2022-12

PROPOSED DESIGN OF A LOW-COST, COUNTERRADIO-CONTROLLED IMPROVISED EXPLOSIVE DEVICE FOR THE PHILIPPINE MARINE CORPS RAPID EQUIPAGE

Bonavente, Joel C.

Monterey, CA; Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

PROPOSED DESIGN OF A LOW-COST, COUNTER–RADIO-CONTROLLED IMPROVISED EXPLOSIVE DEVICE FOR THE PHILIPPINE MARINE CORPS' RAPID EQUIPAGE

by

Joel C. Bonavente

December 2022

Thesis Advisor: Leo J. Blanken
Second Reader: Kristen Tsolis

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2022	**3. REPORT TYPE AND DATES COVERED** Master's thesis

4. TITLE AND SUBTITLE PROPOSED DESIGN OF A LOW-COST, COUNTER–RADIO-CONTROLLED IMPROVISED EXPLOSIVE DEVICE FOR THE PHILIPPINE MARINE CORPS' RAPID EQUIPAGE	**5. FUNDING NUMBERS**
6. AUTHOR(S) Joel C. Bonavente	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

The Philippine Marine Corps (PMC), a significant command in the Philippine Navy, is equipped to perform a wide range of tasks in support of various operational defense missions. Most PMC units are stationed in areas where local insurgent and terrorist activity is prevalent and frequently involve improvised explosive devices (IED) triggered by a signal from a terrorist's mobile phone. Given the PMC's limited resources, its current counter radio-controlled IED (RCIED) inventory is inadequate to secure the country's critically impacted areas.

Hence, this study designs a low-cost counter-RCIED to bolster the PMC's counter-IED capability. Built from commercially available components, the prototype is a lightweight, portable mobile phone signal jammer designed specifically for front-line PMC units operating in conflict-ridden areas. The study's development process also suggests improvements to the combat systems and facility development programs within the Corps' successful research and development programs within the modernization program. Thus, adopting this device can promote a culture of innovation in the PMC and throughout the Armed Forces of the Philippines. If a design for the counter-RCIED is achieved, then what? Therefore, it is important to implement the design successfully and for users to adopt it along with a culture of innovation. Hence, the first step in embracing that culture is to address critical challenges.

14. SUBJECT TERMS Philippine Marine Corps, PMC, Armed Forces of the Philippines, COTS counter-RCIED, radio/cellphone jammer, IEDs, terrorists, secessionists, insurgents, innovation, adoption	**15. NUMBER OF PAGES** 77
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release. Distribution is unlimited.

PROPOSED DESIGN OF A LOW-COST, COUNTER–RADIO-CONTROLLED IMPROVISED EXPLOSIVE DEVICE FOR THE PHILIPPINE MARINE CORPS' RAPID EQUIPAGE

Joel C. Bonavente
Colonel, Philippine Marine Corps
MA, Development Academy of the Philippines, 2017

Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN DEFENSE ANALYSIS
(IRREGULAR WARFARE)**

from the

**NAVAL POSTGRADUATE SCHOOL
December 2022**

Approved by: Leo J. Blanken
Advisor

Kristen Tsolis
Second Reader

Carter Malkasian
Chair, Department of Defense Analysis

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

The Philippine Marine Corps (PMC), a significant command in the Philippine Navy, is equipped to perform a wide range of tasks in support of various operational defense missions. Most PMC units are stationed in areas where local insurgent and terrorist activity is prevalent and frequently involve improvised explosive devices (IED) triggered by a signal from a terrorist's mobile phone. Given the PMC's limited resources, its current counter radio-controlled IED (RCIED) inventory is inadequate to secure the country's critically impacted areas.

Hence, this study designs a low-cost counter-RCIED to bolster the PMC's counter-IED capability. Built from commercially available components, the prototype is a lightweight, portable mobile phone signal jammer designed specifically for front-line PMC units operating in conflict-ridden areas. The study's development process also suggests improvements to the combat systems and facility development programs within the Corps' successful research and development programs within the modernization program. Thus, adopting this device can promote a culture of innovation in the PMC and throughout the Armed Forces of the Philippines. If a design for the counter-RCIED is achieved, then what? Therefore, it is important to implement the design successfully and for users to adopt it along with a culture of innovation. Hence, the first step in embracing that culture is to address critical challenges.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I. INTRODUCTION 1
A. THE THREAT OF IEDs TO PHILIPPINE DEFENSE AND SECURITY 2
B. APPLICABILITY OF THE INNOVATION: REVIEW OF RELATED LITERATURE 4
C. ADDRESSING THE GAP: PMC'S CURRENT COUNTER-RCIED CAPABILITY 7
D. THE PMC'S IMMEDIATE NEED FOR AN INNOVATIVE SOLUTION 9
E. STATEMENT OF THE PROBLEM 11
F. SIGNIFICANCE OF ADDRESSING THE PROBLEM 12
G. RESEARCH APPROACH 13

II. ADOPTING COUNTER-RCIED TECHNOLOGY FOR TACTICAL SOLUTIONS 19
A. INTRODUCTION 19
B. THE CONCEPT OF THE COMMERCIAL-OFF-THE-SHELF PRODUCT 19
C. READILY AVAILABLE PORTABLE COUNTER-RCIED EQUIPMENT 21
1. Elisra's EJAB (Electronic Jammer Against Bombs) 22
2. The C-GUARD RJ Manpack 23
3. Thales STORM H 24
D. PMC COUNTER-RCIED INNOVATION CONCEPT 24
1. Signal Spectrum 25
2. Jamming Power Output Requirements 25
3. Power Source 26
4. Signal Monitoring, Controlling, and Jamming Interfacing Devices 26
E. COUNTER-RCIED COMPONENTS 27
F. CONCEPTUAL DIAGRAM OF PROTOTYPE 31
G. CHALLENGES AND LIMITATIONS 32
1. Completion of the Prototype Assembly 32
2. Counter-RCIED Prototype Criteria and Evaluation 33
H. CONCLUSION 34

III. INNOVATION'S CHALLENGES AND POSSIBLE SOLUTIONS 35
A. CHALLENGES 35

1. Organizational Challenges 35
2. Capability Challenges 39
B. ADDRESSING THE CHALLENGES 40
1. Market-Based Assessment 40
2. Cost-Benefit Analysis 41
C. CONCLUSION 42

IV. CONCLUSION AND RECOMMENDATIONS 45
A. CONCLUSION 45
B. RECOMMENDATIONS 47
1. Follow-on Study 47
2. A Process Toward Adoption 47
C. ACTION PLAN FOR ADOPTION 48

LIST OF REFERENCES 51

INITIAL DISTRIBUTION LIST 57

LIST OF FIGURES

Figure 1. Graphical Trends of IED Attacks in the Philippines 3

Figure 2. Number of Casualties in the Philippines by Target Type 4

Figure 3. Photo of Current PMC Counter-RCIED 7

Figure 4. Test and Evaluation of the PMC Counter-RCIED 10

Figure 5. Counter-RCIED Innovation Conceptual Framework 17

Figure 6. Elisra's EJAB (Electronic Jammer Against Bombs) 22

Figure 7. The C-GUARD RJ ManPack 23

Figure 8. Thales STORM-H 24

Figure 9. Proposed Counter-RCIED Prototype Conceptual Diagram 31

Figure 10. Practicable Process of Implementation 49

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

Table 1. PMC Counter-RCIED Equipment and Specifications. 8

Table 2. Market Research Quotations and Specifications of Needed Components 28

Table 3. Planning Matrix for the Adoption of the Capability 36

Table 4. SWOT Analysis 41

Table 5. Way-Ahead Planning Considerations 49

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ASG	Abu Sayaff Group
AFP	Armed Forces of the Philippines
BIFF	Bangsamoro Islamic Freedom Fighters
COTS	Commercial-Off-The-Shelf
CPP	Communist Party of the Philippines
CREW	Counter-Radio controlled improvised explosive device Electronic Warfare
DAS	Defense Acquisition System
DCAPS	Defense Capability Assessment and Planning System
DND	Department of National Defense
DRMS	Defense Resource Management System
DSOM	Defense System of Management
DSPS	Defense Strategic Planning System
FTO	Foreign Terrorist Organization
GPS	Global Positioning System
GSM	Global System for Mobile Communication
GTD	Global Terrorism Database
GUI	Graphical User Interface
FAR	Federal Acquisition Regulation
IED	Improvised Explosive Device
ILS	Integrated Logistics Support
INA	Immigration and Nationality Act
LCD	Liquid Crystal Display
MILF	Moro Islamic Liberation Front

MBLT	Marine Battalion Landing Team
MNLF	Moro National Liberation Front
MOTS	Modified-Off-The-Shelf
NDF	National Democratic Front
NDI	Non-Developmental Items
NPA	New People's Army
NPS	Naval Postgraduate School
OEM	Original Equipment Manufacturer
PBDC	Philippine Bomb Data Center
PCHT	Packaging, Crating, Handling, and Transportation.
PMC	Philippines Marine Corps
RCIED	Radio Controlled Improvised Explosive Device
RCU	Remote Controlled Unit
RF	Radio Frequency
RTDO	Research and Technology Doctrine Office
SDR	Software Defined Radio
SWOT	Strengths, Weaknesses, Opportunities, Threats
TOE	Table of Organization and Equipment
TWG	Technical Working Group
UNIDIR	United Nations Institute for Disarmament Research
US	United States

EXECUTIVE SUMMARY

The Philippine Marine Corps' Marine Battalion Landing Teams (PMC-MBLT) have years of experience fighting against terrorist and lawless groups who utilize radio-controlled improvised explosive devices (RCIED) to harm the government and civilians. Most attacks involving RCIEDs have occurred in local terrorist strongholds. In the unfortunate event of such attacks, there is a significant risk to innocent civilians and ground soldiers, which is a significant issue for the security sector and its communities.

To bridge the PMC's capability gap while leveraging the country's limited resources, this study addresses the research question, "How can a low-cost, portable, counter–radio-controlled IED (counter-RCIED) be designed with commercial-off-the-shelf (COTS) components to address the IED threats to the operating troops of the Philippine Marine Corps?"

This research develops a customized counter-RCIED prototype for use by PMC troops in the operational area. The PMC acquired a counter-RCIED in 2021 to bridge the capability gap in protecting government personnel and innocent civilians from the lethal effects of IEDs. The prototype device is a modified version of the PMC's current counter-RCIED capability, designed specifically to meet the unit's budget, functionality, and weight requirements.

This research project primarily focuses on developing a low-cost COTS counter-RCIED prototype as part of the PMC's modernization projects that can identify and disrupt cellular signals widely utilized by local terrorists. The organization will save resources by adopting the prototype system. This will also allow them to sustain the current counter-RCIED equipment without incurring further costs.

It is important to emphasize that adopting the low-cost COTS counter-RCIED prototype device will involve organizational, capability, and operational challenges. From an organizational standpoint, the concerns are primarily about the policies and procedures that must be defined and followed to achieve the prototype's essential requirements. Resources and facilities constitute the most critical challenges in relation to capabilities,

personnel, and training. If such a prototype is adopted, addressing these challenges will be essential to the system's operational readiness.

To overcome these concerns, several factors must be considered and incorporated into the process. To that end, addressing the issues requires the implementation of the following measures:

- Ensure the acquisition program is in line with the defense system of management to integrate low-cost COTS counter-RCIEDs into the defense plan. To ensure operational readiness and sustainment, counter-RCIEDs should be considered part of Integrated Logistics Support and included in the PMC's Table of Organization and Equipment (TOE).

- Allocate adequate rapid prototyping infrastructure, training facilities, and hardware to ensure that innovations are implemented, and personnel has gained the knowledge and experience to meet the challenges. Likewise, further study is recommended to improve and sustain this project.

The recommendations in this study form part of a comprehensive planning process used to prepare this proposal. Finally, the research is in the long-term interest of obtaining an innovative approach to the operational difficulties experienced by PMC troops during operations.

ACKNOWLEDGMENTS

I want to thank my wife, Jesica, for never giving up on me. Despite our hardships, she stayed by my side through thick and thin. I appreciate the sacrifices you've given by caring for our family. To my daughters, Jana Joelle and Janessa Julia: you both make your parents proud. Your diligent study and good attitude are remarkable. You both served as my inspiration and motivation to complete my schooling. For our family, it was a wonderful and memorable journey.

My deepest gratitude to my advisory team, Dr. Leo Blanken and Professor Kristen Tsolis, for their valuable guidance and encouragement with this study. For believing that I can contribute more towards the service's development through innovation. Your commitment and dedication as my advisory team are exceptional. Also, my heartfelt appreciation to Professor Mike Stevens for checking up with the procurement office for the essential RCIED components. Your efforts are highly regarded and remarkable.

I am grateful to Professor Darren Rogers for his generous support and guidance in providing technical advice. I could not carry on this project without his altruistic attitude. Equally, I would also like to thank Professor Ric Romero and Mr. Manuel "Butch" Badiola for their technical assistance and expertise. Maraming Salamat!

Captain Christian Thiessen, USMC, for his help and assistance with my thesis. To all of my Marine brothers around the world. Semper Fi.

To the entire NPS family, NSAM personnel, professors, the IGPO team, GWC coaches, thesis processors, and the International Editing team. I admire your devotion to embodying the true meaning of the NPS motto, "Excellence through Knowledge." To my cohort in Defense Analysis, we have indeed made history. Heartfelt thanks to everyone.

To my Filipino and U.S. friends, fellow International Military Students, and colleagues, thank you for the memorable and fun-filled adventures we've shared here in the United States.

Above all, I thank our Almighty God as the greatest author and architect of our life. He is indeed good all the time. To God be all the glory.

HIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

Terrorism remains a global security concern that poses a significant challenge to defense and the military. Since the 9/11 attack, many more acts of terrorism have occurred and cost thousands of lives, including those of innocent civilians.[1] Recalling the report on the Boston Marathon incident, the coordinated attacks in Paris, the Davao bombing, and many others, it is evident that acts of lawlessness orchestrated by terrorists have evolved from conventional to non-conventional weapons.[2]

One such weapon of choice for terrorists is the improvised explosive device (IED), which is considered a "homemade" weapon of mass destruction.[3] In most cases, the device is used to destroy, incapacitate, harass, and distract government entities or the state itself. Since the explosive is improvised, it is often sophisticated and lethal, making it very dangerous, if not fatal. The term IED first became common during the Iraq war in 2003.[4]

By 2017, the devices had become notorious, prompting the United Nations Security Council to pass resolution 2370, condemning them for their fatal effects. Said resolution also condemns the continued flow of weapons and their components, pointing out the IEDs used and their connection among terrorists, their affiliates, and other criminal and lawless groups.[5] It thereby urged cooperation among member states to prevent any support for any terrorist act.

---

[1] Rohan Gunaratna et al., "The 9/11 Effect and the Transformation of Global Security," Council on Foreign Relations - Council of Councils, September 1, 2021, https://www.cfr.org/councilofcouncils/global-memos/911-effect-and-transformation-global-security.

[2] Alexander Kelle and Annette Schaper, *Terrorism Using Biological and Nuclear Weapons: A Critical Analysis of Risks after 11 September 2001*, PRIF Reports No. 64 (Frankfurt, Germany: Peace Research Institute Frankfurt (PRIF), 2003), https://www.hsfk.de/fileadmin/HSFK/hsfk_downloads/prif64.pdf.

[3] National Academies and Department of Homeland Security, "IED Attack: Improvised Explosive Devices" (Washington, DC: Department of Homeland Security, May 19, 2022), https://www.dhs.gov/publication/ied-attack-fact-sheet.

[4] National Academies and Department of Homeland Security.

[5] United Nations Institute for Disarmament Research, "Preventing Terrorists from Acquiring Weapons: An Expert Seminar to Examine Options to Effectively Implement United Nations Security Council Resolution 2370," UNIDIR, January 1, 2018, https://unidir.org/projects/preventing-terrorists-acquiring-weapons-expert-seminar-examine-options-effectively-2.

A. THE THREAT OF IEDs TO PHILIPPINE DEFENSE AND SECURITY

Over the years, IEDs have been used by the local communists and secessionists operating in most conflict areas of the southern part of the Philippines. Among these terrorist groups are the kidnap-for-ransom Abu Sayaff Group (ASG) and the Bangsamoro Islamic Freedom Fighters (BIFF). Likewise, the domestic insurgency waged by the armed wing of the Communist Party of the Philippines – New People's Army – National Democratic Front (CPP-NPA-NDF) has widely used IEDs as offensive and defensive tactics. As shown in Figure 1, from 2000–2020, IED-involved bombings in the Philippines drove a rollercoaster trend. For the past two decades, the Global Terrorism Database (GTD) has reported that the NPA ranked as the most active perpetrator of terroristic attacks, followed by the Moro Islamic Liberation Front (MILF) and Bangsamoro Islamic Freedom Fighters (BIFF) insurgents.[6] Furthermore, the U.S. Secretary of State declared the NPA in August 2002 to be a Foreign Terrorist Organization (FTO), according to section 219 of the Immigration and Nationality Act (INA).[7] Among local insurgent groups, the NPA, usually called the Communist Terrorist Group (CTG), possesses the most comprehensive operational range.[8]

[6] National Consortium for the Study of Terrorism and Responses to Terrorism, "Global Terrorism Database (GTD)," START, 2022, https://www.start.umd.edu/data-tools/global-terrorism-database-gtd.

[7] Bureau of Counter Terrorism, "Foreign Terrorist Organizations," Terrorist Designations and State Sponsors of Terrorism, accessed November 23, 2022, https://www.state.gov/foreign-terrorist-organizations/.

[8] Sebastian Strangio, "Court Denies Philippine Government Attempt to Declare Communist Party a 'Terrorist' Group," *The Diplomat*, September 23, 2022, https://thediplomat.com/2022/09/court-denies-philippine-government-attempt-to-declare-communist-party-a-terrorist-group/.

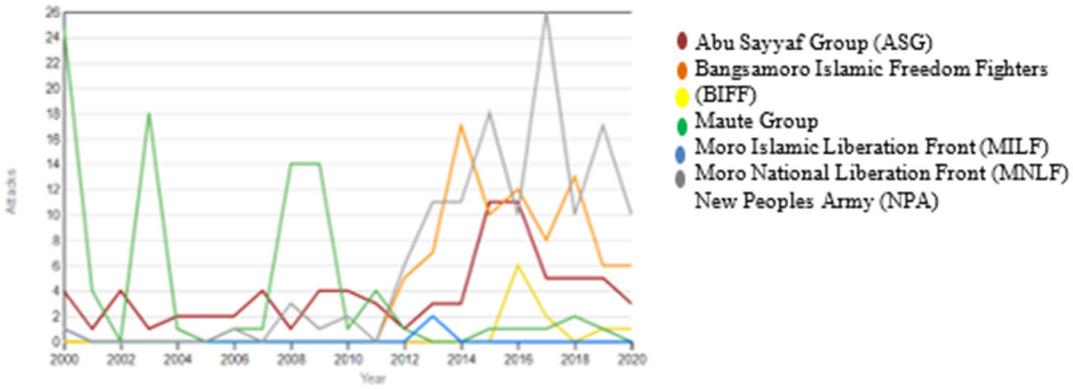


Figure 1. Graphical Trends of IED Attacks in the Philippines[9]

The use of IEDs by lawless groups has been a primary concern of the Armed Forces of the Philippines, particularly the Philippine Marine Corps (PMC). According to a report from the Philippine Bomb Data Center (PBDC), nine fatal IED-related incidents were recorded in June 2021, as well as five bombings, seven recoveries, and 17 component recovery events.[10] As shown in Figure 2, private citizens and law enforcement personnel represented the majority of the victims. Most of these fatalities were caused by IED bombings in Southern Luzon, Western Mindanao, and Central Mindanao.[11]

[9] Source: National Consortium for the Study of Terrorism and Responses to Terrorism, "Global Terrorism Database (GTD)."

[10] Action on Armed Violence, "Philippines Bomb Data Center," Action on Armed Violence AOAV, March 2, 2016, https://aoav.org.uk/2016/philippines-bomb-data-center/.

[11] Jennifer Dathan, "Deadly Attack in Davao City Leaves over 80 Dead and Injured in the Most Harmful Event of Its Kind AOAV Has Recorded in the Philippines," Action on Armed Violence-AOAV, September 5, 2016, https://aoav.org.uk/2016/deadly-attack-davao-city/.

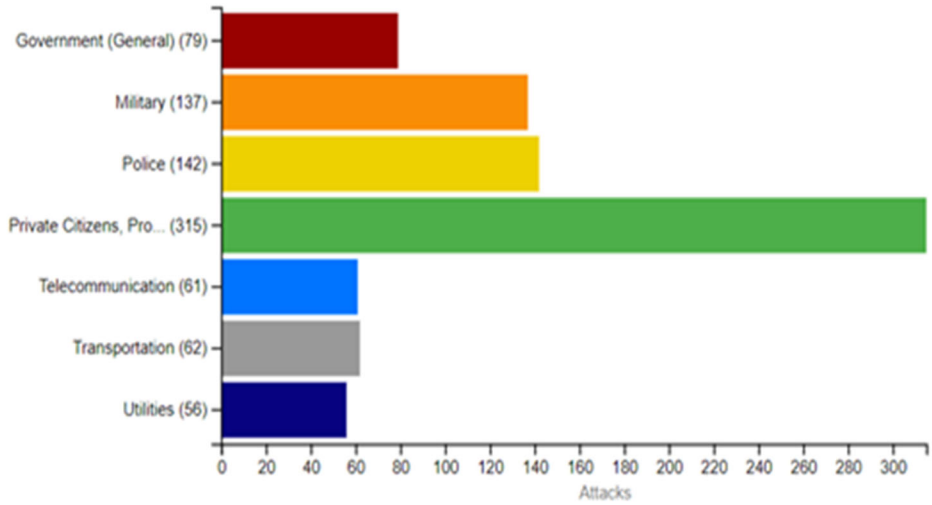


Figure 2. Number of Casualties in the Philippines by Target Type[12]

B. APPLICABILITY OF THE INNOVATION: REVIEW OF RELATED LITERATURE

Countering IEDs has become a concern of militaries and law enforcement agencies across the globe. The approach in most countries has been to innovate by adapting low-cost fabricated signal jammers or counter–radio-controlled IED (counter-RCIED) devices to thwart these bombings because common IEDs are typically connected to radio frequency receivers, usually mobile phones or remote-control electronic devices, as a triggering mechanism. According to Darrin Mortenson's article "Electronic IED Jammers Roll Out to Stymie Bombers," rapid acquisition of countermeasure devices is required to mitigate future combat casualties from RCIEDs,[13] which has been the primary focus of the military's and other security sector entities' electronic warfare (EW) countermeasure efforts against IED attacks perpetrated by terrorist groups.

An article published by Geospatial World in 2014 claimed that the epicenter of IED attacks between 2011 and 2013 was Afghanistan, Iraq, Syria, Pakistan, and India, which

[12] Source: National Consortium for the Study of Terrorism and Responses to Terrorism, "Global Terrorism Database (GTD)."

[13] Darrin Mortensson, "Electronic 'IED' Jammers Roll out to Stymie Bombers," Global Security, July 10, 2005, https://www.globalsecurity.org/org/news/2005/050710-ied-jammers.htm.

accounted for more than 53,000 deaths of civilians and coalition personnel.[14] It also asserted that the attacks brought lessons to the coalition to counter the IED threats through commercial-off-the-shelf (COTS) equipment which is readily available.[15] This equipment consists primarily of portable, vehicle-mounted jammers that cover a frequency spectrum of around 20 MHz to 3000 MHz. Using a cellphone as a receiver, it has a selective jamming mechanism attached to the more significant security umbrella.

During the operations of the United States in Afghanistan, jammers for IEDs had evolved into a more sophisticated and practical capability.[16] The COTS counter-RCIED devices became widely operational. However, the rapid development of this jamming capability also introduced loopholes in coordination and cooperation. To be effective, the system must be institutionalized in all levels of military operations, and it has to be integrated with the electronic interference system during operations. In 2004, for example, IED attacked increased due to loopholes, which disadvantaged the coalition forces.[17]

This thesis employs a systems development methodology to create a counter-RCIED. To develop the device, various processes are used. Similarly, developing such a counter-RCIED device involves a detailed understanding and analysis[18] of how the adversary has capitalized on modern technology and used all commercially available IED components to produce a destructive weapon. According to Michael E. Pesci, in his 2012 paper on "Systems Engineering in Counter Radio-Controlled Improvised Explosive Device Electronic Warfare" (CREW), it is viable to employ COTS to support the frontline

[14] Geospatial World, "Counter RCIED Systems," *Geospatial World* (blog), July 7, 2014, https://www.geospatialworld.net/article/counter-rcied-systems/.

[15] Geospatial World.

[16] Scott Hiromoto, *Fundamental Capability Portfolio Management: A Study of Developing Systems with Implications for Army Research and Development Strategy* (Santa Monica, CA: RAND Corporation, 2013), https://www.rand.org/pubs/rgs_dissertations/RGSD309.html.

[17] Hiromoto.

[18] BAE Systems, "Analysts Play an Important Role in the C-IED Fight," BAE Systems International, accessed December 5, 2022, https://www.baesystems.com/en/our-company/our-businesses/intelligence-and-security/blogs-and-web-series/inside-intelligence-blog/important-role.

warfighter.[19] With the commercialization of jammers, the CREW systems using reactive technology are being engineered by commercial manufacturers and firms to protect the military ground forces from the threats by RCIEDs.[20]

Sometime in 2003, the U.S. Army employed CREW and managed the evolutionary acquisition of the system. It has broadened the army's capability to counter-RCIEDs through a configured CREW based on a COTS system. Consequently, by adopting the CREW system, the army could address the capability gap of the warfighter. The system provided a broader spectrum of frequency to jam and control RCIED threats. As Gareth Evans has explained, the CREW design is highly flexible, allowing innovation and capability growth.[21] While proven effective, the system entailed minimal cost to the U.S. government. Hence, immediate acquisitions of the CREW were made.

In Evans's 2015 report in *Army Technology*, he also pointed out that the best solution to the threat of RCIEDs is to jam the whole radio spectrum.[22] Of course, the solution requires that the bombs must first be identified. To that end, intelligence analysis can assist in disarming triggers by examining the signs and behaviors of bombmakers. The task of identification of bombs, however, can be difficult, especially when there is limited time to implement countermeasures. Furthermore, jamming power and friendly network transmissions limit the number of radio spectrum frequencies that can be blocked, which presents other challenges in employing countermeasures with the CREW system.[23]

---

[19] Michael E. Pesci, "Systems Engineering in Counter Radio Controlled Improvised Explosive Device Electronic Warfare," *Johns Hopkins APL Technical Digest* 31, no. 1 (2012): 58–64.

[20] Pesci.

[21] John Pike, "Counter Remote Control Improvised Explosive Device (RCIED) Electronic Warfare (CREW)," Global Security, July 7, 2011, https://www.globalsecurity.org/military/systems/ground/crew-2.htm.

[22] Gareth Evans, "A New Weapon in the Fight against RCIEDs," *Army Technology* (blog), August 25, 2015, https://www.army-technology.com/analysis/featurea-new-weapon-in-the-fight-against-rcieds-4647155/.

[23] Evans.

C. ADDRESSING THE GAP: PMC'S CURRENT COUNTER-RCIED CAPABILITY

Improving the PMC's counter-RCIED equipment in its inventory can help to reduce the number of incidents caused by roadside bombs that make use of IEDs. Because of this research, the PMC will be able to close the capability gap caused by IED threats present in the frontline area.

In 2021, the PMC acquired 26 signal jammers or counter-RCIEDs, comprising five high-powered signal jammers (TSL-MP) and 21 units of jamming equipment (WH-101A-18-5g). The PMC invested 3 million Philippine pesos in this equipment to counter the RCIED threats in the frontlines.[24] For the operational security requirements of the Corps on the frontlines, the PMC inventory of this equipment was insufficient. Nonetheless, it provided deterrence against potential IED attacks. Figure 3 shows the actual counter-RCIED installation and initial testing.

Figure 3. Photo of Current PMC Counter-RCIED[25]

[24] Timothy Paul Catadal, *After Evaluation Report of Signal Jammers* (Taguig City, Philippines: Philippine Marine Corps, 2022).

[25] Source: Catadal.

As shown in Table 1, the PMC has acquired signal jammers with operational requirements as follows:

Table 1. PMC Counter-RCIED Equipment and Specifications.[26]

Equipment	Specifications
TSL-MP WH-LX11 (High-Powered Signal Jammer)	Total output power: 330 W with 11 channels of 30 W each
	Ultra-long range: 50–50 meter radius (under Signal level ≤ 85 dBm - depends on the surrounding signal strength)
	Cellphone signal: 2G, 3G, 4G, 5G about 100–300 m (depends on natural environment)
	External antenna 360-degree coverage drone; jamming with 500–2,000 meter radius (depends on natural environment)
	Portable trolley case for easy transportation and deployment
	Overlapping OK for a more stable and long-range effect
	Military resin material: anti-bomb, anti-shock, anti-vibration, anti-corrosive, waterproof, and heat resistant
	Innovative cooling with ultra-thick heat sink, large cooling fans, and heat dissipation out shells
	Built-in battery that lasts for one hour after fully charged
WH-121A-18-5G	Jamming mobile phones with 18 full-band jammers is a reliable way to block 2G, 3G, and 4G signals. The method can also be used with Walkie-Talkies, Wi-Fi, GPS, LOJACK, and even remote controls with 433 and 315 channels.
	A maximum output power of 43 W enables a jamming range of 40 m (10 m for VHF/USF)
	With infrared remote control, power is turned on and off at a distance of 2–5 meters
	Ensures external omnidirectional antennas cover all channels; it is possible to adjust or turn off a single band without affecting the other bands and use a more substantial and longer external omnidirectional antenna
	Designed with five cooling fans and an excellent cooling system
	Charges directly from a DC 12 V car charger

[26] Catadal.

D. THE PMC'S IMMEDIATE NEED FOR AN INNOVATIVE SOLUTION

Tests carried out by the Philippine Marine Corps with its current counter-RCIED revealed that it operated properly with AC and DC power supplies from 30 to 70 degrees Celsius. However, continuous plug-in with AC and DC power for 24 hours may cause overheating. Based on the settings of the signal jammer, it will last between one and two hours when connected to a DC power supply. The signal jamming capability was tested and evaluated based on observation reports from PMC end-users:[27]

- For cellular phones, the jammers can interrupt cellphone signals covering 2G/3G/4G/LTE.
- For Harris (VHF/UHF) radios, the jammers are ineffective and cannot interrupt the signals.
- For commercial radios, the jammers are effective. Nevertheless, it was noticed that the jamming capabilities were less effective upon continuous usage while connected to the power supply.
- For COTS drones, the jammers are effective.

Additionally, the device's effective radius is approximately six to ten meters in closed areas and 50–60 meters in open spaces. Convoy operations allow for up to 10 meters. Commercial radios can be jammed about 8–10 meters away. The jammers can disrupt the signals of (COTS) drones at about 20–30 meters, making them uncontrollable.

Among the drawbacks are the device may overheat in the first three to four hours after it starts. Also, there is a three-minute lapse every 15 minutes, during which the equipment is ineffective (i.e., it cannot jam signals). Furthermore, Signal Jammer WH-121A-18 cannot be used for long periods because it easily overheats when being switched on for about 30 minutes and needs to be shut off to prevent damage. Figure 4 shows the actual installation and testing of the procured counter-RCIED equipment in Headquarters MBLT3, Barangay Minara, Roxas, Palawan, Philippines.

[27] Catadal.

Figure 4. Test and Evaluation of the PMC Counter-RCIED[28]

COTS drones can be jammed from 60–70 meters with the TSL-MP WH-LX11 Signal Jammer, while remote control can be blocked from 50 meters with the jammer; the drone will not return home when jammed but will descend two (2) meters above the ground. Furthermore, the jammer must be mounted inside a vehicle to effectively operate the equipment remotely during movements. However, road conditions and terrain may cause vibration that can damage the equipment.

It was also discovered that the High-Powered Signal Jammer (TSL-MP WH-LX11) tends to fail when operated horizontally (antenna pointing sideways). Ideally, the antenna should point upwards. As a result, the High-Powered Signal Jammer (TSL-MP WH-LX11) cannot jam commercial two-way radios using frequencies of 400–470 MHz, which are widely used. It was also noticed that the signal jammer was less effective within two (2) minutes of starting.

Thus, the marine battalions, being the primary end users, have recommended that the equipment be modified in accordance with actual operational requirements based on

[28] Source: Catadal.

the findings of the PMC's current counter-RCIED evaluation.[29] The equipment itself and how the device integrates into the operational environment were the significant points of concern.

E. STATEMENT OF THE PROBLEM

Given the PMC's concerns and requirements, this study focuses on adapting a low-cost, portable, COTS-based signal jammer or counter-RCIED device for integration into operating units of the Philippine Marine Corps. If successful, this innovation will significantly help the PMC save funds, and the rapid equipage of the device to the PMC can immediately address the threats of IEDs commonly used in the country.

With the organization's meager resources, this study intends to design an innovative counter-RCIED device using low-cost components and hardware available commercially for the rapid equipping of the PMC's operating units. Thus, this device can be quickly and seamlessly integrated during real-time combat scenarios, multi-lateral military exercises, and related counter-IED training and simulations. The Philippine Navy's Research and Technology Development Office (RTDO) can also adopt this innovation for further development and production to address the RCIED threats facing the PMC.

In view of this problem statement, the study aims to provide answers to the following research question:

How can a low-cost, COTS-based, portable counter radio-controlled IED device be designed to address the IED threats facing the Philippine Marine Corps' operating troops?

As part of the research project, leadership at PMC must deal with the organizational and operational aspects of adopting and creating a prototype of a low-cost, COTS-based, counter-RCIED. Leadership must address issues in this effort by establishing a culture of acceptance, allocating funds, providing facilities and training support, and implementing and maintaining the device.

[29] Catadal.

F. SIGNIFICANCE OF ADDRESSING THE PROBLEM

The problem is considered an organizational priority concern in the broad spectrum of military operations since IEDs cause deaths and injuries to operating personnel. Aside from that, IEDs have also caused the destruction of private and public properties, damaged social infrastructure, and hindered economic growth. As incidents happened, tourism declined, and the flow of foreign direct investment slowed. Hence, economic activity has been adversely affected.

By addressing the problem, this thesis can help the PMC realize strategic, operational, and tactical gains related to the national security interest, promoting marine security operations and the safety of the operating forces on the ground. The main intention of developing the innovative portable counter-RCIED device is to deter the use of RCIEDs by terrorist groups. From the strategic perspective, this impacts the economic, socio-cultural, and techno-scientific dimensions of the national security framework.

From the economic perspective, since this innovative solution is COTS-based, it would be cost-efficient for the government. As an outcome of the adoption of this device, the Marine Forces on the ground will be able to detect IEDs planted by terrorists and prevent their detonation. In turn, this capability will eliminate or reduce the number of bombings and explosions caused by terrorists. Such will impact the economy since investors and tourists will have renewed trust in the government's security infrastructure. This would also mean promoting peace and security in the conflict-affected Southern Philippines areas. Moreover, this techno-scientific innovation will be useful in rigid marine security operations.

From the operational perspective, the problem continues to be a risk to the operating marine units in combat and routine operations. This is because the current capability in counter-RCIEDs needs to be commensurate with the technological requirements of the operations. Based on PMC status, the demand for counter-RCIEDs in marine operations could not match the command's current capability. Therefore, this research affects the operational demands for counter-RCIEDs.

At the tactical level, the marine operating forces have long recognized the danger of IEDs in the combat zone. This has been proven in many incidents of bombings and explosions. It has become a challenge for tactical operators to address the problem since it requires technological innovation. Thus, the proposal of a low-cost, COTS-based, portable counter-RCIED device would be an enabler for tactical operators to minimize operational risks and successfully accomplish the mission.

G. RESEARCH APPROACH

Due to the current high cost of modern counter-RCIED in the commercial market, the tedious procurement process, challenges with funds allocation, and the bureaucracy related to the acquisition system, it takes a long time to progress through the procurement process, gain approval for the necessary budget allocation, and make use of significant amounts of government funds. The high acquisition cost of this technology will progressively become even more affordable and widely available through rapid prototyping.

Thus, a broad array of information and sources are used to answer the research question, focusing on the organizational, financial capacity, operational requirements of the unit, present inventory of the components, market research, the prototyping and technical aspects of the COTS counter-RCIED hardware and software obtained through open sources, test and evaluation, and the integration of the device into the organization.

Primarily, the study focuses on designing and building a device to counter radio-controlled IEDs, particularly IEDs triggered by signals from mobile phones or other devices commonly used by the local terrorists and insurgents of the country. The author's approach mainly relies on electronic and non-electronic systems engineering through rapid prototyping using low-cost materials and components readily available in the commercial market. The output of the study is the design of a low-cost, COTS-based, portable, counter-RCIED, which is highly significant in addressing the capability gap of the Corps' counter-IED efforts to detect and deter the threats of RCIEDs during combat and security operations.

The study provides an opportunity to utilize the diverse experience of end-users, the technical expertise of focal persons, available resources, and facilities of the Naval Postgraduate School (NPS) to design the proposed counter-RCIED that is operationally effective and combat reliable for integration and use by the PMC. These inputs shall be incorporated and compared with all the available studies, and evidence on the effectiveness of prototyping signaled or counter-RCIED equipment.

An innovation facility such as the NPS "Robo Dojo" serves as the appropriate laboratory to build the design and prototype of the device. Moreover, the same innovation training facility can serve as a model for the PMC to establish a primary hub for related technical innovations. Through extensive consultation with NPS subject-matter experts on technical and administrative aspects and with the available seminars and workshops on prototyping, the author has significantly enhanced his skills and knowledge, which enabled the project to be materialized. Additionally, some reputable international companies have developed communication jamming and security systems for military and security purposes, which can be a source of data and information. Likewise, in 2005, Lieutenant Colonel Francis Seňoron, an army officer from the Philippines, designed and assembled a "disruptor" out of a blasting cap and water canister to safely detonate the IEDs.[30]

The hardware and software requirements recommended by NPS technical experts were also vital to this research. The realization of this project could only be made possible under the guidance and support of technical subject-matter experts of NPS, as well as personnel providing administrative and procurement assistance. Most importantly, this project's development depended on the timely acquisition and delivery of the specific components. Thus, to start with the device prototyping, it was essential to identify the optimal requirements and key features for the device, which consist of the following:

- Omni-directional antenna;

[30] Dexter Cabalza, "Metrobank's Outstanding Filipinos: Bomb 'Disruptor' Saves Lives," *Philippine Daily Inquirer*, September 10, 2018, https://newsinfo.inquirer.net/1030114/metrobanks-outstanding-filipinos-bomb-disruptor-saves-lives.

- Built-in rechargeable lithium battery, AC/DC 12V adapter, or car charger as a power supply source (Solar panel as alternative source);
- Low-cost, COTS components and materials;
- Ability to operate in enclosed areas, urban and jungle environments;
- Compact size and easy to carry;
- Ability to be used directly in a vehicle for convoy and patrol purposes;
- Jamming coverage radius of up to 20 meters (based on the signal density network);
- Ability to effectively block Global System for Mobile Communication (GSM), 2G up to 4G LTE cellphone bands, Wi-Fi / Bluetooth, and VHF/ UHF radio.

Likewise, once the design of the prototype was built, it was tested based on the required parameters as follows:

- Jamming effectiveness: render inoperable or disrupt the radio frequency of all mobile phone signals (2G–4G bands) within the coverage radius of 20 m (10 m for VHF/UHF);
- Portability: compact and lightweight, can be used in vehicle convoys and route patrols;
- Effective cooling system;
- Reliability: working battery time of 2–3 hours
- Operating temperature between -20 to +50 C

Overall, the device's test and evaluation to determine its effectiveness as was approved by NPS to be conducted in Camp Roberts, California, USA, and other appropriate

locations. Thus, the effectiveness of the device was evaluated based on its minimum requirements such as portability, reliability, versatility, and cost-effectiveness.

The results of the testing and evaluation of the device needed to be acceptable in order to convince the Armed Forces of the Philippines' (AFP) leadership to develop and make use of devices of this kind. This would be the tipping point that motivates the decision-makers to adopt an innovative culture if the project is successful. It could be an eye-opener to the research, technology, and development sectors for further development of the device in an affordable and low-cost COTS manner. It could also influence and motivate the leaders of the armed forces to prioritize the organization's innovation and adoption concerns and partner with private companies, science and technology universities, and agencies for further development and adoption.

This research project also contributes to the tactical and strategic level of cooperation between the AFP and the U.S. military as our closest ally. Tactically, the prototype device can be utilized during US-Philippine bilateral exercises and further evaluated in the combat areas to address the capability gap related to possible RCIED threats. Strategically, this output could benefit national security and countries facing similar RCIED threats.

In a nutshell, adopting the Stratign company's framework,[31] which is depicted in Figure 5, the project can be done with the concept as follows:

- Determine the problem/capability gap;
- Perform data research and analysis on RCIED-related incidents;
- Design a low-cost COTS-based counter-RCIED prototype;
- Perform testing and field evaluation;
- Pursue implementation and adoption by AFP;

[31] "Defense Technology Solutions," Stratign Strategic Defence Technology, accessed October 20, 2022, https://www.stratign.com/.

- Partner with private companies and the Research and Development sector; and
- Implement sustainment, training, and support.

Figure 5. Counter-RCIED Innovation Conceptual Framework[32]

[32] Adapted: Stratign.

THIS PAGE INTENTIONALLY LEFT BLANK

II. ADOPTING COUNTER-RCIED TECHNOLOGY FOR TACTICAL SOLUTIONS

A. INTRODUCTION

The defense and security sectors are always searching for the appropriate equipment and devices to defeat terrorists' homemade devices for a fraction of the cost of multimillion-dollar countermeasures. At the same time, many funds have already been allocated to save thousands of lives by detecting, disrupting, and destroying IEDs and their networks. Yet, the proliferation and use of IEDs continue.[33] Different countries have initiated bilateral, regional, and international cooperation with the defense sector to offer training expertise, equipment, monetary aid, and assistance to threatened nations.[34]

Among the ever-changing advancements in technology, the orientation, tracking, and surveillance of mobile phones have become the most vital. A mobile phone, whether or not it is in use, is vulnerable to an information leak. This vulnerability can be exploited, as this study shows, to combat local terrorists in the Philippines who use mobile phones to detonate bombs, particularly IEDs.

B. THE CONCEPT OF THE COMMERCIAL-OFF-THE-SHELF PRODUCT

The concept of using COTS products for low-cost innovative solutions is not new to the military. In fact, the military often uses the term MOTS (modified or modifiable off-the-shelf or military off-the-shelf) depending on the context to refer to such solutions. The said products are designed to be easily used or installed.[35] MOTS equipment is often incorporated or used as a complementary or primary system during operations.

---

[33] David F. Eisler, "Counter-IED Strategy in Modern War," *Military Review* 92, no. 1 (February 2012): 9–15, https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/MilitaryReview_20120229_art006.pdf.

[34] Iain Overton, *Addressing the Threat Posed by IEDs: National, Regional and Global Initiatives* (London: Action on Armed Violence, 2017), https://reliefweb.int/report/world/addressing-threat-posed-ieds-national-regional-and-global-initiatives.

[35] "What Is COTS, MOTS, GOTS, and NOTS?," TechTarget Search Data Center, April 2010, https://www.techtarget.com/searchdatacenter/definition/COTS-MOTS-GOTS-and-NOTS.

With such a concept in the military, these products must be customized to protect the manufacturer's patent and modified for security reasons. In most cases, software and hardware are usually COTS acquired by the military as part of its operations and systems. It is modified or customized by the manufacturer to respond to the specifics of military demands.

As government spending on military and defense equipment is soaring, COTS is a cost-effective option that can reduce the need for expensive government-sponsored research and development programs to produce military technology and products. The COTS equipment allows the military to have a technological advantage while saving costs on equipment development. In his article, "COTS Equipment Helps Satisfy Hardware and Software Needs in Military Applications," Paul Pickering identifies the following reasons for adoption of COTS equipment:

1. The reliability of commercial-grade components and subsystems has improved, eliminating the justification for expensive military specification equipment. Customers can design flexible, high-performance systems at lower cost.
2. Agencies can benefit from current commercial approaches and practices; this simplifies applications' development and deployment, enabling a more rapid adoption of new features and capabilities.
3. As the amount of COTS equipment in a system increases, it becomes more accessible and cheaper to modify the design, supporting more rapid technology refresh and greater adaptability to change.
4. COTS purchases reduce operations and support costs for military customers because suppliers can spread their development costs over multiple market sectors.[36]

For the United States, COTS serves as an alternative to the in-house production of products, and it is less costly since there is no need for maintenance and operational output. The U.S. government's Federal Acquisition Regulations classifies COTS as non-

[36] Paul Pickering, "COTS Equipment Helps Satisfy Hardware and Software Needs in Military Applications," Design World, November 27, 2018, https://www.designworldonline.com/cots-equipment-helps-satisfy-hardware-and-software-needs-in-military-applications/.

developmental items (NDI) supplied under contract to the government.[37] This is to protect and uphold the secrecy and security interests of the government concerning the product.

In the Philippines, there is no standard regulation or law that covers the production of COTS specifically for government applications with respect to counter-RCIED. While this could be a subject of a government contract under existing laws, the patent and security protocols related to COTS as part of the military equipment for counter-attacks have risks. Thus, engaging COTS should be supported by regulatory provisions under the contract of production and/or supply.

C. READILY AVAILABLE PORTABLE COUNTER-RCIED EQUIPMENT

Most militaries have used the readily available advanced technology counter-RCIEDs. A variety of COTS equipment for counter-RCIED is available in the market. As a result, these technologies have been used either to defeat RCIEDs or mitigate their destructive and fatal effects. As described by Richard Tomkins, in his article "Low-rate Production Set for New Counter-IED System," explains that RCIED equipment is typically classified as dismounted, carried in a backpack, mounted as installed in vehicles, and fixed in static locations.[38]

In his article, Glenn Goodman claims that Israel's Elisra, a subsidiary of Elbit Systems, Netline Communications Technologies, and the UK's TRL Technology are among the top producers of anti-IED jammers, along with Thales Communications.[39] For this study, some of the readily available COTS counter-RCIED equipment commonly used by the soldiers on the ground are as follows:

---

[37] Fabric Group Holdings Pty. Ltd., "COTS-Based System - What Is It and What Are the Benefits," *Fabric* (blog), March 22, 2021, http://www.fabricgroup.com.au/blog/cots-based-system-what-is-it-and-what-are-the-benefits.

[38] Richard Tomkins, "Low-Rate Production Set for New Counter-IED System," Defense News, UPI, October 14, 2014, https://www.upi.com/Defense-News/2014/10/14/Low-rate-production-set-for-new-counter-IED-system/9461413294303/.

[39] Glenn Goodman, "Dismounted Counter-IED: Size, Weight & Power Limits," *Soldier Modernisation*, January 2009, https://www.soldiermod.com/volume-2/dismounted-jamming.html.

1. Elisra's EJAB (Electronic Jammer Against Bombs)

The EJAB electronic jammer is an Israeli counter-RCIED technology that can be installed and used in a vehicle or portable suitcase. It has also proven its effectiveness to counter-RCIEDs in combat operations in the Lebanon conflict.[40]

According to Elinor Behar, as published in an Elisra Electronic System Ltd. press release, describes this device as simple, easily programmable, and having an adaptable Man-Packed form.[41] The press release also states that the EJAB has a multi-band jammer capability built into a tough backpack with the capacity to simultaneously block two frequencies with virtually any radio cellular bands, using a single lightweight antenna, as shown in Figure 6. All the performance traits of the entire EJAB family are present in this small system, which weighs about 15 kg, has a four-hour battery life, and uses sophisticated algorithms and an emergency memory wipe for information security.[42]

Figure 6. Elisra's EJAB (Electronic Jammer Against Bombs)[43]

[40] Goodman.

[41] Elinor Behar, "Counter IED Systems Are Programmable and Customizable," Thomas Net, June 22, 2010, https://news.thomasnet.com/fullstory/counter-ied-systems-are-programmable-and-customizable-578724.

[42] Behar.

[43] Source: Behar.

2. The C-GUARD RJ Manpack

Based on the Software Defined Radio platform (SDR), C-Guard RJ ManPack analyzes the entire frequency range between 20 and 2700 MHz or up to 5.8 GHz in real-time,[44] identifying the transmissions that threaten the force being protected. As a result, the force can be flexible and adaptable to new threats and environments. As shown in Figure 7, this jamming system is compact, lightweight, and rugged, designed for infantry's continuous foot patrol operations.

Netline Communications Technologies claims that the ManPack system achieves full protection through reactive jamming capabilities and the following key features:[45]

- Covers all threat bands between 20–6000 MHz, including VHF/ UHF, ISM, W-Fi, and Cellular (2G/3G/4G)
- Addresses multiple concurrent threats
- Compact, lightweight, rugged design, in a MIL-STD backpack
- Rechargeable, hot-swappable batteries—Allow continuous operation
- Radiation Safety – SAR (Specific Absorption Rate) tested and qualified
- Compact shoulder-mounted RCU
- Zeroize function to delete sensitive data from the system.

Figure 7. The C-GUARD RJ ManPack[46]

[44] Netline Communication Technologies, "Man Portable Counter IED," Netline Communication Technologies, accessed November 23, 2022, https://www.netlinetech.com/solutions/counter-ied/man-portable-counter-ied/.

[45] Netline Communication Technologies, "Man Portable Counter IED," Netline Communication Technologies, accessed November 23, 2022, https://www.netlinetech.com/solutions/counter-ied/man-portable-counter-ied/.

[46] Source: Netline Communication Technologies.

3. Thales STORM H

This device is an ultra-compact personal Electronic Counter Measure (ECM) system tested to counter RCIED technology and designed to provide confidence and freedom of movement for dismounted soldiers like using a hand-held radio as shown in Figure 8.[47] The STORM H is a lightweight, reliable, and easy-to-use device with a battery life of up to eight hours.[48]

Figure 8. Thales STORM-H[49]

D. PMC COUNTER-RCIED INNOVATION CONCEPT

This research project focuses on developing an effective COTS counter-RCIED that uses a cellphone as the trigger mechanism in the electronic warfare spectrum. The innovative prototype device will help bridge the gap in capabilities for countering RCIEDs in frontline combat. Within the concept, the counter-RCIED jamming suite comprises a self-contained Electronic Support Measure/ Electronic Counter Measure (ESM/ECM) system that uses cutting-edge methods and waveforms to counter RCIED dangers. The optimized set of system

[47] Thales, "STORM H," Thales, accessed November 27, 2022, https://www.thalesgroup.com/en/markets/defence-and-security/radio-communications/storm-h.

[48] Thales.

[49] Source: Thales.

powers that should cover the entire Global System for Mobile Communication (GSM) spectrum of interest, combined with the generation of smart and effective signal scanning, spotting, and jamming techniques, allows for a rapid response to the detected GSM frame signal and a highly effective radiation power (ERP), both of which improve the system's targeting and jamming requirements. The conceptual design for such tactical counter-RCIED should support the agile, flexible design concept that meets the mobility needs of combat foot soldiers.

Several IED innovations rely on signaling or direct current (DC), a powered hot-wire detonator with a GSM network enabler. The capability to monitor switching systems in these GSM-based, triggered, DC-powered IEDs is required for monitoring the range of GSM bands within the area of operation. To meet these specific requirements, assumptions are made as described in the following sub-sections.

1. Signal Spectrum

Given that the research focuses on using a mobile phone as a triggering mechanism. The scope is limited to the fourth generation (4G) of GSM signaling. However, the GSM broadband signaling incorporates both data and voice, and the range of 4G frequencies includes the 600 MHz, 700 MHz, 1700/2100 MHz, 2300 MHz, and 2500 MHz bands. Thus, the lower frequencies allow carriers to transmit 4G/LTE signals in rural and remote areas.[50] Therefore, the spectrum for analyzing and signal jamming needs to cater to 600 to 2500 MHz.

2. Jamming Power Output Requirements

To meet the basic requirement of jamming, it is important to identify the downlink frequency and power of the base stations to the cellular receiver or the GSM power class number to a mobile. According to Institute of Electrical and Electronic Engineers (IEEE) standards, most GSM base station transmission power does not exceed 40 dBm.[51] Given the average power for mobile handset transmission is just one-eighth of its peak power, it is

[50] "Cell Phone Frequency Bands by Provider," *Wilson Amplifiers* (blog), May 20, 2022, https://www.wilsonamplifiers.com/blog/frequencies-by-provider/.

[51] Ian Poole, "GSM Power Control & Power Class," Electronics Notes, accessed November 27, 2022, https://www.electronics-notes.com/articles/connectivity/2g-gsm/power-amplifier-control-classes.php.

similarly pulsed with a 1:8 duty cycle. The phones are set up so that once a call is established, the radiofrequency (RF) output power is reduced to the absolute minimum required for dependable communication; in the ideal case, the power may be as low as 20 mW' (one-hundredth of full power).[52] However, catering to the minimum requirement and considering such IEDs are placed outdoors, a typical strong outside signal would be between -50 and -70 dBm, whereas anything less than -100 dBm would be deemed poor (-110 means no signal at all).[53] Therefore, the jamming unit's output power must fulfill an output power of 30 dBm or 1 watt.[54]

3. Power Source

The use of a battery in an electronic system necessitates power management that is dependent on the battery type utilized by the system. Frequently, powering the system is an afterthought, as opposed to being addressed at the commencement of design. Early battery considerations are essential because interactions between batteries may impact system performance.[55] Therefore, based on the design and the urgency of counter-RCIED operation requirements, the calculation for watt/hour needs to be calculated for the entire system. The power distribution system should also accommodate charging via a vehicle DC power source or a solar panel power system. In addition, the battery charging and remaining power should be displayable to and should alert the operator according to the defined threshold.

4. Signal Monitoring, Controlling, and Jamming Interfacing Devices

Capturing and displaying RF signals is a must to aid the operators in getting the visuals on widespread RF signals. To achieve this, the design should facilitate visuals of signals, preferably in waterfall visualization form via handheld display units or the touch screen

---

[52] William Andrew Steer, "GSM Phone Signal Analysis," Techmind, March 23, 2002, http://www.techmind.org/gsm/.

[53] "What Is DBm and How Does It Affect Your Cell Signal?," *Wilson Amplifiers* (blog), December 1, 2019, https://www.wilsonamplifiers.com/blog/what-is-dbm-and-how-does-it-affect-your-cell-signal/.

[54] "DBm to Watts Conversion Calculator," DigiKey Electronics, accessed October 17, 2022, https://www.digikey.com.au/en/resources/conversion-calculators/conversion-calculator-dbm-to-watts.

[55] Sam Davis, "Mobile Power Sources Impact Military Operations," Electronic Design, March 1, 2010, https://www.electronicdesign.com/markets/mobile/article/21191972/mobile-power-sources-impact-military-operations.

solution. As Michael Ossmann and Dominic Spill state in their article, "What's on the Wireless," "A waterfall plot comprises a two-dimensional moving spectrogram that displays frequency on one axis and time on the other, the color and degree of brightness signify their signal strength."[56] Similarly, the graphical user interface (GUI) must support tweaking (for frequency gain, bandwidth, and sample rates) for further near real-time analysis of the visuals of suspected signals. Thus, the possibility of enabling or triggering the jamming unit should also be via a soft-switched interface on the same display unit.

Therefore, the researcher intends to utilize HackRF for frequency sweeping, spotting, and generating jamming signals to meet such requirements. A Raspberry Pi will be the main controller to interface with the HackRF, display, and control power amplifier units, and monitor the source supply.

E. COUNTER-RCIED COMPONENTS

The project's objective is to consider a solution based on commercial-off-the-shelf components for an effective deliverable; that is, one that does not require dedicated software. The researcher utilized an open-source solution and enhanced its programming to achieve the desired result. The researcher also conducted thorough technical consultation and guidance with the NPS Engineering Department's technical experts to develop a low-cost solution based on COTS components and build a counter-RCIED prototype.

According to the prevailing price quoted for the components, the requirement for prototyping one COTS counter-RCIED unit costs US$777.73, roughly equivalent to Php 44,330.00 at an average exchange rate of Php 57.00 for every $1 USD. This amount will cover all the requirements and make the developed device operational upon acquisition. For all the MBLTs to have this capability at the respective company level, the Philippine Marines Corps will need an allocation for 12 MBLTs.

Every MBLT has a total of five line companies, comprising three rifle companies, one weapon company, and one headquarters support company. Only the operating three rifle

[56] Michael Ossmann and Dominic Spill, "What's on the Wireless? Automating RF Signal Identification," 2017, https://www.blackhat.com/docs/us-17/wednesday/us-17-Ossmann-Whats-On-The-Wireless-Automating-RF-Signal-Identification-wp.pdf.

companies in this organization would use the developed counter-RCIED in their operations. If all rifle companies of the MBLTs are given this capability, 36 units of the developed counter-RCIED will be needed. Thus, this project will cost almost Php 1.6 million, or an average of US$28,000.00. However, the costs will differ based on the time of purchase.

In order to operationalize the counter-RCIED developed in this thesis, the following key components are needed, as shown in Table 2.

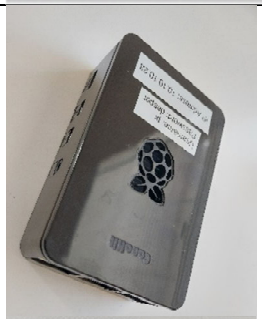
Table 2. Market Research Quotations and Specifications of Needed Components

Components	Picture	Specifications	Prices (in US$)
Antenna		The ANT500 antenna from Great Scott Gadgets works at 75 MHz to 1 GHz. The length can be adjusted from 20 cm to 88 cm. All frequencies will be covered by high-powered antennas. This will be useful during counterinsurgency operations, especially ground patrols.[57]	34.95
Power Supply		A power supply is used to power miniature computers and microcontrollers.[58] The internal battery is 5000 mAh, and the boost converter provides two USB A ports with 2.1 Amps at 5 VDC.[59]	73.95 26.95

[57] "Great Scott Gadgets ANT500 - 75 MHz to 1 GHz Telescope Antenna," Adafruit, accessed November 27, 2022, https://www.adafruit.com/product/3584.

[58] "PiJuice HAT - Raspberry Pi Portable Power Platform," SparkFun Electronics, accessed November 27, 2022, https://www.sparkfun.com/products/14803.

[59] "USB Li-Ion Power Bank with 2 x 5V Outputs @ 2.1A - 5000mAh," Adafruit, accessed November 27, 2022, https://www.adafruit.com/product/4288.

Components	Picture	Specifications	Prices (in US$)
Amplifier[60]		The Holzworth HX2400 is an extremely low-noise RF amplifier that operates between 8 MHz and 4000 MHz. It has a phase noise of 172 dBc/Hz at a 10 kHz offset and an output power of 18 dBm.[61]	215.19
Single Board Computer/RP4	 	The Raspberry Pi 4 is the latest and most powerful model in the Raspberry Pi line. It features an upgraded 64-bit quad-core processor running at 1.5 GHz and dual-band 2.4 GHz and 5 GHz wireless LAN, as well as faster Gigabit Ethernet connectivity.[62] Plus, the 64 GB MicroSD Card is a premium memory card ideal for well-known single-board computers like the Raspberry Pi 4.[63]	75.00 19.95
Raspberry Pi LCD 7" Touchscreen		The Raspberry Pi 3.7" Touchscreen display allows for building a device that can be used as a tablet or interactive interface for a future project. Each display has a full-color 800 x 480 capacitive touchscreen and runs an updated version of Raspbian OS.[64]	60.00

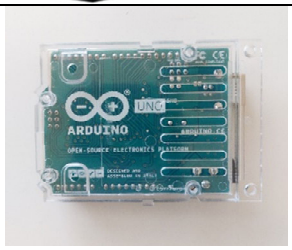
60 Source: RF Amplifier, "HX2400 - Holzworth Instrumentation," EverythingRF, accessed November 27, 2022, https://www.everythingrf.com/products/microwave-rf-amplifiers/holzworth-instrumentation/567-383-hx2400.

61 RF Amplifier.

62 "Raspberry Pi 4 Model B - 8 GB RAM," Adafruit, accessed November 27, 2022, https://www.adafruit.com/product/4564.

63 "Kingston Canvas Go! Plus 64GB MicroSD Card with Adapter," SparkFun Electronics, accessed November 27, 2022, https://www.sparkfun.com/products/16498.

64 "Raspberry Pi LCD - 7" Touchscreen," SparkFun Electronics, accessed November 21, 2022, https://www.sparkfun.com/products/13733.

Components	Picture	Specifications	Prices (in US$)
Software Defined Radio (SDR)		The HackRF One can send and receive radio signals between 1 MHz and 6 GHz. It is an open-source platform that can be used as a USB peripheral or for standalone operation. The device was created to facilitate the testing and development of next-generation radio technologies.[65]	339.95
Mini Wireless Keyboard[66]		The touchpad keyboard offers comfort and wireless connectivity freedom. With the help of this wireless keyboard, users can easily connect to and manage Bluetooth-enabled devices. It has a working range of about 33 feet (10 meters) for over-the-range Bluetooth devices.[67]	19.99
Arduino Uno Rev3 Microcontroller		The Arduino Uno Rev3 Microcontroller is an ATmega328-based microcontroller with 16 MHz processor (CSTCE16M0V53-R0) and six digital input/output pins. To power it, simply plug in a USB cable, AC-to-DC adapter, or a battery.[68]	20.70
Total Cost:			Approx. 777.73

65 "Great Scott Gadgets HackRF One - Software Defined Radio," Adafruit, accessed November 27, 2022, https://www.adafruit.com/product/3583.

66 Source: Amazon, "Fosmon Mini Bluetooth Keyboard (QWERTY Keypad), Wireless Portable Lightweight with Built-In Touchpad, Compatible with Apple TV, PS4, HTPC/IPTVVR Glasses, Smartphones and More," Amazon, accessed November 27, 2022, https://www.amazon.com/Fosmon-Portable-Lightweight-Bluetooth-Controller/dp/B00BX0YKX4/ref=sr_1_1_sspa.

67 Amazon.

68 "Arduino Uno Rev3," Arduino Online Shop, accessed November 27, 2022, https://store-usa.arduino.cc/products/arduino-uno-rev3.

F. CONCEPTUAL DIAGRAM OF PROTOTYPE

A conceptual diagram presenting the basic process for building the designed prototype is shown in Figure 9.

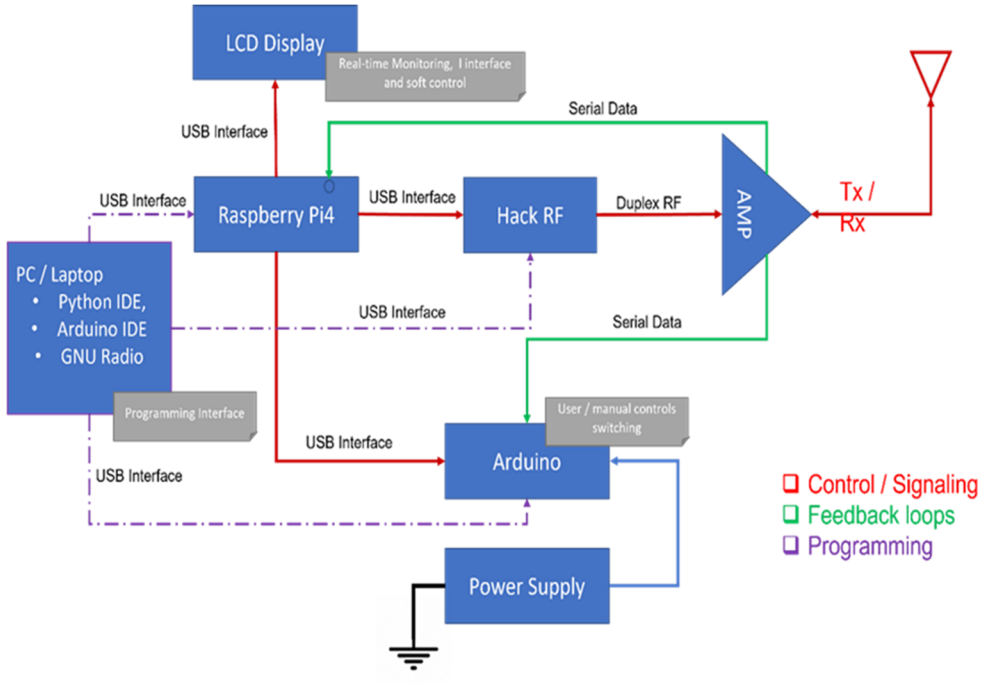


Figure 9. Proposed Counter-RCIED Prototype Conceptual Diagram[69]

Based on the conceptual diagram, following is the basic process used in developing the prototype:

- Programming and troubleshooting of the device is performed on the PC or laptop that will be used to do both of these operations.
- Using a Raspberry Pi OS and a web server configured on the Raspberry Pi, the Raspberry Pi's touchscreen provides access to the GUI interface.

[69] Adapted from: "Introduction to Remote SDR – F1ATB," accessed December 5, 2022, https://f1atb.fr/index.php/2022/01/06/introduction-to-remote-sdr/.

- The Arduino microcontroller can be used to control a manual switch or sensor since the hardware interface is what controls them.
- The Arduino microcontroller and HackRF SDR with LCD will be connected to each other through a serial port on the Arduino, using a serial cable with a serial connection.
- Gnu Radio programming by HackRF allows monitoring GSM to be visually displayed on a screen as it is being programmed. This screen will display a GUI that allows the user to explore GSM wave patterns in more detail.
- The RF amplifier signals will be connected to an Arduino via a serial data cable, which will allow users to read the amplifier's signals.
- The HackRF output is connected to the Power Amplifier by a duplex interface and is amplified by a directional antenna to enhance reception.

G. CHALLENGES AND LIMITATIONS

Due to some limitations and challenges, the counter-RCIED prototype's actual completion was never achieved. The limitation identified was the unavailability of the required components on the commercial market as well as the turnaround for deliveries. Initial components deliveries lasted more than three months, and the unforeseen non-delivery of other items impeded the prototype from being completed. The minimum requirement is to obtain low-cost components as much as possible, despite the fact that there are numerous potential suppliers. Furthermore, the cumbersome procurement process and bureaucratic restrictions also cause challenges. The test and evaluation were also canceled because of these challenges, but general parameters were still provided.

1. Completion of the Prototype Assembly

The researcher could not complete the prototype device assembly as planned due to insufficient time for the delivery of crucial components. It was discovered that some of the reasonably priced components were either out of stock or took more time than expected to arrive. Delivering on time is indeed a challenge, as are the prolonged procurement process

and cumbersome bureaucracy. The initial components were delivered three months later than expected, whereas none of the others arrived.

2. Counter-RCIED Prototype Criteria and Evaluation

Since the counter-RCIED prototype device was not completed, the test and evaluation were not conducted. Hence, the researcher recommends further study of this project. Nevertheless, the following general parameters should be used to test and evaluate the effectiveness of the prototype to be adopted:

- Value: The parts should be affordable, commercial-off-the-shelf, and readily available in the market.
- Size and weight: Both for foot patrols and vehicle patrols, the device must be portable and lightweight enough to allow for easy use regardless of the weather conditions in the field.
- Innovation: In the present technological age, the prototype should accommodate improvements in its design, and its systems may continue to improve in light of technological advances.
- System integration and installation: To ensure that the system's life cycle is protected, the system's installation should be well-engineered.
- Security: The system must guarantee that operations are protected from any potential IED threats.
- Versatility: It must be effective in a variety of mission types and adaptable to any operating environment.
- Reliability: –The durability of the prototype must be guaranteed through the high quality of the equipment and the oversight of the providers' services.
- Flexibility: The system must be user-adaptive and should meet operational needs.

- Usability: For a system to be user-friendly, the procedures and process by which it operates must be simple to understand.

H. CONCLUSION

The continuous threat of RCIED attacks on the PMC has forced the Philippine Government to take the necessary steps to counter them. The development and acquisition of jamming countermeasures were one of the ways in which preventing RCIED attacks could be accomplished. It is true that adapting the low-cost COTS counter-RCIED prototype is not without obstacles. However, it is still necessary to weigh any compromises that may be required.

Using COTS rather than building a system from scratch would allow the organization to save a significant amount of money, according to the findings of the market research. Even with the difficulties involved in persuading higher leadership to adopt the prototype, I think there is a way to advocate for advancement. A countermeasure against the RCIED threat must be in place to prevent harm and death to operating marine forces. If it is to be achieved, this solution is necessary.

If offered to all rifle companies, the alternative counter-RCIED will be less expensive than the one used and tested by the Corps. The use of a prototype is not a brand-new COTS idea. Furthermore, the COTS counter-RCIED might be simple to assemble. The prototype could also be easily evaluated using the criteria established to gauge its efficacy.

III. INNOVATION'S CHALLENGES AND POSSIBLE SOLUTIONS

A. CHALLENGES

The adoption of the system as an innovative approach to address RCIED threats may present some organizational, capability, and operational challenges. As the system will become a new capability for the PMC MBLTs, these challenges need to be resolved prior to the prototype's adoption.

1. Organizational Challenges

Although the need to adopt the system is of the essence, organizational considerations need to be factored in. At the Defense Department level, the COTS acquisition must be programmed under the Defense Systems of Management (DSOM) following its components. On the other hand, there are issues and concerns in the ownership of the innovation that should be settled to make the system readily available and operational.

The technological innovation of having a COTS counter-RCIED to address threats and prevent IED attacks by enemies in every operation of the PMC should follow the process under the DSOM. It has been advised by the Defense Acquisition Office to follow the system DSOM composed of four mutually supporting components: Defense Strategic Planning System (DSPS), Defense Capability Assessment and Planning System (DCAPS), Defense Acquisition System(DAS), and Defense Resource Management System (DRMS).[70]

This report accompanies the necessity for the AFP to address the IED threat and mitigate its effects. Based on the accounts of the soldiers in Jolo, Sulu, it was revealed that many soldiers were wounded and killed during explosions in the Southern part of the

[70] Benigno S. Aquino III, "Memorandum Order No. 17, S. 2011: Directing the Full Implementation of a Defense Reform Program, Institutionalizing the Proper Stewardship of Public Funds by the Department of National Defense (DND) and the Armed Forces of the Philippines (AFP), and Providing for the Expeditious and Effective Investigation and Prosecution of Offending DND and AFP Personnel," *Official Gazette*, May 25, 2011, https://www.officialgazette.gov.ph/2011/05/25/memorandum-order-no-17-s-2011/.

Philippines due to the lawless attacks of the local terrorists using RCIEDs and suicide bombings.[71] So, it is highly recommended the military organization has the counter-RCIED capability. As of this writing, the counter-RCIED capability is not part of the studies of the Naval Research and Technology Development Center.

As pointed out in the various literature, developing technology requires a greater amount of money since there are requirements for the developed technology, which needs to be profitable and recoup the development expenses. Thus, it is more strategic on the part of the defense department to acquire counter-RCIED components that are readily available in the market and could be tailored to the operational demands of the Marine Corps. Therefore, it is significant for the PMC to acquire and develop a low-cost COTS counter-RCIED to avoid the operating costs in its development.

Part of the strategic defense planning for adopting the COTS counter-RCIED is the determination of a short-term to a long-term plan for its acquisition. Shown in Table 3 is the planning matrix for the adoption of the capability.

Table 3. Planning Matrix for the Adoption of the Capability

Requirements	Short-Term (1-3 Yrs)	Medium-Term (4-6 Yrs)	Long-Term (7–9 Yrs)
Training of Personnel			
Equipment Acquisition			
Operational Sustainability			
System Improvement			

Note: The green fading colors depict the various stages and levels of strategic needs for the next three terms of implementation until they are fully achieved.

[71] Jim Gomez, "14 Killed, 75 Wounded in Bomb Attacks in South Philippines," AP News, April 20, 2021, https://apnews.com/article/virus-outbreak-international-news-islamic-state-group-asia-pacific-c23ac98f9ecb64eb8d610c304a95d43c.

For optimal strategic planning, there are four (4) strategic requirements for the adoption of the technology: the training of personnel, acquisition of the system, operational sustainability of the technology, and the future improvement of the system.

For the first three years, it is important to plan and carry out simultaneously the training of personnel, the purchase of equipment, and the maintenance of operational sustainability. Similar to the first term, system improvements should be made throughout the second term while keeping the first three strategic requirements in place. All strategic requirements shall remain constant for the following seven to nine years, or until all strategic requirement objectives have been accomplished. However, the equipment acquisition should take four to six years to accomplish the strategic goals fully.

The capability being considered is available commercially. However, such technological capability may also introduce challenges for the PMC. As part of the procurement process's planning phase, the requirements' determination is the first step. It involves the identification of the essential equipment to be acquired to fill the capability gap and accomplish the mission. Hence, requirements are being defined specifically to fit the marine units' operational requirements. The organization should think out of the box and adopt a culture of innovation to solve operational challenges by utilizing available technological agencies and resources.

Under the modernization program, the COTS counter-RCIED could be programmed into the future acquisition plan since the capability is already determined, and the acquisition of the capability is in phase. The capability will be acquired according to short- to medium-term targets. The operational sustainability of the system will depend on the Philippine Navy program funds, while its sustainment will be incorporated into another DSOM cycle.

There is an urgent need for counter-RCIED equipment in consideration of the terrorist attacks that the marine operations units encountered on the frontline, particularly in Jolo and other parts of southern Mindanao, where local terrorists have employed IEDs

to spread terror and commit atrocities.[72] RCIED attacks in the region continue to be a problem.[73] However, the fundamental concern of program planners at the PMC headquarters level is to have defense systems and equipment synchronized with the Philippine Navy modernization program. Given the doctrinal warfare of having an amphibious operation through the fleet-marine concept, the goal is to support the requirements of marine operations.

At the strategic level, the Department of National Defense (DND) has directed the major branches of service to realistically prioritize their modernization projects after the United States offered more than Php50 billion worth of defense assistance in preparation for the AFP Modernization Horizon 3 program cycle starting in 2023.[74] However, the majority of modernization projects that have been planned include key territorial defense assets and Humanitarian Assistance and Disaster Response (HADR) capabilities, including modernized naval ships and multi-role air assets that can also be employed to support the COVID-19 response.[75]

While the Philippines steps up its territorial security, the defense department should also continue its fight for internal security against local terrorists and communists by investing in innovative initiatives like COTS counter-RCIEDs or cutting-edge jamming equipment to strengthen the anti-terrorism campaign.[76] If this innovative project is considered, this modernization initiative will enhance how we support the fight against

[72] Jennifer Dathan, "Suicide Bombers Leave 14 Dead in Attacks on Jolo Island, Philippines," *AOAV* (blog), August 26, 2020, https://aoav.org.uk/2020/suicide-bombers-leave-14-dead-in-attacks-on-jolo-island-philippines/.

[73] Dathan, "Deadly Attack in Davao City."

[74] Martin Sadongdong, "Faustino Tells AFP: Come up with 'Realistic' Priority List for U.S. Military Grant," Manila Bulletin, October 27, 2022, https://mb.com.ph/2022/10/27/faustino-tells-afp-come-up-with-realistic-priority-list-for-us-military-grant/.

[75] Sadongdong.

[76] Lade Kagabani, "AFP Modernization Enters Horizon 3," *Daily Tribune*, September 1, 2022, https://tribune.net.ph/2022/09/02/afp-modernization-enters-horizon-3/.

terrorism. Nevertheless, the acquisition of COTS counter-RCIED capability was not included in the planned list of special projects for Horizon 3.[77]

2. Capability Challenges

Making the system part of the existing PMC capability requires addressing gaps in doctrine, personnel, training, and facility. These are the aspects of innovation that should be given attention.

On the aspect of doctrine, the inclusion of the COTS counter-RCIED is not supported by any existing doctrine. The PMC has yet to develop a doctrine for operationalizing such capability. Although it is just a countermeasure for possible IED threats, there is still a need to establish policies or doctrine to determine the rules of engagement using the system.

Furthermore, the capability of COTS counter-RCIED could be immediately employed, yet no procedures have been established regarding how the system will serve the MBLTs. It might be an easy-to-operate system, but it should be supported with policy and doctrinal procedures. As the systems will have a peculiarity in their employment, there must be procedures and policies to cover it. In consultation with the Doctrine Center, it is vital to establish a policy covering the entirety of COTS counter-RCIED operations.

Since this innovation is new to the organization, the country should take advantage of security cooperation with our allied partners through training exchange and education. Special training for counter-RCIED and U.S. counterparts could be carried out during Philippines-US bilateral exercises focusing on EW and communication scenarios.

Moreover, there is also a need to have a quality management system on the standard of quality for the COTS. Employing COTS for military operations would require higher sensitivity because the enemy might also counter it. It is also important to have security measures related to acquiring the materials because they might also be offered to other markets aside from the military. This is a concern related to operation, because low-cost

[77] "Philippine Defense Resource," *Philippine Defense Resource* (blog), accessed December 6, 2022, https://www.phdefresource.com/search/label/Special?updated-max=2020-02-14T22:18:00-08:00&max-results=5.

material would also be attractive to and easy for the enemy to obtain and use to come up with a counter-counter measure.

In terms of facility requirements, testing for reliability and effectiveness will be a major consideration in the system's adoption because it must be evaluated initially before the systems are rolled out to the MBLTs for their use. The PMC and even the Philippine Navy lack appropriate testing and evaluation facilities for COTS counter-RCIEDs. This aspect is a challenge for the PMC because the system must become accustomed to the standards of marine operations.

B. ADDRESSING THE CHALLENGES

In reference to the existing challenges and gaps in organization, capability, and operations, it is vital to come up with a market-based assessment of the possible undertaking to make the COTS counter-RCIED fully operational. The assessment can identify the advantages and disadvantages the system could present to marine operations. It can also weigh the costs over the benefits of the COTS counter-RCIED. The concept of how it will operate can also be revealed.

1. Market-Based Assessment

The market-based assessment result is a SWOT analysis of the system that the PMC will adopt to adopt the counter-RCIED. The analysis for adopting the COTS counter-RCIED is shown in Table 4.

Table 4. SWOT Analysis

Internal Factors	Strengths	Opportunities
	The system is low maintenance.	Offers a new capability in a counterattack.
	Integrated Logistics Support will be ensured by the provider.	Closes the capability gap in counter-RCIED attacks.
	It is cheap since there is no cost for development.	Enables the Philippine Marine Corps to provide an economical solution.
	Technology can be easily replaced.	Offers learning opportunities for Marine Corps personnel.
	It is easy to operate and can be learned in a short time.	
	The equipment is lightweight and portable.	
External Factors	Weaknesses	Risks/Disadvantages
	It is prone to patent infringement.	Limited availability of parts from local suppliers. Thus, high-cost of parts mainly imported from foreign Original Equipment Manufacturers (OEM)
	Security can be compromised.	Subject to long procurement process and bureaucracy. Including the effects on global inflation.

The COTS counter-RCIED will be relatively hassle-free for the PMC to maintain as its parts and replacement are generally available in the market. Maintenance, as well as the logistics requirements for its operations, will be provided by the supplier. The technology is easy to learn as other foreign militaries have used it. Yet, there are also aspects of COTS that have to be accounted for, including the possibility of their vulnerability to patent infringement and security compromise. The acquisition of COTS counter-RCIED will be an add-on capability to the existing capabilities of the PMC. This will be a learning opportunity for personnel to address IED threats and mitigate the explosion's impact, if not prevent it. Nevertheless, the acquisition of this system is at risk due to the absence of a local provider and the tedious procurement system.

2. Cost-Benefit Analysis

Based on the prevailing prices, the cost of employment of the counter-RCIED per marine company would be Php 43,330.00. If all the marine rifle companies are given the capability, the expected amount needed is roughly Php 1.6 million pesos.

Compared to the current counter-RCIED of PMC in its inventory, the PMC can save significant time and money by adopting the design of a COTS prototype for counter-RCIED. In developing its own solution, the acquired training within the organization would help put together a team of technical experts who know and develop the technology. It is important to organize a technical working group (TWG) to study the technology on how the counter-RCIED device will be further develop. Such an effort would entail identifying who would do the research as well as who would manage the development process. From finding the idea to making it a reality, the organization would need millions of dollars for just one project.

It has been emphasized by the Defense Acquisition Office (DAO) to pursue small items modernization projects that have a great impact on military operations.[78] Indeed, the COTS counter-RCIED will provide the organization with a production advantage since it will be outsourced from a contractor or provider, but the said undertaking has to be confined to the national security interest so that patent infringement can be avoided.

With limited funds and support, the armed forces must seek an alternative and innovative solution to the problem of RCIED threats. COTS military equipment is ideal since there will be no production, operating, or development costs. It will be a straightforward acquisition. Nevertheless, the availability of a well-equipped innovation facility and technical training skills are the key points in developing the prototype design of the counter-RCIED device.

C. CONCLUSION

Having the prototype counter-RCIED enabled by COTS components is cost-effective to the organization; however, the solution brings various organizational, capability, and operational considerations. These are partly beyond the control of the PMC and would need to be lobbied for with the higher headquarters. Adopting the prototype is indeed an organizational concern based on need, but acquiring the equipment requires approval from higher authorities.

[78] Kagabani, "AFP Modernization Enters Horizon 3."

In reality, organizational concerns are components of the policy and legal requirements that have to be met to acquire competence. On the other hand, since they would require organizational measures, the capability concerns are things the PMC might work on. Furthermore, the capability issues might have internal remedies. While operational viability and adaptability must be crucial components of the prototype's testing and evaluation processes. In this instance, they are already taken into account while setting up the test and evaluation parameters for the COTS counter-RCIED.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

Incidents encountered by the Philippine Marine Corps brought about by RCIED have caused injuries to and deaths of personnel since 2000.[79] This problem is quite alarming to the organization, given the proliferation of RCIED terrorist attacks in the Southern part of the Philippines, particularly in the provinces of Jolo, Basilan, and Central Mindanao.

Despite the international condemnation of the use of IEDs in terrorist and/or lawless attacks, these devices continue to be a primary concern of the military. Over the years, this threat has been encountered by the ground forces of the PMC (especially the MBLTs). As the threat continues to cost soldiers' lives, it is urgent to provide the PMC with a reliable and a cost-effective RCIED countermeasure device.

In that connection, a low-cost, COTS-based, portable counter-RCIED is proposed to address the IED threats to the PMC's operating troops. The effectiveness of this system has been postulated in various articles describing the experiences of foreign militaries. Indeed, low-cost COTS solutions have become a trend for the military to resolve capability gaps without spending much on hardware or equipment development.

There are many low-cost COTS counter-RCIEDs available in the market, but for the PMC, the available system had to be modified to accommodate the operational requirements of the ground forces. As a first step, the system requirements needed to be fully identified to attain the objective of adapting this technological innovation.

Yet, even when the COTS counter-RCIED has been modified to meet the identified, requirements, the PMC will face various challenges relating to the capability itself and the system's operationalization as the organization begins adopting the capability. As to the organizational challenges, the main concern of system acquisition is the modernization

[79] National Consortium for the Study of Terrorism and Responses to Terrorism, "Global Terrorism Database (GTD)."

priority of the Armed Forces of the Philippines based on the DSOM. Although radio jammers are part of the special projects listed under the Horizon 2 of the modernization program, the proposal to have a low-cost COTS counter-RCIED was not identified as part of the list.[80] Hence, this should be incorporated into the priority list of the modernization program.

As mentioned earlier, challenges to adopting the COTS counter-RCIED are related to doctrine, personnel training, materiel, and facility requirements for testing and assessing the capability. The concept of how the system can be incorporated into the operation could be learned but should be guided by policy and doctrines. So, a policy must be crafted to have a well-established guideline on how it will work during operations and its rules of engagement.

In parallel with the doctrinal requirement, personnel must be well-trained to avoid risk and observe security measures employing the system. Because no one in the organization has technical knowledge of how the system works, training is highly recommended. This constitutes personnel readiness which is added to the aspect of operational readiness of the system. Then, facility requirements for testing and evaluation of the system must be established since its accuracy and effectiveness must be determined.

To help the PMC to address these challenges, a SWOT analysis and a cost-benefit analysis were used to establish parameters to shape the courses of action. Given this fact, the focus was more on the system's strengths that could be offered to the organization rather than the weaknesses. Therefore, the organization must consider the inadequacies through strict implementation of contractual obligations with the provider or supplier of the system.

Finally, compared to its cost, the benefit analysis could provide to the PMC's combat operations of adopting a customized, low-cost, portable counter-RCIED based on

[80] Mike Yeo, "Here's the Philippine Military's Wish List for Its Newly Approved Modernization Phase," Defense News, June 21, 2018, https://www.defensenews.com/global/asia-pacific/2018/06/21/heres-the-philippine-militarys-wish-list-for-its-newly-approved-modernization-phase/.

COTS components an affordable solution to address the types of threats and related-IED attacks that PMC has previously encountered.

B. RECOMMENDATIONS

The researcher presents two key recommendations for the adoption and development of the project. Since it was not possible to complete the assembly, testing, and evaluation of the device, future research could focus on these areas using the same approach and types of components. The project could be realized as improvements occur in the supply chain, resource allocation, and programming, and as a culture of innovation is nurtured that can also sustain the project

1. Follow-on Study

It is strongly recommended that the concept be continued using the same components and other high-end technologies while maintaining a low cost for COTS components. The researcher's proposal could only produce a concept due to difficulties encountered during the procurement process and insufficient time to deliver the components due to out-of-stock issues. After putting the system together, testing and evaluation are carried out to determine its effectiveness.

2. A Process Toward Adoption

The adoption of the low-cost COTS counter-RCIED will require the Philippine Marine Corps to take the following actions:

a. Lobby to Higher Headquarters for the Inclusion of Low-Cost COTS Counter-RCIED

Adopting the system would entail a fund requirement on the part of the organization; this concern is beyond the control of the PMC since the fund allocation will be coming from the modernization program. In this case, the end-user must lobby for the inclusion of the system to higher headquarters so that it will be included in the list of special projects under the Horizon 3 of the AFP Modernization program.

b. Align the Programming of Acquisition with the DSOM

There are capability challenges related to having the system. These challenges should be part of the DSOM planning and should ensure personnel will be fit to operate the system. People must know how the system will work and how it will be employed about existing doctrines and policies. These are part of strategic defense planning because capability gaps must be addressed. Other than that, weaknesses and the risks associated with the system's employment must be strategically assessed to mitigate its effect to the organization and operations.

c. Consider Integrated Logistics Support to Ensure Operational Readiness

It is useful to consider the life cycle of the low-cost COTS counter-RCIED so that the replacement and improvement of the system will be programmed appropriately. The system's operational readiness should be ensured through ILS programs. Furthermore, the programs must be embedded in planning the system's adoption. This also means customized innovation must be maintained and updated since the technology may become obsolete.

C. ACTION PLAN FOR ADOPTION

The program of acquiring the low-cost COTS counter-RCIED to address the threats and attacks by RCIEDs must follow a doable implementation process. Hence, as shown in Figure 10, a framework is recommended to implement the adoption of the counter-RCIED. This framework comprises the planning, proposal, programming, execution, and evaluation processes of the entire initiative that can be adapted for the project implementation.

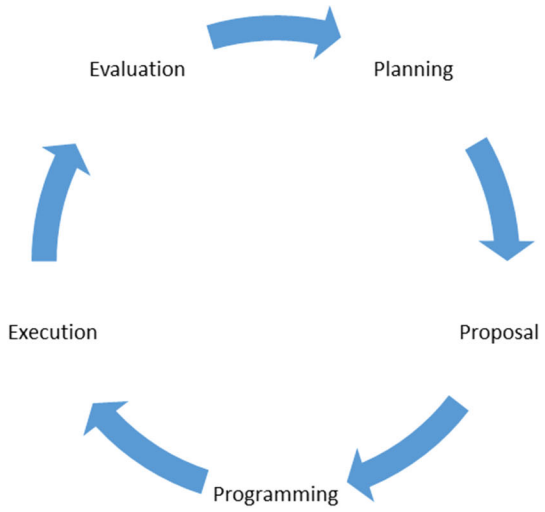


Figure 10. Practicable Process of Implementation

Under this practicable process of implementation is the recommended action plan for the implementation of the project as depicted in Table 5.

Table 5. Way-Ahead Planning Considerations

Implementation Process	Planning Consideration
Planning	Creation of Technical Working Group for the project Doctrines Needed Materiel Support Innovation Facility Center, complete with equipment
Proposal	Adoption of low-cost COTS counter-RCIED
Programming	Resources Allocation Horizon 3 Special Projects for AFP Modernization Consideration of required ILS and inclusion in the TOE Personnel's Training Package
Execution	The procurement must include the following basic components: • Antenna • Power Supply • Amplifier • Interface LCD TouchScreen • Mini Wireless Keyboard • SBC/RP4 • SDR • Arduino microcontroller
Evaluation	Acquisition and Acceptance of the project in compliance with the Philippine Government Procurement Law (RA9184)

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Action on Armed Violence. "Philippines Bomb Data Center." March 2, 2016. https://aoav.org.uk/2016/philippines-bomb-data-center/.

Adafruit Industries. "Great Scott Gadgets ANT500 - 75 MHz to 1 GHz Telescope Antenna." Accessed November 27, 2022. https://www.adafruit.com/product/3584.

———. "Great Scott Gadgets HackRF One - Software Defined Radio." Accessed November 27, 2022. https://www.adafruit.com/product/3583.

———. "Raspberry Pi 4 Model B - 8 GB RAM." Accessed November 27, 2022. https://www.adafruit.com/product/4564.

———. "USB Li-Ion Power Bank with 2 x 5V Outputs @ 2.1A - 5000mAh." Accessed November 27, 2022. https://www.adafruit.com/product/4288.

Amazon. "Fosmon Mini Bluetooth Keyboard (QWERTY Keypad), Wireless Portable Lightweight with Built-In Touchpad, Compatible with Apple TV, PS4, HTPC/ IPTVVR Glasses, Smartphones and More." Accessed November 27, 2022. https://www.amazon.com/Fosmon-Portable-Lightweight-Bluetooth-Controller/dp/B00BX0YKX4/ref=sr_1_1_sspa.

Aquino III, Benigno S. "Memorandum Order No. 17, S. 2011: Directing the Full Implementation of a Defense Reform Program, Institutionalizing the Proper Stewardship of Public Funds by the Department of National Defense (DND) and the Armed Forces of the Philippines (AFP), and Providing for the Expeditious and Effective Investigation and Prosecution of Offending DND and AFP Personnel." *Official Gazette*, May 25, 2011. https://www.officialgazette.gov.ph/2011/05/25/memorandum-order-no-17-s-2011/.

Arduino. "Arduino Uno Rev3." Accessed November 27, 2022. https://store-usa.arduino.cc/products/arduino-uno-rev3.

BAE Systems. "Analysts Play an Important Role in the C-IED Fight." Accessed December 5, 2022. https://www.baesystems.com/en/our-company/our-businesses/intelligence-and-security/blogs-and-web-series/inside-intelligence-blog/important-role.

Behar, Elinor. "Counter IED Systems Are Programmable and Customizable." Thomas, A Xometry Company, June 22, 2010. https://news.thomasnet.com/fullstory/counter-ied-systems-are-programmable-and-customizable-578724.

Bureau of Counter Terrorism. "Foreign Terrorist Organizations." Terrorist Designations and State Sponsors of Terrorism. Accessed November 23, 2022. https://www.state.gov/foreign-terrorist-organizations/.

Cabalza, Dexter. "Metrobank's Outstanding Filipinos: Bomb 'Disruptor' Saves Lives." *Philippine Daily Inquirer*, September 10, 2018. https://newsinfo.inquirer.net/1030114/metrobanks-outstanding-filipinos-bomb-disruptor-saves-lives.

Catadal, Timothy Paul. *After Evaluation Report of Signal Jammers*. Taguig City, Philippines: Philippine Marine Corps, 2022.

Dathan, Jennifer. "Deadly Attack in Davao City Leaves over 80 Dead and Injured in the Most Harmful Event of Its Kind AOAV Has Recorded in the Philippines." Action on Armed Violence-AOAV, September 5, 2016. https://aoav.org.uk/2016/deadly-attack-davao-city/.

———. "Suicide Bombers Leave 14 Dead in Attacks on Jolo Island, Philippines." *AOAV* (blog), August 26, 2020. https://aoav.org.uk/2020/suicide-bombers-leave-14-dead-in-attacks-on-jolo-island-philippines/.

Davis, Sam. "Mobile Power Sources Impact Military Operations." Electronic Design, March 1, 2010. https://www.electronicdesign.com/markets/mobile/article/21191972/mobile-power-sources-impact-military-operations.

DigiKey Electronics. "DBm to Watts Conversion Calculator." Accessed October 17, 2022. https://www.digikey.com.au/en/resources/conversion-calculators/conversion-calculator-dbm-to-watts.

Eisler, David F. "Counter-IED Strategy in Modern War." *Military Review* 92, no. 1 (February 2012): 9–15. https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/MilitaryReview_20120229_art006.pdf.

Evans, Gareth. "A New Weapon in the Fight against RCIEDs." *Army Technology* (blog), August 25, 2015. https://www.army-technology.com/analysis/featurea-new-weapon-in-the-fight-against-rcieds-4647155/.

F1ATB. "Introduction to Remote SDR." Accessed December 5, 2022. https://f1atb.fr/index.php/2022/01/06/introduction-to-remote-sdr/.

Fabric Group Holdings Pty. Ltd. "COTS-Based System - What Is It and What Are the Benefits." *Fabric* (blog), March 22, 2021. http://www.fabricgroup.com.au/blog/cots-based-system-what-is-it-and-what-are-the-benefits.

Geospatial World. "Counter RCIED Systems." *Geospatial World* (blog), July 7, 2014. https://www.geospatialworld.net/article/counter-rcied-systems/.

Gomez, Jim. "14 Killed, 75 Wounded in Bomb Attacks in South Philippines." AP NEWS, April 20, 2021. https://apnews.com/article/virus-outbreak-international-news-islamic-state-group-asia-pacific-c23ac98f9ecb64eb8d610c304a95d43c.

Goodman, Glenn. "Dismounted Counter-IED: Size, Weight & Power Limits." *Soldier Modernisation*, January 2009. https://www.soldiermod.com/volume-2/dismounted-jamming.html.

Gunaratna, Rohan, Patrycja Sasnal, Wesley Wark, John B. Bellinger III, and Anne Koch. "The 9/11 Effect and the Transformation of Global Security." Council of Councils, September 1, 2021. https://www.cfr.org/councilofcouncils/global-memos/911-effect-and-transformation-global-security.

Hiromoto, Scott. *Fundamental Capability Portfolio Management: A Study of Developing Systems with Implications for Army Research and Development Strategy*. Santa Monica, CA: RAND Corporation, 2013. https://www.rand.org/pubs/rgs_dissertations/RGSD309.html.

Kagabani, Lade. "AFP Modernization Enters Horizon 3 - Daily Tribune," September 1, 2022. https://tribune.net.ph/2022/09/02/afp-modernization-enters-horizon-3/.

Kelle, Alexander, and Annette Schaper. *Terrorism Using Biological and Nuclear Weapons: A Critical Analysis of Risks after 11 September 2001*. PRIF Reports No. 64. Frankfurt, Germany: Peace Research Institute Frankfurt (PRIF), 2003. https://www.hsfk.de/fileadmin/HSFK/hsfk_downloads/prif64.pdf.

Mortensson, Darrin. "Electronic 'IED' Jammers Roll out to Stymie Bombers." Global Security.Org in the news, July 10, 2005. https://www.globalsecurity.org/org/news/2005/050710-ied-jammers.htm.

National Academies, and Department of Homeland Security. "IED Attack: Improvised Explosive Devices." Washington, DC: Department of Homeland Security, May 19, 2022. https://www.dhs.gov/publication/ied-attack-fact-sheet.

National Consortium for the Study of Terrorism and Responses to Terrorism. "Global Terrorism Database (GTD)." START, 2022. https://www.start.umd.edu/data-tools/global-terrorism-database-gtd.

Netline Communication Technologies. "Man Portable Counter IED." Accessed November 23, 2022. https://www.netlinetech.com/solutions/counter-ied/man-portable-counter-ied/.

Ossmann, Michael, and Dominic Spill. "What's on the Wireless? Automating RF Signal Identification," n.d. https://www.blackhat.com/docs/us-17/wednesday/us-17-Ossmann-Whats-On-The-Wireless-Automating-RF-Signal-Identification-wp.pdf.

Overton, Iain. *Addressing the Threat Posed by IEDs: National, Regional and Global Initiatives*. London: Action on Armed Violence, 2017. https://reliefweb.int/report/world/addressing-threat-posed-ieds-national-regional-and-global-initiatives.

Pesci, Michael E. "Systems Engineering in Counter Radio Controlled Improvised Explosive Device Electronic Warfare." *Johns Hopkins APL Technical Digest* 31, no. 1 (2012): 58–64.

Philippine Defense Resource. "Philippine Defense Resource." Accessed December 6, 2022. https://www.phdefresource.com/search/label/Special?updated-max=2020-02-14T22:18:00-08:00&max-results=5.

Pickering, Paul. "COTS Equipment Helps Satisfy Hardware and Software Needs in Military Applications." Design World, November 27, 2018. https://www.designworldonline.com/cots-equipment-helps-satisfy-hardware-and-software-needs-in-military-applications/.

Pike, John. "Counter Remote Control Improvised Explosive Device (RCIED) Electronic Warfare (CREW)." Global Security, July 7, 2011. https://www.globalsecurity.org/military/systems/ground/crew-2.htm.

Poole, Ian. "GSM Power Control & Power Class." Electronics Notes. Accessed November 27, 2022. https://www.electronics-notes.com/articles/connectivity/2g-gsm/power-amplifier-control-classes.php.

RF Amplifier. "HX2400 - Holzworth Instrumentation." EverythingRF. Accessed November 27, 2022. https://www.everythingrf.com/products/microwave-rf-amplifiers/holzworth-instrumentation/567-383-hx2400.

Sadongdong, Martin. "Faustino Tells AFP: Come up with 'realistic' Priority List for U.S. Military Grant." Manila Bulletin, October 27, 2022. https://mb.com.ph/2022/10/27/faustino-tells-afp-come-up-with-realistic-priority-list-for-us-military-grant/.

SparkFun Electronics. "Kingston Canvas Go! Plus 64GB MicroSD Card with Adapter." Accessed November 27, 2022. https://www.sparkfun.com/products/16498.

———. "PiJuice HAT - Raspberry Pi Portable Power Platform." Accessed November 27, 2022. https://www.sparkfun.com/products/14803.

———. "Raspberry Pi LCD - 7" Touchscreen." Accessed November 21, 2022. https://www.sparkfun.com/products/13733.

Steer, William Andrew. "GSM Phone Signal Analysis." Techmind, March 23, 2002. http://www.techmind.org/gsm/.

Strangio, Sebastian. "Court Denies Philippine Government Attempt to Declare Communist Party a 'Terrorist' Group." *The Diplomat*, September 23, 2022. https://thediplomat.com/2022/09/court-denies-philippine-government-attempt-to-declare-communist-party-a-terrorist-group/.

Stratign. "Defense Technology Solutions." Stratign Strategic Defence Technology. Accessed October 20, 2022. https://www.stratign.com/.

Tech Target Contributor. "What Is COTS, MOTS, GOTS, and NOTS?" TechTarget Search Data Center, April 2010. https://www.techtarget.com/searchdatacenter/definition/COTS-MOTS-GOTS-and-NOTS.

Thales. "STORM H." Accessed November 27, 2022. https://www.thalesgroup.com/en/markets/defence-and-security/radio-communications/storm-h.

Tomkins, Richard. "Low-Rate Production Set for New Counter-IED System." Defense News. UPI, October 14, 2014. https://www.upi.com/Defense-News/2014/10/14/Low-rate-production-set-for-new-counter-IED-system/9461413294303/.

United Nations Institute for Disarmament Research. "Preventing Terrorists from Acquiring Weapons: An Expert Seminar to Examine Options to Effectively Implement United Nations Security Council Resolution 2370." UNIDIR, January 1, 2018. https://unidir.org/projects/preventing-terrorists-acquiring-weapons-expert-seminar-examine-options-effectively-2.

Wilson Amplifiers. "Cell Phone Frequency Bands by Provider." *Wilson Amplifiers* (blog), May 20, 2022. https://www.wilsonamplifiers.com/blog/frequencies-by-provider/.

———. "What Is DBm and How Does It Affect Your Cell Signal?" *Wilson Amplifiers* (blog), December 1, 2019. https://www.wilsonamplifiers.com/blog/what-is-dbm-and-how-does-it-affect-your-cell-signal/.

Yeo, Mike. "Here's the Philippine Military's Wish List for Its Newly Approved Modernization Phase." Defense News, June 21, 2018. https://www.defensenews.com/global/asia-pacific/2018/06/21/heres-the-philippine-militarys-wish-list-for-its-newly-approved-modernization-phase/.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California