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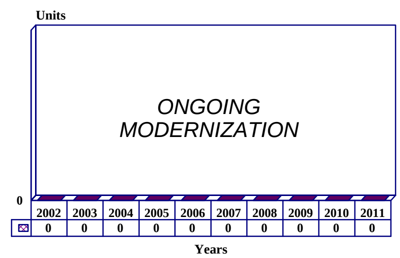
CG-47 Ticonderoga Class - Archived 3/2003

Outlook

- Construction ceased and will not resume
- Future expenditure concentrating on upgrade programs to maintain capability
- Unclear if five earliest ships will be upgraded
- Class Conversion Program will split CG-47 into two groups
- Much of upgrade work will be leveraged into future warship programs

10 Year Unit Production Forecast
2002 - 2011



Orientation

Description. Guided missile cruisers with a primary mission of providing anti-aircraft and anti-missile defense for aircraft carrier battle groups and amphibious forces.

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www.lmco.com/orss/ocean/ew
www.lmco.com/orss/ocean/commandcontrol
(ASW, EW equipment, systems)

Licensees. No production licenses have been granted.

Status. In service. Systems upgrade continues.

Total Produced. A total of 27 ships of this class have been built.

Pennant List

Number & Name	Builder	Launch	Commissioning	Fleet
CG-47 *Ticonderoga*	Ingalls Shipbuilding	4/1981	1/1983	Atlantic
CG-48 *Yorktown*	Ingalls Shipbuilding	1/1983	7/1984	Atlantic
CG-49 *Vincennes*	Ingalls Shipbuilding	1/1984	7/1985	Atlantic
CG-50 *Valley Forge*	Ingalls Shipbuilding	6/1984	1/1986	Atlantic
CG-51 *Thomas S. Gates*	Bath Iron Works	12/1985	8/1987	Pacific
CG-52 *Bunker Hill*	Ingalls Shipbuilding	11/1985	9/1986	Atlantic
CG-53 *Mobile Bay*	Ingalls Shipbuilding	8/1985	2/1987	Atlantic
CG-54 *Antietam*	Ingalls Shipbuilding	2/1986	6/1987	Atlantic
CG-55 *Leyte Gulf*	Ingalls Shipbuilding	6/1986	9/1987	Atlantic
CG-56 *San Jacinto*	Ingalls Shipbuilding	11/1986	1/1988	Atlantic
CG-57 *Lake Champlain*	Ingalls Shipbuilding	4/1987	8/1988	Atlantic
CG-58 *Philippine Sea*	Bath Iron Works	7/1987	2/1989	Pacific
CG-59 *Princeton*	Ingalls Shipbuilding	10/1987	2/1989	Atlantic
CG-60 *Normandy*	Bath Iron Works	3/1988	9/1989	Pacific
CG-61 *Monterey*	Bath Iron Works	10/1988	12/1989	Pacific
CG-62 *Chancellorsville*	Ingalls Shipbuilding	7/1988	9/1989	Atlantic
CG-63 *Cowpens*	Bath Iron Works	3/1989	3/1991	Pacific
CG-64 *Gettysburg*	Bath Iron Works	7/1989	6/1991	Pacific
CG-65 *Chosin*	Ingalls Shipbuilding	9/1989	1/1991	Atlantic
CG-66 *Hue City*	Ingalls Shipbuilding	6/1990	9/1991	Atlantic
CG-67 *Shiloh*	Bath Iron Works	9/1990	7/1992	Pacific
CG-68 *Anzio*	Ingalls Shipbuilding	11/1990	5/1992	Atlantic
CG-69 *Vicksburg*	Ingalls Shipbuilding	8/1991	11/1992	Atlantic
CG-70 *Lake Erie*	Bath Iron Works	7/1991	3/1993	Pacific
CG-71 *Cape Saint George*	Ingalls Shipbuilding	1/1992	4/1993	Atlantic
CG-72 *Vella Gulf*	Ingalls Shipbuilding	6/1992	9/1993	Atlantic

Number & Name	Builder	Launch	Commissioning	Fleet
CG-73 *Port Royal*	Ingalls Shipbuilding	1/1992	7/1994	Atlantic

Mission. To conduct prompt, sustained combat operations at sea in support of a carrier battle group or amphibious assault group; to detect, classify, and track several hundred potential targets simultaneously in the air, on the surface, and under the sea; and to destroy hostile targets using a variety of weapons, including surface-to-air missiles (SAMs) and surface-to-surface missiles as well as deck guns, torpedoes, rapid-fire close-in weapons, and electronic jammers and decoys.

Price Range. The CG-47 ships have a unit price of US$1.282 billion.

Technical Data

	Metric	US
Dimensions		
Length:	172.5 m	565 ft
Beam:	16.8 m	55 ft
Draft:	9.5 m	31 ft
Displacement		
Light:		7,019 tons
Fully Loaded:		9,589 tons
Performance		
Speed:	52 kmph	28 kt
Range:	11,100 km at 37 kmph	6,000 nm at 20 kt
Fuel Load:		2,000 tons
Crew:	33 officers, 327 enlisted	

	Type	Quantity
Armament		
Missile Launchers:	Mk 41 Mod 0 VLS	2x61
Missiles – AAW:	Standard SM-2 Block IV	86
ASuW:	Tomahawk	16
	Harpoon	2x4
Guns:	5 in L54 Mk 45	2
	Mk 15 Phalanx	2
	25 mm L87 Mk 38	2
Anti-Submarine Warfare:	VL-ASROC	20
Torpedo Tubes:	Mk 2 Mod 14	2x3
Torpedoes:	Mk 46 Mod 5, Mk 50	24
Helicopters:	SH-60 LAMPS III	2
Electronics - Radar		
Long-Range Air Search:	SPS-49	1
Target Indication:	SPY-1	1
Missile Fire Control:	SPG-62	4
Surface Search:	SPS-55	1
Gunnery Fire Control:	SPQ-9A	1
Navigation:	SPS-64	1
	LN 66	1
Electronics - Sonar		
Bow Array:	SQS-53A/B/C	1
Towed Array:	SQR-19	1
Electronic Warfare		
ESM:	SLQ-32(V)3	2
ECM:	SLQ-32(V)3	2

	Type	Quantity
COMINT:	SSQ-108(V)2 (some only)	1
Decoy Launchers:	Mk 36 SRBOC	4
Torpedo Decoy:	SLQ-25 Nixie	2
Electronics – Communications		
Datalinking:	Links ll, l4, 4A	
SATCOM:	OE-82	2
SATCOM receivers:	SSR-1	4
SATCOM transceivers:	WSC-3	2
TACAN:	URN-25	1
IFF:	UPX-29	1
Electronics - Combat Direction Systems		
AAW:	AEGIS	1
ASW:	SQQ-89	1
ASuW (Tomahawk):	SWG-3	1
ASuW (Harpoon):	SWG-1	1
Computers:	UYK-7, UYK-20, UYK-4	
Machinery		
Gas Turbines:	GE LM 2500	4x27,500 shp
Power Generation:	Allison 501-K34 gas turbines	3x2,500 kW
Propellers:	Controllable pitch, 5-bladed	2

Design Features. The CG-47 Ticonderoga class is a linear development of the AAW version of the DD-963 Spruance class. The DD-963 design was originally intended to be convertible between the AAW and ASW roles. It contained internal provision for missile magazines fore and aft in the spaces occupied by the ASROC launcher and NATO Sea Sparrow launchers featured in the ASW design. These magazines are used for the Mark 26 in the first flight of CG-47 cruisers and accommodate the Mark 41 VLS boxes in the remainder.

Below the main deck, the CG-47 is virtually identical to the DD-963. The hull lines remain unchanged, and the ship features identical flare and sheer to the earlier version. However, the greatly increased displacement of the CG-47 has caused the ship to sit lower in the water with corresponding increases in wetness forward. As a result, bow bulwarks and strakes have been fitted.

The main changes are in the superstructure. These ships, often also referred to as AEGIS cruisers, were the first US warships to be fitted with the AEGIS. AEGIS is the overall weapons system (Weapons System Mk 7) that uses a SPY-1 radar to control SM-2 anti-aircraft missiles. It is built around Command and Decision System Mk 1, AEGIS Display System Mk 1, and Weapons Control System Mk 1. All of these systems are built around UYK-7 computers.

In the Mod 3 version, AEGIS employs 16 UYK-7s, 11 UYK-20 minicomputers, and one UYK-19 computer. The display system has four very large (42 x 42 in) paired screens and is entirely new. In principle, one pair of screens is for the ship's captain and one for the embarked group commander. Each pair of large screens is supported by two command-display consoles, a data input console, and five automated status boards (ASTABs). In addition, two ASTABs are on the bridge.

The AEGIS system requires a very large Combat Information Center (CIC). Compared to the small volume and restricted dimensions of the Operations Rooms on British frigates, the CIC of the CG-47 is almost palatial in terms of space and comfort. As the NTDS system on the CG-47 is replaced by ACDS, the CIC is being renamed the CDC (Combat Direction Center). Directly underneath the CDC is a very large computer room.

These two compartments require a major increase in the superstructure volume of the ship. In contrast, British ships have their Ops Room deep in the hull, hence the restricted dimensions. This larger superstructure volume has combined with the requirement to mount the SPY-1 radar antennas on the bridge faces to produce a very distinctive "bloated" superstructure. Consequently, topweight has increased significantly.

The ship's powerplant consists of four LM2500 gas turbines arranged in two engine rooms, each room geared to a single shaft. The machinery is laid out on the unit principle, so the elimination of a single engine room does not totally immobilize the ship. The engine rooms are cross-geared so that one engine room can drive both shafts in an emergency. The gas turbines were originally rated at 20,000 shp, but this has been increased in stages to 21,500 shp per engine, perhaps even as high as 29,500 shp. Although gearing constraints prevent the full exploitation of this increase in available power, the higher rating does provide a greater reserve to offset any loss in power if a single turbine becomes dysfunctional. Top speed of this ship is in the range of 28-30 knots.

Operational Characteristics. Modern US Navy guided-missile cruisers perform primarily in a Battle Force role. These ships are multimission (AAW, ASW, ASuW) surface combatants capable of supporting carrier battle groups or amphibious forces. They are also capable of operating independently and as flagships of surface action groups. Due to their extensive combat capability, these ships have been designated as Battle Force Capable (BFC) units. The cruisers are equipped with Tomahawk ASM/LAM, giving them additional long range strike mission capability.

The operational characteristics of the CG-47 class specifically are dominated by the AEGIS AAW combat direction system. Technological advances in the Standard Missile coupled with the AEGIS combat system in Ticonderoga class cruisers and the upgrading of older cruisers have increased the AAW capability of surface combatants to pinpoint accuracy from wave-top to zenith. The addition of Tomahawk ASM/LAM in the CG-47, CGN-36, and CGN-38 classes has vastly complicated unit target planning for any potential enemy and returned an offensive strike role to the surface forces.

The large screens of the AEGIS system display processed rather than raw radar video as tracks, NTDS symbols, and AEGIS symbols in white on a blue background. Each screen can operate individually at its own range scale, and controls allow for irrelevant tracks to be suppressed, for tracks to be tagged (track numbers or alphanumeric labels of up to 24 characters in 3 lines), and for offsets from a display centered on the ship. Additional information is supplied on the associated command-display consoles and the ASTABs above the large screens. In principle, the commanding officer and tactical action officer (TAO) sit at the two command-display consoles, with a data input assistant at the adjacent input console.

Because the two displays of either group can show the same situation at radically different scales (calling up the same computer database), operators can position their ball tabs on either large-scale display (LSD), and operators working to different scales or in different warfare areas can share the same target data without changing screens or even manually pointing, unlike in standard NTDS systems. Important tracks and symbols can be highlighted without being tagged.

The display system can also store up to 40 patterns, such as formation diagrams, anchorages, and amphibious boat lanes. It can automatically initiate up to 16 simultaneous track histories until ordered to stop doing so. It can also provide digital maps of the area in which the ship is operating, refreshing its own position every 2.5 seconds. AEGIS as a whole is credited with the ability to handle 128 tracks. The SPY-1 radar can actually handle more; the extra capacity is used to avoid overflow. The most important limit to track capacity is the interface with the track file in the associated command/control system. The margin in the radar prevents overflow when numerous long-range tracks of little immediate interest are present.

The majority of CG-47 cruisers are armed with Mark 41 vertical launch systems fore and aft. These have a total of 64 cells each, three of which are occupied by a reload and strike-down crane. Thus the total magazine capacity is 122 rounds. These ships are to be refitted with the strike-down crane deleted, adding six missiles to the total load-out. These can consist of any desired mix of SM-2 Block IV anti-air missiles, Tomahawk long-range anti-ship and land attack missiles, and vertical-launch ASROC ASW rockets. The normal load-out is given in the data section under armament; however, during the Second Gulf War, the USS *San Jacinto* was designated as a "special weapons platform." Officially, this indicated that it was carrying an all-Tomahawk load-out, but the term "special weapons" normally has a much more sinister connotation.

ASW operations are controlled by the SQQ-89 ASW combat direction system. This is an integrated surface-ship sonar and fire control suite roughly similar to the submarines' BQQ and BSY series. From the USS *San Jacinto* (CG-56) on, newly completed AEGIS cruisers had SQQ-89 installed as initial equipment.

SQQ-89 was conceived to handle the much larger number of passive contacts provided by the modern SQS-53 sonar and the towed arrays. Nothing short of a computer could keep track of several passive targets, conducting several target motion analyses (TMAs) simultaneously, so existing manual ASW displays had to be replaced. SQQ-89 is the latest of several attempts to produce an ASW equivalent to the highly automated AAW-oriented CDSs; it might be considered an ASW equivalent to AEGIS. It requires about twice as many lines of source code as does the AEGIS system, mainly for multiple target TMA.

The SQQ-89 employs SQR-19 towed arrays and LAMPS III helicopters as passive sensors, operating in conjunction with the bow-mounted SQS-53B/C sonar. The display consoles are OJ-452/UYQ-21s. The combination acts as an underwater equivalent to NTDS. Operators at the displays detect the targets (decide when passive sensors are showing real targets) and enter them into system memory. The computers compile a full tactical picture and conduct the multiple simultaneous TMA. The system then inserts target data into the ship's NTDS system. The sonar supervisor has some of the role of the track supervisor in NTDS but generally does not have a dedicated console. The system also receives data (particularly ESM and radar data) from the ship's NTDS. These data can be used to eliminate non-submarine contacts and to identify potential surface targets which can be detected by their sound emissions, beyond the visual or radar horizon.

Side-by-side comparison was impossible in earlier systems, which relied on paper LOFARgrams and lacked any electronic memory. SQQ-89 achieves its high performance because several operators can see the same displays together; seven to nine people cooperatively work the ASW problem. Moreover, the system uses LAMPS III as a sensor, fully equivalent to the towed array and hull sensors because the data link has such a wide bandwidth and thus can transmit sonobuoy data fully.

In a typical version, three consoles are lined up together, separated from the fourth by an equipment rack containing a control indicator, a time code/control box, a data terminal set (UYQ-69), and a pair of audio amplifiers. The acoustic-display converters are at the ends of the row of display consoles. The three consoles working together might be divided into one for SQS-53 and one for SQR-19, with the fourth also used for SQR-19. Presumably, one of the SQS-19 consoles would be switched to SQQ-18 when a helicopter was launched to prosecute a contact.

SQQ-89 was originally a combination of multipurpose sensor displays weakly integrated with a track-keeping computer. Only in the later versions is the distinction between sensors and fire control eliminated (as in AEGIS). For all the electronic sophistication of the CG-47, their individual combat direction systems are not linked together or integrated by way of an overall command system. In this respect, their ability to handle a multidimensional threat is significantly inferior to that of a Royal Navy frigate, for example. This limitation is now being addressed by the US Navy with a series of remedial programs which link various subsystems within integrated tactical combat aids (for example, RAIDS). The problem will not, however, be fully solved until the USN adopts integrated distributed command systems equivalent to those in use elsewhere.

CG-56 USS *San Jacinto*

Source: Ingalls Shipbuilding

Variants/Upgrades

The CG-47 Ticonderoga class is divided into variants according to the AEGIS system baseline installed.

Baseline 0 is the original configuration as applied to the first pair of CG-47 class ships, the USS *Ticonderoga* and USS *Yorktown*. They have two Mark 26 twin-rail Standard SM-2MR missile launchers, Weapons Control System Mark 1, RIM-66C Standard SM-2 MR Block 1 missiles, the Mark 116 Mod 4 anti-submarine warfare fire control system, RUR-5A ASROC, and the SH-2F LAMPS I helicopter. Baseline 0 is now defunct, both ships having been brought up to Baseline 1 standards.

Baseline 1 was installed as built on CG-49 through CG-51. In this variant, the Recovery, Assist, Secure & Traverse (RAST) helicopter recovery system is added to the flight deck. The helicopter is the SH-60B LAMPS III, and the SQQ-28 LAMPS III data link is added to the system. The anti-aircraft missile system is the RIM-66C Standard SM-2 MR Block 2, and the SPS-64 navigation radar is added, as are an enhanced electronic warfare suite and improved data displays. The two masts are tripods, as opposed to the quadrupods of the first two ships.

In spring 1999, the Navy proposed upgrading these ships' weapons systems by making them capable for VLS, ERGM, LASM, Tomahawk, and Standard Missile 2.

Baseline 2 covers the CG-52 through CG-58 ships, incorporating all the improvements of the Baseline 1. In addition, it substitutes the Mark 41 Mod 0 Vertical Launch System for the Mark 26 twin-rail launchers. The CG-52 through CG-58 can carry BGM-109 Tomahawk missiles but not the RUR-5A ASROC. However, they do have the Link 11 Mod 5. The CG-54 and CG-55 have a stand-alone SQR-19 towed array sonar. CG-56 through CG-58 form a subgroup to Block 2, because they have the SQQ-89(V)3 Anti-Submarine Warfare Combat System (composed of the SQS-53B, SQR-19, and the Mark 116 Mod 6 Anti-Submarine Warfare fire control system), in addition to the other improvements listed above.

The Navy's spring 1999 proposal suggested upgrading these ships' Navy Theater-Wide missile system and Standard Missile 3 as well as the battle management system.

Baseline 3, composed of CG-59 through CG-64, includes all previous upgrades. This baseline introduces the SPY-1B radar, the UYQ-21 consoles, and UYK-43/44 computers. Some of the improved computer programs for the UYK-43/44 were not introduced until CG-65 and later ships. There is also an increased battle group control capability in the AEGIS Display System.

The 1999 Navy upgrade proposal for this particular batch included installation of Navy Theater Wide Missile defense systems on four ships and the Navy Area Wide on two ships. It also included making them capable for Standard Missile 3 and the Area Air Defense Commander battle management system.

Baseline 4 equips CG-65 through CG-73 and includes all previous upgrades. This baseline converts computer programs to the new UYK-43/44 computers and provides a further increased battle group control capability in the AEGIS Display System. AEGIS Baseline 4 also equips the first six DDG-51 class destroyers.

In the 1999 Navy proposal for capability upgrade, it was suggested that this particular batch of ships receive Area Theater Ballistic Missile Defense capability, along with application of ERGM, LASM, and Standard Missile 2.

Baseline 5 is a modification that introduced the SM-2 Block IV missile, JTIDS, a new combat direction finder and tactical graphics capability. Originally intended for the DDG-51 class, key features of Baseline 5 will be retrofitted to the CG-47 class.

Baseline 6 includes the upgraded SPY-1D radar, Evolved Sea Sparrow Missiles for point defense, defensive capabilities against tactical ballistic missiles, and the equipment needed for the Cooperative Engagement Capability. This will equip the first DDG-51 Flight IIA class destroyers, and key features will be backfitted to the CG-47 class.

Baseline 7 will include a cueing sensor, upgrades to the Tomahawk missile system, improved anti-ballistic missile capability, and installation of more advanced processing equipment. The UYK-43/44 computers will be replaced by commercial off-the-shelf equipment. The existing federated architecture of the system will be replaced by a fully distributed format.

Baseline 8 is still in a conceptual stage. Eventually it will make AEGIS part of a fully integrated warship command system. This may involve technology developed as part of the Canadian SHINPADS project.

CG-21. This is the notional designation of the new class of cruisers that is intended to replace first the older, unmodernized Ticonderogas, starting in about 2015. The program is of substantial significance in the USN's surface combatant strategy, since the Navy's ability to maintain a 300-ship fleet is being increasingly questioned.

Conversion of Standard SM-2 Missiles to LASM. Plans reportedly exist to convert more than 2,000 of the USN Standard SM-2 Block II and Block III SAMs to LASM standard. Presumably, this would be done in order to perform naval surface fire support (NSFS) missions on the AEGIS cruisers. The changes needed for the new role only concern the missiles' payload section, including the incorporation of a GPS/inertial navigation system guidance package.

Conversion to Mk 41 Vertical Launch Systems. This concept has been proposed repeatedly, and in June 1997 it appeared that funding might become available with support from the Pentagon. An engineering feasibility study is expected to be awarded to Ingalls Shipbuilding to lay out the plan for the mid-life upgrades and conversions. This proposal has, however, never become reality, although it continues to be promoted.

ESCE Upgrade. Litton was contracted, first in May 1998 and then again in February 1999, to provide Integrated Bridge Systems, Machinery/Damage Control, Internal Wireless Communications Systems, and Integrated Logistics Support for the cruisers. This upgrade ties in with the efforts to introduce different parts of the Smart Ship concept on the Ticonderogas, but the focus here is on engineering control systems. The aim eventually is to replace legacy systems, also previously supplied by Litton, with modern digital control systems on all Ticonderoga class ships.

In its first stage, though, the contract called only for a firm requirement of four systems, with options for 22 additional systems. The work is expected to be completed by December 2003.

Smart Ship Concept Trials. The USS *Yorktown* is being used as a test bed for the surface navy's Smart Ship concept, which fundamentally entails introduction of more automated functions, thus reducing the need for manpower for routine operations. Besides savings in direct crew salaries, however, it is also expected to offer reductions in maintenance requirements, along with higher accuracy and speed in the processing and analysis of the data coming from the multitude of platform sensors. Speed in particular is a key issue in the future joint warfare scenarios, in which each member of the team is feeding and receiving large amounts of data in the interconnecting network linking operators at sea, on land, and in the air.

The means to achieve those goals include adding computer technology on board, ranging in applications from a cashless electronic payment system to a fiber-optic backbone for information system management. Part of the effort includes using commercial, off-the-shelf (COTS) componentry as much as possible in order to save costs but also to offer a higher degree of modularity, familiarity for the operators and maintenance personnel, and flexibility between different components.

If the processing speed and the accuracy of handling the data can be maintained at a high level, the ship's commander is better positioned to make intelligent battlefield decisions. By the same token, from the human aspect alone, reducing the manning even by about 10 percent, which is already seen as a realistic target, means that the liabilities for human operators and their risks are greatly reduced, assuming that the ship's functions and capabilities are at least the same if not greater.

Program Review

Background. In early 1972, the Chief of Naval Operations directed the design of a new ship, the DG class, specifically conceived to carry the new AEGIS AAW combat direction system. Subsequently, a range of nuclear-powered ship alternatives and retrofit options were considered. The high construction costs typical of nuclear-powered vessels caused the Secretary of Defense to initiate development of a gas-turbine-powered ship in June 1975. In order to keep the program costs down, this ship, designated DDG-47, used the hull design of the AAW variant of the DD-963 Spruance class.

The preliminary design of DDG-47 was completed in April 1976, and the contract design was completed in August 1977. Ingalls Shipyard, Pascagoula, Mississippi, Bath Iron Works Corporation, Bath, Maine, and General Dynamics Corporation, Quincy, Massachusetts, all took part in the design phase. Bath Iron Works dropped out of the competition, leaving General Dynamics and Ingalls to compete for the construction contract. In FY77, an AEGIS engineering development model successfully demonstrated its capabilities at the US Navy's Combat System Engineering Development Site in Moorestown, New Jersey and at sea aboard the trials ship USS *Norton Sound*. Concurrently, the Standard SM-l and SM-2 missiles were test fired from a horizontal launcher and a prototype vertical launcher.

In April 1978, the US Navy awarded RCA Corporation a US$226 million contract to produce the first AEGIS weapon system. This was followed by the award of a US$287.8 million cost-plus-award-fee contract to Ingalls in September 1978 to build the first DDG-47 class destroyer, the USS *Ticonderoga*. The US Navy's choice of the hull and engineering systems of the DD-963 Spruance class destroyer played a major role in this decision, since Ingalls was the only yard that built the DD-963.

In January 1980, the US Navy changed the classification of the new ships from a destroyer (DDG-47) to a cruiser (CG-47), reflecting the inclusion of group command (flagship) capabilities in the design. Litton received a US$76.2 million modification to a previous US Navy contract, bringing the total contract value to US$364.9 million, for long-lead time materials for the construction of the next (CG-48) cruiser. Three months later, the US Navy awarded Litton a US$298 million contract for the CG-48. In parallel January 1980 contracts, RCA received US$45.9 million for long-lead time materials for the AEGIS fire control system for the CG-48, and FMC Corporation received US$31 million for Mark 26 Mod l guided-missile launching systems for the CG-48.

The US Navy's FY80 and 198l research and development program emphasized the development and testing of a vertical launch system for the Standard missiles as well as modifications to the AEGIS system to incorporate Standard missile improvements. Technical evaluations of the vertical launch system began in FY80, followed by operational evaluations in FY81; approval for production was given in FY82. In FY84, the US Navy decided to integrate the BGM-109 Tomahawk cruise missile to the vertical launch program. All cruisers after CG-53 were to be equipped with the Mark 41 vertical launch system. In April 1980, the US Navy gave RCA Corporation a US$9 million contract for the design, development, and testing to integrate the Mark 41 vertical launch system with the AEGIS system.

The FY82 program included procurement funding for three cruisers (CG-51 through 53). The FY83 program also included procurement funding for three cruisers (CG-54 through 56). The Area Air Defense program saw continued support for the engineering development Model 1 system on the USS *Norton Sound*, the Battle-Group Anti-Aircraft Warfare Coordination effort, and the vertical launch system.

In the FY84 budget deliberations, Congress chopped US$150 million from the CG-47 class program, but funding was provided for all three requested ships. The CG-47 research and development effort concentrated on class upgrades for the newer ships. The Combat System Engineering Development Site program completed the UYK-21 display system testing, held LAMPS Mark III (SH-60) integration, and completed SM-2 Block II integration. The SPY-1 improvement program aimed at installing the engineering development Model 4 at the Combat System Engineering Development Site to start systems tests.

The Combat Systems Improvement program conducted additional BGM-109 Tomahawk development testing, started long-lead procurement of UYK-21 components, started Link 11 Mod 5 combat systems engineering, and modified software to support certification testing. The US Navy also outlined its "Big 7" alteration program, which affected the CG-49 and follow-on ships. The foremast and signal shelter were redesigned, the AEGIS cooler was relocated aft, a Ship's Signal Exploitation Space was installed, small arms allowance was increased, the main mast was redesigned, and the 04 Level deckhouse and the forward AEGIS coolers were both relocated.

In FY86, Bath Iron Works received a contract for two ships and Ingalls received the award for the third ship. The US Navy commissioned two CG-47 class ships: the USS *Valley Forge* (CG-50) on January 18 and the USS *Bunker Hill* (CG-52) on September 20. The *Bunker Hill* was the first ship equipped with the Mark 41 vertical launch system. The CG-47 class ships received their baptism under fire during the April 1986 raids on Libya. The USS *Ticonderoga* and the USS *Yorktown* both served with the naval battle groups and maintained a comprehensive air coverage over the battle group, reducing the need for constant combat air patrol by carrier-based fighter aircraft. The *Yorktown* launched an RGM-84 Harpoon missile that destroyed a Libyan patrol boat.

Problems developed with the USS *Thomas S. Gates* (CG-51), the first Bath-built cruiser. Reports circulated that the ship had been launched with its bow approximately six inches off the centerline and that there were other structural problems that may have resulted from, or may have been the cause of, the bow's being out of true. These problems caused a delay in the construction of USS *Philippine Sea* (CG-58), the next Bath-built ship. At the same time, while these reports were circulating, other reports suggested that Bath was facing US$90 million cost overruns on the six ships it was constructing.

The US Navy awarded two contracts on February 25, 1988. Ingalls received US$769.1 million for four cruisers, with work to be completed by January 1994. Bath's US$226.1 million contract called for one ship to be completed by June 1993. The first CG-47 to be equipped with the SQQ-89, the USS *San Jacinto* (CG-56), was commissioned in January 1988.

The cruiser USS *Vincennes* (CG-49) shot down an Iranian airliner on July 3, 1988, over the Persian Gulf. This action took place in a highly confused and very ambiguous environment, which effectively left the cruiser attempting to perform IFF by behavior patterns (an exceptionally difficult and imprecise art). It also appears that there was a conflict involving track number labels between different elements of the task group.

The US Navy inquiry that ensued placed most of the blame for the incident on the Iranian jet's failing to respond to warnings (it was reported in 2001 that the civil aircraft was using all four radio channels, including its emergency "guard" channel, to communicate with Iranian Air Traffic Control). It also noted that the cruiser's crew was under considerable stress. The only recommendation involving the AEGIS system was that the US Navy "reassess the design of the AEGIS large-screen display to allow the option of displaying altitude information directly on the large screen display." It also advised the US Navy to determine whether the sensitivity time control nets had been overloaded and to issue a class advisory if that were the case.

The first cruiser equipped with the SPY-1B radar, the USS *Princeton* (CG-59), was commissioned in February 1989. It spent part of the year testing all the Baseline 3 improvements. Research and development efforts under Program Element #0604303N included commencing the checkout of SPY-1 transmitter and signal processor improvements and the final UYK-44 and Mark 41 vertical launch system integration testing with the AEGIS system, BGM-109 Tomahawk, and the Mark 116 Anti-Submarine Warfare Control System for the initial computer program delivery. Baseline 4 Combat System integration and testing were completed, and an upgraded AEGIS Display System doctrine and advanced graphics were integrated and tested. In addition, a Baseline 4 major engineering test was held at the Combat System Engineering Development Site.

On February 18, 1991, during its deployment for the Second Gulf War, the USS *Princeton* detonated an Italian-made MRP acoustic mine on the seabed under the ship's fantail. The gas bubble from the explosion spread underneath the ship's keel, lifting the stern nearly out of the water. The shock wave traveled from stern to bow, whipping the ship along its longitudinal axis. The blast also detonated another mine 300 yards off the starboard beam. This added a horizontal component to the vertical shockwaves buffeting *Princeton*.

The damage was devastating. At frame 72, 40 feet from the stern, the shock had snapped steel I-beams, heaving the deck upward 20 degrees and nearly severing the fantail from the rest of the ship. At frame 260, a six-inch crack opened in the *Princeton*'s aluminum superstructure, running from the doorway to the AEGIS radar room on the main deck, up through the radio room, and down the other side of the ship. Steel teeth snapped from the elevation drive on the aft gun mount. Restraining bolts broke from several missile launchers on the fantail, and four Harpoons burst through their membrane coverings before sliding back into the launcher tubes. In the crypto vault, where the ship's classified documents were stored, the shock sheared away 22 bolts fastening the door frame to a bulkhead, tossing the frame and its thick steel door 20 feet down a corridor. The *Princeton* was left dead in the water with 80 percent of the structural strength of the ship destroyed. A US$1.2 billion cruiser had been knocked out of the war by two mines that together cost less than US$70,000. The cost of the repairs was US$19.03 million. The ship was returned to the fleet over a year later.

In 1992, three ships were commissioned. The CG-71 was commissioned in April 1993, and the last of the CG-47 ships, USS *Port Royal*, was commissioned July 9, 1994. In February 1998, the Navy submitted a report to the Congress, with plans to request funds for the modernization of 22 CG-47s, all but the first five units, at a cost of $90 million per ship. The goal is to "eventually modernize all Baseline 2, 3 and 4 cruisers," according to the report. The "upgrades include significant improvements to the command and control systems for theater air warfare capability, upgrades in computer equipment and programs, installation of extended range guided munition [ERGM] guns, and installation of modernized machinery control systems" along with other Smart Ship technology. The machinery control system portion of the project was begun in May, and Litton won a $138.6 million contract for 4-22 systems.

Implementation of the new engineering control system on the ships was begun in 1998, with the intention of bringing into the propulsion control the same degree of integrated networking technology that was already in service in the AEGIS combat system and was being introduced through the IT-21 information management systems. In the bigger picture, this was all part of the effort to introduce the Smart Ship concept in this ship class. The program was relatively ambitious but was meant to generate long-term savings in both manpower needed for the operation of ships and money. The program would also allow more effective decision-making across the board.

Soon after it was awarded, the program hit a snag. The General Accounting Office (GAO) forced a renewed competition because of procedures that could be interpreted as favorable to Lockheed Martin, which won the original bidding. A stop-work order was issued on the project in May 1998. This was lifted a year later, after GAO reconfirmed Lockheed Martin as the winner of the contract.

In September 1998, it was reported that the Navy was considering shifting long-term funding strategies in order to better finance the planned capability upgrades of the CG-47 class cruisers. Instead of allocating the funds under the conventional Shipbuilding and Conversion - Navy (SCN) budget line, plans existed to shift some of the necessary funding for these multiyear projects from procurement and operations and maintenance accounts instead. This would enable the Navy to spend less money in the early years of the program and stretch the payments out to FY07. Under such a scheme, the Navy would begin by spending US$116 million in FY02 and US$350 million in FY03, followed by US$475 million in FY04 and US$482 million in FY05. The actual conversion work at the shipyard is not expected to begin until 2004. On the other hand, it was estimated that spreading the funding out over a number of fiscal years would mean having to justify the spending several times over, thus making the availability of funding far less secure than if a contracted time frame were used.

In spring 1999, the Navy had plans to pilot a US$4.5 billion upgrade program, known as the Cruiser Conversion Program, in an effort to carry out upgrades of the existing cruisers to extend their effective operational age.

Subsequently, attention has become more focused on the potential use of these ships for ballistic missile defense. The capability of the SPY-1 radar was demonstrated during the Second Gulf War when CG-47 class ships repeatedly locked in on inbound Scud missiles, but the SM-2 missiles available lacked the performance to engage the targets. As a result, an advanced family of missiles has been developed which provide significant anti-ballistic missile capability. This program, known as Navy Theater Wide, promises to provide an early solution to some aspects of the ballistic missile defense problem.

In May 2001, the Cruiser Conversion Program was expanded to cover the five earliest CG-47 class ships, with a resulting increase in cost to US$5.5 billion. This program envisaged the class being split into two subgroups. The first would be the Strike Leader Group, which would combine ballistic missile defense capability and enhanced ability to strike at inland and shoreline targets. This package would consist of the CG-47 to CG-51 and CG-65 to CG-73. The second group, the Defense Commander Group, would feature cooperative engagement capability facilities for networked theater-wide air and ballistic missile defense. This group would consist of CG-52 to CG-64.

Funding

In FY78, Congress appropriated US$930 million to procure the first DDG-47 class destroyer. During FY86, PE#0604303N funded the continued development and engineering of the fire control system power supply voltage tolerance increase and completion of fire control system upgrade studies for the cross field amplifier tube and solid state modulator. In PE#0604303N, the US Navy continued design and engineering of the fire control system solenoid power supply and began the SPY-1 alternative designs for the transmitter and signal processor. The US Navy's Five Year Shipbuilding Plan in FY88 called for two ships per year in FY88 and FY89 and one ship in FY90. When Congress passed the FY88 budget, it appropriated funds for four cruisers, while authorizing five ships, if savings could be found in other programs. This resulted in the buy-out of the CG-47 program, two years ahead of schedule.

The procurement funding for new CG-47 class ships is complete now. The detailed funding for the various electronic system modernizations and upgrades, including the AEGIS system, is found in the *Land & Sea-Based Electronics Forecast* binder under respective systems and programs.

Recent Contracts

Contractor	Award ($ millions)	Date/Description

Contractor	Award ($ millions)	Date/Description
Tracor Applied Sciences	24.1	April 1997 – Engineering, technical, and logistics services contract in support of radio communications systems (RCS) and C^3I systems aboard the CG and DDG-51 class ships. Contract is expected to be valid for the lifetime of the products.
Lockheed Martin Government Electronic Systems (LMGES)	12.9	September 24, 1997 – AEGIS Lifetime Support Engineering Services, also covering DDG-51 class ship combat systems. Potential total value $73.9 million if options are exercised. Expected completion: Sep 1998.
Litton Industries Ingalls Shipbuilding Div.	(85.4)	September 26, 1997 – Option on an FY98 contract, for continued life cycle engineering and technical services in support of CG-47, DD-963, and DD-993 class destroyers.
Southwest Marine	35.0	Spring 1998 – Three-year maintenance contract on seven Ticonderogas.
Litton Industries Ingalls Shipbuilding Div.	138.6	May 22, 1998 – Design and manufacture of engineering control systems equipment (ECSE) and integrated bridge systems (IBS) for backfit, with a firm requirement for four systems and options for 22 more.
Litton Industries Ingalls Shipbuilding Div.	(86.7)	September 30, 1998 – Option for continued life-cycle engineering and technical services (covers also Spruance, Kidd class destroyers).
Southwest Marine	8.7	January 12, 1999 – Regular overhaul on CG-63 (USS *Cowpens*).
Lockheed Martin	180.7	January 13, 1999 – Three AEGIS systems, Mk 41 VLS, ESSM Quads.
Southwest Marine	11.5	February 15, 1999 – Regular overhaul on CG-59 (USS *Princeton*).
Interactive Television	(24.6)	July 1999 – Development of naval fire control systems (also DDG-51).
Norfolk Shipbuilding and Drydock	12.8	January 2000 – Extended drydocking selected restricted availability of CG-55, including structural, electrical, and mechanical repairs.

Timetable

Month	**Year**	**Major Development**
	1972	DX design work initiated
Apr	1976	Preliminary design of DDG-47 completed
Aug	1977	Contract design completed
	1977	AEGIS engineering model demonstrated
	1978	First ship ordered
Jan	1980	Designation changed from DDG to CG
Jan	1983	First ship commissioned
	1988	Last ship of class ordered
Jul	1994	Last ship (CG-73 *Port Royal*) commissioned; program shifted to maintenance/upgrade mode
May	1998	Litton wins major ECSE contract
Summer	1998	Protest lodged against Litton's contract; stop-work order issued, upheld by GAO
Feb	1999	Litton wins the ECSE contract upon renewed bidding
Jun	1999	GAO confirms validity of Litton contract; work restarted
Jan	2000	USN finalizes plan to replace class with 27 units of CG-21 starting in FY2014
Dec	2002	Finish date for updating of naval fire control software project
Dec	2004	Estimated completion date for Litton ECSE contract
	2006	Projected deadline for upgraded cruisers to meet new capability requirements
	2015	First ships of the class expected to begin decommissioning

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Forecast Rationale

The US Navy's construction plans for the CG-47 class have been filled, with the total number of hulls amounting to 27. The class has quickly become the baseline standard by which all other major surface combatants are judged. The CG-47s have grown into premier ASW and AAW ships with a formidable capability in surface combat and land attack using Tomahawk cruise missiles. Now, they appear poised to add ballistic missile defense to that portfolio, further increasing the value of these remarkable ships.

The first point of interest with these ships is the fate of the first five. These have twin-rail Mark 26 launchers instead of VLS boxes and a topweight problem. A drastic modification program to bring them up to the standard of the later ships has been proposed, but the costs involved are very high, especially since it could be argued that cutbacks in the carrier fleet have actually left a surplus of AEGIS ships of this type in the Navy. One fact supporting this argument is that in 1997, the USN was reportedly offering the five oldest Ticonderogas to Britain, in case the Royal Navy canceled the Project Horizon Common New Generation Frigate. The project was indeed canceled in spring 1999, to be replaced by the wholly British Type 45 Daring class destroyers. The offer of the five Ticonderogas appears to have lapsed and was probably never seriously considered, but it does suggest the willingness of the US Navy to part with the ships rather than go to the expense of rebuilding them.

If this assessment is correct, it implies that the proposed cruiser upgrade program will be applied only to the 22 VLS-equipped cruisers. The latest conversion plan appears to be based on the perception that the basic CG-47 design is too small to accommodate the weapons and systems required to carry out the full range of intended duties. Instead of filling the ballistic missile defense, land attack, and netcentric air defense roles, the class will be split into two groups, each of which will have two of the three capabilities. Since the ships will be externally identical (except for some minor differences in antennas), this should present future enemies with a nasty problem in threat assessment.

Another area that is becoming increasingly significant is the spread of automation and other crew-reduction technologies throughout the ships. Funded as part of the so-called Smart Ship programs that are developing the baseline technology for application to the next generation of US warships, these technologies offer substantial savings in both capital and running costs of warships. They will see their full application with the new DD(X) class destroyers (the replacement for the ill-fated DD-21 Zumwalt class destroyers), but backfitting some of these technologies into the CG-47s will overcome many of their short-term limitations.

In the longer term, the CG-47s will be replaced by the new (and still largely undefined) SC-21 class. At the moment current rumors suggest that these ships will be derivatives of the proposed DD(X) with a multirole capability (including anti-air and strategic ballistic missile defense capability) supplementing the DD(X) concentration on the land attack mission. The proposed new ships will have an all-new electronic outfit, including an active array descendant of the SPY-1 radar system presently in early development. However, given the current pace of technical development, any speculation as to the nature of the prospective SC-21 design must be considered exactly that: speculation subject to radical change.

Overall, the CG-47 class have now earned their place alongside the aircraft carriers at the center of the US Navy. They are likely to hold that position for many years to come. However, the class is now complete, no additional ships of this type will be built, and any further expenditure will be concentrated on upgrades and retrofits. This report will be archived next year.

Ten-Year Outlook

No new production is projected. Modernization and upgrade activity of the onboard systems will continue throughout the forecast period well into the 21st century. The forecast chart is therefore omitted.

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