# SISO-GUIDE-003-00-2016

# Guide for UCATT Live Simulation Standards and Architecture

## Version 1.0

## 9 May 2016

## Prepared by Urban Combat Advanced Training Technology (UCATT) Product Development Group

## Revision History

| Version | Section | Date (MM/DD/YYYY) | Description |
|---|---|---|---|
| 1.0 | All | 05/09/2016 | Published version |

## Participants

At the time this product was submitted to the Standards Activity Committee (SAC) for approval, the UCATT Product Development Group had the following membership and was assigned the following SAC Technical Activity Director:

### Product Development Group

Capt Sander Cruiming (Chair)
Mr Staffan Martinsen (Vice-Chair)
Mr Joachim Eisenhauer (Secretary)

Mr Grant Bailey (SAC Technical Activity Director)

Mr. Magnus Alexandersson
Mr. Jesse Campos
Mr. Mark Chamberlain
Mr. Michelle Coriat
Mr. Thomas Defachelles
Mr. Philippe Desruelles
Mr. Uwe Dobrindt
Mr. Rudi Gouweleeuw
Maj Johnny Gullstrand
Maj Roger Karlsson
Mr. Anders Lindström
LtCol Peter Makowski
Mr. Armin Thinnes
Mr. Jan Vermeulen
Mr. Thierry Vinatier
Mr. Gary Washam
Mr. Ingo Wittwer

The Product Development Group would like to especially acknowledge those individuals that significantly contributed to the preparation of this product as follows:

### PDG Drafting Group

Anders Lindström (Editor)

Mr. Magnus Alexandersson
Mr. Jesse Campos
Mr. Mark Chamberlain
Mr. Michel Coriat
Capt Sander Cruiming
Mr. Thomas Defachelles
Mr. Philippe Desruelles
Dr. Uwe Dobrindt
Mr. Joachim Eisenhauer
Mr. Rudi Gouweleeuw
Maj Johnny Gullstrand
Maj Roger Karlsson
LtCol Peter Makowski
Mr. Staffan Martinsen
Mr. Armin Thinnes
Mr. Jan Vermeulen
Mr. Thierry Vinatier
Mr. Gary Washam
Mr. Ingo Wittwerr

The following individuals comprised the ballot group for this product.

## Ballot Group

Mr Magnus Alexandersson
Mr Alf Axerud
Mr Ernst Christians
Capt Sander Cruiming
Dr. Uwe Dobrindt
Mr Joachim Eisenhauer
Mr Max Fenner
Mr Rudi Gouweleeuw
Maj Johnny Gullstrand
Mr Paul Handley
Mr Jan Erik Holen
LtCol Peter Makowski
Mr Staffan Martinsen
Mr Jean-Philippe Michel
Mr Nico de Reus
Mr Jonathan Searle
Mr Armin Thinnes
Mr Jan Vermeulen
Mr Ingo Wittwer

When the Standards Activity Committee approved this product on 19 April 2016, it had the following membership:

## Standards Activity Committee

Jeff Abbott (Chair)
Marcy Stutzman (Vice Chair / Secretary)

Grant Bailey
Jean-Louis Igarza
Lance Marrou
Lana McGlynn
Chris McGroarty
Thom McLean
William Oates
Stefan Sandberg
John Stevens
Simone Youngblood

When the Executive Committee approved this product on 9 May 2016, it had the following membership:

## Executive Committee

Michael O'Connor (Chair)
Bob Lutz (Vice Chair)
Jane Bachman (Secretary)

Jeff Abbott
Anthony Cerri
John Daly
John Diem
David Graham
Paul Gustavson
Katherine Morse
Roy Scrudder
Robert Siegfried
Eric Whittington

# TABLE OF CONTENTS

# LIST OF FIGURES



# LIST OF TABLES

# 1 Overview

## 1.1 Scope

The Urban Combat Advanced Training Technology (UCATT) Live Simulation Standards and Architecture are aimed at providing joint and combined military training through the ability to interconnect live simulation training systems, otherwise known as Combat Training Centres (CTCs). CTCs contain a multitude of interfaces over which data is sent and received before, during and after an exercise. UCATT has identified some of those interfaces to be internal (only of interest to the system itself) and some to be external interfaces (data sent to outside of the system).

To achieve full interoperability, all or most interfaces will need to be standardized. To date, 11 external interfaces have been identified and considered standardization candidates. The UCATT standard is, therefore, considered a family of standards, even though each individual standard can also be used on its own. This, and the fact that 15 years of study and analysis have taken place prior to its publication, makes the UCATT family of standards quite complex. Therefore, the UCATT PDG developed this guidance document.

Although the initial scope of the various Working Groups (MSG-032, MSG-063, MSG-098/099 and the SISO UCATT PDG) was directed at Urban Operations training, as the UCATT acronym suggests, systems using individual UCATT standards will have no limitations in deploying in environments elsewhere. Indeed the standards have benefitted from the considerations required due to the urban environment and the unique challenges, complexity and context that describes.

This guide is intended to grow and develop over time, based on community requirements and future standard development, also resulting from actually using the standard.

## 1.2 Purpose

The purpose of this product is to provide context for the UCATT family of standards and architecture to:

- Enable data exchange between (legacy) live simulation systems from different suppliers and end-users;
- Enable data exchange between subsystems of live simulation systems from different manufacturers and end-users;
- Support the design, development and construction of live simulation systems;
- Give guidance to the definition of future live simulation system requirements to support interoperability.

## 1.3 Objectives

The objectives of this guidance document are to:

- Provide context and understanding for the related UCATT standards;
- Provide a functional architecture which show UCATT standard interrelationship;
- Give historical context to the development of the UCATT standards;
- Give guidance to UCATT standard implementation and system design;
- Serve as a knowledgebase for future standard development;

## 1.4 Intended Audience

The primary audience for this document is the Modelling and Simulation (M&S) community. Even though developed with live simulation systems in mind, other communities are encouraged to leverage this standard for use within their own community.

Within the M&S community this document is primarily intended for (industry) system engineers, procurement agency personnel and (military) end-users.

### 1.5 Structure

This document starts with providing historical background to the development of the UCATT family of standards, which has started over fifteen years ago and went from study and analysis to delivering its first standard to the community. After that an explanation is given about the basis of all UCATT work to date: the operational use cases, Capability Requirement Matrix, the functional architecture, together with the benefits of the standard and study approach. The following chapters explain each individual functional and physical interface, giving guidance on system design. UCATT based its technical interoperability work on the OSI 7-layer model, which is explained in the final chapter.

### 1.6 Acknowledgements

This document was created as a community effort by the NATO UCATT working group (MSG-032/063/098/099) and the Urban Combat Advanced Training Technology Product Development Group (UCATT PDG). The PDG was chartered by SISO in November 2013. This product would not have been possible without the hard work and dedication of the following individuals:

**MSG-098/099 UCATT members (if not already listed as PDG members):**
Mr Steve Blahnik
Mr Max Fenner
LtCol Rolf Lerch

## 2 References

### 2.1 SISO References

| Document number | Title | Date |
|---|---|---|
| SISO-ADM-001-2011 | Policy for Numbering of SISO Products | Jun 2011 |
| SISO-ADM-02-2011 | SISO Policies & Procedures | Apr 2011 |
| SISO-ADM-03-2011 | SISO Balloted Products Development and Support Process (BPDSP) | Nov 2011 |
| SISO-ADM-05-2011 | Policy for: The Style and Format of SISO documents | Jun 2011 |
| SISO-PN-008-2014 | Product nomination for Standardization of UCATT architecture external interfaces for live simulation instrumented training interoperability | Apr 2014 |
| SISO-REF-042-2013 | UCATT Study Group Final Report | Jan 2013 |
| SISO-STD-001.1-2015 | Standard for Real-time Platform Reference Federation Object Model (RPR FOM), Version 2.0 | Aug 2015 |
| SISO-STD-007-2008 | Standard for: Military Scenario Definition Language (MSDL) | Oct 2008 |
| SISO-STD-011-2014 | Standard for Coalition Battle Management Language (C-BML) | Apr 2014 |
| SISO-STD-016-00-2016 | Standard for UCATT Laser Engagement Interface | May 2016 |

## 2.2 Other References

| Document number | Title | Date |
|---|---|---|
| STANAG 2019, edition 6 | NATO Joint Military Symbology App-6(C), May 2011 | May 2011 |
| AC/323(MSG-032)TP/293 | MSG-032 UCATT Final Report | Apr 2010 |
| | MSG-063 UCATT Final Report | To be released |
| ISO/IEC 7498-1 | Information Technology – Open Systems Interconnection – Basic Reference Model: the Basic Model | |
| RTO-TR-8/AC323(SAS)/TP-5 | Land Operations in the year 2020 | Mar 1999 |
| RTO-TR-071/AC323 (SAS030)TP/35 | Urban Operations in the year 2020 | Apr 2003 |
| STANAG 5525 | Joint C3 Information Exchange Data Model | Jun 2007 |
| IEEE Std 1516™-2010 | IEEE Standard for Modeling and Simulation (M&S) High Level Architecture (HLA)—Framework and Rules | Mar 2010 |

# 3 Definitions, Acronyms, and Abbreviations

## 3.1 Definitions

The following definitions are given for clarity only, not as guidelines.

| Term | Definition |
|---|---|
| **After Action Review** | Providing interactive and objective feedback to the training audience regarding its exercise performance. |
| **Architecture** | The structure of components in a program/system, their relationships and the principles and guidelines governing their design and evolution over time. |
| **Combat Training Centre** | A Combat training centre is an instrumented range, urban operations training village or exercise area. It can also be a mobile system capable of instrumenting a training area. |
| **Dynamic Object** | A live, virtual or constructive element in the training environment that 1) has a presence in the environment and either 2) has a valid status, or 3) can influence the status of other DOs (execute engagements) or possesses both of these characteristics.<br><br>Ad 1. Presence: a DO can be seen, observed or detected in the training environment. For example, a vehicle can be seen by the naked eye, observed in infrared, detected by radar and be tracked by C4I systems. But even a CBRN area can be detected with specific sensors.<br><br>Associated with its presence is its position. During an exercise the position of a DO can be dynamic (e.g., a soldier can move around) or static (e.g., a wall generally stays on the same position during an exercise). |

Ad 2. Status indicates the (level of) capabilities of a DO. It can be very basic (such as for example dead/alive for human beings, or operational/destroyed for weapon systems and infrastructure), or it can be more complex, distinguishing between more levels of degraded performance. The status of a DO can be changed during an exercise, either by engagements from other DOs or by (interventions from) the training system. It could be required that a DO has a fixed status that cannot be changed, thus rendering it untouchable or indestructible in an exercise. A typical example of such a DO is an Observer/Controller (O/C), whose status cannot be changed, but can engage other DOs.

Ad 3. Engagement. Generally a DO can influence the status of other DOs, especially in the context of urban combat. For example, a soldier can fire an anti-tank weapon at a vehicle or at a building, a wall could be destroyed and with its debris it can engage DOs in its vicinity, and a CBRN area can affect unprotected DOs that enter it.

However, examples of DOs that cannot engage are a pop-up target or an unarmed UAV, which is just a sensor platform.

**Exercise Control** — The ability to conduct the following functions: exercise planning, exercise preparation, conducting an exercise, preparing and providing After Action Review.

**Facility Control** — The capability to represent the static environment (infrastructure, buildings, roads, etc.) This can either be fixed or mobile (e.g., containers).

**Interoperability** — The ability of a model or simulation to provide services to and accept services from other models and simulations, and to use these exchanged services to operate effectively together.

**Live Simulation** — A simulation involving real people operating real systems.

**Model** — A physical, mathematical or otherwise logical representation of a system, entity, phenomenon or process.

**Modelling & Simulation** — The discipline that comprises the development and/or use of models and simulations.

**MOUT facility** — A building, or number of buildings, dedicated to training military units to operate in the urban environment.

**Observer/Controller** — Role played in the training area by exercise staff in support of the exercise provided with equipment to monitor events, influence events and provide feedback to the training audience.

**Simulation** — A method for implementing a model over time.

**System** — A group of related hardware units or programs or both, especially when dedicated to a single application.

**System Control** — The capability to monitor and control the training system itself, necessary to support the training exercise.

## 3.2 Acronyms and Abbreviations

| Acronym or Abbreviation | Meaning |
|---|---|
| AAR | After Action Review |
| AG | Architecture Group |
| AGDUS | Ausbildungsgerät Duellsimulator (German for: training equipement duel simulator) |
| BMS | Battlefield Management System |
| C4I | Command, Control, Communications, Computers and Intelligence |
| C-BML | Coalition Battle Management Language |
| CBRNe | Chemical Biological Radiological Nuclear explosives |
| CNR | Combat Net Radio |
| CRM | Capability Requirements Matrix |
| CTC | Combat Training Centre |
| DA | Design Architecture |
| DIS | Distributed Interactive Simulation |
| DO | Dynamic Object |
| EU | European Union |
| EXCON | Exercise Control |
| FA | Functional Architecture |
| FIBUA | Fighting in Built-Up Areas |
| HICON | Higher Control |
| HLA | High Level Architecture |
| IED | Improvised Explosive Device |
| IEEE | Institute of Electrical and Electronics Engineers |
| JC3IEDM | Joint Consultation, Command and Control Information Exchange Data Model |
| LG/8 | Land Group 8 (Group under NAAG) |
| LO2020 | Land Operations in the Year 2020 |
| LVC | Live Virtual Constructive |
| M&S | Modelling and Simulation |
| MILSTD | Military Standard |
| MIP | Multinational Interoperability Programme |
| MOD | Ministry of Defence |
| MOOTW | Military Operations Other Than War |
| MOUT | Military Operations in Urban Terrain |
| MSMP | Modelling and Simulation Master Plan |
| NAAG | NATO Army Armaments Group |
| NATO | North Atlantic Treaty Organisation |
| NMSG | NATO Modelling and Simulation Group |
| O/C | Observer Controller |
| ORBAT | Order of Battle |
| OSAG | Optische Schnittstelle für AGDUS und Gefechts Ǘbungszentrum Heer |
| PDD | Personal Detection Device |
| PDG | Product Development Group |
| PfP | Partnership for Peace |
| PID | Player Identity |
| PSO | Peace Support Operation |
| R&D | Research and Development |
| RTO | Research and Technology Organisation |
| SAS | Studies, Analyses and Simulation |
| SAT | Small Arms Transmitter |
| SE | Synthetic Environment |
| SG | Standards Group |

| Acronym or Abbreviation | Meaning |
|---|---|
| SHAPE | Supreme Headquarters Allied Powers Europe |
| SISO | Simulation Interoperability Standards Organization |
| STANAG | Standardization Agreement |
| STO | Science and Technology Organisation |
| STOG | Simulation, Training and Operations Group |
| TAP | Technical Activity Proposal |
| TES | Tactical Engagement Simulation |
| TG | Task Group |
| TOE | Team of Experts |
| TOR | Terms of Reference |
| TSWG | Training and Simulation Working Group |
| TTP | Tactics, Techniques and Procedures |
| UAV | Unmanned Aerial Vehicle |
| UCATT | Urban Combat Advanced Training Technology |
| UN | United Nations |
| UO | Urban Operations |
| UO2020 | Urban Operations in the Year 2020 |
| WES | Weapon Effects Simulator |
| WG | Working Group |

# 4 Urban Combat Advanced Training Technology (UCATT)

## 4.1 Background

### 4.1.1 Team of Experts (TOE)

Two NATO studies have been fundamental to taking the work of the UCATT WG forward: the NATO Research and Technology Organisation (RTO) 1999 Technical Report, Land Operations in the Year 2020 (LO2020) and the 2003 Urban Operations in the Year 2020 (UO2020) report. LO2020 concluded that NATO forces would likely have to conduct future operations in urban areas.

Urban warfare is arguably the most deadly type of warfare and tends to neutralise the technical superiority of modern militaries. Nation's investments in the first generation of MOUT training facilities began in the early 1990s. Much has been learned over the past decade but there is minimal effort in the area of formal standardisation and interoperability. The NATO structure and objectives make it the most suitable organisation to harmonise training requirements and spearhead the effort toward common technical architecture and standards for the next generation of MOUT facilities and CTC's.

The NATO Modelling and Simulation Action/Master Plan (MSMP) identifies the need for common open standards and technical frameworks to promote the interoperability and reuse of models and simulations across the Alliance. Included in this requirement is the need for a common technical framework for "Live" training among members of the Alliance.

In 2002, a Team of Experts from NATO NAAG completed a feasibility study in order to investigate the need for a generic set of requirements for NATO/PfP countries in relation to live instrumented training. The conclusion was that a number of potential interoperability areas were identified and assessed to be worthy of further investigation.

### 4.1.2 MSG-032 UCATT-1

The Urban Combat Advanced Training Technology (UCATT) Task Group (TG) was established within the NATO Modelling and Simulation Group (NMSG) in 2003 as MSG-032 TG 023. The UCATT TG was tasked to exchange and assess information on MOUT facilities and training/simulation systems with a view toward establishing best practice. In addition it was required to identify interoperability requirements, a suitable architecture and a standard set of interfaces that would enable interoperability of MOUT training components. Uniquely the UCATT TG, from the outset, drew its members from both government and industry.

UCATT has become the NATO focal point for MOUT training technology and exchanging information with the military community and is well regarded among industry as a driving force within the live domain.

Over a three-year period the UCATT TG held 12 meetings in various NATO and PfP countries.

Although in its Terms of Reference it was required to liaise with a number of groups both within Supreme Headquarters Allied Powers Europe (SHAPE) and outside of NATO, which included the STOG (formerly TSWG), Topical Group 3 from the NAAG and SISO, the main contact group was the NATO Urban Operations TG (formerly FIBUA/MOUT WG).

Besides a technical report, TG 032 delivered a website where all main NATO/PfP MOUT sites are registered (http://www.fibuamoutsite.info). This site is still maintained and supervised by the NATO Urban Operations TG.

### 4.1.3 MSG-063 UCATT-2

The UCATT-2 WG was the successor of the first UCATT WG within NMSG and was chartered in 2007 as MSG 063 TG 040. The UCATT-2 WG was tasked to continue the work of the previous UCATT WG; to exchange and assess information on MOUT facilities and training/simulation systems with a view toward establishing best practice. In addition it was required to organize an interoperability demonstration to prove standards and start the process of defining standards for laser communication, data communication and audio & visual effects.

It did just that, which resulted in a successful technical demonstration in 2011, held at the Marnehuizen MOUT training facility in The Netherlands. During this demonstration a proof-of-concept was presented, showing systems from multiple manufacturers exchanging information and simulated battlefield effects.

### 4.1.4 MSG-098/099 UCATT-3

The success of the UCATT-2 technical demonstration led to the institution of two new WG's: the MSG-098 UCATT Architecture Group (AG) and the MSG-099 Standards Group (SG). Since UCATT had now reached the "delivery phase", the decision was made to split up into two WG's to bring focus to the work at hand.

Both WGs operated in close cooperation with joint meetings to aid communication and reduce delay.

The AG was tasked to revise and develop requirements for each individual interface (see Functional Architecture, Ch 7). It then handed over those requirements to the SG, which was tasked with standardizing, based on those requirements.

In accordance with SISO policy, a UCATT PDG was instated.  This occurred at the end of 2013. The work done in all the UCATT WGs, the SISO SG and PDG have resulted in this standard.

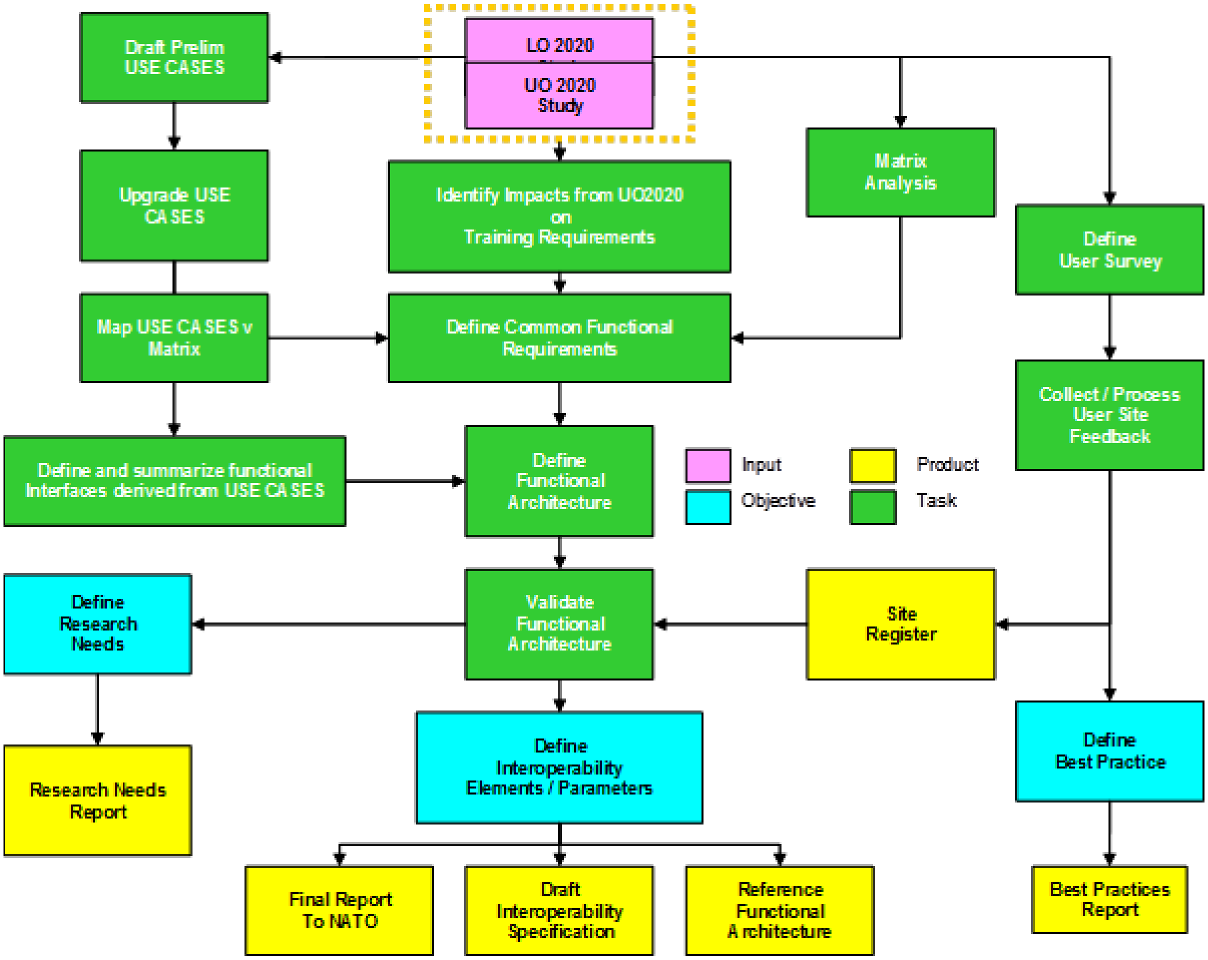


**Figure 1: UCATT 1 and 2 study approach**

## 4.2 Military Benefit

The military end-user benefits greatly from having interoperability between live simulation systems. Since countries are looking to partner with other countries within different alliances more and more (NATO, EU, PfP, etc.), multinational exercises have become more rule than exception.

Having the ability to use their own live simulation equipment during those exercises brings about a higher quality of training, together with an increased sense of “fair play”.

Using the UCATT standard also opens up many more (urban) training facilities to the different nations than before. This again, gives more variety to training and therefore a higher level of readiness.

## 4.3 Procurement Benefit

From a governmental procurement perspective, there are also benefits to be found. Since this product is aimed at interoperability at a modular level, procurement no longer has to follow the “whole system” approach. This decreases vendor lock-in and gives more flexibility to the procurement process. High cost and often bespoke efforts needed to make systems interoperable with specific other vendors or CTC’s (stove pipe couplings) will no longer be necessary in the future if this Standard is widely adopted.

## 4.4 Industry Benefit

Industry partners were invited to work within the UCATT WG's. The benefit that they gained while providing their expertise was that those members of industry were able to form a close relationship with those nations participating and their urban simulation experts. This has enabled industry to understand the user needs and help to direct their own R&D work.

Having an interoperability standard also provides the possibility for industry to enter markets that are now closed due to "vendor lock-in" and give more focus to their areas of expertise.

Industry involvement helps greatly to establish a solid user base for the UCATT standard as it is more likely to be implemented in future products.

## 4.5 Use Cases

The main objective in developing a set of Use Cases was to ensure that all training requirements could be identified and that a generic architecture could be built that was able to accommodate each nation's requirements. It also provided an opportunity for starting the process of cooperation with the Urban Operations (UO) TG, which was asked to validate the Use Cases and answer a set of generic questions for each one.

The UO 2020 report describes the capabilities needed by NATO commanders to conduct operations in urban environment in that timeframe. In addition, to support the development process, the UCATT WG used a U.S. Army presentation of a *Vision of the Future Force 2020* to further ensure that members had an understanding of how the urban battle space might look like at that time. Based on the report, presentations and thoughts of each of the national representatives, the UCATT WG developed a set of Use Cases and supporting scenarios, which not only describe the current situation but also accommodate how it was considered that nations might need to train in the future.

The Use Cases developed ranged from the conduct of national training on a national site, with no need for any interoperability, to staff training in a mission area with several nations participating in coalition operations (joint, combined and inter-agency).

The results of the work were five Use Cases and supporting scenarios that were thought would help to both visualize and understand the complexities in each case that had to be considered, in order to determine training requirements. The Use Cases were verified in conjunction with the UO TG. This also helped in capturing the training needs of the different nations.

An overview of the Use Cases can be found in the table below. Further explanation is available in the different UCATT RTO Technical Reports.

**Table 1: Overview of the identified use cases**

| # | Title |
|---|---|
| USE CASE 0 | National training on National site |
| USE CASE 1 | Live MOUT training Multinational force on National site (consolidated combined training) |
| USE CASE 2 | Use other nations training facility and staff |
| USE CASE 3a | Distributed combined training |
| USE CASE 3b | Combined training in mission area |
| USE CASE 4 | Command and staff training for engagements in different mission areas |

# 5 Capability Requirements Matrix (CRM)

## 5.1 Introduction

It was recognized in 2003 that doctrine published by individual NATO/PfP countries did not support or identify joint or combined requirements for conducting effective military operations in an urbanized environment. Very few training exercises were conducted at the joint or combined level in an urban training environment. Countries had different requirements for the level of live training conducted from squad (4-8 personnel) through to Brigade level.

As late as 2006 urban training was not mandated by many of NATO and PfP countries. The UCATT WG, as one of its tasks, sought to identify the needs of the different countries' training capability requirements, evaluate those requirements and make recommendations on a generic set of capability requirements for urban operations training in the Live, Virtual and Constructive (LVC) domains. In order to carry out this task a Requirements Matrix Sub-Group was established.

## 5.2 Purpose

The purpose of the capability requirements matrix was to identify those components needed to support training at all levels from Squad to Brigade, including non-military (MOOTW) and Peace Support Operations (PSO). Although it was initially intended to include all three environments only the live training environment was completed. The development of the matrix and its subsequent analysis was used to identify common elements, interoperability issues and where standards could be applicable in conducting urban training. These were then addressed in the functional architecture and interfaces that are described in Chapter 7, through the definition of a common set of functional training requirements. More information and the complete Capability Requirements Matrix can be found in Annex F of the MSG-032 RTO Technical Report.

# 6 Functional Architecture

## 6.1 Purpose

The capabilities identified in the CRM describe the requirements for a CTC from a user point of view. In order to derive from these capabilities, a generic set of requirements for the development of CTC's, it is necessary to have a common understanding of the training system from a system point of view. This means that there must be insight into the functions of the training system, how they are grouped together into components and what types of interactions take place between those components. Only then it is possible to discuss interoperability issues and compose the desired requirements.

In order to gain this insight and bridge the gap between the capabilities on the one hand and requirements for the development of CTC's on the other hand, an architecture must be created and agreed upon.

Formally, an architecture is "the organizational structure of a system or component, their relationships, and the principles and guidelines governing their design and evolution over time" (IEEE 610.12). There are many different types of architecture, but two main categories are the functional and design architectures:

- A Functional Architecture (FA) is "an arrangement of functions and their sub-functions and interfaces (internal and external) that defines the execution sequencing, conditions for control or data flow, and the performance requirements to satisfy the requirements baseline".
- A Design Architecture (DA) is "an arrangement of design elements that provides the design solution for a product or life cycle process intended to satisfy the functional architecture and the requirements baseline" (IEEE 1220).

It was the purpose of UCATT to set requirements for interoperability, which is the ability of systems to exchange data, information and services to enable them to operate effectively together.

At the same time, industry should have the freedom to propose and implement the most cost-effective solutions, as long as they satisfy the interoperability requirements. So in fact, this product's main focus is on system interfaces. In this context, an interface describes the characteristics at a common boundary or connection between systems or components.

To identify and define the system boundaries and interactions with other systems (external interfaces), it is sufficient to create and analyse an FA of a CTC. This functional architecture must be representative enough to cover all of the Use Cases defined in Chapter 5 and the requirements from the CRM, while not touching specific design or implementation issues. The FA captures what the system can or might do, not how it does or should do it (e.g. the requirement, not the implementation such as communication which might actually be by wireless transmission or through a cable). The UCATT FA is illustrated in Figure 2 Another subject of particular interest is the level of detail of the functional architecture. Too few details will result in insufficient possibilities for interoperability, while too many details will result in losing oversight and identifying irrelevant interfaces for interoperability.

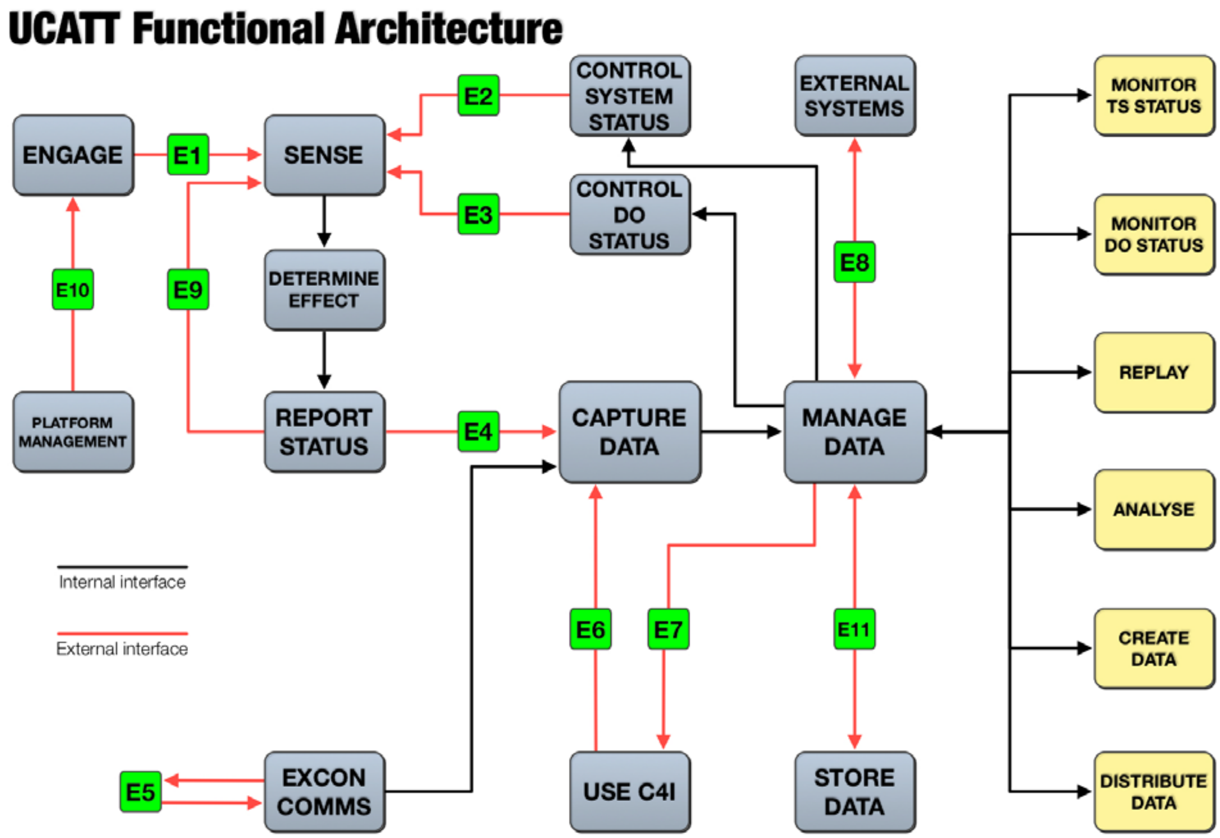


Figure 2: UCATT Functional Architecture

## 6.2 Internal and External Interfaces

In the case of the FA, an interface exists where data is exchanged between functions that reside in the architecture. While the complete FA described and identified all functions and interfaces that can be found in a CTC, it did not definitively identify the interfaces that needed to be standardized to establish interoperability.

In order to do that, a difference was made between internal and external interfaces.

Internal interfaces handle data communication that only takes place in the system itself or a designated subsystem, whereas external interfaces communicate to either outside the system or to a system component that can be replaced by a third party counterpart (e.g., a PDD or SAT from a different vendor). The internal interfaces where considered proprietary and out of scope for standardization, since they were not mandatory for achieving interoperability.

By identifying the external interfaces, it is made explicit what interfaces need to be standardized to achieve interoperability. The external interfaces were subsequently given the designation “E”, followed by an identifying number. From there on these “E’s” formed the basis of all the work done by UCATT, especially during the final delivery phase. A standard definition for each interface can be found in one of the attached annexes to this document.

## 6.3 Interface Definitions

### 6.3.1 E1 – DO Engagement (Engage → Sense)

This interface represents an action of one DO on (one or more) other DO(s), with the purpose to change the status of that other DO(s). The engagement contains only the characteristics of the action, not the resulting status of the affected DO(s), the resulting status has to be determined based on these engagement parameters.

Examples:
- Direct or indirect fire from a shooter to a target;
- The explosion of a mine, possibly affecting the status of DOs in its influence sphere;
- Medical treatment of a medic on an injured person;
- A repair action by a maintenance engineer on a damaged vehicle.

### 6.3.2 E2 – Training system status change (Control training system status → Sense)

This interface controls the technical status of a DO, enabling its functioning in the training environment. Through this interface it is possible that a DO is initialised, reset, calibrated, etc. It also accommodates the distribution of an (altered) terrain representation or damage models for systems that require this data at decentralised nodes, for example in each DO for determination of engagement effects.

Examples:
- Initialization of equipment;
- Calibration of equipment.

### 6.3.3 E3 – DO Status change (Control Dynamic Object status → Sense)

Through this interface the (simulated) operational status of a DO is set. It contains the new status of the affected DO. This interface implements:

- A direct action of an O/C, for example a reset;
- Distributing the outcome of an engagement that is centrally evaluated (typically in EXCON). In this case a DO is not provided with the engagement parameters to determine the outcome (that is E1), but only with the resulting status. This interface is required for those Geo Pairing and other training systems that centrally evaluate engagements and change affected DO’s statusses.

Examples:
- Artillery fire simulation, effecting one or multiple DO’s.
- CBRNe effects in a certain area.
- Players are reset when entering a designated area (configuration area’s).

 

### 6.3.4 E4 – DO Reporting (Report status → Capture Data)

A dynamic object reports its (change of) status through this interface to the rest of the world. The status contains for example:

- Operational status, location, supplies, engaging or being engaged, etc.;
- This interface exists in different physical domains, for example:
- The communication of the status to EXCON (typically radio communication);
- The communication of the status to players, including visual presentations (smoke, lights) or sounds (explosion).

Remark: the interfaces to trigger the physical devices (for example pyrotechnics when shooting or being hit) are considered internal interfaces.

### 6.3.5 E5 – EXCON Communication (Use EXCON Communication ↔ Use EXCON communication)

This interface enables the communication between training staff members of different systems operating in the same exercise. It covers:

- Voice radio communication;
- Exchange of for example electronic notes, pictures, video.

### 6.3.6 E6 – Receive C4I Data (Use C4I (capture) → Capture Data)

This interface transfers data from C4I systems to a UCATT training system. This includes Battlefield Management System functionality such as a report from a scout that he has detected an enemy vehicle or a graphical sketch showing the situation. This data can be stored in the training system for analyses purposes and can be used during AAR. Existing standards, like the SISO approved Coalition-Battle Management Language or the MIP JC3IEDM standard are being considered as eligible candidates.

Examples:

- Capturing reports of enemy dispositions through a Battlefield Management System (BMS).
- Capturing overlays, messages, etc.

### 6.3.7 E7 – Send C4I Data (Use C4I (manage) ← Manage data)

This interface transfers data from a training system to C4I systems.

For example, an operational overlay created by the training staff and used in EXCON can be distributed to the C4I systems of the troops that are training. It could also be possible that the training system provides status information of (simulated) entities (either “live” dynamic objects or “virtual” players) to the C4I systems.

Examples:

- Cyber warfare injects (e.g., wrong position data);
- Transfer of overlays from training staff to training audience;
- “Synthetic wrapping”

### 6.3.8 E8 – Event Data exchange (External systems ↔ Manage Data)

This interface enables the exchange of data between systems, which can influence the course of the training session and generally has a dynamic, time critical character. Examples of event data exchange are (updates of) status of DOs and the creation of a minefield in System A, which is communicated to System B. IEEE 1516-2010 High Level Architecture (HLA), possibly in combination with the SISO approved RPR-FOM are considered to be eligible candidates for this interface.

Examples:

- Connection to a (NATO) distributed training network;
- Exporting CTC position data to a virtual UAV.

#### 6.3.9 E9 – DO Association and pairing (Report Status → Sense)

This interface enables the logical linking of objects in the training environment, this includes linking of DOs amongst each other (DO association) and linking equipment that is not modelled as a DO with DOs (equipment pairing).

Examples:

- Personnel mounting and dismounting vehicles;
- Personnel or vehicles entering or leaving (parts of) buildings;
- Personnel picking up weapons.

#### 6.3.10 E10 – Exchange platform data (Platform management → Engage)

This interface enables the exchange of data between the training system and computers (such as the fire control system or platform management system) of the instrumented real systems. This is a bidirectional interface. Data exchange from the platform to the training system is used to enable or influence the behaviour and the engagements of the DO in the training environment.

Examples are selected ammunition type, dynamic lead, environmental parameters and relevant vehicle parameters.

Data exchange from the training system to the platform is used to influence the behaviour of the real platform, for example providing the platform with target distance information delivered from the training system in case of a laser based training system, visualising tracers and fall of shot in the visual sensors or adding sounds to the communication systems (e.g., explosions, messages for training purposes).

Examples:

- Usage of ballistic tables for trajectory calculation;
- Usage and logging of fire modes used by the gunner;
- Dynamic lead;
- Environmental parameters.

#### 6.3.11 E11 – Reference data exchange (Store data ↔ Manage Data)

This interface enables the exchange of data that is generally used for reference purposes, e.g. the transfer from System A to System B of an ORBAT definition, damage model definitions, geospatial (terrain) data such as the layout of a building composed of separate walls, a created scenario or a recorded exercise. It generally contains non-time critical information and is therefore used mostly prior to an exercise, but it can be used during the execution of an exercise. Existing standards, like the SISO approved Military Scenario Definition Language (MSDL) standard are being considered as eligible candidates.

Examples:

- ORBAT definition and input;
- Geospatial data;
- Weather data;
- Input of the layout of buildings.

## 6.4 Considerations Regarding the Functional Architecture

Special care has been taken in the definition of the architecture to allow for different implementations. For example, an engagement between a shooter and a target can be modelled in two different ways:

- Distributed solution – The shooter (DO1) engages the target (DO2). Subsequently, the target senses this engagement through its “sense” capability and activates its “determine effect” capability. The resulting change of status is then reported.
- Centralized solution – If the “Determine effect” capability does not reside locally in a DO, the result of engagements is determined centrally in the capability “Control dynamic object status”. A possible dataflow can then be: an engagement is sensed and the characteristics of the engagement are captured and through “Manage data” provided to “Control dynamic object status. That capability determines the effects of the engagement and subsequently provides the results to the target. The target senses the command to change its status, performs the status change and reports its new status, so other components of the system are aware of this.

It is also envisioned that a weapon can be modelled as a DO. In that case it should also be possible to transfer such a weapon to another operator (also a DO), possibly applying restrictions regarding the pairing of the type of operator and the type of weapon. Because in this situation the weapon has its own “Sense” capability, it is possible to damage or destroy the weapon without affecting the operator or that killing the operator affects the operational status of the weapon.

# 7 Physical Interfaces

This chapter presents the most common physical architecture of a combat training centre and the relation between functional interfaces and physical interfaces.

The physical architecture that is presented here is just an example of implementation. Each arrow in the diagram represents a physical interface.

 

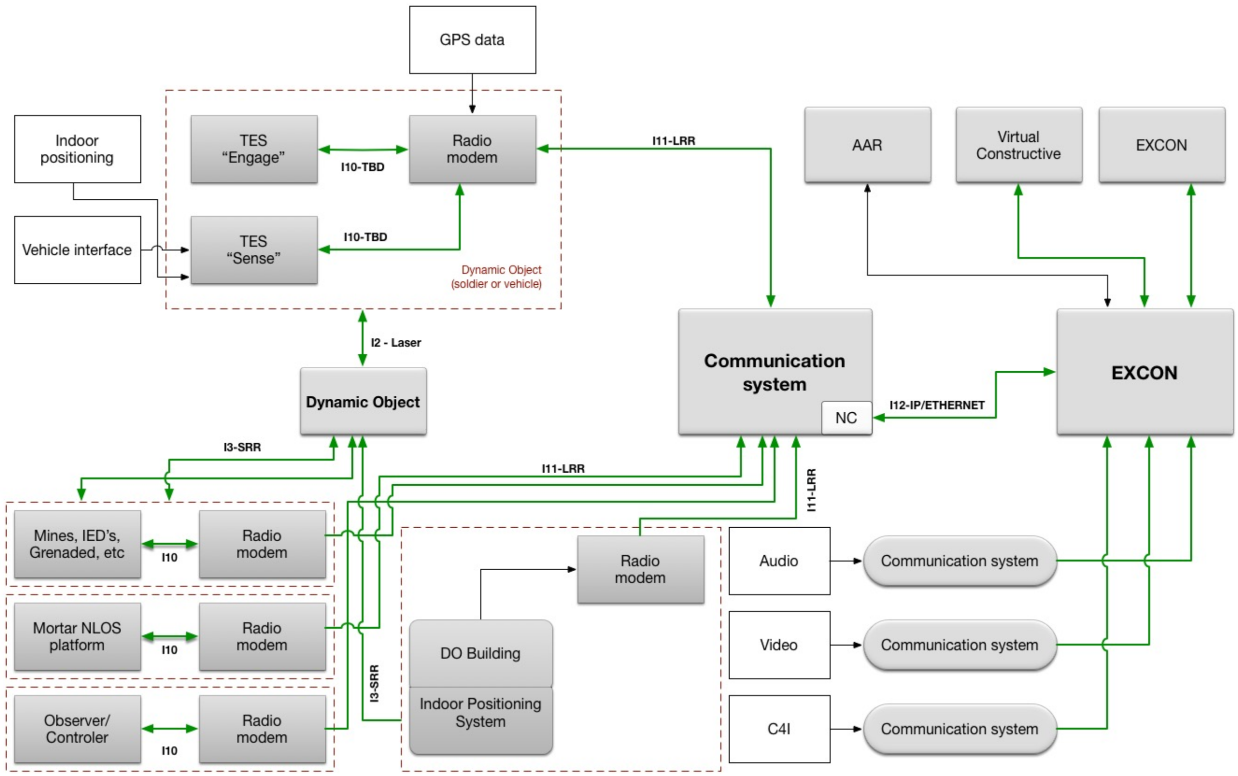


**Figure 3: Example of a physical architecture**

## 7.1 From Functional To Physical

When going into the physical layer of interfaces in a system, functional interfaces (E's) are implemented by physical interfaces (I's). The aim of the UCATT group is to define and standardize a set of physical interfaces to allow interoperability between systems in the live simulation domain.

The links between functional and physical interfaces are summarized in the following matrix.

A physical interface may be found in several functional interfaces. For example, the laser interface (I2) is used for direct engagement simulation (E1), DO technical or operational status control by the Observer/Controller using an umpire gun (E2 and E3) and for indoor positioning (E3).

**Table 2 : Functional to physical matrix**

| | | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 | E11 | E12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I1 | Long range radio DO to DO | X | | | | | | | | | | | |
| I2 | Laser | X | X | X | | | | | | | | | |
| I3 | Short range radio | X | | | | | | | | | | | |
| I4 | IR- Short Range | | | | | | | | | | | | |
| I5 | Reserved | | | | | | | | | | | | |
| I6 | Reserved | | | | | | | | | | | | |
| I7 | Reserved | | | | | | | | | | | | |
| I8 | EXCON to EXCON | | | | | | | | X | | | | |
| I9 | Fire Control unit interface | | | | | | | | | | | | |
| I10 | Serial interface between TES and Radio modem | | X | X | X | | | | | | | | |
| I11 | Long Range Radio – DO / EXCON | | X | X | X | | | | | | | | |
| I12 | Ethernet – NC to EXCON | | | | X | | | | | | | | |

### 7.1.1 I1 - Long Range Radio (LRR) interface – DO to DO

The I1 interface is a long range radio interface (generally 0 to 10 km) used to transmit data and command between two dynamics objects in the field without requiring EXCON services.

This communication can be broadcast (One DO to multiple DO) or point-to-point (One DO to one DO) communication.

Examples:

- This interface can be used to simulate indirect engagement without using EXCON services.

In such an engagement the engaging DO needs to know the location and the address of the target DO or the engaging DO transmits, in broadcast, to each DO the position of the projectile in “real time”.

### 7.1.2 I2 – Optical Laser interface

The I2 interface is a laser interface used to transmit data and command between two dynamic objects in the field.

I2 is mainly used for direct fire simulation (E1), but is also often used for O/C action (E2 and E3) or indoor positioning (E3).

### 7.1.3 I3 - Short range radio (SRR) interface

The I3 short-range radio interface can be used to simulate short range (0 to 100 m) area weapon system such as grenades, mines or IED.

The short-range radio interface currently implemented on the existing products is either based on radio standards such as Bluetooth, Zigbee or with proprietary radio.

### 7.1.4 I4 - Infra Red

The I4 Infra red interface may be used to communicate data or command between a DO and a peripheral device (e.g., medical treatment PDA).

### 7.1.5 I5 – Reserved

*Reserved for future use.*

### 7.1.6 I6 - Reserved

*Reserved for future use.*

### 7.1.7 I7 – Reserved

*Reserved for future use.*

### 7.1.8 I8 – EXCON to EXCON

I8 is the physical interface used to communicate between two EXCONs. In most cases, Ethernet is used for this interface with an application protocol that is often DIS or HLA.

### 7.1.9 I9 – Fire Control unit interface

Interface between the TES and the firing control unit, enabling exchange of data from or to the actual platform.

Example:

- CAN bus , Ethernet, 1553

### 7.1.10 I10 - TES to radio modem interface

The I10 interface is the link between the TES and the radio modem. It is used to exchange tactical and technical status, commands and events (fire event, target event) between DO and EXCON.

In the existing products, this interface is usually made with a serial link such as RS232, CAN bus or USB.

### 7.1.11 I11 - Long Range Radio – DO & EXCON

The I11 interface is a long range radio (LRR) interface (generally < 10 km) used to transmit report events (fire event, target event) from DO to EXCON and tactical and operational command from EXCON to DO.

In the existing CTC’s, the interfaces used are for example: TETRA, 4G or more often a proprietary radio system.

### 7.1.12 I12 - Network Controller to EXCON

The I12 interface is the link between the Network Controller and the EXCON.

In most cases, Ethernet is used for this interface with an application protocol (layer 7 of OSI model) that could be DIS or HLA.

# 8 OSI 7 Layer Model

The OSI (Open System Interconnection) model defines a networking framework to implement protocols in seven layers. Control is passed from one layer to the next, starting at the application layer in one station, and proceeding to the bottom layer, over the channel to the next station and back up the hierarchy.

The OSI model is a conceptual framework made to understand complex interactions that are happening. The OSI model takes the task of internetworking and divides that up into what is referred to as a vertical stack that consists of the seven following layers defined in sub-sections below. To achieve full interoperability in a joint and combined military training environment, CTC interface standards need to consider all layers of the OSI model.

## 8.1 Physical (Layer 1)

This layer conveys the bit stream - electrical impulse, light or radio signal -- through the network at the electrical and mechanical level. It provides the hardware means of sending and receiving data on a carrier, including defining cables, cards and physical aspects. Ethernet, RS232, and USB are protocols with physical layer components.

Layer 1 Physical examples include Ethernet, FDDI, B8ZS, V.35, V.24, RJ45.

## 8.2 Data Link (Layer 2)

At this layer, data packets are encoded and decoded into bits. It furnishes transmission protocol knowledge and management and handles errors in the physical layer, flow control and frame synchronization. The data link layer is divided into two sub layers: The Media Access Control (MAC) layer and the Logical Link Control (LLC) layer. The MAC sub layer controls how a computer on the network gains access to the data and permission to transmit it. The LLC layer controls frame synchronization, flow control and error checking.

Layer 2 Data Link examples include PPP, FDDI, ATM, IEEE 802.5/ 802.2, IEEE 802.3/802.2, HDLC, Frame Relay,

## 8.3 Network (Layer 3)

This layer provides switching and routing technologies, creating logical paths, known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

Layer 3 Network examples include AppleTalk DDP, IP, IPX.

## 8.4 Transport (Layer 4)

This layer provides transparent transfer of data between end systems, or hosts, and is responsible for end-to-end error recovery and flow control. It ensures complete data transfer.
Layer 4 Transport examples include SPX, TCP, UDP.

## 8.5 Session (Layer 5)

This layer establishes, manages and terminates connections between applications. The session layer sets up, coordinates, and terminates conversations, exchanges, and dialogues between the applications at each end. It deals with session and connection coordination.

Layer 5 Session examples include NFS, NetBios names, RPC, SQL.

### 8.6 Presentation (Layer 6)

This layer provides independence from differences in data representation (e.g., encryption) by translating from application to network format, and vice versa. The presentation layer works to transform data into the form that the application layer can accept. This layer formats and encrypts data to be sent across a network, providing freedom from compatibility problems. It is sometimes called the syntax layer.

Layer 6 Presentation examples include encryption, ASCII, EBCDIC, TIFF, GIF, PICT, JPEG, MPEG, MIDI.

### 8.7 Application (Layer 7)

This layer supports application and end-user processes. Communication partners are identified, quality of service is identified, user authentication and privacy are considered, and any constraints on data syntax are identified. Everything at this layer is application-specific. This layer provides application services for file transfers, e-mail, and other network software services. Telnet and FTP are applications that exist entirely in the application level. Tiered application architectures are part of this layer. Layer 7 Application examples include WWW browsers, NFS, SNMP, Telnet, HTTP, FTP.

**Table 3: OSI 7 layer model**

| Group | # | Layer Name | Key Responsibilities | Data Type Handled | Scope | Common Protocols and Technologies |
|---|---|---|---|---|---|---|
| **Lower Layers** | **1** | **Physical** | Encoding and Signaling; Physical Data Transmission; Hardware Specifications; Topology and Design | Bits | Electrical or light signals sent between local devices | USB, Ethernet, RS 232, CAN |
| | **2** | **Data Link** | Logical Link Control; Media Access Control; Data Framing; Addressing; Error Detection and Handling; Defining Requirements of Physical Layer | Frames | Low-level data messages between local devices | IEEE 802.2 LLC, Ethernet Family; Token Ring; FDDI and CDDI; IEEE 802.11 (WLAN, Wi-Fi); HomePNA; HomeRF; ATM; SLIP and PPP |
| | **3** | **Network** | Logical Addressing; Routing; Datagram Encapsulation; Fragmentation and Reassembly; Error Handling and Diagnostics | Datagrams / Packets | Messages between local or remote devices | IP; IPv6; IP NAT; IPsec; Mobile IP; ICMP; IPX; DLC; PLP; Routing protocols such as RIP and BGP |
| | **4** | **Transport** | Process-Level Addressing; Multiplexing/ Demultiplexing; Connections; Segmentation and Reassembly; Acknowledgments and Retransmissions; Flow Control | Datagrams / Segments | Communication between software processes | TCP and UDP; SPX; NetBEUI/NBF |

| Group | # | Layer Name | Key Responsibilities | Data Type Handled | Scope | Common Protocols and Technologies |
|---|---|---|---|---|---|---|
| **Upper Layers** | **5** | **Session** | Session Establishment, Management and Termination | Sessions | Sessions between local or remote devices | NetBIOS, Sockets, Named Pipes, RPC |
| | **6** | **Presentation** | Data Translation; Compression and Encryption | Encoded User Data | Application data representatio ns | SSL; Shells and Redirectors; MIME |
| | **7** | **Application** | User Application Services | User Data | Application data | DNS; NFS; BOOTP; DHCP; SNMP; RMON; FTP; TFTP; SMTP; POP3; IMAP; NNTP; HTTP; Telnet |