The Cobra Mist Test Antennas

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1. Introduction

The AN/FPS-95 system (originally code-named Sentinel Fan, then Sentinel Mist and, more latterly, Cobra Mist**)** was planned to be the most sophisticated operational Over-The-Horizon radar of its time, with the purpose of monitoring aircraft and missile activity in western USSR. Originally intended to be installed in Turkey, ensuing political difficulties meant that eventually the system was constructed at Orford Ness, with construction beginning on the site in 1967.

The Cobra Mist radar employed a very ambitious antenna design based on a fan arrangement of log-periodic dipoles and extremely high transmit power (originally specified to be 10 MW peak). Unfortunately the development programme was beset with difficulties and delays, the most serious and persistent being that of range-related noise which significantly reduced the detection sensitivity (and therefore operational utility) of the radar. The source of the problem was never definitively established, and this ultimately led to the abandonment of the project in mid-1973.

Various experiments were undertaken at the time to try to locate and remedy the source of the noise, initially by the MITRE and Naval Research Laboratory (NRL) teams already on-site for the Design Verification System Testing (DVST) phase, and latterly co-ordinated by a specially appointed Scientific Advisory Committee (SAC) which was set up in a last ditch effort to get to the bottom of the problem. Some of the testing involved additional antenna structures (at least one being beyond the main radar compound), and it is the purpose of this short paper to describe these antennas, in terms of their experimental purpose, their physical design, and any remains on the ground.

2. The Test Yagi

Probably the most impressive supplementary antenna constructed was the nine-element Yagi which was located approximately half a mile to the south of the main Cobra Mist building. It was designed by Dr Robert Rafuse, who was acting as a consultant to the USAF at the time.

The antenna itself was made of duralumin (an aluminium alloy) and had dimensions of approximately 111’ long by 17’ wide, being tuned to 23.145MHz. It was expertly TIG-welded in one of the brick workshops on Orford Ness by ‘Coded Welders’ Graham Chaplin and Doug Mills during early 1973, and erected in part during a snow storm.

The build quality of the antenna had to be extremely high in order to avoid it causing spectral contamination of the signals it was supposed to be measuring. Frank Bartram, a rigger involved in the installation of the antenna fortunately took a number of photographs around this time, a selection of which are shown in Figures 1 to 4 below.

This horizontally polarised antenna was mounted approximately 40’ in the air on two wooden poles sourced from Sweden. Graham Chaplin has stated that the antenna was mounted approximately

100’ in the air (achieved by joining two wooden poles together to double the height), though this seems inconsistent with the photographic evidence. It is not known whether the installed height was lower than that originally planned.

Figure 1: The Yagi antenna being transported prior to installation.
Wooden railway sleepers were laid to allow the crane to reach the marshy location.

Figure 2: The antenna being lifted up for installation on top of the two poles

The purpose of the Yagi antenna was to allow comparison with the main radar system (in particular its log periodic dipole array) and permit associated investigations into ionospheric propagation. It was used in a measurement campaign from 6th to 11th March 1973, an experiment which also used the Cobra Shoe OTHR system in Cyprus (transmitting westward for reception by Cobra Mist and the test Yagi), and a van housing receive electronics. Before being used in Cyprus, the van was set up on Dunwich Heath and monitored line-of-sight transmissions from Cobra Mist.

Figure 3: Rigging pole to anchor blocks
'Stay' Clamps visible in this 1973 photo

Figure 4: Riggers installing the antenna on a wooden pole
Working from the extended ladder of a fire engine

The Yagi was probably connected to the main Cobra Mist building by a 650m long coaxial cable. Possibly only in use for a matter of weeks, the Yagi antenna was soon removed and largely forgotten about.

However its site can still be located within National Trust land on Orford Ness at:
(latitude 52.095189º N, longitude 1.578014º E).

Remaining Test antenna infrastructure located

Physical remains at the site include the two wooden masts (now of course felled) and numerous concrete blocks, arranged in four groups, used to guy the masts.

Figures 5, 6 and 7, below, show the remains of the Yagi antenna discovered in May 2021.

Figure 5: Metal base for one of two wooden masts
With a metal plate and retaining metal cup

Figure 6: Anchor blocks showing metal clamp
Used to 'stay' the two vertical poles.

Figure 7: One of two felled Yagi-support poles
Now have different lengths of 10.5m and 16m.

Figure 8: Test aerials - Locations on Orford Ness
Showing Cobra Mist installation, Yagi's known location and possible location for Fan Dipole

The alignment between the two poles (and hence the pointing direction of the Yagi antenna) is approximately 114º, showing that the installation was specifically designed to look towards Cyprus.

Although it is possible they have been moved since 1973, the four groups of concrete blocks are consistent with the guying of each of the vertical poles with sets of three wires (probably made of fibre-glass, as per the main Cobra Mist antenna) at different heights.

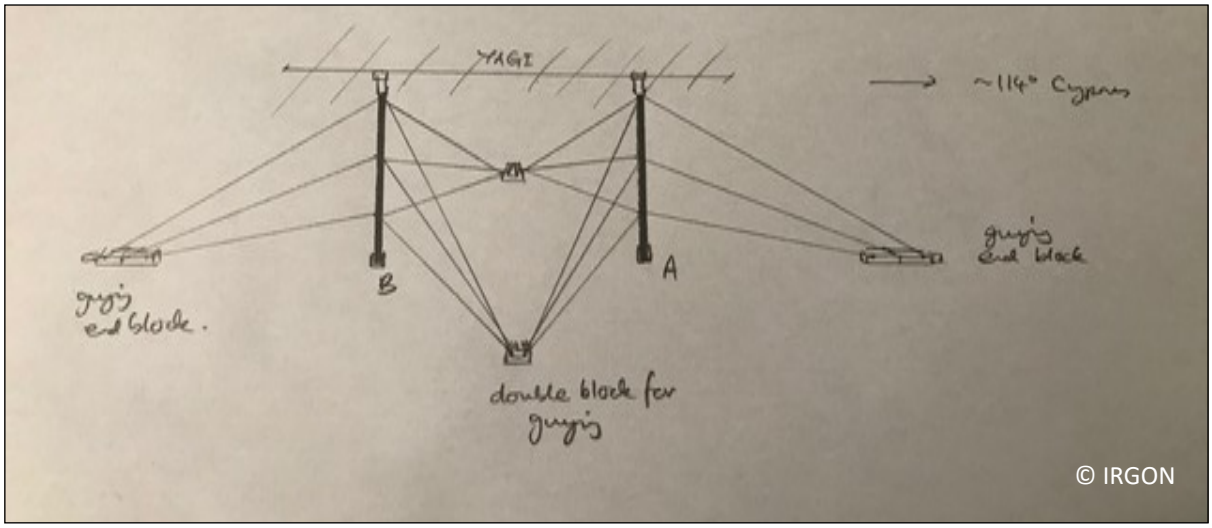

Figure 9: Speculative sketch of a possible configuration of the Yagi's supporting poles.

This possible arrangement is illustrated in the sketch above. There may have been further fibre-glass guys for the Yagi antenna element itself.

3. Fan Dipole

The Yagi antenna was not the only additional one employed in Cobra Mist experiments; indeed it was preceded by a broadband fan dipole which was used for similar comparative one-way propagation measurements in November 1972. Currently few details are known of this antenna, though like the Yagi it may have been located some distance from the main site, in this case on the sea wall. It is likely to have been 5 or 6 metres high, and was designed by Oakley M. Woodward of RCA (Woodward was a well-known antenna designer in his time).

Its precise location has not yet been definitely established, although there are fragmentary concrete remains near the sea wall to the south and east of the main Cobra Mist site which may relate to the fan dipole. The antenna was in place by the end of October 1972, when it was used on various frequencies to measure the spectral purity of transmissions from the main antenna.

The Fan Dipole is known to have been vertically polarised (i.e. electromagnetic field oscillating in the vertical direction), so that the main transmitting members (probably wires) would have been in the vertical plane. A rough sketch showing what the antenna might have looked like is below.

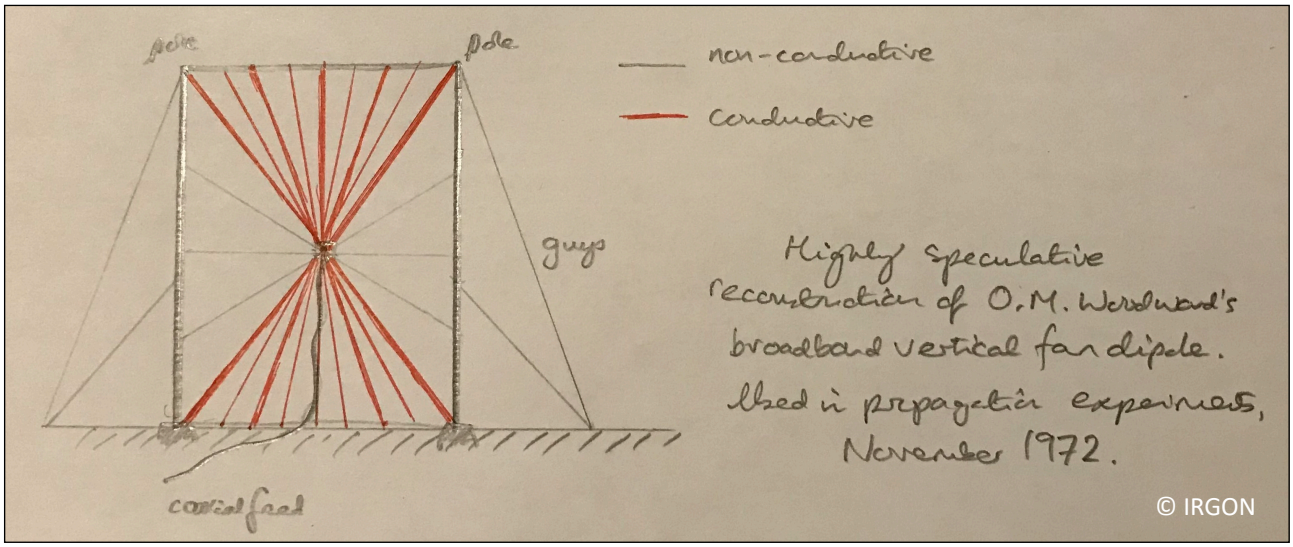

Figure 10: Speculative configuration of temporary Fan Dipole located on Orford Ness

We would welcome further information on the design of this antenna and its possible location.
(Click Contact Us to go to the relevant page in the IRGON website)

4. Other Antennas

Various other antennas, probably all temporary, were used in the noise investigations. These included a loop antenna (deployed at the focal point of the main antenna in an experiment of June 1972); a vertically polarised monopole on the sea wall (used in July 1972); and a vertical dipole on the sea wall (used in September 1972, and almost certainly not the fan dipole described previously). Some experiments were even undertaken using airborne equipment; in October 1972 a helicopter hovered about ½ mile from the radar and transmitted a low power signal (to be received by the radar) using a vertical dipole suspended 300' below it. A similar experiment was undertaken in March 1973 using an aircraft with a trailing antenna.

David Emery
IRGON, September 2021

Notes & Acknowledgements

1. The original interest in the test Yagi was generated by photographs kindly provided by Frank Bartram, who was a rigger involved in the construction and maintenance of the main Cobra Mist array and this Yagi

2. An informative and amusing written narrative was provided Graham Chaplin, a 'coded welder' involved in the construction of the Cobra Mist array and this Yagi

3. David Warren (IRGON) located and photographed the remains of the Yagi antenna on Orford Ness in 2021.

4. The author thanks Glen Pearce, National Trust's Orford Ness Manager, for allowing IRGON researchers to search for the remains of these two test aerials on the Ness.

Sources

The following de-classified papers have been used as the basis of the technical details of the antennas and their use:

- "The Enigma of the AN/FPS-95 OTH Radar", E. N. Fowle, E. L. Key, R.I. Millar and R. H. Sear (de-classified by ARPA, 23 March 1993)
- "AN/FPS-95 Research and Development Program – Final Technical Report, Noise/Interference Environment", J.F. Thomason, NRL Report 2715, March 1974 (de-classified February 1997)
- "Radar Ionospheric Propagation Effects Determined from One-Way Path Tests", D.B. Trizna and J.M. Hudnall, NRL Report 2701 (de-classified February 1997)
- "AN/FPS-95 Research and Development Program – Final Technical Report, Long-Path One-Way Propagation Effects", D.B.Trizna, NRL Report 2721, March 1974 (de-classified February 1997)

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