Geolocating Near Vertical Incidence Skywave (NVIS) Transmitting Sites. Current Methods and Direction in NVIS geolocation.

Discussion

NVIS is thought to be an effective radio-operational technique to prevent or degrade Radio Direction Finding (RDF) to a repeatable and operational useful precision and such thought makes up part of the popular NVIS discussion in the USA. This thinking seems to have originated in the U.S. 'prepper' community and is a common discussion when NVIS is the subject.

This research paper seeks to provide discussion and evidence that NVIS is not immune to RDF and that NVIS RDF technologies have been available since the 1980's. This affects Communications Security perceptions of NVIS being, somehow, more secure from RDF than Line of Sight or Groundwave propagation.

Previous RDF systems, like the U.S. TRACKWOLF, developed in the 1980's, is capable of NVIS RDF capability and contemporary (Signals Intelligence) SIGINT systems can DF NVIS as well. So, contrary to popular opinion, NVIS RDF solutions have been available since that time. This information has publicly available for at least 20 years, so the origins of the idea that NVIS is difficult to RDF are founded in rumor and is unsupported by fact.

NVIS is thought to be much less geolocatable than Line of Sight (LOS) and groundwave propagation, which may be true with Angle of Arrival (AoA) methods, but NVIS is not immune to RDF by Time Difference of Arrival (TDOA) or Correlative Interfermoetry (CI). The ionosphere that reflects the skywave is not a uniform surface but undulates constantly like the surface of the sea and this changing surface geometry causes changes in the Angle of Reflectance of the NVIS skywave, resulting in the movement of that reflected NVIS wave onto the earth's surface within the NVIS footprint. This change in the point of original wavefront creates numerous opportunities for TDOA/CI observations that can extrapolated to their origins: first the area of reflection from the ionosphere averaged together to an angle, then that angle extrapolated to the Point of Origin on the ground, 90 degrees of incidence.

The U.S. military has developed contemporary NVIS systems as well and with these systems, there is consideration of NVIS RDF for intelligence purposes. The recent, contemporary use of U.S. military NVIS probably stems from a recognizance that satellite communications was suffering from a bandwidth insufficiency and some communications were shifted to NVIS on mobile platforms and NVIS is likely to become a standard for tactical mobile communications.

Terrestrial Geolocation Solutions

The 1980's era TRACKWOLF system is capable of NVIS RDF. TRACKWOLF likely employed interferometric methods.

The 2006 era ESMERALDA system, by Thales, is capable of NVIS RDF.

In an RFP, dated 13NOV2020, the U.S. Department Of Defense (DOD) requested a RDF solution using TDOA with a small form factor antenna specifically for NVIS DF, citing increasing use of this propagation technique by other actors. This system will be used by DOD and the civilian Federal Communications Commission (FCC).

Civilian Software Defined Radio (SDR) systems are capable of TDOA and will likely be employed by amateurs to RDF NVIS transmissions. A skywave TDOA solution that can extrapolate the Take off Angle from skywave observations. Conceptually, this is determining the angle "A" from the hypotenuse.

Airborne and Spaceborne Geolocation Solutions

The first leg of the NVIS transmission, from transmitter to ionosphere, will be RDF and collectable by drones and aircraft.

Spaceborne system will likely not be capable of NVIS reception given the ionosphere is opaque to NVIS frequencies, otherwise this propagation method would be impossible. This is a small matter since terrestrial and spaceborne systems will suffice.

The Snowden catalog provides some information regarding spaceborne collection capabilities and there does not appear to be a specific NVIS collection capability, which would be in the High Frequency bands of 3-30 MHz. USA spaceborne SIGINT collection appears to be in the VHF-SHF frequencies.

Civilian/Military Considerations

Civilian geolocation, aside from radio enthusiasts, is concerned with spectrum management and enforcement. Enforcing licensing requirements requires detection of unlicensed transmitters and also with detection of transmitters causing interference and jamming.

Military concerns involve the detection and geolocation of threat transmitters as part of developing the Electronic Order of Battle (EOOB), for SIGINT exploitation or neutralization. NVIS geolocation is returning to military application as a parallel development as NVIS communications is receiving further military attention.

In the case of NVIS being used by Non-State Actors for insurgency and civil disobedience, the civilian agencies, like OFCOM and the FCC, would likely acquire NVIS geolocation capability and provide civil law enforcement with necessary police intelligence to geolocate suspect transmitters. The UK has a history of such civil/military partnerships from the Northern Ireland experience. In the USA, separation of military and civilian police would point to federal law enforcement, the lead in terrorism investigations, as the likely lead in domestic counter-insurgency. The UK again provides an excellent reference for police/civil/military cooperation.

Conclusion

Geolocation of NVIS transmitters can be accomplished with methodologies over 30 years old. TDOA techniques are the current method to geolocate NVIS transmitters and is seeing the largest growth and implementation. As Software Defined Radio and Free, Open Source Software (FOSS) proliferate and improve, then TDOA methods of transmitter geolocation will also proliferate into publicly accessible spaces.

Contact & Document Checksums

https://pastebin.com/nnxdkQAA

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