Abstract:
This paper describes the content of an e-training course on satellite communications prepared under contract to ESA and now available at the ESA Telecom User Support Office website. The contract to develop this online training was led by EADS Fleximage with significant contributions from a team of subcontractors including EADS Astrium, British Telecom Exact Technologies, ENSAE/SUP’Aéro and ISU. The course is divided into five modules covering the following areas in an animated and progressive way:

- Systems and Services
- Communication Link
- Networking
- Space Segment
- Earth Segment.

Trainees have the possibility to choose their own level of training and to evaluate their knowledge through a series of exercises. Completing the entire course requires a total of around ten to fifteen hours online time. The paper focuses on the goals in terms of learning objectives and target users, as well as the content in terms of the main modules of the course and their scope and depth. Small-to-medium enterprises (SMEs) wishing to work with ESA in their ARTES-3 programme form a key target audience for this training material that will also prove useful as a complement to traditional satellite communications courses in academic institutions.
1. Introduction and Background

The work described in this paper was funded by the European Space Agency (ESA) as part of its Telecom Programme. ESA Telecom's activities are focused on areas where a strategic lead in research and development will provide most benefit. Input from many sources is collated and analysed in order to decide where this focus should be. The programme is divided into elements according to a framework called ARTES (Advanced Research in Telecommunications Systems) which is a set of legal and financial frames that allow the implementation of research and development activities with different degrees of technical and commercial maturity. ARTES activities range from market studies and competitiveness analyses to full system development and technology led activities. Table 1 illustrates the relationship between ESA’s programme lines and the ARTES elements reflecting the evolution into a pragmatic and topic-related approach.

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Table 1: Relationship Between ESA Telecom’s Programme Lines and ARTES Elements

The ‘User Segment’ programme line promotes near-to-market development activities in the area of satellite communications that have a direct impact on the user community. ESA’s User Support Office (USO) provides instruments and facilities to support start-up entrepreneurial initiatives to flourish in the space telecommunication business. It provides help with promotion, online information and training on how to work with ESA and a support environment that gives access to information and technical resources. ESA issued an Invitation to Tender (ITT) for development of an ‘e-Training System for ARTES Users’ in mid-2002. A Kick-off Meeting with the successful team of contractors was held in Jan 2003 and most of the work involved in developing the course was completed in the following fifteen months. The course itself went online at the ESA USO website (http://telecom.esa.int/wbts/wbts/index.htm) in Spring 2004 and is free of charge.

2. Objectives of the e-Training Project

The following paragraphs concerning the main objectives of the e-Training Project are based on ESA’s ITT for ‘e-Training System for ARTES Users’ (AO/1-4242/02/NL/US, 27/5/2002):

Satellite communications are more and more an integral part of end-to-end content delivery systems and new entrants have become increasingly involved in the satcom domain in recent years. ESA has recognized this emerging approach to business as an important means to promote the uptake of a competitive market in satcom applications and services in ARTES 3 programme. New entrants are expected to deal with professional organisations in the satcom sector, to take
decisions on options, and to understand operational issues that require some knowledge of this sector. They often find it difficult to gain familiarity with basic satcom concepts and terminology and this lack of understanding can have a detrimental effect on decision-making when technical options are at stake. In addition, during the utilisation phase, the lack of a basic understanding of all the issues can generate misinterpretations and difficulties of communication with satcom professionals preventing the smooth deployment of operational services. Besides the problems of entering the satcom world, new entrants often experience difficulties in engaging in ARTES programme due to the perceived high barriers presented by ESA’s procedures and practices.

On the basis of the above considerations, ESA’s Telecom Department decided to increase their efforts, particularly in support of small-to-medium enterprises (SMEs), through a specific initiative named the User Support Office (USO). The USO offers a suite of services to promote, ease and assist the work of the ARTES contractors and partners to gain access to the space telecommunications business. The provision of a training course based on advanced multimedia educational techniques represents one of the basic foundation elements of the USO.

EADS-Fleximage, EADS-Astrium, both of France, ENSAE/SUP’Aéro in Toulouse, British Telecom Exact Technologies from the UK and the International Space University (ISU) in Strasbourg, France worked together under ESA funding and management to develop the system (total contract value of 500 Keuro). The main roles of the participants are shown in Table 2.

3. A Summary of the Training Modules

The end products from the development contract summarized above are Web-Based Training Systems (WBTS) on ‘Working with ESA’ and ‘Satcom Technology’. An online Help Centre included in the tool describes the different functionalities of the WBTS, including a User Manual, a guided tour of the WBTS and answers to Frequently Asked Questions.

The 'Working with ESA Telecom' training includes information on ESA Telecom Initiatives, General Clauses, Contract Conditions, how to register as an ESA bidder, etc. This module makes use of a ‘voice-over’ facility and differs from the Satcom Training in two other respects: there are no different user levels and no exercises for the user to test his knowledge.

The Satcom Training provides an introduction to the fields of satellites and telecommunications and is divided into five major modules, each offered at three levels. The user can select the preferred path and each level builds on a lower level by providing additional detail. The trainee is free to select any activity and any group of elements within that activity, including the advanced elements, offering the flexibility to allow the trainee to tailor the learning to his/her needs.

- **Basic level** – this is aimed at non-technical staff with little or no experience within the satellite communication industry. It provides a learning tool for sales, marketing, managerial or administrative staff requiring an introductory insight into communication satellites usage.

- **Intermediate level** – designed for technical staff without experience in the satcom field. This corresponds to technical staff new to the satellite industry, for example an IT engineer requiring a more in-depth appreciation of the associated technology. A basic scientific background in mathematics and physics is assumed as obtained after 2-3 years undergraduate education at polytechnic or technical college.

- **Advanced level** – aimed at technical staff with working experience in the satcom field. This corresponds to graduate engineers who are interested in acquiring knowledge in satellite communications. The required education is an academic qualification at the level of a
Masters degree or equivalent in Electrical Engineering or Computer Science with a major in communications, or appropriate professional experience in one of these fields.

The User Support Office (http://telecom.esa.int/telecom/www/area/index.cfm?fareaid=29) originated the idea for the training programme, wrote the Statement of Work, managed the contract on behalf of the Agency and now acts as host for the WBTS. For further information about USO activities contact the Programme Development Officer Andrea.Cotellessa@esa.int

FLEXIMAGE (http://www.fleximage.fr/)
The Management & Technical team involving Web Designers, Web Programmers & Online Training Experts were responsible for:
- Management of the project through direct interface with ESA
- Development of the Content Management System (CMS) and the Web Based Training System (WBTS)
- Design and creation of the "Working with ESA Telecom" storyboards
- e-learning expertise for all the contents
- Production of all the multimedia content of "Working with ESA Telecom" and "SATCOM Technology" courses.
- Maintenance of the e-learning system and contents (for an 18 month period after delivery of the e-Training system).

For further information about EADS-Fleximage work in this e-training project contact dominique.medal@fleximage.fr or luisa.picornell@fleximage.fr

ASTRIUM (http://www.space.eads.net/)
Author of SATCOM Technology storyboards for
- Systems & Services
- (Parts of) Communication Link
- Space Segment
- Networking

ASTRIUM Space School (http://www.jobsatastrium.com/html/tnd.htm)
- General pedagogical validation

SUPAERO/ENSAE (http://www.supaero.fr/)
Expertise & pedagogical validation of:
- Systems & Services
- Communication Link
- Space Segment
- Networking

British TELECOM Exact Technologies (http://www.btxact.bt.com/)
Author of SATCOM Technology storyboards for
- (Parts of) Communication Link
- Earth Segment
Table 2: Project Responsibilities of the Team Responsible for the e-Training System

4. Further Description of the Content of the Training Modules

Here we simply list the main content of the ‘Working with ESA Telecom’ training because, though very useful, it is not so relevant to readers of the Online Journal of Space Communications. Furthermore, the user needs only about 2 hours typically to work through ‘Working with ESA Telecom’, compared to around 10 – 15 hours needed for ‘Satcom Training’, depending on the trainee’s experience and the level of the path. The main subjects covered are:

- ESA Telecom Initiatives
- General Clauses and Contract Conditions
- Structure of a Tender
- Submission of a Proposal
- Management, Financial and Administrative Proposal
- Forms for Cost and Planning Data (PSS A) Forms: Simulation Exercises
- Proposal Evaluation and Contract Award

The ‘Satcom Training’ is broken down into five modules as follows:

- Systems and Services  ) Each of these modules requires around 2 – 3 hours to complete
- Communication Link  ) depending on the trainee’s experience and the level of training
- Networking  ) chosen (basic, intermediate, advanced). Modules may also be
- Space Segment  ) divided into a few distinct sub-modules e.g. ‘Space Segment’ is
- Earth Segment.  ) split into 3 sub-modules: Spacecraft, Comms payload, Antenna.

Each of these five modules, or the sub-modules within them, are progressively broken down into ‘activities’ and ‘elements’ as defined below together with other terms used in the WBTS.

‘Activities’ are sets of ‘elements’ linked within a common technical subject heading. For example, the ‘Systems and Services’ module is broken down into five activities:

- Introduction to Telecommunication Satellites
- Satellite System Architecture
- Orbits
- Frequency Bands and Regulatory Issues
- GEO Satellites over Europe

An ‘element’ is the lowest level in the hierarchy and includes all the contents of the learning material that appears on-screen at any moment or that can be directly accessed from the screen in question e.g. by clicking on an icon. Each element is normally made up of text in the right-hand half of the middle frame of the WBTS screen, and accompanying illustrations or animations on the left. Upper and lower frames include ‘help’ buttons, navigation bar, etc.

On average there are around 6 elements in an activity, each requiring of the order of 2 minutes to complete, but the number may vary from only a very few to more than 10 depending on what is needed for a clear explanation and proper understanding of the subject. As an example the
'Introduction to Telecommunication Satellites’ activity in the above list is made up of these 12 elements:

1. Radio Communications
2. Radio Frequency Bands
3. Satellite Communications
4. System Architecture
5. Type of Orbits
6. Telecom Applications
7. Internet via Satellite
8. Satellite Mobile Communications
9. Assets
10. Limitations
11. Satellite Communication Evolution
12. Terminal and Platform Size

‘Media’ is the term used to describe the graphical representation of a concept, and each element may have up to five Multi-Media Items (MMIs) of different types, each accessible by clicking on a clearly recognizable icon. The main types of MMI include:

- Illustrations or photographs, these being static items
- Video or linear animations (with progression bar and play/pause buttons)
- Interactive animations including instructions explaining what the user must do.

Further explanation of the screen content can be obtained in some elements by rolling the cursor over a highlighted part of a diagram or by clicking on the title of a ‘linked’ document.

A set of ‘exercises’ is provided at the end of each ‘activity’, generally taking the form of multiple-choice questions in which the score is recorded as a measure of the trainee’s level of understanding of the preceding elements. Trainees may also use this self-assessment as a ‘pre-test’ to define their level of knowledge in deciding which training path to follow.

To illustrate the terms defined above the decomposition one of the five main modules down through its sub-modules and activities to the individual element level is shown in Table 3. The on-screen appearance of the WBTS is shown in Figure 1. As an example the element describing ‘Satcom Evolution’ in the Spacecraft Overview activity of the Space Segment module is shown together with associated features in the surrounding frame (help button, etc).

5. Concluding Remarks about the Development and Use of the Training

From the above descriptions it is clear that this online course aims to provide practical information responding most directly to users’ needs in the SME community, as opposed to strictly academic instruction. Nonetheless the content of the Satcom Training is a useful supplement to course material taught at bachelors and masters level especially in the ‘advanced’ level of the training path. In developing the content a mix of skills has been applied - coming from within the Agency, from industry and from academic institutions – and this has helped to ensure that both the practical and the pedagogical aims are met.

The prime contractor EADS-Fleximage was already well experienced in the development of e-training programmes. However, for most other participants, the steps involved from initial decomposition through the subsequent preparation, production and validation of text, exercises, illustrations and animations, were fairly new experiences. Anyone entering this field for the first time should be warned that the development of e-training is a very labour-intensive and time-
This was particularly true for the Satcom Training where the range of topics, the total number of elements and their depth, as well as the desired high quality and consistency of the end product, resulted in the need for a team of several contributing experts, each skilled in particular areas.

As far as the use is concerned this is best experienced directly by going online and sampling the course at [http://telecom.esa.int/wbts/wbts/index.htm](http://telecom.esa.int/wbts/wbts/index.htm). The popularity of the WBTS varies depending on the parallel promotion activities among other factors. However, it can be said that on average each month there are 300-400 unique visitors and around 10,000 page views. Considering that the ESA Telecom website has a very narrow target audience, this is a very good result. In presenting this paper at Forum ISSAT 2004, and in a demonstration in the poster session, a brief outline will be given of the main features (see Figure 1) including:

- **“What is What?”** - briefly describing each different section of the WBTS
- **“Getting Started”** - a guided tour describing different functions and how to use them.
- **FAQ** - listing all frequently asked questions about the WBST functioning.
- **User Manual** - describing the WBTS, its interfaces and functionalities.

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<tr>
<th>Sub-Module Level</th>
<th>Activity Level</th>
<th>Element (or Exercise) Level</th>
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<td>Spacecraft and its Subsystems</td>
<td>Spacecraft Overview</td>
<td>Payload and Platform Evolution (see Figure 1) <em>Spacecraft Overview Exercise</em></td>
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<td>Telemetry, Tracking &amp; Command</td>
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|                               | *Transponder Exercise*  
| Spacecraft Antenna | Antenna Overview  
|                               | Antenna Subsystem Overview  
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| Coverage Contour | Coverage Definition  
|                               | *Coverage Exercise*  
| Antenna Technology | Feed Elements Overview  
|                               | Reflectors: Sizing and Geometry  
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Table 3: ‘Space Segment’ Module Decomposition to Element Level