THE PIONEERING OF E-LEARNING IN MEDICAL PHYSICS

THE DEVELOPMENT OF E-BOOKS, IMAGE DATABASES, DICTIONARY AND ENCYCLOPAEDIA

S. TABAKOV, V. TABAKOVA

LONDON 2015

The Pioneering of e-Learning

in Medical Physics

(The development of e-Books, Image Databases, Dictionary and Encyclopaedia)

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This book, describing a 20-year long sequence of international
Medical Physics e-learning projects, Dictionary and Encyclopaedia,
is dedicated to all colleagues, sponsors and friends (included in the book),
who contributed to the pioneering work of these projects and supported their results.

The Pioneering of e-Learning in Medical Physics *(The development of e-Books, Image Databases, Dictionary and Encyclopaedia)* describes a chronology of 7 EU-funded international projects (1994-2014) which are among the first to develop and introduce original e-learning in the teaching process.

The first described project, developed before the existence of the terms e-learning and e-books, created some of the world's first ISBN-numbered electronic Image Databases (on CD-ROM) and e-books. The projects also developed the first Medical Physics Multilingual Dictionary of Terms (in 29 languages) and a professional Encyclopaedia - both supported by the International Organization for Medical Physics (IOMP) and currently used by thousands of specialists worldwide through the web portal: www.emitel2.eu.

The book shows the development of the ideas/concepts; their implementation into practice (in medical physics); the challenges and successes of the international project team. The book also includes description of the methodology used by the team to develop Multilingual Dictionary and develop/organise an Encyclopaedia.

The description of our practical experience and path of development of these original e-learning materials can be of use to a broad range of specialists.

We gratefully acknowledge the contribution in copy-editing to Sonia Rouve-Uvalieva and in pre-print preparation to Magdalena Stoeva and AM Studio.

S Tabakov, V Tabakova,

London, 2015

CONTENT

Foreword

The period 1990-2010 was very important for education and training in medical physics and for the international growth of the profession. The developments during these two decades naturally followed the innovations in medical technology during the previous two decades (1970s and 80s) when many new types of medical equipment were introduced in healthcare – e.g. Diagnostic Ultrasound, Computed Tomography, Single Photon Emission Tomography, Positron Emission Tomography, Magnetic Resonance Imaging, Electronic Portal Imaging, various Digital imaging detectors, etc. The workforce of medical physicists, dealing with the safe and effective medical use of this equipment, needed new forms of expanded education and specialised practical training. The oldest and most advanced medical physics societies – the UK Institute of Physical Sciences in Medicine (IPSM, currently IPEM – Institute of Physics and Engineering in Medicine) and the USA American Association of Physicists in Medicine (AAPM) developed specific guides for medical physics curricula and training/residency programmes. At the beginning of the 1990s these became firmly embedded in the education and training systems of both countries and were used as examples by other medical physics societies. However many of these other societies had not yet established their own education and training systems. At the same time, as per the data from the International Organization for Medical Physics (IOMP) the number of medical physicists was growing, and together with it – the need for international guides for education and training.

By the beginning of the 1970s IOMP (the federative organisation of medical physics societies worldwide, established in 1963) had 10 National Medical Physics Societies members with approximately 8,000 medical physicists. At the beginning of the 1980s these numbers grew to 28 member societies (c. 10,000 medical physicists) and at the beginning of the 1990s the numbers further increased to 44 member societies (c. 12,000 medical physicists worldwide). The largest Regional Organisation of IOMP – the European Federation of Organisations for Medical Physics (EFOMP) issued useful statistics for the need of medical physicists in various fields of the profession, as well as recommendations for education and training in Europe. EFOMP was formed in 1980 and by the beginning of 1990s included about half of the IOMP societies with c. 5,000 medical physicists. The majority of these professionals were from the UK and naturally the recommendations were following the experience of the IPSM.

While guidelines existed, a specific problem at this time was the lack of teaching materials and textbooks to support the need for expansion of medical physics education and training. Also, studying this medical technology was related to its practical use, but very limited time was available for training, as the medical equipment is used intensively for diagnostic and therapeutic purposes. Finally, the dynamic development of the profession needed equally fast and flexible methods for development of such materials. At that time the customary printed media involved a significant period between the development of the materials and their paper print. The answer to these challenges was in the use of IT technology (and later Internet) for quick development and dissemination of effective teaching/training materials.

On this background our project team of specialists with considerable teaching/training experience took on the task of developing the first e-learning materials in medical physics. At the same time the team did not follow other e-learning examples, as there were no publications with practical methods and steps for development of e-learning materials, or e-Encyclopaedias. This is how we solved the task through a sequence of 7 fully original projects (4 on e-learning and 3 with other related educational activities EMERALD, EMERALD II, EMIT, EMITEL, CONFERENCE, ERM, BALTIC). This book aims to give a more detailed description of this development process, its challenges and successes, as well as the testing and implementation of e-learning in the profession – an experience which could be useful to other e-learning developers and colleagues (this is consistent with the main concept of our projects - “learning through examples”). In this way the book keeps the chronology of the creation of the ideas and their development through various stages, as well as the methodology we applied for this.

Although the book has a specific scientific background and approach, it also presents an example of successful international team work. To emphasise this angle of the collaboration the book describes the comradeship and communications between the team members, all of whom worked on the projects mainly during their free time. The described projects generated more than a hundred publications and presentations, which could form a separate index, but here we have aimed to focus on the working methods, outcomes and impact of the projects.

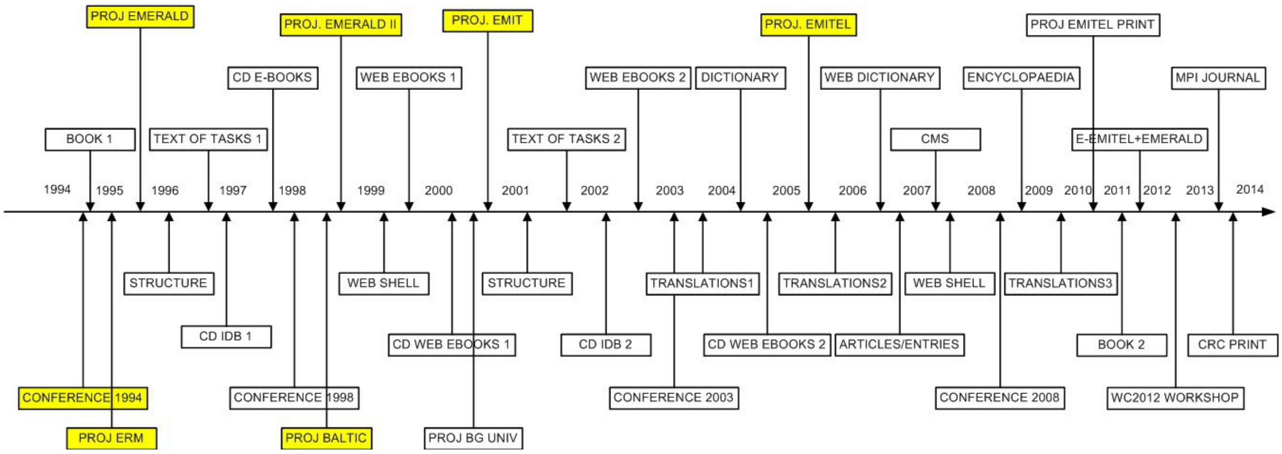
The first projects described in the book were initiated when the terms *e-learning* and *e-books* did not exist. Today these are parts of the educational process and medical physicists could be proud that the profession was one of the first in the world to develop its own original e-books and Image Databases and fully embrace e-learning. Our team of ‘pioneers’ also believed in the advantages of e-publishing and was one of the first in the world to publish Educational Image Databases CD-ROMs with ISBN numbers – i.e. as printed books.

This book describes a sequence of international educational projects (1994-2014), which developed:

- Four International Conferences on Medical Physics Education and Training

- Five textbooks (Workbooks) with training tasks in Medical Physics
- Five e-books based on the above Workbooks
- Five CD-ROMs with Image Databases for Medical Physics training
- Three Educational web sites in Medical Physics
- A Multilingual Dictionary of Medical Physics
- An on-line Encyclopaedia of Medical Physics
- A number of MSc courses in Medical Physics

In total, approximately 250 training tasks, explained in 1300 pages with 3100 images, were developed. The Multilingual Dictionary of Medical Physics cross-translates into 29 languages. The e-Encyclopaedia includes about 3000 entries/articles with some 2500 images and diagrams (a volume about 1 GB).



The timeline (chronology) of the projects described in the book (1994-2014) – start of main projects is in yellow

These e-learning materials were disseminated in more than 100 countries. Today thousands of colleagues from all over the world are regularly using the pioneering educational web sites hosting our e-learning materials (in 5 volumes), e-Encyclopaedia of Medical Physics and e-Dictionary of Medical Physics. Other colleagues and projects (also briefly described in the book) developed and presented additional e-learning materials, web sites, simulations and methods. All these, often free and highly effective teaching materials, helped enormously the global development of the profession, especially in the developing countries. As per the IOMP data, at the beginning of the year 2000 there were 72 member societies with c. 15,000 medical physicists, while at the beginning of 2010 there were 84 societies (including most of the countries in the world) with c.18,000 members (in 2015 these members are expected to be about 20,000). This presents a global growth of c.4,000 professionals per decade during the last 20 years. This significant growth was underpinned by various education and training activities, including the e-learning developed by the projects described here. The success and global impact of these projects was the reason for the inaugural award for education of the European Union – the *Leonardo da Vinci Award*, which our team received in 2004. For all members of our projects teams, and indeed for the whole profession, this high recognition was extremely important, as it was also a boost for the visibility of the importance of medical physics in contemporary healthcare. In this way the financing from the European Union (EU), which supported these e-learning projects (among many other projects in other areas), was not only fundamental for the realisation of the initiatives and ideas, it was crucial for the development of many spheres of life in Europe and beyond. In all our projects we always acknowledged gratefully this support from the EU – both financial and consultative through the programme officers.

The book also shows an example of continued success in international collaboration. The first project EMERALD, described in the book, was initiated in 1994 by a small enthusiastic team of about 15 ‘pioneers’ from UK, Sweden, Italy, Portugal, Ireland and Bulgaria, but after 10 years the final project EMITEL attracted some 300 specialists from 36 countries, making it the largest international project in the profession. Altogether, the projects described in the book attracted about 400 participants, contributors and supporters. The results achieved could not have been possible without the hard work and ideas of all these colleagues. As a sign of our gratitude and appreciation we decided to dedicate to them this book with the ‘story of the pioneering of e-learning’.

Speaking about the project team I would like to specially underline the priceless support of Prof. Colin Roberts, who was at the heart of our first projects. Nothing could have been initiated without his staunch support, his educational experience and his outstanding project management. His advice was highly valued by all project members and together we worked closely during the first 10 years of these projects. During the next 10 years, after Colin’s retirement, we worked in a similar way with Dr Cornelius Lewis, who was one of the main contributors to the Encyclopaedia project and a supporter during all this time.

Finally, although I was seen as the driving force for the development and coordination of these projects, I was helped in every step of the process by my wife and colleague Dr Vassilka (Assia) Tabakova. Without her full non-stop help I could hardly imagine the success of these projects, especially for the crucial and difficult work with the many tasks and reports we had to prepare in the course of the projects.

Slavik Tabakov, PhD, FIPEM, FHEA, FIOMP

President, International Organization for Medical Physics (June 2015 - June 2018)

1. The Medical Physics Education and Training Conference, Budapest 1994

The necessity for a pan-European forum in the field of Medical Physics & Engineering education and training was discussed on various occasions including the 5th Mediterranean Conference on Medical and Biological Engineering held in Patras, Greece (1989) and the Weimar Clinical Engineering Workshop in the former GDR (1990). During the Intra-European Workshop held in Szentendre, Hungary in May 1991 (coordinated by N Richter), it was agreed that there was considerable interest and need for future collaboration between Central/Eastern and Western European countries in the area of professional training, and activities for future collaboration were initiated. The activities started with the formation of a Network of specialists in 1993 and obtaining important political support for the future projects.

The timing was perfect, as after the fall of the Berlin Wall and the democratic changes in Eastern Europe during 1989, new opportunities for East-West European collaboration were opened. The European Union also started special programmes with projects aiming to boost this collaboration and harmonise the education and training activities throughout the whole of Europe. As a result of this a project submission was made successfully to the European Commission (EC) - CEC project CIPA 3510 - aiming to support the organisation of the *First European Conference on Education in Medical Radiation Physics* (which was in fact the first international conference on the subject). The Department of Medical Engineering and Physics at King's College London (headed by Prof. V C Roberts) was very well placed to run such a Conference – it had just been approved as a Regional Training Centre for South-East England and had recently introduced a specific MSc programme in Medical Engineering and Physics, developed especially to support practical training (using IPSM guidelines).

It was decided to hold the Conference in Budapest, Hungary – a convenient central point for colleagues from East and West Europe. The objectives of the Conference were:

- To increase East/West European co-operation in the field of Medical Physics;
- To establish the status and needs of education and training in Medical Radiation Physics in Central/Eastern European countries;

- To formulate proposals for the advancement of post-graduate education in Medical Radiation Physics and identify resource sharing initiatives;
- To consider the need for a Training Authority and a professional network in the field of Medical Physics & Engineering in Central/Eastern Europe.

The Organising Committee was set up in London with members: C Roberts, S Tabakov, C Lewis (helped also by V Tabakova and D Smith). The Local Organising Committee was set up in Budapest with members: P Zarand, N Richter, I Polgar. Very few people had emails at that time, hence most of the organisation was done with faxes.

The European Federation of the Organisations for Medical Physics (EFOMP) was also involved in the conference, the concept of which was accepted enthusiastically in almost all countries invited to participate. The delegates to the conference were senior medical physicists, each being a nominee of their European professional society and/or their University (Fig. 1.1). In total 37 Institutions, Societies and Universities from 23 European countries were represented at the Conference.

The European Conference on Post-graduate Education in Medical Radiation Physics was held in Budapest, 12-14 November 1994. It included reports about the current status of medical physics education and training in each of the presented countries and organisations. Here was also the first presentation of the European Scientific Institute in Archamps, France, which later became one of the main Schools of the EFOMP.

All reports were later included as papers in the book "*Medical Radiation Physics – A European Perspective*", editors C Roberts, S Tabakov, C Lewis, King's College London, 1995, ISBN 1 870722 02 7. The book was also published as an electronic PDF book (on a floppy disk) and distributed to most Medical Physics Societies in Europe and the world (more than 1000 copies of the book and the floppy disk were disseminated). This book triggered many new MSc-level medical physics courses in Eastern Europe. It also underpinned a number of future EC projects, including our EMERALD, ERM and Baltic projects (see chapters 2, 3 and 4). Later the experience from this Conference was used to trigger the development of medical physics education and training in Asia. As part of this further development large Workshops on the subject were organised as satellite to the World Congresses in Sydney (WC2003) and Seoul (WC2006). The reports from these Workshops were included in a further book "Medical Physics and Engineering Education and Training", editors S Tabakov, P Sprawls, A

Krisanachinda, C Lewis, ICTP Trieste, 2011, ISBN 92 95003 44 6 (also distributed in more than 1000 copies as paper book and e-book).

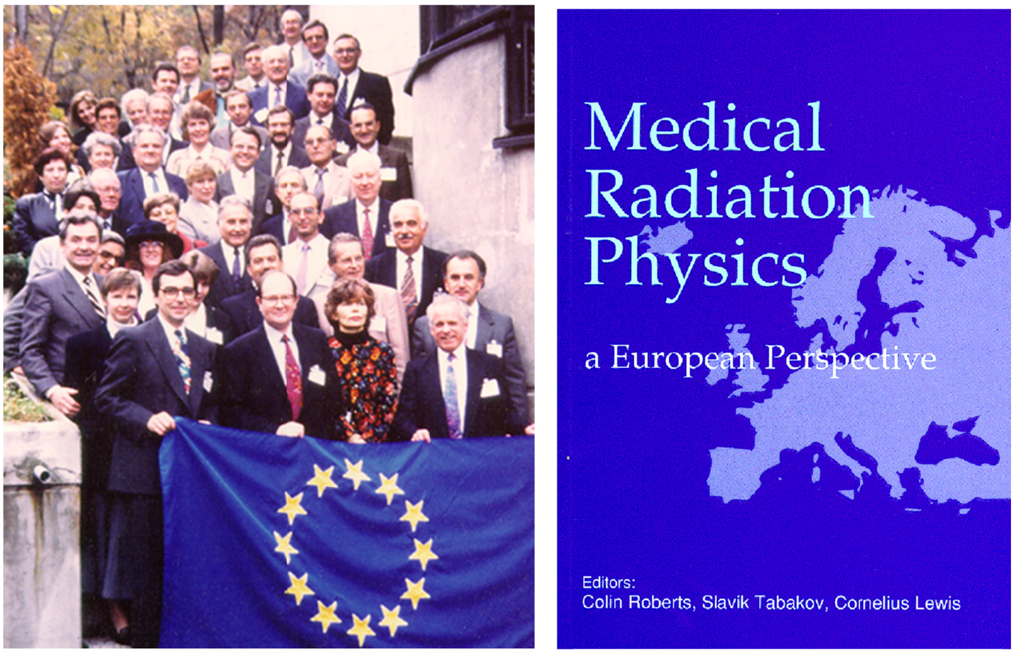


Fig. 1.1 Some of the delegates to the European Conference on Post-graduate Education in Medical Radiation Physics, held in Budapest,12-14 November 1994, and the Book after the Conference (Delegate names: S Aid, M Antoneanu, B Aubert, A Benini, Y Dekhtyar, P Frangopol, M Gershkevith, J Gomez da Silva, D Gubatova, A Karadjov, S Kovaceva, V Laginova, I-L Lamm, Y Lemoigne, C Lewis, F Milano, C Milu, M Morawska, L Musilek, A Noel, V Orel, G Pawlicki, I Polgar, B Proimos, M Ribas Morales, N Richter, C Roberts, W Seelentag, S Sherriff, N Sheahan, D Smith, S Spyrou, I Stamboliev, S Tabakov, V Tabakova, P Trindev, A Vaitkus, M Vrtar, M Wasillevska-Radwanska, H Zackova, P Zarand.)

The Budapest Conference delegates made a review of the current situation, which revealed that the main weaknesses in most of the MSc programme curricula were associated with the specific specialist topics. A weakness associated with practical training was lack of structure and uniform method for training delivery. The Conference also underlined the need of professional translation of medical physics terminology (this was realised after 10 years through our EMIT project).

It was agreed that collaboration between East/West European countries was essential for the advancement of the profession in Europe and a Declaration of Intent was signed by all delegates. The Network founded in 1993 was expanded and its first meeting was associated with the Congress of Medical Physics in Krakow, Poland (September 1995), coordinated by M Radwanska (Fig. 1.2). The Network had its own Bulletin (printed in King's College London). It was active for about 2 years and later many of its members became part of the projects described further in the book.

The Budapest Conference triggered many European projects related to Medical Physics Education and Training, the first being the projects EMERALD and ERM.

Fig. 1.2 The first workshop of the European Network on Medical Physics Education and Training at the 10th Congress of the Polish Society of Medical Physics (Krakow, September, 1995, part of the delegates).

2. EMERALD Project – the Development of the First Medical Physics e-Learning Materials

The first international conference in Budapest addressed the problems and goals of medical physics education in Europe. The delegates at this conference exchanged expertise on education, which was summed up in the book "*Medical Radiation Physics – a European Perspective*". This book triggered the establishment of a series of new educational courses in Eastern Europe and other countries. Many of these courses were established as EU-supported international projects. We also made one of the first such projects (ERM) in Plovdiv, Bulgaria.

However, another very important element of the formation of medical physicists was gaining strength at the beginning of the 1990s: practical training. The first training schemes developed by the American Association of Physicists in Medicine (AAPM) and the UK Institute of Physical Sciences in Medicine (IPSM, later Institute of Physics and Engineering in Medicine and Biology IPEMB, and now Institute of Physics and Engineering in Medicine IPEM), provided guidance for the education and training of medical physicists and engineers. The UK booklet on this subject (first published in 1993) incorporated a short list of competencies which must be met in order to satisfy requirements for corporate membership of IPSM. Since 1993 this training scheme booklet has been regularly updated and published by the Institute, providing a starting point for programmes of practical training. The MSc Medical Engineering and Physics at King's College London was one of the first MSc courses in the UK to be accredited to provide the necessary academic support for the practical training. At the time there were 4 trainees at the Department of Medical Engineering and Physics (King's College London and King's College Hospital) and their feedback was that they needed specific teaching/training materials to support their practical training.

Our strong belief was that such materials would need to include many images of equipment, phantoms, artefacts, etc – in other words what was necessary was an Educational Image Database. At that time Digital Imaging was taking its first steps in our everyday life and only a limited number of image databases existed. The first electronic materials supporting teaching were using predominantly video frames as images. The quality was not great, but was much more effective than that customary for the time: colour print of images. One such product was the *Videodisk Echocardiography Encyclopaedia* – a collaborative project of Yale University, USA and Erasmus University, the Netherlands, published in 1989. To our knowledge this was the first set of electronic teaching materials in medicine. The Echocardiography Encyclopaedia included 1200 items with short video clips, text and graphics (we have not seen/used this videodisk project and do not know if it has been released for sale). The only other electronic teaching materials in medicine, known to us at that time, were in King's College London (developed by N J D Smith in 1992) – this was the Distance Learning course on Dental Radiography, using images on *Photo CD* – the new invention of *KODAK*, using a special CD player (*Photo CD player* or *CD-i player*). The course was running successfully for several years and triggered a new web-based distance learning course (in the mid-1990s the *Photo CD* declined due to the rapid expansion of CD-ROM technology). Educational Image Databases were very few (the majority being in the field of art) and these were not easily available for personal or domestic use. Our intention was to develop something very new. There were no publications about such projects and we expected the road ahead to be difficult. At the same time we believed that this was the way of the future and that during the project development we would have more information and would gain skills to develop it.

The EMERALD Project – Introduction

A conference in Coventry, UK, during the spring of 1995, provided an excellent opportunity for the development of a project supporting medical physics training. This was the first Conference of the new EC Leonardo programme in the UK and as soon as their application materials were received we drafted a proposal for a project aiming to develop medical physics structured training timetables, training tasks and educational image database.

We sent the project proposal to some of the colleagues from the Budapest Conference with whom we had discussed the possibility for a similar activity. Although we already had emails, we posted the proposal (email exchange of large files was still not a secure way to transfer information). It was very encouraging to see the first answers – enthusiastic support from Sven-Erik Strand from the University of Lund and similar support from Franco Milano from the University of Florence. We collected the project submission documents from the other partners via exchange of faxes. We also invited as a partner the International Centre for Theoretical Physics (ICTP) and their Acting Director at the time (Prof. Luciano Bertocchi) immediately supported the idea (he was, and still is, one of the great supporters of medical physics in ICTP).

The project documents were developed with incredible speed. With Colin Roberts we included concepts from our previous industry training – namely structured training activities with indicative time for completion. However, the new elements were the electronic teaching materials that we planned to develop and introduce into practice (at that time the words *e-books* and *e-learning* did not exist and terms such as *multimedia* and *electronic materials* were used instead). The project needed a catchy name/acronym and this is how we named it EMERALD standing for “European Medical Radiation Learning Development”. The whole budget was made in ECU - the European Currency Unit, used in all EC projects at that time (not in real circulation, Fig. 2.2), later replaced with the Euro. S Tabakov also developed a logo of the project (Fig. 2.1) and submitted the application to the European Commission (EC) in June 1995 (with special EMERALD headed paper, made in one of the few places in London with colour printers).

Fig. 2.1 The EMERALD Logo from 1995, as it continues to be used today (elements of it are present in all later projects of ours).

Fig. 2.2 One ECU coin from Britain (a commemorative coin from 1995). We presented (as a souvenir) each project partner with one of these coins.

The results from the EC were expected in about 6 months, but we were determined to develop these electronic materials and started project preparations before the project approval. The first action was to buy a new computer. Typical parameters were Pentium 66 MHz (Windows 95), 16 MB RAM, 0.5 GB hard drive. Two floppy-disk slots were included to allow later a CD-ROM drive in one of these (it was extremely expensive at the time). The PC included external modem (56 kB/s), Sound card (e.g. SoundBlaster 16), Video card with 1MB memory, a ‘staggering’ 17 inch monitor and a 300 dpi B/W laser printer. At that time an average PC configuration had a price of about £2500.

The same summer we collected as much information as possible about software for creating multimedia content. The first one we explored was *Creator* – a software organising text and images into electronic pages and books. It seemed suitable for our project, but lacked some possibilities we wanted (years after this *Creator* was taken over by the company *Promethean*, which now produces Interactive White Boards). Similar software was *Macromedia Director*, which appeared to be directed toward video (later this software was purchased by *Adobe* and became *Adobe Director*). Other software was also explored and one programme – *ToolBook*, seemed to satisfy the need of the project. It was designed to create training multimedia lessons and electronic assessment (*ToolBook* continues to exist until this day).

During September we had a call from the UK Department of Education and went to discuss the project with them (they were very supportive). A month later we had a call from Brussels asking us "Do we really mean to develop our own CDs with electronic materials, and do we know how much this would cost?" The answer was "Yes, all this was planned and calculated" (in fact after 3 years we completed this large project with 5.7% difference from the approved budget – about 300 000 ECU). On 6 December 1995 we had a call from the UK Department of Education that the project is approved 'with minor reduction of budget'. We still keep some of the enthusiastic emails from our partners after this news was announced the same day.

The partners in the project were a Consortium of Universities and Hospitals from UK, Sweden, Italy and Portugal: King's College London - School of Medicine and Dentistry, University of Lund, University of Florence, King's College Hospital, Lund University Hospital, Florence University Hospital, The Portuguese Oncological Institute in Lisbon, the High School of Medical Technology Lisbon and the International Centre for Theoretical Physics (ICTP) in Trieste, Italy. Project Contractor was Prof V C Roberts, Coordinator was Dr S Tabakov and representatives of the Partners were: Prof S-E Strand, Prof J Gomes da Silva, Prof F Milano, Dr C A Lewis, Dr I-L Lamm, Dr A Campagnucci and Dr A Benini.

The project was managed and co-ordinated by King's College London and was supported by the European Federation of Organisations for Medical Physics (EFOMP), the European Association of Radiology (ESR), the International Atomic Energy Agency (IAEA) and the Medical Physics societies of the partner countries.

The objectives of EMERALD were: "Development of four common vocational training modules in medical radiation physics, which will incorporate materials for distance learning on CD and multimedia". The initially planned modules were: Physics of X-ray Diagnostic Radiology, Physics of Nuclear

Medicine, Physics of Radiotherapy and Physics of Medical Imaging. The approved length of the project was 3 years.

EMERALD – The first meetings and structuring the work (1996)

The Foundation meeting of the project Consortium was in London (17-18 March 1996) – Fig. 2.3.

This meeting discussed in detail the training needs in the member countries and made specific plans for the development of the tasks in the project:

1. Structuring the training syllabi of the training modules (i.e. training timetables)
2. Preparation of the Training Workbook concept
3. Preparation of Students' Manuals (Workbooks with tasks) for each module
4. Preparation of Teachers' Guide
5. Preparation of CD Image Database (IDB)
6. Development of a Credit Transfer Scheme
7. Evaluation of the modules
9. Development of multimedia training materials

8+10. Introduction of the modules with manuals, guides, CD image data-base.

The Training syllabi for the 3 modules (aka Training Timetables) were specially discussed and three sub-groups were formed to develop these:

- Module on Physics of Diagnostic Radiology (X-ray) – led by the UK Group
- Module on Physics of Nuclear Medicine - led by the Swedish Group
- Module on Physics of Radiotherapy - led by the Italian and Portuguese Groups.

It was also decided that the University partners should lead the syllabi development, while the Hospital partners should lead their practical implementation. The assessment of the materials was to be carried out by all partners plus External Assessors.

The Consortium also decided to apply an adjustment of the project (due to the small reduction of requested budget, and the large volume of materials to be developed) - the planned module Physics of Medical Imaging to be removed from EMERALD and to be developed in future as a separate project (what later became the basis of project EMIT). EC approved this modification.

The initial time/budget allocation distributed (according to the tasks ahead) was planned as:

1. Structuring the syllabi + 2. Preparation of a work book concept (15%)

3. Preparation of Students' Manuals content + 4. Preparation of Teachers' Guides (15%)

5. Preparation of CD image database (35%)

6. Development of Credit Transfer Scheme + 7. Evaluating the modules (5%)

9. Development of multimedia training materials (25%)

8+10. Introduction of the modules (5%)

During the project development the work on the Training tasks (i.e. the content of the Student Manuals, renamed to Training Workbooks) took considerably more time and so 1+2 came to a proportion of time similar to the development of the CD image database (35%). Also, due to the format of our e-learning materials, the multimedia (as planned) appeared to be of limited use to practice and only 5% of time/budget was spent on it (most of its function was taken by the IDB). The rest of time/budget allocation was kept as predicted.

B-A Jonson and S Tabakov demonstrated some possible software and it was agreed to consider for future development of the materials the software *Adobe Acrobat* and *ToolBook*. The selection of *Acrobat* and its PDF format proved to be very suitable for our needs, while some of the multimedia-related creative software of that time disappeared after a few years. PDF format was an excellent free format, allowing various text files to be transferred into one file (.pdf), which can be read by all computers with the free *Acrobat Reader* programme. This excellent concept was the only solution for the plethora of text files at that time (and now).

This meeting also agreed on the file formats to be used, the future email communication, the unique numbering of the project documents and specific file names associated with different tasks. At that time the file names were still limited to 8 symbols and the large international group needed a common way to present their results. The size of files and images (in pixels and resolution) was also agreed.

The system for naming and keeping files was very important, as a significant part of the project was to be developed by three independent Workgroups. We used such system also in the future projects, namely EMITEL, where the number of files in the final result was more than 50,000.

Fig. 2.3 The Foundation Consortium meeting of EMERALD in KCL London (1997) – from L>R: Inger Lena Lamm, Sven Erik Strand, Colin Roberts, Bo-Anders Jonsson, Franco Milano, Anna Benini, Cornelius Lewis, Slavik Tabakov

After the meeting in London all groups began developing the structure of their modules (Fig. 2.4). This was a very important task, as it became the basis of the future Training Syllabi (and Training tasks). From that time on, all Consortium members were mainly working on the project during their free time – evenings and weekends (which remained as a pattern in all our future projects).

Most of the work of the three initial Workgroups had to be based on email exchange, a relatively novel information exchange at the time. The software *EUDORA* of *Qualcomm* was the preferred email program in the Consortium, as it allowed separate saving of emails and attached files (we used very effectively this programme until 2005, as it allowed only its Mailbox exe file to be carried on external memory and used in other PCs; later *Eudora* was transferred under *Mozila/Thunderbird* and discontinued in 2010). Due to the immediate need of exchanging files between partners, the Workgroups tested the exchange of files over email after the meeting. In order to estimate better the quality of the transmitted and received images, an image of a bird (Fig. 2.5) was chosen to include both colour and B/W elements, high and low contrast, as well as high and low resolution elements. This file was the first image exchanged between the partners and, following this email, data transfers were established between the Workgroups.

At the same year (1996) we purchased our first Digital camera (*Kodak*, 640 x 480 pixels, approximate cost £1500) and our first Multimedia projector (just over £3000). Until this time all Power Point presentation files were transferred to a large PC-photo device, which was photographing them on colour film slides (which, after developing and framing, were projected by a slide-projector).

All project partners had a number of photo-slides with images of equipment and phantoms, as well as X-ray films with information related to image quality and artefacts. In order to digitise all these slides for the Image Database (in JPG format) we purchased a high resolution scanner with adapter for transparent media (approximate cost £1500).

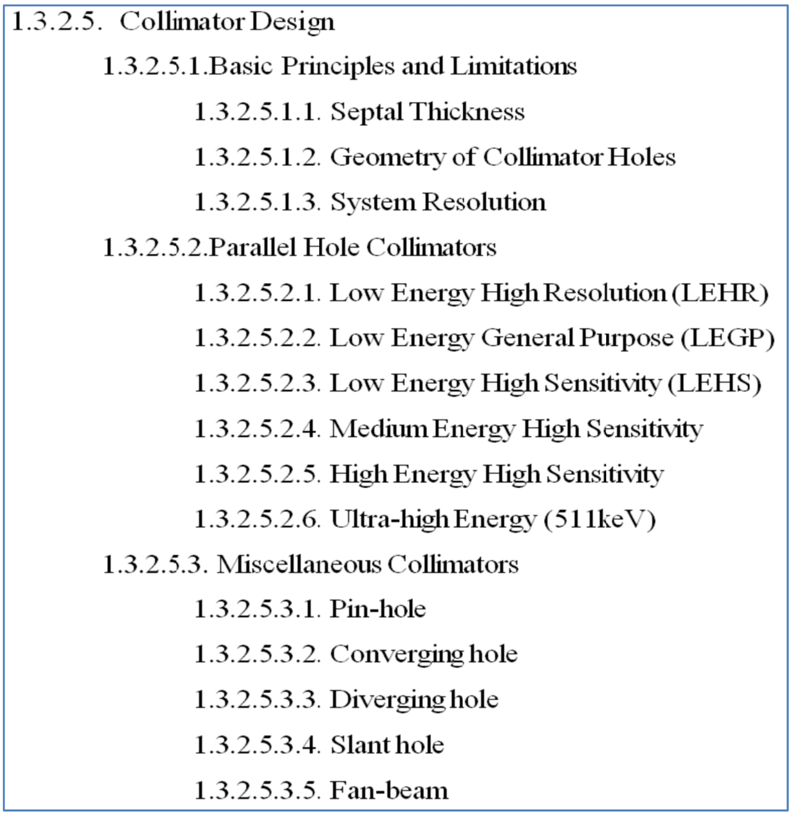

1.3.2.5. Collimator Design
1.3.2.5.1.Basic Principles and Limitations
1.3.2.5.1.1. Septal Thickness
1.3.2.5.1.2. Geometry of Collimator Holes
1.3.2.5.1.3. System Resolution
1.3.2.5.2.Parallel Hole Collimators
1.3.2.5.2.1. Low Energy High Resolution (LEHR)
1.3.2.5.2.2. Low Energy General Purpose (LEGP)
1.3.2.5.2.3. Low Energy High Sensitivity (LEHS)
1.3.2.5.2.4. Medium Energy High Sensitivity
1.3.2.5.2.5. High Energy High Sensitivity
1.3.2.5.2.6. Ultra-high Energy (511keV)
1.3.2.5.3. Miscellaneous Collimators
1.3.2.5.3.1. Pin-hole
1.3.2.5.3.2. Converging hole
1.3.2.5.3.3. Diverging hole
1.3.2.5.3.4. Slant hole
1.3.2.5.3.5. Fan-beam

Fig. 2.4 – Above: Example of the educational structure of EMERALD modules (sample from Nuclear Medicine); Below: Emerald early website home page and Budapest book as floppy disc e-book (as re-published on web in 2001)

The Second Consortium meeting was in Lund University (30-31August 1996) – Fig. 2.6. We flew from London to Copenhagen and took a speed boat to go to Sweden (the huge Øresund Bridge did not yet exist).

This meeting introduced to the group Michael Ljungberg from Sweden and Nuno Teixeira from Lisbon. Michael's and Bo-Anders' extensive knowledge of software proved to be very important for the future development of EMERALD. The meeting discussed the Module structures and agreed on the next step – development of Training tasks, and most importantly – the collection of images for the database. Initial software for this was discussed (such as *ShoeBox)*, but later *ThumbsPlus* was found to be a very suitable software for our purpose.

We also agreed that the entry knowledge level for the students using the materials should be MSc-level. The necessary competencies were decided to be those developed by the UK IPEM (also used by the EFOMP). A very important decision agreed (based on our experience) was that the expected training of one student should be between 4 and 6 months (full time). The first part "intensive training" was to be the subject of EMERALD and could be performed internationally, while the second part was to be completed in the student's country in order to acquaint him/her with the local requirements, methods and regulations. This decision was important for establishing the number of training tasks and the indicative time for each task to be performed and respective competencies achieved. EMERALD training for each module was fixed as 80 days (4 months) "intensive training". The second part of the training was left to be established separately by the respective country.

The structure of the Training Timetables was also agreed. The planned training tasks within these were agreed to be developed in a way to allow future experienced users (namely Training Supervisors) to substitute certain task(s) or part of task(s) with protocols, methods and practices used in the particular country (or hospital). This decision proved to be very useful, as it allowed a great amount of training flexibility, which led to the later wide international use of EMERALD and EMIT e-learning materials.

It was agreed that a standard Training task should be similar to a University Laboratory exercise description. Due to this a number of Universities were later using the tasks as labs. Typical structure of a Training task was agreed with the following sub-sections:

- Task name and aim
- Competencies addressed
- Equipment and materials
- Procedures and Measurements

- Results (Calculations, Diagrams, etc)
- Observations, Interpretations, Questions, Conclusions
- Reference documents
- Verification (the completion of each task had to be verified by the Teacher/Trainer).

Another important decision taken at this meeting was to publish the electronic materials as books - with ISBN numbers. C Roberts had already arranged such numbers for the Department of Medical Engineering and Physics in King's and a decision was taken that these should be used for the purpose of EMERALD.

A project milestone was the development of a web site of the project (only a few websites existed at that time) and soon this was ready (Fig.2.4) with the help of colleagues from the parallel project ERM, which was running at the same time (please see chapter 4).

Fig. 2.5 The first image file emailed between the partners (image including colour and B/W elements with varied contrast and resolution)

Fig. 2.6 The Second EMERALD Consortium meeting in Lund: from L>R standing: N Teixeira, S Tabakov, A Campagnucci, F Milano, C Lewis, C Roberts, in front B-A Jonsson, S-E Strand, I-L Lamm

Later in 1996 the paper book from Budapest was transferred into a PDF electronic book for distribution on a floppy disk (Fig.2.4, as re- e-published in 2001, after the upload of the e-book on our E2 web site).

The same year S Tabakov made the first use of EMERALD e-learning materials (images and tasks) at the 1996 Medical Physics College, organised by our partner ICTP, Trieste. These materials (related to

Quality Control of X-ray equipment) were enthusiastically accepted by all students in Trieste (coming from more than 30 countries). In future this College was to be a major dissemination vehicle for our project materials.

EMERALD – Training tasks and Image Database (1997)

The Third Consortium meeting was again in London (10-14 January 1997) – this time with the specific task to learn how to use *ToolBook*. A training session was specially organised with the newly appointed KCL multimedia specialist D Byrne. It was exciting, but difficult for some of the members and we soon decided to have, additionally to the Workgroups developing content, a Workgroup working with the multimedia software.

The EMERALD training tasks were based on the concept "learning through examples" and we distributed the first training tasks (Quality Control of X-ray equipment) as templates for the other Workgroups. It was also decided that the images would be collected with resolution 800x600 pixels (the current SVGA monitor resolution), which was a relatively high resolution for digital photography at the time. A software platform for the images was also discussed.

The Training syllabi (Timetables) were almost ready and these were now very useful for the development of the training materials. The organisation of the Training tasks was planned to form a smooth learning curve, where each step was used as a background for the next one. The Training tasks were planned to be organised in Groups of Tasks (Chapters), thus allowing gradual systematic build-up of specific competencies, associated with the elements of the medical equipment and its clinical application. The Training tasks were numbered according to their progression in the specific modules (Fig. 2.7).

The Training tasks were to be developed in a way allowing other international Training Centres to substitute certain measurement/assessment methods with their own (having similar learning outcome).

The description of the Training tasks was made in tables and it was decided that the main competencies described be expanded versions of the IPEM competencies. The indicative time (days) for acquiring a certain competency, after the completion of each task, was to be based on practical testing of the tasks and further writing of their description (i.e. preparing part of the Training portfolio). The number of tasks and their indicative time for completion were based on the experience of the authors, but it was expected that some of these would be modified after the first assessment of the materials (expected in 1998).

No.	Sub-module and Subject	Necessary materilas/arrangements	Competencies acquired	Days	Comments
5.x	**X-ray tube and generator**		**Understand/measur / compare separate X-ray tube/gen. parameters *(2,3,4,5,14,15,22)**	7	
5.1	X-ray tube Components. X-ray tube Characteristics. Loading diagram of a X-ray tube. Some typical X-ray tube characteristics. Special X-ray tube types.	X-ray tube diagrams; Different company brochures; Several types tube inserts	Understand/compare X-ray tube paramet.	2	
5.2	Tube housing - construction. X-ray beam filtration. Light beam diaphragm. HVL measurement. Estimating the total filtration from the HVL. Shielding, leakage radiation.	Tube housing; X-ray radigr. room; Dosemeter; Al plates HVL/Filt. diagrams; ~6 X-ray film/cassettes	Understand/measure X-ray tube filtration	1	Repeated in No.7 as part of a whole QC test
5.3	X-ray tube output parameters (consistency, output variation, linearity). Typical parameters. Factors affecting tube output. X-ray tube output spectrum and distribution. Measuring of the focal spot . Assessing the beam alignment. Seasoning of a new X-ray tube . X-ray tube failure.	X-ray radiogr. room; Dosemeter; calculator, Foc. spot meas. tool; LBD align. tool	Understand/measure /calculate tube output param., focal spot size and LBD. Learn to season the tube	2	same

Fig. 2.7 EMERALD Training Timetables (Training Curriculum) – sample from Diagnostic Radiology module – submodule with tasks related to X-ray tube assessment.

The Consortium expected a large number of files and images and the system developed for file names was based on parallel Folders of files with text and with images, each having an easily distinguishable filename – e.g the Diagnostic Radiology chapter 5, training task 3 (i.e. task DR 5.3) was described in file dr053.pdf, while the images associated with this task were with file names dr05301.jpg, dr05302.jpg, etc. This was very important for the organisation of the data with its various files – text, images, video, etc. Also these file structures were to be very useful in the future project work with batches of files.

It was obvious now to all partners that the project was a pioneering work of significant importance for the development of the profession. EMERALD was a project surpassing the potential impact of an average EC project and each member of the Consortium took it as a priority. It was decided that the Work-in-progress be presented at national and international conferences and the first presentation to be at the World Congress on Medical Physics and Biomedical Engineering same year (WC1997, Nice, France).

The next months were occupied with the first Interim Report to the EC (we did not have experience with these huge reports and it took a lot of time to do the first one). However during this time the results were "pouring" into the Coordination office from all partners. The existing structure of the training tasks (the Timetables) and the file-name system proved to be very useful for the classification of this large volume of data.

At that time V Tabakova decided to quit her full time work in order to volunteer with the two simultaneously developed EC projects (EMERALD and ERM in Plovdiv – see chapter 4).

The new computers we purchased to be used for the work with the images and multimedia were now more powerful (some up to 200 MHz clock) and with bigger memory. The price of these was about £3500 each. We also purchased the first CD-Writers, which engraved CDs (with speed x1). Their cost was now about £1000 – significantly less than the prices of such devices at the time of project preparation. The cost of one empty CD-R had also fallen to about £2. Other associated accessories as CD-writing software, CD jewel-boxes, CD-cover printers and CD labels were also at more affordable prices. Thus we also purchased a CD-label printer, which was in fact an adapted *SEIKO-Precision* ink-jet printer, but with cost of about £900 (i.e. about 3 times its prototype). At that time we also purchased our first laptops. Their price was above £4000 each, their power was below that of a desktop PC (and their weight about 4 kg), but they were very convenient for our international meetings, associated with work and demonstrations of e-learning materials.

The Fourth Consortium meeting in Florence (17-22 July 1997) – Fig. 2.8 was hosted by the new Multimedia Centre of the Florence University (Centro Didattico Televisio). Other colleagues joined us at this meeting – L Bertocchi from ICTP, G da Silva and A Pascoal from Lisbon, and L Ricciardi from Florence. The meeting aimed to agree the beginning of tests of the first products – a task given to the Hospital partners. Alongside this it was decided that part of the materials be tested in the new Medical Physics Education Centre in Plovdiv, Bulgaria (established under our parallel project ERM). It was very important to see how the products would be used on international scale. One of the agreements was for two Swedish trainees to come to London and pass their training (using EMERALD materials) in King's College Hospital.

More than 50% of the tasks were completed and it was obvious that good adherence to the agreed format of the training tasks is necessary in order to form cohesive Training Workbooks.

Fig. 2.8 The Fourth EMERALD Consortium meeting in Florence: from L>R standing C Roberts, J Poveda, S-E Strand, A Benini, F Milano, C Lewis. L Bertocchi, L Ricciardi, A Pascoal, J da Silva, in front B-A Jonsson, S Tabakov, I-L Lamm. Next photo – the Consortium at work, Lisbon meeting (Workgroup discussion).

The work on our Image Database was slowly gaining momentum – part of the images was collected, but their processing (when/where needed) was still a task which had to be learned and performed. Image editing at that time was not as popular as now and the partners decided to use either *Adobe PhotoShop* or *JASC PaintShop Pro*. The latter was a bit easier to learn and some Consortium members decided to use it (this programme was purchased by *Corel* in the mid-2000). The software for the Image Database was not yet decided. Very few Image databases existed and the available experience on creating such Databases was minimal. Additionally to the previously discussed database programmes (*Kodak QuickSolve* and *Adobe Fetch),* we assessed the *PhotoAlbum* of *Image Resource*. The program was easy to use, but did not allow compiling the database and exporting it on a CD-ROM. Some attempts to use *Microsoft Access* were also investigated, but this appeared to be a more complex route. A requirement for the users was to have their own version of *Access*, which would make the use and dissemination more difficult. It was however decided that the collection of images would continue until suitable software was found. Indeed only several months later one of the PC Journals published a short review of software *ThumbsPlus* by *Cerious Software* – it had the functionality we needed. After several contacts with the company we purchased the software for our needs and all our Image Databases were made with it and its CD-creating version (as per 2015 *Cerious Software* continues to exist).

The project meeting in Florence was not only useful, but pleasant for EMERALD members, as at that stage we had become not only partners, but also good friends, who were sharing both their working knowledge and their free time. A fantastic dinner in F Milano's home confirmed this. That evening colleagues from 7 European countries were chatting and laughing together alongside the long table under the beautiful Florentine sky and Franco's cypresses (Fig. 2.9, Fig. 2.10). We are sure many of us will remember forever this magical time when some of us realised the other dimension of our projects – linking not only science and education, but also culture, philosophy and benevolence. One small episode was that Franco told us that unfortunately there is a potential problem with his excellent rural house and garden (in the village of Fiesole – one of the historic sites around Florence, full with character and Etruscan remains, and also the legendary place where Leonardo da Vinci tested successfully his flying machine) - the Council of the village wanted to use the place for a cemetery, which could perhaps endanger the beautiful place where we were at the moment. A decision was taken immediately that all members of the Consortium would write to the Mayor from different countries asking him to re-consider the project as it would ruin the beauty of the place. We did it as soon as we returned, informing also colleagues from other countries to write to the Mayor of Fiesole. Several months later Franco informed us that at a local meeting the Mayor informed the people that he would stop the project, due to letters from so many countries.

The project work continued on the next day with planning of the Teacher's Guide, which would include all Timetables and explanations about the use of the training materials. We also decided (an idea of A Benini and C Lewis) to add to the Guide the necessary Radiation Protection information. This was due to the fact that developing a common international Radiation Protection training was quite difficult at that stage due to the significant difference between the respective legislation in various countries (around 2010 this was harmonised in the European Union and such programmes were developed with the active involvement of ESR and EFOMP – e.g. project *MEDRAPET – Medical Radiation Protection Education and Training*, coordinated by J Damilakis). The 2015 CRC book (IOMP&IRPA-commissioned) *Radiation Protection in Medical Imaging and Radiation Oncology* (Editors R Vetter and M Stoeva) also discusses issues related to the international approach to Medical Radiation Protection education/training.

The publicising of EMERALD was also on the agenda and the first presentations were agreed for the World Congress in Nice, France, September 1997. In Nice the project generated a lot of interest and later a number of colleagues came to collaborate with us – initially externally to the projects, after that as part of our future project EMITEL. In Nice we demonstrated for the first time our Image Database.

We believed that pure digital publications have to be considered as paper publications. This way simultaneously with the demo of the IDB we allocated ISBN numbers (arranged by C Roberts) both for our paper Workbooks and for our CD-ROMs with the Emerald Image Database (see below).


Fig. 2.9, Fig. 2.10 Consortium dinner at F Milano's house in Fiesole, near Florence

The Fifth Consortium meeting was in Lisbon (15-16 November 1997). Its main topic was the completion of the Training Tasks and the Teaching Guide, and agreement on their publication, assessment and dissemination.

Alongside the three Training Timetables (Training Curricula) and the basic Principles of Radiation Protection (plus other Safety issues), the Teaching Guide included information on:
-List of Competencies (as per the IPEM Training scheme)
-Training Agenda
-Statement of Mutual Intent
-Continuous assessment and feedback
-Training Portfolio
-End-point assessment.

The Image database was also finalised and it was decided that each image be with embedded EMERALD Logo. This approach was found to be more useful for our purposes (compared with the Watermark, used by *PhotoShop*, which, even in maximal transparency, was seen over the image). The other copyright-heavy option was *Digimark* – a tool writing into the image file unique code for protecting the copyright of images for online use. However the Consortium decided that our ultimate goal was the development of medical physics, and we should allow images to be used free. The small logo was considered sufficient reminder for future users to cite EMERALD (Fig. 2.11, Fig. 2.12).

To expand the announcement of the project, additional publications were also made in Sweden, Portugal, UK and discussions were included in EFOMP meetings through I-L Lamm. Additionally B-A

Jonsson made a presentation at the first World Congress on the Internet in Medicine (Brighton, November, 1997). The first full paper about EMERALD was published in the European Journal of Nuclear Medicine (1998, the publication was headed by S-E Strand). The feedback from these presentations was excellent, the needs were obvious, and the Consortium considered further dissemination activities – the most important being a specific EMERALD International Conference in ICTP, Trieste, Italy.

The EMERALD Conference structure was also approved in Lisbon and potential Referees (and Conference delegates) were identified. It was agreed that the future assessment have several main stages:

- Assessment by independent specialists
- Practical testing by students
- Assessment at a Conference
- Editing the Training tasks and images

The progress was excellent, but exactly at this period of time it was announced that the EC programme Leonardo would revisit all its projects and stop some of them (if not effective). Although the Consortium was confident EMERALD would prove its effectiveness, there was a substantial hurdle ahead with a specific Final Report to the EC (based on 2 years completed), plus re-submission of the final stages of EMERALD as a Continuation project. So far we had produced one large report to EC (about 100 pages) with interim results, but now we had to quickly complete almost all possible for the new “Final Report”. By that time about 80% of all Training tasks were ready, but their assessment, planned for the 3rd project year, was not initiated.

In just one month all Training Workbooks had to be edited and prepared in suitable form for presentation; the images had to be included in the database and a demo Multimedia had to be made.

For this demo we developed only one task from Emerald Diagnostic Radiology and published it on a separate CD-ROM (we did not allocated an ISBN to it, as it was only a demo). The small “multimedia book” looked nice and attractive, but it was not easy to produce (we used *ToolBook*). Also it did not add more to the educational value of the materials, as the text there was the abbreviated text from a Training task, and images were the same as in our Image Database. The fact that it was in a book-like form where one can “turn pages” electronically presented an attractive look, but the same was true for our Image Database. Also, fixing only one type of software for the Multimedia, could have limited our eventual future simulations (which could be done with various other software, capable of producing Executable files).

This way the hard work for completion of the first two years had an important future consequence – the Consortium later decided that the time and cost spent on the specific multimedia-type e-book were significantly more than their added educational value for our potential users/students.

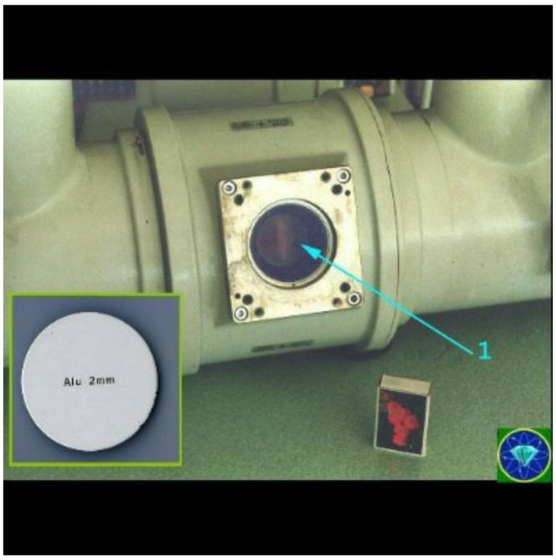


Fig. 2.11 An image from CD Image Database with EMERALD logo (DR module) – its caption (not displayed here) includes also the name of the author

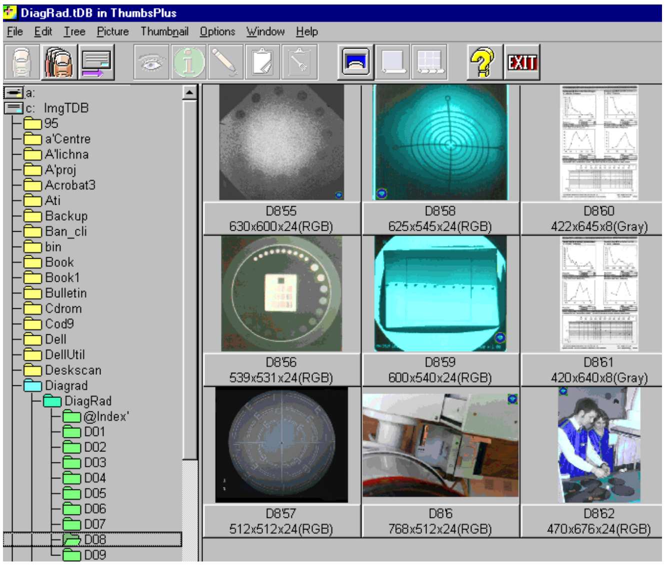


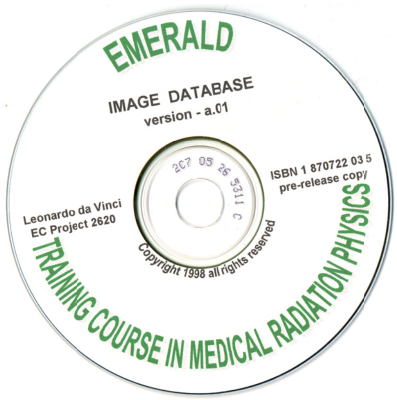
Fig. 2.12 The Interface of the Image Database with thumbs (slides) for easy finding each image. The Folders with images correspond to the Workbook chapters - a sample from the hard drive source

An addition to all work for completion of the training materials was another 100+ pages Report to EC (plus full financial statement for the first two years). Perhaps we have never had so much work in such a short period of time. The Workgroups did their best to collate the Workbooks with Training Tasks; the majority of images for the Image database were collected in London (where the first CDs were made); the Report and the Financial statements were made also in our Coordination office with help from C Roberts and A Webb.

The report was submitted to EC on 20 February 1998 and it included our first official CD with the Image Database. By that time one of the three volumes of the Image Database was fully completed - the X-ray Diagnostic Radiology (for this task special help was received by the colleague A Litchev from the parallel project ERM in Plovdiv).

The new electronic media carriers (e.g. CD-ROM) contained the same information as print media (paper books), surpassing them in potential volume, image quality and cost-effectiveness. Due to this reason it seemed logical to us that these carriers have the same identification, ISBN, as printed books. This way the Consortium decided to send our first Image Database to the EC with its unique ISBN (as pre-release of the full EMERALD set), and later to add the two remaining volumes (the CD-ROMs with the Image Databases on Nuclear Medicine and Radiotherapy). It was also decided that the CD front cover include images from all 3 specialities. Our first official CD (Fig. 2.13, Fig. 2.14) was published on 19 February 1998:

EMERALD Image Database version a.01, 1998 , ISBN 1 870722 03 5



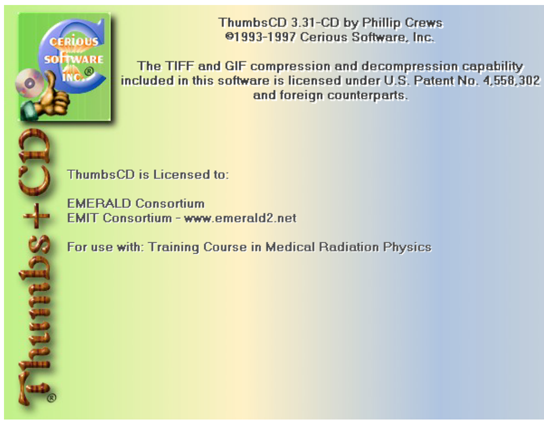


Fig. 2.13 The first CD with EMERALD Image Database

Fig. 2.14 Opening page of the Image Database

At that time CD-ROMs were not assigned ISBN (International Standard Book Number). Even the important paper book "*Electronic Publishing on CD-ROM*" by S Cunningham and J Rosebush (O'Reilly & Associates Inc, ISBN 1-56592-209-3, published in 1996) had an ISBN for its paper version, but not for its accompanying digital copy on CD-ROM – an excellent early PDF e-book. The *Microsoft ENCARTA* Encyclopaedia was also without an ISBN.

The very small number of electronic books issued on CD-ROM at the beginning of the 1990s used ASIN numbers (Amazon Standard Identification Number - a 10-characters identifier of Amazon) after 1994, instead of ISBN numbers.

According to some sources the first electronic book (later to be named "e-book") with ISBN was released in 1998 (by Kim Blagg), but other sources claim that other e-books (using *Dynatext*) had been produced in the early 1990s (citing Chaucer's *The Wife of Bath's Prologue*, ISBN 0-521-46593-1). Such electronic book on CD-ROM was the *Alfred's Basic Piano Library* – September 1, 1995, ISBN 0739022482, also *Illustrated Catholic Bible Multimedia CD* – October, 1996, ISBN 1886877394, etc.

After 2000 all e-books and other digital materials use unique ISBNs. Even an e-book with different formats (for different e-book Readers) is required to have different ISBNs for each format.

The excellent teaching potential of CD-ROMs with imaging material was recognised quite early and libraries had specific guides on the subject (e.g. *CD-ROM licensing and copyright issues for libraries*, 1990). The first ISBN-numbered electronic Image Databases (on CD-ROM, all in the field of medicine) emerged almost simultaneously (within 4 months), our EMERALD being one of these:

- Atlas of Pathology: Urological Pathology CD-ROM, 30 Dec 1997, Springer-Verlag, ISBN 3540146571
- EMERALD Image Database, Training Courses in Medical Radiation Physics CD-ROM, 19 February 1998, King's College London, ISBN 1870722035
- Developmental Psychology Image Database CD-ROM, 30 April 1998, McGraw-Hill, ISBN 0072896914

To our knowledge these are the world's first ISBN-numbered electronic Image Databases (on CD-ROM). Additionally we have not found other types of ISBN-numbered e-learning materials published before the three above, but even if some had existed, we can be proud that EMERALD was one of the first such products in the world (and definitely the first in Medical Physics). Almost everything in our materials (and their form) was original and invented by the project for the purpose of education and training. The fact that we had been on a right way from the beginning is clear – now, more than 15 years from its publishing, EMERALD continues to be used on a daily basis by colleagues from all over the world (with more than 2000 users per month) – see Fig. 10.7.

EMERALD – Assessment and Publishing (1998)

The Final Report for the first two years was quickly approved by the EC. Similarly, the re-submitted Project Continuation was also quickly approved. The monitoring visits from the UK Leonardo Office were very encouraging and this was important for the Consortium as the year ahead (1998) was also quite challenging.

The evaluation of the EMERALD materials was planned on several levels:

-First level – the Training tasks (developed by various specialists) were exchanged and discussed internally inside the Workgroups;
-Second level – each Group of tasks was evaluated as an entity by the Workgroup (additionally young colleagues, who had just completed their training, were asked to check their cohesion).
-Third level – the Groups of tasks were exchanged between the different international Workgroups
-Fourth level – External Assessors were appointed to provide independent review of the products
-Fifth level - full Training module (all tasks) was used by un-trained graduates
-Sixth level – an International Conference of experts was organised to comment on the tasks from the point of view of their use in various European countries (this being an EC project)
-Seventh level – based on the feedback above the materials were edited by the Workgroups and the final product was again seen as a totality by the Consortium and the External Assessors.

This was a very thorough assessment, and it would be simplified in the future, but for the moment we wanted to ensure that every step was correct.

The Sixth Consortium meeting was held in Lund (15-16 May 1998). During it, the Consortium discussed the completion of most of the first three Evaluation levels, and also selected the first students to pass Emerald training.

Two students from Lund (Ulf Petersen and Mikael Folkesson), who had tested in Lund tasks from the Nuclear Medicine module, were selected to test the whole Diagnostic Radiology module in London. The Swedish EC Leonardo Office supported their travel and KCH arranged their accommodation. It was also agreed that their experience, alongside with the experience of the King’s College Hospital students/trainees, be presented at the EMERALD Conference in ICTP.

It was agreed that the Conference in ICTP discuss not only the feedback from EMERALD e-materials, but also the framework of Medical Physics training in Europe. This Conference was the first International Conference on Medical Physics Training. Specific Questionnaires were developed and points for future development were discussed.

The first feedback from the External Assessors was also discussed. The first reports (by Alain Noel and Andy Rogers) had found EMERALD Diagnostic Radiology very useful, expanding the breadth of the existing competencies, but at the same time too prescriptive in some of the tasks. It was decided that future experience could give information about the level of detail of the tasks. It was also decided to include in the EMERALD description information about the possibility to replace listed methods (examples in the Training tasks) with other similar methods used locally. It was further decided that the EMERALD materials be sent to the International Atomic Energy Agency (IAEA) for information and feedback (which was later reived by P Andreo, J Izewska, F Pernicka and Sobol).

The opinion of the students who used some training tasks was that the indicative time was sufficient to perform the tasks, but the expectations for the training portfolio writing required additional time. They also commented on the need to have more time for contact with their Training Supervisors – a problem which is still not fully resolved, as few Hospitals provide the supervisors (who are specialists with clinical duties) with sufficient time for training.

This meeting discussed also the need of a Credit Transfer Scheme for Training, which would allow training from one country to be approved in another. Although EMERALD made some steps towards this, such widely-used Credit Transfer still does not exist at international level.

The e-Learning materials developed very well and the Consortium decided to apply to EC for permission for Commercialisation. This permission was granted by EC in September 1998 and during April 1999 all our Training Workbooks and CD-ROMs were commercially available. These were presented for the first time at the Congress of the British Institute of Radiology in May 1999.

The other discussions in Lund were related to the version of the Image Database and Multimedia to be released. It was decided that the Multimedia Alpha version should be used during the training assessment (Alpha is the first phase of the software following only initial testing). In case of need of software debugging, this would be made in parallel with the assessment. The Beta version was to be ready for distribution after the feedback from the Conference (Beta is the ready software which can be released for wide testing and use).

At that time the term *e-book* became popular. A number of e-book Readers were made, including the *Rocket eBook*, *SoftBook*, and the *Cybook*. Announcements were made by a couple of online retailers planning to start selling e-books (such as *eReader.com* and *eReads.com*). Yet from those announcements it was obvious that there would be a “War of the Formats” for e-books. Of course these were only software Readers which aimed at reading purchased electronic books (the copyright issues - e.g. the Digital Right Management *DRM* - became popular after the 2000). One of the most popular software programmes for creating e-book files at the time was *Mobipocket*. The widespread hardware e-Readers (e.g. *Amazon Kindle*) were still things of the future (in 2005 *Amazon* purchased *Mobipocket* and used it in its *Kindle Development Kit*). However e-books on CD-ROM were available (although quite rare) – one of the first such CD-ROM e-book Reader was *Sony's Data Discman*, but it was bulky and did not have a good market response. At the same time Encyclopaedia on CD-ROM was one of the novelties immediately accepted by all scholars. This was supported by the fact that the CD devices had become cheap and all new computers were sold with a CD-ROM drive. One of the most popular CDs was *Encyclopaedia Britannica*, which was offered even at the airports and despite its high price was gaining huge popularity. The *Microsoft* Encyclopaedia *Encarta* was also popular, but mainly due to its low cost and more illustrations (its volume could not be compared with *Britannica*).

This was the e-background on which we further developed EMERALD, and at this stage we decided that we should prepare in the same year another EC project (EMERALD II – see chapter 3), which would develop further our e-learning materials and would publish these on Internet. Another aim was to publish these in parallel as an e-learning web site, engraved on CD-ROM. This aimed at distributing our Training materials in the developing countries, where Internet was in its infancy, while there was a huge need of well-trained medical physicists. Our idea for Web site on CD-ROM was original, as we had never encountered it before (and we invented it in the project), but at the same time surely other specialists also had it around this time (or shortly before us – the idea was simple and effective). We were driven by the incredible speed of project preparations, e-learning inventions and development, endless EC Reports, etc and we could not find spare time during this period to publish these ideas. In the years to come almost every PC Magazine was issuing its additional materials as web site on CD-ROM.

The new project EMERALD – Internet Issue (aka EMERALD II, or EMERALD 2, or E2) was a natural continuation of EMERALD. It was submitted to the EC in mid-1998 and was approved by the end of the year (see chapter 3).

At the time of this new project preparation the two students from Lund were passing their EMERALD training in our Department in London. They were very thorough, and although with limited previous experience in X-ray Diagnostic Radiology, they completed 80% of the training in 3 months. Following this they submitted exemplary Training portfolios (about 180 pages each, used as examples to our trainees for many years to follow). The final stage of their assessment was by an International Examining body (including members of the Consortium), which they passed extremely well. C Roberts commented at the time that he had never attended more thorough assessments (of several hours per person).

The students‘ feedback and the feedback from the External Assessors was introduced into the Training Workbooks with tasks to be used at the EMERALD Conference in ICTP.

The EMERALD Conference (24-26 September 1998) was organised under the banner "*The First International Conference on Medical Physics Training*". It included experts from 26 countries, as well as EFOMP Officers. Each delegate received a copy of our Training materials and the CD with the Image Database. The three EMERALD modules were assessed and reported in separate Workgroups of experts. One important element of the Conference was the presence of young colleagues (students and trainees) who had tested the materials. They were included in each of the three training module groups. The venue (ICTP, Trieste, Italy) had excellent computer rooms and each of the delegates had the possibility to test their own CD-ROM with materials and to comment on these.

The delegates strongly supported EMERALD. The main points they highlighted were: the Structuring of the Training; the specific Training tasks; the use of Image Database. The feedback included recommendations for each specific module, as well as more general proposals such as: increasing the number of References; including Glossary of Terms; Expanding the Introduction to the modules (to explain better their application); Emphasising the flexibility of EMERALD to modify tasks; Including more Questions to students; Expanding the Teacher's Guide; Moderating the level of detail; Including some new methods and equipment. All this was taken into consideration by the Consortium and later included in the final edition of the three modules.

The comment for including new methods and equipment was in fact a crucial one. We developed EMERALD in a period when Medical Imaging (especially X-ray Diagnostic Radiology) was going through a dramatic change – when we began the project in 1995 the first X-ray Computer Radiography system was installed in our Hospital (all other Radiographic equipment was using X-ray films); when we finished the project in 1999 there was only one film-based X-ray equipment left in our hospital - all others were already digital (the situation was similar in most developed countries). Later we arranged an update of the materials including the digital equipment, but we still keep the tasks for old equipment as it is useful for the developing countries (we now plan to transfer the tasks for the old equipment in a History Chapter).

Immediately after the Conference the Consortium had its Seventh meeting in ICTP. All partners were encouraged by the very successful Conference. EMERALD was now spread in 26 countries and our colleagues enthusiastically supported the project results and gave us very useful and constructive feedback.

The details for the specific modules were discussed in the Workgroups and it was decided to request from EC four months extension of the project – thus ending it in the spring of 1999 (the Consortium expected the new project EMERALD II to be approved by then). The success rate of the European projects at the time was approximately 1 out of 8 applications approved, but we never lost confidence that our projects would be approved – they were real, addressing existing need, very innovative, delivering tangible results and enthusiastically supported for implementation not only in Europe, but worldwide. The Leonardo Office listed our project in several of their brochures as a show-case, and we were invited to a number of Conferences discussing the international development of e-learning.

The EMERALD Conference had another outcome – during the Conference it was obvious that some colleagues were struggling to communicate some of the terms and needed further explanation about the terms used in English and the meaning of these terms. In other words we needed a Medical Physics Multilingual Dictionary. This was a huge task which we could not discuss with the Consortium at that stage – there was still a lot of work ahead plus another project to develop (E2). No one before in the profession had attempted such activity and there was no example to follow. A lot of project Contributors were needed for such a project and it was not clear how such a huge project could be coordinated. We decided to investigate the possibilities for this and to act when there were suitable conditions for this endeavour. However this idea was very important for us and we believed that it was do-able. After several years it was successfully carried out in the projects EMIT and EMITEL (see chapters 5 and 8).

The Eight Consortium meeting aimed to complete the project. It was in London (7-8 December 1998). There it was reported that almost all phases of the project were completed. The materials were edited and ready for distribution.

At the time of the meeting the approval of the EMERALD II was announced and the Consortium planned steps for this further project.

In London the Image Database was demonstrated in its full version (in 3 volumes, as per the three Training modules) – it included 1400 specially selected images. Each image included a fully searchable caption, used also for the image search. The Software of the Database also included possibilities for image editing and manipulation (useful for learning image processing) plus utilities allowing creation of various image filters – standard and new ones. The free version of the software *ThumbsPlus* was also included, allowing users to create their own additional collections of searchable images. The ISBNs of the three volumes (3 CDs) of the Image Database were:

Image Database vol. 1 - Physics of X-ray Diagnostic Radiology: ISBN 1 870722 03 5
Image Database vol. 2 - Physics of Nuclear Medicine: ISBN 1 870722 08 6
Image Database vol. 3 - Physics of Radiotherapy: ISBN 1 870722 09 4

The full set of these CD-ROMs with EMERALD Image Databases (including our first CD-ROM from 1998 – vol. 1, Physics of X-ray Diagnostic Radiology) were published during June 1999.

Another decision taken at the Eight Consortium meeting in London was to upload most of our materials to our web site (at that time hosted at a sub-domain at the King's College London server). This was in fact the first educational web site in medical physics. The update and maintenance of this web site was complicated. We needed greater flexibility for our materials, uploads, tests and international use of materials. This is how we decided to register own domain name (which was *emerald2*, as *emerald* was already taken) and host it on an independent server – this was done during 1999. The web site *emerald2* continues to work actively to this day with about 2000 unique users per month worldwide.

The Final Report to EC, this time including all completed results (plus all Financial details as well), was again done in London and took a lot of time, but was smoothly approved. One important moment was that despite the huge amount of work produced (considerably surpassing the normally expected results), we had to again develop a larger demo of the multimedia (in order to adhere to our initial tasks).

At that time our Department in London was in the process of moving into new premises and we had only a small temporary building. The demo was programmed in this house, mainly by B-A Jonsson, who came to London for the purpose. It used *ToolBook* software and text and images arranged by S Tabakov into training e-learning modules. In three days (and nights) the demo was ready (Fig. 2.15) and we happily included in its start an extract of Beethoven's 9th symphony (the 2nd movement) – its dynamism and inspiration fitted very well the project aims, and also the product now had a very "European feel". We kept this fantastic music in all our later e-learning materials (a number of colleagues commented on the suitability of the selected musical theme).

In addition we included a colleague from the parallel project ERM in Plovdiv (G Belev) to help with the development of a simulation of Geiger-Mueller (G-M) Counter with *ToolBook*. He made a very useful simulation (including a *Matlab* programme running in the background). The simulation was excellent, and all students liked it. The simulation worked for several years, but after several upgrades of the *ToolBook* software it stopped (Fig. 2.16). This was an important lesson for our future projects.

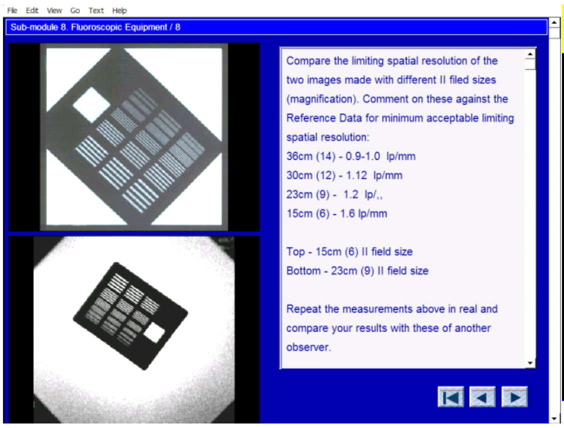


Fig. 2.15 Sample page from the first EMERALD Multimedia demo (*Toolbook* e-book - DR module)

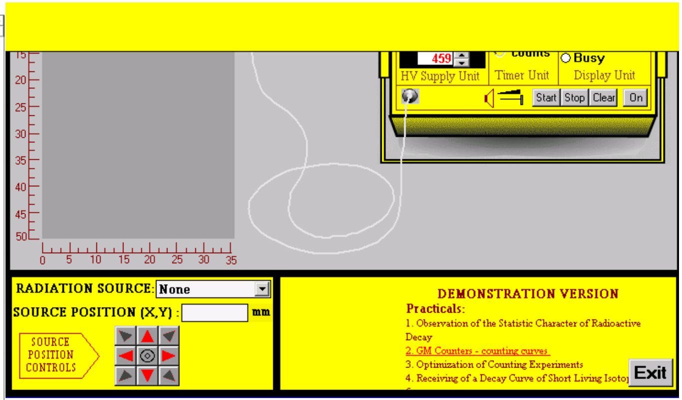


Fig. 2.16 Sample of the G-M Counter simulator, when it stopped working in 2004 (after the software upgrade)

The multimedia demo looked nice and attractive, but actually we had the same educational effect from our e-Workbooks and Image database. This is why we took a firm decision not to continue with such software, but to concentrate on the inclusion of the Workbooks and the Image Databases on the Internet (which was the aim of our next project E2). We never looked back to specific multimedia development software – an important decision, which proved after several years to be of significant importance for the sustainability and longevity of our e-learning materials.

The main benefit of multimedia authoring software was the possibility of including a degree of interactivity (which was later seen to be of limited educational value). However the main disadvantage was the relative difficulty of future partial updating of some tasks (imperative in our dynamic profession). The continued need for flexibility and economy dictated that we take a different path of e-learning authoring. It was this that dictated our move to a simple platform (as *Adobe Acrobat*) with added image information through HTML hyperlinking – something we realised during the next project EMERALD II.

EMERALD Results

EMERALD Consortium developed three Training modules, each including specific Workbook with Training tasks and Image Database. Each module has a length of 4 months (80 days). During this time the trainee is expected to acquire most necessary professional skills. This part of the training was called "condensed" and can be performed in most countries, where training conditions are set up. Further the trainees can spend several months in their own country/state where they can additionally study the local Regulations and professional requirements.

Each of the three modules is based on Training tasks. Each task was given a notional completion time (in days). To achieve completion of all three modules in a period of 1 year would require very intensive work. However the design of the EMERALD scheme would allow the individual modules to be taken separately with intervals between each.

A. EMERALD Training Modules – an overview

Each of the three Training Modules incorporates:

- List of Competencies (in accord with the IPSM Training scheme);
- Structured Timetable (Syllabus with the approximate time necessary for each task);
- Student Workbook with tasks (performance of each task leads to certain competency).
- CD-ROM with Image Database

Each task in the Workbooks is described using a standard format. It contains explanations and protocols to be followed and requires answers to specific questions and problems. The tasks were designed to build-up methodologically various skills and competencies. The proper performance of each task should be verified by the Trainer and on this basis the Trainee can continue with other tasks. To help in this process a Course (Teacher's) Guide was prepared.

The overall volume of the materials in English is: 760 pages of text and 1400 images. These, with the Guide and Training Timetables, are now available free to all colleagues through: http://emerald2.eu/cd/Emerald2/

These materials covered in total 12 months structured training. As a comparison the majority of the other EC projects at that time were developing training of several days (even less, rarely several weeks). These other projects were developed for a similar funding and period of time (about 3 years).

The main types of Training tasks are:
- Observing real activities and taking notes
- Using existing Regulations, Protocols, Software
- Using various types of measuring equipment
- Understanding the basic characteristics & parameters of equipment
- Performing Measurements (including Dosimetry), Collecting Results, Calculating Parameters and other activities most often related to Quality Control (QC).
- Full Assessment (QC) of various Equipment

B. Module 1 - "X-ray Diagnostic Radiology Physics"

This module was developed mainly by the UK partners. The 49 Training tasks in the Diagnostic Radiology (DR) Physics Workbook are grouped in the following chapters:
- General principles of DR radiation protection;
- General principles of DR quality control;
- X-ray dosimetry and patient dosimetry;
- Radiological image parameters;
- X-ray tube and generator;
- Radiographic equipment;
- X-ray films/screens and laboratory;
- Fluoroscopic equipment;
- Digital imaging and CT equipment;
- Basis of shielding in DR

C. Module 2 - "Nuclear Medicine Physics"

This module was developed mainly by the Swedish partners. The 46 Training tasks in the Nuclear Medicine (NM) Physics Workbook are grouped in the following chapters:

- General principles of Radiation Protection in NM;
- General principles of NM Quality Control organisation and equipment;
- Fundamentals and basic properties of radiopharmaceuticals and radioisotopes;
- Pharmacokinetics and internal dosimetry;
- Single detector systems and survey meters;
- General principles of Scintillation Camera systems;
- Single Photon Emission Tomography – SPECT;
- Positron Emission Tomography with dedicated PET or Dual-Head Coincidence Scintillation Camera;
- Image evaluation and Data analysis;
- Preparation and QC of radiopharmaceuticals;
- QA of equipment and software;
- Radionuclide therapy;
- Radiation Protection of NM staff;
- Radiation Protection of NM patients;
- National and EU legislation in Radiation Protection and Radiopharmacy.

D. Module 3 – "Radiotherapy Physics"

This module was developed mainly by the Italian and Portuguese partners (with input from Swedish partners specifically for Brachytherapy). The 48 Training tasks in the Radiotherapy Physics (RT) Workbook are grouped in the following chapters:

- Basic methods in Radiotherapy Physics;
- Quality Assurance of a Dosimetric System;
- Calibration of a Kilovoltage X-ray Beam;
- Calibration of a Megavoltage X-Ray Beam;
- Calibration of an Electron Beam;
- Calibration of an In-vivo Detector;
- Acquisition of Open Beam Data;
- Acquisition of Dose Distributions and Dose Profiles;
- Acquisition of Wedged Beam Data;
- Manual Monitor Unit and Dose Calculation for Photon and Electron Beams;
- External Beam Treatment Planning using a Computerized System;
- Quality Assurance of an Orthovoltage Unit;

- Quality Assurance of a Teletherapy Unit;
- Quality Assurance of a Linear Accelerator;
- Basic Checks of a Treatment Planning System for external beam therapy;
- Calibration of Brachytherapy Sources;
- Manual Treatment Planning using ^{192}Ir Sources for Interstitial Brachytherapy;
- Manual Treatment Planning for Intracavitary Brachytherapy;
- Surface Moulds in Brachytherapy;
- Computerised Treatment Planning Systems for Brachytherapy;
- Quality Assurance in Brachytherapy.

After completion of all modules, the Trainees' Workbooks were sent for assessment to independent experts. Following this a European Conference on Medical Physics Training was held in ICTP, Trieste, Italy in 1998 at which senior representatives from medical radiation physics departments throughout Europe were invited to review the modules.

E. Course Guide (Teachers' Guide)

The EMERALD programme has been prepared with the intention of using it widely at centres throughout Europe and elsewhere. To achieve consistency of use the programme includes a Course Guide which provides recommendations for its use. These include instructions for the supervisor on monitoring and assessing the progress of the trainee. The Course Guide also includes a section which discusses radiation risk, the framework for radiation protection and the application of radiation protection principles in the three subject areas. The Training timetable for all three modules is also included in the EMERALD Course Guide.

The Content of the Course Guide includes:

-Introduction to EMERALD project
-Trainees and Training scheme
-Training Agenda
-Mutual Intent
-Continuous Assessment
-Feedback on Placement and Manuals
-Training Timetables (full Training Syllabus)

-Principles of Radiation Protection and Risk Assessment
-EURATOM 96/29 and 97/43 Directives implementation
-EMERALD Forms (Training agenda, Statement of Mutual Intent; Safety; Continuous assessment; Feedback)
-APPENDICES (Training Portfolio; End point viva; Cheating and plagiarism).

F. EMERALD CD-ROM Image Database

EMERALD project produced one of the world's first ISBN-numbered electronic Image Database (on CD-ROM). This is also one of the first ISBN-numbered e-Learning materials in the world (and the first ISBN-numbered e-Learning material in Medical Physics).

The volume of the IDB is about 1400 images of Imaging/Radioherapy equipment and its components; Block diagrams and performance parameters, graphs, waveforms; QA procedures and measuring equipment; Test objects and image quality examples; Typical images and artefacts, etc.

A PC type image browser (*ThumbsPlus*) is used for quick and easy search through the IDB. The browser presents each image as a 128x128 slide, which can be further viewed in its original size (JPEG up to 1024x1024 pixels). Each image is visualised with corresponding caption, on which basis Keyword search of IDB can be performed as well. The IDB is engraved on three CD-ROMs – one for each Training module (Fig. 2.17). The image organisation (in folders) within each IDB follows the chapters in the Training Workbooks.

G. Conclusion

Almost everything in the EMERALD materials (and their form) was original and invented by the project (1995-1999) for the purpose of education and training in Medical Physics. We did not have examples to follow and were led only by the objective to produce training materials which will support the development of the profession. The impact of EMERALD proved that our Consortium was on the right path from the beginning. As to its sustainability – now, more than 15 years from its first publishing, EMERALD continues to be regularly used by colleagues from all over the world.

About 2000 full copies of our e-learning materials were issued (some given free to colleagues from developing countries). These copies were updated and expanded with the EMIT materials (to be discussed in chapter 5) and uploaded on the Internet during the EMERALD II project (to be described in chapter 3). The web site has now thousands of users each month. The global impact of EMERALD was recognised by the inaugural award for education of the European Union – the Leonardo da Vinci Award (received by our next project EMIT in 2004 – see chapter 5). From 2012 the EMERALD web site with e-learning materials has been free for use by all colleagues. In future the update of these e-learning materials will be handled by the IOMP (International Organisation for Medical Physics) aiming to support the global development of the profession.

The following ISBN numbers were assigned to the EMERALD materials:

	PRINTED	
1.	Workbook on Physics of X-ray Diagnostic Radiology :	ISBN 1 870722 04 3
2.	Workbook on Physics of Nuclear Medicine :	ISBN 1 870722 05 1
3.	Workbook on Physics of Radiotherapy:	ISBN 1 870722 06 X
4.	Course Guide:	ISBN 1 870722 07 8
	ELECTRONIC (CD-ROM)	
5.	Image Database vol.1 - Physics of X-ray Diagnostic Radiology:	ISBN 1 870722 03 5
6.	Image Database vol.2 - Physics of Nuclear Medicine:	ISBN 1 870722 08 6
7.	Image Database vol.3 - Physics of Radiotherapy:	ISBN 1 870722 09 4

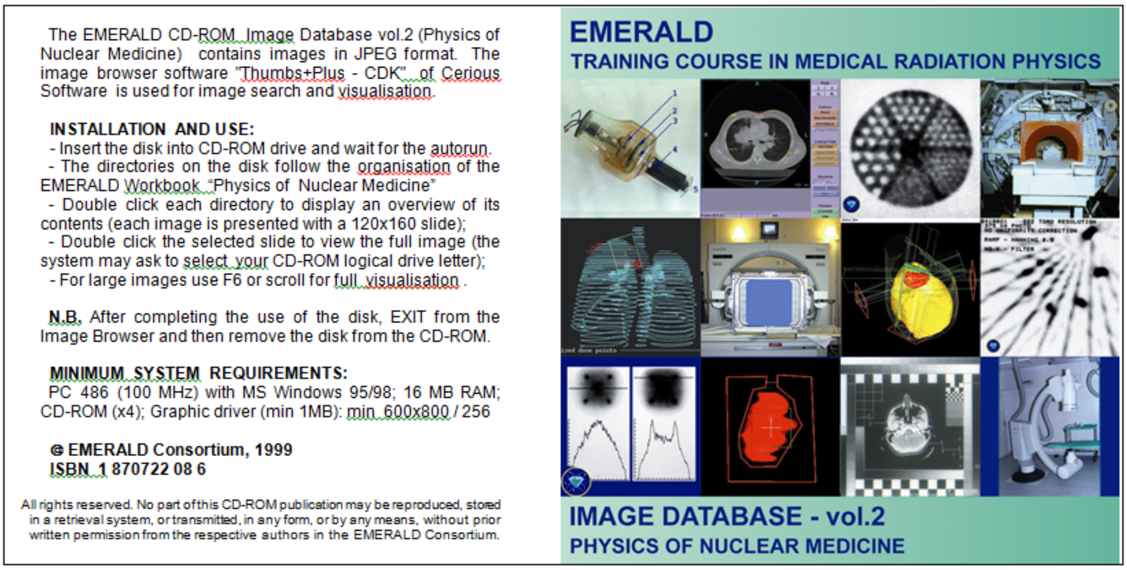


Fig. 2.17 CD-ROM Jewel case Front cover and second page from volume 2 of the CD-ROM EMERALD IDB

3. EMERALD II Project – the First Medical Physics Educational Web Site

EMERALD – Internet Issue (1999-2000)

The new project EMERALD - Internet Issue (EMERALD II, or E2) was an EC Multiplier Effect Project, continuation of EMERALD. In fact it started slightly earlier than the official end of EMERALD.

The goals of EMERALD II were:
1. To form a Network EMERALD of Medical Physics professionals from all over Europe, who would apply the EMERALD products to their training;
2. To transfer the commercial products of EMERALD (Student Workbooks, Teachers' Guide, CD-ROMs) through a framework of 8 Seminars "Train-the-Trainers" in all participating countries (with invitations to colleagues from neighbouring countries);
3. To organise an Electronic Bulletin EMERALD
4. To adapt the EMERALD e-Learning product and to make it suitable for Internet distribution;
5. To develop a web site dedicated to the EMERALD Training methods and e-Learning products.

The Consortium was expanded with new partners from France, Czech Republic, Ireland, Northern Ireland and Bulgaria (as an additional partner) – it included: King's College School of Medicine and Dentistry; King's Healthcare Trust; University of Lund; Lund University Hospital; Portuguese Institute of Oncology, Lisbon; University of Florence; Florence University Hospital; Centre Alexis Vautrin - Nancy; Czech Technical University in Prague; Northern Ireland Regional Medical Physics Agency - Belfast; St James's Hospital, Dublin. The new expert colleagues, who joined us were: Dr A Noel, Prof. L Musilek, Dr P Smith, Dr N Sheahan and Dr S Bowring. As in EMERALD, Project Manager was Prof. C Roberts, and project Coordinator Dr S Tabakov. The approved length of the project was two years.

The Consortium now had considerable experience from the previous project: on e-Learning (the term now existed), on EC project development, and on international collaboration. The First Consortium meeting of E2 was in Florence (26-27 July 1999) in a very special venue – the 15th century building of Palazzo Orlandini del Beccuto (Fig.3.1). The Board room, where the Consortium meeting was held, was with Renaissance frescoes of the time of Leonardo da Vinci.

Fig. 3.1 The First EMERALD II Consortium meeting in Florence: from L>R standing S-E Strand, A Noel, C Lewis, F Milano, P Smith, N Teixeira, J da Silva, C Roberts, L Musilek, in front L Masi, L Ricciardi, I-L Lamm, N Sheahan, S Tabakov, S Bowring. Next photo –interior of Palazzo Orlandini del Beccuto.

One of the important tasks was to prepare the plan for the future dissemination Seminars "Train-the Trainer", which were planned to help our colleagues in Europe to use the e-Learning materials EMERALD. Identical programmes were agreed for each Seminar/Workshop (these will be discussed further down). Other dissemination activities (as brochures and leaflets) were also agreed and a list of Conferences/Congresses was compiled, indicating where EMERALD would be presented.

The partners agreed also how to continue the work on the e-learning materials (the combination of text and images). It was obvious that this would be on the Internet, but the format was not yet clear. The new (and perhaps more stable) carrier of digital information was obviously Internet. The CD-ROMs were at the peak of their use for data storage at the time, but the DVD-ROMs were quickly entering the field and obviously these were expected to replace the CD-ROMs (at least because of their larger volume – around 4.7 GB at the time, compared with maximum 0.8 GB of the CD-ROM). We had already seen how the previous optical memory (*KODAK Photo CD*) had disappeared and expected that other digital data devices would emerge in future, hence we needed to think about the longevity of our e-learning products. Indeed this decision proved to be right as soon CD-ROMs became mainly a music-recording medium (this was in fact the initial application of the CD – the maximum information volume of one CD being based on the full length of Beethoven's 9th Symphony, HiFi stereo recording).

The Image Database software had its own tool for uploading the image collection on the Internet, but the Consortium was looking for a solution which would be software-independent. A new web site was agreed to be opened and Lund University proposed their flexible server to be used. The web site would have its own unique domain name *emerald2.net* (later *emerlad2.eu*). It was agreed that our existing web site would stay (as a portal to the e-learning web site).

The font to be used for the text of the electronic books was also discussed. It was agreed to use Sans Serif fonts as such fonts are better seen on screen. *Arial* was selected as one of the most widely used such fonts.

The development of the web site was discussed and several possible programmes were considered as *Front Page, Dreamweaver* and others. These programmes however used different templates, which could eventually hamper the website development in future (when templates change). Additionally part of the template content was something we did not need and could only slow down the internet access. A possible solution was to programme the web site with *HyperText Markup Language* (HTML) from scratch – a laborious process, but the result could be a tailor-made web site. The demo of our new EMERALD II web site was made this way and was launched at the end of 1999 – this being the first dedicated education/training and e-learning web site in medical physics.

At that time there were some e-learning software programmes developed, but most of them were aiming at the development of platforms for managing the education process. These platforms were often handling simple teaching materials (such as *Power Point* slides/handouts, *Word* documents, or *Adobe* PDF files with materials). We aimed at the development of e-learning materials, which could additionally enhance the learning process through their unique content and presentation. Obviously our set of original Training tasks with images (through internal hyperlinks) was the way for this, but we also discussed, if it is viable to add simulations. Our previous experience with the G-M counter simulation was sufficient warning for the hurdles ahead on this road and we did not continue with these ideas.

One specific issue discussed was related to the expected problem with the “2000 bug” – something that was predicted by many specialists as a problem with possible dis-functioning of PCs at the beginning of 1st January 2000. Related to this, each PC had to have special “2000 fixer” software and we were all making backups of all our data. By 1999 just a few people were using the old 3.5’’ floppy disks (1.44 MB each). The main back-up devices were the 100 MB Zip-drives (with slightly larger diskette). CD-ROMs with their about 750 MB were also often used (DVD drives were still at the beginning of their use for data). Full back-up of a Hard Drive (which at the time was several GB) was possible only with an external Tape Drive (some reaching the almost "unimaginable" volume of 100 GB). The Tape recorded all data files and the Operating System with all Software. These were slow devices (a large back-up often taking all night), but this was the only option possible. As most people at that time, we made full back-up of all our files, but after the 1st January 2000, the "bug" problem did not affect the work of the PCs.

The Second Consortium meeting of E2 was in Lille France (18-19 June 2000) and at this meeting, after long discussion, the Consortium agreed on all details of our new (own-design) Educational web site. The main drivers of this development were B-A Jonsson and M Ljungberg from Lund. Their University was already firmly on the path of e-learning and they had their own platform for distance learning through Internet – the e-learning management system LUVIT. It was decided that our new web site would have two parts – the current emerald2.net would continue to stay at its commercial server, but it would be linked to the Lund server, where our new educational web site would be hosted. The decision to have a tailor-made web site proved to be very important – this web site has now worked for 15 years without any interruption or problem (during 2007 M Stoeva and A Cvetkov re-programmed the web site, keeping its concept, and it now works at emerald2.eu). It was decided that the E2 server have user-friendly platform handling PDF documents and images (many hyperlinked). This also allowed swift future upgrades of materials – something very important for our quickly developing profession.

The text, images and image-captions were made to be in specific HTML frames. M Ljungberg prepared additional software to embed automatically the elements of our e-learning materials in HTML frames. All X-Ray Diagnostic Radiology materials were collected in London and embedded into frames, similarly the Nuclear Medicine materials were prepared in Lund, and the Radiotherapy materials - in Florence. Each Training task had to be linked to the respective images with hyperlinks, and after this transferred to PDF format. Nowadays this is an easy task, but at the time this was the beginning of such activities and the PCs were not so fast (e.g. a simple transfer of a *Word* file with images/diagrams to PDF took several minutes). After this we had to test the hyperlinks in all tasks (which were thousands).

All materials were collected in Lund and collated into one web site. The internal structure of the web site was following the structure of the three Training modules. New folders were also added for further video or other materials, which could be included in future to the web site. The web site had about 4000 files organised in 30 folders. These were our new Internet-based e-books (Fig.3.2).

The use of these e-books (e-learning training materials) is still the same - it requires simultaneous work with two browser windows (main window and image window). The main window includes a large Text Frame for the PDF file; a Contents Frame for navigation through the training tasks; and an “Image-slide” Frame for browsing the images. The additional image window contains the respective image (hyperlinked to the text) and image caption. The images are in JPG format, embedded in separate HTML frames (the image window). When an image is called this window appears (pop-up) over the main window and has its own minimise/close buttons. All functionality of *Adobe Acrobat Reader* is preserved, allowing saving and printing of each part of the e-learning materials. Also, each image could be saved separately as JPG file. This simplicity allows the users to learn directly on their existing computers and their Internet browser and *Adobe Acrobat Reader* (without the necessity to install additional software). The Graphical Interface of the e-books is shown below - Fig. 3.2.

The tests of the new web site took several weeks. The ready materials had to be tested as well with all possible Internet Browsers and *MS Windows* operating systems (95, 98, 2000). One distinctive advantage of the new web site was that while the CD Image Database was made only for PC (*Windows* operating system – the often used one in EU), the web site could be used with other operating systems – notably *Apple Mac* (often used in the USA). Finally at the end of 2000 the new e-learning web site was ready for release and was soon used by many colleagues (its initial volume was about 300 MB – a huge web site for the time). In March 2001 students and colleagues at the EMERALD Workshop in London used this web site and all gave very positive feedback. The initial entry image of the web site was designed by B-A Jonsson and we updated it later for our new EMIT project (Fig. 3.3).

Fig. 3.3 Screen capture of the welcome web page of EMERALD II (2000), later updated for the EMIT project.

Fig. 3.2 Screen captures of the EMERALD II e-book (from 2000) using *Netscape* browser (showing the two windows – for text and pop-up image), and screen capture (from 2015 - *Firefox*) showing the 3 HTML frames.

The new web site was very easy to navigate – it had all necessary elements – content, text and images, arranged in a very logical manner, thus very much resembling browsing a text book. The text and images could be copied and printed, and also all images could be seen in a collection using identical small icons (thumbs), as those in the Image Database. It was very easy to add the new e-books from the web site to the CD with the Image Database, thus we made three new CDs, including both (the e-Workbook and the Image Database) – Fig.3.4 (the structure of one CD with embedded web site can be seen in Fig. 5.10). The 3 new CDs were released on 27 March 2001 with their unique ISBNs as:

Emerald e-Workbook and Image Database vol.1 - Physics of Diagnostic Radiology, ISBN 1870722 10 8
Emerald e-Workbook and Image Database vol.2 - Physics of Nuclear Medicine, ISBN 1870722 11 6
Emerald e-Workbook and Image Database vol.3 - Physics of Radiotherapy, ISBN 1870722 12 4

Approximately at the end of 2000 the French National Institute for Nuclear Sciences (INSTN) ordered 20 full sets of EMERALD CD-ROMs for all 20 Training Centres in the country (later we decided to translate our future e-learning materials into French, and that was materialised in the project EMIT). The orders were now coming from various countries, Hospitals and Universities.

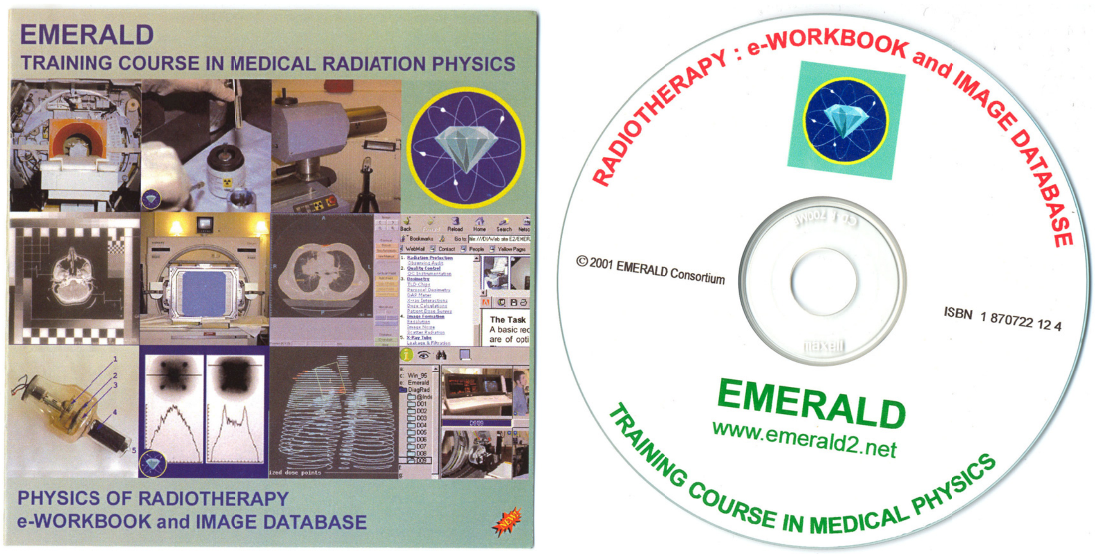


Fig. 3.4 CD cover and CD-ROM of Emerald II (e-Workbook and Image Database volume 3 – Radiotherapy), 2001

All CDs were published in our Department in London, where the Coordinator's office had become a small CD Workshop with 2 PCs for recording CDs, 2 CD Writers, 2 CD printers, Printer for the covers, cutters, etc. The empty CDs were with white printable surface. The procedure started with the CD label printed on it, after this the colours were fixed with lacquer spray, then after this the CD was recorded (copy of the master CD), after this the jewel case was made (with its back and front covers), etc. Several thousand CDs were made this way over the coming years.

The Third Consortium meeting of E2 was in London 16-17 March 2001, it followed the final E2 Workshop with users of EMERALD. During this period of time colleagues from all over Europe (as well as at the World Congress on Medical Physics and Engineering in Chicago) were confident in their use of EMERALD e-learning. Feedback was collected and the materials were updated.

The final task was again related to the preparations of the Final Report to EC. This time a completely new system for registering the Partners Contribution was required (without a guide as to how to do it). As a result, C Roberts "invented" the new forms for this system, which were not only accepted by EC, but included in all future projects as "standard". C Roberts also developed an Authoring Agreement for 5 years, which was accepted by all our Consortium members and also distributed to other EC projects as example.

The update of some of the materials was already agreed. These were from the module on X-ray Diagnostic Radiology – D Evans took the preparation of new Training Tasks on Computed Radiography, while M Lewis prepared the new Training Tasks on Spiral Computed Tomography. The tasks were soon ready and were updated swiftly on the new E2 web site. From that moment we all were confident that the future updates would be very easy.

The feedback from all previous E2 Workshops (to be described in the next chapter about EMIT project) was analysed and it was seen that there was no need of specific changes of the e-learning paradigm. All our colleagues had concluded that EMERALD was building smoothly a very consistent package of knowledge and competencies. All students were happy with the materials and we decided to test the practical use of the e-Learning materials in the ICTP International Medical Physics College in Trieste, where students from many developing countries gather every other year. As College Co-Directors, A Benini and S Tabakov were asked to speak with our partner ICTP about this possibility. This was quickly agreed and from 2002 until now all medical physics students in ICTP receive a full set of our e-learning materials.

The EMERALD II team was working very well – to use a description from *Winnie-the-Pooh*, we all felt "friends and relatives". All our project meetings were during the weekends (when also the flight tickets were cheaper) and the hard work was always completed with pleasant evenings and lots of fantastic moments – museums, theatrical/musical or other cultural events. The colleagues in our Consortium were very happy to collaborate and to show each other the specificities of life in their countries. Remembering just a few of these fabulous moments, we would mention the party in J Gomes da Silva's house in Lisbon (when we also photographed one of the oldest X-ray tubes); the Christmas dinner in I-L Lamm's house in Lund (Fig. 3.5); the celebrations with the French Society in the old city of Lille (arranged by A Noel and S Naudy); the time we spent on the new London Eye (Fig. 3.6) and the musicals in West End, London; the famous restaurant "Il Latini" and the museums in Florence; the opera in Prague, etc, etc.

The EMERALD Network had already reached 150 colleagues and the use of our e-learning materials and our web site was increasing. The statistics showed that in the period from 2002 to 2012 the web site (currently www.emerald2.eu) had been used by around 2000 colleagues per month, which is a significant number for our profession (at present, 2015, there are about 20,000 medical physicists worldwide).

Fig. 3.5 EMERALD Christmas dinner in *I-L Lamm's house*, Lund, 2001

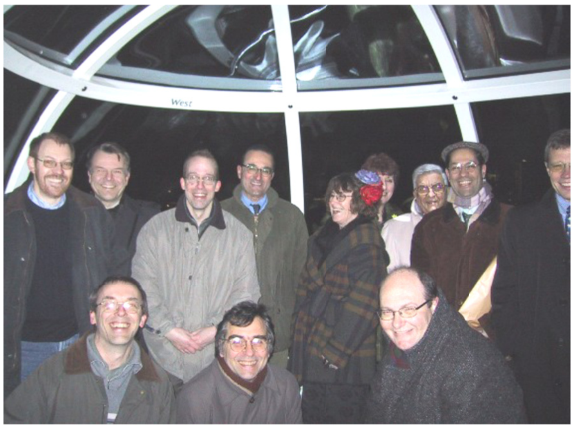


Fig. 3.6 EMERALD visit to the new London Eye, 2001

This sizable number was sufficient to pursue the idea of the Medical Physics Dictionary. We also decided to include explanation to each term, thus turning it into an Encyclopaedia. However for the moment this could have been too much for all project partners. We all were taking part in this project additionally to our everyday clinical and teaching duties and the majority of the e-learning materials were made during our free time. We decided to work on this huge task step-by step - to include in the next project only the Dictionary, and to leave the Encyclopaedia for another project at a later stage.

The new project was already clear – we should complete the initial objectives of EMERALD, thus developing the abandoned module on Medical Imaging Training. We had fantastic e-learning platform (our web site), we had all the expertise to develop e-learning materials, we had the Network of specialists, and we simply had to develop the new project. This is how we entered into the new project EMIT. Its application was developed before the submission of the Final Report to EC for EMERALD 2 (in May 2001), and was approved during October 2001. We have to add here that all our project applications were large documents (about 50 pages each) with detailed description of the project need and objectives, working phases, budget distribution, support letters, etc.

EMERALD II – Application, Evaluation and Dissemination (2000-2001)

The dissemination of EMERALD was a very important part of the project E2. It was not intended to be simply a sequence of “Train-the-Trainer” Seminars with introduction of e-learning use, but also a very good source for feedback.

Each Seminar was based on a short previous sample test/assessment of EMERALD. The structure of the Seminars covered the following general topics:

- Necessity of Medical Physics Training
- Training programmes/Initiative/Needs in the represented countries
- EFOMP/IPEM Training experience and recommendations
- Introduction to e-learning
- Introduction to EMERALD concepts
- Structure of EMERALD Training
- Workshop with use of the Image Database and Internet e-books
- Organisation of Medical Physics Training with EMERALD
- Specific training discussions in 3 Workgroups (focussing on the 3 modules)
- Feedback from Trainers (Supervisors/Teachers) using EMERALD
- Feedback from Trainees using/assessing the e-learning materials
- Possibilities for application in the represented countries
- Collection of feedback for improvement

Following the EMERALD Conference in Trieste (September 1998), a sequence of EMERALD presentations and Seminars were organised:

1999, March, London and Leeds, UK – here EMERALD participated with full presentations and demos at the IPEM Training Scheme Roadshow;

1999, March, Plovdiv, Bulgaria – here EMERALD was used as a sample case for the beginning of Leonardo Program in Bulgaria and stimulation of e-Learning activities in the country

1999, May, Birmingham, UK, at the Congress of the British Institute of Radiology – here we made the first sales of EMERALD CDs and had a boot with the e-Learning materials, visited by many colleagues;

1999, June, Tallinn, Estonia, at the 11-th Nordic-Baltic Conference on Biomedical Engineering – here we had a Plenary talk and one full session EMERALD. This was also associated with our parallel project developing joint educational courses on Medical Physics and Engineering in the three Baltic countries.

1999, September, Nottingham, UK, at the IPEM Annual Conference in Nottingham - here we organised 3 separate sessions with EMERALD (as per the three Training modules). These were accepted very well and later excellent reviews appeared in the IPEM Journal *SCOPE* (by A Rogers and E Aird).

1999, September, Patras, Greece, at the International Conference on Medical Physics – here a full session was dedicated to EMERALD and the project was invited to participate in the European Framework for Education and Training in Medical Physics and Biomedical Engineering (later EMERALD was included also in the book of this International project, Editor Z Kolitsi).

1999, October, Riga, Latvia and Kaunas, Lithuania – here full sessions and demos were made at the Annual meeting of both National Societies, introducing e-learning use in Medical Physics

2000, February, Dublin, Ireland – here a specific two-day EMERALD Workshop was held with full use and practical test of EMERALD - this was an E2 activity.

2000 June, Lille, France - here also a specific two-day EMERALD Workshop was held with full use and practical test of EMERALD - this was an E2 activity, parallel to the French National Conference on Medical Physics.

2000, July, Chicago, USA – this was our second presentation at the World Congress on Medical Physics and Biomedical Engineering, where again we had a full session dedicated to EMERALD. By this time our project had gained a name as a global supporter for Medical Physics training and at WC2000 S Tabakov was elected Chair of the IOMP Education and Training Committee.

Fig. 3.7 EMERALD II Seminar for Eastern Europe, Prague 2000 - part of delegates

Fig. 3.8 EMERALD II Seminar for Eastern Europe, Prague 2000 – working session

2000, September, Prague, Czech Republic – this E2 activity was aimed at all East European Countries and was attended by representatives of 14 Eastern European countries (Fig. 3.7, Fig. 3.8). The two-day seminar not only introduced the concepts of EMERALD e-Learning, but also discussed the development of Medical Physics in this part of the world. It was stated that during the 5 years after the Budapest Conference (1994), almost all Eastern European countries have developed their own Medical Physics University courses (at Master level).

2000, November, Lisbon, Portugal – this E2 activity triggered the largest Medical Physics Conference in the country by that time. It included again three parallel Workshops and exchange of expertise.

2001, January, Lund, Sweden – the E2 activity gathered colleagues from all Nordic/Scandinavian countries and had sessions/Workshops on the use of EMERALD for Medical Physics training (Fig. 3.9).

2001, March, London UK – this was the final activity of E2, following the established pattern with many Training Supervisors from UK (Fig. 3.10). The meeting gathered excellent feedback for the further improvements of the modules.

2001, September, Belfast, UK, at the International Conference on Medical Physics – this activity came immediately after the approval of the E2 Report to EC and again had full day Seminar with parallel Workshops.

Fig. 3.9 EMERALD II Seminar for Scandinavian countries, Lund, 2001 – part of delegates

Fig. 3.10 EMERALD II Seminar in UK (trainees and trainers), London, 2001 - part of delegates

In total EMERALD II carried out 45 dissemination activities of our e-learning materials (16 printed abstracts, 5 printed papers, 10 conference presentations, 8 dedicated sessions and 6 international seminars). These activities included hundreds of colleagues and students.

Our dissemination activities generated great interest in EMERALD (the Coordinator's emails alone, associated with these activities in 1999-2000 were about 4000), as well as demand for CDs. With the help of the colleagues from the parallel Bulgarian project ERM (A Litchev, M Stoeva, A Cvetkov) we succeeded in answering the need, by developing almost 1000 new CDs (many distributed free to colleagues to start their training activities).

When the E2 Report to EC was submitted with information from all these dissemination activities it was about a 540 page document. It took us another month to prepare and collate it – this was our largest EC Report so far (but more was to come).

The most important outcome of this dissemination was that EMERALD was now known in 30 European countries (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Rep., Slovenia, Spain, Sweden, UK, Ukraine, Yugoslavia) – Fig. 3.11.

Outside Europe our materials were presented in Australia, Armenia, Brazil, China, Israel, Malaysia, Mexico, Turkey, UAE and USA. Additionally, a number of EMERALD materials were purchased by the International Atomic Energy Agency (IAEA) through which these have been sent to other countries.

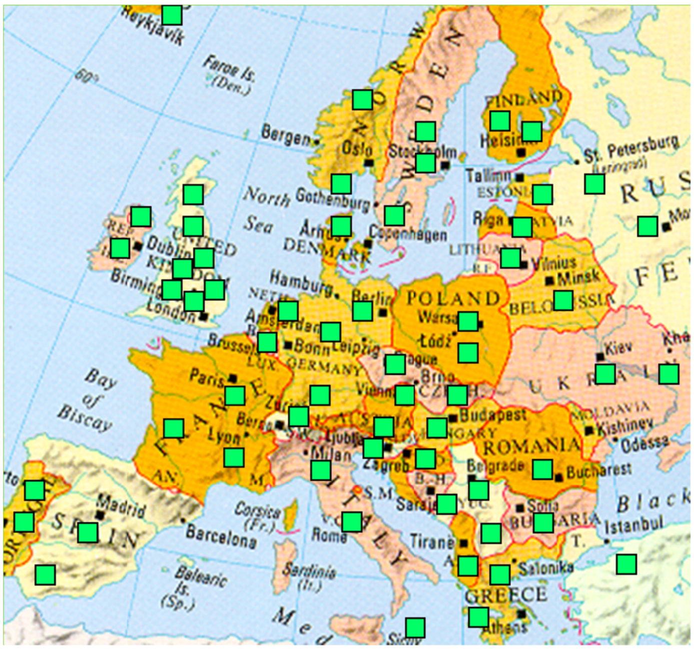


Fig. 3.11 Map of Europe with indication where Emerald was disseminated

Something very important from these seminars was the feedback we received from our colleagues all over Europe. It was covering three aspects – the Training in Medical Physics, the use of e-Learning and the EMERALD materials.

At that time the main advantages of e-learning were identified as:

- Easy inclusion of unlimited number of images
- Text hyperlinked with images allows easy learning
- Easy transport of information (on CD or Internet)
- The e-learning activities allow flexible learning
- The ready e-materials are much less expensive for publishing
- The e-learning platform facilitates regular updates
- Keyword search is possible in both the e-learning materials and the Image Database
- Browsing the CD with recorded Internet web site is easier than browsing the Internet

At that time the main disadvantages of e-learning were identified as:

- The initial production of the e-learning materials is very expensive and time consuming

- The learning from screen leads to eye fatigue (only some participants indicated this)
- The use of two computer windows (as in our e-books) could lead to distraction (again, limited number of participants indicated this)
- e-learning use requires initial investment in good computer with fast Internet link (this was a problem in 2000)
- e-learning was a new way of learning at the time, which was a concern for some conservative teachers/lecturers
- All attendees underlined that e-learning should not replace the need of a good paper book

The critics toward EMERALD were mainly related to:

- Complex training modules with large volume
- Some conservatism from supervisors to use e-learning
- Difficult implementation "as is"

To facilitate this we prepared special brochures and materials explaining that the whole training pack is made to be flexible by:

- Introduction of "own" (country specific) tasks (in such case our prescriptive tasks could be used only as examples)
- EMERALD could support various training schemes (not replacing them)
- EMERALD Training Timetables are very useful for suggesting additional areas of training (the times associated with each task were only indicative).

In general, the feedback at that time led to the following conclusions about e-learning:

- e-learning is very suitable for physics/engineering, however it is very difficult to prepare e-materials;
- Some Universities do not realise the full paedagogical potential of specific e-learning materials and use e-learning platforms mainly for Managing the educational process and Distance Learning;

- The efforts to produce specific e-learning materials are often underestimated by students and Universities;
- Blending of e-learning with classical learning is the most effective educational approach.

At that time it was also obvious from the feedback that only a few colleagues realised the cost associated with e-learning – for preparing materials, for equipping premises, for training staff and students how to use it.

Another finding was that although all colleagues found the EMERALD Image Database very useful, only a few of them used fully its potential. The possibilities for image filtering, processing, search, etc were used only if specifically shown. Similarly we had included in EMERALD some hidden Q&A for students to explore and answer, but in reality very few students went to these depths. This was quite unexpected for us, but gave us a very good lesson – in our dynamic life most people (both students and trainers) do not find time for such additional tasks. We were about to find the same with our future projects, but still do not have the answer how to deal with this problem – decreasing the dynamics of life is hardly acceptable, and the day has only 24 hours.

The practical survey on how e-learning influences the pedagogical process (a survey we made with a group of students) showed interesting results about the Training tasks we developed. We took at random 18 students from our course, which had theoretical lectures on the subject, but had never performed the practical tasks associated with the training.

The questions they were asked were related to:

- The clarity of the e-learning Training task
- The objectives set for the Training task
- How the sequence of tasks builds knowledge pack
- Is the Task pertinent to the practice
- Are the Training tasks technically correct

- Is there enough information in the Training tasks
- Is the detail in the Training tasks sufficient
- What is the overall rating of the Training task
- Would you recommend it to other trainees
- How do you assess your knowledge before the task performance (based on lectures only)
- How do you assess your knowledge after the task performance

Here below is the Questionnaire and the results from the survey – Fig. 3.12 (another group of 11 students used different tasks, from different module, and showed similar results):

Objectives						
	Unclear	1	2	3	4	Clearly Stated
	All Objectives Not Met	1	2	3	4	All Objectives Met
Content	Task sequence Poor	1	2	3	4	Sequence Appropriate
	Not Pertinent to my Job	1	2	3	4	Pertinent to my Job
	Technically Incorrect	1	2	3	4	Technically Correct
	Insufficient Information	1	2	3	4	Sufficient Information
	Excessive Detail	1	2	3	4	Detail About Right
Overall Rating	Poor	1	2	3	4	Excellent
Recommendation						
Would you recommend this learning activity to others?	Never	1	2	3	4	All the time
How would you rate your level of knowledge:						
Before the learning activity?	Low	1	2	3	4	High
After the learning activity?	Low	1	2	3	4	High

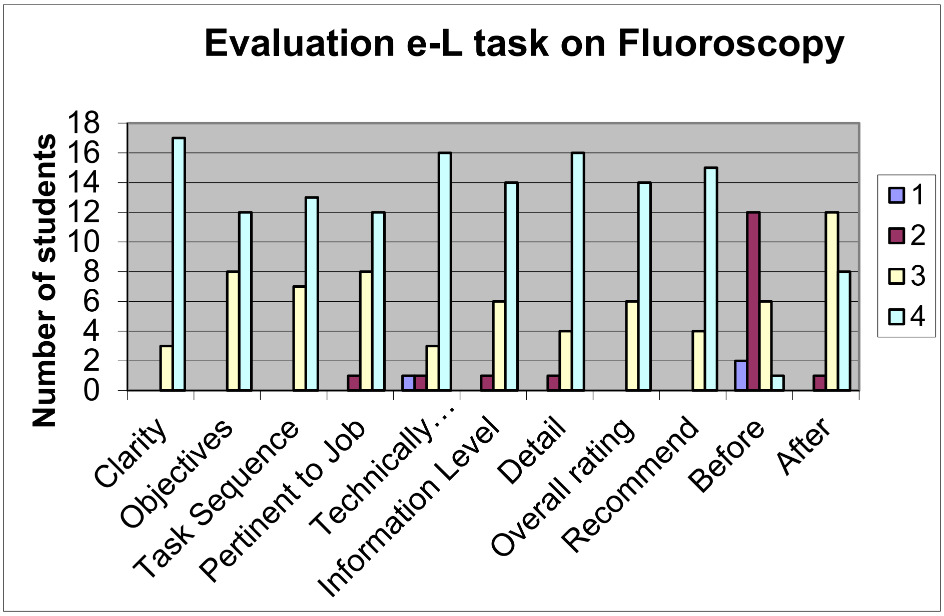


Fig. 3.12 Results from the assessment of our e-learning materials

Additionally we distributed an evaluation questionnaire to 10 experts (Training supervisors)

Here below is the Questionnaire and the Rating scale (1= inadequate, 2= acceptable, 3= good, 4= very good):

1. What do you think of the EMIT and EMERALD approach to training? 1 2 3 4
2. Do you like the way the tasks were written? 1 2 3 4
3. Are there a sufficient number of tasks? 1 2 3 4
4. Would you recommend other tasks? 1 2 3 4
5. How would you rate the image databases? 1 2 3 4
6. Will the e-learning material be useful for training/education in your country? 1 2 3 4
7. How would you rate the material as tools for e-learning? 1 2 3 4
8. Do you foresee any problems in the introduction of the e-learning material?
9. How many people would use the e-learning material in your country?
10. What would be your suggestions about future developments of the material?

All experts rated the e-learning approach to training as very good (4) and the way the tasks were written, the image databases, the usefulness of the material and how they would rate the material for e-learning were scored as either good (3) or very good (4). Nine people answered the question on whether there were sufficient tasks and only one of them indicated that there was room for additional tasks. However, five people did recommend other tasks. The problems identified included the time required to undertake the tasks and the lack of material in the participant's native language.

The number of physicists, identified as being able to make use of the material in the participant's home country, ranged from between 5 to 30 (with four people commenting that there was a much larger number of other health professionals who could use the material). Finally, suggestions for future developments included that there should be planned updates; that the material be used to train other health professional groups and that regular meetings of training providers be held to discuss and develop the material further. In addition to the evaluation via the questionnaire the experts were asked in a discussion session what the pros and cons to this form of e-learning are. The positive comments included usefulness of the additional e-learning features, flexibility and ease of update. The negative comments included eye strain, technical requirements of the computer and internet connection, and the fact that people would miss using paper books to learn.

The majority (84%) of both participants (students and experts) rated the e-learning material and its features as good or very good (ratings of 3 or 4). Both student groups reported 25-35% improvements in their knowledge, indicating that engaging with the material had been effective. All students rated the pertinence/relevance of the material highly (mean score 3.5).

E2 was completed very successfully, which paved the way for the next project approval (EMIT).

4. EC TEMPUS Projects (Medical Physics) in Bulgaria and The Baltic States

Immediately after the Budapest 1994 Conference we started an EC project in Bulgaria (ERM) in parallel with the project EMERALD. This was a natural continuation of the Conference objectives for strengthening East/West European relations. In fact, due to the earlier deadline, the ERM application was submitted to EC slightly earlier than EMERALD. We submitted the project in the newly established EC programme TEMPUS (a Trans-European Cooperation Scheme for Higher Education), one of its objectives was to support the synchronisation of Eastern European University education with this at the EU.

Project ERM – The Inter-University Centre for Education in Medical Radiation Physics

During 1988-89 we developed and presented at the MEDICON Conference in Patras, Greece (September 1989) an effective educational model for small countries starting their new education in medical engineering and medical physics, using International Education/Training Centres. For us it was obvious to use our Bulgarian expertise to start such a project. We planned the project during 1993-94 and naturally used the base of the Medical University Plovdiv (MUP) as a host of this Centre (S Tabakov had worked in the MUP, Department of Roentgenology and Radiology until 1991, had installed there the first Digital X-ray equipment in the country and was still holding an honorary position there).

Seeking a suitable name for the project we selected the name of Saint Erm (The Holy Apostle Hermas of the Seventy – pronounced Erm in Bulgarian), who was known to have been the first Bishop of Plovdiv during the I-II century AD (the city has existed for about 8000 years under various names, at that historical time it was known as Philippopolis and Trimontium). The name ERM was an excellent acronym for Education for Radiation in Medicine, which was the objective of our project. Later we celebrated St Erm several times during our project, including at the opening of our Medical Physics Educational Centre ERM under the patronage of Dr A Stoyanova (the wife of the President of Bulgaria

HE P Stoyanov, both from Plovdiv). With this high support the name of St Erm quickly entered into the life of the city. Now its feast, 31 May, is specially celebrated in Plovdiv.

We completed the project proposal soon after the Budapest Conference, including in it our new partners (all attendees at Budapest Conference) from University of Florence, Italy (led by Prof F Milano) and from Trinity College Dublin (led by Dr N Sheahan). Coordinator and Contractor of the project was King's College London, UK – (Contractor Prof V C Roberts, Coordinator Dr S Tabakov) and the Bulgarian counter-parts were the Medical University Plovdiv (the project part was led by Prof K Velkova) and the Technical University – branch Plovdiv (the project part was led by Prof L Genov and Prof G Stoilov). Later the University of Plovdiv also joined the project (the project part was led by Prof N Balabanov).

The project objective was to introduce MSc/Diploma degree course in Medical Radiation Physics plus short CPD courses in the field of radiation applied to medicine. The project was supported by SIEMENS, IAEA, EFOMP, The Bulgarian Academy of Sciences, The Bulgarian Ministry of Health and The Parliament of Bulgaria - this being one of the first projects to introduce the widely used in Europe university degree system of Batchelor - Master into the education in Bulgaria (the system previously used in Bulgaria was 'Diploma-degree', equivalent to Master and based on 5 years University education). The project was also supported by the Bulgarian Scientific Societies of Biomedical Physics and Engineering and of Roentgenology, Radiology and Radiobiology, as well as the UK Institute of Physical Sciences in Medicine (IPSM, currently IPEM).

We learned about the project approval on 15 August 1995. This was at the TEMPUS Bureau in Sofia. The project was realistic and we believed it would be approved, but at that stage we learned that only one of eight projects had been approved. Our objectives, description and budget had been found sound and necessary. Indeed after 3 years we completed the project with all planned activities fulfilled and the final budget was less than 1% different from the predicted one.

ERM was initiated during October 1995 in the Old city of Plovdiv – a very appropriate place for starting a project in one of the oldest continuously inhabited cities in the world (Fig. 4.1, Fig. 4.2).

The first year of the project was exciting and difficult, as we had to find place for the new Educational Centre and at the same time to organise all lecturers in the international team to exchange information and begin the preparations of the syllabi of the modules and the books with lecture notes.

Fig. 4.1 Old city of Plovdiv (the Roman Amphitheatre, II c AD)

Fig. 4.2 ERM project start in Plovdiv's Old city

The plan was for every module of the MSc programme to have its own textbook with lectures in English (later these books were used in many countries).

With the help of the Rector Prof A Djurdjev and the Heads of the Department of Roentgenology and Radiology of the Medical University (the past Head Prof. I Delov and the current Head Prof. K Velkova) a space was allocated within the Department to be used for the new Inter-University Medical Physics Educational Centre (Fig. 4.3). The representative of SIEMENS Bulgaria Dr V Pavlov secured funding for the renovation of the space while funding from ERM project was used for purchasing of equipment. It took just several months to prepare a teaching room for 20 students, laboratory, office for lecturers with small library, store, and another room for the visiting lecturers.

The course was developed as one academic year fully modularised course, consisting of 12 modules, divided in three parts – here below is the structure of the MSc curriculum:

- Part 1 - Basis of Medical Physics (including modules in the field of Human Anatomy, Radiation Physics, Radiation Detection and Measurements, Radiobiology);
- Part 2 - Special subjects of Medical Physics (including education on the principles and equipment of Radiotherapy, Diagnostic Radiology, Nuclear Medicine, and other Imaging modalities);
- Part 3 - Continuing Professional Development CPD (this part includes subjects on Radiation Protection, Hospital Safety, Medical Informatics and European Integration, which were open to external medical specialists applying radiation, as CPD courses).

TERM 1 (MSc Curriculum Part 1: September - December)

1. Basis of Human Anatomy and Physiology (approx. 90 acad. hours; test assessment)
2. Radiation Physics (approx. 90 acad. hours; exam)
3. Radiation Detection and Measurements (approx. 90 acad. hours ; exam)
4. Radiobiology (approx. 60 acad. hours, test assessment)
5. Physics and Equip. of Ultrasound, Lasers, MRI (approx. 90 acad. hours, exam)

TERM 2 - 1st part (MSc Curriculum Part 2: January - March)

6. Physics and Equipment of Diagnostic Radiology (approx. 80 acad. hours, exam)
7. Physics and Equipment of Nuclear Medicine (approx. 80 acad. hours, exam)
8. Physics and Equipment of Radiotherapy (approx. 80 acad. hours, exam)
9. Image and Signal Processing in Medicine (approx. 60 acad. hours, test assessment)

TERM 2 – 2nd part (MSc Curriculum Part 3: April - May)

10. Radiation Protection and Hospital Safety (approx. 80 acad. hours, tests, Certif.)
11. Medical Informatics (approx. 30 acad. hours, test)
12. European Integration (approx. 30 acad. hours, test)

Awarding Post-graduate Diploma in Medical Physics

MSc Research Thesis development (approximately 5 months)

All education was planned to be in English and this was one of the entry requirements for the students. A specific feature of the Curriculum was that it included both physics and engineering aspects of the specialist modules, thus allowing students to work, if necessary, also as service engineers – something useful for a small country. The Curriculum also included one of the first modules on European Integration in Bulgaria (its lectures by V Tabakova were later published as textbook for other Universities in the country). Each module was based on condensed delivery (1 to 3 weeks) to allow external lecturers to visit the Centre. Each module had its Bulgarian module Organiser and European module Adviser. Each Bulgarian lecturer visited his/her counterpart to adapt their model of lecturing and several Workshops were made to synchronise all modules. We were arranging all visits in the UK and all lecturers coming to London were often visiting our house - Fig. 4.4. The same was with all other visits to the other countries, which created a very good friendly atmosphere and comradeship between the lecturers. The names of all lecturers to the Inter-University Centre are listed further down, including the textbooks they authored. Together with them, we are very grateful to our family and friends in Plovdiv, who helped us enormously in the course of the project.

Fig. 4.3 Inter-University Medical Physics Centre, MU Plovdiv

Fig. 4.4 Some of the lecturers at re-training visit in London

Other lecturers also took part in the ERM project – namely from the Institute of Medical Engineering of the Bulgarian Academy of Sciences, the Medical Academy of Sofia and Sofia University (Prof. Daskalov, Prof. Dotzinsky, Prof Nentchev, Prof. Trindev, Prof. Pressianov). This intra-Bulgarian collaboration was a highly appreciated step for the quality of the curriculum of the Educational Centre. All colleagues who took part in ERM project developed 20 textbooks with specific lectures (the total volume was over 3000 pages). The publishing of the lectures will be described later.

At that time another MSc course on Medical Physics (in Bulgarian) was just initiated in the University of Shumen (North-East Bulgaria). We invited them to join the project, but due to the difference in the curricula (and language) the courses were not able to collaborate at that time.

The Bulgarian Universities in the project signed declarations allowing mutual recognition of the Medical Physics degrees, and the Diplomas were signed by the Rectors of all participating Bulgarian Universities. This way all three Universities (each having specific speciality – medicine, engineering, physics) made their first Inter-University Centre. The Universities were sharing their Laboratories for the needs of the Centre (MU allowed use of its medical equipment in the late afternoons). All lecturers received honorary status to the Centre – either as visiting lecturers or visiting professors. All these activities were approved by the Academic Councils of the three Bulgarian Universities and during the spring of 1997 the Centre was officially established (Fig. 4.5, Fig. 4.6). The teaching in the Centre and its organisation was made similar to the UK programmes (External Examiner was Dr P Smith).

The premises of the Centre were ready, most of the lecture notes were prepared, and during May 1997 we interviewed and selected our first group of 10 students. Following this we all celebrated the day of St Erm (31 May).

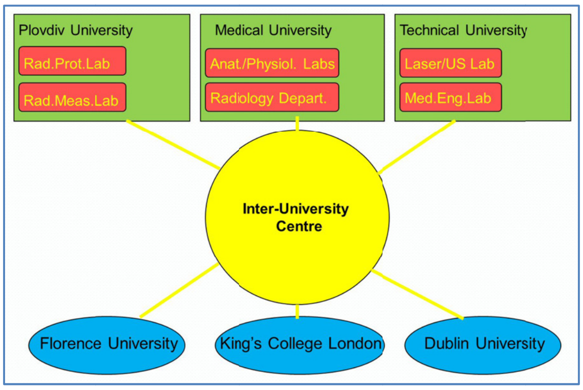


Fig. 4.5 Inter-University Centre structure

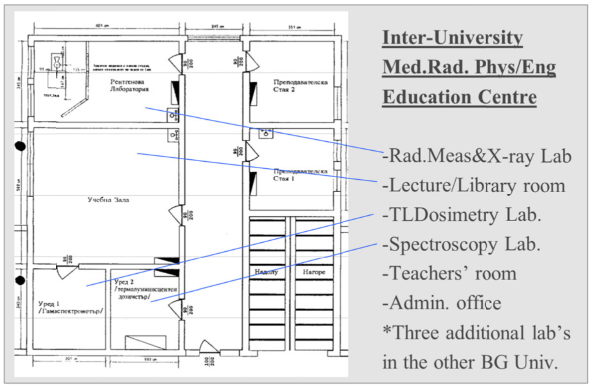


Fig. 4.6 Inter-University Centre premises

While the development of our ERM project was progressing well, the economic situation in the country was deteriorating. On one side the conditions of the EU accession included privatising of the industry, which led to selling/re-selling/closing of many factories. Although most of those factories were less efficient than those in Western Europe, they provided means of living for many people and unemployment rose to almost a third of the population. On the other side the returning of the land to their original owners (from the time before WWII) was a very positive step, but many of these people were already detached from agriculture and the food market was in poor shape. The war in neighbouring Yugoslavia and the related embargo created additional problems. Inflation during the second half of 1996 was increasing by the hour. This decreased dramatically the income and savings of the majority of the population. Many banks were closing and transfer of funds was very risky (a number of EC projects at that time lost some of their funds). In order to keep ERM going we decided to purchase a metal Bank safe in the Centre and to carry all necessary funds in cash. All of us travelling from UK to Bulgaria had to travel with thousands of British pounds in cash (up to the allowed maximum), which were later locked in our Bank safe (with 2 keys held by two separate colleagues). All expenditures from the ERM Bank safe were strictly recorded and monitored. This way the project continued successfully all its activities.

One additional activity associated with the ERM project was that at one of the visits to UK we went to Oxford with the Rector of the MU Prof. A Djurdjev to gather ideas for new gowns for the University. Based on this new gowns were made in MU. These were introduced in ceremonies of the Medical University Plovdiv from 1997/98 onwards.

Project ERM – The MSc course in Medical Radiation Physics

The official opening of the ERM Inter-University Centre and the start of its first academic year was at the beginning of September 1997. It attracted the majority of our lecturers (from all Universities), students and project supporters (Fig. 4.7). The ceremony was in the Old city of Plovdiv in the presence of the First Lady Dr A Stoyanova, a Representative from the Parliament - Dr B Kitov, MP, the Deputy-Minister of Education Dr A Totomanova, The Director of the EC Tempus office Dr S Djukendjiev, the Director of British Council in Bulgaria Mr K Lewis, The Mayor of the Old City of Plovdiv Mr D Hadjipetrov, the Rectors of the three Bulgarian Universities (A Djurdjev, L Genov, O Saparev), the Presidents of the Scientific Societies supporting the project (L Djankov, I Daskalov and V Todorov) and representatives of the City Council and other Institutions.

Fig. 4.7 The official opening of the Inter-University Centre for Medical Radiation Physics ERM, 5 September 1997

The teaching process started soon after the opening. The Centre had its small office with administrator (M Alabinova) and soon it became a focal point of discussions and meeting of colleagues and lecturers. The success of the Centre was reported at the World Congress in Nice (WC2007), together with the first announcement of the EMERALD e-learning results. The lecture notes, structure and experience of this Centre were later used in the forthcoming Tempus projects with the Baltic States and a number of other countries.

The work associated with the Centre was mounting as at that time we were running two projects (EMERALD and ERM) in parallel and this external teaching was additional to these project-related organisational activities (not to mention the double number of large annual EC Reports). However both required preparation of similar teaching materials, hence we were able to exchange materials. This way a number of colleagues from the ERM project were included additionally in the EMERALD projects and in our e-learning work in King's College London (especially contributing were A Litchev, G Belev, and later N Boyadjiev, M Stoeva and A Cvetkov). We also used the ERM MSc course to test a number of EMERALD tasks with the students in Plovdiv. At that stage we repeated an experiment we had made during 1990 (when we were developing a Medical Engineering MSc course in Plovdiv with Prof I Stamboliev) – it was a simple test to evaluate the difference between alphanumerical memory and image memory of our students. We used tasks explained verbally and explained mainly through images, and were asking the students to perform the tasks and evaluate how they had understood these. In both cases the students were showing 80% better understanding when using images - something all our lecturers knew well from practice, but we needed these small tests as a proof of the need to use Educational Image Databases (which was one of the main tasks in the EMERALD project).

At that stage we decided that to support the future of the Centre after the end of the EC funding we would need to establish a legal body associated with it. This is how we decided to set up a Foundation (we were helped for this by the lawyer B Sabev). This Foundation included as members all Bulgarian ERM lecturers and was named "Physics Engineering Medicine XXI" (Физика, Инженерство, Медицина XXI, ФИМ XXI). The Foundation was led by N Balabanov and S Tabakov. Through this Foundation, one of its functions being publishing, we arranged the proper ISBN publishing of all MSc lecture notes in medical physics (in total more than 3000 pages, Fig. 4.9). These were later transferred into PDF e-books and were sold to MSc courses in other countries (Latvia, Estonia, Lithuania, Czech Republic, Macedonia, Belarus, Costa Rica, Jamaica, Malaysia, Thailand), as income to ERM, allowing some financial flexibility of the Centre.

List of the textbooks with teaching materials:

1. Basis of Human Anatomy and Physiology (part 1), N Boyadjiev, ISBN 954 9807 12 6
2. Basis of Human Anatomy and Physiology (part 2), S Kostianev, ISBN 954 9807 13 4
3. Radiation Physics, N Balabanov, M Mitrikov, ISBN 954 9807 05 3
4. Laboratory Manual on Radiation Physics, N Balabanov, M Mitrikov, ISBN 954 9807 06 1
5. Radiation Measurements (part1) - Counting Statistics. Gas filled Detectors, A Antonov, G Belev, ISBN 954 9807 02 9
6. Radiation Measurements (part2) - Scintillation Counting. Semiconductor Detectors, A Antonov, G Belev, ISBN 954 9807 02 9
7. Radiation Measurements (part3) - Electronics for Radiation Detection, G Stoilov, ISBN 954 9807 03 7
8. Radiobiology, M Yaneva, L Michova, ISBN 954 9807 11 8
9. Non-ionising Medical Imaging - Ultrasonic Medical Instrumentation, I Daskalov, ISBN 954 9807 08 8
10. Non-ionising Medical Imaging - Lasers for Medicine, M Nentchev, E Stoykova, ISBN 954 9807 07 X
11. Non-ionising Medical Imaging - Magnetic Resonance Imaging, G Spassov, ISBN 954 9807 09 6
12. Diagnostic Radiology - Physics and Equipment, S Tabakov, A Litchev, ISBN 954 9807 17 7
13. Nuclear Medicine - Physics and Equipment, N Sheahan, P Trindev, ISBN 954 9807 01 0
14. Radiotherapy - Physics and Equipment, F Milano, E Milieva, ISBN 954 9807 10 X
15. Introduction to Signal and Image Processing, A Litchev, G Petrova, ISBN 954 9807 19 3
16. Image Processing in Medicine, I Dotsinsky, ISBN 954 9807 20 7
17. Radiation Protection and Hospital Safety (part 1), D Pressianov, P Pavlova, ISBN 954 9807 15 0
18. Protection and Hospital Safety (part 2), C Roberts, ISBN 954 9807 16 9
19. Information Technology in Medicine, G Spassov, ISBN 954 9807 18 5
20. Introduction to European Integration, V Tabakova, ISBN 954 9807 14 2

The MSc projects of the first cohort of students (Fig. 4.8) were all related to real hospital problems, which was very useful for the Medical University Plovdiv. This tradition continued with the later cohorts. During 1999 the MSc course received UK accreditation through the UK IPEM – this being the first non-UK MSc course in Medical Physics with such accreditation. The MSc course continued its delivery in English at the Inter-University Centre in the Medical University until 2003. Later it was delivered and examined in Bulgarian (however using the English text books, hence knowledge of the language was an entry requirement). Later the MSc course was transferred to the University of Plovdiv and it continues there with Director T Dimitrova (the link of the MSc with the Medical University is made through M Stoeva).

Fig. 4.8 Some of the first MSc graduates of the Inter-University Medical Physics Centre, MU Plovdiv

Fig. 4.9 The set with MSc lecture notes of ERM project

Fig. 4.10 Lecturers and students from the Inter-University Centre celebrate St Erm's Day, 31 May 2000

The graduates from this MSc course work in various hospitals in Bulgaria and abroad, some of them are now taking leading positions, but most importantly this was an excellent stimulus for the development of the profession in the country and its experience was used in other countries as well. For many years the lecturers on this MSc gathered to celebrate St Erm's Day (Fig. 4.10). In 1999 the Medical University Plovdiv bestowed upon Prof Colin Roberts (the Contractor and Manager of the project ERM) the degree Doctor Honoris Causa, for his strong support and exceptional contribution for the establishment of the Inter-University Centre (Fig. 4.11). During 2013 the Medical University awarded S Tabakov with its Honorary Medal.

Fig. 4.11 Medical University Plovdiv awards Prof C Roberts with Doctor Honoris Causa degree, presented by the Rector Prof A Djurdjev, Plovdiv, Dec 1999

Other educational projects in Bulgaria, following ERM project

During the 1990s a number of EC Educational projects (part of programme TEMPUS) were made in Eastern Europe. Dr Sonia Rouve-Uvalieva, a colleague from King's College London, was running one such language-related project. The success of ERM and her project was used by the Bulgarian Embassy in London to stimulate other similar educational projects in the country. A seminar was made at the Embassy (supported by King's College London and the British Council) which triggered further EC projects between Bulgarian and UK Universities (Fig. 4.12).

The expertise from our two projects was later used (1999-2001) for the development of additional educational projects in Bulgaria, aimed at transforming University education according to the EU requirements. One of these projects was aimed at the establishment of an European type of system for University self-assessment in the country (project Coordinator was I Minkov from Plovdiv University) Fig. 4.13. Another such project was aimed at development of European type of system for scientific research evaluation and accreditation methodology (project Coordinator was A Vutzova from the Bulgarian Ministry of Education) Fig. 4.14. Both projects were successfully completed with the active support from our Department in King's College London (C Roberts being Contractor of both projects). Dr S Rouve-Uvalieva took most active part in these projects and during 1999 the University of Shumen, Bulgaria, conferred on her their Doctor Honoris Causa degree.

Fig. 4.12 EC projects Seminar at the Bulgarian Embassy in London, supported by King's College London and The British Council, 1997

Fig. 4.13 EC project meeting for development of University self-assessment procedures in Bulgaria, Plovdiv University, 2000

Later another European Twin project (2001-2003) was made by the Ministry of Healthcare of Bulgaria aiming to prepare the country for the implementation of the EURATOM Directive (Fig. 4.15). Colleagues from the Inter-University Centre and King's College London also took part in this large project, which developed specific requirements for Radiation Safety education of various groups of professionals dealing with this subject in healthcare.

Fig. 4.14 EC project meeting for development of EU-synchronised University system for accreditation in Bulgaria, meeting in King's College London, 2001

Fig. 4.15 X-ray Quality Control Workshop, part of the EC twinning projects, Inter-Univ. Centre Plovdiv, 2003

The Baltic Project (JBMEP)

Soon after we started the ERM project a colleague from Riga Technical University (Prof. Yuri Dekhtyar), who was a delegate to the Budapest Conference in 1994, asked us to help them develop a similar project for Latvia, Estonia and Lithuania. We started working with him – these were several months hard work, but the first application in 1996 was not successful. However we re-designed the project, which was approved as a TEMPUS project at the end of 1997. This is how in the next year we started this new project "Baltic Biomedical Engineering and Physics Courses". The project Coordinator was Prof. Y Dekhtyar and the Contractor was our colleague Prof. Ake Oberg from Linköping University, Sweden.

The Objective of the project was: development of a new Joint Baltic Medical Engineering and Physics Master course (JBMEP) on the basis of developing new educational modules and restructuring of some existing modules on Medical/Biomedical Engineering and Physics (including their teaching materials) delivered as part of various MSc programmes in the universities of Latvia, Lithuania and Estonia.

The project partners were: Linköping University, Sweden (represented by A Oberg and P Ask); Riga Technical University, Latvia (represented by Y Dekhtyar, Co-ordinator and I Knets); Kaunas Technical University, Lithuania (represented by A Lukosevicius and D Adliene); Tallinn Technical University, Estonia (represented by H Hinrikus and K Meigas); University of Tartu, Estonia (represented by A. Soosaar and P-H. Kingisep); University of Latvia (represented by J Spigulis and M Auznis); King's College London (represented by C Roberts and S Tabakov).

This project started in mid-1998 and developed quite quickly - we had already lots of experience from the ERM project, and also many teaching materials were ready (both from ERM and EMERALD). The Universities in Kaunas and Tallinn already had medical engineering courses, which was very useful. The structure of the joint Baltic MSc course was different from the ERM MSc course – in the Baltic project the students had to travel (for some of the modules) between the countries, but this was facilitated by the fact that the distances were small and there were no border problems. The colleagues from the three Baltic states were enthusiastic and this created an excellent working atmosphere. The King's team also included Mr J Lee, who at that time was leading the MSc course on Medical Engineering and Physics.

Fig.4.16 Baltic Tempus project first Consortium meeting, Riga, Latvia 1998

The Coordinator Y Dekhtyar was also helped by A Katashevs and they set up a Teaching Centre in Riga. The Centre had its own laboratories (Fig. 4.20) – based on our idea from ERM project, which we were not able to realise in Bulgaria. These laboratories included old decommissioned medical equipment, which was revived and maintained for training purposes only. This was an excellent asset for the students. These activities in Latvia led to quick development of medical physics in the country. The development was very efficient and later (during 2008) Riga hosted one of the International Conferences in the profession, while Y Dekhtyar was elected member of the Latvian Academy of Sciences. Similarly the activities of D Adliene led to several excellent international medical physics educational workshops in Lithuania.

The JBMEP project purchased all teaching materials from the ERM project and all EMERALD e-learning materials. A number of the further EMIT training tasks (Ultrasound) were tested through the students there. The colleagues from this project also took part later in the EMITEL project – they were the main translators of the Dictionary terms in Latvian, Estonian and Lithuanian, as well as taking part in writing some materials for the Encyclopaedia of Medical Physics (see chapters 6 and 8). During the whole project development there was very good collaboration between the colleagues from the Baltic project and those from the Bulgarian projects and EMERALD/EMIT projects (Fig.4. 17, Fig. 4.18)

Fig.4.17 Joint meeting of the Bulgarian and Baltic projects at King's College London, 1998

Fig.4.18 Joint meeting of the EMERALD II and the Baltic projects at Prague, Czech Republic, 2000

The places of the Consortium meeting of the Baltic project rotated between the 3 Baltic countries. The first project meeting was in Riga, Latvia (Fig. 4.16), while the next one was in Tallinn, Estonia. This meeting was made as satellite to the 11th Nordic Baltic Conference on Biomedical Engineering (Tallinn, June 1999). This International Conference was supported both by the IFMBE and the IOMP and was very well attended – not only by colleagues from the European Nordic countries, but from representatives of more than 30 countries (the main organisers of the Conference were H Hinricus and K Meygas) – Fig.4.19.

Fig.4.19 The International Advisory Committee of the 11th Nordic Baltic Conference on Biomedical Engineering, Tallinn, Estonia, June 1999

The Baltic project revealed significant need for specialists in medical physics and engineering in the three countries. While EFOMP had published minimal requirements of about 20-30 medical physicists per country of this size, the rapid healthcare development in the Baltic countries predicted figures of 200-300 medical physicists and engineers per country. These figures are yet to be achieved, however ten years later the overall number of medical physicists and engineers in these three countries is around 200. Without doubt our Tempus project was playing a significant role in the education of this rapidly increased number of such professionals in the Baltic region.

The Curriculum development in the Baltic project included development of new modules and restructuring of existing modules in the Baltic Universities. This created a number of specific specialist modules (especially in medical engineering). The number of modules and their syllabi formed a considerable list of options (24 modules in biomedical engineering and 17 modules in medical physics). These were published in the following book:

Auzinsh M, Spigulis J., Dekhtyar Y., Knets I., Katashev A., Hinrikus H., Meigas K., Kingisepp P., Soosaar A., Lukosevicius A., Oberg A., Roberts C., Tabakov S., Lee J. (2000), Baltic Biomedical Engineering and Physics MSc Courses, Riga, ISBN 9984 681 52 1 (Fig. 4.21)

Fig.4.20 Lab premises of the Baltic project, Riga, Latvia

Fig.4.21 Book with Baltic Curricula and Syllabi

This Curriculum followed the requirements of the EU Bologna Declaration (accepted by 29 European countries in 1999), which aims to adopt a system of comparable university degrees. Due to this reason the Baltic MSc-level Curriculum was designed to be delivered over 2 years. Each country had the freedom to include various combinations of the optional modules, thus creating a flexible workforce. An initial form of this Curriculum had the following structure based on credits (one credit being equal to one full week of education):

First year			
First semester		**Second semester**	
Basic courses 1		Basic courses 2	
	Credits:		Credits:
1. Human and biological sciences		1. Biomedical engineering	
1.1 Anatomy	2	1.1. Med. instrumentation	3
1.2 Physiology	4	1.2. Biomechanics	2
2.Analytical methods:		1.3. Biosensors	3
2.1. Computers and modelling	3	2. Biomedical physics	
2.2. Biological signals and systems	3	2.1. Radiology	3
3. Background of medical technologies:		2.2. Radiotherapy	3
3.1. Medical electronics			
3.2. Medical physics and biophysics	3		
	3		
	18 cr		14 cr.
Advanced courses 1		Advanced courses 2	
	Credits:		Credits:
Alternatives:	2	**Alternatives**:	
1. Bioelectromagnetism		1. Signal and image processing	3

2. Radiation physics **Free elective** 1. Regulatory approach to physiology	4 (additional) 2 Cr	2. Advanced biomechanics and biomaterials **Free elective** 1. Rehabilitation technologies 2. Applied haemodynamic 3. Telemedicine	3 6 cr.
Total, credits: 20		Total, credits 20	

Second year			
Third semester		**Fourth semester**	
Basic courses 3		Basic courses 4	
1.Medical engineering design 2.Safety and standards 3.Quality assurance in health care 4.Mathematical statistics 5.Medical information systems	Credits: 3 3 2 3 3 14 cr.	Work on MSc thesis	Credits: 16 cr.
Advanced courses 3		Advanced courses 4	
Alternatives: 1. Biomedical instrumentation 2. Diagnostic radiology **Free elective** 1. Biosensors and physiological measurements 2. Radiotherapy	Credits: 3 3 6 cr.	**Alternatives**: 1. Clinical engineering and medical informatics 2. Radiation protection **Free elective** 1. Ethics 2. Management of healthcare	Credits: 2 2 4 cr.
Total, credits: 20		Total, credits 20	
		MSc Total - 4 semesters 80 credits	

The rotating Consortium meetings concluded with a meeting in Kaunas, Lithuania (Fig.4.22), where the project products were approved and its future implementation was planned.

Fig.4.22 The Baltic project Consortium meeting in Kaunas, Lithuania, April, 2000

During the whole project lecturers from the Baltic countries were visiting partners in Sweden and UK, in order to synchronise their educational practices with those in Western Universities. The project (1998-2001) paved the path for further medical physics and engineering international projects and conferences and proved a boost for the professional development in the Baltic countries.

Later the MSc programmes created in this project continued with the active involvement of Prof F Milano (Florence University), who took part in the lecturing, examination and placements (in Italy) of many Latvian students. Further F Milano transferred his experience from Bulgaria and Latvia in the development of similar medical physics courses in Ukraine (Zhytomyr University), who conferred on him their Doctor Honoris Causa degree in 2014.

5. EMIT Project - EMERALD Continuation and Medical Physics Dictionary

The project EMIT was developed as a continuation of project EMERALD. Its main aim, as per the EC application was to use the original e-learning platform of EMERALD for adding two new Training modules related to Medical Imaging - Magnetic Resonance (MRI) and Ultrasound Imaging (US). The project was submitted to EC before the completion of EMERALD II, and was approved during October 2001.

The pilot project European Medical Imaging Technology Training (EMIT) was made to support the training of medical physics graduates (primary target group) and also for radiologists, radiographers, sonographers and other users of this equipment. The training to be developed in EMIT was again planned to be structured in the same way as EMERALD and to apply our e-learning concepts. Such training resources did not exist at the time and there was a clear need for them. An additional aim of EMIT was to develop a Digital Dictionary of terms used in Medical Imaging (later expanded to all Medical Physics) – this was the beginning of the large project EMITEL (to be discussed in chapter 8).

The Consortium included as partners: King’s College London - School of Medicine and Dentistry; King’s College Hospital Healthcare Trust; University of Lund; Lund University Hospital; University of Florence; Florence University Hospital; Hospital Albert Michallon, Grenoble; the European Federation of Organisations for Medical Physics (EFOMP). This was the first EC project for EFOMP, which paved the way for future European projects for the Federation. Later the project was joined by two more partners: the International Centre for Theoretical Physics (ICTP), Trieste, Italy and the Tempus Medical Radiation Physics Centre in Plovdiv, Bulgaria (part of Medical University Plovdiv).

The new expert colleagues, who joined the project were: Dr A Simmons, Dr S Keevil, Dr C Dean, Dr D Goss, Dr V Aitken, Dr R Wirestam, Prof. F Stahlberg, Dr M Almqvist, Dr T Jansson, Dr J-Y Giraud. As in the EMERALD and E2, Project Manager was Prof C Roberts, and project Coordinator – Dr S Tabakov. The approved length of the project was two years and a half (it was later extended to 33 months).

Project EMIT – Introduction

The main parts of the EMIT project (Work Packs) were:

- Development of Training Curricula and Timetables
- Development of Training Workbooks (e-books) with Training Tasks
- Development of CD-ROMs with Image Databases
- Development of Course Guide (and its translation into 4 languages)
- Evaluation of the two Training modules (US and MRI)
- Development of a Digital Dictionary of Medical Imaging and its Translation into 6 languages
- Practical Introduction of the two Training modules
- International assessment and dissemination of EMIT through an EuroConference
- Editing and Publishing of the Project Results

This time the requirements of EC for the budgeting of the activity were different. The budget headings for e-learning development and assessment were separated from the activities associated with Consortium meetings and project management (in additional Work Packs). In fact the project organisation was similar to EMERALD and these changes affected mainly the EC reporting.

The First EMIT Consortium meeting was held in King's College Hospital, London on 15-16 February 2002. The meeting agreed on the work plan, the deadlines and the project logo (including elements of EMERALD – Fig. 5.1). It was also decided to implement a system of work allowing more EFOMP colleagues to join the project meetings.

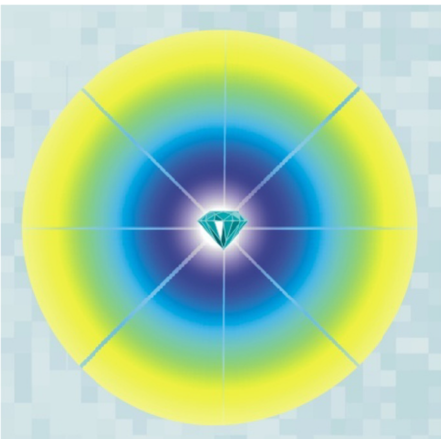


Fig. 5.1 The new logo of Project EMIT

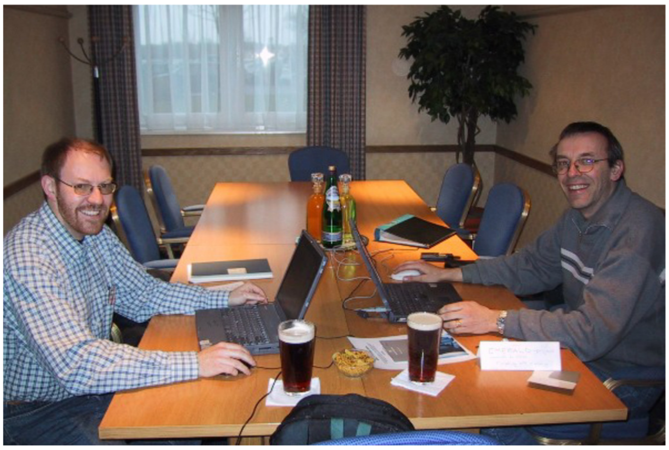


Fig. 5.2 The work on EMIT was now a pleasure (BAJ and ML)

Due to the existing experience of the partners the project was initiated before its official start by the EC. This way the Curricula of both modules (i.e. the Training Timetables) were quite advanced prior to the meeting. R Wirestam from Lund led the MR Curriculum and C Deane from London led the Ultrasound Curriculum. Specific tasks were agreed to be additionally prepared for radiographers and ultrasonographers. The system for file numbering (images, text, etc) was agreed to follow the exact principles developed in EMERALD. The collections of images were to be gathered in the Coordination office in London, where these were to be prepared for inclusion in the two new Image Databases (again using *ThumbsPlus*). The Dictionary was also briefly discussed (this will be described in a separate sub-chapter). All materials in this part of the project were to be translated in French and a group of translators was agreed (led by J-Y Giraud and A Noel).

The structure of the new Training modules was agreed – similar to EMERALD – with module length of 80 days each. The competencies were also based on the existing IPEM Competencies. In other words all EMIT training was very similar to EMERALD, but with different content (US and MRI) which allowed easier project work (Fig. 5.2).

At that stage software packages for group working over common files on the Internet were available, but the Consortium decided not to spend resources on this, as the majority of the Training tasks were to be developed by sub-Workgroups with unique specialisms. As before, all project materials were to be developed by several (mainly three) Workgroups working in parallel. The Gantt chart of the project (Fig. 5.3) was also easier than EMERALD as we knew what time and effort were necessary for almost all parts of the project.

The Second EMIT Consortium meeting was held in Lund (3-4 August, 2002). By that time EMIT had its own extended web site with Bulletin and the Consortium took additional measures for the dissemination of the project results. It was also decided, additionally to the planned EMIT EuroConference, to include extended sessions at the World Congress on Medical Physics and Biomedical Engineering in Sydney, Australia, 2003. It was also decided that the Dictionary be presented at the World Congress (as work in progress). EFOMP undertook the task to present the project at the European Congress on Radiology.

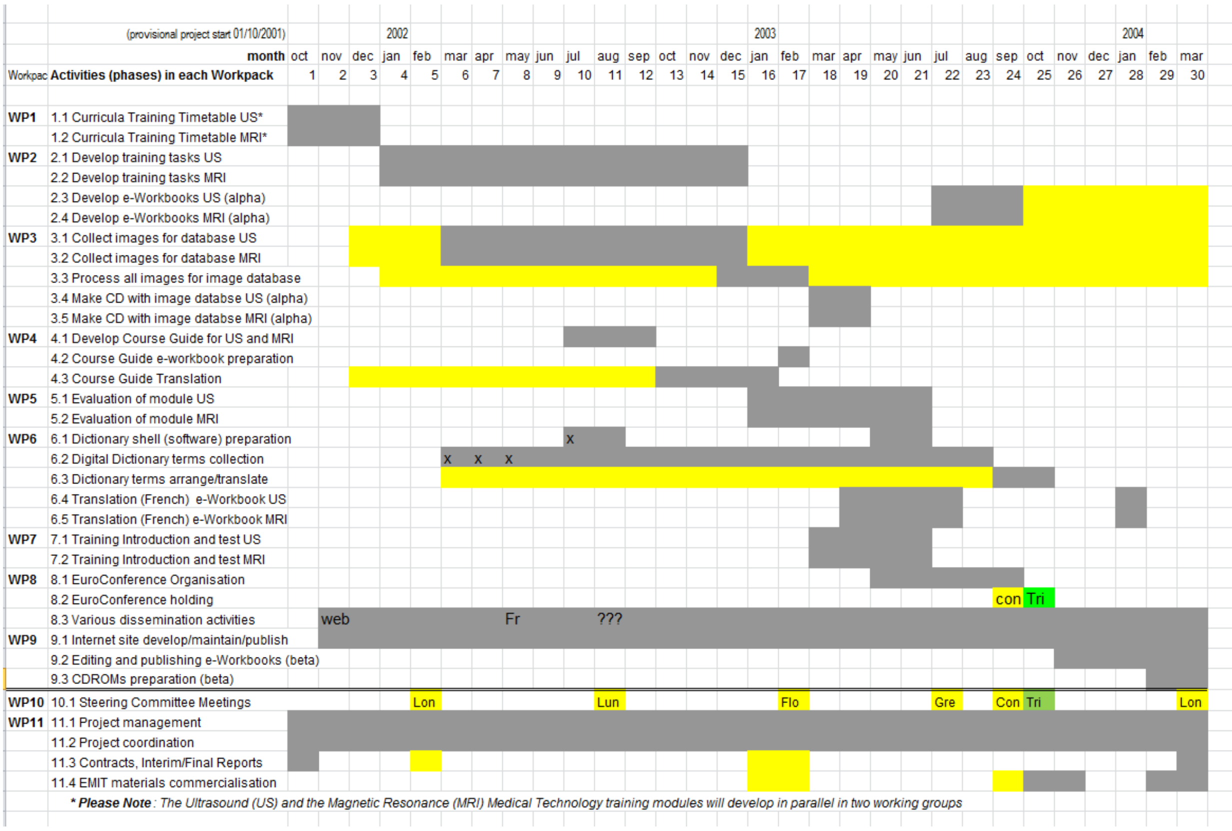


Fig. 5.3 Initial activity chart and timetable of project EMIT (as per the Work Packs – WP1 to WP11)

The MRI and Ultrasound modules were developing very well and a decision was made to include in the Training Tasks additional student exercises and demonstration cases using the powerful imaging software *IDL (Interactive Data Language)*. Small programmes were written by Consortium members to convert to JPG format the image files from the proprietary formats of different scanners.

It was decided to include, as additional partners to EMIT, the ICTP, Trieste and the Medical Physics Centre in Plovdiv, Bulgaria. As a result the colleagues from the Plovdiv Centre M Stoeva and A Cvetkov (medical physicists and specialists in software and web technologies) took part in several project activities. Our collaboration with these colleagues continued in the years to come and a lot of our software was designed by their small company AM Studio.

The web shell of the first Medical Physics Dictionary was approved and the first languages to be included, were agreed as English, French, Italian, Swedish, German. EFOMP secured the participation of colleagues from Germany (M Buchgeister and G Helms) in the Consortium.

At the end of the first project year we had to prepare an Interim Report to EC – a task which was completed as usual in London.

EMIT – e-learning testing and Thesaurus/Dictionary development

The Third EMIT Consortium meeting was in Paris (7-9 February 2003) in the historic building of the *Institut Curie* (Fig. 5.4). This and the next meeting included also the topics of translation of both EMIT Training modules in French.

Fig. 5.4 EMIT Consortium, Paris, 2003: standing from L>R: J-Y Giraud, M Ljungberg, F Milano, A Simmons, S Sheriff, P Smith, R Wirestam, C Deane, C Lewis, G Clarke, A Noel, V Aitken, M Almqvist, T Jansson, in front: S Tabakov, D Goss, C Roberts, I-L Lamm, B-A Jonsson

The Consortium started to prepare for the completion of the Training tasks. With this in mind the testing of the modules was discussed and External Referees were agreed. The *EuroConference EMIT* was also structured and specialists-delegates were identified. It was decided that the Conference be announced under the banner "*The First International Conference on e-Learning in Medical Physics*". It was also decided that the Conference additionally include representatives from IOMP and IFMBE (the International Federation on Medical and Biomedical Engineering). The venue of the Conference was to be in ICTP, Trieste (as had been the EMERALD Conference).

Something typical for these meetings was that the existing e-learning platform was an excellent boost for the Consortium confidence. We created a system of folders with e-learning materials, similar to the EMERALD one, and filled them with the new Training tasks and images for the new EMIT modules. These new systems of folders (the new e-learning materials) were hyperlinked to the new updated front page of our Training web site. This way the development of the new e-learning materials was through the Internet – all team members could see the progress of the Working groups developing the two additional sub-websites (MRI and Ultrasound). This was also very convenient for the internal testing of the modules (their web addresses were available only to project members).

This way all internal testing of the EMIT materials was online (through our web site). The convenience of this approach was that this was going on in parallel with the beta testing of the web site. After the completion of the tests we made the web address of the two modules available (with password) to all users. This test assured us that we can use our platform for various other e-learning needs.

The project was developing as per the agreed schedule and we were almost ready with the materials, when the Network server of one of the UK partners developed a fault, which also erased the backups. It was disastrous for the Hospital and for some of our new Training tasks, which had to be completed again. Since then we have never kept our materials saved only on the server and internal backup was made on weekly basis. We also arranged regular back up of our EMERALD/EMIT web site, as all ready materials were there.

The Fourth EMIT Consortium meeting was in Grenoble, France (26-27 July 2003). It discussed the tests and evaluation of our e-Learning materials by our students/trainees. All feedback was excellent. These tests were made mainly in UK and Sweden. The Image Database (this time on MRI and Ultrasound) was again found to be extremely useful. The Consortium decided to include in the Training tasks elements of the Image processing possibilities of the *ThumbsPlus* software plus a free version of the *IDL* software (with permission from the company).

The collaboration of our project with this region of France had another dimension – it supported the establishment of a new MSc programme in Medical Physics and related practical training activities at the Universities of Grenoble and Lyon.

The statistical analysis (at the time) of the use of our web site www.emerald2.net (currently - www.emerald2.eu) showed that we had around 1500 visits. This number was smaller than the EMERALD CDs produced, but in 2003 Internet was still not with easy global access as it is now. About 40% of these visits were associated with the ICTP College on Medical Physics (Sept 2002) – by the students and their colleagues. The largest number of EMERALD users was in Brazil. This was further to be developed over the years and currently EMERALD Diagnostic Radiology is being translated into Portuguese (and expanded) for use in Brazil – a project led by P Costa. Most of our users had *Windows 98* and *Windows 2000* PC Operating systems; the most often used Internet Browsers were *Internet Explorer* and *Netscape*; the most frequently used computer screen resolution was 1024x768 pixels, 16 bits (the times of the 800x600 resolution had gone).

The translations for the Dictionary were going in parallel to the e-learning development and by this time it was ready for distribution. Special mini-CDs (50 MB) with original envelopes were prepared in Bulgaria – to be disseminated free at the World Congress in Sidney. The Dictionary (at this moment in 5 languages – English, French, German, Italian, Swedish) was also issued with its ISBN 1 870 722 20 5. The mini CD-ROM with the Dictionary in 5 languages was published on 24/7/2003 (Fig. 5.5).

A full session on e-Learning was included in the World Congress WC2003 in Sydney. With this the Consortium planned further expansion of the EMERALD and EMIT use in Asia. S-E Strand prepared additional materials for the dissemination of our e-learning in China.

It was decided to open fully the Dictionary for additional languages. It was also decided that the final stage be the translation of the EMIT materials in French. At that stage the Consortium considered the use of Translation software but this was soon abandoned as all “automatic” translations were below the accepted quality. At the time of writing (2015) automatic language translation is still a challenge.

The EuroConference EMIT - *The First International Conference on e-Learning in Medical Physics* – was held in ICTP, Trieste, 9-11 October 2003. Experts from 26 countries took part in it. Additionally we invited students/trainees who had used EMIT to share their experience.

Fig. 5.5 The Medical Physics Dictionary (mini CD and its sleeve), as distributed at the World Congress in Sydney, Aug 2003

This large evaluation activity included also the reports from the External assessors (for MRI: S Keevil and P Vestergaard; for Ultrasound: C Oates and A Evans). The Training tasks were discussed in detail in two separate Workshops with experts, additionally the overall provision of Medical Physics Training was discussed (with emphasis on the EFOMP activities in Europe). The Conference also included specialists from the USA (P Sprawls, representing AAPM and IOMP), from Asia (A Krisanachinda, representing AFOMP and IOMP) and from IFMBE (R Magjarevic, representing Croatia and IFMBE). All delegates to the Conference received CDs with the e-Learning materials and explanation about their structure (Fig. 5.6).

The overall opinion was that the common structure adopted for all of the Training tasks will present the trainees with a consistent and familiar format that will enhance their learning. As before the modular design of the Training and the many images were highly appreciated. The inclusion of parts of *Power Point* slides was also accepted well, but some drawings needed to be improved. The necessity of more content related to safety was also discussed, as well as the inclusion of more theory (the modules included mainly lists with recommended textbooks).

Obviously there was a need for some theoretical explanations, although this was not the aim of the Training modules. At this stage we decided to introduce the concept of Medical Physics Encyclopaedia. This was accepted extremely well, (while understanding the potentially huge amount of development work). This was an excellent indication that the idea would be supported (which was materialised in our next project EMITEL).

The Dictionary was accepted very well and many colleagues decided to add to it their own languages. This way at the Conference a number of new Language Groups were created for expanding the Medical Physics Dictionary (similar response was received at the World Congress in Sydney, 2003 where the mini CD with the Dictionary was distributed). These two events were a major boost for the inclusion of new languages into the Dictionary.

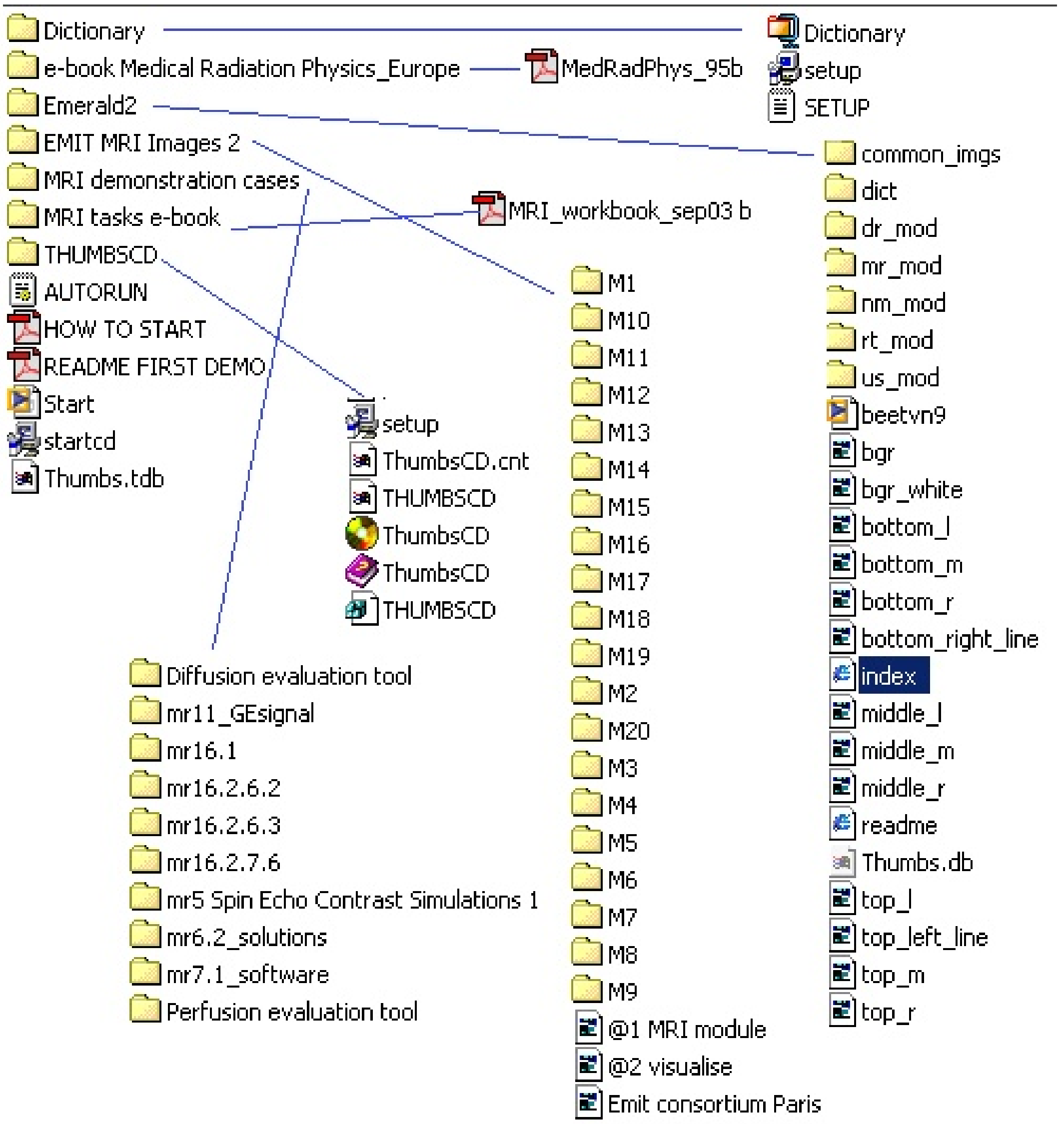


Fig. 5.6 Structure of the EMIT e-Learning CD (MRI module), including the Dictionary, the Image Database, *ThumbsPlus*, the Training Tasks and additional demonstration cases and simulations.

The EMIT Conference (Fig. 5.7) discussed extensively the students' experience in using e-learning and firmly supported its effectiveness in Medical Physics: the need of images was easily satisfied with e-learning materials; the dynamic development of Medical Physics was firmly supported by the easy update of the e-learning materials; the students acquired easily the necessary knowledge and skills through e-learning; the students had no problem with using e-learning materials. The assessment of materials by students showed more than 30% improvement of their knowledge, compared with use of conventional methods. Interestingly all, teachers and students, were supporting a blended delivery of classical and e-learning. This was also the opinion of the Consortium, and we were happy with this unanimous support. Currently blended delivery is a widely accepted educational method.

A very important decision of the EMIT Conference was that at the end the delegates signed a Declaration of Intent for cooperation between all colleagues to develop further Education and Training in Medical Physics (Fig. 5.8).

Following the EuroConference the Consortium asked for three-month extension of the project deadline, which was granted. One unexpected event at this stage was the retirement of Prof C Roberts, whose experience in project management was an excellent asset for our projects. The Coordinator Dr S Tabakov took his role alongside the coordination and reporting to the EC.

Fig. 5.7 Delegates at the EMIT EuroConference on e-Learning in Medical Physics, ICTP, Trieste, 2003: Standing from L>R: C Lewis, C Deane, A Cvetkov, C Oates, T Jansson, D Goss, G Helms, S Keevil, M Buchgeister, M Stoeva, C vaan Pul, G Clarke, K Nagyova, A Krisanachinda, P Sprawls, Dr Nick Fernando Poutanen, J Young, Y Ider, A Milan, A Rosenfeld, A Simons, R Wirestam, I Hernando, V Gersanovska, P Zarand, P Caplanis, F Stahlberg, C Etard, N Fernando, R Stollberger, P Smith, F Milano, A Lukoshevicius, V Aitken, E Perrin, A Evans, A Briquet, C Bigini, A Paats, M Almqvist, G Boyle, F Fidecaro; in Front: C Roberts, J-Y Giraud, Mr L Torres, S Riches, S Tabakov, I-L Lamm, M Radwanska, S Naudy, R Magjarevic, L Musilek, T Wehrle

DECLARATION OF INTENT

We all participants at the European Conference on Medical Physics Training (Magnetic Resonance and Ultrasound Imaging), organized by EU Leonardo Project EMIT at the Abdus Salam International Centre for Theoretical Physics, ICTP, Trieste, Italy (10-11 October 2003), underline the very important role of Medical Physics Training for the effective and safe use of medical imaging equipment in healthcare.

The education and training in Medical Physics is vital for the development of healthcare and we highly appreciate the activities of the European Union, IAEA, ICTP, IOMP, IFMBE, EFOMP and other international and national institutions in this direction.

We declare our intend to collaborate in the development of various initiatives in education and training, including e-Learning, related to medical technology (in its medical physics, medical engineering and medical application aspects), which will complement and integrate existing programmes. In this connection we agree to form a Network, which will facilitate our aim to harmonise activities and opportunities available to students and colleagues working in healthcare throughout Europe and other countries.

11 October 2003
ICTP, Trieste

Signed by:	Representing:
J. A. Evans	
Ladislav Musilek	Czech Technical University in Prague
(Y. Z. Ider)	Bilkent University Ankara Turkey
Elke Rosenfeld	FH Merseburg, University of App. Sci Germany
Arūnas Lukoševičius	Kaunas University of Technology, Lithuania
St Keevil	King's College London
[illegible]	AGH University of Science & Technology Krakow, Poland
CRISTIANO BRAGUIN	INFM, UNITÀ "TOR VERGATA" ROMA ITALY
[illegible]	St. James's Hosp, Dublin
Jo Young	King's College Hosp, London
Gill Clarke	King's College Hospital, London.

Fig. 5.8 Main (first) page of the Declaration of EMIT EuroConference on e-Learning in Medical Physics.

The Fifth EMIT Consortium meeting was in London (5-6 March 2004). It approved the edited materials after the EuroConference and assessed the progress of the translation of the Training tasks in French. Due to the parallel editing and translation, a system was made for incremental synchronisation between edited and translated tasks. Again the modification of the file names (as per the stage of development) was very important for keeping track of our activities.

At this meeting we decided on the content of the two EMIT CDs (with e-books and Image Databases), on their CD covers and the unique ISBN numbers for each CD.

From the beginning of our projects we were extensively using the *MS Windows Explorer* programme for dealing with large number of files in separate groups. We were using change of folder icons (colours and shapes to indicate various stages of the files in the folders), as well as the field Comments for any additional information. Later we used also the file management software *PowerDesk*, which additionally allowed print of folders and their content.

During the final stage of the project our efforts were concentrated on the update of the Thesaurus/Dictionary. Most of the time of our last Sixth EMIT Consortium meeting (28-30 June, 2004, Florence) was devoted to this question (several colleagues joined us over VideoConference from Lund). At this stage we completed the Medical Physics Thesaurus (in English) and later updated the current translations. The idea for the Encyclopaedia was now firmly established. We prepared the draft of the new project EMITEL and during 2005 discussed it with the UK Leonardo Office. It was agreed that the work on this huge project begin in 2006. During 2005 the Dictionary translations continued and the number of languages doubled (to the original French, Italian, Swedish, German we added Spanish, Portuguese, Polish and Thai).

One task however was still in front of us – the final report (Fig. 5.9). This was the largest of all Final Reports as we had to collect, additionally to the normal documents, all receipts for all expenses of all Consortium members (from new laptop to cup of coffee or bus ticket). It was a very difficult task, but as usual finely completed by us and approved quickly by the EC.

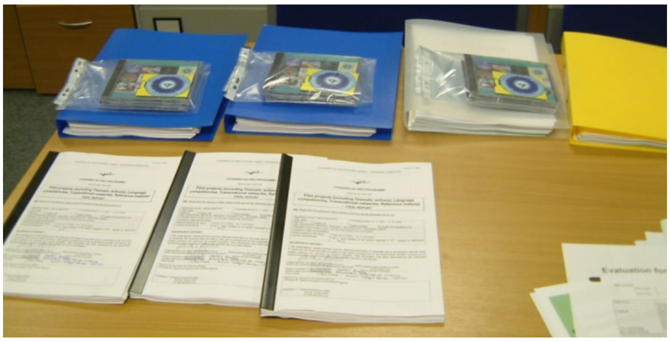


Fig. 5.9 The final EMIT report to the EC – the unseen part of any project (with several hundred pages).

EMIT Results

The project EMIT developed two training modules (on MRI and Ultrasound Medical Imaging) each with a common length of 4 months (80 days) – as in project EMERALD. During this time the trainee would have to acquire most necessary professional skills - this is the "condensed" part of the training which can be performed in most countries where training conditions are set up. Further the trainees can spend up to 2 months in their own country/state where they can additionally study the local Regulations and professional requirements.

A. EMIT Training modules – An overview

Each EMIT training module incorporates:

- List of Competencies (based on the UK IPEM scheme);
- Student Workbook with tasks (leading to competencies);
- Structured Timetable (Syllabus approx. time for each task).

Each training task contains explanations and protocols to be followed and requires answers to specific questions and problems. All tasks have a similar structure: Objectives; Competencies addressed; Equipment and Materials; Procedures and Measurements; Calculations; Observations, Questions and Interpretations; References. Similarly to the previous training pack EMERALD, EMIT allows high flexibility – i.e. the tasks can be used "as is", or complemented by the supervisor with other tasks following local procedures. A Course Guide was developed, aimed at helping the training supervisor. All EMIT e-learning materials are translated in French.

As in the EMERALD project the main types of EMIT tasks are:

-Observing real activities and taking notes

-Using existing Regulations, Protocols, Software

-Using various types of measuring equipment

-Understanding the basic characteristics & parameters of equipment

-Performing Measurements, Collecting Results, Calculating Parameters and other activities most often related to Quality Control (QC).

-Full Assessment of various Equipment

EMIT e-learning materials are now available free to all colleagues through:

http://emerald2.eu/cd/Emerald2/

B. Diagnostic Ultrasound Imaging Module

The Ultrasound printed Workbook includes 327 pages. The 54 training tasks in the Diagnostic Ultrasound Imaging Physics Workbook are grouped in the following chapters:

- Introduction to Ultrasound imaging systems, basic physics
- Introduction to Doppler ultrasound
- Introduction to clinical instrumentation
- B-mode ultrasound. Principles and factors affecting image quality including phantom measurements
- Spectral Doppler continuous and pulsed wave systems – principles and implementation
- Colour flow methods – principles and implementation
- M-mode – principles and implementation
- Safety of ultrasound, standards and measurement
- Measurement of total acoustic power
- Measurement of acoustic pressure and intensity
- Quality assurance - B-mode standards and techniques
- Quality assurance – Doppler /colour Doppler techniques
- Ultrasound image storage
- Blood flow and Doppler measurement
- Transmission techniques (ToF, attenuation , f-dependent attenuation)
- Contrast agents, physics, clinical use, safety
- 3-D ultrasound, methods, applications, QA

- "New techniques" in ultrasound imaging
- Purchasing, specification, evaluation and maintenance
- General medical applications
- Small parts applications
- Obstetrics applications
- Gynaecological applications
- Vascular applications
- Cardiac applications
- Therapeutic and interventional ultrasound

C. Magnetic Resonance Imaging module

The MRI printed Workbook includes 185 pages. The 50 training tasks in the Magnetic Resonance Imaging Physics Workbook are grouped in the following chapters:

- Introduction to the MR unit. Coil systems and corresponding magnetic fields. Software, graphical user interface, acquiring basic MR images. Patient information.
- Getting acquainted with available pulse sequences
- Designing and manufacturing a gel phantom for investigation of MRI signal and contrast
- MRI signal and contrast using basic pulse sequences. Influence of tissue and pulse-sequence parameters
- Image quality parameters (signal-to-noise ratio, field-of-view, bandwidth, spatial resolution, etc.)
- Basic k-space properties (simulation study)
- Investigation of advanced pulse sequences
- Image artefacts in MRI
- Properties of contrast agents in MRI
- MR angiography (MRA) and flow quantification. Pulse sequences and evaluation (MIP, MPR, etc.)
- Pulse sequences and evaluation routines in MR spectroscopy (MRS)
- Overview of clinical applications
- Comprehensive quality control/quality assurance (QC/QA) programme for MRI and MRS
- Image file transport protocols. Network issues. MR image formats and image storage
- Post-processing of MR images. Perfusion and diffusion maps. Functional MRI (fMRI)
- Safety issues, guidelines, normal policy and legislation
- Patient safety

- Safety regarding surrounding equipment and implants: Methods for testing the MR compatibility of various devices with respect to ferromagnetism (translational forces and torques), heating, image artefacts, etc.
- Commissioning and purchasing routines.

D. EMIT CD-ROM Image Databases

As in EMERALD the digital Image database (IDB) of EMIT is an important part of the results (Fig. 5.10). The volume of the IDB is about 1700 images of equipment and its components; block diagrams and graphs; QA procedures and measuring equipment; test objects and image quality examples; typical clinical images and artefacts, etc. A PC type image browser (*ThumbsPlus*) is used for quick and easy search through the IDB. The browser presents each image as a slide, which can be further viewed in its original JPEG size. Each image is visualised with a corresponding caption, on which basis a Keyword search can be performed. The IDB is engraved on 2 CD-ROMs.

Additionally the above Training modules were published as e-books and engraved together with the Image database on two CD-ROMs (one for each module).
The MRI e-book and IDB CD-ROM structure includes about 4600 files.
The Ultrasound e-book and IDB CD-ROM structure includes about 8900 files.
CD-ROM EMIT – Ultrasound Imaging (Guide, e-book, IDB) ISBN 1 870 722 14 0
CD-ROM EMIT – MRI (Guide, e-book, IDB) ISBN 1 870 722 13 2

Both combined CDs were published on 13/8/2004. Each CD-ROM also included our Dictionary of Medical Physics (translating to/from 7 languages - English, French, German, Italian, Swedish, Spanish and Portuguese).

E. Course Guide (Teachers' Guide)

The EMIT programme has been prepared with the intention of using it widely at centres throughout Europe. To achieve consistency of use the programme includes a Course Guide which provides recommendations for its use. These include instructions for the supervisor on monitoring and assessing the progress of the trainee. The Course Guide also includes a section which discusses safety aspects of MRI and Ultrasound Imaging. The Training timetables (Syllabi) for both modules are also included in the EMIT Course Guide. The Guide is made to be very similar to the EMERALD Guide, thus providing a common training framework (see chapter 2 for its Content, the difference was only in the part related to Protection – this time covering Ultrasound and Magnetic Resonance).

F. Training web sites

Two special web sites were developed, holding the e-books with image collections. These were merged with the existing EMERALD web site, thus forming a common web site for all five Training modules (X-ray Diagnostic Radiology, Nuclear Medicine, Radiotherapy, Magnetic Resonance Imaging and Ultrasound Imaging). The web sites also include the two Teachers' Guides – for EMERALD and for EMIT materials. The web site was originally at http://www.radfys.lu.se/emerald2/ , later moved to: www.emerald2.net and currently at www.emerald2.eu - free access : http://emerald2.eu/cd/Emerald2/

Fig. 5.10 EMERALD and EMIT CD-ROMs with sample CD jewel boxes (and CD covers). The content of one CD (DR) is shown on left, including the IDB (folder DiagRad) and the Web site with e-books (folder Emerald2)

G. Thesaurus and Dictionary of Medical Physics

In order to achieve wide European usability, the EMIT project produced a Digital Dictionary of terms covering the whole field of Medical Imaging Technology (ionising and non-ionising radiation) plus Radiotherapy and Radiation Safety. This was initiated with the creation of a Thesaurus, including c. 3700 terms (in English). These were translated initially in 4 languages (French, German, Italian, Swedish), and later further translated to Spanish and Portuguese (soon after this two more languages were added - Polish and Thai). The collection of terms for the Thesaurus is made by the teams taking part in both projects EMERALD and EMIT. The shell of the e-Dictionary has been made together with the Inter-University Medical Physics Centre in Plovdiv (by AM Studio). The Digital Dictionary is available on the Internet (the web site of EMERALD and EMIT), currently together with the Medical Physics e-Encyclopaedia – www.emitel2.eu

H. Conclusion

The original EMERALD e-learning concept was applied in the EMIT project. Almost everything in the EMIT e-learning materials (and their form) was original. Now, more than 10 years from its first publishing, EMIT continues to be used on a daily basis by colleagues from all over the world (together with the EMERALD materials). About 1000 CD-ROMs EMIT have been produced and distributed to colleagues from various countries. By 2003 our EMERALD and EMIT results were disseminated in 65 countries. By 2015 all our e-learning materials (including also the Dictionary and Encyclopaedia) reached more than 100 countries (Fig. 5.11).

The EMIT Project produced the world's first training materials on MR and Ultrasound Imaging. It also produced the first Thesaurus and Multilingual Dictionary of Medical Physics. Currently these are translated into 29 languages and have more than 2000 users per month.

From 2012 the EMERALD and EMIT web site with e-Learning materials is free for use by all colleagues. In future the update of these e-learning materials will be handled by the IOMP (International Organisation for Medical Physics) aiming to support the global development of the profession.

The following ISBN numbers were assigned to the EMIT materials:

EMIT Training Course Guide (incl.Curricula)	ISBN 1 870 722 15 9
EMIT Training Workbook (e-book) on Ultrasound Imaging	ISBN 1 870 722 19 1
EMIT Training Workbook (e-book) on MRI Imaging	ISBN 1 870 722 18 3

CD-ROM EMIT Image database on Ultrasound Imaging	ISBN 1 870 722 17 5
CD-ROM EMIT Image database on MRI Imaging	ISBN 1 870 722 16 7
CD-ROM EMIT – Ultrasound Imaging (Guide, e-book, IDB)	ISBN 1 870 722 14 0
CD-ROM EMIT – MRI (Guide, e-book, IDB)	ISBN 1 870 722 13 2
EMIT Medical Physics Dictionary	ISBN 1 870 722 20 5

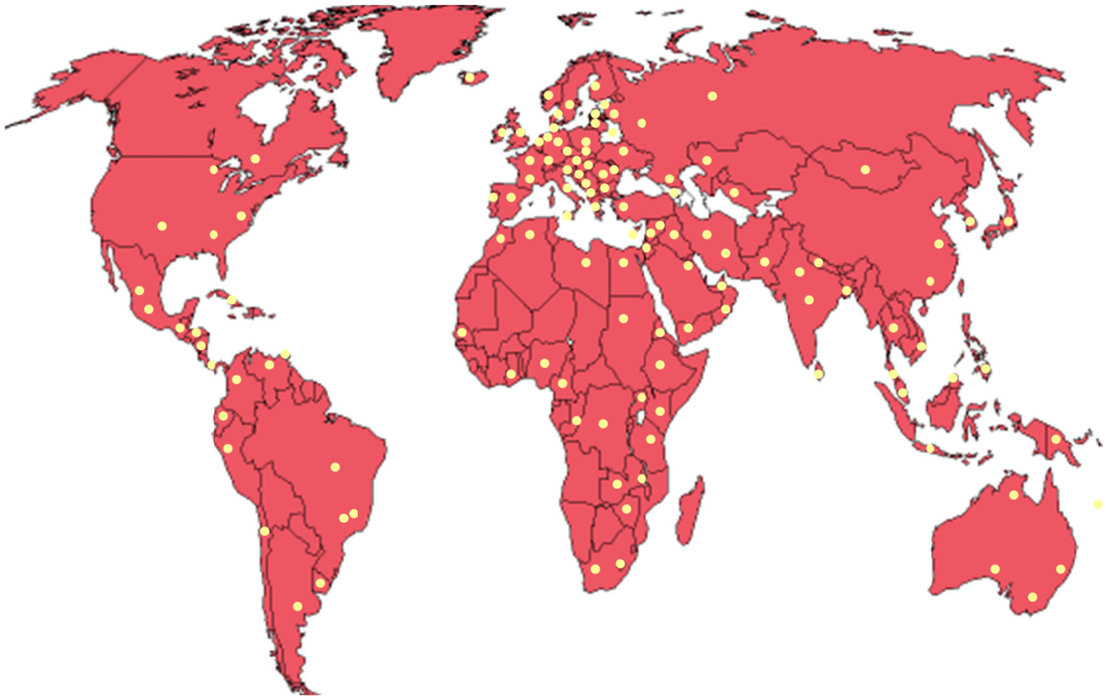


Fig. 5.11 EMERALD, EMIT and EMITEL materials disseminated in more than 100 countries.

The EU Leonardo da Vinci award (2004)

In early 2004 EMIT members from the UK team attended a large EU Leonardo Conference in Birmingham, which gave an overview of many EU-funded projects in education and training. The following features became clear: the number of e-learning projects had now increased considerably; the majority of those projects were developing training courses lasting several days only; many of the projects were implementing existing e-learning software platforms (and were subcontracting the actual task of e-learning); only a few projects were using original software design. Members of the Lund EMIT team had gathered similar information in Sweden.

In this light our projects EMIT and EMERALD appeared to be very strong with their materials covering a total of 400 training days (5 modules, 80 days each). The complexity and innovation of our original e-learning materials added a further strength to our projects.

This internal assessment which EMIT Consortium did was very timely as during the spring of 2004 the inaugural European Award for Vocational Education (The Leonardo da Vinci Award) was announced by the EU. It was decided that it would be viable and logical to file an application for the Award. The application was prepared in London and submitted to EU in June 2004 with the support of the UK Leonardo Office (at that time the UK officers providing help in various project management issues were mainly K Egriboz, G Pinkstone, F Izaki, N Wajda, R Hoy and K Jacques) – Fig. 5.18.

In October 2004 we were informed that the EMIT project was shortlisted together with 31 other projects. It was at this stage when we realised the scale of the inaugural EU Leonardo Da Vinci Award. It covered 10 years with more than 4000 educational projects. Several hundreds of projects had applied for the Award, 165 had been long-listed and of these 32 had been short-listed. The next stage included presentation of all shortlisted projects (including EMIT) at the high level Conference "Strengthening European Co-operation in Vocational Education and Training", held in Maastricht, The Netherlands, on 14-16th December 2004 (part of the summit of all European Ministers of Education). The event was organised by the Directorate General for Education and Culture of the European Commission together with the European Union Dutch Presidency. It was co-hosted by the new EU Commissioner for Education and Culture, Mr Ján Figel and the EU Dutch Presidency, represented by their Minister of Education, Culture and Science, Mrs Maria van der Hoeven.

This was a really impressive achievement for the project and there was a very quick media reaction to this. There was a call from the team of the *EuroNews* TV channel to arrange a filming session about the EMIT project in the coordinating Department of Medical Engineering and Physics of the UK partner – King's College London. The film featured most of the staff at the Department, including trainees medical physicists and ultrasonographers.

S Tabakov and C Lewis were going to do the presentation and prepared posters, flyers, CD-ROMs and other supporting materials. On arrival in Maastricht we had just set up the stand allocated for EMIT, when the Jury for the Award visited us. By the questions they asked we could see that the prepared materials and the scale of the project were making an impression on them. The cross-translating in the Dictionary between 7 languages was demonstrated at the end of the interview and that, together with the number of countries using the project results, was obviously a highly appreciated feature. Now, 10 years later, our Dictionary of Medical Physics with a cross-translation between 29 languages (in 8 alphabets) has retained its cutting edge not only in the field of Medical Physics but also among other professional Dictionaries. Soon after the Jury, the EMIT stand was visited by Mr C Clarke, the then UK Secretary of State for Education and Skills, who congratulated the EMIT team on the high standard of the achievements (Fig.5.12).

On 15 December 2004 was the special gala ceremony, held in the impressive building of Fort Saint Pieter. At this special event, in the presence of almost all Ministers of Education from Europe, the EMIT project was announced as the first among the three winners - recipients of the Leonardo da Vinci Award - Fig.5.14. In the words of the Jury *"… these e-learning materials are unmatched in their breadth, depth, and impact, and the dedication of the EMIT team is very impressive…*".

Fig. 5.12 At the EMIT stand in Maastricht – C Lewis and S Tabakov with Mr C Clarke, Secretary of State for Education and Skills, UK 2002-2004

Fig. 5.13 Presenting the EU Leonardo Award by Mr Van Der Pas – the Director General of DG XI of EC (Education, Training, Culture and Multilingualism)

The Award was presented by Mr Nikolaus van der Pas, Director General of Education and Culture of the European Commission, Mr Mark Rutte, Dutch State Secretary of Education and Mrs Jane Davidson, the Welsh Minister for Education and Lifelong Learning (Fig.5.13).

One of the immediate effects of the Award was the increased visibility of our profession among politicians and other officials visiting the Conference. On the next day the EMIT stand attracted a lot of attention and many politicians were interested to learn in more detail about the subject of medical physics. The media coverage of the Leonardo da Vinci Award was impressive – it was on all EuroNews for several days. This Award also paved the way for our next and largest project – EMITEL – the Encyclopaedia of Medical Physics.

Fig. 5.14 The Leonardo da Vinci Award Certificate

Fig. 5.15 The UK EMIT team with the Leonardo da Vinci Award: L>R: standing: L Blache, C Lewis, S Tabakov, A Simmons, C Deane, D Goss; sitting: V Tabakova, G Clarke, V Aitken (missing: C Roberts, S Keevil)

Fig. 5.16 The Lund EMIT team with the Leonardo da Vinci Award: L>R: standing: M Ljungberg, B-A Jonsson, S-E Starnd, F Stahlberg; sitting: M Almqvist, R Wirestam, I-L Lamm (missing: T Jansson)

The Award statuette was a beautiful engraving of one of Leonardo's drawing – the wing from the "Flying Man" (Fig.5.17). As an acknowledgement to all teams participating in the EMERALD and EMIT projects, replica statuettes were produced. A special copy of the Award was presented by C Lewis to the

European Federation of the Organisations for Medical Physics (EFOMP, one of our project partners) at the International Medical Physics Conference ICMP2005 in Nűrnberg, Germany.

Fig.5.17 The original EU Leonardo da Vinci Award statuette

Fig.5.18 The UK Leonardo Office team celebrates the Award of the EMIT project.

6. Thesaurus and Multilingual Dictionary Development

Introduction

The quick international dissemination of the e-Learning materials of project EMERALD led to the need of a Multilingual Dictionary of Medical Physics. To address this need a sub-task was added to the next project EMIT– creation of a Dictionary of Medical Physics. Initially the Dictionary was planned to include 5 main languages (English, German, French, Italian and Swedish), however after the first announcement of the Dictionary a number of colleagues from other countries volunteered to include their languages and by 2013 the Dictionary included 29 languages in 8 alphabets.

Initial discussion was held about the name of this project. As per the Oxford Dictionary, a Dictionary is "a book that lists (usually in alphabetical order) and explains the words of a language, or gives equivalent words in another language". Clearly we were doing a list of words with their equivalents in other languages, hence we were preparing a Multilingual Dictionary (later in the description of the project we shall use only the term Dictionary). This project aimed to translate the Medical Physics terms (words) to several languages, but also it aimed to clarify some terms, described with different words in different publications (e.g. the X-ray tube Effective focal spot, named also Apparent focal spot, or Optical focal spot), or some terms often used with their abbreviations (e.g. ADC, which could be Analogue to Digital Converter, or Apparent Diffusion Coefficient), or some words with various meaning according to the field of use (e.g. Attenuation in Radiation and in Ultrasound). This way in the formation of the initial list of Medical Physics terms (in English), we were listing these with their synonyms – i.e. our initial list of terms could be described as a Thesaurus. This term fitted both our immediate aim, as well as our long-term goal, as Thesaurus, in its narrow sense, does not give a definition of the words (what is often the case with a Dictionary). At the same time Thesaurus (coming from the Greek *thesauros*, meaning *treasure*) is sometimes used as synonym of Encyclopaedia (and we planned in future to explain each term in more detail, hence the final goal was an Encyclopaedia of Medical Physics). Using this logic the Consortium decided that the initial list of Medical Physics terms in English should be the Medical Physics Thesaurus, its further translation into various languages to be the Medical Physics Multilingual Dictionary, and the further explanation of each term (in English, with images, diagrams, etc) to be the Medical Physics Encyclopaedia (this was planned as a separate project - EMITEL, see chapter 8).

We did not have a guide for the organisation and development of a Thesaurus/Dictionary. Here below we shall describe our experience as one successful method to develop and organise a Thesaurus/Dictionary.

Thesaurus of Medical Physics terms

The first main task of the Dictionary project was to develop a list of the terms used in the profession - a Thesaurus of Medical Physics Terms. To deal with this the Working Group of the partnership selected 20 established Medical Physics books covering various fields of the profession. All these books were in English and this was the language used for the creation of the Thesaurus. The terms were formed of one or more words (e.g. Dose, Absorbed Dose, Absorbed Dose Conversion Factor, etc). The core terms from the Indexes of these books were selected and listed in parallel Excel tables. The initial list included almost 15,000 terms in English, but many were repetitions and very old terms. Removing those reduced the number to about 8000. As the Dictionary was an EC project, it was decided to use English (UK) spelling throughout.

Following this the terms were grouped and distributed according to their field (specialism). This process included the following main steps:

-Merging identical terms;

-Grouping the terms according to their field (large groups);

-Organising synonyms and homonyms in small groups;

-Identifying other terms (from medicine, physics, chemistry, mathematics, etc) with specific use in Medical Physics;

-Creating a master table (Thesaurus) with Medical Physics Terms.

The further work of condensing the volume of the Thesaurus was made by all members of the EMIT Consortium (Fig. 6.7), where Groups of experts were created in all sub-fields of the profession. At this stage it was decided that some non-specific terms (e.g. colours, some basic physics terms, etc) be included in the translations, but not in the future Encyclopaedia.

This way the first Thesaurus of Medical Physics was created with 3706 terms. However this number included a number of terms known with their abbreviations (e.g. AEC as Atomic Energy Commission, and AEC as Automatic Exposure Control). Such terms were listed as two terms, followed by the abbreviation, and as two identical abbreviations, followed by their different meanings. Similarly terms with use in several fields were listed several times (e.g. Contrast Media in Ultrasound, in MRI, in X-ray, etc - with their different physical properties). At that project stage this was necessary for the formation of a paper-print alphabetical index.

We assigned an Identification number (ID) to each term from the Thesaurus and from this moment all translations were based on the IDs of the English terms. The ID number was the main identificator of each term. These were arranged in a Master table (in *MS Excel*), where the rows were fixed (no row could be added, as this would change the ID). New columns however could be added to the Master table – a column for each language. The first column of the Master table was the ID, and the second column – the English language terms (arranged alphabetically, according to the Thesaurus compiled by the Consortium) – these two columns were also fixed. All additional columns were added by the translation groups – one per language (Fig. 6.1) .

	A	B	C	D	E	F
1	ID	English (master file) Final update	BULGARIAN	Lithuanian	CHINESE corrct	Arabic
11	10	3D (three dimensional)	тримерен (3D)	3D (trimatis)	三维	ثلاثي الابعاد
12	11	3D display	тримерен дисплей	3D vaizduoklis	三维显示	عرض ثلاثي الابعاد
13	12	3D imaging	тримерно изобразяване	3D vaizdavimas	三维成像	تصويرثلاثي الابعاد
14	13	3D spatial abilities	възможност за тримерно изобразяване	3D erdvinė geba	三维空间能力	قدرات (امكانات)فضائية ثلاثية الابعاد
15	14	3D visualization	тримерна визуализация	trimatis (3D) vaizdinimas	三维可视化	تصور ثلاثي الابعاد
16	15	Helium	Хелий (He)	Helis	氦	هيليوم
17	16	A number	атомен номер	Numeris, skaičius	A 模式	العدد الذري A
18	17	A mode	A режим (в ехографията)	A-moda, būdas, režimas	原子序数	نمط (طريقة) A
19	18	Abdominal imaging	изобразяване на абдомена	Pilvo (abdominalinės) srities vaizdinimas	腹部成像	تصويربطني (جوفي)
20	19	Absolute risk	абсолютен риск	Absoliuti rizika	绝对风险	مخاطرة (مجازفة) مطلقة
21	20	Absolute scale of merit test	абсолютна скала (за изпитване) на качеството	Absoliutinės kokybės vertinimo skalės testas	绝对标准刻度测试	المقياس المطلق لاختبارالاستحقاق
22	21	Absorbed dose	погълната доза (доза)	Sugertoji dozė	吸收剂量	الجرعة الممتصة

Fig. 6.1 Dictionary Master Table with translations, showing “excluded ID” (here ID 13) and questionable Terms translations (e.g. in Lithuanian)

Groups of translators were formed in each language, usually including specialists in the main fields of the professions (Physics of: X-ray Diagnostic Radiology, Nuclear Medicine, Radiotherapy, Ultrasound Imaging, Magnetic Resonance Imaging, Radiation Safety). General terms were covered by all translators (mainly terms related to relevant frequently-used terminology from physics, mathematics, medicine, etc). Each Language Group received the Master Table and worked (translated) in their own column (one term in a cell, as per the ID).

Soon the initial 5 languages were joined by additional translations into Spanish and Portuguese (please see at the end a list of the Translation Groups members). Parallel tables for each translation Group were created (aligned as per the term ID), forming a multilingual database. This allowed for a smooth move from one language to another – i.e. cross-translation between any two languages, as per the ID number in English (i.e. the row of the table).

The Main Dictionary Coordinator (the Project Coordinator) had organised all files for each Language in a separate folder (e.g. Spanish). The folder included the Master Table with translations and some possible queries from the translators. The Main Coordinator transferred the queries and related answers to the other Translation Groups, thus performing inter-group sync. Each Master Table with translation had a unique name, including the current date in its filename (e.g. Spanish120607.xls), this way identifying different stages of the translation.

Each Translation Group had its own Language Coordinator, who was collecting the translations from the Group members (usually colleagues with different specialisms). The Language Coordinators were in contact with the Main Dictionary Coordinator, where all important partial results were sent, and where the Master Table was kept (with all languages). Translations in need of further discussion were highlighted in colour. If a specific term did not exist in a certain language, the English term was included in the corresponding cell in the Language column.

During the process of this development the Thesaurus was gradually updated with new terms coming from the specialists involved in the project. This was mainly due to the quick evolution of the profession in the past decade and the related inclusion of new terms. To handle this, the IDs of the existing terms were left 'as is', and a new continuation of the main English Master Table was made (again in alphabetical order). The additions to the Thesaurus were made in three stages, each new inclusion of a batch of terms starting after the next round number (in 500 increments) – i.e. ID 4000, ID 4500, etc (e.g the second batch is from 4001 to 4320; after time the third batch is from 4501 to 4817; the next one would start with ID 5001, etc). A total of 756 new terms were added this way after ID 4000 (Fig. 6.2).

However when the Dictionary was uploaded on our Web site and the Search was much easier (i.e. no need of paper list of all existing terms), the initial Thesaurus list was reduced by 990 terms, excluding some terms which could be explained through other terms. The 'excluded terms' continued to have their IDs, highlighted in grey to indicate these would not be translated. Following this the overall number of terms in the Encyclopaedia was 3576.

The Thesaurus was first made in 2003 and was updated 3 times by 2013. These adaptations were related also to the further explanations of the terms in the Encyclopaedia. In the web Encyclopaedia and Dictionary hyperlinks were used to link the abbreviations with their full terms (see chapter 9).

During the paper print of the Encyclopaedia (2010-12) the number of terms covered with articles was further reduced (mainly through merging of terms and excluding abbreviations), but the above number of articles still exists on the EMITEL web site.

	A	B	C	D	E
1	ID	English (master file) Final updated Mar 2009	BENGALI	GREEK	RUSSIAN
4162	4455	Well counter detector efficiency	ওয়েল (গণনাকারী)সনাক্তকারক দক্ষতা	Απόδοση ανιχνευτή τύπου απαριθμητή πηγαδιού	Эффективность колодцевого детектора в радиометре
4163	4456	Well-type ion chamber	ওয়েল টাইপ আয়োন (চেম্বার/প্রকোষ্ঠ/কুয়াকৃতির আয়ন প্রকোষ্ঠ	Θάλαμος ιονισμού τύπου πηγαδιού	Колодцевая ионизационная камера
4164	4457	WHO	ডব্লিও.এইচ.ও., বিশ্ব স্বাস্থ্য সংস্থা	WHO (Παγκόσμιος Οργανισμός Υγείας)	Всемирная организация здравоохранения (ВОЗ)
4165	4458	Z transformation	জেড-রূপান্তরণ	Μετασχηματισμός Z	Z-преобразование
4166	4459	Zonography	জনোগ্রাফী	Ζωνογραφία	Зонография
4167					
4168	4501	Adaptive radiotherapy		Προσαρμοστική ακτινοθεραπεία	
4169	4502	Alpha emission	আলফা নি:সরণ	Εκπομπή άλφα	Эмиссия альфа-частиц, альфа-излучения
4170	4503	Anatomical body planes	শরীর গঠনতত্ত্বীয় তল	Ανατομικά επίπεδα σώματος	Анатомические плоскости тела
4171	4504	Anatomical relationships	শরীর গঠনতত্ত্বীয় সম্পর্ক	Ανατομικές συσχετίσεις	Анатомические взаимосвязи
4172	4505	Anti-idiotype Antibody Technique	অপ-ইডিওটাইপ এন্টিবডি পদ্ধতি	Αντι-ιδιότυπη τεχνική αντισωμάτων	Методика антител с набором анти-идиотипических дет
4173	4506	Apoptosis targeting	এপপটসিস টারগেটিং (প্রতিকোষ মৃত্যু) লক্ষ্যবস্তুকরণ	Στοχούμενη απόπτωση	Мечение апоптоза, визуализаци апоптозных клеток
4174	4507	Asymmetric energy window	অপ্রতিসম শক্তি গবাক্ষ/বাতায়ন/জানালা	Ασύμμετρο ενεργειακό παράθυρο	Асимметричное энергетическое окно

Fig. 6.2 Dictionary Master Table with translations, showing one of the updates (from ID 4501)

EMIT CD-ROM Multilingual Dictionary of Medical Physics

The need for electronic dissemination of the first Dictionary led to the inclusion of software developers in the team in 2003 (M Stoeva and A Cvetkov, both medical physics graduates from the ERM project in Plovdiv and software specialists with their own small IT company AM Studio). At that stage the development of a future Encyclopaedia was already planned and the interface of the Dictionary was created to be able to display text associated with the respective term from the Thesaurus database (temporarily filled with an image with the logo of the project – Fig. 6.3).

The use of indexed tables with languages, arranged as per their ID, meant that the Dictionary could cross-translate from and into any of the included languages.

The first e-Dictionary was developed early in 2003 (using *Visual Basic*) and was engraved on a Mini CD, together with demos of the e-Learning materials EMERALD and EMIT. The Mini CD included an executive file of the Dictionary and required its installation on the PC of the user. The interface required selection of the two languages for the translation (From .. To…) and included the necessary fonts. This user-friendly design allowed very easy use of the Dictionary (Fig. 6.3). There were three Dictionary windows: the Left Search window (From), where the user types the term; the Left Display window, which presents a limited list of the respective Language table from the database (from the Input Language); a Right (To) window presenting the translation of the selected text from the Output language. Search was performed in the usual way of handling databases – the first letters from the searched term displayed instantly the corresponding term from the list (displaying also alphabetically listed neighbouring terms). Scrolling the terms in the Left Search window scrolls in fact the corresponding Language column, while the highlighted term in this language displays the corresponding translation in the Right window.

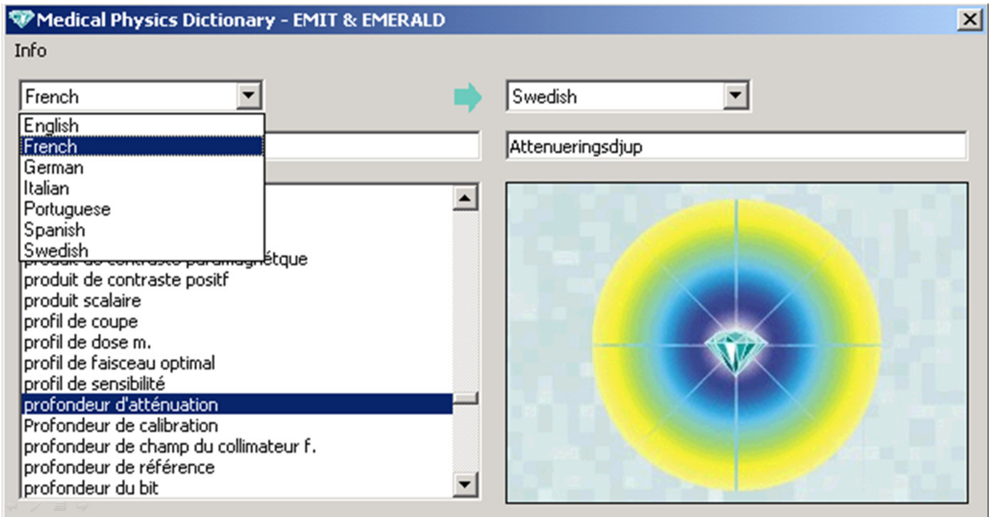


Fig. 6.3 Graphic interface of the first CD-based Medical Physics Dictionary (2003-2005) distributed free on mini CD, and also with the EMERALD and EMIT CDs

One thousand of these Mini CDs (see Fig. 5.5) were distributed free during the World Congress on Medical Physics and Biomedical Engineering in Sydney, Australia (August 2003). This dissemination of the Dictionary and the Thesaurus of Medical Physics Terms triggered the development of some future Dictionaries in specific languages (transferred later into EMITEL).

The EMIT Conference in 2003 assessed the Dictionary and found it extremely useful. This was supported by the use of the Dictionary during the International Medical Physics College in the following year (ICTP, Trieste, 2004). These two events and the World Congress triggered enormous interest in the Dictionary and many colleagues from various countries volunteered in the translation of the Thesaurus into their languages.

The WEB Dictionary

The inclusion of new languages in the Dictionary presented new challenges because of the different alphabets, which were difficult to be handled by the existing software used for the mini CD. However at that time the current web technologies advanced enough to allow transferring the Dictionary on the Internet. A new domain was registered and the new software was created by AM Studio (www.emitdictionary.co.uk). The initial design was using directly the synchronised tables of the Dictionary (Fig. 6.4).

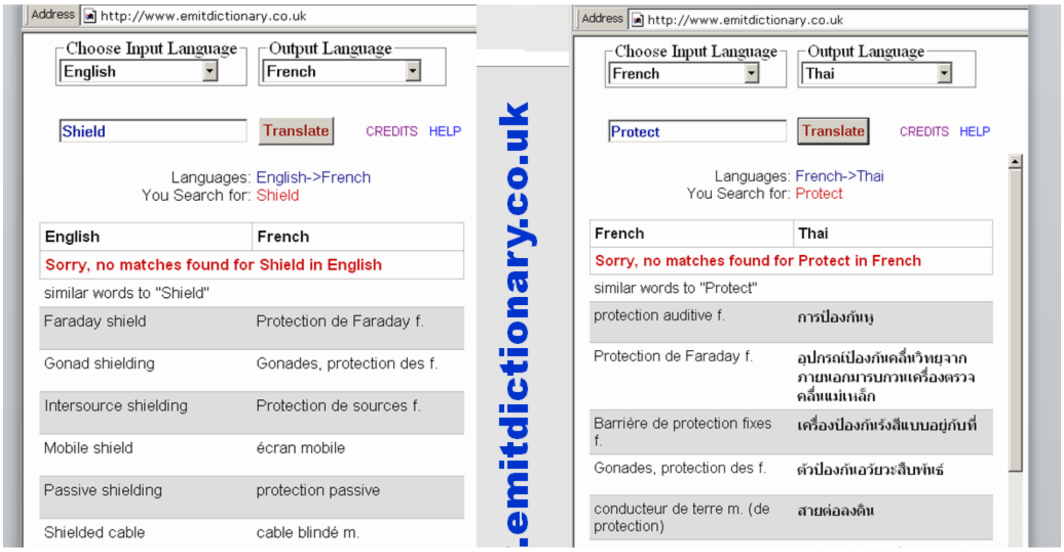


Fig. 6.4 Screen shot from the first web design of the Medical Physics Dictionary (2005-2009) showing cross translation English > French and French > Thai

This new phase of the Dictionary (the Web Dictionary) was dependent on the settings of the Internet browser, which allowed various alphabets to be used. This led to rapid expansion of the number of languages in the Web Dictionary. However at that time the search was still based on the beginning of the first word of the term. This was not convenient for complex terms (e.g. the term Dose will not call related complex terms starting with other letter – as Absorbed dose or Effective dose). This was later improved in the final EMITEL Web Dictionary.

The Web Dictionary design included again a user-friendly interface with windows for Input and Output Languages and a small Search window for the term to be translated. The results were displayed as two parallel tables of corresponding terms (scrollable).

The new Web Dictionary was launched in 2005 and for several months attracted thousands of users (it is still in use). This led to further increase of the number of languages. A number of societies realised at this stage that no specific translation exists for some terms in their own language. The rapid development of the profession, often triggered by quick publications in English, had left some terms without sufficient coverage in the respective language. This triggered creation of national terms and respectively some changes in the Dictionary translations (even some Translation groups added some brief explanations into the terms translation – e.g. in Thai). All these changes were submitted to the Coordination office and uploaded regularly.

EMITEL Encyclopaedia with Dictionary

The Dictionary of terms with explanations was further developed in the project EMITEL, which aimed at developing explanatory articles for each term, thus transferring it to an Encyclopaedia. This project was approved by the EC during 2006 and will be described in chapter 8.

A new web site was developed for EMITEL (www.emitel2.eu, opened for free use in 2009), handling both the Dictionary and the future Encyclopaedia. New design was introduced, again by AM Studio, now a full partner to the project. It included a new Web database, but still used the initial parallel language tables, which proved very useful. Two Search Engines were designed – one of those being Multilingual (handling the Dictionary), the other one – in English, only for the Encyclopaedic entries (Fig. 6.5).

The EMITEL Dictionary Search engine allowed direct search for terms, or part of terms. Hence a search for the term Dose is now returning all complex terms including Dose - Absorbed dose, Effective dose, Mean absorbed dose to air, etc (see Fig.9.6). This also reduced eventual problems with misspelling.

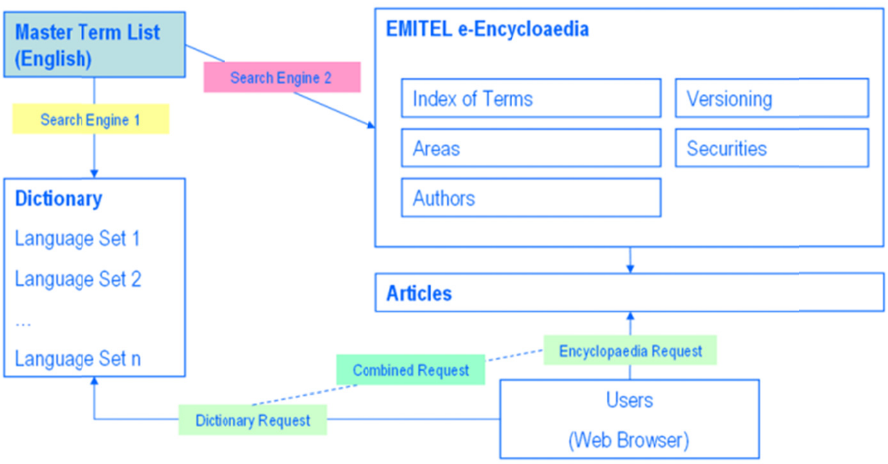


Fig. 6.5 Schematic block diagram of the new web site www.emitel2.eu (with Dictionary and Encyclopaedia)

Dictionary Use and Conclusion

As many users had been accustomed to use www.emitdictionary.co.uk since 2005, it was decided to leave this web site running alongside the new EMITEL Encyclopaedia+Dictionary web site (www.emitel2.eu). The old web site www.emitdictionary.co.uk continues to attract users (currently some 1200 users per month).

During the period March 2013- March 2014 the Dictionary (emitdictionary.co.uk) has been used c. 18,000 times (Fig. 6.6) , while the new web site EMITEL, including the Encyclopaedia and Dictionary, has been used c. 56,000 times (see chapter 8).

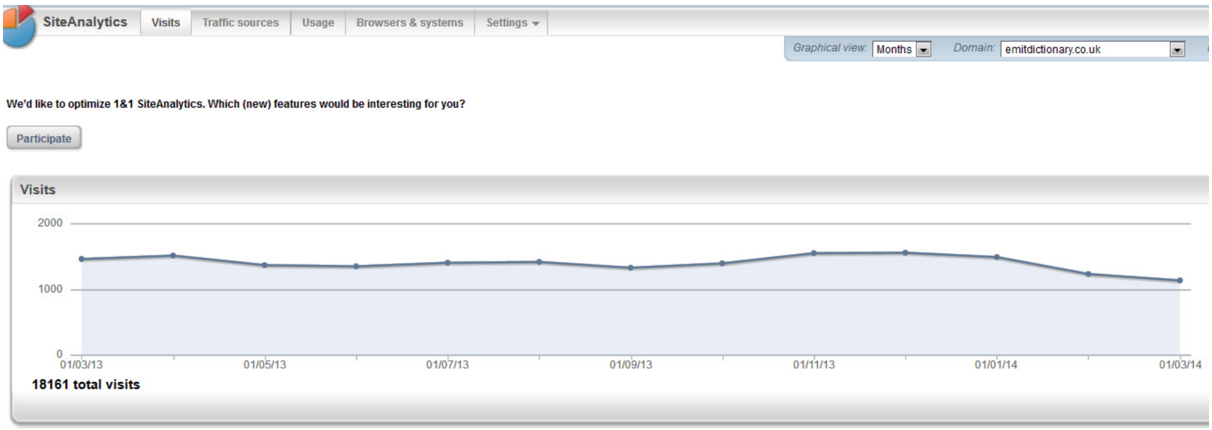


Fig. 6.6 Official 1&1 server Statistics of web Dictionary use per month in the period March 2013 - March 2014 (for www.emitdictionary.co.uk)

Currently the Dictionary exists in 29 languages (in 8 alphabets), translated by colleagues listed at the end of this chapter. Thus the original 7 languages were supplemented by new 22 languages and the final Dictionary included: Arabic, Bengal, Bulgarian, Chinese, Croatian, Czech, English, Estonian, Finnish, French, German, Greek, Hungarian, Italian, Japanese, Korean, Latvian, Lithuanian, Malaysian, Persian, Polish, Portuguese, Romanian, Russian, Slovenian, Spanish, Swedish, Thai and Turkish.

Today, more than 10 years since its first introduction, the Multilingual Dictionary of Medical Physics continues to be one of the most important references of the profession. The constant assessment and update of the Dictionary through various activities keeps the Dictionary up-to date and in line with the development of the profession. In future the update of the Dictionary will be handled by the IOMP aiming to support the global development of the profession.

The first Thesaurus of Medical Physics Terms provided background for other Medical Physics Dictionaries and will be the starting point of potential new projects.

One very important outcome of the project was that it gathered for the first time in the profession a team of about 200 specialists from 29 countries. These included senior officers of IOMP, EFOMP, AFOMP, ALFIM and Past and Present Presidents of 34 National Medical Physics Societies.

Fig.6.7 EMIT Consortium meetings in Lund (left – work in Groups) and London (right) – working on the Dictionary
On the right photo (London): standing L>R: M Buchgeister, B-A Jonsson, A Noel, G Helms, M Ljungberg, F Milano; in front L>R: S Tabakov, I-L Lamm, J-Y Giraud

ACKNOWLEDGEMENTS

EMITEL gratefully acknowledges the financial support from the EC Leonardo Programme and the voluntary translation of the Dictionary made by the following Contributors (included in the EMITEL Network together with the Contributors to the Encyclopaedia).

The list below (as per the arrival of the translations) includes all colleagues who took part in this large international project (see also Fig. 8.19):

English Terms Collection (Thesaurus) - all EMIT and EMITEL project Consortium members

German Translation:

Dr Markus Buchgeister [German Coordinator] (Universitätsklinikum Tübingen); Dr Gunther Helms (Universitätsklinikum Tübingen); Dr Stefan Delorme (DKFZ Heidelberg)

French Translation:

Dr Alain Noel (Centre Alexis Vautrin, Nancy); Dr Jean-Yves Giraud [French Coordinator] (Hôpital Albert Michallon, Grenoble); Dr Hélène Bouscayrol (Service de radiothérapie, CHR Orléans); Mr Louis Blache (Bioconceil International, Nimes, France)

Swedish Translation:

Dr Inger-Lena Lamm (Universitetssjukhuset I Lund) [Swedish Coordinator]; Dr Monica Almqvist (Universitetssjukhuset I Lund); Dr Thomas Jansson (Universitetssjukhuset I Lund); Dr Ronnie Wirestam (Lunds Universitet); Prof. Sven-Erik Strand (Lunds Universitet); Dr Bo-Anders Jonsson (Lunds Universitet); Dr Michael Ljungberg (Lunds Universitet); Prof. Freddy Stahlberg (Lunds Universitet)

Italian Translation:

Prof. Franco Milano (Universita degli studi di Firenze)

Portuguese Translation:

Dr Ana Pascoal [Portuguese Coordinator], (Universidade Catolica Portuguesa); Prof. Nuno Teixeira and Prof. Nuno Machado (Escola Superior Tec. Saude de Lisboa); Dr Paulo Ferreira (Portuguese Cancer Institute in Lisbon);

Spanish Translation:

Dr Ana Paula Millán [Spanish Coordinator] (Técnicas Radiofísicas, S.L. Zaragoza); Dr Alejandro García (Hospital Clínico Universitario Lozano Blesa. Zaragoza); Dr Ignacio Hernando (Hospital Universitario Río Hortega. Valladolid)

Polish Translation:

Prof. Marta Wasilewska-Radwanska [Polish Coordinator], Dr Aleksandra Jung, Dr Katarzyna Matusiak, Dr Zenon Matuszak (all from AGH University of Science and Technology, Faculty of Physics and Applied Computer Science, Department of Medical Physics, Krakow, Poland)

Thai Translation:

Prof. Anchali Krisanachinda [Thai Coordinator]; Prof. Sivalee Suriyapee; Mr Tanawat Sontrapornpol; Mr Panya Pasawang; Mrs Chotika Jumpangern; Mr Taweap Sanghangthum; Mr Isra Israngkul Na Ayuthaya; Mr Sornjarod Oonsiri (all from King Chulalongkorn Memorial Hospital, Bangkok, Thailand).

Hungarian Translation:

Prof. Paul Zarand [Hungarian Coordinator], Dr Istvan Polgar (Uzsoki Hospital, Radiation Oncology Dept, Budapest), Prof. Geza Safrany; Dr Tamas Porubszky (National Institute for Radiobiology and Radiohygiene, Budapest) Dr Janos Martos (National Inst. of Neurosurgery, Budapest) Dr Tamas Daboczi (Budapest University of Technology and Economics) Dr Jozsef Varga (University of Debrecen, Hungary)

Lithuanian translation:

Prof. Diana Adliene [Lithuanian Coordinator], Prof. Arunas Lukosevicius, and Ms Dovile Serenaite (all from Kaunas University of Technology), Dr Algidas Basevicius (Kaunas University Hospital)

Estonian translation:

Prof. Kalju Meigas (Tallinn University of Technology) Dr Kalle Kepler [Estonian Coordinator]; Mrs Sigrid Rootsmaa; Dr Jüri Vedru (University of Tartu, Estonia); MSc Eduard Gershkevitch

Romanian translation:

Mrs Daniela Andrei [Romanian Coordinator] (National Commission for Nuclear Activities Control, Bucharest); Mrs Cristina Petroiu, (INFORAD EXPERT SRL, Bucharest); Prof. Aurel Popescu and Prof. Octavian Duliu, (University of Bucharest), Dr Raducu Popa, („Alexandru Trestioreanu" Oncological Institute, Bucharest); Prof. Constantin Milu (Institute for Public Health, Bucharest, Romania)

Turkish translation:

Prof. Perihan Unak [Turkish Coordinator], Prof. Fatma Yurt Lambrecht, Dr Turgay Karalý, Dr Zumrut Biber Muftuler, Dr Serap Teksoz (all from Institute of Nuclear Sciences, Ege University, Izmir, Turkey)

Arabic translation:

Dr Farida Bentayeb [Arabic Coordinator] (University Mohammed V Agdal, Rabat , Morocco); Dr Rachida El Meliani (University Mohammed V Agdal, Rabat ,Morocco); Dr Ibrahim Elyaseery and Dr Nagi Hussein (Garyounis Univ., Libya) ; Dr Salem Sassi (Royal Marsden Hospital, London, UK)

Greek Translation:

Dr Stelios Christofides [Greek Coordinator], Dr Prodromos Kaplanis, Mrs Georgiana Kokona, Mr Demetrios Kaolis, Mr Georgios Menikou, Mr Christos Papaefstathiou, Mr Charalambos Yianakkaras, Mrs Dora Charalambous, Ms Demetra Constantinou, Mr Yiannis Gerogiannis, Mr Michalis Heraklides, Mr Andreas Mikelides, Mr Nicos Papadopoulos, (all from Nicosia General Hospital, Cyprus); Dr Spyros Spyrou (Cyprus University of Technology); Mr Christodoulos Christodoulou (Private sector), Cyprus; Mrs Anastasia Sissou (Ministry of Labour and Social Insurance); Mr George Christodoulides (Consultant, Cyprus)

Latvian Translation:

Prof. Yuri Dekhtyar [Latvian Coordinator], Dr Aleksei Katashevs, Ms Lada Bumbure, Dr Juris Rauzins, Ms Sandija Plaude, (all from Riga Technical University); Dr Dzintars Emzins, Dr Sergejs Popovs (from Oncological Centre of Latvia), Ms. Marite Chaikovska (Radiation Safety Centre Latvia)

Czech Translation:

Dr Ing. Ivana Horakova, [Czech Coordinator] CSc. (SURO, Prague); Ing. Josef Pacholik (SÚRO)
Ing. Anna Kindlova (FN Motol Praha); Ing. Simona Trampotova (VFN Praha); Ing. Daniela Kotalova

(VFN Praha); Prof. Ing. Václav Husak, CSc. (FN Olomouc); Ing. Jaroslav Ptacek (FN Olomouc);

Bengal Translation:

Prof. Golam Abu Zakaria (University of Cologne, Germany); Ms Hasin Azhari (Anupama) [Bengali Coordinator], Mr Md Akhteruzzaman, Mr Safayet Zaman, (all from Gono University, Dhaka)

Chinese Translation:

Dr Andy A Zhu [Chinese Coordinator] (David C Pratt Cancer Centre, St Louis Missouri); Prof. Wu Wenkai (Chinese Academy of Medical Sciences); Prof. Bao Shanglian (Beijing Key Lab of Medical Physics and Engineering); Prof. Geng Jianhua (Chinese Academy of Medical Sciences); Prof Yimin Hu (Cancer Institute CAMS Beijing); Prof. Yin Yong (Shandong Hospital Jinan); Prof. Zhang Jiutang (Hunan General Hospital, Changsha); Prof. Xu Xiao (Tianjin Medical Univertsity); Dr Dai Jianrong (Chinese Academy of Medical Sciences); Mr Dai Liyan (Shanghai Jiaotong University School of Medicine); Mr Dai Xiangkun (PLA General Hospital Beijing); Dr Wang Yunlai (PLA General Hospital Beijing); Mr Fu Guishan (Chinese Academy of Medical Sciences); Mr Geng Hui (Hong Kong Sanatorium and Hospital); Mr Wang Jianhua (Lihuili Hopsital, Zhejiang); Mr He Zhengzhong (Hubei Hospital, Wahan); Dr Xu Zhiyong (Fudan University, Shanghai); Mr Zhang Yue (TomoKnife Company Ltd, Beijing).

Bulgarian Translation:

Dr Jenia Vassileva [Bulgarian Coordinator] (National Center of Radiobiology and Radiation Protection); Prof. Petar Trindev (Medical Academy, Sofia); Dr Borislav Constantinov (Consultant, Sofia); Prof. Venceslav Todorov (Consultant, Sofia); Mr Anastas Litchev (Consultant, Plovdiv); Prof. Slavik Tabakov (Medical University Plovdiv, BG and King's College London, UK)

Russian Translation:

Prof. Valery Kostiliev, [Russian Coordinator] (AMPHR) Dr Nina Liutova (AMPHR); Dr Tatyana Ratner, Dr Boris Narkevitch, Mrs Marina Kislyakova (all from Cancer Research Centre, Moscow)

Malay Translation:

Dr David Bradley [Malay Coordinator] (Surrey University), UK; Dr Suhairul Hashim, (University of Technology Malaysia)

Persian Translation:

Prof. Azam Niroomand-Rad [Persian Coordinator] (Past President IOMP, USA); Prof. Alireza Binesh, (Payam Nour Univ., Fariman, Iran); Dr Ali Asghar Mowlavi, (Sabzevar Tarbiat Moallem University, Sabzevar, Iran); Prof. Ishmael Parsai (University of Toledo, Ohio, USA); Mr Behrouz Rasuli (Behbahan Faculty of Medical Sciences, Behbahan, Iran); Mr Ali Mahmoud Pashazadeh (Bushehr University of Medical Sciences, Bushehr, Iran).

Slovenian Translation:

Prof. Ervin B. Podgorsak (McGill University Canada); Mr Bozidar Casar [Slovenian Coordinator]; Dr Vili Kovac; Mr Damijan Skrk; Ms Petra Tomse; Mr Boris Sekeres; Mr Urban Zdesar, Mr Urban Simoncic (all from Institute of Oncology Ljubljana)

Japanese Translation:

Dr Koichi Ogawa [Japanese Coordinator] (Hosei University); Dr Katsuyuki Nishimura (Ibaraki Prefectural University of Health Sciences); Dr Kanae Nishizawa (National Institute of Radiological Sciences); Dr Suoh Sakata (National Institute of Radiological Sciences); Dr Hidetoshi Saitoh (Tokyo Metropolitan University); Dr Keiko Imamura (St. Marianna University)

Croatian Translation:

Dr Mario Medvedec [Croatian Coordinator]; Mr Jurica Bibic; Mrs Ana Buinac; Mr Hrvoje Hrsak; Mrs Sandra Kos; Mr Nenad Kovacevic; Prof. Srecko Loncaric (all from University Hospital Centre Zagreb, Croatia); Dr Tomislav Bokulic; Mrs Iva Mrcela (all from University Hospital Sestre Milosrdnice, Zagreb, Croatia); Dr Zeljka Knezevic; Dr Saveta Miljanic (all from Rudjer Boskovic Institute); Prof. Dario Faj (University Hospital Osijek, Croatia); Mr Slaven Jurkovic; Mrs Deni Smilovic Radojcic (all from University Hospital Centre Rijeka, Croatia); Prof. Igor Lackovic (Faculty of Electrical Engineering and Computing), Prof. Branko Breyer (Laboratory Breyer, Zagreb, Croatia); Dr Milica Mihaljevic (Institute of Croatian Language and Linguistics, Zagreb, Croatia)

Finnish Translation:

Prof. Hannu Eskola, Dr Paivi Laarne (all from Tampere Univ. of Technology, Tampere, Finland)

Korean Translation:

Dr Changhoon Choi [Korean Coordinator], Dr Wee-Saing Kang (Seoul National University, Korea), Prof. Tae Suk Suh (Catholic University of Korea, Seoul)

Dictionary Web Design:

Dr Magdalena Stoeva and Mr Assen Cvetkov (AM Studio Ltd, Plovdiv, Bulgaria)

Dictionary Coordinator:

Dr Vassilka Tabakova (King's College London, UK)

Overall Project Developer and Main Coordinator:

Dr Slavik Tabakov (IOMP, King's College London, King's College Hospital, UK)

7. Other Medical Physics e-Learning Projects

At the time of our projects EMERALD II and EMIT a number of other Medical Physics e-Learning activities were initiated around the world. In fact the term e-Learning gained popularity in 1998 through the paper of A Morri in *Connected Planet* (Nov 1997) "*A bright future for distance learning: One Touch/Hughes alliance promotes interactive 'e-learning' service*". Approximately around this time many people started using the term e-learning.

In 1998, as soon as EMERALD e-Learning was ready to go ahead, we prepared an EC project (alongside EMERALD II) aiming to develop a dedicated server for Medical Physics e-Learning (an "*e-Broadcast for education*"). The project would be led by our Italian partner F Milano and the main counterpart was in Poland (led by M Radwanska), where we intended to host the dedicated e-learning server. This was a very innovative project, but it was rejected by EC. We could not pursue the project due to our commitments with EMERALD II and EMIT. However, when we were presented with the EU Leonardo da Vinci Award in 2004, one of the adjudicators remembered this project and told us that it was "well ahead of its time" and very few of the project assessors believed it was feasible. This way the idea was not further developed.

One exciting project at that time was the *NICER Electronic Encyclopaedia of Medical Imaging* (Editor in Chief Holger Pettersson), which began its electronic publication in June 1999. The first CD of this set (with dedicated ISBN, written on the CD booklet) included, alongside the medical entries, approximately 900 medical physics short entries with illustrations. The CD used *Macromedia* software and the images were in *PICT* format (the CD was suitable for both PC and Mac computers). It was expected that the Medical Imaging profession will use these new methods for delivery of knowledge. This large reference material (at that time c. 17,000 Radiology entries with about 7000 images) was released on several consecutive CDs with incremental increase of the volume. The project was supported by the NICER Institute in Oslo, Nycomed Amersham and Lund University. By the end of 2001 the full set was ready, but its price was very high. Soon after this the project was transferred to GE Healthcare and now it continues to exist under the name *Medcyclopaedia* (www.medcyclopaedia.com). The use of this resource requires registration.

The most important Medical Physics website at the time was developed by Prof Perry Sprawls (www.sprawls.org). P Sprawls is undoubtedly the doyen of the global Medical Physics education (in 2003 he was awarded the inaugural IOMP Harold Johns Medal for excellence in teaching and international education leadership in medical physics). His books on Physics of Medical Imaging and MRI were solid sources of information from the mid- 1970s. His web site includes his lectures, text from the books, materials with images, visuals and additional data.

The sprawls.org web site uses a very simple and effective way to transfer the educational content - large web pages with text and images for each chapter. These have common parts:
Outline and Guide; Mind Map; Objectives and Activities; Visuals; Online Module (Fig. 7.1).

This way the learner is easily and effectively guided through the learning process. P Sprawls's use of the method for remembering the material (*Mind Maps*) is unique for Medical Physics. This web site is still one of the most visited websites in the profession.

Sprawls.org and EMERALD complemented each other very well – one providing the academic lectures (i.e. the education), the other – the practical tasks (i.e. the training). Both websites (developed fully independently) shared a common vision – simple and effective web shell, whose main function is to deliver the necessary knowledge. Both web sites were intentionally distanced from the most hyped web technologies and placed the emphasis on the educational content. Both websites have dedicated programming without any third-party templates. Both websites are run by experts, enthusiastically supporting the development of Medical Physics. Both websites have continued to run for more than 15 years with thousands of visitors. It was only natural to collaborate and indeed P Sprawls became one of the main contributors to the EMITEL Encyclopaedia.

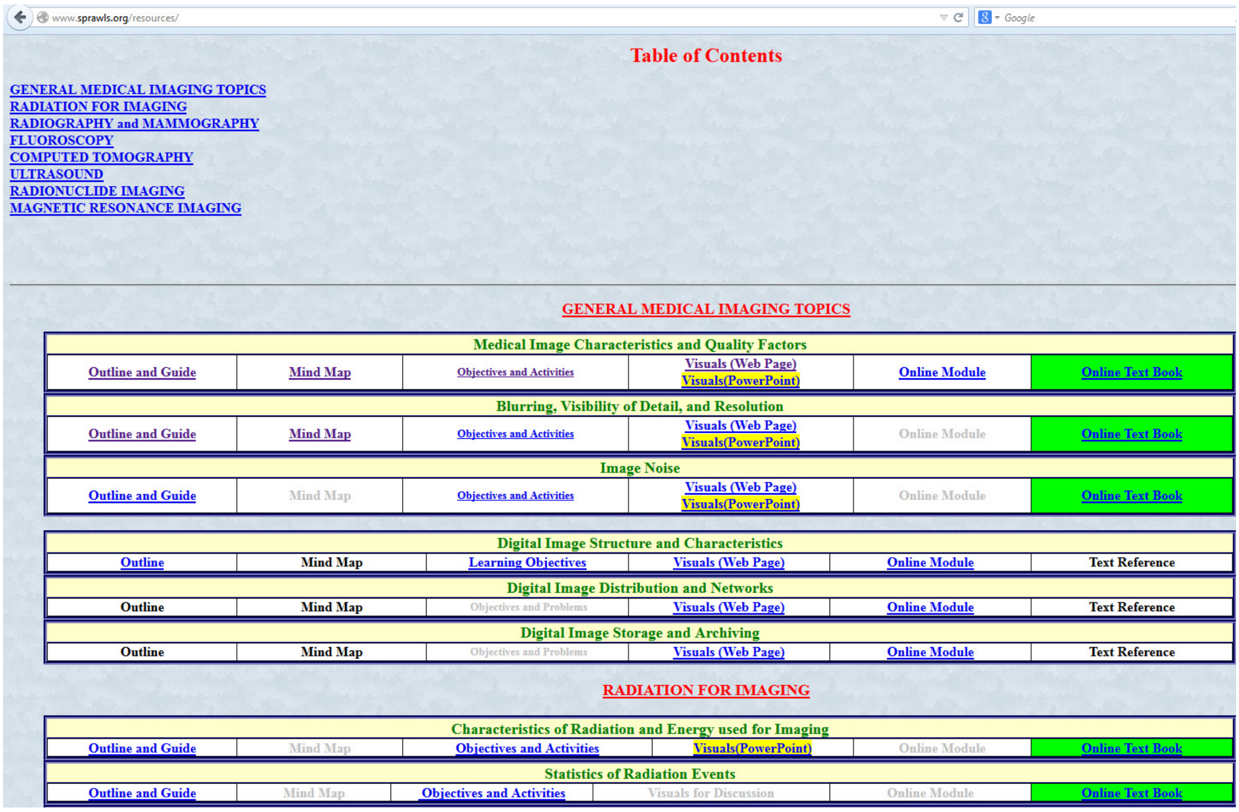


Fig. 7.1 Sample Graphic interface of P Sprawls's web site

After the dissemination of EMERALD in 2001 the use of our e-learning materials spread far beyond Europe. One of the most successful global disseminations was through the ICTP International College on Medical Physics.

ICTP (The Abdus Salam International Centre for Theoretical Physics) was opened in 1964 in Trieste, Italy. This world-renowned scientific institution operates under the aegis of UNESCO and IAEA and has supported and produced a number of Nobel Award Winners. The first ICTP College on Medical Physics took place in 1988 - a 4 week activity with many participants from the developing countries. The regular series of such Colleges started in 1992 and continues to run on a regular basis (usually bi-annually) with similar number of participants. Until now the ICTP has educated more than 1000 young medical physicists - mainly from developing countries (low and middle income countries).

The transfer of knowledge and experience to the developing countries is a major objective of the College. Each participant receives a full set of lecturing materials, including *MS Power Point* slides and lecture notes. ICTP was partner of both EMERALD and EMIT projects. This way all College participants (from 2002 onwards) received, additionally to the other materials, free copies of our EMERALD and

EMIT e-learning materials (Fig. 7.2). A specific re-organisation of these materials was made for the College participants – all e-learning was compiled on a single CD (with the hyperlinked images, but without the Image Database). So far participants from more than 80 developing countries have attended the College. They have triggered tens of Medical Physics activities and courses in their countries using the materials from the College. This way hundreds of colleagues from developing (and other) countries have received help in the practical implementation of the profession. Currently many of the College alumni are leading medical physicists in their countries, some – founders and leaders of their National Medical Physics Societies.

In fact part of EMERALD materials has been used in the ICTP College since 1996, when we introduced some of the Diagnostic Radiology tasks into the College curriculum. These Training tasks are still used in the College as PC-based labs.

Fig. 7.2 The ICTP College on Medical Physics (2002), where all participants received for the first time our e-learning materials –Directors: P Sprawls, A Benini, S Tabakov, L Bertocchi. The photo includes about 12 future Presidents of National Medical Physics Societies and Officers of Medical Physics Regional Organisations.

From 2004 Sprawls.org also delivered a number of College lectures as on-line content. This way both sets of materials from Sprawls.org and EMERALD were given to all College participants as e-Learning materials.

The activities of the College were also very important for testing a number of Training tasks (at each College the students/users fill a Questionnaire for assessing the materials). Also, what is more important, the contribution to the Medical Physics Dictionary was supported by some College participants. The translators of several languages were attendees of the College – Bengal, Iranian, Arabic, Thai and Turkish. A number of languages in the Dictionary were also tested by the College participants.

Around the end of 2002 another set of CDs with teaching materials appeared – issued by the IAEA. As EMERALD, these three CDs (focussed on Radiation Protection) were covering 3 main fields of Medical Physics – Diagnostic Radiology, Nuclear Medicine and Radiotherapy. They included ready lecturing materials as *Power Point* slides. These 3 CDs were also distributed free and were of great help to the medical physics community. Some of their slides included images from the EMERALD Image Database (Fig. 7.3). The easy inclusion of images to the digital teaching materials was now almost a standard for medical physics. These excellent materials also included Manual for Trainers and Multiple Choice Questions.

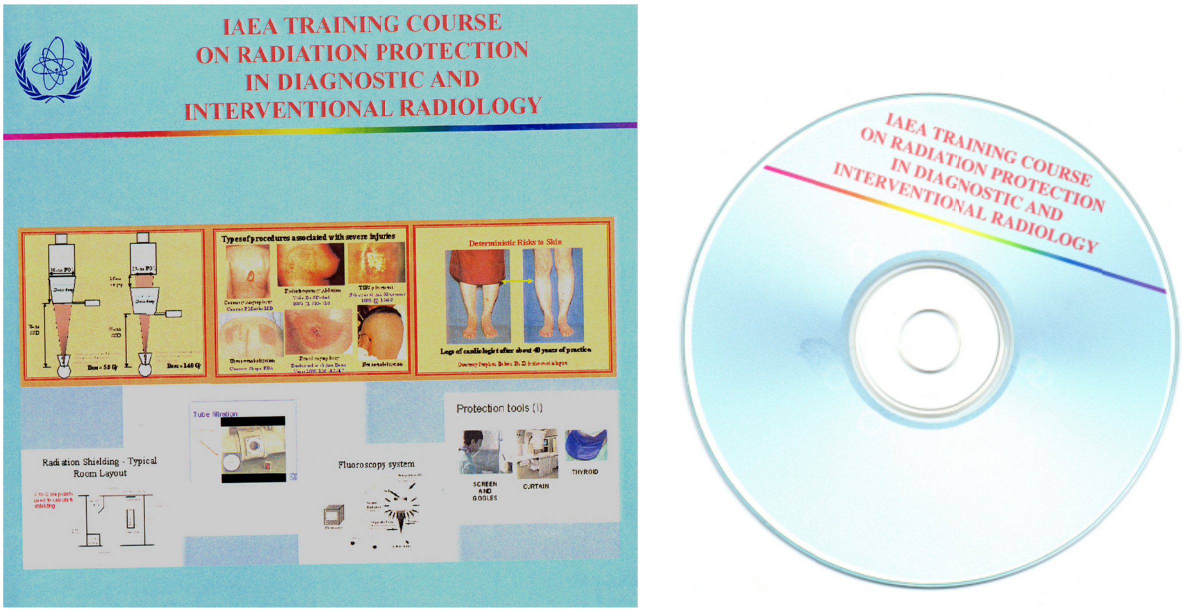


Fig. 7.3 IAEA CD with Power Point Slides – cover and CD-ROM (volume on Diagnostic Radiology, 2002).

The use of EMERALD materials outside Europe started in April 1999 in Campinas, Brazil. We used our materials for a two-day National Seminar on CT Quality Control (led by S Tabakov, with local counterpart R Corte). This was followed by Plenary Lecture and a sample case for e-Learning in Radiology at the 29th Congress of the Brazilian Society of Radiology in Sao Paulo. The audience supported strongly our e-learning materials and soon several images were contributed for use in

EMERALD. Colleagues from other countries have also contributed materials to our projects. In 2000 we introduced EMERALD in Malaysia in a similar way – both as material supporting the X-ray Quality Control activities and the establishment of training programmes (led by S Tabakov, with local counterpart S Salikin). Another project in Malaysia, aiming to develop a new MSc course in the country, was led at that time by A Tajuddin and S Tabakov.

Further our materials were used for Quality Control courses in Armenia (2001, 2002, led by S Tabakov and A Litchev), where all e-learning formed a training package, later used in the IAEA project for establishing of National QA Laboratory in Yerevan. Our hosts in Armenia – Mr K Stepanyan and Dr S Hovhannisyan formed at the time (with other colleagues) a Medical Physics Group (Fig. 7.4).

The use of EMERALD in Thailand was also very successful (2002, 2003, led by S Tabakov, with local counterpart A Krisanachinda) – Fig. 7.5. There the e-learning materials were used both for training and supporting the formation of a new MSc course in Chulalongkorn University in Bangkok and in the Chiang Mai University (here the ERM lectures were also used). The project triggered a number of activities and was presented at the National Radiology Congress in 2002. This activity was also part of an IAEA project and its Manager Dr Anchali Krisanachinda led a number of activities in the region establishing new societies and stabilising existing ones. Currently Dr Krisanachinda is President of SEAFOMP and Officer (Treasurer) of the IOMP. She together with Petcharleeya Suwanpradit, from the same University, provided images for a further set of training materials of the IAEA. The educational activities in Bangkok were later supported by Prof F Milano.

Fig. 7.4 X-ray QC Workshop with EMERALD, Yerevan, Armenia, 2002

Fig. 7.5 X-ray QC Workshop with EMERALD, Bangkok, Thailand, 2002

Similar use of EMERALD was made in other IAEA projects in Macedonia (2003) and Belarus (2004). The project in Belarus was led by our colleague A Litchev from the Medical Physics Centre in Plovdiv, Bulgaria. The local counterparts were V Belyakovski and M. Yermalitsky. The project in Macedonia was also helped by the colleagues in Plovdiv (the ERM project). The local counterpart was R Stamenov.

EMERALD played an important role in the large European project in Bulgaria (Sofia, 2003) related to Radiation Protection and QC in Diagnostic Radiology. Local counterpart in this project were J Vassileva, B Konstantinov and V Todorov. The project included a number of National Workshops, led by A Benini and S Tabakov. These activities linked with another large National Project in Bulgaria (a twinning project with Germany, 2003-2004). This project included the main Radiation Protection Agencies in Bulgaria and prepared the adaptation of National Legislation to the EURATOM requirements. The project also developed specific Radiation Protection Training Syllabi for the country (in several layers: for Medical Physicists, for Radiologists, for Radiographers and for other specialists using radiation in medicine).

All these projects received full sets of the EMERALD materials. Similar projects were made with the Czech Republic (2003-2005, S Tabakov), where the colleagues I Horakova, L Judas and S Tramptova visited King's College London for discussions on the development of Training programmes and X-ray Quality Control activities. At that time similar activities for Brazil were carried out in our Department by C Lewis and S Kudlulovich.

A useful book was published in 2003 by Springer "*The Internet for Radiology Practice*", A Mehta (ISBN 0-387-95172-5). The book promoted Teleradiology and included an extensive list of web sites with e-Learning materials related to radiology, but also useful for medical physics.

e-Learning was gaining popularity in Medical Physics and Engineering and a number of new projects and activities were initiated. This was only natural as, apart from the specific professional knowledge, our colleagues had excellent computer and software skills. These projects could be grouped in **three** main directions of e-learning development:

1. Development of e-learning modules

These were projects such as *EMERALD, EMIT* and *Sprawls.org*, other examples of such courses were the project *Demystifying Biomedical Signals* (a signal-processing educational project led by University of Southampton, R Allen, A De Stefano, D Simpson, M Lutman) and *A web-based course on Medical Physics for School Teachers* (led by University of Lund, B-A Jonsson), etc.

A common feature of such projects is that they are very informative (with many images and diagrams) and are easy to update. However these modules required inventiveness in the development and organisation of teaching materials. One important element for such modules was the added facility to print the material on paper – i.e. these are excellent for hybrid/blended learning (classical and e-learning). Usually such modules have long life (depending on the use of software tools).

A variation of this trend is the Virtual Library of the American Association of Physicists in Medicine (AAPM), launched around 2006. This is an excellent educational tool, based on the videos of many open lectures presented at the AAPM meetings. The web site is with free access for medical physicists from the developing countries (http://www.aapm.org/education/VL)

2. Development of e-learning Computer simulations

These are projects simulating the functions of medical equipment (as our G-M counter simulator). Some very useful simulations were developed in the University of Patras, Greece (for medical image processing, including X-ray equipment simulator, a project led by N Pallikarakis), University of Cagliari, Italy (an X-ray equipment simulator, a project led by V Fanti), etc.

The common feature for such projects is that they are very effective teaching tools, but are difficult to develop. Most importantly - they are software dependent and usually have short life cycle (all simulations above stopped working after several years). Some other simulations (e.g. in the field of Radiotherapy, as the project *Prism*, led by B Hartmann and J Meyer, used in University of Canterbury, New Zealand) have prolonged life, but still the use of specific software makes their practical implementation more difficult (especially in developing countries).

In fact Computer simulations in Medical Physics existed from the beginning of the 1990s. We refer specifically to an Image Back-projection Reconstruction simulation on a floppy disk, prepared by a colleague from India and distributed through the IAEA. The 1990 decade, and the first decade of the

2000, saw a number of very good simulations in the field of Imaging and Radiotherapy. However this trend lost speed during the second decade of the 2000, as a number of simulations stopped working with the introduction of new 64-bit PC Operating systems, which discouraged some teams.

3. Development of whole Structured study programmes

This approach is the most difficult one and rarely used. Such a programme was developed in the Medical Physics Centre in Plovdiv, Bulgaria, but could not be maintained for more than a few years. Another such project was KISS at the University of Graz, Austria (led by H Hutten).

Most educational programmes these days use an easier variant of these - one of the standard e-learning platforms (e.g. *Moodle, Web CT, Blackboard*, etc). These are in fact programmes managing the delivery of the material. These platforms usually facilitate the process of learning by allowing easy access to lecture notes, as well as facilitate the management of the educational programmes. Many MSc courses these days use such platforms.

One of the first Medical Physics MSc programmes to offer e-learning plus tele-teaching was at the University of Malaya (an activity led by K H Ng and supported by AAPM and Sprawls Foundation).

The increased use of e-Learning in Medical Physics led to the invitation from the Editorial Board of the *Journal of Medical Engineering and Physics* in 2004 to run a special issue on e-learning. The Editor in Chief (R Allen) supported the idea. The Special Issue on e-Learning in Medical Engineering and Physics was published in 2005 (vol. 27, No.7, September 2005, Guest Editor S Tabakov). It soon triggered significant interest and some of its papers were among the most frequent downloads of the Journal. This high professional interest in e-learning was very promising for the profession. This way in 2008 another Journal - *Biomedical Imaging and Intervention* published its Special Issue on e-Learning (Guest Editor Kwan Ng).

A very useful educational web site was launched in September 2006 - the IAEA Radiation Protection for Patients (RPOP) web site (rpop.iaea.org) – an enormous project led by the IAEA (initiated and coordinated by M Rehani). This project was a combination of modular, structured programme and information hub (Fig. 7.6).

This free website is orientated towards a very large audience – medical physicists, radiologists, radiographers and various medical staff applying radiation, but most importantly - patients. The web site provides free download of training materials as *Power Point* slides and posters on radiation protection. This was one of the first professional web sites to allow download of large files with Power Point presentations and other materials. Soon the web site was at the top of the "Radiation Protection" lists of all Search engines. This was helpful for many patients undergoing radiation procedures in medicine and currently this is the most visited web site in the profession with hundreds of thousands visits per year (c. 286,000 in 2012).

This large web site is supported by a team in IAEA and has regular updates. Most of the materials are translated into Spanish and Russian. This web site is also used as a portal to various Radiation Protection IAEA projects – e.g. SAFRON (an integrated voluntary reporting registry of radiation oncology incidents and near misses).

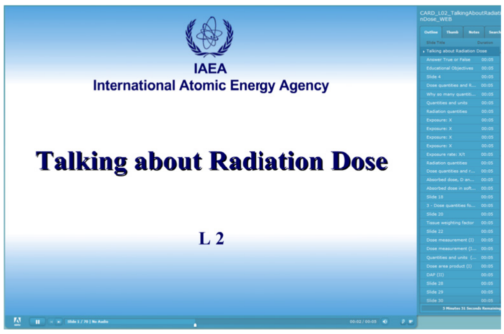


Fig. 7.6 The Home page of the IAEA RPOP Web site and first slide of one of the Power Point presentations.

IAEA published other excellent education and training resources and guides (some will be listed in chapter 10). This is only natural as IAEA is the largest provider of medical physics training for the developing countries. To acknowledge this IOMP awarded two IAEA officers with its Harold Johns Medal for excellence in teaching and international education leadership in medical physics – M Rehani (2009) and A Meghzifene (2012).

By this time e-learning was already a hot topic in all Universities and professions. Significant developments in the field were also made by our biomedical engineer colleagues. A real hub of this development was in Finland, Tampere University of Technology, led by J Malmivuo. One of the projects EVICAB (www.evicab.eu) moved into novel fields of use of learning technologies (including transfer of e-learning materials on mobile devices). EVICAB (2006-2007) included a number of e-learning materials/modules for MSc-level biomedical engineering education (supported with specific video and graphics). A very good summary of these developments and their tests could be seen in the PhD thesis "Impact of Modern Educational Technologies on Learning Outcomes – Application for e-learning in Biomedical Engineering" by A Kybartaite, 2010. Another excellent European educational project in biomedical engineering was BIOMEDEA (www.biomedea.org), led by J Nagel (University of Stuttgart, Germany). This project started slightly earlier than EVICAB and developed criteria, guidelines and protocols for the harmonization and accreditation of high quality Medical and Biological Engineering education and training in Europe. We were invited to take part in both BIOMEDEA and EVICAB projects, but the extensive work on the EMITEL Dictionary and Encyclopaedia did not allow this at the time.

The extensive feedback we collected over the years from various developers and users of e-learning materials and programmes could be summarised in several points:

1. The majority of colleagues apply e-learning alongside classical contact-teaching (both for University education and for Professional training). Obviously hybrid (blended) learning brings together all positive elements from both paedagogical approaches and is expected to be the preferred method in the years to come.

2. The e-learning materials need to be supported by a good structure of the included knowledge. Often the students will use it by themselves (without other academic support), and the logical structure will be their only guide into the realms of the new knowledge.

3. During the development of e-learning materials the platform used for the actual build-up of the materials is very important. Unsuitable selection of the authoring software could lead to dramatic shortage of the life-time of the e-learning material – hence a waste of effort. Currently web sites with uncomplicated friendly structure are the most versatile tools for the purpose.

4. Development of e-learning materials is very difficult and resource-consuming. Development of such materials and programmes requires teams of professional experts, software specialists and specialists in learning technologies and paedagogy.

8. EMITEL Project – The Encyclopaedia of Medical Physics

EMITEL Project – the structuring of the Encyclopaedia of Medical Physics

As we described in the previous chapters, the idea of a Medical Physics Dictionary was born during 1998 and it was obvious that the idea would later develop into an Encyclopaedia – a very large and complex project. We separated this activity into two sub-tasks – Thesaurus and Dictionary (initiated in the EMIT project), and Encyclopaedia – the main part of the new project EMITEL. The first task was initiated during 2001 and in 2003 it was completed with the creation of a Medical Physics Thesaurus and Dictionary (initially in 5 languages). The next task was to explain each term from the Thesaurus with a short entry/article – thus creating an Encyclopaedia of Medical Physics.

The project EMITEL (European Medical Imaging Technology e-Encyclopaedia for Lifelong Learning) was drafted immediately after the end of the EMIT project. This way the new project was presented to the UK Leonardo Agency in mid-2005 and, based on their feedback, was prepared for full submission during 2006. It was soon approved ‘as is’ (in June 2006). The start of the project was officially announced at the World Congress on Medical Physics and Biomedical Engineering in Seoul, Korea (August 2006, soon after this a number of senior colleagues volunteered to join the team on behalf of IOMP). At this World Congress IOMP awarded S Tabakov with its Harold Johns Medal for Excellence in Teaching and International Education Leadership.

The objective of the pilot project EMITEL was to develop an original e-learning tool, to be used for lifelong/continuing learning of a wide range of specialists in Medical Physics and Medical Imaging Technology. The tool was planned to be linked to our existing EMERALD and EMIT materials and to include (additionally to Medical Imaging) Radiation Protection& Hospital Safety and Radiotherapy topics, thus forming a one-stop knowledge database (or rather a Web portal) for those who want to acquire a specific competence and for those who want to refresh their knowledge and to learn about the new developments in medical physics. EMITEL was also planned to be linked to our existing Digital Dictionary (which by that time included 7 languages), and to double the number of languages in the Dictionary.

EMITEL was developed by a large group of professionals. It was expected that other health care specialists using medical imaging technology and applying radiation protection in hospitals will also use the project results. EMITEL was planned to address not only the newest developments in the field, but also classical medical technology and issues related to radiation protection. The product was planned to be web based, so allowing quick and easy upgrades –vital for the dynamic development of the profession. Special activities were planned for the assessment of the Encyclopaedia (System of Refereeing and International Conference).

The project Consortium included as partners: King's College London - School of Medicine and Dentistry; King's Healthcare Trust; University of Lund; Lund University Hospital; University of Florence; AM Studio, Plovdiv, Bulgaria; the International Organization for Medical Physics (IOMP). This was the first EC project for IOMP, which paved the way for future European projects of the Organisation. Later the project was joined also by the International Centre for Theoretical Physics (ICTP), Trieste, Italy. This way the project included most of the partners from the previous projects EMERALD and EMIT. This was logical, as EMITEL used lots of images prepared in both projects, as well as the Thesaurus and Dictionary developed under EMIT project.

EMITEL was approved as a 2-year EC project (Leonardo Programme), but in fact it later included extensions and was completed in about 3 years (with significantly more outcomes) – Fig. 8.1.

As per our initial plan the main EMITEL project phases (Work Packs) were:
- Structuring e-Encyclopaedia and Dictionary;
- Developing the e-Encyclopaedia content;
- Translating the main terms into many languages;
- Developing the software and web shell;
- Internal and external refereeing;
- Testing the products;
- Editing of the e-Encyclopaedic articles;
- Dissemination events (incl. International Conference);
- Publishing and Commercialisation

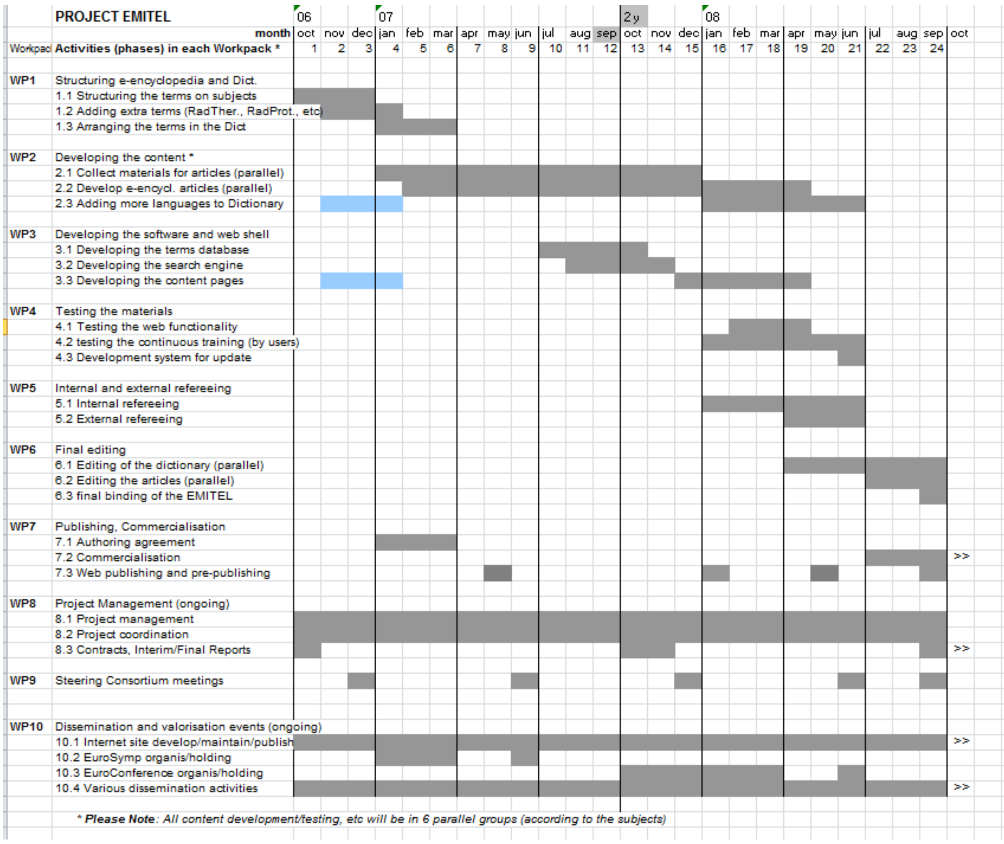


Fig. 8.1 Initial activity chart and timetable of the EMITEL project (as per the project Work packs: WP1-WP10)

One specific feature of this project was that it required parallel work of 7 Work Groups. This was the only way to complete the huge task ahead. The 7 Work Groups were separated as per the internal topical division of the medical physics profession:

- Diagnostic Radiology (X-ray) physics - DR
- Magnetic Resonance Imaging physics - MR
- Nuclear Medicine physics - NM
- Radiotherapy physics - RT
- Radiation Protection in Medicine - RP
- Ultrasound Imaging physics - US
- General topics - GEN

The seventh group "General" included various medical, material, mathematics, physics and other topics related to medical physics. Additionally there was a Web-development Working Group dealing with the complex web site of the e-Encyclopaedia. Another completely separate set of activities (with many sub-groups) was the translation of the Medical Physics Thesaurus into various languages – the Dictionary part of the project. In fact before the official start of the project we had already arranged the translation of Polish, Thai, Hungarian and Lithuanian (this was in addition to the completed in project EMIT translations into French, German, Italian, Swedish, Spanish and Portuguese, plus the English Thesaurus). This way terms were already translated into 11 languages and ready to be included into the new Encyclopaedia web site.

EMITEL was an enormous project – not only the largest in the profession, but also with extremely complex coordination. It was obvious from the very beginning that the project would need an extension to the original 24 months, and also that it would have a second (perhaps a third) phase outside the EC project. The inclusion of IOMP in this project was vital as the project needed experts from all parts of the world, and also IOMP could provide the necessary future updates of the Encyclopaedia and Dictionary.

As soon as the project was approved we purchased a good laptop with interactive screen (Fujitsu-Siemens, at the time its price was around £3000), as well as an Interactive White Board (Promethean 77-inch, at the time with price around £1500). These, together with graphic tablets and suitable software, were planned to be used for the preparation of the many diagrams in the future Encyclopaedia. Both were also very useful for our teaching process (especially for the application of e-learning and studying software use).

The first meeting of EMITEL Consortium was at King's College Hospital, London (10-11 September 2006); its main objective was to agree the project plan, timetable and distribution of workload (in the parallel Working Groups). The meeting also identified the IOMP experts from various countries who would join the team. It was also agreed that anyone contributing 5 to 10 articles/entries (depending on their size) will be acknowledged as contributor to the Encyclopaedia.

The Consortium agreed that after the end of the EC project (which envisaged developing the on-line e-Encyclopaedia) a contact would be made with CRC Press, Taylor & Francis Group, to arrange the paper print of the materials (as a second phase of the project). The project budget was also agreed and, due to the extremely complex task, a part-time Assistant to the project Manager and Coordinator (S Tabakov) was appointed. During the first year of EMITEL this was J Chick, and from 2008 this was V Tabakova (who from the beginning of the project was working on it on a voluntary basis). The colleagues from the large Swedish group appointed M Peterson to coordinate their internal writing of articles.

EMITEL Encyclopaedia was based on the existing Thesaurus of Medical Physics, but it was expected that it would be updated with new terms during the work on the project. This way the Thesaurus was used as the Encyclopaedia Index – Fig. 8.2. It was in 7 parts (as per the topics of the profession, now distributed between 7 Working Groups)

An important part of this meeting was the discussion about the structure of the web database and the web site to host the e-Encyclopaedia. The concept of this web site was proposed by S Tabakov and AM Studio (M Stoeva and A Cvetkov) and the Consortium agreed its main structure and functionality. It was intended that the web site should have a simple and flexible structure allowing easy use and update. It was also agreed that the web site be built with our own design, not based on external templates, which would make it dependent on future software updates from the template owner. We already knew that the constant “modernisation” and software updates of the commercial companies could shorten the longevity of the product. Our goal was to develop a web site which would deliver effectively the information to our colleagues. The most important part of the web site (the Encyclopaedia content) was planned to have long life and to allow easy update in the future. Indeed the web site which was developed by AM Studio (using .NET technology) has now served the profession for almost 10 years without any problems (uninterrupted work with about 1000-2000 users per week from various countries). The design and the structure of the Content Management System (CMS) of the web site were also agreed at this meeting (and also developed by AM Studio).

At this meeting the project domain name was agreed as www.emitel2.eu (‘emitel’ was already taken) and a hosting was purchased in the large internet provider company *1&1*.

Another important outcome of the meeting was the agreement on the Word template (to be used for writing the articles); as well as the folder/file naming system which would be used in the database. All these elements of the EMITEL project will be described in detail in chapter 9 of the book.

Finally the project agreed its logo (Fig. 8.3) and the dates of future Groups meeting and Coordination meetings.

Fig. 8.2 S Tabakov and V Tabakova in front of the Encyclopaedia Index used for coordination of the project development

Fig. 8.3 EMITEL Logo, symbolising the international character of the project, designed mainly by M Stoeva

EMITEL Project – the Network and the development of the content

The work on the development of the Encyclopaedia started immediately after the first Consortium meeting. The selected IOMP contributors were officially invited to join the respective Working Groups and most of them accepted immediately the invitation. The dissemination of the information about the project was also initiated. P Smith, who was the IOMP representative in EMITEL, included information about the project in the IOMP Bulletin at the World Congress in Seoul (WC2006) and following this regularly informed the IOMP Executive Committee and all National Member Societies of the Organisation. This was mainly through publications in the IOMP Newsletter Medical Physics World (its Editors since then have been I Parsai, D Frey and V Tsapaki).

In only a month we had in the Coordination Office about 100 new encyclopaedic entries (articles). In order to keep track of the content, the authors and related data, J Chick developed an *MS Access* database - it was later upgraded several times, but was always used as the Master Database for project coordination.

Also, negotiation started with the Dictionary Translation Groups into Estonian, Czech, Bulgarian, Russian, Turkish, Arabic and Persian languages. Adding these new languages to the existing ones would result in 18 languages (more than the planned 14 languages in the project submission). This project expansion was a good reason to apply to EC for project extension in the future (which was an obvious need).

The second Consortium meeting was held in Lund University, Sweden (11-12 May 2007). This meeting (called "*Euro Seminar EMITEL*") included colleagues from various IOMP countries, including USA. The following tasks were reported as completed in the period October 2006 – May 2007

- New Web site with Web dictionary were developed and launched;
- Internal project contracts were made;
- 4 new languages were added to the Dictionary (Estonian, Romanian, Turkish, Arabic);
- New CMS system was developed, fully tested and launched;
- More than 250 entries were developed;
- Authors Guide and CMS Guide were made;
- CRC Printing negotiations were initiated;
- IOMP support and introduction of new members to the team was achieved;
- The work pack for structuring the e-Encyclopaedia and Dictionary was completed
- The web site visits (for the Dictionary and Project data only) were about 3000.

The Consortium agreed milestones for the completion of articles/entries. It was also planned to request a larger project extension from EC, based on the increased deliverables for the Dictionary (the ready Dictionary translations at the moment were 15), but also used for preparing articles/entries. The Consortium also agreed to start the refereeing of the ready entries in parallel with the writing of the new encyclopaedic entries. This was the only way to complete on time the huge task ahead. Each Working Group assigned an internal Coordinator, an Editor and an Uploader to the CMS. This way the ready entries were subject to internal refereeing before their upload to the web site. At the same time the Consortium agreed to invite External Reviewers, who would have the task to check the uploaded entries. At that time the main encyclopaedic part of the web site was made available only for internal use, so the refereeing and editing could be made online.

These activities (Fig. 8.4) assured very good level of assessment of the entries, but doubled the coordination work in the coming months, as each group had two activities – writing entries and refereeing entries (which included two web uploads – of the initial entry and the final edited encyclopaedic entry/article). To facilitate the work with the various stages of entry completion we developed a new system of specific file names. This system of work continued to the end of the project (the system is described in detail in the next chapter 9).

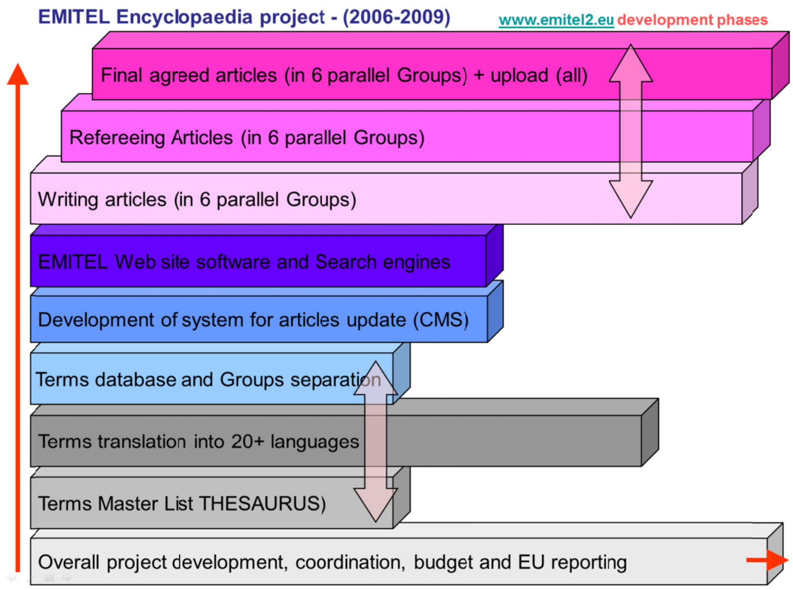


Fig. 8.4 Initial activity chart and timetable of EMITEL project

The second Consortium meeting in Lund (Fig. 8.5) included specific Work-group separate meeting, where all group members (as per the professional topics) could discuss their specific internal questions related to the explanation of specific entries. The groups highlighted the importance of explanation of the entries, which would increase their educational value. It was also decided to include later students in each of the groups, who would test the clarity of explanations of the entries.

Fig. 8.5 EMITEL Consortium meeting, Lund, 2007 (part of participants): from L>R first row: P Smith, E Nordh, G Clarke, A Benini, J Chick, S Keevil, S Tabakov, F Stahlberg; middle row: G Boyle, A Cvetkov, M Stoeva, F Milano, B-A Jonsson, R Wirestam, D Goss; upper rows: P Sprawls, M Peterson, M Ljungberg, M Radwanska, J Thurston, A Simmons, S-E Strand

Immediately after the end of this Consortium meeting we submitted documents to EC requesting 4 month project extension. This was followed by an EC monitoring of the projects development at King's College London. Soon after this the requested extension was granted.

Also in this period the translation of the Medical Physics Thesaurus in Czech, Persian and Bulgarian was almost completed, and negotiations were made for the translation into:
Greek, Croatian, Malay, Russian and Finnish. The use of the Dictionary was now growing and the unique users were about 1500 per month.

At that time the project main activity of writing encyclopaedic entries was complemented by the parallel reviewing of these. All external reviewers were later included in the project. IOMP included project discussions at all its meetings and accepted the project as one of the main reference sources of the profession. This was in line with the agreement of the Consortium that in future the update of the Dictionary and the Encyclopaedia be handled by the IOMP (International Organisation for Medical Physics) aiming to support the global development of the profession.

At this period of time new Internet Social Networks were spreading fast (such as *Facebook*). It could have been a good vehicle for the project dissemination, especially among young colleagues, but we had the excellent support of the IOMP existing professional network. Perhaps we could have explored this as well, but the later use of EMITEL showed that we were reaching all colleagues without Internet Social Media.

The third Consortium meeting was held in Florence University, Italy (10-11 Nov 2007) – Fig. 8.6. The main topic of this meeting was again the development and reviewing of the encyclopaedic entries (by that time about 40% of the initial entries were ready). It was agreed to include new entries and to expand the Thesaurus with new medical physics methods and equipment. These were entered in the database with new ID numbers and were sent (after the meeting) to the groups with translators for the update of the Dictionary. It was also agreed that some terms be excluded or be explained with hyperlinks to other terms.

The above discussions for expansion and modification of the Database required inclusion of an additional Search Engine to the EMITEL web site – in English, looking inside the text of the entries (the other Search Engine already existed - multilingual for the Dictionary). It was decided that this be done in the beginning of 2008 as part of the preparations of the web site for partial launch for the large EMITEL International Conference (planned to be in ICTP, Trieste, Italy during October 2008).

A Publishing agreement for 5 years was also made between the Consortium partners, aiming to create a Network which would further update the Encyclopaedia and later transfer its update to another institution (as agreed - IOMP). The meeting also expanded the list with Reviewers and included, as before, specific discussions of the Working Groups related to the entries in their topics.

Fig. 8.6 EMITEL Consortium meeting, Florence, 2007 (part of participants): from L>R front row: A Cvetkov, S Keevil, A Benini, M Radwanska, L Sweetman, J Chick, M Stoeva, D Goss, F Milano, S Tabakov; back row: A Simmons, M Almqvist, G Boyle, P Smith, S-E Strand, T Jansson, J Thurston, C Lewis.

A very pleasant surprise for the colleagues at the meeting was the arrangement made by our host F Milano with the city officials – all Consortium members were granted the privilege to visit the famous Corridoio Vasariano, the historical site with gallery above Ponte Vecchio, which is opened only for special occasions – Fig. 8.6, Fig, 8.7.

Fig. 8.7 Corridoio Vasariano, above the Old Bridge of Florence (Ponte Vecchio)

Fig. 8.8 A special guided visit of EMITEL Consortium to the famous Corridoio Vasariano in Florence.

The time after the Consortium meeting was immediately occupied with the Interim Report to the EC (which was submitted the same month and was soon approved), alongside with the development of more and more encyclopaedic entries. Two more translations for the Dictionary were completed and the translation in Chinese and Bangladeshi began. This required further tests of the web site of the Dictionary to work with these specific characters, but the task was not so difficult this time as most of the Internet Browsers were now quite advanced and allowed work with various alphabets.

The main Internet browsers we used until that moment were *Netscape Navigator* and *Internet Explorer* (plus limited use of *Opera*). The team did not use Mac-Browsers, as all the work in our projects was Windows-related (typical for many European projects). During EMITEL *Mozilla Firefox* made very good advance and we included it in all tests. We also purchased an Apple Mac laptop to use it for tests with the *Safari* Browser. All our materials were now on Internet and we were dependent on the Web browsers. During the period after the Florence meeting AM Studio updated the design of the EMITEL web site and migrated it to an SQL Server. This allowed improved access to the database and increased speed of upload and download. The updated web site was later tested with various Internet browsers (now including also *Chrome*), as well as with access from mobile devices (tablets and smartphones).

The fourth Consortium meeting was held in London (17-18 May 2008) – Fig. 8.9. By that time the translations into Greek, Czech and Latvian were completed and the number of external Reviewers had increased to 28 – listed as per their professional topic/Work Group:

DR (Don Frey, Alain Noel, Nikolas Pallikarakis, Mario de Denaro, Kalle Kepler)
NM (Anchali Krisanachinda, George Mawko, Ana Millan, David Bradley)
RT (Markus Buchgeister, Jean Yves Giraud, Pal Zarand, Iva Horakova, Barry Allen)
MR (Martin Leach, Jacques Bittoun, Ewald Moser, Gunther Helms, Tobias Schaeffter)
US (J A Evans, Crispian Oats)
RP (Cari Borras, Stelios Christofides, David Platten, Kjeld Olsen)
GEN (Erwin Podgoršak, Ratko Magjarevic, William Hendee)

This way the colleagues contributing in the EMITEL Encyclopaedia were already representing 23 countries. More than half of the entries were completed, but we were still behind the initially set deadlines. In order to help with this the Consortium agreed to further increase the number of project participants. Gradually these reached 100. One challenge with this was the need to pass some of the entries through English editing before submission for Reviewing. At this stage we also included students (mainly from the MSc course Medical Engineering and Physics, King's College London, led by S Tabakov) as second Reviewers of the level of explanation of the entries.

The Consortium discussed and agreed the Guides for Contributors and Guides for Reviewers, defining the methodology of work. The Consortium also agreed in future the upload of entries to the CMS to be handled by the Coordination Office (mainly by V Tabakova) in order to have a single version of the uploaded files. This was supported by a further system of folders with entries with specific names as per the stage in their reviewing (described in chapter 9).

As usual the meeting included specific discussions of the Working Groups. Finally the meeting agreed on the timetable for the *EuroConference EMITEL* in ICTP Trieste.

Fig. 8.9 EMITEL Consortium meeting, London, 2008 (part of participants): from L>R front row: E Morris, M Radwanska, G Clarke, V Aitken, C Lewis, I-L Lamm, J Chick, M Almqvist, C Deehan, B-A Jonsson, E Nordh, S Tabakov, A Cvetkov, M Stoeva, G Taylor, J Thurston; back row: V Tabakova, T Jansson, P Smith, C Deane, D Goss, F Milano, M Lewis, J Boyle, M Peterson.

By that time the number of files and folders had increased dramatically (both in digital and paper form) – all these had to go through specific path - Work Flow (Fig. 8.10). The fact that we had our new premises in the KCH Department helped a lot as we were able to constantly put new shelves with folders and had many walls to stick lists with entries at various stages of their completion (Fig. 8.11). The laptops had large disks for the time (500 GB) which helped handling the large number of encyclopaedic files (word files, images and graphics at various stages of their assessment) - around 25,000. From time to time the only way to work with this huge amount of information was simultaneous work on two computers (Fig. 8.12). Having said that we have to emphasize that the project team was very lucky at the time as the whole development of EMITEL was made with one PC Operational system (*Windows XP*). This was a stable system and all project contributors were comfortable with using the software for it. Just one year after the end of EMITEL this system was replaced with the new *Windows 7* (its 64-bit version required software updates and new familiarisation with it). With this system our CD-ROMs with Image Database stopped working (and software update for its re-creation was not available). It was a bit sad to leave behind this precious product of ours after 10 year uninterrupted use, but fortunately all its content – images and Training tasks - was already on Internet at our web site (as e-learning alongside EMITEL).

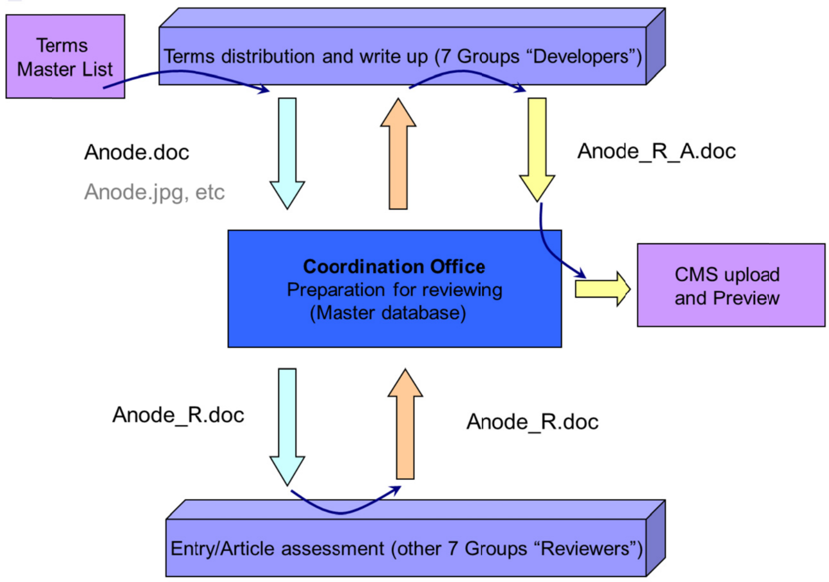


Fig. 8.10 EMITEL project main workflow (example of an entry "Anode" with its files and changing of file names during the process of Preparation > Refereeing/Reviewing > CMS Upload). This was performed in parallel in all 7 Groups of Developers and Reviewers. The distribution was at the Coordination office with 4 parallel large folders of the Encyclopaedia (depending on the development stage of the Entry) – Initial Entry; Reviewed Entry; Approved Entry; Final Upload.

The work over the period following the London meeting was extremely intensive. We had not been able to reach the planned number of entries (expected to be ready before the EMITEL Conference) and this required all efforts to be at this front. It was at this time that we found two old encyclopaedic publications, but with much smaller volume. One of these was an old Encyclopaedia with considerably smaller number of entries than EMITEL (a small number of large entries) - the *Physics in Medicine & Biology Encyclopedia* (in 2 volumes, Editor T.F. McAinsh, published in 1986 by Pergamon Press) – we found only its second volume. The other was a Dictionary with brief explanations (214 pages) – *The Radiological Sciences Dictionary*, D J Dowsett, SetDown Publishing Ltd, Dublin, 1999. Unfortunately we could not use either of these for our work, as the number of entries of the first one was much smaller, while the second one was very brief. Also at this period of time we learned that in Seoul, South Korea an English-Korean Dictionary of Medical Physics (translation of terms) had just been made (likely triggered by our first Dictionary distributed free at WC2003, Sydney). The Korean team (Dr Tae Suk Suh and Dr Wee Saing Kang) later discussed that this had been very useful for their society. Further, as a continuing collaboration, both colleagues took part in the editing of the EMITEL Korean translation.

Fig. 8.11 The Coordination Office - part of the folders and materials for the EMITEL Encyclopaedia project

Fig. 8.12 The Coordination Office – work on the classification of the many files with entries (text, images, graphics, translations)

The EMITEL Conference

The large EMITEL Conference was held at the premises of our long-standing project partner - ICTP, Trieste (23-26 October 2008) – Fig. 8.13. Although the Conference was announced in EC as EuroConference, this was International Conference (through the support of IOMP). Its main objective was the assessment of the e-Encyclopaedia materials, their further development, dissemination and use.

The Conference included project members, also a group of students, who used the e-Encyclopaedia for several months and gathered very useful feedback, and also medical engineering professionals, thus widening the scope of EMITEL. The Conference was by invitation only, gathering about 70 specialists - leading experts in Medical Physics. These included 21 present and past Presidents of Medical Physics Societies, Federations and Organisations (including a number of IOMP Officers).

The inclusion of medical engineers (through the IFMBE – the International Federation of Medical and Biological Engineering) was actually preceded by their expression of interest to our Encyclopaedia of Medical Physics. They invited EMITEL experts to take part in several of their conferences (e.g. the 11th Mediterranean Conference on Medical and Biological Engineering and Computing MEDICON 2007 in Ljubljana, Slovenia; the 14th Nordic-Baltic Conference on Biomedical Engineering, 2008 in Riga, Latvia, etc). The cooperation with the medical engineers continued during the World Congress WC2009 in Munich, Germany and during the 12th Mediterranean Conference on Medical and Biological

Engineering and Computing MEDICON 2010 in Chalkidiki, Greece. As a result a project was planned aiming to develop similar e-Encyclopaedia of Medical Engineering, which is under way at this moment.

Fig. 8.13 EMITEL Conference, ICTP, Trieste, Italy, 2008 (part of participants): from L>R front row sitting: E Morris, E Chaloner, J Calvert, G Clarke, J Chick, A Krisanachinda, I-L Lamm, M Radwanska, B Allen, M Lewis, R McLauchlan, I Horakova, M Almqvist, V Tabakova, S Tabakov, A Benini; front row standing: C Oates, K Olsen, G Mawko, M Petersson, B-A Jonsson, R Magjarevic, M Secca, E Moser, J Boyle, P Bregant, N Pallikarakis, S Christofides, D Bradley, F Schlindwein, S Keevil, R Wirestam, F Milano, E Podgorsak, D Frey, A Cvetkov, K Keppler, D Goss; second row standing: M DeDenaro, C Deehan, M Buchgeister, G Taylor, A Simmons, T Schaeffter, J Thurston, D Platten, H Terrio, M Leach, T Jansson, C Deane, P Zarand, A Evans, M Grattan, P Smith, C Lewis

The access to the EMITEL e-Encyclopaedia was given to all delegates through a special password-protected web site http://previewsql.emitdictionary.co.uk and feedback started to be collected before the Conference. This event gathered many of the encyclopaedic entries Developers and Reviewers, plus students for each of the Work Groups. More than half of the Conference was in topical groups, followed by group reports, assessment and decisions.

One of the important decisions was to support the Consortium views of avoiding internal hyperlinks between the entries (apart from abbreviations), which could make the whole project difficult for future updates. The experts also supported the Consortium views that entries/articles would include a list of Related Entries/Articles. Specific feedback was collected from all Work Groups; from the students reading the entries; as well as from the users about the Encyclopaedia as a whole – its access, learning outcomes, updates, etc. This EMITEL Assessment ("Valorisation", as per the EC terminology) was very useful.

The delegates also suggested other topics to be included in future – e.g. Optics and other Non-ionising radiation methods, Famous medical physicists, etc. This was all accepted to be included in the further updates of the Encyclopaedia. It was also discussed that another similar Conference would be needed in future, most likely co-organised with some of the IOMP events, in line with the agreed future IOMP involvement in EMITEL.

The Conference delegates highlighted the impact of the previous e-learning projects (EMERALD and EMIT) on the global development of the profession. The Conference also assessed highly the impact of our new web site with EMERALD and EMIT e-learning materials plus the Medical Physics Dictionary, already used by more than 2000 colleagues per month – this being about 1/3 of all medical physicists whose main language is not English (Fig. 8.14). The Conference also decided to encourage further updates of EMERALD and EMIT, as well as the inclusion of more languages into the Dictionary. This way by 2013 the number of languages increased to 29 (using 8 alphabets).

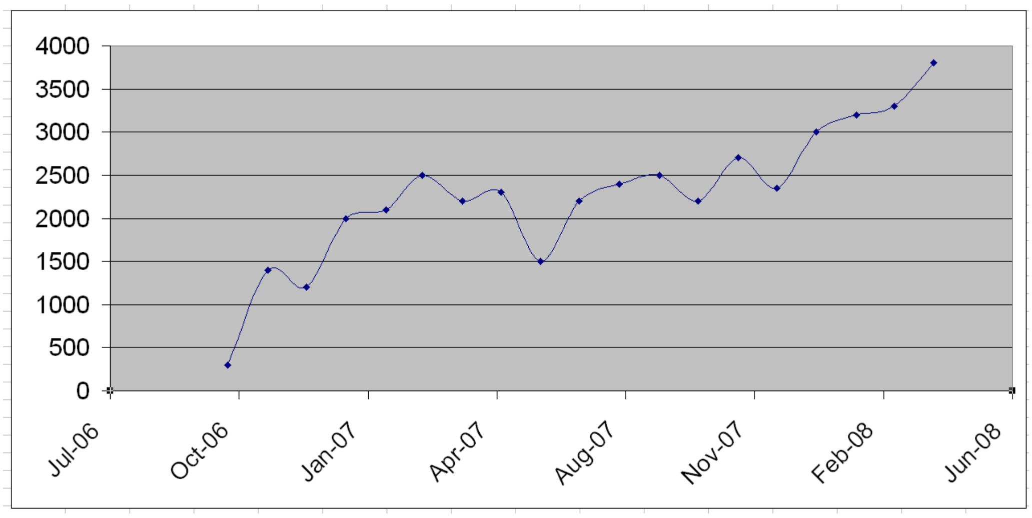


Fig. 8.14 Statistics (users per month) of the new websites of *emerald2* and *emitdictionary*: period 2006 - 2008

The students' feedback was also very encouraging – they all found the entries concise, easy to understand and very useful for their studies. A note was also made on the consistency of some formulae (inevitably a challenge in the work of an international team). The educational level and complexity of the entries were found to be consistent. The students had graded about 70% of all entries/articles as good and excellent. The Consortium took a decision to edit accordingly the other entries. It also agreed to include specific sub-headings for longer entries to simplify their understanding. Finally the Consortium agreed to include in the final version a full index of the Encyclopaedia. This was materialised in the next phase (outside the EC project) - paper print of the EMITEL - and was further included in the e-Encyclopaedia.

EMITEL Project Completion and the Next Phase – Paper Print

Discussing the paper print of EMITEL with CRC Press, Taylor & Francis Group, (after the completion of the EC phase of the project), the Consortium agreed to include more specialists at this Paper-print phase (expected to take 2 years), and agreed a draft timetable for this additional phase of the project (Fig. 8.15). This phase was necessary to include additional Editorial Printout and steps aiming to prepare the material for CRC print by the end of 2011.

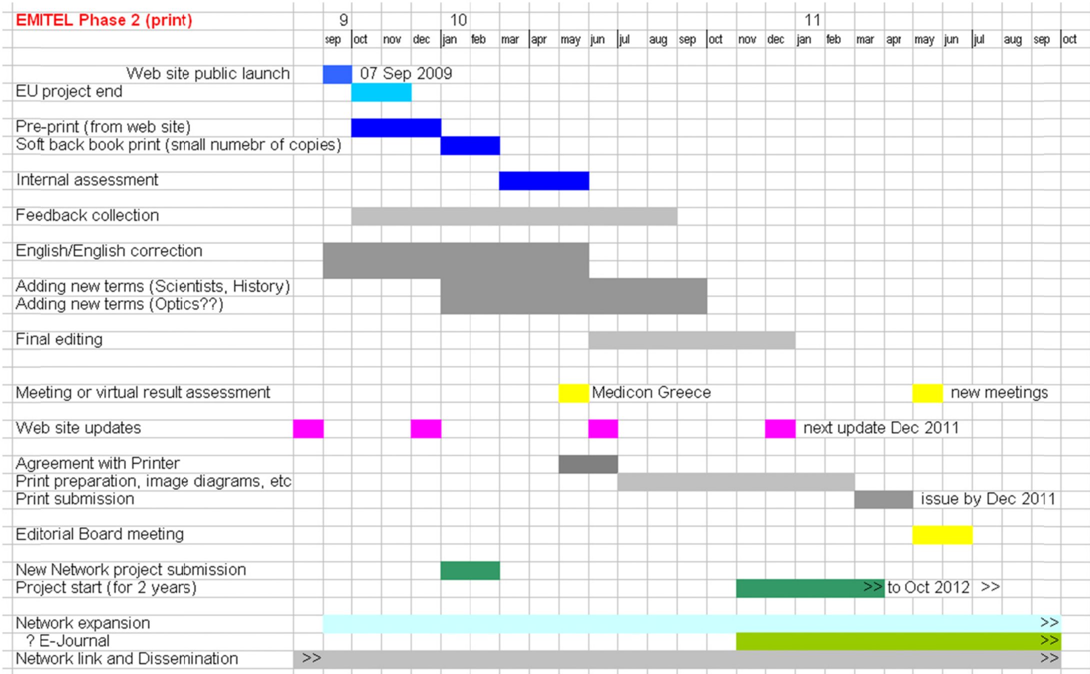


Fig. 8.15 Initial timetable of the EMITEL second phase (paper print) – 2009-2011

Following the EMITEL Conference the Consortium included a number of additional contributors, as well as graduates and students in order to help with the completion of the final entries (it was decided that the corrections should be included in the Encyclopaedia after the completion of the EC phase of the project). In order to complete the task another (final) meeting was necessary and project extension of two months was requested. This was granted by the EC and this way the project covered 30 months (to April 2009).

The final Consortium meeting was in London (20-21 March 2009) aiming to discuss the completion of the Encyclopaedia (Fig. 8.16). It included a number of MSc students (who had assessed the final articles/entries). The meeting evaluated highly the scope and usefulness of the project. The Web designers from AM Studio were specially acknowledged - Fig. 8.17 (later, in 2013 IOMP awarded M Stoeva the Young Scientist IUPAP Medal, mainly for the work on the Encyclopaedia). It also agreed that all corrections would be made in the several months between project official completion and Final Report submission to the EC. Finally it was agreed that the official launch of the EMITEL Website (www.emitel2.eu) be on 7 Sept 2009 at the World Congress in Munich, Germany (the EMITEL Opening at WC2009 Munich was over-full and on 11/9/2009 an extra Seminar was held in its Exhibition area).

The Consortium also agreed on the specific steps in the next phase of the project – the paper print of EMITEL. This was planned to be completed by 2011, but in fact the internal CRC checks took another year (see chapter 9).

Fig. 8.16 EMITEL Consortium final meeting London March 2009 (part of participants): from L>R front row sitting: T Underwood, E Morris, J Calvert, J Chick, M Radwanska, G Clarke, G Taylor, N Dulai, V Tabakova, S Tabakov, H Richardson; second rows standing: B-A Jonsson, M Ljungberg, F Milano, P Smith, J Thurston, D Goss, S Keevil, M Petersen, S-E Strand, C Deehan, T Jansson, J Boyle, A Benini, A Simmons, M Lewis, C Deane, C Lewis

The Consortium acknowledged that alongside the EMITEL project the largest professional Network had been created, including about 300 experts from 36 countries. Both the Dictionary and Encyclopaedia contributors, forming the Network, included 61 Past and Present Presidents of Medical Physics National Societies and related professional societies, and Officers of International Federations and Organisations of the profession.

It was decided that the Network would be supported in future by the IOMP and an e-Journal on Education and Professional issues would be launched to support such activities and international collaboration (later in 2012 this Journal was opened by IOMP – *Medical Physics International* – a very successful activity, attracting currently about 1000 readers per week – see chapter 10).

The Final project to EC was one of the largest we had ever made. It took some two months to be prepared. It was approved without any remarks (Fig. 8.18)

EMITEL RESULTS

The objective of the pilot project European Medical Imaging Technology e-Encyclopaedia for Lifelong Learning (EMITEL) was to develop an original e-learning tool, which would be used for lifelong/continuing learning by a wide range of specialists in Medical Physics and Medical Imaging Technology. The product of the project surpassed our expectations (in terms of volume and number of languages). The final product is the first dedicated e-Encyclopaedia of Medical Physics (including Medical Imaging, Radiotherapy and Radiation Protection) plus a unique e-Dictionary of Medical Physics Terms cross translating between its 29 languages.

EMITEL e-Encyclopaedia and Multilingual Dictionary was an ambitious task, not undertaken in the profession so far. This required the final product to be supported by a number of intermediate products (some of these quite large). Also it required attracting colleagues from many countries, which created a large International Network (about 300 specialists from 36 countries), which continued to look after the EMITEL products after the end of the project. An indicator of the impact and quality of the product is that before the project completion the Dictionary had some 3500 users per month.

A. The Encyclopaedia system of work and project web site

The first product – the EMITEL web site was made to coincide with our previous projects (EMERALD and EMIT). This required developing a new joint web site and the transfer of the previous web sites to the new one. This aimed at creating a one-stop reference tool (or rather a Web-portal). The web site included a small newsletter which was regularly updated. As with our previous projects, this web site continues to be supported after the end of the project.

The next two products (EMITEL Authors' Guide and EMITEL Referees' Guide) were temporary and aimed at providing the necessary guidance to our contributors. It was expected from the beginning that EMITEL would attract many specialists from various countries. This required parallel collective work, which had to produce results with similar outlook and quality. The Authors' Guide showed not only the necessary steps in writing the articles, preparing the supporting materials (images, diagrams, formulas, tables, etc) but also provided examples and templates. The Guide included also a system for collection of articles (filing system in specific folders and file names) – see chapter 9. Special attention was given to the development of the taught/academic approach to EMITEL. It was decided that explanatory articles should be written assuming existing MSc-level knowledge of the users. Later this was specially addressed during the testing phase (by experts – Reviewers/Referees and by MSc trainees/students, who had just completed their academic studies). The Referees' Guide provided a system for refereeing and addressing the comments of the reviewers. It also included a system for file identification, as each article existed in 3-4 different stages (written, refereed, accepted, final). These Guides continue to be used and updated after the end of the project.

B. The Medical Physics Multilingual Dictionary and its Web site

The next product EMITEL Multilingual Dictionary of terms needed a large international involvement. Our dissemination activities attracted about 200 volunteers and this enthusiastic support of Medical Physics experts from 29 countries was the pinnacle of the success. The project began with sorting all existing terms and distributing these into 6 categories. The initial temporary results included a large Excel spreadsheet (6 MB) and an *Access* database. These included information about each term, its ID, its area, the Group working on it, possible interlinks with other terms, the writer, the referee and the acceptor of the final article. Based on these a Master List of terms (Thesaurus, in English) was made and distributed to the first groups of translators. As we already had the terms cross-translated in 7 languages - English, French, German, Swedish, Italian, Spanish and Portuguese (the last two were added after the completion of our previous project EMIT) work on these was not performed at this stage. The translation work began for Bulgarian, Czech, Greek, Hungarian, Lithuanian and Polish. Our dissemination had already created strong interest in the profession and on this background we included after the EuroSymposium 6 new languages: Estonian, Romanian, Turkish, Russian, Thai and Arabic (thus having a total of 20 languages). To make all translations immediately usable through Internet we had to develop an additional web site for the Dictionary. After the EuroConference (October 2008) the list of terms was updated. This resulted in some additions, exclusions, amalgamations, corrections, etc.

These were all included into a new English spreadsheet and sent to all 20 languages for editing. The work was completed on time and the updated Dictionary was very soon used by thousands of colleagues around the world. Towards the end of 2008 the project additionally included 3 more languages – Slovenian, Malay and Chinese. These were completed just before the end of the project alongside with two additional new languages (Bengal and Persian) which were added in the last month as well. Another 4 languages were completed and included into the Dictionary after the end of project. The Dictionary continues to be used and updated by the EMITEL Network.

The next product (the web site www.emitdictionary.co.uk) was necessary to make all languages immediately available to the users. Although our main EMITEL web site includes both the Encyclopaedia and the Dictionary, we knew that it would be ready at the end of the project and needed to attract users earlier. The web site emitdictionary.co.uk was made as a temporary web site, but we left it open after 2009 and it is still used. This early web site was made fully functional and was updated several times to handle various alphabets. The search engine developed for this site was later transferred to our main web site. One of the features of this web site was using parts of words (useful in case of spelling mistake) and suggesting similar terms. The e-Dictionary translated between any of its languages, which is very important for cross-translations . The web site emitdictionary.co.uk was tested internally and externally and updated.

C. The Encyclopaedia Update tool (Content Management System – CMS)

The next product was the EMITEL CMS Web site (http://cms.emitel2.eu). This “hidden” web site includes the whole EMITEL database – both languages for the Dictionary and Encyclopaedic entries/articles with their images, diagrams, etc. The Content Management System (CMS) handles the content of our web site emitel2.eu and allows its upload, editing and management. The idea for the CMS came from our partner AM Studio after the launch of the project and the CMS was the main result of the first project extension. This product includes two interlinked web databases – one for the Dictionary and one for the Encyclopaedia. It has a password protected interface and several layers of access, allowing each uploader to see the other entries/articles, but to edit only his/her ones. Each entry/article includes specific fields for text, images, references, hyperlinks, related articles, etc. The unique IDs of the articles are preserved. Each article can be seen with the dates of its previous editions and who has made these (see Fig. 9.8 and Fig. 9.9). The development of this product took several months. It is based on *Microsoft* products and feeds directly the information to the main web site emitel2.eu . The CMS can handle also sound, video and small animations to allow for future updates of EMITEL. The testing of this web site was vigorous through various platforms and browsers. It has worked flawlessly for almost 10 years. The database was updated with the latest SQL and was transferred to a new powerful business-type server (where emitel2.eu is hosted). The CMS is accessed only by password. Although this large web site is invisible by the users it is the heart of the open product emitel2.eu and provides all its information.

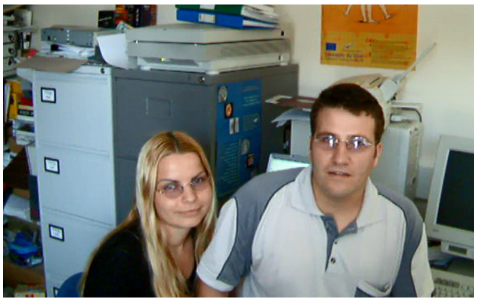


Fig. 8.17 The EMITEL web site developers – M Stoeva and A Cvetkov (AM Studio)

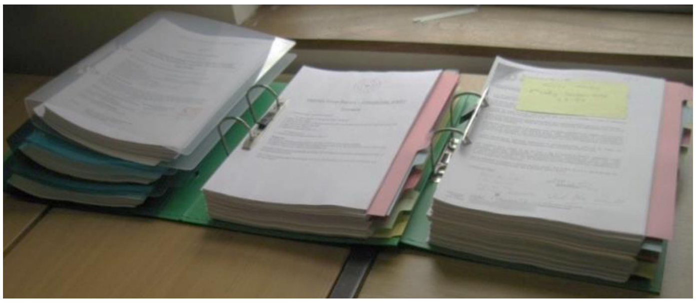


Fig. 8.18 Final report to EC of the EMITEL project (excluding the volume of the Encyclopaedia and Dictionary - see Fig. 9.11)

D. The Entries (articles) of the Encyclopaedia

The next (and the largest) product are the EMITEL Encyclopaedic entries/articles. These form the volume of the first dedicated e-Encyclopaedia of Medical Physics. Its development took more than half of the time and budget of the project. It was developed by about 100 colleagues. The development and the testing of the articles was supported by the Authors' Guide and the Referees Guide. All articles were separated into 7 groups and, internally in each group, separated into themes. This presented an easier way to write the articles. All writers were asked to develop their own supporting materials (images, diagrams, etc). All these were refereed internally in each Work group and coordinated with the other Work groups during the Consortium meetings. The *EuroConference EMITEL* was a very important moment of this task, as at this forum the writers and the referees met and exchanged opinions. At this stage an "exchange of roles" exercise was made - each referee wrote several articles and the authors refereed these. To facilitate the process of article assessment all these were pre-printed on paper and distributed to the Working groups who had several workshops with the referees. The following meetings revealed the need of an update of the main database with articles. The aim of this was to increase the educational value of the articles. This required amalgamation of some articles, expansion of some articles, deletion of some articles, interlinking of some articles, doubling of some of the articles etc. This way the articles entering into the final Editing phase needed more time and an additional 2-month project extension was granted. The work on the database update was made in the Coordination Office with the help of all Group coordinators. This was e-published (uploaded) at the CMS and the updated Work Group Lists were distributed among all partners. The final project meeting included also the various assessors and evaluated the overall project results. This was made in parallel with the online assessment of these by many representatives from the Language groups (who are also Medical Physics experts). It was found to be of high quality and very useful for the profession. The final number of articles is about 3200. Their volume (main Word files and JPG images) is more than 1GB. The images, diagrams, etc are approx. 2500. The final printed volume, in alphabetically arranged A4 pages, depends on the typeset - when the default Times New Roman 12 was used, it reached 2100 pages. All the articles were uploaded to the main web site emitel2.eu, which was launched free to all users at the opening ceremony of the World Congress of Medical Physics and Biomedical Engineering (Munich, 7 September 2009). The colleagues who took part in the EMITEL Encyclopaedia included some of the most senior medical physicists in the profession. According to their opinion EMITEL is one of the highest educational achievements in the profession which has significant global impact. The Network EMITEL formed during the development of both products (Encyclopaedia and Dictionary) continues to support and update the products after the end of the project.

E. The large combined web site of Encyclopaedia + Dictionary

The final product of EMITEL was the web site www.emitel2.eu which displays both the Encyclopaedia and Dictionary. The interface of this web site (aka PREVIEW) was agreed by all partners and was designed by AM Studio. This web site handles both the Encyclopaedia and the Dictionary. It was specially made to handle various alphabets. To allow specific searches this original web site was created with two Search engines – one Multilingual to search in all article titles (terms) and another in English to search inside the text of each article (it handles partial requests, which is useful in case of spelling mistakes). The web site and the engines have worked flawlessly for some 10 years now. Each request for additional entries, expanding of articles, etc is be handled by the existing Work Groups. The web site www.emitel2.eu was opened free at the World Congress (September 2009).

EMITEL is the largest international project in Medical Physics. At the end of the project all members of EMITEL Consortium and Network expressed their gratitude to the EC Leonardo da Vinci programme and to their Institutions for the support of this project. However the project was supported mainly by the huge commitment of each individual who took part in it.

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Encyclopaedia Contributors:

Aitken, Victoria, (Editorial Board), King's College, London, UK
Allen, Barry, St George Hospital NSW, Australia
Almqvist, Monica, (Editorial Board), Lund University Hospital, Lund, Sweden
Batchelor, Philip, King's College London, UK
Benini, Anna, Ringshospitalet, Copenhagen, Denmark
Bibic, Adnan, Lund University, Lund, Sweden
Bittoun, Jacques, CIERM-Hôpital de Bicêtre, France
Bloch, Karin, Lund University, Lund, Sweden
Blythe, Kirsty, King's College Hospital NHS Foundation Trust, London, UK
Borras, Cari, University of Pernambuco, Brazil
Boyle, Gerard, St James's Hospital, Dublin, Ireland
Bradley, David, University of Surrey, Guildford, UK
Bregant, Paola, University Hospital "Ospedali Riuniti", Triest, Italy
Brockstedt, Sara, Lund University, Lund, Sweden
Buchgeister, Markus, Beuth University of Applied Sciences, Berlin, Germany
Calvert, Justine, King's College Hospital NHS Foundation Trust London, UK
Chaloner, Elizabeth, King's College Hospital NHS Foundation Trust London, UK
Cheung, Kin-yin, Hong Kong Sanatorium and Hospital, Hong-Kong, PR China
Chick, Joan, (Editorial Board), King's College London, UK

Christofides, Stelios, Nicosia General Hospital, Nicosia, Cyprus

Clarke, Gillian, (Editorial Board), King's College Hospital NHS Foundation Trust, London, UK

Clinch, James, King's College Hospital NHS Foundation Trust, London, UK

Conaghan Patrick, King's College Hospital London, UK

Cvetkov, Asen, (Editorial Board), AM Studio Ltd, Plovdiv, Bulgaria

Deane, Colin, (Editorial Board), King's College Hospital NHS Foundation Trust, London, UK

Dedenaro, Mario, University Hospital "Ospedali Riuniti", Triest, Italy

Deehan, Charles, (Editorial Board), Guy's and St Thomas's NHS Foundation Trust, London, UK

Dulai, Navneet, King's College Hospital NHS Foundation Trust, London, UK

Dunlop, Alex, King's College Hospital NHS Foundation Trust, London, UK

Eskola, Hannu, Tampere Technical University, Tampere, Finland

Evans, Anthony, University of Leeds, Leeds UK

Evans, Phil, Institute of Cancer Research and Royal Marsden Hospital, UK

Footman, Michelle, King's College Hospital NHS Foundation Trust, London, UK

Frey, George D, Medical University of South Carolina, SC, USA

Giraud, Jean-Yves, Grenoble University Hospital, Grenoble, France

Goss, David, (Editorial Board), King's College Hospital NHS Foundation Trust, London, UK

Grattan, Mark, Northern Ireland Cancer Centre, Belfast City Hospital Trust, Belfast, UK

Hakansson, Kristina, King's College Hospital NHS Foundation Trust, London, UK

Harris, Nicola, King's College Hospital NHS Foundation Trust, London, UK

Helms, Gunter, University Clinic Göttingen, Germany

Hendee, William, Medical College of Wisconsin, Milwakee, WI, USA

Hernando, Ignacio, University Hospital Río Hortega. Valladolid, Spain

Hogg, Naomi, King's College Hospital NHS Foundation Trust, London, UK

Horakova, Ivana, National Radiation Protection Institute, Prague, Czech Republic

Jansson, Tomas, (Editorial Board), Lund University Hospital, Lund, Sweden

Joel, Emily, King's College Hospital NHS Foundation Trust, London, UK

Jonsson, Bo-Anders, (Editorial Board), Lund University, Lund, Sweden

Jonsson, Lena, Lund University, Lund, Sweden

Keevil, Stephen, (Editorial Board), King's College London, UK

Kepler, Kalle, University of Tartu, Estonia

Knutsson, Linda, Lund University, Lund, Sweden

Krisanachinda, Anchali, Chulalongkorn University, Bangkok, Thailand

Lamm, Inger-Lena, (Editorial Board), Lund University Hospital, Lund, Sweden

Latt, Jimmy, Lund University, Lund, Sweden

Leach, Martin, Institute of Cancer Research and Royal Marsden Hospital, UK

Lewis, Cornelius, Editor, (Editorial Board), King's College Hospital NHS Foundation Trust, London, UK

Lewis, Maria, St George's Hospital, London, UK

Ljungberg, Michael, (Editorial Board), Lund University, Lund, Sweden

Magjarevic, Ratko, University of Zagreb, Croatia

Mannfolk, Peter, Lund University, Lund, Sweden

Marsden, Paul, King's College London, UK

Mawko, George, Queen Elizabeth II Health Sciences Centre, Halifax , Canada

McClean, Brendan, St Luke's Hospital, Dublin 6, Ireland

McLauchlan, Ruth, Charing Cross Hospital, London, UK

Milano, Franco, Editor, (Editorial Board), University of Florence, Florence, Italy

Millan, Ana, Radiophysics Techniques Inc, Zaragoza, Spain

Morris, Elizabeth, King's College London, UK

Moser, Ewald, Medical University of Vienna, Vienna, Austria

Ng, Kwan Hoong, University of Malaya, Kuala Lumpur, Malaysia

Nickel, Mattias, Lund University, Lund, Sweden

Nilsson, Markus, Lund University, Lund, Sweden

Nilsson, Anders, Lund University, Lund, Sweden

Noble, Jonathan, King's College Hospital NHS Foundation Trust, London, UK

Noel, Alain, Centre Alexis Vautrin, Vandeouvre-les-Nancy, France

Nordh (Lindholm), Emil, (Editorial Board), Lund University, Lund, Sweden

Nuesslin, Fridtjof, (Editorial Board), Technical University Münich, Germany

Oates, Crispian, Newcastle Hospitals NHS Foundation Trust, Newcastle-upon-Tyne, UK

Olsen, Kjeld, University Hospital Herlev, Denmark

Olsrud, Johan, Lund University, Lund, Sweden

Pallikarakis, Nikolas, University of Patras, Greece

Peterson, Mikael, (Editorial Board), Lund University, Lund, Sweden

Phillips, Jonathan, King's College Hospital NHS Foundation Trust, London, UK

Platten, David, Northampton General Hospital, Northampton, UK

Podgorsak, Ervin, McGill University, Montreal, Canada

Radwanska, Marta, AGH University of Science and Technology, Krakow, Poland

Richardson, Hamish, King's College Hospital NHS Foundation Trust, London, UK

Rydhog, Anna, Lund University, Lund, Sweden

Schaeffter, Tobias, King's College London, UK

Schlindwein, Fernando, University of Leicester, Leicester UK

Secca, Mario, New University of Lisbon, Lisbon, Portugal

Sibley-Allen Christopher, King's College Hospital NHS Foundation Trust, London, UK

Siikanen, Jonathan, Lund University, Lund, Sweden

Simmons, Andy, (Editorial Board), King's College London, UK

Smith, Peter, (Editorial Board), IOMP

Sprawls, Perry, Editor, (Editorial Board), Emory University, Atlanta, GA, USA

Stahlberg, Freddy, (Editorial Board), Lund University, Lund, Sweden

Stoeva, Magdalena, (Editorial Board), AM Studio, Medical University Plovdiv, Bulgaria

Strand, Sven-Erik, Editor, (Editorial Board), Lund University, Lund, Sweden

Tabakov, Slavik, EMITEL Project Manager and Coordinator; Editor, (Editorial Board), King's College London, UK

Tabakova, Vassilka, King's College London, UK

Taylor, Graeme, Guy's and St Thomas's NHS Foundation Trust, London, UK

Terio, Heikki, Karolinska University Hospital, Stockholm, Sweden

Thurston, Jim, (Editorial Board), Royal Marsden Hospital, London UK

Underwood, Tracy, King's College Hospital NHS Foundation Trust, London, UK

Valcinov, Emil, University of Patras, Greece

Walmsley, Bruce, Guy's and St Thomas's NHS Foundation Trust, London, UK

Wastling, Stephen, King's College, London, UK

Wirestam, Ronnie, (Editorial Board), Lund University, Lund, Sweden

Zarand, Paul, Uzsoki Hospital Medical Physics Lab. Budapest, Hungary

Working Group Coordinators:

- **Diagnostic Radiology (X-ray):** Slavik Tabakov, Perry Sprawls, Maria Lewis
- **Magnetic Resonance:** Andrew Simmons, Stephen Keevil, Freddy Stahlberg
- **Nuclear Medicine:** Sven-Erik Strand, Bo-Anders Jonsson, Mikael Peterson
- **Radiation Protection:** Cornelius Lewis, Peter Smith, Jim Thurston
- **Radiotherapy:** Franco Milano, Inger-Lena Lamm, Charles Deehan, Joan Chick

- **Ultrasound:** David Goss, Tomas Janson
- **General terms:** Graeme Taylor, William Hendee
- **EMITEL Web software:** AM Studio Ltd. - Magdalena Stoeva, Asen Cvetkov
- **Network Administrator and Editorial Assistant**: Vassilka Tabakova

Fig. 8.19 Photo collage of part of the EMITEL Contributors – Encyclopaedia and Dictionary

Fig. 8.20 EMITEL souvenir mug, including the names of all contributors and supporters

9. Organisation and Development of the Encyclopaedia

Introduction

The earlier development of the Dictionary was very useful for the development of the Encyclopaedia of Medical Physics. However the work on such a huge project and its coordination was really challenging. While developing this project we did not have a guide for the organisation and build-up of an Encyclopaedia. Here below we shall explain our experience as a method which proved successful and delivered very good results.

The first decision to be taken was related to the type of the Encyclopaedia. To decide on this we purchased several Encyclopaedias and discussed their design. In general there are two main types of these Reference books – with small number of large articles, or with a large number of small articles.

A number of specialist Encyclopaedias include relatively small number of extensive articles and additional Index of many terms, mentioned in various articles. The Encyclopaedias with small number of large articles are relatively easier to organise (each author prepares a large article on specific subject), but are difficult to search (specific Index is needed for this).

An example of such type specialist Encyclopaedia is the *Encyclopaedia of Imaging Science and Technology* (in 2 volumes, Editor Joseph P. Hornak, published in 2002 by John Wiley & Sons) – as a comparison its letter N has 1 article (covered in 15 pages), letter O has 3 articles (covered in 81 pages). Similar type was also the only Encyclopaedia in our field we came accross (in fact we found only its second volume) - the *Physics in Medicine & Biology Encyclopedia* (in 2 volumes, Editor T.F. McAinsh, published in 1986 by Pergamon Press) – its letter N has 15 articles (covered in 57 pages), letter O has 2 articles (covered in 6 pages).

The Encyclopaedias with large number of small articles are easier to search and update. They normally do not have an Index, as the alphabetically arranged articles are an extended index by itself. However such Encyclopaedias are more difficult to organise as they include many Authors, many articles/entries and many Referees. A well-known general knowledge Encyclopaedia with many small articles is *Larousse*.

As we already had the Multilingual Dictionary, based on our Medical Physics Thesaurus, it was logical to accept the second design (with a large number of small articles). This was also suitable as Reference in the dynamic profession of Medical Physics, where updates would be necessary quite often. By that time *Wikipaedia* was gaining popularity and it also used this concept.

This way EMITEL developed 3000+ encyclopaedic articles/entries. An indicative example of the EMITEL outcome (using the two samples above, and the EMITEL pre-print in 2010) shows: in EMITEL letter N has 73 articles and 11 hyperlinks (covered in 48 pages), letter O has 43 articles and 12 hyperlinks (covered in 32 pages).

The next point to agree was the academic level of the Encyclopaedia entries (articles). This was unanimously agreed to be at Master level (MSc, or equivalent) and above. This way it was not necessary to use very simple explanations, and at the same time was a way of allowing medical physics MSc students to use EMITEL as an educational resource (the word encyclopaedia most likely coming from the Greek *enkyklios paideia* – general education). All articles/entries were planned to be written in English (translation of such large volume into several languages and its editing/control would require much more time and efforts).

Following this we prepared guides for different types of articles/entries (short, medium, large). The use of font sizes, images, tables, diagrams, captions, References, etc was standardised in order to help the significant number of authors to prepare entries with unified look. *MS Word* Templates were made for the writing of the entries – Fig.9.1.

C. SHORT ARTICLE - SAMPLE

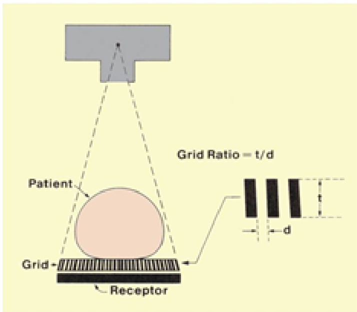
Article title	**Grid Ratio**	Arial 12 bold
		1 space
Subject area	Diagnostic Radiology	Arial 12
		2 spaces
Text of the article	The grid ratio of an anti-scatter grid is a design characteristic of a grid as illustrated on Figure 1. Higher ratio grids have increased attenuation of scattered radiation and produce improved image contrast at the cost of a reduced sensitivity.	Arial 10 (some subheadings in bold)
Internal subheadings (if any)		Bold for some subheadings in the text
Single image (or formula)		Formulas will be presented as Images
Or double image/formula		
Image Format JPG (or anim. GIF)		Image taken from elsewhere could have different fonts inside and in caption
Caption under external image	Figure 1. Grid ratio concept and formula. (Courtesy of P. Sprawls)	Arial 9
Possible further text in Arial 10		
	Related Articles: Grid efficiency	Arial 9
Further Info and web sites (without hyperlinking)	FURTHER INFORMATION:	Arial 9
	- Sprawls P, Physical Principles of Medical Imaging, 2002, Medical Physics Publishing, Madison	Image max 500 pixels width for single image, or 200 px width for 2 images (the other pixel size – height - as much as it takes).

Fig.9.1 Sample article/entry from the EMITEL Guide for Authors

Organisation of Encyclopaedia Files

We expected more than 20,000 files (text of the articles/entries, associated images/diagrams, remarks, etc) and needed to have a sound structure supporting this large volume of information. The information was held in several ways:

- Folders with the files in the main Coordinating computer (during the development period) – The Master Computer storage – this was used only during the development.

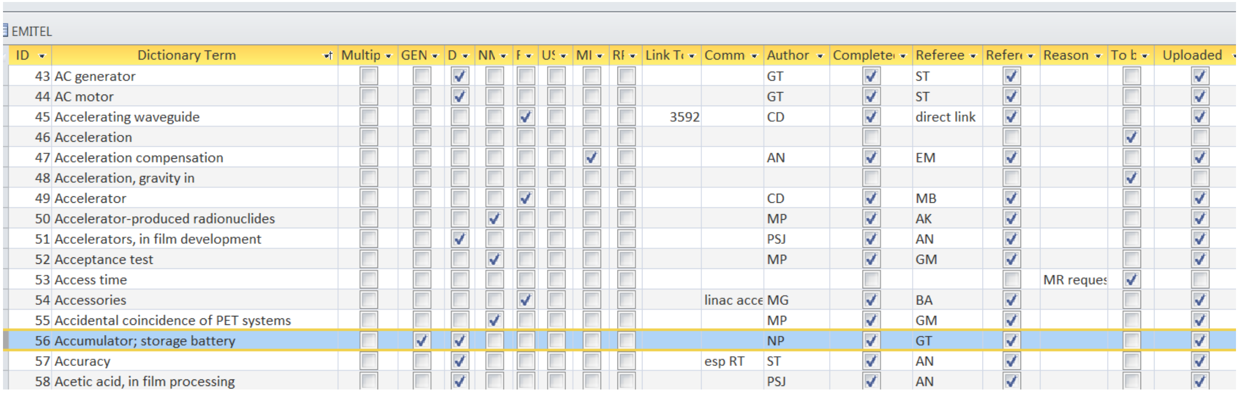
- Printouts of all entries (in the Coordination Office, used during the development period and further preparation of paper prints) – the Master printout
- Web database with the entries ready for free access on Internet (the final product, which was accessible to the Consortium from the beginning during the development) - this was the final database to stay after the completion of the project

The development of the Encyclopaedia was made by 7 Workgroups developing articles/entries in parallel. These were the same as the Groups in the Medical Physics Dictionary: X-ray Diagnostic Radiology, Nuclear Medicine, Radiotherapy, Ultrasound Imaging, Magnetic Resonance Imaging, Radiation Safety, General. Each group had its own Coordinator and held regular internal meetings (both during the Consortium meetings and on-line). The main Project Coordinator (S Tabakov) was regularly exchanging information with the Workgroup Coordinators.

All data was gathered in our Coordination office at the Department of Medical Engineering and Physics, King's College Hospital, where we employed a specialist dedicated to collect and organise all incoming data - J Chick (Oct 2006-Oct 2007) and V Tabakova (Jan 2008 to Aug 2011).

The dataflow was recorded in an original *MS Access* database, which was created at the beginning of the project in 2006 and was updated regularly after this (it was expanded several times). This was the Master Database, where we could easily find the author/reviewer and status of each entry/article.

We kept the ID numbers of the entries identical to those in the Dictionary. Following this the entries were separated according to their Workgroup, to allow the progress of separate Workgroups to be easily followed. Each entry was associated with an Author and later also with a Referee. The stage of completion of the entries and of their refereeing was also indicated (as well as the final upload to the Encyclopaedia web site). The hyperlinks between entries were reflected in the Database by the destination ID (see Fig.9.2). The Master Database also included additional useful information, such as dates (of various stages), comments, reasons to delete an entry, etc (Fig. 9.2). All new entries were allocated new IDs, as per the system used in the Dictionary (see chapter 6). A Master Excel Spreadsheet was regularly printed from the Database for facilitating the progress monitoring. These Excel Spreadsheets were saved with different file names, indicating the current production date.


EMITEL

ID	Dictionary Term	Multip	GEN	D	NM	F	US	MI	RF	Link To	Comm	Author	Complete	Referee	Refer	Reason	To b	Uploaded
43	AC generator			✓								GT	✓	ST	✓			✓
44	AC motor			✓								GT	✓	ST	✓			✓
45	Accelerating waveguide					✓				3592		CD	✓	direct link	✓			✓
46	Acceleration																✓	
47	Acceleration compensation							✓				AN	✓	EM	✓			✓
48	Acceleration, gravity in																✓	
49	Accelerator					✓						CD	✓	MB	✓			✓
50	Accelerator-produced radionuclides				✓							MP	✓	AK	✓			✓
51	Accelerators, in film development			✓								PSJ	✓	AN	✓			✓
52	Acceptance test				✓							MP	✓	GM	✓			✓
53	Access time															MR reques	✓	
54	Accessories					✓					linac acce	MG	✓	BA	✓			✓
55	Accidental coincidence of PET systems				✓							MP	✓	GM	✓			✓
56	Accumulator; storage battery		✓	✓								NP	✓	GT	✓			✓
57	Accuracy			✓							esp RT	ST	✓	AN	✓			✓
58	Acetic acid, in film processing			✓								PSJ	✓	AN	✓			✓

Fig. 9.2 Sample Print-screen of the Master Database. Here entry ID 56 is covered by two Workgroups; Entry 53 has been deleted (to be explained in another entry); Entry 45 has been hyperlinked to Entry 3592, etc.

The Master Computer storage included a system of folders and sub-folders. There were 8 Main folders - 7 for the separate Workgroups (DR, NM, RT, RS, MR, US, GEN) and one Summative (SUM, much larger) for an aggregation of all entry folders. Each Main folder had many Entry folders – one for each Encyclopaedic Article/Entry. Inside the Entry folders were the text files, image files, and other data associated with the specific entry (Fig. 9.3).

The Entry folders had the same names as the Entries – e.g. “Absorbed Dose”. Each Entry folder included a Word .doc file (created with formatting as in the templates). The file had the same name as the Entry – e.g. “Absorbed Dose.doc”. This Entry file included all the text, formulas and images, the captions, etc., exactly as it was going to appear later in the printed article (or on Internet, the only difference being that the images on Internet were with smaller resolution).

The images inside the Entry folder were saved as JPG in two resolutions – for the Paper print (300 dpi) and for the Internet (72 dpi). The image file name was the same as the name of the Article – e.g. “Absorbed Dose 1h.jpg” (for the second image the file name would be “Absorbed Dose 2h.jpg”, etc…). Here h stands for high resolution. In case the image was required to be in colour in the paper book, this was indicated in the file name with c - e.g. “Absorbed Dose 3hc.jpg” (a number of the images for paper print were in black/white). The diagrams were mainly with white background.

The small JPG images (for Internet) were resized from the large JPG images. In case of single image the Resize was to 500 pixels width. In case of two images (one next to the other) – these were resized each to 200 pixels width (the height of the image was not restricted). The formulas were also stored as JPG images (taken from the original with Print Screen), keeping the same pixel sizes. These images (and formulas) were also named as the Entry – e.g. "Absorbed Dose1.jpg" (for further images - "Absorbed Dose2.jpg" and "Absorbed Dose3.jpg",etc); for formula "Absorbed Dose4.jpg", etc. N.B. for these small images there was no h after the file name. These small images (for the Internet upload) were all in colour.

Any information regarding copyright correspondence was also saved in the Entry folder (for example letters sent, received replies, agreements, etc.) with the name of the Entry. Initially we allowed all Authors to upload their files on the EMITEL web site, but for the purposes of standardisation this job was taken over directly by the Coordination Office. This way at the end of each month the Authors were compressing/zipping the ready folders and were sending these to the Workgroup Coordinator, who was directing these to the Project Coordinator. The upload used the text from the file – e.g. "Absorbed Dose.doc", and the small images associated with it – e.g. "Absorbed Dose 1.jpg".

It is obvious that File management software was essential for the development of the Encyclopaedia (initially this was *MS Windows Explorer,* later we used *PowerDesk*). This was essential part of the development process which at the end exceeded 50,000 files.

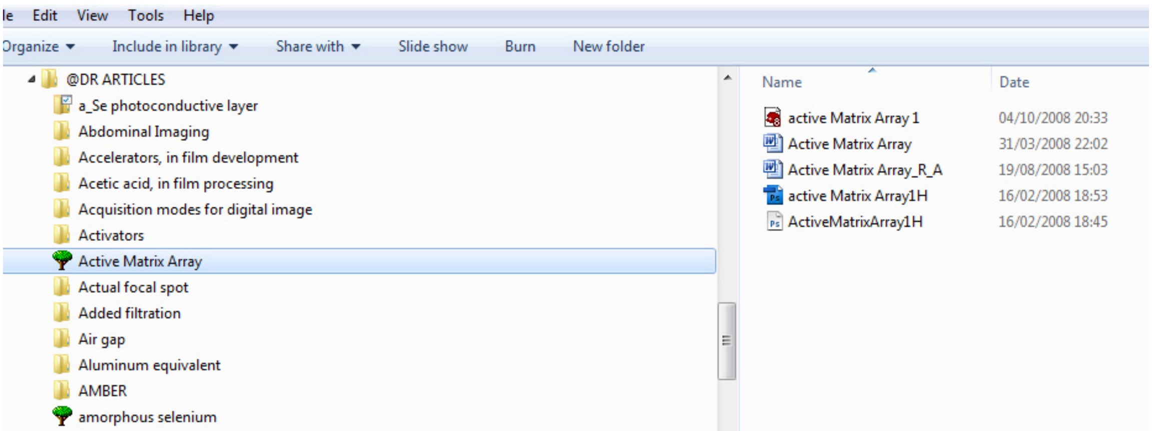


Fig.9.3 Sample Print-screen of the Main Folder DR (Diagnostic Radiology) with various alphabetically arranged Entry folders. Here the Entry folder "Active Matrix Array" is with green icon (indicating that refereeing is completed and the entry is ready for final Internet upload). This folder includes Word file and several Image files (high/low resolution). N.B. the specific icon of the first folder ("a_Se …") indicates that additional data is required (e.g. copyright).

Special Guidelines for System of Work were prepared by us for each Encyclopaedia author. As they facilitated the smooth creation of thousands of Entries, we are providing them below:

>>

EMITEL Encyclopaedia System of work

EMITEL has many contributors from various countries. This System of work aims to help authors in preparing their articles. The system is not imperative, but provides an easy work flow for developing the Entries for EMITEL.

A. Preparation for work

1. Try to work on themes. Having selected a group of articles on a common subject (theme) helps to concentrate on the subject and could save time for drawings;

2. Consult the Main Excel spreadsheet for information about similar/related entries (either from your Group or from another one), which could have images/diagrams to share, or simply add to your list of "Related Articles";

3. Browse the main list of terms to identify possible duplicate terms to your chosen ones. The duplicates will be useful in the Dictionary, but will only be hyperlinked in the encyclopaedia – e.g. main Entry "Absorbed Dose", duplicate "Absorbed radiation";

4. Identify the sequence of Entries you shall develop within the theme. Work could start with the simplest and continue towards more complex Entries (this creates a rhythm and allows better preparation of paragraphs);

5. Create in your HardDrive empty folders for your Entries (both for the Entries and for the duplicates to be covered by Hyperlinks) and name these as agreed with the name of the Entry (e.g. "Absorbed Dose");

6. Inside each folder of a duplicate entry/term (e.g. "Absorbed radiation") create an empty TXT file and name it to link to the main Entry (e.g. "See Absorbed Dose"). This will help the future hyperlinking in EMITEL Web site;

7. Identify the main sources of books, web sites, etc. to be used in writing the Entries within the theme;

8. Identify existing diagrams, images, etc and save these in the appropriate folders without renaming them yet;

9. Use/prepare own images/diagrams. If this is not possible you need to ask for copyright permission. Any information regarding copyright correspondence should also be saved in the Entry folder. When you get the permission, please notify the Project Coordinator;

B. Writing the Entries

10. Open your *MS Word* template and save it in the appropriate folder for your first Entry (use file name as the Entry - e.g. "Absorbed Dose.doc");

11. Write the Entry in paragraphs with images/diagrams in between to facilitate the user's educational build up of knowledge;

12. The "normal length" of an Entry is between 150-500 words, but if necessary the entry can be made longer. Some limited duplication could take place, as it could make the use of EMITEL easier, rather than forcing the reader to jump to a number of related Entries to understand the subject of your Entry;

13. Select the images/diagrams you need for the Entry and crop them to show only the important features. Save these images as JPG high resolution files (10% compression, or 90% quality) in your working folder with the name of the Entry and sequence number (e.g. "Absorbed Dose 1h.jpg, Absorbed Dose 2h.jpg, etc). Here h denotes – high resolution (your max resolution). If you want specifically the image to be in colour both on the web and in the printed book (where most illustrations will be b/w), then add c after h – e.g. Absorbed Dose 3hc.jpg;

14. In case the JPG compression does not show the detail you want to be seen, or the vector graphics does not transfer well into JPG, then name appropriately and save in your folder the original files either as TIFF or as Original drawing file (e.g. Absorbed Dose 3hc.tif or Absorbed Dose 2h.cdr). This can be useful for the future paper print;

15. Open your high resolution images in an image processing software (e.g. *Photoshop, Paint Shop Pro*, etc) and resize/resample these to decrease the file size to max 500 pixels width (in case of 1 image between the text paragraphs), or to 200 pixels width (in case of 2 adjacent images between the

paragraphs). Assess the quality of your resized image and if not sufficient, try to make two images – e.g. full image and detail. Save the resized images in your Entry folder with the same name, but without h in it (e.g. "Absorbed Dose 1.jpg"). The height of the image is of no importance. If all original images are small you can save them all without h ;

16. Make Print Screen of complex formulas in your Word text and store these as images (with the same sizes). Name these as the name of the Entry - e.g. Absorbed Dose 4.jpg. Note that you can write simple (1 line) formulas directly into the text of the Entry;

17. Place the resized images in the tabulated places in the Entry with text. This Entry is now ready for upload to the web site EMITEL;

18. Write the small captions below the images in their tabulated places. Do not use long captions (the max length is 200 symbols) and do not use symbols, super/sub scripts, etc. The Internet web caption fields are without these functions. If necessary you could further explain the image in the paragraphs above/below the image (where all symbols can be used);

19. Consider a possible small example to be added to the Entry. Also try to use some real figures in the article to facilitate the user (e.g. "The X-ray tube anode angle is most often between 10^0-20^0");

20. Special images (very large, video clips, etc.) will be dealt with separately. These should be saved in the folder with extensions e.g. . Absorbed Dose 5s.avi) and will be uploaded separately;

21. When preparing the References try to avoid general book references (EMITEL is a reference book by itself). Add References and web addresses only where necessary;

22. List the names of the Entries which resemble yours most closely in the appropriate fields (Related Articles);

23. Change the footer of the Word file with the Entry to show its file name, date and your author's name. Save the file in the working Entry folder and delete from the folder all other working files. You could use the file Comment field (in the file Properties) to put some useful info, which could be later displayed in *Windows Explorer*;

24. Read your Entries in the theme to check their style. Remember that EMITEL will be used by many colleagues whose first language is not English, hence try to use appropriate wording, avoiding idiomatic phrasing;

25. Once the article is ready refrain from constant re-editing. In the project there are special periods planned for this purpose – after the internal assessment of Entries and after the Refereeing;

26. Remember that the Web Database system is not made for online editing. Its prime functions are two – to allow all authors to see the articles of others (and perhaps borrow images, or use text) and to allow future Update of EMITEL. Due to this reason make your editing over your Word files and send these to the Coordinator;

27. Once a month send your Entry folders with text, images, etc. to your Group coordinator as ZIP (who will also send these to the Project Coordinator). When you edit your article re-send the file and indicate that this is a repeat (use the agreed different Folder icon for the purpose).

ST, 10 July 2007

>>

Each Entry file, written by an author, had to go through several stages of Refereeing/Editing:

- Internal refereeing (in the Workgroup)
- First Editing by the author, based on remarks from Internal refereeing
- Sending to project Coordinator for upload to the web site for internal viewing only: preview.emitel2.eu
- Feedback from the other Workgroups
- Possible Second Editing by the author in case of need
- Sending the file to an External Referee by the project Coordinator
- Feedback from External Referee discussed by the author and the Workgroup
- Final (Third) Editing by the author
- Final sending to project Coordinator for upload to the web site (www.emitel2.eu - open for all)

To help with the internal workflow of the Entries most of the Group Coordinators were using their own Tables with colour coding to indicate the progress stages of each Article/Entry (completed, Internal refereeing, editing 1, sent to Project Coordinator for upload to the web site, External refereeing, editing 2, final upload, etc).

The Refereeing Process

We had limited time and the external refereeing began with the Entries that were already prepared, while the Workgroups were completing the remaining files. This parallel work required additional indications in the Entry File names to show the stage of assessment. To avoid possible mismatch all Main Folders (in the Master Computer storage) were doubled in a second Main Folder to handle separately the External Refereeing files (the number of files exceeded 50,000).

This way in the Master Computer storage we had two sets of Main Folders – one holding the Entry files during their creating and internal refereeing; the other one - holding the Entry files during their external refereeing and final editing. The final files from this second set of Main Folders were ready for the final uploading and use.

The changes of the File names in the second set of Main Folders were: e.g. “Absorbed Dose_R.doc” (the file is ready for sending to External Referee), and following this “Absorbed Dose_R_A.doc” (the file has been returned from External Referee to the Author and the final editing has been made). The Word file names were included in the footer of the files, alongside with information about the file pathway and date of access.

When this final ready Entry file was uploaded to the EMITEL web site its folder icon was changed to green folder (see Fig. 9.3).

To unify the process of Refereeing, we made a template for the External Referees (Fig. 9.4).

In order to handle the Refereeing process easily, the External Referees were allocated themes with Entries within their specialism (e.g. Diagnostic Radiology – X-ray Equipment; Diagnostic Radiology – Image quality, etc). All EMITEL communication with the External referees was through the Coordination Office. The two sets with Main Folders were very useful to separate the two main workflows – the creation of Entries and the refereeing of Entries. This was a huge and very complex process which had to be done with meticulous precision by us in the Coordination office, as all 7 Workgroups were developing the Encyclopaedia in parallel and all refereeing was also in parallel. There were days with hundreds of emails with data (entries, images, comments, corrections, etc) to be answered, forwarded and sorted. Due to the very large volume of data the backups were handled with the software *Super Flexible File Synchroniser*, which allowed backup of changes only over the existing massive of data.

EMITEL: Referees Report

Term and Area: (as per article title)

Referee name:

Overall Opinion:

Enter: Y or N (and add Editing over the *MS Word* file with *Track Changes*)

Acceptable as it is	
Acceptable with minor changes	
Major changes necessary	

Add Comments, if necessary:

1. Scientific/ Clinical/medical

2. Presentation and Clarity

3. Language, Spelling , Grammar

4. Other Comments

Fig. 9.4 Template for Referee report (further suggestions for Entry changes were included as Track Changes or Comments)

During the refereeing process the referees suggested some additional images/diagrams or occasionally whole new articles. In the latter case we had to go through the reverse process – to ask the Referee to write the article, while someone from the Workgroups was refereeing it. This was also related to another parallel task – translating the new terms in 29 languages.

Following the completion of an Entry and its final upload to the EMITEL web site, the folder with this file was moved to the final Summative Main Folder, where all Entries (from all 7 areas) were listed consecutively in alphabetical order. This Summative Main Folder was prepared for the final stage of the Encyclopaedia – its paper print (this stage was outside the scope of the EC project) – Fig. 9.5.

Before describing this final paper-print stage, we have to explain the structure of the web site handling the Encyclopaedia. In general the web site had a web database and two layers of web site above it – the Database was fed with information through a Content Management System (CMS, open only to the Consortium members) and the data from the CMS was displayed for worldwide use through the free-access web site www.emitel2.eu (open for all users of the Encyclopaedia). All elements of this web site were made by our partner AM Studio (M Stoeva and A Cvetkov).

Fig. 9.5 Part of the Working paper files of EMITEL

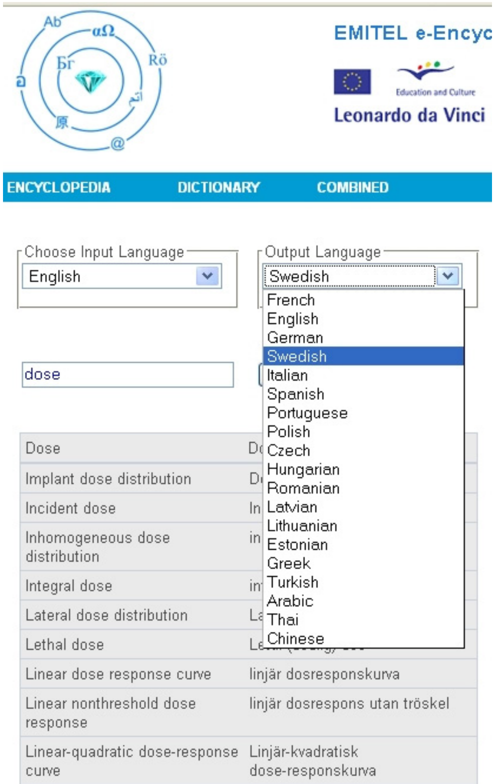


Fig. 9.6 Sample Print-screen of the Dictionary web site

Web Database, Web Site Structure and User Interface

The development of the EMITEL web database passed through several stages. During 2008 the web users of the Dictionary were more than 3000 per month, which was an indication that the web site could be overloaded when the full Encyclopaedia is launched (Fig. 9.6). To improve the access to the database and the speed of upload and download, the database was further developed and migrated to an SQL Server. This server was more reliable and allowed scalability of the content. The server allowed 100 GB monthly traffic and could work with two databases (an important feature allowing simultaneous user access to the information and the database maintenance through the CMS). The server was chosen with sufficient volume to be able to handle future expansion of the database.

The web site handled both the Encyclopaedia and the Dictionary and provided all necessary links between them. The interface allowed both - to use separately the two elements and to use these simultaneously. To serve both functions two separate Search Engines were added to the Web site. The first Search Engine serves the Multilingual Dictionary (it can work with various alphabets, as per the Internet browser settings of the user). The second Search Engine serves the Encyclopaedic articles (entries in English), this way allowing search for synonyms, acronyms and other words inside the text of the articles. This Search Engine can also search within articles specific to one of the areas of the Encyclopaedia (X-ray Diagnostic Radiology, Nuclear Medicine; Radiotherapy, Ultrasound Imaging, MR Imaging; Radiation Protection). Each Entry displayed at the web site has an additional Area indicator (e.g. the entry Anode is available in two areas/fields – General and Diagnostic Radiology). Selecting the area field displays the relevant Entry (in the example - Diagnostic Radiology – Fig. 9.7)

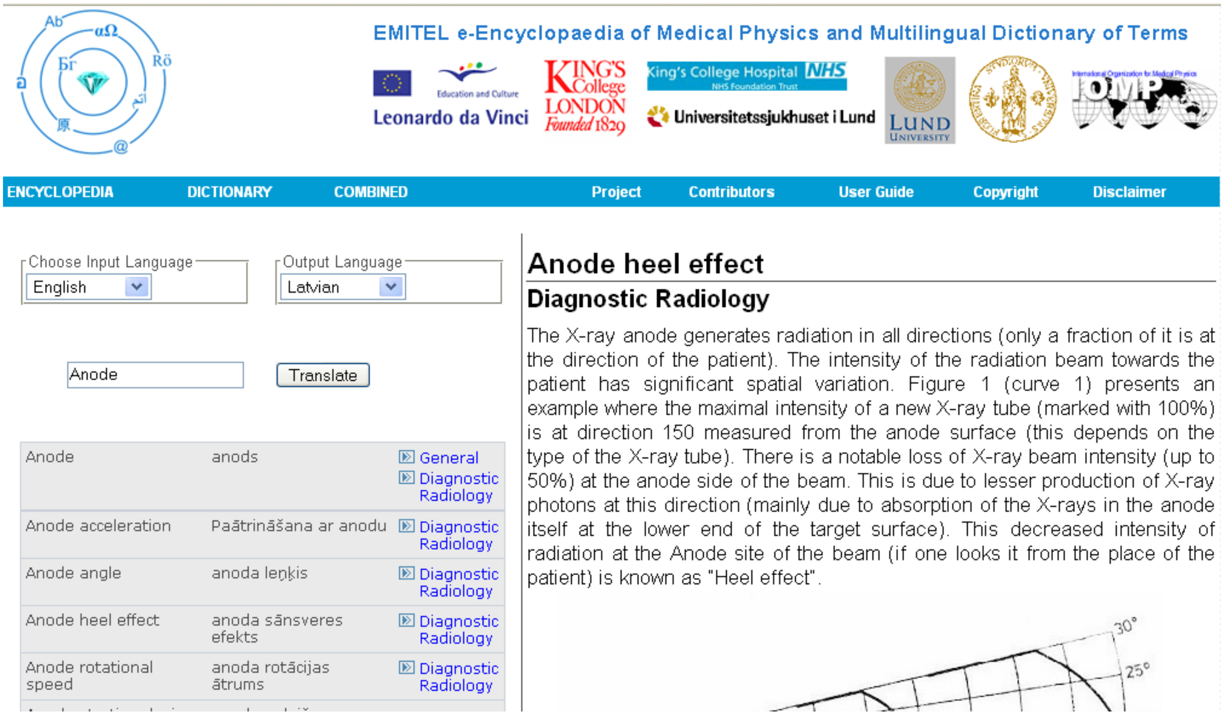


Fig. 9.7 Sample Print-screen of the Encyclopaedia web site – Combined Dictionary and Encyclopaedia

The web site preserves and updates all previous functions of the Dictionary (e.g translating between any two languages) plus fast access to the Encyclopaedia content. To allow the latter all images (equipment, medical, formulas, diagrams, etc) were scaled down to max 500 pixels width. Care was taken to preserve the important information in each image.

The EMITEL web site has sufficient security through its commercial host (*1and1* – the largest in Europe at the time of the project). It also allows future updates and improvement, including full web traffic statistics.

Content Management System (CMS)

The primary role of the CMS is to allow online management of the content of the database. The CMS includes separate interface, through which articles can be uploaded or edited. The CMS access is password protected and is the main tool of the refereeing process of EMITEL. Its main features are Automated templating; Editable content; Preview function; Scalable features sets; Web standards upgrade. The Administrative tools of the CMS include: Adding new terms; Deleting terms; Authoring Information; Documents handling. The CMS also allows preview of the uploaded article, as well as information about any previous stages of file editing (Fig. 9.8, Fig. 9.9).

The uploading of the Entry files was a delicate process, as it required exclusion of the Word formatting (when uploading the text) and each paragraph had to be verified for adherence to the original. The upload of the related images/diagrams/tables also required careful checks. A specific Guide was developed for the use of the EMITEL CMS.

Before going live both the Web site and the CMS passed vigorous testing with most available Internet browsers. At the World Congress WC2009, Munich, the EMITEL web site (www.emitel2.eu) was officially launched for free use by all colleagues worldwide.

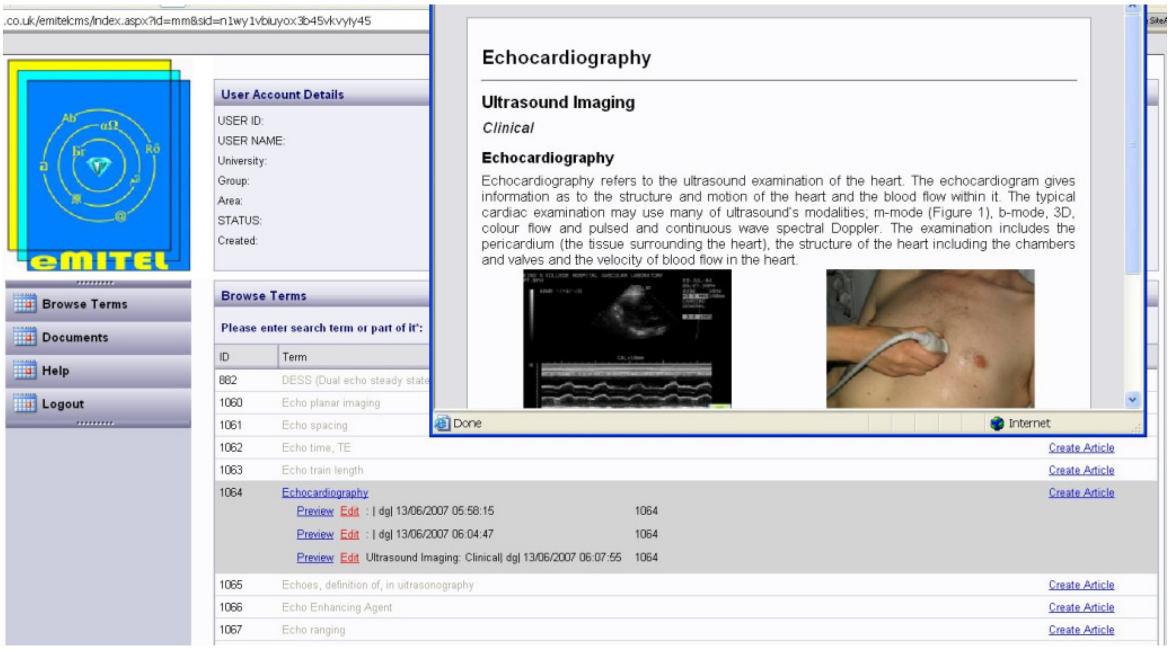


Fig. 9.8 Sample Print-screen of the CMS – information about the entries and a preview window

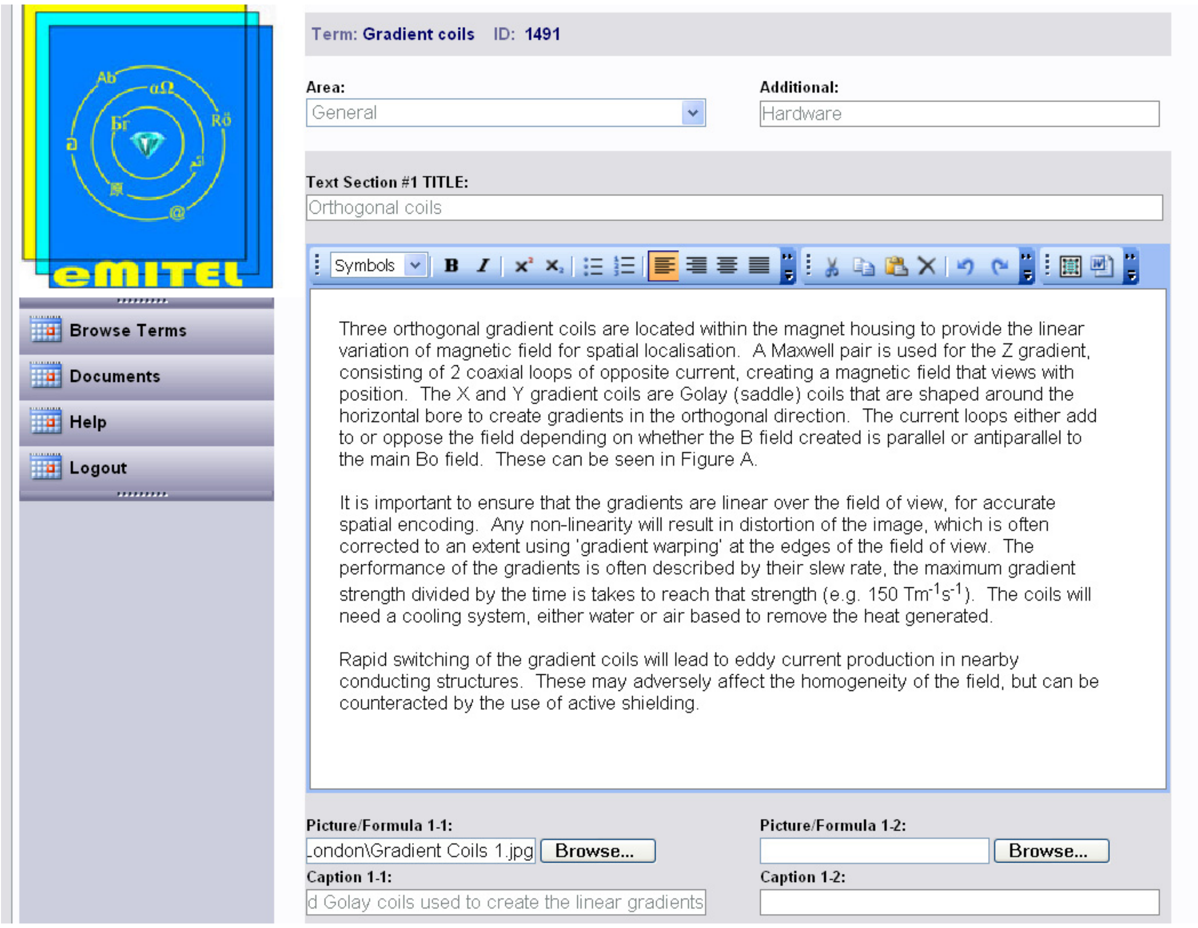


Fig. 9.9 Sample Print-screen of the CMS – upload of information (entries) window

Paper Print of the Encyclopaedia

Although the EC project EMITEL aimed at the development of an on-line e-Encyclopaedia only, its paper-print was planned by the Consortium from the beginning of the project activities in 2006. The paper-print phase was following the completion of the EC project and was mainly done at the project Coordination office in London with the collaboration of the Editors of the paper issue.

This phase had several sub-phases (see chapter 8). We started by using the ready Word files (e.g. “Absorbed Dose_R_A.doc”) from the Entry folders, arranged alphabetically in the Main Summative folder. This might seem an easy task, but was time consuming and took several months.

We grouped all these Word files in new alphabetic folders and formed from these large Word files for each Letter chapter of the Encyclopaedia (e.g. “A.doc”, “B.doc”, etc). The adjustment of the text of the Entries and the associated high quality images was a demanding Word processing task. It required resizing some of the images/diagrams/tables to fit into the A4 pages (all text was in a single column).

Headers, footers and consecutive page numbers were added to each Letter file, as well as Introduction to the Encyclopaedia, Guide for its use on the Internet and List of all Contributors.

Folders with paper prints were made for each Letter chapter (see Fig.9.5). These folders were checked for some small typos or errors and corrected. All corrections were introduced also in the Main Folders of the Encyclopaedia and uploaded on the EMITEL Web site.

Following this a PDF file was created from each Letter file (with *Adobe Acrobat*) – e.g. A.pdf, B.pdf, etc. The PDFs were grouped in 3 volumes, each about 700 pages (A-G; F-O; P-Z). The overall volume of this pre-print of the Encyclopaedia was about 2100 pages. It was printed on paper in 100 sets during March 2010 and distributed to all EMITEL Encyclopaedia contributors. This activity had two aims – to send a full paper copy to each author, and also to collect final feedback for eventual corrections before the submission to CRC Press for commercial paper print.

The internal process for final Refereeing included not only all authors, but also many of the students from our MSc Programme Medical Engineering and Physics. Their feedback was necessary from the point of view of the clarity of Entries and their suitability for MSc students. This internal assessment process took longer than expected – about one year. During this period we were collecting feedback from all Workgroup Coordinators – minor editing of some articles was still coming in, as well as suggestions for clearer explanations from the students. Additionally, colleagues from all over the world were contacting us proposing own images/articles for inclusion in the Entries (several new entries were also added by these colleagues). All this final editing was again discussed/approved by the Workgroup Coordinators and included in the Main Folder in the Coordination Office, as well as uploaded to the EMITEL Web site. This work was completed by mid-2011.

In parallel to the above work, four new languages were included into the Dictionary (Japanese, Croatian, Finnish and Korean). Another parallel work was the Publishing arrangements with *CRC Press, Taylor and Francis* (handled by J Navas and later by F McGowan). CRC Press undertook the publication of the Encyclopaedia on paper, while the Web site continued to be updated by EMITEL and used free on the Internet by the profession. At that stage it was obvious that the Encyclopaedia is a very important Reference for the whole profession (and especially for the developing countries). This also highlighted the need of regular update of the Encyclopaedia and the Multilingual Dictionary. As mentioned previously, in future the update of the Dictionary and the Encyclopaedia will be handled by the IOMP (International Organisation for Medical Physics) aiming to support the global development of the profession.

The next phase - the Editing by CRC Press - took another year. The leading person from the CRC side for this process was S Thirunavukarasu. For this we sent to CRC Press all Letter files, as well as the Main Summative folder.

This phase included transfer of all Entry files into the approved CRC template in two columns with specific use of text formatting. This process was slow as we had to check every line of the new material – there were some small typos related to the word processing. Image captions and figure numbering also had to be modified as per the CRC requirements. The work was organised Letter-by-Letter (Fig.9. 10). The Figures numbers in this phase were named in consecutive order, as per the letter of the chapter (e.g. for letter O - Fig. O1, Fig. O2, etc). For each Encyclopaedic Letter (chapter) there were some queries from the CRC Editor, as well as some formulae unification. Some of these were answered directly by the Coordination office, others had to be sent back to the Workgroup Coordinators and EMITEL paper print Editors. In case of additional editing, it had to be registered also in the Main Folder and re-uploaded at the web site.

During the work on the paper issue a small number of entries were merged. A full index was added to each volume, as well as other useful information (relevant constants, atomic weights, periodic table, etc). The paper issue editing was completed in mid-2012 (Fig.9.11).

O

O

Object–film distance

(*Diagnostic Radiology*) The term *object–film distance*, *OFD*, is used in planar x-ray radiology to describe the distance between the central axes of the object being imaged and the surface of the film. In modern digital radiology where film is no longer used, the distance between the object and the detector is called the *object–detector distance* (*ODD*) or the *object–image receptor distance*
AQ1 (*OID*) (Figure O.1).

Related Articles: Focal–film distance (FFD), Target–film distance (TFD), Magnification

Object image receptor distance

(*Diagnostic Radiology*) See *Target–Film Distance*

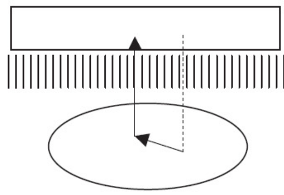


FIGURE O.2 Compton scatter in object prior to detection. The dotted line represent the true line of response and the black arrows are the photon pathway. Object scatter events lead to less contrast in areas with high radioisotope concentration.

……..

[AQ1] Please check the cross references to Figures O.1 to O.22 for correctness

Fig. 9.10 Sample from the CRC Press Editorial remarks with Questions to Authors (AQ1, AQ2, etc,)

The final ready files were again verified by the EMITEL Editors (S Tabakov, F Milano, S-E Strand, C Lewis, P Sprawls) and only after this the Encyclopaedia was submitted to print. It became available for sale (including on Amazon.com) at the end of February 2013. The CRC issue was printed on two hard-bound paper volumes (ISBN 978-1-4665-5550-1 and ISBN 978-1-4665-5555-6).

The emails exchanged with the Coordination office during the preparation of the Encyclopaedia were about 10,000.

Fig. 9.11 The paper files with the EMITEL Editorial work, pre-print, Final Print and work-flow line, Feb 2013

A Brief Guide: ***How to use EMITEL web site (www.emitel2.eu)***

Select Encyclopaedia > write the term you are searching into the window > click Enter. A list with terms is displayed – against each one is a blue hyperlink related to the area of the term > click the hyperlink to read the article.

EMITEL can search also inside the text of the articles. To do this select Search in Full Text, after this specify the area and proceed as above. In case of UK or American English differences (i.e. colour>color; optimise>optimize) try both spellings or search only part of the term (e.g. colo, optim).

To use the Dictionary select Dictionary > choose the Input and Output languages > write the term you want to see at the window > click Enter. A list of terms is displayed, where the terms are found either single, or in combination with other words (the e-Dictionary assumes that the user's Internet browser already supports the Input Language and Output Languages).

To use both the Encyclopaedia + Dictionary select Combined and proceed as above (this search is limited only to the title of the article, not inside its text).

10. Post-EMITEL activities and the IOMP Journal *Medical Physics International*

After 2009 - the official launch of the web site of the EMITEL e-Encyclopaedia and Dictionary (www.emitel2.eu) - the popularity of these materials began to grow rapidly. The searches per month were between 30,000 and 80,000 (Fig. 10.1), while the unique users (from all over the world) quickly reached several thousand - Fig. 10.2. The impact of these e-learning materials was important for the International Organization for Medical Physics (IOMP), which was also a project member in EMITEL.

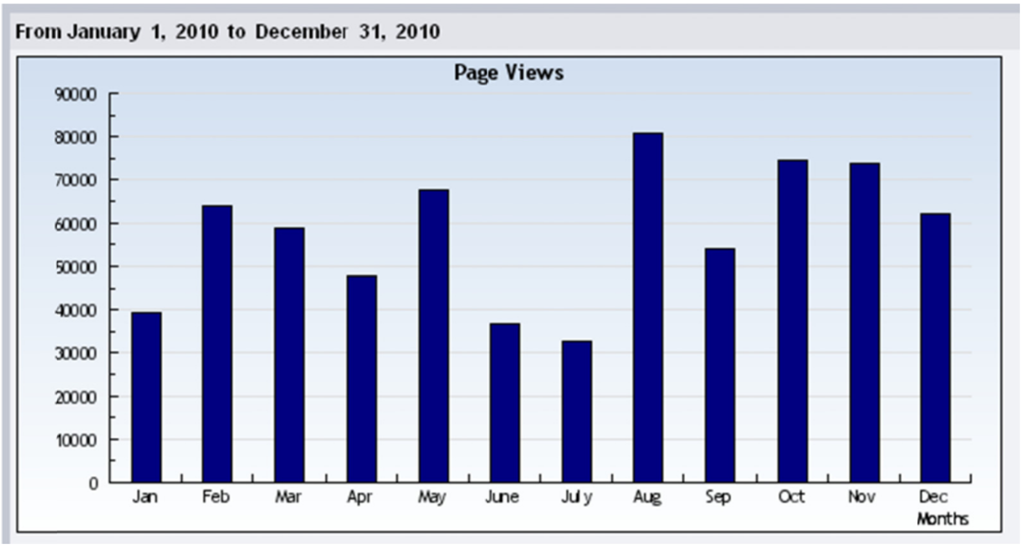


Fig. 10.1 Screen shot showing EMITEL searches (page views) during 2010 (1&1 Statistic panel)

The IOMP Model Curriculum Project and other International Education Publications

At the time after the launch of the EMITEL Web site most activities were focused on the preparation of the Encyclopaedia for paper print. In parallel we returned to other Education and Training activities started during 2005, but slowed down due to the enormous work related to the Encyclopaedia and Dictionary.

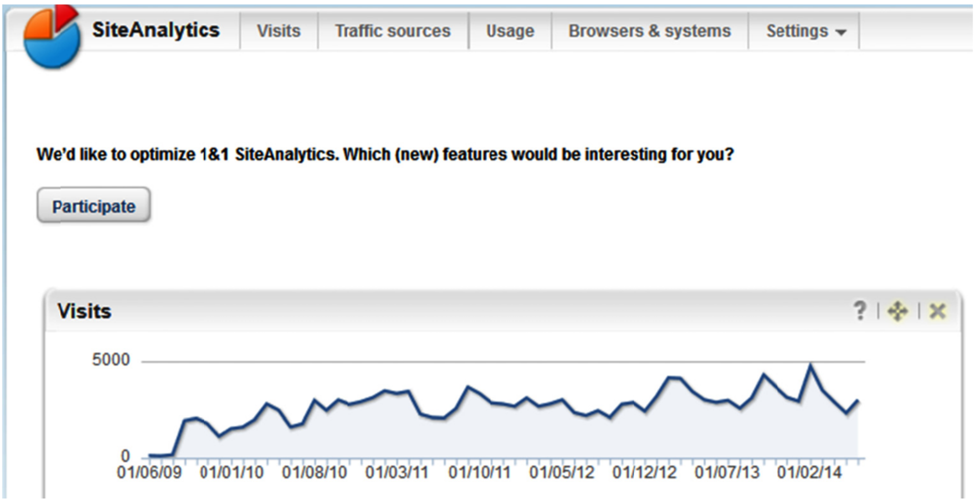


Fig. 10.2 Screen shot showing EMITEL new web site (emitel2.eu) monthly unique visitors 2009-2014

In fact these activities started during 2005, when at the high-level World Conference "Physics and Sustainable Development" (Durban, South Africa, 2005) specialists from all over the world discussed the future trends in applied physics. This high UNESCO forum had several trends (all supported by ICTP), one of these being *Physics and Health*, co-organised by IOMP (represented mainly by P Sprawls and D Van Der Merwe, with the help of A Niroomand-Rad and S Tabakov). All e-learning materials (from Sprawls.org and Emerald/Emit), as well as other professional developments of Medical Physics were shown at this forum and attracted widespread interest. Due to this one of the four specific topics highlighted by the Conference for the development of applied physics in the 21st century was *Physics and Health.* Following this the International Union for Pure and Applied Physics (IUPAP) funded a project of the IOMP to develop an IOMP Model Curriculum for medical physics educational courses. This activity was the idea of P Sprawls and intended to pave the way for future official international recognition of medical physics educational courses. The Project Group set up for this syllabus included: P Sprawls, S Tabakov, A Krisanachinda, E Podgorsak and C Lewis.

The main parts of the project included recommendations on:
- Overall number of classroom contact and self-reading hours;
- MSc project and thesis;
- Structure of the Curriculum and Models of content delivery;
- Entry requirements and students' assessment;
- Principles of validation of courses/programmes;
- Indicative content of the Curriculum.

The IOMP Model Curriculum project was announced and presented at the World Congresses in 2006 and 2009, and was published during 2011.

The project was well supported also by the parallel IAEA activities related to medical physics education and training. These included the book "*Review of Radiation Oncology Physics: A Handbook for Teachers and Students*" (2004) edited by E Podgorsak; the RPOP Web site (explained in chapter 7); a new book on Imaging Physics (published in 2014: "*Diagnostic Radiology Physics: A Handbook for Teachers and Students*", edited by D Dance, S Christofides, A Maidment, I McLean, K Ng) and another one - just announced ("*Nuclear Medicine Physics: A Handbook for Teachers and Students*", edited by D Bailey, J Humm, A Todd-Pokropek, A van Aswegen). In this line a number of IAEA guides on Education and Training were published: *Clinical Training of Medical Physicists Specializing in Radiation Oncology* (2009); *Clinical Training of Medical Physicists Specializing in Diagnostic Radiology* (2010); *Clinical Training of Medical Physicists Specializing in Nuclear Medicine* (2012).

The IOMP Model Curriculum project was also supported and used the experience of many colleagues attending the ICTP College on Medical Physics (2004, 2006, 2008, 2010) and the IOMP Workshop during the World Congress in 2006 (WC2006, Seoul) "Medical Physics and Engineering Education & Training - Global Perspective". Selected materials from these activities were used for the assessment of needs and development of the IOMP Curriculum. All these were published in the book "*Medical Physics and Engineering Education and Training*", 2011, ICTP, Trieste, Editors: S Tabakov, P Sprawls, A Krisanachinda, C Lewis (ISBN 92-95003-44-6). The book included status reports from 27 countries and a number of International Organisations. It also included information about current e-Learning projects. The book was launched during the International Conference on Medical Physics in Porto Alegre, Brazil (ICMP, April 2011) – Fig. 10.4. Similarly to the previous book from the Budapest Conference in 1994, this book was published as e-book and uploaded at the Emerald web site for free use by all colleagues. Just for one year the book had more than 1000 downloads:
http://www.emerald2.eu/mep/e-book11/ETC_BOOK_2011_ebook_s.pdf

In this period of time IAEA issued two guides for MSc-level courses: "*El físico médico: Criterios y recomendaciones para su formación académica, entrenamiento clínico y certificación en América Latina*" (2010), Fig. 10.3 and *Postgraduate Medical Physics Academic Programmes* (2012) Fig. 10.5. The latter was also used for the development of an international MSc course in Medical Physics

(Directors R Padovani and R Longo) – a collaboration between ICTP and Trieste University, supported by IAEA, IOMP and EFOMP. This MSc course is now regularly used by many students from the developing countries.

In 2010 an IAEA Workshop "*Medical Physics in the Baltic States*" (Kaunas, Lithuania) collected and published educational experience from 17 countries (mainly in Eastern Europe). In this period a number of papers on medical physics education in Europe were published by C Caruana et al.

Fig. 10.3 IAEA Guide for medical physics education (in Latin America), 2010

Fig. 10.4 Book on medical physics education with the IOMP Model Curriculum, 2011

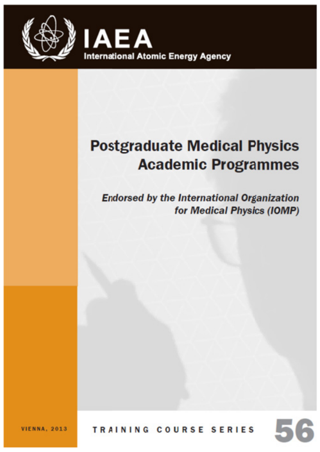


Fig. 10.5 IAEA Guide for medical physics education, 2012

Other Educational Projects and Textbooks

Since 2010 we have taken part in IOMP projects associated with the development of medical physics in the Russian Federation (an activity led by V Kostylev), in Latin America (associated with the ICMP 2013, led by A-M Marques da Silva) and in Africa (a large project initiated by F Nuesslin, S Tabakov, KY Cheung, M Rehani, R Wu, J Damilakis, R Nakatudde, T Ige, A Ibn Seddick).

During 2011 we decided to file another EC Educational project (Transfer of Innovation) which aimed to adapt and transfer our e-learning materials from the previous project EMIT and EMERALD to new users. The project aim was to prepare and deliver short e-Learning courses in the field of Digital Medical Imaging for technologists, radiographers and teachers. This was in line with the increased need of such materials for radiographers (what we sensed from the EMIT use for ultrasonographers), and also the increased interest in medical physics from schools (upper classes) and Universities undergraduate studies.

However at that time new developments were necessary in the delivery of MSc-level education and training of medical physicists in the UK (as per the NHS project Modernising Scientific Careers). This way we did not submit the project but planned textbooks to be written for undergraduate students (explained further down). Meanwhile the UK College of Radiographers developed its own e-learning materials.

The existing EMERALD, EMIT and EMITEL materials found good place in the education of our students from the new MSc programmes we developed – MSc Clinical Sciences (Medical Physics) and MSc Clinical Sciences (Clinical Engineering), which were developed in 2011 as per the requirements of the Modernising Scientific Careers and launched same year (currently there are 120 MSc students following these studies in King's College London) – Fig. 10.6. Some of these young colleagues submitted ideas for the update of the Encyclopaedia.

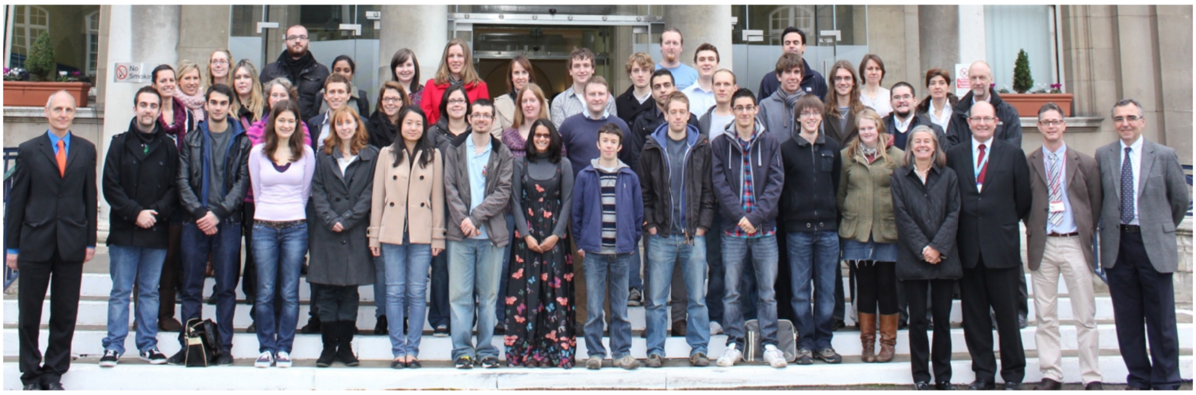


Fig. 10.6 Students from the first cohort of the new MSc Clinical Sciences (Sept 2011) photo with the Head of Medical School of KCL Prof. A Greenough, Sub-Dean Dr J Koffman, Dept MEP Head Dr C Lewis, IPEM Past-President Dr K Ison and MSc Programme Director S Tabakov

At the same time the collaboration of IOMP with CRC Press led to the publication of many books, supporting professional education in the profession. These were published under the *Series in Medical Physics and Biomedical Engineering.* Two of those were planned during the time of the projects EMIT and EMITEL – *Medical Equipment Management* by K Willson, K Ison, S Tabakov, ISBN 978-1420099584, CRC Press, 2013; and *Introduction to Medical Physics* (Editors: C Lewis, S Keevil, T Greener, S Tabakov), planned for print in 2016. The first book was related to the eponymous module of the MSc Medical Engineering and Physics (introduced in 2004 in our MSc in King's College London), which was greatly appreciated by many medical physicists and clinical engineers. We considered including such topics in our e-learning materials and some of the EMIT tasks included equipment management elements. The second book was triggered by the increased interest shown in medical physics from a number of undergraduate (BSc-level) University courses, for which no specific introductory materials existed. Some of the materials from the second book will also include e-learning materials (for the moment planned to be based on the emerald2.eu and emitel2.eu web sites). These additional materials further strengthen the delivery of medical physics education.

During 2012 a bi-lateral project (under the FAPESP Programme) was initiated between King's College London and the Catholic University of Sao Paulo. Its aim was to translate the EMERALD (Diagnostic Radiology) e-learning materials in Portuguese and to adapt these for national application in Brazil. The main project partners included P Costa (Coordinator) and R Terini from Sao Paulo and S Tabakov and C Lewis from King's College. The translation of these e-learning materials was completed during 2014 and a Training seminar was held to assess the results and discuss their application in Brazil (Fig. 10.8). The results from the assessment showed that about 2/3 of all participants assessed the materials with their highest score and about 80% of them expressed their intention to use the EMERALD e-learning materials in their institutions for training young medical physics graduates. Currently the project updates some of the training tasks and the Course Guide (to suit its use in Brazil).

During 2014 an update of the EMITEL web sites was initiated by colleagues from the IOMP. The initial IOMP ETC Task Group for this includes: G Boyle, P Bregant, KY Cheung, A Cvetkov, J Damilakis, M De Denaro, C Deehan, A De Stefano, P Dunscombe, G Ibbott, L Livieratos, R Longo, R Padovani, M Rehani, M Stoeva, S Tabakov, V Tabakova, S Tipnis, V Tsapaki.

The IOMP Journal *Medical Physics International*

With time, more and more colleagues were directing their activities towards the development of education and training in medical physics. The number of University courses in the profession (and most importantly the number of countries delivering such courses) increased manyfold. This was reflected in the number of such presentations at the World Congresses of Medical Physics and Biomedical Engineering, where one could see an increase of education and training topics:

- WC2003 (Sydney) - 6 sessions and 1 Workshop on these issues (with a total of 34 presentations);
- WC2006 (Seoul) - 6 sessions and 1 Workshop on these issues (with a total of 42 presentations, plus 20 posters);
- WC2009 (Munich) - 8 sessions and 2 Workshops on these issues (with a total of 85 presentations, plus 12 posters);
- WC2012 (Beijing) - 5 sessions and 2 Symposia on these issues (with a total of 61 presentations, plus 10 posters);
- WC2015 (Toronto) – planned 6 sessions and 2 Symposia on these issues (with a total of 62 presentations, plus 14 posters).

Alongside the increased global use of the EMITEL e-Encyclopaedia with Dictionary, the e-Learning materials of the other two projects (EMERALD and EMIT) continued to be used by many colleagues around the world (Fig. 10.7). The number of IOMP activities, Conferences and Workshops specially discussing professional and educational topics was also growing. During the 2012 IOMP international elections the projects Coordinator Dr S Tabakov was nominated and elected as President-Elect of the Organisation.

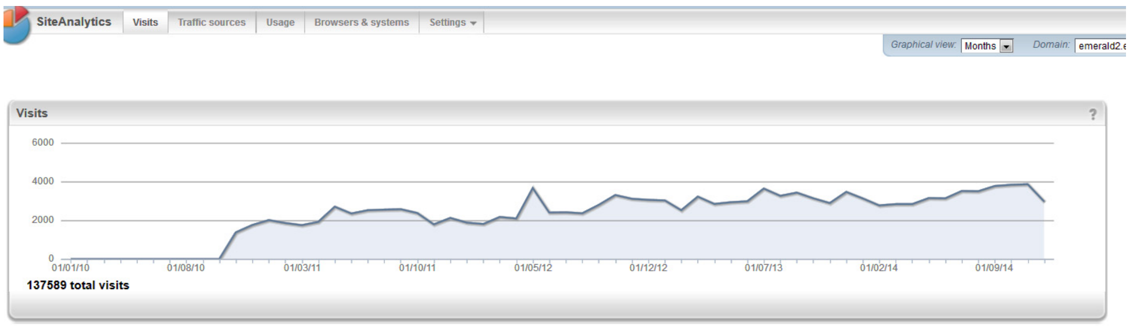


Fig. 10.7 Screen shot showing EMERALD and EMIT new web site (www.emerald2.eu) after its launch - unique visitors (monthly in the period Oct 2010 – Dec 2014 (1&1 Statistic panel)

The interest in education and training showed that there is an obvious need for an international forum on these issues. A new Journal on the subject was proposed for approval by the IOMP ExCom over the summer of 2012. Its name was suggested by W Hendee as "*Medical Physics International*" (MPI), and agreed by the IOMP ExCom. The new ISSN 2306-4609 for it was obtained at the end of 2012. It was decided that this be a free on-line Journal and its web domain was registered as www.mpijournal.org .

The Co-Editors in Chief were approved as P Sprawls and S Tabakov and the Editorial Board included additionally: KY Cheung, M Rehani, W Hendee, T Suk Suh, V Tsapaki, S Kudlulovic Renha, A Krisanachinda, T Ige, M Stoeva, A Cvetkov, J Damilakis, R Wu, V Tabakova. The first issue of the new Journal was published in April 2013 (Fig. 10.9). Since its beginning the readers of the Journal are approximately 4000 per month. Apart from specific Education and Training and other professional issues, the Journal also publishes a number of Tutorials, Innovations from the industry, PhD theses abstracts, Abstracts from Conferences and others. Currently the Journal is published bi-annually.

A number of e-learning and other educational and professional projects were published in the Journal, including a new activity initiated by the IOMP with the aim to help medical physics capacity building in developing countries.

Fig. 10.8 Participants of the Workshop EMERALD-BR project in São Paulo, Brazil, March 2014.

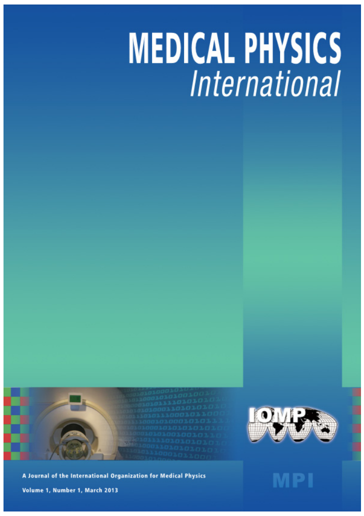


Fig. 10.9 First issues of the Journal Medical Physics International, 2013

Parallel to the educational projects described thus far, an extremely important development was in preparation. After years-long negotiations between IOMP, IFMBE and IUPESM with the International Labour Organisation (ILO, Geneva), the occupations of medical physicists and biomedical engineers were explicitly included in the *International Standard Classification of Occupations* (ISCO-08). Medical physicists were listed under number 2111; biomedical engineers listed under number 2149. This news, officially announced in 2012, was crucial for all medical physicists and biomedical engineers, especially those from smaller countries, who previously could not be employed as such specialists due to the lack of a professional classification number. Without doubt the extended activities of many colleagues, including our projects, were some of the supporting pillars for this high-level recognition as such occupations/professionals are required to have specific education and training.

Another very important medical physics international activity during the past years was related to strengthening the links between IOMP and the World Health Organisation (WHO). In 2015 this resulted in the recognition of IOMP as a Non-Governmental Organisation (NGO) to the WHO – which was another strong step in the global visibility of the medical physics profession.

CONCLUSION

"*The Pioneering of e-learning in Medical Physics*" describes a chronology of 7 international projects which were among the first to develop and introduce original e-learning in the teaching process. During the period of these projects (1994-2014) both medical physics and university education underwent significant changes: medical physics fully embraced digital imaging technologies; university education fully embraced e-learning. New sub-specialities of medical physics emerged, as well as a new branch of educational specialists (Learning Technologists). Everyday life and human communications also advanced drastically. Here we tried to present briefly the timeline of these changes, which simultaneously supported and challenged the project teams.

All colleagues who contributed to these projects supported e-learning fully and applied it in their professional and educational activities. This allowed us to gather enough experience and realise that e-learning cannot completely replace classical learning, and a hybrid of both is the best way forward.

Our original training and education materials, e-books, CD-ROMs with image databases, e-Dictionary and e-Encyclopaedia found a firm place in the formation of thousands of young medical physicists around the world. The colleagues who contributed to the development of these e-learning materials can only feel proud of these achievements. And now, having collected so much experience, one naturally wonders what will come next in this field?

We have reached a time when most contemporary information is in a digital form. However, this information relies only on digital file formats, which are often proprietary. These formats could change and become unreadable without specific update of the software version. This could endanger one of the cornerstones of progress– the transfer of knowledge. While until now history has shown that access to information is based on the stability of the carrier (be it carving on stone, or writing on parchment, or printing on paper, etc), now we have as a carrier a very fragile medium – changeable file formats.

Obviously there is an urgent need for a stable format (perhaps as PDF), which can always be accessed free from various computer systems and various file-readers. We are sure that this will be one of the important future steps, as the specific software for digital publications is only the carrier of the intellectual product of the author.

The problem with longevity of digital publications can be seen on a smaller scale with the use of some software programmes and their products, which were created before the development of the 64-bit computing systems and ceased working with their introduction. As we mentioned in the book, the short life span of a number of e-learning related products increases additionally the cost of the products. More importantly it could discourage the development of similar new products (often these are made by academics and specialists during their free time with the aim of enhancing the teaching process). Related to this is the question of the maintenance and update of the e-learning products. This is of special importance in the field of sciences, where it depends on the competence of a very few narrow specialists (often only the creator of the e-learning product). Extending the longevity of the e-learning products is another important future step. Perhaps one of the solutions is creating e-learning materials with simple user-friendly shells, allowing the emphasis to be on the content and not so much on the current graphic design.

Another important aspect is the use of simulations. Computer simulations are perhaps the most powerful e-learning products, also the most complex and most expensive. It is important to integrate these simulations in a specific educational structure supporting the e-learning materials; additionally including User Guides and questions/testing at the end of each exercise. This will strengthen the learning outcomes. Again, blending the use of the simulations with classical learning and real laboratory exercises is crucial.

As clearly demonstrated, the creation of e-learning materials is a demanding, innovative process, which requires extensive knowledge and rigorous testing. The future advancement of this dynamic field depends on the recognition of these activities from Institutions as *bonafide* research. This was emphasised by the majority of the colleagues we worked with.

One specific need for most science-related subjects is the existence of an International Forum, where all new e-learning products and the results from their implementation, are announced. This will greatly help the effective use of the still short-lived e-learning materials. Medical physics can be proud that it is one of the first professions to develop and fully embrace e-learning and to create such a Forum (the Journal *Medical Physics International*). This publication not only stimulates the use of e-learning and supports the teaching process, but also encourages other colleagues to contribute to it.

In this book we described the development process of e-learning materials in medical physics. Today there are numerous paedagogical publications describing the teaching process, assessment and results of the implementations of e-learning. We are sure that the reader will find a lot of useful information in these publications. At the same time we believe that the description of our practical experience and path of development of these original e-books, Image Databases, e-Dictionary and e-Encyclopaedia, can be of use to a broad range of specialists – from medical physics and other professions.

To conclude, we would like to underline again that these results could not have been achieved without the exceptional international collaboration of so many colleagues, institutions and supporters, whose innovative and dedicated project contribution was the main pillar of the success during these 20 years of the pioneering of e-learning in the medical physics profession.

Flags of the countries and institutions who collaborated in the projects described in the book