LAND TENURE CENTER
University of Wisconsin - Madison

Consultancy Services to
The Government of the
Republic of Trinidad & Tobago

LAND USE POLICY AND ADMINISTRATION PROJECT (LUPAP)
LAND SURVEYING COMPONENT

HYDROGRAPHY CATEGORY REPORT

Prepared by Richard Wylde FRICS

Ordnance Survey

Reviewed by Fred Brazier and Charisse Griffith-Charles

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30 Queens Park West, Port of Spain, Trinidad & Tobago. Tel: + 1 (868) 628-2241; Fax + 1 (868) 628-2260; Email: lupap@tstt.net.tt

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INTRODUCTION

This report has been prepared by hydrographic consultant, Richard Wylde of Ordnance Survey working on LUPAP (Land Use Policy & Administration Project). The report details the findings of the Hydrographic consultant and gives the background and basis for the recommendations made in the hydrography category of land surveying.

1. SCOPE

The consultant was required to review changes in hydrographic surveying technology and methodologies and to see how these are currently being used within Trinidad and Tobago and make recommendations on how they may be accommodated within the 1996 Land Surveyors Act and reflected in the revised Land Surveyors Regulations and Rules.

It was recognised that there was overlap concerning technical aspects of hydrographic surveying and the disciplines of geodesy and engineering surveying. The project also has consultants in geodesy (Ian Wilson) and engineering surveying (David Powell), and these consultants have agreed that the scope of the hydrographic work will encompass: -

a) the geodetic datums used offshore

b) transformations between the various datums (offshore)

c) recommendations for engineering survey (offshore)

Although this scope has been agreed, the consultants are working together to ensure that recommendations are not contradictory.

Research

Meetings have been held with individuals who practice hydrographic surveying, who are users of hydrographic data and who let contracts to perform hydrographic surveys in and around Trinidad and Tobago. A full list can be found in Annex A.

Several of the references detailed within the geodesy report have been utilised within the research for this report and the reader should refer to that report for further details.

In addition to the above meetings with individuals, companies and government officials, a group meeting was arranged for all professionals in hydrography. An advertisement was placed in the Trinidad and Tobago Guardian on Saturday 12 February 2000. A copy is at Annex B – Invitation to Meeting and a list of attendees is at Annex C – Attendees of the Hydrography Meeting on Wednesday 16 February 2000.

2. TECHNOLOGY, METHODOLOGY AND STANDARDS

Hydrographic surveying has gone through fundamental changes in measurement technology within the last ten years. Multibeam acoustic and airborne laser systems now provide almost total seafloor coverage and measurement as compared to the earlier sampling by bathymetric profiles. The capability to position the data precisely in the horizontal plane has been increased enormously by the availability of satellite positioning systems, particularly when augmented by differential techniques. In the offshore industry, undersea positioning using hydro-acoustic methods allow great precision to be achieved. Users of hydrographic data make up a much more diverse group than has previously been recognised. Hydrographic surveying and data acquisition is not just carried out for the compilation of nautical charts. Hydrographic data is also important for coastal zone management, environmental monitoring, resource development (including hydrocarbon and mineral exploitation), legal and jurisdictional issues, ocean and meteorological modelling, engineering and construction planning and many other uses. To increase its usefulness, users require data that is more up to date, detailed, reliable, and in digital form. Depth measurement technology has kept pace with increases in horizontal positioning accuracy, and whilst many hydrographic surveys will continue to be conducted with single beam echo sounders which only sample discrete profiles of the seafloor, it is likely that 100% bottom search techniques utilising a combination of multibeam echo sounders and side-scan sonar technology will be employed for critical areas.

As with all types of survey, the requirement will always be that the standards that should apply relate to the principle of being “fit for purpose”

2.1 Hydrographic surveying for safe navigation

The required positioning accuracies associated with this type of hydrographic surveying previously were based on the practical limitations of draughtsmanship at a given scale. Automated data management (i.e. GIS and electronic charting systems) now allows data to be presented at any scale. Therefore the accuracy requirements for positions must now be a function of the errors contributed by positioning and sounding systems and the likely use of the data.

The advances in satellite positioning technology highlighted above mean that navigators are now able to position themselves with greater accuracy than that of the data on which charts are based.

The combination of these factors, together with rapidly developing technology in depth measurement mean that the adherence with the latest international standards for hydrographic surveying are essential. The IHO Special Publication No.44 (4th edition, 1998 or later) is recommended as the minimum standard for hydrographic surveys related to the compilation of nautical charts. The principal

aim of this publication is to ensure that hydrographic data collected according to these standards is sufficiently accurate and that the spatial uncertainty of data is adequately quantified to be safely used by mariners (commercial, military or recreational) as primary users of this information.

This publication provides a graded classification of surveys with different accuracy statements for different usage of the hydrographic data.

2.2 Hydrographic surveying for other purposes

The required positioning accuracies will of course vary depending on the use to which this data will be put. In many cases, such as oceanographic data acquisition etc, this may be of high tolerance, but for specific tasks, such as Seismic exploration or drilling site investigation surveys, a lower tolerance may be more appropriate.

There are many sources of information that may assist with providing guidelines for data acquisition; one of the sources with international recognition is that of the UK Offshore Operators Association (http://www.oilandgas.org.uk/publications). UKOOA also produce a series of specifications for co-ordinate data exchange in digital format, which can be used for a multitude of hydrographic and land survey purposes.

There are also developing standards for the exchange of Metadata (data about or describing data), which have been published by the Society of Exploration Geophysicists (http://www.seg.org/).

3. OFFSHORE GEODESY TRINIDAD AND TOBAGO

3.1 Co-ordinate systems in current use (offshore)

Fundamental to any hydrographic surveying, precise navigation and positioning within the EEZ of Trinidad & Tobago is an understanding of the geodesy of the Nation State and its marine boundaries.

Reference should be made here to the geodesy report prepared by Ian Wilson concerning the general situation with respect to geodesy onshore Trinidad and Tobago.

Trinidad 1903

The first geodetic datum for Trinidad and Tobago was established in the early part of the last century. This first geodetic datum is usually known onshore as ‘the Cassini’ (although this describes the projection, rather than the datum). Offshore it is commonly known as the Trinidad 1903 or “old Trinidad Datum”, though the author has seen some reference to Trinidad 1901. This geodetic datum defines the co-ordinate system in common usage by the Ministry of Energy and Energy Industries for defining the boundaries of the offshore exploration and exploitation licences.

It is sometimes difficult to appreciate the importance of these licence boundaries, but when one considers that Oil and Gas currently contributes around a third of the GNP and more than two-thirds of the exports of Trinidad and Tobago, then

this may help put it into context. The offshore boundaries of these licences can be considered a form of offshore cadastre, with the associated potential for boundary disputes, both internal and international.

It is important that these boundaries are adequately and unambiguously defined.

The details of the “old Trinidad” co-ordinate system can be found in Annex D.

Naparima 1955

It can only be assumed that this practice of using the Trinidad 1903 system predated the introduction of the ‘Naparima 1955’ geodetic datum. Naparima 1955 defines the co-ordinate system in common use today onshore Trinidad, and until recently has been the preferred system for use offshore, both for charting and positioning. Until recently, the Ministry of Energy and Energy Industries supported its use for the submission of data, though any reference to the individual licences and boundaries still required reference back to the Trinidad 1903 system.

It should be noted here that there seems to have been some confusion, at least in the offshore hydrographic community, concerning the epoch associated with Naparima Datum. The accepted system onshore is Naparima 1955, but most of the Oil Companies operating offshore refer to Naparima 1972. This has to some extent been compounded by outside geodetic agencies, such as NIMA – the US National Imagery and Mapping Agency (previously known as DMA – Defence Mapping Agency), who refer to it as Naparima BWI.

In 1972, a connection was made between the Trinidad control network and that of Tobago. A partial re-adjustment was performed with assistance from the DMA. Unfortunately, following this adjustment, which only applied to stations within Tobago, it would appear that the epoch 1972 has crept into common parlance and has led to considerable confusion since (see Annex D).

The existing charts published by the Hydrographic Unit of the Lands & Surveys Division, relate to Naparima 1955 and most near shore charting for planning purposes, the establishment of lights and buoys for the shipping channels etc. are similarly specified.

WGS 84

WGS 84, the geocentric geodetic datum and co-ordinate system utilised by the Global Positioning System (GPS) is beginning to be specified by many agencies now for data collection and mapping offshore. Its universal acceptance has been the driving force behind this, more than the recognition that the transformation of co-ordinate data between different co-ordinate systems is prone to errors when their exact relationship is not known or well understood.

International charting agencies such as the UKHO are starting to issue new/revised chart releases in WGS 84 and within Trinidad & Tobago, the MEEI, as well as the IMA, are accepting information collected within this system.

GPS has become the de-facto system of choice for both navigation and positioning and it is expected that adoption of WGS 84 as the co-ordinate system

of choice offshore Trinidad & Tobago will increase either with, or without legislation to effect it. Details of WGS 84 can be found in Annex D.

The IHO in their latest version of SP44, the IHO standards for hydrographic surveying, require all positions to be referenced to a geocentric reference system, recommended as WGS 84 and states that where alternative co-ordinate systems are used, these should be tied to WGS 84. The relationship between the co-ordinate systems of Trinidad 1903, Naparima 1955 and that of WGS 84 is therefore a matter of urgent concern.

To place this need for adoption of a recognised relationship into context, reference should be made to the diagram below, which details the magnitude of the error potential that may occur through misunderstanding of or misapplication of co-ordinate system. Each of the crosses shows a point within Port of Spain with the same geographical co-ordinates. However, each set of co-ordinates refers to a different co-ordinate system, Trinidad 1903, Naparima 1955 or WGS 84. The scale bar indicates the magnitude of the problem.

DIAGRAM IS HERE

PSAD56

When one looks at the international boundary that was agreed by treaty between Republic of Trinidad & Tobago and the Republic of Venezuela on 18th April 1990, the boundary points are stated in the Provisional South American Datum 1956. In order to correctly interpret these co-ordinates within any of the co-ordinate systems described above, a relationship has to be established between PSAD1956 and that system, either directly or via WGS 84. For some time, the Government has been silent on this issue of the definitive relationship between theses co-ordinate systems. It is recommended that this be rectified as soon as possible.

The details of PSAD56 in Venezuela can be found in Annex D.

3.2 Current practice in the Offshore Exploration and Production Industry

The author contacted a number of oil companies operating offshore Trinidad and Tobago and several different solutions appear to have been adopted.

Some companies operate and store their data in Trinidad 1903 – so that the data directly relates to the concession boundary information.

Some operate and store their data in Naparima 1955 (72*), transforming between WGS 84 and Naparima for acquisition and between Naparima and Trinidad 1903 for reference to their concession boundaries.

Some have transformed their boundary co-ordinates and all previous data to WGS 84 and now acquire, operate and store their data in this form.

In recognition of the need for understanding of this relationship, following work undertaken by BP-Amoco during the early 1990's, the MEEI sent a fax/letter around the various offshore companies registered as operators offshore Trinidad & Tobago on March 20th 1998. This stated explicitly its understanding of the relationship between Trinidad 1903 and Naparima 1972 (for which we should read 1955 as detailed above) and that of WGS 84. These parameters were given pending provision of official standard shift parameters by the Trinidad Lands and Surveys Division.

Following this statement, and in the absence of any other more official statement, it has become accepted industry practice amongst the majority of offshore operators and their contractors to adopt these transformation parameters.

The MEEI transformation parameters are listed in Annex D.

It is recommended that a unified and consistent approach be adopted with respect to these relationships. Though an attempt has been made by MEEI to standardise on these parameters, the late issue of this notice has resulted in many operators and their contractors utilising a variety of other transformation parameters. In some cases these have been "locally derived", by which I mean that a couple of onshore stations whose co-ordinates have been known in Naparima 1955 or possibly in Trinidad 1903, have been occupied at the same time as work has been undertaken offshore, and hence a locally-derived shift

derived between these and **WGS 84** has been calculated and applied to the data acquired offshore.

This piecemeal approach, whilst valid in the absence of alternative information, is to be discouraged for future operations offshore where such work is being undertaken with respect to the exploration and exploitation of MEEI defined licence blocks. In relation to this type of work, it is recommended that a unified and repeatable approach be adopted.

The only caveat here would be where specific co-ordinates have been the subject of a legal unitisation resolution. It is probable that those unitisation disputes that have been resolved to date do not include such provisions.

The issue with the relationship between PSAD56 and Trinidad 1903 will shortly become one where MEEI will have to make a ruling. The last round of offshore exploration licence award is currently open for bidding, where several of the international boundary points constitute part of the concession boundary (in the Gulf of Paria), whilst it is understood that one of the international oil companies operating within the Trinidad and Tobago EEZ is about to drill a hydrocarbon prospect fairly close to the international border line with Venezuela, in the Columbus Channel. This opens up the possibility of a future unitisation issue with Venezuela if the field is proved to straddle the border, where the relationship between PSAD1956 and Trinidad 1903 and indeed the co-ordinate systems of Naparima 1955 and WGS 84 will be called into play, possibly within the International Courts.

3.3 Current Practice in other offshore surveys

For other hydrographic survey and offshore positioning work, practice varies between acquisition directly in **WGS 84** or in Naparima 1955. The latter is usually undertaken to tie in with existing onshore features or structures or to match with coastline or onshore mapping, which is currently defined in this co-ordinate system.

Current practice, as stated above and in the geodetic report of Ian Wilson, is the piecemeal approach. Essentially a pragmatic and logistically viable approach to transferring Naparima 1955 co-ordinates offshore, this approach is entirely valid when attempting to position objects or co-ordinate objects within the Naparima 1955 co-ordinate system.

Where **WGS 84** is used both for positioning and data acquisition offshore, there is the issue of how is this data plotted or portrayed with respect to the coastline of Trinidad, Tobago and its international boundaries.

The Lands and Surveys Division do not have available a definitive coastline file for use by either Government or Industry in digital form, either in Naparima 1955 or **WGS 84** form. This should be addressed with some degree of urgency. If made available it would be a valuable aid to overall planning and development of the nation. Coastal development and change is occurring at such a rate within Trinidad & Tobago, that the absence of this data is a severe limitation.

Acquisition of this type of information, together with regular maintenance could be most simply handled by remote sensing techniques.

Where international boundaries are concerned, the Government should make an official statement regarding the relationship it regards as valid between PSAD 1956 and WGS 84, and seek Venezuelan ratification of that agreement, so as to prevent potential navigation disputes occurring.

3.4 Mapping and charting offshore Trinidad and Tobago

The current charts issued by the Hydrographic Unit of the Lands and Surveys Division date from the late 1980's. The past ten years has seen a dramatic change in technology and acquisition methods concerning classical hydrographic surveying for this purpose. The methodologies of both acquisition and production as well as the levels of accuracy and completeness have all changed.

During this period the number and size of cargos passing through Trinidad and Tobago territorial and coastal waters have increased dramatically. The nature of their cargos has also changed, with a significant increase in the number of environmentally sensitive if not hazardous cargos. There has also been a significant increase in the number of dredging operations as well as coastal developments concerned with development of the Chaguaramas area as well as others in Port of Spain and the Gulf of Paria generally. Off the west coast there have been significant infrastructure developments in support of the Oil and Gas production industry with a number of pipelines now in place. Development of gas fields to the North of Trinidad will soon result in a major gas line being laid through the Gulf of Paria down to Port Fortin.

Accurate modelling of the dispersion of oil spills and creation of ocean current and circulation models in and around Trinidad and Tobago is presently hampered by poor knowledge of the bathymetry.

Trinidad and Tobago are a member of the International Hydrographic Organisation (IHO), and hence have an obligation to ensure that hydrographic surveys and charting within their waters are performed to International standards and are made available to the various international charting agencies for inclusion on their chart series.

The Hydrographic Unit is currently moribund. Through a sequence of Ministry moves, compounded by promotion and/or departure of senior officers and lack of maintenance of equipment and vessel it no longer has an active charting capability. However the requirements and commitment to perform the necessary surveys still exists.

To re-equip and re-staff to the level necessary to fulfil its commitments would be uneconomic. The logistics and cost of maintaining a full suite of hydrographic equipment is such nowadays that it can only be afforded by the major government hydrographic services and multi-national survey companies. Most countries with significant coastlines are now only able to meet their obligations and commitments by commercial contract.

The Hydrographic Unit can still have a significant role to play through project management and QC of data acquisition and chart production and in undertaking the move of existing data from Naparima 1955 into WGS 84 for the issue of a new chart series based on **WGS 84**.

All of the marine traffic using the coastal waters of Trinidad and Tobago now have GPS receivers and WGS 84 should be confirmed as the new co-ordinate system of choice for all new charting activity. The new SP44 regulations issued by the IHO stipulate significantly tighter accuracy requirements than have been used in the past for port approaches, particularly where hazardous cargoes are involved, and the requirement for these surveys is such that 100% bottom search is a necessity.

Further suggestions concerning the future of the Hydrographic Unit are detailed in Annex D.

Public domain data

In the absence of a functional Hydrographic Unit most of the major Agencies and Government departments have been letting commercial contracts on an ad-hock basis. Whilst this may fulfil their individual needs they do not contribute to the nationwide hydrographic data needs. The hydrocarbon industry performs annually a significant amount of survey work in support of both its Exploration and Exploitation needs. The Ministry of Energy and Energy Industries does require that digital copies of this data is lodged with them, but currently this is in confidence and held in secure archive with a contractor in Houston. It is recommended that this hydrographic data be made available to the general good of the country in the form of a national archive, which could be maintained by the Lands and Surveys Division. Other Agencies and Ministries should also be charged with contributing their past and future data. In this way the Hydrographic Unit would then have a considerable data set on which to call for update and maintenance of their new map/chart series.

3.5 Tidal data

Knowledge of the tidal regime present within Trinidad and Tobago is currently fragmented. The Hydrographic Unit owns and manages a number of tide gauges, but their records has been compromised of late by lack of funding for maintenance and replacement of equipment. The IMA, through its involvement with CPACC (Caribbean Planning for Adaptation to Climate Change), has undertaken the role of the regional sea-level data archiving centre, establishing new automated tidal recording stations with satellite transmission capability. Unfortunately there has been no tie undertaken as yet between the two systems. It is recommended that this be undertaken with some urgency and a proper co-ordination undertaken relating the two data sets to ensure that past trends are incorporated with the more modern equipment. A phased replacement of the older systems is also encouraged with ties made to any future geoidal model that may result from the recommendations made in the geodetic report by Ian Wilson.

4. THE FUTURE

4.1 The Datum Issue

The de facto mapping datum onshore in Trinidad and Tobago is Naparima 1955.

Offshore it is clear that WGS 84 or its internationally respected realisation ITRF (International Terrestrial Reference Frame) is accepted as the standard. The international boundary with Venezuela used PSAD 1956. The MEEI have continued to offer its "cadastre" of offshore exploration and production licences in the Trinidad 1903 system. To change these accepted practices would cause only further confusion, and so a definitive statement has to be issued defining the relationships between all systems.

In recognition of the datum issues, the Lands and Surveys Division and the Ministry of Energy and Energy Industries have contacted Geodetic Services (GeoS) to compute optimal sets of transformation parameters to convert co-ordinates from and to each of the four datums detailed above. A provisional study paper, only available from the Director of Surveys, has been prepared by Geodetic Services, dated 27th October 1999. It is titled "*The Computation of Accurate Transformation Parameters for Trinidad and Tobago*". This paper gives an account of the computation of various transformation parameters. The computation is rigorous and the statistical analysis very comprehensive. This work could provide supportive evidence towards an accepted set of national parameters. Its results largely support the figures currently issued by MEEI for both Trinidad 1903 and Naparima 1955 (not surprising as they are based upon the same set of data), and it is recommended that the original set in current use be confirmed with this report as evidence of their value.

4.2 Offshore Petroleum licensing

The current practice is to produce licences using the Old Trinidad 1903 co-ordinate system. It is recommended that this continues, but that co-ordinate system to which the licence co-ordinates relate is explicitly defined as Trinidad 1903 and that the relationship concerning the boundary co-ordinates expressed in this system is confirmed against that of WGS 84. The current practice is that the bounding points are described in geographical and projected co-ordinates, but without a statement concerning which co-ordinate system they refer to.

The lines bounding these licences should also be explicitly defined. Currently, licences show bounding points in both geographical and projected co-ordinates (Links), with no statement as to which is the definitive set. This leaves the operator in doubt as to whether the lines joining the bounding points are meridians and parallels, or geodesics approximating to a normal section. This obviously leads to confusion whether the area values for the licence should be expressed in spheroid or grid terms.

Each of the above statements, once defined, should greatly reduce the confusion that currently exists, as well and remove much of the potential for litigation over unitisation issues – other countries with similar issues have similar problems.

An official amendment must be made to each of the existing petroleum licences detailing these clarifications.

Future licences should be issued with co-ordinates listed in both Trinidad 1903 and WGS 84 co-ordinates, together with a clear statement that the definitive set would remain the Trinidad 1903 values.

4.3 Revised charting

As detailed in section 3.4 above, it is recommended that all future charting activity offshore Trinidad and Tobago be conducted in the **WGS 84** co-ordinate system. It is recommended that the coastal waters charts be upgraded as a matter of urgency to the standards set out in IHO SP44, particularly with respect to port approaches. This should be achieved by means of commercial tender with onboard QC and overall contract supervision from the Hydrographic Unit.

As such a number of Agencies, Ministries and Industry would benefit from such an exercise, it is recommended that a pool of funding be created. This could be supplemented by creative means.

Currently all of the offshore operators of petroleum licences in Trinidad and Tobago waters contribute annually to a fund for environmental problems associated with oil spillage. It is proposed that some of this funding be used to assist in the undertaking of improved charting by means of commercial tender.

A levy could be made on port traffic to help fund updates and maintenance associated with this activity.

New and cost efficient, techniques such as airborne laser depth sounding could be explored, where sediment conditions allow.

4.4 EEZ definition and mapping

The United Nations Convention on the Law of the Sea (UNCLOS) requires Nation States to submit claims to the Commission on the Limits of their Continental Shelf within a specified time frame. The successful submission will give rights to seabed resources on the Continental Shelf in perpetuity and potentially has long-term ramifications for Trinidad and Tobago. Whilst the international boundaries have been ratified with Venezuela, there are as yet no agreements in place with neighbouring Grenada and Barbados.

It is not known whether Trinidad and Tobago have made a submission as yet to the Secretary General of the United Nations describing the outer limits of its continental shelf, but it is understood that a time limit exists within which such submission should be made. The said submission should be supported by relevant information, including charts and geodetic data.

As above, it is recommended that the geodetic datum chosen for such submission should be a geocentric one, such as WGS 84, in order to avoid future disputes and aid in unambiguous interpretation and potential demarcation.

5. THE SURVEY REGULATIONS

There is a danger implicit in introducing too much detail into the Act concerning hydrographic survey regulations. One only has to look at the rate of change of technology and methodology within the hydrographic surveying industry over the last ten years to appreciate this. The IHO have recognised this, preferring to introduce instead a set of minimum standards.

5.1 Standards

5.1.1 Hydrographic Surveys

In the introduction of the latest revision of the "*IHO Standards for Hydrographic Surveys, Special publication No. 44*", the IHO provides a minimum set of standards with equipment and procedure used to achieve the standards left to the discretion of the agency or body responsible for the survey quality. This publication is regularly reviewed and so it is the author's recommendation that the standards of hydrographic surveys performed within the Trinidad and Tobago EEZ should broadly conform to IHO SP44. Even if the standard does not always specifically address the user's needs, it is felt that it provides a basis on which to assess the quality of the hydrographic data.

5.1.2 Hydrographic Surveyors

The IHO booklet "Standards of competence for Hydrographic Surveyors" defines 3 categories of FIG/IHO Hydrographic course:

a) *Category A* - A course which provides a comprehensive and broad-based knowledge in all aspects of the theory and practice of hydrography and allied disciplines for individuals who will practise analytical reasoning, decision making and development of solutions to non-routine problems.
Someone who has successfully completed a *Category A* approved course will have completed a course equivalent to a degree. Though the course contains an element of "field training", the International Advisory board is of the strong opinion that hydrographic surveyors must posses both education and experience to carry out their work effectively. The board stresses that an aggregate period of at least two years varied field experience in hydrographic surveying is necessary to reach the minimum level of competence. It is therefore suggested that for Trinidad & Tobago, successful attendants of this type of course still need to have requisite practical experience, and would additionally require a "practical task".

b) *Category B* - A course which provides a practical comprehension of hydrographic surveying for individuals with the skill to carry out the various hydrographic surveying tasks.

c) *Unclassified Courses* - Courses of training for support personnel employed in hydrographic operations. Such courses are defined to local requirements and are not intended for international recognition.

The International Advisory Board that assesses these courses does not provide recognition to individuals, however the Board encourages institutions in each country to provide individual recognition to those who have completed a FIG/IHO recognised course and requisite experience, as detailed above.

5.1.3 Application of standards

Optimum results are achieved when the appropriate procedures and equipment are used in conjunction with the expertise and training of the hydrographic surveyor, hence the importance of professional judgement cannot be overemphasised.

The role of the hydrographic surveyor has changed dramatically over the last fifteen years and will probably do so even more within the next fifteen. The hydrographic surveyor now has to have a detailed knowledge of position fixing, setting out, data management, GIS, remote sensing and project management and reporting skills. There is increasing overlap between his particular skill area and that of other disciplines of the surveying profession.

Therefore, the author considers it essential that the survey regulations do not preclude the experience and professional judgement of other registered survey disciplines nor that of the expatriate hydrographic surveyor brought in under contract to perform work in Trinidad and Tobago waters.

Whilst it may be preferable in some cases to register the company rather than the individual, if this is the case then the company's registration should be contingent upon a registered hydrographic surveyor or surveyors being part of that company.

5.2 Practice

It is recommended that a series of "best practice" statements be issued by the Land Survey Board from time to time to cover changing technology and methodology over time.

To derive maximum benefit from the surveys carried out in Trinidad and Tobago it is essential that all hydrographic surveys explicitly specify the geodetic datum to which the survey data relate.

Whilst it is expected that in future most hydrographic surveys will be carried out directly in WGS 84, or its more precise derivative ITRF, it is recognised that for

specific purposes it may be necessary to either position or navigate in an alternative co-ordinate system. One should not regulate against this, but it should be mandatory that the relationship between that co-ordinate system and that of WGS 84 should be stated. In addition a check set of co-ordinates should be supplied with any report, chart or other output such that it is possible both to verify the correct application of the necessary transformation.

6. CONCLUSIONS AND RECOMMENDATIONS

The full spectrum of hydrographic surveying and offshore positioning can be found to operate on Trinidad & Tobago waters.

This ranges from the more traditional analogue charting to the resource intensive hydrocarbon exploration mapping, dynamic positioning and now deep-water bathymetry surveying over the offshore Oil & Gas Industry.

Generally, standards of practice are high, though the general feeling amongst those questioned is that closer contact between clients and the hydrographic community would result in more correctly specified tenders and hence both better value for money and data being available post-mission for re-use by others.

It is recommended that –

6.1 Mapping Datum

Preparations should be commenced to move all future offshore chart preparation and production to WGS 84.

A clear statement should be issued jointly by the Lands and Surveys Division and the Ministry of Energy and Energy Industries confirming and endorsing the figures contained within their fax/letter of 20th March 1998 as the definitive relationship between Trinidad 1903 and WGS 84 and Naparima 1955 and WGS 84 for use offshore.

6.2 Petroleum Licence Definitions

The Ministry of Energy and Energy Industries should issue an official clarification of the co-ordinate system associated with past petroleum licence boundary co-ordinates, together with a clarification of whether these are grid or spheroidally based.

Future licences should be issued with co-ordinates listed in both Trinidad 1903 and WGS 84 co-ordinates, together with a clear statement that the definitive set would remain the Trinidad 1903 values.

6.3 International Boundary Transformations and EEZ definition

An official statement should be issued by the Government concerning its interpretation within WGS 84 of the PSAD 1956 values contained within the Treaty with Venezuela of 18th April1990. If possible agreement to these values should be confirmed with Venezuela.

Future international boundary delimitations should be attempted with Grenada and Barbados and a submission filed with the Secretary-General of the UN under UNCLOS defining the continental shelf surrounding Trinidad and Tobago. Any associated boundary co-ordinates should use a geocentric co-ordinate system such at ITRF (or WGS 84), as should any associated charts.

7. ACKNOWLEDGEMENTS

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Francis Charles for his discussion of the background to the past success of the Hydrographic Unit and last, and by no means least, I would like to thank the Director of Surveys Mr Tyrone Leong for his co-operation while I was researching material for this report.

ANNEX A – INDIVIDUALS MET DURING RESEARCH.

Tyrone Leong,	Director of Surveys
Francis Charles	Past DOS and past head of Hydro Unit
Alan Williams	LUPAP Project Manager
Ronald Nowbutt	Officer in Charge, Hydrographic Unit
Clinton Stewart	Hydrographic Survey Asst, Hydro Unit
Junior Gomes	Hydrographic Survey Asst, Hydro Unit
Joanne Williams	Cartographer, Hydro Unit
Richard Cattermole	Hydrographer, Cane Associates
David Neale	Hydrographer, Cane Associates
Hayden Nanton	Chief Surveyor, Capital Signal Company Ltd.
Mark Fisher	Maritime Services, Ministry of Works
Hazel McShine	Deputy Director, Institute of Marine Affairs
Shelly-Ann Jules-Moore	Hydrographer, Institute of Marine Affairs
Graeme Jaques	Base Manager, Racal NCS
Alan se La Bastide	Senior Geoscientist, Trinidad Shell E&P B.V.
Selwyn Lashley	Chief Technical Officer, Ministry of Energy and Energy Industries
Garth Ward	Snr Cartographer, Ministry of Energy and Energy Industries
Karla Edwards	M Phil Student, UWI
Helena Inniss	Geologist, Ministry of Energy and Energy Industries
Dr Keith Miller	Lecturer in Geodesy and Hydrography, UWI
David English	Manager, Fugro Trinidad
Alicia Naimool-Ramdass	Asst Manager DMPF, Lands and Surveys

Contact was also made with representatives of Arco, BP-Amoco, BG, BHP, Conoco, Elf, Enron, Exxon, Repsol, Shell and Talisman.

ANNEX B – INVITATION TO MEETING

Ministry of Agriculture, Land and Marine Resources and
Ministry of Housing and Settlement

NOTICE
Information Circular to Surveyors of Trinidad and Tobago
LAND SURVEYORS REGULATIONS: HYDROGRAPHIC SURVEYING CATEGORY

Land Use Policy and Administration Project: LUPAP

Surveyors and persons interested in hydrographic surveying are invited to attend a:

Meeting to be held at 4:30 p.m. on Wednesday 16 February 2000 at the Lands and Surveys Division, 118 Frederick Street, POS.

Richard Wylde, who has an MSc in surveying, is a past President of the Land and Hydrographic Division of RICS, and has been a hydrographic surveyor since 1982, will make a presentation on:

- The changing and expanding role of the hydrographic surveyor
- The increasing use of GIS and the challenges of large volume data management
- New developments in hydrographic surveying and positioning
- The importance of geodesy offshore
- The situation in Trinidad and Tobago:
  - Establishing the relationship between existing datums
  - The need for standards and/or legislation - regulations or best practice guidelines

Your attendance at this meeting would be very much appreciated to ensure that we are aware of the views of surveyors and others interested in hydrographic surveying and offshore positioning.

For further information contact:

Fred Brazier 633 8948 or 625 0427 email: fbrazier@wow.net

Charisse Griffith-Charles 640 2959 or 662 2002 Ext. 3314 email: charain@tstt.net.tt

ANNEX C – ATTENDEES OF THE HYDROGRAPHY MEETING

Held at Lands & Surveys office, 118 Frederick Street, 16 Feb 2000.

No.	Name	Speciality / Profession
1	Keith Miller	Hydrography, Geodesy Lecturer
2	Clinton R Stewart	Hydrography, Engineering Surveying
3	J Gomes	Hydrography, Engineering Surveying
4	L Antoine	Student UWI
5	R Rambhai	Recent Graduate
6	F Omar-ali	Student UWI
7	Tyrone Leong	Director of Surveys
8		Info Systems - GIS
9	Shelly-Ann Jules-Moore	Hydrography, GIS
10	Glenn Wilkes	Land Surveyor
11	Stephanie Elder-Alexander	Surveyor
12	Garth Ward	Min of Energy
13	Peter Beard	Land Surveyor
14	David English	Fugro, Surveyor
15	Ronald Nobutt	Hydro Unit
16	Charmaigne Delpeche	IMA Geologist
17	F Ragirsingh	Surveying/GIS
18	Cheryl Ann Eldu	Land Surveyor
19		
20		
21		
22		

Unable to attend the meeting, but provided with separate presentation were:

Francis Charles – founder of Hydrographic unit and former DOS

David Neale – Hydrographer, private practice.

ANNEX D – GEOGRAPHICAL AND PROJECTED CO-ORDINATE SYSTEMS OF TRINIDAD & TOBAGO

Geographical Co-ordinate System	**Trinidad 1903**	**Naparima 1955 (72*)**
Area of Use	Trinidad & Tobago	Trinidad & Tobago
Geodetic Datum	Trinidad 1903	Naparima 1955(72*)
Geodetic Datum origin	(Unknown)	Fundamental Point – Naparima Latitude 10deg 16min 44.860sec N Longitude 61deg 27min 34.620secW
Prime Meridian	Greenwich	Greenwich
Ellipsoid Name	Clarke 1858	International 1924
Semi-major axis (a)	20926348	6378388
Unit	Clarke's foot	metre
Ellipsoid inverse Flattening (1/f)	294.26068	297
Projection Co-ordinate System	**Trinidad 1903/Trinidad Grid**	**Naparima 1955(72*)/UTM zone 20N**
Axis Units	Clarke's Link	metre
Source Geog CS	as above	as above
Projection Name	Trinidad Grid	UTM zone 20N
Projection Method	Cassini-Soldner	Transverse Mercator
Latitude of natural origin	10.263	0
Longitude of natural origin	-61.2	-63
Units	DDD.MMSSsss	DDD.MMSSsss
Scale Factor at Natural Origin		0.9996
False Easting	430 000	500 000
False Northing	325 000	0
Units	Clarke's Link	metre
		* See note in section 3.1 concerning the confusion that has existed between the epochs associated with Naparima – 1955 and 1972.

Geographical Co-ordinate System	**WGS 84**	**La Canoa (PSAD 56)**
Area of Use	Trinidad & Tobago and World-wide	Venezuela
Geodetic Datum	World Geodetic System 1984	La Canoa
Geodetic Datum origin	Origin at geocentre	Fundamental Point - La Canoa* Latitude 8deg 34min 17.170sec N Longitude 63deg 51min 34.880secW
Prime Meridian	Greenwich	Greenwich
Ellipsoid Name	GRS80 (Global Ref System 1980)	International 1924
Semi-major axis (a)	6378137	6378388
Unit	metre	metre
Ellipsoid inverse Flattening (1/f)	298.2572221	297
Projection Co-ordinate System	**WGS 84/UTM zone 20N**	**La Canoa/UTM zone 20N**
Axis Units	metre	metre
Source Geog CS	as above	as above
Projection Name	UTM zone 20N	UTM zone 20N
Projection Method	Transverse Mercator	Transverse Mercator
Latitude of natural origin	0	0
Longitude of natural origin	-63	-63
Units	DDD.MMSSsss	DDD.MMSSsss
Scale Factor at Natural Origin	0.9996	0.9996
False Easting	500 000	500 000
False Northing	0	0
Units	metre	metre
		* Origin is also adopted for PSAD 56 (Provisional South American Datum 1956). In Venezuela PSAD 56 is known as La Canoa

Transformation Parameters

Trinidad 1903 to WGS 84 - MEEI-TT	Naparima 1955(72*) to WGS 84 - MEEI-TT
Source = Trinidad Ministry of Energy and Energy Industries	Source = Trinidad Ministry of Energy and Energy Industries
Transformation method = Geocentric translations	Transformation method = Geocentric translations
Area of use = Offshore Trinidad and Tobago	Area of use = Offshore Trinidad and Tobago
Dx = -61.702m	Dx = -0.465m
Dy = 284.488m	Dy = 372.095m
Dz = 472.052m	Dz = 171.736

ANNEX E – THE HYDROGRAPHIC UNIT, ITS CURRENT AND FUTURE VIABILITY AND POTENTIAL AND WHERE IT FITS WITHIN THE NATIONAL MAPPING FRAMEWORK OF TRINIDAD & TOBAGO

The hydrographic unit (HU) was developed with the following objective in mind; to provide the nation with the capacity to survey and chart the sea areas under its jurisdiction in order to assist other national agencies concerned with the management of marine resources, safety of marine transport and environmental protection.

Prior to the inception of the HU, most of the navigational charts of Trinidad and Tobago waters, published by international chart agencies, were out of date. Since it commenced obtaining and distributing hydrographic data in 1983, the HU contributed to new editions of six charts and issued two printed colour charts of its own, namely charts TT002 and TT003 covering the Port of Spain and Approaches to the Port of Spain respectively. It has also undertaken a substantial amount of fair sheet production in the past.

However it is some time since the HU last performed any data acquisition. Neither of its original vessels is currently functional. The original Pirogue is no longer in service and the main vessel, the *Meridian*, has not been operational now for the last 4-6 years due to maintenance/safety deficiencies that have not been able to be resolved due to lack of funds. Of the original full time crew, the captain has left and the situation with the engineer is unclear.

Of the original vessel mounted survey equipment operated by the HU, only the echo-sounder remains functional. Chart work has virtually stopped due to the absence of “in-house” acquisition capability.

The author questions whether resources should be further expended in the ongoing maintenance of a vessel and crew when there are several other government and private vessels to which access could be arranged at reasonable call-off rates to accomplish survey work.

Promotions of previous senior and extensively trained staff members, coupled with losses of others either to private practice or other government departments or agencies has left the HU moribund. The HU is now understaffed to a level that would not sustain serious acquisition work, should that ever become a possibility in the future. Also, technology has advanced so quickly over the past 10 years within the field of hydrographic survey, that it is difficult to see how the HU could catch up to its previous status, let alone develop further without a radical rethink of its mode of operation.

The original reason for the establishment of the HU remains a valid one. Many national agencies still require hydrographic data and in the absence of a working vessel, are forced to obtain this information from the private sector. Whilst this provides useful stimulation to this sector within a small nation such as Trinidad &

Tobago, the respective national agencies often poorly specify their requirements and the data acquired tends then to reside with that agency and not be used for the general benefit of the nation. Additionally, Trinidad & Tobago are members of the International Hydrographic Organisation (IHO), and, as members of this august body have an obligation to contribute data to the world stage concerning Safety of Navigation. These things require redress.

The HU has been bounced between different Ministry units in the past and currently sits as a separate part of the Lands & Surveys Division of the Ministry of Housing and Settlement. Suggestions have been made in the past that it would sit better with a more marine related group, such as the Marine department of the Ministry of Works or even the coastguard, but this would again require major investments to be made in the HU that may not fully materialise. It is the author's opinion that the HU should remain within the Lands & Surveys Division and be fully integrated with that department. It should not be housed in a separate building and should shed itself of the enormous overhead of having and maintaining its own dedicated vessel. Many of the functions of its staff and some of the equipment used, and which could be used, are common with the Lands & Surveys Division. Integration would go a long way to change the current malaise exhibited by the HU. Sharing of resources would significantly reduce costs and present a wider resource base on which to call upon for more rapid fair sheet completion, under the supervision and guidance of the existing trained hydrographic staff, as well as providing additional background tasks for the existing staff.

The Lands and Surveys Division provide a natural focal point for collection of spatial data. The Director of Surveys (DOS) already sits on the requisite committees and has good contacts with the National agencies that require hydrographic services to be undertaken. Proper integration of the HU will enable it to provide a needed public service through providing its specialist skills and experience assisting agencies and government departments with the correct preparation of tenders for hydrographic survey work. It would enable existing and future hydrographic staff to participate in the survey work as Quality Control observers and ensure that the data is both acquired to specification and outputs in a form suitable for the funding agency and also for inclusion on and contribution to the national and international charting sheets.

Liaison at the correct level between the Lands and Surveys Division and National agencies such as the Ministry of works, the Institute of Marine Affairs and especially the Ministry of Energy and Energy Industries amongst others, would enable better access to hydrographic data being acquired by these agencies. It would also allow more innovative funding methods to be explored to contribute to the national hydrographic charting capability.

For example:

1. Already the Ministry of Works levies funds from vessel owners using the nation's ports to enable maintenance of navigation lights in Ports and their approaches, this could be expanded to contribute to the maintenance of charts and mapping of potential underwater obstructions.

2. There is a need to monitor coastal zone development, and a minor levy could be made on coastal zone projects to cover the mapping/charting maintenance work associated with this.

3. The Ministry of Energy and Energy Industries levies all of the Oil & Gas operators offshore Trinidad & Tobago to contribute to the "National Oil Spill Contingency Plan". One of the current limitations in mathematical modelling that has been undertaken to test & support this plan is the lack of knowledge of the bathymetry of the Trinidad & Tobago EEZ. If a portion of this Oil and Gas levy could be secured to fund a detailed mapping project this could then be used as a base for the nation's hydrographic charting as well as many other environmental and planning activities. If this was let as a monitored and supervised commercial contract, the majority of the base mapping could be acquired at a stroke requiring thereafter only minor supplemental revision and maintenance work. The Offshore operators would benefit greatly from access to this data for their own navigation and modelling purposes and the aviation as well as maritime safety organisations would also be presented with a product that would fit their needs.

These days, hydrographic surveying is not just carried out for the compilation of nautical charts. Hydrographic data is also important for coastal zone management, environmental monitoring, resource development (including hydrocarbon and mineral exploitation), legal and jurisdictional issues, ocean and meteorological modelling, engineering and construction planning and many other uses. It is a resource that is expensive to acquire and should be made available to all.

Over the past twenty years a significant amount of hydrographic data has been acquired over the EEZ around Trinidad & Tobago. This currently resides in reports, on shelves etc, and even the digital data is archived in warehouses without the HU having had access, sight or in most cases, even knowledge of its collection. There needs to be a concerted effort put to sourcing this data, assessing and documenting its quality and determining its potential contribution to a future national geo-spatial archive.

Many countries are starting to realise that the acquisition of spatial data is an expensive and resource intensive exercise and that the storage of such data in a form that can enable ready and speedy access is of great benefit. Searching for existing data, retrieval from archive and the copying of both hardcopy and digital data is also a hugely time consuming and expensive exercise. Cataloguing what data exists and digital archival of its spatial reference has achieved considerable success and both future cost and time savings for those countries that have invested in it. Whilst the author is not suggesting this necessarily lies within the scope of a future integrated HU, the concept of utilising the Lands & Surveys Division GIS for hydrographic data in addition to land is an obvious area of synergy that should be explored.

A project should be set up, perhaps as a funded research activity for a post graduate student of UWI to undertake a data cataloguing and retrieval exercise such as detailed above. Letters could be written to the Oil & Gas operators and

other sectors of industry asking for access to files/data records etc. Indeed part sponsorship may even be found from these bodies if they are approached in the right way.

The Tide gauge monitoring and environmental data collection currently undertaken within the HU could also be simply merged with the Lands & Surveys Division. The additional manpower that would then be available for maintenance and monitoring of the equipment would be invaluable. Also, a better credibility and backup would assist in incorporating such measurements as may be achieved from other agencies such as the IMA.

The Director of Surveys is shortly to be visiting the UK as part of a training exercise organised in conjunction with Ordnance Survey International. The head and deputy head of the digital mapping unit will accompany the DOS. It is recommended that they be taken on a short tour of the UK Hydrographic Office, Taunton, UK to see what the requirements of an International Charting Organisation are with respect to an archipelagic nation such as Trinidad & Tobago and how the UKHO might be able to contribute in terms of advice to, and training of, Trinidad & Tobago's hydrographic personnel to accomplish this potentially new role.

ANNEX F – SUMMARY OF STATEMENTS AND RECOMMENDATIONS CONTAINED WITHIN THE REPORT.

Fundamental to hydrographic surveying, precise navigation and positioning within the EEZ of Trinidad & Tobago is an understanding of the geodesy of the Nation State and its marine boundaries. GPS has become the de-facto system of choice for both navigation and positioning and it is expected that adoption of WGS 84 as the co-ordinate system of choice offshore Trinidad & Tobago will increase either with, or without legislation to effect it.

1. The Government should publish a definitive relationship between the co-ordinate systems of Trinidad 1903, Naparima 1955, PSAD1956 and that of WGS 84 as a matter of urgent concern. It is recommended that a unified and consistent approach be adopted with respect to these relationships.

2. A clear statement should be issued jointly by the Lands and Surveys Division and the Ministry of Energy and Energy Industries confirming and endorsing the figures contained within their fax/letter of 20th March 1998 as the definitive relationship between Trinidad 1903 and WGS 84 and Naparima 1955 and WGS 84 for use offshore. The report published by UWI should be used as supporting evidence of these figures.

3. With respect to the definition of hydrocarbon exploration and exploitation licensing offshore, the current practice of using the Old Trinidad 1903 co-ordinate system should continue. The Ministry of Energy and Energy Industries should issue an official clarification of the co-ordinate system associated with past petroleum licence boundary co- ordinates, together with a clarification of whether these are grid or spheroidally based. Future licences should be issued with co-ordinates listed in both Trinidad 1903 and WGS 84 co-ordinates, together with a clear statement that the definitive set would remain the Trinidad 1903 values.

4. It is recommended that all future charting activity offshore Trinidad and Tobago be conducted in the WGS 84 co-ordinate system.

5. It is recommended that the standards of hydrographic surveys performed within the Trinidad and Tobago EEZ should broadly conform to IHO SP44. Even if the standard does not always specifically address the user's needs, it is felt that it provides a basis on which to assess the quality of the hydrographic data. The IHO Special Publication No.44 (4th edition, 1998 or later) is recommended as the minimum standard for hydrographic surveys.

6. It is recommended that the coastal waters charts be upgraded as a matter of urgency to the standards set out in IHO SP44, particularly with respect to port approaches. This should be achieved by means of commercial tender with onboard QC and overall contract supervision from the Hydrographic Unit. New and cost efficient, techniques such as airborne laser depth sounding could be explored, where sediment conditions allow.

7. It is recommended that Trinidad & Tobago embark on a systematic mapping programme of its EEZ. As a number of Agencies, Ministries and Industry would benefit from such an exercise, it is recommended that a pool of funding be created. Possible sources could include the oil-spill contingency fund, a levy on port traffic to help fund updates and maintenance associated with this activity.

8. It is also recommended that copies of all hydrographic data acquired in the exploration and exploitation of the EEZ be made available for the general good of the country in the form of a national archive, which could be maintained by the Lands and Surveys Division. Other Agencies and Ministries should also be charged with contributing their past and future data. Working examples of this can be found in UK and Norway.

9. It is recommended that the Lands and Surveys Division issue a definitive coastline file for use by either Government or Industry in digital form, either in Naparima 1955 and/or WGS 84 form. This should be addressed with some degree of urgency. If made available it would be a valuable aid to overall planning and development of the nation. An accuracy of +/- 5 metres would be appropriate.

10. Future international boundary delimitations should be attempted with Grenada and Barbados and a submission filed with the Secretary-General of the UN under UNCLOS defining the continental shelf surrounding Trinidad and Tobago. Any associated boundary co-ordinates should use a geocentric co-ordinate system such at ITRF (or WGS 84), as should any associated charts. It is not known whether Trinidad and Tobago have made a submission as yet to the Secretary General of the United Nations describing the outer limits of its continental shelf, but it is understood that a time limit exists within which such submission should be made. The said submission should be supported by relevant information, including charts and geodetic data.

11. The new automated tidal recording stations currently monitored by the IMA, through its involvement with CPACC (Caribbean Planning for Adaptation to Climate Change), should be tied with the gauges operated by the Hydrographic Unit of the Lands and Surveys Department. The two data sets should be integrated to ensure that past trends are incorporated with the more modern equipment. A phased replacement of the older systems is also encouraged with ties made to any future geoidal model.

12. It is recommended that the Survey Board issue a series of “best practice” statements. These can then be updated from time to time to cover changing technology and methodology.

13. To derive maximum benefit from the surveys carried out in Trinidad and Tobago it is essential that all hydrographic surveys explicitly specify the geodetic datum to which the survey data relate. It should be mandatory that the relationship between that co-ordinate system and that of WGS 84 should be stated. In addition a check set of co-ordinates should be supplied with any

report, chart or other output such that it is possible both to verify the correct application of the necessary transformation.

14. Future survey regulations do not preclude the experience and professional judgement of other registered survey discipline nor that of the expatriate hydrographic surveyor brought in under contract to perform work in Trinidad and Tobago waters.

15. Whilst it may be preferable in some cases to register the company rather than the individual, if this is the case then the company's registration should be contingent upon a registered hydrographic surveyor or surveyors being part of that company.