MINISTER'S INNOVATION AWARD

CAAS — Civil Aviation Authority of Singapore

MERIT AWARD

ENHANCED C-UAS CAPABILITIES IN CHANGI AIRPORT

New Advance C-UAS Systems

C-UAS Operations Command and Control Centre (OCC)

Drone Defence Command, Control and Comms (DDC3) System

PROJECT TEAM

Civil Aviation Authority of Singapore

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IMPETUS FOR PROJECT

In June 2019, Changi Airport encountered multiple Unmanned Aircraft (UA) incursions which affected more than 60 flights and 10,000 passengers. Apart from being a major safety concern to aviation, unauthorised UA also disrupted airport operations which led to significant financial losses and caused significant impact to Changi Airport's reputation as a safe international air hub. Immediately after the UA incursion, CAAS, together with CAG and DSTA set-up a temporary Operations Command and Control Centre (OCC) to conduct 24/7 C-UAS operations at Changi Airport, initially with baseline C-UAS capabilities (such as leased C-UAS systems, ground patrol teams and jammer guns) to protect against unauthorised UA. We also developed a provisional C-UAS CONOPS to ensure that proper processes and linkages were established for the safe conduct of C-UAS operations. However, with the rapid proliferation of UA use and evolving UA technology, it is imperative that we enhance our Counter-UAS capabilities to protect against unauthorised UA.

BREAKING Drone sightings force closure of a runway at Changi Airport

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Temporary OCC

Statement of Need:

Following the unmanned aircraft incursions in 2019, CAAS, CAG and DSTA leased and deployed several types of Counter Unmanned Aircraft Systems (C-UAS) systems at the airport to (a) trial and assess the capabilities and performance in the airport environment while providing immediate protection, (b) gain deeper insights to the commercially available C-UAS systems and capabilities, and (c) support operational testing and learning in terms of the strengths and limitations of these systems. Drawing from the lessons learnt from the initial deployment of leased systems, and with the data gathered, CAAS worked with CAG and DSTA to progressively and systematically develop and enhance our C-UAS capabilities at Changi Airport.

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EXTENT OF INNOVATIVENESS

Systematic Enhancements of C-UAS Capabilities in Changi Airport

New C-UAS Capabilities. Using the lessons, observations and test results from the leased C-UAS systems, we established the detailed tender specifications and acquired full suite C-UAS systems with better range and coverage to best meet the operational requirements. The C-UAS systems have been deployed and operationalised at the respective runways to protect against unauthorised drones. As C-UAS systems were new capabilities that may interfere with aircraft, airport and air traffic systems, we had to develop (from scratch) comprehensive safety assessment to ensure that they could co-exist without disrupting existing systems and operations. Similarly, we had to develop new testing and evaluation methodologies for the C-UAS systems, given that there were limited references for such new capabilities. Moving forward, we will conduct Proof of Concept (POC) for new C-UAS capabilities, to further enhance the detection, disruption and neutralisation capabilities in Changi Airport.

Strengthen Command and Control (C2). Deployment of physical C-UAS system aside, we recognised the need for robust C2 for operational effectiveness. As there were no existing C2 centres in Changi Airport to leverage on, we designed and operationalised a purpose-built Ops Command and Control Centre (OCC) to centrally command, control and coordinate 24/7 C-UAS operations to protect the airport against unauthorised UA. The team innovatively used operations workflow as a key design consideration for the OCC to enable, sensemaking, quick and effective decision making and timely response to unauthorised UA activities. To operationalise effective C2, we saw the need to use technology as an enabler and decision support tool. To this end, CAAS worked with DSTA to design and develop the first Drone Defence Command, Control and Communication (DDC3) - a centralised system to integrate all C-UAS systems deployed in Changi Airport to (a) provide a comprehensive UA situational picture, and (b) enable simultaneous control of multiple C-UAS systems. The DDC3 enhances the C-UAS ops cycle, supports data sharing across agencies, and reduces the resources required to conduct C-UAS operations. The open architecture also allows future integration of new C-UAS sensors and capabilities, as and when these are acquired and deployed. Given that DDC3 is the first of its kind for C-UAS operations, MHA and MINDEF will also be developing their respective C2 systems based on the DDC3 design and architecture.

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Integrated C-UAS Operations in Changi Complex. Being the first agency to conduct comprehensive C-UAS operations in Singapore, CAAS had to develop the C-UAS CONOPS and SOP for Changi Airport C-UAS operations without any references, within Singapore and internationally. Notwithstanding, we not only developed the CONOPs for the protection of Changi Airport but also progressively developed the C-UAS CONOPS for Changi Complex, elevating it to an integrated C-UAS operation that leverages on the C-UAS capabilities from the Whole-Of-Government (WOG) agencies to enhance the conduct of C-UAS operations. With this new development, we established Joint SOP enabling agencies to coordinate and co-share data and information to detect and disrupt unauthorised UA beyond their areas of interest. To validate and assimilate the CONOPS, CAAS also conducted two multi-agency C-UAS exercises (involving more than 10 agencies and 100 participants) and several red-teaming exercises within Changi Complex to drill the ops processes.

DDC3 System

C-UAS OCC
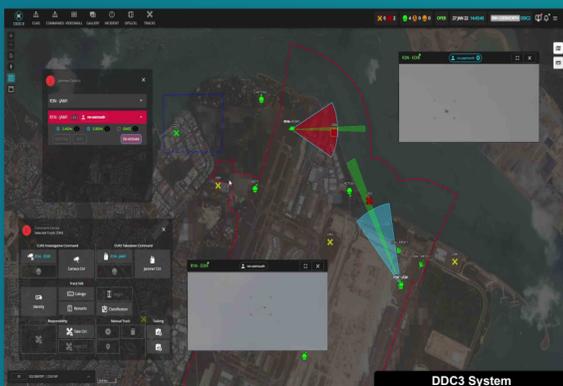
Innovation Highlights:

Innovative Deployment Strategy. As C-UAS was a nascent capability, the team worked with DSTA and CAG to develop a leasing strategy to test the capabilities of several commercially available systems before deciding on the most appropriate system for Changi Airport. The team developed a testing regime with evaluation methodologies (including test measurements, pass/fail criteria, drone flight profiles etc) due to the lack of existing references. The team also had to develop the Safety Assessment Framework to ensure that the new C-UAS sensors and systems deployed in the airport would not interfere with aircraft and air navigational systems.

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First-of-its-kind DDC3. The development of the Drone Defence Command and Control (DDC3) system is the first centralized C2 system designed to integrate C-UAS systems locally. This integration enhances the effectiveness of C-UAS operations by providing a comprehensive UA situational picture that can be shared across agencies. The DDC3 also enables the simultaneous control of multiple C-UAS systems and is designed with an open architecture to allow for future integration new C-UAS sensors/systems. MHA/MINDEF adopted the DDC3 software design and architecture to develop the national C-UAS command and control system.

Creating an Integrated CONOPs to better protect Changi Airport. Beyond conducting C-UAS operations at Changi Airport, the team developed an integrated C-UAS CONOPs and collaborated with other WOG agencies (C-UAS stakeholders) within 5km of Changi Airport. Using the concept of Changi Complex, the team innovatively leveraged on the C-UAS capabilities and resources of WOG agencies in the vicinity of Changi Airport to enable OCC to "see further and act earlier" to enhance the overall effectiveness of C-UAS operations.

Proposed-built OCC. Recognising the need for C-UAS capabilities in the airport, CAAS designed and developed of a purpose-built Operations Command and Control Centre (OCC) to centralise the C2 for 24/7 C-UAS operations, ensuring swift and effective responses against unauthorised UA activities.

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IMPACT AND VALUE-CREATION

The systematic enhancement of C-UAS capabilities in Changi Airport offers significant impact and tangible benefits as follows (a) protects the airspace against unauthorised UA to ensure aviation safety and minimise disruption to airport operations, (b) developed comprehensive criteria for testing and evaluating to ensure C-UAS systems do not interfere with aircraft and airport navigation systems, and (c) collaborated with WOG agencies to develop integrated C-UAS CONOPS within Changi Complex, leveraging their capabilities and resources to enhance situational awareness and response times.

Economy: The implementation of new C-UAS capabilities reduced the manpower required, up to 20%. By leveraging a centralised C2 system to integrate all C-UAS systems, the OCC has been able to streamline its operations to be more efficient and enhances overall productivity.

Efficiency: Changi Airport has effectively utilized WOG agencies capabilities to enhance its C-UAS operations. By integrating various government capabilities, the airport can "see further and act earlier" with better coverage and tighter coordination. This proactive approach ensures that any potential disruptions are addressed swiftly and efficiently, maintaining the continuous operations at the airport.

Effectiveness: The outcome of the implementation has resulted in zero disruptions to airport operations, ensuring that flights and passenger activities continue without interruption. This underscores the effectiveness of the measures in place. The CONOPS and SOPs have been refined through the conduct of two multi-agency C-UAS exercises (involving more than 10 agencies and 100 participants) and several red-teaming exercises within Changi Complex to drill the ops processes.

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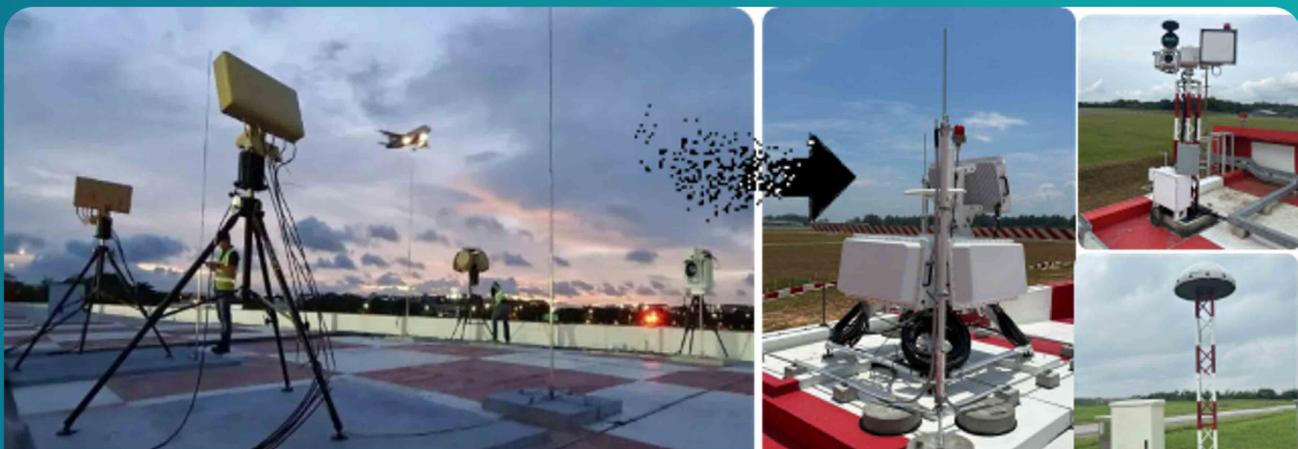
New and Advanced Systems

Outcome:

The systematic enhancement of C-UAS capabilities at Changi Airport has delivered critical operational and national impact. It proactively safeguards the airspace against unauthorised UA, ensuring aviation safety and maintaining uninterrupted airport operations. Rigorous testing and evaluation criteria were developed to ensure that C-UAS systems do not interfere with aircraft or airport navigation systems. Through close collaboration with WOG agencies, an integrated C-UAS CONOPS was established within the Changi Complex, leveraging inter-agency capabilities to enhance situational awareness and accelerate response times. These efforts have resulted in reduced manpower requirements for C-UAS operations, improved efficiency by enabling agencies to "see further and act earlier," and ensured zero disruption to airport operations despite emerging UA threats.

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FEASIBILITY AND SCALABILITY

Feasibility: The C-UAS operations have expanded from Changi Airport to Changi Complex (which is the 5km of Changi Airport), enabling a more comprehensive approach to unmanned aircraft threats with earlier detection and response. The integration of systems and resources across the complex enhances the effectiveness of C-UAS operations, providing higher security and situational awareness. Additionally, the coordination of C-UAS operations across multiple agencies has been significantly improved, ensuring seamless communication and collaboration. This integrated approach allows for timely and effective responses to threats, optimizing resource use and improving operational efficiency.

Scalability: The DDC3 architecture is adaptable and scalable, serving as the foundation for developing the other agencies' C-UAS systems. This architecture allows agencies to create their own C2 systems while maintaining compatibility with the national framework for UA, ensuring seamless coordination and information sharing. As technology evolves, the DDC3 system's open architecture will allow the integration of new sensors and technologies without extensive modifications, keeping it at the forefront of innovation and response capability.

Potential of Project:
By enhancing C-UAS capabilities at Changi Airport, including the development C2 systems and collaboration with WOG agencies, the initiatives established a robust framework for countering unmanned aircraft threats. The integration of innovative technologies and methodologies further strengthens the initiative's foundation. This comprehensive approach ensures aviation safety and operational efficiency.