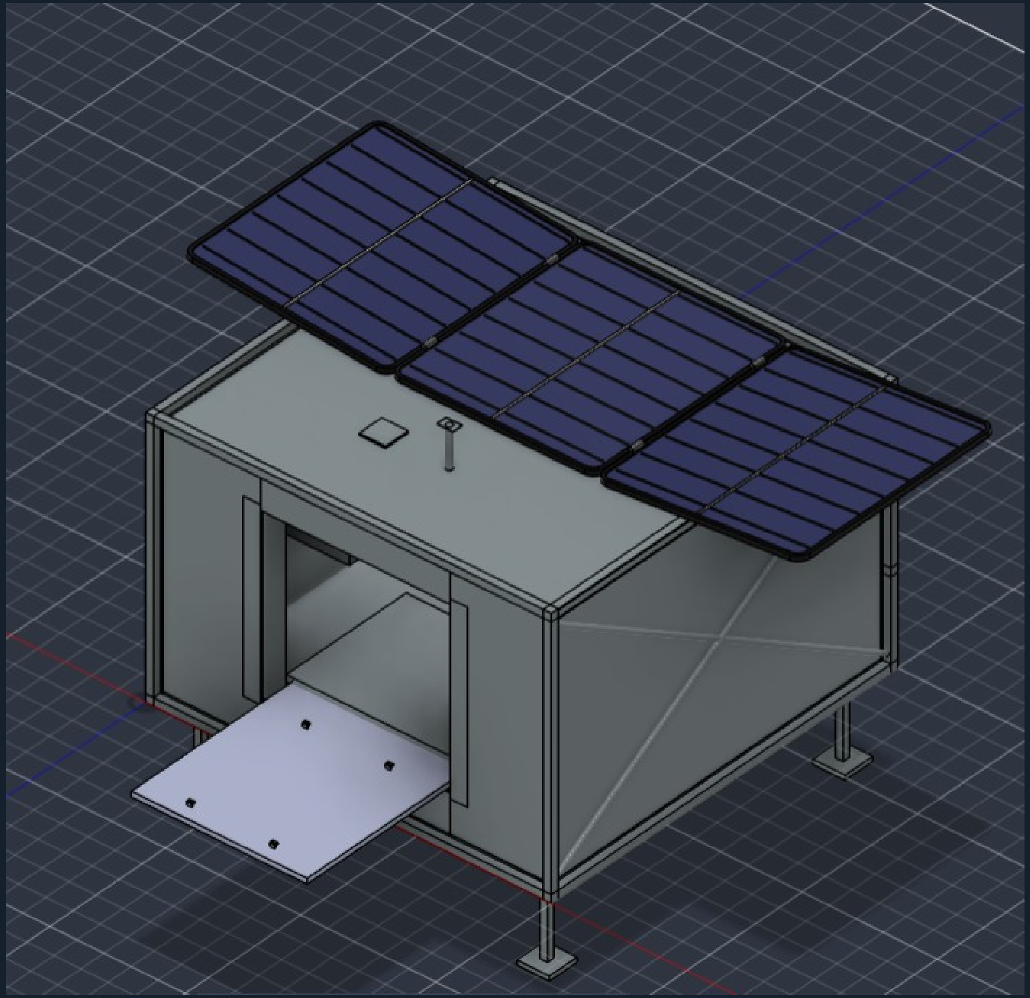
L’SPACE MISSION CONCEPT ACADEMY

Lunar south pole exploration

A base station and autonomous scout for terrain and environmental surveying



Sid Gupta

Project Manager, Team 24
Summer 2026

A fixed hub supports a mobile scout

The mission concept surveys terrain and environmental hazards near permanently shadowed regions.

Base Station	Scout Drone
Solar power, charging and thermal support	Autonomous excursions into difficult terrain
Bulk data storage and direct-to-Earth radio	Imaging, depth sensing and environmental measurements

175 kg

Combined launch-mass ceiling

1.5 × 1.5 × 1.0 m

Stowed envelope requirement

≥1 TB

Data archive target

My role as project manager

20

team members

Science, engineering and programmatics

Project management

Coordinated subteam leads, task ownership and schedules through successive mission reviews.

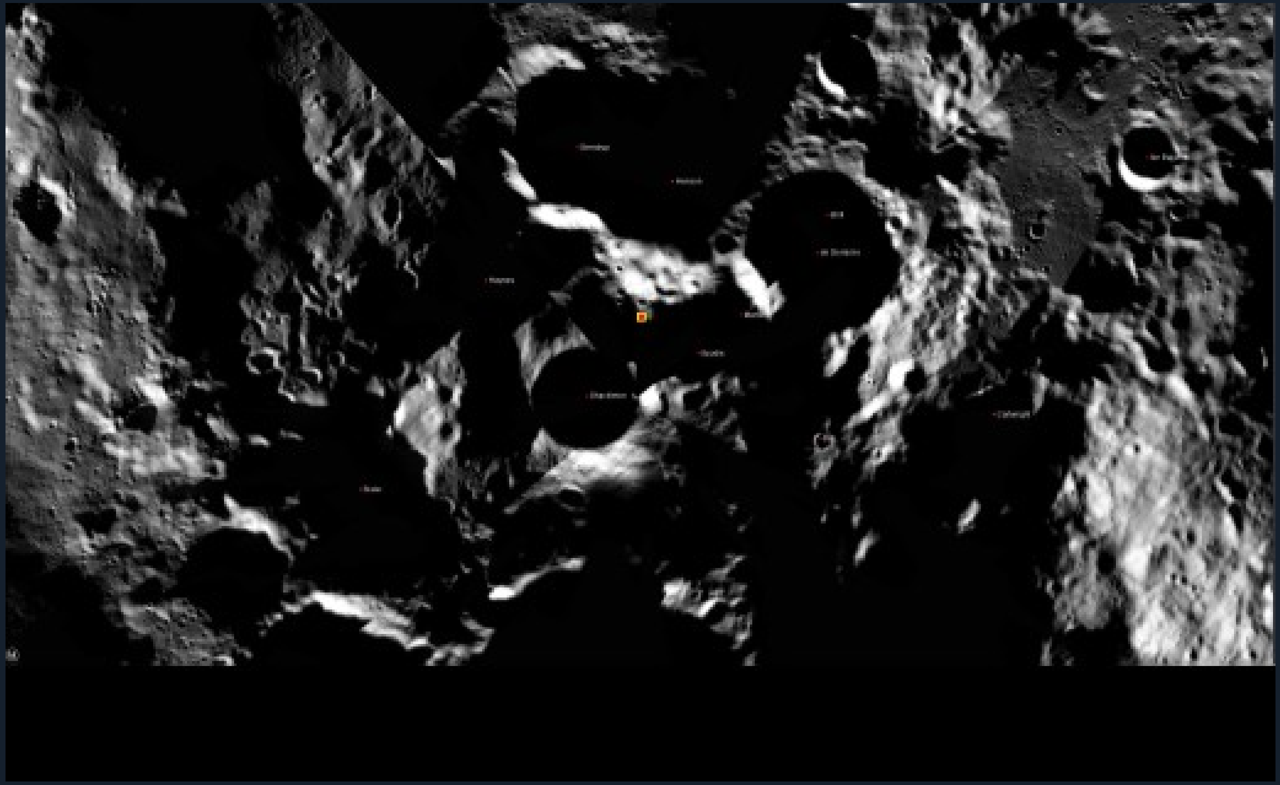
Science coordination

Helped connect science goals and instrument choices with mission and subsystem requirements.

Mechanical design support

Contributed to preliminary vehicle CAD and mechanical-design discussions alongside the engineering team.

Why Shackleton–de Gerlache Ridge



Selected site: approximately 89.46°S, 223.06°E

Sunlight for the hub

The ridge offers favorable illumination for solar generation and battery recharge.

Shadowed terrain nearby

Nearby permanently shadowed regions provide targets for terrain and hazard measurements.

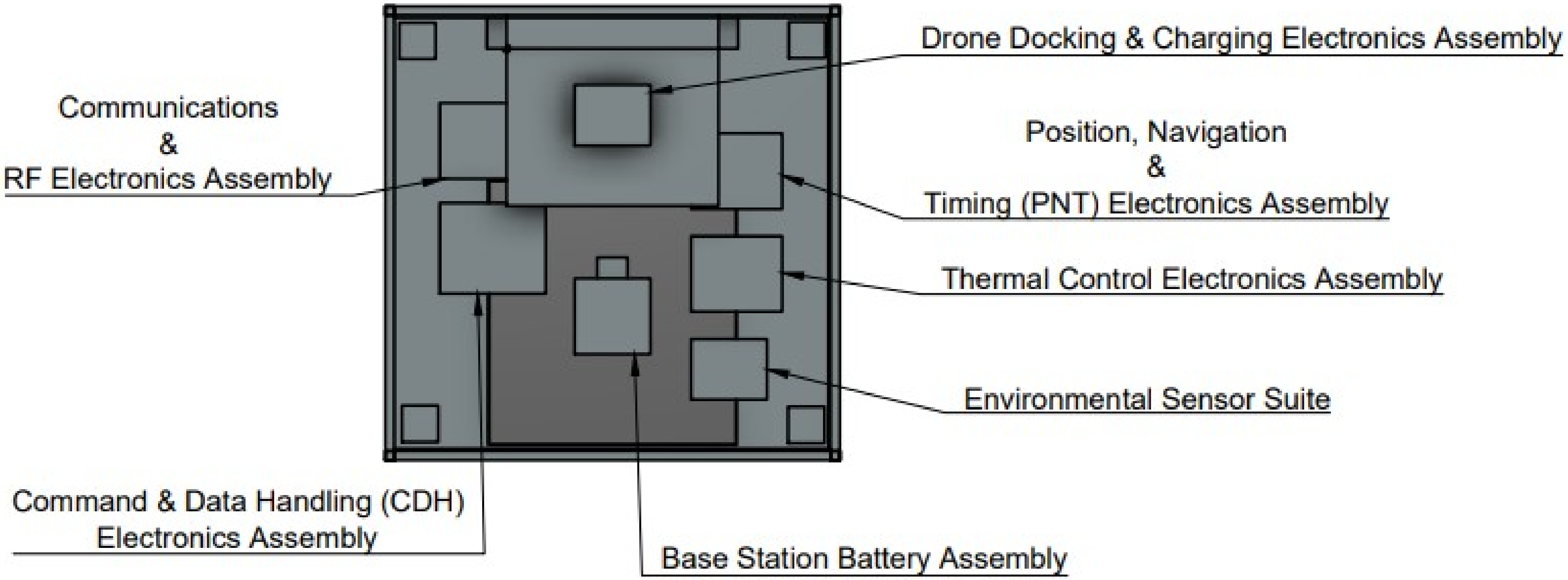
Landing and radio access

Site selection balances low slopes, solar access and visibility to Earth.

Science goals drive the engineering

Science question	Measurement approach	Design consequence
Terrain and illumination	Optical navigation, stereo terrain imaging and floodlights	Sensor fields of view and lighting in shadow
Dust and radiation	Dust-impact measurements and radiation dosimetry	Environmental protection and exposure tracking
Platform dynamics	Gyroscope and inertial measurements	Stability, vibration and load requirements
Autonomous routing	Depth sensing, flight software and power monitoring	Hazard avoidance and return-energy decisions

Base station structure and packaging



Preliminary interior CAD

6061-T6 aluminum

Selected for the base frame’s balance of strength, mass and manufacturability.

Physical integration

Allocated mounting space for batteries, electronics, thermal hardware and the docking bay.

Next step: verify clearances, load paths and thermal distortion in the detailed assembly.

Scout design for mobility and sensing

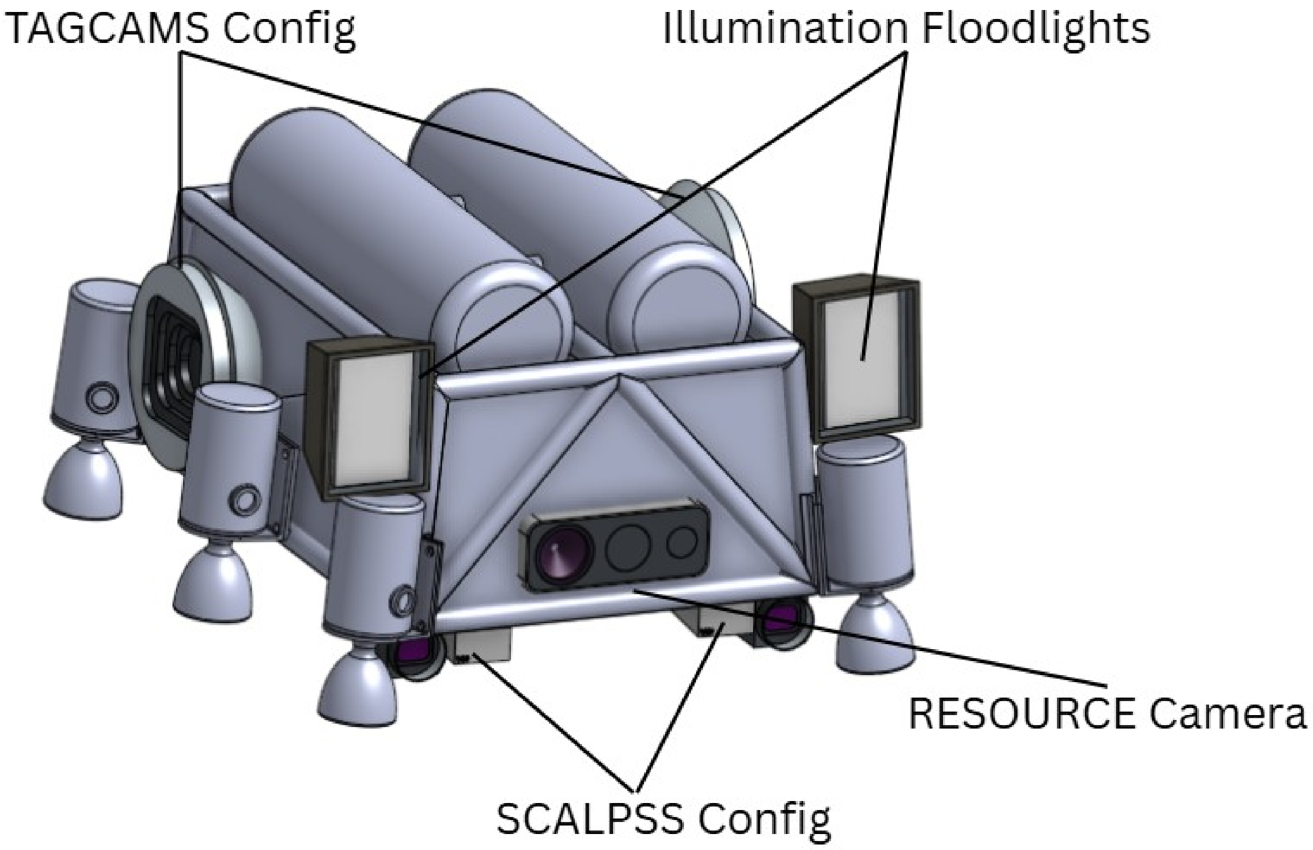
7075-T6 frame

Selected to support payload and propulsion hardware with high strength relative to mass.

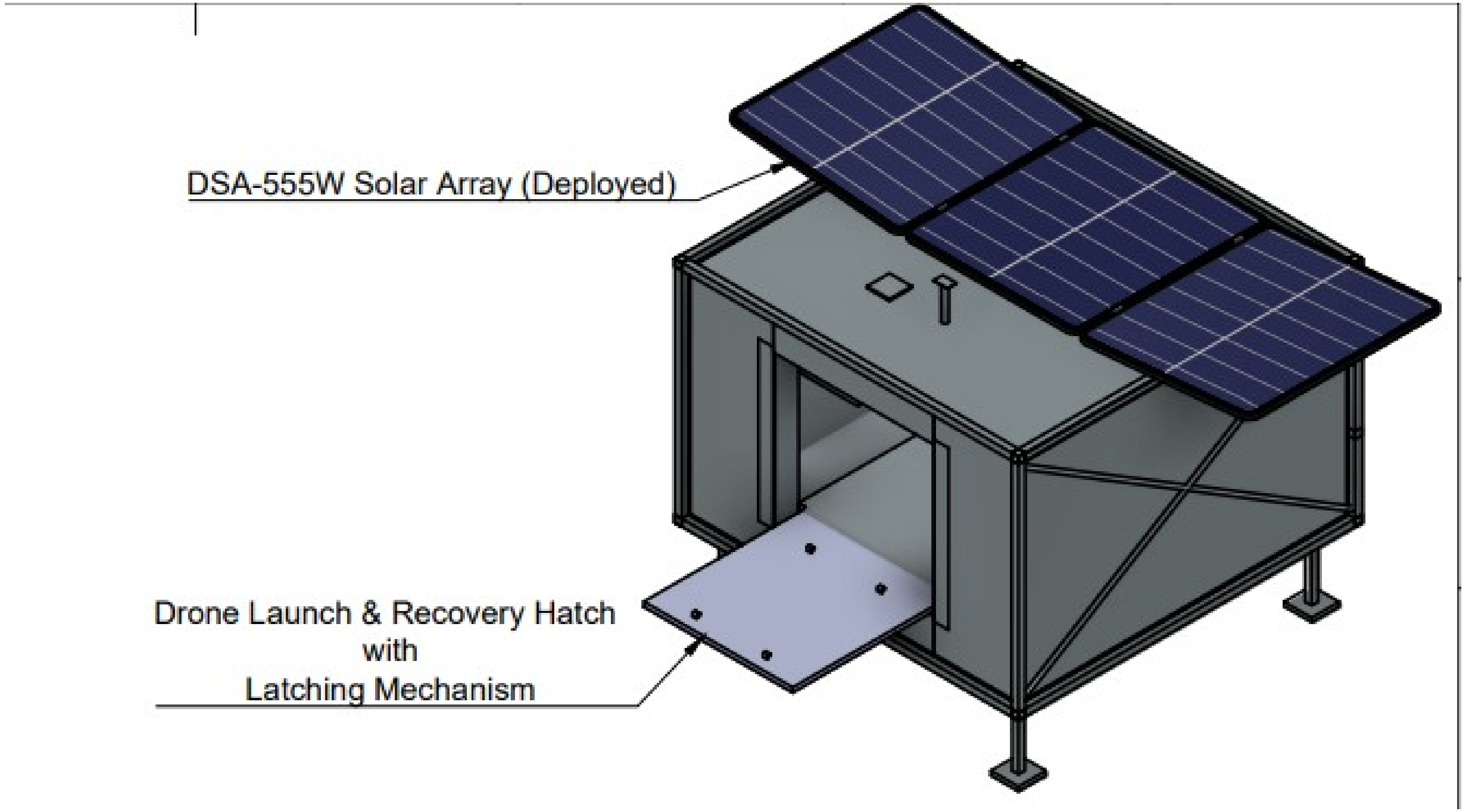
Sensor placement

Optical, stereo and depth sensors provide complementary views for mapping and navigation.

Cold-gas propulsion concept Thrust, propellant and excursion duration remain open sizing work.



Docking connects the two vehicles



Mechanical interface

Retention for launch and transit, controlled release, and repeatable alignment on return.

Charging interface

Spring probes and target contacts transfer power after the scout lands and docks.

Docking reliability depends on dust tolerance and thermal-cycle performance.

Power and thermal design are coupled

Energy storage

Solar generation supports the base station. Independent batteries power both vehicles, with load shedding during low-energy periods.

Thermal control

Multilayer insulation, thermal straps and radiators work with heaters and localized cooling to protect sensitive hardware.

$$29.5\ \mathrm{W} \times 130\ \mathrm{h} \approx 3.84\ \mathrm{kWh}$$

Base-station survival-energy estimate from the PDR’s stated load and dark-period sizing assumption.

Still to close

Usable battery capacity, actual solar input, heater duty cycle and coupled thermal margins.

Autonomy, communications and data

Function	Preliminary architecture	Why it matters
Autonomous control	Onboard flight computer, inertial sensing and depth-camera input	Local hazard response without real-time piloting
Vehicle communications	UHF local link between scout and base station	Commands, health telemetry and science transfer
Earth communications	Base-station X-band direct-to-Earth link	Returns data without assuming an orbital relay
Fault recovery and storage	Cold-spare computing, onboard logging and redundant base storage	Preserves control and data through selected faults

The data archive target requires an end-to-end link and duty-cycle budget.

A repeatable surface-operations cycle

95 days

Planned surface mission

4 excursions

Planned exploration cycles

Stage	Operational purpose
Commissioning	Check health, verify links and establish instrument references
Exploration	Collect terrain data, track hazards and relay priority telemetry
Dock and recharge	Dock, transfer stored data and restore the scout’s battery
Survival / closeout	Use survival modes as needed, then downlink and archive data

Verification follows the mission risks

Risk	Design response	Planned verification
Dust or docking failure	Protected interfaces, alignment features and secondary retention	Dust exposure and repeated docking tests
Structural or thermal damage	Material selection, load paths, insulation and thermal control	Structural analysis, vibration and thermal-vacuum tests
Power or electronics faults	Load isolation, survival modes and backup computing	Fault injection and hardware-in-the-loop tests
Lost control or data	Priority telemetry, onboard storage and recovery logic	Integrated autonomy and data-recovery tests

Hardware qualification remains future work.

Cost and schedule shaped the concept

$240.8M

Preliminary mission estimate

Against a $250M exercise cost cap. Approximately $9.2M of remaining headroom.

Estimate covers Phases C–F. Launch, transit and lunar delivery are excluded.

Planning milestone	PDR target
Critical Design Review	July 2027
Integration readiness	1 Dec 2028
Launch readiness	1 Feb 2029

Procurement and separate vehicle qualification campaigns drive the schedule.

Design maturity and next steps

Propulsion and excursion sizing

Close thrust and propellant budgets, then reconcile range and excursion duration with available energy.

Integrated vehicle budgets

Reconcile mass rollups, solar-array selection and subsystem power allocations in one controlled baseline.

Detailed mechanical design

Finalize packaging and drawings. Analyze loads, stability, thermal distortion and docking clearances.

Coupled system validation

Model thermal survival and data return, then test autonomy, docking and recovery with representative hardware.

A complete mission study through PDR

Team outcome

A preliminary mission architecture with vehicle CAD, science traceability, subsystem requirements and interface definitions.

Risk, procurement and verification plans supported by a cost model, mission schedule and outreach plan.

What I contributed

Coordinated the work across disciplines and reviews, helped align science goals with engineering, and supported mechanical design.

Sid Gupta

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