to access the potential transition techniques, a sub-set of the activities was selected on which a transition to OOA was performed (see Figure 4). The activities encompassing "engaging targets with indirect fire" (within Employ Fighting Power) were selected. These were identified in the AOA comparison spreadsheet, as possessing high potential benefit and local domain expertise on this area was available.
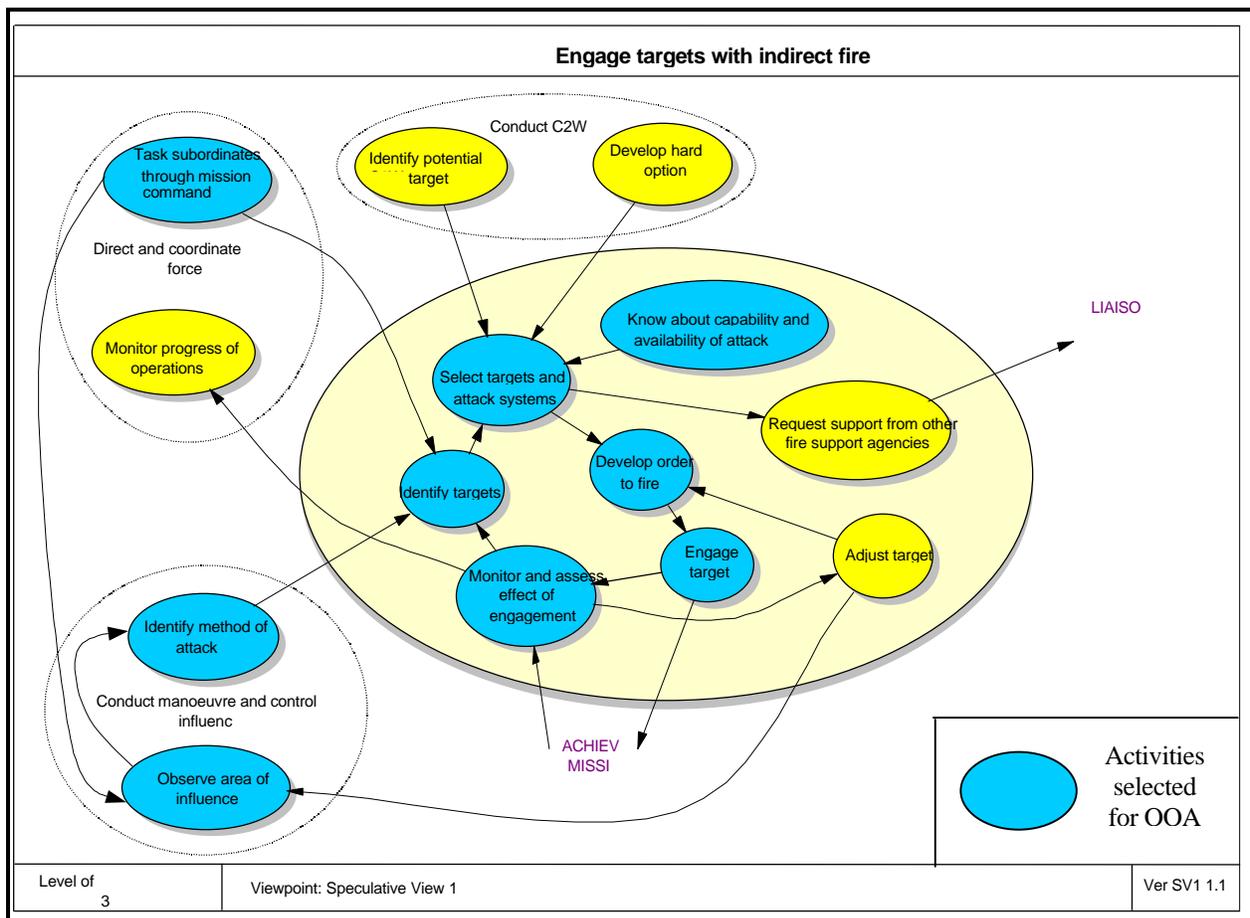
Figure 4. Selected Area of Analysis

The selected level 3 AOA activities considered to be within the scope of the experimental transition to OOA are:

- Task subordinates through mission command
- Observe area of influence
- Identify the method of attack
- Identify Targets

- Know about capability & availability of attack systems
- Select the targets & attack systems
- Developing order to fire
- Engage target
- Monitor & access effect of engagement

4.3 *Step 3 – Identify Actors*

The human actors (roles) involved with these activities are all different members of artillery "branch" and are:

- Observers   Forward Observer (FO)
- Gun End   Command Post Officer (CPO)
- Artillery Commanders   Battery Commander (BC), Commanding Officer (CO).

The System Use Case Diagram (Figure 5) shows the activities (Use Cases) within the scope of the analysis and the actors who participate in each.
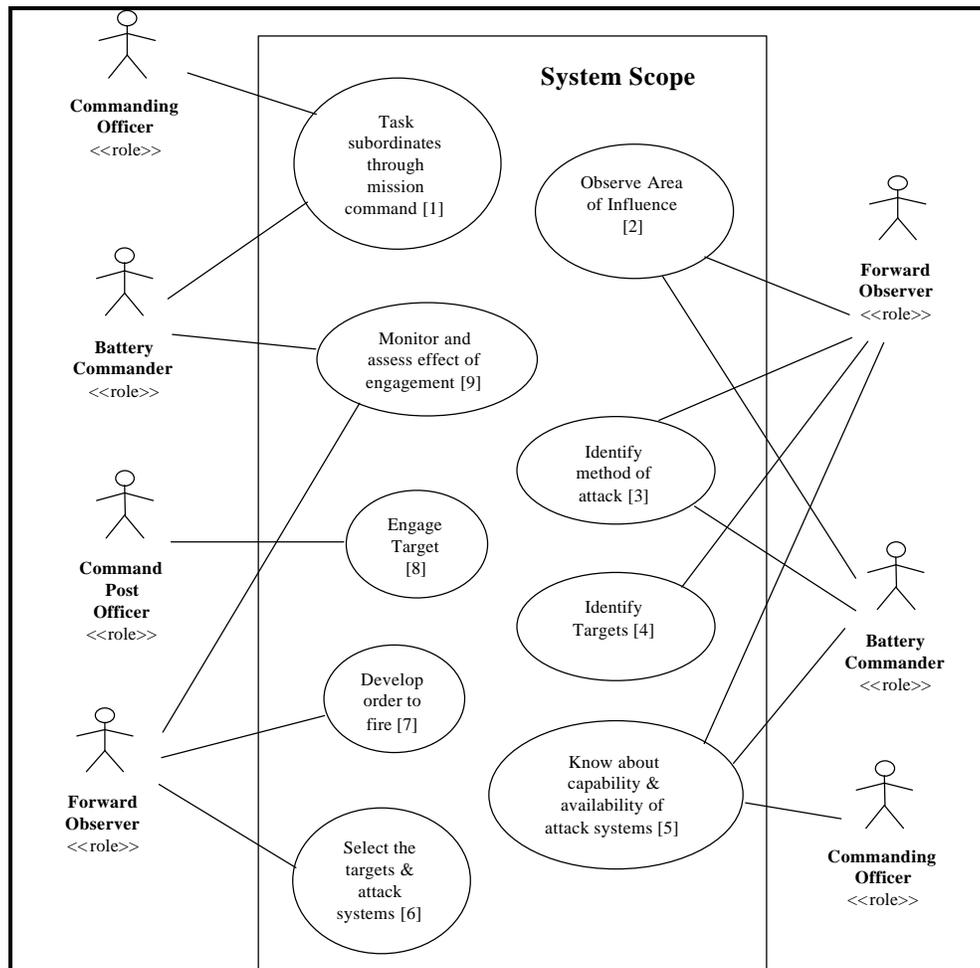

Figure 5. System Use Case diagram

4.4 *Step 4 - Use Cases and Candidate Objects*

This section presents the set of Use Cases that have been derived directly from the AOA CM. Potential objects were identified within each of these Use Cases by underlining the nouns. Note that these Use Cases are illustrative of the transition process; they have been generated rapidly and would normally be developed further before objects are derived from them.

Use Case 0.1 :   Task Subordinates through Mission Command
    Actor: CO, and BC.
    Pre-Condition: Know Commander's intent.
    Description: Issue a set of orders to FOs and any other target acquisition assets.
                         Produce a surveillance & target acquisition plan.
                         Deploy the indirect fire controllers (artillery & mortars).
                         Obtain Surveillance Picture from the All-Source Cell.
    Exceptions:
    Post-Condition:

Use Case 0.2 :   Observe Area of Influence
    Actor: BC, and FO
    Pre-Condition:
    Description: Deploy our sensors in accordance with EMCON measures.
                         Observe Arcs.
                         Liase with internal and adjacent units (exchange observation information – correlation).
    Exceptions:
    Post-Condition: Brief the supported arm commander.

Use Case 0.3 :   Identify Method of Attack
    Actor: BC, and FO.
    Pre-Condition:
    Description: artillery commander conducts an appreciation with supported arm commander.
                         artillery commander negotiates resources with his senior artillery commander.
                         Determine Plan of Attack (exclusive, direct or indirect fire engagement or combination).
    Exceptions:
    Post-Condition:

Use Case 0.4 :   Identify Targets
    Actor: FO
    Pre-Condition:
    Description: Acquire target(s) location.
                         Acquire target(s) description.
                         Assess the targets degree of protection.
                         Assess size and level of target(s).
                         Assess target(s) intent.

Exceptions:
Post-Condition:

Use Case 0.5 :   **Know about capability & availability of attack systems**
    Actor: CO, BC, and FO
    Pre-Condition:
    Description: Confirm <u>indirect fire assets availability</u> (number, nature of ammo, duration).
                   Determine <u>indirect fire assets capability</u> (<u>achievable coverage</u> for each <u>target type)</u>.
    Exceptions:
    Post-Condition:

Use Case 0.6 :   **Select the targets & attack systems**
    Actor: FO
    Pre-Condition:
    Description: Match the <u>delivery system</u> to the <u>target</u>(s).
                   Determine the <u>required effects</u> on the <u>target</u>.
                   Select <u>method of fire</u>.
    Exceptions:
    Post-Condition:

Use Case 0.7 :   **Develop order to fire**
    Actor: FO
    Pre-Condition:
    Description: Create a <u>warning order</u> (<u>call to fire</u> to specific <u>fire units</u> to include location & method).
                   Issue <u>adjustment orders</u> (include 'a direction' etc)
                   Continue adjustment of <u>mean point of impact</u> (send <u>firing correction</u>)
                   Adjust the <u>fire for effect</u> (check <u>footprint</u>).
    Exceptions:
    Post-Condition: <u>Final method of fire</u>.

Use Case 0.8 :   **Engage Target**
    Actor: CPO
    Pre-Condition: Receive <u>initial orders</u> (warning).
    Description: Prepare <u>ammunition</u>.
                   Check the <u>lay of the guns</u>.
                   Produce the <u>ballistic computation</u>.
                   Issue <u>firing data</u> to adjust <u>gun(s)</u> (to allow continue with adjustment – in response to <u>observers</u> <u>fire orders</u>).
    Exceptions:
    Post-Condition:

Use Case 0.9 :   **Monitor and access effect of engagement**
    Actor: BC, and FO

Pre-Condition: A <u>target engagement</u> has occurred.
Description: Assess <u>target engagement</u>.
Identify <u>new targets</u>.
Exceptions:
Post-Condition: Issue <u>end of mission orders</u>.

4.5 *Step 5 – Develop Multi-level Use Cases*

The Use Cases identified in Step 4 would normally require further decomposition before candidate objects could be identified. This step is omitted here to avoid over complicating the example.

4.6 *Step 6 - Candidate Objects*

- Commander
- Order
- FO
- Target acquisition asset
- Surveillance & target acquisition plan
- Indirect fire controls (artillery & mortars)
- Surveillance Picture
- All-Source Cell
- Sensors
- EMCOM measures
- Arcs
- Units (internal & adjacent)
- Observation (information)
- Supported ARM Commander
- Artillery Commander
- Resources
- Senior Artillery Commander
- Plan of Attack? (Course of action)
- Fire Engagement (Exclusive, Direct, Indirect, or combination)
- Target (location, description, degree of protection, size, level, intent)
- Indirect Fire Assets Availability
- Indirect Fire Assets Capability
- Achievable Coverage
- Target Type
- Delivery System
- Required Effects
- Method of Fire
- Warning Order
- Adjustment Order (includes direction)
- Mean Point of Impact
- Firing Correction

- Fire for Effect (Footprint)
- Final method of Fire
- Initial Orders (warning)
- Ammunition
- Lay of the Guns
- Ballistic Computation
- Firing Data
- Guns
- Observers
- Fire Orders
- Target Engagement
- New Targets
- End of Mission Orders

This object list is far richer than the set of objects derived using the transition method "CPTM to Objects". The Use Case analysis could be developed further in order to build an object model that meets the IT support requirements. This method flows naturally into OOA and it is clear it will lead to a more detailed object model than could be achieved using any of the other three methods.

5. **SHORAD Example**

5.1 *Purpose of the SHORAD Digitisation Project*

The example has been developed by Hi-Q Systems based on their work for the SHORAD package within the Defence and Evaluation Research Agency (DERA) Applied Research Programme. The aim of the project was to illustrate digitisation issues associated with the design of the SHORAD Battlefield Information System Application (BISA). Central to the design was understanding and incorporating a new operational requirement to change from an autonomous mode of operation to one that exploited the use of external air surveillance and targeting information. The initial task was to provide a high-level SSM activity model of "new" SHORAD in the joint force environment. The model was independent of organisation and represent what the SHORAD business had to do in order to be the provider of AD protection to the Land Component whilst contributing to the Defensive Counter Air campaign (See Figure 6). It had also to embody the emerging SHORAD C3I doctrine providing for increased situational awareness, alerting, cueing and moving towards positive control measures for the declaration of air platform allegiance.

5.2 *Effect of Limitations on the Transition*

The starting point for creating a BOM is a CPTM that has been developed to the extent that:

- Information support requirements (I/O) and Measures of Performance (MoPs)) for each CPTM activity have been identified.

- Real world organisational structure has been mapped onto the CPTM after analysis by the analyst and the user (i.e. the responsibilities for the delivery of CPTM activities in terms of individual roles and/or organisations has been determined).

The SHORAD SSM model lacked the depth required to identify readily the detailed SHORAD information services necessary to define business object associations. Nevertheless the model did provide the means to develop a set of scenarios, enable the use of ISM and enable the extraction of objects from activities. In view of this limitation, it was not possible to complete all eight steps of the selected transition method to the detail necessary for a fully developed BOM. Consequently other sources of information have been used to provide expeditiously a more complete set of high-level business objects and their associations namely the SHORAD Tasking/Siting Data Flow Diagrams (DFD), taxonomies and scenarios. DERA's on-going task of providing functional specifications of tools to support "digitization" business will ultimately provide a more detailed understanding of the objects to be modelled, the services they provide and the interfaces between objects.
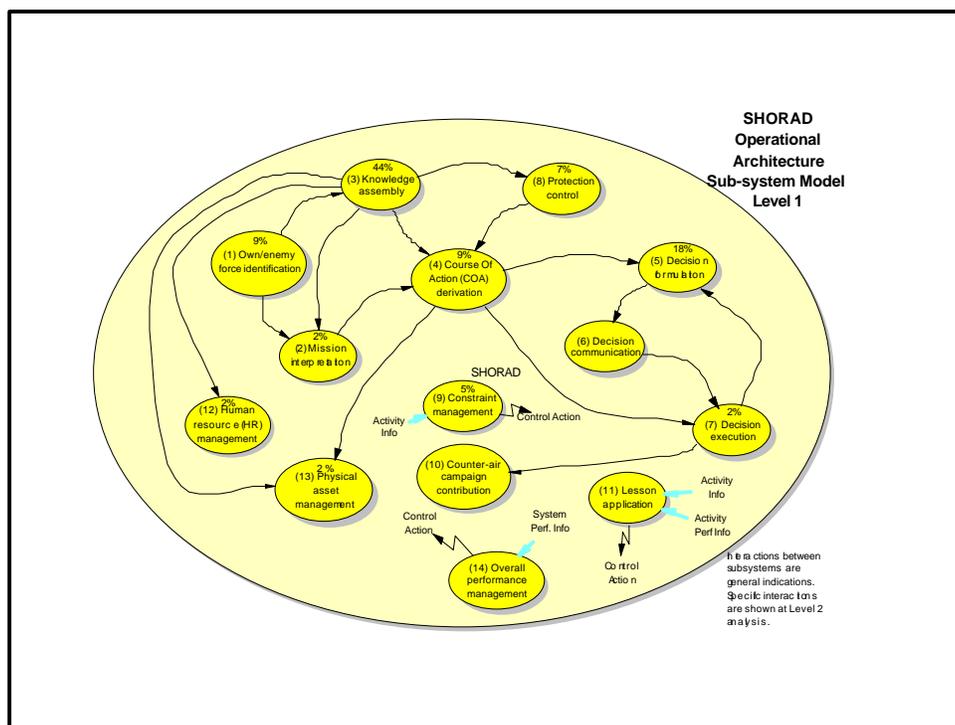

Figure 6. SHORAD SSM CPTM

5.3 *Step 1- Identify Focus*

The focus or theme for the transition was developed from a combination of the high value processes (HVPs) identified in the Statement of User Needs (SUN) and analysis of the aspirations for SHORAD through improved C3I found from the SSM model and doctrine. The HVP within the SUN were selected from those C2 processes thought to benefit most from Digitization. The SHORAD processes, depicted at Figure 7, were selected as those thought to return the greatest operational benefit from digitization. The extent of the increase in SHORAD

operational effectiveness due to IT support depends on a full analysis of the contribution made by the current IT provision, recorded by populating the southern half of the Maltese Cross during ISM.

The focus is based on the degree of guarantee surrounding the level of protection given by the AD Commander to the Operational Commander and requires a set of scenarios covering Joint force, AD planning and operations. The SHORAD activities include the estimate, the IPB, tasking, siting and conduct of SHORAD operations. The scenarios show the nature and source of information external to SHORAD that would be obtained from the set of Common Service Tools (CSTs) such as orders, air IPB, airspace control orders and mapping provided through Digitization.
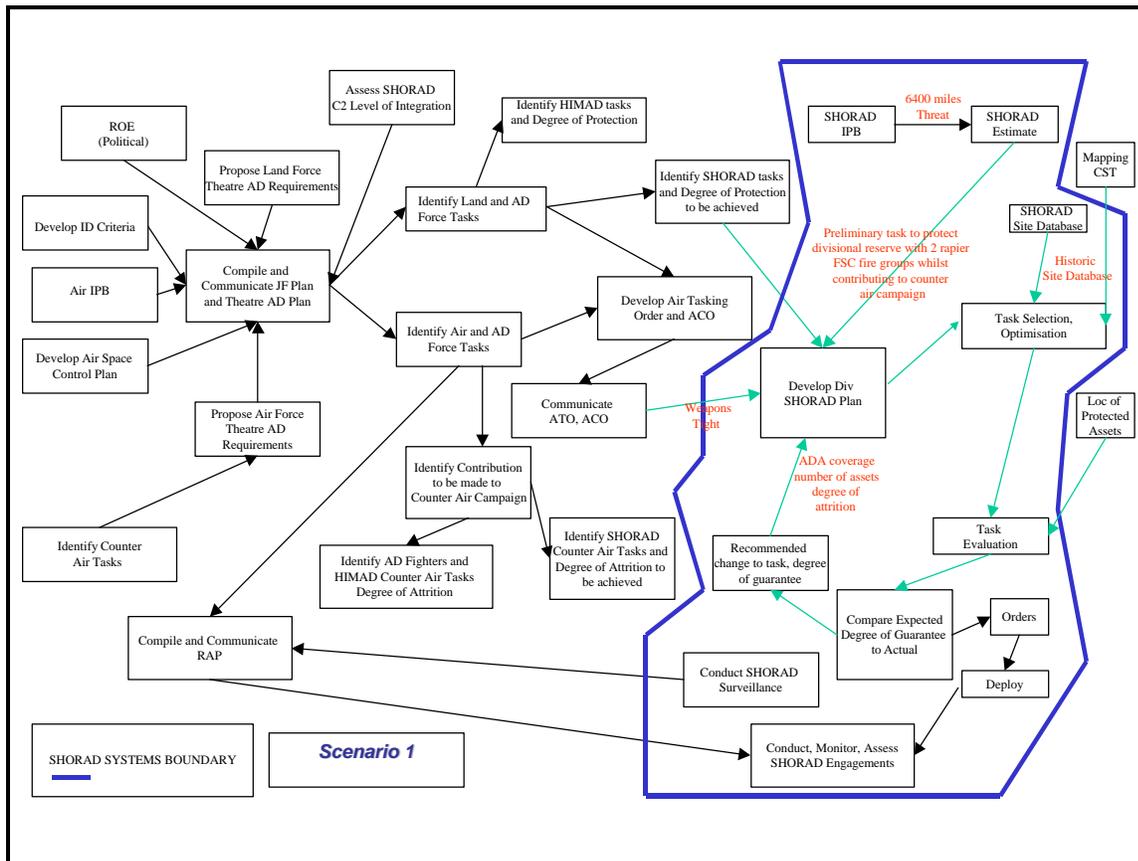

Figure 7. Scenario - Joint Force AD Planning and Operations

5.4 *Step 2 Identify Scope*

The specific scenarios were used to identify the scope in terms of selecting specific SHORAD SSM activities. Figure 8 below shows an initial mapping of the high value SHORAD processes onto the SSM activity model. (This associates the selected SSM activities with Use Case names.

SHORAD Activity Model and Use Case No.	SHORAD HVP/Activity	Use Case Name
2	**Mission interpretation**	
2.2	Obtain mission requirements	Receive full set of orders from superior commander
2.3	Interpret mission requirements	Extraction of orders
3	**Knowledge assembly**	
3.2	Forecast enemy air offensives	SHORAD IPB Process
3.5	Assemble intelligence about actual offensives	Current Air-Related IPB
4	**Course of action derivation**	
4.3	Derive potential courses of action to achieve mission and provide required protection	AD Estimate process including candidate deployment options
4.4	Define desired courses of action	Selection of preferred deployment option
8	**Protection control**	
8.1	Assess degree of protection desired	Determination of degree of protection required
9	**Constraint management**	
9.1	Know about operational and political constraints	Understand political and operational constraints
10	**Counter-air campaign contribution**	
10.1	Know about the counter-air campaign	Understand required contribution to the air-campaign
13	**Physical asset management**	
13.1	Define physical assets availability to AD forces	Understand allocation of available AD assets
13.2	Assess capability requirements of physical AD assets	Assess the AD assets system capabilities
13.3	Assess their capability with regard to requirements	Determine the optimum mix of allocated AD assets

Figure 8. Use Case Names

5.5 *Step 3- Identify Actors*.

For each activity the analyst and the domain expert identified the actors (roles, organisations, devices, and systems) that perform the activity. The results are listed at step 4 within the Use Cases. The technique of mapping existing and possible future organisations on the CPTM was used.

5.6 *Step 4 – Develop Top Level Use Cases*

5.6.1 *Construction of Use Cases*

The Use Case analysis was done in conjunction with a subject matter expert. The descriptions for the Use Cases were developed further from consideration of the SHORAD Taxonomies, information category analysis and DFDs. Figure 9 shows the SHORAD taxonomy used to develop the Use Case (2.3) Extraction of Orders. It should be noted that it shows the context and manner for identifying the Commander's required degree of guarantee.
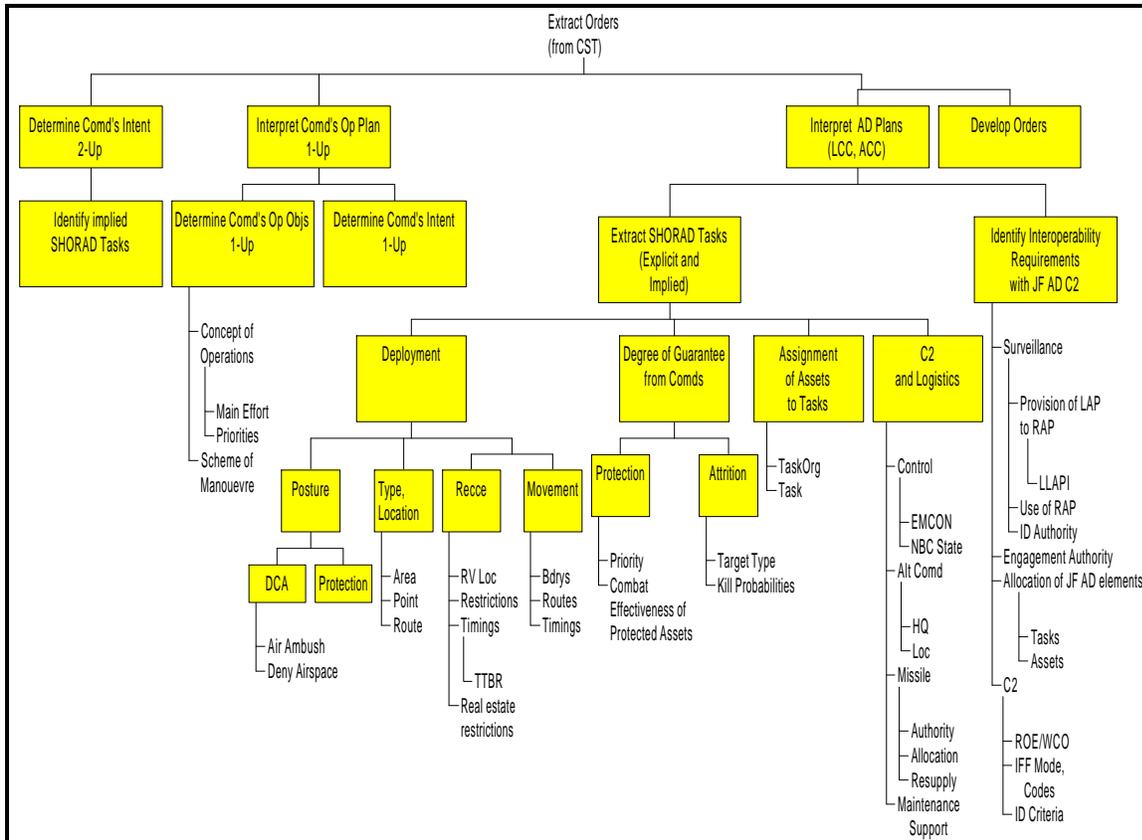
Figure 9. SHORAD Taxonomy for Extraction of Orders

An explanation follows of the features of Use Cases. SSM model activity 2.3 is "Interpret Mission Requirements". This maps with the SHORAD activity of "Extraction of Orders". The "actors" for extraction of orders were assessed as being the Commander AD, the AD Commanding Officer and the AD Battery Commander. For each Use Case, any pre-conditions and post conditions were named. For example, in Use Case 2.3 the pre-condition is the subject of another Use Case (Use Case 2.2: Receive full set of orders from Superior Commander (Obtain Mission Requirements))

The description of the Use Case is a list of the tasks that are performed to complete that activity, for example "assess the AD tasks to determine the locations, priority, duration, time to be ready and the degree of guarantee". Where a Use Case can fail, this is described within the exceptions.

For example, Use Case 13.3 has an exception, that being when the Commander's degree of protection can not be fully met. In a complete use case analysis these exceptions would themselves be the subjects of Use Cases. The post condition describes the result of the activity.

5.6.2 *Use Case Results[2]*

Use Case 2.3 :   Extraction of Orders (Interpret Mission Requirements)
    Actor: COMD AD, AD Regt CO, AD BC
    Pre-Condition: Full set of orders. **(2.2)**
    Description: Understand Comd's intent 2-up.
                 Understand Comd's plan, priorities, Main Effort (ME) and required level of combat effectiveness for protected assets.
                 Assess AD tasks: locations, priority, duration, Time To Be Ready (TTBR) and Degree of Guarantee.
                 Assess any implied tasks.
                 Understand allocation of AD assets (13.1).
                 Understand command authority.
                 Understand Political & Operational Constraints (9.1).
                 Understand required Contribution to the Counter Air Campaign (10.1).
    Exceptions:
    Post-Condition: Extracted Orders.

Use Case 4.3 :   AD Estimate Process (Derive Potential Courses of Action to
                 Achieve Mission and provide required protection)
    Actor: COMD AD, AD Regt CO, AD BC
    Pre-Condition: Extracted Orders. **(2.3)**
    Description: Assess the current tactical situation (Land, Sea & Air).
                 Perform **SHORAD IPB Process (3.2)**
                 For each task:
                 Assess the AD assets system capabilities (13.2).
                 Assess the deployment posture: defence, attrition or ambush.
                 Assess current EMCON State and it's effect.
                 Assess current Weapon Control State (WCS) and it's effect.
                 Assess logistic support, missiles, re-supply and maintenance support for each asset.
                 Assess communications connectivity.
                 Assess the need for additional AD assets from Superior Comd.
                 Determine the optimum mix of allocated AD assets (13.3).

                 Derive potential Degree of Protection achievable for task(s) under each deployment option.
                 Assess contribution to Counter Air Campaign for each deployment option.
                 Assemble candidate deployment options.
    Exceptions:

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[2] Emboldened text represents the name of a Use Case; italicised text represents the name of a Use Case not yet defined.

Post-Condition: Candidate deployment options.

Use Case 4.4 : **Selection of preferred Deployment Option**
(Define desired course of action)
Actor: Formation Comd, COMD AD, AD Regt CO, AD BC
Pre-Condition: Candidate deployment options. **(4.3)**
Required Degree of Protection. **(8.1)**
Description: Identify SHORAD selection criteria for deployment recommendation.
Inform Superior Comd of deployment options with recommendation(s).
Obtain conformation of priorities, combat effectiveness thresholds and degree of guarantee of task(s) from Superior Comd.
Obtain decision on selection of the preferred deployment option from Superior Comd.
Exceptions:
Post-Condition: Preferred deployment option selected.

Use Case 3.2 : **SHORAD IPB Process** (Forecast Enemy Air Offensives)
Actor: COMD AD, AD Regt CO, AD BC
Pre-Condition: Current Enemy ORBAT, weapons, tactics and capability. *(3.2)*
Current Air related IPB. *(3.5)*
Extracted Orders. **(2.3)**
Description: Determine AD Task Type
Determine Enemy Force Primary, Secondary and Tertiary potential weapon delivery choices (situation overlay).
Determine Line of Weapon Release (LWR) for enemy's potential weapon delivery choices.
Assess enemy tactics for attacking the task Type (Event Overlay).
Assess the ability of the potential Air Platform to operate day/night and all-weathers.
Determine terrain effects on enemy tactics (fly-lines).
Assess the enemy Suppression of Enemy Air Defence (SEAD) and enemy ARM capability.
Consider enemy combat effectiveness, status of air platforms, moral.
Consider enemy Air Platform Engagement Envelope from Operating Base.
Exceptions:
Post-Condition: Threat Integration Overlays produced.

Use Case 13.3 : **Determine the optimum mix of allocated AD assets**
(Assess their capability with regard to requirements)
Actor: COMD AD, AD Regt CO, AD BC
Pre-Condition: Given task(s), SHORAD system capabilities (**13.2**), EMCON, Weapon Control Status, Communication connectivity, Allocated AD Assets, Logistic support, IPB Process (**3.2, 3.5**). Terrain/mapping. Commanders expected DOP. Task type, task size, DOG (Priority) location, threat, fly-lines, day/night capability, all weather, what training, direction of attack, base location of threat, LWR, how far out.

Description: Iterative process of:

Placement of allocated assets onto terrain/map, to give the optimum coverage of a given task(s) to meet commanders expected degree of protection.

This process is done for each task. The task details, the task size and where the task is are taken into account. Using the expected threat, what the threat is, what weapons are likely to be used, what the air platforms are, how are they likely to be used and understanding how to employ SHORAD assets against that threat. This information is supplied through the task orders, the Estimate for the expected threat, and the SHORAD IPB for the terrain. Use the system to suggest sites, and use historic sites. Do "what ifs". Manual process, use an A4 sheet of paper on a 1:50,000 map for a Rapier FSC. Allocate AD assets; take account of logistics (helicopter drop in).

Exceptions: Commanders expected DOP not met

Post-Condition: Optimum allocation of mixed assets, and predicted deployment for given set of tasks.

Use Case 13.2 : **Assess the AD assets system capabilities**
(Assess capability requirements of physical AD assets)

Actor:

Pre-Condition: Performance characteristics of weapons and sensors including sensor detection envelope and weapon platform engagement envelope, Allocated AD assets

Description: Assessing the weapon and sensor coverage against threat, terrain and environment factors. Normally using a "look up table".

Exceptions:

Post-Condition: Optimised sensor and weapon template

Use Case 8.1 : **Determination of Degree of Protection Required**
(Assess degree of protection desired).

Actor: Formation Comd, COMD AD, AD Regt CO, AD BC

Pre-Condition: Extracted orders. **(2.3)**

Description: Superior Comd sets criteria and thresholds that define the Degree of Protection, attrition and Combat Effectiveness with advise from the AD Comd.

Superior Comd to set Degree of Protection and attrition for task(s) if not stated in Orders.

Exceptions:

Post-Condition: Degree of Protection and attrition required by Superior Comd

5.7 *Step 5 – Develop Multi-level Use Cases*

Multi-level Use Cases are derived from a decomposition of the top-level Use Cases. This was not done directly due to the limitations already discussed. However, many of the descriptions defined in the Use Cases are at a level of detail akin to that required by multi-level Use Cases.

The objects that would have been extracted were derived using the alternative techniques of DFDs, Taxonomies and scenarios.

5.8 *Step 6 - Identify (High Level) Objects*

5.8.1 *Extraction of Objects from Use Cases*

The following analysis showed the first stage of extracting objects from the Use Case analysis. Although the transition procedure only specified the identification of objects, for the purposes of this example the attributes and services were identified. This process was limited by the degree of detail contained within the Use Cases, and is provided here for illustrative purposes only.

Key to highlighting
- Candidate Class / Objects An object is an instantiation of a class. There maybe multiple objects of a class. Objects provide the behaviour and knowledge of the system.
- Attributes of Objects. Holds the information of the object.
- Services. A service in an object provides a certain piece of system functionality.

Use Case 2.3 :   **Extraction of Orders** (Interpret Mission Requirements)
Actor:	COMD AD, AD Regt CO, AD BC
Pre-Condition:	Full set of orders. **(2.2)**
Description:	Understand Comd's intent 2-up.
	Understand Comd's plan, priorities, Main Effort (ME) and required level of combat effectiveness for protected assets.
	Assess AD tasks: locations, priority, duration, Time To Be Ready (TTBR) and Degree of Guarantee.
	Assess any implied tasks.
	Understand allocation of AD assets (13.1).
	Understand command authority.
	Understand Political & Operational Constraints (9.1).
	Understand required Contribution to the Counter Air Campaign (10.1).
Exceptions:	
Post-Condition:	Extracted Orders.

Use Case 4.3 :   **AD Estimate Process** (Derive Potential Courses of Action to Achieve Mission and provide required protection)
Actor:	COMD AD, AD Regt CO, AD BC
Pre-Condition:	Extracted Orders. **(2.3)**
Description:	Assess the current tactical situation (Land, Sea & Air).
	Perform **SHORAD IPB Process** (3.2)
	For each task:
	Assess the AD assets system capabilities (13.2).
	Assess the deployment posture: defence, attrition or ambush.
	Assess current EMCON State and it's effect.

Assess current Weapon Control State (WCS) and it's effect.
Assess logistic support, missiles, re-supply and maintenance support for each asset.
Assess communications connectivity.
Assess the need for additional AD assets from Superior Comd.
Determine the optimum mix of allocated AD assets (13.3).

Derive potential Degree of Protection achievable for task(s) under each deployment option.
Assess contribution to Counter Air Campaign for each deployment option.
Assemble candidate deployment options.

Exceptions:
Post-Condition: Candidate deployment options.

Use Case 4.4 :   Selection of preferred Deployment Option
                  (Define desired course of action)
Actor: Formation Comd, COMD AD, AD Regt CO, AD BC
Pre-Condition: Candidate deployment options. **(4.3)**
                  Required Degree of Protection. **(8.1)**
Description: Identify SHORAD selection criteria for deployment recommendation.
                  Inform Superior Comd of deployment options with recommendation(s).
                  Obtain conformation of priorities, combat effectiveness thresholds and degree of guarantee of task(s) from Superior Comd.
                  Obtain decision on selection of the preferred deployment option from Superior Comd.
Exceptions:
Post-Condition: Preferred deployment option selected.

Use Case 3.2 :   SHORAD IPB Process (Forecast Enemy Air Offensives)
Actor: COMD AD, AD Regt CO, AD BC
Pre-Condition: Current Enemy ORBAT, weapons, tactics and capability. *(3.2)*
                  Current Air related IPB. *(3.5)*
                  Extracted Orders. **(2.3)**
Description: Determine AD Task Type
                  Determine Enemy Force Primary, Secondary and Tertiary potential weapon delivery choices (situation overlay).
                  Determine Line of Weapon Release (LWR) for enemy's potential weapon delivery choices.
                  Assess enemy tactics for attacking the task Type (Event Overlay).
                  Assess the ability of the potential Air Platform to operate day/night and all-weathers.
                  Determine terrain effects on enemy tactics (fly-lines).
                  Assess the enemy Suppression of Enemy Air Defence (SEAD) and enemy ARM capability.
                  Consider enemy combat effectiveness, status of air platforms, moral.

Consider ==enemy Air Platform Engagement Envelope== from ==Operating Base==.

Exceptions:

Post-Condition: ==Threat Integration Overlay==s produced.

5.8.2 *Object Extraction from DFDs*

The DFDs for the SHORAD business were used as a source for identifying objects. In the case of the DFD for the siting of SHORAD assets (Figure 10) the candidate objects that can be extracted include such items as the Air Platform, the Deployment status, the Weapon Control Status (WCS) and the Recce Plan. The information services were also noted from the information flows, written on the lines between external processes and databases and the internal siting process.
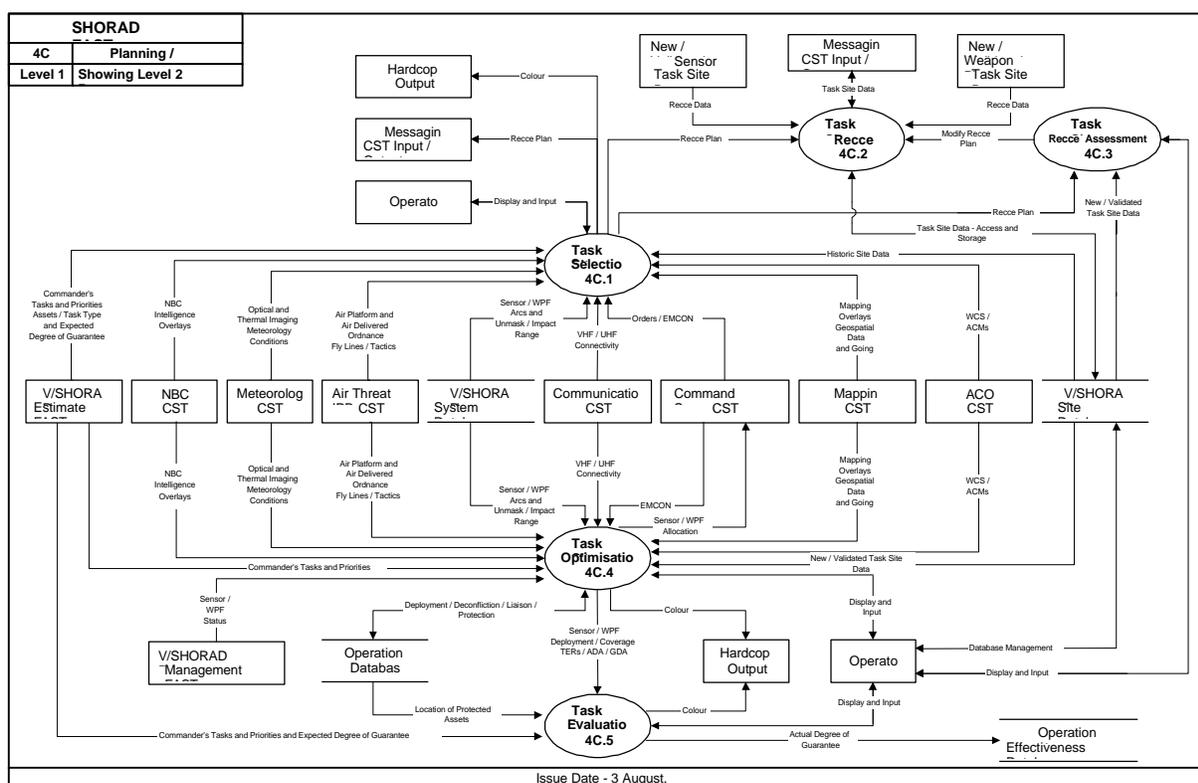
Figure 10. Siting DFD

5.8.3 *Object Extraction from Scenarios*

Another important source of candidate objects was the set of scenarios which show the data flows (and hence the objects and their information services) between elements of the Air Defence community. The scenarios follow a thread through the planning, siting, deployment and conduct of operations, with the emphasis on the dynamic monitoring of the actual degree of guarantee of protection against that expected by the Operational Commander.

5.8.4 *Consolidated Business Objects List*

Figure 11 shows an example from the hierarchical list of business objects that has been recorded in MOOD.
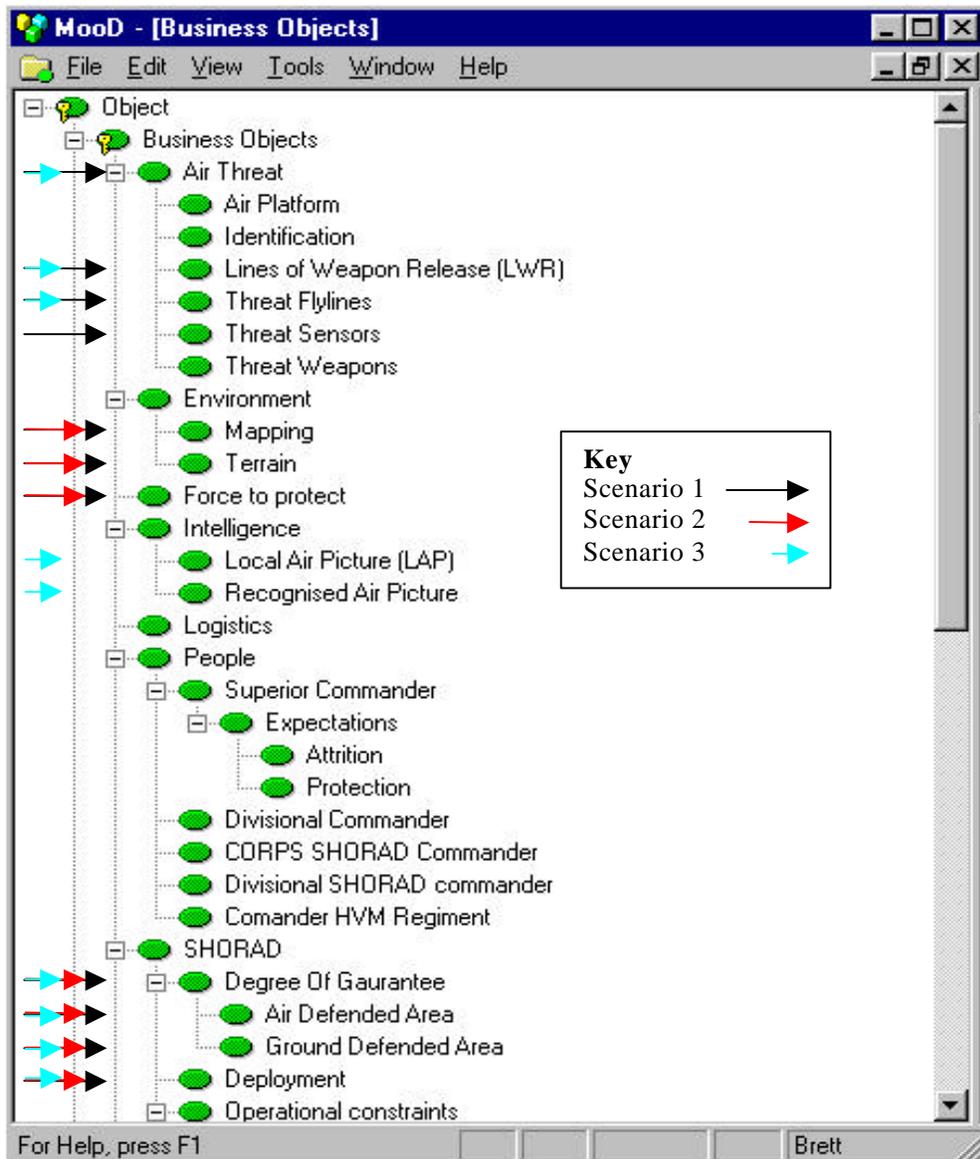
Figure 11. Business Objects Hierarchy

5.9 *Step 7 - Map required (High-Level) services onto objects*

5.9.1 *Identify Services*

Services were derived initially from the ISM analysis developed through the various steps of the transition up to the extraction of objects. The services were expressed as the types of information either input to a given SHORAD activity (information consumed by the activity) or

output from that activity (information produced by that activity). In the case of ISM the information type is known as an information category whereas the type deduced during the transition may be more specific and could be a real world information flow or product.

The services identified during the transition originated either from the scenario or the Use Case analysis. This was a matter of convenience since scenario and use cases are independent. High-level services come from the pre and post conditions whereas the multi level services are derived from the detailed descriptions. In the case of degree of guarantee, the scenarios reveal information services such as the provision of AD tasks from the operational commander to the SHORAD and within SHORAD the evaluation of the required tasks. The pre and post conditions of Use Case 4.4 suggests that information services are needed to obtain the required degree of guarantee (from the operational commander) and to select the deployment option that best meets that guarantee (negotiated between the operational and SHORAD commander).

5.9.2 *Production of the BOM*

Services were mapped onto the set of objects extracted at Step 6 to create the BOM. Figure 12 shows an illustrative BOM for the general SHORAD planning and conduct of operations scenario. It shows the dependencies between objects, the sources of information whether from legacy systems or data storage and the possible presentation components. The objects required to produce the services in the degree of guarantee example include "Degree of Guarantee", "Deployment" and "Plan" all with parent object SHORAD.
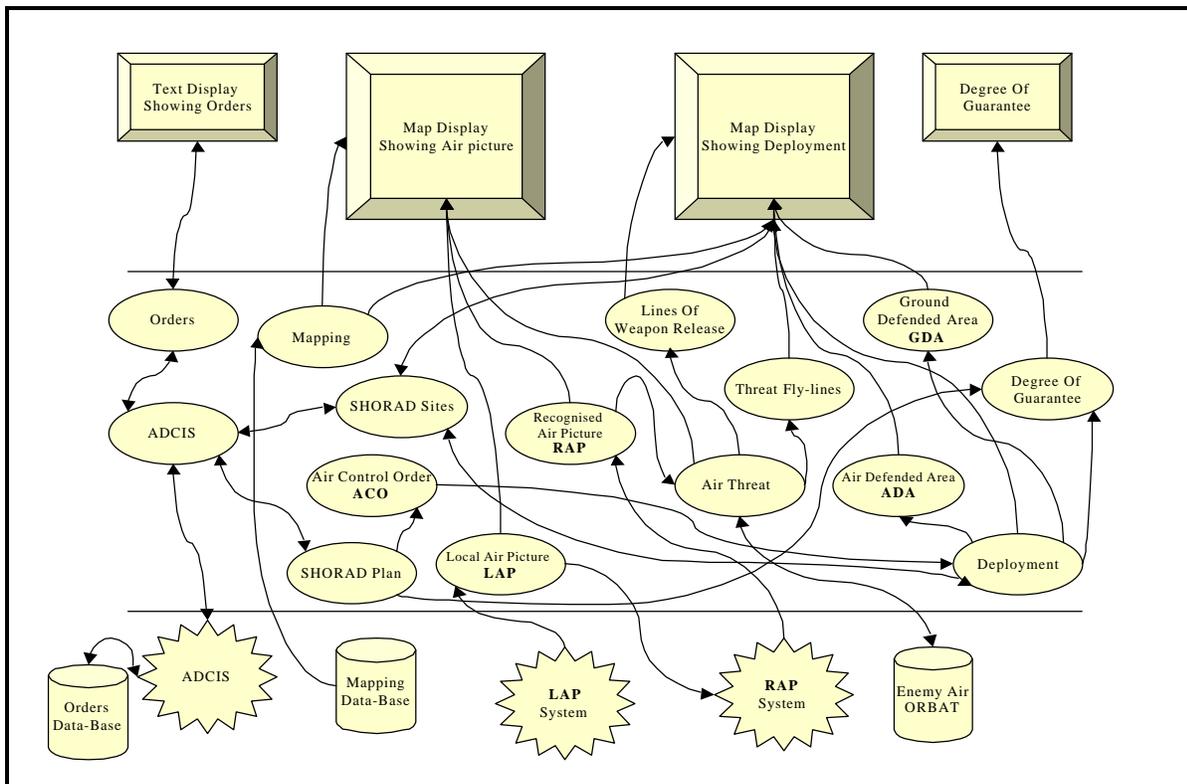

Figure 12. Business Object Model

5.10 *Step 8 - Continue OOA/D*

The OOA could be continued using a suitable OO methodology and notation e.g. Object Modelling Technology (OMT) with UML.

6. **Conclusion**

6.1 *Benefit*

The preferred transition method exploits the consensus view of what the business is there to do, and hence the development of vital information needs for the business. The expeditious use of the results of the SSM business analysis increases the prospect of convergence with the OOA Use Case analysis. There is singular benefit by comparing the needs of the business with those that are currently being supported by IS. In support of change management, it results in a clear view of the IS support required to migrate from the former business system to a successor. The results of the ISM are used to validate the OOA and visa versa.

The transition method advocates the simultaneous and complementary use of SSM and OOA engendering confidence amidst developers and users that an early, and effective, design can be agreed. It also aids project managers in judging when to move from SSM to OOA thereby making efficient use of resources. Effort between the business analysis within SSM and the analysis of the IS required to support the business in ISM and OOA is therefore optimised.

6.2 *Exploitation*

The transition method may be dovetailed into both SSM and OOA in a manner that reduces the extent of analysis undertaken in the separate methods. The techniques identified in the transition study of scenarios, DFDs and taxonomies facilitate this process.

There is a strong case for considering how to re-use the results of the extensive IDEF work completed during the production of the Force XX1 operational architecture in order to make recommendations on improving both the transition method. In turn providing a transition to allow SSM techniques to impact on US IDEF work may offer improvements to the Force XX1 methodology.

7. **Acknowledgements**

7.1 *Transition Study*

Hi-Q Systems was sponsored by DCIS(A). Maj Harry Duncan whose guidance and involvement throughout the project was appreciated.   Dr Brian Wilson kindly ensured that the principles of SSM were upheld during the innovative exploration into the world of object orientation.

7.2 *SHORAD example*

The original SHORAD work relied heavily on collaboration with the subject matter expert, Maj Mike Gordon from DERA. His significant contribution resulted in an immediate and for the main, uncontested appreciation by the SHORAD development community of the digitisation issues associated with the transition from SSM to OOA.

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