

INNOVATIVE LOCALIZER ANTENNA INSTALLATION

Wellington International Airport runway is built on a narrow neck of land.

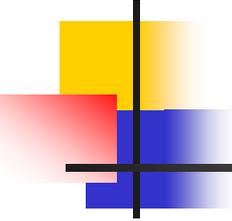
The south end of the runway finishes adjacent to the open sea of Cooks Strait whilst the Northern end finishes adjacent to Wellington harbour.

The next photograph illustrates this layout.

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New Localizer Antenna

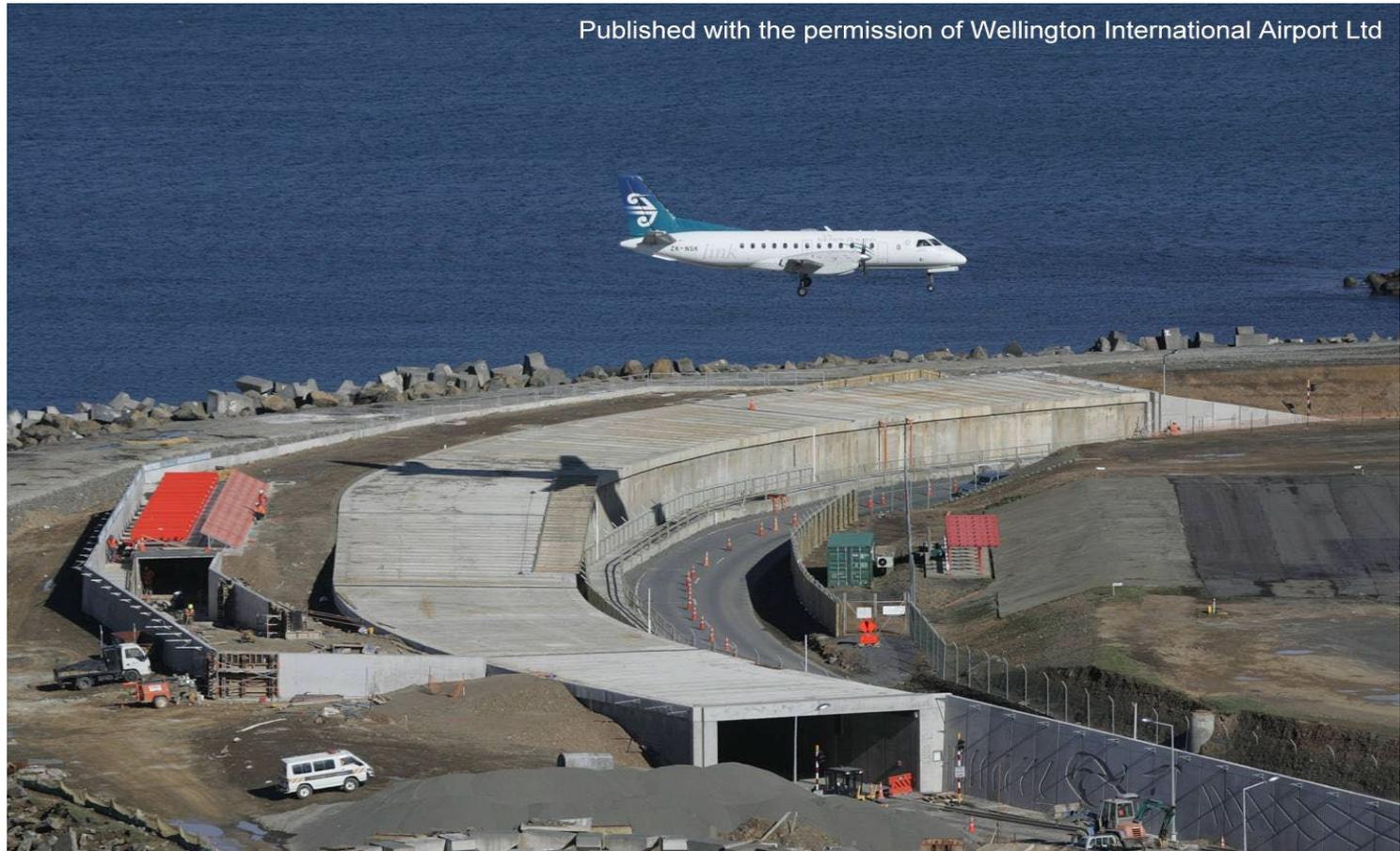


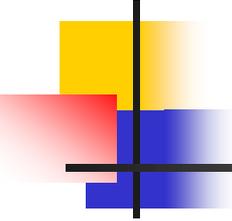
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- Inline ILS systems serving both approaches were first installed some 30 years ago.
- The localizers associated with those ILS's had their 8 element antenna systems mounted down the bank at each end of the runway strip so as to avoid penetrating Obstruction Clearance Surfaces. This arrangement also provided protection for the antenna system from direct jet blast. The next photo shows the previous antenna in this configuration.

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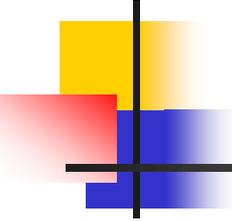
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- In order to provide for a runway end safety area at the Southern end of the runway the runway strip needed to be extended over an existing roadway and up to the edge of an existing wave trap. There was no possibility of locating a Localizer antenna down the bank into the wave trap and so we began consideration of locating a reduced height antenna on the surface of and at the end of the RESA adjacent to the wave trap.

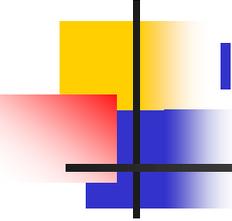


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Issues we faced in accomplishing this were threefold

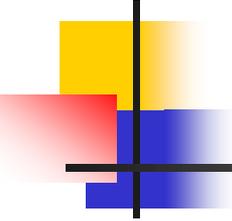
- Firstly - Antenna Height :

Obstruction Clearance Surface requirements limited the total available height for the new Localizer antenna to no greater than one metre. This restriction could impact adversely upon both the Localizer antenna element matching as well as the achieved Localizer coverage.



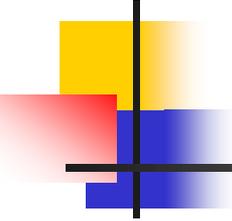
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- Secondly - Protection from Sea Spray:
- During Southerly Storm weather conditions a significant quantity of sea spray is dumped over and beyond the wave trap at the southern end of the runway. Sea spray had already been a cause of shutdown with the previous 8 Element Localizer antenna. With the new Localizer antenna located closer to the sea the problem of spray dump is much greater.



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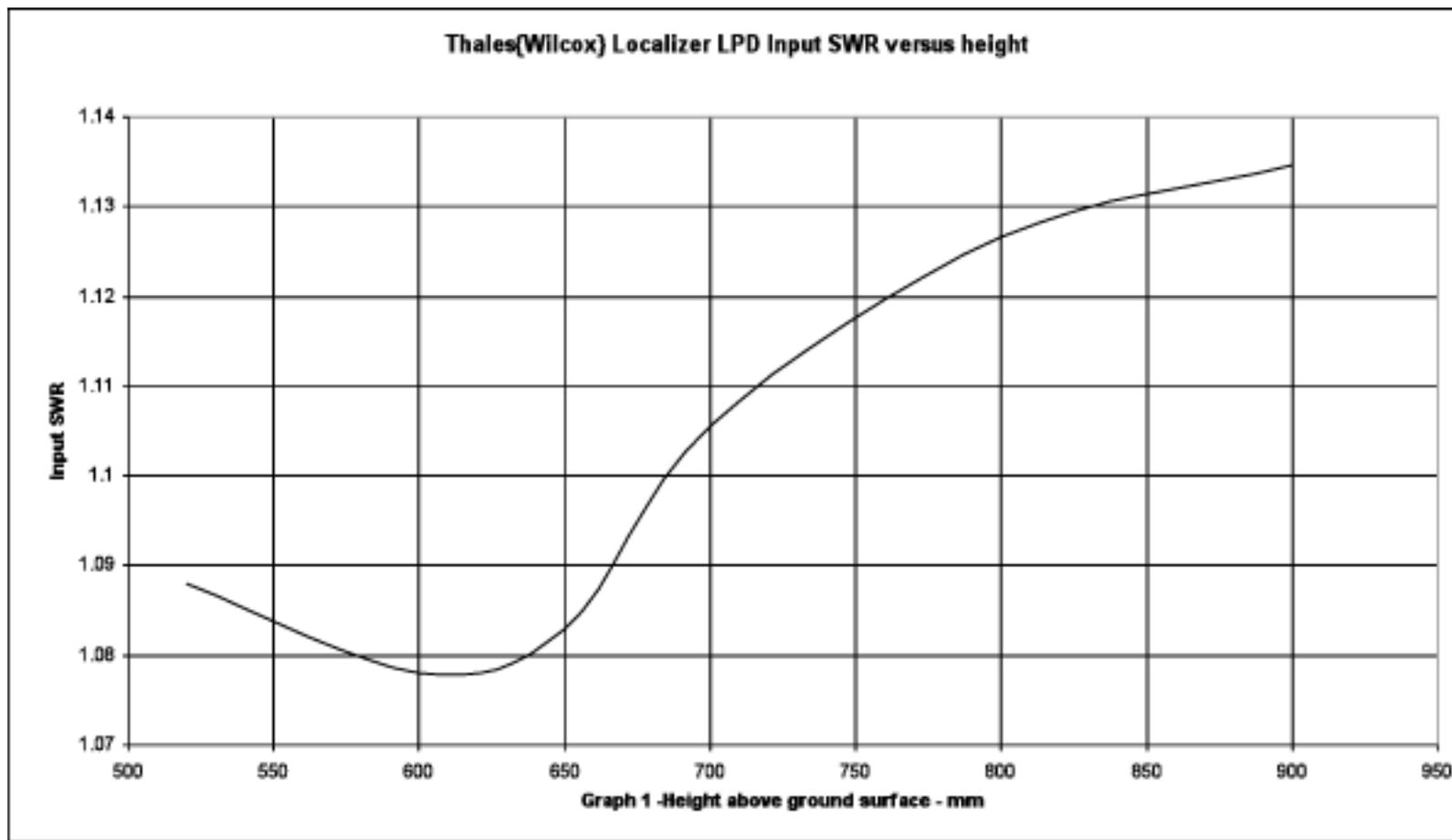
- Thirdly – Protection from Jet Blast:
- The new Localizer antenna would be only 53 metres from the runway starter extension. At this distance the antenna could be subjected to jet blast wind speeds greater than its design limit.

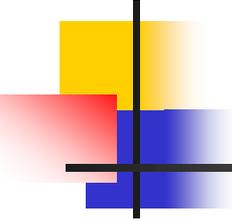


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- Antenna Height Issues:
- To check the effect upon the antenna element matching a single antenna element was mounted on a variable height support and the Input feed VSWR measured at various heights.
- The following plot shows that matching was not going to be a problem and was best at around 600mm height.

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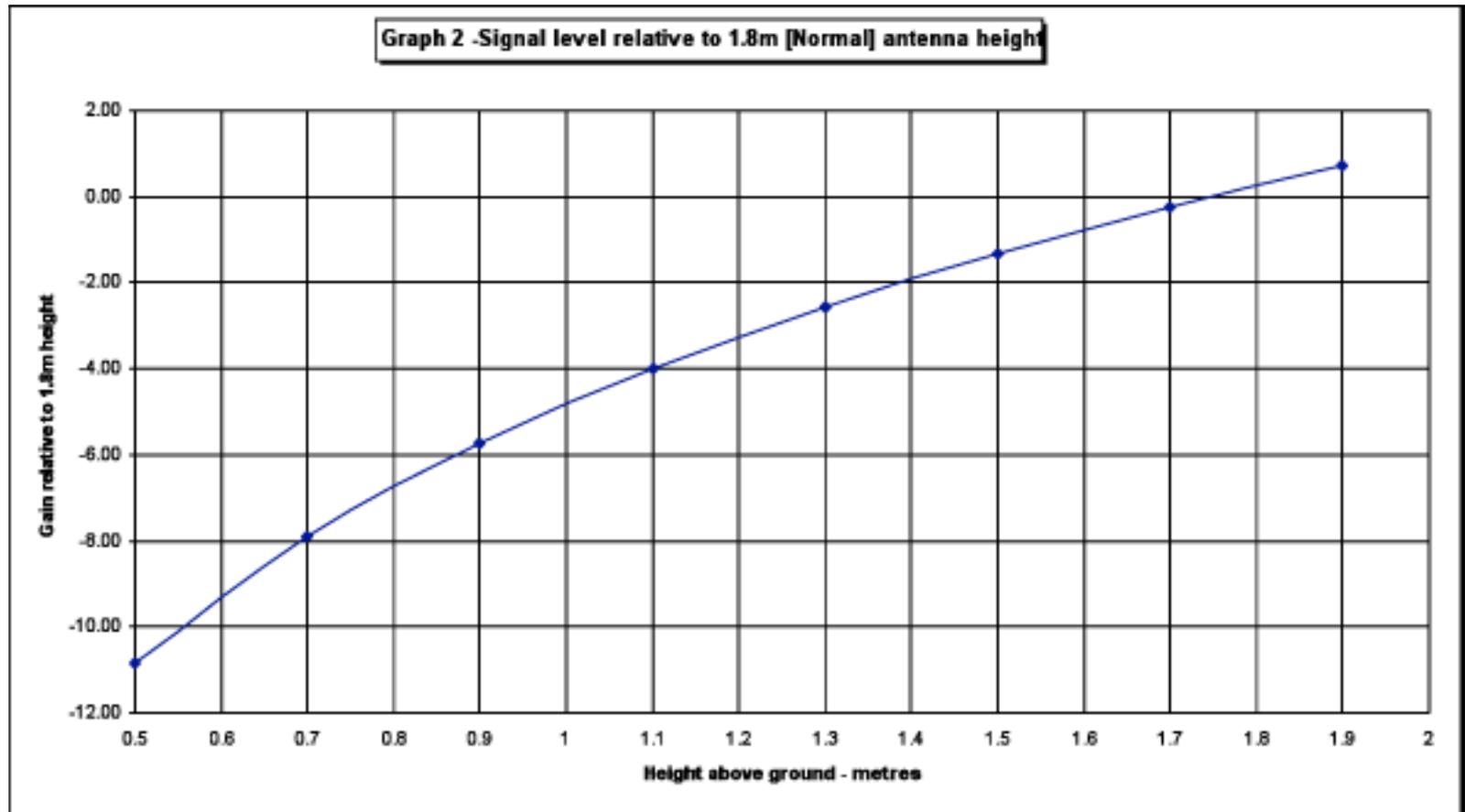


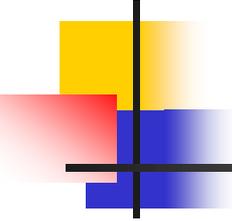


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- Localizer coverage –
- The difference in signal strength in the user airspace between a ‘down the bank’ mounted 8 element antenna and a normal height [1.8m] surface mounted 8 element antenna is approximately 10dB. A graph of the relative signal level versus height for a surface mounted array is displayed in the next plot. This shows the 10dB reduction occurs around 0.55m height. This suggested a suitable minimum height to mount the antenna array.

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- Whilst a low mounted antenna system appeared to potentially match the coverage of the previous ‘down the bank’ system it was decided to add some margin by using a 14 element array together with placing the equipment room underground immediately below the antenna array so as to minimize cable loss. We were then confident that we would achieve a coverage not less than that previously obtained with the down the bank antenna.

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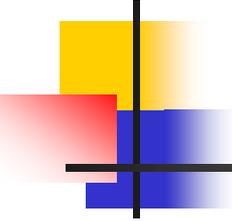
- Protection from Sea Spray Dump:
- This Picture shows the proximity of the new Localizer antenna to the Ocean



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- This picture shows a moderate sea spray dump over the new Localizer Antenna.



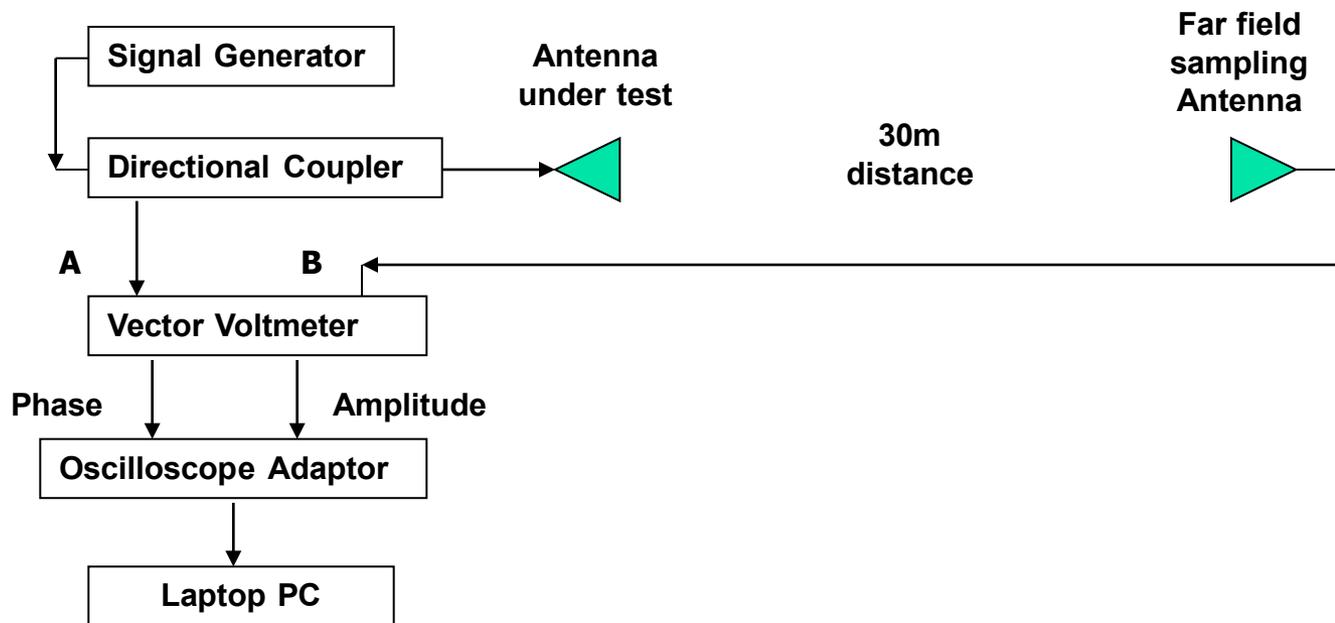


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- To investigate sea spray dump protection measures we undertook tests upon a single antenna element to determine what parts were most sensitive to the presence of salt water.
- The test setup is illustrated in the next three slides.

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■ Measuring Equipment Setup

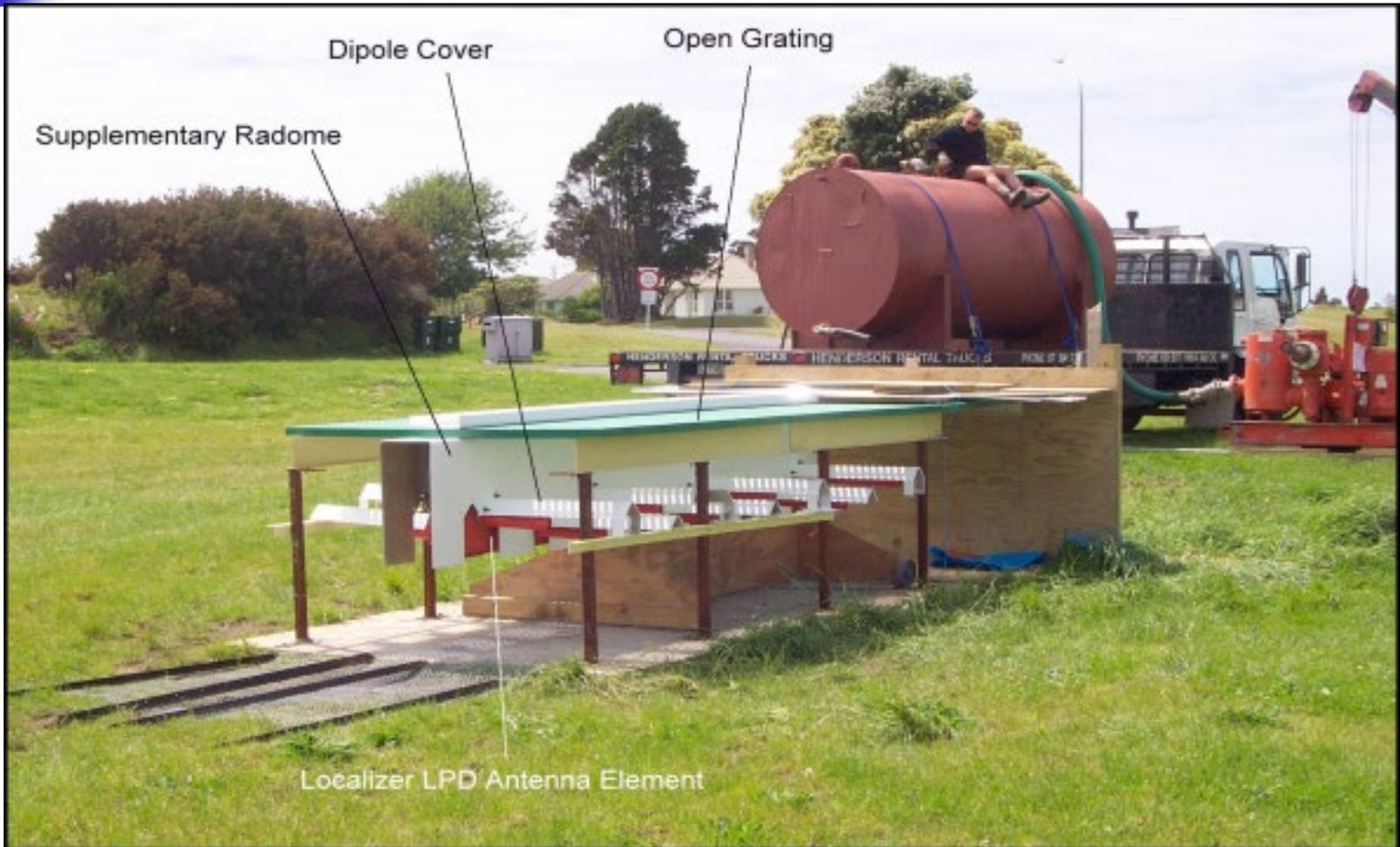


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Test Equipment Location



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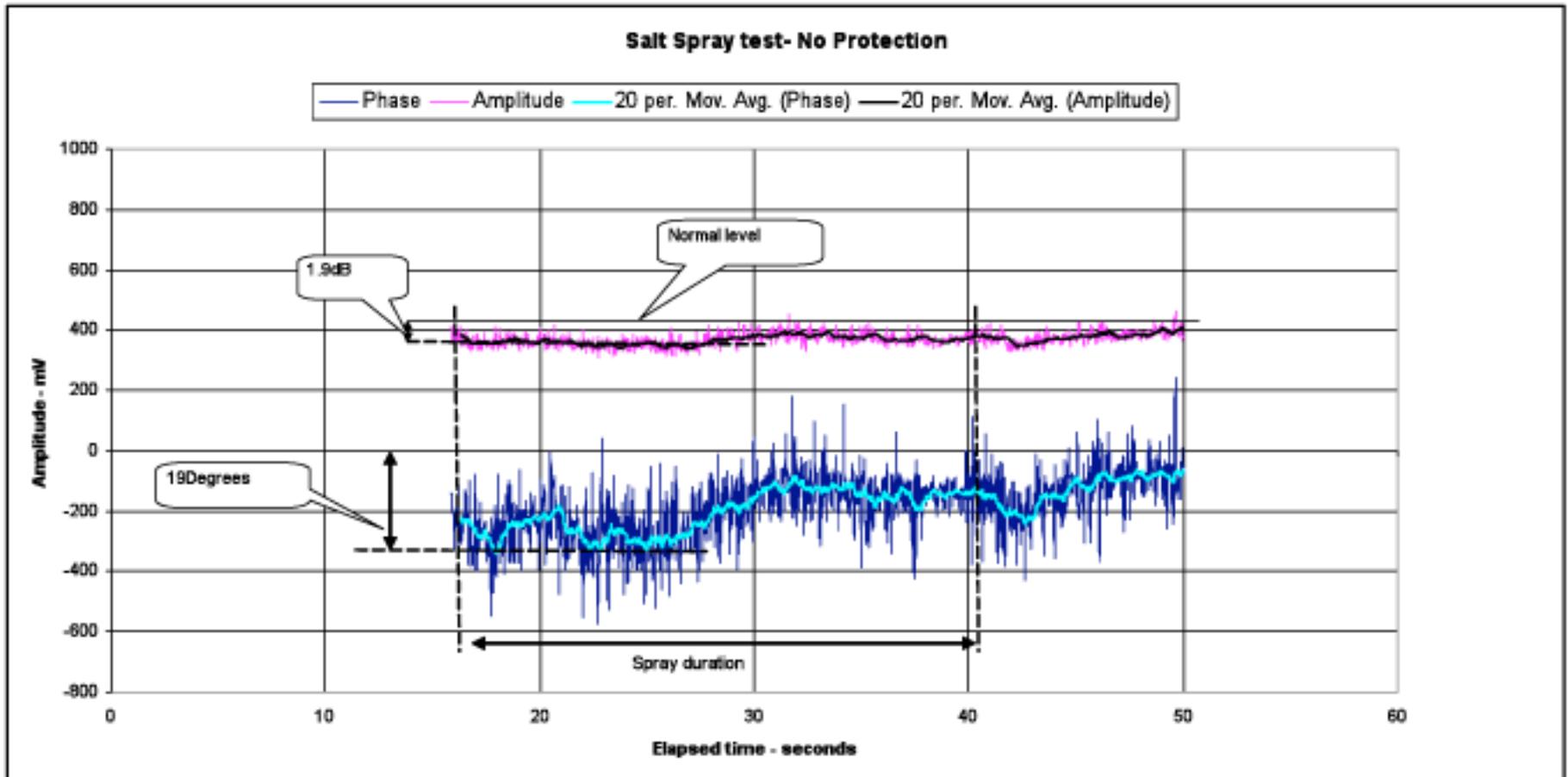
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Sea Spray Dump Simulation



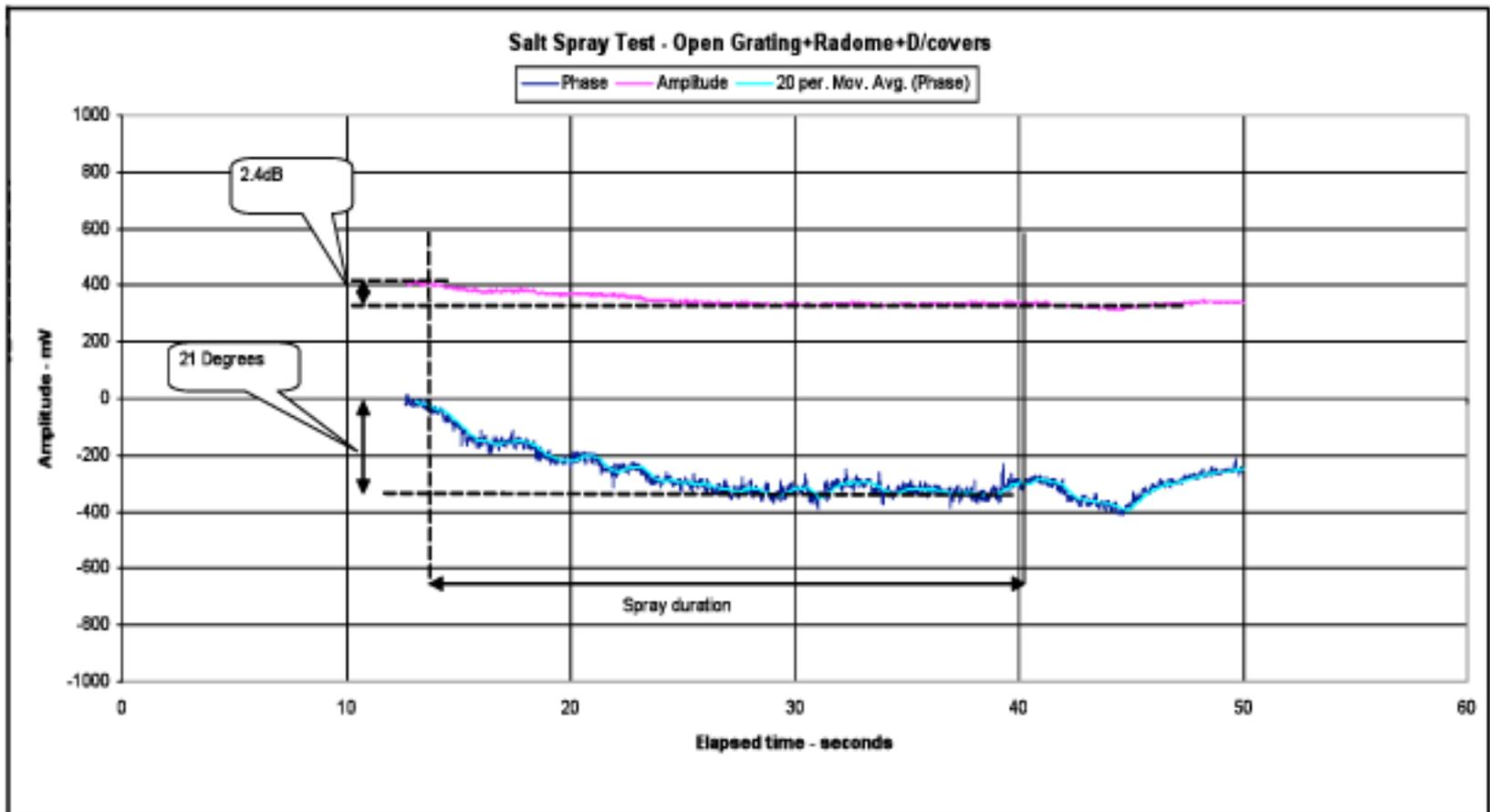
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Spray Test Results – 1



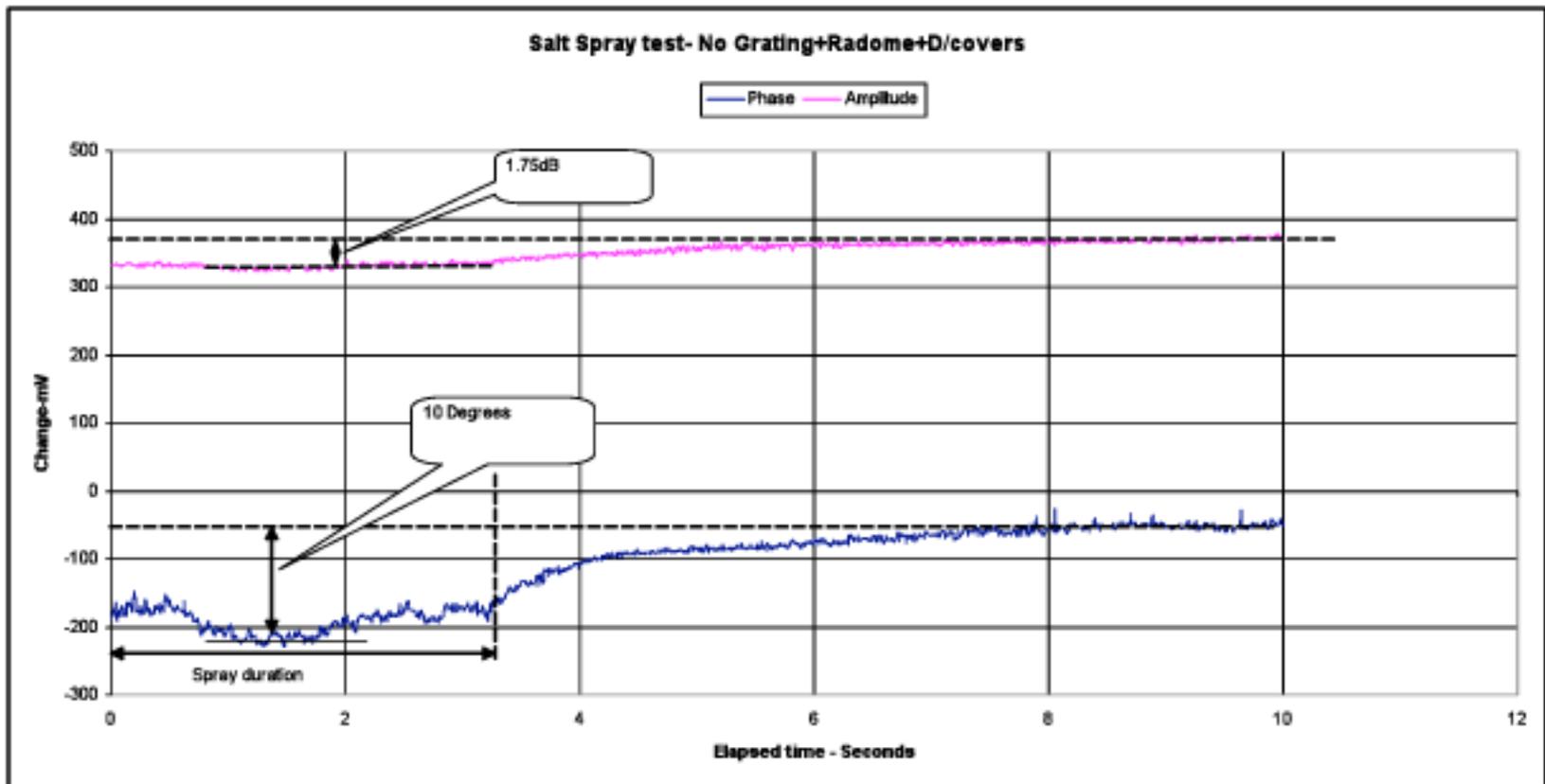
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Spray Test Results - 2



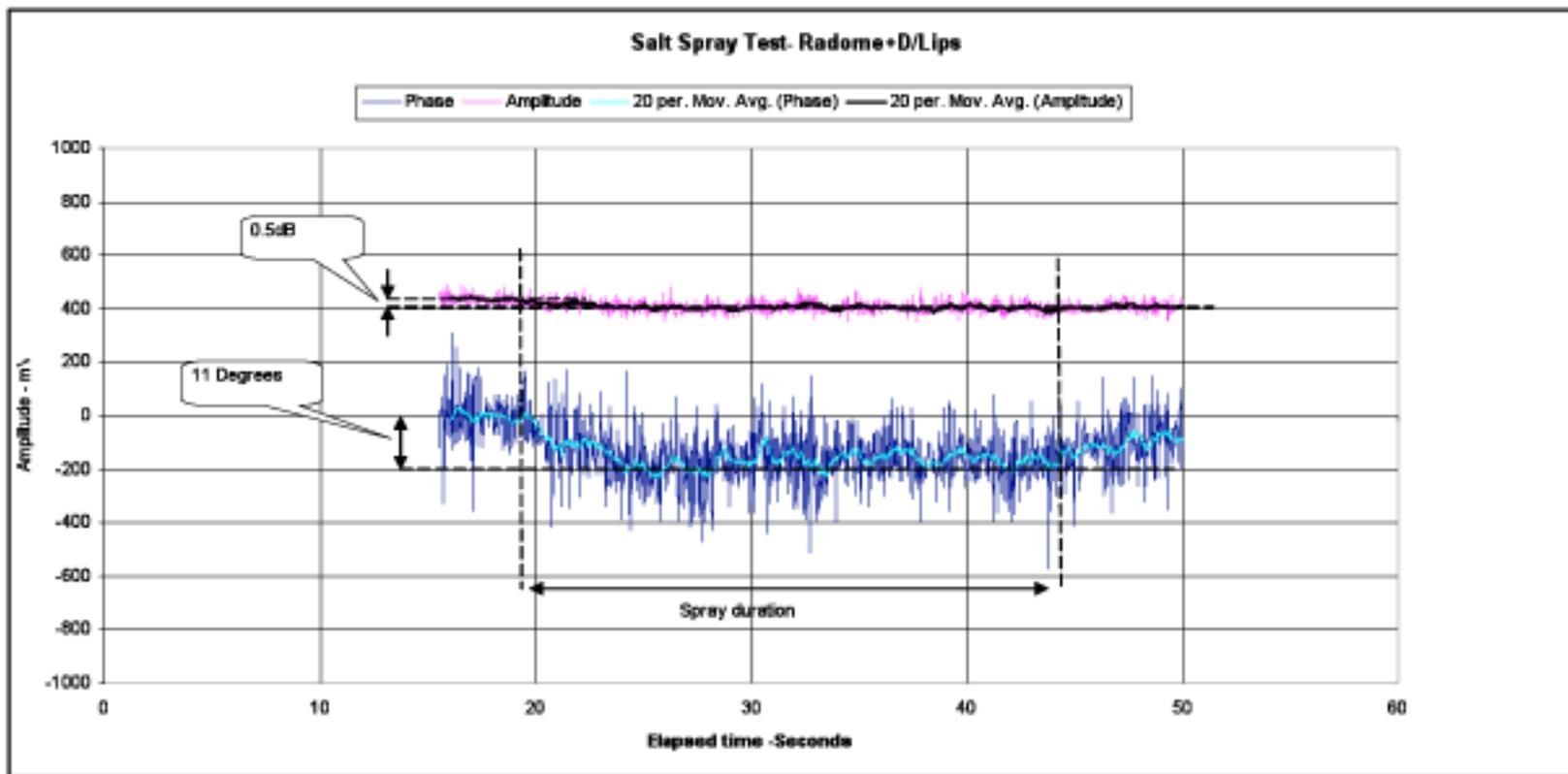
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Spray Test Results - 3



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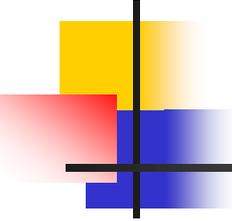
Spray Test Results - 4



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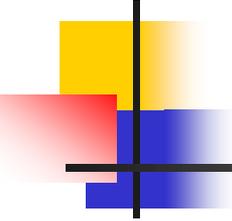
Final Prototype Radome Protection Configuration





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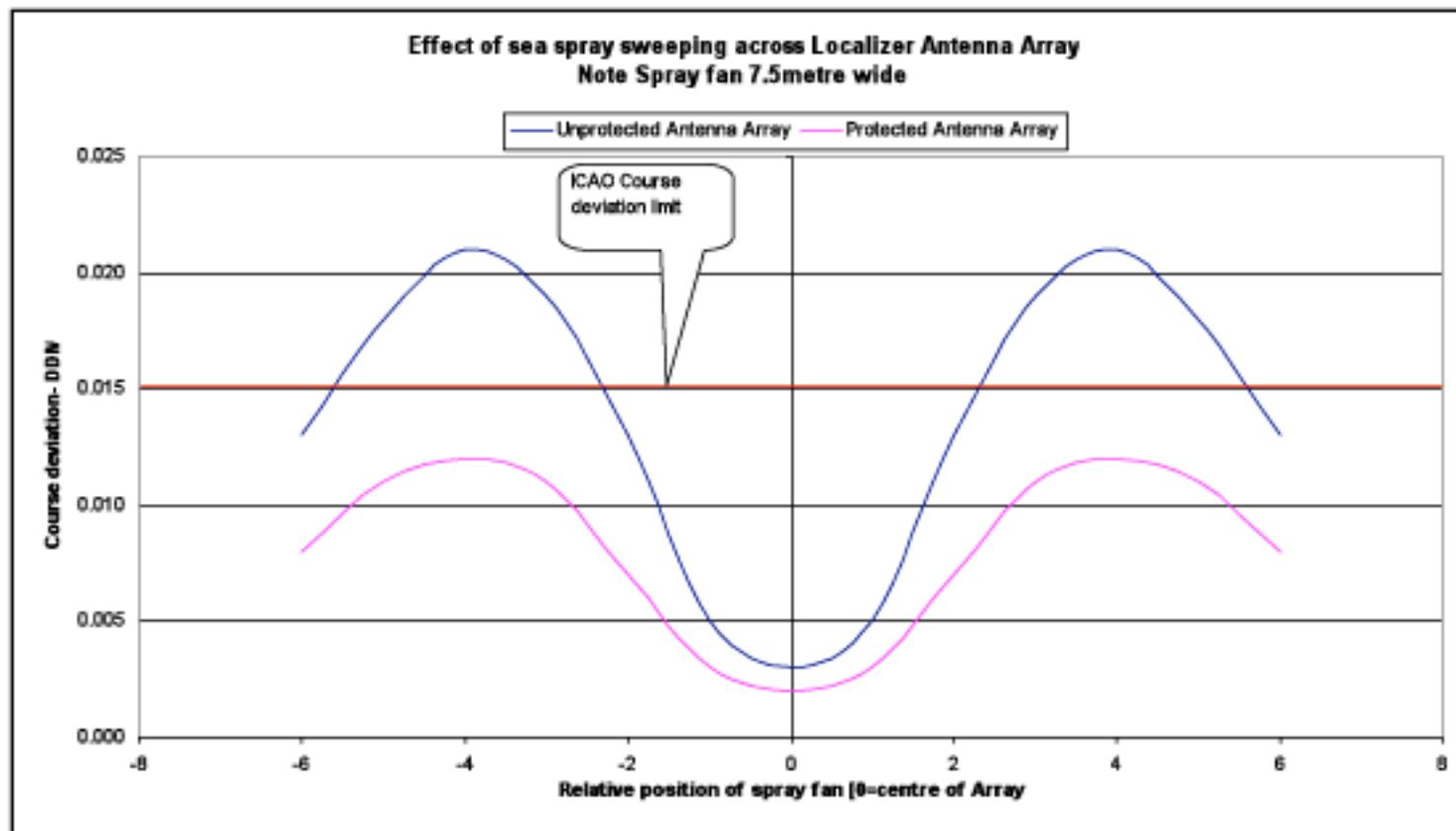
- This final protection configuration reduced the signal amplitude disturbance to an insignificant amount.
- The signal phase disturbance remained essentially the same as with the full dipole covers.
- Overall this final protection scheme provided around a 2:1 improvement for signal phase disturbance over having no protection.

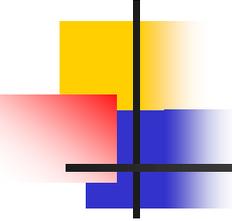


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- These single antenna results were then inserted into a computer model of the 14 LPD antenna array proposed for the new Runway 16 localizer.
- For this simulation a spray fan 7.5m wide [i.e. covering three antennas at a time] sweeping across the array from West to East was used as this was considered to best replicate what happened in reality.
- The next slide shows the resulting prediction of the Localizer Course disturbance with and without the protection measures applied. This shows that the protection measures applied would likely overcome Localizer outage during Southerly storm conditions.

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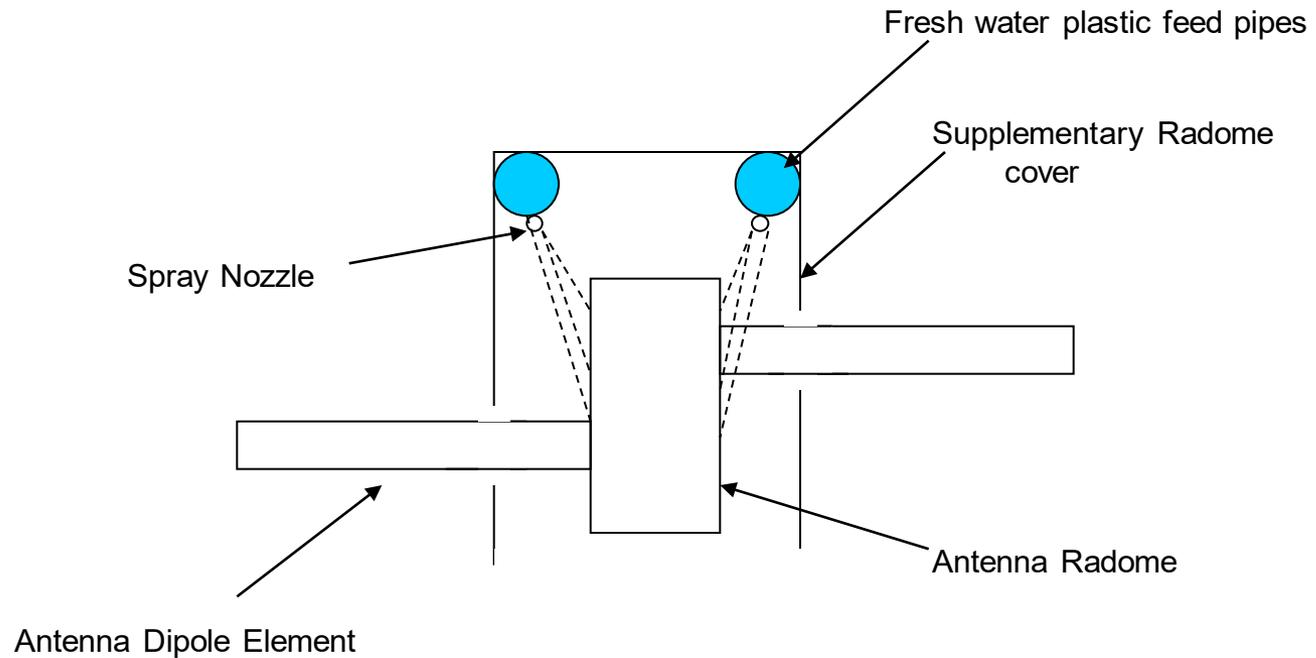


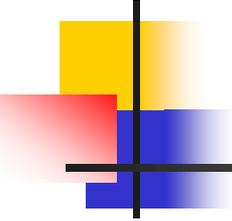
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- With the supplementary protective radome in place there remained the possibility of salt contamination building up over time on the antenna radome. To address this possibility a fresh water spray cleaning system was installed. The configuration of this cleaning system is illustrated on the next slide..

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■ Fresh Water wash layout





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- Each antenna is equipped with fourteen spray nozzles [seven along each side] to clear away any salt accumulation. The fresh water supply to each antenna is controlled by a solenoid operated valve , and the fourteen antennas are washed in pairs symmetrically displaced about the Localizer array centreline.
- To determine the minimum quantity of water needed for the wash a test rig was setup. This consisted of a short length of transmission line placed on one side of a fibre glass sheet [to simulate the antenna feed arrangement] with a spray nozzle above. The impedance of the transmission line was monitored using an RF Bridge .
- The sheet was encrusted with a dry salt layer and then sprayed at various water rates and patterns noting the time taken for impedance change to stabilize back to normal. This test resulted in adopting a fine mist fan spray with a flow rate of 0.6 litres/minute which equated to 16.8 litres per minute for each of the seven antenna pairs. At this rate a heavy salt accumulation was cleared in approximately 12 seconds.
- The setup for this test is shown below.

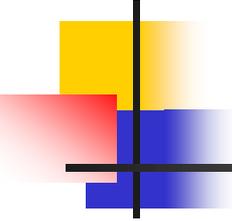
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- Antenna wash system plumbing



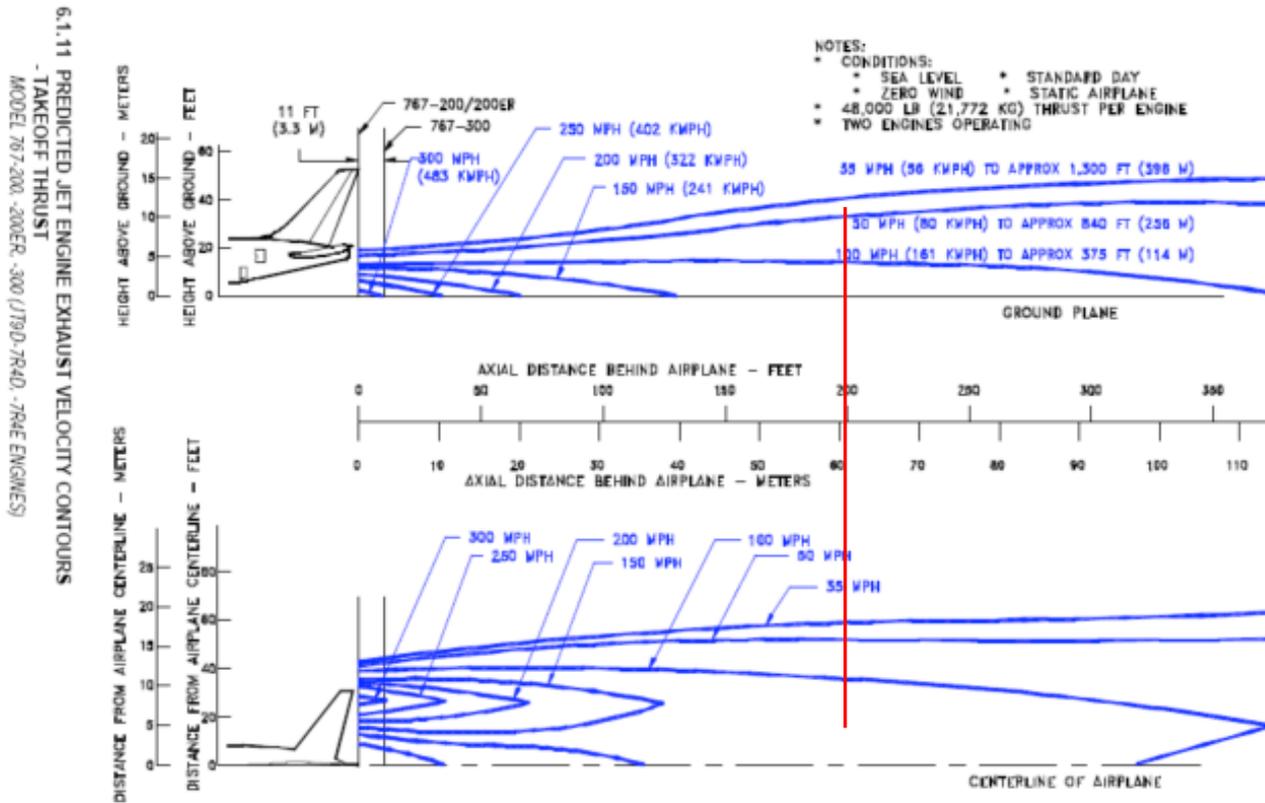


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- Jet Blast protection.
- The largest aircraft using the airport is the Boeing 767. A plot of the Jet blast velocity versus distance is shown on the next slide.
- It will be seen that at 53m distance behind the aircraft the exhaust air velocity is greater than 100mph.

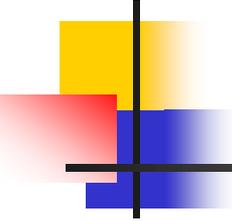
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Boeing 767 Takeoff Thrust Exhaust Velocity



D6-58378

SEPTEMBER 2005 165



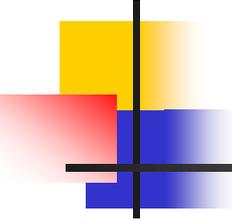
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- Clearly it was possible that the wind speed design limit for the Localizer antenna array could be exceeded. Therefore a jet blast deflector needed to be placed directly in front of the array. Electrically the deflector design should introduce minimum attenuation to the localizer signal from the Array.
- A design was conceived employing a comb like structure having only vertical aligned metal strips. Furthermore the dimensions were tailored such that the top of comb presented a high impedance between adjacent strips. The next slide shows the prototype deflector.

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- Prototype Jet Blast deflector





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- With this prototype jet blast deflector placed immediately in front of the Test antenna at a minimum possible distance, no change in either the amplitude or phase of the far field received signal was detected.
- Following this test the prototype design was modeled and tested in a wind tunnel to determine whether the reduction in wind speed would be adequate.
- The following slide shows the wind tunnel model.

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- Jet Blast deflector Wind tunnel Test Model



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Proto Type Jet Blast Deflector Wind Tunnel Results

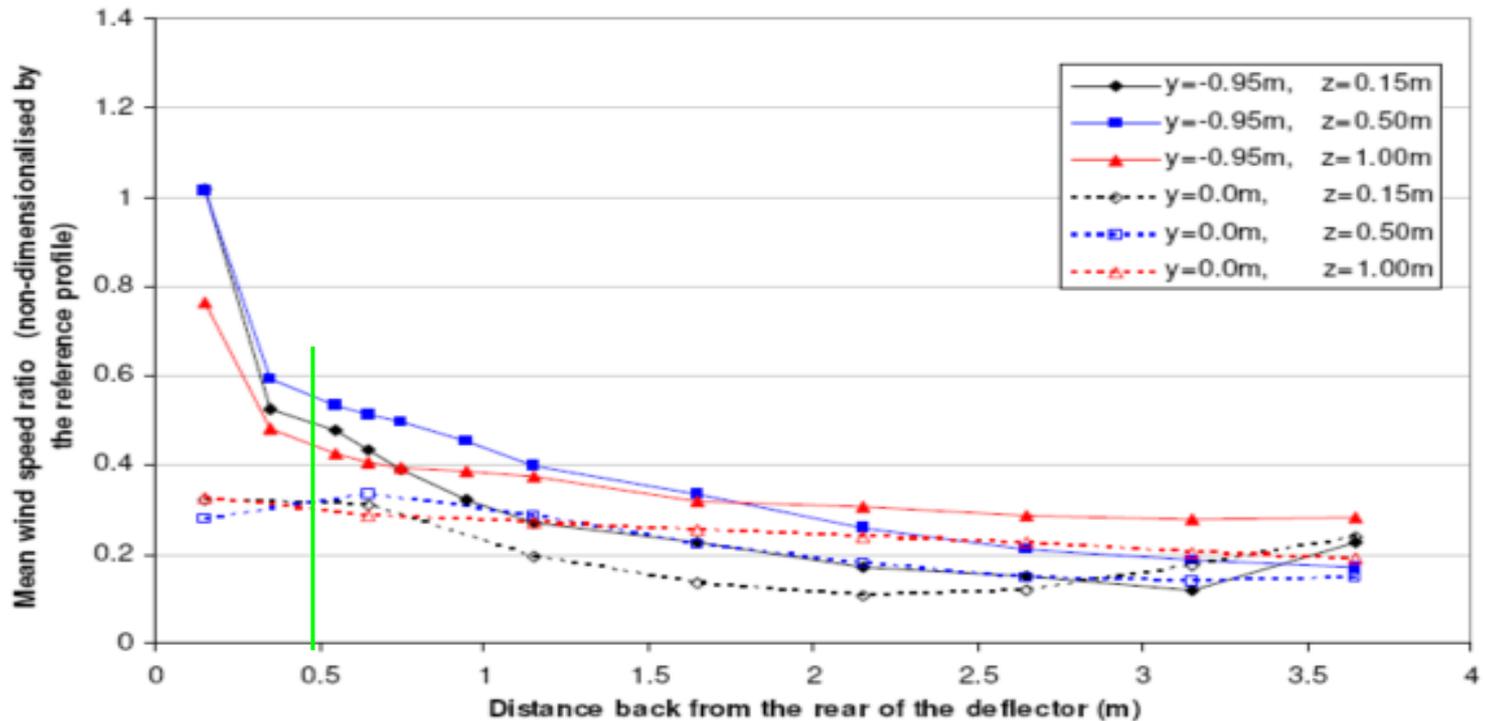
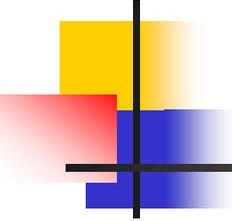
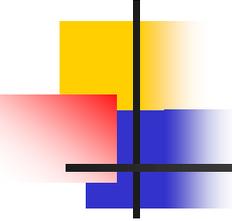


Figure 4(a) Mean wind speed ratio : Effect of height (z) and downstream distance (x) for the jet blast deflector and wall combination (i.e configuration B)



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- Having completed the design concepts it was then the task of the Structural engineers to replicate the basic form of the prototype deflector into a practical piece of hardware complete with the necessary shear pins to provide for a frangible structure.
- The following slides show the final design installed on site.

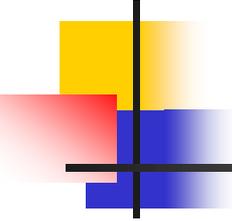


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- It was a requirement that there be no interruption to the ILS service during the period of this RESA construction.
- To achieve this much of the Civil Work was carried out late at night.
- The new Localizer had to be installed and commissioned into service before the previous Localizer was removed. As part of this process a reinforcing mesh screen was laid along the edge of the roadway underpass to ensure that this edge was electrically parallel to the New Localizer antenna array until the gulley remaining between the underpass and the old localizer had been backfilled .

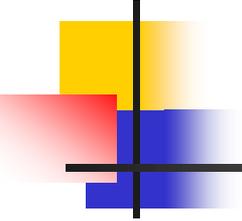
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- FINALE
- To date sea spray dump has not caused shutdown of the new Localizer.
- Flight Inspection recorded the coverage to be slightly better than for the previous Localizer installation and comfortably meets the ICAO 18/10nm alternative criteria.
- The testing to prove the concept was conducted during 2004 and 2005. The civil works began in 2006 and the new Localizer was commissioned in 2007.
- Work has commenced to install a similarly configured Localizer on the opposite approach [Runway 34].

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- Whilst sea spray dump was a significant issue for this Runway 16 localizer location there may be locations elsewhere in the world where the low height profile and jet blast protection features of this configuration would enable an inline localizer to be installed on a runway strip where previously it was thought to be not possible.