Comparison of a Southern Avionics Diamond Portable Antenna with a New Design Proposed by Nautel

John Pinks
Chief Engineer Emeritus
January 2004

Nautel Limited
10089 Peggy's Cove Road,
Hackett's Cove, NS, Canada B3Z 3J4
T.+1.902.823.2233 F.+1.902.823.3183
info@nautel.com

U.S. customers please contact:
Nautel Maine, Inc.
201 Target Industrial Circle, Bangor ME 04401
T.1.207.947.8200 F.1.207.947.3693
info@nautel.com

e-mail: support@nautel.com
www.nautel.com

Comparison of a Southern Avionics Diamond Portable Antenna with a New Design Proposed by Nautel

The power radiated by any vertical radiator is defined by the product of Antenna Current and the Vertical Height in which it flows.

Consider a simple vertical conductor, with a physical height that is very short compared to the operating wavelength. The input current tapers from it's full value at the feed point, to zero the top, in a near linear fashion.

The average current flowing in its physical height is therefore one half of the input current and its effectiveness can be expressed as its physical height (H) multiplied by half of the input current (I_a).
ie. Its Radiated Power (P_R) α ½ I_a x H

Another way of expressing this relationship is to assume that the full current flows in an effective height (H_e) that is one half of the actual height.
ie. Radiate Power (P_R) α ½ I_a x H_e
Where H_e = effective height
= ½ H for a simple vertical radiator

This concept is shown graphically in Figure 1.

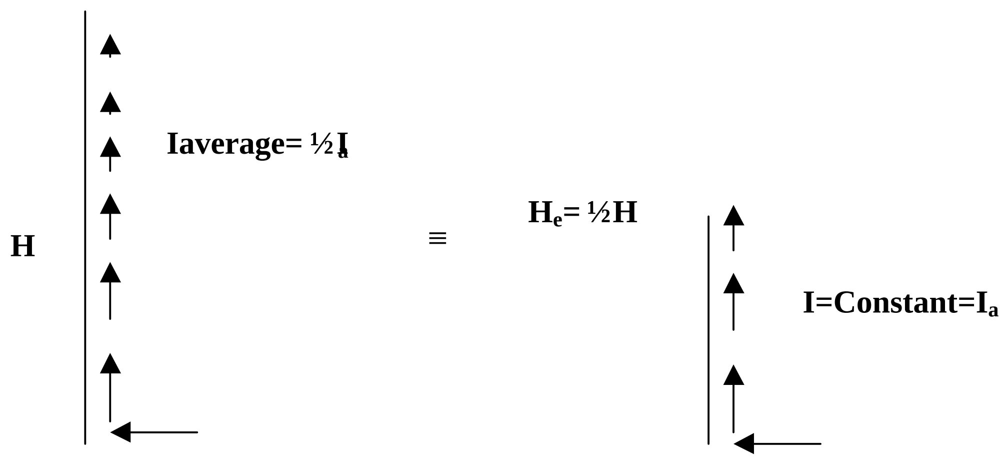

Figure 1 The Concept of Effective Height

This concept of effective height H_e provides a useful tool that can be used to compare one antenna to another.

A technique commonly used to improve the effective height of a vertical radiator, without increasing the actual height, is to extend it horizontally at the top, as shown in Figure 2.

This shows how the tapering of the current extends to the end of the horizontal section and the average current flowing in the vertical section is increased. Clearly this improvement would increase as the length of the horizontal section is increased. The effective height is, in fact, directly related to the capacitance of the top hat, compared to the total capacitance.

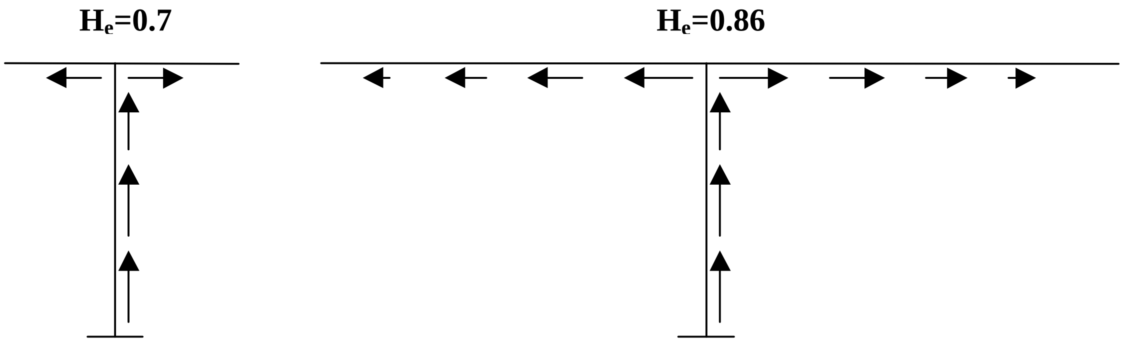

Figure 2 Top Loading Improves Effective Height

A second characteristic that defines the performance of electrically short antennas is the value of its input capacitance. A low value of input capacitance (high capacitive reactance) requires a large loading coil with a high inductance. As the Q value of the loading coil, and hence its loss resistance, is limited by its physical size, a high inductance value results in a high loss resistance. Techniques used to increase the input capacitance usually comprise the addition of parallel wires. Additional wires that are placed in close proximity to other wires give a very small improvement. Wires placed as far as possible from each other provide the greatest improvement. Increasing the capacitance of the top loading section (usually referred to as the top hat) is the best place to add additional capacitance because the effective height H_e is proportional to the top capacitance divided by the total capacitance. An increase in the capacitance of the top hat increases the effective height, whereas an increase in the capacitance of the vertical section actually lowers the effective height.

A technical paper prepared by Nautel entitled "NDB Antennas" provides a means to calculate the operational parameters of a short, vertical radiator (See Attachment 1). This method has been used to compare the Southern Avionics Diamond Portable Antenna to a new design offered by Nautel.

Figure 3 shows the basic configuration of the SAC Diamond Portable Antenna. Its radiating elements comprise six vertical wires sloped apart from the feed point at the base, where they are supported by six monofilament guys. They then continue vertically sloping together to a common point at the top of an insulated support rod that is 36 feet high. The total length of each of the six vertical wires is estimated as 51 feet. Hence, total wire length is 306 feet. Due to the degree of separation of the wires from each other, a capacitance of 1.1 picofarads per foot is estimated (See Attachment 1, Paragraph 3.2).

Hence, total capacitance is 306 x 1.1 = 336.6 picofarads.

As the antenna comprises only vertical radiating components, the effective height is one half of the actual height. ie. H_e = 18 feet.

Using a frequency of 300 kHz, where the wavelength (λ) = 1000 meters or 3280 ft.:
The Radiation Resistance (R_R) =
$160\pi^2(H_e/\lambda)^2$ =
0.0476 ohms
(See Attachment 1, Paragraph 2.2)

Figure 4 shows an improved configuration proposed by Nautel. It uses a similar 36 ft. pole supported on a 40 ft. guying radius. A different arrangement of the radiating conductors is used. The input is fed to a single, 36 ft. long, vertical wire that connects at the top of the support rod to six, 27 ft. long wires that slope downward to six monofilament support points. These six support points are joined horizontally by a hexagon-shaped wire loop that is 108 ft. long. The total length of wire is 306 ft. Hence, at 1.1 pf per ft., like the SAC antenna, the total capacitance is 336.6 picofarads.

The capacitance of the vertical wire (C_m) is 36 x 1.1=39.6 pf

The capacitance of the top hat (C_h) is (27+18) x 1.1 x 6 = 297 pf
Hence, C_m, with an effective height of 18 ft., contributes 11.7% of total capacitance, and C_h, with an effective height of 27 ft., contributes 88.3% of total capacitance. This results in an overall effective height (H_e) of 18 x 0.117 + 27 x 0.883 = 25.94 ft.

Using the same frequency of 300kHz,
Radiation Resistance =
$160\pi^2(H_e/\lambda)^2$ =
0.0988 ohms

Advantages of Nautel Equipment
The Nautel design has twice the R_R value of the SAC antenna. As the radiated power is proportional to the radiation resistance ($P_R = I_a^2 \times R_R$), it can be seen that twice the radiated power can be achieved for the same antenna current with the Nautel design.

The SAC transmitter has an efficiency of 40%, compared to 70% for a Nautel transmitter.

Hence, combining this greater transmitter efficiency with the increased efficiency of the Nautel antenna, a 3.5:1 overall advantage is achieved.

This could translate to either:

- 3½ times the radiated power for the same energy consumption

or

- 3½ times the operating time at the same radiated power level for a given amount of battery energy.

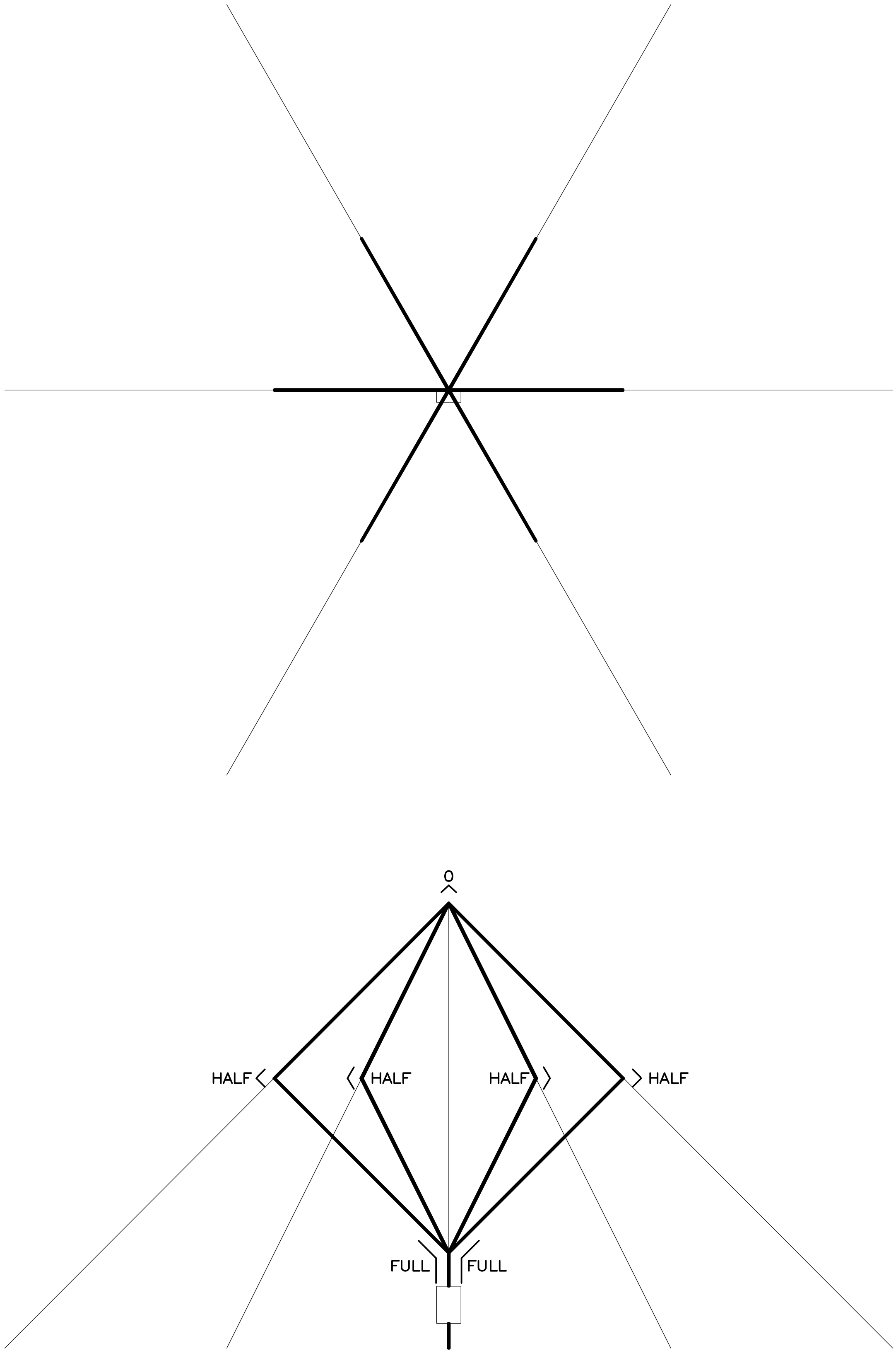

Figure 3 Basic Configuration of Diamond Portable Antenna

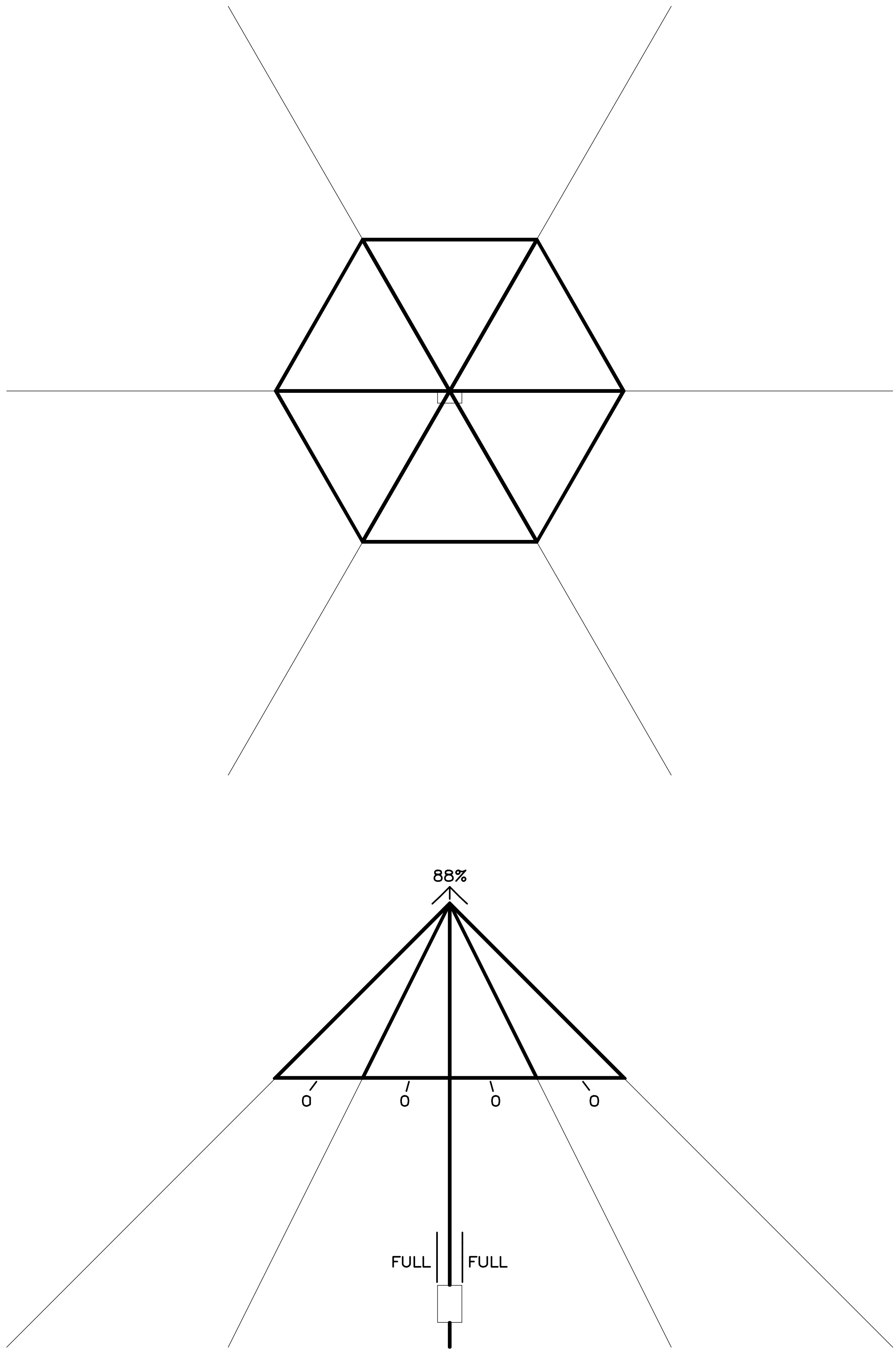

Figure 4 Basic Configuration of Proposed Nautel Antenna