REGION 5

Bicol River Flood Plain:

DREAM LiDAR Data Acquistion and Processing Report

TRAINING CENTER FOR APPLIED GEODESY AND PHOTOGRAMMETRY

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Introduction

Introduction

1.1 About the DREAM Program

The UP Training Center for Applied Geodesy and Photogrammetry (UP TCAGP) conducts a research program entitled "Nationwide Disaster Risk and Exposure Assessment for Mitigation (DREAM) Program" funded by the Department of Science and Technology (DOST) Grants-in-Aid Program. The DREAM Program aims to produce detailed, up-to-date, national elevation dataset for 3D flood and hazard mapping to address disaster risk reduction and mitigation in the country.

The DREAM Program consists of four components that operationalize the various stages of implementation. The Data Acquisition Component (DAC) conducts aerial surveys to collect Light Detecting and Ranging (LiDAR) data and aerial images in major river basins and priority areas. The Data Validation Component (DVC) implements ground surveys to validate acquired LiDAR data, along with bathymetric measurements to gather river discharge data. The Data Processing Component (DPC) processes and compiles all data generated by the DAC and DVC. Finally, the Flood Modeling Component (FMC) utilizes compiled data for flood modeling and simulation.

Overall, the target output is a national elevation dataset suitable for 1:5000 scale mapping, with 50 centimeter horizontal and vertical accuracies. These accuracies are achieved through the use of state-of-the-art airborne Light Detection and Ranging (LiDAR) technology and appended with Synthetic-aperture radar (SAR) in some areas. It collects point cloud data at a rate of 100,000 to 500,000 points per second, and is capable of collecting elevation data at a rate of 300 to 400 square kilometers per day, per sensor.

1.2 Objective and Target Outputs

The program aims to achieve the following objectives:

a) To acquire a national elevation and resource dataset at sufficient resolution to produce information necessary to support the different phases of disaster management,

b) To operationalize the development of flood hazard models that would produce updated and detailed flood hazard maps for the major river systems in the country,

c) To develop the capacity to process, produce and analyze various proven and potential thematic map layers from the 3D data useful for government agencies,

d) To transfer product development technologies to government agencies with geospatial information requirements, and,

e) To generate the following outputs

1) flood hazard map
2) digital surface model
3) digital terrain model and
4) orthophotograph

1.3 General Methodological Framework

The methodology employed to accomplish the project's expected outputs are subdivided into four (4) major components, as shown in Figure 1. Each component is described in detail in the following sections.

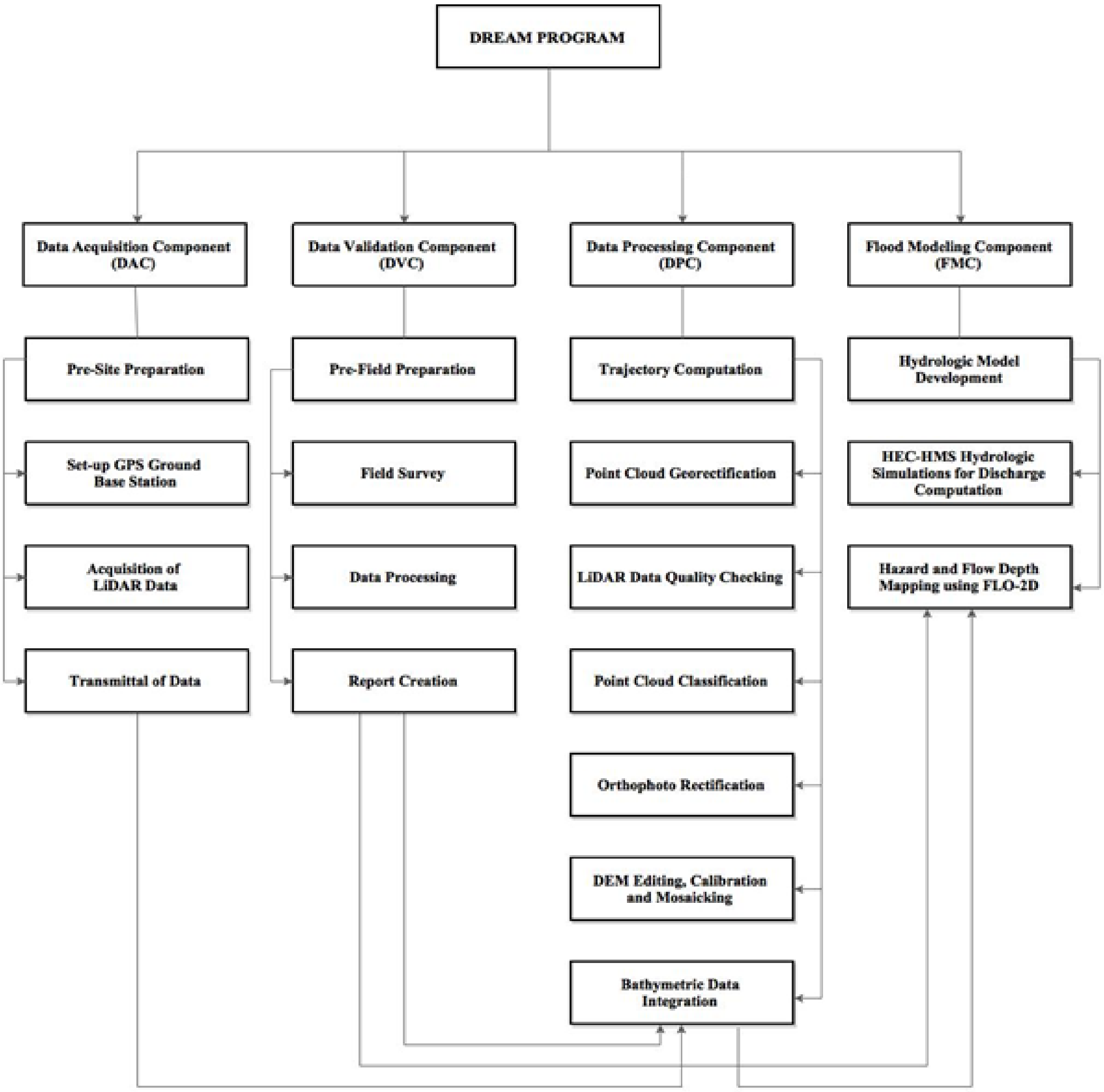


Figure 1. The General Methodological Framework of the Program

Study Area

Study Area

The Bicol River Basin is the eighth largest river in the Philippines in terms of drainage basin size, having an estimated basin area of 3,770 square kilometers. The river drains the south-western part of the island of Luzon and passes through the central portion of Camarines Sur, the northern portion of Albay, and a portion of Camarines Norte in the Bicol Region. It is also bounded by a chain of volcanoes, highlands and lowhills. The location of Bicol River Basin is as shown in Figure 2.

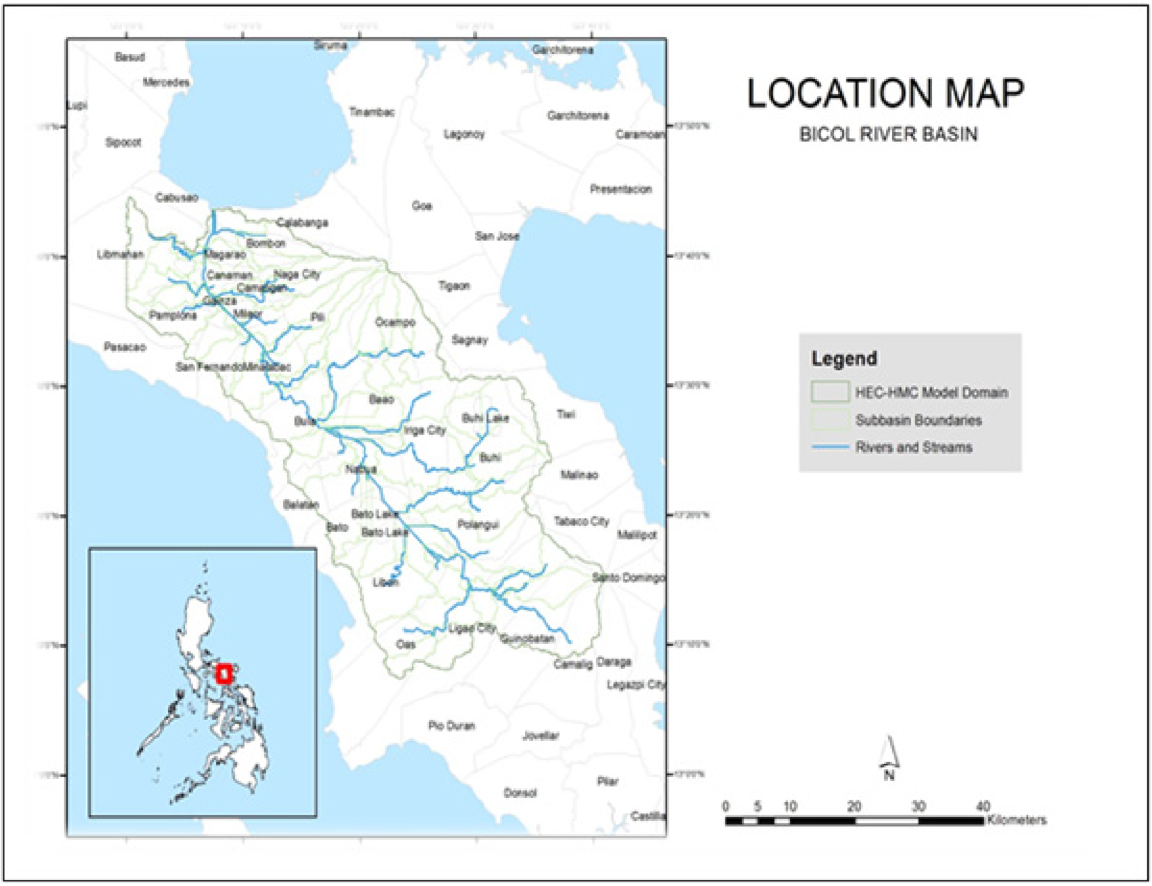


Figure 2. Bicol River Basin Location Map

Average annual rainfall ranges between 1,850 – 2,300 millimeters in the lower basin and 2,000 – 3,600 millimeters in the southwestern section of the basin. Storm surges associated with slow-moving typhoons cause flooding in the alluvial plain near or over the San Miguel Bay. Flood target areas are the central part of the basin, extending from Baao Lake to Bato Lake and the alluvial plain, which extends from Naga City to the river mouth.

The land and soil characteristics are important parameters used in assigning the roughness coefficient for different areas within the river basin. The roughness coefficient, also called Manning's coefficient, represents the variable flow of water in different land covers (i.e. rougher, restricted flow within vegetated areas, smoother flow within channels and fluvial environments).

Study Area

The shape files of the soil and land cover were taken from the Bureau of Soils, which is under the Department of Environment and Natural Resources Management, and National Mapping and Resource Information Authority (NAMRIA). The soil and land cover of Bicol River Basin are shown in Figures 3 and 4, respectively.

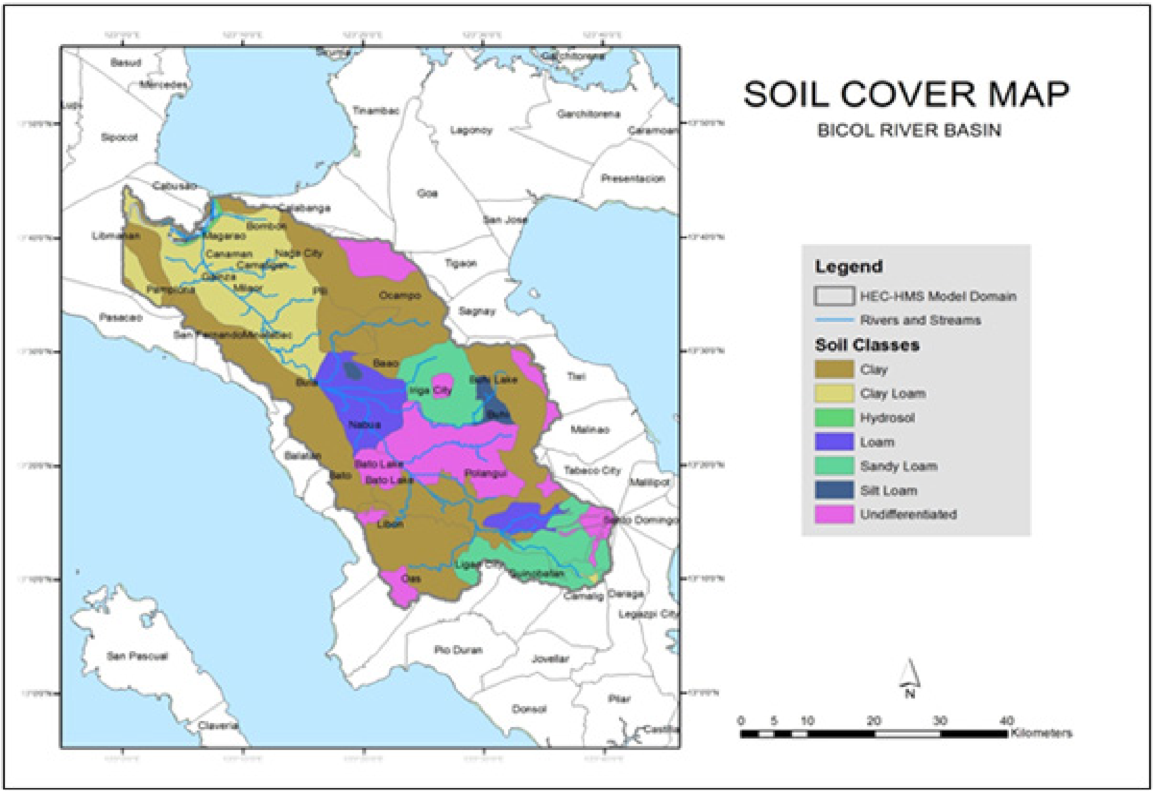


Figure 3. Bicol River Basin Soil Map

Study Area

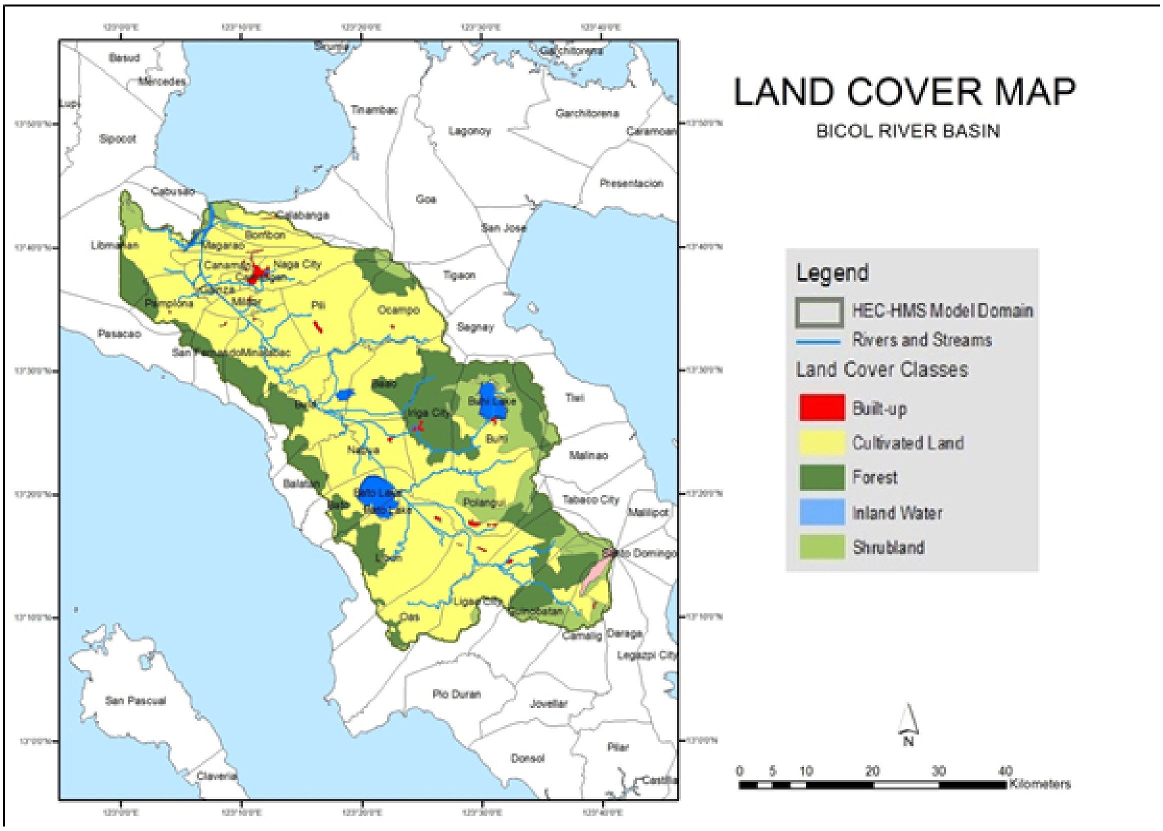


Figure 4. Bicol River Basin Land Cover Map

Methodology

Field Survey Methodology

3.1 Acquisition Methodology

The methodology employed to accomplish the project's expected outputs are subdivided into four (4) major components, as shown in Figure 5. Each component is described in detail in the following sections.

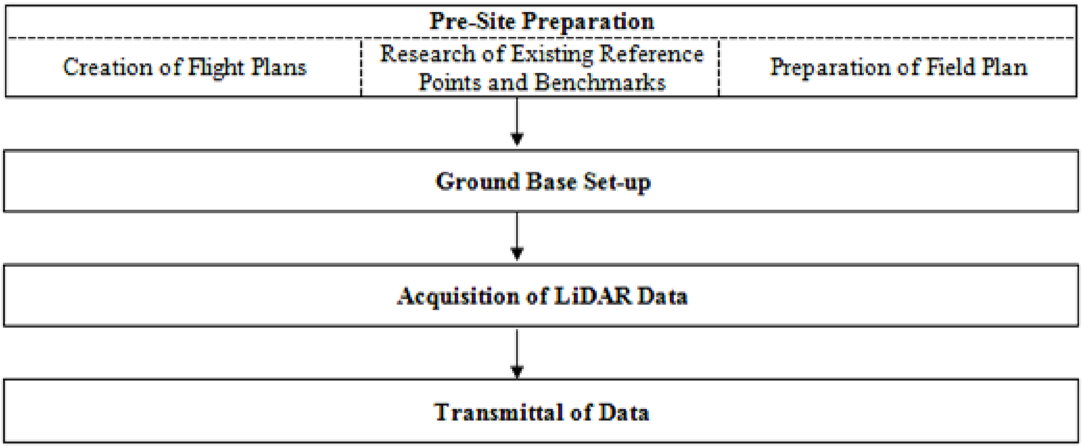


Figure 5. Flowchart of project methodology

3.1.1 Pre-site Preparations

3.1.1.1 Creation of Flight Plans

Flight planning is the process of configuring the parameters of the aircraft and LiDAR technology (i.e., altitude, angular field of view (FOV)), speed of the aircraft, scans frequency and pulse repetition frequency) to achieve a target of two points per square meter point density for the floodplain. This ensures that areas of the floodplain that are most susceptible to floods will be covered. LiDAR parameters and their computations are shown in Table 1.

The parameters set in the LiDAR sensor to optimize the area coverage following the objectives of the project and to ensure the aircraft's safe return to the airport (base of operations) are shown in Table 1. Each flight acquisition is designed for four operational hours. The maximum flying hours for Cessna 206H is five hours.

Field Survey Methodology

Table 1. Relevant LiDAR parameters.

SW (Swath Width)		SW = 2 * H * tan (θ/2)	H – altitude Θ – angular FOV
Point Spacing	ΔXacross	ΔXacross = (Θ * H) / (Ncos2(Θ/2))	ΔXacross – point spacing across the flight line H – altitude Θ – angular FOV N – number of points in one scanning line
	ΔXalong	ΔXalong = v / fsc	ΔXacross, ΔXalong point spacings
Point density, dmin		dmin = 1 / (ΔXacross * ΔXalong)	ΔXacross, ΔXalong point spacings
Flight line separation, e		e = SW * (1 – overlapping factor)	SW – swath width
# of flight lines, n		n = w / [(1 – overlap) * SW]	w – width of the map that will be produce in meters. The direction of flights will be perpendicular to the width.

Table 1 shows the parameters set in the LiDAR sensor to optimize the area coverage following the objectives of the project and to ensure the aircraft's safe return to the airport (base of operations). Each flight acquisition is designed for four operational hours; maximum flying hours for Cessna 206H is five hours.

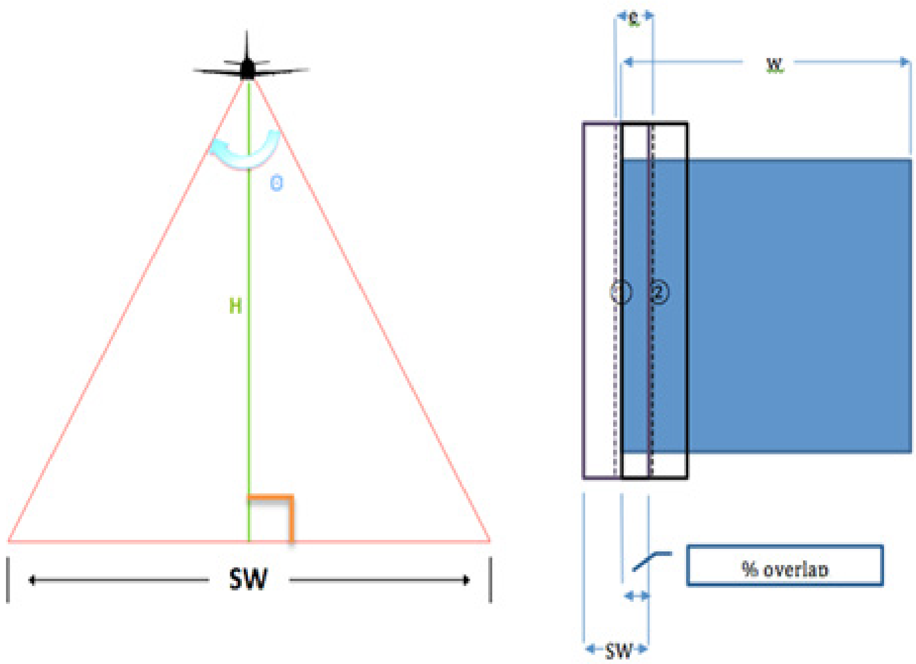


Figure 6. Concept of LiDAR data acquisition parameters

Field Survey Methodology

The relationship among altitude, swath, and FOV is show in Figure 6. Given the altitude of the survey (H) and the angular FOV, the survey coverage for each pass (swath) can be calculated by doubling the product of altitude and tangent of half the field of view.

3.1.1.2 Collection of Existing Reference Points and Benchmarks

Collection of pertinent technical data, available information, and coordination with the National Mapping and Resource Information Authority (NAMRIA) is conducted prior to the surveys. Reference data collected includes locations and descriptions of horizontal and vertical control (elevation benchmarks) points within or near the project area. These control points are used as base stations for the aerial survey operations. Base stations are observed simultaneously with the acquisition flights.

3.1.1.3 Preparation of Field Plan

In preparation for the field reconnaissance and actual LiDAR data acquisition, a field plan is prepared by the implementation team. The field plan serves as a guide for the actual fieldwork and included personnel, logistical, financial, and technical details. Three major factors are included in field plan preparation: priority areas for the major river basin system; budget; and accommodation and vehicle rental.

LiDAR data are acquired for the floodplain area of the river system as per order of priority based on history of flooding, loss of lives, and damages of property. The order of priority in which LiDAR data surveys are conducted by the team for the floodplain areas of the 18 major river systems and 3 additional systems is shown in Table 2.

Field Survey Methodology

Table 2. List of Target River Systems in the Philippines

	Target River System	Location	Area of the River System (km2)	Area of the Flood Plain (km2)	Area of the Watershed (km2)
1	Cagayan de Oro	Mindanao	1,364	25	1,338.51
1.1	Iponan	Mindanao	438	33	404.65
2	Mandulog	Mindanao	714	7	707.41
2.1	Iligan	Mindanao	153	7	146.38
2.2	Agus	Mindanao	1,918	16	1,901.60
3	Pampanga	Luzon	11,160	4458	6702
4	Agno	Luzon	6,220	1725	4495
5	Bicol	Luzon	3,173	585	2,587.79
6	Panay	Visayas	2,442	619	1823
7	Jalaur	Visayas	2,105	713	1,392.00
8	Ilog Hilabangan	Visayas	2,146	179	1967
9	Magasawang Tubig	Luzon	1,960	483	1,477.08
10	Agusan	Mindanao	11,814	262	11,551.62
11	Tagoloan	Mindanao	1,753	30	1,722.90
12	Davao	Mindanao	1,609	54	1555
13	Tagum	Mindanao	2,504	595	1,909.23
14	Buayan	Mindanao	1,589	201	1,388.21
15	Mindanao	Mindanao	20,963	405	20,557.53
16	Lucena	Luzon	238	49	189.31
17	Infanta	Luzon	1,029	90	938.61
18	Boracay	Visayas	43.34	43.34	n/a
19	Cagayan	Luzon	28,221	10386	17,835.14

3.1.2 Ground Base Set-up

A reconnaissance is conducted one day before the actual LiDAR survey for purposes of recovering control point monuments on the ground and site visits of the survey area set in the flight plan for the floodplain. Coordination meetings with the Airport Manager, regional DOST office, local government units and other concerned line government agencies are also held.

Ground base stations are established within 30-kilometer radius of the corresponding survey area in the flight plan. This enables the system to establish its position in three-dimensional (3D) space so that the acquired topographic data will have an accurate 3D position since the survey required simultaneous observation with a base station on the ground using terrestrial Global Navigation Satellite System (GNSS) receivers.

Field Survey Methodology

3.1.3 Acquisition of Digital Elevation Data (LiDAR Survey)

Acquisition of LiDAR data is done by following the flight plans. The survey uses a LiDAR instrument mounted on the aircraft with its sensor positioned through a specially modified peep hole on the belly of the aircraft. The pilots are guided by the flight guidance software which uses the data out of the flight planning program with a mini-display at the pilot's cockpit showing the aircraft's real-time position relative to the current survey flight line. The reference points established by NAMRIA are also monitored and used to calibrate the data.

As the system collected LiDAR data, ranges and intensities are recorded on hard drives dedicated to the system while the images are stored on the camera hard drive. Position Orientation System (POS) data is recorded on the POS computer inside the control rack. It can only be accessed and downloaded via file transfer protocol (ftp) to the laptop computer. GPS observations were downloaded each day for efficient data management.

3.1.4 Transmittal of Acquired LiDAR Data

All data surrendered are monitored, inspected and re-checked by securing a data transfer checklist signed by the downloader (Data Acquisition Component) and the receiver (Data Processing Component). The data transfer checklist shall include the following: date of survey, mission name, flight number, disk size of the necessary data (LAS, LOGS, POS, Images, Mission Log File, Range, Digitizer and the Base Station), and the data directory within the server. Figure 7 shows the arrangement of folders inside the data server.

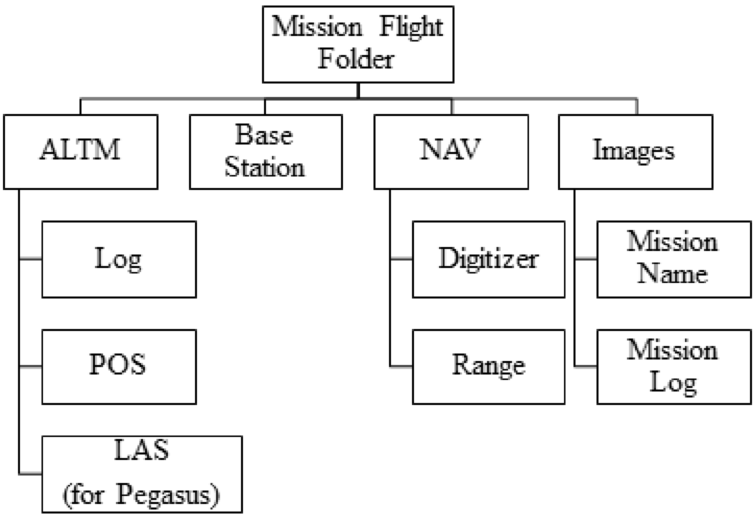


Figure 7. LiDAR Data Management for transmittal

3.1.5 Equipment

3.1.5.1 ALTM Pegasus

The ALTM Pegasus (Optech, Inc) is a laser based system suitable for topographic survey (Figure 8). It has a dual output laser system for maximum density capability. The LiDAR system is equipped with an Inertial Measurement Unit (IMU) and GPS for geo-referencing of the acquired data (Annex A contains the technical specification of the system).

The camera of the Pegasus sensor is tightly integrated with the system. It has a footprint of 8,900 pixels across by 6,700 pixels along the flight line (Annex B contains the technical specification of the D-8900 aerial digital camera).

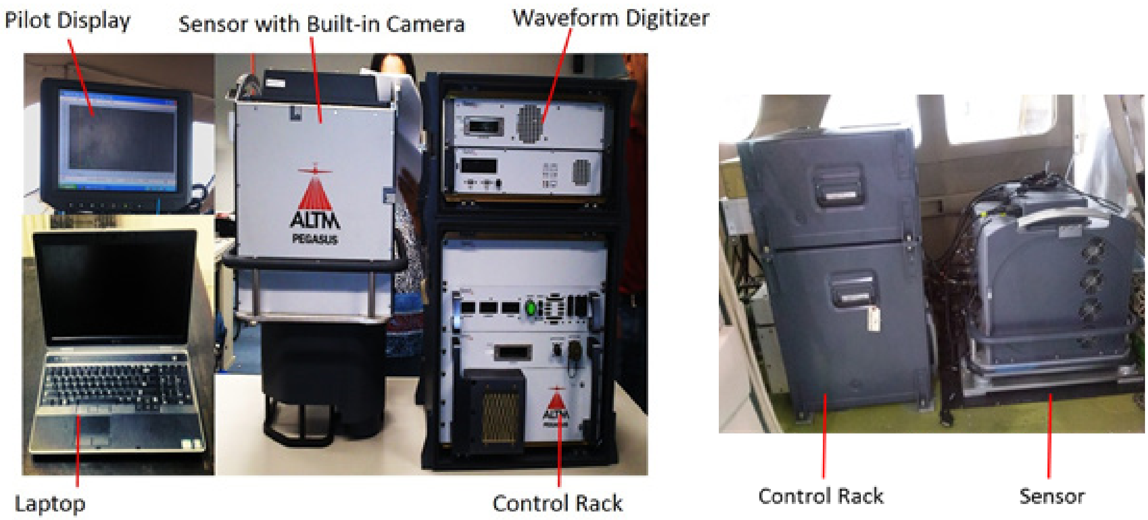


Figure 8. The ALTM Pegasus System: a) parts of the Pegasus system, b) the system as installed in Cessna T206H

3.1.5.2 ALTM Gemini

The ALTM Gemini (Figure 9) is a laser based system suitable for topographic survey especially in high altitude areas with 16 kHz of effective laser rate (Annex A contains the technical specification of the system).

Figure 9. ALTM Gemini System

3.2 Processing Methodology

The schematic diagram of the workflow implemented by the Data Processing Component (DPC) is shown in Figure 9. The raw data collected by the Data Acquisition Component (DAC) is transferred to DPC. Pre-processing of this data starts with the computation of trajectory and georectification of point cloud, in which the coordinates of the LiDAR point cloud data are adjusted and checked for gaps and shifts, using POSPac, LMS, LAStools and Quick Terrain (QT) Modeler software.

The unclassified LiDAR data then undergoes point cloud classification, which allows cleaning of noise data that are not necessary for further processing, using TerraScan software. The classified point cloud data in ASCII format is used to generate a data elevation model (DEM), which is edited and calibrated with the use of validation and bathymetric survey data collected from the field by the Data Validation and Bathymetry Component (DVBC). The final DEM is then used by the Flood Modeling Component (FMC) to generate the flood models for different flooding scenarios.

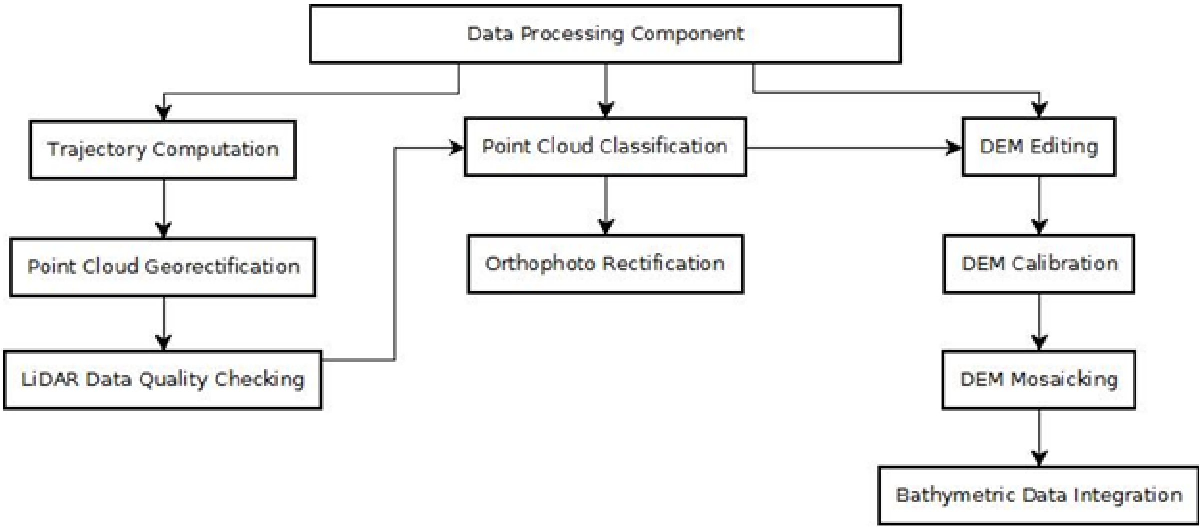


Figure 10. Schematic diagram of the data processing

3.2.1 Data Transfer

The Bicol mission is named 2BCLA069B, which was flown with the Airborne LiDAR Terrain Mapper (ALTM™ Optech Inc.) Gemini system on March 10, 2013 over Bicol. The Data Acquisition Component (DAC) transferred 8.53 Gigabytes of range data, 192 Megabytes of POS data, 5.25 Megabytes of GPS base station data, and 19.3 Gigabytes of raw image data to the data server on March 14, 2013. The whole Bicol dataset was fully transferred on March 20, 2013.

3.2.2 Trajectory Computation

The trajectory of the aircraft is computed using the software POSPac MMS v6.2. It combines the POS data from the integrated GPS/INS system installed on the aircraft, and the Rinex data from the GPS base station located within 25 kilometers of the area. It then computes the Smoothed Best Estimated Trajectory (SBET) file, which contains the best estimated trajectory of the aircraft, and the Smoothed Root Mean Square Estimation error file (SMRMSG), which contains the corresponding standard deviations of the position parameters of the aircraft at every point on the computed trajectory.

The key parameters checked to evaluate the performance of the trajectory are the Solution Status parameters and the Smoothed Performance Metrics parameters. The Solution Status parameters characterize the GPS satellite geometry and baseline length at the time of acquisition, and the processing mode used by POSPac. The acceptable values for each Solution Status parameter are shown in Table 3.

The Smoothed Performance Metrics parameters describe the root mean square error (RMSE) for the north, east and down (vertical) position of the aircraft for each point in the computed trajectory. A RMSE value of less than 4 centimeters for the north and east position is acceptable, while a value of less than 8 centimeters is acceptable for the down position.

Table 3. Smoothed Solution Status Parameters in POSPac MMS v6.2

Parameter	Optimal values
Number of satellites	More than 6 satellites
Position Dilution of Precision (PDOP)	Less than 3
Baseline Length	Less than 30 km
Processing mode	Less than or equal to 1, however short bursts of values greater than 1 are acceptable.

3.2.3 LiDAR Point Cloud Rectification

The trajectory file (SBET) and its corresponding accuracy file (SMRMSG) generated in POSPac are merged with the Range file to compute the coordinates of each individual point. The coordinates of points within the overlap region of contiguous strips vary due to small deviations in the trajectory computation for each strip. These strip misalignments are corrected by matching points from overlapping laser strips. This is done by the LiDAR Mapping Suite (LMS) software developed by Optech.

LMS is a LiDAR software package used for automated LiDAR rectification. It has the capability to extract planar features per flight line and to form correspondence among the identical planes available in the overlapping areas (illustrated in Figure 11). In order to produce geometrically correct point cloud, the redundancy in the overlapping areas of flight lines is used to determine the necessary corrections for the observations.

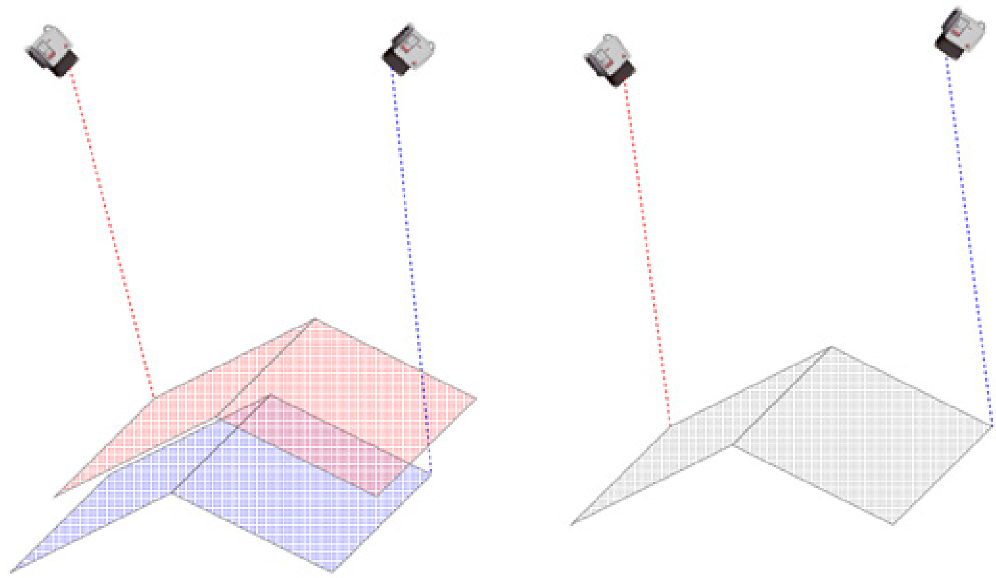


Figure 11. Misalignment of a single roof plane from two adjacent flight lines, before rectification (left). Least squares adjusted roof plane, after rectification (right).

The orientation parameters are corrected in LMS by using least squares adjustment to obtain the best-fit parameters and improve the accuracy of the LiDAR data. The primary indicators of the LiDAR rectification accuracy are the standard deviations of the corrections of the orientation parameters. These values are seen on the Boresight corrections, GPS position corrections, and IMU attitude corrections, all of which are located on the LMS processing summary report. Optimum accuracy is obtained if the Boresight and IMU attitude correction standard deviations are less than 0.001°, and if the GPS position standard deviations are below 0.01 meter.

3.2.4 LiDAR Data Quality Checking

After the orientation parameters are corrected and the point cloud coordinates are computed, the entire point cloud data undergoes quality checking, to see if: (a) there are remaining horizontal and vertical misalignments between contiguous strips, and; (b) to check if the density of the point cloud data reach the target density for the site. The LAStools software is used to compute for the elevation difference in the overlaps between strips and the point cloud density. It is a software package developed by Rapidlasso GmbH for filtering, tiling, classifying, rasterizing, triangulating and quality checking Terabytes of LiDAR data, using robust algorithms, efficient I/O tools and memory management. LAStools can quickly create raster representing the computed quantities, which provide guiding images in determining areas where further quality checks are necessary. The target requirements for floodplain acquisition, computed by LAStools, are shown in Table 4.

Table 4. Parameters investigated during quality checks

Criteria	Requirement
Minimum per cent overlap	25%
Average point cloud density per square meter	2.0
Elevation difference between strips (on flat areas)	0.20 meters

LAStools can provide guides where elevation differences probably exceed the 20-centimeter limit. An example of LAStools output raster visualizing points in the flight line overlaps with a vertical difference of +/- 20 centimeters (displayed as dense red/blue areas) is shown in Figure 12.

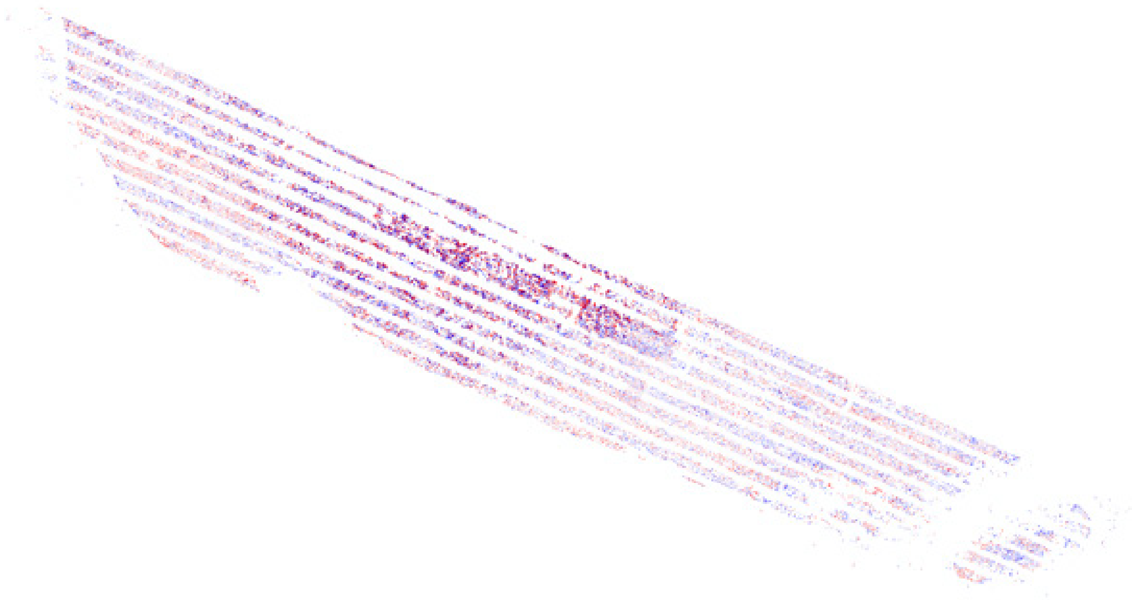
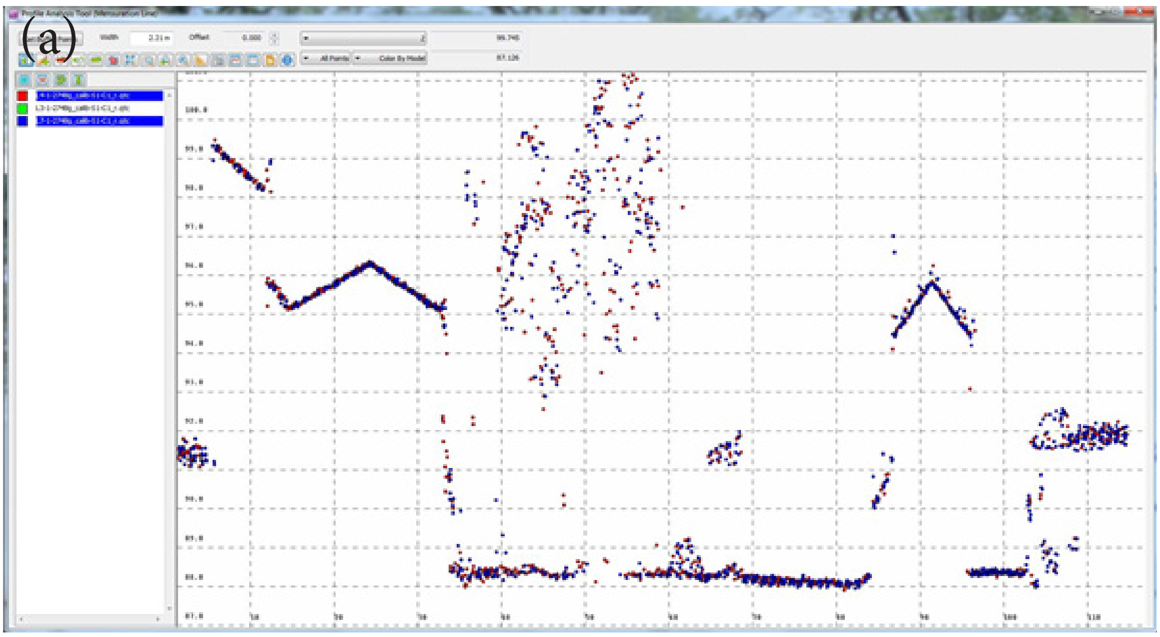


Figure 12. Elevation difference between flight lines generated from LAStools

To investigate the occurrences of elevation differences in finer detail, the profiling tool of Quick Terrain (QT) Modeler software is used. QT Modeler is a 3D point cloud and terrain visualization software package developed by Applied Imagery, Inc. The profiling capability of QT Modeler is illustrated in Figure 13.



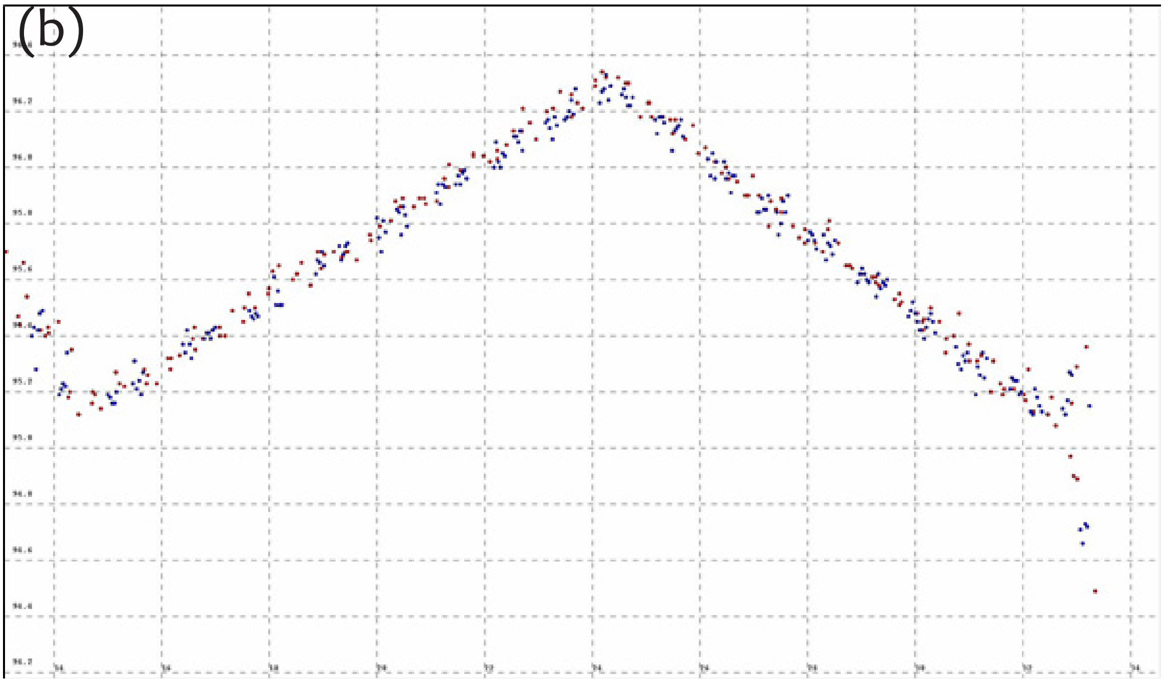


Figure 13. Profile over roof planes (a) and a zoomed-in profile on the area encircled in yellow (b)

The profile (e.g., over a roof plane) shows the overlapping points from different flight lines which serve as a good indicator that the correction applied by LMS for individual flight lines is good enough to attain the desired horizontal and vertical accuracy requirements. Flight lines that do not pass quality checking are subject for reprocessing in LMS until desired accuracies are obtained.

3.2.5 LiDAR Point Cloud Classification and Rasterization

Point cloud classification commences after the point cloud data has been rectified. TerraScan is a TerraSolid LiDAR software suite used for the classification of point clouds. It can read airborne and vehicle-based laser data in raw laser format, LAS, TerraScan binary or other ASCII-survey formats. Its classification and filtering routines are optimized by dividing the whole data into smaller geographical datasets called blocks, to automate the workflow and increase efficiency. In this study, the blocks were set to 1 kilometer by 1 kilometer with a 50-meter buffer zone to prevent edge effects.

The process includes the classification of all points into Ground, Low Vegetation, Medium Vegetation, High Vegetation and Buildings. The classifier tool in TerraScan first filters air points and low points by finding points that are 5 standard deviations away from the median elevation of a search radius, which is 5 meters by default. It then divides the region into 60 meters by 60 meters search areas (the maximum area where at least one laser point hits the ground) and assigns the lowest points in these areas as the initial ground points from which a triangulated ground model is derived. The classifier then iterates through all the points and adds the points to the ground model by testing if it is (a) within the maximum iteration angle of 4°

by default from a triangle plane, and (b) if it is within the maximum iteration distance (1.2 meters by default) from a triangle plane. The ground plane is continuously updated from these iterations. The ground classification technique is illustrated in Figure 14. It is apparent that the smaller the iteration angle, the less eager the classifier is to follow changes in the point cloud (small undulations in terrain or hits on low vegetation). An angle close to 4° is used in flat terrain areas while an angle of 10° is used in mountainous or hilly terrains.

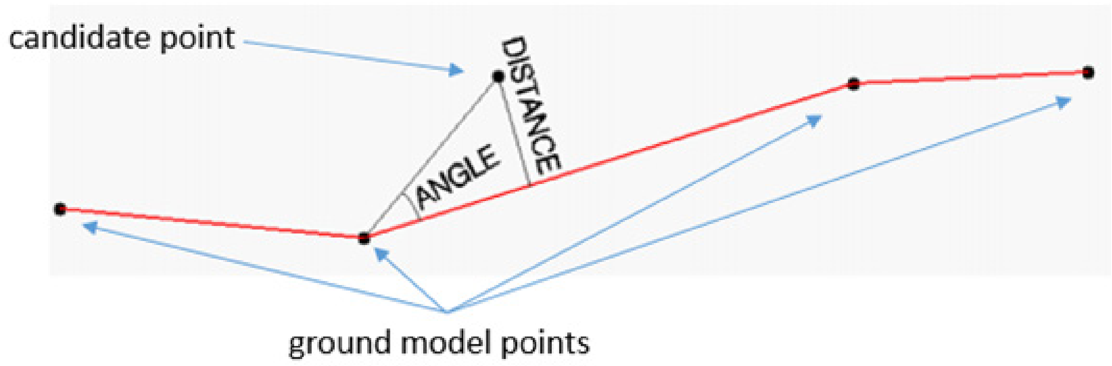


Figure 14. Ground classification technique employed in TerraScan

The parameters for ground classification routines used in floodplain and watershed areas are listed in Table 5.

Table 5. Ground classification parameters used in Terrascan for floodplain and watershed areas

Classification maximums	Floodplain (default)	Watershed (adjusted)
Iteration angle (degrees)	4	8
Iteration distance (meters)	1.20	1.50

The comparison between the produced DTM using the default parameters versus the adjusted is shown in Figure 15. The default parameters may fail to capture the sudden change in the terrain, resulting to less points being classified as ground that makes the DTM interpolated (Figure 15a). The adjusted parameters works better in these spatial conditions as shown in Figure 15b. Statistically, the number of ground points and model key points correctly classified can increase by as much as 50% when using the adjusted parameters.

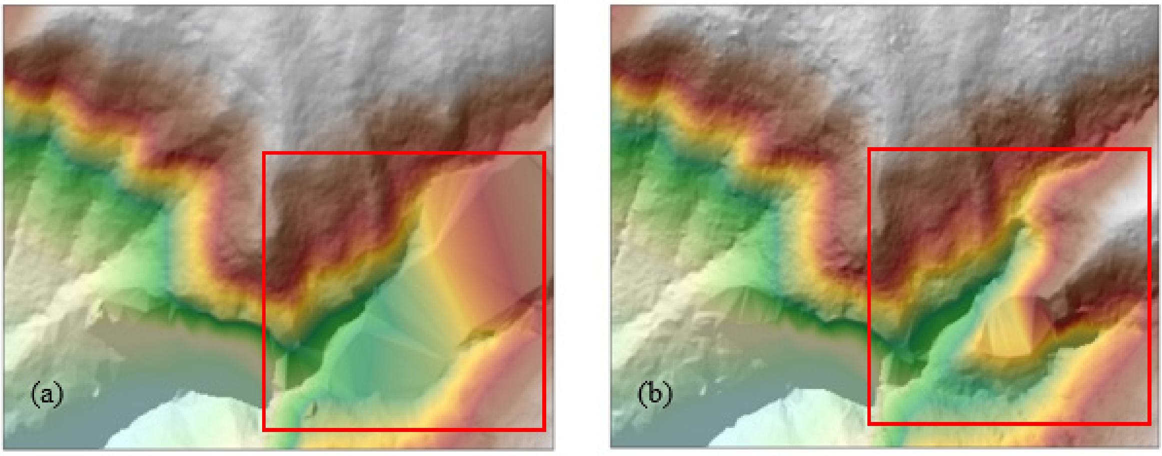


Figure 15. Resulting DTM of ground classification using the default parameters (a) and adjusted parameters (b)

The classification to Low, Medium and High vegetation is a straightforward testing of how high a point is from the ground model. The range of elevation values and its corresponding classification is shown in Table 6.

Table 6. Classification of Vegetation according to the elevation of points

Elevation of points (meters)	Classification
0.05 to 0.15	Low Vegetation
0.15 to 2.50	Medium Vegetation
2.50 to 50.0	High Vegetation

The classification to Buildings routine tests points above 2 meters if they only have one echo, and if they form a planar surface of at least 40 square meters with points adjacent to them. Minimum size and Z tolerance are the parameters used in the classify buildings routine as shown in Figure 16.

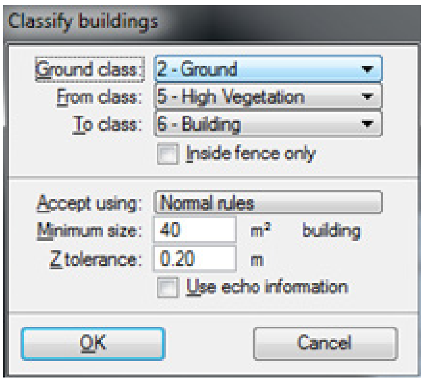


Figure 16. Default TerraScan building classification parameters

Minimum size is set to the smallest building footprint size of 40 square meters while the Z tolerance of 20 centimeters is the approximate elevation accuracy of the laser points.

The point cloud data are examined for possible occurrences of air points which are to be deleted manually in the TerraScan window. Air points are defined as groups of points which are significantly higher or lower from the ground points. The different examples of air points are shown in Figure 17.

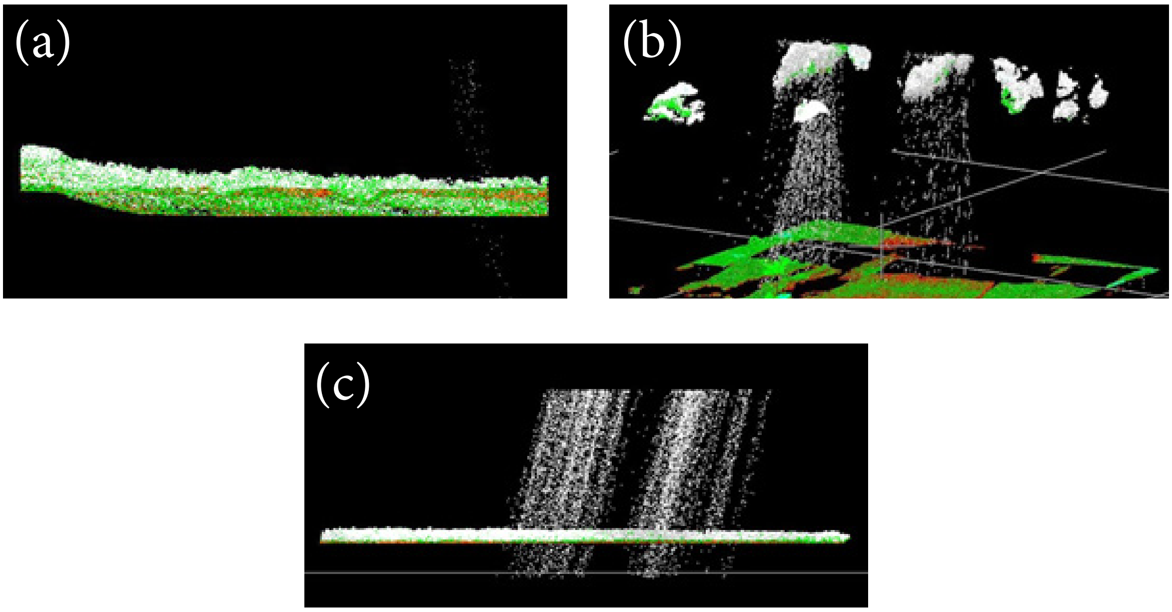


Figure 17. Different examples of air points manually deleted in the TerraScan window

The noise data can be as negligible as shown in Figure 17a or can be as severe as the one shown in Figure 17c. A combination of cloud points and shower of short ranges is displayed in Figure Figure 17b. Shower of short ranges are caused by signal interference from the radio transmission of the tower and the aircraft. During every transmission on a specific frequency (around 120 MegaHertz), the signal is getting distorted due to the interference causing showers of short ranges in the output LAS.

Classified LiDAR point clouds that are free of air points, noise and unwanted data are processed in TerraScan to produce Digital Terrain Model (DTM) and the corresponding first and last return Digital Surface Models (DSM). These ground models are produced in ASCII format. DTMs are produced by rasterizing all points classified to ground and model key points in a 1 meter by 1 meter grid. The last return DSMs are produced by rasterizing all last returns from all classifications (Ground, Model Key Points, Low, Medium, High Vegetation, Buildings and Default) in a 1 meter by 1 meter grid. The first return DSMs on the other hand are produced by rasterizing all first returns from all classifications. Power lines are usually included in this model. All of these ground models are used in the mosaicking, manual editing and hydro correction of the topographic dataset, in preparation for the floodplain hydraulic modelling.

3.2.6 DEM Editing and Hydro-correction

Even though the parameters of the classification routines are optimized, various digital elevation models (DTM, first and last return DSM) that are automatically produced may still display minor errors that still need manual correction to make the DEMs suitable for fine-scale flood modelling. This is true especially for features that are under heavy canopy. Natural embankments on the side of the river might be flattened or misrepresented because no point pierced the canopy on that area. The same difficulty might also occur on smaller streams that are under canopy. The DTM produced might have discontinuities on these channels that might affect the flood modelling negatively. Manual inspection and correction is still a very important part of quality checking the LiDAR DEMs produced.

To correctly portray the dynamics of the flow of water on the floodplain, the river geometry must also be taken into consideration. The LiDAR data must be made consistent to the topographic surveys done for the area, and the bathymetric data must be "burned" into the DEM to make the dataset suitable for hydraulic analyses. However, no cross-sectional survey was performed for this area.

Results and Discussion

4.1 LiDAR ACQUISITION IN BICOL FLOODPLAIN

4.1.1 Flight Plans

Plans were made to acquire LiDAR data within the floodplains. Each flight mission had an average of ten to twelve (10-12) flight lines and ran for at most 4 hours including take-off, landing and turning time. The parameter used in the LiDAR system for acquisition is found in Table 7.

Table 7. Parameters used in LiDAR System during Flight Acquisition

Fixed Variables	Values		
Flying Height (AGL – Above Ground Level) (m)	750	1000	1200
Overlap	30 %	30 %	30 %
Max. field of View (θ)	50	50	50
Speed of Plane (kts)	130	130	130
Turn around minutes	5	5	5
Swath (m)	661.58m	882m	1058.53m

The parameters that set in the LiDAR sensor to optimize the area coverage following the objectives of the project and to ensure the aircraft's safe return to the airport (base of operations) are shown in Table 7. Each flight acquisition is designed for four operational hours. The maximum flying hours for Cessna 206H is five hours.

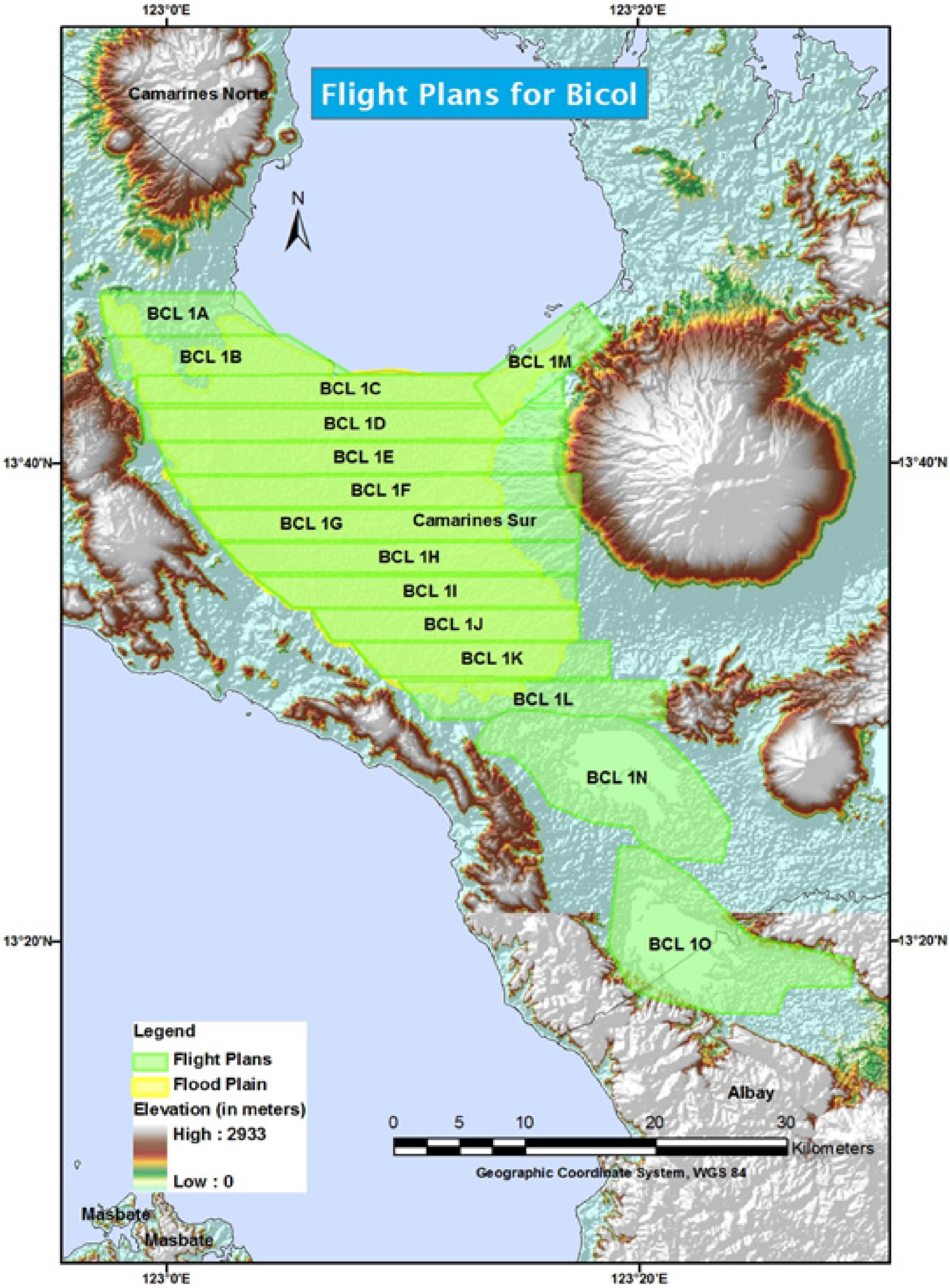


Figure 18. Bicol floodplain flight plans

Results and Discussion

4.1.2 Ground Base Station

The project team was able to recover two (2) NAMRIA control station (CMS-28 and CMS-3358) with third (3rd) and fourth (4th) order accuracy, respectively. The ground control point (GCPs) was used as reference point during flight operations using TRIMBLE SPS R8, a dual frequency GPS receiver.

Table 8. Details of the recovered NAMRIA horizontal control point CMS-28 use as base station for the LiDAR Acquisition

Station Name	CMS-28	
Order of Accuracy	3RD Order	
Relative Error (horizontal positioning)		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13° 56’ 11.37883”
	Longitude	121° 25’ 11771”
	Ellipsoidal Height	78.31300 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	545989.271 meters
	Northing	1541188.355 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13° 56’ 6.15095” North
	Longitude	121° 25’ 37.06686” East
	Ellipsoidal Height	124.52500 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	329910.19 meters
	Northing	1541170.73 meters

Figure 19. NAMRIA control station CMS-28 is located along the road going to Brgy. Fundado, Canaman

Table 9. Details of the recovered NAMRIA horizontal control point CMS-3358 use as base station for the LiDAR Acquisition

Station Name	CMS-3358	
Order of Accuracy	4th Order	
Relative Error (horizontal positioning)		
Geographic Coordinates, Philippine Reference of 1992 Datum (PRS 92)	Latitude	13° 56’ 11.37883”
	Longitude	121° 25’ 11771”
	Ellipsoidal Height	78.31300 meters
Grid Coordinates, Philippine Transverse Mercator Zone 5 (PTM Zone 5 PRS 92)	Easting	545989.271 meters
	Northing	1541188.355 meters
Geographic Coordinates, World Geodetic System 1984 Datum (WGS 84)	Latitude	13° 56’ 6.15095” North
	Longitude	121° 25’ 37.06686” East
	Ellipsoidal Height	124.52500 meters
Grid Coordinates, Universal Transverse Mercator Zone 51 North (UTM 51N WGS 1984)	Easting	329910.19 meters
	Northing	1541170.73 meters

Figure 20. Station CMS-3358 is located San Isidro, Baao Camarines Sur, about a meter SE of San Isidro Barangay Hall’s entrance gate and 0.50 m from the fence

Results and Discussion

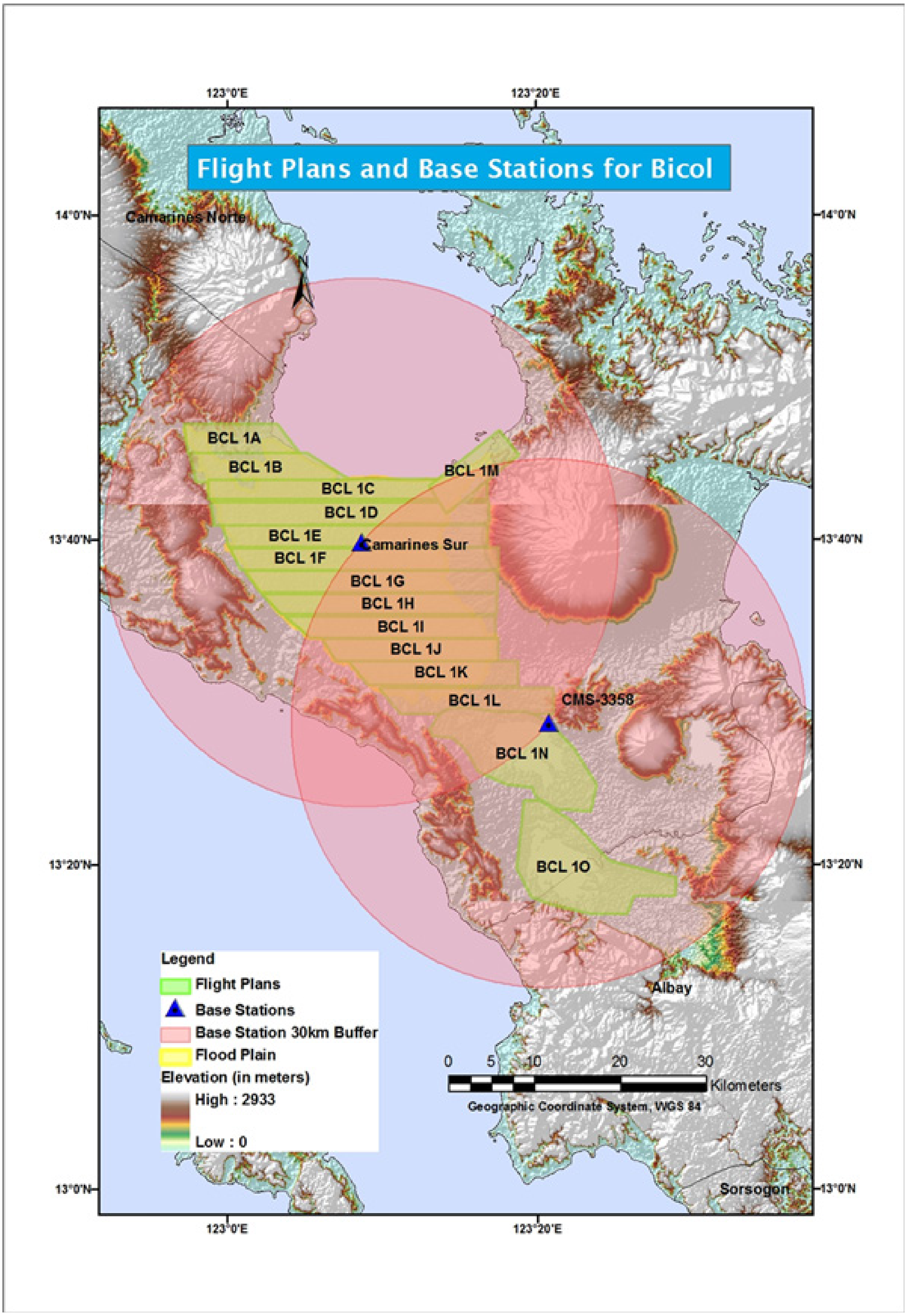


Figure 21. Bicol Flight Plans and Base Station

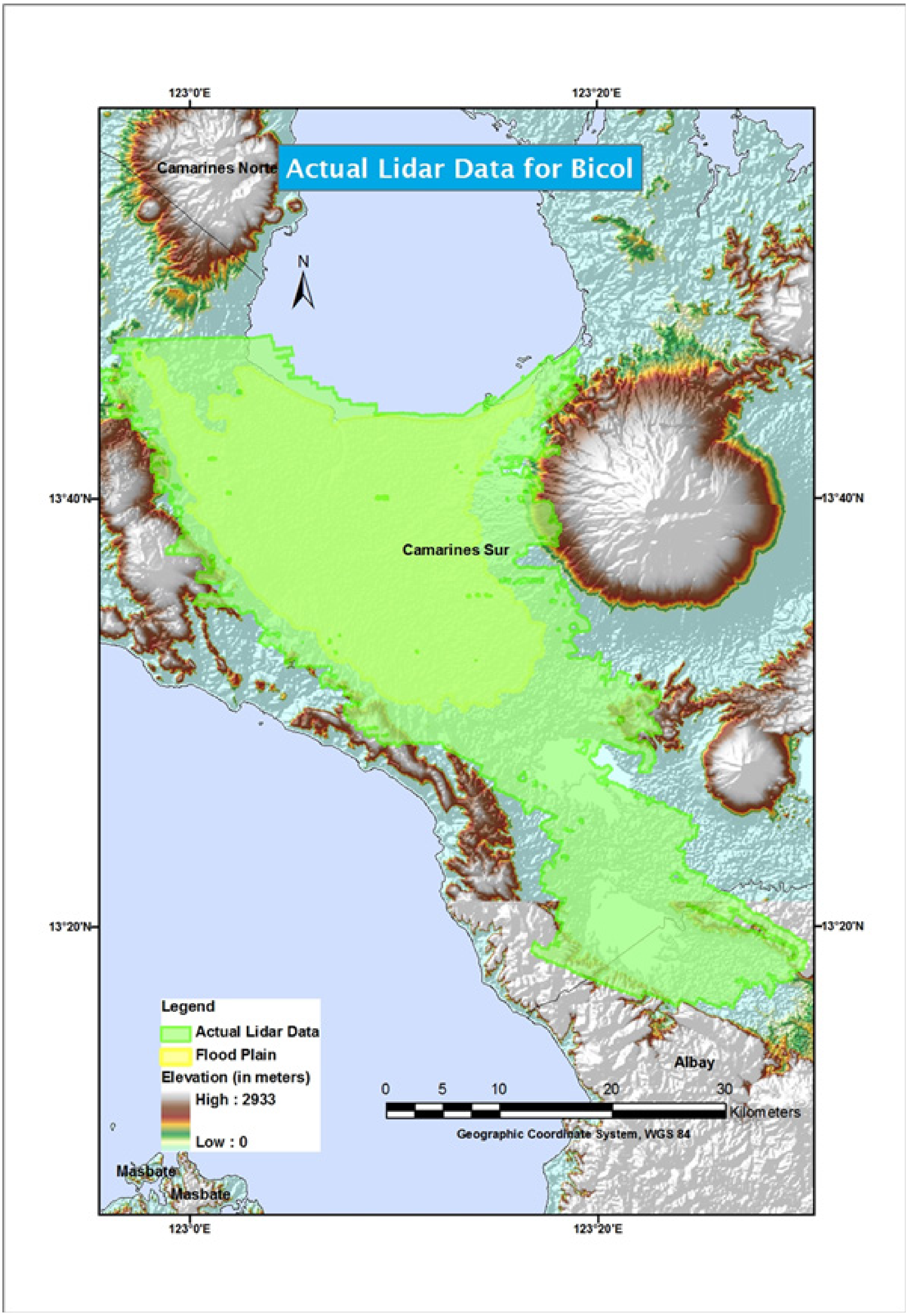


Figure 22. Bicol Floodplain Data Acquisition Coverage

Results and Discussion

Twelve missions were conducted to complete the LiDAR Data Acquisition in Bicol floodplain, for a total of 20 hours and 40 minutes (20+40) for RP-C9022; and 28 hours and 20 minutes (28+20) of flying time for RP-C9122. All missions were acquired using the Pegasus and Gemini LiDAR System. Table 10 shows the total area to be surveyed according to the flight plan and the total area of actual coverage per mission.

Table 10. Flight Missions for LiDAR Data Acquisition in Bicol floodplain

Date Surveyed	Name	Flight Plan Area (km2)	Surveyed Area (km2)	Area Surveyed Within the River Systems (km2)	Area Surveyed Outside the River Systems (km2)	Total number of Images (Frames)	Flying Hours	
							Hours	Minutes
March 7 & 10, 2013	BCL M	39.928	63.922	53.981	9.941	334	3	50
March 7& 10, 2013	BCL IJ	107.764	206.08	199.371	6.709	Mission aborted	2	42
March 10, 2013	BCL A	41.779	71.913	43.256	28.67	313	2	15
March 11, 2013	BCL D	87.117	120.52	120.52	0	Mission aborted	2	55
March 11, 2013	BCL B	51.75	98.106	83.451	14.655	427	3	0
March 11, 2013	BCL KL	106.81	228.73	220.795	7.935	441	2	48
March 12, 2013	BCL E	77.04	124.22	124.22	0	292	2	32
March 13, 2013	BCL C	92.007	141.61	136.137	5.473	578	3	0
March 12, 2013	BCL N					339	2	10
March 13, 2013	BCL GH	137.999	210.143	203.229	6.914	0	2	55
March 14& 15, 2013	BCL F	87.565	158.81	0	121.58	947	6	20
March 15, & 17, 2013	BCL O	158.81	239.802	239.802	0	825	5	8
March 17, 2013	BCL CS	52.671	52.671	52.671	0	350	2	8

Results and Discussion

Table 11. Area of Coverage of the LiDAR Data Acquisition in Bicol floodplain

Location	Date Surveyed	Operator	Mission Name	Floodplain Surveyed Area (km²)	Total Floodplain Area (km²)	Water-shed Surveyed Area (km²)	Total Water-shed Area (km²)
Bicol	March 7, 2013	PEARL MARS	2BCLM066B	0	585	0	2,587.79
	March 7, 2013	GREGORY ANO	1BCLI066B	0		0	
		LOVELY ACUNA	2BCLM069A	0		25.836	
	March 10, 2013	JASMINE ALVIAR	1BCLIJ069A	0		0	
		JASMINE ALVIAR	1BCLIJ069B	0		0	
	March 10, 2013	PEARL MARS	2BCLA069B	12.45		30.806	
	March 11, 2013	JASMINE ALVIAR	1BCLIJ070A	145.29		54.081	
	March 11, 2013	LOVELYN ASUNCION	2BCLD070A	99.525		20.995	
	March 11, 2013	PEARL MARS	2BCLB070B	12.45		30.806	
	March 11, 2013	GREGORY ANO	2BCLK070B	74.781		146.01	
	March 12, 2013	JASMINE ALVIAR	1BCLN071A	0		62.56	
		LOVELY ACUNA	2BCLE071A	93.86		30.36	
	March 12, 2013	GREGORY ANO	1BCLGH072A	145.45		57.779	
	March 12, 2013	LOVELYN ASUNCION	2BCLC+D-LINE2&9072A	104.72		31.417	
	March 12, 2013	PEARL MARS	2BCLF073A	0		0	
	March 16, 2013	PEARL MARS	2BCLRF074A	121.58		37.23	
	March 15, 2013	JASMINE ALVIAR	1BCLO074A	52.183		15.144	
	March 17, 2013	GREGORY ANO	1BCLO074A	0		239.8	
	March 17, 2013	LOVELY ACUNA	2BCLCS076A	52.671		0	

Results and Discussion

4.2 LiDAR DATA PROCESSING

4.2.1 Trajectory Computation

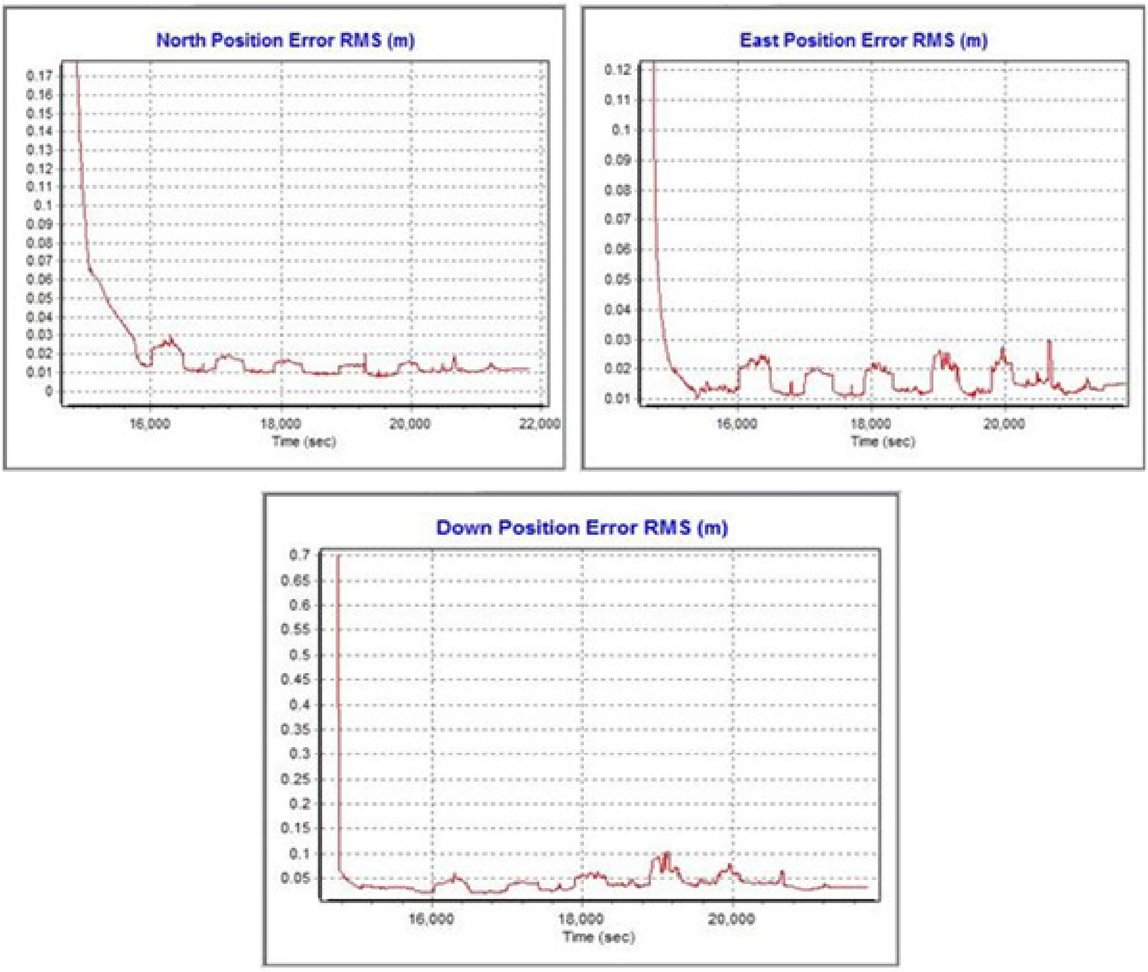


Figure 23. Smoothed Performance Metric Parameters for North (a), East (b), and Down (c) of Bicol flight

The Smoothed Performance Metric parameters of the Bicol flight are shown in Figure 26. The x-axis is the time of flight, which is measured by the number of seconds from the midnight of the start of the GPS week. The y-axis is the RMSE value for a particular aircraft position with respect to GPS survey time. The North (Figure 23a) and east (Figure 23b) position RMSE values fall within the prescribed accuracy of 4 centimeters, and all Down (Figure 23c) position RMSE values fall within the prescribed accuracy of 8 centimeters.

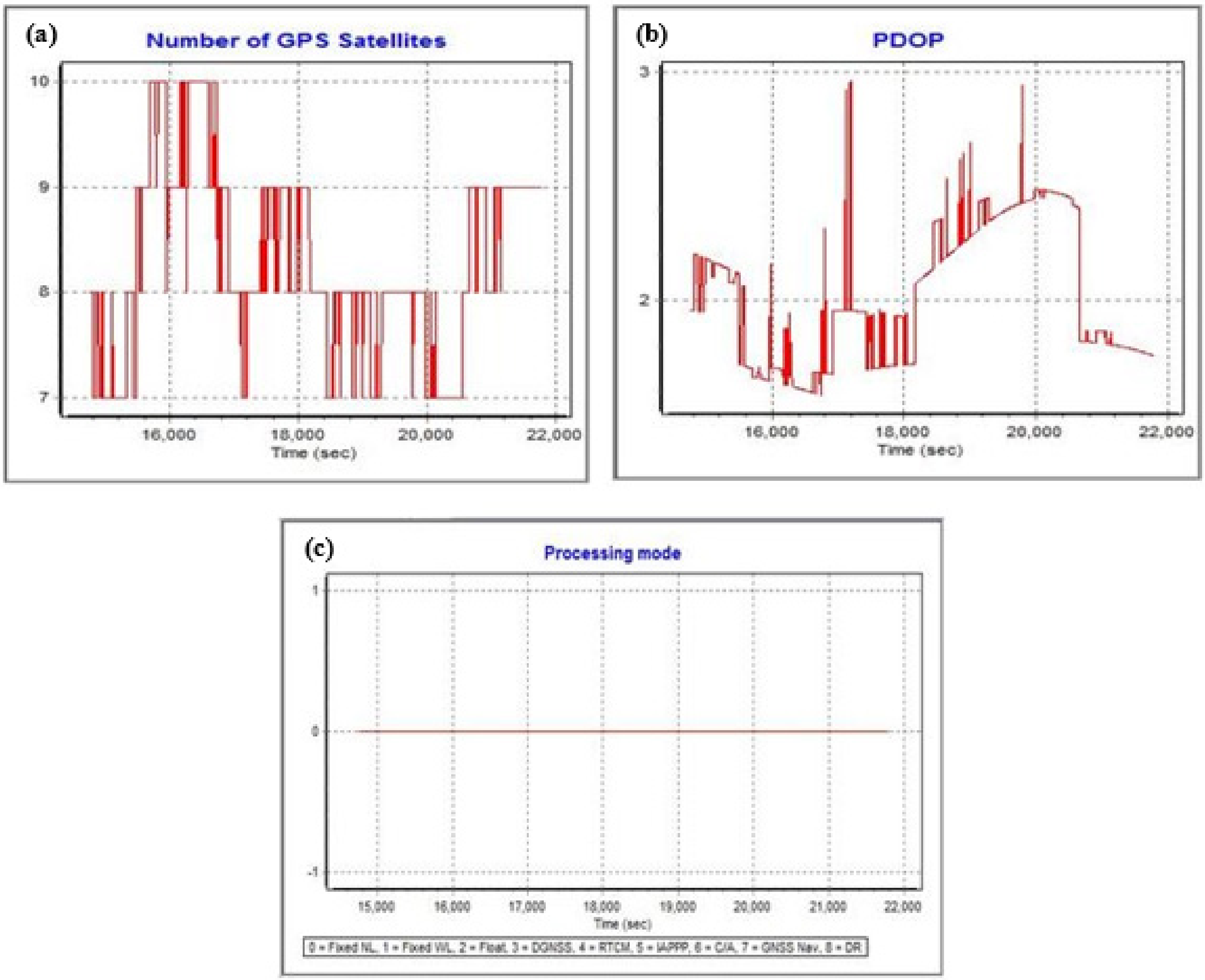


Figure 24. Solution Status Parameters of Bicol flight

The Solution Status parameters of the computed trajectory for Pampanga flight, which are the number of GPS satellites, Positional Dilution of Precision (PDOP), and the GPS processing mode used are shown in Figure 24. The number of GPS satellites (Figure 24a) graph indicates that the number of satellites during the acquisition was between 7 and 10. The PDOP (Figure 24b) value does not exceed the value of 3, indicating optimal GPS geometry. The processing mode (Figure 24c) stays at a value of 0, which corresponds to a Fixed, Narrow-Lane mode, which indicates an optimum solution for trajectory computation by POSPac MMS v6.2. All of the parameters satisfied the accuracy requirements for optimal trajectory solutions as indicated in the methodology.

Results and Discussion

4.2.2 LiDAR Point Cloud Computation

The LAS data output contains 14 flight lines, with each flight line containing one channel, a feature of the Gemini system. The result of the boresight correction standard deviation values for the channel is better than the prescribed 0.001°. The position of the LiDAR system is also accurately computed since all GPS position standard deviations are less than 0.0009 meter. The attitude of the LiDAR system passed accuracy testing since the standard deviation of the corrected roll and pitch values of the IMU attitudes are less than 0.001°.

4.2.3 LiDAR Data Quality Checking

The LAS boundary of the LiDAR data on top of the SRTM elevation data is shown in Figure 25. The map shows gaps in the LiDAR coverage that are attributed to cloud cover present during the survey.

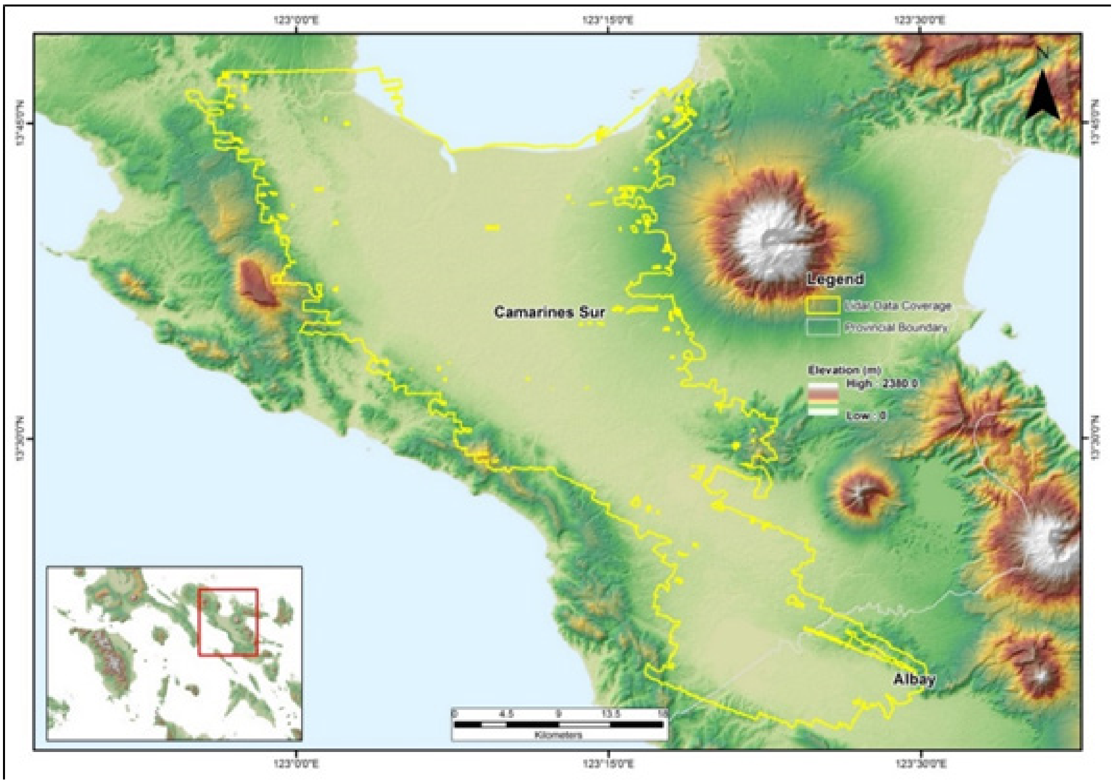


Figure 25. Coverage of LiDAR data for the Bicol mission

The overlap data for the merged LiDAR data showing the number of channels that pass through a particular location is shown in Figure 26. Since the Gemini system employs one channel, an average value of 2 (blue) for areas where there are only two overlapping flight lines, and a value of 3 (yellow) or more (red) for areas with three or more overlapping flight lines, are expected. The average data overlap for this Bicol flight is 48.03%.

Results and Discussion

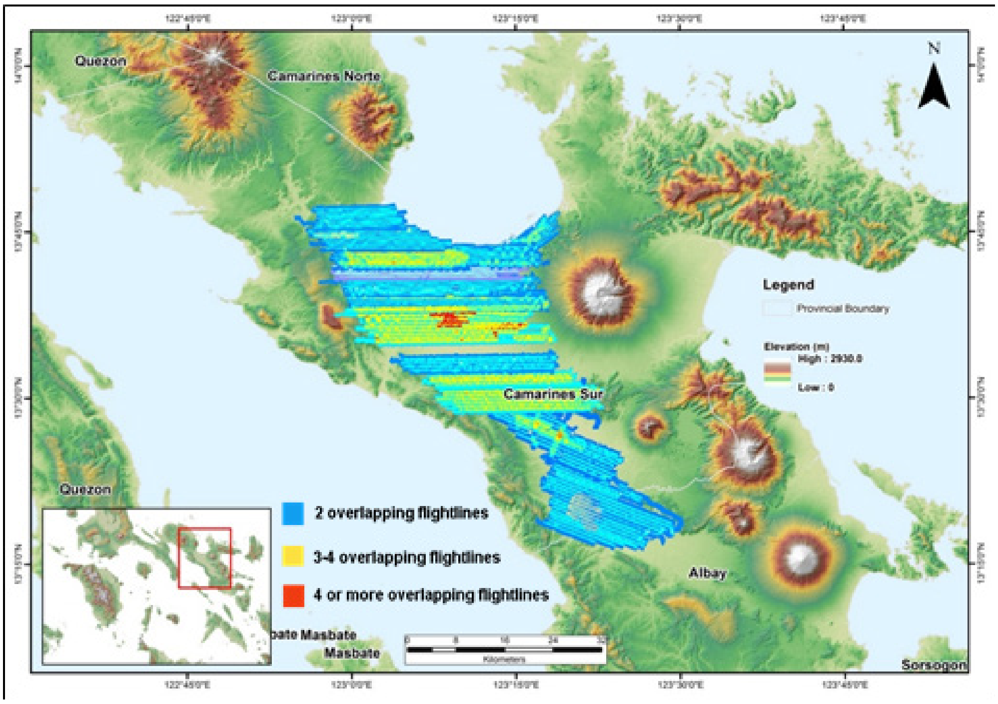


Figure 26. Image of data overlap for the Bicol mission

The density map for the merged LiDAR data, with the red areas showing the portions of the data that satisfy the 2 points per square meter requirement, is shown in Figure 27. It was determined that 81.22% of the total area satisfied the point density requirement, and the average density for the entire survey area is 2.95 points per square meter.

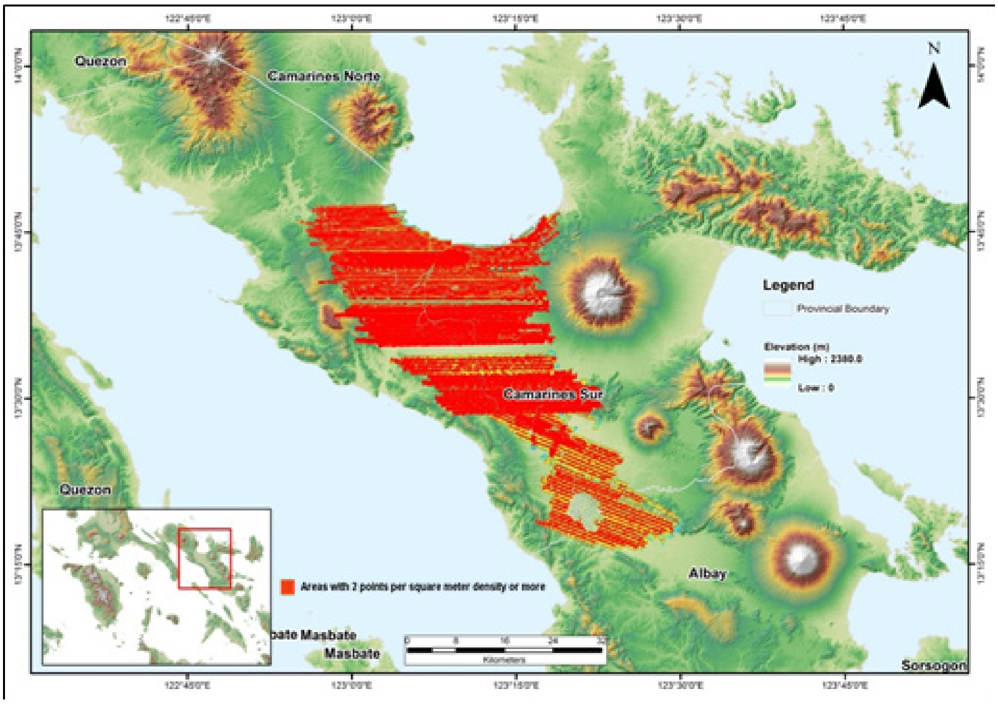


Figure 27. Density map of merged LiDAR data for the Bicol mission

Results and Discussion

The elevation difference between overlaps of adjacent flight lines is shown in Figure 28. The default color range is from blue to red, where bright blue areas correspond to a -0.20 meter difference, and bright red areas correspond to a +0.20 meter difference. Areas with bright red or bright blue need to be investigated further using QT Modeler.

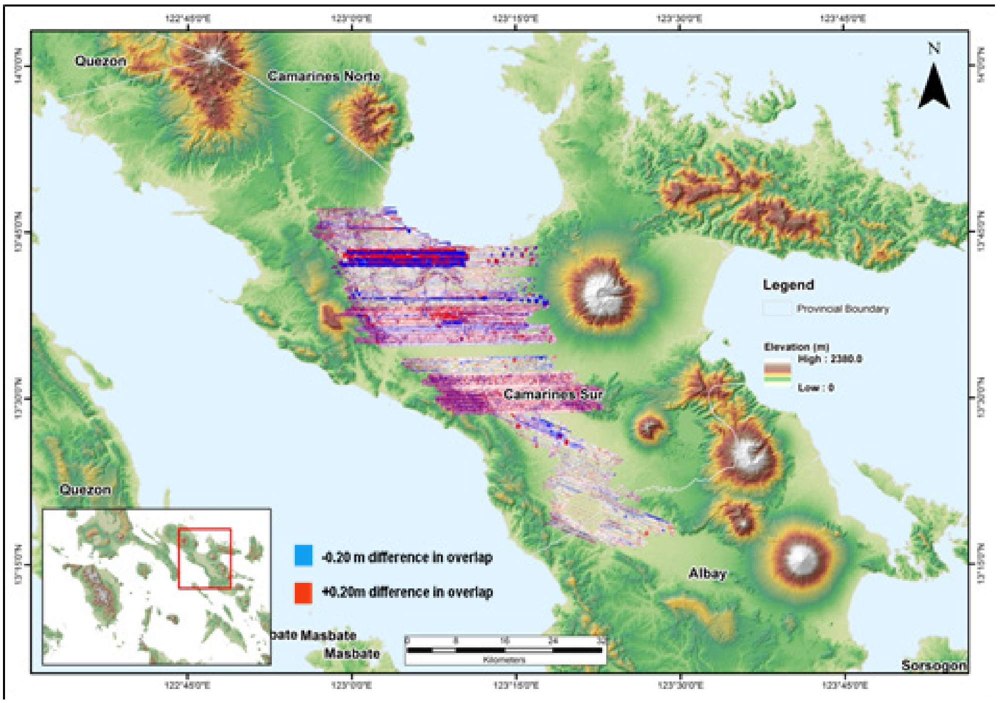


Figure 28. Elevation difference map between flight lines

A screen capture of the LAS data loaded in QT Modeler is shown in Figure 29a. A line graph showing the elevations of the points from all of the flight strips traversed by the profile in red line is shown in Figure 29b. It is evident that there are differences in elevation, but the differences do not exceed the 20-centimeter mark. No reprocessing was necessary for this LiDAR dataset.

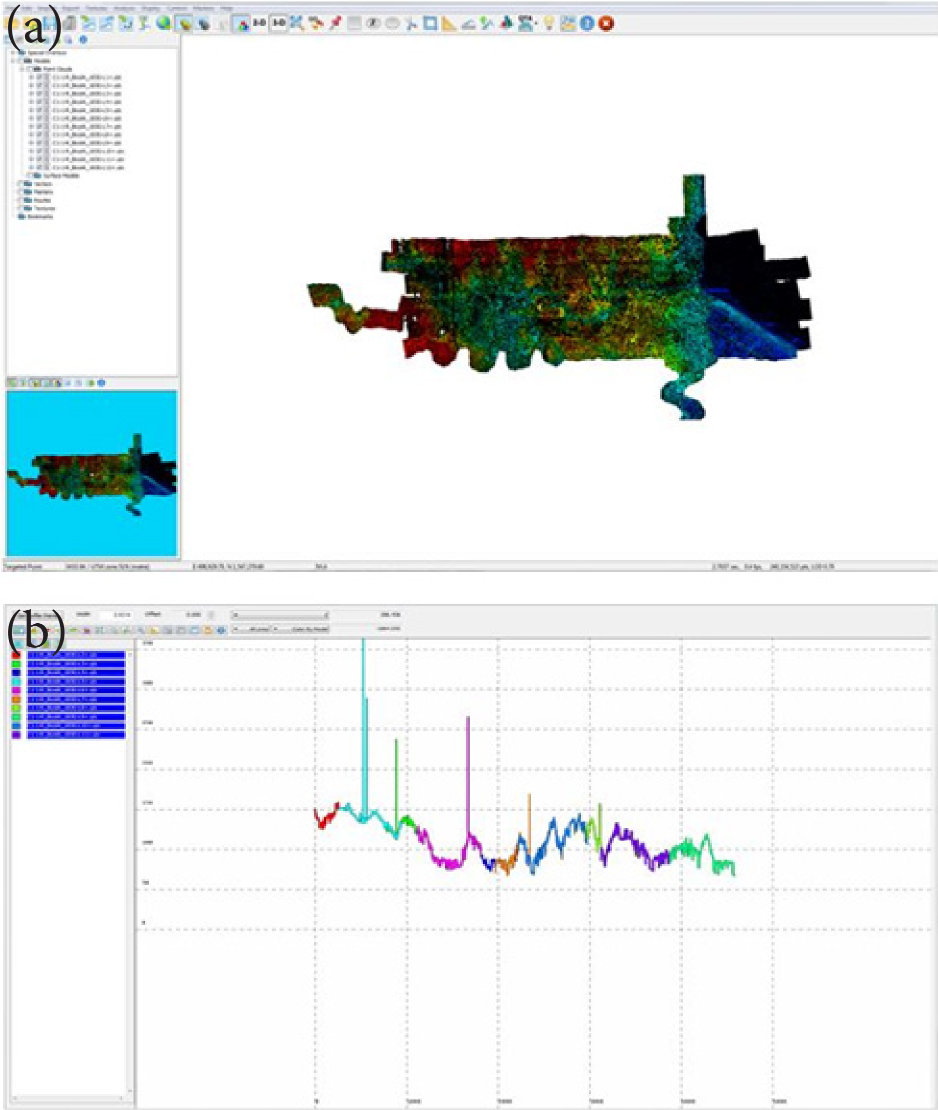


Figure 29. Quality checking with the profile tool of QT Modeler

4.2.4 LiDAR Point Cloud Classification and Rasterization

The block system that TerraScan employed for the LiDAR data is shown in Figure 30a generated a total of 2,210 1 kilometer by 1 kilometer blocks. The final classification of the point cloud for a mission in the Bicol floodplain is shown in Figure 30b. The number of points classified to the pertinent categories along with other information for the mission is shown in Table 12.

Results and Discussion

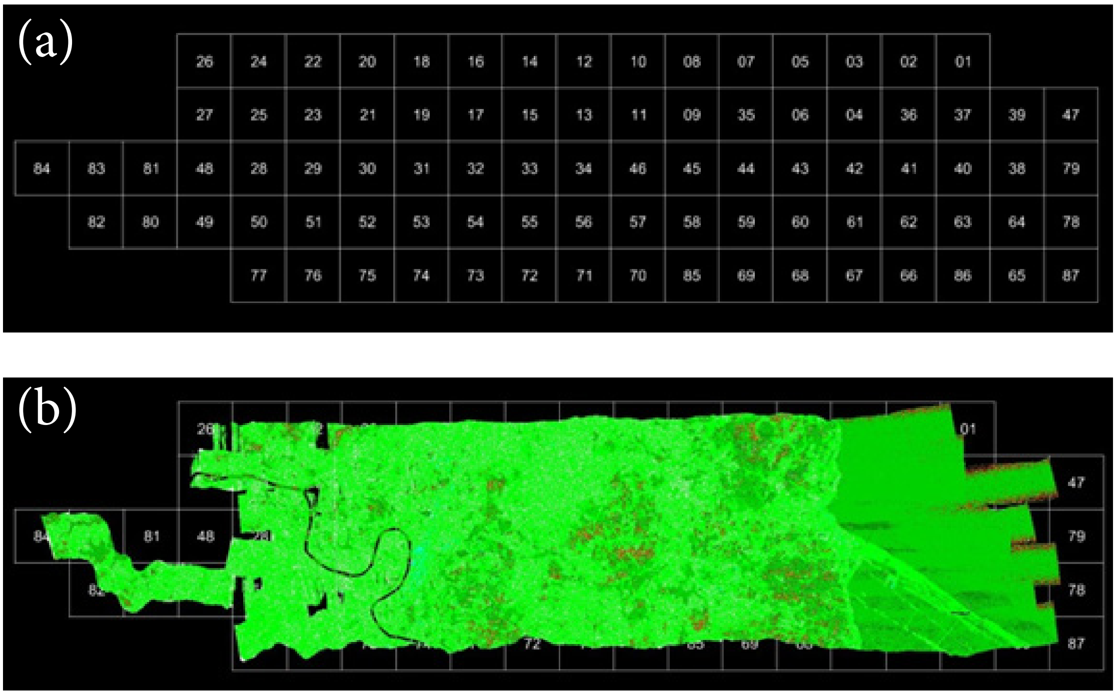


Figure 30. (a) Bicol floodplains and (b) Bicol classification results in TerraScan

Table 12. Bicol classification results in TerraScan

Pertinent Class	Count
Ground	1,220,661,950
Low Vegetation	1,691,297,080
Medium Vegetation	1,448,794,929
High Vegetation	1,037,239,195
Building	72,234,299
Number of 1km x 1km blocks	2,210
Maximum Height	645.87 m
Minimum Height	34.29 m

An isometric view of an area before (a) and after (b) running the classification routines for the mission is shown in Figure 31. The ground points are in brown, the vegetation is in different shades of green, and the buildings are in cyan. It can be seen that residential structures adjacent or even below canopy are classified correctly, due to the density of the LiDAR data.

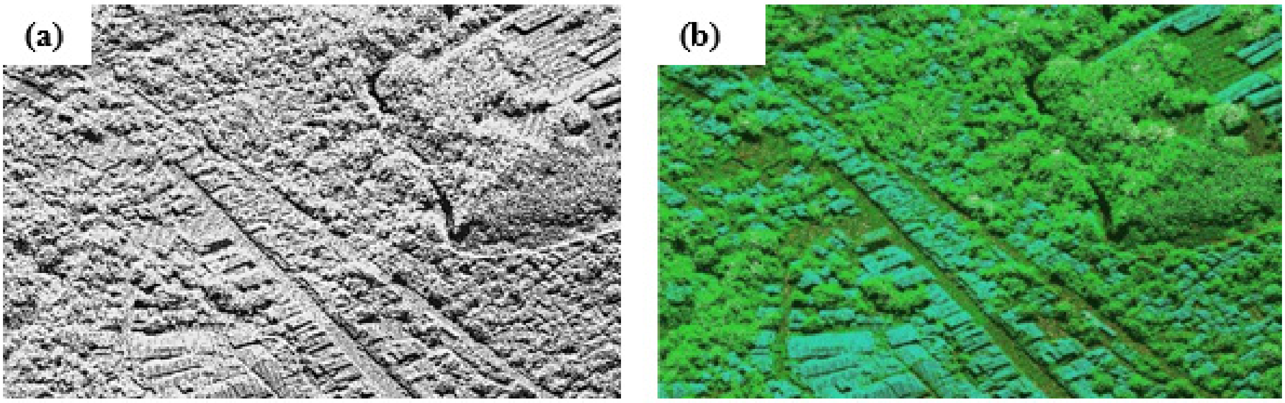


Figure 31. Point cloud (a) before and (b) after classification

4.2.5 DEM Editing and Hydro-correction

Portions of DTMs before and after manual editing are shown in Figure 32. It shows that the embankment might have been drastically cut by the classification routine in Figure 32a and clearly needed to be retrieved to complete the surface as in Figure 32b to allow to hydrologically correct flow of water. A small stream suffers from discontinuity of flow due to an existing bridge in Figure 32c. The bridge is removed also in order to hydrologically correct the flow of water through the river in Figure 32d.

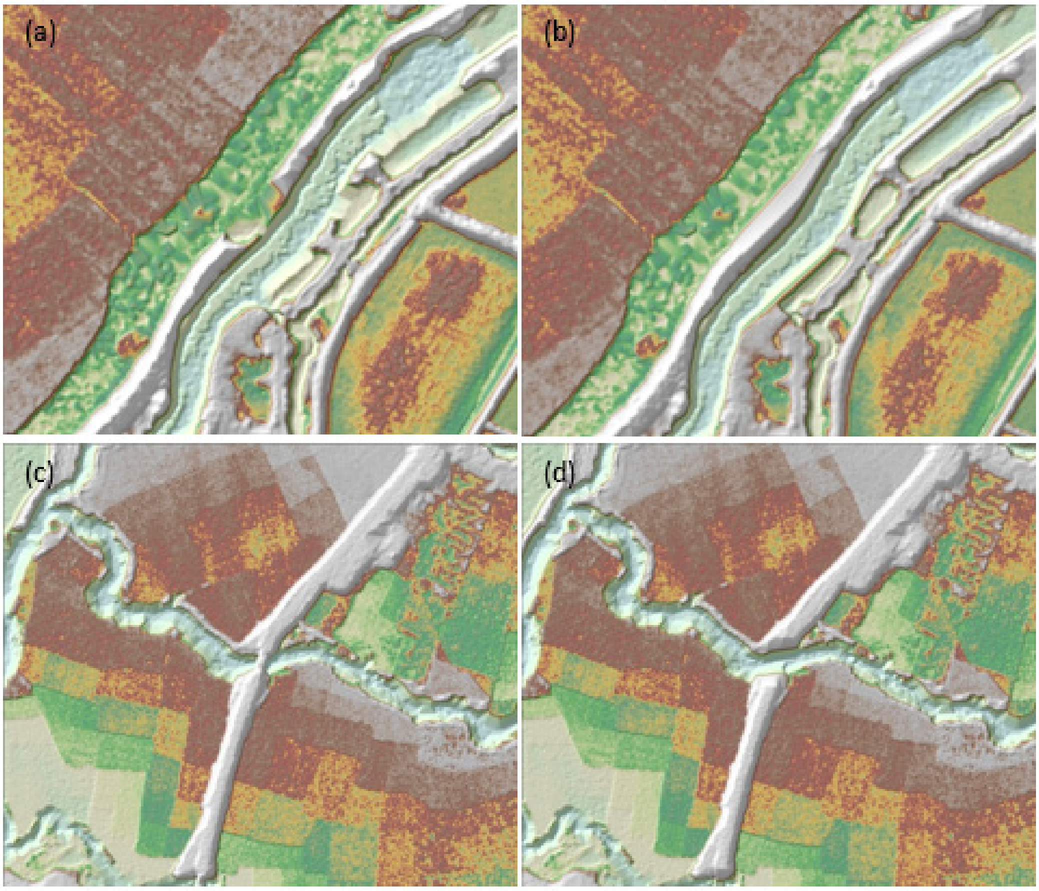


Figure 32. Images of DTMs before and after manual editing

The extent of the validation survey done by the Data Validation Component (DVC) in Bicol to collect points with which the LiDAR dataset is validated is shown in Figure 33. A total of 10,729 control points were collected. The good correlation between the airborne LiDAR elevation values and the ground survey elevation values, which reflects the quality of the LiDAR DTM is shown in Figure 34. The computed RMSE between the LiDAR DTM and the surveyed elevation values is 16.655 centimeters with a standard deviation of 16.311 centimeters. The LE 90 value represents the linear vertical distance that 90% of the sampled DEM points and their respective DVC validation point counterparts should be found from each other. Other statistical information can be found in Table 13. The final DTM and extent of the bathymetric survey done along the river is shown in Figure 35.

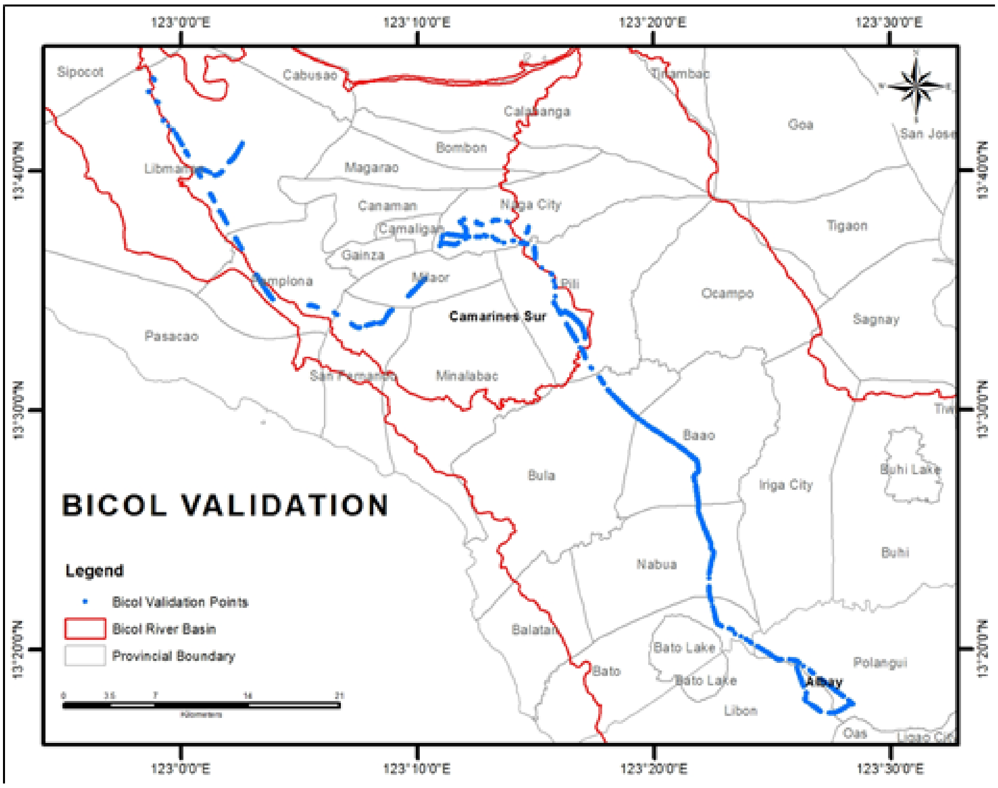


Figure 33. Map of Bicol River System with validation survey shown in blue

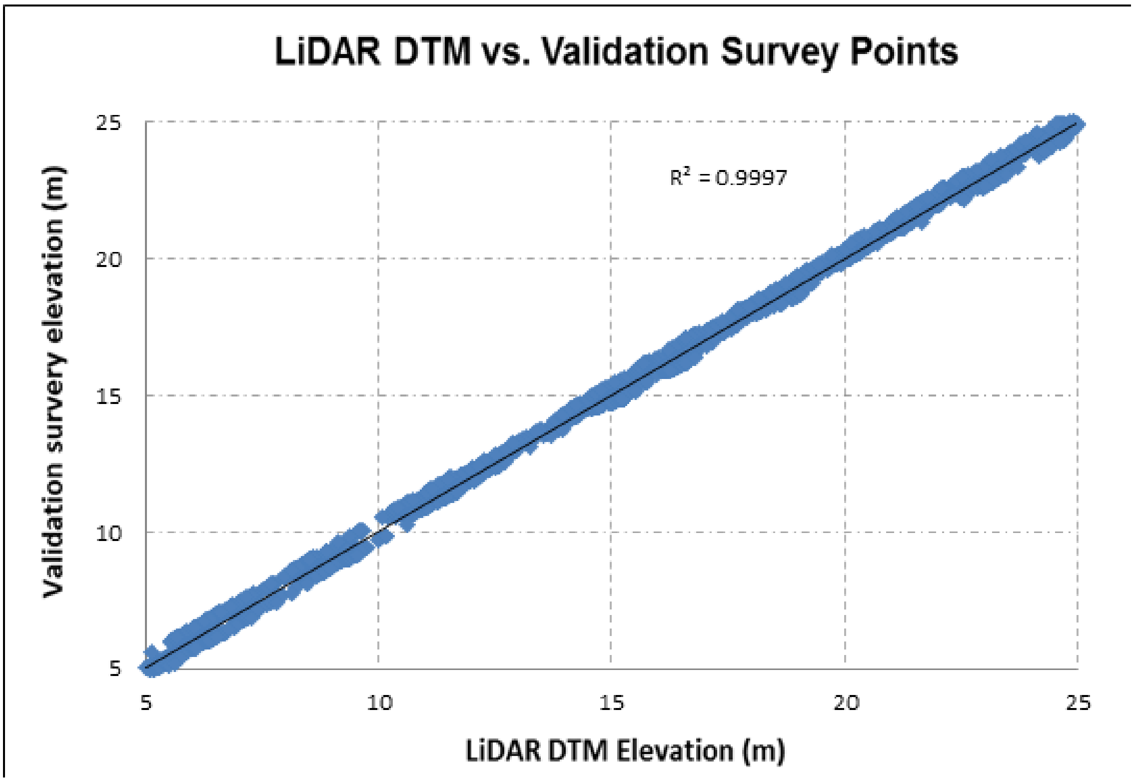


Figure 34. One-one Correlation plot between topographic and LiDAR data

Results and Discussion

Table 13. Statistical values for the calibration of flights

Statistical Information	Values (cm)
Minimum	-46.82
Maximum	39.933
RMSE	16.655
Standard Deviation	16.311
LE90	31.064

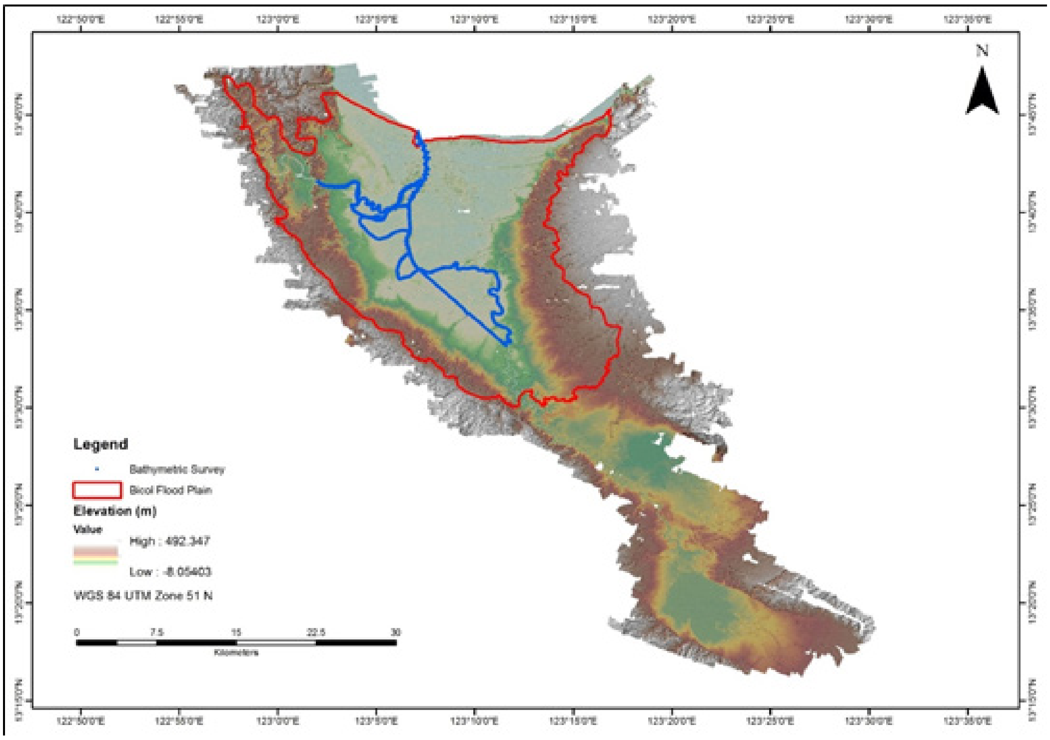


Figure 35. Final DTM of Bicol with validation survey shown in blue

The floodplain extent for Bicol is also presented, showing the completeness of the LiDAR dataset and DSM produced, is shown in Figure 36. Samples of 1 kilometer by 1 kilometer of DSM, DTM and orthophoto are shown in Figure 37, Figure 38, and Figure 39 respectively.

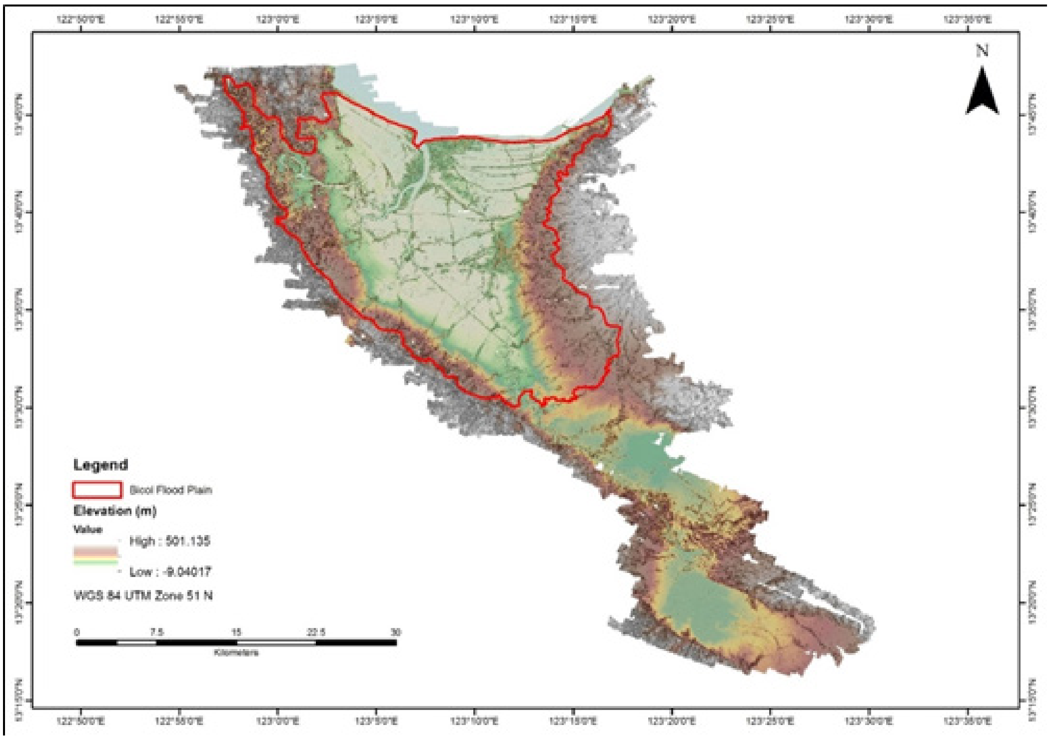


Figure 36. Final DSM in Bicol

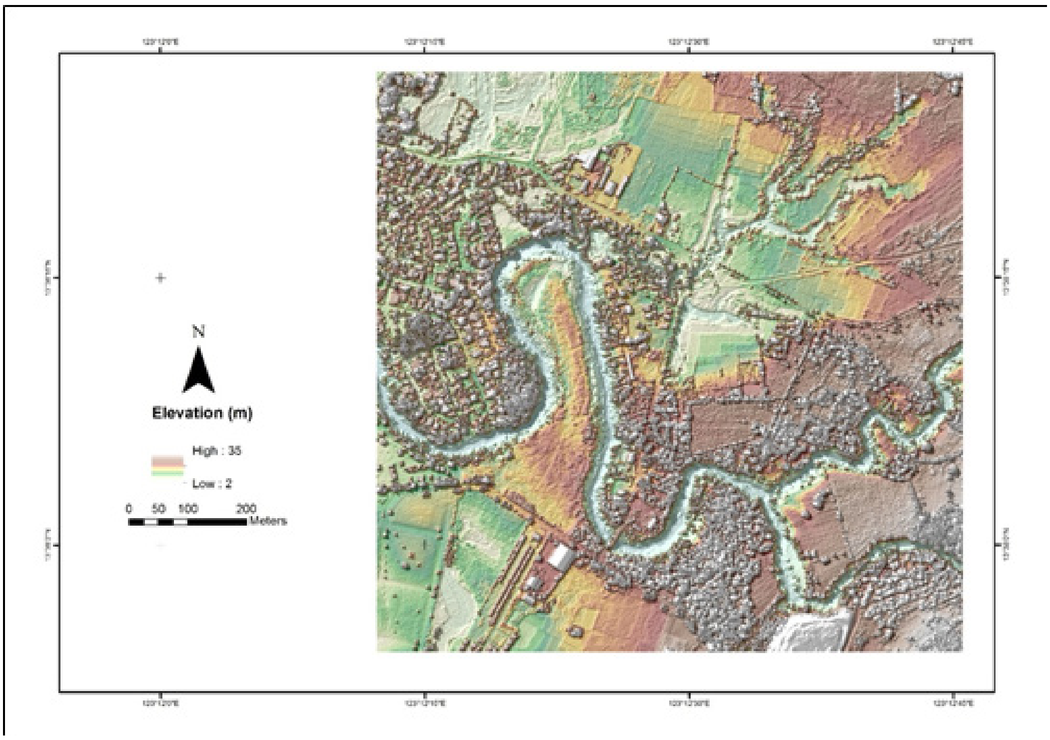


Figure 37. Sample 1x1 square kilometer DSM

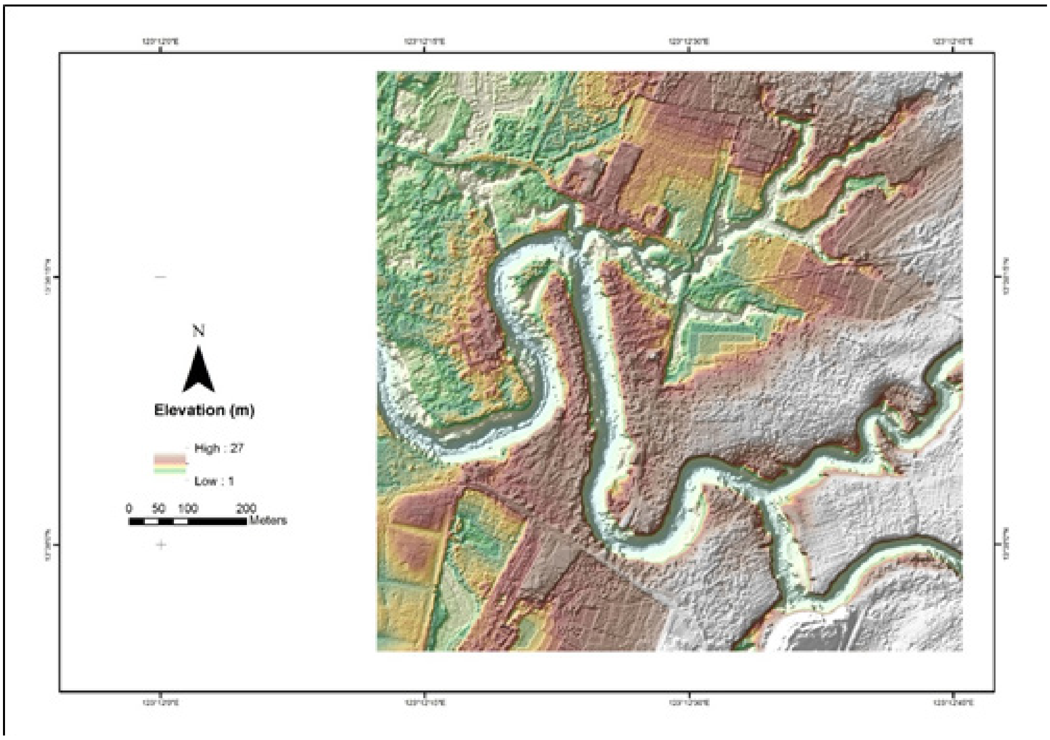


Figure 38. Sample 1x1 square kilometer DTM

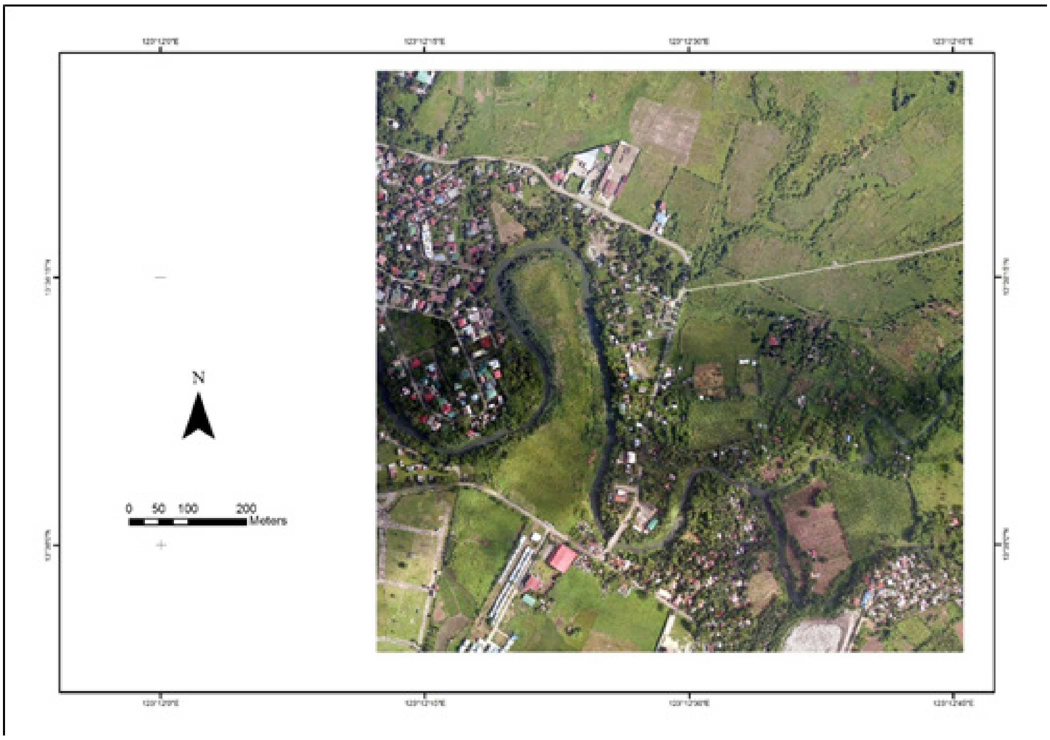


Figure 39. Sample 1x1 square kilometer Orthophoto

Annexes

Annex A

OPTECH TECHNICAL SPECIFICATION OF THE PEGASUS SENSOR

Parameter	Specification
Operational envelope (1,2,3,4)	150-5000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, 1σ
Elevation accuracy (2)	< 5-20 cm, 1σ
Effective laser repetition rate	Programmable, 100-500 kHz
Position and orientation system	POS AV ™AP50 (OEM)
Scan width (FOV)	Programmable, 0-75 °
Scan frequency (5)	Programmable, 0-140 Hz (effective)
Sensor scan product	800 maximum
Beam divergence	0.25 mrad (1/e)
Roll compensation	Programmable, ±37° (FOV dependent)
Vertical target separation distance	<0.7 m
Range capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	Up to 4 intensity returns for each pulse, including last (12 bit)
Image capture	5 MP interline camera (standard); 60 MP full frame (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V, 800 W, 30 A
Dimensions and weight	Sensor: 630 x 540 x 450 mm; 65 kg;
	Control rack: 650 x 590 x 490 mm; 46 kg
Operating Temperature	-10°C to +35°C
Relative humidity	0-95% non-condensing

Annex A

OPTECH TECHNICAL SPECIFICATION OF THE GEMINI SENSOR

Parameter	Specification
Operational envelope (1,2,3,4)	150-4000 m AGL, nominal
Laser wavelength	1064 nm
Horizontal accuracy (2)	1/5,500 x altitude, (m AGL)
Elevation accuracy (2)	<5-35 cm, 1 σ
Effective laser repetition rate	Programmable, 33-167 kHz
Position and orientation system	POS AV™ AP50 (OEM); 220-channel dual frequency GPS/GNSS/Galileo/L-Band receiver
Scan width (WOV)	Programmable, 0-50˚
Scan frequency (5)	Programmable, 0-70 Hz (effective)
Sensor scan product	1000 maximum
Beam divergence	Dual divergence: 0.25 mrad (1/e) and 0.8 mrad (1/e), nominal
Roll compensation	Programmable, ±5˚ (FOV dependent)
Range capture	Up to 4 range measurements, including 1st, 2nd, 3rd, and last returns
Intensity capture	Up to 4 intensity returns for each pulse, including last (12 bit)
Video Camera	Internal video camera (NTSC or PAL)
Image capture	Compatible with full Optech camera line (optional)
Full waveform capture	12-bit Optech IWD-2 Intelligent Waveform Digitizer (optional)
Data storage	Removable solid state disk SSD (SATA II)
Power requirements	28 V; 900 W;35 A(peak)
Dimensions and weight	Sensor: 260 mm (w) x 190 mm (l) x 570 mm (h); 23 kg Control rack: 650 mm (w) x 590 mm (l) x 530 mm (h); 53 kg
	-10˚C to +35˚C (with insulating jacket)
Operating Temperature	0-95% no-condensing
Relative humidity	0-95% non-condensing

Annex B

OPTECH TECHNICAL SPECIFICATION OF THE D-8900 AERIAL DIGITAL CAMERA

Parameter	Specification
Camera Head	
Sensor type	60 Mpix full frame CCD, RGB
Sensor format (H x V)	8, 984 x 6, 732 pixels
Pixel size	6µm x 6 µm
Frame rate	1 frame/2 sec.
FMC	Electro-mechanical, driven by piezo technology (patented)
Shutter	Electro-mechanical iris mechanism 1/125 to 1/500++ sec. f-stops: 5.6, 8, 11, 16
Lenses	50 mm/70 mm/120 mm/210 mm
Filter	Color and near-infrared removable filters
Dimensions (H x W x D)	200 x 150 x 120 mm (70 mm lens)
Weight	~4.5 kg (70 mm lens)
Controller Unit	
Computer	Mini-ITX RoHS-compliant small-form-factor embedded computers with AMD TurionTM 64 X2 CPU 4 GB RAM, 4 GB flash disk local storage IEEE 1394 Firewire interface
Removable storage unit	~500 GB solid state drives, 8,000 images
Power consumption	~8 A, 168 W
Dimensions	2U full rack; 88 x 448 x 493 mm
Weight	~15 kg
Image Pre-Processing Software	
CaptureOne	Radiometric control and format conversion, TIFF or JPEG
Image output	8,984 x 6,732 pixels 8 or 16 bits per channel (180 MB or 360 MB per image)

Annex C

THE SURVEY TEAM

Data Acquisition Component Sub-team	Designation	Name	Agency /Affiliation
Data Acquisition Component Leader	Data Component Project Leader –I	ENGR. CZAR JAKIRI S. SARMIENTO	UP TCAGP
Survey Supervisor	Chief Science Research Specialist (CSRS)	ENGR. CHRISTOPHER CRUZ	UP TCAGP
LiDAR Operation	Senior Science Research Specialist	LOVELY GRACIA ACUNA	UP TCAGP
LiDAR Operation	Senior Science Research Specialist	LOVELYN ASUNCION	UP TCAGP
LiDAR Operation	Senior Science Research Specialist	MARK GREGORY ANO	UP TCAGP
LiDAR Operation	Research Associate	JASMINE ALVIAR	UP TCAGP
LiDAR Operation	Research Associate	PEARL MARS	UP TCAGP
Ground Survey	Research Associate	ENGR. GEROME HIPOLITO	UP TCAGP
Ground Survey	Research Associate	ENGR. JAMES WILBERT BELTRAN	UP TCAGP
Data Download and Transfer	Research Associate	CHRISTOPHER JOAQUIN	UP TCAGP
LiDAR Operation	Airborne Security	SSG. EUGENE LOGARTO	Philippine Air Force (PAF)
LiDAR Operation	Pilot	CAPT. ARNEL AGBAYANI	ASIAN AEROSPACE CORP (AAC)
LiDAR Operation	Pilot	CAPT. JAMAAL CLEMENTE	AAC
LiDAR Operation	Pilot	CAPT. LAWRENCE MADAYAG	AAC
LiDAR Operation	Co-pilot	CAPT. MARK TANGONAN	AAC
LiDAR Operation	Co-pilot	CAPT. RAUL CZ SAMAR II	AAC

Annex D

GCP'S NAMRIA CERTIFICATION

CMS-28

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

May 10, 2013

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **CAMARINES SUR**
Station Name: **CMS-28**
Order: **3rd**

Island: **LUZON**		Barangay: **KASURAY**
Municipality: **MAGARAO**		
	PRS92 Coordinates	
Latitude: **13° 39' 55.17390"**	Longitude: **123° 8' 33.78230"**	Ellipsoidal Hgt: **5.53400 m.**
	WGS84 Coordinates	
Latitude: **13° 39' 50.15228"**	Longitude: **123° 8' 38.74291"**	Ellipsoidal Hgt: **56.92117 m.**
	PTM Coordinates	
Northing: **1511153.635 m.**	Easting: **515439.814 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,510,624.70**	Easting: **515,434.41**	Zone: **51**

Location Description

CMS-28

From Naga City proper, travel north along Elias St. up to Magarao ijunction for about 6 Km. then turn left and travel for about 4 Km. up to the station. The station is located along the road igoing to Brgy. Fundado, Canaman. It is situated at the N wing on the E end of the bridge, about 0.22 m S of parapet.

Mark is ithe head of a 4" copper nail centered in a drilled hole with cement putty and inscripted thus, CMS-28, 1996, NAMRIA.

Requesting Party: **Christopher Cruz**
Pupose: **Reference**
OR Number: **3943636B**
T.N.: **2013-0416**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

9905102013160235

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

CIP/4701/12/09/814

Annex E

CMS-3358

Republic of the Philippines
Department of Environment and Natural Resources
NATIONAL MAPPING AND RESOURCE INFORMATION AUTHORITY

May 10, 2013

CERTIFICATION

To whom it may concern:

This is to certify that according to the records on file in this office, the requested survey information is as follows -

Province: **CAMARINES SUR**
Station Name: **CMS-28**
Order: **3rd**

Island: **LUZON**
Municipality: **MAGARAO**
Barangay: **KASURAY**

	PRS92 Coordinates	
Latitude: **13° 39' 55.17390"**	Longitude: **123° 8' 33.78230"**	Ellipsoidal Hgt: **5.53400 m.**
	WGS84 Coordinates	
Latitude: **13° 39' 50.15228"**	Longitude: **123° 8' 38.74291"**	Ellipsoidal Hgt: **56.92117 m.**
	PTM Coordinates	
Northing: **1511153.635 m.**	Easting: **515439.814 m.**	Zone: **4**
	UTM Coordinates	
Northing: **1,510,624.70**	Easting: **515,434.41**	Zone: **51**

Location Description

CMS-28

From Naga City proper, travel north along Elias St. up to Magarao ijunction for about 6 Km. then turn left and travel for about 4 Km. up to the station. The station is located along the road igoing to Brgy. Fundado, Canaman. It is situated at the N wing on the E end of the bridge, about 0.22 m S of parapet.

Mark is ithe head of a 4" copper nail centered in a drilled hole with cement putty and inscripted thus, CMS-28, 1996, NAMRIA.

Requesting Party: **Christopher Cruz**
Pupose: **Reference**
OR Number: **3943636B**
T.N.: **2013-0416**

RUEL DM. BELEN, MNSA
Director, Mapping and Geodesy Department

9 9 0 5 1 0 2 0 1 3 1 6 0 2 3 5

CERTIFICATION INTERNATIONAL ISO 9001:2008
CIF/4701/12/09/814

NAMRIA OFFICES:
Main : Lawton Avenue, Fort Bonifacio, 1634 Taguig City, Philippines Tel. No.: (632) 810-4831 to 41
Branch : 421 Barraca St. San Nicolas, 1010 Manila, Philippines, Tel. No. (632) 241-3494 to 98
www.namria.gov.ph

ANNEX F. DATA TRANSFER SHEET FOR BICOL FLOOD-PLAIN

DATA TRANSFER FILE CHECKLIST
MARCH 20, 2013

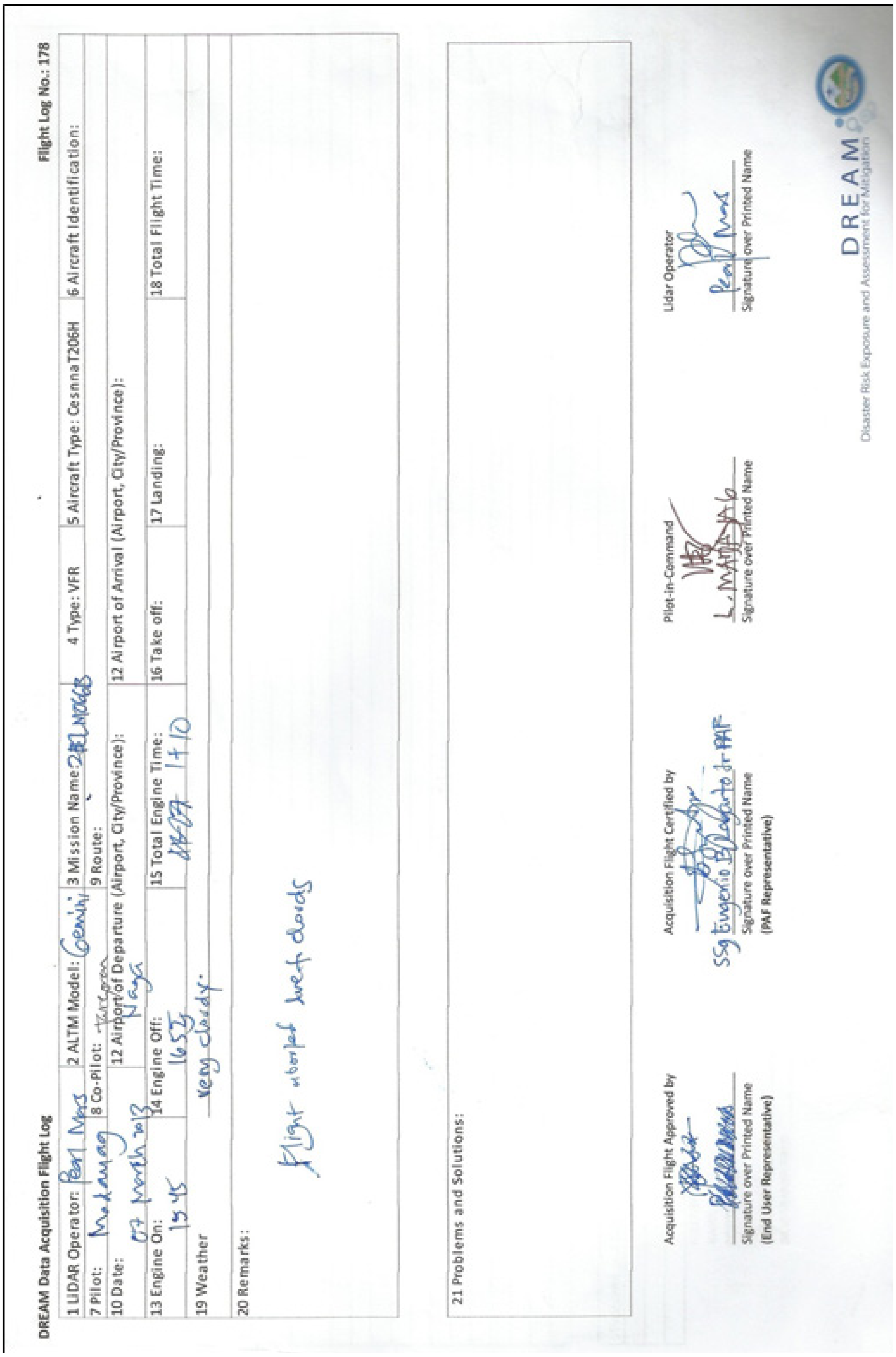
Date	Flight No.	Mission Name	Sensor	RAW LAS	LOGS	POS	RAW IMAGES	MISSION LOG FILE	RANGE	DIGITIZER	BASE STATION	SERVER LOCATION
10/mar/2013	181	2BCLM069A	GEMINI	N/A	405 KB	222 MB	20.5 GB	165 KB	8.14 GB	NO DIGITIZER	5.25 MB	\\FREENAS\DAC\181G
10/mar/2013	183	2BCLA069B	GEMINI	N/A	379 KB	192 MB	19.3 GB	424 B	8.53 GB	NO DIGITIZER	5.25 MB	\\FREENAS\DAC\183G
11/MAR/2013	184	1BIJ070A	PEGASUS	233 MB	1.37 MB	159 MB	41 GB	296 KB	19.3 GB	NO DIGITIZER	5.19 MB	\\FREENAS\DAC\184P
11/MAR/2013	185	2BCLD070A	GEMINI	N/A	537 KB	236 MB	27.8 GB	128 KB	12.6 GB	NO DIGITIZER	5.19 MB	\\FREENAS\DAC\185G
11/MAR/2013	186	2BCLB070B	GEMINI	N/A	501 KB	265 MB	27.7 GB	213 KB	11.3 GB	NO DIGITIZER	5.19 MB	\\FREENAS\DAC\186G
11/MAR/2013	187	1BCLK070B	PEGASUS	238 MB	1.22 MB	139 MB	29.4 GB	222 KB	22.6 GB	NO DIGITIZER	5.19 MB	\\FREENAS\DAC\187P
12/MAR/2013	188	1BN071A	PEGASUS	87.5 MB	.99 MB	128 MB	22.2 GB	170 KB	14.8 GB	NO DIGITIZER	7.78 MB (CMS3358 for PEGASUS)	\\FREENAS\DAC\188P
12/MAR/2013	189	2BCLE71A	GEMINI	N/A	498 KB	212 MB	17.7 GB	1/1/8/194/1/39 KB	13.6 GB	NO DIGITIZER	7.78 MB (CMS28 for GEMINI)	\\FREENAS\DAC\189G
13/MAR/2013	190	1BGH072A	PEGASUS	201 MB	1.10 MB	157 MB	36.4 GB	265 KB	20 GB	NO DIGITIZER	6.04 MB	\\FREENAS\DAC\190P
13/MAR/2013	191	2BCLC072A	GEMINI	N/A	665 KB	263 MB	35.5 GB	5/288 KB	15.4 GB	NO DIGITIZER	6.04 MB	\\FREENAS\DAC\191G
14/MAR/2013	192	2BCLF073A	GEMINI	N/A	517 KB	255 MB	27 GB	1/218 KB	10.5 GB	NO DIGITIZER	6.44 MB	\\FREENAS\DAC\192G
15/MAR/2013	193	1BO074A	PEGASUS	130 MB	1.6 MB	195 MB	39 GB	297 KB	20.7 GB	NO DIGITIZER	9.25 MB (CMS3358 for PEGASUS)	\\FREENAS\DAC\193P
15/MAR/2013	194	2BCLRF74A	GEMINI	N/A	855 KB	278 MB	31.3 GB	1/144 KB	11.6 GB	NO DIGITIZER	9.25 MB (CMS28 for GEMINI)	\\FREENAS\DAC\194G
17/MAR/2013	195	1BV075A	PEGASUS	108 MB	728 KB	106 MB	14.9 GB	117 KB	10.9 GB	NO DIGITIZER	5.59 MB (CMS3358 for PEGASUS)	\\FREENAS\DAC\195P
17/MAR/2013	196	2BLCS76A	GEMINI	N/A	399 KB	175 MB	21.5 GB	173 KB	8.77 GB	NO DIGITIZER	5.59 MB (CMS28 for GEMINI)	\\FREENAS\DAC\196G

RECEIVED FROM:
NAME: CHRIS JOAQUIN
POSITION: RA
SIGNATURE:
DATE TRANSFERRED: 032113

RECEIVED BY:
NAME: UOIDA F. PRIETO
POSITION: SSRS
SIGNATURE:
DATE TRANSFERRED: 032/2013

ANNEX G. FLIGHT LOGS

Flight Log for 2BCLM066B Mission


DREAM Data Acquisition Flight Log

Flight Log No.: 178

1 LiDAR Operator: Pearl Mars	2 ALTM Model: Gemini	3 Mission Name: 2BCLM066B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification:
7 Pilot: Madayag	8 Co-Pilot: Tarcoran	9 Route:			
10 Date: 07 March 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1545	14 Engine Off: 1655	15 Total Engine Time: 1+10	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: very cloudy.					

20 Remarks:

Flight aborted due to clouds

21 Problems and Solutions:

Acquisition Flight Approved by
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by
SSg Eugenio B Robarto Jr PAF
Signature over Printed Name
(PAF Representative)

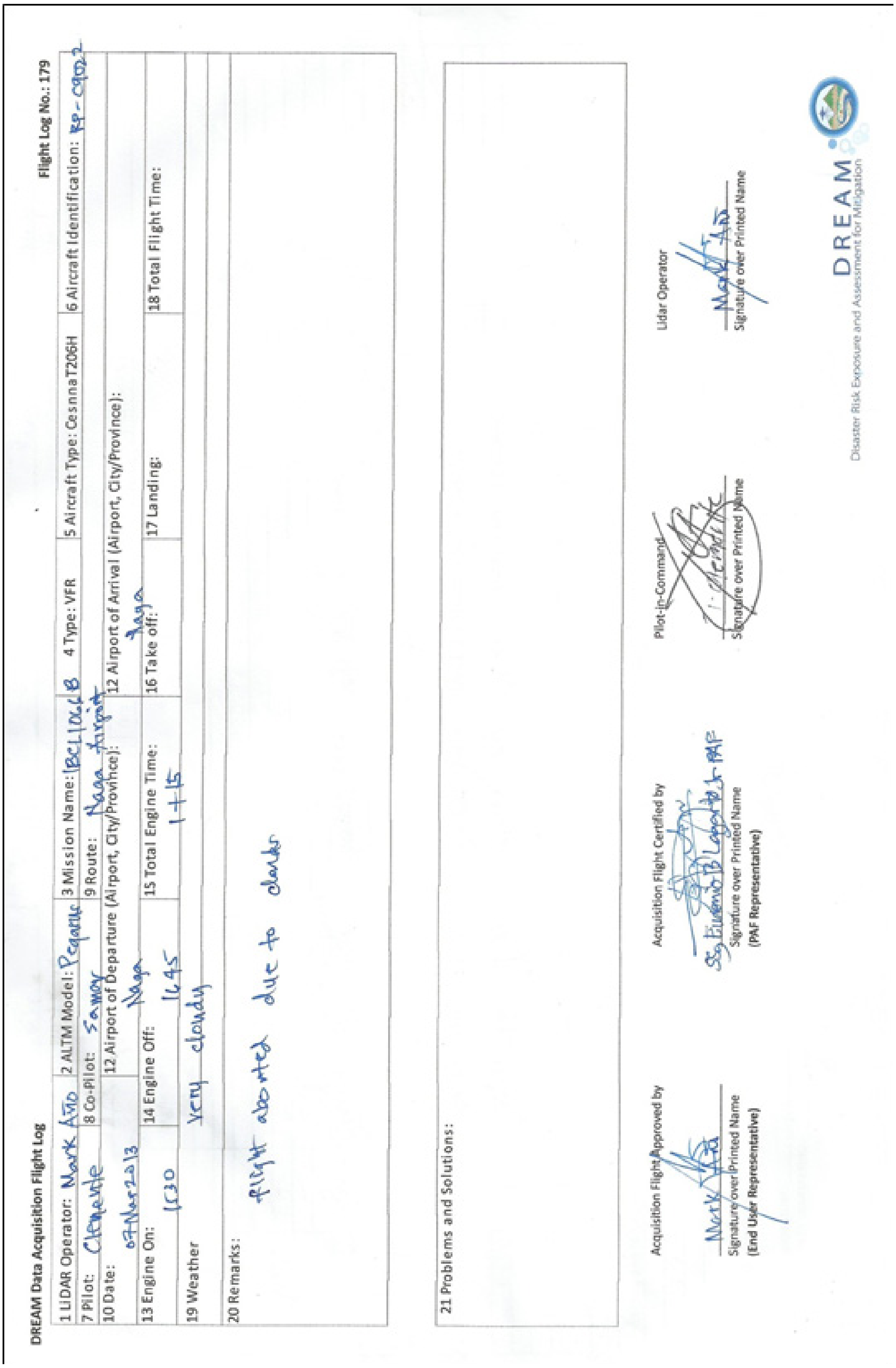
Pilot-in-Command
L. MADAYAG
Signature over Printed Name

Lidar Operator
Pearl Mars
Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLI066B Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 179

1 LiDAR Operator: Mark Año	2 ALTM Model: Pegasus	3 Mission Name: 1BCLI066B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: Clemente	8 Co-Pilot: Samoy	9 Route: Naga Airport			
10 Date: 07Mar2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 1530	14 Engine Off: 1645	15 Total Engine Time: 1+15	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: very cloudy					

20 Remarks:

flight aborted due to clouds

21 Problems and Solutions:

Acquisition Flight Approved by

Mark Año

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

SSg Eduardo B Lagarto Jr PAF

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

Clemente

Signature over Printed Name

Lidar Operator

Mark Año

Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLIJ069A Mission

DREAM Data Acquisition Flight Log | Flight Log No.: 180

1 LiDAR Operator: J. Alviar	2 ALTM Model: Pegasus	3 Mission Name: 1BCLIJ69A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. Clemente	8 Co-Pilot: R. Samar	9 Route: Naga			
10 Date: 10 March 13	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0700H	14 Engine Off: 0800H	15 Total Engine Time: 1+00	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

Mission aborted due to AHRS failure.
850m AGL flying [illegible]

21 Problems and Solutions:

Clouds ~~too~~ at 1000m AGL, lowered to 850m AGL

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
		J. Clemente	J. Alviar
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLIJ069B Mission

DREAM Data Acquisition Flight Log — Flight Log No.: 182

1 LiDAR Operator: J. Alviar	2 ALTM Model: Pegasus	3 Mission Name: 1BLJ69B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. Clemente	8 Co-Pilot: R. Samar	9 Route: Naga -			
10 Date: 10 March 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0928	14 Engine Off: 1055	15 Total Engine Time: 1+27	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

The mission was aborted due to very low cloud ceiling. Survey was attempted at 850m, 750m and 600m AGL flying heights but clouds were still below the aircraft.

21 Problems and Solutions:

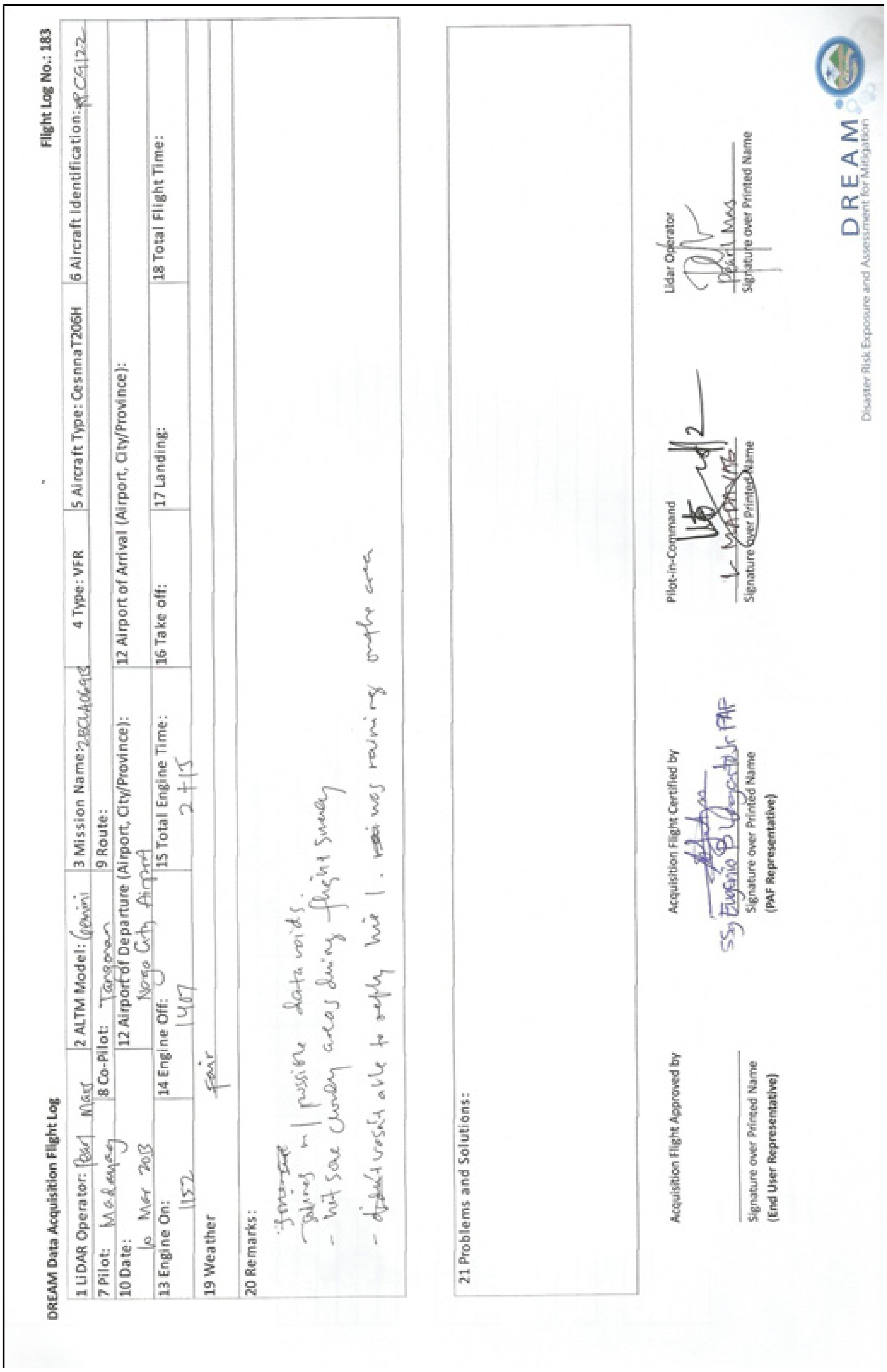
low cloud ceiling – to change plan to lower flying height, minimum possible height still with clouds, mission aborted

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
		J. Clemente	J. Alviar
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM — Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLA069B Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 183

1 LiDAR Operator: Pearl Mars	2 ALTM Model: Gemini	3 Mission Name: 2BCLA069B	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9122
7 Pilot: Mabaylag	8 Co-Pilot: Tangonan	9 Route:			
10 Date: 10 Mar 2013	12 Airport of Departure (Airport, City/Province): Naga City Airport		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1152	14 Engine Off: 1407	15 Total Engine Time: 2+15	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather: Fair					

20 Remarks:

- possible data voids:
- hit some cloudy areas during flight survey
- didn't able to apply line 1. it was raining on the area

21 Problems and Solutions:

Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by — SSgt Eugenio B Vergara Jr PAF — Signature over Printed Name (PAF Representative)

Pilot-in-Command — Signature over Printed Name

Lidar Operator — Pearl Mars — Signature over Printed Name

DREAM — Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLD070A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 184

1 LiDAR Operator: J. Alvar	2 ALTM Model: Pegasus	3 Mission Name: 1BLJ070A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. Clemente	8 Co-Pilot: R. Samar	9 Route: Naga			
10 Date: 11 March 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0705H	14 Engine Off: 0942 H	15 Total Engine Time: 2+37	16 Take off: 0723 H	17 Landing: 0930 H	18 Total Flight Time: 2+07
19 Weather	clear				

20 Remarks:

mission completed

21 Problems and Solutions:

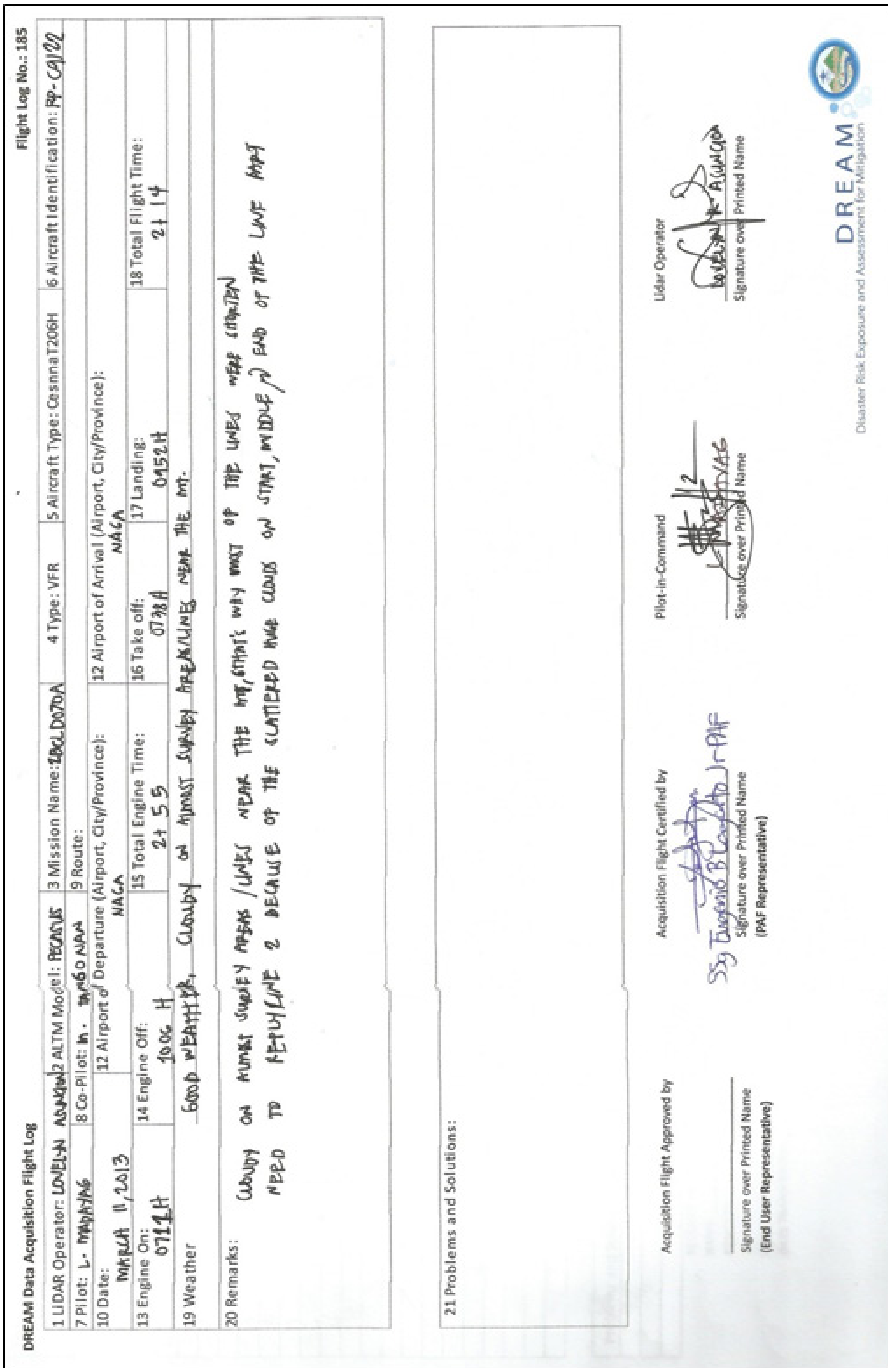
reloaded plan and restarted laser before start of mission

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	J. Clemente Signature over Printed Name	J. Alvar Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLD070A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 185

1 LiDAR Operator: LOVELYN ASUNCION	2 ALTM Model: PEGASUS	3 Mission Name: 2BCLD070A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9122
7 Pilot: L. MADAYAG	8 Co-Pilot: M. TANGONAN	9 Route:			
10 Date: MARCH 11, 2013	12 Airport of Departure (Airport, City/Province): NAGA		12 Airport of Arrival (Airport, City/Province): NAGA		
13 Engine On: 0711H	14 Engine Off: 1006 H	15 Total Engine Time: 2+55	16 Take off: 0738H	17 Landing: 0952H	18 Total Flight Time: 2+14
19 Weather	GOOD WEATHER, CLOUDY ON ALMOST SURVEY AREAS/LINES NEAR THE MT.				

20 Remarks:

CLOUDY ON ALMOST SURVEY AREAS / LINES NEAR THE MT, THAT'S WHY MOST OF THE LINES WERE SHORTEN NEED TO REFLY LINE 2 BECAUSE OF THE SCATTERED HUGE CLOUDS ON START, MIDDLE, END OF THE LINE AMT

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
	SSg Eugenio B Loyola Jr PAF	L. MADAYAG	LOVELYN ASUNCION
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLB070B Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 186

1 LiDAR Operator: Pearl Mae	2 ALTM Model: Gemini	3 Mission Name: 2BCLB70B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RPC9122
7 Pilot: Clemente	8 Co-Pilot: Tangonan	9 Route: Naga Airport			
10 Date: 11 March 2013	12 Airport of Departure (Airport, City/Province): Naga Airport		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 1101	14 Engine Off: 1407	15 Total Engine Time: 3+06	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	Fair				

20 Remarks:

- overexposed images. clouds moving & obstructing light

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	SSg Eugenio B Loberto Jr PAF Signature over Printed Name (PAF Representative)	For Ma. Marj J. Clemente Signature over Printed Name	Pearl Mae Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLK070B Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 187

1 LiDAR Operator: M. Añño	2 ALTM Model: Pegasus	3 Mission Name: 1BCLK070B	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: A. Agbayani	8 Co-Pilot: R. Samar	9 Route: Naga			
10 Date: 11 March 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 1104H	14 Engine Off: 1352H	15 Total Engine Time: 2+48	16 Take off: 1120H	17 Landing: 1340H	18 Total Flight Time:
19 Weather: partly cloudy.					

20 Remarks:

—

21 Problems and Solutions:

- Camera did not trigger automatically, need to trigger manually, possible camera voids. (Note: the camera triggers on the Option Mode).

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

Signature over Printed Name

Lidar Operator

Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLN071A Mission

DREAM Data Acquisition Flight Log — **Flight Log No.: 188**

1 LiDAR Operator: J. Alviar	2 ALTM Model: Pegasus	3 Mission Name: 1BN071A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: J. Clemente	8 Co-Pilot: M. Tangonan	9 Route: Naga			
10 Date: 12 March 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0820H	14 Engine Off: 1020H	15 Total Engine Time: 2+10	16 Take off: 0832H	17 Landing: 1012H	18 Total Flight Time:
19 Weather: cloudy					

20 Remarks:

surveyed 9/14 lines with data gaps due to clouds. mission aborted.

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLE071A Mission

Flight Log No.: 189

DREAM Data Acquisition Flight Log

1 LIDAR Operator: Lovely Acuña	2 ALTM Model: Gemini	3 Mission Name: 2BCLE71A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: Capt. L Madayag	8 Co-Pilot: R. Somer	9 Route: Naga → Camsur			
10 Date: 08/12/2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0820H	14 Engine Off: 1052H	15 Total Engine Time: 2+32	16 Take off: 0840H	17 Landing: 1035H	18 Total Flight Time: 1+55
19 Weather	Good weather but low base clouds				
20 Remarks:	finished all lines but possible data gaps due to low clouds				

21 Problems and Solutions:

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Lovely Gracia Acuña Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLGH072A Mission

DREAM Data Acquisition Flight Log — **Flight Log No.: 190**

1 LiDAR Operator: Mark Arce	2 ALTM Model: Pegasus	3 Mission Name: 1BCLGH072A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: Marc Clemente	8 Co-Pilot: Tanganan	9 Route: Naga			
10 Date: 13 Mar 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0710	14 Engine Off: 1005	15 Total Engine Time: 2+55	16 Take off:	17 Landing:	18 Total Flight Time: 1+30
19 Weather: clear to cloudy					

20 Remarks:

clear weather to (cloudy) w/ precipitation. data voids.

21 Problems and Solutions:

data voids due to clouds.

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Mark Arce		J. Clemente	Mark Arce
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLC+DLINE2 & 9072A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 191

1 LiDAR Operator: LOVELYN R. ASUNCION	2 ALTM Model: GEMINI	3 Mission Name: 2BCLCDLINE2 9072A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9122
7 Pilot: L. MADAYAG	8 Co-Pilot: R. SAMAR II	9 Route:			
10 Date: MARCH 19, 2013	12 Airport of Departure (Airport, City/Province): NAGA		12 Airport of Arrival (Airport, City/Province): NAGA		
13 Engine On: 0750	14 Engine Off: 1055	15 Total Engine Time: 3+05	16 Take off: 0809	17 Landing: 1043	18 Total Flight Time: 2+34
19 Weather: GOOD WEATHER, PARTLY CLOUDY					

20 Remarks:

SUGGESTED TO REPEAT LINES 7, 1, 3 & 5 DUE TO POSSIBLE DATA GAPS

21 Problems and Solutions:

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

L. MADAYAG
Signature over Printed Name

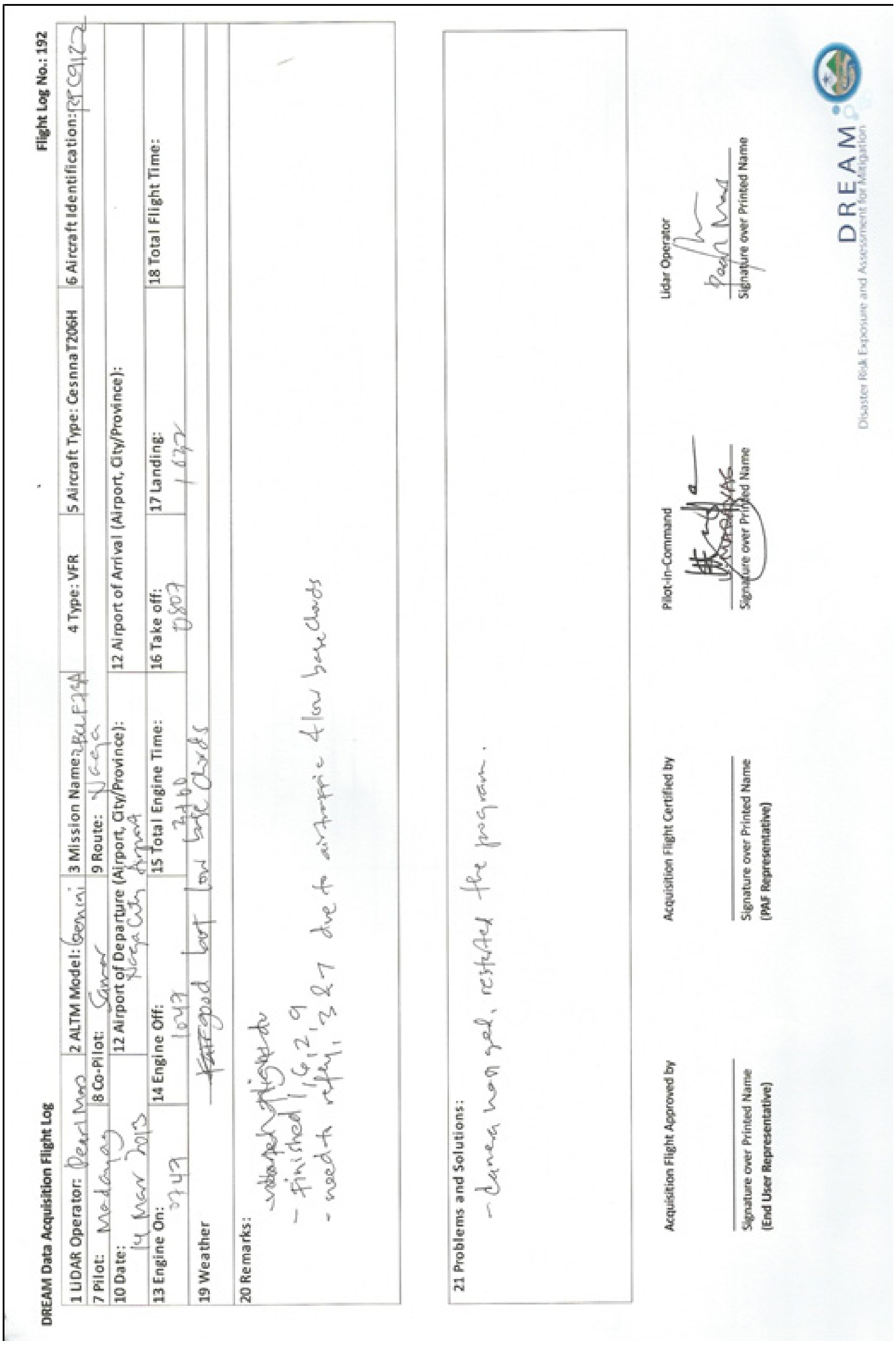
Lidar Operator

LOVELYN R. ASUNCION
Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLF073A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 192

1 LiDAR Operator: *Pearl Mars*	2 ALTM Model: *Gemini*	3 Mission Name: *2BCLF73A*	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: *RP-C9122*
7 Pilot: *Medanag*	8 Co-Pilot: *Sanor*	9 Route: *Naga*			
10 Date: *14 Mar 2013*	12 Airport of Departure (Airport, City/Province): *Naga City Airport*		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: *0747*	14 Engine Off: *1047*	15 Total Engine Time: *3+00*	16 Take off: *0807*	17 Landing: *1032*	18 Total Flight Time:
19 Weather	*~~Fair~~ good but low base clouds*				

20 Remarks:

- ~~[illegible]~~
- finished 1, 6, 2, 9
- need to refly 3 & 7 due to airtraffic & low base clouds

21 Problems and Solutions:

- camera hang-ed, restarted the program.

Acquisition Flight Approved by	Acquisition Flight Certified by	Pilot-in-Command	Lidar Operator
Signature over Printed Name (End User Representative)	Signature over Printed Name (PAF Representative)	Signature over Printed Name	*Pearl Mars* Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 1BCLO074A Mission

DREAM Data Acquisition Flight Log

Flight Log No.: 193

1 LiDAR Operator: J. Alviar	2 ALTM Model: Pegasus	3 Mission Name: 1BC0074A	4 Type: VFR	5 Aircraft Type: Cesnna T206H	6 Aircraft Identification: RP-C9022
7 Pilot: A. Agbayani	8 Co-Pilot: R. ~~Clement~~ Samson	9 Route: Naga			
10 Date: March 15, 2013	12 Airport of Departure (Airport, City/Province):		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0700	14 Engine Off: 1013	15 Total Engine Time: 3+13	16 Take off:	17 Landing:	18 Total Flight Time:
19 Weather	clear				

20 Remarks:

mission completed

21 Problems and Solutions:

pilot display error (not updating) - restarted before start of survey

Acquisition Flight Approved by

Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by

Signature over Printed Name
(PAF Representative)

Pilot-in-Command

For J. Clemente
Signature over Printed Name

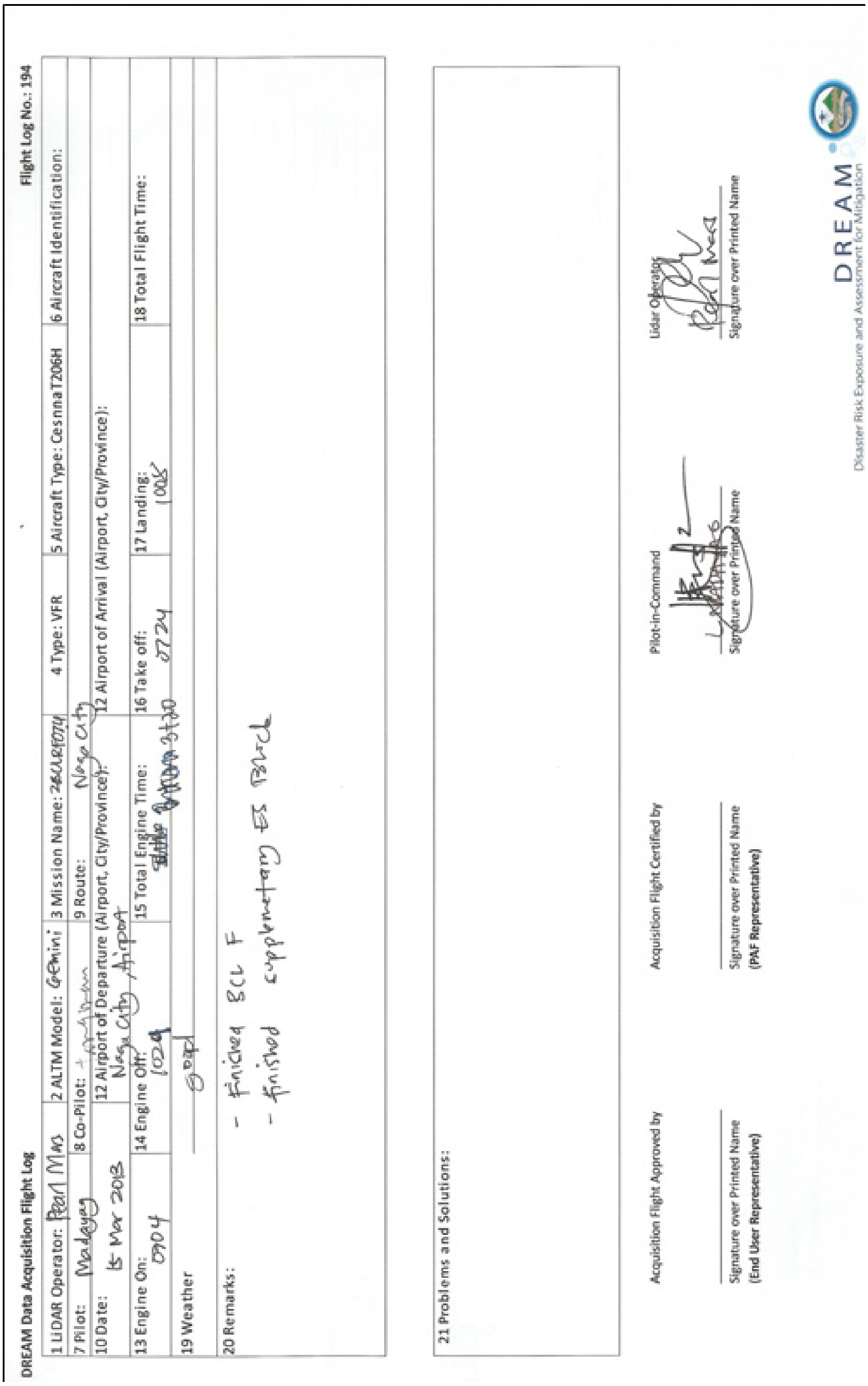
Lidar Operator

J. Alviar
Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLRF074A Mission



DREAM Data Acquisition Flight Log — Flight Log No.: 194

1 LiDAR Operator: Pearl Mars	2 ALTM Model: Gemini	3 Mission Name: 2BCLRF074	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification:
7 Pilot: Madayag	8 Co-Pilot: [illegible]	9 Route: Naga City			
10 Date: 15 Mar 2013	12 Airport of Departure (Airport, City/Province): Naga City Airport		12 Airport of Arrival (Airport, City/Province):		
13 Engine On: 0904	14 Engine Off: 1029	15 Total Engine Time: [illegible]	16 Take off: 0724	17 Landing: 1008	18 Total Flight Time:
19 Weather: good					
20 Remarks: - Finished BCL F - finished supplementary ES Block					

21 Problems and Solutions:

Acquisition Flight Approved by — Signature over Printed Name (End User Representative)

Acquisition Flight Certified by — Signature over Printed Name (PAF Representative)

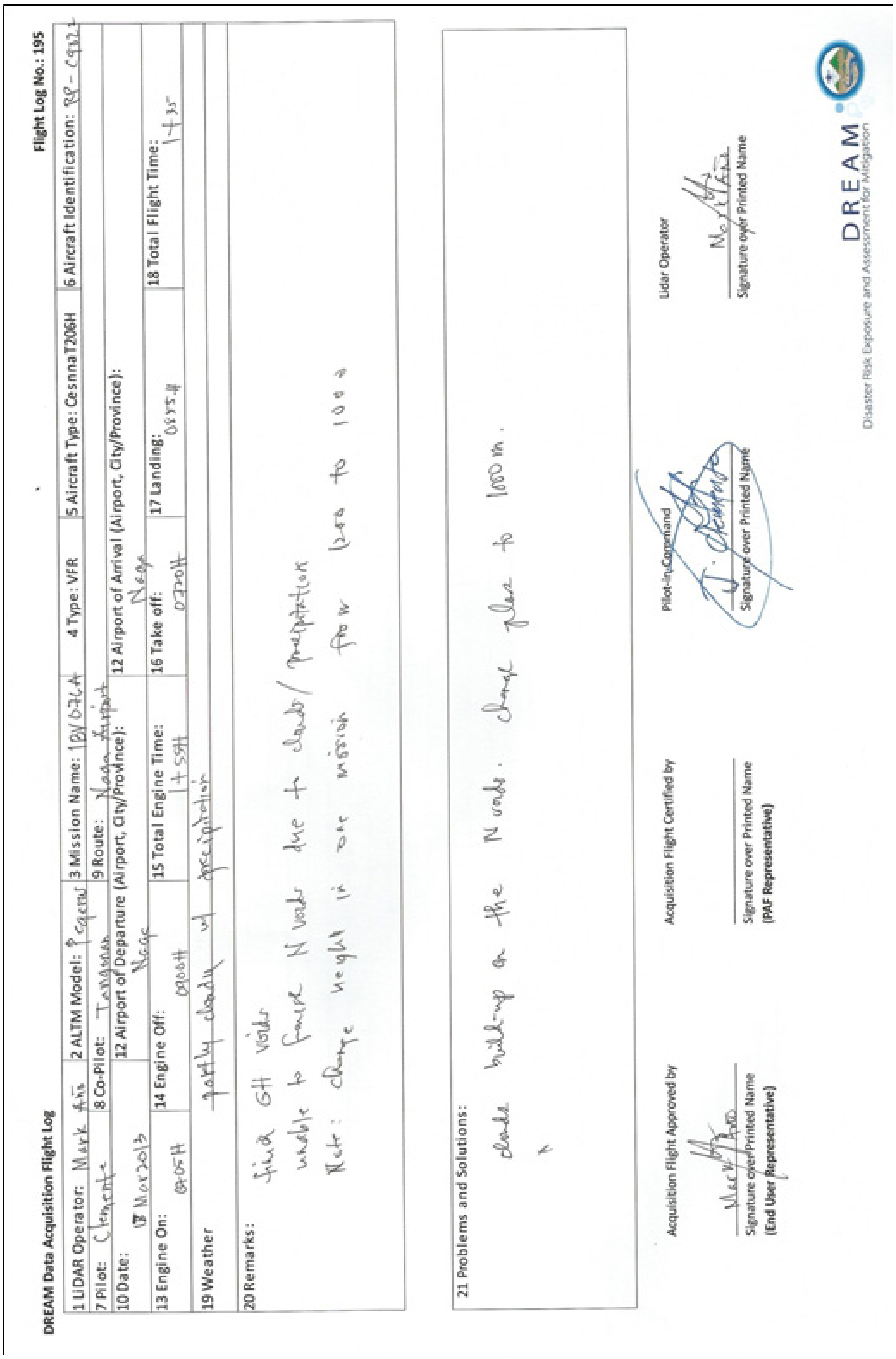
Pilot-in-Command — Signature over Printed Name

Lidar Operator — Signature over Printed Name

DREAM — Disaster Risk Exposure and Assessment for Mitigation

Annex G

Flight Log for 2BCLCS076A Mission



DREAM Data Acquisition Flight Log

Flight Log No.: 195

1 LiDAR Operator: Mark Año	2 ALTM Model: Pegasus	3 Mission Name: 1BV076A	4 Type: VFR	5 Aircraft Type: CesnnaT206H	6 Aircraft Identification: RP-C9322
7 Pilot: Clemente	8 Co-Pilot: Tangonan	9 Route: Naga Airport			
10 Date: 17 Mar 2013	12 Airport of Departure (Airport, City/Province): Naga		12 Airport of Arrival (Airport, City/Province): Naga		
13 Engine On: 0705H	14 Engine Off: 0900H	15 Total Engine Time: 1+55H	16 Take off: 0710H	17 Landing: 0855.H	18 Total Flight Time: 1+35
19 Weather	partly cloudy w/ precipitation				

20 Remarks:

finish GH voids
unable to finish N voids due to clouds/ precipitation
Note: change height in one mission from 1200 to 1000

21 Problems and Solutions:

clouds build-up on the N voids. change plan to 1000m.

Acquisition Flight Approved by
Mark Año
Signature over Printed Name
(End User Representative)

Acquisition Flight Certified by
Signature over Printed Name
(PAF Representative)

Pilot-in-Command
J. Clemente
Signature over Printed Name

Lidar Operator
Mark Año
Signature over Printed Name

DREAM
Disaster Risk Exposure and Assessment for Mitigation

Bibliography

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D R E A M

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