(Scroll down to get to the article)

COMMAND
MODERN AIR / NAVAL OPERATIONS

The gang that created the Waypoint magazine and resurrected the computer version of the Harpoon naval & aerial warfare simulator in the early 2000s, strikes again!

Command: Modern Air Naval Operations is the high-fidelity warfare simulator from **WarfareSims.com**. Combining massive scale (the entire earth is your theater) and incredible depth and breadth (conflicts from 1946 to 2020+) with unprecedented detail, realism and accuracy, a powerful Windows interface and challenging AI, Command has set the new standard for air-naval war games.

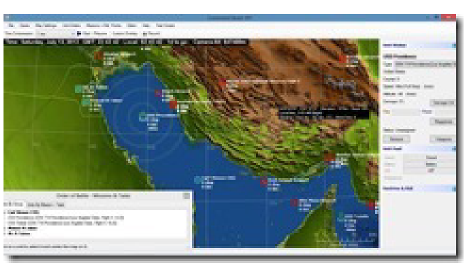
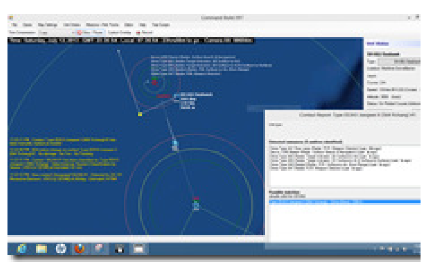
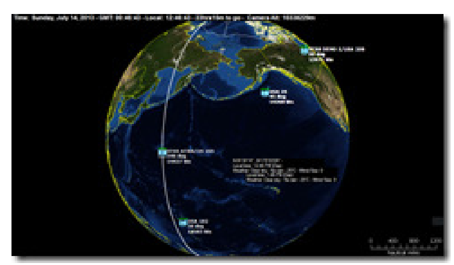
Praised by military professionals, hobbyists and the gaming press alike, Command swept the *Wargame Of The Year 2013* awards and shattered sales records in its category:

> **United States Naval Institute:** *"Command will find a following not only among civilian gamers but might have value among military, government, and policy circles as a simulator of modern warfare. […][This] is a game with broad appeal for everyone from casual gamers to government users looking to model unclassified, informal simulations. It likely will be the main choice for hard modern warfare simulators for years to come."*
>
> **Michael Peck, War Is Boring:** *"This isn't just a game. It's a simulation that's as close as many of us will ever get to real Pentagon simulation.* C:MANO*, as fans call it, is a real-time game that boasts an incredibly rich—and unclassified—database of the aircraft and ships of the Cold War and beyond. [...] I strongly suspect that this game won't prove any less accurate than the government's tippity-top-secret simulations."*

Multiple awards.
Over 150 scenarios (as of June 2014).
Thousands of fanatical players.
Tens of thousands of planes, ships, submarines, land units, satellites, weapons, sensors, and other systems.

Command: Modern Air Naval Operations is available only at Matrix Games.

For more information go to **WarfareSims.com**.

MANAGING THE CHAOS: THE POSTWAR EVOLUTION OF NAVAL C3 SYSTEMS

The three main schools of thought on the development of effective combat, command & control systems for naval forces

By **Dimitris V. Dranidis**

It is hard to comprehend the need for the presence of computerized, highly automated combat, command and control (C3) systems aboard naval vessels, before first understanding the very need for any such systems in the first place, and the factors that shaped their evolution and progression.

The traditional naval duties of warships have been two: Sea Control (essentially to permit the free usage of sea lanes by friendly naval assets, in both peacetime and wartime), Sea Denial (to disrupt the enemy's ability to conduct effective Sea Control operations during wartime). Some claim land-intervention to be an additional duty; while this in the past was executed mainly by Sea Control (ensuring that men and goods/supplies reached their destinations intact) and limited shore bombardment, the advent of shipborne long-range deep-strike weapons (such as cruise missiles) has enabled it to grow in a completely separate branch of its own.

All these key missions dictate that the ships must go in harm's way, probably engaging enemy units. In its environment, the warship faces multi-dimensional threats, with attacks coming from under the sea, from the surface and from the air. From the period between the world wars, the sheer volume of data generated by shipborne sensors started surpassing and overwhelming the abilities of the staff to handle the incoming threats. Without integrated C3 systems, the capability of naval commanders to assess, evaluate and exploit (or simply defend against) the tactical situation as it is presented to them is considerably compromised.

Why computers in the loop?

In the First World War, the naval commanders usually had a buffer time of several hours available to them, from initial enemy unit detection to engagement, to plan their moves and strategies. Orders and situation reports were exchanged between naval units without significant time pressure, often even in the midst of the battle. In the Second World War, with the aircraft emerging as the key weapon over land and sea, this available reaction time shrunk to several minutes. Even with that constraint, more often than not, important tactical and operational-level thinking had to be interrupted by the tedious and time consuming (but concurrently essential in order to provide a cleat tactical picture) manual processes of data fusion, deconfliction and integration. Even after an idea for action was dropped on the table, lots of complex calculations often had to follow to test its feasibility under real-world data (endurance of ships or aircraft, ranges of weapons, fire co-ordination etc.). With the then current technology, it was the best at hand.

In the projected Third World War scenarios, the reaction time to any advanced was estimated at being mere seconds. The situation has not altered until today. Be it an enemy surface group being revealed either directly or by third parties' sensors, a swarm of sea-skimming anti-ship missiles incoming fast, or a submarine appearing and disappearing on sonar scopes, the need to quickly identify the situation and control it, being one step ahead instead of behind it, is paramount. This is where the speed and automation offered by computing systems falls into place. The aim here is to analyze the different perceptions followed by the American, European and Russian naval forces in the Cold-War era (with appropriate examples of their philosophies) and examine the future of these trends in the realities and challenges of the coming decades.

It is worthwhile here to emphasize a point: The discrimination between combat systems and command & control systems is very thin and ambiguous in modern ship designs. This is a direct result of the need for integration of all previously independent activities taking part aboard a warship, from combat to maintenance to damage control to everyday activities. For this reason, these systems are hereby collectively referred to as C3.

The American Model

Shortly before the end of WW2, the US Navy was in the process of rapid re-organization in the closing phase of a long struggle in the Pacific, with the lessons of recent battles still fresh in mind. Of particular notice was the effectiveness with which massive Japanese air attacks were able to overwhelm the formidable air defenses of US carrier groups, Kamikaze squadrons being the deadliest of all. There was a clear need to improve the command capabilities of capital ships and any of their subordinate units, including aircraft.

It was in this context that the idea of a "battle-center" inside a ship was created, a central point of censor data fusion and weapon control (including air assets). This was aptly termed as the Combat Information Center (CIC). This is not to say that the concept was immediately formerly implemented: in ships under construction, the process of establishing a CIC usually fairly casual: a normal compartment would be reserved for it and then the original operators were given carte-blanche to manage the layout according to their varied personal preferences and prejudices. It goes without saying that this often created utter chaos between ships with totally different (and thus incompatible) CICs. Nevertheless, the concept was to prove its worth in subsequent battles towards the end of the war, especially in night fights when electronic sensor data was the dominant form of information available.

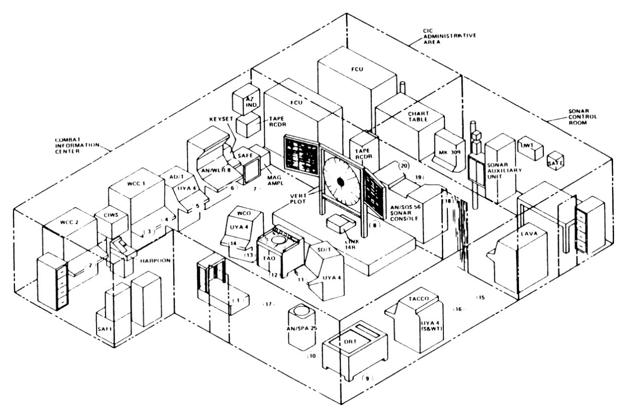
By the end of the war, the technological base had largely matured, and CICs had begun settling on standardized forms. A natural progression was steadily followed during the 50s, leading to an almost complete standardization of systems and procedures for these now accepted systems. However, by the late-50s, the hitherto manual procedures normally followed in CICs had been overtaken by the emergence of threats allowing even less reaction time, such as the massive re-arming of Soviet Naval Aviation bombers with long-range anti-ship missiles. The initial stopgap measure was to automate the CIC using the best computer technology available at that time. The now-standard NTDS (Navy Tactical Data System) had its birth at this era, while the Royal navy went on its own way with ADA (Action Data Automation). These systems were initially nothing more than computerized track-keepers, with raw sensor data being fed into a computer, which itself drove an analog display system. The computers themselves did not process the track data, and all tactical decisions were still at the hands of CIC officers. Subsequently, the tracks generated were treated as standard computer files, permitting the automated calculations needed to produce intercept vectors for missiles and aircraft.

The next step from these early computerized systems was the provision of the ability to transfer target data, and subsequently the whole tactical picture, between ships. This concept had its roots on the Kamikaze experience of the Pacific War, where the USN regularly deployed radar-picket ships well ahead of the protected assets with good results. The establishment of effective data links would allow the automation of the (hitherto manual) procedure of target track data exchange between ships, to allow for a vastly improved reaction time and better asset coordination. Thus the first data-link systems were introduced, Link-11 being the defacto standard for decades (and still in widespread use today). A descendant of it, Link14, was devised for use by ships without an integrated C3 system.

Naturally, somebody figured that the data-link compatibility factor would be less of a headache if there existed a level of commonality between the C3 systems of different NATO navies. This led to the wide distribution of the NTDS within NATO, forming the basis of most variants existent in European navies, such as the French SENIT, the Italian SADOC and the German AGIS, PALIS and SATIR systems (interestingly enough, the British had already separated themselves from this procedure by sticking to ADA, although it did natively support the Link-11). A fusion of the core elements of NTDS with ADA brought about the Dutch SEWACO family of C3 systems.

The big, BIG machine back there

A common denominator in all the aforementioned systems along their evolutionary path, was the fact that they were strictly centralized. A central computer mainframe handled all the data traffic and processing duties, and that was that. To a large extent, this reflected the legacy of mainframe development, ever since the Colossus and ENIAC went operational. Partially, this was purely a matter of technical and economic conservatism: The sheer size of the US fleet meant that any radical developments in command and control facilities would result in enormous expenses, because the changes in system architecture would have to be spread across the fleet if compatibility was to be ensured (the technological base was not yet mature enough to allow for a gradual phasing-in of the system). For the US requirements (and indeed, those of most Europeans until the late 70s), the centralized nature of NTDS worked, and worked well, thus reducing the incentive for radical innovations. Instead, the basic combat management philosophy of the NTDS's early incarnations was progressively refined with more powerful computing sets, and further enhanced with automatic data entry facilities. This evolutionary series culminated in some highly effective C3 systems, including the impressive Aegis system.



The basic layout of the CIC in the Perry-class frigate shows clearly the US tendency to concentrate all the major sub-systems of the C3 system in a limited area, often in a single room.

Aegis is a fully automated complex integrating the sensor, computer and weapon systems of its installed ship in order to coordinate not only the parent ship's functions, but of the entire task force that the ship is leading. The core of the system (Mk7 Mod3 Baseline 1 & 2 configuration) is comprised of 16 UYK-7 mainframes, 1 UYK-19 server and 11 UYK-20 minicomputers (all provided by Unisys). The computing modules are grouped together physically to form a unified main processing unit, interfacing through 4 Hughes AN/UYA-4 color displays and 4 additional PT-525 smaller displays with a capacity of displaying up to 128 target tracks (this is an artificial limit to avoid system saturation; it can be raised in combat). In automatic mode, the computers receive full control authority not only of the ship's own sensor (particularly the massive and highly-accurate SPY-1 phased-array radar) and weapon systems, but also of any other nearby ship whose systems have been subordinated to Aegis control (provided that the other ship hosts a suitable NTDS or compatible system). The system structure is fully compatible with previously existing NTDS protocols and can flawlessly exchange data with NTDS-equipped ships through Link-11 and Link-16 (JTIDS) datalink networks. In the evolved Baseline 3 & 4 configurations, more advanced UYK-43/44 mainframes are used, offering significantly greater processing output. The UYQ-21 display system is also being retrofitted for improved display volume and quality. Overall, the Aegis system offers the capability to effectively co-ordinate the defense of an entire task force against massive air and missile attacks while in fully-automatic operating mode, by integrating a clear picture. In semi-automatic or manual mode, it provides unprecedented tactical awareness to the group commander for decision support. This capability was amply demonstrated in Beirut in 1983 and the 2nd Gulf War in 1991, when the system provided a clarity and volume of tactical situation data never before achieved.

The European Viewpoint

For quite a while after the end of WWII, the US was the sole supplier of naval vessels to European navies who were struggling to restructure – as was almost anyone else in Europe at that time. Furthermore, the formation of the NATO alliance seemed to advance the idea of a truly unified system of strategies and the systems designed and procured to serve them (although, as mentioned, several decisions, as the British adoption of ADA, had already shaped a different perspective of priorities). The US, having the greatest contribution to NATO resources, was naturally spreading its own methodology of standardization in military hardware, and this inevitably included naval C3 systems. However, progressively over the decades, serious deviations in the European thinking began to emerge. One of the most fundamental differences was identified in the degree of system automation, a chasm that exists to a strong degree up to today, and a point that warrants some closer examination.

A European assessment (with which US analysts profoundly disagree) is that US radar & C3 designers attempt to automate all possible functions, on the basic assumption that human judgment cannot be trusted. European practice, on the other hand, has long been to retain a considerable proportion of human influence within the decision loop, on the grounds that machines lack the inherent flexibility and decision-making capability necessary for proper performance. This European assessment, while sound in principle, fails to recognize that the US problem lies not in whether judgment can be trusted, but in handling the massive number of potential targets. The US Navy, at least during the Cold War, was faced with controlling a multi-dimensional battle stretching out to over 200-300nm, probably incorporating friendly and neutral contacts. In contrast, the European battle horizon until recently rarely exceeded 50nm (limited by the range of onboard missiles) and encompasses a much smaller number of potential targets. (Friedman, 1993)

This debate was recently illustrated on some of the Royal Navy's criticisms of the Aegis system following operations during the 1991 Gulf War. British officers who have visited US Aegis-equipped ships believe that the system denies the radar operators access to raw (unprocessed) radar data and places far too much reliance on the processing capability of the system. Aegis provides operators with the facility to select the rules for handling data, including changing the scan program and blanking some targets to avoid system overload. One problem here is that there is a tendency to forget the rules adopted and to confuse synthetic video (which is much clearer and easier to understand) with raw reality. This point was driven home in the so-called 'Cessna incident', in which a light aircraft was detected by conventional 2-D radar but not by Aegis, because the existing velocity filter rules washed the contact out. Such levels of automation were for a long time unaffordable by European navies, and only the rapidly declining cost of computer power is bringing them into widespread availability.

This debate, however, among with a score of other lesser points of disagreement, has acted merely as a front for the far more fundamental disagreement regarding the C3 system's basic architecture. As already seen, the US has at least until very recently stood favorably for centralized systems. The European perspective, on the other hand, places an ever-increasing emphasis on de-centralized & distributed systems. Systems, in other words, that delegate the various functions of a modern C3 system into several terminals instead of concentrating them into a single unit.

Why distributed?

To someone familiar with the US practice of centralizing a ship's command systems into a single main unit, this would appear to be making perfect sense, under the light of necessary conservatism and evolutionary rather than revolutionary path already mentioned. However, the idea of "all the eggs in one basket" does include inherent weaknesses. N. Friedman (Navies in the Nuclear Age, 1993) comments on the shortcomings of this method:

"[...] even as the processing capacity requirement is resolved by natural technology evolution, there is a more fundamental problem with the concept. Even the best-designed, best-equipped and best-crewed ships get hit. Off the coast of Vietnam the USS Worden, a guided-missile cruiser, was mistaken by an F-4 fighter for an enemy [surface-to-air missile] site. A single [anti-radar missile] was fired by the F-4. The missile worked perfectly while the cruiser,

detecting the missile but assuming it was aimed at a hostile target, took no defensive measures. The resulting explosion shattered the ship's electronic installations and wrecked the CIC, leaving the cruiser dead in the water and defenseless. Fifteen years later, HMS Broadsword, engaged in operations off the Falkland Islands, was strafed by an Argentine [fighter]. A single 30mm shell struck the bridge. With unerring precision, it severed the ship's main databus, again effectively knocking out every single electronic system on the ship. […]"

These examples depict all too clearly that the centralized structure, while technically simpler and more attractive from a system engineer's point of view, was nevertheless a gamble in a tactical situation where post-battle damage survivability and continuity of operations was a high consideration. Especially for the European navies, whose fleets usually lacked the sophisticated air-defense systems necessary to ensure a high ratio of successful intercepts of incoming attacks (and thus, were much more probable to receive at least partial damage to their units), the prospect of their capital units being taken out of the battle by a single "cheap shot" was not a particularly welcomed one. Additionally, there is a finite limit to the processing power that can be stored in a single unit. The distribution of functions and data over a large number of sub-units would increase significantly the overall processing capability of the integrated C3 system.

A further consideration weighed in favor of such an architecture was the foreseen equipment upgrades. While a warship has an expected hull-life of 25 to 40 years, it is safe to project that her weapons and sensors will become obsolete and in need of replacement at least once during this period. The centralized computer C3 system concept, with its inherent inflexibility, results in a change intolerance that makes even minor changes to the weapon and sensor suite an expensive and potentially difficult task.

Chips anyone?

With computing power being expensive and scarce, however, the Europeans had no choice but to make do with what the American thinking had to offer. Following the centralized architecture seemed as the only practical solution for more than a couple of decades. That being said though, the mindset and wish for something different was still there, waiting a chance to manifest itself.

This opportunity came in the late 70s, when the computing revolution showed its first signs. Practical computer systems became available to the mass market. Prices began taking the rollercoaster ride. For the first time, purchasing a number of computer units and connecting them was not an option confined into richly-funded research projects. It was now possible to dispense with the central computer entirely, and design a truly modular system in which each operator terminal or console would have its normal individual responsibilities. The data could now be shared, transferred, or re-routed via one or more databuses as the tactical situation dictated. The result of these new developments was a radical departure in C3 system design. The very nature of the modular architecture made upgrades and module replacements much easier. Battle damage can only now degrade the effectiveness of the C3 system, and often not even that: The reconfigurability of modern systems means that, for example, *'it is the work of a few seconds to re-assign the navigational console on the bridge to take over the functions of the anti-air console burning in the CIC (in recent equipment, this is done by simply inserting the appropriate authorization card into a slot)'* (Friedman, 1993).

The various subsystems are either connected by main databuses or, if they are in reasonably close proximity, further integrated into small Ethernet-based Local Area Networks (LANs). In these, the equipment forming the LANs is linked by cheap data exchange interfaces, while the LAN central hubs themselves feed the main databuses. The ever-decreasing cost of electronics has enabled the installation of over0reudant databus and LAN connection routes, increasing the system's tolerance to battle damage considerable. The whole architecture could easily be compared to a spider's web, as the destruction of a single node does not affect the integrity of the whole system.

The introduction and adoption of distributed architecture has been matched by considerable improvements in the databuses available. The latest generation, for instance, includes fiber-optics cabling instead of the traditional copper wiring. Apart from providing much improved data transfer rates and saving considerable weight, this results in increased safety as it eliminates the fire and toxicity problems inherent in the insulation material used for copper wiring. A good example of this generation is represented in the Dutch SEWACO VII system. This uses 3 separate high-capacity databuses for voice, data and video communications.

The STACOS-FD system of the MEKO-200TN Track IIA class frigate represents a clear manifestation of the trend towards fully-distributed systems explained above: The core of the system lies on 8 Signaal MOC multifunction console stations equipped with 20in high-resolution CRT screens. These are connected through multiple redundant SigMA network servers equipped with multiple Sun SPARC 12,5MIPS-capable microprocessors. The network formed by this architecture is governed solely by the software, which is written in ADA MIL STD-1815A language. Some of the servers are stand-alone units, whereas the rest are integrated into the consoles themselves. All the network sub-systems are connected through a double-bus Ethernet IEEE 802.3 LAN, supported by a double video-distribution bus. This network also trades data with systems outside the core command system, such as the weapon system modules and the DAIL combat information bus. It also supports standard NATO Link-11/14/16 connections. Overall, the STACOS-FD is fully capable of performing:

- Multiple sensor data fusion and integration into a coherent tactical display
- Threat assessment and prioritization, automatic multiple target engagement
- Task force operations support
- Combat management support
- Tactical navigation (including GPS support)
- Tactical air-asset control
- Systems simulation

The Russian perspective

Post-war, and indeed until the mid-sixties, the Soviet Navy was primarily a coastal defense force. Not needing blue-water fleets because of the absence of any vital overseas interests or established colonies, and concurrently threatened directly by the massive numbers of post-WWII US and British aircraft carriers (most of which represented a nuclear-capable threat to the homeland), Soviet naval assets were expected to accomplish a very specific wartime task: destroy any enemy strategic naval assets that would be within striking range of the USSR.

As long as the West naval threat towards the Soviet homeland remained in the form of nuclear bombers launched from carriers, the procedure was relatively simple and straightforward: Enemy units would be initially detected by a massive early warning and direction-finding network designated Krug (which included picket listening posts in Cuba, Vietnam and elsewhere). They would then be localized by large maritime patrol aircraft, and subsequently attacked by overwhelming amounts of missiles (possibly nuclear-armed) launched from surface vessels, bombers and submarines. All friendly assets were to be controlled and coordinated by shore command centers, which were also the receivers and relays of the information provided by the pickets. These command centers utilized the first practical Soviet computer complexes, literally behemoths in size and maintenance requirements. The short distance between these centers and their subordinate forces at sea, as well as the fact that their targets were easy to track once initially detected, placed little burden on this type of command infrastructure. It also implied that air cover was available at short notice and in large numbers, eliminating the need for costly aircraft carriers. However, the basic parameters on which this system was designed and operating, started to change from the early sixties, leading to the need for reorganisation.

Ocean: The playground of the big boys

From the early sixties, the US Navy commenced the regular deployment of ballistic missile submarines (SSBNs). Britain and France were soon to follow. The striking range (and destructive power) of the missiles was, from the start, much greater than any carrier strike-planner could ever dream of, and constantly expanding. From the opposite perspective, this implied that in order to credibly secure the homeland from enemy naval strike, the Soviet Navy had to dominate an ever-increasing battlespace, with a shift of emphasis on underwater combat (thought the carrier threat was retained). The short-term solution was the introduction of anti-submarine aircraft and helicopters and submarines of improved range, speed (including nuclear-powered) and weaponry, but these were all stopgaps without strong surface presence. The Soviet Navy had to firmly enter the oceans.

This, naturally, was easier said than done. Whole classes of surface ships, initially constructed to carry heavy anti-ship missiles and not much else, had to be redesigned and re-equipped, both in order to accomplish their new mission and to have a reasonable chance of survival outside friendly air cover. More importantly, the new target was much more elusive, and its first sign of presence could very well be the last. Fast data integration between friendly assets was no longer a luxury, but a necessity.

Several approaches were taken to this end. On tactical level, hunter-killer groups comprised of surface units and aircraft were created. Their sensor data of an initial sub contact would be transmitted to a shore command center, and processed and fused there. The center was then to provide the group with an estimated position of the sub. The coordination of fire from team members was left to a specially designed data-link (NATO codename Fig Jar). On fleet level, for the first time, some limited degree of co-ordination and command was handed over to surface flagships (the Kara-class cruisers), with the partial transfer of previously shore-based command sub-systems on them. The ships that accepted them needed to be specially re-designed with lots of available space, increased available electrical power and other modifications. Most probably, it was the power limitation that, in this phase, precluded the full transfer of command authority from shore to sea (although political intricacies among High Command members cannot be overlooked).

The transition phase took part for the most of the 60s, and left the impression of a well-balanced Soviet Navy coming out on blue waters, with powerful new units and a revised command structure to exploit their potential. Complete revision of this attitude, however, was not far away.

Okean-70: Time for changes….

Okean, commenced at the summer of 1970, was the codename for the first major world-wide naval exercise conducted by the rebuilt Soviet Navy. It was meant to be a clear manifestation of the USSR's will and capability to challenge the hitherto established naval supremacy. From the Western perspective, it was exactly that. From the (then classified) Russian point of view, it was a coordination disaster. The shore command concept worked well for the 50's environment, but the 70's (let alone the foreseeable future's) comms and data traffic simply overwhelmed it. The sub-systems installed on flagships performed somewhat better, being closer to their subordinate units, but the fleet-level control was a fictional notion. In simulated engagement procedures, naval units were often neutralized before even receiving their orders to engage the enemy. The surface combat control was bad enough, but the anti-submarine section was something else. Soviet sub commanders (simulating western subs) wreaked simulated havoc upon their hunters with frustrating ease.

Heads rolled with equal ease, as the post-exercise review revealed the transfer of command and control to flagships to be an overriding requirement. The electrical power and space requirements of the new proposed systems were to exceed anything previously installed on any Soviet combatant, as was the level of local control. New pawns were added into the naval chess board, such as satellites and early warning sea-floor-based sensor networks. These would tax the new command architecture even more. There emerged a clear need to create a system based on a totally new philosophy, with great abundance of expandability and robustness, and to place in into a new class of flagships designed from the keel up to house them. The established discrimination of the navy's primary focuses (anti-carrier and anti-SSBN) meant that separate systems with separate command authorities would be installed in different ship classes. These ships needed to be extremely heavily protected, and their true purpose should be concealed, if possible, presenting them as simply powerful combatants instead of the crucial fleet nerve centres they would be.

By pure coincidence, a new class of four heavy anti-sub cruisers (the Kiev-class) was commencing construction when these important decisions were taken. They were quickly assigned to the anti-sub group flagship role, and additional defensive electronic and weapon systems were added. In accordance with the disguise principle (and to keep away any surface vessels that might interfere with the sub-hunting operations), they were fitted with the offensive capability of a surface-strike cruiser. On the other hand, the surface warfare flagship was literally drawn around the new system. The four Kirov-class battlecruisers were clearly in a class of their own, and attracted considerable Western attention (ranging from respect to outright panic) when the lead ship entered service in the early 80s (several years after the Kiev) after a protracted development period, no doubt owing to the complexity of the new command system. The traditional problems of space, weight and power supply were addressed with a no-compromise philosophy. 28,000 tons of displacement provided amble internal space, while two nuclear reactors (coupled with oil-fired steam boilers for increased speed) provided unlimited electrical power. In this case, concealing the ship's mission was verging on the impossible, so the designers were left free to fill available space with extremely powerful offensive batteries, potent anti-sub facilities (that, as an off-set, enabled them to easily complement the Kievs in sub hunts) and ridiculously dense defensive arrays, totaling literally dozens of electronic sensors and hundreds of guns and missiles.

The transition phase essentially was completed in 1983, when the 2 major Russian fleets had at their disposal at least one anti-carrier and one anti-SSBN flagship each. By this time, the new system had been recognized as offering substantially greater flexibility and allowing all involved assets in an operation to exploit their individual sensor and weapon capabilities. The two command systems were retained in service throughout the 80s and after the Cold War, and with the present economic difficulties facing the Russian armed forces, it is highly unlikely that they are to be substituted in the foreseeable future.

The C3 system of the Kirov-class battlecruisers can be regarded as a classic representative of this mindset. Open-mouthed as the Russians are about their marketable military systems nowadays, it is understandable that vital components of their war-fighting effectiveness are still closely guarded and covered, to a much greater degree, by a shroud of secrecy. Nevertheless, information important to comprehend the radically different nature and doctrine of this system has been made available.

It is known, for instance, that multiple redundant systems comprise the internal command network of the ship. The degree of redundancy is much greater than in either US or European systems (it is estimated that at least 4 super-computers are placed in each flagship, whereas even one of them is adequate for handling the data traffic even under intense conditions). This is partly because the distribution of duties between the command modules is not as great as in the European methodology. For example, a navigation console can undertake certain other functions normally assigned to other stations, but not all of them. This leads to a minimum required number of stations operative if the system is to remain 100% effective after expected battle damage. Furthermore, the Russians are far more cautious of the catastrophic effects of battle damage or malfunction on the system, and place the modules at far greater separation. The power-distribution problems usually associated with such a practice are easily offset by the availability of nuclear power. This also lifts the usual restrictions of power-sharing between command, propulsion, weapon and electronic warfare systems (and provides power that enables the ships' main radar-jamming modules to emit with power lethal to humans at 50ft!!!). As far as external communications and control is concerned, all 4 units have extensive (again redundant) datalinks with the shore-based Krug stations for initial target location data. A special satellite data link (code-named "Punch Bowl") is used to receive targeting information from the EORSAT and RORSAT-series satellites, while the Z-346 datalink is used to communicate with the ships' own heavy cruise missiles while they're in flight. This allows the launch of the missiles as soon as the target's general location is established, with updates or even steering commands transmitted to the missiles on the fly for targeting refinements or re-prioritization. The same datalink is used for information exchange with maritime surveillance aircraft. The "Fig Jar" datalink is maintained, and a new control system has been established for the co-ordination of the anti-air capabilities of the whole task force leaded by the battlecruiser (conceptually similar to the Aegis system in that respect). Overall, the system represents the typical Russian philosophy of a robust, highly protected system that can support the Russian Navy's operations for prolonged periods after hostilities have initiated.

The Future

As shown, the post-war development of naval C3 systems can be likened to 3 parallel axes: the idea of centralized computers, the distributed architecture, and the philosophy of the unique command center, either on land or afloat. More than a decade after the end of the Cold War, the world’s navies still find themselves in the awkward process of adapting to the post-Cold War environment and finding new missions, with different priorities and, quite significantly, with sharply reduced budget funds available.

Most navies experienced a tremendous downsizing during the 90s, similar in size to the one enforced after the First World War Financial realities now dictate that only a fraction of the naval unit swill be still available at sea. This, in turn, means that each naval force’s units that are actually at sea, are going to become virtually invaluable assets. The military, and perhaps more importantly, the political cost of even a single naval unit lost in combat is going to become unacceptable. C3 systems must be able to function with an even higher degree of battle-damage survivability, and posses even greater computing capabilities to offer more complete defensive options.

Furthermore, the change of geo-political realities dictates a drastic shift in the naval engagement environment. Most major naval powers have predicted since the early 90s that the next major naval engagements are going to take place in littoral environments, and combat experience so far has given merit to these views. This places a much greater emphasis on quick reaction; the vast oceanic environment that allowed a clear horizon for early detection of most incoming threats is simply not going to be present in such confrontations. Naval forces must be able to monitor areas richly populated with islands, mountain ridges, and a host of other radar-blocking obstacles. The range of options available for defence must include response to asymmetric or non-conventional attacks, like the raft-bombing of the USS Cole.

This threat environment will make instant data exchange between properly positioned units even more vital. Extremely fast reactions will be needed to counter incoming air threats that will make extensive use of terrain masking to minimize their exposure. The wide-spread proliferation of advanced anti-ship cruise missiles, most of which are able to avoid early detection by skimming the sea surface, must also been taken into account. This environment issues the demand for highly integrated C3 systems, which, even if operating normally under heavy human influence, should also have the capability to switch to full-automatic mode (much like the current operational mode of the Aegis system) in order to engage such threats in time.

Complex hydrographic conditions, which are found in shallow coastal areas, are also bound to offer sub-surface forces a much greater ability to inflict casualties on friendly assets than in open oceans; anti-submarine warfare is probably going to receive an even greater degree of priority.

All these converging needs inevitably lead to the natural question of which architecture/philosophy is to dominate future C3. During the 80s and 90s, the distributed architecture managed to gain an impressive momentum. The naval community (outside the US) has fully embraced its offered advantages, and consider it as the driving force behind the definition of a sensors & weapons fit for any given warship design proposal. How far this point has gone is illustrated by the fact that future Royal Navy construction programmes are likely to have the C3 system integrator as the prime contractor, rather than the shipyard actually building the ship.

The US Navy, on the other hand, has generally lagged behind in following this avalanche of trends. One reason for that has already mentioned, being the sheer vastness and cost of a potential program to re-equip its fleets with such systems[1]. Moreover, the European C3-system industry attributes this reluctance to the US emphasis on strictly integrating the operations of a large group of ships, rather than also integrating the activities within each vessel. US

[1] This is not to say that the USN is not actively experimenting with active units to improve the integration of their C3 systems: the “Smart Ship” initiative on the cruiser Yorktown is an obvious example. Others include the provision for greater electronics integration is newly-constructed units.

perceptions naturally differ. They emphasize the undeniable fact that the distributed architecture uses the system's computing power inefficiently, meaning that the potential power of the systems is much lower than the actual need for day-to-day and even combat use. This however, is a price gladly accepted by the Europeans which, having experienced the problems caused by having inadequate power in a C3-system, they now ensure the existence of a massive excess of processing capability in their architecture[2]. The true reason for US reluctance seems to be the harsh fact that distributed systems are much more expensive than their centralized equivalents. While acceptable for the small number of units in European navies, this is a strong headache for the USN's size.

The Russian model, on the other hand, being tailor-made on a specific doctrine shaped under very special conditions, and indeed perceptions, is hardly applicable in the future environment. It would not come as a surprise if the Russian Navy's replacements for the Kirov-class, in the long-term, embrace the European perspective, at least as far as the C3-systems are concerned. That would make sense both from the perspective of a rapidly shrinking Russian Navy, and from the longer-term inclination of Russian technology towards European, rather than US standards. It is already noteworthy that already numerous Russian defence development programs have begun making extensive use of European electronics technology, carefully avoiding anything that is subject to US restrictions.

In the context of the future naval environment, the importance of effective C3-systems simply cannot be over-emphasized. It is now fully understood in western military circles, that the next major war is going to be won and lost not so much in the front lines, but much more in front of electronic displays. With that in mind, the need for these displays to be the naval commander's most critical and most helpful tool becomes instantly comprehensible.

[2] An interesting example of this is the RN's Outfit DNA Command Management System, which uses less than 30% of its available computing power.