NAVAL HELICOPTER ENGINES IN THE BEGINNING

BY

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ABSTRACT

In 1964 the *Journal* (Volume 15 No.1 pp88–102) published my article on helicopter engines. However, this was concerned with how the engines worked, and in my relative innocence at that time it ignored how the system supporting these engines also worked. Perhaps this final article, thirty four years later, will put the record straight.

In the late 1950s and the 1960s, the Royal Navy started serious operation of helicopters over the sea, using single unreliable engines, and this produced an appalling record of accidents. The results of this experience show that at the time, helicopter aircrew (including a future First Sea Lord) were at much greater risk of an accident (FIG. 1) than their fixed wing contemporaries and it is interesting to consider why this was not generally recognized at the time. Here are some facts.

The DRAGONFLY, a Sikorsky S51 built under licence by Westlands in the 1950s was powered by an Alvis Leonides engine, and more or less got away with it.

The DRAGONFLY was followed by a series of Sikorsky S55s, also built under licence by Westlands. The WHIRLWIND 1, powered by a Pratt and Whitney WASP R1340 (600 BHP) first appeared in 1952, followed shortly afterwards by the WHIRLWIND 3, powered by a Wright CYCLONE R1300 (700 BHP). The RN were also given some genuine Sikorsky versions of the WHIRLWIND 1s (HRS) and 3s (HO4S3) under the US Mutual Defence Aid Pact, and these were known as the WHIRLWIND 21 and 22 respectively. The two elderly American engines used in these marks of WHIRLWIND were tried and tested units, but new production had long ceased, and so faced with the prospect of having to produce a relatively large number of anti-submarine helicopters to replace the GANNET, the Ministry of Supply (MoS) issued specification H-135D for the new WHIRLWIND 7, which included a new engine.

FIG. 1—WESSEX 1 XS 869 OF 820 SQUADRON HAVING DITCHED FROM HMS 'EAGLE' 17 AUGUST 1967

The MoS then selected the Alvis Leonides MAJOR to satisfy H-135D. This was a pre-war design which had laid dormant since 1938, as a requirement for it had never materialized. It was a two row, fourteen cylinder radial engine of relatively high performance, and from a smaller cubic capacity than the Wright CYCLONE 1300 it produced another 50 BHP by using higher revs and higher boost—2900 RPM and 47″ boost against 2300 RPM and 39½″ boost. The same old story was therefore waiting to be told, if you thrash a machine harder, then you will probably pay for it in reliability.

However, there was another critical factor in the Leonides MAJOR's design which was only discovered when the first one was actually being installed at Westlands. It went the wrong way round! (A difference which still exists between American and British aero engines). Alvis were then tasked at very short notice to make it run backwards, (not too difficult in a radial engine) but possibly due to the urgency, it was not recognized that reverse rotation would also change the relative position of the crank pin oil feed hole. This moved it from where it should have been, just forward of the point of maximum contact pressure (to exploit the benefit of the MICHELL effect) to the actual point of maximum pressure itself. This turned out to be the hidden and fundamental Achilles heel of the Leonides MAJOR in its early years, causing many engine seizures, particularly in hot weather. Engine seizure became a way of life in the first WHIRLWIND 7 Intensive Flying Trials Unit (IFTU), but as a matter of expediency this was not taken very seriously, as the first operational squadron had already been committed to Exercise STRIKEBACK.

The RN bought 129 WHIRLWIND 7s and used them between 1957 and 1977. 79 were written off in service, giving an attrition rate of 61%. The majority of these write-offs were due to engine failure. In the closing years of its life, an engine Mean Time Between Removals (MTBR) of about 150 hours was finally achieved. The financial control underwriting this shocking performance was simply cost plus, meaning that the lower the reliability, the greater the work and reward for the design and repair organizations, and in this case they both happened to be the engine manufacturer.

As an ex-FAA Engineer I appreciate that this no longer represents the way the MoD conducts its affairs, although as a cynical MoD engine repair contractor, facing competitive fixed price contracts, I view these past arrangements with envy, if not with sympathy!

The WHIRLWIND 7 was closely followed by the WESSEX 1, which promised far greater payload and endurance in the anti-submarine role. Arrangements were therefore made by the MoS for Westlands to produce the Sikorsky S58 under licence, which was powered by a Wright CYCLONE R1820 of 1525 BHP.

The decision was also made to use a gas turbine engine, which at the time called for a major step forward in helicopter engine control technology, particularly in matching engine output to collective input. As a development tool, the MoS acquired an S58 (XL 772) which was converted by Westlands to take a Napier NGa11 of 1100 SHP, and this was first flown at Yeovil in early 1957. Further development led to the WESSEX, with the WESSEX 1 IFTU subsequently forming at RNAS *Culdrose* in 1960, followed by formation of the first front line squadron in July 1961. 133 WESSEX 1s were purchased, all powered by the Napier GAZELLE 161 engine of 1400 SHP. Between 1967 and 1968, 40 WESSEX 1s were converted to WESSEX 3s, using the uprated GAZELLE 165 of 1600 SHP.

The GAZELLE proved to be a most unreliable and temperamental engine (FIG. 2), and with the demise of Napiers, development and production of the last batch of engines passed to Rolls Royce, East Kilbride in 1962. Despite the attention of a new design team, the engine could not shake off its reputation for unsatisfactory performance, tempered by the fact that its failure modes were not always the relatively forgiving ones occurring in a low level hover, as had usually been the case with the WHIRLWIND 7.

After a succession of fatal accidents, a team of which I was part, was formed in 1969 to review the situation. The most serious accidents were due to failures in the engine's reduction gearbox, causing disconnection of the engine's free power turbine from the rotor load, allowing it to accelerate away and burst in milliseconds, with the trajectory of the red hot turbine particles being coincident with the fuel tanks. These occurrences were reported by spectators as a mid-air fire, quickly followed by a catastrophic explosion.

Fig. 2—Wessex 1 XS124 of 820 Squadron being recovered on board HMS Eagle after ditching on 16 September 1968

The review team found that since the Wessex had first been produced in 1960, by 1969 41 (31%) had already been lost in accidents. This figure would have been much higher, but for the introduction of flotation gear in 1965 (Fig. 3).

The team's analysis of incident and accident signals revealed a serious in-flight engine malfunction rate of 1 per 500 flying hours, and further analysis

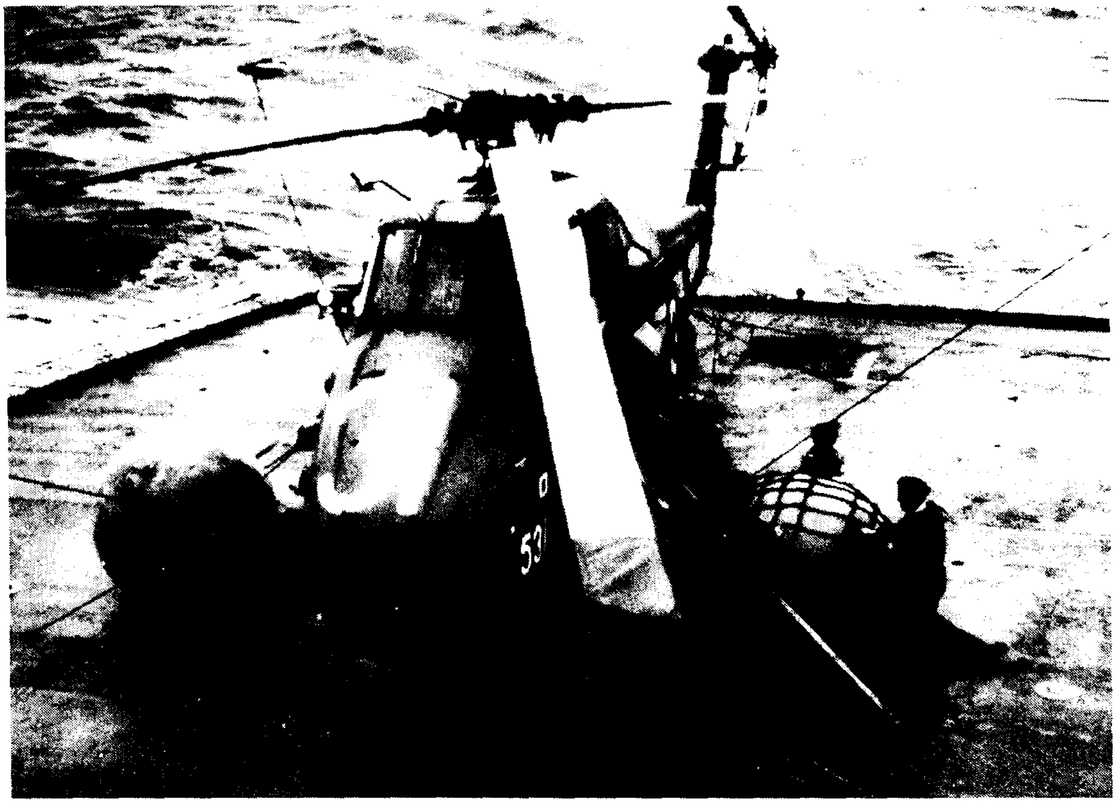

FIG. 3—WESSEX ON BOARD RFA 'TIDEPOOL' AFTER THE INADVERTENT INFLATION OF FLOTATION GEAR

of the manner in which the 41 WESSEX which had been destroyed indicated that 26 were due to engine failure - an engine induced attrition rate of 20%. The situation was eventually stabilized by rigorous routine oil analysis, together with fitting a containment shield round the free power turbine.

When the WESSEX 1s and 3s effectively left service in 1983, out of the original purchase of 133, 64 (48%) had been lost in accidents, and as stated, most were engine related. After 23 years in service, subject to continuous and costly post design development, the GAZELLE engine finally achieved a retirement MTBR rate of about 240 hours.

The WASP was developed to be an organic part of a frigate's ASW system. The P531 prototype first flew in July 1958, and this led to the first production WASP in 1962, followed by the IFTU at *Culdrose* in 1963. The WASP was initially powered by the NIMBUS 101, which was a development of a series of Turbomeca engines built under licence by Blackburns, and it was rated at 650 SHP. Further lifecycle development produced the NIMBUS 103 and 104.

The RN bought 98 WASPS, and by the early 1980s 24 had been lost, of which 14 were attributed to engine failure. In addition, 4 other engine failures caused accidents where the aircraft ditched, but were subsequently recovered. Had flotation gear not been available (FIG. 4) this would have given an engine induced attrition rate of 18%. The introduction of routine oil analysis in 1968 was responsible for detecting many impending engine failures, which helped to minimize further losses. This required a 365 day decisive service by the Naval Aircraft Materials Laboratory (NAML), which demonstrated a unique understanding of both the technical and operational priorities facing the WESSEX and WASP fleets.

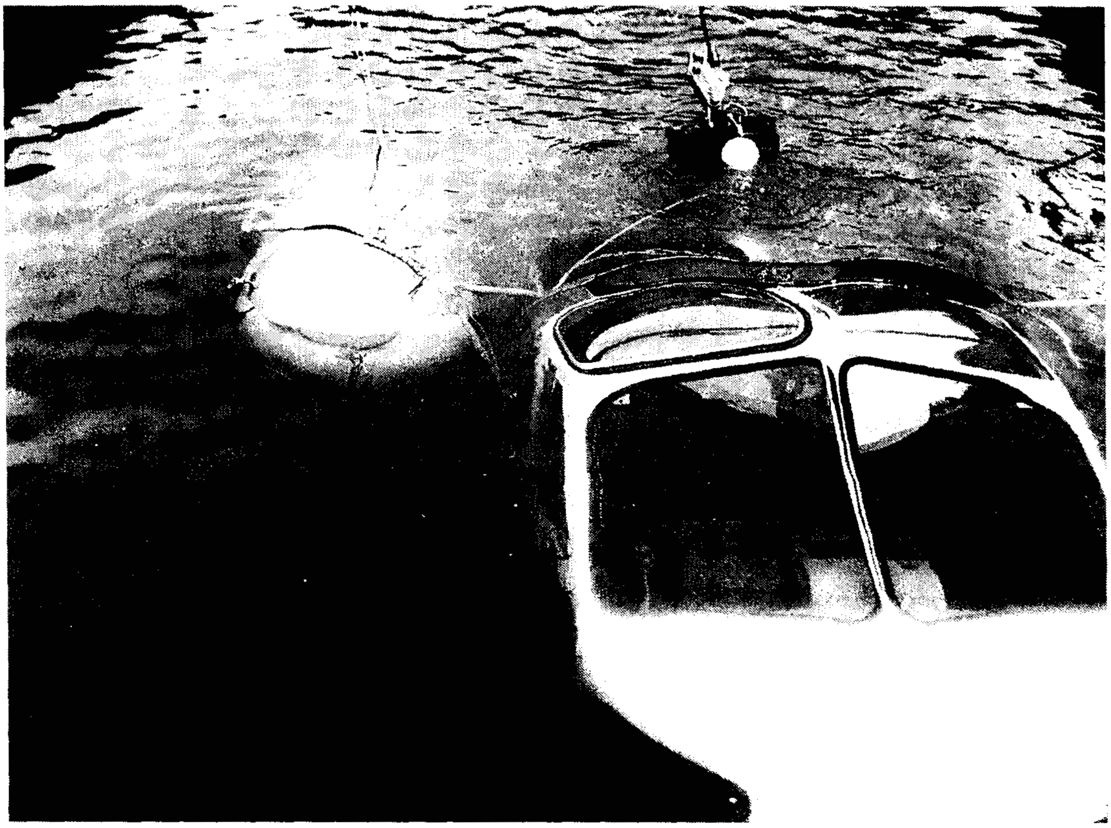

FIG. 4—DEVELOPMENT TRIALS OF WASP FLOTATION GEAR BY THE FAIREY AVIATION DIVISION OF WESTLAND AIRCRAFT, at HAYES IN NOVEMBER 1964

The NIMBUS was also the subject of some very expensive modification campaigns, with the last one (Mod 719) actually reducing the MTBR from 230 hours to 127 hours. This, after 21 years in service subject to continuous development, against a background of no financial restrictions on making the engine more reliable (FIG. 5).

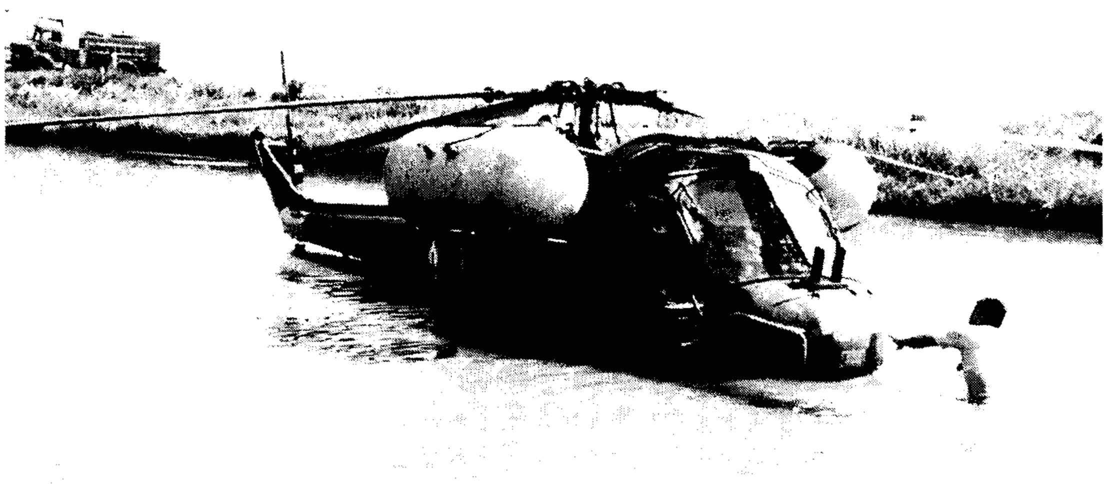

Fig. 5—INDONESIAN NAVY WASP 8 JUNE 1982

The WESSEX 5 was powered with the GNOME engine, basically the successful General Electric T-58 engine built under licence, with the added insurance of having two of them. The WESSEX 5 was not without some drama in its history, but it was generally successful and popular, and it proved the logic of using multi engine helicopters to operate over the sea.

I will stop at this point, as it would be inappropriate to make further reminiscences involving the SEA KING and LYNX, as they are still in service. Also, the FAA must now be looking forward to operating the MERLIN, which thankfully has three engines.

However, looking back on the shocking record of the engines fitted to the WHIRLWIND 7, the WESSEX 1 and 3, and also the WASP, it poses the question of what went wrong? In the first instance it can be argued that we procured the only equipment which was available, but on the other hand it can also be argued that the whole saga, like many others, was managed in such an unmanageable way that our response to poor design and development was both passive and ineffective. Whatever argument is used, there was no lack of money to develop better solutions, which must be the final and conclusive indictment of the system in place at the time to give the FAA its technical and logistic support. It was an experience, which, as a relatively junior officer, coloured my attitude towards my own technical establishment until later on, when I was able to see that the problem was one of properly trained and motivated people, all locked up in an inoperable system.

This is now part of the FAA's history, and those involved in it have moved on. In my view, this experience was the result of attempting to manage a relatively small inventory of equipment, with the same management infrastructure which had been developed during World War 2. Three Flag Officers, and four different MoD Departments, reporting to two Admiralty and one Air Force Board member, all separately assumed the responsibility for part, but not for all of what was going on, and the indistinct boundaries between these tribal territories were fiercely defended.

The direct result of having so many people refusing to abdicate what they perceived as their authority, meant that in the end no-one was really accountable for anything. In particular, the cash flow concerned with lifecycle costs, was, in today's terms, both staggering and uncontrolled. All the statistics and evidence that I have quoted here were readily available at the time, although probably inextricably mixed up with the mountain of other data, all routinely reported from the sharp end, but apparently never prioritized and recognized at the blunt end. For example, the 1969 investigation showed that starting with the IFTU, 140 A21 Defect Reports had been raised on the GAZELLE's Reduction Gear Box, all pointing to some form of distress in this critical area, but without any serious technical reaction to the problem, until aircrew protest eventually created it on flight safety grounds.

To a large degree, this was due to a tendency for the existing aggressively competitive management clans to emasculate each others efforts, a system which until the early 1980s was still regarded as the norm, and in my final appointment in the service I discovered how dangerous it was to challenge it.

I am told that things are different now, and that the combination of proper budgetary control, used within a rational and accountable management system, will prevent the situation I have described from ever happening again. I hope so.