ENGLISH HERITAGE

RAF Fylindales, Lockton, North Yorkshire

Roger J C Thomas

SURVEY REPORT

ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

HISTORIC BUILDING REPORT

RAF Fylingdales
Snod Hill
Lockton
North Yorkshire

March 1998

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ROYAL COMMISSION ON THE HISTORICAL MONUMENTS OF ENGLAND

North Yorkshire **NBR No: 59858**

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Snod Hill

RAF Fylingdales (Ballistic Missile Early Warning System - BMEWS)

SUMMARY

RAF Fylingdales is situated adjacent to the A169, approximately 13km (8 miles) south of Whitby, and 14km (8¾ miles) north-north-east of Pickering. The site is located on Lockton High Moor, an area of peat moorland overlying mid Jurassic oolite beds. The tracker site is actually situated on a spur called Snod Hill, some 268m (879ft) above the Ordnance Datum.

The radar station is Site III of the Ballistic Missile Early Warning System, or BMEWS III. Together with two other sites, Thule Greenland (BMEWS I) and Clear Alaska (BMEWS II), RAF Fylingdales provides early warning against missile attacks on the North American continent and the United Kingdom. BMEWS III has been operational since January 1964; the three AN/FPS-49 radars in their familiar 'golfballs' stood sentinel over the bleak North York Moors until the 1st October 1992, when they were relieved of their duty by a new AN/FPS-115 Solid State Phased Array Radar (SSPAR) or 'pyramid'.

At the time of survey (October 1992), the site consisted of three 25.60m (84ft) diameter radar arrays housed in three radomes, or 'golfballs' (trackers 301 - 303), a solid state phased array radar or SSPAR 'pyramid', a power generating house, a stores/warehouse building, workshops, a fire section, a motor transport section, an officers' mess, a junior ranks' club and sergeant's mess, the station headquarters, a guard house, and a number of ancillary structures.

Domestic accommodation is provided on another site and is not covered by this report.

NB Since the site was surveyed, the American AN/FPS-49 'tracker' equipment has been dismantled, and the famed 'golfballs' have been demolished (1994).

HISTORY

1940/45 The site formed part of the artillery range impact area adjacent to Derwent Head, within the Army Practical Training Area (PTA).

1957 August. The USSR tests its first rocket system with a range of 8046.71 km (5000 miles), which was capable of functioning as the vehicle for an Inter-Continental Ballistic Missile (ICBM).

October 4th. Launch of Sputnik 1, the world's first artificial satellite, weighing 83.46 kg (184 lbs).

November 3rd. The USSR launch Sputnik 2 satellite, weighing 507.11 kg (1118 lbs).

1958 January. The Ballistic Missile Early Warning System (BMEWS) proposals were sanctioned by the US Government.

February 8th. The Radio Corporation of America (RCA) was awarded the contract for BMEWS.

July. Construction work commenced on BMEWS I (Thule, Greenland) and BMEWS II (Clear, Alaska).

1959 September 14th. The construction of BMEWS III at Fylingdales was sanctioned by the US Department of Defence.

1960 February 15th. Formal US/UK Memo of Agreement for Site III was signed.

The UK contracts were let out for tender.

Prototype AN/FPS-49 tracker built at Moorsetown.

Ministry of Public Buildings and Works (MoPBW) established a presence on the future site of RAF Fylingdales.

1961 April 12th. USSR launched a 4717.36 kg (10,400 lbs) capsule containing the Cosmonaut Yuri Gagarin - the first man to orbit the earth.

1962 February. Construction work on Tracker 302 was sufficiently advanced to be ready to receive the base ring of the geodesic radome 'golfball'.

February 20th. The USA launches 'Mercury 1' carrying the astronaut John Glenn into earth orbit in a capsule weighing 1354.88 kg (2987 lbs).

May 21st. The first base panel of the radome of tracker 302 was put in place.

August 1st. Squadron Leader Carmen became the first Commanding Officer of RAF Fylingdales.

October. All three radomes were completed, and the private branch exchange (PBX) was made operational by the General Post Office.

1963 January 20th. The construction site became totally cut off by snow, with seven hundred men being stranded. The only means of access was by helicopter.

The first United States Air Force (USAF) operational staff arrived on site.

March. Main construction work completed.

March 17th. Group Captain Betts became the Station Commander.

July 22nd. Twenty-four hour manning commenced.

September 17th. Formal commissioning of RAF Fylingdales (BMEWS III) took place.

1964 January 15th. The Royal Air Force assumed full responsibility for the BMEWS III, and RCA commenced its contract for the operation and maintenance of the site.

February. The power house was accepted by the MoPBW, permitting the station to become a self-contained unit.

April. Landscaping consisting of the planting of grass and trees was carried out to improve the appearance of the site.

June. The temporary 'Labour Camp' adjacent to the site entrance was demolished.

August 18th. USSR's first triple payload rocket was launched.

September. Construction work on the Electronic Counter Counter Measures (ECCM) tower was commenced.

November. A total of 500 man-made objects had been catalogued in orbit.

December. The ECCM tower and radome was completed.

1965 May. Total of 1,000 man-made objects had been catalogued in orbit.

1966 Tropospheric scatter station equipped with 'slab-wall' arrays built to the west of the main gate.

May 19th. Work commenced on the re-painting of the radomes.

December. A meterological station was completed.

1968 January. USAF confirmed that 'Spacetrack' was an operational BMEWS requirement.

1969 April. Members of the Campaign for Nuclear Disarmament (CND) mounted a protest at Fylingdales.

July. 4,000 man-made space objects catalogued.

1970 September. Due to the building of new quarters, the domestic site at East Barnby was vacated.

December 18th. Work commenced on the replacement of the 'Bullring' bearing bed of Tracker 303, with the assistance of 38 Sqn Royal Engineers.

1975 October. The 'Bullring' bearing bed of Tracker 301 was replaced.

1976 May. 10,000 man-made space objects logged.

1978 July. The 'Bullring' bearing bed of Tracker 302 was replaced.

1979 March. Six Japanese Buddhist monks and 100 students mount a demonstration.

November 8th. 15.30 hrs, false Russian nuclear strike alert issued by NORAD computer.

Late 1970s The Carter administration started to examine the politically vexed question of the up-grading the BMEWS system.

1980 A decision to abandon the proposed up-grade of BMEWS was made on the basis of cost and the possibility of violating the Anti-ballistic Missile (ABM) Treaty.

1981 As a consequence of a fire in a radome at Thule, the fibreglass and cardboard honeycomb panels of Tracker 301 were replaced by an aluminium frame supporting a flexible Kevlon skin. During the following two years, the radomes of the other two trackers were

also replaced.

1982 The Reagan administration interpreted the limitations of the ABM Treaty differently from the previous administration, sanctioning the up-grading of BMEWS, awarding the first contract to the Raytheon Company in 1983.

1986 May 22nd. An agreement was announced by the US and British Governments to up-date the facilities at RAF Fylingdales.

1988 June 30th. Contract awarded by the US Government to the Raytheon Company for a new Solid State Phased Array Radar (SSPAR) to replace the arrays at Fylingdales.

1989 July. Contract for the construction of the SSPAR building awarded to John Laing (Yorkshire) Ltd.

August. Construction work commenced.

1991 Latter part of the year witnessed the installation of the SSPAR equipment into the so-called pyramid.

1992 June. Health and Safety testing completed.

October 1st. The Fylingdales SSPAR was declared operational. The new system cost a total of £160 million, the USA providing £112 million to cover the cost of the radar, and the British contributing £48 million for the infrastructure.

1994 Total of 23,000 man-made space objects catalogued, and 7,500 actually in orbit.

February 14th. Phased demolition work by Alan Davison (Construction) Ltd commenced on redundant BMEWS structures.

April 22nd. Official 'golf ball demolition press day'. The press were invited to inspect the site and watch the staged demolition of the north lock tunnel entrance, and the removal of the Kevlon panels from the Tracker 301 radome.

August. The removal of the troposcatter building, the water treatment works, the radomes and tracker buildings was completed.

1994 Late October. Completion of surface regrading.

1995 February. Completion of moorland restoration work.

Operational Function

When built, RAF Fylingdales was a component part of the American Ballistic Missile Early Warning System (BMEWS), the role of which was to detect, identify and transmit the warning of a missile attack upon the United States of America or Europe. The system consisted of three sites - Thule, Greenland (BMEWS I), Clear, Alaska (BMEWS II), and RAF Fylingdales (BMEWS III).

The sites at Clear and Thule were primarily responsible for the tracking of Inter-Continental Ballistic Missiles (ICBM) launched from the Soviet Union over the Arctic. RAF Fylingdales' role was slightly different, in that its primary role was to track Intermediate Range Ballistic Missiles (IRBM) launched from either the Soviet Union or any of the Warsaw Pact countries.

Since that time, the political situation has changed dramatically, with the result there is no longer a single major threat to NATO's security. This is reflected in the fact that the SSPAR system has a 360° arc of coverage; however, the primary function of the detection and warning of a ballistic missile attack remains the same.

In 1968, RAF Fylingdales formally acquired a secondary role, that of space surveillance, or 'Spacetrack'. All man-made satellites are classified as either payloads or debris. A payload is any operational satellite deliberately placed in space to undertake a particular function - space exploration, communications, weather monitoring, research, or military surveillance. Debris can include any non-functioning man-made item which has remained in orbit - tools dropped by astronauts, rocket sections, etc.

Nearly every space launch produces a number of satellites, and as the years have passed, the total has grown dramatically. In April 1994 for example, there were 7,548 objects in earth orbit, of which, only 2192 were actually payloads. At that date, the total number of satellites logged since the launch of Sputnik I stood at 23,018, and since then, it has continued to increase.

It is necessary to track all such items to predict the future orbits of the satellites, and to monitor any decay or changes of orbit. This is particularly important as most intelligence gathering satellites are steerable and can alter their orbit on command. These so-called 'spy satellites' can monitor radar and communication transmissions, or undertake a variety of forms of aerial photography using visible and non-visible methods. The monitoring of these satellites enables warnings to be given to a variety of sensitive military sites, informing them of when their establishment could be subject to scrutiny, and when they are free of surveillance. Spacetrack also enables new payloads to be readily differentiated from old, and it permits the prediction of the re-entry of any decaying satellites into the earth's atmosphere.

All spacetrack data gathered by RAF Fylingdales is sent to the Space Surveillance Centre (SSC) at Cheyenne Mountain, Colorado Springs, where analysts can track and up-date the information held on the constantly changing satellite population. This information has been forwarded to the Royal Greenwich Observatory, the Royal Aircraft Establishment at Farnborough, and a occasionally to some Universities. The SSC is also responsible for informing the National Military Command in Washington of any satellites falling into the territory of the Commonwealth of Independent States. This is to ensure that Russia is informed, in order that a decaying satellite is not mistaken for a re-entering warhead.

Description

RAF Fylingdales (BMEWS III) is situated on a spur called Snod Hill, some 268m (879ft) above Ordnance Datum, on the north-eastern flank of Lockton High Moor. It occupies a site of irregular plan 1011 hectares (2,500 acres) in extent, bordered by the A169 Pickering to Whitby road, Eller Beck and the re-routed footpath known as the Robin Hood's Bay Road. The latter having been re-routed to take into account a radiation hazard area.

The Support Area occupies approximately one-tenth of the over all site area. It is contained within a chain-link fenced boundary, entered on its western flank by an access road from the A169. The principal buildings of the Support Area include the Guard House, Station Headquarters, Fire Section, Motor Transport (M/T) Section, Sergeants' Mess, Officers' Mess, Canteen, Stores and Maintenance Section, and the Powerhouse.

As originally completed in 1963, the Technical Area consisted of three AN/FPS-49 radars (Trackers 301, 302 and 303), each contained within a radome on the roof of a tracker building. One year later, an Electronic Counter Counter Measures (ECCM) tower was added to the complex. Adjacent to, but separate from both the Support Area and the Technical Site was a communication complex, which consisted of an electronics building, tropospheric scatter arrays, and a microwave tower.

Access to all of the tracker buildings was by means of a loop-road with a one-way traffic flow, which at the approach to the trackers, was enclosed by a 1.2 km (¾ mile) long, steel-framed tunnel or utilidor 6.09 x 5.48m (20 x 18ft) high. Externally, the tunnel was clad with heavy gauge corrugated steel sheeting, which provide a radiation shield, while internally the walls were lined with concrete blocks. The tunnel did not go underground, but ran on the surface to the rear of buildings 301 and 303, and through 302. Each end of the tunnel was protected by a double-doored, radiation-shielded chamber guarded by a police post: the North and South Locks. All inter-building cabling and ducting was carried on cable trays suspended from the concrete block walls, or below the ceiling. The tunnel was sufficiently large to permit the free movement of maintenance vehicles and buses with passing places located at the unloading bays of each of the tracker buildings.

Each of the 11.27m (37ft) high three-storey tracker buildings were built using steel-framed girder construction, clad with the same heavy gauge steel sheeting as the entrance tunnel. The integrity of the radiation protection was maintained by an absence of windows and air conditioning. The steel frames were built on substantial reinforced concrete foundations, which enclosed a further massive foundation that supported the radar tower. The tower foundation consisted of eight 2.43m (8ft) diameter concrete pillars sunk 15.23m (50ft) through peat to the bedrock below. The pillars were topped by an 2.34m (8ft) thick octagonal reinforced concrete slab, which further supported the three-storey 11.27m (37ft) high concrete radar tower, that rose

up through the centre of the building.

Tracker buildings 301 and 302 were built to an identical 39.62 x 36.57m (130 x 120ft) rectangular plan, which enveloped the concrete radar tower. At roof level, the radar tower was surmounted by a 10.05m (33ft) pedestal base, which supported a 25.60m (84ft) diameter parabolic dish array, that was enclosed within a 31.69m (104ft) diameter radome. The ground floor (Level 0) of each building was entered directly from the access tunnel and was equipped with a variety of switch-gear and excitor cabinets. The first floor (Level 1) housed the Klystron cabinets and the power generating display panels, while the second floor (Level 2) contained the wave guide trunking and the mixing area.

Building 302 differed from the other tracker buildings in that a 48.76 x 36.57 x 11.27m (160 x120 x 37ft) extension was built to the rear, housing the Computer Room, the Control Switching Cabinet Room, the Operations Room (Missile Warning Operations Centre or MWOC), and the Control Room (Central Systems Monitoring Room or CSMR).

The Computer Room was located on the ground floor (Level 0). It originally housed IBM 7090 missile impact predictor (MIP) computers, which were replaced during the early 1980s by a new main frame system called Control Data Cyber 170, Series 700. The system worked by receiving raw analog radar data which was converted by a video range interpreter into digital information. This was then analyzed independently by duplicate computers to compare and verify the accuracy of the analysis, of whether any of the tracks could possibly be a target trajectory and therefore a threat.

The Operations Room was manned 24 hours a day, and seven days a week monitoring the output of the computers, which was digitally displayed on the colour-coded panels of the duplicated situation display consoles. In addition to the situation display consoles, the operations room housed various pieces of communication equipment, wall mounted situation boards, the electronic counter measures (ECM) consoles, and the counter measures consoles.

The Control Room was located immediately adjacent to the Operations Room. It was manned by civilian staff who monitored and controlled all of the operational equipment. Colour-coded situation boards indicated the serviceability of equipment: green - satisfactory, yellow - marginal, and red - system failure. Due to the need to minimise 'downtime', all sub-systems were duplicated, and had any system gone to red, it could simply be switched to the back-up. During the 29 year life of the AN/FPS-49 radar system and all associated equipment, RAF Fylingdales only suffered a total downtime of 14 hours.

The radar array consisted of a 25.60m (84ft) diameter parabolic dish, formed by a two-piece 6.70m (22ft) diameter central hub, with twenty-four 9.44m (31ft) long radial lattice girders, bolted together by diamond set tubular braces

to form a series of circumferential trusses. The dish was supported by a four-sectioned bolted steel counterweight/axle, carried by aluminium bracket frames. Four waveguides emerged from the pedestal base, two to either side of the bracket frame, before passing through the dish to be united at the hornfeed.

The whole dish structure had a rotated weighed of 113.82 tonne (112 tons) in azimuth, which was carried on a 2.74m (9ft) diameter ball-bearing race, or 'bullring'. The bullring was mounted on the apex of the pedestal base, which consisted of a hollow 10.05m (33ft) high cone, with a base diameter of 6.4m (21ft). The cone was built up of bolted steel segments arranged in four superimposed rings. The lower ring was equipped with a series of hydraulic rams around its base, to enable the aerial to be levelled. Two doorways permitted access into the interior.

Each array was capable of producing a radar 'surveillance fence' approximately 42.67m (140ft) high and 2,150.66m (2352yds) long, out to a range of 4828 km (3,000 miles), scanning an arc of 20° per second, at a peak power output of 5 mega watts. The three arrays were operated in such a way that two worked in scan, while the third operated as a tracker.

The geodesic radomes were designed by Goodyear Aerospace Ltd. and were built with their assistance by the contractor Wood Pritchett. Each radome originally consisted of 1,646 pentagonal and hexagonal panels, built of a 15.23cm (6in) glazed fibrous cardboard honeycomb, covered with an inner and outer fibreglass sheet, coated with a polyethylene film. The panels of an individual radome were held together by a total of 60,000 bolts at reinforcement points on the edges. The whole structure was then painted with pale blue Hypalon paint. On completion, each radome weighed approximately 113.82 tonnes (112 tons) and was capable of withstanding winds of up to 209 km (130 mph). External ropes and bosun's chair line attachments were fixed to the radomes to permit basic maintenance and the clearance of snow.

The radomes were built to provide dielectric cover, which permitted the efficient transmission of microwave signals, while simultaneously affording the equipment and personnel protection from the extremes of the weather. Due to a potential fire hazard, the original radomes were all between 1982 and 1984 1980s. The replacements were constructed of aluminium frameworks, clad in a tensioned Kelon plastic skin. These new radomes were however, not without their own problems, as birds started pecking their way through the skin, with the result that 'bicycle tyre' repairs had to be effected on occasions. During 1994 demolition, the radomes were de-skinned prior to being demolished by hauling the bare framework off the tracker buildings, using steel hawsers and heavy hydraulic machinery.

Solid State Phased Array Radar (SSPAR)

The current radar system operated at RAF Fylingdales is the AN/FPS-115 Solid State Phased Array Radar or SSPAR. The SSPAR is contained within

a chain-link fence perimeter, which has gravel aprons to each side, permitting the early detection of an intruder using remote ground sensors (RGS). Vehicle and pedestrian access is via a gateway in the southern perimeter, protected by a single-storey rectangular plan Guard House.

The equipment is housed in the Technical Facility/Scanner Building, which has the appearance of a truncated pyramid some 32m (120ft) high, on a two-storey rectangular base. The building is of steel-framed construction, clad with plastic coated, 14-gauge, corrugated steel sheeting, and a concrete and steel roof. It has an internal floor area of approximately 15,000 m^2 (16,404 yds^2), which contains two stand-by generator sets, a plant room, workshops, a computer room, communication facilities, offices, and an operations room.

The three faces of the pyramid function in combination as the radar array. Each face is fitted with 2,650 individual transmit and receive modules and their associated dipole antennas, forming a circular array with a diameter of 25.60m (84ft). Each antenna has a power output of 340 watts, giving an overall mean power output of for the three faces of approximately 2.5 mega watts.

The system has been designed with ease of maintenance and operational reliability in mind. A graceful degradation of 5% of the dipoles is permissable without any detrimental effect on the array's performance. Utilising the modular design of the array, virtually all maintenance work can be carried out with the minimum of fuss, while the array is operating at full power.

Unlike the earlier mechanical AN/FPS-49 radars, the Solid State Phased Array Radar system has no moving parts and does not require a large dish array. Its operation can be likened to a row of boys dropping stones in sequence from a sea-wall; the wave produced by each successive stone deflecting that of the previous one. Basically each of the dipoles can send out its pulse at a fractionly different time, or phase than the next. In combination, it is possible to transmit an energy wavefront that can be directed at a particular target or direction by simply changing the phasing of the transmitters. Given that these changes in phase can occur in a very short period of time, the SSPAR is capable of maintaining a radar boundary, and at the same time, track up to 800 separate objects out to a range of 4,828 km (3,000 miles).

Visited by:	Roger JC Thomas & Jane Harding (24th Sept.1992 & 25th Apr.1994)
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SOURCES
The majority of information used to produce this report has been based on fieldwork and information provided by Royal Air Force briefings.

BCF Wilson, *A History, Royal Air Force Fylingdales*, (Sunbury-on-Thames, 1983).

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AA92/04516	AN/FPS-49 TRACKING RADAR ANTENNA, DIAMETER OF 84 FT., WEIGHING 112 TONS IN AZIMUTH AND 40 TONS IN ELEVATION. TRACKER 302. (COLOUR).
AA92/04517	AN/FPS-49 TRACKING RADAR ANTENNA IN ELEVATION, TRACKER 302. (COLOUR NEG).
AA93/02973	SILHOUETTED DISTANT VIEW FROM GOATHLAND MOOR, VIEWED FROM THE NORTH-WEST.
BB97/09912	VIEW ALONG THE ACCESS TUNNEL FROM THE SOUTH.
BB97/09913	THE THREE RADOMES VIEWED OVER THE INNER PERIMETER FENCE, FROM THE SOUTH.
AA94/03133	DISTANT VIEW OF 'GOLFBALLS' AND THE 'PYRAMID' OFF GOATHLAND MOOR, FROM THE NORTH-WEST.
AA94/03134	DISTANT VIEW OF THE 'GOLFBALLS' OFF GOATHLAND MOOR, FROM THE NORTH-WEST.
AA94/03135	'GOLFBALL' OF TRACKER 301 WITH DEMOLITION SIGN IN FOREGROUND VIEWED FROM WEST NORTH WEST.
AA94/03136	'GOLFBALL' OF TRACKER 301 WITH GAS CYLINDERS IN FOREGROUND VIEWED FROM WEST NORTH WEST.
AA94/03137	'GOLFBALL' OF TRACKER 301 VIEWED FROM FROM THE WEST, WITHIN THE DOUBLE PERIMETER FENCE.
AA94/03138	'GOLFBALL' OF TRACKER 301 WITH LOWER SECTION OF 'KEVLON' SKIN REMOVED, VIEWED FROM THE WEST. {PORTRAIT FORMAT}

AA94/03139	'GOLFBALL' OF TRACKER 301 WITH LOWER SECTION OF 'KEVLON' SKIN REMOVED, VIEWED FROM W.N.WEST. {LANDSCAPE FORMAT}
AA94/03140	NORTH LOCK AND 'GOLFBALL' OF TRACKER 301 WITH PRESS PHOTOGRAPHERS IN THE FOREGROUND, VIEWED FROM W.N.WEST.
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AA94/03143	CEREMONIAL COMMENCEMENT OF THE DEMOLITION OF THE NORTH LOCK FRAME TWO OF A SEQUENCE OF THREE.
AA94/03144	CEREMONIAL COMMENCEMENT OF THE DEMOLITION OF THE NORTH LOCK FRAME THREE OF A SEQUENCE OF THREE.
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AA94/03147	MECHANICAL SNIPS BEING USED TO DEMOLISH THE NORTH LOCK, VIEWED FROM THE NORTH-WEST {PORTRAIT FORMAT}
AA94/03148	SOLID STATE PHASED ARRAY RADAR {SSPAR} 'PYRAMID',VIEWED FROM THE WEST.
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