Article

Doing 'All We Can To Help Mr Tizard' The Role of Sholto Douglas in Radar Development and Its Application

By Dr Katharine Campbell

Biography: Dr Katharine Campbell was a neuroscientist before becoming a writer, completing her PhD at University College London and staying on as a post-doctoral fellow. Her biography of her father Sholto (MRAF Lord Douglas of Kirtleside), *Behold the Dark Gray Man*, published in 2021, was selected for the 2022 CAS' Reading List. She collaborates with historians across Europe and with world experts on PTSD. She was invited to participate in the Australian Royal Commission into Defence and Veteran Suicide, in which she is still involved.

Abstract: The prevailing historical narrative has been that the creator of the 'Dowding System' of air defence, of which radar was a vital part, was the brainchild of Air Chief Marshal Sir Hugh Dowding, the contribution of other Air Force officers, including my father Sholto Douglas, having been largely ignored. However, Sholto was involved in radar development from its early days in 1936, when he coordinated the first aircraft interception experiments as Director of Staff Duties at the Air Ministry. From that point up to and into World War Two, he was at the forefront of radar evolution and its application, particularly to night fighting, pursuing this engagement for the remainder of WWII as AOC-in-C of Fighter Command especially, but also when he oversaw Middle East and Coastal Commands.

Air Chief Marshal Sir Sholto Douglas, C-in-C Fighter Command, inspecting film in his office at Bentley Priory, December 1942. © Getty Images.

Introduction

Until I began researching the life of my father, Marshal of the Royal Air Force Lord Douglas of Kirtleside (known always as 'Sholto', which he preferred), to write his biography,[1] I subscribed to the prevailing narrative, articulated by the historian Dr David Jordan, that success in the Battle of Britain 'was the result solely of the efforts of Air Chief Marshal Sir Hugh Dowding as Air Officer Commanding-in-Chief [AOC-in-C] of RAF Fighter Command.' But as Dr Jordan continues, this 'obscures the fact that success was built upon a long period of development,'[2] beginning in World War One. Following the 'Gotha raids' in 1917, in which, among other atrocities, twenty-three children aged between four and six years old were killed on one day alone, eighteen of whom died when a bomb demolished Upper North Street Council School in Poplar,[3] the London Air Defence Area was formed under the command of Major General E. B. Ashmore. He also oversaw the foundation of the Observer Corps in 1925, which was to become a vital part of what was, and is, known as the 'Dowding System.'

The Radar Chain was another essential element of this network of air defences, becoming, as Vincent Orange observed: "'the catalyst of defence science". In short, Watson-Watt gave it birth; Tizard supported it; and Dowding grasped it.'[4] However, in his biography of Dowding, Orange neglects to mention the other Air Force officers who championed radar from the

beginning, including Sholto, who was not only responsible for instigating the Biggin Hill radar experiments, but who also sanctioned the necessary funds to make those trials a reality.

In January 1936, Sholto, who had been promoted to the rank of Air Commodore, was appointed Director of Staff Duties (DSD) at the Air Ministry, a position that he took up officially in the same month.[5] The most important element of his work was to take care of the training programme for the entire RAF, including organising major exercises,[6] and it was in this post that his involvement with radar began.

The Biggin Hill interception experiments

Following moderately successful demonstrations of the utility of radar in detecting aircraft under daylight conditions in 1935 and 1936, Watson-Watt made a prediction that the success of fair-weather radar detection meant that a potential enemy would be driven to night attack, or attack through cloud. This was presented to the Committee for the Scientific Survey of Air Defence (CSSAD), chaired by Henry Tizard and therefore known as the Tizard Committee, in February 1936, and thereafter Watson-Watt's team set to work on developing airborne radar equipment, which, because of the difficulties in its realisation, would not come to fruition until 1941, when Sholto was AOC-in-C Fighter Command. Along with its essential counterpart, Ground Control Interception radar (GCI),[7] Airborne Interception (AI)[8] would be instrumental in ending the Blitz.

Tizard had come to the same conclusion as Watson-Watt: that techniques would have to be developed that would direct fighter pilots to the point of interception with enemy bombers whatever the conditions. He had a meeting with the Deputy CAS (DCAS), Air Marshal Christopher Courtney, on 13 July 1936 to obtain approval for experiments. Tizard wanted to know how long it would take to intercept an enemy bomber following receipt of the bomber's approximate position ten minutes from the coast. Furthermore, Watson-Watt and his team of AI investigators needed to know the minimum distance that an aircraft required for effective interception.[9]

Sholto, as DSD, was given the task of implementing the proposed interception experiments. On 14 July, the day after Tizard and Courtney's meeting, Sholto wrote to the AOC No.11 (Fighter) Group, Air Marshal Philip Joubert de la Ferté, to inform him of the aircraft and ground facilities needed for the exercises. Sholto wrote: 'we are very anxious to do all we can to help Mr Tizard, as these experiments are, in our opinion, most important, particularly from the bearing that they have on the future employment of the RDF [radio direction finding] system.'[10] Together, Sholto and Joubert de la Ferté decided on the sector station at Biggin Hill in Kent as the optimum location, Sholto informing Courtney of this suggestion.[11] From this time on, they were known as the Biggin Hill Experiments. As soon as Sholto had established both the location and that the necessary aircraft could be supplied from both Bomber and Fighter Commands, on 27 July he wrote a preliminary letter to the AOCs-in-C of these Commands, and the AOC of No.22 Army Co-operation Group.

The following day Sholto received a reply from Dowding who had taken over as AOC-in-C Fighter Command in July. He was a little put out that little information concerning the exact nature of the experiments was contained in the letter, and that therefore the station commander at Biggin Hill, Wing Commander Grenfell, and Tizard, would be 'in complete control not only of the details but also of the experiments as a whole.'[12] Dowding wanted to be included in the loop, and particularly to be in personal touch with Tizard. Sholto replied within three days to Dowding with all the information that he required.

Dowding then arranged a conference between himself, Tizard, and the major players who would be involved in the exercises including Joubert and Grenfell, on 7 August without apparently inviting Sholto,[13] to whom he wrote a letter that was critical of the Air Ministry while at the same time appearing to exclude him. Dowding wrote that the Air Ministry needed to take more action, specifically to provide more specialist staff and to allow more time for the experiments, although the Air Ministry already had in hand the task of appointing a navigation officer, an essential member of the proposed team, and had made tentative suggestions regarding time scale to fit in with Tizard's schedule. The RAF Signals History notes that Sholto sanctioned the continuation of the experiments for as long as was necessary, into 1937 if need be.[14]

It is clear from Dowding's correspondence that there was a definite 'prickliness' to his communication, and that, as Sholto had observed many years before, he was suspicious of those in the Air Ministry. Sholto's initial letter was intended only as a preliminary approach, but Dowding thought immediately, without any foundation, that he was being sidelined. Perhaps, as he indicated, he did not like being told what to do by those who had until quite recently been his subordinates, even though Sholto was acting at Courtney's behest.[15] Or perhaps there was some truth to the assertion, made almost exactly four years later in a very controversial memo sent anonymously to influential people in the government, parliament, and the RAF during the summer of 1940, that 'HQ Fighter Command is substantially a one man show and is ruled by Air Chief Marshal Dowding who has definite personality…..He is also a classic example of a complete non-co-operator either with the Air Ministry or any other authority.'[16] Although Air Vice-Marshal Keith Park, AOC No.11 (Fighter) Group, praised Dowding for his ability to delegate tactical control of fighter operations to his group commanders, when it came to supervision of the elements of what has been called the Dowding system, he was certainly a micro-manager.[17]

The Biggin Hill interception experiments began on 5 August 1936, and the suggestion was quickly made that it would be most desirable for the two RAF navigation officers in the Operations Room to be provided with some form of automatic equipment for calculating the fighter course needed to intercept the bomber, as well as the estimated time of interception, taking into account the wind, relative positions, and the track and ground speed of the fighters and bombers. The RAF officers decided initially that the practised eye or 'dead reckoning' was the best method.

At first, bombers were instructed to fly on a pre-arranged straight course from a known starting point and at an agreed height, in which case interception was very successful (twenty-six out of twenty-eight runs). In the second series of experiments, they were allowed to alter their courses at will, necessitating frequent redirection of fighters with delays resulting from having to work out another course, and sometimes a failure of interception altogether. Nevertheless, the fighters became more expert as the tests continued, and the bombers were permitted to make changes to course, height and finally to speed.

In the important meeting on 7 August, the matter arose of the aircraft to be used for searchlight experiments, and Dowding said that these exercises were to be kept quite separate from those carried out in daylight under different weather conditions.[18] Even at this early stage, night fighting did not seem to be a priority for Dowding. Failure to deal with this expeditiously would later be one reason for his undoing.

Tizard noted in a memo on 3 September that the longer the time lapse to interception and the more frequent the changes of direction of the bombers, the more likely it was that the error in dead reckoning would increase, necessitating the need for direction finding (D/F) or other methods. He emphasised that the object was to effect interception of enemy aircraft in the shortest possible time, but certainly to intercept them before they crossed the coast on their return journey.[19]

Continuation of the Biggin Hill interception trials until April 1937 demonstrated that 85% of twenty experiments had 'advanced to a stage at which the fighters had been navigated to within three miles of a bomber even though it was changing height, speed and course'. The changes that were made due to the discovery of flaws in the D/F system during the Biggin Hill experiments illustrated that these exercises were foundational for the development of RDF as a vital part of air defence.[20]

Investigations on multiple interceptions continued in early 1937 but were hampered by the slow speed of the Westland Wallace aircraft being used as bombers, so Sholto wrote to the AOC-in-C of Bomber Command, Sir John Steel, requesting that he liaise with Dowding to ascertain which aircraft would be most suitable.[21] In a meeting on 21 April 1937, it was emphasised that up to this point, no RDF had been available for these experiments, but that it was hoped that one inland RDF station to assist with the Biggin Hill exercises would be operational from July 1937.[22]

Meanwhile, work on RDF at the Bawdsey Radar Research Establishment continued, if somewhat chaotically due to Watson-Watt's informal management style. The team there were becoming adept at plotting the incoming tracks and heights of civil airliners, especially Dutch KLM aircraft.[23] However, cooperation with Biggin Hill in any potential interceptions of the KLM aircraft would have been hampered by the limited coverage of the Bawdsey station and the lack of suitable RDF stations near the coast, although one was being constructed at Canewdon

in Essex and an advanced R/T station at Dunkirk in Kent. Tizard commented drily in the meeting that interception of incoming civil aircraft 'would afford valuable experience in conditions closely approximating to what might be expected in war but that regular interceptions of foreign Air Liners would be undesirable for political reasons and should be avoided.'[24]

To address the problem of coverage all along the coast, plans for a coastal radar chain had been under way since July 1936, and Squadron Leader Raymund Hart, an RAF Signals specialist, was attached to Bawdsey to assist in its development. He became very influential in the methodology of improving and integrating the use of radar into the increasingly sophisticated system of air defence and worked closely with Sholto when he took over from Dowding as C-in-C Fighter Command.[25]

The meeting on 21 April had shown that there was still a reluctance to conduct experiments in night interception due to the extra challenges involved, although Dowding suggested that a limited number of these should be made and could run concurrently with those examining the control of multiple formations.[26] The exercises continued through 1937, and began to address something that was on everyone's mind: how would our fighters differentiate between friendly and hostile bombers by day and also by night?[27] Bawdsey had the nucleus of a method but considerable time would elapse before it was established.

A further problem was the probability of deliberate radio jamming by an enemy, necessitating alternative R/T systems that would operate over a narrower frequency band. Deliberate jamming by German and French broadcasting stations was being experienced every time an exercise was held but could be mitigated to some extent by avoiding certain frequencies. It was proposed that an outside source such as the GPO or the Admiralty could provide organised jamming for the experiments.[28]

In November 1937, Dowding suggested that the Interception Experiments be transferred from Biggin Hill to the Air Fighting Development Establishment (AFDE) at Northolt,[29] but this idea was quickly countered by Sholto and Group Captain Robert Saundby, Deputy Director of Operations at the Air Ministry (and a significant figure later in the War as Deputy AOC-in-C Bomber Command), because of the installation of new equipment at Biggin Hill and its proposed use in conjunction with the Dunkirk RDF station. Nevertheless, they agreed that, in future, all experimental work of a similar nature should be centralised at AFDE.[30]

There was continuing tension between the Air Ministry and Dowding over these exercises, evident in a letter sent by Dowding to Sholto on 20 December 1937 in which Dowding said that he had received a copy of a programme for the next round of interception experiments that the Station Commander at Biggin Hill had been instructed to carry out, but which had come to Dowding's notice by chance. He said that he proposed to carry out his own series of experiments that would limit the use of *his* RDF stations for the Biggin Hill trials to times when they would not be required by his team, and that, in future, all instructions concerning

experimental programmes for Biggin Hill should be sent through his HQ.[31] Dowding received a reply not from Sholto but from Saundby stating that certain paragraphs in Dowding's letter 'suggest that some misunderstanding exists regarding the detailed arrangements for these experiments.' Saundby reminded Dowding that events had proceeded entirely in the manner agreed by Dowding himself at the meeting on 21 April 1937, and that close communication had been maintained between Bawdsey and Fighter Command HQ, between Tizard and Dowding himself, and between RAF Biggin Hill and the Directorate of Research at the Air Ministry. He stated further that the programme that had come to Dowding's notice had been devised by the CO of Biggin Hill, not by the Air Ministry, and that there had been no question of instructions being issued to Biggin Hill directly without reference to Fighter Command HQ.[32]

Despite these hiccups in communication, the Biggin Hill experiments continued and without them, 'it is doubtful whether Fighter Command could have been adequately prepared for the Battle of Britain. Apart from their value in developing new interception techniques, the exercises brought other advantages. The sector commander at Biggin Hill was emphatic that one of the benefits of the new system was the great confidence it gave to pilots in the air. They learnt the value of accurate flying. When a method was evolved, primitive at first, to ensure that pilots' positions were always roughly known to their commanders on the ground, they knew that they could always be brought home in difficult conditions. This was an essential part of the new tactics and had an immense moral effect. An important feature of the Biggin Hill experiments was their freedom from undue guidance from higher authority. The operational flying problems anticipated on account of the development of radar were allowed to work themselves out in the hands of competent men at squadron and sector level. In consequence the results of the experiments were essentially practical and well fitted for adoption by those on whom the task fell in war.'[33]

The run-up to World War Two

At the beginning of 1938, only 18 months after Sholto's promotion to Air Commodore, he was promoted to Air Vice-Marshal, and with that he hoped that he would be posted to an operational command, having been a staff officer at the Air Ministry for the past five and a half years. However, instead of a command of his own, Sholto was appointed to a newly created post, that of Assistant Chief of the Air Staff (ACAS). In his new post, Sholto was to serve directly under the CAS, Cyril Newall, and to be responsible for the Directorate of Staff Duties, which he had headed for the past two years, and the Directorate of Operational Requirements. He was involved still with the Biggin Hill interception experiments and the development of AI for use at night. He also insisted on being kept abreast of developments in the technology to identify friendly from enemy aircraft, termed 'Identification Friend or Foe' (IFF).[34]

Just after Sholto had been promoted to Air Vice-Marshal, Tizard wrote a letter to him, saying that his promotion might mean a move away from the Air Ministry, which would be bad from some points of view.[35] It is clear from correspondence between them that Sholto was in

the vanguard of the Air Staff's communication with Tizard, seeking to 'ensure a closer liaison between the Air Staff and your Scientific Committees in the study of air tactics and equipment generally.'[36]

Tizard's valuable work with the Air Staff was too often disrupted by the clash between him and Churchill's scientific adviser, Professor Lindemann, who consistently pressed his own agenda for such outlandish ideas as 'aerial mines' and undermined the committee's valuable work on radar. Sholto wrote that Lindemann never really believed in radar, which was problematic when he had the ear of Churchill. No doubt ironically, Sholto even called Lindemann 'the evil genius of radar' and thought that he was not a very good scientist,[37] but he was a good statistician, and it was in this latter guise that he was useful to Churchill.[38]

Sholto regretted that the Air Staff had not made more use of Tizard's other Committee, for the Scientific Survey of Air *Offence*, which had been formed in 1936. In December 1938, Sholto became a member of both Tizard Committees and used the opportunity provided to keep his Air Tactics section fully up-to-date with all their developments.[39] On the Offence Committee, he also worked with Tizard to devise a realistic programme for the resolution of problems regarding a possible bomber offensive against Germany, especially difficulties with navigation and target identification and bombing by night.[40]

In July 1938, Watson-Watt had put forward to the Air Staff a proposal for the formation of an inter-Service committee on RDF to keep all three Services informed of progress in RDF research, development, application and production, to be chaired by a member of the Air Staff. Sholto was chosen to be its chairman.[41]

Six days after Chamberlain's 'Peace in our time' statement following the signing of the Munich agreement with Hitler on 30 September 1938, Sholto held a meeting to discuss emergency measures to increase war readiness. It was agreed that work on the Radar Chain should be stepped up to reach completion by 1 April 1939. A further meeting was arranged to thrash out how these measures would be implemented practically by the projected deadline. The day before the Munich Agreement was signed, the process had begun to move the Filter Room from Bawdsey to Bentley Priory, Fighter Command's HQ. The assembly of the Filter Room was carried out with amazing speed so that it was able to take control on 8 November staffed by experienced personnel from Bawdsey.[42]

In the year that was gained between Munich and the actual outbreak of WWII, the rate of RAF expansion began to outstrip that of the *Luftwaffe*, particularly in those vital areas of air defence - fighter aircraft and radar - so that by September 1939 there were at least enough modern fighters for the British to make a stand, supported by a radar screen that seemed largely effective, but which needed further development. Sholto wrote that those in the Air Ministry had been hardened to panic 'in the forge of fright'[43] over a long period of time, having observed the mass bombings carried out by the Germans and Italians in Spain.

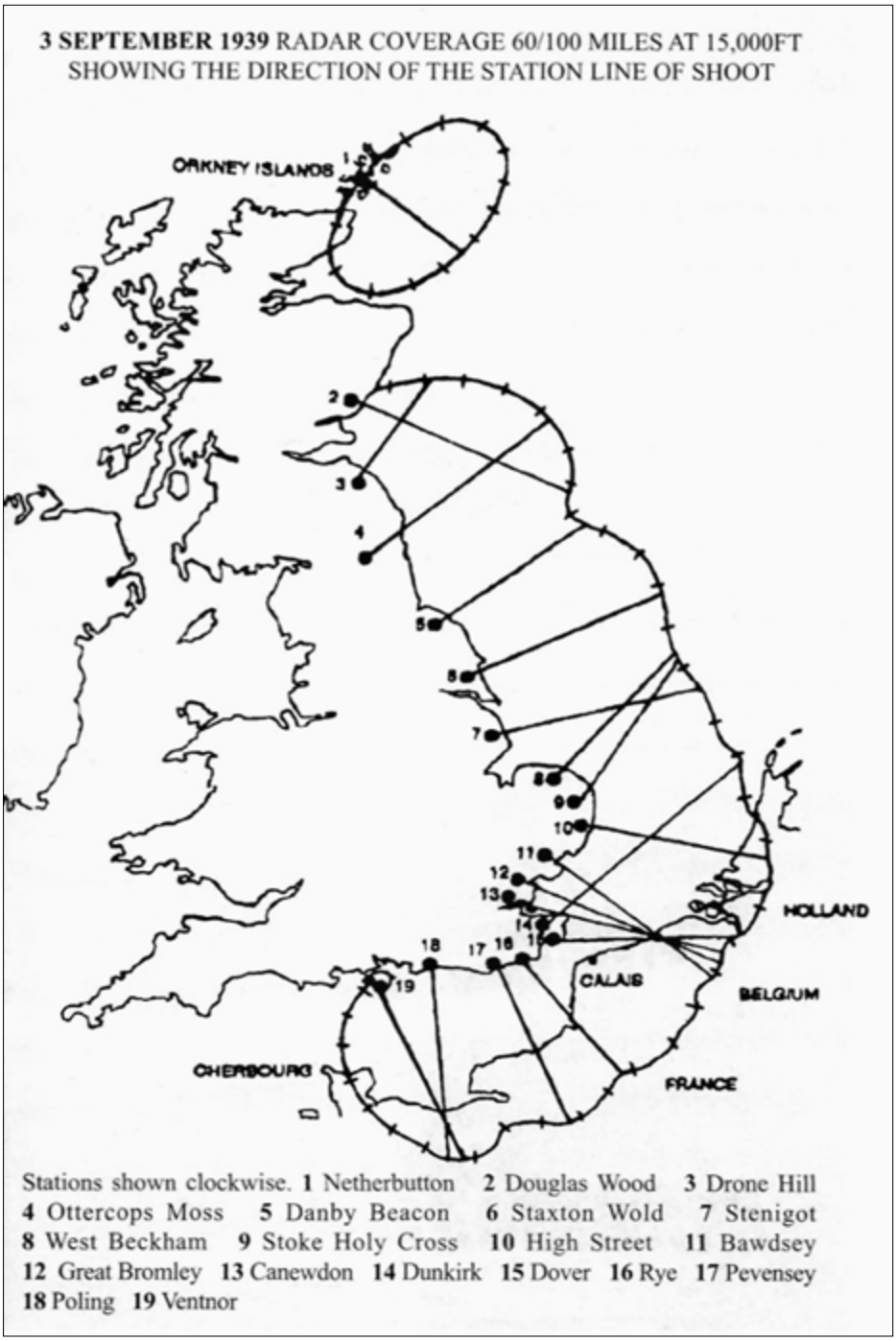
Further progress in radar interceptions was made during 1939, causing the physicist A P Rowe, who had by then replaced Watson-Watt as Superintendent of the Bawdsey Research Station, to invite Dowding to a demonstration at Martlesham, near Woodbridge in Suffolk on 16 June. Unfortunately, this did not go well as the pilot of the Fairey Battle that was being used to monitor progress made a very bad landing, causing Dowding to remark: 'that the most important thing is to land the aircraft the right way up.' Barely two weeks later, Dowding attended a conference at the Air Ministry convened to consider problems with interception. Orange remarked that: 'Although Douglas was chairman, several scientists had been invited to attend and were able to give substance to the discussions.'[44] This implied criticism of Sholto was wholly unjustified. Dowding reported on the success of the Biggin Hill trials and said that radar detection from British coasts was now possible up to a range of 60 miles, but at that distance the radar operators could not distinguish between friendly and possibly hostile aircraft, something of which Tizard, also present at the meeting, was acutely aware.

However, progress was made on AI, a special preoccupation of Sholto's.[45] In early July, Dowding was given a flight demonstration, in a single-engined Fairey Battle fitted with an AI radar set, of a successful interception with a target aircraft. He wrote an enthusiastic report to the Air Ministry on 10 July, recommending that a twin-engined fighter with a two-man crew might be used for further tests and suggesting the Blenheim, used for both bomber and fighter operations, as a possible candidate. On 14 July, as a result of Dowding's report, Sholto initiated a scheme in which a Blenheim was fitted with AI radar in order that the tactical use of the equipment could be worked out. This was to be given top priority. Furthermore, he instructed that 21 AI sets should be made by hand, six to be given to Fighter Command, and the others to be kept for emergencies. Four Blenheims were to be equipped with the sets, which was achieved by 30 August, and these experimental aircraft were attached to a special flight of No.25 Squadron.[46] A day later, war was declared.

World War Two

At a meeting of the Inter-Service RDF Committee on 19 September, Sholto brought up the matter of AI development yet again, and Watson-Watt told the Committee that arrangements were being made to equip a further 144 aircraft with AI, firstly more Blenheim fighters, and subsequently Bristol Beaufighters. At the next meeting on 23 October, Sholto enquired on progress with the production of AI sets and stressed that every first line Blenheim fighter would need to be equipped with one of these, necessitating the provision of 336 sets, and that the Beaufighter installation would commence the following year in May or June.[47]

The next few months saw further timely improvements in radar development. Although the series of radar stations around the coast, Chain Home (CH), were operational, the fact that they could not detect aircraft flying below 1,000 feet meant that another layer of protection, named Chain Home Low (CHL), had to be installed. The first of these low-looking radar stations was opened on 1 November 1939. Nevertheless, there were still gaps in the coastal coverage and inaccuracies in estimation both of altitude and numbers of aircraft above three.



United Kingdom radar coverage as of 3 September 1939. Reproduced from Michael Bragg, RDF1, Plate IX.

Additionally, there was a 90-second time lag between sighting by a radar operator to the plot appearing on group and sector tables. As late as 8 March 1940, Dowding wrote that radar was 'very capricious and unreliable, but it is better than nothing, as being the best evidence we have of what is going on over the sea.'[48]

On 14 March 1940, at the instigation of Dowding and Tizard, a 'Night Interception Committee' was formed, to coordinate all the efforts being made to solve the problems of defence against night attack and to apply practically the research and development being done on night interception. The Committee comprised scientists including Tizard himself, Sir George Lee (Director of Communications Development at the Air Ministry) and Watson-Watt, and Service officers including Dowding, Sholto, who took the chair at the early meetings, and Raymund Hart, as well as Army representatives. The topics under discussion over the next few weeks were the development of radar equipment and techniques, aircraft detection using infrared apparatus, the use of aircraft-towed flares to provide illumination of the enemy and advances in anti-aircraft (AA) gunnery and searchlight capability. At the first meeting of the Committee, the Fighter Interception Unit (FIU) was formed and was thenceforth based at RAF Tangmere. This resulted in the first airborne radar intercepted 'kill' in history, achieved on the night of the 22/23 July 1940, when a Blenheim intercepted an enemy Dornier Do 17 aircraft and sent it plunging into the sea off the Sussex coast south of Bognor Regis. The German crew was rescued later.[49]

Progress was also being made on strengthening both CH and CHL. Unfortunately though, IFF was not yet operated at CHL frequencies. This was pointed out at a meeting of the Air Ministry RDF Panel in July 1940, when it was realised that it was essential that IFF should be extended to these aircraft to distinguish between enemy aircraft engaged in mine laying or other low altitude operations and low-flying friendly aircraft.[50]

Furthermore, there were shortcomings in the early warning CH radar stations. They were unable to indicate accurately the number of aircraft in a group and were inconsistent when reading aircraft altitude. Radar was being pressed into use before it was fully developed, and it became a race against time in which waiting for improved equipment inevitably meant delays.[51]

Night Fighting

During the Battle of Britain, Sholto became dissatisfied with what he felt was Park's failure to deal with the new threat of enemy night raids that began on 7 September 1940, the Blitz. On 28 September Sholto sent a letter to the CAS and VCAS, with a copy sent to the Director of Operations (Home), Air Commodore Donald Stevenson, which stated that in Park's report of 12 September, he had dealt 'almost entirely with day fighting; night fighting is barely mentioned, save for a brief reference in the final paragraph.'[52] In fact, Fighter Command was making desperate attempts to develop a night-fighting capability. The problem was that the use at night of Hurricanes and Defiants not equipped with radar, known as Cat's Eye fighters, something that Sholto had championed as a stopgap,[53] greatly increased the Command's

accident rate. In the period 10 July to 11 August, out of 115 accidents, 28, fully one quarter of the total, occurred during night flying practice. Six of them were fatal. This high price was in no way compensated by success in night interceptions. All those involved knew that the Beaufighter equipped with AI manned by a skilled radar operator was the answer, but the first of these aircraft had not become available until 27 July.[54] It was mid-September before a squadron of them became operational,[55] and mid-October when the first successful interception was made and an enemy bomber shot down.[56]

Earlier, at a meeting on 11 September that was a precursor to the Salmond Night Air Defence Committee, at which both Sholto and Dowding were present, Sholto emphasised that the various methods of controlling interception referred to in the agenda for the meeting were nothing new, but that their application at night might be extended, specifically the control of AI night fighters by sub-controllers at selected forward positions, implying a decentralisation of operational control. Dowding reported that the adaptation of RDF to searchlights was promising, but as was confirmed later, these lights had only a limited range and pilots could not use searchlights to detect enemy aircraft flying at heights of over 10,000 feet.[57] Above 12,000 feet, they could not even see the searchlight beams, even on 'bright and clear nights.'[58] To address this problem, Sholto introduced an idea that he had received from the Ordnance Board for the use of naval star shells in AA guns. These were very powerful and could be used to light successive strips of cloud in the path of a raider flying above cloud and out of reach of searchlights. Fighter interception would be facilitated by the silhouette of the raider seen against the lighted cloud. He recommended that star shells be given a trial.

On 16 September, at the first meeting of the newly formed Salmond Committee, Sholto proposed that the control of operational aircraft at night should be vested in the sector commander instead of being under the control of Group HQ as it was at present, and when RDF stations became available for controlled interception work only, interception over the sea should be controlled by the RDF station itself. Sholto also took the opportunity to criticise Fighter Command's practice of filtering RDF information, suggesting that it should be given straight to Groups to speed up the process of night interception. This proposal received support from Air Vice-Marshal Arthur Tedder, who was working in the Ministry of Aircraft Production (MAP) and who was also present at the meeting. Sholto's third suggestion was for the immediate formation of a Night Fighter Training Unit combined with a Tactical Development Section and incorporating searchlights. The Committee understood that Fighter Command would need more staff specialised in night fighting both at Fighter Command HQ and at Group level to implement these changes.[59]

All these recommendations were reiterated at an Air Council meeting on 24 September, principally by Sholto, and it was decided that Dowding should be consulted on the location of the proposed Night Fighter Training Unit. The development of radar operation using searchlights, Searchlight Control Radar (SLC), nicknamed 'Elsie', was underway, the responsibility for which had been given to MAP, which was hastening its production. Despite pressures due

to the scale of daytime attacks, MAP was also attempting to expedite the development of everyone's preferred option, the AI-equipped Beaufighter.[60]

However, in his response on 27 September to the findings of the Salmond Committee, Dowding stated that the Committee had been under a misapprehension as night operations had normally been controlled by sector commanders for several years! Regarding decentralisation of filtering, in his reply Dowding dismissed this too, saying that it had been suggested earlier in the year when he thought that he had disposed of it. Dowding felt that the suggested Night Fighter Training Unit could be built up on the existing Fighter Interception Unit without any large increase in establishments, and the extra staff recommended by the Committee at HQ and Group level could be of lower rank and less numerous than the Committee members had proposed. Furthermore, he was anxious to keep a small portion of night-trained pilots in the day Squadrons, deploying them to take part in night operations only in certain locations when day activity was not intense. He felt that the withdrawal of existing experienced 8-gun fighter pilots for the benefit of a Night Fighter Training Unit would hamper his plans.[61]

Nevertheless, Dowding was making strenuous efforts to improve night interception, but considerable difficulties were encountered both with AI, and with the gun-laying (GL) RDF systems used by AA guns at night to track enemy aircraft, but by 21 September, encouraging results were achieved with GL sets in the Kenley sector, which proved to be more accurate than either the Observer Corps or even RDF stations on the South Coast. But success in tracking still did not mean effective interceptions of enemy aircraft.[62] General Frederick Pile, the C-in-C of AA Command, wrote in his memoir: 'The teething troubles with radar were enormous. By the beginning of October 1940 we had not succeeded in firing a single round at night. It was bitterly disappointing - we got the sets rigged up in wonderful time, but then we had the greatest difficulty in calibrating them. Every plan we made broke down and always from causes beyond our power to deal with. The whole GL technique was so empiric that many were the disappointments we had to endure before radar settled down into the killer it became.'[63]

As for Sholto's suggestion of using RDF over the sea for interception, Dowding observed that this would be possible, but it was a refinement that could not be allowed to interfere with existing trials to determine the accuracy of searchlight radio sets or Elsies. His experiments with this equipment were useful in that they showed that Elsie was incapable of being used as a short-term expedient until the problems with GL sets had been addressed, because it could not locate aircraft in cloudy weather or at heights above 10,000 feet. Additionally, it did not respond to IFF then fitted to Blenheims and Beaufighters and so could not distinguish friendly from enemy aircraft. So Elsie could only be used as a searchlight pointer, and Dowding postulated that the real solution to night interception, which was realised in 1941, would be the use of GCI, used in conjunction with AI in aircraft.[64] The advantages of GCI were that it had a longer range than the GL set, and it was possible to track both enemy bombers and British fighters by the same equipment instead of following one with GL and the other with

radiotelephone direction finding (R/T D/F), the accuracy of which was inadequate for night interceptions.[65] However, GCI also had its teething troubles, notably 'gaps' in its coverage at a range of 15 or 20 miles, but Dowding was optimistic that a height finding feature would be included in it that would enable better interception, and meanwhile, he hoped that Elsie's ability to gauge the altitude of aircraft would be improved also.[66]

Problems were also encountered with the Beaufighter and in his report of 30 September, Dowding wrote that not more than one of these aircraft had been in the air on any night, and that such flights as had been made were often terminated prematurely due to breakdowns in AI equipment, which was susceptible to damp, or technical difficulties with the Beaufighter itself. The Blenheims however had had greater success and had shot down one or possibly two enemy aircraft in the preceding week. Dowding's next report of 11 October emphasised the Blenheims' continuing success despite their earlier version of AI and inferior performance versus that of the Beaufighter, whose bullet-proof windscreens were more susceptible to icing when descending through cloud from altitude.

At the second meeting of the Salmond Committee on 1 October, Dowding said that transferring filtering directly to Groups would not improve the efficiency of night interception. Furthermore, it would be extravagant in his view, and then there was the difficulty of recognition and identification of aircraft. This would be largely solved when IFF was generally fitted and working.[67] Dowding opposed the Air Staff's belief that Group filtering would save time, which assumed that Operations and Filtering work could be done on the same table, thereby removing the need for 'telling' plots between the two functions. Unfortunately, calculations of the size of table that would be needed showed that it would be so large (50 x 60 feet) that manual plotting during intensive operations would be impossible, so separate tables using the existing arrangements continued.[68] Nevertheless, in the meeting the Air Staff, including Sholto, insisted that filtering should be devolved to Group level as soon as IFF had been installed more widely, which was due to be completed in November of that year, and as for Dowding's rather parsimonious concern about extravagance, the Air Staff was of the view that the damage being caused by day and night bombing was ample justification for the extra expenditure.[69]

Interestingly, by May 1941 when Sholto had replaced Dowding as C-in-C Fighter Command, he was having second thoughts about decentralisation of filtering. He wrote to Portal, now CAS: 'My predecessor was strongly opposed to decentralisation…I think the present centralised system works quite well from the point of view of efficiency, and I do not think there is much to be gained by the proposed change.'[70]

Although Dowding was being challenged at every opportunity, without his meticulous approach in tackling each obstacle to effective night interception, the system that evolved eventually would not have been possible. However, his careful plan was not solving the current problems. During the month of September, the *Luftwaffe* had flown an estimated 6,135 sorties at night, yet only four German bombers had been destroyed by fighters.

This small number had to be offset against 1,500 civilians killed in the week ending 26 September, 1,300 of whom lived in London. A further 1,700 were killed there during the following seven days, quite apart from the heavy damage sustained.

Perhaps the greatest blow to Dowding's handling of night air defence, which was instrumental in his removal from Fighter Command, was the devastating raid on Coventry, which took place on the night of 14 November 1940, when more than 4,300 homes were destroyed and around two-thirds of the city's buildings were damaged. An estimated 554 people were killed (the exact figure was never precisely confirmed), with another 865 badly injured,[71] and 393 sustaining lesser injuries. Fighter Command flew 125 night sorties but failed to shoot down a single *Luftwaffe* bomber, the blame for which was laid at Dowding's door.[72]

Four days after the Coventry bombing and a week before he replaced Dowding as C-in-C Fighter Command, Sholto wrote a paper precisely articulating what he thought needed to be done regarding night interception. His ambitious recommendations included the provision of 24 specialist night fighting squadrons instead of the current ten, which should be located in a semi-circle from Newcastle in the north round to Prawle Point in Devon, with a special squadron each for Coventry/Birmingham, Liverpool and Glasgow. Regarding methods of deployment, two or more Beaufighters should work over the sea in the forward part of each sector, controlled by CHL stations and later by GCI stations as these became available, augmented by AI. Further back, there should be a 'half-back' line of Defiants or Hurricanes working with Elsie controlled searchlights. Lastly, over the actual targets being attacked, there should be a 'full-back' or 'goal-keeper' line of Beaufighters, Hurricanes or Defiants operating with the RDF methods enumerated thus far, but with the aid of star shells should the experiments with these prove successful. More control facilities would be needed, and to this end, better trained controllers. A school for these had just been started at Uxbridge. Additionally, more and better aerodromes with 100% night flying facilities were required, including those for blind landing in zero visibility, homing beacons and AI. Sholto insisted on intensive specialist training for personnel involved in night flying and wrote that the recent formation of a night fighter Operational Training Unit (OTU), for which he had been pressing for a long time, was a step in the right direction. All pilots and gunners, before selection for night fighter duties, should be tested for night vision. Finally, Sholto observed that radar scientists were complaining that one of the reasons why better results were not being obtained was indifferent maintenance, so he proposed the allocation of engineers or scientific officers to each Night Fighter Wing, in the same way as scientific officers were being allocated to AA batteries.[73] Tizard fully supported Sholto's observations, stating in a note written at the end of December that the disappointing results from AI were due to 'lack of training, maintenance and good engineering, not to lack of science.'[74]

Fighter Command

In the two years that Sholto spent as C-in-C of Fighter Command, by far his greatest difficulty was 'what happened under cover of darkness.'[75] He wrote in a report later: 'The burning

question…was how to stop the Hun's night bombing. I was sent for by Winston, who told me that I had to concentrate everything on stopping the bombers. Every facility would be placed at my disposal.'[76] By the end of 1940 there was still no answer to the German night bomber. Sholto wrote in a report on 8 December, two weeks after taking over Fighter Command: 'It cannot be said that, since my predecessor's last report on 17th November, any great success in night interception has been achieved…In nearly 500 sorties, only 31 enemy aircraft have been sighted.' Sholto had been visiting fighter squadrons in the South of England, and had identified problems with night interception, such as the inaccuracy both of tracking enemy aircraft inland from the coast and of assessing the height of enemy bombers. He welcomed a proposal by General Pile to install a 'carpet' of GL radar sets along a 60-mile belt from Kent to Bristol to address these problems and had even asked for Dowding's views on this plan. All the other devices that had been trialled had yet to prove their worth, including AI, although Sholto had visited stations where research was being carried out and was most impressed with its performance, 'even in its present immature state.'[77]

In the same report, Sholto reasserted that there should be more specialised night fighter squadrons. He only had 11 of these, but wanted at least 20 as soon as possible, including 12 comprised of twin-engined fighters fitted with AI. An adjunct to Sholto's report, which he wrote on 14 December, reiterated his suggestion of Fighter Regional Control Aerodromes specially equipped for night fighters. To improve radio control at these aerodromes, Sholto advised that specialised Control Officers be employed, including, as he also suggested for pilots, transferring professional Control Officers from Civil Aviation for war service.

AA Command was almost three times as successful as Fighter Command in shooting down bombers, claiming 102 enemy aircraft at night between June and December 1940 as against 35 shot down by fighters. German night raids on London did decrease in December, but there were more attacks on other cities. Civilian casualties were still high for that month: 3,793 killed and 5,044 injured.[78] The official historian Basil Collier criticised Sholto for his suggestion of using Cat's Eye fighters at night, especially in the poor weather conditions that prevailed in the winter of 1940/41. However, there were experienced pilots who supported Sholto in this endeavour, including Quintin Brand, the AOC of No.10 Group. In WWI he had succeeded in shooting down a number of enemy bombers at night flying a single-seater fighter. The prevailing opinion of the Salmond Inquiry was that the use of these aircraft at night should be tried until AI became effective.[79]

In his later response to Collier's draft of his Official History, *The Defence of the United Kingdom*, Sholto defended his advocacy of Cat's Eye fighters. Citing Collier's own Appendix 34 in the book, he wrote that several visual contacts were made by these aircraft, especially during the period January-May 1941, when they had made almost as many detections as twin-engine Beaufighters using AI. It is hard to see how Sholto arrived at this conclusion, since a glance at the figures shows that single-engine fighters made visual contact on 7.5% of sorties flown, whereas Beaufighters detected enemy aircraft by AI on 34% of sorties. However, the number of

combats made by these two types of fighters were closer in number: 39.6% for single-engine fighters and 30.2% for twin-engine aircraft. Sholto conceded that although that Cat's Eye fighters could only ever be a fair-weather weapon at night, and this is borne out by the figures, he asserted that this was being wise after the event, since at the time, it was necessary to try anything as Beaufighters were still in such short supply.[80]

In a letter to Portal on 9 December 1940, Sholto wrote: 'I do not think that Hurricanes, Spitfires or even Defiants will ever be anything but "fine weather" night fighters.' He ended his letter with an impassioned plea: 'I do feel most strongly about this. It is vital to defeat the enemy night bomber - we may even lose the war if we don't', adding: 'Actually I think my demand is really a modest one.'[81] Nevertheless, Sholto tried to make use of Cat's Eye fighters by instigating what he called 'Fighter Nights', when large numbers of these fighters were sent up in high concentrations on nights of good visibility.[82] But this form of patrol, even in ideal weather conditions, was profitable only in an area of concentrated enemy activity, such as over London on 10 May 1941.[83] Another priority was to have GCI sets installed at all Fighter Command Sector Stations, especially those near London, which was recognised as 'by far the most important development in the Command.'[84]

However, the solution was closer than Sholto realised. Soon after he had settled into Bentley Priory, he was pleased to receive Trenchard as one of his many visitors. They discussed the difficulties that Fighter Command was having with its radar-equipped night fighters, and Trenchard said: 'Never mind, Sholto, you take my word for it…a man will arise.'[85] In fact, on the night of the 20 November, three weeks before Trenchard's visit, an event had occurred that heralded the fulfilment of Trenchard's prophecy. The Germans staged the second of three nights of heavy raids on Birmingham. One of the night fighters in the skies that night was a Beaufighter of No. 604 Squadron, stationed at Middle Wallop in Hampshire. It was flown by Flight Lieutenant John Cunningham with Sergeant John Phillipson as his radio observer. They managed to intercept and shoot down a Junkers 88. One month later on 20 December, the same team shot down another raider, a Heinkel that was part of a heavy force of enemy bombers that attacked Liverpool and Birkenhead.

Nevertheless, problems with the radar chain continued into 1941, made worse by the latest enemy tactic: German bombers were flying at heights of 50 to 100 feet above sea level, attacking shipping travelling along the east coast of the UK. CHL was of little use in combatting this menace. The Telecommunications Research Establishment, as it was now known, relocated from Bawdsey to Worth Matravers near the Dorset coast, suggested altering the position of CHL aerials and increasing the power of CHL at shorter wavelengths.[86]

Over the next few months, the number of engagements with the enemy rose, as did the number of aircraft destroyed, from two in the whole of January to 65 in the first week of May alone.[87] By the end of January, when Sholto had been at Fighter Command just two months, the GL 'carpet' that Pile had suggested had been installed with the exception of wire mats that

were to be laid at GL sites to improve their accuracy.[88] Although this carpet was supposed to be a temporary expedient, the initial slowness both of progress in GCI and in the supply of AI/GCI night fighters meant that it continued to operate for many more months.[89] However, by the end of July, increased use of GCI and improvements in Elsie meant that Sholto could dispense with the GL carpet for the South of England.[90] In fact it was found impractical to keep GCI and searchlight areas apart, so arrangements were being made for these to work together.[91]

The end of January also saw the completion of another of Sholto's ideas, a new searchlight layout in clusters of three to improve detection of night raiders. However, he was still desperately concerned about the slow supply of night fighter aircraft to the Command, and the shortage of well-trained night fighter pilots he described as 'serious.' The total number of night fighter squadrons of all types had risen by only two to 13. He wrote that he had 'appealed to the Air Ministry for assistance' and had renewed his request for ex-night bomber pilots who had for the time being finished their allotted span of operational flying over Germany. He had been against this idea the previous year, but now the desperate reality of enemy night attacks that it was his responsibility, as C-in-C Fighter Command, to stop had caused him to change his mind completely.

In a letter to the Air Ministry written in March, Sholto wrote that on two nights in that month, six Beaufighter sorties destroyed ten enemy aircraft, whereas 431 Cat's Eye fighters only accounted for five 'in the most favourable conditions possible for them.'[92] Watson-Watt added his support to this conclusion, observing: 'GCI makes an AI aircraft about five times as effective in producing night combat, and about six to seven times in destruction or damage as is the AI aircraft with other forms of ground control or on patrol.'[93] Meanwhile, Sholto had the continuing problem of enemy attacks being mounted at lower altitudes, possibly to avoid detection by AI and GCI, since AI became ineffective when close to the ground and GCI could not see enemy aircraft at low altitudes. However, Sholto proposed illuminating these aircraft more effectively with searchlights so that they would be once again forced upwards.[94]

Another idea that Sholto had was to use plan position indicator (PPI) tubes[95] fitted in CHL stations that would work with AI and GCI to improve detection of these low flyers. He also proposed that the wavelength at which AI then operated be altered to attenuate the decrease in its effectiveness at low altitude due to reflections from the earth's surface or from the sea. He also thought that single-engine fighters aided by Elsie searchlights might be another solution to the problem.[96]

Sholto kept up his incessant pressure on the Air Ministry to provide more aircraft such as Beaufighters and Douglas Bostons/Havocs to form more twin-engined night fighter squadrons. Over the next two months, despite aircraft and pilot shortages, the success of AI coupled with GCI continued to accrue, night interceptions aided by such developments as the fitting of an improved version of IFF in aircraft, which responded to the GCI frequency and made the identity of the fighter plain.

7 May 1941, King George VI talking with C. F. (Jimmy) Rawnsley, John Cunningham's navigator (sixth from left), just before they went off on patrol and shot down a Heinkel, which the King observed. Sholto called this episode a 'Command Performance'. He is standing with his back to the camera. Cunningham is on the extreme left and Group Captain Elliott, Station Commander at Middle Wallop, is standing next to Sholto. Collection of Katharine Campbell.

Sholto was trying all sorts of other methods to increase the likelihood of successful night interceptions and the destruction of enemy night raiders. These included various ways of illuminating hostile aircraft, such as flash flares, 4.5-inch naval star shells and Helmore Searchlights carried in the nose of aircraft. Bad weather, particularly when there was a 'haze', hampered the effectiveness of both the flares and the shells, and the latter only really worked when there was perfect coordination of the firing of the shell with the appearance of the target aircraft.[97]

The airborne searchlights showed promise, but Sholto felt that more experiments were needed. Meanwhile the telephone communication network between ground searchlight stations was a top priority, in order that searchlight and fighter efforts could be properly coordinated. One of the greatest dangers in cooperation between fighters and radar-operated ground searchlights was of the searchlights illuminating the fighter itself rather than the raider that it was approaching. Sholto therefore found it a matter of grave concern that no means of responding to IFF signals from aircraft was incorporated into the Elsie equipment.[98]

In the next Night Air Defence Committee meeting on 12 May 1941, chaired by Churchill, Sholto continued to press for more Beaufighters equipped with AI and aided by GCI. The VCAS, Air Chief Marshal Wilfrid Freeman, suggested that Bostons/Havocs would do just as well, but Sholto was most insistent on Beaufighters. In this and in every other point that he made at the meeting, he was backed up by Churchill.[99] By the end of June, Beaufighters were being produced in sufficient numbers to convert to these aircraft squadrons operating older types, but Sholto was concerned by the shortage of AI operators and radio mechanics to service AI both in Beaufighters and in Defiants that were to be newly supplied with AI. However, he noted that enemy night attacks were decreasing, and tracings of the tracks of enemy aircraft over the UK revealed that on many occasions their paths were erratic, which, coupled with the fact that they were not flying high,[100] suggested that they had not been using their beam navigation system.[101]

A month later, Sholto wrote that experiments with searchlight clusters had shown them to be less effective than single searchlights spaced at intervals of 6,000 yards and equipped with Elsie.[102] By the end of October, just as Sholto had managed to get the twelve Beaufighter Squadrons on which he had insisted at the beginning of the year, he had to release the aircraft, pilots and AI operators for a complete night fighting squadron to the Middle East. Demands such as this would inevitably postpone further expansion of the night fighter force that he had fought so hard to build up.[103] He raised this issue in the next Night Air Defence Committee Meeting over which Churchill presided. Churchill said that the weakening of Fighter Command to strengthen the Middle East must be accepted to meet air attacks on the Suez Canal and the Nile Delta.[104] In this, Churchill was supported by Portal and Sinclair, although they were both concerned that, if attacks against the UK increased the following spring, there should be enough home defence squadrons to repel them.[105]

Low altitude flying and enemy jamming

As winter turned into the spring of 1942, despite the opening up of the Eastern Front, it became clear that the Germans had maintained a force of some 200-250 bombers in the West, available for night operations against the UK. Their principal operations included minelaying, followed by attacks on shipping and lastly raids against land targets on the British mainland. German operations over the sea were conducted at low altitude, making interception difficult. So as well as decreasing his own losses, the enemy inflicted considerable damage on British shipping. Sholto considered that to counter this threat, the range of the GCI stations would have to be increased. Experiments using two CHL stations for interception purposes had also met with success, these having a range of 60-65 miles compared to the 35-40 miles of ordinary GCI stations. Sholto proposed that a further 18 CHL stations be adapted for the interception role.[106] Three months later, Sholto had discovered that the use of AI in conjunction with Elsie could lead to faster interceptions, and he wrote that he had restricted the use of GCI/AI fighters to operating over the sea while Elsie 'belts' provided the next line of defence inland, thus minimising complications arising from the simultaneous operation of GCI and searchlight-controlled fighters within the belts.[107]

A continuing problem with which Sholto had had to contend in the winter of 1941/42 was that of aircraft identification, both from the air and from the ground. The need for greater accuracy had become more urgent with the increasing number of raids conducted by Bomber Command over Europe, and it was essential that fighter aircraft should not be involved in useless chases of friendly aircraft while enemy bombers arrived and dropped their bombs before Fighter Command was aware of their true identity. Devices had been tried such as an infra-red air-to-air identification system, but Sholto's hope for identification from the ground lay in the latest Mark III IFF. However, this would not be produced until July, when Bomber Command aircraft would be the first to be fitted with it.[108] Six months later, much to his frustration, Sholto stated in his report to the Night Air Defence Committee that although the infra-red system showed promise, the new form of 10-centimetre (10 cm) AI did not respond to Mark IIG IFF and Mark III had still not been introduced.[109]

Sholto expected that the changes to the ground element of radar would be accompanied by the rapid introduction of newer marks of AI that operated on the 10 cm wavelength, which was designed to operate at lower altitudes, as opposed to the 1.5 metre (1.5 m) wavelength in general use up until that point. A few of these new AI sets had been used already with considerable success, and Sholto felt that 10 cm AI would prove to be a most valuable asset to the UK's night defence,[110] being much more resistant to enemy jamming.[111] GCI was also vulnerable to interference, but this would also be countered if mobile GCI stations were operated on variable frequencies using a shorter 50 cm wavelength than the 1.5 m wavelength currently in use.

In a memo for the Night Air Defence Committee, Tizard confirmed Sholto's observations, the Germans having effectively jammed the 1.5 m equipment in an area east of a line from Selsey to Gravesend from land jamming stations on the north coast of France. The supreme example of jamming came on 12 February 1942 when it enabled the Channel Dash: the escape of the battlecruisers *Scharnhorst* and *Gneisenau* and the heavy cruiser *Prinz Eugen* from the port of Brest up the English Channel to their home port in Kiel.[112] Use of the new form of AI still depended largely on skilled ground control from GCI stations fitted with 1.5 m equipment and on radio communication within the 2.5 m waveband, both of which were susceptible to enemy jamming. Therefore, Tizard reiterated Sholto's suggestions to provide mobile GCI stations working on variable frequencies and the use of Elsie in conjunction with AI but operating on a different band to the 1.5 m wavelength on which it operated at present. Tizard also suggested organised attacks on the enemy ground jamming stations at the right time and the interception of jamming aircraft by 'specialised machines.' In order to implement these changes, more staff would be needed.[113] Following Tizard's memo, Sholto was informed by the Air Ministry that his views on the need to insure against enemy interference had been fully accepted.[114] In a meeting a few days later at which Tizard, Sholto and Churchill were present, Sholto reiterated that every effort should be made to improve jamming countermeasures, particularly those involving ground to air communication.[115]

By September, although there was no evidence that enemy jamming aircraft were being used against the UK, their use was being reported in the Middle East and Malta. However, extensive jamming was being used primarily against CHL and GCI stations in the UK from the enemy ground stations along the French coast. Sholto reiterated his demands for equipment more resistant to jamming by radio or by the use of metallised leaflets,[116] including the use of high-powered VHF transmitters with directional aerials capable of flooding any attempt to jam from the ground or from the air.[117]

Middle East and Coastal Commands

Although Sholto's most intense contribution to radar ended when he left Fighter Command, his involvement with it continued when he was AOC-in-C Middle East Command from January 1943. He instigated a large expansion programme involving armament, signals and navigation instruction.[118] As AOC-in-C Coastal Command from January 1944, he was keen to equip his squadrons with the latest marks of air-to-surface vessel radar to combat U-boat activity,[119] both during and after Operation Overlord, insisting on extended training to maximise the equipment's effectiveness and the confidence of his personnel.[120]

Conclusion

It is interesting that when Watson-Watt considered in his memoir the RAF officers who were for him the greatest champions of radar, he wrote: 'Sholto Douglas, (Director of Staff Duties when we first met) was imaginative, enterprising, receptive and constructive. We owed him much of our education as amateur air staff officers, perhaps too ready to teach our teachers! He was decisive and vigorous in action, and as he progressed rapidly to Assistant Chief of Air Staff, Deputy Chief of Air Staff, and Air Officer Commanding-in-Chief of several of the Commands that we hoped to serve most directly, he carried many of our hopes and potentialities with him. If I were given the invidious task of naming the Royal Air Force officer, outside the little group of those engaged wholly on radar duties, who did most to ensure that radar became an effective weapon of war, effectively wielded, I think I should name Air Chief Marshal Sir W. Sholto Douglas, K.C.B., M.C., D.F.C., now Lord Douglas of Kirtleside…'[121]

Acknowledgements

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Notes

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[91] Ibid., Night Air Defence Committee Meeting, 11 August 1941.
[92] Ibid., Letter from Douglas to Air Ministry, 'Expansion and re-equipment of night fighter squadrons', 22 March 1941.
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[95] PPI is a type of radar display that represents the radar antenna in the centre of the display, with the distance from it and height above ground drawn as concentric circles. As the radar antenna rotates, a radial trace on the PPI sweeps in unison with it about the centre point. It is the most common type of radar display.
[96] TNA, AIR 16/524, Progress Report by the AOC-in-C Fighter Command on Developments and the results obtained in Night Interception for the period 1 August to 24 October 1941.
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[98] Ibid., Progress Report by the AOC-in-C Fighter Command on Developments and the results obtained in Night Interception for the period 20 March to 9 May 1941.
[99] Ibid., Night Air Defence Committee Meeting, 12 May 1941.
[100] Ibid., Progress report by the AOC-in-C Fighter Command on the Development and the Results obtained in Night Operations for the period 10 May to 19 June 1941.
[101] The German beam navigation technique and equipment (X-Gerät and Knickebein) were based on the *Lorenz* blind-landing system developed in Berlin during the 1930s. The beams were transmitted from the other side of the Channel to guide enemy bombers to their targets for the night. Coupled with this was a special Squadron of trailblazers that marked with incendiaries the targets to be bombed.
[102] TNA, AIR 16/524, Progress report by the AOC-in-C Fighter Command on the Development and the Results obtained in Night Operations for the period 20 June to 31 July 1941.
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[104] TNA, AIR 16/525, Night Air Defence Committee: Minutes of meetings, Reports etc., November 1941 – August 1943. Night Air Defence Committee Meeting, 17 November 1941.
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[109] Ibid., Progress report by the AOC-in-C Fighter Command on the Development and the Results obtained in Night Operations for the period 1 July to 30 September 1942.
[110] Ibid., Progress report by the AOC-in-C Fighter Command on the Development and the Results obtained in Night Operations for the period 16 November 1941 - 31 March 1942.
[111] Ibid., Memo from Douglas to Director General & Inspector of Signals (DGIS), 6 June 1942.
[112] Bragg, *RDF1*, p. 279.
[113] TNA, AIR 16/525, War Cabinet, Night Air Defence, Jamming of RDF, Memorandum by Sir Henry Tizard, Chairman of the Radio Policy Sub-Committee, 4 July 1942.
[114] Ibid., Letter from DGIS to Douglas, 10 July 1942.
[115] Ibid. Meeting to discuss Sir Henry Tizard's memorandum, 19 July 1942.
[116] Metallised leaflets were a radio countermeasure in which incoming aircraft spread a cloud of small, thin pieces of black paper backed with aluminium foil cut to half of the target radar's wavelength, which either appears as a cluster of primary targets on radar screens or swamps the screen with multiple returns. Originally named *Window* by the British and *Düppel* by the Germans (from the Berlin suburb where they were first developed).
[117] TNA, AIR 16/525, Progress report by the AOC-in-C Fighter Command on the Development and the Results obtained in Night Operations for the period 1 July to 30 September 1942.
[118] TNA, AIR 41/71, Flying training during World War II: volume 2 part 3; operational training, 1952, Chapter 21, training in Middle East Command, p. 940.
[119] Andrew Hendrie, *The Cinderella Service, RAF Coastal Command, 1939-1945*, (Barnsley, Pen & Sword Aviation, 2010 [2006]), p. 156.
[120] TNA, AIR 41/71, training in Coastal Command, p. 889.
[121] Sir Robert Watson-Watt, *Three Steps to Victory: A Personal Account by Radar's Greatest Pioneer* (London, Odhams Press Ltd, 1957), p. 163.