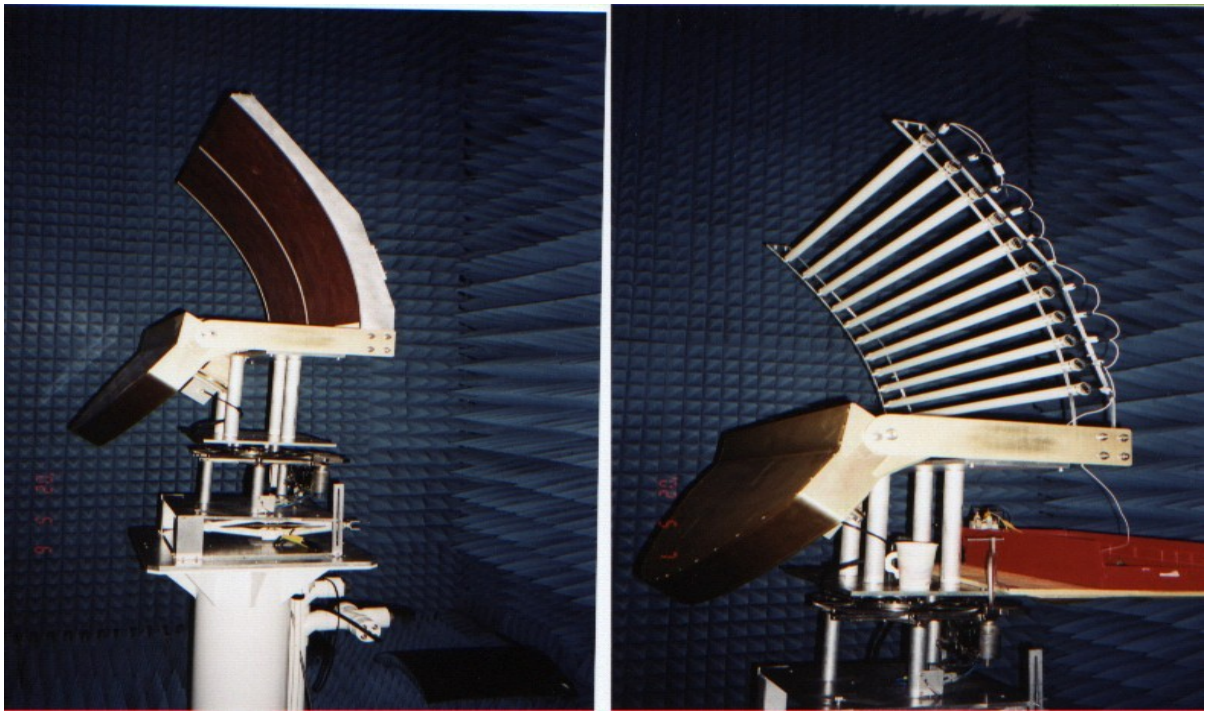
Summary of Accomplishments of Haleakala R&D, Inc on Plasma Antennas

Dr. Ted Anderson, CEO, Haleakala R&D, Inc.

Haleakala R&D, Inc has developed mathematical theories, computer codes, experiments, prototypes, and commercial prototypes of plasma antennas, plasma frequency selective surfaces, plasma radomes, plasma waveguides, and plasma coaxial cables. While Haleakala R&D, Inc. has developed a variety of plasma technologies, the primary focus has been on the plasma antenna. The company has researched, developed, and prototyped plasma reflector antennas, plasma AM/FM radio antennas, transmitting and receiving plasma antennas up to 20 GHz (we can go much higher), high powered plasma antennas which can transmit up to 5 Megawatts of power in the pulsed mode, and a smart plasma antenna which is compact, light, and can steer 360 degrees in milliseconds, find and lock onto transmitters, has a reconfigurable beamwidth and the ability to reconfigure from single to multilobe antenna patterns.

Plasma Antenna for AM/FM Radio Prototype. This is on display at the Booz Allen" Technology Petting Zoo" in Mclean, VA



Metal Reflector Antenna on Right and Plasma Reflector Antenna on Left.
Both antennas are installed in an electrical anechoic chamber. The metal reflector antenna designed to be an identical twin to the plasma reflector antenna. The microwaves are generated by a line antenna, focused in one dimension by the metal pillbox, and focused in the second dimension by either the plasma antenna or a metal twin.

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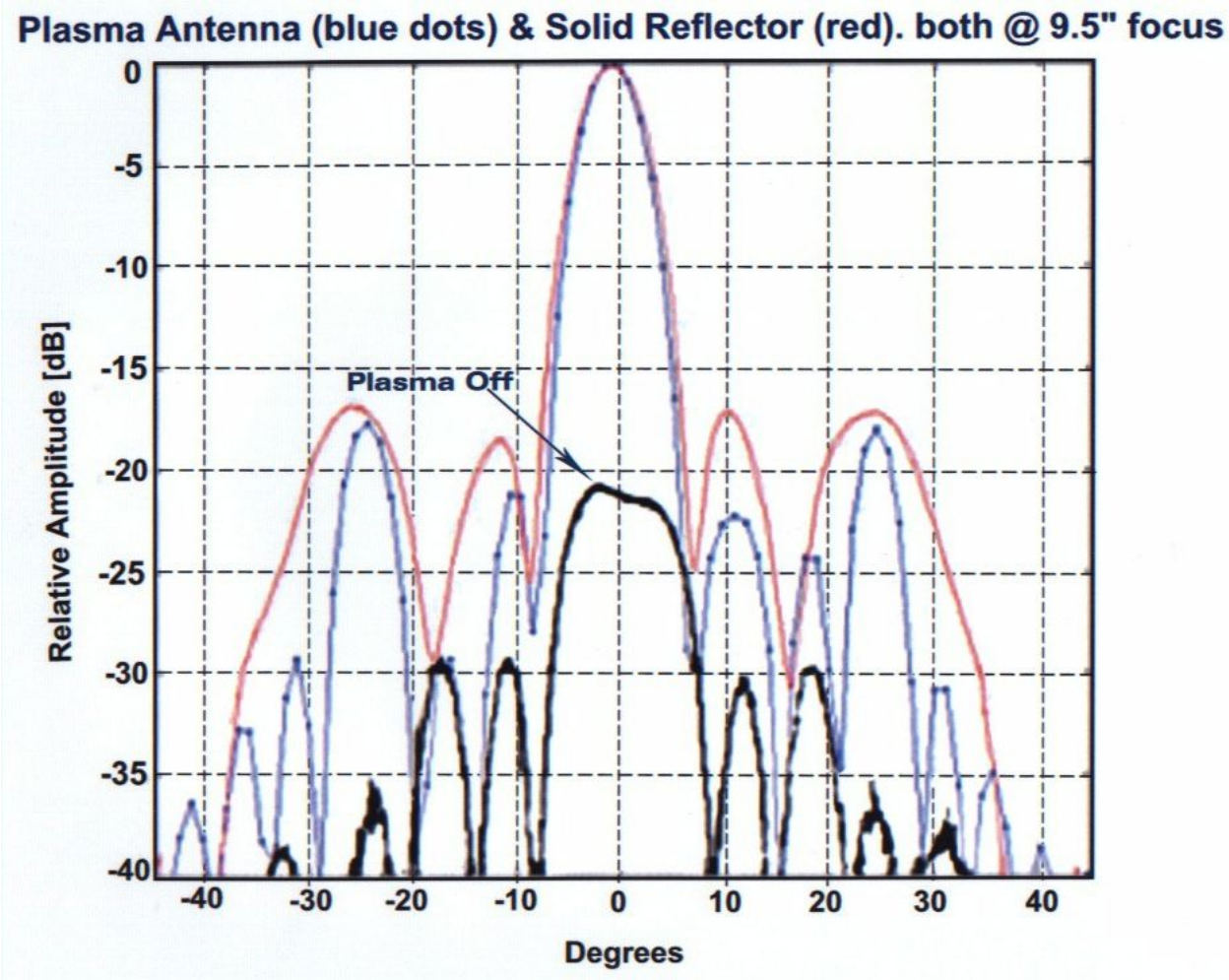

Radiation Pattern of plasma reflector antenna superimposed on the pattern of the metal antenna.

- **The main lobe plasma reflector antenna is identical to the main lobe of the corresponding metal reflector antenna.**
- **When the plasma antenna is turned off it is invisible to all RF frequencies.**
- **The plasma reflector antenna can operate at lower frequencies and be stealth at high frequencies.**
  - higher frequency RF waves will pass through a lower density plasma.
- **The side lobes of the plasma reflector antenna are less than the side lobes of the corresponding metal reflector antenna.**
  - Soft surface effects of plasma

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The Haleakala smart plasma antenna uses plasma physics to steer and shape the antenna radiation pattern from one internal plasma antenna surrounded by a cylindrical ring of plasma tubes. Tubes that are off or of low plasma density are transparent to RF waves and are called open plasma windows. A highly directive beam can emerge from open plasma windows. The
tubes that are on or of high density plasma are very reflective with a reactive skin depth. We have determined a way to reduce the amount of energy and power needed to maintain the ionization and even maintain high ionization by pulsing the plasma tubes with microsecond pulses every few milliseconds. We can do this, because the plasma will last on the order of milliseconds and does not need a continuous energy source.

Our smart plasma antenna currently weighs less than 10 pounds and currently costs about $175 to build. We have ruggedized the tubes by encapsulating them in synfoam and rugged plastic. The synfoam has an index of refraction of nearly one and is transparent to RF waves. It is a very rugged material and gives the plasma tubes protection.

Our future smart plasma antenna will steer in microseconds using Fabry-Perot-Etalon Effects. Our smart plasma antenna compared to other smart antennas has compact size, light weight, stealth and jam resistant.

Current features of our smart plasma antenna are:

- It currently weights about 10 pounds.
  - Some weight (but not much) will be added when we make the base rugged and surround the tubes with SynFoam to protect the tubes.
  - Future iterations of the prototype can be made smaller.
  - But nevertheless it is much smaller and lighter than large phased array antennas, and the performance is in many ways better.
  - Even in the prototype stage, our prototype is relatively inexpensive for a steerable smart antenna. Manufacturing would significantly reduce the price.
- It can steer the antenna beam 360 degrees in milliseconds.
  - Our future prototypes will steer in microseconds using Fabry-Perot-Etalon Effects.
- This is an intelligent, high performance steerable antenna with:
  - Compact size
  - Light weight
  - Stealth and jam resistant
- Rugged packaging has been done
- We have manufacturing capability on our commercial prototype with:
  - Impeccable Instruments, Inc. (CEO, Jeff Peck) in the Knoxville, TN area.
  - Industrial Instruments, Inc. (CEO, Fred Dyer) in the Knoxville, TN area.
  -

Below are two photographs of our smart plasma antenna commercial prototype

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Haleakala R&D, Inc. unhoused smart plasma antenna prototype next to prototype engineer

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Haleakala R&D, Inc. ruggedized smart plasma antenna prototype.

Haleakala R&D, Inc has researched, developed, and prototyped plasma nested antennas and stacked plasma antenna arrays. For plasma nested antennas the higher frequency plasma antennas will transmit through the lower frequency plasma antennas, and we can nest the antennas like the layers of an onion. This design cannot be done with metal antennas but enables the nested plasma antennas to reconfigure from broadband, to multiband, and to narrow band in milliseconds. Likewise the higher frequency plasma antenna arrays can transmit through the lower frequency plasma antenna arrays and this also yields broadband, multiband, or narrow band reconfigurations.

Haleakala R&D, Inc. has proved by theory and experiment that plasma antennas have less thermal noise than corresponding metal antennas. This is largely a result of lower electron atom collision rates in a plasma than in a metal and Ramsuaer Townsend effects in the plasma. This could result in a higher data rate antenna system if the plasma antenna is used in conjunction with plasma feeds, low noise receivers, and pointed at the sky. The company has also shown that the infrared signature is insignificant in a plasma antenna because a plasma antenna is not a Blackbody Radiator and IR radiation does not transmit through glass.

An important feature of plasma antennas is that they can transmit and receive at lower frequencies and be transparent and stealth at higher frequencies. As the frequency goes down, plasma antennas and metal antennas need to be larger. However as the frequency

goes down, the plasma density goes down and the plasma becomes more transparent or stealth for a wider range of frequencies. Hence the RCS for plasma antennas becomes less as the frequency decreases whereas for metal antennas the RCS goes up. Plasma antennas can be made to transmit through each other by changing the relative plasma density in each antenna. One may also turn off all the plasma antennas except the one being used to eliminate antenna interference.

The company has shown that by using plasma antennas in a multipole expansion that electronically steerable, low frequency plasma antennas can be made to fit on an aircraft or a vehicle. The physics of this depends upon being able to turn the plasma antennas off or on which cannot be done with metal antennas.

Haleakala R&D has participated and published on plasma antennas with major IEEE and APS conferences and has three journal articles published with two more journal articles being processed for publication. The company has seven issued patents on plasma antennas with two more being processed.

Haleakala R&D, Inc. will continue to ruggedize plasma antennas by making custom made plasma tubes and inserting the plasma tubes in a rugged but light weight material called Synfoam which has an index of refraction of about one making it transparent to RF waves.

Plasma Antenna Patents owned by Haleakala Research and Development, Inc.
These are the issued patents (with US patent numbers) Haleakala owns on plasma antennas:

1. 7,342,549. Configurable arrays for steerable antennas and wireless network incorporating the steerable antennas.

2. 6,922,173. Reconfigurable scanner and RFID system using the scanner

3. 6,700,544. Near-field plasma reader

4. 6,870,517. Configurable arrays for steerable antennas and wireless network incorporating the steerable antennas

5. 7,292,191. Tunable plasma frequency devices

6. 7,453,403. Tunable plasma frequency devices.

In addition two more patent applications have been filed:
Filed Patents

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1. High SNR plasma antenna. Application Serial Number 12/324,876, Filed 12/01/2008.

2. Reconfigurable scanner and RFID. Application Serial Number 11/879,725, Filed 7/18/2007

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