90

AIR SUR SQN FOR FILE

OP OPAL WARRIOR '88

Moomba
Tirrawarra
Daralingie
Bookabourdie
Innamincka

Toolachee
Dullingari
Gidgealpa
Strzelecki
Packsaddle

PROJECT REPORT

4th FIELD SURVEY SQUADRON

ROYAL AUSTRALIAN SURVEY CORPS

90

4 FIELD SURVEY SQUADRON

PROJECT REPORT

OPERATION OPAL WARRIOR 88

18 APRIL 88 TO 18 MAY 88

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PROJECT REPORT
OPERATION OPAL WARRIOR 88
AUGUST 1988

Reference: A. DGOP-A Tasking Directive 1/87 A86-575 dated 12 May 1987

B. Land Comd OPORD No 4/88 dated 26 Mar 88

C. Map NTMS Sheet SH54-2 STRZELECKI ED 1 1:250 000

D. Map NTMS Sheet SG54-14 INNAMINCKA ED 1 1:250 000

E. DSVY-A Technical Directive A474-5-65 dated 11 Apr 88

INTRODUCTION

1. OP OPAL WARRIOR 88 was mounted by 4 Fd Svy Sqn in the COOPER BASIN region of South Australia (SA) during the period 18 Apr to 18 May 88. The op utilised two recently acquired svy instruments, those of the Global Positioning System (GPS) and Inertial Positioning System (IPS) to achieve the aims of the task assigned at Ref A.

2. The authority for conduct of the op, as subordinate to Land Comd, is given at Ref B.

AIM

3. The aim of OP OPAL WARRIOR 88 was to acquire 1:50 000 scale mapping control and photo identify selected control points within the Area of Operations (AO). Refs C and D delineate the AO whilst a schematic of the region is shown at Annex A.

OPERATIONS

4. The op was conducted as fol:

a. GPS Phase. This phase was conducted during the period 21 Apr to 12 May 88 using 4 on-line TI 4100 GPS Receivers and 1 spare to obtain horz and vert control over the AO. Refer to Annexes B and C for the control and GPS technical reports.

b. IPS Phase. This phase was conducted during the period 6 May to 17 May 88 using the Ferranti Inertial Land Survey - III IPS to obtain horz and vert control throughout the AO. Refer to Annexes B and D for the control and IPS technical reports.

c. Point Marking/Panelling. All horz points estab in the AO, along with selected existing ident points were progressively marked and panelled during the complete period of the GPS phase.

d. Photo Identification. Ident photography of req points was flown during the period 2 May to 12 May 88 using the WILD RC10 Camera. Refer to Annex E for the Photo Ident Report.

Objectives Achieved

5. The following objectives were achieved IAW the direction given at Ref E:

a. 34 horz control points were observed using GPS relative positioning techniques.

b. 26 horz control points were estab using GPS.

c. 13 horz control points were observed and estab using IPS.

d. 107 vert control points were observed using IPS and marked on enlarged photography.

e. 2 Third order level connections were made to existing BM's.

f. 1 GPS connection was made to an existing BM.

g. 52 new and existing horz control points were panelled and absolute imagery obtained. Two of these points were existing BM's.

Operational Support

6. Rotary Wing. RW spt was provided from AAAvn resources. Acft were utilised for the following tasks:

a. Positioning of GPS fd parties.

b. Positioning of drummed fuel for IPS traverses.

c. Marking and panelling party movt.

d. Carriage of IPS for conduct of the IPS traverses.

e. Stores movt for transfer of fd parties.

7. AAAvn LOH spt was supplied as follows:

a. 162 Recce Sqn during the period 20 Apr to 4 May 88. A total of 79.9 task hours were flown.

b. 171 Comd and Liaison Sqn during the period 4 May to 18 May 88. A total of 78.3 task hours were flown.

Annex F provides a graph of acft usage rates over the periods listed above.

8. LOH spt throughout the op was based at and from MOOMBA.

9. Fixed Wing. FW spt was provided by AAAvn, with 173 Gen Spt Sqn flying 28.1 task hours on aerial photography. The acft used was that of a Pilatus Porter fitted with an RC10 Camera. The period of spt was 2 May to 12 May 88. Refer to Annex F.

10. Personnel. Pers spt was provided through Land Comd and HQ 4MD resources. Att pers worked well throughout the op and contributed to the successful completion of all tasks. A nominal roll is at Annex G.

11. Vehicles. Vehs were provided from unit resources and Log Comd through 41 Sup Bn. Tasking included the following:

a. Movt to and from the AO.

b. Positioning of GPS fd parties.

c. Marking and panelling of points.

d. Resupply tasks.

e. General tpt tasks.

12. The vehs in general performed well. On leaving Adelaide for the AO one GS Landrover suffered engine failure and was replaced by unit resources. Other malfunctions were as follows:

a. Landrover clutch failure, and

b. snapped engine mount on a landrover.

These repairs were effected in the AO by the att Veh Mech fom Adel Wksp Coy. All vehs have since been returned to 41 Sup Bn.

13. One UNIMOG was used on the op for tpt of major stores and positioning/retrieval of drummed AVTUR.

14. Total distance covered by all vehs on the op was 28 021 kilometers. Average fuel consumption for Landrovers was 4.45 km/l, and the UNIMOG 3.10 km/l.

ADMINISTRATION AND LOGISTICS

15. Visitors. Visitors to the op were as follows:

a. LTCOL H.E. Hansen, SO1 SVY Land Comd.

b. MAJ P.H. Cates, OC 4 Fd Svy Sqn.

c. WO1 W.P. Griggs, SSM 4 Fd Svy Sqn.

d. CAPT P.A. Jensen, SO3 SVY DSVY-A.

e. COL A.W. Laing, DSVY.

16. Medical. Few medical problems occurred during the op. No medical assistance was taken to the AO as pers were at all times within contact of the Royal Flying Doctor Service (RFDS) network and paramedic facy located at MOOMBA. One minor case of tooth abciss was treated by referral to the paramedic facy.

17. One elm of discomfort experienced by all pers on the op was that of the abundance of mosquitos and sandflies. It is recommended that an 'extremely effective' repellant be taken on future ops in arid areas.

18. Pay and Allowances. All op pers were paid prior to the conduct of the op. Allowances paid consisted of TA and incidentals for the mov into and out of the AO. Annex H to this report provides details of the expenditure incurred on the op. An overspend on T and S allocated resulted from unforseen accn and movt requirements for AAAvn LOH tradesmen. Refer to Annex B.

19. Petty Cash. A Petty Cash advance of $300-00 was issued from RFO Adelaide. $26-05 was expended from this advance on minor items purchased in the AO.

20. Accommodation. The main base fot the op was estab in loc MOOMBA, with main base pers residing in accn provided by South Australia Northern Territory Oil Search (SANTOS) Limited. Accn costs are as shown at Annex H.

21. The facy at MOOMBA was selected as main base due to its proximity to the main aerodrome and the availability of a viable infrastructure ie. fuel, med spt, comms and rations to spt the op elms in the fd.

22. The main base GPS and IPS computing facy's were erected in the 30 room accn block provided by SANTOS, whilst the integral shower facy was converted into a dark room for production of photo idents.

23. The accn provided had airconditioners within each room, and these were sufficient for the operation of both the GPS and IPS microcomputer systems. However, power fluctuations from the central gas processing unit did cause spikes in the power provided to the TI PPC. It is recommended that a line conditioner be purchased as CES for each microcomputer system in order to avoid these problems on future ops.

24. Rations. The rations for the op were provided by the following two means:

a. Direct rationing through SANTOS where base pers were rationed in a mess similar to that provided in Army bks.

b. Fd rationing, again through SANTOS, where fd elms were resupplied fd rations by main base pers.

This system of rationing worked well during the op.

25. Accounting Procedures. The repayment to SANTOS for both the accn and rats was carried out on a weekly basis by OC Det. A roll book and ration order supplement were used to validate movt of pers in and out of the main base area.

26. POL. POL for the op was obtained as follows:

a. AVTUR. Prior to the conduct of the op, sixty drums were pre-positioned at MOOMBA for subsequent fd positioning by the det. Due to the wet nature of the AO, drums had to be positioned by acft ie. sling load by LOH to IPS traverse centres. Some loads were able to be positioned by UNIMOG. Sixteen drums containing 1000 litres of unused fuel were unable to be recovered due to roads being closed at the end of the op, caused by rain. A further 14 300 litres of fuel was used in bulk from the SHELL distributor located at MOOMBA. Refer to Annex H.

b. MSP and Dieso. During insertion and extraction of op elms to/from the AO, contract sellers at HAWKER, LYNDHURST and PORT AUGUSTA were utilised to refuel. During the op, contracts were arranged for refuelling at MOOMBA and INNAMINCKA. Refer to Annex H.

c. LPG. The op det used a 45 kg gas bottle for resupply of fd parties. This was refilled through local resources in the AO.

27. Stores and Equipment. Logistic spt for the op was generally satisfactory. Predominant use was made of civil tpt to move equip and stores to Adelaide prior to the op, and then movt by the det to the AO.

28. During the op a delay in the arrival of RC10 carrying cases was experienced due to road closures south of the AO.

29. At all times, the provision of emergency stores was effected efficiently through liaison with unit HQ in Adelaide.

30. No stores were written off or destroyed as a result of the op.

31. Survey Equipments. The following technical equipments were loaned from other sources:

a. 5 * TI4100 GPS Receivers,

b. 2 * TI PPC Micros and CES,

c. 2 * FILS III IPS units,

d. 2 * IPS PC's and printers, and

e. 1 * RC10 Camera c/w CES.

All equipments functioned satisfactorily during the op, with minor malfunctions being repaired or solutions found during the op. Annexes C through E give a detailed description of malfunctions/problems arising in operation of each equipment.

32. Morale. Morale throughout the op was high. Experience with state-of-the-art svy equipments was invaluable to all concerned.

33. Discipline. There were no incidents requiring mil law to be effected.

34. Communications. Comms within the AO were estab by use of the ANPRC F3 radio sets. These sets performed extremely well during all phases of the op, providing the necessary comms between main base and GPS fd parties during observing sessions. This is especially important when GPS observation is done in the relative mode. Frequency interference was experienced mainly at night.

36. Comms outside of the AO were established by use of STD facy's in MOOMBA and by use of a Telecom card.

37. Mail. Mail for det members was directed through SANTOS in Adelaide, and then redirected by SANTOS to MOOMBA.

CONCLUSION

37. OP OPAL WARRIOR 88, being the first of its kind in the application and utilisation of the GPS and IPS, was successfully carried out with all objectives being achieved.

38. Although the problems associated with terrain impassability due to the wet, and LOH downtime due to tail rotor wear caused minor upsets during the op, all op members worked well and contributed to this success.

19 Aug 88

(P.H. CATES)
MAJ
OC

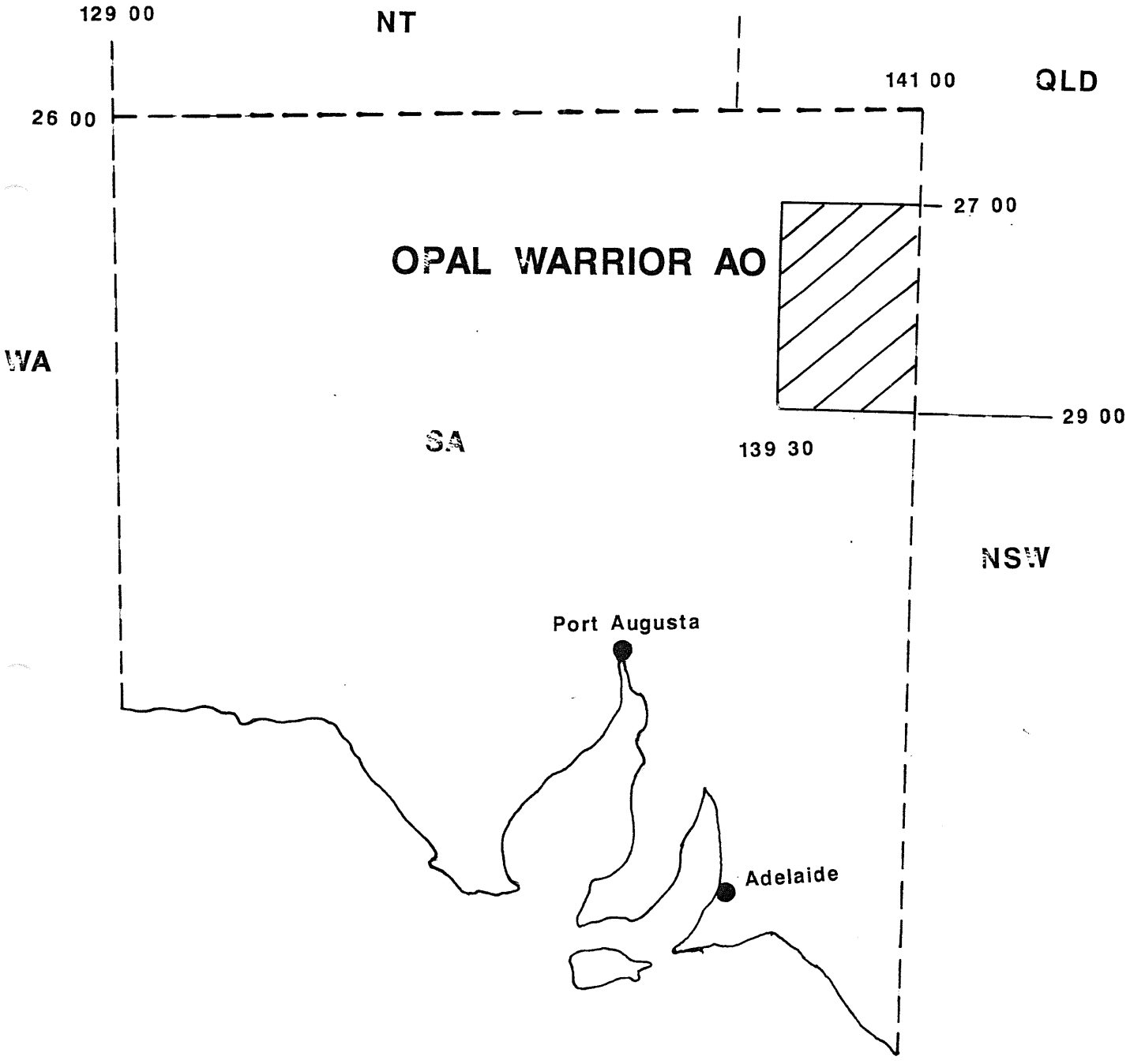
ANNEX A TO

PROJECT REPORT

DATED 19 AUG 88

AREA OF OPERATIONS

OP OPAL WARRIOR 88



ANNEX B TO
PROJECT REPORT
OF OPAL WARRIOR 88
DATED 19 AUG 88

CONTROL SURVEY TECHNICAL REPORT

INTRODUCTION

General

1. The purpose of this report is to detail the technical aspects of the control survey. A description of the planning prior to the operation and methods employed to achieve the aim and results is provided.

Nature of AO

2. The AO for this operation was essentially an arid area with north-south sand ridges being the predominant feature of terrain. The North-East corner of the AO is characterized by mesa and bute fmns. the main water features are those of the Cooper Creek and Scrzelecki Creek.

3. During the conduct of the operation, the majority of the AO was inundated with water from the Cooper Creek flowing in from Queensland. The level of inundation was such to cause virtually no vehicle movement for the total period of the operation.

Objectives

4. The objectives of the operation were as listed in Refs A and E.

PLANNING

5. Technical planning for this operation commenced in 1987 upon finalization of the AO at formation level. The planning criteria used was aerotriangulation blocks at 1:250 000 scale and using the following perimeter control criteria:

a. Horizontal control points every sixth model on the top and bottom of each area, and

b. Horizontal control points located on every third run of mapping photography along the edges of each 250 000 area.

A combination of new and existing control was selected to satisfy the above criteria. The control proposal (and approved plan) required the placement of further horizontal control across the centre of each 250 000 area in order to satisfy the third order observation requirements for IPS Traverses.

6. The proposed plan was submitted to both Army Survey Regiment and DSVY-A for approval in March 1988. The plan was subsequently approved on 5 April 1988. Refer to Appendix 1.

7. GPS Operations. Planning for execution of this phase was necessarily delayed due to introduction into service of the equipments and completion of a managers and operators course in February 1988.

8. Subsequent planning was based on use of 4 receivers deployed for observation in the relative mode, with a planned occupation rate of one session per day.

9. IPS Operation. Planning for this phase had occurred since completion of the IPS acceptance trials and course in November 1987. Deployment of the IPS was based on LOH mobility, requiring two 220km traverses to be completed each day.

EXECUTION

GPS Observations

10. The planned mode of mobility for the deployment of these equipments was that of vehicle, with outlying stations to be visited by helicopter teams. Due to the inundated nature of the AO during the observing period, predominant use had to be made of the LOH to move observing parties.

11. The modus operandi hence became a move to the selected site during the day, panel and mark the station, complete documentation and observe early the following morning. The party would then be moved to the next observing location if the session had been observed successfully by all receivers simultaneously.

12. Overall, the GPS phase required 22 observing days to acquire 34 stations. A combination of receiver operator error, satellite unavailability, station inaccessibility and helicopter downtime contributed to the above observation rate. Refer to Annex C.

13. Data Quality Control. The quality of data obtained during observations was checked where possible, on a daily basis by the main base processing of observed data ie computation of baselines observed in each session, and polygon misclosure checks.

14. Station Documentation. Upon completion of occupation, all station documentation and data were fowarded to main base at Moomba for checking of completeness and accuracy.

15. Problems Encountered. Annex C provides a detailed description of the problems encountered in the operation of these equipments.

16. Two points need to be emphasised in relation to GPS observations, those being:

a. Communication between parties and main base when operating in the relative mode need to be efficient and functional at all times.

b. Post Processing/computing teams must operate on an extended shift basis to confirm field data obtained. The assignment of two teams to this task is preferrable.

IPS Observation

17. The execution of the IPS phase consisted of 12 traverses being completed by LOH. Due to the nature of the terrain, ie devoid of restrictive vegetation cover, no LZ were required to be cleared.

18. The planned employment for the IPS was to complete two 220 km north south traverses per day, with equipment realignment points being located at the junction point of the two traverses in the centre of the AO. Due to the problems listed at Annex D to this report, one traverse per day became the norm.

19. The overall employment of this equipment was successful, with minor problems creating delays and changes to previously conceived modes of operation for the equipment and its operators.

20. Data Quality Control. As with GPS, the IPS results were post processed on completion of the days activity at main base. No operational problems occurred at this stage, however, the allocation of control to the traverse adjustment procedure was changed from that previously taught on course. Refer to Annex D.

21. Problems Encountered. Annex D lists the main problems encountered during the phase. Of predominant importance for planning and conducting operation using IPS is cognizance of the requirement for operators to conduct a thorough map and photo reconnaissance prior to departing on a traverse. Rarely will operators be given the benefit of a prior ground reconnaissance in the operational environment, and this fact should be addressed in future courses.

Station Marking

22. Horizontal stations established in the AO were a combination of the following:

a. RASVY brass plaque stamped with station ID, set in concrete. Three RMs and a galvanized iron pipe WP were positioned for recovery purposes.

b. RASVY brass plaque stamped with station ID, set in a 600mm FENO spike with aluminium head and driven to ground level. Three RMs consisting of 600mm FENO spike and aluminium head along with a galvanized iron pipe WP were positioned for recovery purposes.

In each case the WP was painted white, capped and stamped with Station ID number.

23. The use of the FENO mark was widely accepted as being effective whilst economical in manpower and resource usage against that of concrete. In cases where the ground mark was hammered below ground level, a cement collar was required.

Panelling/Photography

23. Each GPS team and main base personnel were responsible for panelling selected control. Photography was flown over both phases of the operation, the results obtained being satisfactory. Refer to Annex E.

Problems Encountered

24. Aside from the problems listed above and detailed at Annex C through E, the following had profound effects on operational progress.

a. Inundated Terrain. The flooding caused by high eastern state rainfall and flow down the Cooper Creek caused vehicle mobility to be drastically restricted, most areas being 'NO-GO'. This necessitated greater emphasis on movement of parties and fuel by LOH.

b. LOH Downtime. Excessive Tail Rotor wear was experienced due to the amount of fine dust in the atmosphere eating away the rotors leading edge. LOH spares were constantly flown in to keep the aircraft airborne and hence the operation progressing in both phases. NCO tradesman also had to accompany the spares in order to provide the correct level of aircraft release for flight tests, which placed a greater burden on operational T & S expenditure. Dust also caused problems in servo mechanisms and chip light detection, again requiring aircraft downtime for repair.

c. Survey Equipment Operation. The problems experienced with WI03 were unforeseen and technical in nature. These problems are to be addressed by extensive testing of this IMU over the Hume Test Range/Sydney Test Range.

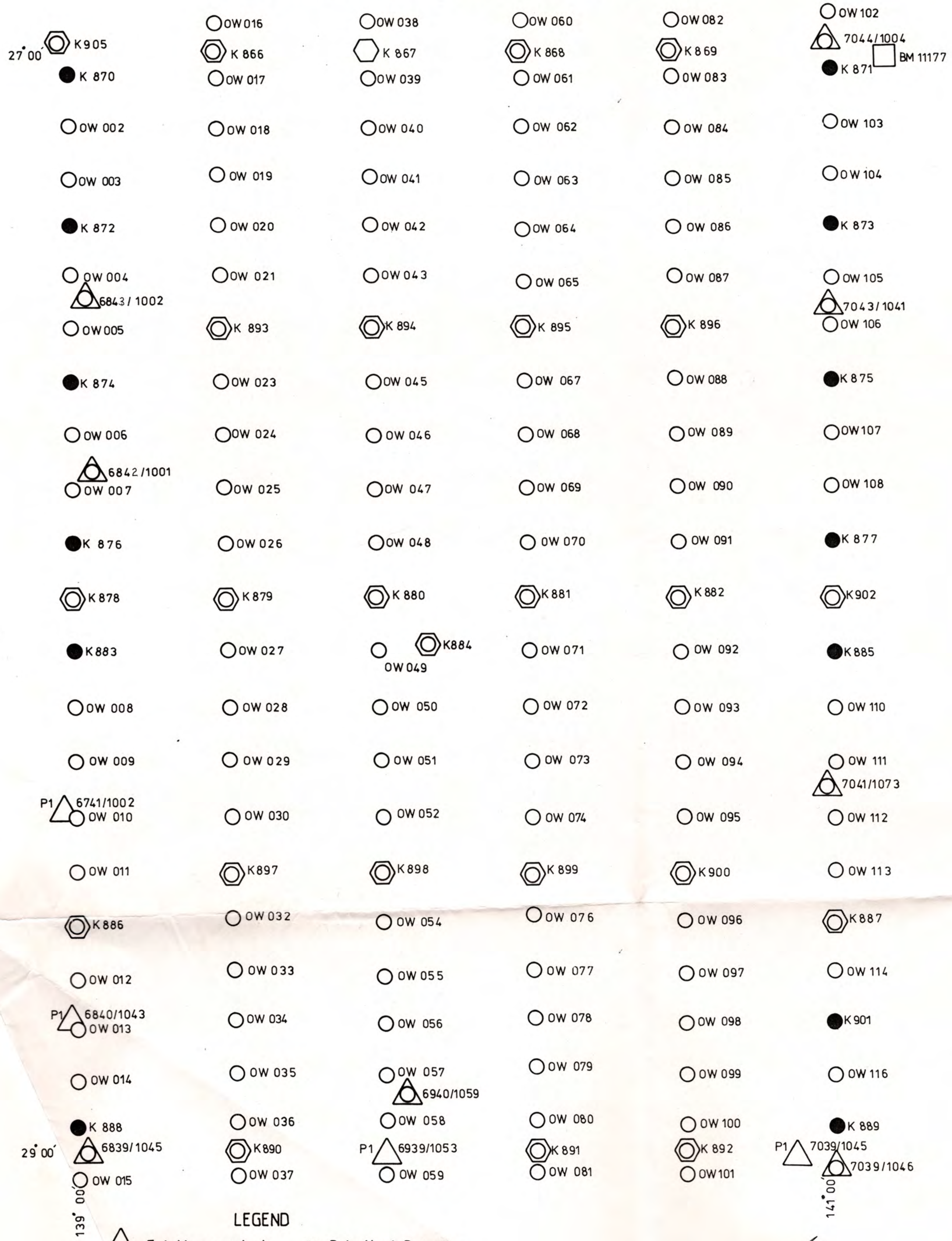
CONCLUSION

25. The control survey for OP OPAL WARRIOR 88 was successfully planned and conducted whilst the operation was the first of its type in the concurrent employment of GPS and IPS, it has served to highlight those problem areas to be addressed in future operations.

26. Due to the rapid employment and data acquisition nature of GPS and IPS systems, operational support plans (logistics and administration) need to be extensively researched and implemented in finest detail. The recommendation in the following annexures need to be addressed in detail for future operations.

OPERATION OPAL WARRIOR

HORIZONTAL AND VERTICAL CONTROL



LEGEND

△ Existing control P1 Priority 1 Panelling

⬡ GPS Point

● IPS ~~Vertical~~ Horizontal

○ IPS ~~Horizontal~~ Vertical

Compiled: SPR S.A.ELLIS

Checked: WO 2 VAN LEEUWEN

ANNEX C TO
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

GPS SURVEY TECHNICAL REPORT

References: A. Technical Instruction No 302 dated 29 Mar 88

B. DSVY Technical Directive A474/5/65 dated 11 Apr 88

INTRODUCTION

General

1. TI4100 Global Positioning Systems (GPS) were deployed by 4 Fd Svy Sqn during Apr-May 88 to acquire necessary 3rd order control over the 1:250 000 map sheets of INNAMINCKA SG54-14 and STRZELECKI SH54-2. The Inertial Positioning System (IPS) was utilised during the operation for extension of vertical control and establishment of additional horizontal control. A requirement existed for the supply of provisional co-ordinates of GPS control points prior to the commencement of the IPS phase.

Aim

2. The aim of this report is to detail the planning, preparation, method of deployment and operation of the GPS equipments. Post processing procedures, equipment serviceability and any aspects relevant to future efficient use of the equipments will be covered.

PLANNING

3. The initial GPS proposal was submitted in Feb 88 and finalised/approved in late Mar 88. Operational requirements were:

a. Occupation by GPS of nine existing stations.

b. The establishment of 25 new stations.

c. The introduction of vertical control from 3rd order level traverses into four of the existing stations in sub para a.

d. A minimim of 51 base lines to be observed.

4. The Relative Positioning technique was to be employed for the operation with Navigator being the approved operating system. Thirty minutes of data was the required minimum recording interval.

5. During the planning stage the task was assessed with consideration being given to the number of receivers to be utilised, Technical Instructions/Directives, and mode of movement between stations. The observation window and any anticipated difficulties posed by the terrain in the AO was also examined. Five receivers were allocated for the operation, four to be deployed with the remaining receiver as a back up unit.

6. Because of time constraints and distances involved in levelling from BMs to control points, one BM was incorporated in the GPS network with the option remaining open for another to be occupied by GPS should the need arise during the operation.

7. Standard source data searches were carried out during planning. 1:65 000 mapping photography flown Mar 87 was examined and areas selected for optimum horizontal control point positioning in relation to aerotriangulation requirements. Enlargements of approx 1:15 000 were produced by Army Survey Regiment for use by field parties. Enlargements were also produced for proposed IPS vertical control points.

8. Based on four receivers a total of 16 sessions was required to fulfil operational requirements. Three field parties were to be vehicle mounted and the fourth party would move by vehicle/helicopter as dictated by weather conditions and accessibility of control points. Final planning allowed for 16 days with a maximum of one session only per day to complete the GPS phase.

Preparation

9. Five TI4100 GPS and two TI PPC equipments arrived in ADELAIDE ten days prior to departure for AO. This enabled training to be undertaken, calibration testing carried out and vehicles prepared for mounting of the receivers and recorders.

10. Training. A pre operation technical training programme was instigated to ensure personnel were proficient in the relevant technical procedures to be utilised during the operation. Training was mainly for the benefit of junior personnel and was also an opportunity to display the GPS equipment to the Squadron in general.

11. Equipment System Calibration. This was carried out in accordance with TI's. A small network of control stations was established within the KESWICK area and measurements done over two recording sessions. A base line was measured for comparisons using EDM. Post processing and analysis of results proved all equipments were serviceable and providing acceptable results. Some minor operator problems emerged and these were resolved satisfactorily.

12. Vehicle Mounting of GPS. Sydney Workshop Company manufactured prototype mounting trays for the receiver and recorder units. External antenna mounting brackets were also constructed. These were installed in vehicles prior to departure for the AO.

EXECUTION

Method

13. The computing section at Main Base prepared field prediction sheets for each observing session. A primary constellation was designated with a suitable secondary constellation as a reserve. These prediction sheets were either collected by field parties on movement through MOOMBA or else passed over the communications network.

14. The observing window for recording sessions ranged from 0500 to 1000 hr local time over the duration of the GPS observations. With three of the parties being vehicle mounted it was possible only to plan for a maximum of one recording session per day utilising four receivers. At times two sessions were observed. However, this was the result of one of the parties either being late arriving on location or encountering some operator problem and not being able to commence recording with the other parties at the pre designated time. The additional session enabled completion of the days planned activities.

15. The spare receiver at main base was utilised as a fifth receiver at points easily accessible from MOOMBA and was incorporated into six recording sessions.

16. The normal procedure was to arrive on location during the day and carry out ground marking, recovery, and documentation. Recording was done early the following day. Parties then moved to their next location unless remaining as a pivot station for the following days observations.

17. Vehicle Deployment. Vehicle parties utilised Series 3 FFR Land Rovers. The radio racks were removed in ADELAIDE prior to departure for the AO. This enabled the installation of the mounting trays and provided a much larger area for stores and equipment. The power source for receivers was internal 24 volt through the vehicle junction boxes. Power was drawn from 2 x 12 volt 25 plate 200 amp batteries. This proved a very successful mode of operation with charging being done by vehicle alternator when moving locations. The 200 ft antenna cables ensured recording at stations could be undertaken with the GPS equipment remaining installed in vehicles. Because of the topography of the area combined with the cables, no walk on stations either new or existing were encountered.

18. Aircraft Deployment. Movement was by LOH. Initially it was requiring three lifts to insert two personnel and equipment on location. By discarding unnecessary stores and leaving the GPS transit boxes at main base, it was possible in most instances to carry out insertion/extraction in two lifts, thus conserving valuable aircraft hours.

19. Power for the equipment was supplied by two 12 volt fully sealed batteries requring nil maintenance. These batteries weighed 8kg each and because of their characteristics/composition, battery boxes were not required for transportation in the aircraft. The aircraft parties carried no facilities for battery charging and fresh batteries were re supplied from main base.

Equipment Performance

20. Overall the T14100s performed well and the problems that occurred were operator related. No repairs were necessary to either receivers or recorders. Problems encountered in the early stages were:

a. attempting SV acquisition prior to completion of 20 minute oscillator warm up period;

b. entering almanac information and searching for an SV that had not risen;

c. errors caused by finger problems with CDU on the omission of a sequence in the procedure for SV acquisition.

d. unscheduled auto switching on recorder drives caused by using unexercised, tight tapes.

General Comments

21. a. Cable Reels. Some of the reels could not stand up to the wear and tear. By the end of the operation they were twisted and broken.

b. Antenna Cables. Temporary covers were designed for the cable ends to keep out dust and dirt. These consisted of either rubber caps or simply masking tape covering the apertures. The caps were soon lost and the tape left a sticky residue which collected dust, defeating the purpose.

c. CDU. Concern was expressed about the fragile appearance. Many already have stress cracks at the sides. The display was diffiuclt to read in sunlight.

d. Tape Drive Cover. The dust cover should be kept firmly screwed down at all times and only opened during head cleaning or tape changing.

22. Once the initial teething troubles with operators were sorted out and correct operating procedures adhered to, recording sessions ran smoothly.

23. Base acquisition of observation data. Cassettes and station documentation from aircraft parties was returned after completion of each station. Vehicle parties handed in data when passing through main base. Depending on movements and location in the AO, this often resulted in 2-3 days delay before the computing section acquired all cassettes for a particular session, finalised post processing and verified base lines.

24. Recording Session Control (Communications). ANPRC F3 radios were utilised for communications and functioned quite well. Because of the nature of terrain in the AO all parties carried 27 ft telle masts to enhance reception capabilities. Reception was very poor at night and problems could have been expected had the observing window been over night. Main base was able to control and monitor recording sessions. Most problems were able to be addressed and rectified and the start/finish times of recording sessions adjusted accordingly.

25. Once data was being recorded heavy interference came over the radio if it was in close proximity to the GPS equipment. Initially some operators were either distancing their radios or switching them off when recording commenced. It was imperative radio comms were maintained at all times during recording and this interference/discomfort had to be tolerated.

26. Had an overnight window existed with bad communications, then a possible approach might have been for all parties to record both primary and secondary constellations as standard operating procedure.

27. Batteries. In considering weight limitations for aircraft parties, various battery types and their performance in relation to GPS operations were investigated. A quantity of Exide RE12-24 maintenance free 12 volt recombination electroylte batteries was purchased. When fully charged these 20 amp/hr batteries provided approximately 4 hours service when the T14100 was in operate mode before voltage dropped below the critical level of 22 volts.

28. Because of battery composition, constant voltage current limiting charging had to be utilised. A suitable 240 volt charger which did not exceed the maximum allowable current during charging of 6 amps was purchased. However, depending on the condition of the battery it sometimes took up to 15 hours to bring a battery to a state of full charge. During the operation with only one aircraft party operating, it was possible to maintain a re supply of light weight batteries. However, when three aircraft parties had to be deployed because of adverse ground conditions the lengthy charging time presented this recurring. Standard 12 volt lead/acid batteries had to be obtained to ensure continuation of operations.

29. Mounting Trays. Prototype mounting trays were manufactured by Sydney Workshop Company for trial during the operation. The trays were specifically designed to mount GPS receivers/recorders in vehicles and OP OPAL WARRIOR provided an excellent opportunity for assessment/user trials. The long term plan is to produce a suitable tray for eventual use in the 110 Series Land Rover.

30. Vehicles used were FFR Series 3 Rovers and prior to departure from ADELAIDE radio racks were removed and trays mounted with some modification to stud alignements being required.

31. The GPS equipment travelled well when mounted. The topography and conditions the field parties encountered was typical of survey operations. The capability to arrive at a station and basically commence recording was well received by the operators. The additional space the vehicles afforded by not carrying transit boxes was a definite bonus.

32. An external antenna pole was mounted onto the FFR aerial bracket. Although not utilised during the operation it remained mounted and did not vibrate loose or cause any problems when travelling through scrub.

33. Overall the trays worked successfully with modifications required on the fasteners at front and rear to ensure recorder/receiver are secure from movement and vibration.

Results

34. The following results were obtained:

a. Eight existing control points re-occupied. The ninth point could not be located and a new station was established in close proximity.

b. A total of 26 new GPS stations established.

c. Height introduced into three existing control points. Two were levelled to and the third had height introduced by GPS occupation of BM.

d. The required minimum 51 base lines were successfully obtained.

35. A fourth BM in the NW of AO was treated as a GPS point. During the recording session satellite malfunctions occurred and results obtained could not be processed. Due to time/logistics this session was not re-observed.

36. A total of 26 recording sessions was observed with 20 of these sessions providing acceptable data. Appendix 1 to this report shows details of all base lines obtained.

FIELD DATA PROCESSING

General

37. Data processing was carried out from main base at MOOMBA for the duration of the operation. The processing section was housed in an accommodation building with 240V mains electricity and air conditioning to all rooms. This provided a reasonable dust free environment for computer operations and security for the equipment.

Manning/Responsibilities

38. The section was run as a combined operations and processing area. Composition was Detachment OC and Technical WO. Responsibilities were:

a. Plan recording sessions, issue station documentation, process numbers and information on party movements;

b. Run SATPLAN and compile/issue field prediction sheets;

c. Monitor and control recording sessions;

d. Receipt and check GPS field records and station documentation;

e. Cassette translation/Base line determination via GEOMARK;

f. Network precision determination for each session;

g. Computation of provisional co-ordinates; and

h. preparation of data package for DSVY.

Data Processing Requirements

39. The technical directive required the determination of all possible base lines and for precision checks to be carried out on all triangles formed for each session. This imposed a heavy workload on the section where most times only one person was available to carry out post processing.

40. The ideal situation for processing was to obtain all station observations at the completion of each recording session and carry out base line determinations/precision checks in the one instance. This did not happen very often and usually data to complete 2-3 sessions would arrive at main base, resulting in long periods of computing.

41. When this situation occurred it was imperative to assess data as quickly as possible so that any re observations necessary could be planned for. Base line determinations only were done with no consideration given for mets/antenna heights. Later when time permitted base lines were re run properly, reports generated and precision checks done.

Results

42. Of the 26 sessions observed, 22 were considered acceptable for post processing. Of the four rejected, two fell well short of the minimum recording time of 30 minutes. The remaining two were unsuccessful because of operator error.

43. The following problems occurred:

a. SV selection. In the early sessions certain baselines could not be computed because satellite constellations to be tracked were being entered in the incorrect sequence.

b. Satellite failure. Two sessions failed when processed. The data translated but was unacceptable for baseline determinations. During recording, all equipments functioned properly and the monitoring of SVs and statistics gave results well within allowable tolerances. It can only be assumed that adjustments were being carried out to SVs during these times.

c. Random baseline failure. The failure to compute a baseline in a session for no apparent reason and the inability to compute a baseline in the reverse direction.

44. A total of 74 precision triangle checks and 263 baselines were computed. Appendix 2 to this report provides a comprehensive breakdown of results.

General Comments

45. With post processing procedures an enormous quantity of paperwork was generated. It was essential that an efficient filing system be initiated to avoid confusion and misplacement of documentation.

46. Precision Checks. The requirement to carry forward co-ordinates from each preceeding baseline in triangle checks resulted in much additional

computing. A large percentage of these lines was not suitable for use in calculating provisional co-ordinates. A programme was written to compute accuracies. This worked well, saving time and also providing a hard copy for record purposes. The programme was written for triangles only and should be modified to accept data from any figure.

47. Recomputing of baselines was necessary when an existing control point with height introduced by levelling/GPS was reached. This required recomputing of parts of the network to distribute correct heights through points already processed.

48. Recording Interval. All data accepted for post processing was in excess of 30 minutes apart from two sessions where the loss of an SV during observation resulted in the recording of 23 and 26 minutes of data respectively. Because of logistics and time frame of the operation these sessions were not re observed. Precision checks on the data gave results ranging from 1.0 to 3.98 PPM, well within specification.

49. The requirement for 30 minutes of data to be recorded resulted in the use of two cassettes per station per session. Random sessions were selected, data edited and precision checks carried out using 25 and 20 minutes of data. The resultant PPMs varied minimally to those obtained from 30 minutes of recording.

50. These results, together with information on problems encountered in post processing will be forwarded to DSVY for assessment and comment.

51. Provisional Co-ordinates. There was an operational requirement to provide provisional co-ordinates for the IPS phase of the operation. IPS was to commence a few days after the completion of GPS observations. However, because of adverse weather conditions and the failure of some recording sessions, the two phases overlapped. Instead of being able to supply a complete list of co-ordinates a trickle feed system had to be utilised. This enabled the IPS traverses to commence in accordance with the basic planning concept.

52. DSVY Adjustment Requirments. On return to ADELAIDE a package was despatched to CANBERRA for use as input/reference data for the adjustment of GPS observations. As OP OPAL WARRIOR was the first deployment of the equipment for acquisition of mapping control, information on the package is listed below.

a. GPS Baseline Diagram. Shows all possible successful baselines. The lines are numbered sequentially.

b. Session Diagrams. Show all possible successful lines for a particular session. The numbers on this diagram relate to the above baseline diagram.

c. Baseline Computation Reports. The reports will have two sets of numbers. One refers to initial computations for accuracy checks/provisional co-ordinates unique to a session. The second number system relates to sub para a and b. A report is supplied for each baseline. If available, reports for computations in both directions will be supplied. These reports can

be from lines calculated in accuracy checks and do not necessarily have to be those used to compute provisional co-ordinates.

d. Provisional co-ordinate listing.

e. Listing of co-ordinates for existing horizontal control points used in determining provisional co-ordinates.

f. Copies of field observation sheets.

g. Accuracy check printouts.

h. Summary of levelling done for introduction of AHD height.

i. GPS Field Report.

j. Copies of Station Notes.

Relevant extracts of the package are shown at Appendix 3.

Equipment Performance

53. Some minor hardware problems were encountered in the early stages of the operation.

a. Computer failure. The probable cause was a power surge from an air conditioner operating on the same circuit. The spare computer was brought into operation and remained serviceable for the duration. The air conditioner was switched off whenever the computer was operating.

b. Keyboard faults. On occasions keys stuck due to a build up of dust. Removal of keys and cleaning rectified this problem. Covering of the system when not in use and daily cleaning was essential.

54. The actual software functioned satisfactorily and no major problems emerged. Modifications to some sections are required to ensure a more user friendly product. The procedure for the implmentation of mets data in GEOMARK is one area where improvement is required. Also the ability to edit raw data would be an advantage. This would hopefully overcome such problems as SVs being inadvertently tracked in the incorrect sequence.

55. Overall the TIPPC and ancillary equipments gave good service for the duration of the operation.

56. Draft SOPs were issued to field parties and the post processing section. Comments and recommendations have been collated and forwarded to School of Military Survey for consideration/action. Modified booking forms were used and examples have been forwarded with SOP comments.

CONCLUSION

57. OP OPAL WARRIOR was the first long term deployment of GPS equipment in an operational environment. It provided a good test of both the equipment and personnel. The rapid rate of control acquisition highlighted the need for careful planning and logistic support. Personnel involved performed well and contributed to a successful operational phase.

RECOMMENDATIONS

58. It is recommended that:

a. the prototype mounting trays be inspected and necessary modifications be done for implementation in the 110 Series Land Rovers;

b. the trays be mounted behind the seats for good accessability to equipments;

c. proper end caps be manufactured for antenna cables;

d. heavy duty reels be obtained for antenna cable storage;

e. the CDU be enclosed in a protective rubber glove to prevent damage and the development of stress cracks;

f. investigations be carried out on ways to overcome problems with charging of 12V lightweight batteries. The present time frame of 15 hours per battery prevents them being a viable proposition;

g. A line conditioning unit be purchased for use with the TIPPC to prevent power surges and resulting damage;

h. the TIPPC keyboard be covered with a clear plastic cover to reduce the ingression of dust;

i. a proper cover be provided for the TIPPC and ancillary equipments to provide protection when not in use;

j. source code for software packages be obtained;

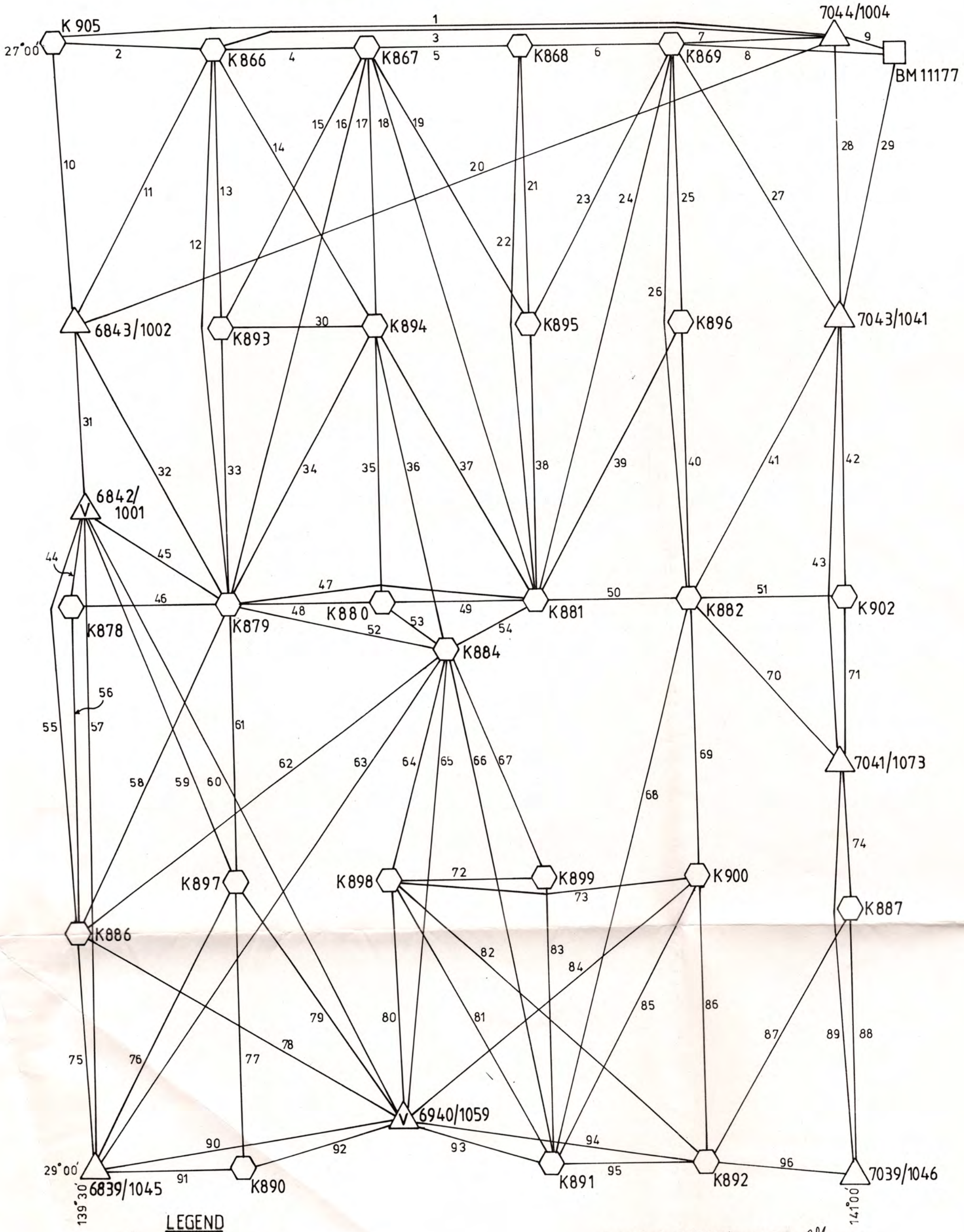
k. a hard copy of mets input for GEOMARK be a requirement for record purposes;

l. In future operations the processing section consist of two dedicated personnel thus enabling shift work when required.

APPENDIX 1 TO
ANNEX C TO
OPAL WARRIOR 88
PROJECT REPORT

OPERATION OPAL WARRIOR

GPS BASELINE DIAGRAM



LEGEND

- Existing control
- GPS Point
- Bench mark
- GPS Baseline
- V 3rd Order Levelling

Compiled: SGT D.Stanmore
Checked: SSGT M.J.Hogan
Date: 27 May 88

APPENDIX 2 To
ANNEX C To
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

POST PROCESSING SUMMARY

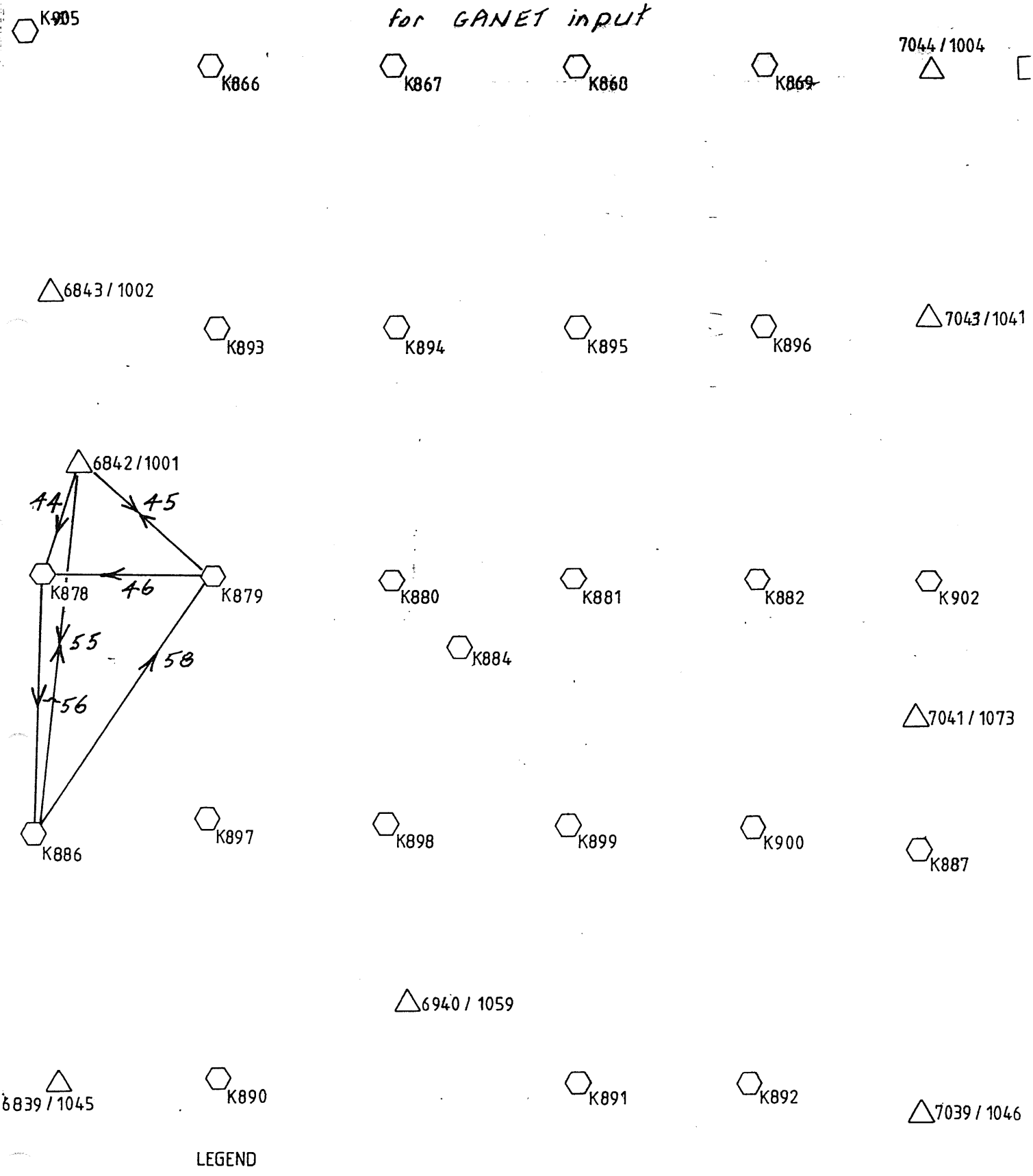
DATE	SESSION	PRECISION CHECKS	BASELINES COMPUTED	ACCURACY PPM	REMARKS
21 APR	1	-	-	-	Rejected
21 APR	2	1	7	0.9	
21 APR	3	-	-	-	Rejected
22 APR	4	1	5	0.2	
23 APR	5	2	11	0.5,0.8	
24 APR	6	4	19	1.6-2.3	
25 APR	7	5	18	0.1-0.6	
26 APR	8	1	4	0.3	
27 APR	9	-	-	-	Rejected
27 APR	10	-	-	-	Rejected
28 APR	11	4	11	0.8-9.1	
29 APR	12	1	4	0.7	
29 APR	13	1	7	1.5	23 minutes of data
30 APR	14	4	19	1.1-7.4	
1 MAY	15	-	-	-	unable to compute SV's not operating
2 MAY	16	10	32	1.5-7.6	
4 MAY	17	4	14	0.7-1.6	
4 MAY	18	1	4	0.9	
5 MAY	19	-	-	-	unable to compute SV's not operating
6 MAY	20	1	4	5.6	
6 MAY	21	4	18	1.0-4.0	26 minutes of data
8 MAY	22	4	16	1.6-3.4	
9 MAY	23	10	25	0.6-12.3	
10 MAY	24	10	23	0.4-5.1	
11 MAY	25	1	8	0.7	
12 MAY	26	4	14	0.4-2.7	

NOTE.
1. PDOP range for all sessions was below 7

OPERATION OPAL WARRIOR

GPS SESSION No : __11___

for GANET input



LEGEND

- ⬡ GPS POINT
- □ BENCHMARK
- △ EXISTING CONTROL

Levelled Ht

LINE 6

00045

6842/1001 (24039) TO K879 (24038) 28 APR 88
OP OPAL WARRIOR 88 SESSION 11

REPORT DATE: 05/05/88
SURVEY DATE: 04/28/88
REFERENCE: 6842/1001 (24039) 28 APR 88
REMOTE: K879 (24038) 28 APR 88

EARTH-CENTERED EARTH-FIXED POSITIONS WGS-84		GEODETIC POSITIONS LOCAL DATUM AUST	GRID COORDINATES UTM
REFERENCE	X: -4296513.135 M Y: 3663916.920 M Z: -2956048.944 M	LAT: S 27:47:32.35029 LON: E 139:32:32.50681 ELLIPSOID ALT: 46.622 M MSL ELEVATION: 49.573 M	X: 356398.282 M Y: 6924940.642 M ZONE: -54
REMOTE	X: -4305188.620 M Y: 3638145.855 M Z: -2975029.865 M	LAT: S 27:59:10.28040 LON: E 139:47:56.09273 ELLIPSOID ALT: 29.305 M MSL ELEVATION: 31.924 M	X: 381885.900 M Y: 6903735.827 M ZONE: -54

MONUMENT TO MONUMENT BASELINE DISTANCE

GEODESIC BASELINE DISTANCE: 33161.3670 M BASELINE UNCERTAINTY: .1014 M

ELLIPSOID HEIGHT DIFFERENCE: -17.3166 M DIFFERENCE UNCERTAINTY: .0525 M

FORWARD AZIMUTH: N 130:26:27.872
BACK AZIMUTH: N 310:19:15.851

AZIMUTH UNCERTAINTY: .9150 SEC

MONUMENT TO MONUMENT VECTOR COMPONENTS (WGS-84)

		ERROR			ERROR
X:	-8675.4850 M	.1063 M	E:	25238.4590 M	.1471 M
Y:	-25771.0650 M	.1151 M	N:	-21510.3840 M	.0415 M
Z:	-18980.9208 M	.0397 M	U:	-103.7210 M	.0525 M

BASELINE VECTOR LENGTH: 33161.5318 M

ANTENNA OFFSETS

	REFERENCE	REMOTE
E	.000 M	.000 M
N	.000 M	.000 M
U	1.246 M	1.469 M

LOCAL DATUM PARAMETERS

DELTA X: 133.0 M
DELTA Y: 48.0 M
DELTA Z: -148.0 M
DELTA A: 23.0 M
DELTA F: .000000081200

PRECISE EPHEMERIS SOURCE: NOT ENABLED
70 MEASUREMENTS / CARRIER PHASE TRIPLE DIFFERENCE / TROPOSPHERIC & IONOSPHERIC CORRECTIONS

15

Baseline Determination Status

4100 ERROR WAS FOUND DURING REMOTE CASSETTE TRANSLATION
4[illegible] ERROR WAS FOUND DURING REFERENCE CASSETTE TRANSLATION
RECEIVER MEASUREMENT DISCREPENCIES AT ELAPSED TIME 33 MIN.

Final Results
Unadjusted Vector Length = 33161.539 meters
3-D Uncertainty = 0.1616 meters

6842/1001 (24039) 28 APR 88 K879 (24038) 28 APR 88

Number of Solution Candidates = 1

0% 25% 50% 75% 100%
Receiver Measurements Left to Process
Processing Time Interval = 35 min.

Press any key to continue

NORMAL TERMINATION OF BASELINE DETERMINATION

K878 K886 K879

SESSION 11 OBSERVED 04/28/88

X1 = 23080.28	Y1 = -19871.12	Z1 = -56609.25
X2 = -42440.36	Y2 = -2568.606	Z2 = 57004.6
X3 = 19360.16	Y3 = 22439.73	Z3 = -395.4789

SUM OF MONUMENT TO MONUMENT VECTORS

X VECTOR = .078125
Y VECTOR = .0078125
Z VECTOR = -.1234436

THE LINEAR MISCLOSURE IS .1462972 meters

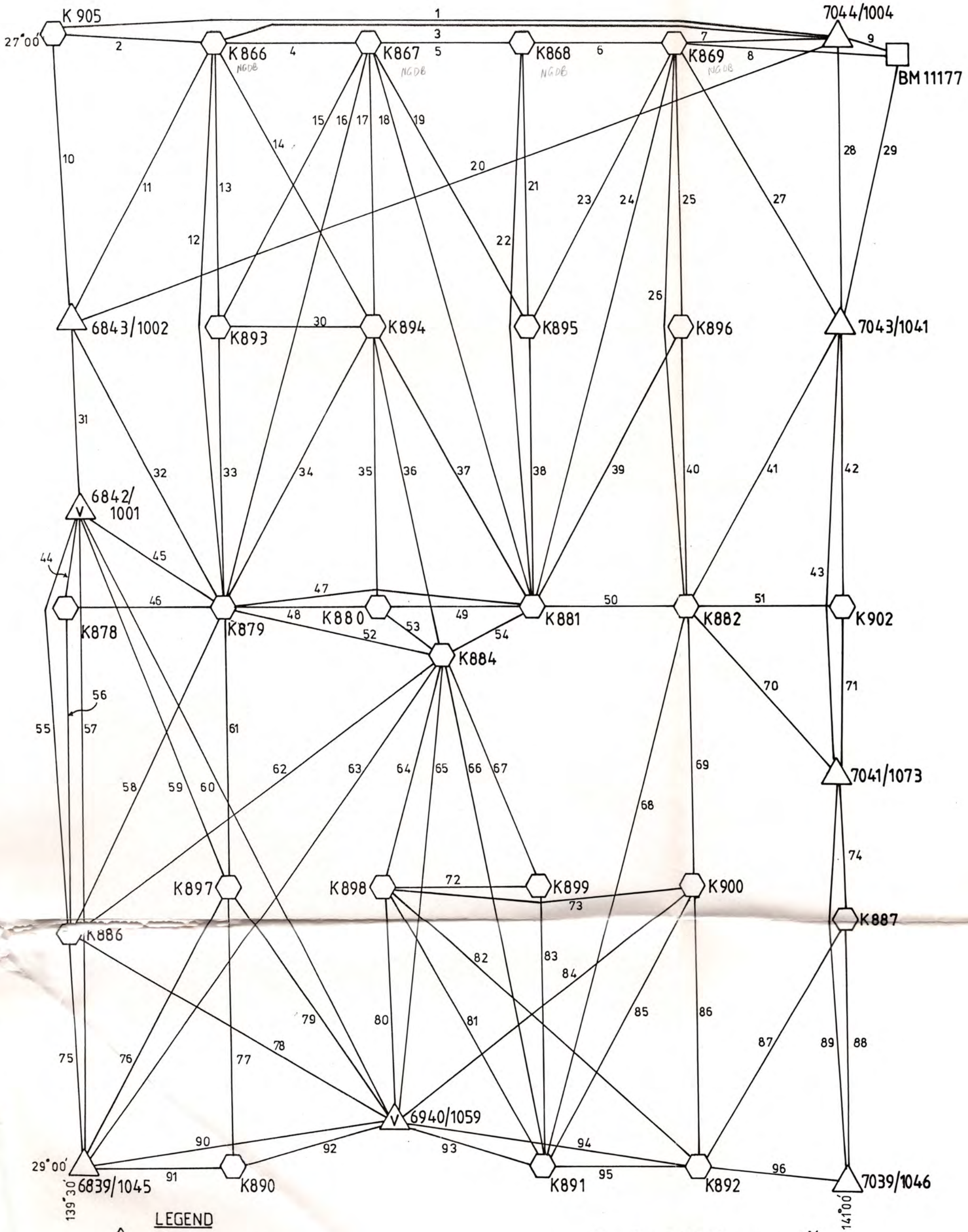
SUM OF BASELINE VECTOR LENGTHS IS 165036.4 meters

ACCURACY OF THE CLOSURE IS .8864541 ppm

APPENDIX 3 TO
ANNEX C TO
PROJECT REPORT

OPERATION OPAL WARRIOR

GPS BASELINE DIAGRAM



LEGEND

- Existing control
- GPS Point
- Bench mark
- GPS Baseline

Compiled: SGT D. Stanmore
Checked: SSGT M.J. Hogan
Date: 27 May 88

NETWORK COMPUTATION REGISTER

OPERATION OPAL WARRIOR

STATION	SESSION		FROM	COORDINATES			MEAN COORDINATES		
	NUMBER	LINE	STATION	E	N	HT	E	N	HT
K894	16	18	K866	410 837·523	6 954 816·268	37·711			
	16	15	K879	410 838·099	6 954 815·368	36·320	410 837·536	6 954 815·424	36·525
	23	2	K879	410 837·366	6 954 815·480	36·011			
	23	6	K884	410 837·158	6 954 814·858	36·059			
K895	17	5	K881	440 887·690	6 955 345·950	37·263	440 887·3775	6 955 345·840	37·362
	18	2	K869	440 887·065	6 955 345·731	37·462			
K896	26	1	K869	470 112·451	6 954 925·966	135·876	470 113·000	6 954 926·182	136·132
	26	13	K882	470 113·544	6 954 926·399	136·389			

COMPILED: SSGT. KOTNYCHK... CHECKED: SGT. STANMORE... DATE: 15 MAY 88

PROCESS No: 24037 STATION No: K878 STATION NAME: . OPERATION: OPAL WARRIOR

SERIAL No: TI 4100 : Ø7 PARTY IC: SSGT LUTWYCHE

RECORDER: Ø7 DATE: 28 Apr 88 JULIAN DAY: 118

ANTENNA : Ø7 SVs IN USE: 3, 6, 9 & 11

ANTENNA HEIGHT: 1.01 m ⊕/- AGM UD MODE: Ø

WEATHER: Fine, clear, mild No OF CASSETTES USED: 2

TIME: 0727

LAT N/S: 27 59 19.80 ECEF X -4285832.5 m

LONG E/W: 139 29 55.97 ECEF Y 3660592.1 m

MSL ALT : 23.4 m ECEF Z -2975432.8 m

PE: 0.5 M PDOP: 3.1

SV No :	3	6	9	11
HEALTH:	0000	0000	0000	0000
RES:	0.002	-0.001	-0.001	-0.002
R RES :	-3.5	-1.5	3.4	-0.4
L1 db :	43	40	38	42

TIME: 0803

LAT N/S: 27 59 19.82 ECEF X -4285832.4 m

LONG E/W: 139 29 56.04 ECEF Y 3660589.0 m

MSL ALT : 21.3 m ECEF Z -2975431.9 m

PE: 0.4M PDOP: 2.8

SV No :	3	6	9	11
HEALTH:	0000	0000	0000	0000
DR RES:	0.000	0.000	-0.001	-0.001
R RES :	1.3	0.5	-0.1	1.3
L1 db :	43	42	42	42

TIME: 0747

LAT N/S: 27 59 19.82 ECEF X -4285835.2 m

LONG E/W: 139 29 56.09 ECEF Y 3660591.3 m

MSL ALT : 25.0 m ECEF Z -2975433.0 m

PE: 0.5 M PDOP: 2.8

SV No :	3	6	9	11
HEALTH:	0000	0000	0000	0000
DR RES:	-0.001	0.000	-0.001	-0.000
R RES :	2.4	3.5	-0.4	-0.2
L1 db :	42	39	40	40

TIME:

LAT N/S: ECEF X m

LONG E/W: ECEF Y m

MSL ALT : m ECEF Z m

PE: PDOP:

SV No :				
HEALTH:				
DR RES:				
R RES :				
L1 db :				

METS	TIME	PRESS mb	td °C °F	tw °C °F	HUM %
	0727	1018.4	55.0 239	50.7	75
	0805	1018.7	56.8 285	51.7	72
	0744	1018.55	13.28		73.5

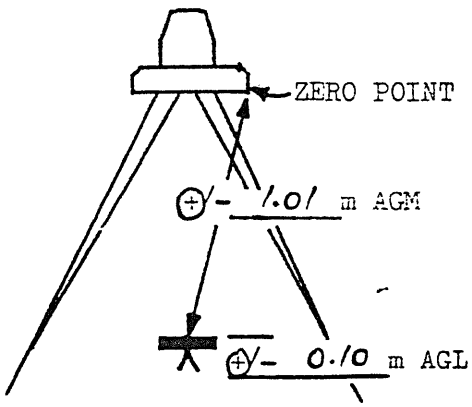
REMARKS: 80C8 entered at 0747

COMPILED: SSGT B J Lutwyche

CHECKED : R.D. GRAF CPL (Print Name and Rank) (signature)

DATE : 28 Apr 88

ANTENNA DIAGRAM



ANNEX D TO
4 FD SVY SQN
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

IPS OPERATION REPORT

Reference: A. TI Number 301 dated Dec 87

B. SOP for IPS dated Oct 87

General

1. The IPS phase for OP OPAL WARRIOR 88 was conducted during the period 6 May to 17 May 88 and its objectives were to acquire both horizontal and vertical control over the entire AO.

2. To facilitate the conduct of this phase, a dedicated IPS team from 2 Fd Svy Sqn was detached to the operation. This team consisted of the following:

a. IPS Manager - 179773 CAPT D.W. Sankey, and

b. IPS Operator - 1202701 WO2 R.H. Gillies.

Aim

3. The aim of this report is to detail the planning, execution and results obtained from the IPS.

Planning

4. The planning for this phase had commenced as early as Oct 87 when the various requirements for the equipment operation had been decided by experience at School Mil Svy and DSVY-A. The issue of Ref A in Dec 87 then allowed finalisation of planning for the conduct of the IPS survey.

5. Control Requirements. During planning for the operation of the IPS, cognizance had to be given to the following in relation to control position:

a. The amount and density of horizontal and vertical control already existing in the AO.

b. The requirement for the positioning of horizontal control by GPS to satisfy aerotrig requirements.

c. Adherence to Ref A,ie. no more than 60 km between control for 3rd order traverse specifications.

d. The order of control to be used from sub paras a. and b. above.

e. The requirement for vertical control every 6th photo model east-west and in the overlap of adjoining photo runs north-south within a 1:250 000 block at a photoscale of 1:65 000.

When all of the above was taken into account, the traverse configuration shown at Appendix 1 was adopted for observation by IPS. Traverse Identifiers K00001 to K00012 are taken from Ref A.

6. Hence, a traverse was to consist of, for example K00003 commencing at K880, out to OW038 and returning to the finish at K880. Control requirements for 3rd Order are satisfied by the placement of K894 in the centre of the traverse.

7. Coordinates for each of the horizontal control points were obtained from those observed by GPS and were provisional.

8. Equipment Requirements. Refs A and B detail the major aspects relevant to operation of the IPS. However, in planning the following major points had to be addressed:

a. IPS Mobility.LOH or Veh mounted? This is dependant on traverse length and terrain type. An AAAvn Kiowa was used for this op.

b. Equipment Endurance. Related to a. above, each traverse has to be completed in less than six hours before IPS system errors become too large and hence results degrading.

c. Alignment and realignment control points to be provided for system orientation.

d. Provision of refuel facilities for the veh being used and how power is to be supplied to the IPS when main supplies are cut.eg, LOH Hot Refuelling is not condoned by AAAvn.

e. Nature of Terrain. A requirement can exist for the clearing of LZ's in LOH operations.

9. The above considerations are given as a guide to planning for future IPS operations. They are not exhaustive and do not relate to other considerations such as acft and pilot fatigue, and also IPS operator fatigue after long traverses.

Execution

10. Equipment Tests and Calibrations. The following tests and calibrations were performed on IPS equipments prior to conducting traverses:

a. Simple Functional Test,

b. Navigation Performance Test - Static,

c. Navigation Performance Test - Dynamic, and

d. X - Gyro Calibration.

An Azimuth performance Test was not performed due to operational committments and adverse weather conditions preventing observation of an azimuth point.

11. Traverse Preparation. Prior to each traverse, a map and photo recon of the next days traverses was conducted by the operator to determine the following:

a. Steering coordinates to vertical and horizontal control points.

b. Refuel locations.

c. Existence of any prominent navigation features.

12. This aspect of pre-traverse preparation proved necessary on the operation. Knowledge of the terrain to be encountered beforehand is invaluable, and without the benefit of a prior ground recon this form of preparation becomes mandatory. Problems in navigation tend to compound themselves when travelling at 60 to 90 knots 500 feet off the ground, whilst also trying to drive the IPS itself.

13. Photo enlargements, at 1:15 000, of each vertical point to be obtained were used by the operator both for navigation and actually locating the control point for later image transfer.

14. Traverse Conduct. Traverses were conducted as described at para 6 to this report. The IPS was initially aligned at MOOMBA airstrip and then realigned at the traverse start point. Where possible, two traverses per day were completed.

15. Initially, the IPS operator sat in the rear of the LOH with a navigator in the front seat. This proved unsuccessful due to weight restrictions imposed by the LOH and on all further traverses, the operator sat in the front and fulfilled both roles of navigator and operator.

16. During a traverse, the photo enlargement was used to select the control position. This position was identified on the photo with a pin prick. A dumpy peg with panelling plastic attached was then hammered into the ground next to the Vehicle Reference Point (VRP). This served to provide a temporary mark for the point and a navigable target for the operator on the return leg.

Post Processing.

17. The post processing of the captured data did not present any major problems. It was noted however, that control points on the return leg of each traverse had to be held as CONTROL rather than REVISITS. Control file coordinates changed their value if revisits were assigned to the adjustment.

18. The provision of dust covers for the IBM micros and power boards is seen as a necessary addition to the CES for the IPS equipment. These articles need to accompany the equipment so that a measure of protection can be afforded and minimum power outlets utilised.

Results

19. The results obtained from the IPS in the field were those relevant to PROVISIONAL coordinates only. These were deemed acceptable with differences between forward and reverse observed coordinates being less than three meters in all axes.

20. Appendix 2 details the provisional results obtained for differences calculated from the ADJUSTED GPS observations. At this stage the results are being analysed by DSVY-A to determine equipment performance characteristics versus that of software performance in the results being obtained.

21. Ref A requires the actual differences between forward and reverse traverse coordinates, including meaned results in geographic and grid, to be forwarded to DSVY-A. The amendment of the IPS software to facilitate this task more easily is currently being undertaken by this unit.

Operational Problems.

22. Aircraft Suitability. During the IPS phase, the LOH used suffered from dust intrusion into the aircraft and also tail rotor wear. Both instances caused down time to repair the faults and it is believed AAAvn is addressing these problems now.

23. However, the fact that weight limitations are affecting both the performance of the aircraft and the IPS cannot be ignored. On several occassions the lift capability of the LOH was doubtful, even with one operator in the passenger seat. The configuration for the all up weight of the IPS and an operator does not vary greatly, no matter what the weight of the operator is, and therefore a larger lift capacity helicopter would be seen as necessary for future ops. If outside air temperatures are increased, the lift capability of the LOH with the IPS and 400 lb of fuel has to be deemed questionable and hazardous.

24. Fuel Positioning. Fuel positioning for IPS traverses was on two occassions found to be inaccurate. Fuel drums should be marked with panel plastic, different in colour to the surrounding terrain. Aborted traverses can be avoided if this is adhered to.

25. Flight Following. The flight following service for the operation was provided through Broken Hill. On several occassions it was necessary to maintain altitude for extended periods so that the pilot could advise Broken Hill of his location. It is recommended that the flight following service be given a brief on and copy of the traverse overlay prior to IPS operations.

Equipment Problems

26. Equipment problems resulting from the operation have been addressed in detail in separate reports provided by 2 Fd Svy and Syd Wksp Coy. Problems relevant to the power requirements for the total system came to light on the operation and these are to be rectified through further testing of the IPS. The provision of a light generator for power requirements during refuel is highly recommended.

27. IMU 103 displayed erroneous results during the operation and this unit has since been recommended for further extensive testing over both the Sydney and Hume Test Ranges. IMU 102 performed well throughout the operation.

SOP Developement

28. Suggested changes and/or amendments to SOP will be advised to School Mil Svy separately.

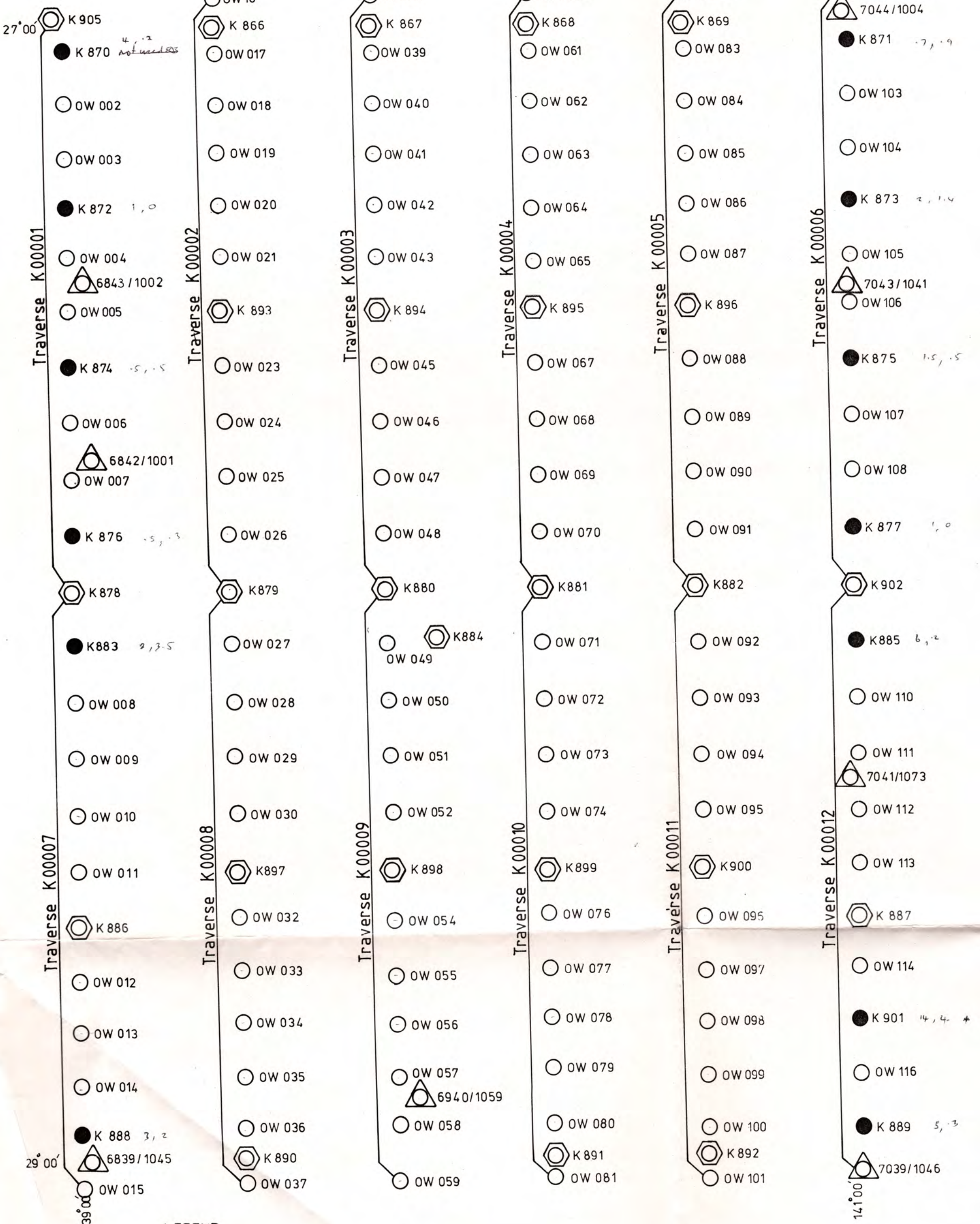
Conclusion

29. This operation was the first to employ the IPS and proved a learning experience for all concerned. The lessons learned will serve to reduce operational and equipment problems for future operations of this kind.

APPENDIX 1 TO
ANNEX D TO
OPAL WARRIOR 88
PROJECT REPORT

OPERATION OPAL WARRIOR

IPS TRAVERSE DIAGRAM



LEGEND

- Existing control
- GPS Point
- IPS Vertical
- IPS Horizontal

Compiled: SGT D.Stanmore

APPENDIX 2 TO
ANNEX D TO
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

SUMMARY OF PROVISIONAL TRAVERSE COORDINATES
MAXIMUM DIFFERENCES BETWEEN FORWARD AND REVERSE LEGS

TRAVERSE IDENTIFIER	DIFFERENCE		
	EASTING	NORTHING	HEIGHT
K00001	1.58	1.17	1.99
K00002	1.50	0.66	2.84
K00003	1.40	0.44	2.16
K00004	0.67	1.64	3.02
K00005	1.65	1.69	1.00
K00006	3.27	1.18	1.61
K00007	1.60	1.08	1.32
K00008	2.81	1.88	1.16
K00009	5.69	0.56	1.41
K00010	1.00	2.63	1.49
K00011	4.78	1.31	1.11
K00012	4.48	1.85	0.91

Note: All differences displayed are expressed in meters.

ARMY SURVEY REGIMENT
RECEIVED 17 FEB 89
Folio

MEMORANDUM

FROM: A FLD SVY SQN | FILE: C 851 - 2 - 19 | DATE: 16 FEB 89

REFERENCES: A TELECON STANFORD / KELLY of 15 FEB 89

ATTENTION: SSGT KELLY

TO: RSR

SUBJECT: OPAL WARRIOR 88 : IPS - FINAL COORDS

1. Results of IPS Traverses observed during OP OPAL WARRIOR 88 have been approved.
2. Final coordinates are unchanged from provisional coordinates previously despatched.
3. Enclosed are listings of final coordinates for each of the 12 traverses observed.

SSGT KELLY

Liaise with NO Lutwyche on filing of attached coord listings.
Place covering memo on file.

[signature]
23/2/89.

Enclosures: 1. 12 x IPS Summary of Final Coordinates

SIGNATURE: [signature] | NAME: P. C. DEMAINE | RANK: CAPT | APPOINTMENT: OPS OFFR | PHONE NO: 29[illegible]

REGT/MISC/1174

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00001
DATE : 9 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
[illegible]76	351947.58	6912944.98	26.86	0.94	0.65	0.28
OW007	351917.72	6923088.62	20.35	0.97	0.86	0.38
OW006	352001.42	6933825.61	22.05	1.58	1.17	1.24
K874	352159.59	6943952.23	23.31	0.82	0.87	1.70
OW005	351789.75	6954940.94	28.76	0.39	0.15	1.99
OW004	350891.90	6965773.18	35.99	1.31	0.08	0.37
K872	350970.04	6975524.11	25.76	1.29	0.37	0.00
OW003	351386.49	6986870.34	27.89	1.15	0.17	1.23
OW002	350566.46	6996454.17	43.15	0.98	0.08	1.31
K870	350438.60	7007103.52	59.65	0.13	0.29	0.30

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00002
DATE : 12 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
OW026	381925.89	6913449.53	33.06	0.35	0.01	2.21
OW025	381655.43	6923557.32	26.69	0.59	0.29	2.84
OW024	381511.34	6934534.03	22.77	0.48	0.17	2.38
OW023	381711.69	6944744.10	27.41	0.61	0.07	1.52
OW021	381089.12	6965232.03	35.83	1.50	0.66	1.44
OW020	381419.44	6975303.94	28.64	1.33	0.24	2.41
OW019	381481.58	6987490.24	33.03	0.71	0.12	1.52
OW018	380631.94	6997247.73	37.28	0.34	0.03	2.27
OW017	381047.69	7007825.88	43.62	0.16	0.50	2.12
OW016	380732.23	7016785.88	29.20	0.01	0.41	0.15

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88
DATE : 10 MAY 88

TRAVERSE : K00003
GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
OW048	411199.90	6913473.64	39.13	0.00	0.00	0.00
OW047	411447.25	6925133.71	34.30	0.00	0.00	0.00
OW046	411277.38	6934210.40	36.42	0.00	0.00	0.00
OW045	411293.83	6943746.05	41.84	0.00	0.00	0.00
OW043	411456.55	6966938.53	33.00	0.29	0.40	1.84
OW042	410913.21	6976565.34	26.64	0.08	0.44	2.16
OW041	411320.39	6987356.65	29.08	1.19	0.38	0.35
OW040	410707.01	6998200.99	31.39	1.40	0.26	0.95
OW039	410763.52	7008668.53	28.21	0.77	0.00	1.01
OW038	410652.15	7018047.61	28.24	0.07	0.06	0.04

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00004
DATE : 12 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
OW070	441170.67	6912424.14	40.86	0.02	0.82	0.73
OW069	440955.94	6922342.36	41.49	0.06	0.11	2.24
OW068	440923.14	6934566.67	51.32	0.65	0.20	1.65
OW067	440741.91	6945290.66	40.29	0.24	0.72	0.94
OW065	440551.28	6966189.70	41.26	0.39	1.64	3.02
OW064	440677.35	6977198.03	34.32	0.67	1.16	2.56
OW063	439933.68	6987722.85	35.31	0.42	0.10	0.19
OW062	440319.39	6997370.37	34.40	0.44	2.37	1.41
OW061	440393.46	7007948.25	33.89	0.09	0.63	0.56
OW060	440667.52	7018103.92	34.57	0.01	0.01	0.28

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88
DATE : 14 MAY 88

TRAVERSE : TRAVERSE K0
GRID K00005

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
(91	470407.29	6913359.41	58.08	10.42	4.38	2.22
OW090	470170.10	6924466.25	49.32	5.93	2.98	0.05
OW089	470528.13	6934439.33	49.47	2.56	3.17	2.58
OW088	470519.65	6946088.72	73.70	0.60	2.20	2.80
OW087	471009.83	6965998.49	72.83	0.97	1.42	0.55
OW086	470880.94	6975890.53	53.77	1.36	1.21	0.55
OW085	470476.55	6987616.28	45.42	1.65	0.30	0.58
OW084	470458.91	6997833.60	45.78	0.99	1.69	3.55
OW083	470456.07	7008215.84	41.62	1.56	1.06	1.00
OW082	470668.96	7018157.69	46.07	0.11	0.36	0.33

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00006
DATE : 15 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
K77	500028.20	6914221.08	76.96	1.29	1.18	0.48
OW108	499887.62	6923829.95	67.68	2.38	0.60	0.61
OW107	499751.41	6935279.92	55.99	3.27	0.32	0.33
K875	499832.52	6945668.98	63.34	2.52	1.01	0.02
OW106	499862.77	6956266.99	184.18	0.91	0.19	0.36
OW105	499826.93	6966073.74	117.76	0.47	1.25	1.15
K873	499832.72	6976387.93	189.06	0.66	0.52	0.88
OW104	499836.54	6987060.64	137.60	0.70	1.01	0.03
OW103	499824.29	6998050.62	111.11	0.04	0.33	0.60
K871	499826.80	7008325.14	81.50	0.02	0.26	1.61
OW102	499801.21	7016650.67	76.06	0.04	0.02	0.05

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00007
DATE : 9 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
K003	352587.83	6892098.95	20.27	1.12	0.76	0.72
OW008	352493.56	6881117.84	25.01	1.60	1.08	1.25
OW009	352970.25	6870265.97	20.32	1.54	0.03	1.98
OW010	352976.14	6859028.49	20.49	1.27	0.11	1.97
OW011	352522.07	6849353.03	18.80	0.81	0.10	1.03
OW012	353366.64	6827909.51	28.24	0.24	0.49	1.32
OW013	353777.66	6817087.74	22.28	0.40	0.74	0.94
OW014	353800.89	6807152.26	15.73	0.39	0.16	0.72
K888	353786.98	6796520.55	11.92	1.01	0.29	0.37
OW015	353529.50	6785661.44	17.37	0.00	0.00	0.43

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00008
DATE : 8 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
O 27	382063.97	6891534.67	26.13	1.19	1.09	0.78
OW028	382158.71	6880820.55	24.64	2.50	1.40	1.16
OW029	382215.10	6869858.36	25.42	2.81	1.78	1.15
OW030	382433.75	6859434.68	19.99	1.12	0.28	0.58
OW032	382863.48	6838867.96	23.66	0.02	1.88	0.83
OW033	383062.56	6828220.85	16.76	0.56	1.44	0.11
OW034	382661.84	6818375.98	22.70	0.65	1.27	0.73
OW035	383180.61	6806795.89	24.52	0.04	1.24	0.30
OW036	383240.74	6797156.84	25.02	0.58	0.10	0.49
OW037	382876.90	6785442.21	30.92	0.09	0.04	0.32

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00009
DATE : 12 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
Ow049	411295.89	6892169.39	31.47	3.19	0.56	0.31
OW050	411254.65	6880917.63	29.46	5.22	0.43	0.77
OW051	411889.71	6870565.19	40.39	5.69	0.21	1.41
OW052	411998.24	6860302.20	40.06	3.33	0.27	0.29
OW054	412297.28	6840252.22	27.18	0.20	0.22	0.47
OW055	411626.04	6829414.38	25.64	0.73	0.15	0.01
OW056	411712.73	6818350.65	22.90	0.79	0.20	0.92
OW057	411856.58	6807327.45	21.97	0.63	0.51	2.10
OW058	412604.83	6797586.03	21.63	1.50	0.21	0.21
OW059	412268.42	6785850.04	23.98	0.14	0.42	0.30

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00010
DATE : 13 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
OW071	220373.06	3445541.00	19.77440746.12%6891082.00			39.54
OW072	440868.38	6881390.24	44.69	0.30	0.86	0.47
OW073	440999.78	6870561.55	33.07	0.11	2.55	1.49
OW074	441157.76	6860526.15	32.22	0.07	1.14	1.07
OW076	441492.90	6838798.46	36.24	1.00	4.10	0.00
OW077	441396.91	6829772.64	35.45	0.77	1.12	0.64
OW078	441222.04	6818450.57	35.74	0.80	1.91	0.66
OW079	441335.49	6808258.72	41.92	0.46	2.63	0.42
OW080	441809.55	6796672.00	45.49	0.44	0.06	1.43
OW081	440930.13	6785839.41	44.20	0.07	0.22	0.14

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88 TRAVERSE : K00011
DATE : 17 MAY 88 GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
[illegible]92	469861.51	6892395.53	62.08	4.14	0.16	0.34
OW093	470652.60	6881907.01	62.85	4.78	0.82	1.11
OW094	470430.65	6872616.36	51.94	2.64	0.53	0.28
OW095	470475.37	6860775.54	44.91	1.79	0.47	0.56
OW096	471043.52	6839680.64	60.37	1.08	1.31	0.19
OW097	470308.80	6828681.58	48.74	1.87	0.93	0.47
OW098	471147.73	6818720.25	61.92	1.57	0.80	0.18
OW099	470893.13	6807926.21	56.51	1.65	2.29	1.00
OW100	471020.71	6797245.99	66.57	1.49	2.58	1.47
OW101	470612.33	6786509.53	69.52	0.05	0.01	0.32

INERTIAL POSITIONING SYSTEM

SUMMARY OF FINAL COORDINATES

MEAN RESULTS

OPERATION : OP OPAL WARRIOR 88
DATE : 17 MAY 88

TRAVERSE : K00012
GRID

POINT	EAST	NORTH	HEIGHT	DIFFERENCES E	N	Z
K 05	499539.09	6891946.24	86.40	4.42	0.04	0.91
OW110	499182.81	6881278.32	79.12	4.48	1.85	0.56
OW111	499436.25	6871594.09	79.83	2.52	0.02	0.88
OW112	499920.95	6860940.52	79.58	0.35	0.28	0.32
OW113	499809.48	6850985.87	84.75	1.32	0.32	0.53
OW114	500065.68	6829382.97	90.09	1.64	0.58	0.31
K901	499549.96	6818370.93	104.33	3.19	0.36	0.65
OW116	499798.80	6808928.45	116.26	2.17	0.02	0.08
K889	499685.16	6797788.44	109.42	2.13	0.22	0.65

DEFENCE COMMUNICATIONS NETWORK

DEFCOMMNET

SOUTH AUSTRALIAN REGION

ASACOMMCEN ADELAIDE
KESWICK BARRACKS
KESWICK S. AUST 5035
PHONE (08) 2939280
FAX (08) 2973079
TELEX ARMY AA82090

FACSIMILE TRANSMISSION

PRECEDENCE	DATE TIME GROUP	STATION SERIAL NUMBER
PRIORITY	Ø8 Ø2ØØ Z DEC 88	131
FROM	**No OF PAGES**	**FAX TRANSMISSION No**
4 FD SVY SQN	14	

ADDRESSEES	ADDRESSEES FAX No's
ARMY SURVEY REGIMENT	057 - 93 1154

SUBJECT: OP OPAL WARRIOR 88 - IPS RESULTS

TO BE DELIVERED TO: ARMY SVY REGT - ~~[illegible]~~ WO2 B.J. LUTWYCHE

IN REPLY QUOTE: R851-2-19

RELEASING OFFICERS NAME		PHONE No
[signature] CAPT		08-2939408
SIGNATURE	**RANK**	**DATE**
CAPT T. LORD	CAPT	8 DEC 88

MEMORANDUM

UNCLAS

Write or Print Clearly

From	File	Date	References
4 FD SVY SQN	R851-2-19	8 DEC 88	A. DSVY-A SIC 224 SVY024 DATED 300005Z NOV 88 B. TELECON CAPT LORD/WO2 LUTWYCHE OF 7 DEC 88

To	Attention
ARMY SVY REGT	WO2 LUTWYCHE

For information

Subject: OP OPAL WARRIOR 88 - IPS RESULTS

1. In accordance with Ref A attached find the provisional IPS coordinates resulting from OPAL WARRIOR.

2. As discussed at Ref B, these coordinates are to be confirmed by DSVY-A and until that time they are to be regarded as PROVISIONAL.

3. For your further action.

Signature	Name	Rank	Appointment	Phone No.
[signature] CAPT	T. LORD	CAPT	2IC/OPSO	2939408

SECURITY CLASSIFICATION

UNCLAS

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 9 MAY 88

TRAVERSE: K00001

POINT	EASTING	NORTHING	Ht	DIFFERENCES		
				E	N	Z
K876	351947.74	6912944.39	27.09	0.94	0.75	0.24
OW007	351918.01	6923087.57	20.75	1.00	0.99	0.33
OW006	352001.77	6933824.32	22.60	1.59	1.19	1.24
K874	352159.82	6943951.39	23.66	0.83	0.88	1.70
OW005	351789.91	6954940.38	28.97	-0.37	0.17	2.00
OW004	350891.79	6965772.82	36.09	1.69	0.03	0.51
K872	350969.50	6975524.14	25.55	2.30	0.55	0.36
OW003	351385.46	6986870.96	27.29	2.79	0.48	1.83
OW002	350585.07	6996454.86	42.39	3.31	0.43	2.16
K870	350436.81	7007104.55	58.61	2.82	0.13	1.37

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 TRAVERSE: K00002
DATE: 12 MAY 88

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW026	381925.87	6913449.54	33.06	0.42	0.01	-2.20
OW025	381655.43	6923557.32	26.89	0.62	-0.28	-2.84
OW024	381511.35	6934534.04	22.78	0.50	-0.17	-2.38
OW023	381711.70	6944744.10	27.41	0.63	-0.07	-1.52
OW021	381088.63	6965232.00	35.87	2.16	-0.59	1.35
OW020	381418.85	6975303.88	28.73	2.64	0.38	2.24
OW019	381480.61	6987490.15	33.19	2.78	0.33	1.23
OW018	380630.62	6997247.60	37.49	2.41	0.26	1.87
OW017	381045.97	7007825.71	43.90	3.33	0.84	1.58
OW016	380729.83	7016785.63	29.56	0.77	-0.33	-0.28

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 TRAVERSE: K00003
DATE: 10 MAY 88

POINT	EASTING	NORTHING	Ht.	DIFFERENCES E	N	Z
OW048	411200.09	6913473.63	39.15			
OW047	411447.55	6926133.69	34.29			
OW046	411277.67	6934210.40	36.43			
OW045	411294.03	6943746.06	41.86			
OW043	411455.71	6966938.53	32.84	2.23	0.51	-1.44
OW042	410911.59	6976565.22	26.33	4.16	0.73	-1.45
OW041	411317.88	6987356.50	28.59	4.69	0 78	0.67
OW040	410703.60	6998200.70	30.71	5.95	0.84	2.28
OW039	410759.24	7008668.18	27.36	7.88	0.73	2.67
OW038	410647.30	7018047.22	27.30	1.35	0.17	0.21

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 TRAVERSE: K00004
DATE: 12 MAY 88

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW070	441170.72	6912424.13	40.88	-0.05	-0.83	-0.74
OW069	440956.02	6922342.34	41.52	-0.13	-0.08	-2.28
OW068	440923.16	6934566.66	51.35	0.04	0.21	-1.07
OW067	440741.93	6945290.65	40.30	0.29	0.71	-0.92
OW065	440550.62	6956169.87	41.17	0.97	1.72	-2.86
OW064	440675.88	6977197.94	34.14	2.37	1.37	-2.22
OW063	439931.39	6987722.65	35.05	4.33	0.25	0.35
OW062	440316.48	6997370.14	34.07	6.40	2.78	-0.71
OW061	440389.72	7007947.96	33.47	7.47	1.19	0.31
OW060	440662.56	7018103.63	33.95	1.78	0.13	-0.08

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 14 MAY 88

TRAVERSE: K00005

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW091	470411.85	6913359.08	58 56	2.13	-3.74	-3.13
OW090	470173.33	6924465.99	49 68	0.12	-2.48	-0.63
OW089	470530.32	6934439.20	49.71	-1.19	-2.91	2.13
OW088	470520.61	6946088.69	73.80	-0.92	-2.11	2.60
OW087	471009.10	6965888.49	72.74	2.99	1.51	-0.37
OW086	470879.50	6975890.44	53.59	4.95	1.53	0.88
OW085	470474.22	6987616.05	45.14	6.84	0.88	-0.09
OW084	470455.89	6997833.18	45.41	5.41	2 65	-2.89
OW083	470452.42	7008215.09	41.18	5.77	2.68	-0.18
OW082	470663.58	7018156.81	45.41	1.16	0.62	-0.18

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 **TRAVERSE:** K00006
DATE: 15 MAY 88

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
K877	500028.20	6914221.08	76.96	1.25	-1.18	-0.48
CW108	499887.62	6923829.95	67.69	2.34	-0.60	-0.61
CW107	499751.40	6935279.94	55.98	3.22	-0.33	-0.32
K875	499832.50	6945669.00	63.33	2.47	-1.00	-0.01
CW106	499862.74	6956267.02	184.16	0.88	-0.19	0.36
CW105	499826.85	6966073.74	117.68	-0.33	-1.24	1.31
K873	499832.55	6976387.94	188.89	-0.36	0.51	-0.52
CW104	499836.27	6987060.64	137.31	1.20	1.00	0.60
CW103	499823.91	6998050.62	110.71	0.68	-0.33	1.40
CW102	499800.43	7016650.65	75.24	0.05	-0.01	0.04
K871	499826.31	7008325.14	81.00	0.98	0.28	2.63

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 TRAVERSE: K00007
DATE: 9 MAY 88

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
K883	352587.84	6892098.96	20.29	-1.09	0.76	0.68
OW008	352493.56	6881117.84	25.01	-1.56	1.08	1.24
OW009	352970.26	6870265.98	20.33	-1.47	0.03	1.95
OW010	352976.14	6859028.49	20.48	-1.21	-0.11	1.97
OW011	352522.06	6849353.03	18.80	-0.78	-0.11	1.07
OW012	353366.45	6827909.45	28.16	0.65	0.63	1.49
OW013	353777.28	6817087.60	22.09	1.21	1.03	1.27
OW014	353800.33	6807152.08	15.46	1.52	0.57	1.24
K888	353786.23	6796520.28	11.56	2.52	0.27	0.29
OW015	353628.52	6785661.07	15.85	0.20	0.08	-0.36

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 8 MAY 88

TRAVERSE: K00008

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW027	382063.97	6891534.67	26.13	1.19	1.09	0.78
OW028	382158.71	6880820.55	24.84	2.60	1.40	1.16
OW029	382215.10	6869858.36	25.42	2.81	1.78	1.15
OW030	382433.75	6859434.68	19.99	1.12	0.28	0.58
OW032	382863.48	6838867.96	23.66	0.02	1.88	0.83
OW033	383062.56	6828220.85	16.76	0.56	1.44	0.11
OW034	382861.84	6818375.98	22.70	0.65	1.27	0.73
OW035	383180.61	6806795.89	24.52	0.04	1.24	0.30
OW036	383240.74	6797156.84	25.02	0.58	0.10	0.49
OW037	382876.90	6785442.21	30.92	0.09	0.04	0.32

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 12 MAY 88

TRAVERSE: K00009

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW049	411295.93	6892169.44	31.47	-3.21	-0.58	0.31
OW050	411254.74	6880917.68	29.46	-5.27	-0.46	-0.78
OW051	411889.78	6870565.24	40.40	-5.86	0.12	-1.41
OW052	411998.23	6860302.21	40.06	-3.50	-0.36	0.28
OW054	412297.40	6840252.23	27.17	-0.39	-0.23	-0.44
OW055	411626.27	6829414.35	25.61	-1.11	0.12	0.06
OW056	411713.08	6818350.61	22.87	-1.39	-0.25	0.99
OW057	411857.04	6807327.40	21.92	-1.45	-0.56	2.20
OW058	412605.50	6797586.04	21.56	0.90	-0.23	-0.12
OW059	412269.47	6785850.20	23.93	0.01	0.42	-0.29

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88 TRAVERSE: K00010
DATE: 13 MAY 88

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW071	440746.14	6891081.98	39.54			
OW072	440868.38	6881390.23	44.69	-0.25	-0.89	-0.47
OW073	440999.78	6870561.55	33.08	-0.05	-2.56	-1.49
OW074	441157.77	6860526.15	32.23	-0.03	1.15	-1.07
OW076	441492.82	6838798.48	36.19	1.23	-4.08	0.10
OW077	441396.78	6829772.65	35.36	1.14	1.10	-0.46
OW078	441221.81	6818450.57	35.59	1.36	1.80	-0.36
OW079	441335.17	6808258.71	41.71	1.18	2.65	0.84
OW080	441809.14	6798671.98	45.23	0.43	0.08	1.97
OW081	440929.63	6785839.47	43.66	0.05	0.24	-0.06

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 17 MAY 88

TRAVERSE: K00011

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
OW092	469861.52	6892395.53	62.08	-4.09	-0.18	-0.35
OW093	470652.60	6881907.01	62.85	-4.74	0.82	-1.12
OW094	470430.68	6872616.35	51.96	-2.62	0.54	0.23
OW095	470475.36	6860775.54	44.93	-1.80	0.46	0.58
OW096	471043.26	6839680.64	60.36	-0.49	1.30	-0.17
OW097	470308.24	6828681.59	48.72	-0.65	0.91	0.51
OW098	471146.87	6818720.26	61.89	0.24	-0.82	0.23
OW099	470891.98	6807926.23	56.47	0.71	-2.32	1.09
OW100	471019.28	6797246.02	66.50	1.40	-2.63	1.58
OW101	470610.36	6786509.59	69.39	0.56	-0.01	-0.30

INERTIAL POSITIONING SYSTEM
SUMMARY OF PROVISIONAL COORDINATES
GRID

OPERATION: OP OPAL WARRIOR 88
DATE: 17 MAY 88

TRAVERSE: K00012

POINT	EASTING	NORTHING	Ht	DIFFERENCES E	N	Z
K885	499537.94	6891945.86	86.48	-4.00	0.14	0.91
OW110	499181.64	6881277.94	79.20	-3.82	-1.69	0.55
OW111	499432.25	6871592.82	80.08	-2.39	0.09	0.88
OW112	499915.22	6860938.70	79.94	-0.13	0.41	0.30
OW113	499806.72	6850985.00	84.93	-0.78	0.54	0.47
OW114	500063.38	6829382.33	90.27	2.28	0.56	-0.37
K901	499549.93	6818371.12	104.41	4.53	-0.39	-0.77
OW116	499796.89	6808928.18	116.47	4.22	0.04	-0.28
K889	499683.43	6797788.32	109.66	5.01	0.25	-0.90

ANNEX E TO
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

AERIAL PHOTOGRAPHY REPORT

Reference: A. Our SIC SIC Z27 SVY 145 dated 04015Z Jul 88

1. General. Identification photogrphy of horz and vert stations was conducted during the period 2 May to 11 May 88. Photography was acquired using a WILD RC10 Camera Number 1465, with a SAG II lens Number 2006. The camera was mounted in a Pilatus Porter acft Number A140687.

2. Results. The fol results were achieved:

a. Identification Photography.

(1) Fifty two stations were photographed of which 12 were previously established. Two stations were Bench Marks BM 11177 and BM 1450. The remaining thirty eight stations are now established, with Appendixes 1 and 2 to this report detailing actual locations within the AO.

(2) Each ident station was photographed with at a minimum, 3 exposures and greater than sixty percent forward overlap. The flying altitude was 9,600 feet above ground level.

3. Personnel. The following personnel were involved:

a. Porter Pilot - CAPT D. Carroll,

b. Porter Mech - CPL D. Ellaby, and

c. RC10 Operator - CPL R. Graf.

4. Processing. Processing was carried out in a shower/toilet facility within the main base accn at MOOMBA. Use was made of B5 tanks. Drying of film was done on a string line. After acceptance of the photography, steno bromides were produced and annotated with station location and number.

5. Dispatch. Developed RC10 film and accompanying A36 photographic reports were dispatched by safe hand to CPE Laverton for remedial processing as necessary.

6. Equipment Problems. The following equipment problems were encountered:

a. Fiducial illumination faulty. One mark intermittently missing on exposure.

b. Shutter speed very slow in reaching the desired setting. The setting was difficult to maintain and drifted requiring constant monitoring.

c. Circuit panel to Number 2A was considered faulty and replaced with panel Number 2.

These faults have been advised to Syd Wksp Coy at Ref A.

Appendices: 1. Identification Photography Summary

2. OPERATION OPAL WARRIER - Ident Photography INNAMINCKA/STRZELECKI BLOCK

APPENDIX 1 TO
ANNEX E TO
PROJECT REPORT
DATED 9 AUG 88

IDENT PHOTOGRAPHY SUMMARY

Serial	Station Number	Lat/Long	Flight Direct	Date Flown	Mission Number	Frame Nos
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	K889	28°57' 141°00'	E	2 May 88	325	0001-0003
2	7039/1046	29°03' 141°00'	W	2 May 88	325	0004-0006
3	7039/1045	29°01' 141°00'	W	2 May 88	325	0007-0009
4	K892	29°01' 140°42'	W	2 May 88	325	0010-0012
5	K891	29°00' 140°24'	W	2 May 88	325	0013-0015
6	6939/1053	29°01' 140°07'	W	2 May 88	325	0016-0018
7	K890	29°00' 139°48'	W	2 May 88	325	0019-0021
8	6839/1045	29°00' 139°32'	W	2 May 88	325	0022-0024
9	K888	28°57' 139°30'	E	2 May 88	325	0025-0027
10	6940/1059	28°53' 140°08'	E	2 May 88	325	0028-0030
11	K887	28°34' 141°00'	W	2 May 88	325	0031-0033
12	K900	28°28' 140°42'	W	2 May 88	325	0034-0036
13	K899	28°28' 140°24'	W	2 May 88	325	0037-0039
14	K898	28°28' 140°06'	W	2 May 88	325	0040-0042
15	K897	28°09' 139°48'	W	2 May 88	325	0043-0045
16	6741/1002	28°23' 139°30'	W	2 May 88	325	0046-0048
17	K884	28°06' 140°12'	E	2 May 88	325	0049-0052
18	K896	27°32' 140°42'	W	5 May 88	327	0001-0003
19	K895	27°31' 140°24'	W	5 May 88	327	0004-0006
20	K894	27°32' 140°06'	W	5 May 88	327	0007-0009
21	K893	27°31' 139°48'	W	5 May 88	327	0010-0012
22	6843/1002	27°28' 139°31'	W	5 May 88	327	0013-0015
23	7044/1004	26°59' 141°00'	W	5 May 88	327	0016-0018
24	K869	27°00' 140°41	W	5 May 88	327	0019-0021
25	K868	27°00' 140°24'	W	5 May 88	327	0022-0024
26	K867	27°00 140°06'	W	5 May 88	327	0025-0027
27	K866	27°00' 139°48'	W	5 May 88	327	0028-0030
28	BM1450	26°48' 139°36'	W	5 May 88	327	0031-0033
29	K870	27°03' 139°00'	E	5 May 88	327	0034-0036
30	K885	28°04' 141°00'	S	7 May 88	328	0010-0012
31	K902	28°00' 141°00'	N	7 May 88	328	0013-0015
32	K877	27°54' 141°00'	N	7 May 88	328	0016-0018
33	7043/1041	27°30' 141°00'	N	7 May 88	328	0019-0021
34	K873	27°20' 141°00'	N	7 May 88	328	0022-0024
35	K871	27°03' 141°00'	N	7 May 88	328	0025-0027
36	7044/1004	27°00' 141°00'	N	7 May 88	328	0028-0030
37	6842/1001	27°47' 139°33'	E	7 May 88	328	0031-0033
38	K876	27°54' 139°30'	E	7 May 88	328	0034-0036
39	K879	27°59' 139°48'	E	7 May 88	328	0039-0041
40	K880	28°00' 140°05'	E	7 May 88	328	0042-0044
41	K881	28°00' 140°24'	E	7 May 88	328	0045-0047
42	K881	28°00' 140°24'	E	7 May 88	328	0048-0050
43	K882	28°00' 140°42'	E	7 May 88	328	0051-0053
44	K902	28°00' 141°00'	E	7 May 88	328	0054-0056
45	K877	27°54' 141°00'	W	7 May 88	328	0057-0059
46	K875	27°37' 141°00'	N	7 May 88	328	0060-0062

Serial	Station Number	Lat/Long	Flight Direct	Date Flown	Mission Number	Frame Nos
(a)	(b)	(c)	(d)	(e)	(f)	(g)
47	K875	27°37' 141°00'	E	7 May 88	328	0063-0065
48	7043/1041	27°30' 141°00'	W	7 May 88	328	0066-0068
49	K874	27°37' 139°30'	E	8 May 88	329	0001-0003
50	K874	27°37' 139°30'	S	8 May 88	329	0004-0006
51	K876	27°54' 139°30'	S	8 May 88	329	0007-0009
52	K878	27°59' 139°30'	S	8 May 88	329	0010-0012
53	K883	28°05' 139°30'	S	8 May 88	329	0013-0015
54	6741/1002	28°23' 139°29'	S	8 May 88	329	0016-0018
55	K886	28°34' 139°30'	S	8 May 88	329	0019-0021
56	K886	28°34' 139°30'	E	8 May 88	329	0022-0024
57	6840/1043	28°45' 139°30'	S	8 May 88	329	0025-0027
58	6840/1043	28°45' 139°30'	E	8 May 88	329	0028-0030
59	K888	28°57' 139°30'	N	8 May 88	329	0031-0033
60	K883	28°05' 139°30'	E	8 May 88	329	0034-0036
61	K878	27°59' 139°30'	E	8 May 88	329	0037-0039
62	6843/1002	27°28' 139°31'	N	8 May 88	329	0040-0042
63	K872	27°20' 139°30'	N	8 May 88	329	0043-0045
64	K872	27°20' 139°30'	E	8 May 88	329	0046-0048
65	K870	27°03' 139°30'	N	8 May 88	329	0049-0051
66	K870	27°03' 139°30'	E	8 May 88	329	0052-0054
67	K905	26°57' 139°27'	E	8 May 88	329	0055-0057
68	K871	27°03' 141°00'	E	8 May 88	329	0058-0060
69	BM11177	26°59' 141°07'	W	8 May 88	329	0061-0063
70	K873	27°20' 141°00'	E	8 May 88	329	0064-0066
71	7039/1046	29°03' 141°00'	N	11 May 88	330	0001-0003
72	K889	28°57' 141°00'	N	11 May 88	330	0004-0006
73	K901	28°46' 141°00'	N	11 May 88	330	0007-0009
74	K901	28°46' 141°00'	E	11 May 88	330	0010-0012
75	K887	28°34' 141°00'	N	11 May 88	330	0013-0015
76	K885	28°04' 141°00'	E	11 May 88	330	0016-0018
77	7041/1073	28°19' 141°00'	E	11 May 88	330	0019-0021
78	7041/1073	28°19' 141°00'	N	11 May 88	330	0022-0024

MISSION NO :

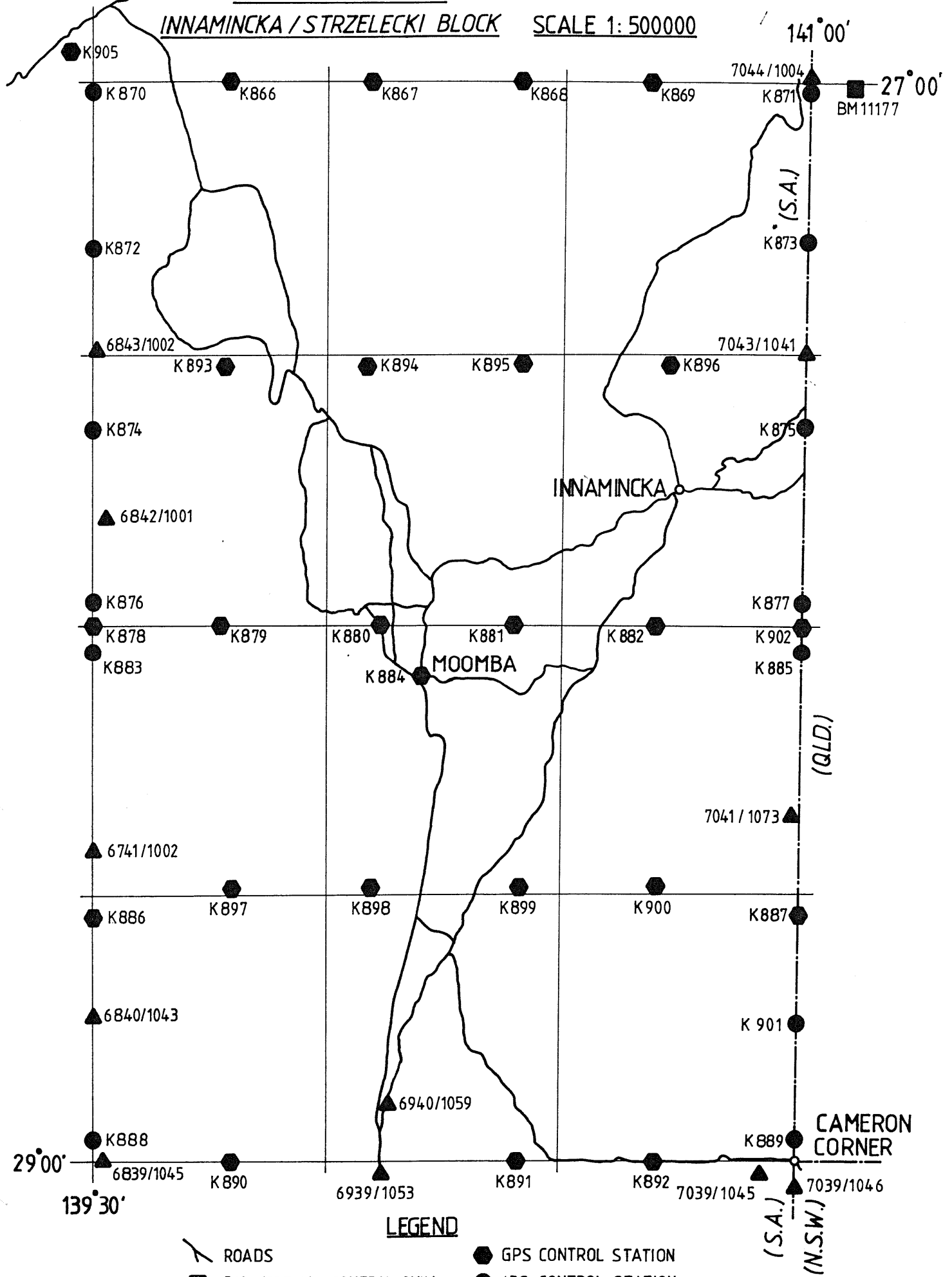
325
327 TO 330

CPE NO :

33483
33484 TO 33487

OPERATION OPAL WARRIOR
IDENT PHOTOGRAPHY
INNAMINCKA / STRZELECKI BLOCK

SCALE 1: 500000

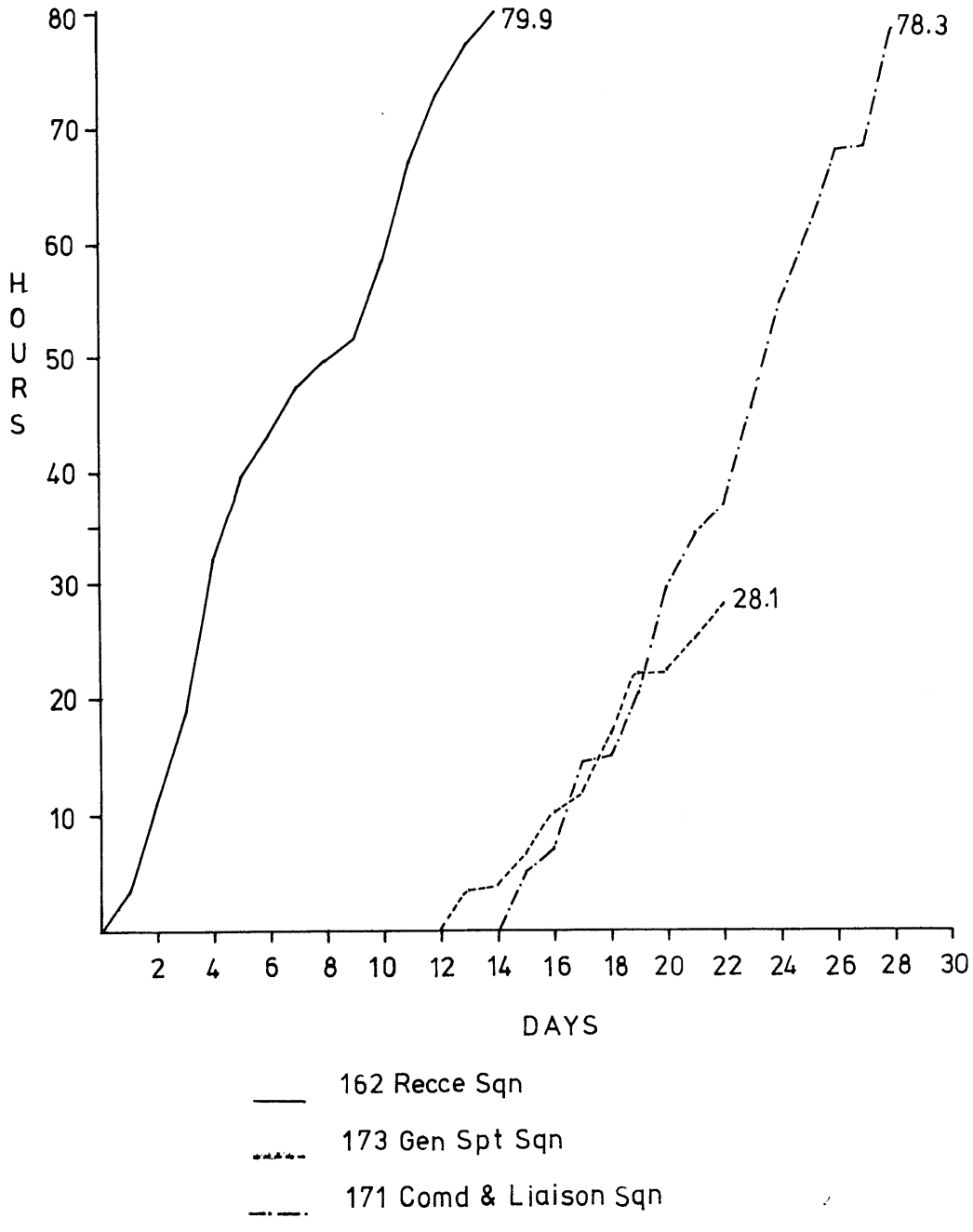


LEGEND

- ROADS
- BM VERTICAL CONTROL ONLY
- BM HOR/VER CONTROL STN
- GPS CONTROL STATION
- IPS CONTROL STATION
- ESTABLISHED CONTROL STN

ANNEX F TO
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

AIRCRAFT USAGE RATES



ANNEX G TO
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

NOMINAL ROLL

1. The following personnel were involved in OP OPAL WARRIOR 88:

REGT NO	RANK	NAME	UNIT
227126	CAPT	T. LORD	4 FD SVY SQN
157511	WO2	A.B. VAN LEEUWEN	"
318928	SSGT	M.J. HOGAN	"
219056	SGT	W.J.C. CHILCOTT	"
1203980	SGT	D. STANMORE	"
F63145	SGT	G.D. PARK	"
2790227	CPL	R.D. GRAF	"
319893	CPL	H.J. MCRAE	"
4401491	LCPL	P. LANGEBERG	"
31355	SPR	S.A. NOKES	"
179773	CAPT	D.W. SANKEY	2 FD SVY SQN
1202701	WO2	R.H. GILLIES	"
6708956	SSGT	B.J. LUTWYCHE	ARMY SVY REGT
282019	CAPT	M.H. SEDSMAN	162 RECCE SQN
222335	LT	C.J. BUTLER	"
58483	CPL	M.A. BANNISTER	"
3200006	CFN	C.M. PIELE	"
4401617	CAPT	D. CARROLL	173 GEN SPT SQN
181852	CPL	D. ELLABY	"
	CAPT	W.J. JOHNSON(US)	171 C & L SQN
453095	LT	D. FAWCETT	"
62626	CPL	J. COAD	"
232793	CFN	T. FORD	"
4400557	CFN	C.J. LOOKER	ADEL WKSP COY
224684	SGT	R.M. CHAPMAN	SYD WKSP COY
317645	SGT	E.F. CARPENTER	"
321563	LCPL	R.S. NEWLAND	"
227566	CFN	J.R. LOHMANN	"

ANNEX H TO
4 FD SVY SQN
PROJECT REPORT
OP OPAL WARRIOR 88
DATED 19 AUG 88

OP OPAL WARRIOR 88
Financial Expenditure

ITEM (a)	AMOUNT $ (b)	REMARKS (c)
Travel Allowance	4217-00	
Incidentals	4397-00	
Fares	3573-00	
Rations and Accn	20880-00	Accn at MOOMBA incl all meals.
Field Rations	1563-51	Rats supplied to field parties.
Sub Total	34630-51	
Freight and Cartage	2613-90	
POL		
MSP (4827-05 litres)	3137-58	0.65 cents/litre
Dieso (2149.78 litres)	1182.38	0.55 cents/litre
AVTUR (14380 litres) (6200 litres) (1000 litres)	6954.17 2998.32 803.60	Bulk from MOOMBA Drummed Fuel Drummed fuel not retrieved from field
Sub Total	15076.05	
Petty Cash	26-05	
TOTAL	52346-51	