Joint NASA-CNES Review Committee
20th – 22nd October 2008

Satellite Laser Ranging Station

Review Committee Report

December 2008

Executive Summary

The SLR station at Papeete is in a geographically important location providing essential information on the orbits of satellites that address climate change and geohazards research as well as basic research in geodetic science for the South Pacific Basin. Unfortunately the SLR station has been operating far below the ILRS standard for data quantity. A Site Review Committee was organized by UPF, CNES, and NASA to assess the operating condition of the SLR station, identify obstacles inhibiting its data production, define the actions necessary to improve near-term performance, and recommend a strategy for long-term operation. The ILRS has tracking standards in data quantity and quality that are the basis for rating a station as operational. This standard should be used as the criteria for evaluating the performance of the Papeete station.

The Review Committee met in Papeete on October 20 - 22 to conduct its review. It met with the station staff, with officials of the University and with Territorial government and French government officials. This report is the output from that study.

The station is operated by a senior technician and two junior technicians whose tenure is limited. The station underwent major maintenance by NASA in May and is now operating three-8 hour night time shifts (24 hours) per week. The technician, who has worked at the station since 2001, has done quite well considering his very isolated situation. Two junior technicians are in training. There is no SLR engineering expertise on site; all major maintenance and repair is done by Honeywell Technical Solution Inc. (HTSI). The station has been plagued with labor turnover because, while two of the technician positions are permanent, under local labor regulations, only native Tahitians can occupy these positions permanently. All other nationalities, including mainland French nationals, are limited to a four year maximum term. For this reason, only the senior technician whose is a native Tahitian has a permanent appointment. This results in high staff turnover and thus a crew which is very light on training from well experienced personnel.

The trailer and the system are in stable condition at the moment. Recent leaks in the trailer have been repaired. The aircraft spotting radar is not operational, so an aircraft spotter (second person) is required during operations. Once the radar is repaired and the junior technicians are fully trained, single operator operation may be possible, provided local safely laws will permit it. Of the three ground targets, two of them are now precluded from ranging due to the encroachment of new housing and other buildings. Some provision must be made to replace these.

Logistics and shipments of goods have been a problem due to customs issues, but the University and local officials are prepared to address this with the proper authorities.

If the station is going to fulfill the ILRS tracking requirements, it should have:

a. a stable crew of technicians for operations on a 2-shift (80 hour) per week basis; with local regulations limiting night time working hours and leave time; this will require four operators including the senior technician;

b. an engineer to maintain the system, and participate in tracking a few days per month to remain knowledgeable and facile with the systems;

The Committee recommends that once the station achieves operational status, we should consider the replacement of the current system with the next generation system to be decided by CNES and NASA.

Acknowledgements

The review committee would like to acknowledge the contribution of Honeywell Technical Solution Inc in the provision of data statistics, performance projections, and operational procedures.

Contents

1. INTRODUCTION

Following discussions held at the ILRS workshop in Grasse, France in September 2007, the three parties involved in the operation of the Tahiti Laser Ranging Station (UPF, NASA and CNES) based at the Tahiti Geodetic Observatory (OGT) decided to form a review committee to examine the station and make recommendations regarding its operation. The following review committee was named (see Table 1), and, after a number of attempts, the date for the review committee visit to the Tahiti Geodetic Observatory was fixed for 20th-22nd October 2008.

Committee Member	Position	Area of expertise
• John Labrecque	Lead, Earth Surface and Interior Focus Area Science Mission Directorate NASA HQ	NASA programmatic issues
• Mike Pearlman	Director, ILRS Central Bureau Harvard-Smithsonian Center for Astrophysics	Laser Ranging
• David Carter	NASA SLR networks manager	Moblas system maintenance and future laser system development
• Jean-Pierre Barriot	Director, Tahiti Geodetic Observatory (OGT) University of French Polynesia	Laser station operations
• Richard Biancale	Executive Director, Groupe de Recherche de Géodésie Spatiale	French geodetic infrastructure
• Francis Pierron	French Mobile Laser Ranging System Manager, Cote d'Azur Observatory	Laser Ranging operations
• Steven Hosford	Solid Earth Programmes Manager, Strategy and Programmes Directorate, CNES HQ	CNES programmatic issues

Table 1. Members of the Review Committee

A number of objectives were established for the review committee:

- Establish the current operating status of the station;
- Identify problems associated with the material and functional environment of the station which prevent the station from functioning in an optimal manner;
- Provide recommendations intended to alleviate these problems;
- Initiate a discussion on the long-term future of the station, specifically looking at the replacement of the current system and maintaining laser operations in the future;
- Meet with the representatives of the University, local territorial government and French government to impress upon them the unique position and importance of the OGT to the international geodetic infrastructure.

The findings and recommendations of this committee are intended to provide guidance to CNES, NASA and UPF on improving the performance of the Laser Ranging Station and making long term plans.

1.1. HISTORICAL ASPECTS

In February 1997, an agreement was signed among NASA, CNES, and the French University of the Pacific (Université Française du Pacifique) (now the University of French Polynesia - UPF) for the installation of a NASA Satellite Laser Ranging (SLR) System in Tahiti, French Polynesia (full text of the agreement is provided in Appendix A). The NASA SLR system (MOBLAS-8) was shipped from Quincy, California to the new site located at the UFP site in Tahiti in 1997. It was envisioned that the site, equipped since 1994 with a Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS) beacon and since 1995 with a Precise Range And Range-rate Equipment (PRARE) beacon, would be a fundamental space geodetic site within the global fiducial network. At the time of the MOBLAS-8 installation, a Global Positioning System (GPS) was in the process of being relocated to this site. The MOBLAS-8 system had its site dedication ceremony in May 1998. At the present time, the OGT includes the SLR system, the DORIS beacon, and two IGS GPS systems which are all in operational status. The GPS data from the site is furnished routinely to the IGS, however it appears to have some multipath issues and the IGS has suggested to us that an alternative site might be more optimal. There is another GPS site used by IGS at the Faaa Airport about 5 miles away.

Prior to being shipped to Tahiti, the MOBLAS-8 system had ranked among the top data producing systems in the International Laser Ranging Service with a crew operating three shifts per week. When MOBLAS-8 had steady crew operations with NASA on-site personnel, the Tahiti site had months of strong tracking. However, due to personnel turnover at UPF, MOBLAS-8 part failures, and reduction of the supporting NASA engineering staff, data acquisition has suffered significantly.

1.2. NEED FOR A SITE IN TAHITI

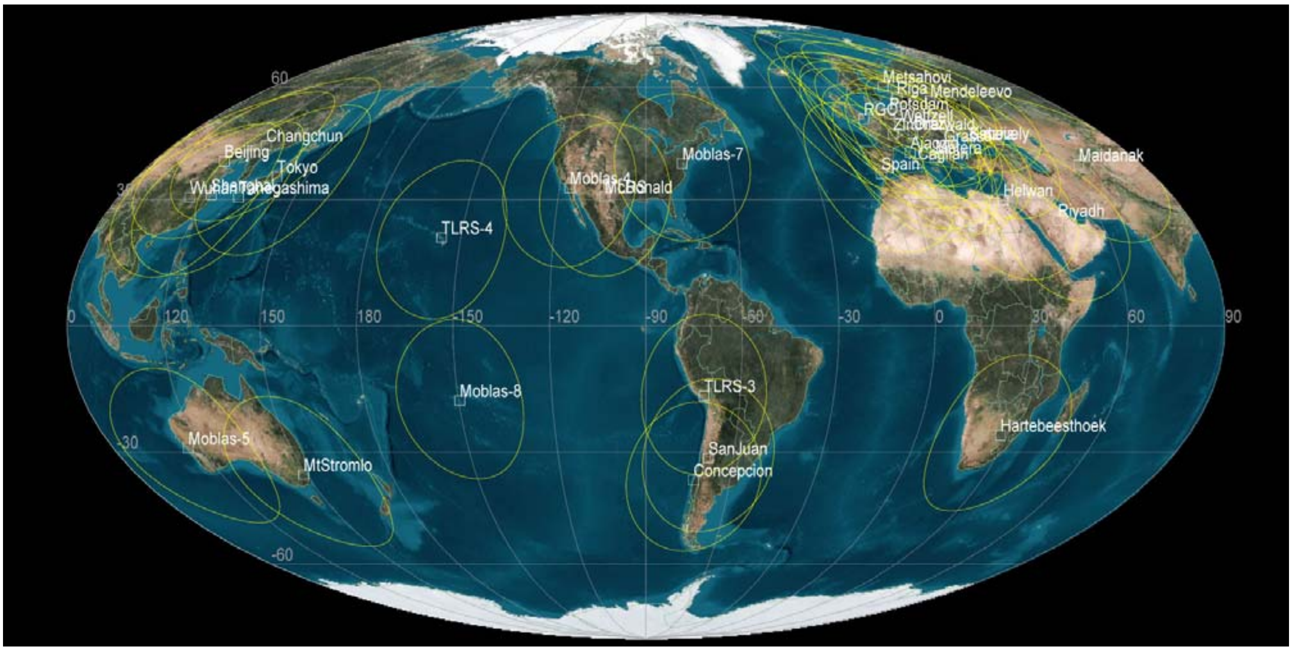
The Territory of French Polynesia consists of 120 islands which are stretched over an area in the Pacific Ocean of 4.87 million km^2, an area as large as Europe, stretching from 134° to 155° W-longitude and 7° to 28° S-latitude. This French territory is a politically stable part of the Pacific with an autonomous government.

Considering the need for secure hosting and operations, there are only a few places in the southern Pacific Ocean that are capable of providing the geographical coverage of the satellite laser tracking network. Tahiti is one such place, and, by virtue of its status as a French Territory, it can also benefit from support from French agencies such as the Space Agency.

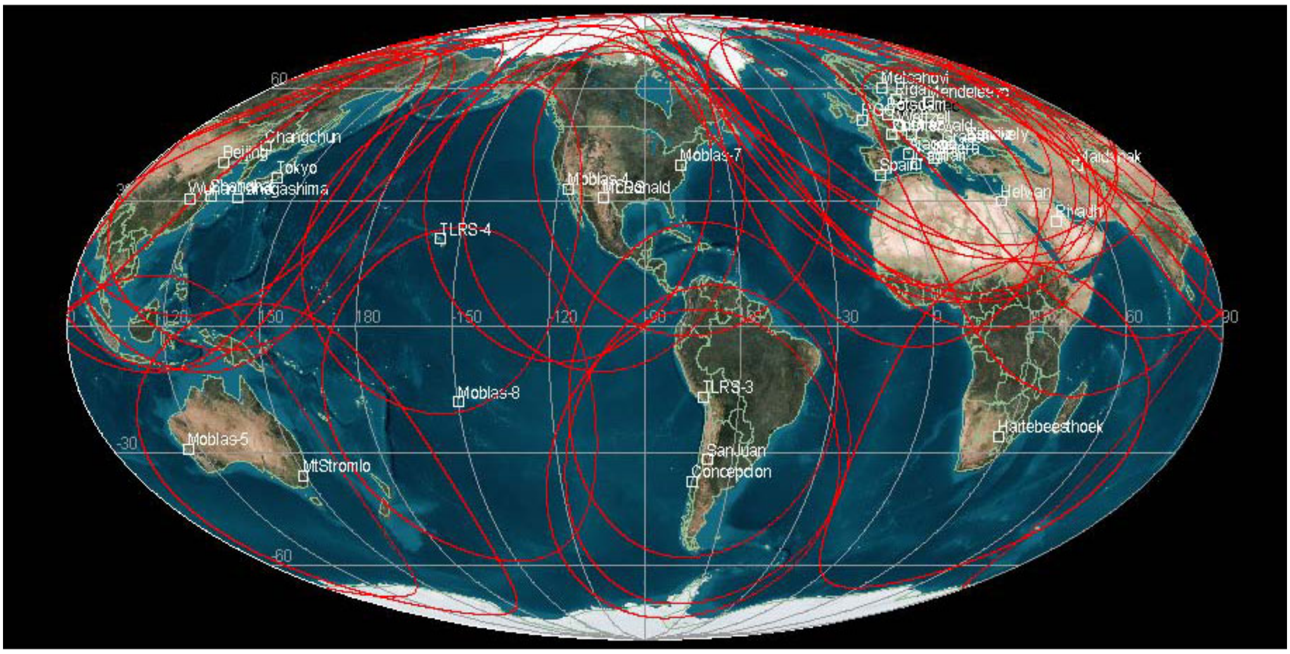
The University of French Polynesia (UPF) has become a motivated and efficient partner on the French side (together with CNES) in the development of the cooperation with NASA in installing the MOBLAS-8 SLR station on its campus and performing observations.

Of the 40 SLR stations around the world, Tahiti is the only station to provide coverage of the southern Pacific. Tahiti and Haleakala, Hawaii, are the only SLR stations on the vast Pacific tectonic plate. The sparseness of the southern hemisphere network is a significant weakness for SLR. Figure 1 shows the unique coverage that is provided by the Tahiti station for both low orbiting satellites and Lageos. In this context, the Tahiti site has a very important role to play.

Figure 1. SLR Network Map showing the tracking region of each station



SLR tracking circles for the Jason Satellites for 20 degree horizon



Tracking circles for the Lageos Satellites for 20 degree horizon

The contributions of the SLR technique are numerous and concern the definition or the measurement of:

- - the Terrestrial Reference Frame (TRF) and plate motions
- - the Earth orientation parameters
- - the geocenter motion
- - the standard for the mass of the Earth
- - the dynamical flattening (C20)
- - …

The SLR technique also provides:

- long term monitoring of geophysical effects using dedicated retroreflector equipped targets (e.g. Lageos, Starlette) already tracked for more than 30 years;
- calibration and validation of satellite-borne altimeter systems (e.g. Envisat, Jason)
- absolute validation of the orbit accuracy at the cm level (e.g. CHAMP, GRACE)
- origin and fixing of scale (together with VLBI) for the Terrestrial Reference Frame
- orbit determination for rescuing satellite missions when active electromagnetic systems fail (ERS1, GFO, Topex, Meteor-3M)

For all these objectives, it is crucial to homogenize the SLR tracking network following the example of the DORIS system with the aim of achieving a balanced global distribution of stations. In this context, Tahiti provides a unique location which gives significant network augmentation in the southern hemisphere in a large and sparsely populated region of the Earth. It also covers a vast ocean region for altimeter orbit calibration and validation.

1.3. MINIMUM DATA STANDARD

The International Laser Ranging Service (ILRS) has a set of minimum standards for operational SLR stations in its network. Performance guidelines, which continue to evolve as our service matures, are divided into three categories (data quantity, data quality, and operational compliance).

Yearly data quantity guidelines are:

- 1000 Low Earth Satellite (LEO) Passes
- 400 LAGEOS 1,2 Passes
- 100 High Satellite Passes

Data quality guidelines are:

- 1 cm LAGEOS NP precision
- 2 cm short term bias stability (1)
- 1 cm long term bias stability (2)

Operational compliance guidelines are:

- Data delivery within 12 hours (data latency)
- Specified ILRS NP data format
- Current site and system information form (i.e. site log)

(1) the standard deviation about the mean of pass-by-pass range biases from the weekly LAGEOS analysis.

(2) the standard deviation of monthly range bias estimates from the weekly LAGEOS analysis for at least 8 of the last 12 months.

The Committee recommends that these criteria be used as the level for acceptable performance once satisfactory resolution has been found for the issues expressed later in this document. The station already satisfies the second and third categories; deficiency is in data yield.

The standard above is viewed as current minimum performance. As newer technologies are implemented providing better performance and more automated operations, the minimum standard will become more stringent.

2. CURRENT STATUS

2.1. PERFORMANCE

Historically the station has gone through periods of ups and downs, but it has never met the ILRS standards for data quantity. The annual data yield since the year 2000 is shown in contrast to other stations in the Southern Hemisphere below in Figure 2.

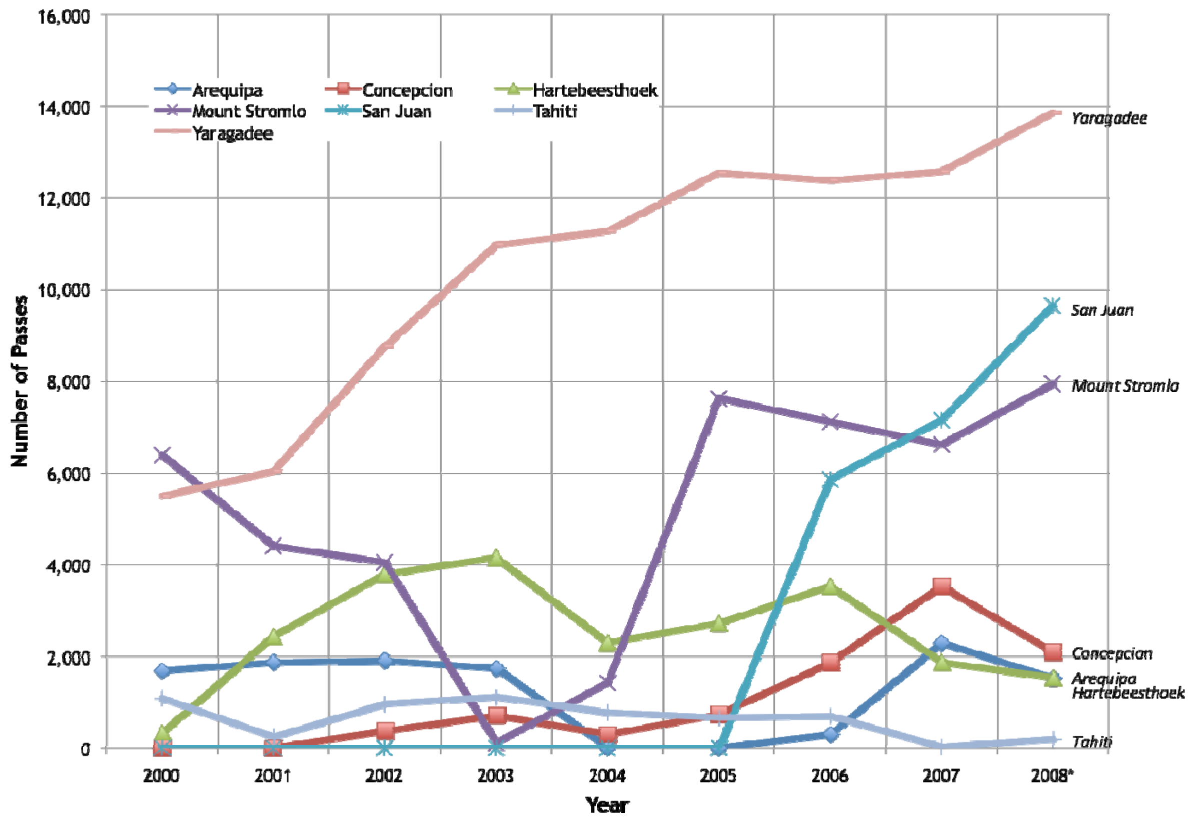


Figure 2. Number of satellite passes acquired per year for Southern Hemisphere stations

Since the station underwent major maintenance by Honeywell Technical Solution Inc. (HTSI) in May 2008, operations have been conducted 3 nights per week, during the hours of 6:30 pm – 2:30 am. Since early June a little more than a month has been lost due to equipment and facility issues and vacation. The tracking experience during this period is shown below. If the station had been manned for the full night time hours, 7-days per week (80 hours) rather than the current 24 hours, we would have expected data yield to be approximately three times larger, or about 1000 passes. The station was able to track satellites in all categories but tracking was weak on the GNSS satellites.

Tracking operations were conducted during two nights of our visit (20th and 21st October) while the senior technician was carrying out training of new observers. The sessions were limited to 6:30pm – 2:30am. The station tracked 13 passes on the first night and 15 passes on the second night. Satellites tracked included Lageos 1 and 2, GFO, Starlette, Stella, Larets, Envisat, Ajisai, ERS-2, Jason 1 and 2, Grace-A and –B, TerraSAR-X, Grace, Be-C, Champ, and Glonass-109. Operations followed the schedule tasking issued by NASA. This indicates that under good conditions the station could track approximately 15 passes in an evening session. There were still a number of satellite passes in view after 2:30 am, but the station was not manned.

The data yield and our observation do not imply that the weather is not a challenge. However, large amounts of data are being lost because the station is operated only 24 night time hours per week and potentially very productive tracking hours are not being covered.

Table 2. Passes acquired during the period June 12 – October 22, 2008

Satellites	June	July	August	September	October	Total
Ajisai	1	8	4	1	14	28
TerraSAR-X	0	0	0	2	1	3
Starlette	2	2	0	5	12	21
Stella	2	6	3	9	8	28
Lageos-2	5	8	4	12	16	45
Lageos-1	6	12	5	6	9	38
Larets	1	3	2	4	8	18
Glonass-109	0	0	0	1	2	3
Envisat	2	6	3	3	10	24
ERS-2	1	6	3	4	10	24
Jason-1	4	5	2	0	8	19
GraceB	0	1	0	4	5	10
GraceA	0	2	0	1	5	8
Jason-2	0	5	2	1	3	11
GFO	4	6	2	0	1	13
BEC	0	0	0	1	0	1
Champ	2	3	0	0	4	9
Total Passes	30	73	30	54	116	303

2.2. MATERIEL / EQUIPMENT

The NASA MOBLAS-8 system is currently in operational status. The system was not operational from April 2007 to May 2008 due to component failures. The system was brought back to operational status in June 2008 with the latest NASA MOBLAS system upgrades. The radar is the only component that is currently not operating, which means that an outside aircraft spotter is required. The radar components have been sent from NASA and are on-site. The station is awaiting a NASA engineer to complete the repair.

This system, like the other Moblas systems, is over 25 years old with many obsolete parts, requiring increasing frequent maintenance and care.

We also learned that the GPS station at the Observatory reports its data to the IGS. However the IGS has another GPS receiver at FAAA airport which it views as its primary station in the area.

Since the OGT was established in 1997, staff remain on average around 20 months and over this period more than fifteen people have been employed. These employees in general have a technical qualification (two years technical training in the French system) but have little hands-on experience of complex electro-mechanical equipment. The station does not have sufficient engineering talent to maintain the system, diagnose repairs, and implement repairs and upgrades.

Station operations are constrained by local labor laws. Civil servant technicians (Yannick Vota and Laurent Mercier) cannot work more than 38.5 hours per week, and they must have 54 working days of vacation per year. They can work nighttime hours (10 pm – 5 am) at a salary premium of 50%.

Youri Verschelle, whose position is funded by CNES, can work only 35 daytime hours per week; he has 30 working days per year of vacation. He can work eight additional daytime hours per week at a salary premium of 25 %. Again, he can work nighttime hours (10 pm – 5 am) at a salary premium of 50%.

A shift cannot exceed 10h (night or day), and must have a break of at least 30 minutes.

Yannick Vota is a fairly well trained operator; he is not familiar with some of the esoteric issues with the system, but he has done remarkably well considering his isolation. He is a very patient teacher of the new members of the crew.

The situation is further complicated by the fact that two current employees Mercier and Verschelle are non-Tahitian natives and as such are subject to local employment laws which mean their contracts will be terminated in February 2010 and June 2009 respectively.

The impact of all of these constraints is that the station operates only three nights per week, eight hours per night. This can be expanded as soon as the current trainees can operate without Yannick Vota on site.

2.3. FINANCE

The information provided in this paragraph has been established taking into consideration the OGT budget over the last four years. The average annual operating cost of the OGT is around 110k€ composed of:

- 40k€ Temporary technician
- 40k€ Electricity
- 15k€ Customs fees et Value-added tax on imports (replacement parts)
- 8k€ Travel
- 7k€ Diverse

110k€ Total

In order to meet these costs, the OGT receives funding from several sources:

- 70k€ CNES
- 10k€ National Geospatial Agency (for GPS antenna)
- 15k€ French Ministry of Education and Research
- 15k€ UPF

110k€ Total

It should be noted that the legal framework (local legislation) within which the OGT operates evolves frequently. This has resulted in recent years in additional costs for the temporary technician's salary. Customs fees and VAT on imports have also been significant costs in 2008 with the repairs carried out on the station. Electricity costs have also increased significantly (around 20% in 2008 alone).

2.4. OPERATING CONDITIONS

Weather

Weather at the station is strongly linked with the seasons. During the dry season (June to September) the weather is normally quite good, with less than 10 % dataless nights. During the wet season (October to

May), typically 30 % of the nights are lost, although losses may not be complete and some passes can still be tracked.

The precipitation map provided in Figure 3 shows cumulative yearly rainfall in mm's. Assuming rainfall is an accurate proxy for cloud cover, the OGT site can be seen to be optimally positioned in the driest part of the island. There is no impact of the weather on the electronics. Leaks in the station have been repaired and the roof has been repainted.

Local Environment

Dust due to the close proximity of the road does not appear to be a problem. They have not observed any abnormal deposition of dust on the optics of the telescope. Because of the many houses around the Observatory, only one of the three calibration targets can be used. This means that they cannot do any azimuthal testing or validation of range calibration. Mirrors on the unused targets have been vandalized by local children, so security on the targets is an issue. A house is now in the line-of-sight between one of the unused targets and the Observatory, so this target cannot be recovered. A problem with lighting in a local parking lot is soon to be fixed by the university.

Aircraft

The Observatory is within a few miles of FAAA airport. Although air traffic is modest, it includes commercial carriers and private planes plus some military aircraft. Once the radar is repaired they may be able to reduce the shift crew to a single operator, but for safety reasons, it may be best to operate with two-man crews at least until new members of the team gain sufficient tracking experience. The station must be extremely vigilant. There have been some incidents of people using low power laser to illuminate aircraft and visits to the station by local police occur almost monthly.

Power

The air conditioning system (three units) is in poor condition, with no temperature control system. Electric power is a huge drain in their budget, averaging about 3300 € per month. Funding has been made available by CNES to upgrade the air-conditioning system. This work is scheduled for the first quarter 2009.

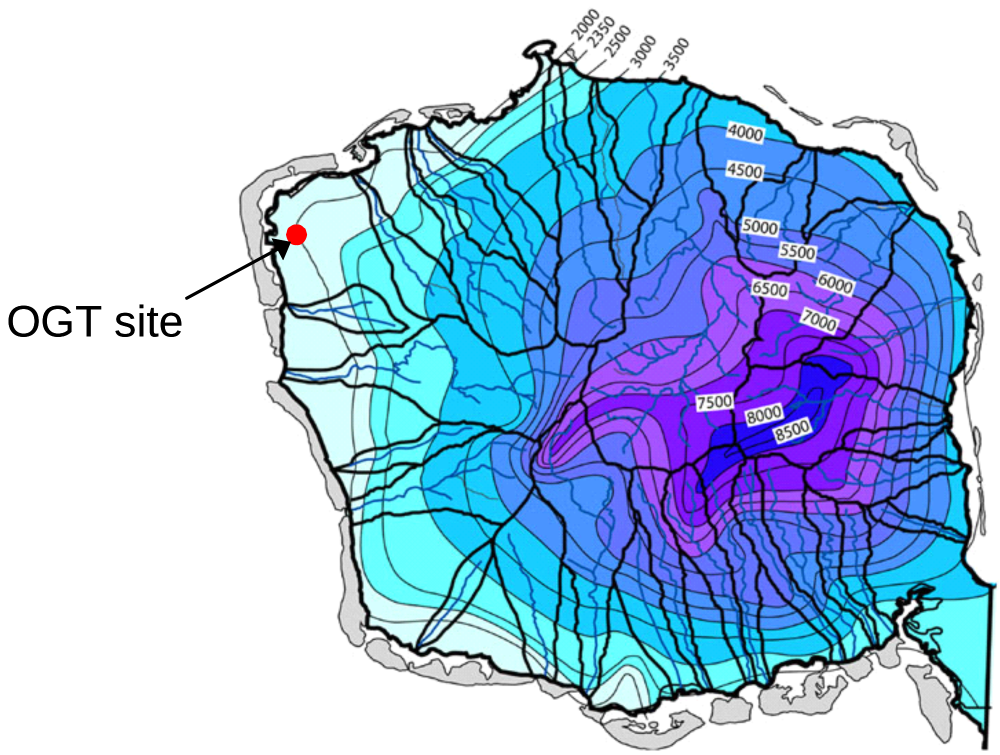


Figure 3. Precipitation map of Tahiti Nui (mm's of rainfall per year) with the island's watersheds plotted in black and rivers plotted in blue and contour lines of equal precipitation

3. NEAR TERM IMPROVEMENTS

3.1. ANTICIPATED PERFORMANCE

We have estimated the data production that might be anticipated for the station by using a pass forecast schedule and some assumptions about operating conditions (see Table 3). For these forecasts, a shift includes five nights/week, eights hours per night (40 hours per week). Aside from intrinsic issues (personnel and system) at the station, data production will be limited by weather and the low latitude location of the site. With an estimated 50% data loss due to weather and a 20 % data loss due to system issues during good weather periods, the model says that a single evening shift, 5 days per week will not satisfy the ILRS data standard (line c), and furthermore, the estimate for high satellites is an overestimation of anticipated performance based on high satellite experience to date. A second shift will be required. Our estimates assume that staffing is secure and experienced, and system and operational issues are promptly addressed.

We recommend that priority scheduling be given initially to night time hours when tracking should be easiest and when weather conditions are best during the rainy season. The schedule can be expanded to include some daytime hours as crew experience increases.

Table 3. Projected Pass Statistics for the Tahiti Station				
Total available passes for all satellites for a full year	**High**	**Lageos**	**Low**	**Total**
a. Full time operation (24/7)	2392	2860	8632	13884
b. Single shift (05:00 - 13:00) five days per week	705	743	1857	3305
c. Single shift (05:00 - 13:00) five days per week assuming 50% loss due to weather and 20% loss during good weather periods due to systems issues	282	297	742	1321
d. ILRS Standard	100	400	1000	1500

3.2. MATERIEL / EQUIPMENT

With CNES funding in early 2009, they plan to replace the air conditioning system; this should provide at least a 20 % saving on the electricity bill.

Once the radar system is back in operation and the technicians are fully trained (with some experience), the station should be operable with a single technician per shift. The aircraft spotter would no longer be needed. Under single person operation, a remote safety system for the technician should be in place. Until the radar system is repaired and the operators are experienced, the second person will be necessary. The faster the process gets started the faster the station will achieve full operation.

We had several observations that may help in improving the station operations.

1. The range gate width used by observers during night time observations was set at 4 microseconds. In the MOBLAS system, there is an oscilloscope display of the range gate interval and any returns that fall within that time period. We noted a jitter between the gate opening and the return time (typically one microsecond).

Considering the current accuracy level of the predictions on the satellites, this jitter is probably in the range gate generating system.

This issue, although not critical for night time tracking, will definitely lead to difficulties during daylight tracking. With the sky conditions in Tahiti, a narrower range gate window will be necessary to keep the background noise level low.

2. The HP chronometer displays the return range times. In 10 – 25% of the registered returns, the chronometer registered values about 1 ms short of the anticipated (contiguous) value. On the tracking oscilloscope a very weak pulse appeared about 1ms before the opening of the range gate; this is probably the source of the problem. The spurious pulse appears to be synchronised with the range gate. This could be a discriminator gating for the HP5370b counter. It might be possible to correct this problem by adjusting the threshold.

3. The stability of the laser is very impressive with energy of about 100mJ/shot at 532 nm and 5 Hertz and a very nice spatial distribution. Nevertheless, the link budget on the Lageos satellites appears to be very weak; the satellite was not captured low in the sky and the success rate was lower that we would have expected. This may be partially due to operator inexperience and local conditions. The laser team also confirmed that ranging to the GPS and Glonass satellites has been very difficult and returns are rare. This situation seems different from the other MOBLAS systems. This leads us to suggest that some checks and fine tuning may be required.

4. The operators had to continually adjust the pointing of the telescope during all passes including Lageos. This may be partially a result of inexperience, but it may also reflect errors in the mount model.

3.3. PERSONNEL

The station needs an engineer or a fully qualified senior technician to maintain the system. This person should have systems level experience in addition to full electronics capability and some facility with optics. Someone from an SLR environment would be preferable, but this may not be possible.

The crew will need organized training from HTSI, with some annual program to refresh operational practices. Presumably the on-site engineer can eventually take over this activity, but the remoteness of the site argues for routine visits.

The MOBLAS-8 system should be maintained in an operational status with operators available to perform routine tracking. The long term stability of the crew is essential. Station personnel turnover, adversely impacts the technical capability at the station and the data tracking quantity is severely compromised. Station personnel need proper training in operations, maintenance, troubleshooting, and repairs. UPF should develop a station personnel hiring plan which includes strategies to ensure long term crew stability. NASA should develop a training plan which includes on site and off site (NASA-GSFC, other NASA SLR sites) training. NASA should also provide an annual MOBLAS-8 system health check-up which should include training.

If the station is able to reach single operator performance, four technicians will be adequate to operate the station six to seven nights per week. Assuming that one technician is unavailable each week due to vacation, sick leave, or daytime duties, the other three technicians could operate 72 – 90 hours per week. One thought is to use extended shifts of 10 – 12 hours per night. If it is not possible to reach full single-operator operations, they should consider hiring additional trainees or students to augment the crews and thereby provide the second person. They may also be a way to provide new technicians to accommodate crew turnover.

3.4. FINANCE

Over the past several years the OGT budget has been balanced with a “last-minute” contribution from the University, however this situation is untenable. In recent years several different costs have increased considerably with little scope to cover these new costs with increased funding. Balancing the budget has become increasingly difficult and appears challenging in the years to come.

In order to alleviate this problem, the current air-conditioning system which is particularly inefficient is to be replaced in the coming months. This is likely to reduce the electricity by, at most, 20%. Customs fees and VAT on imported spare parts are also a major drain on financial resources. All avenues must be investigated to modify the current legislation to exonerate scientific apparatus from these fees. In addition, the travel budget should be increased and a line in the budget for training mission should be envisaged.

3.5. OPERATING CONDITIONS

To maximize operational conditions, the station personnel should

- follow operations and maintenance procedures for the equipment;
- follow reporting procedures when station is experiencing difficulties with hardware/software or operations;
- regularly perform routine maintenance to ensure that the health and safety of the ranging system and facilities are optimal;
- maintain the required spare parts on-site and immediately send request to NASA to replace needed items.

A more complete set of recommended procedures is included in Attachment 1.

NASA should review logistics procedures to ensure that items are shipped in a timely manner. UPF should notify NASA of any customs issues for import/export of parts. Communication between NASA engineers and station personnel is critical to the success of the station.

The operational tracking schedule should be optimized to maximize tracking success by including consideration for prioritized tracking opportunities and local weather. It is preferred to have tracking 7 days per week with two shift operations (40 hours each). Operations might include some days with two shifts and other with one shift. It might also be possible to use extended shifts to cover the operational hours more effectively.

The station needs a proper store of spares that is kept timely. They also need a fully documented set of procedures and diagnostics, with a set of tools that would permit the engineer to maintain the system.

All of the operators need full training; a training program with set milestones should be developed.

4. RECOMMENDATIONS AND LONG TERM OUTLOOK

4.1. RECOMMENDATIONS

This paragraph presents a set of point recommendations for each of the subjects discussed in the document.

Performance

- Establish an eighty-hour a week tracking regime; consider using 10 – 12 hour shifts per night to extend coverage.
- Use the ILRS standard to evaluate the progress of the station

Material

- Bring the radar system into operational status as soon possible
- Maintain on site stocks of basic spare parts and appropriate tools
- Resolve equipment issues highlighted in the report
- Upgrade air conditioning system and consider other measures to reduce energy costs
- Establish an annual station health check-up by NASA personnel

Personnel

- Establish and maintain a stable qualified team composed of the following skills:
  - Four technicians capable of observing autonomously
  - Senior technician/engineer
- Develop a training plan for station personnel (operations, diagnostics, and routine maintenance)
- The Review Committee is pleased to learn of the recruitment of an Assistant Professor who will work with space geodetic data (including SLR observations). It recommends that this person should establish links with the research community in the US (NASA) and France (GRGS).
- Consider hiring students to help the SLR operations team

Finance

- Resolve customs and tax (VAT) issues
- Establish a balanced sustainable budget for the SLR station ensuring that sufficient budget is available for training (travel principally)

Operating conditions

- Schedule an operations review by an appropriately qualified person from another Moblas station
- Review the procedure for ordering and shipping spare parts in order to improve responsiveness (removing tax and customs duty may allow for a more responsive system)
- Establish an operations schedule to optimise tracking coverage (including tracking over 7 days if possible)
- Extend this review process to encompass periodic assessments by the committee of progress made (first review within 12 months)

4.2. LONG TERM OUTLOOK

The MOBLAS-8 is over twenty-five years old and is suffering from parts failures requiring frequent maintenance. Finding replacement parts is becoming more and more difficult as it is with all of the Moblas systems. The current system requires continuous operator intervention; severely limiting potential for improved performance, including daytime operation and automation. The site is remote and even with the addition of engineering expertise the station will still be very labor intensive. The weather at the site poses some challenge, but more automated operation, tighter range gates, more accurate pointing, narrower fields of view, etc, which would be available with newer technology would have a dramatic impact on station efficiency. With careful nurturing and regular support from NASA, the system may last another few years, but a long term SLR operation in Tahiti will require a new system. One possibility is the New Generation SLR (NGSLR) system being developed at GSFC. We urge NASA and CNES to address the need together, perhaps based on the NGSLR or some other agreed upon technology.

Although the weather is certainly not comparable to that at sites like Yarragadee, Australia, initial information suggests that the current site is probably one of the best in the region; however a study should be conducted to examine possibilities for a new site in a more appropriate environment with respect to:

- Weather conditions
- Safety requirements (private buildings surrounding the site)
- Air traffic
- Collocation with other geodetic systems like VLBI (if planned)

A final decision on the long term plan should be based on a trial period at the stations of a couple of years.

5. MEETING WITH LOCAL OFFICIALS

The Committee met with local officials in the afternoon of October 20 to brief them on US and French Space Geodesy programs, the role of the Tahiti Station, and the problems currently facing the station. The list of attendees and their positions is included in Table 4. We met again with the President of UPF on the afternoon of October 21.

During these meetings the unique position of the OGT and its potential contribution to the geodesy community was made clear to the local officials. This message was well received and the support of the university, the local Tahitian government and the French government was expressed. The officials present at this meeting understood the need for Tahiti to exploit the unique potential of their island where this exists. The Geodetic Observatory is a clear example of how such potential can be realised.

Table 4. Attendees at the meeting with local officials

Monday, October 20, 2008

Name	Title	Email address
Louise Peltzer	President of UPF	louise.peltzer@upf.pf
Jean Luc Tristani	General Secretary of UPF	jean.luc.tristani@upf.pf
Priscilla Tea Frogier	Representative of the Office of Research and Science of French Polynesia	priscille.frogier@recherche.gov.pf
Pierre Mery	Representative of the French Department of Research	pierre.mery@polynesie-francaise.pf.gov.fr
Pascal Orlega	GEPASUD	pascal.orlega@upf.pf
Abdelal Fadil	OGT	abdelali.fadil@upf.pf
Youri Verschelle	OGT	youri.verschelle@upf.pf
Yannick Vota	OGT	yannick.vota@upf.pf
Lydie Sichoix	OGT	lydie.sichoix@upf.pf
Laurent Mercier	OGT	laurent.mercier@upf.pf

Appendix A

NASA Recommended System Maintenance

for the MOBLAS System

Facilities and Equipment Aspects:

1. Perform regular and routine maintenance to ensure health and safety of the system is optimal. This includes ranging system and facilities.

2. Allow critical station items and/or components within the system to warm up and become stable before operations. Key examples include:

   a. Operate the HVAC system in the MOMS and Instrumentation Vans at all times and never turn off

   b. Allow laser to stabilize by operating amplifier and oscillator heads (allowing them to flash, but block oscillator to inhibit lasing) 15 minutes before taking calibration or satellite data.

   c. Allow laser chiller to operate at all times. Do not turn off.

   d. Allow PMT MCP to stabilize by applying high voltage ½ hour before taking calibration or satellite data.

Operational aspects:

1. Optimize tracking schedules to maximize tracking success. Include consideration for prioritized tracking opportunities, historical local weather, budget, etc. If possible, provide tracking 7 days per week over multiple shifts, with priority to 7 day coverage first over multiple shifts per day.

2. Follow reporting procedures (Distributed by Dennis McCollums through e-mails on several occasions) when station is experiencing difficulties with HW/SW or operations. Proper notification and communications is key to quick resolution of any issues.

3. Notify NASA/NASA when system will be unmanned for more than a few days for holidays, vacations, loss of power, other.

4. Notify HTSI/NASA of any customs issues for import/export of parts.

5. Maintain temperature stability in laser room by

   a. Setting thermostat in console room to 68 degrees F and leave at this setting always

   b. Keep door between laser room and laser anteroom closed at all times

   c. Keep door between laser anteroom and console room closed at all times

   d. Maintain and monitor laser performance daily as specified in the Daily Laser Checks document provided by T. Oldham.

6. Perform monthly the Stability Test, CFD Test, and MINICO Test.

   a. Notify NASA when tests are submitted and request data feedback.

   b. Review feedback and monitor system performance

   c. Note changes in performance, look for trends over time, and alert NASA engineering of negative performance trends

7. Maintain records of angle biases applied during satellite tracking.

   a. Make note of bias values, time of day, day of year, elevation angle, and azimuth angle.

   b. Look for drifts in angle biases as this will help in alignment troubleshooting.

   c. When angle biases become greater than 6 millidegrees in magnitude, perform a coelostat and boresight.

   8. Once per week spot check several stars to monitor accuracy of star calibration model. If biases are greater than 6 millidegrees, perform star calibration.

9. Maintain Inventory Log of spare parts

   a. Each time a part is used, note on log remaining amount of inventory

   b. Once inventory is reduced to certain level, resupply inventory

   c. Different parts will required different inventory threshold for resupply.

      i. E.g. flash lamps will need to be replaced more often than laser rods.

      ii. Perform inventory of spare parts on a yearly basis. Suggest inventory 10% of parts each month.

10. During periods of poor weather, and as long as threat of rain is low, exercise the system by performing ground calibrations.

11. Maintain log of system operations on a per shift basis noting changes, repairs, adjustments, etc. made to equipment.

12. Always use daylight filter during daylight operations. Never use daylight filter during nighttime use.

13. Always use the same PMT voltage for pre-calibration, satellite pass scenario, and post-calibration.

14. Turn off lights in area of telescope during tracking operations.

End of recommendations

APPENDIX B

Agreement for the installation and operation of a Satellite Laser Ranging System

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

@epiy to Attn of: IY

DEC 1 1 1996

Mr. Gerard Blondeau
Head, International Relations
Centre National d'Etudes Spatiales (CNES)
2 pl. Maurice Quentin
75039 Paris, Cedex 01
France

Dear Mr. Blondeau:

The purpose of this letter is to establish an agreement between NASA and the Universite Francaise du Pacifique (hereinafter referred to as "UFP") of French Polynesia in conjunction with the Centre National d'Etudes Spatiales (hereinafter "CNES") of France concerning the installation of a NASA satellite ranging station in French Polynesia.

In continuation of the very successful NASA-CNES cooperative program conducted from 1982 to 1994 utilizing satellite laser ranging (SLR) technology for space geodetic measurements in French Polynesia, NASA, CNES and the Universite Francaise du Pacifique (hereinafter referred to as "UFP") have decided to cooperate in the installation and operation of a Satellite Laser Ranging (SLR) system at the UFP site in Tahiti. It is envisioned that the site, equipped since 1994 with a Doppler Orbitography and Radio Positioning Integrated by Satellite (DORIS) beacon and since 1995 with a Precise Range And RAnge-rate Equipment (PRARE) beacon, will be a fundamental space geodetic site within the global fiducial network and it is anticipated that other space geodetic measurement systems, such as Global Positioning System (GPS), will be collocated at this site for permanent measurements.

The following terms are proposed for an agreement, without exchange of funds, between the French participants (composed of CNES and the UFP) and NASA (hereinafter referred to as the "Parties").

NASA will:

1. Provide a NASA MOBile LASer (MOBLAS) Ranging System on a long-term loan basis, at no cost, for operation at Punaauia, Tahiti, French Polynesia. NASA will transport, help install, and help maintain the MOBLAS system and its support equipment;

2. Provide the technical hardware and software items required for the full operation of this MOBLAS Ranging System;

3. Provide technical personnel for a time period to be determined by mutual agreement, for:
   (a) support of the initial installation of the MOBLAS Ranging System, and
   (b) SLR system training;

4. Provide all software required for the full operation of the MOBLAS Ranging System and provide sustaining engineering, depot-level maintenance, and technical consultation throughout the loan period;

5. Provide satellite schedules, orbital predictions, and reports for satellites tracked regularly by the Tahitian MOBLAS Ranging System;

6. Provide technical consultation to the MOBLAS Ranging System engineering team;

7. Provide data processing of the data from the MOBLAS Ranging System;

8. Provide for the evaluation of the MOBLAS Ranging System's data on a continuing basis, for the assessment of data quality, and the identification of anomalous operating conditions. In addition, NASA will provide system modifications necessary for continued compatibility with the NASA geodetic network;

9. Provide unique equipment (as available) on loan, at no cost, if needed for special requirements of a specific experiment, as mutually agreed;

10. Make available to the French Participants, processed laser data and results of data analyses from the other SLR stations in the global network as well as all preprocessed and analyzed space geodetic data in the Crustal Dynamics Data Information System;

11. Accommodate UFP personnel on visits to NASA for training in data processing and analysis and for scientific collaboration;

12. Inform the French Participants of all NASA Space Geodesy Program and other related meetings; and

13. Cooperate with investigators from North America, Europe, South America, Australia, Africa, and Asia for the cooperative program of space geodetic observations to measure plate motion, regional deformation, and polar motion.

The French participants, with the support of the French and European third parties will:

1. Provide the site and site facilities, i.e., pad, electricity, communications (including internet access), security, and technical accommodations at the UFP site for the MOBLAS Ranging System;

2. Provide to NASA, through electronic mail, all data acquired by the Tahiti MOBLAS Ranging System;

3. Coordinate station operations with the priorities and schedules of the global SLR network as prescribed by the SLR Subcommission of Commission VIII, the International Coordination of Space Techniques for Geodesy and Geodynamics (CSTG);

4. Maintain the MOBLAS Ranging System in an operational status, with the support of NASA, so that it can be returned at the termination of the present agreement in the same condition, less normal wear and tear;

5. Support the NASA SLR configuration control system of both hardware and software to assure continued compatibility of the MOBLAS Ranging System with the NASA SLR and GPS networks;

6. Provide for the attendance of French investigators at space geodesy and other related meetings, when appropriate;

7. Provide qualified personnel and other support necessary for routine SLR operations on a schedule of approximately sixteen hours per day, five days per week (i.e. two shifts);

8. Provide funds for travel and subsistence for training of French engineers and MOBLAS Ranging System operators in the United States, as necessary and mutually agreed;

9. Make available to NASA, copies of any published papers resulting from data acquired by the MOBLAS Ranging System; and

10. Arrange for clearances and customs exemptions for equipment and operational supplies required for the MOBLAS system.

Each Party will bear the cost of discharging its respective responsibilities, including travel and subsistence of its own personnel and transportation of all equipment for which it is responsible. Further, it is understood that the ability of each Party to carry out its obligations is subject to the availability of appropriated funds.

The points-of-contact, who will be responsible for the coordination and execution of this agreement, will be:

For NASA:
Dr. Miriam Baltuck, Chief
Solid Earth and Natural Hazards Branch
Code YS
NASA Headquarters
Washington, DC 20546
USA

For CNES:
Dr. Jean-Louis Counil
Earth Observation Programmes
CNES, 2 Place Maurice Quentin
75039 Paris Cedex 01
FRANCE

For the UFP:
Dr. Alain Bonneville
Director of the Geosciences Laboratory
Centre Universitaire de Polynesie Francaise
BP 6570, Faaa Aeroport
Tahiti
FRENCH POLYNESIA

Release of public information regarding this project may be made by the appropriate agency for its portion of the program as desired, and, insofar as participation of the other is involved, after suitable consultation.

With regard to activities undertaken pursuant to this agreement, neither Party shall make any claim against the other, employees of the other, the others' related entities (e.g., contractors, subcontractors, investigators or their contractors or subcontractors), or employees of the other's related entities for any injury to or death of its own employees or employees of its related entities, or for damage to or loss of its own property or that of its related entities, whether such injury, death, damage or loss arises through negligence or otherwise, except in the case of willful misconduct.

The Parties further agree to extend this cross-waiver to its own related entities by requiring them, by contract, or otherwise, to waive all claims against the other Party, related entities of the other Party, and employees of the other Party or of its related entities for injury, death, damage or loss 'arising from or related to activities undertaken pursuant to this agreement.

The Parties are obligated to transfer only those technical data and goods necessary to fulfill their respective responsibilities under this Agreement, in accordance with the following provisions:

1. Interface, integration and safety data (excluding detailed design, development, production,

and manufacturing data, and associated software) shall be exchanged by the Parties without restrictions as to use and disclosure, except as specifically required by national laws and regulations.

2. In the event a Party, finds it necessary to transfer technical data or goods other than those specified in paragraph I above in carrying out its responsibilities under this Agreement, the provisions of this paragraph shall apply. In transferring data and goods which are proprietary or subject to export controls, and for which protection is to be maintained, such technical data shall be marked with a notice and such goods shall be specifically identified to indicate that they shall be used and disclosed by the receiving Party, institutions acting on its behalf, and its contractors and subcontractors only for the purposes of fulfilling the receiving Party's responsibilities under this Agreement, and that the marked technical data and identified goods shall not be disclosed or retransferred to any other entity without prior written permission of the furnishing Party. The receiving Party agrees to abide by the terms of the notice, and to protect any such marked technical data or identified goods from unauthorized use and disclosure. Nothing in this article requires the Parties to transfer technical data or goods contrary to national laws and regulations relating to export control or control of classified data.

3. The Parties are under no obligation to protect any unmarked technical data or unidentified goods. However, all technical data and goods transferred under this Agreement will be used exclusively for the purposes of fulfilling the Parties' responsibilities under this Agreement.

Each Party will facilitate duty free entry of equipment required for this project and provide for entry of equipment, hardware and software free of import taxes, subject to its respective country's import and export regulations. Such arrangements shall be fully reciprocal. If a Party is unable to facilitate free customs clearance, the Party whose government seeks to impose such duties or taxes shall pay any such assessments. Also, subject to its laws and regulations, each of the Parties will facilitate provision of the appropriate entry documentation for the other Party's nationals who enter or exit its territory in order to carry out activities under this agreement.

Nothing in this agreement shall be construed as granting or implying any rights or interest in patents owned or inventions which are independently developed by the parties or their contractors or subcontractors.

In the event that an invention is jointly made by employees of the Parties, their contractors or subcontractors, during the implementation of this agreement, the Parties shall consult and agree as to the responsibilities and costs of actions to be taken to establish and maintain patent protection (in any country) for such invention and on the terms and conditions of any license or other rights to be exchanged or granted by or between Parties.

The agreement will be for a period of ten years. Towards the end of this period, CNES, UFP, and NASA will assess their respective interest in continued joint activity and consider renewing this agreement for an additional period of time.

The agreement may be terminated either by NASA or the French participants by one party submitting a written notice to the other party twelve months in advance of the desired termination date.

The parties agree that any dispute as to interpretation or implementation of this Agreement shall be resolved through consultation between the Parties.

If the above terms and conditions are acceptable to you, I propose that this letter with all three signatures constitute an agreement to proceed with this project.

Date: 11 Dec. 96

Lisa R. Shaffer
Director, Mission to Planet Earth Division
Office of External Relations
NASA

Date: 21 fevrier 97

Mr. Gerard Blondeau
Deputy Director, CNES International Relations
FRANCE

Date: 27 fevrier 97

Professor Pierre Verin
President, Universitaire Francaise du Pacifique
FRENCH POLYNESIA

APPENDIX C

Glossary

CNES	Centre National d'Etudes Spatiales – French Space Agency
DORIS	Doppler Orbitography and Radio Positioning Integrated by Satellite
GNSS	Global Navigation Satellite System
GRGS	Groupe de Recherche de Géodésie Spatiale – Space Geodesy Research Group
GSFC	Godard Space Flight Centre
HTSI	Honeywell Technical Solution Inc.
IGS	International GNSS Service
ILRS	International Laser Ranging Service
MOBLAS	MOBile LASer Ranging System
NASA	National Aeronautics and Space Administration
NGSLR	Next Generation Satellite Laser Ranging
OGT	Tahiti Geodetic Observatory
PRARE	Precise Range And Range-rate Equipment
SLR	Satellite Laser Ranging
TRF	Terrestrial Reference Frame
UPF	Université de Polynésie Francaise - University of French Polynesia -
VLBI	Very Long Baseline Interferometry

APPENDIX D

OGT Review Committee – Meeting Agenda

Meeting Schedule – Monday, 20th October

9h30 – 12h	Preparatory meeting, OGT • Organisation of the Monday afternoon meeting • Coordination of presentations • Discussion on the organisation Tuesday/Wednesday	
12h00	Lunch	
14h00	Welcome from the President of the University of French Polynesia Presentation of the University	President, Secretary General
14h30	Science policy in French Polynesia	Representative of the FP government
15h	French Support for DR in French Polynesia	DRAST representative
15h30	Presentation of the Tahiti Geodetic Observatory	JP Barriot
16h00	NASA Geodesy programme	M Pearlman, D Carter
16h30	CNES Geodesy programme and the French Geodesy Research Group	S. Hosford, R Biancale

Meeting Schedule – Tuesday, 21st October

Review of current status

9h00	Introduction and presentation of the Tahiti Geodetic Observatory	JP Barriot
10h00	Current status on NASA contributions to the OGT	J Labrecque
10h30	ILRS perspective	M Pearlman
11h00	Current status on CNES contributions to the OGT	S Hosford
11h30	OGT in the context of French Geodesy laboratories contributions to GGOS	R Biancale
12h00	Lunch	

Improving station performance

14h00	Potential themes (HR, equipment, site)	JP Barriot
15h00	US perspective	M. Pearlman, D. Carter
16h00	French perspective	F.Pierron, R. Biancale,
17h30	Conclusions	All

Meeting Schedule – Wednesday, 22nd October

9h30 – 12h	Conclusions and actions	
12h00	Lunch	
14h00 – 17h00	Inspection of potential sites for future OGT installations	