Title: **Developing Coherent, Concise And Comprehensive User Requirements Using The MoD Architectural Framework (MODAF)**

Topic: C4ISR/C2 Architecture

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ABSTRACT

Articulating user requirements is arguably one of the most difficult and yet critical challenges in any Information System Project. Within the British Army, the Directorate of Command and Battlespace Management (Army) has been developing its user requirement methodology and practice over the last few years and now uses the Ministry of Defence Architectural Framework (MODAF) as a corner stone of its approach. This paper explains the methodology that has been developed to overcome some of the difficulties associated with user requirement engineering for Command and Battlespace Management IS. The specific difficulties are:

- How to bridge the gap between users who may not know what they want and industry who may not understand the intricacies of the military business to be supported.
- How to articulate URs in a manner concise and digestible enough for users to review effectively, yet comprehensive enough for industry to fully understand the requirement and the military business effected by the system.
- How to ensure a User Requirement Document (URD) is consistent and coherent with URDs for other IS within the System of Systems.

The approach taken revolves around use of the MODAF framework, instantiated using the MooD Transformation Tool Set.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JUN 2005		**00-00-2005 to 00-00-2005**

4. TITLE AND SUBTITLE
Developing Coherent, Concise and Comprehensive User Requirements Using the MoD Architectural Framework (MODAF)

5a. CONTRACT NUMBER
5b. GRANT NUMBER
5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Directorate of Command and Battlespace Management (Army),Capability Integration Branch,Shannon Building, Blanford Camp,Dorset, DT11 8RH Uk, ,

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**37**	

D CBM(A)/07/10/06

14 March 2005

DEVELOPING USER REQUIREMENTS USING THE MOD ARCHITECHTURAL FRAMEWORK (MODAF)

INTRODUCTION

1. User Requirements (URs) for Information System Projects should convey the requirements of military business in such a way that all parties (users/customers and suppliers) have a clear, unambiguous, and common understanding of what is required. Information systems must be designed to support military processes; either current processes or new processes developed as a result of the IS being introduced. Therefore understanding and communicating what the business wants to achieve, and how it intends to use information (the military processes) to achieve that end, is fundamental to procuring an information system that contributes to operational capability in the desired manner.

2. Text based descriptions of URs generally fail to convey, on their own, the full military need: they are either too brief, leaving room for assumption and hence misinterpretation, or are too cumbersome for a user to check that they accurately convey the intended requirement. The use of graphical models to derive and augment URs, adds both detail and ease of understanding. The nascent MOD Architectural Framework (MODAF)[1] is a description of a framework for breaking down a complex mix of ideas such as objectives, processes, organisations and technical resources into easily digestible graphical representations, which can be linked together to describe an entire military enterprise. Models developed in a MODAF compliant manner combine (and are referred to collectively as an architecture) to describe an enterprise of interest to the target audience in a concise yet comprehensive manner. MODAF compliant architectures compliment text based URs and are used to inform and support traditional User Requirement Documents (URD). When combined, the URD should explicitly state the requirement, and the architecture should provide the understanding and context required to minimise[2] ambiguity and achieve common understanding between the customers and suppliers.

3. Information Systems offer opportunities to improve military processes as well as performing existing process faster and more easily. However, users often struggle to specify more than an automation of existing process and practices using text based URs alone. It is this phenomenon that led to the Canadian Digitisation experience – as soon as users were given an IS system, their experience with it changed their requirements. The rich yet concise nature of MODAF models acts as a *lingua franca* and provides improved understanding that facilitates meaningful discussions between users and contractors that enable each evolution of an information system to make greater progress than it otherwise might.

AIM

4. The aim of this paper is to outline how use of graphical architectures based on MODAF improves the development and articulation of User Requirement Documents for information systems. The UK MoD's Best Practice Guide to Digitisation User Requirements[3] gives more detailed guidance on developing user requirements, and is aimed at those actually writing URDs.

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1 MODAF is a standard being developed from the American DoDAF, sponsored by CM(IS) and project managed by DEC CCII. The main additions to DoDAF are the Strategic and Acquisition Views. Formal release is expected to be June 2005.

2 Eliminating ambiguity entirely is an aspiration rather than an achievable end state, just as achieving 100% safety is an unachievable aspiration.

3 Best Practice Guide to Digitisation User Requirements. D Info(A)/695/10/Info Coherence
Issue 1.0 – 28 Oct 03.

This paper does give an outline of the elements of MODAF most relevant to user requirements[4], but the emphasis is on explaining what each MODAF view contributes to the requirements process rather than providing a definitive guide to MODAF itself.

LAYOUT OF THE PAPER

5. This paper gives an overview of the user requirements derivation process supported by MODAF, which is intended to orientate the reader. This is followed by a brief description of the architectural framework with emphasis on the purpose and content of the different MODAF views in relation to deriving URs. The Section on Construction of the URD explains the elements of a digitisation URD and which MODAF views inform them. The process is still evolving, and so the last Section before the Summary and Conclusion describe the known areas for future development.

OVERVIEW OF THE USER REQUIREMENTS DERIVATION PROCESS SUPPORTED BY MODAF

6. The process of deriving user requirements is iterative, each step will inform both the previous and subsequent steps. In outline the process is:

a. Identify the capability requirement or gap, this could be an end state or a stated deliverable.

b. Scope the boundary of the issue and understand the capabilities involved.

c. Understand the military business 'As Is', using models as appropriate to assist.

d. Determine what improvements to the business are desired.

e. Develop models that describe the military business as it is 'To Be'.

f. Construct the URD to articulate the requirements for the future military business need.

IDENTIFY CAPABILITY REQUIREMENT

7. The capability need or gap is identified and articulated using MODAF Strategic Views (StV). Capability is expressed without identifying a particular application or new system as the solution to meet the gap. For example the Joint Force HQ and Component Commands[5] have a capability gap in that they require, but do not have, a single view of the Joint Force Combat Service Support assets and resources.

8. Under SMART procurement, identification of capability gaps and initiating projects to fill them is the responsibility of the DEC[6]. The process used by this organisation to articulate URs does not normally begin until the DEC has identified the capability gap. In this case Strategic Views are used to improve the Customer[7] 2 understanding of capability as it is expressed by the

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4 Some views in MODAF that are of more relevance to the Developers of systems and the Integration Authority/DCSA who have to maintain a system of systems understanding.

5 Land, Fleet and Air Component Commands.

6 The Directorate of Equipment Capability (DEC) are responsible managing the total equipment capability. Despite SMART procurement, other organisations often perform this process as well. For example the DLO have previously sponsored their own projects, with capability requirements being identified by the DLO Business Change Teams.

7 Customer 2 provides the expert guidance on military business (customer 2 core leader) and receives and manages the equipment in service (pivotal manager).

Centre. It is also believed that the Strategic Views defined by MODAF should be used to aid the DEC during the capability audits and help them prioritise and group identified gaps into projects.

SCOPE BOUNDARY AND UNDERSTAND CAPABILITY

9. The main aim of this stage is to gain a clear understanding of the high-level military objectives to be supported. The purpose of any IS project should be to improve the delivery of military capability and therefore the project must be focused on how that improvement is to be achieved. It clearly follows, that an information system developed from a poor understanding of capability is unlikely to result in capability improvement. Numerous academic studies cite a poor understanding of the business objectives systems were intended to improve as one of the main causes of IS project failure.

10. The understanding gained about the capability areas of interest can then be used to define the boundaries of the military enterprise that must be fully understood in order to develop the user requirements for a particular project or IS. For example, the capability gap identified in the JFHQ and Component Commands is understood in terms of how gaining a single view of CSS contributes to, and affects the delivery of military capability. Having understood the capability, the boundaries are identified and agreed as extending back to the DLO[8] and forward to Brigade Supply Area assets, as they impact on the target organisation's ability to deliver the required capability.

UNDERSTAND THE 'AS IS'

11. Thoroughly understanding how military capability is currently delivered, enhances individuals ability to design sensible improvements for future delivery. You cannot plan a journey from A to B if you do not know where A is. In particular, it is necessary to understand the many and varied relationships between processes, resources and military objectives in order to ensure changes achieve the desired effects, and avoid unintended consequences.

12. Models are developed to provide the understanding necessary to decide how military business should be changed in order to achieve the desired outcome. The modelling activity must be carefully considered to avoid nugatory work (detailing processes to be made obsolete by the new system), whilst gaining sufficient shared understanding of the current situation to discuss and design the desired future situation.

13. The level of 'As Is' modelling will vary considerably on any given project, but maximum use of existing work must be made to minimise work and avoid wasting the time of the user community. It is recommended that all modelling work is held in an MOD Architecture Repository, and that where appropriate architectures are used to inform tactics and doctrine publications in order to achieve an efficient maintenance of the corporate knowledge gained through the modelling work: Architectures based on MODAF provide an effective means of managing and communicating knowledge to all levels of an enterprise and therefore could readily and usefully be incorporated into Concepts, Doctrine, Tactics Notes and SOPs.

DETERMINE THE CHANGES REQUIRED

14. Shared knowledge and understanding achieved through the development of the capability and 'As Is' models enables informed decisions to be made about what is required in the future. This should include changes to all Lines of Development[9] (LOD) not just the technical application or system that is to be specified in the equipment element of the URD.

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8 The Defence Logistic Organisation (DLO) is responsible for all Logistics in the MoD.

9 The MoD breaks capability down into 'Lines of Development': Finance, Equipment, Structures and Estates, People, Training and Concepts & Doctrine.

MODEL THE 'TO BE'

15. The aim of the 'To Be' models is to provide the understanding required to derive the URD and to support the URD by providing improved understanding of what is required and how it is to fit into the business. Appropriate use of selected MODAF views provides a far richer, yet more readily digestible communication of the requirements and their context than a text based URD could ever hope to achieve on its own. The 'To Be' models should not attempt to impose solutions and care must be taken to avoid doing so inadvertently. That said, it is quite legitimate to express business constraints, for example an application aimed at a battle group must be hosted on the Bowman infrastructure.

16. Developing the 'To Be' architecture is an iterative process that may produce a number of variants. The understanding it provides will lead to further development of the ideas expressed within the architecture. Development of the architecture should not be seen as having an end state; development will continue long after the URD and even the SRD has been agreed. Architectures developed initially for deriving and articulating URs are also likely to become an integral part of experimentation and prototyping activities.

CONSTRUCT THE URD AND CONOPS/CONEMP

17. Despite the contention that MODAF models communicate requirements more effectively than a traditional URD, the URD still has a role to play. A URD is more explicit in what the user requires the project to deliver, providing atomic statements against which a project can deliver and be measured. The models enhance the shared understanding and are intended to close the gaps between 'what the user wanted', 'what the user asked for' and 'what the supplier understood the user to want'. The URD and the models are complimentary, not mutually exclusive.

18. Similar arguments apply to the CONEMP and CONUSE documents. The text-based documents are easily accessible in that they can be read from beginning to end with out need of external explanation. The graphical models contained in an architecture provide a logical basis on which to base the CONEMP and CONUSE, and provide further understanding and context.

DESCRIPTION AND USE OF THE FRAMEWORK

19. This Section describes the views most commonly used in the requirements derivation process. The total Architectural Framework contains over 30 different views, split into strategic, operational, system, technical, and acquisition categories. MODAF should be considered as a toolbox, and only those views that inform the issue in hand should be used. The user requirements derivation process makes use of only some of the MODAF views; for example, the Technical Views are not currently used when deriving URs (but may be in future developments to improve the use of Standards in URDs – See paragraph 53).

STRATEGIC VIEWS

20. The Strategic Views (StVs) give high-level clarity to what is being sought by the MOD and the expected time frame. They allow the brigading together of supporting Operational Views and can show the coupling between Capability elements and supporting System clusters, in big picture terms.

21. This organisation currently uses Soft System Methodology (SSM) based conceptual models to investigate and articulate capability and scope the boundaries. The MODAF Project Team are developing 5 Strategic Views that should augment D CBM(A)'s use of SSM to understand capability. This work is not yet complete and therefore the views are not described in this paper. The StVs can be presented through the following Products:

- Capability Vision (StV-1): Provides an outline of the strategic vision for a capability area over a particular time frame and informs the long-term capability planning process.
- Capability Functions (StV-2): Describes functions that make up military capability, including attributes and metrics.
- Capability Phasing (StV-3): Describes how capability is delivered and improved over time.
- Systems of Systems Clusters (StV-4): Provides a means of analysing the main dependencies between capability functions and identifies logical grouping of capabilities.
- Capability to Systems Deployment Mapping (StV-5): Uses a synthesis of information from the other strategic views to show the planned capability deployment and interconnection by echelon/epoch, providing more detailed dependency analyses than StV-3.

22. Use of Strategic Views in the 'As Is' Models.

a. The Strategic views are used to their full extent in the 'As Is' models, where understanding the military objectives is paramount as discussed in paragraph 13. A lack of *common shared* understanding will inevitably lead to misconceptions and inappropriate decisions about how the future should look.

b. Capability tends to be enduring and therefore the modelling work is likely to be carried forward in the 'To Be' models; it is the manner of delivery and required levels of effectiveness that tends to change rather than the capability itself. Even if the capability is to change, an understanding of the current situation will improve the quality of decisions made about how the future should be.

c. The Strategic Views are also used to scope and confirm the boundaries of the problem situation as discussed in Paragraph 10.

23. Use of Strategic Views in the 'To Be' Models. The Strategic Views in the 'To Be' architecture will be one of the principle means of communicating to the IPT[10]/contractor the context in which the delivered system is to operate, the military objectives it is to support and the benefit it is to deliver. Text based URDs can only convey the 'letter' of the requirement, whereas the Strategic Views can also enable suppliers to understand the 'spirit' of the requirement and to ask more informed questions. Any system design should be considered against these models, to ensure it contributes to the overall capability in the manner intended.

OPERATIONAL VIEWS.

24. The Operational Views (OV) are a description of the organisations[11], activities, and information exchanges required for a particular military mission or business need. OVs are likely to be produced for a range of scenarios, as the interaction between organisations and process may vary, dependant on the mission and environment. The OVs provide an increasing level of detail ranging from the high level context diagram (20,000 ft view of the Capability – the "PowerPoint view") to the full operational activity model.

25. Overview of Operational Views. The total set of operational views consists of:

- High-Level Operational Concept Graphic (OV-1): An overview graphic.
- Organisation Connectivity Model (OV-2): A description of how organisations interact.
- Information Exchange Matrix (OV-3): A table of information exchanged between organisations.
- Organisation Relationship Diagram (OV-4): A command relationship 'wiring diagram'.

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10 Under SAMRT procurement, projects are delivered (and managed through life) by Integrated project Teams (IPT).

11 Formally referred to as operational nodes. The models can contain organisations, sub units, roles, actors and or informal groupings.

- Operational Activity Model (OV-5): Process models.
- Operational Activity Sequence and Timing Descriptions (OV-6, OV-a, OV-b, and OV-c): A description of behaviour over time.
- Logical Data Model (OV-7): A description of the nature of the information and its attributes.

The Command Relationships (OV-4) may provide useful background information to a contractor, but do not directly inform the requirements, and hence are not addressed in this paper. Equally, the Activity Sequence views (OV-6) may have a part to play in developing user requirements, but that aspect has not yet been developed fully.

26. High Level Operational Representation OV-1. The OV-1 should not be mistaken with the strategic views, but often is. It is essentially a high-level briefing or marketing tool. Whilst it can be used to focus detailed discussions, the Strategic Views are more suited to this purpose. An important point to note is that everything that appears in the OV-1 should be present in the main set of MODAF views. It is recommended that the OV-1 be produced as a summary of the modelling, not the starting point.

a. Use of OV-1 in 'As Is' Models. The OV-1 is probably not required in the 'As Is' models, unless a briefing tool is required above and beyond that provided by the Strategic Views.

b. Use of OV-1 in 'To Be' Models. Produced as a briefing tool, the OV-1 is a useful aid when 'selling' the proposed application to the user community and senior officers.

27. Organisational Interconnectivity OV-2. The OV-2 identifies relevant organisations and the relationships between them in terms of the need to exchange information. The OV-2 is essential to understand the organisational boundaries, identify the potential customers, and make explicit their relationship with each other in terms of information exchange. Having identified a need to exchange information the nature of the information being exchanged can then be identified and articulated. Views may contain either organisations or roles, but it is recommended not to mix the two in the same model. The example in Figure 1 is a simple organisational connectivity model, in which the lines represent information exchanges and the labels on the lines indicate the type of information being exchanged. The view also allows (not shown in the example) for additional fields such as 'purpose' to be defined against each organisation.

a. Use of the OV-2 in 'As Is' Modelling. The 'To Be' views identify the organisations involved in the relevant area of operations at the current time. It offers the first opportunity to identify the high level IERs, and confirms the organisational boundary of the situation under investigation. The level of modelling has to be carefully considered to avoid nugatory work where the organisations may be subject to change. In general, the modelling will be limited to the Unit/Sub unit level, although each situation will vary.

b. Use of the OV-2 in 'To Be' Modelling. The 'To Be' models are likely to be developed in more depth. They convey to the contractor who needs to do what, and what their IERs will be. They may well show individual roles or staff branches. Other constraints and factors may be shown against organisations or the information exchanges between them, conveying to the supplier[12] a richer picture of the requirement. For example, geographical or operational requirements that apply to only some of the organisations, such as the need to deploy as airborne forces, can be shown against each relevant organisation

12 Both the IPT and the Contractor

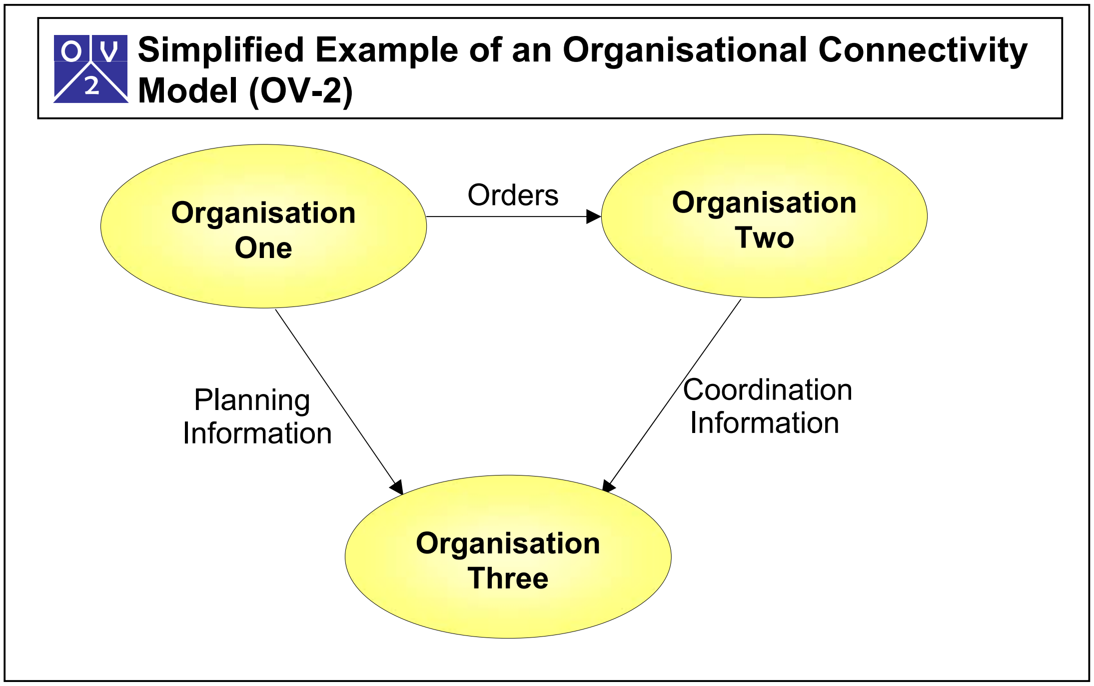


Figure 1: Example of an OV-2

28. Process Models OV-5. The purpose of OV-5 models is to express the military business processes intrinsic to achieving the operational aim. As discussed in Paragraph 15, care must be taken to avoid inadvertently imposing constraints by detailing processes to operate the IS itself as oppose to achieving the business aim. A full and shared understanding of business processes is essential to developing URs. Whilst the Armed forces are very good at doing what they do, they are not so good at communicating clearly and meaningfully what it is that they do. Equally, many requirements span a significant scope of activities, and users rarely have a clear, comprehensive and up to date understanding of how the entire business operates. OV-5 models offer a means of communicating processes in a manner that is meaningful to both the military and suppliers alike. Processes are performed by organisations. The modelling tool set is used to associate organisations created in the OV-2 with activities in the OV-5. Just as organisations have IERs, so do activities. Once the activities are articulated, the full IERs that support them can be created and associated with the process model. Identifying IERs for both the organisations that perform activities and the activities themselves provides a cross check to ensure that all relevant IERs have been identified. Use of an object based modelling tool enables the IER to be created once and used in both views.

a. Use of OV-5 in 'As Is' Models. The 'As Is' process views are used primarily to understand how the business operates currently, in order that development of the future processes is informed by knowledge of the past. More emphasis should be placed on understanding the intent of the processes, than should be placed on understanding the detail of what is done (although the later may be necessary to fully understand the intent). Again, careful consideration is required to avoid modelling non-enduring processes below a level of detail that serves the purpose of aiding discussions about the future.

b. Use of OV-5 in 'To Be' Models. The 'To Be' OV-5 models are the primary set of models that will describe the functional requirements of the system and the military processes with which it is to operate. Great care must be taken to only show what is to be achieved, without inadvertently constraining potential solutions (solutioneering). The modelling will start with the processes that are required throughout the area of operations under investigation, but should then make explicit those processes that are to be delivered or directly supported by a particular programme or project. The models should show increasing fidelity, until each object with a model represents an atomic functional UR.

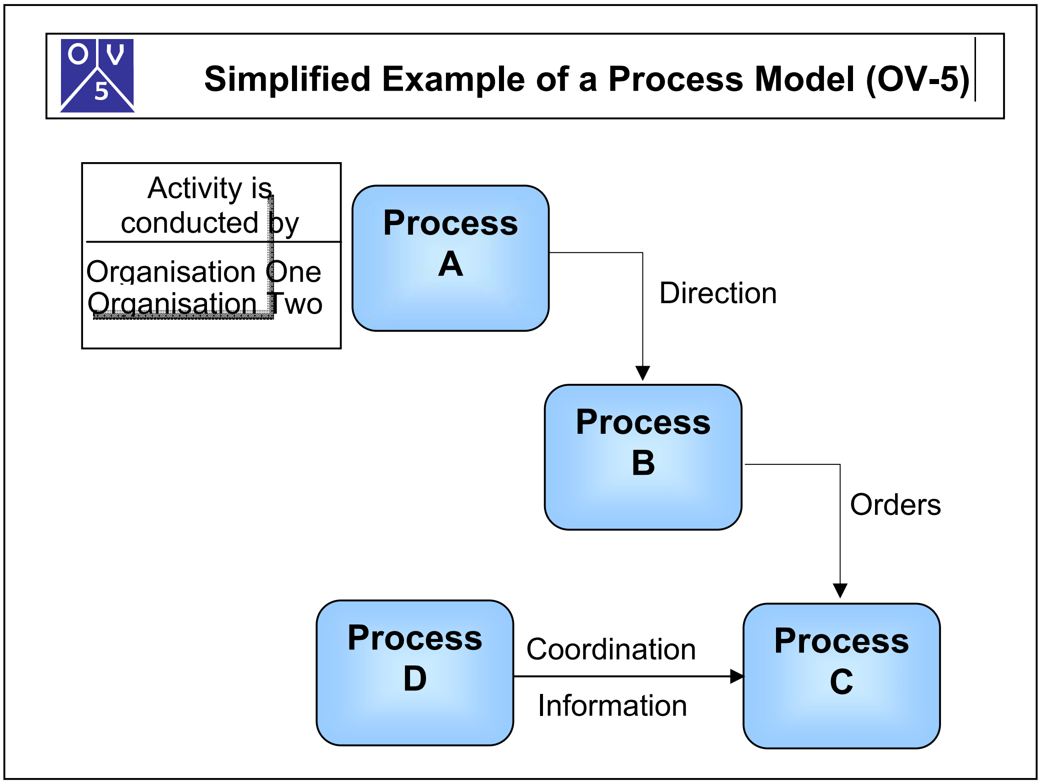


Figure 2: Example of an OV-5 Process Model

29. Information Exchange Requirements OV-3. The OV-3 shows the information categories being passed between organisations during the conduct of activities. It is used to convey *who* exchanges *what* information, with *whom*, *why* it is necessary and *how* it is done. It may also contain more detail about the information that supports the process. It is not a model in its own right and does not contain any information not held in other operational views. It is a report summarising the IERs derived in the organisational connectivity models (OV-2) and activity models (OV-5), possibly with additional information gleaned from the Logical Data Model (OV-7). The utility of the view is the focus it provides on information categories.

Simplified Example of Information Exchange Requirement Matrix (OV-3)

Activity	Information Exchanged	Format	Source Node	Destination Node	Security Classification	Criticality	Frequency
A	Orders	Text	One	Two	S	High	Event driven
B	Coord Info	Formatted R3	Two	Three	R	Routine	Daily
D	Planning Info	Text & R3	Three	Two	S	High	Daily

Figure 3: Example of an OV-3

a. Use of 0V-3 in 'As IS' Models. The OV-3 focuses on information categories and as such could be used to cross check against known IERs for other systems (existing and planned) in order to identify potential overlaps or to make decisions relating to the apportionment of work to appropriate systems, organisations or personnel. Generally, it should not be used as the primary document presented to users when asking them to confirm that all IERs have been identified; the graphical representations used in the organisational connectivity (OV-2) and activity (OV-5) views are far better suited to this purpose.

b. Use of OV-3 in 'To Be' Models. The focus on information categories provided by the OV-3 may be used in conjunction with the Logical Data Model (OV-7) to identify information based URs.

30. Information Model Using CBML (Description of the Information Used) OV-7. OV-7 is a view defined in DODAF as the Logical Data Model. One of the problems with Logical Data Models is that they do not enable a business to describe the information that is important to it, without also describing the structure of the data. Descriptions of data structure (and hence Logical Data Models) are more appropriate to System Requirements and System Design than to User Requirements, where a more simple view of information, independent of implementation issues, is required. For this reason D CBM(A) has developed Corporate Business Modelling Language (CBML), which enables the business to describe the nature of the information used in the IERs identified from the organisational (OV-2) and activity (OV-5) views and listed in the Information Exchange Requirement (OV-3). It is proposed[13] that MODAF Operational View –7 (OV-7) recommends the use of both Information Models (in the form of CBML) and Logical Data Models. Information Models should be used at the business end of the development spectrum and Logical Data Models at the Technical end of the development spectrum. CBML Information Models enable subject matter experts to understand and confirm the nature of information used in the Logical Data Models (which should be developed to support the System Requirements and Design), without confronting them with the complexity of Logical Data Models themselves. The example in Figure 4 describes two ways of categorising bridges by design type: arched and military pontoon.

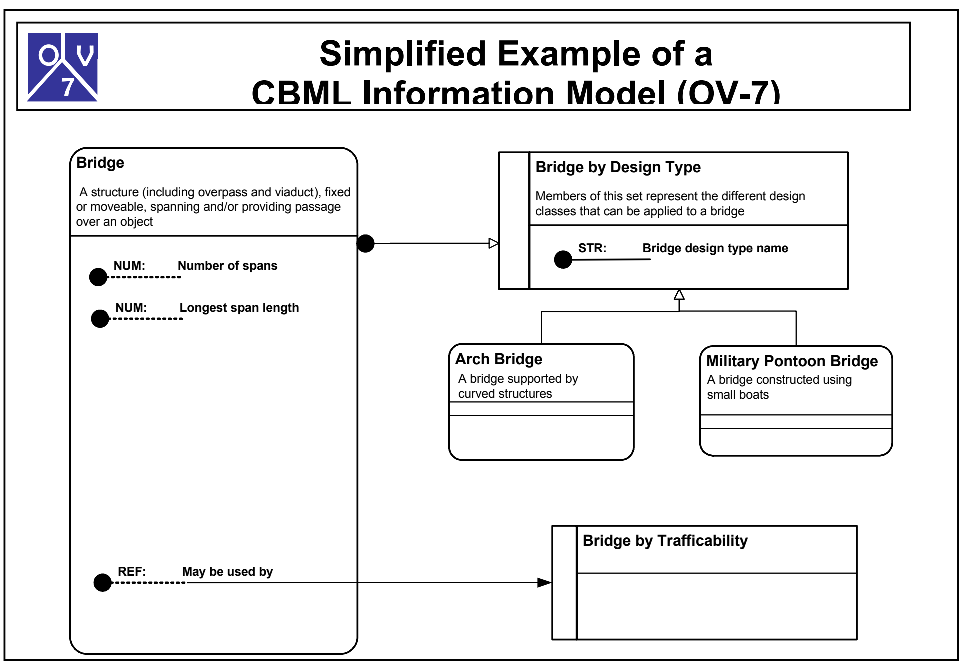


Figure 4: Example of CBML OV-7 model

13 The decision has not yet been made. Information Models may become a sub category such as OV-7a.

a. Use of the Information Model (OV-7) in 'As Is' Models. The Information Model is used to identify and communicate the nature of the information that the potential system is concerned with. The models must provide sufficient understanding of the nature of the information to ensure that proposed future processes and organisations are coherent with information requirement.

b. Use of the Information Model (OV-7)in 'To Be' Models. The level of detail must be sufficient that when the contractor provides the means to: capture, manage and distribute the information described in the Logical Data Model (OV-7); to meet the processes described in the OV-5; and the organisational structure described in the OV-2; then the business need will be met in full. Understanding and articulating the full nature of information to be input, manipulated and output from a system is the one of the most critical aspects to achieving project success. Failure in this respect can lead to significant project problems and may result in the information system not providing the anticipated benefit to military capability.

SYSTEM VIEWS

31. System Views describe existing and proposed information systems, their interconnections and functions. They are primarily used during system design rather than user requirement development but they do have their place in eliciting valid business constraints upon a set of requirements. In the Network Enabled Capability (NEC) era where capability is delivered through a System of Systems (SoS) there are genuine system constraints that need to be expressed. This is not 'solutioneering' but an essential aspect of achieving a coherent System of Systems. For example it may be quite valid for an application intended for use by a deployed Battle Group to dictate that it must be able to use the Bowman radio system as a data bearer. Bespoke hardware may be the optimum for the application, but the field force cannot support a plethora of hardware infrastructures. The primary views used in the UR development process are:

- Systems Interface Description (SV-1). A Model of discrete information systems and how they interact.
- Systems Communications Description (SV-2). A model of the communication systems used to provide system connectivity.
- Systems Functionality Description (SV-4). A description of the functions of systems.
- Operational Activity to Systems Functionality Traceability Matrix (SV-5). A mapping of business process to Application functions.

32. Systems Interface Description SV-1. The systems interface view depicts information systems that exist at organisational nodes, and the interconnection between those systems. It acts as a link between the operational views and system views, by showing IS against the organisations depicted in the Operational Interconnectivity Models (OV-2). An example SV-1 is shown in Figure 5. Its primary purpose in the UR process is to highlight other IS that various organisations may have (now or in the future) in order to identify business constraints upon the system. For example, if it is decided that an application must be hosted on BOWMAN but organisations depicted in the OV-1 are outside the BOWMAN lay down, then the System Interface Description SV-1 will indicate a requirement to host the application beyond the existing BOWMAN infrastructure.

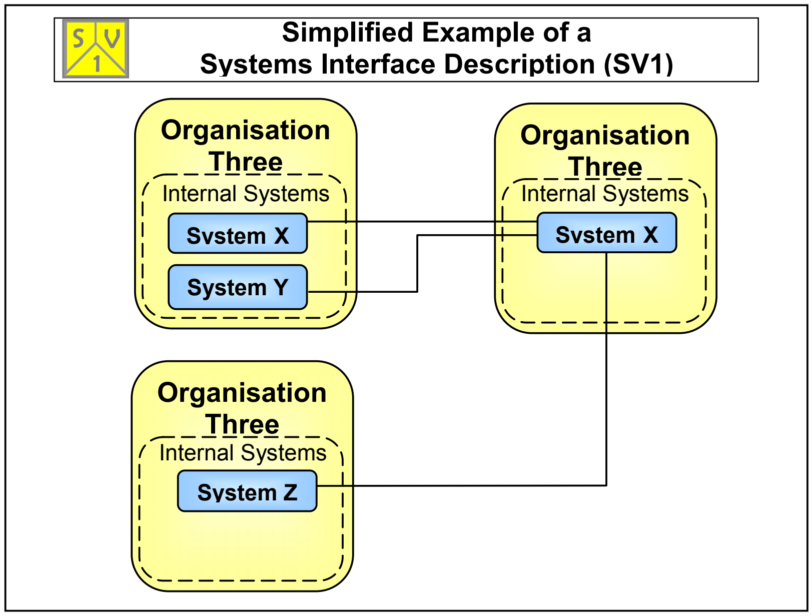


Figure 5: Example of an SV-1 Systems Interface Description

33. Systems Communications Description (SV-2). The SV-2 view depicts the methods of communications used to implement the interfaces depicted in SV-1. Again it is used to understand and articulate the business constraints relating to communications. An example of an SV-2 is shown in Figure 6.

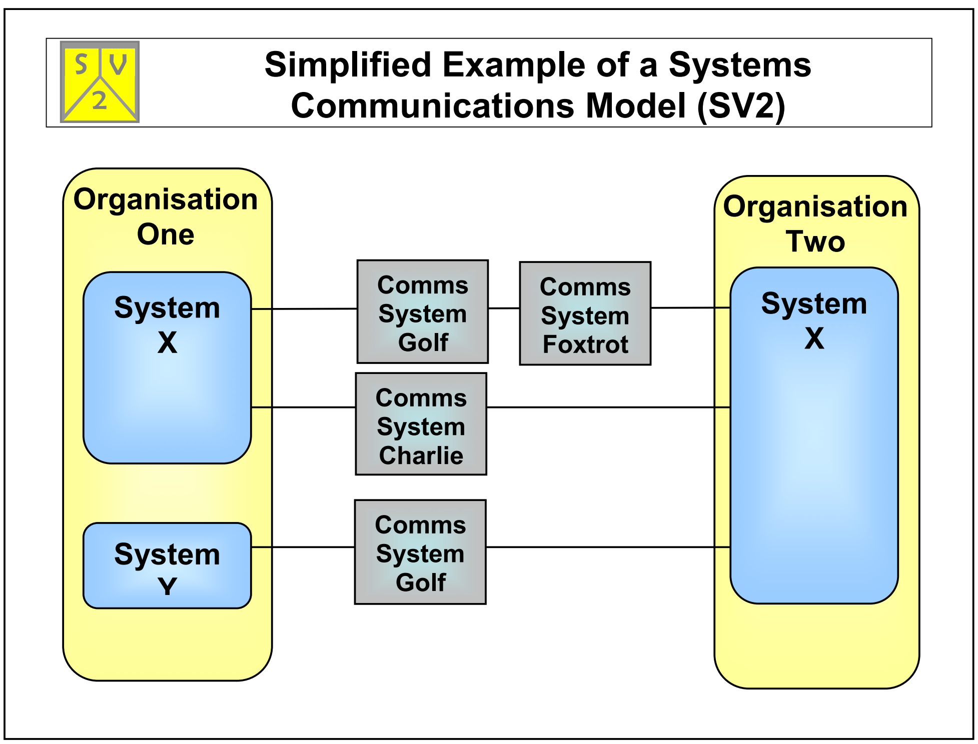


Figure 6: Example of SV-2 Systems Communications Model

34. Systems Functionality Description (SV-4). The SV-4 view is used to understand the functions, hierarchies and data flows of existing and proposed IS. It is used to understand what parts of the required processes are already covered by other IS in order to make informed decisions about business constraints or opportunities. It may also be used to inform investment appraisal

decisions. There are a number of formats that could be used for this view, but which ever is chosen should facilitate a mapping between the System Functional Descriptions (SV-4) and the Operational Activity Models (OV-5) in order to understand how the requirement is met by other IS.

35. Operational Activity to Systems Functionality Traceability Matrix (SV-5). The SV-5 provides a mapping between the functions performed by other IS and the required processes depicted in the activity models (OV-5). It is likely that there will not be an obvious one to one mapping between the System Functionality Description (SV-4) and the process models (OV-5s); they may be produced to different levels of detail or structured differently. Where this is the case the Traceability Matrix (SV-5) makes the mapping clear.

CONSTRUCT THE URD

36. Users' requirements will be derived using a number of techniques, of which architectural modelling using MODAF as the framework is only one, albeit the major source. The following section describes how use of MODAF products contributes to development of the URD.

PART 1: GENERAL DESCRIPTION

37. The Part 1 of the URD is intended to provide an introduction and context. It should not be used to convey requirements as such, although it may reflect (duplicate) requirements that are expressed explicitly in more detail in later sections. The various elements of Part 1 are informed by, or derived from, the Strategic Views. It will also be informed by capability themes such the Defence Capability Framework (DCF), enduring tasks such as the Mission Essential Task Lists (METLs), and explicit business knowledge such as doctrine or lessons learnt. However, comprehensive Strategic Views will contain such information, and should prove to be a more readily digestible format. The main sources for the various elements of Part 1 are shown below:

Serial	**Section Heading**	**Informed by**
(a)	(b)	(c)
1.	Introduction	StV-1 Capability Vision StV-2 Capability Functions
2.	Background	StV-1 Capability Vision StV-2 Capability Functions StV-4 System of System Clusters
3.	Single Statement of User Need	
4.	System Owned/Operated By	StV-2 Capability Functions
5.	To do *p*	StV-2 Capability Functions StV-5 Capability to System Deployment Mapping
6.	By doing *q*	StV-2 Capability Functions StV-5 Capability to System Deployment Mapping
7.	In order to do *r*	StV-1 Capability Vision StV-2 Capability Functions
8.	Within Constraints	StV-1 Capability Vision
9.	Required Operationally Available Date	StV-3 capability Phasing
10.	Operational Context	StV-1 Capability Vision StV2 Capability Functions Doctrine and DCF
11.	Assumptions and Dependencies	TBD

PART 2: KEY USER REQUIREMENTS (KURS)

38. Key User Requirements (KUR) are simply those requirements expressed in Part 3 that are deemed key to the capability to be delivered. The deletion or dilution of a KUR is likely to have a serious and immediate impact on the ability of the project to deliver the expected benefit as described by the URD and any associated business case. The prioritisation of the URs is informed mainly by the Capability Vision and Functions, and to a lesser extent the other Strategic Views. The Operational Views will further influence prioritisation.

PART 3: USER REQUIREMENTS (UR)

39. The Part 3 contains the actual user requirements. The headings in a URD vary depending upon the author, but Reference A recommends the following (details of which are contained in Reference A):

a. Unique Ref Number: An enduring number that remains constant throughout all versions of a URD.

b. UR Title: A short description.

c. User Ability: A more detailed explanation of the requirement.

d. Context: A description of the situation that the UR is aiming to improve or support.

e. Effectiveness Envelope: A numerical quantifier of how well the UR has to perform its task. Normally expressed in terms of Stretch (ideal), Plan (minimum standard required), and Now (how well its currently performed). At the User level, they should be expressed in terms of the higher-level goals, not specific functions. For example the user should only be concerned with how long it takes from identifying a target to rounds hitting it. EEs about parts of that process are the domain of the system requirements, not user requirements.

f. Owner: The person responsible for defining and amending a UR. Can also include the organisations directly effected by the UR.

g. Justification: Why the UR is required.

h. Verification: Every UR must have a means of verifying that it has been met. Although it is common to state the type of test such as Field Trial, it is more helpful to describe the degree of achievement that will constitute compliance. For example "The system shall display x during an Armoured Brigade CPX."

i. Priority: The priority of the UR expressed as one of 4 priorities:

(1) Key: Essential. Without it there is no capability.

(2) Priority 1: Highly desirable

(3) Priority 2: Desirable

(4) Priority 3: Nice to have.

URs are traditionally split into functional and non-functional requirements.

40. Functional Requirements. The Operational Activity Models (OV-5) should lead to a structuring of functional requirements that make them digestible in readily understood chunks.

D CBM(A) Requirements group contend that functional requirements for an information system take one of 3 basic forms[14]: process based requirements, information exchange based requirements and requirements about how the user wishes the future system to support the business derived from assumptions about that future system.

a. Process based URs. The primary type of functional requirements are process based i.e. "the User shall be able to *do something"*. The Operational Activity (OV-5) 'To Be' models should clearly articulate what the processes are that the business need to conduct in order to deliver the required capability. Within any military capability area, a particular information system project will only deliver part of the capability. Whilst the whole capability should be modelled to varying degrees of granularity in order to convey the context, the Operational Activity models should make explicit those process that are (and those that are not) to be delivered by the project. Such processes should be decomposed to a point where each atomic requirement in the URD is represented by one activity in an OV-5 model. The fields are derived in the following manner and shown graphically in Figure 7:

(1) UR title: Taken directly from the object in the OV-5.

(2) User Ability: Articulated in a memo field in the OV-5 for each object that is to provide a UR for the project.

(3) Context: A textual summary of how the UR contributes to the wider process. The information is derived manually from understanding the agreed set of OV-5s.

(4) Effectiveness Envelopes (EE): The method of expressing EEs within MODAF products has not yet been fully confirmed,[15] however the Strategic Views and the OV-5 process models will enable individual EEs be expressed and justified in terms of higher level goals and process requirements.

(5) Justification: The importance of the process to the whole process and higher level goals can be seen by understanding the Strategic Views and the OV-5 process models. The justification field should commence with a numerical reference to the model(s) from which the UR was derived.

(6) Verification: MODAF says nothing about how the test may be performed, but the pass criteria can be derived from the subsequent processes in the OV-5 that are dependent upon the process from which the UR was derived.

b. Information Based URs. The nature of the information to be input to, used by and output from various processes is critical to the system delivering the required capability at the required place and time. The full nature of all the relevant information will be described using CBML in the Logical Data Model (OV-7). However, there will often be value in verbalising the CBML and including it in the URD to describe the nature of the information used by a single process or group of processes. Alternatively URs will refer directly to the Logical Data Model.

c. Derived URs. When articulating user requirements it is not uncommon to encounter a number of URs that are difficult to categorise as either functional or non-functional. This can be due to requirements that are derived from reasonable assumptions made about the system that will be delivered. For example '*the user shall be able to define the percentage*

14 They are unlikely to appear as group heading in a URD, but are used to understand the nature of functional requirements, with all 3 types being intermingled in a URD.

15 Future development may lead to qualities being shown against specific elements of the models, which are then used as effectiveness envelopes.

battery level at which a warning is given'. The enterprise does not have a business requirement to have batteries, rather a reasonable assumption is made that the solution may involve a computer and therefore it may have batteries and therefore a user definable warning is required. Although this might strictly be a system requirement, it is something that the user is concerned with, and hence maybe a valid user requirement. For the purposes of this paper, such URs will be referred to as 'derived requirements'.

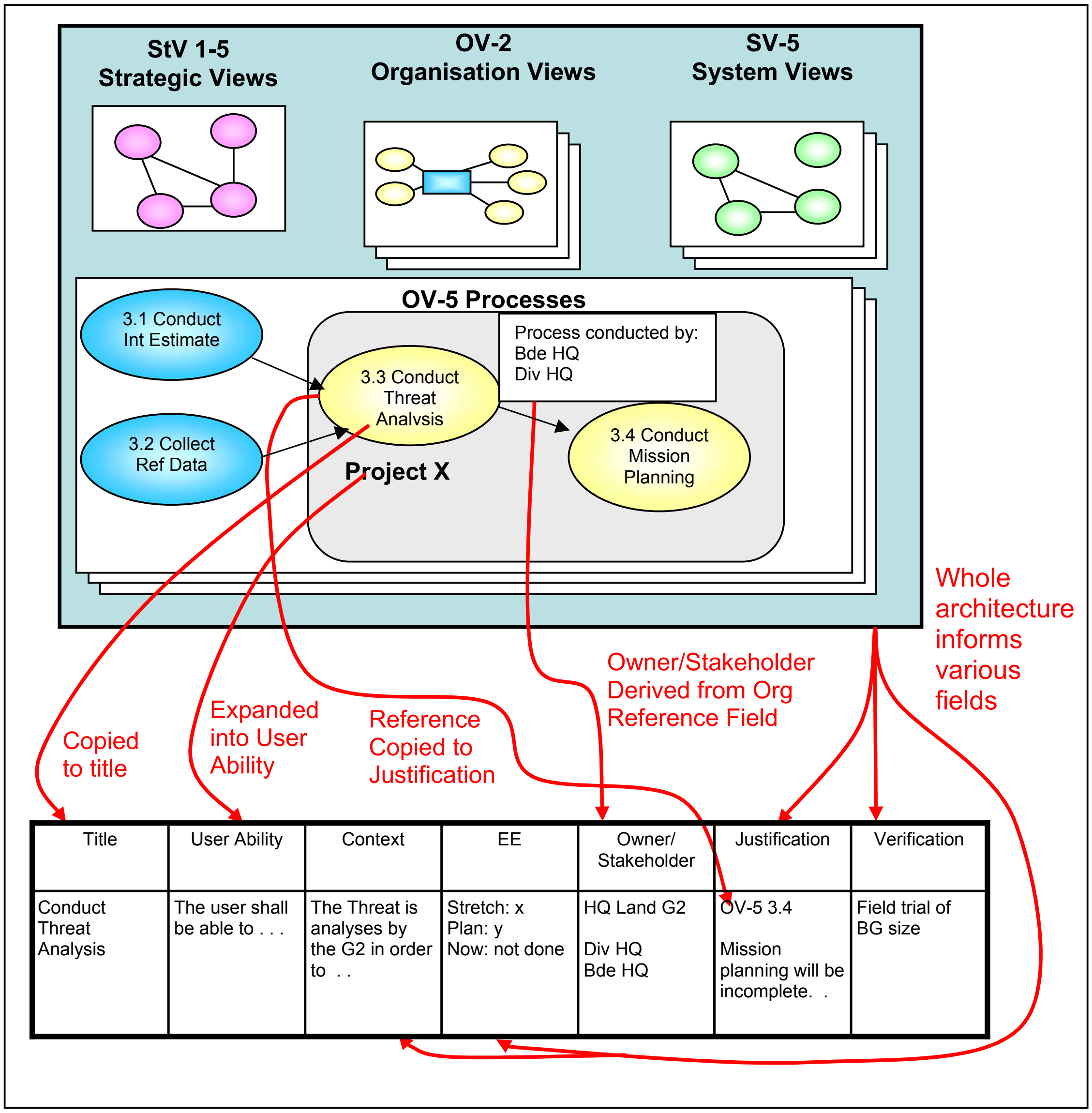


Figure 7: Mapping MODAF to Functional URs

41. Non-Functional Requirements. Non-functional requirements should describe the required characteristics of the system, and perhaps more importantly the business constraints that should be applied to it. It has been a tenet of SMART procurement that best value for money is achieved by giving IPTs complete freedom of action. However, as the "Nash Equilibrium" (Nash: 1950) makes clear, mutual benefit is not maximised through each group (IPT in acquisition terms) doing just what is best for itself, but also what is best for the business as a whole. In other words groups have to balance what is best for them against what may be best for the business as a whole. Sub-optimised parts may be necessary to achieve the optimum whole. Hence, an expression of business constraints and opportunities for cross system rationalisation is essential to achieving a coherent, affordable and effective SOS. The Strategic, Operational and System views offer a means by which

capability working groups can understand the SOS constraints and opportunities for cross system rationalisation. The decisions made by the Working Groups should be expressed as non-functional requirements, making clear the difference between opportunities and desirable or mandatory constraints. Such URs should refer to the MODAF models from which they were derived/justified.

42. Non-Functional Requirements by Lines of Development. The most significant proposed change to non-functional requirements is the intention to include a section on each Line of Development (LOD). Traditionally, the URD is a statement of requirement for the equipment line of development, however "information systems are not equipment programmes, but business programmes enabled by technology" (McCartney: 2000). Furthermore, the IPT Team Leader now has single point responsibility for ensuring that all lines of development are delivered. Including all LOD in the URD ensures that a statement of requirement for the whole project is brought together in the one document that the user community (Customer 2 as well as Customer 1) has the most involvement in. The URs for each line of development will state what needs to be achieved in order to deliver the capability.

a. Concepts and Doctrine. The URD should contain high-level statements outline changes required to Concepts and Doctrine (C&D). Ideally, the capability audit and resultant system definition should be conducted and defined against agreed and published C&D. However, IS projects often either precede formal C&D, or they impact on other areas of it. An example is the Recognised Theatre Logistic Picture: Logistic C&D is documented in Joint Warfare Publication (JSP) 04. However, the current version only mentions the RTLP very briefly despite it having a significant impact on the way logistics will be conducted in the future. The URD for any project delivering elements of the RTLP should therefore articulate a project dependency on changing JWP 04.

b. Equipment. The Equipment LOD is addressed by the URD in its traditional form.

c. Training. Training is one of the most challenging LODs in Digitisation. The URs must not only express the requirements to achieve a trained workforce, but also convey sufficient business constraints to ensure the field force are able to cope with the training burden imposed. The strategic views, particularly the Capability Functions (StV-2), made in light of the system groupings identified in the System of Systems Clusters (StV-4), will highlight the opportunities for rationalising training. The various StVs should be used to express to the Front Line Commands the potential training burden for the whole of a capability, thus enabling them to express business constraints on training, which can then be articulated as URs. Consideration needs to be given to methods of modelling training requirements and associating them with the applications and SOS clusters they support.

d. Structures. The differences in the Organisational Views (OV-2) articulated in the 'As Is' and 'To Be' models will indicate the changes required to structures. Those requirements for change should be expressed as URs where possible.

e. Sustainability. Sustainability is partially covered by the Availability and Administration sections in a traditional URD. However, the SOS aspect of NEC means that URs for a particular system need to identify business constraints to ensure the delivered solution is the most efficient for the business as a whole, and not just the system in question. Sustainability is influenced by 3 major factors:

(1) Availability/Operational Criticality. The availability required should be derived from the system's criticality to operations. The combination of the Strategic Views, OV–5 (process models) and System Views should inform the discussion as to what availability is required in terms of operational criticality. The URs should refer to the models as justification for the requirements.

(2) SOS Administration Capability. The requirement to use common administration resources across systems could be considered a design solution and therefore outside of the remit of a URD. However, if it is considered to be a valid business constraint (and it probably should be) then it should be expressed in the URD. This decision should be taken by a pan-system working group, informed by the various system MODAF models.

(3) Phasing of Systems. Decisions about SOS administration should be informed by the phasing of SOS delivery, expressed in the Capability Phasing (StV-3) models.

f. People. The People LOD introduces valid business requirements. Influences on the people LOD are not currently expressed in MODAF models other than in the OV-2 models. Their impact on the URD has yet to be considered.

INCORPORATING USER REQUIREMENTS INTO THE ARCHITECHTURE

43. MIDAS is an implementation of the MODAF framework in the MooD Transformation Toolset (a modelling application), which D CBM(A) uses to develop MODAF compliant architectures. D CBM(A) has now incorporated user requirements into the MooD Integrated Defence Architecture Solution (MIDAS) V1.2. The intention is to retain a URD format as a standalone MS Word document or a DOORS database but in the future these documents will be produced as an export from an architecture that contains the URs. The URs will be derived from, and referenced to, the other elements within the architecture using the methodology described in the previous two sections. Incorporating the URs into the architecture from which they were derived presents a number of opportunities, the most significant of which are described below.

44. Improved Understanding. The references between URs and elements of the architectures that informed them, improves understanding by providing the background and context that led to the requirement. This in turn reduces the number of unintended constraints by providing suppliers with the information that enables them to ask more relevant and informed questions. It is recommended that the architecture that led to a URDs is supplied to industry along with the URD itself.

45. Assessment Gaps. Architectures are intended to provide a visual representation of the entire military business under consideration, which as stated earlier, should enable subject matter experts to confirm that a subject has been covered comprehensively. The functionality provided by architecture modelling tools (such as MooD) facilities easy cross checking between a URD and the architecture to ensure that a set of URs provide comprehensive coverage of a specified area, as defined by the architecture.

46. Assessment of Coherence. D CBM(A) has now developed a tool called rCAT in partnership with Hi-Q Systems. rCAT exploits the relationships between URs and other elements in an architecture to assess coherence between URs within a single set (one URD) and between URs in different projects. The coherence is expressed in terms of potential overlaps and inconsistencies between URs related to common elements of the architecture and is based on analysis of direct and indirect relationships expressed in the architecture. The tool also facilities the production of MODAF compliant process models from existing URDs (imported from MS Word or DOORS) and suggests relationships between those new processes and existing architecture elements. As a result the rCAT tool provides a powerful means of assessing the coherence between the User Requirements of existing and potential projects within the MoD's System of Systems. All results of the analysis can output to simple reports, for further consideration by project staff and subject matter experts. For further details on rCAT, contact the Requirements Group in Capability Integration, D CBM(A).

FUTURE DEVELOPMENT

47. The MODAF itself is still being developed, and its use to develop user requirements is particularly new. There are a number of factors not yet incorporated into the use of MODAF, and it is likely that more will emerge as experience is gained.

48. Use of Technical Views to Support Standards. One of the problems with the use of standards in a URD is that they are often applied in a broad-brush manner with little consideration of the effect to be achieved by their use. The result is a stated user requirement to comply with complete standards, not all elements of which are relevant or even desirable. It is difficult, if not impossible, for a supplier to unequivocally separate from a URD those parts of a standard that are desired relevant requirements, and those parts that are not relevant or desired. Equally, standards are blandly applied to the whole URD without qualification, rather than being directed at the URs to which they should apply. Whilst tailoring the use of standards is, and should be, largely the domain of the IPT and the System Requirement Document, there is a need to apply standards in a more qualified and considered manner at the User Requirement level. Expressing standards in technical views, should enable agents acting on behalf of customer 2 to:

a. Use the Standards in a more informed, and therefore considered manner.

b. Apply standards with qualifying statements, thus avoiding unintended consequences, whilst achieving the desired effect through the application of standards

c. Apply standards in a more selective manner, often only using relevant parts of a standard.

The use of technical views to express standards and associate them with other elements of the architecture has yet to be addressed by D CBM(A).

49. Environment. The military environment places a number of constraints upon individual requirements and systems as a whole. Examples might be the need to perform certain actions in red light conditions, or for certain processes to be performed by airborne organisations from the back of a helicopter. Methods of modelling and therefore understanding and articulating such constrains need to be developed.

50. Location/Distance. The communication requirements for information exchange are affected by location and distance. This organisation has not yet fully considered a method for modelling the requirements related to location and distance.

51. Temporal Requirements. The Operational Views include OV-6, OV- 6a, OV-6b and OV-6c which are Activity Sequence and Timing Descriptions. Whilst this is predominantly the preserve of the system engineer, there may well be valid user requirements that should be borne out of an understanding of timing and sequence. There are 3 types of temporal consideration:

a. The behaviour of the processes over time, i.e. Process A must be done within a day of process B. Understanding this type of temporal consideration is likely to improve the quality of effectiveness envelopes.

b. The changing nature of the system of systems over months and years (often referred to as Epochs within digitisation.) Links between MS Project and the Mood Transformation Toolset have been established, although this work needs development before it can be used directly in the derivation of URs.

c. The changing nature of the requirements and business processes over time. This needs development in the same way as changes in the system of systems.

52. Interoperability. Traditionally, interoperability is a stand-alone section in the Non-Functional Requirements. Whilst this has value, the statements are often very general in nature, and included more for the sake of the approvals process rather than conveying real requirements to the IPT. In the NEC environment, most IS will contribute to and or be supported by other IS. Therefore, it may be appropriate to include statements of interoperability with each group of functional requirements.

53. Training/Peacetime/Exercise. Clearly the field force spends the majority of its time in peacetime activities, either in barracks or on exercise. Whilst any system has to be optimised for operations, it must be possible to use it in peacetime if the users are to retain training currency and hence be able to deliver capability. This has a number of implications, including generating exercise/training data sets, and possibly more than one set of business processes that have to be supported. It is likely that the differing requirements dictated by 'in barracks', exercise and operational activities will need to be identified by developing models for each of these scenarios, however that has yet to be fully considered by D CBM(A).

54. System Requirements. Examination of system requirements is largely outside the remit of D CBM(A). However, the principles expressed in this paper could be applied to the development of system requirements. The rCAT toll could also be expanded very easily to assess coherence between system requirements within the System of Systems.

SUMMARY

55. Using MODAF products to understand capability and military business enables User requirements to be derived in a logical and defensible manner and expressed in a richer, yet more digestible format.

56. Using the Strategic, Operational and to a lesser extent the System Views the current situation can be fully understood, enabling requirements to be derived which better match the desired future military business and are more likely to contribute to operational capability. The improved shared understanding should enable customers and suppliers to collaborate more effectively, thus achieving greater improvements with each evolution of a system.

57. Incorporating all Lines of Development into the URD places the emphasis on delivering capability rather than just an equipment. This is important in all acquisition projects, but absolutely critical in IS projects, which simultaneously enable and constrain military capability.

58. Incorporating URs into the architecture from which they were derived provides greater understanding of the intended meaning and facilitates extensive analysis of coherence within the System of Systems.

CONCLUSION

59. The use of MODAF products to derive and articulate URs needs further development, but even in its current state the concept should be used as the basis for deriving the User Requirements for all future Information Systems. That said, its use needs careful consideration and adoption to the particular situation in hand in order to achieve the desired outcome. For that reason, mandating it as a process should be avoided, as mandation tends to lead to blind concentration on the process rather than the outcome.

ARMY

Developing Coherent, Concise and Comprehensive User Requirements Using the MoD Architectural Framework (MODAF)

Lt Col Chris W Bailey (RE)

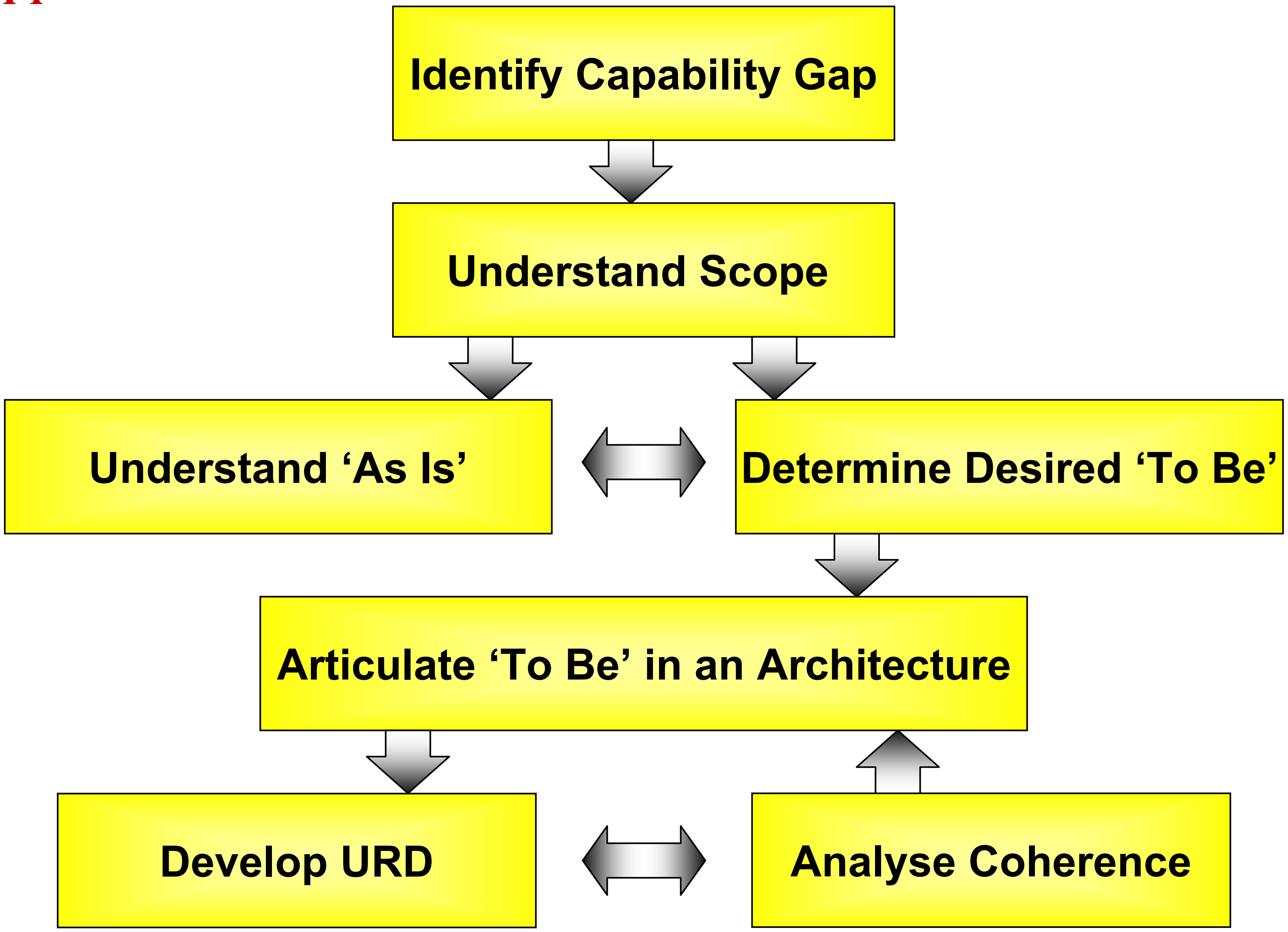
Maj Richard M Garbutt (REME)

ARMY

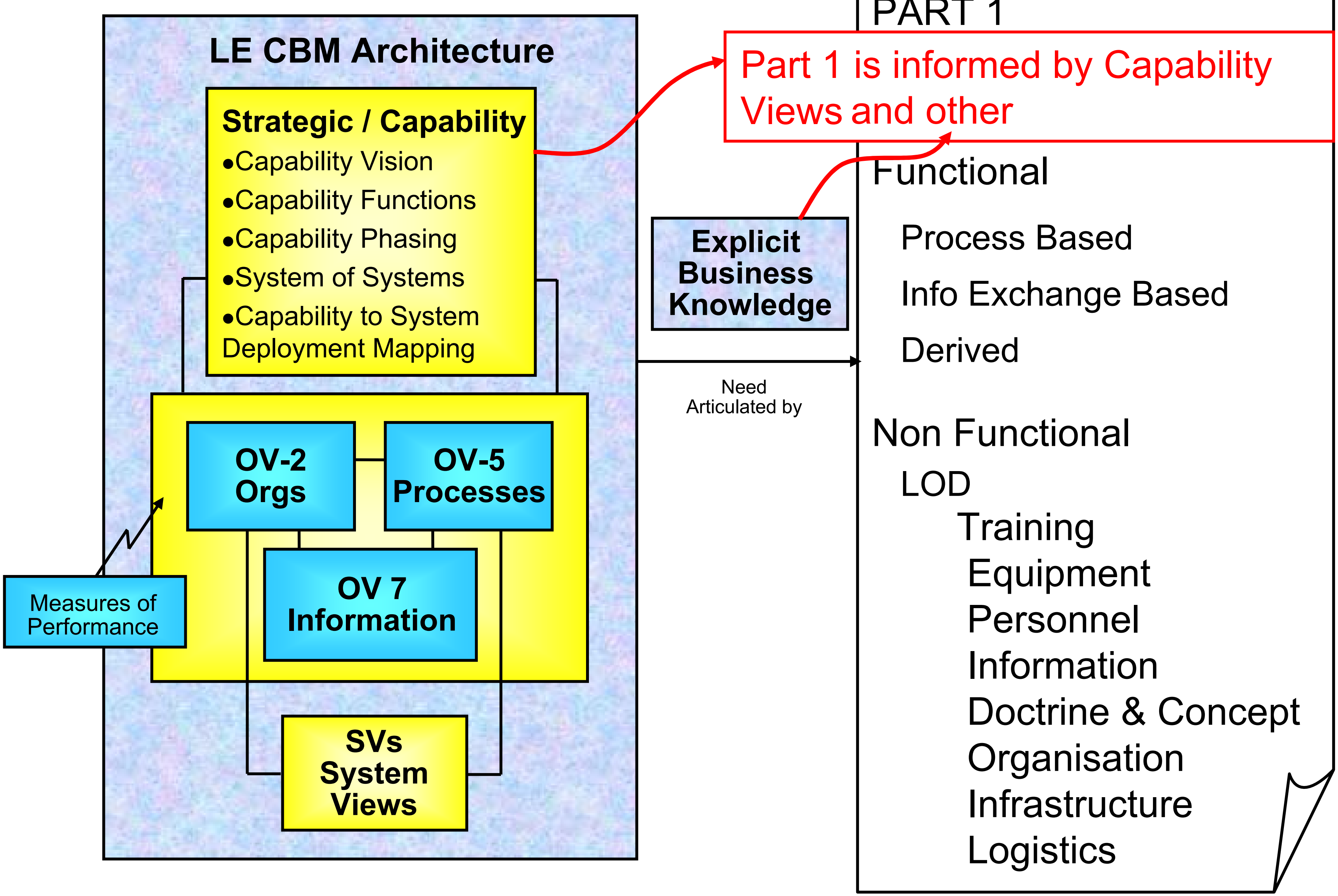
Introduction – The Problem

- The Military is Good At Doing – Bad At Describing
- Unambiguous & Comprehensive v Clear & Digestible
- Unintended Constraints
- Insufficient Information To Support Future Decisions
- Difficult To Review Text Based User Requirements For Completeness And Coherence With An Increasingly Complex System Of Systems

Outline Process



Using Architecture to Inform URD



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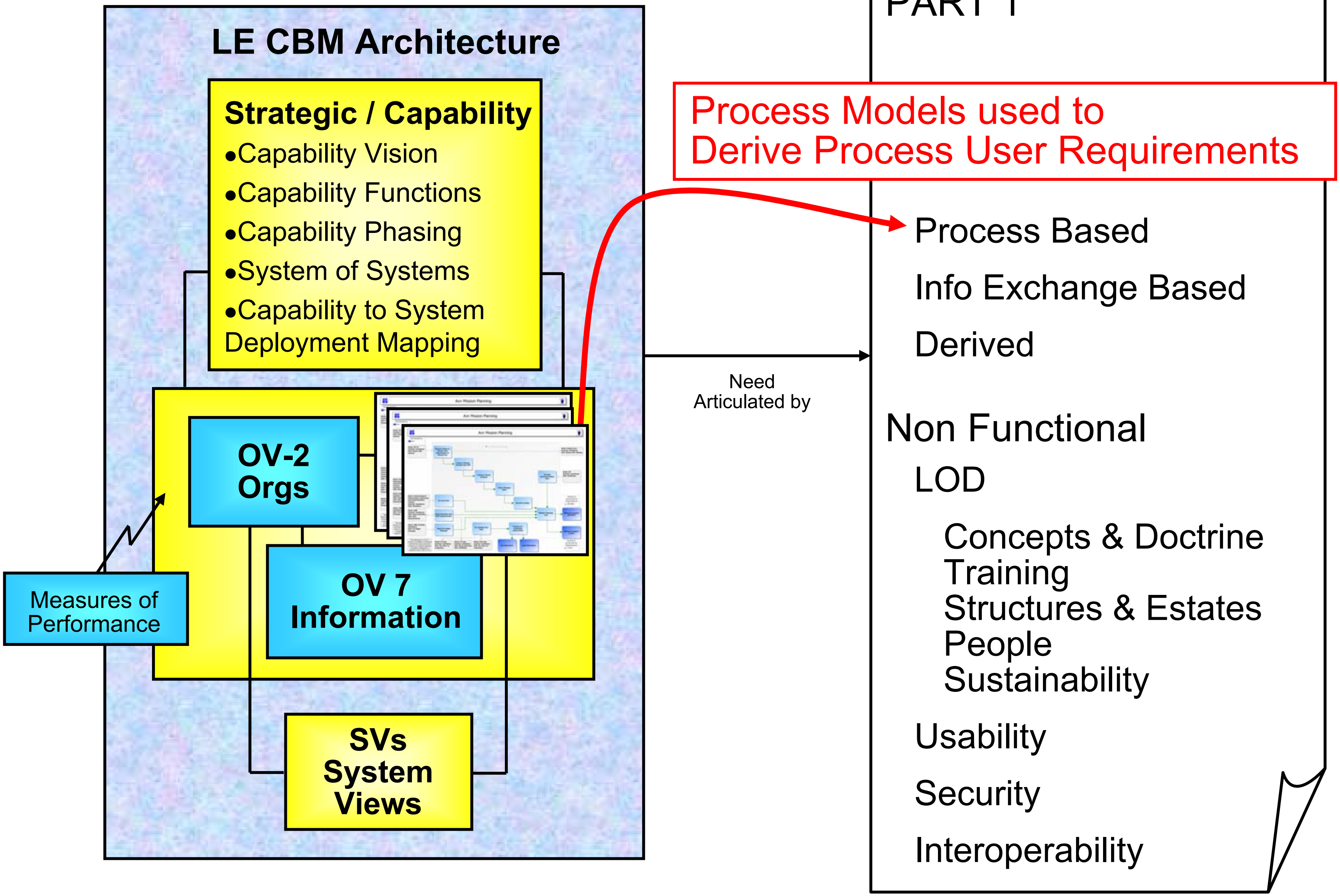

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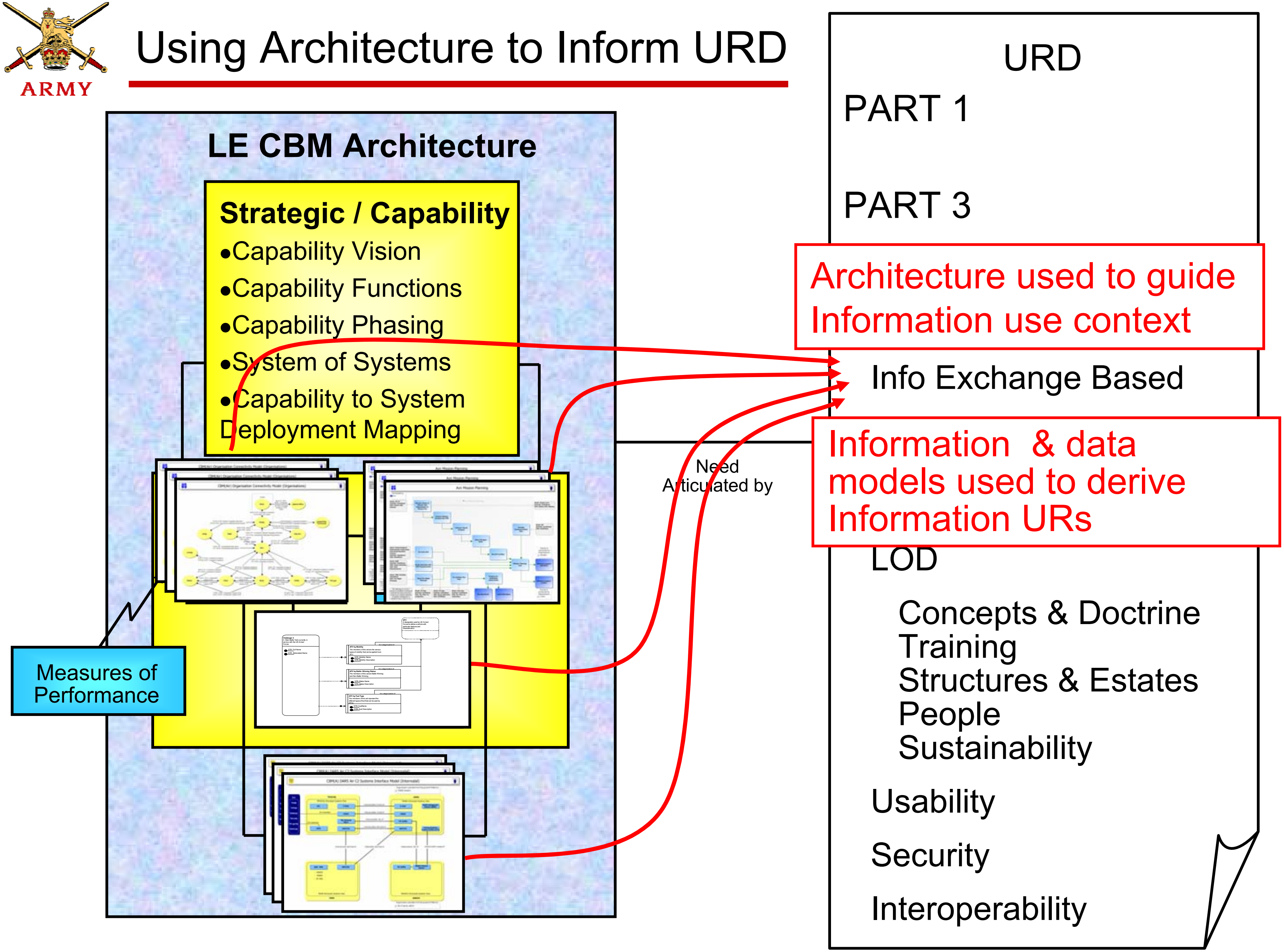
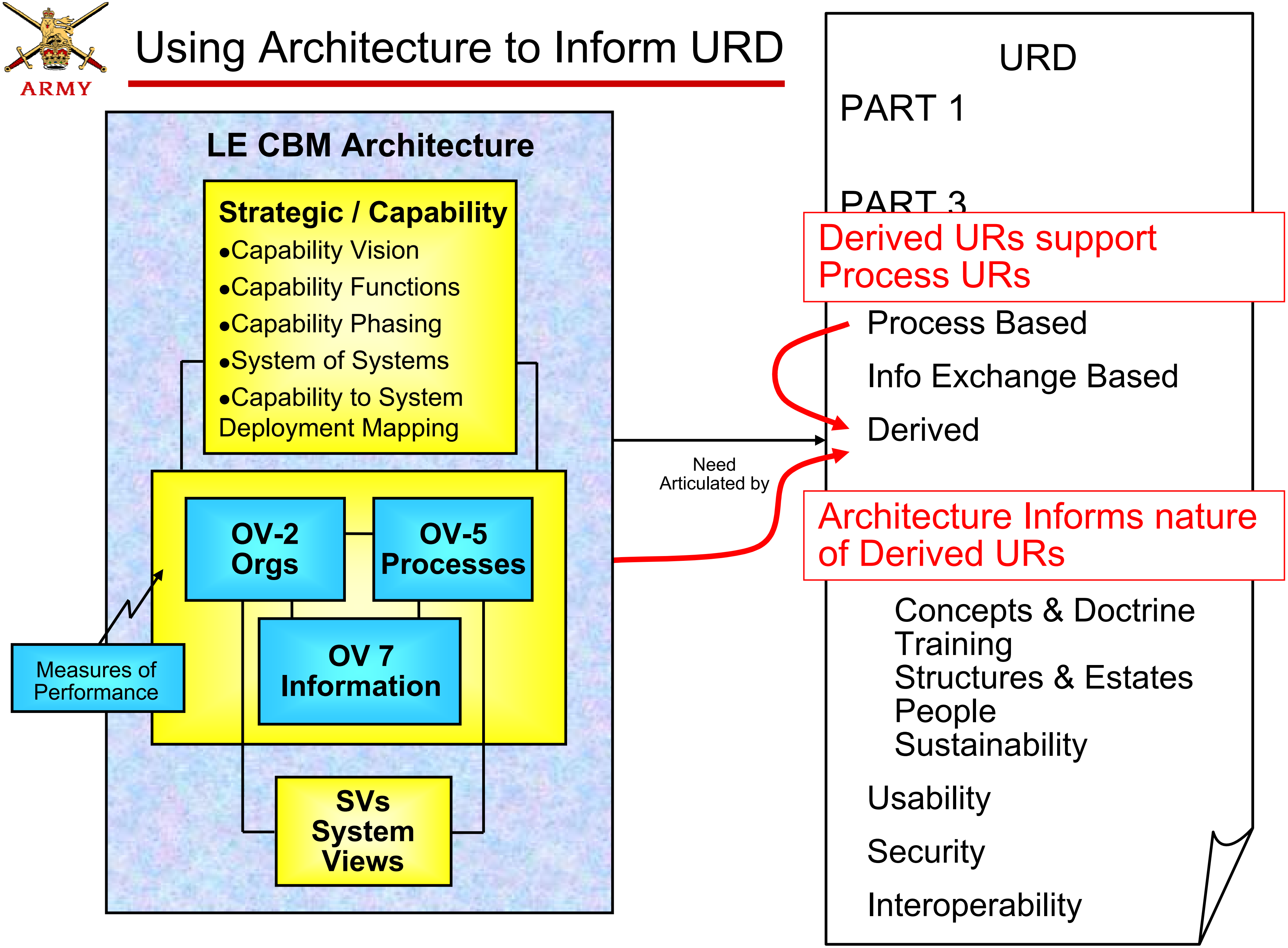
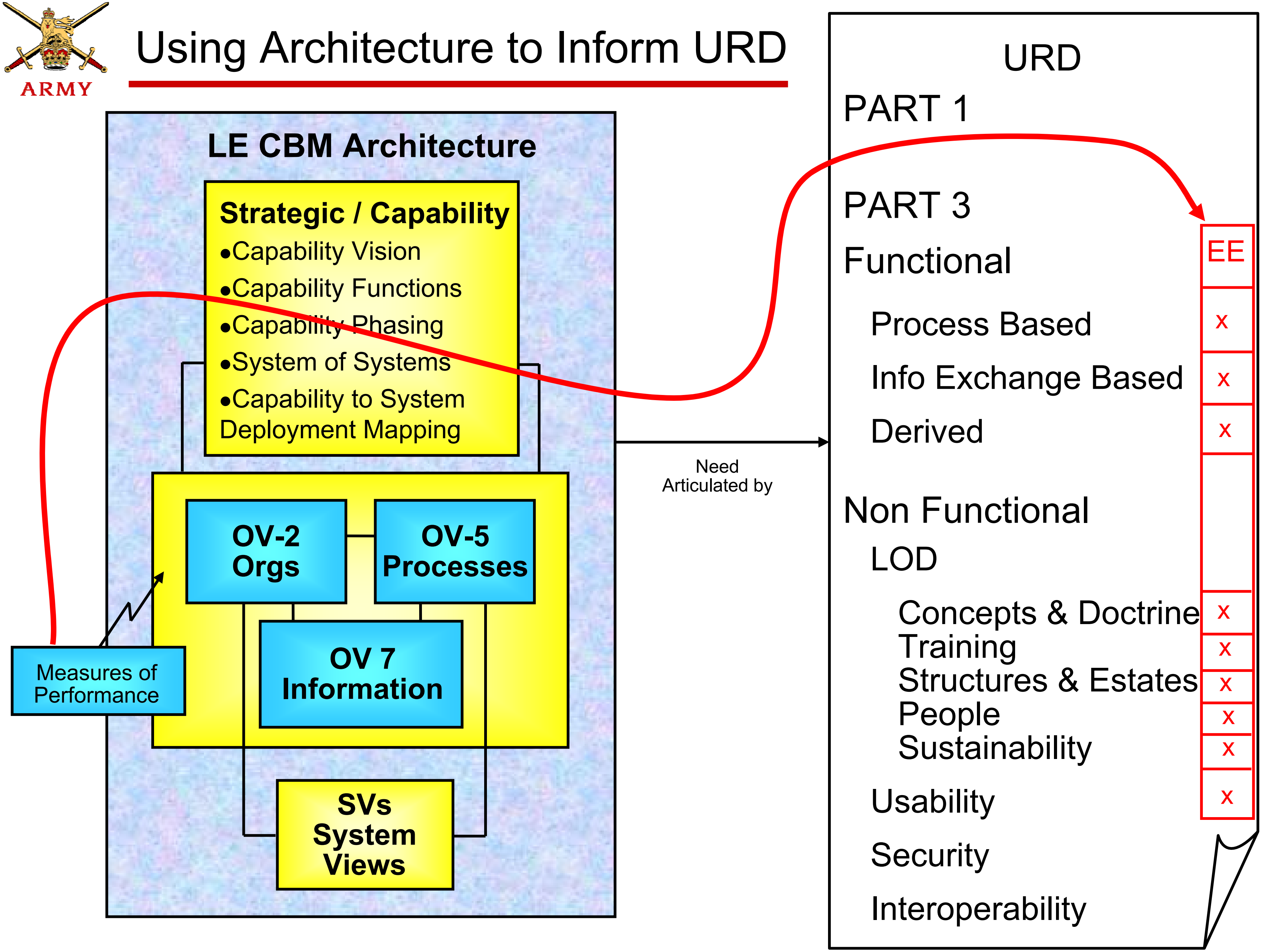


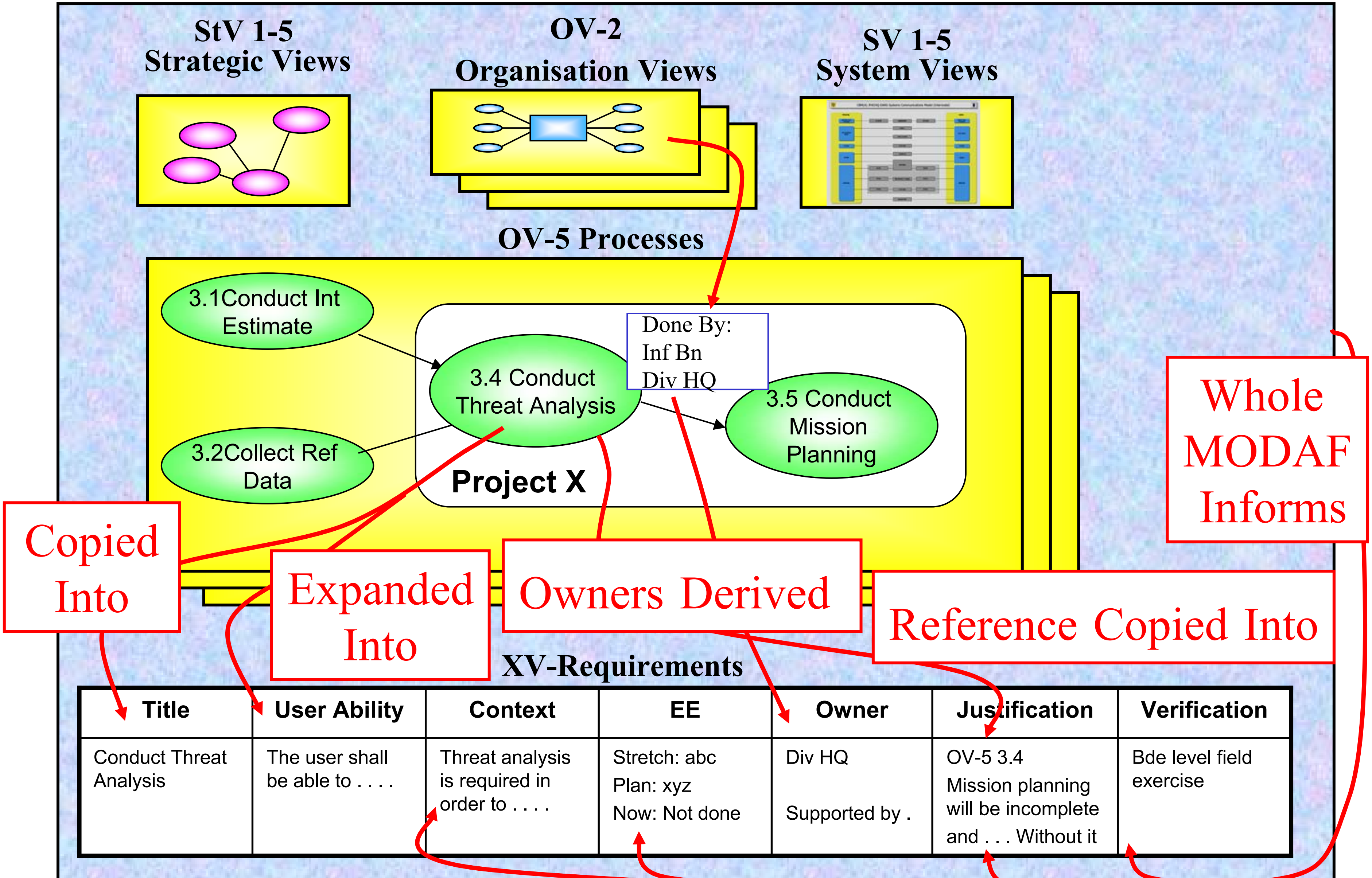
Using Architecture to Inform URD



Using Architecture to Inform URD



Using MODAF to Construct the URD



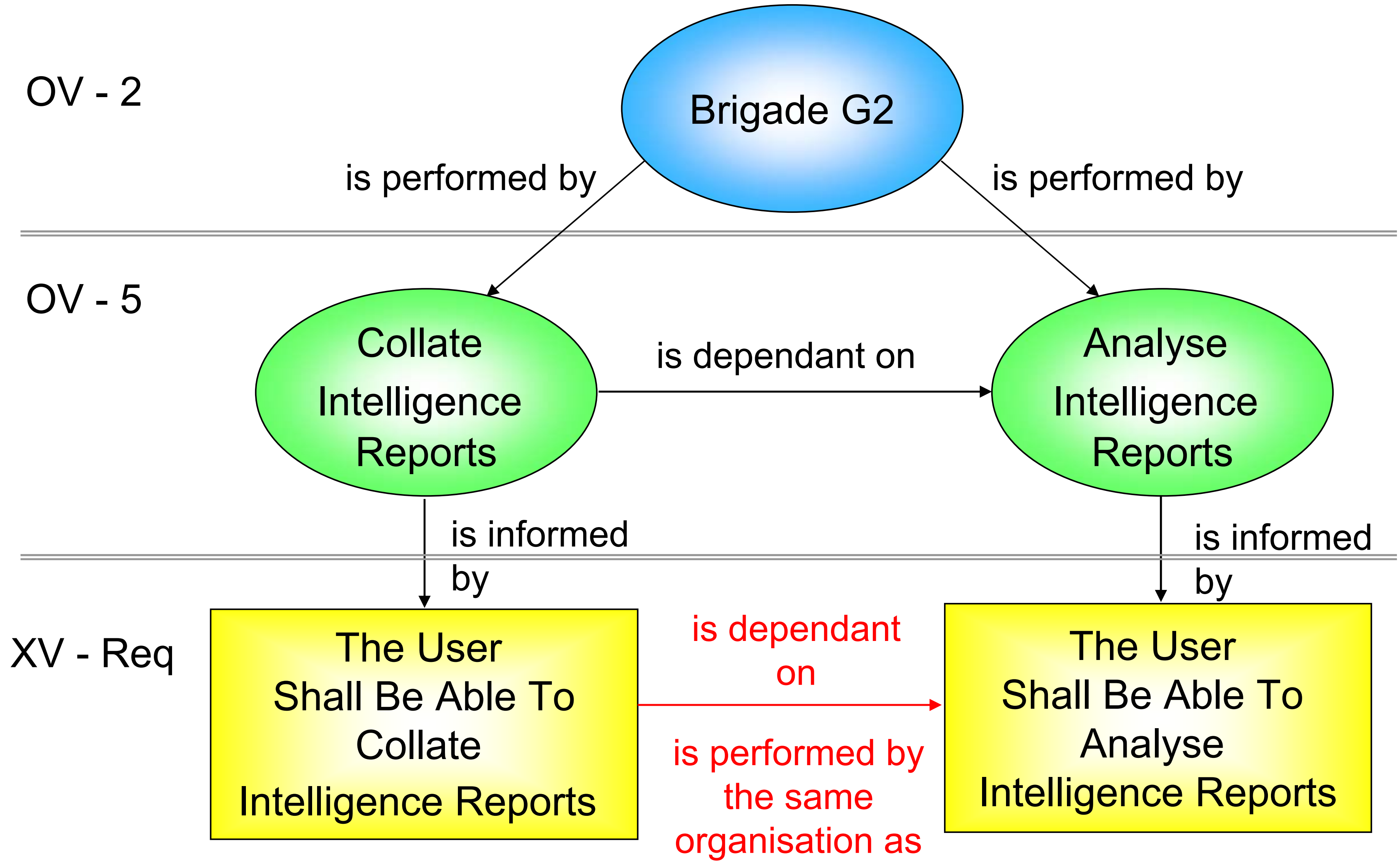
Title	User Ability	Context	EE	Owner	Justification	Verification
Conduct Threat Analysis	The user shall be able to	Threat analysis is required in order to	Stretch: abc Plan: xyz Now: Not done	Div HQ Supported by .	OV-5 3.4 Mission planning will be incomplete and . . . Without it	Bde level field exercise

So What?

- Improved Articulation of the Requirement
  - Communicate the Intended Meaning and Provenance
  - Communicate the Context of each Requirement
  - Inform the Requirement Trading Process
  - Reduce UNINTENDED constraints
  - Understand the impact of business changes on projects under development

- Enables Analysis of URs based on complex relationships – Requirements Coherence Analysis Tool (RCAT)

Complex Relationships



Sources and Types of Relationships

- Sources
  - Relationships articulated in the architecture
  - Relationships derived by RCAT analysis
  - Relationships derived (and implemented) in the architecture

- Types
  - Encapsulation
  - Dependency
  - Reference:
    - A requirement is derived from . . . (one to one)
    - A requirement is informed by . . . (many to one)

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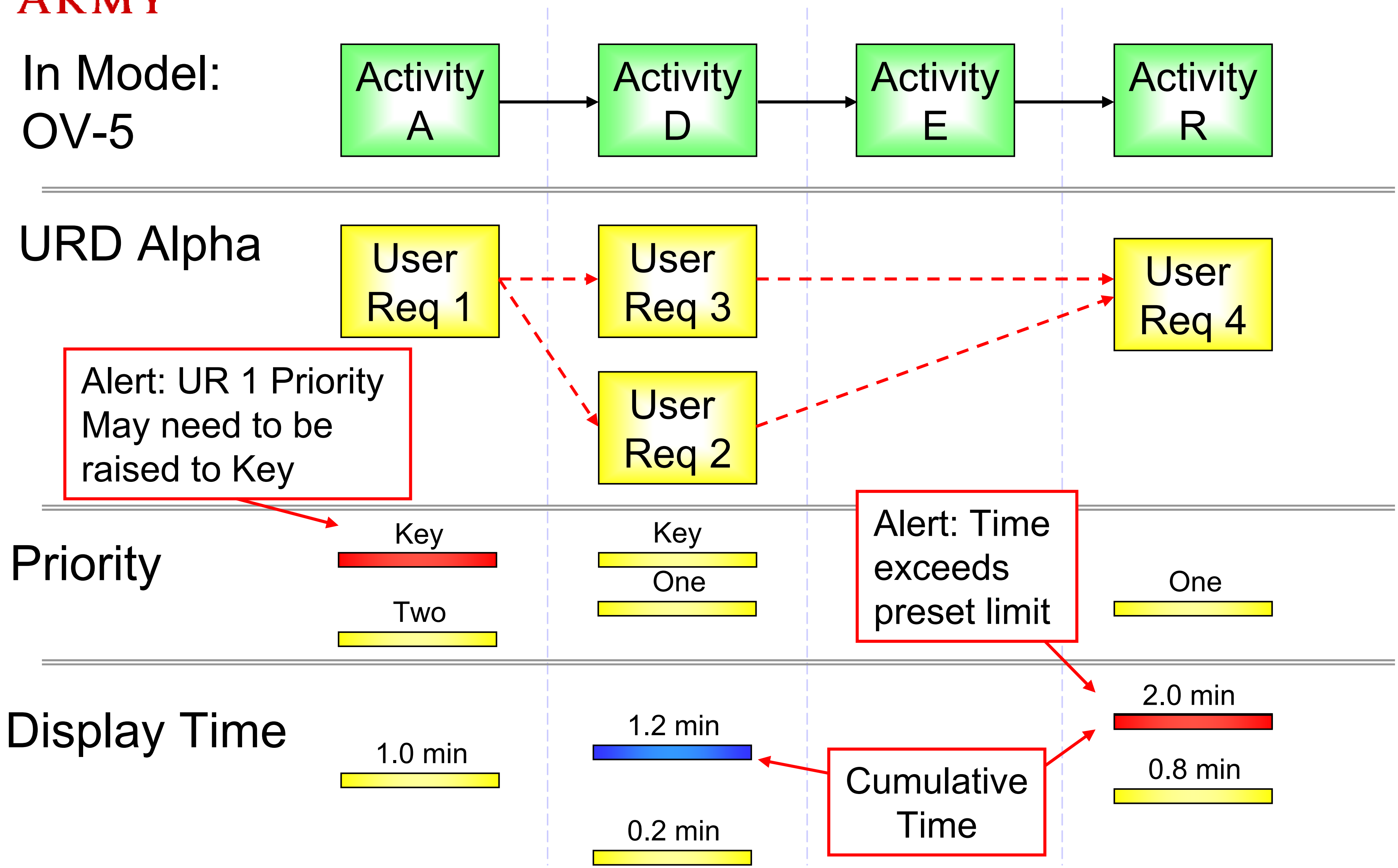
The British Army's Requirement Engineering Tools

- MooD Transformation Toolset
- MooD Instantiation of the Defence Architecture Solution (MIDAS)
- Land Environment Command and Battlespace Management Architecture
- Requirement Coherence Analysis Tool

Types of Analysis – Thread Analysis



Create and Analyse a Single URD

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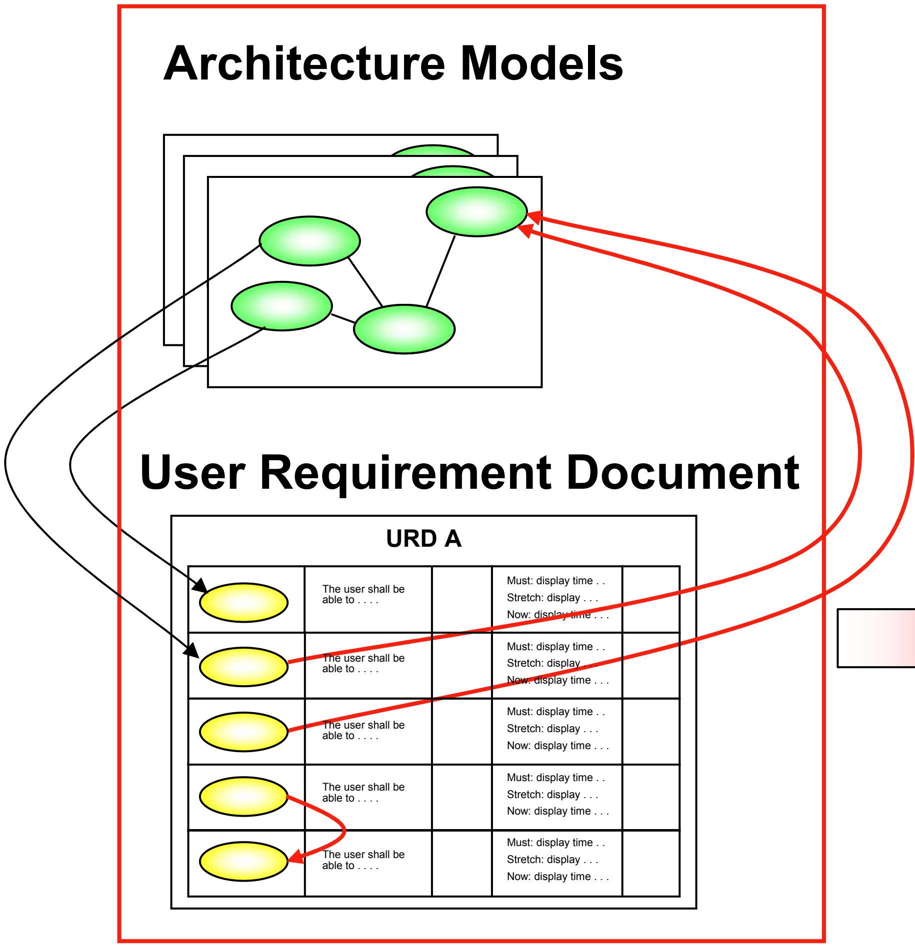
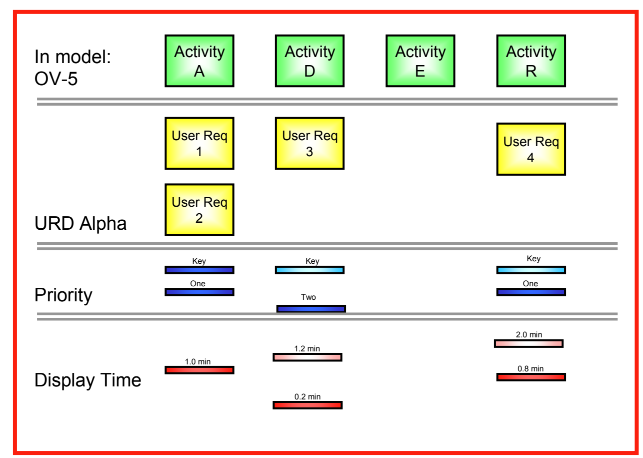
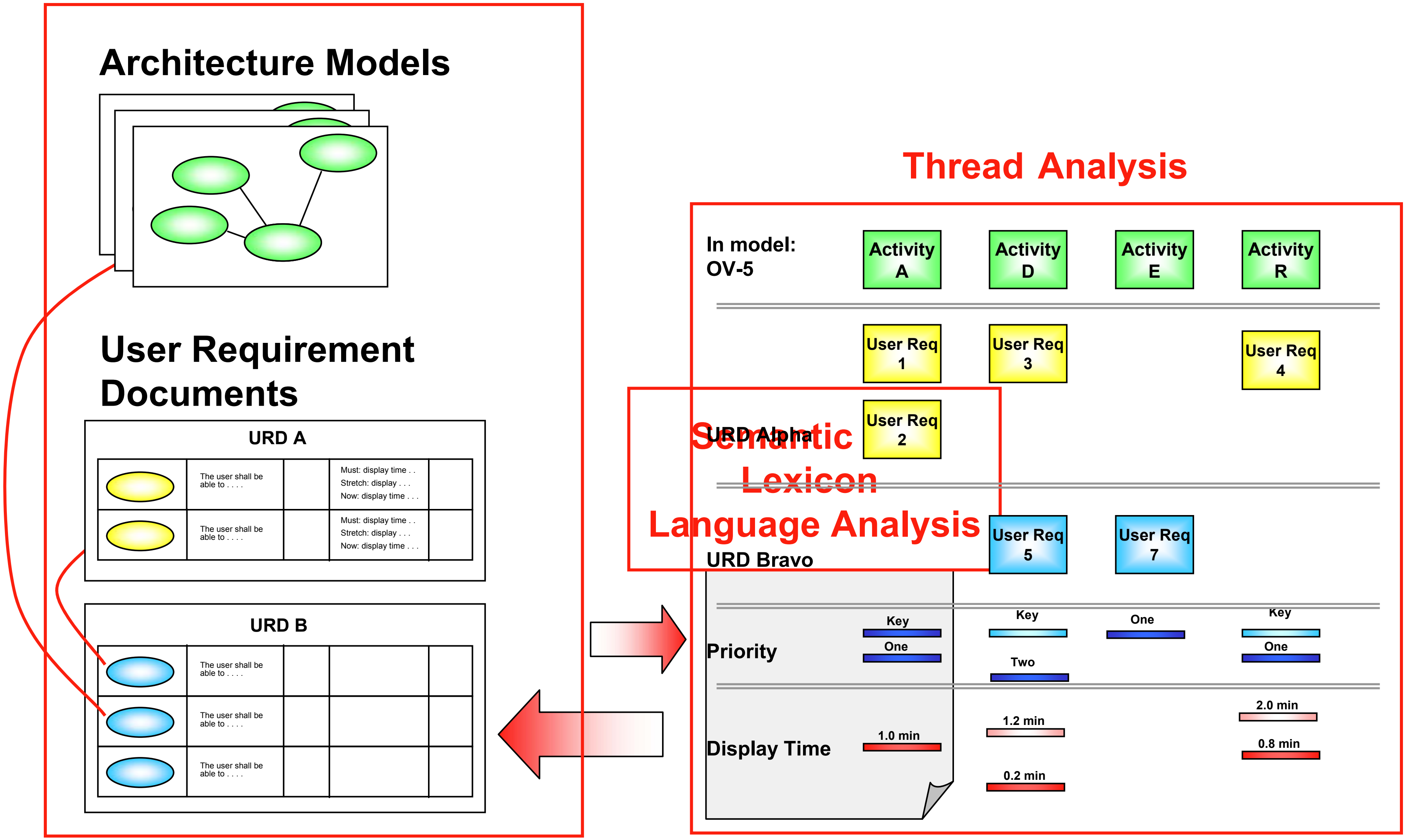


Semantic and Lexicon Language Analysis

Thread Analysis



Analyse Coherence Against Existing URDs



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Summary

- Requirements Derived from, referenced to and stored in MODAF
- Comprehensive Coverage That is Understandable by Users and Industry
- Coherence Analysis of URs based on complex relationships expressed in an Architecture