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Enabling National Security Through Dual-Use Technology

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Enabling National Security Through Dual-Use Technology

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Major General Tzyh-Chyang Chang—is currently the superintendent of Chung-Cheng Institute of Technology (CCIT). MG Chang leads the Institute's educational efforts in cultivating erudite professionals with expertise in military technology and establishing an internationally recognized academic research facility in defense science and technology. He guides the CCIT faculty using its engineering research capability to help and solve the problems of R&D, maintenance and production units within the Republic of China Ministry of National Defense (MND). As the director of the Materiel Production Center in 2009, which includes eight different types of arsenals, he committed himself to the establishment of self-contained national defense capabilities, especially in the field of R&D and manufacture of traditional weapons. Appointed the director of the Acquisition Management Division in 2006, MG Change was in charge of all matters related to MND's defense acquisition management including integrated logistic support, program and project management, systems engineering management, and testing and evaluation of weapon systems and equipment. Prior to that position, he was assigned to be the deputy commander of the 202nd Arsenal in 2006 for a short period of time (six months). Before that, MG Chang was the director of the Technology and Industry Division since 2004, in charge of the technology development policy of MND, and also the supervision and management of defense cooperation with industry on armament manufacturing and technical information exchange.

Abstract

Dual-use technology refers to tools or techniques, developed originally for military or related purposes, which are commercially viable enough to support adaptation and production for industrial or consumer uses. Consequently, expensive technologies that would otherwise only serve military purposes can also be used to benefit civilian commercial interests when not otherwise engaged. With defense budgets in decline, industrialized nations must address affordability, as well as performance, in the acquisition of new weapon systems. This paper explores how the utilization of dual-use technology in the United States and the Republic of China is leveraging advanced technologies and efficient production capabilities of commercial industry.

> We've had 20 years since the end of the Cold War [and there is] sort of a presumption in the United States that we are technologically superior militarily. I don't think that that's a safe assumption. (Weisgerber, 2014)
>
> Frank Kendall,
> under secretary of defense for
> acquisition, technology, and logistics

Background

Since World War II, military superiority for the United States and its international allies has been based on our combined advantages in technology. Maintaining this technological advantage is vital in the unpredictable security environment we now face.

Over the last four decades, special defense requirements and business practices increasingly segregated the defense sector from the commercial industrial base. As a result, important defense research and development (R&D) essential to developing certain defense-specific technologies and knowledge has become increasingly isolated from its counterpart in commercial industry.

Current economic realities dictate that the defense budgets of the past 10 years are no longer sustainable. During this fiscal downturn, there is increasing concern that the Department of Defense (DoD) will not retain adequate funding to develop technology for weapons that could help the United States and its allies win a war 20 years from now. For more than a decade, the warning has been to modernize and integrate our defense industrial base:

> Military advantage in the future will be conferred upon defense establishments that are able to mine the globalized, commercialized technology base the fastest, keeping ahead of competitors who will be able to draw from much of the same base. It is crucial to U.S. military advantage that it be a faster adopter and adapter of technology, since it can no longer hope to be technology's exclusive owner. … The single most powerful mechanism to make defense a smart buyer of technology is to reduce the artificial barriers that separate defense businesses from commercial businesses. (Carter & White, 2000)

A dual-use technology strategy designed to overcome the barriers between the commercial and defense industries is one response to these new global economic and technical realities.

Dual-Use Technology Strategy

For this paper, the term *dual-use technology* is defined as tools or techniques, originally developed for military or related purposes, which in turn are commercially viable enough to support production for industrial or consumer uses (DoD, 1995).

Figure 1 displays an overview of the dual-use concept and highlights the process by which expensive technologies and capabilities needed by the military can also be utilized to benefit civilian commercial interests. An innovative dual-use strategy would involve a fundamental shift toward an integrated, national industrial capability that would achieve "best-in-class" benchmarks for cost, quality, and cycle time. Additionally, this would enable defense to capitalize on economies of scale to reduce production and sustainment costs.

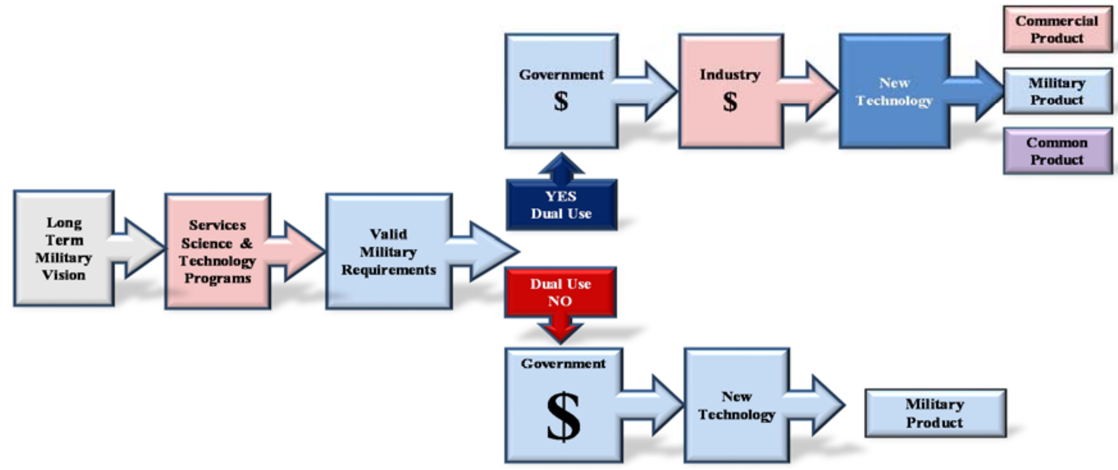

Figure 1. Dual-Use Technology Concept

Defense systems may require upwards of 15 to 20 years to design and develop. These complex systems are designed for low volume and to meet rigorous performance demands. In contrast, commercial products often take only a few months to three years. Commercial production is designed for high volume, reliability, and affordability (Xiangyang & Yanjun, 2008). Table 1 summarizes the differences between defense-related and commercial organizations.

Table 1. Product Development in Industry and Defense Markets
(Ting, 2012)

Factor	Commercial	Military
Impetus for design	Market driven, opportunistic	Dictated by military requirements
Types of products/services	Simple, reliable, moderate performance	Complex, stringent requirements
Funding for R&D	Financed by company itself	Government financed
Types of R&D	More applied and short term	More basic and long term
Nature of response	Rapid incremental change, punctuated by fundamental redesign	Slow, large improvements
Product cycle	Months or years	Years or decades
Priorities	Process technology for low cost manufacturing, high quality and flexibility	Product technology for functional performance and long shelf life
Linkage of R&D and production	Integrated management of R&D, production and customer service	R&D and production separately contracted
Basis of competition	Competition of free market; overall value, price and quality is the basis of competition	Few competing contracting firms. Often required to partner with competing firms
Technology sharing	Success based on proprietary advantage	Often technology sharing with competitors imposed by Defense

Increased reliance on dual-use technology will break down the barriers between defense and commercial industries, allowing for the development of state-of-the-art weapon systems to meet the following goals (DoD, 1995):

- shortening weapon system development time and increasing the pace at which technological improvements are incorporated into new military systems;
- reducing costs for procuring and sustaining leading-edge technology; and
- enhancing breakout ability to respond rapidly to national security emergencies (DoD, 1995).

The key to the successful implementation of a dual-use policy is to recognize where defense and commercial industries have mutual interest, and then collaborate to develop those technologies that meet both defense and commercial needs. This can be, and has been, done in the past as the result of another crisis of sorts, The Cold War.

Historic Dual-Use Examples

Dual-use technology utilization is a proven tool with examples stretching back decades to when the advanced industrial base met defense needs for higher quality and increased performance of new weapons systems while providing the consumer with innovative products. Table 2 highlights some well-known dual-use technologies from the past 60 years.

Table 2. Dual-Use Technology Examples

Capability	Defense	Commercial
Laser-Based Listening Technology	Detection of quiet-operating submarines at great distances deep beneath the ocean surface	Aircraft radar detection of turbulence produced in the wake of large aircraft, forms of clear-air turbulence, wind shear, and microbursts, or sharp downdrafts
Sonar	Submarine/anti-submarine warfare	Mammogram x-ray for minuscule abnormalities Ocean Bottom Profiler hazards detection
Global Positioning System	Mapping Navigation Precision guided munitions	Mapping Navigation Package/service tracking
Rocket Technology	Missiles ICBM	Space program Commercial satellite programs
Nuclear Development	Nuclear propulsion Nuclear weapons development	Provide lifesaving radiopharmaceuticals and electricity
Computers	Space program Defense networking	PC—Laptops CD ROM Tech
Internet	Information Processing Techniques Office (IPTO) within DARPA, U.S. DoD interconnection of main computers at Cheyenne Mountain, the Pentagon, and SAC HQ	Worldwide web for mail, commerce, information sharing, and tracking

Contemporary Drivers

More recently, there is a need for greater dual-use technologies in the following three areas: force modernization, autonomous systems, and logistics and sustainment.

Current Force Modernization

The application of dual-use technology in military modernization represents a fundamental shift in modernization strategy. The strategy of “performance at all costs” must evolve to a strategy of the right performance at the rights costs. For example, for more than 40 years, the defense sector has designed and developed special purpose equipment, subsystems, and computer chips under the veil of requirements. The defense sector often ignores commercially available technologies that “almost” meet the requirements, while simultaneously, industrial partners employ commercial technologies such as materials, avionics, and propulsion systems in weapon systems modification programs.

Autonomous Systems

The use of autonomous systems has grown exponentially over the past 10 years and will only continue to grow as more technology is developed, creating ever-greater capabilities. As a result, both commercial and defense sectors continue to make significant investments in autonomous systems. From a defense point of view, these investments are vital to counter growing personnel costs while enhancing force protection and survivability.

Agile Logistics

Logistics and sustainment is an area ripe for dual-use technologies and practices. Decades ago, the commercial sector transformed its supply chains from cost centers to competitive weapons. The defense sectors in democratic countries could dramatically reduce costs and improve responsiveness by more aggressively adopting commercial technologies such as asset visibility, fleet management, and anticipatory demand planning.

Contemporary Examples

Within the past decade, dual-use technology continues to provide innovative solutions for both military and civil use. Three current examples of dual-use technology insertion include the K-MAX power life helicopter, the Human Universal Load Carrier (HULC), and carbon nanotube development and production.

K-MAX

The partnership between Lockheed Martin and Kaman Aerospace Corporation has successfully transformed Kaman's proven K-MAX power lift helicopter into an unmanned aircraft system (UAS) capable of autonomous or remote-controlled battlefield cargo resupply for the U.S. military.

The K-MAX UAS enables military logistics units to deliver supplies day and night to precise locations without risk of losing life in the process. Designed and tested to perform repetitive external lifting, K-MAX has proven itself well suited for lifting operations in austere environments and has flown more than 750 hours in autonomous mode since 2007. The unmanned aircraft is capable of delivering 6,000 pounds of cargo at sea level and more than 4,000 pounds at 15,000-foot density altitude, making it ideal for resupply missions in Afghanistan (Lockheed Martin Corporation, 2013b).

Commercial operators for the construction and logging industries used the manned version of K-MAX for repetitive lift operations. Additionally, K-MAX pays a critical role in emergency response missions ranging from firefighting and disaster relief to search and rescue or mobilization and logistics. (Kaman Aersopace, 2014)

Human Universal Load Carrier (HULC)

The Human Universal Load Carrier (HULC) is an exoskeleton developed by Lockheed Martin for dismounted soldiers. Originally developed by Ekso Bionics, Lockheed Martin entered into an exclusive licensing agreement in January 2009 in order to co-develop HULC (Army-Technology.com, 2014).

HULC is an un-tethered, hydraulic-powered, anthropomorphic exoskeleton designed specifically to fit around the body of a dismounted soldier. The systems' flexible design poses little to no restriction of movement, a crucial element for warfighters. The primary function of HULC is to assist soldiers to carry heavy loads with minimal strain on their body (Lockheed Martin Corporation, 2013a).

Although HULC is currently designed for military use, exoskeleton technology development will eventually provide civilian capabilities by enhancing firefighting ability, allowing rescue workers to survive dangerous environments, and allowing disabled persons to walk again.

Carbon Nanotube Technology

A carbon nanotube is a tube-shaped material, made of carbon, having a diameter measuring on the nanometer scale. A nanometer is one-billionth of a meter or about one ten-thousandth of the thickness of a human hair (Nanocyl, 2009).

Carbon nanotube technology is currently being developed for military use in lightweight composite materials for unmanned aerial systems and more notably for the F-35, as the first mass-produced aircraft to integrate structural nanocomposites in non–load bearing airframe components. Defense as well as commercial applications of carbon nanotube technology currently include the following (Nanocyl, 2009):

- Conductive plastics

- Structural composite materials
- Flat-panel displays
- Gas storage
- Antifouling paint
- Micro- and nano-electronics
- Radar-absorbing coating
- Technical textiles
- Ultra-capacitors
- Improved lifetime of batteries
- Biosensors for harmful gases
- Extra-strong fibers

As the above examples demonstrate, the use of carbon nanotubes is already widespread in industries, and is likely to play a significant role in developing next-generation electronic circuits and components, potentially simplifying actual designs and reducing manufacturing costs (Walker, 2013).

An International Model: Chung Shan Institute of Science and Technology, Republic of China

Taiwan's unique political and strategic position makes the utilization of dual-use science and technology an integral part of its defense and commercial development. The Chung-Shan Institute of Science and Technology (CSIST) is the primary research and development institution of the Ministry of National Defense's Armaments Bureau, and has been active in the development of various dual-use technologies. It is also involved in developing systems for Taiwan's civilian space program. The institute is administered under the Armaments Bureau of the Republic of China Ministry of National Defense (MND) (Chung Shan Institute of Science and Technology, 2014).

The CSIST integrates research systems from defense technology, academic research, and civilian industries with the objective of managing and strengthening dual-use technologies between military and industry. Besides following processes similar to the one described in Figure 1, when developing technologies for new military equipment, CSIST took a more aggressive effort to explore the possible commercial applications of existing defense technology. It established a unit called the Lung-Yuan Research Park to be the window of converting defense technology into civil industries business value. CSIST has formed a partnership with the Technology Development Program (TDP) of Ministry of Economic Affairs (MOEA). The MOEA is a program that includes many different sub-projects that helps native industries improve their R&D and production capabilities, and intellectual property exhibitions presented at the Taipei International Invention Show & Technomart.

Through this partnership, CSIST cooperates with industries, officials, academics, and institutes in Taiwan to convert the once military-specific technology into dual-use technology, carrying out the policy of promoting national economic developments and local defense industries. Until now, the program has had the cooperation of more than 60 universities or corporations, responsible for producing thousands of technology-transfer cases between hundreds of industrial companies. In turn, military–civil dual-use technologies are applied to the civilian sector with technology transfers to promote the development of national defense technology and enhance the R&D capabilities of the civilian sector, as highlighted in Figure 2 (Chung Shan Institute of Science and Technology, 2014).

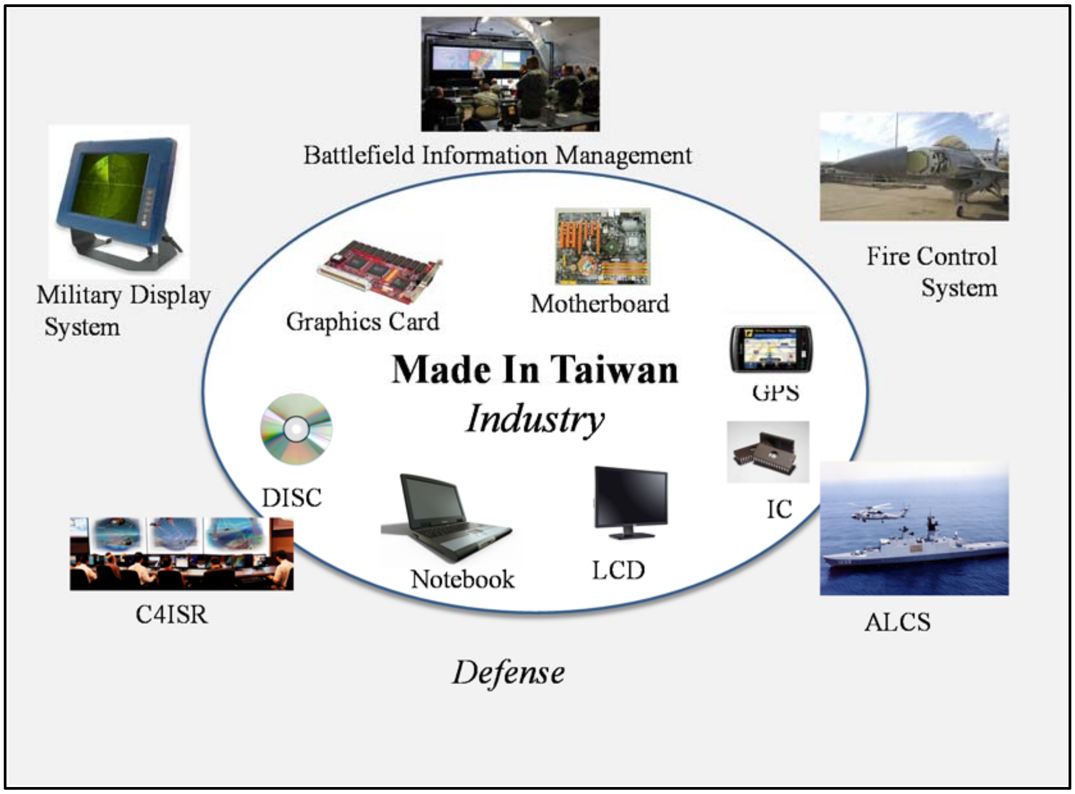

Figure 2. Chung Shan Institute of Science and Technology

Recommendations/Objectives

Military strength and economic strength are mutually supportive. The key to the implementation of dual-use technology is to identify where defense and commercial industries have mutual interest, and can work together to develop technologies that meet both defense and commercial needs (DoD, 1999). Dual-use technology contributes to both military and economic strength through the following:

- **Military and Industry R&D Partnerships**: The U.S. and its international defense allies will build new partnerships with industry and academia to enable access to leading-edge dual-use technologies. This will enable the military to introduce industry's continuous stream of innovations and updates, both during the development and throughout the life cycle of its weapons systems, thereby shortening development times while increasing technological advances.
- **Affordability**: A greater reliance on commercial capabilities will reduce costs for procuring and sustaining military systems by integrating industry components, technologies, and subsystems at much lower cost via economics of scale. Meanwhile, it can also reduce the cost of keeping and evolving related technological capabilities.

- **Survivable Adaptive Infrastructure; Capability to Rebuild**: An integration of the defense and private sectors will strengthen our nation's industrial capabilities to respond rapidly in time of national emergencies.

Dual-use technology development can be the driving element to satisfy military requirements in the face of declining resources. An integrated, national industrial capability that achieves best-in-class benchmarks for cost, quality, and cycle time will allow defense to exploit the rapid rate of product development and the market-driven efficiencies of commercial industry to meet military needs.

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