Research Notes on the

Lockheed CP140 Aurora

Compiled by John Griffin

Part 1/1

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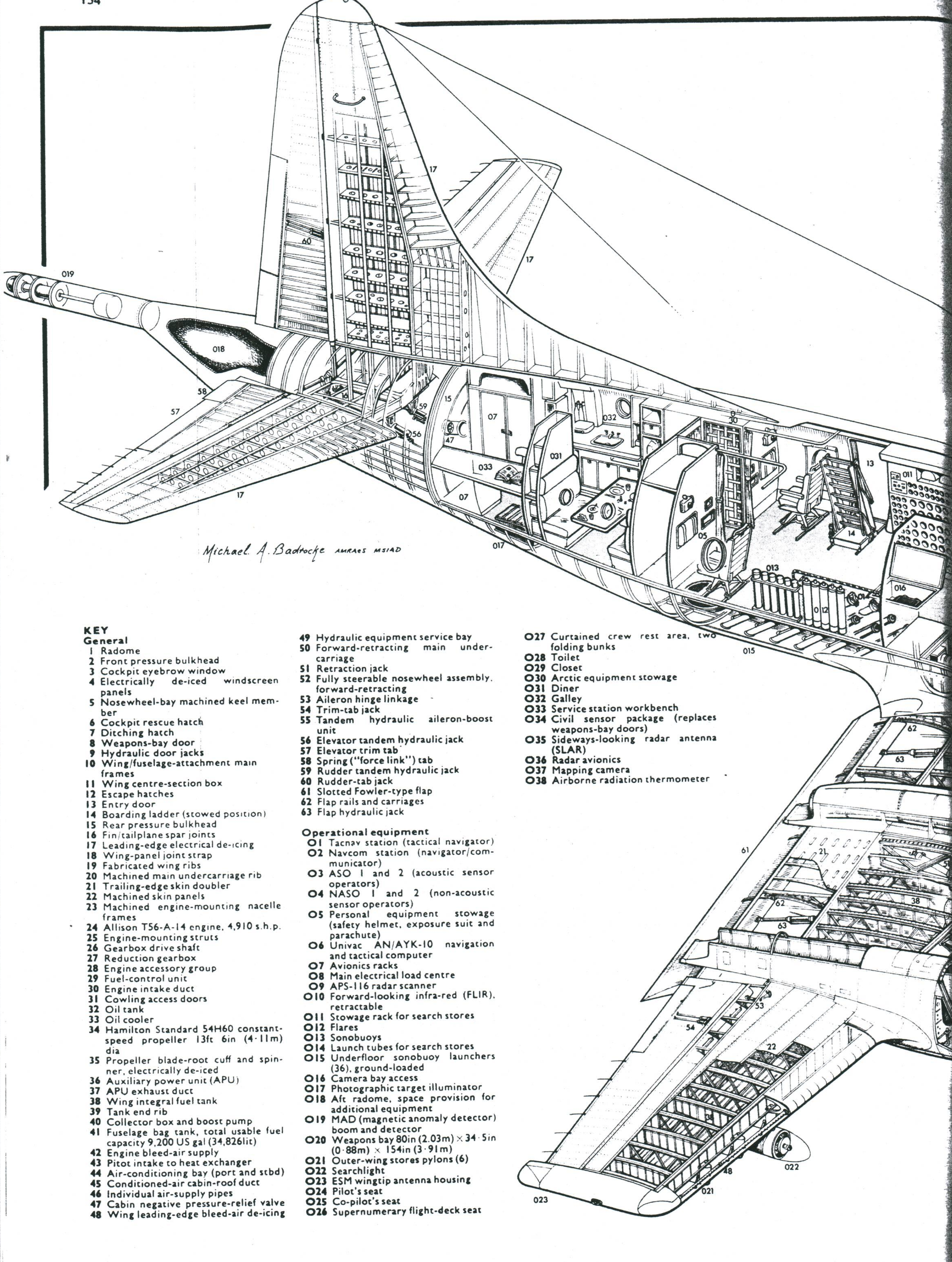
L'KHEED AURORA



KEY

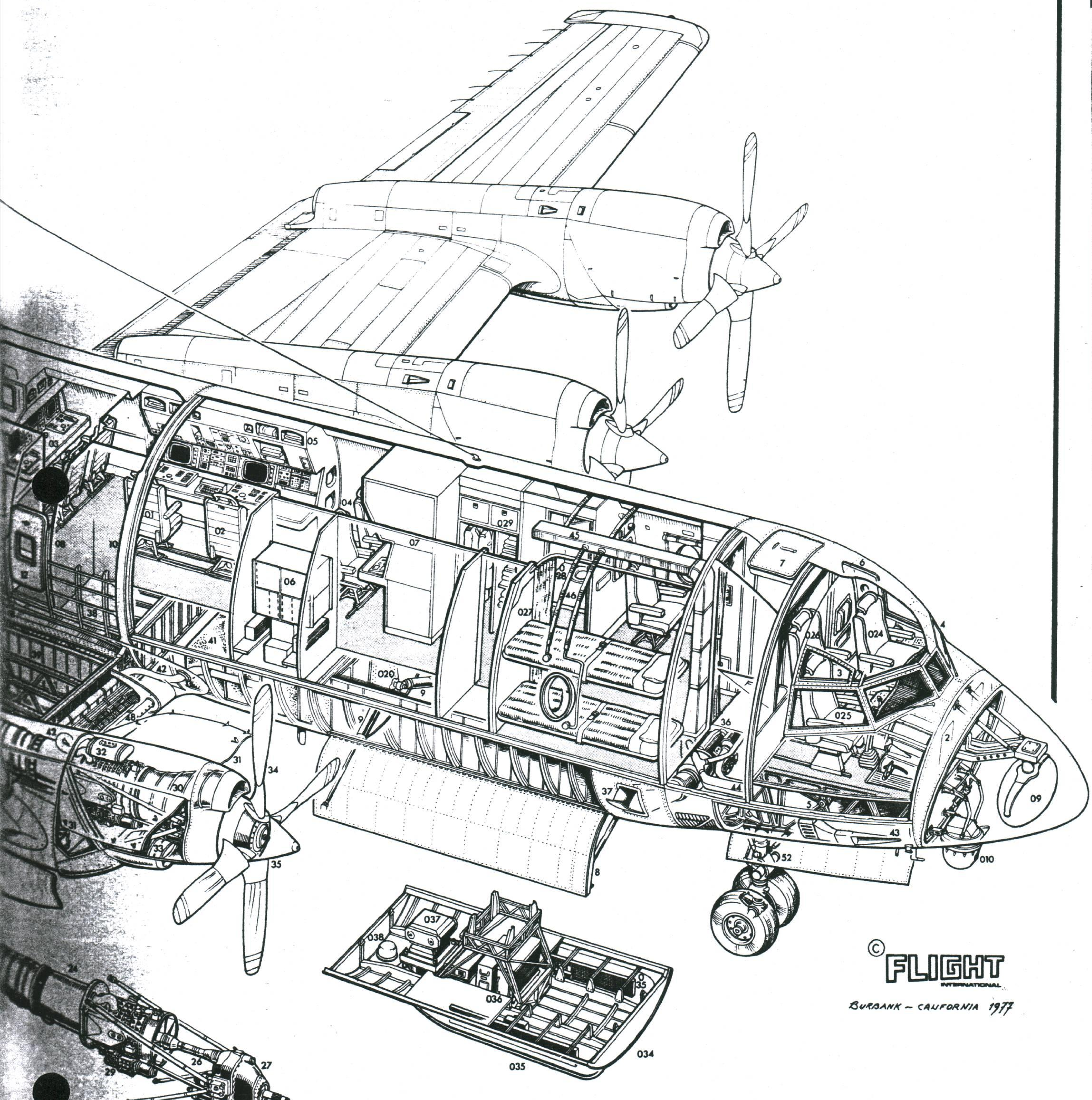
General

1 Radome
2 Front pressure bulkhead
3 Cockpit eyebrow window
4 Electrically de-iced windscreen panels
5 Nosewheel-bay machined keel member
6 Cockpit rescue hatch
7 Ditching hatch
8 Weapons-bay door
9 Hydraulic door jacks
10 Wing/fuselage-attachment main frames
11 Wing centre-section box
12 Escape hatches
13 Entry door
14 Boarding ladder (stowed position)
15 Rear pressure bulkhead
16 Fin/tailplane spar joints
17 Leading-edge electrical de-icing
18 Wing-panel joint strap
19 Fabricated wing ribs
20 Machined main undercarriage rib
21 Trailing-edge skin doubler
22 Machined skin panels
23 Machined engine-mounting nacelle frames
24 Allison T56-A-14 engine, 4,910 s.h.p.
25 Engine-mounting struts
26 Gearbox drive shaft
27 Reduction gearbox
28 Engine accessory group
29 Fuel-control unit
30 Engine intake duct
31 Cowling access doors
32 Oil tank
33 Oil cooler
34 Hamilton Standard 54H60 constant-speed propeller 13ft 6in (4·11m) dia
35 Propeller blade-root cuff and spinner, electrically de-iced
36 Auxiliary power unit (APU)
37 APU exhaust duct
38 Wing integral fuel tank
39 Tank end rib
40 Collector box and boost pump
41 Fuselage bag tank, total usable fuel capacity 9,200 US gal (34,826lit)
42 Engine bleed-air supply
43 Pitot intake to heat exchanger
44 Air-conditioning bay (port and stbd)
45 Conditioned-air cabin-roof duct
46 Individual air-supply pipes
47 Cabin negative pressure-relief valve
48 Wing leading-edge bleed-air de-icing
49 Hydraulic equipment service bay
50 Forward-retracting main undercarriage
51 Retraction jack
52 Fully steerable nosewheel assembly, forward-retracting
53 Aileron hinge linkage
54 Trim-tab jack
55 Tandem hydraulic aileron-boost unit
56 Elevator tandem hydraulic jack
57 Elevator trim tab
58 Spring ("force link") tab
59 Rudder tandem hydraulic jack
60 Rudder-tab jack
61 Slotted Fowler-type flap
62 Flap rails and carriages
63 Flap hydraulic jack

Operational equipment

O1 Tacnav station (tactical navigator)
O2 Navcom station (navigator/communicator)
O3 ASO 1 and 2 (acoustic sensor operators)
O4 NASO 1 and 2 (non-acoustic sensor operators)
O5 Personal equipment stowage (safety helmet, exposure suit and parachute)
O6 Univac AN/AYK-10 navigation and tactical computer
O7 Avionics racks
O8 Main electrical load centre
O9 APS-116 radar scanner
O10 Forward-looking infra-red (FLIR), retractable
O11 Stowage rack for search stores
O12 Flares
O13 Sonobuoys
O14 Launch tubes for search stores
O15 Underfloor sonobuoy launchers (36), ground-loaded
O16 Camera bay access
O17 Photographic target illuminator
O18 Aft radome, space provision for additional equipment
O19 MAD (magnetic anomaly detector) boom and detector
O20 Weapons bay 80in (2.03m) × 34·5in (0·88m) × 154in (3·91m)
O21 Outer-wing stores pylons (6)
O22 Searchlight
O23 ESM wingtip antenna housing
O24 Pilot's seat
O25 Co-pilot's seat
O26 Supernumerary flight-deck seat
O27 Curtained crew rest area, two folding bunks
O28 Toilet
O29 Closet
O30 Arctic equipment stowage
O31 Diner
O32 Galley
O33 Service station workbench
O34 Civil sensor package (replaces weapons-bay doors)
O35 Sideways-looking radar antenna (SLAR)
O36 Radar avionics
O37 Mapping camera
O38 Airborne radiation thermometer

CP-140 AURORA



Drawing by MICHAEL A. BADROCKE, AMRAeS, MSIAD

CANADA'S ARCTIC PATROLLER

◄ page 153

stage of the contest. The DC-10 would have met the $700 million Canadian cost target, but its sheer size would have meant a far greater investment in new hangars and runways. Super Atlantic was excluded in part simply because it had only two engines. The Royal Air Force and the British Government were keen to launch Improved Nimrod, with refanned Rolls-Royce Spey-67s and slipper tanks, as a UK/Canadian collaborative programme. But the risks of such a programme were high and even the improved aircraft did not quite meet the Canadian requirements.

Pickering feels that the competition was good news for the CAF. Renton was trying hard to make a comeback in the maritime business, and Boeing company money had flown an ASW demonstrator system in a 720. The Boeing threat, in the best tradition of competition, caused Lockheed to modify the CP-3C in the contract stage to include many of the systems originally developed for the carrier-based S-3A Viking, including the more powerful and more compact Univac AYK-14 processor and the APS-116 radar. Use of the Viking equipment, particularly the processor, saved space inside the CP-3C; the particular Canadian requirements made internal volume a major sales point for the 707.

In the final evaluation the Boeing proposal came out ahead of Lockheed on capability and cost. It arrived on station sooner than the P-3, and its bigger cabin gave it much greater flexibility in "detachment capability." It could have carried spares and groundcrew to support itself at Yellowknife or Frobisher for up to 20 days. Some CAF people felt that the turboprop might look archaic in the year 2000, but the continuing US Navy Update programmes did a lot to increase confidence in the basic P-3.

But the 707 needed longer runways and bigger hangars —"money on the ground, not in the air"—and it burned more fuel, an unpredictable cost factor. Eventually the CAF decided that the extra capability wasn't worth $500 million and the CP-3C was selected.

Then, in 1976, came the financial crisis which almost sent the LRPA programme back to square one. The contract set out by the Lockheed letter of intent demanded a higher spend in FY1979 than the Canadian DND had anticipated. After 12 days of very hard thinking Lockheed came up with a new contract, which was signed last July 21. Delivery dates for the aircraft, now designated CP-140, slipped by about a year to 1980-81; some of the Canadian modifications were eliminated, such as provision for Category 2 automatic landing, and the "civil missions" pack was left out of the original buy. It will now be designed in Canada to Lockheed specifications.

The contract to develop and fly the CP-140 was the first fixed-price military development commitment taken on by Lockheed since the S-3A, and the company had thought then that it would never have to sign another. "It's one of the tightest contracts we've been involved in," comments programme director Walt Schoch. "We don't normally negotiate fixed-price contracts in the USA covering development and production over five years. It's just not done any more."

Other new management problems have arisen because Lockheed is negotiating with civil and military officials and departments. "We have to work out who has the right to call which shots," comments one executive, and another observes that "it's a lot different from selling P-3Cs to the US Navy." The project is under the control of the Canadian senior management board, comprising the assistant deputy ministers in the three Canadian ministries involved: DSS (Department of Supplies and Services), ITC (Industry, Trade and Commerce) and of course the DND. "It's pretty amazing to us," is one comment, "because if we couldn't get resolution of a problem we might have to go to the Prime Minister."

The three-department control is a result of the strong emphasis on offset and the resulting involvement of ITC. "We have a total objective of close to $900 million in business for Canadian companies in 1976-93," sales manager Deryck Childs explains. Some of this is a firm contractual commitment, while some depends on all divisions of Lockheed—aircraft, missiles and shipbuilding—doing its best to put future work in Canada.

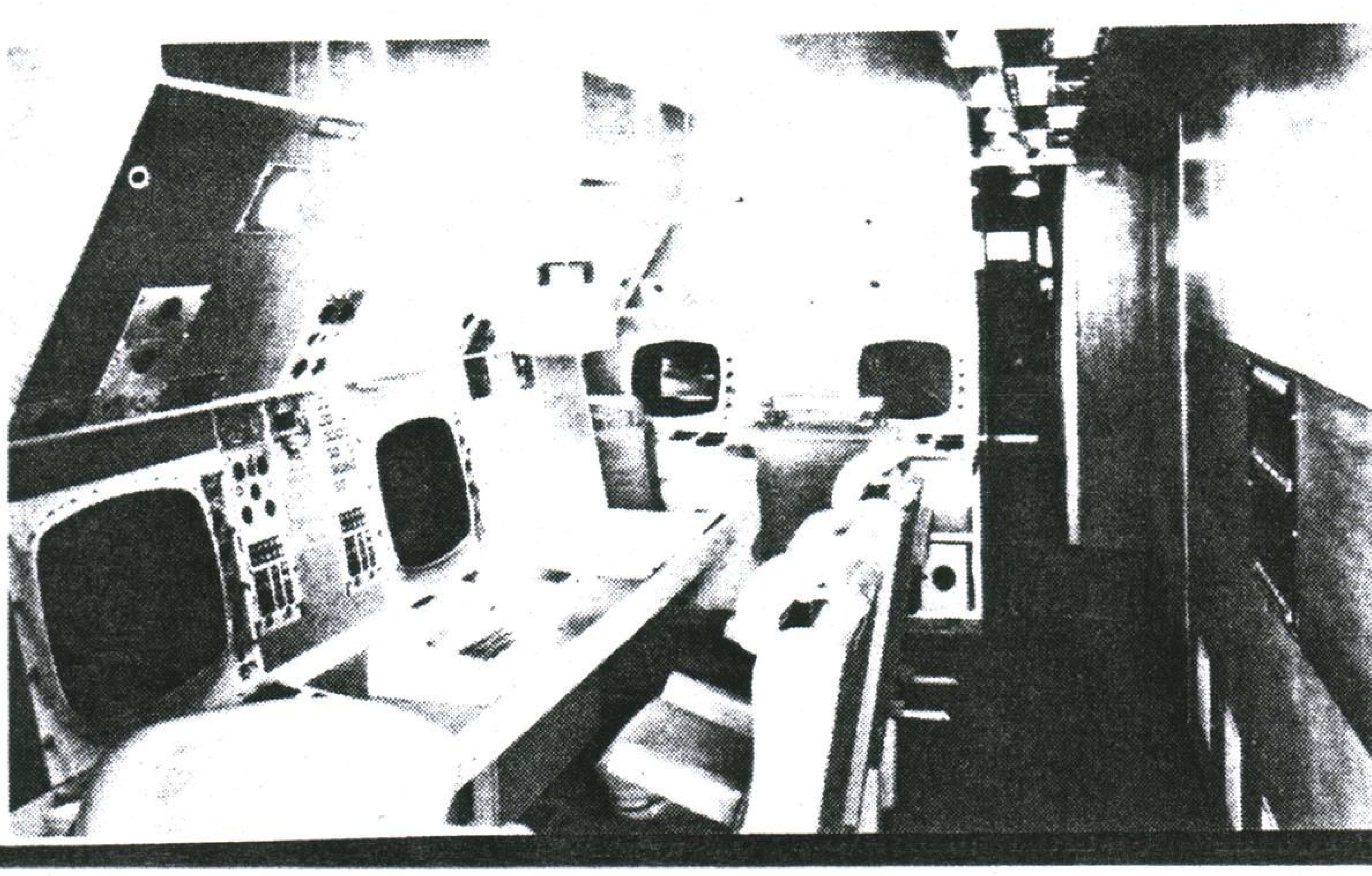
Under present arrangements, which Lockheed would like to see changed, work is defined as offset only when it exceeds the Canadian company's average of Lockheed work over the previous three years. The largest single commitment so far is the order for 150 ship-sets of outer wings, flight decks and tail and fuselage components for USN and export P-3s as well as for CP-140s.

Lockheed is committed to produce a certain amount of offset, quarter by quarter, and $414 million of the total $933 million commitment is subject to penalty. One of the main management jobs for DND and ITC is the definition of what does and does not constitute offset. So far the process has gone smoothly; Lockheed says that the total eventually agreed at the end of 1976 was twice its original claim.

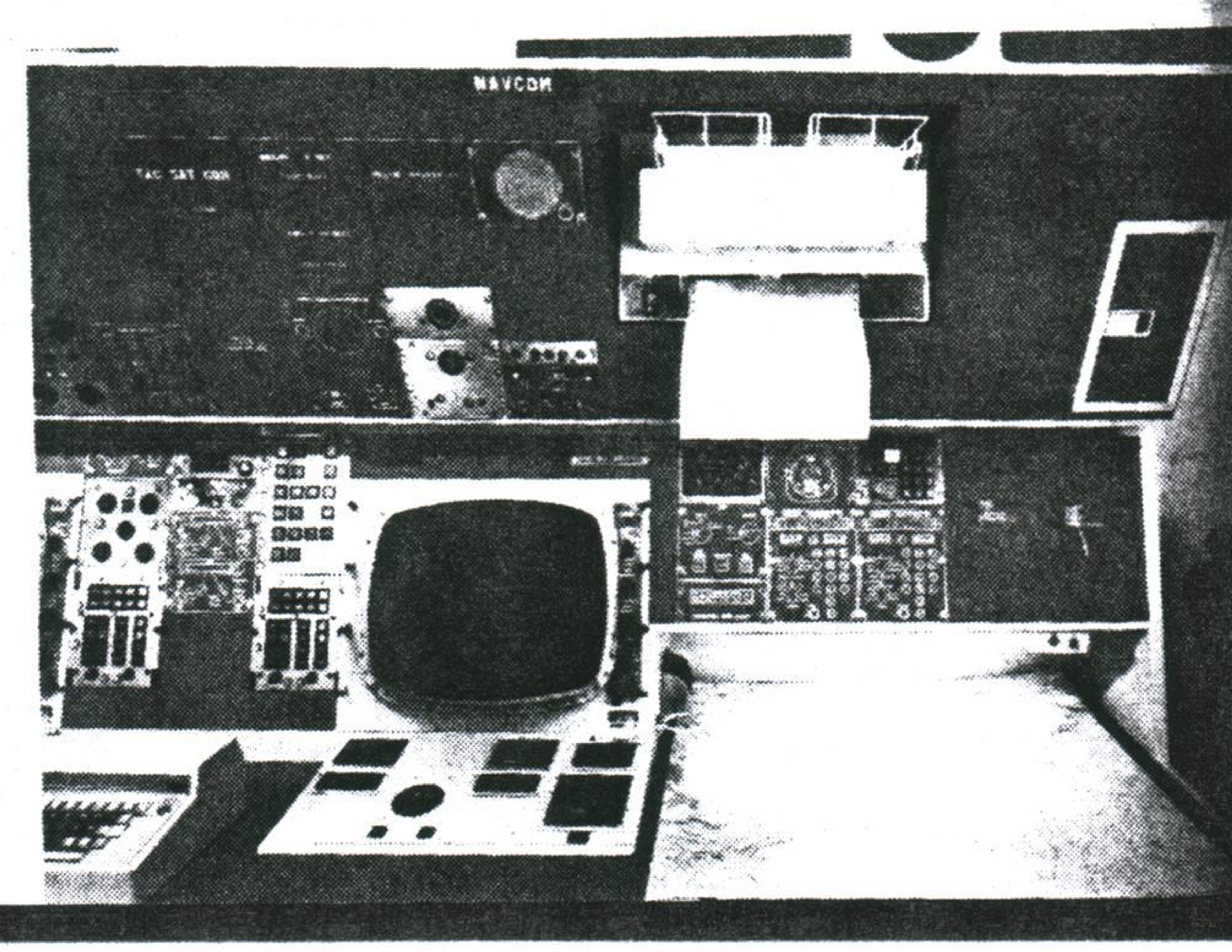
Schoch, heading day-to-day negotiations on offsets, has no complaints about the quality of the Canadian Government managers. The civil servants seem to stay on the project longer than the military; several of the DSS officials have now been on LRPA since the contract-definition stage and there are no complaints of amateurism.

Eighteen Auroras will begin to replace 26 CL-28s (six more of the older aircraft are in storage) in 1980 and 1981. Four aircraft will be attached to 407 Sqn, at Comox on Vancouver Island; the remainder will be allocated to 404, 405 and 415 at Greenwood. 449 will probably be allocated to Greenwood as a training unit, but that deployment has not received final approval.

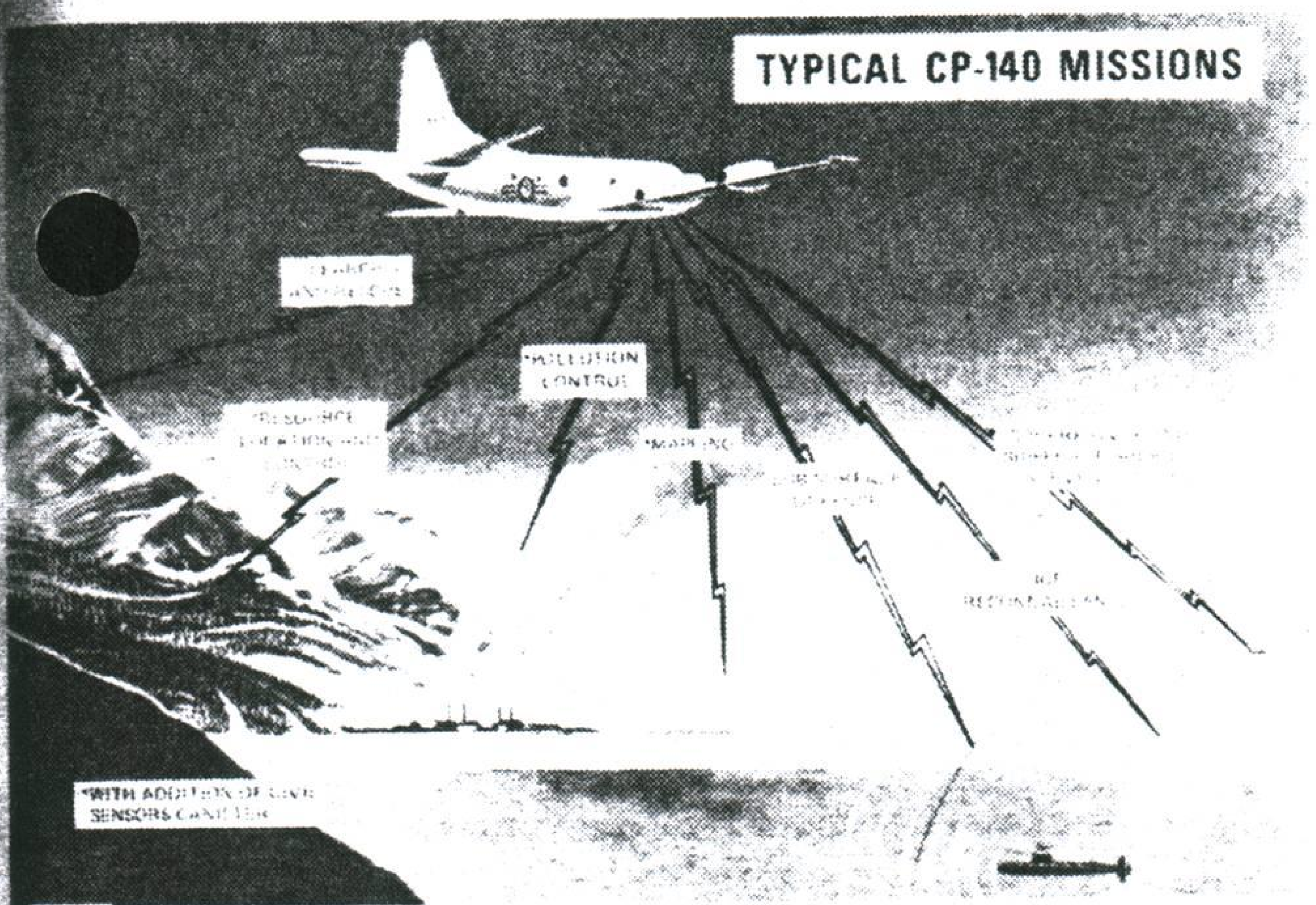
As well as the maritime reconnaissance role, the Auroras will take over the "civil missions" which the Argus has had to add to its repertoire since 1970. The primary mission is still anti-submarine warfare, but the Canadian



The Aurora cabin mock-up shows how the tactical crew is grouped in the centre of the cabin



The Nav/com station features a radar display and map table, plus panel space for satellite communications



Government has become increasingly aware of the importance of the far north of the country. The main civil missions will be sovereignty patrol and ice reconnaissance. The importance of the latter is increasing because bergs present a menace to offshore oil rigs and there is a large amount of research into berg tracks under way.

The civil missions have led to some of the changes between the P-3 and the Aurora, such as the installation of a cartographic camera, accessible in flight, in place of some pre-loaded sonobuoy chutes. The main item of civil equipment, however, is the sensor pack. This will be fitted inside the weapons bay and will contain an APD-10 side-looking airborne radar (SLAR). This would have been provided by Lockheed under the original contract, but was eliminated during the cash crunch last May. Lockheed will now supply drawings and make full provisions for the equipment aboard all the CP-140s. Six packs will be built in Canada when funding permits.

The CAF is telling the Canadian Government that the fleet is needed to replace the Argus in the ASW role alone, and that the civil missions have been added on without increasing the Aurora fleet. The Auroras will each fly about as many hours as the CL-28s, but will put in more time on station because of their higher transit speed. On the other hand, the fleet is smaller. CAF officers involved with the CP-140 programme would like money spent on two or three more Auroras rather than a new fleet of smaller sovereignty-patrollers.

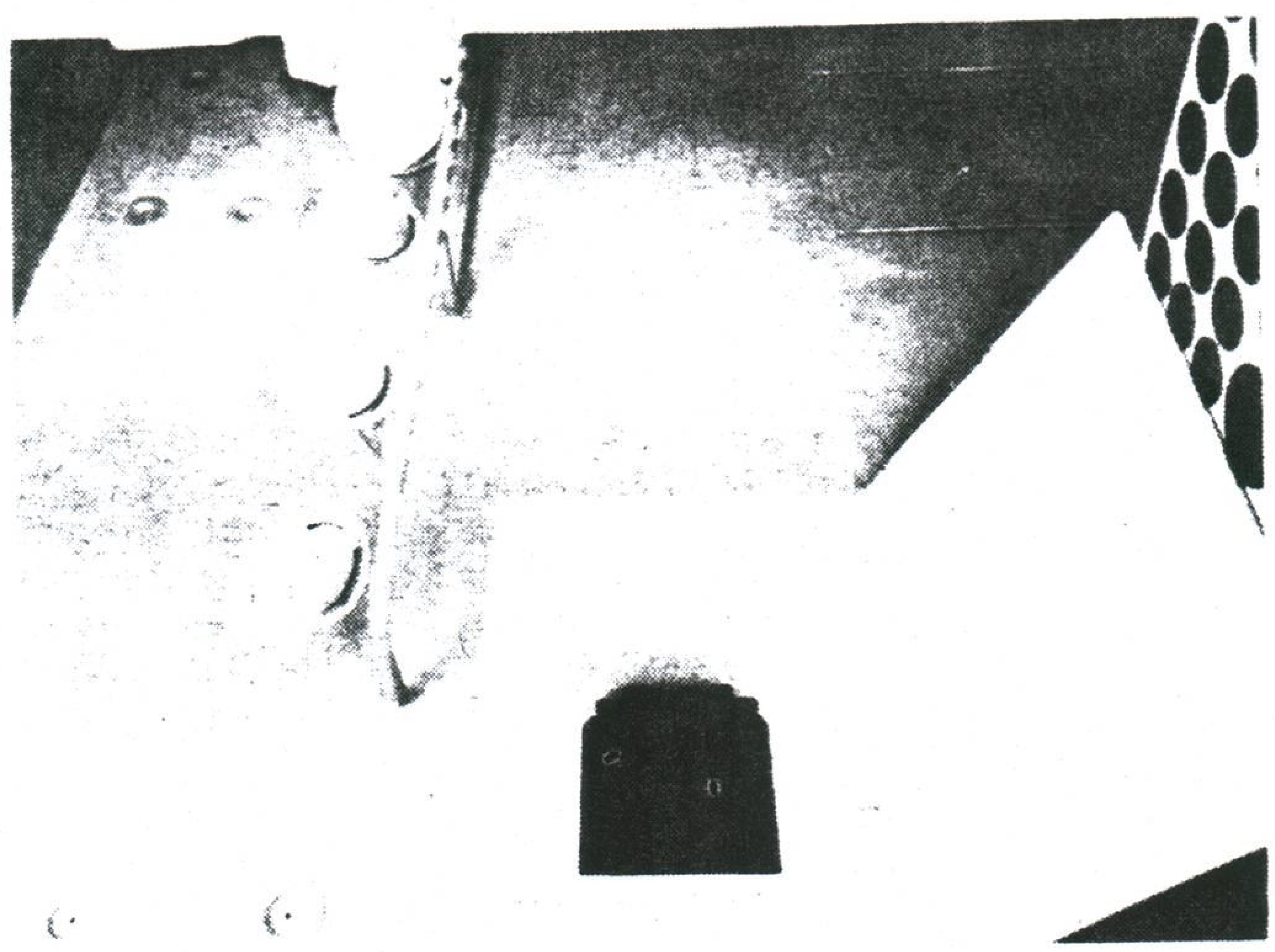
Expansion of the Aurora fleet and extension of the CP-140's capability are subject to the same budgetary limits that have dictated the course of the whole programme. Provision is made for carrying Harpoon missiles, for instance, but it is hard to say when the CAF will receive this weapon.

The most striking innovation in the Canadian aircraft, however, is the interior layout. In the Aurora the tactical co-ordinator, navigator and communications operator are centralised in a single compartment, rather than occupying separate cubicles as on the USN P-3. The interior is "less sterile" and less military than that of the P-3. "The CP-140 configuration is the envy of every VP squadron who've looked at it," observes Pickering. Lockheed acknowledges the assistance of the CAF and the Canadian Defence and Civil Institute of Environmental Medicine in designing the new interior. Lockheed also brought S-3 and P-3 experience to the programme, and some of Boeing's ideas also found their way into the CP-140. Canada's experience in human engineering was based on 18hr Argus missions, and the feeling is that the 12hr Aurora mission will itself dramatically increase crew effectiveness.

Some other items of equipment and avionics are Canadian or built by Canadian subsidiaries of US firms. CAE is building the MAD (magnetic anomaly detector) equipment, and Canadian Marconi the Doppler set. Zeiss of Canada is supplying the cartographic camera. Companies supplying equipment directly, such as Sperry Rand Univac with its AYK-10 computer and Litton with the twin LN-33 inertial platforms, will place other business in Canada.

Development of the CP-140 will cost about $122·6 million, and in addition the programme cost to Canada includes the $520 million expense of setting up the new fleet and its support facilities. Greenwood will be the main base, and the main data-interpretation and analysis centre (Diac) will be located there. When the development programme is completed Lockheed's electronic integration rig at Burbank will be transferred to Greenwood, where it will serve as a systems simulator. Eventually the mini-Diac at the detachment base at Comox should be built up into a full facility as at Greenwood. Single analysis centres for photographic and forward-looking infra-red (FLIR) data will be operated, one at Comox and one at Greenwood. The CAE flight simulator will be located at Greenwood.

Also located at Greenwood will be the Vast (versatile automatic shop test) equipment, derived from the USN system used to test the S-3A and F-14. It will be largely common with the USN system, but will differ to accommodate the P-3C equipment, such as the automatic flight-control system and secondary navigation equipment, which is fitted to the CP-140.



The Canadian Zeiss mapping camera is accessible in flight, a facility not available on the P-3C. Visible to the left of the camera are sonobuoy chutes

The CP-140 is not currently compatible with the USN's tactical support centres (TSC), which do the same job as Diac for the P-3 fleet. On the ASW mission the CP-140s will constantly be using US bases as part of Canada's normal contribution to Nato, and the CAF is working with the USN to make the TSCs compatible with the CP-140. Diac is simpler than TSC in that it only has to cope with the one type of aircraft; TSC also has to support the carrier-based Viking.

The prospects for the CP-140 are fairly bright. Lockheed accepts that the Canadian aircraft may be interesting to third-party customers, and Japan has shown some interest in the course of its search for an ASW aircraft. CP-140, Lockheed believes, offers something different from the standard P-3C.

Canada would receive $500,000 royalty on any CP-140s sold to a third country, in addition to the value of offset P-3 components and the Canadian equipment specific to the type. There is also a royalty payable on any features developed for the CP-140—such as the wingtip ALR-47 ESM system from the S-3A—which may be adopted for the USN Update 3 programme. Update 3, which may start emerging in hardware form in the early 1980s, is another indicator of the probable longevity of the P-3 in the age of the derivative. The USN study of the P-3's eventual successor, the VPX, seems to be settling down for a record run, and P-3X, based on the same airframe, could well replace it. Despite some early misgivings, the CP-140 is thus unlikely to look too archaic by the year 2000.

Aurora: Canada's shining light

MIKE GAINES reports from NOVA SCOTIA

IT was becoming obvious in 1967 that the Canadian Armed Forces (CAF) would soon have to think seriously about an Argus replacement.

The piston-engined, unpressurised Argus employed 1950s avionics and was slow, noisy and tiring. It usually took the crew a couple of days to recover from the customary 18hr patrols. The noise and vibration from the Wright Cyclone engines did nothing for either crew comfort or the vacuum tube electronics. Eighty per cent of the crew's time was spent processing the incoming tactical information; the other 20 per cent was applied to the solution—to detect, locate and kill a submarine. The 115/45 fuel for the piston engines was becoming harder to find and more expensive to buy. Eventually, CAF placed a contract to have the fuel specially refined for them—at market price plus a 10 per cent surcharge for doing it.

Canada's special long-range land and sea-patrol requirements and fairly limited budget led to the formulation of the Long-Range Patrol Aircraft (LRPA) requirement, as it was known before the selection of contractors. There were no off-the-shelf aircraft available to fit the requirement and an all-Canadian design to replace Canada's Argus was considered too ambitious.

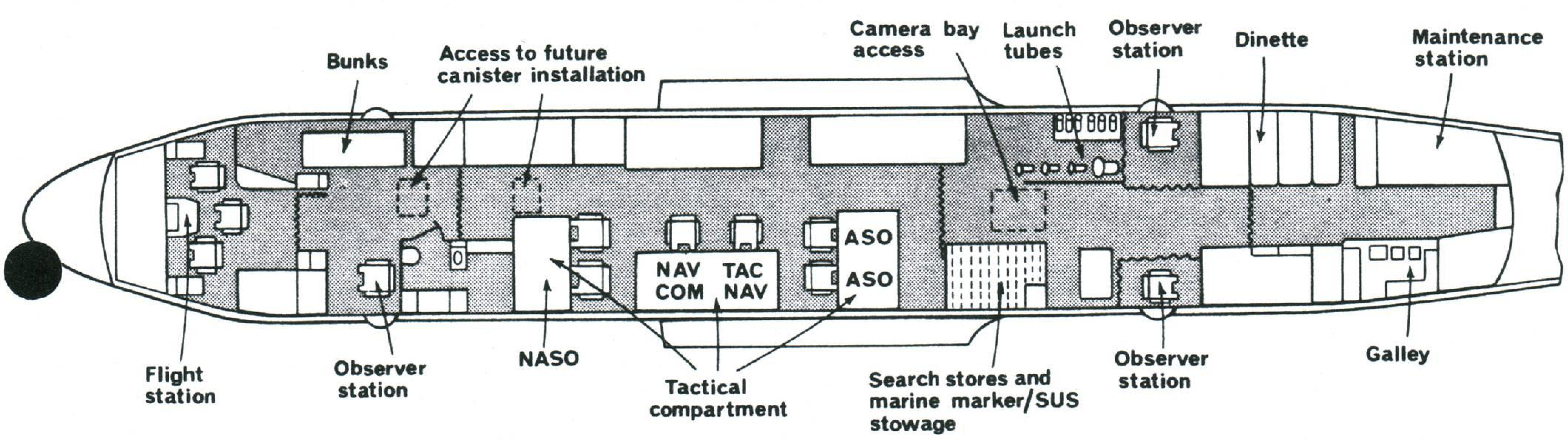
In 1968 the CAF came close to buying the P-3C, but the Canadian Government set up a committee to examine the requirements in greater detail before approving an outright purchase. The committee produced a requirement for an aircraft entering service in the 80s. The CAF thought this more realistic and the LRPA contest began, with requests for proposals scheduled for mid-1972.

Lockheed, a clear favourite from the start, was given a run for its money. The LRPA submissions were: the Lockheed CP-3C; the Nimrod MR.2 from Hawker Siddeley and a Spey 67-engined Improved Nimrod; Dassault-Breguet came up with the Super Atlantic M4; McDonnell Douglas with a version of the DC-10; and Boeing made a strong case for its 707-LRPA.

These were whittled down to the CP-3C and the Boeing proposal. The Super Atlantic was dropped for several reasons—not least because the Canadians were not keen on a two-engine configuration. The DC-10 met the then $700 million target cost but would, due to its size, need a big investment in new hangars and runways. The Improved Nimrod, which both the RAF and British Government were keen to launch as a joint UK/Canada programme was considered to be too high a risk and the aircraft would not quite meet the requirements of the CAF for the money available.

The threat from the Boeing 707-LRPA caused Lockheed to re-think its proposal. The inclusion of the S-3A Viking's Univac AYK-14 computer and APS-116 radar, both more powerful and compact than their P-3C counterparts, increased the internal volume of the CP-3C. This was a major sales point for the Boeing 707 which could carry more support groundcrew and spares for detachments to Yellowknife or Frobisher. Eventually, it was decided that the 707 would need bigger hangars and better runways and was

Below *CP-140 interior layout*

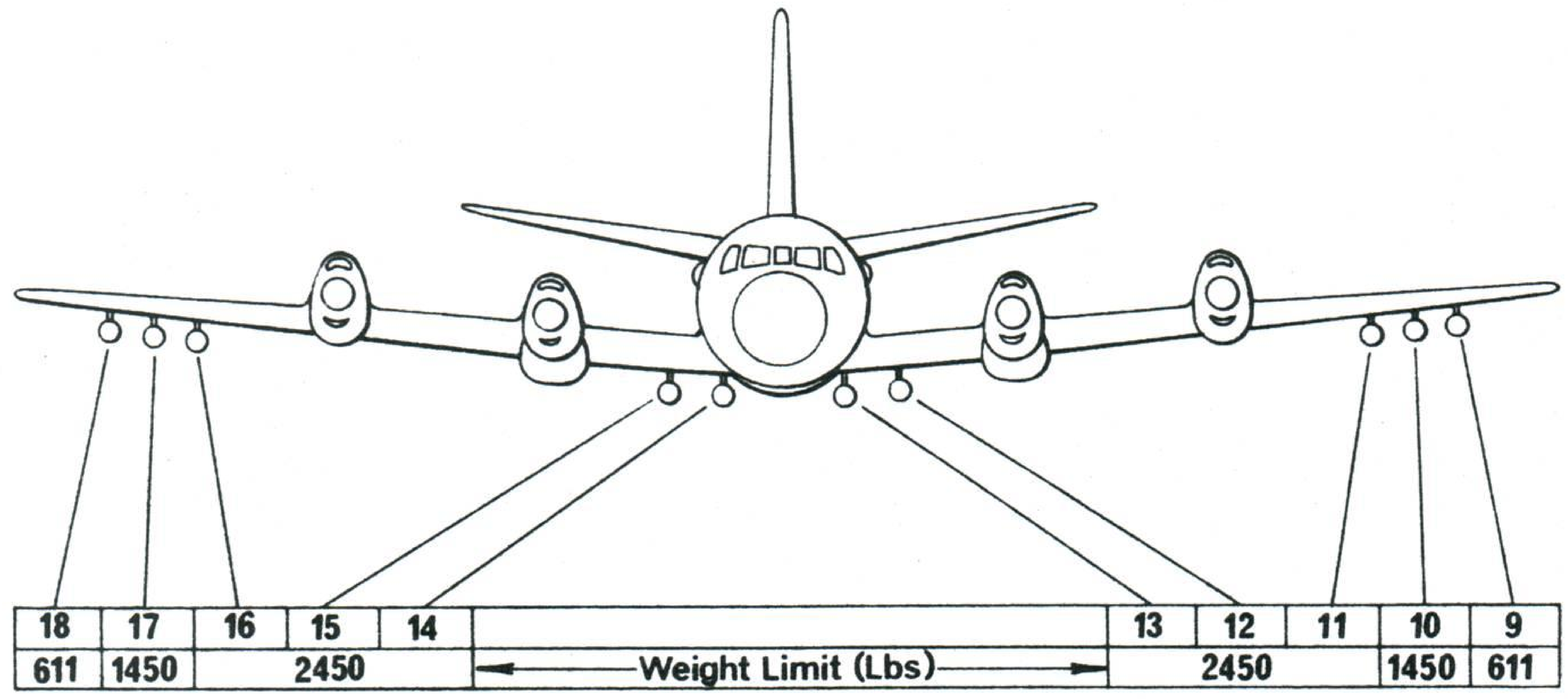


not as fuel efficient as the turboprop CP-3C. As future fuel costs were an unpredictable cost factor, except for the safe assumption that prices would increase, the 707 was dropped in favour of the CP-3C.

In 1976 the Canadian Department of National Defence (DND) came up against a cash-flow problem. Lockheed's contract demanded more money in FY1979 than DND had anticipated. But Lockheed then came up with a new contract which was signed on July 21, 1976. The CP-3C, now designated CP-140, suffered a one-year slippage of delivery date. At this stage the civil mission pack, a removable weapons bay sensor package containing side looking radar for geo-physical and IR linescan survey work, was deleted from the contract (although the wiring remains in the aircraft for a possible future revival).

From the outside there is little apparent difference between the CP-140 and the P-3C from which the airframe and mission concept was largely evolved. The inside of the CP-140 is vastly different from the P-3C. The S-3A Viking's electronic and data-processing systems and new technology mission equipment have been laid out with ergonomics very much in mind.

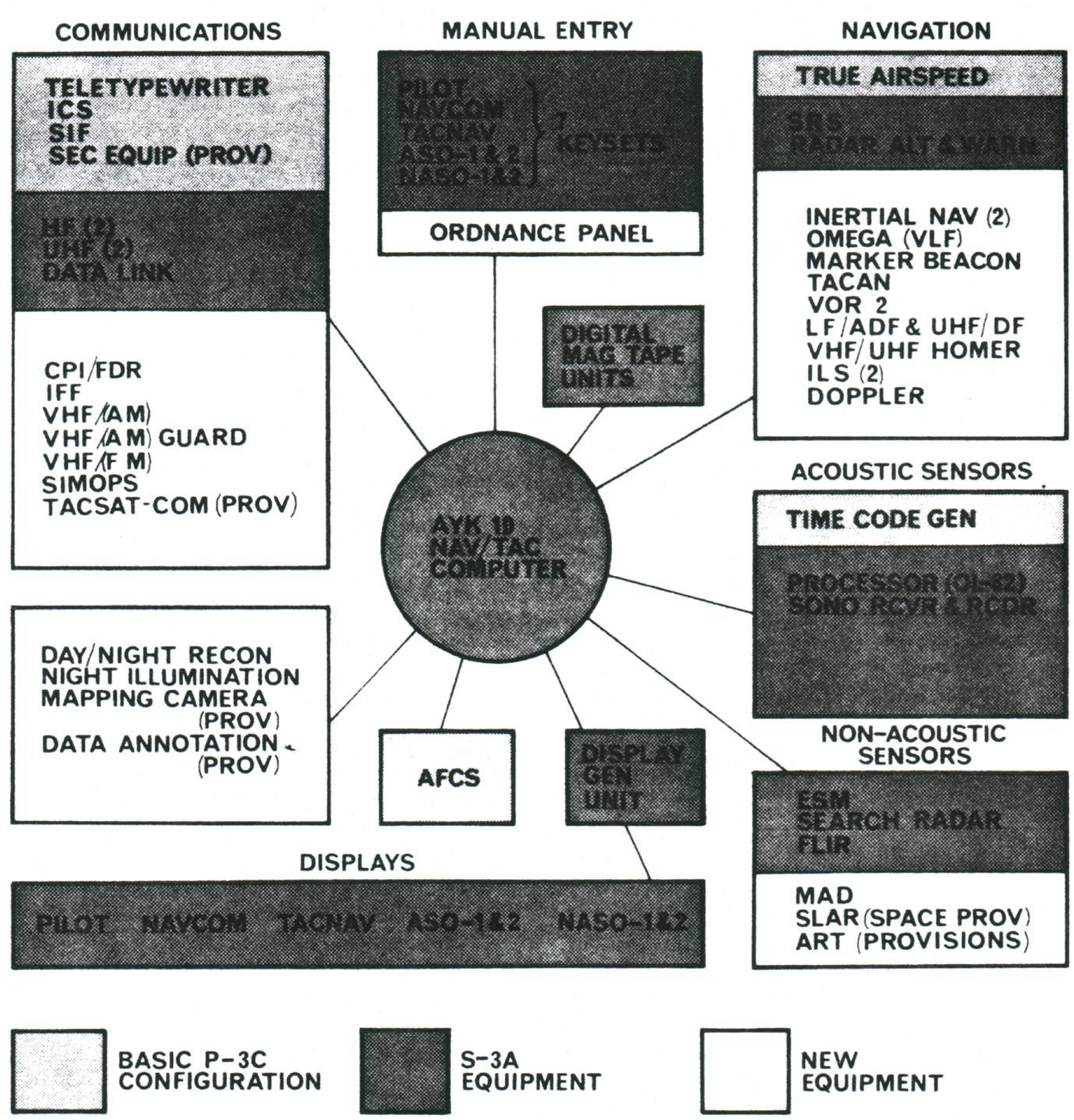
The Aurora's sensors are the usual ASW mix of radar, sonics, electronic surveillance measures (ESM), forward looking infra-red (Flir), magnetic anomaly detector (Mad) and cameras both fixed and hand-held. There are three visual search positions, with provision for a fourth if the lower of two crew rest bunks is removed.



On the flight deck, lit by a new blue filtered white lighting system, the pilots have an ASA-82 CRT display mounted on the centre panel. This screen gives a real-time presentation of the sensor information and tactical situation, including a Flir output. Cues and alerts are displayed on the periphery of the screen. A keyboard on the central pedestal provides direct communication with the computer and control of the displayed information.

Aircraft-system controls and indicators are mounted on the central pedestal and overhead panels. Armament, communications, airways navigation and photographic equipment controls are distributed between the two side consoles and the centre pedestal. Directions from the navigator/communicator (Navcom), who handles routine navigation, and the Tacnav are fed via the AYK-10 Nav/Tac computer to the pilot's AJN-15 flight director which provides attitude, heading and fly-to-point references for close-in tactical manœuvering. For long-range navigation, the Horizontal Situation Indicator is followed. The automatic flight-control system has full-time barostatic or radio-altimeter control and proportional control wheel steering.

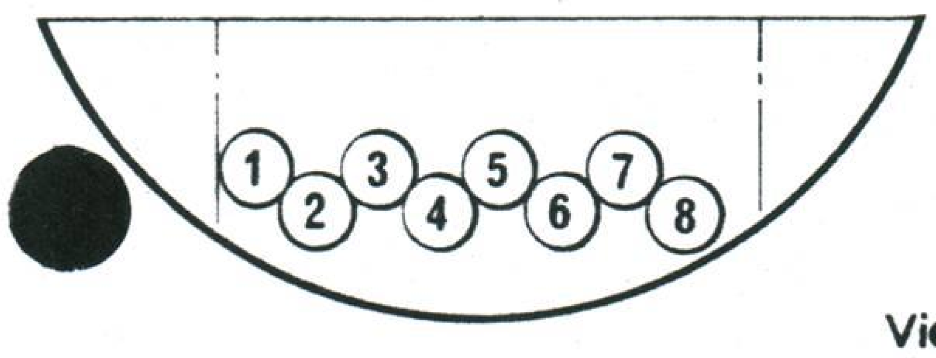
Block schematic of the CP-140 avionics showing the derivation of the systems



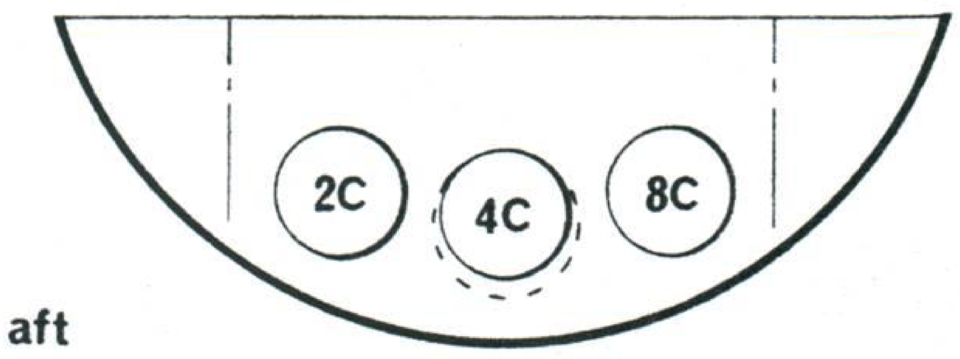
Another new feature of the Aurora is the layout of the tactical crew compartment. Centered on the tactical navigator (Tacnav), it gives him a view of all the displays and enhances his ability to direct and co-ordinate the other systems operators.

All six stations in the tactical compartment are equipped with similar multipurpose displays with a keyboard and rolling ball for control of the the computer and display. The Tacnav, as crew leader, keeps a tactical plot; data is sent to his display, via the computer, from the other operators. Routine tasks are handled by the computer leaving the Tacnav more time for planning and tactics. The Tacnav can call up both Flir and radar on his display and also controls the Sonobuoy Reference System (SRS). The SRS enables an update of a buoy field to be made without overflying individual buoys in turn. The Tacnav also has the main weapons-control panel.

The Navcom, handling the routine navigation and communications has two inertial systems as his main aids: Omega and Doppler. A large, well lit chart table is to the right of his display screen. The extensive communications fit consists of HF, VHF (FM), VHF (AM) and UHF, a digital data link, fed by teleprinter, with provision for secure communications; and tactical satellite communications systems. The Navcom also operates the belly-mounted reconnaissance camera. Navcom's keyboard set and display are available to the Tacnav should his equipment fail.



Views looking aft



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600								←Weight Limit (Lbs)→	1450	2450	1450

Left *Aurora's weapon stations and their weight limits. The wiring for Harpoon anti-shipping missiles is incorporated for possible future use*
Above *Two alternative layouts are shown for weapon bay loads. An air-droppable rescue package is another possibility*

The two sonics operators share a dual, aft-facing console. Each has his own main display screen on which is shown either the tactical plot or acoustic data; each display has its own keyboard and rolling ball. Common to the two stations is an auxiliary read-out unit with a centrally mounted CRT dedicated to acoustic display. The position also contains the aircraft time-code generator and a 28-track tape recorder.

The two Non-Acoustic Sensor Operators (Nasos) sit side by side at a dual forward-facing console: again each display has an individual keyboard and roller ball. The Nasos handle the radar, Flir and Mad, the IFF, SIF and the video tape recorder. The Mad is fitted with a Fully Automatic Compensation System (Facs) which adjusts to compensate for changes in the aircraft magnetic field, caused either by manœuvring or the dropping of stores. In the Argus, the Mad head was rail mounted and moved closer or further from the aircraft to compensate; the Facs can act faster, and being non-mechanical is more reliable.

Immediately aft of the galley/dinette areas is an in-flight maintenance area equipped with a workbench, microfiche reader and 28V DC and 115V, 400HZ AC power outputs. The illuminator for night photography is located under the floor in this area.

The Aurora ground-support package may be considered as two separate systems: the Data Interpretation and Analysis Centre (Diac) and the Ground Support Computer Complex (GSCC).

Diac provides operational support for the squadrons while GSCC gives technical support for operational software and maintains a record of the aircraft's actual software configuration. Between them, Diac and GSCC will provide the entire operational support needs for the Aurora force.

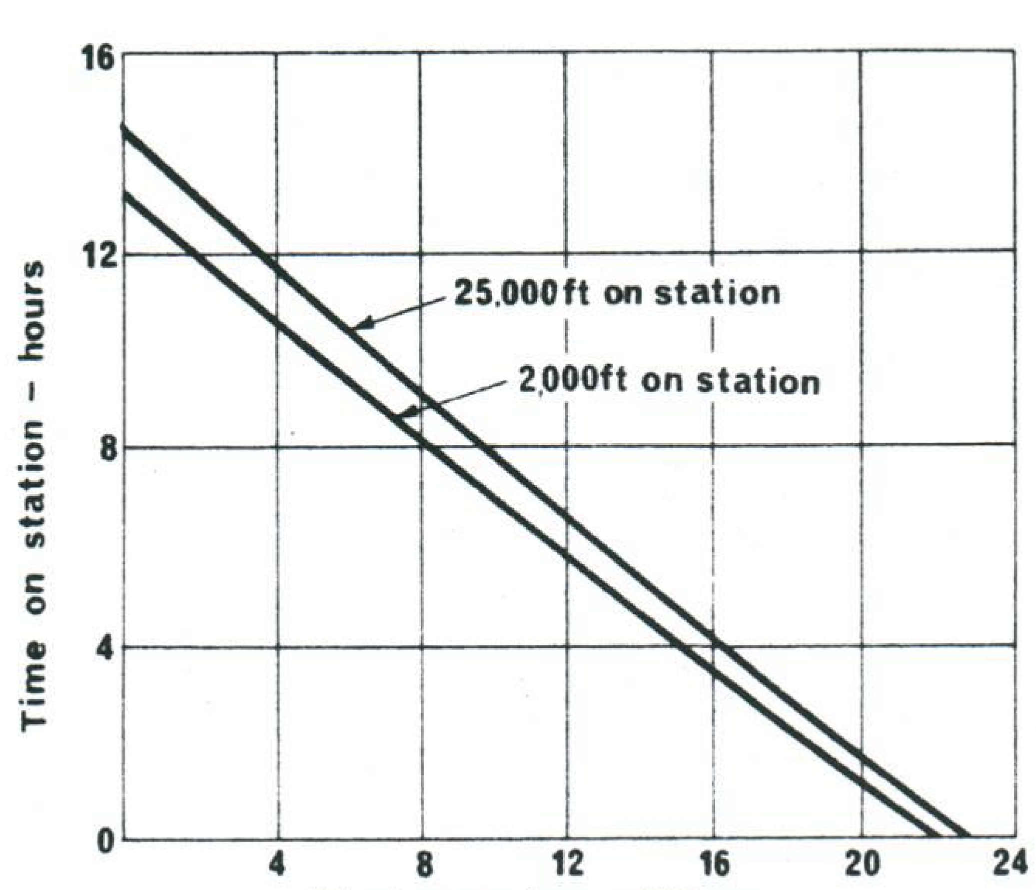
Diac provides on cassettes all the data needed for pre-mission and mission briefing, in-flight support, mission de-briefing and the reduction of mission, acquired data for intelligence purposes—Diac is essentially a computerised operations centre. Secondary functions will include the provision of statistics and summary reports such as submarine activity, infractions of the economic zone and off-shore fishing movements. In the other direction flows the operational plans and orders from the Maritime Air Group Commander to the squadrons.

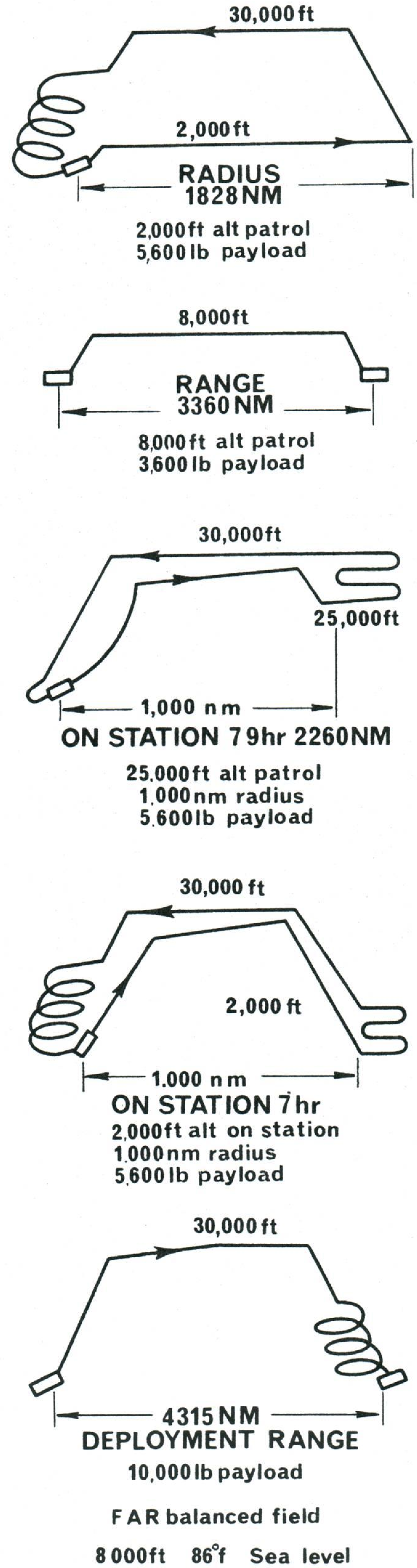
The GSCC has five major functions: the design, development, and integration of Diac software; the design and verification of CP-140 software; the duplication and generation of operational software for both Diac and the CP-140 fleet; compatibility checks between the software program and the CP-140 systems; and the verification of programs with the Aurora's avionics configuration. A secondary role of GSCC is to support the Diac and the avionics test facilities.

The Aurora simulator, based at Greenwood, consists of a six-degrees-of-freedom flight-deck section with a computer-generated visual system and a static mission simulator. Unlike the Nimrod simulator for instance, the two cannot be linked together. CAF looked at this possibility but decided that it was not a cost-effective proposition.

The 18 Auroras will fly 12hr patrols as compared with the 16hr of the 26 Arguses. However, more time will be spent in the patrol area than with the Argus, due to the higher transit speeds.

Canada has, as far as she can afford, equipped her anti-submarine forces with one of the most advanced aircraft in the world. But the question remains, however: are 18 aircraft enough? One official stated that 50 aircraft would be a more realistic figure to cover Canada's vast area of responsibility, but Canada must also find funds for the CF-18 programme, the Leopard tank—just coming into service—and the much needed frigate replacement programme. ◄





Above *CP-140 performance is illustrated, in terms of mission radius, range, and on-station endurance, for several typical sorties*

Left *The graph shows endurance on-station at four-engine cruise ceiling as a function of mission radius and on-station altitude*