Location and Timing

Knowledge Transfer Network

Pinpoint

The newsletter of the Location and Timing Knowledge Transfer Network

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Spring 2009

A signal for change

A consortium of UK universities has been awarded grants worth nearly £3 million to research possible exploitation routes of new GNSS signals.

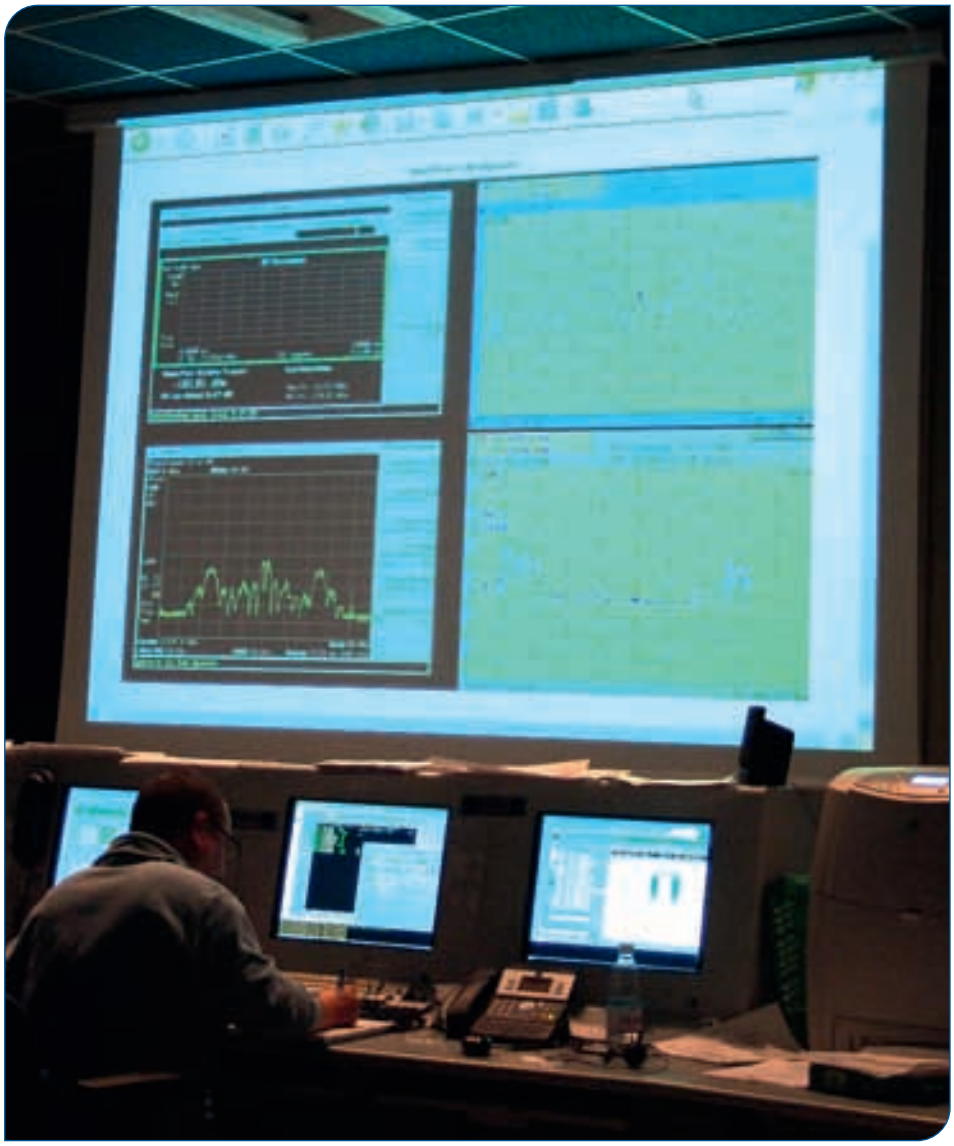


Image courtesy of ESA

A screen in the control room at Fucino displays the spectra of signals received from GIOVE-B shortly after the spacecraft began transmitting navigation signals.

A major re-think of the fundamentals of satellite navigation will have to take place over the coming years as 1960s-designed GPS satellites are replaced with up to date models with more sophisticated signal structures. Furthermore, other non-US global navigation satellite systems, such as Europe's Galileo system and China's Compass, are planned and Russia's GLONASS is also being upgraded. By 2012 we can expect more than 120 satellites to be transmitting highly complex navigation signals and this new research project is directed towards establishing the best way to exploit them – all the way through from receiver design to delivering positioning, tracking and navigation-based products to users.

The new signal structures will enable more accurate positioning outdoors, and the dream of reliable indoor positioning will finally become a reality thanks to the signals' penetrability. One of the consortium's lead researchers, Professor Paul Cross of UCL says that "A far better performance can be expected in the future - leading to the development of a raft of new applications including those in the emergency services and those to support critical infrastructures such as our rail and road systems."

UCL, Imperial College London, and the Universities of Nottingham and Westminster won the four linked grants from the UK's Engineering & Physical Science Research Council (EPSRC). Nine commercial companies and government agencies (Air Semiconductor, EADS Astrium, Nottingham Scientific Ltd, Leica Geosystems, Ordnance Survey of Great Britain, QinetiQ, STMicroelectronics, Thales and the UK Civil Aviation Authority) are providing in-kind input to the project totalling £2.2 million. The research project is being led by Professors Paul Cross and Marek Ziebart at UCL, Professor Washington Ochieng at Imperial College London, Professor Terry Moore and Dr Chris Hill at Nottingham, and Professor Izzet Kale at Westminster.

This project (known as 'Extending the Applications and Improving the Efficiency of Positioning Through the Exploitation of New GNSS Signals') builds on the legacy of a successful project called SPACE (Seamless Positioning in All Conditions and Environments), which was initiated by the Location & Timing KTN, and involved many of the same researchers. Professor Cross states that "The collaboration of four leading universities and nine of the major industrial and user agency partners makes us the largest group in the world tackling these problems."

Digital society doctorates

The University of Nottingham has won funding from the Engineering and Physical Sciences Research Council (EPSRC) for a new Doctoral Training Centre (DTC) in ubiquitous computing that will generate the scientists and engineers needed for the future of the UK.

The Centre, worth in excess of £8.5 million in funding, will help nurture the next generation of technological leaders. It will train the brightest postgraduates to tackle pressing global challenges and keep the UK at the cutting edge of scientific research.

The DTC for the Digital Society is particularly concerned with the areas of location-aware and ubiquitous computing in which millions of computers become embedded into the world around us. This is the most exciting and significant technology to emerge since the internet and promises to transform the way we work, shop, travel, learn, socialise and play. The DTC students will be at the heart of this revolution, exploring new uses of ubiquitous computing, creating new technologies, and studying their impact on people's lives.

Supported by the EPSRC and over thirty industry partners (including Nokia, Ordnance Survey, Location & Timing KTN, EADS Astrium, and Trinity House), the DTC will train a community of over 50 PhD students to form the next generation of industrial and academic research leaders in this field. They would also be interested to develop contacts with other companies who would like to be involved.

Image courtesy of iStock Photo

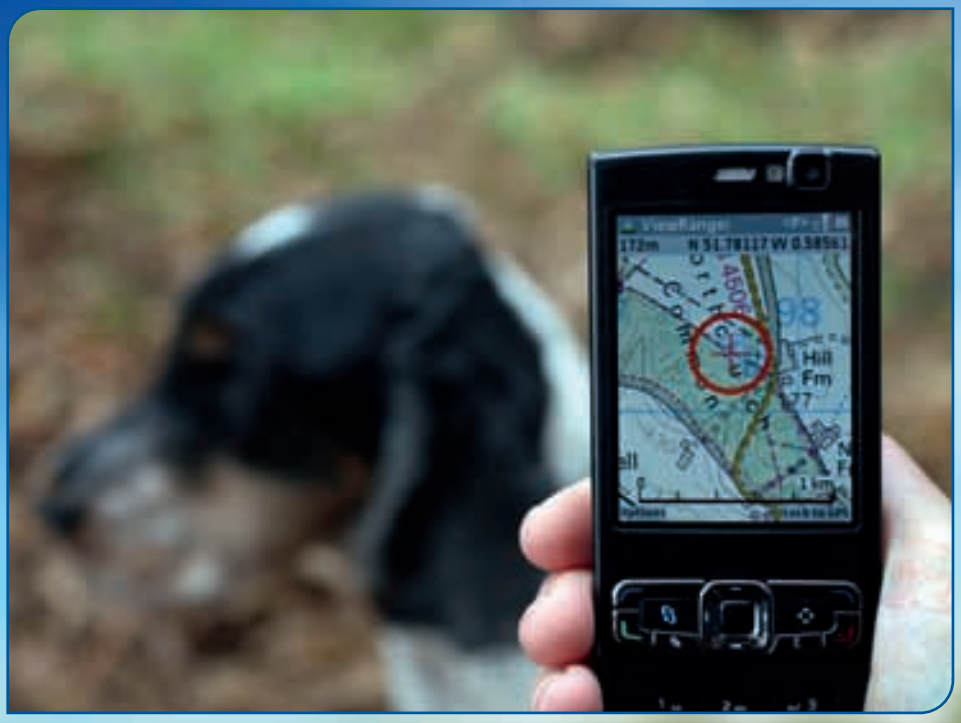
The DTC provides a range of benefits to its students, including: a fully-funded four-year programme that integrates a PhD research project with research training in interdisciplinary skills; a personalised pathway through this programme that enables students to gain a balance of skills across key technology areas, future applications, and human and societal issues; training in innovation and ingenuity to equip students for careers in industry; a three-month industry internship; supervision from international leaders in the field of Ubiquitous Computing; use of facilities including positioning and sensing testbeds and transport simulators; and dedicated office and laboratory space on Nottingham's Jubilee Campus.

Expertise within the DTC spans diverse disciplines, so candidates from a range of backgrounds including computer science, engineering, geospatial science, psychology, sociology, humanities, business, and the arts are invited to apply. The DTC is also keen to develop its links with industry further, so any companies interested in getting involved should get in touch too.

If you would like to find out more, please visit: **www.pgstudy.nottingham.ac.uk/DoctoralTrainingCentres.aspx**

Bright eyes, glossy coat, GPS-enabled…

Cars, people, parcels, and now - dogs can be tracked down using location technologies.



A new product called 'Retrieva' combines 3 different tracking systems (GPS, GSM, and RF) to track dogs, both large and small. The technology's versatility means it could also be used to track virtually anything, such as people, horses, boats, cars, and caravans.

Tracking dogs with GPS is by no means a new idea, but there are very few well-designed products currently on the market – some consist of a GPS receiver housed in a neoprene pouch that attaches to the dog's own collar – therefore they are not necessarily considered to be collars with integrated GPS. There is also the obvious issue of the ease with which a thief could remove the device from a dog they intend to steal.

However, high-tech GPS-integrated dog collars are now becoming a reality. Russian Prime Minister Vladimir Putin's beloved black labrador "Koni" was one of the first dogs to trial M2M Telematica's GLONASS-enabled dog collar.

Many people who use the less sophisticated collars experience problems with signal coverage, durability, battery life, mobile tracking, and water damage. Retrieva Ltd, a UK-based company selling this new product, called on UK designers, Triteq Ltd to carry out the detailed design for the product and solve these problems. The product is now available from Retrieva Ltd. following its successful launch at Crufts in March 2009.

The problem of patchy GPS coverage has been solved in two ways. Firstly, the design of the collar means that the GPS receiver stays in the correct position, pointing upwards from the back of the dog's neck, rather than dangling like a necklace - out of sight of the satellites. Secondly, the collar does not solely rely on GPS. It also carries a mobile phone sim card that can be tracked via the GSM network, and if both of those fail it also carries a radio frequency transceiver. Durability and waterproofing issues have also been ironed out, so dogs are free to roll around, splash through puddles, or go for a swim.

One of the biggest advantages is that if you lose sight of your dog you can track it via your own mobile phone. If your mobile phone is GPS-enabled you can view your own location relative to that of your dog, which should help you find it quicker. The Retrieva system uses the 'ViewRanger' mapping application, which won the 2008 'Most Innovative Product in Navigation' Ordnance Survey award.

There are some useful added benefits to Retrieva – a panic button for dog walkers who feel vulnerable when out on their own, when pressed it sends their location to friends or family via text message. Also if a thief tries to cut the collar, or tamper with its lock a text message is sent to the owner giving details of its location.

Alongside identification technology like microchipping, lost & found websites, and the old-fashioned 'Lost Dog' signs on lampposts, Retrieva should hopefully help owners protect their dogs with this innovative use of location technology.

Retrieva Technical Specifications

GSM/GPRS: Cinterion MC55i Quad Band GSM module. Communication using GSM Text messaging or over GPRS TCP/IP to server

GPS: Fastrack iTrax310 Module with active Antenna, incorporating the SiRFstarIII chip GSC3f/LP

Battery: Li-Ion Polymer rechargeable. 1200 mAh. Battery Life = 2-4 weeks

RF Transceiver: High sensitivity (–111 dBm at 1.2 kBaud, 868 MHz, 1% packet error rate)

Main Control Processor: Microchip PIC24FJ64.

The product is over-air code upgradeable to allow software updates to be implemented without the need for a return to base.

The processor handles all collar operations including location, communication and geo-fence functions as well as power and battery management of the device.

Images courtesy of Retrieva

Space debris - location & timing's greatest challenge?

Tracking cars, people *(or dogs, as seen on page 4,5)* are small potatoes compared with what must rank as the greatest challenge in location and timing: how do you accurately track ~18,000 pieces of debris — some no bigger than tennis balls — orbiting Earth at various altitudes, and travelling at a minimum of 7 kilometres per second, in order to avoid many millions of pounds worth of damage being caused to the very infrastructure we depend on to track everything here on Earth?

The destructive collision of an operational Iridium satellite, and a defunct Cosmos satellite in February 2009 ~800 km above northern Siberia (see image), and the ensuing cloud of debris, highlights the critical importance of having reliable location & timing information for all objects in Earth's orbit. So how is space debris currently characterised and tracked?

Space debris can be anything from defunct satellites (such as the Cosmos satellite mentioned above), spent rocket bodies, or a myriad of smaller objects such as bolts or flecks of paint. The velocities of objects in space mean that even a tiny paint fleck travelling at typical orbital speeds (minimum of 7 kilometres per second, or 16,000 mph) can damage spacecraft. The average speed of impacts in low Earth orbit is an eye-wateringly fast 11 kilometres per second. NASA's space shuttle windows, for example, are routinely replaced as they sustain frequent damage from sub-millimetre debris impacts. Impacts with debris just a few centimetres across could destroy a spacecraft.

The International Space Station (ISS), by far the most expensive object in orbit, has carried out nine collision avoidance manoeuvres since its inauguration in 1999, the most recent one being in late March 2009. The first seven manoeuvres occurred during the first four years of its life. The drop-off in these manoeuvres in recent years is due to improvements in space surveillance tracking accuracy and the assessment procedures used. However, in March 2009, there were two close approaches of space debris with ISS. During the first incident, on 12th March, the ISS crew were moved into the safety of the Soyuz landing craft due to a warning of a close approach of debris received too late to manoeuvre away from. Fortunately the debris passed by without damaging ISS. The second close approach warning, on 23rd March, was received with sufficient time to manoeuvre the ISS and the Discovery shuttle out of harm's way.

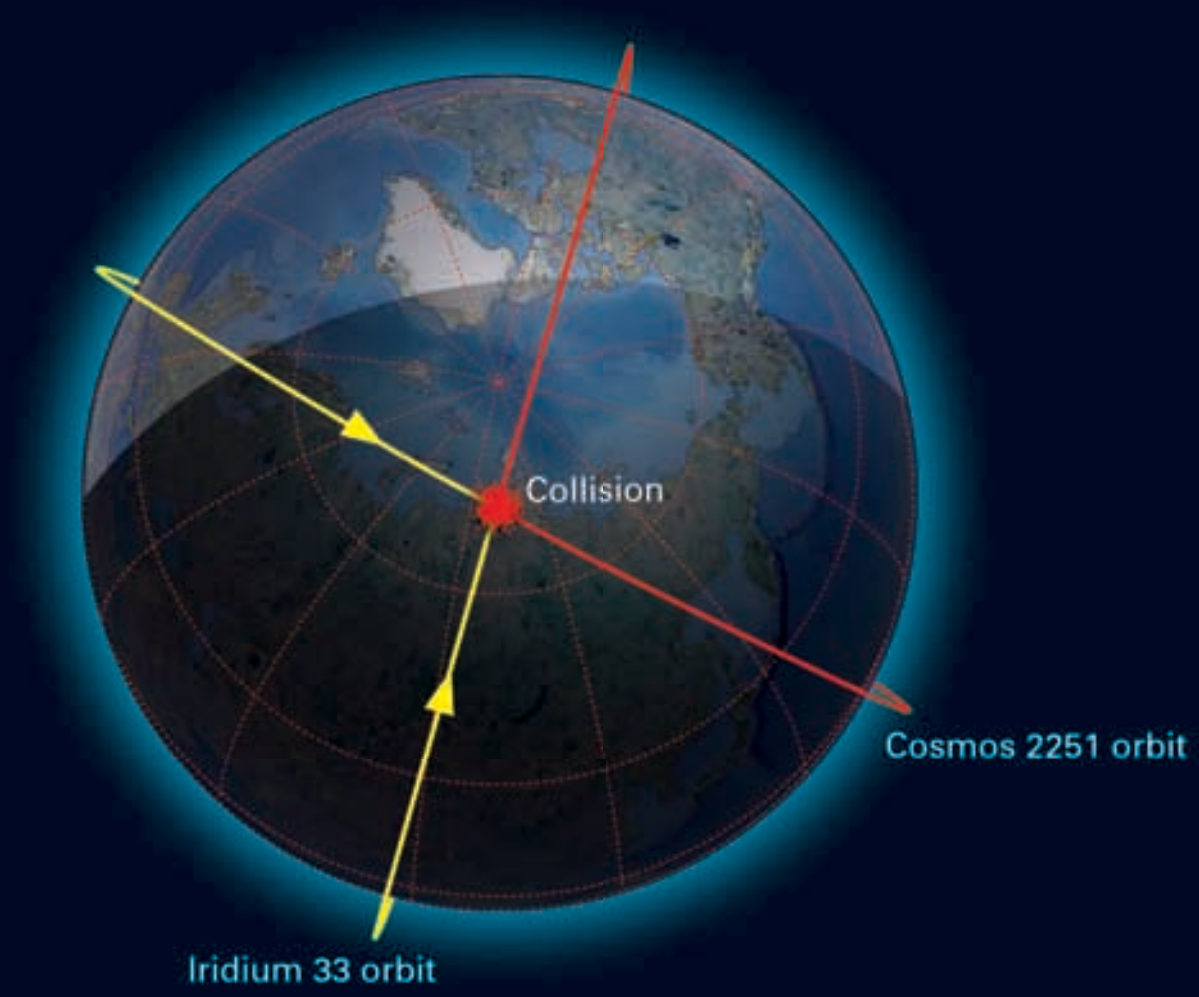
Tracking down debris

Debris objects do not signal their location, so radars are used to detect debris larger than 2-3 millimetres in low Earth orbit up to an altitude of ~2,000 kilometres. Debris larger than 10 cm can be detected, and tracked via this method. Optical telescopes, which see sunlight reflected from debris larger than ~1 metre, are used for higher Earth orbits up to an altitude of ~40,000 kilometres. Based on sightings of debris, predictions for near misses with operational satellites are made, and satellite operators can then decide on evasive manoeuvres. Such activities protect satellites and preserve space-based services - like communications, weather, and location - on which we all depend.

Because space debris is such an important international issue, all space-faring nations pool resources to monitor the problem. The UN, through its Committee on the Peaceful Uses of Outer Space, provides debris mitigation guidelines; the Inter-Agency Space Debris Co-ordination Committee (IADC), an intergovernmental forum which by invitation advises the UN, brings together international experts in space debris to share information, work together on debris surveys, and determine spacecraft protection and debris mitigation strategies.

Space insight

The British National Space Centre, a partnership of government departments and research councils, co-ordinates the UK's role at the UN and the IADC. BNSC contributes to the IADC's debris surveys which help the world's space agencies gain an understanding of the distribution and quantity of debris. In the UK, Space Insight, a small specialist company working for BNSC, uses advanced optical telescope systems to survey for debris in the higher Earth orbits,



Iridium 33 & Cosmos 2251 collision, 10 February 2009, 16:56 UTC

including the geostationary orbit and the 12-hour orbits used by the navigation satellite constellations. Results from Space Insight's surveys are reported to the IADC as part of the UK's contribution to the international efforts on understanding the space debris problem.

The US Department of Defense Space Surveillance Network and its Russian equivalent routinely monitor the intact satellites in GNSS orbits, as well as the rocket bodies that placed them there. However, relatively little is known about the debris population in GNSS orbits. There have been no known fragmentations in this region, but debris in elliptical orbits does routinely pass through it. For any constellation-based service (like GPS or Galileo), a major concern is that any debris produced during an impact would spread along its parent's orbit and increase the damage threat to other satellites in the same orbital plane, or to those whose orbital planes intersect with it.

One debris mitigation measure is the disposal of defunct satellites into 'graveyard' orbits, to keep them out of the way of operational satellites. With Galileo soon to join GPS and Glonass GNSS constellations, making sure that 'graveyarding' and other debris risk reduction procedures are in place is an important step to ensuring the safety of the GNSS orbital zone.

To emphasise Europe's commitment to the debris problem, the European Space Agency hosted its fifth European Space Debris Conference in March 2009, attended by engineers, scientists and legal experts from around the world. Debris surveys, graveyarding, risk analysis, and legal issues were among the many discussion topics.

Oxford Archaeology: 'Going Open'

It's probably not widely known, but archaeological excavation in the UK is primarily funded by the construction industry. Since 1990, whenever any construction work has been undertaken, it has been a legal requirement to undertake archaeological investigation first. The work required, from a simple desk-based assessment of a site's known history to a full-scale excavation, is decided at an early stage in the planning process and tendered out to commercial archaeological units.

Oxford Archaeology is one such organisation and one of the largest commercial archaeological units in Europe, with over 300 staff. Together with Wessex Archaeology, they worked on the largest archaeological excavation in the UK - the development of Heathrow Terminal 5.

They work to very tight budgets and extremely strict deadlines, within a chain that includes many other contractors and in a harsh environment, gathering and using many different types of data. Consequently information systems (IS) requirements can be quite demanding, both technically and financially.

Oxford Archaeology: their open approach

In response to these challenges, Oxford Archaeology implemented an open archaeology GIS policy based on three strands, open data, open standards and open source. This covered the GIS requirements for; digital field data capture, 3D site modeling and post excavation analysis.

Data captured on-site should be available in perpetuity. Often this is all that remains of a site once it is dug up; to be of real value, artefacts need the context that the archaeological data gives them. There is also the possibility that future research will interpret the data differently, re-writing the history books. Consequently choosing open standards for data,

What is Archaeology?

© Oxford Archaeological Unit

Archaeology is the study of past societies through their material remains. The purpose of archaeology is not, however, simply to understand how our ancestors lived, but to provide insight into how we got to where we are now. For example how did our ancestors survive (or cause?) environmental change, epidemics, or warfare?

and allowing open access to it, makes archaeology more sustainable.

Choosing open source software adds to the sustainability of the data as formats are public and free to implement, and the analytical process can be entirely transparent and reproducible. It also gives more control, immunity to changes in software licensing or file formats, and the freedom to modify the software to suit specific needs.

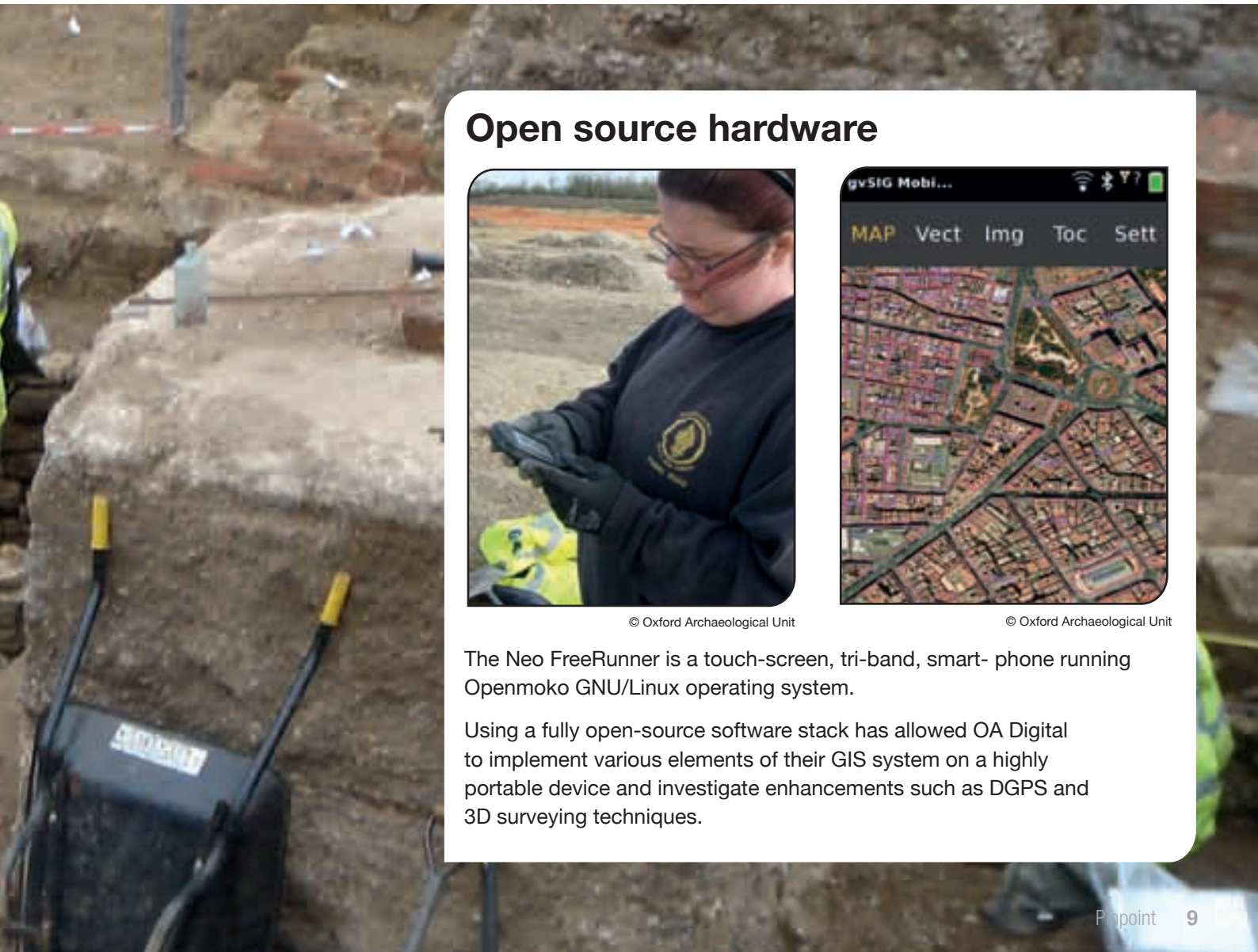
Field archaeology is a small market for GIS; the major packages need adapting to meet specialist needs and data files converting to enable open access. Building a completely open source software stack gives the maximum control over the data, yet flexibility within the workflow. This is achieved by a modular approach where each stage is addressed with a different package. Each package is chosen for suitability for a particular task, and can be replaced as necessary without jeopardising the rest of the stack, in contrast to the monolithic approach where one package attempts to do everything. This also enables innovation in the use and application of the software, such as the move towards equipping field staff with a mobile device with GPS for recording data and running mobile GIS software.

Oxford Archaeology has invested in technical staff to research and manage the new packages. The investment in IT staff has formed a core group of highly skilled people who know the packages very well and have been able to develop training, provide consultancy and investigate other implementations of open source GIS – eg. GIS on a USB stick (www.archaeogeek.com/blog/portable-gis). This group of IT staff now forms OA Digital.

The mission to "Go Open" is still ongoing, and it's fair to say that Oxford Archaeology have found it a learning process, and not always easy. However, they think the long-term result will be a better software stack for their staff, more efficient and flexible workflows, as well as some interesting diversification opportunities.

www.thehumanjourney.net
www.oadigital.net

Open Source GIS packages.
Amongst other packages, Oxford Archaeology are using:
PostgreSQL (www.postgresql.org),
GeoServer (www.geoserver.org)
GvSIG (www.gvsig.gva.es)
OpenLayers (www.openlayers.org)
SQLite (www.sqlite.org)



Open source hardware

© Oxford Archaeological Unit

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The Neo FreeRunner is a touch-screen, tri-band, smart- phone running Openmoko GNU/Linux operating system.

Using a fully open-source software stack has allowed OA Digital to implement various elements of their GIS system on a highly portable device and investigate enhancements such as DGPS and 3D surveying techniques.

Mixed reality – the future of location?

The Mixed Reality Laboratory (MRL) at the University of Nottingham is a dedicated studio facility where computer scientists, psychologists, sociologists, engineers, architects and artists collaborate to explore the potential of ubiquitous, mobile and mixed reality technologies to shape everyday life.

As the computer has moved out of the world of office and work it has left its image of being a dull grey box behind. Digital devices such as mobile phones, cameras, mp3 players and satellite navigation open up new possibilities for us to use computer systems to entertain in new ways.

Position technologies are beginning to play a major role in this trend as they move beyond navigation and asset management. Pastimes such as 'Geocaching', an outdoor treasure-hunting game in which the participants use a GPS to hide and seek containers ('geocaches' or 'caches') anywhere in the world, and 'GPS drawing' where GPS traces of people's movement create new art, are becoming increasingly popular. The Mixed Reality Laboratory is exploring what new forms of entertainment may be offered through the use of position technologies.

As part of the EU-funded project 'IPerG' (Integrated Project on Pervasive Gaming), a variety of 'pervasive games' have been created – these are new game experiences that are tightly interwoven with our everyday lives through the items, devices and people that surround us and the places we inhabit. They integrate computer gaming with emerging mobile and ubiquitous technology, in order to create game experiences that combine virtual and physical game elements. While ordinary games are played in certain spaces at certain times by certain players, pervasive games tend to expand game play temporally, spatially, and socially.

'Day of the Figurines' is a text messaging game for mobile phones developed by the MRL in partnership

Image courtesy of Blast Theory

Rider Spoke participant at the Barbican, October 2006

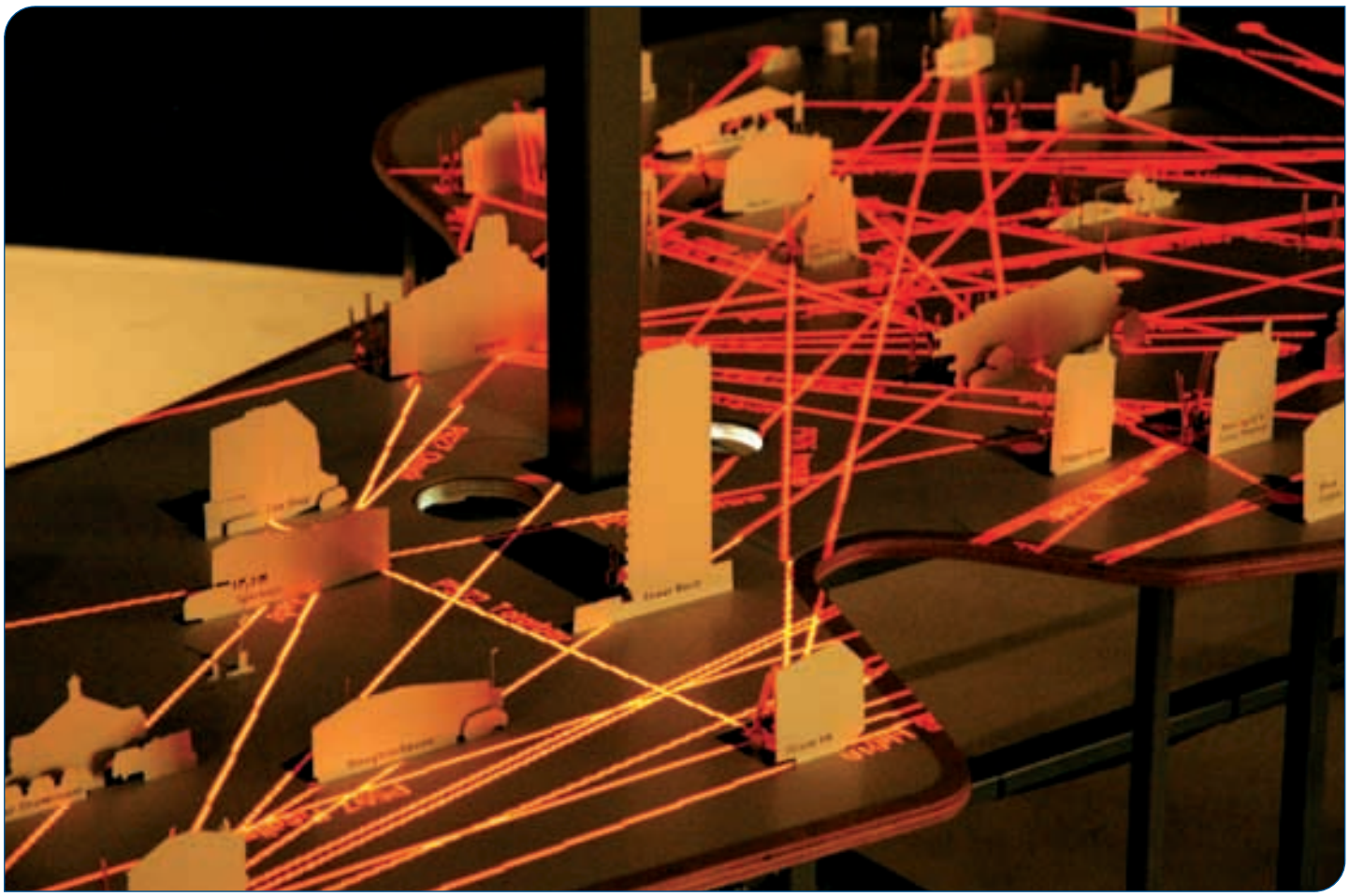

Image courtesy of Blast Theory

Projected pathways of players' movements around the city in Day of the Figurines

with Blast Theory, an innovative new media art group. Players interact via SMS, visiting different destinations in a virtual city, chatting with other players and experiencing events, missions and dilemmas. This is a deliberately slow paced game, with one day of virtual game time being mapped to twenty four days of real time, thus allowing the scenario to be integrated into (and interrupting) the players' everyday lives. Participants become part of a community exploring a parallel world and interacting via SMS. They play a large part in determining what happens as the story unfolds, supported by a combination of part-automated and part-human improvised rules. By integrating into their everyday lives (and interrupting normal patterns of life so unexpected people may have impact on their play) this game demonstrates both temporal and social expansion. Day of the Figurines has been showcased in the UK, Europe and the Far East, and had an honorary mention for Interactive Art at Prix Ars Electronica.

A second game called 'Rider Spoke' - also produced in collaboration with Blast Theory - combines theatre with game play and state of the art location technology for cyclists. The audience cycle through the streets of a city searching for a hiding place, record a short message there, and then search for the hiding places of others. They are equipped with a handheld computer mounted on the handlebars; the screen of the device acts as a navigation system, showing where they are and whether there are any hiding places nearby. Each hiding place combines two properties: the physical location and the electronic location as reported by the device and, for this reason, position itself is slippery and changeable. To enable this, a system has been designed that uses WiFi access points to determine the position of each rider. Participants can cycle where they like, making the spatial boundary of the game unclear and player-defined, and players may listen to the messages other players have left on previous days allowing the game to be long-lived. Rider Spoke was first shown at the Barbican in London in October 2007 and has since been presented in Athens, Brighton and Budapest.

The IPerG project, involved collaboration with partners including the artist group Blast Theory, Nokia Research, Sony Europe and the Fraunhofer Institute.

The MRL is always interested to hear from industry, if you would like to find out more, please visit **www.mrl.nott.ac.uk**

Galileo Open Service: does one size fit all?

Following the Royal Institute of Navigation's 'The Galileo Open Service: Does one size fit all?' event in February 2009, we asked some attendees to give their views on Galileo's priorities.

Terry Moore
(Professor of Satellite Navigation/ Director of the IESSG / Director of GRACE - University of Nottingham)

"The RIN event addressed this topic from many directions but there did seem to be a consensus that the Open Service would satisfy most users' needs. And the most important factor was that Galileo becomes operational and credible as soon as possible. Moreover, the additional complexity (and cost) required to deliver the additional services was not justified compared to the potential benefits. But, there are an increasing number of users of GNSS who perhaps do want a little more than the level of service which will be provided by the Open Service, and these users will benefit from signals on additional frequencies.

We have been using both frequencies of GPS for years now, even though we only have an 'open service' provision of a single code on a single frequency. We have found ways to work around the encrypted signals on the second frequency, and dual-frequency receivers are common in some areas. Indeed, the augmentations many navigators use through EGNOS and WAAS would not be possible without dual-frequency receivers at the reference stations. So, it could be argued that there are many indirect users of dual-frequency data.

Taking all this into account it is therefore pleasing that the Galileo Open Service will be dual-frequency, and of course the modernised form of GPS will eventually be triple-frequency. But to get maximum benefit from Galileo we would ideally like to use not two but three (or more) frequencies on which to make measurements. And we would like full access to those signals, so that we don't have to use 'work around' solutions. This sort of access will enable a whole new range of applications of reliable, robust decimetre (or better) positioning, not just for relatively niche applications, such as surveying, but for mass market and mission critical applications.

However, if we learn anything from the past it should be that 'we will find a way'. Let us assume that the Commercial Service becomes operational and is encrypted; do we really believe that there will not be concerted efforts to find ways to use the signals without subscription?

So, in conclusion there are users who want all signals that we can get access to, but don't really want to pay. But, what if the additional signals are encrypted? Well that sounds like an interesting challenge!"

Tony Haddrell
(GPS Architect ST-Ericsson)

"What we, as mobile phone chip makers, are looking for in Galileo is availability of a modernised signal, enabling us to solve some current problems with sensitivity limits and multipath performance, and without adding another frequency. GLONASS offers extra signals, but nothing in terms of improved characteristics in the navigation sense (although it does give improved jamming and cross correlation resistance).

So here we are waiting for Galileo, or more precisely - waiting for the L1 'open service' (OS) signal. We could use it as soon as there are a few satellites and the signal is released and stable, by combining it with GPS and taking the performance improvements on an 'as available' basis.

However, no one in the various Galileo organisations has so far has been able to suggest a date for achieving this status, suggesting instead that we wait for the complete system availability in 2013 (or beyond). In that case, given the design and life cycle of mobile phones, we don't yet need to design it into the current generation of technology. Or maybe one of the other "modernised" offerings will be first (GPS III, for instance).

With the possibility of royalties for the codes still hanging over us, we are inclined to wait until that is sorted

out too. There is no information on if, how, or at what level such payments might be collected. For mobile phones, zero royalty is the only way to get Galileo in.

So in conclusion, Galileo needs to be soon, free of royalties and with stable OS signals in L1 for it to penetrate the mobile phone market."

Francisco Salabert
(NAV infrastructure and GNSS activities manager – EUROCONTROL)

"Today, GPS offers a very efficient service and with adequate augmentation, is being used as a positioning source for B-RNAV (Basic Area Navigation), NPAs (Non Precision Approaches) and RNAV (Area Navigation) approaches. It has been estimated that around 70% of the flights over ECAC are made by aircraft equipped with GPS. However, GPS has some deficiencies impeding its comprehensive use in aviation (e.g. number of satellites, single frequency and low power signal and the lack of integrity and single operator).

The expected GNSS developments (e.g. more constellations like Galileo and more powerful signals in more frequency bands) will overcome most of the current GNSS deficiencies enabling the provision of enhanced positioning services for all phases of flight, for ground movements at airports and for automatic dependent surveillance-broadcast (ADS-B) applications.

Aviation is undertaking a transition to a multi constellation GNSS as this is considered to be the most cost efficient technology to meet future operational, environmental and safety requirements. A multi constellation GNSS is defined as a system of systems comprising GPS, Galileo, GLONASS, Compass and onboard, local or regional augmentations.

The aviation community awaits the prompt availability of the Galileo Open Service as a key element of the multi constellation GNSS, but with the elements available yet, the aviation community cannot derive exclusive operational benefits from the Galileo Safety of Life (SoL) and therefore strongly question its need."

Dr Sally Basker
(Director of Research & Radionavigation - General Lighthouse Authorities of the United Kingdom & Ireland)

"This event brought together a diverse audience: policy makers, service providers and technology manufacturers as well as mission-critical and mass-market users. Given this diversity, the high level of consensus was quite surprising. Broadly speaking, there will probably be just one "partner of choice" for GPS and we all hoped that it would be Galileo. A strong need or desire for the Galileo Open Service was expressed although it needs to be operational in some form by 2013 otherwise Galileo may miss key aviation and maritime opportunities. There appears to be little, or no, need for the other Galileo navigation services and, as time goes on, GLONASS or Compass may become very attractive alternatives for some market segments.

One conclusion, perhaps, is that there appear to be gaps between what the users want, what the programme has committed to, and what the engineers are building. Right now, however, I believe we all need a free, fully open system with realistic plans and a commitment to delivery on time and to budget. This will give those with the responsibility for managing long-term investment programmes the confidence to include Galileo in the technology mix.

Getting the downstream market engaged – users, application developers and service providers – must now become a priority. Regulation is not the answer. I believe that the best approach is to make Galileo entirely open and to pump-prime a hothouse of creativity and innovation in much the same way that the US did for GPS in the 1980s and early 1990s. If we follow this approach, then we need four things as soon as possible: an open, published and realistic plan with a commitment to delivery; an open, published performance specification; an open, published Galileo Open Service signal-in-space interface control document; and a small number of satellites delivering the Galileo Open Service that allows receiver/chip manufacturers, application developers and users to experiment and develop innovative applications and services."

See back page for upcoming Location & Timing KTN events.

Time for ISIS

Location & Timing KTN's technology translator **Peter Lancaster** takes a trip down memory lane to find out how 1960s technology synchronises cutting-edge 21st century science.

In South Oxfordshire, next to an earthy mound, at the end of an old second-world war runway lies ISIS. Not an Egyptian Goddess, nor the source of the nearby River Thames but the world's leading pulsed neutron and muon source, owned and operated by the Science and Technology Facilities Council.

Twenty-five years ago, I started my electronics career there, working on a waveform switching system to route signals back to the main control room. Last month I visited it again to see how successful it has been and how it has changed since that time.

I met with Bob Mannix, leader of the ISIS Controls Group, by coincidence in the same lab that I worked in twenty-five years ago.

The most significant change has been the building of the £145 million second target station.

Building the second target station has been a major engineering project, integrating it with the existing control system, that was developed over twenty-five years ago, has been a challenge.

ISIS was built reusing some of the components from an older accelerator (NIMROD) and some parts date back to the 1950s. The magnet power supply has a 1 MW DC bias and a 50 Hz motor-generator set; this isolates the system from any variation in the frequency of the mains supply.

The magnets themselves form a large, 50 Hz resonant circuit with a separate building for capacitor banks and a 90 ton, 1 MJoule choke – both of which were originally built in 1963 for another synchrotron (NINA) at Daresbury Laboratory and currently scheduled for replacement. Smaller magnets tune the circuit,

Image courtesy of Science and Technology Facilities Council

these compensate for the change in Q as the energy of the protons increases. It's old technology, but it has worked reliably for over twenty years, ensuring that the scientists get the neutrons they need for their experiments.

The timing electronics generates a machine start synchronisation signal phase-locked to the 50 Hz AC supply. This dictates the 20 millisecond cycle that governs the entire machine. Within this 20 milliseconds an ion source feeds H- ions (hydrogen atoms with an extra electron), into a linear accelerator to be accelerated into a beam pulse, 200 microseconds long at 70 MeV.

The beam passes into the synchrotron ring, through a 0.3 micrometre aluminium foil that strips off the electrons leaving a beam of protons. Once 2.8×10^{13} protons have been collected in the synchrotron, the beam is squeezed into two separate pulses that are accelerated to 800 MeV. Now there are two bunches of protons, each 100 nanoseconds long with 230 nanoseconds between them, at opposite sides of the 52 metre diameter ring travelling at about 84% light speed.

Only after a handshaking cycle with all the instruments, to ensure that they are ready, are the fast extraction magnets fired to direct the burst of protons down towards the tungsten target. The current in the extraction

magnets ramps from 0 kA to 5 kA in 100 nanoseconds. The proton pulse hits the target, releasing first a burst of gamma rays and then neutrons. The gamma rays must be stopped from reaching the experiments, as they would swamp the instruments and possibly damage the equipment. Large, heavy rotating disks block the first part of the pulse, but slots allow the neutrons through, down the beam lines, to the individual experimental stations.

How could pulses of protons be sent to the new, second target station, without affecting the users of the first target station too much? The second target station has been designed to produce slower neutrons with tightly controlled energies. Slower neutrons need a longer gap between pulses, so the solution was to feed every fifth burst of protons from the synchrotron to the second target station. This has given a challenge to the timing system, previously a burst of protons was extracted every 20 milliseconds, synchronised to the 50 Hz magnet supply. Now four bursts go to the first target station, then one to the second target station; the first target station 'skips a beat' every one tenth of a second.

At the target stations, vacuum beam-lines guide the neutrons to the instruments.

To obtain neutrons of the precise energies needed by the experiments, smaller rotating choppers select neutrons of specific speed, either arrays of synchronised, slotted disks or cylinders with long, curved, slots across the diameter that rotate at up to 600 rpm. The curvature and the rotational speed are adjusted to allow only neutrons of exactly the right speed (or energy) to pass through.

At ISIS, old-school heavy electrical engineering mixes with state-of-the-art technology to enable world-leading research, and I was delighted to have had the opportunity to visit.

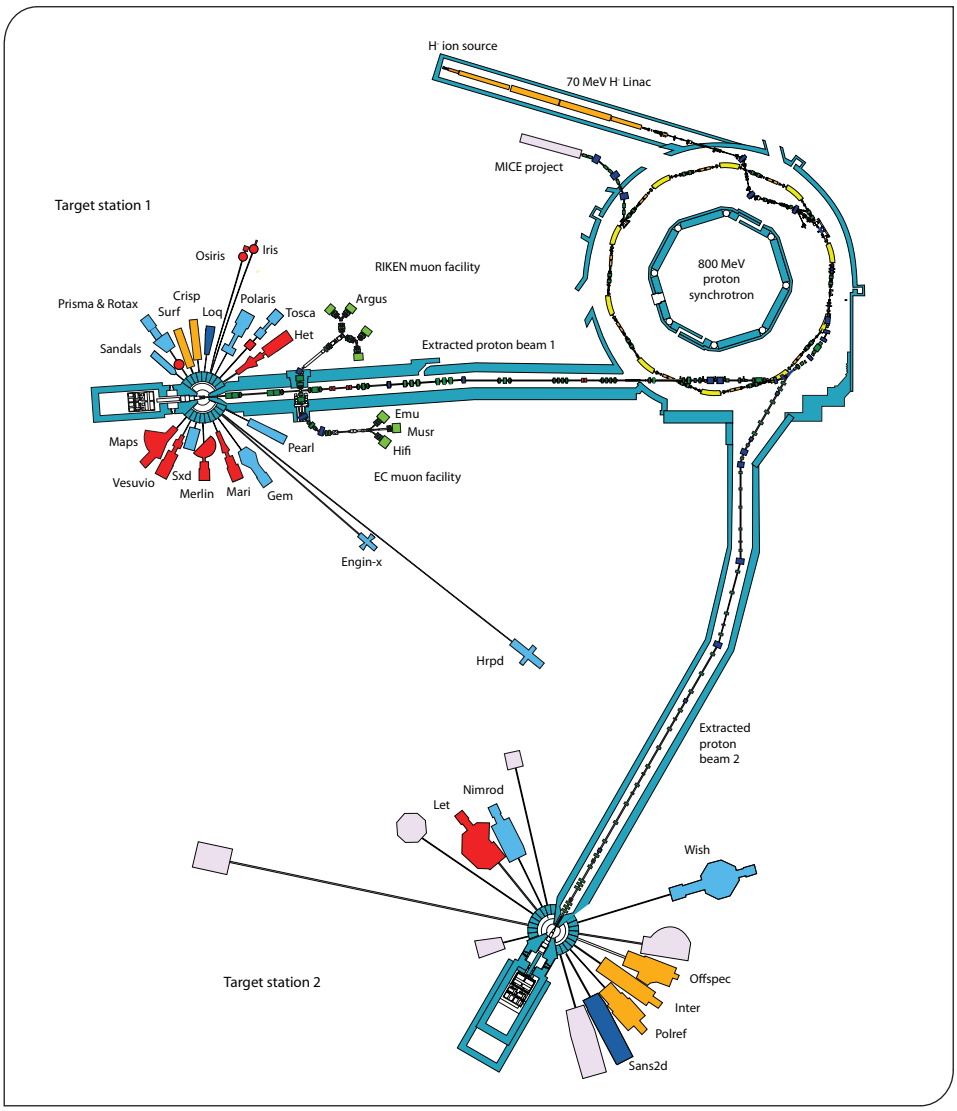

Image courtesy of Science and Technology Facilities Council

What can we use neutrons for?

Neutrons penetrate deep into materials, being scattered only by the nucleus of the atoms, giving a unique method for identifying and locating individual atoms within materials.

They probe deep into solid objects such as turbine blades, gas pipelines and welds giving a microscopic insight into strains and stresses that affect the operational lifetimes of crucial engineering components.

Neutrons are used to study the dynamics of chemical reactions at interfaces for chemical and biochemical engineering, food sciences, drug synthesis and molecular biology. The patterns formed by the deflected neutrons depend upon the structure and constituents of the material under test. The energy of the neutrons is critical.

As semiconductor geometries shrink, so they become more susceptible to changing state when struck by a neutron (single event upset), and a problem that was once only seen on spacecraft and high altitude aircraft, is now seen at ground level with potentially catastrophic effects. ISIS can control the energy of the neutron pulses tightly enough to be able to accurately simulate neutrons created by cosmic rays, these can then be used to test semiconductors and electronics for the effects of a single event upset.

Keeping children safe online

John Carr is the Secretary of the Children's Charities' Coalition on Internet Safety, here he outlines the issue surrounding the recent explosion in availability of location information, in terms of its implications for the online safety of children.

"Historically, mobile operators were the only parties able to provide location information in relation to a mobile device. Any use of such information was subject to a strict Code of Conduct which was agreed in 2004 and is still in place. However, since 2004, the type and availability of location information has evolved.

Now there are a number of additional ways in which a mobile device can be located:

Firstly, via GPS - nine of every ten smart-phones will contain GPS in 2014, compared with one in three in 2008 (ABI Research).

Secondly, via open Cell ID – this is an open source database comprising mobile network cell ID data across all mobile networks around the world. It is compiled by an open source community who upload the discovered geographic coordinates of mobile cell towers. The cell ID to which a mobile handset is connected is available in the handset and can be used by an application; the application can now look up the geographic position of the cell from open Cell ID, and thereby deduce the user's location

Thirdly, WiFi location – for example, Skyhook has mapped over 100 million hotspots

These methods of location are not governed by the UK mobile operators' code. Indeed mobile operators may no longer be the primary source of location information so it clear that the current Code of Practice is largely obsolete. It needs to be reviewed and re-written to ensure that new and innovative location services can be introduced whilst guaranteeing user privacy and ensuring minors are protected, regardless of the source of location information being used.

We are keen to work with industry to put a new and more appropriate regulatory framework in place. It must embrace all of the relevant players, not just the mobile phone companies. Whether or not that new framework needs legislative backing or can be reconstituted as a new self-regulatory code is an open question. Doubtless Lord Carter's deliberations around the Digital Britain strategy will address the issue but, from a child protection perspective, we sincerely hope it is put in a box marked Urgent."

L&T Events

Locating objects and resources
National Space Centre, Leicester
3rd June 2009
Joint event with De Montfort University and EMDA
karen.barlow@npl.co.uk

Timing, Assurance and Applications
National Physical Laboratory, Teddington
3rd June 2009
Joint event with NPL's Time & Frequency User Club
gill.roe@npl.co.uk

New Navigator Seminar 2009
Imperial College, London
17th June 2009
In partnership with The Royal Institute of Navigation
conference@rin.org.uk

The Informed Traveller
National Physical Laboratory, Teddington
9th July 2009
Joint event with The Mobile Data Association
karen.barlow@npl.co.uk

Contact the Location and Timing KTN

The Location and Timing KTN is managed by the National Physical Laboratory. Membership is free.

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The Location and Timing KTN has a powerful online platform and knowledge base featuring news, events, careers, funding, and information about location technologies. It also includes a very popular searchable capability directory of our members.

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