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THE UNESCO BILKO PROJECT: DEVELOPING TRAINING CAPABILITY FOR COASTAL AND MARINE REMOTE SENSING

The UNESCO Bilko Project has matured since its conception in 1987 within the UNESCO TREDMAR[1] programme. It now provides dedicated computer based learning materials for the teaching and study of coastal and marine remote sensing to over 1,900 registered users that are distributed globally within 70 countries. It has provided a means for students and teachers to approach and work within the complex subject of marine and coastal remote sensing, generating confidence and knowledge that ultimately results in better analysis and decision making for the marine and coastal environment. The Bilko Project will continue to grow and, in the new era of "operational" oceanography, integrated coastal management and Internet connectivity, will continue to provide the fundamental understanding necessary to build sustainable capacity for marine and coastal remote sensing.

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[1] Marine Science Training and Education Programme / Programme de formation et d'enseignement en sciences de la mer / Programa de Capacitación y Enseñanza sobre Ciencias del Mar

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Abstract

The UNESCO Bilko Project began in 1987 and continues today. Its primary aim is to make remote sensing training materials accessible to those without specialist resources at their disposal and to promote good teaching practice by tapping the diverse skills and expertise of an expert community. Considerable resources have been generated by the project including a DOS and Windows based image processing software package. Pedagogical materials include a wealth of short self-study lessons focused on a particular remote sensing technique, oceanographic phenomenon or sensor that students can work through in their own time. Collectively, the Bilko project provides a remarkably diverse but comprehensive resource for teaching coastal and marine remote sensing. Recently, the project has adopted a thematic framework in order to deliver more focused material and to keep pace with rapidly evolving remote sensing sensors, platforms and algorithms. The project currently serves some 1,900 users located in over 70 countries and has supported several international workshops and training courses with both teaching materials and expertise. Several networks have been developed that are monitored by the Bilko steering committee including a network dedicated to Bilko lesson authors another for Bilko users. All material is available from the Bilko project web site (http://www.bilko.org) or from the Bilko Project Office, ITC, Enschede, the Netherlands.

Introduction

The considerable international investment in remote sensing technology over the past 20 years has significantly increased our capacity to measure, predict and manage changes in the marine environment. Remote sensing measurements constitute an unparalleled data resource providing a unique perspective in both time and space. A variety of sensors on satellites and aircraft can measure the sea surface temperature (which can also show current patterns), ocean colour (from which the chlorophyll concentration, and hence the phytoplankton distribution, can be derived), variations in sea level (from which ocean currents can be estimated) and surface roughness (giving surface waves and derived winds). Arguably, remote sensing has resulted in a paradigm shift in the way that governments and scientists view the marine environment.

The application of remote sensing to address real-world problems is of paramount importance. In turn, improvements in strategic decision-making and the development of wider national and international marine public policy in the coastal and marine environment can be expected. But to achieve this vision, the benefits and possibilities offered by remote sensing must be familiar to a broad community including: ocean scientists and engineers; marine, freshwater, and coastal planners; natural resource managers, policy makers and industry leaders; local, national and international agencies; non-governmental organizations, educators and students. For many, remote sensing is no longer a specialist technology pursued by a few: it is simply another, albeit extremely powerful, observational tool. But, in some areas of the world this is not the case. Significant barriers still exist to the effective use of remote sensing in the coastal and marine environment. If programmes such as the Global Ocean Observing System (GOOS), that rely heavily on remote sensing in their regional implementation, are to realize their full potential, shortfalls in both human and material remote sensing capacity need to be addressed.

The UNESCO Bilko Project was initiated in 1987 under the Marine Sciences Training and Education Programme (TREDMAR) of UNESCO to develop training capability in coastal and marine remote sensing through a series of computer-based learning (CBL) modules. The project has generated eight modules of computer-based lessons and distributed copies to over 500 marine science laboratories and educational establishments and to over 1,900 individual users in over 70 countries around the world. The Bilko Project continues to innovate and now through its user network, supports a virtual global faculty working in coastal and marine remote sensing.

This paper provides an overview of the UNESCO Bilko Project, its approach, client base, scope, accomplishments, and its strategic vision for the sustainable development of marine and coastal remote sensing capacity.

The UNESCO Bilko approach to building capacity in coastal and marine remote sensing

Marine and coastal remote sensing is a particularly complex subject requiring knowledge of physics, biology, oceanography and, computer science, amongst other fields. The remote sensing laboratory resides in the virtual world of a computer and the benefits of remote sensing can only be explored by those having at least a basic grasp of all these disciplines. This is true for both students and teachers. Students can be deterred by the prospect of challenging and detailed background study. Teachers, not familiar with remote sensing or having limited access to appropriate resources or infrastructure, may choose not to provide instruction in remote sensing.

When UNESCO considered these issues in the mid 80s, the interpretation of satellite images could be undertaken only on large computers using expensive commercial image processing software that typically had long learning curves. Satellite and aircraft images were often seen as having military importance, so access to the equipment and technologies for teaching image interpretation was privileged and even restricted. The original aim of the Bilko Project was to facilitate "hands-on" training in coastal and marine remote sensing for those traditionally excluded from such training. Three recurrent themes focused the project:

(i) that the interpretation of satellite images is a skill of great international, strategic and economic importance which should be developed widely and distributed globally,

(ii) that UNESCO should take a role in the development of new media of instruction, specifically the use of small computers to teach topics normally denied to those having no access to large computers or local teaching facilities,

(iii) that UNESCO should seek to improve the quality of teaching in selected fields by demonstrating what can be done by distance-education methods.

Rather than follow the conventions of the day, UNESCO chose to back a project based on personal computers (PCs) which were then beginning to emerge in large numbers. A specification for the target recipients was derived using a “lowest common denominator” approach. It was assumed, for example, that recipients would be relatively isolated from others working in the field but having access to a low-performance standalone PC computer. Only marginal teaching support and access to reference materials would be available.

Four primary actions were agreed for the project:

(i) A software tool for would be developed and made freely available for the display and interpretation of remotely sensed data. This would allow the topic to be taught using low cost computer terminals rather than specialized equipment.

(ii) As the software on its own would have been of marginal benefit, it would be supported by lessons that exemplify its power and teach the fundamentals of image analysis and interpretation by allowing users themselves, through “hands on” practical exercises, to explore different remote-sensing data.

(iii) A distribution system would be developed to bring the software and accompanying lessons to anyone with an interest in coastal and marine remote sensing. Copyright of all project material would be vested in UNESCO and recipients would be encouraged

to copy Bilko material for students and colleagues – the sole restraint being that it should not be sold.

(iv) A means for teachers and students to exchange, assess, criticize and enhance Bilko software and lessons would be developed and maintained. This would be used to provide feedback for new and updated lessons and so lead to future innovation and development.

The substance of these original actions is still valid today and each is maintained within the Bilko Project at all levels.

The Bilko image processing software

Given the severe constraints imposed by the typical PC computer systems that used the DOS operating system, Bilko functionality was kept deliberately modest. The Bilko software was originally developed for the 4-bit (16 colour), 640 x 350 pixel format of the Enhanced Graphics Adapter (EGA) display system. Rapidly, this was superseded by more powerful Video Graphics Array (VGA) display systems providing 256 greyscale/colour levels and a full screen 512 x 512 pixel display. Bilko was rewritten to embrace this enhanced functionality. The DOS based Bilko software that emerged was a fast, menu driven image processing toolkit that allowed the display and analysis of remote sensing data at a pixel resolution. The toolkit had inbuilt context sensitive help screens to guide students and provide help for all of the functions provided with the software. Considerable attention was given to making the software extremely user friendly so that students with no previous experience of computers would not be intimidated. Indeed, emphasis was placed on having an impressive image on the computer screen as soon as possible within every session in order to maintain student confidence and interest. In this way, attention was focused on the image data rather than on the software techniques that had placed it there (Robinson et al. 1993). At that moment in time, the Bilko toolkit was a small revolution in the sense that satellite and airborne digital images could now be analysed on a desktop computer by anyone.

The original DOS-based Bilko image processing toolkit has now developed from a modest toolkit into a professional image processing environment called Bilko for Windows running under the Microsoft Windows operating system. The enhanced capabilities of the Windows operating system have allowed the Bilko software team to provide considerable functionality comparable to many commercial image-processing systems including tri-band colour composite, geometric rectification, a powerful image calculator and the ability to handle many image data formats and image data sets all at once. Bilko for Windows supports various common data file formats including HDF, 8, 16 and 24 bit flat binary files and, calibrated GIF files. Although the Bilko team deliberately target 8 bit compressed file formats to ease the burden of data storage and transfer, the team also recognizes that a number of standard data file formats are operationally used to supply data to users that should also be supported (e.g., HDF).

The migration of Bilko from DOS to Windows has not compromised the original philosophy of the project, and the new functionality offered by the Windows system were harnessed and an innovative document interface was developed in which the navigation model, menus, icons, layout and colours are all intuitive and supportive of the user's goals. The

Document interface concept allows users to conceptualise operations that can be performed on a particular image data set. For example, an image document type groups image handling operations together, a stretch document type groups different contrast enhancement operations together. Table I describes the main Bilko document types used within the Bilko for Windows system.

Table I Main document types and functions offered by the Bilko 2000 software.

Bilko document types	**Associated functions**
Image	Filters, rectifications, re-sampling create image associations, image zoom functions
Stretch	Edit and apply a number of different lookup table stretches
Palette	Generate, edit and apply colour lookup tables
Filter	Specify and apply up to a 15x15 kernel digital filter
Formula	Use a text editor to script and apply complex mathematical operations to image data
Table	Generate ground control point files for remapping images to geographic projections, shows matrix results of covariance and correlation
Scatter	Generate a scatter plot derived from two connected (associated) images
Histogram	Produce a histogram distribution of image data
Set	Allows users to manage a collection of images as a ‘stack’ (allowing ‘data coring’ operations such as time series analyses, Hovmuller plots) or as a ‘tile’ allowing combination analyses.

Figure 1 presents a demonstration Bilko for Windows session screen showing the use of traditional menu and toolbars characteristic of the Windows interface. Users are instantly presented with an interface that is familiar and follows the style of other Windows applications so that those with some Windows experience are confident and secure in the environment. ►

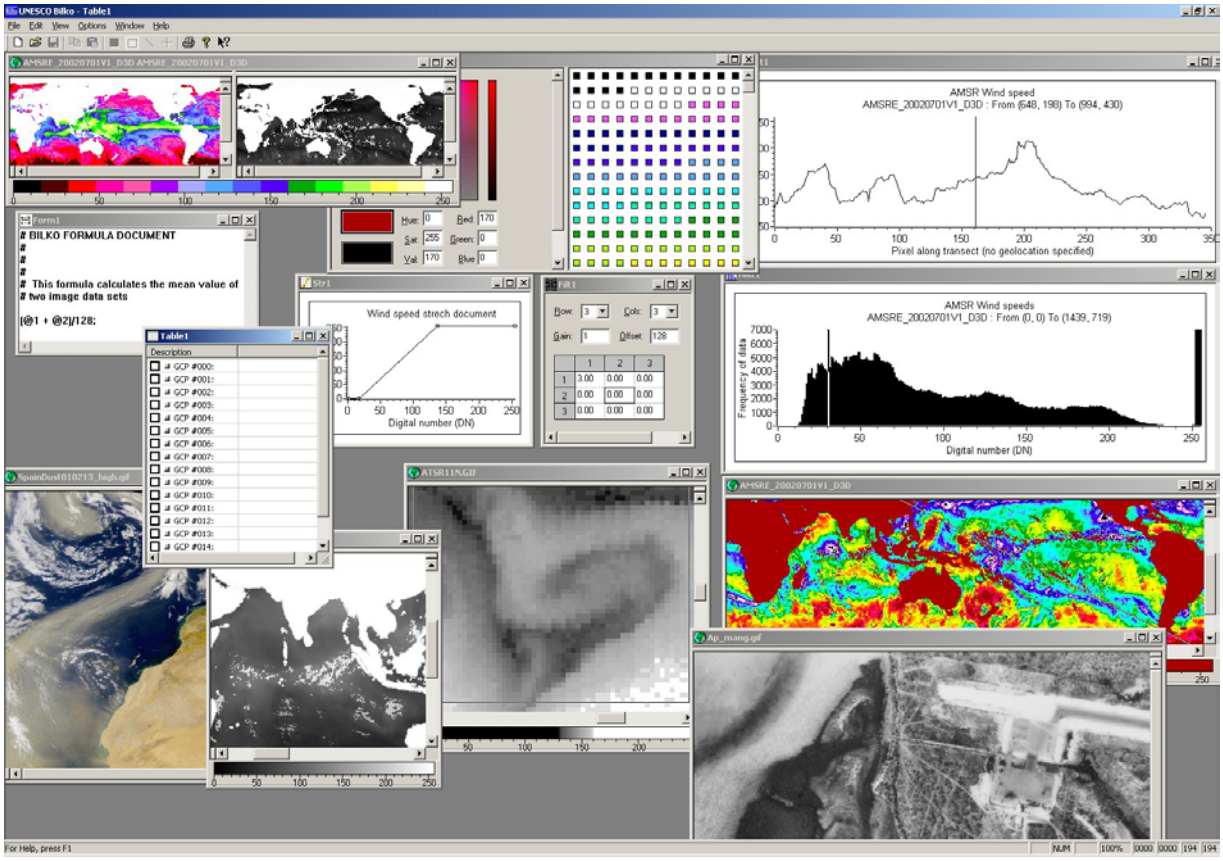

Fig. 1. The Bilko for Windows screen demonstrating many of the functions offered by the software.

Bilko allows operations to be performed on multiple images that are connected (associated) together within the software. Each image is assigned a variable number which is used to refer to the image when writing mathematical formulae. This exceptionally powerful feature allows complex multi-image algorithms to be applied and tested. It also provides a base from which to undertake fundamental Geographical Information System (GIS) operations. In this way, the Bilko software can serve the needs of many people already familiar with remote sensing, and perhaps working at an advanced level either in research or in the applications sector, without having to invest in expensive image processing systems. This is an important feature as it allows Bilko to penetrate beyond basic remote sensing training needs contributing to material capacity at a local level.

The basic functionality of the software system is supported by a specially written introductory tutorial that guides students through the various functions of the Bilko software. This is in effect the Bilko “user manual” but is not written in the conventional style of a manual. Instead it follows a particular pedagogical style that has been the hallmark of all Bilko lesson material and arguably, the root of the project success.

Bilko lessons and modular structure

The Bilko project distinguishes between lessons and modules. Lessons constitute "A focused learning experience dealing with a single topic which can be completed within 1-3 hours". Initially, in the DOS based era, Bilko lessons were provided in paper copy format and students would use the paper lesson together with the computer software. The Windows environment has allowed lessons to be written in the hypertext format providing an altogether different medium to present lesson material. Pop-up windows, hypertext jumps, interactive menus and questions are all possible. Furthermore, images, video clips, sounds and any other multi-media object can, in principle, be included within the lesson as required. However, experience has shown that writing in a hypertext environment should be treated with care and attention because many students still prefer to print a copy of the lesson and preserve computer screen "real-estate" for using Bilko for Windows. We have discovered that the Adobe Portable Document Format (PDF) provides a useful compromise for lesson presentation as hypertext links and many media objects can still be included in the lesson while still leaving students free to print lesson material in a format they find comfortable.

Bilko lesson format

It is worth exploring the structure and format of Bilko lessons which, over the years, has proved exceptionally powerful in terms of generating material, editing for quality and, delivering models of good teaching practice. It is the consistently high quality and pedagogical style of Bilko lessons that set this project apart from other similar image processing toolkits and systems. Bilko lessons are designed for students and teachers working on their own with limited technical support or backup. Distance education demands that everything required to complete a lesson must be self-contained within a lesson or a module. Consequently lessons must be complete (as far as practically possible), written in a direct but clear style Authors must attempt to foresee the questions that will be asked by students and provide answers in the correct format and place. Feedback loops must be included to remove weaknesses of presentation and to focus student attention. Reasoning should be repeated but not by simple word repetition. Such a text, although redundant, considerably helps understanding - a technique we refer to as "constructive redundancy" (Blackburn and Edwards, 2002). In the absence of an instructor to question performance, lessons should be written as "active text", and so promote active learning, by interspersing questions and other activities throughout the lesson. All questions should be provided with model answers and an indication of how they were obtained. Lessons call for considerable effort on the part of authors and the Bilko development team has written a number of reference documents to facilitate their production (Blackburn and Edwards, 2002).

Lessons are edited by a Bilko editorial team to a common standard and put into a common format, a task that is considered essential. One of the few inflexible rules of the Bilko system is that every lesson must begin with a statement of aims, objectives and a brief description of the lesson. This is followed by the lesson itself and then by a summary of the lesson. The repetition is deliberate to consolidate the knowledge gained during the course of the lesson.

The lesson "aim" provides a statement of the aspirations that the lesson author holds for students working with the lesson. For example,

The aim of this lesson is to introduce the basic concepts of digital image analysis.

The aim sets out in global terms the desired outcome of the lesson and reveals what is educationally distinctive about one lesson in comparison to others. It allows a student or teacher to select the most appropriate lessons for a given purpose.

Lesson "objectives" specify tasks that students should be able to undertake as a result of studying the lesson. For example:

After completing the lessons in this introduction, you should have learned to:

1 Run the Bilko for Windows software and load digital images for analysis;

2) Select and apply the image analysis and image modification routines of the Bilko for Windows system;

3) Call for Help files when in doubt about any image handling procedure.

Lesson objectives allow students to discover if they have satisfied the requirements set out under the heading of aims. Together with a short description of the lesson, the Bilko lesson aims and objectives present the student and teacher with a succinct appraisal of the lesson. This allows teachers especially to rapidly review and select appropriate Bilko material for inclusion within their own course structure.

Bilko modules

A Bilko module is simply a collection of Bilko lessons. A thematic module is a collection of lessons focused around one theme such as a subject area or a region.

Table II UNESCO Bilko computer based learning training modules in applications of satellite and airborne remote sensing.

Module	Title	Reference
1 (DOS)	Some Marine Applications of Satellite and Airborne Remote Sensing. A Computer-based Learning Module.	MARINF/70. Unesco, Paris. 1989. 90 pp.
2 (DOS)	Applications of Marine Image Data. Second Computer-based Learning Module.	MARINF/81. Unesco, Paris. 1991. 85 pp.
3 (DOS)	Applications of Marine and Coastal Image Data from Satellite, Airborne and *In-situ* Sensors. Third Computer-based Learning Module.	MARINF/83. Unesco, Paris. 1992. 101 pp.
4 (DOS)	Applications of Marine and Coastal Image Data from Satellite, Airborne and *In-situ* Sensors. Fourth Computer-based Learning Module.	MARINF/90. Unesco, Paris. 1993. 102 pp. (Also available in Russian)
5 (DOS	Aplicaciones de Datos de Imagen Costeros y Marinos provenientes de Satelites, Aviones y Sensores *in situ*. Quinto Modulo de Aprendizaje sobre Base Informatica.	MARINF/96. Unesco, Paris. 1994. 141 pp.

Module	Title	Reference
5 (DOS)	Applications of Marine and Coastal Image Data from Satellite, Airborne and *In-situ* Sensors. Fifth Computer-based Learning Module.	MARINF/96. Unesco, Paris. 1996. 110 pp.
6 (WIN)	The first Bilko for Windows: An experimental module	CD-ROM available together with all other modules from the UNESCO Bilko project office on request
7 (WIN)	Applications of Satellite and Airborne image data to coastal management	CD-ROM available together with all other modules from the UNESCO Bilko project office on request
8 (WIN)	Applications of remote sensing to fisheries management	CD-ROM available together with all other modules from the UNESCO Bilko project office on request
9 (WIN)	Applications of remote sensing to coastal erosion	In preparation expected mid 2003. Contact Dr Tjeerd Hobma. (hobma@itc.nl)
10 (WIN)	Vulnerability through the eye of a satellite	In preparation expected mid 2003. contact Dr. Craig Donlon (craig.donlon@jrc.it)
11 (WIN)	Applications of remote sensing to coastal management in India.	In preparation. Contact Dr R. Sudarshana. (rsudarshana@hotmail.com)
12 (WIN)	Applications of remote sensing to natural hazards.	In preparation contact: Dr Cees van Westen. (westen@itc.nl)

Each module is a self-contained package of:

(i) the image processing software (Bilko)

(ii) an introductory tutorial on how to use the software

(iii) lessons on the application of remote sensing to oceanography or coastal management

(iv) satellite and airborne remotely sensed images to accompany the lessons.

Eight Bilko modules, listed in Table II, containing over 60 individual lessons, have now been produced and distributed by the Bilko project in the period 1989-2002. Several more thematic modules are now in preparation.

The concept of modules is particularly powerful in terms of building capacity at a regional level because local knowledge, resources and expertise can be used to train local students on specific issues. The development of a Bilko Module is a considerable task in itself, but the benefits in terms of establishing an active community and network of users that become engaged in developing the module, together with the support of the UNESCO Bilko are immense. For example, the Global Ocean Observing System (GOOS) are considering the development of regional GOOS Bilko modules to build capacity in this way.

Project management

The UNESCO Bilko project has been steered from its inception by Dr Dirk G. Troost of UNESCO during the period 1987-1995 assisted by a small team operating at different international institutions and convening on an ad-hoc basis. In 1998, a formal Bilko Steering committee was established and a Secretariat based at the Division of Applied Geomorphological Survey at ITC in the Netherlands now co-ordinates the day-to-day running of the UNESCO-Bilko Project. The international secretariat and editorial board maintain pedagogical standards, coordinate module development, arrange for production and distribution of Bilko material, manage both client feedback and strategic development. In particular, the secretariat maintains a comprehensive database of statistics relating to the Bilko project and collates all user feedback and project reporting.

Dissemination of UNESCO Bilko material

The first Bilko module was released with a series of 5 ¼" floppy disks and was a considerable success. Several distribution media types were considered before the floppy disk was chosen which are reviewed by Troost et al. (1991). The floppy disk was successful because every PC computer system had the capability to read and write to a floppy disk: they were cheap to duplicate in large numbers; and they allowed for modifications and updates to the material as required. The major limitation was storage space. As the copyright of all Bilko material is vested with UNESCO, all lesson material is open to modification, improvement and extension by teachers for their own purposes. Each lesson is provided in electronic format both as text and as a word processing document to facilitate this process. Such an "open-source" approach to the use and development of Bilko lesson material is considered an important element of the project as it provides a fundamental mechanism for building confidence and capacity at a local level (Troost et al., 1991). Today, Bilko modules are provided on CD-ROMs. These provide so much storage capacity, that all Bilko modules are included in each Bilko CD-ROM distribution.

At the time Bilko migrated from DOS to the Windows environment, the Internet was expanding exponentially The development of web-browser technology initially appeared to provide a form of communication well matches to the needs of Bilko students. The Bilko team invested some time and energy exploring what could be achieved using a combination of Internet based lessons and local operation of the Bilko software. An advanced lesson, following the pedagogical style of Bilko, was written in the Hypertext mark-up language (HTML) so that the web browsers could be used to display the lesson.

Many of the new features offered by the Bilko for Windows software were employed in the lesson and student answers could be submitted to the lesson author via the web browser. The author could then assess the student performance and return a marked appraisal of the students' performance by an e-mail. In theory, image data sets, lesson material and even the Bilko software itself could be obtained via internet transfer. The new Internet based Bilko system appeared to be ideal. However, despite widespread promotion of the new Internet lesson within the Bilko community, the new lesson was used only by a small number of students having high bandwidth Internet connections and resident in the United States. Consequently, the Bilko project decided that until Internet connectivity was better established, all Bilko material would be made available in CD-ROM format.

As Internet connectivity grows throughout the world, the Bilko project will initiate further steps to harness and make full use of this new capability. However, at this present time, extensive use of the Internet to provide distance-learning modules is, in our opinion, premature. A virtual teaching laboratory based on the use of the Internet alone cannot provide training to a large number of countries where Internet access is unavailable or at best, sufficient for small data transfer (e.g., e-mail).

Feedback: The currency of success

Feedback is essential to the Bilko Project. Because all Bilko material is provided free of charge, there is no traditional measure of success in terms of sales or number of modules distributed. Feedback provides the main evidence that the project goals are being achieved, justifying the financial and human investments made by many who have contributed to the project free of charge. Feedback format is varied. In many cases it is an e-mail or a letter thanking the team for their endeavours, in others, it is a reference to the Bilko Project in a report or journal paper. Soliciting useful feedback and quantifying its value is not easy for a project as this.

The approach adopted by the Bilko Project requires that each recipient of Bilko material return a feedback questionnaire provided within the distribution. On return, this information is entered into a database that is periodically reviewed and updated by the Bilko secretariat. Originally, a traditional letter was sent to each member identified in the database. This has now been largely replaced by the use of e-mail. Personal letters are still set to a few places where effective e-mail is not available.

If a recipient does not reply, it is assumed that either they have moved on or are no longer in need of the Bilko Project. Suggestions and requests made by users of Bilko are always treated seriously and are forwarded to the appropriate member of the Bilko Steering committee for consideration. Software requests and suggestions for improvements are reviewed and considered against the general philosophy of the project which is to provide new functionality only if the existing functions cannot be used in some combination to achieve the same result. Bilko is about teaching the tools, techniques and methods used in remote sensing, it is about exposing their power and their limitations. It is not about providing closed "blackbox" solutions to daily problems. Many other image-processing systems provide this latter type of functionality: they may be elegant in the performance of their function, but they do not teach.

As the Bilko Project has matured, a global network has developed in which users themselves become lesson authors through interactions and feedback loops external to the "formal" Bilko Project. The wealth of accumulated project knowledge, expertise and information, combined with associated informal generation and exchange of educational material within a wider community is viewed a considerable testament to the success of the project.

A virtual global facility for marine and coastal remote sensing: The UNESCO Bilko project

Today, the UNESCO Bilko Project provides a framework in which individuals, teachers, projects and institutions can interact and work together creatively to build and develop capacity for the application of remote sensing in the coastal and marine environment. Bilko has grown from an experiment into a network of students, teachers and scientists connected by a common interest in the use and application of remote sensing images. For some, it is the ability of Bilko to reveal the beauty and fascination of digital imagery of the ocean and coastal zone that ties them to the project. For others it is a means to an end; a way to teach Remote sensing, a source of course material, part of a University degree, a dedicated training workshop or a daily tool that is used to analyse and interpret image data for research or decision making. For whatever reason people are involved with the Bilko Project, it is true to say that collectively, they represent a global network.

Viewed from a different perspective, Bilko now constitutes a virtual global faculty for marine and coastal remote sensing. It has built confidence and knowledge in the use of remote sensing, abolished the view that remote sensing is the domain of wealthy countries and exposed the strategic benefits of remote sensing in the marine and coastal environment. As no charge is made for any material, the Bilko Project sees itself as an “honest broker” of capacity building initiatives without vested interest. This self perception is justified considering that the project has largely developed on a volunteer basis, both within the secretariat and in relation to the many lesson authors, translators, software programmers and teachers that have contributed to its material free of charge.

The ultimate target of the Bilko Project is to place the information, knowledge and the power of remote sensing into the hands of the people who actually live and work in the areas so often imaged by satellites and aircraft systems. In this view, capacity can be built at three related levels:

(i) an individual level at which it provides standalone tools and data for teaching of remote sensing and its application to the marine and coastal environment,

(ii) an entity level (e.g., a University department, Government laboratory or training workshop) which reaches large numbers of students and where teachers teach themselves (training of trainers) using Bilko materials,

(iii) a systemic or regional level (e.g., national and international projects) where thematic material is produced at a local level taking advantage of the wider framework of Bilko. Here, the creation of self sustaining user-producer networks that build capacity from within but focused on specific national issues may flourish. This is the so-called “user-producer” network that has used resources provided by the Bilko Project to become a self-standing and independent reality in several cases (Robinson et al., 1994).

At the individual level, the Bilko project database holds records for over 1900 subscribers actively engaged in the project (as indicated by a positive response) in over 70 countries. The UNESCO Bilko web site server (http://www.bilko.org) currently has a minimum of 5 downloads of Bilko software and lesson material per week. However, because all Bilko Project material is freely available and the project encourages its duplication and dissemination external to the project itself, there are probably many more users of Bilko than we report here.

At the entity level, Bilko has, for over ten years, provided hands-on experience of image processing and helped to teach practical aspects of remote sensing to both Bachelors and Masters Students at universities. At the University of Newcastle Module 7 is used with students reading for a MSc. in Tropical Coastal Management while oceanographic lessons are used for students reading for a BSc. in Marine Biology. At the University of Southampton School of Ocean Sciences, Bilko is currently used in both MSc. and BSc. courses. Typically, dedicated lesson material is prepared for a particular course and then yields lessons which are produced by groups of teachers and students working together. Other courses known to have made use of DOS Bilko modules include those held in Nairobi, Kenya; La Reunion; Caracas; Venezuela; Ensenada, Mexico; Enschede, the Netherlands; Lepe, Spain and Rio Grande, Brazil. In the case of the course held in Lepe, Spain, this directly led to the preparation of Bilko Module 5.

More recently, several successful remote sensing short-courses, one in Zanzibar and one in Thailand (see Fig. 2), have utilized Bilko for Windows to provide targeted training in specific areas. The first short-course was an IOC-UNEP Regional Training Course on Seagrass Mapping using Remote Sensing. This was held at the Institute of Marine Sciences, Zanzibar in November 1997. Participants came from East Africa and international organisations in the region. The workshop concentrated on the application of remote sensing to coastal management with a special focus on the mapping of seagrass areas and seagrass standing crop. The second course formed part of an International Ocean Colour Coordinating Group (IOCCG) Training course on Applications of Marine Remote Sensing. It was held at the Asian Institute of Technology (AIT), Klong Luang, Thailand in November 1999. This was the third IOCCG training course its purpose being to increase the user base of ocean-colour data throughout the world. Some 30 participants from 12 countries in the SE Asian region attended. Several Bilko lessons written for this course: they focussed on the Indian Ocean Ocean using thermal infrared, colour and altimeter radar data of sea surface temperature, chlorophyll and, sea surface height.

The Bilko Project is entering a new phase in terms of developing capacity at the systemic or regional level. Some International organizations have identified a need for training in remote sensing if their programmes are to develop satisfactorily. The Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), Global Ocean Observing System (GOOS) and Global Climate Observing System (GCOS) have all formed dedicated working groups. Marine and coastal remote sensing has a fundamental role within globally oriented programmes and one identified priority action is for training in coastal and marine remote sensing. The UNESCO Bilko Project provides an ideal framework which allows for the training of individuals and teachers Through Bilko's modular framework they have a means to help regional groups develop their own targeted teaching material in a form that can be used in other areas of the world.

Fig. 2 Students at work using Bilko for Windows. (a) Course participants from mainland Tanzania, Zanzibar and Kenya work on Bilko Module 7 practical lessons at the Institute of Marine Sciences, Zanzibar (November 1997). (b) Course participants work on dedicated lessons designed for the IOCCG training course at the Asian Institute of Technology, Bangkok, Thailand (November 1999)

From the viewpoint of the Bilko Project it is clear that there is scope for mutually beneficial partnerships with these organizations for Bilko can contribute a strong record of teaching in remote sensing while the organizations can bring unparalleled expertise in particular aspects of remote sensing.

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