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# METEOROLOGICAL SERVICES LEADING TO D-DAY

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# INTRODUCTION

Allied operations on 6 June 1944 (D-Day) were the centrepiece of World War Two (WWII). The story of the famous weather presentations made by James Stagg (Fig.1) to Eisenhower and his commanders is described in detail in Stagg's book *Forecast for*



**Figure 1 Gp Cpt J M Stagg**

*Overlord*; and to mark the 30th Anniversary of D-Day in 1974, Stagg himself was interviewed for the BBC World Service (copy of the tape and transcript held in the National Meteorological Library). Further material on this subject has also been published over the years by Douglas, Ratcliffe, Gordon, Hogben, Cornford and others. As these briefings were so vital, this concentration of interest is understandable, but only a handful of meteorologists was directly involved. Focusing attention solely on them completely fails to bring out the massive contribution made throughout WW II by the Met Office as a whole, working primarily for the RAF which had its own key roles in connection with D-Day – by no means just the mounting of a single operation, but rather the culmination of a long and wide-ranging campaign, well planned, brilliantly executed and involving the Met Office at all stages.

One extremely important aspect of the UK's Met Service during WW II was that it was fully integrated into the RAF operations, and this involvement was most effective. The advantages that can stem from such an approach had been well learnt by the RAF before the War. As Professor R V Jones, wartime Head of Scientific Intelligence, pointed out: "It was the coming together during the late 1930s of scientists like Tizard and Watson-Watt with serving officers of Fighter Command which led to the development and deployment of the Home Chain radar network that had such a profound influence on the outcome of the Battle of Britain." The RAF applied the same co-operative approach in its relations with Met Office staff during WW II; irrespective of rank, and even as civilians, forecasters were accepted by the RAF as an essential part of their operational organization, and even at outstations with no forecasters, the Assistants and WAAFs were often treated similarly. UK practice in this respect was streets ahead of the formal procedures that were the norm in the armed services of other countries, including the USA.

This paper paints a broad canvas, starting with some general remarks about the organization and development of the Office and its staff in wartime. The large majority of the services provided were to meet the needs of the RAF, whose acceptance of meteorological staff as part of their operational organization implied that the staff involved should understand what was going on and what the problems were. Background information about RAF operations is therefore included in this paper so that readers of it may also understand. It should not be overlooked that many wartime operations were classified until the mid-1970s or even later, by which time immediate post-war recollections and popular histories had already been published, perforce making no reference to them. It is a tribute to the security minded climate of those days that even those of us who were personally involved have only recently been able to look at the fuller picture. We were told what we needed to know to make our part in the operations effective, but what we did not need to know, we were rightly not told.

# MET OFFICE ORGANIZATION AND DEVELOPMENTS DURING WW II

The administrative HQ of the Met Office remained in Kingsway throughout the War, but other HQ units were dispersed from London. Forecasting and Communications were evacuated, briefly, to Birmingham, but early in 1940 were established on Dunstable Downs, where they remained until long after the War, and were known as ETA<sup>1</sup>. The TOP SECRET so-called IDA Unit for decryption was set up alongside and worked closely with Bletchley Park. The Sferic Unit for thunderstorm detection and later the East Hill unit for weather radar development were also nearby. Climatological, Marine and Instrument Branches, also the Library and Stores, took over the requisitioned premises of Wycliffe College at Stonehouse, near Stroud in Gloucestershire. The Training School in Berkeley Square which had closed in Spring 1940 was re-established in December that year at Gloucester, but returned to the London area later in the War.

There were four types of Met Office outstation. Type I stations provided fully-independent forecasting services on a 24 hour basis; these were located at Command and Group HQs and were known as Main Meteorological Offices (MMOs). Type II stations had one or more experienced forecasters who were allowed to predict independently for specific operations; 24 hour forecaster coverage was normally available, at least on call. The forecasters at Type III stations were not fully independent and were supervised as necessary by their Group MMOs; some of these stations maintained a 24 hour forecast watch, but others only covered local hours of flying.

Type IV stations had no forecasters at all, their Assistant grade staff acting primarily as observers, but also as suppliers of up-to-date weather reports and Group forecast products as needed locally by the RAF. The maintenance of a good observation network was of paramount importance, and reports were also made at Type III, Type II and some Type I stations. The network reached its maximum density around the time of D-Day when, astonishingly, over 500 stations in the UK were making reports, most of them hourly. Admittedly, though, this figure was swollen by many USAAF reports. There were a few Auxiliary stations (e.g. Coastguards), and RAF Flying Control personnel made observations at some small airfields, but the very large majority of the data came from Met Office staff.

The total number of people working in the Met Office increased throughout WW II to reach a peak of nearly 10,000 by late 1945, including considerable numbers by then serving with the RAF overseas in Europe, the Mediterranean area, Africa, the Middle East, India and the Far East, and even in places like Iceland, Bermuda and the Azores. In addition to its primary duties for the RAF, the Met Office also covered all the needs of the Army, Smoke Screens, Chemical Warfare and FIDO research and development. Although HQ staff in London and elsewhere remained as civilians, by April 1943 all outstation forecasters and assistants were in RAF uniform, including those serving with Army units; there was also direct recruitment of both officers and airmen into the Meteorological Branch of the RAFVR. Over 1800 WAAFs were recruited and after training took over all the assistant/observer posts at UK outstations. Some 40 or so WAAF officers were commissioned and trained to fill forecaster posts at Flying Training Command (i.e. non-operational) stations in the UK.

The civilian (Air Ministry) meteorological offices before, and at first during the War, were not normally rank-conscious places, and thankfully this relaxed tradition

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<sup>1</sup> For a glossary of acronyms, abbreviations, etc., please turn to page 23.

continued after the forecasters were put (almost overnight !) into uniform. The Met Office was often the only place on an RAF airfield where aircrew of all ranks could meet on level terms for both meteorological and social reasons, and this happy state of affairs brought benefits for both sides. Aircrew could develop their meteorological understanding, whilst forecasters learnt more about in-flight problems. The good personal rapport and mutual respect that came about in this way undoubtedly improved the quality of the vital debriefing reports received after operations or local air tests. Forecasters at many stations were issued with RAF Flying Logbooks; they were encouraged to get as much flight experience as possible, and the RAF normally welcomed this.

Outstation weather reports were sent, mostly by teleprinter (T/P) but some by telephone, to Collecting Centres at MMOs, where they were assembled into Group Collectives for onward transmission to ETA at Dunstable and subsequent broadcast. During the early war years all T/P work outside ETA was performed by Met Assistants, and T/P training was eventually added to all Met WAAF courses; but the sheer volume of switchboard work and message transmission at MMOs made it essential to introduce rosters of WAAF T/P operators to look after this non-meteorological work.

## **FIGHTER COMMAND, 2TAF AND AIR DEFENCE OF GREAT BRITAIN**

At the start of WW II there were three Groups in Fighter Command – 11 Group at Uxbridge, 12 Group at Watnall (near Nottingham) and 13 Group at Newcastle. As a precaution against air attack, the operational sections including Control Gallery and MMO were 60 feet underground. HQ Fighter Command at Bentley Priory (Stanmore) and the three Fighter Groups formed later – 10 Group at Rudloe (near Box in Wilts), 9 Group at Preston and 14 Group at Inverness – also had MMOs but these were all in large houses above ground. 81 (OTU) Group in Fighter Command did not have an MMO. The duties of the MMOs were to advise Air Staff and Controllers, to provide forecasts for outstations including those in 81(OTU) Group, Air Transport Auxiliary (ATA) Ferry Pools and Balloon Barrages in the Group area, also ballistic winds for Army AA Batteries.

Type IV observing offices were set up at all the Sector HQ airfields like Biggin Hill and were retained at satellites such as Croydon and Lympne, which had been civil airports. The violent German attacks during the Battle of Britain on airfields in the South-east forced the move of Sector Ops Rooms in that region away from the airfields to less-vulnerable sites, mostly in large houses requisitioned for the purpose, and the Met Offices moved with them to maintain the essential up-to-the-minute flow of weather reports to the Controllers. The observing offices were eventually able to move back to the airfields, but not until after D-Day; so, from Autumn 1940 to Autumn 1944, the observations nominally from Sector HQ airfields in the South-east region were, in fact, made at sites some two to three miles away from the airstrips.

During the early part of the War, forecasters were not thought necessary at any fighter airfield, and this policy continued to apply throughout the War at airfields and Advanced Landing Grounds which had only day fighters. But when twin-engined aircraft – initially Blenheims, then Beaufighters and later Mosquitos – started night flying using Airborne Interception (AI) radars, forecasters were added to the night shifts in the Met Offices at those Sector HQs which controlled them. During 1941 and 1942, night-fighter control gradually passed from the Sector Ops Rooms to the new Ground Controlled Interception (GCI) radar stations. It then made sense to move the forecasters to the night-fighter airfields, where they could brief the aircrews face to face (something the RAF always preferred) and advise both GCI and Sector

Controllers, as needed, by telephone. At this stage in late 1942, these stations were upgraded to Type II, which was especially timely because, following the cessation in October 1942 of the so-called Baedeker raids to places like Bath, Norwich and Canterbury, there was a comparative lull in German night raiding for over a year, and some of the Mosquito Squadrons that were increasingly coming into service started flying intruder missions as well as covering night defence. Independent forecasters were of course needed to participate in local planning for those operations.

In June 1943, as part of the forward planning for D-Day, 2 Group with its medium bombers was transferred from Bomber to Fighter Command, and at the same time Army Co-operation Command ceased to exist as a separate entity, being amalgamated with some 20 day-fighter squadrons to form a new 83 Group; 2 Group and 83 Group were then linked into an embryo Second Tactical Airforce (2TAF) within Fighter Command. Five months later, in November 1943, two more new Groups (84 and 85) were formed from the strength of Fighter Command and were added to 2TAF, which with its four Groups then became independent. This left a rump of barely 30 day- and 12 night- fighter squadrons in what was christened Air Defence of Great Britain (ADGB) which replaced Fighter Command. Responsibility for Air-Sea Rescue in the Channel was added to the duties of ADGB, and four squadrons specializing in that work were transferred to ADGB from Coastal Command. The Allied Expeditionary Air Force (AEAF) also came into being in November 1943, bringing together 2TAF, ADGB, the Airborne Forces and the US 9th Air Force which, like 2TAF, was devoted to tactical operations. The CMetO at AEAF was Dr Sutcliffe, and this new Unit took over the MMO at the old HQFC in Bentley Priory; 2TAF was lodged at Uxbridge, pending its move in due course to the Continent.

Preparations for D-Day were thus well in train when the slimmed-down ADGB was given its first major challenge. On 21 January 1944, the Luftwaffe launched what came to be known as the Baby Blitz, aimed primarily at the London area, which continued at night for about four months. The RAF response was mounted for the most part by the Mosquito Squadrons at Ford, West Malling, Bradwell Bay and Castle Camps, with a little help from Coltishall towards the end; no doubt the Met Offices at these five airfields were kept very busy. Thankfully, despite its reduced size, ADGB stood firm, shooting down 25 enemy aircraft on the first night and well over 300 – almost 2/3 of the entire force allocated by the Germans for this campaign – before it ended in May 1944, not long before D-Day.

The met units attached to 2TAF were by definition mobile, and as early as the autumn of 1943 many of them were already living in tents, with converted 3-ton lorries as offices. For example, George Cowling who had been at PRU Benson (see later) helped to set up a dedicated 2TAF Photo Recce Wing at Hartford Bridge (later known as Blackbushe); in April 1944, the Wing moved to Northolt, still in tents, and in August it was posted across the Channel to France. Similarly, Peter Deeks became part of the 83 Group HQ Met Office under John Bell; this was for a time at Gatwick, but a month or so before D-Day moved into a wood at Cosham, near Portsmouth, and went across the Channel on D+5 when the bridgehead was still quite small. To emphasize the mobile, transitory nature of these pre-D-Day locations, all the names of airfields housing 2TAF aircraft were in mid-May replaced by numbered Wings.

## **COASTAL COMMAND**

During 1941 and 1942, losses of shipping on the Atlantic had become alarming, and among the huge total missing, principally due to U-boat actions, were the two British Weather Ships known as Panthers, that were sunk with all hands, including the six meteorologists on board. Over and above the loss of the ships and their crews, the

cargoes brought in from Canada and the USA were a vital life line to an isolated country at war. But the mounting figures also had direct implications for D-Day, and in 1942 Field Marshal Montgomery pointed out that victory in the Battle of the Atlantic was an essential pre-requisite for successful invasion of Europe.

The primary activities of Coastal Command were the provision of air cover for coastal shipping and convoys, also the flying of reconnaissance missions. There were MMOs at Command HQ (Northwood) and at the main Group HQs – 15 (Liverpool), 16 (Chatham), 18 (Pitreavie) and 19 (Plymouth) – but not at 17 (Coastal OTU) Group. These provided advisory services to the Air Staff and back-up for all the out-stations, but, unlike most Fighter and Bomber Command operations, those of Coastal Command normally involved only a few aircraft at a time, so that forecasts and briefings had to be prepared and delivered at local airfields and flying boat bases which in consequence normally had Type II staffing for their Met Offices, i.e. independent forecasters.

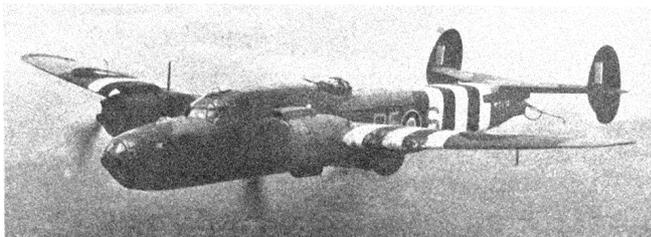
By 1942, Bomber Command was attacking U-boat construction yards and bases and also mining harbour approaches (an activity known as 'Gardening'), while Coastal Command continued its reconnaissance missions aimed primarily at locating submarines in action or in transit. The Casablanca Conference in January 1943 called for even greater efforts against ports and U-boats from both Commands. Fortunately, soon after this, Coastal Command obtained some new American aircraft with much greater range – the Liberators and, in particular, the Catalina flying boats, which could, and sometimes did, remain airborne on patrol for more than 24 hours. Flights of that duration would pose a severe challenge to present day forecasters, let alone those during WW II who had no satellite data and indeed few data of any kind other than the observations Coastal Command aircrew themselves made.

By mid-1943, great progress was being made in the Battle of the Atlantic, and U-boat sinkings began to exceed the number of ships they sank by a large margin. In part, this was due to new equipment like the Leigh Light and the Air to Surface Vessel (ASV) radar installed in the improved aircraft, but a key fact was that the cryptanalysts at Bletchley Park, helped by the capture of an Enigma Machine and code book from a U-boat brought to the surface by an RN destroyer, managed to break the naval Enigma code. This sometimes enabled the RAF to be told when U-boats would be approaching their bases in Western France on the surface, and thus be at their most vulnerable. The Luftwaffe tried to provide air cover for these operations but Coastal Command had by then also acquired several squadrons of Beaufighters based in Cornwall who attended to that. By the spring of 1944, the Battle of the Atlantic had largely been won.

In addition to the U-boat patrols and general co-operation with the Navy, Coastal Command was also responsible for two types of operation of direct interest to the meteorologists. The Photo-Recce (PR) Units at Benson, Leuchars and St Eval were part of Coastal Command, the SMetO for the major Type II office at Benson being S/Ldr Eric Kraus. At any given moment, there was a long list of targets to be visited, and selection was normally made by the RAF on the day, in the light of the weather, after full discussion in the Met Office. When the USAAF brought over its own PR squadron, the forecasters responsible for it were attached to Benson for training in the Met Office there. Prior to taking over at Benson, Kraus had a great deal to do with the introduction of the Meteorological Reconnaissance Flights which got under way in the spring of 1941 and were also part of Coastal Command; these were based in the UK at Docking, Wick, Tiree, Brawdy and St Eval. As a matter of convenience, the Met Recce Squadrons took over the famous THUM Flights at Bircham Newton and Aldergrove, together with the associated high-level PRATA Flights, which from November 1943 operated from Manston.

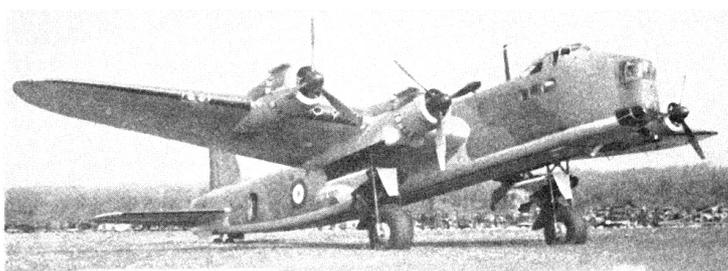
# AIRBORNE FORCES AND SPECIAL OPERATIONS

Although as early as the summer of 1940, Churchill had demanded the creation of some UK Airborne Forces, for obvious reasons progress was slow. By July 1942, however, with the formation there of a new Heavy Glider Conversion Unit, Brize Norton (then in Training Command) became the centre of a group of airfields at which pilots were trained to fly the large Horsa and Hamilcar gliders that had been chosen by the Army. In March 1944, this training commitment was moved elsewhere, and Brize Norton, together with several other stations, became bases for operational glider flights under 38 Group, Transport Command. The towing aircraft were Albemarles, Stirlings and Halifaxes.



**Figure 2 Armstrong-Whitworth Albemarle**

At this same time early in 1944, Transport Command also set up a new 46 Group equipped with Dakota aircraft which could fulfil the dual role of transporting men (either paratroopers or in gliders) and, when the beachhead was large enough to allow construction of an airstrip, provide a casualty evacuation service that could land to pick



**Figure 3 Short Stirling**

up the wounded and fly them straight back to England. This latter vital operation was able to start only a week after D-Day, and from mid-June onwards several of these dual purpose operations were flown by each squadron daily.

Obviously the operations of these two Airborne Forces Groups had to be integrated into the flight patterns of the enormous numbers of RAF and USAAF aircraft flying over Southern England, the Channel and Northern France, and this was achieved by bringing both 38 and 46 Groups under the umbrella of the AEF at Bentley Priory. The HQ of 46 Group was at Harrow Weald, in the building that shortly after the War became the Harrow component of Met Office HQ, accommodating all the Branches that returned from Stonehouse. But with only three active stations in the Group and an operational pattern that overlapped considerably with that of 38 Group, it was decided that the MMO at 38 Group HQ (Netheravon) would act as MMO for 46 Group also. Type III Met Offices at the airfields were sufficient to cover D-Day itself, but some of them were later upgraded to Type II.

During WW II, the RAF carried out many activities to which the adjective 'special' could fairly be applied, but none more so than those of 138 and 161 Squadrons at Tempsford in Bedfordshire. This station was administered by 3 Group of Bomber Command, but its work was quite unconnected with strategic bombing, because from 1941 onwards this was the home base for the cloak and dagger activities of the Special Operations Executive (SOE). On moonlit nights, Lysander aircraft provided very accurate low-level supply drops to the Resistance in enemy-occupied territory, and often landed to deliver and/or pick up agents. These Lysanders sometimes used Tangmere as an advanced base for refuelling. Hudson aircraft operated similarly over

a wider range when acceptable simple airstrips or at least dropping zones could be prepared by the Resistance. They were also able to give invaluable assistance, especially as D-Day approached, by flying at 20,000 ft or so near the Dutch coast, acting as radio relay stations for messages passing between the UK and the Resistance. Men and materials in bulk were dropped by parachute from larger aircraft, initially Whitleys, then Stirlings and Halifaxes. During 1944, all these activities increased. In May, over 6000 containers were flown to France, and the majority of these are known to have reached their intended recipients.

Having to give forecasts and weather briefings for all these unique operations at high and low level, including landing at night in enemy-occupied territory, where the only observations were a few aircraft reports and whatever could be gleaned from Bletchley and the IDA Unit, must have posed many problems for the Met Office at Tempsford which, like that covering PR work at Benson, was staffed at Type II level. It must have been very satisfying when, after the War, staff were able to read the RAF Report on the hectic activities shortly before D-Day. "So great a weight of supplies was delivered to Western Europe during the first half of 1944 that Resistance movements everywhere found themselves sufficiently well equipped to fulfil, even beyond SOE expectations, the rôle which they had been allotted". Reception by the Resistance was set in train on receipt of messages hidden in the texts of BBC broadcasts.

## **BOMBER COMMAND**

Very little was achieved by Bomber Command during the early years of the War. The renaissance from 1942 onwards stemmed from three things: (i) the appointment of Harris as AOC in C; (ii) the new heavy bombers (Stirlings, Halifaxes and Lancasters) coming on stream; (iii) progressive introduction of better navigational aids – GEE, OBOE, H2S and G-H (see later).

By the time of D-Day, 2 Group with its medium bombers had been moved to 2TAF, leaving Groups 1 (Bawtry), 3 (Exning), 4 (York), 5 (Morton Hall, Swinderby) and 6 (RCAF) (Allerton Park) as the Main Force. But added to these were two new Groups, which gave tremendous help to the Main Force, namely 8 (PFF) Group, the Pathfinders who came on the scene in mid-1942 and 100 (BS) Group, formed in late 1943 to co-ordinate various aspects of bomber support. These will be dealt with separately.

HQBC (High Wycombe) and all seven operational Bomber Groups had 24-hour MMOs, staffed by experienced independent forecasters, as did the three OTU Groups – 91 (Abingdon), 92 (Winslow) and 93 (Egginton). However, as most (though not all) heavy bomber operations involved aircraft from more than one Group, there had to be co-ordination of the information supplied, especially the winds, because only in that way could the attack be concentrated and the aircraft stream be kept together to provide an element of safety in numbers; stragglers were always more vulnerable. To achieve this, daily conferences (using scrambler telephones) were introduced in December 1940 between all MMOs in the Command; from February 1942, CFO also participated in these discussions, and being at the centre of communications was able to bring not only forecasting expertise but also up-to-the-minute information not yet broadcast e.g. from the Met Recce Flights, or decrypted German data from Bletchley Park and the IDA Unit. From January 1943, the new Upper Air Unit at Dunstable played a major part.

As not even the Group MMOs were entirely independent, bomber airfields initially had only Type III offices with dependent forecasters. But just as Fighter Command had Sector Stations and subsidiary airfields, during 1943 the five Main Force Bomber

Groups were organized with Base Stations and satellites; for example, I was stationed in 1 Group at 14 Base, Ludford Magna, with two satellites at Wickenby and Faldingworth. Base Met Offices had three forecasters to provide full 24 hour forecast coverage. One of the three posts was eventually filled by a F/Lt, independent forecaster, making the office technically Type II, but apart from non-operational flying such as cross country training, bases normally continued to operate in a dependent mode. Although 8 (PFF) and 100 (BS) Groups did not formally have Base Stations, the special work at many of them necessitated Type II status (see later). Satellite airfields never had more than two forecasters and gave forecast cover only while operations were pending or in progress. However, despite their dependent status, both Base and Satellite forecasters did make positive contributions to operations, because every Group held its own daily telephone conference (in which all outstations participated) to discuss local weather for take-off and, especially, for returning in the small hours, covering the possible need for diversions, use of FIDO and so on.

At Base Stations, on days when HQBC was planning operations for that night, the Duty Met Officer was told the target, timing, route etc. in strict confidence by about 10 am, before having to attend separate morning conferences held by both Base and Station Commanders. At the afternoon mass Squadron briefings, we usually illustrated our presentations with a surface chart and a pictorial cross section, both drawn using coloured chalks on blackboards. After the briefings and questions, we then had to rush back to the office to produce copies for each crew of the final forecast and upper winds received from our Group MMO. Duplication facilities in those days were primitive in the extreme. The text produced using hectographic ink or carbon paper was first imprinted onto the surface of a large jelly in a tray, with copies then made one by one by pressing blank forms onto the jelly image. At stations with two squadrons like our satellite Wickenby, coaxing 40 or more copies from one jelly image was a very dodgy business. Forecasts were then taken in bulk to the Crew Room.

After take-off, the Met Office was normally quiet for a time, but local weather had to be watched very closely, especially the surface wind, visibility and any signs of low stratus. Runway lighting in those days was usually just goose-neck flares, so, if the runway had to be changed, this took at least half an hour, because all the flares had to be collected onto a lorry and then be re-laid on the new strip. If FIDO had to be lit, this too took half an hour or more to get the lighting crew in position and allow time for the initial smoke to disperse. The forecaster then had to position himself with the Airfield Controller and his caravan close to the touch down point. One knew from the Controller's R/T when an aircraft was approaching in the funnels, but one could not hear it because of the roaring noise produced by the burners, and saw it only when it burst through the fog above the FIDO cross-bar, barely 100 yards away! Once the aircraft had landed, the final essential task was to accompany the RAF Intelligence Officer to debrief the aircrew before they went to bed. The information gleaned then had to be summarised and passed to the Group MMO as vital input for the ongoing operational planning at HQBC. Needless to say, if the forecast had proved to be seriously in error, our ears were well and truly bent!

## **UPPER AIR FORECASTING**

In 1942, upper air charts were still rudimentary, but more data were coming to hand and it was realised that what was happening well up in the troposphere played an integral part in general weather developments. As forecast upper winds were also of great importance to Bomber Command, it was decided to set up, with effect from 1 January 1943, a special Upper Air Unit at Dunstable under Sverre Peterssen (see later) to work alongside C K M Douglas in CFO, to develop upper-air prediction techniques and, in due course, to participate in the daily Bomber Command

Conferences. This arrangement for pooling expertise proved so successful that it was subsequently used as the model for producing the vital D-Day forecast advice for Eisenhower. Although there was also an Upper Air Unit at HQBC High Wycombe, in practice Peterssen's Unit in CFO was universally known as the "Bomber Command Upper Air Unit", and the wind forecasts sent through MMOs to airfields originated from Dunstable.

Having issued the final winds for Main Force operations, the Upper Air Unit naturally kept them under review in the light of new data coming to hand (e.g. from the IDA Unit or Bletchley) and there were rare occasions when the need for amendment arose before the aircraft had taken off. Amendment slips then had to be prepared at the departure airfield Met Offices, and I can recall having to cycle out with them to the end of the take-off runway and hand one to someone in each aircraft as it turned from the perimeter track to the runway!

Once PFF had settled down and gained experience with their navigational aids (in particular OBOE and H2S - see later), a new procedure was introduced whereby

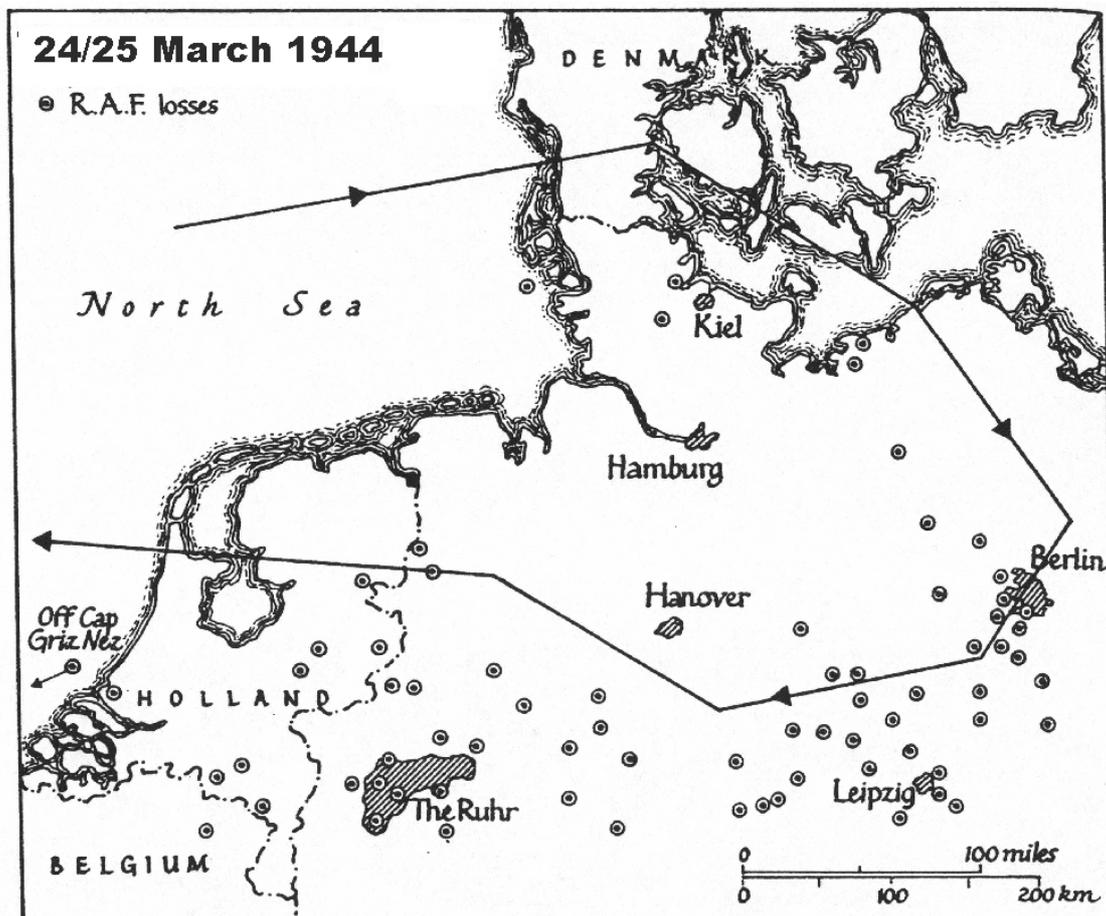


Figure 4 The raid of 24/25 March 1944 (Middlebrook 1988)

selected crews in the first wave of markers were nominated as wind finders; this started with effect from 23 December 1943. Having made very careful wind measurements, these crews reported the information back to the UK by radio and these messages were passed to the Dunstable Upper Air Unit. In the light of these data and any late reports from IDA or Bletchley, amended zone winds were then prepared and broadcast to all the aircraft as they approached the target. For the most part, this wind finding system worked very well indeed, but there was one spectacular failure.

During the final large-scale Main Force attack on Berlin on the night of 24/25 March 1944, forecast winds were northerly around 40 kt, but by the time the wind finders reached Denmark they were calculating speeds of well over 100 kt. Believing that winds of this strength at 500 mb were impossible, some wind finders assumed they had made an error and arbitrarily reduced, or were ordered by their Captains to do so, the speeds reported. Data coming back to Dunstable were thus all over the place, and regrettably the Duty Upper Air Forecaster compounded the error by sending out amended wind speeds that differed little from those originally issued. I can still vividly recall debriefing a lazy, cocky but none-the-less brilliant French Canadian navigator on 101 Squadron who had bothered to compute only three winds over the entire route to Berlin. But one of these, based on an astro-fix, gave a speed of over 120 kts, and it never entered his head that he might have made a mistake. He ignored the amended winds from Dunstable, instructing his Captain on the basis of his own jet speed winds, and I think this aircraft must have been one of very few indeed in the whole Command that was on track that night, as evidenced by the plot of positions at which aircraft were shot down in relation to the planned track (see Fig.4). The reason for this catastrophic error became apparent when I looked at the charts and German DWRs held in Met Office archives. Pressure was rising rapidly over the UK behind a deep low that had moved through to the east, leaving a northerly flow over the North Sea, Denmark and North Germany. CFO thought the upper low had moved to about 32°E by 24 March, but, in fact, as the German DWRs showed, the 500 mb centre had regressed from 23°E on 23 March to 21°E on 24 March. This tightened the northerly gradient considerably, as confirmed by a radio-sonde from Berlin itself, giving a wind at 5 km of 200 kph (i.e. well over 100 kt). Although often suggested that the USAAF first found the jetstream near Japan in 1945, the RAF beat them with this one.

## **THE PATHFINDER FORCE (PFF)**

As noted earlier, PFF was established in July 1942, formally becoming 8(PFF) Group at Huntingdon under A/Cdr (later AVM) Donald Bennett in January 1943; needless to say it had its own MMO. The primary task of the Group was to provide clear and accurate visual marking of targets for the Main Force to attack. For PFF, navigational accuracy was thus of the essence. The first major navigational aid to come into service was GEE, which had been under development since before the War. By February 1942, when Harris took over as AOC in C, about 1/3 of his force had already been fitted with it. All PFF aircraft had it, and it was available to the entire force before long. Pulse transmissions from a 'Master' and two 'Slave' stations on the ground 100 miles either side of it enabled a navigator using his 'GEE Box' (containing a cathode-ray tube) to determine his position from the time lag between receipt of the two signals. Among its great advantages were that it was simple to operate, gave a fairly reliable fix, could be used simultaneously by any number of aircraft and emitted no signal onto which enemy night fighters could home (as it was NOT a form of radar). The only major disadvantage was a maximum range of only about 350 miles, but the Ruhr area was within range.

Next on the scene was a device called OBOE, which was used only by certain PFF aircraft and was never issued to the Main Force. Once an aircraft got within 10 minutes flying time of its target ETA, it could pick up transmissions from an OBOE 'Cat' station and then fly at a constant distance from it along an arc leading to the target, being tracked by radar and advised of any deviations from this arc; meanwhile a 'Mouse' station monitored the aircraft progress and distinctively signalled the moment for release of flares. The great advantage of OBOE was the precision of the fixes, but its two disadvantages were a maximum range slightly less than that of GEE (although this was extended when the aircraft were flying high like the Mosquitos) and the fact that each pair of stations could control only one aircraft during its ten-minute run to the

target; i.e. even when three pairs of stations were set up, no more than 18 aircraft could be looked after per hour. The equipment was first installed in December 1942 in the Mosquitos of 109 Squadron, then at Wyton, being added the following year to 105 and 139 Squadrons. In April 1944, Harris authorised 5 Group to carry out its own marking for purely 5 Group operations, and Bennett had to transfer 627 Mosquito Squadron to lead the 5 Group marking; this went to Woodhall Spa, and presumably the aircraft were fitted with OBOE.

There has been much debate about the origin of the term H2S to describe the airborne ground observing radar which came into service early in 1943. Professor R V Jones thought the term was coined by scientists working on its development when Professor Lindemann dismissed their excuse for slow progress by saying "It stinks"! To a trained operator, the cathode-ray tube images distinguish between urban and country areas and also clearly show coastlines, estuaries, lakes and rivers. The first installations were in PFF aircraft which needed this for all targets beyond GEE/OBOE range, but eventually it was put into nearly all the heavy aircraft in the Command (except 101 Squadron, see later) and even into some Mosquitos.

When 2 Group was moved in June 1943 from Bomber Command to 2TAF, Harris managed to retain control of its two Mosquito Squadrons and allocated them to 8(PFF) Group. 105 Squadron then joined 109 Squadron as a second OBOE squadron, and these two between them led the heavy marker aircraft which did not have OBOE. The other ex-2 Group Squadron (139) at first acted as support for 109 and 105, but also started making diversionary raids that successfully attracted German night fighters away from the main target. By this time, Mosquito aircraft were being built in substantial numbers, and Bennett was able to form new squadrons (eight more by the end of the War) to work (with 139 Squadron as their lead markers) in what became known as the Light Night Striking Force (LNSF) which ranged widely over Germany, flying at levels between 25,000 and 35,000 feet, above much of the thick tropospheric cloud. Each of these aircraft carried a 4000 lb bomb. This kept the German night fighters busy, though few could challenge the Mosquitos at these altitudes, and caused air raid sirens to be sounded in cities night after night. The trip to Berlin became known as "The Milk Run", and there was one spell early in 1945 when sixty or more aircraft went on it during 36 consecutive nights. All these operations were planned, organized and operated by 8(PFF) Group, whose MMO prepared the forecasts, making sure they were consistent with the Main Force predictions based on the Command Conference. The forecasters at the LNSF bases (Upwood, Oakington and Graveley at the time of D-Day) then had to brief on those lines.

When on duty at Oakington one potentially foggy night during the winter of 1942/43, I was surprised to receive a personal phone call from Donald Bennett, AOC of the PFF, asking for, and then discussing, our latest wet- and dry- bulb temperatures. He was interested in and extremely well informed about meteorology, and one of the first things he did after his appointment to lead PFF was to try to bring the PAMPA (Photo-recce And Meteorological Photography Aircraft) flights under his command. This took six months or so, but on 1 April 1943 the eight Mosquito aircraft engaged in that work were withdrawn from 521 (Met) Squadron at Docking to form a new 1409 (Met) Flight at Oakington; nine months later the Flight moved to Wyton, where it remained for the rest of the War.

Having decided on a probable target in the light of meteorological advice, C in C Bomber Command might order a PAMPA flight before tactics for the night were finalised. Flights could be sent anywhere at short notice, and the navigator had to prepare his own flight plan to cover the given objectives, but including sundry course changes to mask the specific areas of interest. Clearly very careful meteorological briefing at Type II level was needed. At full strength, the Flight had ten crews to cover

as many as four flights per day. The crew members were not professional meteorologists but were chosen carefully from those who had already completed a tour with Bomber Command and had subsequently done well at the Mosquito OTU. The chosen navigators were then given Met Air Observer training. Cloud features could be photographed using a hand held camera and the aircraft might deliberately fly into cumulonimbus cloud at various levels to determine the degrees of airframe icing and turbulence. Vertical temperature profiles could also be obtained when required, and winds were computed very carefully as a routine throughout the flight.

On landing, the navigator reported his findings immediately on a scrambler telephone to the MMO at HQ 8 Group, who fed this information into the Command planning process for the night's operations. Some time after HQ Bomber Command introduced the Master Bomber procedure (first used on the Dam Buster Raid in May 1943), the PAMPA Flight sometimes flew additional missions 30 minutes or so ahead of the first OBOE target markers and then gave an up-to-the-minute weather report for the target area directly by radio to the Master Bomber or his Deputy. On the final mass raid to Berlin, the Deputy Master Bomber actually flew lying on cushions in the nose of the PAMPA aircraft which on that occasion had to remain in the target area throughout the raid.

## **BOMBER SUPPORT (BS)**

During 1943, several air activities connected with the strategic bombing offensive had begun to grow outside HQBC control. In December of that year, the Air Ministry agreed requests from Harris to bring these within his Command by setting up a new 100 (BS) Group, with its HQ at Bylaugh Hall, Norfolk, to co-ordinate all bomber support operations. The brief for the new Group was twofold: (i) to mount INTRUDER flights against German night fighters and their airfields; (ii) to develop and operate Radio Counter Measure (RCM) flights against the Luftwaffe and its Control centres and communications. Both of these activities played important roles on D-Day. Most 100 Group operations were unique to the Group, whose MMO prepared the necessary forecasts.

Four Mosquito night fighter squadrons were transferred from Fighter Command to the new Group for INTRUDER work, at least two of these equipped with the latest narrow-beam airborne radar designed for low level work. These aircraft ranged widely in small numbers to the airfields most likely to be used against the bomber stream on the particular night, and clearly required special forecasts and briefings, as they had received from the Type II offices at the night fighter airfields.

At the core of the RCM development task were the very special activities at Foulsham, where 192 Squadron (sometimes known as the Snoopers) was based, equipped with Halifax and some Mosquito aircraft. This Squadron was formed in January 1943 from the Wireless Investigation Flight of 109 Squadron (see under PFF) that had inter alia test flown OBOE in secrecy at Tempsford and Gransden Lodge. Throughout 1943 and 1944, 192 Squadron operated widely over Germany and the occupied countries, its crews listening to enemy radio chatter to discover the frequencies being used, and checking similarly on German ground and airborne radars. The Bomber Support Development Unit was also based at Foulsham from Spring 1944, and there was a FIDO installation there as well. With all these special operations to look after, the Met Office must have been kept very busy indeed and was no doubt manned as Type II.

Another unique piece of RCM development was carried out at Oulton by 214 Squadron, the only one in the RAF equipped with Flying Fortresses. Strictly speaking, this was not bomber support at all, but it unquestionably came into the RCM field,

because its task was to seek evidence (if any) that the V 2 rockets were being radio controlled. These were under development at Peenemunde, which had been attacked by Bomber Command in a memorable raid on 17/18 August 1943 but remained the principal location for all rocket test flights. The V 2 rockets were first launched against England on 8 September 1944.

The first warning received by the Germans of approaching RAF aircraft normally came from their ground radar stations near the coast, so an important aspect of RCM work was to blind these by heavy jamming. The equipment was called MANDREL, and the appropriate stretch of coast line could be covered by a number of carefully positioned aircraft flying race track patterns through the period of coverage. This work was carried out by Stirlings of 199 Squadron based at North Creake, where special forecasts and briefings were needed with an emphasis on winds so that the aircraft could maintain position without drifting away.

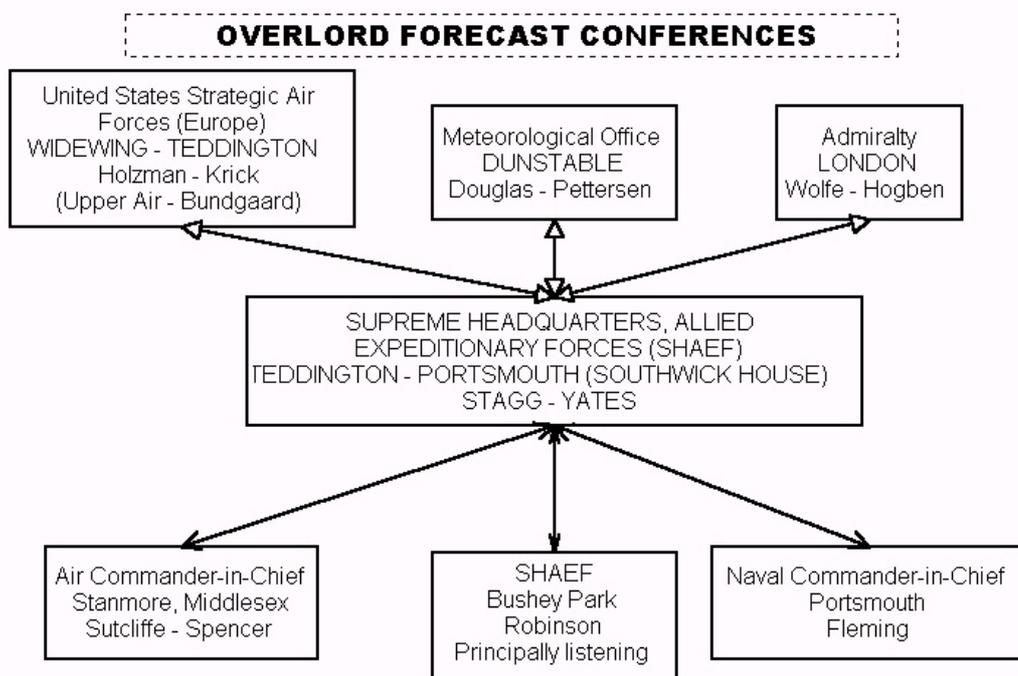
Two quite different RCM approaches were developed to minimise the effectiveness of the German night fighter attacks on the bomber stream. Three Mosquito Squadrons (141 and 239 at West Raynham and 169 at Great Massingham) were equipped with a device called SERRATE which enabled them to home onto the airborne radar carried by the Luftwaffe night fighters, then jam the signals and/or shoot down the aircraft. The other RCM aircraft normally flying with this unique role in every bomber stream, were the Lancasters of 101 Squadron at Ludford Magna. They carried special equipment known as the Air Borne Cigar (ABC), together with an extra German-speaking crew member to operate it. Although unquestionably carrying out 100 (BS) Group work, 101 Squadron was kept as part of I Group because their aircraft carried a bomb load as well as the ABC equipment which was bulky but not especially heavy. The purpose of ABC was to monitor all the frequencies used for R/T between the German night fighters and their controllers. Having identified a transmission of this kind, the ABC operator immediately switched one of his jammers onto that frequency and then searched elsewhere. Each aircraft carried three jammers, and the bulkiness of all the equipment meant that there was no room in the aircraft to fit the H2S, whose operation might well have been nullified by the jammers anyway. The navigators on 101 Squadron therefore had to be first class, and on arrival from the Lancaster Finishing School at Hemswell had to fly several cross country checks before being allowed to go on operations – see under Wind Finding above for an incident showing the accuracy that could be achieved. As 101 was the only Squadron in the Command with this equipment, a few of its aircraft had to go on every major raid, whether 1 Group was involved or not. It was therefore claimed that 101 probably took part in more operations than any other Squadron on Main Force operations in the entire Command. Having served at 14 Base with 101 Squadron for nearly two years, I can confirm personally that we in the Met Office had to work like beavers, and having a FIDO installation as well just added even more to the work load.

## **FORECAST FOR OVERLORD**

To anyone who knew the sort of weather the Channel can produce, even in summer, it was self-evident that meteorology might come to play a vital role in the very hazardous operation of invading the Continent. The US and the UK had very sensibly agreed that Eisenhower's Chief Meteorological Officer should be British, with a Deputy from the USAAF, but when, in November 1943, Nelson Johnson, Director of the Met Office, nominated Dr Stagg for this post, many people were surprised, including Stagg himself. Although he had done a little forecasting in Iraq before the War, he was not really a forecaster at all, had not been trained as such, and did not consider himself as one. But Johnson knew that whoever was selected would have firstly the unenviable job of drawing together the probably conflicting advice from UK and US forecasters

into an agreed story, and secondly of presenting this to Eisenhower and his Senior Commanders, then standing up to and dealing with their searching questions. In these circumstances, an ability to work under pressure coupled with tact and, above all, character were likely to be more important than personal skill as a forecaster. When appointing him, Johnson suggested to Stagg that the optimum way of consulting and resolving differences would be to use scrambler telephone conferences similar to those which had been used with such success for Bomber Command operations.

Almost unbelievably, Stagg was told when appointed that "because of the exigencies of the time" he could not be given any facilities for preparing his own charts. Whilst in London, he had to wait for forecasts to arrive by dispatch rider from CFO at Dunstable! When SHAEF was set up in Bushy Park, Teddington, near the USAAF Centre known as Widewing, which was already there, Stagg's USAAF Deputy, Colonel Yates, gave him copies of their charts. During the last week when the centre of action had moved to the SHAEF HQ in Southwick House near Portsmouth, Stagg had to work in Cdr Fleming's Naval Met Office there and use their charts. One might have thought that, for such a momentous event, the Chief Meteorological Officer would have been given a small independent forecast unit of his own instead of having to use material prepared by other professionals who could have had axes to grind. But this did not happen and, indeed, he was not even given a WAAF Corporal to do his typing until May 1944, prior to that having to borrow a USAAF Sergeant from Colonel Yates! Later in May, he was at last given a UK Deputy in the person of S/Ldr Robinson from 2TAF, who remained at Bushy Park when Stagg moved with Eisenhower to Southwick House. So, for the vital forecasts during the final period before D-Day, from 29 May onwards, the personnel participating in the Conferences which Stagg had to chair from Fleming's office were as shown in Fig.5.



**Figure 5 Conference participants**

CKM Douglas was far and away the most experienced of the forecasters. He had served as a pilot and meteorological air observer with the RFC during the First World War and had worked as a forecaster ever since; his memory for past weather situations was legendary. Although a natural forecaster, he worked from the bedrock of a strong theoretical understanding, as underlined by his joint authorship with Professor Brunt of a classic pre-war paper on ageostrophic effects. Douglas firmly believed that

there was NO scientific basis at that time for prediction beyond 48 hours (sometimes not even beyond 24 hours), except in a few very static situations. He therefore mistrusted those who claimed to be able to see further ahead, putting him on a collision course, in particular with Irvine P Krick at Widewing and with the Admiralty.

Sverre Petterssen, a Norwegian, had trained at the famous Bjerknes School and had been a forecaster in Norway before appointment to a Chair at MIT. He had written a classic textbook and was a pioneer in the analysis and application of the upper-air data that were increasingly coming to hand. He was invited to the UK to lead a new Upper Air Unit at Dunstable with effect from 1 January 1943, working alongside Douglas and his team. His staff (e.g. Robert Ratcliffe, Gerald Mathewman, Priestley, Swinbank, Berson) found him helpful, often inspirational and naturally enthusiastic. He respected Douglas as a forecaster but did not always agree with him, sometimes allowing his belief in the role of upper-air data to run away with him. His didactic approach undoubtedly rubbed some people up the wrong way, in particular Krick at Widewing, with whom he argued at great length.

As Deputy to Stagg at SHAEF, Col. Yates was in a very difficult position because, as the senior USAAF meteorologist in the UK, he was also in charge of Widewing and thus responsible for its output. Fortunately, Stagg and Yates got on quite well together, and not infrequently Yates managed to moderate the dogmatic views put forward by Krick in particular. Both the forecasters at Widewing came from Cal Tech; Holzman was reasonably liberal and accommodating in his views, unlike his colleague Krick, who was obsessed with analogues and thought they could be applied at all times and were capable of producing reliable forecasts for up to 5 days ahead.

Neither Stagg nor Douglas was prepared to accept Krick's beliefs; indeed, Douglas's opposition to them strengthened as D-Day approached. He knew that some months previously the Meteorological Research Committee had looked into the subject of extended-range predictions up to 5 days ahead and concluded that it could not then be done. When Robinson arrived in May 1944, the first task Stagg gave him was to check the success or otherwise achieved by the experimental 5-Day forecasts produced up to then. He found that the agreement between forecasts and reality diminished rapidly through Days 3, 4 and 5, so much so that using the Day 2 forecasts also for Days 3, 4 and 5 would have done as well or better. As one who whilst at CFO during the early 1960s tried to produce 4-Day forecasts manually, this does not surprise me at all.

In the light of all this, Stagg was similarly unimpressed by forecasters of the Admiralty, who were happy to predict 5 days ahead. Neither he nor Yates managed to find out what basis if any they used for their extended predictions – nor, for that matter, could anyone in CFO during the 1960s. Unfortunately, Stagg and Fleming (in whose office at Southwick House he had to work) were more or less at daggers drawn, and it appears that this 'needle' between the Admiralty Forecast Centre and the Met Office was perpetuated by many people, including, in particular, Larrie Hogben of the RNZN, who was, at the time, the youngest participant in the Overlord Conferences. Despite his pleasant manner, he was still laying down the poison more than 50 years later whilst living in retirement in France.

Conferences and 5-Day presentations at SHAEF took place weekly through April and daily through May, becoming twice daily from 29 May after the move to Southwick House. The invasion had been planned for 5 June, but at the crucial conference on 3 June both Dunstable and the Admiralty thought wind and cloud would be equally unacceptable on 5 June. Widewing were wildly optimistic, but were eventually persuaded by Yates to back down so that a unanimous forecast could be given to Eisenhower, who in the light of this deferred matters for 24 hours. Had the invasion gone ahead on 5 June there would have been Force 5 or 6 winds on the beaches and

full low cloud cover, which would have prevented both the vital pre-landing aerial bombardment and the parachute/glider landings – in other words, a complete catastrophe. Astonishingly, Krick was still claiming 40 years later in the mid-1980s that he had been right and that Eisenhower should have gone ahead on 5 June as originally planned. We must give heartfelt thanks that the telephone conference system led to Krick's views being completed outvoted.

24 hours later, though Dunstable still had reservations, Douglas did agree to fall into line with the majority in predicting not only fairly clear conditions for the air assault and airborne troop landings but also wind and sea states just about tolerable on the beaches. His reservations related primarily to the further outlook and were at least partially justified. All three centres were wrong in believing that the key low near Shetland would fill and move NE; in the event it certainly filled, but moved SE into the North Sea. This undoubtedly kept the winds on the beaches higher than had been hoped, making the build-up of supplies difficult, but it brought also a counter-balancing advantage by delaying the next depression in the family, for a couple of days, giving far fewer cloud problems with the air support operations. There was thus an element of good fortune in that the Forecast for Overlord turned out tolerably well.

If Eisenhower had decided not to seize the chance offered for invasion on 6 June, the next dates acceptable from the tidal point of view would have been a fortnight later on 19 or 20 June. As it turned out, the weather during the period 19 to 22 June would have been quite disastrous. The sudden and protracted storm that then occurred was the one that caused havoc on the beaches and wrecked one of the Mulberry Harbours. Not surprisingly, Eisenhower's note to Stagg acknowledging the great help he and his fellow meteorologists had rendered included the short sentence "I thank the gods of war that we went when we did". The storms of June 1944 were without question abnormal in their severity; the whole summer and autumn period was poor, apart from a brief fine spell during the first half of August that provided the only quiet weather between May and quite late in the year.

## **RAF OPERATIONS COVERING THE D-DAY PERIOD**

From the initial planning stage, it was realised that complete air superiority was an essential pre-requisite for successful invasion of the Continent. By mid-1943, with clear signs that the Battle of the Atlantic was being won (see earlier), it became possible to raise attacks on German fighter aircraft (together with all the industries and ground facilities that sustained them) to top priority alongside the campaign against the U-boats. This policy was confirmed six months later in January 1944 as a vital preliminary to D-Day, and RAF Bomber Command pursued it with vigour.

When Air Chief Marshal Sir Arthur Tedder was appointed as Deputy Supreme Commander to Eisenhower, he started thinking about the possibility of using Bomber Command in a Tactical rather than just a Strategic role. Early in March 1944, he asked Harris to arrange some trial attacks on rail centres in France and Belgium. Being well within OBOE range, these attacks led by PFF were very successful, and when Bomber Command was brought formally under Eisenhower on 14 April 1944, Tedder's Transportation Plan was approved. Harris was given a list of 37 rail centres and communication targets to be attacked. By the time of D-Day, successful raids had been made to each and every one of these. Needless to say, from the meteorological point of view, the forecasts and briefings for these targets were simpler than for the much more distant targets well inside Germany.

Enormous efforts were very properly devoted to convincing the Germans that the invasion would take place somewhere other than in Normandy. The invasion of Sicily had taken the Germans by surprise because by various means we had convinced them that we were heading either for Sardinia or Greece or both! So once the decision to land in Normandy was taken, many things were done to convince the Germans that our aiming point was the Pas de Calais, and these efforts were brilliantly successful. As part of the overall deception strategy, Bomber Command was given inflexible orders that, for every obvious communications or defence target attacked anywhere in the planned Normandy invasion area, at least two attacks were to be made on similar targets elsewhere. This certainly covered the detailed execution of the Transportation Plan. Thanks to this approach, and the very thorough deception operations on D-Day itself (see below) after the landings had taken place on 6 June, the Germans still thought of these as merely a diversion. Believing that the real invasion would follow further north in the Pas de Calais, they kept a large bulk of their troops in that area.

The essential attack on the coastal defence batteries was held back until the night of 5/6 June, immediately before the landings. Within a few hours, Bomber Command then sent 100 or more 'heavies' led by PFF to each of the ten major artillery sites within range of the beaches. The effectiveness of the long campaign to establish complete air superiority over Normandy was proved beyond doubt by this massive assault; out of the 1335 aircraft that took part, just 6 were lost. The meteorological forecasts and briefings for this Command operation were reasonably straightforward.

An essential feature of protection for Bomber Command and the Airborne Forces was the blinding of all the coastal radars by the MANDREL screen operated by Stirlings of 199 Squadron from North Creake with some assistance from 803 Squadron of the USAAF Flying Fortresses from Oulton. For D-Day, twelve centres had been carefully chosen to enable all the coastal radars between Cherbourg and Le Havre to be jammed (see Fig.6). Each of these points was patrolled for some hours by a pair of aircraft flying a race track pattern. The key items in the forecast for these aircraft were

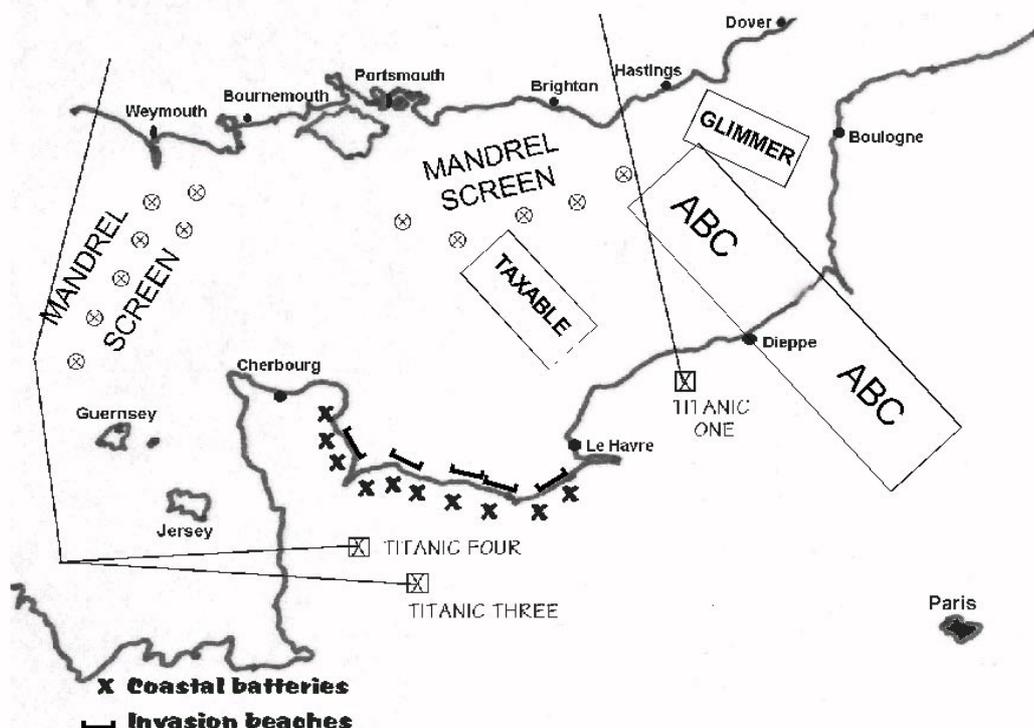


Figure 6 RCM and Deception Flights (Based on Delve - 1994)

the winds, but with GEE to help navigators, as well as some radio fixes, maintenance of position seems to have been achieved well; post-facto analysis suggests that the MANDREL screen was at least 95% effective.

The four Mosquito night INTRUDER Squadrons spent a busy night. Two of them operated over the Normandy beaches and the other two went as normally to the German night fighter airfields in Holland. Needless to say, the 11 Group/85 Group night fighters protecting the airborne forces aircraft and the ships were similarly very active, but the scarcity of German night fighters meant that there was little offensive action. Only a few days later, both 85 and 157 Squadrons had to be detached temporarily from Swannington to West Malling to deal during the night hours with the flying bomb (V 1) attacks which first reached the UK on 13 June 1944. They managed to shoot down 70 of these before returning in August to Swannington for normal 100(BS) Group operations.

As part of the overall deception strategy, those aircraft which normally operated over Germany independently of Bomber Command Main Force did so on the night of 5/6 June as well. Thus, 31 Mosquitos from the LNSF bombed Osnabruck without loss, and as many as 48 aircraft from 100(BS) Group (including the INTRUDER flights) also operated over Germany. All these raids helped to keep the German night fighters well occupied at home and unable to move to Normandy.

No doubt the 100(BS) SERRATE Mosquitos operated with PFF and the Main Force over the invasion beaches, but by all accounts they were not offensively occupied, as few German night fighters seem to have been working in that area. The final essential protective operation was flown by 101 Squadron from Ludford Magna with 24 of their ABC Lancasters. They had to patrol an area of about 120 miles by 30 miles between Paris and the Sussex coast for well over 4 hours (see Fig.6). Having no H2S and no G-H (see later), they had to fly using GEE alone, plus a few radio fixes and dead reckoning, and to do this with split second timing. Accurate wind forecasts were essential, and I can remember very clearly the vast amount of work done by the Squadron Navigation Leader, a personal friend of mine, to complete flight plans for each individual aircraft using the winds I gave him, so that the Squadron as a whole would give even coverage over the area and so protect not only the massive Bomber Command assault on the coastal batteries but also the arrival of the Airborne Forces.

The final pièces de résistance were the three deception operations flown during the night of 5/6 June. The first of these, code-named TITANIC, was flown by 3 Group Stirlings from Methwold and Tuddenham, together with some Halifaxes from Tempsford that were normally used for SOE flights. The idea here was to confuse the enemy and draw him away from the real parachute and glider landing zones by dropping hundreds of dummy paratroopers equipped with sound and light simulators that after reaching the ground would mimic a small arms battle. The dummies were dropped through a screen of Window. This was the code name for the strips of metalised paper that paralysed the German radars. It had been devised as early as the spring of 1942 but for various reasons was not cleared for operational use until July 1943, when it was used with devastating effect during the fire bomb raids on Hamburg that produced such huge and prolonged fires that the updraught eventually caused cumulonimbus and thunderstorms to form. The dummy dropping zones and aircraft routes are shown on Fig.6.

Even more ingenious than TITANIC were the two fake invasion fleets; one (Operation TAXABLE), heading for an area near Le Havre, was flown by 16 Lancasters from Woodhall Spa in 5 Group, and the other (Operation GLIMMER), heading for the Pas de Calais, was flown by 6 Stirlings of 218 Squadron at Woolfox Lodge, then being used by 3 Group. The idea behind these deceptions was thought up by W/Cdr Dickie

of the Radar Section at HQBC. For TAXABLE, eight aircraft in line abreast 2 miles apart at an altitude of just over 3000 feet, flying at precisely 200 knots, had to drop bundles of special Window every 5 seconds! After 8 miles (2 minutes 30 seconds), each aircraft would turn slowly and fly a reciprocal course 1 mile to the right of the outward track with no Window dropping for 7 miles (2 minutes 10 seconds), then turn again and repeat the procedure. The net effect of this was that aircraft flying at 200 knots were able to simulate a surface convoy sailing at 8 knots. With no bomb load, there was plenty of room to carry five extra crew members – a second Pilot, second Navigator and three people amidships with stop watches to tip out the bundles of Window. To make matters even more complicated, there were two types of special Window – a thin strip to use during the first 4 miles and then a thicker strip for the next 4 miles before the turn, with a system of red and green lights to help the crew to remember when to change. To rub home the vital importance of precise flying and timing during this operation, crews were briefed that any errors exceeding 50 feet in altitude or of more than 4 seconds on the ETAs for turns, would destroy the entire illusion! The implications of this were also rubbed into the meteorologists responsible.

For the required navigational precision in the TAXABLE operation, 617 Squadron had to rely on GEE alone to refine the flight plan, based on the forecast winds given to them before take-off. Not surprisingly for such a complicated procedure, the Squadron had to practise for months before G/Cpt Cheshire led out the eight aircraft to cover the first two hours. A second flight of eight aircraft then took over for the second half of the operation. Post-facto analysis suggests that the deception was brilliantly successful, but due to a combination of the effect of the Bomber Command assault on the coastal defences, the MANDREL screen, the activities aimed at the German night fighters, including ABC, SERRATE, INTRUDERS and the AEA night fighters of 11 Group and 85 Group, plus the diversionary attacks in Germany mounted by the LNSF and 100(BS) Group, there was no overt reaction at all from the Germans in the air, by sea or from the land.

218 Squadron, which flew the GLIMMER deception convoy heading for the Pas de Calais, was chosen because it was the first RAF squadron to be fitted with the latest navigation aid known as G-H that would eventually be installed in all 3 Group aircraft. This was a development of GEE (which gave general navigation advice) coupled with an airborne radar set which gave an exact determination of position. In effect, this system had the accuracy of OBOE (i.e. to a few yards) but with the tremendous advantage of being able to guide as many as 80 aircraft using just one pair of stations. The pin point accuracy was exactly what was needed for this type of operation.

The six Stirlings took off from Woolfox Lodge just before midnight heading for the shortest sea crossing (where the Germans expected the invasion to occur) to a coastline where the radars had not been blinded by a MANDREL screen. The procedures were basically the same as those used by 617 Squadron, and success was almost immediate. Searchlights came on and guns opened fire on what the Germans took to be an approaching invasion fleet. Both night fighters and E-boats were active in the area but, needless to say, no ships were found. A lot of German effort was held away from the real invasion area by this operation.

## EPILOGUE

The D-Day operations in June 1944 were by no means the end of the War in Europe; the Ardennes offensive, the Arnhem operation, the Rhine crossing and much else were still to come. But the patterns of RAF and Met Office involvement between June 1944 and May 1945 and in the months following VE Day were essentially natural

developments of what had gone before, together with the stimulated re-establishment of pre-war national Met Services throughout western Europe.

This paper has addressed the build-up for and operations on D-Day. It was a privilege to have been a part, albeit peripherally, in such a momentous historical event and I hope that the Met. Office involvement has been fully brought out. I am most grateful to Maurice Crewe for providing the photographs of Gp. Cpt. Stagg and the two aircraft, and for his work in massaging my poor typescript into such an elegant type for the reader. Some photographs of ETA at Dunstable and the staff that served there during WW II have already appeared in Brian Audric's Occasional Paper No.2 {Audric, B (2000)}.

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The most comprehensive compilation of information about RAF stations is to be found in the ten volumes of that invaluable and, I believe, definitive series "Action Stations". These volumes, written by various authors, were published by Patrick Stephens, Cambridge, between 1979 and 1987. There are entries for every single wartime airfield in the UK, describing what RAF, FAA, and USAAF units were based on them and when. The volumes are extremely well indexed, so that one can use them in reverse mode to follow the movements of individual RAF and USAAF units.

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# GLOSSARY

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AA	Anti-aircraft (artillery)
ABC	Airborne Cigar (radio countermeasure)
ADGB	Air Defence of Great Britain (formed from Fighter Command)
AEAF	Allied Expeditionary Air Force
AI	Airborne Interception (radar)
AOC	Air Officer Commanding
ASR	Air Sea Rescue
ASV	Air to Surface Vessel (radar)
ATA	Air Transport Auxiliary (delivery flights to airfields)
AVM	Air Vice Marshal
BC	Bomber Command
BS	Bomber Support (100 Group)
CalTech	California Institute of Technology
CC	Coastal Command
CFO	Central Forecasting Office
CH	Home chain radar network
ETA	Wartime code name for CFO
FAA	Fleet Air Arm
FC	Fighter Command
FIDO	Fog Investigation and Dispersal Operation
Gardening	Sea-mine-laying from aircraft
GCI	Ground Controlled Interception
GEE	Radio navigational aid ( <u>NOT</u> radar)
G-H	Development of GEE
GLIMMER	D-Day Deception Flight
HCU	Heavy Conversion Unit (introducing pilots to 4-engined aircraft)
HGCU	Heavy Glider Conversion Unit
H2S	Airborne radar navigation aid
HQ	Headquarters (especially of Commands and Groups)
IDA	Wartime codename for decryption unit with CFO
INTRUDER	Offensive night operation to fixed point on specified target
LFS	Lancaster Finishing School (final training in 1, 3 and 5 Group, following HCU)
LNSF	Light Night Strike Force (BC Mosquito raids)
MANDREL	Airborne jammer for ground radars
MIT	Massachusetts Institute of Technology
MMO	Main Met Office (at Commands and Groups)
PAMPA	Photo-recce And Met Photography Aircraft

Glossary continued on page 24

Panthers	Weather ships
PFF	Pathfinder Force (8 Group)
PR	Photographic Reconnaissance
RAF	Royal Air Force
RAFVR	Royal Air Force Volunteer Reserve
RCAF	Royal Canadian Air Force
RCM	Radio Counter Measures
RFC	Royal Flying Corps (WW I)
SERRATE	Airborne radar to locate enemy fighters
SHAEF	Supreme HQ Allied Expeditionary Force
SOE	Special Operations Executive
2TAF	Second Tactical Air Force (the first TAF covered North Africa and the Mediterranean; 3TAF was in the Far East)
TAXABLE	D-Day Deception Flight
TITANIC	D-Day Deception Flights
T/P	Teleprinter
UK	United Kingdom
USAAF	United States Army Air Force
WAAF	Women's Auxiliary Air Force (the term is used both for the Force itself and for serving individuals)
Widewing	USAAF Met HQ in the UK
Window	Metallized paper strips dropped by bombers to disrupt enemy radar
WW II	World War Two