In this monograph, Robert Haddick examines a variety of emerging technologies and techniques that could improve the sustainment and effectiveness of distributed SOF operations, especially in access-denied environments. He begins by describing a challenging yet plausible notional unconventional warfare campaign scenario. He describes how current SOF planners would attempt to cope with this scenario under current doctrine and sustainment capabilities, explores current and emerging technologies that could provide new options and capabilities, and evaluates new technologies that promise to reduce logistic demand for distributed SOF operations. Haddick proposes research and development recommendations that provide SOF with capabilities that improve their capacity to execute clandestine UW campaigns in denied areas. This monograph helps close the gap between current conditions and what will be necessary in an access-denied future.

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JSOU Report 16-2 Improving the Sustainment of SOF Haddick JSOU

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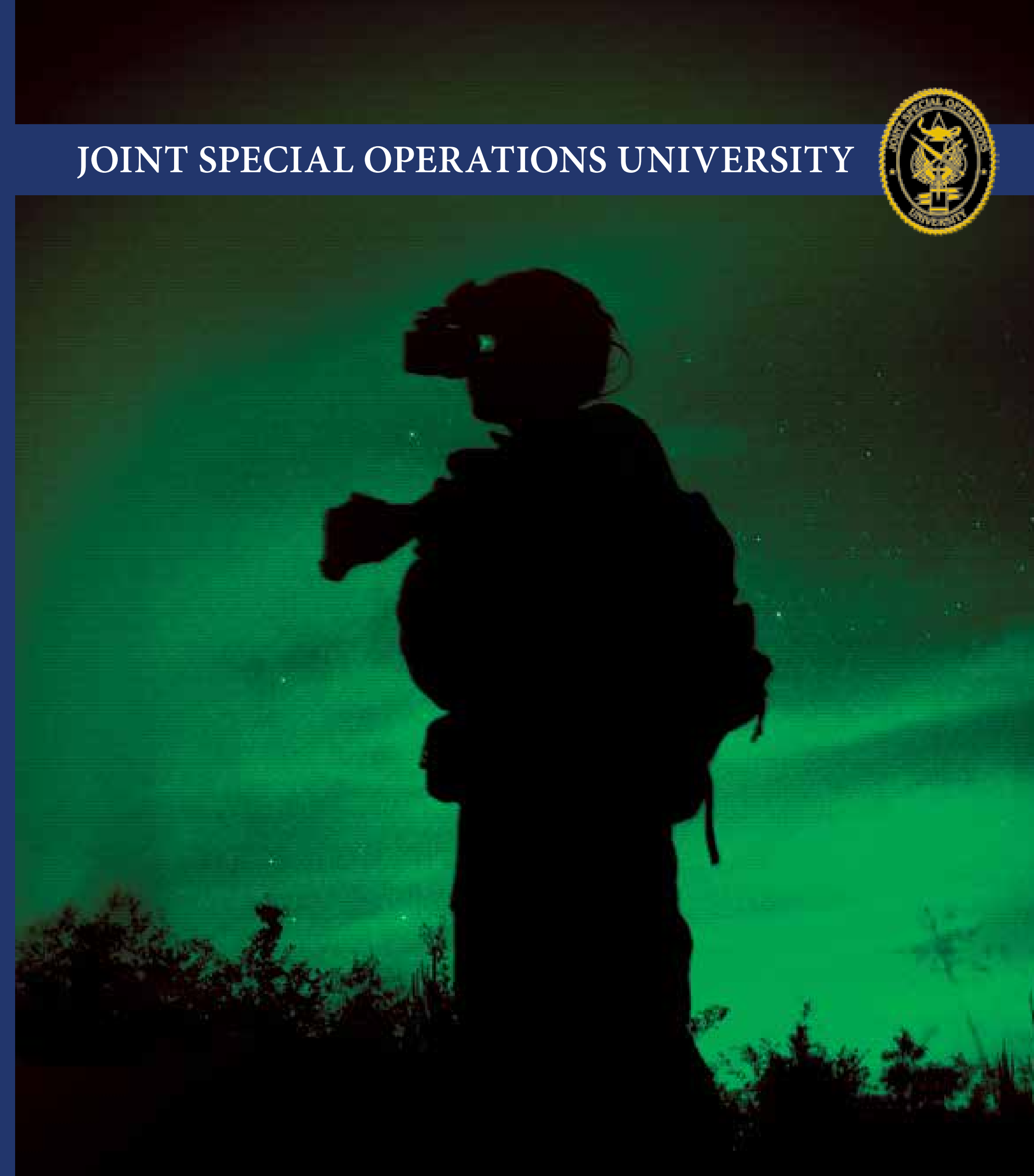
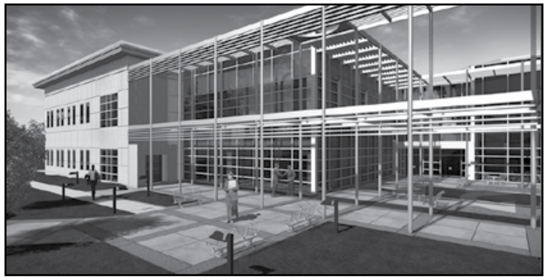


Improving the Sustainment of SOF Distributed Operations in Access-Denied Environments

Robert Haddick

JSOU Report 16-2



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Improving the Sustainment of SOF Distributed Operations in Access-Denied Environments

Robert Haddick

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MacDill Air Force Base, Florida
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Foreword

In his monograph, *Improving the Sustainment of SOF Distributed Operations in Access-Denied Environments*, Robert Haddick examines a variety of emerging technologies and techniques that could improve the sustainment and effectiveness of distributed SOF operations, especially in access-denied environments. This is a terrific piece of scholarly work. The writing style is compelling, well sourced (directly drawing from historical contexts to frame proposed solutions), contains realistic technology assumptions, and most importantly, actionable recommendations. The monograph begins by describing a challenging yet plausible notional unconventional warfare (UW) campaign scenario. The first chapter describes how current SOF planners would attempt to cope with this scenario under current doctrine and sustainment capabilities. Haddick finds that SOF units and planners assigned to the campaign would benefit from emerging technologies and techniques that could reliably overcome the access barriers in the campaign scenario. In addition, these technologies and techniques provide sustainment and mobility to distributed SOF and insurgent forces in the UW operating area, and reduce their demand for outside sustainment, which would ease the burden on whatever logistics system emerged from the planning process.

The second chapter explores current and emerging technologies that could provide new options and capabilities for resupply, especially for clandestine distributed SOF operations in denied areas. This is important to note because a non-standard logistics operation that can move meaningful quantities of supplies and equipment across a denied frontier offers the potential of a substantial competitive advantage for the guerrilla force and thus an acceleration of its insurgency. Haddick, in the third chapter, describes and evaluates emerging technologies that promise to reduce logistic demand for distributed SOF operations and thus the burden on a prospective clandestine UW sustainment system. These technologies include viable aerial, seaborne, overland, and subterranean delivery channels that SOF logisticians could exploit to support a UW campaign inside an access-denied area. Finally, Haddick proposes research and development recommendations that provide SOF with capabilities that improve the capacity of SOF to execute clandestine UW campaigns in denied areas. The 15 recommendations presented address a gap in what Haddick argues is the lack of attention in recent years devoted to the UW mission generally, and the sustainment of challenging UW missions in particular.

This monograph is not just for the SOF logistician. It will be of interest to those in the conventional force as well as SOF who are tasked with supporting a friendly guerrilla force inside an access-denied area. Haddick provides a holistic view of what it takes for SOF operational success. This monograph helps close the gap between current conditions and what will be necessary in an access-denied future. If nothing else, it is a reminder for the reader of the challenges ahead.

Kenneth H. Poole, Ed.D.
Director, Center for Special Operations Studies and Research

About the Author

Robert Haddick is a former U.S. Marine Corps officer. He served in infantry and field artillery units in the 3rd Marine Regiment and commanded a rifle company in the 23rd Marine Regiment. While on deployment he conducted security force assistance activities with host nation and partner military forces in the Western Pacific, East Asia, the Indian Ocean region, and Africa. He served on a battalion staff and participated in the Personnel Reliability Program.

In the private sector, Haddick is a Visiting Senior Fellow at the Mitchell Institute for Aerospace Studies. The Mitchell Institute is an independent, non-partisan national security policy research institute specializing in the study of aerospace power and strategy, and is affiliated with the Air Force Association located in Arlington, Virginia. He was Director of Research at The Fremont Group, the investment affiliate of Bechtel Corporation. He led Fremont's economic and investment research team, founded and led its proprietary trading unit, led one of Fremont's overseas subsidiaries, and established a trading network that spanned the United States, Europe, Latin America, Asia, and Australia.

From January 2009 to September 2012, Haddick was the author of This Week at War, a weekly column on national security affairs for *Foreign Policy*. His column covered the counterinsurgency campaigns in Iraq, Afghanistan, and elsewhere; the Pentagon's budget and reform efforts; the evolution of U.S. military doctrine and operational concepts; and adaptation to emerging security challenges. Simultaneously, Haddick was the managing editor of *Small Wars Journal*, a leading intellectual resource on modern conflict, irregular warfare, and emerging threats.

Haddick's essays on national security issues have appeared in the *New York Times*, *Wall Street Journal*, *Washington Post*, *Air & Space Power Journal*, *The National Interest*, *War on the Rocks*, and other publications. He has conducted numerous interviews with media outlets such as the BBC, various NPR affiliates, CNBC, and others. Haddick has been a paid adviser to the U.S. State Department, U.S. Central Command, and the National Intelligence Council.

Haddick is the author of *Fire on the Water: China, America, and the Future of the Pacific* (Naval Institute Press). Fire on the Water discusses how China's reemergence as a great power is leading to a growing clash of interests in the Asia-Pacific region. The book explains how China's strategy, based on non-military assertiveness and its exploitation of the missile and sensor technical revolution, is taking advantage of vulnerabilities in longstanding U.S. and allied operational concepts in the region, which current U.S. policies and programs are struggling to address. *Fire on the Water* provides a detailed description of diplomatic, military, and acquisition reforms the U.S. and its partners in the region should undertake if they are to maintain stability and protect their interests.

Haddick's previous JSOU Press monograph is *Challenges in the Asia-Pacific Theater for U.S. and Partner Nation Special Operations Forces* (2014).

Introduction

Since 2001 the majority of United States Special Operations Forces (USSOF) operations occurred with the nearby presence and support of conventional military forces and their logistics and sustainment infrastructure.[1] However, SOF should prepare for missions of significant size and duration where such conventional combat service support will not be present.[2]

There may be an increasing possibility that policymakers will task SOF to execute unconventional warfare (UW) missions. The U.S. Department of Defense (DOD) defines UW as:

> activities to enable a resistance movement to coerce, disrupt, or overthrow a government or occupying power by operating through or with an underground, auxiliary, and guerrilla force in a denied area.[3]

The DOD has also stated the role UW plays in the national strategy of the United States:

> UW is a politico-military tool which, under certain circumstances, may provide the most feasible, acceptable and suitable option by which the U.S. Government can achieve its objectives. National objectives may be to influence, coerce, disrupt, replace, or overthrow an adversarial governing authority by affecting the competition for legitimacy. UW is a combination of the direct and indirect application of national power that leverages relevant foreign resistance movements or insurgencies opposing a governing authority to achieve the U.S. national objectives. A UW operation renders national strategy into an appropriate and relatively inexpensive policy option for decision makers. UW operations contain political risks; however, those risks may be considered less than those associated with inaction or the introduction of large-scale military forces.[4]

UW is an offensive yet indirect military technique, and an option that may be increasingly sought by U.S. policymakers in the future. As a result, SOF leadership has assigned a high priority to bolstering Special Operations Forces (SOF) UW capabilities in the period ahead.[5] Such missions could find SOF detachments operating for sustained periods at long distances from friendly bases of support. Such operations are also likely to be 'distributed,' with small autonomous detachments operating beyond the range of mutual support. Political, diplomatic, and operational security considerations may require that some UW campaigns remain clandestine.[6]

The falling relative costs and increasing availability of highly effective anti-aircraft and anti-ship missiles and associated sensor networks will in many cases greatly compound the challenge of executing distributed UW missions.[7] The increasing presence and effectiveness of such 'anti-access' technology will greatly increase the risk of moving SOF units into and around an unconventional warfare operating area (UWOA). The proliferation of access denial technology will similarly increase the costs and risks of sustaining UW detachments and friendly guerrilla forces during the long interval normally required to successfully execute a UW campaign.

Despite these strenuous challenges, SOF planners have an obligation to be ready to operate and succeed in these environments. SOF planners need to prepare for the likelihood that policymakers will call on them for options when other alternatives are impractical. It may be the case that diplomacy, political pressure, economic sanctions, and other forms of nonviolent coercion will have failed to achieve the effects that policymakers have sought. Likewise, conventional military operations may be impractical, or may have been tried and similarly failed. When policymakers have concluded that a national security objective remains important, they may turn to SOF commanders and planners for options such as UW, found in the irregular portion of the conflict spectrum.[8] SOF commanders and planners have an obligation to be prepared for the increasing likelihood of such circumstances.

For these reasons, U.S. Special Operations Command (USSOCOM) headquarters expressed interest in a research study that would provide background and recommendations for how that command and the SOF community can better prepare for distributed operations in access-denied environments and scenarios. Specifically, *Special Operations Research Topics 2015*, published by Joint Special Operations University Press, described this research interest:

> The majority of SOF operations during the last ten years of conflict have been conducted in the context of substantial general purpose force presence and support. As SOF look toward 2020 and beyond, more distributed operations will likely become the norm. What

> capabilities and technologies can be used to perform distributed operations and sustainment functions in the future? What options could enable support to units operating in a global, complex environment in response to emerging anti-access and area-denial security challenges to joint operational access concept, as well as support to dispersed special operations units? In this context, describe technology and advanced systems solution that: Reduce drivers for logistics requirements, particularly power and energy, maintenance, fuel and water by fundamentally changing the demand characteristics of the force and increasing capabilities that allow demand to be satisfied at the point of need; improve intra-theater mobility and distribution; and improve near real-time visibility of logistics information. Is there a logistics-centric research and development (R&D) investment strategy that could achieve these objectives?[9]

This monograph responds to this interest and will examine a variety of emerging technologies and techniques that could improve the sustainment and effectiveness of distributed SOF operations especially in access-denied environments.

The first SOF Truth states, "Humans are more important than Hardware."[10] That truth certainly remains intact. Better technology will never substitute for high standards of SOF training, leadership, experience, and teamwork. What some of the emerging technologies in this study may provide are new capabilities that will allow mission success in scenarios where such confidence would not otherwise have been present.

The monograph will begin by describing a challenging yet plausible notional UW campaign scenario. This 'pacing' UW scenario will feature a prospective substantial, distributed, and clandestine UW campaign executed without an overt conventional military logistics infrastructure and against an adversary possessing sophisticated access-denial capabilities. This chapter will describe how current SOF planners would attempt to cope with this scenario under current doctrine and sustainment capabilities. It will also illuminate some of the gaps between what such a pacing scenario will demand and the doctrine and logistic capabilities that exist today.

The second chapter will explore current and emerging technologies that could provide new options and capabilities for resupply, especially for clandestine distributed SOF operations in denied areas. This chapter will discuss new technologies for aerial, water-borne, terrestrial, and subterranean resupply methods, and examine technologies and techniques that could aid nonstandard resupply operations for clandestine UW operations.

The third chapter will describe and evaluate emerging technologies that promise to reduce logistic demand for distributed SOF operations and thus the burden on a prospective clandestine UW sustainment system. The chapter will discuss technologies that could improve the efficiency and reduce the demand for stored electrical power, electrical generation, nutrition, and munitions.

The final chapter will propose research and development recommendations that will provide SOF with capabilities that will improve the capacity of SOF to execute clandestine UW campaigns in denied areas. The chapter will make specific recommendations to SOF commanders and planners on ways to implement the concepts, techniques, and technologies discussed in the previous chapters. A conclusion will then sum up the findings of the monograph.

The acquisition of access-denial technology by adversaries of the U.S. and coalition partners will in some cases raise the barriers to SOF success. At the same time, policymakers are likely to increasingly turn to SOF for options to resolve many national security challenges. The emerging technologies examined in this study could allow SOF to keep up in this competition and provide the options that policymakers will demand.

1. The Struggle for Greenville Province: A Pacing Scenario for a Distributed UW Campaign in an Access-Denied Area

This chapter will describe a fictional insurgency against a geostrategic adversary of the United States and its partners and a UW campaign U.S. policymakers have requested in support of that insurgency. The purpose of this descriptive and fictional chapter is to orient the reader to the challenging pacing scenario SOF planners may have to prepare for when contemplating future distributed UW operations in denied areas. The chapter will also illustrate the limitations and shortcomings of existing UW sustainment doctrine and technology. This chapter will lay the path for the monograph's subsequent chapters, which will describe emerging technologies and techniques that promise to improve the sustainment capacity for challenging UW campaigns such as the one described in this chapter. The fictional scenario begins below.

Legal authority for a UW campaign in the People's Democratic Republic of Redland

The United States National Command Authority has directed USSOCOM and other government agencies to conduct a UW campaign in support of a resistance movement opposing the government of the People's Democratic Republic of Redland (hereafter simply "Redland"). The president has signed a covert action finding relating to Redland, and Congress has authorized and appropriated DOD and intelligence service funding for a clandestine UW campaign inside Redland.

Description of Redland

Geography. Redland is a mid-sized country in Asia, with roughly the same land area and half the population of France. Redland enjoys access to the ocean to its east. On this coast the broad Green River drains into the ocean. The Green River traces its way upstream through roughly the geographic center of Redland to the large capital city of Redville, and then through Redland's foothills and mountains to the river's origin on Redland's north and west borders. The Green River is navigable to commercial traffic from the ocean to just beyond Redville.

Redland's climate, terrain, and vegetation are diverse. The mountainous north and west is alpine while the hilly midsection around Redville is temperate with humid summers and cool winters. The port city of Greenville, found at the mouth of the Green River, is warm and humid year-round. The terrain in Greenville Province and around the mouth of the Green River is mainly swamp, jungle, and farmland.

Redland's mountainous borders on its north and west are impassible in the winter and with the exception of a few roads, are passable only by foot or pack animals in the summer. Redland's eastern coast is populated by numerous small and medium-sized fishing villages. Redland's southern boundary is marked by mostly heavy forest and numerous major and minor roads leading into the neighboring country Orangeland.

Ethnography and demographics. Redland is composed of two major ethnic groups: the Omegas (thought to be about 55 percent of the population and found mainly in the southern and eastern provinces), and the minority Alphas (estimated at 35 percent of the population), found mostly in the center and in the foothills to the north and west. The ethnic makeup of the population of the capital is thought to resemble that of the country, although no formal ethnic census has been conducted in over two decades, when a military coup brought the current governing structure to power. Before the coup, ethnic tensions were very rare and Alphas and Omegas lived in every region of the country. That is still the case today, but the concentrations in their respective regions have increased since the military coup two decades ago.

Of Redland's 25 million inhabitants, 5 million live in Redville and 3 million live in Greenville, Redland's two major cities. About 60 percent of Redland's population lives in mainly agricultural villages, with the majority of these peasants belonging to the Omega ethnic group. Redland is economically underdeveloped with recent corruption and economic mismanagement causing its per capita income to decline, especially outside Redville.

Government. Two decades ago a military coup, led by Colonel Red of the Redland Air Force, overthrew the constitutional monarchy and parliament. The junta began its reign with high popular approval, especially among ethnic Alphas, which are heavily represented in Redland's officer corps, its business elite, and the government technocratic class. Omegas did have representation in the early years of the military government. Today, however, there are very few ethnic Omegas in leadership positions in Redland's institutions.

Military governance inevitably led to economic mismanagement, incompetent public administration of civilian functions, a drop in foreign investment, and increasing corruption, which transformed from being a petty feature of Redland's culture to become a major economic disease. Ethnic Alphas increasingly carved the shrinking economic pie in their favor and embittered disaffected Omegas as they did so.

Five years ago Colonel Red died, leaving his son, a weak and unserious man, as his appointed successor. In fact, a fractious and avaricious cabinet, composed entirely of Alphas, has attempted with diminishing effect to hold the government together. Omegas are left out of governance and much of the value-added sectors of the economy; the standard of living in the south and east has been in a sharp decline for at least a decade.

Foreign and military policies. Redland's external policies became sharply more aggressive following the military coup. After consolidating its position, Colonel Red's government greatly strengthened its ties to Blackland, a major power and a peer competitor of the United States. Over the past 15 years, Blackland has provided military and technical advisers to Redland's military forces and military-related industries. With Blackland's technical assistance, Redland has built a small but growing inventory of short- and medium-range ballistic missiles. Redland has also managed to acquire a world-class integrated air defense system, high-end anti-ship cruise missiles, and precision land-attack cruise missiles. Redland began a chemical weapons program and has built up militarily useful inventories of nerve agents, which it openly tests on animal subjects at a proving ground in the northwest.

The main mission for Redland's ground forces is to patrol and defend its southern border with Orangeland. Redland's army backs up its customs and border patrol forces and is responsible for the country's air defense network. Redland maintains several combined arms mechanized brigades at a high state of readiness which are thought to be capable of short-notice offensive operations, at least for potential punitive operations into Orangeland.

Finally, Redland has been contemptuous of several international legal norms. Interpol and numerous foreign intelligence services suspect that Redland provides safe haven for numerous Islamic terror figures with open international arrest warrants. Redland does not participate in either the Missile Technology Control Regime or the Proliferation Security Initiative. Finally, although it is a signatory to the Nuclear Non-proliferation Treaty, Redland refuses to allow inspectors from the International Atomic Energy Agency to inspect what is suspected to be a heavy water reactor (capable of eventually producing bomb-grade plutonium) under construction at one of Redland's military bases.

The United States lost its diplomatic and human intelligence presence in Redland a decade ago, when the government declared the entire U.S. embassy staff (in both Redville and Greenville) *persona non grata*.

Insurgency in Greenville Province

Shortly after Colonel Red's death, an armed insurgency began to self-organize in Greenville Province. This rebellion featured both urban elements in the port city of Greenville and rural components in the agricultural territory elsewhere in the province. Representative guerrilla activities include small arms ambushes on police and military convoys in the countryside and improvised explosive attacks on police and government facilities in Greenville. The responses by government security forces have been harsh but disorganized due to low troop morale and the ability of Omega forces to occasionally suborn officers in the security forces. On the other side, a lack of weapons, supplies, and secure communications equipment is severely limiting the potential capacity of the Omega insurgency.

Orangeland

Orangeland is a mid-sized and rapidly growing neighbor south of Redland. Orangeland is a successful, if fractious, parliamentary democracy, and has pursued a strictly nonaligned diplomatic strategy, coupled with a minimal investment in defense forces and supporting institutions.

The northern provinces of Orangeland (adjacent to Redland) are majority ethnic Omega. Until recently, this fact had little bearing on Orangeland's domestic politics. However, the recent deprivations suffered by Omegas in Redland have increasingly become an issue in northern Orangeland, with pressure building on the Orangeland government to revisit its longstanding policy of nonalignment and noninterference.

During a recent crackdown on insurgents in Greenville Province, three Orangeland citizens, all Omegas, were arrested and convicted of aiding the insurgency, a capital crime in Redland. The Orangeland government eventually traded a Redland intelligence officer it had convicted several years ago for the three Orangeland citizens. The Redland intelligence officer returned to a hero's welcome. The three Orangeland Omegas also returned to hero's welcomes in northern Orangeland. Their criticism of their government's failure to support Redland's Omegas and its seeming indifference to the threat posed by Redland sparked an intense debate on national security inside Orangeland.

United States' assessment of a prospective UW campaign in Redland

The president of the United States very reluctantly signed the finding that authorized the UW campaign in Redland. He did so after concluding that all the alternative courses of actions were worse. In a briefing in the White House Situation Room, the USSOCOM commander explained to the president and his national security team that the proposed UW campaign inside Redland would risk the capture and exposure of U.S. military and intelligence personnel. He also explained that given current technology and techniques, support and sustainment of the UW campaign inside Redland would be highly challenging.

The growing menace and instability inside Redland caused the Orangeland government to reexamine its longstanding policies of neutrality and noninterference inside Redland. The Orangeland government quietly approached the U.S. Government about its concerns. After a lengthy period of discussions, the Orangeland government agreed to provide covert and nonvisible support to the U.S.'s proposed UW campaign across its northern border into Redland's Greenville Province, the heart of the insurgency. This was an important success for USSOF planners. However, the USSOF support presence in north Orangeland would necessarily have to be invisible and likely small in scale. This ruled out the large conventional combat service support presence SOF had grown accustomed to during recent campaigns in Central Asia, the Middle East, and elsewhere.

The good news for U.S. policymakers and SOF planners was that there seemed to be abundant room for expanding the friendly insurgency inside

Redland. U.S. policymakers, intelligence officials, and SOF commanders held meetings with insurgent representatives in the city of North Orange, near the Orangeland-Redland border. These meetings established working relationships and provided an exchange of information about the status of the insurgency, its future plans, and its support requirements.

After these meetings the guerrilla high command agreed to host a small team of USSOF and intelligence personnel, who clandestinely came ashore on a remote stretch of Greenville Province's coastline. There the team linked up with an insurgent escort and traveled to a meeting site with the resistance movement's leadership. After touring several guerrilla camps and meeting with commanders and soldiers, the SOF team exfiltrated and subsequently delivered a positive report to SOF commanders and U.S. policymakers.

Should the U.S. UW campaign successfully enable a much larger and more effective insurgency inside Redland, there seemed to be a reasonably strong prospect of toppling the increasingly unpopular and malignant Redland government. That outcome would greatly support U.S. interests. It would remove a regime that supported international terrorism and was a likely proliferation source of chemical, biological, radiological, and nuclear weapons. Finally, a friendly regime in Redland would presumably curtail Blackland's expanding influence inside the country and the nearby region, one of the highest concerns of U.S. policymakers.

Planning a UW campaign inside Redland

U.S. policymakers and SOF planners had concluded that a UW campaign in Redland, although risky, offered the best chance of bolstering U.S. interests in the region. An assessment of the prospective campaign's potential, based on numerous meetings with insurgent leaders and an onsite inspection by USSOF and intelligence personnel, delivered a positive report. The U.S. Army's 1st Special Forces Group assigned specific detachments to the prospective UW campaign and began focused preparation for the forthcoming mission.

Unfortunately, SOF planners found doctrine for logistically sustaining the upcoming distributed UW campaign inside denied territory to be vague and superficially brief. Combat service support doctrine as it relates to UW has not kept pace with the development of other aspects of UW doctrine.[11] United States Army Special Operations Command (USASOC) has a specialized organization—the 528th Sustainment Brigade, Special Operations (Airborne) (SBSO(A))—designed to provide logistics, medical, and communications support to its deployed SOF units.[12] However, it has been over four decades since the U.S. Government last attempted a significant UW campaign into a defended, access-denied area.

We should assume that commanders and planners in the 528th SBSO(A) and the broader SOF community are aware of the unique challenges of such a scenario and consider it in their planning. But there are questions about whether SOF sustainment units currently have personnel adequately trained to conduct nonstandard UW logistics in challenging access-denied environments, and whether these personnel have the experience in planning and resourcing UW operations in denied or semi-denied areas.[13]

The SOF community had long become used to operating alongside conventional military forces and their abundant combat service support infrastructure. The highly successful UW campaign in Afghanistan in late 2001 benefited from a relatively secure rear area controlled by the Northern Alliance, which SOF sustainment elements were able to access without opposition. As a result, SOF planners have had no recent experience with the scenario presented by the upcoming UW operation in Redland. Planners at Special Operations Command—Pacific (SOCPAC) and 1st Special Forces Group, supported by a permanently assigned liaison team from the 528th SBSO(A), concluded that they would have to improvise a logistics sustainment plan, using their own judgment and resources to do so.[14]

Planning logistics support for a UW campaign in Redland

SOCPAC, 1st Special Forces Group, and Army Special Operations Forces (ARSOF) Liaison Elements (ALEs) from the 528th SBSO(A) began their logistics planning by referring to Chapter III, Section F (Logistics) of Joint Publication (JP) 3-05.1/*Unconventional Warfare* (Initial draft).[15] This doctrinal publication provided a very basic outline for organizing logistics support to a UW campaign, but provided little detail or guidance on how to actually execute such a sustainment effort.

From JP 3-05.1, the planners were reminded that they would have to establish a logistics support operation that would have to execute the following functions:[16]

1. **Supply chain infrastructure.** For supply and equipment items that the guerrilla force could not procure from its own indigenous sources or through battlefield recovery, SOF planners would have to establish supply chains from product origin (the U.S. or elsewhere) to the guerrilla's base camps.[17] One critical link in these chains would be intermediate staging facilities in both northern Orangeland and at sea. Major considerations regarding supply chain infrastructure would include operational security and storage security.

2. **Supplies.** SOF planners would have to establish several categories of supplies, systems for tracking their demand, and systems for tracking their location in the supply chain and for custodial responsibility. Categories would include supplies and equipment required by U.S. forces and those required by the guerrillas. Further categories would include supplies procured through battlefield recovery, from indigenous sources, from U.S. sources, and from third-party sources.[18]

3. **Transportation.** The first phase of the transportation problem would be the inter-theater shipment of supplies and equipment to intermediate staging facilities. A paramount concern would be techniques and procedures for inter-theater shipment that would preserve operational security. The second and far more challenging phase would be transportation of supplies and equipment into Redland, which would require clandestinely and repeatedly transgressing Redland's border and its access-denial military defenses. The transportation challenge would only intensify as the insurgency grew in strength, a fundamental goal of the UW campaign plan.[19]

4. **Communications.** SOF planners and insurgent forces would need to establish a communication network that eventually would span from the United States through intermediate points in the chain of command and logistics chain and all the way to SOF detachments operating with insurgent forces inside Redland. Redland's relatively sophisticated military forces would present a challenge to communication planning; planners would have to contend with Redland electronic attack and electronic intelligence capabilities.[20]

5. **Medical.** Sustaining the insurgency would require increasing the quality and quantity of medical support (for humans, pack animals,

and livestock), especially in anticipation of the insurgency's hoped-for growth. Supported medical functions would include preventive care (especially for tropical diseases), battlefield care, local aid stations, and guerrilla hospitals and convalescent facilities. The medical and transportation plans would also have to account for the rapid evacuation of certain casualties out of Redland in order to receive required care.[21]

6. **Financial.** SOF will rely heavily on various financial resources to successfully execute a UW campaign. SOF will have to establish procedures for transporting banknotes, informal currencies, barter goods, precious commodities, and electronic funds into the proposed UWOA for use in procuring supplies and equipment, paying for labor, and suborning Redland security forces. Financial arrangements will also require procedures for accounting and custody.[22]

The UW logistics planning and execution cycle

After understanding the six logistics functions they would have to execute, the SOF planners at SOCPAC, 1st Special Forces Group, and 528th SBSO(A) ALEs concluded that they would have to formulate for themselves a generalized model of UW campaign resupply action, since no such model currently exists in doctrine.[23] A six-phase generalized resupply model serves as guidance for what the Joint Special Operations Task Force in and around Redland will have to execute during the forthcoming UW campaign.[24] These six phases are:

1. Receive the mission, namely to establish and operate comprehensive logistics networks to support SOF and guerrilla forces executing a UW campaign in Redland.

2. Conduct a multi-category UW logistics feasibility assessment. This phase will be explained in more detail in the next section.

3. Determine nonstandard resupply approaches. The Redland UW campaign will occur in denied territory protected by high-end access-denial forces and networks. This will require nonstandard resupply approaches through the air, by water, over land, and underground in order to deliver supplies and equipment to SOF and guerrilla forces inside Redland.

4. Incorporate a coordinated, supporting military deception plan with the resupply approach. Deception will be required to access Redland and to maintain the secrecy of the campaign.

5. Execute the UW resupply operation.

6. Incorporate feedback into future resupply operations as necessary.

This generalized model of nonstandard UW logistics operations illuminates some of the substantial differences that exist between conventional military logistics operations and those in support of UW campaigns. UW logistics operations require the assessment of unique factors (explained in the next section). UW logistics operations require the application of nonstandard resupply techniques (smuggling and tunneling are such examples). Finally, UW logistics operations require unique forms of deception that greatly differ from those required for conventional operations.

A four-factor UW logistics assessment model

The SOF planners began to assemble their improvised sustainment plan by referring to a four-factor UW logistics assessment model. The model's four factors are the security situation in UWOA; the physical environment of the UWOA; infrastructure in the UWOA; and the status of the supported guerrilla force.[25]

1. Security situation in the UWOA. The SOCPAC, 1st Special Forces Group, and 528th SBSO(A) ALE planners produced a mixed assessment of the security situation in Greenville Province, the heart of the insurgency and the proposed UWOA. On the favorable side of the ledger, planners concluded that a large majority of the population in the province either actively supported the guerrillas or avoided taking sides. In doing so they did not supply intelligence and support to the government's security forces. Redland's police, especially in Greenville Province, were mostly inefficient and easily corrupted, factors which the guerrillas used to their advantage. Over a decade ago, the late Colonel Red had organized a brutally efficient secret police force responsible for internal security. However, owing to fears of a palace coup led by the secret police, the current collective leadership of Redland has largely disbanded the force, much to the benefit of the guerrillas. As a result, the insurgency has been able to establish havens for training and rear area operations in Greenville Province's cities and rural areas.

More worrisome for the planners was the high quality of Redland's border security and conventional military forces. Redland possessed an advanced and dense integrated air defense system. Its border patrol and customs officials were more efficient and less corrupt than the common police. Redland's navy and coast guard efficiently patrolled Redland's coast and harbors.

The UW logistic planners concluded that Redland had a 'hard shell and soft interior.' It would be difficult and risky to move people, equipment, and supplies across Redland's frontiers, but once inside, the insurgents would be able to make good use of the support they thus obtained.

2. Physical environment of the UWOA. The physical geography and climate of Greenville Province was mostly favorable to the insurgency. The province's tropical climate allowed year-round operations while the swamps and jungle provided cover for small insurgent bases. The province's agricultural output could also sustain a cadre guerrilla force should a surge in government security activity force the insurgency into deep hiding. That said, a monsoon season and periodic cyclones would threaten potential aerial and seaborne resupply techniques.

3. Infrastructure in the UWOA. The infrastructure of Greenville Province—its road network, seaports, coastline, facilities along the Green River, and its airports—on balance were not helpful for the insurgency. Greenville City's seaport and airport were firmly in government hands, with the customs officials and inspectors efficient and generally not open to subornation by the insurgency. This ruled out these facilities as significant access points for supplying the insurgency. There were numerous stretches along the ocean coast and along the banks of the Green River where insurgents could recover supplies. But surface landing craft would first have to get past naval and coast guard patrols to reach these points. Similarly, the SOF planners discovered numerous farm fields and open patches of terrain where guerrillas could recover supplies delivered by air. But these air deliveries would first have to get past Redland's robust air defenses.

Finally, the road network in the rural area of Greenville Province was sparse. The SOF planners concluded that this on balance favored the government's security forces. The limited number of roads made it easier for the security forces to monitor the movement of the guerrillas. Although the shortage of roads made it more difficult for the government to access the province, its helicopter-borne capabilities mitigated this shortfall, a capability the guerrillas completely lacked.

4. Status of the guerrilla force. The status of the insurgent force is the final factor in the assessment model. The SOF planning team concluded the insurgency was well organized to accommodate an expansion in its order of battle. It enjoyed operating havens inside the province even as access through the 'hard shell' remained a problem. Also notable was the support the insurgency enjoyed among the population in northern Orangeland. This could prove helpful to supporting the insurgency across Redland's southern border.

Study of historical U.S. UW campaigns

The SOCPAC, 1st Special Forces Group, and 528th SBSO(A) ALE planners then looked to past U.S. UW campaigns in denied areas. A review of historical case studies of logistical support to UW operations inside denied areas revealed a universal reliance on aerial delivery of equipment and supplies to U.S. adviser teams and the guerrillas they supported.[26] The cases studied in this historical review included an Office of Strategic Services (OSS) unit operating in Burma during World War II; support to an anti-Communist partisan unit operating north of the 38th Parallel during the Korean War; the Central Intelligence Agency's support from 1956 to 1974 to an insurgency in Tibet; and support to various anti-Communist resistance forces in Southeast Asia during the Vietnam War (1960 to 1975). In all of these cases, resistance forces were unable to sustain themselves purely by living off the land or through battlefield captures of equipment, weapons, and supplies. In all cases, the United States provided support through aerial delivery, usually on a large scale.[27]

In the case of the forthcoming UW campaign in Redland, SOCPAC, 1st Special Forces Group, and 528th SBSO(A) ALE planners were very skeptical that aerial resupply, at least with current technology and techniques, would be a feasible way of supporting and sustaining the planned expansion of guerrilla forces in Greenville Province.[28] Redland's integrated air defense system seemed to preclude aerial supply to meet the goals of the UW campaign they contemplated. Supply by sea seemed equally problematic due to the patrolling efficiency of Redland's navy and coast guard.

That left Redland's southern border and the employment of nonstandard supply techniques across that border, a euphemism for smuggling.[29] A modest amount of smuggling activity occurred across the border. This smuggling activity was limited to mainly illicit consumer goods such as drugs, banned media, and consumer items that were in short supply inside Redland due to strict price controls. Heretofore there was little history of smuggling weapons and military items through Redland border checkpoints and so there remained great uncertainty about whether Redland border inspectors could be suborned to accommodate weapons smuggling to the extent that they were suborned to permit the smuggling of consumer products.

In summary, SOCPAC, 1st Special Forces Group, and 528th SBSO(A) ALE planners faced significant challenges formulating a feasible plan to logistically support the planned expansion of the insurgency in Greenville Province. Ever since the 1942 behind-the-lines effort conducted by the OSS in Burma, United States UW campaigns have heavily relied on aerial delivery of equipment and supplies through airspace that was either uncontested or that was dominated by U.S. airpower. Redland's integrated air defense system ensured that would not be the case over Greenville Province, at least as it applied to the aircraft technology and techniques available to SOF. There were seaborne and riparian approaches into the province. But planners doubted that surface craft would be able to get past Redland's naval and coast guard patrols in the numbers and reliability needed to support the UW campaign plan. The U.S. Navy was unwilling to risk its submarines for the campaign, and they were unsuited in any case for the sustainment mission. That left smuggling across the southern border, an unfamiliar and largely untried practice for SOF on the scale that the campaign would require.

USSOCOM, SOCPAC, and 1st Special Forces Group had the other elements of the campaign plan in place. It had assessed the internal prospects for the insurgency and found them favorable. Congress had appropriated funding for the mission. 1st Group detachments were trained and ready to infiltrate Greenville Province to support the expansion of the insurgency. The Group Support Battalion, assisted by 528th SBSO(A) ALEs, formed forward logistic element teams to support deployed operator detachments from sites in northern Orangeland and inside Greenville Province.[30] Other U.S. Government agencies were standing by to provide their supporting functions. The final barrier to success was logistics tactics and techniques that could clandestinely penetrate Redland's hard shell, supply and equip the buildup of the insurgency, and sustain it across the years of campaigning ahead.

The SOF units and planners assigned to the campaign would benefit from emerging technologies and techniques that could reliably overcome the access barriers into Redland, provide sustainment and mobility to distributed SOF and insurgent forces in the UWOA, and reduce their demand for outside sustainment, which would ease the burden on whatever logistics system emerged from the planning process.

The remainder of this monograph will discuss emerging technologies and techniques that promise to address the logistics and sustainment barriers described in the Redland scenario. The monograph will conclude with recommendations for a research and development agenda focused on improving the sustainment of SOF distributed operations in access-denied environments.

2. Technologies and Techniques for Delivering Supplies, Equipment, and Personnel to Distributed SOF Executing a UW Campaign in a Denied Area

Unconventional warfare is distinctive for the challenges it presents to logisticians tasked with supporting such an operation in potentially non-permissive environments and perhaps on a large scale.[31] Logistics systems for conventional military operations are typically designed to function within optimized supply chains. Logistics support to UW campaigns, however, is carried out through nonstandard supply networks, the consequence of executing clandestine operations in access-denied areas.[32]

Due to constraints on access to a UWOA and the need to maintain secrecy, guerrilla forces and SOF operators supporting a UW campaign will be inclined to look first to foraging; battlefield recovery of weapons, ammunition, and supplies; and indigenous sources to supply guerrilla formations.[33] Relying on purely internal sources of sustainment reduces the insurgency's dependence on outside provision, mitigates the consequence of a sudden and unexpected cutoff of outside support, and reduces the political exposure of the United States and its partners who would otherwise have to run higher risks in order to support a guerrilla force from the outside.

These advantages can come at a price, however. A nonstandard logistics operation that can move meaningful quantities of supplies and equipment across a denied frontier offers the potential of a substantial competitive advantage for the guerrilla force and thus an acceleration of its insurgency. Such an outside-source logistics capability could tilt the initiative to the insurgency and provide it the opportunity to culminate the campaign, a prospect it might not otherwise have if it had to depend solely on foraging, battlefield recovery, and other internal sources.

Finally, certain items and services—such as high-quality medical equipment and supplies, secure communications equipment, night vision equipment, certain advanced weapons and optics, and intelligence and early warning—may only be available in quantity to the guerrillas from a SOF-operated logistics system. These types of items may be critical for maintaining the morale of the guerrilla force and for providing the competitive advantages it will require to prevail over government security forces.

SOF planners should thus prepare to establish multi-dimensional and multi-modal nonstandard logistics networks for the UW campaigns they have been ordered to support.[34] The following sections of this chapter will examine aerial, seaborne, terrestrial, and subterranean methods of delivering supplies, equipment, and personnel to SOF operators and guerrilla forces operating inside an access-denied UWOA. Each of these sections will describe current capabilities as they relate to the UW mission requirement explained in Chapter 1 and discuss the shortcomings of current techniques and technology. The sections will then explain new research, development, and engineering approaches that could close gaps between current capabilities and what potential pacing UW missions will require.

Aerial delivery

As with past UW campaigns since 1942, SOF logisticians executing future UW campaigns are very likely to rely on aerial delivery as the primary means of delivering routine and bulk supplies and equipment to guerrilla forces and the SOF operators supporting them. The United States is one of the few countries to possess a variety of air power forms with global reach. Air power, including various forms of aerial delivery, is a competitive advantage possessed by U.S. forces. In addition, U.S. military forces are the leaders in low-observable (stealth) technology and the tactics and techniques required to penetrate sophisticated air defense systems. As a result, with the exception of unusual situations, aerial delivery is likely to be the method that offers the greatest resupply capacity, promptness, reliability, and flexibility compared to alternatives such as seaborne delivery or smuggling across borders or through tunnels (techniques discussed later in this chapter).

Helicopters and their limitations for UW campaigns

Until the recent advent of precision guided parachutes, helicopters have been the U.S. military's most-used technique for bringing supplies and personnel into and away from distributed outposts. However, in a scenario where the adversary possesses a sophisticated integrated air defense system, we should not expect helicopters to be the routine method of sustaining SOF operators and friendly guerrilla forces operating inside an access-denied UWOA.

In such a case, helicopters will have a role for the rare insertion or extraction of personnel. An example of such a rare use of helicopters would be emergency evacuations of casualties. But given the importance of such instances, it will be critical to avoid overusing the helicopter option for routine resupply tasks in order to deny the adversary opportunities to learn and adapt his air defense system to countering helicopter operations. SOF commanders and logisticians executing a UW support campaign should thus develop other methods of cross-border transport in order to preserve the helicopter option for truly critical missions.

It is unlikely that cargo helicopters, due to their size, shape, and characteristics inherent to rotary wing aircraft, can be made as stealthy as fixed-wing aircraft.[35] In addition, stealth is not a yes or no proposition, but a matter of degree that air mission planners consider when assessing a particular adversary's air defense capability, and when planning ingress and egress routes in and out of hostile airspace.[36] Thus the utility of helicopters, including those with reduced signatures, will depend on particular circumstances that must account for adversary air defenses in the mission area, surprise, the mission's importance, and the willingness to accept risk. The utility of helicopters for the support of UW campaigns can thus vary widely based on these and other factors.

Beginning in 2011, the U.S. Marine Corps began using the K-MAX unmanned autonomous cargo helicopter to deliver supplies and equipment to distributed combat outposts in Afghanistan. K-MAX can carry 6,000 pounds of cargo at sea level and 4,000 at 15,000 feet density altitude.[37] K-MAX unmanned helicopters flew 1,730 resupply sorties for the Marine Corps in Afghanistan, delivering four million pounds of cargo.[38]

We should expect all of the services to continue developing unmanned aerial systems (UAS) technology, including more capable successors to K-MAX. USSOCOM logistics planners should monitor these developments and look for applications to distributed UW operations. However, unmanned autonomous cargo helicopters still possess roughly the same signature problems and vulnerabilities as manned versions. Although there would not be a risk to a flight crew with such a UAS, high signature systems, manned or unmanned, may not be a clandestine, reliable, or affordable delivery method to forces operating inside an access-denied UWOA.

As a planning rule, SOF commanders and logisticians should prepare other transport means for routine deliveries of bulk supplies and equipment,

Figure 1. U.S. Marines with Combat Logistics Battalion 5 return from familiarizing themselves with the downward thrust of a K-MAX unmanned aerial vehicle during initial testing in Helmand province, Afghanistan. Source: U.S. Marine Corps photo by Corporal Lisa Tourtelot

and reserve helicopters for only the most critical and emergency missions involving (generally) the evacuation of personnel from access-denied UWOAs.

SOF fixed-wing aircraft and their limitations for UW campaigns

Air Force Special Operations Command (AFSOC) operates several fixed-wing aircraft types with missions to support SOF in high-threat or access-denied areas. The MC-130J Commando II aircraft is a variant of the C-130 cargo and troop transport aircraft and is modified to perform special operations missions. According to its U.S. Air Force fact sheet, the MC-130J:

> flies clandestine, or low visibility, single or multiship, low-level air refueling missions for special operations helicopters and tiltrotor aircraft, and infiltration, exfiltration, and resupply of special operations forces (SOF) by airdrop or airland intruding politically sensitive or hostile territories.[39]

The MC-130J will achieve covert infiltration and exfiltration from defended airspace by flying at night and at low altitudes, using terrain to mask adversary radar coverage. The MC-130J's ability to safely fly at low levels at night and in bad weather will be enhanced after these aircraft receive new terrain-following/terrain-avoidance radar, which has yet to be installed on this variant.[40] When it is fully capable, the MC-130J (along with its MC-130 predecessors) will be able to deliver 42,000 pounds of payload or dozens of personnel to ongoing special operations missions and exfiltrate battlefield casualties and personnel from expeditionary air strips.

AFSOC also operates the CV-22 Osprey tiltrotor aircraft. The CV-22 combines vertical takeoff and landing with the long range, fuel efficiency, and speed of fixed-wing turboprop aircraft. According to its U.S. Air Force fact sheet, the CV-22 is:

> equipped with integrated threat countermeasures, terrain-following radar, forward-looking infrared sensor and other advanced avionics systems that allow it to operate at low altitude in adverse weather conditions and medium- to high-threat environments.[41]

The CV-22 can deliver up to 32 personnel or 10,000 pounds of cargo, and exfiltrate battlefield casualties without the need for an air strip on which to land.

These two aircraft are likely the most capable cargo aircraft in AFSOC's inventory for supporting distributed SOF operators executing a UW campaign inside an access-denied UWOA. With their advanced night vision equipment, avionics, navigation tools, terrain-following/terrain-avoidance radar, advanced communications equipment, defensive sensors, and other features, they are the best equipped U.S. cargo aircraft to infiltrate and exfiltrate from heavily defended airspace. However, such missions, when repeated, will become increasingly risky as adversary air defense forces inevitably adapt to their operations. As with helicopter usage, SOF commanders and logistics planners will likely tightly ration the employment of these fixed-wing capabilities in a prospective UW campaign against an adversary possessing a capable integrated air defense system. AFSOC's fixed-wing/tiltrotor resupply assets will be a highly important benefit for a UW campaign. But SOF logisticians should not plan on relying on these capabilities for routine resupply into a denied UWOA. SOF logisticians should plan on reserving these capabilities for the most critical and infrequent situations that occur during the course of a long UW campaign.

Precision delivery of supplies by parachute

Experience derived from the first few years of Operation Enduring Freedom (OEF) in Afghanistan (October 2001 to December 2014) indicated the need for a much better method of delivering supplies and equipment to the growing number of coalition outposts in that country. Parachute airdrops of humanitarian aid and supplies to Afghan citizens occurred on the very first night of the war.[42] But OEF soon faced numerous logistics challenges. Many combat outposts were eventually established on steep and remote terrain that was in most cases either inaccessible to surface transport or located in ways that made supply convoys highly vulnerable to enemy attack. A shortage of helicopters greatly hampered the logistics effort. Unguided parachute airdrops were employed in the early years of OEF, but the results were deemed unacceptable to ground warfighters.[43]

The solution was the Joint Precision Airdrop System (JPADS), which became a Rapid Combat Fielding Initiative program in 2004, managed by the U.S. Army Natick Soldier Research, Development, and Engineering (RD&E) Center's Aerial Delivery Directorate.[44] JPADS employs a steerable parachute canopy, an attached airborne guidance unit that receives global positioning system (GPS) telemetry, electro-mechanical steering actuators to guide the canopy, and a mission planning kit to program the rig where to land.[45] The result is the capacity to airdrop cargo bundles of varying sizes (from 10 pounds to 42,000 pounds) from as high as 25,000 feet mean sea level and 20 miles horizontally from the target, and deliver these bundles precisely to soldiers in the field.[46] The accuracy experience of JPADS with a standard 2,000 pound load is 80 percent of such attempts land within 80 meters of the target.[47]

JPADS made its combat debut in Afghanistan in August 2006.[48] It proved critical to supplying numerous combat outposts in Afghanistan. Before U.S. Army planners fully realized the high utility of the JPADS concept, they expected that a purchase of 5,300 units would satisfy Army needs for 20 years. Instead, in 2011 the Army was purchasing a JPADS variant (the Low Velocity-Low Cost Aerial Delivery System) at a rate of 10,000 units per month in order to sustain over 29,000 soldiers at 42 forward operating bases in Afghanistan.[49] In 2011, over 85 million pounds of cargo were delivered by precision parachute airdrop in Afghanistan.[50]

Research to improve the JPADS concept continues. Planned refinements to the concept include further improvement in accuracy (rooftop landings to be regularly achieved by 2020), reduced costs for JPADS units, and reducing or eliminating the reliance on GPS telemetry for aerial delivery operations in denied areas.[51]

Figure 2. A JPADS guides itself to the ground following its drop from a C-130 aircraft at Normandy Drop Zone in Fort Bragg, North Carolina. Source: U.S. Army photo by Sergeant Amanda Tucker

Using stealthy aircraft for JPADS delivery in denied areas

Executing aerial delivery through sophisticated adversary air defenses will require SOF logisticians, the joint force, and contractors to adapt aerial delivery packaging for low-observable aircraft such as the F-35 A/B/C (operated by the U.S. Air Force, Marine Corps, and Navy, respectively) and the B-2A operated by the U.S. Air Force.[52] These aircraft have been designed to penetrate and operate inside adversary air defense systems in order to precisely deliver numerous ordnance types on a variety of targets. Aerial delivery of supplies should be added to this list of missions and capabilities for these strike aircraft.

The U.S. Air Force's F-35A has two internal weapon bays, each of which can carry one 2,000-pound GBU-31 guided bomb (weapons must be carried only in the internal bays in order for the F-35 to retain its low radar observable characteristic).[53, 54] Alternatively, the F-35A will be able to carry four GBU-39B small diameter bomb units in each of the two weapons bays. The GBU-39B is a 250-pound weapon.[55] The U.S. Air Force's B-2A long-range stealth bomber can deliver 16 GBU-31s or 80 GBU-38s.[56] These two stealthy strike aircraft are platforms USSOCOM and its service and contractor partners could seek to employ as a delivery method for resupply missions inside areas defended by high-end integrated air defense systems.

As discussed above, the 2,000-pound air delivery bundle became the most frequent JPADS size employed during parachute resupply operations in Iraq and Afghanistan. To make use of the F-35 and B-2 aircraft for resupply through air defense systems, designers would have to fabricate a safe, highly reliable, and balanced casing that could mate to the weapon deployment hardware and software in the two aircraft. The casings would also have to support the parachute equipment and deployment method associated with JPADS. The Air Force has long experience with this particular requirement since its nuclear gravity bombs (including the B61-11, still in the inventory) have for decades been equipped with parachutes to slow their descent after release.[57]

The result of this development effort would be a container that could be deployed from F-35 and B-2 aircraft inside an adversary air defense system. The container would use JPADS to deliver the cargo precisely to friendly forces on the ground. Engineers should develop 2,000-, 500-, and 250-pound containers resembling the GBU-31, GBU-38, and GBU-39B sizes of bomb casings. With this variety of container sizes, one aircraft sortie could deliver resupply containers to several distributed SOF elements operating with guerrilla forces across a UWOA.

Engineers would face several challenges implementing this concept. The JPADS-adapted parachute system would have to meet the high safety standards aircraft operators would demand for cargo deployed from the weapon bays of very high-value aircraft. Logisticians would have to learn how to properly load these containers in a manner that meets weight and balance and safety requirements. Finally, UW logisticians would have to take into account the environmental extremes (such as air temperature and pressure) that such cargo would have to endure during flight and deployment.

Low-observable aircraft with small radar signatures are not invisible to radar. But small radar cross sections increase the difficulty for air defense systems to reliably engage such aircraft when the attacking stealthy aircraft crews properly plan their routes. For a UW campaign, the adversary government would likely know that the U.S. Government was employing stealthy aircraft to deliver supplies; U.S. policymakers would have to be prepared if the adversary government publicly raised objections.

But in spite of these challenges, aerial delivery from stealthy aircraft such as the F-35 and B-2 offers the potential of a flexible, prompt, reliable, and high-volume resupply delivery channel to distributed SOF supporting a UW campaign inside a denied area.

Using micro unmanned aerial vehicles to deliver supplies

Very small unmanned aircraft, applied with scale, have the potential to clandestinely deliver low-weight, high-value supplies and equipment across defended borders. For decades, recreational hobbyists have flown radio-controlled small model aircraft. These aircraft have been powered by small liquid-fueled or battery-powered motors. Using such aircraft to deliver illicit supplies across a defended border would not be a new development; drug smugglers in Mexico have employed micro unmanned aerial vehicles (UAVs) to deliver contraband cargo across the U.S. southwestern border.[58]

Commercially available and off-the-shelf hobbyist micro UAVs can easily be fitted with auto-pilot systems directed by GPS signals. The unit cost of such a micro UAV would range from $500 to $1,000. Given their size and composition, these micro UAVs would be difficult for air defense radars to detect. They could be vulnerable to small arms fire, but resupply operations could take place at night using remote egress routes.[59]

Current micro UAVs are capable of delivering one kilogram (2.2 pounds) at a delivery radius of 30 kilometers. New micro UAVs will soon be available that will deliver two kilograms to points 50 kilometers distant. These are admittedly small loads per aircraft. But given the low unit cost of the aircraft, it is feasible to scale up the delivery effort into a micro UAV 'conveyer.' Logisticians could organize the launch and recovery of up to 200 aircraft during one night, which would deliver over 400 pounds of cargo to one or more destinations inside a UWOA.[60]

The micro UAV concept could be employed on a small scale to deliver high-value items such as medical supplies, vaccines, cash, and water purification equipment. On a larger scale, the concept could deliver routine supply classes to combat outposts, patrols, and remote guerrilla and SOF operator sites. Although preparing 200 micro UAVs for a night mission would be a tedious task and would risk creating an unfavorable signature in the host country, spreading the load among that many delivery vehicles would mitigate the risks when delivery aircraft are lost to malfunction or enemy action.

In sum, micro UAVs are another affordable and practical method for delivering some classes of supplies and equipment across a defended frontier. Improving electronics, batteries, and small motors now make it feasible to fashion and employ very small unmanned systems as cargo delivery aircraft. This will provide one more tool for SOF logisticians to consider when designing a nonstandard logistics system to support UW campaigns in access-denied areas.

Seaborne delivery of supplies and equipment to a denied UWOA

Throughout history, cargo ships have been used to deliver supplies, equipment, and personnel to war zones to support military campaigns. However, in the case of a UW campaign occurring in an access-denied area, traditional maritime shipping techniques are unlikely to be suitable. Against an adversary with significant naval power, maritime surveillance capability, and coastal patrol and defense capacity, even the delivery of supplies by small vessels at night to remote coastlines may not be feasible. Even so, seaborne approaches offer the potential for delivering substantial amounts of supplies to SOF operators and guerrilla forces. Innovative techniques may be able to exploit this potential.

SOF logisticians should develop the concept of using small unmanned autonomous submarines to deliver supplies to SOF operators and friendly guerrilla forces operating inside a denied zone. These undersea vehicles could be deployed in international waters by Navy or leased commercial ships (or by parachute from cargo aircraft). They would then autonomously sail to a preset destination to rendezvous with SOF operators and guerrilla forces. After delivery of the cargo, the unmanned undersea vehicle (UUV) would return to a preset point in international waters for recovery and reuse.

Figure 3. Members of Submarine Development Squadron Detachment 5 (SUBDEVRON 5 Det.) Unmanned Undersea Vehicle (UUV), Keyport Undersea Warfare Center, and Penn State University lower SUBDEVRON 5 Det. UUV's first UUV LTV-38 into the water to conduct its first in-water training. Source: U.S. Navy photo by Breanna Zinter

The U.S. Navy is developing UUVs for missions centered mainly on reconnaissance and expanding maritime domain awareness. UUVs will also be increasingly used for dangerous missions such as countering adversary naval mines. As with unmanned vehicles in other domains, the Navy foresees using unmanned vehicles for "dull, dirty, dangerous, and distant" operations, freeing up manned platforms to perform higher-complexity missions.[61] Logistics operations are almost never mentioned as possible roles for UUVs.

In its unclassified "U.S. Navy Program Guide 2015," the U.S. Navy describes two UUV programs. The first program is the Large Displacement Unmanned Undersea Vehicle (LDUUV), which the Navy is developing to achieve "robust, long endurance, persistent, multi-mission, unmanned undersea vehicle capability for the Navy," presumably for a variety of reconnaissance, anti-submarine, and counter-mine missions. The LDUUV is still under development with fielding expected by 2022.[62]

A possible example of the LDUUV concept might include the Proteus mini-submarine developed by Huntington Ingalls Industries. In unmanned autonomous mode the Proteus mini-sub can deliver 3,600 pounds of cargo to a destination 350 nautical miles distant at a speed of 10 knots and a depth of up to 200 feet. Proteus has 170 cubic feet of cargo space, enough for six swimmers, thus providing an infiltration and exfiltration option from a UWOA for SOF operators.[63]

A second Navy program is the Littoral Battlespace Sensing-Unmanned Undersea Vehicles (LBS-UUV). These vehicles comprise both long-endurance buoyancy-powered undersea gliders and electrically powered UUVs. The missions of the LBS-UUVs include oceanography, anti-submarine operations, mine countermeasures, expeditionary operations, naval special warfare planning and execution, and persistent intelligence preparation of the environment. The LBS-UUV set of vehicles is operational at several overseas locations.[64] These UUVs in service may be candidates for adaptation as cargo carriers for UW sustainment.

There are several additional UUVs that have been developed in the private sector. Commercial firms such as oil exploration and telecommunication companies need advanced and persistent access to their undersea assets. As mentioned above, utilizing commercial technology could contain development costs, speed acquisition of needed capabilities, and provide plausible deniability for clandestine operations. The Bluefin UUV, developed by the Battelle Company, is a large autonomous UUV being developed for both military and commercial applications. In September 2013, a Bluefin UUV prototype autonomously sailed underwater from Boston Harbor to New York Harbor, a distance of over 500 miles, in 109 hours.[65] There are similarities between this achievement and a mission a SOF logistician might assign to a cargo delivery UUV.

We can thus see that UUV technology has advanced to the point where cargo delivery by such vehicles to SOF supporting UW campaigns could become a feasible operational concept. USSOCOM should partner with the Navy and outside contractors to develop this concept and deliver the capability to SOF planners and logisticians.

Overland and subterranean delivery of supplies and equipment to a UWOA

SOF and guerrilla forces will likely have to establish and use terrestrial and subterranean cross-border channels to move supplies and equipment into a UWOA, and to infiltrate and exfiltrate personnel from the campaign. For a UW campaign against an adversary with robust border defenses and access-denial capabilities, the terrestrial and subterranean movement of supplies, equipment, and personnel will essentially constitute smuggling, an ancient art dating back thousands of years.

The employment of pack animals across unpatrolled portions of borders, along with cash and in-kind payments (bribes) to border security personnel, might be the most ancient smuggling techniques of all, and will undoubtedly need to be employed by SOF and guerrilla forces in a future prospective UW campaign.[66] However, SOF UW logistics planners should examine several emerging technologies that could be useful in exploiting terrestrial and subterranean movement opportunities. These technologies include additive manufacturing or 3-D printing; the manipulation of adversary databases through cyber intrusion; and the development of an expeditionary tunneling capability. The following sections will discuss these approaches.

Using 3-D printing to support smuggling

In situations where the use of pack animals is not practical or provides insufficient capacity, UW logisticians will usually have to employ cars and trucks to smuggle cargo across borders. That in turn will almost certainly require concealment preparation of the vehicle prior to attempting a crossing through a controlled border checkpoint. In order to conceal illicit cargo on vehicles, smugglers have long used false compartments to hide cargo from border security personnel.[67]

Additive manufacturing, or 3-D printing, can greatly ease the task of fabricating customized panels, containers, concealment vessels, and other such modifications to vehicles in order to hide cargo from border inspectors. Examples of such modifications include car and truck batteries with most of the cells removed to free up space for contraband and fuel tanks similarly subdivided with panels to conceal illicit cargo.[68] Logisticians employing vehicles to smuggle cargo through border checkpoints will likely have to use a wide variety of vehicle types during a campaign; improvisation rather than standardization will likely be the norm. For this reason, a 3-D printer's ability to fabricate one-off customized parts will be a valuable feature for such a line of effort.

SOF UW logisticians located at an intermediate logistics point on the friendly side of the border could use 3-D printing equipment to fabricate concealment parts that would be customized for each vehicle and transport mission requirement. The use of 3-D printing technology would allow logisticians to quickly and easily prepare numerous vehicles for customized mission requirements. 3-D printing is an increasingly ubiquitous technology, a characteristic that would support plausible deniability for those inevitable occasions when border security personnel uncover a smuggling attempt. Finally, 3-D printing could be used to create license plates, passport covers, false documents, and spare parts supporting the UW logistics line of effort.[69]

Using cyber intrusion techniques to manipulate adversary security databases

It is becoming standard for national security forces to employ biometric data, collected in databases available to security personnel at border crossings and points of entry, to reliably verify the identities of people attempting to enter their countries. For example, the U.S. Government requires visitors to the United States to submit 10 fingerprints during pre-travel visa interviews. These fingerprints enter a permanent database that U.S. Customs and Border Protection personnel later access when a person appears at a U.S. point of entry.[70] Other biometric information now commonly used includes computerized facial recognition and scans of irises.[71]

The use of biometric databases by border security personnel will greatly reduce the ability of people attempting to illicitly cross through border checkpoints through the use of forged travel documents and disguises.[72] This development will have deleterious implications for SOF logisticians and guerrillas who are attempting to smuggle supplies, equipment, and personnel through hostile and controlled border crossing. Prospective smugglers who cannot obtain prior clearance in a target country's biometric database may find it difficult or impossible to obtain low risk access through controlled points of entry. In the past, smugglers used forged documents, disguises, and bribes to obtain access. But biometric databases threaten to greatly reduce the utility of at least forged documents and disguises.

Cyber intrusion capabilities may in some cases offer a solution to this problem. In this case, DOD or other U.S. Government cyber forces would clandestinely access the target country's border security databases and create approved files for prospective SOF, other government agency, and guerrilla border crossers. These files would include the required biometric data that border security personnel will collect at the point of entry to compare to the approved database. When successful, this use of clandestine cyber intrusion will facilitate the movement of SOF operators, other government personnel, and friendly guerrilla personnel through border checkpoints, along with concealed supplies and equipment they may be transporting in vehicles.

Subterranean supply channels into access-denied UWOAs

Highly sophisticated tunnels are increasingly used by non-state military forces and transnational criminal organizations as techniques to move supplies, equipment, and personnel. Tunnels should also be useful for sustaining UW campaigns across defended frontiers.[73] In 1990, U.S. border security personnel discovered the first tunnel constructed and employed by drug cartels across the southwest border. Through 2011, security personnel exposed 154 illegal tunnels across the U.S. frontier.[74] How many were constructed during this period or are still in use is unknown, but is likely substantial.

One tunnel revealed in San Diego in 2010 was 2,200 feet long at 90 feet below the surface and featured shoring, electricity, ventilation, and a rail track. The tunnel began in a kitchen in a house in Tijuana, Mexico, and terminated in a warehouse in Otay Mesa, California. This particular tunnel likely took one year and $1 million to construct.[75]

In the Middle East, the non-state military group Hamas at one time possessed over 500 tunnels spanning the Egyptian and Israeli borders, including

Figure 4. Seized drugs from a sophisticated smuggling tunnel from Tijuana, Mexico to Otay Mesa, California. Source: U.S. Immigration and Customs Enforcement

one tunnel that was 1.5 miles long, 66 feet deep, and cost $10 million to construct.[76] Although they can be expensive to build, border security personnel will find it difficult to discover all the tunnels crossing under a border; deep tunnels are not vulnerable to discovery by ground-penetrating radar, which can peer only a few feet down.[77]

SOF logisticians should work with U.S. Army engineering elements and outside contractors to develop an expeditionary tunneling capability. An example of an expeditionary effort to rapidly drill a deep tunnel was the 2010 rescue of 33 Chilean miners who became trapped underground after a partial cave-in occurred. Arizona-based International Drilling Services (IDS) was called in to quickly drill a targeted, directional tunnel 28 inches wide from the surface to the mine workshop where the miners were gathered 2,300 feet below the surface. IDS achieved this objective in 53 days.[78]

The expeditionary tunnel IDS drilled for the Chilean mine rescue roughly approximates the width and length that would be useful for moving supply bundles and small or disassembled equipment across a defended border into a UWOA. As a lateral resupply tunnel, an expeditionary tunneling system should include the installation of shoring as the drilling advances, the construction of a rail track and winch-driven pull-cable to facilitate the movement of bundles, and a pump system to evacuate water. The system should be designed to permit drilling, tunnel system installation, and the removal of soil, all performed from a concealed position inside a building on the friendly side of the border. And of course the tunnel should terminate at a pre-designated point under the reliable control of guerrilla forces.

Once in operation, such a tunnel would permit the movement of large quantities of supplies and equipment. Indeed the limiting factor for guerrilla sustainment would not likely be the throughput capacity of the tunnel but rather the guerrilla force's ability to further move and distribute received supplies without creating a signature at and around the tunnel terminus.

SOF logisticians and the guerrilla force would thus have an interest in constructing as many tunnels as would be practical. Numerous tunnels would ease distribution signature problems in the UWOA. And it would diversify the risk of occasional but inevitable discovery of tunnels by hostile security forces. We should conclude that expeditionary tunneling promises to be an effective additional tactic for supplying SOF operators and guerrillas executing a UW campaign.

Conclusion

U.S. policymakers and military planners should not conclude that sophisticated adversary anti-access forces automatically rule out the prospect of supporting friendly guerrilla forces opposing that adversary regime. As we have seen in this chapter, there are viable aerial, seaborne, overland, and subterranean delivery channels that SOF logisticians could exploit to support a UW campaign inside an access-denied area.

If any further evidence is needed that logistics support to guerrillas operating inside an access-denied UWOA is feasible, one need only consider the ongoing problems the U.S. Government endures as it attempts, with mixed results, to maintain the security of its borders. In spite of large and growing border security forces, budgets totaling tens of billions of dollars annually, and the employment of the most advanced technologies, every year transnational criminal organizations and petty smugglers are able to transport thousands of illegal migrants and thousands of tons of illicit cargo into the United States. Persistence, ingenuity, and perhaps structural advantages favoring the offense are in this case able to offset the well-funded efforts of U.S. border security agencies.

SOF logisticians charged with supporting a UW campaign inside an access-denied area can similarly take advantage of persistence, ingenuity, the structural advantages accruing to the offense, and a multiplicity of options available to deliver support to guerrilla forces. The final chapter of this monograph will discuss organizational reforms and a research and development agenda that will prepare SOF for the types of challenges a 'pacing' UW campaign would present.

3. Technologies and Techniques for Reducing the Logistics Demand of SOF Distributed Operations

Chapter 2 discussed the variety of channels—aerial, seaborne, terrestrial, and subterranean—by which SOF logisticians could provide supplies and equipment to SOF operators and guerrilla forces, and also move personnel in and out of a UWOA. The feasibility of each of these potential channels and the capacity of each will depend on the particular circumstances defined by the security situation in the UWOA (the threat posed by the adversary government's security forces), the physical environment of the UWOA, the state of the infrastructure in the UWOA, and the status of the guerrilla force.[79] The influence of these factors will determine the adequacy of the planned logistics operation for the prospective UW campaign.

But even when such resupply capacity is adequate at one moment during the campaign, such logistics channels are bound to be fragile. Enemy action, security breaches, and environmental effects can quickly degrade what were once adequate or even robust resupply channels. A guerrilla force that has become highly dependent on outside sources of supplies and equipment risks finding itself cut off and vulnerable should such a reverse in external resupply capacity suddenly occur.

It will thus always be desirable for SOF planners and guerrilla commanders to mitigate this risk by carefully monitoring the insurgency's external dependency level, categorized by supply class. As mentioned in Chapter 2, guerrilla exploitation of foraging, battlefield recovery, and other indigenous sources will reduce dependency on outside SOF-supplied items. On the other hand, it is likely that certain items that will be important to deployed SOF operators and the guerrilla force will need to be substantially supplied through the external SOF-organized nonstandard logistics channels and networks. Regarding these items, SOF operators and the guerrilla force can reduce risks to the insurgency by taking active measures to minimize their consumption, and thus reduce demands on the external logistics networks. This will reduce external dependency, reduce risk, and increase the likelihood of the insurgency's success.

This chapter will examine some emerging technologies and techniques that offer the prospect of reducing the consumption of a variety of supply classes by deployed SOF operators and guerrilla forces, with a goal of reducing demand pressure on a nonstandard UW supply system. This chapter will also describe emerging technologies that could allow deployed SOF operators and guerrilla forces the ability to fabricate several classes of supplies in the UWOA, thus satisfying at least some logistics requirements at the point of need. When developed and successfully employed, these technologies and techniques will increase the combat capacity of a guerrilla force, reduce its risk exposure to external sustainment, and thus increase the probability of a UW campaign's success.

Reducing demand for electrical power and batteries

SOF operators deployed to a UWOA in support of a friendly guerrilla force will require electrical power to execute their mission. These operators will deploy with radios, night vision equipment, navigation tools, small computers, lighting, and other devices that will require batteries, which run down and thus require replacement or recharging. If batteries are recharged from generators, those generators will require fuel, lubricants, and spare parts to remain in service during an extended campaign.

The supported guerrilla force will also have a requirement for electrical power and batteries, especially if it hopes to become competitive with the hostile government's military and security forces, which are likely to enjoy advantages in funding, technology, equipment, and training. Increasing the military competence of the guerrilla force will likely require improving the command and control of its combat forces in the field. That in turn will very likely require the acquisition and fielding of secure tactical communication equipment, which in turn will require electrical power and batteries. Guerrilla forces will increase their combat effectiveness when they are able to maneuver reliably and confidently (through the use of GPS navigation devices) and at night and in poor visibility (using night vision devices and other powered optics). Finally, command and staff elements of the guerrilla force could improve their efficiency through the use of small computers. All of these improvements will require electricity sources and batteries.

SOF operators and the guerrilla force will benefit greatly from locally based and generated electrical power sources that reduce the dependency on the external SOF-managed logistics network. The remainder of this section will discuss emerging technologies and techniques for generating and storing electrical power in the field and at the point of need, thus reducing the demand placed on the nonstandard logistics networks supporting the UW campaign.

Expanding the use of photovoltaic cells for electrical power generation

U.S. expeditionary forces in Afghanistan made increasing use of solar power and photovoltaic (PV) cells at various forward operating bases. As early as 2011, two forward operating bases in Afghanistan were entirely powered by solar energy, with several others receiving at least 90 percent of their electrical power from this source.[80] Solar panels and associated batteries at these bases powered large computer networks and lighting arrays during the night. The increasing use of solar power devices and technology has already reduced logistics system demand for conventional forces, a trend that will grow in the future.

SOF operators executing distributed UW operations can also employ these techniques at the detachment level and in support of guerrilla forces. New PV products under development at the U.S. Army Natick Soldier RD&E Center's Expeditionary Basing and Collective Protection Directorate can apply directly to such a distributed UW campaign.

One such product is the PowerShade, a 22-foot by 40-foot flexible and foldable pole-supported shade that has PV cells woven into its fabric. This product serves two purposes: it provides shade to soldiers in the field while also generating two kilowatts of electrical power (in context, a laptop computer consumes 0.05 kilowatts-hours per hour; lighting a typical room consumes 0.1 kilowatt-hours per hour).[81] The PowerShade is simple to use, requires minimal maintenance, and comes with the equipment to convert the PV energy to standard 120 volt alternating current.[82]

SOF operators can direct the electrical output from the PowerShade to a variety of small battery charging adapters also developed by Natick and outside contractors. These battery charging adapters connect to the BB2590 and BB390 rechargeable lithium-ion batteries, which are the standard batteries for a wide variety of U.S. military tactical radios and other field equipment.[83] In addition to the PowerShade, the size and power of which is appropriate for

Figure 5. Marine Corps solar energy equipment undergoing testing at Marine Corps Air Ground Combat Center, Twentynine Palms, California. Source: U.S. Marine Corps photo by Lance Corporal Michael Nerl

a SOF detachment at a small expeditionary camp, Natick has also developed small, foldable, and man-portable PV arrays suitable for recharging requirements on foot-mobile operations.[84]

Further improvements of PV cells are under development. These emerging PV cells will have two features that will be important for SOF distributed operations. First, Natick engineers are greatly increasing the physical flexibility of PV cells with the goal of incorporating these flexible cells into fabrics like a tarpaulin that can be bent and shaped around other objects. Second, Natick engineers are colorizing PV cells in order to camouflage their appearance. Such flexible and colorized PV fabrics offer the potential to provide at least four simultaneous benefits to SOF operators: shade, protection from wind and rain, camouflage, and electrical power generation.[85]

Improved expeditionary storage batteries

Maximizing the benefits of solar power and PV cells for small SOF detachments operating in mobile or distributed forward sites will require improvements to base electrical storage and centralized battery arrays. Tesla Motors, known for its high-end electric-powered sports car, is introducing the Powerwall home battery. Powerwall is a rechargeable lithium-ion battery fashioned as a decorative panel able to be hung on a wall. The highest-end version of Powerwall can deliver 10 kilowatts of electrical power during the night when PV cells don't produce electricity. Nine such panels can be linked together to produce a larger panel with 90 kilowatts of capacity. Powerwall is a residential consumer product (price $3,000-3,500) and not suited for military use. But it is likely technically feasible to reengineer the Powerwall technology to make it rugged enough for expeditionary field use and employable either by foot-mobile teams or at small operating bases.

When used in conjunction with products such as PowerShade, such a combination could be especially appropriate for small SOF detachments conducting distributed operations such as a UW campaign.[86] Detachments possessing such a small but powerful central electrical storage device could use PV cells to charge the unit by day and harvest its charge during the night, for lighting and small computers or to recharge smaller batteries used in radios, night vision devices, GPS receivers, optics, etc. Improved and more efficient PV cells and storage batteries at small distributed forward bases will allow SOF operators and guerrilla forces the ability to conduct sophisticated combat operations day and night; with reduced or even zero dependence on a nonstandard SOF logistics network for a continuous supply of batteries and diesel fuel for generators.

High-powered and long-lasting batteries powered by radionuclide decay sources

Recent experience in Afghanistan and Iraq shows that U.S. infantrymen and SOF operators have routinely been required to carry loads exceeding 100 pounds, with batteries and power packs accounting for 20 to 30 percent of these loads.[87] Batteries currently used by small unit military forces produce power through electrochemical reactions, a longstanding technique considered safe and reliable. However, such batteries suffer from very low energy density and the laws of chemistry and physics hold out little hope of dramatic improvements in their efficiency.

By contrast, batteries powered by radionuclide decay generate an energy density over a million times greater than the electrochemical batteries (such as rechargeable lithium-ion cells) now in use. Radionuclide batteries have long been used to power building exit signs and are particularly well-suited for continuous long-duration power generation.[88] Although care must be used in handling the radioisotope sources that would form the inner workings of radionuclide batteries, the technology is well known and has been in use for many decades in industrial and medical settings. Such batteries can easily be produced and distributed by supply chains and safely employed by SOF.[89]

There are several design concepts in hand for radionuclide batteries useful for SOF detachments. Such a battery would be approximately the size of a current D-cell chemical flashlight battery but would weigh less than one pound and would produce one to five watts of power continuously for many years.[90] A foot-mobile SOF operator or infantryman could use such a radionuclide battery to power his entire suite of battery-powered devices for months or years. The radionuclide battery could be connected to a bus-bar into which the soldier would plug his various devices (radios, GPS device, night vision goggles, optics, etc.). Alternatively, radionuclide batteries could be scaled down in size and power and be embedded by manufacturers into each device, with battery replacements not required for years.[91]

The implications of radionuclide batteries for both SOF operators and logisticians would be dramatic. The load carried by SOF operators, especially those deployed on foot patrols lasting more than 72 hours, would be substantially reduced since these operators would no longer have to carry spare batteries. SOF logisticians would be free to almost completely eliminate batteries and electrical power generation as a supply planning consideration. It could also make the provision of devices such as power generators, PowerShade, Powerwall, PV arrays, central electrical storage arrays, and associated equipment unnecessary. For SOF logisticians supporting a UW campaign with a nonstandard resupply system, eliminating batteries and electrical power from the requirements would free up logistics capacity for other needs while also reducing the overall demands and risks placed on the logistics system.

There are perceived risks attached to radionuclide batteries that have thus far prevented their employment by U.S. military forces in the field. Existing designs include very hard casings that both protect soldiers and the environment from radiation and that prevent damage and possible radiation leakage from the battery. Batteries that were destroyed in combat would release a small amount of low-level radiation; if necessary such points could be located and cleaned up.[92] Finally, the amount of radioisotope used in each battery is tiny and would not in any way constitute a nuclear proliferation problem.[93] Even so, the military supply chain, to include a nonstandard resupply system for a UW campaign, would have to adapt to handle such a product. This would include accounting in the distribution system, custody and receipt responsibility, prevention of loss in the field, and return to the supply chain for storage, reuse, and eventual decommissioning.

More broadly, U.S. policymakers and military commanders will have to overcome fears and visceral reactions that come with the employment of any nuclear materials. That is likely the highest hurdle that has thus far prevented the DOD from exploiting this technology for the benefit of SOF operators and infantrymen who have otherwise had to endure large loads of replacement batteries. Adoption of this technology, although understandably difficult, could provide a major benefit to SOF operators and logisticians.

Improving the efficiency of combat feeding in UW campaigns

As mentioned previously, organizing principles such as simplicity, sustainability, and risk mitigation will argue for supplying guerrilla forces and supporting SOF operators from local sources to the maximum extent practical.[94] This dictum would seem to apply especially heavily to the task of combat feeding.

There are numerous reasons SOF commanders and planners should expect the supported guerrilla force to provide its own food and water, not only for its own fighters but also to the SOF operators deployed with the guerrilla force. Guerrilla fighters will already be familiar and adapted to the local food and diet. It is likely that as the guerrilla force has formed and grown, it will have developed its own techniques and processes for acquiring, distributing, and preparing food for its fighters. Next, it would seem highly impractical for a likely fragile nonstandard SOF supply network to take on the task of supplying food to the guerrilla force, especially in the early stages of a UW campaign. Finally, USSOF operators are taught from the earliest phases of Special Forces training of the need to gain the acceptance and respect of the supported guerrilla force. A critical method of gaining this acceptance and respect is living with the guerrilla force and partaking in its camp activities, including meals.

These principles and assumptions are likely to dominate the planning for food and nutrition for a UW campaign. However, SOF commanders and planners should keep in mind some of the risks and drawbacks attached to these principles and assumptions, especially as they relate to long-lasting UW campaigns.

SOF planners and operators should consider the safety of indigenous food and water consumed by the guerrilla force and presumably by the SOF operators supporting that force.[95] There is likely to be a substantially increased risk of food-borne and water-borne diseases and maladies suffered by guerrilla fighters and SOF operators when living off indigenous food and water sources in remote and unsettled areas of relatively undeveloped countries. The risks of such contamination will compound after guerrilla fighters begin concentrating in camp settings, especially if camp sanitary procedures are not strictly enforced.

Throughout history, camp diseases, many tracing back to food and water, have been more debilitating to armies than combat action. Although Western conventional armies have largely solved this problem through modern base camps and logistics systems, those solutions might not apply to prospective UW campaigns such as those described in this monograph. In spite of the large burden it would place on the nonstandard UW logistics system, the external provision of food and water purification methods could substantially increase the manning level and combat effectiveness of the guerrilla force. SOF planners should consider whether such a benefit would be worth the cost, expense, and risk it would place on the logistics system.

Should guerrilla commanders and SOF operators solve the problem of food-borne and water-borne diseases, SOF planners will have to consider whether indigenous food will supply the guerrilla force and SOF operators with the high amounts of protein, calories, and other nutritional characteristics that soldiers will require to be effective during an open-ended combat campaign. This could be a particular risk for SOF operators who are deployed for weeks or months with a guerrilla force during a UW campaign. These operators, having likely established a substantial level of muscle mass, along with protein and calorie consumption rates in a Western military training setting, may find the indigenous guerrilla diet over a prolonged period leading to dissipation and malnutrition.[96] SOF planners will have to decide whether SOF operators deployed in support of a guerrilla force will require supplemental nutrition supplied through the UW logistics network.

In addition, nutrition is directly linked to soldier physical performance, cognitive performance, and metabolic recovery from exertion and stress.[97] These are critical factors in the performance of military forces, especially during long-term campaigns. Nutrition is thus likely to be a competitive factor relative to the government security forces the guerrillas will be fighting.

Nutrition and its bearing on guerrilla physical and cognitive performance will thus be either a competitive handicap or a competitive advantage during the ensuing campaign against government security forces. SOF planners should make an assessment of guerrilla nutrition and compare it with the nutrition supplied to the adversary government forces. If a gap exists, these planners will then have to decide whether the nonstandard UW logistics system should be used to close the nutrition gap the guerrillas suffer compared to the government security forces. Alternatively, SOF planners could also decide that improved guerrilla nutrition, supplied through the SOF UW logistics network, could create an important competitive advantage over the adversary government forces.

Emerging technologies supporting combat feeding in UW campaigns

The Combat Feeding Directorate at the U.S. Army Natick Soldier RD&E Center is developing several technologies that could be useful to SOF operators and logisticians executing a UW campaign in an access-denied area. These technologies focus on reducing the food load carried by foot-mobile SOF operators and infantrymen; reducing the load food resupply places on a logistics system; reducing the risk of food and water-borne infections; increasing the ability of expeditionary SOF operators and units to create nutrition locally through foraging; and improving the physical and cognitive performance of SOF operators through better nutrition. As a result of these combat feeding RD&E efforts, SOF operators and soldiers should expect to see significantly different combat rations and feeding techniques by 2025.[98]

Concepts and technologies under development at Natick to achieve these goals include:

- A handheld device that will allow a SOF operator in a foraging situation to determine which local species are safe and nutritious;

- Expeditionary equipment that will convert locally gathered biomass into edible food;
- 3-D printing of food products at forward bases and camps;
- Highly concentrated and compact rations that provide high quality nutrition while greatly reducing logistics weight, cube, and soldier load;
- Bio-engineered, single-cell proteins designed to maintain muscle mass;
- Biometric identification of the nutrient needs of individual soldiers, along with the capability to subsequently produce nutrition to meet identified gaps.[99]

In summary, feeding a military force in the field is frequently the single greatest burden on a logistics system. This will likely be the case regardless of whether the military force consists of conventional units or guerrilla formations. A guerrilla force is unlikely to enjoy the benefits of a modern military logistics system that in recent decades has allowed Western armies to virtually eliminate ancient military-logistic maladies such as malnutrition and widespread disease. Adversary government security forces are likely to enjoy greater camp cleanliness, better preventive measures, and better access to the nutrition needed for sustained physical and cognitive effectiveness. Finally, a nonstandard UW logistics systems operating inside an access-denied area will likely be hard-pressed with other resupply requirements besides combat feeding.

Nevertheless, there are emerging technologies and techniques that SOF operators supporting a UW campaign may soon be able to employ to boost the prospects of supported guerrilla forces. These developments include the ability to concentrate and reduce the size and weight of nutrition and to improve the ability to forage and produce better food in the field at the point of need. When developed and available to SOF operators, these technologies and techniques will reduce the burden on the UW logistics system while also improving the nutrition and combat effectiveness of the guerrilla force.

Use of precision munitions to reduce demands on the UW logistics system

SOF commanders and planners supporting a guerrilla force should consider the benefits (along with the risks) of supplying precision munitions through the nonstandard UW logistics system. A guerrilla force (as with any military force) employing precision munitions should be able to achieve desired battlefield effects with a far lower expenditure of munitions. This would, all else being equal, greatly reduce the amount of ammunition a UW logistical system operated by SOF logisticians would have to transport and distribute to SOF operators supporting a guerrilla force.

For example, a guerrilla force operating 120 millimeter mortars might increase battlefield effects and reduce logistic demand if supporting SOF operators supplied the guerrilla force with GPS-guided mortar rounds for these systems. In March 2011, U.S. Army mortar crews in Afghanistan began employing the XM395 GPS-guided mortar round. The XM395 is a modification to the standard unguided M934 high explosive 120 mm mortar round. The modifications include a fuze with a GPS receiver and small guidance fins, along with additional folding guidance fins in a tail attachment. Soldiers use a mission planning computer and input device to program impact coordinates into the fuze before firing. The XM395 has a Circular Error Probable (CEP) of less than 10 meters at any range.[100] This compares very favorably with a CEP of 136 meters for the unguided M934 round at maximum range. Use of the XM395 will give a 120 mm mortar crew a 'first round, fire for effect' capability and thus greatly reduce the amount of ammunition required to reduce a target.[101]

Another example would be the choice of a direct-fire weapon to counter armored vehicles, other vehicles, and bunkers. For a supported guerrilla force, the standard choice for such a direct fire weapon would seem to be the Soviet-era rocket propelled grenade (RPG), the unguided, shoulder-fired rocket now found seemingly on every battlefield. Keeping with its Soviet origins, the RPG is rugged and simple to use. It would be an especially attractive choice for SOF operators clandestinely supporting a guerrilla force because its employment by any guerrilla force would be expected and thus would maintain the plausible deniability of a clandestine UW campaign.

Even so, SOF commanders and planners could also consider the benefits of employing a precision-guided alternative such as the fire-and-forget Javelin missile or some internationally produced equivalent shoulder-fired, precision-guided missile. As with the GPS-guided 120 mm mortar, using a precision missile like the Javelin instead of the unguided RPG would, all else equal, greatly reduce the quantity of such munitions the nonstandard UW logistics system would have to transport and distribute in order to achieve the same or better battlefield effects.

Policymakers and SOF commanders will naturally have to weigh the benefits against the risks of distributing precision-guided munitions to a supported guerrilla force. Depending on the status and fragility of the nonstandard UW logistics system, it may be a paramount consideration to deliver to the guerrilla force the greatest level of firepower and battlefield effectiveness per weight and cube transported by the system. This would argue for the delivery of precision-guided weapons. On the other hand, policymakers and commanders could be understandably concerned about the delivery of such powerful munitions into a situation where ongoing custody, control, and eventual recovery could be questionable. Precision munitions employed against adversaries today might be employed against allies or U.S. forces in the future. Finally, it is likely to generally be the case that the higher the sophistication of the weapons supplied to the guerrillas, the greater the risk the U.S. Government will run in terms of plausible deniability.

In the late 1980s, the U.S. Government faced this same dilemma regarding its support to Afghan guerrillas opposing government forces and the Soviet army. After much internal debate, U.S. policymakers decided to supply the Afghan guerrillas with the Stinger advanced precision-guided shoulder-fired surface-to-air missile. By that point in the conflict, maintaining plausible deniability was no longer a policy concern. But concerns about proliferation and possible future threats to civilian air traffic remained. Fortunately, custody and technical measures successfully mitigated this risk. Meanwhile the introduction of the Stinger missile created favorable shifts in Soviet air power tactics and effectiveness with substantial benefits to the guerrilla force. And the logistics system supporting the Afghan guerrillas was able to easily support the transport and distribution of Stinger missiles to guerrilla forces in the field.

Policymakers and SOF planners managing another prospective UW campaign will face these and other considerations that balance the tradeoffs between logistics capacity, battlefield effectiveness, political risk, and proliferation risk. The existence of precision munitions will give policymakers and SOF planners more choices, along with some challenging decisions.

Conclusion

Many factors are required to achieve success in combat. In keeping with the SOF Truths, the quality of warfighters—reflected in attributes such as training, conditioning, leadership, tactical skill, morale, teamwork, the will to prevail, etc.—will usually be more reliable predictors of success than the equipment and technology employed by those warfighters.[102] This precept applies equally to an insurgent guerrilla force fighting to defeat government security forces, which are likely to be better funded, equipped, and supplied than the guerrillas.

Applying the SOF Truths, guerrilla commanders and the SOF operators supporting them will attend first to the guerrillas' training, leadership, tactical skill, conditioning, morale, and other human factors that bear closely on battlefield success. But while focusing on those tasks, SOF operators will boost the guerrillas' chances of success when they strive to supply the guerrillas with weapons and equipment that can provide a more even matchup against the government security forces. And that in turn will require an improvised, nonstandard, and likely fragile logistics system to get equipment and supplies to the guerrillas. When the UW campaign occurs in an access-denied area, the challenges placed on the nonstandard logistics system only compound.

This chapter has described several techniques and technologies that a guerrilla force and supporting SOF operators can employ to create required supplies and resources in the field and at the point of need, thus reducing the demands placed on the UW logistics system. These techniques and technologies range from the mundane yet critical supply of nutrition, to higher-end combat enablers such as electrical power for radios and night vision devices, and finally, to relatively exotic items such as precision-guided missiles and munitions.

Some of these technologies are available now while others remain under development and could be available over the medium term. The characteristic they all have in common is how their employment will reduce the demands placed on the nonstandard logistics system supplying the guerrilla force. This risk reduction benefit will occur even as some of the items described in the chapter, such as secure radios and other electronic devices and precision missiles and munitions, will multiply the combat power of the guerrilla force. Achieving both of these benefits presents a strong case to

SOF commanders as they make difficult decisions on how to sustain a UW campaign inside an access-denied area.

Successfully supplying UW campaigns will require SOF planners to design and execute a fully-integrated logistics strategy. Such a strategy will subsequently require these SOF planners and logisticians to assess what they will supply to the guerrilla force; the establishment of channels and routes by which supplies and equipment will reach the guerrillas; and active measures and techniques that will allow the guerrilla force to both provision itself locally and to reduce the demand for support that can only be supplied externally.

The first three chapters of this monograph have discussed how SOF planners and logisticians should approach these challenges for a UW campaign occurring in an access-denied area. The final chapter of the monograph will list and discuss recommendations USSOCOM and USASOC commanders and staff planners should consider in order to better prepare SOF to sustain a UW campaign in an access-denied area. These recommendations will act as both a summary of the monograph and guidance for actions the SOF community can take to prepare for the most challenging UW missions.

4. Recommendations for Improving the Sustainment of SOF Distributed Operations in Access-Denied Environments

There are numerous reforms USSOCOM and DOD can implement that would improve the prospect of sustaining distributed UW campaigns in access-denied areas. A portion of this reform agenda should focus on various RD&E initiatives that would expand the capacity of SOF to resupply operational UW detachments and friendly guerrilla forces by exploiting the full range of resupply channels and that would reduce consumables demand by SOF operators and guerrilla forces operating in a UWOA. This chapter will discuss a detailed RD&E agenda for improving the sustainment of distributed UW campaigns operating in access-denied areas.

However, SOF logistics reforms should extend beyond just RD&E initiatives. DOD, USSOCOM, and USASOC should implement institutional reforms that will raise the awareness of UW logistics operations and remedy existing shortfalls in UW logistics doctrine. In addition, there is much USSOCOM and USASOC should do to prepare for UW operations in denied areas, to improve the training of SOF logistics personnel to support UW operations, and to expand the capacity of the SOF enterprise to execute substantial UW operations, especially in the most challenging scenarios. This chapter will also discuss recommendations in these dimensions.

Training logisticians to support UW campaigns

USSOCOM and USASOC appear to lack a comprehensive and well-organized training program and training establishment to prepare SOF logisticians to support UW campaigns, especially those that would require nonstandard logistic techniques. Joint UW logistics training in the SOF community is almost completely ad hoc.[103] There are few structured training opportunities for logisticians operating within the USASOC and USSOCOM enterprises.[104] UW logistics experience within the SOF enterprise is developed almost entirely through on-the-job training and improvisation.[105] Worst of all, due to security classification, unit barriers, and the lack of a UW logistics structure, knowledge and best practices on UW logistics techniques is almost never shared within the SOF community or across the joint force.[106] As a result, there is no opportunity or structure within the SOF community to pass on lessons learned or to advance the art and science of the sustainment of UW operations in denied areas.

A review of existing schoolhouse syllabi revealed one brief course dedicated to SOF logistics operations for UW campaigns. As of June 2015, the course catalogs at the United States Army John F. Kennedy Special Warfare School and Center (USAJFKSWSC) listed no courses on logistics and sustainment of UW operations, or any courses on nonstandard resupply techniques.[107] At Joint Special Operations University (JSOU), a new pilot course on nonstandard logistics appeared for the first time in May 2015. The course is five days in length and is continually developing.[108]

JSOU's addition of a new course on nonstandard logistics is commendable and a large step forward. However, as this monograph has attempted to explain, the nonstandard techniques required to sustain UW campaigns in denied areas are complex, multifaceted, and involve risk. Much larger amounts of training, resources, and practice across the SOF community will be required to master these techniques and technologies. If USSOCOM and DOD are serious about preparing for a future that will call on readiness for UW campaigns, these institutions will have to dedicate greater leadership attention and resources to training future cadres of SOF logisticians who will be prepared to support challenging UW campaigns. There presently seems to be little organized preparation for such contingencies.

Recommendation 1: USSOCOM and USASOC should establish formal training programs to prepare SOF logisticians for UW campaigns in denied areas.

First, USSOCOM, and USASOC in particular, should develop a comprehensive training program to prepare SOF logisticians to support UW campaigns in denied areas. This would mean extensively preparing SOF logisticians to clandestinely manage the inter-theater movement of supplies, equipment, and personnel; establish clandestine intermediate supply and transit points in an operational theater; establish procedures for clandestinely and efficiently acquiring locally sourced supplies and equipment; the clandestine movement of supplies, equipment, and personnel across hostile borders defended by challenging access-denial networks; and the movement, distribution, and storage of these items to benefit SOF and friendly guerrilla forces inside a UWOA.[109]

Mastering these tasks and building a SOF cadre skilled in their employment would be a challenging training mission. However, it is one that would build a highly valuable capability not only for SOF but for top-level policymakers in the U.S. Government. Building this training program would, however, require a substantial commitment of talent, funding, time, and leadership attention from USSOCOM and USASOC.[110] USASOC, in coordination with the leadership at the 528th SBSO(A), should establish a dedicated UW sustainment curriculum, course list, and instructor cadre at USAJFKSWSC. AFSOC should establish UW sustainment programs at its schoolhouse in ways appropriate for its roles and missions. USSOCOM should have the staffing necessary to coordinate these training efforts into a comprehensive UW sustainment capability.[111]

USSOCOM and USASOC should establish a four-phase training program for future SOF UW logisticians.[112] The first phase would consist of indoctrination and would have the SOF logistician trainees interface with SOF operators in order to fully understand UW combat service support (CSS) requirements and associated mission planning. The second phase would consist of cross-training in all aspects of CSS functions with an emphasis on UW mission requirements, operations in austere and clandestine conditions, and operations that involve independent action and minimal supervision. The third phase would expand trainee exposure to operations with joint and interagency partners with a goal of establishing these relationships and operational synergies. The fourth phase would consist of a high-fidelity capstone UW logistics training exercise, conducted at a national training center. The training exercise would have the trainees implement the techniques they learned in the first three phases to support a challenging UW scenario in an access-denied area.

Second, after the various SOF components have established their schoolhouse UW sustainment programs and instructor cadre, USSOCOM should establish a joint UW sustainment mobile training and support team capacity. The purpose of this mobile training and support team would be to support and reinforce theater special operations command (TSOC) planners when regional combatant commands are assigned a significant UW mission and require additional technical and planning capacity to execute UW sustainment support.

Third, USSOCOM should establish a global UW sustainment information network that would share best practices, lessons learned from operations, and logistician experiences.[113] Feedback from these experiences would benefit SOF logisticians operating elsewhere. This feedback would also be crucial in maintaining and improving the instructor cadre and curricula at SOF schoolhouses.

Institutional reforms to support the UW sustainment function

The previous section discussed the shortfalls in USSOCOM and USASOC training as it relates to preparing logisticians for distributed UW campaigns in denied areas. The absence of formal training programs for this complex mission reveals larger institutional shortcomings in USSOCOM and USASOC regarding preparations for UW sustainment. The broad SOF community lacks the formal institutions, careers paths, personnel management, staffing, and senior-level advocacy the UW sustainment function requires. Until this institutionalization of UW sustainment occurs, it is unlikely that complex UW campaigns in denied areas will become a realistic option available to senior military leaders and policymakers.[114]

Recommendation 2: Establish USSOCOM and USASOC institutions that will advocate for the UW sustainment mission, create a rewarding career path for UW-specialized logisticians, and advance and propagate knowledge in this field.

First, both USSOCOM and USASOC should establish staff sections that specialize in nonstandard UW sustainment.[115] At USSOCOM, this staff section would be located within the J4 and would support active UW campaigns globally. The USSOCOM J4 UW sustainment staff section would support regional TSOCs actually executing UW campaigns by deploying mobile training and support teams that would provide expertise and planning resources to the regional commands and through the coordination of the various service-level SOF logistics functions. This staff section would be the single point of contact at USSOCOM for UW sustainment and would also coordinate U.S. sustainment efforts with other government agencies and international and nongovernment partners.[116]

At USASOC, a dedicated UW logistics staff section would be located in the 528th SBSO(A) which would oversee UW sustainment schoolhouse training (in partnership with USAJFKSWSC) and the advancement and distribution of UW sustainment knowledge throughout the global Special Forces community. This staff section should also contribute to the expansion of useful UW sustainment doctrine, which currently is very limited and provides inadequate guidance to practitioners in the field.[117] After taking ownership of UW logistics doctrine development, and schoolhouse and field training, the 528th SBSO(A) UW logistics staff section would then take responsibility for transferring this knowledge and expertise to operational units in the field through the training, preparation, and deployment of 528th's ALEs assigned to TSOCs and other commands around the world.

Second, USSOCOM and USASOC should establish a rewarding career path for logisticians who learn nonstandard logistics techniques and apply them in operational missions.[118] The U.S. Army and perhaps the other services could create a specific military occupational specialty code for UW-trained logisticians or alternatively an additional skill identifier designation.[119] The USSOCOM J1 staff and the USASOC G1 staff should establish processes for tracking the training and careers of UW-qualified logisticians and create upward career paths for soldiers who receive this training and perform these duties.[120]

Third, USSOCOM and USASOC should establish RD&E centers that would focus on the development of equipment and techniques that will advance nonstandard UW sustainment capabilities, especially for the most challenging distributed UW missions in denied areas. As the previous chapters and this chapter will make clear, there is now a substantial gap between the equipment and tools SOF operators and logisticians currently possess to execute challenging distributed UW campaigns in denied areas and those they will require to successfully execute these missions. UW sustainment RD&E centers would work with other military RD&E commands (such as Natick Soldier RD&E Center) and outside contractors to develop improved equipment solutions for UW sustainment.

Fourth, USSOCOM and USASOC should create appropriate billets to command this multifaceted UW sustainment enterprise, which will comprise personnel management, intelligence assessment of adversary access-denial capabilities, training, field operations, strategic planning, research and development, and program management. Creating a serious UW sustainment capability will require significant staffing, complex training, global operational capacity, expanding engineering and technical knowledge, and significant budgets. Such an enterprise would require an officer of requisite rank to command it and be an advocate for the enterprise within the SOF community and beyond.

As mentioned above, USASOC should create a dedicated UW logistics staff section within the 528th SBSO(A) to oversee these duties and functions within ARSOF. Given these wide-ranging responsibilities and large budget, the dedicated UW sustainment staff section should probably be commanded by a lieutenant colonel (O-5) who would report to the commander of the 528th SBSO(A). USSOCOM should likewise consider creating an O-5 billet at the J4, with responsibility for coordinating UW logistics training, preparation, and execution across the SOF global enterprise and in coordination with other government agencies, partner governments, and nongovernment entities.

Research, development, and engineering agenda

This section will discuss specific technologies and techniques USSOCOM, USASOC, and other parts of the SOF community should develop in order to create the sustainment capabilities that will be necessary to successfully execute a distributed UW campaign inside a denied area. The author's site visit to Natick Soldier RD&E Center and interviews with skilled and dedicated engineers and program managers revealed some impressive work aimed at improving the support soldiers in the field will receive in the future.

However, this research also revealed the gap between what these programs will deliver and what the most challenging UW sustainment missions will require. The main explanation for this gap is the lack of attention in recent years devoted to the UW mission generally, and the sustainment of challenging UW missions in particular. We can hope that renewed top-level command attention on UW and UW sustainment will result in greater leadership attention, a focus on the search for solutions, and an interest in a new RD&E agenda for UW sustainment challenges.

Recommendation 3: Managers of the RD&E agenda for UW sustainment should to the extent feasible adapt existing technology for their purposes and use, and adapt equipment widely available in the international marketplace, maintain operational security, and look to incremental improvement to remain competitive against adversaries.

Four general principles should guide program managers and decision makers regarding the development and acquisition of equipment and technology for nonstandard resupply techniques of SOF executing distributed UW campaigns in denied areas.

First, program managers should maintain a preference whenever possible for adapting existing technologies rather than endeavoring to create wholly new equipment and technologies. Developing new systems is risky, almost always expensive, and usually very time-consuming. The typical result is solutions, if they ever arrive in the field, do so late and in quantities too small to meet operators' needs. When existing systems can be adapted to UW sustainment needs, program managers should almost always prefer this path.

Second, (and related to the preceding point) program managers should have a preference for employing and adapting equipment and technologies openly found in the civilian market and widely available to foreign civilian customers. As a corollary, program managers should welcome, and even have a preference for, foreign-supplied equipment. A clandestine UW campaign will under some circumstances benefit from plausible deniability. Should SOF personnel executing a UW campaign be captured, the U.S. Government should not have a policy of denying their status as U.S. soldiers, in order to improve the prospect of better treatment during their captivity. But regarding the use of unmanned vehicles for resupply operations, plausible deniability would be useful should such equipment be captured. The U.S. Government will be able in a better position to plausibly deny an operation in such a case should it use equipment widely available in the international marketplace.

Third, UW logisticians and program managers should establish and maintain operational security over the technologies, equipment, and techniques they develop through RD&E efforts, concept development, and training. UW sustainment into access-denied areas is a competitive, multi-move process that planners should assume will be executed against a smart and determined adversary. Individual UW sustainment technologies and techniques will therefore be perishable. The maintenance of operational security should extend the lives of technologies and techniques, a valuable outcome for UW logisticians and SOF operators.

Fourth, the broad SOF UW sustainment enterprise should operate under a principle of continuous incremental improvement in both its equipment and its operational techniques. Competitive adversaries will place constant pressure on UW sustainment techniques, which means that UW logisticians will themselves be compelled to improve in order to execute their missions. However, spending resources on large 'leap-ahead' improvements is a risky approach that could result in shortfalls in needed capabilities in the future. UW logistics planners can mitigate such risks by opting for incremental improvement approaches.

Recommendation 4: USSOCOM should work with the U.S. Army, Air Force, and outside contractors to develop new aerial delivery techniques that use low-observable characteristics to deliver supplies and equipment by air through access-denied barriers. Specifically, USSOCOM J4 should contact the Aerial Delivery Directorate at the U.S. Army Natick Soldier RD&E Center to establish such a project and request Natick's experience and guidance in executing such a program. As described in Chapter 2, the product from such a program should be 250-, 500-, and 2,000-pound containers that stealth strike aircraft such as the F-35A/B/C, B-2A, and forthcoming Long Range Strike Bomber (LRS-B) could carry internally and then deploy by parachute, utilizing JPADS equipment technology to deliver precisely to SOF operators supporting a guerrilla force during a UW campaign in an access-denied UWOA. The Aerial Delivery Directorate at Natick has long experience with this type of project and should be the first resource for project management.

Recommendation 5: USSOCOM J4 should work with all four services and outside contractors to investigate the potential of employing micro UAVs in large scale 'conveyor' arrays to deliver supplies and equipment (especially high value, low weight items) to SOF operators and guerrilla forces operating in access-denied UWOAs. USSOCOM J4 should initially make contact with the Aerial Delivery Directorate at the U.S. Army Natick Soldier RD&E Center to obtain an initial feasibility assessment of this concept. Over the past two decades, USSOCOM and all four services have acquired extensive experience operating a wide variety of small UAS in many different environments and settings. These operations, however, have largely focused on intelligence, surveillance, and reconnaissance missions and tasks. That said, there should be broad experience within operational small UAS units across the joint force that should be available for adaptation to UAS logistics operations. USSOCOM J4 staff and Natick Aerial Delivery personnel should be able to make an assessment of the applicability of this experience for the employment of small and micro UAVs for resupply operations in an access-denied UWOA.

Recommendation 6: USSOCOM J4 should work with the U.S. Navy and outside contractors to develop unmanned undersea cargo vehicles to clandestinely deliver supplies and equipment to SOF and friendly guerrilla forces.

USSOCOM J4 should contact the U.S. Navy Sea Systems Command and the U.S. Navy Office of Naval Research to establish the feasibility of employing cargo UUVs in support of clandestine UW campaigns. These three entities should develop and establish a program to develop cargo UUVs that can support SOF operators and friendly guerrilla forces operating in access-denied areas.

Recommendation 7: USSOCOM J4 and the 528th SBSO(A) UW logistics staff section should work with the U.S. Army Research, Development and Engineering Command, other relevant government agencies, and outside contractors to develop expeditionary additive manufacturing tools and techniques that could support the movement of supplies and equipment through hostile border checkpoints.

USSOCOM J4 and 528th SBSO(A) UW logistics staff section personnel should contact other relevant government agencies that likely have experience with the infiltration and exfiltration of equipment, supplies, and personnel through border checkpoints under hostile control in order to acquire knowledge of current techniques and best practices. After acquiring this knowledge and experience, USSOCOM J4 and the 528th SBSO(A) UW logistics staff section should establish contact with the U.S. Army Research, Development and Engineering Command and appropriate outside contractors to develop expeditionary 3-D printing tools and techniques that could be employed by SOF logisticians in clandestine settings to prepare cargo and vehicles for crossings through hostile border checkpoints in support of UW campaigns.

Recommendation 8: USSOCOM J3, J4, and J6 personnel should work with U.S. Cyber Command and other relevant government agencies to develop intrusive cyber tools that could facilitate the infiltration and exfiltration of personnel and equipment through hostile checkpoints.
USSOCOM personnel should establish partnerships with these U.S. Government cyber agencies to establish intrusive cyber capabilities, such as the manipulation of adversary databases, which could enable SOF operators and other personnel to safely transit border crossings controlled by hostile security forces, in order to support UW campaigns in access-denied areas.

Recommendation 9: USSOCOM J4 and 528th SBSO(A) UW logistics staff section personnel should work with the U.S. Army Research, Development and Engineering Command and outside contractors to establish an expeditionary tunneling capability.
USSOCOM and 528th SBSO(A) UW logistics staff section personnel should establish a working group with U.S. Army engineers and outside tunnel and drilling contractors to develop an expeditionary tunneling capacity that could support the sustainment of SOF operators and guerrilla forces operating on the far side of a hostile border. The working group should establish the feasibility of this concept, conduct realistic experiments, and then develop a deployable expeditionary capability that would create useful supply tunnels in a low profile, clandestine manner.

Emerging technologies to reduce consumables demand by SOF and guerrilla forces

Chapter 3 discussed technologies that are currently available or will be in the near term that could reduce many types of logistics demand during UW campaigns, and thus ease the burden on prospective nonstandard resupply programs that UW logisticians would have to execute. This section will discuss specific recommendations USSOCOM should consider in order to exploit the techniques and technologies discussed in Chapter 3.

Recommendation 10: USSOCOM J4 and component SOF should work with the Expeditionary Basing and Collective Protection Directorate, U.S. Army Natick Soldier RD&E Center to improve and expand the options and usage of PV devices and materials by SOF operators, focused on generating electrical power at the point of need for distributed operations in UW campaigns.

USSOCOM and component SOF should establish a program to develop variants of the PowerShade PV tarpaulin for employment by small foot-mobile teams and in small- and medium-sized base camp settings. The goals of such a program should be to produce PowerShade devices in various sizes; to field flexible PV cells embedded in tarpaulin-type products; to field colored PV cells in order to produce camouflaging PowerShades; to ensure the connectivity of PowerShade devices to converters, electrical buses, and central and distributed rechargeable batteries; and to continuously improve the efficiency of PV cells for SOF usage.

Recommendation 11: USSOCOM J4 should work with the Expeditionary Basing and Collective Protection Directorate, U.S. Army Natick Soldier RD&E Center to determine the feasibility of developing a ruggedized, military-grade central storage battery, perhaps based on technology similar to the Tesla Powerwall, to provide power to small SOF expeditionary bases for nighttime operations and device recharging.

USSOCOM and the U.S. Army Natick Soldier RD&E Center should establish a research program to explore a Powerwall type concept to provide rechargeable centralized electrical power to small SOF outposts. This feasibility study should determine whether a ruggedized, parachute-deployable centralized battery can be fabricated at scale; whether such a battery can be made either man or pack-animal mobile; whether the battery can be linked to PowerShade or similar PV devices; whether such batteries could be linked to increase storage capacity; and whether the number of times it can be recharged will make it useful for military operations. If the feasibility can affirm these and other basic questions of viability, USSOCOM and component SOF should then consider prototyping and field experimentation.

Recommendation 12: USSOCOM J4 should find appropriate government, academic, and scientific partners to explore the design, experimentation, and possible fielding of very long endurance radionuclide-powered batteries for SOF operations.

The USSOCOM J4 staff should establish a partnership with the U.S. Army Natick Soldier RD&E Center, the Defense Advanced Research Projects Agency (DARPA), engineering universities such as the Massachusetts Institute of Technology, and outside contractors to develop radionuclide powered batteries as described in Chapter 2. The goals for such an effort should include developing a safe, ruggedized, field-ready prototype; developing buses and power distribution methods adapted to existing soldier devices; establishing custody and tracking systems and protocols for such batteries; and achieving leadership acceptance of the field use of radionuclide batteries.

Recommendation 13: USSOCOM J4 and USASOC G4 should work with the U.S. Army Natick Soldier RD&E Center to develop advanced, highly concentrated food and nutrition products designed to enhance physical and cognitive capacity while also reducing the weight and cube demands on a nonstandard UW logistics system.

The SOF community should work with Natick researchers and program managers to develop, experiment with, and eventually field highly concentrated food and nutrition products that are specifically designed for open-ended UW campaigns that require SOF personnel to have extended endurance and that have to be sustained through nonstandard logistics networks. A working group composed of SOF operators and Natick combat feeding specialists would establish nutritional requirements for such scenarios, likely logistic system constraints and characteristics, and then fashion feasible nutrition product options in response to these design criteria. The working group should consider coordinating its research and trials with Army resiliency and fitness centers such as those located at U.S. Army War College and the U.S. Military Academy at West Point. Prototyping and experimentation in field settings should then follow.

Recommendation 14: USSOCOM J4 and USASOC G4 should work with the U.S. Army Natick Soldier RD&E Center to develop devices and tools that would allow SOF operators and supported friendly guerrilla forces the capability to safely forage for nutrition from local sources, especially in survival and expeditionary situations, and to produce nutrition from locally acquired biomass.

As discussed in Chapter 3, the U.S. Army Natick Soldier RD&E Center Combat Feeding Directorate is researching devices and tools to assist survival foraging and the conversion of locally acquired biomass into human nutrition. USSOCOM J4 and USASOC G4 should partner with Natick, DARPA, and outside contractors to expand and deepen this RD&E line of effort with a goal of developing prototypes for these devices. Experimentation and eventual fielding of these capabilities should follow.

Recommendation 15: USSOCOM should consider the merits and risks of supplying supported guerrilla forces with precision-guided rockets, mortars, and missiles with the goals of improving the combat effectiveness of the supported force and to reduce the munition demands on the nonstandard UW logistics network.

All appropriate staff sections at USSOCOM should participate in a working group to examine this issue and make recommendations regarding its suitability. If the concept is approved, USSOCOM and USASOC should identify candidate munitions and weapon systems generally available in the international market for prospective transfer and use by supported guerrilla forces (the purpose of this point is to retain plausible deniability by the U.S. Government). After identifying such candidates, SOF operators should train on their employment and be ready to train and equip supported guerrilla forces. USSOCOM and DOD should then acquire appropriate inventories of these munitions and systems in order to be prepared for prospective UW campaigns.

5. Conclusion

Experience over the past two decades should indicate to U.S. policymakers and military planners that irregular warfare in its various forms will persist and perhaps expand in areas of the world important or vital to U.S. national interests. Indeed, all U.S. geographic combatant commands are currently engaged directly or indirectly in some form of irregular warfare. The prospective return of great power competition involving the United States and other major powers would likely add to this trend; should the United States and another competitive great power maintain respective nuclear and conventional military deterrence, the competition could spill out into forms of irregular warfare, a pattern observed during the Cold War.[121] Thus U.S. policymakers and planners must prepare for an unending era of irregular warfare and be prepared to achieve U.S. national security objectives under these conditions.

It is a longstanding principle of war, and a cornerstone of U.S. military doctrine, that offensive action is eventually necessary to achieve military success.[122] This principle applies to irregular warfare as to any other form of warfare. U.S. policymakers and military planners confronting the challenges of irregular warfare will thus need offensive options in order to achieve U.S. objectives in such circumstances.

UW is an offensive military operation. In the larger realm of irregular warfare, UW will likely be the military option U.S. policymakers and military commanders will need in order to achieve U.S. national security objectives.[123] Political constraints will frequently restrict the ability of U.S. policymakers to employ conventional military power in ways to achieve U.S. objectives. In addition, emerging great power rivalries will likely impose practical restrictions on the employment of conventional forces. Thus policymakers are likely to increasingly turn to irregular methods to protect U.S. interests. UW will frequently be the offensive option that will be necessary to achieve success in irregular warfare.

The proliferation of long range anti-access munitions and weapons systems such as integrated air defense systems, precise and long range anti-ship missiles, and sophisticated sensors and other guided munitions will increase the difficulty of obtaining access to critical theaters of military operations.[124]

These anti-access difficulties will apply not only to conventional military forces but also to SOF operators and logisticians tasked with supporting a friendly guerrilla force inside an access-denied area.

In spite of these challenges, this monograph has shown that there are numerous techniques and technologies available and ready for development that SOF operators and logisticians could employ to make the support of a guerrilla force inside an access-denied UWOA a feasible proposition. The monograph described aerial, seaborne, terrestrial, and subterranean methods of resupply across hostile borders. It also described a variety of techniques and technologies that when employed will reduce the external logistics requirements of SOF operators and supported guerrilla forces, thus reducing the demands placed on a nonstandard UW logistics system.

Given the current and future operating environment and its propensity for irregular warfare, U.S. policymakers will almost certainly call on U.S. military commanders and planners to operate and prevail in this environment. The SOF community must prepare for this challenge, the difficulty of which will only compound as access-denial technology and techniques continue to proliferate.

Winning in such an environment will require the execution of offensive options like UW. The SOF community can prepare for these challenges by studying the recommendations in this monograph, which will improve the ability of SOF logisticians to sustain SOF distributed operations, such as UW campaigns, in access-denied areas. Developing these capabilities will create options for policymakers and commanders, impose costs on adversaries, and deny enemies sanctuaries for their forces and preparations. The result will be the creation of an important tool for protecting U.S. interests and achieving policy goals despite otherwise challenging circumstances.

Appendix A: Acronym List

AFSOC	U.S. Air Force Special Operations Command
ALE	Army Special Operations Forces Liaison Element
ARSOF	Army Special Operations Forces
CBRN	chemical, biological, radiological, and nuclear
CSS	combat service support
DARPA	Defense Advanced Research Projects Agency
DOD	United States Department of Defense
G4	general command (U.S. Army and Marine Corps) staff section responsible for logistics
GBU	guided bomb unit
GPS	global positioning system
J3	Joint command staff section responsible for current operations
J4	Joint command staff section responsible for logistics
J6	Joint command staff section responsible for command, control, communications, and computer/cyber operations and planning
JP	Joint Publication
JPADS	Joint Precision Airdrop System
JSOU	Joint Special Operations University
LBS-UUV	Littoral Battlespace Sensing - Unmanned Undersea Vehicles
LDUUV	Large Displacement Unmanned Undersea Vehicle
LRS-B	Long Range Strike Bomber (next-generation U.S. Air Force bomber aircraft, under development)
OSS	Office of Strategic Services

PV	photovoltaic
RD&E	research, development, and engineering
RPG	rocket propelled grenade
SBSO	Sustainment Brigade, Special Operations (refers to the 528th Sustainment Brigade, Special Operations (Airborne))
SOCPAC	U.S. Special Operations Command - Pacific
SOF	Special Operations Forces
TSOC	theater special operations command
UAS	unmanned aerial systems
UAV	unmanned aerial vehicle
UUV	unmanned undersea vehicle
USAJFKSWSC	United States Army John F. Kennedy Special Warfare School and Center
USASOC	United States Army Special Operations Command
USSOCOM	United States Special Operations Command
UW	unconventional warfare
UWOA	unconventional warfare operating area

Endnotes

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