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Smartphones in the Tactical Environment: A Framework for Financial Analysis of U.S. Marine Corps Options

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Panel 10. Issues in Distributing Software Components to the Tactical Edge

Wednesday, May 14, 2014	
3:30 p.m. – 5:00 p.m.	**Chair: Reuben Pitts,** President, Lyceum Consulting, LLC **Discussant: Michael Schwind,** Vice President Maritime Sector, Siemens PLM Software ***Smartphones in the Tactical Environment: A Framework for Financial Analysis of U.S. Marine Corps Options*** Nick Dew, Naval Postgraduate School Glenn Cook, Naval Postgraduate School John Gibson, Naval Postgraduate School ***"Pushing a Big Rock Up a Steep Hill": Acquisition Lessons Learned From DoD Applications Storefront*** Amanda George, SPAWAR Systems Center Pacific Michel Morris, SPAWAR Systems Center Pacific Matthew O'Neil, SPAWAR Systems Center Pacific

Smartphones in the Tactical Environment: A Framework for Financial Analysis of U.S. Marine Corps Options

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Abstract

The purpose of this analysis is to explore the application of commercial smartphone technology in the United States Marine Corps (USMC) tactical environment. Based on our research and financial analysis, we conclude that the dual-use potential of smartphones makes their economics more attractive than the existing radios the USMC has available, and, therefore, the business case for deploying sleeved smartphones in the tactical environment complements the military rationale for adopting this technology. Because uncertainty exists about what the true productivity benefits of smartphones might or might not be for different kinds of USMC users, we recommend that the USMC adopt a staged investment approach to smartphones, starting with a substantive trial of the technology in order to better understand the potential economic benefits.

Introduction

In 2013, the typical U.S. teen sent 3,339 text messages a month (i.e., over 100 per day).

The original proposal on which this report was based started with the premise that smartphones of the kind used by the typical U.S. teen might have tactical utility for the United States Marine Corps (USMC). Some of the same teens mentioned above go on to become newly minted USMC riflemen. So why not take a technology that they use ubiquitously in their personal lives and apply it to improve their warfighting capabilities and their productivity? After all, some Marines already BYOD (bring your own device) when authorized by their commander or acquire mobile cellular capabilities from local providers while deployed. In other words, they are even willing to bring their own gear/stuff to work in order to work faster and better (i.e., more productively). Some of those productivity benefits undoubtedly spill over and are captured by the Department of Defense (DoD).

In our proposal, we posited the potential value of a secure mobile virtual network operator (sMVNO) concept for USMC tactical operations as a way of implementing smartphones over a private cellular network. Since we wrote the proposal, quite a lot has changed in the fast-moving tactical communications environment: The technical options are evolving at a clip, USMC requirements have changed, and—not least of all—the budgetary environment (with sequestration and a likely budget drawdown) has altered considerably with several of the USMC budget priorities cut back significantly, including some in the command and control (C2) area. USMC end strength, currently at 195,000, will almost certainly fall, perhaps by as much as a quarter in the medium term (to around 150,000) depending on future congressional appropriations. Certainly, the prospects of a significant USMC end-strength reduction cannot be ignored.

The good news is that opportunities for deploying smartphones via DoD private cellular networks have increased and offer one potential way of soaking up some of the USMC end-strength reduction by improving the warfighting capabilities and productivity of the individual Marines that remain and, consequently, the Corps as a whole compared to what it would otherwise be. It is the usual story: a smaller fighting force, but one that packs more punch per rifleman/sailor/pilot. Achieving this requires innovation in the way the USMC does things, something that is already high on the strategic agenda at the USMC.

The analysis we provide in this report is designed with this guidance in mind. We see the combination of commercial off-the-shelf (COTS) smartphones and COTS private cellular networks integrated with military hardware and software as providing innovation potentialities that are well worth further analysis and experimentation. The report reflects the most up-to-date information that is available to us about the directions that the USMC and the DoD are following for deploying smartphones and private cellular networks. This looks like it will not include the sMVNO concept we mooted a year ago, so in the report we focus on analyzing two more likely paths of smartphone and cellular network adoption:

- the deployment of a secure H2 smartphone sleeve to increase capabilities at the squad level (a project already initiated by MARCORSYSCOM (Marine Corps systems command) under the MOBILITY JCTD); and
- the deployment of Oceus Networks private cellular systems to increase the capabilities of the company combat operations center (COC; a project similar to one already developed via the JOLTED TACTICS JCTD, of which the U.S. Army has already initiated purchases).

Importantly, the report is designed to be of practical use to USMC stakeholders, specifically staff at MARCORSYSCOM, and potentially also in the U.S. Army, which is considering similar initiatives to the USMC.

Our basic conjecture is that sleeved smartphones may be not just militarily justifiable owing to their tactical utility, but are financially justifiable based on their *dual-use economics*: They may pay for themselves by generating productivity benefits for Marines while dwelling at home station, even if we attribute zero financial benefits for the days the phones are deployed in the field. Or, to put the same point in a different way, if a sleeved smartphone offers similar tactical utility to the PRC-152 and PRC-153 radios currently used, then the tactical benefits are a “wash” in the financial analysis, and we can therefore ignore them. Instead, we can focus on the relative costs of the different alternatives and on their potential for productivity benefits. In fact, there may be a financial case for adopting smartphones without an H2 sleeve for non-tactical use, simply based on their productivity benefits. We explore these alternatives in this report.

Our approach is to examine the business-case analysis (BCA) for sleeved smartphone and private cellular network adoption by analyzing a reasonable set of assumptions around this issue, but we acknowledge that we have made many simplifications in our approach. Partly, this is owing to constraints (i.e., data incompleteness). But, just as importantly, these simplifications are a choice. For example, we know that salaries vary among riflemen according to the exact rank make up in a particular squad, platoon, or company. However, for the most part, we use an E1 salary as a benchmark for evaluating the BCA. This is not because we don’t know better; it is because it reduces the number of assumptions we make in the analysis, keeps the math more simple and therefore more transparent, and makes it easier for others to replicate or test and alter. Also, it means we have made some choices about what we think are the key drivers of the analysis, the factors that really make a difference in producing the main results. Because our approach is high level (we make some very general assumptions), our analysis is in fact best thought of as a “first cut” that will be useful in helping to frame the business case for/against smartphone and cellular network adoption and to point to where some more detailed analyses might be worth doing.

As a preview of our findings, the main conclusion we draw is that the dual-use potential of smartphone technology makes the economics more attractive than the existing radios USMC has available. Hence, the business case for deploying tactical sleeved smartphones complements the military rationale for adoption. The big economic benefit of smartphones will be in how they enable Marines to work smarter when at their home base as well as fighting better when deployed (if that in fact proves to be the case).

We draw a second important conclusion concerning the implementation of smartphones in light of uncertainty about exactly what their productivity benefits might be. The key point is that there is no substitute for actually trialing the technology to find out more about the benefits case. Therefore, it would make a lot of sense for the USMC to adopt a staged investment plan where it deploys, for example, 1,000 smartphones across a wide variety of users and then collects data on the actual productivity benefits that accrue. A larger scale roll-out of smartphones would be contingent on the results of the test stage.

The Context for Tactical Smartphone Adoption

Smartphone Diffusion Is Happening at a Rapid Clip

People like having a mobile computer in their pockets. The market penetration of mobile phones is already over 100% in the United States (102% in 2012), which trails Europe, where diffusion averages 126% in the six biggest European countries (Germany, the United Kingdom, France, Italy, Poland, and Spain). In many ways, this tells its own story: Households obviously find mobile phones a compelling proposition whose value to the household (or individual) significantly outstrips what they have to pay to acquire mobile service.

Consumers are quickly transitioning from mobile phones to smartphones, which are experiencing a tremendous growth in sales. In the United States, Nielson research reported that smartphone penetration of the mobile phone market is 75% among 18–24-year-olds, 78% among 25–34-year-olds, and 61% in the total market (Mashable, 2013). The United States is among six countries globally with smartphone penetration rates greater than 50%.

It is worth highlighting that this trend is driven by the high level of commercial research and development (R&D) spend on mobile technology development. Some sources suggest commercial firms are spending $60 billion/year on competitive R&D in this industry (Oceus Networks, 2013). As this year-on-year spend accumulates, it significantly outstrips DoD R&D spend on proprietary mobile communications, leading to an observed gap. Based on the DoD budget outlook, it is unlikely that this gap will close and rather more likely that the gap between proprietary and COTS may continue to grow in upcoming years.

This gap between proprietary and COTS system would not matter if DoD entities didn’t want the capabilities that very high data rates coupled with powerful smartphones can offer, such as full-motion video, powerful mapping and visualization capabilities, and a raft of productivity-improving applications. However, these capabilities are highly desirable for our tactical forces. We need to have them, and we need to acquire them faster than our adversaries do. To do so requires that we find some mechanisms for leveraging fast-improving COTS technology, suitably adapted for our military's needs.

The Private–Public Productivity Gap

Accompanying this mobile technology gap, some evidence suggests that an important productivity gap has opened up between the private and public sectors over the past 25 years.

U.S. budget director Peter Orszag (2010) highlighted that there is a growing productivity gap between the public and private sectors. "Government too often is inefficient and wasteful, he argued, and Americans are rightly skeptical about its ability to perform effectively" (Eggers & Jaffe, 2013, p. 6). Orszag (2010) highlighted that historically public and private productivity were very similar. But starting in 1987, private-sector productivity improvements picked-up, while in the public sector after 2000 data suggests productivity actually fell (see Figure 4).

Orszag (2010) argued that citizens perceptions of government inefficiency were being fueled by the gap they observed between public-sector and private-sector use of information technology and that they saw large improvements in efficiency and technology at work and home (the Internet, mobile devices) but not in their interactions with government.

The main message here is that there are productivity arguments for smartphone/private cellular network adoption by the USMC, as well tactical benefits.

MARCORSYSCOM H2 Smartphone Sleeve

Given the context for tactical smartphone adoption laid out in the previous section, various DoD initiatives are underway to leverage COTS smartphone and cellular networks for military use. One of these is a MARCORSYSCOM initiative to develop a sleeved smartphone as a Trusted H2 device under an initiative dubbed the Mobility JCTD (Dixon, 2013).

Currently, the USMC has no plan for acquiring an alternative technology that will enable data at the squad or platoon level before fiscal year (FY) 2017. The capability gap that this represents is recognized in the USMC and could be filled by the Mobility JCTD.

The basic user requirement for a Trusted H2 device is as follows:

- multiple small-form factor devices (i.e., smartphone and tablet sizes);
- lightweight, sufficiently rugged device;
- low battery use;
- enough data storage capacity for mission requirement;
- access to multiple data domains via cellular network, WiFi, and Bluetooth;
- COTS multitasking operating system;
- a display readable in direct sunlight and no light;
- GPS;
- meets security requirements;
- voice recognition, audio alerts, push-to-talk;
- camera;
- and affordability (replacing instead of repairing).

Though the Mobility JCTD is framed in terms of meeting the USMC's tactical requirements, this initiative may be equally important from a productivity-enhancing perspective, and hence the financial parameters of the project are crucial to consider. This forms the basis of the BCA we assess in this study.

JOLTED TACTICS JCTD

One major initiative that is ongoing to develop COTS cellular technology for the U.S. Army is the JOLTED TACTICS JCTD. This JCTD utilizes technology from Oceus Networks, among other vendors, to enable secure battlefield communications.

The JOLTED TACTICS JCTD has been the major DoD venue for developing and evaluating Oceus Networks 4G LTE cellular technology for tactical use, including NSA (National Security Agency) security acceptance and the development of a "Deployable Spectrum Plan" for the acquisition of suitable government-owned or commercially owned cellular spectrum globally.

As of the time of writing, the Army has bought 36 XIPHOS 4G LTE systems from Oceus Networks for $17 million (M. Liguori, personal communication, August 2013). These systems are a small, deployable, private Cellular system that can be fixed or mobile (land, sea, air) and that creates a cellular network "bubble" that delivers tactical broadband capability (exceeding 1.5 mbps, potentially ranging up to several hundred mbps) over a range of up to 20 miles. If those systems work well, the Army may extend that purchase to between 2,000 and 5,000 Oceus Networks systems over time to meet aspects of its tactical communications requirements.

At this point, JOLTED TACTICS is more of a U.S. Army initiative than a USMC initiative, but the capabilities offered by such a system may also be attractive for USMC.

In what follows, we consider opportunities to deploy an Oceus Networks cellular network to increase the capabilities of the USMC company COC. The alternative we consider is a highly mobile, Oceus Networks-based COC as a substitute (under some circumstances) to the current convention of a semi-mobile COC with tents, tables, communications gear, generators, and so forth. Radical though this might appear at this time, what we propose is a thought experiment that envisages a somewhat old-fashioned/traditional company COC that is composed of a few Humvees occupied by the company's command staff, with all of their work accomplished on mobile devices (such as iPads and smartphones). Supporting this would be a complete virtualization of all of the software COC personnel require to accomplish their warfighting tasks (i.e., an entirely cloud-based IT architecture). This thought experiment forms the basis of the second BCA we assess in this study.

Smartphone Benefits: Where Do They Come From?

The Achilles heal of prior studies of smartphone technology adoption (Ball, 2013; Dixon & O'Neal, 2011) has been identifying why smartphones generate benefits (causes of benefits) and *how much* benefit they generate (size of benefits). Both need to be framed clearly in order for decision-makers to have a clear idea of the value proposition of deploying smartphones in whatever capacity. This is true for evaluating the tactical benefits of having smartphones available, as well as the productivity benefits.

It is worth noting that the productivity benefits of smartphones come from combining their capabilities with changes to organizational (or household and individual) processes and practices. It is important to understand that smartphones on their own do not improve productivity; instead, they are better viewed as an enabler or facilitator of productivity improvements (i.e., they help make people more productive by changing the ways they can accomplish tasks). However, the pervasiveness of mobile telecoms technology impacts on economic activity calls to mind the notion “general purpose technologies” described by David (1990). Such technologies make their impact felt by the sweeping changes they allow to productive arrangements, as highlighted by David’s (1990) famous study of the impacts of the dynamo on a wide range of manufacturing and household activities. Of note, it takes time—historically, several decades—for general-purpose technologies to bleed through the economy completely because of the cycle of capital investment: For example, the reorganization of U.S. manufacturing plants took several decades of the early 20th century (David, 1990).

To study the benefits case for smartphones, we looked at a wide expanse of research, ranging from macro economic studies of cross-country comparisons of mobile phone use, to micro-level studies of the use of mobile devices in healthcare settings (scientific studies using control groups), to case study evidence (i.e., anecdotal data).

Data Collected

Macro Economic Studies

The impact of mobile devices is detectable at the macro level by studying cross-country variations in mobile phone penetration and correlating it with measures of economic growth and productivity improvements.

Although it is possible that the causal relationship between mobile phones and growth and productivity might be reversed (i.e., represent a wealth effect, with more mobile devices being purchased because countries are richer), it seems unlikely that mobile devices are not contributors to productivity improvements. To see why this is, one has to look at more detailed data on mobile device use, which we do next. In the meantime, we should hold the thought in mind that the overarching relationship between mobile phone penetration and productivity or GDP growth could flow causally in both directions (i.e., be a case of reciprocal causation).

The Structure of Smartphone Benefits

In this section, we summarize what we have learned about the basic benefits yielded by smartphone use. We organized them into six overarching categories: scavenging time, faster response times, increased information availability, speedier data entry, elimination of paper/printing/publishing costs, and cheap, already adopted technology.

Measuring the Benefits: Consumer Surplus

The mix of data on the economic benefits of mobile phones suggests that while it is true (based on case-study and health data) that every particular situation has a different set of costs and benefits (which makes measurement an idiosyncratic, case-by-case affair), it is also true that these benefits aggregate to a common picture of significantly positive productivity impacts of mobile technology, which is visible at the country level.

For the purposes of the analysis in this study, we wanted a broader, aggregate measure of benefits that—while representing an average across many users—could ultimately provide a robust basis for analyzing USMC options for smartphone deployment without having to conduct a time-and-motion study for many different USMC smartphone deployment opportunities. For this, we followed the Office of Management and Budget (OMB) guidelines, which suggest using “consumer surplus” as a guide to benefits, where available.

OMB A-94 Financial Analysis Guidelines

Consumer surplus is defined as "the maximum sum of money a consumer would be willing to pay to consume a given amount of a good, less the amount actually paid" (Zients 2013, p. 18).

It is worth noting that while consumer surplus is a well-grounded concept that is frequently used in economic theory, measuring it is much more difficult. For example, OECD (Organization of Economic Cooperatio & Development) and Massachusetts Institute of Technology (MIT) economists have engaged in a significant public debate over telecommunications policy in Mexico that in large part is driven by disagreements over the appropriate measurement of consumer surplus (OECD, 2012; Hausman & Ros, 2012). Here we follow OMB guidelines in using commercially available data wherever possible to make an estimate of consumer surplus. The following is according to OMB Circular A94 (Zients, 2012):

> ***Measuring Benefits and Costs.*** The principle of *willingness-to-pay* provides an aggregate measure of what individuals are willing to forego to obtain a given benefit. Market prices provide an invaluable starting point for measuring willingness-to-pay, but prices sometimes do not adequately reflect the true value of a good to society. … When market prices are distorted or unavailable, other methods of valuing benefits may have to be employed. *Measures derived from actual market behavior are preferred when they are available.*
>
> ***Inframarginal Benefits and Costs***. Consumers would generally be willing to pay more than the market price rather than go entirely without a good they consume. The economist's concept of *consumer surplus* measures the extra value consumers derive from their consumption compared with the value measured at market prices. *When it can be determined, consumer surplus provides the best measure of the total benefit to society from a government program or project.* (p. 7)

Financial Analysis

Methodology and Assumptions

For this economic analysis, we are applying standard economic principles that account for the total operational cost of the items under consideration. This analysis will not only consider the direct costs of the acquisition of the smartphones and sleeves, but will also consider the time value of those purchases, as well as the operational considerations. By following standard evaluation principles, this analysis can be logically compared to other potential choices on an even footing.

Operational considerations for this analysis include the fully burdened cost for fuel, fuel consumption, and maintenance, as well as the consumer surplus extracted from the deployment of the gear. Factors and assumptions are as follows.

- Net Present Value
- Inflation and Discount Rates
- Economic Life of Equipment
- Fully Burdened Cost of Fuel
- Fuel Usage
- Unit of Analysis/Force Size

Baseline Analysis: Squad Level (13 riflemen)

Alternative 1/1A: Sleeved Smartphones vs. PRC-152/152A

The first case is the baseline of a single smartphone with the trusted H2 sleeve. The items are purchased in year 1, with an expected life of five years (see Table 3). We assume that 20% of smartphones need replacing every year; therefore, we built the cost of a replacement phone into the smartphone analysis. Sleeves are assumed to be rugged enough not to need replacing, but they will need maintenance. The net present value of this option over five years was $1,389.

In order to demonstrate the implications of this analysis on a USMC unit, we chose the smallest combat organization of a squad. Typically, a squad has 13 members, of which four currently utilize communications devices. By extending the prior analysis from a single smartphone with sleeve to 13 devices (one each for every squad member) the NPV increased to $19,700 and achieved an internal rate of return of 50%.

Alternative 2: Smartphones for Barrack's Use Only

The second alternative to consider is to look at the use of the smartphone as a communications and management tool in the home base/barracks environment. This is the area where some Marines are currently using personal smartphones for their daily lives. For this analysis, we consider a 13-person squad that will employ sleeveless phones for official management and communications tasks. There will be no changes to tactical equipment, and we assume that there is no tactical broadband available.

In this scenario, the smartphone with sleeve has a positive NPV of $34,000 over a period of five years. These benefits are gained through the application of consumer surplus, which is greater than the purchase price.

Alternative 3: Smartphones Sharing 1/14 Oceus Networks System (No Sleeves)

The next alternative for the squad level involves a shared Oceus Networks system paired with smartphones for each member of the squad. The Oceus Networks system is the Army's JOLTED TACTICS capability and will require upfront investment cost for the USMC. For this analysis, which is at the squad level, we are assuming that each squad requires only 1/14 of the total system; thus, only those costs will be considered. We recognize that an entire Oceus Networks system will need to be purchased, thus providing capabilities for multiple squads.

The NPV of this alternative is $1,858, which is less than the sleeved phones option due to the need for greater investment in the first year. However, this option does have a positive NPV and internal rate of return, thus making it economically viable. With the additional capabilities the Oceus Networks system provides regarding tactical broadband, this alternative may be attractive to the commander.

Alternative 4: L-3 Guardian Option Sharing 1/14 Oceus Networks System

Concerns may exist about the use of commercial technology in the tactical environment when secure systems are required. The L-3 Guardian was developed with oversight by the National Security Agency (NSA) to enable classified communications using both voice and data. The L-3 Guardian is configured to allow both classified and unclassified communications over commercial as well a government networks. This alternative also allows for tactical broadband capability.

Although the L-3 Guardian does not require a sleeve for secure communications, it is more expensive and its ability to be upgraded depends on government contracts. The price for a single L-3 Guardian is $3,250. This alternative looks at the incorporation of the L-3

Guardian into the Oceus system at the squad level. This alternative will consider 1/14 use of the Oceus capacity.

This alternative has a NPV of -$60,579 due to the high cost of investment in both the Oceus systems as well as the L-3 Guardian phones. With productivity being the sole benefit, this approach would not achieve a positive NPV due to the need to update the technologies. However, this might still be a viable option when security is of primary consideration.

Alternative 5: Tethered Smartphone Concept (Tethered to PRC-152)

The U.S. Army developed a concept where a smartphone could be physically tethered to a PRC-152A radio to allow for some additional capabilities. This solution adds minimal costs to an existing squad if we assume that the current inventory of one PRC-152A per squad would remain unchanged. However, in order to provide a comparison point to a sleeved smartphone capability, in the current analysis we analyze the cost of providing all 13 members of a squad with a smartphone tethered to a PRC-152A. This option would not provide tactical broadband capabilities.

This alternative has a NPV of -$47,042 due to the high cost of providing each Marine with a PRC-152A in addition to a smartphone and the tethering equipment. This might be a viable alternative for initial testing, where no additional PRC-152As need to purchased. However, this option becomes very expensive because of the need to purchase new $10,000 PRC-152As (instead of a $1,100 sleeve) plus $1,434 of tethering equipment, in addition to the cost of smartphones.

Baseline Analysis: Company Level Analysis

The next alternatives look at the application of smartphones at the company level. In these scenarios, there are two different manners in which the company level is considered. First is the COC and support staff of 65 riflemen total, and second is the whole company that comprises 182 people.

Alternative 6: 65 Smartphones for Support/COC Personnel + 1 Oceus Networks XIPHOS 4G LTE System

This alternative provides smartphones to the 65 support riflemen of a company (without H2 sleeves) and a standalone Oceus Networks system. The benefit of this configuration is that it provides tactical broadband capabilities that allow for greater functionality on the smartphones. This is similar in structure to the Army’s JOLTED TACTICS system, but it does not require tethering.

Providing the smartphones to only the tactical side reduces the power and maintenance footprint and inherently makes the COC more mobile. This also assumes that the company retain 50% of existing equipment, such as the PRC-152 and PRC-117. This alternative hs a NPV of $176,606.

Alternative 7: 65 Sleeved Smartphones for Support/COC Personnel + 1 Oceus Networks XIPHOS 4G LTE System

This alternative provides smartphones for 65 members of the company but also adds the trusted H2 sleeves. This is potentially the best-case scenario operationally because it provides both the flexibility of the Oceus Networks capability plus the security of the trusted H2 sleeve. However, because of the sleeve, this option does not proved for tactical broadband capability. The NPV for alternative 7 is $105,106, which is lower than alternative 6 dues to the inclusion of the H2 sleeves.

Alternative 8: Smartphones + Sleeves + Oceus Networks System for Entire Company (182 personnel)

This final alternative takes the last example and extends it to all 182 members of a company (Table 13). This option is similar in functionality to the Army JOLTED TACTICS except we use trusted H2 sleeves for communications rather than tethering. This alternative does not provide for tactical broadband. The NPV at $434,796, is largest for this option, as well as the investment cost due to the expectation of consumer surplus across a larger baseline. The consumer surplus accounts for about 65% of the generated value and is thus the driving factor in this analysis.

Sensitivity Analysis

According to OMB Circular A-94 (Zients, 2013),

> Sensitivity Analysis. Major assumptions should be varied and net present value and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions. The assumptions that deserve the most attention will depend on the dominant benefit and cost elements and the areas of greatest uncertainty of the program being analyzed. (p. 11)

For our analysis, we used the following variables for sensitivities:

- FBCF—average $15; low $10; high $30 / per gallon
- COC fuel savings—average 30%; low 10%; high 50%
- Oceus System cost—$450,000, no salvage value
- Smartphone cost—$640 per unit, price declining over time
- Sleeve cost—average $1,100; high $2,200
- Consumer surplus—average $2.99/day; low $1.50; high $6.00

The purpose of a sensitivity analysis is to determine whether there might be large changes to the NPV depending on the assumptions applied to the analysis. In the analysis of alternatives, we applied consistent and conservative estimates of costs and savings that might be realized. However, there is room for potential cost overruns and benefits that do not materialize at the expected rate.

Based on the original assumptions, we applied several changes to those assumptions to determine whether there would be significant impacts that might change the way we considered the results including changes to the H2 sleeve price, increasing it to $2,200 per unit. Additionally, we provide a comparison changing the consumer surplus to a low of $1.50/day to a high of $6.00/day. In each case, the alternative NPV is reflected. The columns in Table 1 with blue type indicate the original assumption that went into the analysis. In this analysis, we changed only one variable at a time, leaving all others at the level of the original assumptions.

The major outcome of this analysis is that the NPV for most alternatives shifts from positive to negative under the $1.50/day consumer surplus assumption, indicating that the precise assumption about consumer surplus is a key consideration in the business case. By comparison, the NPV results are robust to a doubling of the price of sleeves. Of note, higher consumer surplus assumptions would drive big upsides in the NPV for many of the alternative considered.

Table 1. Sensitivity Analysis: NPV Adjusted for Sleeve Price or Consumer Surplus

	Sleeve Price			Consumer Surplus	
Alternative	Average ($1100)	High ($2200)	Low ($1.50)	Average ($2.99)	High ($6.00)
1	$1,389	$289	$(463)	$1,389	$5,129
2	$34,000	$34,000	$9,931	$34,000	$82,625
3	$1,858	$1,858	$(22,212)	$1,858	$50,482
4	$(60,579)	$(60,579)	$(84,649)	$(60,579)	$(11,955)
5	$(47,042)	$(47,042)	$(71,111)	$(47,042)	$1,583
6	$176,606	$176,606	$(3,019)	$176,606	$539,473
7	$105,106	$33,606	$(74,519)	$105,106	$467,973
8	$434,796	$237,657	$(102,671)	$434,796	$1,529,796

The next part of the sensitivity analysis impacted only alternatives 6, 7, and 8. When we analyzed the alternatives at the company level, we considered the fully burdened cost of fuel (FBCF), as well as the projected fuel savings. These were not considerations at the squad level. In this analysis, we showed the FBCF at a low of $10, an average of $15, and a high of $30. The fuel savings were a low of 10%, an average of 30%, and a high of 50%. The NPV for each alternative is shown in Table 2.

This analysis suggests that the NPV results are robust to downside assumptions about the FBCF and fuel savings. Indeed, there is considerable upside potential if FBCF and fuel savings are higher than assumed in the base case.

The final part of this analysis is to show a best- and worst-case scenario for each alternative, thus highlighting the entire range of possible results. This helps the decision-maker determine what might be the case if all assumptions are either over- or underestimated. Although this situation may not present itself in most cases, understanding both the upside and downside risks adds credibility to the analysis.

When defining the best- and worst-case scenarios, we made the following assumptions:

- Best case: Sleeve cost ($1100), consumer surplus ($6.00), FBCF ($10), and fuel savings (50%).
- Worst case: Sleeve cost ($2200), consumer surplus ($1.50), FBCF ($30), and fuel savings (10%).

Table 2. Sensitivity Analysis: FBCF and Fuel Savings

	Fully Burdened Cost of Fuel (FBCF)			COC Fuel Savings (%)		
Alternative	Low ($10)	Average ($15)	High ($30)	Low (10%)	Average (30%)	High (50%)
6	$120,966	$176,606	$343,526	$65,325	$176,606	$287,886
7	$49,466	$105,106	$272,026	$(6,175)	$105,106	$216,386
8	$426,907	$434,796	$470,707	$323,515	$434,796	$546,076

Table 3. Sensitivity Analysis Best- and Worst-Case Scenarios

Alternative	Worst Case	Average Case	Best Case	Total Variance
1	$(1,863)	$1,389	$5,129	$6,992
2	$9,931	$34,000	$82,625	$72,694
3	$(22,212)	$1,858	$50,482	$72,694
4	$(84,649)	$(60,579)	$(11,955)	$72,694
5	$(71,111)	$(47,042)	$1,583	$72,694
6	$(58,660)	$176,606	$558,019	$616,679
7	$(221,160)	$105,106	$486,519	$707,679
8	$(416,172)	$434,796	$1,545,282	$1,961,454

The average case was the original analysis. The total variance was the differential between the best- and worst-case scenarios.

The results of the sensitivity analysis (shown in Table 3) are revealing, particularly for decisions made at the squad level. The total variance for alternatives 2, 3, 4 and 5 are all exactly the same, which is to be expected considering that the change in variables was limited to the sleeve cost and the consumer surplus. Although this is revealing, it does not tell the entire story. Alternative 2 (smartphones for barracks use only) is the least risky, having the only positive worst-case scenario, and the highest average and best-case scenarios. Conversely, alternative 4 (L-3 Guardian phone with Oceus Networks system) is the riskiest, with negative NPV for all scenarios.

At the company level, all three alternatives are negative in the worst-case scenario and have moderate returns on average, but the best-case scenario for alternative 8 grows very large. This is primarily driven by the consumer surplus, which applies to a larger group of people.

Across the board, consumer surplus (productivity gains) had the single greatest influence on the NPV values, will likely be a primary driver in the decision-making, and therefore is the variable most in need of further research.

Staged Investment (Real Options) Analysis

One method that organizations use to mitigate risk and increase flexibility is the application of real options. Through this approach, decision-makers have the right, but not the obligation, to buy or sell an asset at some pre-determined time in the future. This right provides an opportunity to break investments into stages. An early stage is used to determine whether a risky investment produced the expected returns, and later stages proceed contingent on this information being better understood.

The structure of real options demonstrates that while options are intended to mitigate risk, they are not completely risk-free. In order for real options to mimic financial options, the option buyer must be willing to not exercise the option if the market conditions are not favorable.

In the scenario we are discussing here, the USMC may apply an options approach toward the integration of smartphones into tactical operations. Fundamentally, for the smartphone investment considered here, our sensitivity analysis suggests the size of the consumer surplus is an important variable about which some uncertainty exists. Because of this uncertainty, it may make sense to invest in stages, using information gained about the consumer surplus early stages to inform later stage investments. There are unknowns concerning the robustness, security, and adaptability of smartphones in the tactical environment. Therefore, a less risky place to test the concept with an early stage investment might be in a continental United States (CONUS) garrison environment and use the information gathered as an input into later stage investments.

Smartphones Only Stages (In Order to Test Productivity Benefits First)

As we highlighted in our Introduction, the best way to actually find out what the productivity benefits of smartphones is for the USMC would be to buy a batch of 1,000 phones, deploy them on an experimental basis for use as a productivity tool while dwelling at home base or in barracks, and then rigorously measure the impacts on various tasks Marines do in their everyday routines.

We broke the analysis into a three-part staged analysis where investment in future years would be made only if success was realized from prior investments. For the first option, we chose to analyze outfitting 1,000 Marines with smartphones and nothing else.

The second option would take place in year 3 of the 10 year run, if the analysis proved that the first option provided the projected benefits. This option would extend the smartphones to three divisions of Marines, or 20,000 people. Again, the Marines would receive a smartphone and nothing else.

The same assumptions of price, discount rate, and consumer surplus that were used for prior analyses apply here as well. As with prior analyses, we assume that there is a need for a 20% replacement each year and that the real price of smartphone technology goes down by 5% per year.

The final option (option 3) would take place in year 5 and run through year 10. In this option, the plan is greatly expanded to bring the smartphone to the tactical environment. In this case, we analyze adding the Oceus Networks system to three divisions, assuming an average of 50% capacity utilization across 20,000 users. Additionally, the trusted H2 sleeve was added to the existing smartphones to provide a secure radio option that mimics the systems the USMC already has available. Again, this third stage investment is *contingent* on satisfactory results from the second stage investment and would be made only if those results suggest stage 3 is worthwhile.

Discussion of Results

The results of this analysis indicate that there is much benefit to be realized from taking a staged approach to investment. With the assumption that this program would run for 10 years and return an average level of productivity increase, with incremental investment in years 3 and 5 only if the prior investments were successful, this analysis produced a potential for $169 million in NPV at a risk of only $640,000 for the stage 1 kick-off investment and $12.8 million for stage 2.

Just as with the prior analyses, it is important to consider the sensitivity of the analysis based on the low, average, and high productivity values. Table 4 demonstrates that even with low realized productivity gains, this program has a potential for $54 million in NPV over the full 10-year time span. With a high productivity gain, that value could be as high as $425 million. The realized benefit will likely fall somewhere between the low and high values.

The key to this analysis will be in properly capturing and measuring the actual productivity gains that accrue, something we do not do in this study but is clearly indicated as a key task for future research.

Table 4. Real Options Analysis Results

Low Productivity				
Option	Years	Investment	Annual Efficiency	NPV
1,000 smartphones	10	$(640,000)	$366,825	$2,116,744.00
20,000 smartphones	8	$(12,800,000)	$7,336,500	$31,007,797.00
Oceus + sleeves	6	$(44,500,000)	$10,950,000	$20,962,197.00
Total				**$54,086,738.00**
Average Productivity				
Option	Years	Investment	Annual Efficiency	NPV
1,000 smartphones	10	$(640,000)	$731,205	$5,744,202.64
20,000 smartphones	8	$(12,800,000)	$14,624,090	$88,989,055.14
Oceus + sleeves	6	$(44,500,000)	$21,827,000	$74,863,966.30
Total				**$169,597,224.09**
High Productivity				
Option	Years	Investment	Annual Efficiency	NPV
1,000 smartphones	10	$(640,000)	$1,467,300	$13,072,154.00
20,000 smartphones	8	$(12,800,000)	$29,346,000	$206,118,978.00
Oceus + sleeves	6	$(44,500,000)	$43,800,000	$205,848,414.00
Total				**$425,039,546.00**

Conclusions and Recommendations

The purpose of this analysis was to explore the application and implications of commercial smartphone technology in a tactical environment. As the USMC reduces its force structure over the coming years, the expectation for capabilities of a smaller force has not diminished. Additionally, as young Marines, people who have grown up with smartphone technology, enter the force, their personal expectations will shape the new force.

In this analysis, we looked at the application of commercial smartphone technology from several different angles. These included commercial smartphones used strictly in a home-base environment, as well as smartphones supplemented by a secure tactical sleeve that can integrate with existing USMC equipment. This analysis also took the approach of a phased deployment of the technologies into squad-, company-, and division-level organizations.

The main conclusion we draw is that the business case for deploying sleeved smartphones in the tactical environment may complement the military rationale for adopting this technology. It is the dual-use potential of this technology that makes the economics more attractive than the existing radios USMC has available. Sleeved smartphones may also be outright cheaper than existing equipment, and we have assumed that to be the case in our analyses. But the bigger benefit of smartphones will be in how they enable Marines to fight better when deployed, and work smarter when at home base (i.e., if they create options for innovation).

A secondary conclusion concerns the implementation plan and, in particular, uncertainty about what the productivity benefits of smartphones might—or might not—be. Based on extant research we have examined the economic benefits of smartphone adoption, but there is no substitute for trialing the technology to find out where the benefits lie for Marines. Therefore, we conclude that at this point, a staged investment approach would be a good choice for the USMC: for example, adopting 1,000 smartphones across a wide variety of users. This limited adoption would allow for a closer examination of the productivity benefits of smartphones in a variety of actual working environments. The USMC would retain the option to quit if the results are poor, or to invest in a large-scale roll-out if the results of the initial tests prove smartphone economics are worthwhile.

Although the focus of this report is on economic analysis, and therefore the productivity potential of smartphones, this is not to say that there aren't also significant tactical benefits of smartphones, such as faster and more accurate communication, improved information availability resulting in better situational awareness lower in the ranks, and benefits from automatic GPS functioning and possible monitoring/telemetry devices. These are further investment options for military commanders to consider if the base capabilities of smartphones prove attractive.

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