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ACHIEVING HIGH RESILIENCE IN SUSTAINING OPERATIONS OF CRITICAL AERONAUTICAL INFRASTRUCTURE

(Presented by Hong Kong, China)

INFORMATION PAPER

SUMMARY

Critical Aeronautical Infrastructure (CAI) needs uninterrupted operations for sustaining round-the-clock provision of air navigation services for aviation safety purpose. This paper shares the experience of Hong Kong, China in the planning, design and implementation of CAI in achieving high resilience in supporting its round-the-clock operations, and ensuring a high degree of preparedness among the airport community at the Hong Kong International Airport to cope with severe weather conditions.

ACHIEVING HIGH RESILIENCE IN SUSTAINING OPERATIONS OF CRITICAL AERONAUTICAL INFRASTRUCTURE

1. INTRODUCTION

1.1 CAI refers to an infrastructure that needs to maintain uninterrupted operations for sustaining round-the-clock provision of air navigation services within a Flight Information Region (FIR). It includes, but not limited to, air traffic control (ATC) centres, towers, airports, on-airport and off-airport communications, navigation and surveillance (CNS) stations, systems and electrical and mechanical (E&M) facilities, such as power supply and air conditioning etc. Any degradation in performance of the systems and E&M facilities of CAI may lead to disruption to its operations and even induce closure of the FIR as the last resort fail-safe measure. Resilience, redundancy and robustness are vital factors to consider in the planning, design and implementation of CAI for coping with unexpected emergency circumstances caused by natural disasters (e.g. severe weather conditions) or human-induced incidents.

2. DISCUSSION

ATC System Architecture and Design

2.1 The ATC systems of Hong Kong, China are designed with multiple redundancies consisting of Main and Fallback systems. The Main and Fallback systems are identical systems operating in parallel that could provide immediate backup to each other when one system fails. For safety-critical ATC systems with serious consequence if failure, such as the air traffic management system, one additional layer of protection, namely a Contingency system completely independent from the Main and Fallback systems, is provided by another supplier for further enhancing resilience and mitigating the risk of total system breakdown due to simultaneous failure of Main and Fallback systems.

2.2 To eliminate the single-point-of-failure as far as practicable in hardware and software, all processing systems are interconnected via high capacity redundant local area networks (LANs). Computers providing core common services, such as Surveillance Data Processing Servers and Flight Data Processing Servers, are duplicated with each computer connected to each LAN providing a high degree of redundancy. The two individual LANs keep sharing information and function as main and fallback nodes. A third LAN is used for system logs collection and handling of recording and playback.

Location and Route Diversity

2.3 Location and route diversity are key considerations for robustness as it enables continuous operations even there are disruptions in one location or one communication cable routing. Key components of ATC systems, such as servers and core network switches, are installed at equipment rooms at different physical locations and interconnected via different cable routing such that ATC service would not be affected when one location or route experiences disruption. In the Hong Kong International Airport (HKIA), there are multiple ATC centres/towers with identical systems provisions at different locations. In the event of unexpected emergency situation like fire or communicable disease (such as COVID pandemic) outbreak at one ATC centre or tower requiring evacuation, the backup ATC centre/tower at different locations could be activated within short duration so as to minimize impacts to ATC service. Similarly, fibre optics communication cables are installed in a ring configuration. When there is a failure in communication cables in certain route, relevant system information will be re-routed through another path. Regular activation drills of backup facilities are conducted to ensure readiness and familiarization by personnel involved.

City Mains and Emergency Generators

2.4 The reliable provision of ATC service requires a highly resilient and robust power supply distribution network. The power utility company provides dual feeds with duty/backup transformers in a ring topology to ATC centres and towers at the HKIA, such that a breakage in the ring

will not suspend power. There are multiple emergency generators with sufficient capacity for full ATC equipment loading inclusive of air conditioning to ensure provision of ATC service can be sustained by generators only in case of prolonged city mains failure. Furthermore, the main switchboards are equipped with plugin connection panels for quick hook-up to large-capacity mobile generator provided by the power utility company. Again, regular activation drills of these mobile facilities are conducted to ensure readiness and familiarization by personnel involved.

Uninterruptible Power Supply (UPS)

2.5 All safety-critical ATC system servers installed at ATC centres/towers receive dual power inputs from two independent UPS sources. For ATC system workstations receiving only a single power source, static transfer switches connecting with two UPS are put in place to provide UPS backup through automatic switching from one source to another in case of failure/maintenance. All UPS are designed with capacity much higher than the total demand. Under rare circumstances when power supply from power utility company and standby generator is interrupted, UPS can continuously support hours of uninterrupted operation of safety-critical ATC equipment, thus ATC service.

Air Conditioning

2.6 All safety-critical ATC servers/workstations and operational personnel are continuously and separately cooled by conditioned air to ensure their reliability and performance. In ATC centres, towers and corresponding equipment rooms, primary water-cooled chiller system of the central air conditioning system with redundancy in chillers and total capacity exceeding the full cooling load, operates round-the-clock to cool the ATC equipment and maintain a comfortable working environment for controllers in ATC centres/towers. In case of failure of all water-cooled chillers, which are extremely unlikely, the secondary air-cooled chiller system will kick in automatically to take up the cooling duty. Equipment rooms are equipped with computer room air conditioning units (CRAC) with duty and standby redundancy units.

Airport Preparedness to Cope with Severe Weather

2.7 As one of the busiest airports in the world, it is crucial for HKIA to achieve high resilience in airport operations to cope with severe weather conditions, such as typhoon and heavy rainstorms, to minimize their potential impacts on its operations. Individual stakeholders of the airport community have established their own internal emergency procedures so that collaborative efforts could be made to handle such situations. The Airport Authority Hong Kong (AAHK), the airport operator for the HKIA, has taken the lead to establish a weather preparedness plan for the HKIA which includes response plans, drills and briefings to enhance HKIA's preparedness to manage potential operational disruptions caused by severe weather in a coordinated manner.

2.8 A HKIA Emergency Procedures Manual is produced, maintained and distributed by AAHK according to the aerodrome licensing requirements stipulated by the Civil Aviation Department Hong Kong. The manual details contingency and recovery procedures for the HKIA covering a multitude of emergencies which can affect airport operations (including severe weather). For the purpose of testing the emergency response procedures and enhancing the coordination between the airport community of the HKIA and all relevant emergency response units when dealing with these emergencies, AAHK conducted desktop and site drills throughout the year. In particular, desktop drills relating to pre- and post-typhoon handling are held prior to the onset of the typhoon season. It is encouraging to note that with the benefit of such drills, AAHK and the airport community including Hong Kong Observatory (HKO), Hong Kong Police Force (HKPF), aircraft operators, ground and ramp handling agents and line maintenance operators have been capable of following and executing weather-related emergency procedures effectively and professionally.

2.9 Close communication for disseminating advance and real-time information is essential to uphold safety of the operations during severe weather conditions. In this regard, AAHK maintains close coordination with HKO for advanced weather monitoring and forecasting, particularly throughout the typhoon season. For this purpose, AAHK will, in coordination with HKO and ATC, convene

coordination meetings with the airport community to disseminate the latest weather information, review operational impacts to the airport and coordinate necessary actions from all relevant stakeholders. Depending on the nature and extent of the severe weather conditions, precautionary actions would be appropriately arranged, which include securing ground equipment and other loose items, pre-loading fuel to parked aircraft in the apron area, retracting and/or tying down airbridges and inspecting storm drains. AAHK will also step up inspections on the airfield and relevant facilities to verify that all necessary preparation work has been completed, with the goal of eliminating all potential hazards to airfield operations prior to any severe weather strike.

2.10 In preparation of the upcoming severe weather, an Airport Emergency Centre (AEC) will be activated by AAHK. Led by AAHK at a senior level and supported by representatives from ATC, aircraft operators, ground and ramp handling agents, line maintenance operators, HKPF etc., the AEC acts as the command and control centre for airport operations during emergency situations; mobilises airport-wide resources to minimise any likely operational impact; facilitates emergency response and information consolidation and dissemination amongst the airport community and to the general public; and enables the rapid restoration of the HKIA back to normal operations.

2.11 Following a prolonged disruption to airport operations such as typhoon, the Flight Rescheduling Control System (FRCS) will be activated by AAHK with a view to resuming normal airport operations in an orderly manner. During the activation of FRCS, all aircraft operators will be re-allotted new flight slots, so that the aircraft operators may inform passengers of the flight arrangements, clearing the backlog of passengers. During the recovery period, flight slot clearance requests for all flights to be operated will be handled by AAHK after joint assessment with ATC. In addition, AAHK will also conduct post-typhoon inspections to check the conditions of the airfield and relevant facilities and arrange necessary cleaning and repair, so that operations can resume normal as soon as practicable.

2.12 Unprecedented global warming has led to many challenging weather situations in recent years. In September 2023, Hong Kong was unfortunately hit by the Super Typhoon Saola followed by extremely heavy rainstorms. With the high resilience in CAI and high degree in preparedness by the airport community of the HKIA, the air navigation services in Hong Kong have sailed through the natural disasters in a safe manner with minimal disruption.

3. ACTION BY THE CONFERENCE

3.1 The Conference is invited to note the information contained in this Paper.

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