SOUE News

Issue 5 **Summer 2006**

Society of Oxford University Engineers

Welcome to the fifth issue of SOUE News

This year's Jenkin Meeting is on 22/23 September, and a notice about it is enclosed. The Jenkin Lecture, on Saturday the 23rd, will be by Professor Rod Smith, on *"Railways: the technical challenges of their renaissance"*, about which his experience well qualifies him to talk. There will be a dinner at Mansfield the evening before.

In this issue we have, for those who missed it, or who didn't but would like to read it in print, a full transcript of last year's Jenkin Lecture by John Coates on the reconstruction of the Greek trireme. Lynsey Thomas writes about fibre-optic submarine cables, with which she has been much involved since leaving Balliol in 1999, and Alistair Hann describes his exchange year at Princeton, now a regular option at the Department.

The Lubbock Lecturer this year was, rather unusually, an Oxford graduate. Warren East was at Wadham 1980–3 and is now Chief Executive Officer of the successful electronics firm ARM Holdings. Read how although they make no tangible product, their licensed chip designs and software appear in unbelievable numbers of electronic products.

Joe Todd, who died earlier this year, will be well remembered by anyone who read Engineering from the 1950s to the 1980s. We have included Basil Kouvaritakis' tribute to his Teddy Hall colleague at Joe's Memorial Service in May.

We would also draw your attention to the item on the back cover about revision of the Engineering Science course, and the invitation to those of you with experience of the four-year course to make comments to the subfaculty.

In This Issue

Head of Department's Report to SOUE 2005 – 2006

Richard Darton

Introduction

The Guardian 2006 University Guide confirmed this department as the best place in the UK to study general engineering, reversing last year's narrow preference for Cambridge. In both years Oxford was rated best University overall. Some six hundred undergraduates are reading Engineering Science and associated joint courses, a huge increase from the 170–175 who were in residence in the early 1960s, when the Thom building was opened. Total undergraduate numbers are holding up well (and quality — out of 152 candidates sitting prelims for the first time in June 2006, 75 were awarded distinctions). However the number electing to read Engineering and Computer Science has fallen to single figures, and the decision has been taken reluctantly to cease admissions for ECS in 2007. We believe that our new biomedical paper will prove popular with undergraduates, but we have initiated a course review to ensure that our whole teaching programme remains competitive, attractive and relevant for our outstanding and motivated student body.

Around 230 postgraduates are registered for higher degrees in the Department. Most of these will complete a thesis for a DPhil, but we are now preparing for a new venture: in October 2006 we will be joined by the first graduate students taking an MSc in biomedical engineering. In a few years' time we will be taking 30 graduates each year into this exciting new programme. Our research portfolio remains healthy — work in progress is currently valued at £37.4 million, an increase of 7% above last year. The topics under investigation cover a huge spread of interests from bird strike in jet engines, to growing human cartilage.

Awards

The December SET for Britain event at the House of Commons was again a triumph for Oxford Engineering Science and our research students. Dan Walker, an EPSRC CASE student (with Shell) won both the BP Younger Engineer's Prize and the 2005 Gold Medal (supported by ExxonMobil) for his research on *Interaction of Extreme Ocean Waves with Offshore Structures*. Michael Schwertner won a Rolls-Royce prize for his work on adaptive optics, and Nicholas Hughes won a Vodafone prize for *Information Engineering for the assessment of Drug Safety*. Dan Walker subsequently netted another prize for his work, the IStructE first prize for young researchers, as did Nick Hughes who was a joint winner of the IEE 2005 JA Lodge award, for his analysis of ECG signals. Charles Bibby (Worcester) was awarded the IMechE Mechatronics Student of the Year Award in 2005 for his excellent 4th year project on tracking targets at sea. Joel Evans (Magdalen) and Sarah Series (Somerville) won RAEng 2006 Leadership awards.

Katherine Clough, a 4th year student at St Edmund Hall, won the 2005/6 Higher Education Academy Engineering Subject Centre Student first prize for her essay on *How does your experience of your course compare with any expectations you may have had?* Her perceptive answer can be found on the web. Another prize-winning essayist was graduate student Sarah Bond for *An Incredible Journey* in the 10th Oxfordshire science writing competition.

Other recipients of honours include Professor David Hills who was awarded an RAEng/ Leverhulme Senior Research Fellowship for 2005/6, and Professor Sir Mike Brady who was awarded an honorary degree by Oxford Brookes University. Professor Lionel Tarassenko won a Royal Academy of Engineering silver medal for his innovational work in signal processing. This medal recognises an outstanding personal contribution to British engineering that has led to market exploitation. Also awarded a silver medal was Professor Andrew Blake, who was a lecturer in this department between 1987 and 1999, prior to his move to Microsoft Research in Cambridge, and is now one of our Visiting Professors. Dr Andrew Fitzgibbon, until 2005 a Royal Society Fellow and now a Visiting Fellow in the Department, won one of the two 2006 Roger Needham awards of the British Computer Society — the other winner was Tim Berners-Lee (an Oxford physics graduate), inventor of the world wide web. The head of department gave the 2005 Hartley lecture at the Royal Society, on Sustainability Metrics (webcast available at RS site).

The work of Dr Malcolm McCulloch's group in developing an electric power train for a novel eco-car was recognised by the newspapers, including the Sun which used the headline "Jack's real gas guzzler" with a picture of Jack the teenage driver and his "pocket rocket". Elsewhere numerous staff and graduate students won prizes for best conference and journal publications, showing that the Department's high quality research also receives serious peer recognition.

In the Recognition of Distinction Exercise 2005–6 the title of Professor was conferred on Dr Paul Buckley, Dr Fionn Dunne, Dr Steve Elston, Dr Alex Korsunsky, Dr Richard Stone, Dr Paul Taylor, and the title of Reader was conferred on Dr Rene Banares-Alcantara, Dr Dominic O'Brien, Dr Ian Reid, Dr Yiannis Ventikos, and Dr Amy Zavatsky.

Academic Staff Movements

At the end of the last academic year, two staff members who will be remembered by many generations of students retired — Professor Gill Sills and Dr Gordon Lord. Gill was replaced at St Catherine's College by another civil engineer, Dr Byron Byrne, and Gordon at LMH by Dr Nick Hankins, a chemical engineer. Other University Lecturer appointments were Dr Paul Newman at New College, whose research is in robotics, and Dr Mark Thompson who will augment the tutorial team at Wadham. Mark's research focus is in orthopaedic biomechanics, and his appointment is part of our expansion in the general area of biomedical engineering.

Two new Departmental Lecturers were appointed — Dr Antonis Papachristodoulou in control engineering, and Dr Suby Bhattacharya in civil engineering. Dr Clive Siviour was awarded a Career Development Fellowship in Impact Engineering, in association with St Hilda's.

Alan Cocks took up his post as Professor of Materials Engineering in January 2006, and Professor Phillip Ligrani arrived from the University of Utah in June to fill the Donald Schultz chair in Turbomachinery. Andrew Zisserman was appointed to the Microsoft Research—Royal Academy of Engineering Professorship in Computer Vision Engineering.

Buildings

The new Information Engineering Building which adds considerably to the grace and splendour of our end of the Banbury Road, was given an award by the Oxford Preservation Trust, which recognises projects that preserve or enhance this historic city.

Our next major building project is the Institute of Biomedical Engineering, part of the Old Road Medical Campus development at Headington, on which construction started in March 2006. There was considerable pressure on space in this building, so we reduced our requirement to 2000 m^2. Completion is expected in October 2007, following which several research groups will start to work there, in close contact with various clinical colleagues.

The University gave us conditional approval to establish a new Engineering research laboratory in the Axis Point building on the Osney Mead industrial estate. This building is owned by the University, but currently let to external tenants, and would make an ideal facility for large-scale experimentation, particularly the research that we do for Rolls-Royce in the UTC for Aerodynamics and Heat Transfer. We are currently planning this intricate project, which would involve relocating research from the old Southwell building, and which will cost several million pounds.

Plans to modernise and refurbish the Thom Building feature in our long-term strategy. The building has been heavily used for 43 years now, and is showing signs of middle age — blemished exterior, over-heating in summer, and utilities not functioning as they once did.

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Head of Department's Report to SOUE 2005 – 2006 cont.

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Development and fund-raising

Last year I reported the appointment of a Director and fund-raisers for the Institute of Biomedical Engineering. Donations and pledges from the Bellhouse Foundation now totalling £1.3 million have funded these positions and some other activity, and are also enabling us to appoint a Bellhouse Foundation Lecturer in Biomedical Engineering (drug delivery).

In June we signed a headline-making deal with Technikos, a Sloane-Robinson company, to exchange 50% of the University's rights to licensing and spin-out income in biomedical engineering, in return for an injection of £12 million into the project. We have also been fortunate in securing an award of £1 million from the Wolfson Foundation towards the new building. Taken together, these sums enable us to cover our building costs, and to progress the establishment of some extra new posts in biomedical engineering.

A number of other projects are also under development, related to water research and energy research. I hope to be able to report more fully on these activities next year.

Last year I commented on the need to raise funds for graduate scholarships, and despite some indications of support, the difficulty of finding funding for brilliant graduate students remains.

We have been successful in raising funds to finance the developments that are essential if we are to keep our position as a leading teaching and research department in Engineering Science. To have freedom to develop new activity we must also balance our operating budget, which we have done for more than ten years. The University's budget however has been under pressure, and the proposed settlement for 2006/7, which attempts to rectify underspending in some other areas, is disastrous for physical and life sciences. Although since 2002/3 the University has received a 28% *increase* in income from HEFCE, net formula funds (income less central charges) available to the division have *decreased* by 18% over this period. Most science departments, including Engineering Science, now face large deficits. The discussion about the budget continues, and we hope that these difficulties can be resolved without damage to our strategy of growth and innovation.

The 32nd Lubbock Lecture, 11 May 2006: The Semiconductor Industry: Making Business and Technology Innovation Work

Warren East, CEO of ARM Holdings (Wadham 1980–3) – report by David Witt

Warren told us that the semiconductor industry, after a promising youth, is now "middle-aged", but still young at heart. Since the transistor was invented almost 60 years ago, developments have tended to come in waves. The current wave is bulk CMOS technology, which has had a very successful run. Over the years it has been drastically shrunk in size, so that it needed less and less power, and cost similarly less to make. This has led to a virtuous circle of more sales, more investment and hence continued improvement in performance. But problems are appearing. Current R and D is working on 32 nm features, but at this size transistors do not always behave as their models say they should. So R and D costs are rising, but customers expect prices to go on falling, while shareholders, as ever, expect returns.

The ARM company, of which the speaker is Chief Executive Officer, had for its parents two computer companies, Acorn, which produced the extremely successful "BBC" micro-computer, and Apple. Acorn had followed up the BBC micro by developing a 32-bit RISC (Reduced Instruction-Set Computer) in 1985, but subsequent need for finance led to the formation of ARM in order to exploit it. This RISC design has been around, in successive implementations, for 21 years, and now appears in some 10% by value of all the world's digital ICs.

But ARM does not actually **make** any chips. It **licenses** other companies to use the design, and frequently writes the software to go with it. Increasing the software content enables complexity, and hence functionality, to be increased, while keeping costs down.

ARM started in about 1990 with 12 engineers and one salesman, setting themselves the cheeky challenge "Can we sell a microprocessor to Intel?" It now has about 1200 engineers, and 1300 employees altogether, but claims that the end users of their designs number 1.2 billion people! Their policy is to license the technology to many different "partners", who then make chips which the equipment manufacturers put into a great variety of products, from mobile phones to anti-lock brakes. The partners then pay for it mainly by royalties on the chips they sell. They have negotiated about 400 licences so far, of which about half are bringing in income, thus funding further development, and paying dividends to shareholders.

For management, the problem is how to encourage innovation. For instance, the reduced size of modern chips mean that the transistors become more variable, and don't last as long either. So errors occur in the logic, as they do too if one reduces the power supply voltage to economise on power consumption. But with increased complexity, and clever engineering, errors can be corrected, provided there aren't too many of them.

In fact, it is in times of crisis, towards the end of a project, that people are often most innovative. But because it is a crisis, there is often no time to use the new idea. So there has to be an arrangement for "banking" it, for use some other day. There needs to be a mechanism for giving people "dead time" between projects, and sometimes for rotating them through research groups. You have to take risks, and recognise that people will make mistakes.

The speaker continued with some observations on University/Business collaboration. Universities supply the graduates whom industry employs, and its need is for people who are not only technically competent, but can also appreciate business attitudes. Academics were now showing a tendency to move into business themselves, but there were right and wrong ways to do this. The "spin-off company" is showing signs of being a right way. Business and academia operate in "parallel universes" because of their different time-scales, but the universities do perform the essential function of doing the underlying science. Electronic firms have always been very bad at doing this for themselves — pharmaceutical ones have done much better.

The lecture concluded with a few more brief observations:

Be economical — don't over-engineer things;

One often comes up with a better product the second time round;

Technology and business are inseparable;

The commercial world is not "dirty", but essential;

Keep it simple, simple, simple;

Innovation relies on a culture that encourages it, the necessary basic science, and an economic climate that allows business to flourish.

The 18th Jenkin Lecture, 1 October 2005: Some Engineering Concepts applied to Ancient Greek Trireme Warships

John Coates

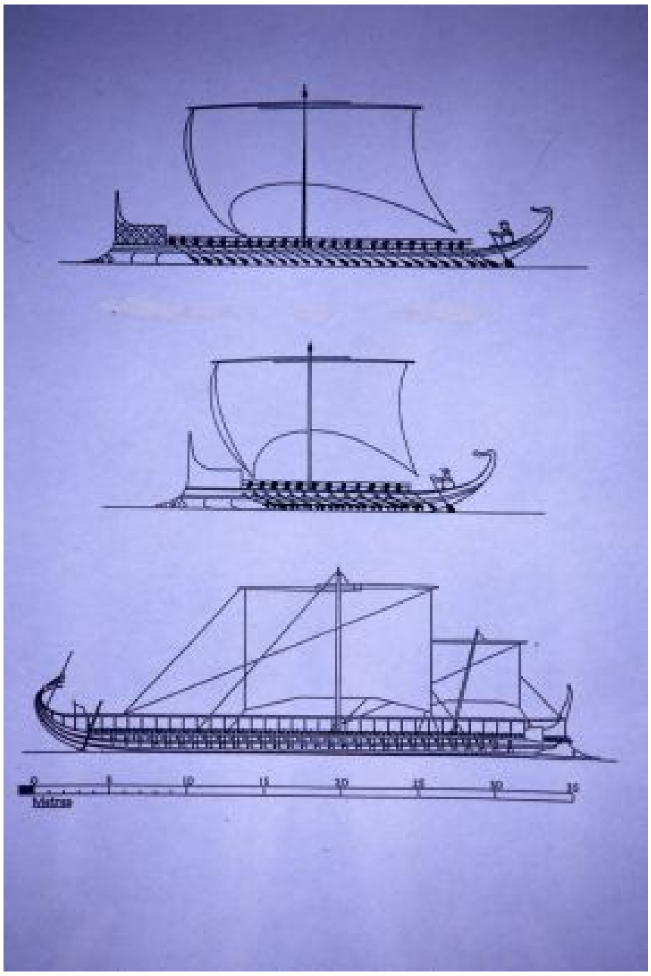
Lectures before engineering societies are more usually about new developments. This one is decidedly retrospective, back to Classical Greece and its warships.

On structures of the Classical period, Vitruvius, a Roman, wrote ten books on architecture, building and military engineering between 30 and 20 BC. He mentions ships but unfortunately in little detail. What we would now regard as useful written information about ships in the past, as about other structures, is indeed rare. Representations are decidedly unreliable as regards essential proportions. The art, concepts and mental stock-in-trade of constructors of all kinds in most of the past seem not to have been valued or considered of much intellectual interest by the writers and elites of their societies, in spite of the scientific and technical achievements of the Greeks, Romans, and Arabs, not to mention the Chinese.

It is therefore not so surprising that 'rude mechanics' tended to keep their knowledge to themselves. Lack of theoretical models of their artefacts, added no doubt to personal penalties if they caused disasters, very sensibly made them to stick to rules based on experience of what worked, no matter why. All this makes reliable replication of ancient artefacts, particularly if they are mechanisms and actually have to operate, a tricky business.

Having, as it were, very briefly commented upon the past technical scene, it is time to introduce my subject, the ancient Greek trireme warship of the fourth century BC (see picture of reconstruction, left). It is a rare and interesting exception technically in that there is a useful amount of evidence about it. Surviving Athenian records and literature provide enough clues to show that it was a finely made and extreme design of ship.

Triremes had nevertheless been a puzzle since the Renaissance when classical texts began to be studied again by scholars. It was clear from that surviving literature that the trireme was the main instrument of naval power in the Mediterranean during the fifth and fourth centuries BC, an important period historically. The crucial naval battle of Salamis between the Greeks and the Persian Empire was fought with well over a thousand triremes. Athenian supremacy at sea afterwards enabled that city state to flower culturally and leave a legacy that still influences the Western world today.



Though later superseded in the battle line by much heavier ships armed with troops and missiles, triremes, very possibly of designs varying as time went on, served in the Roman navy and they are mentioned by Tacitus operating in the Netherlands in the first century AD. From the first mention of it in the seventh century BC, that gives the trireme as a type of warship an operational life as long as eight centuries — a period equal to that from Magna Carta to the present day!

The trireme may have been important historically, but it itself remained a mystery. What exactly was it? Why was it developed? How was it built? How did it work? What could it do? A reconstruction of an Athenian trireme has now been built and operated to find out, and a very instructive project it has proved to be. The ship was built in Greece under contract from the Hellenic Navy and it belongs to that navy. The project itself has been reported and published in this country.

It was clear from the literature that triremes were evolved from earlier warships (facing page), the top two shown here, at the top the 50-oared single-level ship and in the middle the later two-level 50-oared ship. The trireme represented an astonishingly large step from the middle ship. Its cost to build and maintain would have been four or five times as great and, more importantly, crewing costs would have been four times as great. Remember these crews were paid, not slaves. Why make such a big step? What was the naval advantage? There must have been one, but surviving literature is silent. However, as a naval architect one can surmise that it lay in greater sustainable speed, suggesting the need to project naval power and to be able to deal with pirates which were endemic in the Mediterranean. What remains surprising is that such an advantage was enough to make the much greater cost worthwhile, but obviously this advantage, and possibly others not yet identified, were sufficient for the trireme to have been the standard ship of the line in the Mediterranean for about three centuries.

One has to bear in mind that warships had grown from small 20- and 30-oared ships built mainly to carry troops for fighting ashore. Conflicts between warships led to the use of rams to put enemies out of action, and the better manoeuvrability of shorter ships in battle could well have been behind the idea of putting the same number of oarcrew on two levels. In rate of turning and acceleration, both valuable in a ramming battle, the trireme was no better than the two-level 50-oared ship, which actually continued in service alongside triremes for some time.

Scholars had been arguing about the trireme for nigh on five centuries, but it needed the discovery of two sunken wrecks of oared ships with long hulls, and the application of our present knowledge of physics and materials, in short engineering or naval architecture, to the ancient evidence to arrive at a usefully close solution to the puzzle. It happens that surviving evidence about the Athenian version of the trireme, at least, includes sufficient numbers and measurements to lead to the possibility of a reconstruction which would be worthwhile without necessarily accurately replicating every detail. For organising that evidence into a useful form we have to be grateful mainly to the late John Morrison, a Cambridge classicist who published his book, *Greek Oared Ships*, in 1968. I shall not however go into the details of that evidence here because that would need a lecture to itself.

If the design of the trireme had been a fairly relaxed affair, comfortably within physical limits, no one particular reconstruction might have been worthwhile because there would have been room for too much choice among several possible designs. But, like so many weapons in all ages, the trireme turned out to be a design at the limits of practical possibility. Keeping to the numerical evidence while designing a ship, which would be satisfactorily stable, strong enough and likely to perform well enough under oar or sail, hemmed in the main dimensions and arrangement of parts within close limits. The ship had to be of the authentic build and shape demonstrated by the very few other remains of long, oared Mediterranean ships to have been excavated. No wrecks of actual warships have so far been found because warships would not have sunk, being unballasted and

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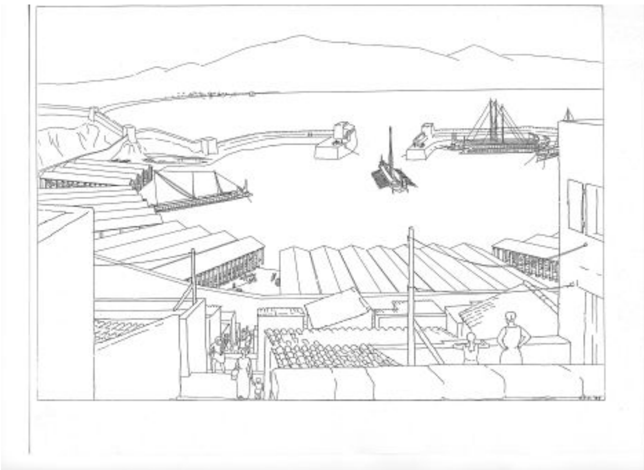
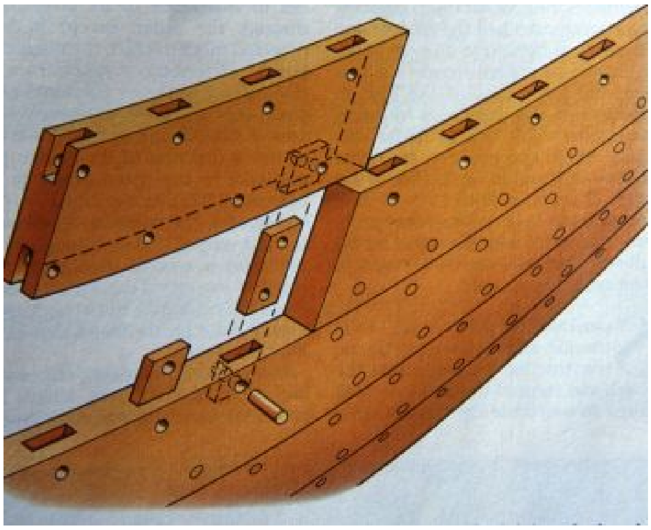
made of timber. The one found in the 1970s near Marsala, Sicily, was probably a fleet supply ship and it had been carrying ballast. To sink, a wooden ship has to be carrying enough cargo or ballast to raise its mean density above that of seawater.



The hull of the reconstruction had be narrow enough to fit inside ship sheds in Piraeus where Athenian triremes were kept (above). Their foundations have been excavated and measured. The hull had to house an oarcrew of 170 men, each able to work one oar effectively while sitting at each of three levels in the ship, one level above the other. That imposed limits of waterline breadth, displacement and height of centre of gravity to obtain sufficient stability for oarsmen to work properly. Oarsmen do not take kindly to rowing in rocking boats.

The recorded length of the oars, the likely speeds of triremes, consequent oar gearing and the maximum practicable slope when blades were immersed, as well as stability, limited the height of the top of the hull above water. The hull was therefore very shallow for the length necessary to house the oarcrew. The waterline length was more than 13 times the depth of the hull. That ratio is about twice that allowed by Lloyd's Rules for wooden ships in the 19th century unless they were strapped with iron to cope with hull stresses at sea. The hull strength of the trireme seemed therefore problematic and on the limit for a wooden hull. I should mention that its underwater form is as slender as that of a modern steel frigate.



Here, three more pieces of evidence came into play to enable the hull to be both strong enough and authentic. First, the planking of all ships in the Mediterranean up to about the fifth century AD was fastened, one plank to the next, by pegged tenons set into their edges (above). This was then the usual way carpenters joined planks side-by-side. But by resisting any shear stresses causing planks to slide upon each other, plank tenons, if tightly fitted, could make the planking into a shear carrying shell in the modern sense, besides holding the plank seams together tightly to be watertight. In ordinary latter-day wooden ships, shear between planks is transmitted only by the friction of caulking rammed tightly into the seams. In the wrecks of the ancient long ships which I have already mentioned, the tenons are thicker and more closely spaced than in the shorter and generally smaller merchant ship hulls, wrecks of which have been excavated in large numbers in the Mediterranean. As fitting these tenons, if they are to resist shear in the shell stiffly, has to be exact (probably by a simultaneous crush-fit) they must have involved a lot of careful fitting work, so it is most unlikely that tenons in long ships were closely spaced for no good reason. Indeed, calculations bear this out, though they are necessarily rather simplified in being applied to wood. The maximum likely shear stress in the shell of the trireme hull indicates that tenons had to be closely spaced to prevent crushing when the ship was on the crest of the worst wave she was likely, by intention at least, to encounter.

To design the reconstruction the height, from trough to crest, of this wave had to be judged. I decided upon a wave of length equal to the waterline length and 1/40th as high which I thought would be about the maximum in which the upper two levels of oars could be rowed, and so about the worst to which a commander would expose the ship to before running for shelter. That height relative to length is only about half what is normally taken in designing ships today. Nevertheless a total of not far short of 20,000 tenons were needed in the hull to be likely to withstand that reduced wave.

A wooden shell of planks tightly fastened together with tight seams would expand across the breadths of the planks when wet and so stretch the transverse frames crossing them. That action has been known to break frames. In ancient Mediterranean ships, however, transverse frames were fitted in three tiers overlapping each other, but not connected to form continuous frames. Frames were also bolted to the shell by copper bolts driven up pine dowels whose relatively soft timber would crush fairly easily to allow the shell to slide a little on each relatively short piece of framing.

The second piece of evidence concerning strength was about great ropes, 47 mm or so in diameter, and nearly twice the ship's length. Two were rigged in each ship when on active service, and two more were carried aboard as spares. A decree laid down the number of men required to rig them in a trireme. The inscription about them is unfortunately damaged, but the space occupied by the missing number indicates that it was probably 50. They were important pieces of kit because their export from Athens was a capital offence.

It seems most likely that these ropes, *hypozomata* in Greek, that is undergirding, acted as tensioned tendons in the hull girder. On the wave being considered, the maximum bending stresses in the hull, amidships, would be, in newtons/mm^2, about –6.7 in the keel and +5.7 at the top of the hull. These would be generated when the ship was on the crest of a wave when the loading on the hull would cause the ends to deflect downwards, known as hogging. Now, Sir William White, an eminent naval architect of the 19th century (a time when both bending and shear in ships had been understood and when wooden ships were still in common use), stated that a tensile stress of only +2.9 was allowable in wooden ships' structure containing scarfed joints, while if there were no scarfs where the structure was heavily stressed, +4.6 would be allowable. Plainly the trireme was heavily stressed in bending as well as in shear. If the *hypozomata* were rigged fore and aft from end to end along the middle line of the hull just under the main beams (after all, they had to be under something!), and tensioned to 13.5 tonnes force, that maximum stress would be reduced to White's allowable level for structure without scarfs. On this point, there is a third piece of evidence, a helpful reference in the literature to the need for long timbers in building warships. One may surmise that such timbers would have been used to form the upper edges of the hull to avoid scarfs where bending stresses were greatest.

Rope tendons had been used in ships before, for instance in ancient Egyptian cargo ships where they are shown in bas reliefs looped under each rising end of the hull and then arching up over struts to form a hogging truss to prevent the ends of the hull from dropping. Hogging trusses have more recently been parts of the design of several types of shallow hulls, for instance Mississippi steamboats and ferries more generally. The trireme's *hypozomata* was more probably a straight tendon. Plainly that could only impose a horizontal thrust on the ends of hull and affect longitudinal horizontal, that is bending, stresses. It could reduce bending stresses in hogging but do nothing to reduce the shearing component of stresses generated by that loading. As is usually the case in ships, hogging is more severe than its opposite, sagging, when in the trough of a wave.

How the *hypozomata* were tensioned remains a mystery. In the Egyptian ships the hogging trusses were plainly tensioned by twisting them together, making what is often called a Spanish

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Windlass. That is not a very efficient mechanism because in twisting the ropes they are bent into helices, so that bending stresses are generated which are about as great as the direct tension which is desired. However, it is clear enough that that was what the Egyptians did. In latter day sailing ships standing rigging was invariably set up by three-fold purchases in which the blocks were without sheaves but greased. They are called deadeyes. I think that method is more likely to have been used in triremes also. Natural fibres relax under sustained tension, so they would have had to be tightened repeatedly, just like sailing ships' hemp standing rigging. That would explain why a spare pair of ropes were carried in triremes, presumably to replace the ropes when they had stretched so much that they could be tightened no more. They might then have recovered somewhat but they would probably have been shortened for further use by refitting the deadeyes. That also was done in latter-day sailing ships when mast shrouds had stretched so that the deadeyes were in contact, 'two-blocks' as it was said.

In the reconstruction, natural fibre ropes could not be obtained in Greece, certainly not in the required size, nor could synthetic fibre ropes with about the same elastic modulus as hemp, so we had to make do with a steel rope. Being much stiffer, and being above the flexural neutral axis of the hull, its tension varied as the hull bent on waves, whereas a natural fibre rope would have exerted a substantially constant tension. That variation in the reconstruction was rather alarming because one could not be sure how big the tension would become on an exceptional wave. On that account I settled for a tension in still water of 9 tonnes force. If one of the timber anchorages were to fail, the steel rope would have snaked down the hull. The photo opposite is of a view down the hull where there were 54 rowers sitting on either side outside the pillars. The rope ran down the middle just under the gangway overhead. The pairs of pillars would have protected rowers but the rope was also securely triced up to the beams at a number of points as a further precaution.

This slide also shows the hull beams and that the hull was structurally speaking an open trough. Open hulls tend to have low frequencies of torsional vibration in the fundamental mode and it seemed to me that it would be most undesirable for that frequency to be within the range of the striking rates of the oars. Without any evidence to support it, I therefore arranged stiff horizontal knees at the ends of the beams near the middle line of the ship, crossbracing between the beams in an effort structurally to close the open trough to make the hull behave more like a tube or decked hull. The idea was to force the beams, when the hull was twisting, to be bent into three-noded curves and hence be much stiffer. The torsional frequency of vibration of the loaded hull is probably about 70 cycles a minute, well above the maximum practicable rate of striking with the oars. In any case, no torsional oscillations were noticeable during rowing trials. Here, it may interesting to note that the 1829 Oxford Boat Race boat, now in the Henley Museum, proved to have become alarmingly floppy in torsion when rowed by its second owners in Scotland, and photographs of the replicas built and raced recently show additional internal longitudinal aluminium sheet triangular spines set between keel and thwarts, presumably to stiffen the hulls torsionally!

I have thus far spoken briefly about what the trireme was, probably why it was developed and more fully about how it was built and some of the structural engineering concepts involved.

Now, how did it work and what could it do? These questions called for some experimental archaeology on quite a large scale, maybe the largest archaeological experiments yet carried out. A trireme needed 200 men besides a captain to man it — 170 oarcrew in three classes, ten soldiers, four archers, three officers, a helmsman, a shipwright, a piper and ten seamen. Nowadays that would be enough to man a frigate! And Athens at one time had about two or three hundred triremes, so at least about 40,000 men were trained and available at need to man them. The sea trials of the reconstruction, *Olympias*, were quite a large operation, the cost of which would have been prohibitive unless the Hellenic Navy had generously provided accommodation in some barracks at Poros, 40 miles south of Athens, and unless sufficient oarsmen and women were willing at their own expense to come to Greece and feed themselves for the trials periods of two weeks in August.

Making *Olympias* work under oar or under sail was quite an experience. No one in our crews had rowed in anything larger than an eight, nor, I guess, had any of them taken part as a team in a large scale co-ordinated manual job such as navvying on a railway cutting or embankment. But here (below) they are in their places on board. Oar blades were only a foot apart in

the water, so synchronism in rowing was essential. Timing and clashing of oars were pretty terrible to begin with, and in motion the ship was likened by one rowing master to a spastic centipede. However, after about two days things improved quickly and so did morale. The crew could speak of nothing else in the local tavernas but this extraordinary experience, they said of a lifetime, and their own achievements.

We were particularly keen to explore the performance of the reconstruction under oar in view of the trireme's reputation for speed and manoeuvrability. We also tested her under sail and having found that she handled well under sail, a most important aspect of operating the ship, we concentrated on the oars. It was in any case necessary to avoid boring our oar-crews by using them for too long as mere ballast. A very few passages under oar are recorded in the literature. Those that were mentioned by ancient historians, were probably recorded because they were outstandingly memorable. The most remarkable of these was one from Athens to Mytilene, 184 sea miles, made non-stop under oar by a volunteer crew almost certainly in a selected ship, to countermand an order to execute all the men captured in that city. Thucydides's description is however baffling. One has to remember that the concept of speed as for instance miles per hour or at sea, knots, did not then exist. Distances at sea were at that time spoken of simply as 'of so many days' voyage', and times of day are rarely mentioned. However, it can be inferred from Thucydides's account that the 184 sea miles were covered in about 30 hours, at therefore an average speed of about 6 knots. If that is right, then such a ship and crew could have reached about $9^1/_2$ knots in a short sprint, say of two minutes.

At $9^1/_2$ knots the effective propulsive power required by the reconstruction is 30 kilowatts. Efficiency of rowing is not easy to measure but measurements during our sea trials indicated an efficiency of 50 to 60%. That leads to an estimate of the average power output per oarsman or woman of 300 to 350 watts. In the reconstruction we reached only 8.5 knots over a period of two minutes, calling for an effective power for the ship as a whole of only 20 kilowatts, a shortfall of about 30%.

Were the figures deduced from Thucydides wrong? Or was the modern crew not up to the

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The 18th Jenkin Lecture, 1 October 2005: Some Engineering Concepts applied to Ancient Greek Trireme Warships cont.

(Continued from page 11)

standard of that of the Mytilene ship? Or is there something wrong with the reconstruction? Probably a bit of all three!

Thucydides writes that on the passage to Mytilene some oarcrew slept and others pulled, turn and turn about. That was almost certainly a good scheme but it complicates calculations. How long were the turns? Also, how smooth was the sea? And so on. The trireme reconstruction was quite new to the modern crews, and they were used only to rowing on rivers and on sliding seats. Not all were as fit as they might have been, nor were they used to the heat of Greece in August. Anachronistically, a fair proportion were women who had the advantage of fitting the ship better than the men who tended to be too tall for the trireme but suited to sliding seats, but the women were not so strong. The ship was built with oars spaced two cubits apart fore-and-aft in accordance with Vitruvius. But which cubit? There were several ancient cubits to choose from!

On that very important dimension in any oared craft, we had decided upon the so-called Attic cubit of 0.444 metre. We are now fairly convinced that that was a mistake, particularly since an unfortunately rather belated publication of a metrological stone of the right period from Salamis, which indicated a more likely cubit of 0.490 metre, 10% larger. That could have made a big difference not only in allowing longer strokes to be made, an important factor in achievable power in rowing where water is smooth enough to allow long strokes. More of the crew could have rowed, as they should, with straight arms. It would also have allowed the heads of the oarcrew in the lowest level to pass under the hull beams freeing them to make much longer strokes. That in turn, because all levels had to take the same length of stroke, would have allowed the whole crew to do the same. Such a change in the spacing of oars could well have eliminated the shortfall of 30% in sprint power and gone far to replicate the speeds probably achievable by the best ancient triremes.

We need another reconstruction! We would also, from experience with *Olympias*, cant the oarcrew so that the butt ends of oar handles would pass beyond the hip of the next man aft, enabling the stroke to be even longer. Oars would be immersed almost entirely forward of athwartships, as indeed they were in the later medieval galleys and are today in sport rowing craft. Our unfortunate choice of the Attic cubit in the reconstruction has a lot to answer for!

Manoeuvres in battle involving for example parts of the crew rowing and others stopping, backing down, or even pulling their oars inboard must have been ordered by hand signals because any sounds would have been drowned by general noise. The rowing master could be seen by at least the after half of the top two levels of oarcrew and the bottom level took their time from these. It is very likely that there was someone else near the mast amidships, where he could be seen by the forward half of the oarcrew, to duplicate the signals by the rowing master.

In the sea trials we measured rates of drift in the wind, and hence the wind resistance of the ship. We also carried out turning circles and a zig-zag manoeuvre to test the ship's stability in motion ahead. We have probably collected enough data on trireme manoeuvres to enable them to be simulated by computer with one of the existing programs on ship manoeuvring. If that proves possible we could go on to simulate tactics by squadrons of them and indeed whole fleets to explore some past battles and so learn more about the realities of naval warfare under oar in Classical times.

To end, may I say that the reconstruction *Olympias*, which is owned by the Hellenic Navy, is on public display at New Faliron, between Athens and Piraeus next to the restored 1910 heavy cruiser *Averov*. For anyone wishing to go further into this project, there is also a book about it entitled *The Athenian Trireme*, published by the Cambridge University Press.

Submarine Cables in 2006

Lynsey Thomas

My father would tell you that my interest in telecommunications began when I was a teenager and spent many a day holed up in my bedroom with the phone glued to my ear; this is not *strictly* true. During my days of studying at Balliol (1995–9) I was fortunate enough to receive a sponsorship from the company formerly known as Cable & Wireless Marine and due to this involvement I started to develop an interest in fibre optics and its use in telecommunications. Hence after I went down I sought out a career in submarine systems engineering. And what amazed me then, and still continues to amaze me, is the lack of general knowledge that exists regarding this fascinating field which we the Internet generation have come to be so dependent upon. For example, if I ask you 'what is the first thing that comes into your head when I say the word telecommunications', what would you say? Perhaps those of an older generation would mention copper cables and analogue signals, youngsters could probably list a number of applications and wax lyrical about the benefits of Voice Over IP. But if you ask anyone in the industry you could get any number of answers ranging from the complexities of sub bottom profiling to the latest Forward Error Correction code developed to aid transmission. 'Qué?' I hear you cry, and thus my aim to enlighten.

Fibre optics have been used in submarine systems since the late 1980s and such systems are installed worldwide for the purpose of carrying telecommunications traffic both nationally and internationally. 'Popular' routes such as the Atlantic can be home to over ten operational fibre optic cable systems. This may not sound like many but when you consider that each system costs hundreds of millions of dollars to install you begin to understand the scale of the business. Furthermore if you consider that upwards of 100 million simultaneous telephone calls can be made down an individual cable, which in deep waters are typically 17 mm in diameter, the fibres within which will have a diameter of around 245 μm, you can only imagine the technology progression in the last 15 years.

As a case study I would like to consider the example of the Apollo Submarine Cable System, currently the most advanced of the transatlantic systems. Apollo was built in 2003 and consists of two legs, a Northern cable route (UK–US) and a Southern cable route (France–US), shown in Figure 1.

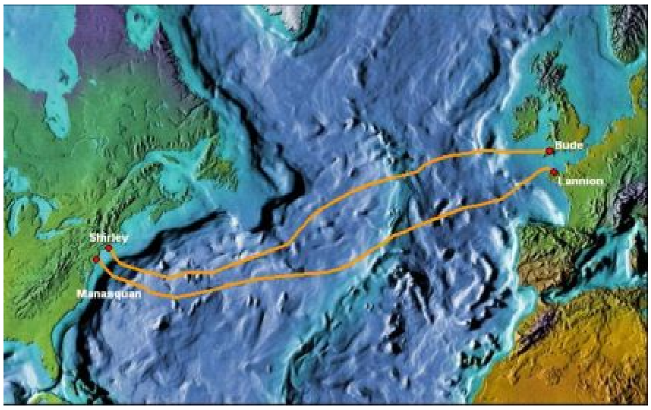

Figure 1: Apollo Submarine System

Each cable route constitutes four fibre pairs (a pair is made up of a transmit and receive fibre), with each fibre capable of carrying 80 channels of 10 Gbit/s traffic, giving a 3.2 Terabit/s capability per leg. The equipment used to transmit and receive the signal is known as Submarine Line Terminating Equipment, SLTE, and in the case of Apollo the SLTE transmits the 10 Gbit/s channels with 50 GHz spacing. That means that adjacent channels are 0.4 nm apart, phenomenal stuff.

The mechanical aspects of submarine systems are equally as impressive. The cable has to be designed such that it is capable of protecting the fibres during installation and once on the seabed. External aggression is made up from many factors, fishing gear and ships anchors being the main culprits. Historical studies show that in the North Atlantic, for example, over 50% of external aggression faults in cable systems are caused by fishing, hence, as you can imagine the relationship between the telecommunications industry and the

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Submarine Cables in 2006 cont.

(Continued from page 13)

fishermen is one which needs constant maintaining. Additionally there is natural aggression from landslips, earthquakes and sand waves exposing areas of burial. Subsequently submarine cable is designed with high tensile strength steel wires protecting the polyethylene insulating layer that encases the fibre core. In the case of Apollo a specially designed cable was deployed with improved crush resistance to withstand impact with fishing gear and other such obstacles.

Marine activities typically commence with a Desk Top Study, which is a paperwork exercise to review a proposed cable route. One of the key issues to be addressed early on in a project is to select a landing site. Landing sites need to be in areas where it will be easy to protect the cable, straightforward to pull it on to the beach, with good proximity to an area which could house a cable station (where the equipment will be installed) *and* it is unlikely that there will be a lot of external aggression: such as a beach. Not surprisingly the tourist boards of coastal towns are none too keen on their beaches being taken over by a bunch of hairy engineers and their noisy toys, which rules out the summer months for any landings. A further area that causes constraint is that of permits and licences. Many a project has been delayed due to the permitting process and its requirements. The protection of rare and often obscure plants and animals, the bog turtle being a prime example, has cost telecom owners a pretty penny or two.

Following this study a survey is carried out to refine the proposed route and determine how much burial will be required, and is possible. The survey results will provide a map of the contours of the seabed and details of its geology. All this data is used to determine the route of the cable. The cable should be laid such that it follows the contours of the seabed, hence enough slack must be built into the system such that there are no suspensions; if you can imagine the cable suspended between two bodies such as rocks, as the cable moves and sways due to transverse currents it will rub at the contact points causing abrasive damage. In shallow waters or areas of danger the cable should be buried as much as possible. Burial is typically performed using a plough (hybrid of the agricultural plough) towed from a winch on the back of a ship. Burial depths are typically around 0.6 m, with further burial possible, and necessary, in soft silty areas. Ploughing is a careful and slow process that calls for vessel speeds as slow as 0.5 knots.

Marine installation operations are often split into shore end works and the main lay, depending on how easy it is to get the installation vessel close to the beach. The completion of shore end operations is also a complex process: the cable is floated with buoys and then attached to a pulling line, which in turn is attached typically to a JCB on the beach. Once the cable has been pulled into place divers will swim out and cut off the buoys and then guide the cable into its seabed position. For the near shore areas that are sandy, divers will use jetting tools to bury the cable.

After this operation is complete, the main lay will commence with plough burial up to 1000–1500 m water depths, obviously dependant on how much burial is possible. After the plough's work is complete the cable will be directly paid out of the ship with the necessary slack, determined during the survey, at speeds of around 4 knots. In the case of Apollo the Northern link is approximately 6200 km and the Southern route is slightly longer at 6500 km. Marine operations lasted approximately six months. It is worth noting that much of the enjoyment factor when working on marine operations is based on i) what time of year the marine operation is being performed and ii) what part of the world the operation is taking place. I myself have been fortunate having spent three months in the Pacific installing the first fibre optic link between Fiji and Hawaii. Unfortunately shortly after completing our shore end works a military coup broke out in Fiji and for a while the only communication out of the island was coming through the cable we were actually laying.

Another key factor of modern fibre optic systems that we have not touched on is optical amplifiers. As channels traverse through the fibre optic core their power is attenuated and subsequently there is a requirement to amplify the signal at regular intervals, typically around 50 km. Historically it was necessary to turn the signal back to its electrical form, perform the amplification and then convert back to the optical domain, all done using a large and cumbersome piece of equipment known as a regenerator. Luckily a bright spark discovered that by exciting doped Erbium fibre (Er^{3+}) it was possible to amplify the signal in its optical state, thus developing the optical amplifier or repeater. As you can imagine this was a fantastic advancement as the less electronics that you have on the seabed the better. Think of how much you grumble when you have to return something to Currys, now imagine chartering a vessel to sail 2000 km out to sea to pick up a repeater from 5000 m depth of water in order to fix a widget — best avoided at all costs.

Unfortunately my time is up before I can enlighten you on the impressive progress in SLTEs and other terminal equipment. There are now Forward Error Correction codes that far exceed standard Reed Solomon codes, allowing for a larger number of errors to be corrected on each channel and hence give extra margin to the Power Budget of a system. Developments in fibre properties have allowed higher output powers to be transmitted from terminal equipment without the onslaught of non-linear effects. Transponder cards are now manufactured to be fully tuneable across a range of channels, allowing operators to key in a required wavelength and the lasers within the transponder will immediately shift across the band. Only when we think that as recently ten years ago cables were carrying 140 Mbit/s over one channel can we truly appreciate the advances in this industry. I look forward to the next ten years.

Figure 2: Deployment of a Repeater

Dr J D Todd

Joe Todd was successively, from 1942 onward, an undergraduate here, a DPhil student, a member of the academic staff and engineering tutor at St Edmund Hall. He will be well remembered by those who were here any time from the 1950s to the 1980s. After spending several years of retirement at Abingdon, he died in February 2006. The following tribute was given at his Memorial Service on 13 May, by Basil Kouvaritakis, his colleague at St Edmund Hall.

Despite his very affable and sociable public persona, Joe was also a strong private family man. This, combined with our short overlap (Joe was my senior engineering colleague at Teddy Hall for seven years) makes the honour of giving an address to celebrate his life rather difficult. Difficult, not because of the lack of superlatives with which to pay tribute to his many virtues and facets of life. Difficult, in terms of not knowing enough about an important aspect of his life that belongs to Peggy and his family alone.

Joe's Oxford story begins in 1942 when he came up to read Engineering, a course he had to interrupt to do his military service. He returned to complete the course, do a successful doctorate, and end up being appointed to a lecturership in Engineering Science. At the time, Engineering dons did not hold fellowships, and when the university first realised this anomaly, Joe was remarkably one of the first to be appointed an engineering college tutor. The reason why this is remarkable is that over Joe's years as tutor, engineering at Oxford changed beyond all recognition. The strength of it now (both at college and department) is, in no small measure, due to the energy, enthusiasm, and inventiveness of people like Joe. When first appointed, he was given a small room (currently used as a kitchen) in the Jenkin building, even though at the time he was the effective senior administrator. But this was not for long: the department expanded massively starting with the erection of the Thom building that was overseen by Joe and few of his immediate colleagues. The same happened in college with the construction of the Kelly and Emden buildings, the SCR, JCR, and the raised quadrangle. Needless to say, Joe served on the committee that directed this enormous expansion of the Hall. His expertise with concrete came in handy. There are rumours that he proposed an innovative, albeit somewhat eccentric, test for the strength of the upper quad; it involved the use of a swimming pool carrying lots of water. He built up the engineering numbers at Teddy Hall to such an extent that a second (and latterly a third) Engineering Fellow was appointed. He had a talent for gaining the trust of schools. His exceptional skill at building good contacts meant that Teddy Hall, frequently, had such an excellent crop of applicants that the Hall would export (to other colleges) our surplus engineering candidates. There was nothing nepotistic about his approach to admissions: the overriding principle was academic merit. So, for example, when I got into difficulties with one of our candidates who whipped up a story in the national press about Teddy Hall turning the tide against sportsmen, Joe was an absolute rock, providing the much needed support: Joe's position was that we judged the candidate on his academic merit and that alone.

Many students may have mistaken Joe's kindly attitude for a weakness but far from it, he was firm, principled, and fiercely fair. He enjoyed a wonderful rapport with our college engineering students. And they demonstrated clearly their affection for him, leaving me feeling somewhat envious, during the end of year dinners. I tried to pretend that this was due to my being a bit of a hard task master, but the truth of the matter is that Joe made them work just as hard while still managing to cut a fatherly figure amongst our women but also our men students. I had a similar story from another colleague who felt Joe outshone him, this time as a tutor at a women's college (we are going back some years here). This other colleague was already a successful tutor at a women's college and recommended Joe to Lady Margaret Hall, only to find out that, in no time, Joe's reputation had overtaken his own. Joe was a superb college tutor, but he left his mark in the department as well. He was one of the terrible three (Howatson, Lund, and Todd) who wrote the students' bible, the dreaded but extremely successful data book known as HLT, and of course he also authored a definitive undergraduate textbook on Structures. A now retired engineering colleague, not known for his hyperbole, and who as a student attended Joe's lectures commented: lucid, audible, coherent, to the point, and taken at just the right pace; learning the subject was a pleasure.

That last attribute was key to Joe's interaction with all of us: whatever he did, seemed fun. He never shirked from doing whatever was needed to get the job done (pleasant or unpleasant), but he did it with infectious enthusiasm and the fun element was never out of sight. So for example, college office found Joe's long stint as Admissions Tutor to be challenging, but always rewarding. Apparently, Joe was the only Fellow to apologise, whenever he felt he was in the wrong. He would exact high standards, but would do so in a convivial way — often matching his generous spirit with the odd bottle of wine. The College Office described him as a private, thoughtful, and lovely man. And a lovely man he truly was, accepting others as they were; using his natural canniness and energy to change things for the better; but also accepting opposite views and endorsing decisions, even when these were against his considerably well informed instincts. His excellent understanding of the college's and university's workings served college well, and in particular during Joe's Pro-Principalship and Vice-Principalship.

His non-academic contributions were multifaceted, starting perhaps from the boat club where as a captain he did much to build it up, and in later years offering his services to the Oxford University Engineering Society. He left a distinct legacy with two innovations: the Todd formula, or modified Todd formula as is now known, which formalised the proper balance between fellows' and college's needs. And the nonlinear pay scale (endorsed by college for many decades now) which provided an ingenuous and compassionate way to compromise between the impoverished younger fellows and the relatively better off old-timers. And in between these, there is an assortment of other activities such as support of the Thames Vale Youth Orchestra, which demonstrated his enormous energy and vision.

As an immediate colleague, Joe was an absolute model: he was utterly discreet, according me as much autonomy as I desired, but always being in the background to provide whatever help I needed. He respected me as a colleague, from my very early years (even when I first reported for duty in 1981 rather pathetically carrying a walking stick, arguably in an attempt to draw sympathy). His respect spurred me on to work for the college to the best of my ability. He did this by example and by a clear demonstration of his love and commitment to college both of which have infected me thoroughly. I could not have wished for a better colleague.

My Experiences on the Oxford-Princeton Engineering Exchange

Alistair Hann

When I arrived at Newark airport in early September 2003, it was the first time I had ever been to the USA. I took a bus from the airport to Princeton, and realised that I was really there and there was no going back. There had been months of preparation: a visa application, obtaining certification of immunisations, and paperwork for the university — finally I was there in the United States and it was really happening. My immediate impression was how big everything was: the cars, the buildings, the billboards — everything was much bigger than it was back home.

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My Experiences on the Oxford-Princeton Engineering Exchange cont.

(Continued from page 17)

My initial impressions of Princeton University were very positive. The university is very well funded and this is reflected in the quality of facilities available to students. The electrical engineering laboratory and computer facilities were excellent, the libraries easy to use and good to work in, and the sports facilities outstanding. After a little while the novelty wore off and I found it difficult to adjust to such a large change in education system. After three years at Oxford this was always going to be a challenge.

In Princeton there are many courses run each semester and it is up to the undergraduates to select a set of courses to meet their needs. It was difficult to choose courses that had content that was new to me, yet were not too difficult. There was a large degree of flexibility in the choice of courses I could make, which meant I could choose to study areas of particular interest to me, and a number of things I was unable to study in Oxford. In my first semester I took Introduction to Artificial Intelligence, Image Processing and Transmission, and Hi-tech Entrepreneurship.

The approach to engineering, as a subject, was very different to that in Oxford. There was less emphasis on a mathematical and theoretical approach to engineering, and a greater concentration on practical skills such as lab work and programming.

For me, one of the greatest academic benefits was the ability to do a number of short research papers as part of my courses, in addition to my fourth year project that would be assessed in Oxford. These papers allowed me to pursue ideas I had, and completely restored my passion to do research. In fact, those papers inspired me to apply for a DPhil which I am now in the second year of doing.

I managed to get involved in a lot of extracurricular activities during my year in Princeton. A number of the Oxford exchange students joined an eating club, which was an excellent way to make friends as well as a supply of great sustenance. Although I had limited experience, I was able to join the university sailing team, and they provided excellent training. I sailed with them throughout the year and took part in a number of regattas.

I attended a training course, run by the college radio station, in how to DJ and I did a number of radio shows during the year. I also joined the university marching band, which was something that I definitely wouldn't have had the chance to do in the UK. When Princeton won the 'Ivy league' at basketball we travelled with the team to Denver and got to play at a first round game of the NCAA basketball championships. There were a number of other chances to explore the USA during vacations and I managed to visit Florida a number times, as well as travelling in Pennsylvania and New York.

I think it is most definitely the friends and people that shaped my year the most. I met a lot of people from very different places and learnt so much from them. In October 2005, after a conference in Connecticut, I had the opportunity to go back and visit Princeton. It was a chance to see friends who were still studying there, but also an opportunity to meet with my supervisors and those professors that taught me whilst I was there. Again, I was impressed by the friendliness of the faculty who were willing to take time out of their schedule to catch up on news, and offer me advice about my career and research.

I wish to thank the Rhodes trustees for providing the funding that made my year in Princeton possible. It was one of the best years of my life, and I learnt an incredible amount — about America, engineering, people, and myself — that I will always carry with me.

Alistair Hann is in his second year of a DPhil in the Signal Processing and Neural Networks Group, supervised by Professor Lionel Tarassenko.

http://www.robots.ox.ac.uk/~ahann/

Obituaries

Dick Tizard (1917–2005) read engineering at Oriel just before World War II, and spent the war as scientific officer first at the Royal Aircraft Establishment and later at the Admiralty Research Laboratory, working among other things on anti-aircraft measures, e.g. a gyroscopic gunsight. In 1947 he went to the National Physical Laboratory, where he was one of the early computer pioneers. In 1961 he was appointed to the newly founded Churchill College Cambridge as Director of Studies in Engineering, a post he held until retirement in 1984. He was also at times Senior Tutor and Admissions Tutor, and must share some of the credit for the rapid rise in Churchill's academic reputation. He was also a keen amateur sailor, a Life Member of Oxford University Yacht Club, and active in Cambridge University's so-called "Cruising Club" after moving there, as well as a member of several other sailing or yacht clubs. On a business trip to the Isle of Wight, he once claimed mileage allowance for travelling there on his own yacht.

(His obituary was in the Times of 15 December 2005.)

Sir Nigel Mobbs (1937–2005) read engineering at Christ Church 1956–9, but it was not really his subject, and he failed Schools. "I went to some of the lectures", he is recorded as saying, "but I didn't really pay attention". Nevertheless he joined SOUE when it was formed in 1988. His life's work was to run Slough Estates, an industrial property company founded by his grandfather. He is said to have run it with an iron hand. He expressed strong views on the poor quality of much industrial building in this country, and Slough Estates evolved some very innovative methods. He was director or chairman of several other companies, Chairman of the University of Buckingham and Lord Lieutenant of Buckinghamshire. He was also fund-raiser and for three years Treasurer of the Conservative Party. Someone described him as "a radical in conservative clothes".

(His obituary was in the Times of 24 October 2005.)

Personalia

Peter McFadden, **Chris Martin** and **Stephen Payne** have received HEFCE-funded Teaching Excellence Awards for their contribution to the teaching of Engineering Science.

John Allen and **Beatrice Annaratone** won an IEE "Innovation in Engineering" award in the Electrical Technologies category, for their improved radio-frequency plasma reactor, a tool used in the manufacture of integrated circuits.

Bhaskar Choubey and **Steve Collins** won an award for best paper at the 2005 Midwest Symposium on Circuits and Systems.

Jo Ashbourn has been given a Crucible Award by the National Endowment for Science, Technology and the Arts, which aims to promote interdisciplinary thinking.

Sarah Bond won a prize in the 10th Oxfordshire Science Writing Competition, for *An Incredible Journey*.

Alex Scotcher, son of the Department's Administrator, was a member of the victorious English Men's 4x200m freestyle swimming relay team at the Commonwealth Games in Melbourne last March. Father Chris was there to see them win their Gold Medal.

Lubbock Day Project Exhibition 2006

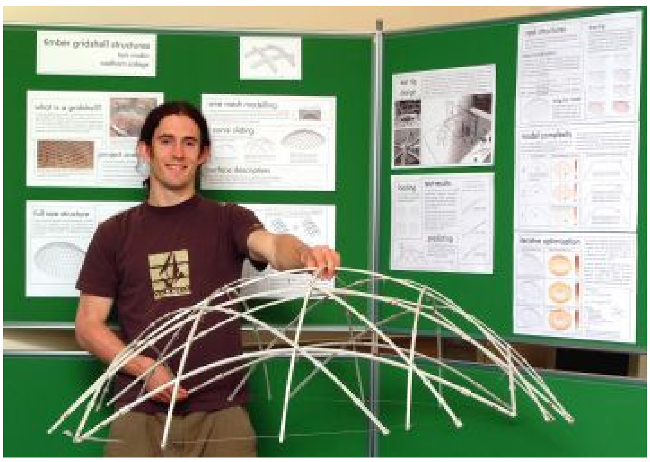
David Witt

There was a lot more prize money to disburse this year, which not surprisingly resulted in a much larger entry. In earlier years the prizes had all come from the limited funds of the SOUE, but in 2005 Sharp Laboratories of Europe, through the good offices of Sunay Shah (Keble 1994–8) gave us £1000 (£500 of it for the best electronic exhibit), and they did the same this year. This inspired three SOUE Committee members, Philip Jenkinson, Claire Edwards and Douglas Craig, to see what they could do with their own firms. The result was £1000 from Atkins, £500 from GlaxoSmithKline and £400 from QinetiQ, which with the £1000 from Sharp and a modest contribution from SOUE came to £3100.

As a result of this, and improved publicity, we had 29 entries, and the exhibition overflowed from LR3 into LR2. The exhibits covered a wide range of activities, and in particular the offer of a £500 Atkins prize for the best civil or structural engineering exhibit elicited seven in that area, far more than we have ever had before, and Guy Houlsby arranged for them to be exhibited for an extended period in the Jenkin Building. Also we had our first ever EEM exhibit, which won the QinetiQ prize (see below).

There were 18 prizewinning exhibits, of which those that won the five larger prizes are shown in the photographs below.

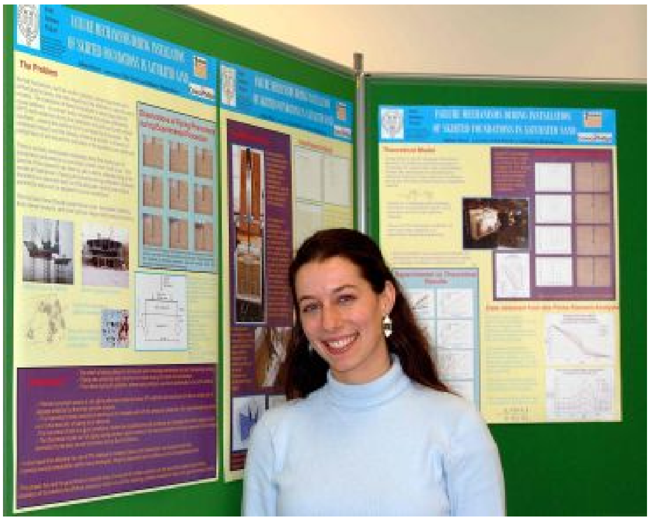
Tom Makin (Wadham) won the £500 Atkins Prize for a civil/structural exhibit with "Timber gridshell structures". These slender doubly curved structures have good strength/weight properties, and the project was concerned with their design and analysis.



Jonathan Shipley (Lincoln) won the £500 Sharp Prize for an electronic exhibit with his "Low-cost inertial navigation system", containing three gyroscopes, three accelerometers and a three-axis magnetometer, all integrated into chips, and a microprocessor to do the "strap-down" calculations.

James Houston (New College) won the £300 QinetiQ Prize for an exhibit working towards an innovative solution of an important problem, with "International charter — space and major disasters". The "Charter" has been designed so that data observed from satellites may be readily obtainable for emergency use after floods, earthquakes etc. The project was to assess how well it was all working, and what could be done to improve it.

Christopher Shucksmith (BNC) won the £300 Hardware Section prize for "Airborne surveillance system". This was in fact a computer-controlled airship with several electrically-driven propellers to control its attitude and position, photographed in free flight here in the atrium of the IEB (Christopher in the left foreground).



Juliana Meyer (St John's) won the £300 Poster Section prize for "Installation of skirted foundations in sand", investigating some of the things that can go wrong with a new method for installing the tower foundations for offshore wind turbines. Water and sand are pumped out from inside the "skirt", which then sinks smoothly into the space left vacant. That at least is the intention!

12 other prizes of £100 were awarded as follows:

Simon Banfield, St John's, "Transverse horizontal-axis water turbine"

Jane Buckroyd, Jesus, "Tunnel-induced settlement damage to buildings"

Katherine Clough, St Edmund Hall, "Lexicographic text analysis"

Twinsen Cui, St Edmund Hall, "Blood flow modelling"

Jamie Darling, St John's, "Switched-mode power supply using transmission-line transformer"

Emma Rann, LMH, "On-line analysis of sulphur dioxide in wine"

Steven Raw, Worcester, "Electromagnetic detection of buried pipes"

Michael Reed, Queen's, "Design of airborne video surveillance platform"

Joseph Rigg, St Peter's and Alan Yee, St Edmund Hall, "Solar sheep" (two exhibits on a lawnmower robot)

Robert Skuriat, St Catherine's, "Power electronic cooling research"

Andrew Welling, Worcester, "Solute transport for inter-vertebral discs"

David Wong, BNC, "Formation of 'freak' waves on the open ocean"

Two of these that particularly intrigued the writer (who *wasn't* one of the judges!) were Simon Banfield's water turbine for extracting power from e.g. tidal currents in shallow estuaries, and Robert Skuriat's exhibit (much more fascinating than his title suggested!) showing how vapour bubbles in boiling coolant could be used to circulate this coolant at high speed around cleverly shaped channels.

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Lubbock Day Project Exhibition 2006 cont.

(Continued from page 21)

The judges, who had to work very hard indeed to do justice to all these exhibits in the time available, were:

Douglas Craig, Balliol 1983–7, now with Qinetiq

Keith Crothers, LMH 1999–2003, now with Atkins

Claire Edwards, St Catherine's 1995–9, now with GlaxoSmithKline

Ben Hassell, Brasenose 1995–9, now with Cosworth

Jeremy Horne, Queen's 1992–6, now with BlueArc

We are very grateful to them, and to the sponsoring firms for their generosity.

Finals and Prelims Prizes Awarded 2006

The Examiners recommended the following awards in respect of Final Honour Schools in 2006:

Engineering Science Part 2

Maurice Lubbock Prize for best performance:

Paul R Thornton, St Edmund Hall

Edgell Sheppee Prize for excellent performance:

Katherine A Clough, St Edmund Hall

ICE Prize for best performance in Civil Engineering:

Charis H Taylor, St Hilda's

IMechE Certificate for the best student in Mechanical Engineering, and nomination to the Frederic Barnes Waldron Prize:

Benjamin WG Twiney, Hertford

IET Prize for outstanding academic achievement:

Ian R Webb, University

IChemE Prize for best performance in chemical engineering:

David W Lowe, Wadham

Best performance in biomedical engineering:

Rebecca Ford, Trinity

Babtie Prize for best project in Civil Engineering:

Thomas Makin, Wadham

IMechE Prize for the best project in mechanical engineering:

Alexander DS Critien, Corpus

IMechE Certificate for an outstanding project in mechanical engineering:

Andrew E Fawcett, Balliol

Prize for an excellent project in mechanical engineering:

Pok W Kwan, St Anne's

Motz Prize for best project in electrical engineering:

Jamie DC Darling, St John's

Ronald Victor Janson Prize for best project in electronic communications:

Thomas S Woolway, Hertford

Best project in biomedical engineering:

Jamie Condliffe, Magdalen

Royal Academy of Engineering Prize for excellent design in a 4th-year project:

Simon A Banfield, St John's

Rolls-Royce prize for an outstanding project displaying innovation:

Hassan Ahmed Jushuf, University

Engineering Economics and Management, Part 2

Maurice Lubbock Prize for best performance:

Ravindra Seeneevassen, Lincoln

Edgell Sheppee prize for best performance in an engineering project:

Brian MT Tang, Balliol

IET Manufacturing Engineering Prize:

Peter R Boal, St Hugh's

Engineering and Computer Science, Part 2

Maurice Lubbock Prize for best performance:

James A Cox, Worcester

Worshipful Company of Scientific Instrument Makers Project Prize:

Christopher D Shucksmith, Brasenose

Engineering and Materials Science, Part 2

Maurice Lubbock Prize for best performance:

Alexandra L Kay, St Hilda's

Engineering Science, EEM and ECS Part 1

Edgell Sheppee prize for laboratory or drawing office work:

James W Hume, Balliol

Gibbs Prize for best Part 1 project, jointly to:

David Adams, St Catherine's; David Carter, Wadham; Helen Davies, LMH; Matthew Greenhalgh, SEH; Adam Hunt, Lincoln; Kevin Jones, Mansfield; Man Ho Lam, Mansfield; Nauman Shah, Exeter; Matthew Watts, Worcester; Oliver Whyte, Wadham (Wireless information systems for medical networks).

and Alexander Bennett, Hertford; Sophie Bishton, Keble; Jonathan Dennis, LMH; Ross McAdam, Keble; Emily Northin, Keble; Owen Price, St Catherine's (SkySailor).

Royal Academy of Engineering Prize for best treatment of sustainability in a project:

Adam Davidson, Exeter; Richard Harrap, Exeter; Pharima Pongpairoj, Pembroke; Melissa Stansfield, Worcester (Production of bioethanol).

The Moderators recommended the following awards in respect of the Preliminary Examination:

Crown Packaging UK plc Prize for best performance:

Gareth Lott, St John's

Shell prize for outstanding performance:

Tuan-Anh Tran, Balliol

Revision of the Engineering Science Course

As Richard Darton says in his Head of Department's report, the subfaculty has "initiated a course review to ensure that our whole teaching programme remains competitive, attractive and relevant ...". The last major change to the course was in the late 80s, when it changed from three years to four. There have been changes in the details since then, but the basic structure is still recognisably the same. The course review committee will necessarily take note of feedback from current undergraduates, but the views of people who have completed the existing four-year course and then gone into the engineering profession might be still more valuable. If you have thoughts about what was good or bad in the four-year course as you experienced it, or suggestions for changes, why not send them to the Academic Administrator, Jane Frew (jane.frew@eng.ox.ac.uk), who will bring them to the attention of the committee.

One change that is already being implemented is to have much longer practicals than the two-hour ones readers will remember. More controversially, the practice of assessing practical reports on a short numerical scale, in use for about 20 years until it was dropped in the late 1980s, is to be reinstated.

Coursework modules, set up at the time of the introduction of the four year course, are still going well, and are expected to continue.

It is often said that there are two kinds of people: those who see a glass as half full, and those who see it as half empty. Engineers, of course, will see that the glass is twice as big as it needs to be.

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