Airborne minefields and Fighter Command's information system

Abstract

On 10 November 1932, former Prime Minister of Britain, Stanley Baldwin, following advice from the Air Ministry, told the House of Commons:

"I think it is as well for the man in the street to realise that there is no power on earth that can protect him from being bombed. Whatever people may tell him, the bomber will always get through."

British air defence in the early 1930s consisted of the possibility of flying standing patrols in the hope that some of their planes would be in the air nearby when an attack came. Frederick Lindemann, Churchill's scientific adviser, lambasted the political establishment for its defeatist attitude and went on to suggest airborne minefields as a solution to enemy air attacks.

However, it was Henry Tizard's and Hugh Dowding's embrace of a new information technology - radar - and the subsequent development of a coordinated air defence information system facilitated by that technology, that ultimately led to a hard won victory in the Battle of Britain in 1940.

'Information technology' and 'information systems' were not part of the vocabulary of the time but the understanding, rare amongst policymakers, that the technology alone cannot solve complex, systemic, socio-political problems was the key to the RAF making this particular information system an effective one.

Introduction

The story of radar has been told wonderfully well and endless times before and most notably by Sue Holwell and Peter Checkland in the context of information systems. It bears re-telling today, however, given the unchecked rush of technically illiterate policymakers towards deploying massive surveillance systems with no clearly defined purpose as "solutions" to the some of the complex issues facing modern society such as terrorism, child protection, healthcare and migration.

Radar and the air defence information system

Radar technology in Britain at the outbreak of the war was fairly rudimentary. Radar operators would sit in a hut near tall transmitting and receiving towers monitoring a cathode ray tube screen. The outgoing signal would register as a blip on the screen and if it bounced off any incoming aircraft, the operator would see another, smaller blip further along the screen. The distance between these blips allowed the operator to estimate how far away the attackers might be. Tracking many planes in different formations simultaneously was more of a black art than an exact science with this equipment. As a result, radar operators' reports were sometimes difficult to interpret or even contradictory. In any case, a guesstimate of how far away the enemy aircraft might be tells us little about how to get the right defending squadrons to the right point in the sky to intercept at the earliest possible moment.

Radar and air defence: IT and IS

So before it became truly useful, that radar technology (the IT) had to be built into a fully integrated and operational air defence system (the IS), the kind of system Henry Tizard's 'Committee for the Scientific Survey of Air Defence' set out to commission in 1935. The terms 'information system' and 'information technology' were not part of the vocabulary of the time but that is exactly what the air defence system and radar were. The data collected by the radar stations would have been useless without the means to quickly filter, assess and act upon that data. The purpose of the system was to enable defensive action – getting the fighters to the enemy positions as soon as possible.

The only suggestion the Air Ministry were able to offer in the realm of air defence in the early 1930s was the possibility of flying standing patrols in the hope that some of their planes would be in the air nearby when an attack came. They had also spent a lot of money on a large and expensive sound location device at Romney Marshes which could be rendered useless by the rattling noise of a passing milk cart.

By 1934 the Nazis were in power in Germany and Henry Wimperis, head of scientific research at the Air Ministry asked Henry Tizard, a respected government scientist, to convene a 'Committee for the Scientific Survey of Air Defence'.

Prior to the first meeting of the committee on 28 January 1935, Wimperis asked Robert Watson-Watt, a radio expert at the National Physical Laboratory, if it would be possible to develop a death ray to blast enemy aircraft or pilots out of the sky. Watson-Watt reported to the Tizard committee that the death ray idea was impractical but that 'radio-detection' might be a 'less unpromising problem'.

Tizard quickly realised that they had been presented with the technical basis of an early detection early response air defence system. Air Marshall Hugh Dowding, who was soon to become Commander in Chief of RAF Fighter Command, was convinced following a successful demonstration of the detection ability of radio waves on 26 February 1935. Tizard and Dowding set about arranging funding for the development of the technology and a chain of twenty radar stations to run round the coast from Southampton in the south to the Tyne in the north. By then the importance of developing some kind defence against attacks from the air was recognised in at least some parts of the highest levels of government, civil service and the military establishment. But the process still had significant political hurdles to negotiate.

Second best tomorrow

Watson-Watt got the job of organising the design and development of the technology and set up operations at Orfordness, moving to Bawdsey Manor in 1936. In many ways he was the ideal leader for a group of clever, focused and enthusiastic young scientists and engineers. He believed in informality and the free exchange of ideas. He also understood that if you collect enough bright people together in one place, provide them with clear objectives, an understanding of the urgency of meeting those objectives, sufficient resources and the freedom to get on with the job, you get a remarkable degree of innovation and unbeatable productive capacity. Watson-Watt only really had two basic rules for his young charges.

Firstly the radar and associated equipment had to be constructed from readily available existing components. There was no time to be wasted developing new basic components. Secondly, when the equipment being developed had evolved to the stage where it was good enough to do the job, it went into immediate production. Watson-Watt set development deadlines which were always met. He said he could deliver good enough machines today, second best tomorrow and if you wanted perfection then forget it. He was building the technology of the air defence system and it was more important that it be available quickly and work in the system than it be the best piece of technology of its kind. “Second best tomorrow” became a kind of a motto for the Bawdsey crew.

Contrast the ‘just good enough’ or ‘satisficing’ approach of Watson-Watt with a situation where the focus was on improving or perfecting the technology, as arguably was the case in Germany, Russia, Japan and the US. In each of these countries development was led by technical experts and there was arguably no high level understanding of the importance of the technology or its potential as a component of a wider operations system. This resulted in Britain being the only country at the outbreak of war with an understanding of the real strategic and operational importance of radar as part of an air defence system.

[Ironically the more primitive technology of the British resulted in an unexpected intelligence payoff too. When the Germans sent an airship up the east coast of Britain on an electronic reconnaissance mission in 1939 prior to the war, their relatively high tech equipment was unable to pick up any useful information. The Germans used centimetre radar equipment and did not conceive of anyone wasting time with longer wavelengths. They spotted the Chain Home stations but concluded that they had nothing to do with radar defence and thought the signals they picked up were from the electricity grid. Also when the Germans captured a British radar set in 1940, a technical assessment declared it to be so primitive as to be useless. Recognition of the technology as merely a primitive component of a wider system might well have improved the scientific intelligence available to the Germans and influenced the conduct of the early part of the war. The technology was just one tool in the overall system.]

The air defence system and operational research

In parallel with this technical development Tizard and Dowding were working on the wider system. They commissioned an army of Post Office technicians to install a dedicated network of phone and teleprinter cables linking all the radar stations, Fighter Command Headquarters, Groups, Sectors, airfields and the Observer Corps. The Observer Corps were a group of 30,000 volunteers who manned 1000 posts inland to visually monitor incoming aircraft once they had passed the coastal radar chains. Their tools consisted of little more than a pair of binoculars, a phone linking them to one of 32 Observer Corps Centres round the country and a book of aircraft shapes and markings which they memorised. The Observer Corps, with no high technology at their disposal, nonetheless constituted a critical part of the system.
By May 1936 the radar station at Bawdsey Manor became the first operational station. Tizard, Dowding and Watson-Watt now had the beginnings of their command and control air defence system (Figure 1).

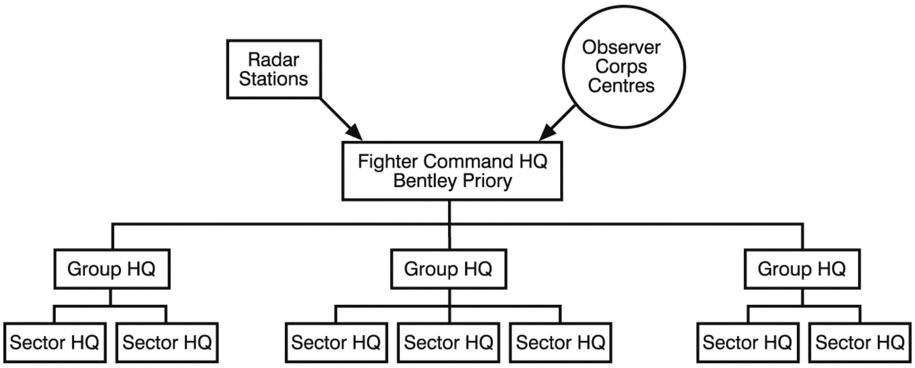

Fig.1 Schematic representation of the structure of the British national air defence system

Dowding immediately instigated a series of air defence exercises.

Scientists, other technical specialists, RAF and WAAF officers and civil servants were involved in these exercises from the start at the three centres, Bawdsey, Bentley Priory and Biggin Hill.

Fighter planes were scrambled to 'intercept' civilian planes. Right away the value of operational research became apparent. Too much raw data from radar operators and observer corps, some of it just plain contradictory or wrong, swamped the controllers and pilots. So a 'Filter Room' was set up at Fighter Command to filter out inaccurate or misleading data (see figure 2 below). The job of the filter room operators became highly skilled and only experienced officers filled the post, judging and interpreting the data based on what they knew about the accuracy of previous reports or equipment or reported faults or inconsistencies.

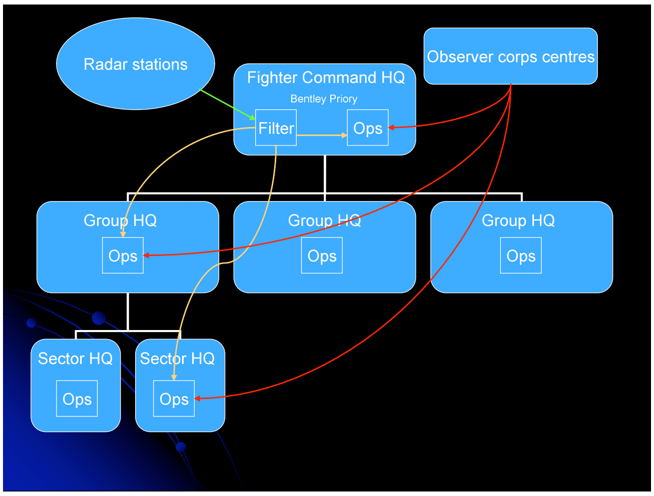

Fig.2 Inside the British national air defence system

Dowding also set about educating his pilots to get used to taking directions from the ground, something they, as typical free-spirited adventurers, did not care for in the beginning. After all, what could people safe on the ground know about flying an airplane let alone the heat of battle? He made sure, for example, that the controllers in the operations rooms were experienced pilots who did understand the mindset and the problems of the men in the air. This created significant friction with the signals branch of the military who felt anything in the signals area was exclusively their do-main. The airmen were also obliged to visit the operations rooms to get an understanding of the problems of the ground controllers as well as the vital jobs they were doing. The skill, tenacity and insight of Tizard and another of his committee members, Patrick Blackett, proved crucial to convincing the pilots that they could not "run wars on gusts of emotion. You have to think scientifically about your own operations."

If all the scientific and engineering development in the lead up to the war was to be of any use, then the pilots had to take notice of what the operations centres were telling them. The technology and the system could only be as good as the users allowed them to be.

Plotting the interception of a moving enemy in three dimensions, even with all the appropriately filtered radar and observer corps data, proved to be a very difficult 'four vector' (three-dimensional coordinates plus relative velocities) problem. So the scientists built specialist calculating machines and used books of trigonometric tables in an attempt to provide rapid answers. During one exercise, Wing Commander Grenfell at Biggin Hill got irritated with the scientists and their "confounded machines" and said he could do a better job by eye. The disbelieving experts challenged him to do just that, whereupon he succeeded in coordinating a perfect interception with the aid of a pencil, ruler and some basic trigonometric calculations. This technique of calculating the "tizzy angle" became the standard method for operational controllers at 'sector' level to determine the interception course for the fighters in the air. The importance of involving the users of the information system in its development is crystallised for me in that single story.

By 1939 a fully functional, people and technology dependent, national air defence system was in operation. It was roughly set up as shown in Figures 1 and 2 above. Fighter Command was the national command and control centre led by Dowding and responsible for strategic air defence for the whole country.

The country was divided into geographic groups, with four group headquarters by the outbreak of war. (The diagram is focused on the structure of the system and is not representative of the actual numbers of group or sector headquarters, radar or observer corps stations or centres.) These groups were further sub-divided into smaller sectors and sector headquarters would be located at the main sector airfield from which operational sorties would be flown. Each sector was also responsible for a number of additional satellite airfields.

The filter room at Fighter Command analysed and filtered the voluminous amounts of data flowing in from radar operators and turned it into useful information. This was sent out to the operations rooms at Fighter Command and Group and Sector headquarters simultaneously to enable aircraft movements to be plotted on the large table maps that will be familiar to anyone who has seen the old war films depicting scenes from the Battle of Britain. When the enemy attack crossed the coastline (and the sea-facing radar towers) reports from the observer corps, filtered through observer corps centres, came into the operations rooms at Fighter Command, Group and Sector level.

Each operations room at each level had their map tables, the controllers on a raised platform from which they could survey and assess the picture of the attack on the map below, a ‘tote’ board of lights showing the readiness of the various squadrons and a clock on the wall with each five minute section depicted in a different colour. Strict rules governed the placement and moving of markers, the details of which we can leave for another time.

Fighter command controlled overall strategic defence and decided, for example, which pattern of air raid sirens should be sounded. Group commanders and controllers decided which sectors and how many squadrons should engage the incoming enemy raids. Sector commanders and controllers controlled the fighters directly until the enemy planes were sighted, at which point control passed to the squadron leader in the air. Once the battle was over, control passed back to the sector controller.

In addition, sector headquarters had an additional DF (‘direction finding’) room which contained a map table used to plot accurate RAF positions based on the information coming from high frequency direction finding (HF/DF) stations, of which there were three in each sector. The DF room was usually next door to the operations room and organised so that the controller could see both maps from his raised platform.

Tizard, Lindemann and aerial minefields

I have so far glossed over the politics of the situation but the politics and personal rivalries at several levels could well have killed or significantly impeded the system’s development.

The most important of these was arguably the relationship between Tizard and Winston Churchill’s scientific adviser, Professor Frederick Lindemann. When he learned of its existence, Churchill engineered the placement of Lindemann onto Tizard’s air defence committee.

So began the battles between Tizard and his former close friend, Lindemann, which could have proved fatal to the process of preparing for air defence. Right from the start Lindemann clashed with Tizard and the two other key scientific members of the committee, Blackett and Hill. Some reports suggest that whatever the three scientists agreed, Lindemann vehemently opposed and outside of the committee used his political connections to undermine. He insisted at one point that they fund a project to develop aerial mines to be deployed by parachute. Then when Lindemann submitted a minority report disagreeing with the conclusions of the rest of the Tizard committee, Blackett and Hill resigned. Tizard promptly had the Air Minister, Lord Swinton, disband the committee and reform it without Lindemann, who was replaced by world-renowned radio expert, Edward Appleton. The committee meetings, at least, went much smoother from then on.

Lindemann was a strong personality and a good, possibly even out-standing (according to Tizard) scientist who firmly believed in the absolute truth of his own perspective, even when he was wrong. He pursued with tenacity the aerial mines idea and many others including the notion that infra red technology research being undertaken by R.V. Jones, a scientist in his laboratory, would be more promising than the radio wave work instigated by Tizard.

[Tizard's committee has been held up as a hugely effective government decision making instrument – a small group of highly motivated experts and system users, with the clarity of purpose, influence and resources to get things done. It is impossible to know how or whether the air defence system work would have progressed as it did, had Lindemann rather than Tizard been in charge. Lindemann's efforts, pursued in what he believed to be the best interests of the country, however, made Tizard's job somewhat more difficult than it would otherwise have been. Whether they might ultimately have led to failure in the development of the system is something we can only speculate about. Both Lindemann and Tizard undoubtedly made mistakes, which only goes to show that smart people with impeccable motives can still get things wrong. But the air defence system did get built and it helped Britain to prevail in the Battle of Britain, though the margin of victory was extremely thin.]
When Churchill became Prime Minister, Lindemann became his sole high level scientific adviser and the only scientist in the Cabinet. Churchill admitted that he himself had a limited level of scientific literacy:

"Lindemann could decipher the signals from the experts on the far horizons and explain to me in lucid, homely terms what the issues were."

[Scientists, though, are not immune to the influence of personal bias and values, as the battles between Tizard and Lindemann demonstrate. The application of science and scientific intelligence to the prosecution of the war would have been different, if Lindemann's advice to the Prime Minister had been subject to regular critical review by a group of scientific peers.] The position of scientifically and technically illiterate politicians having to make decisions about things they do not understand in depth has not gone away.

Lessons of radar: boundaries and purpose

Tizard knew a promising technology when he saw it – as when Watson-Watt dropped radar into his lap just at the moment he began to head up Britain's air defence initiative in 1935 – but more importantly he knew how to ask the right questions and set appropriate boundaries. A lesser group than the Tizard committee might well have got carried away by the technology and focused exclusively on that; or alternatively have planned grand schemes to use this technology to solve all kinds of problems, military, social and political, before the technology had even been tested.

Tizard's committee had a clear purpose with clear boundaries to build a system, with the aid of the information this technology could generate, to enable defending squadrons to intercept enemy raiding aircraft at the earliest possible moment. Being clear about purpose, as well as about the boundaries of the systems and the problems or messes we are setting out to tackle, is critical making decisions about IS. 'Systems thinking' specialists tell us the choice of system boundary has a profound influence on how effective we can be subsequently at tackling complex messes. If Tizard had got distracted by building a radar system rather than retaining his focus on an air defence system, the Battle of Britain might well have had a different outcome.

By 1939 Tizard and Dowding created an integrated information system to collect the raw data on approaching enemy aircraft, from their chain of radar stations (IT) and (visuals from) the Observer Corps (human IT). This raw data was passed on (via the radio telephone and teleprinter networks) to Fighter Command Headquarters' filter room and an integrated set of operations centres, where it was assessed, filtered, analysed and turned into useful information at varying levels. This then facilitated the scrambling of the right fighter squadrons and even more specific instructions to be radioed to the RAF pilots once in the air, to enable them to intercept their enemy at the earliest opportunity.

The Germans had better information technology (radar). The British had the better information system i.e. radar, human intelligence, signals intelligence, and an integrated, purpose-developed system, allowing the situation to be viewed holistically, as well as delivering the right information to the right users, at the right levels, in a useful format and in sufficient time to act on it. The better information system prevailed and it got built because Tizard, Dowding and co. had:

- a clear purpose
- clear boundaries
- the power and political influence to act
- and they engaged and enthused both the users and scientific and technical experts in the system's development.