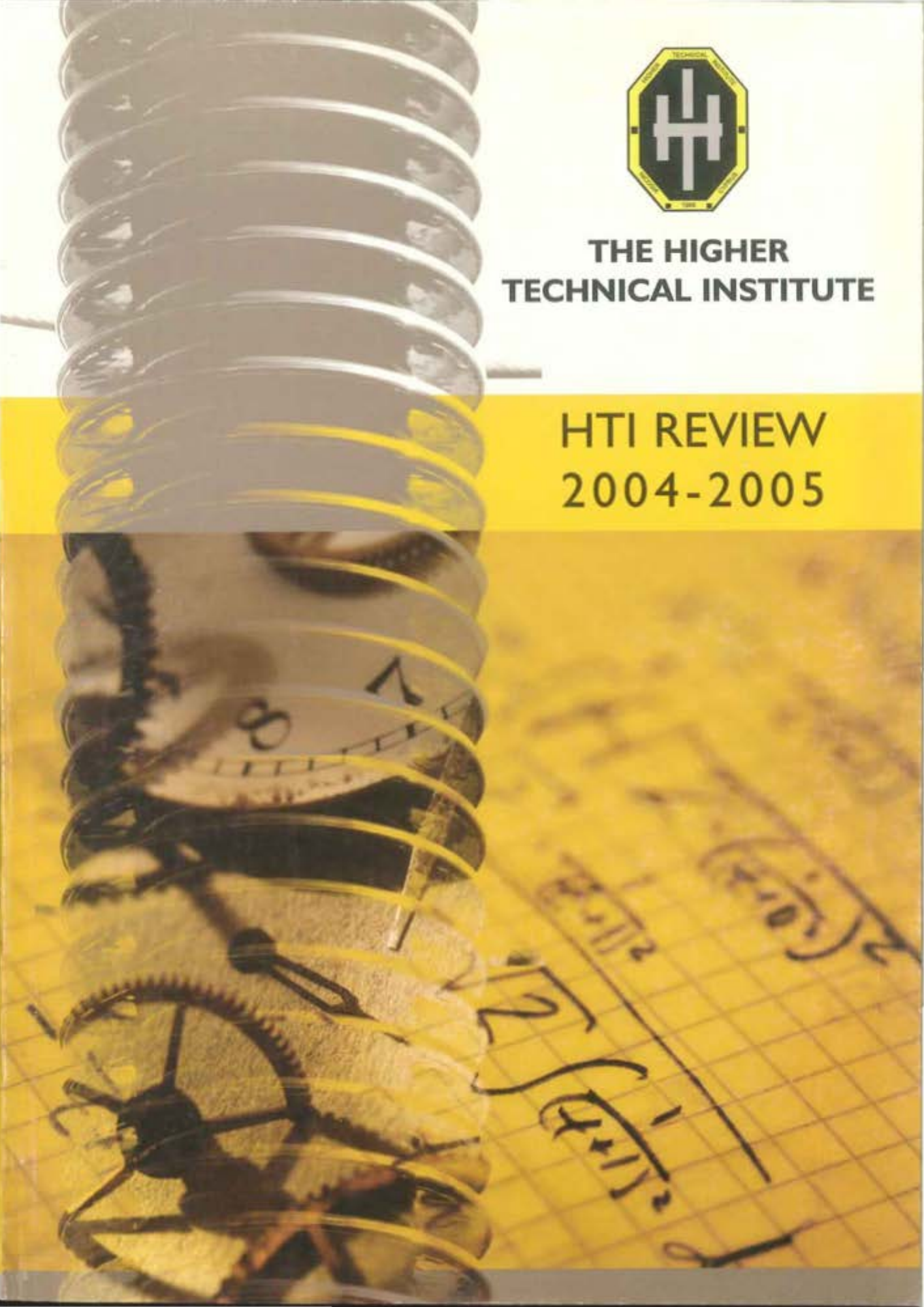

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HTI REVIEW 2004-2005

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The Editors
HTI Review Higher Technical Institute
P.O.Box 20423, 2152 Nicosia - Cyprus
Tel.: 22 406300, Fax: 22 494953/22 406545
e-mail: registry@hti.ac.cy
website: www.hti.ac.cy

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FROM THE EDITORS' DESK...

Welcome to the HTI Review of 2004 – 2005

We would like to welcome all our readers to the latest issue of the HTI Review, a publication which has become a tradition since 1971.

In this issue we have included a collection of scientific and research articles, ranging from the technical to the more academic.

One of the main objectives of HTI has always been the promotion and development of research. For this reason there has been extensive activity on applied research among HTI staff, both at National and European levels.

In this issue, you will find notable articles concerning areas of customer service quality projects, the environment, European issues, solar energy, laser systems, educational debates and others.

We have also included an update of our staff's participation in various courses/seminars/visits abroad. HTI has been actively involved in a number of educational European programmes such as the Socrates-Erasmus, the Leonardo Da Vinci and an array of others involving staff exchanges between Tertiary Education Institutions.

As always we welcome feedback on articles that are featured in the HTI Review 2004-2005 as well as any suggestions you may have for future publications. We have most certainly enjoyed putting it together and we wholeheartedly hope you will enjoy reading through it.

The Editors

IMPROVEMENT OF CUSTOMER SATISFACTION OF TELECOMMUNICATION SERVICES PROVIDERS: A CASE STUDY OF QUALITY FUNCTION DEPLOYMENT (QFD)

By Dr Ioannis Angeli, HTI Dipl, BEng, MPhil, PhD.
Demetris Zangoulos, BSc, MSc.

ABSTRACT

In the last few decades, it has been observed globally, a revolutionary tendency of creating companies that provide their clients with high quality level of products and services. Quality has become an essential issue for any kind of enterprise that wants to be a holder of a valuable share of the market. Moreover, to a very large extent this philosophy has inevitably influenced the local Cypriot market.

Quality Function Deployment (QFD) which is an advance Quality planning tool can be applied not only in manufacturing but was also successfully applied in the Telecommunication's Services providers sector.

In particular, the case study initially had to find ten of the leading companies of the telecommunication's services providers in Cyprus and then had to identify the specialized needs of these top customers through personal interviews. The customer requirements were then translated into questions where the managers were asked to prioritize their requirements. Following the identification of the customer needs, solutions to these needs had to be found. These solutions were identified by a brainstorming session with a team of IT managers of the selected companies (taking short interviews with the IT managers of the selected companies), management executives and the quality manager of the leading telecommunication's provider in Cyprus. With all the necessary data collected, the QFD matrix was completed, and the critical solution and necessary action for improvement were identified.

This investigation which was undertaken by Mr D. Zangoulos (ex student of Sheffield Halam University) in collaboration with Higher Technical Institute concern of pioneer research in the telecommunication services sector of Cyprus that targets to identify the very specialized needs of the top customers. Based on this identification, the improvement of customer satisfaction can be obtained.

RELATED BACKGROUND

A) GOODS Vs SERVICES QUALITY

It has been proved both theoretically and practically, that for all types of companies or organizations (manufacturers or services) quality is a substantial element, in order to keep customers, sustain the profitability and gain significant market share. Moreover, a vital principle in order to achieve high quality levels in any type of organization is the need of viewing all organizations as systems, and focus on each component of the organization individually. -"A system is a set of functions or activities within an organization that work together for the aim of the organization"- [Evans J., Lindsay W., 2005]. However, according to Shwartz, failure to distinguish between product and services will lead to lack of quality in both.
Generally speaking, the word "product" has been defined by the economists as the output or result of an economic activity. Following this definition, "product" will be broken down in two categories:

- The tangible product, which are the goods
- The intangible product, which are the services

Some basic differences should be underlined in order to understand the distinction between "goods" and "services" (Table 1):
1. In the case of service organizations, the output is usually intangible in contrast to the manufacture organizations where the product is tangible. The elusive character of "services" makes the measurement methods of quality very difficult, whereas "goods" are being assessed against the firm design specifications.
2. The customers often are involved in the service process, while in the process of producing "goods" the customer is not present.
3. In the service sector, human interaction plays a vital role for the quality assurance, in contrast to the "goods" production where the conduct between the staff and the customers is limited.

The Majority of GOODS are:	The Majority of SERVICES are:
Tangible (100%)	Intangible (100%)
Storable (100%)	Perishable (100%)
Non participation of the customer in the production process	Customer participate in the process
Production & Consumption: Not at the same time	Simultaneous production & consumption
Immediate purchase is for capability of later performance	Immediate purchase is for immediate performance
Fixed time of production time	Time-perishable capacity
Transportable	Service providers are transportable

Table 1 Differences between GOODS and SERVICES

For Services Organizations, the quality of service experience plays a major role in ensuring customer loyalty, enhancing a product's marketplace reputation and enabling individual companies to maximize their market share. Many service organizations measure the quality of their service process and they try systematically to improve it, by minimizing the service turnaround time and maximizing the customer's satisfaction. Due to the fact that services have intangible quality characteristics the success of high quality services depends upon the performance and behavior of the employees. The proper training of the employees, in terms of how they should behave with the customers, their knowledge on the sector that they represent and their ability to perform correctly with any type of customer, ensure the success of a service organization in the marketplace.

Moreover, the today's competitive global market a new method of interaction with the customers of service organizations has appeared. Information Technology is being used in the last fifteen years by utilizing computing, data processing, communication and various other means in order to convert data into useful information. Nowadays, many service industries exploit information technology to improve their customer service. Without a doubt, this new way of interaction with the customers has led to the improvement of quality and productivity and has become the competitive edge of many service organizations.
"Information Technology is essential for quality in modern service organizations because of the high volume of information they must process and because customers demand service at ever-increasing speeds. However, while information technology diminishes the labor intensity and increases the speed of service, it can have adverse effects on other dimensions of quality... " [Evans & Lindsay, 2005]. In conclusion, both labor and information technology can perform effectively on quality's function, only if they cohabit in a balanced way.

B) TELECOMMUNICATION SERVICES

Today, in the 21st century the ability of achieve high quality standards in the telecommunications' industry is a challenging task, worldwide. The quality, reliability, and performance of telecom services should continuously make forward improvements, because of their critical role in the "digital ages" we live. Moreover, globalization has driven the need for high quality standards, in order to ensure that this critical sector operates in a reliable mode. Therefore, a common set of quality requirements throughout the telecommunications supply chain has been established, in order to make sure that there is homogeneity of the provided telecom services.
Telecommunications services are generally divided into three categories:

- Fixed telecommunication services: They basically provide transmission by using telecommunications networks to communicate between fixed-point-of-transmission senders and receivers. Examples of fixed telecommunication services area) Fixed telephone services, b) Integrated Services Digital Network (ISDN), c) leased circuits, d) data transmission circuits.

- Mobile telecommunication services: They provide transmission services with portable equipment, such as cellular phones, PHS services and pager services.

- Services of inter-telecommunications services: Basic role of this category is to supplement the transmission network of telecom companies, in order to provide their own services.

Finally, the need of reliable telecommunication services should be stressed, because this industry plays the principal role in today's digital economy. In this highly competitive environment of telecommunication services, both reliability and quality of the high-tech telecommunication network is becoming increasingly important.

C) MEANING AND CONTENT OF QFD

Quality Function Deployment has been defined by the American Supplier Institute as: "A system for translating consumer requirements into appropriate company requirements at each stage, from research and product development to engineering and manufacturing to marketing/sales and distribution" [ASI, 1991].Despite the fact, that QFD is not a high technology it certainly has a place in the high-tech realm.

Quality Function Deployment originated in 1967, when it was first mentioned in Kobe's internal literature. Then, in 1972 it was first applied at Mitsubishi's Kobe shipyard site. Toyota was the next large company that applied QFD in its planning process and the results of this application were impressive. In the United States QFD became popular almost one and a half decade later. In 1986, it was first introduced by Xerox and Ford. Since then, many types of companies are using QFD, in order to satisfy their customers' requirements. Nowadays, QFD is used successfully by manufacturers such as General Motors, Motorola and IBM and it is also effectively applicable for the service industry.

When Japanese initially started to use QFD methodology, they became able to capture the voice of the customer. This new system enabled the companies to carry its customers' preferences through the engineering and manufacturing processes.

Quality Function Deployment provides an excellent method for members of a cross functional team, in order to identify and display diverse input data to satisfy customers' wants and establish interrelationships among inputs and outputs. It should be also underlined, that without teamwork approach, QFD loses much of its power. By using this methodology, it is quite possible to produce a higher quality product or service, at a considerable lower cost, over a shorter period of time. In today's world economy, it is a desirable achievement for an organization to produce products or services in "Low cost, High Quality and First to market". QFD enables the user with these three advantageous opportunities, as it is shown in the Figure 1.

One of the names that are being used for the QFD methodology, over the years is "The House of Quality". It is a set of matrixes which relate the voice of the customer (so called WHATS) to a product's or services'

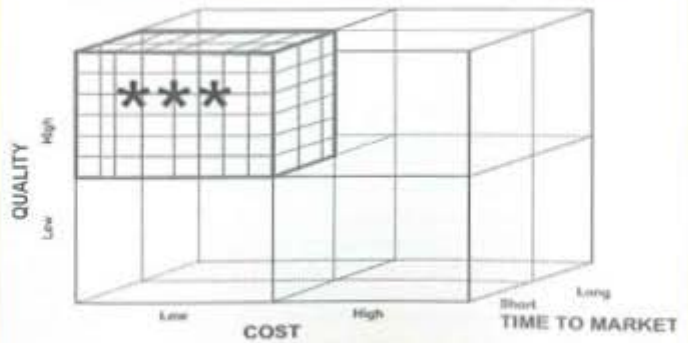

Figure 1: QFD cube (Source: The voice of QFD, DRESSER-RAND, 1993)

requirements, components requirements, process control plans, and manufacturing operations (called HOWS) (it is about product). Figure 2 next, shows the basic parts of the "House of Quality" and demonstrates through these matrixes the variety of processes and information one can reviled.

Despite the fact that in this investigation only the first step of the QFD process was used, it is essential to give a brief description of all the four phases that comprise the whole QFD methodology. A series of matrixes should be utilized as shown in Figure 3, in order to provide the voice of the customer throughout the company from the shop floor to the management. Each of these matrixes is a part of the integrated QFD process, targeting a different phase of the product or service development. Therefore, a complete QFD implementation is comprised by four main phases:

1. Product Planning/ Design: This initial phase of the QFD process enables the company to understand the customers' needs, providing an important marketing function and an excellent management strategic direction. The customers' requirements are identified by direct conduct with the customers and are the main inputs of this first QFD matrix, known as "WHATs". Based on these requirements, solutions and ways for satisfying these needs should be carried out by the team. These solutions are well known as "HOWs" and, are also important input of the first QFD matrix. After detailed analysis, the most important solutions ("HOWs") are carried through to the next phase and are becoming the "WHATs" inputs for the new matrix.

2. Part Planning/ Details: It is quite similar to the first phase but applies to subsystems and components. If it concerns a product, the technical requirements from the first "house" be transferred to the current one and more detailed component characteristics should be found. Once again, the critical parameters that emerge after the analysis are carried through the next phase.

3. Process Planning: Having identified the customers' requirements, the solutions in order to satisfy these requirements and the specific components characteristics, the next step should be the identification of the key process operations that should be followed in order to achieve the targets of the two previous phases. The third matrix makes the transition from the planning to the execution.

4. Production Planning: The most important processes of the previous phase are transferred to this phase which is the last one of the QFD process. This final phase specifies the necessary steps in order to make possible the key processes.

Figure 2: Components of the QFD model (Source: The QFD Book, Guinta R. L and Praizler C. N, 1993)

During the insertion of the data inputs from one phase to the next the team should be very selective. This is the main principle of the QFD process if we want to keep the size and the amount of information which is included in the matrixes manageable. Moreover, it must be noted that only the first two phases are commonly used, because they enable the user to identify and solve possible problems. Most rare are the third and the fourth phase, because of the cost and time required to be effective. They are used only in cases of problems which cannot be solved without changes in the processes and in production lines. As it has been mentioned, for the purposes of this dissertation only the first phase will be used.

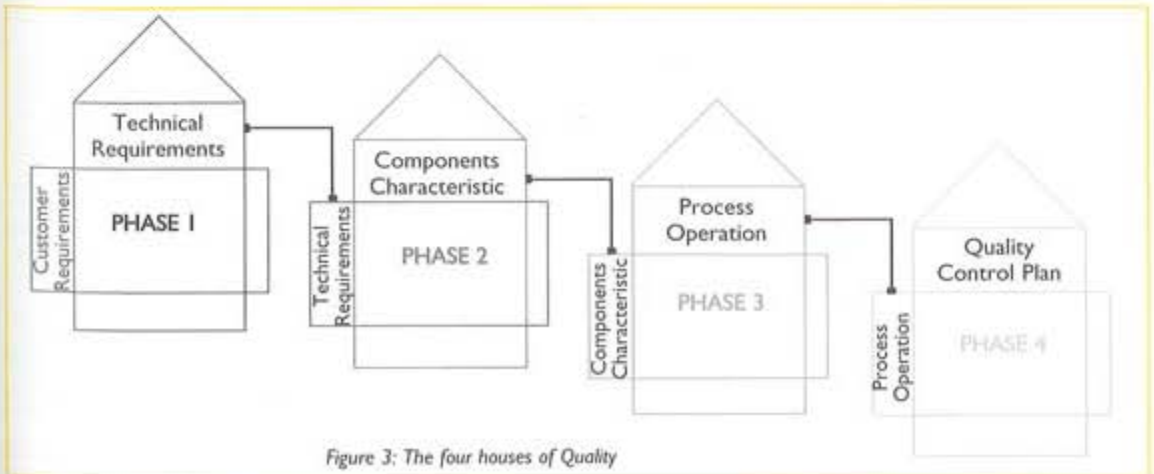

Figure 3: The four houses of Quality

METHODOLOGY ADOPTED

The investigation lasted approximately three months in duration, starting from the beginning of June until the end of August. The following comprise the research methodology and steps that have been followed throughout the prescribed time period:

1. Literature search world wide to identify similar case studies and approaches.
2. Study the importance of quality in service organizations and the QFD methodology.
3. Selection of the customers target group in cooperation with official's telecommunication providers.
4. Interviews with the representatives of the chosen customers in order to determine their specific requirements and needs.
5. Analyze, evaluate and group customer requirements
6. Develop a questionnaire that will be used by the customers in order to evaluate the importance number as perceived by major customers of telecommunications providers.
7. Evaluate the results of the questionnaire in order to identify which of the criteria can be improved in order to boost customer satisfaction from the target group and input the most important ones to the QFD Matrix.
8. Customize the selected QFD software and input the selected customer requirements.
9. Thought workshops, teamwork and close cooperation with a telecommunication provider officials identify the specific factors, decisions or actions, the 'HOWs', that might be taken by them to fulfill the specific customer requirements and determine the essential and critical characteristics for further improvements.
10. Develop in full the QFD planning Phase I, by filling as many parts as possible of the QFD matrix.
11. Identify the most important factors ,"HOWs", or actions a telecommunication provider might take to fully satisfy the specific requirements of its major customers
12. Presentation of the analysis and results with concentration to recommend to the telecommunication provider top level management on how to succeed their Quality objectives and corporate competitiveness.

MAIN INVESTIGATION RESULTS

As it was mention previously the top 10 customers of the telecommunication providers were selected by the authors for personal interviews. There opinions and specific requirements were recorded, filtered, grouped and then converted into specific statements. From that a specific questionnaire presented next, was formulated. That questionnaire was sent back to the same IT managers of the selected companies for assessment of the priority number, with a scale 1 to 9. That number not only is essential to proceed with the QFD methodology, but also gave a value of importance of each specialized requirement. After receiving the answered questionnaires from each customer the average "Priority Number" was calculated for each question and the final results obtained are shown on table 2. The top 5 customer requirements are marked with an asterisk *. These are the most important requirements that the Telecommunications Services Providers should concentrate on, in order to increase their top customers' satisfaction and improve the quality of their current services.

Table 2: The Specialized Needs and importance number

Category – "COST"	Priority Number (1 to 9)
1a) In the case of the "high capacity lines", there should be a decline in the cost.	7.28
1b) Decline of the cost, where there is a need for a connection to a new office with the central/main office of the company with the ultimate purpose of providing "back-up" and "business recovery."	7.57
1c) Change in the charging attitude of "Frame Relay": Charges should be based on the Band-width which is used. Charges should not be based independent of theusage. Charges should be based on the ideology of "You pay as you use," which is an ideology that many European countries use.	7.71
1d) Change in the way that customers are charged when using "Frame Relay": Charges should be based on the "packet" which is used.	4.57
1e) Change in the way that customers are charged when using "Frame Relay": Charges should be based on the time usage (some companies use "Frame Relay" 24 hours a day, whereas others use it during office hours).	6.00
1f) Increase on the discount amount on the landline, based on the account. There should be a number of discounts on various ranges used.	6.28
1g) Increase on the discount amount on the mobile telecommunication, based on the account. There should be a number of discounts on various ranges used.	6.42
1h) Increase on the discount amount on the ISDN lines, based on the account. There should be a number of discounts on various ranges used.	6.28
1i) Decrease of the "fix cost" on all the types of communication (landline, mobile telecommunication, ISDN) etc.	6.42
1j) Decrease of the cost of installing systems like "disaster recovery" or "alternative routing."	8.00 *

Category – "TECHNICAL ISSUES"	Priority Number
2a) Installation of a type of service known as "ALERT" which in cases where there is a malfunction in an office or a department there will be an automatic message sent to the main offices via e-mail or via sms on the cell phone of an IT manager. The message, could for example, say the PVC number xx3 or the Frame Relay is having some problems.	7.57
2b) Παροχή "3G δικτύου" το οποίο είναι είδος "wireless" δικτύου, το οποίο να χρησιμοποιείται σε υψηλές ταχύτητες (256 Kb και άνω) και για "back-up" γραμμές. 2b) Installation of "3G - Network" which is a type of wireless service, and which will be used in high speeds (256 Kb and more) as well as for "back-up" lines.	6.14
2c) Access should be given from the provider of the telecommunication services of the card known as "GPRS" so that when the employees of a company are traveling abroad can access the internet by using this card on their laptop.	5.14
2d) Access of "teleconferencing solution" from the provider of the telecommunication services for "face to face" communication with the clients abroad.	3.85
2e) Provide of GPS system/services for checking and control purpose. By using this kind of technology, company will be able to send its technicians to points that are closer to them.	3.85
2f) Change of the current method of communication, with the use radio telephones, which are used by the technicians of the company. Each car should be provided with a "fax-printer" which will be receiving messages in cases of any problems.	3.28
2g) Access of "broad band" internet which will be available not only by corporations, but also by the employees of a company who will have access from their houses and who will be able to work from any place in Cyprus – we would like this to take place taking into account that the cost will be within logical limits.	6.14
2h)Access of the service "reroutering" in the Frame Relay system with which it will be accessed by using a third office, and will be able to replace communication problems that may exist between two other offices.	7.28
2i) Availability of immediate/direct connection of the offices that are close to each other with the purpose of having the same company own the network. In this way it will not be necessary to pay rent to the provider of the telecommunication services.	6.85
2j) Improvement of the WAN's (Wide Area Network) reliability, in regards to the quality and speed of the lines.	6.85
2k) Περιορισμός των περιπτώσεων, στο ελάχιστο δυνατόν, όπου το «σύστημα είναι κάτω» ("down time"). Ζητούμε 99.9% reliability για ολόκληρο το σύστημα και το εύρος των υπηρεσιών το οποίο παρέχεται. 2k) Minimize as much as possible the cases where the system is down. We ask 99.9% reliability for the entire system and the different kind of the services that is provided.	8.28 *
2l)Πιο άμεση εξυπηρέτηση από μέρους του παροχέα τηλεπικοινωνιών, σε περιπτώσεις όπου υπάρχουν τεχνικές βλάβες. 2l) More immediate assistance by the provider of the telecommunication services in cases where there are technical problems.	8.14*
2m) Minimize the time needed for the installation in new facilities.	7.14
2n) Improvement of the quality of services and the assistance that is provided from the "call center" of the telecommunication services provider.	6.00
2o) 24-hour assistance in regards to issues where there are technical problems.	7.71

Category – "COMPANY RELATION" or "COOPERARTIONS"	Priority Number (1 to 9)
3a) Availability of a specialized advisor for each customer, who will be visiting the company throughout various time intervals and who will be discussing by the IT managers for issues and problems that the company is experiencing.	7.85*
3b) The advisor, who will be appointed by the telecommunication provider, should be able to make important and immediate decisions without having to take too many time-consuming processes, on issues that the customer will need immediate assistance.	8.00*
3c) Availability by the telecommunication provider to the customer of "SERVICE LEVEL AGREEMENT" – also known as SLA's.	7.85
3d) In cases where the customer needs to install a new service which requires a big time frame in order to get approval to be installed, I need from my telecommunication provider, every 2-3 days, to inform me on which stage my "application" is, in order to have this new service available/installed.	6.57
3e) Flexibility on the change of the "packages" and the services that are offered in regards to the "portfolio" of the telecommunication provider.	6.85

Having done this, meeting with telecommunication providers Executives, was well organized and performed. The main purpose of the meeting was the discussion of the whole work that had been done until that moment and moreover, the most important reason of having this meeting was the identification of the "HOWs" and the difficulty factor (1 (very easy) to 5 (very difficult)) of implementing a specific "how", in order to satisfy a specific "what" resulting in the improvement of the customer satisfaction.

The next stage was the filling of the QFD matrix with the input of the weight factors of the "WHATs" and the "HOWs", and their correlation between each other. This was again done with the collaboration of Telecommunication providers Executives, who had the necessary knowledge, expertise and experience to grade this relationship. A special software, QFD Designer, purchased by HTI was used for the QFD development and analysis. By making the input of the data into the QFD matrix, the first phase of the QFD process was completed. The first phase is considered to be the most critical in order for useful conclusions to be obtained, as has been mentioned at earlier stage. The complete QFD matrix Phase I is shown on Figure 4.

From the QFD matrix the most important actions that have to be done from the telecommunications services providers, in order to boost their top customers' satisfaction were identified. This group of the six "HOWs" has a total assessment of more than 220.00 each, and clearly can be distinguished from the remaining "HOWs".
It is observed that the five of the six most important "HOWs" are closely related to the PRICING-Policy and only one is related to the use of new technologies.

In particular, the six most important "HOWs" are the following:

- Change the existing "pricing policy" to a new one.
- New pricing policy for "back-up" connections by creating cheaper "back -up" solutions.
- Installation of a new platform that would enable the company to change its "ATM/FR billing system" – New Billing System based on volume.
- Introduce new products that would enable the organization to change its existing "pricing policy". In particular, introduce the SVC technology (Switch Virtual Circuits), in order to achieve a "pay as you use" pricing policy.
- Create new discount ranges, for land, mobile, and network telecom services.
- Introduce AUTO management for ATM/FR & HDSL. By using the "AUTO management" it will enable the organization to be more effective and have faster reactions when problems appear to the ATM Frame Relay and HDSL.

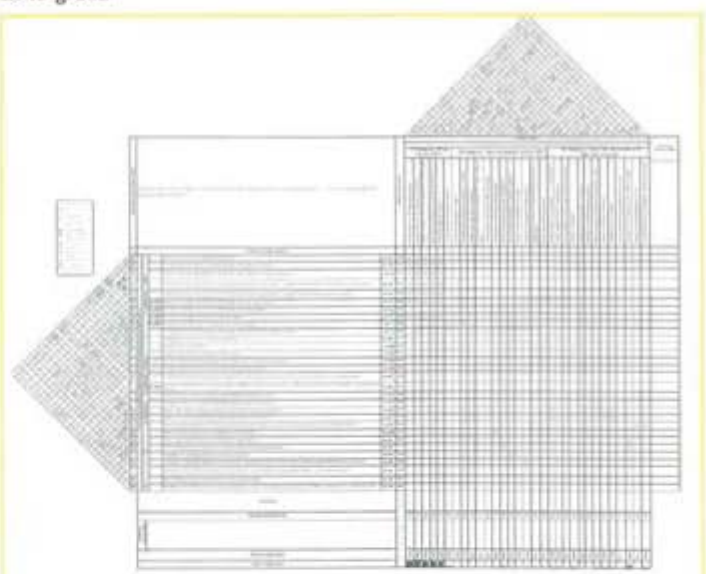

Figure 4: The QFD matrix phase I for telecommunication providers

It should be noted that by following the QFD matrix and rooms, one can find many other correlations or actions that could be done in order to increase the level of cus-

tomer satisfaction. The capabilities of the software are more than those which have been used for the completion of this case study. The software can also generate a "competitive assessment", showing the position of the company amongst competitors. This and many other functions of the software haven't been used because they fall outside of the scope of this investigation.

CONCLUSIONS

Today's highly competitive environment of Telecommunication Services has put the quality aspect to the first place of the priorities that have to be implemented by a telecommunication services provider in order to become a leader in this industry sector and gain as many customers as possible. In particular, the competition of telecommunications services is driven by several factors such as price, network reliability, service features, perceived quality and responsiveness to customers. The reputation along with the increase of the market share of a telecommunications services provider mainly depend on the response level to all these important factors as well as to the speed that new services are introduced into the market.

To this end, the use of such techniques and methodologies which would enable the companies to measure and improve their customers' satisfaction has become an essential issue. The utilization of the Quality Function Deployment methodology, in order to define the specialized requirements of the top customers of telecommunications services providers and their solutions in order to satisfy these needs, was a pioneer academic research for the existing local business status quo. Therefore, QFD methodology was seen by the authors as a very powerful quality tool that could be used for the purposes and findings of this investigation.

The procedure of identifying the specialized requirements of the top customers was perhaps the most interesting part of this project. This identification was made during short interviews with the IT managers of the collaborated "top customers". However, the most critical activity for the success of the project was the preparation of the draft questionnaire. The questionnaire had to be clear by using "strong verbs" (change, install, provide, create etc), in order to give the correct meaning for each requirement. Lastly but not less interesting part was the meeting with the telecommunication provider Executives where the solutions to the customers' needs had to be identified. By recognizing the importance of this project for their organization, the company was represented at this meeting with some of its most important and experienced managers.

Generally, the QFD methodology provides a true competitive edge for any company that wants to be a leader in its sector. However, the results of this particular investigation can be used not only by any local telecommunication provider but also by other local telecommunications services providers abroad which aim to increase their customers' satisfaction in an effective way. Finally, someone could say that the results will be an eye opening and enlightening for the future management plans of the specific telecommunication provider.

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USE OF ARTIFICIAL NEURAL NETWORKS FOR TIME SERIES WIND SPEED PREDICTION

Soteris Kalogirou[1] and Silas Michaelides[2]
[1] *Higher Technical Institute, P. O. Box 20423, Nicosia 2152, Cyprus*
[2] *Meteorological Service of Cyprus, Nicosia 1418, Cyprus*

ABSTRACT

In this paper a time series prediction of wind speed using artificial neural networks is presented. For this purpose the mean hourly wind speed records for the area of Kourris dam, located at the south of Cyprus, are used. Wind data for ten consecutive years (1991-2000) are available for this area. The network was trained to predict the mean monthly hourly wind speed of a year (e.g. 1994) by using the values of wind speed for the same month and same hour for the three previous years (e.g. 1991-1993), consecutively. The data for the wind speed up to the year 1999 have been used for the training of the network whereas those for the years 1997-1999 (input) and 2000 (output) were used for the validation of the network. It should be noted that the data for the year 2000 were completely unknown to the network. The wind speed for the validation data set was predicted with a correlation coefficient of 0.82 which is satisfactory for wind speed which is very unstable. Therefore the method proved to be very promising both for predicting missing values and for forecasting.

1. INTRODUCTION

Wind speed prediction is very important for the long term estimation of the performance of wind turbines. The availability of wind speed data is also very important in the case where suitable locations are selected for the placement of wind turbines. Often there are missing data in wind speed databases due to various reasons. It is therefore very important to be able to predict wind speed (forecasting) and to fill missing data values from databases.

The increased use of energy and the depletion of the fossil fuel reserves combined with the increase of the environmental pollution have encouraged the search for clean and pollution-free sources of energy. One of these is wind energy. This is a clean, inexhaustible and a "free" source of energy that has served the mankind for many centuries by propelling ships, driving wind turbines to grind grains and for pumping water. Despite the high initial cost of wind power this may become a major source of energy in the years to come. This is so because the severe pollution of the planet originating from the burning of the fossil fuels and the nuclear energy risks cannot continue forever.

The present world capacity of wind parks is about 36,320 MW (Sayigh, 2004). Despite the success of Cyprus in solar water heating no other renewable energy applications are investigated on the island. The wind potential of Cyprus is limited but there are certain locations on the island where small wind parks can be installed. One of these is the area near the Kourris dam. In this area the very first wind park will be located by the Electricity Authority of Cyprus. The park will be relatively small and will be constructed on a pilot basis, mainly to evaluate the potential of Cyprus in this form of renewable energy.

The predicted variations of meteorological parameters such as wind speed, relative humidity, water vapour pressure, solar radiation, air temperature, etc. are needed in the renewable industry for design, performance analysis, and running cost estimation of these systems.

For proper and efficient utilisation of wind power, it is important to know the statistical characteristics, persistence, availability, diurnal variation, and prediction of wind speed. The wind characteristics are needed for site selection, performance prediction and planning of wind turbines. Of these characteristics, the prediction of mean monthly and daily wind speed is very important.

Mohamed et al. (1998) have used an artificial neural network (ANN) to predict the wind speed one hour ahead with very satisfactory results. Also, More and Deo (2003) used neural networks to forecast daily, weekly and monthly wind speed at two coastal locations in India. They found that the ANN technique is more accurate than the traditional statistical time series analysis. In another work a multilayered artificial neural network has been used to predict the mean monthly wind speed in a south east region of Cyprus (Kalogirou et al., 1999). Data for the period 1986-1996 were used to train the neural network, whereas data for the year 1997 were used for validation. Both learning and prediction were performed with adequate accuracy. Two network architectures of the similar type have been tried. One with eleven neurons in the input layer and one with five. The second one proved to be more accurate in predicting the mean wind speed. The maximum percentage difference for the validation set was confined to less than 1.8% on an annual basis, which is considered adequate.

Neural networks have also been used before by the authors for the prediction of precipitation (Kalogirou et al., 1998). For the interested reader a review of applications of neural networks in renewable energy systems is given in (Kalogirou, 2001).

In the present work ANNs are used to predict the mean monthly hourly wind speed of an area near Kourris dam using similar values of wind speed of previous years. The mean monthly hourly wind speed is a representative figure of the wind potential of a site. Based on this figure one can decide whether a particular site has a good wind potential for wind energy applications.

2. DATA COLLECTION

The region is located at the southern part of Cyprus as shown in Fig. 1. A meteorological station is in operation in the region for a number of years. The observed data of wind speed in this station cover ten consecutive years (1991-2000). All data are recorded and analysed by the Meteorological Services Department of the Ministry of Agriculture, Natural Resources and Environment. A sample of these data is shown in Table 1.

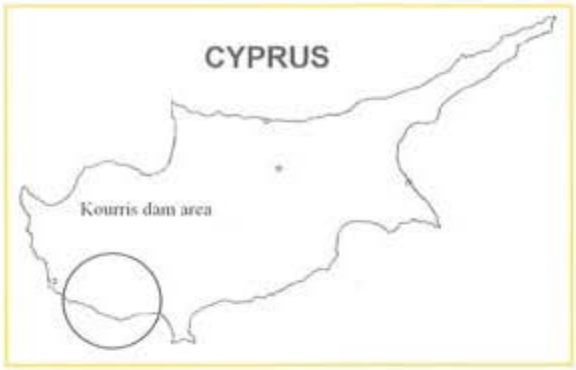

Fig. 1 Map of Cyprus showing the area where the site under investigation is located.

Table 1 Sample of weather data available

Month	Hour	Years									
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	1	4.7	4.4	4.9	4.7	4.6	4.6	4.8	4.4	5.0	5.4
1	2	4.6	4.5	5.0	4.6	5.0	5.0	4.7	4.3	4.8	5.0
1	3	4.8	4.9	4.9	4.7	5.2	4.9	5.0	4.4	4.6	5.0
1	4	4.8	4.8	5.1	4.9	5.2	4.6	5.2	4.3	4.9	4.8
1	5	4.9	4.6	4.8	5.0	5.1	4.6	5.0	4.6	4.8	4.7
1	6	4.9	4.9	5.0	4.7	5.0	4.7	5.0	4.6	5.2	4.8
1	7	4.9	4.7	5.0	4.7	5.0	4.6	4.7	4.8	5.0	4.9
1	8	4.7	4.8	5.4	4.8	4.6	4.4	4.9	4.8	4.7	4.7
1	9	3.7	3.9	4.3	3.6	3.6	3.4	4.4	4.5	3.7	3.7
1	10	3.0	3.1	2.9	3.6	2.6	2.8	2.8	3.3	2.9	3.5
1	11	3.1	3.3	3.3	3.8	3.2	3.4	3.1	3.4	3.4	4.0
1	12	3.6	3.5	3.6	4.0	4.0	3.8	3.7	4.0	3.9	4.8
1	13	3.9	4.0	4.1	3.9	4.2	4.0	4.0	4.6	4.1	4.8
1	14	4.1	4.0	4.2	3.9	4.4	4.2	4.1	4.7	4.2	5.1
1	15	3.9	4.2	4.3	4.0	4.4	4.2	4.4	4.8	4.1	4.8
1	16	3.5	4.0	4.0	3.4	4.1	3.6	4.1	4.1	3.5	4.4
1	17	2.9	3.0	3.2	2.7	3.6	2.8	3.4	3.7	2.8	3.6
1	18	2.5	2.5	2.6	2.7	2.9	3.1	2.6	2.6	2.3	3.5
1	19	3.2	3.1	3.0	3.1	3.0	3.6	3.2	2.5	2.8	3.8
1	20	3.8	3.6	4.0	3.1	3.3	3.9	3.8	2.7	3.6	4.0
1	21	4.4	3.7	4.3	3.7	4.2	4.0	4.2	3.2	3.9	4.6
1	22	4.7	4.1	4.6	3.9	4.5	3.9	4.2	3.7	4.3	4.6
1	23	4.9	4.2	4.7	3.9	4.7	4.3	4.4	3.9	4.8	4.8
1	24	4.8	4.3	5.1	4.1	5.0	4.4	4.7	4.3	4.9	5.2
2	1	4.6	4.4	4.5	4.3	5.5	4.7	4.6	4.1	5.1	4.9
2	2	4.9	4.3	4.4	4.5	5.6	5.1	4.9	3.9	5.2	5.0
2	3	...	...	...	...	...	...	...	...	...	...

3. METHODOLOGY

The available data were manipulated in order to be used for the neural network training and testing. The database used was divided into two sets: A training data set having all wind speed records for each hour of a month for the years from 1991 to 1999 and a verification data set for all the hours of each month for the year 2000. The training data set has been used for the training and testing of the artificial neural network, while the verification data set has been used for validation of the network. The network was trained to predict the mean monthly hourly wind speed of a year (e.g. 1994) by using the values of wind speed, for the same month and same hour, for the three previous years (e.g. 1991-1993), then the data for the years 1992-1994 were used as input and those for the year 1995 as output and so on. This procedure is used consecutively for the preparation of the required databases. The data for the years 1997-1999 (input) and 2000 (output) were used for the validation of the network. In this way the two databases were constructed with the training one to comprise 1728 patterns and the testing database to comprise 288 patterns representing all 24 hourly values for each month for the year 2000. It should be noted that the data for the year 2000 were completely unknown to the network.

Different network structures, sizes and learning parameters have been tried. The architecture that was ultimately selected is shown in Fig. 2. It is composed of five slabs, three of which are hidden. It is a feedforward architecture, which has different activation functions in each slab, as shown in Fig. 2.

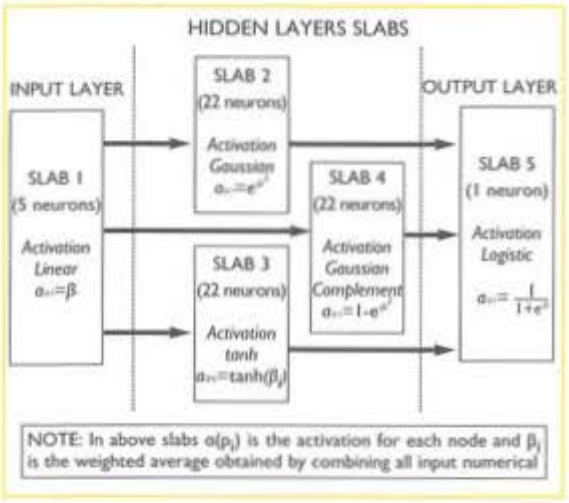

Fig. 2 The selected neural network architecture.

Different activation functions were applied to the hidden layer slabs in order to be able to detect different features in a pattern processed through the network. This type of architecture has been used successfully in a number of engineering applications of neural networks (Kalogirou, 2000, 2001). The activation function used for each slab is also shown in this figure.

The five neuron input layer comprise the input data. These are the month, hour and mean monthly hourly wind speed for three years. The output of the network is a single neuron representing the mean monthly hourly wind speed for the next year. The learning procedure in the neural network was implemented by using the back-propagation algorithm. Also, the learning rate was set to a constant value of 0.1 and the momentum factor to 0.1. The weights were initialised to a value of 0.3. From a total of 1728 patterns, 80 percent were used for training the network (1383 patterns) and the remaining 345 patterns (20%) were randomly selected to be used as test patterns. An increased number of hidden neurons (22 in each slab) were used in order to enable the network to learn the wind patterns correctly.

4. RESULTS AND DISCUSSION

The training patterns were learned with an adequate accuracy. The correlation coefficient obtained from the learning phase is equal to 0.8517. For an independent assessment of the network the results of the verification year 2000 are presented. The correlation coefficient obtained this time is 0.8165, which is considered satisfactory. The results for the year 2000 are shown in Figs. 3 and 4; the first for the months January to June and the second for the months July to December. The maximum error of the wind speed has been found to be 1.25 m/s. The observed and estimated wind speed patterns appear to display a quite satisfactory match. In particular, the seasonality of wind speed is well simulated. The actual average annual wind speed is equal to 4.097 m/s whereas the network estimated value is equal to 4.092 m/s.

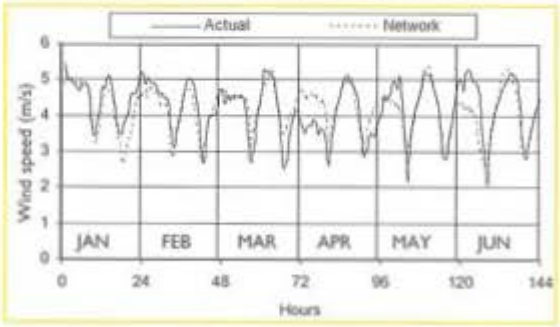

Fig. 3 Actual against network estimated wind speed for the months January to June.

It should be noted that the training of the neural network required about 10 minutes on a Pentium II, 400MHz computer. The subsequent predictions for the validation cases required less than a second on the same machine; so a quick estimation time is obtained without sacrificing accuracy.

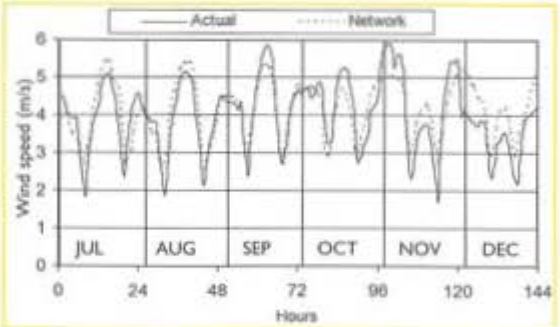

Fig. 4 Actual against network estimated wind speed for the months July to December.

5. CONCLUSIONS

In this paper a time series prediction of wind speed using artificial neural networks is presented. For this purpose the mean monthly hourly wind speed records for the area of Kourris dam, located at the south of Cyprus, are used. The network was trained to predict the mean monthly hourly wind speed of a year by using the values of wind speed for the same month and same hour for the three previous years, consecutively. The training of the network was fast and accurate. The correlation coefficient obtained from the learning phase is equal to 0.8517. The data for one complete year (2000) were used for the validation of the network. It should be noted that these data were completely unknown to the network. The wind speed for the validation data set was predicted with a correlation coefficient of 0.82 which is satisfactory for wind speed which is very unstable. Therefore the method proved to be very promising both for predicting missing values and for forecasting.

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COMPARABLE DEGREE STRUCTURES IN EUROPEAN HIGHER EDUCATION INSTITUTIONS

Dr. Marios Kassinopoulos
marios.hti@cytanet.com.cy
Electrical Engineering Department, Higher Technical Institute, Nicosia, Cyprus

ABSTRACT

The main goal of the Bologna Process is the creation of a European Higher Education Area where there will be no obstacles for student and staff mobility. An important step towards this direction is the adoption of easily readable and comparable degrees. This reform, in addition to the advantages related to mobility, will promote the employability of the European citizens and the International competitiveness of the European Higher Education system. For this purpose the Bologna Process signatory countries, as regards the degree structure, are engaged to work for the adoption of an educational system essentially based on two main cycles, undergraduate and graduate. The first cycle would have duration of minimum three years and the second cycle may last one or maximum two years. The access to the second cycle requires successful completion of the first cycle. The degree awarded after the first cycle will be relevant to the European labour market. This paper considers the introduction of this reform in European Higher Education Institutions during the first years of the Bologna Process (1999). The study comments specifically on the following points: (a) The introduction of two-tier (Bachelor/Master) and three-tier (Bachelor/Master/Doctorate) degree systems in relation with the European credit system ECTS. (b) The implementation of this system in the European countries. (c) The new structure forms that Doctorate degrees would be designed. (d) The introduction of qualification frameworks for the new designed programs. The article also refers to statistical data related to the number of Institutions and European countries, which have introduced completely or partly this reform. It analyses also the involvement of students, professional associations and employers in the design of the curricular of the new programs. This involvement varies considerably from country to country. Finally the paper considers the problems, which may arise from this reform, one of which is the possibility of creating confusion in relation to the level and quality of the degrees of the different Institutions. Finally the introduction of program descriptors and level indicators at European and national level is examined too.

Key Words Bologna, Credits, Degrees, Education, Reforms

INTRODUCTION

It is well known that the main aim of the Bologna Process (BP) is the creation of a European Higher Education Area (EHEA). One of the policies followed to reach this goal is the adoption of a system of easily readable and comparable degrees, essentially based on two main cycles, undergraduate and graduate. This system is expected, to increase mobility [1], to promote the European citizen's employability and to enhance the international competitiveness of the European Higher Education system. The two main characteristics of this system are:

- The access to the second cycle shall require successful completion of the first cycle, which may have a minimum duration of three years.
- The degree awarded after the first cycle should be relevant to the European labour market as an appropriate level of qualification.

Of course these two characteristics are not isolated from the rest of the objectives of this reform. These objectives, which will be developed in the next paragraphs, are the introduction of a European Credit Transfer System (ECTS) in all European Higher Education Institutions (EHEI), the curricular renovation and the recognition and quality assurance of programs of studies. With the implementation of these reforms, already in progress in some European countries, a need has appeared for design of transparent and comparable level descriptors, learning outcomes and accreditation methods.
Another thing that is under discussion is the participation of the employers, professional associations and students associations in the design of these reforms. The degree of participation of them varies from country to country. It has been noted also that among the student's community there was a reservation for the active involvement of the employers in the design of these reforms. It was considered that employability should not be a main criterion at the expense of the academic benefits of the programs.

THE TWO-CYCLE STRUCTURE

The degree system of Higher Education as proposed by the BP is the division of studies in two main cycles. The first cycle (undergraduate) will have duration of 3 to 4 years and will lead to a Bachelor degree and the second cycle (postgraduate) will have duration of 1 to 2 years and will lead to a Master degree (two-tier structure). As it is shown in Table 1 and Table 2 in case of further studies the student could follow a three-tier structure and obtain a doctorate degree. Of course in some special cases like Medicine and Architecture this structure should be modified. The two cycles structure already exist in some European countries like UK, Ireland, Malta and others, but in most of the countries such as France, Germany, Spain and others, the existing systems are different.

Years	1 2 3	4 5	6 7 8
Degree	Bachelor	Master	Doctorate

TABLE 1
THREE CYCLE STUDIES 1

Years	1 2 3 4	5	6 7 8
Degree	Bachelor	Master	Doctorate

TABLE 2
THREE CYCLE STUDIES 2

Although the BP has clearly defined that the first degree, Bachelor, shall be relevant to the European labour market as an appropriate level of qualification, in most countries and most HEI, the Bachelor is considered as a first step for further studies, or as an orientation degree. Only in UK where Bachelor Degrees have been offered for

many years, almost 50% of the HEI expect their students to start working with only the first degree. For the rest of the countries, most of the students continue their studies at postgraduate level. One reason for this is probably the lack of information among the student's community and the employers regarding the employability of the first cycle graduates. Another reason is also the fact that in some countries the opportunities for employment and the associate salaries are higher for graduates with postgraduate studies. In some countries also, in the public service, postgraduate studies give considerable advantages regarding promotion. The possibility of a bad design of the content of the Bachelor programs, which may not offer the appropriate skills and competences that are required to make the first degree graduates employable should be examined too. This is probably a good reason, due to the limited involvement of employers in the design of the curricular in many countries.

The entry to a Masters program usually requires a completed Bachelor degree at a recognized higher education institution. Bachelor and Master degrees should have different learning outcomes and all Bachelors should open access to Masters studies. The entry requirements vary from country to country. The question is whether the responsibility for defining the entry requirement should follow a general policy at institutional level or governmental level or if it should be left to departments, which could decide according to their own programs of studies. A study of the European University Association [2] has indicated that, in almost 30% of the EHEI the responsibility is under the institutions, in 25% is under the department, 25% are discussing this issue and the rest 20% have not tackled the problem yet.

DOCTORAL STUDIES

Although the main discussion on Postgraduate studies is focused on Master degrees, in the BP there is an extensive discussion on the Doctoral studies. The BP encourages HEI to organize study programs at Doctoral level and supports activities based on the cooperation of postgraduate young researchers. In addition to that the EU Higher Education policy makers suggest that HEI should design Doctoral studies in a more structural form, giving more emphasis in employability and including provisions for quality assessment. Until now most of the HEI in Europe followed the traditional method of Doctoral studies, where the students are left on their own and what is provided to them is only individual tutoring and supervision. It has been realized now that this type of studies does not suit any more the new educational methods. It is suggested that in addition to tutoring, courses and joint European programs at Doctoral level should be included. This, in addition to all other positive effects will promote, the mobility of young doctoral students and the creation of the European Doctoral Area.

CREDIT SYSTEM AND TWO-CYCLE DEGREES

The credit system introduced in EHEI is the ECTS, which stands for European Credit Transfer System. Under this system a full time semester program carries 30 ECTS that makes a total of 60 ECTS per year [3]. The distribution of credits in the two cycle degree systems varies according to the duration of the two cycles. The first cycle should carry 180 ECTS to 240 ECTS for 3 and 4 years duration respectively. Any Higher education program carrying less than 180 ECTS is recognized as belonging to the sub-degree level. In relation with the Master degree level programs (Bachelor plus Master), they are expected to carry a total of 300 ECTS. This number of 300 ECTS can be attributed in general at the end of a two-cycle structure program [3]. As it is shown in Table 3, as the Bachelor degree may vary from 180 to 240 ECTS, there is a need for the Master degree too, to have a similar flexibility and it can vary from 60 to 120 ECTS making always a total of 300 ECTS after 5 years studies. The most common pattern for the time being is the 180 ECTS Bachelor, plus 120 ECTS Master, equals 300 ECTS. These 300 ECTS can also be attributed to long integrated programs of studies of 5 years duration, like the engineering studies in France

Years	1	2	3	4	5	ECTS
Bachelor	60	60	60			180
Master				60	60	120
Total						300

TABLE 3
CREDIT SYSTEM OF TWO CYCLE STUDIES

As regards the attribution of credits at Doctoral level, in the majority of the European countries, these studies do not carry any credits. Only in 20 % of the countries ECTS is applied and in other 20 % a different credit system is used. The attribution of credits at Doctoral level is under discussion in the EHEI and it is related to the type of the program of studies. In cases where doctoral studies are in a structured form, the attribution of credits is much easier, compared to the cases of traditional form with individual tutoring and supervising.

IMPLEMENTATION OF THE BACHELOR-MASTER STRUCTURE IN EUROPE

During the few years of life of the Bologna Process (1999) an enormous progress has been made regarding the implementation of this reform among the member countries of the European Union. Table 4 demonstrates the countries of the European Union, which have already changed their legislation to suit the new structure. They are about 70%. We can see also the countries, which are at the adjust stage of their legislation (20%) and those, which are planning to do so (10%). Similarly many other European countries not belonging yet to the European Union are in the process of reforming their educational systems accordingly to the BP. In examining now the implementation of the Bachelor-Master structure among the HEI, it has been found that 33% of the HEI have already the two-tier system. This is the case of many institutions in UK, Ireland and Malta. 21 % are at the stage to implement the new structure like in Germany and France and 36% are planning to introduce it like Portugal and Spain. Only 7.5 % of the HEI are not planning to do such changes yet.

DESIGN OF PROGRAMS OF STUDIES: CURRICULAR AND EMPLOYABILITY

As the BP gives emphasis on the quality of studies and underlines that the graduate degrees should be relevant to the labour market, the design of studies should be focused on the curricular and the employability. In rela-

Country	Already existing 2 Cycles structure	Adjusting their system to 2 Cycle structure	Planning to
UK, Ireland, Italy	X		
Greece, Poland	X		
Netherlands, Austria	X		
Denmark, Slovakia	X		
Czech Republic	X		
Hungary, Malta	X		
Lithuania, Latvia	X		
Estonia, Cyprus	X		
France, Germany		X	
Belgium, Portugal		X	
Finland		X	
Spain, Slovenia,			X
Sweden			X

TABLE 4
IMPLEMENTATION OF 2 CYCLES IN EUROPEAN COUNTRIES

Employability %	Very important	important	Not important
Bologna Process Signatory countries	36	53	11
Bologna Process HEI	56	36	8
Universities	43	x	x
Other Institutions	63	x	x

TABLE 5
EMPLOYABILITY AS CRITERION FOR CURRICULAR DESIGN

tion with the curricular, it is not possible to take a previous 5 or 4 years program and split it in two pieces leaving the curricular unchanged. Each cycle should be seen as a complete program of studies, offering to its graduates the possibility to work or to continue further studies.

Regarding employability it has been noted that, in a great number of students and academic staff, there is a concern that too much emphasis on employability could direct HEI in the wrong path. It is believed that HE could be directed by the short-term request of a fast changing labour market, and that the 2 cycles system could be a step towards the production of employable graduates of short duration studies at the expense of the traditional advantages of academic education.

However, today as a result of further discussions, a greater number of students and staff consider that employability is a main factor in HE and it should be taken in account for the design of the new curricular. As it can be seen in Table 5 the majority of the HEI (53%) among the BP signatory countries, consider that employability is an important criterion for the design of the curricular in their programs. Similarly 36% consider employability to be very important and only 11% consider it not important. If we compare now Universities and other Institutions we can see that less than 50% of the Universities consider that employability is very important for the curricular design compared to 63% of the other Institutions. This is not surprising because in general Universities are more close to academic studies than other Institutions, which usually are oriented to applied sciences. The cooperation between professional associations, employers and HEI in the design of the curricular varies considerably from country to country. This cooperation is at a very high level in more than 50% of HEI in UK, Ireland and Lithuania and in about 40% of HEI in France. On the other hand in the majority of the rest of the countries only around 20% of the HEI have a close cooperation with professional bodies and the employers. So it can be seen that in general there is a need to increase the involvement of professional associations and employers in the curricular design.

PROFESSIONAL RECOGNITION OF BACHELOR LEVEL ENGINEERING DEGREES

In relation to the curricular design and employability of the 3 years duration Bachelor degrees in engineering, the following problem appeared in many countries. Certain professional associations do not recognize the holders of these degrees as Engineers. This is the case in France, Germany, recently in UK, Greece and other countries. They are considered in general as professionals between engineers and technician engineers. For example in UK they are considered as Incorporate Engineers, in France as Senior Technician Engineers etc. In these countries engineering studies traditionally have duration of 4 to 5 years, and the local professional bodies consider that Bachelor engineering degrees of 3 years duration cannot satisfy the level requirements for the engineering profession. This problem is the subject of an interesting debate between the local HE policy makers, the local professional bodies and FEANI.

EXAMPLE: THE CASE OF THE NEW THREE-CYCLE SYSTEM IN FRANCE

France is a good example for showing the reforms that are required in certain countries, in order to introduce the new structure of degrees as proposed by the BP. As it can be seen in Table 6 the existing system in France has a structure with many diplomas and degrees of short duration. These are the DEUG with a 2 years program, Licence, Maitrise, DEA with further 1- year program each, and Doctorat with furter studies of average duration 3 years. The structure of degrees now is modified to a system with 3 cycles: Licence (Bachelor) with a 3 years program, Master with a 2 years program after Licence and Doctorat with a program of 3 years studies after Master. As regards engineering degrees the system proposes a complete integrated 5-years program of Master, including a 2 years initial cycle and then an additional program of 3-years studies. These programs are in most of the cases offered by Engineering Schools (Institutes Polytechnics) and not by the traditional universities.

Years of study	Degrees old system	Degrees new system
8	Doctorate	Doctorate
7	Doctorate	Doctorate
6	Doctorate	Doctorate
5	DEA	Master
4	Maitrise	Master
3	Licence	Licence
2	DEUG	Licence
1	DEUG	Licence

TABLE 6
THE OLD AND NEW FRENCH SYSTEM

THE NEXT STEPS IN THE TWO-CYCLE STRUCTURE

The implementation of the 2-cycle structure in many Institutions in various countries in Europe has shown that in parallel with the advantages offered by this reform, there is a risk of creating new problems. The new structure could hide the differences that exist in various institutions regarding the level and quality of their programs [4]. This is a serious problem, which could create confusion instead of clarity in the EHEA and consequently certain measures should be taken. The proposed measures are mainly the elaboration of qualification frameworks [5]. The qualification framework should be related to the workload, the level of studies, the quality and the learning outcomes. As regards the curricular design, the great degree of freedom that exists today in HEI should be kept. These frameworks could be designed at National and European level and both should be elaborated in a way to assist HEI in their curricular development.

CONCLUSION

Until very recently most of the HEI in Europe had different study and degree structures. This, among other problems, was creating great obstacles regarding the transferability of students, the mobility of academic staff and the employability of the graduates in other countries. The EU in its effort to overcome these problems has recommended to its member countries, among other things, to adopt a European system of degrees based on 2 or 3 cycle studies. The proposed degrees are Bachelor, Master and Doctorate. The introduction of this system is a step forward and a great effort has been undertaken by all European countries to adapt their legislation to the new structure of degrees. The only important problem that appears in this system is that there will be Bachelors of 3 to 4 years of studies and Masters of 1 to 2 years. So someone who graduates a 3-years Bachelor will not be able to continue directly further studies to another university offering 1-year Master. He will need to do additional courses for the equivalent of 60 ECTS.
As regards the design of Doctoral studies, the modification of the traditional system to a system with a more structured program will be very positive for the young researchers. Now with the new revolution of technology and the globalization of the economy there is a need for joint research programs, seminars, workshops and more. Just tutoring and supervising seems not to be satisfactory anymore.

All European countries have adopted this policy, proposed by the BP, and the majority of them adopted the appropriate legislative changes. In the rest of the countries theses legislative changes are at the stage to be introduced and they will be implemented in the coming years. The majority also of EHEI is ready to adopt the new degree structure in most of the countries. The success of the whole effort depends not only on the governmental and institutional administrative work required, but also on the quality of the curricular development of the programs of studies of the new structure. An important issue, which should be the subject of further discussions, is the degree of participation of the employers and professional bodies in the design of the curricular. A great number of students and academic staff have their reservations on putting too much emphasis on employability at the expense of the academic benefits. An important problem regarding the professional recognition of engineers arises also from the introduction of 3-years degrees in engineering institutions. This problem is encountered in many European countries and should be the subject of further discussions between the HE policy makers and the professional associations and employers.
The next step required for the success of this reform is the design of qualification frameworks for the design of their programs. These frameworks should be designed in a way to create descriptors for comparison of the level and quality of the programs of the various HEI institutions.

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EFFECTS OF TREATED WASTEWATER AND SLUDGE IN AGRICULTURE: ENVIRONMENTAL AND GROWTH EVALUATION OF SELECTED CULTURES

1. Kathijotes N. Higher Technical Institute, Nicosia - Cyprus
2. Marinova S. N. Poushkarov Institute, Sofia - Bulgaria
3. Petrov K. University of Architecture, Civil Engineering and Geodesy, Sofia - Bulgaria

ABSTRACT:

Drought conditions usually occurring in southern Europe require a careful use of water resources as well as the thorough investigation of using treated domestic wastewater. The effluent produced after treatment of wastewater together with the sludge produced is considered as important resource.
Ecological and health risks however may result after using the above resource in connection to soil, plant or groundwater. The positive effects connected to plant growth should not be underestimated. This paper investigates benefits and risks as to the use of treated domestic effluent and sludge on yield of crop and presents an engineering overview.

Keywords: wastewater, sludge, crop-yield, fertilization

INTRODUCTION:

In the last few years many wastewater treatment stations were constructed and operated in the Republic of Bulgaria. At present there are 62 stations in operation throughout the country. These stations produce large amounts of good quality wastewater sludge, which if not used accumulates in areas around these stations creating storage and acute environmental problems in the vicinity of these stations.
In view of the water deficit of recent years, treated wastewaters are considered as a valuable water resource and various studies confirm their valuable role in agriculture when used for crop irrigation [1,2,3,4].
A lot of experiments were also carried investigating the effects of wastewater sludge when used in agriculture as a soil conditioner, due to its high levels of biomass with high content of macro and micro elements [5, 6, 8].
It is however necessary to assure that that the concentration of heavy metals and infectious microorganisms will remain at acceptable levels thus not creating adverse effects on soils , groundwater, plants and people [7].
We are investigating here then the effects of combined use of treated wastewater and the sludge produced on crop in terms of grow pattern and consequently crop-yield.

MATERIALS AND METHODS:

For further investigation then, treated wastewater from the Sofia area stations was in an experiment carried in the experimental farm in Kubratovo, on vegetables, lettuce cabbage and potatoes. The experimental farm was composed of 60m3 plots in three repetitions. There were three plot variants namely plots with no fertilizer, plots with mineral fertilizer (N18, P16, K16), and plots with sludge in proportion of 4 tons per dekar. The sludge and mineral fertilizers were placed and mixed with the soil since previous autumn. During the growth period normal soil-water proportions were kept, and irrigation frequency as well as irrigation quantities depended on climatic conditions in the area. Special emphasis was given to maintaining proper water proportions around root zone at all times.
As a matter of comparison all above were irrigated with two water variants, namely treated wastewater and clean groundwater obtained from the farm area.
The soils are alluvium meadow soils light sandy clay, middle to low humus with no carbonates. Soils had low content of total nitrogen, but were good in total phosphorous. The pH varied from low alkaline to low acidic. The chemical characteristics of soil, sludge and treated wastewater used are shown in table 1.
After the harvest of crop, crop-yield, and crop chemical analyses for macro and micro elements were carried.

RESULTS AND DISCUSSION:

Crop-yield of potatoes is shown in table 2.It is clear that the higher yield resulted from variant irrigated with treated wastewater and sludge used as fertilizer. When comparing variants fertilized with mineral fertilizer to variants enriched with sludge, one can notice that mineral fertilizer variant show higher values of yield. This is due to faster absorption of mineral fertilizers in comparison to organic nutrients contained in sludge, whose nutrients accumulate in the plant at a slower rate.
Comparison of the results for the both options – irrigation with farm water and wastewater on potatoes, cabbage and lettuce are given on figures 1, 2 and 3.

Parameters	Treated Wastewater	Soil	Sludge
1. Abs. dry matter %	-	-	66,32
2. Ashes abs. dry matter %	-	-	40,05
3. Ammon. N %	0,008	-	0,02
4. Total N%	0,08	0,2	0,59
5. Total P2O5 %	0,003	0,22	0,79
6. Total K20 %	0,008	0,49	0,24
7. Na%	-	0,08	0,06
8. Mg %	-	0,66	0,1
9. Zn mg/kg dry matter	0,19	110	879
10. Cu mg/kg dry matter	0,05	76	181
11. Mn mg/kg dry matter	0,08	833	310
12. Fe mg/kg dry matter	-	-	35050
13. Pb mg/kg dry matter	0,02	20	32
14. Ca mg/kg dry matter	0,002	<25	8
15. Ni mg/kg dry matter	0,045	12	51
16. Co mg/kg dry matter	0,005	18	6
17. Humus %	-	2,2	-
18. Clay %	-	41	-
19 pH	7,9	7	11

Table 1: Chemical Characteristics of Soil, Sludge and treated wastewater from Sofia Plant

Plots	Yield kg/dka			Average kg/dka
Plots irrigated with farm water				
	1	2	3	
Control Plot	2634	2795	2813	2747
N18P16K16	5089	4554	5089	4911
Sludge	3330	3330	3348	3396
Plots Irrigated with treated wastewater				
Control Plot	2893	2857	2545	2765
$N_{18}P_{16}K_{16}$	4464	4402	4509	4450
Sludge	3777	3839	4152	3923

Table 2: Crop Yield for Potatoes

Similar results are obtained in plots grown with lettuce and cabbage in tables 3 and 4 respectively.

Table 3: Crop Yield for Cabbage

Plots	Yield kg/dka			Average kg/dka
Plots irrigated with farm water				
	1	2	3	
Control Plot	6027	6929	5571	6176
$N_{18}P_{16}K_{16}$	8929	7357	7938	8075
Sludge	7795	6250	8661	7569
Plots Irrigated with treated wastewater				
Control Plot	9625	7348	7482	8152
$N_{18}P_{16}K_{16}$	9768	10294	11372	10479
Sludge	7411	8366	9786	8521

Table 4: Crop Yield for Lettuce

Plots	Yield kg/dka			Average kg/dka
Plots irrigated with farm water				
	1	2	3	
Control Plot	6027	6929	5571	6176
$N_{18}P_{16}K_{16}$	8929	7357	7938	8075
Sludge	7795	6250	8661	7569
Plots Irrigated with treated wastewater				
Control Plot	9625	7348	7482	8152
$N_{18}P_{16}K_{16}$	9768	10294	11372	10479
Sludge	7411	8366	9786	8521

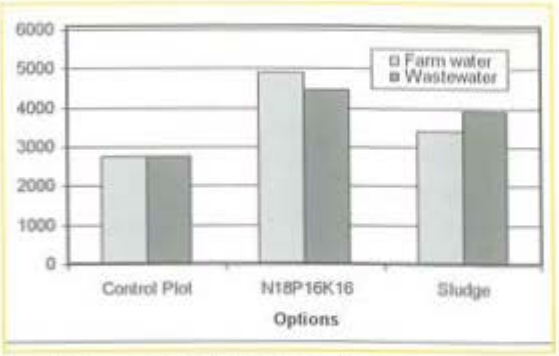

Figure 1: Average Crop Yield for Potatoes kg/dka

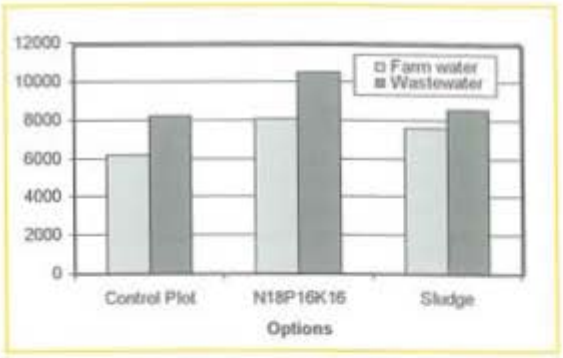

Figure 2: Average Crop Yield for Cabbage kg/dka

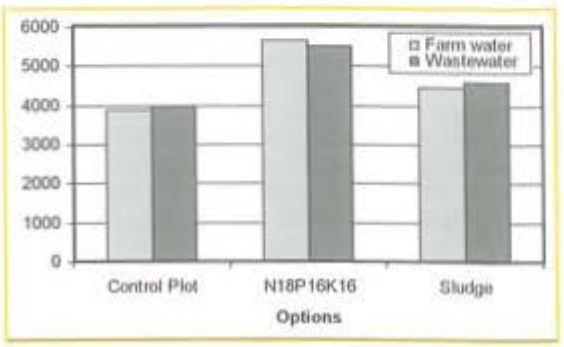

Figure 3: Average Crop Yield for Lettuce kg/dka

CONCLUSIONS AND EPILOGUE:

From the above investigations it is concluded that:

1. Crop yield of cultures fertilized with organic sludge is slower in comparison to those fertilized with mineral fertilizers.

2. There was a higher crop yield on all cultures irrigated with treated wastewater and fertilized with sludge.

Even though initial observations show crop of acceptable quality, a further investigation in regards to its chemical characteristics is suggested in order to reach to a spherical view.
The above results are based on a one year basis. In order to obtain long term results a further investigation period will be necessary.

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PERFORMING REAL EXPERIMENTS IN SOLAR ENERGY OVER THE INTERNET

I. Michaelides[1], P. Eleftheriou[1], K. Economides[2]
[1]Department of Mechanical Engineering, Higher Technical Institute, P. O. Box 20423, Nicosia 2152, Cyprus, imichaelides@hti.ac.cy, peleftheriou@hti.ac.cy
[2]KAE IT Consultants, kaeconomides@gmail.com

ABSTRACT

This paper is concerned with the subject of remote experimentation via the internet. It presents the features of the solar energy e-learning laboratory of the Higher Technical Institute (HTI), which is an example of a web-based laboratory in the field of solar energy.

The HTI solar energy e-learning laboratory comprises a remotely accessible pilot solar energy conversion plant employing the state of the art in software design. Its e-learning platform comprises a number of pre-lab exercises and quizzes which aim at familiarising the student with the e-lab and prepare them for performing the on-line real experiments. There are downloadable instructions for the remote access to the lab and its experiments.

1. INTRODUCTION

Remote engineering is becoming an important element in engineering education; accordingly there is growing need for new learning media and tools. Performing of real experiments remotely was rather difficult in the past; today, with the developments in data acquisition and transfer techniques and the advances in Internet technologies, remote experimentation is not only feasible and realistic but a useful tool in remote engineering.

The HTI solar energy e-learning laboratory, developed within the MARVEL project [1] of the Leonardo da Vinci Programme, is a complete web-based laboratory and is an example of remote experimentation in the field of solar energy over the internet. It comprises a pilot solar energy conversion plant which is equipped with all necessary instrumentation and control devices needed for remote access, control, data collection, and processing. A major goal of this laboratory is to facilitate remotely located students to gain "hands-on" experience and conduct physical experiments in the field of solar energy via the internet.

This paper presents the laboratory setup, it focuses on the system architecture, its features and its functions, and elaborates on the learning scenarios that can be accomplished.

2. LABORATORY SETUP

The HTI solar energy e-learning laboratory comprises a pilot solar energy conversion plant which consists of two flat plate solar collectors having a surface area of 3 m^2 located on the flat roof of the central HTI building, an insulated thermal storage tank located in the solar energy laboratory and other auxiliary equipment and accessories. It is also equipped with all necessary instrumentation, control and communication devices which are needed for remote access, control, and data collection and processing. The schematic diagram of the system is illustrated in figure 1.

The installed hard- and software includes features for controlling external devices, responding to events, processing data, creating report files, and exchanging information with other applications. All relevant weather data as well as operational and output data of the system are registered during an experimental session and are temporarily stored on the controlling PC and are available for downloading for subsequent calculations and/or documentation.

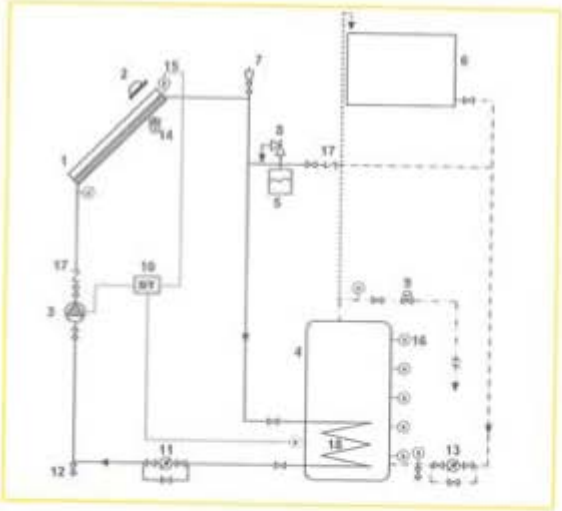

Figure 1: Schematic diagram of the Pilot Solar Energy System, HTI. 1 Solar collector, 2 pyranometer, 3 pump, 4 storage tank, 5 expansion tank, 6 cold water tank, 7 air vent, 8 pressure relief valve, 8, 9 motorised valve, 10 temperature differential controller, 11, 13 flow meters, 12 drain valve, 14-16 temperature sensors, 17 check valve, 18 heat exchanger.

The aim is to use the Internet as a tool to make the laboratory facilities accessible to engineering students, technicians, and other interested parties located outside the HTI premises, including overseas. In this way, the solar energy e-learning lab and its equipment and experimental facility will be available and be shared by many people, thus reducing facility, running, and maintenance costs.

Furthermore, the field of solar energy chosen for this purpose will offer a unique opportunity to students from countries of poor or limited sunshine to have access to real condition experiments with abundant of solar radiation. The system will enable real-time, remote control, data acquisition, and evaluation. It will allow remotely located students to conduct experimental work in an interactive and independent way.

Students from all over the world may obtain online access to the system. A booking tool, shown in figure 2, regulates the access time for the equipment making sure that only one user at a time will have access to the controlling functions of the system. A number of laboratory experiments and learning tasks have already been developed

Figure 2: The solar e-lab booking system which allows for time slot reservations

including familiarisation exercises as well as system performance investigations and e-maintenance tasks [2, 3]. All exercises and learning tasks are supported by web-based learning materials in the form of 'virtual books' [4].

3. INTERFACE AND LEARNING PLATFORM

The architecture of the system is a layered or tiered architecture. It consists of four different layers with each layer providing its services to the next lever by using the services of the layer below it. In the next sections a description for each of the consisting components is given. Figure 3 outlines the different layers with a short description of the responsibilities for each one. For the implementation of this architecture two different computers were used. Figure 4 illustrates this architecture in a graphical way with the four layers separated by dotted lines.

A user may visit the laboratory website anytime from anyplace in the world. The only requirements are a computer connected to the internet and any of the standard web browsers. By typing the address of the HTI Solar Energy e-learning laboratory (http://e-lab.hti.ac.cy), the user can visit the front page of the website. It is possible for visitors with interest in solar energy to read/study on the subject with no requirements or registration or testing. Most of the pages do not require login. As a matter of fact, one may visit most of the pages of the site without the need of creating an account. Login, and thus creating an account, is only needed when the user decides to take the so called pre-lab test. The available activities in the web site are presented in Figure 5.

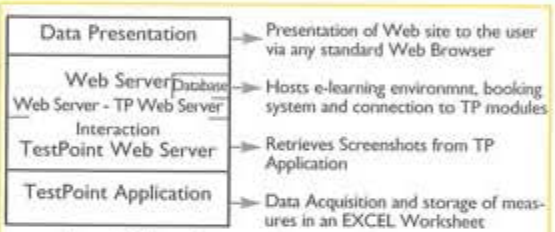

Figure 3. The software architecture of the solar e-lab

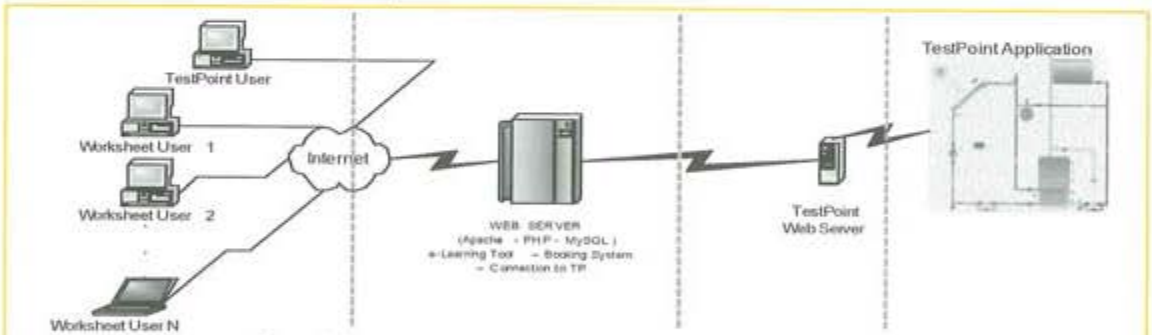

Figure 4. Schematic representation of the system distinguishing the four layers

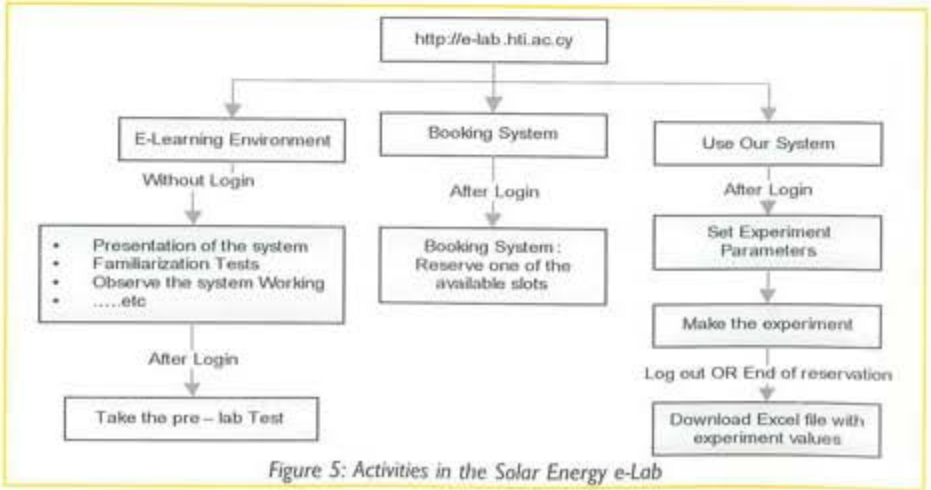

Figure 5: Activities in the Solar Energy e-Lab

The initial idea was to use the very popular LAMP (Linux – Apache – MySQL – PHP) platform for the implementation of the system. This idea was strengthened by the fact that moodle, the e-learning environment used, was written in PHP using MySQL as the supporting database. So the team decided to use this platform with the difference of using MS Windows XP rather than Linux. Apache is considered to be one of the best web servers and the fact that PHP and MySQL are now precompiled in the kernel of this server, made its use imperative. On the Web server all the needed files for Moodle were installed, i.e. the booking and the module used to connect to the system. The MySQL database is also installed on the same machine with all the needed tables to support the installed modules.

The interaction of the web server with the TP web server requires actions from both ends. Once the user logs on to the system, he/she has to set the parameters of the experiment. These parameters are written to a text file and the text file is copied to the machine where the application software (TestPoint [5]) is installed.

TestPoint's Web Server is a part of the Internet Toolkit, an add-on module to commercially available by Keithley [5]. Its job is to supply screenshots of a part or the whole of a defined TestPoint application while running. In web server's settings one may define the working port that is going to be used by the client when requesting these screenshots. No further configuration is needed from the laboratory since its task is very simple and straightforward.

Once the application is started an initialization file is required which allows for the beginning of the measurements,. When the system detects this file, it reads the configuration parameters, it takes all the actions requested (e.g. refreshing water) and it starts logging the values from the various installed instruments. Every 30 seconds these values are also written into an excel file. When the user wishes to logout (or when the reservation slot reaches its end) the configuration file is deleted and the system stops working. The excel file is then copied to the web server, and at the logout screen, and the user is given the option of downloading the file with the stored data as illustrated in figure 6. If the user closes the browser window without logging off first and to avoid having the system running continuously a batch job on the computer running the TestPoint was added as a safety measure. This batch job takes all needed actions ensuring that the system is properly stopped and initializes the various parameters for the next user.

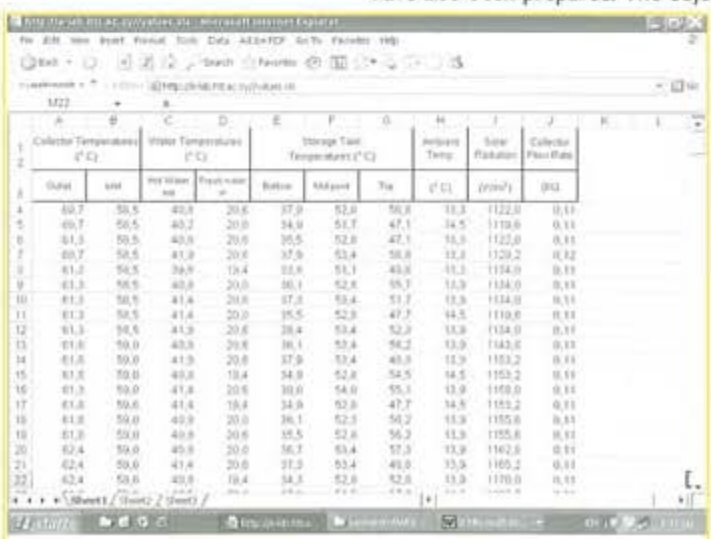

Figure 6. The downloadable EXCEL file with previously recorded data

The selected e-learning platform at the web server is Moodle, which is a course management system provided freely as Open Source software (under the GNU Public Licence). Moodle runs on any computer that can run PHP, and can support many types of databases, particularly MySQL [6]. This choice allows for flexibility in the learning tools and provides various learning environments to suit the requirements of the various courses [7]. In this particular case Moodle is used as a demonstration, a quiz, and an experimental tool. The Moodle capabilities were enhanced so that the running of the actual experimental set-up is only allowed after the successful completion of the preliminary exercises. With this platform, the user can work independently or work as a team with people from the same class or even from a different school far away talking to each other on the special tool provided by the platform.

4. LEARNING SCENARIOS

The learning scenario comprises by a series of exercises of different degree of difficulty and complexity. For each exercise, the user undergoes an online assessment and is allowed to proceed to a real experiment only if he/she is successful to the pre-lab test. It also includes an indexed glossary with a good number of terms and definitions related to the solar energy laboratory. The main exercises are described below:

4.1 FAMILIARISATION WITH THE PILOT SOLAR ENERGY SYSTEM

Two introductory exercises were prepared for the prospective user. Their objective is to familiarize the user with the HTI solar energy e-learning lab and make him/her conversant with the components of the pilot solar energy conversion plant. Upon completion of these exercises the user should be able to name each component in the plant and identify the various components needed to construct a solar plant.

4.2 COMPONENT FUNCTIONS

Two more advanced exercises for the interested user have also been prepared. The objective of these exercises is to familiarize the user with the function of each component and illustrate the system operation. At the end of these exercises the user should understand the function and operation of each piece of equipment in the system and appreciate its role in the system as well as introduce him into the hydraulics and flow circuits of the plant.

4.3 LIVE ONLINE EXPERIMENT, DATA COLLECTION, STORAGE TANK STRATIFICATION, INVESTIGATION OF COLLECTOR INSTANTANEOUS EFFICIENCY

This will take the user into the real world of experimentation. The user will get acquaint with the remote control of the system (getting into the system through the internet, switching ON and OFF the system) and exercise in taking the readings of the various measuring devices, such as temperatures, flow rates, and solar radiation. The user will take sets of readings for various conditions and different scenarios. One of the scenarios will be to elaborate on the stratification of temperatures in the vertical type storage tank and get a first-hand experience of the variation of temperatures across the tank at different operational conditions, explain the stratification effect, and comment on the results.

Another experiment could be to investigate the instantaneous efficiency of the collector or determine the rate of thermal energy removed from the storage tank to the consumption. For this purpose, the user will have to process the recorded readings (incident solar radiation, water flow rates, temperatures, etc.) and using certain thermodynamic equations [8] he/she will determine the performance characteristics of the collector and compare them with those given by the manufacturer of the collectors.

The test may be conducted at various conditions and with different scenarios such as for example: with or without consumption of service hot water, at different temperature differentials, etc. Should the user have more time available, he/she could use the data recorded in the Excel file downloaded at the logout or any time during the experiment, to plot a graph for the collector efficiency. A screenshot of the system diagram labelled with the real readings is shown in figure 7. The image is refreshing in 5 minute intervals allowing the students adequate time to observe all the readings and encourage a discussion on the displayed results.

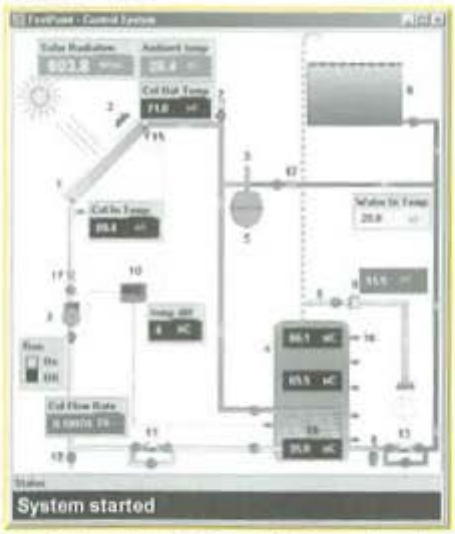

Figure 7. Live online experiment – System real readings

4.4 "PASSIVE" PARTICIPATION TO THE EXPERIMENT - WATCH SYSTEM WORKING (NO INTERACTION)

In case the system is occupied by another user, an interested individual may get into the e-lab as an observer, without any booking and without needing to pass the pre-lab test. The system will open a new window and he/she will be able to have a view of the system in operation and get the readings, but he/she will not be allowed to intervene into the operation or to control the system. He/she can, however, record the readings and use them for calculations if he/she wishes so. There is no limitation to the number of "passive" participants who can log on the system.

5 CONCLUSION

The HTI e-learning lab goes beyond traditional remote labs: it is providing distributed work places for complex remote learning/ work tasks.

An important innovation within this approach is that concepts and examples for real working and learning are developed and accessed on line. Accordingly the system goes beyond 'traditional' online laboratories, because it provides distributed work places for remote engineering in technical and vocational training.

6 ACKNOWLEDGEMENTS

This paper was prepared after the completion of the MARVEL project, which received support from the European Leonardo da Vinci Programme. The authors would like to thank their colleagues at HTI and ARTEC for their support, as well as the MARVEL project partners for their interesting and fruitful discussions. For further information on MARVEL one could visit the MARVEL web site at http://www.marvel.uni-bremen.de.

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ARGUING A CASE FOR ENGLISH

Anastasia Mouskou-Peck
Lecturer of English and Report Writing
General Studies Department

This article aims to raise a few questions concerning the decision of the Government of Cyprus to adopt the Greek language as a means of instruction for the new impending Technological University instead of the English language, which has successfully been used at the Higher Technical Institute since its establishment in 1968.

This article rests on the argument that in deciding to either abolish or adopt a particular language in a particular educational context, the deciding committees should weigh up an array of factors and be willing to examine the whole issue in depth and broadly, rather than politically, and nationalistically.

Understandably, no nation would wish to give special status to a language other than its own, except of course if this would be beneficial for the country itself – which I believe would be the case in Cyprus concerning the new University - as I will indicate shortly.

Let me at this point, draw on the various reasons given by Crystal (2001:106), in order to develop a defence of English, and relate these reasons to the Cyprus reality.
Initially there are historical reasons, emerging from the expansion of British colonialism and the establishment of America as a major source of power. This has led to the creation of numerous institutions which unavoidably will carry out their proceedings in English. These institutions include whole governmental mechanisms i.e. parliament, government agencies, the civil service, the law courts, the national religious bodies, the schools and higher educational institutions along with all the related publications (textbooks, record-keeping) and so on. Almost certainly the majority of the science textbooks which will be available in a potential Technological University, will be in English.

"The volume of literature written in English today is enormous and comparable with the best written in any one language or regional groups of languages." (Dhamija[1] in Hayhoe & Parker (eds.,) 1994:63)

A second spectrum of reasons is internal political reasons. Irrespective of whether a country has imperial antecedents or not - and Cyprus most definitely has, having been a British colony from 1878 to 1960 - English can provide a means of communication between different ethnic groups. The political situation in Cyprus has brought two large ethnic communities together ; the Turkish Cypriots and Greek Cypriots, as well as other minorities seeking employment on the island : Philipinos, Pakistanis, Sri Lankans, Indians, Bulgarians and so on. A common language code is a necessity and although the government might not willingly admit it, realistically it actually does exist i.e. English acts as a linking, intermediary language, providing a unifying nationhood. Additionally there is the extensive use of English on television, in the press, on the radio etc.

Thirdly, because of the USA's powerful economic status many international / multi-national businesses wishing to expand their trade further, are inevitably obliged to communicate in English. Cyprus is certainly a living example of this since many offshore companies have chosen the island as a base for their activities.

Additionally the tourist and advertising industries are heavily dependent on the English language. This is a situation that Cyprus is very much aware of, since a large proportion of the national economy depends on tourism. The hotel market especially owes its livelihood to that. According to statistics, more than 2.4 million tourists visited Cyprus in 2002, an incredible number of visitors when you consider that the recorded population of Cyprus in 2001 amounted to 703.529 people (2004: Statistical Service, Republic of Cyprus). More recently also, and with the accession of Cyprus to the European Union in May 2003, the property market is rapidly expanding, with foreigners purchasing property on the island at a fast-accelerating pace. All these major activities require a common ground for communication, and what other better way than a commonly used language? Whether intentionally or unavoidably, English was the one chosen and is now well established.

A further reason is for practicality. English has long been the language for international air traffic control, and is presently expanding further in international shipping, policing and emergency services. There are now restricted varieties of English internationally recognized, such as Air-Speak, used by air traffic control authorities, its maritime equivalent Sea-Speak and the emergence also of a Euro-language following the operation of the Channel Tunnel in the 1990s, which created the need for Police-Speak and Emergency-Speak. Furthermore the development of electronic systems of communication prompted the creation of another restricted variety of language, EDIFACT.[2] Most likely this trend will intensify in the near future, and this is a reality that cannot be denied by anyone. Therefore, the language that opens up the way for all these opportunities and potentials should be greatly sought and strived for, and this language, whether one likes it or not, is English.

Another set of arguments in defence of English – according to Crystal (2001) - relates to intellectual reasons i.e.

1. P.V. Dhamija carried out a survey, concerning publications, between the years 1980 to 1999, focusing on five major languages: English, French, German, Russian and Spanish. The figures are : English: 21,257, French:13,358, German:12,459, Russian:14,110, Spanish:9,599.Furthermore, if a publication is noteworthy it will most certainly be translated in English, (Dhamija) in Hayhoe & Parker (eds.,) 1994:63).

2. EDIFACT = The International standard for the electronic exchange of goods trading information (Crystal (2001) : 390).

most of the scientific, technological and academic knowledge worldwide is available in English and additionally over 80 per cent of information stored electronically is made available in English. This certainly is a very wide area and needs to be discussed on its own merit, in a possible future article. Similarly one can gain access to Western European culture, religion or literature by either using directly the medium of English, or through an English translation. English has taken over from Latin, which performed the same role over a thousand years ago.

An additional group of reasons is for entertainment purposes. English is the language of popular music, video games, home computers, satellite broadcasting – and in all fairness to the discussion – for some illegal international activities such as drugs and pornography.

Finally – and in order to present a more rounded and impartial argument – Crystal mentions some undesirable reasons for the widespread adoption of English. It is often argued that English has obtained its worldwide status because of its intrinsic linguistic features. It is claimed that English is a simple and easy language to learn, easier to pronounce, possessing uncomplicated grammatical structures with richer vocabulary and generally "more beautiful". It seems though that this reasoning is not validated linguistically. On the contrary, it reveals linguistic naivety and a certain chauvinism.

"Languages rise and fall in world esteem for many kinds of reasons- political, economic, social, religious, literary - but linguistic reasons do not rank highly among them". (Crystal 2001: 106).

All these reasons outlined by Crystal (2001:106 & 390), scratch only the surface of what is at issue here. They do nevertheless bring out two main areas of concern – internationalism and identity. These two areas, however, immediately raise some problems because of their conflictive nature. If a nation wishes to be part of this international dynamism then it has to position itself within this global world ; but at the same time it needs to find a way to balance its needs in relation to that situation, while considering its people's psychology and its identity as a nation.
This is a fine distinction to make indeed, and it is this distinction that I feel the government of Cyprus has failed to observe accurately in its decision concerning the new University. It has failed to apply this fine tuning between these two parameters. Providing the citizens of a country with the potential of universality does not need to diminish their own identity and culture. On the contrary, it can enhance them as human beings.

"Internationalism implies intelligibility. If the reason for any nation wishing to promote English is to give it access to what the broader English-speaking world has to offer, then it is crucial for its people to be able to understand the English of that world, and to be understood in their turn. In short, internationalism demands an agreed standard". (Crystal 2001:110)

On the other side of the argument, preserving one's national identity is a worthy cause, but there are many ways of doing so, other than linguistic exclusion, which can only lead to isolation.

"Identity implies individuality. If a nation wishes to preserve its uniqueness or to establish its presence, and to avoid being an anonymous ingredient in a cultural melting-pot, then it must search for ways of expressing its difference from the rest of the world. Flags, uniforms and other such symbols will have their place". (Crystal 2001:110)

Certainly in the case of Cyprus, continuing to use the English language as a means of instruction will not downgrade or devalue the Greek language or in any way alter the identity of its people. Greek will remain the national language for the majority of the population in Cyprus as it has over the centuries. The array of foreign conquerors throughout the island's long history has not been able to change the Hellenistic character of the island and neither will the use of English in the new University. The citizens of the island will continue to use, protect and value Greek as their national language through their cultural heritage, religion, literature and other forms of expression, but at the same time they will have enhanced themselves with an additional language capable of creating new opportunities for them.

Rounding off the web of reasons we cannot but realize that English is in every aspect of society: technology, education, media, travelling, career, entertainment, and in so many other areas. But underlying all these, there is the relationship between "language and society", and more specifically "language and power". Language gives power to society - and in extension - to the individual citizen because it assists the achievement of various social and personal purposes: enquiry, persuasion, information, entertainment, instruction, communication and so on.
As citizens of any nation we need to view a language critically, not only for what it is but for the power it could offer us.

"Critical language awareness is a matter of being able to recognize forces that shape the ways we think by the language they use. The issues of identity, power and language have become very big issues indeed". (Butler & Keith 1999: 117).

Most certainly the English language is a force that has shaped our way of thinking and our life itself; and governments worldwide seem unable to put a stop to it, or if they try to do so, as in the case of the new impending University in Cyprus this will be – in my opinion - a false and miscalculated decision.

"The global web of corporate power has released forces beyond national government's control...What are the forces acting to de- stabilize government? One main source is a bubbling diversity of change taking place below the level of the nation state, which is not led by governments, though they must respond to it". (Butler & Keith1999:117).

Any government, and the Cyprus government should be no exception, must realize that we are living in an era of global change and if we need to be part of this global world we must try to integrate, rather than alienate ourselves from it.

"The state is withering and global business is taking charge. Globalisation, we should remember, is about relationships between the small and the large, in which each influences the other". (Butler & Keith 1999:118).

Certainly Cyprus is a small country with big aspirations. Being part of a large globalised community will make us not smaller, but bigger because we will be given the chance to promote our country, our reservations and problems, our accomplishments and achievements; and having a globalised language at hand, will provide a great asset, a powerful tool, and if there are means of acquiring such a tool, then this is an opportunity which no-one can afford to miss.

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QUALITY OF SERVICE IN UMTS NETWORKS

S. Voskarides
Higher Technical, Electrical Engineering Department
Brunel University, School of Engineering & Design

ABSTRACT

Quality of Service (QoS) is the collective effect of service performance that determine the degree of satisfaction for the end user. The Third Generation (3G) of mobile systems (Universal Mobile Telecommunication System (UMTS) in Europe) will provide different services to end users, from simple voice telephony to complex data applications including video streaming, video conferencing, web browsing, email, file transfer, etc. [1]. The end-to-end QoS UMTS requirement implies that QoS management is needed in all involved domains as well as the internetworking between these domains.

QUALITY OF SERVICE NEED IN UMTS NETWORKS

QoS is the mechanism insuring that a service can be delivered to the end user in an acceptable time frame and that the service properties are stable over time within predefined boundaries. More specifically, [4] defines QoS as the total outcome of the service performance, measured in terms of speed, accuracy and reliability (specifically-accessibility, retainability & integrity). QoS allows a network to treat different types of traffic differently by means of (i) traffic shaping, (ii) congestion management and (iii) admission control. As the Internet technologies evolve, the demand by users for more sophisticated and QoS demanding multimedia services is increased [2]. The end-to-end QoS UMTS requirement implies that QoS management is needed in all involved domains: wireless domain (UTRAN), core (packet & circuit), and external networks (PLMN, PSTN/ISDN, Internet). Additionally the internetworking between domains should be assured like depicted in figure 1 below [3]:

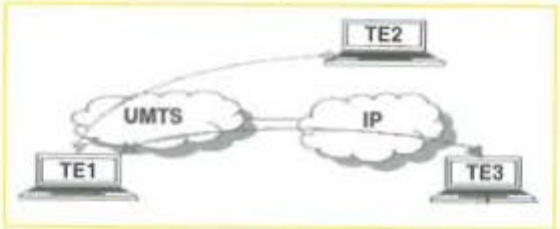

Fig. 1: End–to–end connectivity possibilities (TE=Terminal Equipment).

When examining QoS implementation, factors such as radio characteristics, traffic patterns, resource allocation, latency, and differentiation methods have to be considered. QoS includes four key elements: (i) Resource allocation (absence of resources would produce packet loss or delay or congestion), (ii) Performance optimization (monitoring predefined key performance indicators and tuning all domains of UMTS), (iii) Integrated Services (provision of facility for reservation of sufficient bandwidth) and Differentiated Services (traffic categorisation into classes for quick identification and prioritization).

UMTS TRAFFIC CLASS AND OTHER QoS ATTRIBUTES

The types of service of 3G mobiles can be divided into two main classes: Real Time services (e.g., voice, video conferencing, etc.), and Non Real Time services (e.g., database applications, web browsing, email, etc.) In this context, the 3rd Generation Partnership Project (3GPP) defined four distinct traffic classes of service, for UMTS: (i) Real Time classes (Conversational and Streaming) and (ii) Non Real Time classes (Interactive and Background). Table 1 describes these classes along with their characteristics [1], [4].

In addition to the traffic classes, other QoS attributes have been defined in order to enable more enhanced service differentiation for the UMTS bearers. The traffic class attribute has, however, a specific role because it specifies the other QoS attributes, which are allowed to be used in the corresponding QoS profile (see Table 2).

UMTS END-TO-END QoS FUNCTIONAL DECOMPOSITION

In UMTS terms, the 3rd Generation Partnership Project (3GPP), presented in [4], a functional decomposition of the end-to-end concept in a QoS architecture. In fact, QoS is viewed as a series of "chained" services operating at different levels of a mobile environment (see fig.2).

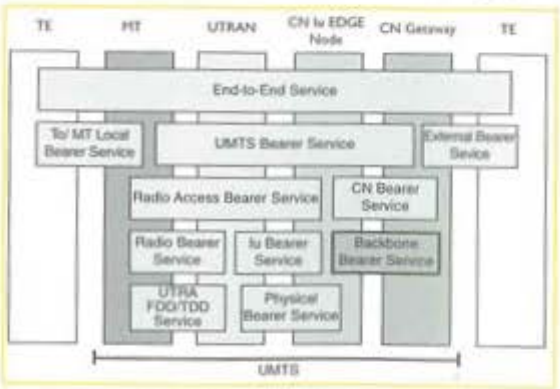

Figure 2 : UMTS QoS Architecture and Levels

Differrentiated Services vs Integrated Services

Differentiated Services (DiffServ) is an IP-based QoS technology, which attempts to solve the QoS problems without making any resource reservation for flow establishment and maintenance. The control is based on DiffServ Code Point (DSCP), which is contained in the IP header. The DiffServ aware routers perform traffic differentiation according to the DSCPs of the received packets. DiffServ routers are not required to keep any state information about the traffic flows. Different flows with the same DSCP value are treated in the same way. The main advantage of the DiffServ architecture is its simplicity. On

the other hand, as all the flows with the same DSCP value are seen as a single flow with a unique per-hop behavior (PHB) DiffServ provides just relative QoS, in the sense that the QoS for one flow depends on the behaviour of other flows [3], [5], [8].
Integrated Services (IntServ) architecture, on the other hand, conveys the application requirements to the network elements, which have to contain QoS mechanisms to insure the promised QoS level. For resource reservation a signaling protocol is used, usually Resource Reservation Protocol (RSVP), which transports the QoS requirements along the path from the sender to the receiver in order for the resource reservations to be made. IntServ provides an absolute QoS, admission control and per-flow statistics, but scalability of the mechanism is a problem. IntServ identifies three service categories: (i) Guaranteed Service which assures firm QoS (ii) Controller Load services which provides the equivalent of a best-effort service in a light loaded network and (iii) Datagram Service characterized by the absence of any QoS level (the same best-effort type of service as traditional IP networks provide) [3], [5], [8].

CONCLUSIONS

UMTS will provide to mobile end users a broader range of services. Only 3G can deliver the services demanded by mobile professionals on the move. Instead of providing more bandwidth to 3G networks, QoS can be implemented to ensure reliable delivery of data and availability of network resources. QoS enables network administrators to centrally define policies that will control traffic to keep the network from being overloaded. Because QoS provides differentiated classes of service according to several characteristics, it can forward data selectively, ensuring delivery of mission-critical data. DiffServ attempts to solve the QoS problems without making any resource reservation for flow establishment and maintenance. DiffServ was introduced to provide a simple and practical way of providing QoS because ISPs found it impossible to deliver QoS through Integrated Services to meet the service level agreements (SLAs) they had with their clients. The end-to-end QoS UMTS requirement implies that QoS management is needed in all involved domains for improved service reliability, the optimization of UTRAN being more demanding than core (PS & CS) and external networks (PLMN, PSTN/ISDN, Internet).

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Class No	Traffic Class	Class Description	Example	Relevant QoS Requirements
1	Conversational	- Preserves time relation between entities making up the stream. - Conversational pattern based on human perception. - Real Time.	- Voice over IP - Video conference - Real Time Multimedia	- Low jitter - Low Delay
2	Streaming	- Preserves time relation between entities making up the stream. - Real Time.	- Real Time Video	- Low jitter
3	Interactive	- Bounded Response Time. - Preserves the payload content.	- Web browsing - Database access	- Round Trip delay time - Low BER
4	Background	- Preserves the payload content.	- Email / SMS - File Transfer	- Low BER

Table 1: The Four UMTS Traffic Classes defined by 3GPP [4]

Traffic class	Conversational	Streaming	Interactive	Background
Maximum bit rate	YES	YES	YES	YES
Delivery order	YES	YES	YES	YES
Maximum Service Data Unit size	YES	YES	YES	YES
SDU format information	YES	YES		
SDU error ratio	YES	YES	YES	YES
Residual bit error ratio	YES	YES	YES	YES
Delivery of erroneous SDUs	YES	YES	YES	YES
Transfer delay	YES	YES		
Guaranteed bit rate	YES	YES		
Traffic handling priority			YES	
Allocation/retention	YES	YES	YES	YES
Source statistics descriptor	YES	YES		

Table 2: UMTS bearer attributes for each traffic class [5].

SPECTRAL MODIFICATION OF TYPE IA FIBRE BRAGG GRATINGS BY HIGH POWER NEAR INFRA-RED LASERS

K Kalli,[1] A G Simpson,[2] K Zhou,[2] L Zhang,[2] D Birkin,[2] T Ellingham[2] and I Bennion[2]
[1] Higher Technical Institute, C. Kavafi Street, Nicosia, 2152 Cyprus
[2] Photonics Research Group, Aston University, Birmingham B4 7ET United Kingdom
E-mail: kkalli@hti.ac.cy
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ABSTRACT

We report the first experimental measurements on the spectral modification of Type IA fibre Bragg gratings, incorporated in an optical network, which result from the use of high-power, near infra-red lasers. The fibre grating properties are modified in a controlled manner by exploiting the characteristics of the inherent 1400nm absorption band of the optical fibre, which grows in strength during the Type IA grating inscription. If the fibre network is illuminated with a high power laser, having an emission wavelength coincident with the absorption band, the Type IA centre wavelength and chirp can be modified. Furthermore, partial grating erasure is demonstrated. This has serious implications when using Type IA gratings in an optical network, as their spectrum can be modified using purely optical methods (no external heating source acts on the fibre), and to their long term stability as the grating is shown to decay. Conversely, suitably stabilised gratings can be spectrally tailored, for tuning fibre lasers or edge filter modification in sensing applications, by purely optical means.

Keywords: Optical fibre sensors, fibre Bragg gratings, type IA grating, photosensitivity, wavelength tuning

1. INTRODUCTION

Type IA fibre Bragg gratings may be considered a subtype of Type I gratings and are typically formed after the prolonged UV exposure of a standard grating in hydrogenated germanosilicate fibre [1,2], although recent improvements in their inscription have shown that they can be readily inscribed in a suitably prepared optical fibre [3]. The spectral characteristics of Type IA gratings are unique; they are distinct from other grating types as they exhibit a large increase in the mean core index that is identifiable as a large red shift seen in the Bragg wavelength (λ_B) of the grating during inscription, figure 1. We observe that the mean wavelength change is characterised by three distinct regimes, with the Type I grating growth being superseded by a quasi-linear region followed by saturation. This saturated red shift is dependent on fibre type and hydrogenation conditions, but for a highly doped fibre is typically in the order of 15-20nm, and for SMF-28 is 5-8nm. The maximum wavelength shift translates to an increase in the mean index of up to 2x10-2. More importantly, IA gratings have been shown to exhibit the lowest temperature coefficient of all grating types reported to date, which makes them ideal for use in a temperature compensating, dual grating sensor, as has recently been demonstrated [4].

Figure 2 shows the spectrum of a 4-mm regenerated IA grating and a 1-mm standard Type I grating. These gratings have been written in the same fibre with the same phase mask, yet their central reflecting peaks are 14.5nm apart after annealing. The large increase in mean refractive index increases the fibre NA to such an extent that it becomes few-moded; the NA of the virgin fibre is 0.161, compared to 0.247 for the modified fibre, accounting for the transmission spectrum ghost mode.

There have been earlier studies of UV pre-exposure in hydrogenated optical fibres; see, for example, Kawano et al [5], Chen et al [6], Lancry et al [7], and Canning et al [8]. However, none of these papers detail the effects of high optical powers on UV pre-exposed and hydrogenated optical fibres.

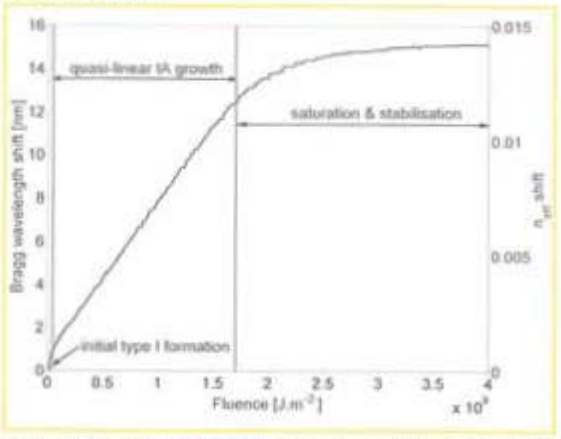

Figure 1. The characteristic red shift displayed during prolonged UV exposure of hydrogenated germanosilicate fibre, shown in terms of the spectral red-shift and associated refractive index change. The three distinct regions of IA growth are shown.

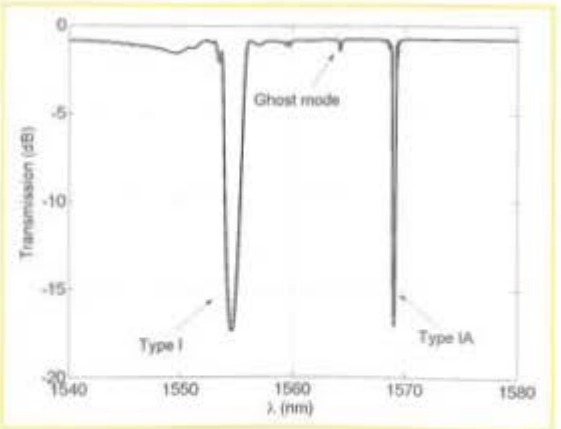

Figure 2. The spectrum of a standard grating (left) and a longer Type IA grating (right) written in the same fibre with the same phase mask.

The 14-nm difference in wavelength is caused by the large increase in mean refractive that accompanies IA grating growth. This also accounts for the ghost mode, as the mean index change is sufficient to cause the fibre to become few-moded.

We have previously shown that there is a strong correlation between the growth of the OH absorption band formation in the optical fibre during prolonged UV exposure and the increase in the mean index change of the fibre grating [3]. Figure 3 confirms the parallel mean index evolution, akin to the maturity level of a Type IA grating, and the associated increase in the absorption band at 1400nm. Both curves follow the three trends of figure 1. This absorption band is a consequence of the formation of OH ions within the fibre and has no dependence on the modulated index change required for a Bragg grating to be formed in the core [9]. It is therefore possible to monitor the transmission loss at 1400nm and glean accurate feedback as to the maturity of the fibre. When the absorption loss saturates, the fibre is fully mature and ready for inscription of any form of IA grating, be it slanted, long period or standard. The peak absorption band loss at ~1400nm is typically ~1.2dB/mm-1 for a B/Ge co-doped fibre. Therefore, if the fibre is pumped with a laser source that coincides with the 1400nm absorption band the fibre will be heated in the region where there is light absorption, e.g. the location of the Type IA grating.

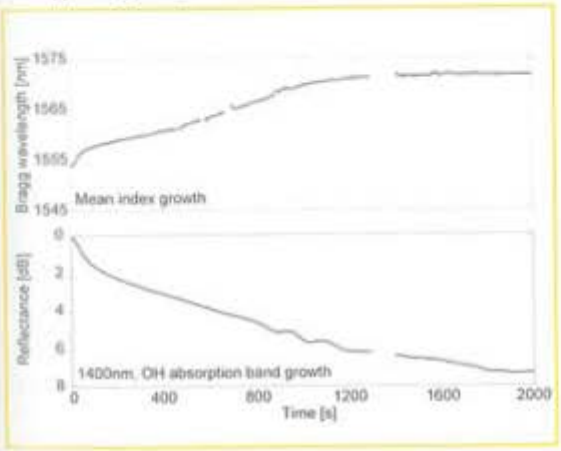

Figure 3. The relationship between the mean index change (or IA maturity) and the 1400nm absorption band under UV exposure. It is this relationship which enables IA index changes to be inscribed without writing a grating since the index change may be monitored by observing the absorption band at 1400nm

2. REVERSIBLE WAVELENGTH TUNING

To test our hypothesis of selective grating spectral modification, we utilised the nework as highlighted in figure 4. A Type IA – Type I dual grating sensor was manufactured, as outlined in reference 4, with the Type I grating used as a reference to subsequent measurements. The IA-I grating consisted of a 2-mm IA grating, manufactured by the blank beam UV pre-exposure method directly adjacent to a 2-mm Type I grating. The network was illuminated with an amplified spontaneous emission broadband source (ASE-BBS) in the spectral region of the gratings and monitored in reflection by the optical spectrum analyser (OSA).

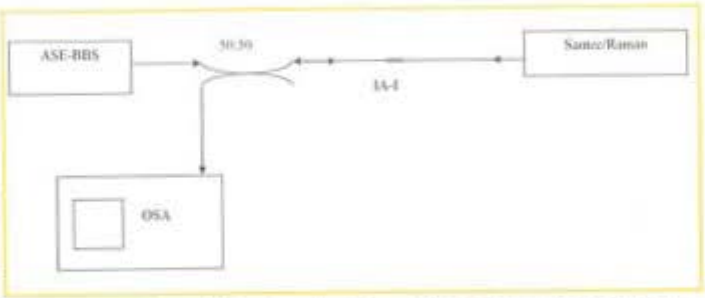

Figure 4. Experimental set-up used for Type IA laser-based modification.

Powerful tuneable lasers were used to coincide with the 1400nm absorption band. Two lasers were chosen for Type IA modification; the first was a 10mW Santec laser with a range of 1410nm to 1490nm, set to coincide with the peak of the absorption band. The second laser was a 5W Raman pump operating at 1425nm, sitting at the edge of the band and coincident with the feature at 1424nm, figure 5.

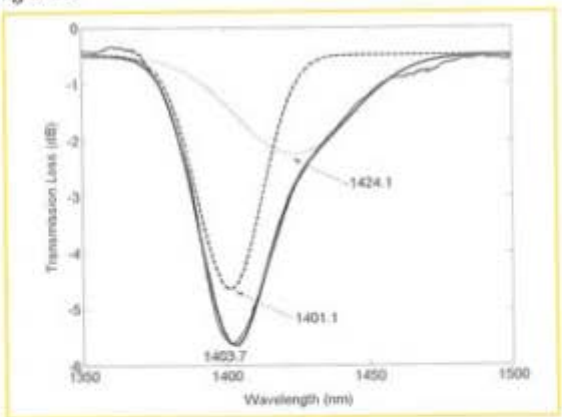

Figure 5. The absorption band at 1400nm deconvolved to show its constituent peaks – a mixture of SiOH (1390nm) & GeOH (1410nm) bands – biased in favour of GeOH under UV exposure conditions.

2.1 TYPE IA WAVELENGTH TUNING – LOW POWER, NEAR ABSORPTION PEAK

Figure 6 shows the shift in λ_B of the Type IA grating with increasing laser power at 1410nm, a wavelength that coincides with the peak of the absorption band, and demonstrates that even for modest optical powers significant wavelength offset can be induced. This could prove to be a deleterious for gratings used as narrow band optical filters in multi-wavelength systems. The demonstrated 100pm wavelength shift would change the grating's spectral response adversely affecting the filter performance, and reducing the isolation between wavelength channels, transmission properties and effective bandwidth. There was no measurable change in the centre wavelength of the adjacent Type I grating, which is expected as the absorption band is located at the position of the Type IA grating alone.

Unfortunately a limiting factor in this data set is the minimum resolvable wavelength change of the OSA, as shown by the pixelated data. In figure 7 the wavelength of the tuneable laser is shifted (1410nm to 1490nm) whilst maintaining a constant output power (10mW) and the

shape of the OH band is used as an edge filter, varying the amount of energy absorbed and hence the tuning of λ_B. The pixelated data again results from the limited OSA resolution.

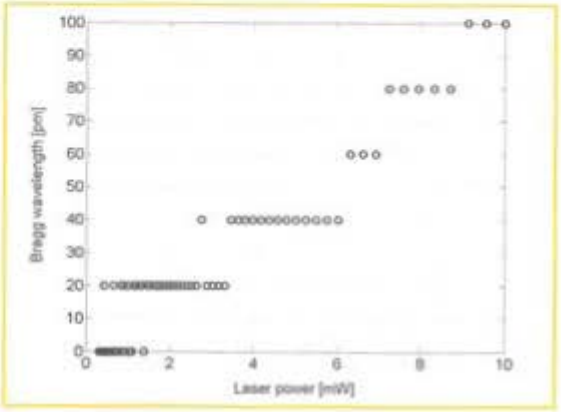

Figure 6. The shift in the Bragg wavelength of a IA grating heated with a 1410nm tuneable laser of varying power levels. This shows that the Bragg wavelength of a Type IA grating may be controlled remotely with strictly optical means. The pixelated data results from the OSA resolution limitation.

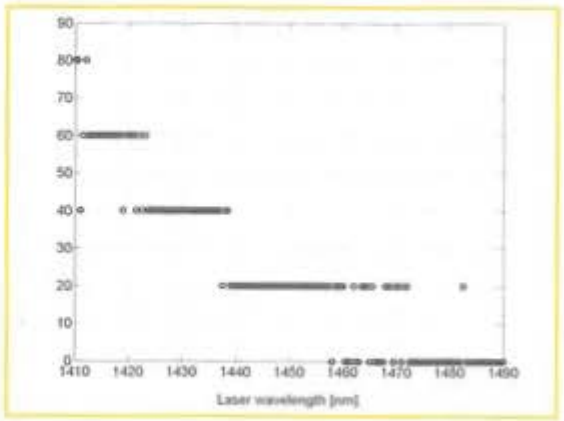

Figure 7. The shift in the Bragg wavelength of the Type IA grating when the tuneable laser was held at a constant power and the wavelength was shifted up the edge of the OH band. This further shows that the Bragg wavelength of a Type IA grating may be controlled remotely with strictly optical means. The pixelated data results from the OSA resolution limitation.

2.2 TYPE IA WAVELENGTH TUNING – HIGH POWER, FAR FROM ABSORPTION PEAK

The experiment was reconfigured so that the high power Raman source, operating at 1425nm and far from the main absorption peak, illuminated the Type IA-I gratings. There was no measurable change in the centre wavelength of the adjacent Type I grating that could be attributed to the pumping with the Raman source, and small shifts were attributed to fluctuations in the ambient temperature over the duration of the experiment. Although the gratings were directly adjacent to one another, the fibre portion that was pre-exposed to UV radiation and contains the higher wavelength IA grating only absorbed the 1425nm radiation; the Type I grating written in virgin fibre with no strong 1400nm absorption band was not heated. The negligible thermal mass of the fibre prevented any significant levels of thermal conduction between the two regions. Thus the application of the Raman laser caused the Type IA grating to spectrally shift whilst the Type I grating maintained a fixed wavelength, again making an optically tuneable grating pair. Table 1 summarises the relative shift of gratings. Figure 8 indicates a linear relationship between Raman power and wavelength shift.

Table 1. Wavelength shifts of the Type I and IA gratings when heated with a Raman source at 1425nm.

Raman Power	$\Delta\lambda_{IA}^{H}$	$\Delta\lambda_{I}$
mW	pm	pm
0	0	-3
25.1	105	0
52.9	245	17
79.22	367	17
103.45	455	-3
124.8	525	17

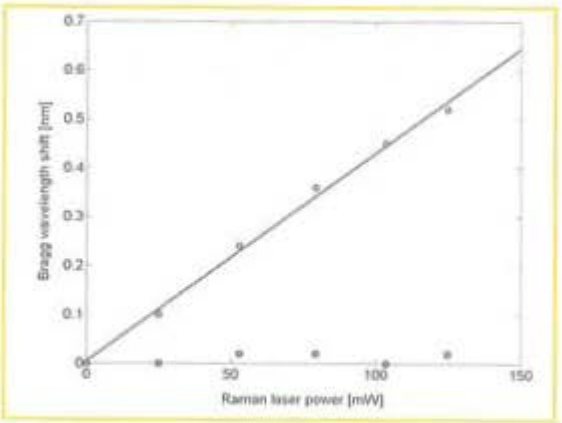

Figure 8. A plot of the wavelength shifts of the Type I and IA gratings when heated with a Raman source at 1425nm. This figure clearly shows a controllable change in the Bragg wavelength of the Type IA grating and a constant Bragg wavelength of the Type I grating.

3. INDUCING CHIRP AND PERMANENT, PARTIAL GRATING DECAY

If we next consider the effect of the Raman source being absorbed along the length of the Type IA grating we note that the heating effect will be non-uniform along the length of the absorbing section of fibre and that the result will be an induced chirp along the grating. Clearly higher Raman powers will induce a larger chirp and we should see an increase in the full width at half maximum (FWHM) reflectance bandwidth. None was noted with the lower power source. The Raman source intensity decay along the Type IA grating length is given by

$$I(p) = I(p\text{-}1).\left(1\text{-}10^{\frac{A}{10}}\right) \propto \Delta T \quad (1)$$

where I(p) is the Raman intensity at a point p, A is the absorption per unit length of the Raman radiation measured in dB and ΔT is the induced temperature increase. Figure 9 (a) shows this relation for the power levels used

to create figure 9 (b) and an estimation of the absorption coefficient of 1.2dB/mm-1. Table 2 summarises this data and details both a clear increase in the Bragg wavelength and the FWHM bandwidth of the reflectance peak.

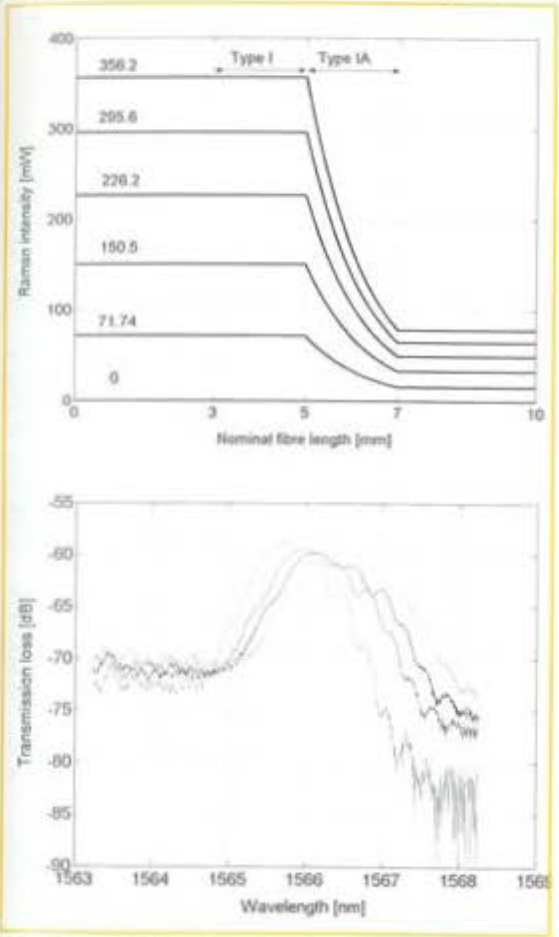

Figure 9. (a) (left) A simulation showing the decay in the intensity of the Raman laser along the length of a 2-mm IA grating. (b) (right) The overlaid reflection spectra of the Type IA grating under the heating effect of a Raman laser. The bandwidth increases sequentially from 1.31 to 1.73 nm, as detailed in Table 2. This figure shows that it is also possible to tune the chirp of the Type IA grating by purely remote optical means.

Table 2. Summary of the wavelength shift and FWHM expansion of the Type IA grating when heated with a Raman source at 1425nm.

Raman Power	$\Delta\lambda_{BS}^{IA}$	FWHM
mW	pm	nm
0	0	1.31
71.74	160	1.36
150.5	250	1.45
226.2	420	1.55
295.6	590	1.65
356.2	620	1.73

The data of Table 2 is plotted in figure 10, indicating linear relationships between the FWHM bandwidth and the Raman intensity (figure 10 (a)) and also the Bragg wavelength shift and Raman intensity (figure 10 (b)).

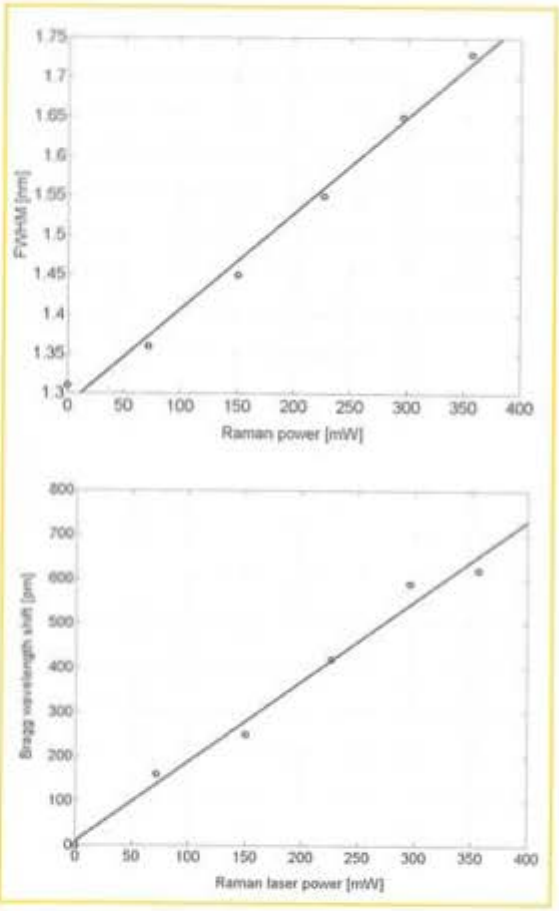

Figure 10. (a) (left) A plot showing the linear relation between the FWHM bandwidth of the Type IA grating and the intensity of the Raman laser. (b) (right) A plot showing the linear relation between the Bragg wavelength shift of the Type IA grating and the intensity of the Raman laser.

Finally, in figure 11, we observe that under continued laser pumping at 1425nm and high power, one can induce partial but permanent erasure of the modulated grating component. Given the controlled nature and on-line monitoring it is important to note that this approach could be used to anneal a Type IA grating during the grating inscription process.

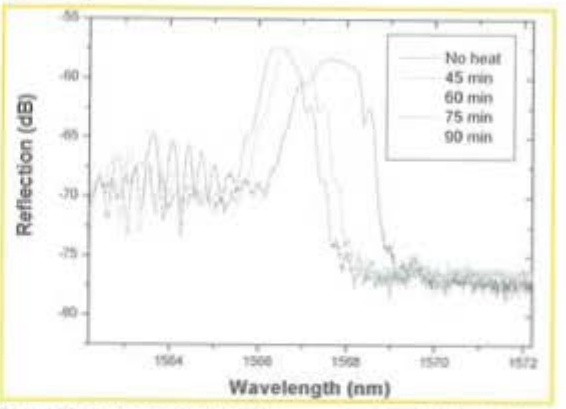

Figure 11. Data represents the permanent, and partial, laser-induced erasure of the Type IA grating with time.

5. CONCLUSIONS

We have shown that it is possible to selectively heat and modify the spectral characteristics of a grating within an array of other gratings by purely optical methods, in this case using two different laser sources operating in the near infra-red. The first laser source has a low power but coincides with the absorption peak of the characteristic 1400nm fibre absorption band, and induces small but significant wavelength shifts of approximately 100pm at 10mW power. The second laser operating at 1425nm and far from the absorption peak induces wavelength shifts in excess of 600pm and a 30% increase in FWHM for a pump power of 350mW. We have induced reversible wavelength shifts, chirp and controlled permanent grating decay (annealing). This has serious implications when using Type IA gratings in an optical network, as their spectrum can be modified using purely optical methods (no external heating source acts on the fibre), and to their long term stability as the grating is shown to decay. We note that high power lasers are increasingly being used in optical networks and our study may have greater implications to all grating types, as laser powers and the useable wavelength spectrum increase. This may result from the presence of absorption bands in the visible and near infra-red that are produced due to the fibre being pre-conditioned, prior to grating inscription (as in this case). Absorption features are notable by their presence at shorter wavelengths for conventional Type I gratings inscribed in hydrogenated fibre. Whereas these absorption features are not typically considered to be of consequence to grating lifetime their impact has yet to be conclusively established. This is being examined as an ongoing activity of the COST270 action "Reliability of Optical Components and Devices in Communications Systems and Networks" [10].

Conversely, there are applications where suitably stabilized Type IA gratings can be spectrally tailored, for tuning fibre lasers or edge filter modification in sensing applications. The latter results from the non-uniform absorption of the pumping laser source at it traverses the Type IA grating, and as demonstrated in the data of figure 9 (b). The fact that this type of spectral tuning can be realized through the use of an additional laser source can be advantageous as no special coatings to the fibre are necessary, and all degrees of tuning can be set during the grating manufacturing process thereby offering great flexibility at the design stage. Since all grating types can be written in a section of pre-exposed fibre this method of optical tuning could be used for all existing Bragg grating applications making the technique invaluable to a multitude of applications. Finally we note that it is possible to tailor the absorption of the pre-exposed section to mirror the decay in intensity resulting in a uniform heating of the grating. However, this would alter the mean fibre index along the pre-exposed section, inducing a potentially large (up to 20nm) chirp across the grating.

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TAILORING THE TEMPERATURE AND STRAIN COEFFICIENTS OF TYPE I AND TYPE IA DUAL GRATING SENSORS - THE IMPACT OF HYDROGENATION CONDITIONS

K. Kalli,[1] A G Simpson,[1] K. Zhou,[2] L. Zhang[2] and I Bennion[2]
[1] Higher Technical Institute, C. Kavafi Street, Nicosia, 2152 Cyprus
[2] Photonics Research Group, Aston University, Birmingham B4 7ET United Kingdom
E-mail: kkalli@hti.ac.cy
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ABSTRACT

We report experimental findings for tailoring the temperature and strain coefficients of Type I and Type IA fibre Bragg gratings by influencing the photosensitivity presensitisation of the host optical fibre. It is shown that by controlling the level of hydrogen saturation, via hot and cold hydrogenation, it is possible to produce gratings with lower thermal coefficients. Furthermore, there is a larger difference between the Type I and Type IA thermal coefficients and a significant improvement in the matrix condition number, which impacts the ability to recover accurate temperature and strain data using the Type1-1A dual grating sensor.

Keywords: Optical fibre sensors, fibre Bragg gratings, Type IA grating, photosensitivity, temperature and strain sensors

1. INTRODUCTION

Type IA fibre Bragg gratings have attracted interest within the sensor community based on their unique spectral and physical characteristics. They are readily identified by their spectral attribute of a large red shift in the Bragg wavelength (λ_B) of the grating during inscription that accompanies an increase in the mean core index [1]. It is recognised that this red shift is dependent on fibre type and hydrogenation conditions, and for a highly doped fibre, such as B/Ge codoped fibre, is typically 15-20nm, whereas the wavelength shift for SMF28 is lower at 5-8nm [2]. The maximum wavelength shift translates to an increase in the mean index of up to 2x10-2. We have previously shown a strong correlation between the growth of the OH absorption band formation in the optical fibre during prolonged UV exposure and the increase in the mean index change of the fibre grating. This change results from the hydrogen combining with Si and Ge centres in the fibre to form stable SiOH and GeOH groups, the latter of which has the greater impact on the strength and peak location of the 1400nm absorption band. As a result of this fundamental material modification Type I and Type IA gratings have been written in the same fibre with a common phase mask, yet with central reflecting peaks more than 14nm apart after annealing. More importantly, this change in the mean index of the fibre core results in their key physical attribute, that they exhibit the lowest temperature coefficient of all grating types reported to date; this makes them attractive for use in a temperature compensating, dual grating sensor [3].

Here we focus on the effect of hydrogenation on the thermal coefficients of Type I and Type IA grating sensors and how this affects the recovery of accurate temperature and strain data. We control the degree of photosensitivity presensitisation of the host optical fibre by controlling the level of hydrogen saturation, via hot and cold hydrogenation. We will show that it is possible to produce Type IA gratings with low thermal coefficients, particularly when compared to Type I gratings. Furthermore, tailoring a large difference between the Type I and Type IA thermal coefficients leads to a significant improvement in the matrix condition number, this impacts the ability to recover accurate temperature and strain data when using a Type1-1A dual grating sensor. We will show that the improvement is significant and makes this dual grating scheme well suited to dual measurand applications, performing well compared with other, more elaborate techniques schemes that utilize multiple Bragg gratings to simultaneously decouple temperature and strain.

2. HOT OR COLD HYDROGENATION?

It is well documented that optical fibres hydrogenated at lower temperatures achieve a higher hydrogen concentration within the core but require significantly longer saturation times [4]. The concentration of hydrogen molecules and the rate at which these molecules diffuse into the core of the optical fibre depend on the temperature and pressure at which the fibre is soaked. The concentration of hydrogen molecules in the optical fibre core at saturation (the equilibrium solubility), K_{sat}, is given by:

$$k_{sat} = 3.3481 p \exp\left[\frac{8670 J/mol}{RT}\right] \quad [ppm]\ (1\ ppm = 10^{-6}\ moles\ H2 / mole\ SiO2) \qquad (1)$$

where p is the pressure of the hydrogen in atmospheres, T is the temperature in Kelvin, and R is the gas constant (8.31451 JK-1mol-1). The saturated hydrogen concentration increases linearly with pressure and decreases as the temperature increases. The variance in K_{sat} for changes of p and T is shown in figure 1 (a). The diffusivity of hydrogen molecules in silica is given by [4]:

$$d_{H2} = 2.83 \times 10^{-4}\ p \exp\left[\frac{-40190 J/mol}{RT}\right] [cm^2 s^{-1}] \qquad (2)$$

and increases with both pressure and temperature.

The variance in dH_2 for changes of p and T is shown in figure 1 (b). Figure 1 shows the trade off that must be made when hydrogenating optical fibres; higher temperatures mean that it is possible to hydrogenate fibres relatively quickly, but only at the expense of the final concentration of hydrogen in the core of the fibre.

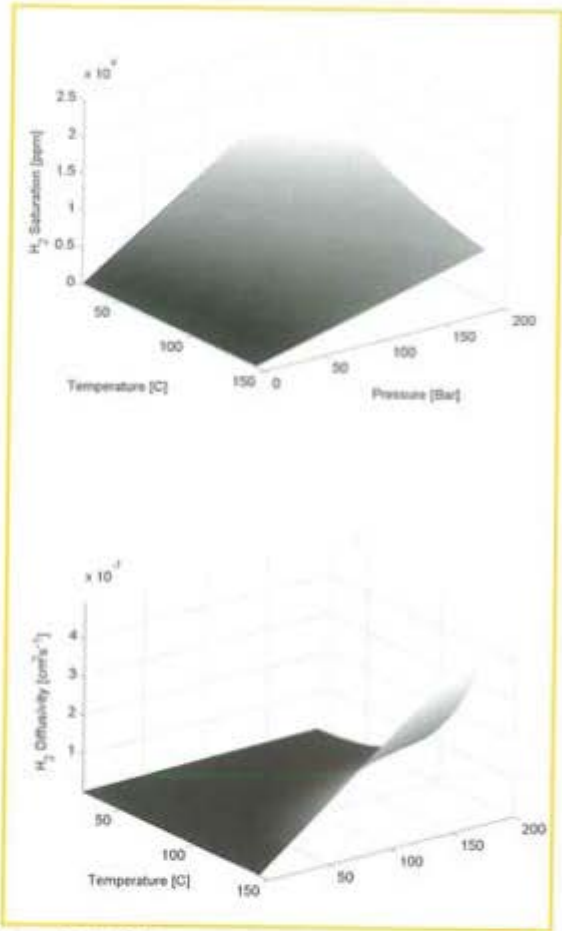

Figure 1. (a) (left) The variance in the hydrogen saturation levels of a silica fibre core for changes of p and T, and (b) (right) The variance in the diffusivity of hydrogen in silica for changes of p and T.

The solution on the axis for outward diffusion in cylindrical geometry is conveniently given by Crank [5] as:

$$\frac{C}{k_{sat}} = 1 - \exp\left(-\frac{a^2}{4 d_{H2}\, t}\right) \qquad (3)$$

where C is the concentration of hydrogen in the fibre and a is the fibre radius.

In order to determine how the type of hydrogenation affects the formation of fibre Bragg gratings, we prepared two identical batches of fibre into which were inscribed Type I and Type IA gratings. Each batch consisted of Corning SMF-28 standard telecommunications fibre and Verillion B/Ge co-doped fibre. One batch was hydrogenated at 80°C, 190Bar for 93 hours and cooled to room temperature over 24 hours by which time the pressure was 160Bar; the other batch was hydrogenated in excess of four months at 180Bar and at room temperature. Both samples were hydrogenated for times well in excess of the equilibrium time and we calculated the hydrogen concentration within the fibre samples using equation 1 based on the hydrogenation conditions outlined above. These results are shown in Table 1.

Table 1. A summary of the hydrogenation conditions for the hot and cold hydrogenated samples, showing the time, temperature and pressure of hydrogenation and the calculated saturation level within the fibre core

	Temperature (K)	Pressure (Atmosphere)	Time (Hours)	(ppm)
Hot	353	178	93	11400
Cold	298	188	>384	21000

Gratings were inscribed using the scanning phase mask technique illuminated with a cw UV laser source operating at 244nm. A 1-mm aperture ensured an accurate top-hat exposure profile along the length of the grating [3]. The stage was scanned at 1mms-1 with 130mW optical power delivered to the fibre. Figure 2 shows the growth rate for the hot and cold samples in the different fibre types. There is a clear trend showing that the fibres hydrogenated at room temperature grow faster then those heated during the hydrogenation process.

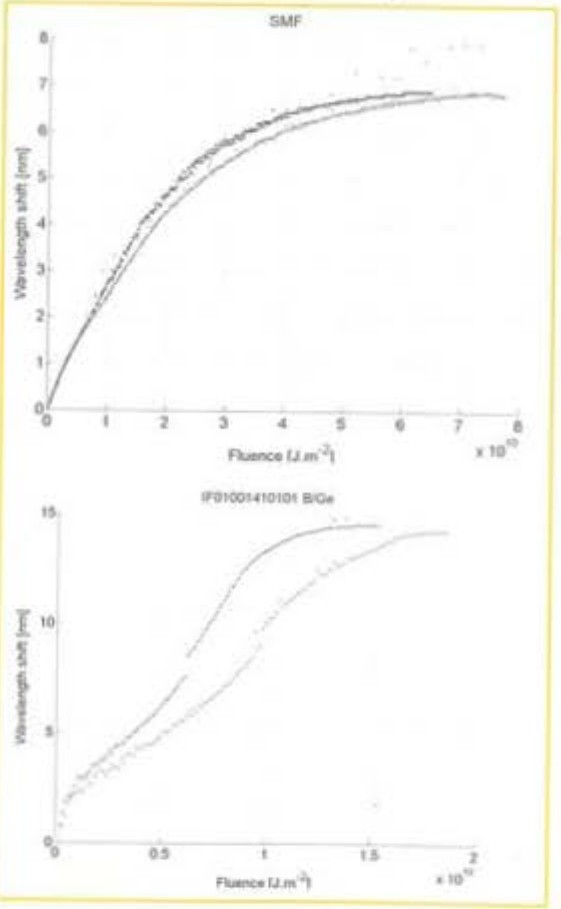

Figure 2. Growth rate of Type IA gratings in the indicated fibre types, for hot (grey) and cold (black) hydrogenation conditions.

In order that the Type IA gratings would have a reference grating whose properties are well understood, a 1-mm Type I grating was written within the same section of each fibre. Figure 3 shows the spectra of each sample before (upper) and after (lower) annealing at 80°C for 96 hours, and highlights a number of differences between the

fabricated gratings; notable examples are the gratings written in Verillion IF01001410101 B/Ge co-doped fibre, where both the IA and I gratings differ significantly in amplitude and the Type I grating would seem to be slightly offset in wavelength. The gratings in SMF-28 are comparable in hot and cold hydrogenated samples and do not exhibit any significant spectral characteristics other than the anticipated short wavelength losses associated with the hydrogenation. The wavelength difference between Bragg resonances of the Type I and IA gratings is summarised in Table 2 for the pre- and post-annealed gratings.

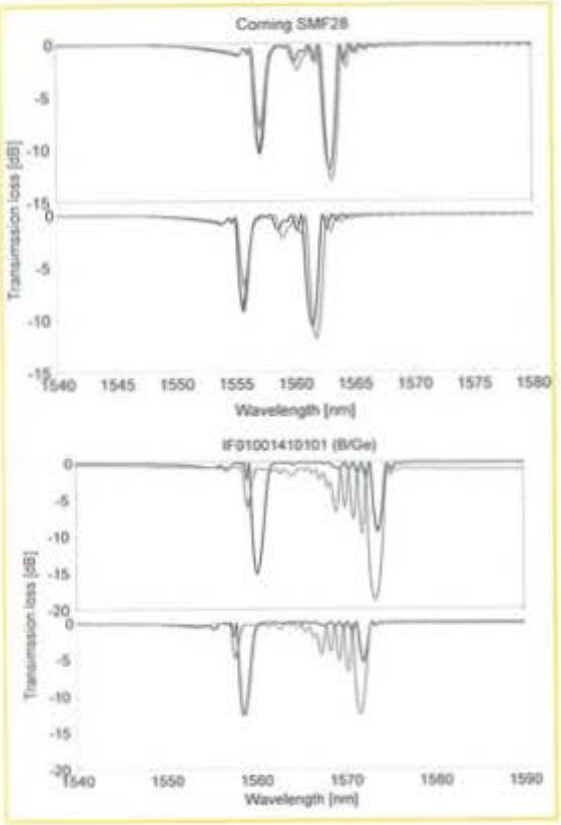

Figure 3. Pre- (upper traces) and post- (lower traces) annealing spectra for Type I and Type IA gratings written in various fibre types (as indicated) for hot (grey) and cold (black) hydrogenation conditions

3. TEMPERATURE AND STRAIN COEFFICIENTS – CONDITION NUMBER

The thermal and strain coefficients of the gratings were measured by placing individual gratings on a temperature controlled block within an insulated chamber and mounted on translation stages. The temperature was controlled by means of a Peltier device connected to a standard, computer operated temperature controller. Temperature feedback was made possible by the placement of a calibrated thermistor and the Bragg wavelength was measured by passing broadband IR radiation from a powerful ASE source through the fibre to an OSA with 0.06nm resolution. The centroid-fitting algorithm (CFA) was used to locate the Bragg wavelength peak recorded by the OSA. A computer was used to set and record the temperature of the grating and the OSA traces; plotted in Figure 3 for each grating and fibre type, as indicated. The thermal coefficients are summarised in Table 2.

Table 2. A summary of the data highlighting the differences between hot and cold hydrogenation in the different fibre types.

Fibre type	Hydrogenation conditions	Manufacturer	$\lambda_{BR}(T)$	$\lambda_{BR}^{ann}(T)$	$\frac{\lambda_{BR}(T)}{\lambda_{BR}^{ann}(T)}$	$\lambda_{BR}^{UV}-\lambda_{BR}^{ann}$	$\lambda_{BR}^{UV}-\lambda_{BR}^{ann}$ annealed
			pm°C^{-1}	pm°C^{-1}	%	nm	nm
SMF28	hot	Corning	10.54	10.427	1.084	5.848	5.761
SMF28	cold	Corning	10.28	9.958	3.233	6.076	6.032
B/Ge	hot	Verillion	9.146	8.27	10.592	14.147	13.925
B/Ge	cold	Verillion	8.531	7.403	15.237	13.474	13.375

Figure 4 shows that both the hot and cold hydrogenated fibres display an unambiguous trend, the cold samples possess a lower temperature coefficient ($\lambda_{BR}(T)$). Moreover the difference between the $\lambda_{BR}(T)$ values for Type I and IA gratings is larger when the samples are hydrogenated at 25°C in preference to 80°C. It is unclear from this experiment alone whether the effect is a result of an increased hydrogen level caused by the longer term, lower temperature hydrogenation, but we believe that this is a reasonable assumption. Regardless, this is almost certainly related to the presence of increased GeOH centres that are formed during the UV treatment of the fibre. The wavelength to strain responsivity displays a smaller but measurable difference that results primarily from differences in the initial centre wavelengths rather than any variation in the material properties.

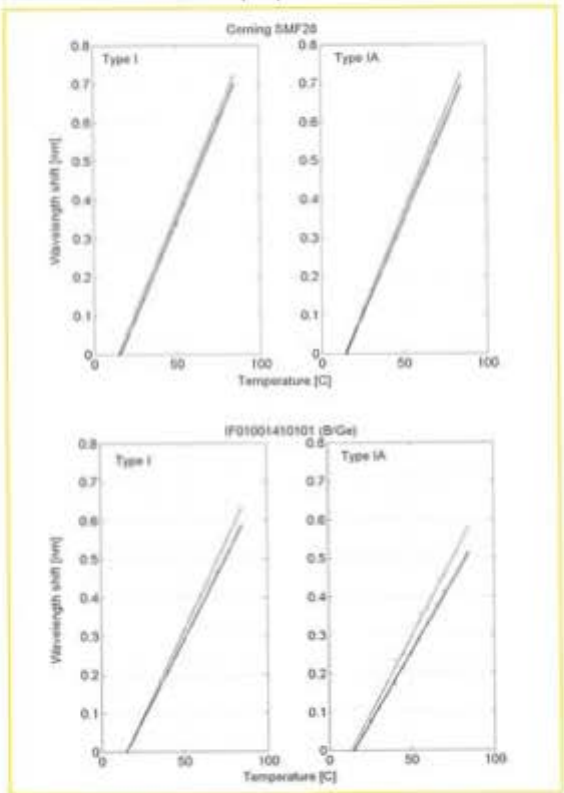

Figure 4. Plots showing the thermal coefficients for Type I (left-hand traces) and Type IA (right-hand traces) gratings written in various fibre types (as indicated) for hot (grey) and cold (black) hydrogenation conditions.

We can compare errors in the derived measurements with those of the ideal case. Ideally, the errors in strain ($\delta\varepsilon$) and temperature (δT) are given by [6]:

$$\begin{pmatrix} \delta T \\ \delta \varepsilon \end{pmatrix} = \begin{pmatrix} \delta\phi_1 / K_{1T} \\ \delta\phi_2 / K_{2\varepsilon} \end{pmatrix} \quad (4)$$

where $\delta\phi_1$ and $\delta\phi_2$ are the measurement errors of parameters ϕ_1 and ϕ_2, in this case the wavelength. The error increases for strain and temperature according to [7]:

$$|\delta\varepsilon| = \frac{|K_{2T}||\delta\phi_1| + |K_{1T}||\delta\phi_2|}{|K_{1T}K_{2\varepsilon} - K_{2T}K_{1\varepsilon}|} \quad (5)$$

and,

$$|\delta T| = \frac{|K_{2\varepsilon}||\delta\phi_1| + |K_{1\varepsilon}||\delta\phi_2|}{|K_{2T}K_{1\varepsilon} - K_{1T}K_{2\varepsilon}|} \quad (6)$$

An alternative description has been provided in [8] where the errors in ϕ_1 and ϕ_2 have been converted to an error ellipse in the (ε,T) plane.

For the case of the Verillion B/Ge fibre the strain coefficients for the Type I and Type IA gratings are λI $BR(\varepsilon)$ = 0.818pm/με and λIA $BR(\varepsilon)$ = 0.828pm/με, respectively. The strain and temperature errors associated with their respective coefficients are ±15.3με/pm and ±1.44°C/pm, for the hot hydrogenation in Verillion B/Ge fibre and ±11.2με/pm and ±1.15°C/pm for the cold hydrogen loading in the same fibre type. These values compare with errors of ±12με/pm and ±1.13°C/pm measured by Xu et al. [9] for two superimposed gratings at markedly different wavelengths. Therefore the approach of controlling the degree of hydrogenation to affect the temperature coefficients of a photosensitive fibre can prove to be very useful for a dual grating sensor used to differentiate between strain and temperature. Furthermore, a useful mathematical tool for quickly assessing the accuracy of a dual sensor arrangement is to calculate the condition number of the sensor matrix [10]. The condition number of a matrix measures the sensitivity of the solution of a system of linear equations to errors in the data. It gives an indication of the accuracy of the results from matrix inversion and the linear equation solution. This is easily calculated in Matlab using cond(c,1) or MathCad using cond1(c) where c is the sensor matrix in question. For the ideal case the condition number of the matrix is 1 indicating a perfectly conditioned matrix. For a mathematical explanation for the procedure of calculating the condition numbers of matrices see, for example [10, 11]. Table 3 shows a comparison of condition numbers for different methods used to separate temperature and strain based on Bragg grating sensors, from which we observe that the cold hydrogenation produces a well-conditioned matrix that compares favourably with other more elaborate techniques.

Table 3. Matrix condition numbers of dual grating temperature-strain isolation configurations – a comparison. The table is ordered with the most effective method (as defined by the lowest condition number) first.

Method	Reference	Condition Number
Bragg gratings in different diameter fibres	James et al, [12]	48
Type IIA and Type IA grating pair	Shu et al, [13]	68
Superimposed grating pair	Xu et al, [9]	123
Type I and Type IA grating pair – Cold / Hot hydrogenation	**Kalli et al, [This work]**	**147 / 214**
First and second order Bragg resonances	Sivanesan et al, [10]	161
Gratings in germanosilicate and Er,Yb doped germanosilicate fibres	Guan et al, [14]	169
Gratings in germanosilicate and B doped germanosilicate fibre	Cavalerio et al, [15]	173
Type IA and Type I grating pair	Simpson et al, [3]	188
First and second order Bragg resonances	Kalli et al, [8, 16]	203
Type IIA and Type I grating pair	Frazao et al, [17]	272

4. CONCLUSIONS

Work has been presented detailing the fabrication and characterisation of dual grating sensors that may be used to simultaneously decouple temperature and strain. The sensor head comprises a standard Type I grating fabricated directly adjacent to a Type IA grating, having a lower temperature coefficient and slightly higher strain coefficient. We have shown for two different fibre types that the concentration of hydrogen within the core directly affects the rate at which Type IA gratings form and the thermo-optic coefficient of the mature Type IA grating; gratings inscribed in fibre samples with a higher hydrogen concentration form faster and have lower temperature coefficients. The degree of photosensitation and hydrogen levels is controlled by the hydrogenation conditions, and typical hot and cold conditions for hydrogenation are implemented.

Using a standard matrix technique it is possible to interrogate the sensor head and decouple strain and temperature with a matrix condition number better than 150. In the case of low temperature hydrogenation there is a significant improvement in the matrix inversion errors and the condition number. This improvement is important as it augments the existing advantages of the Type I-IA dual grating sensor, namely two Bragg wavelengths having good wavelength proximity thereby avoiding costly multiplexing schemes; quick and efficient inscription using a single phase mask, common annealing cycles and the precise placement of sensors located in a common sensor head.

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15. P. M. Cavalerio, F. M. Araujo, L. A. Ferreira, J. L. Santos, and F. Farahi, 1999 Simultaneous measurement of strain and temperature using Bragg gratings written in germanosilicate and boron-co doped germanosilicate fibres ***IEEE Photonics Technology Letters***, 11 1635-1637.

16. K. Kalli, G. Brady, DJ. Webb, DA. Jackson, L. Zhang, and I. Bennion, 1994 Possible approach for simultaneous measurement of strain and temperature with second harmonics in a fibre Bragg grating sensor presented at OFS10, Glasgow, postdeadline paper 2.1.

17. O. Frazao, M. J. N. Lima, and J. L. Santos, 2003 Simultaneous measurement of strain and temperature using type I and type IIA fibre Bragg gratings ***J. Opt. A-Pure & Appl. Opt.***, 5 183-185.

HIGHER TECHNICAL INSTITUTE'S INTERNATIONAL SUCCESS

The Mechanical Engineering Department of the Higher Technical Institute joined the External Research Network (ERN) of the Network of Excellence (KMM-NoE) on July 13th 2005.

This Network of Excellence is in the field of "Knowledge-based Multicomponent Materials for durable and safe performance" (KMM-NoE) which has been established in order to create a coherent pan-European structure of key academic and research institutions, SMEs and large industry partners in the field of Knowledge-based Multicomponent Materials designed for highly demanding loading and environmental conditions. Such materials include functionally graded materials, metal-ceramic composites and intermetallics.

The KMM-NoE brings together a critical mass of 36 organisations with high level expertise in the field of Knowledge-based Multicomponent Materials from 10 countries across in Europe.

The person in charge for HTI is Dr Andreas Stassis, Lecturer in the Mechanical Engineering Department.

PUBLICATIONS FOR THE YEAR 2004-2005

MECHANICAL and MARINE ENGINEERING DEPARTMENT

1. P. Poirazi, C.C. Neocleous, C. Pattichis, C.N. Schizas. Classification Capacity of a Modular Neural Network Implementing Neurally Inspired Architecture and Training Rules. IEEE Transactions on Neural Networks. Vol. 15(3). May 2004, p. 597-612.

2. C.C. Neocleous, C.N. Schizas. Application of Fuzzy Cognitive Maps to the Political-Economic Problem of Cyprus. Proceedings of the International Conference on Fuzzy Sets and Soft Computing in Economics and Finance 2004. St Petersburg, June 17-20, 2004, p. 340-349.

3. Michaelides I., Eleftheriou P., and Economides K. HTI e-learning Laboratory - Remote Experimentation over the Internet. Proceedings 2nd International Conference on Remote Engineering and Virtual Instrumentation (REV2005), Brasov, Romania, 30 June - 1 July 2005, ISBN 3-89958-137-7, (2005).

4. Michaelides I., Eleftheriou P., and Economides K. Remote Engineering Education: Real- world experiments in solar energy over the Internet. IMPULS, vol. 18, , ISSN 1618-9477, ISBN 3-88555-769-X, (2005).

GENERAL STUDIES DEPARTMENT

1. 2004 A.Georgiou, P.Christodoulides & K.Kupiec, Second-order approximation of intraparticle mass transfer rate in adsorption processes, The Cyprus Journal of Science and Technology, 4(2), 116-133.

2. Helen Dobb, David J. Webb, Kyriacos Kalli, Alexander Argyros, Maryanne C.J. Large and Martijn A. van Eijkelenborg "UV light induced fibre Bragg gratings in microstructured polymer optical fibre"
Accepted for Optics Letters 2005.

3. H. Dobb, K. Kalli and D.J. Webb
"Measured sensitivity of long period gratings in photonic crystal fibre"
Accepted for Optics Communications 2005

4. K. Kalli, G. Simpson, K. Zhou, L. Zhang, and I. Bennion [Special Issue on Optical Fibre Sensors]
"Tailoring the temperature and strain coefficients of type I and type IA dual grating sensors - the impact of hydrogenation conditions"
Accepted for Measurement Science and Technology 2005.

5. [Invited paper] D. J. Webb, M. Aressy, A. Argyros, J.S. Barton, H. Dobb, M.A. van Eijkelenborg, A. Fender, J.D.C. Jones, K. Kalli, S. Kukureka, M.C.J. Large, W. MacPherson, G.D. Peng, M. Silva-Lopez

6. "Grating and Interferometric Devices in POF"
The 14th International Conference on Polymer Optical Fiber (incorporating with the 3rd Asia-Pacific POF Workshop), Hong Kong, China, Sept. 2005

7. H. Dobb and D.J. Webb, K. Kalli, A. Argyros, M.C.J. Large and M.A. van Eijkelenborg "UV light induced fibre Bragg gratings in microstructured polymer optical fibre"
The 14th International Conference on Polymer Optical Fiber (incorporating with the 3rd Asia-Pacific POF Workshop), Hong Kong, China, Sept. 2005

8. K. Kalli, G. Simpson, K. Zhou, L. Zhang, D. Birkin, T. Ellingham and I. Bennion "Wavelength tuning, chirping and thermally induced decay of type IA FBGs using purely optical methods" Optical Fibre Sensors Conference, OFS-17, Bruges, Belgium, May 2005.

9. K. Kalli, G. Simpson, K. Zhou, L. Zhang, D. Birkin, T. Ellingham and I. Bennion
"Impact of hydrogenation conditions on the temperature and strain coefficients of type I and type1a dual grating sensors" Optical Fibre Sensors Conference, OFS-17, Bruges, Belgium, May 2005.

10. Long-period gratings fabricated in photonic crystal fibre H. Dobb, J. S. Petrovic, V. Mezentsev, D. J. Webb and K. Kalli Optical Fibre Sensors Conference, OFS-17, Bruges, Belgium, May 2005.

Participation of Staff in Short Courses/Conferences and Educational Exchange Programmes for the Year 2004 – 2005

Conferences/Seminars attended by HTI Academic Staff:

1. Mr Savvas Savvides, Head of the Engineering Practice Department, attended the Annual General Meeting of ***European Higher Engineering Education and Technical Professionals Association (EurEta)*** , Austria , 17 to 19 June 2005.

2. Dr Costas Neocleous, Senior Lecturer in the Mechanical Engineering Department, attended: ***Summer School on Modeling and Control of Complex Dynamical Systems***, Italy, 18-22 July 2005.

3. Mrs Anastasia Mouskou-Peck, Lecturer of English and Technical Report Writing in the General Studies Department, attended a course on ***"Discourses of Difference Within and Beyond Education"*** at the Institute of Education, London University, 15–17 December 2004.

4. Mr Charalambos Chrysafiades, Senior Lecturer in the Electrical Engineering Department, visited the ***18th International Conference and Exhibition on Electricity Distribution***, Torino, Italy, 6–9 June 2005.

5. Dr Chrystalla Demetriade, Lecturer in the General Studies Department, attended the ***4th Mediterranean Conference on Mathematics Education***, Palermo, Italy, 28-30 January 2005.

6. Mr Theodoros Symeou, National Secretary of IAESTE Cyprus attended the ***57th Annual Conference of IAESTE*** held in Cartagena , Colombia, 21 - 28 January 2005.

7. Mr Stylianos Kyzas, Instructor in the Engineering Practice Department, attended the ***European Programme Pancyprian Trade Union Forum on "EU Affairs"***, Nicosia, 13 July 2005.

8. Dr Nicholas Kathijotes, Lecturer in the Civil Engineering Department, attended the: ***"Balkan Economy Reconstruction and Ecology"*** at the Balkan Academy of Sciences and Culture, Bulgaria, 8 – 10 June 2005.

9. Dr Marios Kassinopoulos, Lecturer in the Electrical Engineering Department, attended the: ***Seminar on "Bologna Process"***, Belgium, November 2004.

10. Dr Marios Kassinopoulos, Lecturer in the Electrical Engineering Department, attended the: ***Seminar on "Europass"***, Luxembourg, January 2005.

11. Dr Marios Kassinopoulos, Lecturer in the Electrical Engineering Department, presented a paper in the ICEER Conference, titled: ***"Comparable Degree Structures in European Higher Education Institutions"***, Taiwan, March 2005.

12. Dr Kyriacos Kalli, Lecturer of Physics in the General Studies Department, attended the ***"Optical Fibre Sensors Conference, OFS-17"***, held in Bruges, Belgium, 23-27 May 2005.

13. Dr Kyriacos Kalli, Lecturer of Physics in the General Studies Department, attended a short-term scientific mission as part of COST270: Reliability of optical components and devices in communications networks and systems 23 January 2005 to 3 February 2005 Photonics Research Group, Department of Electronic Engineering, Aston University, UK ***"Annealing study of Type IA fibre Bragg gratings and implications to optical fibre component reliability"***

14. Dr Ioannis Michaelides, Head of the Mechanical Engineering Department, and Dr Polyvios Eleftheriou, Senior Lecturer in the same Department, participated in the final meeting of the ***"MARVEL"*** project, under the Leonardo da Vinci Programme, that took place in Livingston, Scotland, 7-9 July 2005.

15. Dr Polyvios Eleftheriou, Senior Lecturer in the Department of Mechanical Engineering, participated in the 2nd International Conference on Remote Engineering and Virtual Instrumentation (REV2005), Brasov, Romania, 30 June - 1 July 2005. Dr Eleftheriou presented a paper entitled ***"HTI e-learning Laboratory - Remote Experimentation over the Internet"***, co-authored by Dr I. Michaelides (HTI) and Mr K. Economides.

16. The HTI hosted the 4th meeting of the ***"MARVEL"*** project of the Leonardo da Vinci Programme, on 8-9 November 2004. The meeting was organized by the Department of Mechanical Engineering and was attended by 13 participants from Germany, Greece, Portugal, the United Kingdom, Switzerland and Cyprus, representing the 8 Institutions and organizations participating in the MARVEL project. During the meeting, the participants visited the HTI Solar Energy e-learning laboratory which was developed within the framework of the above project.

17. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, attended the ***"ECO Forun 2005"***, and presented a paper, Cyprus, June 2005.

18. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, attended the ***"7th Quality Forum"***, and presented a paper, Cyprus, September 2004.

19. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, attended the ***"Quality Forum"***, and presented a paper, Thessalonica, December 2004.

Short Courses attended by HTI Academic Staff:

1. Dr Costas Neocleous, Senior Lecturer in the Mechanical Engineering Department, attended: ***"EuroGP 2005, EvoCOP2005, EvoWorkshops 2005"***, Switzerland, 30 March – 1 April 2005.

2. Mr Stylianos Kyzas, Instructor in the Engineering Practice Department, attended a ***"5-Day Training for Trainers course on EU Affairs"*** at Ruskin College, Oxford, England, 20-24 June 2005.

3. Mr Constantinos Christodoulou, Lab Assistant in the Mechanical Engineering Department, attended: ***"Implementing and Supporting Microsoft Windows XP Professional"*** (35 hours), Cyprus, 23 - 30 March, 2 - 8 September 2005.

4. Dr George Florides, Senior Instructor of the Engineering Practice Department, attended a course on: ***"Ultrasound Testing of Welds"***, UK, 21 – 24 June 2005.

5. Dr Nicholas Kathijotes, Lecturer in the Civil Engineering Department, attended: ***"Agricultural Engineering Problems"***, at the Latvian Agricultural University, Latvia, 2 – 3 June 2005.

6. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, attended: ***a) "Seminar on new ISO 22000, HACCP" b) "CE Marking for Lifts"***, Cyprus, April 2005.

Visits/Educational Exchange Programmes

1. Mr Charalambos Tsioutis, Instructor of the Engineering Practice Department, visited the TEI Peureus, under the staff exchange Socrates Programme, Greece, 27 March 2005 – 2 April 2005.

2. Mr Theodoros Symeou, Lecturer in the Mechanical Engineering, visited the Budapest University of Technology (BUTE) in Budapest, Hungary, 16 - 20 May 2005.

3. Mr Stylianos Kyzas, Instructor in the Engineering Practice Department, visited the TEI Thessalloniki under the staff exchange Socrates Programme, 28 March 2005 – 1 April 2005.

4. Dr Pavlos Christodoulides, Lecturer in the General Studies Department, visited the Ecole Normale Superieure de Cachan (Paris) for research cooperation on ***"Water waves"*** with Professor Frederic Dias, France, 6 – 14 November 2004.

5. Dr Ioannis Angeli, Lecturer in the Mechanical Engineering Department, attended a five–days visit to TEI Larissas within the Erasmus – Socrates Program. He gave lectures on Quality Management, QFD and SPC, Larissa, Greece, November 2004.

6. Mr Demetris Andreou, Lecturer in the Civil Engineering Department, participated in the Staff Exchange Programme and visited Surrey University, UK, 18 April - 21 April 2005.