FULL-SPECTRUM RDT&E CENTERS:

A 21ST CENTURY PERSPECTIVE

BY

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FOREWORD

This is the third in a series of papers prepared by members of the China Lake Defense Alliance on China Lake's position in the forthcoming Base Realignment and Closure (BRAC) round scheduled for 2005. Each paper deals with the assets and capabilities of the Naval Air Warfare Center Weapons Division as they relate to BRAC.

As a background for our program we believe that it's important to place China Lake's assets and capabilities for supporting national defense in context with the directions being taken by the Department of Defense and military services.

Our approach:

1. Anticipate the future mission responsibilities of China Lake as the United States enters the post-Cold War era. Matt Anderson's paper *Comments on the Future of the Weapons Division* in this series looks at China Lake's future roles in supporting national defense.

2. Evaluate China Lake's assets and capabilities for the future in the context of the BRAC goals set by the Secretary of Defense. *BRAC 2005 Goals and China Lake* addresses this task.

3. Assess the role of a "full-spectrum" RDT&E center in the 21st century. This paper deals with the role of a full-spectrum center in the RDT&E and training environment of the future.

Although the paper focuses on China Lake's position relative to Department of Defense goals, the relationship of China Lake with the Point Mugu Weapons Division facility and Edwards Air Force Base needs to be considered. An understanding of the partnership of these three bases and their relationships to other Southwest Complex bases is necessary to fully appreciate the value of each to national defense.

Volunteers of the China Lake Defense Alliance, a component of the IWV 2000 Corporation, work in partnership with the City of Ridgecrest and Kern County to assure that China Lake continues beyond BRAC 2005 as a premier full-spectrum research, development, test, evaluation and training resource for national defense. IWV 2000 and the China Lake Defense Alliance are not affiliated with the Navy or the Naval Air Warfare Center Weapons Division, China Lake.

China Lake Defense Alliance

Papers in this series:

- *Comments on the Future of the Weapons Division* – Matt Anderson – July 2003
- *BRAC 2003 Goals and China Lake* – Phil Arnold – September 2003
- *Full-Spectrum RDT&E Centers: A 21st Century Perspective* – Phil Arnold – September 2003

PREFACE

China Lakers have taken pride over the years in being associated with a full-spectrum RTD&E center. We all understood what full-spectrum meant for a weapons center: direct and meaningful involvement in the life cycle evolution of a weapon: conception, relevant research and technology, prototype and full-scale development and test, oversight of production, and support of the system in the Fleet. We thought of it as "cradle to grave" support, or as one wit put it, "erection to resurrection".

China Lake is still a full-spectrum center and has taken on an increased role in training as well. A fast-paced evolution is under way on how our forces fight, how we acquire systems and even what we mean by a "system". We believe that it's more important than ever to maintain full-spectrum centers, but the concept of full-spectrum needs to be understood as it applies in an era of transformation to new operational concepts and new applications of technology. This paper is an attempt to contribute toward shaping a paradigm for full-spectrum centers in the 21st century.

Phil Arnold

ACKNOWLEDGEMENT

Most members of the China Lake Defense Alliance are retired China Lake employees. Our experience is long, dating from the 1950s and earlier in the business of developing and testing weapons and the aircraft avionics systems that support them. Although this experience is invaluable to understanding China Lake and its relevance to the present and future, we need to be up to date on the evolution of warfare and the technology that supports it.

One of our members, Matt Anderson, has been directly involved in this evolution as a manager at China Lake before his retirement and now as a senior engineer in the defense industry. Matt has given much thought to the trends in warfare operational concepts, technology and policy that drive defense research, development, test, evaluation and training today. He has been a great resource to our group in helping us to look forward when it would have been much easier to look back to "the good old days" in our efforts to support China Lake.

Matt has helped me better to understand how the paradigms and concepts that apply to a full-spectrum center in the past are changing, how the concept of "system" is evolving, and how it applies to the changing face of warfare. If readers interested in China Lake's role in system acquisition haven't read Matt's paper, *Comments on the Future of the Weapons Division,* I urge you to find a copy and read it.

I take responsibility if the discussion wanders off track in this attempt to relate the full-spectrum center to today's warfare and system acquisition environment, but Matt Anderson is responsible for getting me started down the right track.

Phil Arnold

EXECUTIVE SUMMARY

The Navy has operated full-spectrum research, development, test and evaluation (RDT&E) centers as part of an approach to system acquisition that has been very successful over the years. The ability of research scientists, design and development engineers, test engineers and combat-knowledgeable Naval and Marine Corps officers to work together closely with co-located laboratories and ranges has led to development of affordable equipment that works. The whole organizational structure brought senior headquarters officers in Washington in contact with working engineers from the field in developing new requirements, developing specifications and overseeing the development of weapons, platforms and electronic equipment.

The post-Cold War defense downsizing has altered the organizational placement of full-spectrum RDT&E centers, and acquisition reform has altered the in-house technical role in developing specifications and making system configuration decisions. The change in the international balance of power and advent of new technology is changing the way our armed forces fight. The downsized services must work jointly rather than separately, and new communications and control architectures affect the design and system interfaces of the equipment used by service personnel.

Some of the old system acquisition concepts must be changed to fit the new environment – even the concept of *system* is changing. In network centric architectures the concept of a system now encompasses all of the units involved in a campaign – national sensors, intelligence units, platforms, and individual foot soldiers or Special Forces personnel. The equipments within this new system are procured under acquisition reform, and operational forces commanders are major players in developing requirements and evaluating new equipment concepts.

The role of a full-spectrum RDT&E center must be defined for the 21st century environment. There still is a need for the civilian and military professional staffs, the laboratories and the ranges to support advancing military technology, developing new equipment, integrating weapons and platforms, and supporting the hardware in the field. There also are new needs that emerge from the changing environment:

• *Network centric system engineering* . A contract has been let to develop a network centric warfare architecture, yet the concept of network centric warfare is not well understood within the services and there are no mature, internal service structures to implement and manage the interfaces and operational concepts to support the architecture. Assisting the contractors and service personnel in adapting existing and new hardware to this architecture will be a Herculean task. Full-spectrum RDT&E centers are uniquely qualified to take on this role.

• *Bringing warfighters and the RDT&E community together.* An expanded role of operational commanders in the requirements and RDT&E process offers an opportunity to inject a more realistic assessment of needs into system acquisition and to acquaint

warfighters with the opportunities and pitfalls represented by new concepts. In battle experiments and a continuing dialog, the military and engineering staffs of RDT&E centers and warfighters work together to give the services the full benefits of technology for 21st century warfare.

• *Focusing resources.* Full-spectrum RDT&E centers have a full set of co-located and available capabilities and assets needed to support the services. Co-locating resources supports all aspects of research, relevant technology development, development support, testing, and in-service support in the most effective manner possible at the least cost.

INTRODUCTION

The Navy's approach to acquiring warfare systems differed from the other services in the 20th century. The service established a network of laboratories, field activities and full-spectrum centers to conduct research, technology development, testing, and in-service support of systems. Through World War II it manufactured some ordnance-related systems in in-house plants as a supplement to industry. In basic research the Navy's program was a model for the world at the Naval Research Center, the Office of Naval Research and at RDT&E centers. The Navy's organization for defining and acquiring systems was remarkably flat for a military service: major studies brought together headquarters and field representatives to work together in a collegial problem solving mode, and the laboratory and major RDT&E centers were given remarkable freedom to innovate.

The concept *full-spectrum* was born in this environment in which RDT&E centers combined warriors with knowledge of the operational environment working side by side with top-flight scientists and engineers. Researchers and design engineers had direct access to ranges and test facilities to facilitate experimentation and instant feedback during the conceptual phase of a new development. The system worked well. In Viet Nam, 80% of the air-launched weapons came from one full-spectrum center, China Lake.

During the downsizing of the military establishment in the 1990s, changes occurred that mitigated some of the effectiveness of the old full-spectrum concept. The centers were assigned to System Commands that distrusted the former atmosphere that had encouraged trying new ideas, the flat RDT&E organization became more stratified, and a downturn in investment in research and technology made it more difficult for ONR, NRL and RDT&E centers to support long term needs. In spite of this, much of the spirit still exists in the RDT&E centers, and the full-spectrum concept continues to be supported in the Navy.

Because of the need to respond to new post-Cold War challenges with smaller forces and the requirement to quickly take advantage of new technologies, a major transformation in the military establishment is under way. This transformation is changing many of the concepts that affect the missions of full-spectrum warfare centers. The next section deals with some of these concepts, starting with something as basic as what we mean by *system*.

DEFINITIONS AND CONCEPTS

As a prelude to updating our ideas on full-spectrum RDT&E centers we need to reexamine some of the fundamental concepts that underlie research, technology development and acquiring new systems.

What do we mean by the term *system*? Dictionary definitions are:

1. *A group of interacting, interrelated, or interdependent elements forming a complex whole, and* 2. *A functionally related group of elements* .[1]

These definitions cover political processes, the human body, a gambler's hope to beat the odds, or any other "systematic" organization of ideas, processes or things. In developing software or hardware for military application, the concept of a system has grown over the past half-century from a unit of operational hardware to the totality of components used to fight in a war.

Fifty years ago China Lake engineers talked of a guided missile as a "weapon *system*". So it was. It was a group of elements: airframe, seeker, fuze, warhead, rocket motor and aerodynamic controls that performed the function of flying to and destroying a target. Then the idea of system was expanded to include the launch vehicle, weapons, and its "fire control" components: a ship or airplane, sensors, launchers, electronic boxes, and weapons that performed the functions of locating, acquiring, tracking, flying out to and destroying a target. Then the concept was expanded to include the processes and equipment for planning a mission, finding the target, navigating to the target area, attempting to destroy the target, and determining the damage at the completion of the mission. In the joint networked warfare concept of the transformed armed forces, a system can be thought of as the totality of equipment and processes that gather intelligence, support command planning and decisions, distribute information, and conduct missions to destroy an enemy's ability to oppose joint and allied forces. The idea of a military *system* has become pretty broad.

This all-encompassing concept of a system isn't science fiction or some far-future dream. It's evolving today, and it's essential that every component of the defense establishment structure its organization and programs to be in harmony with the concept. The leadership and key technical personnel of RDT&E centers must think at this higher level or they'll be left behind, either be closed by BRAC or slowly fade into irrelevance.

In the interests of clarity, I will try to restrict the use of the term *system* to its broadest meaning hereafter in the paper. Unfortunately, that might make for some awkward or nonstandard terminology, such as using "equipment" when one would normally use "system".

What is happening in systems acquisition? Certainly, I don't mean that the Department of Defense will start buying "systems" in the sense just described. Airplanes, ships, ground vehicles, weapons and black boxes will continue to be bought. They will be, or at least should be, bought in the broad systems context of the new networked or *network centric* concept of warfare – as *subsystems* if you will.

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[1] *The American Heritage Dictionary of the English Language, Fourth Edition*, Houghton Mifflin Co., 2000 Edition.

The weapon, platform and black box acquisition process is also changing. Acquisition reform is one aspect of the change in which the Department of Defense defines a general sense of what it wants in terms of capability and looks to industry to define the specifics on how to meet the capability. Competition is over who is most competent and has the best and most affordable ideas to produce the capability. Some veteran observers believe that there are structural deficiencies in acquisition reform, especially in view of the greatly diminished industrial competition from the post-Cold War downsizing in industry, but acquisition reform is a fact and will stand or fall on its effectiveness over time.

Other aspects of today's system acquisition process that need to be discussed are "jointness", the approach being taken to upgrade capabilities, and the role of in-house centers to support acquisition:

Joint service system acquisition. One transformation goal is for the services to operate jointly. In Afghanistan and Iraq we saw many of the old inter-service operational barriers breaking down. Joint close air support, strike warfare and special operations were conducted successfully. The joint command concept has worked much better than in Viet Nam or even in Desert Storm, and the old bugaboo of incompatible communications gear is finally being put to rest. In system acquisition the services are buying interoperable communications equipment, the Joint Strike Fighter variants are being designed with a high degree of inter-service commonality, and new weapons procurements are joint. For service RDT&E programs the old service arguments against consolidating RDT&E centers because of worries about losing control of requirements is getting pretty hard to sell.

Capability upgrades. In the past aircraft and weapons were periodically replaced with new designs incorporating improved performance. Over the years the service life of an aircraft type has grown from a decade to 40 years or more with periodic introduction of improved models.[2] With the advent of *spiral development*, the practice of procuring systems with plans to introduce periodic upgrades has become policy[3]. A policy of spiral development for weapons results in long-lived weapons procured in blocks where development will consist of component replacements and new full-scale weapon developments will be rare.

Role of the operating forces in RDT&E. The operating forces in the services are no longer content to sit on the sidelines and wait for new capabilities to be delivered. By inserting themselves directly into the requirements generation process and by direct involvement in R&D via force level experimentation, the operational side of the services has taken an active role in RDT&E that is growing in influence.

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[2] The B-52 has been around for almost 50 years, and although its mission and internal subsystems have changed, it's still a very useful asset.

[3] There is some resemblance to the old concept of Pre-Planned Product Improvement (PPPI), but there are critics who believe that the spiral development policy will encourage initial fielding of products that aren't designed as well or don't perform as well as they should.

Role of in-house RDT&E centers. One would expect that acquisition reform, spiral development, the expanded concept of systems and the changed nature of warfare would have a major impact on the role of the services' RDT&E centers, and that is certainly the case. Acquisition reform and reduced research and technology funding tend to reduce the role of RDT&E centers in direct participation in requirements development, technology advancement and development support. On the other hand, RDT&E centers continue to serve as a direct channel between the operational forces and the development community, and with the advent of battle experimentation this channel has made the connection even more direct and effective. Growing costs and the need to evaluate concepts in the new system environment has spurred the modeling and simulation technology community to develop simulation tools that integrate constructive, virtual and real battle elements in an increasingly realistic virtual environment. RDT&E centers have the technology and contact with service operational environment to take the lead in developing and using these tools. Finally, only the government can afford to invest in the land, air and sea assets needed to develop and test the new transformed system capabilities for the 21st century.

The questions are, do we need *full-spectrum* centers and if so, how will their roles evolve?

FULL-SPECTRUM RDT&E CENTERS IN THE 21ST CENTURY

We've delved into the expanded meaning of *system*, looked at new ways to fight, the latest trends in acquiring equipment and software, and touched on the role of RDT&E centers. At last we can evaluate the role of full spectrum RDT&E centers in context with the world as it is becoming.

We can start to define this role by examining the tasks for which full spectrum centers are uniquely qualified.

Network Centric System Engineering

This expanded networked system concept greatly magnifies the complexity of system engineering compared to that for a single piece of equipment or even a platform-weapon-electronics assemblage. Integrating the elements that go into a battle force, where the number of interfaces expand geometrically with the number of elements that must work together, makes system engineering for a single weapon or even an aircraft seem like a piece of cake. The problem is further complicated by the fact that no single organizational entity controls the process. Each type of equipment is developed and controlled by a different organization and responds to different service requirements. It's only been a few years since the services were communicating on different frequencies and literally couldn't talk to each other. A few years ago deployment of a new ship was delayed because incompatibilities among equipments installed on the ship made overall functioning impossible. Now that ship is but a single entity in a network centric battle force.

Progress is being made. The communications and cross-service coordination problem has been mitigated in the past decade as the push for interoperability is gaining traction. In Operation Iraqi Freedom the inter-service coordination was perhaps the signature feature of the campaign.

However, we still have a long way to go before the dream of a fully functional network centric force is realized. Indeed, today even the meaning of *network centric warfare* isn't well understood, and the services haven't established solid management processes at the internal service levels, let alone across service lines. A huge contract has been let to Boeing to define a network centric architecture, but it isn't clear how the company will interface with the services at an operational or technical level. The job of designing, building and refining a network centric battle force needs support by service elements that fully understand both the operational and technical intricacies of each service's internal and potentially integrated concepts of operations.

Full spectrum centers with their military-civilian teams and facilities offer an enabling instrument for technical coordination, harmonization and evaluation of network centric systems. The Boeing effort may provide an architecture for network centric engineering, but the services themselves need to carry the load of translating that architecture into functional requirements to integrate hundreds of elements, many of them containing proprietary designs and concepts. Tasking full spectrum centers to support this job offers an achievable approach to full interoperability.

Bringing Operators and the RDT&E Community Together. The insertion of operational forces directly into the RDT&E process offers opportunities to evaluate new technologies and operational concepts in a more realistic operational environment. Large and small scale experiments and the direct interchange between experienced military operators and R&D personnel can yield benefits: early shakedown of ideas; an arena for military planners to become acquainted with new ideas and technology; and perhaps most important, an opportunity for suppliers and users to work more closely together to solve operational problems.

Another aspect of operator-R&D personnel interaction is in the area of modeling and simulation. Today's full-spectrum centers have developed a modeling and simulation capability, networked at centers across the country, that support RDT&E, training and operational experimentation, linking new concepts with existing equipment in realistic battle environments. Real, virtual and constructive simulations and equipment with war fighters in the loop allow engineers and military operators to work together to evaluate hardware and operational concepts early in the conceptual phase at reasonable investment costs.

This interchange between operator and engineer can help to protect against one of the concerns of turning over R&D decisions to military operational commanders, the potential problem of focusing so much on immediate problems that long-term technology advancement will be sacrificed for short-term gain. A continuing dialog involving operator, research scientist and engineer enhances the chances of reaching a happy

medium where today's problems are addressed without sacrificing needed far-term capability.

Full spectrum centers are particularly well placed to facilitate an operator-developer interchange. In fact, they've been doing that for years. The new emphasis on operator involvement in R&D makes the interchange more important. In-house centers can work more closely on the large issues because their exposure to the full range of programs gives them a broader perspective, unencumbered by company product lines and proprietary restrictions.

Evolutionary Role of Full- Spectrum Centers. The preceding discussion has focused on the role of full spectrum centers in applying their professional staffs, facilities and unique capabilities on emerging, technology-driven aspects of military forces in transformation. One mustn't forget that the traditional role of full spectrum RDT&E centers may have changed somewhat, but the fundamental need for traditional RDT&E support to the services continues. Weapons may be more sophisticated, aircraft may be more capable and may perform many missions without aircrews, etc., but there continues to be a need to support the development and test of new weapons, platforms and black boxes. A knowledgeable in-house capability is needed to support the services as smart buyers and as testers of equipment. Research and technology in areas where profit potential isn't attractive or the time scale or risk reduces corporate interest is still needed. RDT&E centers provide a responsive capability to bring engineers and technicians into the field to train warfighters in using new capabilities or in solving problems when they arise – in combat areas as well as training bases -- as was shown in Operation Iraqi Freedom.

The need for system engineering at the network centric system level has been discussed, but there also is a continuing need for systems engineering at the weapon-platform level as well. The evolution of new aircraft, for example, leads to a varied set of models in the field that have the same designation, but in fact have many internal and a few external differences. The same is true for guided weapons. An F-18A is not the same aircraft as the F-18E; the Joint Standoff Weapon will evolve over time. Each aircraft type carries many weapons with their own peculiar software interfaces, and the job of keeping these interfaces functionally compatible in the Navy has been the job of full spectrum centers at China Lake and Point Mugu. They have been notably successful in integrating weapon sets on the fixed- and rotary-wing aircraft in the Navy, a job that is well suited to their experience and extensive laboratory and range facilities.

Focusing of Resources. Full-spectrum centers have a unique set of resources to bring to bear on developing and fielding military equipment. Only full-spectrum centers concentrate the scientific and engineering disciplines, laboratory facilities, and test and training ranges in the same arena. Centers like China Lake and Point Mugu have the ingredients that go into developing, testing and integrating weapons and aircraft into a network centric force structure. Unique aspects of full-spectrum RDT&E centers:

• Research in fields without high commercial value, such as explosives and propellants, is conducted, and contact is maintained with the academic and industrial scientific community in all areas relevant to the center's mission.

• Development scientists and engineers have direct access to laboratories covering a broad spectrum of applications and are co-located with ranges and specialized test facilities.

• Aircraft, ships or ground vehicles are immediately available for tests.

• Technical contact is maintained with academic and the industrial community while protecting proprietary ideas and processes.

• Scientists and engineers have security clearances and access to intelligence data not generally available outside the government.

• Daily interchange occurs between the technical community and military personnel with combat experience.

• Feedback on test or operational results is immediately available.

• Scientists and engineers are in direct contact with military units in the field, including during combat use, and military personnel are assigned to centers after they return from combat to inject their experiences into the RDT&E process.

Traditional products and services of full-spectrum centers. One shouldn't forget that network centric warfare, joint service concepts of operations, and the other elements of the transformed force structure still need aircraft, missiles, ships, ground vehicles, electronics equipment, and all the other components that go into the new force. Full-spectrum centers have supported the Navy well for a long time, and can supply the needed products and services in the joint arena to field the needed advanced hardware to the transformed forces in the 21st century.

In summary, full spectrum RDT&E centers can bring together the qualified technical and operational people, the facilities, and the environment needed to support the technology and system development needed for the transformed military forces of the future. If full spectrum centers didn't exist, the needed capabilities to pull things together would be dispersed and without focus throughout industry and government.

CHINA LAKE AS A 21ST CENTURY FULL-SPECTRUM CENTER

If you have read the preceding papers in this series, you will have received a perspective of China Lake's products and services for the future and the relevance of these facilities to the Secretary of Defense's vision for transformation. As stated earlier in this paper, China Lake and Point Mugu should be considered together to appreciate their

contribution to future air weapons RDT&E and training progress. Edwards Air Force Base as the third partner gives the country a total air warfare RDT&E capability.

China Lake's full-spectrum contributions fall into two areas:

1. Continuing to provide full-spectrum support in research, technology, system development support, testing and operational support of weapons and weapon-aircraft integration. Changes in the acquisition policy perhaps alter the nature of China Lake's role somewhat, but new capabilities will continue to be needed and China Lake has proven that it has the technical resources and management responsiveness to support the joint weapon and aircraft-weapon integration needs of the future.

2. Providing the services and the defense department the system engineering support for a network-based, joint warfare capability of the future. China Lake's expertise is directly supporting the evolution of network centric warfare elements today in the area of strike warfare. China Lake engineers are working on a daily basis today with operational personnel to help give them tools they need to evolve into a new kind of joint fighting force for the future.

A full-spectrum support capability is needed more today than ever, and China Lake is positioned to do its share as a full-spectrum RDT&E and training center in developing and fielding the armed forces of the new millennium.