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ROYAL AIR FORCE HISTORICAL SOCIETY

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SELECTED GLOSSARY

ASDIC	Anti-Submarine Detection Investigation Committee
ASR	Air/Sea Rescue or Air Staff Requirement
AST	Air Staff Target
ASW	Anti-Submarine Warfare
ASWDU	Anti-Submarine Warfare Development Unit
CTTO	Central Tactics and Trials Organisation
EASAMS	EA Space and Advanced Military Systems (the EA stood for Elliott Automation, but it was never spelled out)
ECM	Electronic Counter Measures
EOS	Electro-Optical System
ESM	Electronic Support Measures
GR	General Reconnaissance
JMOTS	Joint Maritime Operations Tactical School
LRMP	Long Range Maritime Patrol
MAD	Magnetic Anomaly Detector
MOTU	Maritime Operational Training Unit
MPA	Maritime Patrol Aircraft
MR	Maritime Reconnaissance
NDB	Nuclear Depth Bomb
OCU	Operational Conversion Unit
OR	Operational Requirement
ORB	Operations Record Book (the RAF Form 540)
RCDS	Royal College of Defence Studies
RF	Radio Frequency
RTB	Return to base
RUSI	Royal United Services Institute
SAR	Search And Rescue
SARBE	Search And Rescue Beacon Equipment
SDSR	Strategic Defence and Security Review
SOP	Standard Operational Procedure
SOSUS	SOund SUrveillance System (*See footnote on p117*)
SSN	Submersible Ship, Nuclear
SSBN	Submersible Ship, Ballistic (Missile), Nuclear
SSGN	Submersible Ship, Guided (Missile), Nuclear, ie a cruise missile launcher
STC	Standard Telephones and Cables Ltd
TAF	Terminal Aerodrome Forecast
UOR	Urgent Operational Requirement
VP & VX	In US Navy unit designations: V = heavier than air; P = patrol; X = experimental; A = Attack; etc

ASPECTS OF RAF MARITIME AIR SINCE WW II

RAF MUSEUM, HENDON, 21 October 2015

WELCOME ADDRESS BY THE SOCIETY'S CHAIRMAN

Air Vice-Marshal Nigel Baldwin CB CBE

Ladies & Gentlemen – good morning. Before I introduce our Chairman for the day I have a glitch to announce: the last speaker on your programme for this afternoon told us a few days ago that, unfortunately, he will not be able to be here. Of all our speakers, he is the one serving Royal Air Force officer – in his case in the Ministry of Defence in Whitehall – and it is a risk we always run when we call on serving officers. The tragic Puma helicopter accident last week in Iraq has hit his workload so we are going to have to drop his slot, which, while not exactly history anyway, was going to bring us up to date. He has assured our editor that he will be able to work up a script suitable for publication in the eventual journal. (*Sadly this also proved not to be the case but, in the event, the Chairman for the day was able to plug the gap – see page 140.* **Ed**)

His absence means that the afternoon speakers need not be too constrained by the timings in the programme. For once, we will allow them to wax on a bit if they wish.

Our Chairman for today, Air Vice-Marshal Andrew Roberts, has, as you would expect, a maritime background. Shackletons, followed by the Central Flying School and an instructional tour at the RAF College Cranwell; he was then Personal Staff Officer to one of the Ministers in the MOD before becoming CO and Chief Instructor of the Nimrod OCU at St Mawgan. In 1977, he became Station Commander at Kinloss, followed by RCDS and a tour as Director of Air Plans at the MOD. He was promoted to AVM to be Chief of Staff 18 Group at Northwood.

His final tour in the Service, in the early 1990s, was to lead the Manpower Strategic Studies Team which, amongst other conclusions, suggested that, without reducing the front line, the strength of the RAF could be reduced from 93,500 to about 43,000. Well, the RAF now has about 36,000 personnel which is food for thought – but a subject for another day perhaps.

So we will be in good hands. Andy, you have control.

CHAIRMAN'S OPENING REMARKS

Air Vice-Marshal Andrew Roberts CB CBE AFC

Ladies and Gentlemen, I must start by saying how very pleased I am that the Society has decided to hold this seminar on Maritime Air. Many of us, including many distinguished veterans of WW II, have been very concerned by the way in which, whether through ignorance or some other reason, Coastal Command and the other maritime elements of RAF history often seem to have been almost forgotten.[1]

This is not a new problem, but it does continue, as you can see if you look at the historical aspects of the RAF's *Yearbook*. The level of RAF participation in the 2013 Battle of the Atlantic celebrations was nothing short of a disgrace and many maritime veterans are very disappointed by how limited the presentation of maritime air by the RAF Museum is.

For instance, how many people appreciate the considerable part Coastal Command and its successor, 18 Group, played in the Cold War? Having been more visible to the public, there is widespread recognition of the part played by the V-Force, the UK's Air Defence Force and RAF Germany in deterring Soviet aggression, but how many appreciate the way in which our maritime crews were so often in daily contact with Soviet naval forces and the way in which our crews were often in direct contact with their potential enemy, pitting their wits against Soviet submarine captains? A Russian admiral has recently said that he regards the aircraft as being the greatest of the threats to his submarines. That really is a reflection of the part our MPA (Maritime Patrol Aircraft) crews have played over the years.

How many people appreciate that even the Shackleton could carry nuclear weapons?

So I am delighted that we now have, in some small way, the opportunity to redress the balance today. I am therefore most grateful to those who have taken their time to prepare the various contributions to today's seminar. Thank you also to those coming (some from quite a long way) to support the day and, notwithstanding my reference to

[1] For the record, this Society has previously addressed aspects of maritime aviation in, eg Journals Nos 21, 30, 33, 40 & 45 while one of the 'Bracknell Papers', *Seek and Sink*, 're-fought' the Battle of the Atlantic in 1991. This list is not exclusive. **Ed**

the RAF Museum just now, for making its excellent facilities available to us.

Now, today our presentations are mainly focused on what we used to call long-range maritime patrol but let us not forget the other elements of RAF maritime air power over the years, particularly that played by the Buccaneer and Tornado crews.[2] Going back in history, I believe I am right in saying that the force with the highest loss rates in WW II were Coastal Command's strike wings and I wonder what loss rates our maritime strike crews would have suffered had we gone to war with the Soviets.

Another thing to which I must make passing mention is the relationship between the RAF and the Royal Navy. Historically there has been a little friction from time to time, particularly when the question of whether MPA are best employed in close or distant support of naval forces, or independently. However, my experience is that – notwithstanding the small wrinkles that occurred at the end of the 1950s, when the Royal Navy tried to take over Coastal Command, the two Services have become ever closer – and certainly by the end of the Nimrod era could not have been closer. There is enormous trust between the two Services' operators – usually with the submariners and the airmen uniting to keep their surface colleagues in order!

On one occasion, after I had diverted three frigates and two submarines during a weekend in order to get a Nimrod into a particular area without reducing our overall cover whilst hunting a particularly difficult Soviet *Victor III*, I was thanked by CinC Fleet for the success of the operation at the subsequent briefing. I had to point out that, a generation earlier, I would have had to fall-in in front of him, dressed in sword and medals, to apologise. As he said, the two Services had come a long way since then!

The other aspect I should mention is the international element of maritime air – in the case of the Americans, with the RAF and the US Navy working so closely together that they were acting virtually as one MPA force in the Atlantic. I could perhaps illustrate this with a short personal anecdote. When I was serving at HQ SACLANT, under the fearsome Ike Kidd, the admiral was unhappy about command and

[2] The employment of ASUW Buccaneers/Tornados has been addressed twice, see Journals Nos 33 and 62. **Ed**

control arrangements in general so he decided to put each of his specialist officers under the spotlight by asking what they were doing about C2 in their area. When he growled to the last one: ‘Who is my VP Officer?’, I had to say ‘Me Sir’. ‘What are you doing about C2 in your area?’ I replied, ‘Absolutely nothing, Sir’. There was a deafening silence for at least 20 seconds, then a growl. ‘Explain yourself, young man.’ ‘It is the one part of NATO that works, Sir. Please don’t change it.’ Subsequently, he used these words in his ‘State of the Union’ address to the NATO Council the following December, so I knew I was not going to be sacked!

Returning to ignorance, how many people knew of the part played by the Nimrod Force in protection of the Deterrent? Not many, I suspect. Indeed, I have the strong suspicion that the Prime Minister was not made aware of this when he decided to abandon the Nimrod MRA4. I suspect that I was the one to blow the gaff on this when writing to my MP. As someone in MOD said, when giving me informal advice on whether or not to go public, ‘The Russians know; why shouldn’t the British Public?’

From the first sinking of a submarine by an aircraft, the French *Foucault* by the Austrian Naval Air Service in the Adriatic on 15 September 1916, right up to the present day, it has been a constant technological battle between the aircraft and submarine. At each advance, it is usually the submarine that has led. At the beginning of the period we are examining, I would argue that it was the German Type XXI, with its schnorkel and its ability to creep quietly for about 300 nm without having to come up to breath, which was about to gain the ascendancy. However, through the improvements in radar and the other means about which we are to hear today, the aircraft started to catch up – before nuclear power, with its associated noise, came along – and then advances in passive acoustics provided opportunities for the MPA. And so on.

One can argue that in March 2010, when the Nimrod force was grounded, MPA were in one of the more capable periods of their relative strengths; for example, when, because no RN ships were available, the Nimrod force was able closely to track the latest Russian *Akula* submarine for over a week until it left the UK area.

Anyhow, today is an opportunity to redress this historical ignorance.

RAF MARITIME AIR – THE FIRST POST-WAR DECADE

Wg Cdr Jeff Jefford

'Jeff' joined the RAF in 1959 as a pilot but (was) soon remustered as a navigator. His first tour was on the Tengah-based Canberras of No 45 Sqn. He subsequently flew in Vulcans with Nos 83 and 50 Sqns and instructed at No 6 FTS. Administrative and staff appointments involved sundry jobs at Manby, Gatow, Brampton and High Wycombe. He took early retirement in 1991 to read history at London University. He has three books to his credit, has been a member of the Society's Executive Committee since 1998 and has edited its Journal since 2000.

The aim of this paper is to provide a scene-setter for the day by skimming over the early post-war years, taking the opportunity along the way of looking, in a little more depth, at two issues that the Society has addressed on previous occasions. The timeframe is the first, slightly extended, post-war decade, 1945 to the later 1950s.

Contraction

Coastal Command's Order of Battle (ORBAT) in June 1945, shortly after the end of the European war, is listed at Table 1. Not including the photo-reconnaissance units of No 106 Gp, which were also operated by Coastal Command but were not in a specifically 'maritime' role, there were thirty-nine squadrons. This involved about 1,000 aircraft, 750 combat types and the rest dedicated to air-sea rescue and 'met recce'.

While the fighting had stopped, there was still plenty for Coastal Command to do, including escorting surrendered German vessels and maintaining anti-submarine patrols, just in case a gung-ho U-boat captain had missed the surrender message – or had chosen to ignore it. But the Japanese war was still unfinished in June 1945 and the UK-based Coastal Command represented only half of the RAF's global maritime ORBAT. Overseas there were another thirty-three squadrons (Table 2) distributed throughout the Mediterranean, the Aegean and the Adriatic, around Africa, across to Aden, the Indian Ocean, the Bay of Bengal and even a squadron of Mosquitos down in Australia.

Sqn	Location	Aircraft	Role
15 Gp			
201	Castle Archdale	Sunderland	GR
202	Castle Archdale	Catalina	GR
423	Castle Archdale	Sunderland	GR
59	Ballykelly	Liberator	GR
120	Ballykelly	Liberator	GR
172	Limavady	Wellington	GR
281	Limavady	Warwick/Sea Otter	ASR
518	Tiree	Halifax	Met
16 Gp			
612	Langham	Wellington	GR
254	North Coates	Beaufighter	Strk
280	Beccles	Warwick	ASR
278	Beccles	Walrus/Sea Otter	ASR
521	Langham	Fortress/Hurricane	Met
18 Gp			
224	Milltown	Liberator	GR
86	Tain	Liberator	GR
311	Tain	Liberator	GR
206	Leuchars	Liberator	GR
547	Leuchars	Liberator	GR

Sqn	Location	Aircraft	Role
210	Sullom Voe	Catalina	GR
36	Benbecula	Wellington	GR
143	Banff	Mosquito	Strk
235	Banff	Mosquito	Strk
248	Banff	Mosquito	Strk
489	Banff	Beaufighter	Strk
279	Thornaby	Warwick/Sea Otter	ASR
519	Wick	Fortress	Met
19 Gp			
14	Chivenor	Wellington	GR
407	Chivenor	Wellington	GR
53	St Davids	Liberator	GR
220	St Davids	Liberator	GR
179	St Eval	Warwick	GR
304	St Eval	Wellington	GR
10	Mount Batten	Sunderland	GR
228	Pembroke Dock	Sunderland	GR
422	Pembroke Dock	Sunderland	GR
461	Pembroke Dock	Sunderland	GR
254	Chivenor	Beaufighter	Strk
282	St Eval	Warwick	ASR
517	Brawdy	Halifax	Met

Table 1. UK-Based Maritime ORBAT – June 1945.

Sqn	Location	Aircraft	Role
88 Gp (Norway)			
333	Fornebu	Catalina	GR
334	Fornebu	Mosquito	Strk
247 Gp (Azores)			
269	Lagens	Warwick/Walrus	ASR
HQ RAF Iceland			
251	Reykjavik	Fortress/Warwick	ASR
MACAF (Italy)			
38	Falconara	Wellington	GR
624	Falconara	Walrus	GR
458	Gibraltar	Wellington	GR
284	Pomigliano	Warwick	ASR
293	Foggia	Warwick/Walrus	ASR
520	Gibraltar	Halifax/Warwick/Walrus	Met
AHQ Greece			
252	Hassani	Beaufighter	Strk
AHQ Malta			
283	Hal Far	Warwick/Walrus	ASR
AHQ Eastern Med			
221	Idku	Wellington	GR
AHQ East Africa			
209	Kipevu	Sunderland	GR
HQ BF Aden			
621	Khormaksar	Wellington	GR
294	Basrah	Wellington/Warwick	ASR
AHQ West Africa			
204	Jui	Sunderland	GR
270	Apapa	Sunderland	GR
490	Jui	Sunderland	GR
95	Bathurst	Sunderland	GR
343	Dakar	Sunderland	GR
344	Dakar	Wellington	GR
221 Gp (India/Ceylon)			
230	Rangoon	Sunderland	GR
321	China Bay	Catalina/Liberator	GR
203	Kankesanterai	Liberator	GR
205	Koggala	Sunderland	GR
212	Korangi Creek	Catalina	GR
160	Minneriya	Liberator	GR
191	Red Hills Lake	Catalina	GR
240	Red Hills Lake	Catalina	GR
217	Gannavaram	Beaufighter	Strk
292	Agartala	Liberator/Warwick/Walrus	ASR
Australia			
618	Narromine	Mosquito	Strk

Table 2. Overseas Maritime ORBAT – June 1945.

Sqn	Location	Aircraft	Role
236	UK	Beaufighter	Strk
404	UK	Mosquito	Strk
455	UK	Beaufighter	Strk
524	UK	Wellington	GR
502	Gibraltar	Halifax	Met
272	Italy	Beaufighter	Strk
459	N Africa	Wellington	GR
259	E Africa	Catalina	GR
265	E Africa	Catalina	GR
262	S Africa	Catalina	GR
244	Gulf	Wellington	GR
413	Ceylon	Catalina	GR
354	Ceylon	Liberator	GR

Table 3. Maritime squadrons disbanded prior to the end of the war in Europe.

But, although the Japanese had not yet surrendered, the writing was already on the wall and maritime squadrons had begun to disband, even before the German surrender by which time thirteen squadrons (Table 3) had already gone. But once the bomb had been dropped, the maritime air force, both at home and abroad, began to implode. By January 1946 Coastal Command had already been reduced by about 50%[1] – and still counting. Some of this reduction was, to a degree, more apparent than real in that, although these reductions had cost Coastal Command five squadrons of Liberators, rather than being disbanded, four of them had actually been transferred to Transport Command who used them to operate a trooping schedule to and from India. But this service was living on borrowed time, of course, because at a press conference held on 21 August 1945, less than a

Sqn	Location	Aircraft	UE	Role
UK				
36	Thorney Island	Mosquito	8	Strk
42	Thorney Island	Beaufighter	8	Strk
201	Calshot	Sunderland	5	GR
230	Calshot	Sunderland	5	GR
120	Leuchars	Lancaster	6	GR/ASR
203	St Eval	Lancaster	6	GR/ASR
210	St Eval	Lancaster	6	GR/ASR
224	St Eval	Lancaster	6	GR
202	Aldergrove	Halifax	15	Met
Overseas				
37	Ein Shemar	Lancaster	9	GR/ASR
38	Ein Shemar	Lancaster	9	GR/ASR
88	Kai Tak	Sunderland	5	GR
205	Koggala	Sunderland	5	GR
209	Seletar	Sunderland	5	GR
45/27	Negombo	Beaufighter	16	Strk

Table 4. Maritime ORBAT – September 1947.

week after VJ-Day, President Truman had, somewhat peremptorily, announced the termination of Lease-Lend. So the Liberator's days were numbered, as were those of the Catalina. There were still some of each in the UK but overseas by January 1946 the maritime air force was well on its way to being exclusively 'made in England'.[2]

Squadrons continued to disband over the next eighteen months so that by September of 1947 we appeared to have reached a steady peacetime state (Table 4) with a strike wing at Thorney Island and the makings of another in Ceylon, six squadrons of Sunderlands and

A Beaufighter TF10 of the Ceylon-based No 45 Sqn.

Lancasters in the UK, two of Lancasters in the Mediterranean and three of Sunderlands spread across the Far East. But in 1945 a long range GR squadron had had an establishment of sixteen landplanes or twelve seaplanes; at only five or six aircraft apiece these post-war units were little more than flights – half-squadrons.

The Strike Wings

The Mosquito and Beaufighter could both inflict damage with guns, bombs or rockets but the latter was unique in being able to deliver a torpedo, so one squadron of each had been retained in the UK. It had initially been intended to use both in the Far East as well but there were concerns over the Mosquito's structural integrity in the tropics, so it soon became Beaufighters-only overseas. The intention had been to have three squadrons, but this never really got off the ground. In reality there was just No 45 Sqn in Ceylon with a notional eight aeroplanes, rather than the advertised sixteen, with No 27 Sqn having no more than a nominal existence as an embedded flight. The third unit was to have been the Singapore-based No 84 Sqn but, although it was re-equipped with Beaufighters, it never assumed a maritime strike role and remained a light bomber squadron.

But using the Beaufighter was only supposed to have been a temporary arrangement in any case; the plan had been to standardise on the Brigand for maritime strike. But the Brigand failed to materialise. Instead, in October 1947 the RAF opted-out of maritime strike altogether, leaving this task to the Fleet Air Arm for the next thirty years. Thus far, this writer has failed to locate a specific policy statement to explain why the RAF abandoned the role but at the time it had had a manpower ceiling of 250,000 imposed, and the Air Council was not confident that it could even recruit all of those. One way to sustain the notional front line was, as reflected by Table 4, to run a lot of squadrons at reduced strength. Another was to 'reduce the number of squadrons in less vital categories'[3] and it is reasonable to assume that that must have included maritime strike.

But there was one more turn of the screw. Only a month later, in November 1947, No 224 Sqn was disbanded, although its aeroplanes were shared among the other three so there was still a fleet of twenty-four Lancasters – just one less job for a squadron leader.

Having established the much-reduced strength of the maritime reconnaissance force, what were these aeroplanes for? The U-boats were gone and, notwithstanding Churchill's March 1946 speech about an iron curtain 'from Stettin in the Baltic to Trieste in the Adriatic', the Cold War had not really got going yet and even if it had, the Russians lacked a blue water navy. Crews maintained their anti-submarine skills via attendance at courses run by the Joint Anti-Submarine School (JASS) at HMS *Sea Eagle* in Londonderry and through participation in Fleet exercises. They also flew routine bombing and gunnery practices and occasional met recce sorties, generally the EPICURE route down to the Bay of Biscay, flew but air/sea rescue was a major preoccupation.

The Airborne Lifeboat

The first in-service trial drop of an airborne lifeboat, a 23-foot Mk I, was made from a Hudson of No 279 Sqn in December 1942. The parachutes failed to open and the boat was reduced to matchwood on impact. But the problems were solved and the system became operational in February 1943 with the first successful rescue being made in May. During 1944 the Hudson was largely displaced by the Warwick in the air-sea rescue service. It too could deliver the Mk I boat but by this time the 31-foot Mk II had also been introduced. The Warwick could also carry two sets of the Lindholme gear with which most of this audience will be familiar.

The Lindholme gear was a much more flexible piece of kit than the lifeboat, not least because it could be delivered by a wide variety of aeroplanes with little or no modification required. In its essentials, it

With a 31-foot Mk II airborne lifeboat fitted, RF310, was one of the first Lancaster ASR IIIs to be delivered to No 279 Sqn.

consisted of a number of cylindrical containers joined together by lengths of buoyant rope.[4] Depending on the aeroplane, it could be dropped in a variety of combinations and it was still being carried by Nimrods. Today, one imagines that, should it be necessary, it could probably still be delivered via a Hercules.

But, to return to the lifeboat, well before the end of the European war planning had begun for Tiger Force, a major deployment of heavy bombers to participate in the final stages in the Pacific. Since this would involve lengthy over water operations 100 Lancasters were to be modified to carry the Mk II airborne lifeboat. Although this programme would be short-circuited by the atom bomb, the first lifeboat-capable Lancaster ASR Mk IIIs were delivered to No 279 Sqn in September 1945.

In December the squadron detached five of its new aeroplanes to Pegu in Burma. From there, in March 1946, it mounted an expedition to Singapore where a demonstration drop was laid on. This went without a hitch and a crew from the resident Marine Craft Unit recovered the boat and sailed it back to shore (*see page 28*).

Meanwhile, back in the UK, by late 1947 Coastal Command was equipped with a mixture of Lancaster ASR IIIs and GR IIIs – the latter being much the same but lacking the facilities for carrying a lifeboat, although it could, of course, deliver a Lindholme gear. A trawl through the ORBs of the three Lancaster squadrons reveals that live drops were relatively infrequent, perhaps two or three per squadron per year, typically demonstrations laid on for Staff College visits,

A Mk II lifeboat under its fully-deployed parachutes. The failure of these to detach on reaching the sea was a recurrent problem.

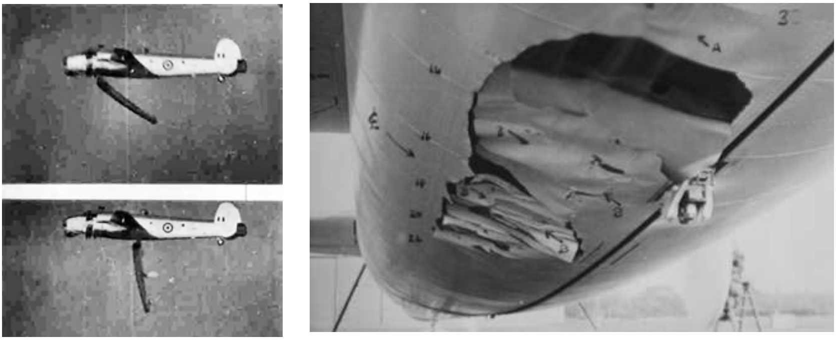
Battle of Britain Days and the like plus the occasional training drop.

In all, between 1947 and 1953, the UK-based squadrons recorded at least 37 drops, including two at Gibraltar, of which five were deemed to have been failures (see Annex A). There were a number of occasions when boats were loaded in response to an emergency having been declared or when a Royal Flight was taking place but there appear to have been only two instances of operational drops.

The first was in July 1948 when a Lancaster of No 236 OCU ditched off the Shetlands. Among the several responses, No 120 Sqn sent a Lancaster with a lifeboat which was dropped, but the parachutes failed to release when it hit the water and the boat overturned. The downed crew were picked up by a Sea Otter which was unable to take off again due to a heavy swell. The Lancaster crew, all of whom had survived, were transferred to a frigate – HMS *Welcome* – which took them to Lerwick with the Sea Otter in tow.

The second incident involved detaching a Lancaster to Reykjavik in order to drop a lifeboat into a glacial lake to support the 1952 British North Greenland Expedition. This was not an emergency but it was an operational task as the boat was needed to support the Sunderlands that delivered supplies. The parachutes opened late and, again failed to detach, and the boat's bow was caved in.

Nevertheless, while there was little actual use of the lifeboat, it had become an accepted item in the inventory so the next stage, in anticipation of the Shackleton, was a Mk 3. At 32 feet it was to be much the same size as the Mk 2 but made of aluminium, rather than



Stills from film of the 27 November 1951 trial drop from a Shackleton MR1, showing the initial trajectory of the lifeboat and the damage sustained by the bomb bay door.

mahogany. About fifty were ordered (sources disagree as to the precise number) and after a successful drop from a Lancaster in August 1951, the programme moved on to the Mk 1 Shackleton but that proved to be less straightforward.

Wind tunnel tests had indicated that the boat should separate from the aircraft cleanly when released but this did not happen in practice. Instead, the bow scraped along the underside of the aircraft, inflicting considerable damage to the bomb bay doors.

The safe separation problem persisted and the trials were suspended in 1952, although a Shackleton Mk 2 carrying a Mk 3 lifeboat was displayed at the 1953 SBAC Show at Farnborough, with the aeroplane making a rather impressive single-engined fly past. A trial fit on a Shackleton MR3 was also carried out, but this combination was not flown. In late 1954 it was still 'not possible to carry a lifeboat in the Shackletons because the Service Trials on the new all-metal lifeboat have not yet been completed.'[5]

While production Mk 3 boats were pre-positioned in twos and threes at Coastal Command stations, none of the RAF's Shackletons ever appear to have flown with one. Furthermore, as late as 1956 problems were still being experienced with the Mk 3 boat itself, never mind its airborne carriage.[6] Not long afterwards, probably in that same year, the lifeboat concept was finally abandoned in favour of the much handier, and far more reliable, Lindholme gear.[7]

Some sort of clearance for carriage by Shackletons must have been

An illegal immigrant vessel, found by No 38 Sqn, being handed off to the 3rd Destroyer Flotilla.

issued at some stage, however, because the SAAF order for eight MR3s included three Mk 3 lifeboats. A successful initial drop was made shortly after the aircraft began to be delivered, ie in 1957,[8] and this may have constituted a home-grown South African clearance. Nevertheless, the SAAF did not consider the boats to be a success and by 1960 they had been abandoned in favour of the Lindholme gear.[9]

Activities Overseas.

No 38 Sqn replaced its Malta-based Warwicks in 1946 when it acquired hand-me-down Lancasters from No 279 Sqn when it disbanded in the UK. Rather unusually, instead of re-instating its own wartime HD unit code letters, No 38 Sqn's Lancasters continued to wear the previous owner's RL. At the end of the year the squadron moved to Ein Shemar in Palestine where it was joined by No 37 Sqn, also flying Lancasters.

The main occupation was Operation BOBCAT, later DOCTOR and later still TERRY, which involved preventing Jewish refugees, many of them Holocaust survivors, attempting to escape from the horrors of their wartime existence, from reaching Palestine to start a new life. Unfortunately, that was contrary to a British policy dating from 1939 which had imposed quotas on Jewish immigration in order

A Lancaster ASR III of No 38 Sqn.

to maintain an acceptable communal balance compared to the resident Arab population. The result was that the RAF was obliged to spend its time on the rather sad duty of searching for Jewish ships and assisting vessels of the Royal Navy to intercept and escort them to Cyprus where their passengers were interned in pretty uncomfortable camps. It was not quite the same as today's trans-Mediterranean migrant traffic, but it still feels a little *déjà vu*.

A 1948 UN decision to partition Palestine between Arabs and Jews led to an increasingly violent turf war and, unable to keep a lid on the rapidly deteriorating situation, the UK announced that it would surrender its mandate. Both Lancaster squadrons had withdrawn to Malta by the end of March and the last British troops left on 30 June.

Both Mediterranean-based squadrons were lifeboat capable and they sometimes mounted an SAR detachment at Shallufa in the Canal Zone, occasionally reinforced by one of the UK squadrons. Between 1947 and 1950, eleven boats were dropped in Middle Eastern waters, three of which had been failures and one a successful live drop to the pilot of a ditched Tempest (see Annex A).

Flying Boats

In December 1950 the long-standing GR – for General Reconnaissance – designation, which had been the standard nomenclature since the introduction of the Anson in 1936, was changed to the more familiar maritime reconnaissance – MR. This applied to both landplanes and seaplanes. The latter had been going about their routine business, again with search and rescue being a primary concern, but there were periods of more intense activity .

Moored at Hong Kong (note Lion Rock Hill), Sunderland ML772 of No 88 Sqn, the aircraft damaged during the 1949 Yangtze Incident. (Andrew Thomas)

The first began in July 1948 in the context of the Berlin Airlift when Nos 201 and 230 Sqns, and No 235 OCU, began operating from Finkenwerder in Hamburg, taking off from the Elbe and landing on the Havelsee. The Sunderlands flew 4,500 tons of freight into the city, including 2,500 tons of salt, and brought out more than 1,000 people, mostly children, until ice on the Havel put a stop to their participation in December. They had flown over a thousand sorties.

A few months later, in April 1949, there was the Yangtze Incident. At the time the Civil War was still going on and it was the practice for the British Embassy at Nanking – about 180 miles up-river from Shanghai – to be provided with a Royal Navy guard ship. HMS *Amethyst*, a 1,300 ton sloop, was about half-way there to replace HMS *Consort* when she was fired on by field guns of the People's Liberation Army (PLA) on the north bank. She was hit more than 50 times and lost 22 men killed and another 31 wounded. Sunderlands of No 88 Sqn from Kai Tak landed on the Yangtze on three occasions to deliver replacement personnel and supplies. One aircraft, ML772, sustained damage from gunfire and had to be replaced. There followed a very tense three-month stand-off; *Amethyst* did not get away until July. In the meantime Shanghai had fallen to the Communists in May and No 88 Sqn had been involved again, evacuating about 100 British nationals in three sorties flown just before the PLA arrived.

A year later, 1950, the Korean War broke out and the three squadrons of the Far East Flying Boat Wing took it in turns to maintain a presence at Iwakuni to patrol the waters off the Korean coast. These Japanese interludes provided diversions from the Singapore-based routine where the Sunderlands were committed to participation in the long-running Malayan Emergency – Operation FIREDOG. A frequent tactic was for the Sunderlands to cruise over the mainland in an area where terrorists were known to be encamped, at night – all night – throwing out the occasional 20 lb fragmentation bomb, of which it could carry a lot, in order to keep the opposition awake and thus undermine their morale.

The Neptune

Meanwhile, the establishment of NATO in 1949, followed by the outbreak of the Korean War, had prompted a major rearmament programme. But, at the time, all that the UK could contribute to the Western Alliance in terms of maritime air was its handful of what now amounted to war surplus Lancasters and Sunderlands. The Shackleton was only just beginning to materialise in 1950 and it would be some time before a significant number could be deployed so, to bridge the gap, in 1951 the Americans allowed the UK to order fifty-two P2V-5 Neptunes under the Mutual Defense Assistance Program (MDAP).

In RAF service, they were all designated as MR Mk 1s, which is a little surprising, as there were several variations on the theme. For instance, the first nine aircraft had the Emerson 20mm turret installed in a, so-called, Aero 9B nose which was significantly shorter than the Aero 9C of the other forty-three.

There was one major drawback to the Neptune. Earlier production aircraft were produced in what became known as the ‘minelaying configuration’, in which most members of the tactical crew sat facing forwards in a compartment ahead of the wing, with the wireless and ECM operators stations separated from them by the substantial main spar, which was 3 feet thick and 7 feet wide. That had been a satisfactory arrangement in 1945 when the Neptune had first appeared but it did not facilitate the close co-operation and co-ordination that became necessary to get the most out of the increasingly sophisticated ASW equipment that began to become available during the 1950s.

To cater for this, the Neptune’s internal arrangements had been

A Neptune MR1 of No 217 Sqn.

extensively revised to create the ‘anti-submarine configuration’ in which all members of the tactical team, with the exception of the wireless operator, were now in the forward compartment sitting alongside each other facing to starboard in what became the conventional side-by-side layout for maritime aircraft. Unfortunately, all of the RAF’s Neptunes were delivered in the early minelaying fit – and they stayed that way.

The anti-submarine configuration was associated with later production models of the P2V-5 which had the tail turret replaced by a MAD stinger and the nose guns with an observation station. Half of the RAF’s Neptunes were retro-fitted in service to incorporate these changes but that did not extend to the crew compartment and none of the RAF’s aeroplanes ever acquired the underwing auxiliary turbojets that were often added by other operators.

The first Neptunes were delivered in 1952 and most retained their US Navy midnight blue colour scheme throughout their service, although by the time that they began to be withdrawn some had been repainted in the newly fashionable overall Coastal Command grey. They were used to equip Nos 36, 203, 210 and 217 Sqns which were primarily, but not exclusively, committed to working in the North Sea. In mid-1951 the UK had considered increasing its bid to a total of 129 aircraft with four additional squadrons in the Mediterranean, but that never happened.

Conclusion

The Neptunes were withdrawn from service in 1957, a year after the last remaining Lancaster had gone to the breaker's yard, although a handful of Sunderlands soldiered on in Singapore until the last of them was beached in June 1959. By that time the Shackleton was well-established in service, which completes this presentation.

Notes:

1 By January 1946, of those listed at Table 1, Nos 10 (RAAF), 14, 53, 59, 86, 143, 172, 206, 228, 235, 278, 281, 282, 407, 422, 423, 461, 489, 547, 612 Sqns had all been disbanded or transferred out of Coastal Command.

2 By January 1946, of those listed at Table 2, Nos 95, 191, 204, 212, 217, 221, 251, 270, 284, 292, 321, 333, 334, 343, 344, 458, 490, 618, 624 Sqns had either been disbanded or transferred to the recently re-established air forces of liberated France, Norway and the Netherlands.

3 TNA AIR20/6766. Air Staff Policy Memo (47)5 dated 31 December 1947 amplifying aspects of 'Plan F – Provisional Intermediate Front Line Target for the Royal Air Force Pending Publication of the Permanent Peace Force'.

4 Formally known as the Sea Rescue Apparatus Type A, the standard composition of a Lindholme Gear in the early post-war years, the Mk 2, was a multi-seat dinghy in the central container, flanked by a pair of supply containers on either side. By the 1960s this had been superseded by the Type A Mk 3, which retained the central dinghy but had only a single supply container either side. See AP 1182D, various editions.

5 TNA AIR19/394. From an unreferenced brief dated 10 November 1954, for USofS providing details of the SAR coverage being put in hand to support a visit to the West Indies by HRH Princess Margaret in the following February. Shackletons carrying Lindholme gear would be involved but the lifeboat facility was to be provided by a Lancaster.

6 TNA AIR24/2379. A note in HQ Coastal Command's ORB for April 1956 states that trials had revealed that 'the method for boarding the [*Mk 3*] lifeboat by distressed crews is suspect' and went on to anticipate a 'final instruction for return to storage.' The last Amendment List for the associated manual, AP4366A, Vol 1, *The Airborne Lifeboat Mk 3*, was No 30 dated July 1956.

7 A primary source reference for the eventual abandoning of the lifeboat concept has proved elusive but, according to Chris Ashworth in his *Avro's Maritime Heavyweight – The Shackleton* (Aston; 1990) p136, the RAF finally declared them obsolete in October 1956.

8 Daniels, Stephen Brewster; *Rescue From The Skies* (HMSO; 1994) p174.

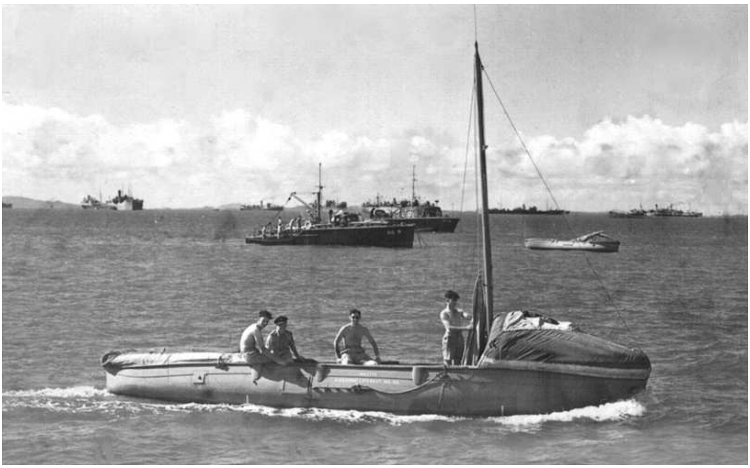
9 According to Steven McLean's *Squadrons of the South African Air Force and their aircraft 1920-2005* (Table View, South Africa; 2005) p316, the Mk 3 lifeboats were 'a dismal failure […] the only [*in service*] air-to-sea delivery exercise ever attempted saw the lifeboat breaking up when it hit the water.' This incident took place on 6 September 1960 and involved a Shackleton MR3 of No 35 Sqn.

Annex A: Airborne Lifeboats dropped 1947-53
(S = Success; F = Failure)

Date	Unit	Location	S/F	Remarks
25 Feb 47	38 Sqn	N of Tripoli	S	Live drop to ditched Tempest pilot
16 Apr 47	203 Sqn	Channel	S	Trial drop
2 May 47	120 Sqn	? (UK)	S	Practice drop
19 May 47	38 Sqn	Malta	S	Practice drop
? Jul 47	120 Sqn	? (UK)	S	Practice drop
? Jul 47	120 Sqn	? (UK)	S	Practice drop
8 Aug 47	St Eval	Martlesham Heath	S	Trial drop
14 Aug 47	224 Sqn	Felixstowe	S	Practice Drop
25 Nov 47	120 Sqn	Great Bitter Lake	S	Practice drop
27 Nov 47	120 Sqn	River Tay	S	Practice drop
10 Dec 47	210 Sqn	Marsaxlokk	S	Filmed drop – for new ASR training film
14 Jan 48	120 Sqn	Bridlington	S	RAFA display
29 Jan 48	37 Sqn	Red Sea	F	Op SHARKBAIT; para malfunction – boat wrecked on impact
? Feb 48	120 Sqn	? (UK)	S	Practice drop
12 Apr 48	38 Sqn	Malta	S	Practice drop
7 Jun 48	37/38 Sqn	Great Bitter Lake	F	Op ALLCHANGE; para malfunction – boat wrecked on impact
23 Jul 48	120 Sqn	off Shetlands	F	Live drop to ditched Lancaster, para malfunction, boat floated inverted
6 Aug 48	37 Sqn	Marsaxlokk Bay	F	Op BATHTUB; hang-up on release, 600 yd overshoot
16 Sep 48	203 Sqn	Teignmouth	S	Demonstration drop
18 Sep 48	203 Sqn	Plymouth	S	Demonstration drop
15 Feb 49	210 Sqn	Martlesham Heath	S	Trial of new drop

				procedure – across wind, instead of up-wind of dinghy
12 Apr 49	210 Sqn	Martlesham Heath	F	Release unit malfunction, landed with boat still on board plus 420 yd of trailing rope
20 May 49	203 Sqn	Martlesham Heath	S	Probably same trial as above
21 Jun 49	120 Sqn	Orkneys	S	Practice drop
16 Sep 49	37 Sqn	Great Bitter Lake	S	Demonstration drop
15 Mar 50	38 Sqn	Marsaxlokk Bay	S	Aircraft had brake failure; boat jettisoned prior to landing as a precaution
28 Mar 50	120 Sqn	River Tay	S	Practice drop
7 Jun 50	37 Sqn	Marsaxlokk Bay	S	Op BATHTUB
8 Jun 50	120 Sqn	River Tay	S	Demonstration drop for Army Staff College
10 Jun 50	120 Sqn	Scarborough	S	Practice drop
14 Sep 50	203 Sqn	Gibraltar	S	Battle of Britain display drop
14 Sep 50	203 Sqn	Newquay	S	Battle of Britain display drop
16 Sep 50	203 Sqn	Plymouth	S	Battle of Britain display drop
12 Dec 50	203 Sqn	Martlesham Heath	S	Trial of new drop procedure
10 Jan 51	210 Sqn	Martlesham Heath	S	Probably same trial as above
5 Apr 51	210 Sqn	Martlesham Heath	S	‘Experimental’ drop (possibly Mk 3 ‘boat)
19 Apr 51	120 Sqn	off Burghead	S	Practice drop
23 Aug 51	210 Sqn	Martlesham Heath	S	Drop of Mk 3 ‘boat
30 Aug 51	210 Sqn	Dartmouth	S	Demonstration drop
12 Sep 51	210 Sqn	Gibraltar	S	Battle of Britain

				display drop
12 Sep 51	210 Sqn	Newquay	S	Battle of Britain display drop
15 Sep 51	203 Sqn	Plymouth	S	Battle of Britain display drop
20 Sep 51	203 Sqn	Teignmouth	S	Demonstration drop
23 Oct 51	210 Sqn	Fowey	S	Drop to demonst-rate rocket failures to manufacturers
8 Aug 52	210 Sqn	Britannia Lake (Greenland)	F	Paras opened late and did not detach – boat damaged
26 Aug 52	210 Sqn	Newhaven	F	Paras malfunc-tioned – boat wrecked
23 Oct 52	210 Sqn	Plymouth	F	Paras failed to detach – filmed by 203 Sqn to invest-igate
9 Feb 53	203 Sqn	St Eval	S	Practice drop



A Mk II lifeboat being recovered by a crew from Seletar's Marine Craft Section after a successful demonstration drop from a Lancaster detached from Burma in March 1946.

MARITIME PATROL AIRCRAFT WEAPONS 1946 TO 2000+

Sqn Ldr Andrew Lovett

Andrew joined the RAF in 1967 and flew as a navigator on Shackletons and Nimrods. Following a stint as Station Weapons Officer at St Mawgan and an exchange tour in Canada flying the Argus and Aurora, he had staff appointments at HQ 18 Group, A&AEE Boscombe Down and MOD (OR). In 1989 he left the RAF to work in the aviation electronics industry. Since retirement he has gained an Open University BA and an MA in Art History from London University.

Introduction

After the Second World War Coastal Command aircraft continued to be equipped with guns, depth charges and bombs for Anti-Submarine Warfare (ASW). Some mining capability was also retained but this was lost in the mid-1950s when the Sunderland was phased out, just as conventionally powered submarines were becoming faster, more capable and quieter. To counter this increasing threat, homing torpedoes were developed as the main ASW weapon. But by the early 1960s the Soviet Navy had deployed a new generation of nuclear powered submarines that gave them a much greater offensive capability. More effective counters to this menace included improved homing torpedoes and the introduction of the nuclear depth charge or bomb. By the time the Nimrod MR1 was introduced in 1970, guns and conventional depth charges had been rendered obsolete. Air-to-surface missiles and further improved torpedoes were introduced to meet the steadily increasing Soviet naval threat. With the introduction of Sidewinder and Harpoon missiles during the Falklands conflict of 1982, the Nimrod MR2 acquired significant air-to-air and air-to-surface capabilities and also gained a conventional bombing role.

This paper describes the weapons and lists the pyrotechnics available to the RAF's maritime patrol aircraft between 1945 and 2010. Included is a brief account of the policy rationale that led to US nuclear weapons being adopted, first for the Shackleton, and then the Nimrod fleets. I wish to acknowledge the help and information that many people have given me while preparing this paper. In particular

The Boulton Paul Type N gun mounting of a Mk 3 Shackleton.

Jeff Jefford, the RAF Museum, Hendon, the National Archive, Kew and several members of the Coastal Command and Maritime Air Association have been most helpful. Any errors or omissions are my responsibility.

Guns

For attacking surface targets, particularly surfaced submarines, Lancasters and Sunderlands had been armed with 0·303 inch Brownings, the Neptune with ·50 calibre machine guns and the Shackleton 20 mm cannon. As the submarine's performance improved, initially through the adoption of 'Snorkel' breathing systems and then nuclear propulsion, which meant that they no longer needed to spend time on the surface, they became much more difficult to find and to attack. The few submarine types that needed to surface in order to fire missiles were so big that machine gun bullets, and even 20 mm cannon shells, would inflict only minimal damage. Bowing to the inevitable, guns were not specified for the Nimrod.

The Shackleton was equipped with Hispano-Suiza HS404 20 mm cannon.[1] Originally fitted in nose, mid-upper and tail turrets; later

A clutch of depth charges about to be loaded into a Shackleton of Gibraltar's No 224 Sqn.

marks of the aircraft had a reduced gun complement. The tail turret was an early deletion while the mid-upper was removed by Mod 771 and replaced by the ORANGE HARVEST Electronic Support Measures (ESM) sensor. The final version of the much-modified Shackleton nose incorporated a Boulton Paul Type N Mk 1 Mounting fitted with a pair of 20 mm Hispano No 4, Mk 5 cannon with 313 rounds per gun. This total included approximately 195 rounds of cannon shells in each ammunition box, 100 rounds in each track system with 18 rounds in each belt feed. The firing rate was approximately 750 rounds per minute.

Mines

The Sunderland could carry 1,000 lb naval mines that were released from traversing racks under the wing centre section onto which they were winched from the bomb room in the fuselage. The manhandling of such heavy weapons must have been difficult, slow and bordering on the hazardous.

Depth Charges

The Sunderland, Neptune and Shackleton were all able to deliver the 250 lb Mk 11 Depth Charge. Hydrostatically fused, its underwater detonation was intended to create an over-pressure that would crush a submarine's hull but, in practice, this was only effective at extremely close range. A killing radius of a mere 3-4 metres was likely against a conventional 1,000 ton submarine, and even the disablement radius only extended out to about 8-10 metres. Significantly increasing the explosive content would have made little difference because the blanketing effect of water decreases the power of an underwater explosion by an inverse cube law, ie doubling the explosive effect at twice the distance would only increase the over-pressure by one eighth.

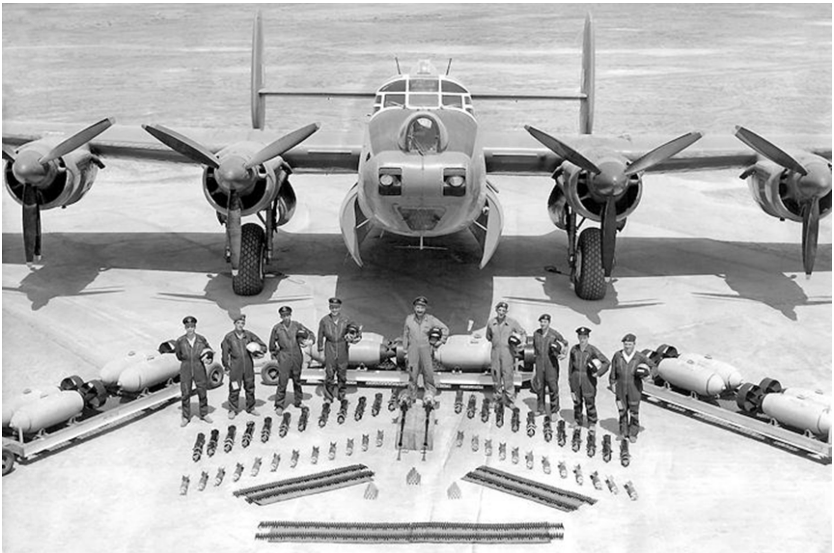
The feeble performance of conventional depth charges was well understood, of course, and in July 1957 the requirement for a Nuclear Depth Charge for Anti-Submarine Operations stated: ‘The depth charge is at present the primary weapon available in quantity for operational use. It is obsolescent and useless against a submerged submarine.’[2]

Bombs

The use of bombs by maritime aircraft was largely confined to campaigns in which they had been diverted into overland operations. The Sunderland could carry up to 2,000 lb in a mix of 250 lb or 10 lb and 25 lb anti-personnel bombs and 500 lb bombs. The Lancaster could deliver as many as fourteen 1,000 pounders while the Neptune carried up to 8,000 lb distributed between the bomb bay and underwing racks.

The Shackleton carried up to fifteen 1,000 lb bombs in the bomb bay. This aircraft had a very versatile but complicated weapons system that allowed almost any of its eleven different types of weapon and/or pyrotechnics to be carried on any one of fifteen weapons stations. Most were loaded externally onto bomb carriers which were then fitted onto the weapons stations in the bomb bay. This had the advantage that each weapon station could then carry multiple small weapons such as 20 lb fragmentation bombs. The carriers had a standard 100 lb or 1,000 lb capacity and there was also a, rarely used, facility for carrying a 2,000 lb bomb.

The Shackleton’s Type F Selector Switchbox controlled the individual electrical circuits of up to sixteen bomb stations but was linked to them in the bomb bay through the Type B Pre-Selector Unit or Connel Pre-Selector Unit. This device allowed any bomb station to be connected electrically to any switch in the Selector Switchbox and thus to any contact on the bomb distributor without disturbing the permanent wiring of the bomb release installation. A manually set Type 7 Distributor allowed a stick of stores to be dropped with the required separation and a bomb firing switch enabled the selected



A Mk 2 Shackleton of the Khormaksar-based No 37 Sqn with a display of the cannon shells and bombs of various sizes, up to 1,000 lb, that could be used in the internal security role.

stores to be released. There were separate safety/armed and weapons jettison circuits and a completely stand-alone circuit for nuclear depth bombs, which required both pilot and navigator input for weapon release.[3]

The routine/attack navigator released the weapons for sub-surface attacks but the pilot released depth charges on a visual target such as a surfaced submarine. The tactical navigator used a Mk 1 high level bombsight for medium level bombing or a Mk 3 low level bombsight for dropping torpedoes on a surfaced submarine. Depending on the operational task, the appropriate bombsight was installed in the bomb aimer's position in the nose of the aircraft.

During the Falklands conflict the Nimrod was modified to carry up to eleven 1,000 lb ballistic or retarded bombs. A simple visual sight was fitted for the co-pilot to use but this device, combined with the limited visibility from the cockpit, meant that accurate weapon delivery would have been problematic. No bombs were dropped in anger during Operation CORPORATE.

Torpedoes

Propulsion. For a successful attack on a submarine a torpedo's speed is of critical importance. An ASW torpedo needs a 50% speed advantage over a submarine to ensure that the target cannot escape. Nuclear submarines, which can operate at depths of up to 1,000 ft, are capable of speeds of around 30 kt. Modern torpedoes are powered either by thermal engines, such as gas turbines and swashplate piston engines, or by electric power. Thermal engine propulsion systems use high density, and often highly toxic, fuel such as Otto II, which provides the oxygen necessary for combustion and subsequent power generation. Electric power is relatively cheap, utilizes long-life silver oxide or magnesium batteries and has the major advantage of being very quiet. However, this is achieved at the expense of reduced range because the power density of batteries is less than that of thermal engines. As with submarines, in an attempt to improve propulsion and silencing, torpedoes have much modified propellers. Pump jet propulsors encase the propellers in a shroud or duct taking water through an inlet in the front of the weapon and pushing it out at the rear which both reduces noise and increases speed.

Guidance. Passive sonar homing torpedoes are reliant on the acoustic noise generated by the target submarine. This noise is produced both from the flow of water over the submarine's hull and that generated by the cavitation of the submarine's propellers as they drive the vessel onwards. A passive torpedo will sense the direction from which the acoustic noise is generated and then steer towards the target. At a pre-set noise threshold, the speed of the torpedo will increase and on impact with the submarine, the warhead is detonated by a pistol. But a passive weapon is of very limited use against quiet modern targets so in recent years active sonar guidance has become the preferred homing method. The acquisition range of the acoustic seeker head of an active torpedo depends on its interrogation rate – its 'ping rate' – which, in order to improve accuracy, increases as the weapon nears its target. The homing seeker's aspect angle, which is the vertical angle that determines the transmission and reception of the pings, decides whether the torpedo searches in a helical or a snakelike search pattern. Most air launched weapons initially use a helical search. Modern torpedoes usually have both active and passive seeking modes.

However, to be successful active homing torpedoes still have to overcome many obstacles. Flow noise over the acoustic seeker head of an active homing torpedo tends to interfere with its operation but in more modern types of weapon better signal processing and seeker head dome shaping have brought about some improvement. Since active sonar can be heard at some distance, a submarine hearing an incoming torpedo may accelerate and release decoys as it attempts to escape. Near the surface or in shallow water, when sound reflections and reverberations interfere, the seeker head may exploit the Doppler effect to distinguish the real target from the clutter. In recent years much effort has been expended in improving seeker head performance in shallow water.

Warhead. Within the constraints of a lightweight torpedo frame it is possible to engineer space for a warhead of about 100 lb. The explosive is usually Torpex or equivalent and this has changed little over the years in spite of the greatly increased size of modern submarines which clearly require additional destructive power if significant damage is to be inflicted. Some torpedoes have shaped charge warheads to force the explosive power in a specified direction, so increasing the weapon's lethality. As a counter to this, some submarines, like the Russian *Typhoon* Class, even have double-skinned hulls with the outer layer acting as a shield for additional protection against an explosive charge.

Mk 30 Torpedo.

Developed from the unsuccessful Dealer project, the Dealer B or Mk 30 (Mod 0) air-dropped passive acoustic homing torpedo was expected to be replaced by the Mk 30 (Mod 1) that incorporated several improvements but in 1955 this weapon was cancelled in favour of procuring an American torpedo. When dropped, the Mk 30 deployed a small parachute to slow the entry into the water. The parachute was then jettisoned and the weapon started to sink, while sea water activated the batteries that started the electric motor. The torpedo then commenced a search pattern, probably a flat circle at a pre-set initial search depth before diving to a pre-set floor depth to repeat the process. If at any time the acoustic sensors detected radiated noise above a set threshold, this would be treated as the target and the

Left, an inert 18-inch Mk 30 torpedo and right, the much slimmer Mk 44. (RAF Museum)

weapon would break off from the search mode and home towards the noise source, at the same time increasing speed.

The Mk 30 was 8 feet long and had a diameter of 18 inches. It weighed 646 lb of which 100 lb was the Torpex warhead. It had a range of 830 yd at 19 kt or 3,000 yd at 12·5 kt. Some 1,200 were built for the RAF and RN and it was in service from 1954 to 1975.

Mk 44 Torpedo

During the 1950s the US Navy started two programmes to develop a new generation of lightweight anti-submarine torpedoes. One project was developed by the Naval Ordnance Test Station in Pasadena, CA, the other by General Electric's Ordnance Department in Pittsfield, MA. The latter was the preferred solution and entered production as the Mark 44 (Mod 0). Fine tuning led to the Mark 44 (Mod 1) that entered US service in 1956. The weapon had similar characteristics to the Mk 30, in that it was air-dropped, retarded by parachute and driven by an electric motor powered by a sea water-activated battery; it used an initial spiral search pattern.

It soon became apparent that the latest deeper-diving and faster Soviet submarines could outrun the Mk 44, rendering it obsolete. Some improvements were made by Honeywell who redesigned the nose mounted transducers and replaced the analogue guidance with a digital system, increasing detection range by about 75% and improving the shallow water performance. Weighing in at only 432 lb with a 75 lb warhead, the Mk 44 was 8·2 feet long but much slimmer than the Mk 30 with a diameter of only 12·75 inches. Capable of 30 kt with a range of approximately 6,000 yd the Mk 44 was very widely used, more than 10,000 being built for the US Navy and it was produced under licence in Canada, France, Italy, Japan and the UK. The Mk 44 torpedo was in RAF service from 1962 to 1982.

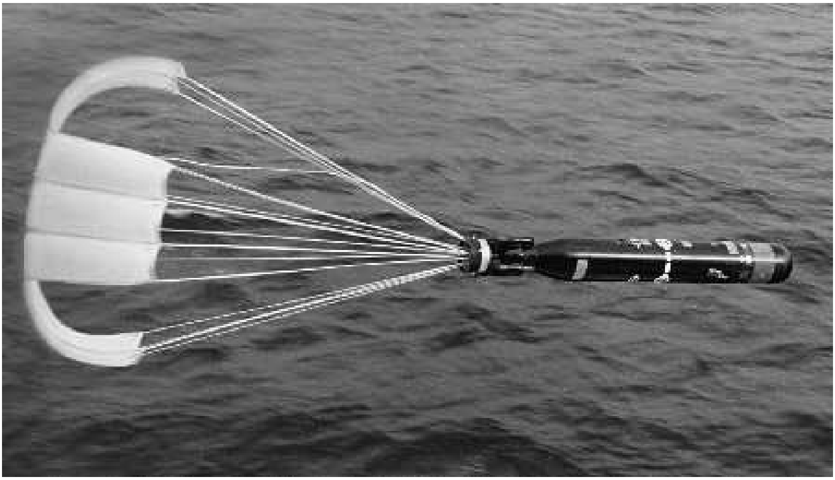
Mk 46 Torpedo

The Mk 46 torpedo, which was both ship and aircraft-launched, entered US Navy service in 1965. Designed by Aerojet-General, it was manufactured by a number of US defence companies, the latest being Raytheon which produced the Mod 5A(S). In September 1996 the US Navy implemented a Service Life Extension Program (SLEP) to produce the upgraded Mk 46 Mod 5A(SW). This provided better counter-countermeasures performance, enhanced target acquisition, a bottom-avoidance pre-set and improvements in acoustic performance, maintainability and reliability. The Mk 46 used a thermal external combustion engine, rather than an electric motor. Apart from needing no atmospheric oxygen, the much higher fuel energy density of its Otto II fuel gave the Mk 46 a significantly better speed and range performance compared to earlier torpedoes. Similar in size to the Mk 44, it was a little heavier at 508 lb and had a slightly larger 96·8 lb warhead. It was capable of better than 40 kt over a range of about 12,000 yd. More than 26,000 were built and it has been supplied to more than thirty countries. It was used by the RAF from 1975 until the 2000s.

Stingray.

To counter the much quieter submarines that began to appear in the 1960s, the UK had sought an active/passive replacement for the Mk 30 torpedo. Despite a great deal of effort and treasure being expended, the Mk 31 project failed to satisfy the requirement and was cancelled, hence the acquisition of the US-designed Mks 44 and 46. But, reluctant to be totally dependent on imported technology, a new British programme was begun as Naval Staff Requirement 7511; this eventually became the Stingray.

Having cost some £920 million to develop, Stingray Mod 0 became operational in 1982 during Operation CORPORATE. It was propelled by a pump jet driven by an electric motor which provided high speed, deep diving and marked agility combined with low noise levels. The weapon was originally manufactured by GEC-Marconi which later became part of BAE Systems. Stingray Mod 1 entered service in 2003, conferring an enhanced capability against small conventional submarines and an improved shallow water performance. Having similar dimensions to the Mks 44 and 46, it was a little heavier



Like all post-war air-delivered torpedoes, Stingray was parachute retarded.

at 589 lb and had a 98 lb Torpex warhead. It could travel at 45 kt and had a range of the order of 9,000 yd. It remained in RAF service until the withdrawal of the Nimrod in 2010 and is still in service with the RN.

Missiles

AS11/AS12

Unlike its predecessor, the cannon-armed Shackleton, the Nimrod MR1 lacked guns so its only option against a surfaced submarine would be to use its torpedoes but these would be ineffective because their minimum depth settings precluded their use against a target with a draft of less than 30 ft. The solution was to procure Nord Aviation's AS12 air-to-surface wire-guided missile. Six feet long and weighing 170 lb with a 60 lb warhead it had been designed in the mid-1950s and equipped the Nimrod MR1 between 1969 and 1975. Aimed and fired by the co-pilot, it had a range of about 8,000 yds but it was difficult to use, as there was no proper sight, and, since the missile flew at only 200 kt, it increased the aircraft's exposure to any opposing fire.[4] A practice weapon, the AS11, had a reduced range and a 15 lb warhead.

MARTEL

MARTEL was an Anglo-French dual-purpose anti-radar (the

Following a successful trial firing on 27 May 1982, Nimrod MR2s were armed with AIM-9G Sidewinders during Operation CORPORATE.

AS37) or TV-guided (the AJ168) air-to-surface missile. It was well suited to an anti-shipping role because of its long range and large warhead. Jointly designed by Hawker Siddeley and Matra, its name was a contraction of Missile Anti-Radiation and Television. Nimrod was only ever intended to be armed with the AJ168 which was controlled by an operator on board the delivery aircraft passing steering commands via a two-way data link in response to the images produced by a TV camera mounted in the nose of the missile. There was a designated MARTEL Station in the aircraft where the TV monitor was to be installed but the missile was only intended to equip aircraft operating from Kinloss and Luqa and the programme had not been fully implemented before it was terminated in 1975, although MARTEL continued to be used by the Buccaneer force until that aircraft was withdrawn from service in 1994.[5]

AIM-9 Sidewinder

During Operation CORPORATE in 1982, the Nimrod MR2 was hastily armed with the Raytheon AIM-9G Sidewinder. Up to four of these 9·4 ft, 192 lb air-to-air missiles could be carried utilising the hard points on the outer wings originally intended to carry the AS12. With a range of about 10 miles at a speed of M2·5+ this provided the Nimrod with a viable engagement capability, the potential target being an Argentinean Boeing 707.

AGM 84 Harpoon

Like Sidewinder, the RAF acquired the AGM-84 Harpoon anti-ship missile during the Falklands campaign. Trials, including one live firing, were flown with the Nimrod MR2 during May/June 1982. Two weapons could be carried line astern in the bomb bay, rather incongruously leaving room for a set of Air Sea Rescue containers in between, although three Stingray torpedoes was the preferred option. The 12·6 ft, 1,160 lb Harpoon was a tight fit and the fact that it could only be accommodated in the bomb bay 'with small rectangular sections being cut out of the bomb door blue foam insulation to give clearance for the fins' is an indication of the somewhat *ad hoc* expedients tolerated during Operation CORPORATE.[6] As the turbojet motor could not be started until the missile had left the aircraft, to provide sufficient time and safe separation for ignition the minimum height for weapon release was 3,000 ft. Thereafter the missile dropped to sea-skimming height and cruised at 460 kt for 60+ miles. Once the target data had been inserted, it was a fire and forget weapon which used inertial navigation en route with active radar terminal guidance.

Accommodating the wings of an AGM-84 Harpoon in the weapons bay of a Nimrod was a snug fit when the doors closed. (britmodeller,com)

Pyrotechnics

A number of pyrotechnic devices were used in maritime aircraft, either for marking a position on the sea surface worthy of further investigation or for illuminating the sky at night. They included:

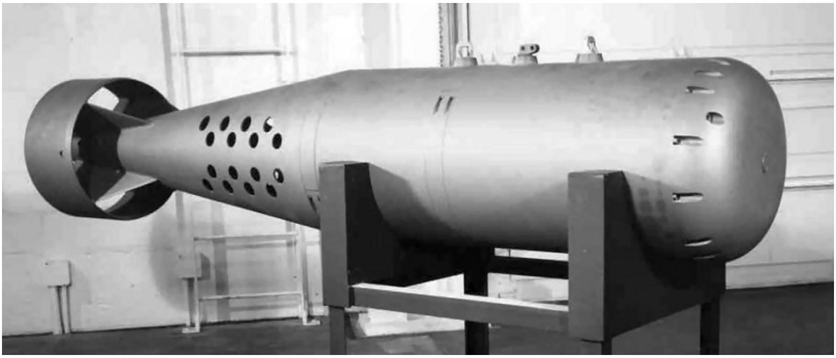
a. Smoke and Flame Floats.
b. Marine Marker No 4.
c. 4·5 in Flare.
d. 5 in Flare.
e. Retro Marker.
f. Cartridges, Illuminating 1·75 in.
g. Cartridges, Photoflash 1·75 in.

Nuclear Depth Bombs

In January 1958 a note from DCAS to the Defence Research Policy Committee, Atomic Energy Sub-Committee gave reasons to develop a nuclear depth charge capability. These included defending our sea communications against attack by enemy submarines and countering the possibility of bombardment by submarine launched nuclear missiles. It was estimated that a 9 Kt bomb would be lethal to a submarine at a depth of 500ft at a range of up to a mile. The requirement was for a nuclear depth bomb (NDB) which would be carried by all marks of Shackleton. The ultimate aim was for a yield of between 30 and 50 Kt, 'However, if economy of fissile material or development time reduced, the Air Staff is prepared to accept lower yields prior to 1970.'[7]

But Coastal Command really needed an NDB long before that. During 1957 there had been correspondence between the Air Ministry and Coastal Command about the inadequacy of the available anti-submarine weapons against the expected increasing soviet nuclear submarine threat. A DDOps(M) memo of July 1957 stated that 'The depth charge is at present the primary weapon available in quantity for operational use. It is obsolescent and useless against a submerged submarine.'[8] The only homing torpedo in the inventory at the time, the Mk 30, could not match the speed of a nuclear boat so a nuclear weapon was considered to be the only effective counter. In December 1957 AOCinC Coastal Command, Air Mshl Brian Reynolds, wrote to ACAS(OR) advising him that during his recent visit to the USA, SACLANT, Adm Jerauld Wright, had indicated a willingness to supply American NDBs, subject to the lifting of the McMahon Act.[9] In the meantime the UK had to go it alone, the requirement being spelled out in OR1156 of January 1958.

Initial thoughts focused on adapting the RED BEARD or one of the other projected British warheads, all of which were still under development, but the partial repeal of the McMahon Act shortly afterwards permitted the US to solve the problem by supplying the Mk 101 Lulu under Project N. This eight-foot long weapon, which is generally recognised as having a yield of 11 Kt, was designated by the British as the Bomb, Aircraft, AS, 1,200 lb MC. It was to be carried by Shackleton MR2s and 3s both of which would require extensive modifications to their armament systems. These were incorporated within the Phase III update programme and upgraded aircraft began to reach the squadrons in 1966, finally satisfying OR1156. Stocks of weapons earmarked for use by the RAF were held and maintained



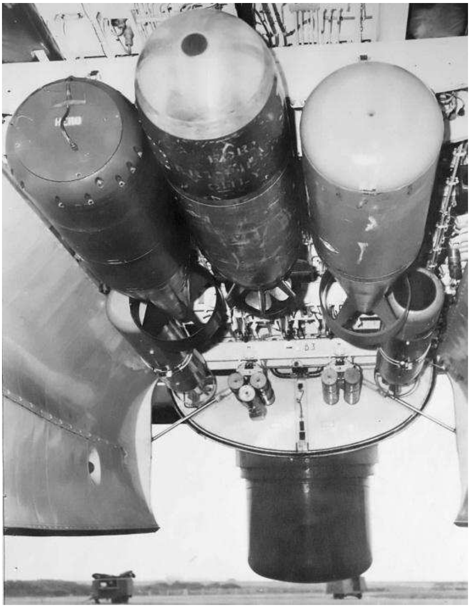
An American Mk 101 Lulu NDB aka
the Bomb, Aircraft, AS, 1,200 lb MC.

under US custody at St Mawgan.

While the US Mk 101 had provided an early solution, the RAF was not entirely satisfied with its performance. For instance there was, reportedly, a significant hazard in that it lacked a facility to prevent the weapon from being armed in the event of an inadvertent release which meant that it was bound to detonate when it reached its pre-set depth. As early as April 1966 OR3 minuted ACAS(OR) to point out that there was currently no British NDB and that, while a version of WE177 could be developed, its kill probability against a submarine was estimated to be no better than 40% and that this would have to be improved 'for the HS801 aircraft to AST357.'[10] Thus the Shackleton Mk 2 replacement programme, the Nimrod MR1, was being used to underpin the case for a bigger better British bomb, although this never actually happened.

The British nuclear weapon requirements, OR 1177, eventually produced the three variants of the WE177 series of which the low-yield WE177A could be delivered as an NDB and this entered service as such with the RN who would have delivered it from helicopters. A document on the 1969/70 nuclear policy file notes that:[11]

> 'The rate of production of WE177A cannot match the build-up of the new strike and LRMR squadrons and it has been agreed that the US will provide weapons for […] the Nimrod force when operating in the Atlantic and Mediterranean areas. […] WE177A will, however, be provided for the Nimrod when

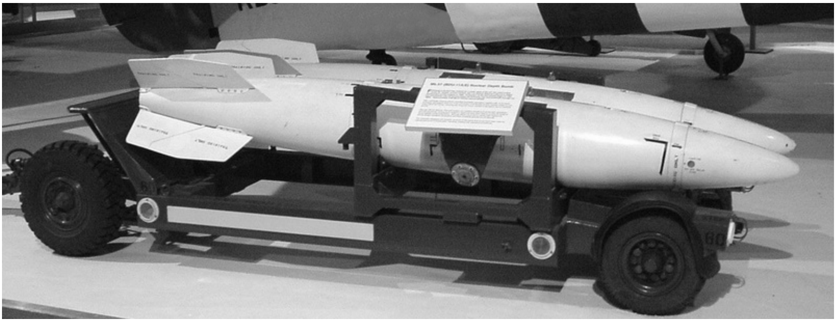


A representative weapon load in a Mk 3 Shackleton might have comprised, as here, a Mk 30 torpedo flanked by a pair of Mk 101 NDBs with, behind, a pair of Mk 44 torpedoes and five marine markers.

production allows.'

It would seem that production never did allow, because WE177A was never allocated to the Nimrod force which continued to be armed with American bombs. Apart from the limitations imposed by production capacity, this may have been a purely political decision. While the UK intended to build sufficient nuclear weapons to maintain a viable, if notional, independent deterrent, NDBs would only be required in the context of a war involving the whole of the western alliance. In that case the availability of American weapons would be assured, so there was no need for the UK to overprovide. Whatever the reason, the Mk 101 Lulu was eventually superseded by the US B57, which could be delivered by a variety of aircraft, including supersonic fighter bombers, so it had a streamlined casing. About 12 ft long with a 10 Kt warhead, it was designated the Bomb, Aircraft, AS, 550 lb MC by the British. As with the Mk 101s, stocks earmarked for the RAF were held at St Mawgan and they remained available until they were withdrawn early in the 1990s following the end of the Cold War.

As an aside, it is interesting to observe that, within the RAF, the Shackleton, and Nimrod, were unique in being able to carry mixed loads of nuclear and conventional weapons.



A pair of US B-57 NDBs, aka Bomb, Aircraft, AS, 550 lb MCs on display at the RAF Museum, Hendon.

Notes:

[1] AP101B-1702-1B1, Sect 5 and AP4267E, Vol 1, Book 1, Section 5, Chapter 3 AL16, Feb 66.

[2] TNA AIR2/13692. AF/CMS 45/64, Part 1, Mar 57-Aug 58). E7A: BE/235/DD Ops (M) July 57 – Requirement for Nuclear Depth Charge for Anti-Submarine Operations, para 13.

[3] AP101B-1702-1B1 Sect 4.

[4] AP101B-0501-1H Nimrod aircraft Servicing Manual Ch 81 (deleted by AL 59 Apr 75).

[5] An account of the development of both versions of MARTEL and of their employment by the Buccaneer force was published in this Society's Journal 62 (2016).

[6] *Constant Endeavour*, Newsletter of the Coastal Command and Maritime Association, Summer 2014, No 33, page 30.

[7] TNA AIR2/13692. AF/CMS 45/64, Part 1, Mar 57-Aug 58.

[8] *Ibid*.

[9] The US Atomic Energy Act 1946, *aka* the McMahon Act, had stipulated that the US would not share information concerning atomic weapons, obliging the British government to embark on a national programme. This situation prevailed until 1958 when, following the UK's demonstration of a viable national nuclear capability, the terms of the Act were relaxed sufficiently to permit the signing of the US-UK Mutual Defense Agreement on 3 July.

[10] TNA AIR2/18509. E20A, Future nuclear weapon system requirements 1966-1970, p1.

[11] TNA AIR2/18210. Nuclear Weapons Policy file, E63, p4.

ACQUIRING THE POST-WAR AEROPLANES

Wg Cdr 'Jeff' Jefford

The aim of this paper is to review the rather tortuous sequence of events whereby the RAF acquired its home-grown post-war maritime aeroplanes – the Shackleton and Nimrod. Other presenters will discuss the characteristics of those aeroplanes; this paper is concerned with how the RAF came to have them – and some others that it might have had.

What follows draws extensively from a recent book by Chris Gibson, *Nimrod's Genesis*.[1] The author was invited to speak himself, but was unable to commit to the date. Nevertheless, he generously permitted this writer to plagiarise his work, and to use many of his illustrations. Broadly speaking, that is what has been done, although the trail laid by *Nimrod's Genesis* has been re-traced in order to identify, and to be able to provide references to, selected key primary sources.

Flying Boats

Although it turned out to be a dead end – one of several – the first avenue that we have to explore is the flying boat. Seaplanes had been an integral element of maritime air power, and commercial aviation, ever since WW I and it was assumed that that would continue to be the case. In 1945, therefore, the RAF, and BOAC, both carried on flying boats more-or-less as if nothing had happened.

Shorts had already built a next-generation boat, the enormous Shetland. Designed to a 1940 specification, the prototype had flown at the end of 1944 but the Air Staff concluded that, without a major re-design, it could not satisfy the RAF's initial thoughts on the characteristics required of a post-war maritime patroller. In December 1945 the Air Council decided that this would not 'warrant the very large cost involved'.[2] That effectively ended the Shetland's prospects, any remaining doubts being removed a month later when the military prototype was burned out at its moorings. Work continued for a while on a second airframe with a view to its use as a commercial transport but that also led nowhere. That left everyone operating the Sunderland or one of its civilian derivatives. But this was underpinned by an assumption that nothing had really changed since the 1930s. But it

Even a task as straightforward as refuelling could be a complicated and cumbersome business afloat.

had, because airfield construction had become a growth industry during WW II and by 1945 much of the globe had been provided with paved or blacktopped runways.

Apart from being inherently far more economic, landplanes are much easier to operate than seaplanes. For instance, the relatively straightforward process of refuelling a landplane was more difficult, even hazardous, afloat, especially if a sea was running. The same was true of maintenance – there was no way to retrieve a dropped spanner and having to manage while working from a raft could make changing an engine a challenging procedure. Furthermore, while any aeroplane may become involved in a landing accident, a relatively minor incident like leaving the runway, or even a belly-landing, was a lot less likely to result in catastrophic damage than a similar incident at sea.

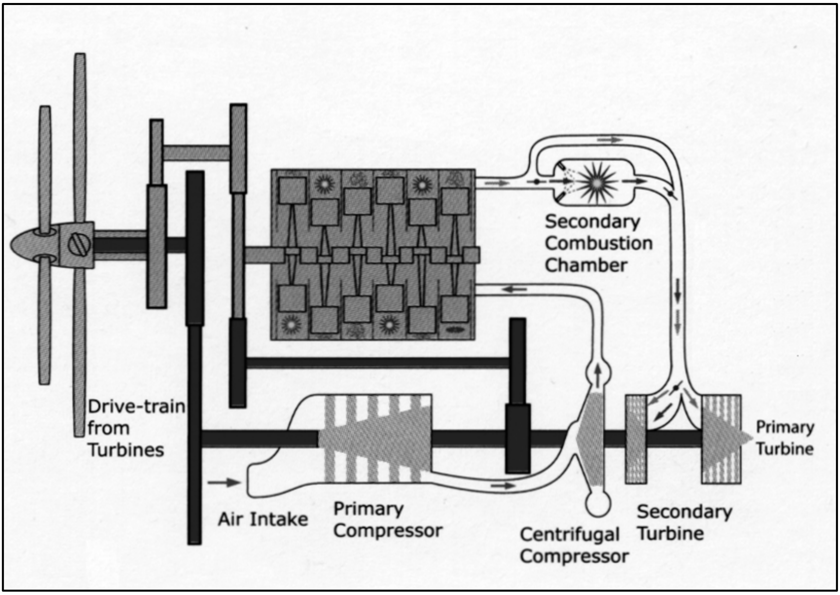
So the writing was on the wall for the seaplane, but dedicated marine aviators, who constituted, to a degree, an air force within the air force with its own very different practices, attitudes and ethos, had some difficulty in reading it. As a result, the voice of the flying boat lobby was loud enough to keep the torch burning – for a while at least.

The first attempt to define the post-war British requirement was outlined in November 1946 in an initial draft of OR231 which envisaged a flying-boat, able to transit at 250 kt and then patrol for 8 hours at 1,000 miles from base while toting an 8,000 lb warload.[3] In due course, OR231's 'wish list' was trimmed back somewhat to reflect reality, resulting in the issue of Specification R.2/48 in October 1948. This called for a boat in the 100,000 lb class with (probably) four engines – type unspecified – able to transit at 200 kt with a 4,000 lb warload and stay on station for four hours 1,000 miles from base while patrolling at a sensible speed.[4]

Blackburns are thought to have shown some interest, but the primary flying boat builders, Saunders Roe, Supermarine and Shorts all submitted firm proposals – three original ideas with Shorts offering two relatively inexpensive alternatives based on exploiting the existing Shetland and Seaford, the latter being an extrapolation of the Sunderland.

The question that was left unresolved was the choice of power plant. By the late 1940s aero-engine technology was in a state of transition. The available turbojets were still limited in power, and thirsty, which made them suitable for little aeroplanes, like fighters, and even medium-ranged larger ones, like the Canberra and Comet but propellers were still needed for really long range – or endurance. Hence the Constellations, Stratocruisers and DC-6s that were currently handling commercial traffic on the transatlantic routes. But powerful piston engines, represented in the UK by the 2,000-2,500 hp Griffon and Centaurus, were just about at the limit of their potential and industry was doing its best to squeeze greater efficiency from them by recovering and re-using the energy represented by the exhaust gas produced by any reciprocating engine.

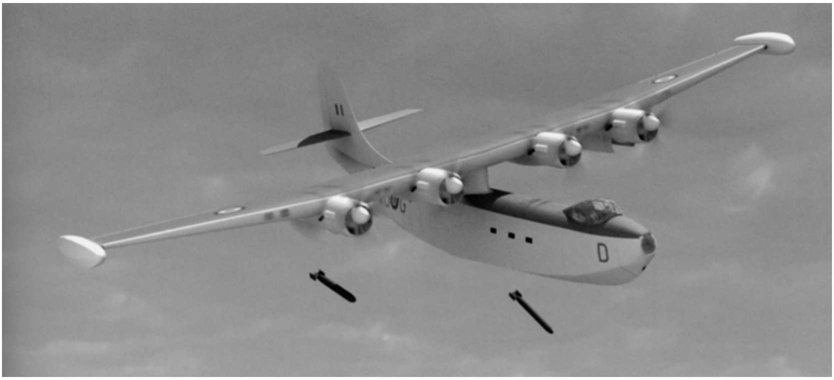
A great deal of effort was expended, particularly by Napiers, in trying to perfect a turbo-compound engine. The idea was to use the exhaust to drive a turbine which would, in turn, drive a compressor which would feed atmospheric air to the cylinders to increase intake manifold pressure – while the shaft rotation was transmitted, via gearing, to the crankshaft to provide a mechanical boost. In the ultimate realisation of the concept a second-stage turbine and compressor was added with the shaft rotation now being used to drive one half of a contra-rotating propeller. While that was easy enough to say, it was much harder to engineer and the complexity of such engines made them prone to failure.



Schematic of a turbo-compound engine providing some impression of its complexity, in the case of the Nomad, the 'boost' element roughly doubled the bulk of the engine. (Chris Gibson)

While Rolls-Royce soon gave up on this concept to focus instead on the relatively simple, and what would become, the industry standard – the turboprop – Napiers persevered with their rather remarkable Nomad until the mid-1950s. The Nomad was almost twice the size of a Griffon, half of its bulk being made up by the supercharging machinery. It was, at heart, a 12-cylinder, horizontally-opposed, compression-ignition engine, that is to say a diesel, that produced better than 3,000 hp, and in the contra-prop case, 4,000 hp and, and this was the real point, the lowest fuel consumption of any engine of similar power. That made the Nomad, at least in theory, the ideal choice for a maritime patroller.

It was considered for retro-fitting to the Shackleton from time to time and a prototype installation actually began, although it was never completed. It has been estimated that the Nomad would have provided a 35% increase in range, on existing tankage.[5] The problem was that, while it may have promised to be the most efficient engine ever, the



A late variation on the theme of Short's PD2 which was the Ministry of Supply's preferred submission to R.2/48 – it was not the Air Staff's. (Adrian Mann)

Nomad has also been described as being the most complicated and that, along with a lack of a specific application, was its eventual undoing.

Two of the submissions for the R.2/48 flying boat were Supermarine's Type 524 and Saunders Roe's P.104. Both would have weighed-in at about 100,000 lb and were offered with a variety of engines, including the conventional Centaurus, the Proteus turboprop or the turbo-compound Nomad. As originally conceived, the third submission, Short's PD2 would have been, like the others, a classic two-deck, Sunderland-style, deep-hulled boat with Centaurus or Nomads but for a Turbo-Griffon option, the two-deck hull was reduced to just one to produce something more akin to the Catalina.

The Air Staff considered Saunders Roe's P.104 to be the best prospect but the Ministry of Supply had doubts about the company's capacity to build it and in 1950 its favoured option was Shorts and its PD2. This decision may not have been entirely unconnected with the fact that Shorts had been nationalised in 1943, so the Government actually owned the company. But, despite this essentially political and economic preference, there was still doubt as to whether to go ahead with any new flying boat.

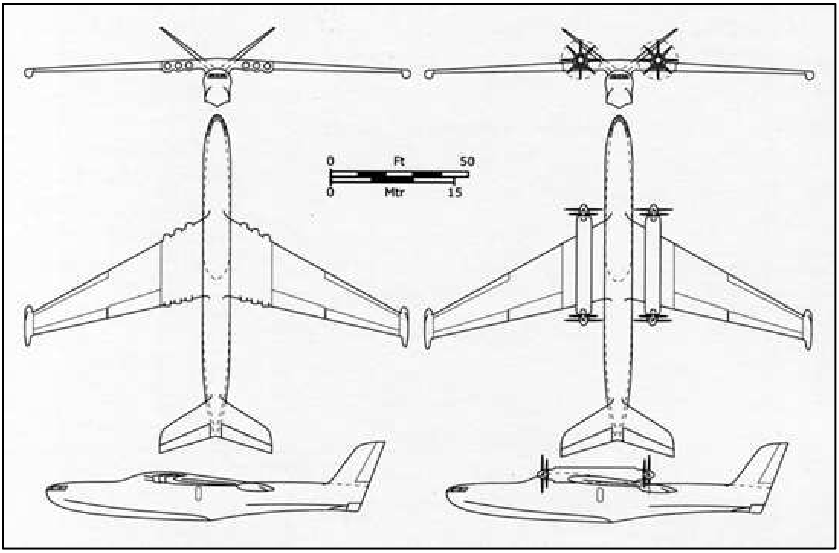
Opinion was becoming increasingly polarised between those who regarded flying boats as an anachronism and the diehards who maintained that they offered unique capabilities. With the outbreak of

A selection of the 338 marine craft required to sustain the eighteen UK-based Sunderlands. Clockwise from top left: a Refueller Mk VI; a Fire Float Mk IA; a Bomb Scow and a Seaplane Tender Mk IA.

the Korean War in 1950 and the need to make a decision as to whether, or not, to replace the Sunderland before the end of the decade, the debate began to intensify. In the light of the Cold War which was now beginning to gain some real traction, CAS, Sir John Slessor, asked a very pointed question in February 1951.

> ‘Does our survival in the early stages, or our ability to win a future war depend on our having a big long-range flying boat?’[6]

A definitive answer did not emerge immediately, but the question does rather suggest which side Slessor may have been on. He was certainly aware that flying boats were relatively expensive, and very fussy, to operate. For instance, one relevant statistic cited in 1955 indicated that to maintain and service the RAF’s then current UK-based fleet of eighteen Sunderlands required no fewer than 338 assorted small craft.[7] This was, of course, in addition to the wheeled fuel bowsers, trucks, Land Rovers, tractors, bomb-trolleys, Coles cranes and all the other conventional vehicles that were required to



Two variations on the theme of Saro's military Duchess. (Chris Gibson)

sustain activities ashore.

An earlier calculation, made in 1951, had indicated that three squadrons, each having five R.2/48 flying boats capable of maintaining a 4 hour patrol at 1,000 miles from base would cost £14·36M. The Shackleton Mk 1 was only expected to be able to provide 4 hours at 800 miles so to maintain coverage at 1,000 would require more of them, three squadrons of eight aircraft each, but this would still cost only £10·09M. In practice, the Mk 1 was probably even less capable so the figure might have been more like ten Shackletons per unit, but even so, at £12·61M that would still have been cheaper than half that number of flying boats.[8]

The scales were tipping inexorably against the seaplane but at about this time, 1951, the US Navy issued a specification for a large jet-powered flying boat. This eventually materialised as the elegant and rather impressive Martin P5M Seamaster. But, while it could have handled reconnaissance and minelaying, its primary function was to be nuclear strike – the Seamaster was a bomber, not an anti-submarine patroller. Nevertheless, perhaps inspired by this American initiative, the UK's flying boat faction began discussing a jet option.

As it happened, Saunders Roe were already working on their Duchess commercial airliner project. Adapted for military purposes the aeroplane might have had six Avons, in place of the original six Ghosts or, in a more drastic form, four Nomads installed as tandem pairs, two pushing and two pulling. With Nomads, the 130,000 lb military Duchess, complete with gun turrets, radar and anti-submarine equipment and weapons had an estimated endurance of some 23 hours – more than enough to have satisfied the requirement, now, re-expressed as Specification R112D of February 1951[9] which actually differed little from the long-standing R.2/48.

While the debate over the pros and cons of seaplanes continued, political and industrial considerations meant that if a decision to proceed was ever made it would probably be for a design tendered by Shorts. Nevertheless, Saunders Roe kept beavering away and by 1952 they were promoting their four-(propeller)-engined P.162 with later versions being offered with an innovative hydro-ski planing bottom. But this was a rearguard action. In January 1955, the Minister of Defence, Harold Macmillan, made a recommendation to the Chiefs of Staff Committee to the effect that

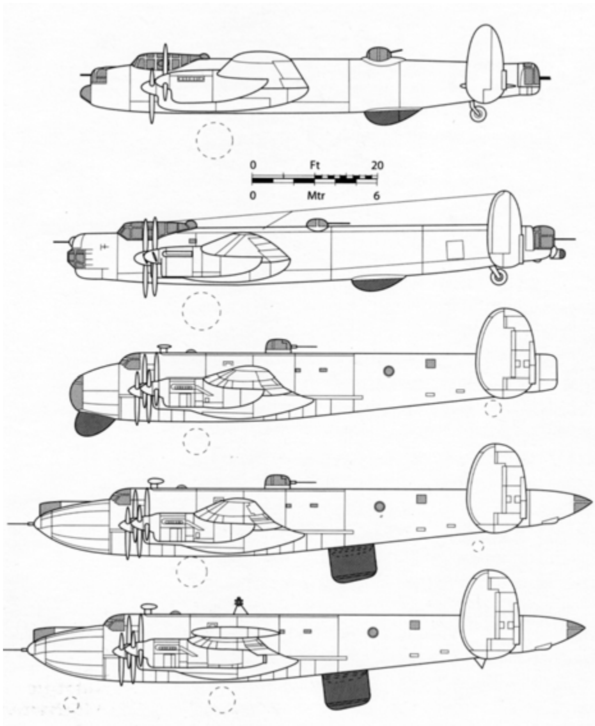
> '. . . resources should not be applied from Defence Votes to the development of a new type of flying boat . . .'[10]

The Chiefs agreed, and that was the end of the matter.

The Shackleton

Meanwhile, compared to the prolonged debate over the decision to replace the Sunderland, replacement of the Lancaster had been a relatively straightforward process. Since the Lancaster had already been stretched to create the Lincoln, which had adequate capacity and range, it had simply been decided to exploit that aeroplane's potential. The requirement was spelled out in OR200 of March 1946 which envisaged, in effect, a 5½ hour patrol at 1,000 miles from base with a 6,000 lb warload.[11]

In that same month Avros were instructed to proceed – there was no design competition – and it was anticipated that the RAF would begin taking delivery of its Lincoln Mk IIIs a year later, but March 1947 proved to be a trifle overoptimistic. The initial draft of the specification, B.5/46,[12] had been circulated only a month after OR200



The evolution of the Lancaster into the Shackleton MR3 via the Lincoln and the Shackleton Mks 1 and 2 was covered by a series of reiterations of a single Specification. (Chris Gibson)

but once Roy Chadwick and his team began to get to grips with the requirement, it led to a series of negotiations that resulted in over a year's delay before the final Specification, by now R.5/46 (R for reconnaissance in place of the original B for bomber) was issued. Its demands had been trimmed back to require a range of 2,600 nm cruising at 170-180 kt at 5,000 ft with only 4,000 lb of bombs, in effect, a 3½ hour patrol at 1,000 miles from base.[13]

The year's delay had resulted from the, specified, engine change to Griffons, in place of the original Merlins and, to provide adequate directional control to meet a three-engined take off requirement, the vertical tail surfaces had had to be substantially increased in size. Furthermore, rather than simply adapting the Lincoln to its new role, which had been the original plan, it was now intended to optimise it and this had led to the fuselage being both deepened and widened, and the opportunity had also been taken to incorporate some features of the Tudor airliner into the project, notably elements of the undercarriage. These changes had been so extensive that, as early as October 1946, more than two years before it would fly, the Lincoln Mk III had become the Shackleton Mk I.

The prototype eventually flew in February 1949 to be followed by the usual series of tweaks and adjustments. The most obvious of these were deletion of the front guns, the tail turret and an in-flight refuelling facility. Production machines began to appear in 1950 and No 120 Sqn began its conversion from Lancasters in April 1951.

By that time R.5/46 (Issue 2) had already been sent to Avros to cover the Shackleton Mk 2 – since December 1950, the MR, as distinct from GR, Mk 2.[14] There was no change to the specified performance requirement which was still 2,600 nm cruising at 170-180 kt at 5,000 ft, ie a 3½ hour patrol at 1,000 miles.[15] The main enhancements to the Mk 2 were reinstatement of guns in a redesigned nose; the provision of a streamlined tail and a retractable tailwheel, all of which served to improve the overall aerodynamics, and relocation of the radar in order to permit 360° scanning. There was also a, not entirely successful, attempt to address the not insignificant problem of noise in the cabin.

In 1953 OR320[16] was raised to cover the Shackleton Mk 3 which re-instated the 5½ hrs at 1,000 miles that had been called for by OR200 back in 1946, although, a little surprisingly, by the time that this had been translated into R.5/46 (Issue 3) the specified patrol time of 3¼ hours was actually slightly *less* than had been required of the Mks 1 and 2.[17] But this was all 'specification-speak', not reality, and in the event the Mk 3, with its tricycle undercarriage and wing tip tanks actually had the longest legs of all the Shackletons. Along the way, of course, there had been many incremental improvements to the equipment fit in both the Mks 2 and 3, but such matters are beyond the scope of this paper.

The Short Range Case

In 1950 Coastal Command was still flying Lancasters but anticipating the early receipt of Shackletons. The Air Staff considered that using its new long-range aircraft for inshore work would be uneconomic and it began to cast about for something handier. The Varsity, which had yet to enter service itself, was an obvious contender and Vickers drew up a series of options involving the provision of a visual bomb-aiming and observation station in the nose, the installation of ASV 13, carriage of torpedoes or depth charges and, in some cases, a gun turret just aft of the flight deck.

Other proposals involved several militarised versions of the Viscount and Airspeed schemed a proposal based on the Ambassador. But all of this work, which was being done in 1950-51 was on an informal basis; none of it would have been underwritten by formal contracts, and all of these projects were shelved when the Americans undertook to provide 52 Neptunes.

That was not the end of the story, however, because, while the Air Ministry had been worrying about short-range work, the Admiralty had been equally concerned about the threat in coastal waters from fast patrol boats, midget submarines and minelaying submarines. The first Gannet had flown in 1949 and was an obvious candidate but, like the RAF's Shackleton, it was considered to be too big and sophisticated – and expensive – for the task.

The Seamew

Some thought was given to something really cheap and cheerful, like the DH6s used for inshore patrols in 1918 or the potentially armed Tiger Moths of 1940, the most likely candidates being the Anson or Oxford of which there were substantial numbers in store, but the Navy wanted something rather smarter than that. The result was Naval Staff Target NA32 of August 1951[18] which eventually produced – the Seamew.

Powered by a Mamba turboprop, equipped with ASV 19 and armed with a torpedo or depth charges, the Navy ordered sixty AS Mk 1s with the intention of operating them from light fleet carriers, or possibly even WW II-style MAC Ships.[19] The prototype was first flown by Wally Runciman in August 1953 and the aeroplane sustained significant damage on landing. It may well be apocryphal but in his post-flight report Runciman is said to have observed that it was difficult to gain access to the cockpit and he recommended that it should be made impossible. The Seamew's handling characteristics did leave something to be desired; Runciman was eventually killed

The Seamew prototype, in Coastal Command grey and white, to represent an RAF MR2 (nearest), and a pair of FAA AS1s at the 1955 SBAC Show.

while displaying one.

Unfortunately (or perhaps fortunately in view of the handling problems), by the time that the aeroplane was undergoing its flight trials, there had been a major change in policy. The Navy had decided to dispose of its remaining light fleet carriers and it now planned to use helicopters for short-range anti-submarine work so it no longer required its sixty Seamews. To avoid unemployment in Northern Ireland, however, it was decided to accept thirty aircraft to equip the RNVR squadrons of the Fleet Air Arm and in 1955 the RAF agreed to take the other half of the production run as MR Mk 2s and to use them to conduct inshore patrols and convoy escort from Kinloss, St Mawgan, Aldergrove and one other site.[20] This was not so much Air Staff policy as political pragmatism, but in due course a dedicated specification was raised to cover the RAF variant.[21]

In February 1956, following a reduction in the defence budget, the Mk 2s for the RAF were cancelled but a year later the Sandys White Paper disbanded the RNVR squadrons of the FAA, along with those of the Royal Auxiliary Air Force, leaving the Seamew with no role at all.[22] The RAF briefly considered using the now totally unwanted aeroplanes as a replacement for the Venom for colonial operations in

The Avro 716. (Avro Heritage)

Aden, but that proved to be a non-starter.[23] With no one to fly them, the unwanted Seamews – about fifteen had been completed, although none had been accepted for service – were stored and eventually scrapped.

Speculative Ventures

In the early-1950s Coastal Command had only recently taken delivery of its Shackletons, so there was no need for a replacement and, as discussed above, consideration was already being given to the acquisition of a dedicated aeroplane for inshore work, which only left the *very* long range case of the mid-Atlantic Gap that had been such a preoccupation in WW II. There was no official requirement to address this case but that did not prevent industry from trying to solve the problem.

Avros initial thoughts on satisfying the notional, actually non-existent, requirement for what might have become a Shackleton Mk 4 emerged as the Type 716. A single-finned aeroplane to be powered by four Centaurus or Nomads, it still had something of the Shackleton about the nose but beyond that it was a new design. As such it would have been relatively expensive and the Air Ministry recommended that it be adapted to use the wings of the Shackleton which would have made it the Type 719.

Bristols were new players at the maritime game but their Britannia airliner had been designed to cater for the transatlantic route which endowed it with considerable potential as the basis for an MR aeroplane, especially if re-engined with turbo-compound Nomads or perhaps the equivalent Wright R3350s from America. But like Avro's 716 and 719, the maritime Britannia was a solution to a non-existent problem.

That said, Bristol's offering had reflected what has since become the norm for maritime patrollers in that almost all post-Shackleton era aeroplanes have been derived from commercial airliners rather than being bespoke designs. The Breguet Atlantic is the obvious exception to this rule, but the Orion, Nimrod, Ilyushin's 'May' and the current flavour of the month, Boeing's Poseidon, have all been derived from airliners.

In the specific case of the maritime Britannia, it was taken up by Canadair and, powered by Wright R3350 Duplex-Cyclones as fitted to the Neptune (the Americans had succeeded in cracking the turbo-compound problem), it flew with the RCAF as the Argus for more than twenty years.

NBMR-2

The inspiration for the next chapter in the saga was the issue of NATO Basic Military Requirement Number 2 in 1957. The idea of the NBMRs, of which there were at least forty, not all of them aviation-related, was to identify a common need and then hold a competition to select the best solution which would then be adopted by everyone. That would result in substantial numbers being built which would realise economies of scale, and production would be shared to provide industrial employment for participating nations. For the military, it would minimise and simplify spares holdings while facilitating the standardisation of training and operating procedures. Everyone would be a winner. Unfortunately, it was all just a shade too ideologically socialist for the capitalist nations of the West. The Cold War wasn't quite cold enough to persuade enough governments to subordinate their national interests to counter the common threat.

Only two of the five major aeroplane design competitions met with any success.[24] NBMR-1 produced the Fiat G.91 lightweight fighter-bomber which was taken up by four nations, two of which (Greece and Turkey) subsequently cancelled their orders, although NBMR-2, for a maritime patroller, did rather better.

The NBMR-2 project was initially supported by the UK, the USA,

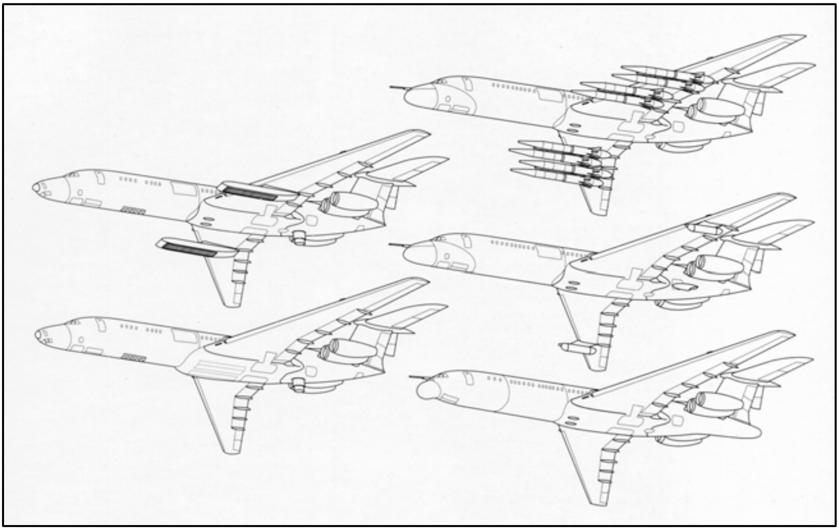
The Breguet 1150 Atlantique/Atlantic to NBMR-2 satisfied the requirements of several European nations, but was regarded as being short of an engine by the British Air Staff.

France, Germany, Italy, the Netherlands and Belgium. In essence, it called for a Neptune replacement. The broad outline of the requirement sought a twin-engined aircraft capable of spending 4 hours on station at 1,000 miles from base at a transit speed of 300 kt. The preferred engine was the Rolls-Royce Tyne. More than twenty designs were submitted, some of them flying boats, by a variety of European and American contractors. British submissions included proposals by Fairey, Avro, Bristols and Armstrong Whitworth.

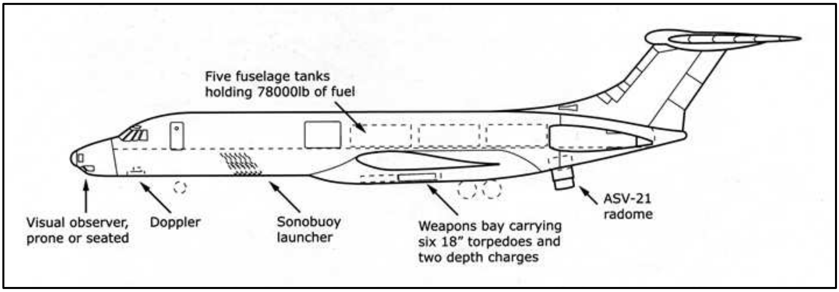
The winner was Breguet's Atlantic which flew for the first time in 1961 and is still in service today.[25] But by 1961 the USA had already gone its own way with the Orion. Belgium and the UK had also both withdrawn from the project. A twin-engined design was never going to satisfy the British Air Staff which had taken the view that a minimum of three engines was essential but, that aside, a replacement for the Shackleton would not be required until the 1970s and the UK Government was disinclined to underwrite the development of an aeroplane that the RAF did not want and would not even need for at least ten years. For the UK, NBMR-2 simply wasn't a good fit.

The Three-in-One Solution

Meanwhile, the Air Ministry had been pursuing what looked to be a very promising prospect, although it would turn out to be another



Above, things to do with a VC10 and, below, an LRMP option. (Chris Gibson)



dead end. The idea was to use a large airframe and play tunes on it to fill a number of roles. This scheme was hatched by Vickers who were promoting their VC10 airliner, which had already been ordered for the RAF in 1961 as a strategic transport. Why not use the VC10 as both a Skybolt carrier (then a very fashionable idea) and as a maritime patroller? Other options might include a tanker and airborne early warning, even a conventional bomber and signals reconnaissance. The VC10 could be all things to all men.

So far as the MR version was concerned, it seemed to be quite a realistic proposition. There would have been a visual bomb-aiming and observation station in the nose and ample space for additional fuel. Doppler and ASV 21 would have been provided with weapons carried, either in large underwing pods or in an extended belly pannier. And with its spacious, pressurised cabin and engines right at the back, the crew would have worked in a shirt-sleeve environment and have been able to converse without shouting.

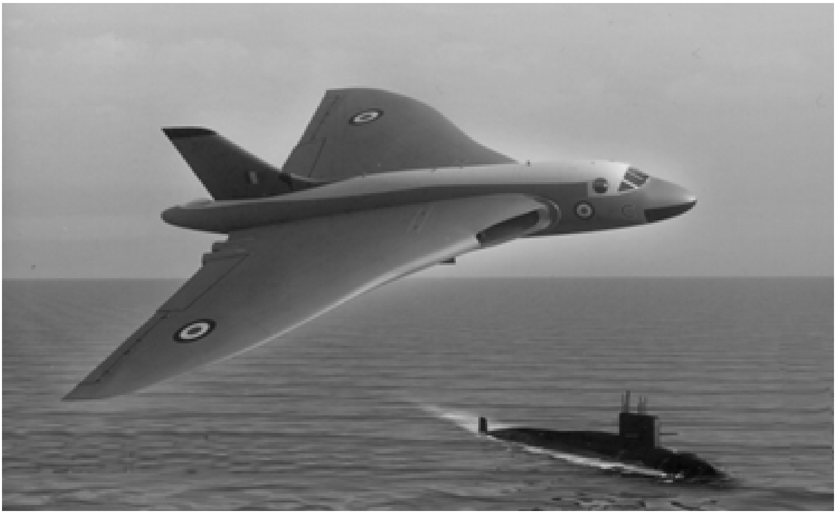
Shorts, BAC and Armstrong Whitworth were also working on 3-in-1 ideas but, since Vickers had the hardware in the shape of actual VC10s, they were the only serious players. But – there is always a but – while the Air Staff were attracted to the concept, there were doubts about some aspects. This was the early 1960s when supersonics were becoming fashionable. Bristols and Hawker-Siddeley had both been awarded development contracts for a supersonic transport as recently as 1959 and the Air Ministry was in two minds as to whether the 3-in-1 project should also be supersonic. This would not be of great significance in the MR case but it could be useful for the strategic transport and deterrent roles. But the aerodynamic demands of supersonic cruise at high level and loitering at a sensible patrol speed at low level were very difficult to reconcile without resorting to variable geometry.

A number of companies were working on such designs, notably the HS 1011 airliner, which had begun life as De Havilland’s DH 130. Some thought was given to adapting this for the MR role but, apart from anything else, its minimum patrol speed would have been better than 200 kt which was considered to be unacceptably high. The upshot of all this was that the conflicting demands of different roles involved too many compromises.

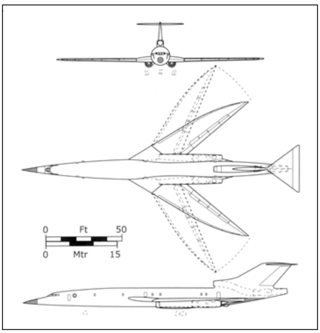
AST350

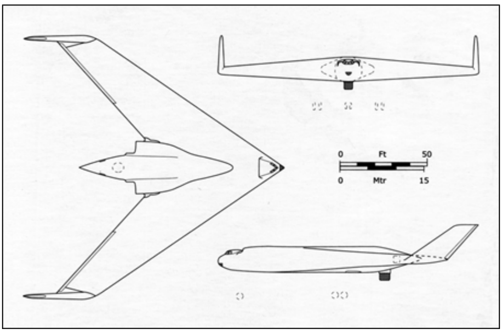
In the meantime, while some elements of the bureaucracy were still trying to outflank a mathematical absolute – that three into one won’t go – other offices had gone back to the drawing board. The Shackleton Mk 3s were expected to be good until well into the 1970s, but what then? After an evaluation of the way in which the threat was thought likely to develop, the Air Staff produced Air Staff Target (AST) 350 of July 1960.[26]

It envisaged up to 8 hours on patrol at 1,000 miles from base, thus reinstating a notional ‘mid-Atlantic Gap’ capability (or, more realistically perhaps, a Greenland-Iceland Gap and/or Barents Sea



Some of the ideas generated by AST350, above a Vulcan derivative (Adrian Mann) *and below, an option based on the HS 1023 VG supersonic airliner and the enormous HP 117 from Radlett.* (Chris Gibson)





capability), the extended time on station being offset by shorter transits due to much higher cruising speeds. A typical 350 kt turboprop was considered to be marginally acceptable, although it would take 3 hours to cover 1,000 miles, whereas a 500 kt jet would take only two, which was, obviously, the preferred option.

Apart from anti-submarine warfare (ASW), AST350 specifically required the aeroplane to be able to handle the Shackleton’s secondary roles – search and rescue and emergency trooping. It would also have to be capable of operating from a 6,000 ft runway – the Gibraltar constraint. A remarkable 17,000 lb warload was specified to include the possibility of nuclear depth bombs and air-to-surface guided weapons, all of which was to be underpinned by appropriate navigation aids and detection devices.

A maritime VC10 was obviously going to be a candidate and by 1963 a number of other solutions had been proposed, including a fat Vulcan, an adapted Belfast freighter from Shorts, a number of options based on the Vickers Vanguard, several variations on the theme of Breguet's Atlantic and MR adaptations of Armstrong Whitworth's projected AW 681 V/STOL tactical transport. The best submission was eventually judged to be the Trident-derived Avro 776, with more extreme solutions being put forward by Hawker Siddeley, who were still proposing a supersonic variable geometry aeroplane, by now with three engines, and Handley Page with an enormous 300,000 lb, 150-foot span, flying wing that was critically dependent on the control of laminar flow.

AST357

With so many widely disparate, and in some cases exotic, solutions being offered it was clear that the question that had been asked had been insufficiently precise so AST350 was cancelled and replaced, in April 1963, by AST357.[27]

This time the requirement was much more detailed, running to 23 pages, compared to just two for AST350, and the aim was more attainable. A minimum of three engines was required, with a transit speed of not less than 450 kt, which more or less meant jets. Internal security, only hinted at in AST350, was now a specified role. The internal weapon load was reduced to a more manageable 8,400 lb, now definitely to include nuclear depth bombs, plus a pair of 1,500 lb externally carried missiles.

The aeroplane was to have the most comprehensive detection devices available and, and this was particularly significant, be able to handle those that were under development or projected. This included Sideways Looking Airborne Radar (SLAR) and, at the time there was talk of 'laser radar' (LIDAR) and of a 100-mile range system able to detect the launch of a submarine-launched ballistic missile and, anticipating the dawn of the digital age, the aeroplane would be expected to have ‘integrated tactical displays’ which implied computers.

In 1963 this was a very ambitious hi-tech target. Computers did exist, but at the time they still tended to be about the size of a small house. The microchip and the integrated circuit had just been invented but it would take several years for them to produce practical miniaturised devices, and the Sinclair ZX Spectrum, that some members of this audience may well have cut their digital teeth on, would not appear until 1982.

AST357 attracted yet another raft of proposals from the usual suspects. Some of the AST350 candidates were still in the frame, like Avro’s 776 and Armstrong Whitworth’s 681. Bristols were back with another Britannia derivative with Vickers doggedly promoting its VC10, now with the engines housed in redesigned nacelles. Other submissions were based on the Trident, the Vanguard and a Tyne-powered C-130.

By this time, however, timing was becoming an issue. The search for a long term replacement for the Shackleton had begun with NBMR-2 back in 1957 but, seven years later, despite a number of attempts, we were no closer to finding the answer and the Mk 2 Shackletons were beginning to run out of fatigue life. The Air Staff was obliged to consider an interim solution. Why not make an off-the-shelf buy of Orions or Atlantics and postpone the long-term target?

ASR381

By the spring of 1964 it had been more or less decided to buy Atlantics to replace the Mk 2 Shackletons and to replace them, and the Mk 3s, with the ultimate – in effect the AST357 – solution in about 1980. To facilitate this, Air Staff Requirement (ASR) 381 was raised in June 1964.[28] In seeking an aeroplane that could patrol for 5 hours at 1,000 miles from base with a transit speed of 300 kt, ASR381 was a close match for NBMR-2, and the fact that it specifically accepted the possibility of a *twin*-engined aeroplane clearly indicated that the Atlantic would be an acceptable solution.[29]

But before the ink was dry on ASR381 the ‘buy British’ flag had been raised. Apart from the obviously adverse industrial implications, there were political reservations about public reaction if the French were to be handed an order for fifty aeroplanes. On the other hand, it

Type	Number*	Unit cost (£M)	Cost inc R&D and Production (£M)	Anticipated CA Release	Completion of Delivery
Orion	47	1·3	66.0	–	1969
Atlantic	47	1·25/1·4	81.9	1966	1969
Comet	41	2·1	111.0	1969	1970
Trident	40	2·1	119.0	1970	1971
BAC 1-11	43	2·45	144.0	1970	1971
Vanguard	47	2·45	142.0	1969	1970
Belfast	45	2·7	149.0	1969	1971
VC10	40	3·85	183.0	1969	1971

* The total number required reflected a front line of the order of 30-34 aircraft, depending on type, plus the MOTU, ASWDU and a reserve.

Potential Shackleton Mk 2 Replacements as at early-October 1964.

was argued, some of the work would go to British industry, notably Rolls-Royce who would provide the Tyne engines. Furthermore, collaboration was increasingly in vogue at the time with the Anglo-French Concorde treaty already signed, and early discussions under way regarding what would become, in 1965, the AFVG and Jaguar agreements to be followed by the joint helicopter programme a little later.[30] A French order might have been more palatable if France could have been persuaded to reciprocate by buying a British aeroplane, but there was little prospect of that, and there were similar political objections to buying American.

Nevertheless, when the Defence Council discussed ASR381 in July 1964 both the Atlantic and the Orion remained in contention along with proposals based on the VC10 and the Trident. One outcome of that meeting was that the Ministry of Aviation, as champion of the British aircraft industry, was to sponsor a report on the comparative merits of a number of potential aeroplanes, including some wild cards, like the Belfast. By early October the options under consideration were as tabulated above.[31]

Clearly, the already-in-production Orion and Atlantic represented the cheapest options and the most timely solutions, but neither were attractive choices and not only because they involved foreign purchases. The Orion, for instance, could not accept British sonobuoys, which would require either extensive and expensive modifications to accept the British kit or, in order to adopt the American system, a major, and unwelcome, change in RAF operating procedures. The Atlantic was bound to meet the tailored specification, of course, but it only just did so, and the fact that it was considered to have limited development potential and had only two engines made it a particularly unattractive option. The VC10, apart from being much bigger than was necessary, was far too expensive and was soon eliminated on the grounds of cost, as were the Vanguard, BAC 1-11 and Belfast.[32] Of the British contenders, that left only the Comet and a maritime Trident.

Both aeroplanes would have to be re-engined with Speys, but beyond that the Comet could be relatively easily adapted to the new role, only requiring, in essence, the grafting-on of an external pannier to accommodate the radar and weapons. By contrast the Trident would require major modification, including, compared to the basic airliner, a 25% increase in wing area and a 65% increase in weight. Although estimated costs and timescales were of the same order, the advantage lay with the Comet in both cases and the figures relating to the Trident were somewhat uncertain in view of the extensive development work that would have to be undertaken.[33]

By mid-November the Air Staff was 'firmly of the opinion that the Comet is the best answer'.[34] On the other hand, for what were essentially industrial reasons, the Ministry of Aviation favoured the Trident. The situation was complicated by the fact that the RAF was already committed to a very expensive 'big three' – the TSR 2, the P1154 and the AW 681 – and it was feared that funding for a new maritime aeroplane might become problematic. These concerns will have been heightened by the fact that there had been a General Election on 15 October and it remained to be seen what changes in policy might be implemented by the newly elected Labour government.

At the end of December a comprehensive report, which had evaluated all of the potential British proposals (MR variants of the Trident, Belfast, VC10, BAC 1-11, Vanguard and two versions of the Spey-engined Comet, one a minimal change, the other beefed up from 162,500 lb to 177,500 lb design weight), was published by Chief Scientist (RAF). Using 50 Atlantics as the basic yardstick, simply for comparative purposes, the exercise had determined the equivalent

The Nimrod MR1 entered squadron service in 1970, one of its well-publicised early tasks being to escort the hull of the SS Great Britain *on the last leg of its journey from the Falklands to Bristol in July.*

number of each type of aircraft needed to carry out a variety of search procedures employing different techniques and equipment; costs had been calculated assuming a ten-year service life in each case. The report concluded that 'the modified Comet has been shown to be the best replacement for the Shackleton Mk 2.'[35]

Concerns about the procurement of future aircraft had been well justified because the new government set about demolishing the RAF's plans with some vigour and in a statement to the House on 2 February 1965 the Prime Minister announced the cancellation of all three projects. However, a little surprisingly under the circumstances, tucked away in the middle of a quite lengthy and detailed statement was a short paragraph that read:

> 'The House will be glad to know that after we had examined a wide range of different aircraft, Comets, specially modified to meet the requirements, will be ordered as a replacement for the Shackleton Mark II [. . .]'[36]

The Nimrod

So the decision had been made – the Atlantic was out, the Comet

Nimrod at North Front, Gibraltar.

was in and the necessary Specification, MR254, which called for a transit speed of better than 400 kt to a 4¾ hr patrol at 1,000 miles from base, was issued in April 1965.[37] As an aside, it is interesting to observe that some of the specified limitations, eg a maximum permitted Emergency Stopping Distance of 8,750 ft, suggested that the MOD was now prepared to forego the use of Gibraltar. As it happened, of course, the performance of the selected aeroplane did permit it to operate from North Front.

Development got underway as the HS 801 and it flew for the first time on 28 May 1967. Just twelve days later it was announced that the aeroplane would be called the Nimrod MR1. But the Nimrod had been ordered to satisfy the essentially Breguet Atlantic-based ASR381, which had been for an interim type, specifically a replacement for the Shackleton Mk 2, pending the selection of something longer term to satisfy AST357. After considering some other options, it was concluded that, since experience with the Nimrod Mk 1, as an aeroplane, had been very satisfactory, the best replacement for it would be another Nimrod. This was spelled out in Specification MR286 of 6 May 1975 which did not require the MR2 to do any more than the MR1, only to do it better, so the emphasis was on updating and upgrading the radar, sonics, ESM, communications, displays and processing power to reflect what had been envisaged by AST357. The Nimrod MR2 first flew in 1977 and it entered service two years later, finally providing the RAF with the capability that it had been angling for since 1963.

By 1993 it was time to consider the next generation and the requirement was spelled out as SR(A)420 the core of which was still the classic 8 hours at a 1,000 miles and more than two engines that had been required by OR231, AST350 and AST357. Up to twenty-five aircraft were envisaged. The more realistic propositions were: a variety of refurbished and upgraded P-3 Orions; the US Navy's choice, the P-7, which was essentially a newbuild Orion; despite its having only two engines, an updated version of the evergreen Atlantic; and the Nimrod 2000 which would be created by recycling MR2 airframes. The RAF's original preference had been for the P-7 which the Americans had been obliged to cancel as part of the post-Cold War 'peace dividend', although Lockheed were still promoting it as the Orion 2000.

While the Nimrod 2000 may not have been the ideal solution, it could be shown to be the most cost effective and since there was, reportedly, an overriding political imperative that required a national solution, in 1996 British Aerospace was awarded a contract for twenty-one aircraft as the Nimrod MRA4.

Unfortunately, while the Nimrod had appeared to be the cheapest option, that proved not to be the case, because the recycling and refurbishing of the MR2 became a substantial rebuild. This was far from straightforward as the original Nimrods had been, to a degree, hand-crafted so there were problems in getting precision-engineered new components to mate with airframes that had been built to more generous tolerances.

As costs rose the number required was cut back to eighteen in 2002, then sixteen, then twelve and by 2008 it was down to just nine. The process of stripping down and reconstructing the airframes had revealed a number of engineering issues and these were thrown into sharp relief by the loss of XV230 in 2006 and the subsequent Haddon-Cave Report.[38] Suffice to say that while the MRA4 did fly, the project was still a work in progress when it was cancelled in 2010 after the expenditure of well in excess of £3Bn.

What might have been – the Nimrod MRA4.

Since the remaining Nimrod MR2s had also been grounded, that left this island nation with none of the maritime air power that it had wielded, as a given, ever since the earliest days of military aviation.

Notes:

[1] Gibson, Chris; *Nimrod's Genesis – RAF Maritime Patrol Projects and Weapons since 1945* (Hikoki, 2015). Other books in the same series by the same author are *Vulcan's Hammer – V-Force Projects and Weapons since 1945* and *Battle Flight – RAF Air Defence Projects and Weapons since 1945*. At the time of writing he is working on a similar volume dealing with air transport.

[2] TNA AIR6/65. The possibility of acquiring a few Shetlands for 'extended service trials' was outlined in Note AC52(45) submitted to the Air Council by VCAS in December 1945. Since this could only be funded at the expense of other projects, however, VCAS's recommendation that the idea should be rejected was endorsed.

[3] TNA AIR54/100. Draft OR231 of November 1946.

[4] TNA AIR54/359. Specification R.2/48 of 6 October 1948.

[5] Gunston, Bill; *The Development of Piston Aero Engines* (Patrick Stephens; Sparkford; 1999) p176.

[6] TNA AIR 8/1737. Slessor to VCAS, 6 February 1951.

[7] TNA AIR19/837. Paper, dated 13 January 1955, on 'The Future Development of Flying Boats' submitted to SofS for Air prior to that day's Meeting of the Defence Committee.

[8] *Ibid.* Paper AC41(51) dated 13 July 1951 by VCAS setting out the case for replacing the Sunderland and recommending that the R.2/48 contract should be placed with Saunders-Roe.

[9] TNA AIR54/359. Draft Specification R112D of 27 February 1951.

[10] TNA CAB131/15. Minutes of Defence Committee Meeting held at 10 Downing St on 21 January 1955.

[11] TNA AVIA13/663. OR200 (Issue 2) dated March 1946. This may be more accessible as Appendix A to Chris Ashworth's *Avro's Maritime Heavyweight – The Shackleton* (Aston Publication, Bourne End; 1990) where it has been reproduced verbatim.

[12] TNA AVIA15/3900. Draft Specification B.5/46 of 25 April 1946.

[13] *Ibid*. Specification R.5/46 of 17 March 1947. See also Appendix B to Ashworth *op cit*.

[14] TNA AIR15/3914. The Resident Technical Officer (RTO) at Avro's, Manchester was notified of the change in nomenclature by memo SB67151/01/RD2L(a) dated 19 December 1950 from the Directorate of Aircraft Research and Development (DMARD).

[15] TNA AIR54/577. Specification R.5/46 (Issue 2) of 3 July 1950.

[16] TNA AVIA65/289. Although dated 31 March 1953, and actually implemented in August as Annex B to R.5/46 (Issue 3), OR320 was not formally approved by the Ministry of Supply until 18 November 1953.

[17] *Ibid*. Specification R.5/46 (Issue 3) of 18 August 1953.

[18] TNA AVIA65/279. Naval Staff Target NA32 of 27 August 1951.

[19] Merchant Aircraft Carriers, or MAC Ships, were wartime bulk carriers to which a flight deck had been added as an expedient which permitted them to carry their own anti-submarine and/or air defence aircraft.

[20] TNA AIR2/12710. Treasury approval for the RAF to take the first thirty Seamews was noted in the minutes of a meeting convened at the Air Ministry on 25 February 1955 to discuss the necessary changes to the standard of preparation of these aircraft.

[21] TNA AVIA65/279. Specification M123P2 dated 17 October 1955, following an initial draft of 2 April.

[22] TNA AIR2/12710. Cancellation of the order for the RAF Seamews was noted in, for instance, a Ministry of Supply memo AC/85/01 dated 28 February 1956.

[23] TNA AIR2/12717. Note 'Seamew Aircraft – Alternative Roles' prepared for the Air Council by DCAS in May 1957.

[24] NBMR-1 lightweight fighter-bomber – Fiat G.91.
NBMR-2 MR aircraft – Breguet Atlantic.
NBMR-3 V/STOL strike/recce – Hawker's P.1154, Dassault's Mirage IIIV, the VFW VAK-191 and the EWR VJ-101.
NBMR-4 V/STOL medium range transport – Breguet 941; LTV XC-142; DHC-4 Caribou.
NBMR-22 V/STOL short range transport – Fiat G.222; Do 31.

[25] As recently as September 2015, ie at the time of writing, a French Atlantique 2 had delivered a laser-guided bomb on an ISIS target in Syria in a co-ordinated strike with Mirage 2000s.

[26] TNA AIR2/15517. AST350 (Issue 2) dated 18 July 1960.

[27] TNA AIR2/17197. AST357 dated 25 April 1963.

[28] TNA AIR20/12497. A copy of 'Air Staff Requirement 381 For An Interim Maritime Reconnaissance Aircraft To Replace The Shackleton MR Mk 2' dated

4 June 1964 may be found on this file where it is included as Appendix B to Specification MR254D&P.

[29] TNA DEFE25/15. A brief, dated 21 September 1964, prepared for CDS by Gp Capt D A Trotman contained the specific statement that ASR381 'had been written largely around the Breguet Atlantic' and much the same was stated in the presentation referred to at Note 34.

[30] The Concorde Treaty was signed in 1962 followed by the Jaguar (SEPECAT), AFVG and helicopter packages in 1966.

[31] TNA AIR20/11772. From a brief prepared for CAS by DCAS dated 7 October 1964. Note that the tabulated figures relate to that specific date; over the following weeks they were subject to repeated amendment to reflect progressive refinement of the source data.

[32] According to Gp Capt Hugh Eccles, who, as DDOR(B) at the time, would have been intimately involved in this issue, the RAF borrowed 'the prototype VC10 and spent an afternoon flying it up to 25,000 ft, diving down to 500 ft off the Isle of Wight, climbing back up again and so on . . .' Despite its size, the VC10 had been considered to be 'absolutely the right aeroplane.' cf *The RAF Historical Society Journal*, No 33, p131.

[33] TNA AIR2/17199. Draft brief prepared for Ministers dated 29 October 1964, by which time the numbers involved had been pruned to 46 Atlantics or Orions or 38 Comets or Tridents..

[34] TNA AIR2/17199. Joint presentation by DOR2 and SASO HQ Coastal Command to the recently appointed Minister of Defence for the RAF, the appropriately named Lord Shackleton, at Northwood on 20 November 1964.

[35] TNA AIR77/466. CS(RAF) Report No 106 dated 31 December 1964: 'The Comparison, On A Cost/Effectiveness Basis, Of The Anti-Submarine Capabilities Of Maritime Patrol Aircraft To Replace The Shackleton Mk 2 (ASR381)'

[36] Hansard, 2 February 1965.

[37] AIR20/12497. Specification MR254D&P of 13 April 1965.

[38] *The Nimrod Review. An independent review into the broader issues surrounding the loss of the RAF Nimrod MR2 Aircraft XV230 in Afghanistan in 2006* conducted by Charles Haddon-Cave QC (published by The Stationery Office, London as HC 1025 on 28 October 2009). This document is (should be) accessible on-line via occasionally temperamental websites.

MORNING DISCUSSION

Dr John Peatey My question, for Sqn Ldr Lovett, concerns the OR for the 'Lulu' NDB, which was dated 1958, but when did it actually become available?

Sqn Ldr Andrew Lovett. It was in about 1966, which was a surprisingly long interval, considering that the weapon already existed – and, of course, it only lasted about four years before the Nimrod came along and we switched to the B57.

Wg Cdr Jeff Jefford. I have a question. You said that the American NDBs were stored at St Mawgan. I always understood that the NDBs were held at Machrihanish and not issued until some stage during Transition To War.

Lovett. No – they were certainly kept at St Mawgan on a permanent basis and I came across no references to Machrihanish while researching the topic.

Peter Crispin. There was definitely a storage facility at Machrihanish. My next door neighbour at St Mawgan was a US Navy guy. There were three shore locations that qualified as 'sea time' for the Americans, St Mawgan, Machrihanish and Alaska! – and he had done three years at Machrihanish in the late 1960s looking after the NDBs.

Air Cdre Bill Tyack. My understanding is that the NDBs stored at Machrihanish were for US Navy aircraft which would have deployed to, and operated from, there in war.[1] I am sure that there were NDBs at St Mawgan and I have personally carried out LOADEXs there involving both the Shackleton and the Nimrod.

Mike Meech. That would, no doubt, account for the US Marines who were stationed at St Mawgan. Can anyone shed any light on the handover procedure – how long it took? – the political dimension?

Lovett. That involves delving back 40 years but, as I recall, crews would periodically carry out a LOADEX. A pan would be 'sanitised' and an aircraft prepared. At the appropriate time the US Marines would emerge from their compound on the far side of the airfield and escort the weapon across to the aircraft. The RAF armourers would take possession of it and load it into the bomb bay. The aircrew would then formally accept custody of the weapon from the Americans and it then became an RAF responsibility. It was a well-oiled procedure practised, I would say, about every six months.

Richard Bateson. While the RAF never used the Lincoln in a maritime role the RAAF did, until as late as 1961 I believe, and I wondered whether any of the Australian experience of operating the Lincoln found its way into the design of the Shackleton?

Jefford. The Australians did adapt their locally-built Lincolns for maritime duties as the Mk 31, which had a much longer nose to accommodate additional equipment and operators, but the timing wouldn't have been right. It would have been in the early 1950s, by which time the Shackleton was already a going concern, so I doubt that there was any interface at all.

Philip Ratcliffe. I don't think the V-Force ever carried live nuclear weapons on exercises. Was that also the case with NDBs?

Lovett. To my knowledge we never flew with live weapons. Very occasionally we would fly a Nimrod to an American base to carry out a LOADEX there. On one occasion I flew in an aircraft that had been loaded with a 'shape' which we then actually dropped in the ocean. It was the most realistic simulation possible. We were about ten miles off Fort Lauderdale at the time and I recall thinking, just as the red 'N' button was pressed 'I do hope they got the right bit of kit out of store!'

Jefford. Just to confirm – the V-bombers never flew fissile material. We did fly fully operational, and fuelled, BLUE STEEL rounds, but without the warhead, and for WE177 there were training shapes, inert lookalikes, and we had a Weapon Release Simulator which recorded the crew's switch selections and duplicated the appropriate responses. Very occasionally we would fly a WE177 surveillance round – a live weapon, without the physics package, its purpose, I believe, being to monitor the state of the internal systems as the weapons aged.

[1] In subsequent marginal conversations, it emerged that Ballykelly- and Kinloss-based aircraft would have flown into Machrihanish to be armed with NDBs and it was thought that this may also have applied to aircraft of some other NATO nations. **Ed**

THE SHACKLETON FROM A NAVIGATOR'S VIEWPOINT

Air Cdre Bill Tyack

Bill Tyack joined the RAF in 1962. Trained as a navigator, he flew in Shackletons with Nos 210 and 42 Sqns, before a lengthy involvement in trials and evaluation work on the Nimrod, much of it at Boscombe Down but including a stint at the US Atlantic Undersea Test and Evaluation Center in the Bahamas. His later appointments included a tour as OC 51 Sqn and filling a number of desks at the MOD. On leaving the RAF in 1999 he spent six years with QinetiQ. He was President of the Royal Aeronautical Society 2014-15.

Introduction

One of my earliest memories is of my father taking me, aged about four, to the end of the tramline on the north shore of Belfast Lough so that we could watch Sunderland flying boats taking off and alighting at the Short Brothers factory on the other side of the lough. I believe that I got the flying bug that day and 17 years later I was flying on the Sunderland's replacement – the Shackleton.

Jeff Jefford has described how the Shackleton was conceived, brought into service and then developed throughout its career.[1] My paper will consider the aircraft, its equipment and its crew in some detail. It explains how the aircraft was used in its primary role of anti-submarine warfare and discusses the many other roles in which the Shackleton was employed. Finally it offers an assessment of the Shackleton's contribution to UK defence. The Shackleton was in service for 40 years and it would be impossible in a paper of this length to describe this entire period in any detail. Therefore I have focused on the aircraft and the force as they were in the late 1960s. That is the period when I flew on Shackletons as a navigator, first on the Mk 2 Phase 2 and Phase 3 with No 210 Sqn at Ballykelly and then on the Mk 3 Phase 3 with No 42 Sqn at St Mawgan. It is also the period in which the Shackleton had been developed to its most advanced state. I am very pleased to have the opportunity to write this paper because, having read many books and articles about the Shackleton, in my view, with the honourable exception of some

A Shackleton MR2 of No 42 Sqn – aka The Growler. (MAP)

articles in *The Growler*[2] they mostly fail to convey what it felt like to serve in Coastal Command in the 1960s. In preparing this paper I have done a fair amount of research and have consulted former colleagues to aid my fading memory. However, I must emphasise that this is my view and any mistakes are mine.

Table 1 shows the Shackleton ORBAT in 1966, comprising: five squadrons of Mk 3 aircraft; six squadrons of Mk 2s; plus, in today's terms, the Operational Conversion Unit[3] and an Operational Evaluation Unit[4]. In total about 90 aircraft. The South African Air Force also operated eight Mk 3 Shackletons.

Base	Units	Variant
Ballykelly	No 203 Sqn	MR3
	Nos 204 & 210 Sqns and ASWDU	MR2
Kinloss	Nos 120, 201 & 206 Sqns	MR3
St Mawgan	No 42 Sqn	MR3
	MOTU	MR2
Gibraltar	No 224 Sqn	MR2
Luqa	No 38 Sqn	MR2
Khormaksar	No 37 Sqn	MR2
Changi	No 205 Sqn	MR2
Long term Detachments		
Gan	SAR	
Majunga	Beira Patrol Mar 66-Apr 72	
Sharjah	Detachment Aug 67-Nov 71	

Table 1. Shackleton ORBAT late-1966.

	Diesel-Electric	Nuclear-Power
Torpedo Attack	268	12 – 15
Cruise Missile	20 – 23	25 – 26
Ballistic Missile	29	7
Total	**317 – 320**	**44 - 48**

Table 2. Soviet Submarine ORBAT ca October 1966.[5]

Table 2 shows the opposition – some 360 Soviet submarines, nearly 50 of which were nuclear powered. The great majority of these were facing NATO in the Soviet Northern, Baltic and Black Sea Fleets. In the event of World War Three, the role of the Soviet attack and cruise missile submarines would have been to oppose the United States Strike Fleets and other American shipping as they crossed the Atlantic to reinforce Europe. The role of the Shackleton Force, as part of the NATO maritime air forces, would have been to prevent the Soviet submarines from getting into a firing position.

The aircraft, crew and equipment

One of the most important aspects of a maritime patrol aircraft's performance is its ability to patrol the oceans at a long range from base. During the Battle of the Atlantic in the Second World War great emphasis was placed on having long-range aircraft and well-positioned bases to 'close the Atlantic Gap' to ensure that there was no place in the Atlantic where German submarines would be immune to aerial attack. This lesson was reflected in the Shackleton's specification[6] and, to demonstrate its capabilities, it performed a notable 'party piece' at the 1960 SBAC Show. There was a major maritime exercise under way at the time (*Fallex 60*) and three participating Shackletons of No 201 Sqn were detached to Farnborough from where one aircraft took off during each day's flying display, to land 22 hours later.

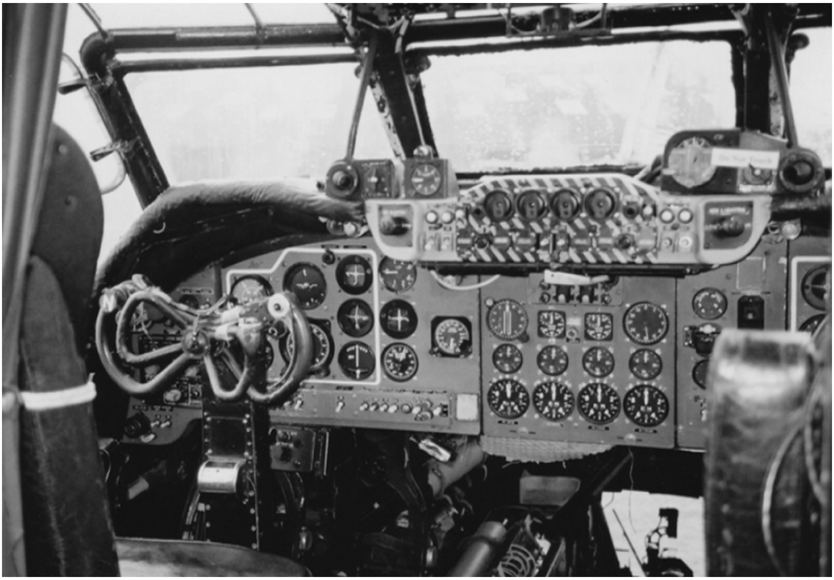
A Coastal Command publicity film of 1961 states that the Shackleton was capable of a '20 hour sortie with full war load.'[7] This equates to a 1,300 nm flight from base, a four hour patrol and a 1,300 nm return. By the late 1960s increasing weight had taken its toll of range. Realistically a Mk 3 Phase 3 carrying a 6,000 lb war load could mount a four-hour patrol at somewhat less than 1,000 nm. This would amount to a flight of 15½ hours and was still a formidable capability.

My longest flights with peacetime fuel reserves were around 13 hours long. This length of flight was long enough for most crew members. The flexible wing meant that the Shackleton was relatively comfortable at low level, but the flights were still physically tiring.

The Shackleton had a crew of ten: two pilots; two navigators; an air engineer; with an air electronics officer (AEO) and four air electronics operators (AEOps) or air signallers to operate the radar, electronic support measures (ESM) and sonar system, to handle communications and to fire the 20mm cannon[8] in the nose of the aircraft. There were still one or two NCO pilots and navigators around, but they were a fast-vanishing breed. Most crews were captained by pilots, but a few had a navigator or an AEO as captain. In the early 1960s Coastal Command had introduced Constituted Crews in which an experienced pilot, navigator and AEO went back to the Maritime Operational Training Unit (MOTU) to join *ab initio* students part way through their training, who would make up the rest of the crew. This Constituted Crew would then complete the MOTU course together and would be posted *en masse* to a squadron with the intention of remaining together for a full 2½ year tour of duty.

I was a member of such a crew. We flew together all the time and, because of the long duration of our flights, we had little choice but to socialise together. We became an extended family and off duty, within the crew, the barrier of rank disappeared. I have no doubt that this was frowned on by the powers-that-be at the time, but accepted as inevitable. I remain great friends with the members of that crew and I am grateful for the education that they gave me. Another manning initiative around this time was the policy of posting a number of former fighter pilots onto Shackleton squadrons as Commanding Officers or Flight Commanders. No doubt this was intended to 'Gee Up' Coastal Command. It is impossible from my lowly perspective at the time to comment on the success of this policy. However, it did cause some exciting moments as some of these pilots, who had all been through the MOTU course, did not seem to appreciate that the Shackleton had somewhat different handling qualities (eg stalling speed in the turn) from the Hunter.

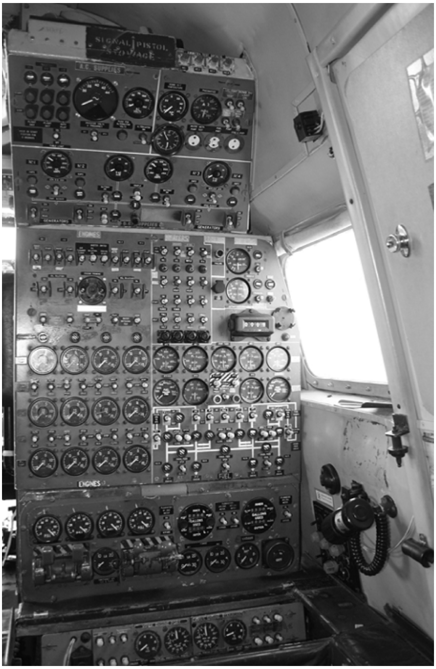
Pilots Notes for the Mk 3 state, 'The aircraft is pleasant to fly and can be quickly and easily trimmed throughout the speed range.'[9] All the pilots that I knew enjoyed flying the Shackleton, but I think that



The 'Office' in a Shackleton MR3 Phase 3.

most of them would have taken this statement with a pinch of salt. There were no powered controls and flying the aircraft tactically above a stormy sea down to a minimum operating altitude of 100 feet by day and 200 feet by night was both physically demanding and not for the faint-hearted. Similarly, landing on an unfamiliar airfield in a crosswind at the end of a fatiguing 12 to 13 hour flight was challenging, especially on the tailwheel aircraft.

Taxying the tail-draggers was also a challenge. The technique was to set the inboard engines at idle and taxi using a combination of differential thrust on the outboard engines and differential braking. The problem was that the brakes were pneumatic and the pneumatic system was pressurised by compressors on the inboard engines. So the pneumatic system was not being charged while the aircraft was taxying with the inboard engines at idle; thus it was possible to exhaust the brake pressure on a long taxi if the brakes were used too much. This would then require an embarrassing call to air traffic to request a turn into wind and a run-up on the taxiway. The brakes were also prone to overheating. However, the Mk 3 with hydraulic brakes and nosewheel steering, overcame the taxiing problem.



The air engineer's station in a Mk 3 Phase 3 with the lid of the desk removed to reveal the controls for the Vipers.

The air engineer was the pilots' right hand man, keeping the engines going and managing all the mechanical systems on the aircraft. Although the Griffon Mk 58 was a superb design, it was an old and highly developed engine operating at high rpm and high boost with frequent changes of power settings required during tactical flying. So it was prone to failure and the engineer had to keep an eagle eye on the engines' vital signs to look for incipient failures. He managed the fuel, electrical, hydraulic, pneumatic and de-icing systems. He also controlled a fairly scary heating and ventilation system that burned AVGAS. So his hands were full and, unlike others of the crew, he could not rest on long transits.

On the Mk 3 Phase 3 Shackleton he operated the Viper turbojet engines using the controls tucked away in his desk. The Bristol Siddeley Viper 203s were installed in the rear of the outboard Griffon engine nacelles. They were originally fitted to enable a fully laden Mk 3 to get airborne from a 6,000 ft tropical runway. Each Viper produced 2,500 lb of thrust and they were surprisingly tolerant of running on high octane AVGAS instead of AVTUR. However, this did impose limitations on running time. Initially the Vipers could only be run for no longer than 5 minutes at full power for take-off. However, the controls were soon modified to enable them to run at 93% for up to three hours. So we could use the Vipers on a heavy aircraft to save running the Griffons at maximum continuous power for long periods, thus extending the life of the ageing piston engines.

The W/T operator had an STR 18B HF set with a trailing aerial and he passed messages using a Morse key. We also had the PTR 175 V/UHF set for communicating with adjacent friendly forces and an Aldis Lamp for talking to HM Ships.

The Shackleton navigation and weapons system was very complicated, with no less than four separate ground position indicators (GPI). It was not as precise as the V-Bombers' Navigation and Bombing System, but it was possibly even more complex, comprising a large number of interconnected electro-mechanical systems with cogs, gears, relays, resolvers, transmitters and secant gears. However, the system required a great deal of human intervention, as did all the other equipment in the aircraft. It was, of course, an era of pencil and paper and a lot of mental arithmetic. The heart of the system was two Mk 7 gyro magnetic compasses, BLUE SILK Doppler (ARI 5885), an air position indicator Mk 2 and GPI Mk 4C. Fixing was provided by LORAN A, GEE Mk 3, TACAN, an AD 712 radio compass and, of course, the ASV 21 radar when close to land. However, these systems had limited coverage, were sometimes unserviceable and were susceptible to atmospheric interference. In addition, the Doppler would unlock over a calm sea and during tactical manoeuvres.

So we relied on the basics. We used an astrocompass Mk 2 for hourly heading checks on sun or stars. The air position indicator was accurate and reliable, and Shackleton pilots were very good at estimating the surface wind speed and direction from the appearance of the sea. The navigator would apply a correction factor for the aircraft altitude to the observed surface wind and thereby had a good estimate of the wind affecting the aircraft and thus the dead reckoning (DR) position. We took frequent drift sight readings and we could find the wind using the drift sight, by flying a quick dogleg and measuring the drift on three different headings then plotting the result on the Dalton computer. As well as the drift sight and the pilots' eyes, the other indispensable aid was the sextant (the hand-held Mk 9A bubble sextant in the Mk 2 aircraft and the Mk 2 periscopic sextant in the Mk 3s). The Shackleton was not the best platform for astro because we flew at low level, where it was turbulent, frequently with clouds above. But sometimes astro was all we had. In October 1967 our crew took a Mk 2 Shackleton from Ballykelly to Majunga in Madagascar. On the leg from Ascension Island to Kinshasa we had nothing to

The navigators' station in a Mk 3 Phase 3 – Tac Nav on the right.

enable us to fix our position but the drift sight and sextant until we arrived at the African coast 1,600 nms away. Luckily both the sun and moon were up and at local noon as the Sun passed almost directly overhead I was able to take a running fix on it. I was quite proud of a landfall error of 3 nm, some nine and a half hours after leaving Ascension.

The tactical navigator sat in the forward of the two seats at the navigation position, just to the rear of the air engineer and W/T operator. On patrol he ran the searches using the GPI Mk 1A, which projected a moving light showing the aircraft position onto a half-million scale chart fixed to the plotting table. This was very useful for navigating pre-planned search patterns or conducting a radar search of an area. At Action Stations the tactical navigator rushed to the nose to act as bomb aimer. The routine/attack navigator[10] in the rear seat was responsible for keeping track of geographic position, taking fixes, shooting astro and finding winds to set on the system. He also managed the weapons system, pre-setting search depths on homing

The ASV 21 radar.

torpedoes and hydrophone depths on sonobuoys, in accordance with the brief, and selecting appropriate sono-buoys, weapons and sea markers for release. At Action Stations he took over control of the aircraft and prosecuted underwater targets with info-rmation passed by the sonics operators using the GPI Mk 1C that projected aircraft position on a large-scale tactical plot.

Radar was the main anti-submarine search sensor. A submarine in transit or on patrol would normally stay submerged the whole time, raising peri-scopes and other sensors occasionally. In addition diesel-electric submarines (that made up the bulk of the Soviet Fleet) needed to raise a snorkel, or snort mast, periodically to run the diesel engines to charge the submarine's batteries that provided the power for propulsion. So the basic anti-submarine task for the Shackleton force was to search an area with radar so as to detect the very small target (typically 1 square metre echoing area) exposed by a submarine during its relatively short snorting period (as little as 20 to 30 minutes every few hours for some of the most advanced submarines). The ASV Mk 21 (ARI 5878) was a centimetric radar developed from the H2S Mk 9 bombing radar. It operated on 9340 MHz with a peak power of 200 Kw.[11] Radar returns were displayed on a ground-stabilised 9-inch diameter plan position indicator.

The radar scanner was housed in a retractable 'dustbin' that was tucked into the aircraft fuselage just behind the bomb bay when the aircraft was on the ground. Once airborne the scanner was lowered to one of two 'Search' positions to give an all-round scan. When the bomb doors were opened the radar scanner could be lowered further to the 'Attack' position to avoid blanking by the bomb doors. Contacts were passed to the pilots and navigators by voice. The ASV 21 was a good search radar for its day and the operators were skilled at detecting targets amongst sea clutter, but the detection range was heavily dependent on the sea state. Under ideal conditions ASV 21 might detect a snort at up to 15 nm, but more realistically at only 6 to 8 nm in the sea states normally experienced in the North Atlantic.

Another challenge we faced was that submarines had radar intercept equipment that could detect our ASV radar transmissions at a much greater range than the radar could detect the submarine. We used various tactics, such as scanning the radar in a sector behind the beam of the aircraft, in an attempt to counter the range advantage enjoyed by the submarine. The hope was that we would detect the submarine, before it had time to submerge in reaction to intercepting the aircraft radar. We could then home onto the radar contact for a direct attack with depth charges or, if it had submerged, lay sonobuoys on the datum to relocate and attack with a homing torpedo. We practised this endlessly, homing onto radar buoys located near the main maritime bases or onto a skid target towed behind RAF marine craft that produced a wake effect similar to that of a snorting submarine. Each practice homing ended in a visual attack, with practice bombs aimed by the pilot from 100 feet in daylight or the bomb-aimer from 200 feet at night. However, to quote AP1300, 'The object of maritime air forces is […] to prevent submarines from attacking shipping'[12] – not necessarily to sink them. So a Shackleton crew might have been tasked to undertake harassing operations against submarines to discourage them from snorting, thus reducing the submarine's speed of advance and its chance of getting into a firing position. The aircraft would be flown, within a specified patrol area, on a random pattern of tracks with the radar transmitting on all-round scan for random periods. So a submarine putting up its ESM mast for a 'sniff' to see if it was safe to snort would be aware that an aircraft was in the vicinity, but would find it difficult with successive 'sniffs' to work out what the aircraft was doing and thus the level of threat it presented.

The other system that we had to search for submarines was Autolycus.[13] This was an ion mobility spectrometer that sampled the air through which the aircraft was flying to detect the ions characteristic of a submarine's diesel exhaust. Once detected, it was possible to home along the exhaust trail to its source. In the open ocean, away from industrial pollution and with few sources of diesel exhaust, Autolycus worked reasonably well. However, it could not distinguish between the exhaust from a submarine and the exhaust from a diesel-engine fishing boat so the false alarm rate was very high and it was not really a practical submarine search sensor.

The Air Sea Warfare Development Unit (ASWDU) conducted a trial of a Magnetic Anomaly Detector (MAD) on a Mk 2 Shackleton in the 1950s. MAD detects the distortion in the Earth's magnetic field created by a large iron mass, like a submarine, even when submerged. It is a short range (hundreds of feet) sensor that can be used to help localise a submerged submarine that has been detected by other means. However the trial established that the Shackleton produced too much background magnetic noise that masked target signatures so MAD did not go into service on the Shackleton.[14]

The 'spark plug' antenna on the top of the aircraft was for the ORANGE HARVEST ESM (ARI 18144). This could intercept pulse radar transmissions in the S or X bands, depending on which receiving head was fitted. It was invaluable for general maritime reconnaissance and for giving warning of surface warships, but it was of limited use as a submarine search sensor, because the chance of a submarine transmitting on its radar system during wartime was vanishingly small.

The other main search aid was the 'Mark One Eyeball'. The Shackleton was provided with excellent lookout positions that enabled eight pairs of eyes to be deployed in a visual search. Visual search was important in the final stage of a radar homing for sight of submarine masts, a wake or the characteristic swirl where the submarine had dived that would confirm that this was indeed a target and not just a bit of flotsam. Visual lookout, augmented by hand-held cameras, was also important for intelligence gathering on surface targets. Visual search was vital for Search and Rescue.

We also used visual search in other roles, such as Internal Security. In July 1969, when two Americans were making historic footprints on the Moon, my Shackleton crew was literally looking for footprints in the sand along the largely uninhabited coast of Oman. Rebels were smuggling weapons and people across the Arabian Sea into Oman. The Shackletons, based at Sharjah, were tasked to fly along the coast

The Sonics Mk 1C display.

of Oman at 100 feet over the beach. Any signs of a landing or sightings of suspicious boats inshore were reported by HF radio to the Trucial Oman Scouts, who managed to intercept an arms shipment on the basis of a report from our crew.

The Shackleton was equipped with a short range sonar system, Sonics Mk 1C, with which to relocate and prosecute submerged submarines that had been detected by other means. This consisted of sonobuoys, dropped from the bomb bay, and a processing and display system in the aircraft.[15] On entering the water a sonobuoy lowered a hydrophone to a pre-determined depth and erected an aerial to transmit sonar data to the aircraft. The passive sonobuoy (T 9003) detected the noise made by the submarine’s propellers. The hydrophone rotated at 3 rpm and thus indicated the bearing. It had an effective range of about 5,000 yards on a Soviet submarine such as a *Whiskey*, *Zulu* or *Foxtrot*; however, this depended on several factors such as the water temperature/depth profile and the background noise.[16] The hydrophone/transducer of the active sonobuoy (T 11514) rotated in steps of 36 degrees; at each step it transmitted a sonar ‘ping’ on one of three pre-set frequencies (between 20·4 KHz and 23·0 KHz) and then ‘listened’ for a return echo reflected by a target. Thus the active buoy provided both range and bearing of a target. The active buoy’s effective range was 2,000-3,000 yards. The sonobuoys had long and short cable settings that could be set before release to enable the hydrophone to be deployed at the optimum depth based on the predicted sonar conditions.[17] Each sonobuoy was pre-set to one of 16 radio frequencies. So it was possible to have a number of buoys in the water at the same time without mutual interference. Each of the two sonics operators could monitor two passive buoys or one active buoy at a time.

Load 4	20 × Sonobuoys
	3 × Mk 30 Torpedoes
	2 × Mk 44 Torpedoes
	6 × Marine Markers
Load 7	10 × Sonobuoys
	1 × Mk 30 Torpedo
	2 × AS 1,200 lb 'Lulu' NDBs
	9 × Depth Charges
	9 × Marine Markers

Table 3. Examples of Typical Shackleton Weapon Loads.[18]

The standard procedure was to drop three buoys – passive, active, passive – across the datum position of the target at 2,000 yard intervals. Subsequent sonobuoys might be laid to maintain contact with the target and achieve weapon release criteria. The sonics operators positioned movable cursors over the sonar returns on their screens and this automatically transmitted ranges and bearings to the attack navigator. Bearings appeared on the navigator's plotting table as narrow beams of light from 'lighthouses' that he manually aligned with the position of each sonobuoy on the plot. Ranges appeared on an electronic indicator.[19] By this means the target was tracked underwater until the attack navigator had the criteria to release a weapon. He conned the aircraft to the weapon release point using the aircraft symbol on the plot and a sonobuoy homer (ARI 18107/4) that enabled the crew to get an accurate 'on top' of an in-contact sonobuoy to update the navigation plot immediately before the attack. This sonobuoy tracking process demanded close co-operation between the sonics operators, navigator and pilots. For training, the whole process could be simulated in the air using the Stage Two Trainers on the maritime bases that transmitted simulated data to an aircraft's sonics system as it flew on a local training range.

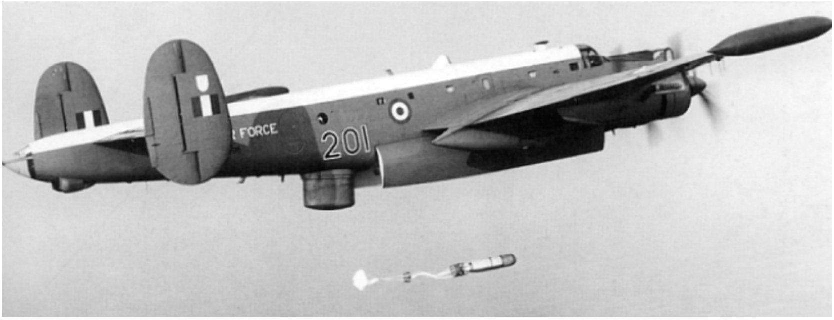
Andy Lovett's earlier paper discussed the flexibility of the weapons loads that the Shackleton could carry. To emphasise this point Table 3 shows two of a range of possible war loads. Load 7 runs the gamut from WW II depth charges for attacking a submarine on the surface, through homing torpedoes, to the '1,200lb Anti-Submarine

A Shackleton in the attack configuration – bomb doors open and radar 'dustbin' fully extended. (Jerry Hughes)

Bombs' as they were euphemistically called.[20] I am not aware of any other aircraft in RAF service that carried a mix of conventional and nuclear weapons at the same time.

A typical (hypothetical) anti-submarine action

This passage takes the reader through the typical ASW scenario for which we trained constantly. Imagine that it is a dark night over the North Atlantic. A Shackleton has been airborne for eight hours on a radar search for conventional submarines. Suddenly the radar operator reports a small radar contact at about 8 nm range that he assesses as a possible submarine. The captain calls 'Action Stations' and the crew is galvanised into action. The first pilot turns the aircraft towards the contact and homes to it under the direction of the radar operator. The co-pilot increases engine power. Meanwhile the attack navigator checks the settings on the weapon and sonobuoy control panels, sets up his plotting table and confirms the sonobuoy serial numbers with the sonics operators. If the radar contact disappears he will take over the homing and direct the pilot to the datum. The tactical navigator passes the latitude and longitude of the contact to the W/T operator, *en route* to the bomb aimer's position in the nose. The W/T operator sends a POSSUB message to the controlling authority.[21] Anybody



A Shackleton Mk 3 dropping Mk 30 homing torpedo. (The Shackleton Association)

spare will man a lookout position in the tail and in the beam. At three miles the pilot selects the bomb doors open and the radar operator lowers the scanner to the attack position. The pilot gradually descends to the attack height of 200 feet, paying close attention to the radar altimeter. At one mile a sequence of pyrotechnic flares is fired to illuminate the target. If the bomb aimer sights the target he gives directions to the pilot and releases a stick of depth charges. Releasing the weapons also fires a series of 20-million-candlepower photoflashes and triggers the downward-facing camera to record the results of the attack, which are also reported by the observer in the tail.[22] (By daylight, the pilot would have attacked with depth charges from 100 feet.) If no target had been seen, a sonobuoy pattern would have been laid across the radar datum and the crew would have attempted to track and attack the submarine using sonar information and homing torpedoes.

As far as I know, no Shackleton ever released a weapon in anger against a submarine and the only time that the Shackleton ‘went to war’ in its primary role was in 1957 when Nos 37 and 38 Sqns gave ASW protection to HMS *Eagle* and the Suez invasion fleet. However, the Shackleton was a mainstay of the Cold War and it served in many operational theatres around the world in a wide range of roles.

Other Roles

General **Maritime Reconnaissance** was a role that we undertook all the time, whether in transit, on a training sortie or on a specially briefed mission we spotted, photographed and reported any Soviet

Bloc vessel that we encountered. Shackletons played a key role tracking Soviet ships in the North Atlantic during the Cuban Missile Crisis. Inshore maritime surveillance was a part of many campaigns, generally looking for arms shipments. Shackletons patrolled the waters around Cyprus during the EOKA crisis, around Malaysia during Confrontation and as part of the Internal Security operations in Arabia. In addition, the Far East squadrons flew anti-piracy patrols. From 1966 to 1971 Shackletons operated out of Majunga in Madagascar to provide surveillance for Royal Navy ships enforcing the United Nations oil blockade of Rhodesia. By the 1960s Coastal Command no longer operated specialist weather reconnaissance aircraft. However, Shackletons filed an hourly weather report wherever they went. In the 1950s Shackletons had provided weather reporting and surveillance for the UK nuclear weapon tests.

Search & Rescue was an important role, for which the Shackleton was ideally equipped with a SARBE Homer for homing onto Personal Locator Beacons and the Lindholme Gear that could be dropped to survivors in the water. This was a 600 yard stick of three containers joined by floating rope. The central container held a MS9 dinghy that inflated automatically on impact with the sea and the outer floating containers held survival equipment. An equivalent system without the dinghy was used for land survival situations. In the UK one, and sometimes two, aircraft were on a one-hour SAR standby 365 days of the year. Similar stand-bys were mounted at the overseas bases, including Gan. The tasks were varied – searching for downed aircraft and aircrew, missing fishing boats and light aircraft or providing top-cover for SAR helicopters. We sometimes ‘escorted’ fighter aircraft that were flying long transits over the ocean. Royal Flights were sometimes supported by an airborne SAR aircraft. Frequently we were tasked to carry out a visual search of an area for a very small target, such as a person in the water or a small wooden boat. Such searches required the aircraft to fly, very precisely on a sequence of closely-spaced parallel tracks. Steering the aircraft through a search that might last several hours with track spacing less than the turning circle of the aircraft taxed the skills of both pilots and navigators. These visual searches also required the whole crew to remain vigilant for a long time. A modification of the Lindholme Gear was used to drop supplies such as mail and small bits of spare equipment to Royal Navy ships

A Shackleton MR2 of No 205 Sqn on SAR stand-by at Gan.

and also to the Ocean Weather Ships. A Coastal Command tradition was to drop a small Christmas tree to each Weather Ship just before Christmas.

Because of its size and range the Shackleton was often pressed into service as a **transport aircraft**. It could carry some 30 troops, with their heavy kit in panniers in the bomb bay. Shackletons carried out a trooping role on several occasions, including the Suez Campaign and in the early stages of the Confrontation with Indonesia.

Throughout its life the Shackleton was used in the **Internal Security** role in the Aden Protectorate and latterly Oman. Operating with ground forces, and employing the air policing tactics developed in Iraq in the 1920s, the Shackleton was used for many tasks: photo reconnaissance; communications relay; air observation; land convoy escort; supply dropping; leaflet dropping; coastal reconnaissance; and ultimately as the 'Big Stick'. Offensive capability ranged from strafing with 20mm cannon and dropping 25lb bombs as 'frighteners', to the ability to drop 15 × 1,000lb bombs. As late as 1969, on detachment to Sharjah, I was practising dropping 1,000lb bombs from medium level.

The Shackleton's long range meant that squadrons were frequently tasked to 'Show the Flag' in some exotic location. I recall that the technical term for these exercises was 'a Jolly'.

Airborne Early Warning

The final role that the Shackleton undertook was Airborne Early Warning (AEW). The Shackleton AEW Mk 2 entered service with No 8 Sqn at Lossiemouth in 1972. It was to be a stopgap until the Nimrod AEW entered service. However, as a result of the delay, and then the cancellation, of the Nimrod, the Shackleton AEW remained in service until 1991. It was essentially the MR2 with the AN/APS-20 radar in a large blister radome under the front fuselage, with the AN/APX-7 IFF Interrogator and an improved ESM system – ARI 18144/1 with interchangeable receiver heads capable of covering either the E and F bands or the H, I and J bands. This radar (it was rumoured the actual sets) had previously been used in Royal Navy Skyraiders and Gannets. Although owned by No 11 Group, in order to cover the threat direction, the Shackleton AEW aircraft mainly operated over the same northern sea areas that the maritime Shackletons had patrolled. The AEW Shackletons also carried out SAR missions, for which they carried the Lindholme Gear.

How did it feel to be in Coastal Command in the 1960s?

Coastal Command in the 1960s was very much the poor relation, out on a limb from the rest of the RAF – at least that is how we saw ourselves. Money had been spent, quite rightly, on Bomber Command and then Transport Command, and there was little left for Coastal Command. For example, Avro worked on various designs for a Shackleton Mk 4with more powerful engines that would have been a more capable variant, but this logical development was quietly dropped in the late 1950s.[23] It showed itself in other more petty ways. I have been evicted from a table in the Transit Mess at RAF Luqa because it was a 'Transport Command table'. The difference was that they were entitled to butter and we were only entitled to margarine! However, being the poor relation engendered a great spirit of camaraderie in adversity – and morale in the Shackleton force was high. Maritime flying taught us perseverance. We made a virtue of making do and pressing on, despite old and unserviceable equipment and highly unsociable hours. If I complained in the crew room about a bit of kit, some hoary ancient in the corner, who was probably in his mid-40s, would rouse himself and say 'I flew with that over Berlin, lad'. End of discussion.

I believe that the Shackleton force was highly professional and that the limitations of our equipment were mitigated by the quality of the crews and their training. I hope that I have managed to convey the picture of a highly motivated and well-trained crew in which each member had a key role to play and where the human brain did much of the interpretation, analysis and synthesis. Our groundcrews were just as high quality. I have referred to unserviceable equipment several times and it is important to place on record that our ground tradesmen worked tirelessly and skilfully to keep our Shackletons flying – often from remote and inhospitable bases. A large percentage of our flights were operational and we saw ourselves as being in the front line of the Cold War, with frequent sightings of Soviet warships and of electronic intelligence (ELINT) trawlers or hydrographic vessels that lurked just outside UK waters hoovering up radio frequency and sonar intelligence. Visual sightings of Soviet submarines were less common, but we spent many hours with our NATO allies hunting them down as they tried to slip undetected into the Atlantic from their bases on the Kola Peninsula or in the Baltic. Needless to say, these incursions frequently coincided with holiday periods. We rarely flew anywhere direct, but always carried out a surveillance exercise (SURVEX) along the way. And on these searches we invariably stayed airborne for as long as possible: to the prudent limit of endurance (PLE).

Two flights stick in my mind. On 8 January 1966 Crew 4 of No 210 Sqn scrambled from Ballykelly in a Shackleton Mk 2 on an SAR mission to look for an aircraft missing from the USS *Nimitz*.[24] The weather was appalling and, sadly, the search was unsuccessful. Coming off task we were told to divert to Keflavik in Iceland because all the northern UK bases were unusable because of weather. On arrival at Keflavik we were unable to land because of low cloud and crosswinds. So we made our way back to the UK where Ballykelly and Kinloss were out of the question. Aldergrove had an acceptable cloud base and crosswind, but was closed because of ice on the runway. However, we were fast running out of fuel and we had to land somewhere. Flight Lieutenant Dave Newell, who had learned to fly in the Second World War, made a superb three-point landing after a gruelling 15 hours in the air and we glissaded down Aldergrove's runway. He rightly received a Green Endorsement.

Then on a Friday in April we were duty crew and had arrived at work at 0800hrs. At about 1630hrs we were tasked with taking some spares to Bodø in northern Norway. After declaring three aircraft (and, from memory, ten engines) unserviceable, we finally got airborne after 0400hrs on the Saturday morning and landed at Bodø, after a SURVEX *en route*, 12 hours and 10 minutes later, some 34 hours after getting out of bed. The pilots had never landed at Bodø before; it was dusk, there were mountains close by and there was a snowstorm in progress. After landing, the Norwegians insisted that we hangar the aircraft, because conditions were getting worse. However, they could not find the Shackleton towing arm, so we taxied the aircraft into the hangar on the two inner engines with members of the crew moving the propellers of the outer engines as the aircraft inched forwards so that the propellers would clear the wings and fins of the many small aircraft already in the hangar. I can truly say that I learned about flying from that.

It was all a great adventure. I spent nearly five years on the Shackleton. In that time I logged nearly 2,500 hours and I became an A Category navigator on a Command Crew. I spent a great deal of time away from home, including the first two Christmases of married life. I became very familiar with maritime airfields around the North Atlantic and Mediterranean. I took part in 18 major national or NATO exercises. I spent four months in Majunga – and a week getting there[25] – four months in Malta and three months in Sharjah. I am sure that this was average and that some others had an even more interesting time.

However, it was not all fun. The Shackleton has the unenviable record of the highest number of aircrew killed –150 – in peacetime on any type of RAF aircraft. Over the aircraft's 40-years of service, twenty-two of the 180 Shackletons built were destroyed in major crashes and at least another five aircraft were written off after lesser accidents. Not all crashes were fatal and several Shackleton pilots displayed exceptional flying skills to bring crippled aircraft safely to the ground. For example, in January 1964 Flt Lt 'Pop' Gladstone was climbing out from Kinloss in a Shackleton Mk 3. The number 3 engine suffered an overspeed and caught fire, eventually falling off the wing. Number 4 engine then caught fire. Pop executed a textbook wheels-up landing on Culloden Moor by the light of the burning aircraft and everyone on board walked away with only minor injuries. He received a very well-deserved Air Force Cross for this incredible act of airmanship. During my time on the Shackleton force, five Shackletons crashed from a variety of causes with the loss of forty-seven souls and only five survivors. Three of these aircraft crashed within seven weeks in November/December 1967. The final blow fell long after I had left the Shackleton force. In 1990 an AEW Mk 2 hit a

Representative of Shackleton accidents, although following a wheels-up incident like this one it was often possible to beat the aeroplane back into shape and restore it to service. (The Shackleton Association)

hill on the Isle of Harris while making an approach to Benbecula airfield in poor weather. Among the eleven people killed was the man who had taught me to navigate the Shackleton 25 years previously.

An assessment of the Shackleton Force

There is no doubt in my mind that the Shackleton was the right platform for its time. It had the range and the carrying capacity that a maritime patrol aircraft needs. However, by the end of its life much of the equipment in the Shackleton was becoming out-dated. In 1965 the Air Sea Warfare Development Unit conducted a tactical evaluation of the Mk 3 Phase 3 Shackleton: ASWDU Trial 427. The report makes rather sober reading.[26] For example, analysis of the attack error on a submarine being tracked by sonobuoys showed that the mean point of impact was some 350 yd from the aiming point with a circular error probable of 400 yd, which was about the acquisition range of a Mk 44 active homing torpedo. This explains, in part, why we had the 1,200 lb Anti-Submarine Bomb. Some modifications were introduced as a result of the trial to improve accuracy. However, the reality by the late-1960s was that the Shackleton had some capability to detect, localise and attack diesel-electric submarines, but virtually no capability to detect the growing fleet of Soviet nuclear-powered submarines, unless the submarines were foolish enough to put a large mast above the surface or needed to surface to launch their missiles. Nevertheless, the Shackleton force played an honourable role in helping to maintain deterrence during the Cold War and we should not underestimate the value of the intelligence gathered by Shackletons on their unending patrols. Moreover, by then the Nimrod was on the horizon with its Jezebel sonar system that could detect submarines at tens of miles, magnetic anomaly detector and a digital navigation and attack system that automated submarine tracking. So, as Coastal Command became 18 Group of Strike Command in 1969, this Cinderella force was on the point of receiving a significant increase in capability. Apart from the maritime role, the Shackleton was the RAF's 'Jack-of-all-trades' aircraft throughout its life. Despite the RAF having fleets of bomber, reconnaissance and transport aircraft, the Shackleton was pressed into service in all of these roles throughout its life.[27] So my final analysis is that the Shackleton and its crews were an important element of the UK's defensive capability for most of the Cold War. But that is just a Navigator's point of view!

Sources and Acknowledgements.
The National Archives.
The RAF Museum.
The Newark Air Museum and Brian Withers.
The Shackleton Association and Nev Fiest
The Farnborough Air Sciences Trust.

Notes:

[1] For completeness, the Phase 1 update, incorporated between 1952 and 1959, introduced: the ASV 21 radar to replace the ASV 13; BLUE SILK Doppler and GPI Mk 4; VHF homer; IFF Mk 10; radio altimeter Mk 5; ILS, zero reader and Autopilot Mk 10. Phase 2, incorporated between 1958 and 1961, introduced: Mk 1C sonics; ORANGE HARVEST; VHF, UHF and sonobuoy homers; TACAN; the ability to carry homing torpedoes. Phase 3, incorporated between 1963 and 1966, introduced: soundproofing; fuel jettison; SARBE homer; GM 7 compass; the nuclear depth bomb; and for the Mk 3, two Viper turbojets. All three programmes involved structural strengthening and the Mk 3s were virtually rebuilt at Phase 3.

[2] The magazine of the Shackleton Association.

[3] The Maritime Operational Training Unit (MOTU) had a fleet of modified Mk 1 aircraft, designated the Shackleton T4, for operational training. In about 1966 MOTU was re-equipped with Mk 2 Phase 3 aircraft that were used for converting squadron crews to the Phase 3 aircraft and for training *ab initio* crew members.

[4] The Air Sea Warfare Development Unit (ASWDU) conducted both tactical evaluations and equipment trials using a mix of established and borrowed aircraft.

[5] Source: US National Intelligence Estimates 11-8-66 & 11-14-66 dated 13 March 1967.
[6] OR 200 of 1944, the original RAF staff requirement, called for an aircraft with a 3,000nm range carrying 6,000 lbs of weapons and other stores.
[7] 'Coastal Command', a 1961 segment on DVD *Royal Air Force Coastal Command, the definitive films collection 1936-1969*; released by Strike Force Entertainment in 2014.
[8] Hispano 20mm No 4 Mk 5.
[9] AP 4267E, Shackleton Mk 3 Phase 3 Pilots Notes.
[10] These are the official titles and description of duties as shown in MOTU notes. However, several sources use different terms. I have no doubt that there were local differences.
[11] AP 4267C Shackleton Mk 3 General & Technical Information.
[12] AP 1300 Operations (4th Edition), Air Ministry, March 1957.
[13] Named after Shakespeare's 'Snapper up of unconsidered trifles' in *The Winter's Tale*.
[14] The Nimrod MR1 was equipped with MAD.
[15] A Mk 1C sonobuoy was 5 feet long, 9 inches in diameter, weighed 80 lbs and, allegedly, cost the same as a Mini Minor.
[16] The rule of thumb was that the passive buoy had a detection range of 1,000 yards per knot of submarine speed above the propeller cavitation speed thus giving a detection range of about 5,000 yards on a *Foxtrot* class submarine (with a cavitation speed of 6 knots) escaping from the datum at 11 knots.
[17] Sixty feet or 140 feet for the passive buoy and 60 feet or 180 feet for the active buoy.
[18] Source AP 4267E, Vol 1, Book 1, Section 2, Chapter 3, AL19 dated June 1966.
[19] Sonobuoy Range repeater: ARI 18103.
[20] The United States' Mk 101 Lulu Nuclear Depth Bomb.
[21] A brief message indicating the detection of a 'possible' submarine, with the position and time. The other categories of message were PROBSUB (probable) and CERTSUB (certain). The target's velocity was added, if known.
[22] An F97 or F91 camera by night or an F24 by day. These cameras were also used for reconnaissance.
[23] One possible design would have had four turbo-compound Wright Cyclone R3350-85 engines and a maximum take- off weight of 132,220lb. Another possible design would have used four Napier Nomads, for which a trial installation in a Shackleton was begun, but never completed.
[24] As an indication of the quality of the aircrew in Coastal Command at the time, the two navigators of this crew retired as air commodores and the co-pilot retired as a group captain. The AEO and one of the AEOps reached squadron leader, and another AEOp was commissioned as an air traffic controller.
[25] Via Gibraltar, Sal in the Cape Verde Islands, Ascension, Kinshasa and Nairobi.
[26] TNA AIR 15/926. HQ Coastal Command Memorandum No 109; 'Tactical evaluation of the Shackleton (ASWDU trial 427)' dated April 1968.
[27] These Cold War roles for maritime aircraft are set out in AP 1300 (*ibid*).

FROM DEEP

Cdre Toby Elliott

Grandson of Maj J B Elliott, ex-RFC and OC 205 Sqn in 1919, and son of a WW II submarine commanding officer, Toby Elliott went to Dartmouth in 1963. He subsequently enjoyed 34 happy years in the Royal Navy, 24 of them in the Submarine Service. He commanded three submarines, a frigate and both a Submarine and a Frigate Squadron. His final appointment was as ACOS (Ops) CinCFleet. He then spent 12 years as Chief Executive of the Service Charity Combat Stress. Now fully retired he lives in Wales.

Introduction

By any stretch of the imagination, those of us who served during the post-World War II period, regardless of service, lived and worked in momentous times. For most of this period the Cold War became the focal point of interest for those caught up in military operations, not least in the highly specialist field of Anti-Submarine Warfare (ASW). The aim of this short article is to review the extent to which air power influenced the outcome of the ASW battle in the 20th Century, and to examine how advances in maritime aircraft and ASW weapons capability were to drive new developments in submarine design and operations, and vice versa.

It is said that 'happiness is 400 feet in a Force 10' – any submariner would heartily agree with this sentiment, bringing it to mind every time his boat encountered heavy weather whilst operating on the surface or at periscope depth. Bathymetric conditions can also be extremely complex, so 400 feet might also be a good depth to sit out a period of air activity over the patrol area.

At the same time, being forced to take the deep, slow and quiet option demonstrates the extent to which a patrolling maritime aircraft can influence the submarine commanding officer's thinking. In some situations the presence of aircraft will place a constraint upon him making it very much more difficult to achieve his operational objective. For instance, he may want to expose his periscope and Electronic Support Measures (ESM) mast to seek visual and electronic information about the target he is searching for. Or he may want to use high underwater speed to get into the best attacking position, or to evade searching forces. But high speed generates noise, and this can be a dead give-away.

So, for the submarine CO, to be faced by enemy forces capable of mounting ASW operations using maritime aircraft, as well as everything else in the ASW locker, can turn life into a bit of a nightmare, and in time of war often prove fatal.

In both World Wars German U-boats nearly brought the United Kingdom to its knees. At the end of the Second World War the latest German submarine and missile technology was eagerly sought by the Allies, as were the scientists and industrialists involved in the development of this new equipment. The material and technical knowledge acquired was to inform subsequent thinking in submarine and missile design, and the start of the nuclear age, that is strategic and tactical nuclear missile systems launched from nuclear propulsion submarines.

It was during this first 40 years of development and war fighting that both land based and embarked maritime aircraft were first to show their potential in the ASW role and then prove their true mettle, making a greatly significant contribution in the longest fought battle of WW II, the Battle of the Atlantic.

First World War

The submarine is a stealth weapon. In its early years it was in reality a submersible torpedo boat, its survival underwritten only by its ability to dive quickly and by the absence of an effective method to detect it whilst dived. It was greatly limited by its slow underwater speed and endurance. It needed to operate on the surface to run diesel engines to charge its batteries and to ventilate. Submarines would usually sit on the surface to take advantage of a significantly better height of eye needed to find the enemy, and to run on the surface for the much greater turn of speed needed to close or catch up with its target, or to reach its operating area.

The submariner’s tools were his binoculars and the periscope. Good eyesight and extremely diligent lookout were essential. Locating the target whilst dived becomes much more difficult unless it is within visual range, and virtually impossible at night. Target bearing and range are required for a torpedo firing setup and this could only be obtained visually. The ability to track a target by the sound of its propellers using passive sonar systems was pretty basic, used more of an aid to evading attacking surface ships than anything more sophisticated.

Despite these limitations, German U-boats were to have a splendid time throughout the war, sinking considerable tonnage around the British Isles and further afield, much of it by gunfire. About the only deterrent was to force the submarine to dive, and to go deep as part of an evasion manoeuver if under attack.

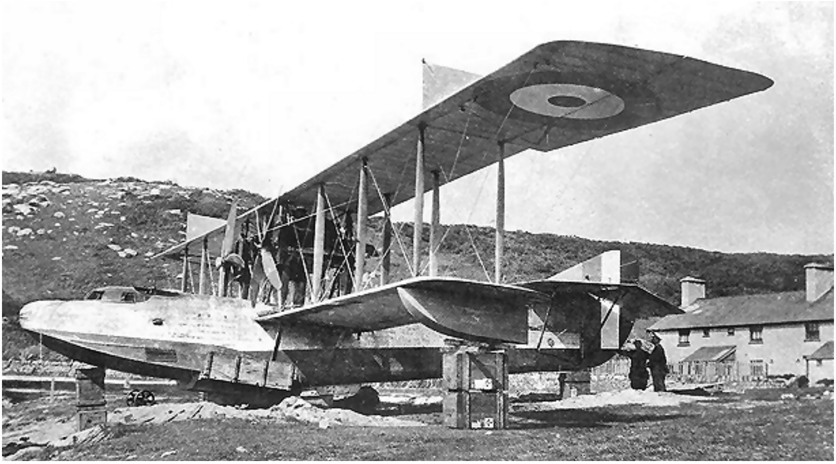
Royal Naval Air Service

Aircraft of the Royal Naval Air Service had readily engaged in land-based operations on the Western Front, but a number of obstacles had to be overcome before aircraft began to be deployed against the submarine.

In 1914 no equipment of any type existed for ASW from the air. There was no established maritime air doctrine. There had been and continued to be changes in the way British air forces were administered and operations overseen. There were issues about the production of sufficient aircraft and their armament. The potential for success required the use of aircraft in a well-organised effort and this was not always achieved, perhaps because local sea area commanders were free to decide how best to use their aircraft.

By the end of the war, in order to deal with the submarine threat, the RNAS had invested heavily in aircraft of all types, aeroplanes, seaplanes, airships and kite balloons. The ASW role consisted of attacking submarine bases, mounting air patrols to hunt for surfaced submarines, and in providing air cover for convoy escorts. Bombing bases was not a successful ploy – hardened shelters gave the protection that was needed. On the face of it, the singleton aircraft flew countless hours on sea area patrols on visual search for an extremely poor return – only one confirmed kill in the whole war. Convoy escort seemed only marginally more effective.

The kill occurred on 22 September 1917 when Curtis H-12 No 8695, a Large America flying boat, sank the surfaced UB 32 in the English Channel.[1] This was the only confirmed case of a British aircraft destroying a German submarine during the war without the aid



A Curtiss H-12 flying boat, like this one, was credited with the only German submarine confirmed as having been sunk by a British aeroplane in WW I.

of surface vessels.

Taken overall, during the last two years of the war there were numerous sightings and close shaves for evading U-boats plus five probable successes where aircraft working with destroyers or patrol vessels sank U-boats. In all there were over two hundred air attacks against German submarines but to have only one confirmed kill seems to be somewhat disappointing taken that searching aircraft had flown many thousands of hours over the seas around Great Britain.

What has been difficult to analyse is the extent to which the presence of a patrolling aircraft or airship had forced surfaced U-boats to evade by diving, but for the CO to remain surfaced by choice would have been a decision not taken lightly, as it obviously put his boat's mission, let alone survivability, at risk. Taken overall, maritime air activity was undoubtedly a deterrent, as just one snapshot reveals: Large America No 8695 accounted for five U-boat sightings and made two attacks during only 16 patrols flown between July and October 1917 (whilst the aircraft was based at Dunkirk).[2]

During these early days of flight the real challenge was to develop a new capability and associated technology – the aircraft and its weapon systems – to grapple successfully with a new threat, namely the submarine. By war's end naval aviators had powerful bombs and accurate sights, and U-boatmen had developed a healthy respect for the potential damage caused by an attacking aircraft last seen roaring in as the bridge watch-keepers tumbled below in a wet welter as the boat was crash dived and started its evasive manoeuvring. The aircrew could not believe how often these attacks, no matter how close their bombs had dropped, had failed, but in reality demonstrating how robustly the submarine hulls and systems could resist punishment (it was estimated that a 330 lb Type D depth charge needed to explode within 14 feet of its target to achieve a kill).

Aircraft were also able to communicate by wireless, transmitting enemy submarine sighting reports to destroyers or ASW patrol vessels. Undoubtedly such warnings did much to frustrate the U-boat CO's ability to get at his potential target. But by war's end aircraft were still only able to detect surfaced submarines visually and only by day, whilst not at all by night or when the submarine was underwater.

Figures are imprecise, but out of about 645 U-boats built or building 178 (28%) were sunk by all causes, one by aircraft, 66 by surface vessels, notably 18 by submarines, 48 by mines, and including 19 accidents.[3] It was a dangerous trade to be in. As already stated, however, though there is only one aircraft kill in these statistics, there can be no doubt that when aircraft were present over surface convoys or the coastal shipping routes they caused the U-boatman some difficulty often frustrating his ability to attack at will. The presence of a maritime patrol aircraft over the convoy was therefore highly valued by the escort force.

The Second World War

Though, in general terms, ASW had been somewhat neglected, by 1939 some advances in capability had been made. After WW I the British had written and published much material about a new apparatus for the detection of submerged submarines. This was ASDIC,[4] which it was claimed could locate and pinpoint submerged targets at a range of many thousands of yards by means of echo ranging. In British official opinion the submarine could therefore be considered a more or less obsolete weapon, and as late as March 1939 Churchill asserted in a memorandum to Chamberlain that 'The submarine has been mastered.'[5] But it had not. The remaining great

Commander of the U-boat fleet and later CinC of the Kriegsmarine, *Grand Admiral Karl Doenitz eventually became Hitler's successor as Head of State.*

weakness was the absence of any better detection system than strenuous visual lookout for surfaced submarines and this applied equally to surface and air units.

Karl Doenitz

Amongst the German submariners who survived WW I was Karl Doenitz, in 1935 to be promoted Rear Admiral and appointed head of the German Navy's new U-boat arm. He took his fledgling force in hand, trained them, and demanded and got Hitler's attention to allocate the resources needed to develop a formidable, perhaps war-winning capability. Doenitz fought the U-boat battle from 1939 until January 1943 as their commander, then as the German Navy's Commander-in-Chief almost to the end of the war.

Doenitz's Memoirs are illuminating.[6] He was to write that in 1935:

> 'I did not consider that the efficient working of Asdic had been proved, and in any case I had no intention of allowing myself to be intimidated by British disclosures. The war was to show that I was right.'[7]

Doenitz was also convinced that the U-boat was an ideal torpedo-carrier particularly at night and in a surface attack, and should use Torpedo Boat tactics. He was well aware that the submarine had a restricted radius of vision and was slow even on the surface, but needed to remain on the surface to conduct torpedo attacks as much as possible. Taking up tactical ideas already emerging towards the end of WW I he advocated concentration of force, wanting his boats to operate together – the Wolf-Pack system – and he developed the extremely complex command, control and communications arrangements needed to make these tactics work.

Doenitz recognised the danger posed by aircraft. Discussing the intense operational training of U-boat crews he wrote:

> 'The training programme covered every possible aspect –

The U-boat pens constructed at ports such as Bordeaux, Lorient and (as here) Saint Nazaire, were virtually impregnable. (KaTeznik)

> conduct of the ship when in enemy waters; the problem of remaining unseen – the commander being required to try to develop a sixth sense with regard to whether or not he had been observed whilst on the surface; the study of the question when to submerge in the face of a sighted aircraft or surface vessel and when it was permissible to remain on the surface.'[8]

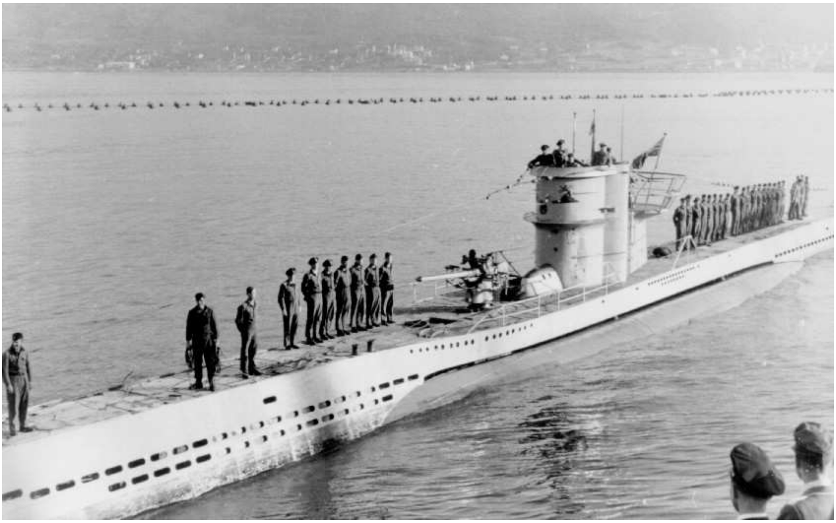
Doenitz had created a most formidable machine, commanding and fighting his boats from his shore headquarters allowing them to run amok amongst the shipping crossing the Atlantic as well as around the Western Approaches to the UK and coastal waters.

As in WW I, the U-boats were protected in their forward bases in France by bunkers impregnable to even the largest of bombs. The boats ranged far and wide, to the Mediterranean, the Caribbean, the South Atlantic and the Indian Ocean. The prime battle was fought in mid-Atlantic out of reach of shore-based ASW aircraft. Once the war had started it took quite a while for the allied forces to get to grips with the U-boat crisis.

RAF Coastal Command

RAF Coastal Command had started the war under resourced and many would say unloved, and not sure of its role. But it had a strong belief in the utility of air power in the maritime role, and ASW in particular. Radar was one of the range of technologies under development, and in due course became operational and fitted widely in ASW aircraft and ships.

In order to get on task expeditiously the submarines would run out through the Bay of Biscay at speed on the surface. In good weather



The most numerous German submarine was the Type VIIC. More than 600 were built. Seen here at Narvik in 1942, this one is U-251.

with clear visibility the bridge lookouts would almost invariably spot a patrolling enemy aircraft and the boat would crash dive before counter-detection. At night or in poor visibility and low cloud it was considered highly unlikely that an aircraft would sight a U-boat on the surface. Notwithstanding, the Bay of Biscay was to prove a focal area for ASW action as the war progressed.

By early 1942 Doenitz and his commanders began to see indications that the allied response was growing in effectiveness, at first suspecting that the submarine cypher had been broken. Now U-boats were disappearing, whilst the few that survived surprise aircraft attacks reported that these had occurred under such circumstances, by day or night, regardless of visibility or cloud cover. Submarine COs also reported a similar change in posture by convoy escorts.

Eventually Doenitz realised that allied aircraft and escorts must have been fitted with a radar locating system. So aircraft had suddenly become an extremely dangerous opponent to the whole method of conducting submarine warfare, and there was no readily available counter to this new technology. Deeply concerned by this development Doenitz desperately sought technical solutions.

It was 1943 before long-range aircraft equipped with new detection devices and weapons, typified by this Liberator of No 220 Sqn, were able to present a realistic counter to the U-boat.

For a while U-boats had their anti-aircraft gun armament up-rated with the idea of staying on the surface to fight it out with attacking aircraft. RAF Coastal Command's proud history includes the gallant battles fought by its aircrew to defeat this tactic. Eventually the boats were fitted with radar detection equipment but this did not always work effectively.

Despite ASDIC, despite radar and despite the convoy system, the U-boats fought on, continuing to cause great loss of merchantmen. But now allied long range maritime aircraft started to come into service, and the tide began to turn. In the early months of 1943 analysis of the U-boat loss rate lead Doenitz to realise his campaign was now unsustainable. His commanding officer's reports from sea painted a picture of allied convoy escorts working in harmony with the specially trained ASW support groups, and with continuous air cover provided by carrier-borne and long-range shore-based aircraft, most equipped with the new radar.

Shocked by his mounting losses, Doenitz was to write

> 'Now […] the situation had changed. Radar, and particularly radar location by aircraft, had to all practical purposes robbed the U-boats of their power to fight on the surface. Wolf-pack operations against convoys in the North Atlantic, the main theatre of operations and at the same time the theatre in which air cover was strongest, were no longer possible. They could

only be resumed if we succeeded in radically increasing the fighting power of the U-boats. […] This was the logical conclusion to which I came, and I accordingly withdrew the boats from the North Atlantic. On 24 May [1943] I ordered them to proceed, using the utmost caution, to the area south west of the Azores.'[9]

After the war Stephen Roskill was to write:

'The battle never again reached the same pitch of intensity, nor hung so delicately in the balance, as in the spring of 1943 […]. After forty-five months of unceasing battle of a more exacting and arduous nature than posterity may easily realise, our convoy escorts and aircraft had won the triumph they had so richly deserved'.[10]

Hitler and Doenitz were not going to give up. The U-boats were to resume operations and fight on until the end. At the same time Doenitz demanded new measures to restore the primary tactical advantage through some revolutionary development in basic design. He believed that the answer lay in high underwater speed and endurance.

German ingenuity and Speer's armament industry did produce a possible answer, the Walter U-boat propelled by an Ingolin high-test peroxide turbine. Other U-boat designs, the Type XXI and XXIII were built. These boats were fitted with the revolutionary *Schnorchel* or snort system, allowing air to be drawn in from the surface for the diesels to be run and their exhaust gases expelled whilst dived. High underwater speed and endurance were achieved through improved streamlining and larger batteries. These boats had much potential and were going to set a new standard for post-war conventional submarine design. Significant improvements included ESM (electronic support measure) equipment, radar, and greatly improved torpedoes with acoustic homing, magnetic (proximity) pistols and longer range.

Production was slowed but not entirely thwarted by the ever-increasing weight of Allied air raids over Germany, and these new boats and equipment were only just becoming operational by February 1945. This was rather too late to make any significant impact, but of keen interest to the Allies as the war came to an end.

In the air new technologies were also becoming available to the allies. Aircraft were fitted with a new low-altitude bombsight that made possible swift attacks on a detection made by radar at night without the need for the Leigh light. Magnetic airborne detector (MAD) equipment together with its retro-bomb was introduced by the US Navy, and enjoyed some success, as did the first sonobuoy system, with its associated air-launched Mark 24 Mine and acoustic homing torpedoes. On the other hand high definition radar detection of the *Schnorchel* head in rough water proved to be extremely difficult.

By war's end the Germans had lost 785 U-boats by all causes, including 245 sunk by shore-based aircraft, 195 of them by British and allied aircraft, 48 US, and 2 shared.[11] Forty-three boats were sunk by ship-borne aircraft. A further 93 shared sinkings involving aircraft were accounted for as well. Sixteen were lost to mines laid by aircraft, and 62 were bombed in their bases or building yards. This makes a grand total of 459 losses involving aircraft of one type or another, 58% of all losses of U-boats during the war. It is worth noting that the Germans had lost 781 boats out of the 1,173 they had built, of which Doenitz states 863 had become operational,[12] a casualty rate of 90%. Equally significant was the loss 30,000 out of 38,000 U-boatmen (79%).

The Cold War, 1945-1991

The formation of the North Atlantic Treaty Organisation brought together nations with a formidable order of battle, but also the vast financial reserves required to produce the technological advances that underpinned NATO's generally successful confrontation with the Soviet Union and the countries of the Warsaw Pact.[13] A large proportion of the costs associated with this lengthy contest can be attributed to maritime activity.

Most navies built conventional (diesel-powered) submarines copying the U-boat technologies already referred to, and the conventional submarine still has an important role today. But, whilst the Walter boat concept was briefly explored, the United States had concentrated on nuclear powered submarine design, realising that this propulsion system brought with it speed and underwater endurance of a kind that not even Doenitz had thought possible. The UK, France and the Soviet Union would in turn follow suit.

The USS Nautilus*, the world's first nuclear-powered submarine.*

In 1954 the world's first operational nuclear powered submarine was launched.[14] The USS *Nautilus* was indeed a true submarine, capable of remaining dived for lengthy periods of time – months, not days or weeks. Its nuclear power plant produced steam to drive propulsion turbines with potential for high underwater speed and unlimited endurance, and turbo generators producing more than sufficient electricity to power the submarine's essential life support system and war fighting capabilities.

The battle for supremacy had begun, with western navies well ahead of Soviet developments in terms of advanced technologies and the materials and men of the right quality to man the boats. There is, of course, a great deal more to ASW. If the Soviet submarine arm was going to be defeated a considerable number of capabilities and organisations had to be melded together. Operational intelligence required a wide range of systems in order to provide timely location information and target signature data – and these included satellite imagery and ELINT data, and the vaunted SOSUS[15] system used to cue into position US and UK ASW units searching for Soviet nuclear submarines operating in the Norwegian Sea and North Atlantic.

Maritime aircraft were seen as essential components for these operations, not least for their capability to deploy quickly to locate and track a submarine target when first detected. In wartime, of course, a kill could have resulted. In times of raised tension or in peacetime a number of options were exercised well short of weapon release, and it is ‘open source’ that tracking aircraft often handed their targets on to other ASW units including submarines. These operations were usually entirely covert in nature and could last for weeks and sometimes months.

It was noise, or rather noise detection and noise quietening, which was to become the dominant issue involving the allocation of considerable resources to develop the equipment able to track ever quieter submarines. The Soviet Union was some way behind in all this and was desperate to find a solution to defeat the NATO ASW forces they knew were rendering largely ineffective the ‘out of area’ operations mounted by their Northern Fleet submarines. Espionage was one way to catch up, but it was not until the Walker/Whitworth spy scandal broke in 1984[16] that the United States discovered quite by how much USN operations, including sensitive submarine information, had been betrayed. Walker’s spy ring had gathered and handed over to the Soviets a huge amount of highly sensitive information over the previous 18 years. The step-change Soviet submarines made in terms of noise quietening and the nature of their operations in the early ‘80s has been attributed in part to Walker’s activity.

At the same time the allies witnessed the gradual withdrawal of Soviet strategic missile carrying SSBNs into the Northern Fleet ‘bastion’, a much more easily defended area close to their bases, encompassing the Arctic Sea and the Arctic ice edge. From this bastion it was believed that the Soviet Navy would launch first strike ballistic missiles, with later classes of SSBN, the *Delta* III and IV and the massive *Typhoons* being able to launch from under the ice – at last, this capability had finally made them pretty invulnerable.

It was anticipated that the Northern Fleet would also generate ASW forces, primarily submarines, to attack Western nuclear-powered ballistic missile submarines, conduct cruise missile attacks and so on. Northern Fleet submarines had given NATO allies plenty of business during the 1960s and ‘70s, and by the early to mid ‘80s Soviet *Victor* Type III and the highly capable *Akula* class SSNs were to be seen in the Norwegian Sea and North Atlantic. These boats were undoubtedly practising their war role whilst conducting occasional anti-western SSBN sweeps and intelligence gathering. In turn these

Dwarfing its tug, TK-20 Severstal*, the last of the six massive 48,000-ton Typhoon Class submarines to be commissioned.*

operations gave western (mainly US and UK) ASW forces ample opportunity to hone their skills and gain valuable in-contact time.

The battle for supremacy was to rage on right up to the end of the Cold War and beyond. Much of what actually occurred at sea during this, the longest ASW battle of all, remains highly classified.

Command Control Communications and Intelligence

No discussion of ASW or the part maritime aircraft play in the battle can be complete without mention of co-ordination of a wide range of effort – scientists, industry, technical and tactical development, training and the part proper command, control and communications has to play to make it all work. Essential to the process is the gaining, analysis and melding-in of operational intelligence. It is difficult in a few short lines to emphasise how vital this is to the timely prosecution of ASW.

Perhaps the example of Admiral Sir Max Horton, CinC Western Approaches from 1942 to the end of the war, serves best to illustrate this point. It was Air Chief Marshal, later Marshal of the Royal Air Force Sir John Slessor who said:

> ‘No one knows more about the Battle of the Atlantic or played a more critical part in that battle than Admiral Horton. […] The association of the airman and the scientist with the sailor, which

Leaders in the campaign to counter the U-boat campaign in WW II, Admiral Sir Max Horton and Air Marshal Sir John Slessor

stood us in such good stead […] must be developed and extended in all forms of air/sea warfare.'[17]

Equally, Max Horton had of course given full credit to Coastal Command and its distinguished Commanders for the superb contribution made by this intrepid command during what was labelled the longest battle of the war.[18]

Dark blue/light blue 'Jointery' flourished in Horton's operational headquarters, and was to continue well past the end of the Cold War. Indeed it was the way ASW was to be conducted, in shore training, at sea in exercises and in live operations. ASW was, and remains, an 'all-hands' game involving a large number of players with close cooperation being essential to success.

Cooperation was still going strong when I finished a two-year spell as ACOS(Ops)CinCFleet in 1997. The co-location of CinC Fleet's intelligence and operations divisions with AOC 18 Group's maritime air operational tasking staff ensured the best co-ordination of all assets, submarine, surface ship and aircraft for covert ASW. During my time underground I observed first-hand the AOC, Air Marshal Sir John Harris, at the shoulder of the CinC, and I concluded that operational decision making about ASW and other operations involving prime assets, including aircraft, could not have been better conducted.

History may not take long to happen, but it often takes a considerable length of time before it can be properly written about. We await the final analysis and the verdict with interest.[19]

Notes:

1 TNA ADM137/377, 311-12. Seaplane 8695. Report of Bombing Submarine, 22 Sept 1917.

2 TNA AIR 1/71/15/9/124. SO RNAS Dunkirk to Vice-Admiral Dover Patrol, 30 Sept and 15 Oct 1917.

3 Terraine, John; *Business in Great Waters* (Barnsley, Leo Cooper, 1989) Appx G, pp772-3.

4 The name was an acronym for the Anti-Submarine Detection Investigation Committee. **Ed**

5 *Ibid*. p177.

6 Doenitz, Karl; *Memoirs: Ten Years and Twenty Days* (Translation, Cleveland, The World Publishing Company, 1959).

7 Terraine. *Ibid*. p188.

8 Doenitz. *Ibid*. p.15.

9 *Ibid*. p341.

10 Roskill, Captain S W; *The War at Sea 1939-1945, Vol II* (HMSO,1956) p377.

11 Terraine. *Ibid*. p722.

12 *Ibid*. Appx 6, p489.

13 Hennessy, Peter and Jink, James; *The Silent Deep* (London, Allen Lane, 2016) p81 *et sec*.

14 *Ibid*. p132.

15 *Ibid*. p325 *et sec*.

16 Ring, Jim; *We Come Unseen* (London, John Murray, 2001) pp156-7.

17 Royal United Service Institute Lecture, February 1947.

18 Chalmers, V S; *Max Horton and the Western Approaches* (London, Hodder & Stoughton, 1954) p244.

19 But see Hennessy and Jinks, *op cit*.

VIEWS FROM THE COCKPIT

Wg Cdr Mike Cockrill

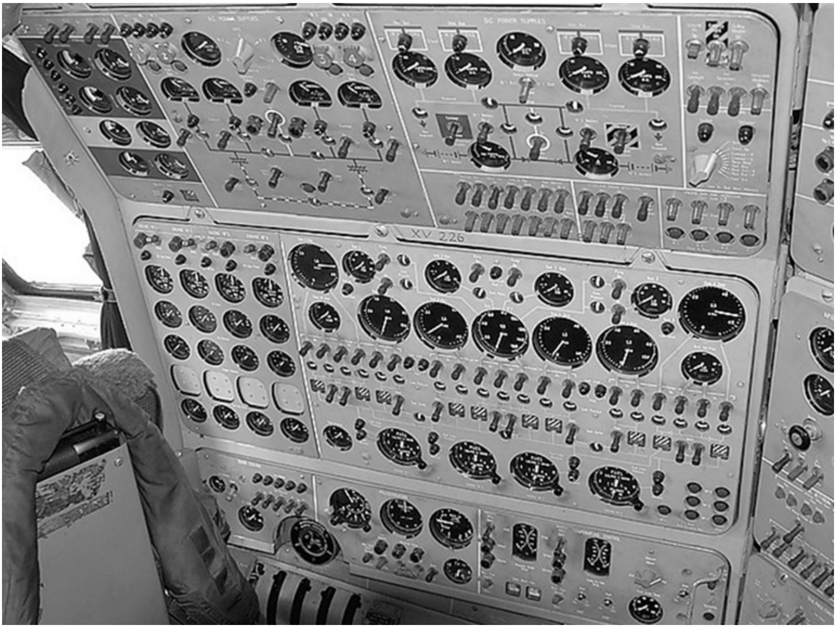
Mike Cockrill joined the RAF as a pilot in 1965. After a stint on Shackletons, he joined No 1 Nimrod Course, subsequently flying them with Nos 201, 203 and 42 Sqns and as OC 236 OCU, 1988-91. Time on the ground was spent with CTTO and HQ 18 Gp at Northwood, the JMOTS at Turnhouse and, finally, with the MOD's Flight Safety staff. Following retirement from the RAF in 1996 he joined BAE to work on the Nimrod 2000 project. While still in uniform he had become a QFI and commanded the Yorkshire UAS and he subsequently joined the RAFVR(T) to fly with the AEF at Woodvale; he still instructs on light aircraft today.

As the title of my presentation suggests, I offer a pilot's take on Nimrod MR operations during the period 1970 to 1991. Research has come from my own log books, reflecting some 5,000 flying hours on Nimrod MR1s and 2s, four role-related ground tours and some most enlightening conversations with friends and former colleagues – and there is little doubt that the older we get the better we were!

I will mention the conversion course before describing the two marks of aircraft, the crews and their sensors, the Nimrod's activities during the Cold War and during two hot conflicts. To finish I will offer an illustration of a Cold War Nimrod MR1 sortie, typical of so many flown around forty years ago.

Conversion Course.

The twelve-week conversion course was designed for role-experienced aircrew and called for classroom work, hands-on equipment training and twenty-five sorties, totalling 110 hours of airborne time. A new training tool for pilots and air engineers was the full motion Dynamic Simulator. It incorporated a visual system using a small TV camera tracking over a model of the Cornish countryside surrounding St Mawgan. A little lacking in handling fidelity, this lead to some interesting manoeuvres on short finals. In parallel, maritime navigators and sensor operators were also provided with dedicated specialist, fixed-base training devices for the first time. In all, quite a



The air engineer's station on a Nimrod.

training investment that was rewarded by crews quickly achieving high operational standards.

The Nimrod Mk 1 force was formed over a period of two years. The first aircraft was delivered to Coastal Command's Maritime Operation Training Unit (MOTU) on 27 October 1969. Following the absorption of Coastal Command into Strike Command at about the same time, the MOTU was redesignated as No 236 OCU in July 1970. Squadron conversion began in early 1970 with the three Shackleton MR3 squadrons Kinloss followed by No 42 Sqn at St Mawgan with the re-equipment of the Malta-based No 203 Sqn completing the transition to an all-jet MR force by the end of 1972.

Technical Aspects of Nimrod MR1

The Nimrod MR1 was a delight to fly. Powered flying controls were light enough to fly with one hand. Trim, in all three axes, was manual. The air engineer controlled major elements of the aircraft's power generation, fuel and environmental systems. Four generators supplied the main busbars, and the output of two was sufficient to

'The Nimrod MR1 was a delight to fly.' The innovative (for Coastal Command) RMI was at bottom left of the panel of primary flight instruments (boxed here in white).

support a full loading of utility and tactical systems. Six hydraulic pumps, across four engines provided pressure to servodynes and ancillary services. These, in turn, were backed up by AC and DC pumps.

Both marks of aircraft were powered by four Rolls-Royce Spey 250s, each providing 12,000 lb of thrust. These highly reliable by-pass engines also supplied off-takes for air conditioning and pressurisation. It was normal practice to shut down the outboard engines, sequentially, as aircraft weight reduced during the course of a sortie.

One system that had not achieved Release to Service prior to delivery of the first aircraft was the autopilot. However, by 1972 the system had been granted a full release and thus the complete Smith SF6 Flight System and SEP6 autopilot became available to the pilots. An addition to the traditional flight instruments was a radio magnetic indicator (RMI), normally found on airliners and used to display VOR bearings. However, the Nimrod installation had selectable options for each pointer that included sonobuoy homing and drift. These functions were invaluable during tactical flight. Also, the Omni Bearing Selector had a feed, selectable by the navigators, to indicate an accurate on-top of sonobuoys.

Tactical System and Sensors

The navigation system was produced by EASAMS, with an Elliot 920B, 8K processor at its heart, and included the Elliot E3 inertial platform, Decca Doppler, Loran C and twin GM 7 compasses. The tactical plot was displayed on a 23-inch diameter monochrome screen.

The Nimrod Mk 1's sensors were a mixture of old and new. The radar was the ASV 21D carried over from the Shackleton. Although proven equipment, relocation to a nose installation created a tail shadow on the display. This was partly offset by the aeroplane's higher speed, which was around 50% faster than its forebear. If necessary the Nimrod could double Shackleton search speeds, although this inevitably incurred penalties in terms of fuel burn and fatigue. The Sonics 1C short range acoustic system also came from the Shackleton. However, the twin AQA-5 acoustics suite (Jezebel) was new. The AQA-5 system produced 'Jez Grams', hard copy print-outs on electro-sensitive paper, which permitted full-time simultaneous monitoring of eight sonobuoys and was the key to passive detection, localisation and tracking of submerged nuclear submarines. The interpretation of Jez Grams required manual measurement of target signatures and, thus, relied exclusively on the analytical skills of the system operators. Nevertheless, AQA-5 gave the UK a rapid response to Soviet sub-surface threats in areas of national importance. Most significantly, it allowed the UK to become a member of the SOSUS club, bringing with it major intelligence benefits.[1]

A word or two about sonobuoys. The Nimrod Mk 1 carried two types. The elderly, short range, Sonics 1C active and passive buoys were large, expensive and usually in short supply; they were carried in, and dropped from, the bomb bay. Passive Jezebel buoys were carried internally. They were about 3 feet long, of much slimmer 'NATO standard' diameter, weighed around 5 lb and had 31 RF channels available. Basically, all sonobuoys comprise a casing to withstand air loads following release, a retard apparatus to slow its fall, a floatation device, a variable length cable with a hydrophone attached and a 1-watt transmitter with a timer and battery. Jezebel buoys were dropped from two sets of single-buoy pressurised launchers, employed when the aircraft was pressurised, or multiple-buoy unpressurised launchers. The four launcher exit ports were to the rear of bomb bay.

Compared to the electronic support measures (ESM) equipment available in the Shackleton, the Nimrod's ARAX/ARAR ESM system, with its aerials housed at the top of the fin, provided a major capability gain against radars in S, C and X bands. While all bands could be monitored simultaneously, for greater sensitivity a single band would usually be monitored in isolation. Again it was a system that relied heavily on the operator's skill and speed of analysis.

The Magnetic Anomaly Detector (MAD) was, and remains, a very short range sensor, with detection being determined primarily by target size and depth. The detection magnetometers are placed at the end of a tail boom to reduce interference from electrical equipment and ferrous airframe components.

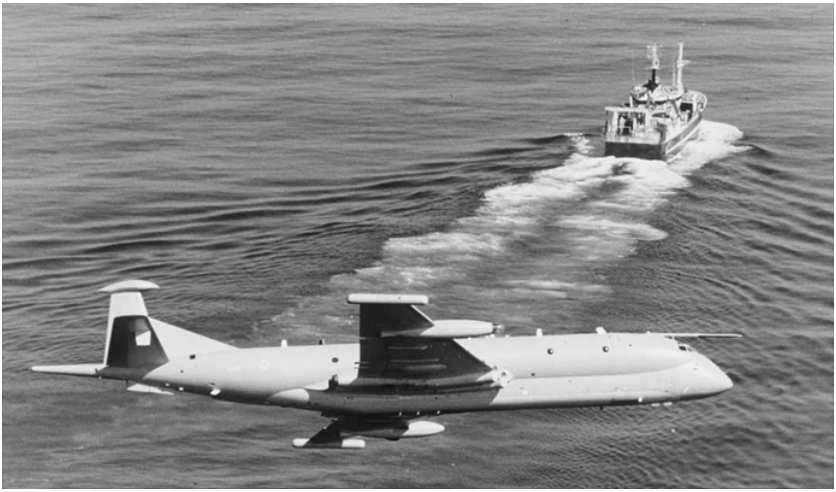
The Crew

Mk 1 crew complement was two pilots, two navs, an AEO, an air engineer, three dry sensor operators, and three wet sensor operators. Dry men operated radar, ESM, MAD and radio. The 'Wetties' specialised in passive and active acoustics and radio if needed. Crew executives ('execs') were considered to be the 1st pilot, 1st nav and the AEO, one of whom was the captain.

Pilots were trained to fly from either seat and normally flew trip and trip about from the left seat. Nosewheel steering was only available on that side. Similarly, navigators were trained to operate from the routine workstation and the tactical seat, again swopping duties in a similar fashion to the pilots. Wet and dry operators manned their equipment as demanded by the task. Generally, systems operators changed sensor stations and duties every 45 minutes or so. These work patterns were considered to aid concentration and counter fatigue. All crew members took turns to help with galley tasks, like distributing cold drinks and serving 'TV meals'. In addition, many crews benefitted from a 'Masterchef' or two who could deliver excellent 'in-flight, fine dining' – particularly appreciated during long transits!

Tasks

So what did the crews do with the Nimrod? The three main tasks



Operation TAPESTRY, the surveillance of the UK's Exclusive Economic Zone, was a routine task for the Nimrod.

were anti-surface warfare (ASUW), anti-submarine warfare (ASW) and Search and Rescue (SAR). It is noteworthy that throughout the life of the force, one aircraft was on 1 hour standby, all day, all night, 365 days every year to handle SAR or any other short-notice reactive tasking.

Anti-Surface Warfare

Anti-Surface Warfare was a major task throughout the Cold War; and, during the South Atlantic and Gulf conflicts. Nimrods located, photographed and monitored deployed Soviet naval units across the Atlantic, Pacific and Indian Oceans. Merchant ships with 'interesting cargo' were also located and photographed. However, apart from the small, short range AS12 missile, which was withdrawn from service in 1975, the Nimrod lacked an anti-surface punch until Harpoon arrived in 1982. Thus, tactics were developed within 18 Group to deliver the ASUW punch via Buccaneer-launched TV MARTEL, and later Sea Eagle, missiles. A Nimrod would shadow the target and broadcast its location with the Buccaneers using this information to deliver their weapons. Known as attack support, these procedures were embraced by NATO with the creation of experimental tactics – EXTACs – that involved MP aircraft co-operating with attack aircraft as disparate as, *inter alia*, the Lynx, the F-16 and the B-52. In addition, Operation TAPESTRY, the surveillance of the UK's Exclusive Economic Zone, became a regular task. Two or three such sorties were flown each week, providing a routine presence over sovereign waters, including oil rigs in the North Sea, and, when appropriate, a rapid reaction in support of mineral and fishing issues.

Anti-Submarine Warfare

Cold War ASW was, of course, the task that provided the majority of challenges. Initially, nuclear submarines were described as 'noisy', offering good tracking opportunities to AQA-5-equipped aircraft. However, the Soviets quietened their boats considerably thanks, in part, to activities of the Walker/Whitworth spy ring, and tracking became increasingly difficult. Nevertheless, Nimrods tracked *Hotel* and *Yankee* classes of SSBN en-route to and from their US east coast patrol boxes, *Echo* 2 and *Charlie* classes of SSGN transiting to and from 'The Med' where they shadowed US 6th Fleet carrier groups and *Victor* class SSNs looking for NATO submarines. In addition diesel-powered boats such as the *Foxtrot*, *Tango*, *Kilo* and *Juliett* were located and tracked with use of radar, passive and active acoustics.

Search and Rescue

Regular media exposure meant that search and rescue was probably the role that the British public most associated with the Nimrod. Nimrods routinely carried marine markers and droppable survival equipment (Lindholme gear) whether on training flights or operational tasks so they were always able to respond immediately to an emergency. Acting in concert with other assets and agencies, or alone, military and civil SAR missions came in many guises. Rapid reaction was, of course, fundamental and over the life of the force the average scramble time, from crew room/messes to airborne, was 28 minutes.

Special Tasks

Nimrods were regular participants at displays and flypasts from local RNLI Open Days to major international air shows. Special tasks also included the annual, national Aird Whyte, and the international Fincastle ASW competitions. All squadrons and the OCU took part in the Aird Whyte, with the winner subsequently representing the RAF against Canadian, Australian and New Zealand crews in the Fincastle. However, if the OCU won the Aird Whyte, as it did many times, it was always the silver medal squadron crew that flew in the Fincastle. In the twenty-one years from 1970, Nimrod crews won the Fincastle Trophy on ten occasions.

South Atlantic Campaign

Moving to more serious matters, the Nimrod force first saw hot action during the Falkland conflict of 1982 (Operation CORPORATE). This involved the deployment of both marks of aircraft. On 6 April, two Mk 1s, and three crews of No 42 Sqn arrived at Ascension Island and established the Nimrod Detachment. The following day a mixed anti-surface and ASW search was flown to the south to search for Argentine surface vessels and submarines rumoured to be moving north. This sortie also acted as a comms link for forward deployed RN submarines. Just over a week later the first Mk 2 arrived from Kinloss. One of 42 Squadron's last sorties was to deliver to HMS *Antrim*, at extreme range, the orders for Operation PARAQUAT, the retaking of South Georgia. Without air traffic constraints, cruise climb techniques were used to the full and the aircraft arrived back at Ascension with an hour's fuel in the tanks. The arrival of a second Mk 2 permitted the withdrawal of the Mk 1s.

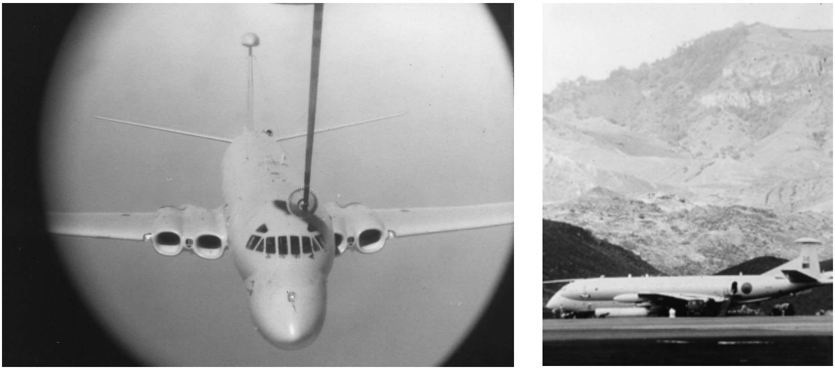
Before we continue, some words about the new aircraft – the Nimrod Mk 2. Created by recycling Mk 1 airframes, the MR2s returned to the squadrons with the black boxes of a bygone era replaced by modern light grey work stations – apart from the flight deck, which remained pretty much the same! Sensor updates including the long-awaited Searchwater radar. At that time this was considered to be the world's best, in-service, airborne maritime radar. It had an abundance of advanced features, including pulse compression, pulse-to-pulse frequency agility, digital signal processing and computer control. The display was a colour raster-scan. Notwithstanding the high degree of processing, the operator remained a vital part of the detection loop, having considerable authority over the radar, permitting him to reconfigure it according to the situation.

The acoustics suite was completely remodelled with the British ASQ-901 system, and several new types of passive and active sonobuoys were introduced. All sonobuoys were now carried

The only external differences between a Nimrod MR1 (top) and an early MR2 (they were the same airframes) was a new paint scheme, a cooling air intake to the left of the fin and a high pressure duct aft of the bomb bay, but it soon acquired a refuelling probe, an additional keel surface under the tail, auxiliary finlets and wingtip pods to accommodate the YELLOW GATE antennae.

internally, most reduced in size, whilst increasing in capability. Sonobuoy RF channels increased to 99. Both routine and tactical navigation systems received major upgrades.

Later, wingtip-mounted YELLOW GATE ESM replaced the ARAX/ARAX, another step change in capability. YELLOW GATE was not available during the Falklands conflict but several Urgent Operational Requirements (UOR) were implemented to introduce hardware and software mods to carry, fire and/or drop: Stingray torpedoes; AGM-84 Harpoon anti-ship missiles; AIM-9 Sidewinder air-to-air missiles; 1,000 lb iron bombs and BL755 cluster bombs. Other UORs were approved which improved the long term accuracy of the navigation system and added an air-to-air refuelling (AAR)



Left, among a number of enhancements, the Nimrod MR2 gained an in-flight refuelling capability during Operation CORPORATE; right, a Nimrod at Ascension Island during the campaign.

capability. In the event none of the new weapons were ever used in action. Nevertheless, release clearances were obtained, aircrew and groundcrew trained and the weapons were available.

The UOR for AAR was actioned by BAe Woodford with remarkable alacrity; it was a mere nineteen days between the company being notified of the requirement to the first dry contact. The initial AAR plumbing was very basic with two bowser hoses running from the probe above the cockpit through the tactical area before disappearing into the floor ahead of the galley. A rapid programme of receiver training was conducted with extremely effective results. Once cleared, MR2P aircraft – P for Probe – flew anti-surface and ASW missions lasting up to 19 hours. Most sorties operated with three pilots, only one of whom was AAR qualified, plus an extra air engineer.

Nimrod Mk 2Ps began flying from Ascension on 9 May backed-up by three Victor tankers, during a sortie, lasting 12 hours 45 minutes, that provided ASW support to the UK Task Force. On 19 May a 201 Squadron crew departed Ascension heading south. After two in-flight refuellings the aircraft had reached a point 150 miles north of Port Stanley. From there it headed west, before turning right to fly parallel the Argentine coast, at a range of 60 miles. Flying at altitudes between 7,000 and 12,000 ft, in daylight and unarmed, the aircraft was extremely vulnerable, to say the least! Following a third ‘prod’, the crew arrived back at Ascension after 19 hours and 5 minutes. Two days later a crew from No 206 Sqn set a new distance record of 8,453 miles on an 18-hour 50-minute ASUW mission ahead of the San Carlos landings. This is believed to be the longest distance operational reconnaissance mission ever flown; it is most certainly the longest by an RAF aircraft.

In addition, Nimrods provided SAR cover and comms relay to the BLACK BUCK missions. During Op CORPORATE Nimrods flew 111 missions.

After the conflict all Mk 2s were brought up to a common Mk 2P standard, permitting the 'P' suffix to be dropped in 1984. By the middle of that year the Nimrod force finally became an all Mk 2 entity with the conversion of the last crew of the St Mawgan-based, No 42 Sqn.

Gulf War I

In August 1990, an initial part of the UK's response to the invasion of Kuwait was to dispatch three Nimrods to the Gulf. A detachment HQ was established at Seeb International airport. Operations began with searches for blockade runners involving co-operation with many coalition navies. With a maximum of four aircraft, the detachment remained there throughout Operation GRANBY. Aircraft were fitted with self-defence BOZ flare and chaff pods. Sidewinders were not carried, but crews did practise anti-fighter self-defence tactics. The Sandpiper electro-optical sensor was fitted to enhance surface search and classification. Once DESERT STORM was launched most Nimrod sorties were flown in support of the US Navy's *Midway* Battle Group, operating in the northern Gulf. Tasking was predominately anti-Fast Patrol Boat missions using attack support procedures. Nimrod targeting information resulted in the sinking of several Iraqi craft by US Navy attack aircraft. Airborne SAR was mounted in support of certain sensitive air operations. A two-aircraft detachment was also based at Akrotiri to support the Royal Navy's presence in the Eastern Mediterranean.

A Typical Cold War Nimrod Sortie

Having set the clock back by about forty years, to the mid-1970s, we can recreate the activity of a typical Nimrod MR1 crew on the newly appointed Duty Squadron at Kinloss. It is 2100hrs. They have already been on SAR standby since 0900hrs, having first assembled in Station Ops an hour earlier. During the morning they had conducted specialist ground training before dispersing to their respective messes for lunch. The crew is aware that Keflavik-based US Navy P-3Cs are tracking a probable *Yankee* class SSBN, heading south west through the Iceland/Faroes gap and that 18 Gp expect to take over tracking it the next day. A final check-in call to Ops indicates that all is quiet so most of the crew turn in around 2230hrs.

Two hours later the phone rings beside the captain's bed. It is Station Ops relaying the message that HQ 18 Gp want the crew on Immediate Readiness by 0100hrs. 'It's ops, not SAR. See you ASAP.'

The co-pilot starts the wake-up calls; and the Station night shifts commence the well-practised procedures used to launch the SAR aircraft. Within 15 minutes the crew execs and the two lead operators are in Station Ops. Here they find that the picture has changed. A second Soviet 'Nuke' has been detected further north. HQ 18 Gp have agreed to take over tracking the original contact, with Keflavik and No 333 Sqn RNoAF concentrating on the new target. The declared on-task time is 0300hrs local, just over two hours away with a 500-mile transit. Not a problem. The other half of the crew have gone directly to the aeroplane. They start two engines and wind-up the sensors as more sonobuoys are loaded. Back in Station Ops, the execs and leads pick up the complex briefing material. There has been another intelligence update that indicates that the target may not be a *Yankee* after all; it could be a *Charlie* en route to the Med, or possibly a *Victor* heading into the UK's North West approaches. As this will be the first sortie, flown by a Nimrod crew, against this particular target only basic acoustic data is available; however, every known detail is briefed.

At 0125hrs with all four engines now running, and all systems on internal power, the captain calls for an intercom check and equipment status. The crew check in; no snags. A minute later the co-pilot, in the left hand seat, taxies forward. He will fly the aircraft for the first two hours. Take off performance data is reviewed. All up weight is just under max at 177,000 lb, of which 82,000 lb is fuel. All checks complete. Power up. Brakes off. V1 – 123 kt. Rotate – 142 kt. Positive rate of climb established. Flaps up. Safety speed. Game on!

Minimum comms – the crew listen out with Highland Radar and head for the Oceanic airspace boundary, climbing to Flight Level (FL)

The Nimrod's prey covered a wide variety of Soviet submarines– this one is Yankee Class boat..

260. During the transit, the crew develop the plan; sonobuoys are loaded; all active equipments remain silent. With thirty minutes to go to on-task, the AEO confirms that the tactical checks outbound are complete, and the captain briefs the initial plan. Shortly afterwards, the acoustic operator reports the first RF signals from two of the buoys already deployed by the P-3C; sonobuoy DF shows them to the north of track, which is logical. As they near the on-task area, more sonobuoy RF is detected and DF'd. In fact there are lots of legacy buoys in the water – but no sign of the target. Not unusual!

SOPs dictate a silent handover. As the P-3C's off-task time approaches the wet team focus on the handover buoys' channels. What information they display will determine the crew's initial reactions. Within two minutes of the scheduled time, the first handover buoy appears. At least three pairs of eyes stare intently at the Jez Grams; acoustic audio is monitored; recorders are turning. There is a possible contact on the northerly handover buoy – Confidence Level 2. Doppler is low on the expected centre frequencies. Stopwatches are started and the crew position to on-top the handover pattern of two buoys. The position and geometry of the buoys should indicate the last known position and track of the target submarine.

Having descended to 8,000 ft, clear of cloud, one outboard Spey is shut down and configured for a rapid re-start. The aircraft is slowed as the air engineer confirms current weight, fuel and minimum drag speed (Vmd). As Vmd +5 kt is reached, power is increased and trims adjusted.

Handover geometry suggests the target's track is south westerly. Using a combination of computer steering, sonobuoy DF and sonics homer, the positions of the handover buoys are displayed on the tactical navigator's screen. The AEO reports, 'Contact weakening.

Doppler low on the northerly of the handover buoys. No contact on the second handover buoy.'

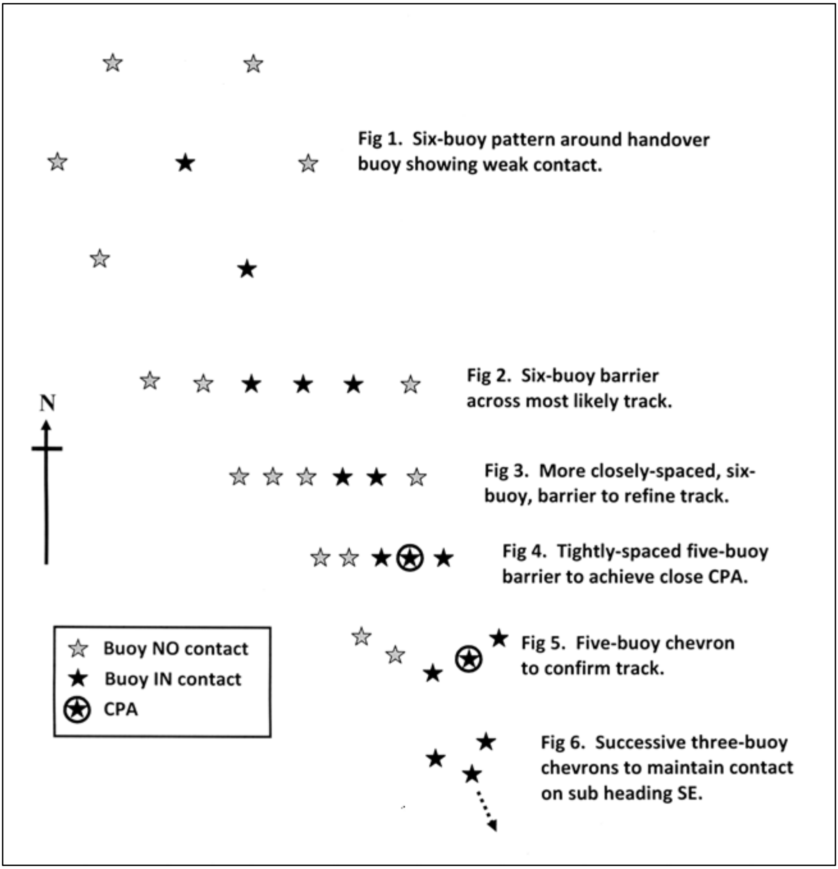
The crew will continue to exploit the Doppler phenomena throughout the sortie. As a reminder from school days, the Doppler effect is the change in frequency of a sound source moving relative to a static observer, or vice versa. The difference in the tone of a train whistle as it approaches and leaves a station at speed is the usual illustration. In the ASW context, the sonobuoy hydrophone is static and the submarine is the moving noise source.

After 3½ minutes of contact, the AEO reports, 'Contact lost.' As neither target direction nor speed has been established, it is decided to circle the last buoy in contact with six buoys, spaced at the estimated median detection range (MDR) of the target. IAS is increased to 250 kt, the maximum speed for sonobuoy release. The initial plan is scrapped and the new plan is briefed using buoys with 1-hour settings (see Fig 1).

What is the target doing? Has it slowed? – turned to new heading? – did it hear the P-3C's propellers? – or has it manoeuvred for one of another dozen possible reasons? Forget the why. The crew needs to focus on re-establishing a solid contact and then work the situation from there.

First buoy in the water – no contact. Second buoy is unserviceable – no RF. The crew replaces the unserviceable buoy and continues to drop others until the lead wet operator reports, 'Contact on a buoy to the south east of the handover datum – high confidence – Soviet nuke,' adding, 'Doppler just high; looks like our target.'

Whilst the tactical team have not yet determined the precise position or speed of the target, there is evidence that it is heading southerly, maybe with a bit of east. The next tactic – a six-buoy barrier with 1-hour life settings, deployed south of the datum and the buoy in contact (see Fig 2). RF from the previous aircraft's buoys complicates sonobuoy channel options and the captain suggests a descent to 1,000 ft. Altimeters are reset to the area QNH and the navs and pilots cross check every 1,000 ft during the descent. The aeroplane is turned towards the buoy in contact (in Fig1), for an on-top and plot lock. The pilots use the flight director's Hi Gain steer mode in combination with sonobuoy DF and sonics homer inputs, to manoeuvre the aircraft onto the desired south-easterly outbound track. 'On top now, now, now,'



reports the co-pilot, as he presses his on-top button, and the tactical display is updated automatically to the buoy.

For successful tracking it is essential to get a close pass on a sonobuoy by the submarine, this event is termed a closest point of approach (CPA). A short range CPA should confirm the all-important centre frequencies of tracking lines. Hopefully the next six-buoy barrier, laid to the south of the previous pattern, and with tighter spacing, will provide that CPA (see Fig 3). Following the drop, two buoys are in contact; the lead wet starts reporting and his information is quickly converted into possible position, speed and heading. Measurement of Doppler shift is a skill requiring sharp eyes and very precise measurement of the lines displayed on the Jez Grams. As analysis continues, the buoy that is likely to provide the best CPA is identified. Still at 1,000 ft, the pilots are very aware of the danger of alerting the target by an inadvertent overflight. However, without the benefit of a tactical display they are obliged to use pencil and paper diagrams and close monitoring of the intercom to maintain situational awareness. Both the tac nav and the AEO provide regular sensor updates to the crew. Fairly confident that the target will shortly penetrate the barrier, the next pattern is planned.

Throughout the period that the aircraft is on-task, the radio operator is receiving TAFs and current weather states for airfields of interest on the 18 Gp broadcast. Details of the relief aircraft and its on-task time are also received. The route nav and flight deck periodically cross-check fuel remaining against handover and latest off-task times. Leuchars is the No 1 diversion but crosswinds are forecast to approach the Nimrod's maximum of 25 kt. The further the diversion is from base, the less fuel is available for on-task. The air engineer continues to calculate fuel, AUW and Vmd at 30 minute intervals and the pilots respond with small, fuel-saving reductions to engine rpm. With the autopilot engaged, bank angles are kept shallow during the loiter periods between pattern drops; this aids movement around the tactical area, eases sonobuoy loading and continues to conserve fuel.

Sonobuoy loading is handled by the dry team who also share manning the radio and ESM. These sorties were, generally, conducted using passive buoys only. Dexterity and quick response by the loaders to action a drop plan were key to success. First, a buoy with the required RF channel had to be located from the storage racks adjacent to the launchers. It then had to be loaded into the correct launcher position, with the correct life and cable length. The wrong buoy or an incorrect setting meant a blocked RF channel.

Having obtained a reasonable CPA on a buoy in the previous barrier, the wet team have a much better appreciation of the target signature, speed and tracking options in these waters. Further refinement is achieved by positioning a five-buoy barrier, with even tighter spacing between buoys, ahead of the target (see Fig 4).

The crew have now been on task for just over an hour, and if their calculations, responses and assumptions have been basically correct then this barrier will give them the close CPA that will trigger the move from localisation to tracking. The barrier is laid, as before, on an east/west axis. All buoys are reported serviceable and the three easterly buoys are all in contact. The wet team use a hand-held Hewlett-Packard programmable calculator, state of the art in the mid-1970s, to convert Doppler values to angles-off for each of the in-contact buoys. When the CPA occurs it is assessed as 400 yd. An excellent result – cheers all round! The crew review the tracking options and opt for a five-buoy chevron, just in case the analysis of target parameters is not quite correct (see Fig 5). The question – why has the target turned south, and will it continue on its south, south easterly track? – remains unanswered. More RF checks confirm clear channels and the aeroplane is positioned for the chevron. Smooth, accurate, fuel-efficient flying, is required even with 45º banked turns.

This drop will be made from 500 ft for greater accuracy of buoy spacing. All buoys are reported serviceable with contact on the three easterly buoys. Now with contact both ahead and behind the target, plus another close CPA, the crew can use standard three-buoy tracking chevrons for further surveillance (see Fig 6). The aim now is to maintain contact with minimum buoy usage. The crew settles into the tracking routine of ‘Monitor – Analyse – Plan – Load – Position – Drop – Monitor’ for the rest of, what has become, the surveillance phase of the sortie. Throughout the remainder of the on-task period, reasonable acoustic contact is maintained and the crew feel they are up with target, although there are a couple of heart-stopping moments when two critically positioned buoys fail.

Four hours after take-off the other outboard Spey is shut down to further conserve fuel. The target manoeuvres again, first increasing speed then turning right on to a SSW track – but the crew are on top of their game and they still have him. The radio operator keeps passing weather updates – no change to the diversion or relief aircraft details.

During the final hour on-task, thoughts are focused on a precise handover. To confirm the accuracy of the target’s position, course and speed, a five-buoy chevron is chosen as the final pattern. With ten minutes to go to handover, the relieving crew should already be receiving signals from the chevron. Exactly on time, the handover buoys are released, and the Nimrod is accelerated to 250 kt for windmill relights while climbing to 5,000 ft – the ‘not above’ height for the off-going aircraft. The northerly handover buoy indicates CPA one minute after off-task time, at a range of 700 yards. Not perfect, but good enough to provide a strong foundation for the new crew.

At 50 miles from the datum a climb to FL 250 commences. On reaching that height, the crew have the option of shutting down one engine for ultimate range performance but, with AVTUR to spare, all four Speys are kept turning for a fast RTB. Having now been on duty for more than 24 hours, fatigue is evident among the crew. During the transit the tactical crew prepare material for the debrief that still lies ahead. Compilation of nav logs, charts, tapes and Jez Grams is coordinated by the AEO. Unused buoys are removed from launchers and returned to the storage racks. Tactical checks inbound are completed just before the aircraft crosses the Scottish coast.

With no cloud below 5,000 ft and with 20 miles to run the captain opts for a simple, downwind join to a visual approach – the co-pilot's smooth touch down is greeted by a round of applause from the back of the aircraft. At 1005hrs the chocks are in place. The crew have been airborne for 8 hours and 25 minutes, over 6 hours of which was at night. An hour later, with all post-flight procedures complete the crew learn that they are programmed for a 4-hour standby from 0600hrs the following morning. After a final check with Squadron Ops, the crew head for the back bars of their messes for less formal debriefs.

Hey ho, not an unusual start to a stint as Duty Squadron.

Conclusion

As a former Nimrod pilot, I hope that I have conveyed, albeit in the broadest terms, some idea of the steadily increasing capabilities of the sensors and systems available to, and the diversity of operations undertaken by, the Nimrod Force between 1970 and 1991. It was the resourcefulness of the crews that made the difference between mission success and failure. It was they who were confronted by, and overcame, the challenges presented by Cold War surveillance, quieter submarines, attack support, air-to-air refuelling, fighter evasion, SAR scrambles, actual conflict – twice – and still found the time to win the Fincastle Trophy on ten occasions.

[1] SOSUS – the SOund SUrveillance System – was (is?) a chain of underwater listening posts deployed by the US Navy to detect Soviet submarines transiting between Greenland, Iceland and the UK, the so-called GIUK Gap, as they commenced their Atlantic patrols. There was a similar array in the Pacific. **Ed**

AFTERNOON DISCUSSION

Robin Woolven. Bill and Mike both spoke of routine sorties of up to 14 hours or so and in the case of the Falklands campaign, much longer. In the context of aircrew fatigue, I have recently corresponded with a Dr James Pugh at Birmingham who is researching the use of Benzedrine. He is primarily concerned with WW II, but I have told him that on No 206 Sqn at St Eval in 1957-58, what we understood to be, Benzedrine was available to anyone who wanted it. As a twenty-year old, I didn't myself, but I believe that some folk may have used it. Dr Pugh has suggested that this may have been Dexedrine – I don't actually know the difference. So – my question, does the panel, or anyone else in the room, recall taking Benzedrine in the Shackleton era?

Air Cdre Bill Tyack. I'm not aware of that at all. But I can offer a related 'war story'. I was in the co-pilot's seat of a Shackleton and we were cruising at about 1,000 feet on autopilot. It was about 3 o'clock in the morning. I began to doze off and suddenly woke up with one of those sudden reflexive jerks of the head. Having forced myself to stay awake, I looked across to the left hand seat only to find that the captain was fast asleep. I woke him – gently – and we then did an intercom check. Every member of that crew was asleep.

Crew fatigue was a very real issue; witness the anecdote I recounted earlier, about a trip to Bodø involving, what had amounted to, a 34-hour working day. That was not at all unusual. It is difficult to imagine that sort of thing happening today, but at the time, many of the men we were flying with were wartime veterans who were accustomed to operational losses – and relatively high accident rates in the early post-war years. As a result there was a very different attitude towards the acceptance of risk. As I said earlier, we regarded ourselves as being operational, with the Shackleton force representing the front-line in the Cold War so, with our elders and betters calling the shots, we just pressed on.

I can offer another illustration. In the Shackleton there was a box called the Bomb Distributor, basically a circular selector switch – a wiper arm that energised a series of contacts as it rotated – it was the device that determined the timing of the release of a stick of bombs. The navigator needed to adjust the settings, reset the thing to zero and so on, but it was poorly insulated and every time you touched it, you got a shock! It could be quite a severe one – on occasion I have been knocked clean out of my seat! But with our more experienced colleagues setting the tone with their 'I used that over Berlin' line, we accepted such things as normal, didn't complain and just got on with the job. In the end, on a Categorisation Board sortie, a navigator was knocked unconscious and that was finally enough to get something done about it. The solution turned out to be very simple; the box was painted with Shellac, which seemed to do the trick.

But the prevailing attitude was – press on.

Wg Cdr Mike Cockrill. Slightly different answer from the Nimrod. It was standard practice to change seats quite frequently during transits. So you would get rear crew members coming up to the flight deck to sit in one of the pilot's seats and working the autopilot. In their turn one of the pilots might give the air engineer a break while he went down the back to organise a cup of tea. The aim of the game was to keep everyone moving around to relieve the inevitable boredom while at the same time enhancing crew co-operation by making everyone increasingly familiar with what everyone else did. And it seemed to work

As to drugs, speaking for myself, I have never heard of any drugs, legal or illegal, being offered to, or used by, Nimrod crews. Although I have heard it said that in some other parts of the air force – transport crews perhaps? – Temazepam may have been prescribed.

AVM Andrew Roberts. Temazapam was developed at Farnborough by RAF doctors and it was first used during Operation CORPORATE by, I think, selected transport co-pilots and probably Victor crews – on a trial basis.[1] It permitted you to sleep for a set number of hours and then wake up with no after-effects but it wouldn't have been offered to Nimrod crews at the time. I don't know whether it is still used today – in Afghanistan for instance.

Tyack. Post-CORPORATE, when I was Station Commander at Wyton, this was in the late 1980s, I could authorise Temazepam for specific sorties by Nimrod R crews. I took it myself on several occasions on the grounds that, if I was going to authorise its use I ought to know its effect. It was very good. Having long been accustomed to having to get up at 3 in the morning, I was never able to get to sleep knowing that I was going to have to get up at 3am! Temazepam was very good for that. It put you to sleep and then enabled you to start your day, whatever time that was, fully refreshed.

Wg Cdr Jeff Jefford. Two questions. Mike, you may already have answered this one – but, to be clear, can you confirm that, in the Shackleton era, you had no ground simulators at all? – no way of practicing that complex three-dimensional game of chess? And, secondly, once you had located a submarine and begun tracking it, as you described, did the submarine know that you were doing it?

Cockrill. I'm not sure that I can answer the second question definitively. At the time we believed they probably didn't know, but in the light of the Walker/Whitworth case and what that revealed, it seems that they were probably actually reading our broadcasts and possibly even our post-flight analysis – the contact ranges that we were achieving and so on. That said, I'm still very sensitive about that sort of information, so I'd rather that no one asked me to be specific about ranges and the like . . .

Roberts. Toby – you might be able to tell us whether you knew you were being stalked.

Cdre Toby Elliott. Once we had a towed sonar array, we could tell when an aircraft, especially a Shackleton, was making a run across us, or at least across the array.

Cockrill. The big difference was that the Nimrod was pretty much the only jet, most anti-submarine aircraft had propellers and they were the giveaway. A jet's noise is broadband and undistinctive so the Nimrod had no particular noise 'signature', unlike the propellers of a P-3 or an Atlantic which produced a harmonic that the submarines could detect, and identify, from several miles away.

Roberts. Even more true of the contra-rotating propellers of a Soviet *Bear*! This is, incidentally, an important point to bear in mind in the context of the current campaign to replace the Nimrod. There are people trying to sell us propeller-driven solutions – and that isn't a good idea because there are times when you really do need to be covert.

Cockrill. As to procedural training, we had no, what we would now call, 'fixed base training aids' for the Shackleton crews. There was a room laid out to resemble the various crew positions in an aeroplane with photographs of instrument panels, or in some cases actual pieces of kit, but its primary function was as an intercom trainer. Many of us were first tourists, of course, and, never having worked in a large crew environment, we needed to become accustomed to working together in a co-ordinated fashion and comms procedures and discipline were a part of that.

Tyack. To an extent we were able to simulate the tracking procedures on the ground. The sonics operators would get simulated signals on their receivers and wind the handles to relay this information to the navigators who could then work with the ranges and bearings. But it was more often done in the air, flying around one of the local buoys – although I have done it in an aircraft on a pan plugged into a ground power unit and picking up the signals from the Stage Two Trainer.

Cockrill. I don't recall the pilots ever being involved in those exercises – perhaps co-pilots were 'volunteered'!

Richard Bateson. A few months after VE-Day, Hellmuth Walter arrived at Barrow-in-Furness to work with the Admiralty on his innovative *Ingolin*-powered submarine engine.[2] Could anyone expand on that?

Elliott. I can't add a great deal. I know that, as the war was ending teams were sent forward, sometimes, I believe even ahead of the front-line, in order to capture German scientists and their research and spirit them away to the UK or the USA to exploit their advanced technology. Walter came to the UK. This is a well-documented topic which has been covered in a number of books.

Clive Radley. I wonder whether anyone could comment on the British reluctance to carry the American AN/SSQ-110 explosive sonobuoy. I wouldn't expect there to be a security issue – it's a matter of record that they exist and that we conducted trials with them.[3]

Tyack. I'm not in a position to talk specifically about SSQ-110 but, from my time in and around the Ministry in the early '90s, I am aware that there was strong opposition to making loud noises of any kind in the ocean because of its impact on the fauna – whales, dolphins and the like. We were certainly obliged to take that into consideration in Operational Requirements and I'm guessing that it was felt that making frequent explosions in the water, in peacetime, would have been regarded as being inimical to marine life.

There followed a rather incoherent discussion, without recourse to the microphones, focusing on safety and issues relating to internal and/or external carriage. This was brought to a close by:

Phil Halley. I think the big issue is, 'What happens if it doesn't go off?' You get two bangs from an SSQ-110, so that you can use it twice, but on at least one occasion, the second detonation failed. You are then left with an unexploded ordnance problem which means that you have to quarantine the area for however long it takes for the buoy to run out of power. And, as has already been pointed out, crews were concerned over having explosive ordnance inside the cabin, especially as the SSQ-110s weren't stored in SLCs (Sonobuoy Launch Containers) nor did they have the 'two-event criteria' that all UK sonobuoys are required to have in order to prevent inadvertent detonation. So there were a lot of potential problems and the UK's conclusion was that an electro-acoustic device is more efficient than an explosion because you can get a lot more pings than bangs for your buck.[4]

Roberts. This might be a good moment for me to touch on some issues that Peter Williamson might have raised had he been able to attend and give his presentation. The first is the date of the forthcoming Strategic Defence and Security Review (SDSR), which is now understood to be 25 November. The second point is whether it will deal with MPA and I think there is a very good chance that it will. A year ago, had Philip Hammond still been Defence Secretary, he would have announced an order for P-8s but his successor was persuaded that there had to be a competition and that call was backed up by, among others, RUSI for example. That said, some of us believe that when you consider the available options, the only one that meets our strategic need is the P-8.

We have a number of people working on the project and one could almost claim that the P-8 has been brought into service by the RAF! This is because we have the P-8 units at Jacksonville and Pax River packed with our chaps, mainly because the acoustic system is based on the one we developed for the Nimrod MRA4 so the Chief of Naval Operations was only too pleased to accommodate us when we asked if we could send our people to the States in order to preserve a cadre on which to build a future capability.

I had a hand in setting up that arrangement and in 2013 a crew of RAF operators was formed within VP-30, which is the P-8 OCU at Jacksonville, and they proceeded to win that year's US Navy Anti-Submarine Warfare Trophy – which was a pretty good start.

At Farnborough last year I had the privilege of being able to get on board the P-8 which had been cleared of everyone except: the captain, an RAF flight lieutenant; the first navigator, an RAF squadron leader; the lead wet man, an RAF master AEOp, and the lead dry operator, an RAF flight sergeant. They switched on all the systems for me (and told me a lot of things that I probably wasn't cleared to know) and I was very impressed. I still have one or two reservations regarding the P-8, notably time on task – the MRA4 had demonstrated in its trials that it was quite capable of achieving ten hours on task at 1,000 miles – and I would have preferred the British radar for ASW, but radars can always be upgraded, of course, and there are new American radars in prospect which will be much better.

But the reason that I was prompted to raise this was the discussion on explosive sonobuoys. When I was Chief of Staff at 18 Group, I thought that we ought to be using sonobuoys as an array, rather than as individual buoys. I was delighted to find (and this is not classified information; you can read all about it in *Aviation Week*), that the Americans have gone the same way – they call it Multi-Static Active Coherent (MAC) anti-submarine search. It involves dropping a field of receiver sonobuoys plus a single sound source – which is electronic, not explosive. Each of the various sonobuoys in the array receives a slightly different ping reflected from the target and this information is relayed to the aircraft where a sophisticated computer programme, the key to the system, analyses the data to locate the submarine. I should add that everything that has been achieved in America we have also achieved in the UK. Indeed, I suspect that Ultra Electronics might reasonably claim that they are actually doing better than the Americans. As to the MAC system, I can't cite figures of course (they are highly classified), but the results are dramatic. This is an *active* search capability and we *have* to have it in our new aircraft.

I am reasonably confident that we will get a new MPA – the Lords and the Commons are both on side and Col Bob Stewart, who is on the Defence Select Committee, has been instrumental in keeping things moving in the right direction. The question now is – will we get the *right* aeroplane? It simply won't be possible to produce a home-grown solution in the available timescale and my concern is that we will go for something inadequate. I hope I'm not treading on anyone's toes when I say that one of the main competitors is the twin-engined turboprop C295 from Airbus. It lacks the range of the P-8 and it won't be able to stay on task at 1,000 miles for anything like 5 hours (2 at the most). The worry is that we may be obliged to accept the wrong aircraft for political reasons. There are other options – the maritime Hercules, which would have 'strap-on' weapons bays fore and aft of the undercarriage housings but, again, it's a turboprop, and it won't have the capability of the P-8 – and there are a number of other smaller aircraft on offer. But we just have to wait and see. I'm 90% sure that a new MPA will feature somewhere in the SDSR – I think the Government would be too embarrassed not to provide one – but whether it will be the right aeroplane remains to be seen. In my opinion it's a matter of quality, not quantity because, when it comes to ASW, if you compromise on quality you are probably wasting your money.

Sir Freddie Sowrey. I understood that we had people flying MPA with other countries; could you say something about that?

Roberts. Yes, we have people flying with the Australians, the New Zealanders and the Canadians as well as the Americans. But the critical element is the people who have been working on the P-8 with the Americans. Although they have made a major contribution at the OCU – VP-30 – their involvement with VX-1, the development squadron, has been even more important. I am told that our people, and the Australians who are also on strength, have been given unrestricted access to everything that is going on. Not just the P-8 but including, for instance, the MQ-4 Triton, a very large unmanned system for persistent oceanic surveillance which the Australians are planning to operate in conjunction with their P-8s. Although the MQ-4 is only a surface search system; it has no anti-submarine capability.

So to wind up – thank you Nigel for having me and thank you to the Society for hosting a maritime symposium – something that we do need from time to time. Thank you, of course, to the speakers, and especially Toby for contributing a dark blue element.

I hope that the weather will have improved since this morning and I wish you all a safe journey home.

POSTSCRIPT

On 23 November 2015, it was announced that the UK would acquire 'Nine new Boeing P8 Maritime Patrol Aircraft to increase further the protection of our nuclear deterrent and our new aircraft carriers. These aircraft will be based in Scotland and will also have an overland surveillance capability.'[5] On 11 July 2016, on the first day of the Farnborough International Airshow, Prime Minister David Cameron announced: 'We have today signed the contract for nine new P-8 maritime patrol aircraft for the Royal Air Force . . .' The cost would be £3Bn over the next decade, and the Minister for Defence Procurement, Philip Dunne, said that the first aircraft was expected to be delivered in 2019 with all nine in service within the following twenty-four months. **Ed**

Notes:

1 For more on the use of Temazepam, see Journal 57, p62.

2 '*Ingolin*' was a codeword for high test peroxide (HTP), a rich potential source of oxygen which could be used to power a submarine without its having to surface frequently to recharge its stock of atmospheric oxygen. Walter's method of propulsion could double the range of a submarine and an early wartime prototype is said to have demonstrated a speed of 23 kt – twice that of a conventionally powered boat. The drawback was the dangerously volatile nature of HTP and, although development work continued, no *Ingolin*-powered submarines ever became operational. Post-war the RN continued to work on the principle until it was abandoned in favour of nuclear power. **Ed**.

3 Clive Radley considers SSQ-110 in his *Sonobuoy History From A UK Perspective* which is reviewed on page 150.

4 These issues are addressed by Radley – see Note 3.

5 Cm1961 National Security Strategy and Strategic Defence and Security Review 2015

The programme for the day had included a presentation on the Nimrod's latter day evolution from a strictly MPA asset into one capable of operating overland in the context of Intelligence, Surveillance and Reconnaissance. Unfortunately, the speaker was obliged to withdraw at short notice but the Chairman was subsequently able to secure the services of two experienced Nimrod operators who were familiar with these developments and who agreed to produce a supplementary paper to complete the story. **Ed**

A REFLECTION ON THE NIMROD MR2, THE MARITIME FORCE AND ITS INHERENT ADAPTABILITY

Air Cdre Robbie Noel and Gp Capt JJ Johnston

On 23 November 2015 the Government announced its decision to procure nine P-8 Poseidon maritime patrol aircraft (MPA),[1] reflecting its intention to acquire a capability that would have to meet a broad continuum of threats, ranging from state-based, to those that recognise no borders. The purpose of this short essay is to reflect on what might be learned from the Royal Air Force's recent history of maritime aviation, and most notably its evolution from a heavy emphasis on deep-water Anti-Submarine Warfare (ASW) to a much more diverse role over sea and land. It should inspire confidence among those charged with tackling the 'darker and more dangerous world' that the Secretary of State for Defence, Rt Hon Michael Fallon MP described recently.[2]

When invited to reflect on the Nimrod MR2 from our experience in command,[3] the authors embraced the opportunity to reflect on a Force that, for a long time, was better understood by its dark blue, rather than light blue, colleagues. Much of its work was conducted in support of naval commanders, and under the cloak of Cold War secrecy. The detail might be sparse, but the critical role that MPA played in securing the North Atlantic against a Soviet adversary has never been in doubt. Less well recognised is the wider contribution it made to the UK's defence and security, particularly after the Berlin Wall fell.

Out of the shadow, and over the desert

Reporting on Nimrod MR2's arrival at Prince Sultan Air Base, Saudi Arabia in the spring of 2003, a decade after the Iron Curtain fell,

A Nimrod MR2 taking off from an airfield 'somewhere in the Gulf region'.

the *RAF News* quoted the UK Air Component Commander commenting on this 'fish out of water'. Preparing to contribute to Operation TELIC, the future CAS, AVM Glenn Torpy, recognised the value of the sophisticated and adaptable capability that the Nimrod would bring to the coalition air campaign. Operations, both at home and abroad had, for decades, demanded a broader skill set than ASW to meet the emerging threats associated with terrorism, narcotics and other ills of the globalised world. The post-Cold War security challenges posed new questions, with the old bi-polar order and relative predictability of east against west replaced by a more confused and cluttered environment, demanding greater insight for commanders and other decision makers wrestling with opaque and novel threats. And so it was that the Nimrod was adapted to provide essential Intelligence, Surveillance and Reconnaissance (ISR) over land, as well as the ocean.

In some respects, the very tragic loss on 2 September 2006 of fourteen souls aboard XV230 served to illustrate how the Nimrod MR2 had evolved and was contributing to the challenges of the time. Based in Oman, the crew had been operating in support of troops engaged in a land-locked counter-insurgency campaign. Such sorties as those flown on 2 September, often included maritime tasking at the start or finish of a 10-12 hour sortie, extended by air-to-air refuelling, but it was the overland tasks that drove the plan. Many of the skills learned and developed over the North Atlantic were now being exploited over the deserts of Helmand, Kandahar and beyond. Where the contemporary US warfighting doctrine for such missions was codified by Find, Fix, Track, Target, Engage and Assess (F2T2EA), so the Nimrod crews were well practised in a doctrine of Search, Detect, Locate, Identify, Track and Attack/Exploit. The equipment had changed, but the methodology was similar, and the people were the same.

The utility and flexibility of the Nimrod placed it in high demand and, in support of national and NATO commitments, it operated overland in Afghanistan and, in a maritime context, as far north as the Northern Arabian Gulf, and as far south as the Horn of Africa. Meanwhile, the home base was not immune from threat, and protection of key national capabilities, not least the independent nuclear deterrent, required an operational footprint to be preserved at RAF Kinloss throughout. So its versatility, agility and adaptability had placed a huge demand upon, and appetite for, the Nimrod Force; it was in the thick of the fight.

Cold War to Hot War

When retired from service in 2010, the Nimrod MR2 was committed to more military tasks than any other Defence capability. Despite the unfortunate perceptions shaped by the findings made by Charles Haddon-Cave QC,[4] and the failed Nimrod MRA4 programme, the Nimrod (Mks 1 and 2) Force had made a hugely significant contribution to national and international security, and maritime safety for four decades. Operations against a Soviet Navy determined to demonstrate its ability to project power globally had provided trade for the Nimrod community as far west as the eastern seaboard of the US and as far south as the Mediterranean; the Falklands Campaign saw it deployed to the southern hemisphere. Maritime missions to combat terrorism and narcotics often led to interdictions of illicit activity; these rarely exposed the Nimrod itself, but without its covert contribution many of these operations would not have been possible. On the other hand, its contribution to the search and rescue of those in distress at sea was more overt. For many years the Nimrod had developed high-end, niche capabilities leaning on cutting edge technology to support military and other Government Departments in roles conducted over land. The Nimrod MR2 had, by necessity, become highly versatile. Reacting to an ever-changing security context, it had grown into a multi-sensor platform, whose adaptability, responsiveness and flexibility, all underpinned by highly skilled crews, provided an attractive range of choices to political and military decision-makers for over a generation.

Following in the footsteps of the Mk 1, the Nimrod MR2 was designed and developed to deliver precision effects across the spectrum of environments: above water; under water; in the littoral; and over land, with even a brief flirtation into air with the Sidewinder fit during Op CORPORATE. The aircraft was able to employ these capabilities in support of the UK's Foreign and Defence Policy working autonomously, or embedded within a Joint or Combined command structure. Working as part of the all-arms approach to ASW had inculcated a culture of co-operation and collaboration in the Force. Decades of working with other nations, and the other Services, the Royal Navy in particular, had cemented a predisposition towards 'jointery'.

It should be stressed that the Nimrod MR2, along with its predecessors and its planned successor, was a *combat* aircraft. Once it had successfully searched, detected, located, identified and tracked its target, it was able to destroy it. With tailored command arrangements, and the application of appropriate Rules of Engagement, this enabled a range of adaptive options for the Nimrod's employment. In the relatively regimented action and response that characterised the Cold War, this supported a centralised approach to decision-making to avoid strategic over-reaction. In the more fluid, less predictable post-Cold War era, it allowed for a more decentralised and flexible approach to action in response to local conditions. Over time, the Nimrod MR2 proved to be as relevant in prosecuting insurgents as it had been in pursuing Soviet nuclear submarines.

'Power to the Hunter'[5]

The Nimrod MR2 became a 'system of systems',[6] with a comprehensive array of weapon options that included, *inter alia*, the nuclear depth bomb, the Stingray torpedo, the AGM-84 Harpoon anti-ship missile, the AIM-9G Sidewinder air-to-air missile and conventional bombs along with Search and Rescue (SAR) packs/dinghies, sonobuoys and target markers. The carriage of such an extensive list of stores was made possible through the largest single-section bomb bay of any aircraft ever flown; most other platforms,

Left, the WESCAM MX-15 EOS and, right, a BOZ-107 chaff and flare dispenser.

including the B-52, have their bomb bay split into individual bays. To put this into perspective, the Nimrod's bomb bay could concurrently carry two Harpoons, three Stingrays and an SAR dinghy pack. This was complemented by a WESCAM MX-15 Electro-Optical System (EOS) under the starboard wing and BAE/Bofors BOZ-107 chaff and flare dispensers under both wings.

The weapons system represented one end of the kill chain, a cycle made possible by the extensive sensor suite that had benefited greatly from spiral development over the previous decades. A world-leading acoustic system was at the heart of the Nimrod's prowess in ASW. Hardware, software, tactics and procedures were all developed vigorously to combat an increasingly capable submarine force placed at the centre of the Soviet Navy. Nevertheless, the advanced technology invested in a modern nuclear submarine force made it all too easy for a skilled submariner to deceive ASW professionals by feint, disguising the sounds produced by the boat as noises similar to those generated by Norwegian fishing boats or sea-life.

The Searchwater radar, designed and honed to detect periscope-sized targets at ranges measured in 10s of miles, richly rewarded the crews who refined their tactics and techniques to meet the mercurial conditions of the Norwegian Sea, the Atlantic and the Mediterranean. Magnetic Anomaly Detectors, thermal imagers and other non-acoustic technologies were all at the disposal of the crew, and yet still it was the Mark 1 eye-ball that often proved the most successful sensor. Crews fought hard, often together with friendly submarines, ships and helicopters, to detect and track those seeking to compromise the UK's security. Out of the consciousness of all but a few, the Cold War cat and mouse game raged for long before, and after, the fall of the Berlin Wall.

Of course, success in seeking, arranging and blending all the available information required to achieve the task, be it against a submarine or a ship, was entirely down to those aboard. Like any other facet of air power, the man in the loop made the difference. Often it was the air engineer who would spot the 'feather' of a periscope flushing through the water, or the analytical skill of an acoustic operator that provided positive identification of a target. Commissioned pilots and Weapons Systems Officers might have been responsible for the delivery of a weapon, but it was usually the non-commissioned aircrew on the sensors whose judgement made it possible to take the decision to employ it. Training and operating as constituted crews fostered the discipline, confidence and trust that was necessary in such demanding circumstances. These hard yards against a difficult adversary provided a bulwark against complacency, leaving the crews well placed to meet the emerging and quite different challenges of operations over Afghanistan and Iraq.

If the current ISTAR[7] Force applies the Direct-Collect-Process-Disseminate cycle to support the commander's intent, then so too did the Nimrod MR2. Simply put, getting the right information (or intelligence if possible) to the right person at the right time was the driver behind the way that crews operated and reported. The hard-earned experience of determining a 'pattern of life' (PoL) in the maritime environment, both above and below the surface, paid dividends in the new overland setting. Reliance on acoustic and radar sensors was replaced by electro-optical and infrared cameras, and the development of the Recognised Maritime Picture was replaced by the PoL ahead of convoy routes, along rat-runs through the desert and over the sea, and around compounds harbouring enemy forces. If the Cold War required such intelligence to be reported for political as much as military sensitivity, then the latter years of Nimrod operations were characterised by time-sensitive targeting. An enemy that was elusive, fleet of foot, and operating in a much looser command structure than the Soviet Navy demanded the delivery of an equally agile and rapid effect.

Meeting the new threat

In early 2002 an informal 'lessons learnt from Afghanistan' seminar was hosted at Northwood by the MPA Staff; the Nimrod MR2 had by then been flying in support of UK ground forces in Afghanistan for some four months. Whilst the Nimrod and its crews were already providing critical support, the Executive wanted to know whether anything more could be done to assist the troops. Utilising experiences from those involved on the ground it became apparent that the 'Mighty Hunter' could add to three aspects of operating:

a. Enhanced spatial awareness for the ground forces, particularly during the 'infil' and 'exfil' phases of an operation, via the use of electro-optics providing black-and-white, colour and IR imagery.

b. The ability to provide third party weapons carriage (eg GBU-10 Paveway II).

c. Provision of a command platform and/or strategic reach communications.

And so Programme MAGIC ROUNDABOUT (UOR 10158) was born to enhance the Nimrod MR2's capability in support of operations in Afghanistan and subsequently in Iraq. It comprised:

- Project DOUGAL: four aircraft fitted with WESCAM MX-15 EOS
- Project DILL: in-flight and post-flight image capture (recording)
- Project SAGE: in-service and logistical support
- Project HECTOR: provision of a fifth aircraft's worth of spares/support and hand-held night imaging devices (for the use in the beam windows)

Project DOUGAL was implemented with impressive speed: the first turret was bought on 11 December 2002;[8] the first multi-disciplinary meeting was held at BAE Systems Woodford on 19 December and, on 18 January, just twenty-nine days later, the first aircraft fitted with a working turret took off from Kinloss. The addition of a truly harmonised (positional feed, pointing accuracy and datum), integrated (compatible and interoperable) and capable electro-optical system added real weight to the already impressive punch of the Nimrod MR2.[9] The communications side was also procured rapidly, with a cross-Defence solution delivered with the Harris Radio, harmonising spectrum and encryption to allow secure communications between ground and air, either line-of-sight or through satellite routing.

Despite the attraction of creating a potentially persistent, armed ISR platform (which would later be provided by the unmanned MQ-9 Reaper) it was a step too far for the Nimrod. The assurance cost for weapon release clearances, securing the necessary range time and the training burden which would have been imposed on an already overheated programme, and Force, precluded it from going forward; but the idea had clearly been technically viable.

To the future

There is the thread of an argument that places the Nimrod as the forerunner of today's ISTAR Force. Clearly articulated, tightly bound, requirements to meet the attendant transparency behind public spending led to the P-8 Poseidon being annotated as an MPA. To meet the value-for-money argument, and, more importantly, the demands of modern warfare, however, it must be developed as a multi-mission aircraft, a term that so accurately described the Nimrod MR2. As the mothers of invention, it was a series of crises in the southern and northern hemispheres, over sea and over land, and at the hands of state-based threats and terrorists that shaped the Nimrod. Aged, difficult to support when deployed away from its main base, and suffering from increasing obsolescence, this remarkable aircraft

The P-8 Poseidon will restore an essential capability that the RAF has lacked since the grounding of the Nimrod in 2010.

nevertheless provides an example of a system of sensors, communications, weapons and crew as relevant to the challenges of 2010 as it had been 40 years earlier when entering service.

The Poseidon's MPA nomenclature is a clear reference to its main role, but to meet the current and future defence and security challenges, the ambition for this capability should be high. The versatility its predecessor had offered provides a glimpse of what could be done in an analogue age. Wherever, and however, the threat emerges in the future, the UK will be better placed to counter it with Poseidon at its disposal.

Notes:

[1] Cm 9161; National Security Strategy and Strategic Defence and Security Review 2015.

[2] From a public statement made on 5 November 2015 during a visit to HMS *Ocean* in the context of NATO Exercise TRIDENT JUNCTURE.

[3] Air Cdre Robbie Noel was Station Commander RAF Kinloss 2008-10 and Gp Capt JJ Johnston, 2010-12.

[4] HC1025; *The Nimrod Review. An independent review into the broader issues surrounding the loss of the RAF Nimrod MR2 Aircraft XV230 in Afghanistan in 2006,* dated 28 October 2009.

[5] The motto of RAF Kinloss.

[6] A 'system of systems' may be defined as a collection of task-oriented or dedicated systems that pool their resources and capabilities to create a new, more complex system which offers more functionality and performance than simply the sum of the constituent systems.

[7] ISTAR: Intelligence, Surveillance, Target-Acquisition and Reconnaissance

[8] Although it is considered highly unlikely that this would happen today, the first turret was actually bought on an Amex Card (£15,000 deposit) at 1635hrs on 11 December 2002; if that had not been done then the Spanish would have acquired the next four turrets and our programme would have been delayed until May 2003 – too late for Gulf War II.

[9] The Nimrod had previously been fitted with TICMS (Thermal Imaging Common Module System) internally (beam window) and SANDPIPER (fitted to the starboard wing, and IR capable only); the mounts for SANDPIPER were later used for the WESCAM MX-15 turret – which created a number of issues in itself!

BOOK REVIEWS

Note that the prices given below are those quoted by the publishers. In most cases a better deal can be obtained by buying on-line.

The Silent Deep by Peter Hennessy and James Jinks**.** Allen Lane; 2015. £30.00.

> ‘One of the strangest and most singular professions a British citizen can pursue. Their world spans the front line of national defence (surveillance and intelligence gathering) to the last line (nuclear retaliation as the country’s near unthinkable ‘last resort’).’ *Preface, page xxx.*

This is an important book, not least as the debate about the UK’s nuclear defence policy intensifies again. Those interested in the huge technical challenges of designing and building immensely complex SSNs and SSBNs, developing high performance and ‘new technology’ weapons systems and nuclear propulsion plants will find much information to contemplate. The story from Polaris to Trident is covered at length. The future of SSN operations are brought into stark relief as we read yet more of the resurgence of Putin’s Navy and recent activity of Russian SSNs in the North Atlantic and around our shores.

Both authors are well known for their specialist subjects and here combine forces to pull together a broad range of information to describe in great detail the history of The Royal Navy Submarine Service since 1945. This is a big subject, because the authors were given unprecedented access to documents, personnel and submarines, both operational and decommissioned, all of which has been used to reveal for the first time in significant detail the activities of the Submarine Service since the end of WWII. So there is much ground to cover, and whilst some will find it heavy reading, this is a book that many will find difficult to put down.

Many of the files held by the MOD, even those covering operations that took place over 50 years ago, still remain too sensitive to release, but there is more than enough detailed description of submarine v submarine operations during the Cold War to give the reader a good understanding of what was (and remains) undoubtedly real front line business. There is also much fascinating detail about the role of the boats that took part in the Falklands War, effectively blockading the Argentinian Navy in their bases after the *Belgrano* sinking.

The authors witnessed potential submarine commanding officers being tested at sea on the *Perisher*,[1] and spent some time with the USN/RN team watching HMS *Vigilant* preparing for and conducting a test firing of a Trident missile. Here Peter Hennessy's and James Jinks's journalistic skills are really evident – they miss no detail, forget nothing they hear. And this book most certainly lays out what makes a career in the Submarine Service so challenging for submariners and for their families in almost every respect.

This book, with its 823 pages, including extensive notes and a comprehensive bibliography, is the first opening up of the Silent Service in an authoritative manner, a text book for every aspiring submarine commanding officer, and a must read for those who want to know as much as is likely to be released into the public domain about UK submarine operations in the future. Highly recommended.

Cdre Toby Elliott

Sonobuoy History From A UK Perspective by Clive Radley. (2016; available most conveniently via the author direct at clive.radley1@ntlworld.com). £18.00 inc p&p.

This, nicely produced, 170-page, 19·5 × 26 cm softback, deals with a somewhat esoteric subject which is likely to appeal to (perhaps even be really understood by) only a relatively small proportion of the membership, so it would not normally have been considered for a review. However, since this edition of the Journal focuses on ASW, it is appropriate to afford it some space.

Although sub-titled *RAE Farnborough's Role in Airborne Anti-Submarine Warfare*, it also takes in, along the way, the work done by other institutions and industry, notably QinetiQ and Ultra Electronics Ltd. Presented, broadly chronologically, the first four (of fourteen) chapters review the early development of an aspect of ASW – acoustics – that began to be exploited during WW II when the UK lead the field with the invention of the sonobuoy. It subsequently

[1] Reflecting its high failure rate, the RN's long-running, and very demanding, Submarine Command Course is colloquially known as the *Perisher*.

maintained its pre-eminence as the technology matured with the 1950s seeing an early, and notably successful, innovation in the field of standardisation with NATO specifying three sizes for sonobuoys; this imposed constraints on designers but ensured that nationally developed devices could be employed by allies. Later chapters chronicle the introduction of increasingly sophisticated techniques and sensors, progressing via DIFAR, Barra and CAMBS to HIDAR and LOFAR, the incorporation of GPS and, ultimately, the current state of the art – multistatics.

That last sentence highlights one of the problems with the narrative; there is some jargon and the text is replete with acronyms. Many of the latter will be familiar to maritime aviators but the 'amateur' may need to consult the glossary quite frequently, where he may not always find the decrypt he seeks, eg VERA, BERT, TIDGET, BUTEC, ASSAM, FMS, TMSL, LCC, etc. There is a lot of techno-speak too, such as 'phase-locked loop frequency control' and 'acoustic wavelength is comparable to the water depth and Modal propagation predominates'. Clearly – ASW is complicated!

The complexity of the subject matter aside, the book would have benefitted from an independent editor. This might have permitted the removal of several instances of passages being repeated a few pages apart and of what appear to be sentences that have been re-written but with the original version not deleted – and I am pretty sure that there is a 'one' missing from the first sentence on page 120. The text is well supported by illustrations, most of them in colour, although a few have been poorly scanned/copied resulting in soft images and/or interference patterns. The photograph on page 46 of a crew at work in a Shackleton is captioned as being in a Sunderland – again, an editor would surely have spotted this. The narrative includes several sections that have been reproduced verbatim from other publications, and, in all cases, duly acknowledged. Two of these, first hand impressions of Shackleton and Nimrod operations by, respectively, Bill Tyack and Ian Coleman have been taken from this Society's Journal 33.

Chapter 13 is devoted to the Nimrod MRA4 saga. The first part considers the pros and cons of the three contenders in the form of a lengthy appreciation that appeared in the 15 May 1996 edition of *Flight International*. This is followed by the author's robust defence of the project in which he disputes the validity of the reasons cited for its cancellation in 2010. While he welcomes the planned acquisition of the P-8, he notes some significant limitations (compared to the MRA4), including its incompatibility with UK-produced sonobuoys and the Stingray torpedo. It is possible that these limitations may eventually be overcome but, in the meantime, without the Nimrod, the only application for the UK's state-of-the-art multistatic system will be in the ASW version of the Merlin helicopter.

Not being a maritimer, I did not find this a particularly easy read. But that says a lot more about me than it does about the book and I am confident that it will satisfy folk who already have some understanding of the arcane art of ASW. Recommended – certainly for the cognoscenti.

CGJ

Clipped Wings (Vol 1) by Colin Cummings. Nimbus Publishing (October House, Yelvertoft, NN6 6LF); 2009. £25.

The indefatigable Colin Cummings continues his self-imposed task of locating, collating and publishing the details of losses of RAF aircraft. In a series of books that began to appear in 1997 he has already recorded all accidents that resulted in an aeroplane's being written off between 1945 and 2009. This runs into several thousand incidents and for each one we are given: the date and location; the type of aircraft involved, identified by serial number and unit; and details (generally full name, rank, age and aircrew category) of fatalities, all of this being amplified by a brief description of what happened. But that was the 'easy' stuff, since then he has repeated the trick, twice, with a volume covering the period between VE-Day and the end of 1945 and another devoted to losses suffered by all transport and special duties aircraft and assault gliders, 1940-45. I would imagine that both of these will have been a bit more difficult than the post-war books because of imprecise and/or missing wartime records.

But these problems are surely dwarfed by the scale and scope of his latest undertaking which aims to chronicle, as his subtitle explains, *Pre-Operational Training Aircraft Losses*. That is to say those that occurred in such units as an EFTS, an SFTS, an AOS, a B&GS, an AGS, a (P) or (O)AFU, and so on – and on. But, and here is the punch line, the project is going to embrace the RAF's *global* wartime training system, not just the UK. This will require four volumes, the first of which addresses only units in the UK, Rhodesia, India and minor territories between 1939 and 1942. Vol 2, which should be 'out in time for Christmas', will cover training write-offs in Canada, South Africa, New Zealand, Australia and the USA over the same period. Vols 3 and 4 will repeat the exercise for 1943-45. Since Vol 1 alone runs to 706 softbound A5 pages one is going to need to reserve a good 7 inches of shelf space to accommodate the full set!

This is an admirable endeavour and the author, and his several collaborators (Cummings modestly claims to be no more than a compiler and editor), are to be congratulated on their industry and perseverance in ferreting out this information and making it so readily accessible. Books of this nature may represent a niche market but for those of us who lurk in this niche, this series is an invaluable resource. Furthermore, a proportion of the proceeds goes to charity.

CGJ

First Out In Earnest by David Gunby. (Fighting High; 2016). £25.00.

The title of this biography of J O 'Jo' Lancaster refers to the fact that he was the first man to use a Martin Baker ejection seat 'in anger' when he was obliged to abandon one of the two experimental Armstrong Whitworth AW 52s in 1949.[2] That incident is likely to be all that many people will know about Lancaster but he had a particularly interesting career both before and after that singular event.

Having begun an apprenticeship with Armstrong Whitworth in 1935 he joined the RAFVR in 1937 and, at the age of 19, he was soon flying Harts in his spare time. Unfortunately, he crashed an Avro Cadet which resulted in his being discharged. Nevertheless, he was accepted back into the fold in 1939 to undergo the wartime flying training sequence, emerging as a sergeant in 1940 and going on to complete a tour on Wellingtons with No 40 Sqn, during which he was commissioned. He spent most of 1942 instructing with Nos 22 and 28 OTUs before joining No 12 Sqn to fly a second bomber tour, this time on Lancasters, his total of 54 operational sorties being recognised by a well-earned DFC in 1943. After a few months with No 1481 Flt, Jo

[2] Fortunately, he had been flying alone at the time – the flight test observers compartment in the AW 52 was not provided with an ejection seat.

was posted to the A&AEE where he was able to fly a wide variety of aircraft, mostly on armament trials, before joining No 3 Course at the ETPS in 1945. Demobbed in 1946, he spent some time with Boulton Paul and Saunders Roe before re-joining Armstrong Whitworth in 1949. That kept him busy until 1962 flying from Bitteswell in locally-built Meteors, Sea Hawks, Hunters, Javelins and, eventually, the Argosy.

Although he had recently acquired an ATPL, Jo was not attracted by the prospect of 'bus driving' and he began a third career in what ICAO defines as 'Aerial Work'. His first endeavour was in crop-spraying with the Nicosia-based Aerosprays (Cyprus). This involved flying Piper Super Cubs to fulfil contracts in the Sudan, Austria and Syria, the descriptions of operations in the field sometimes recalling tales of pre-war barnstorming. As a co-director and shareholder, Jo had a vested interest in the company and while the flying was satisfactory, aspects of its financial management were not and the business closed in 1965, with Jo still owed a substantial sum. It was not long before he was engaged to fly with Meridian Air Maps of Shoreham, soon becoming its Aviation Manager. The company specialised in precision aerial survey using photography to produce accurate mapping to support civil engineering developments, motorway construction, bridge building and the like. Apart from contracts in the UK, the small fleet of aircraft, mostly Piper Aztecs and Navajos, operated globally and at various times worked on projects in France, Portugal, Ireland and as far afield as Egypt, Cyprus, South, East and West Africa, and the Caribbean. Although this enterprise was successful, it eventually failed in 1984, largely as a result of a Nigerian client defaulting on a substantial payment. Once again Jo was out of pocket and, now in his sixties, he retired.

To tell this story, David Gunby has drawn heavily on interviews and correspondence with the subject and a substantial proportion of the book is presented in Jo's own words. These passages feature many interesting and informative asides, notably, for members of this Society, on aspects of his wartime experiences in the RAF. The chapters covering his years in uniform have been skilfully fleshed out by the author who has made extensive, and acknowledged, use of such reliable secondary sources as Middlebrook and Everitt, Chorley and Mason, and his own history of No 40 Sqn. I found only a few hiccups, eg Wickenby is NE (not NW) of Lincoln; the FN82 was a tail (not mid-upper) turret and the Meteor 14 had a one- (not two-) piece sliding cockpit canopy (see page 13 of the book's own photographic insert). But these do not detract from what is a well-told story that was well worth telling. Jo Lancaster had flown some 150 types of aircraft in the course of accumulating 11,000 hours almost all of them, as he points out himself, under manual control. He is, as the book's jacket points out, 'one of the rapidly diminishing survivors from the golden age in British aviation.'

CGJ

Tornado Boys by Ian Hall. Grub Street; 2016, £20.00.

I am a great fan of the Grub Street 'Boys' books, not least because they provide a fascinating historical perspective on some very important aeroplanes. Aircraft in themselves are inert objects which only achieve great things when they come into the hands of dedicated, skilled and imaginative professionals.

Unlike iconic British aircraft designs, such as the Canberra and the Vulcan, the Panavia Tornado comes across as a rather clunky workhorse – an ungainly 'compromise' aircraft sired by an international committee. This is a pity because the Tornado has played a starring role in the most significant air campaigns over the past 30 years.

To tell the aeroplane's story, Ian Hall, a former fighter-bomber pilot himself, has brought together a host of experienced Tornado mates, past and present, who are well-placed to cover specific, self-contained chapters on aircraft development, international training, Gulf Wars 1 and 2, Scud hunting, exchange flying with the Saudis, the introduction of Storm Shadow and Sasha Sheard's female perspective on Afghan operations. Many of the contributions are written by retired 'starred' offices who occasionally lapse into the 'thanks to my inspired leadership' school of anecdotal history. That said, *Tornado Boys* maintains a lively pace and it really does add to the sum total of our aeronautical knowledge.

There are some gems in here including John Peter's visit to the SAM-5 site south-west of Berlin on which he would have been expected to deposit a nuclear weapon had the Cold War ever got out of hand. Dropping a WE177 on a SAM-5 site is not the most intelligent example of weapon-to-target matching, but if your strike aircraft lacks legs you can only hit what you can reach. At the other extreme, when former DCinC Air Command, Iain McNicholl, refers to the debate about replacing Harriers in Afghanistan with Tornados, he is deliciously indiscrete when he talks about the lead civil servant at the PJHQ 'whose ignorance of military matters did not constrain her views'. Shades of Chilcot.

Air power academics tend to get carried away with Venn diagrams and worthy talk of paradigms. If you want to understand how modern mission planning is for real, read the chapter by David Robertson, former OC 617 Squadron. His namesake, Gordon Robertson, is equally good on the maritime Tornado which suddenly found itself hauling Sea Eagle on the retirement of the Buccaneer. This was not a success story, which is why this book is so good – it tells things as they really were, which is how good history ought to be.

I have to admit to knowing several of the contributors to what the blurb describes as 'thrilling tales from the men and women who have operated this indomitable modern-day bomber.' That is a bit OTT but the 208-page *Tornado Boys* is a cracking piece of work which I finished in short order on my summer holiday. It more than complements the drier official histories of recent air campaigns. This is real air power history written by real operators who were there, did that and got the t-shirt to prove it.

Heartily recommended.

Wg Cdr Andrew Brookes

Contact – A Victor Tanker Captain's Experiences in the RAF, Before, During and After the Falklands Conflict by Bob Tuxford. Grub Street; 2016. £20.00

Squadron Leader Bob Tuxford's name will always be associated with the massive AAR effort that made possible the BLACK BUCK Vulcan attack on the airfield at Port Stanley in 1982. His story otherwise is of great interest, describing a remarkable career for one who would once have been described as a General List officer. That he successfully avoided a ground appointment until taking optional retirement at the age of 38, twenty years after entering Cranwell, sets the scene for a very readable account of life in the Cold War RAF.

An air cadet career spanning air experience flights, first solo flying in gliders, the award of a flying scholarship and a place on the coveted International Air Cadet Exchange led Bob Tuxford in 1966 to Biggin Hill and selection, his account of which is self-deprecating and very recognisable. Nonetheless, the following year, the gates of the Royal Air Force College swung open to admit him to one of the last ‘old Cranwell’ courses. His account of that, of advanced flying training on the Varsity at Oakington and of his first five years on Victor tankers at Marham (‘El Adem with grass’) are well and amusingly written. He paints a clear picture of the variety and demands of the AAR role in the Cold War.

Tuxford’s exchange posting to Mather AFB in California was, professionally, both a feather in his cap and fulfilling. He writes affectionately of nearly three years there as a KC-135 captain and home-grown instructor pilot. Besides the sheer scale of the operation, he offers some dry asides about USAF attitudes and practices, notably the complexity of mission briefings and differences of approach between the two air forces to training. His view of Vulcan pilots is similarly frank!

Amazingly after three consecutive flying tours, Bob Tuxford was straight back into the cockpit, first, following the CFS course, as a newly promoted squadron leader at No 7 FTS, Church Fenton, then in short order, first to 57 Squadron at Marham, then to 55 Squadron as a Flight Commander. His account of his part in the Falklands campaign is fascinating, covering early photo- and maritime radar reconnaissance sorties and the associated dearth of current and timely intelligence. However, it is Tuxford’s frank account of his critical part in the BLACK BUCK operation and the flexibility and courage demanded of him and his crew that is the most striking passage in this book. His description reflects the deservedly high esteem in which the RAF’s tanker squadrons are held to this day.

Given his wide experience of tanker operations and the imminent enhancement of the tanker fleet with VC10 and TriStar, Bob Tuxford again escaped the fate of a ground tour. Having successfully completed the Empire Test Pilot School course, he spent a further four years in the cockpit at Boscombe Down. He provides a wonderful flavour of the variety and intensity of his work there in the final chapters of the book. As his 38th birthday approached, he resisted the temptation of a desk in MoD(PE) and decided to retire, leaving the

Service with no regrets and with evident affection for it.

Given my real enjoyment of this 206- page hardback, with its many B&W and colour photographs, it seems churlish to draw attention to occasional errors of detail which, with the passage of time, are understandable lapses of memory. For example, Bob Tuxford's description of the ATC gliders which he first flew is rather muddled and his account of 'Goering's beam' in the Gütersloh Officers Mess diverges somewhat from the usual version of that much repeated and embellished tale. His attribution to AOC 1 Group of responsibility 'for the overall air defence of the UK' is wide of the mark, splendidly though the then incumbent would have discharged the task. Much less easy to forgive than these trivial errors, are the many spelling mistakes left undetected by editors or proof readers, which do less than justice to an excellent book. It will, nonetheless, be much enjoyed by members of the Society.

AVM Sandy Hunter

Forever Vigilant by Graham Pitchfork. Grub Street, 2016. £25.

Written by an ex-CO, this 272-page hardback celebrates, as its subtitle says, *Naval 8/208 Squadron RAF – A Centenary of Service from 1916 to 2016*. In brief, the squadron was hastily formed, initially within the RNAS and soon standardised on the Sopwith Triplane, and later the Camel, which permitted it to establish an enviable operational record during WW I. Selected as one of the handful of number plates that would constitute the peacetime air force, No 208 Sqn spent the inter-war years in Egypt flying in the army co-operation role. By 1939 it was equipped with Lysanders but, as in Europe, it soon became clear that such traditional-style army co-operation aeroplanes, and the procedures associated with them, had become outmoded and the squadron had received its first Hurricanes before the end of 1940.

Having spent much of 1941 in Greece and Palestine, the squadron was back in the Western Desert before the end of the year where it played a leading role in refining and establishing what would become standard fighter reconnaissance (FR) procedures. Notable among these was the practice of flying in pairs, one pilot focusing on the recce task protected by a 'weaver'. When first introduced there was some resistance to this idea, as it automatically doubled the number of aircraft required for every mission, but OC 258 Wg, Gp Capt Kenneth

Cross, was adamant and this eventually became accepted – in all theatres – as the way to conduct a tactical reconnaissance (TacR) sortie if there was any likelihood of encountering opposition. The squadron spent 1943 in the Levant before moving to Italy for the rest of the war, still in the FR role, but now mounted on Spitfires.

Post-war, No 208 Sqn was based in Egypt flying Spitfires and Meteors until 1956 when it relocated to Cyprus. After a brief episode with Venoms in Kenya in 1959-60 the squadron re-equipped with Hunters which it took, first to Aden, and then the Persian Gulf before disbanding in 1971. Reformed on the Buccaneer in 1974 it flew these, latterly in the maritime attack role, for twenty years including, much to everyone's surprise, participation in the First Gulf War in which the veteran bomber acquitted itself with some distinction. Following the squadron's withdrawal from the front line in 1994, its identity was sustained by renumbering No 234(R) Sqn, one of the units within No 4 FTS at Valley, as No 208(R) Sqn. Since then the Hawk-equipped squadron has played an essential part in the training sequence followed by all RAF fast jet pilots.

Forever Vigilant is one of an inevitable rash of squadron histories that are appearing in print as the handful of units that survive in today's much reduced air force reach their hundredth birthdays. All of the recent crop have been admirable and this one is no exception. Just to prove that I really have read it, I will flag up a couple of minor errors, Wadi Nostrum (instead of Natrun – p131) and the practice of painting squadron emblems on an aeroplane's fin in one of three standard badge frames – spearhead, grenade and star – began in 1936 (not 1930 – p79), following the introduction of formally approved unit badges. But these are mere details. The book is very well-presented on coated paper which has ensured excellent reproduction of the more than 150 B&W illustrations and two inserts that present another twenty-six pictures in colour. Sixteen of the latter portray a variety of flamboyant 'special' schemes sported by some of the squadron's latter day Hawks to mark a variety of anniversaries. It is notable that, while there are ample pictures of aeroplanes, a large proportion of the illustrations are of people, fostering an impression of the squadron as 'a family', rather than an impersonal 'unit'. This may have been amplified during WW II by the fact that some pilots served with the squadron for as long as two years, surely much longer than the norm in the UK.

The last line in the narrative reads '. . . all were hoping that there would remain a sufficient demand for flying training to keep 208 Squadron in existence beyond its centenary.' Sadly, simultaneously with its publication it was announced that the squadron would disband on 1 July 2016. In all probability, therefore, the last word on No 208 Sqn may already have been written. Fortunately, it has been very well done.

CGJ

Gloster Javelin by Michael Napier. Pen & Sword; 2016. £25.00.

Michael Napier is proving to be a prolific author; this is his third title to appear in just thirteen months. As with the others, this one is very well-written in an easy, readable style. In this writer's opinion, it has only one significant deficiency – an appendix which sets out to summarise the careers of all 435 Javelin airframes by tabulating their individual histories. Unfortunately, something has gone awry with the alignment of the columns, so that dates, units, etc do not always line up across the page, making the entries difficult to interpret in places; furthermore the information provided is somewhat sparse compared to the relatively comprehensive data that has previously been published elsewhere.[3] That aside, however, there is little else to complain about – although I am pretty sure that the proposed transfer of two of No 29 Sqn's last Javelins to FEAF, with tanker support, in 1967 (page 165) never actually happened.

The narrative adheres strictly to the book's sub-title, *An Operational History*, so the early development problems are dealt with in just a couple of pages. Even so there is room to explain exactly why looping manoeuvres were prohibited as are, somewhat later, the rather curious characteristics of the Javelin's reheat system. Thereafter the structure of the book may seem a little odd at first but it turns out to be quite logical. It is conditioned by the aeroplane's rather complicated evolution which saw this iconic fighter run through eight variants, nine if you allow for the incorporation of an AAR capability, plus a trainer in a service career lasting a mere twelve years. Thus the author

[3] As long ago as 1975-76, Roger Lindsay published two slim, card-wrapped monographs that covered the service history of the Javelin, including relatively detailed 'biographies' of each airframe.

has found it convenient to deal with the squadrons in instalments as the various marks of Javelin came and went, with the picture being complicated by re-numbering exercises in which units changed their identities.

Along the way the reader is provided with insights into: the early type-conversion courses conducted on-site by the Javelin Mobile Training Unit; the conduct of the major air exercises of the day; contemporary radar intercept techniques and the differences between AI 17 and AI 21; live aerial gunnery; the introduction of Firestreak; the Sapphire's centreline closure problems, and its seemingly crude 'Rockide' solution, and much else. Most, if not all, of the major accidents are discussed and ample space is devoted to the Javelin's involvement in the various political crises of the 1960s, notably over Berlin, Rhodesia's declaration of UDI and the Confrontation with Indonesia. All of this is amplified by personal contributions from crew members who flew, and some of those who were obliged to abandon, Javelins.

A notable feature of this 264-page hardback is that it has about the same number of illustrations. As a result pages without pictures are few and far between – and the photographs are mostly of excellent quality and very well reproduced. There is a second appendix providing coloured illustrations of the way in which the Javelin squadrons displayed their markings on that huge fin.

Perhaps because of its relatively short service life, the Javelin has attracted less attention than some of its contemporaries, the Canberra, the Hunter and the V-bombers, for instance, but it was a state-of-the-art bomber interceptor in its day. It participated in, at least its fair share of, high tension episodes and it made a substantial contribution to making the use of air-to-air refuelling and missile armament routine procedures. While it may have been somewhat overlooked, the Javelin was not an insignificant aeroplane and this attractive book goes a long way towards putting the record straight. I liked it.

CGJ

ROYAL AIR FORCE HISTORICAL SOCIETY

The Royal Air Force has been in existence for more than ninety years; the study of its history is deepening, and continues to be the subject of published works of consequence. Fresh attention is being given to the strategic assumptions under which military air power was first created and which largely determined policy and operations in both World Wars, the interwar period, and in the era of Cold War tension. Material dealing with post-war history is now becoming available under the 30-year rule. These studies are important to academic historians and to the present and future members of the RAF.

The RAF Historical Society was formed in 1986 to provide a focus for interest in the history of the RAF. It does so by providing a setting for lectures and seminars in which those interested in the history of the Service have the opportunity to meet those who participated in the evolution and implementation of policy. The Society believes that these events make an important contribution to the permanent record.

The Society normally holds three lectures or seminars a year in London, with occasional events in other parts of the country. Transcripts of lectures and seminars are published in the Journal of the RAF Historical Society, which is distributed free of charge to members. Individual membership is open to all with an interest in RAF history, whether or not they were in the Service. Although the Society has the approval of the Air Force Board, it is entirely self-financing.

Membership of the Society costs £18 per annum and further details may be obtained from the Membership Secretary, Wg Cdr Colin Cummings, October House, Yelvertoft, NN6 6LF. Tel: 01788 822124.

THE TWO AIR FORCES AWARD

In 1996 the Royal Air Force Historical Society established, in collaboration with its American sister organisation, the Air Force Historical Foundation, the *Two Air Forces Award*, which was to be presented annually on each side of the Atlantic in recognition of outstanding academic work by a serving officer or airman. The British winners have been:

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THE AIR LEAGUE GOLD MEDAL

On 11 February 1998 the Air League presented the Royal Air Force Historical Society with a Gold Medal in recognition of the Society's achievements in recording aspects of the evolution of British air power and thus realising one of the aims of the League. The Executive Committee decided that the medal should be awarded periodically to a nominal holder (it actually resides at the Royal Air Force Club, where it is on display) who was to be an individual who had made a particularly significant contribution to the conduct of the Society's affairs. Holders to date have been:

Air Marshal Sir Frederick Sowrey KCB CBE AFC
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