

# Nautel Vector Series

## Non-directional Radiobeacon (NDB) Systems

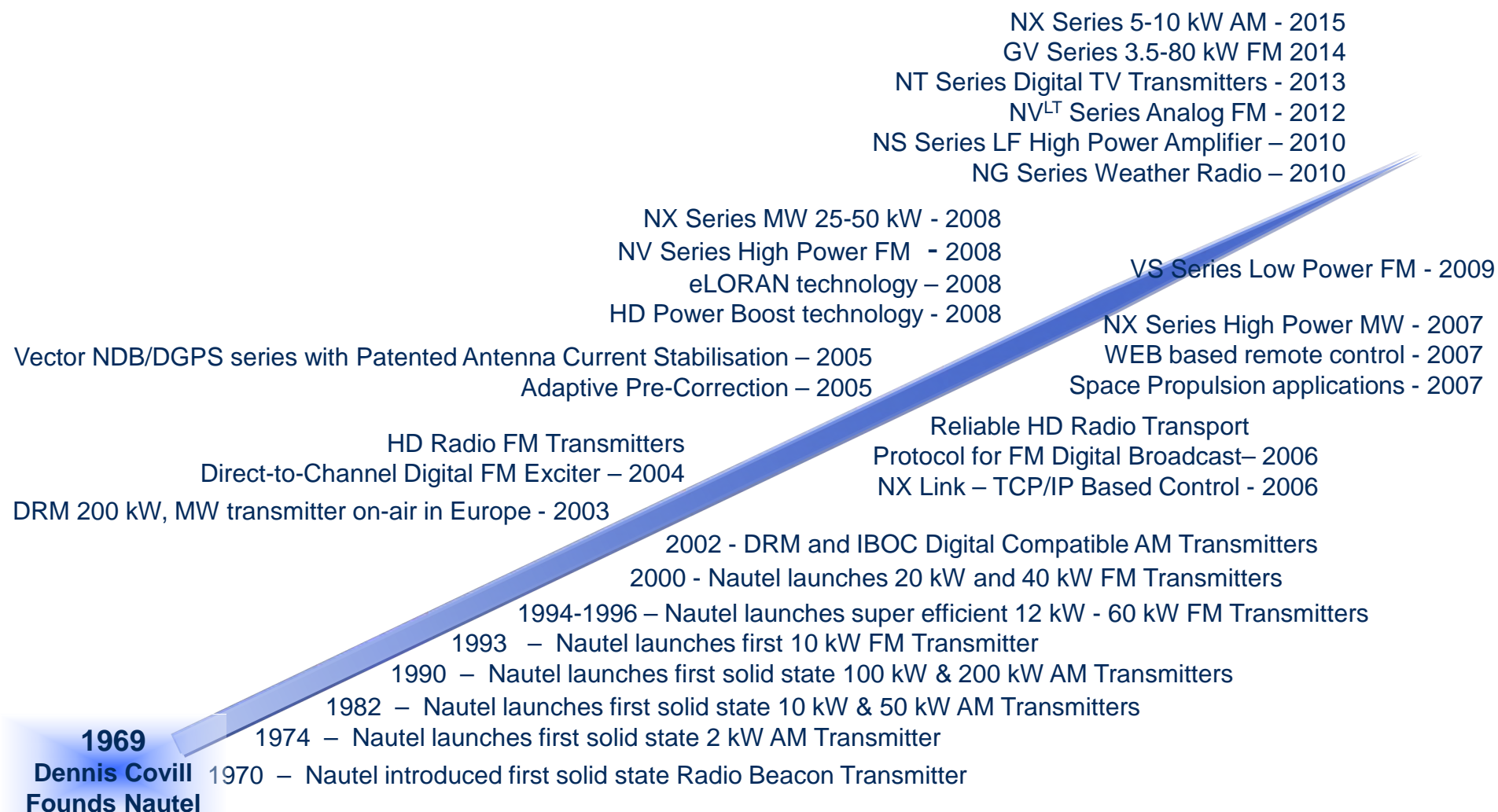
Gary Galbraith, P.Eng.  
Technical Sales Representative,  
Navigational Products



# Corporate History

- Design, manufacture, sales and support of  
**Navigational products**  
**AM and FM broadcast transmitters**  
**Industrial RF & Communications products**  
**Sonar**
- Established in 1969 (**50<sup>th</sup> anniversary in 2019!**)
- Products installed in over 177 countries
- Exceptional field reputation for reliable products
- Dedicated, long-term staff
- Quality Management System audited by Bureau Veritas and registered/certified to **ISO 9001:2015**.

# 50 Year History of Innovation



# Product Lines

- MF AM radio broadcast transmitters (both analog and digital)
- VHF FM radio broadcast transmitters (both analog and digital)
- **LF/MF Navigational non-directional radio beacon (NDB) transmitter systems**
- LF/MF Differential Global Positioning System (DGPS) transmitters
- MF NAVTEX transmitter systems
- HF amplifiers and tuning/matching networks for industrial applications and plasma rocket engines
- Next Generation eLORAN (Long Range Navigation) transmitters
- LF/VLF communications transmitters
- VHF FM weather radio transmitters
- LF Sonar amplifiers

# Worldwide Navigation Customers

**FAA**

**USCG**

**USAF**

**US FHWA**

**CCG**

**NAV Canada**

**AirServices  
Australia**



**World Wide Civil Aviation  
Authorities**

**ONGC**

**Shell**

**INFRAERO**

**SAIPEM**

**ICAO**

**Worldwide Offshore  
Systems Integrators**

# Design Capabilities

- Multidisciplinary Research & Development team of over 40 technical staff
- In-house design skills:
  - Solid state amplifier design from 100 kHz to 200 MHz
  - Antenna Design and Computer Simulation
  - Analog and Digital Communications theory
  - RF matching, combining and filtering at high power and high voltages
  - RF Magnetics
  - Power Supplies
  - Digital Hardware Design
  - Digital Signal Processing
  - Data Communications Systems
  - Networking and TCP development

# Facilities



## **Nautel Limited**

Nova Scotia, Canada:

- Headquarters
- Design, Production
- + 70,000 sq. ft.



## **Nautel Maine, Inc.**

Maine, USA:

- Production
- + 36,000 sq. ft.



## **Nautel C-Tech**

Ontario, Canada:

- Sonar products
- Design, Production

Additional Parts Depots - Memphis, TN USA & Cranleigh, Surrey UK

Customer Service Center – Quincy, IL USA

# Production Capabilities



*Computerised Fabrication Shop*



*PWB Assembly*



*Light Assembly*



*Final Assembly*



*Final Production Test*



*Packing and Shipment*

# Quality Manufacturing

- Quality Management System registered/certified to the **ISO9001:2015** international quality standard
- products built to stringent quality standards with industry leading features, performance, and reliability
- products are the result of the pride and craftsmanship of dedicated professionals
- each product is assembled by a team of individual people - no assembly robots or fabrication lines
- production staff with an average of 15 years experience
- Nautel controls every aspect of production from workmanship to electrical components to sheet metal fabrication

# Product Families

## AM



J1000



NX3



NX5



NX10



NX15



NX25



NX50



NX100 to 2 MW

## FM



VS Series



NVLT Series



GV Series

## Navigation



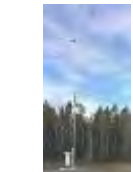
Vector Series NDB/DGPS/Navtex



NDB/DGPS/Navtex Antenna Tuning Units



NL Series Next Generation Loran



LF Antennas

## Industrial RF



HF Amplifier



LF/VLF Comms



NG Series  
Weather Radio Transmitters

## SONAR

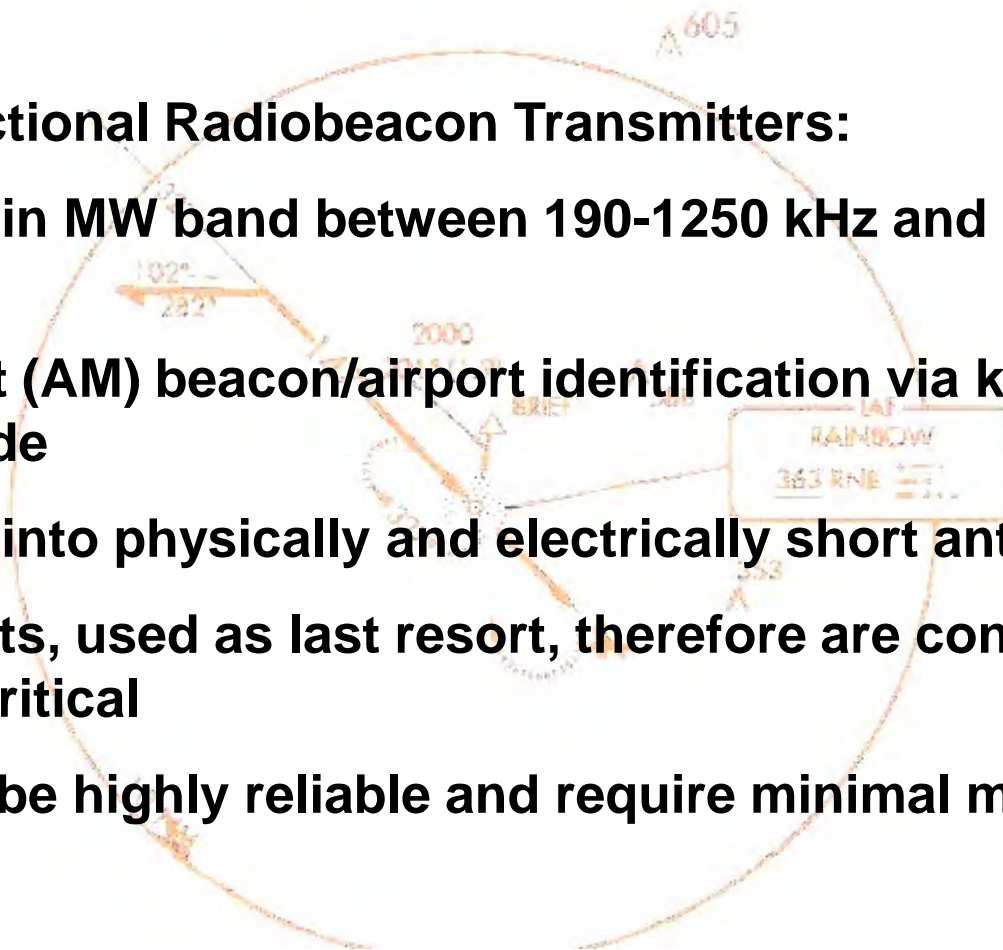


NS Series  
LF High Power Amplifier

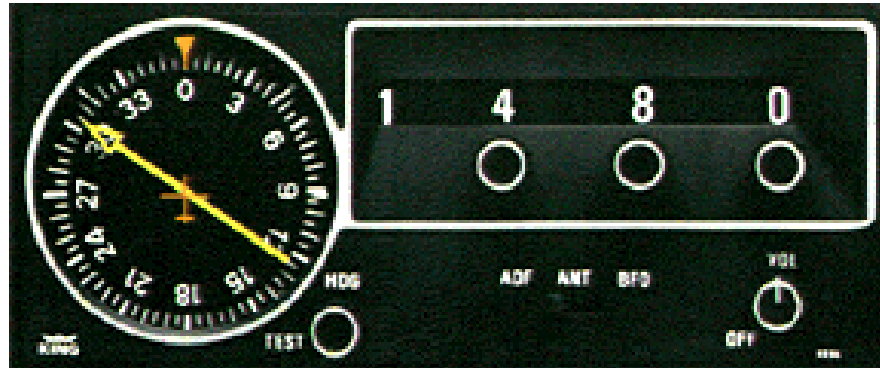
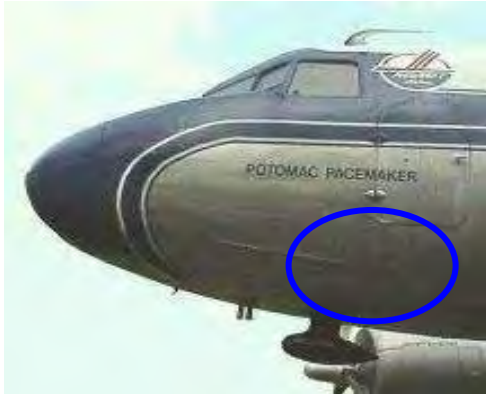
# NDB Overview

## Non-Directional Radiobeacon Transmitters:

- Operate in MW band between 190-1250 kHz and 1600-1800 kHz
- Transmit (AM) beacon/airport identification via keyed Morse code
- Operate into physically and electrically short antenna
- In airports, used as last resort, therefore are considered mission critical
- Need to be highly reliable and require minimal maintenance



# NDB Overview

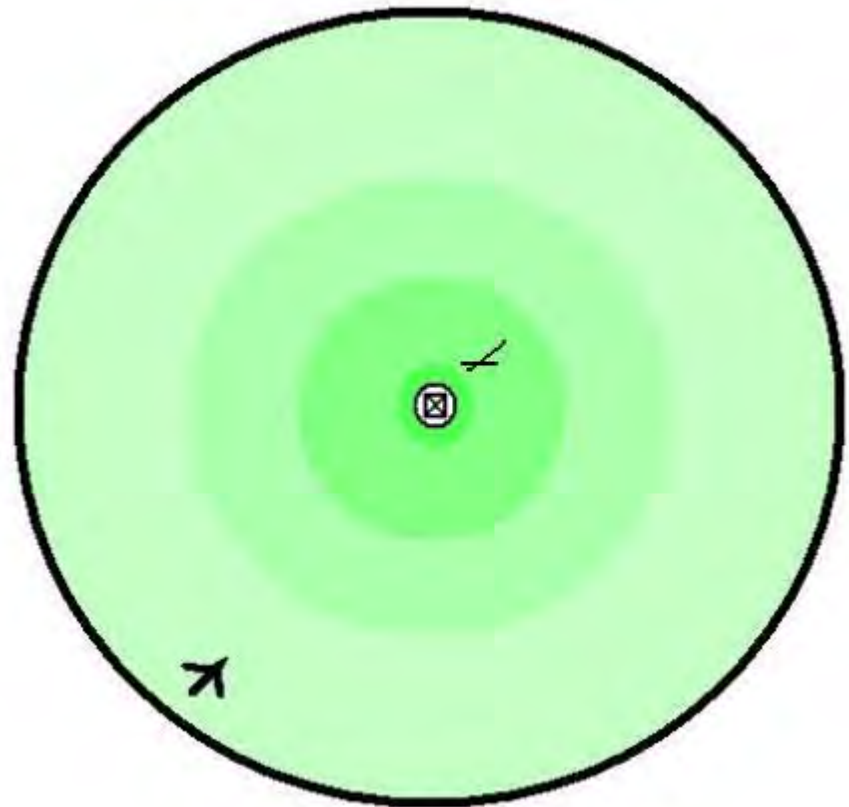


## ADF Receiver:

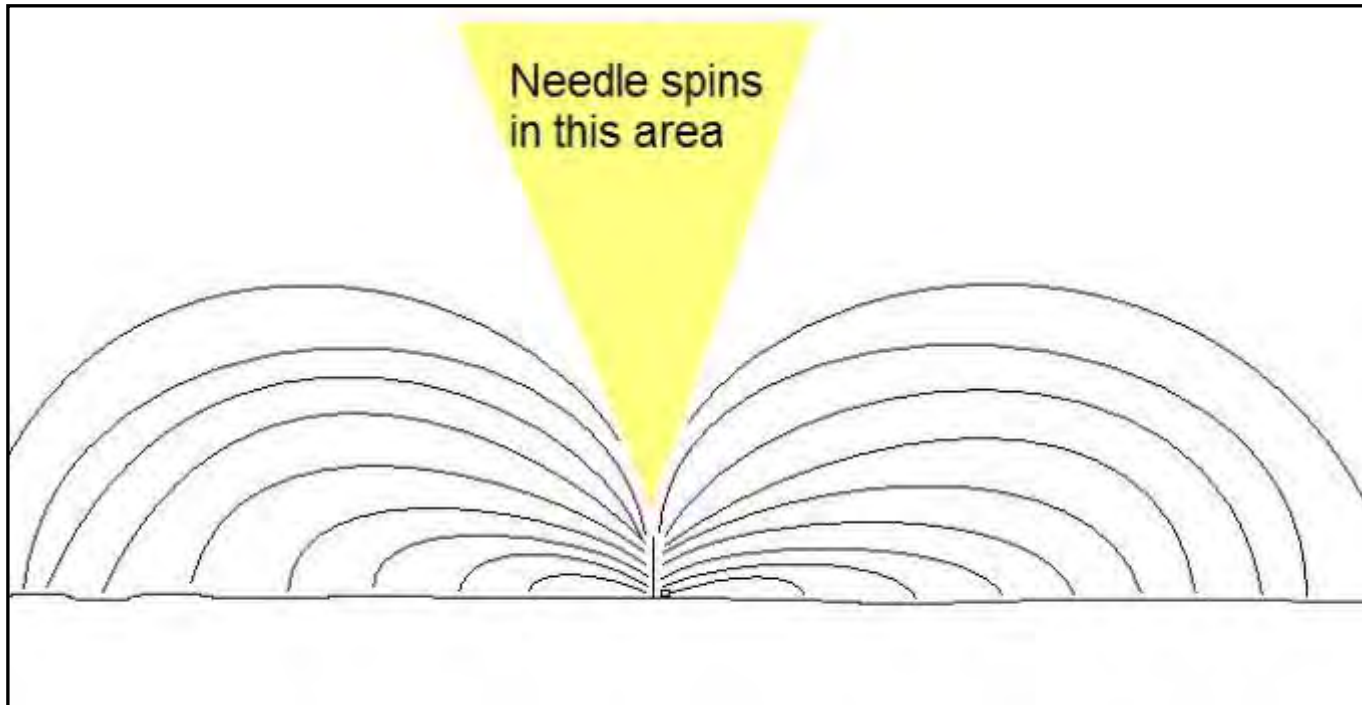
- Located in aircraft, consist of simple frequency selectable receiver, indicator, and rotating antenna
- Acts as field strength meter, with a direction finding needle
- Needle points toward strongest indicated source of selected frequency, based on antenna position
- When target is underneath, needle spins in circles

# NDB Overview

As the aircraft approaches the NDB site, the signal strength increases and the needle indicates the direction of the NDB antenna



# NDB Overview



- In almost all cases, radiation is omnidirectional
- Structures can cause reflections and false readings on cockpit instruments

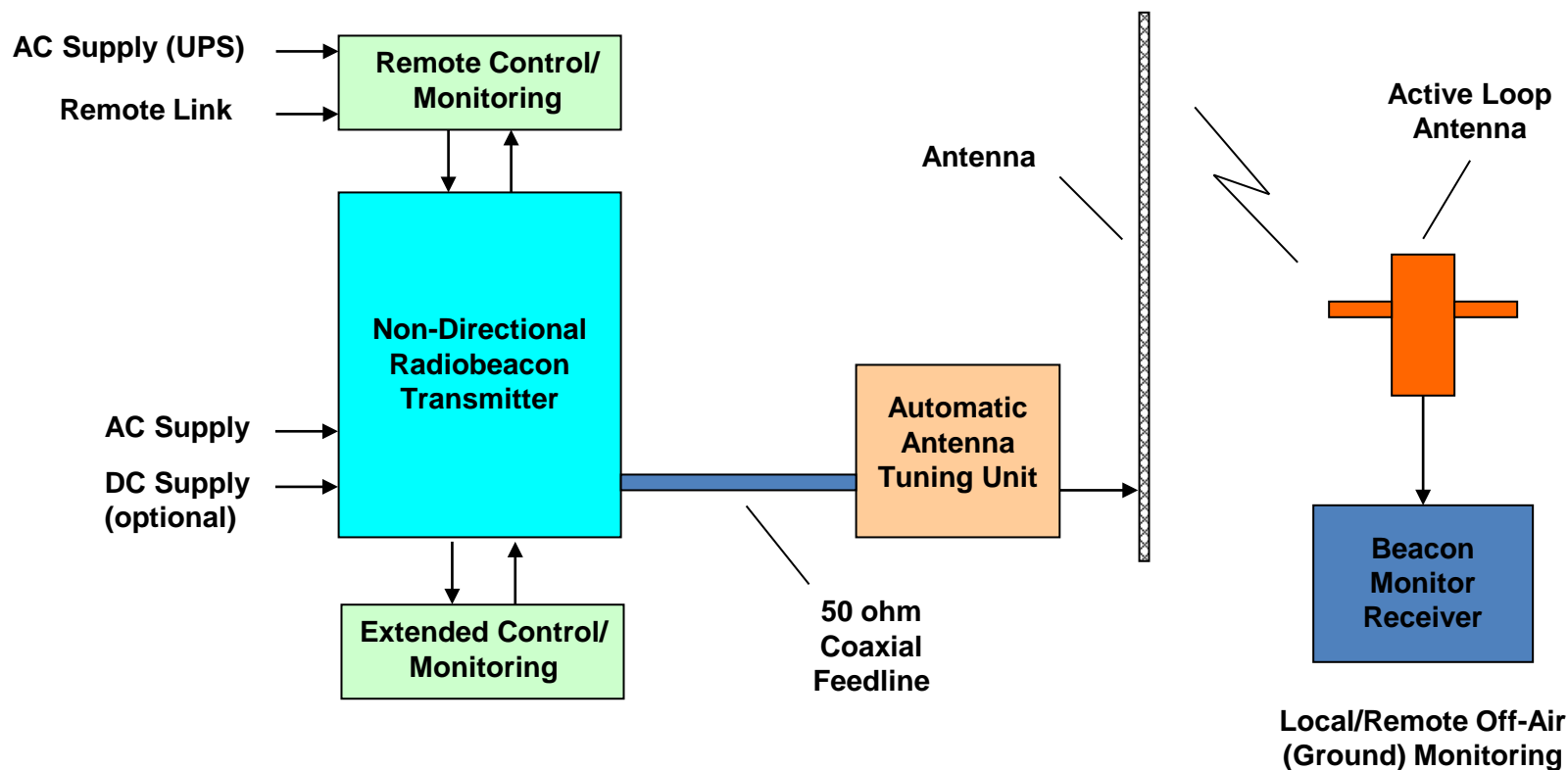
# NDB Overview

NDB sites typically require a high level of reliability and redundancy, with minimal maintenance



# NDB Overview

## TYPICAL NDB SYSTEM



# Vector NDB System Components

**VR125/VR250**



125 W & 250 W NDB

**ATU-LP**



125 W & 250 W NDB

**VR500, VR1000 &  
VR2000**



500 W, 1000 W & 2000 W NDB

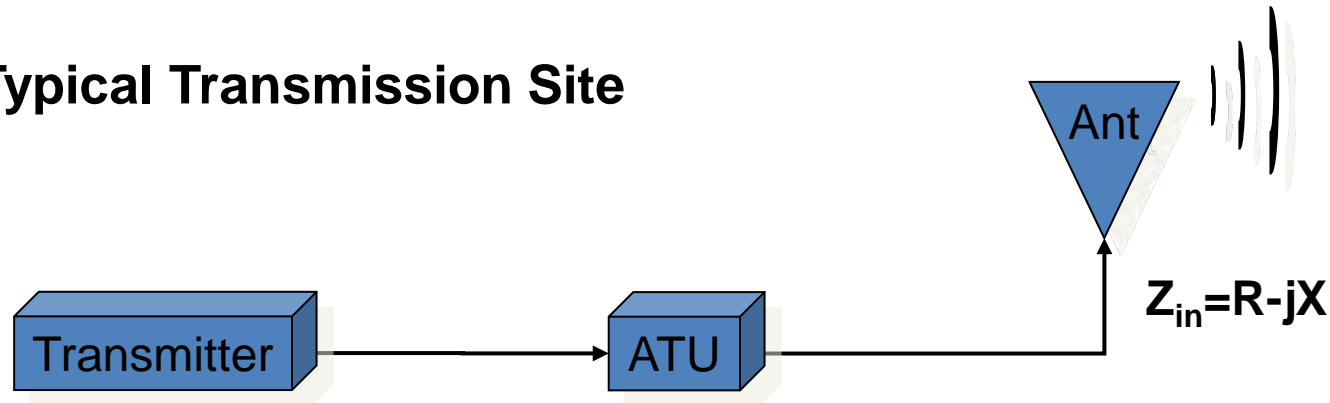
**ATU-HP**



500 W, 1000 W & 2000 W NDB

# Vector System Approach

## Typical Transmission Site

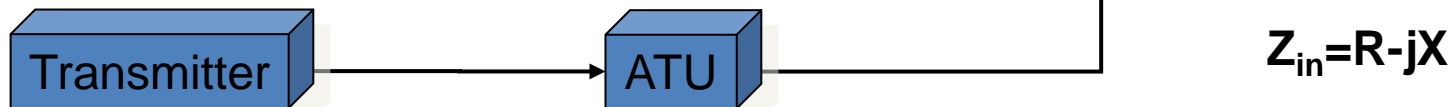


Value of  $X$  typically 100 times greater than  $R$ . Conventional technology resonates  $X$  with an auto-tuned loading coil then matches the resulting  $R$  to 50 ohms required by the transmitter using a tapped matching transformer that is set up on installation.

# Vector System Approach

## Environmental Effects

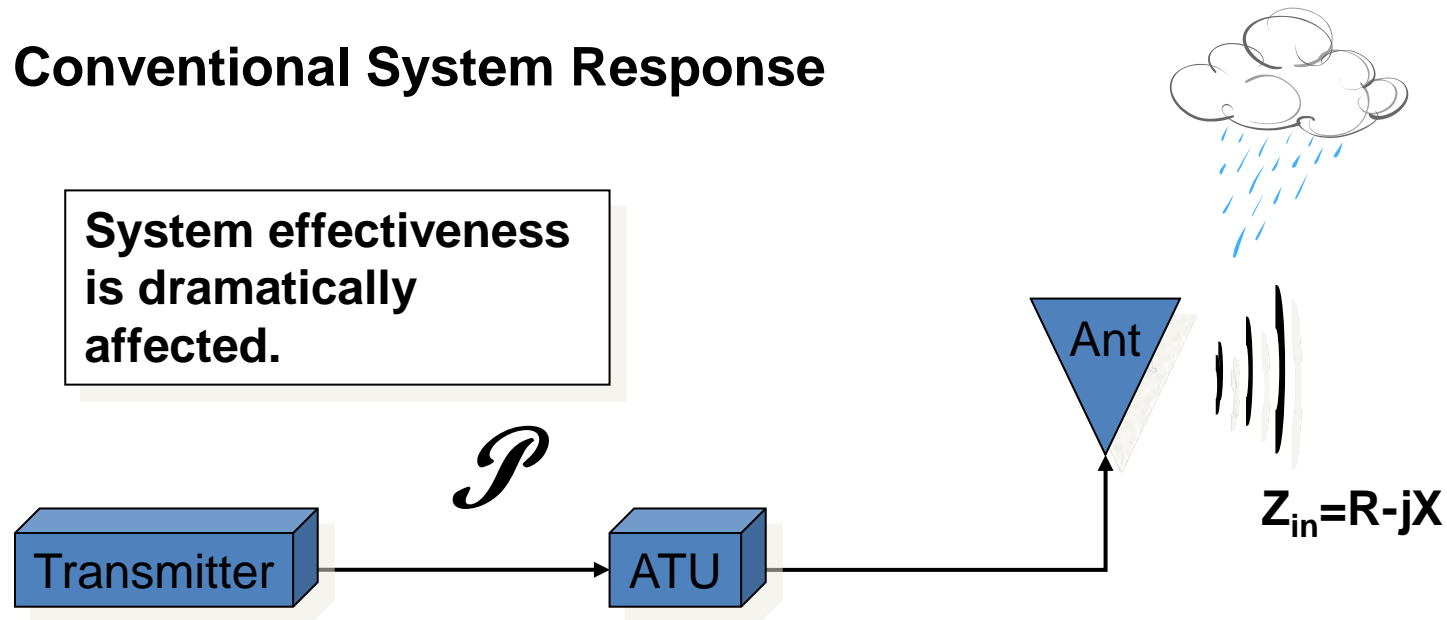
Rain, fog, ice, snow and pollution can change the electrical characteristics of the antenna system



1. Input impedance changes  $R \pm 50\%$   $X \pm 5\%$  causing VSWR and change of antenna efficiency.

# Vector System Approach

## Conventional System Response

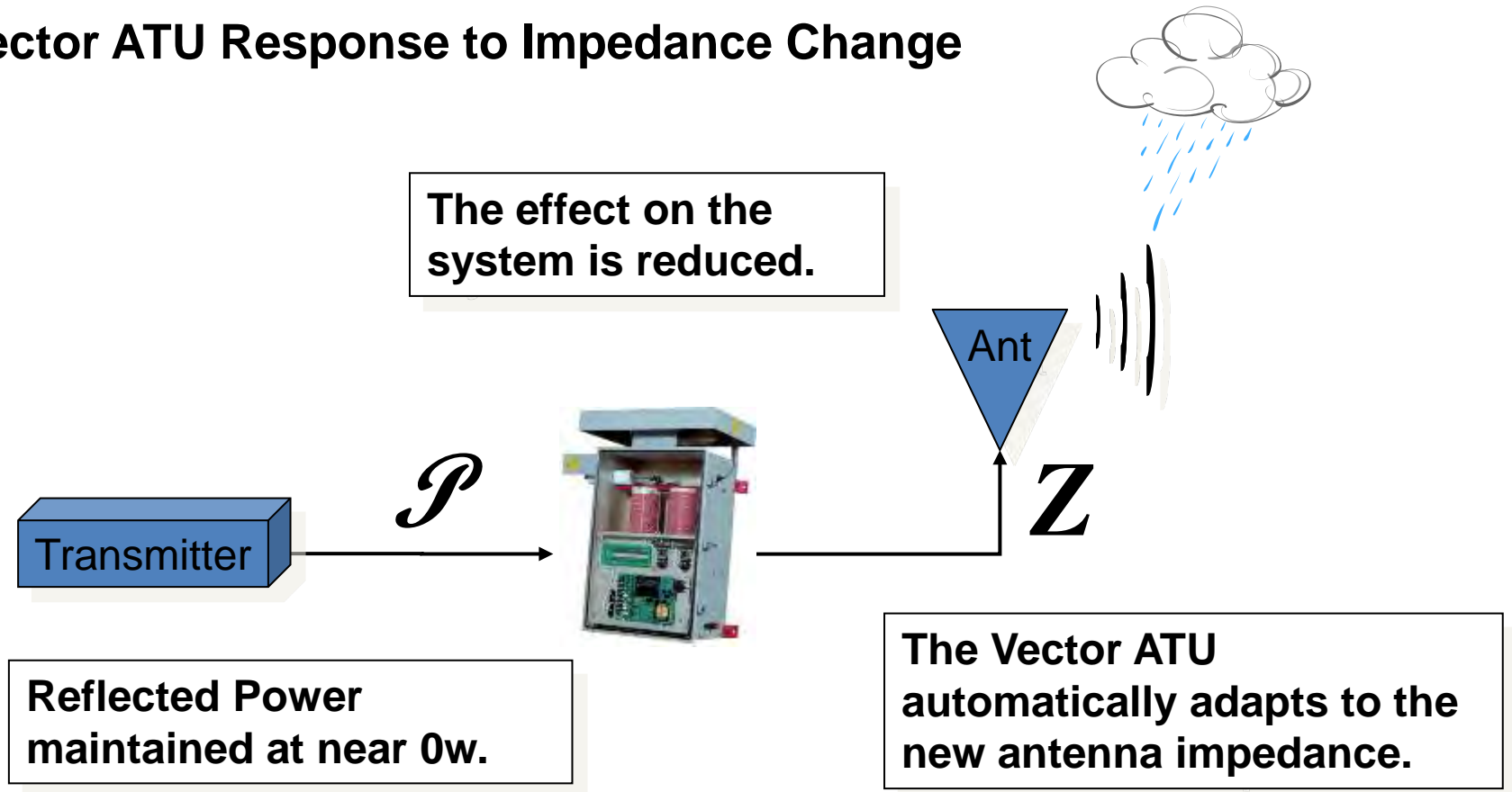


Auto tuning mitigates variation of  $X$ . Change of  $R$  causes two detrimental effects:

- **High VSWR** – Transmitter lowers its output power to reduce resulting reflected power. In extreme cases, transmitter may even shut down.
- **Change of Antenna Efficiency** – Even if transmitter power were maintained constant, the variation of antenna efficiency would cause variation of radiated power. A 50% increase in  $R$  requires a 50% increase in transmitter power.

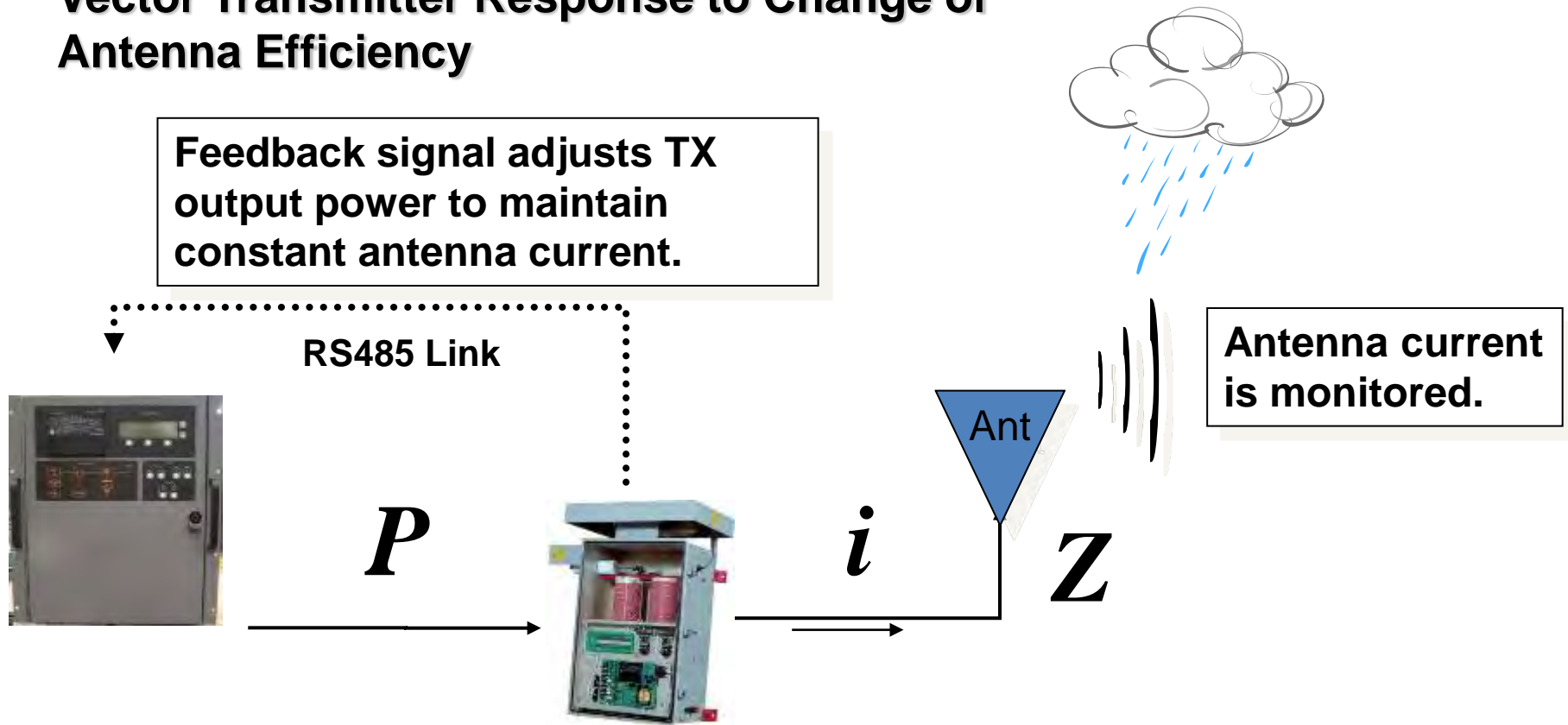
# Vector System Approach

## Vector ATU Response to Impedance Change



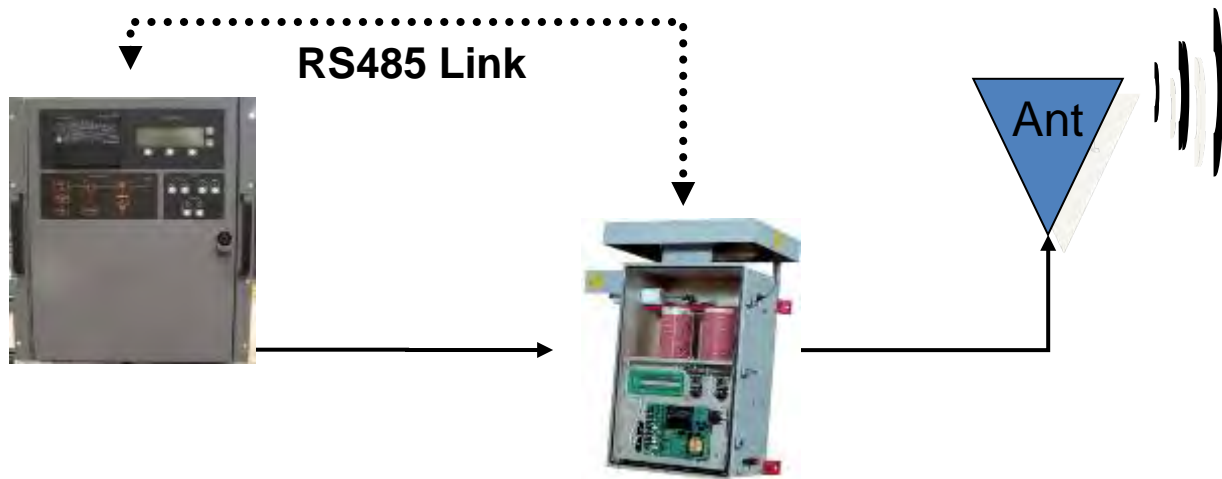
# Vector System Approach

## Vector Transmitter Response to Change of Antenna Efficiency



# Vector System Approach

## RF Field Exposure

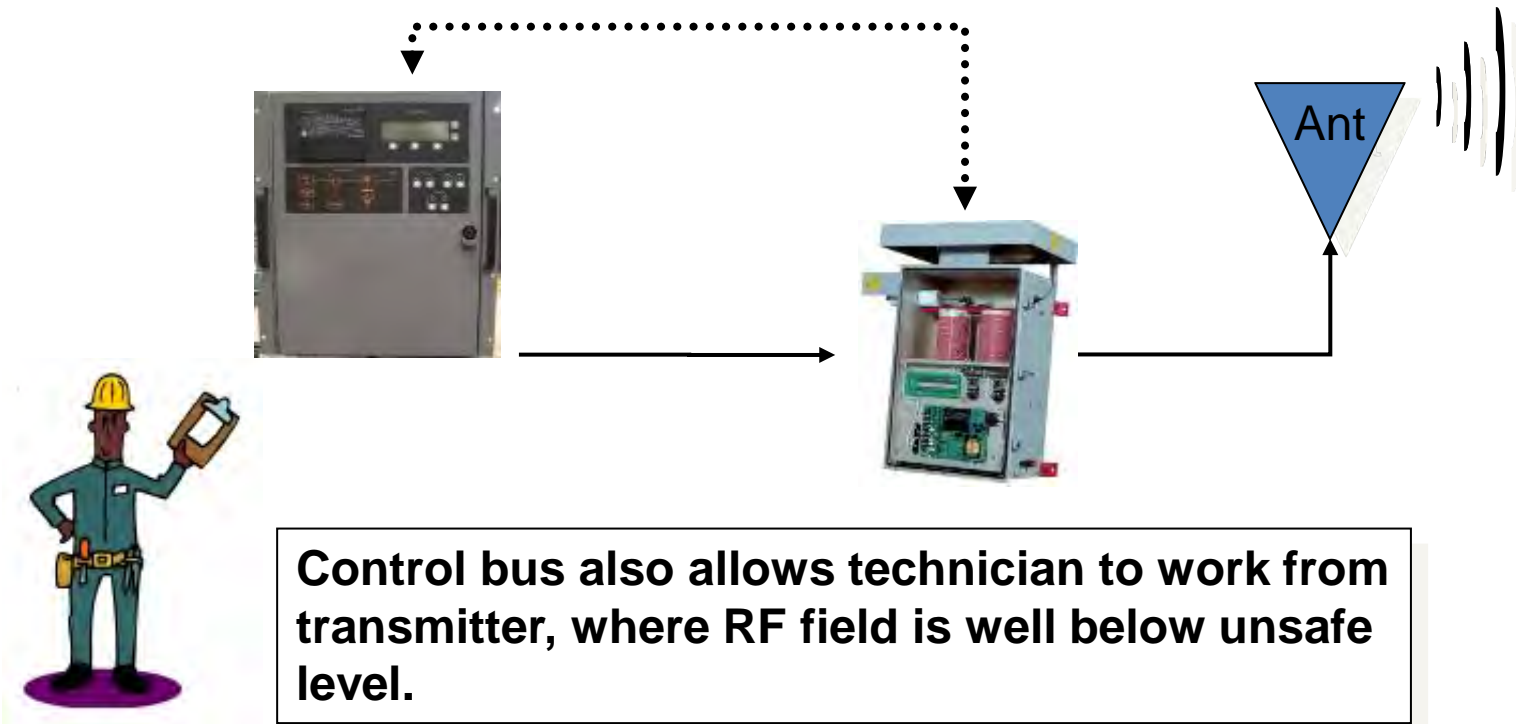


**Unlike manually tuned ATUs, the Vector system reduces the need to expose technicians to the high RF fields near the ATU**



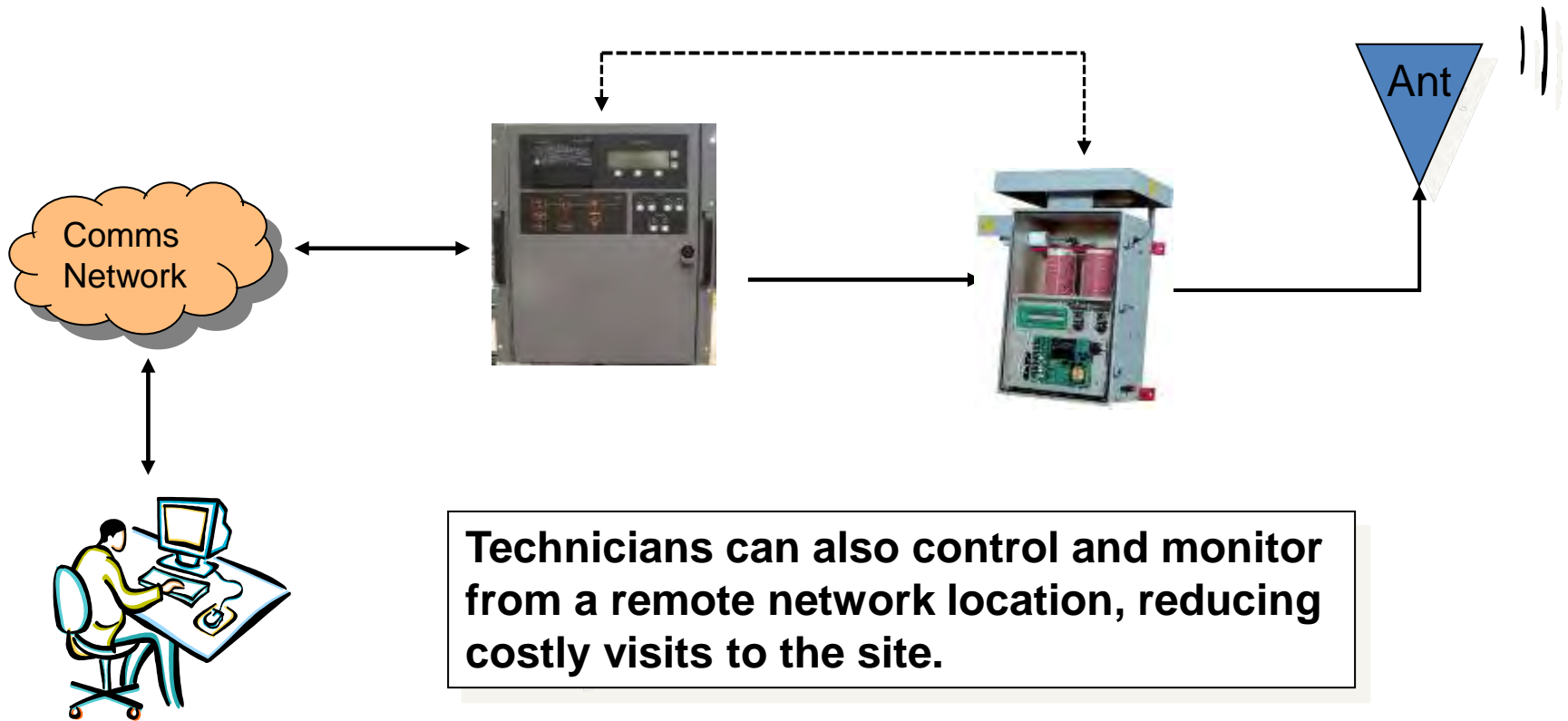
# Vector System Approach

## Vector Remote Control and Monitoring



# Vector System Approach

## Vector Remote Control and Monitoring



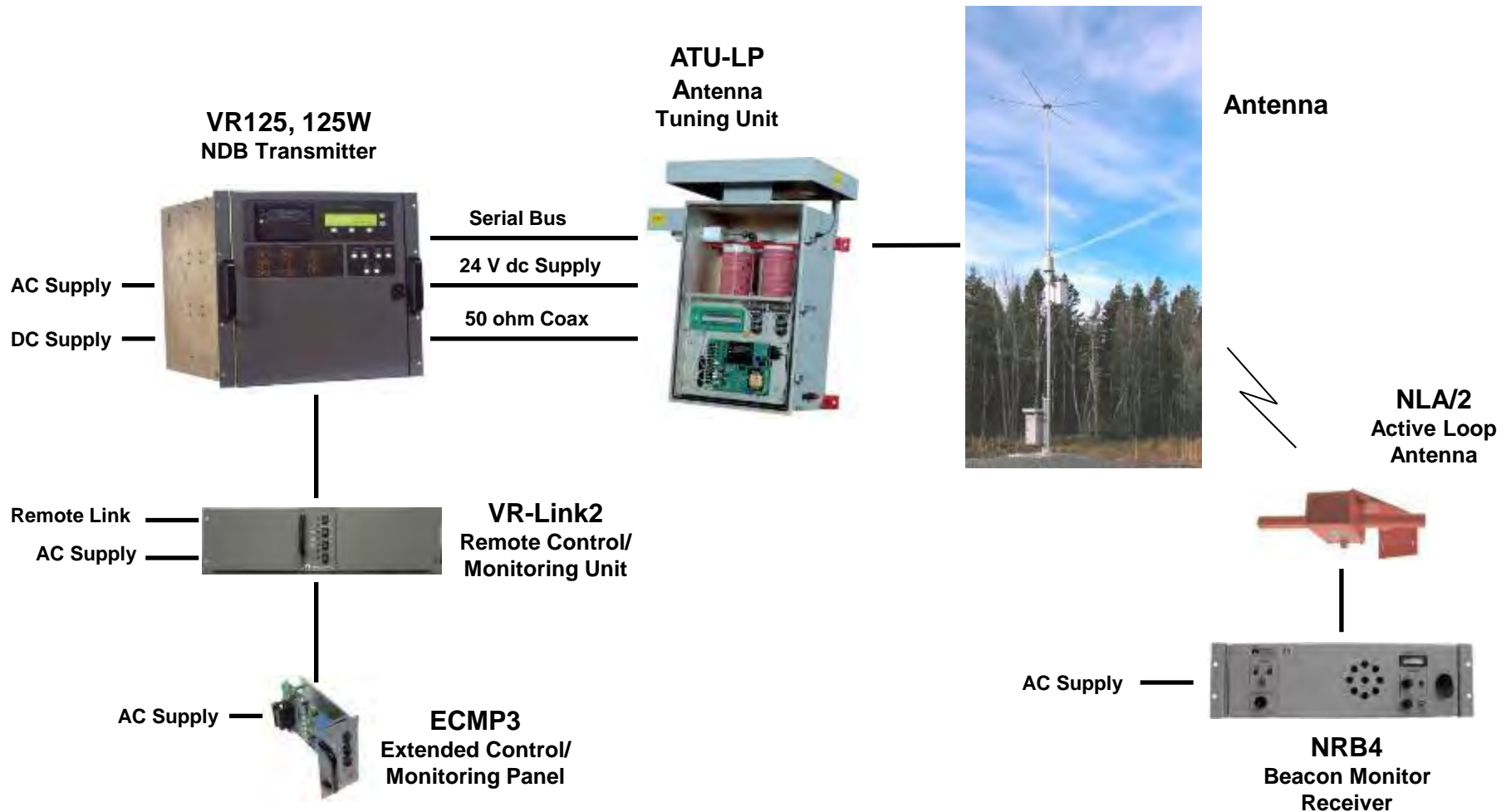
Remote Network Location

# Vector NDB Transmitters

- Patented solution to maintain system coverage regardless of undesirable antenna effects such as ground resistance changes
- Built in Diagnostics allows the user to easily identify fault to Lowest Repairable Unit locally or remotely
- Non operational side can be tested locally or remotely without need for dummy load while main side remains on air
- Available in Single and Dual Configurations
- Remote control and monitor of the ATU limits worker exposure to strong RF fields
- Enhanced Remote Control/Monitor to extended and remote control/monitoring locations



# 125 Watt Vector NDB System



# VR125/VR250 (125W/250W) NDB Transmitter

## Exciter/Monitor

- Available with Single or Dual Direct Digital Synthesizer, LVPS, modulator driver, keyer, monitor
- Analog and digital metering
- Remote Interface with several standard and optional configurations
- Simple LCD graphical user interface



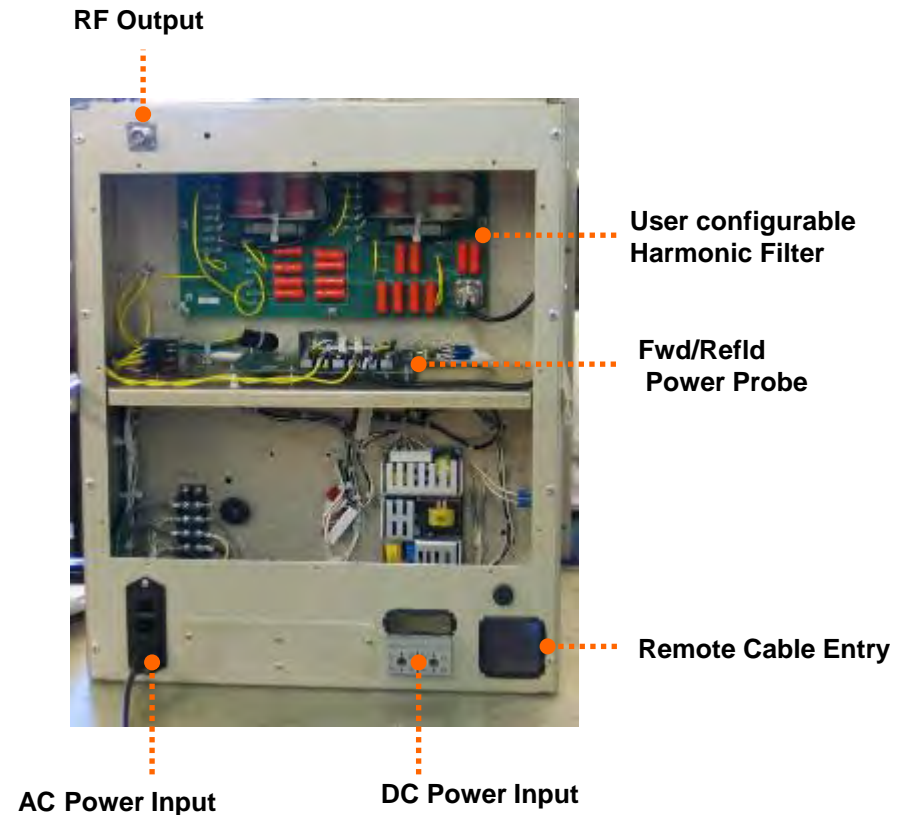
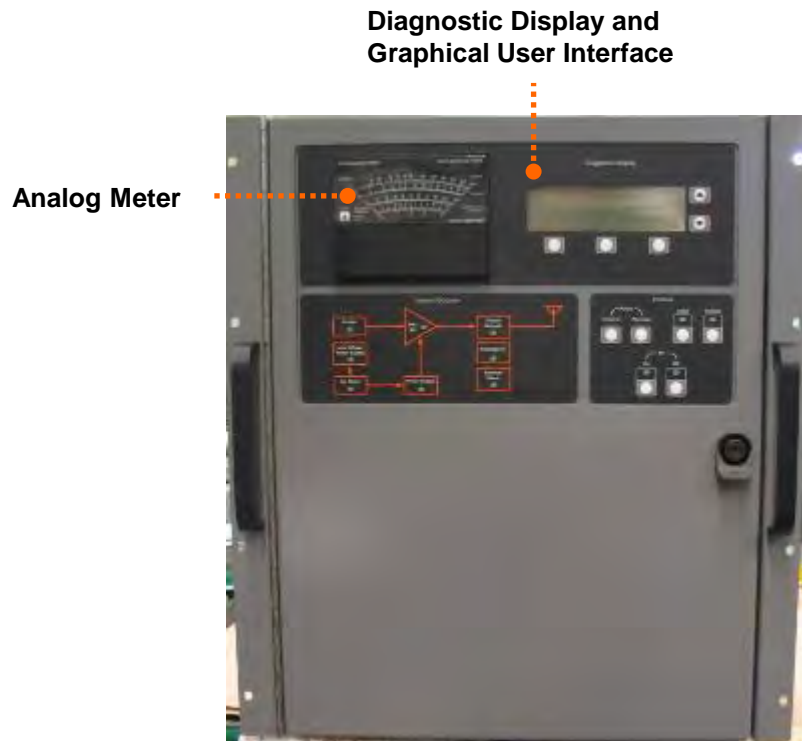
## 125 W RF Power System

- Available with Dual or Single Highly efficient power modules containing PAs, modulators, SMPS
- Frequency agile harmonic filter

## Back-up DC Supply Option

- +24 V dc or + 48 V dc Input is optional with reverse polarity protection and low voltage disconnect
- External +24 V dc or + 48 V dc Battery charger available

# VR125/VR250 Front and Rear View



# VR125/VR250 Graphical User Interface & Display

## Analog Meter

User configurable display including, but not limited to, any one of any one of the following parameters: Forward Power, Reflected Power, Antenna Current, Modulation Percentage, DC Voltages, DC Current, VSWR, AC Voltage, Transmitter Temperature and PA Volts



## Diagnostic Display

Allows complete local transmitter and ATU control, status and local/remote health monitoring and provides a 256 event log

## System Diagram

Provides user with local display of the status of the critical blocks within the transmitter

# VR125/VR250 - 125 W/250 W Power Module



Highly Efficient  
Pulse Duration Modulator (PDM)

PDM Filter

Highly Efficient  
Class D Power Amplifier

Impedance Matching  
RF Transformer

Switch Mode Power Supply

- 90 V ac to 270 V ac (Vector 125)
- 170 V ac to 270 V ac (Vector 250)
- 47 Hz to 63 Hz
- No adjustments necessary

# VR125/VR250 Exciter

## Direct Digital Synthesizer

Single channel with 100 Hz steps having a Frequency Stability of  $\pm 0.0003\%$  over full environmental range

## Exciter Interface

Contains circuitry to switch exciters when dual and provides interface between exciter pwbs and the other blocks contained in the transmitter



## Exciter/Monitor/Generator

Monitors critical ICAO parameters and contains microprocessor controlled keyer for ease of programming of 1,2,3,4,5 or 6 Morse letters or numbers, Frame lengths of 4 to 20 seconds, Sequence repetitions, standby codes and Keyed Tone Frequencies of 400 Hz or 1,020 Hz  $\pm 5\%$

## Modulator Driver Pwb

Creates the low level drive signal for the Pulse Duration Modulator which includes line voltage compensation

## +24 VDC Supply Output for ATU

# VR125/VR250 Control/Monitor

## Liquid Crystal Display

## Control/Display Pwb

Performs most of the operations associated with control, monitor, protection and display for the transmitter. It is essentially the "brain" for the Vector.

## Speaker

Allows user to audibly monitor the Identification Code

## Sonalert

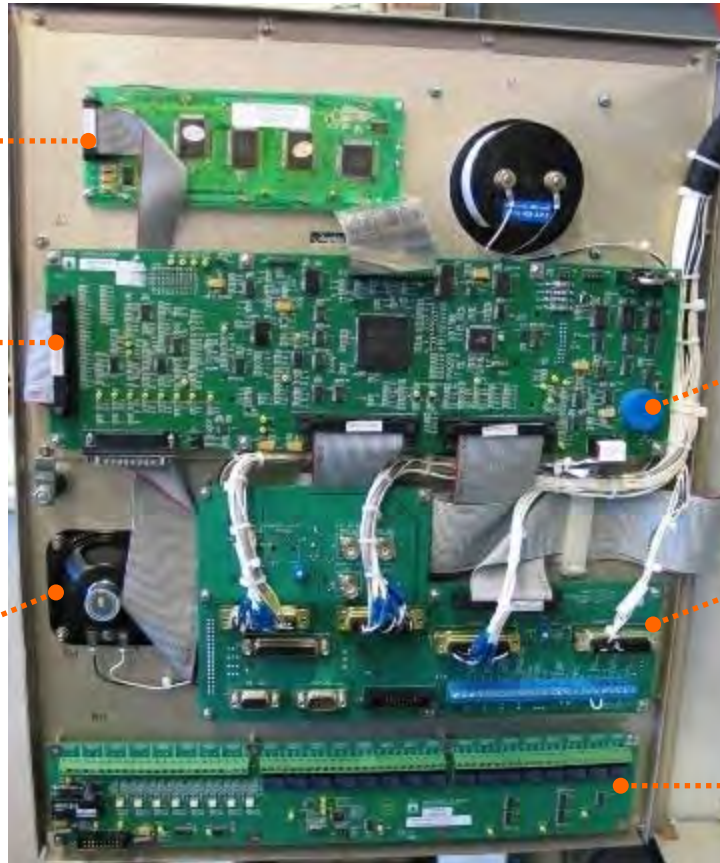
Provides user capability to configure alarms to be audible

## Remote Interface

Contains user interface connections for ATU Control/Monitor and Remote Control/Monitor

## Site Control/Monitor

Contains 16 optically isolated monitor inputs and 16 form C contact relay closure control points to allow the Vector local or remote control/monitor to control/monitor other equipment at the site



# VR500/VR1000/VR2000 Transmitter Overview

## Exciter/Monitor

- Dual Exciter and Critical Monitor available
- Analog and digital metering
- Enhanced Remote Control/Monitor
- Simple LCD graphical user interface

## AC Distribution

- AC Circuit Breaker is optional



## Power Probe and Series Combiner

## RF Power Blocks

- Highly efficient and hot pluggable dual power modules containing PAs, modulators, SMPS
- Frequency agile harmonic filter
- Cost effective field upgrades to higher power level

## DC Distribution

- +48 V dc or +144 V dc Input is optional with reverse polarity protection and low voltage disconnect
- +48 V dc Battery charger can be installed internally

# NDB Antenna Tuning Units

**ATU-LP**



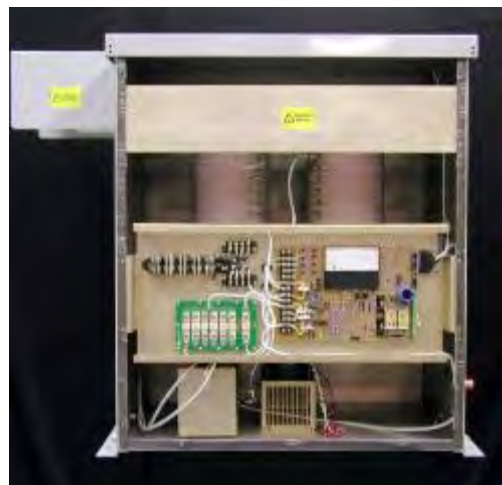
125 W & 250 W NDB

**ATU500SR**



125 W NDB

**ATU-HP**



500 W, 1000 W & 2000 W NDB

# NDB Antenna Tuning Units

ATU-LP

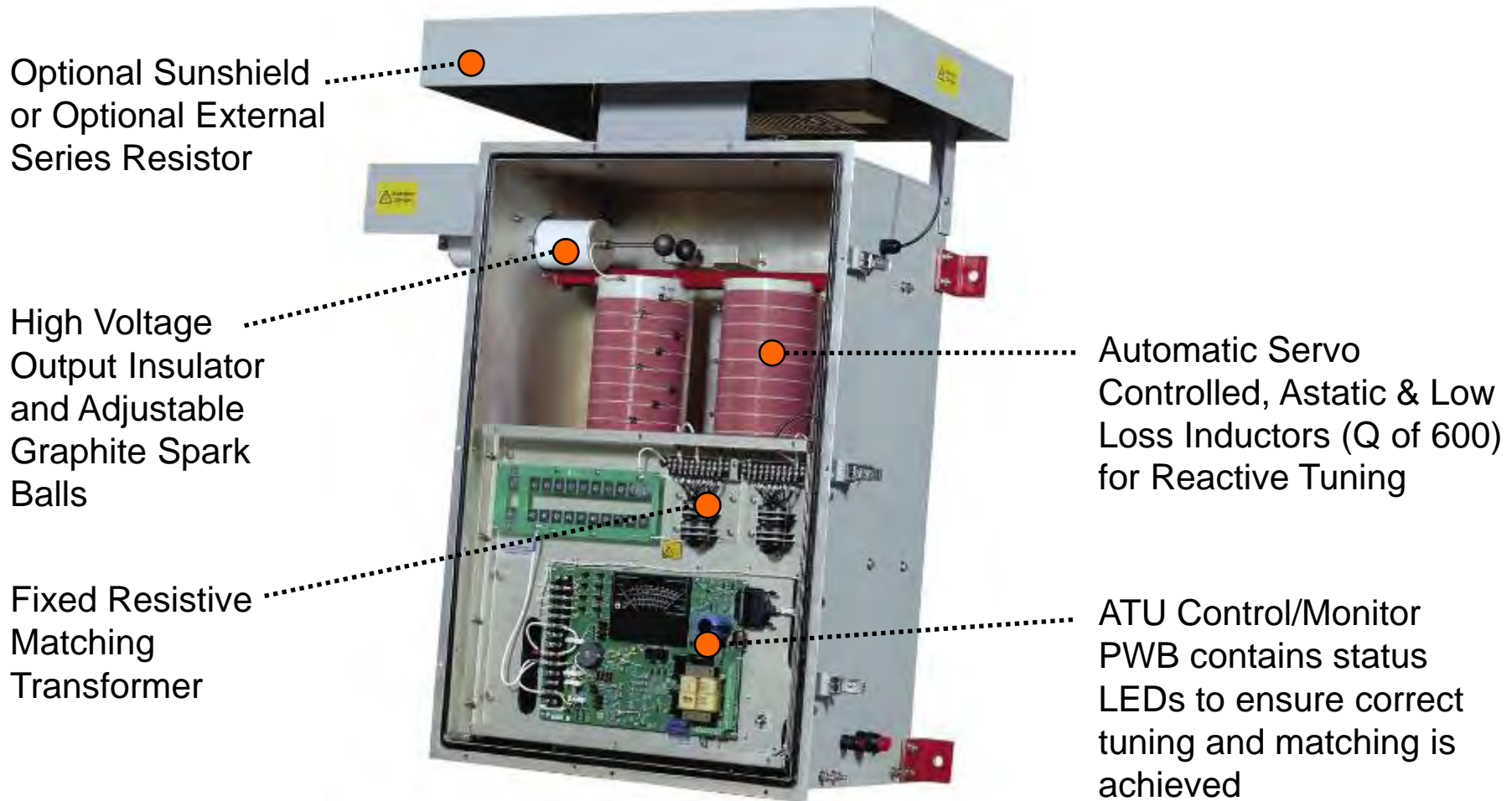


- Automatic Resistive Matching (ATU-LP & ATU-HP)
- The serial data link between the ATU and the Vector transmitter stabilizes the antenna current, and the radiated power, by automatically adjusting the transmitter output power
- Remote control and monitor of the ATU limits worker exposure to strong RF fields
- An external resistor bank for the ATU adds additional resistance in series with the antenna, optimizing the trade-off between antenna bandwidth and efficiency

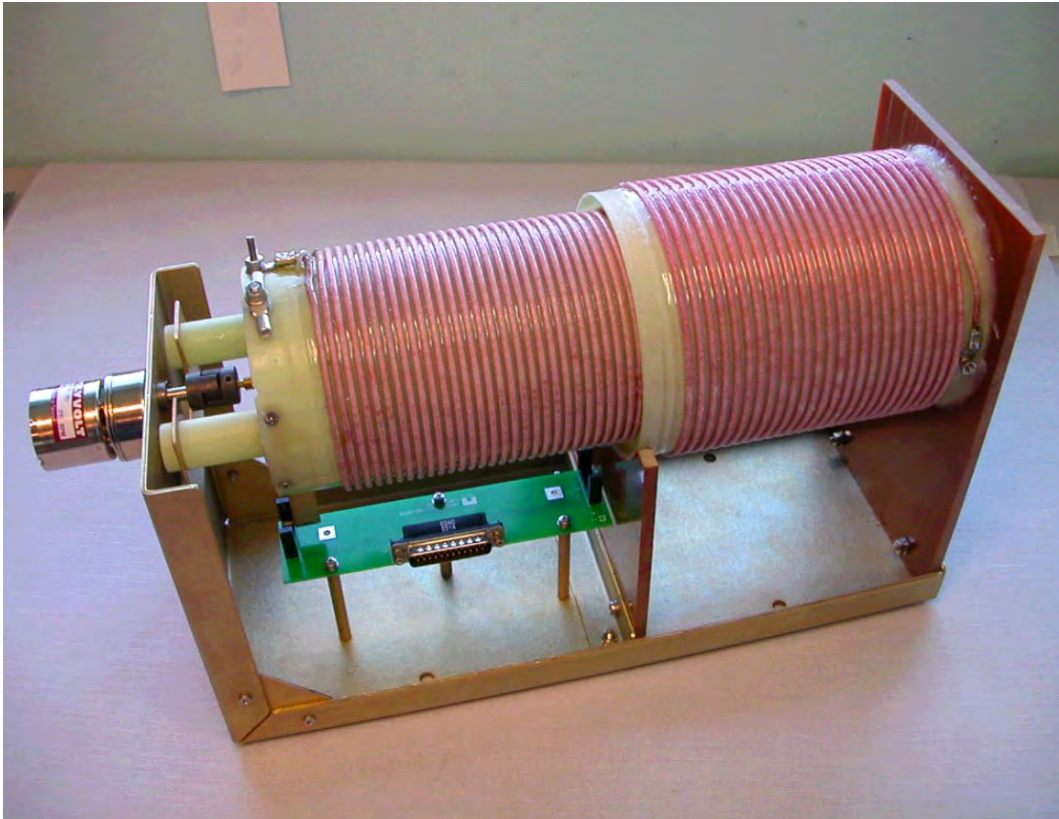
ATU-HP



# Vector ATU-LP Overview



# Automatic Resistive Matcher



Servo Controlled

Mutually Coupled Inductors

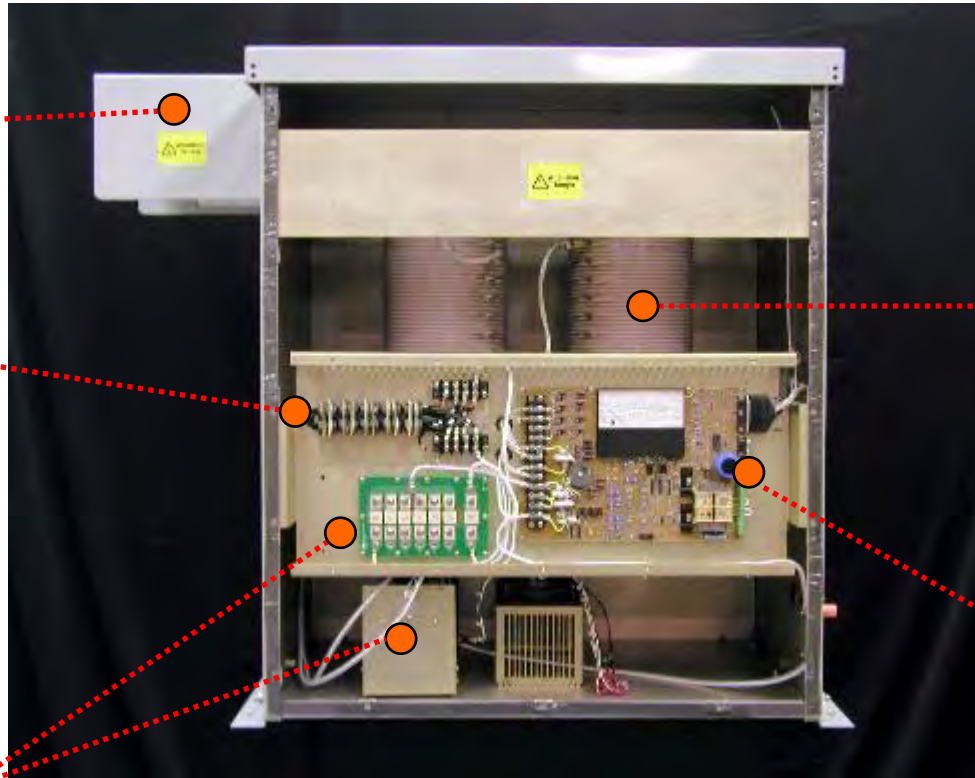
$\pm 2:1$  change in resistive load  
(or 4:1) overall

# Vector ATU-HP Overview

High Voltage  
Output Insulator

Fixed Resistive  
Matching  
Transformer

Automatic Servo  
Controlled Resistive  
Matcher



Automatic Servo  
Controlled and Low  
Loss (Q1000)  
Astatic Inductors for  
Reactive Tuning

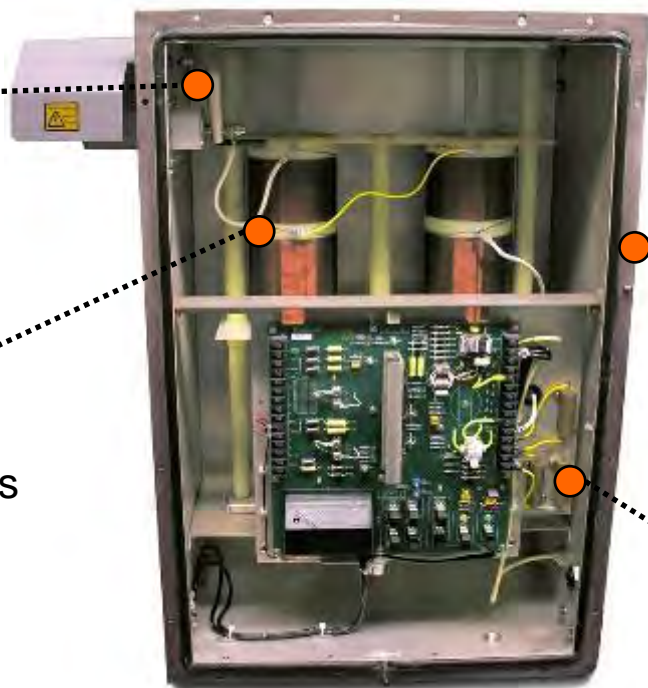
ATU Control/Monitor  
PWB contains status  
LEDs to ensure  
correct tuning and  
matching is achieved

# ATU500SR Antenna Tuning Unit

## ATU500SROS

Adjustable Spark Gap  
with intrinsic static drain

Servo Controlled and  
Automatic Fine Tuned  
Astatic pair of Loading coils  
which can be connected in  
series or parallel for  
maximum agility



IP66 rated enclosure  
manufactured from Marine  
Grade Aluminum with  
protective finish suitable for  
global environments

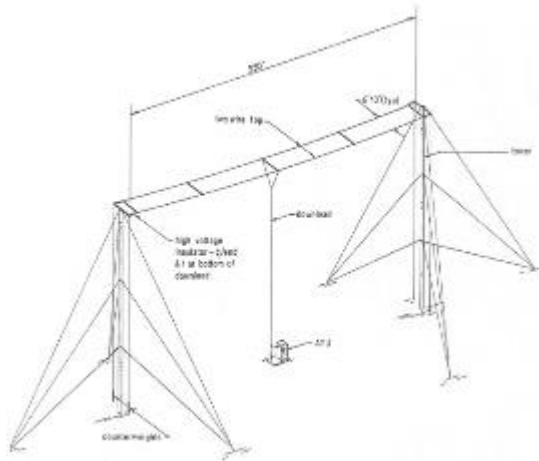
Bandwidth Optimization to  
minimize VSWR, sideband  
attenuation and distortion as  
compromise between bandwidth  
and range

# NDB Antennas

**CL-40**  
(Nautel Manufactured)



**T-20/T-35/T-50**  
(Nautel Manufactured)

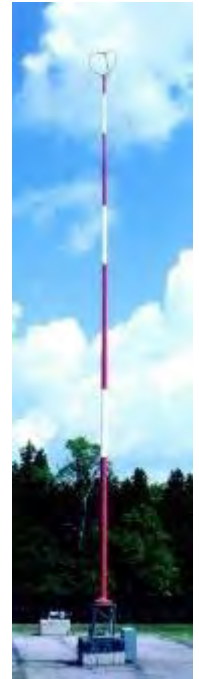


## Base Insulated Monopoles (Vendor Item)



### Whips

(Vendor Item)



# Antenna Performance Notes

- The minimum bandwidth required for 400 Hz modulation should be in excess of 800 Hz and for 1020 Hz modulation should be in excess of 2040 Hz.
- Modulating tone which exceeds the bandwidth will result in significant sideband attenuation, inability to achieve 95% modulation and VSWR at the transmitter.
- The addition of series resistance (available as standard in the ATU500SR and optionally in the ATU-LP) can be used as a trade off between bandwidth and range if necessary
- The ATU500SR/ATU-LP will not tune most whip antennas below 250 kHz due to the low capacitance of the antenna.



# ECMP3 – Extended Control/Monitor



- Extended control and monitor functions within a maximum distance of 152 m (500 ft) from the VR125 NDB transmitter.
- 7 visual system indicators (LEDs) and indicator Test switch. LED brightness is adjustable to one of three levels.
- 2 switches for remote command and 1 user configurable spare command switch.
- User configured and enabled timer and audible alarm.
- User configurable to remotely control/monitor any of the Vector System's remote control/monitor points.
- Site Interface PWB for VR125 transmitter required.

# ECMP3 – Extended Control/Monitor

## **SONALERT**

The ECMP3 contains a Sonalert, which can be configured to provide an audible indication that a monitor point is asserted.

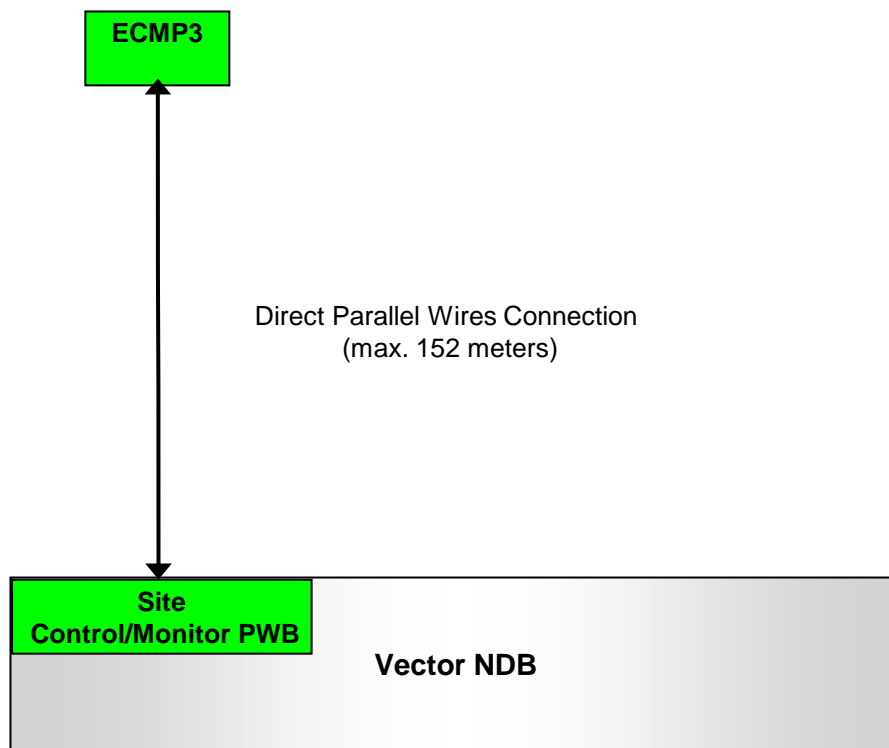
Each monitor point can be configured to independently activate the Sonalert.

Sonalert volume is adjustable to one of three levels.

The Sonalert may be configured to sound when a monitor point activates or when a monitor point activates or de-activates (alarm occurs or alarm disappears).

The Acknowledge momentary push button switch is used for silencing an audible alarm event.

# Vector NDB & ECMP3 Interconnection



# Vector NDB RCMS via VR-Link2



- Economical means of remote control/monitor of one Vector NDB system.
- Standard VR-Link2 connections to the NDB include RS232 & RS422. Optional leased line/dial-up modems and Wired/Wireless Serial Server connections for network applications are also available.
- Complete control/monitor of the NDB transmitter and ATU using a text based display via hosted web page.
- ECMP3 (Extended Control/Monitor Panel) can be integrated into VR-Link2 or a total of 3 ECMP3's can be connected externally to the VR-Link2 via RS-485 serial communication.

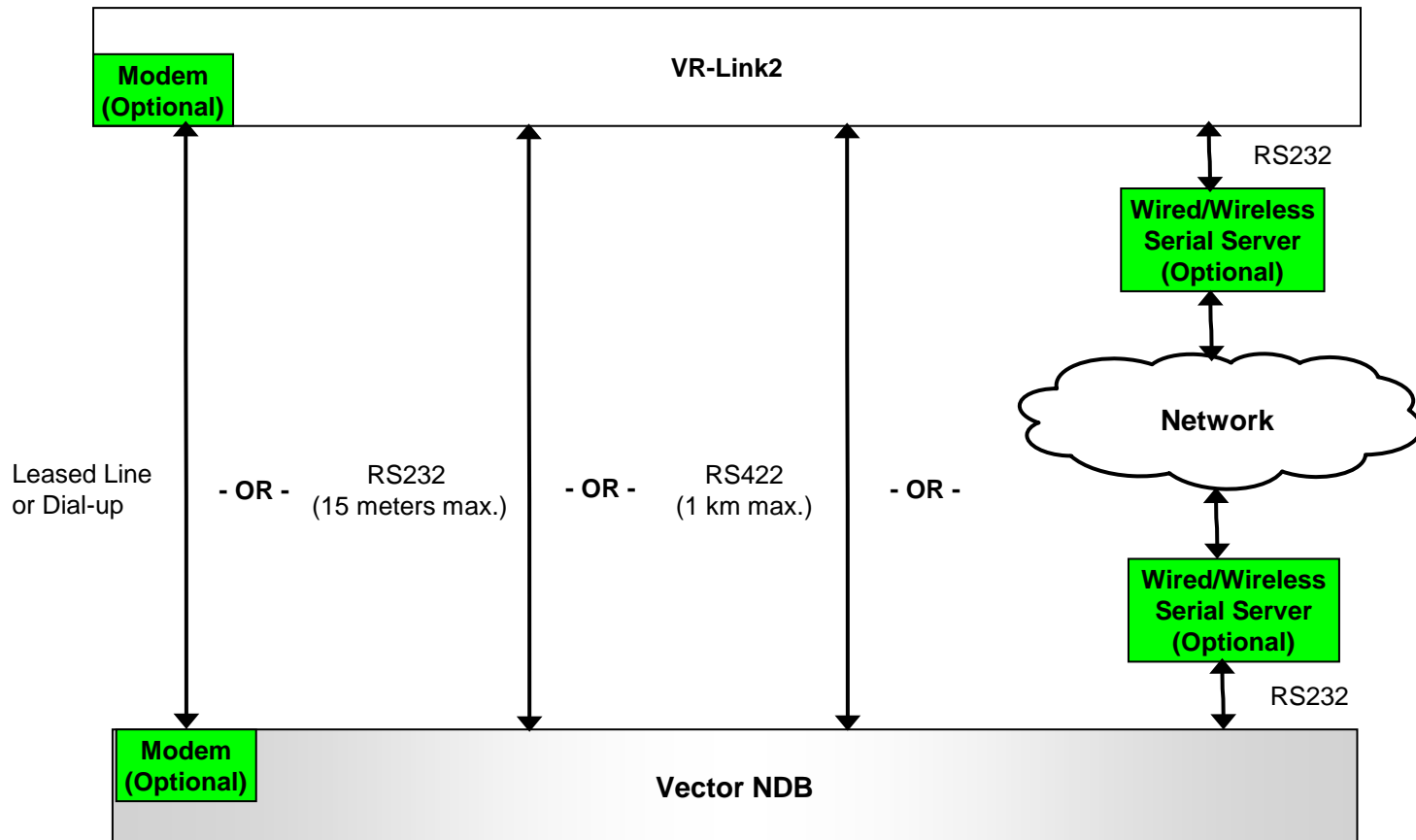
# VR-Link2 - Web Based RCMS

- Web based remote monitoring and control of NDB system
- Remote access to alarm/information logs
- Email reporting of critical alarms, upon request
- Data server for integration with existing remote control equipment

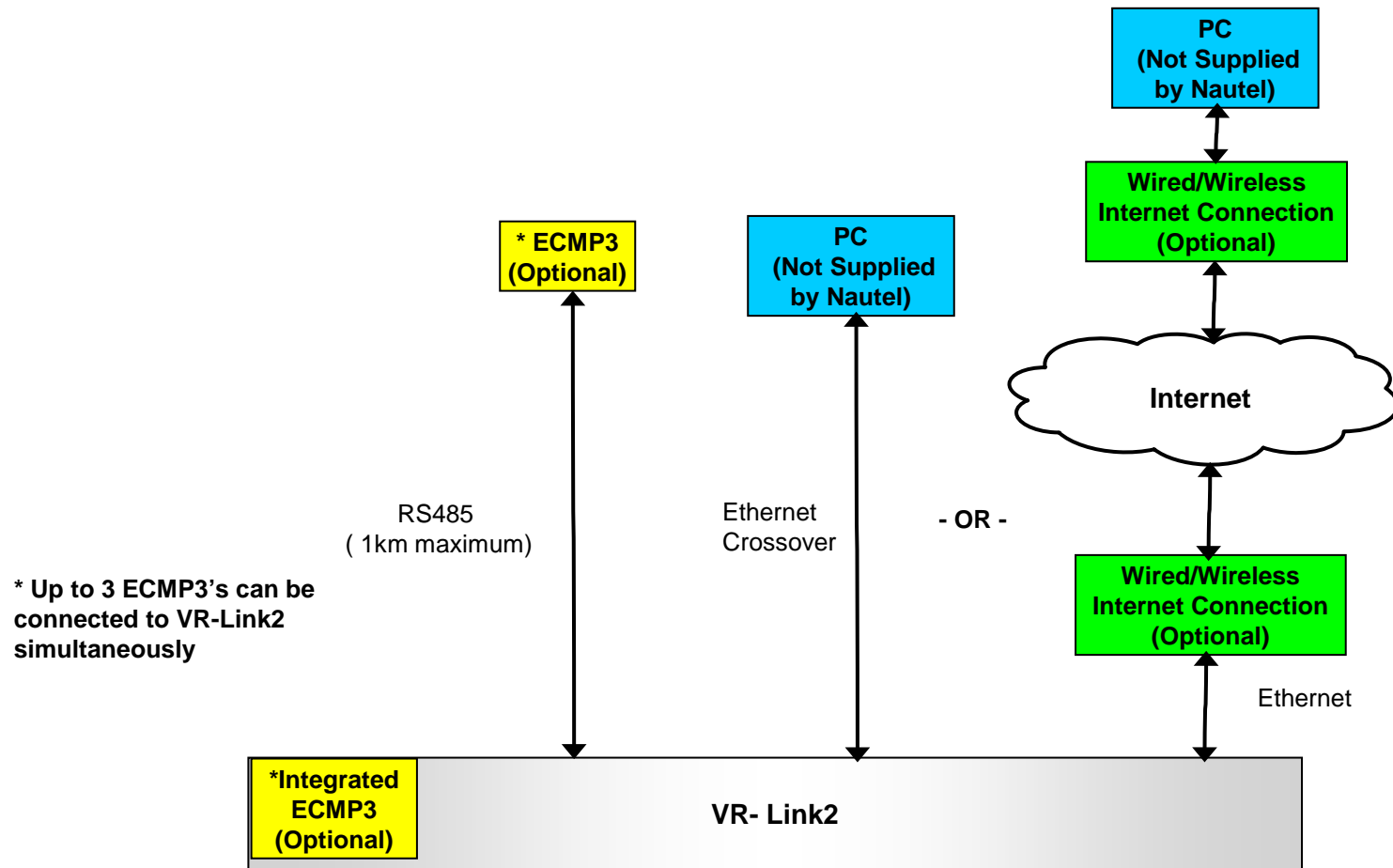
The screenshot displays the VR-Link2 Web Based RCMS interface. The top header shows the device status: "Device Status: XR6 - KNTL" with a timestamp "Data retrieved 2007-02-09T14:21:15". The left sidebar contains navigation links: "Home", "Equipment" (with a sub-link "XR6 - KNTL"), and "Administration" (with sub-links "Setup" and "Users"). The main content area is titled "Analog Inputs" and lists various parameters with their current values and control buttons. The parameters include Forward Power (1.40 kW), Reflected Power (0 W), B+ Voltage (198 V), PA Voltage (64.0 V), DC Current (8.5 A), RF Drive Power Supply (62.5 V), Fan Power Supply (47.7 V), +24V (23.0 V), +15V (14.3 V), +5V (5.00 V), -15V (-15.1 V), Ambient Temperature (26 C), PDM B (32.79 %), PDMA (33.07 %), and VSWR (0.00). The interface also features a "Status/Control" tab and a "Reset Schedule" button.

Analog Inputs		
Forward Power	1.40 kW	<input type="button" value="Increase"/> <input type="button" value="Decrease"/>
Reflected Power	0 W	
B+ Voltage	198 V	
PA Voltage	64.0 V	
DC Current	8.5 A	
RF Drive Power Supply	62.5 V	
Fan Power Supply	47.7 V	
+24V	23.0 V	
+15V	14.3 V	
+5V	5.00 V	
-15V	-15.1 V	
Ambient Temperature	26 C	
PDM B	32.79 %	
PDMA	33.07 %	
VSWR	0.00	

# Vector NDB & VR-Link2 Interconnection



# Vector NDB RCMS via VR-Link2



# NDB Site Remote Control/Monitoring

## Site Control/Monitor PWB (optional)

- Provides site control and status monitoring capability at the NDB site and via the Remote Control/Monitor system, if connected to the NDB
- 16 optically isolated inputs
- 16 form C relay contact outputs
- Can be used to control and monitor the status of ancillary equipment located at the NDB site

# SPU1 Surge Protection Unit



# SPU1 Surge Protection Unit

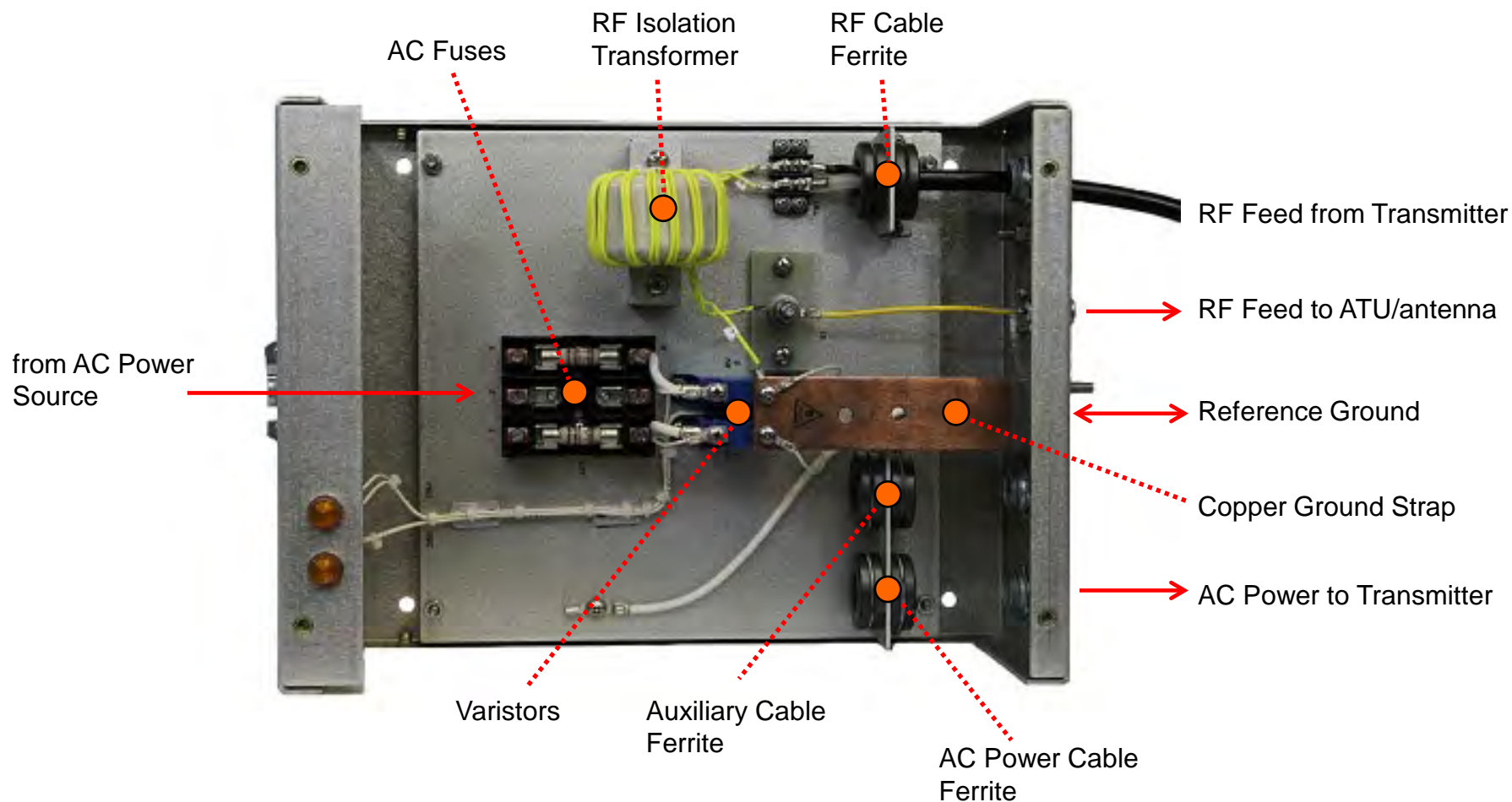
The SPU1 surge protection unit prevents lightning induced voltage/current transients from flowing through the transmitter. Isolation of the transmitter and the desired lightning protection is accomplished by:

- Inserting a 1:1 isolation transformer in the RF feed cable. This ensures there is no dc connection between the transmitter's RF output and the antenna system.
- Connecting suitably rated varistors between the ac line and the station reference ground.

# SPU1 Surge Protection Unit

- Passing all wires and their shields, through ferrite toroids. The ferrite forms an inductance which is transparent to normal signals/voltages but presents an impedance to lightning induced transients.
- Connecting the shield of the coaxial cable from the antenna directly to the reference ground.

# SPU1 Surge Protection Unit



# NRB4 & NLA/2 “OFF AIR” Monitor

## NRB4



*Beacon Monitor Receiver*

## NLA/2



*Receiving Loop Antenna*

# NRB4 & NLA/2 “OFF AIR” Monitor

## NRB4 Beacon Monitor Receiver



Monitors:

- Presence of Carrier
- Presence of Keyed Tone

Provides visible alarm if either carrier or modulation fall below thresholds.

# NRB4 & NLA/2 “OFF AIR” Monitor

## NRB4 Beacon Monitor Receiver



Provides:

- Transformer coupled audio output sample
- Contact closures for external carrier or mod fail alarms – these can be used to activate user supplied audible alarm if required

# NRB4 & NLA/2 Features

## Precise and Frequency Agile

- Direct Digital Synthesizer
- No additional parts required for change of frequency
- Excellent selectivity defined by stable IF crystal filter

## Off-Air Monitoring of FAA and ICAO requirements

- Adjustable thresholds and Time delays for reduction in carrier power , reduction in modulation depth and loss of keying
- Local and Remote Audio Monitoring
- Calibrated Carrier Level Meter

# Vector NDB System Customers

- Airservices Australia – **101** VR500-ASA & ATU-LP
- DHMI Turkey – **43** VR125D, **23** ATU-LP & **20** ATU500SR
- ROMATSA Romania - **20** VR125S x2 & ATU-LP
- NCAA Netherlands – **14** VR125D & ATU-LP
- Ukraine – **9** VR125D, **5** VR250 & 14 ATU-LP
- DFS Germany – **13** VR125D & ATU-LP
- Nav Canada – **6** VR500 & ATU-HP; **2** VR250D & ATU-LP
- Egyptian Air Force – **8** VR500 & ATU-HP
- INFRAERO Brazil – **7** VR250D & ATU-LP; **4** VR1000 & ATU-HP
- USCG – **84** ATU-HP

# Vector NDB System Customers



# Vector NDB System Customers



# Vector NDB System Customers



# Key NDB System Configuration Parameters

- Carrier frequency (kHz)
- Modulation frequency (400 Hz or 1020 Hz)
- Identification (Morse) Code
- Maximum carrier power
- Transmitter configuration (single or dual)
- Transmitter enclosure requirement (customer cabinet, deluxe cabinet, or IP66 enclosure)
- DC operation requirement (DC or battery back-up)
- Remote control/monitoring requirement (number of locations and distances to the NDB)
- Off-air reception and monitoring requirement (NRB4 Receiver + NLA/2 Loop Antenna)
- Antenna type

# Other Considerations

- Training
  - Nautel factory
  - Nautel representative/distributor premises
  - end user premises
- Installation Supervision
  - end user technical staff
  - Nautel representative/distributor technical staff
  - Nautel technical staff
- Commissioning and Site Acceptance
  - end user technical staff
  - Nautel representative/distributor technical staff
  - Nautel technical staff
- Extended warranty (available in yearly increments after initial 36 month warranty)

# Customer Service & Training

- Emergency technical support is available 24 hours a day, 7 days a week and is provided by Nautel Customer Service technical staff
- Facilities house a full inventory of parts, modules, and sub-assemblies to support customer's maintenance needs
- Parts depots also exist in the UK and in Memphis, TN, USA to assist in serving Global customers
- Nautel's first priority is getting customers back on the air, even if the model in question was shipped in 1970
- Installation Supervision and Commissioning Services are available
- RF Basics, System Specific Training and Certified Installer/Maintainer programs, comprised of classroom as well as hands-on practical instruction, are available from Nautel

# Nautel User's Group

Membership includes:

- Online access to Nautel's NUG website
  - Technical FAQs
  - Technical manuals
  - Information sheets
  - Field upgrade documents

# Contacts

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# Thank You