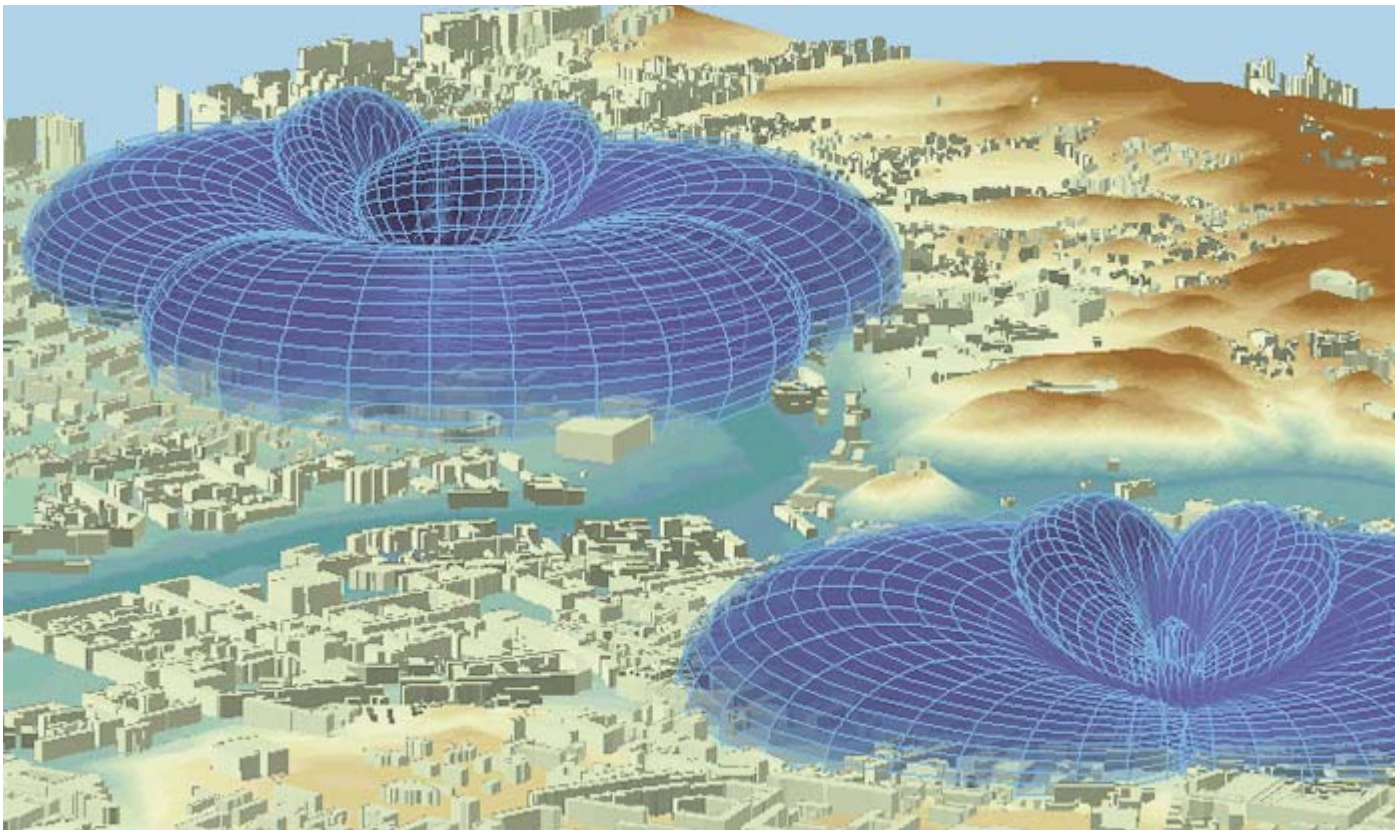


The GIS revolution

In common with the network-centric revolution the advent of geographical information systems (GIS) is bringing new uses for maps – and enabling users to share high-quality aerial mapping and satellite imagery for a number of aerospace and aeronautical applications. **TIM ROBINSON** finds out more.

With the sudden explosion of the Internet in the late 1990s, one of the most fascinating websites to spring up was the Federation of American Scientists (www.FAS.org), a US think-tank. There, amateur intelligence analysts, and those interested in defence could browse through pages and pages of interesting material and, most excitingly, declassified spy satellite imagery. These ranged from Cold War imagery, to Gulf War reconnaissance pictures, to the latest Kosovo and Operation Desert Fox bomb damage assessment (BDA) imagery distributed as part of media briefings.

Since then, what was previously the domain of the intelligence analyst, or photographic imagery interpreter, has gone open-source and is now almost ubiquitous. Google Earth, for example, has brought the capabilities that the CIA could only dream of in the Cold War, to anyone's desktop. Microsoft too, has its own Virtual Earth software. Switch on the news anytime and aerial or satellite images will not only be used in the weather reports, but to illustrate the last movements in a murder case. Online, too, many news stories now carry a 'minimap' that geographically positions it in time and space. Google maps now even carries a traffic density function — which allows drivers not only to plan routes, but to receive live info where there might be traffic jams. Furthermore, as Google Earth shows, maps can be enhanced with hyperlinks, embedded pop-up photos, links to Wikipedia, locations (and links) of webcams – becoming 'content rich' as users add to these mapping tools to create new ways of looking at our world. Key to this explosion in 'citizen mapping' and open source intelligence is the ability to share it with others.

ESRI

This democratisation of mapping is not just useful for those who want to locate the nearest place of interest on holiday by consulting Google Maps or find their house on a satellite map. It also is bringing in new ways of sharing information for professional users too, with revolutionary new capabilities in defence and aerospace applications. One of the companies leading the way in geographical information systems (GIS) is ESRI which produces a range of software and tools to allow exploitation of digital mapping and information. It perhaps could be thought of as a 'Microsoft for GIS', with its suite of ArcGIS applications being able to be customised by third parties to solve a range of mapping problems.

Indeed, it could be argued that the GIS revolution is the 'glue' or an enabler that is allowing a transformation to 'network centric' operations

A 3D visualisation of an urban area incorporating threat 'domes'.

both in civil and military fields. Though the massive upsurge in civilian uses for GPS has increased civil applications, according to John Day, director defence business development at ESRI, the defence and intelligence community is still the largest customer base of 'users'. ESRI in fact has 85% of the the defence GIS market in the UK.

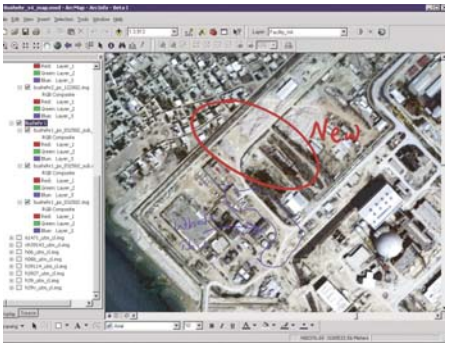
Charts and mapping

One classic example is in aeronautical charts. Previously charts needed to be regularly updated, printed and then distributed. With modern digital charts, updates can be automatically applied to all copies and an electronic audit trail created. With high quality colour printers too, only the relevant charts need to be printed — a massive saving and reduction in waste. Finally, if users do their own printing of only the charts they need, the distribution of regular updates is much simplified. Like software, maps can automatically be set to look for the latest edition and keep themselves current — ending much of the problem of out-of-date publications.

To this end, in November 2008 ESRI UK and consultancy spin-off Helyx, under Lockheed Martin UK's Team Sparta, recently won a three-year UK MoD contract to research the Common Geospatial Tool Set (CGTS), which will investigate ways of how the the UK military could get a standardised set of GIS systems — greatly enhancing the production and updating of military maps, charts and airspace publications.

Mapping the human terrain

The GIS revolution, too, is bringing new capabilities to those on the front line. UK forces in Afghanistan have now got access to high quality maps with not only geographical features on, but also cultural and social trends and events. Called 'mapping the human terrain', this is allows patrols, in real time, to feed back date and intelligence about the population and situation on the ground. A prototype GIS system for the US Army, using ESRI-derived patrol planning tools, even randomly assigns patrol routes to objectives so that troops will never use route patterns that can be exploited.



Imagery analysts can now collaborate remotely using GIS software, sharing information in real time.

As a patrol moves around a city and notes changes, this information can be fed into the unit's intelligence process in real time using handheld PDAs — informing other patrols and the command chain of any new developments on the ground live as it happens. Says Brigadier Nick Rigby, non-executive director at ESRI UK: With GIS, "at various levels information is being shared in real time and everyone can see this in real time."

Though these developments are primarily aimed at the 'soldier as a sensor' concept, improving local intelligence, avoiding ambush sites, or being aware of cultural events like a festival or market days, there are applications too for aerospace.

For one, the reliance of NATO forces in Afghanistan is especially on close air support to bring in the heavy firepower. Thus up-to-date and accurate maps are a must. Air imagery is vitally important to ensure accuracy and avoid collateral damage. With annotated aerial photography and a Rover terminal which shows what a close air support aircraft (or UAV) is looking at, forward air controllers (FAC)s can now be much more certain of getting bombs on the right target. Indeed, reports of FACs calling in air strikes in close proximity of their positions are a testament to the FACs, pilots and the maps being used. In the future, CAS will be even more precise. Using GIS systems it is now already possible to insert moving targeting pod video or sensor imagery as a 'layer' into a digital map, with software automatically rotating and correcting it to make it fit exactly over the terrain. These 'video layers' inserted into maps will have great potential for CAS, intelligence and BDA applications.

However, there is still room for improvement. A number of tragic bombings by US aircraft of Afghan wedding celebrations (which traditionally involve much firing of personal weapons into the sky) might have been prevented if an aircrew briefing involved 'human terrain' observations or intelligence. Aircrew in the US and UK know that 4 July and 5 November celebrations in their respective countries involve fireworks in the sky — which perhaps could, in some circumstances, be mistaken for AAA or missiles. In another example, a recent book by the commander of 800 NAS Sqn described how he struggled to identify a 'rotating object on fire' from his Harrier cockpit. Was it the prelude to an ambush on nearby ground forces? In fact it turned out to be a car tire on fire swinging on a rope marking the date of a holy festival. Thus in these type of intelligence-led conflicts against insurgents — context is everything and GIS cultural intelligence can also benefit the pilot in the cockpit.

Force protection

This type of 'human terrain mapping' and the sharing of geo information via laptops or PDAs to build a common operating picture can also add to force protection of airbases and airfields in theatre. For instance, the DragonMap application, from ESRI UK and its Helyx consultancy allows non-specialist users to 'drag-and-drop' data or information on PDAs or mobile devices. Using this method, patrols can build up intelligence outside the wire, while the direction and spread of incoming mortars and rockets, once put into the system, can start identifying launch positions and patterns in the attacks. A GIS system of a deployed expeditionary airbase can also enable planners to see, at a glance, answers to questions like, where is the best place to put the fuel dump? Off-load passengers? Site a guard post for maximum visibility and line-of-sight? Or mount a radar antenna to give the best coverage?

Airport planning

This facilities management aspect, as might be guessed, also has a crossover into the civil world, with interactive GIS solutions able to enhance commercial airport planning and management. Noise footprints are an obvious one but also bird hazards or other environmental issues can also be overlaid over airport diagrams and maps. Furthermore, like the military, once all the correct data is entered, the system can also be used to predict future possibilities, for example, what would be the effect of a new runway on noise for nearby residents? When today's airport inquires can halt or stall airport development, it is vital that decision makers can consider all the options and visualise them too.

Another usage is for marketing. As well as operational applications for charts and flight planning, airlines, like many companies are can exploit GIS systems as part of their marketing efforts — identifying pockets of potential customers to better target market strategies. These systems, as used by big supermarkets and retailers, allow consumers to be targeted to

uncanny levels of geographic focus. For airlines, this could benefit more focused advertising campaigns, mailshots, outside posters and/or billboards and the like to capture the right customers.

Defence Estates

GIS for facilities management is also being used by the UK's Defence Estates Agency to manage the 240,000 hectares of facilities, ranges and buildings it is responsible for. Previously this information was fragmented and, until quite recently, there was no central map of all the land owned by the MoD. Any enquiries meant travel to regional offices and physically looking for deeds and certificates. Since 1995, however, it has, with ESRI derived solutions, been able to develop a web-mapping portal known as GEODE, accessible anywhere. In addition, another system called e-Terrier allows the Agency to manage its land purchases and sales. It even includes digitised copies of land registry documents dating back, in some cases, to Napoleonic times. This saves time and money in travelling to regional offices as well as ensuring records are kept updated. It also allows information about these (in some cases) sprawling bases to be distributed across the MoD efficiently — for example, so that units visiting other bases can receive up-to-date base maps of married quarters, gyms, shops, aiding deployments or relocations.

Intelligence

While the proliferation of open source intelligence on the Internet may be worrying, it is the way in which it is collated and analysed that is the important factor. For example, in a demonstration at a recent ESRI users conference, Jeff Bird from the Defence Geographic Centre, MoD, showed how easy it was to use non-classified sources to create a hypothetical 'target' folder for Terminal 5 at Heathrow. Using maps available the ArcGIS software, he was able to create in a week a presentation of T5 with a 3D model of the building, Wikipedia entry linked in with photos and Metacarta streaming news reports keyed in of every story that referenced T5 but that was also geo-referenced nearby. This use of Web 2.0 tools for GIS he calls 'NeoGeo'.

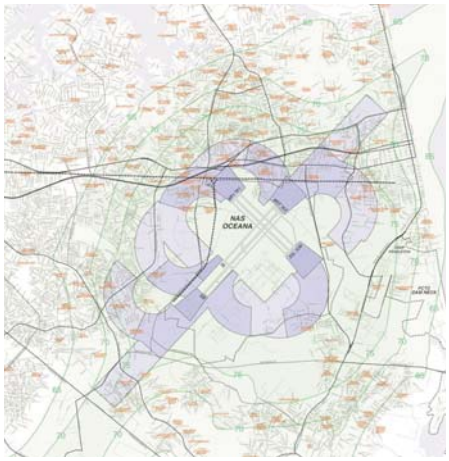
Indeed printouts of Google Earth found in insurgents hands around Basra in 2007 were found to have the UK forces base at Basra marked on them — a sign that not only the 'good guy's are adept at exploiting the revolution in GIS.

The revolution means that GIS systems are evolving at a rapid pace for intelligence and imagery interpretation uses — speeding up the whole collection cycle. New user tools, for example, can help automate traditionally some of the toughest interpretation tasks. Image recognition software now exists that can scan reconnaissance photos for changes since the last photo was taken – highlighting perhaps a camouflaged facility or recent digging. Other tools can now automatically calculate building dimensions and structures, from shadows, automatically filling in shapes to produce accurate 3D models. Finally, automatic shape recognition tools can recognise the visual, IR and thermal signature of tanks, vehicles or aircraft on the ground.

However, it is important to remember that these interpretation tools available to the military and intelligence community are not intended to replace the skilled analyst. Instead they are tools to aid efficiency, speed up the process and to get them looking in the right place to begin with — the training and experience of the analyst then making a decision on what the structure is, or whether those are indeed tanks the computer has flagged up.

> ***Indeed printouts of Google Earth found in insurgents hands around Basra in 2007 were found to have the UK forces base at Basra marked on them — a sign that not only the 'good guy's are adept at exploiting the revolution in GIS.***

As well as being used to interpret images or display data taken at a particular 'snapshot' of time, some GIS tools can now display map-based information based on time as well. For instance, in intelligence operations, vertical lines can, for example, track phone calls or money transfers in terror networks — bringing to light hidden patterns of funding, linkages or discovering who the ringleaders are. In urban operations a vertical slider could show when each road was targeted by insurgents and find patterns there. Finally a timeline could also analyse sortie rates or the effects of a bombing campaign — revealing an opponents strategy clearly and graphically over time or aiding in judging bomb damage assessment.



Environmental mapping around NAS Oceana — showing how different approaches affect local neighbourhoods.

Digitising the intelligence cycle also has another benefit as it allows the workflow to be optimised and human analysis focused on what really matters. With collaboration possible over the using of secure links, intelligence analysis can continue around the clock in different timezones on the same imagery allowing local analysts in theatre to collaborate with intelligence analysts back home, or even with coalition partners or allies.

Accident investigation

GIS software is also being used more and more in accident investigation too. While rerunning flight data recorders through a 3D interface may help explain loss of control in a fatal accident, the inclusion of GIS or terrain features, obstacles or radar coverage may also help accident investigators in their task. GIS systems were used, for example, to plot the debris field of the Space Shuttle *Columbia* when it broke up during Texas during re-entry in 2003. Despite the vast area the debris was scattered over after the high-altitude break-up, geographic logging of pieces found allowed investigators to carefully target their search and find the crucial pieces of evidence that would allow them to discover the cause of the tragedy.

Mission planning

Another use for GIS is in mission planning — where a GIS system can allow for not only accurate routes to be planned but aid in visualisation and situational awareness by incorporating such things as SAM engagement domes, data link coverage or areas where surveillance aircraft cannot see. Thales, for example, has developed in 14 months a mission planning

system called 'MPlanit' based on ESRI software which uses a modular approach to create a reusable mission planning system. The first customer for this is the Royal Navy's Sea King ASaC Mk7 (airborne surveillance and control) platform. The new system, WISP2, uses elements of the previous mission planning software, is able to work with the vast amounts of data that the ASaC links into, can be used for weapons targeting and allows sophisticated 2D and 3D visualistion of the mission. The modular system means it is upgradeable and will support and future ASaC upgrades — as well as being an important milestone on the road to MASC (Maritime Airborne Surveillance and Control) for the future carriers. Research on integrated mission planning systems needed for CVF and MASC/JCA (Joint Combat Aircraft) is already underway by the UK's Dstl (Defence Science Technology Laboratory) at Portsdown West. Some clue to the massive advance it brings is that it has reduced the squadron's time needed to plan for theatre or operational deployment from two weeks to three minutes.

Meanwhile, in the US, a GIS mission planning system, FalconView, originally created for the Air National Guard F-16 community in the early 1990s, has spread across all the US services and government agencies to become the *de facto* US GIS mission planner.

In the future a mission planner may also, like the ground patrol tools now beginning to be developed, be able to suggest better routes to mask strike aircraft, or to be able to randomise ingress and egress routes to baffle any attempt to predict a strike routing. (It has to be remembered that a contributing factor in the shoot-down of a F-117 stealth fighter in 1999 during Operation Allied Force, was due to predictable flight paths that Serbian SAM operators were able to exploit).

Simulation

From mission planning it is thus a small step to mission rehearsal using fly-by-views and thus on to simulations. Some GIS advocates, for example, question why inaccurate geo-information is acceptable in a simulation, when real data could be used. Like the merging of video games and synthetic environments (see Serious Playtime, *Aerospace International,* October 2008) this crossover between mission planners, mission rehearsal, simulators and debriefing tools is likely it increase over time — as databases, terrain models increase in fidelity and scope. The mantra now is, according to GIS specialists "create once, use across the whole mission area." Already there are terrain analysis tools that can calculate, for example, a tank's movement over certain terrain. If this is combined with behavioral-based doctrine models of how an army deploys and fights, then this can create powerful, realistic AI forces for wargaming or simulation.

In urban operations, already there are software applications available that can generate '3D cities on the fly' using either laser radar or standard colour cameras to create hyper accurate buildings. Could these in the future, for a hypothetical expeditionary operation, generate a GIS derived and constantly updated single 'virtual city' that would allow helicopters, ground forces and air platforms all to rehearse, learn, train and experiment before they are even deployed — integrating not only geographic information but the human terrain, road traffic patterns and real-time intelligence on insurgent hot spots?

Media and open source intelligence

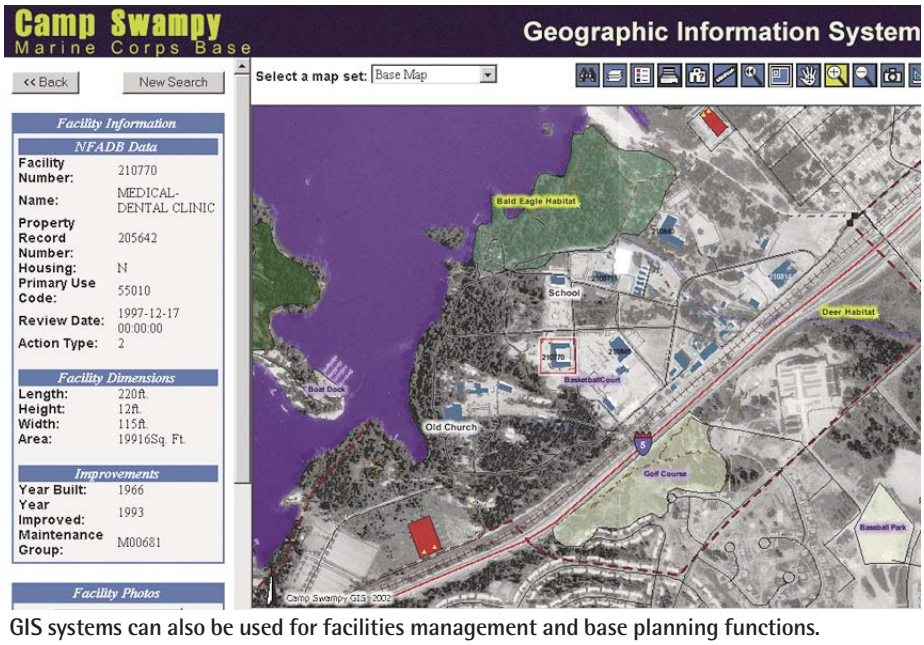
A final use of GIS is one already noted previously — in the media or for civilian intelligence systems. Jane's, for example is currently 'geo-coding' or 'geo-tagging' its news stories to allow cross-referencing and for subscribers to identify patterns in terror attacks, piracy or other important events worth monitoring. In its equipment guides, too, it is working towards not only for users to read an aircraft's specifications and see a picture but also, using ESRIs suite of ArcGIS software, by a click of a mouse, jump to active bases where that platform is operational. A further click would reveal the aircraft or missiles range on the map — allowing easy and quick analysis of conflict situations or arms build-ups.

The organisation too, like many other news-gathering agencies also makes use of commercial satellite imagery now available on the open market. However, what is also interesting is that this demand for a certain geographical area is also a tip-off that something interesting has been found. A scoop regarding a secret Chinese submarine base derived from this analysis of where commercial imagery satellites are being tasked to image.

Collection is thus another important sector, with both higher and higher resolution aerial photography and commercial satellite imagery, being demanded by both professional and the consumer market.

Conclusion

In summary, the revolution in GIS systems is closely linked in with the information and the network centric revolutions — allowing the sharing and rapid updating of a God's eye view of the battlespace or increasing civil safety and efficiency. GIS is thus integrating more closely with command and control. While the phrase network-centric can be difficult to visualise, GIS is evolving to provide commanders, politicians, pilots and managers with the easiest and quickest way to grasp fast–changing data — the map. 'Fusing' different disparate types of information too, such as moving video, LIDAR, photos, 3D models and text reports into these maps is thus beginning to realise the true potential of network-centric systems and enabling effects-based targeting with minimum collateral damage.



GIS systems can also be used for facilities management and base planning functions.