Executive Summary
CVX Flexibility/Integrated Electric Power

In January 1997 the Naval Research Advisory Committee (NRAC) was tasked by the Honorable John Douglass, Assistant Secretary of the Navy (Research, Development and Acquisition [ASN (RD&A)], to conduct a study of science and technology (S&T) opportunities that might beneficially impact the engineering and operational flexibility of CVX as well as other new classes of Navy ships. Sponsors of the NRAC study on CVX flexibility were RADM Michael T. Coyle, Deputy Commander for Engineering, Naval Sea Systems Command (NAVSEA) and RADM Dennis V. McGinn, Director, Air Warfare Division (N88), Office of Chief of Naval Operations (OPNAV). In order to credibly address the broad range of issues associated with CVX flexibility, a panel of seven NRAC members was augmented with experts from industry and government as well as two former Navy flag officers with extensive carrier operations experience.

To maximize flexibility, CVX must be effective, available, reconfigurable, and affordable. **Effectiveness** is the ability to undertake any assigned mission, ranging from strike warfare to humanitarian, and to perform under all weather conditions. For CVX to be **available,** anywhere and anytime, requires a high speed sprint capability. Once on station, CVX must have the endurance to perform its mission for as long as necessary. A critical key to CVX availability is its ability to survive in the 21st century threat environment. In order to (1) minimize operational limitations due to damage, (2) adapt quickly and effectively to new missions, and (3) adopt new technologies as required during the life of the ship, CVX must be rapidly and affordably **reconfigurable** . If today's problems of a Department of the Navy (DON) budget dominated by personnel, operating and maintenance costs are to be mitigated in the future, the requirement for life cycle **affordability** must be incorporated from the first conceptual stages in the design, construction, manning, operation and maintenance of CVX.

The Panel concluded that CVX must be designed to support a large (80 aircraft) airwing and conduct flight operations in heavy sea states in order to execute the most demanding power projection missions. The challenge is to ensure that CVX can normally be operated effectively with a smaller airwing, but can be surged to a larger airwing appropriate for the most stressing missions on short notice. If successfully executed, this strategy will reduce operating costs during peacetime while retaining critical flexibility to meet the most demanding power projection requirements. Sustained high speed sprint capability is necessary if CVX is to be available for rapidly evolving crises. A nuclear-fueled power plant will provide the ability for CVX to operate in this mode without impinging upon aviation fuel and ordnance capacities necessary for sustained operation. Survivability requires attention to reduction of signatures, adoption of adequate protection measures, and the ability to recover from damage.

An essential element of CVX flexibility is the ability to rapidly and affordably reconfigure for damage control, adapt for new missions and adopt new technology. A key to lifetime CVX affordability is an all-electric ship with modular architecture. The all-electric ship, with its common source of power for all systems, can be rapidly reconfigured in case of damage--power can be redirected to undamaged propulsion systems or mission critical combat systems. A modular architecture with large accessible spaces and standardized utility interfaces will allow CVX to be rapidly reconfigured for different missions. Over the 50-year service life of CVX, several generations of aircraft, Command, Control, Communications, Computers and Intelligence (C^4I) and Hull, Mechanical, and Electrical (HM&E) technologies must be accommodated. The combination of a modular architecture, which allows rapid reconfiguration of mission critical payload and support spaces, and the all-electric ship, with its universal power source, is the only approach that can accommodate these anticipated changes in a cost effective manner.

Four major features of CVX flexibility are delineated: (1) for maximum availability, the ship should have a **nuclear** propulsion plant; (2) for maximum effectiveness, in all weather and for all missions, the ship must be **large** , on the order of 100,000 tons, and (3 and 4) finally, to be optimally reconfigurable, **modular architecture** and a common source of **electric** power are essential.

For a large, nuclear-powered carrier to be affordable for the future, major reductions are required in ship manning, operation and maintenance (O&M) costs, as well as construction costs. Proven commercial methods and technologies for automating watch-standing functions, handling of supplies and reducing maintenance requirements offer low risk approaches to affordability in many areas. In order to best control O&M costs, the Panel recommends that CVX be designed with the goal of eliminating the mid-life overhaul. The rapid reconfiguration capability provided by an all-electric ship and modular architecture should reduce O&M costs by reducing the length and frequency of shipyard availabilities.

It is considered imperative that the CVX design/build team be selected and funded early, that it include participants who represent the users and maintainers as well as the designers and builders and that the team be empowered to identify and resolve life cycle cost related issues. In order to minimize design cost and to ensure that attention is focused on those issues requiring Research and Development (R&D) investment, it is necessary to fix the design drivers (i.e., ship size, type of power plant, etc.) as soon as possible in the integrated design process. The commercial shipbuilding industry, in order to be competitive in the world market, has adopted many manufacturing and construction methods that reduce the cost of building ships. Many of these practices may be applicable to naval construction; however, current design standards for Navy ships may preclude their use. It is essential that these modern commercial methods be given full and careful consideration in the design process.

By insisting on an all-electric ship, the DON will ensure O&M savings, reconfiguration flexibility and arguably, design and construction savings as well. This is equally true for both conventionally and nuclear powered ships. The ability to rapidly and affordably reconfigure for damage control, changing missions and changing technologies must be designed into CVX from the beginning. The all-electric ship concept supports this approach. Large areas, high in the ship, must be provided with easy access and standard interfaces to allow rapid exchange of pre-equipped, mission specific modules. Elsewhere in the ship the C^4I systems, combat systems and HM&E equipment installations should be modularized or palletized to allow for rapid exchange.

In summary, the NRAC CVX Flexibility Panel found arguments favoring large, nuclear powered carriers to be persuasive when considered in the light of reduced overseas bases and the wide spectrum of rapidly evolving crises which are likely in the 21st century environment. In order to take best advantage of this potential, CVX should be an all-electric ship with modular architecture to allow for rapid and affordable reconfigurability for enhanced damage control, adaptation to new missions and adoption of new technologies. Survivability against probable 21st century threats must be a priority for CVX designers and this requires the reduction of acoustic and electromagnetic signatures to decrease the likelihood of being targeted. Affordability should be pursued through adoption of proven commercial methods and technologies for reducing manning, O&M and construction costs.