GOVERNMENT OF SAMOA

SAMOA SECOND INFRASTRUCTURE AND ASSET MANAGEMENT PROJECT (SIAM II)

COMPONENT 5.01: LAND ADMINISTRATION & SURVEY

SAMOAN GEODETIC NETWORK

UPGRADE ACTION PLAN

TECHNICAL ASSISTANCE REPORT NO. 11

SUBMITTED TO

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1.0	22 May 05	Initial Draft submitted to MNREM	A Dyson
2.0	16 August 05	Amended in response to MNREM feedback and changes to proposed GPS training.	A Dyson

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ABBREVIATIONS & ACRONYMS

BM	Bench Mark
CGPS	Continuous Global Positioning System
GA	Geodetic Adviser
GoS	Government of Samoa
GPS	Global Positioning System
ITRF	International Terrestrial Reference Framework
MNREM	Ministry of Natural Resources, Environment & Meteorology
MSL	Mean Sea Level
MWTI	Ministry of Works, Transport and Infrastructure
NSA	National Survey Adviser
NTF	National Tidal Facility (Australia)
PCGIAP	Permanent Committee on GIS Infrastructure for Asia and the Pacific Region
PS	Principal Surveyor
PUMA	Planning & Urban Management Agency
SGRS	Samoan Geodetic Reference System
SIAM-2	Second Infrastructure Asset Management Project
SLC	Samoa Land Corporation
SPSLCMP	South Pacific Sea Level & Climate Monitoring Project
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984

1. INTRODUCTION

1.1 Summary

This report has been prepared as part of the Government of Samoa (GoS) Second Infrastructure Asset Management Program (SIAM-2), Component 5.01 - Sustainable Management, Land Administration and Survey (the Project).

Within the project, Component 1 – Survey & Geographic Information will provide Samoa with a survey and geographic information system which supports the management of the environment, national emergencies and sustainable management of land and natural resources.

The Geodetic Survey sub-component will provide a single strengthened and unified geodetic reference framework capable of supporting land information integration with particular application to cadastral boundaries.

This report provides an action plan for the upgrading of the Samoan Geodetic Network. It follows on from, and should be read in conjunction with *Technical Assistance Report No. 6 - Samoan Geodetic Network Initial Review & Options for Upgrade*. This report should be regarded as a working guide to the upgrade process and will be subject to change as the project progresses. Recent amendments have been made to reflect the timing of the GPS training to be presented by the supplier of the GPS equipment because they were unable to provide the training at the time requested.

The report includes specifications for each level of the network. Specifications are provided for the construction of monuments.

Reconnaissance and monumentation activities have been completed for the Primary Network and Secondary Networks.

A timeframe of activities to complete the upgrade of the geodetic network and responsibilities for these activities is included together with some of the logistical details.

Finally a training needs plan is presented.

No recommendations are made for the vertical network pending a response from MNREM to the recommendations in *Technical Assistance Report No. 6 - Samoan Geodetic Network Initial Review & Options for Upgrade*.

This report was prepared by Mr Andrew Dyson, Team Leader/Geodetic Adviser, with the assistance of staff of Ministry of Natural Resources, Environment & Meteorology. In particular, the assistance of Mr Ueligitone Seiuli, Principal Surveyor.

National Survey Adviser, Mr Seve Keilani Soloi provided invaluable input and support for activities associated with the preparation of this report.

2. GEODETIC NETWORK SPECIFICATIONS

2.1 Horizontal Network

The recommended specifications for the different levels of the upgraded geodetic network are based on the US Federal Geodetic Control Committee's document *Geometric Geodetic Accuracy Standards & Specifications for Using GPS Relative Positioning Techniques*.

The following relative positioning standards apply at the 95 percent confidence level:

First Order	10 parts per million;
Second Order	20 parts per million;
Third Order	50 parts per million;

The order is verified by an analysis of the minimally constrained least squares adjustment of the network and taking into account the standard of the field techniques employed. Factors to consider are: the type of GPS equipment used; length of observations; connections to control points of equal or higher order; the number of independent observations; and the observation technique. This information will be detailed in the *GPS Guidelines* to be produced at a later stage.

3. SPACING & LOCATION OF CONTROL MARKS

3.1 Horizontal Network

Recommendations were provided in the *Samoan Geodetic Network Initial Review & Options for Upgrade – Technical Assistance Report No 6* regarding the proposed spacing of control points for the upgraded geodetic network. In accordance with the recommendations, reconnaissance activities have been conducted to relocate marks from the existing Primary Network on Upolu and Savai'i and for the selection of new control points to achieve a spacing of approximately 15 kilometres. In addition, reconnaissance has been completed for the Secondary Network in the Salelologa area of Savai'i and for Apia.

A field inspection was carried out in Apia to determine the likely extent of the Tertiary Network and density of marks.

3.1.1 Primary Network

The recommended spacing for marks in the Primary Network is at approximately 15km around the coastline of the two main islands of Upolu and Savai'i.

It is proposed that the two Continuous GPS (CGPS) stations at Faleolo Airport and the old Fagali'i Airport be incorporated into the upgraded geodetic network. Coordinates from these two sites will provide International Terrestrial Reference Framework (ITRF) coordinates and the tectonic plate movement vectors to be incorporated into the coordinates of the new Samoan Geodetic Reference System (SGRS). Data will be required from both sites during the period of the observations.

With the closure of Fagali'i Airport and suggestions to sell the land it is important that measures are taken to ensure that the CGPS installation is protected from development. The site itself and sufficient land to maintain access and protection for the facility should be retained in government ownership. Of equal importance, if the site is to remain viable and collect worthwhile data, is that

any future development surrounding the site should not interfere with satellite visibility or be of such a form that it creates the potential for multi-path.

Multi-path occurs when signals from the satellites are reflected from nearby objects onto the antenna. The delay in the arrival of the reflected signal causes inaccuracies in determining the time taken for the signal to reach the antenna and hence the distance to the particular satellite which in turn degrades the precision of the position determination.

The Principal Surveyor has consulted with Geoscience Australia to determine their exact requirements regarding the maximum permitted elevation angle for any obstructions and the requirements to minimise the possibility of multi-path. Arrangements are being made to construct a fence around the installation.

The location of marks in the Primary Network is to be found on the map in Appendix 1.

For Upolu, preliminary reconnaissance activities located seven old control points that are considered suitable for new Primary Network stations. Further reconnaissance was conducted on 20th & 21st April to select the locations for four new points. Together with the CGPS stations there will be 13 primary stations on Upolu.

For Savai'i preliminary reconnaissance activities located 7 old control points that are considered suitable for new Primary Network stations. Further reconnaissance was conducted from 26th – 28th April. Another two existing points were selected as suitable together with the locations for 3 new points. This gives a total of 12 primary stations on Savai'i.

3.1.2 Secondary Network

Second order control will be provided in areas where tertiary control is to be established. There is no specific requirement for second order control, but it will be provided to facilitate efficient GPS operations in establishing the tertiary control.

Second order points should be provided as close to the particular third order project as possible. They are used as the reference stations to extend the third order control throughout the project. The suggested spacing of second order control points is a maximum spacing of 5km throughout the tertiary network areas. A maximum spacing of 5km enables greater efficiencies in the GPS observations for the tertiary network than if the spacing were to be increased because shorter observations are possible. The length of observations will be dependent upon the number of satellites available at the time of observation.

The second order control points must be selected in locations with optimum satellite visibility, any obstructions at these points will seriously affect the quality of the third order observations because fast-static techniques will be used. Using this technique, only short observations are conducted at each tertiary point and it is vitally important that unbroken data is collected by the GPS receiver at the reference station throughout the observation.

If possible the second order control should be established over a fairly wide area in one operation so that it can be observed and adjusted as one discrete area, rather than as a number of small individual projects.

It is estimated that about five or six new second order control points will be required in Apia. Data will be required from the Fagali'i CGPS site during the Apia observations.

For any future tertiary network activities in Salelologa two second order points are required to supplement the primary control point north of the town. Two existing control points were selected as suitable during the recent reconnaissance activities on Savai'i.

3.1.3 Apia Tertiary Network

Given that the majority of surveys are conducted in Apia, the priority for establishing tertiary control is within Apia. The recommended spacing for marks in the Apia tertiary network is approximately 250m spacing, with the proviso that where appropriate the spacing between marks may be increased. Within the central business district it may be appropriate to reduce this spacing.

From the field inspections it is apparent that residential development extends over a quite considerable area. An indication of the area to be covered by the tertiary network can be seen by referring to the map in Appendix 2. This is a copy of the *Apia Physical Framework Plan 2003-2013* provided by the Planning & Urban Management Agency (PUMA) formerly a part of MNRE but now part of MWTI. The area defined as the "Settlement Area" approximates the area designated for the Apia Tertiary Network.

It is estimated that about 450 tertiary network marks will be required throughout the whole of Apia.

The aims of the tertiary network are to:

- spatially locate all surveys and the cadastre to support the integration of all land related information; and
- control the position extent and orientation of surveys to prevent the creation of gaps and overlaps.

It was intended that a usable system would be in place in Apia by the conclusion of the project so that MNREM and private sector surveyors would be able to connect their surveys to the new network and hence all surveys will be on the new datum. To achieve these aims it was essential that every effort be made to incorporate the existing cadastral reference marks into the tertiary network. The placement of new marks would be restricted to locations where no existing cadastral marks could be recovered.

Accordingly, significant effort was required to conduct a comprehensive office search of all survey plans in the tertiary network area and the grouping of all information about surveys and survey marks. Apia was to be divided into a number of manageable areas for the searching.

After the office search has been completed for each area it is necessary to conduct a field inspection to locate the survey marks and then to select the most appropriate marks for inclusion in the tertiary network. Once this preliminary search and reconnaissance is complete the locations for any new marks can be selected.

Any other existing survey marks should be considered for incorporation into the tertiary network. Of particular importance are the deep BMs from the SEAFRAME tide gauge BM array and any other BMs as these will assist in the extension of heights throughout the tertiary network.

To ensure that the Apia Tertiary Network could be completed during project implementation it was imperative that Survey Section allocate sufficient resources to the office and field searching activities. The adviser requested that staff be allocated on a full time basis or there was a serious risk that the searching would not be completed in time for the GPS observations to be made under the guidance of the Geodetic Adviser.

3.1.4 Salelologa Tertiary Network

The recommended spacing for marks in the Salelologa tertiary network is approximately 250m, with the proviso that where appropriate the spacing between marks may be increased. The area

suggested is the existing developed area of the town and the area that has been subdivided for future development.

Procedures similar to those described above for Apia, will be required.

4. MONUMENT SPECIFICATIONS

New monuments constructed as part of the upgrade of the geodetic network will be constructed to the following specifications:

4.1 Horizontal Network

(i) Unless part of substantial concrete structures, new control points will be concrete monuments, poured on-site, with dimensions as follows:

First Order: 0.3m x 0.3m cross section at the top;
0.4m x 0.4m cross section at the base;
0.7m long;
protruding 0.2m above ground level (normally).

Second Order: 0.25m x 0.25m cross section at the top;
0.35m x 0.35m cross section at the base;
0.5m long;
protruding 0.1m above ground level (if set in a footpath, the mark is to be flush with the footpath).

Third Order: 0.20m x 0.20m cross section at the top;
0.30m x 0.30m cross section at the base;
0.4m long;
protruding 0.1m above ground level (if set in a footpath, the mark is to be flush with the footpath).

(ii) If bedrock is reached before the hole is excavated to the required depth, it is permissible to attach the mark to the bedrock provided that the surface of the bedrock is properly keyed and cleaned to ensure that the monument is properly attached to the bedrock.

(iii) In some situations where an above ground mark may be dangerous or a nuisance to local people or vehicles, consideration must be given to constructing the monument flush with the surface.

(iv) In some situations, where the stability of the ground is questionable, a larger monument may be appropriate.

(v) All concrete monuments will have a brass plaque or rod (subject to availability) set in the centre and be inscribed with the appropriate point number. If brass plaques or rods are

unavailable then an alternative non-corroding substitute should be used to denote the exact position of the control point.

(vi) If established on substantial concrete structures or solid rock, new control points may be:

- copper or concrete nails in cement patties, inscribed with the point number;
- drill holes, marked with the point number;
- screws, bolts or "tut tut" nails set in drill holes.

(vii) To enable a GPS antenna to be set securely over the mark when using a range pole and bipod set-up on fast static surveys, it is essential that the rod, nail, screw or bolt used to mark the point is punched with a centre punch, or has a cross cut in it or some other suitable alternative is provided to prevent the tip of the range pole slipping from the point during the observation.

4.1.1 Estimated Quantities of Concrete

The estimated volumes of concrete required for construction of the monuments with dimensions as indicated above are as follows:

First Order: $0.1m^3$.

Second Order: $0.05m^3$.

Third Order: $0.025m^3$.

5. POINT NUMBERING

Every point (horizontal & vertical) in the Samoan Geodetic Network must be allocated a unique number. To avoid confusion it is suggested that the existing numbering system for horizontal control points is maintained and extended to include all new control points, BMs and other existing survey marks. Compliance with this system will enable the simple integration of all data for all control points into the Survey Database that will be developed as part of the project.

To avoid the possibility of double numbering it is critical that all previously allocated point numbers are determined and the point to which they have been allocated identified. A record must be kept of point numbers as they are allocated to ensure that double numbering does not occur.

The relevant details for all control points must be entered onto a Point Number Allocation Sheet until the Survey Database has been developed and all appropriate information entered. From then on, point numbers should be allocated from the database.

Particular care must be exercised in the allocation of point numbers to avoid any mistakes.

Consideration should be given to extending the point numbering to include all reference marks from cadastral plans whether coordinated by geodetic survey or not.

6. TIMING & LOGISTICS

A workplan outlining the individual activities and relationship to each other is appended to this report. More details and indicative times to complete each activity are provided in the individual tables below:

6.1 Primary Network

6.1.1 Reconnaissance & Monumentation

Upolu

Activity	Days
Preparation	1
Reconnaissance for 5 new points & check others (1 team – GA, NSA, PS)	2
Monumentation & repairs to existing marks(1 team, 2 pts/day/team) (4 new)	3

Note: GA = Geodetic Adviser; NSA = National Survey Adviser; PS = Principal Surveyor

Savai'i

Activity	Days
Preparation	1
Reconnaissance for 3 new points & check 2 others (1 team – GA, NSA, PS)	3
Monumentation & repairs to existing marks(1 team, 2 pts/day/team) (3 new)	3

The reconnaissance and monumentation activities are complete for Upolu and Savai'i.

6.1.2 GPS Activities

Activity	Days
GPS Training	10
Mobilisation & Preparation for GPS observations	1
Primary Network GPS (3 receivers in 3 independent teams)	10
Data Processing	15
Adjustment	5

The GPS equipment was delivered on 9th August. Two days were allocated for checking and testing the equipment. Operating procedures will be developed from 12th August to 19th August.

The two weeks of GPS training originally scheduled to commence on 22nd August has been deferred to commence on 26th September because the supplier's accredited trainer is not available before then. The GA will provide two days of basic training from 22nd-23rd August to be followed

by observation of the Apia Secondary Network as a training exercise. This will be followed by the GPS observations for the Primary Network on Upolu and Primary and Secondary Networks on Savai'i. Primary Network observations will commence on Upolu on 30th August and should be completed on 13th September.

MNREM are to provide three observing teams for the duration of the training and observations. These teams will at various times be accompanied by representatives from the private sector, other government agencies and possibly other sections of MNREM who have an interest in obtaining some GPS training and experience or exposure to GPS technology.

Throughout the training and observation period, MNREM is to provide a suitable vehicle for one (1) GPS team and the ancillary equipment to support three (3) GPS teams. The MNREM vehicle must be capable of carrying four persons, a set of GPS equipment, ancillary equipment and personal effects. It must be maintained in good working order and provide appropriate protection from the elements and security for all equipment and personal effects. The Project is to provide sufficient operational funding and fuel to support the MNREM staff and MNREM vehicle. The MNREM vehicle must be available at all times as it is possible that travel and observations will take place outside normal working hours.

Two (2) suitable vehicles will be provided by Land Equity International (LEI).

Staff selected to participate in the data processing operations and training (including adjustments) will participate in the basic GPS training and observation activities.

6.2 Secondary Network

6.2.1 Reconnaissance & Monumentation

Apia

Activity	Days
Preparation	1
Reconnaissance for 7 new points (1 team – GA, NSA, PS)	2
Monumentation (1 team, 3 pts/day/team)	3

The GA and NSA carried out the reconnaissance for selection of the Secondary Control Points during the last week of July. Site selections were discussed with the Principal Surveyor after he returned from Salalologa and later with the ACEO TS. Ministry assistance was given to gain land owner approval for some sites.

Salelologa

Activity	Days
Preparation	1
Reconnaissance for 2 new points (1 team – GA, NSA, PS)	1
Monumentation (1 team, 3 pts/day/team) – **None required**	-

The above activities have been completed.

6.2.2 GPS Activities

Apia

Activity	Days
Mobilisation & Preparation for GPS observations	1
Secondary Network GPS (3 receivers in 3 independent teams)	3
Data Processing	3
Adjustment	2

GPS observations for the Apia Secondary Network should commence on 24th August after completion of the two day basic GPS training. They will be used as a training exercise to ensure that all staff are competent to undertake the observations for the Primary Network. Observations should be completed on 26th August. Data processing operations will be combined with the processing for the Primary Network.

MNREM are to provide three observing teams for the duration of the observations. These teams will at various times be accompanied by representatives from the private sector, other government agencies and possibly other sections of MNREM who have an interest in obtaining some GPS training and experience or exposure to GPS technology.

Throughout the training and observation period, MNREM is to provide a suitable vehicle for one (1) GPS team and the ancillary equipment to support three (3) GPS teams. The MNREM vehicle must be capable of carrying four persons, a set of GPS equipment and ancillary equipment. It must be maintained in good working order and provide appropriate protection from the elements and security for all equipment and personal effects. The Project is to provide sufficient operational funding and fuel to support the MNREM staff and MNREM vehicle. The MNREM vehicle must be available at all times as it is possible that travel and observations will take place outside normal working hours.

Two (2) suitable vehicles will be provided by Land Equity International (LEI).

All staff selected to participate in the training should be involved in the field observations.

Salelologa

Activity	Days
Mobilisation & Preparation for GPS observations	1
Secondary Network GPS (3 receivers in 3 independent teams)	1
Data Processing	1
Adjustment	1

The GPS operations for the Savai'i Secondary Network will be incorporated into the Primary Network observation campaign as indicated above.

6.3 Tertiary Network

6.3.1 Searching, Reconnaissance & Monumentation

Apia

Activity	Days
Searching	50
Reconnaissance for existing reference marks	50
Reconnaissance for new control marks	50
Monumentation	50

The estimates provided in the table above were preliminary estimates and were not based on reliable data. It was intended that after a reasonable sample of the area had been searched and reconnaissance activities completed these estimates would be refined to provide more realistic figures.

Office searching was originally scheduled to commence on 4th April but did not commence until a month later on 3rd May, under the guidance of the NSA. It was suggested that initially, two parties be assigned to the office searching and that as they completed the searching in a particular area they then conduct the reconnaissance for existing reference marks.

Only after completing the initial reconnaissance for a particular area is it possible to select the most appropriate marks for inclusion in the tertiary network. The locations for any new marks can then be selected.

To date insufficient personnel from Survey Section have been available to undertake searching activities and only on a part time basis. The lack of suitable vehicles for field searching has prevented significant field operations. Only one day of field searching has been possible and only by using the NSA's vehicle.

As at the date of this report, office searching has been completed for approximately 30% of the Apia urban area. The GPS equipment has been delivered and the training and the observation campaign will commence on 22nd August. Accordingly, it is unlikely that sufficient resources will be allocated to complete the preliminary activities over the complete urban and significant peri-urban area of Apia in time for the GPS observations to be made during project implementation, under the guidance of the Geodetic Advisers.

The delays in the procurement process for acquisition of the GPS equipment has in turn significantly delayed the primary and secondary GPS observation campaigns and limited the time available for the third order GPS observations during project implementation.

In summary:

- there has been a long delay in providing a response to the draft of this report;
- only limited preliminary activities have been completed to date;
- the commencement of GPS activities is imminent; and
- the time available for the third order observations is significantly less than originally envisaged.

Accordingly, the strategy proposed is to complete the third order control over a specified area of urban Apia in which there is active development and which will be suitable for practical testing of the principles of cadastral coordination. Using the provisions of the new Survey Act, the CEO will specify *"rules for the conduct of cadastral surveys"* in the specified area. This will enable the survey manuals to be tested, reviewed and modified as necessary on the basis of practical experience in the specified area. This strategy also allows for the progressive introduction of what are significantly new cadastral survey methods to the practicing surveyors, and MNREM Draughting and Plan Examination Staff.

MNREM survey staff will be in a sound position to extend the Apia Tertiary Network on an area priority basis and to manage the physical maintenance of the network. The second order control established during the project will be sufficient for all foreseeable third order control requirements in Apia.

Throughout the reconnaissance and monumentation activities, MNREM are to provide suitable vehicles and the necessary equipment and materials to support these activities.

Salelologa

It was suggested in the *"Initial Review & Options for Upgrade"* that there may not to be time to complete the Salelologa Tertiary Network activities, apart from establishing the Second Order control, during project implementation. The delays in commencing activities in Apia makes this scenario ever more likely. Accordingly it is suggested that consideration be given to completing these activities after completion of the project. It will serve as a good test of Survey Section's ability to sustain the technology.

6.3.2 GPS Activities

Apia

Activity	Days
Mobilisation & Preparation for GPS observations	1
Tertiary Network GPS (3 receivers in 3 independent teams)	30
Data Processing	30
Adjustment	33

GPS observations for the Apia Tertiary Network will commence immediately after completion of the Primary Network observations. Based on the current workplan, observations should commence on 16th September and are expected to continue until about 27th October. Note that there will be a break in Tertiary Network Activities for the GPS training from 26th September – 7th October. This training is to be provided by GeoSystems, the GPS supplier.

MNREM are to provide three observing teams for the duration of the observations. These teams will at various times be accompanied by representatives from the private sector, other government agencies and possibly other sections of MNREM who have an interest in obtaining some GPS training and experience or exposure to GPS technology.

Throughout the tertiary network observation period, MNREM is to provide a suitable vehicle for one (1) GPS team and the ancillary equipment to support three (3) GPS teams. The MNREM vehicle must be capable of carrying four persons, a set of GPS equipment and ancillary equipment.

It must be maintained in good working order and provide appropriate protection from the elements and security for all equipment and personal effects. The Project is to provide sufficient operational funding and fuel to support the MNREM staff and MNREM vehicle. The MNREM vehicle must be available at all times as it is possible that travel and observations will take place outside normal working hours.

Two (2) suitable vehicles will be provided by Land Equity International (LEI).

It is anticipated that staff selected to participate in the data processing operations and training will have minimal involvement in the field observations as they will be primarily involved in planning and the data processing operations.

7. RESPONSIBILITIES

The suggested responsibilities for the various activities associated with the upgrade of the geodetic network are detailed below:

7.1 Primary & Secondary Networks

Activity	GA	NSA	MNREM Survey
Preparation	✓	✓	✓
Reconnaissance	✓	✓	✓
Monumentation			✓
Mobilisation for GPS observations	✓	✓	✓
GPS observations	✓	✓	✓
Data Processing	✓	✓	✓
Adjustment	✓	✓	✓

Note: GA = Geodetic Adviser; NSA = National Survey Adviser.

7.2 Tertiary Network

Apia

Activity	GA	NSA	MNREM Survey
Searching	✓	✓	✓
Reconnaissance for existing reference marks	✓	✓	✓
Reconnaissance for new control marks	✓	✓	✓
Monumentation			✓
Mobilisation for GPS observations	✓	✓	✓
GPS observations	✓	✓	✓
Data Processing	✓	✓	✓
Adjustment	✓	✓	✓

Salelologa

Activity	GA	NSA	MNREM Survey
Searching	✓	✓	✓
Reconnaissance for existing reference marks			✓
Reconnaissance for new control marks			✓
Monumentation			✓
Mobilisation for GPS observations			✓
GPS observations			✓
Data Processing			✓
Adjustment			✓

8. LOGISTICS

8.1 Communications for GPS Observation Campaign

All GPS observations for the upgrade of the Samoan Geodetic Network will be made using relative positioning techniques. For this technique simultaneous observations are made at each point being

occupied during a session. If a sufficient period of simultaneous observations is not achieved, the session must be reobserved.

The number of points to be occupied in each session will be three as the Project is purchasing three GPS receivers. The overall network will be observed as a series of interlinked triangles. Logically, the observations will commence at one end of the country and as each session is completed, some or all of the GPS teams will move to occupy the control points in the next triangle.

Preliminary planning suggests that there will be about 23 two hour sessions and 2 three hour sessions over a period of about ten days to observe the new Primary Geodetic Network. The observing programme will be finalized at a later date.

There are two options to ensure simultaneous observations:

1. *Sessions are observed for the required duration in accordance with a precise pre-arranged time schedule.*

   This option is usually used if good communications between parties cannot be relied upon or if there is no one in the field with the necessary knowledge and authority to determine when sufficient data has been recorded.

   When planning this type of operation it is necessary to have a good knowledge of the travel times and any difficulties that are likely to be encountered. To minimise the risk that sufficient simultaneous observations may not be achieved because one or more parties fails to arrive at their site and start their observations on time it is essential that additional travel time and possible delays are taken into account when designing the observing schedule.

2. *As soon as all points in a session are occupied, the session is observed for the required duration.*

   If good communications between GPS parties can be relied upon, sessions may be observed when all parties are in position and the schedule may be adjusted for maximum efficiency. This technique also provides the opportunity for the team leader to increase the session length if for some reason the need for an increase becomes apparent during the session. This could be caused by a prolonged power failure at one site, less than the required number of satellites, poor geometry or some unexpected interruption to the observations at one or more points.

Option 2 enables the observations to proceed with a greater level of efficiency and reduces the likelihood that it may be necessary to reobserve some sessions because insufficient simultaneous data has been recorded at all points in a session.

To achieve this level of efficiency the GPS teams need effective radios or a suitable alternative method of communicating reliably over distances of 20+ kilometres.

It is anticipated that the Geodetic Adviser will operate independently of the three GPS field parties so that he can spend some time with each party each day, at least during the early part of the observation campaign, and that he will be available to assist any party experiencing difficulties.

Accordingly it would be advantageous if the adviser had access to the same communication system.

It was recommended that MNREM investigate the availability of suitable radios or an alternative method of communicating reliably over distances of 20+ kilometers for the use of the GPS teams and Geodetic Adviser for the duration of the GPS training, Primary and Secondary GPS observing campaigns.

It is imperative that enquiries are made as soon as possible as the availability or unavailability of an effective communication system must be known before detailed planning for observations to be made during the training or subsequent observation campaigns can take place.

MNREM have declined to assist in the provision of a means of communication and suggested that responsibility lies with LEI. Since then, the NSA has followed up with SamoaTel and has been advised that they have a new mobile phone system which may be able to provide the coverage required for the GPS operations. It utilises a roving CIM card.

The NSA was advised that an approach from the CEO, MNREM to the CEO, SamoaTel may be regarded favourably and would provide the best chance of obtaining some of these new mobile phones with the roving CIM card. The project could be seen as a test of the new system and its capabilities.

Therefore it is recommended that MNREM follow up with SamoaTel as a matter of urgency.

9. PUBLICITY

It is important that MNREM or the Project provide appropriate advice to the public and land owners about the purpose of the project and in particular the upgrade of the Samoan Geodetic Network, survey control marks and the GPS observations. In this way the observing parties should experience minimum obstruction or delays in their operations and be provided with full support from local people.

As part of the reconnaissance activities the Principal Surveyor and NSA made every effort to ensure that local land owners and village officials were fully aware of the purpose of the project; both new and existing control points; and that survey teams would be carrying out GPS observations later in the year.

For the long term protection of the control points it is vital that MNRE maintains contact with land owners and village officials, conducts regular inspections and makes local people aware of the long term importance of the control points.

MNREM should consider the placement of witness or marker posts close to each control point to aid in the relocation and protection of the marks. A plate could be attached to the post indicating the responsible agency, that it marks the location of a survey mark, a contact phone number and the penalty for interference with or destruction of the mark.

10. TRAINING PLAN

The project will provide training to enable MNREM's Survey Section to undertake the GPS observations required to upgrade the Samoan Geodetic Network and ensure that MNREM is able to maximise the benefits of GPS technology and ensure long term sustainability.

The training will provide staff with the skills and knowledge to plan and undertake all aspects of GPS surveys. The GPS surveys may be for extension and maintenance of the Samoan Geodetic Network, for the provision of survey control, for supporting cadastral surveys or any other purpose.

If required the *GPS for Managers Training* could also be offered to other interested persons from within MNREM and other agencies with an interest in GPS to provide them with a basic overview of GPS and its applications.

10.1 GPS Training Aims

Fulfillment of the following training aims will ensure long term sustainability:

- To provide competent technical operators to undertake all field activities to successfully complete GPS surveys.
- To provide competent supervisors to plan and supervise GPS surveys, and to process and adjust GPS data for both quality control and production of final coordinates.
- To provide management with awareness of GPS capabilities.

10.2 GPS Training Objectives

At the end of the *Basic GPS Training* all participants should be able to:

- Demonstrate a broad understanding of the GPS system and principles and in particular its application to surveying.
- Set up and operate the GPS receivers to record data in static, fast static and kinematic modes.
- Download data from the GPS receiver to a computer.

At the end of the *GPS Processing & Adjustment Training*, the participants should be able to:

- Process GPS data using the baseline processing software.
- Analyse GPS processing results and reprocess problem baselines by changing processing parameters.
- Adjust processed GPS baselines using the GeoLab software.
- Analyse adjustment results to determine the quality of GPS observations.

At the end of the *GPS for Managers Training*, the participants should have:

- An awareness of GPS capabilities
- An overall appreciation of GPS surveying and its applications

10.3 GPS Training Outline

In designing the training programme, the skills and knowledge to be achieved were identified and the existing skill levels determined.

The training programme will provide both formal and on-the-job training for Survey staff during the GPS observation campaign, data processing and adjustment phase. Consideration should be given to short term GPS work experience training after completion of the project to reinforce what has been learnt during the project and provide exposure to the operations of an organisation with considerable GPS experience.

The GPS Training will be conducted over 14 weeks as follows (note that some activities are concurrent):

2 Weeks	Formal course conducted by supplier with assistance from Geodetic Adviser & National Survey Adviser to cover an overview of GPS, GPS receiver operations, and data processing.
7 Weeks	On the job training conducted by the Geodetic Adviser & National Survey Adviser in continued receiver operation and data collection for the Primary, Secondary & Tertiary Networks.
7 Weeks	On the job training conducted by the Geodetic Adviser in data processing, and planning and supervising GPS operations. (**Need a suitable computer loaded with appropriate licensed baseline processing software, for each participant)**
6 Weeks	On the job training conducted by the Geodetic Adviser in data adjustment and planning and supervising GPS operations. (**Need a suitable computer loaded with licensed GeoLab adjustment software, for each participant. Additional licences must be purchased for the duration of the training.)**
1 day	GPS for Managers

Appendix 1 Primary Network Plan

Appendix 2 Apia Physical Framework Plan 2003-2013