INNOVATIVE APPROACHES FOR THE ADVANCED COMBAT MAN SYSTEM

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ABSTRACT

The Singapore Army was equipped with the Advanced Combat Man System (ACMS) in 2010 to enhance the survivability and combat capability of soldiers in urban operations. While the ACMS achieved its objectives, the Project Management Team (PMT) identified areas for improvement which resulted in a lighter system and an enhanced user interface utilising multi-touch technology similar to commercial electronic devices such as smartphones.

This article captures the journey taken to develop and design a newer and lightweight variant of the ACMS – the ACMS iLITE, using a soldier-centric approach. The article also shares lessons learnt from this process, and introduces some concepts and futuristic technologies that the PMT is exploring to enhance the fighting capabilities of the soldier in the Singapore Armed Forces.

Keywords: urban operations, ACMS, COTS, smartphone, soldier-centric

INTRODUCTION

With the prevalence of global urbanisation, the Singapore Army will inevitably need to engage in urban operations. The urban environment presents a whole new multi-dimensional battlefield – one which not only requires changes to conventional combat operations and tactics, but also a need to overcome the strategic advantage afforded to an adversary that is concealed and entrenched in an urban environment.

The Advanced Combat Man System (ACMS) is an urban fighting system for the Third Generation Army. It is designed to address the challenges faced in urban operations by enhancing command and control (C2), situational awareness, survivability and lethality of the soldier. In addition to being equipped with the ACMS, soldiers are equipped with remote sensors such as surveillance robots and keyhole sensors. With the ACMS and these sensors, soldiers become part of a networked force. Soldiers' situational awareness is thus enhanced, allowing them to engage their targets effectively. Soldiers are also able to navigate accurately through the urban battlefield to avoid known danger areas. The key components of the ACMS are illustrated in Figure 1.

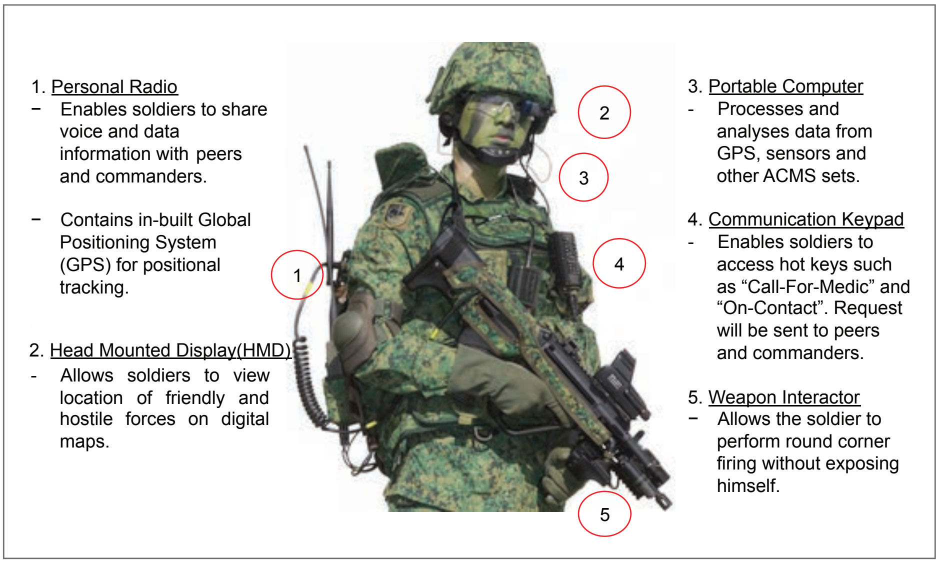

Figure 1. Overview of the ACMS

The ACMS also allows selected appointment holders to tap the wider resources of the battalion, such as the TERREX Infantry Carrier Vehicle (ICV) for fire support and sustenance, and even utilise higher command resources to further enhance the lethality and situational awareness of their units (see Figure 2). The soldiers themselves become sensors on the ground, providing real-time information to the commanders for improved battlefield coordination.

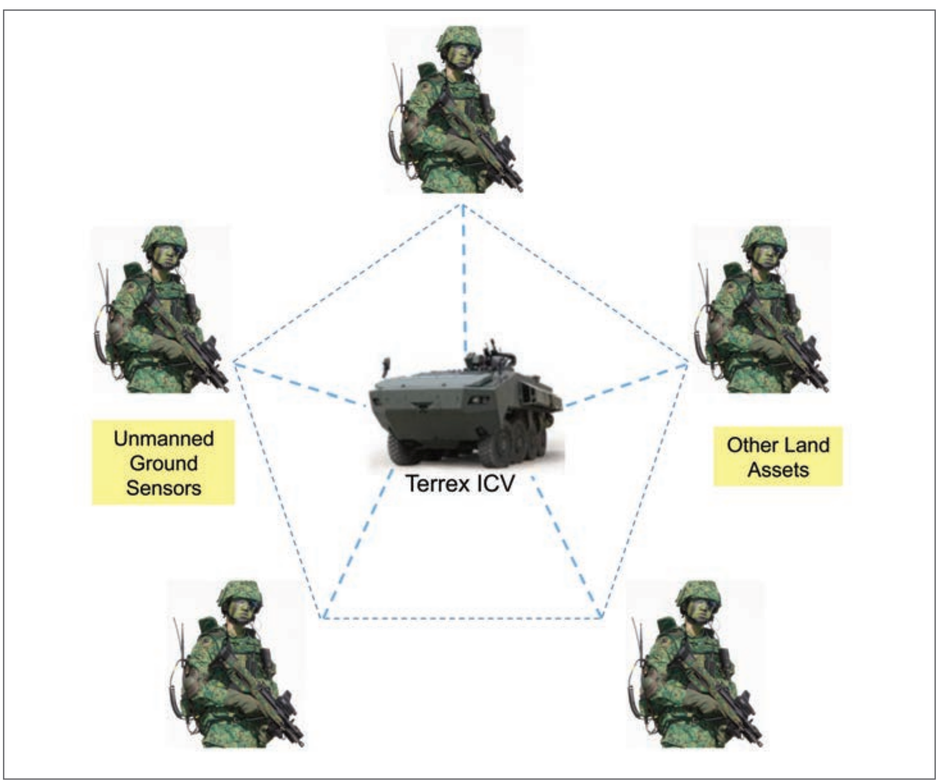

Figure 2. The networked soldier and his complementary capabilities

A FORCE MULIPLIER

Prior to the fielding of the ACMS, battlefield information was disseminated verbally. This limited the speed and accuracy of engaging targets, with soldiers requiring a longer time to interpret commands, identify targets and engage them. The ACMS, with its graphical presentation of battlefield information, has enabled soldiers to share up-to-date information in a precise and swift manner.

The ACMS has also connected dismounted soldiers to their TERREX ICV. This has allowed the sharing of a common operational picture and provision of support fire from the weapon system of the TERREX ICV.

REINVENTING THE ACMS

While the ACMS met its intended objectives in terms of weight and capabilities, and benchmarked well against other leading soldier modernisation programmes globally, the Project Management Team (PMT) was cognisant of the need to continually reinvent the system to ensure relevancy. One area of interest was in the field of personal infocomm technology. The introduction of smartphones redefined the traditional concept of a phone. Features like emails, messaging, photography, video, maps, games and other applications were packed into an elegant, lightweight device. A multi-touch user interface replaced physical buttons and keyboards.

Not surprisingly, smartphones were well received by consumers. It did not take long for the consumer market to be saturated with smartphones and similar lifestyle technologies. The smartphone soon became a pervasive lifestyle device.

As the smartphones packed tremendous computing power in a small form factor, the PMT envisaged that the use of smartphones in the ACMS could achieve weight reduction and enhance usability.

THE BIRTH OF A LIGHTWEIGHT ACMS VARIANT

In light of the rapid development of lifestyle devices, the PMT determined the need to develop a new version of the ACMS that would be more useful and better received by soldiers. The opportunity arose when feedback, gathered through trials and exercises, indicated that it was desirable to reduce the weight of the ACMS. It was also noted that the lower echelons (section-level and below) did not require the full suite of ACMS capabilities since they would be occupied with the immediate fire fight. Thus, the idea to create a new lightweight variant of the ACMS which would only have the essential capabilities required at the tactical levels, was conceived. This was the iLITE.

It was envisaged that the iLITE would leverage both the existing technologies employed for the in-service ACMS as well as commercial-off-the-shelf (COTS) technologies. The iLITE would be lighter, simpler and more intuitive to use while meeting the required operating duration and conditions. It was clear that maximising battery life would be a key design consideration as this would reduce the number of batteries required and consequently the overall system weight. To make the iLITE simple and intuitive to use, familiar COTS smartphones would be adopted as the medium through which the soldier interacts with the system. These became the key design considerations for the iLITE.

DEVELOPMENT OF THE ILITE

Quest to Adopt COTS Smartphone

At the outset of the iLITE's design, the PMT had initiated the use of a COTS smartphone as the input, display and processor of iLITE. However, knowledge of hardening third party smartphones was still lacking. There were also concerns about the ability of COTS devices to comply with military ruggedisation standards suitable for soldier use. Hence, the PMT was faced with the undesirable option of adopting bespoke smartphones with features modelled after COTS smartphones.

These concerns did not deter the PMT from their vision of an iLITE design based on COTS smartphones. Moreover, the PMT assessed that the commercial sector, with its huge R&D funding, would continue to spearhead innovations in the field of personal infocomm technology. In addition, the huge commercial market provided better leverage for access to the latest technologies such as high-speed processors and longer battery life. This convinced the PMT that a bespoke smartphone was unlikely to match up to the COTS smartphones that the soldiers were accustomed to. It was also likely that a bespoke smartphone would be made obsolete before long.

The PMT overcame the challenges involved in hardening COTS smartphones by tapping the wider expertise within DSTA. At the same time, a variety of COTS solutions for waterproofing and shock protection for the more popular smartphones was entering the market, potentially addressing the Army's ruggedisation needs.

Selecting Smartphone for iLITE

The search for a suitable COTS smartphone for iLITE began with the selection of a suitable mobile Operating System (OS). The Android OS was eventually selected over other OSs due to its ability to be customised to meet the PMT's requirements, and it having the largest market share at the time of development which would reduce the risk of hardware obsolescence.

A study was then conducted on a range of leading COTS Android smartphones in the consumer market. It came to the PMT's attention during the market research that each phone manufacturer had something different to offer and there was no such thing as a best smartphone.

After much deliberation, the PMT decided on a set of key considerations that would guide the selection of a suitable smartphone. First, it should have the largest market share among the Android smartphone makers which would increase the availability of COTS ruggedised casings. Second, it should possess superior technical performance to provide greater utility in the iLITE. Third, it should have a screen which was large enough for viewing while still allowing operation with one hand. Last of all, it should come with a power-efficient screen technology that would prolong the operating duration. A smartphone was finally selected based on the above guidelines.

Strategy for Weight Reduction

The implementation of a COTS smartphone was a crucial part of the PMT's strategy to reduce system weight. Instead of incorporating two distinct subsystems (the portable computer and the communication keypad) within the in-service ACMS, the iLITE smartphone served as the integrated mobile processor, input and display subsystems. This reduced the system weight by more than 50%. The lower power requirements of the processor[1] used in the Android OS also made it possible to reduce the number of batteries required for the iLITE.

There are two key differences between the current ACMS and the iLITE. First, the iLITE uses a COTS smartphone as an integrated mobile processor and display subsystem, instead of a separate soldier computer and head mounted display. Second, the iLITE requires only one battery for the entire mission as opposed to three in the ACMS. The key differences are shown in Figure 3.

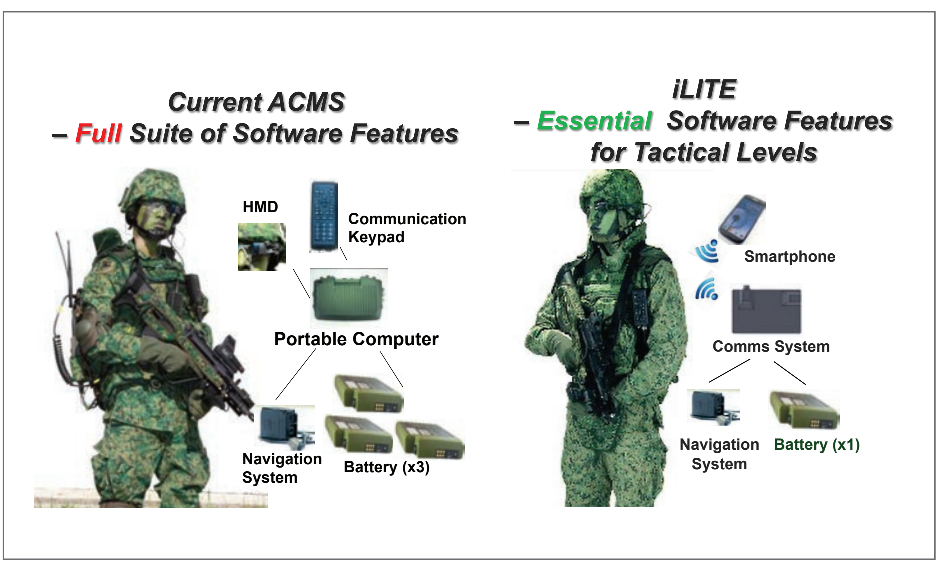

Figure 3. Key differences between ACMS and iLITE

Although the Army was prepared to trade ruggedness[2] of the smartphones for weight reduction, the PMT remained steadfast in pursuing COTS solutions to meet the Army's ruggedisation needs. At that time, the commercial market was rolling out a variety of products and solutions for waterproofing and shock protection of popular COTS phones. These include waterproof phones, ruggedised protective casings and even water-repellent nano-coatings. The PMT's effort paid off when user trials validated that the COTS protective cases provided adequate ruggedisation for the smartphones.

Strategy to Improve System Ergonomics

To improve soldier receptivity towards the iLITE, human factors engineering expertise was engaged to enhance its ergonomics. This included wearability studies to determine the optimal placement of the iLITE components on the soldier, as well as the design of the iLITE C2 Graphical User Interface for greater ease of use. Numerous trials were conducted during the development of iLITE as part of an iterative process to gather user feedback on the system design.

A phased equipping approach was also implemented for the iLITE, where lessons learnt and feedback received from preceding deliveries would be incorporated into subsequent batch deliveries.

OPPORTUNITIES BROUGHT FORTH BY ILITE

The advent of the smartphone also provided functionalities beyond the iLITE requirements. For instance, the smartphone could be used by soldiers to access e-learning materials such as those provided on the LEARNet platform at their own time. Other useful utility applications that were commercially available in the Android's application store (such as the compass and range finding tools) could also be made available to the soldier.

On a more complex scale, the iLITE could be integrated with other systems such as the Tactical Engagement System[3] (TES) to achieve weight and cost savings. Through suitable applications, the iLITE's smartphone could also be used to control unmanned platforms to complement a soldier's mission.

LESSONS LEARNT

While COTS products can be cost-effective solutions, the fast pace of technological advancements in COTS infocomm technologies can render these solutions obsolete in two to three years. A comprehensive obsolescence management plan would need to be adopted to facilitate the insertion of new technologies and tackle potential hardware obsolescence issues:

a) **Modular Architecture** - System components should be kept modular, wherever possible, to ensure that an upgrade or modification in one subsystem would not have a significant impact on the rest of the subsystems.

b) **Phased Equipping** - A phased equipping approach should be adopted to enable incorporation of refinements due to technological improvements and user feedback.

c) **Software Portability** - The C2 software should be designed for ease of modification and expansion in anticipation of future upgrades, such as hardware changes or insertion of new technologies. For the Android OS in particular, C2 functionalities should be implemented at the application level, where applicable, to allow the developed C2 software to be ported to the latest firmware version with minimal effort.

d) **Regular Reviews** - The PMT should keep abreast of technological improvements and development in market trends in order to assess the evolution of COTS smart devices and OS trends at regular pre-planned reviews. If there is an anticipated shift in the OS market share or obsolescence of existing hardware that could impact the project severely, the obsolescence management plan should be updated accordingly.

FUTURE TECHNOLOGIES

The introduction of iLITE has put the Army at the forefront of soldier digitisation. It is imperative to stay updated on new technologies that are being developed constantly throughout the world. These new technologies need to be harnessed at appropriate junctures to enhance mission effectiveness for soldiers. Several emerging technologies that could possibly see application in the ACMS are as follows:

a) **Wearable Technologies** - The commercial market has a variety of wearable technologies, ranging from smart watches to eyewear such as the Google Glass. Although these wearable

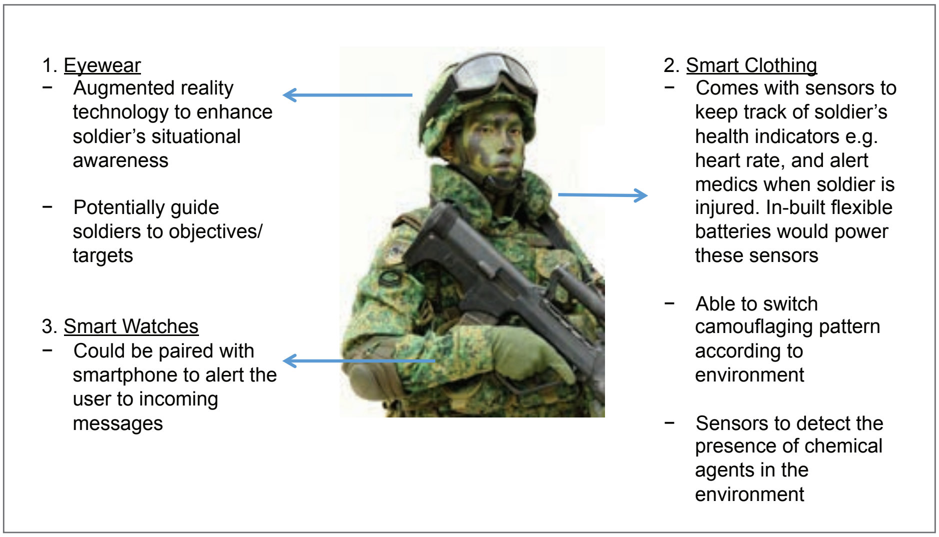

Figure 4. Potential applications for wearable technologies

technologies have yet to gain traction, it remains an interesting and exciting area to monitor. Figure 4 highlights some potential applications of wearable technologies.

b) Simultaneous Localisation and Mapping (SLAM) - SLAM allows soldiers to construct a map of an unfamiliar environment as they are navigating through it. This technology would be extremely useful when soldiers navigate through buildings and internal spaces. This could be achieved by networking the iLITE to a SLAM-enabled unmanned ground vehicle (UGV). This technology, while still in its infancy, would further enhance the capabilities of the networked soldier.

c) Voice and Gesture Recognition Applications - Voice and gesture recognition applications would enhance the ability of soldiers to control sensors assets such as UGVs. In addition, voice recognition would enable soldiers to perform the desired function on the smartphone without having to go through the process manually, thus giving rise to quicker responses.

d) Wireless Charging - Wireless charging could be explored to provide additional charging options for the Army. Potential applications include wireless charging in vehicles that enables the batteries on soldiers to be charged while in vehicles. Vehicles could also serve as hot-spots for wireless charging, allowing soldiers to charge their devices in close proximity to the vehicle.

e) Energy Harvesting - As soldiers carry more electronic gear, the growing energy demands pose an enormous burden on the logistics support system. Soldiers will also have to cope with the weight of extra batteries. Energy harvesting techniques could be explored to improve the sustenance of soldiers in the battlefield. One promising technique is biomechanical harvesting, in which electricity is generated via body motion such as walking.

CONCLUSION

The PMT's decision to design the iLITE based on a COTS smartphone was forward looking. The iLITE has met its key objectives of weight reduction, improved system ergonomics and intuitiveness. This enhanced ACMS variant improves the Army's fighting capabilities greatly by packing more punch at a lower weight requirement.

The successful implementation of COTS technologies in iLITE has proven the viability of leveraging COTS solutions for operational equipment. Trade-offs were managed to deliver cost-effective COTS solutions that not only met the Army's requirements, but were also highly adaptive to the dynamic pace of technological advancement.

ACKNOWLEDGEMENTS

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ENDNOTES

[1] ARM processors are a family of 32-bit Reduced Instruction Set Computer (RISC) microprocessors developed by Advanced RISC Machines.

[2] Smartphones are COTS products with designs that cannot be modified easily.

[3] TES is a laser-based system currently used in combat training exercises to simulate the effects of weapons.

BIOGRAPHY

LIM Wei Qiang is an Engineer (Land Systems) involved in identifying and leveraging technologies to enhance power management and load reduction for soldiers. He was part of the team that developed the Advanced Combat Man System (ACMS) and the iLITE. Wei Qiang graduated with a Bachelor of Engineering (Mechanical Engineering) degree from Nanyang Technological University in 2010 with specialisation in Energy and the Environment.

PEH Han Yong Lester is a Project Manager (Land Systems) currently overseeing the development of the ACMS iLITE. In particular, he is involved in leveraging technologies of interest to further enhance the capabilities of the ACMS iLITE. Under the DSTA Undergraduate Scholarship, Lester obtained a Bachelor of Science in Engineering (Electrical Engineering) degree from the University of Michigan, USA, as well as a Master of Science (Management Science and Engineering) degree from Stanford University, USA, in 2007 and 2008 respectively.