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In this edition of Ranger...

In this edition of The Ranger the articles range from the historical to current technical operations. The southern hemisphere is the focus for a number of the articles including the Ross Sea and South Georgia. This time the South African Hydrographic Office is the Commonwealth geographic department and adds to the southern hemisphere dimension.

At the DSA Seminar in July 2016 Jeff Jefford gave a fascinating presentation on the RFC and RAF in the Great War. He has expanded his presentation with an article. The story of 42 Survey Engineer Regiment continues with Part 3.

The current technical articles are centred on the Firth of Forth and the question of whether or not the Royal Navy's new aircraft carriers will be able to pass under the bridges and proceed to sea. In recent years "Cloud Computing" has become part of every day life, for those in industry or are computer savvy and use this capability to store their data. Dave Campney looks at potential options for the MoD UK.

There are reports on the DSA Seminar and the AGM Dinner and Lecture.

Recently Ranger has featured eminent surveyors and in this edition Colonel Sir Charles Arden-Close is the selected personality. However there is more than just a summary of his achievements and there was a major initiative, supported by many in the DSA, to acquire his medals as part of the DSA "Heritage" remit. This is told.

What of the future? The Ranger Summer 2008 has a short piece on "The Future of Denison Barracks". Things have happened but much has not happened and the DSA is not in the business of forecasting or predicting the future. Nevertheless the Royal School of Military Survey is still at Hermitage. The DSA will try and balance its activities between Hermitage and Wyton.

In 2027 the DSA will be 100 years old. Whilst there is no immediate need of a decision some thought will be given on how the 100th Anniversary may be celebrated.

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DEFENCE SURVEYORS' ASSOCIATION

In 1927, a group of officers who had contributed to the great success of the Artillery in 1917-1918 by the provision of counter-bombardment data from Sound Ranging & Flash Spotting and led by the Nobel Prize-winners Sir Lawrence Bragg and Harold Hemming formed the Field Survey Association as an old comrades association and a known pool of expertise if called upon for another war. The association was in abeyance during the Second World War but many members again saw active service. The Association resumed activities in 1945 and, in 1997, was renamed the Defence Surveyors' Association more properly to reflect the multi-disciplined changing nature of Geographic Intelligence support to the three Services

The aim of the DSA is to promote an understanding and appreciation of defence surveying, mapping, and charting and geospatial intelligence in historical, current and future contexts and to keep past and current members of that community in touch with one another. Members are from defence, industry, academe and private sectors.

Chairman's Remarks

The year 2016 has been a year of major events. It is a year in which the Battle of the Somme has been remembered, the Olympic Games were held in Rio de Janeiro, and it is the year of a national referendum, where a majority voted for the United Kingdom to withdraw from the European Union. For the DSA 2016 has been one of continuing to provide our members with opportunities to attend an excellent seminar, a visit to the Bodleian Library and the DSA Annual Dinner. These events are covered within this edition of Ranger.

With the publication of Ranger the year will draw to a close but perhaps not quite. A major activity, generously supported by the members and others, enabled the medals of Sir Charles Arden Close to be purchased at auction. It is intended that they will be presented to the Royal Engineer Museum and it is agreed that they may be displayed in a Geographic unit. The display of the medals should happen before the end of the year.

The purchase and display of the Close medals may prove to be a catalyst for the raising of the profile of the historic work of the military surveyor. The Royal Engineers have recently formed an historical group and preliminary discussions have elicited an interest in a D-Day battlefield tour with the mapping story playing a major part. The Geographic Branch of the Royal Engineers Association has recently placed over 800 images on their web site. The DSA Council will continue to support heritage initiatives.

We have over the years presented prizes to many talented individuals. Some have joined the DSA but many have not. We understand that the young geo person, whether soldier, sailor, airman or academic, civil servant or practitioner is busy with their careers and probably families. In 2017 the DSA will be talking with the senior military management exploring ways in which Geo and DSA may come closer together and attract a younger membership.

The world is moving away from mapping and charting as understood in an historical sense and the skills of today are those of the data manager and the geographic intelligence specialist. The DSA is therefore pursing options to sponsor continued professional development meetings at locations focusing on current and emerging issues. Our business may be modified to accommodate the changes in the way mapping and charting is addressed today. In doing this we should of course aim to retain our historic links with the Royal Navy Hydrographic Department, Royal Engineers and the Royal Artillery.

In 2017 the DSA plans to hold 2 seminars and an annual dinner. We will continue to publish Ranger and encourage people to contribute to this excellent publication. The recognition of excellence will continue. In addition we invite members to comment and to come forward with suggestions relating to the future direction and activities of the DSA.

Christopher Nash - *Chairman*

Four Two – The Regiment

A brief overview of 42 Survey Engineer Regiment

Part Three: Soldiering in the Sixties - 1963 to 1972

By Alan Gordon

Introduction

In late May 1963 a small advance party under the command of Major John Henshaw arrived at A Camp Barton Stacey and thus started a new, and very different, chapter in the Regiment's story.

Life for the military surveyors would from now on be changed in many ways and for several reasons. Throughout the previous two decades a wartime soldier would have instantly recognised almost all aspects of regimental life; the uniforms, weapons, tented accommodation, the technical equipment and the techniques used. Now, the so-called 'swinging Sixties' would become the definitive decade of change in every aspect of life including within the Armed Forces. The only thing that would remain unchanged was the fabric of A Camp which would remain firmly rooted in the wartime years throughout the Regiment's unexpectedly long stay which was despite the early arrivals being told that the unit's stay was only temporary until better accommodation could be found.

Reorganisation

On arrival in the UK the Regiment reorganised to be once again a three squadron unit. 22 Production Squadron was renamed 22 Lithographic Squadron and its air survey and cartographic elements removed to form the two troops of the new 47 Cartographic Squadron. 22 was then organised into two troops, one static and the other mobile equipped with the new Mobile Train. 19 Topographic Squadron, albeit it was still in the Middle East, remained the same but the Regimental Headquarters Squadron was reduced to a Troop.

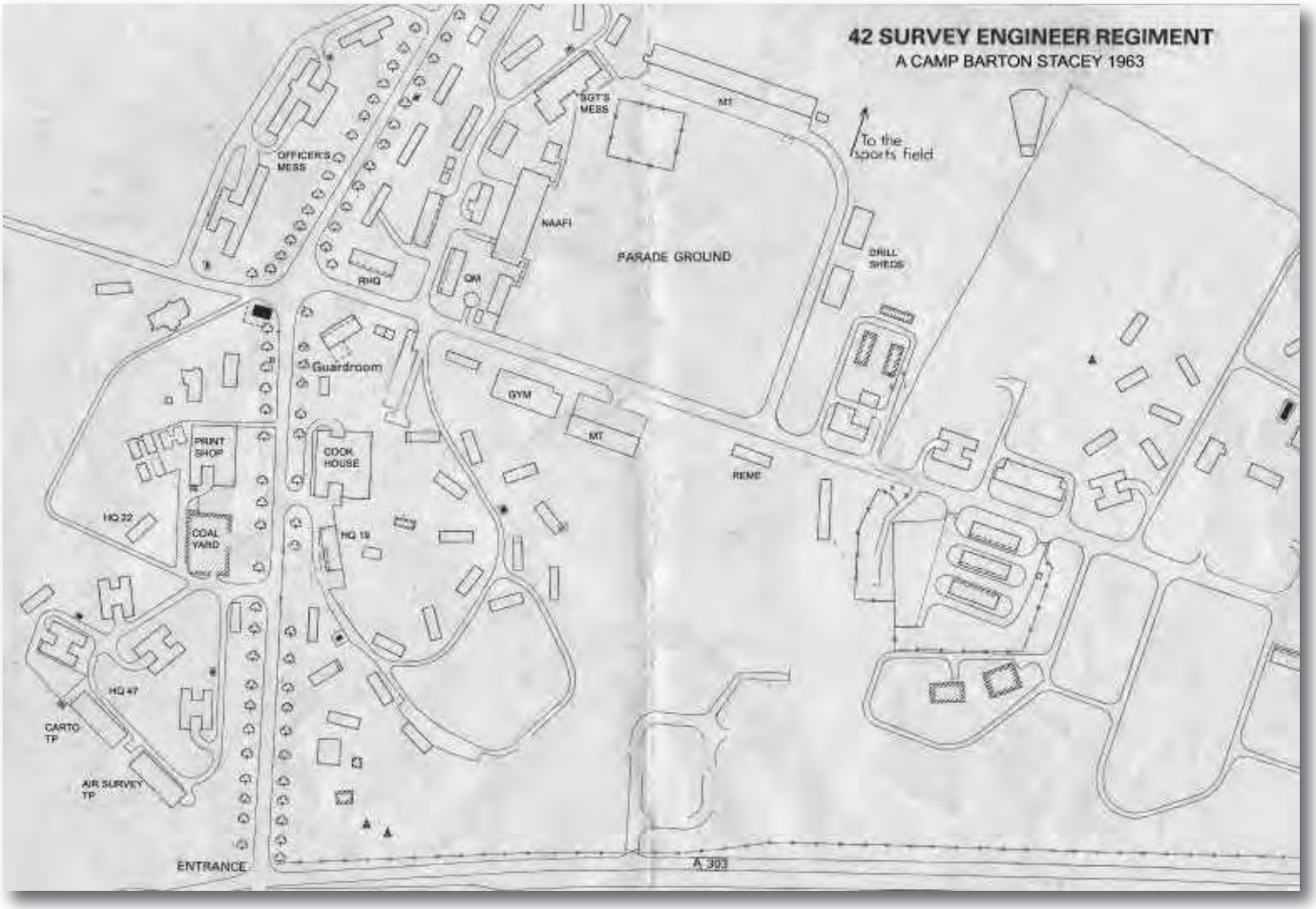
The Regiment's establishment was 14 officers and 217 soldiers with an authorised civilian increment of 80 to assist in the camp administration although it would be some time before these were recruited with soldiers carrying out these duties in the meantime.

The unit had been understrength for some time due to the ending of national service and the gapping of posts latterly in Cyprus due to the imminent move to UK. Hence, the majority of the soldiers completing a course at the School at Hermitage or leaving the Apprentice Collage at Chepstow were posted to the Regiment.

Barton Stacey Camp

At the outbreak of the Second World War four army camps were built straggling along the hilltop four miles east of Andover. Three, imaginatively named A, B and C, were on the northern side of the A303 and D on the southern side. Each was self-contained and comprised a mix of brick and wooden single storey huts and an enormous, bleak parade square. Between B and C Camps there was a hutted post office and a large corrugated iron SKC cinema. In early 1963 A and B Camps had been empty for several years, C Camp housed a light air defence regiment and D Camp a REME unit but by the end of that year 42 Regiment was ensconced in A Camp, 32 Medium Regiment RA in B Camp and the REME had left D Camp which had been converted into substandard married quarters as had several huts in A and B Camps.

Shortly after you cross the River Test on the A303 heading towards London there is a small hill at the top of which there is a road off to the left running along the hill and then down to Longparish. A Camp straddled this small road with 47 Squadron occupying two long brick buildings immediately on the left running parallel to the A303 and 19 Squadron the wooden huts on the right hand side. Farther along on the left were a number of brick buildings which were the single soldiers' accommodation other than 19 which 'enjoyed' the wooden huts adjacent to their HQ. Next along the road on the left was the misnamed Coal Yard, for it contained little coal but mountains of coke, and then an old cookhouse then the home of 22 Squadron's static troop opposite which was the Regiment's cookhouse and soldiers' dining hall. There was then a crossroads with a brick and flint cottage on the left which was occupied by the camp gamekeeper who bred pheasants on the camp and



looked after the Army's stretch of the nearby famous trout filled River Test. Over the crossroads on the left was the Officers' Mess whilst on the right, oddly situated in the centre of the camp, was the guardroom and facing it across the road was RHQ's brick building. Turning right at the guardroom a road ran down through to B Camp with the QM's empire on the left and then the vast parade square. On the right hand side was a large gymnasium and a row of MT garages. Alongside the western edge of the square were the NAAFI and Sergeants' Mess, across the top ran a long row of MT garages and down the eastern edge were two huge drill sheds.

During the Regiment's stay the only major change to the fabric of this relic of the Second World War was the replacement of coke stoves with gas fires in late 1965 leading to the demolition of the hated Coal Yard which was replaced by a car park, a small sign of the rising affluence of the servicemen.

Life at Barton Stacey

It took over a year to recruit the civilian staff and during that period every sapper and most junior NCOs spent quite some time on 'Regimental duties' as either a mess barman or waiter, RHQ runner or labouring for the QM. The worst jobs were working in the cookhouse 'tin bash' tasked with cleaning the endless stream of greasy pots and pans and the coal yard gang filling metal tubs with coke and delivering them to every building in the camp. Guard duty and fire piquet came around with amazing regularity and then for some months in 1964 the Regiment was tasked with also providing a guard each night on the new RAF CDA building within Thatcham Depot.

Each day started on the road next to the parade square when at 0800 hours squadron right markers marched onto the square and then the rest 'fell in'. After a brief inspection each squadron was then marched off through the camp to their squadron lines.

The early days were filled with settling into the camp and setting up equipment and there was no real technical work until early 1964. At morning break time a van appeared from Barton Stacey village selling newspapers and chocolate bars which tended to be favoured over the trip up to the NAAFI. Every Wednesday morning was allocated to military training often starting with a drill parade but always ending with pay parade for this was long before the days of the cheque book soldier. The afternoon was, of course, sports afternoon.



22 Squadron team ready for a fire trailer race. Inter-squadron competitions were a regular feature of regimental life.

As the weather turned colder with the coming of winter so immediately after the tea meal came the daily task of warming up the room. It is very difficult to get coke to light especially when there was always a shortage of kindling and so as the year drew on soldiers could be found all over the camp scavenging for wood but if none could be found then a large blob of the orange floor polish would do the trick! Then each morning the stove had to be emptied of ashes and left clean, floors 'bumpered', beds made and nothing left out on show before going off for morning parade.

Few had any form of transport so off duty life centred around the nearby local village pubs which after a while tended to be squadron based - 47 The George, 19 The Plough (recently voted as the top gastro pub in the South) and 22 The Cricketers. The NAAFI was used only if very short of funds or if snooker was your thing. The cinema in B Camp was popular albeit the films tended not to be the latest but as the last bus from Andover back to camp left before the town's cinemas finished their show it had a captive audience.

Married quarters were very scarce and most married junior ranks lived in privately rented accommodation in surrounding towns and villages, some as far away as Alresford, or in the sub-standard converted wooden huts.

Technical Equipment and the Mobile Train

Air Survey Troop occupied Block 101 a quite large, long brick building in which was housed a long bar 7 projector Mark 2 Multiplex and a three projector set in one room and three more three projector sets in another room next door, both suitably 'blacked out'. A long room adjacent to the multiplex rooms contained two very long tables designed to take bridging base sheets and to mosaic strips of photography. Another room contained wooden draughtsmen tables and another had a very large slotted template laydown board. In a small room there was a sturdy butcher's wooden bench on which was the Cambridge Stereocomparator that 512 Field Survey Company had taken to Egypt in 1940. All this equipment had been brought from Cyprus.

Carto Troop and 47 Squadron Headquarters were housed in Block 100, a building identical to its adjacent neighbour 101. The drawing offices were equipped with light tables that were essential for scribing which was now the standard draughting technique.

22 Squadron's Static Troop helio and photographic equipment had been brought from Cyprus and was housed in Building 94 and in smaller brick huts to the rear whilst its presses were two second-hand Crabtree double demy two colour machines provided from COD Donnington. These were erected over a period of weeks but on testing one was found be unusable and turned out to be parts from two separate machines. This was eventually replaced. Virtually all the lithographic consumable stores had been carefully shipped to the UK but on opening most were found to be unusable due to age and so a whole new procurement procedure had to be set up with HMSO.

Mobile Troop was equipped with the 'Mobile Train' the then brand new mobile map reproduction equipment housed in 10 ton semi-trailers towed by Thornycroft prime movers. The Train comprised two semi-trailers housing Crabtree Princess presses, one housing helio platemaking equipment, one with a process camera, one was a darkroom and one with a graining machine and guillotine. 13 Squadron had another Train in Aden, 14 Squadron was also equipped with one as was 135 Squadron, Military Survey's TA unit.



Mobile train setting up on exercise.

19 Topographical Squadron in the United Kingdom

Newly trained trig surveyors were posted to Barton Stacey whilst 19 Squadron was still in Aden and so provided effectively an advanced party although most were employed on regimental duties. The Squadron Headquarters formed up at Barton Stacey in the New Year of 1964 and with it came a very different squadron life - gone were the years of virtually autonomous operation as the unit was now fully integrated into the Regiment and future surveys both in the United Kingdom and overseas would be carried out by small detachments or by a single troop rather than the entire squadron.



Corporal Pete Smith with a Wild T4 at Alport Heights in Scotland carrying out geodetic work typical of the time.

The unit's first major task in the United Kingdom was to work on a new survey of Sark in the Channel Islands. The Dame of Sark requested a new survey of the island as the latest map that then existed had been produced in 1943 when the island was occupied by the Germans and was consequently not only dated but inaccurate. The RAF flew survey standard photography of the island and in June 1964 two officers and twelve soldiers deployed to carry out the field work needed for the production of a new map. They fixed the precise position of the island by astronomical methods and the exact height above sea level by observation and measurement from the datum in St Peter Port, Guernsey which was six miles away. Ground control was then put in by theodolite and tellurometer with the Dame's staff providing definitive names and boundary details.

From the time of its arrival at Barton Stacey the squadron carried out surveys both large and small the length and breadth of the United Kingdom. Of note are the detachments carried out during 1965 and 1966 to the Scottish Western Isles tasked with astronomical and gravity observations and in 1966 in Northern Ireland for Laplace observations 180 miles apart as a check on the Irish Azimuth Variation. Later that year saw the start of a seven month project working with the Ordnance Survey checking the scale of the primary triangulation of Great Britain, a task that harked back to Military Survey's early years. During the years covered by this chapter the squadron did a number of tasks for the Hydrographer including first order work to determine the azimuth and deflections from the vertical and extensive surveys of the Clyde approaches. The RAF was assisted by surveys of airfields and of power lines across the country and the sighting of radar installations at RAF Wyton.

19 Squadron's Overseas Surveys - Surveying Jungles and Once Again Deserts

The Squadron's first overseas deployment came only a month after setting up at Barton Stacey when on the 7th of February 1964 1 Troop left for Sarawak to assist 84 Survey Squadron in producing the plan and height control for series T 735, the 1:50,000 scale mapping of Borneo. In August that year they were relieved by 3 Troop which remained in Borneo until February 1965. During the twelve months in Sarawak the surveyors made extensive use of Royal Navy and RAF Wessex and Whirlwind helicopters to move around the rugged and impenetrable terrain and at the same time developed techniques for carrying out altimeter heighting whilst hovering over the control point. Auster light aircraft were also used especially in the identification of control points when a 35mm camera was bolted to the fuselage and used to produce strips of photography. Both these techniques were innovative and the need for air support in future overseas surveys became accepted practise.

1965 was a busy year for 19 Squadron as 2 Troop moved to Norway to produce control for new mapping, the first of many deployments from the Regiment to Norway, and only a month after returning to the United Kingdom 3 Troop left for Aden to support 13 Field Survey Squadron where they completed a tellurometer traverse connection between the Yemen border and 13 Squadron's work in Aden. 1 Troop replaced them in November and over the next six months carried out control work in both the Eastern Aden Protectorate and on Masirah Island returning to Barton Stacey in April 1966.

Field parties went to Cyprus in 1968 and again the following year to assist 1 ASLS in a boundary survey and a control survey in Libya and two levelling projects on Malta one of which involved 120

miles of levelling. 1968 also saw a troop deploy to Australia for six months and to Canada in 1969



Corporal Chris Moorhouse calibrating gravimeters during the Trinidad and Tobago detachment.

There followed a particularly busy year with a composite troop detached to Australia and New Guinea from the 17th of July until the 7th of December 1970 where they joined an aerodist and altimeter heighting operation in support of the Royal Australian Survey Corps. The task was to provide control for new mapping and involved the use of a variety of aircraft but despite problems with aircraft serviceability and the old aerodist equipment and poor weather the major part of the requirement was met. At the same time another troop spent from June to October on Operation Mandau in Indonesian Kalimantan and at the end of that year a survey party left to spend four months in the Bahamas and Trinidad.

Exotic detachments filled the field surveyors' year in 1971 with deployments to Australia once again working with the Royal Australian Survey Corps, several to the Caribbean involving work on the Bahamas, Trinidad and Tobago and the Turks and Caicos Islands and rather less exotic tasks in Abu Dhabi and Bahrein.

Production Work

42 Regiment and its main predecessor, 512 Field Survey Company, had been in effect the survey production centre for the Middle East. However, now based in the United Kingdom the situation was different as there was already the mainly civilian manned Survey Production Centre RE (SPC RE) at Feltham tasked with map production. In effect, 22 and 47 Squadrons became in many ways an extension to the Feltham production facility in that they were almost solely involved with map production and reprinting to top up Depot stocks. Although there was weekly military training there



The Mobile Train camouflaged on exercise.

was little talk of 'war roles' and few Regimental exercises albeit support was given from time to time to 14 Squadron in Germany such as in 1966 when a detachment made up from all the squadrons deployed there on Exercise Dominate V.

Once all its equipment was declared operational 22 Squadron's Static Troop was then tasked with routine printing of standard series mapping from the Military Survey print programme and also took on the usual range of miscellaneous tasks that have always been a part of the repro workload. Meanwhile the Mobile Troop spent the next three years employed on displays and exhibitions throughout the country especially during the summer months and taking part in exercises to practise its war role.

However, 47 Squadron initially lacked technical tasking until Carto Troop started work on UTM gridding 91 sheets of 1:250,000 scale mapping of Bechuanaland. With everyone else involved in production work Air Survey Troop tended to become the Regiment's main labour pool and its first technical work occurred when an already completed task of mapping the Archer's Post area of Kenya was sent from SPC as a training task and a large mosaic of Chatham was produced for the RSME. Its first 'live' mapping task came in the late summer of 1964 when work started on the multiplex plotting of the Sark map which was then complied and fair drawn by Carto Troop. In April 1965 3,500 copies were printed ready for the Regiment Second-in-Command, Major Stanley Ireland, and Canadian Exchange officer Captain JC Sinclair to visit Sark on the 6th of May and formally present the Dame with a framed copy. Thus ended the Regiment's first end to end map production task in and of the United Kingdom.

January 1965 saw the first steps in a major mapping programme when the Regiment was tasked with the production of a block of 22 sheets of series K669, new 1:100,000 scale mapping covering south Arabia that was urgently needed to support operations there. Air Survey Troop was to plot the detail using multiplex and Carto Troop to compile and scribe the fair drawing. Work commenced in January 1965 with the production of a pilot sheet. This was completed in October 1965 and after review in theatre the final specification was agreed and the air survey and cartographic work on the main task commenced at the end of the year. The squadron went onto a permanent shift system that was driven by a firm completion date of 31 July 1967 and, to meet this tight schedule, was reinforced by several air surveyors on detachment from the Survey Liaison Section (UK) at RAF Wyton. The task involved several innovative techniques including the first use of analytical aerial triangulation and airborne profile recorder data in the air survey process and plastic relief models in Carto Troop. The last sheet was cleared off the press and passed catch released on the 28th of July 1967, three days before the deadline.

When the plotting of K669 was finished 47 Squadron was tasked with producing a number of sheets of T735, the 1:50,000 cover of Borneo, followed by a Libyan Training Area Map.

In July 1968 the squadron deployed to Mjöllfjell on the first Exercise Carto Norge to produce PIRs and height control and carry out field annotation for the subsequent plotting at 1:25,000 of a map of the artillery range in the mountains nearby using solely the new Wild B8. This task was assessed by the Norwegian mapping authority and accepted as meeting their national standards. As a result, an annual mapping project, known as Carto Norge, commenced in 1969 involving a squadron deployment to Norway to carry out the necessary field work and then the production of 1:50,000 sheets for series M711. This tasking provided the main technical work for 47 Squadron for the rest of its existence.



Sergeant Colin Price creating a PIR during the first Exercise Carto Norge.

There were other small tasks over the period such as in 1969 when Air Survey Troop was tasked to take photographs at night with an F49 air survey camera of flares fired from Moody Down ranges. The tracks of the flares were then coordinated using the Cambridge Stereocomparator. The data was analysed elsewhere as part of a project researching battlefield illumination. Other rather different tasks that year included a photomap of Abu Dhabi and an experimental pictomap of Buraimi Oasis.

New Equipment

April 1967 saw two air surveyors sent on a 2-week Wild B8 course to the Swiss School of Photogrammetry in St Gallen and a B8 was installed soon after. This was the first step in the programme to replace the aged multiplex equipment although further machines were not purchased until 1971.The first tasks for the new plotting machine were not topographical mapping but the plotting of plans covering Cayman Brac in the Caribbean and the Simian Gorge in Ethiopia for the Military Works Force to plan civil engineering projects.



Corporal Bill Huckle overseeing the removing of a Countess press.

In November 1969 22 Lithographic Squadron was re-equipped with three new Crabtree Countess two-colour presses and the best Crabtree Ensign was retained for the printing of RAF target maps. These were colour separated on the cameras and printed with a black on both sides of the card stock. The Countess machines were the first new printing machines to be received by the unit, the previous consignment of new presses had been to its predecessor 512 Company in the early days of the Second World War.

13 Field Survey Squadron Return to the United Kingdom

The British government had every intention of granting freedom to the Aden Protectorate but only once a stable viable local administration was ready to take over. However, from 1963 the territory became increasingly riven with terrorism and two main bodies emerged fighting each other for primacy with both factions fighting the British at the same time. The situation became so anarchic that the government decided on early withdrawal in 1967 irrespective of the political situation it would leave behind. As a result 13 Squadron's main party left Aden at 24 hours' notice on the 29th of June 1967 and then took up residence in B Camp Barton Stacey, vacant since the Artillery regiment left a year or so earlier.

In October 1967 13 Squadron's mobile train was returned to the Command Ordnance Depot at Donnington for a sorely needed overhaul; in the three and a half years in the heat and dust of Aden it had produced over half a million maps. To ensure that the Print Troop could continue working it took over 22 Squadron's mobile train and with it the task of supporting displays and exhibitions throughout the country. 22 Squadron then reorganised to operate a two shift system with their static equipment.

A parade was held on the 27th of October 1967 to mark the return of 13 Squadron to the United Kingdom and for the presentation of Commander-in Chief's Commendations for four unit personnel. 13 Squadron, which comprised 6 officers and 105 soldiers, remained an independent unit until the 4th of March 1968 when it came under the command of the CO 42 Regiment but remained on a separate establishment. On the same date the Regiment came under command of 12 Engineer Brigade whose headquarters was also in B Camp but technical control remained with the Director of Military Survey but now exercised by the newly appointed Deputy Assistant Director Survey at Headquarters Army Strategic Command at Wilton.

13 Squadron's Tasks

Although 13 Squadron was now virtually co-located with the Regiment it was still established and equipped as an independent unit and in most respects it continued to operate as such, indeed its taskings were in the main much more interesting and varied than those of the Regiment's squadrons.

13's field surveyors were set to work almost immediately when in September 1967 they were tasked with heighting over 23,000 points along the runway at Boscombe Down to provide data for trials affecting the undercarriage of Concorde. The task was completed in the January in time for deployments to the Shetlands to fix the positions of Loran C aerials to geodetic standards.

Detachments went to Australia in May 1968 for six months and the following year field surveyors deployed to Canada to provide mapping control in Nova Scotia and in 1970 they worked in West Kalimantan with the Royal Australian Survey Corps and the Indonesian Army. Jamaica, Anguilla and the Trucial States were all locations on the Squadron's task list in 1971 and early 1972 saw a team deployed to assist the Military Advisory Team in the Gulf.

Field survey tasks were also carried across the length and breadth of the United Kingdom during the years from 1967 to 1972, less glamourous than the overseas work but providing vital support to all three services. Of particular note was the survey of man-made obstructions over 200 feet high that took several years from 1969 with over 100 obstructions found during the operation which involved some 59,000 miles of road travel and 218 flying hours with the Army Air Corps.

Meanwhile the air survey, cartographic and reprographic trades were all equally busy with the plotting of Trucial States town plans, the first air survey task. For the Repro Troop there was continuous tasking of stock topping printing from the Military Survey print programme and also, along with the draughtsmen, many non-standard jobs for a wide variety of 'customers'. Highlights were the production of 134,000 copies of 31 sheets of the new M60WM wall map sheets of Germany in 1969, printing almost 400,000 impressions on the Princess press in 1970 and the Rotaprint turning out 425,000 impressions the following year.

In 1968 the unit was tasked with producing two experimental 'pictomaps' which were enhanced air photo mosaics and being considered as a rapid response product in lieu of standard mapping. However, after considerable discussion the idea was not pursued.

The Development of a Close Support Capability

Military Survey had started to investigate forms of providing a rapid response capability when the 'troubles' in Northern Ireland provided an impetus to the project when multiple copies of large scale town plans collected from local councils in the province were urgently required to support the deployment of troops. In early 1970 13 Squadron was tasked with providing 4,900 copies of 41 plans and a three-man Rapid Response Team equipped with an Océ dyeline printer and a Agfa Gevaert Rapidoprint, an early form of photocopier, was set up to carry it out. It proved to be a challenging task in many ways with innovative solutions to problems such as the use of baby oil to render paper plans transparent for use on the dyeline printer.

The Rapid Response Team then became the Close Support Team with its equipment mounted in a long wheelbase Land Rover allowing it to accompany a formation headquarters into the field and to generate copies of graphical products in a minimal time. The system now comprised a Rotolite Diazo Jet Mk II dyeline machine, a contact frame, an Agfa Gevaert Rapidoprint and a Rototrim guillotine and there was a 12 foot square side tent that was attached to the vehicle that in turn could be 'blacked' out. The power was be obtained from the formation supply. The team was then deployed on an exercise to support Headquarters 3 Division on Salisbury Plain and it proved to be a sharp learning curve for not only the team, who had no previous experience of working directly with the field army, but also for the headquarters which was not familiar with having such reproduction capability. It was deemed to be a success and the Team regularly joined the headquarters for exercises over next few years.

TRANET



TRANET Station 016: in 1970 this wartime wooden hut housed some of the most advanced technology in the world.

The Transit Doppler system was devised in the USA almost immediately after the Soviet launch of Sputnik 1 in 1957 and was the first satellite positioning system. Ground stations, known as TRANET Stations, whose positions were known precisely were essential to support the system and five were built across the USA with the sixth built at Lasham in Hampshire. Military Survey had been involved with satellite geodesy since 1963 when 512 Specialist Team RE (STRE) was formed in Washington DC. In March 1970 it was decided to transfer responsibility for the United Kingdom TRANET Station to 512 STRE and so for convenience the station was transferred to 42 Regiment's base at Barton Stacey. A station pillar was built and fixed to first order standard from the OS trig points at Inkpen and Butser and on the 15th of July 1970 the equipment arrived at the old wooden hut and was immediately installed and became operational as station number 016 on the 21st of July.

The new station was the first to have an automatic running capability and so, although it produced satellite data 24 hours a day, its operator was in attendance for only eight of these hours. Lieutenant John Critchley was the first station manager but in 1972 a REME SNCO electronics technician post was established to oversee the day to day operations. For a junior air or field surveyor a six month tour as the TRANET Operator was considered to be a plum job as it excused them all the petty irritations of Regimental life; squadron parades, RSM's drill parades, menial duties, block inspections and the like and was hence a very much sought after post.

The Sixties – The Decade of Change

The ending of National Service and then the decision to withdraw troops from 'East of Suez' led to huge changes starting from the early Sixties. To encourage the recruitment of regular soldiers the Royal Engineers recruiting theme was "Become a Sapper of the Sixties: Travel and a Trade". Military Survey certainly lived up to this claim with field surveyors deployed from Canada to Australia and from the Caribbean to Indonesia and with the introduction of technician trades initially for boy soldiers and then for all entrants.



Working inside the helio trailer; note the 13 Squadron scarf – a relatively short lived fashion.

In 1963 there were still a few wearing battledress rather than the new Number Two dress and all wore the studded boots that their grandfathers would have known. Guard mounting was still in best uniform with a stiff inspection and in that first winter in the United Kingdom all wore greatcoats of First World War vintage. The webbing worn for military training was the 1937 pattern used by their fathers during the Second World War and blanco and brasso were an essential in everyone's locker. However, change was in the air in almost every aspect of life for the military surveyor. Uniforms continually changed throughout this period with working dress becoming pullover order, firstly with the issue V-necked version, then soldiers were encouraged to purchase a crew neck pullover and finally the army issued the green heavy duty pullover. For a short period this was enhanced by a squadron scarf worn cravat style; green for 19, red for 22, blue for 47 and black for RHQ Troop. The American style combat cap, as shown in the earlier photograph of the Mobile Train, was also a short-lived fashion. Lightweight and barrack dress trousers were introduced, the studded boots were replaced by the rubber soled 'boots DMS' and the more comfortable 1958 pattern webbing did away with the need for endless blancoing. As the 60s turned into the 70s so many of the more rigid military aspects of daily life were relaxed and even the weekly pay parade disappeared when soldiers' pay went straight to their bank. In an attempt to follow fashion, the soldiers' hair grew longer and the moustaches grew bushier and droopier engaging the SSMs in a non-stop battle to maintain 'standards'. By 1972 all the camp's support roles had long been filled by civilians and so the day to day life of the other ranks was much more comfortable and easier that in it had been a decade before.

Reorganisations

In 1962 almost all military surveyors were serving in units overseas but now a decade later the opposite was the case with only 14 Squadron, 1 ASLS and 512 STRE, the latter two both very small units, outside the country.

A new regimental establishment was produced in 1971 and so yet again the Regiment was reorganised – this time bringing its four squadrons down to three. On the 26th of November that year 13 Squadron became an integral part of the Regiment and 22 and 47 Squadrons were to amalgamate to become 22 Map Production Squadron comprising three troops; Air Survey, Cartographic and Print. In early 1972 the army reorganised and Army Strategic Command became United Kingdom Land Forces (UKLF) and the former DAD post was upgraded to an Assistant Director level with responsibility for tasking the field surveys of both 13 and 19 Squadrons.

A formal parade to mark the changes in the Regiment's organisation took place on the 16th of March 1972 during which 13 Squadron's flag was symbolically handed over to the Regiment sealing another chapter in the Regiment's history.



Regiment Reorganisation Parade 16th of March 1972
Left: Captain Savage reporting 47 Squadron ready for amalgamation thereby ending 25 years as a Survey squadron.



Right: Captain Paul handing 13 Squadron's flag to the CO, Lieutenant Colonel Busk, symbolically ending the unit's independent status.

Filling in the Whitespace at the bottom of the Earth, 100 years on.

By Lieutenant Kate Retallick Royal Navy

When I received an assignment order to *HMS Protector* during my attendance on HM Advanced Survey course I knew it would be an exciting opportunity to see a part of the World most people only dream of being able to visit. The prospect of an Antarctic circumnavigation seemed thrilling if not slightly daunting. With the last visit to the Ross Sea by a Royal Navy ship over 80 years ago, there is little opportunity to visit this remote and inhospitable region.



HMS Protector breaking ice in McMurdo Sound.

HMS Protector's usual stomping ground is the Antarctic Peninsula, the mountainous region jutting out from the main Antarctic continent at around 60°W and separated from South America by the notorious Drake's Passage. The United Kingdom has responsibility for maintaining a large region of navigational charts here in the British Antarctic Territory. Data collected by Protector is processed on board and rendered to the United Kingdom Hydrographic Office (UKHO). Owing to infrequent visits, a short summer season, harsh operating environment and expansive ice cover, there remain vast areas of chart which are just plain whitespace and the words 'Unsurveyed' leave navigators breaking out in a cold sweat. In a break from Protector's normal routine of Austral summers in the Peninsula, the Ship deployed South in September 2015 to complete a circumnavigation of the Antarctic continent and deployment to the Ross Sea via the Suez canal, Indian Ocean and Australia.

After a period of regeneration in the UK, involving a significant docking period in Hebburn and embarkation of hundreds of tins of rhubarb, *HMS Protector* and her Ship's company found themselves just about as far away from their base port as it would be possible for a ship to reach. Venturing to the Ross Sea presented a unique opportunity for the Foreign and Commonwealth Office to demonstrate the reach of the Royal Navy and the United Kingdom's commitment to maintaining a peaceful and environmentally sound Antarctica. It was fitting that the trip coincided with the Shackleton Centenary expeditions marking the end of the ill-fated Endurance expedition in which, having become beset and lost his ship to the ice, Shackleton sailed a small lifeboat, the James Caird, to South Georgia from Elephant Island. It was two years before the crew of Endurance was finally rescued by Shackleton and the Chilean Captain Lieutenant Luis Pardo embarked in the Chilean ship Yelcho.

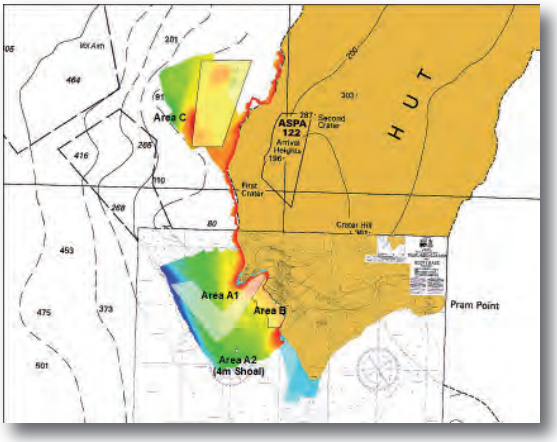


HMS Protector and SMB James Caird IV

Embarked on board Protector, along with the usual additional support crews of divers and Royal Marines cold weather experts, were members of the Royal Australian Navy, Australian Border Force and New Zealand Defence Force. *HMS Protector's* primary mission for the period was inspection of fishing vessels operating under the CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) regulations. The programme was highly effective with *HMS Protector's* inspection teams working alongside New Zealand and Australian enforcement officers to inspect a number of fishing vessels in the region.

Although *HMS Protector* has a wide range of capabilities and is tasked with a variety of activities, there is chance to conduct survey operations focussed on specific areas of interest. In addition to the Ship's survey outfit, based around a Kongsberg EM710 Multibeam Echo Sounder, *HMS Protector* carries the *Survey Motor Boat James Caird IV* (the third such vessel named after Shackleton's lifeboat).

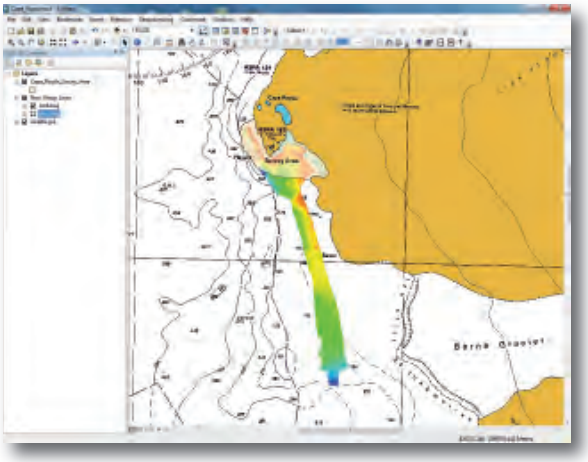
The New Zealand hydrographic authority, LINZ (Land Information New Zealand) and the United States NSF (National Science Foundation) submitted requests for multibeam survey data in vicinity of Ross Island and McMurdo Sound. Situated at the Southern extreme of the Ross Sea, the Sound is about as far South as it is possible to travel by Ship. The largest station in Antarctica, the United States' McMurdo station is located here at the base of Ross Island and is approached by a channel in the ice carved annually by a powerful ice breaker. The area around the station contains a number of shoal areas and a charted sounding that presents navigational challenges for approaching ships, which are often not actually ice breakers themselves since the Ross Sea is ice free for a small period each year enabling resupply by cargo ship.



Survey coverage McMurdo.

LINZ requested surveys of the approaches to Cape Royds and Cape Evans. These sites are maintained as historically important under the Antarctic Treaty and contain the historic huts from Shackleton's Nimrod and Captain Scott's Terra Nova expeditions. The area is part of New Zealand's national responsibility for charting and is increasingly visited by a number of cruise ships and small boats landing tourists to visit the historic huts.

With only a few days on task in which to conduct survey operations, and with no opportunity to conduct on-site reconnaissance of the areas, *HMS Protector's* surveyors set about obtaining as much information as possible to facilitate the work using the normal limitations of bandwidth on board the ship. GIS map and chart products were provided by the UKHO and BAS (British Antarctic Survey) whilst remote sensing data from Polar View was combined with a sophisticated GIS Product from JOMOC (Joint Operational and Meteorological Centre at Northwood) to provide an enhanced assessment of ice cover. This and supporting meteorological evidence from both JOMOC and the US NSF was vital to ensure *HMS Protector* could safely operate in the region without risk of becoming beset by ice or hampered by storms. The weather can change rapidly in Antarctica and with boats deployed, accurate forecasting is important to ensure operations can be conducted safely and boats recovered.


Survey coverage, Royds.

HMS Protector has a team of 16 hydrographic surveyors on board working in a three watch system with 2/3 of the team on board at any one time. In addition to surveying, the team also operate the Ship, carry out deck work and keep watches on the bridge. Although kept busy, their dedication to surveying combined with 24 hour daylight, which has the strange effect of making you forget how late you are working, ensured time on task was maximised.

Survey operations during the Ross Sea deployment were not without their challenges. The cold environment affects survey equipment in a number of ways and it is normal to expect to have to deal with ice accretion and extended 'warming up' times before kit will perform as expected. During a normal season, Protector routinely works to around 68°S in the Peninsula. Operating in the Ross Sea brought new difficulties as WADGPS (Wide Area Differential GPS) corrections were not received below 72°S. The positional information received by the system is refined by an Inertial Measurement Unit (IMU) and fortunately the system retained suitable horizontal accuracy required for the survey.

Tidal observations are of great importance to hydrographic survey and soundings need to be reduced taking in to account the height of tide so depths can be referred to a sounding datum. Limited access to land areas, which were largely surrounded by unsafe and broken ice, made the practicality of obtaining tidal information problematic. Installing a tide gauge would have required a period of observations not afforded by the limited time on task and a failure of the tide gauge installed at McMurdo meant there was no suitable data covering part of the survey period. Predicted tides for the area were used as a last option which unfortunately increased the tidal error and meant the final product would likely meet only IHO (International Hydrographic Organisation) Order 2. Although less accurate than the standard normally required for this type of survey, the improved coverage and



Ships Company walk to Terra Nova Hut.

number of soundings combined with a full sea floor search, was a vast improvement on the chart in existence. The hydrographic data was complemented with additional daily records for weather, ornithological and marine mammal observations.

The opportunity to conduct survey operations in a region of particular Antarctic historic importance was both challenging and immensely rewarding. Thanks to assistance from the NZ Antarctic Heritage Trust, members of the Ship's company were able to visit the historic sites at Cape Evans and Cape Royds. The occasion provided a unique insight into the challenges and hardships endured by those who came before us a centenary ago and who persisted against all odds in the name of science and Antarctic exploration. To continue their work today is an honour.

With the circumnavigation of Antarctica completed, *HMS Protector* now continues her epic multi-year deployment having steamed over 18,000 nautical miles, surveyed 3,000km2, visited 6 continents, worked with personnel from a vast number of nations and reached the furthest South since James Clark Ross. The Ship is now well into the Austral winter with a programme of surveying around the African continent prior to returning South to the Antarctic Peninsula next season.

Note: high resolution image for aerial view of *HMS Protector* also available from: http://www.navy-marin.forces.gc.ca/assets/NAVY_Internet/images/news-nouvelles/2016/prtr-ice-breaking-2.jpg



Lt Retallick joined the Royal Navy in January 2007 having served in the RAF police for 6 ½ years during which time she completed several deployments including two tours in Afghanistan. After completing initial officer training at BRNC Dartmouth and sea training in the Atlantic, North Sea and Far East on a number of ships, she attended HM(H) course at *HMS Drake* and obtained a BSc in Maritime Science. Assigned to *HMS Echo* in 2010 as Gunnery Officer, she deployed for 2 years to the Arabian Gulf and Indian Ocean. During this busy period, she also completed a BSc in Geosciences with the Open University prior to commencing a MSc in GIS, finally completed in 2016. Assignments to *HMS Scott* and *HMS Enterprise* as Navigator followed in 2013-14 with deployments to the Mediterranean, Indian Ocean and North Atlantic as well as a busy training period in the UK undergoing Operational Sea Training and Exercise Joint Warrior. Assignment to HMAS (Advanced Survey) course in 2014 was followed by 2 years serving in *HMS Protector* as Survey Manager and alternate Operations Officer for the Ship's deployment to the Ross Sea and circumnavigation of Antarctica.





Cloud Computing through the GIS Optic "The 'SaaSification' of Defence GIS"

"GIS has been waiting for the cloud. GIS was born to exist in the cloud. The Cloud is fertile ground for a GIS. The Cloud has enormous potential to change that, shifting spatial gears and accelerating the wider use of GIS functionality.

Direction Magazine (2011)

Introduction

This article aims to increase the understanding of cloud computing[1] (CC) technology, focusing on the Software as a Service (SaaS)[2] capability. The article also assesses the potential evolution and challenges of implementing cloud technology, particularly at the tactical edge, and considers the benefits of providing GIS services and/or geospatial data via the cloud. It examines and predicts the potential uptake by MOD.

Current trends within the MOD see emerging initiatives towards the procurement of software as a service (SaaS). This transition from a product-centric to a service-centric approach is in line with the direction in which commercial GIS vendors have been travelling over the last decade. Such 'SaaSification' of Defence GIS could provide significant potential for change that revolutionises the speed and effectiveness of information delivery across a battle space. The use of wireless and cloud technology to deliver current and authoritative geographic data sets to the front line soldier, underpinned by powerful GIS technologies and an endorsed spatial data infrastructure (SDI), should see an increase in agility.

Cloud Computing (CC)

MOD's Defence Information Strategy (DIS) (MOD, 2016) have recently declared that MOD will *"continue its 'cloud first' policy, moving away from legacy applications and hosting towards a cloud computing model". The National Institute of Standards and Technology define CC as: "A model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."*

Type of cloud	Definition of Cloud Infrastructure
Private	Provisioned for exclusive use by a single organisation comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organisation, a third party, or some combination of them, and it may exist on or off premises.
Community	Provisioned for exclusive use by a specific community of consumers from organisations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organisations in the community, a third party, or some combination of them, and it may exist on or off premises.
Public	Provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organisation, or some combination of them. It exists on the premises of the cloud provider.
Hybrid	A composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardised or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

Table 1: Definitions of Cloud Infrastructures

The provision of virtual service models exploited by thin client technology, including infrastructure, platforms, data and software, can give efficiency savings as they are used on a pay-per-use basis and maintained remotely.

There is reliance, however, on an Internet Protocol (IP)-based network to allow interaction between the service providers and service customers.

[1] the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.
[2] a software licensing and delivery model in which software is licensed on a subscription basis and is centrally hosted



Figure 1 – Multiple clients access to cloud-based infrastructure, platforms, data, software and applications 'as a service' via the Internet cloud

EFFICIENCY	
Current Environment	**Future Cloud Environment**
Low asset utilisation (server utilisation <30% typical)	Improved asset utilisation (server utilisation > 60 70%)
Fragmented demand and duplicative systems	Aggregated demand and accelerated system consolidation
Difficult to manage systems	Improved productivity in application development, application management, network, and end user devices
AGILITY	
Current Environment	**Future Cloud Environment**
Years required building data centres for new services	Purchase "as a Service" from trusted cloud providers
Months required increasing capacity of existing services	Near instantaneous increases and reductions in capacity
	More responsive to urgent agency needs
INNOVATION	
Current Environment	**Future Cloud Environment**
Burdened by asset management	Shift focus from asset ownership to service management
De coupled from private sector innovation engines	Tap into private sector innovation
Risk averse	Encourages entrepreneurial culture
	Better linked to emerging technologies

Table 2: Cloud Benefits: Efficiency, Agility, Innovation (DOD, 2012)

Outline of Geospatial Information System (GIS) and the Cloud

Traditional GIS applications have been reliant on 'thick client' technology[3] where powerful and large desktop computers would process geospatial information and perform spatial analysis algorithms, computations and analysis, storing data and products locally on the client computer. Bhat et al. (2011) promote the use of cloud technology and implicate its potential to improve the scalability, accessibility and usability of GIS resources.

Software as a Service (SaaS)

Software as a Service (SaaS) is one particular type of service offered via the cloud[4]. Recent GIS developments have seen the introduction of WebGIS (ESRI, 2015) allowing geospatial data and GEOINT[5] to be transformed into web services or web maps.

[3]Thick clients, also called heavy clients, are full-featured computers that are connected to a network.
[4]Subsets of CC are Platform as a Service (PaaS), Infrastructure as a Service (IaaS), Software as a Service (SaaS), Data as a Service (DaaS), Security as a Service (SECaaS), and Communication as a Service (CaaS), collectively known as Anything as a Service (XaaS).
[5]Geospatial Intelligence (GEOINT) is defined as *"the spatially and temporally referenced intelligence derived from the exploitation and analysis of imagery intelligence (IMINT) and geospatial information (GEOINF) to establish patterns or to aggregate and extract additional intelligence."* (JDP 2-00, 2012, p2-11)

The Challenge for the Provision of GEOINT Cloud Services at the Tactical Edge

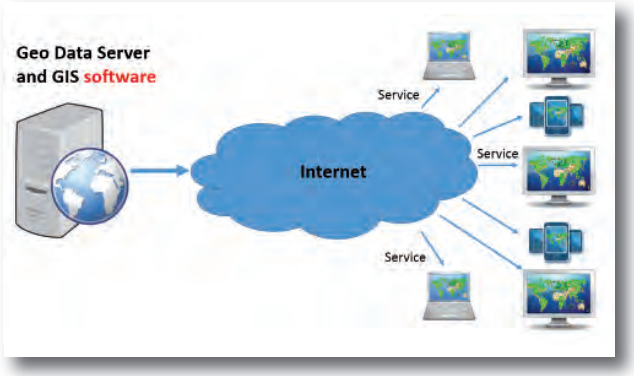


Figure 2 – GIS 'Software as a Service' using Cloud Computing Technology

There are a number of challenges ahead. Research on the development of cloud technology, with its embedded GIS services, in the tactical space, is essential. GIS is the one example of where The MoD potentially needs more detail in order to provide richer services (tactical mapping and other data heavy layers)? It is of paramount importance that there is a robust network for any cloud and that virtualisation type services to be viable and trusted. For example Broadband Global Area Network (BGAN) services and radios have reasonable data rates which can provide simultaneous voice and broadband data, but come at a cost.

Further investigation needs to confirm which type of cloud model should be used to provide optimum Geo services to the front line. Possible options are:

1. to implement a single-authority model, where a single coalition member nation or organization is responsible for providing, controlling, managing and disseminating Geo services for other nations to consume or,

2. to implement a multi-authority model where each nation or organization are responsible for their own geospatial data and services and share it across the mission network.

Likely Evolution of Technology

The manner in which the MOD addresses the issues will ultimately determine whether the migration to cloud services is successful or not in the Defence environment. Whilst recognising that the complexity of the cloud cannot be underestimated, the following questions must be addressed::

1. How will the MOD prioritise its multiple resources within the cloud?

2. Will essential geospatial updates be afforded priority over voice, email and other data transmissions? How will cloud technology ensure that different levels of classified data can only be seen by those who 'need to know'?

3. How will it protect its information and infrastructure against the constant cyber-threat?

Other challenges to overcome will include the means of preventing or deceiving the enemy from fixing locations when broadcasting information across clouds, and mechanisms enabling the MOD to ensure timely replication and synchronisation of information across multiple sites.

Data encryption techniques will also need to evolve, to stay one step ahead of those adversaries trying to access confidential and secret information and intelligence. The development of revolutionary homomorphic encryption[6] techniques, for example, will allow processing directly on encrypted GEOINT and other data, enabling it to be queried by untrusted third party services or cloud providers, without revealing the source data.

There is also an argument for obtaining a better understanding of how the MOD and GIS specialists can measure cloud performance. How will MOD be able to monitor cloud services and its providers in the future, and hold them accountable for the services they provide? How can the MOD establish and enforce regulations to maintain control and data assurance? A solution could be crafted through the continued refinement of the current range of common standards already in use for cloud services. If MOD cannot ensure the end user has access to the accurate geospatial information they need, at a time they need it, they may be forced to use unassured and potentially inaccurate sources of spatial information.

[6]Homomorphic encryption allows computers to perform math directly on the encrypted data without having to decrypt any of the data and thus expose it to attack. In theory, it means programs -- or whole Virtual Machines -- could run while encrypted and exchange encrypted data between them as they did so (InfoWorld, 2014)

Current research is being conducted on Identity and Access Management (IDAM) to provide information asset owners with greater ability to control their information assurance by creating centrally administered digital identities (Advance, 2014) and this needs to continue. The challenge also remains to convince system and security accreditors that a potential lack of information assurance should not necessarily halt progress by acting as an anchor, thus allowing trials and implementation of new technologies in the process.

Impact Assessment for the MOD

The 'SaaSification' of Defence GIS using CC technology will:

1. Enhance soldier mobility through device and location independence, while providing on-demand secure global access to mission critical GEOINT data and enterprise services.

2. Enhance C2, Common Operating Picture, Intelligence, Surveillance, Target Acquisition and Reconnaissance capabilities.

3. Bring greater flexibility, agility, scalability, availability and resilience to the tactical edge.

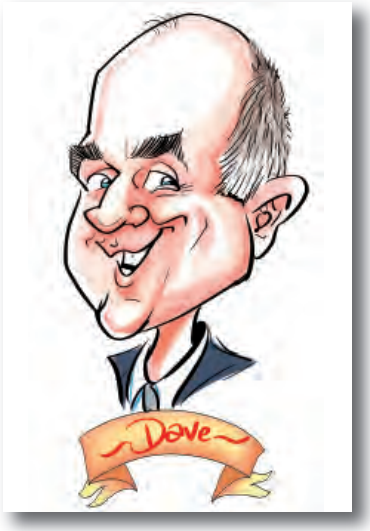
Conclusion

In conclusion, the MOD is encouraged to increase secure information sharing and collaboration, enhancing its mission effectiveness and decreasing costs using GIS and the Defence cloud services. This will lead to ensured consistency, the optimisation of benefits and will achieve the goal of providing game-changing GEOINT services in an efficient and effective manner using cloud technology.

Recommendations for the MOD

The exploitation of the potential of Cloud Computing is a huge political and technical challenge. If the potential is to be realised commitment and investment by the MoD is essential. It is recommended that the MOD invest resources into carrying out further assessments and research in the following areas:

1. **Cyber security** – protection of critical Geo systems and geospatial data against cyber-attack.
2. **Geo data replication and synchronization** to ensure continuity of operations and provision of resilience.
3. **Trials** to provide Information Assurance for Geo data across limited bandwidth networks at times of peak traffic.
4. **Acquisition and exploitation** of Open Source Geo data and GEOINT via the Internet cloud.
5. **Possible use of local mobile CC** in the military tactical environment in order to alleviate issues of unreliable networks, low bandwidth and low power (SWaP efficiencies).
6. **Provision of Geo services** from fixed to deployable (tactical) networks.
7. **Monitor Commercial off the Shelf** (COTS) CC and GIS solutions outside of the military environment and implement where appropriate.
8. **Risk reduction activities** should include ensuring sustainable funding is in place for the long-term procurement and development plans.
9. **Collaboration and coordination** of development activities with allies, industry partners and academia to refine and mature CC and GIS approach.
10. **Development of data encryption** technology to ensure the security of geospatial information and intelligence.
11. MOD is recommended **to procure** the following:
    - **State of the art cloud infrastructure** with scalable data storage and processing capability.
    - **Latest GIS software** which uses portal technology and is compatible with coalition partners, in order to maximize cloud capability through the provision of software as a service.
12. **A roadmap for the deployment of new technology** is essential. Although CC and GIS technology could be deployed on today's Mission Networks, it is unusable at the mobile/network edge due to the fact that information is needed in real time, or is otherwise time critical.
13. Ensure emerging GIS technology and direction of travel is highlighted to **future programmes** for inclusion (e.g. MORPHEUS)
14. Inclusion of **coalition partners** in GIS SaaS development trials circa 2018 (US exercise)



Major Dave Campey commissioned into the Royal Engineers in 2005 having served 23 years in the ranks. On completion of his trade training he served in Cameroon, Kenya, Norway, and Australia, and on Operations in Bosnia and Kosovo. More recently he deployed as SO3 Geo on Op HERRICK6 attached to 26 Engineer Regiment, Headquarters Task Force Helmand. He has served as the RSM of the City of Edinburgh Universities Officer Training Corps, a Troop Commander at 1 RSME Regiment, and 2ic 14 Geographic Squadron. He completed the MSc in GEOINT in 2010 at the Royal School of Military Survey and then served with Headquarters 3rd (United Kingdom) Division as the SO3 GEOINT. Posted on promotion to Major, Dave then spent three years as an integral member of the Command and Control Development Centre (C2DC) and Capability Development Information Branch in Warminster. He is currently employed as SO2 GEOINT in Directorate Information, IX Branch in Army Headquarters where he also is the UK Armies GEOINT SME within the FVEY ABCA Community. He regularly represents the Army at judo, is the UK Armed Forces Judo Team Manager.



Corps Reconnaissance 1914-18

By Wg Cdr Jeff Jefford

This paper was originally prepared for an RAF Historical Society seminar held in 2012 to mark the centenary of the creation of the Royal Flying Corps[1]. The theme for the day was to consider the two earliest operational functions of the RFC – that is to say, permitting the general to 'see over the hill' and the direction of artillery fire – and the way in which these two functions continued to be discharged, during the inter-war years and WW II by the RAF, and, ultimately, by the Army Air Corps. That said, we should acknowledge that even the RFC of 1912 had its antecedents, so it is appropriate to begin with just a little pre-history. What is generally recognised as having been the first successful powered flight in this country was made by Sam Cody in 1908 and within two years a number of enthusiastic junior officers had begun flying on their own initiative. By that time, and contrary to what is often alleged about the Army's having a totally dismissive attitude towards aviation, the General Staff was sufficiently interested in the potential of the aeroplane to employ a few, albeit borrowed ones, during the annual manoeuvres of 1910 which were held on Salisbury Plain.

It was during these exercises, on 21 September, that Bertram Dickson, until very recently a captain in the Royal Horse Artillery, made what is generally accepted as having been the first military aerial reconnaissance sortie. Five days later, the notable actor/aviator Robert Loraine made the first air-to-ground wireless transmission in this country.

These events, and other considerations, led to military aviation being put on a firmer footing with the establishment of the Air Battalion of the Royal Engineers in April 1911. That arrangement lasted only a year, however, and, a Royal Warrant of 13 April 1912 established the Royal Flying Corps. Its organization was to include a Central Flying School to provide appropriate instruction and No 1 CFS Course was run at Upavon between August and December 1912. It was chiefly concerned with getting folk to fly without breaking their aeroplanes or their necks, but there was a substantial amount of technical instruction in the workshops and about 50 hours of formal classroom time. Significant among these, from the perspective of this paper, were:

Functions of aircraft in war on land	1 hour
Map reading	2 hours
Observation of artillery fire	3 hours
Practical navigation	1 hour
Formations of foreign armies	1 hour
Conclusions drawn from use of aeroplanes on manoeuvres	2 hours

In reality, many of these 'lectures' are likely to have been more in the nature of group discussions. At the time, there was little practical experience, let alone doctrine, on which to base a syllabus because the military aviation community was still feeling its way.

For the manoeuvres of 1912, each side was assigned seven aeroplanes and an airship. The opposing generals, Haig and Grierson, both made use of them for reconnaissance work and many lessons were learned. For the war games of 1913 the RFC fielded no fewer than thirty-five aeroplanes and about 550 men. Again, much was learned, and increased attention was paid to the problem of communication. There was some more experimenting with wireless, but the most practical way at the time was to drop scribbled notes on a marker laid out on the ground near the HQ.

There were no manoeuvres in 1914, because war had broken out on 4 August. The BEF crossed the Channel to take up positions near Mons, with the French Army on its right and not much at all on its left, because the Belgians were falling back to the north west, toward Antwerp. The RFC's operational echelon, flew across to France where it set up shop at Maubeuge, about 10 miles behind the British line. The first reconnaissance sortie was flown on the 19th of August but it appeared that it was 'all quiet on the western front.' It did not stay that way for long, however, and on the 22nd, when twelve sorties were flown, crews reported German troops moving westwards from Brussels

towards Ninove where they had turned south west, clearly indicating an intention to turn the exposed left flank of the British position.

The overall picture being established by aerial reconnaissance was clear, and, after a holding action at Mons, a withdrawal was ordered which, by preventing its position from being enveloped, undoubtedly saved the British Army.

The RFC was involved in this retreat, of course, and over the next three weeks it moved house – or tents – or barns – twelve times. But it kept flying reconnaissance missions throughout this period and, while there was some initial reluctance to accept the reports of the airmen in some quarters, this was soon replaced by increasing confidence as these reports were repeatedly shown to have been correct. It was, for instance, the RFC that first reported that the German thrust had unexpectedly changed direction from south west to south east on 31 August, thus exposing its own right flank, and that the Germans had actually crossed the Marne on 4 September, leading to the battle of that name.

Despite the helter-skelter nature of the retreat, the RFC was learning on the job and with the German advance on Paris having been blocked by the Battle of the Marne, the next engagement, the Battle of the Aisne, changed the nature of the war. Neither side could make any headway, so they both dug in and by the end of October what had been a campaign of manoeuvre had become one of static trench warfare.

Now able to operate from a relatively stable location, the RFC began to expand its capabilities. Previously confined to visual reconnaissance and liaison flights, during the Battle of the Aisne, which was fought in mid-to-late September 1914, the RFC notched up several significant 'firsts'.

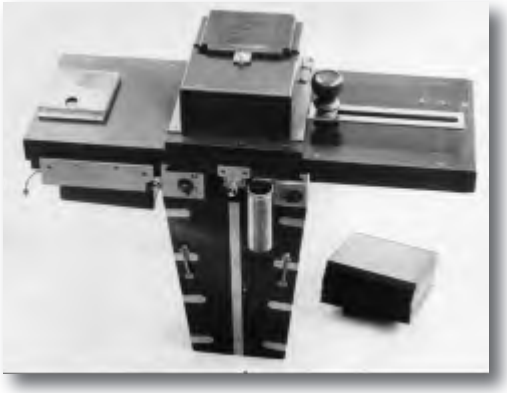
- It took the first airborne photographs – of any consequence.
- It applied the concept of the gridded map.
- It made the first practical use of W/T transmissions from the air.
- It made the first attempts to direct artillery fire.

Some pre-war experimental work had been done in all of these fields, of course – but realistically speaking these were operational 'firsts' which we can consider in turn.

Photography

Photography was a very obvious way to enhance reconnaissance reports by taking images that recorded permanently, and in detail, what had been seen relatively fleetingly. What was of critical importance was the production of mosaics – overlapping vertical pictures – which were used to create maps. Photographic coverage, of the whole Front, was constantly repeated over the next three and a half years, sometimes on a daily basis, to permit the maps, or, to be more specific, the trench overlays to be updated.





Left, the hand-held single-shot Type A camera; right, the magazine-fed Type C which was mounted on the airframe. (Barry Gray)

It took time for the necessary cameras to be designed and produced in quantity, of course, and it was an evolutionary process that continued throughout the war. First up was the hand-held Type A of 1915. It was a hefty, brass-bound wooden box which weighed about 10 lb. Changing the individual 5"×4" glass plates and resetting between shots required ten distinct actions, which would have been no joke at sub-zero temperatures in the 70 mph slipstream.

It was soon superseded by the Type C which was a practical and robust device of similar construction and appearance but, its weight, now some 26 lb, more or less precluded its use as a hand-held, so it

was mounted on the airframe. It was fed by a magazine containing eighteen 5"×4" glass plates, making changing them between exposures much easier.

The Type C was still in use in 1918 but a lot of progress had been made by then and it had been largely superseded by the Type L which was of metal construction and much smaller. It could be operated manually, either directly, or remotely from within the cockpit via a Bowden cable, or the glass plates (still in magazines of eighteen 5"×4") could be changed mechanically after exposure by a windmill-powered flexible drive so that, if the aeroplane were flown in a straight line at a predetermined height and speed, it would automatically produce a series of pictures with the desired degree of overlap.



The Williamson Type L.

While the major customers were the planning and intelligence staffs and the map-makers, artillerymen and balloon observers, also required photographs of their areas of local concern. Their demands sometimes involved oblique photographs to amplify specific details and they were also useful to record fleeting events. These were usually taken by the observer, using a P-series hand-held camera.

In the early days, photographic processing was carried out at a Wing HQ, the RFC having been decentralised into wings as early as November 1914. But as the scale of the task expanded the wing photographic sections became increasingly overloaded and this slowed down the rate at which they could turn out prints – and with intelligence product speed is of the essence. The answer was more decentralisation and in the spring of 1916 the task was devolved to squadrons who would now process pictures at unit level for relay directly to its customers. In 1916 the establishment called for a corporal and three men but by the summer of 1918 this had increased to a sergeant, a corporal and 14 men – per squadron.

The scale of the work carried out was remarkable and escalated as the war went on. The figures below, which were compiled shortly after the war, show that more than ten and half million prints had been made in France – and there would have been more in Italy, Salonika, Palestine and elsewhere[2].

Year	No. of Prints
1915	(Est) 80,000
1916	552,453
1917	3,925,169
1918	5,946,096
Total	**10,503,718**

Expansion and Reorganisation

It is convenient to make a slight detour here in order to sketch in some of the background. The devolution of responsibility for photographic processing in early 1916 was symptomatic of a much more extensive reorganisation of the, by now, much larger RFC. In January of that year a brigade structure was introduced, one RFC brigade being assigned to each of the four armies that constituted the BEF by that time. While the RFC had been expanding, however, it had also been broadening the spectrum of operational functions that it could undertake and with squadrons beginning to specialise in particular activities, they were grouped into specialised wings, generally of four squadrons.

Army Wings operated under the direction of the Army HQ and delivered proper 'air power' functions, like reconnaissance in depth, bombing, strafing and mounting offensive and defensive fighter patrols, all of these becoming more clearly defined and refined as the war progressed.

The Corps Wings did the short range work. These were the units that worked directly with the troops. These were the 'Army co-operation' squadrons and they were generally assigned one to each corps within an army.

It should be made very clear at this point that, despite the attention paid, at the time and since, and perhaps especially since, to the pilots who flew Camels and SE5as, the RFC – and the wartime RAF

– was really all about supporting the Army and the aeroplanes that actually did that were those that were flown by the far less glamorous corps reconnaissance squadrons. So it is appropriate to say a few words about the aeroplanes they flew.

While early use was made of sundry Blériots, Farmans, Avros, Moranes and the like, the RFC's workhorse for the first three years of the war was the BE2c and the later BE2e. Heavily criticised at the time, and since, the BE2 was not fundamentally a *bad* aeroplane. It did exactly what it said on the tin. The problem was that the tin was well past its sell-by date.



The much maligned BE2c was a very workmanlike aeroplane in its day. Unfortunately, its day was done by the end of 1915 but it was still in widespread use in the spring of 1917.

Geoffrey de Havilland had set out to make an inherently stable aeroplane that would carry two men, in safety, for three hours or more, and be relatively easy to dismantle, erect and maintain in the field. It did all of those things but the very sensible idea of putting the second crewman in the front seat, more or less on the centre of gravity, so that the aeroplane could be flown solo without incurring any balance problems, proved to be a severe handicap.

There had been little thought of aerial combat when the BE2 had been designed back in 1912 but when it was committed to action two years later it proved to be virtually defenceless because it was practically impossible to wield a gun effectively from the front cockpit – and that highly desirable degree of designed-in stability had become a lack of manoeuvrability. That said, the BE2 was still a viable aeroplane in early 1915. The problem was that the RFC was still flying it two years later – hence 'Bloody April'.



From the summer of 1917 until the Armistice 75% of the of the corps reconnaissance squadrons in France flew the RE8; this one belonged to No 3 Sqn AFC.

By that time, however the RE8 had begun to appear, not that it seemed to be all that promising. The first of them had arrived in France in late 1916 with No 52 Sqn, but they suffered so many accidents that the RE8s were withdrawn and replaced by yet more BE2s. They were not that successful in combat either, No 59 Sqn lost twelve during April – six of them on a single photographic mission flying in formation for mutual protection. That was actually the problem. The RE8 was a significant improvement on the BE2; it had the observer in the back seat, where he could actually use a gun and it had a significantly better performance. But it was hardly a 'two-seat fighter'.

The new Bristol F2b, did turn out to be 'a fighter' – eventually – but it too proved to be a major disappointment when it was committed to action for the first time in April 1917. Flying in formation, just like the RE8s, when No 48 Sqn flew its first patrol with its Bristols on the 5th four of them were shot down, and it happened again on the 11th when three more were lost.



The very capable Bristol Fighter would have replaced the RE 8 and FK 8 had the war continued into 1919. This was one reached No 5 Sqn in the winter of 1918-19.

At much the same time Armstrong Whitworth's FK 8 was also becoming available, although this one managed to get itself established without any disastrous losses. These were all 'second-generation' aeroplanes, of course, but the RFC had not yet found out how to use these new tools. Having been obliged to persevere with the BE2 and the Sopwith 1½ Strutter during 1916, it had become normal practice to fly in formation in the hope that the combined defensive fire power just might offset their increasingly inferior performance compared to the opposition's new Halberstadt and Albatros fighters.

It would take a while for the RFC to work it out but the answer was for the new RE8s and FK 8s to stick to corps work, which meant that they would stay relatively close to the lines, where we ought

to be able to maintain control of the airspace, permitting the observation aircraft to operate alone. Longer-range reconnaissance would be conducted by the Army Wings using the Bristol Fighter which, when not constrained to flying in formation, could take care of itself quite well.



An Armstrong Whitworth FK 8 of No 82 Sqn. (Mike O'Connor).

In fact the Bristol was so successful that it was intended to use it to replace the RE8 and FK 8, but industrial problems, mostly to do with the production of engines, meant that this plan was never realised and Bristols were only just beginning to trickle down to the corps squadrons as the war ended.

Maps and Grids

We can now return to our list of innovations introduced during the battle of the Aisne, the second of which was the use of gridded maps. If flyers and gunners were going to work together they needed to use the same maps and be able to identify a specific feature without being able to jab a grubby finger at it – because one of the guys was up in the air.

Today we are accustomed to aeronautical charts being marked with latitude and longitude and the UTM grid and our Ordnance Survey maps having a National Grid overprint. But this was not the case in 1914. If you examine an OS map of that era it is very detailed, but there is no easy way to create a map reference.

What Capt Donald Lewis of the RFC did at the Aisne was to draw a simple square grid in pencil on the available 1 in 80,000 map, permitting him to define the co-ordinates of a target that could be interpreted by a gunner using a duplicate squared map provided by Lewis. And that principle came to be applied wholesale.

The provision of suitable mapping was a problem to begin with because existing Belgian and French mapping did not fit together, because they used different projections and, whereas most nations had agreed back in 1884 to treat Greenwich as the international prime meridian for measuring longitude, the French were still using Paris. Furthermore, continental mapping was in metres – and the Royal Artillery didn't speak French. As a result, before the end of 1914 the British had already decided that they would have to produce their own maps.

It was done by the Ordnance Survey which produced the famous 'trench maps', initially by using existing Franco-Belgian material which was progressively refined by conventional field survey parties operating in friendly territory, information on the far side of the lines being extracted directly from aerial photography and/or, where available, cadastral information refined by aerial photography.

It took about a year to map the whole Front, and the style of coverage evolved with time but the eventual outcome was that the OS produced base maps at a scale of 1 in 20,000 which was also printed in scaled-up and -down versions at 1 in 40,000 and 1 in 10,000. A scale of 1 in 10,000 is better than 6 inches to the mile – which is pretty big – the runways at Heathrow, for instance, would be well over a foot long. These options were not exclusive, of course, maps in even larger scales could be produced for specific operations – and the 'balloonatics' routinely used 1 in 2,000 maps (ie about 30 inches to the mile).

One last thought, the British trenches were originally shown in blue with the German lines in red. The French had got it the wrong way round, but in the interests of allied co-operation, in early 1918 we reversed our convention to conform with French practice.

Artillery Direction

Moving on to the third function on our list, the direction of artillery fire, this writer makes no claim to having any expertise in gunnery, beyond a few basic facts. One point worth making is that, despite the machine gun's evil reputation, the real damage was done by the artillery, which accounted for practically all the material devastation and is said to have been responsible for more than 60% of the casualties inflicted during the war.

There was a wide variety of guns available to the British Army, but the standard piece for the Royal Field Artillery was the 18 pounder. Depending on the mark, this had a range of up to 11,000 yds –



The classic illustration of the destructive power of artillery – Passchendaele in June and December 1917.

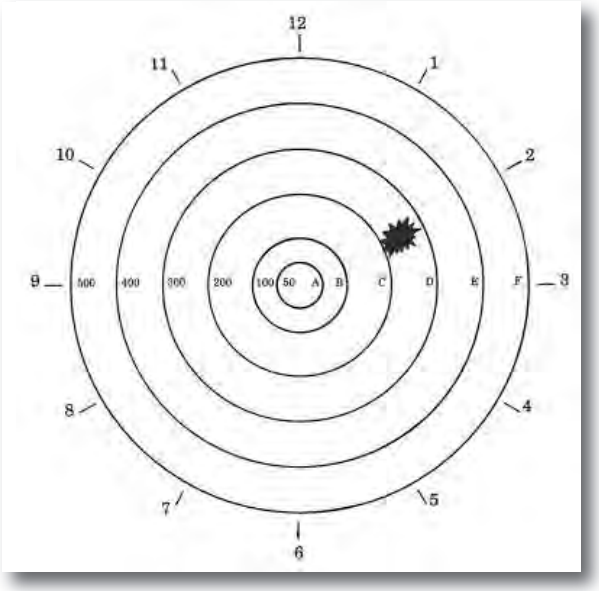
say 6 miles – but that presupposed that you could see what you were shooting at. If there was no line of sight to the target you had to resort to indirect fire and that meant using a howitzer – that is to say a gun that shoots at high angles of elevation to produce an arcing trajectory and plunging fire.

There were lots of these to choose from running from the 4·5" howitzers of the Royal Field Artillery, through the Royal Garrison Artillery's 8" and 9·2" howitzers and even a few rail-mounted monsters.

The trick when using indirect fire, of course, is to know where the target is – because you can't see it – and to know whether you have hit it or missed and, if so, by how much – because you can't see it. And that is where the corps squadrons came in.

At the risk of stating the obvious, it may be useful to provide some idea of the geographical extent of the BEF's commitment on the continent, since that governed the operational parameters of the RFC. Using ballpark figures, the British manned a sector running more or less north-south for *about* 100 miles between the coast (actually a few miles inland – the coastal strip was held by the Belgians) and the River Somme, roughly Albert.

From 1916 until the end of the war, the British had five (at times temporarily only four) armies in the field, so each one had a front of *about* 20 miles. While the length of the BEF's front was relatively constant, however, the steady expansion of the RFC/RAF meant that it could increase the density of aeroplane deployed along that front and it was also possible to concentrate force in support of a particular sector when an offensive was launched. For the Battle of Arras in April 1917, for instance, the effective strength of some of the corps reconnaissance units within I, III and IV Bdes was increased from the usual eighteen aircraft to twenty-one, and in some cases twenty-four[3].



The clock face was oriented with 'noon' at True North and the miss distance was related to the lower of the two range rings; in this case C2.

But that 'usual eighteen' aircraft was in itself a symptom of the RFC's expansion that tends to be overlooked. We tend to focus on the number of squadrons in the field but while there were more of them, they were also becoming much larger. In 1914 a squadron was established to have twelve aircraft. In 1916 this was raised to eighteen and in 1918 to twenty-four, although most had reached only twenty-one before the war ended. By the time of the Armistice, the RAF had twenty dedicated corps reconnaissance squadrons in France fielding between them more than 400 aeroplanes[4]. So what did that mean?

The composition of an army was not set in stone, but, in general terms, an army had four corps, so each of those would have had a front of about 5 miles and, since each corps was assigned a squadron, that more or less determined the width of that squadron's area of concern.

So if it was 5 miles wide, how long was it? That was determined by the range of the guns. That varied, of course, but the main counter-battery guns, the 9·2" howitzers, could fire up to *about* 8 miles – and the opposition would have had much the same capability, so you finish up with a box of airspace, about 5 miles by 10, divided by No Man's Land.

That was a very small area, of course, and it could be even smaller. Bearing in mind that a corps reconnaissance squadron of 1918 would (should) have had a strength of twenty-one aeroplanes, of which about 90% would have been serviceable (that is a reasonable figure for the period) it would actually have had about eighteen to play with. They could be operated in three, three-hour shifts, of six aeroplanes each. So the first six crews might go up at dawn, say 5am, and land at 8am; they

would have six hours on the ground while the second and third teams were on station, then go up again between 2pm and 5pm, and so on.

Six aeroplanes spread across a 5 mile sector of the front meant that they would each cover a strip *about* 1,500 yds wide[5] and, with a bit of reinforcement when a big push was on, that could be reduced as little as 1,000 yds and that density of cover could be maintained throughout the hours of daylight[6]. Once again, it should be stressed that these are ballpark figures, and that operations at that level of intensity could not have been sustained indefinitely, but it was certainly feasible on a 'surge' basis.

So, how was a shoot actually conducted? Before describing that, we need to discuss wireless, the fourth item on our list of significant 'firsts' achieved in 1914. For the moment, suffice to say that the key tool in the box was the clock code, which was first used at Neuve Chappelle in March 1915. The precise location of the target having been established using the squared map, the aircrew and the gunners referred to it by superimposing on the map a series of imaginary concentric lettered range circles centred on that position and oriented to True North. This was often done using a transparent overlay – but for a pre-planned target, the rings were sometimes printed on a photograph.

When the crew observed the impact of a shell, it would be plotted on the map and the miss distance passed to the battery by reference to the clock face and the lower of the two lettered rings bracketing the shell burst.

Balloons

We should make another slight diversion at this stage to register the fact that, apart from aeroplanes, the RFC – and the RAF – made extensive use of balloons for the direction of artillery fire, as did the Germans. Indeed the first generation of balloons used by the British were a pirated-version of the German *Drachen*.



A Caquot Type M observation balloon.

Their initial introduction was a little awkward as the Admiralty had been given responsibility for all lighter-than-air aviation in January 1914, so when the Army wanted to see what balloons could do, they had to ask the Navy to oblige. The first RNAS Kite Balloon Section was deployed at the front in May 1915 and there were four such naval units in the field before control of all balloons in France was reassigned to the RFC in October. In 1916 the original *Drachens* were superseded by a superior French design – the Caquot – which was pretty much the barrage balloon of WW II.

In action, a kite balloon might remain aloft for as long as ten hours at a stretch. Suspended above the lines, typically at about 3,000 feet (although there was enough cable to get up to 5,000) beneath some 30,000 cu ft of highly inflammable hydrogen (think Hindenburg) in what amounted to a laundry hamper that swung wildly in windy conditions, the balloon observer's environment was not an enviable one.



'Balloonatics' were suspended above the lines at about 3,000 feet in what amounted to a laundry hamper.

Furthermore, balloons were vulnerable to marauding enemy fighters, at some risk from the friendly anti-aircraft guns that were supposed to ward off these attackers and occasionally in the direct line of fire in an artillery duel. Many were shot down and damage to cables caused others to slip their moorings and drift away over the battlefield, usually towards the enemy lines as a result of the prevailing westerly winds. To cater for these situations, balloon observers were unique among British aviators of the period in that they were provided with parachutes, and while these were far from perfect, they did save many lives[7].

What a balloon observer did was pretty much what the crew

of an aeroplane did, but he observed his relatively restricted patch from a fixed vantage point, and thus became very familiar with the lie of the land and able to detect the most subtle of changes. Using much the same squared map and clock code as an aeroplane observer, he did not have to use Morse as he was provided with a land line, so he could simply phone-in his observations directly to the battery. In fact, by 1918, rather than being connected to the battery, he was often plumbed into a mobile telephone exchange that could patch him through to any extension on the entire network.

That was pretty sophisticated stuff for 1918 and way ahead of the facilities available to aeroplane crews who were restricted to Morse or visual signals. Some use was made of signal lamps and, particularly in the early days, pyrotechnics, but by 1916 the primary method was wireless.

Air-to-Ground Communications – Wireless

Which takes us to the third item on our list of significant firsts at the Aisne. Since these were all achieved before the end of 1914 they were all pretty tentative at that stage, but they established the possibilities and, as with the cameras, the necessary wireless equipment was designed and introduced, and operational procedures for using it were worked out.

Until wireless started to become relatively commonplace, which was not until mid-1915, the primary method of air-to-ground communication remained the message bag but, for registering the fall of shot, some use was made of pyrotechnics – Very lights. Green Red, for instance, meant 'Over to the Left'. A double Red meant 'Over to the Right'. Red Green meant 'Short to the Right', and so on, with a direct hit being Red Green Red. It was a bit vague – there was no miss distance and only a crude indication of direction – but it was better than nothing, and, if necessary, more complex messages could be passed by Morse using a signal lamp and coded groups. But by 1916 these relatively crude methods of communicating had been largely superseded by wireless.



The Sterling Telephone & Electric Co Ltd's Transmitter Type 52.

The standard equipment was the Type 52, more commonly known, after its manufacturer, as 'the Sterling set'. Powered by a 6-volt accumulator, it was a simple spark transmitter which worked on wavelengths between 140 and 260 metres using a 120-foot trailing aerial that you had to wind out *(and back in when you were done)*. Its 30-40 watt power output gave it a range of up to 10 miles – which was adequate for the relatively small box of airspace within which a corps aeroplane would operate. The equipment had a number of limitations but the greatest of these was that it was one-way air-to-ground only. It used Morse at a notional 8 words per minute, which was the pass rate for aircrew – compared to the 20 or more that was the norm for a professional wireless operator.

Are you receiving my signals?	R
Am returning to landing ground	CI
Are you ready to fire?	KQ
Column	COL
Fire	G
Stand by	A
Stop firing	MQ
Battery Fire	BF
Salvo	VO
Infantry	FAN
Guns at pre-arranged target No 'x'	N
Guns firing in position (co-ords)	NF
Guns not firing in position (co-ords)	NT
Continue firing in your own time	GO
Over	O
Short	S
Right	R
Left	Q
All available batteries to fire (Zone Call)	LL

Fig 1. Representative code groups for transmission by wireless and/or by signal lamp.

It was necessary for the crew and the ground operator to agree the frequency to be worked and once airborne, positive contact had to be established, bearing in mind that there would be other aeroplanes operating in adjacent orbits on very similar, if not the same, frequency. Since the aircrew had no receiver, whenever they transmitted they were quite likely to do it over the transmissions of another crew – so that they jammed each other. That aside, with several aeroplanes on task, there was clearly potential for confusion – who was talking to whom? The impact of this could be minimised by rigid discipline, particularly the use of callsigns, which were frequently changed for security purposes.

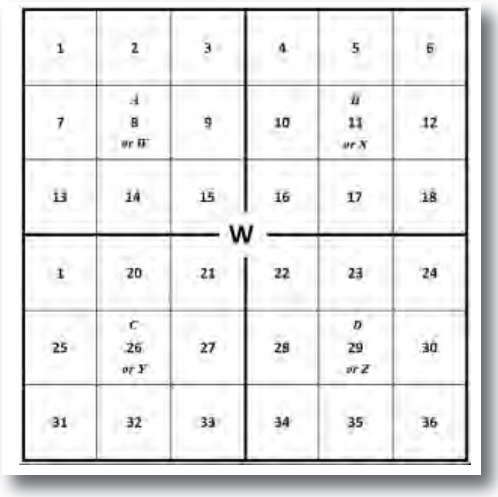
But the situation was considerably eased in 1916 by the introduction of a device called 'the clapper break'. What this did was to alter the tone/the pitch of an aeroplane's transmission. This could be detected by the ground

operator permitting him to filter out irrelevant traffic. That called for a great deal of skill, of course, and I should make it clear that the ground operators were RFC personnel deployed in the field with the artillery batteries. So, while service in the RFC usually implied the relatively safe environment and comfortable lifestyle associated with working on an aerodrome well behind the lines, like the balloon handlers and balloon observers, hundreds of RFC wireless operators shared the rigours of the trenches and the dangers of working on what was actually a prime target for enemy guns[8].

The length of wireless transmissions was reduced to a minimum by the use of one, two or three-letter groups which had predetermined meanings. These were largely the ones that had been established earlier for use with a signal lamp – Figure 1.

The Conduct of a Shoot

So now – finally – we can look at how a shoot was actually conducted. There was very close direct – personal – liaison between the crews of a corps reconnaissance squadron and the men of the batteries with which it was working and the target – or targets – for a particular sortie would be identified before the flight. Typically, these might be a particular stretch of a trench, a dug out or one or more German gun sites. All of these were plotted and annotated on the trench maps which were constantly being revised and updated – so a particular sortie might anticipate firing on, for instance, pre-designated targets Nos 3, 7 and 9 within a particular Zone.



A Zone.

So what was a Zone? Each trench map, in all scales, was overprinted with lettered 6,000 yard squares, each of which was divided into 36 numbered 1,000 yard squares and, superimposed on this, was a 3,000 yard quadrant lettered A to D (or W to Z). That was a target Zone – a specific 3,000 yard square identified by a two-letter group, the first letter indicating the 6,000 yard square and the second the quadrant within it.

Once the crew was on task, they set up a flight pattern, typically, an elongated figure of eight (Figure 2), and established contact with the ground operator. The aeroplane headed first towards the battery and transmitted the order to fire – the Morse letter 'G'. The crew watched and noted when the gun fired, at which point they reversed direction so that they could see where the shell would fall. They knew precisely when that would be, of course, because it was part of the stock in trade of a corps aviator to be familiar with such arcane issues as a shell's time of flight over a given range, and they needed to be sure that it was their battery's shell that they were seeing and not a miss from the gun next door.

Having observed the shell burst, they headed back towards the battery, plotted the fall of shot on their map and, using the clock code, passed the miss distance to the gunners by wireless. They would then return to the start point and repeat the exercise for each gun in the battery until all the shells were registering pretty much on the target, at which point, instead of sending G, they might order BF for 'battery fire' or VO for 'salvo'. When the damage had been done, the instruction would be 'stop firing' – 'MQ' and when the crew's slot time expired they would signal 'CI' for 'I am going home'. These are just examples – see Figure 1.

The system made provision for a crew to engage an unplanned target. There were a number of variations on the theme, but the classic case was the Zone Call – which, could redirect the fire of all batteries (or, however many guns, local RA standing orders laid down) assigned to engage targets within that Zone, which, you will recall was a 3000 yd square. If, for instance, while carrying out a routine bombardment of a number of known artillery positions, the crew observed that a site, that was not included in their task, had actually opened fire, they might consider that it should be neutralised as soon as possible in order to save the lives of the troops on the receiving end.

Under those circumstances, a Zone Call might read 'LL NF WB16', which translates as (LL) all guns to engage (NF) guns now firing at (WD16) known site Number 16 in the lower right hand quadrant of map square W. That gave an RFC 2nd/Lt the de facto authority of a brigadier general – so he needed to be sure that a Zone Call really was justified – because he had just disrupted the general's pre-planned firing programme for the day. In short, it was a judgement call, and there was provision for dealing with targets of opportunity with less urgency. In this case, the crew might have elected not to have invoked the 'executive' LL and merely sent 'NF WB16'; that is to say they would

simply have advised the gunners of an opportunity and left the decision to them.

If on the other hand, the crew had seen a large column of infantry on the move, they might consider that too good to miss, in which case the call might be 'LL COL 2000 FAN E W29a24'. That translates as (LL) all guns to engage (COL) a column (2000 FAN) of 2,000 infantry (E) moving east at (W29a24) a map reference to an accuracy of +/-50 yards. It would have been quite a challenge to send that message accurately via a silent Morse key – silent, because there was no receiver so you could not actually hear what you were sending. In practice, just a 1000-yard square, in this case W29, would sometimes suffice as the location – especially for a moving target – like troops. The deciphering of trench map references is something of an art form – see Annex A.

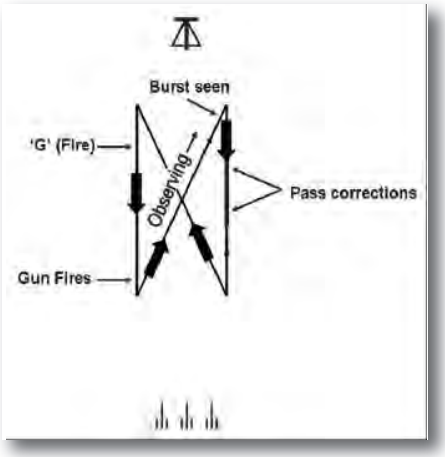


Fig 2. Schematic (not to scale) of a typical pattern flown during an artillery shoot.

Having previously noted the way in which the air service expanded, it is worth providing some indication of the scale of the work that it was able to carry out. This varied, depending upon the level of activity on the ground and could be heavily influenced by factors affecting visibility, so low cloud and fog would seriously interfere with observation. By the early summer of 1917 the RFC had nineteen corps reconnaissance squadrons in France, all of them with a notional establishment of eighteen aeroplanes, and all but one of them now equipped with the new RE8 or FK 8. Routine daily activity fluctuated wildly but on a typical day aeroplane crews might direct the artillery to engage between 70 and 100 targets, mostly hostile batteries, and balloon observers another 20 to 40, but much more could be achieved when associated with an offensive. The figures at Table reflect the work done during the run up to, and the initial stages of, the Battle of Messines, which was fought between 7 and 14 June 1917[9].

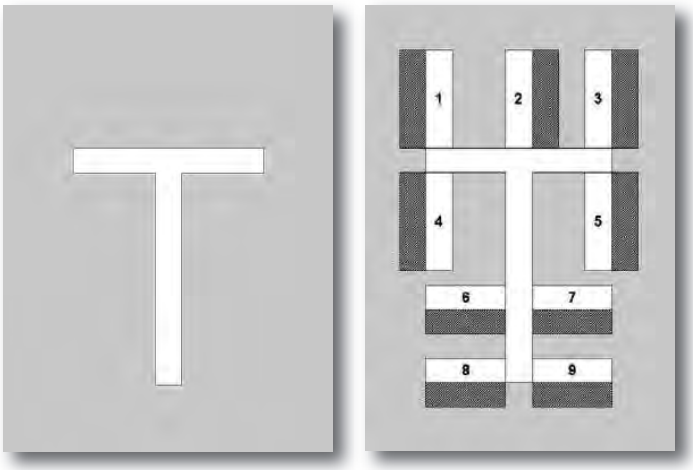
	Targets Engaged By	
Date	**Aeroplanes**	**Balloons**
3 Jun 17	193	107
4 Jun 17	214	164
5 Jun 17	180	208
6 Jun 17	161	135
7 Jun 17	247	27
8 Jun 17	154	53
9 Jun 17	112	13

Table 1. Artillery shoots directed by the RFC during the run up to and the first three days of the Battle of Messines.

Contact Patrols

Although it did not feature as one of the innovations introduced on the Aisne, there is one other role that qualifies as one of the early activities that would become core functions of the RFC – keeping the general posted on the tactical situation by permitting him to 'see over the hill' or, to be more precise, to keep track of the front line.

While the war had become a mutual siege before the end of 1914, both sides would occasionally try to break the stalemate by mounting an offensive. Until 1918, these never met with much success, but whenever there was some movement on the ground commanders needed to know exactly how far the troops had advanced or retreated, not least to ensure – or attempt to ensure – that they did not shell their own men.



Above, the 'T' or Popham Panel. and, below, the pad used by aircrew to record the succession of symbols.

Keeping track of the ground picture required the RFC to fly contact patrols. Various methods were tried, including having the troops display white panels or wear shiny metal discs on their backs, or the use of coloured flares which were to be ignited at pre-determined intervals after H-hour – or, better still, in response to a klaxon being sounded by an aeroplane. That permitted the air observer to determine the positions of the leading elements, plot these on a map and drop it to the relevant HQ in a message bag. The first serious attempt to mount contact patrols was at the Battle of Loos in 1915. This met with only mixed success but, as with all the other procedures, techniques improved with time. That said it was rarely 100% successful because of the instinct for self-preservation. A soldier

under fire in No Man's Land might well consider that, if he revealed his position to the crew of a friendly aeroplane, he could just as easily be seen from a German one, and there was always the risk of a sniper. Perhaps unsurprisingly, some soldiers were reluctant to light flares or wave flags.

Ground-to-Air Communications

Apart from the need to indicate their position, there was also a requirement for troops to be able to send much more complicated messages. This applied to the gunners, as well as the infantry, and later on to cavalry and tanks. Since the available wireless facility was air-to-ground only, however, this had to be done using visual signals. In the case of an artillery shoot, therefore, the patrol orbits at Figure 2 had to be elongated sufficiently for the crew to be able to see the guns in order to receive any messages. These could be sent by Morse, using a signal lamp, or by laying out pre-arranged patterns on the ground using strips of white cloth.

Several variations on this theme were tried but the eventual answer was the 'T', or Popham, Panel and this remained in use until it was finally superseded by the increasingly widespread availability of two-way R/T in the late 1930s.



248 – 'have gained final objective'. The soldiers are Americans.

It was an 8 ft × 10 ft rectangle of dark blue cloth with a white 'T' sewn to it. Nine additional white extension arms were sewn to the basic 'T'. Each of these extensions was numbered and flanked by a strip of dark cloth, forming a loose flap which could be folded over to obscure the adjacent numbered white arm.

Thus, by covering and exposing particular combinations of arms, a large number of numbered patterns could be created, many of which were assigned universally understood predetermined meanings. A message might involve a sequence of a dozen patterns, with all arms being covered by flaps to present the basic 'T' after each coded symbol.

Aircrew were not required to read/interpret these messages. Their function was to record the succession of patterns on a pre-printed pad, omitting the intervening 'T's, and then deliver the message, in a bag, to the Dropping Station of the relevant HQ for them to decipher. For instance, 158 meant 'more stretcher bearers required', 247 'have gained third objective' and 567 'am about to advance'; there were many others.

Conclusion

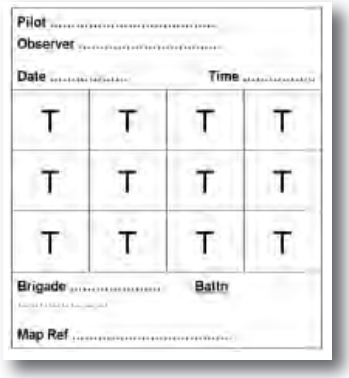
Before closing, it should be stressed that the techniques and procedures that have been outlined here were those that were devised to prosecute the positional warfare that dictated the nature of the Western Front for three and a half years. When the stalemate was broken by a German offensive in March 1918 the system was put under considerable strain.

Balloons were very cumbersome things to move. They had either to be completely deflated and packed, which meant that they were not immediately available when they reached their new location, or kept on a short lead and moved at walking pace by a large party of handlers.

Similarly, the wireless-based system of artillery direction also tended to break down, because the W/T aerials had to be dismantled in order to retreat and land communication between squadrons and batteries, all of which were repeatedly relocating, was impeded by the need to re-lay the copper wire upon which the field telephone links depended. Similar problems had to be coped with in the summer when the Allies began to advance and that also meant expanding the well-established concept of infantry contact patrols to deal with cavalry and tanks, an ever-increasing involvement in, what we now call Close Air Support, while, at the same time, beginning to introduce two-way Radio Telephony – R/T – in place of one-way wireless telegraphy – W/T.

And there I have to stop. But the message that I hope that I have conveyed, and that I want to leave you with is that, while the foundations of, what would become, 'air power' were laid between 1914 and 1918, the air war was on a relatively small scale. That is not to say that the RFC's (and the

RAF's) contribution was not significant. It was, indeed, it was crucial, but the Great War was all about the Army and, specifically, the artillery, and it was only in that context that air power made a real difference.



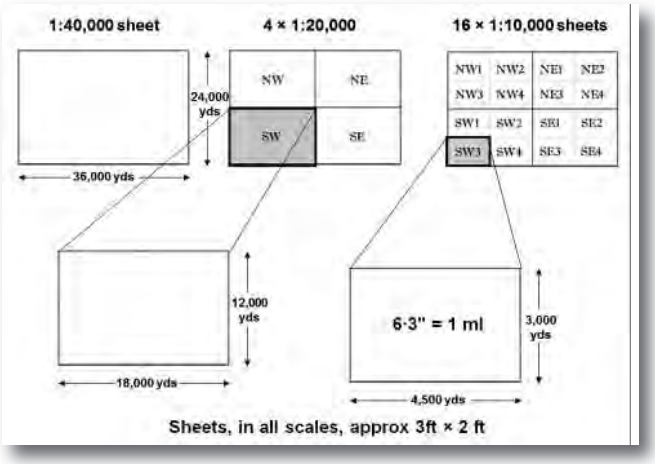
It is no coincidence that of the sixteen most senior numbered squadrons in the RFC/RAF, twelve spent the entire war on corps reconnaissance duties. It follows that the iconic image of the First War in the Air really should be the RE8 – and not the Sopwith Camel.

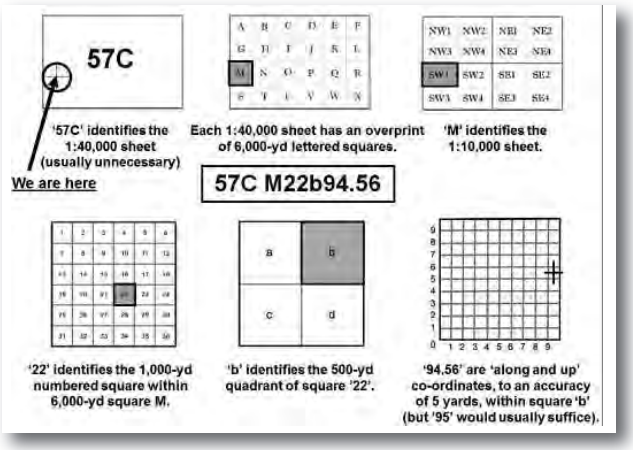
Notes:

[1] *RAF Historical Society Journal* No 54 (2013).
[2] National Archives, AIR1/724/91/6/1.
[3] Nos 2, 7, 9 and 59 Sqns were to have twenty-one aircraft while Nos 8, 12, 13 and 16 Sqns were to have twenty-four. Apart from No 59 Sqn, which had RE8s, all of these units were still operating, mostly late-model, BE2s.
[4] Nos 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 15, 16, 21, 35, 42, 52, 53, 59, 82 Sqns RAF and No 3 Sqn AFC.
[5] $\frac{5 \text{ mls} \times 1760 \text{ yds}}{6} = 1466 \text{ yds}$
[6] Another way to do the math would be to consider the 100 miles of the British Front as a whole. Assuming 90% serviceability, only 360 of the notional 400 aeroplanes would actually be available. Operating these as three shifts of 120, each aeroplane would cover a
sector of $\frac{100 \text{ mls} \times 1760 \text{ yds}}{120} = 1466 \text{ yds}$
[7] Alan Morris notes, in *The Balloonatics* (Jarolds, London, 1970), that 106 parachute descents were made between June 1916 and June 1917 within 2nd (Balloon) Wing alone, 2/Lt S Jolley making five (of an eventual total of seven) jumps in the course of a mere 97 hours of airborne time in May-June 1917.)
[8] When the RFC went to France in 1914, beyond the handful of 'enthusiasts' with the Wireless Telegraphy Unit (WTU), it had no designated wireless personnel, but the requirement for specialist manpower grew inexorably to keep pace with the expansion of the RFC/RAF. By August 1918 the establishment of a corps reconnaissance squadron included an attached captain, specifically for liaison with the artillery, plus a corporal and three air mechanics to maintain the equipment, which included the transmitters installed in the aircraft, the squadron's own receiver and the receivers of the batteries of the corps with which the squadron was working. All other wireless personnel were held centrally on the establishment of the regional RAF HQ which then assigned them to units in the field. For squadrons in France, their allocation was two second lieutenant technical officers and four wireless operators, a sergeant, a corporal and two air mechanics. HQ RAF in the Field also provided, on attachment to the Royal Artillery, the wireless operators who worked all of the Ground Wireless Stations. At the time of the Armistice there were 1,081 such stations manned by 1,840 RAF personnel.

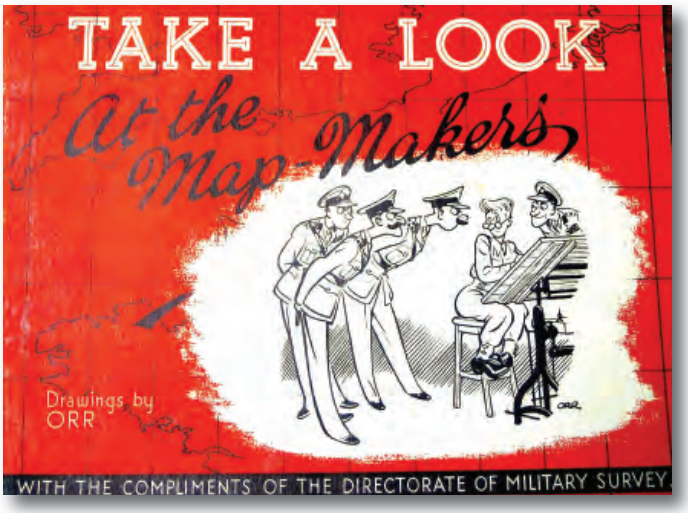
It is frequently observed that, because aerodromes were located 10 or more miles behind the front and out of range of artillery fire, domestic conditions for RFC/RAF personnel were relatively comfortable and civilised. That was true for the majority, but not for the wireless operators who were an, indeed the, essential link in the communications chain; without them the air service would not have been able to carry out what was, throughout WW I, its primary function – the direction of artillery fire. A few were located with controlling HQs at division, brigade and corps level but the majority were deployed well forward with the guns and, since both side's guns were the main mechanisms of destruction, counter-battery fire was frequent. Unlike most of their colleagues, wireless operators lived and worked in dug outs and were in the direct line of fire.

[9] Figures drawn from *Royal Flying Corps Communiqués 1917-1918* (edited by Chaz Bowyer; Grub Street, London, 1998), so they will, inevitably have been tinged with a degree of optimism. It seems unlikely that all 1,768 targets noted in the table will actually have been 'destroyed' in the seven-day period that it covers. On the other hand, the engagements will all have taken place and the results will have been reported in good faith.





Take a Look at the Map-Makers



Hughenden Manor, near High Wycombe, was the home of one of Queen Victoria's most famous Prime Ministers, Benjamin Disraeli. In World War Two it housed a Survey Production Centre, code-named SPC Hillside, producing Target Maps for RAF Bomber Command working largely under the direction of Major J.C.T. Willis R.E. then serving in the Air Ministry and, later, a Director General of the Ordnance Survey. The SPC was commanded by a Royal Engineer officer, Major Quaife, but the personnel were mainly, though not wholly, RAF. A group photograph also includes some RE personnel.

Hughenden Manor is now a National Trust property which includes a small display recording the activities carried out there during the war.

A visit to Hughenden Manor to research RAF Target Maps brought to light pages from a small, humorous, booklet of cartoons entitled "Take A Look At The Map-Makers" produced by the Directorate of Military Survey.

The cartoons in this booklet were all drawn by "Orr". Edward Cecil Parker Orr was born in Glasgow on 29 September 1909, the son of Edward Hammond Orr, a fish and poultry merchant. He was educated at Gourock and Greenock High Schools before studying at Glasgow School of Art. He became a freelance artist at 18, and took a staff position with Associated Scottish Newspapers.

While there he drew "Susie and Sambo" for Fun for the Family, a supplement to the Glasgow Daily Record. In 1941 he joined the RAF and served for the remainder of the Second World War, presumably mostly at SPC Hillside. After returning to civilian life, he drew illustrations for magazines including the Radio Times, and drew strips in humorous and adventure styles for the weekly comics.

Strips he drew included "Happiest Days of Your Life" (1950) for Knock-Out, "Ticket to Tomahawk" (1950) for Sun, "Monty Carstairs" (1951-56) and "Stormalong" (1952) for Mickey Mouse Weekly, "Not So Simple Susie" (1953) for Girls' Crystal, "The Rolling Stones" (1954-61) for Swift, "Kiki" (1958) for Zip, "Babe and the Family" (1960) for School Friend, and "June and Jiffy" (1965) and "Bessie Bunter" (1965) for June. He died in Hendon, Middlesex, on 23 August 1965.



Fortress of Kars

By Steve Ackland - Bodleian Library

Dramatically situated at the bottom of a hill on which sits a citadel Kars has had a long and turbulent history. Now in north-eastern Turkey the town has been fought over many times and controlled by most of the major Empires of the East; the Armenian, Byzantine, Mongol and Ottoman to the Russian.

The Bodleian holds four items in its map collection on Kars. Three are conventional maps showing topography and defences, with one focusing on the battle fought between Turkish and Russian troops on the 29th of September 1855. The fourth item is a pictorial representation of the battle. Drawn from a low-lying position to the south of the town the picture dramatically shows in the foreground one of the Turkish batteries firing on the Russian troops on the distant hills. This image is unique within the map collection. More a picture than a cartographic work this item. *The fortress and field defences of Kars, representing the action between the Russians under General Muravieu, and the Turks under General Williams on the 29th September, 1855*, seems to have come into the collection as a companion piece to the maps. All four items were produced by the Topographical and Statistical Department at the War Office under the direction of T.B. Jervis. There is also a fold-out map of the battle within a pamphlet by George Kmety, a Hungarian General at the time of the battle, who wrote *'A narrative of the defence of Kars…'* published in 1856 in defence of his actions during the 29th.



Russian forces moved into Anatolia in 1855 in an attempt to relieve the pressure on Russian troops trapped in the siege on Sevastopol. Kars lay in the path of the advancing army. During the battle Turkish defences were dug in on the high land to the north of Kars, separated by the deep gorge of the Kars Tchai river from the town. A number of tabias, the Turkish word for entrenchments, faced west and the approaching Russian army. Attacking before dawn on the 29th Russian troops had both the steep slope and a heavy barrage to deal with. Breaking with conventional tactics defending troops were concentrated behind the Tachmas tabias, as it was evident that this was where the first Russian advance was directed. Russian troops outnumbered the defending Turks to the extent that 'Each of these columns was composed of several strong battalions, and so heavy that I could not help afterwards considering it most fortunate for us that so great a part of them were at the time enveloped in the smoke and twilight. In the full light of day some dismay might have been produced by their appearance alone'[1]. These columns were met with devastating

[1] Kmety, George. *A narrative of the defence of Kars on the 29th September, 1855.* (1856)

fire, both from the front and flanks. Despite suffering heavy losses the Russians soon regrouped and advanced again against less-defended positions and, for a short time at least, gained control of these defences despite brave opposition from Turkish troops and officers. Having to fire from below the crest of the hill and out of sight of the front-line Russian artillery caused great loss of life amongst their own troops, weakening their position and eventually going some way towards forcing a general retreat. At the end of the day losses in killed and wounded in defenders were 1094, known Russian dead 6500, with more taken away in the retreat.

Kars features in a recently published book by the Bodleian, *Treasures from the Map Room.*



Maps in the Peninsular War

By Dick Tennant

This paper examines the use, or the lack, of adequate maps in two of the key decision processes during the Peninsular War. Much of the text has been extracted directly from the published works of several eminent historians and this has been compared with the actual maps of the period.

Introduction

The local topography

For military purposed it is essential to make a distinction between chaussées, country roads, and mere mule trails.



Duke of Welloington.

In Britain, France and the territories of the Holy Roman Empire there was a network of adequately surfaced, or paved, main roads. These were rarely to be found in the Iberian Peninsula.

Portugal

Ian Robertson quotes that General Anstruther[1], then at Almeida, had warned Moore of the lamentable state of the Portuguese roads, hardly one of which did not have 'very bad steps; these are generally in or near villages, of which the streets are almost universally narrow, rocky and full of short turns impracticable for carriages of any sort …', merely confirming what the Portuguese had admitted : 'that even in their own country they would be at a loss to indicate any road that was practical for artillery.'



Sir John Moore.

An extract from *Conversations with the Duke of Wellington* by Earl Stanhope[2]:

He told us that in Portugal the only road at all deserving of the name was from Lisbon to Pombal. From Lisbon to Elvas it was most detestable, often only the dry bed of a rivulet.

What then do they do, I asked, when the rivulets are full? *"Stay at home, I believe,"* said the Duke, laughing. "But I have been obliged more than once to give orders at the villages that the large stones and fragments might be picked out of these rivulets, so that the troops might march on these roads."

Spain

Oman makes a detailed summary of the roads in Spain in Vol I, pages 78 – 85: 'Spanish (and also Portuguese roads), generally avoid the river banks and run along the slopes far above them.

Roads always take the 'line of least resistance' in early days, and seek for easy passes, not for short cuts. The idea that 'time is money', and that instead of going round two sides of a triangle it may be worthwhile to cut a new path across its base, in spite of all engineering difficulties, was one very unfamiliar in Spain. Nothing shows more clearly the state of mediaeval isolation in which the kingdom still lay in 1808 than the

[1] Brigadier-General Robert Anstruther (3 March 1768–14 January 1809) commanded the Rear-guard during the retreat to Corunna where, before the battle, he died from fatigue and exhaustion. Moore was buried next to him.

[2] Philip Henry Stanhope, 5th Earl Stanhope FRS (30 January 1805 – 24 December 1875).

condition of the roads. Wherever the country presented any serious obstacles, little of no attempt had been made to grapple with them since the days of the Romans.

What roads there were, when war of 1808 broke out, were in a state of dreadful neglect.

There were many other points at which a division travelling in light order without guns or baggage could cross the watershed … but for an army travelling with all its impedimenta such bypaths were impracticable.

Summing up the general characteristics of the road-system of Spain, we note first that the main routes are rather at right angles to the great rivers than parallel to them. Just because the roads do not cling to the valleys, but strike across them at right angles, they are always crossing watersheds by means of difficult passes.'

In his *Diary of Campaigns in the Peninsula*, Lieut William Swabey, Royal Horse Artillery, notes for 20th May 1812, 'Close to this town (Torremexia) runs a road, or rather the remains of one, made by the Romans and formerly reaching from Merida to Lisbon, these relics of which there are many in Spain are called Calhada[3].'

Ian Robertson states the following (Oct 1807 – Sept 1809, footnotes p 62) 'George Ticknor, the American historian of Spanish literature, when first visiting the country a decade later, before any form of 'diligence service' had been set up, remarked that. 'There was no travelling in Spain. Between Barcelona and Madrid, in a journey of thirteen days, we met only a few muleteers, a few carts and one single coach like our own, only half a dozen in all; and yet the road was the main highway between the capital and one of the principal cities of the kingdom'; but it had long been so.

Major William Dalrymple[4], travelling in the Peninsula while on leave from the Gibraltar garrison in 1774, setting out from Ponferrada for Galicia, had remarked on the road being 'very bad' after having 'travelled on a new road for about two miles, which is intended to be carried to the sea,' adding : 'And here I must observe, that except at La Carolina in the Sierra Morena, and for a few leagues about Madrid, I never seen any made (i.e. surfaced) roads. There are no heavy carriages in the country I have passed, otherwise it would be impossible, particularly in winter, for them to travel. Left the Camino Real *(the Royal Road)* and came into an abominable road … began to ascend the mountain, the road like steps of stairs.'



Bridge and mule trail at Barba del Puerco over the Rio Agueda.

Given the topography of the two countries and the communications networks, it is therefore not at all surprising that, in both Spain and Portugal, it was customary to carry most merchandise on pack animals rather than by wheeled transport.

The mule trails had been in use for decades and often were, or had been, surfaced, particularly on severe inclines. Many of the bridges dated back to Roman times, often in their original format of not having a parapet.

Having established the general surface conditions of these roads, it is interesting to briefly consider their width, and here Wellington's General Orders give an insight into this aspect :

Whereas it is stated in the *Rules and Regulations for the Formations, Field-Exercise and Movements of His Majesty's Forces*, 1803 edition, page 368 :

[3] In Spain there were also the Cañada, which were the, unsurfaced, cross-country trails used to bring livestock to the major towns and cities.
[4] William Dalrymple (1736 – 16 February 1807) was a Scottish soldier and Member of Parliament.

The Column of Route

… All marches are therefore made in column of divisions of the line, and never on a less front than 6 files where the formation is 3 deep, or 4 files where it is 2 deep …

However, another picture emerges from the *General Orders* for 16th March 1811 :

The Commander of the Forces requests that for route marches each company in every battalion of infantry may be told off in threes; when the column is to be formed for the march the companies must be wheeled up or backward by threes, and each stand in column of 3 men in front, *which is as large a number as the greater proportion of the roads in Portugal will permit.*

It must be therefore considered that with the majority of the roads in Portugal being of this width, an artillery team, hitched two horses wide, could have significant problems.

Larpent[5] makes an interesting note for 7th July 1813 at Irurita, in the Pyrenees, 'More Portuguese troops and artillery are now passing this way. I believe no English artillery has come up this road. The Portuguese guns are not so wide in the wheels, having been made for their own roads, and are therefore more adapted to this.'

Peninsular War Cartography

Extract from *Wellington's Headquarters* by SGP Ward, pages 103/104

At the outbreak of the Peninsular War, maps of both Spain and Portugal comparable in accuracy to those of other parts of Western Europe were not to be obtained. What maps there were, were infinitely inferior to the geodesic survey of France carried out and published by the Cassini family, and those of the Low Countries based on Ferraris's survey, the two best-mapped countries of the continent. Mathematics had been neglected for more than a century in the Spanish and Portuguese universities. At Salamanca mathematical study had been deliberately restricted by the Jesuit influence in the governing body *como cosa del diablo*. Until the expulsion of the Jesuits in the 1770's little progress could therefore be made in such a science as triangulation which depended both for its practice and its reputation upon a live school of mathematicians. In default of accurate maps topographical information was drawn from less authentic sources. A young French officer, who later reached distinction (or perhaps notoriety) in his service, has described how the Spanish general, in planning his invasion of Portugal in 1762, compiled his topographical intelligence; how, surrounded by his staff, he questioned them all on the Portuguese roads – one knew from a merchant that the roads from such and such were so and so, and another had heard from a lady in Valladolid that the roads in such a province were impassable. 'Tout se passait en conjectures, en ouï-dire, et il n'y avait pas de projet de campagne faute de connaître le pays.'

However, information from ladies at Valladolid and the like, though not eliminated by the time of the war, played less and less part as the decades of the century went by. A sensible improvement came in the immense compilation of information, derived from many different sources, printed in the series of maps known collectively as 'López'. These were published province by province from 1765 onwards by D. Tomás López (1730-1802), and by his son, D. Tomás Mauricio López (1776-1835), who continued the publication and the revision of the original plates after his father's death. 'López' was the basis of all maps of Spain in currency at the time of the war. His maps gave a tolerable representation of the ground and a moderately accurate notion of distances which would satisfy a traveller. But they were not based upon a trigonometrical survey, and the methods used for indicating the quality of the roads were almost useless to a general or a military topographer.

Tomás Mauricio López de Vargas Machuca (1730-1802)

He studied geography and cartography with Jean-Baptiste Bourguignon D'anville from 1752 to 1760 in Paris. He then became the official geographer of the Kingdom of Spain. He produced a large series of maps from different regions of the world while emphasizing the mapping of his homeland, Spain. Towards the end of the 18th century, the King of Spain asked Don Tomás López to realize a large survey among all municipalities in the Kingdom in order to overcome the lack of mapping of the Kingdom. He addressed a letter to all the Spanish priests, asking them to draw a map of their parish,

[5] Francis Seymour Larpent (15 September 1776 – 21 May 1845) was a British lawyer and civil servant. From 1812 to 1814, he served with Wellington as Judge-Advocate General of the British Army.

within a radius of approximately fifteen kilometres around their bell tower. The majority of these men of the church, having received no cartographic education, merely described their literal territory. However, five hundred of them met the demand and send an extraordinary amount of doodles, drawings or perspective kinds of intuitive maps as possible ways to represent the territory.

Don Tomás López spent his life trying to gather these disparate sources, that were inconsistent with each other, into one document of maps and died exhausted in 1802.[6]

López however, was not just producing maps of Spain, but of the whole Iberian Peninsula. Whilst he could apply this approach in Spain, we would not have been able, or allowed even, to contact the priests in Portugal.

Obviously this made the content of these maps to be extremely dubious in many aspects.



El Atlas Geográfico de España (1804) – Tomás López

When the war commenced, the most current maps of Spain were those in *El Atlas Geográfico de España* by Tomás López, which was published by his sons in 1804, shortly before Napoleon invaded Spain. The map was reprinted in 1810, during the war. The Atlas contained 38 maps divided into 102 pages and with different scales for each map, which varied between l: 140,000 and 1:640,000.

Part 1 – Masséna's invasion of Portugal - September 1810

Opening status

During the siege of Almeida, the British army had been held in apposition somewhat less advance and more concentrated; Wellington had brought back his headquarters from Alverca to Celorico, where he had the Light Division under his hand. Picton and the 3rd Division had been drawn well back from Pinhel to Carrapinchana [west of Celorico, on the road south of the Rio Mondego], but Cole and the 4th remained firm at Guarda.

The French held back, close to Almeida, with a strong advance guard at Pinhel.

On the morning of 26th August, the fortress of Almeida was largely destroyed by an explosion, forcing the garrison to surrender on the following day.

On 2nd September a brigade of infantry and 1,200 horse drove in the British cavalry outposts to Maçal de Chaõ, only five miles in front of Celorico[7][8].

The French cavalry patrols will have initially pushed west, scouting out the possible routes. Initially it would have been obvious to the scouts that part of the British army had taken the mule trail to the

[6] Source : http://fr.wikipedia.org/wiki/Don_Tomas_Lopez (in French).
[7] This was from 3rd Division of General Loison with the Cavalry Brigade of General Lamotte.
[8] Extracted from *History of the Peninsular War by Oman*, Volume III.

west from the bridge over the Coa River. The reconnaissance in strength on 2nd September will have confirmed that it was unsuitable for artillery since all the bridges along the route were destroyed.

So the decision for the French Staff was just how to proceed.

Masséna's Maps

Extracted from *The French Campaign in Portugal 1810-1811, an Account by Jean Jacques Pelet*[9], edited, translated and annotated by Prof DD Horward.

Pelet was first aide-de-camp to Marshal Masséna during the invasion of Portugal and it is interesting that he was tasked with planning the invasion rather than the Chief of Staff, General Fririon or the Quartermaster General Lambert.

'We were in effect without maps, since that of López, in spite of its large scale, was poorly marked, the roads and rivers horribly drawn and the terrain even more poorly represented.'

On the López map, published in 1779, the routes were copied from Juan Bautista de Castro's *"Itinerary"*, officially known as *"Roteiro Terrestre de Portugal"* published in Lisbon in 1748. López also used Castro's *"Mappa de Portugal"* published in 1762[10] and Thomas Jefferys' maps of Portugal drawn in 1762. The map scale is two leagues to an inch.

Pelet then continues from page 135 :

'Following are the various data on which our entire plan for the campaign was founded, as well as the resources put at my disposal for working on it. We possessed only the maps of Jeffreys and López, the inaccuracies of which have already been mentioned. There was also a poor little map by a Portuguese major, not to mention several even more defective ones drawn on the previous maps. Quite a few private drawing had been given to us, but they could not be of any help; they showed even more errors, for their scale was larger. Meanwhile there was excellent material in Paris that I have seen since. Although it would not have been enough to draw a complete topographic map of Portugal, copies would have enlightened us considerably during our operations if they had been sent and used to fill the gaps found in our information[11]. These aids were withheld and the only things that the Prince was able to obtain from the Depot of War at the time of his departure was kind of geography of Portugal. Composed of very incomplete manuscripts translated from works printed in this country and a military reconnaissance of the kingdom, the document carried a note in the corner with the signature of Dumouriez, which appropriately reflects on his abilities[12]. Finally there were some very insignificant materials on the campaign of the Gallo-Spanish army in 1762.

General Thiébault sent us two good memorandums on Portugal. The presence of this distinguished general would have been very useful to our army[13]. A single conversation with him at that moment might have enlightened us on everything. However, we had been given a fatal quantity of itineraries, notes, inventories and statements of every description which contradicted each other; they were either based on misinformation or apparently drawn up to confirm the specific systems or campaign plans of their authors. This is not what an individual writing a military report should do. The misfortune was that none of these self-styled strategists had ever gone over the ground they were describing, and they could not answer the only thing we asked them. 'Can a carriage go on this road? Is this river deep? Is this range of mountains impracticable?" In the end I felt obliged to compile an extract of the best accounts and attach it to a few ideas on a plan for the campaign in Portugal.

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[9] According to Pelet's service record at the *Archives de la Guerre*, he held the rank of *chef de battaillon* during the campaign; this usually equated to the rank of Major, however, in duties this rank corresponded more closely to that of Lieutenant Colonel (non-existent in Napoleon's army). Masséna's letters to Pelet always addressed him as *Colonel*.

[10] An English map of Portugal by Thomas Jefferys, map-engraver and geographer to George III. Jefferys' map is not mentioned in the list of his publications in the Dict. Nat. Biogr., but is in the British Museum. It is in six sheets. The soundings have been closely followed by López, whose map is on nearly the same scale.

[11] When Junot's army was returned to France by the British Navy in the fall of 1808, all topographical material produced by the French engineers in 1807/1808 went with it and were deposited at the *Depot de Guerre* at Paris. The most reasonable explanation appears to be that the *Depot de Guerre* was neither ready, nor willing, to send such precious originals on the hazardous voyage through guerrilla infested Spain and Portugal and that there was neither time nor personnel enough to have everything copied. From Charles Raeuber, Centre d'Histoire et de Prospective Militaires, Switzerland.

[12] Dumouriez's *"Etat present de royaume de Portugal en l'annee 1766"* was published in 1775; it was used by both the French and the Allies during the Peninsular War.

[13] General Paul Charles François Adrien Henri Dieudonné Thiébault (1769 - 1846) had been Chief-of-Staff to Junot in 1807/1808. In 1809 he commanded the province of Burgos and in 1810 became the governor of Salamanca. His Plan d'une nouvelle campagne en Portugal was drawn up at Burgos on 12 January 1810.

The presence of the Portuguese officers was particularly disastrous for us…. a dismal listing of all the errors transmitted to us in the information that the Prince or I requested…

We were even less fortunate in what we had been told about the military topography of Portugal, about the inaccessibility of the Serra da Estrela and the banks of the Zezere, the nature of the Tagus and the country in general, the roads, and the positions of Bussaco and Murcella.

I had to begin by correcting the map, or rather by drawing a new one based on the confused and often contradictory notes. Then, with little information, I had to learn the military topography of the kingdom in order to draw up some kind of description.

…[we knew that] *the enemy had worked everywhere to augment the obstacles which we would encounter. On the most direct road to Coimbra, between the Mondego and the Serra da Estrella they had carefully fortified the position of Ponte de Murcella, which was already very formidable, rendering it almost inaccessible*[14]*. We had been told that some good roads extended on the right bank of the Mondego through open, easy country up to Coimbra.*

Given the lack of good information available, his basic plan for the campaign was an advance on Vizeu, which lies to the north of the Mondego.

The advance guard would thrust through Celorico. This was led by 6th Corps under Marshal Ney and would be followed by 2nd Corps of General Reynier moving up from Guarda.

Whilst López's map does not show a road to the west from the bridge over the Coa River to Celorico[15], the scouts had followed the British retreat along a mule trail and this route had been added in red ink on Masséna's staff map.[16]

The 8th Corps under General Junot would take the more northern route to Vizeu. López's map [included above] depicted the road from Pinhel, sweeping north through Valcovo to Transcoso [Transcolo] and then on to Viseu as being, at least, as well constructed as the route by Celorico. For this reason the reserve artillery, the baggage train, and General Louis Montbrun's cavalry was to form the rear of 8th Corps' column. Yet it was, in fact, the worst road that Masséna could have selected for the movement of the wheeled columns.

It is interesting to recall that Sir John Moore faced a similar lack of topographical information when preparing for his invasion of Spain in the autumn of 1808. He was assured by the Portuguese Army that neither the Coimbra nor Guarda roads were fit for artillery. Faced with this intelligence, Moore had little choice but to send his artillery (but for one battery) with a strong escort and all his cavalry by a long and circuitous route via Elvas, the bridge at Almaraz and Talavera. This extended the march by more than a third and the resulting delay in the concentration of the army was a very critical two to three weeks.



Masséna's Staff Map – Tomás López 1778.

[14] An extensive network of fortifications composed of redoubts and trenches was thrown up at Ponte de Murcella on the Mondego and near the mouth of the Zezere.
[15] This route is, however, shown on the 1790 Jefferys *Mappa ou Carta Geogrphica dos Reinos de Portugale e Algarve* but it was possibly not depicted on the 1762 edition.
[16] The actual case of plans used by the staff of the Army of Portugal was acquired from the French baggage train by Major James Walker of the 42nd in the rout following the Battle of Vittoria in 1813 and is preserved in the Special Collection at the Library of Queen's College Belfast.

López's map depicted the actual road from Pinhel going north through St Eufemia and Cotimos, on up to a crossroads north of Soutomaior, before turning left down to Transcoso. However, on Masséna's staff map there is a red ink line turning due west at Valbon, through Povoa del Rey and Amial to Transcoso.

On page 53 of Prof DD Horward's other book, *The Battle of Bussaco*, he notes :

The rugged roads became progressively worse as the reserves artillery and supply wagons reached Povoa del Rey. … The men attending to the wheeled columns were not only forced to climb and descend four craggy mountain chains between Pinhel and Viseu, they also had to repair and actually construct the roads over which they were to pass. Captain Noel recounted in his journal :

We passed the little village of Transcoso with is battlements; all the country is mountainous and rocky. There is no road, only a narrow rocky and dangerous path that causes the artillerymen considerable difficulty. I am forced to send cannoneers forward armed with picks and shovels to open and mark the route. One soldier marches before them carrying an iron bar the same width as our wagons to indicate the extent that the passage must be widened.

I have only an incomplete map of López to guide me.

At noon of the 18th, marching isolated from my company, I halted with my two batteries after two hours of continual climbing to find myself at the crest of a mountain bordering on the right bank of the Taueres. From this point, the countryside extends as far as the eye can see, and I am dismayed by the sight of the desolate country and the roads we must cross. Before me a perpendicular descent into a deep valley and opposite, as ascent as far as the eye could see, cut by a tortuous path.[17]

Part 2 – British Staff Maps

Information about the British staff maps available is given in *Wellington's Headquarters* by SGP Ward, pages 103-110 : The atlas of López's maps (printed by Faden[18]) which Sir John Moore carried with him is still in existence.

Both Moore and Sir John Hope had copies of the Mentelle map.[19]

Stockdale's version of López did not find its way to the Peninsular until December 1808 after Moore had left Lisbon.[20]

Henry Bence was a Lieutenant in the 16th, or Queen's, Light Dragoons, with his commission dating from 20th October 1808. He appears to have been a conscientious young man since he had handwritten the regimental Standing Orders of 16th Light Dragoons on 122 pages of a leather-bound booklet.

In early 1808 the regiment was posted for Portugal and he equipped himself with a map : Map of Spain & Portugal by Don Tomás López , published by Faden in 1808. 57x47cm, 16 panels mounted on linen, hand coloured in outline,

The regiment arrived in Portugal on 13 April 1809 and would see continuous service throughout the Peninsular War.

Once Bence had tried using his López, one suspects that he discovered its inaccuracies, since his collection of papers includes another, somewhat better map : *Mappa corografico dos reinos de Portugal e Algarves, copiado do Inglez de W. Faden*. What is now a very rare Portuguese copy of a Faden, published 1809.

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[17] JNA Noel, *Souvenirs Militaires d'un officier du premier empire, 1795-1832* (Paris 1895) pp112-115.
[18] William Faden (1749 – 1836) was an engraver and publisher of maps – not strictly a cartographer. In 1783 he took over the business of Thomas Jeffreys. He was in contact with map-makers throughout Europe.
[19] *Carte d'Espagne et de Portugal en neuf feuilles*, by Edme Mentelle et Pierre-Giles Chanlaire,
[20] John Stockdale was a somewhat controversial publisher.

75x53 cm, hand coloured in outline, 12 panels mounted on linen, in a slip-case.



Mappa corografico dos reinos de Portugal e Algarves, copiado de W. Faden.

At the other end of seniority scale is Lieut General Sir John Cradock who commanded in Portugal from 14 Dec 1808 until Wellesly returned on 22 April 1809. He owned a copy of :

Mappa ou Carta Geographica dos Reinos de Portugale e Algarve, by T Jefferys.

This was a second edition published in 1790 by Wm. Faden, successor to the late T. Jefferys. 92x170 cm, 36 panels 23x19 cm, mounted on linen, hand coloured in outline. Notes in English & Portuguese.



Mappa ou Carta Geographica dos Reinos de Portugale e Algarve, by T Jefferys.

Jasper Nantiat's map of Spain, published by Faden on 1 January 1810, must have been in the hands of the Army early that spring, as one of Beresford's A.D.C.'s, Warre, was asking his family for a copy in that March.[21]

[21] Warre to his father, Coimbra, 21 Mar 1810 (Letters from the Peninsula 1808-1812 (ed. Rev. Edmond Warre, London, 1909), p.116. Major William Warre was first ADC to Field Marshal Beresford of the Portuguese Army.

Jasper Nantiat

A New Map of Spain and Portugal Exhibiting the Chains of Mountains with Their Passes the Principal and Cross Roads, with Other Details Requisite for the Intelligence of Military Operations. Published by W. Faden, London.1810. 161 x 115cm, divided into 4 sheets, each dissected into 15 sections, backed on to linen / cloth.



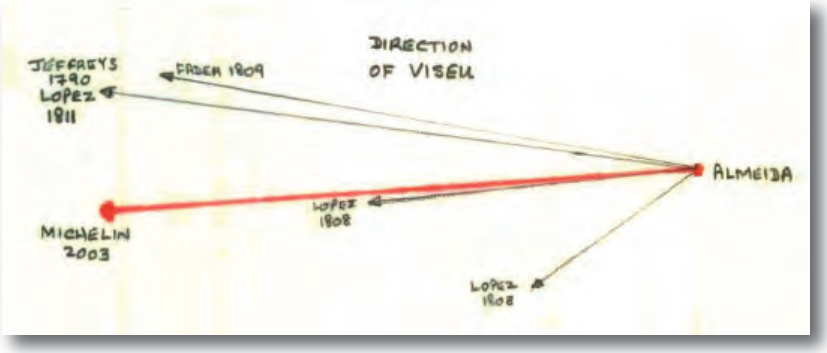
New Map of Spain and Portugal for the Intelligence of Military Operations.

This is a large map and really only suitable for staff tables. For more convenient use 'in the field' Faden brought out a condensed edition in 1812 : *Map of Spain and Portugal, reduced from Jas'r Nantiat's Map in four sheets*. 55.5 x 79.2cm, showing Spain, Portugal, the Balearics and southern France.

Lt. William Swabey RHA entered in his diary for 4th May 1812, "*I pasted one of Faden's maps, which my idleness has long neglected"*. Therefore most of these 'campaign maps' could be purchased in the plain printed form and it was up to the owner to cut it into panels and mount these on linen.

Not surprisingly, Sir George Murray, the Quartermaster General, had a complete set of López, a Mentelle, a Carta Militar[22] and a Faden.[23] He also possessed a fairly complete set of Cassini[24], which, as a matter of fact, he ordered up too late from Lisbon for it to be of use to him in the advance from the Nive in the spring of 1814.

Even a cursory study of all these maps of precisely the same area will make one aware of their differences. This is not only with the roads themselves, but also in the relative positioning of Vizeu and Almeida.



[22] *Carta militar das principaes estradas de Portugal*, by Major Lourenco Homem da Cunha d'Eca and Romão Eloy de Almeida. Library of Congress catalogue number : 2010589541.
[23] List of the Papers, Books and Maps in the Quartermaster-General's Office, Lisbon, 15 Aug and Dec 1810 (Murray Papers, 28, fos. 249-56; 31, fos. 134-41); Reynett to Mackenzie, Alverca, 24 July 1810 (ibid. 103, p. 94).
[24] The Cassini maps comprised 181 pages from the geodesic survey of France carried out by the Cassini family between 1756 - 1789 and published from 1756 to 1815.

Of course, all these maps had been produced by publishers who had never actually been 'into the field' - even López described himself as a 'desk cartographer'.

Extract from Wellington's Headquarters by SGP Ward, page 110

When the war was over Murray obtained permission from the Treasury for an officer to reside in Spain and Portugal for four years to complete the sketches of the battlefields which had been begun during the war for the Military Depot. The task was entrusted to a draughtsman of outstanding ability, Captain Mitchell, whose finished drawings were published, after many vicissitudes, by the London geographer James Wyld, in 1841.

Wyld's Atlas containing the principle battles, sieges and affairs of the Peninsular War, is an elaborate and monumental work of almost unimpeachable accuracy.



Vizeu **Celorico** **Almeida**

Part 3 – Wellington's Advance to the Ebro – June 1813

The Battle of Vittoria on 21 June 1813 has, quite rightly, been the focus of much study by military historians. Perhaps not enough attention has been given to Wellington's undoubted logistical success of moving his army of around 81,000 officers, men and their equipment[25] from the borders of Portugal, some 500 km / 310 miles[26], in the 27 days between 24 May and 19 June.

On 27 May King Joseph began to evacuate Madrid and pulled his forces back to Vallodolid to hold the line of the Rio Duoro. By 3 June Wellington's entire army was north of the river, forcing the French to retreat north back to Burgos. On the 12 June their line of defence was again turned as Hill's southern column[27] appeared behind Reille's right flank. They blew up Burgos castle and once again retreated back up the 'great highway' to defend the line of the Rio Ebro.

Wellington now faced the most difficult terrain of the whole advance, the country being mountainous and criss-crossed by gorges and good defensive positions. Indeed, the area to the north of Burgos in unlike any other part of Spain, with wooded plateaux fringed with sheer drops and ravines. It was also the terrain through which the French thought it impossible to bring guns and wagons.[28]

They were still using the same set of Lopez maps that Masséna had used in 1810[29]. Most of the pages of the Atlas were found after the Battle of Vittoria; on the map of Alava (90) and the second part of Laredo (11) there are pencil annotations indicating Joseph's line of retreat along the 'great highway' from Miranda de Ebro to Vittoria. The pages 7 and 9 of the Province of Burgos show, quite clearly, but not that accurately, a network of roads. One can only conclude that the French Staff of

[25] Supported by a 15,000 strong mule-train (private and public), Wellington's commissariat was able to feed the troops – several diarists speak of biscuit being short, but meat was not, even though they lacked enough salt to go with it.
[26] This is the average distance from Ciudad Rodrigo taken by the central column. Graham's left column started from northern Portugal, whilst Hill's troops which formed the right column marched from their cantonments by the Tagus.
[27] General Rowland Hill (11 Aug 1772 – 10 Dec 1842) was Wellington's most corps commander. This southern column was about 30,000 strong.
[28] From *Vittoria 1813*, by Ian Fletcher. Osprey Campaign Series.
[29] The atlas would appear to have belonged to Joseph, and to have been handed over to Massena for the purposes of the campaign in Portugal. On Massena's disgrace the atlas passed to Marmont, and remained with the army of Portugal until Souham was deprived of the command on joining Joseph in November 1812, when the atlas returned into Joseph's possession. Per TJ Andrews *The English Historical Review* Vol 16, No 63 (July 1901) pp. 472-497.

Marshal Jourdan[30] had come to, quite rightly, distrust the Lopez for other than the main routes. It is almost certain that Joseph and Jourdan placed far too much faith in the impossibility of passing through the mountainous region to the north of the 'great road'.

Whilst John Murray, Wellington's Quartermaster General had sent out several cavalry staff officers and members of his own QMG staff[31] to examine the practicality of the roads that were planned to be used, he will have greatly benefited by the access to the Nantait maps.

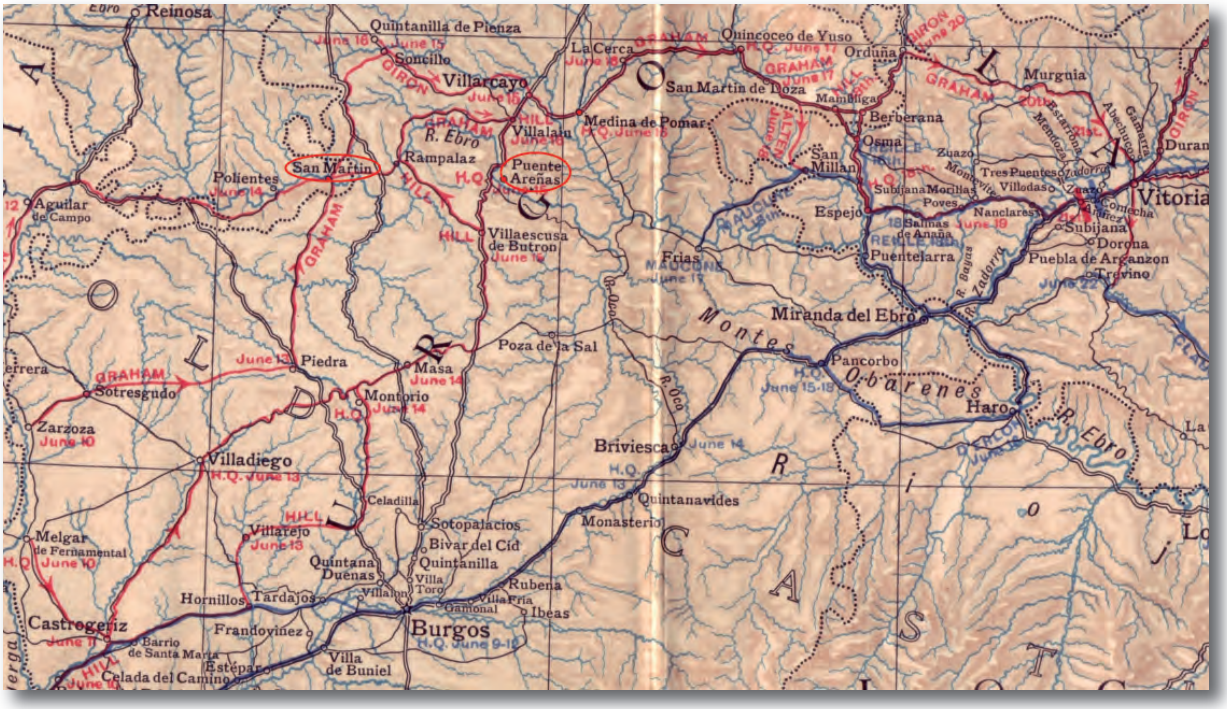


New Map of Spain and Portugal for the Intelligence of Military Operations.

The Headquarters divisions and Hill's column moved, using all available secondary roads, from their position opposite the lower Urbel , by Villadiego and Montorio respectively, on the bridge of Puente Arenas.[32] Graham's[33] left column with six divisions passed the Rio Ebro some fifteen miles higher, over the bridge of San Martin. All three columns had on the 13th – 14th – 15th very hard marches of four long Spanish leagues[34] on three successive days, across upland roads where artillery had never been seen before. The move would only have been practicable at mid-summer.[35]

The lack of good intelligence on the French side was a great factor in their downfall and it is remarkable that for four days they had no idea of Wellington's whereabouts.

[30] Marshal Jean Baptiste Jourdan (1762-1833) was Chief-of-Staff to King Joseph and must take a large slice of the blame for the French defeat at Vittoria. Indeed he was sacked soon afterwards.
[31] Thomas Mitchell (of Wyld's Atlas) was sent to examine the region north of the Duoro from its junction with the Esla to Benavente. *Wellington's Headquarters*, p111, by SGP Ward.
[32] Whilst Oman states that Hill's divisions crossed the Ebro behind the HQ column at Puente Arenas, Fortescue states that they crossed at the bridge of Rampalaz.
[33] General Thomas Graham (19 Oct 1748 – 18 Dec 1843) had served under Moore and was one of Wellington's most trusted lieutenants.
[34] One Spanish league was equal to four English miles, per Nantiat's 1810 map scale.
[35] History of the Peninsular War, Vol VI, p361/2, by Charles Oman.



History of the British Army, vols IX & X Maps, by JW Fortescue.

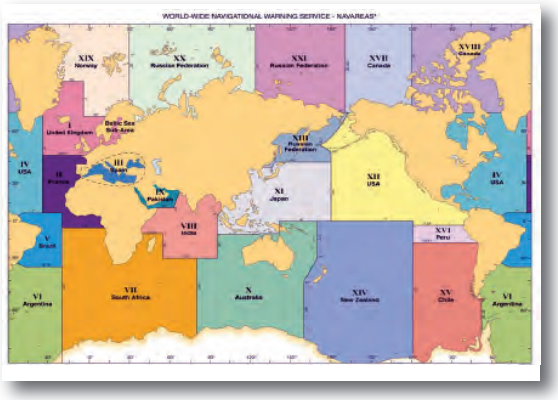


Puente Arenas Bridge - looking south.

South Africa a Maritime Nation and it's Hydrographic Office

By Captain Abri Kampfer

South Africa occupies an important geo-strategic position, a maritime choke point, in the Southern Hemisphere, being surrounded by three great oceans – the Indian, South Atlantic and Southern Oceans. The closest continents are South America (about 7 000 kilometers to the west), Australia (nearly 8000 kilometers to south-east) and the frozen continent of Antarctica; 4,200 kilometers to the south.



It is surrounded by the ocean on three sides – to the west, south and east – and has a coastline of 3,924 km. The coastline includes South Africa's sovereign possessions of Prince Edward and Marion Islands (collectively called the Prince Edward Island Group). Prince Edward Island has a coastline of 32 km, while Marion Island's is 134 km. The size of South Africa's Exclusive Economic Zone (EEZ) is 1, 553,000 square kilometers.

The importance of its geo-strategic position is followed by its maritime zones, marine resources, marine ecology and conservation - as well as its maritime trade.

The Coasts

The coastline itself is an even, closed one with few bays or indentations naturally suitable for harbours. The only ideal natural harbour along the coastline is Saldanha Bay on the west coast. Most river-mouths are unsuitable as harbours because large sandbars block entry for most of the year. Only the largest rivers, such as the Orange and Limpopo, maintain narrow permanent channels through the bars.



Harbours and Ports

South Africa operates sevensix major ports (from the east coast to west – Richard's Bay, Durban, East London, Port Elizabeth, Ngqura, Cape Town and Saldanha Bay), a further one under construction (the port of Coega) on the Eastern Cape coast, and a naval harbour (Simon's Town). There are also other minor harbours and ports with extensive harbour infrastructure which provide important containerisation processing, ship repair, limited ship construction and maintenance facilities. The two Kwa-Zulu Natal ports, Richards Bay and Durban, provide the largest concentration of modern port facilities on the Southern African coast. Critical to an understanding of the concept of South Africa being a maritime nation is that these harbours and ports are at the seaward end of a network of roads and railways that landlocked neighbours are also completely dependent on the seven major ports that serve South Africa.

International Maritime Obligations

South Africa also has various obligations - such as to its neighbours in the Southern African Development Community who rely on the Republic of South Africa's ports as a gateway for their trade. South Africa is also a member of a number of maritime organisations which, in turn, result in various maritime obligations to be met.

An example is the responsibility it has for navigation charts, coastal navigational and navigational area (NAVAREA) warnings in her assigned areas in terms of the membership of the International Maritime Organisation and the International Hydrographic Organisation. South Africa also has a massive search and rescue area of responsibility of some 5,57 million square nautical miles (17,2 million square kilometres) — vested in the country by the conventions of the International Civil Aviation Organisation.

THE SOUTH AFRICAN NAVY HYDROGRAPHIC SERVICE

The South African Navy's first foray into hydrographic surveying started in 1922 when all surveys were supplied to the UK Hydrographic Office. The South African Navy Hydrographic Office (SANHO) was established in Cape Town on 1 April 1955 as a result of a Ministerial delegation issued to the SA Navy in 1954 for the provision of a hydrographic service. After a few teething problems the first South African chart, one of Bouvétøya Island, was published in April 1956.

History

In 1922 *HMS Crozier* was converted into the first *HMSAS Protea* which carried out sterling service as a hydrographic survey vessel until she was laid up in April 1933. She was followed by the converted Flower class corvette *HMS Rockrose* - also named *Protea* in 1950. *SAS Natal*, a Loch class frigate, was converted in 1957 and she was supported by the former Ford class Seaward Defence Boat *SAS Haerlem*, which undertook the inshore work. In 1972 the SA Navy acquired their first purpose built survey vessel - the modern Hecla class *SAS Protea*. She is still operational and has become a familiar figure along the South African coastline and, in 1992, represented South Africa at the International Hydrographic Organization (IHO) Conference in Monaco.



HMSAS Protea 1922- 1939



HMSAS Protea 1950- 1957



SAS Natal 1957- 1972

The Work of the Hydrographic Services

The Hydrographic Services support safe and efficient navigation, foster national maritime development, help to safeguard life and property at sea, facilitate the protection of the marine environment and support the administration and sustainable development of the national maritime zones.



SAS Protea 1972 and still in service.

More than 80% of international trade in the world is carried by sea. Maritime commerce is a basic element for a coastal nation's economy. Modern nautical charts are required for safe navigation through a country's waters and along coasts and to enter its ports.

Chapter V of the International Convention on Safety of Life at Sea (SOLAS) stipulates the provision of Hydrographic Services as follows:

- *Regulation 4 requires that Contracting Governments "Shall take all steps necessary to ensure that, when intelligence of any dangers is received from whatever reliable source, it shall be promptly brought to the knowledge of those concerned and communicated to other interested Governments."* Regulation 9 requires that Contracting Governments *"Undertake to arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation,"* Additionally, Contracting Governments should *"Take into account, whenever possible, relevant international resolutions and recommendations"* adopted by the IHO to achieve the greatest uniformity and standardization in collection techniques, data management and product display, and *"Undertake to coordinate their activities to the greatest degree in order to ensure that hydrographic and nautical information is made available on a worldwide scale as timely, reliably and unambiguously as possible."*

Contracting Governments are all those nations that are signatories to the International Maritime Organisation (IMO) resolutions and South Africa is one of them. It is therefore the responsibility of the South African Navy Hydrographic Service to meet these international obligations on behalf of the South African Government.

Gathering of Information

The Hydrographic Office (SANHO) is responsible to issue Hydrographic Instructions to the survey vessels in accordance with a prioritised survey plan specifying the surveying requirements. Although all the waters around the coastline of South Africa have been surveyed, some areas (± 40%) still require surveying by modern standards. The *SAS Protea* underwent a modernisation, some years back, in terms of underwater sensors to enable it to conduct deep-water surveys. The modernisation included the fitment of a deep-sea echo sounder and a multi-beam system with a 3000m-range capability. The three survey launches are also fitted with multi-beam echo sounders for inshore survey operations.

Completed surveys are rendered to the Hydrographic Office and once it has passed a rigorous validation process, it is accepted and incorporated into the survey database. This new data is then used to update existing charts and publications or to produce new charts or new editions.



The SANHO has twenty-eight staff members, most of whom are non-uniformed or civilian members of the national Defence Force, and comprises of five Sections, namely:

- Paper Charting;
- Electronic Navigation Charting;
- Tidal;
- Maritime Safety Information and Nautical Publications; and
- Detached Survey Operations and Survey Training.

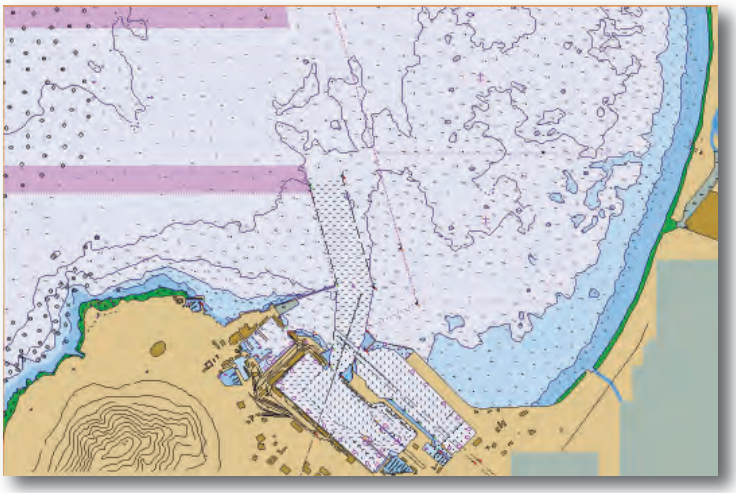
The latter Section is staffed by uniformed members and is closely linked to the survey vessel *SAS Protea*. It conducts detached surveys around the coast utilising small craft of opportunity or a survey launch from *SAS Protea*. Additionally this Section conducts all the hydrographic survey training of Ratings and Officers as well as foreign learners as part of a regional capacity building initiative.

Use is also made of satellite imagery and aerial photographs as well as visits to harbour authorities in order to obtain the latest information about harbour changes and developments for inclusion into the products of the SANHO.

Where possible the SANHO contributes to the General Bathymetric Charts of the Oceans (GEBCO) by providing data collected by research and other vessels operating from South African ports and within RSA waters to the IHO GEBCO Data Centre in the USA.

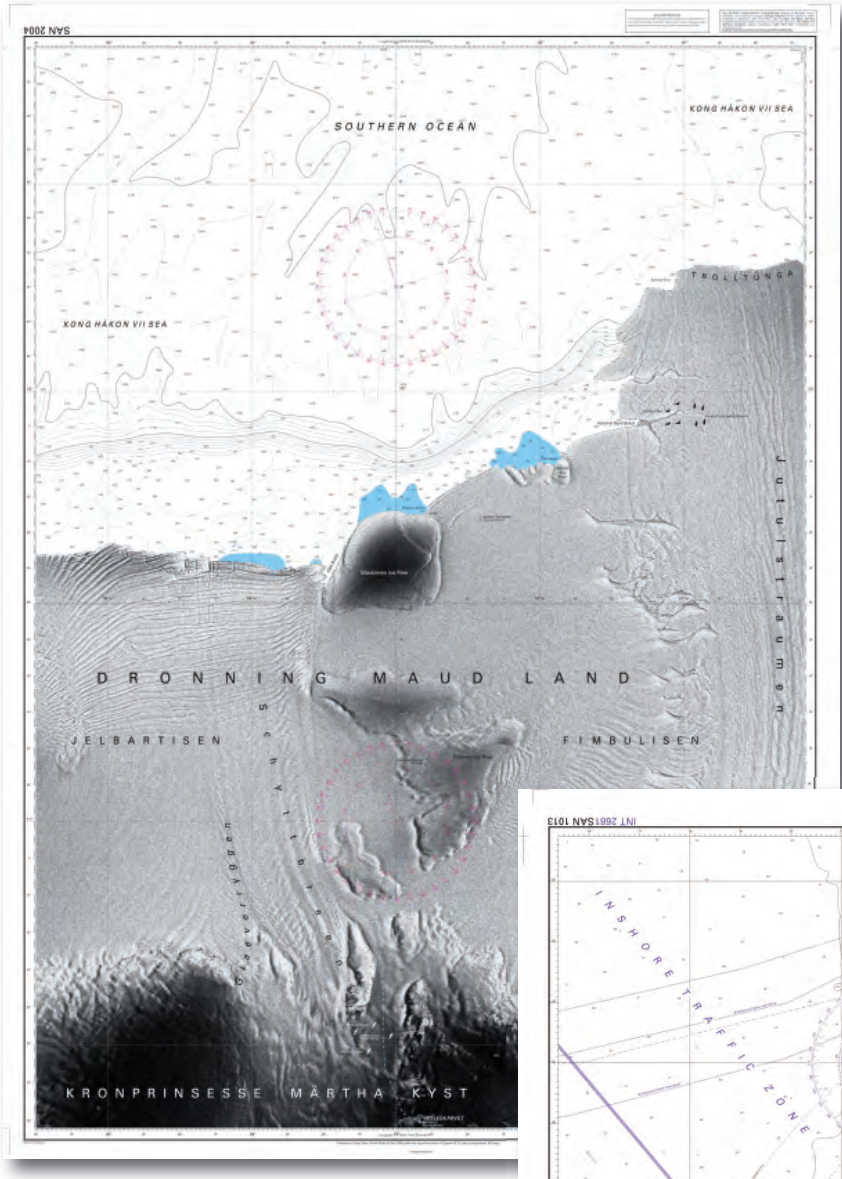
Products and Services South African products conform to International Standards and recommendations issued by the IHO.

Navigational Charts and other Charts



The majority of navigational charts and publications are printed at the Naval Printing Unit situated in Simon's Town and stored and issued from the SANHO Chart Depot. All products are available to the public through a network of appointed chart agents. Since 2007 the SANHO has also introduced a Print-on-demand facility at the Office for the printing of paper-based navigational charts.

In addition to its national charting programme covering the Waters of South Africa and Namibia, the Hydrographic Office has an international charting responsibility to coordinate full coverage in the IHO Charting Region H (Southern

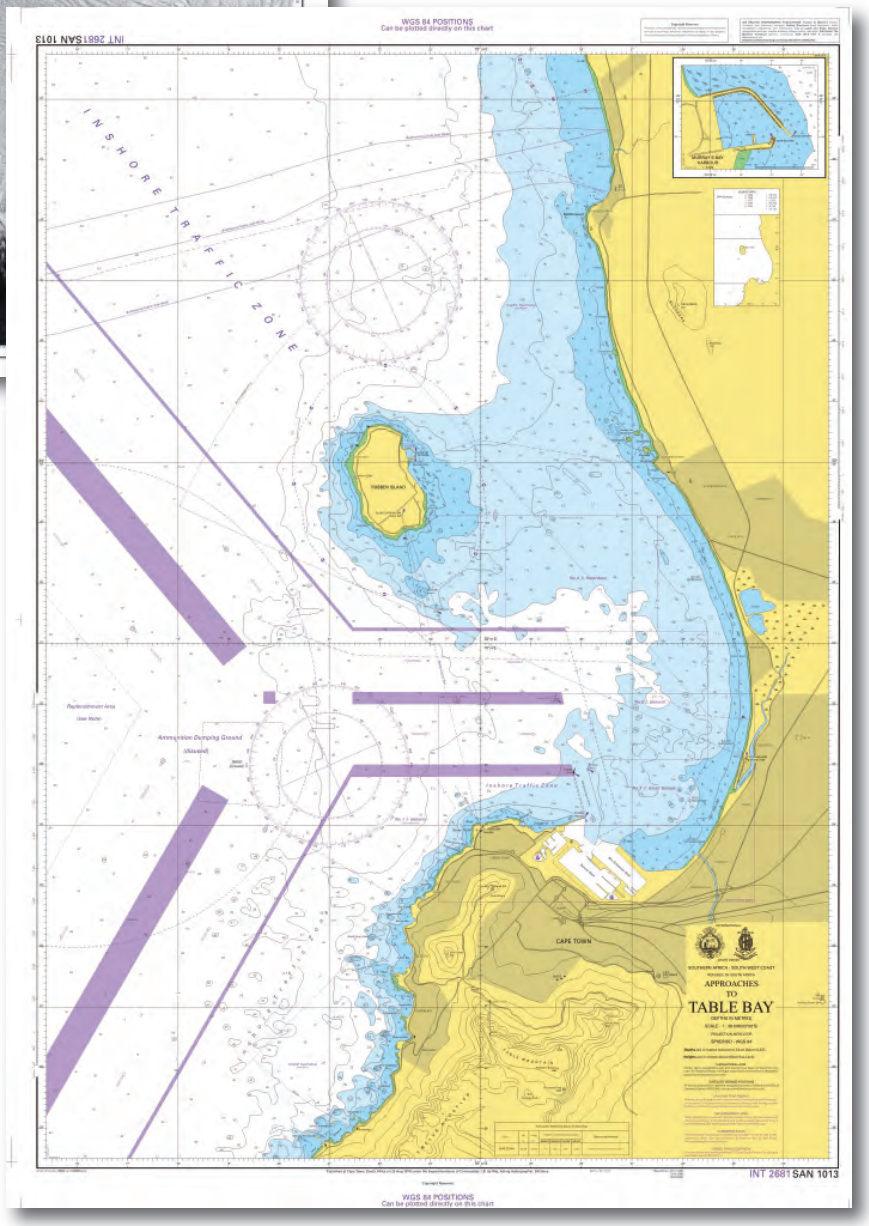


Africa and adjacent islands) as well as a single chart in Region M (Antarctica) (for the approaches to Dronning Maud Land where South Africa has a research station SANAE IV).

Instructional Charts and Small Craft Charts of waters of interest to leisure craft are also produced.

Electronic Navigational Charts (ENCs)

In 2003 SANHO became the first African Hydrographic Office to produce and publish ENCs on the continent. These charts are based on the paper navigational chart and therefore have an equal standing as a navigational product in terms of IMO Regulations.



All ENCs and ENC updates are sent to the Regional Electronic Navigational Chart Centre (IC-ENC) for final validation and are then distributed through a system of Value Added Resellers (VARs) of IC-ENC to the end user.

To date fifty-six ENCs are commercially available and maintained up to date from Notices to Mariners.

Publications



THE SANHO is responsible to produce the following hydrographic publications:

South African List of Lights.
South African Sailing Directions.

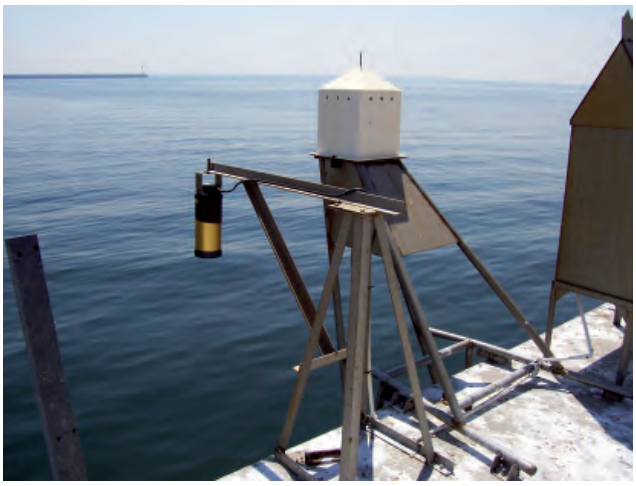
- Volume I.
- Volume II.
- Volume III.

South African Symbols and Abbreviations for Charts.
International Regulations for Preventing Collisions at Sea *(Colregs 72)*.
Chart Catalogue.
South African Tide Tables.

Maritime Safety Information (MSI)

The SANHO is the nodal point for the collection of hydrographic information. Mariners report discrepancies observed in products or any new dangers which will then be investigated and, if found to be valid, such discrepancies and/or dangers are communicated to mariners through navigational warnings as soon as possible after receipt if they affect safety, otherwise they will be incorporated in the relevant navigational product by Notice to Mariners action.

SANHO is the NAVAREA VII Coordinator and transmits navigational warnings for the entire region.



Tidal Service

The Tidal Section maintains a network of twelve tide gauges around the South African and Namibian mainland coastline and constantly measures the height of tide. Based on this database of tide recordings, the tidal predictions for each year are produced and published in the South African Tide Tables. These Tide Tables are available in hard copy from appointed chart agents. Limited data is also provided for the current month as well as the month thereafter on the SANHO website.

This Section also supplies near real time data to the Indian Ocean Tsunami Warning Centre as well as several institutes that monitor sea level rise, both nationally and internationally.

The SANHO Website

SANHO maintains a website (www.sanho.co.za) in which the information about current and new hydrographic products and services is provided as well as the provision of certain data and publications such as MSI, Notices to Mariners and tidal information.

Supply of Data

The SANHO provides data to approved individuals, academia and commercial companies for academic and commercial usage under data usage agreements.

International Commitments

South Africa has been a full member of the International Hydrographic Organisation (IHO) since 1951. Active participation in IHO committees and work groups ensures that the SANHO continues to deliver products and service of the highest international standards. SANHO is represented on the following IHO Committees:

- IHO Hydrographic Commission on Antarctica (HCA).
- IHO Inter-Regional Coordination Committee (IRCC).
- IHO Hydrographic Services and Standards Committee (HSSC).
- IHO Southern Africa and Islands Hydrographic Commission (SAIHC).
- IHO Capacity Building Sub-Committee (CBSC).
- IHO Tidal and Water Level Working Group (TWLWG).
- IHO ENC Standards Maintenance Working Group (ENCWG)
- IHO Nautical Cartography Working Group (NCWG).
- IHO World Wide Navigational Warning Service Sub-Committee (WWNWS).

Capacity Building



SANHO has provided training opportunities in hydrographic surveying and cartographyTraining opportunities in hydrographic surveying and cartography to several neighbouring states and has also assisted with the installation of tide gauges in Namibia and Mozambique. has been provided by SANHO. The Hydrographer of the SA Navy has conducted technical visits to Uganda, Namibia, Malawi, Tanzania, Kenya, Mozambique, Seychelles and Mauritius as part of an IHO capacity building effort to provide advice on the establishment of hydrographic services. The technical visits provided a very good overview of the needs of the states which were incorporated in a Regional Capacity Building Register that forms the baseline for all capacity building efforts in the region.

Conclusion

Since its establishment the SA Navy Hydrographic Office has demonstrated innovative planning and rendered excellent service and as a result has earned a reputation with the international hydrographic community for proven professional conduct. After 61 years of dedicated service, the SA Navy Hydrographic Service is abreast with modern technology and has embraced the challenges of ENC production and Print-on-demand technology.

Captain Abri Kampfer SAN – Alexander Dalrymple Award

Captain Abri Kampfer, the Hydrographer of South Africa was awarded the prestigious Alexander Dalrymple Award for services to hydrography at the United Kingdom Hydrographic Office's World Hydrography Day celebrations in 2009. The award is a symbol of recognition for outstanding dedication and contribution to world hydrography and as such is an extremely prestigious award in this sector. It takes its name from Alexander Dalrymple who established the UK Hydrographic Office in 1795 and is regarded as a leading figure in the history of the development of hydrography.



Paying tribute to Kampfer UK National Hydrographer, Rear Admiral Ian Moncrieff said: *"Despite difficulties in retaining a small qualified staff of just 24 people, the South African Office is a mature centre of expertise in the region. Abri has worked painstakingly, often in isolation, to represent the region and develop its capabilities"*.

Captain Abri Kampfer joined the SA Navy in 1979 and qualified as a warfare officer with particular specialist skills relating to mine warfare, before completing a CAT A Advanced survey course at *RNHMS Drake* and a post graduate qualification from Plymouth University. He had command of several ships including the SA Navy survey ship *SAS Protea* as his last command. He was appointed Hydrographer of the South African Navy in 2004. Captain Kampfer represents South Africa at various committees of the International Hydrographic Organisation(IHO). He is the current chairman of the IHO Regional Hydrographic Commission, Southern Africa and Islands Hydrographic Commission (SAIHC).

Forth Bridges Survey

By SSgt Ollie Teasdale, Sgt Scott Vickery, Cpl Warren Slade, LCpl Kevin Bryant - 42 Engineer Regiment (Geographic)

Introduction

The end of February 2016 saw a four man survey team from 42 Engineer Regiment (Geographic) deploy to the Firth of Forth in Scotland. Tasked by the United Kingdom Hydrographic Office (UKHO) at the bequest of the Navigation Officer on board HMS Queen Elizabeth, the team's objective was to conduct a survey of the navigation lights on the Forth Bridge and Forth Road Bridge. This was to be done in collaboration with HMS Gleaner, the Royal Navy's home waters coastal and inland waters survey vessel. This article details the geodetic survey work undertaken by surveyors from 42 Engineer Regiment (Geographic).



HMS Queen Elizabeth.

Background

Having been built in modules at various shipyards around the United Kingdom the Royal Navy's new aircraft carriers are currently being assembled in the Rosyth Dockyard, Fife. Located on the north bank of the Firth of Forth approximately ten kilometres west of Edinburgh, Rosyth has played host too many warships over the years; most notably the Dreadnought Battlecruiser Squadron used Rosyth as its war station during the First World War. More recently the Invincible class carriers were frequent guests with HMS Illustrious undergoing refit there in 2010/11. Standing between Rosyth and the open ocean are two and a half large obstacles. The first is the half, more commonly known as the Queensferry Crossing. This is the new bridge being constructed over the Firth of Forth due to be completed in the winter of 2016/17. The second is the Forth Road Bridge. The current road bridge was constructed in the late 1950's and early 1960's and is of suspension bridge design. The third and final obstacle is the iconic Forth Bridge. Built in the late nineteenth century, the Forth Bridge was and still is a marvel of engineering, so much so it is now listed as a world heritage site along with the likes of the Great Pyramids of Giza and Stonehenge.



GNSS observations on a pier. Note the new Queensferry Crossing under construction in the background.

HMS Queen Elizabeth and her sister ship the Prince of Wales are the largest warships ever commissioned for the Royal Navy. It was therefore quite understandable that the Navigation Officer of HMS Queen Elizabeth would be keen to ensure that there wouldn't be any mishaps when the ship sails out of the dockyard for sea trials later in the year. The Firth of Forth is well accustomed to dealing with large ships with a regular seasonal flow of cruise liners however the new carriers are quite a different proposition. The Admiralty Chart published by the UKHO gives worst case scenarios for the clearance under the bridges with maintenance gantries in place and at Highest Astronomical Tide. Taken at face value and given the vessels design heights they simply would not fit under the bridges. The Port of Edinburgh Authority have published values for the clearance under the bridges that indicate the carriers would fit with perhaps a metre or so to spare but no survey data to back it up. Combined with the significant changes to the bathometry in the Firth

of Forth due to construction of the Queensferry Crossing a complete survey campaign of the area was deemed appropriate. Having the Queen's namesake multi-billion pound flagship of the Royal Navy crash into a world heritage site on her maiden voyage would not make for pretty headlines. To that end HMS Gleaner were tasked with conducting a full bathometric survey of the Firth of Forth whilst 42 Engineer Regiment (Geographic) were tasked with determining the heights of the navigation lights on the Forth Bridge and Forth Road Bridge.

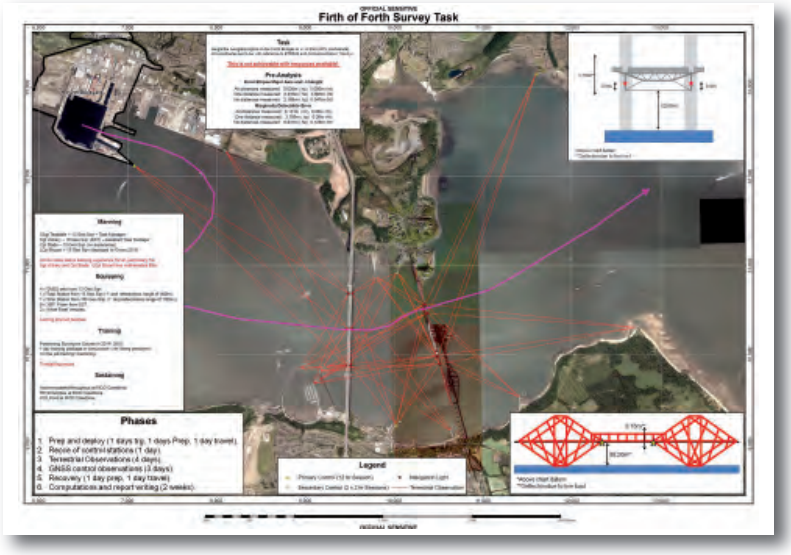
Planning

The task first came onto the radar in the autumn of 2015. On first appearances it appeared a relatively simple problem. "How hard can it be to measure the clearance of a bridge above the water?" was the stock answer given by the uninitiated. The Forth Bridge was indeed a fairly straightforward problem. Built using the cutting edge technology of its day, the Forth Bridge takes its strength from its cantilever design and the sheer weight and strength of the materials used in its construction. This means it is effectively rigid and stands the strains imposed upon it by man and the elements through brute force. The Forth Road Bridge is quite a different prospect. Modern construction techniques are based on different principles. Despite being built in the middle of the twentieth century the Forth Road Bridge is still a modern structure. It is designed to move with the forces imposed on it and in so doing that is where its strength lies. The Forth Road Bridge is quoted as having a maximum deflection (up and down) range of approximately ±3 metres. It has a longitudinal range of motion of approximately ±7 metres. As surveyors we are used to positioning static features at the millimetre or centimetre level. There was also some caution at the prospect of accepting the task. The stakes for getting it wrong would be high and incredibly embarrassing.

A reconnaissance was conducted in January. During this visit to Rosyth the problem was discussed with the crew of HMS Gleaner and work already undertaken was highlighted. The Gleaner crew had already established a number of geodetic control stations in and around the Firth of Forth and identified potential terrestrial observation stations. With this information in hand a meeting of the Royal Engineers (Geographic) community's survey experts was convened to discuss the problem. This saw involvement from within the regiment along with participation from 135 Geographic Squadron (Volunteers) and the Royal School of Military Survey. A number of methods were discussed and discounted as being either unsuitable or not within the capabilities of the Regiment. Finally, with a plan formulated the task was scheduled to commence in late February 2016.

Method

The fieldwork was to be based on three phases. Firstly was a detailed reconnaissance to identify the maximum number of suitable sites to conduct terrestrial observations. This reconnaissance was also to include identifying suitable reference objects (ROs) and indivisible stations. Once the stations had been identified Global Navigation Satellite System (GNSS) static phase observations would be conducted to derive precise geodetic coordinates for the observation stations and ROs. The final phase was the observation of horizontal and vertical angles and distances to the navigation lights. In the case of the Forth Bridge this would be a fairly straightforward intersection problem, albeit with relatively poor station geometry (the targets are only visible from one side of the bridge). The road bridge would be more challenging. It has become standard practice to use instrument manufacturer published standard errors in the stochastic model for adjustment computations. Given the high levels of movement in the bridge and the fact we would be observing with 1" instruments this approach would not be suitable. Kinematic GNSS observations at the navigation lights would have been the optimum solution and is the standard industry practice for monitoring and measuring bridges and large structures. Unfortunately the location of the navigation lights on the underside of the bridge meant that GNSS observations would not be



Planning map for Forth Bridges survey task.

suitable. Instead the same approach of using angles and distances would be applied. Movement of the bridge would be accounted for by observing eight rounds of angle and distances, a total of sixteen measurements to each target from each observation station. Instead of applying global standard errors to the covariance matrix in the adjustment computations the standard deviations calculated from the observations would be used. This would ensure that the solution would provide a realistic measure of absolute accuracy whilst maintaining statistical significance with regards to the standard tests applied to network adjustments.

Execution

A congested calendar meant that a maximum of two weeks could be spent conducting field work. As anyone who has ever visited Scotland will tell you, the weather can't be relied upon. In the event of poor weather, particularly visibility, the plan would fall over instantly. It was with great surprise and pleasure that the team arrived in Rosyth with the sun shining and little or no wind. With the weather set fair for the next week these were perfect observing conditions. Given the weather it was decided to change the plan slightly. The reconnaissance would go ahead as planned but the terrestrial observations would commence immediately.



Sgt Scott Vickery and a member of HMS Gleaner under the Forth Road Bridge.

Pre-analysis of the proposed solution had identified that distance measurements would be critical in determining the 3D coordinates of the navigation lights. This was caused by the poor observation geometry imposed on us. Luckily, for this task the height component was significantly less affected by a lack of distance measurements than the horizontal. Some of the observations being made were nearly three kilometres in distance. Equipped with an Electronic Total Station capable of measuring up to one kilometre to any surface, the fixing of retro reflective targets to the structures, particularly the road bridge was critical. This meant that we would have to access the bridges. Efforts were made to contact the bridging authorities prior to our arrival. In the case of the Forth Bridge we were unsuccessful in gaining access to the bridge but Amey who manage the Forth Road Bridge were extremely accommodating. After being briefed on the health and safety implications of working on the bridge and in particular down in the gantries the senior bridge civil engineer gave us a fascinating talk on its construction and maintenance. The bridge had recently been closed to traffic due to a stress fracture around the piers. This was high profile and made national news. We received a full explanation of what had happened, how it was identified and what remedial work had been done to rectify the problem. From there we were taken on a guided tour of the bridge. Clad in full high visibility suits and hard hats we climbed down into the gantry



Prism attached to Forth Road Bridge next to navigation light.



Observations onto the Forth Bridge.



Observations from the high ground.

and located the navigation lights. There, we attached our prisms as close to the navigation lights as possible. The sensation of being fifty plus metres above the water stood on a moving platform was quite unnerving and leaning out over the side to attach the prisms was not to the liking of all team members.

Terrestrial Observations

Once the prisms were in place and the observation stations were suitably identified and marked, observations could begin. Terrestrial observations were conducted over a four day period where we were blessed with unseasonably good weather. The observations were conducted in two teams with members of HMS Gleaner spending one day in the field working in collaboration with us. A number of the stations being used for observations were located on piers that are only accessible at low tide. There were a number of occasions when observations were conducted with the water lapping at the team's feet. One incident saw Cpl Slade and LCpl Bryant making a mad dash to recover an RO before it was washed out into the North Sea. Despite these minor issues the observations were completed without a hitch. Even a number of successful distance observations were made in reflectorless mode onto the Forth Bridge.

GNSS Observations

After a day off in Edinburgh watching the Six Nations it was back to work on the middle Sunday. The GNSS observation phase hailed in a significant change for the worse in the weather. Over the next few days there was lots of sitting in the rain for hours on end. Static observations were conducted at two control stations located on secure MOD sites both north and south of the Firth of Forth. These stations along with the OSNet station in Edinburgh were subsequently used as control for positioning the observation stations located around the bridging sites.

Heighting HMS Queen Elizabeth

The final field observations conducted were heighting HMS Queen Elizabeth. The ship has an associated design height but as the plans have changed over time, problems with construction been encountered it was decided to measure the keel to mast height of the ship. This was done using an arbitrary control network adjacent to the ship. Horizontal and vertical angles and distances were then measured between the plimsoll lines around the waterline and the various masts and radars on top of the vessel. From these measurements and knowing the offset between the keel and the



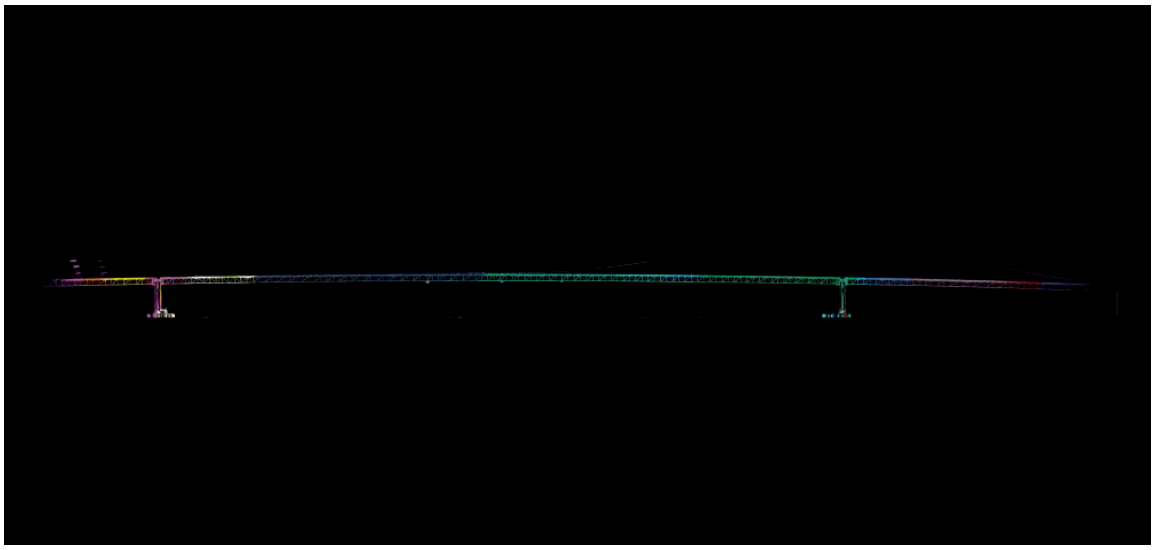
Cpl Slade and LCpl Bryant heighting HMS Queen Elizabeth.

plimsoll lines a mast to keel height was determined. The ship is moored in a controlled harbour which shouldn't be affected by the tide. To ensure that this was the case the tide was monitored by the crew of HMS Gleaner throughout the observations and proved to have changed by a negligible amount.

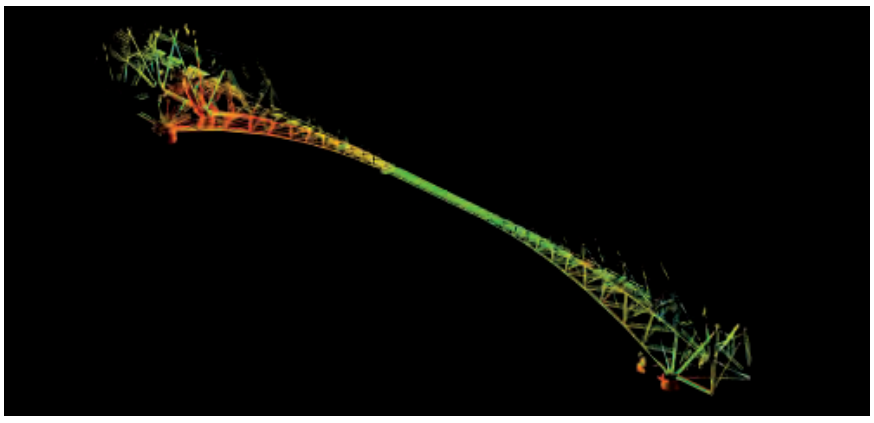
Computations

Having collected the observational data now came the time to crunch the numbers. To ensure the most precise results possible were achieved a transverse Mercator projection with its central meridian running through the centre of the two bridges was designed. This effectively allowed the computations to be conducted on a flat earth assumption and thus ignore the national grid scale factor. The most difficult aspect of the computations was ensuring the correct weighting was applied to observations. Particularly with the road bridge the types of quality statistics were exceeding those usually associated with precision survey. The temptation to exclude observations from the computations due to high residual values was high. Due to the high deflection and longitudinal movement of the bridge all observations had to be scrutinised.

Around the same time as we conducted our survey Historic Scotland had commissioned a laser scanning survey of the bridges for historical recording purposes. They were kind enough to provide a sample of the point cloud dataset for us to use as an independent check. The heights derived from the point cloud dataset compared favourably with the heights derived from our computations and thus gave confidence in our results.



Forth Road Bridge from Historic Scotland point cloud dataset.



Forth Bridge from Historic Scotland point cloud dataset.

Results

The burning question that everyone will now want to know is will the ships fit under the bridges? Well, unfortunately it's not as simple as that. The answer is yes they will, but only on certain tides. This all makes getting the ships out to sea a complicated business. Fortunately that is for the wet surveyors to answer.

Hydrographic Instruction 1490 – Firth of Forth.

By Lieutenant Marc Taylor RN, Commanding Officer, HMSML GLEANER

2015 proved to be another busy year for Her Majesty's Survey Motor Launch GLEANER. The year began in Dover before *HMSL Gleaner* moved on to conduct surveys in Plymouth, Guernsey and Campbeltown. Following a transit through the Caledonian Canal she finished off the year on the Firth of Forth, where the Royal Navy's newest and largest Aircraft Carriers ever built, *HMS's Queen Elizabeth* and *Prince of Wales*, are currently being built.

For the nine personnel of *HMSL Gleaner* - at 16m the Royal Navy's smallest commissioned vessel - the survey tasking in the Firth of Forth incorporated everything and all in the name of Carrier Strike and the future departure of *HMS Queen Elizabeth* from Rosyth. Measurements in bathymetry, topography, tidal streams and bridge heights all had to be obtained whilst meeting the challenges of major defects, the Scottish winter weather and the demanding estuarine environment.

HMSL Gleaner was tasked with providing modern, accurate geospatial data to support the safe departure of *HMS Queen Elizabeth* from Rosyth and out into the deep water channel within the Firth of Forth. Bathymetric data gathering was split into three areas: the main channel passing under the iconic Forth Road and Rail Bridges; the Rosyth Channel (post dredging); and finally the main basin in Rosyth where *HMS Queen Elizabeth* is currently berthed. Assessing and analysing the complex tidal regime proved challenging, exacerbated by the fresh water outflow in the winter months. Of particular importance to the survey was collection and analysis of tidal stream data in the Forth as this had last been collected in the 1950s. This was on top of the requirement to calculate the clearances *HMS Queen Elizabeth* would have under the two bridges that currently span the estuary. The third bridge, the Queensferry Crossing, is the newest road bridge and construction was in its infancy when *HMSL Gleaner* arrived in the area. Thankfully, *HMSL Gleaner* was not on her own when it came to calculating bridge heights; a detachment from 42 Regiment Royal Engineers (Geographic) was on hand to support the topographic elements of the survey.

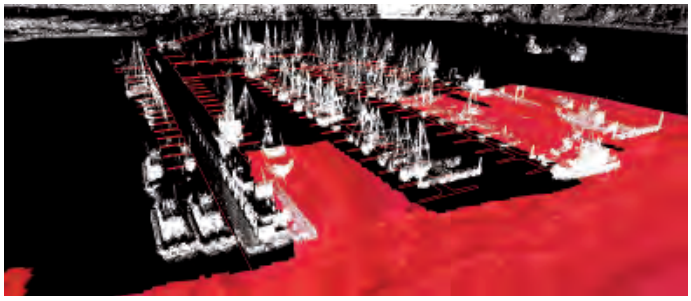
Collection of soundings began in early November 2015, following the establishment of tidal infrastructure. An existing tide pole and pressure gauges installed in Rosyth and in South Queensferry provided the main tidal data source. Validations were also conducted on the UKHO Vertical Offshore Reference Frame (VORF) model for future use. A number of geodetic control marks were established in the survey ground to support future topographic work and for VORF validation and verification purposes. November also saw the first deployment of four Acoustic Doppler Current Profilers (ADCPs) to gather data for the tidal stream analysis. These ADCPs provided tidal flow data through the water column (seafloor, mid water and water surface). In addition to all the survey work, November was also busy with a Commanding Officer's supersession and a trial of two marine LiDAR systems. These systems were used to map the topography around the bridges across the Firth of Forth. Both systems had integrated IMU/GNSS navigation systems and were secured to the wheelhouse roof of *HMSL Gleaner*. Following installation and calibration, data collection was able to begin in short order and in a few hours the whole area around the two bridges was surveyed. These impressive results, shown in image 1, demonstrated how quickly and efficiently accurate topographic data can be acquired and used to support inshore survey work.



HMSL Gleaner, the Royal Navy's smallest commissioned vessel.

The data obtained provided spheroidal heights of the bridges and using the UKHO VORF model, reductions were made to Chart Datum. To aid further qualitative assessment of these systems, RTK mapping was conducted in Port Edgar Marina and overlapping data sets were fused together and showed excellent correlation. Image 2 shows bathymetric, topographic LiDAR and RTK data for Port Edgar Marina combined and displayed using Fledermaus software.

The initial bathymetric focus, using *HMSL Gleaner's* Kongsberg EM2040 multibeam sonar, was in the main navigation channel in the Firth of Forth. Although the



The repeatability of all three systems: Multibeam bathymetry, RTK mapping of the pontoons & LiDAR imagery of Port Edgar Marina, South Queensferry.

Scottish winter weather lived up to expectations, it provided enough of a window to allow for a significant area to the west of the bridges to be completed prior to Christmas leave. During this period, it became evident that the sound velocity (SV) regime in the area was particularly complex, resulting in unacceptable uncertainty in the outer most parts of the multibeam swath which required careful editing of the data to remove the erroneous soundings. The extremities of the swath are subject to the highest degree of uncertainty when the SV values have the greatest variation. This was clearly visible on *HMSL Gleaner's* high resolution EM2040 system. Notwithstanding this, survey progress was good and *HMSL Gleaner* departed the survey area in December as scheduled to conduct her annual maintenance period in the northeast of England. However, a major defect threatened to prevent *HMSL Gleaner* from returning to finish the survey.

On craning the launch out of the water to commence the annual maintenance package, it became evident that the blister pod attachment had failed during the transit from the Firth of Forth to Sunderland; the sonar had detached from the hull and was no longer present! Whilst plans were made in earnest to rectify the situation, it became clear that a repair would not be in place for some time. To that end a contingency plan was swiftly developed to ensure the important survey could continue uncompromised. The Ship's Company of *HMSL Gleaner* was loaned the Fleet HM Unit's *Survey Motor Boat, Shackleton*, to use in the interim. *SMB Shackleton* is another highly capable survey platform, and although slightly smaller and less tolerant of Scottish winter weather, she is also equipped with a Kongsberg EM2040 mulitbeam system and supporting Applanix IMU and C-Nav GNSS receiver. This survey system set-up is consistent throughout the RN's Hydrographic capability.



The view from the navigation gantry under the Forth Road Bridge, in the background you can see SMB Shackleton who has just sailed from Port Edgar Marina.

On receipt of *SMB Shackleton* two days of calibrations and comparison between the multibeam data already gathered with *HMSL Gleaner* were conducted to ensure good repeatability. Bathymetric data gathering recommenced in earnest at the start of February. Once again the SV regime proved to be a challenge to manage, particularly during peak ebb and flood tides and after significant precipitation. The fact that some of the precipitation was snow meant fresh water run-off was often significantly delayed with the consequent effects often evident long after the precipitation. Where data required significant removal of erroneous soundings in the outer beams extra lines were run in order to meet the necessary data density requirements for object detection. Sounding continued throughout February with SMB Shackleton, and four ADCPs were re-deployed to gather improved tidal flow information around the bridge areas. During February, *HMSL Gleaner's* team was also joined by several members from 42 Regiment Royal Engineers (Geographic). They were tasked with observing the heights of the bridges at each navigation mark on both the east and west sides of the bridges. Access to these navigation marks, through the normally restricted gantries leading down from the pedestrian walkway, was made available to allow occupation as shown in image 3. Image 4 shows the area of the navigation marks with *SMB Shackleton* departing Port Edgar Marina for a days sounding.



The prism reflector installation by 42 Regt RE around the port (west) navigation mark on the Forth Road Bridge.

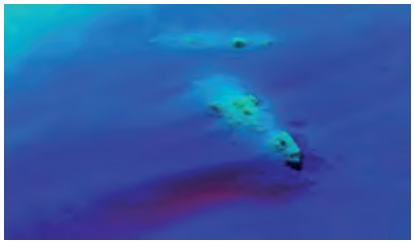
To calculate clearance we also needed to know the masthead heights of *HMS Queen Elizabeth*. As-built heights were taken from technical drawings and provided by the ship's Navigating Officer. An independent check of these height calculations was then undertaken using the same principles as that used to height the bridges. Using 42 Regt's Leica Total Station, which unlike GLEANER's, had a reflectorless Electronic Distance Measurement (EDM) function, angles and distances were taken without the need for personnel to occupy *HMS Queen Elizabeth's*

masts. All data from these observations, together with that from the bridges, was fed back to her Navigating Officer to allow the accurate calculation of bridge clearances for the departure of the Royal Navy's future flagship. Reassuringly, the results of all measurement techniques used (both LiDAR and Total Station) to height the two bridges closely aligned, providing the reassurance that *HMS Queen Elizabeth* should pass safely under the bridges at low tide. The bridge height tasking was a great opportunity for Royal Navy surveyors to work alongside their Army counterparts. The different equipment and observation procedures prompted interesting discussion and analysis on how to get the very best out of our equipment and further interoperability between the Hydrographic Meteorology (HM) branch of the Royal Navy and 42 Regiment Royal Engineers in the future.

Before returning *SMB Shackleton* to its parent unit, all four ADCPs were recovered from their second deployment and the data analysed. Although this data has not yet been verified by the UKHO, early indications show that the tidal streams are significantly stronger than predicted. This is hardly surprising given that the existing road bridge was not in place when the last set of observations were conducted and now a second road bridge is nearing completion. As the water funnels between the bridge supports, it was no surprise to see a greater tidal flow than the predicted tidal stream. Given that the ADCP can measure tidal flow (amongst other variables) in the upper, middle and lower water column, it showed an inflow of a large volume of saline water at depth, together with the outflow at a greater speed at the surface. This further highlighted just how dynamic the whole area is and why accurate SV modelling and measurement was proving challenging, resulting in uncertainties in the bathymetric data.

SMB Shackleton was returned with gratitude to Fleet HM Unit in early March, and following her prolonged and unplanned stay in the northeast of England, a repaired and fully operational *HMSL Gleaner* returned to Scotland. Following dredging work, the survey of the Rosyth Channel was undertaken and wreck investigations completed. Image 5 shows the wreck of two vessels, the largest visible debris is part of a ship which sank in the early twentieth century, almost on top of another vessel, the smaller debris, which had been wrecked 30 years previously.

Nearing the completion of the survey, *HMSL Gleaner* locked in to the Rosyth Main Basin to gather bathymetric data in the immediate vicinity of *HMS Queen Elizabeth*. This provided a fresh challenge to the team as the basin is impounded water and cannot be related directly to Chart Datum. To rectify this, a tide gauge was installed within the basin and a gauge-to-gauge comparison conducted between it and the existing tidal infrastructure during a brief period when the lock gates were open, allowing a free flow of water into the basin. Joining *HMSL Gleaner* to finish off the survey was *HMS Queen Elizabeth's* new Commanding Officer, Captain Jerry Kyd Royal Navy who drove a few survey lines himself before inspecting his latest Command up close from the seaward side. There was always time for a photo opportunity and luckily the Scottish spring weather was kind, providing a well-lit backdrop to show the smallest and largest Royal Naval vessels together, as seen in images 6 and 7. It was pleasing to hear from Captain Kyd how the work from a small team of surveyors from *HMSL Gleaner* and 42 Regt plays such a pivotal role supporting the strategic Carrier Strike capability.



Multibeam data from two wrecks, the largest being a vessel which sank in the early 20th century, the other vessel behind sank some 30 years previously but in very nearly the same location.

You can see that the imagery was produced in late 2015 owing to the very little that existed of the new road bridge in the background.



HMSML Gleaner conducts survey operations inside the main basin in Rosyth with HMS Queen Elizabeth firmly in the background.



The Navy's biggest and smallest vessels basking in the Scottish spring sunshine.

Crossing The Digital Threshold

By Alan Gordon

This article is based on a presentation given at the Maps and Surveys seminar on the 21st of June 2008.

Just as with first crossings of the Atlantic - Leif Ericson maybe, Columbus, Cabot, Lindbergh etc– there were many first crossings of the digital threshold. This is the story of 42 Survey Engineer Regiment and the Survey Production Centre RE, now the Defence Geographic Centre, first using a digital computer for the photogrammetric stage of a standard map production task.

Introduction

"We will forge a nation in the white heat of science" – with these words Harold Wilson set alight the 1963 Labour Party conference – indeed this promise of using technology to thrust Britain forward is seen as the driver that gained Labour election victory the following year. At the time the reality of the 'white heat' was owning a Dansette record player to play the new LP records and pulling a piece of wire to open the door in the revolutionary world beating new Mini.

Military Survey had already embraced this 'white heat' by purchasing a Pegasus computer which was installed at Feltham – it was 1 of only 38 produced. Pegasus was a milestone in the history of both computers and Military Survey for, in terms of innovation, the Pegasus was the IT equivalent of Bleriot's monoplane in the world of aviation, not the first but an early major leap forward – and Military Survey had one. The organisation at that time was, if not actually ahead of the game, certainly up with the leaders.

Pegasus

At this time computers were seen only as a means of doing large, complex calculations; nobody would have envisaged a graphical user interface or even a graphical output never mind what they have become today.



A Pegasus computer in a publicity photograph - not the Military Survey machine.

Pegasus was an early thermionic valve, that is vacuum tube, machine built by Ferranti Ltd. The first Pegasus 1 was delivered in 1956 and the improved Pegasus 2 followed in 1959. Ferranti sold twenty-six of the Pegasus 1 machines and twelve of the Pegasus 2, making it their most popular valve computer. Its internal workings comprised 'packages' that each had three valves, plus resistors, capacitors and sometimes 'mercury delay lines'; all very state of the art in the early Sixties. It boasted a 7k magnetic drum store which was extremly impressive at the time.

It was bought by Military Survey essentially to carry out geodetic computations such as converting graticule values to grid values and vice versa and, least squares adjustments of field surveys, work that until the arrival of Pegasus was carried out in rooms full of human calculators working with hand-cranked machines.

This cutting edge technology was housed on the middle floor of an old barrack block at Feltham, now known as Clarke Building, and was managed by Ted Hyams. The computer itself was about 3 feet wide, ten feet long and 8 foot high (these measurements are of course in imperial measure – no metric at that time!) The power pack that fed the computer was of similar size and that was fed electricity from an alternator housed in its own small building outside. When in operation the system generated a very uncomfortable amount of heat. There were two cathode ray tubes above the console on which

the operators could watch the progress of their least squares solutions. The console had two banks of switches that were used to manually program the machine.



5-channel punched tape.

Programs and data were input on 5-channel punched tape that was supplied in 1000-foot reels - programs were punched onto blue durable tape and data onto yellow paper tape. Output was again as punched tape that fell into 2-foot cube tape bins that were on castors for easy movement. A Creed 9-inch wide teleprinter which had a travelling 'golf ball' mounting the letters rather than the traditional keys, could provide typed results.

Characters on the tape were punched with an 'odd parity', that is, each character had an odd number of holes across the tape. If a character presented an even number of holes, then an extra 'parity hole' was punched. This enabled the tape reader to make some check for punching errors. The corollary to this was that reading errors could occur. John Howliston recalls an error when after much investigation he removed the tape from the reader and he could then see that a small winged insect was splattered across a hole so blocking the scanning light. This anecdote is included to give a feel for what it was like in the very early days of IT when, again to quote John, "Computers was computers in them days!"

Aerial Triangulation



A two-projector Multiplex machine.

Aerial Triangulation, or air trig as it's more usually known, is the extension by photogrammetric methods of a framework of ground control points in order to provide sufficient control to carry out absolute orientation of each stereoscopic model in a block of photography. This latter procedure requires points with known plan and height values positioned in the four corners of the model. Until the time in question, this had been carried out by the analogue procedure using the Multiplex machines and known as bridging which required all the models to be set up in succession with readings taken to common points in each model and to tie points between strips and to ground control points. Graphically derived corrections were applied to these readings to relate them to the known values of the ground control points. It was time consuming, required very skilled operators and, particularly in areas of difficult terrain such as south Arabia and Borneo, a very difficult process with results of doubtful accuracy.

The analytical process required precise observations to be made using a stereocomparator to points on the photographs in the same positions as for bridging and to the ground control points. The model would then be formed and adjusted mathematically followed by the formation and adjustment of the strip and finally the entire block to fit with the sparse amount of ground control. This process might or might not be quicker but it certainly promised to produce a more accurate solution. The problem was that although the theory was well known, it was not practical to carry out the computations for large projects by hand. For Military Survey, Pegasus could solve the problem.

By the mid Sixties Pegasus was becoming an old computer and plans were afoot to replace it with the newer ICL1902. However, now with several years experience in computing, Military Survey was looking to expand its use and the 'computing-heavy' process of analytical aerial triangulation was an obvious avenue to pursue. Others such as the OS under Don Procter, Professor Ackermann and probably the commercial leaders of the time, Huntings and Faireys, were also working on the problem but Military Survey decided to produce its own solution and so the program was an in-house product designed by AND Smith, Head of Geodesy, and programmed in the computer language PLAN by Peter Verrall. It was ready for use by 1967, all that was needed was a suitable task to use it on…and there was one….the production of series K669, a 1:100k series covering the Aden Protectorate. The map production process was about to change forever.

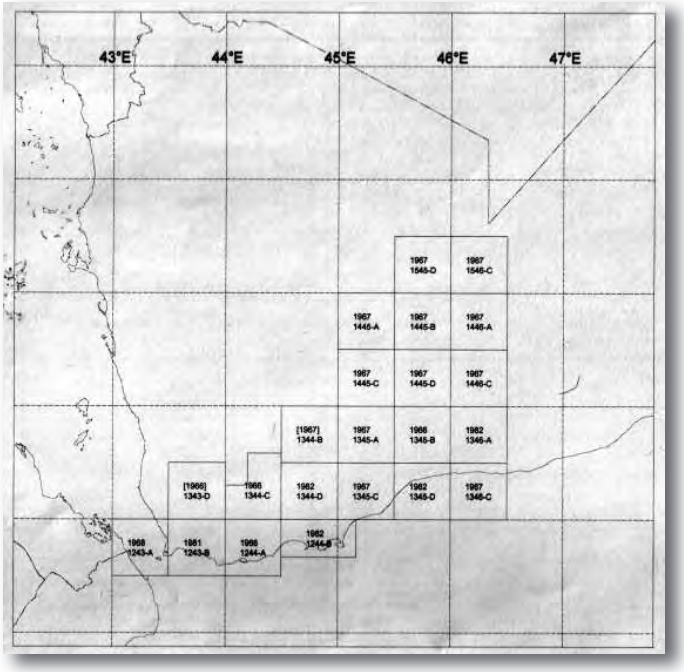
K669

In 1964 the Aden Protectorate, as the southern part of south Arabia was then known, was in the throes of an insurrection and much internal violence. The only mapping of the area available was series K667 which was of poor accuracy and in the main without contours. A new survey was urgently required to support operations and the mapping was to include not only contours but also fully modelled hill shading which was to meet the needs of aircrew.

13 Field Survey Squadron supported by a troop from 19 Topographic Squadron put in the field control in extremely rugged and dangerous terrain.

The RAF provided the photographic cover with sorties taken from the mid-Fifties onwards using the F49 Mark 2 camera. This camera produced imagery that suffered from 'corner falloff', that is, a darkening and lack of resolution in the corners. This created a major problem for photogrammetric operators as at the extremities of each stereo pair one image was generally light and relatively sharp and the other dark and unclear making it difficult to form a stereoscopic image on the anaglyph Multiplex equipment.

42 Survey Engineer Regiment based at Barton Stacey in Hampshire was then to be responsible for the subsequent stages in the production of a block of 22 sheets up to the actual printing which was to be carried out in theatre by 13 Squadron, thus removing the need to transport bulk stocks. However, in the event 13 Squadron returned to the United Kingdom in June 1967, a year earlier than planned and so 22 Lithographic Squadron took over the printing work.



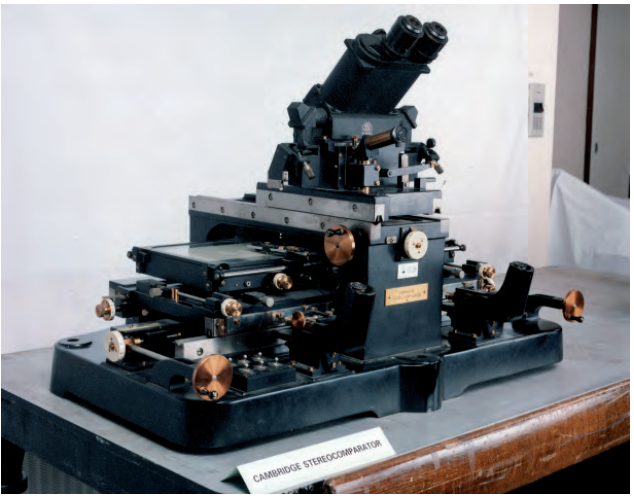
Series K669 cover diagram showing the 22 map sheets.

Work commenced in January 1965 with the production of a pilot sheet. This was completed in October 1965 and after review in theatre the final specification was agreed and the air survey and cartographic work on the main task commenced at the end of the year in 47 Cartographic Squadron which was on a permanent shift system that was driven by a firm completion date of 31 July 1967.

Aerial Triangulation Equipment

Initially the aerial triangulation was carried out by the bridging method using both short and long bar Multiplex machines but by late 1966 SPC at Feltham declared that it was capable of computing analytical air trig.

This provided the second component necessary for analytical air trig, the computer and program. The first component is a means to very accurately measure stereoscopically observed coordinates on the air photographs and this was provided, paradoxically, by an instrument that was made in the mid-1930s, some 30 years previously and long before anyone had dreamed of automated computations.



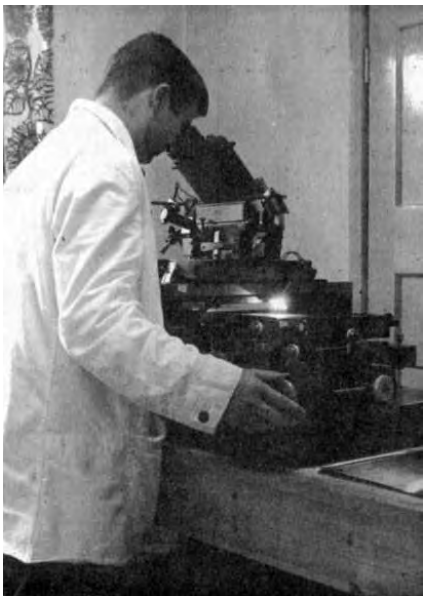
The Cambridge Stereocomparator.

In 1930 Lieutenant Colonel EH Thompson developed a new stereocomparator to provide the measurements from which minor control points could be calculated. This instrument was manufactured by the Cambridge Instrument Company and by 1937 it was in general use and known as the Cambridge Stereocomparator. The design was truly innovative at the time and the resultant instrument was an attractive symphony in steel, brass and glass. The instrument comprises two tables to hold the photographs mounted on axes that can rotate through 360º. These axes in turn are mounted on carriages that move along tracks in the x direction. An invar scale engraved in millimetres and read by microscopes is fixed along the x tracks. The binocular viewing head rides over the photograph tables in the y direction on a bridge with engraved millimetre scales read by microscopes. Micrometers took the readings to 0.01mm and a slide allowed for estimation to 0.001.

There is photographic evidence that 512 Field Survey Company took at least one instrument with them to Egypt in 1940 and, knowing how the Army closely accounts for and stores its equipment, it is very likely that the self same instrument was one of two that were with 512's successor unit, 42 Survey Engineer Regiment, at Barton Stacey over 25 years later in the Sixties…elderly but ready for use on K669.

The instruments were surprisingly heavy and so for safety and stability they were mounted on, in Army vernacular, "benches butchers", very sturdy wooden benches used by butchers to chop up meat. These safely held the instruments but unfortunately raised the binocular eyepieces above the observer's eye line. The initial suggestion of shortening the bench legs was met with incredulity by the Quartermaster who couldn't comprehend the concept of wantonly damaging government property hence small, wooden platforms were built for the operators to stand on.

The Aerial Triangulation: Observation Process



Cpl Peter Redfern observing points – note the butcher's bench. The 'scientific' nature of the work was highlighted by the wearing of 'consultant' style white coats!

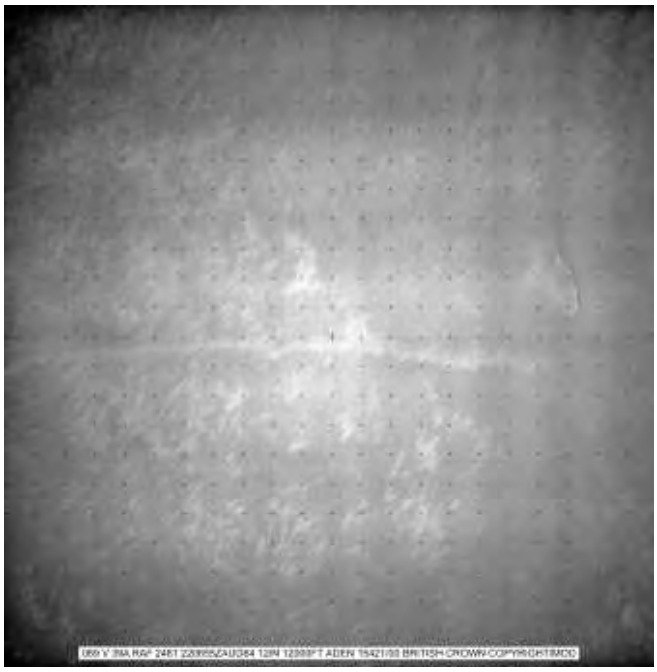
Four experienced corporals together with four sappers were taken from the Multiplex section of Air Survey Troop, which was at that time manned to cover 24-hour shifts, and were formed into the Air Trig Section. Initial work involved visits to Feltham to devise the observing process and point numbering system, designing the booking sheet and agreeing procedures for dealing with failures at the computation stage.

The point numbering system used comprised 7 digits; the first two defined the points function – orientation point, tie point, plan or height control, the next three were the photo number and the final pair defined the point's position on the photograph.

The original plan was for each instrument to be manned by two observer/booker teams so that whilst one team was preparing a strip the other was observing. However, this soon proved impractical and so a two shift system – one early the other late - was adopted with each team first preparing then observing a strip.

The preparation stage involved mosaicing a strip, selecting and marking the orientation points in the classical positions and points that fell in the lateral overlap between adjacent strips to act as strip tie points, transferring any ground control points that fell on the strip from the Point Identification Report photography on which it had been identified in the field to the air trig photograph. Points were marked with a very fine pin pricked hole. The block diagram was then updated and the points to be observed detailed on a new booking sheet together with the calibrated focal length of the camera that took the photography.

It was now onto the stereocomparator and the first observations were monocular and taken in x and y to the principal points and fiducial marks of both photographs. Readings were recorded to the nearest micron. Stereo observations were then make to the first orientation point and then to the nearest reseau cross. Observations were then similarly made to all the remaining points in the stereo pair. A short break taken, in those days often a 'fag break', and then a second round of observations made each of which had to come within the narrow tolerance of 30 microns of the initial value. If the second reading fell outside the limit then the booker called 'foul'…or words similar but did not indicate whether it was high or low. Generally after several attempts an acceptable reading could be achieved and if not this was followed up generally by selecting an alternative point.



F49 Mark 2 photograph of the coastal plain area showing the featureless terrain from which identifiable points had to be selected and also the corner fall-off that made stereo vision difficult.

For the observer it was a task requiring considerable concentration and straining on the eyes, for the booker it was a tedious and boring duty….so much so that it was known on occasion to drive them to drink! When all models in a strip had been successfully observed the booking sheets were taken to SPC for computation.

Airborne Profile Recorder

At the same time as analytical air trig became possible so another new technique found its way into the programme. Huntings Air Surveys had flown some of the area to be mapped with their airborne profile recorder, an instrument that used radar to provide a trace of the terrain profile directly underneath the aircraft and took small format photographs in rapid succession whose exposure position could be identified on the profile. If it was then possible to locate the principal point of the spotting photography onto the survey prints then, after a series of corrections had been applied to the profile height, you had an additional height control point.

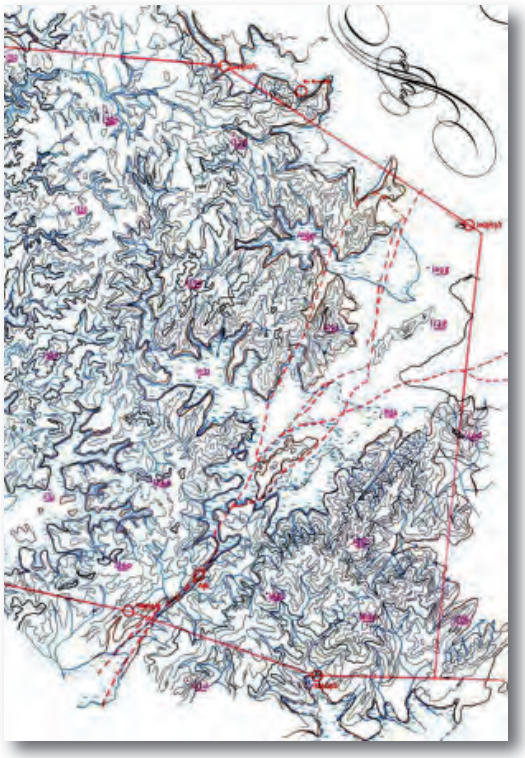
Considerable effort was put into attempting to extract these additional height points, a difficult task due to the large scale differential, the poor quality of the F49 imagery and the general paucity of ground detail. However, some points were achieved and input to the solution.

The Computing Process

The first stage in the computing process was for the Data Preparation Section at Feltham to produce the 5-track punched tapes from the booking sheets. Next the blue program tapes holding the model formation program were loaded and then the data tapes. Pegasus then mathematically formed the model. This was the point at which failures most commonly occurred as residual parallax readings failed to reduce to within tolerance. The reason was inevitably poor point selection due again to the paucity of detail in the area of the coastal plain or the difficulty in seeing a good clear stereo image on photography with significant corner fall off.

The next stage was to join adjacent pairs of models together to form sections. The SPC air trig solution was the only solution to do this, a stage that was introduced in order to reduce the number of variables to be handled. The join was achieved by mathematically transforming the coordinates of the point observed in the second model to be the same as those in the first model. These sections were then joined together mathematically to form the strip. All plan and height control points observed in the strip would now have coordinate values in the strip coordinate system. As their true coordinate values were known the next stage was to transform the control point strip values to true values then applying the same corrections to all orientation and tie points – this was strip adjustment.

Having adjusted the first strip the procedure of model, section and strip formation and then adjustment was carried out for the second strip which was then joined to the first strip by means of the strip tie points. In this manner the strips were added until the entire block had been mathematically constructed and adjusted to fit the ground control. Inevitably as the process progressed further errors were identified, often selection of good strip tie points was difficult in the narrow lateral overlap between strips, again an area blighted by corner fall-off. Re-observations were commonplace – when the telephone rang in Block 101 at Barton Stacey and the caller said *"Hello Steve Fullom here, could I speak to Cpl…."* it started the whole chain of point selection and observation again. Identification of the control point onto the air photo by the field surveyor was another area of potential error – a small needle prick in the emulsion was the sole real control mark – it could only done once as a second attempt then produced either multiple holes or a giant crater…as sometimes was the case…. causing the air surveyor transferring the point to the air trig photography to have 'guestimate' the actual position on the photograph.



The last Multiplex plot from series K669.

The entire computational process involved considerable inputting and output of hundreds of feet of paper tape. John Howliston recalls Steve Fullom dropping a reel of tape that spilled across the floor. Colleagues helped him to collect the precious load into a tape bin which was carefully carried to the top floor of the building from where Steve lowered the tape down the deep stairwell and proceeded to slowly wind the tape back onto the reel…some 700 or 800 feet of it! Whilst Steve was carefully winding the tape some wag cut out the shape of a fish and taped 'the catch' to the end of the tape – such was life in the early days of computing!

Eventually an acceptable solution for the block was achieved and the results were sent to Barton Stacey in the form of a line printer sheet giving grid coordinates and heights for every orientation, tie and control point in the block from which the base sheets for the Multiplex plotting and the large plot compilation traces used by the cartographic draughtsmen to compile the sheet for fair drawing were produced.

Finishing the Task

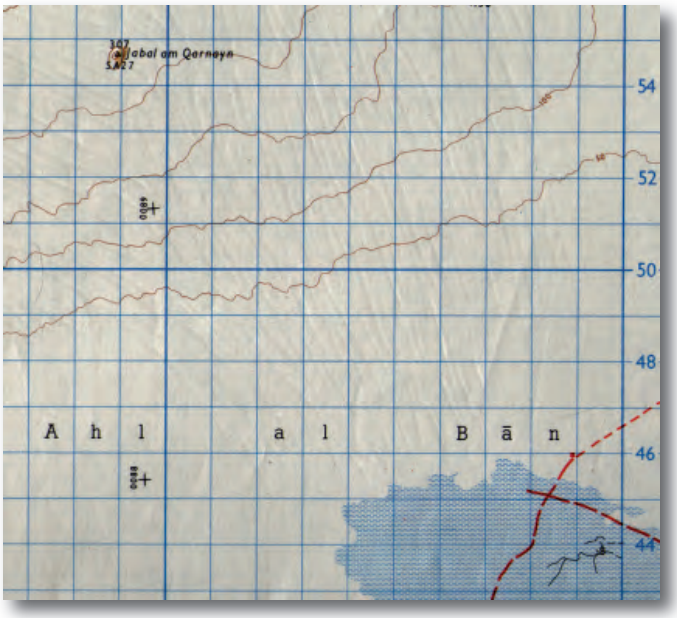
The use of analytical air trig was not the only innovation on this task as the specification required full hill shading which was produced by the cartographers using leather workers tools to make a three dimensional plastic model of the terrain which was then photographed to produce the shadow effect. The result, particularly in the mountainous hinterland was an extremely attractive cartographic product.

22 Lithographic Squadron then printed the sheets and on the 28th of July 1968, three days before the deadline, the last sheet was cleared off the press and passed catch release.

Postscript

The K669 mapping programme started out using traditional graphical and analogue methods but midway through used analytical aerial triangulation for the first time taking British military photogrammetry into the truly digital age.





Extracts from K669 showing the mountainous hinterland and barren coastal plain.

Thus, at the height of the 'Swinging Sixties' amidst Beatlemania and the advent of the mini – both car and skirt - in a wartime brick hut a few soldiers wearing clinical white coats and using 1930s vintage instruments stood on butcher's benches and, observing onto photography of the featureless, arid wastes of south Arabia taken with wartime cameras, Military Survey crossed the photogrammetric digital threshold.

Shortly after completion of K669, the venerable Cambridge stereocomparators were replaced by Hilger Watts instruments that output the observations directly onto punched tape…42 Survey Engineer Regiment itself then truly joined the digital age. Oddly, the Hilger Watts instruments were in turn replaced by the Stecometer – an instrument manufactured by Zeiss Jena, a doyen of East Germany and the Communist Block! It was probably the only item on a military inventory anywhere within NATO that was made by a Warsaw Pact country.

Ironically in 1966, as the Regiment was well into the task of producing K669, the now Prime Minister Harold Wilson decreed that British Forces would withdraw from the Aden Protectorate in 1968 but a rapid deterioration in the situation led to the withdrawal being brought forward and the last troops left Aden at the end of 1967….six months before K669 was completed!

Cartography of The Sands or Oman Revisited

By Tony Keeley

Introduction



Desert Camp, a collage produced by Chrissie Breach from images supplied by Tony Keeley.

First of all I would like to explain the somewhat pretentious title. I was asked by the President of the Hakluyt Society to deliver a lecture in February 2016 at the Warberg Institute, the Society's contribution to a series of lectures titled 'Maps and Society'. The lectures ranged from medieval mapping to present day topics. I was asked to supply a catchy title and so the lecture 'Cartography of the Sands' it was with not the faintest element of cartography included! I chose to speak on a survey task I undertook in Oman in 1984 which consisted of the provision of ground control for 100,000 mapping.



Oman.

Historical Background

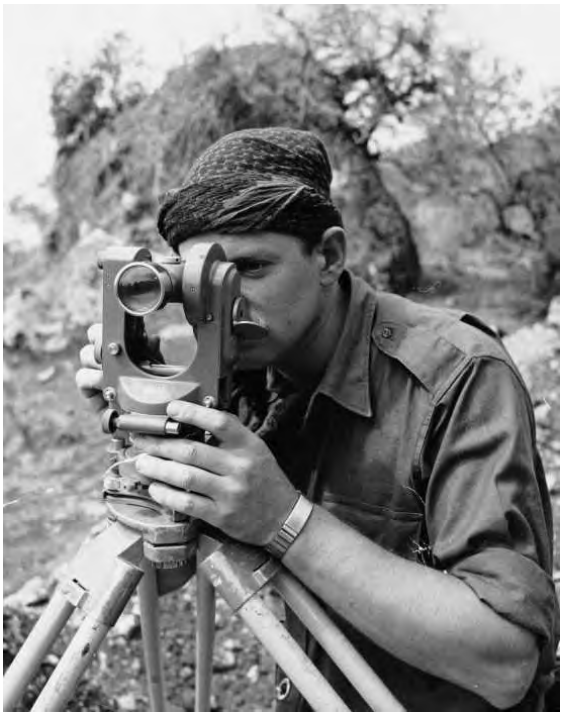
I will start off with a little potted history of Oman including the British and consequently military involvement in that country and also my early experience as a troop commander with 11 Field Squadron at the end of the Dhofar War. Oman is bordered by the United Arab Emirates, Saudi Arabia and The Peoples' Democratic Republic of Yemen (PDRY). There had long been a British interest in the area, continuing to the present time. In the early 1800s Oman had colonies in Africa including Zanzibar, profiting from the slave trade but in the mid-19th century when the British declared slavery illegal the Sultanate's fortunes declined, the population of Muscat falling from 55,000 to 8,000 and many Omani families moving to Zanzibar. When Sultan Said bin Sultan Al-Busaid died in 1856 his sons quarrelled over the succession and through British mediation the principality was split between Zanzibar and Muscat and Oman. However there was little unity in the country of what is now Oman. Franco-British rivalry was rife in the area and continued through the 18th and 19th centuries but in 1908 the British entered into an agreement of friendship and it is perhaps from here onwards that the British influence was more strongly in evidence. The country continued to be divided with the Sultan ruling in Muscat but the Iman holding sway in the interior, the Treaty of Seeb in 1920, formally recognising the individuals' sovereignties bring a temporary element of stability. Not till 1951 was the country formally recognised by the United Kingdom as the Sultanate of Muscat and Oman.

In 1954 oil was discovered in the lands of the Iman which precipitated an attack by the Sultan and 5 years rebellion by the Iman. The Sultan was aided by British forces and the Shah of Persia. In the

early 60s the Iman was exiled to Saudi Arabia. In 1964 a separatist revolt began in the Dhofar province aided by communists from the PDRY. This rebellion continued well into the 70s. In 1970, Qaboos bin Said al Said, educated at Sandhurst, ousted his father, Sa'd bin Taimur who later died in exile in London. The overthrow was aided/engineered by British forces including SAS and Loan Service officers and from this time on UK's overt presence in the country was much in evidence.

The Military in Oman

Till now I have been largely drawing on standard historical accounts but I can now speak from personal experience. In 1977 I was in Oman as part of the roulement Engineer Squadron supporting the Dhofar Brigade in the south. This was part of 'Operation Tenable' a once classified operation, 38 Engineer Regt based in Ripon supplying the in theatre squadron. I was lucky enough to be in 11 Sqn who deployed to Oman in Jan 77 for 6 months. The Squadron's role was varied, building fortifications on the border with Yemen, road building, mine clearance and constructing mosque/clinic/school complexes for small settlements. This support was very much in keeping with Qaboos winning over former dissidents through paying and arming the rebels as the Firqua Force and actively looking after the ordinary people. The Dohofar Brigade was largely officered by Loan Service/Contract British officers and still with a heavy SAS contingent. The infantry were predominantly Beluchis, the Omani Regiments generally tucked out of harms way in Muscat for ceremonial duties. Other Engineers were supplied by Iran and Jordan amongst others. The Sqn role in May/Jun shifted to flood relief and I spent many a happy hour blowing up rocks on dirt air strips to enable higher payloads for Skyvans. And in the middle of this the OC of the Squadron told me to do a survey of a road being built to see how much had been completed (to settle a argument on how much the former squadron had built). This on the basis that I was about to do the Army Survey Course. So I borrowed a theodolite hence the image of me. It appeared on the cover photograph of Soldier Magazine so it cost me quite a few beers!



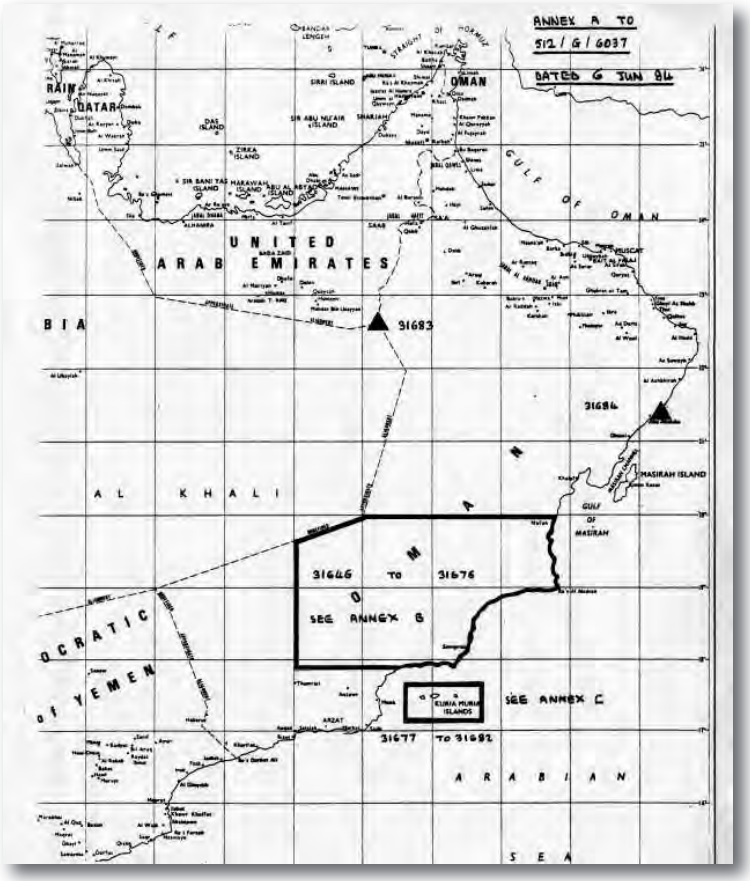
Yours truly surveying road built by 11 Sqn. 1977.

Early Surveys

Going back some way i.e. to the early 1900s. Mapping was sporadic and largely confined to coastal inhabited areas. The Petroleum Development of Oman (PDO) and Huntings Surveys from the 50s onwards undertook numerous surveys some of a relatively low order consisting of traverses across the country, occasionally flying traverse i.e. not anchored on control at one end however the Fahud Datum was established. In pursuit of oil exploration they also established many height points though from several different datum's i.e. Muscat, Salalah and on the coast opposite Masira. Some series mapping was also produced by Military Survey but of limited coverage. In support of military operations both 19 and 13 Survey Squadrons, part of the then 42 Survey Engineer Regiment undertook survey work from the 59 onwards, often under considerably dangerous conditions, vehicles occasionally blown up by land mines and one sapper was killed when his Landrover hit a mine. In 1964 13 Field Survey Squadron connected the Fahud Datum to Dubai with a Tellurometer Traverse, also establishing a trig network in the Dhofar province in an area not covered by PDO.

The Task

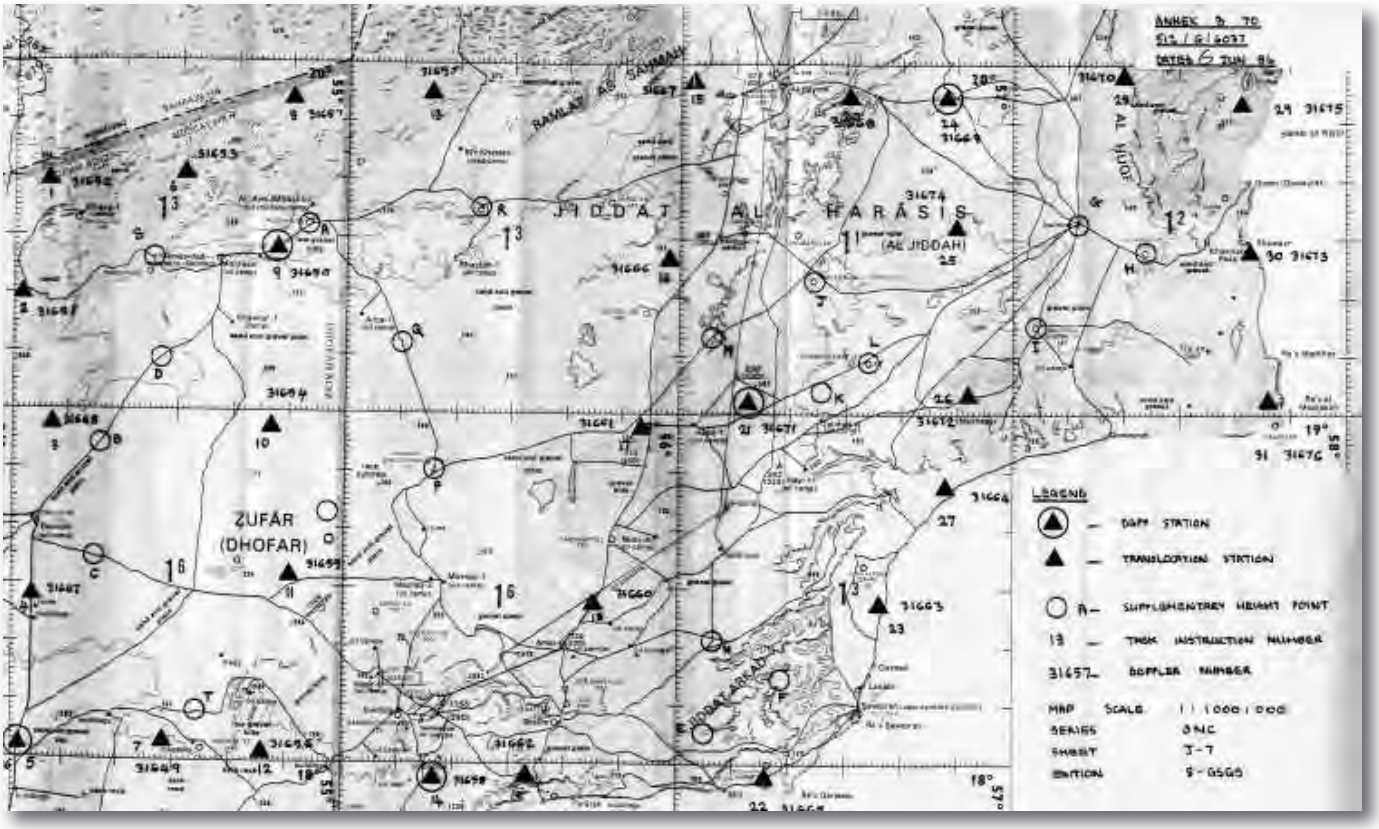
In December 1983 I was No 2 Section Commander of 512 Specialist Team Royal Engineers (STRE) and, as a change from the usual role of either static tracking on the Special Mission Tracking Phase (SMTP) or occupation of existing trig stations, the Section was given a task to supply ground control for mapping. Doppler fixation would be the basis for the control. I will say little about the techniques *(See Mike Stanbridge's article in Ranger 2014)* except that as the aim was not to tie to existing control translocation methods were more than adequate. Hence on 17 December 1983 I flew to Muscat to commence arrangements, other members of the team arriving later.



Location of Survey Task.

The task was, in principal very straightforward, i.e. to produce ground control for 100,000 mapping for an area of approximately 350 x 150 Km plus fixation of a number of points on the Khuria Muriya Islands – but more of that later. I was supplied with aerial photography at 60,000 scale, flown by the RAF during the preceding year. The overlap was about 80% so I had boxes of at what at first sight looked like a range of fine to coarse sandpaper which I received on Christmas Eve in country – not the ideal Christmas present I thought.

The photography was marked up with locations where ground control was needed, this in no way indicated that they were photo-identifiable features, merely the ideal location for ground control for the aerial triangulation of the photography and subsequent plotting. A total of 31 plan points were required, 24 also having associated height points, 7 points on the coast not requiring specific height values (Sea level being used). Also 20 extra height points were needed for the block triangulation. All plan points needed to be photo-identifiable, not always an easy task in often featureless terrain. That would be the end point of the project as far as I was concerned. The Mapping and Charting Establishment (MCE) at Feltham producing the final printed maps, the K6611



The Survey Scheme.

series, some 35 or so sheets. Names/description of features etc were supplied by Oman in Arabic, appropriate translation, transliteration then taking place, place names being checked through the Permanent Committee on Geographical Names (PCGN)

The Reconnaissance and Planning

On Boxing Day 1983 I left Muscat, with something of a hangover, for Salalah in the south of Oman and hence had a high speed recce by helicopter of the area of interest, using 250,000 maps Joint Operational Graphics (JOGs) and handfuls of air photographs, fortunately the pilot knew what he was on about and I got a fairly good feel for the country, dunes in the west, the Empty Quarter, gravel and sand plains and sabkha (salt plains) in the middle and steep slopes in the East, the Jebel. However it was not until the first of February 1984 that the survey started in earnest, the intervening time being spent in gathering stores and arranging signals and engineer support. We had to be totally self supporting with vehicles, tentage and vast quantities of spare tyres; inflatable jacks/sand channels etc. We also had to carry enough water for about a month though this was fairly readily available. Needless to say food was basic, half British compo rations and half Omani (lots of dried fish and curry)

Field Work

The base of operations was Thumrait from which we sallied forth living in the desert for a month at a time. We deployed to the first two points 31646 and 31647 with an escort from the Western Frontier Regiment, once again Beluchis, for security near the border and for signals communication. We had two Bedford's, two Landrovers for the Survey Parties and a further two Bedford's for the signals detachment (not that communications worked much which suited me very well, the OC of 512 STRE being in Washington). Our team of surveyors was nine in total but typically no more than 5 at any one time. Working hours were dawn to dusk, with report writing/computations on return from the field in the evening. At the end of each month in the field we returned to Thumrait for the delights of showers, relatively fresh food and the odd beer during which time I had to finalise my monthly accounts!



Desert Camp.

On the diagram showing the Survey Scheme, the points shown as triangles in circles were the places occupied i.e. 5 camps in all, triangles alone unoccupied. In all cases it was necessary to survey in points on the ground identifiable on the air photos. To this end we drew vicinity sketches and an awful lot of tonal sketches! Because we wanted the precise points to be recoverable i.e. normally in rock outcrops or oil drums sunk in the ground these points would not be visible on photos. Hence local surveys including azimuth and distance would be undertaken, generally azimuth by sun shots but occasional by Polaris, distance by AGA14 Geodimeters.

As well as plan points extra height points were needed these were produced using altimetry, not a rigorous process but certainly adequate for the task in hand. Simplistically, using four altimeters, two on a known point, i.e. a heighted manned Doppler Station and two roving, readings would be taken every 15 minutes and hence the difference in height calculated. There would obviously be limitations on distance and the need to return to the base station to 'close the loop'. This was done by Landrover, not ideal with the travel on tracks. This was a lengthy process but towards the end of the task there was ample manpower. Ideally this altimetry scheme would have been undertaken by helicopter but we were constrained by availability i.e. it was in the Exercise Season. As there was also considerable PDO height control opportunity was taken to connect to these points. We moved camp as necessary, 5 locations in all. The scheme itself was split to complete the Kuria Muria Island task as both naval support and Skyvan/helicopter support were essential i.e. we had to avoid an exercise window.

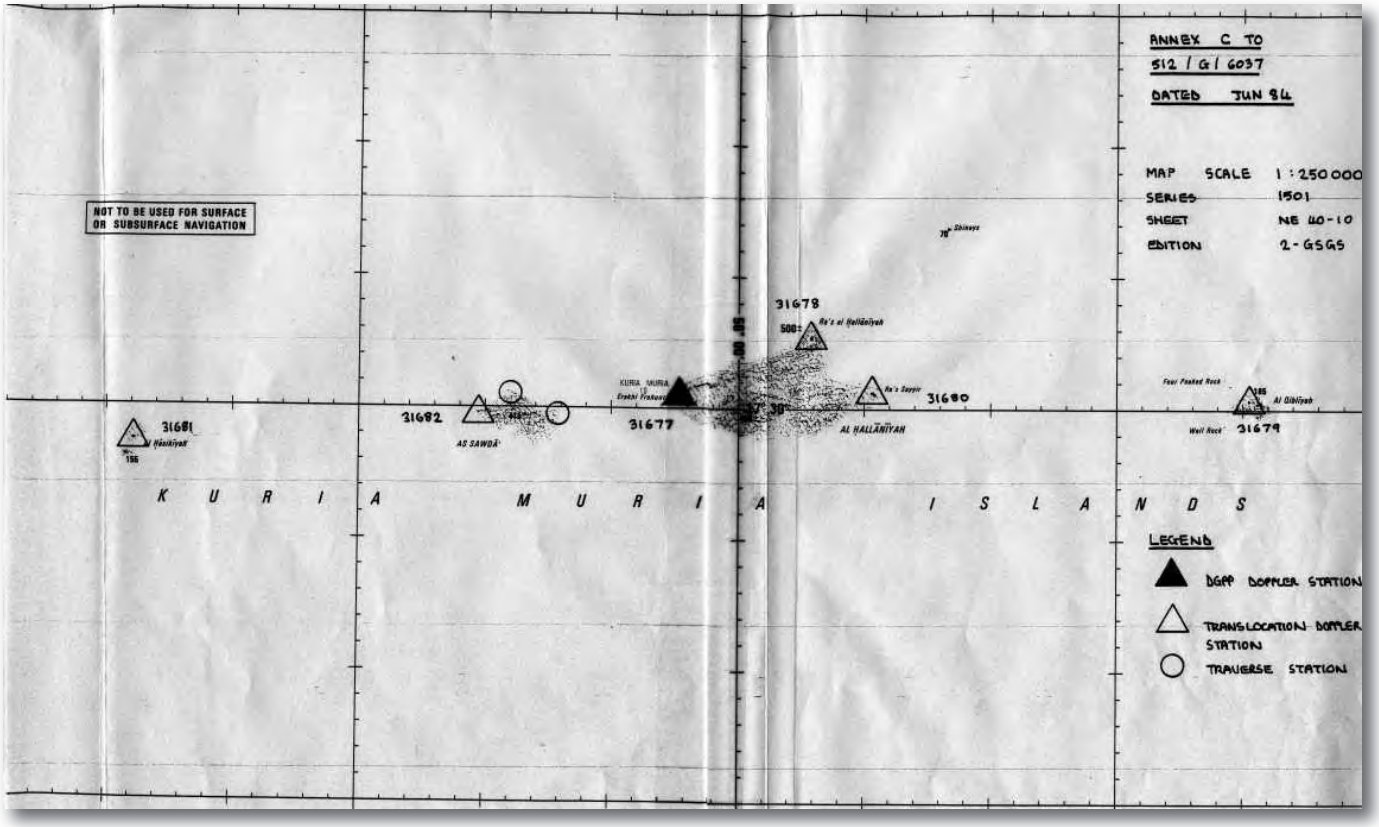
Overall once we became familiar with matching ground features to the photography the task proceeded fairly smoothly. Travel to some of the western points i.e. in areas of dunes required considerable care. In general we started very early, before dawn when there was a slight crust on the sand. In one instance I was occupying a remote Doppler station, usually unmanned, the Sgt had driven about a kilometre to a photopoint (I then did a sun azimuth and distance to the point). He was a long time in returning and when he did so he was not best pleased and minus his trousers. It transpired that he had bogged in and the only way he could extricate himself was to put his trousers under the offending wheel to get traction and keep going. There were numerous incidents of vehicles bogging in, inflatable jacks, attached to the exhaust helping but these were eventually destroyed through over usage. Sand channels were also invaluable as long as you could get somewhere to stop and recover them. Other issues were punctured tyres; Landrovers generally carried at least two spares which we replenished on our monthly return to Thumrait.

Kuria Muria Islands



The Island Group (Khuria-Muriya).

This was a secondary task, partly at the request of the Hydrographic Office – Oddly it appears that at a similar time the Royal Navy were interested in the position of the islands as some uncertainty existed. The islands were ceded to Britain in 1868, rumour has in exchange for a snuff box from Queen Victoria – At the time I wondered who got the better deal. The islands were then part of Aden (Now PDRY) – The Aden Settlement but in 1967 returned to Oman at the wishes of the inhabitants. The main island was inhabited but the others, as I recall not. Much aroma of guano was encountered during the survey and also quite phenomenal bird life. Eight Doppler points were observed including the manned station. My 2IC Capt Stephen Walker had recced this and arranged the stores and support, an enormous help. Part of the team deployed to the islands by Skyvan on 10 April, stores going overnight by boat from Raysut courtesy of Sultan of Oman's Navy (SON). A slight complication/limitation was that the Sultan of Oman's Air Force (SOAF) would not allow single-engined helicopters to operate over the sea so only the VIP flight had twin-engined helicopters hence we had to fit our survey plan to the availability.



The Khuria Muriya Survey Scheme.

We stayed on the main island of Al Hallaniyah, Al Hasikiyah and one station on As Sawda being visited by sea, the other stations being established by helicopter. The same survey routine in general being applied as in the mainland task except that heighting was not the same issue. The islands of Al Hallaniyah and As Sawda were also well controlled for orientation, the former by multiple Doppler points, and the latter by supplementary conventional traverse/azimuth observations. For Al Qibliyah and Al Hasikiyah orientation/scale was controlled by distance and azimuth observations.



Khuria Muriya Island Camp.



Tony Keeley doing a sun azimuth with his taxi hovering impatiently in the background!

The survey problems were not great but the time factor was critical i.e. landing and recovery by helicopter, they did not hang about! The islands survey represented a relief from the relentless heat of the mainland at times up to 50˚ Centigrade. Because of the need to observe numerous sun shots, these by their nature were taken around noon, much care being taken not to inadvertently touch the theodolite eyepiece with your eye! By 23 April our island sojourn was complete and we returned to the heat of the desert.

Life in the field

Life was very basic, survey, compute, eat and sleep. Showers consisted of tipping a jerry can of hot water over your head. Water would be drinkable but invariably hot. We did occasionally have cool water courtesy of chuggles i.e. canvas bags on the front of the Landrovers, water evaporating from the surface cooling the interior (The Bedouin having porous clay pots operating on the same principle). We slept on camp beds on the ground, with mosquito nets, largely to keep the scorpions and camel spiders at bay! A considerable difficulty was dust, it got everywhere, in the equipment and in the tents (these were extremely basic). Occasionally we had the luxury of staying in PDO air conditioned trailers if we were in the vicinity of the massive mobile oil camps.

Broadly speaking the main task was over but not quite! The Defence Attaché, Col Richard Lea ex SAS I believe, 'asked' me to survey the point between Oman, Emirates, Saudi, Umm Al Zamul, previously surveyed in 1964. I knew this was contentious as MCE had already printed 100,000 maps of this area. Hence I did the fix with a station description in purely descriptive terms with no reference to international boundaries. The discrepancy in Northings, though not great was certainly plottable at 100,000 namely around 300m. When I finally returned to UK, i.e. Feltham, I was called in to explain to the Head Geodesy, Norman Leopard, what I had been up to. It was a salutary lesson on the importance of understanding datum's and spheroids, not a question of right or wrong coordinates! Overall the Oman task was highly enjoyable and on departure on 11 June I rounded off my 512 tour, about 16 months in all, by a delightful few months in the game parks and costal resorts of Kenya – my last survey in the field.



Early Days of Satellite Geodesy

By Bill Codd - 512 STRE BC-4 Section in South Georgia, South Atlantic



Introduction

Many of us own a Satellite Navigation (SatNav) device, which we use to navigate in our cars. It uses advanced technology from the Global Positioning System (GPS) to show our position and directions to reach our destination shown on a digitized map projected onto a small screen. GPS is now commonly used by the military for navigation and targeting and by surveyors for controlling map production and engineering works.

Geodetic Surveying

Geodesy is the branch of mathematics dealing with figures and areas of the Earth or large portions of it. It involves measurement of the size and shape of the Earth and the locations of points on its surface. Before 1960 geodetic surveys were carried out using precise theodolites and distance measurement tools for determining horizontal and vertical positions. Geodetic positions were calculated from measurements on the ground using a selected spheroid of computation adjusted to fit a selection of stations whose geographical coordinates had been calculated from precise astronomical measurements. This best mean fit defined the datum of the geodetic system and covered only part of the Earth's surface. Consequently the land masses were covered by a patchwork of geodetic systems, the sea surface was not included and the centre of the Earth was not defined.

The Space Age

The Soviet Union launched Sputnik on 4th October 1957, and scientists in the USA were able to determine its orbit by analysing the Doppler shift of its radio signals. It was realized that if a satellite's position were known and predictable, the Doppler shift could be used to locate a receiver on Earth. The US Navy developed this principle into TRANSIT, a system of satellites and supporting ground stations that was intended primarily for navigation of ships at sea. The same concept could also be exploited for accurate geodetic positioning of stationary control points. Subsequently in May 1960 the first US balloon satellite Echo I was launched. This satellite could be photographed against a background of stars using ballistic cameras. Photographs taken simultaneously at separate ground survey stations could be used to determine the relative positions of those stations even when separated by hundreds of miles.



C&GS BC-4 Programme

In August 1963 the US Coast and Geodetic Survey (C&GS) began a programme to fix the positions of geodetic survey stations covering the whole of North America; the geometric satellite triangulation. In this programme the Echo I satellite was photographed against a background of stars taken with a Ballistic Camera-4 (BC-4). The Echo II satellite was launched in 1964. This balloon satellite was a 30 metres diameter sphere coated with vapour-deposited aluminium inflated in orbit at 1,600 kilometres which acted as a giant reflector of sunlight and could be seen from the Earth with the naked eye. C&GS soon realized that with a higher balloon satellite it would be possible to conduct a Worldwide Geometric Triangulation Programme with stations



separated thousands of miles apart on different continents. Consequently in June 1966 NASA launched the Passive Geodetic Satellite (PAGEOS) into an orbit of approximately 4,000 kilometres altitude. Like terrestrial triangulation, satellite triangulation determines only the shape of the network of points and scale must be provided by a baseline. Fortunately C&GS had already embarked on a programme of high-precision traverses using laser-based distance measuring equipment. This Transcontinental Traverse provided the length of the base-line connecting Moses Lake, Washington and Beltsville, Maryland, the two BC-4 station in the USA. Additional projects were undertaken in different parts of the world to establish high-precision traverses to adjust the scale of the network.

The BC-4 Programme had become a worldwide programme with consequent increases in personnel, equipment and expenditure. The military potential was recognized and the US Department of Defense (DOD) authorized the Army Map Service (AMS) to participate.

British Involvement

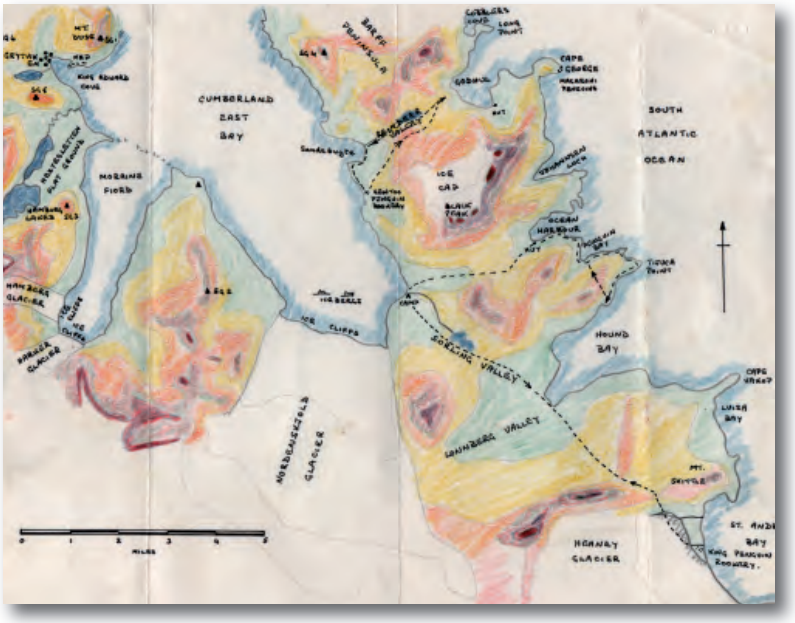
When the United States entered the Second World War in 1941 DOD held little Geographic Intelligence of the rest of the world. British Military Survey's extensive Map Library was made available to DOD and liaison was established to ensure that there was no duplication in wartime map and aeronautical chart production. After the war ended a joint programme was begun to provide worldwide cover of maps and aeronautical charts at 1:250,000 scale in the Joint Operation Graphics (JOG) Series. In 1958 a British Liaison Officer's post was established in Washington DC and AMS established a Liaison Officer's post in MOD Directorate of Military Survey (DMilSvy) in Feltham Middlesex to facilitate the sharing of Geographic Intelligence.

In March 1963 DMilSvy established a team led by Maj Prescott to take part in the AMS Sequential Collation of Range (SECOR) programme. A Specialist Geodetic Survey Team (SGST) was approved on 5 July 1966 to include the SECOR section and a BC-4 Section led by Maj Batterham which was formed in October 1966. The SGST was commanded by Lt Col Ayers, who also had the title Assistant Director Survey (ADSvy) Washington DC. The unit changed its name to 512 Specialist Team Royal Engineers (512 STRE) in 1967 and the 2 sections operated independently of each other in separate programmes. According to Maj Batterham the 2 sections met unexpectedly in June 1967 in Maui, Hawaii. In 1967 the BC-4 Section personnel changed as the tours were for 12 months unaccompanied. Maj Nott-Bower was OC in early 1968 when the Section was deployed to South Georgia a remote mountainous island in the South Atlantic.

The BC-4 Section on South Georgia

I was posted to 512 STRE in July 1968 and flew with WO2 Ron Birch RE to Washington DC. We were greeted by Lt Col Ayers at HQ AMS, which was adjacent to the British Embassy on Massachusetts Avenue. The rest of the Section had arrived several weeks earlier. They were SSgt Weston Robertson REME, Instruments Artificer, and Cpls Bob Flynn and Alex Chalmers, who were RE Field Survey Technicians II. After some necessary administration including US Army driving tests, we moved to Beltsville, Maryland for training on the BC-4 equipment. Two weeks later we were joined by LCpl Eddie Friis-Smith of the Army Catering Corps (ACC) who would be our cook on South Georgia. We were also joined by Mr Jack Fried a C&GS electronics engineer, who was accompanied by his wife, 3 years-old daughter JJ and 4 months old baby Lara. Jack was a burly, bearded civilian who had been working on the BC-4 programme for 4 years. He was responsible for maintenance





of the electronic equipment, for tracking time and communications with C&GS in Beltsville.

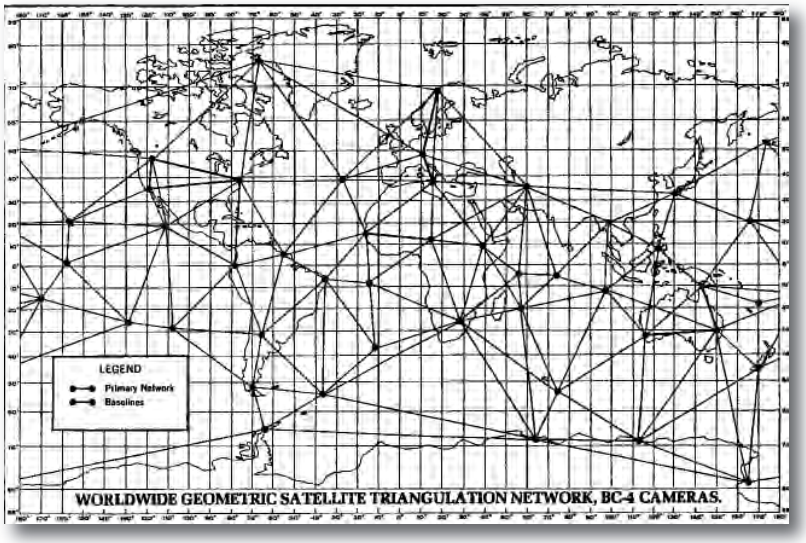
The Section then flew to Montevideo, Uruguay where we became passengers on a US Army supply ship *FS216* commanded by Skipper John King. He was 65 years old and looked like Burl Ives. He had a wife and family in USA, another in Okinawa, another in Manila, and mistresses around the Pacific Ocean. He lived in Montevideo with an 18 years-old bar girl. He took me to the lowest and ritziest bars in town and the only way that I could distinguish between them was by the size of the bills. The crew were all Philippine nationals and they had been in Montevideo for so long that Skipper King worried that the ship was stuck on the harbour mud. When we left harbour dozens of whores waved the crew off with tears in their eyes. As the *FS216* a ship of only 850 tons had no watertight bulkheads and we were heading out into the South Atlantic Ocean they probably thought that they were unlikely to see their regular clients again. After five days at sea we steamed into Port Stanley, Falkland Islands where I reported to the Governor Sir Cosmo Haskard to deliver the Diplomatic Bag which the British Embassy in Montevideo had entrusted to me. We bought supplies in the Falkland Island Company store and two days later we sailed for South Georgia many hundreds of miles away to the East and well South of the Antarctic Convergence. We steamed along the length of the spectacular North coast of this island which is mountainous and has large glaciers tumbling into deep fjords. On 22 August 1968 we entered Cumberland Bay East after dark in bright moonlight. It is an incredibly beautiful place.

The BC-4 section was operating on King Edward Point, where the Falkland Islands administration of the whaling industry was based. Across the cove was the deserted Norwegian whaling station of Grytviken, which had closed two years earlier when whaling had become no longer commercially viable. There were two Norwegian caretakers at Grytviken but the Falklands administration had been slower to withdraw. The Administrative Officer's house and the large hostel Shackleton House were built 4 years earlier for the administration of up to 2,000 whaling station employees only just before whaling ceased. It was planned that the entire administration would be withdrawn in November 1969 when the settlement would become the HQ of British Antarctic Survey (BAS).

The entire population of South Georgia, all 16 souls including the outgoing personnel of the BC-4 section, met us on the jetty. The mail, the first for 3 months, was quickly taken ashore, the post office opened and the letters sorted and distributed within half an hour. The next day was glorious, with bright sunshine, glittering snow and the most magnificent mountains and glaciers that I had seen outside the Alps. Mt Paget (altitude 9,625 ft) is across the Bay and the beautiful fluted ice cone of Mt Sugartop (7,623 ft) is temptingly close. We changed accommodation with the outgoing section personnel led by Maj Nott-Bower and established our operations in the Customs House, a cosy wooden bungalow, with the adjacent BC-4 camera in its dome and the instruments shelter, containing timing, communications and other electronic equipment. After two days handover and a farewell party the old section left and we settled into a routine. The next ship was expected in November. Until then our sole means of communication with the outside world was our radio links with Beltsville, Maryland and the Falkland Islands.

Two members of the section observed each night which meant that each person observed every other night. It took about two hours to set up the equipment and take a satellite pass and we normally had two predictions each night. The week's predictions of look angles, times, exposures and other information was passed to us by radio every Friday and we were concerned with photographing both PAGEOS and Echo II satellites. Echo II was the same size as PAGEOS but its orbit was smaller at about 1,600 kilometres above the earth. It was brighter, faster and moved in a different direction across the heavens. The camera had rotating shutters which were synchronized with time from the Time Code Generator (TCG), a precise crystal clock, with a precision of 1 millionth of a second. The satellite's photographic trail crossed the glass plate and was produced as a series of coded dots against

a backdrop of stars, hence the time of each exposure or dot could be determined to the nearest ten thousandth of a second, and its direction measured from its position relative to the stars. The satellites were photographed simultaneously from Punta Arenas in Chile, Villa Dolores in Argentina, Natal in Brazil, Johannesburg and Tristan da Cunha. Cloud cover and bad weather in the South Atlantic hampered operations. In December 1968 two more stations were established on the Antarctic continent at Palmer and Mawson Stations.



WORLDWIDE GEOMETRIC SATELLITE TRIANGULATION NETWORK, BC-4 CAMERAS.

During a pass one observer operated the console inside the shelter, while the other took meteorological readings outside, opened the dome and set up the camera for direction, f-stop, etcetera, and loaded the plate. The plate was exposed to the stars for 20 minutes before the satellite "on-plate" time. Then for 5 minutes "on-plate" and for 5 more minutes after the satellite pass to check the coded images in case there had been any slight movement of the camera. The shutters opened and closed as directed by punch-tape fed into the computer in the shelter and those orders were synchronized with the TCG. Everything that happened was monitored on an oscilloscope and recorded on brush tape that spilled out of the equipment by the yard. Brush tape had a carbon base and was about 4 inches wide. Twenty electric brushes burnt images on it as it passed out of the console and from these coded images we were able to calculate the time of each star and satellite image. As it burnt it smelled like scorched rubber.

Lights of different colours flashed on and off during the satellite pass and hooters sounded if the camera shutters gears fell out of synchronization. Inside the shelter only red lights were lit so that the operator could see the green spaghetti on the cathode ray screen of the oscilloscope. Cigarette smoke and the smell of scorching brush tape created an atmosphere of science fiction hell. During the pass the camera operator had to remain outside the shelter with binoculars to check that the satellite was following its predicted orbit. Sometimes the predictions could be up to 10 minutes early or late and the operators needed to react quickly to speed up or slow down the programme on the camera. We were unable to shine a light outside, because it would fog the images on the plate, so the outside man had to be very careful not to fall over a sleeping elephant seal in the dark. One night SSgt Robertson was gazing at PAGEOS through binoculars when my cat jumped onto the back of his neck. He nearly had a heart attack. After each pass the plate was removed from the camera and placed in an insulated bag. It was then removed to the darkroom in Shackleton House where it would warm slowly during the night to 67degrees Fahrenheit at which temperature it could be developed by one of the section who had been off duty during the night. The gears of the camera shutters had to be changed between PAGEOS and Echo II passes as different coded images were used for the two satellites. It was very interesting work and required operators to be very alert in the wee small hours.

The Administrative Officer of South Georgia was responsible to the Falkland Islands Government. He was Captain Coleman a retired merchant navy officer, about 55 years old and very short and bald. He had lived on the island for 8 years and was accompanied by his wife, a slim, energetic woman who spent the afternoons skiing or walking to keep fit. Captain Coleman was very cooperative and allowed me to make modifications to the accommodation provided I asked his permission first. The doctor was a 30 years old bachelor, who had spent 2 years on contract in the Falklands, followed by one year on South Georgia. He had only 16 people to look after and no infectious diseases, so he spent his time drinking coffee in the Customs House in the mornings and in the evenings playing Mah Jong and drinking whisky. He lived in one end of Shackleton House where there was a hospital. The Assistant Administrative Officer, Customs Officer and Postmaster was about 25 years old, very scruffy, and kept whisky hidden in various secret places so that he could keep permanently topped up. He had almost no work to do but every Tuesday he issued rations from the food store to the steward of Shackleton House. By Thursday he had recovered from the strain of Tuesday's efforts and could be seen typing telegrams for Captain Coleman for transmission to the Falklands by the radio operator. The radio shack was the domain of a small, young Glaswegian who communicated with Port

Stanley twice a day by Morse code telegrams.

Much of his time was spent tearing round the mountains on skis or on foot and sitting in the Customs House eating our biscuits and making derogatory remarks about anyone in authority. The entire settlement had an electricity supply from a power station with three diesel generators. An Irish mechanic kept the generators working assisted by a young Chilean. The Irishman was accompanied by his English wife and two dogs, which occasionally rolled in a seal wallow and became untouchable until washed. We rarely suffered a power failure in the year that we were on the island. The steward of Shackleton House and his wife are typical Falkland Islanders. He got drunk every Sunday with the older Norwegian caretaker of the whaling station and his wife baked leaden bread loaves and served mutton stew for almost every meal. They were nearly 60 years old, lived in a bungalow furthest from Shackleton House and in winter had difficulty skiing up the road. His speech was very slurred and completely incomprehensible to anyone except his wife. This disability was rumoured to have been caused by a fall on his face from a Landrover travelling at 30 mph in Port Stanley one Saturday night. However they did look after Shackleton House well and were both very friendly and well liked.

There were two Chilean stewards who were so incompetent that one had been reassigned as meteorological man and the other as assistant diesel mechanic. He spoke English and so helped communication between the Irish engineer and his Chilean deputy who had no common language. The policeman / handyman and his wife were Falkland Islanders. They had a baby daughter who was born on HMS Lynx, which was called into South Georgia to take her mother to Port Stanley. He was rumoured to have a policeman's uniform hidden away somewhere but even on South Georgia he had a reputation for being lazy, so he was lucky to have an assistant. Norman came from Solihull. He was 35 years old and tall with an impressive patriarchal beard. He always smoked a foul-smelling pipe and spent much of his spare time striding up the smaller mountains. He had a squeaky voice and was rather simple, but very hardworking, obliging and helpful. He often went mountaineering with me, when he would squeak continually: "If my mother could see me now".

One day several members of the section skied over to Cumberland West Bay and Norman met us at Echo Pass on our way back. This was a great achievement for him because he had very little control of his planks. We started down and he fell at the top and lost one of his skis that shot away into the other valley. No-one noticed so he had to flounder through deep snow for a half mile to recover it. Things like that happened to Norman. He would spend hours unblocking Jack Fried's drains which choked up every two weeks. He regarded South Georgia as paradise and his 3 years on the island were the happiest of his life. Sir Ernest Shackleton was his hero and he tended his grave in the Grytviken cemetery with great care. The younger caretaker at Grytviken Finn Samos was 31 years-old and had been on the island for 10 years. He and I were good friends and we went skiing and mountaineering together frequently. He took me across the East Bay in the whaling station launch to Sandebugte on the Barff Peninsula and we walked across to Godhul on the far coast.



The *FS216* returned with supplies on 26 November and Finn decided that he should return to Norway to enjoy a more rewarding life. Skipper King was anxious to get back to Montevideo because he had a new speedboat on deck, no doubt he would be tearing about off the beach with bikini clad girls water skiing behind. He said that he was having trouble with pregnant women. His crew had been in port for far too long. The developed photographic plates and timing records were entrusted to the skipper for onward posting to Beltsville via US Diplomatic Service. I had the end of month accounts and reports to complete and the Falkland Islands Company bills to sort out. This company was the most confusing and muddled organization that it had ever been my misfortune to deal with. When I complained that their tonic water had no fizz, they replied that I had not ordered fizzy drinks. The ship left after two days taking Finn with it, which ruined my chances of climbing Mt Paget and Mt Sugartop.

HMS Endurance was due to visit South Georgia on 12 December but just 2 hours from us she was diverted to the Antarctic Peninsula to rescue the crew of BAS Otter aircraft that had force landed on Grahamland. HMS Endurance was the British Ice Protection ship commissioned in 1967 and the only British ship in the South Atlantic



to carry a helicopter. In 1967 the Perla Dan a commercial ship designed to operate in frozen seas, was under contract to BAS and was taking a crated aircraft to the base on Deception Island. That year this active volcano erupted and the base was evacuated. The aircraft was left at South Georgia instead. In 1968 *HMS Endurance* was due to collect the aircraft from King Edward point and deliver it to the reoccupied base on Deception Island. She arrived on 5 January 1969 and stayed for just 16 hours owing to a tight schedule. The Captain invited me for supper and a film show on board. In mid-January the Perla Dan visited for two days on her way South to the BAS base at Halley Bay. They slaughtered 50 elephant seals on the point to feed the huskies on the base for the next 12 months. Blood and guts covered the shore and the skuas and petrels gorged themselves until they could hardly fly. After Finn left the island Thorsen took his launch out of the water and was not at all keen to take us across the Bay. After SSgt Robertson and I worked on the boat engine and repairs we persuaded him to take us to the Sorling Valley where we camped and made long expeditions to Tijuka Point and to the king penguin rookery in St Andrews Bay.

We had no satellite work for most of December and January when many of the Atlantic stations moved and the stations on the Antarctic mainland were set up. During this hiatus we filled in the time on field surveys to tie the RN Hydrographic stations to the BC-4 satellite station on King Edward Point. The summer weather was pretty awful; rather like winter in Western Scotland, it snowed often but usually melted soon after settling. In mid-February the Perla Dan called in on the way back from Halley Bay. I was still having problems with the Falkland Islands Company bills, so with Lt Col Ayers permission I hitched a lift in the ship back to Port Stanley. I stayed with the Colonial Treasurer there and made contact with the RN Hovercraft Team and with the Royal Marines platoon. I had made friends with some of the BAS personnel returning from Halley Bay and with one of them I rehung the bells in the parish church. The RN team took us to Kidney Island for a few days stay to watch the colonies of sea lions and rock hopper penguins. The *FS216* was due to arrive in Port Stanley for her last journey South on 1 March but her departure from Montevideo was delayed for two weeks because the Uruguay customs would not release the Doppler Time Transfer equipment any earlier. This was an atomic clock of great accuracy, which was carried by a C&GS electronics technician between the BC-4 stations to calibrate their TCGs. The ship arrived in Port Stanley on 9 March and sailed for South Georgia the following day. Despite the barnacles on her hull the *FS216* arrived at King Edward Point at 2030 hours on 12 March. I had enjoyed a wonderful holiday but I was glad to get back.

The BAS ship *RRS John Biscoe* called into South Georgia on 9 April and she was the last scheduled visitor to the island until we were due to leave in mid-July. We resumed our satellite observations but SSgt Robertson reported sick on 24 March with stomach pains, which were diagnosed by the doctor as a partial strangulation of the small intestine. This was quite serious as there was a danger of a complete blockage which would require emergency surgery. Two days later he was much worse, when a Russian trawler "Ostrovski" appeared unexpectedly, which carried a doctor, who examined Robertson and made an emergency call to the Russian fisheries research ship "Academic Knipovitch" which had a surgeon on board. She was Dr Pavlova, who was sent ashore by boat and stayed for 4 days. She decided that she could not operate until there was a complete obstruction of the bowel, because surgery under such primitive conditions would carry a high risk of infection. The "Knipovitch" returned on 30 March, recovered its surgeon and sailed away. On 1 April Robertson's condition worsened, with violent distensions of the intestine and swelling of the belly. He thought that he was dying and I began to think so too. What really worried me was the fact that the doctor gave up drinking. On 2 April I sent a signal to the Governor of the Falklands requesting his immediate evacuation.

The BAS ship *RRS Shackleton*, was carrying out a magnetometer survey in the Drake Passage, and was sent to South Georgia arriving on 6 April. Captain Frosty Turnbull brought her in through the most pitch black night that I had ever seen on the island. Robertson was taken aboard the next morning and she sailed for Port Stanley. The ship encountered calm sea and reached the port 24 hours ahead of schedule enabling a connection with *RMS Darwin* sailing for the Chilean port of

Punta Arenas in the Magellan Straits. Robertson was accompanied by Dr Holmes of BAS and then was flown to Santiago, where he spent 4 days in hospital before catching a flight to London on 18 April. He was met at LHR Airport by paramedics with an ambulance from Millbank Hospital who were surprized when he walked through the arrivals lounge without assistance. He made a miraculous recovery without surgery.

The next 3 months passed without further incident. South Georgia is a beautiful island when the sun shines but the weather is generally wet, cold and windy. The soldiers required resilience and ingenuity to avoid boredom. We took every opportunity to take exercise outdoors by walking, exploring the mountains, fishing, skiing in winter, bird and seal watching and photography. We read books, wrote letters, developed and printed photographs, socialized in the evenings, playing Mah Jong and entertaining the locals. We gave LCpl Friis-Smith one day off each week and took turns cooking.

The *FS216* was withdrawn in May, therefor AMS had to charter a ship to bring replacement personnel in July. Maj Underwood and his team flew to Punta Arenas and sailed to South Georgia in the chartered Falkland Islands Company ship *AES*; I thought that all ships had proper names until then. After a short handover we departed leaving Jack Fried and LCpl Friis-Smith behind. The latter had volunteer to stay with the new team, until it left the island. We arrived in Port Stanley 5 days later and then spent 3 weeks there waiting for passage in the *MS Darwin* to Montevideo. During this wait we stayed with the RN Hovercraft detachment and we enjoyed an exhilarating hovercraft journey round the North coast of the islands. The Governor and his wife also travelled back on the Darwin so we had interesting meals at the Captain's table. From Montevideo we flew to Washington DC and after debriefing by the CO we flew to New York, where we stayed for 2 days before catching an RAF VC10 to Brize Norton in late August 1969.

The Apollo 11 moon mission was launched from Cape Canaveral a few days after we left South Georgia and it landed on the moon on 20 July 1969. The crew of Armstrong, Collins and Aldrin travelled back to Earth, and then spent 3 weeks in isolation/decontamination. They still got home before we did!

Later Developments

The BC-4 programme was wound up in 1972 and the data produced was included in the US DOD World Geodetic System of 1972 (WGS 72). Doppler satellite tracking techniques provided faster results because they could be used in cloudy conditions. They could also use navigation satellites thus eliminating major costs. As equipment was developed using solid-state electronics it became more portable and less fragile. In 1984 the first GPS satellites were launched and surveyors rapidly moved into this new technology which produced horizontal and vertical position in WGS 84. During the first six years of the 1990's I was the Deputy Director of Ordnance Survey of Northern Ireland in Belfast and in 1995 we entered into a joint programme with Ordnance Survey of Ireland in Dublin to carry out a new geodetic survey of all of the island of Ireland using GPS dual frequency receivers at 11 stations. This campaign took 3 weeks of field observations and the data was passed to the University of Nottingham for computation. In early 1996 the IRENET Zero-Order network was accepted into the European Geodetic Network.

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From left to right:
Major Bill Codd - (Mil Svy)
LCpl Eddie Frii-Smith - (ACC)
Cpl Bob Flyn - (Mil Svy)
Mr Jack Freid - (USA Coast & Geodetic)
WO2 Ron Birch - (Mil Svy)
Cpl Alex Chalmers - (Mil Svy)

The DSA Seminar 2 July 2016

The DSA 2016 seminar took place slightly later in the year on Saturday 2nd July and once again the facilities of Hermitage Station were made available. The programme was wide ranging and the attendance excellent. Of great encouragement was the presence of Nigel Clifford the Chief Executive of the Ordnance Survey and his wife Jeanette and the audience of 80 plus at who attended. The Medmenham Association and the Royal Institute of Navigation were well represented.



Mike Nolan - Organiser

As with all the best laid plans something happened. Stuart Wheeler, The Tank Museum, Bovington, found that he was required to attend the commemorations of the Battle of the Somme. In true style the cavalry arrived (or should it be the tanks arrived). Gareth Davis stepped into the breach and gave a very interesting talk on the evolution of the tank during the First World War and its employment on the battlefield. He looked at why the tank was introduced, how tactics evolved and why the ground on which they operated could have a major impact on their success or otherwise. Gareth has retired and now is an historian and leader of battlefield tours. James Prain our last presenter on the day was with Gareth in HQ UNPROFOR in Zagreb in the 1990s.

Jeff Jefford, Editor, Journal of the RAF Historical Society continued with the 1914 -1918 theme but this time from the air. He emphasised the role of the RFC and the RAF as being support to the Army and the balance between the observer aircraft and fighter aircraft with the role of the fighter to protect the observer aircraft. Biggles and Captain Johns have a lot to answer for in terms of the portraying the crucial work of the observers but then perhaps aerial photography and artillery observation is not as exciting as chasing the Red Baron. Jeff explained how Corps reconnaissance on the Western Front was essentially a short range tactical business, aircraft rarely venturing more than 50 miles from home. He considered the evolution of the tools of the trade - wireless, photography, the artillery code, the clock code, trench maps, etc. and how they were all put together to conduct 'an artillery shoot'. At the end of the presentation there was a feeling that "here is a topic that has more to come" and another presentation in the future will be very well received.



Allan Williams from The National Collection of Air Photography/The Air Reconnaissance Archive, Edinburgh travelled south and he entered the unknown of Hermitage and the DSA and presented to the audience much that was totally unknown to the majority of the audience.

The presentation explained the windy road that was taken to the establishment of the National Collection of Aerial Photography (NCAP). As with all events the desire to "go home" and the lack of interest in the material gleaned and used often leads to it destruction. Fortunately much of the WW 2 photography (Allies and German) has survived and enables historians and others such as town planners to see what went before. One of the post WW2 uses was to identify locations of unexploded bombs. The taking of reconnaissance photography was a major mission and as part of his presentation Alan gave an overview of the aerial photography created during Operation Crossbow, the hunt for Hitler's vengeance weapons, and the associated photographic interpretation effort. It was a fascinating story of the photography and the volume of material that has survived and is now held in NCAP.

Chris Brading, late The Directorate of Military Survey and Falkland Islands Dependencies Survey (FIDS) is known to many in the DSA. He told the story of his work and the work of the survey team



in the Antarctic in the early days of the Tellurometer. For those who have used tellurometers, logistics have always been a problem and in particular the carriage of batteries, charging generators and fuel. Add to this the fairly hostile Antarctic environment and the problems that had to be overcome present a very interesting challenge.

The use of the first tellurometers in the Antarctic in 1958 by FIDS was about learning how to use them in the Falkland Islands, measuring base lines to control the DOS mapping, through to measuring across the Bransfield Strait from the South Shetland Islands to the Antarctic Peninsula. In the work included the overall triangulation of the northern peninsula. Chris highlighted his talk with personal photographs (good old 35 mm roll film). How young the team looked.

This look back to an era where the surveyor had to go out on the ground and not use imagery or satellites to fix position is very much in the past in relation to the massive strides taken over the last 50 years in the science of surveying and mapping. What Chris did is the reason many in the DSA became surveyors – to go out into the world and have adventures. This was a fantastic adventure.

John Tulloch is a man who talked from personal experience. He was with the ANZACs in Vietnam. The mapping was not good and movement through jungle and swamps was not easy. Maps were produced including pictomaps. However it is always better to be safe than sorry. The lack of reliability and vagaries of some mapping of the jungles of Vietnam prompted innovative ways of mapping, survey and navigation within the jungles patrolled by the ANZACs. John explained how the application of Indirect Fire to support and create Mapping, provide temporary Survey and assisting Navigation in the Jungle was applied. Using field artillery and the application of sound and bearing as a survey tool, basic operational maps of the jungle were created called 'Road Maps' and became a vital tool. Temporary future artillery locations were surveyed using artillery. This was back to basics soldiering and perhaps in this era of technology back to basics may need to be exercised more frequently.



James Prain is the MOD sponsor for the AGIS project (Advanced Geospatial Infirmation and Intelligence Services) which has been running for four years and has been delivered by the GeoCore consortium led by Envitia in partnership with Helyx, QinetiQ and University of Nottingham. James highlighted the ten research topics that have been covered by this project. He explained why the research was being undertaken: to understand what is relevant and possible, to help identify future requirements and to help de-risk new capabilities.

His conclusions were that AGIS has been very successful in terms of: outputs and potential benefits, close stakeholder engagement, and the outputs will help establish the GEOINT Enterprise. He concluded that it is now up to the operational staff and acquisition staff to exploit this research.

This was an intriguing look at what the future may hold.

In the middle of the day all repaired to the Officers Mss for a superb regimental curry. Perhaps lunch was a little hurried and more time may be needed in future to allow people to meet and mix. The 2017 event will be held at the Arlington Centre, Donnington on Saturday the 27th June.



|*The 2016 Annual Dinner.*

The subject matter at these seminars is also wide in nature. The aim is to look back with affection to what our forebears did, to keep up to date with what is going on now and also to look to the future. Much of the content is historical simply because so many come forward to speak on historical subjects but we are always on the lookout for speakers on current techniques. We will continue to mark the anniversary of 1914-1918 for the next three seminars and we continue to welcome speakers on Military History as well as on "Geoint".

DSA AGM and Annual Dinner 2016

By Rapporteur

Prizes, Medals, a Lecture and a Dinner

The DSA AGM and Annual dinner was held at Denison Barracks, Hermitage on the 1st September 2016. The AGM passed the accounts, elected the Council and completed the statutory requirements. For the past 3 years the AGM has preceded a lecture and dinner and this year followed a similar pattern.

The lecture and dinner was a very well attended event enjoyed by all. However the occasion is more than just a lecture. The evening began at 1700 in the Officers' Mess with tea. The lecture, held in the RSMS Lecture Theatre, was this year presented by Captain David Robertson RN, but before this the DSA presented the annual prizes and introduced the Charles Close medals.

Prizes

The DSA presents annual prizes and the purpose of the award of prizes is to recognise the most significant contributions within this community by both members of the Armed Forces and civilians through the award of the Annual Prizes. The DSA prizes are open to all military personnel, civil servants and civilians including those from the academic world who, in the opinion of the relevant Head of Profession and the DSA Council have made a significant contribution to the Defence geospatial arena. This year there were 3 winners.

Tom Richardson

Tom is the Defence Standards Manager at the United Kingdom Hydrographic Office (UKHO), working in the Defence Maritime Geospatial Intelligence Centre (DMGIC) was awarded a prize for his involvement in hydrographic standardization activities within the IHO community and his collaboration efforts over the last year.Moving to the standards branch in 2010 he quickly developed an appreciation of IHO and other standards. Specifically he became the UK representative on the IHO standards working group. In his current role as Defence Standards Manager Tom has closely collaborated with NATO and the Defence Geospatial Information working group on the maintenance and development of geospatial standards to support military users. Tom's enthusiasm and dedication to improving Hydrographic Standards has been second to none. Through his extensive involvement in standardization activity within the IHO community Tom has gained a broad understanding of hydrography within the digital age. Unfortunately Tom was not able to attend the prize giving.



Cpl Jack Whelan and Roy Wood.

Lance Corporal Jack Whelan

Jack was assigned to provide geographic support to Headquarters British Forces South Atlantic Islands (HQ BFSAI) over the period Dec 16 – Apr 16. His work has been commended for re-defining the level of geographic support available to the HQ. Through superb initiative and selfless commitment, he has provided enduring benefit to BFSAI through a complete refresh of the geographic products available, thus significantly enhancing situational understanding. LCpl Whelan has demonstrated an exceptional commitment to his role as a geographic technician and an outstanding level of professionalism and dedication well beyond his rank.



Lt Marc Taylor and Roy Wood.

Lieutenant Marc Taylor RN

Marc assumed command of *HMS Gleaner*, the RN's smallest warship in mid Nov 2016. His primary task has been in support of what will be the RN's largest warship: *HMS Queen Elizabeth (QNLZ)*. This has involved acquiring, assimilating and manipulating the Geospatial data necessary to allow the effective planning and execution of her safe exit from Rosyth. Key geospatial data acquisition and analysis has been focussed around bathymetry, tides, bridge heights, tidal streams and positions of conspicuous shore objects for navigating out of the Rosyth Channel and in the Firth of Forth. In managing the geospatial data, Marc has worked tirelessly to ensure the data is of the highest quality and accuracy, knowing that even the smallest errors could prevent this huge warship from sailing as planned.

Ramus

The "Ramus Award" is presented by the DSA to members who have given outstanding service to the DSA. It is not an annual award. The Council took the decision to standardise the award with the recipients receiving an engraved crystal bowl.



Two members were selected for the award:

Colonel Mike Nolan who for 10 years, has organised seminars and other events and also served on the Council. Unfortunately he was not present as he was away on holiday.



Tony Keeley with a Ramus Bowl.

The second was **Major Anthony Keeley** who has been on the Council for 12 years and secretary for 10 years. He has also been the organiser of much of the administrative support to events.

Much of the DSA's recent success and in particular the events programme is due to the efforts and dedication of Colonel Mike and Major Anthony and the public recognition of their contribution to the DSA is very well deserved.

Charles Close Medals

Earlier in the year it came to our attention that the Charles Close medals were coming up for auction. Who was Charles Close? Well Sir Charles Arden Close was a Royal Engineer and between 1911 and 1922 the Director General of the Ordnance Survey. He received national and international recognition for his services to surveying and mapping and he played a significant role in the production of mapping during The Great War. A more detailed description of his career is included in this edition of Ranger.

The Ordnance Survey and the Charles Close Society had no particular interest in acquiring the medals. The DSA is not a medal collecting organization but has a remit to support "heritage". The Chartered Surveyors Sapper Club (CSSC) through Sir Idris Pearce their chairman set the ball rolling with a sum of money promised towards the purchase of the medals. The CSSC is a major donor to the Royal Engineer Museum. The DSA too put forward a donation. Many members of the DSA individually made generous donations. These individual sums together made up a very large part of the overall money available for the purchase. The Friends of the Royal Engineer Museum also agreed to support the initiative. At the auction the DSA was well positioned to make a competitive bid.

The medals were secured at auction and it has been agreed that they will be presented to the Royal Engineers Museum. The medals came in a number of packets and a box; all loose. To ensure that they do not simply disappear into storage and can be seen by as many as possible they have been professionally mounted to exacting museum standards.



Charles Close: The medals, portrait and detail (framed).

There are a very limited number of pictures or photographs of Charles Close available and the best were taken when he had long retired, held In the National Portrait Gallery, in civilian clothes. There is also a photograph in service dress when he was a young colonel but without his medals. This and a copy of his portrait from the dust cover of a book in the London Library were used to produce portraits.

All parties believe that in relation to Charles Close and Military Survey they should be seen by as many in the survey geographic world as possible and they will be displayed in a Geographic unit as part of the Geographic Heritage. To this end the current plan is to install and display them at the RSMS.



The Medals with on the right Sir Idris Pearce, Maj Gen Roy Wood and Rebecca Nash.

The framed medals were revealed to the audience and it was a great pleasure for the DSA that Rebecca Nash the acting Director of the RE Museum was present at the introduction of the medals.

The Lecture

The main event in the lecture theatre was a presentation on the voyage of *HMS Protector* to the Ross Sea earlier in 2016.

Captain David Robertson RN who is The Hydrographer of the Navy and Captain HM very kindly agreed to personally lead the presentation. He was assisted by Lieutenant Kate Retallick RN who literally flew in from a deployment to Chile for the lecture. She has served for 2 years in *HMS Protector* as Survey Manager and alternate Operations Officer for the Ship's deployment to the Ross Sea and circumnavigation of Antarctica.

In this edition of Ranger there is an article on the voyage of *HMS Protector* and rather than report on the lecture encouragement is given to read the article.





Captain Robertson and HMS Protector on the screen.

All agreed that it was a very informative, interesting and enjoyable presentation and Captain Robertson, who went the extra (nautical) mile to ensure that it happened, has our grateful thanks.

The Dinner

Post the lecture a reception was held in the Officers' Mess and then 65 people sat down to dinner. The tables were decked with Regimental Silver and the Mess Staff produced an excellent menu and wines. The DSA had as guests a number of supporters from industry and local dignitaries as well as key players in the Charles Closes medal acquisition. Lieutenant Colonel Kingston, The Station Commander, was present and it is hoped that in future others from 77 Brigade will attend our events. The dinner does give the DSA the opportunity to thank those from outside the organization who support us and we hope that this may continue into the future.



Lt Retallick and Captain Robertson.



The Loyal Toast, port, cheese and coffee ended the dinner.

Overall the evening was a great success. By looking outwards the DSA engages with the local community, other organizations and supporters. This is to our mutual benefit and the DSA looks forward to widening and deepening these links.



In Service Dress, National Portrait Gallery.

Colonel Sir Charles Arden-Close KBE, CB, CMG, Sc.D, FRS.

Charles Frederick Close was born in St. Saviour's, Jersey, on 10 August 1865, the son of Major-General Frederick Close, of Shanklin. He was educated at a dame-school in Rochester, then Thompson's School, Jersey, followed by a crammer, after which he went to the Royal Military Academy in 1882. In 1884 he passed out first, with the Pollock Gold Medal, and was commissioned into the Royal Engineers and joined the School of Military Engineering (S.M.E.) in Chatham.

After a year in Gibraltar, 1886, he was first attached and later commanded the Balloon Section in Chatham, 1887-88. This was followed by survey work in Burma. In 1895 he was posted to West Africa, to survey the boundary between the Niger Coast Protectorate and German Cameroons.

He was appointed to the Ordnance Survey in 1898 and oversaw the survey of the boundary between British Central Africa and Northern Rhodesia with German East Africa. For his services he was awarded the C.M.G. In 1900 he led a small survey detachment to South Africa and saw action at the Vet River and Zand River.



With his medals - a recent painting, - Tim Johnson.

During 1902-05 he was chief instructor in surveying at the S.M.E. at Chatham. In 1905 he was appointed head of the topographical (geographical from 1907) section of the general staff at the War Office. Due to his experience in South Africa where few worthwhile maps existed, Close and his directors in MI4 took the precaution of preparing maps for probable European theatres of war. As a result of this foresight, the British Army entered the Great War better prepared with maps than in any previous confict. Close was appointed Director-General of the Ordnance Survey in 1911 and retired in 1922. For his services as Director-General at this critical time, he was created a C.B. in 1916 and K.B.E. in 1918.

He served on the Council of the Royal Geographical Society, 1904-40; was Victoria Gold medallist, 1927, and President of the Society, 1927-30. He was Chairman of the National Committee for Geography; General Secretary of the International Geographical Union, serving as President, 1934-38. As a member of the Palestine Exploration Fund, he was first Treasurer, 1919-30, then Chairman, 1930-45. Close was elected a Fellow of the Royal Society in 1919 and received an honorary degree Sc.D. from Cambridge in 1928. He was also an honorary member of the Belgian, Dutch, German, Russian, Spanish and Swiss geographical societies. In addition to his British awards, he was awarded the Belgian Order of Leopold and the Afghan Order of Astaur. In 1938 he changed his name by deed poll in order to comply with the terms of a bequest. He was President of the Royal Geographical Society, 1947. He died in Winchester on 19 December 1952.



At OS.

His publications include: Text Book of Topographical and Geographical Surveying, 1905; The Early Years of the Ordnance Survey, 1926; The Map of England, 1932; Geographical By-Ways, 1947.

His contribution to cartography and the history of the Ordnance Survey was recognised in 1980, with the formation of the The Charles Close Society - for the study of Ordnance Survey Maps.



Major General John Kelsey, Director of Military Survey.

Major General John Kelsey, died aged 95, was Director of Military Survey from 1972 to 1977.

In 1940, having taken Part I of his degree, he was called up for training in Military Survey at Fort Widley, Portsmouth, and was commissioned into the Royal Engineers. His unit was posted to Algeria and Tunisia with the First Army in 1942. He commanded No 1 Topographic Section 518th (Corps Field Survey) Company RE that consisted of some twenty surveyors plus about ten logistical staff, such as cooks, drivers, etc.

The following year, he took his men south towards Tebessa, Algeria, where he provided survey support to an American artillery unit which had lost their surveyors in battle at the Kassarine Pass. Throughout the rest of his career, Kelsey played an active part in the advances that were occurring in the sciences of surveying, cartography and photogrammetry with the inventions of electronic distance measurement, digitisation of mapping and the transformation of geodesy by satellites.

He was a member of the International Association of Geodesy from 1966 to 1975 and secretary and, later, president of the Western European Commission on Satellite Geodesy. He was also a member of the National Committees for Geodesy and Geophysics, Photogrammetry and Satellite Geodesy of the Royal Society and was active in the Royal Institution of Chartered Surveyors and the Photogrammetric Society. Immediately post-war, Kelsey played rugby for Richmond and for the county XVs of Kent, Dorset and Wiltshire. He was secretary of the Army and Combined Services Rugby Clubs from 1962 to 1967 and was one of the Army representatives on the committee of the Rugby Football Union from 1966 to 1967. In 1968 he was appointed CBE for his services to Army and Combined Services Rugby.

From 1978 to 1987, he served as a non-executive director of Wild Heerbrugg, a Swiss company making surveying instruments, and later with Ernst Leitz Wetzlar of West Germany.

John Kelsey married, in 1944, Phyllis Smith.

Major General John Kelsey, born November 1 1920, died June 10 2016

Source: Daily Telegraph 13 July 2016



Eric Barton, Director of Military Survey.

Major General Eric Barton, who has died aged 87, was appointed Director of Military Survey in 1980 shortly before the outbreak of the Falklands War.

When the conflict started in 1982, Military Survey received a deluge of requests from the Task Force. The Army needed the equivalent of an Ordnance Survey (OS) map to navigate, plan and conduct operations. The RAF required large-scale air charts for operations, and moving map display film-strips for their Harriers.

Not the least of the problems was the difficulty of reconciling the map projections between two grid zones and the sheer logistical task of producing several hundred thousand map sheets at the shortest of notice. Photogrammetry (the science of using photography for mapping) and the full exploitation of digital imagery and geodetic positioning for terrain analysis, visualisation, target identification and precise positioning were in their infancy. Eric Walter Barton was born on April 27 1928 and was educated at St Clement Danes School, London, before taking a degree in Engineering at the Royal Military College of Science.

Commissioned in 1948 into the Royal Engineers, his first three postings were to Libya, Egypt and the Arab Legion in Jordan. Having qualified in surveying, he was posted to the Directorate of Overseas Surveys in Kenya.

Back in Britain, he instructed at the School of Military Survey. Teaching air survey involves drawing geometric figures on the blackboard precisely so that circles intersect where they should and tangents touch at the right point. Barton's pupils were struck by his ability to produce perfect diagrams, until forensic work on their part revealed the fact that the figures were drawn first in pencil invisible to the class and then traced over in chalk.

After qualifying in photogrammetry he was posted to the Joint Air Reconnaissance & Intelligence Centre, where his outstanding work was recognised by his appointment as MBE.

Command of 13 Field Survey Squadron in Aden came next. A spell at HQ Allied Forces Central Europe was followed, in 1977, by a move to OS as Director Surveys and Production.

Barton was Colonel Commandant Corps of Royal Engineers from 1982 to 1987 and served on the governing bodies of the Royal Geographical Society, the British Schools Exploring Society, the Photogrammetric Society, and as chairman of what is now the Defence Surveyors' Association.

He enjoyed sailing, water polo and competitive swimming among many other activities, and joined the Caravan Club as director of club sites for nine years.

Eric Barton is survived by his third wife, Pamela Frimann, whom he married in 1984 and who devotedly cared for him through the past decade; two sons by his second wife, and Pamela's daughter by her previous marriage.

Major General Eric Barton, born April 27 1928, died March 11 2016

Source: Obituary Telegraph 16 April 2016

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Story: Early Days of Satellite Geodesy.



