A Geospace Radar for 21st Century Space Physics and Aeronomy

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This whitepaper concerns the development and deployment of a new Geospace Facility, the descendant of the existing American chain of incoherent scatter radars (ISRs) and the bridge to the future of radar remote sensing of geospace. ISRs can measure plasma state parameters (N_e, T_e, T_i, ion composition, and plasma drifts) directly below and above the F peak and be used to infer electric fields, plasma conductivity, currents, and neutral atmospheric state parameters. It is the most incisive instrument available for ground-based remote sensing of geospace. The envisioned facility will be specified and designed to meet the most pressing scientific needs of the AGS community. It will also play an important role in education and professional development. Finally, it will be a vehicle for advancing technology within our discipline.

A workshop was held in April of 2021 at the request of the Geospace Section in AGS to consider the future of the geospace facilities program. A report on the outcome of the workshop is available at `https://landau.geo.cornell.edu/workshop_report.pdf`. During the workshop, ten science priorities were identified that necessitate an investment in one or more ISR-class facilities by the AGS Facilities Program. Those priority areas, which span our discipline, include cross-scale coupling, data assimilation, space weather, neutral/plasma coupling, MLT instabilities and dynamics, meteor science, aeronomy, planetary radar, plasmaspheric radar, and solar radar.

The tactics for pursuing these science priorities became the three cross-cutting themes of the workshop: (1) exploiting emerging technologies in facility design, (2) involving and leveraging knowledge from adjacent science communities, and (3) incorporating workforce training and development, along with international collaboration, in any new facility undertaking.

Finally, the ten science priorities and the three cross-cutting themes in the report were distilled down to two recommendations for the Geospace Section:

1. The community should undertake the development of a new geospace facility, a geospace radar, following in the footsteps of contemporary, worldwide developments in radio astronomy and radar techniques.
2. It is imperative to train the next generation of scientists and engineers to take over ISR research and technology as an integral part of any next-generation facility.

The first recommendation highlights the use of radio-array technology in the facility architecture. We envision one or more transmitters in the low VHF band surrounded by multiple receive arrays which could be operated in a multistatic fashion and which could bridge aperture-synthesis imaging methods into ISR methodology. (The motivation for low-band VHF is explained in the report.) The second recommendation points to an increased role for educational institutions in the management and operations of facilities going forward.

This whitepaper builds on the workshop report by adding a third recommendation: that the facility in question should focus on science in the subauroral region where a number of important research foci would benefit immediately:

1. Subauroral electrodynamics, including SAPS, SAID, and STEVE
2. Plasmasphere and plasmasphere boundary layer science
3. Inner magnetosphere and ionosphere coupling through heat fluxes and ion upwelling/ outflow
4. Energetic particle precipitation and impacts on atmospheric chemistry
5. Atmosphere and ionosphere coupling via waves, TIDs, and neutral instabilities
6. Midlatitude instability physics (TGI/GDI)

Such a facility could be constructed with sites in the northern continental United States. Ideally these sites would have access to ample renewable electrical power, be accessible to researchers and students for hands-on educational experiences, and be coordinated with local community outreach and public science education efforts.