

DYNAMO Site Survey Trip Report 18-26 February 2010

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Locations: Hulule Island, Maldives, Male Island and Male (capitol city), Maldives, Addu Atoll, Maldives (including Gan, Feydhoo, Maradhoofeydhoo and Hithadhoo. Male lies at 6°N, 73°E. Addu Atoll lies at 0.5°S, 73.8°E.

Participants: From NCAR at all locations: Jim Moore, Jim Wilson, Jeff Bobka and from JAMSTEC, Kunio Yoneyama. On Addu Atoll: Chuck Long from DOE/ARM PNL, Miki and Shiruyiki from JAMSTEC.

Overview

The NCAR participants arrived in the Maldives (Male) on 20 February. It takes much of 3 days to get from the US to the Maldives flying east. After heading eastbound from the US, a layover in Dubai, UAE was required after flying from evening of 18 February to evening of 19 February. The outbound journey was completed on the PM on 20 February. As a footnote, it is also possible to fly westbound from US through Tokyo, with stops in Hong Kong or Bangkok or Delhi, and a layover in Singapore. Travel time is again much of 3 days and there is no significant difference total flight time, ~25 hours in the air, not including airport layover times.

As a summary comment, we very much appreciate all of the support given to us by a number of people in The Maldives. The success of our trip was only possible because of the efforts of our local hosts to answer questions and show us the various instrumentation sites on Addu Atoll.

We have divided the report into several sections addressing issues raised in Male and on ADDU Atoll. We have summarized discussions with all the organizations that will need to assist us in making this project happen. Information here applies specifically to S-Pol as well as the ARM AMF and SMART-R deployments being considered. We introduce the specific radar site survey results in this main document.

A large number of photographs were taken by the participants and are combined into two Powerpoint presentations and a detailed set of site panoramas. These are available from EOL DYNAMO Web site at:

<http://www.eol.ucar.edu/projects/dynamo/>

This documentation includes detailed photo analysis of clutter and blockage for radar sites as well as documentation of local logistics, lodging and other support.

Detailed Discussion (by location and organization)

Meetings in Male and on Hulule Island 21 February 2010.



Figure 1. Primary locations on Male and Hulule (Airport Island) relevant to DYNAMO Site Survey

Shipping

A meeting was held with *Asian Forwarders Shipping Company*, the group that will handle the shipment of NCAR equipment in coordination with Seajet. Seajet made contact with this group in advance of our trip and arranged for the meeting. The route of NCAR (likely SMART-R and ARM as well) will be out of Long Beach, CA by ship. The Pacific and Indian Ocean crossing will take a total of 50-60 days. Once in Male, all the containers and radar truck will be transferred to small vessels for transport to Addu Atoll. There is sufficient equipment in Male and Addu to handle all containers including the 15 ton S-Pol items. The plan will be for the SMART-R radar to be driven on and off ships in Male and Addu Atoll using a 'landing craft.' Further details on the handling of equipment is discussed in the Addu Atoll section below.

Maldives Meteorological Service (MMS) Headquarters

A meeting in the afternoon was held at the *Maldives Meteorological Service (MMS)* Headquarters Office on Hulule Island to introduce the project to the staff and discuss the procedures for and timing of receiving government approval to bring facilities to the Maldives for the project. Moore Wilson and Bobka were in attendance along with a JAMSTEC representative (Yoneyama). There were a number of important points to come out of these discussions and they are listed below.

- The MMS is interested in the project and will provide support at several levels
- The MMS Gan Office will act as our local contact point for all activities on Addu Atoll
- The MMS Headquarters will handle the 'official' requests for approval to conduct the project with the various affected national ministries
- A unified request from all parties interested in locating DYNAMO instrumentation on Addu Atoll is preferred by MMS
- The process of gaining these approvals should be started as soon as possible. (As a footnote, it took JAMSTEC nearly 2 years to gain site approval for their radar used in MISMO in 2006).
- Information from this trip report will include the background material required to send proposal letters to other Maldives government agencies
- Other Maldivian agencies likely involved in DYNAMO support include the Ministries of Environment (MMS), Customs (Waiver of 25% Import Duty on the value of each facility), Home Affairs (Province Office), Tourism (Work Permits) and the Addu Atoll Police.
- We did gain a sense of land ownership/responsibility for the several possible site. (This information will be described in detail for each site below)
- The MMS will try to assist with manning for the supplemental raob site on Gan being provided by ARM.

Meetings and Site Visits on Addu Atoll 22-25 February 2010

Gan Office of MMS

The NCAR team met with Mr. Ali Wafir, Head of the *Gan MMS* Office on the morning of 22 February. His office will be the project's and EOL's primary contact for support on Addu Atoll. We provided an overview of the meetings held in Male. Mr. Wafir and Mr. Mohamed drove us all around the Atoll, reachable by road, to look at potential sites. Their support was essential to our ability to discover and assess potential sites as well as to learn more about the permissions and logistical details needed to bring our facilities to Addu Atoll. Chuck Long from ARM/PNL joined the survey on the second and third day and met with Wafir regarding siting of the ARM main facility near the Gan MMS facilities on the second day. Together we evaluated 6 sites for possible location of 'supersite' facilities on the Atoll. Appendix 1 has a complete assessment of the final sites that meet criteria for logistics and exposure for the radars, lidars and other instrumentation.

Bluelink Ltd (Local Representative of Asia Pacific Shipping on Addu Atoll)

We met with the Gan shipping agent, Mr. Ali Nizar, General Manager of Bluelink Pvt. Ltd. He was very helpful with describing the handling and placement of facility containers and vehicles coming to Addu Atoll for DYNAMO. We received a tour of the port facilities on the atoll where radar facilities would be received as transported to their respective site locations. There is a 25 ton crane to handle the off load of all containers at the main port (long wharf). The rental rate for the crane is 1400 Rufiyaa (~\$110) per hour. Two different size fork lifts are available. Rental rates for the smaller one likely used at the S-Pol is 500 Rufiyaa (\$40/hour. There is a truck and trailer (one each for 20 and 40 ft sea containers) to transport containers, one at a time to any site on Addu Atoll (west side).

The special transport requirements of the SMART-R can be accommodated. It will be possible to bring the radar truck on a landing craft from Male to Adu Atoll. It can then be driven off of the landing craft directly onto shore at a site available for this type of unloading.

It is important to note that all shipping and handling arrangements in the Maldives will be arranged through the Asia Pacific contacts rather than directly with a shipping representative on Gan.

Mr. Nazir did offer advice related to obtaining the sites for the radars. It includes deciding on the sites as soon as possible and making application with the land representatives (Province Office, Ministry of Fisheries, etc.) as well as the Ministry of the Environment. [Note: These requests will be done through the MMS (part of the Ministry of the Environment) who will handle the details within the government]. In addition, if the SMART-R is used at different sites near the road, it is wise to alert the local police.

Dhiraagu Communications

We met with the Manager of Southern Operations (Mr. Hussain) to discuss the communications support requirements for DYNAMO including high-speed Internet access and telephone service. Dhiraagu should be able to support all of the project needs. It appears that T1-T3 and then maybe higher to 10-15 Mbits/s data links will be possible using copper (lower) or microwave relay (higher rate). We also were given the impression that services will continue to improve over the next 18 months. For example, Hussain noted that 2 Mb/s 3G service should be available all over the Atoll by the end of summer, 2010. Communications (cell and Internet) within the island should be just fine. The problem is the international Internet links beyond the Maldives. Their main trunk lines are strung to Sri Lanka (undersea cable) and then it moves on through India to Italy to join the international backbone.

The time for set-up of service at any of the sites on Addu Atoll is estimated by Dhiraagu at 45 days or less. Depending on location and the actual service requirements, the set-up time will likely be more like 1-2 weeks. It will be possible to set-up a purchase order for this work.

There are a number of pre-paid and monthly cell phone service plans. In addition the EOL DSM phone did work all over the Maldives. It is recommended that local cell service be established for staff during the deployment for all local support needs.

Electrical Power

The power company in the Addu Atoll is called the *Southern Utilities Company*. The power is 240V/50Hz single phase all over the island. There are no 3-phase options. They have modernized the power grid with all power lines now underground over the entire atoll. All power is produced using diesel generators. Our experience is that the power is reliable and stable, even during an impressive electrical storm and heavy rain (57mm in 2 hours) event that occurred during our visit. Power is nearby all of our potential sites because the sites are reasonably close to the main road where all the underground power is drawn. We did not speak with a power company representative. We need to have more details about sites and facility power requirements before contacting the company. We were told that the utility company is responsive to temporary installation requests. Details will be provided through the MMS contacts once specific site locations are finalized.

South Province Office

The survey team met with staff from the South Province Office that is part of the Ministry of Home Affairs. The Deputy State Minister, Mr. Ali Mohamed and Mr. Abullah Solig, Atoll Councilor, described the role and support function that this office provides on Addu Atoll. This agency is responsible for handling individual or special requests for land access in the area. In our case, this agency will be responsible for granting access to sites for the DYNAMO radars and ARM main site, unless another Federal agency has responsibility. The process for requesting and receiving permission to access sites will take many months. We were encouraged to begin this process as soon as possible. We were told that once the Province Office receives a request for land access, they should be able to issue an approval within 1.5 months. I caution that this time can be much longer when other agencies are involved in the approval process for a site. We know this will be the case in at least one of the principal sites.

There is one data point for consideration related to getting site permissions. The JAMSTEC folks noted it took them nearly 2 years to receive permission to use the site near Gan airport for their radar during MISMO. In that case they were working with the Gan MMS office and the Airport Authority.

During the rest of the day, the Mr Solig provided excellent support by providing a crane manual lift that allowed Wilson and Bobka to take accurate measurements at two preliminary sites. These measurements allowed the team to eliminate one of the sites in an undeveloped residential section. It is our impression that the Province Office really wants to help allow DYNAMO to locate facilities on the Addu Atoll.

Equator Village Resort

We stayed 2 of our 3 nights in Gan at the Equator Village Resort. This is a very modest resort in appointments and price. The cost per night was \$98 inclusive of 2 meals (breakfast and dinner in our case). This rate is during the high season. The rooms are adequate with good working air conditioning and a reasonably comfortable firm bed. There is hot water provided by a flash heater on the wall in the shower. There is no hot water for the sink. When you take a shower you can heat the water flowing through the device to temperatures maybe as high as 110F. There is no phone and no TV. There is good cell phone coverage with the local phone system (Dhiraggu) as well as GSM system access. There are two TVs in the lobby/commons area that seem to have a few channels. We only saw BBC World and the German News channel. The high point of this location is a very large and clean pool area with a swim up bar. There is a small area of beach but swimming is risky on the feet with lots of coral in the reef. We did see snorkelers in the water near the hotel beach front and the hotel organizes 2 snorkel trips a day. The clientele of this resort is mostly German, British and Russian with a few others mixed in. As near as I could tell we were the only Americans at the resort at that time.

We met with the general manager of the Equator Village resort. I discussed the possibility of renting from 10-15 rooms continuously from 1 September 2011 through April 2012. This would cover the set-up and operations period of most of the facilities. Note I was being inclusive of all facilities, not just focused on S-Pol. The manager noted that providing all the rooms we needed at a competitive (sic discounted) rate is possible from September through 15 December and after 15 March. The period from before Christmas to 15 March is the high season. They typically have room blocks set up with international travel agencies that fill the hotel. We should be hearing from the manager by the end of March about accommodating our request.

Dhoogas Hotel

This is the only other hotel on Gan Island with reasonable access to the instrument sites. There are 2 quite expensive resorts on other islands in the Addu Atoll. The Dhoogas is very basic with no resort type amenities. It is a former British base that has been modernized at a very basic level. The room is air conditioned but with no phone, no TV, no hot water, no potable water, no toilet paper (though we understand some did show up after we left), soap or shampoo. It is likely that some

folks may have to stay in this hotel for some period of time especially during the high season if rooms are not available at the Equator. The hotel can provide 3 meals a day. It is local Maldivian (Indian and Sri Lankan mostly) cuisine with curry dishes being a staple of the diet. The room cost us \$25 a night plus \$9 for 3 meals so it is very cheap.

Banking

Banking is a challenge on Addu Atoll. We tried 3 different ATMs (2 at Bank of Maldives and 1 at Bank of India) and none worked with our Visa cards (US Bank or Elevations CU). We were advised that it may be possible to fix this by talking with the bank to open up credit cards, one at a time. We did not pursue this on this visit. We did get cash from the HSBC Bank (Hong Kong) ATM in Male with no difficulty. The hotel in Male (Relax Inn) and the Equator Village both provide money exchange but recognize that all hotel expenses can be paid with the US dollar.

The currency is the Maldivian rufiaa and about 12 of them is equivalent to one US dollar. That said, the US dollar is legal tender in most hotels on the islands and places of business in the city of Male. In the more rural areas we have the impression that the rufiaa is preferred.

Fuel

There do not seem to be any issues with getting diesel #1 or regular unleaded gasoline for system generators and/or vehicles. Diesel prices at this time are running about \$0.90 US per liter or around \$3.50/gallon. It is reasonable to guess that prices might be around \$4.00/gallon during the 2011-12 field deployment. There are several fuel trucks on Addu Atoll to supply the sites as needed. All the sites being considered will have road access.

Frequency Allocation

The project will need to register and get approval to transmit at all the frequencies planned for the radars and lidars. This request and registration will be made with the Communications Authority of the Maldives through the MMS. We have been requested to prepare a table with all frequencies and associated power output planned for DYNAMO. This approval process will take 6 months, based on previous experience.

Radar Sites Detailed Evaluation

The focus of the trip to Addu Atoll was to assess the potential sites for the multiple radars proposed for DYNAMO. Figures 2 and 3 summarize the potential sites assessed during our visit. Other details photos are available from EOL.

S-Polka/ARM/SMART-R Radar Sites on Addu Atoll (South Section)

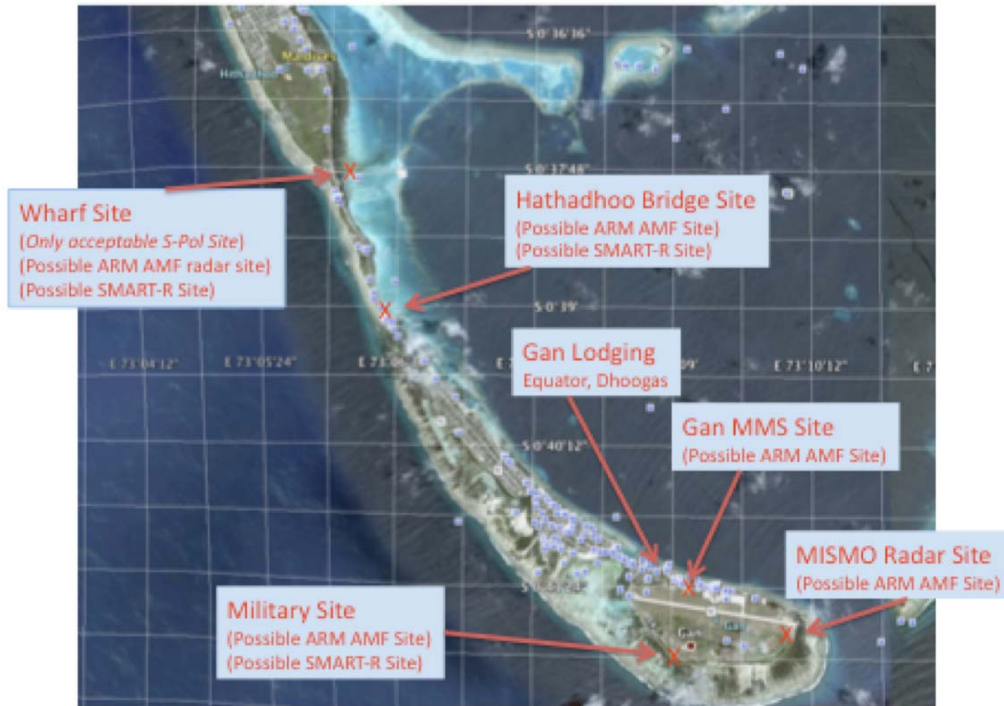


Figure 2. Potential sites for DYNAMO radars on southern portion of Addu Atoll

Potential S-Polka/ARM/SMART-R Radar Sites on Addu Atoll (North Section)



Figure 3. Potential sites for DYNAMO radars on northern portion of Addu Atoll

All islands in the Addu Atoll that are linked by road from the island of Gan were thoroughly searched for radar sites. The islands are flat and forested by tall Palms and Iron Wood trees that can reach heights of 100-150 ft. All sites have tree obstructions that limit the quality of low-level scans. Since the ocean is easily seen from all sites sea clutter will also be a data quality issue.

This report is focused on possible sites for the scanning radars. This means the ability to have unobstructed horizon views down to almost zero degrees is desirable. Figures 2 and 3 show how the surveyed sites sit on the islands that make up the west side of the atoll.

Photographic panoramas were prepared for the discussed sites and are available from EOL. Chuck Long transferred our pictures into panorama's using some newly available software from Microsoft. The panoramas include rough estimates of the elevation angle of the horizon and direction of view. The direction and horizon elevation angles should be considered rough estimates for they were obtained with hand-held devices atop a 20 ft shaky ladder contraption

Site Name	Latitude	Longitude
Military	00° 41.05' S	73° 08.30' E
Gan MMS	00° 41.251' S	73° 09.00' E
Hithadhoo Bridge (West)	00° 39.085' S	73° 06.467' E
Hithadhoo Bridge (East)	00° 39.047' S	73° 06.475' E
Wharf	00° 37.826' S	73° 06.175' E
Spit	00° 36.453' S	73° 05.748' E
Magmendhoo	00° 37.188' S	73° 05.894' E

There are only two sites that provide reasonable low-elevation angle 360 deg azimuthally views. They are called the Wharf and Spit Sites. We note two other locations called the **Hithadhoo Bridge** and Military sites which offer at least 180 deg unobstructed views over the water. These sites may be of interest to the SMART-R if it chooses to be mobile to focus on precipitation in a specific direction.

The **Wharf Site** is the only site suitable for S-Pol. With the exception of a small island of the coast from the Spit site which would present some very interesting logistic challenges. The Wharf site would also be the desired location for the scanning DOE radars. Because of the lower height of the DOE and SMART R radars the blocking will be somewhat greater at the Wharf site than indicated by the measurements taken at 20 ft. If the SMART R chooses to be only at a fixed site suitable locations would be limited to the Spit and Wharf Sites.

The entire eastern semi-circle exposure from the Wharf Site is an unobstructed view over the ocean with the exception of a 5-10 deg sector extending to a maximum of 1.5 deg directly to the east caused by the buildings at the far end of the manmade

Wharf. It is roughly estimated that sea clutter will extend to a radar range of at least 20 km but this will require further analysis.

Palm trees and Iron wood trees make-up the horizon in the western semi-circle. The highest obstruction is 3 to 3.5 deg centered at roughly 320 deg caused by 150 ft high Ironwood trees. Tree blockage of 2 deg or more extends over 60 deg from an azimuth of 270 to 330 deg. Tree blockage greater than 1 deg is present between roughly 220 and 330 deg. It is possible the Iron wood trees will be cut back some.

The ***Spit Site*** is suitable for the SMART R and possible one or two components of the ARM AMF. Access is via a narrow sand/coral road. The road will require some widening and repair. The site has a 360 deg view that is as good or better than the Wharf site. There is a 200 deg unobstructed eastern view over the water from about 170⁰ through 90⁰ to 330⁰. The western horizon has tree blockage that is mostly between 1 and 2 degrees. There is one small group of trees < 10 degrees in azimuth near 230⁰ (SW) that extends to an elevation of 5 degrees.

We examined the potential for a radar site on the very southern tip of the Addu Atoll on Gan Island. This is the ***Military Site*** and is south of the airport along the southern edge of the island. It could be a possible site for the SMART-R. This site has a 210 deg unobstructed view over the Ocean towards from SE (120⁰) through S to NW (330⁰). In all other directions there is major blockage by underbrush and trees. The Maldives Defense Force would have to clear a site for the radar.

An additional panorama is provided for a site called ***Magmendhoo*** although it was rejected because of excessive blockage. Much time was spent around this location with the 20 ft ladder in hopes of finding a suitable S-Pol site. Two other panoramas are included for the proposed ARM AMF2 main site: one near the ***Gan MMS*** office and the other the former MISMO radar site. Of these, the Gan MMS office site is the preferable location for the AMF2 main site, and was discussed with Mr. Wafir by Chuck Long.

Random Comments (Radar Issues)

Male Radar – The Male Weather Service has a recently acquired an EEC, S-band, 1 or 1.5 deg, Doppler Radar. It is on a tower near the Male airport. It was given to them by some disaster relieve organization following the Tsunami that occurred in that part of the world a year or two ago. What a Doppler radar has to do with a Tsunami was not clear to me. The radar has very limited archive capability and presently the link between the radar and weather service is broken. I saw one reflectivity image. They have no expertise in how to use the radar. This is an opportunity for some technology transfer by the project. I would think data from this radar would be of use to Dynamo since it should be quality data.

Radar sea clutter and clear air return – Sea clutter could be a significant issue, particularly at S-band. The Male radar would be very useful for evaluating the

degree of clutter and for testing sea clutter mitigation software (Cathy Kessinger may have some). When S-Pol was in the Caribbean clear-air Bragg return was common over the ocean, this can be very useful for mapping winds. Again the Male radar could be helpful in determining if this may be the case in the Maldives also.

Lightning and outflows – We were told that lightning was infrequent during the Oct-Dec period and more common at other times. We experienced lightning on three different occasions while on Gan. One occurred during the middle of the night dumping 57 mm of rain in less than an hour. One afternoon we experienced a large gust front from a line of storms over the ocean. It was accompanied by a roll-cloud and little rain. This made me wonder about the possibility of a microburst incident at the Male airport; there are numerous Boeing 777 that land there from all over the world.

RHI's over the GAN airport – DOE will probably install their vertical pointing radar and lidar at the GAN airport. Thus RHI scans over the Gan airport is desirable. From both the Wharf and Spit sites there is no blockage in the direction of the airport while from the spit site the wharf building is in line-of-site. However given that the spit site is about 2.5 km to the north of the wharf (thus the building is low in the view), and given the lower range gate limits of the ARM vertically pointing radar, excellent RHI will be possible from either site.

Other Comments of Note During Our Trip

- Do not drink the tap water on Addu Atoll, bathing in it seems to be OK.
- A large quantity of drinking water will be required for a DYNAMO deployment on Addu Atoll. Judging from water consumption by the participants, I would estimate no less than 2 liters per person per day while in the field.
- The GSM telephone worked well throughout our visit. The international phone call rates for calls from the Maldives was (See Rochelle). Service was reliable near Gan island. There do seem to be some 'dead areas' for cell coverage
- We recommend purchasing of local cell phone service (using local phones from Dhriaggu Telephone Co. Same rates apply for all calls throughout the island chain.
- While we will work with the local ISP to have Internet Service at the project sites, one can also purchase wireless 'hot spot' access throughout the islands. It was reliable in 2 locations but did not work in a third. In addition, it appears the NCAR spam filters block messages coming through that system, at least for some folks.
- There is electrical activity in the storms in this region. We experienced lightning and thunder in nocturnal storms on two evenings during our stay.
- The composition of the surface layer on the Addu Atoll is basically coral and sand. Surface water from heavy rains seeps through the surface layer very quickly, although the road areas did have large puddles following the heavy rain.

- We were told that rental cars are available on the island but we did not see a named rental agency (Hertz, Avis, etc.) sign or office during our visit. Motor scooters may be an option. There do seem to be rental locations but only by local shop owners that I saw.
- A major caution in the scheduling of air travel to the Maldives. One must allow ample time to connect from one flight to another in Dubai. It appears a minimum of 3 hours between flights in Dubai is required to avoid being closed out of a flight an hour before scheduled departure.
- We stayed at the Relax Hotel in Male City the first night we arrived. It was OK with Internet access
- We stayed at the Dhoogas Hotel our first night in Gan. It was very basic and is definitely the second choice to the Equator Village
- We stayed at the Equator Village Resort for 2 nights on Gan. It was adequate lodging with meals served 3 times a day if required. It had Internet access that we judged to be the most expensive we have ever heard of (\$17 for 15 minutes) They obviously want you in the pool, not on the web.
- We stayed at the Hulule Island Resort on our last night in the Maldives. It is very nice but over priced. It had Internet access

Contact Information During the DYNAMO Site Survey Trip

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