

INVINCIBILITY

CHANGES IN H.M.S. 'INVINCIBLE' DURING REFIT

BY

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ABSTRACT

H.M.S. *Invincible* is nearing the end of the first CVSA refit, and, in it, a large improvement package has been undertaken to bring her up to *Ark Royal* standards, involving extensive re-arrangement. The upgrading provides full Flag facilities for controlling an ASW task force; it permits expansion of the air group by nearly 50%, including Airborne Early Warning helicopters; it increases accommodation by 20%; and improves much of the weapon and radio equipment.

Introduction

Most people know that H.M.S. *Invincible* (FIG. 1) has been refitting at Devonport for the last two and a half years and everyone will have been expecting her to have been updated in some way, but few will have realized the extent of this, or that it makes her refit the most expensive undertaken in Western Europe in 1988. Why was it necessary, what are we getting for our money, why did it take so long, and what happens next?

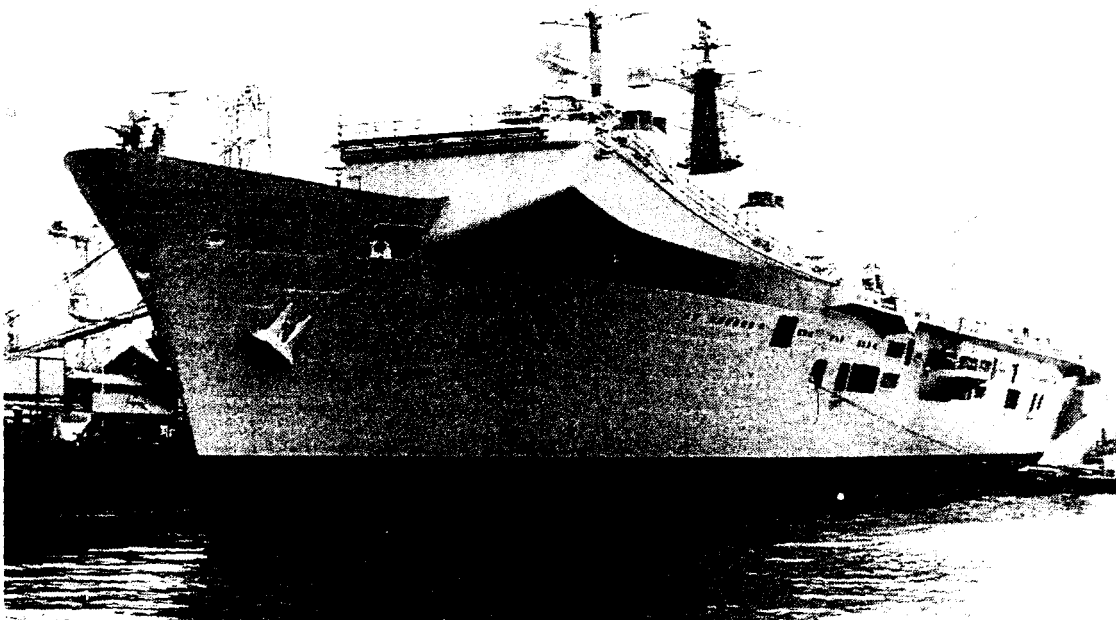


FIG. 1—H.M.S. 'INVINCIBLE' NEAR THE END OF THE REFIT

Photograph by courtesy of the Commanding Officer,
H.M.S. 'Invincible'

The Through Deck Cruiser

The design for the Command Cruiser sprang out of the decision not to proceed with the new strike carrier in 1966, from the increasing realization of the efficacy of large anti-submarine helicopters against nuclear submarines,

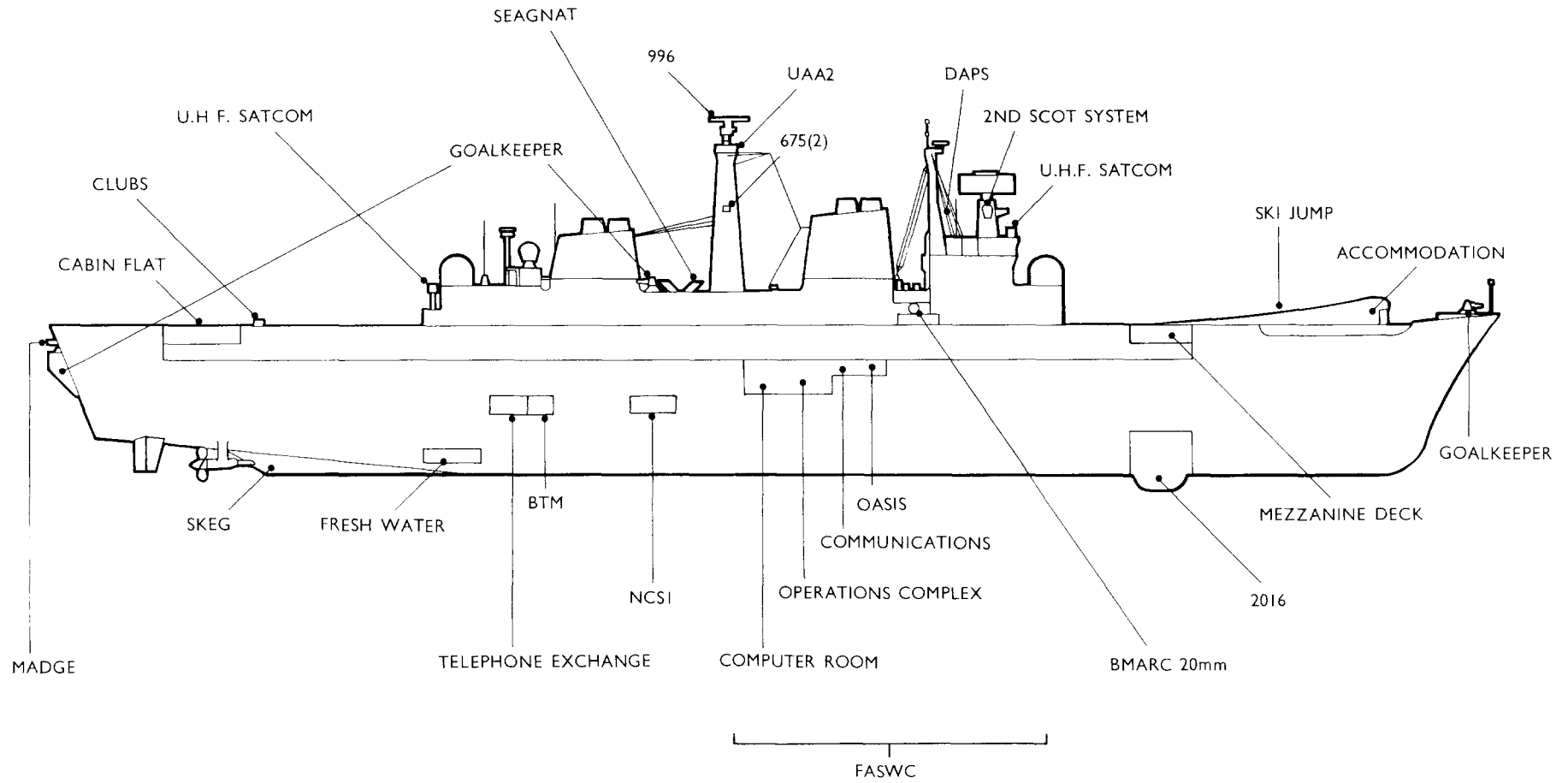


FIG. 2—ADDITIONS IN THE 1986-88 REFIT OF H.M.S. 'INVINCIBLE'

and from the need for a command ship to control air and sea assets over a wide area of ocean. It was initially known as the 'Through Deck Command Cruiser' and this was thought by the public to be a euphemism coined by the Navy to conceal a carrier rebirth, but study had shown that a full bow-to-stern flight deck was the most efficient way to operate large helicopters. The sketch design which accompanied the approved Staff Requirement in 1970 was no replacement for a strike carrier, deploying as it did only 12 aircraft, but, even then, 3 V/STOL air defence aircraft derived from Harrier were included in the envisaged mix.

Her functions were principally to control a task force and land-based aircraft, and to operate large helicopters for area ASW defence, with other roles covering medium range Surface to Air missile defence, use of the V/STOL aircraft and emergency troop lift of a Commando Group. This she was to do with a provisional complement of 951 and accommodation for just under 1000, and hangar space to house all the aircraft with room for a Sea King successor to be substituted.

Ultimately, this was largely the ship which became operational in 1980, though by then the complement had increased, the Exocet installation had been eliminated on cost grounds, and the air group had risen to 14 (9 Sea Kings and 5 Sea Harriers) with no increase in hangar or flight deck size.

Shortfalls and Improvements

In a way, *Invincible* is a victim of her own success, because her flexible design quickly showed that greater exploitation was possible and appropriate changes were therefore made to *Ark Royal* while building. Corresponding upgrade to *Invincible* soon became desirable, and ultimately became essential as commonality with *Ark Royal* as one of three available command ships for COMASWGRU 2 (later COMASWSTRKFOR) operations was developed. The Falklands War in 1982 showed *Invincible's* lack of Anti-Ship Missile Defence (ASMD) and Airborne Early Warning (AEW) radar but also demonstrated the ship's ability to embark and operate many additional aircraft. An interim ASMD fit was quickly provided, with two Phalanx mountings, and later some temporary Command and Control upgrading took place to ensure adequate interoperability with the U.S. Navy, but, by the time *Ark Royal* was completing in 1984, it was clear that *Invincible* needed some major improvements.

Ark Royal had greatly improved ASMD hard and soft kill equipment, an air group almost 50% larger than *Invincible's*, AEW helicopters, the larger 12° ski jump, more accommodation, and C³I facilities befitting her Force Anti-Submarine Warfare Command (FASWC) role. It was therefore decided that *Invincible's* first refit starting in 1986 should be lengthened and enhanced to bring her up to *Ark Royal* standards. The improvement package that was finally carried out actually makes her even more capable in some respects because of lessons learned and the availability of more modern equipment.

The Jigsaw Puzzle

The more important improvements are described below. The order has been chosen not for their priority but for ease of explanation, as the whole update is a jigsaw puzzle which fits together logically. (see FIG. 2).

Goalkeeper

The INVINCIBLE Class was not designed with specific anti-ship missile defences (ASMD) but the growth in the power and number of these weapons in all navies made them more and more necessary. An interim fit of two Phalanx mountings was made to *Illustrious* during the Falklands War and

to *Invincible* shortly afterwards, but its shortcomings of limited arcs and obstruction to the flight deck aft were obvious. *Ark Royal* was therefore completed with three Phalanx mountings permanently fitted in positions which gave excellent overlapping arcs of fire and which reduced the obstructions to aircraft. During *Invincible's* refit, these same positions have been chosen for her permanent ASMD fit, but the opportunity has been taken to upgrade to Goalkeeper, which offers greater weight of ammunition, higher rate of fire, longer range and better performance in multipath conditions. The forward mounting is fitted on a new platform in the eyes of the ship, resulting in substantial decking over of the fo'c'sle and partially obstructing the view from the bridge. Its magazine is provided in the front of the new ski-jump but considerable difficulty was experienced in finding room for the radar offices within the permissible wave guide lengths. Eventually, the inflammable store at 3A was taken over and consequential re-arrangements resulted (FIG. 7). The midships mounting (FIG. 3), on the starboard side of the Alaskan Highway at 1 L/M was easier to fit but required the building of a 50 tonne deckhouse bridging the air weapons supply route and meant the final loss of the Admiral's/Captain's motor boat. This mounting has excellent arcs of fire over the whole starboard side, with its radar offices, workshops and a new Chief Bo's'n's Mate's (CBM's) office built into the deckhouse.



FIG. 3—THE DECKHOUSE FOR THE MIDSHIPS GOALKEEPER AND STARBOARD SEAGNAT, SHOWING THE AIR WEAPON TRANSFER ROUTE

Photograph by courtesy of the Commanding Officer,
H.M.S. 'Invincible'

The aft mounting position (FIG. 4) is a miracle of the constructor's art, as it had to be fitted on the port quarter, causing no obstruction to aircraft operation, causing minimum removal of flight deck area and avoiding excessive salt water contamination. This has been achieved by cutting away the corner of the officer's cabin flat on 2 and 3 decks and fitting a large sponson at inter-deck level which fairs into the hull at the waterline. The magazine and the mounting are fitted on the sponson and radar offices take up some more of the cabins, resulting in a loss of eight in all.

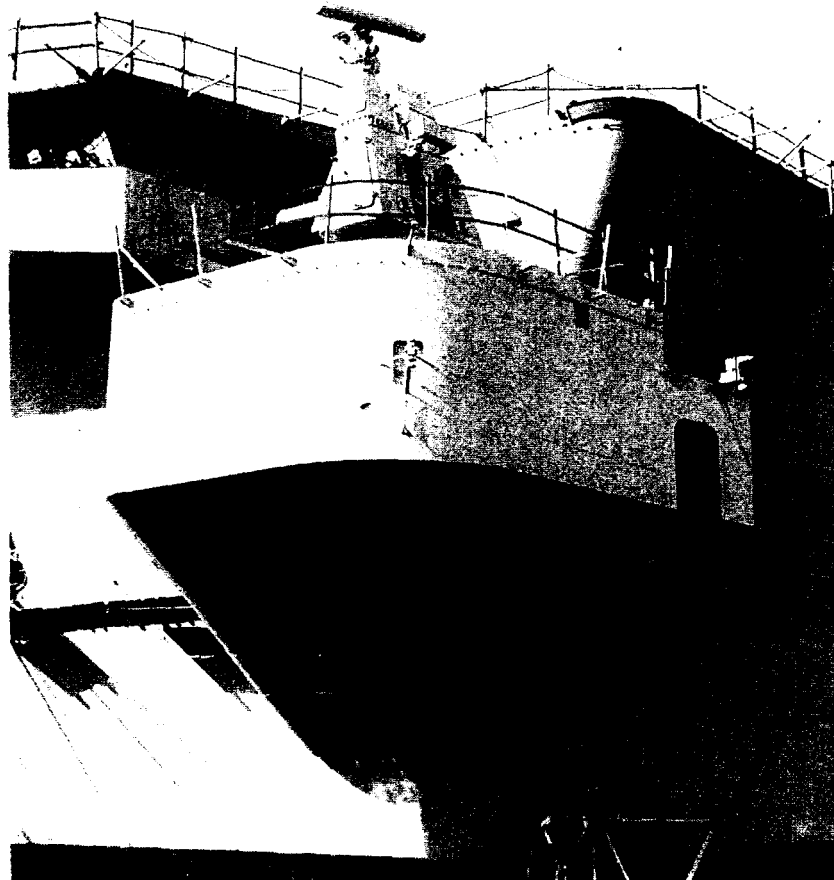


FIG. 4—THE SPONSON FOR THE AFT GOALKEEPER WITH ITS EXCELLENT ARCS OF FIRE AND THE RESULTANT FLIGHT DECK CUT OUT

Photograph by courtesy of the Commanding Officer, H.M.S. 'Invincible'

Chaff Launchers

Prior to refit, *Invincible* was provided with two 3 inch rocket launcher systems (RLS) firing from 02 deck on the island, supplemented by SRBOC. Not only was 3 inch RLS obsolescent and due for replacement by Seagnat, but a more practical site for the port launchers was vital to avoid interference between rockets and aircraft on the flight deck. Thus Seagnat has been fitted, with its starboard launcher as far outboard as it will go on the midships goalkeeper deckhouse at 02L. The port launchers, however, have required more thought (FIG. 5). A large sponson has been fitted in the boat bay at K Section port to accommodate them and their magazines and this has necessitated moving the fast motor launch and its davits to the aft end of the Alaskan Highway at 1N and, regrettably, losing one of the two 36 ft. work boats. Fitting of the midships goalkeeper deckhouse has also made a resiting of the

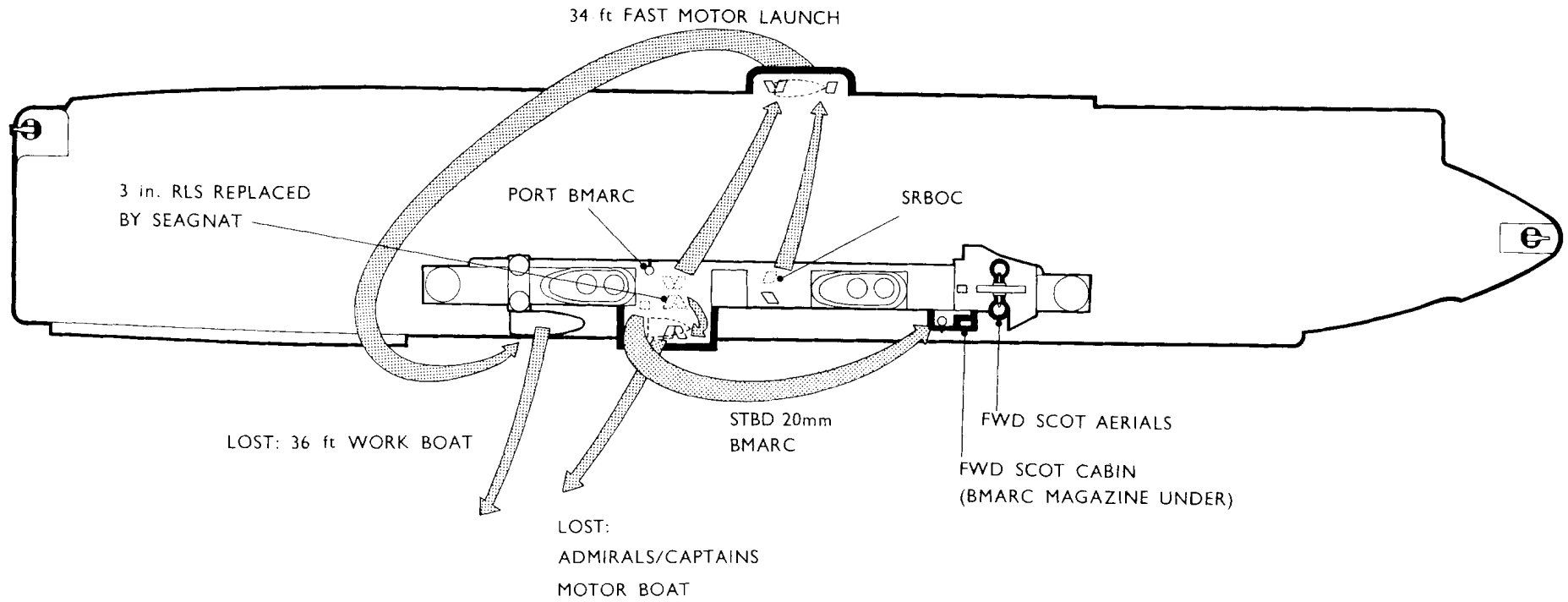


FIG. 5—THE CONSEQUENCES OF DISENGAGING AIRCRAFT AND CHAFF. HEAVY LINES INDICATE NEW STRUCTURE

starboard 20 mm BMARC gun mounting necessary. An excellent new position has been created for it on a sponson over the Alaskan Highway at 01J and the associated magazine provides a deck at 02H for the new SCOT cabin when required (see p. 315). Unfortunately it has not proved possible to move the port 20 mm BMARC gun mounting from the island during this refit and so it still continues to fire dangerously across the flight deck.

Expansion of the Air Group

Invincible's original staff requirement in 1970 called for an air group of 12 (9 Sea King and 3 V/STOL aircraft), but, by late 1974 when the development of the Maritime Harrier had already been approved, the envisaged aircraft mix was 9 Sea Kings and 5 V/STOL aircraft and this was the normal peacetime air group with which *Invincible* operated during her first commission. However, Falklands experience showed that considerably more aircraft could be operated from the ship provided upgrades of accommodation and services were provided, and, in any case, a flight of 3 AEW Sea Kings was now a necessity. The current refit therefore provides for an enhancement to an air group of 20, consisting normally of 8 Sea Harriers, 9 Sea King Mk. 6 and 3 Sea King AEW. The accommodation increase is dealt with on p. 313 but the contribution which this air group expansion alone makes is to add a substantial 93 to the ship's complement (24 officers, 30 senior ratings and 39 junior ratings). To clear the hangar deck of some of the equipment stored there at present, a large mezzanine deck has been built at 2 deck in the forward end of the hangar, although this is less successful than hoped because of low permissible floor loadings and poor access. However it does provide two new squadron engineering offices. The AEW flight brings with it a large transportable electronic maintenance room for the Searchwater radar and this has had to be given a site in the hangar (aft starboard side) further reducing the space available for aircraft. To cope with the greater number of aircraft, a substantial increase in ammunition stowages has been provided in the magazines, but this has resulted in loss of a junior ratings' mess deck, thereby exacerbating the squeeze on accommodation.

Sonobuoys

The trend towards the greater use of passive sensors by ASW helicopters has made the original sonobuoy provision in 8S inadequate. Accordingly, the naval stores Receipt and Despatch area has been moved down to 8S, which is well served by stores lifts, and the sonobuoy store has been reprovided in part of the space vacated at 4B, being convenient for the hangar (FIG. 6). Only part of that space was available, as a new Inflammable Store had to be created in the other half, it having been displaced by the forward Goalkeeper radar office at 3A; so an additional sonobuoy store has been made underneath at 5B in a void compartment. Total sonobuoy capacity thus rises very substantially.

Briefing Rooms

The embarkation of a third aircraft type required separate squadron offices and an extra briefing room. The offices have been found on 2 deck forward in an old ceremonial store and in the new mezzanine deck. The briefing room has been created in the Awning Store/CBM office which has been reprovided at 1 deck in the midships goalkeeper structure. This new briefing room at 2F is conveniently placed next door to the aircrew refreshment bar. However, other work was required to expand one of the existing briefing rooms at 2G to house the greatly expanded ASW helicopter squadron, which was done, but only by displacing air operations offices and stores to other smaller sites along 2 deck starboard.

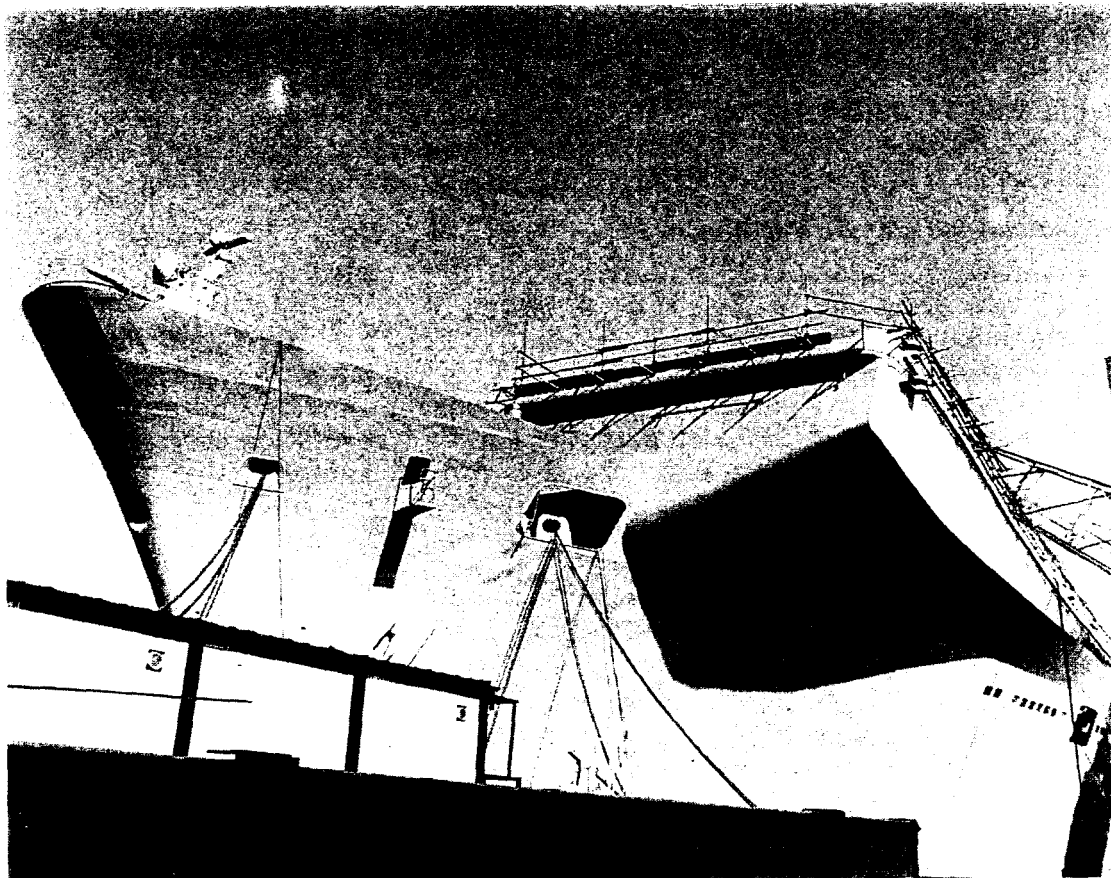


FIG. 6—THE NEW RAMP STRUCTURE, WHICH IS MORE ROOMY THAN 'ARK ROYAL'S

Photograph by courtesy of the Commanding Officer,
H.M.S. 'Invincible'

Avionics

Two useful aviation additions to the ship are due to be Linepost, which allows the Sea King's sonobuoy communications receiver to be checked in flight before departure, and Madge II, a microwave landing aid, which provides several features, the most novel of which is to be able to update the Navhars computer in the Sea Harrier before launch, eliminating the need for the flight deck crew to run up with a blackboard for the pilot to read. Thus we should achieve the same advanced state as Buccaneer 25 years ago.

Fuel

Since Sea Harrier operations started in the INVINCIBLE Class it has become clear that the ships' and aviation fuel capacities have not been balanced, as replenishment of Avcat is generally required well before Dieso. To correct this anomaly and extend the ship's endurance between replenishment, three Dieso tanks and two void spaces have been converted to Avcat storage. Another shortcoming has been the ability to pump Avcat to the flight deck only from aft at 7R, despite there being Avcat tanks and transfer pumps forward. This has now been rectified by providing a limited pumping station at 8F, but the bulk chart store has thereby been displaced and reprovided at 4K port underneath the new chaff sponson.

Ski Jump

Finally in the aviation upgrade comes the new 12° ramp (FIG. 6), similar to *Ark Royal's*. *Invincible's* former 7° ramp was fitted on top of the existing flight deck during build after its invention by Lt-Cdr. Taylor in the mid 1970s. At high ambient temperatures, this ramp imposed limitations on Sea

Harrier payload and almost always required the full runway to be used. By contrast, there are no limitations using the higher ramp and most launches can start forward of the aft lift, thus removing another restriction and offering greater deck space for parking and helicopter operations. The new ramp will also be vital to exploit the full potential of the heavier Sea Harrier FRS2. The new ramp is a much larger structure than the old one, being not only higher but also starting earlier and extending further towards the bow. Its deck profile is the same as *Ark Royal's* but the structure beneath is more roomy—another advantage. The disadvantages are the obstruction it causes to the view from the bridge and to the low level arcs of Sea Dart. However, inside, it provides most of the extra junior ratings' accommodation (FIG. 7) made necessary by the enhanced air group and the new weapons systems. Three mess decks have been built with 60 bunks in total, together with upper deck stores and two magazines. This is, however, a massive structure and the work in wake of its building has been extensive, right down through the ship causing bathrooms to be shifted, passages to be created, beams to be inserted and, the cells to be moved.

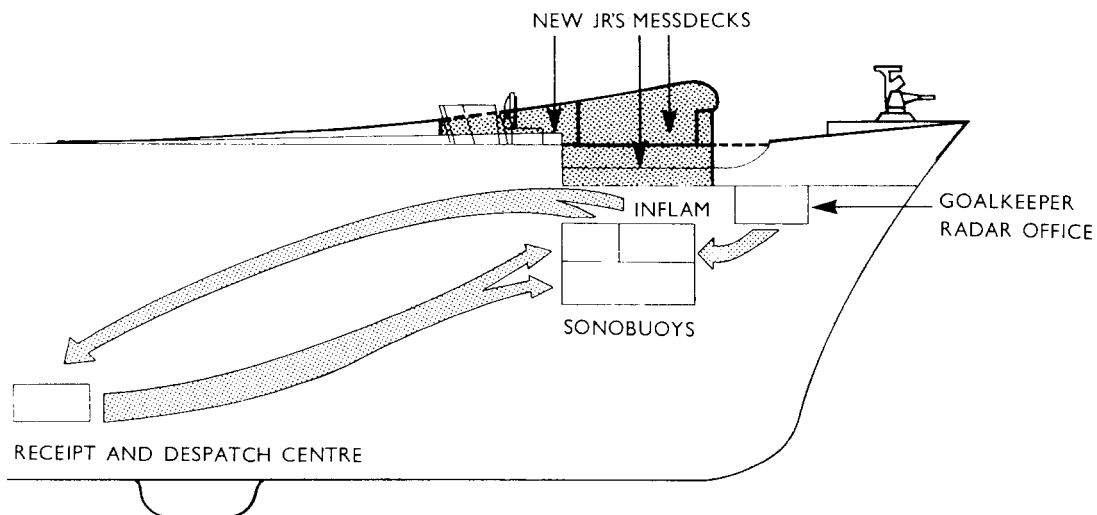


FIG. 7—THE EXTRA JUNIOR RATINGS' ACCOMMODATION AND THE MOVES NECESSARY TO INSERT THE FORWARD GOALKEEPER RADAR OFFICE. HEAVY LINES INDICATE NEW STRUCTURE; SHADED AREAS DENOTE NEW MESSDECKS

Accommodation

Mention has already been made of the cabins lost to the aft Goalkeeper mounting, of the mess deck gobbled up by extra magazines and of the additional men brought by the enhanced air group. It will surprise readers unfamiliar with these ships to hear that they have spare bunks only when the air group is disembarked and that, during major exercises, which are their bread and butter, camp beds proliferate. It was therefore quite clear that not only did the bunks absorbed by equipment changes have to be replaced, but a substantial accommodation expansion was necessary. The initial approach was to try to provide beds for the full revised scheme of complement including the ship's company, air group and flag staff, but experience with *Illustrious* during major exercises before and during the early parts of the refit showed that a more realistic and statistical approach was needed, as the CVSG's role as a command ship meant that many more had reason to be on board. The main reprovision and expansion has taken place as follows:

- 25 officers in eight multi-bunk (temporary) cabins built in a new mezzanine deck in the top of the hangar at 2S;

- senior ratings in two bunk spaces at 6Q and 7R made out of a pipe/cable space and a quiet room;
- junior ratings in the ramp as mentioned and in a new mess deck at 7E, displacing the NAAFI gift shop and beside the very noisy new sonar, making this mess only reserve accommodation.

Added to this basic upgrade are as many additions as could be achieved in the refit:

- for officers, 51 pipecots, one added to each cabin on 2 deck but with no additional locker space thus classifying them as 'austere';
- senior ratings in a new bunk space at 7R created out of the wardroom baggage store (also austere);
- junior ratings in bunks added to three mess decks round the ship.

The accommodation balance which has thereby been achieved is shown in TABLE I. This should be compared with the number (969) envisaged in the original Staff Requirement in 1970, upgraded to 1001 in 1972 for an air group of 12 aircraft. Three other points should be noted. While this provides a wonderful and most welcome expansion of accommodation which largely meets *Invincible's* needs in major NATO exercises, any wartime or 'out of area' requirements are additional. Secondly, none of this accommodation is provided for the CVSG's secondary role of 'providing a helicopter platform and a troop lift capability for UK/NL amphibious operations' (the quick dash role) when a commando group is embarked, and they continue to sleep where they fall over. Thirdly, no extra heads, bathrooms, galleys, store rooms or dining halls have been included over the years of expansion, and pressure on them is intensifying.

TABLE I—*Accommodation changes*

	<i>Officers</i>	<i>Warrant Officers and Senior Ratings</i>	<i>Junior Ratings</i>	<i>Total</i>
Pre-Refit	133	265	609(+ 15)	1007(+ 15)
Lost in Conversion	8	0	(15)	8(+ 15)
Created in Conversion	78	42	90	210
Post-Refit	203	307	699	1209

In addition there remain 5 Sea and Duty cabins

() = unofficial accommodation not included in the official statement

Fresh Water

One service which has been given some alleviation is fresh water supply, by the fitting of a Reverse Osmosis plant in the aft air conditioning machinery compartment at 7Q. This will be particularly useful with troops embarked. It adds 30% to the present steam generator/evaporator arrangement, which has no redundancy, but fresh water storage still remains a problem.

Telephone Exchange

On build, *Invincible* was fitted with the 500 line electro-mechanical telephone exchange removed from H.M.S. *Victorious*, and she has suffered ever since from its unreliability and obsolescence. The electronic M500 exchange has now been fitted, involving extensive rewiring throughout the ship, and, with the advantages of contemporary technology, this now provides better priority call and external operator facilities. The exchange equipment is halved in size, thus providing a new compartment at 6N for a BTM bottle store.

Main Machinery Space Gas Drench

Before her refit, *Invincible's* fixed methods of fighting fires in the main machinery spaces were by using high level salt water sprays in the deckheads and by BCF injection into the gas turbine and diesel generator modules. Now the third option of BTM gas drench of the whole machinery space is available from two bottle stores, one created aft in the space vacated by the telephone exchange, and the other in a new compartment made by re-arrangement of the conversion machinery room at 6K.

Hull Vibration

Those who remember *Invincible's* hull vibration, particularly aft, will be heartened to hear that, in addition to some further work on shaft alignment, a fairing has been added to the skeg between the shafts to bring her up to *Ark Royal's* standard. This is, however, not a great improvement and wobbly writing will continue to be a feature of letters written home by those in aft cabins.

Sonar

H.M.S. *Invincible* was designed to carry Sonar 2016 and its associated large array, but it was not available at build, so Sonar 184 was fitted in lieu. 2016 has now replaced it, as in *Ark Royal*, but arrangements are different in that the consoles and operators in *Invincible* have been removed from the operations room to make space for ADA improvements and have been placed in a new sonar control room created in an unused area of the hull outfit at 7E. This has brought with it the attendant disadvantages to the operators of emergency escape, noise and difficulty of communication with the ASW Director but the new sonar will certainly be a great improvement.

Oceanography

To assist with ASW operations, the oceanography computer SEPADS has been fitted in the operations room with displays there and in the Met. office.

OASIS

Invincible must be one of the last ships other than *Illustrious* to receive OASIS 1. The processor has been fitted in the naval stores office, reduced in size by the staff and paper work reductions made possible with its introduction. Twenty-one visual display units have been installed around the ship in compartments slightly modified by *Ark Royal* experience. It remains to be seen whether the upgraded 4 disc store will permit all the administrative features of OASIS 1 to be available at all user positions.

Satellite Communications

An operational limitation of the *Invincible* Class as designed was the wooding of the SCOT 2 aerials at 03N by the funnels and masts forward in high latitudes. This has been solved rather inelegantly in *Invincible* by the installation forward of a SCOT 1C system with its aerials on sponsons either side of the radar 1022 stump mast at 06G and the equipment cabin bolted to the roof of the starboard 20 mm BMARC magazine at 02H starboard (p. 311). This forward system will be embarked only when required and is not integrated with the aft system in any way.

Force Anti-Submarine Warfare Commander (FASWC)

The primary role of *INVINCIBLE* Class ships is to 'provide facilities for both the command of a task force and for the FASWC whilst operating aircraft in ASW, AAW and ASVW roles'. To allow *Invincible* to continue

carrying out this function and particularly to act as the flagship of COM-ASWSTRKFOR with all its implications of commonality with the U.S. Navy, a substantial upgrade was necessary and this proved to form the critical path of the refit. It was first necessary to clear areas near the operations room for the new flag facilities, which was done by: moving the air operations office at 5K starboard into No. 2 NBCD section base at 5K port, displacing it aft into a duty cabin which was not reprovided; moving the Admiral's duty cabin from 5K starboard to 5J Port taking up the space offered by the reduced naval stores office; moving the staff duty cabin from 5K starboard into a stationery store at 5K port (not reprovided); and by eliminating the ND section office at 5K starboard. These areas, together with part of the Junior Rates' Dining Hall, have been converted to provide properly equipped flag operations, flag communications and planning rooms. To provide all the extra communications and display facilities has required a major modification to the computer and display system DAF/JZS and a substantial rebuild of operations room, main communications office and computer room. In the operations room, the opportunity has been taken to move from totes to mini-totes, all with the much clearer raster scan, raising the number of labelled plan displays (LPD) by three. All Link equipment has been grouped together under a link supervisor, an LPD has been provided for the Command so that he does not have to share the tactical plots, and major re-arrangement has taken place in the missile/gun area to control Goalkeeper and to run multiple Sea Dart engagements. SNAPS tables replace the old ARL plots. In the communications area, UHF Fleet Satcom has now been permanently fitted, with trainable aerials at each end of the island, and re-arrangement of the main communications office was necessary to introduce the consoles for the second SCOT outfit. Both HF and UHF supervisors' control panels were expanded to cope with the large increase in communications user positions, and, in the course of all this rebuild, the opportunity was taken to remove as much Darvik bulkhead lining material from the main communications office and operations room as was economic, as it generates acrid smoke in a fire.

Electronic Warfare

Invincible's direction finder UAA1 has been substantially modified, thus upgrading it to UAA2. This was partly re-engineered for reasons of maintainability and reliability but at the same time the warner channels have been increased in number, the emitter library has been moved on to magnetic tape for much quicker access, and the capability for rejection of own ship's transmissions is improved. *Invincible* had no jammer fitted on build and this is now regarded as a vital layer in a task group's defences. Outfit 675(2) has been fitted in the mainmast with aerials on sponsons either side of it, working in association with UAA2. For both these outfits Fleet Weapon Acceptance will be conducted during *Invincible's* trials.

Radar

Another newcomer to the fleet is radar 996, one of the first weapon outfits to be procured by the cardinal point specification procedure. It replaces the ageing radar 992R for target indication and aircraft control, with improved ECCM and clutter performance and other features. It has a larger aerial than 992R which fits onto the new bearing head provided on the main mast for UAA2, and, again, Fleet Weapon Acceptance is taking place in *Invincible*. There has also been some upgrade of all the other radars in the ship.

Maintainability Changes

Three important outfits have been changed for reasons of obsolescence. These are: NCS1 compass in place of the Mk. 19; the landing sight DAPS exchanged for a militarized version; and the other landing sight HAPIS replaced by CLUBS.

Omissions

The line must be drawn somewhere on improvements, either through lack of money, design effort or equipment. Some of those which did not make it into *Invincible's* present package are:

- A point defence missile system.
- A single SATCOM system with no blind arcs to replace the two fitted at present.
- A new design of aircraft lift.
- A new design of liquid oxygen plant to replace the present one ex H.M.S. *Eagle*.
- More deep freeze capacity.
- Expanded and improved catering facilities.
- Aft movement of the aircraft crane at 1F to allow Sea King engine runs forward of the island, as in the other two ships of the class.
- Even more accommodation!

What Now?

H.M.S. *Invincible* now starts her sea trials period, which may sound long at five months, but which will actually be a scramble, considering that trials include five Fleet Weapon Acceptances, more Weapon/Radio trials than the average frigate after build, and a proving programme for a unique ADAWS software edition for which no shore development facility exists. If all goes well, by mid 1989 she will start working up and will then embark the squadrons from H.M.S. *Illustrious*, before rejoining the Fleet.

Acknowledgements

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