Annex 4

Recommendations of the International Advisory Panel on Sustainable Air Hub Executive Summary

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Climate change is an existential problem that causes widespread disruptions and affects the lives of billions around the world. Changes in weather patterns impact air travel directly, affecting critical airport infrastructure and aircraft performance and causing delays and disruptions. The international civil aviation sector must play its part and take firm and decisive actions to decarbonise its operations. No single country or organisation can achieve this on its own; the push for sustainable aviation will require coordinated State actions, cross-sectoral collaboration, public-private partnership and greater climate consciousness amongst corporates and the travelling public.

As an international business, aviation and aerospace hub, Singapore can play an important role as a pathfinder and convenor for the cross-sectoral collaboration and public-private partnership needed to reconfigure the aviation ecosystem to support sustainable operations and make it a commercially viable reality. As an active member of the International Civil Aviation Organization (ICAO) and the international civil aviation community, Singapore can also exercise thought leadership and work with other countries and international organisations to drive and support climate actions globally and regionally.

Singapore has started work on this by voluntarily taking part in the ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) in its pilot phase. Additionally, Singapore is embarking on a one-year pilot to use blended Sustainable Aviation Fuel (SAF) at Changi Airport. It is also actively partnering with other like-minded countries and has inked a Memorandum of Arrangement with New Zealand to establish, amongst other things, a green travel corridor. As a next step, CAAS is developing a Sustainable Air Hub Blueprint to bring together all these efforts and to set a roadmap with clear 2030 and 2050 targets and tangible pathways for achieving them. The Sustainable Air Hub Blueprint is a significant initiative which will help provide thought leadership and further catalyse investments, actions and collaborations with private sector companies and other countries.

The IAP seeks to contribute to the development of the Singapore Sustainable Air Hub Blueprint by proposing specific projects that Singapore can initiate, leveraging its hub position and strong partnerships with international bodies, other countries and private companies. In doing so, the IAP has taken an action-oriented, industry-driven approach, tapping on the experience and expertise of its members, which include senior executives of global aviation bodies and key aviation companies.

Specifically, the IAP has recommended 15 initiatives across the three key domains of airport, airline and air traffic management.

Airport

Airport operations are highly energy intensive. They rely on electricity for air-conditioning airport terminals and to power operational systems, and on fossil fuels for airside vehicles. To reduce carbon footprint, airports must consider ways to reduce electricity usage and switch to renewable energy. This is particularly challenging for Singapore, which has limited access to renewable energy.

To improve the sustainability of airports in Singapore, the IAP recommends that CAAS work with stakeholders on the following initiatives:

a. Deploy solar power on the airfield. Singapore Changi Airport is already tapping on solar energy through solar panels installed on the rooftops of its terminal buildings. There is scope to significantly increase the use of solar energy if solar panels can also be installed on the airfield. The IAP recommends that CAAS conduct a technical study on the feasibility of deploying solar panels on the airfield. This would include assessing their impact on radar signals, pilots and airport and flight operations, energy yields, transmission losses and economic viability. If shown to be viable, CAAS would engage ICAO and other industry bodies on standards and implementation.

b. Secure and increase the use of renewable electricity. The IAP recommends that CAAS work with stakeholders to secure imported low-carbon electricity for Changi Airport and set medium-term 2030 and long-term 2050 targets for the use of renewable electricity.

c. Improve building energy efficiency by reducing the air-conditioning carbon footprint. The air-conditioning system is the largest energy consumer at Changi Airport. The airport has various ongoing initiatives to lower air-conditioning use and reduce the energy used in running the air-conditioning system, to reduce its carbon footprint. The IAP recommends that CAAS work with stakeholders to further improve the energy efficiency of the air-conditioning system through innovative energy-efficient technologies and design concepts. The recommendations include assessing potential alternative cooling methods or technologies to guide the design for Terminal 5 and retrofitting existing terminals to achieve maximum energy savings.

d. Facilitate the transition of airside vehicles towards clean energy sources. Changi Airport has already started on the electrification of its airside vehicles fleet. The IAP

recommends that CAAS work with stakeholders to facilitate the transition of all airside vehicles towards cleaner energy options. This can be achieved through three pathways – electrification of the airside fleet, conversion to hydrogen-powered vehicles and the use of biofuels. A simulation and modelling study, along with technology trials, will facilitate better understanding of the deployment scale, operational challenges, policies and regulations needs for each pathway.

e. Explore system optimisation with a digital twin project. System optimisation at the airport level can improve operational efficiency and reduce carbon emissions systemically. Changi Airport could benefit from developing a digital twin to mirror static and dynamic assets and integrate data from various sources. This can then be presented in a human-centric interface for advanced predictions, simulation and process optimisation. The IAP recommends that CAAS work with stakeholders to study the feasibility of a digital twin modelling process at Changi Airport. The study should include planning, design, and end-to-end optimisation of airport processes to reduce energy consumption and minimise emissions from aircraft and airside vehicle movements.

f. Enhance resource circularity through an on-site waste-to-energy facility. Changi Airport has been adopting circularity practices to reduce the volume of waste generated and consume less external resources. Beyond this, a more direct decarbonisation pathway to reduce energy offtake from the grid would be through an on-site waste-to-energy facility at Changi Airport, which could work by channelling waste as feedstock to generate biofuels or electricity. The IAP recommends that CAAS work with stakeholders to study the potential and feasibility of establishing a waste-to-energy facility in Changi Airport, particularly whether there are sufficient economies of scale for such a facility. If feasible, such a facility can contribute to Changi Airport's carbon reduction efforts through resource recovery and a reduction in energy offtake from the national grid.

Airline

Flight operations account for the bulk of global aviation emissions. The decarbonisation of international civil aviation will require significant climate action in the airline domain.

To improve the sustainability of airlines operating to, from and through Singapore, the IAP recommends that CAAS work with stakeholders on the following initiatives:

a. Develop and implement a roadmap to create a long-term secured SAF supply ecosystem. The global SAF market is still nascent, and the availability and affordability of SAF must be boosted. Likewise, Changi Airport needs to develop a

long-term secured supply of SAF to support increased adoption by its airlines. The IAP recommends that CAAS work with stakeholders to develop and implement a roadmap to create a long-term, secured ecosystem for SAF supply in Singapore and the region. This entails building up and strengthening the SAF supply chain and upstream capabilities to establish a SAF ecosystem in Singapore and the region, validating regional feedstock to align with global standards and investing in new SAF pathways.

b. Establish a "Singapore / ASEAN Corporate Buyers' Club" to create demand signals. Long-term demand certainty is required to incentivise SAF suppliers to expand SAF production capacity. There is scope to strengthen the demand signals for SAF in Singapore, to encourage an increase in SAF production. The IAP recommends that CAAS work with stakeholders to establish a buyers' club to encourage early adopters of sustainable air travel to take collective action, thereby aggregating SAF demand and providing stronger demand signals for SAF production and scale-up. As a global business and logistics hub, Singapore has opportunities to tap on business travellers and air cargo users and encourage them to become first movers by joining the corporate buyers' club. Thereafter, there is also the potential of collaborating with regional partners to expand the buyers' club to the broader ASEAN region.

c. Design and introduce a structural offtake mechanism and create demand signals for secured long-term, lower-cost SAF supply. To create long-term, predictable SAF demand, Changi Airport needs to introduce and implement a structural mechanism to encourage sustained SAF adoption amongst airlines. The IAP recommends that CAAS work with stakeholders to design and introduce a structural SAF offtake mechanism. It should catalyse a self-sustaining ecosystem and flow of funds for SAF in Singapore to encourage greater adoption of SAF at Changi Airport. The offtake mechanism needs to consider the unique context and characteristics of the air hub, its airlines and passengers, the funding sources, and the metrics used to determine the offtake mechanism.

d. Innovate to build deep aviation industry vertical offerings in carbon markets, develop a support ecosystem for aviation carbon offsets solutions and encourage uptake among corporates and consumers. Beyond in-sector measures, carbon offsets are necessary to achieve net-zero emissions. As the carbon offset market is still nascent, there is scope to build up such a market for aviation carbon offsets in Singapore to support the decarbonisation of the aviation sector. The IAP recommends that CAAS work with key players in Singapore's emerging global carbon services hub to build up the market for aviation carbon offsets. This includes products and platform innovations for aviation carbon offsets, developing an enabling ecosystem of carbon support services to improve the reliability, traceability and accountability of aviation

industry offsets and exploring the possibility of raising voluntary demand for carbon offsets amongst corporates, passengers and cargo users.

e. Explore a potential technical centre for capability-building to ensure that Singapore can be an early adopter of aircraft technology. Singapore would need to remain at the forefront of advancements in aviation technology to reap their full benefits. The IAP recommends that CAAS work with stakeholders to explore setting up a technical centre in Singapore. This entails tapping on Singapore's strong research and development ecosystem and collaborating with aircraft original equipment manufacturers, like-minded aviation partners and stakeholders to strengthen its technical capabilities and position itself for the future. This initiative complements existing efforts to explore the potential use of hydrogen at Changi Airport.

Air Traffic Management (ATM)

Improvements in ATM and operational procedures can help reduce unnecessary emissions and improve environmental performance. Such efforts should be closely aligned with plans and guidance from ICAO, which seek to achieve a global interoperable air navigation system that is safe, efficient and environmentally sustainable.

The IAP has identified the following four short- and medium-term recommendations to optimise ATM for improved environmental performance:

Short-term (2022-2026)

a. Implement advanced demand-capacity balancing. CAAS has been working with stakeholders to enhance the management of air traffic vis-à-vis available capacity, including through the Asia-Pacific Cross-border Multi-Nodal Air Traffic Flow Management (ATFM) Collaboration (AMNAC). The IAP recommends that CAAS work with stakeholders and partner Air Navigation Service Providers (ANSPs) to build on these efforts and introduce advanced demand-capacity balancing initiatives. These include implementing Long Range ATFM to improve coordination and management of longer-haul flights. Additionally, integration between meteorology (MET) and ATM could be strengthened through conducting translational studies of the impact of weather on ATM operations to enhance ATM decision-making and operations.

b. Enhance performance-based navigation. Performance-based navigation initiatives can enable more direct routings and optimise descent profiles for aircraft, thus reducing fuel burn and carbon emissions. CAAS has conducted operational trials for

direct route operations for flights arriving at Changi Airport and is facilitating Continuous Descent Operations (CDO) for Changi arrivals when traffic permits. The IAP recommends that CAAS expand on these initiatives. This entails formalising the implementation of direct route operations for Changi arrivals on specific route segments to provide airlines with the flexibility to plan for the most optimal route in terms of flight and fuel efficiency. Additionally, smart tools should be developed to facilitate CDO within Changi Airport for flight profile optimisation and reduction in fuel burn and emissions.

c. Optimise gate-to-gate trajectory. CAAS has been closely following global advancements in ATM that can optimise efficiency during all phases of flight, including Trajectory-Based Operations[1] (TBO) and re-categorisation (RECAT) of aircraft weight categories to reduce the separation between aircraft to optimise runway efficiency. The IAP recommends that CAAS collaborate with stakeholders and partner ANSPs to advance these initiatives to optimise the gate-to-gate trajectory at Changi Airport and increase fuel savings. This includes implementing enablers for TBO, such as Flight and Flow Information for a Collaborative Environment (FF-ICE) and System Wide Information Management (SWIM), and further optimising runway efficiency by extending the implementation of RECAT from arrivals to include departures.

Medium-Term (2027-2032)

d. Implement TBO and free route airspace (FRA) in collaboration with stakeholders and partner ANSPs. TBO and FRA are advanced concepts of operations that could revolutionise ATM, optimising efficiency and reducing carbon emissions from flights. As these would take longer to develop and implement, the IAP recommends that CAAS collaborate with partner ANSPs to further develop the key building blocks for TBO and FRA, such as through demonstrations to refine these advanced concepts of operations.

The IAP believes that the above 15 initiatives, taken together, are transformative and will allow Singapore to distinguish itself as a sustainable air hub. Their effective implementation will require strong government action and close collaboration with the industry. The IAP recommends that CAAS develop and include in its Sustainable Air Hub Blueprint critical enablers in the areas of policy and regulation, industry development, infrastructure planning and provision, and workforce transformation. These enablers are necessary for providing the right conditions to implement these initiatives effectively.

[1] TBO represents a fundamental shift in ATM. Instead of relying heavily on tactical air traffic control, flight trajectories can be planned ahead and executed more precisely to improve the management of traffic flows.