

The Rise and Fall of the Flying Boat

Drawing on the 2½ years, 1945-47, that I spent at the Marine Aircraft Experimental Establishment (MAEE), Felixstowe, this Note sketches the history of the flying boat and the reasons for its demise – a chapter in the history of aviation.

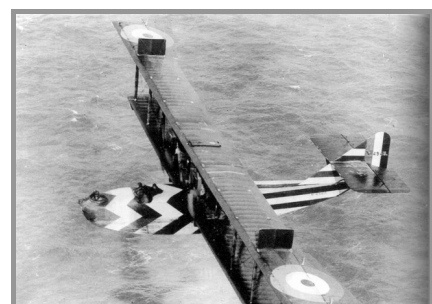
Early Days

Henri Fabre's 'Hydravion' was the first aircraft to take off from the surface of the sea, on 28th March 1910 at Martigues near Marseilles in southern France. He continued to develop his flimsy craft, also known as 'Le Canard', but the first practical flying boat was built and flown by Glenn Curtis at Hammondsport NY in 1912.



A British officer, John G Porte, went to the USA to work with Curtis and was able to make improvements in hull design. The Admiralty showed little interest but in 1913 Winston Churchill was taken up in Short S41 seaplane from RNAS Felixstowe and realised the potential for reconnaissance over the sea.

On the outbreak of war in 1914, Porte returned to command the Royal Naval Air Service (RNAS) station at Felixstowe. Curtis' boats were imported and modified, becoming the 'F' (for Felixstowe) series. Those based at Felixstowe were used for reconnaissance over the North Sea and not infrequently were forced down by engine failure and towed home, or taxied home if an engine could be restarted. It is not surprising that the flying boat came to be seen as superior to the landplane for over-water duty, with the added advantage of being able to take off from any reasonably sheltered stretch of water.



Felixstowe "F2a"

In 1919, Curtis and the US Navy built four NC-4 craft in order to attempt an Atlantic crossing. Two met with accidents early on, one came down on the sea and taxied 200 miles to the Azores, and one made it to Lisbon and on to Plymouth. The US Navy had deployed 68 destroyers across the route for navigation and rescue purposes. A couple of weeks later the better-known non-stop crossing by Alcock and Brown in a modified Vickers Vimy bomber - a landplane - took place.

Porte's 'F' series set a standard, being sold abroad and adapted for civil use, and remaining in RAF service until 1925. The basic configuration, which remained typical until well into the 1930's, included: a broad wooden hull

with a deep step; biplane wings set above the hull; engines mounted high, clear of spray; tail set high for the same reason; and a large wing area giving low take-off and alighting speed.

Porte died in 1919, before the Treasury got round to paying out rewards to inventors for their contribution to the war effort.

MAEE was founded in 1918, the year the RAF was formed, and moved to Felixstowe in 1924. Its main function was proving trials on flying boats and seaplanes being considered for the RAF. By 1928 there had been trials on 11 large flying boats, submitted by 8 manufacturers. All but one of these followed the same basic layout as the “F” series, the exception being an all-metal monoplane well ahead of its time (1925). A monoplane is cleaner, aerodynamically, than a biplane and the wooden hulls that were the norm, while beautiful examples of the carpenter’s skill, were necessarily heavier than could be achieved in metal. On the other hand, metal carried the risk of corrosion. The RAF played safe and chose the wooden-hulled “Southampton”, later versions of which did have metal hulls once the corrosion problem had been solved. In 1929 MAEE produced its first research report, on water pressures, useful data for the economical design of metal hulls.

Felixstowe was home to the High Speed Flight, which in the 1920’s competed annually for the Schneider Trophy, a prize competition for seaplanes. France, Italy, and USA all had winning entries until, having won three times in succession; Great Britain retained the trophy outright in 1931. The winning seaplane, the Supermarine S6b, was designed by R J Mitchell who went on to design the famous Spitfire.

In the early thirties T E Lawrence - *Lawrence of Arabia* - serving as a motor-boat coxswain under the pseudonym *Aircraftman Shaw* - made a valuable contribution to MAEE’s work on motor boats and air-sea rescue equipment.



Supermarine S6b

NB: the term ‘seaplane’ is reserved for an aircraft with a fuselage mounted on separate floats, like this.

Metal Monoplanes

Dornier, a German manufacturer, was an early advocate of the all-metal monoplane and in 1929 launched the huge 12-engined “DoX”. It struggled to take off – not the last example of a flying boat too big for the available engines. A publicity tour from Europe, down the African coast, across to South America, up to New York and across the Atlantic again, suffered so many failures and repairs, that it took the best part of nine months!

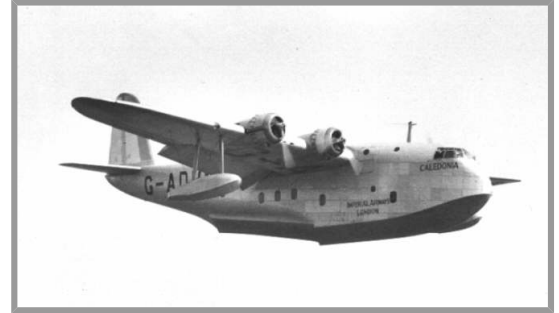


Dornier DoX

Pan American Airlines had more success with their Sikorski high-wing monoplanes and ran regular flying boat services in the Pacific region from 1928.

The UK, Short Bros. offered a monoplane to Air Ministry Specification R 21/21 for a two-engined flying boat, but the Ministry stuck to the bi-plane military use, opting for the bi-plane "Stranraer" which, with the four-engined "Singapore" was still in service at the start of WW2.

The Air Ministry was responsible for Civil Aviation, but did little about it until 1935, when the Government finally accepted the case, made ten years earlier, for mail to the Empire to go by air at no extra charge. Suddenly, Imperial Airways, used to buying aircraft in penny numbers, needed a big fleet. Routes would be over water, and with few runways in existence flying boats were the obvious choice. Shorts offered the "C" class and 28 were ordered "off the drawing board", the first of them delivered in



deep hull of the "C" class, necessary to keep the propellers clear of spray, gave plenty of room for mail and passengers, but weight was severely restricted. Crew were not even allowed to take a spare pair of shoes, but a semblance of luxury was considered essential. The run from Southampton to Sydney, opened in 1938, took 10 days, with overnight hotel stays, dawn starts, and about 30 stops for re-fuelling and mail transfer. Folding bunk beds were provided for night flying but this was not attempted because of the hazards of navigation and alighting (better not to call it "landing"!). In any case, the latches could not be released in flight due to distortion of the hull.

The "C" class had insufficient range for the trans-Atlantic route. Options considered included catapult launching; the Mayo 'piggy-back'; and in-flight re-fuelling. The last of these was decided on, but the war intervened. Meanwhile the larger "G" class had been ordered, but in the end it was the Boeing 314 that established the trans-Atlantic service.



The "C" class is often remembered somewhat romantically, but the record of what actually happened to the 31 that were built reveals the hazards of long distance flight over water. Five of them crashed on alighting; three were forced down in the open sea and sank; three were lost due to navigation errors; two crashed on take-off; one hit a submerged wreck; one suffered engine failure on a test flight; and five were lost due to enemy action. Only eleven survived until scrapped in 1946-7.

Even that understates the losses. "Corsair" crashed in a tributary of the Congo, well off its route. It was salvaged and repaired *in situ*, took off in too short a stretch of river and crashed again, was repaired again and finally took off successfully – crew members running towards the stern at the crucial moment to bring the nose up.

Imperial Airways' requirement for the "C" class arose at the time when Shorts were working on an Air Ministry specification that resulted in the "Sunderland" so it is no surprise that the two have much in common. The Sunderland first flew in 1937. 30 of them had been delivered by the start of

WW2 and it played an important part in the anti-submarine effort. By the time production ceased, 749 had been built. It remained in military service, in New Zealand, until 1966 and a civil version operated between Sydney and Lord Howe Island until 1974.

The twin-engined “Lerwick” having hit problems, it was decided to import the Consolidated PB4Y, which the RAF named “Catalina”. Some were amphibians with retractable wheels, as were the single-engined “Walrus”, and its successor the “Sea Otter”.

Experiences at MAEE

I arrived at MAEE, my first job after graduating, in July 1945 and was placed in the section concerned with trials of new prototypes. The “Seaford”, originally called the Mk IV Sunderland, had recently arrived and its handling and stability in the air and on the water were to be investigated. The Seaford was a heavier and more powerful version of the Sunderland. For extra buoyancy its hull was lengthened by duplicating some of the mid-ships frames and effectively widened by flaring the chines (where the bottom of the hull meets the sides). Thicker metal gave extra strength. To compensate for the larger side area forward of the wing, the fin and rudder were enlarged. Preliminary flights suggested these relatively small changes had adverse effects on stability and control. These



Short “Seaford”

were investigated by a series of runs, on water and in the air, at a range of steady speeds and with the aircraft carrying a range of loads, sandbags disposed so as to put the centre of gravity in various positions in its range. When heavily loaded the craft could take off but, before alighting, we had to throw out the sandbags.

To record the data, transmitters were fitted to the control surfaces (elevator, rudder and ailerons) and, with other instruments, connected to an ‘automatic observer’ (an instrument panel facing a movie camera). Before each run, the human observer would give the pilot detailed instructions about the required speed, height, engine settings, etc. A few minutes flying led to hours of reading the recordings, and calculation.

Our test pilots had been trained at the Empire Test Flying School but some were short on flying boat experience. Setting out one January afternoon, we drifted too far down wind to be able to turn into the usual position for take-off, and had to make a somewhat hazardous take-off in the river that enters the harbour at Harwich. Having finished making the test runs back and forth over the sea we came lower to see where we were. George, the Short Bros representative, recognised Great Yarmouth so Brian, the pilot, set the compass to fly south and head for Felixstowe. After a while, I happened to look out and saw the land on our left when it should have been on our right! We crossed the North Sea at full speed, through a

thunderstorm. I parted from my lunch in the WC and we just reached Felixstowe in the fading light.

The techniques for testing handling in the air were the same for flying boats as for land-based aircraft, so I will concentrate now on the problems of handling on the water.

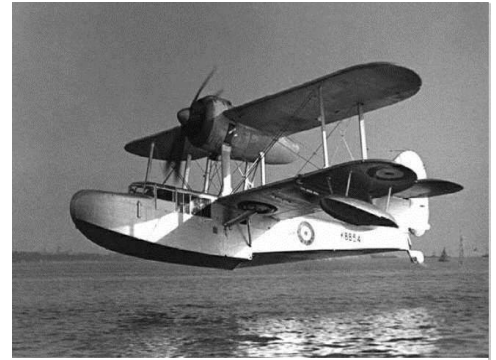
At the start of the take-off run the hull is pushing water aside and, as the speed increases so does the drag on the hull. The nose lifts until at “the hump” the water detaches from the afterbody and the ‘boat is planing “on the step”, the hydrodynamic drag is much reduced, the craft accelerates and takes off. The position, depth, and shape of the step are important for a smooth transition from displacement to planing – “getting over the hump”. A well-behaved ‘boat will adopt the correct attitude if the control column is held central. However, once the ‘boat is planing, pushing the control column forward can produce ‘porpoising’. The reduced angle between keel and water surface reduces aerodynamic lift from the wings and shifts the centre of water pressure forward. This lifts the nose again and the net effect is to set in motion a pitching oscillation. A small oscillation may be damped and stable (but unpleasant and dangerous in waves), in more extreme cases the craft may leave the water in the ‘nose-up’ phase, and in the worst case the amplitude of the oscillation can increase, and lead to disaster.

Pulling the control column back has a somewhat similar, but more complex, effect. Both forebody and afterbody are involved intermittently and the nose may lift so far as to cause the wings to stall. In a stalled ‘landing’ the afterbody hits the water tipping the ‘boat down on the forebody, which tips it up again - like skimming a flat stone across a pond.

The aim of testing was to define the stable region between these extremes. The plots were made in steady-speed runs, with a gyroscope recorder, and confirmed in actual take-off and alighting. Some flying boats have an unstable region near the hump and rely on the skill of the pilot to get through this region rapidly and without mishap. Fortunately the Sunderland and its derivatives were not of this kind. Tank tests on a model can give some indication of possible unstable regions but aero-dynamic and hydrodynamic scale effects act differently so tests have to be done at full-scale or, failing that, on a model at least one-third size.

A problem with the Seaford, that had not been experienced with earlier Sunderlands, was a marked ‘patter’ evident when taking off or alighting on nearly-calm water. This might have been related to the noticeable ‘dishing’ of the plating between the frames. A structural expert, Anne Pellew came down from the Royal Aircraft Establishment at Farnborough and affixed strain gauges to the plating. When asked what she was doing, she replied that she was “...interested in exciting forces on the bottom.”

Getting over the hump rapidly is a question of sufficient thrust. In rough water it can be difficult and we did some experiments with rocket-assisted take-off. I was the observer on the test with the Sea Otter. We were towed out into the rough water outside the harbour. David McCall, the pilot, opened up and when we reached the hump, fired the rockets. In no time we were 600 feet up in the air, whereupon the engine stopped, we hit the water again and I found the instrument panel on my knees. It took the rest of the morning to throw us a rope and tow us home. The Group Captain came in the launch to watch the fun, thereby distracting the coxswain who towed us into the wing of a moored Sunderland on the way. All this bother caused by a bit of grit in the carburettor.



“Sea Otter”

Rockets were used to power a radio-controlled model of the SRA1 jet fighter, then on the drawing board. It proved difficult for a pilot to control it remotely with the necessary accuracy for testing stability, by vision alone and without any ‘seat of the pants’ feel.

A flying model was used to test the idea of replacing the step by forced ventilation through vents. A compressor mounted in the hull left just enough room for the pilot and Jimmy Hamilton (later Sir James, and in charge of the Concorde project at the Ministry of Technology). The idea worked. Its purpose was to reduce drag in the air, increasingly important with increasing speeds. The ‘draggy’ deep straight step of the early ‘boats had been successfully modified to a “V” shape, given less depth, and faired, but the compromise between air drag and stability on the water was a delicate one. The last of the Sunderlands was built with naturally ventilated slots instead of a step. With the vents open it worked well, with them closed it ‘skipped’.

It is a pity that better streamlined hulls had not been developed sooner. Tank tests in the US and completed in 1948 showed that the hydrodynamics of a slim hull (length/breadth=15) differed little from a conventional hull (length/breadth=6). The Martin ‘Mars’, built with a slim hull, achieved a lift/drag ratio as good as any contemporary land-planes, overcoming one of the flying boats’ major disadvantages – but it came too late.

Some problems of operating on water are worth a brief mention. To get a flying boat out of the water, beaching legs and a tail trolley are put in place. These are made buoyant so as to float at the right height for attachment to the hull, but the operation can be tricky in rough water or in a hurry.

Boarding is by dinghy or launch. Getting on board to fix the instruments, for instance, could take time and I’ve spent many an hour yelling “dinghy!” at the top of my voice, having finished what I had gone on board to do.



Manoeuvring on the water is an art, especially in a cross-wind. Adequate flow of air past the rudder is essential for steering. We did some

experiments with reversible propellers on the Seaford. They certainly make it easy to turn, but the reversed propeller on the inside of the turn produces negative lift on that wing and, in a cross-wind can submerge a wing-tip float and damage the propeller. We had several German 'boats, brought over at the end of the war, and instead of wing-tip floats they had 'sponsons' – stubby wing-shaped things at water level. At high speed, as in take-off, these served to keep the wings level, but they had little effect at slow speeds. One day a pilot, determined to find a way of turning across a strong wind, revved up, then cut the engine on one side and applied full rudder. The effect was like a hand-brake turn in a car. Back in the cabin was chaos, with toolboxes spilled and the rigger and fitter somewhat shaken. The latter came into the cockpit and politely asked “if you are going to do that again, sir, please tell us”.

Picking up the mooring buoy is also tricky, depending on wind and tide. Drogues (like bottomless canvas buckets) can be deployed as brakes at the end of the approach, but if the bowman fails to catch the mooring with his boathook, going round again can be difficult. If the drogues get tangled together under the hull, sorting them out is a job for a diver.

After about two years of strenuous testing one of our two prototype Seafords was declared unfit to fly and we took the opportunity to see how it behaved on the water when loaded well beyond the accepted take-off weight limit. We were particularly interested in spray, as we already had evidence that it could seriously damage propellers. The idea was to make runs under a variety of conditions and control settings, photographing the spray pattern from several angles – the crane, a helicopter, and a launch. After several hours of this an engine caught fire and burned through its bearings. The photographer on the fire tender got this shot as it rushed up, spraying foam. Joe Taylor, a flight observer of great experience, was the first to realise what was happening and was getting into the rubber dinghy he had launched, was smothered in foam. He was later granted £5 for a new suit. I took the pictures to the seaplane tank at Farnborough where equivalent runs were made on a scale model to see whether the full-scale spray patterns could be predicted. They could, to some extent, but at model scale the water does not break up like it does at full scale.

The Seaford did not enter RAF service, but a successful civil version, the Solent, was developed from it. More powerful Pratt & Whitney engines were fitted to later Sunderlands, creating the Mark V, a well-behaved craft in all respects, which saw service in both military and civil versions.



“Land pilots who never had to park their aeroplane amongst cars, coaches and lorries, were being trained to handle their flying boat amongst native canoes, Arab dhows and ocean liners. Pilots learned the vagaries of water landing and how the many variables could affect their landing wind, current, swell, and tides.....”

Imperial Airways and the “C-class”

The prototype of the Shetland, intended successor to the Sunderland, came to MAEE for trials. Performance tests having been completed, it was due to come over to the group I was in for handling tests. But it was not to be. For security, two crew members slept on board and on waking up would start the auxiliary power unit to cook their breakfast. One January morning in 1946, the unit caught fire due to the presence of petrol fumes. The crew jumped out and swam ashore and the Shetland burned down to the waterline and sank. A civil version had also been built, but the airlines showed no interest and it was scrapped.

I left MAEE, and the world of aviation, at the end of 1947.

Demise

The prototype of the SRA1 arrived at MAEE shortly after I left. The first true jet flying boat, intended for service in the far east, it was being demonstrated in a Battle of Britain Day flypast off the Felixstowe seafront when it crashed, killing Sqdn Ldr Pete Major. Another of the pilots I had worked with, David McCall, was killed flying the “Sealand” amphibian on a demonstration flight in Norway. Two sadly wasted lives.



SRA1

General opinion in official circles at the end of the war was that there would be demand for big civil aircraft, powered by turbo-props as pure jets were thought only suited to fighter aircraft. The Brabazon Committee, set up to prepare specifications for aircraft to meet post-war needs in civil aviation, ignored the flying boat, though Brabazon later said he regretted this. Nevertheless, work continued on the “Princess”.

This was the brain-child of Arthur Gouge, the vastly experienced Chief Designer at Short Bros, who had been driven out by Stafford Cripps, Minister of Aircraft Production, and moved to Saunders-Roe in 1943. I witnessed the tank trials of a model of the Princess and it promised to be a well-behaved and efficient craft. However, when it was built, the engines had gearbox problems and did not deliver their designed power. The prototype was moth-balled and eventually scrapped. It had only once

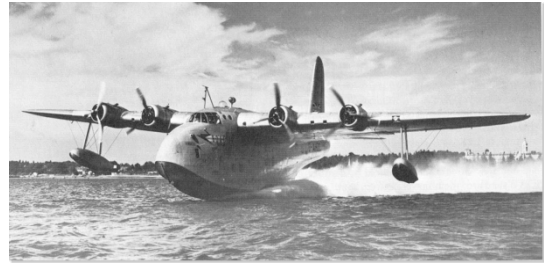


The SARO “Princess”

become airborne – unintentionally during a taxi-ing trial. The Princess was not alone in being under-powered. In the US, the Kaiser-Hughes “Spruce Goose” only managed to get airborne once. It had been planned as a troop carrier and built of wood ply because of the shortage of aluminium.

What really got civil aviation going was the ready availability of wartime aircraft such as the Dakota and the Lancastrian, now surplus to military requirements. A few flying boat services were run by the

“Sandringham” class of converted Sunderlands, and by the “Solent”, derived from the Seaford. Pre-war flying boat bases had been rudimentary and there were proposals for sheltered lagoons with landing aids. But these proposals gave the game away. If flying boats needed such facilities, their remaining advantage over landplanes was lost. Governments the world over were converting wartime runways to civil use or were building new ones.



MAEE was disbanded in 1958, the Government having abandoned all flying boat development. Ironically, RAF Felixstowe had taken over responsibility for the Blind Landing Experimental Establishment (BLEU) at nearby Martlesham Heath. BLEU had developed the safe landing systems that had helped drive the flying boat out.

Sporadic military flying boat development continued in Russia, Japan and USA but the only remaining role for the flying boat is water-bombing of forest fires, especially in Canada. The Martin ‘Mars’ is still operating in that role and new ‘boats specially designed for the purpose have recently appeared. The ability to scoop up tons of water in a matter of seconds is the flying boat’s one remaining unique virtue.



Bombardier “Superscooper” (1993)



MAEE was here



The “F” series remembered