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Radar in Scotland

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Chapter 1

Radar in Scotland 1938–46

The Scottish connection with radar goes back to the very origins of the technology, and the work of the Scot James Clerk Maxwell. In 1864 he calculated the theoretical existence of radio waves (Dummer, 1978: 53), which were not actually discovered until the experimental work of Heinrich Hertz in 1887 (Dummer, 1978: 61). However, it took the Italian Guglielmo Marconi to demonstrate that radio had a practical application, culminating in his transmission across the Atlantic in 1901 (Dummer, 1978: 63). Three years later a German, Christian Hülsmeyer, patented an obstacle warning device known as the Telemobiloscope, which bounced radio waves off objects in front of a ship. This would ring a bell, warning of the presence of the object. Sadly, the Telemobiloscope was a commercial failure (Pritchard, 1989: 13–20). This was not the end of the story in Germany, where the first true radar – which could not only detect an object but locate it as well – was demonstrated in Kiel Harbour in May 1934 (Kroge, 2000: 23).

In Britain, the theories of radio propagation were well known. In 1924 Edward Appleton was able to calculate the height of the Heaviside layer of the upper atmosphere by bouncing radio waves off it (Clark, 1971: 42). Appleton, however, used continuous waves, whereas British radar would eventually be developed using pulses, which made the calculation of range much easier. Consequently, although Appleton was ranging with radio waves, his work was not a direct ancestor of British radar, which did, nonetheless, have its origins in atmospheric radio research (Watson-Watt, 1957: 90–2). However, although the technology existed, there was no drive towards developing radar until the rising political threat from Germany prompted the Air Ministry to take action. Concerned that there was no effective form of air defence, in December 1934 the Committee for the Scientific Survey of Air Defence was set up to investigate all possible applications of science to this problem (Bragg, 2002: 22).

Prior to its first meeting, Harry Wimperis, Director of Scientific Research and a member of the committee, made an informal approach to Robert Watson Watt of the Radio Department of the National Physical Laboratory. Wimperis was aware of all the imaginative claims that had been made for death rays over the years, but wanted Watson Watt's opinion on whether a radio death ray was possible.

Calculations confirmed that a death ray was completely impracticable, but Watson Watt suggested that perhaps radio could be used for detection. Further calculations confirmed that sufficient energy would be reflected to make detection possible. Money would be required for development and approval for this would be needed from the Air Member for Research and Development, Air Marshal Sir Hugh Dowding. Dowding wanted an experiment to prove the mathematics, and consequently, on 26 February 1935, a demonstration was carried out which used a receiver in a small van, a Handley Page Heyford bomber as the target and the BBC transmitter at Daventry. This has since become known as the Daventry experiment. Its success convinced Dowding to approve the £10,000 requested for research (Bragg, 2002: 23–33).

By July 1935 ranges of 40 miles were being achieved (Bragg, 2002: 38) and Watson Watt was talking about a chain of stations at 20 mile intervals around the country. On 30 November 1935 Wimperis submitted a proposal to the Treasury for a chain of five radar stations providing coverage over the Thames Estuary and the approach to London, at a cost of £68,000. This was approved on 19 December (Bragg, 2002: 49–50) and the first of these stations, at Bawdsey in Suffolk, was handed over to the RAF in September 1937.

The story of the radar defences of Scotland begins at a meeting on 30 June 1937, when the Air Staff requirement for radar coverage in the UK was outlined. Coverage sufficient to provide warning of aircraft approaching at a minimum height of 3,000 feet at a distance of 40 miles was to be provided between the Isle of Wight and Lowestoft; between Lowestoft and St Andrews the Air Staff would be satisfied with detection of aircraft at 5,000 feet at 35 miles. However, in the coastal areas of the Forth, Tyne, Tees and Humber, coverage of the same standard as required for the Isle of Wight to Lowestoft area was stipulated. The Forth, Tyne, Tees and Humber were to be given the greatest possible radar coverage because of the great naval importance of these rivers, indicating that they were just as important as the defences of London and the aviation industries in the Midlands. Rosyth Naval Base in the Forth had already been selected as the main base for the Home Fleet and was clearly a facility of major importance (Air Ministry, 1950 (1): 29).

The first stage in the provision of this coverage was the selection of approximate positions for the stations. Such locations were chosen at St Abb's Head/Fast Castle, St Andrews (Strathkinness) and St Cyrus. These proposed sites had been selected using maps to give spacings of about 40 miles, this being considered the optimum distance between stations. However, relying on maps meant that when survey teams went to the locations, they found many of the sites were unsuitable (Air Ministry, 1950 (1): 31–2).

No further progress was made towards the provision of radar cover in Scotland until the wider political situation intervened. With the growing international crisis due to German territorial claims over the Sudetenland, on 16 September 1938 the Deputy Chief of the Air Staff and Director of Operations and Intelligence at the Air Ministry, Air Vice-Marshal Richard Peirse, ordered that mobile equipment should immediately be set up at Drone Hill near St Abb's Head, Ravenscar in Yorkshire and West Beckham in Norfolk. These three stations were set up with equipment which had been planned for use overseas, and the scale of the urgency can be gauged from the fact that Drone Hill was on the air 12 days later. This was the first new radar site erected

since the five-station chain had been built round the Thames Estuary and demonstrates the importance of providing early warning coverage for the Forth–Clyde area and, in particular, the vital naval base at Rosyth (Air Ministry, 1950 (1): 45; TNA, AVIA 7/299).

On 19 January 1939 Peirse held a meeting to discuss extensions to the radar chain, and it was decided to extend it northwards towards Scapa Flow. Early warning of an attack on the Home Fleet base at Scapa Flow was to be given by a station at Kirkwall and one at Stonehaven (Air Ministry, 1950 (1): 60). It was that same month that the Home Fleet selected Scapa as the Main Fleet Base instead of Rosyth (Hewison, 1990: 233) and, despite the shortage of equipment, radar coverage was immediately allocated for Scapa Flow. In fact, the defence of Scapa Flow had such a high priority that the radar station there had to be equipped on an emergency basis. New wooden huts were ordered, but the necessary towers came from Drone Hill and the transmitter, receiver and aerial systems from Ravenscar. As a result of these emergency measures, Netherbutton (the station at Scapa Flow) became operational on 2 June 1939 (TNA, AVIA 7/308) and Schoolhill (the station near Stonehaven) in November 1939 (TNA, AVIA 7/303).

By that time, another station had become operational. This was Douglas Wood, which went on the air on 10 March 1939. It appears that this station, besides acting as another link in the Home Chain, was to provide additional coverage over the approaches to the Forth. This improved coverage was possible by virtue of Douglas Wood working as an Intermediate Chain Home (CH) station before Drone Hill Intermediate CH became operational later that spring (TNA, AVIA 7/302).

By the outbreak of war on 3 September 1939 the continuous east coast radar coverage extended as far north as Dundee, with a station operating in isolation on Orkney. However, the Home Chain was far from complete, and there were a number of additional strategic requirements, one of which was raised at a meeting between Admiralty and Air Ministry personnel on 2 October 1939. At this meeting Vice-Admiral Sir James Somerville, appointed on special service at the Admiralty with responsibility for the co-ordination and development of radar for the Royal Navy, stated that warning cover should be given in Orkney of the approach of hostile aircraft from the south and west. The possibility of converting Netherbutton into an 'all-round looking' station, with four lines of shoot at right angles to each other, was discussed, as was the erection of a mobile station near Wick (TNA, AVIA 7/308); the latter was not completed until February 1940 (Hubert Nettleton, pers comm).

Plans were also being implemented for the erection of a station at Hillhead, to plug the gap between Schoolhill and Netherbutton. Here again naval considerations were overriding: it had originally been intended to give Hillhead a line of shoot of 30°, but this was changed to 45° at the insistence of Air Marshal Sir Philip B Joubert de la Ferté. Joubert was on Special Duties, RDF (Radio Direction Finding), and thus closely involved with the development of radar in the RAF. The change to Hillhead's line of shoot was made in order to give longer-range warning on raids approaching Scapa Flow from the south-east, despite the fact that this reduced the coverage of the Moray Firth (TNA, AVIA 7/304).

By the time the Advance CH station at Hillhead became operational in December 1939, a number of developments, both strategic and technical, had taken place which affected the Home Chain in Scotland. The most

1 Map of radar stations in Scotland, September 1939.
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2 Map of radar stations in Scotland, August 1940.
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important of these was the introduction of the technically more advanced Chain Home Low (CHL) stations. This equipment came from work being carried out by War Office scientists attached to the research team at Bawdsey Research Station under Robert Watson Watt. The Army 'cell' was working on equipment to track ships for the needs of coast artillery, and by 1939 this had reached an advanced stage. Aware of the Army's work, the Air Ministry took over the Coast Defence (CD) equipment for their own needs and pressed it into service as CHL. Operating on a wavelength of 1½ metres, as opposed to the 5 to 13½ metres of CH, meant that CHL produced a narrower beam which could be mechanically swept over an arc. More importantly, the vertical coverage was of a lower angle than CH and therefore extended farther at lower altitudes. For the Air Ministry, this meant CHL could detect low-flying aircraft at much greater ranges than was possible with CH and was therefore of great importance to the radar defences; in particular it was to prove invaluable in combating the menace of low-flying minelaying aircraft (Bragg, 2002: 133–5).

The urgency of the requirement for low-level coverage was such that the prototype equipment, which had been undergoing trials at the Air Defence Experimental Establishment operated by the War Office at Christchurch, was pressed into service as the first operational station. However, this first site was to be an Admiralty, not Air Ministry, station. Vice-Admiral Somerville had devised a scheme for the deployment of CDU stations (the Admiralty term for CHL stations operated by the Navy) in the Orkney and Shetland Islands. This scheme would make it possible to detect U-boats passing through the Fair Isle Channel into the Atlantic. However, the torpedoing of HMS *Royal Oak* in Scapa Flow by U-47 on 14 October 1939, and the subsequent withdrawal of the Home Fleet, meant that provision of CDU cover for the Forth was given the highest priority. As a result, the Christchurch prototype was sent to Edinburgh instead of Shetland and was operating at Anstruther a few days after test flights were carried out on 17 November 1939 (Clifford Evans, pers comm). As soon as additional equipment became available, a CDU station was set up at Sumburgh Head and two stations on Fair Isle. It was originally intended to site a station on one of the northern Orkney Islands, but this plan was abandoned. Nonetheless, the Sumburgh station became operational on 27 December 1939 and the two Fair Isle CDUs were operating by 1 March 1940 (HRA, Naval Shore Radar).

By that time, the Air Ministry had implemented the first 'crash' programme of CHL construction, producing sufficient sets to erect a number of stations in areas urgently requiring coverage against low-flying aircraft. As a result, Cockburnspath CHL became operational on 26 January 1940 and was followed by a number of stations set up under the second 'crash' programme, at St Cyrus, Doonies Hill and Rosehearty, all of which were operating before the end of February 1940. Although these urgent CHL construction programmes had placed a considerable strain on No 2 Installation Unit, which was responsible for the erection of the radar chain, the result of the effort was that, by the early spring of 1940, low-flying aircraft could be detected along the east coast of Britain as far north as Kinnaird Head, and the Fair Isle Channel was covered against U-boats attempting to pass through on the surface (Air Ministry, 1950 (1): 84–5).

However, by early 1940 German aircraft were increasingly flying farther into British airspace over the west coast and the Irish Sea, and a number of other gaps in the radar

coverage were identified. As a result, in January 1940 the highest priority was given to the provision of coverage in the Firth of Clyde, Cromarty Firth, Central Scotland and the Shetland Islands. Consequently, CH stations were set up at Skaw, Noss Hill and Whale Head, with increased CHL coverage in the area of the Orkney and Shetland Islands in the form of stations at Gaitnip, Tannach, Saxavord, South Ronaldsay and Dunnet Head. Cromarty CHL, covering the Cromarty Firth, became operational in August 1940. By the time most of these stations became operational, the German invasion of Denmark and Norway on 9 April 1940, followed by the British evacuation of southern Norway in early May 1940, meant that the Germans were in possession of an extensive coastline facing the north-eastern coast of Britain, and within close striking range of the Home Fleet base at Scapa Flow. The threat to the northern coast was clear (Air Ministry, 1950 (1): 124).

This threat was to be realised in March and April 1940, when a series of air attacks were launched against Scapa Flow. These were an attempt to destroy the Home Fleet at harbour, much as the Japanese were to attempt at Pearl Harbour some 18 months later (HRA, Naval Shore Radar). An estimated 15 aircraft attacked on 16 March and the cruiser HMS *Norfolk* was hit and damaged (Hewison, 1990: 292–3). Larger attacks were launched on 8 April, by around 25 aircraft (Hewison, 1990: 298), and on 10 April, with a mass raid of around 60 bombers (Hewison, 1990: 301). The attacks on 8 and 10 April were detected by the CDU stations at Sumburgh and Fair Isle and the CH station at Netherbutton, providing sufficient warning for the defences to be prepared (HRA, Naval Shore Radar). On 10 April the effective deployment of anti-aircraft barrage fire over Scapa Flow, with 1,700 rounds of heavy anti-aircraft ammunition being fired, broke up the attack, with only minor damage caused to the cruiser HMS *Suffolk* (Hewison, 1990: 300–1), and contributed to the destruction of 6 enemy aircraft (Ramsey, 1987: 77). The defeat of these attacks, without serious loss to the Royal Navy, demonstrated the value of the radar defences in the northern isles. In particular, had the bulk of the Home Fleet not sailed from Scapa Flow on 7 April (Roskill, 1954: 159), and the mass raids on 8 and 10 April been successful and inflicted a heavy blow on the Home Fleet, the consequences might have been catastrophic. The serious damage to British naval power could have resulted in defeat in the Battle of the Atlantic, and the war overall.

However, it was events not only in Norway, but also in France, which were to have important consequences for the radar chain in Scotland. As a result of the fall of France in June 1940, and therefore German possession of the French Channel ports, British shipping was transferred almost immediately from the English Channel to the North Channel. Consequently the scale of attacks on shipping in the Irish Sea and North Channel grew alarmingly. It was therefore urgent to increase both high- and low-level coverage in this area, with additional stations in Northern Ireland, Islay and the Isle of Man being proposed (Air Ministry, 1950 (1): 142); as a result 11 new stations became operational in late 1940 and early 1941 (Air Ministry, 1950 (1): 549). Included amongst these was the Mobile Radio Unit (MRU) sent to North Cairn on 26 June 1940. Such installations, with additional stations such as Sango CH to protect the large amount of shipping sailing round the north of Scotland, proved essential in the battle to protect shipping in coastal waters during the early part of the maritime war. It was also naval considerations which led the Commander-in-

Chief, Rosyth, to request in January 1941 a station in the Glasgow area to protect Rosyth Naval Base from air attack from the west. In consequence, an MRU was set up at Kilmacolm, west of Glasgow, before the end of the month (TNA, AVIA 15/256).

The naval war was intensifying, as a result of the order issued by Adolf Hitler on 6 February 1941 that the German forces should direct their full strength against Britain's overseas supplies (Roskill, 1954: 338). In response, on 6 March 1941 Prime Minister Winston Churchill issued a Directive to the Chiefs of Staff to the effect that it must be assumed that the Battle of the Atlantic had begun, and that improved radar coverage for the defence of shipping was to be given the highest priority. In order to improve radar coverage over the north-western approaches, CHL stations were to be sited on the Faroe Islands and Iceland (Air Ministry, 1950 (1): 151–3). This coverage was to be supplemented with a number of new CHL stations in the Shetland Islands, Western Isles and the west coast of Scotland (Ben Hough, Carsaig, Clett, Eorodale, Greian Head, Islivig, Kendrom, Point of Stoer, Rodel Park, Sango and Watsness), which were known as the Battle of the Atlantic stations. Other stations were proposed, but later rejected, for St Kilda, Rona and the Flannan Islands. The Prime Minister also suggested the erection of stations on Rockall, Tory Island, the hills south of Lough Erne and one of the islands off County Kerry, although these too were rejected (Churchill, 1950: 664).

Another development of early 1941 was the introduction of Ground Control of Interception (GCI) equipment, with mobile stations being set up at St Quivox and Dirleton in April 1941. This equipment arrived just as the night blitz was at its height, and at least two German bombers attacking Clydeside were destroyed by aircraft under the control of St Quivox GCI (TNA, AIR 26/103).

The year 1941 was also to see further development of CHL equipment. The hand-turned twin-gantry stations suffered severe problems in high winds, when it became impossible to rotate the aerials and they had to be lashed to the ground in a fixed position. Clearly this was undesirable since any such station was only watching in a single direction and might not detect an incoming attack. Proposed ways of dealing with this included building screens around the aerial arrays, but eventually the problem was solved with the introduction of what was known as the 1941 Type CHL. This was a technical improvement on the original equipment, with a single power-turned aerial array for both transmitting and receiving, and a single combined T & R Block, made usually of brick, to house the equipment. These stations were built in Scotland during 1941 and 1942, and were responsible for a great improvement in the CHL coverage (Bragg, 2002: 261–2).

At about the same time, the War Office was also introducing its own early warning chain. The CD equipment which the Air Ministry had used for CHL was developed into CD/CHL for War Office use. Fears of a German invasion of Britain with the onset of spring in 1941 led to the construction of a chain of CD/CHL stations to warn of approaching landing craft. This chain would be extended around the major part of Britain's coast throughout 1941 and 1942, to provide radar coverage of naval movements and to pass such information to Naval Plotting Rooms (NPRs) and thence to coast batteries (Air Ministry, 1950 (1): 137–9). CD/CHL stations at Gin Head, The Law, Westburn and Crannoch Hill became operational in mid-1942 (TNA, AIR 26/100, AIR 26/103).

Despite this improving coverage, by early 1941 the German Air Force was increasingly making low-level attacks on shipping along the eastern coast of Scotland (Air Ministry, 1950 (1): 139). German aircrews were clearly aware that aircraft could fly in under the radar cover and remain undetected on their approach to the coast. This problem was not to be solved until the introduction from 1942 onwards of stations operating at centimetric wavelengths. Thus, by 1 January 1943 there were five low-power 10 cm stations operational in Scotland – South Ronaldsay, Dunnet Head, Rosehearty, May Island and Lamberton Moor) (Air Ministry, 1950 (1): 578).

The improved performance possible with centimetric radar was also appreciated by the War Office, which introduced CA radars not only to plot vessels but also to observe fall of shot and provide aiming corrections. Although the CA radars in Scotland did not have any hostile targets presented to them, they nonetheless demonstrate the importance the War Office attached to the provision of such coverage (Sayer, 1950: 140–3).

By the end of 1943 the great expansion in the number of radar stations, both in the Home Chain but especially overseas, had placed a tremendous demand on the numbers of trained personnel to operate and maintain these installations. In fact, demand was beginning to outstrip supply at the same time as there was a decreasing threat to Scotland. A review of the situation was made by Fighter Command in November 1943, as a result of which it was decided to implement economies in the Home Chain to release personnel for service overseas. Consequently, nationally 13 stations were to be dismantled, with another nine to be placed on care and maintenance. A number of other stations were reduced to operating on a part-time basis (Air Ministry, 1950 (1): 516). Further contractions of the Home Chain took place in 1944 with the closure of another eight stations, and by March 1945 most of the stations on the west coast had been reduced to a care and maintenance basis (Air Ministry, 1950 (1): 636–8).

At 4.30 pm on 15 March 1946, No 13 Group Filter Room in Inverness closed down, and all remaining radar stations in Scotland went off the air. This was the end of eight years of radar coverage, and it would be several years before Scotland's radar screen would be reactivated in the face of the increasing threat from the Soviet Union (TNA, AIR 26/93).

However, although the last radar stations in Scotland closed down in 1946, it was not the end of the story. Scotland also had several chains of radio navigational aids assisting aircraft in the area. The story dates back to 1941, when it was realised that only one-tenth of Bomber Command aircraft were dropping their bombs within 5 miles of their targets in the industrial area of the Ruhr, never mind hitting them. An idea from the previous year was developed, producing the system known as Gee. The ground element of this was AMES Type 7000, or Type 7K. The time difference in the signals between a master and several slave stations enabled the navigator in the aircraft to determine his position in a grid of parabolic curves. Several chains of stations were built in Britain, with the Northern and North Western chains providing navigational assistance to transatlantic ferry aircraft, for operational missions across the North Sea towards Norway and to the Continent, and for long-range maritime and meteorological reconnaissance missions (TNA, AIR 29/147, AIR 29/167).

The United States developed a similar system, known as Loran, with the Eastern Atlantic Chain having stations in Iceland, in the Faroe Islands and at Mangersta on Lewis. This

3 Map of radar stations in Scotland, August 1942.
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4 Map of radar stations in Scotland, March 1945.
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5 Map of radar stations in Scotland, March 1946.
(© Historic Environment Scotland)

6 Map of Northern Gee Chain stations.

chain was part of a wider network, providing navigational assistance for Atlantic convoys as well as Coastal and Ferry Command aircraft across the length of the Atlantic (Air Ministry, 1956: 205–8). A version of Loran called Skywave-Synchronized, or SS Loran, relied on the signal being bounced off the atmosphere to synchronise two widely separated ground stations. The SS Loran station at Port Errol was linked with a mobile unit in Bizerta, and this system was used for navigation over Europe and certainly for navigation on several bombing raids (Air Ministry, 1956: 202).

Although their military role declined with the ending of hostilities in 1945, radio navigational aids remained operational in Scotland long after the closing of the last wartime radar station in 1946, and they were the forerunners of the modern satellite Global Positioning System (GPS) that still allows aircraft and other vessels to locate their position accurately.