TRANSFORMING RANGE PRACTICES WITH THE MULTI-MISSION RANGE COMPLEX

LIM Peter, YEO Qiu Ling Tammi, LIM Meng Kee Johnson, LAU Chin Seng Eric

ABSTRACT

The Multi-Mission Range Complex (MMRC) is a three-storey live-firing training hub jointly developed by DSTA and the Headquarters 9th Division/Infantry of the Singapore Army. The MMRC has been cited in many domains as an excellent example of how Singapore overcame the challenges of resource and space constraints with innovative solutions[1].

This article outlines the evolution of marksmanship training from traditional and manually operated targets in an open field to advanced and safe live-firing training solutions in an indoor environment. It also highlights the benefits of the MMRC.

Keywords: indoor live-firing, judgemental shooting, multi-tier shooting, reconfigurable urban operation range, land saving

INTRODUCTION

Supported by efficient services to enable soldiers to fully focus on shooting, the Multi-Mission Range Complex (MMRC) was conceptualised as a one-stop marksmanship training hub for soldiers to hone and sustain varied marksmanship competencies.

The three-storey MMRC features seven live-firing indoor ranges encompassing advanced simulation, acoustic sensing and range technologies to provide realistic scenario-based live-firing training. It eliminates the traditional process of range administration by outsourcing routine, non-core pre-range and post-range administration, logistical and maintenance functions.

The MMRC is an accumulation of the requirements of multiple shooting ranges into one facility. It has enhanced the way the Singapore Army trains by providing it with the flexibility to train safely under different realistic scenarios and environments. It has also increased the productivity and efficiency of the Army by allowing it to conduct 50% more training opportunities within the same timeframe.

OVERVIEW OF LIVE-FIRING SYSTEMS

Other than conventional targetry systems (e.g. the Portable Electronic Targetry System and Stationary Electronic Targetry System) which are deployed in other outdoor ranges, the live-firing systems in the MMRC consist of two new modules: the Video Targetry System (VTS) and the Single-Rail Moving Electronic Targetry System (METS).

Video Targetry System

The VTS is a leading-edge computer-based marksmanship, tactical and judgemental live-firing targetry system comprising three main simulation subsystems: a VTS box target measuring 2m by 2.7m, a Range Control Computer and a Firing Point Computer.

The VTS allows soldiers to train beyond the basic marksmanship settings provided by traditional baffled ranges. Using computer generated imagery or customised videos, it can generate an

Figure 1. Live-firing at the VTS screen

Figure 2. VTS screens setup in the 50m range

assortment of conditions realistically (see Figure 1). With the VTS, soldiers are able to conduct long distance marksmanship training of up to 1,000m in a 50m range setup (see Figure 2).

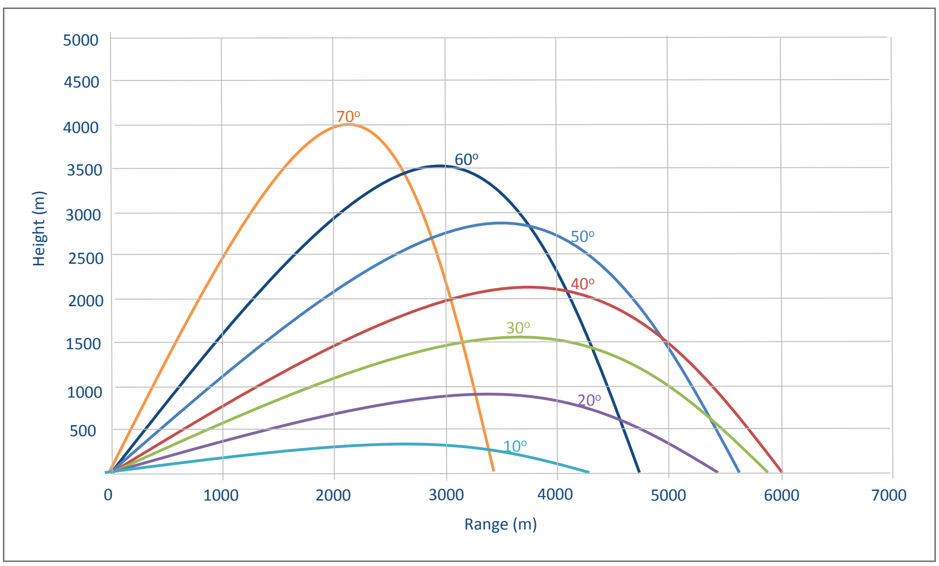

Figure 3. An example of a ballistic table

The VTS' shot detection system utilises precision acoustic technology to project bullet trajectories based on the actual ballistic tables within millimetre accuracy (see Figure 3).

The VTS box target resembles a box with a rubber screen installed at the front and at the back which allows bullets to pass through (see Figure 4). The construction of the box contains the shockwaves (generated by the bullet passing through) within the box to minimise noise. Twelve acoustic sensors are installed within the box to detect these supersonic shockwaves (see Figure 5).

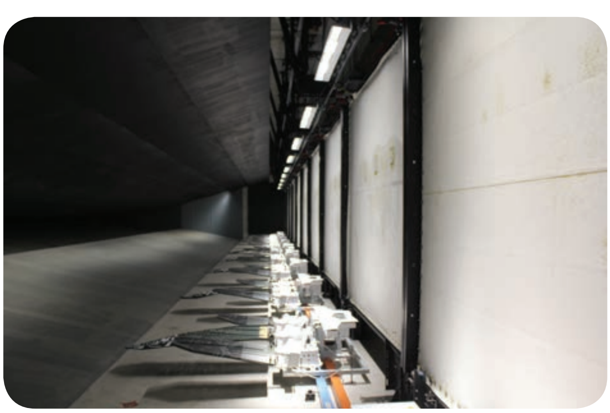

Figure 4. The back of a VTS box target

Figure 5. An acoustic sensor

The actual location of the bullet impact is then determined by monitoring the shockwaves via the acoustic sensors optimally located at the edges of the screen (see Figure 6). The location of the bullet would then be calculated by extrapolation.

However, subsonic ammunition such as the 9mm round is designed to operate at speeds less than the speed of sound and will not create supersonic shockwave as it travels. The detection is instead computed when the projectile hits the rubber screen like a drum.

Based on mathematical models and the actual bullet impact point on the screen, the trajectory of the bullet is then calculated and simulated for distances beyond the physical distance of the screen (see Figure 7).

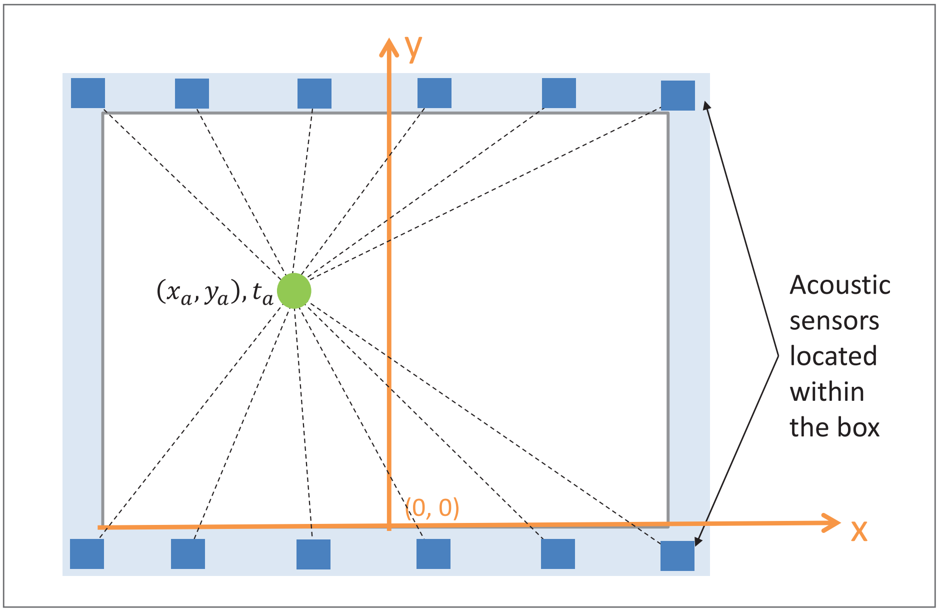

Figure 6. Coordinates of shot (x, y) determined by extrapolation of shockwaves/sound detected by the sensors

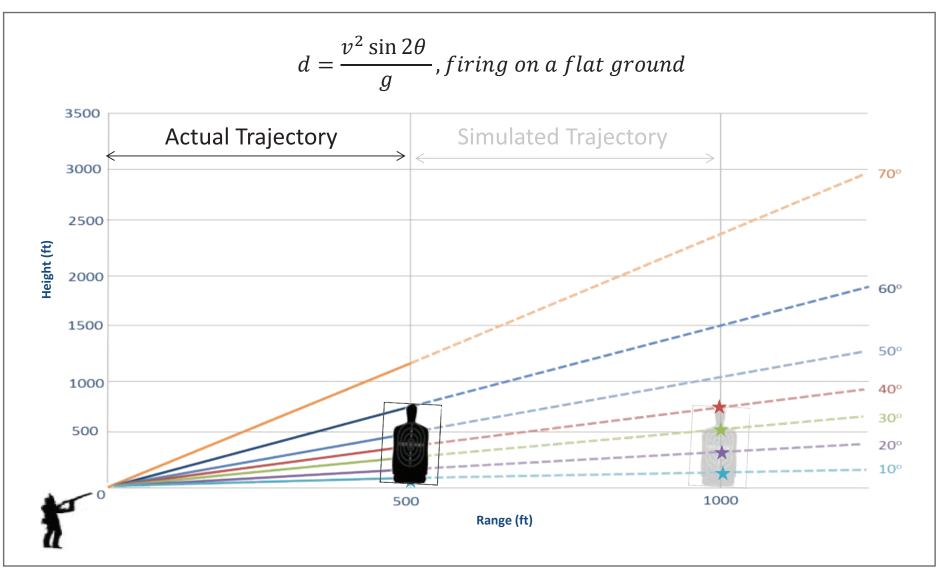

Figure 7. Simulating trajectory of a bullet beyond the physical distance

Moving Electronic Targetry System

The multi-tier range at the MMRC features a single-rail METS co-invented by DSTA (see Figure 8). The new single-rail METS eliminates any potential line-of-sight issues for trainees located on lower levels firing at higher-level targets. Unlike conventional moving targetry systems as shown in Figure 9, the new design requires a shorter installation depth (0.96m instead of 2.4m) and utilises only one motor to drive the single rail of targets. Hence, for a range with 10 firing lanes, this new design saves an average of about 70m^2 per range.

allowed in the ranges from designated firing points. Portable hard traps that are constructed from armoured steel are overlaid with shredded rubber panel mounted on spacer bars and are used as bullet traps in the Urban Operations Range. In addition, all ranges have walls (inclusive of columns), floors and ceilings that are made of reinforced concrete designed in compliance with requirements stipulated in the JSP403 UK range safety handbook and verified to be able to effectively contain the rounds fired in the MMRC.

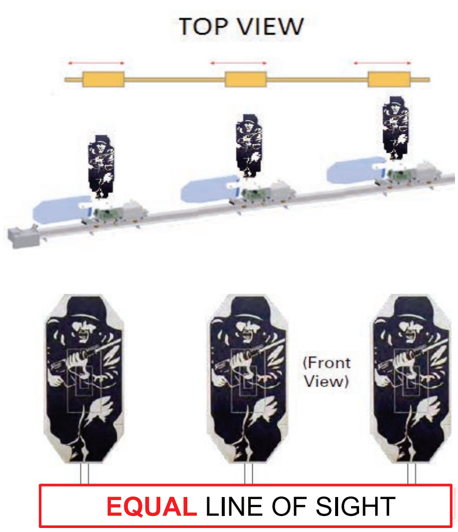

Figure 8. Single-rail METS

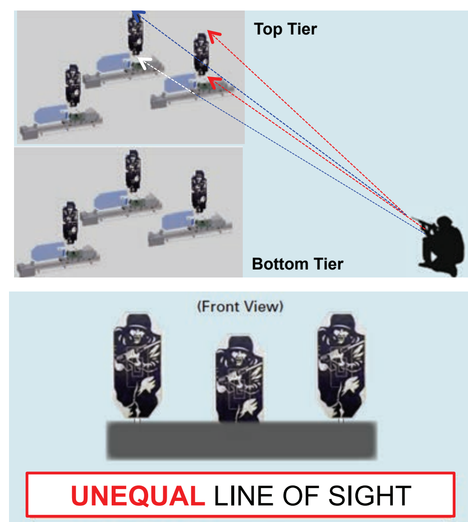

Figure 9. Conventional METS

MAINTAINING HIGH SAFETY STANDARDS

As this is the Singapore Armed Forces' (SAF) first indoor multi-storey live-firing facility of this scale, maintaining high safety standards for firers, facility personnel and the facility itself is of the top priority. All ranges in the MMRC are fitted with robust ballistic protection systems that were subjected to strict and rigorous validation prior to installation, to mitigate the hazards associated with firing in an indoor range.

Overall Round Containment

The MMRC is designed for full round containment and hence there is no need to cater for a weapon danger area outside the range. In order to ensure total round containment, steel escalator bullet traps and granular rubber bullet catchers are installed in the 50m and 100m ranges to contain the ammunition

Hazardous Ricochet and Backsplash Hazards

Ballistic protection systems are installed to prevent hazardous ricochets and backsplash associated with firing in indoor ranges. They also serve as additional protection to prevent round escapement and protect the ranges' concrete walls and ceilings from occasional shots.

Shredded rubber panel (SRP) is used extensively in the ranges to prevent hazardous ricochet and backsplash hazards to the firers. Majority of the SRP are mounted on spacer bars, which in turn are welded to armoured steel plate. This system is used for the range walls, ceiling baffles, target mechanism protection system and floor baffles to prevent ricochet and backsplash hazards to the firers (see Figure 10). Bullets that pass through the SRP and strike the steel would either fragment or deform, and the density of the SRP prevents any fragments or deformed projectiles from passing back through into the range area.

Figure 10. Ceiling baffles in 50m Range 1 and 2

Redirective guards are positioned immediately in front of and above the throat of the bullet catchers (see Figure 11). In most cases, the redirective guards will be within the weapon danger area and therefore require thicker armoured steel plate. The guards are hung at an angle to ensure that projectiles are directed into the throat of the bullet catcher and will continue their travel into the deceleration chamber of the bullet catcher. In addition, the angle at which the plates are hung would also ensure that the pitting on the steel plates would not cause hazardous ricochet and fragments, and injure the firers.

Protection of Personnel in Control Room and Learning Gallery

Ballistic glass is installed in the control room and learning gallery to allow trainers and soldiers to observe the live-firing activities safely (see Figure 12). The ballistic glass is rated to be able to withstand 7.62mm x 51mm NATO rounds, and its performance was verified during component testing.

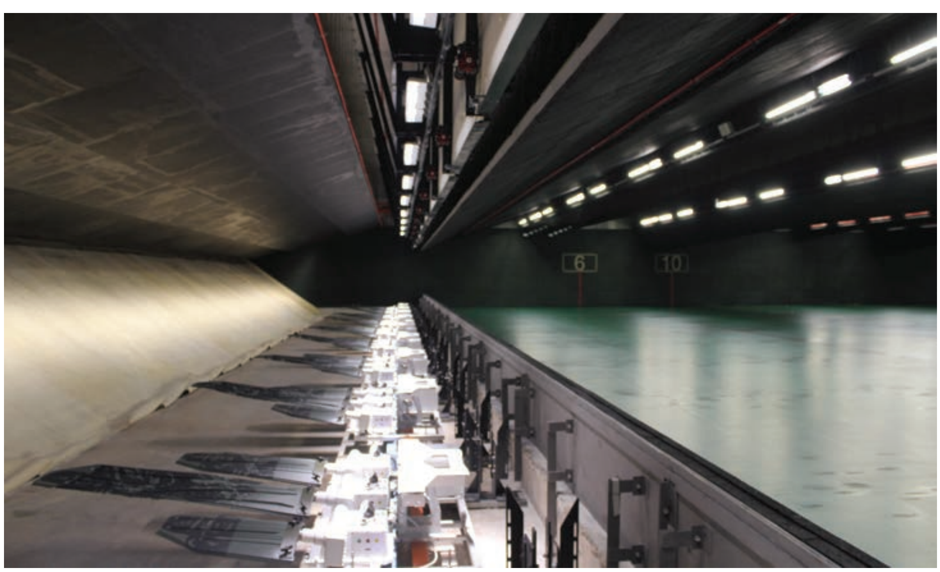

Figure 11. Redirective guards used at the bullet traps

Figure 12. Ballistic glass installed at the control room and learning gallery

Ensuring Safety during Fire and Movement

To ensure the safety of soldiers during live-fire tactical training involving the firing of small arms, a safety angle is applied between the side of the firing point and the nearest firer on the adjacent lane. This safety angle comprises a ricochet safety angle plus the appropriate cone of fire angle.

For fire and movement training[2], it was determined that a wider firing lane was required for each firer. Instead of having 10 firing lanes for static firing, the range had to be reconfigured to have just seven firing lanes. To comply with the requirement, the team successfully redesigned the range to allow the 10-lane range to be easily reconfigured into a seven-lane range (see Figure 13). This was achieved by mounting the static electronic targets on movable rails which allow the targets to be moved manually and locked into position.

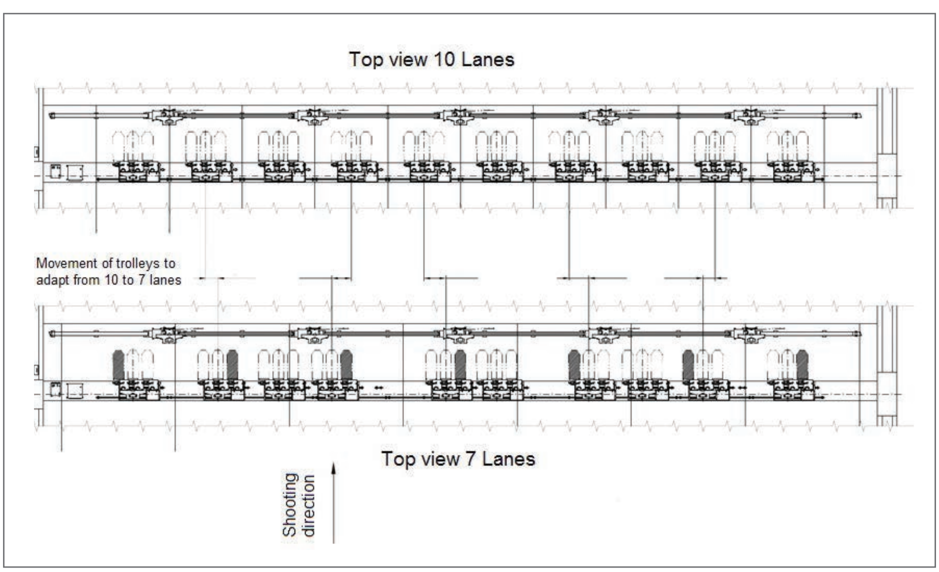

Figure 13. Comparison between a 10-lane and seven-lane range

Environmental Safety

The ranges in the MMRC are ventilated mechanically. The design of the range ventilation system is crucial in minimising the accumulation of contaminants in the range as well as in preventing contaminants from flowing into the adjacent spaces. This reduces the risk of contaminants inhalation by soldiers and instructors.

The range ventilation system is designed to create a low-velocity, uni-directional airflow towards the targetry area where an exhaust system filters the contaminants before discharging the air into the external environment (see Figure 14). For such a complex task, numerical modelling using Computation Fluid Dynamics (CFD) was used in designing the range ventilation system for the first time in Singapore (see Figure 15). Areas of stagnation and high air velocity were identified and the design was refined over several iterations to improve air flow. To prevent the outflow of contaminants to the adjacent spaces, the air pressure in the range is maintained at a slightly lower pressure than the surrounding spaces. Differential pressure sensors are installed to measure the pressure differential between the range and its adjacent spaces. The Building Automation System monitors these sensors in real time and regulates the speed of the exhaust system to maintain a differential pressure of 5Pa to 15Pa between the range and the adjacent area.

Figure 14. Schematic of range ventilation system

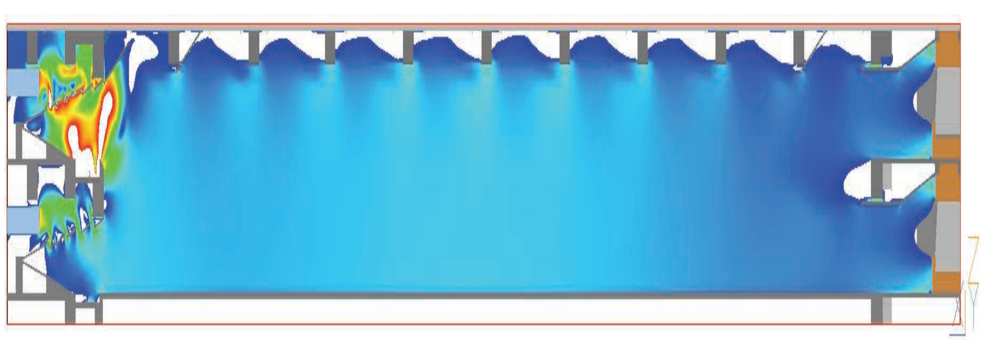

Figure 15. CFD modelling of air flow velocity in the range

BENEFITS OF THE MMRC

The operationalisation of the MMRC has brought about many benefits to the SAF and commercial entities.

Optimising Allocation of Resources

To ensure training hours are optimally utilised, a soldier-centric workflow was created to enhance the positive experience of soldiers from registration to exit. All routine, non-core administrative tasks were streamlined and outsourced to a commercial entity, allowing the SAF to focus on core competency development. Conversely, the commercial entity is able to leverage its creativity and experience to manage its operation and staffing efficiencies to meet contractual performance requirements. Unlike traditional outdoor ranges, training is not subjected to external weather and lighting conditions in the MMRC. In particular, soldiers do not need to cease training due to a downpour or wait long hours after their daytime training for nightfall before proceeding with their nighttime training. Hence, the waiting time and time needed for administration and logistics matters have been efficiently converted into training time for soldiers.

Aligned Vision in National Development

Some of the existing outdoor live-firing ranges in Singapore are sited on valuable state land that have to be returned to the Singapore Land Authority (SLA) progressively for land redevelopment. The DSTA Integrated Project Management Team performed detailed studies and planned strategically for the land required to build the MMRC and reduced the total footprint for constructing seven typical outdoor ranges by at least 3.7 times. This approach also enabled the Ministry of Defence (MINDEF) and the SAF to achieve total land savings of 22 hectares, equivalent to 30 football fields. With the delivery of the MMRC, the land occupied by existing outdoor firing ranges can be returned to SLA progressively. The MMRC also minimises the need to develop new conventional ranges.

CONCLUSION

The MMRC has become a critical training facility of the Army and provides a pleasant experience for our current generation of national servicemen. It has also paved the way for future training infrastructure and systems development. It is at the forefront of training development and has crossed new boundaries, creating a paradigm shift in the way the SAF conducts its live-firing training. The capabilities delivered by the MMRC have provided the SAF with a safe yet challenging environment to train and sustain instinctive and judgemental shooting competencies, and instils a positive experience in every soldier that trains in the facility.

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ENDNOTES

[1] The MMRC was awarded the IES Prestigious Engineering Achievement Award (2014), Defence Technology Prize Team (Engineering) Award, MINDEF Innovation Project and Savings And Value Enhancement (SAVE) Awards in 2013.

[2] Fire and movement training is a shooting drill that requires soldiers to take cover, take aim, fire and move forward to another location to repeat the drill.

BIOGRAPHY

LIM Peter is a Programme Manager (Networked Systems) who led in the delivery of the Multi-Mission Range Complex (MMRC). Peter graduated with a Bachelor of Technology (Electronics Engineering) degree and a Master of Engineering (Electrical and Computing) degree from the National University of Singapore (NUS) in 2001 and 2005 respectively. He further obtained a Master of Science (Software Engineering) degree from the Naval Postgraduate School, USA, in 2011.

YEO Qiu Ling Tammi supported the delivery of targetry and simulation systems in the MMRC when she was a Project Manager (Networked Systems). She is currently pursuing a Master of Science (Operations Research) degree at the Naval Postgraduate School, USA. Tammi graduated with a Bachelor of Engineering (Electrical Engineering) degree and a Master of Science (Industrial Systems Engineering) degree from NUS in 2006 and 2012 respectively.

LIM Meng Kee Johnson is a Manager (Building and Infrastructure). He has more than 15 years of experience in designing and commissioning air-conditioning, ventilation and fire protection systems for military facilities. Johnson graduated with a Bachelor of Engineering (Mechanical Engineering) degree from Nanyang Technological University and a Master of Science (Industrial and Systems Engineering) degree from NUS in 1996 and 2008 respectively. He further obtained a Master of Science (Fire Protection Engineering) degree from the University of Maryland, College Park, USA, in 2010.

LAU Chin Seng Eric was a System Manager (Systems Management). As the range safety engineer for the MMRC, he provided technical assessment and advice in ensuring that the design of the ranges in MMRC complied with existing range safety guidelines. Eric has represented Singapore in the annual International Range Safety Advisory Group meeting which comprises experts and practitioners in range. He graduated with a Bachelor of Engineering (Chemical Engineering) degree from NUS in 2006.