# Near Vertical Incidence Skywave (NVIS) Antenna and Propagation Research in The Netherlands

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Near Vertical Incidence Skywave (NVIS) propagation can be used to realize radio communication without the need for an intermediate network. NVIS uses the ionosphere as a reflector to cover a large area (200 x 200 km) around the transmitter, on frequencies ranging from 3 to 10 MHz. NVIS is therefore used for telecommunication in areas that lack a telecommunication infrastructure, or in areas where the existing infrastructure is destroyed by a large scale disaster, such as the 2005 flooding of New Orleans. We will give an overview of the NVIS research performed:

- Simulations, using software capable of tracing radio wave paths through a model of the ionosphere (PropLab Pro), reveal the relationship between frequency, distance and elevation angle. This relationship is confirmed empirically using a professional radio direction finder. These measurements also show that NVIS produces stronger signals than ground wave at distances above 20 km on 7 MHz, and above 80 km at 3.5 MHz.
- NEC4 simulations of horizontal dipole antennas above ground show an optimum for NVIS at a suspension height of 0.18-0.22 λ (depending on soil type) for transmission, where antenna gain counts, and 0.08-0.11 λ for reception, where signal-to-noise ratio is important. Simultaneous measurements on dipole antennas suspended at 5 different heights confirm the simulations for transmission, but contradict those for reception. The optimum height of the receive antenna was around 0.16 λ.
- According to Appleton's magneto-ionic theory, radio waves entering the ionosphere are split in two characteristic waves, one with Left Hand Circular Polarization (LHCP) and one with Right Hand Circular Polarization (RHCP). Measurements show high isolation between those paths (>20 dB). This makes dual Circular Polarization antennas interesting candidates for Diversity Reception or HF MIMO.
- Further experiments are planned to measure characteristic wave isolation for different azimuthal orientations and at other latitudes. Research is ongoing on the mechanism of the residual nighttime propagation, occurring at frequencies above the theoretical Maximum Useable Frequency (MUF).

This research into the NVIS propagation mechanism and into the adaptation of the antenna to the propagation mechanism contributes to an increase in link reliability and power efficiency of disaster relief telecommunications.