Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Progress report

UAV–LiDAR and spaceborne remote sensing for site survey and habitat condition monitoring in the Beetaloo

Progress against project milestones

Progress against milestones/tasks are approved by the GISERA Director, acting with authority in accordance with the GISERA Alliance Agreement.

Progress against project milestones/tasks is indicated by two methods: Traffic light reports and descriptive Project schedule reports.

1. Traffic light reports in the Project Schedule Table below show progress using a simple colour code:

- **Green**:
  - Milestone fully met according to schedule.
  - Project is expected to continue to deliver according to plan.
  - Milestone payment is approved.
- **Amber**:
  - Milestone largely met according to schedule.
  - Project has experienced delays or difficulties that will be overcome by next milestone, enabling project to return to delivery according to plan by next milestone.
  - Milestone payment is withheld.
  - Milestone payment withheld for second of two successive amber lights; project review initiated and undertaken by GISERA Director.
- **Red**:
  - Milestone not met according to schedule.
  - Problems in meeting milestone are likely to impact subsequent project delivery, such that revisions to project timing, scope or budget must be considered.
  - Milestone payment is withheld.
  - Project review initiated by GISERA Director.

2. Progress Schedule Reports outline task objectives and outputs and describe, in the 'progress report' section, the means and extent to which progress towards tasks has been made.

Project schedule table

TASK NUMBER	TASK DESCRIPTION	SCHEDULED START	SCHEDULED FINISH	COMMENT
1	UAV-LiDAR data collection	1 Aug 2023	31 Oct 2024	1200 ha of high-quality UAV-LiDAR collected over different habitat types. Representation of wet and dry season conditions.
2	3D point cloud analysis and SAR calibration	1 Sept 2023	29 Nov 2024	Processing of UAV-LiDAR complete. Calibration of SAR backscatter signal for different months of the year completed.
3	Upscaling to larger areas with spaceborne SAR	1 Nov 2024	31 Mar 2025	Random Forest modelling predictions based on SAR completed.
4	Project reporting	1 Dec 2024	31 Mar 2025	This Milestone will be delivered by 16th May 2025.
5	Communicate findings to stakeholders	1 Aug 2023	20 Apr 2025	This Milestone will be delivered by 30th May 2025.

Project schedule report

TASK 1: UAV-LiDAR data collection

BACKGROUND

UAV-based LiDAR offers a tremendous opportunity to develop a high quality and quantity monitoring program for change in habitat structural conditions of any ecosystems in response to disturbance. There is a clear opportunity to harness this technology to improve the monitoring framework for the Beetaloo Sub-region once an unconventional gas industry is established. The main step in the use of UAV-LiDAR is to obtain the high-resolution point clouds that are required to provide a basis for assessing structural change and for calibrating spaceborne imagery. This task focuses on selecting suitable sites to meet the project objectives, obtaining flight plan permissions, and conducting the UAV surveys to collect the data.

TASK OBJECTIVES

i) Acquire high-resolution UAV-LiDAR data over select study sites at key times in the seasonal cycle; ii) Process IMU trajectory, GNSS base-station, and UAV-LiDAR flight data.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

Analysis ready datasets in the form of geolocated point clouds (.las format version 1.4).

PROGRESS REPORT

UAV-LiDAR acquisition have been completed:

- The project team acquired 1200 ha of high-quality UAV-LiDAR over the course of two campaigns.
- Dry season (Oct 2023) and wet season (April 2024) conditions are represented in the dataset.
- Extensive flooding and major road works limited launch sites to the southern side of the Carpentaria highway, but diverse habitats are represented.
- Processing of the GNSS base-station data, the IMU trajectory, and the raw point cloud data through to geolocated point clouds is complete.

TASK 2: 3D point cloud analysis and SAR calibration

BACKGROUND

Changes in habitat structure for each study site will be assessed from voxelised versions of the time-series point cloud data collected in Task 1. Cloud-to-cloud distancing will be used to quantify the degree of change occurring in different components of the vegetation canopy through time. These voxelised representations of 3D structure and structural change will be used to test the sensitivity of Sentinel-1 C-band SAR for habitat structural condition monitoring. Time-series of Sentinel-1 backscatter intensity and coherence will be developed for each site for modelling against the voxel outputs.

TASK OBJECTIVES

i) Develop voxelised representations of structural change; ii) download and prepare Sentinel-1 data for analysis; iii) complete raw processing of Sentinel-1 data; and iv) define a suite of UAV-LiDAR metrics that have ecological relevance to key species of interest in the region.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

Classified and segmented LiDAR voxels (.ply format). Volumetric reconstructions of individual trees and branches (.ply format). Height and canopy cover structural metrics.

PROGRESS REPORT

UAV-LiDAR processing has been completed:

- Canopy height and cover rasters representing a broad range of vertical and horizontal structural metrics have been generated from the LiDAR point clouds collected in Task 1.
- Canopy metrics have been produced at 20 m resolution to match SAR pixel resolution, and stored as cloud optimised geotiffs (COGS).
- The processed LiDAR point clouds are available stored as .LAZ (v1.4) files.
- Individual tree segmentation was unsuccessful in some habitat types, but for areas where individual trees were separable the segmented trees and their volumetric reconstructions are available in .PLY format.
- Sentinel-1 scenes intersecting the region of interest have been downloaded and processed through to gamma naught backscatter intensity, and stored as COGS.

Task 3: Upscaling to larger areas with spaceborne SAR

BACKGROUND

Cost-effective monitoring of habitat condition over large areas requires a satellite-based solution, with systematic wall-to-wall mapping at regular repeat time intervals. This task will use the outputs from Tasks 1 & 2 to develop a Deep Learning model that relates metrics of habitat structure and dynamics from voxelised LiDAR point clouds to signals observable from Sentinel-1 SAR imagery. Reliability across larger spatial area will be validated with existing airborne LiDAR datasets.

TASK OBJECTIVES

i) Develop a Deep Learning model for relating UAV-LiDAR characterisation of 3D structure and change to Sentinel-1 SAR image properties; ii) publish workflow and write up final report.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

i) Deep Learning model; and ii) Jupyter Notebook with detailing processing workflow.

PROGRESS REPORT

The suite of UAV-LiDAR metrics derived in Task 2 were tested for correlations with Sentinel-1 SAR backscatter intensity (VV and VH polarisations) and Sentinel-2 surface reflectance (VNIR, red-edge, and SWIR bands wavelengths) for different times of the years and for different temporal composites, to identify the best windows for long-term monitoring. Vertical and horizontal

components of woody vegetation, as quantified from UAV-LiDAR, were strongly correlated with imagery from spaceborne sensors at 20 m resolution.

Seasonal composites from the dry-season months were used in subsequent predictive models. We implemented a Random Forest modelling approach to predict woody vegetation structure across the Beetaloo region at 20 m spatial resolution, using the UAV-LiDAR metrics as training and validation data. The fusion of Sentinel-2 and Sentinel-1 performed better than the use of Sentinel-1 alone. Woody vegetation canopy density, gap fraction profile, leaf area index, vertical diversity, and the 75th percentile height were the top five variables, with concordance correlation coefficients ranging from 0.76-0.89.

This study has shown that key attributes of vegetation 3D structure in the Beetaloo region can be mapped at scale with open-source satellite imagery and processing tools, provided that high-quality training and validation data is available.. These findings lay the foundation for systematic on-going monitoring of vegetation structure over the broader region.

Task 4: Project Reporting

BACKGROUND

Information from this project is to be made publicly available after completion of standard CSIRO publication and review processes.

TASK OBJECTIVES

To ensure that the information generated by this project is documented and published after thorough CSIRO internal review.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

1. Preparation of a final report outlining the scope, methodology and findings;
2. Following CSIRO ePublish review, the report will be submitted to the GISERA Director for final approval; and
3. Provide 6 monthly progress updates to GISERA office.

PROGRESS REPORT

The final report is close to completion, undergoing internal ePublish review.

Task 5: Communicate project objectives, progress and findings to stakeholders

BACKGROUND

Communication of GISERA research is an important component of all projects. The dissemination of project objectives, key findings and deliverables to relevant and diverse audiences allows discourse and decision making within and across multiple stakeholder groups.

TASK OBJECTIVES

Communicate findings to stakeholders through meetings, Knowledge Transfer Session, fact sheets, project reports and journal articles, in collaboration with GISERA Communication officers.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Communicate results to GISERA stakeholders according to standard GISERA project procedures, which will include but is not limited to the activities listed below.

1. Engagement with an established technical reference group.
2. Two project fact sheets: one developed at the commencement of the project, and another that will include peer-reviewed results and implications at completion of the project. Both will be hosted on the GISERA website.
3. Project reporting.
4. Knowledge Transfer session with Government/Gas Industry.
5. Preparation of an article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.
6. Peer-reviewed scientific manuscript ready for submission to relevant journal.

PROGRESS REPORT

This task will be completed in May 2025.

Variations to Project Order

Changes to research Project Orders are approved by the GISERA Director, acting with authority, in accordance with the GISERA Alliance Agreement. Any variations above the GISERA Director's delegation require the approval of the relevant GISERA Research Advisory Committee.

The table below details variations to research Project Order.

Register of changes to Research Project Order

DATE	ISSUE	ACTION	AUTHORISATION
26/06/24	Due to equipment issues and a big wet season which has prevented access to some sites, data collection is not complete therefore some UAV-LiDAR acquisitions have been pushed to later in the year. This delay has had a flow on effect for all other tasks.	Milestone 3 and 4 start dates extended by 4 months. Milestones 1, 3, 4 and 5 delivery dates extended by 4 months; milestone 2 delivery date extended by 5 months. The new project delivery date will be April 2025.	

DATE	ISSUE	ACTION	AUTHORISATION
07/02/25	The project team acquired 1200 ha of high-quality UAV-LiDAR over the course of two campaigns with diverse habitats represented. Further surveys were constrained due to technical issues, road works and extensive wet season flooding.	Reduce number of planned repeat UAV-LiDAR surveys and use the data collected to date (2 surveys). A budget reduction of $50,304 which will bring overall budget down to $404,187.	

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GISERA is a collaboration between CSIRO, Commonwealth and state governments and industry established to undertake publicly-reported independent research. The purpose of GISERA is to provide quality assured scientific research and information to communities living in gas development regions focusing on social and environmental topics including: groundwater and surface water, greenhouse gas emissions, biodiversity, land management, the marine environment, and socio-economic impacts. The governance structure for GISERA is designed to provide for and protect research independence and transparency of research.