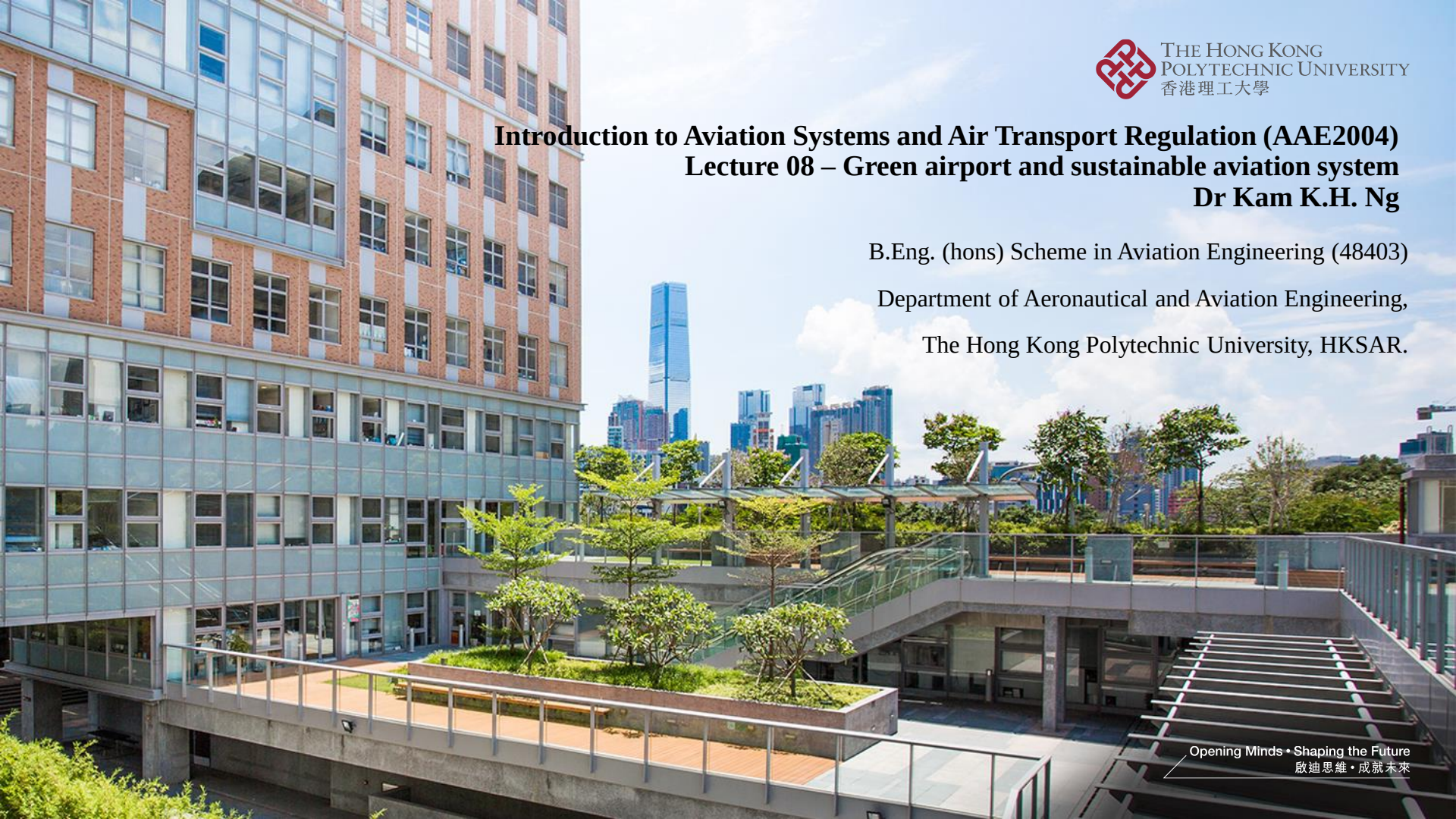

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Introduction to Aviation Systems and Air Transport Regulation (AAE2004)
Lecture 08 – Green airport and sustainable aviation system

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Agenda

- Aviation emission
- Environmental impact of aviation emission
- ICAO environmental protection plan
- Aviation emission calculator by ICAO
- Impact of high speed ferries and proposed mitigation measures
- Design of marine travel route and speed controlled zone
- Implementation and monitoring

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Aviation emission

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Introduction

The Special Report was prepared by IPCC following a request from ICAO and the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (IPCC, 1999):

- The state of understanding of the relevant science of the atmosphere, aviation technology, and socio-economic issues associated with mitigation options is assessed and reported for both subsonic and supersonic fleets;
- The potential effects that aviation has had in the past and may have in the future on both stratospheric ozone depletion and global climate change are covered;
- Environmental impacts of aviation at the local scale are not addressed;
- The report considers :
  - All the gases and particles emitted by aircraft into the upper atmosphere;
  - The role that they play in modifying the chemical properties of the atmosphere and initiating the formation of condensation trails (contrails) and cirrus clouds.

Introduction (cont’d)

- Airports are very much part of the communities;
- Reduce impact on the environment is a major focus for many airports around the world;
- Airports and the rest of the aviation industry are active on climate change and reduction of greenhouse gas emissions;
- Responsibility of the environmental stresses is subjected:
  - On the ground are less than those commonly encountered in aviation or under water;
  - Still exceed an individual's powers of adaptation.
- Several meetings and summits related to the "Aviation & Environment" hold in past years & are taking place around the world to discuss.

Climate change as main environmental crisis

- A change in the "average weather" that a given region experiences, including such factors as storm frequency, temperature, wind patterns and precipitation;
- The rate and magnitude of global climate changes over the long term have many implications for natural ecosystems;
- Society becomes increasingly reliant on energy consumption in work at home and for mobility

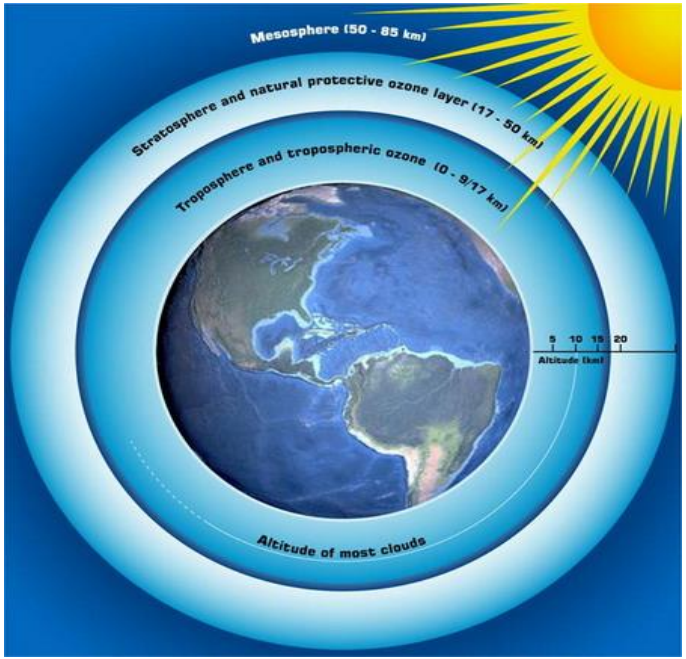
  → The heat-trapping nature of the atmosphere has increased;
- Scientific understanding of this situation increases

  → Public concern & require for a policy response;
- Aviation contributes a small but growing proportion to this problem (less than 4% of man-made atmospheric emissions);
  - Some of aviation's emissions are emitted in the upper atmosphere and may have a more direct effect.

Climate change as main environmental crisis (cont'd)

- The science of climate change is still relatively new and the future is uncertain;
  - A broad consensus that policy needs to be enacted now if climate change related problems and costs are to be avoided (EUROCONTROL).
- The Earth is rapidly getting warmer;
- The change in the climate threatens serious and catastrophic disruption to societies & natural environment with food and other vital resources;
- Cause by a build-up of 'greenhouse gases' that are released by human activities:
  - Burning of fossil fuels (coal, oil and gas);
  - Deforestation;
  - Certain types of agriculture.
- Gases trap the sun's heat in the atmosphere in the same way as a greenhouse;
- Over the course of the 20th century, the average surface air temperature increased by around 0.6°C globally, by almost1°C in Europe and by no less than 5°C in the Arctic;
- Have many discernible impacts around the globe.
  - Climate change will affect all countries but developing countries are particularly vulnerable while being least able to afford the cost of adapting to it.

Ozone layer sensitivity to GHGs



Causative source of pollution

- Air pollution (GHGs, aerosol, smoke and particulate, dust,)
- Water pollution
- Hazardous materials

Air quality

- Aviation air quality concerns - related to the areas on and around airports;
- The most significant air quality related emissions in most airports presently come from ground transport (cars, buses, trains, etc.);
- Aircraft is expected to become the dominant air quality related pollution source for many airports:
    - Growth in demand, more public transport access to airports, and the long service life of aircraft, etc.
- The significance of aviation's impact on air quality will vary depending on many other factors such as:
    - Background pollution levels, other sources of pollution, weather and proximity of residential areas;
    - Around many airports some large emission sources already exist (power stations, factories) that are not related to the airport at all;
    - Local roads and motorways, even roads associated with an airport, may be heavily used by non-airport traffic.

Air quality (cont'd)

- The chief local air quality relevant emissions attributed to aircraft operations at airports are as follows:
  - Oxides of Nitrogen (NOx);
  - Carbon Monoxide (CO);
  - Unburnt hydrocarbons (CH4 and VOCs);
  - Sulphur Dioxide (SO2);
  - Fine Particulate Matter (PM10 and PM2.5);
  - Odour.
- Produce by aircraft engines, auxiliary power units, apron vehicles, de-icing, and apron spillages of fuel and chemicals.
- Local factor influence the significance of individual emissions species for each airport, but often NOx is by far the most abundant and is often considered the most significant pollutant from an air quality standpoint.

Water pollution

Sea level

- One of the key factors to evaluate for many impact studies in low lying coastal regions is the current level of the sea relative to the land;
- Ecstatic sea level (the volume of water in the oceans) appears to have been rising during the past century;
- Large regional deviations in relative sea level from this global trend due to local land movements;
- Subsidence, due to tectonic movements, sedimentation, or human extraction of groundwater or oil, enhances relative sea-level rise;
- Uplift, due to post glacial isostatic rebound or tectonic processes, reduces or reverses sea level rise;
- Most studies of vulnerability to sea-level rise use the mean sea-level at a single date. Studies employing the IPCC Common Methodology use the level in 1990;
- To assess coastal vulnerability to sea-level effects, baseline tide gauge and wave height observations are required:
    - Reflect tidal variations in combination with the effects of weather such as severe storms and atmospheric pressure variations.

Water pollution (cont'd)

Inland water levels

- The levels of lakes, rivers and groundwater also vary with time, usually for reasons related to the natural balance between water inflow (due to precipitation and runoff) and losses (due to evaporation and seepage);
- Human intervention can also affect water levels:
  - Flow regulation and impoundment, land use changes, water abstraction and effluent return and large scale river diversions.
- Fluctuations in levels can be very large sometimes (often much larger than mean changes anticipated in the future);
- Important to be able to identify the likely causes of fluctuations (i.e. natural or anthropogenic) where time series are available:
  - Influence the selection of an appropriate baseline period.

Hazardous materials

Hazardous materials in the airport

- Use in operations:
  - The Airport Authority, airlines, fuellers, car rental companies, couriers, maintenance shops, construction companies and a number of other tenants located on Sea island.
- Waste products of some airport-related operations.

Chemical products and wastes considered hazardous materials may include:

- Flammable liquids (aviation fuel, jet fuel, solvent, paint)
- Compressed gases (propane, natural gas, nitrogen, oxygen)
- Corrosives (batteries, battery acid, sodium hypochlorite)
- Poisonous or infectious chemicals (medical samples, syringes)
- Others (PCBs, waste oil, and asbestos)

Hazardous materials (cont'd)

- The majority of hazardous wastes generated by the Airport Authority include waste oil, waste paint, antifreeze, waste fuel, batteries and oil filters;
  - These materials are generated during spill clean-ups, vehicle preventative maintenance and line painting, among other things.
- The Airport Authority has designated areas where hazardous materials can be stored;
- All wastes are inventoried and labelled prior to being shipped offsite for disposal or recycling.

Noise

- A major concern for communities surrounding many airports:
  - Aircraft, particularly during take-off and landing.
- A focus for ACI and their member airports even though noise from new aircraft has been substantially reduced in the past 10 years (and is expected to be further reduced in the next decade), it remains an important issue.

Aeronautical noise

Noise associated with an airport can be attributed to a number of sources or activities, such as:

- Aircraft take-offs and landings;
- Aircraft over-lights of residential neighbourhoods;
- Engine run-ups - tests performed on aircraft engines and systems after maintenance to ensure they are functioning safely;
- Reverse thrust - use to slow an aircraft when landing on the runway;
- General noise from ground service equipment.

Link between aviation impacts and environmental crisis

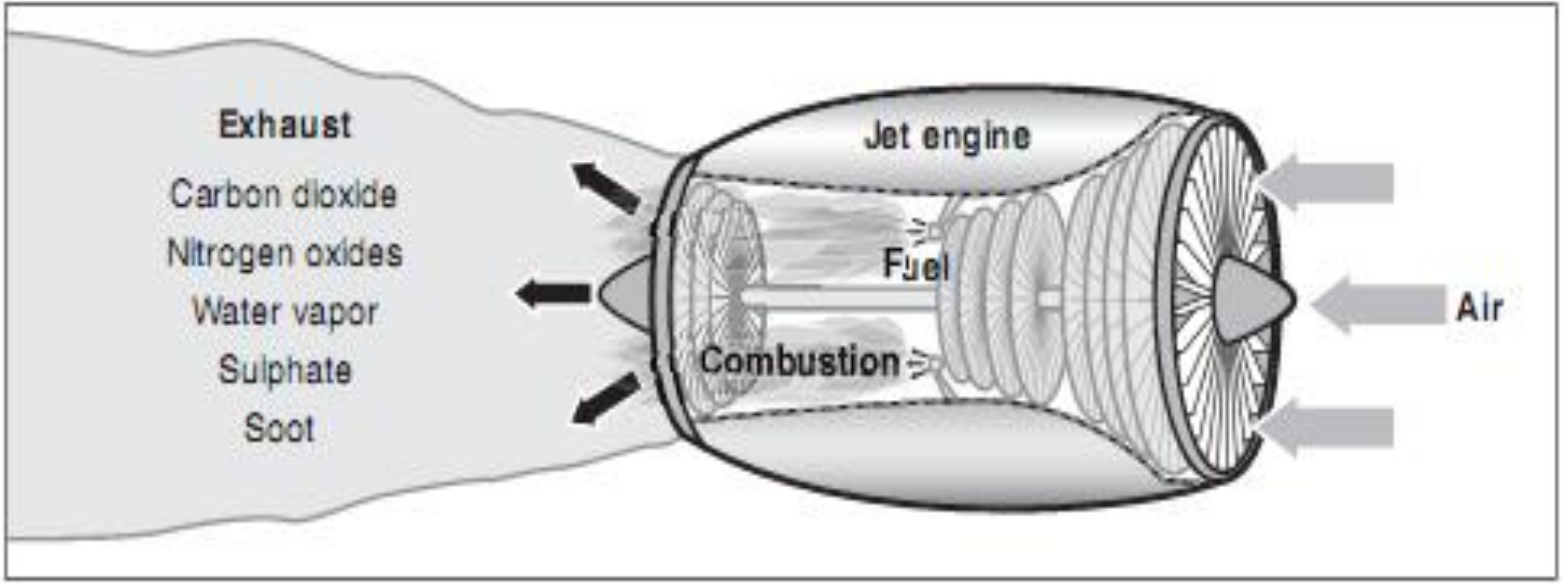
- Association of Asia Pacific Airlines (AAPA) strives to continually consider solutions to mitigate the environmental impacts;
- Environmental impacts are seen as systemic beyond the control of the operators;
- Inefficient management of airspace, restrictive operational procedures and inadequate infrastructure:
    - Offset the investments by airlines to mitigate its effects on the environment.

The aviation challenge

- The Asia Pacific Region is predicted to be the largest and fastest growing aviation market in the world, outstripping the United States and Europe;
- Volatile oil prices, a slowing world economy, falling revenue, rising fuels costs and increasing pressures due to environmental considerations such as global warming and climate change;

→ Need a major review of the plan, not just aviation needs, but for transportation systems as a whole.

Selected greenhouse gases and other emissions from aircraft at cruising altitude



Source: GAO.

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Impact of non-CO2 emission

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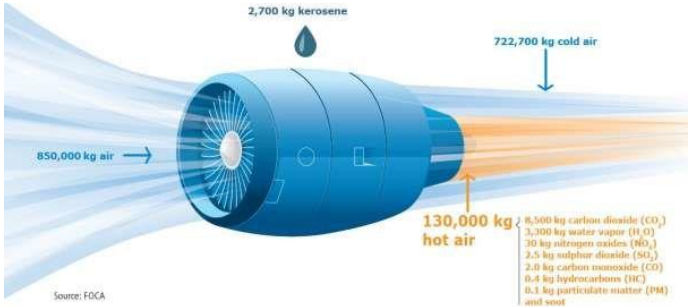
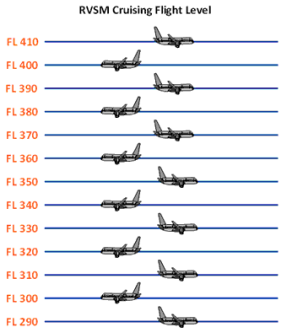
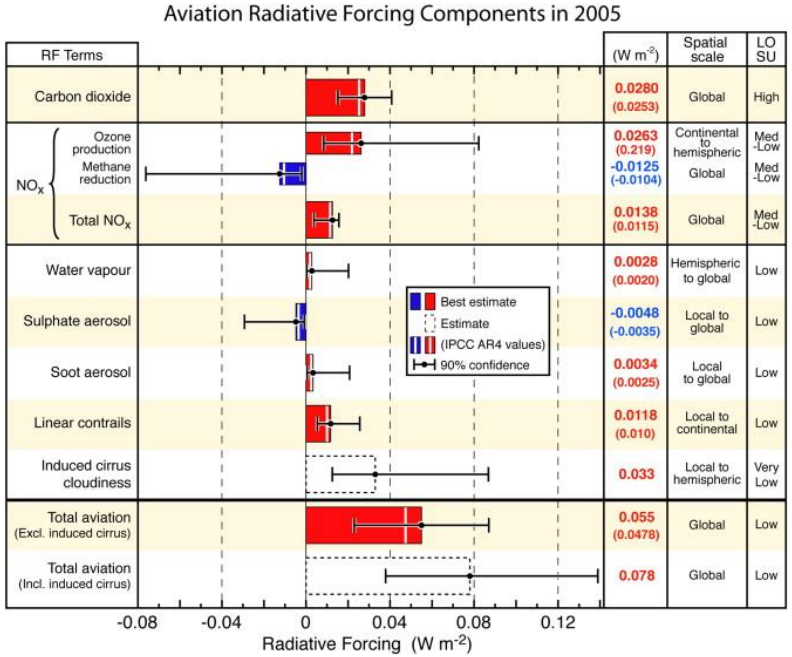
Introduction

The impacts of aviation emission is highly related to engine types & atmosphere at different flight level.







Aviation contrails

Aviation’s dirty secret: Airplane contrails are a surprisingly potent cause of global warming

https://www.sciencemag.org/news/2019/06/aviation-s-dirty-secret-airplane-contrails-are-surprisingly-potent-cause-global-warming

SHARE

120

Plane contrails have been found to increase heat in the upper atmosphere. NURPHOTO/CONTRIBUTOR/GETTY IMAGES

Aviation’s dirty secret: Airplane contrails are a surprisingly potent cause of global warming

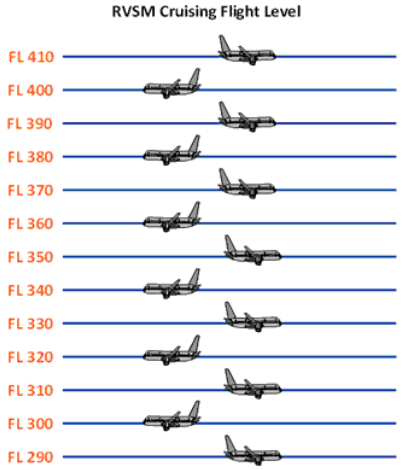
By Katie Camero | Jun. 28, 2019 , 11:20 AM

Aviation contrails

At different flight levels, the wind direction and speed are different.

The relative **humidity to water & relative humidity to ice** are also different!!!

The airplane contrail will hold for a very long time … …



Contrail formation

Parameters	Description
RH_s^w	The relative humidity to water on en-route s
RH_s^i	The relative humidity to ice on en-route s
r^{contr}	The contrail formation threshold value
T_s	The temperature on en-route s
T^{contr}	The estimated threshold temperature for contrail formation at liquid saturation
$e^{liq}(T)$	A function of the saturation vapor pressure over water at given temperature T

The condition of Contrail formation

$$r^{contr} \leq RH_s^w \leq 100\% \;\&\; RH_s^i \geq 100\%$$

$$r^{contr} = \frac{G(T_s - T^{contr}) + e^{liq}(T^{contr})}{e^{liq}(T_s)}$$

$$T^{contr} = -46.46 + 9.43\log(G - 0.053) + 0.72\log^2(G - 0.053)$$

$$G = \frac{El_{H_2O} G_p P}{\varepsilon Q(1-\eta)}$$

$$, where\ El_{H_2O} = 1.25$$

$$G_p = 1004\ [j\ per\ kg]$$

$$\varepsilon = 0.6222$$

$$Q = 43 \times 10^6 [j\ per\ kg]$$

$$\eta = 0.15$$

$$e^{liq}(T) = e_0 \times 10^{\frac{7.5T}{237.3+T}}, where\ e_0 = 6.11\ hPa$$

hPa is the symbol for hectopascal and SI unit of pressure and stress equal to 10^2 pascals.

帕斯卡（符號 Pa 或 Pascal）是國際單位制（SI）的壓力單位。

$$1\ hPa = 100\ Pa$$

$$1\ PA = 1\ {}^{N}/_{m^2} = 1\ kg.m.s^{-2}/m^2$$

$$RH_s^i = RH_w^i \frac{6.0612 \exp\frac{18.102T}{249.52+T}}{6.1162 \exp\frac{22.577T}{237.78+T}}$$

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Environmental impact of aviation emission

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Human dimension

- People living near airports have long suffered from aircraft noise, traffic congestion and air pollution;
- New evidence shows that air travel is contributing towards a far greater threat as Climate Change;
- Global warming could lead to the displacement of millions of people;
- Rising sea levels, floods and drought could make former land inhabitable;
- Changing weather patterns could effect food crops and accelerate water shortages;
- For the first time environmental refugees out numbered those displaced by war according to a Red Cross report in 1999;
- Aircraft emissions can also have a significant effect at ground level. Air and ground traffic at major airports can lead to pollution levels as high as city centres:
    - A recent study of Gatwick airport predicts that NOx emissions from cars could decrease by 75% by 2000 due largely to cleaner vehicles, but aircraft emissions of NOx are expected to double by 2008;
    - The National Air Quality standards for nitrogen dioxide (NO2) may be exceeded in nearby towns.
- A report undertaken for the Health Council of the Netherlands reveals airports have a negative impact on public health:
    - Public health impact assessments of airports - assess the cumulative way people are exposed to hazards including air pollution, noise and safety from airport operations.

Urban environment (local, regional and global)

- Concerns about the environmental effects of aviation have increasingly focused on emissions from airport operations :
  - Emissions from aircraft;
  - The ground equipment that services aircraft;
  - The vehicles that transport passengers to, from, and within airport grounds.

According to the Environmental Protection Agency (EPA):

- Aviation activities result in the emission of pollutants that account for less than 1% of the total local air pollution in the United states, but the contribution of these pollutants in areas surrounding airports can be much larger:
  - Estimate pertains to aircraft emissions;
  - Does not include emissions from other sources at airports, such as vehicles and equipment that service aircraft;
  - In areas that do not meet federal Clean Air Act requirements for ozone (formed from nitrogen oxides and volatile organic compounds), aircraft emissions are estimated to contribute as much as 3 percent of this pollutant.
- Aviation-related pollutants such as nitrogen oxide (which contributes to ozone formation) are expected to increase based on forecasted growth in the aviation sector.

Urban environment (local, regional and global) (cont'd)

- Better scientific understanding of the potential health effects of certain aviation emissions and the contribution of aviation emissions (i.e. carbon dioxide) to climate change:
  - Intensify concerns about the overall impact of aviation emissions;
- Communities have gained more awareness of the health and environmental effects of aviation emissions:
  - Opposition to airport expansion projects has broadened to include emissions (focused primarily on aviation noise);
- Airport expansion projects (which can result in increased emissions) must comply with federal Clean Air Act (CAA) requirements;
- Expanding airport capacity will be necessary to accommodate both the predicted increases in air traffic envisioned for the coming decades & the development of the Next Generation Air Transportation System (intend to handle those increases);
- Major challenge to aviation growth in the coming decades:
  - Address the effects of airport ground emissions & other types of aviation emissions.

Urban environment (local, regional and global) (cont'd)

- Aircraft engines produce emissions that are similar to other emissions resulting from any oil based fuel combustion:
  - Like any exhaust emissions can affect local air quality at ground level;
  - Emissions from aircraft below 1,000 ft. above the ground (typically around 3 km from departure or, for arrivals, around 6 km from touchdown) that are chiefly involved in influencing local air quality;
  - These emissions disperse with the wind and blend with emissions from other sources such as domestic heating emissions, factory emissions and transport pollution.

Natural environments (terrestrial, aquatic, atmospheric)

- Pollutants and climate change with affect on all types of environments - terrestrial, aquatic & atmospheric;
  - Human, animals, plants and all non-living materials.
- Results of studies in the California have emphasized the strong linkage between levels of air pollution-related atmospheric nitrogen (N) inputs into montane watersheds and levels of nitrate in surface and subsurface drainage waters;
- Interaction of N deposition with land management activities

  → Possible that past, present, and future land management practices (including fire suppression, introduction of invasive species, and forestry practices) could minimize or exacerbate the adverse effects of N deposition on terrestrial and aquatic ecosystems.
- Hydrologic flow paths in a watershed influence the impact of atmospheric N deposition on aquatic ecosystems;
- Chronic N deposition results in excess N in terrestrial, riparian, and aquatic habitats

  → Dramatic change in the chemical environment of these habitats has high potential to upset the normal communities of vegetation, microbes, and micro- and macro-flora and fauna either via direct effects on sensitive organisms or via cascading effects on the food chain.

Natural environments (terrestrial, aquatic, atmospheric) (cont'd)

Birds moved from YVR

- In 2005, approximately 1.6 million birds were moved away from aircraft operating areas using a variety of harassment techniques, including pyrotechnics, sirens, lights, propane cannons and specially trained Border Collies. This represents a 7% increase over 2004.

Birds killed by intervention

- While habitat management and harassment techniques are the primary tools used, killing occurs when the officer perceives wildlife behaviour to be a safety risk. This may consist of an immediate risk to an approaching aircraft, or a potential or chronic risk that has increased to unacceptable levels. In 2005, 1.060 birds were killed by control officers.
- In 2005, 222 birds were killed in 155 bird-strikes with aircraft, a 34% increase over 2004. However, compared with 2004, a larger portion of the bird-strikes in 2005 involved barn swallows, which, because of their small size, pose less of a safety risk than larger bird species.
- Factors that contribute to bird-strikes include aircraft operations, environmental conditions and variability in bird population. In 2005, ducks, dunlin, starlings and swallows accounted for more than 86% of birds killed by aircraft and control officers at YVR.
- Annual summary reports of the Airport Authority's wildlife control activities are prepared and submitted to Transport Canada, Environment Canada and B.C. Ministry of Environment.

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ICAO environmental protection plan

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Roles of ICAO in sustainable aviation system

- Aviation is a global enterprise that requires uniform international product acceptance and operating procedures;
- Recent European actions threaten the ability of the International Civil Aviation Organization (ICAO) to establish global standards and practices that foster continued growth while reducing the impact of aviation on the environment;
- Acting responsibly in concert with ICAO, international aviation has demonstrated a history of reducing aviation's environmental impact;
- For example, over the past 40 years, carbon dioxide emissions have been reduced by 70%;
- National, regional, and local solutions have not been successful because of ICAO's leadership role;
- An international approach remains critical.

ICAO

CAEP - key milestones

- Global Climate
- Noise
- Local Air Quality Emissions

Template for voluntary measures

Guidance on ETS (2007)

Guidance on operational measures (2004)

Guidance on linking ETS (2010)

Guidance on offsetting (2010)

CO_2 Trends Assessment (2010)

Support to develop Guidance on States' Action Plans (2011)

Validation of IFSET (2011)

CO_2 Standard Certification Requirement (2013)

Updated guidance on operational measures (2012)

CO_2 Trends Assessment (2013)

1970 1980 1990 2000 2010

New noise Standard for subsonic jet aeroplanes (Chapter 2)

ICAO policy on noise charging

New Standard on LAQ-related emissions from turbojet and turbofan engines

Noise Standard for jet and turboprops made more stringent (Chapter 4)

Guidance on Balanced Approach

Airport planning manual

NOx emissions Standard made more stringent (1992, 1998, 2004, 2010)

CAEP proposes that the Chapter 4 noise Standard be made more stringent (Chapter 14) (2013)

Noise Standard for jet and turboprops made more stringent (Chapter 3)

Guidance on LAQ emissions charging

Noise trends assessment

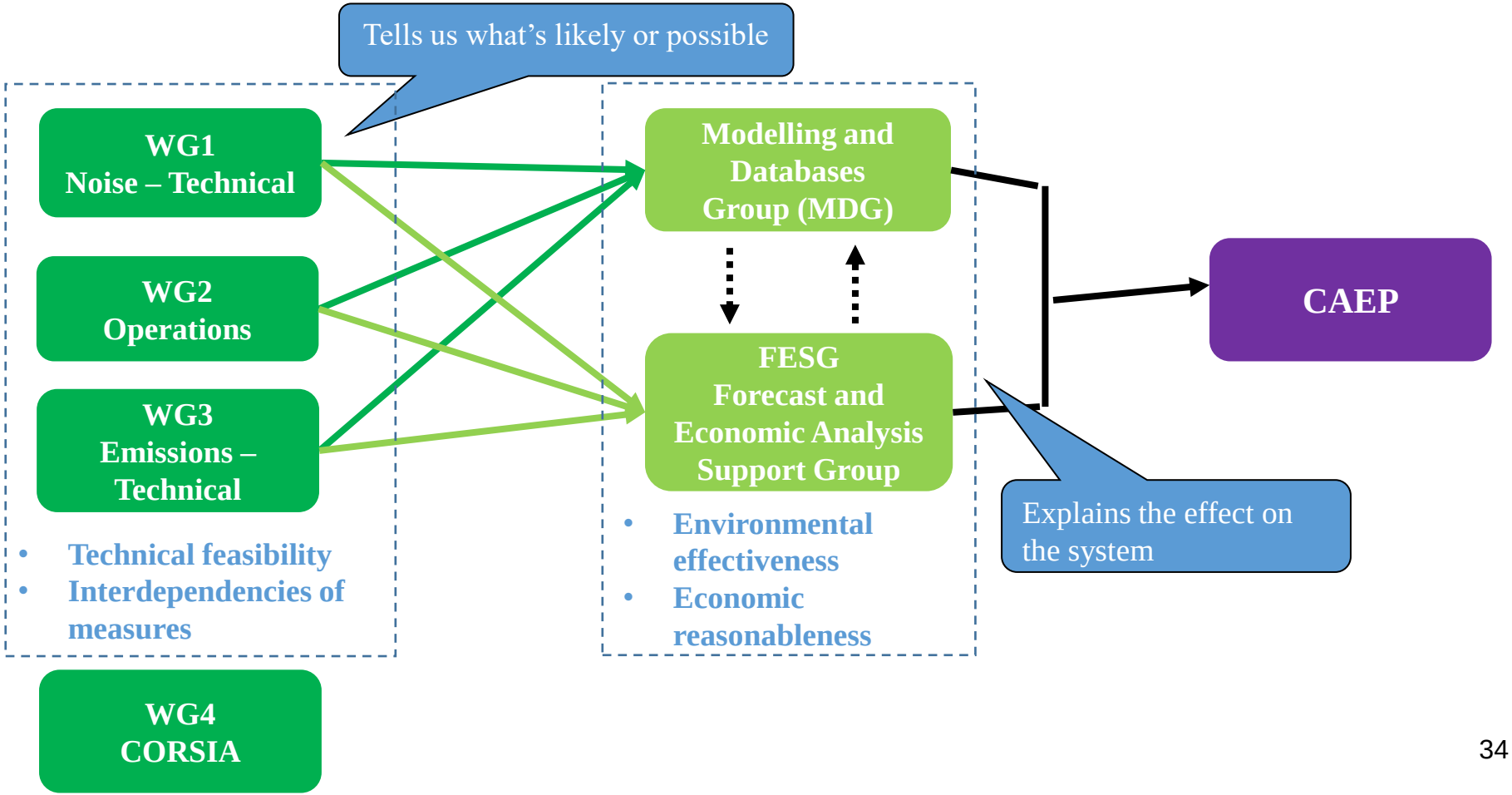
LAQ trends assessment

EMS practices in the aviation sector

Airport Air Quality Manual (2011)

Phase-out of Chapter 2 aeroplanes begins in 1995

CAEP standards - analysis framework



CAEP - modelling and databases group (MDG)

Key areas of activity:

- Environmental modelling (local air quality, noise, and greenhouse gas emissions) & development/maintenance of databases to support:
  - Environmental trends projection;
  - Analysis of environmental effectiveness of measures.
- Evaluation of environmental models;
- Review of environmental analysis methodologies;
- Guidance on the development, application, and review of environmental models.

Description of the work:

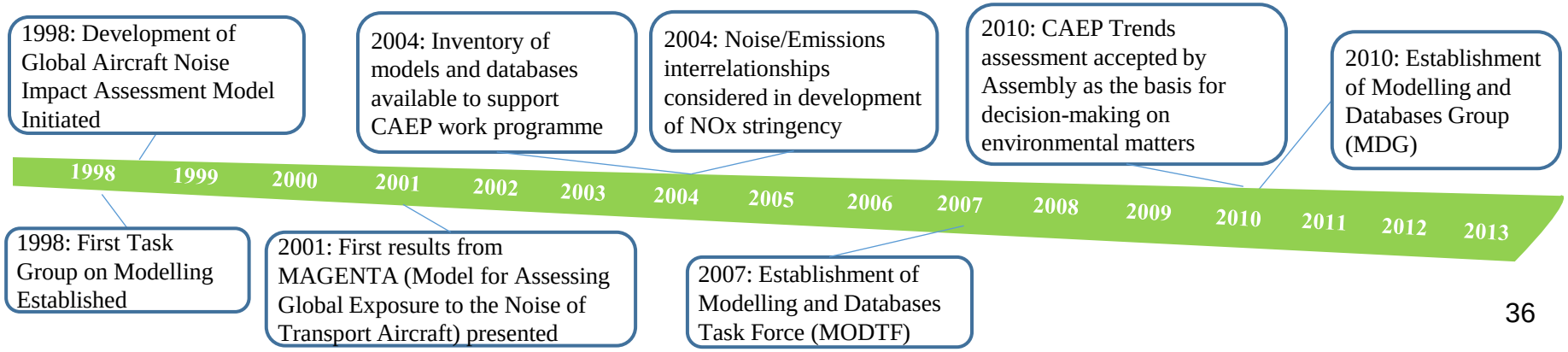
- Synthesize the input provided from the technical working groups & the Forecasting and Economic Analysis Support Group (FESG)
  - Provide results suitable for decision making and public information.
- Typical analyses include the projection of future environmental trends, the evaluation of stringency options for environmental Standards, and environmental benefits associated with proposed measures.
  - A critical element of the Standards setting process;
  - Enable policy makers to understand the environmental effectiveness and environmental interdependencies of proposed measures.
- The group's work is carried out through the use of the most sophisticated aviation local air quality, noise, and greenhouse gas emissions models available worldwide and related databases (development and operation represent substantial investments by States and observer organizations).

CAEP - modelling and databases group (MDG) (cont'd)

- Before being considered for use in CAEP, proposed models are subject to a rigorous review process to confirm their suitability
  - They are carefully applied ensuring that consistent assumptions and input data are used.
- Today 16 models have been graciously made available and approved for use within CAEP, along with qualified experts to run them.

Main publications:

- Trends assessment as the basis for decision-making on environmental matters (37th and 38th Sessions of ICAO Assembly)
- Doc 9889 – Airport Air Quality Manual
- Doc 9911 - Recommended Method for Computing Noise Contours Around Airports



CAEP - modelling and databases group (MDG) (cont'd)

Current work:

The MDG work programme for the CAEP/12 cycle (2019-2022) includes various topics such as:

- Supersonics:
  - Contribute to an exploratory study to provide CAEP with a better understanding of aircraft noise impacts resulting from the introduction of supersonic aircraft;
- Environmental trends projection:
  - Conduct an updated trends projection for noise, NOx, PM, fuel burn, and CO_2;
- Existing model and database management:
  - Maintain version control of models and databases used in support of specific CAEP analyses;
- Evaluation process of the new candidate models and tools;
- Maintenance of ICAO Doc 9911 (Recommended Method for Computing Noise Contours Around Airports) & support for other relevant ICAO documents, as requested through the coordination with other working groups.

CAEP - forecast and economic analysis support group (FESG)

Key areas of activity:

- Traffic and fleet forecasts for scheduled and non-scheduled traffic;
- Cost-effectiveness analysis of environmental policy options including aircraft noise, emissions, market-based measures, etc.
- Evaluation of economic models used by CAEP.

Description of the work:

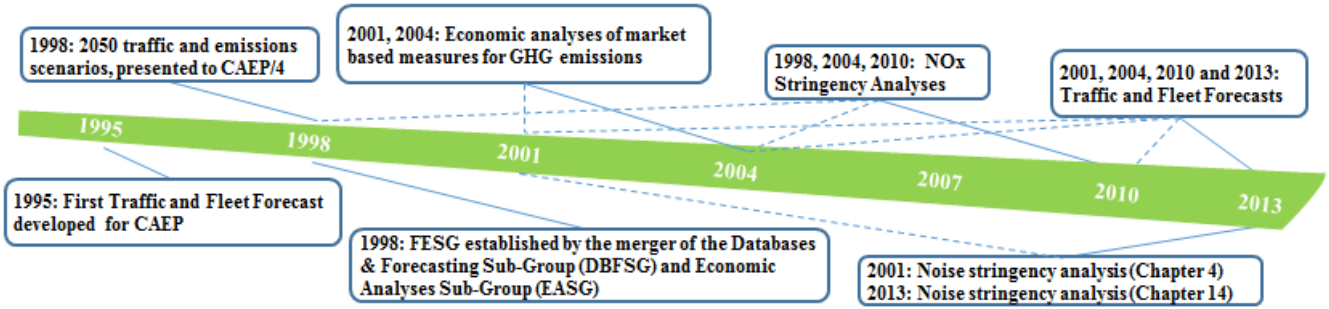
- Assess the economic reasonableness of environmental policy options considered/ analysed by CAEP;
- Develop forecasts for those areas that are unique to environmental analyses, in particular the world aircraft fleet, including business jets.
    - Combine with inputs on technology from other CAEP working groups to form the basis for noise and emissions modelling by MDG;
- Perform economic analyses and studies of proposed aviation environmental Standards.
    - A critical element of the Policy and Standards setting process as it enables policy makers to understand the cost-effectiveness of proposed measures.
- The group is composed of subject area experts from manufacturers (aircraft and engines), airlines, air navigation service providers, non-governmental organizations and government officials who have been nominated by their respective CAEP members and observers.

CAEP - forecast and economic analysis support group (FESG) (cont'd)

- The group's work is carried out through the use of economic models and related databases that are made available to CAEP by States and observer organizations.
- Before being considered for use in CAEP, proposed economic models are subject to a rigorous review process to ensure their suitability.

Deliverables:

- Aviation and the Global Atmosphere, IPCC Special Report, 1999
  (Chapter 9: Aircraft Emissions: Current Inventories and Future Scenarios)
- Traffic & Fleet Forecast for CAEP/4, CAEP/5, CAEP/6, CAEP/8 and CAEP/9
- Analysis of Voluntary Agreements and Open Emission Trading systems for the limitation of CO2 emissions from aviation with the AERO modelling system (CAEP/6)
- Analysis of open emission trading systems for the limitation of CO2 emissions from aviation with the AERO modelling system (CAEP/6)
- Cost-effectiveness analysis of Noise standards (CAEP/3, CAEP/5, CAEP/9)
- Cost-effective analysis of NOx standards (CAEP/4, CAEP/6 and CAEP/8)
- Cost-effectiveness analysis of aircraft noise and emissions charges (CAEP/7)



CAEP - forecast and economic analysis support group (FESG) (cont'd)

Current work:

The FESG work programme for the CAEP/12 cycle (2019-2022) includes various topics such as:

- Supersonics:
  - Contribute to an exploratory study to provide CAEP with a better understanding of airport noise impacts resulting from the introduction of supersonic aircraft;
- Forecast:
  - Develop a new CAEP forecast in support to the CAEP/12 analyses (e.g. passenger and freighter fleet forecasts, retirement curves, and supersonics) using as an input the long-term passenger and cargo traffic forecasts developed by the ICAO Aviation Data and Analysis Panel (ADAP);
- Economic models:
  - Review of economic models for the future analyses;
  - Include analysis of underlying economic cost assumptions used in the fleet evolution modelling tools, and of data and methodologies used to assess manufacturer and airline costs;
- Airport capacity constraints:
  - Assess a proposed methodology to evaluate airport capacity constraints and its effects on global air traffic, fleets and emissions.

CAEP - working group 1 – noise (WG1)

Key areas of activity:

- Noise technical issues;
- Supersonic transport;
- Noise reduction technology.

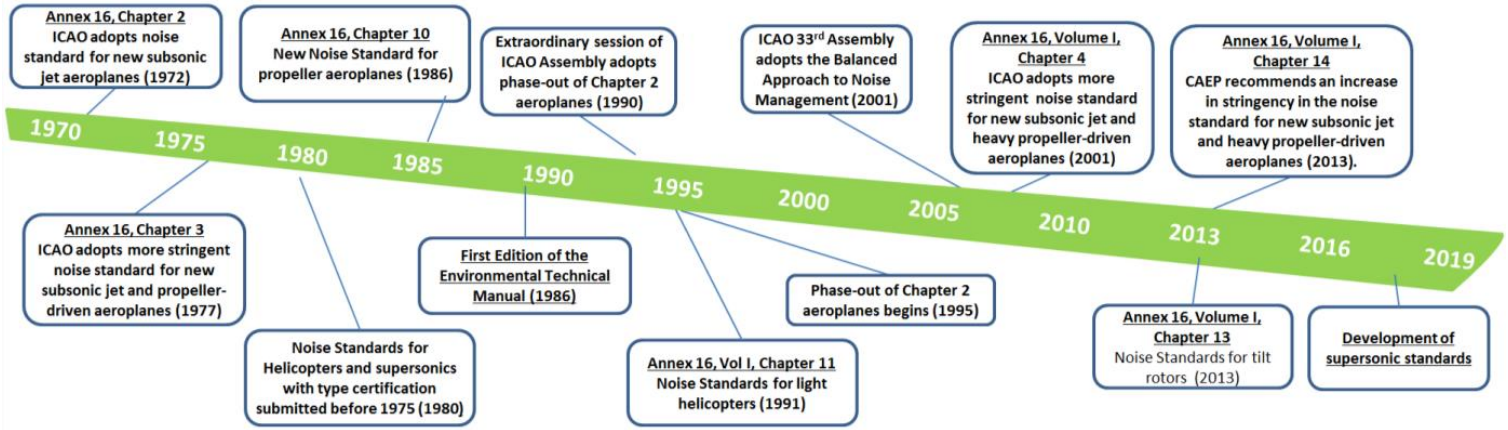
Description of the work :

- Keep ICAO noise certification standards up to date and effective, while ensuring that the certification procedures are as simple and inexpensive as possible.
- Include monitoring and reporting of national and international noise technology research programmes, involving assessing progress towards achieving CAEP noise technology goals.
- Work on the development of a noise certification standard for future supersonic aircraft and monitors and reports on the status of supersonic aircraft projects.
- The CAEP working groups liaise on the interdependencies of ICAO environmental Standards and Recommended Practices (SARPs) and WG1 is advising on the noise technical aspects associated with the development of the ICAO Aeroplane CO2 Standard.
- During this CAEP cycle WG1 is also reviewing the status of Unmanned Aerial System noise certification and is conducting a review of noise technology advancements for helicopters.

CAEP - working group 1 – noise (WG1) (cont'd)

Main publications (Reference publications):

- Annex 16 – Volume I, Aircraft Noise (Sixth Edition, July 2011)
- Doc 9501 – Environmental Technical Manual, Volume I – Procedures for the Noise Certification of Aircraft (First Edition, 2010)
- Doc 9829 – Guidance on the Balanced Approach to Aircraft Noise Management (Second Edition, 2008)
- Doc 9888 – Noise Abatement Procedures: Review of Research, Development and Implementation Projects - Discussion of Survey Results (2010)
- Doc 9943 – Report by the CAEP Noise Technology Independent Expert Panel. Aircraft Noise Technology Review and Medium and Long Term Noise Reduction Goals. Report (2010)
- Doc 10017 – Report by the Second CAEP Noise Technology Independent Expert Panel. Aircraft Noise Technology Review and Medium and Long Term Noise Reduction Goals. Report (Pending, 2014)



CAEP - working group 1 – noise (WG1) (cont'd)

Current work

The WG1 work programme for the CAEP/12 cycle (2019-2022) includes various topics such as:

- Supersonics:
  - Development of an exploratory study to provide CAEP with a better understanding of airport noise impacts resulting from the introduction of supersonic aircraft;
  - Continue to develop a scheme for enroute noise/sonic boom certification for supersonic flight;
- Research monitoring:
  - Monitor and report on the various national and international noise research programmes, including emerging noise reduction technologies, sonic boom characterization, quantification, measurement, and acceptability;
- New entrants noise:
  - Monitor developments around the noise of new entrants such as RPAS/UAS, electric aircraft, and air taxis;
- Helicopter noise:
  - Monitor the availability of data to assess the helicopter noise certification scheme and its relevance to day-to-day operations, as well as its suitability to assess helicopter hover noise.

CAEP - working group 2 – airport and operations (WG2)

Key areas of activity:

- Airport management and land use planning;
- Operational measures to reduce noise and emissions;
- Environmental guideline for airport planning;
- Airport noise monitoring.

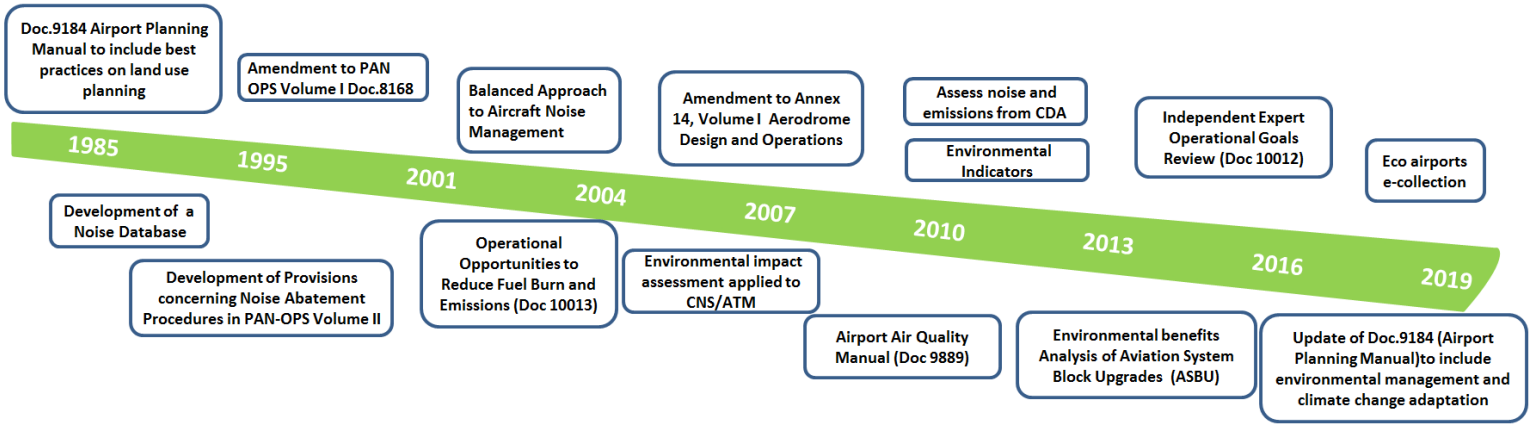
Description of the work :

- Consider environmental issues related to airports and aircraft operations in the vicinity of the airports;
- The objective of WG2 is to provide guidance to airport authorities and planners on environmental issues related to airport expansion, construction and operation, define operational procedures and strategies;
- Do not have a set work programme where the tasks evolve from one CAEP cycle to the next.
    - Require the membership and structure evolve with each CAEP cycle to ensure that the right expertise is available to carry out the work.

CAEP - working group 2 – airport and operations (WG2) (cont'd)

Main publications (Reference publications):

- Doc 9184 - Airport Planning Manual, Part 2, Land Use and Environmental Management
- Eco-Airport e-collection
- Doc 9968 - Report on Environmental Management Systems (EMS) Practices in the Aviation Sector
- Circular 351 – Community Engagement for Aviation Environmental Management
- Doc 10013 - Operational Opportunities to Reduce Fuel Burn and Emissions (ex Cir. 303)
- Doc 9889 - Airport Air Quality Manual
- Doc 10021 -Independent Expert Report on Medium and Long Term Operational Fuel Burn Goals
- Doc 9829 – Guidance on the Balanced Approach to Aircraft Noise Management (Second Edition, 2008)
- Doc 10031 – Environmental Assessment Guidance for proposed Air Traffic Management Operational Changes
- Doc 9750 – Global Air Navigation Plan for CNS/ATM Systems
- Doc 8168 – Procedures for Air Navigation Services – Aircraft Operations(OPS)
- Doc 9931 – Continuous Descent Operations (CDO) Manual
- Circular 317 – Effects of PANS-OPS Noise Abatement Departure Procedures on Noise and Gaseous Emissions
- Doc 9911 – Recommended Method of Computing Noise Contours around Airports (ex Cir. 205)
- Doc 9888 – Noise Abatement Procedures: Review of Research, Development and Implementation Project – Discussion of Survey Results (2010)



CAEP - working group 2 – airport and operations (WG2) (cont'd)

Current Work

The WG2 work programme for the CAEP/12 cycle (2019-2022) includes various topics such as:

- Airport Planning – Land use and environmental management:
  - Investigation on possible indicators for encroachment;
  - Eco-Airport Toolkit collection;
  - Monitor developments and maintenance of ICAO Publications.
- Climate Change Risk Assessment, Adaptation, and Resilience:
  - Determine a methodology and timeline for ensuring the information in the synthesis stays current and incorporates the latest scientific information;
  - Review and assess the synthesis information for suitability and relevance for dissemination by facts sheets;
  - Develop and distribute a report on identified steps to develop climate change risk assessments, adaptation and resilience measures for aviation stakeholders to consider in air and ground planning.
- Operational measures to reduce noise and emissions:
  - Operational Opportunities to Reduce Aircraft Noise;
  - Assessment of the potential for an airport database on noise and emissions management initiatives.
- Air navigation and traffic management:
  - Review of the 2019 update to the Global Air Navigation Plan;
  - Understand Aviation Stakeholder Community Engagement needs in the context of delivering ATM change;
  - Environmental metrics of relevance to the Global Aviation System;
  - Flight efficiency;
  - Environmental impact of Unmanned Aircraft Operations at and around airports.

CAEP - working group 3 – emissions (WG3)

Key areas of activity:

- Emissions technical issues;
- Aeroplane CO_2 Standard;
- Particulate Matter Standard.

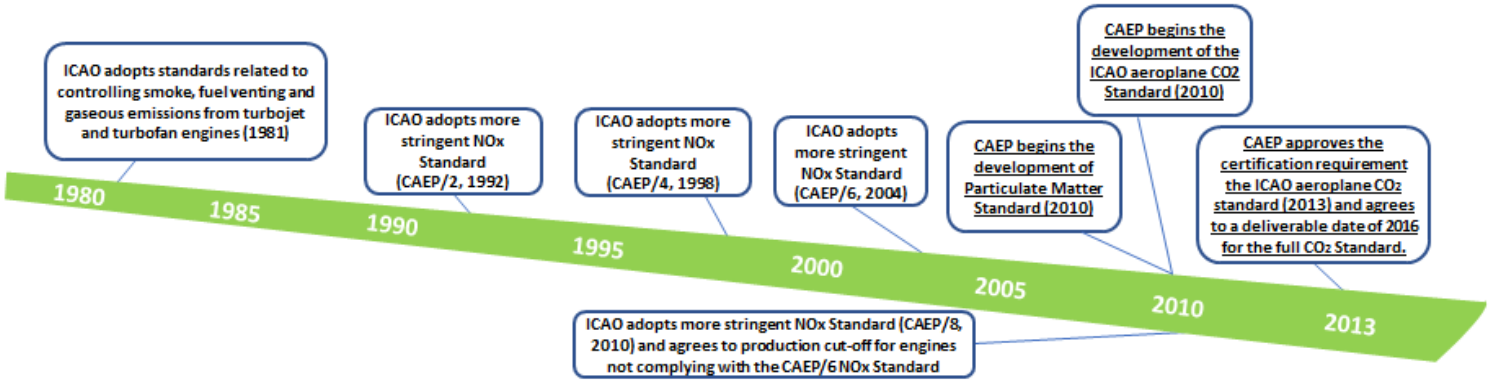
Description of the work :

- Keep ICAO engine emissions certification standards up to date and effective, while ensuring that the certification procedures are as simple and inexpensive as possible;
- In conjunction with the other CAEP working groups, is currently working on the development of the ICAO Aeroplane CO_2 emissions Standard, which should be complete during late 2015.
- The group is tasked with assessing advances, within the context of the existing CAEP technology goals, in aircraft and engine design technologies with regard to their impact on fuel burn.
- Work on issues associated with Local Air Quality (LAQ):
    - Include the development of a non-volatile Particulate Matter (PM) Standard, advancing the understanding of volatile PM, and monitoring and reviewing combustion technologies and advances in combustion design with the aim of understanding future impacts on gaseous emissions and PM.

CAEP - working group 3 – emissions (WG3) (cont'd)

Main publications:

- Annex 16 – Volume II, Aircraft Engine Emissions (Third Edition, July 2008)
- Doc 9501 – Environmental Technical Manual Volume II – Procedures for the Emissions Certification of Aircraft Engines (First Edition, 2010)
- Doc 9884 – Guidance on aircraft emission charges related to local air quality (2007)
- Doc 9887 – Report of the Independent Experts on the LTTG NOx Review and Medium and Long Term Technology Goals for NOx (2008)
- Doc 9953 – Report of the Independent Experts to CAEP/8 on the Second NOx Review and the Establishment of Medium and Long Term Technology Goals for NOx (2010)
- Doc 9963 – Report of the Independent Experts on the Medium and Long Term Goals for Aviation Fuel Burn Reduction From Technology (2010)
- Circular 337 - Circular on the CO_2 Standard Certification Requirement (2014, Pending)



CAEP - working group 3 – emissions (WG3) (cont'd)

Current work:

The WG3 work programme for the CAEP/12 cycle (2019-2022) includes various topics such as:

- Supersonics:
  - Contribute to an exploratory study on supersonic aircraft by providing estimates on LTO engine emissions as well as aeroplane fuel burn and CO2 emissions data (cruise and full-flight), subject to feasibility assessment;
  - Provide information regarding trades among noise, emissions, fuel burn, and Mach number.
- Monitor trends in supersonic technology:
  - Assess consequences for engine emissions, aeroplane CO_2 emissions and certification standards.
- Emission certification databases:
  - Maintain aeroplane CO_2 certification database and engine emissions certification databank.
- Review of CO_2 information:
  - Monitor, review and analyse latest CO2 information for subsonic aeroplanes and any available certification data;

  → Assess margin relative to the CO2 subsonic standard.
- Review of nvPM regulatory levels:
  - Include the collation and analysis of the certified and certification-like nvPM mass and number emissions data that becomes available for all in-production engines.
- Fuel composition and emissions:
  - Monitor trends in aviation fuel supply composition of petroleum-based kerosene, blended and sustainable fuel types.

CAEP working group 4 - CORSIA

Description of the work :

- Deal with technical issues relating to the implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA);
- The maintenance of the related Standards and Recommended Practices (SARPs), the Convention on International Civil Aviation and related guidance contained in the Environmental Technical Manual.

Current work:

- Maintenance of the related SARPs, the Convention on International Civil Aviation and related guidance material;
- Work on the ICAO CORSIA CO_2 Estimation and Reporting Tool (CERT);
- Development of further guidance on monitoring, reporting and verification (MRV) in CORSIA;
- Development of recommendations related to the management of emissions units in CORSIA;
- Technical analysis to support deliberations on CORSIA in relevant ICAO bodies.

THE HONG KONG POLYTECHNIC UNIVERSITY
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Aviation emission calculator by ICAO

Opening Minds • Shaping the Future
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Aviation carbon calculator support group (ACCS)

The ICAO Carbon Emissions Calculator

- Calculate the carbon dioxide emissions from air travel for use in offset programmes;
- Allow passengers to estimate the emissions attributed to their air travel;
- Simple to use & require only a limited amount of information from the user;
- Apply the best publicly available industry data to account for various factors.

e.g. aircraft types, route specific data, passenger load factors and cargo carried

Aviation carbon calculator support group (ACCS) (cont'd)

Summary of the methodology used:
CO_2 Emissions per passenger take into consideration the load factor and are based only on passenger operations (i.e. fuel burn associated with belly freight is not considered).

The steps for the estimation of CO_2 emissions per passenger:
Step 1: Estimation of the aircraft fuel burn.
Step 2: Calculation of the passengers' fuel burn based on a passenger/freight factor which is derived from RTK data.

Step 3: Calculation of seats occupied (assumption: all aircraft are entirely configured with economic seats). Seat occupied = Total seats * Load Factor

Step 4: CO2 emissions per passenger = (Passengers' fuel burn * 3.16) / Seat occupied

Note: for flights above 3000 km, CO2 emissions per passenger in premium cabin = 2 x CO2 emissions per passenger in economy

https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

Carbon calculator (One-way HKG-SIN)

One Way/Round Trip	Cabin Class	Number of Passengers
One Way	Economy	1

Leg	From City/Airport	To City/Airport
1	HKG	SIN

Delete All Location(s) | Delete Leg | Add New Leg

Reset | Compute

Metric (KG / KM) | **Standard** (LBS / MI)

Total

Dep Airport	Arr Airport	Number of passengers	Cabin Class	Trip	Aircraft Fuel Burn/journey (KG)[ab]	Total passengers' CO2/journey (KG)[c]
HKG	SIN	1	Economy	One Way	23460.5	172.0

Flight Stage Detail

Dep Airport	Arr Airport	Distance (KM)	Aircraft	Aircraft Fuel Burn/leg (KG)[a]	Passenger CO_2/pax/leg (KG)
HKG	SIN	2562.0	320, 333, 359, 388, 772, 773, 77W, 787	23460.5	172.0

a. Fuel Burn information provided are for 1 aircraft per leg

b. Aircraft Fuel Burn/journey = ∑Aircraft Fuel Burn/leg

c. Total passengers' CO2/journey = ∑Passenger CO2/pax/leg×Number of pax

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Impact of high speed ferries and proposed mitigation measures

Opening Minds • Shaping the Future
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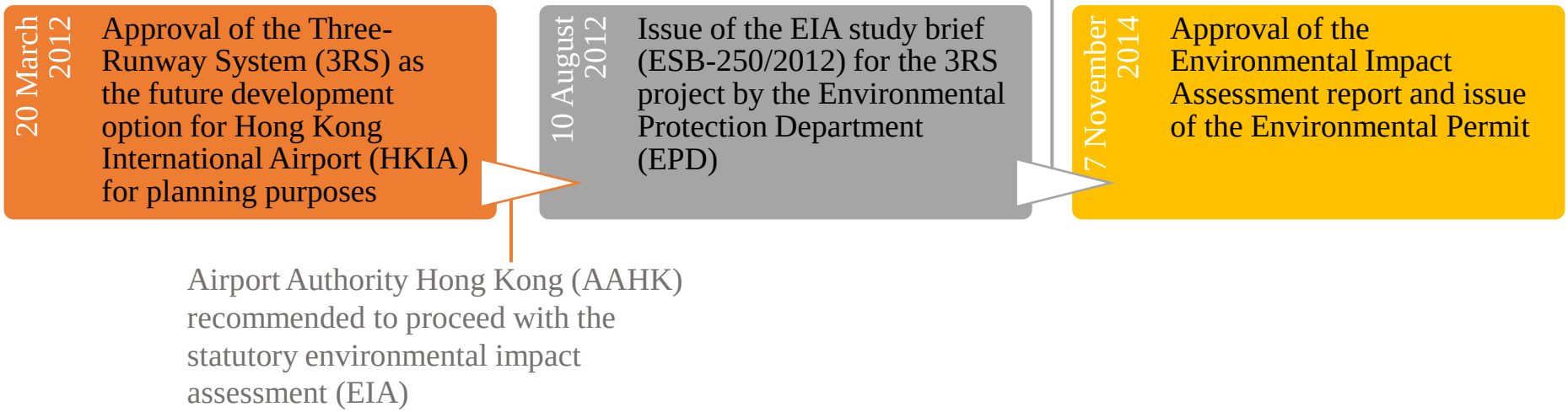
Background

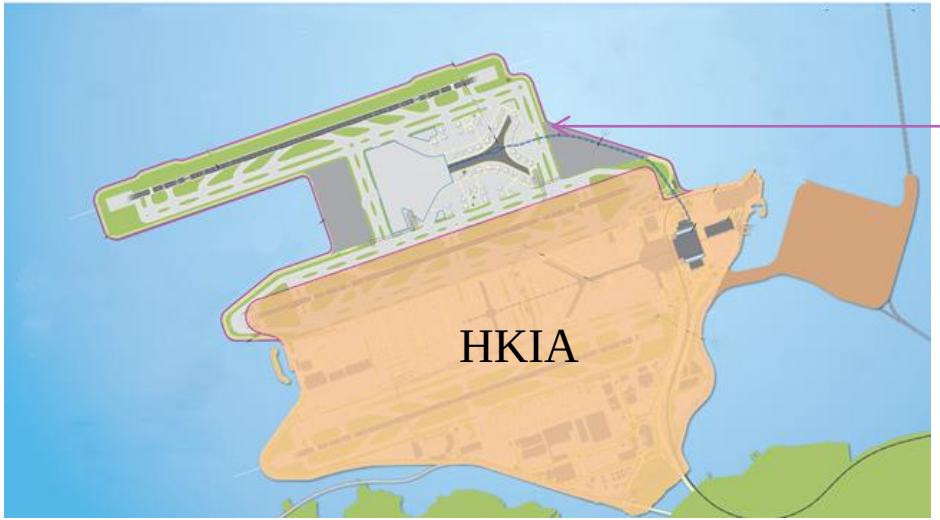


As stated in the approved EIA, the project primarily comprises:

- New third runway with associated taxiways, aprons and aircraft stands;
- New passenger concourse building;
- Expansion of the existing Terminal 2 building;
- Related airside and landside works, associated ancillary and supporting facilities.

Background (cont'd)

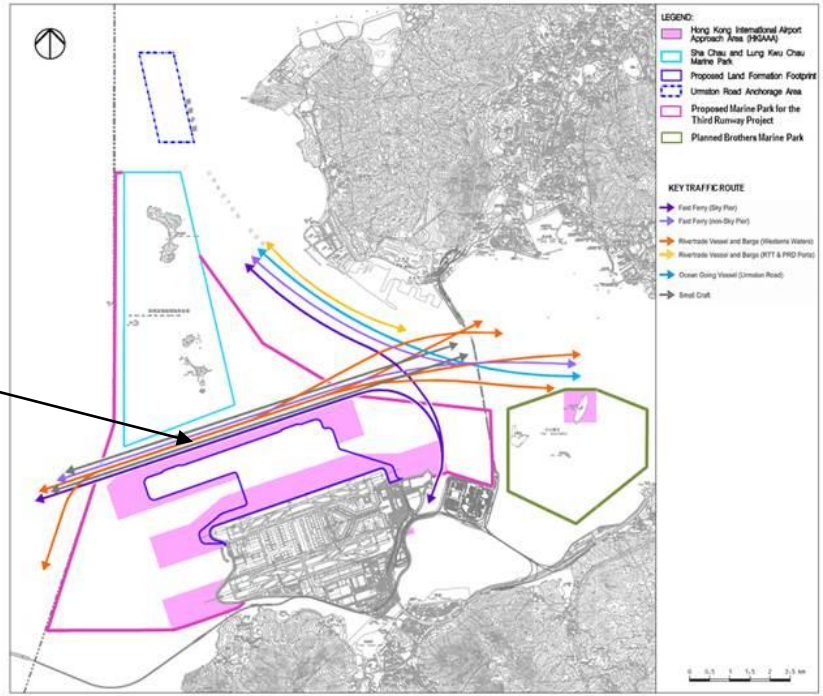
- The area around HKIA is well used by a variety of vessel types:
  - High Speed Ferries (HSFs) pose the most significant collision threat to Chinese White Dolphins (CWDs) & generate the loudest underwater noise;
- During the 3RS land formation, works area will be designated and demarcated by floating booms.



Reclamation footprint:
- North of HKIA in North Lantau
- Formation of approximately 650 ha

Background (cont'd)

Figure 1 Key traffic routes for future traffic environment



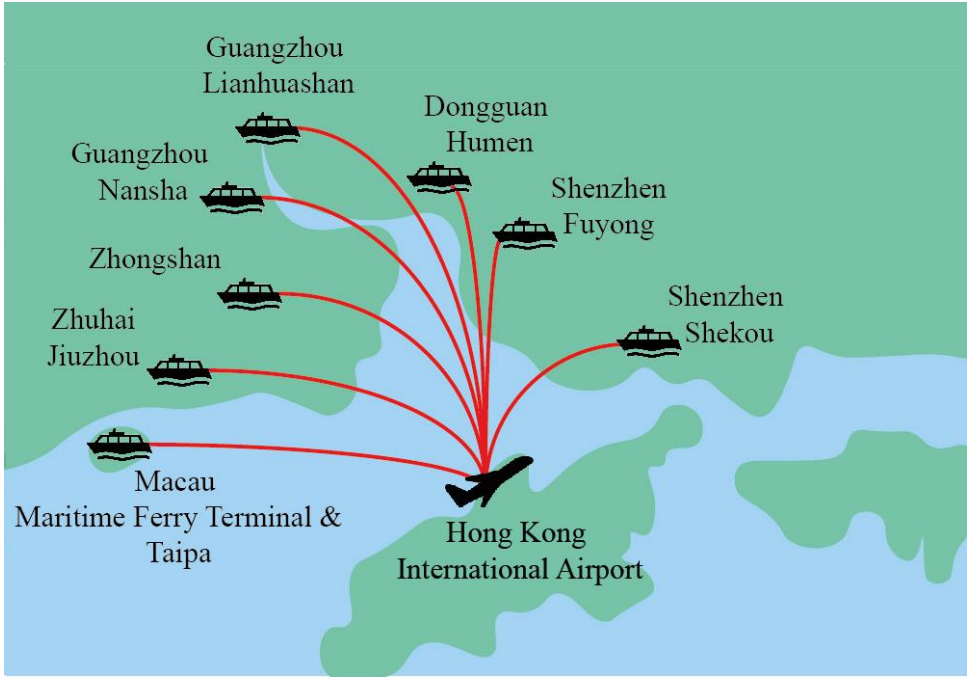
Navigation routes for vessels will be constrained to within a narrower area once the 3RS new platform is formed.

- Continue to comprise two-way transits east and west;
- No change to the direction of traffic flows are expected.

High speed ferries of SkyPier

SkyPier

- Located at north-east of HKIA;
- Provide HSF service for transfer passengers to nine ports in Pearl River Delta and Macau.



High speed ferries of SkyPier (cont'd)

- The draft of SkyPier HSFs travelling in the waters north of Lantau Island is approximately 1 – 2 m;
- The plan focuses on SkyPier HSFs traveling to / from Macau and Zhuhai
  - The route for these services passes through waters between the HKIAAA and the Sha Chau and Lung Kwu Chau Marine Park (SCLKCMP);
  - Important travelling area for CWDs requiring the development of mitigation measures at both the construction and operation phases of the 3RS project;
  - ➢ Reduce identified impacts to an acceptable level.

Impact of high-speed ferries on Chinese White Dolphins (CWDs)

- The waters to the north of the existing airport are an important travelling area for CWDs:
  - Mainly for moving between the main feeding areas;
  - Known areas of higher CWD abundance around the Brothers, in west Lantau and around Sha Chau and Lung Kwu Chau.
- Indirect impacts of HSFs currently navigating in the waters between the HKIAAA and the SCLKCMP on CWDs (e.g. CWD travelling area) at both the construction and operational phases:
  - Increase acoustic disturbance;
  - Changes to CWD movement patterns;
  - Increase risk of injury/mortality associated with marine traffic.

Impact of high-speed ferries on CWDs (cont'd)

Potential Impact	Source	Receiver	Significance of Impact	Further Mitigation / Enhancement Required
Construction Phase				
Increased acoustic disturbance from changes to marine vessels and ferry traffic	HSF	CWD	Moderate	Yes
Changes to CWD movement patterns as a result of marine traffic	HSF	CWD	Moderate	Yes
Increased risk of injury/ mortality to CWDs from marine traffic	HSF	CWD	High	Yes
Operational Phase				
Increased acoustic disturbance from increased marine traffic	HSF	CWD	Moderate-high	Yes
Changes to CWD movement patterns from marine traffic	HSF	CWD	Moderate-high	Yes
Increased risk of injury/ mortality	HSF	CWD	High	Yes

Table 1 Summary of HSF impacts on CWDs

Impact of high-speed ferries on CWDs (cont'd)

1. **Behavioural change induced by high speed ferries**

- The HSFs utilising the SkyPier would move up to full speed of 30 – 40 knots in 1-1.5 km after leaving the pier and would slow down within approx. 1 km of approaching the pier;
- The HSFs would move at high speed while navigating through the waters north of the airport island;
- Vessel movements caused intermittent behavioural changes in CWDs
  - Attempt to avoid rapid and noisy ferry approaches, especially while foraging or transiting across ferry lanes;
- The effects of vessel traffic on cetaceans around the world:
  - Behavioural changes e.g. spatial avoidance, increase in swimming speed, changes in diving behaviour and acoustic behaviour;
- The risks to CWDs decrease as vessel speeds are reduced
  - Any reduction in speed from 30-40 knots will reduce potential adverse impacts on CWDs.

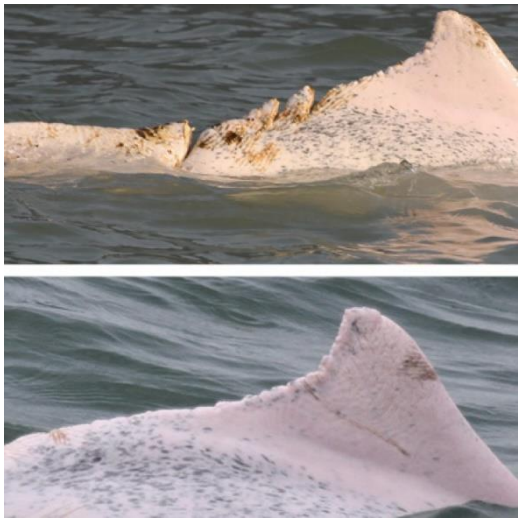
Impact of high-speed ferries on CWDs (cont'd)

2. Injury / mortality from high speed ferries

- HSFs and CWDs would have to share the newly constrained stretch of marine waters between the new HKIAAA and SCLKCMP.

➢ The increased risk of collision;

➢ Lead to serious injury and mortality for the CWDs.

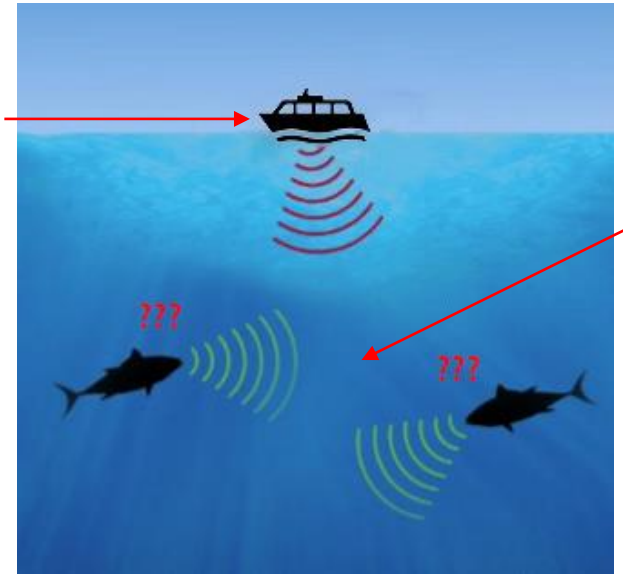


Impact of high-speed ferries on CWDs (cont'd)

3. Acoustic disturbance from high speed ferries

- HSFs release a lot of noise energy into the marine environment along their travel route.

- A ferry approaching at a speed greater than 20 knots at 166 m distance from the hydrophones;
- In an overall sound pressure level of around 120 dB re. 1 µPa, with levels still being as high as 100-105 dB at 565m, in the CWD communication range of about 3 kHz and higher.



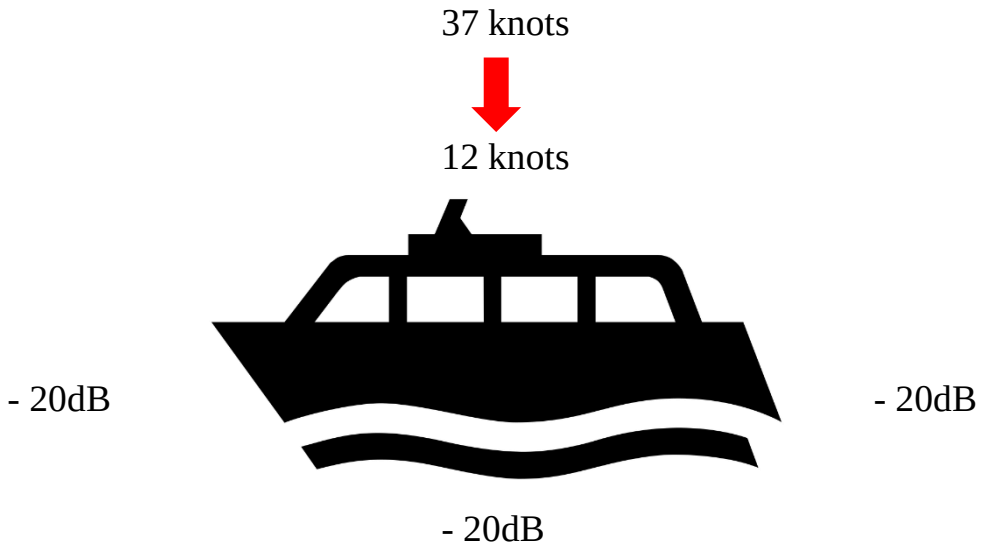
- CWD sounds have been measured as about 168 dB re. 1µPa, 1 m distance from the CWD's head;
- Sounds attenuate strongly with distance.

- Fast ferries may mask or restrict the range of CWD communications.
- SkyPier HSFs have moderate noise impact on CWDs during construction phase and moderate-high impact during operation phase.

Impact of high-speed ferries on CWDs (cont'd)

3. Acoustic disturbance from high speed ferries

- The underwater radiated noise from a high-speed jet propelled watercraft while the vessel passed at speeds of 12, 24 and 37 knots:
  - When the speed of the ship was reduced from 37 knots to 12 knots, the broadband (0-22kHz) sound pressure levels at all directions (e.g. bow aspect, broadside aspect and stern aspect) decreased up to 20dB.



Impact of high-speed ferries on CWDs (cont'd)

3. Acoustic disturbance from high speed ferries

- Ecological Acoustic Recorders (EAR) data collected during the 3RS EIA:
  - High speed ferries were tracked by the land-based theodolite station at the northeast of the HKIA, with the underwater sound simultaneously recorded by the nearest EAR Station at approximately 500 m from the existing HSF route;
  - Sound pressure levels in the 4-8 kHz octave band (important for CWD whistle communication) proportional to HSFs speed were recorded, with each sound level calculated as a mean from 5 ferries per speed category from 6-8 knots to 26-30 knots;
  - A reduction of about 60% underwater sound energy in the CWD whistle communication frequency (comparing of the measurement results of 26-30 knots HSF speed to15 knots);
  - Similar underwater noise reduction will be expected by slowing the HSFs from 30-40 knots to 15 knots.

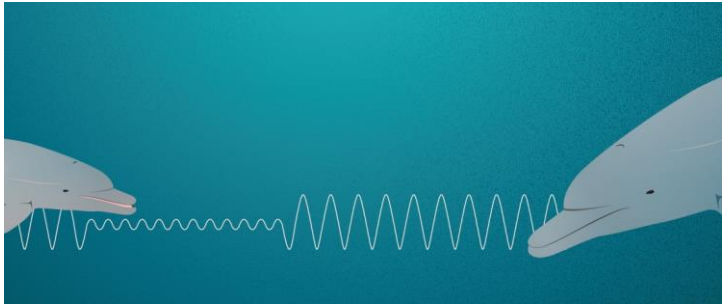
Speed of HSF (knots)	Sound Pressure Level (dB)*
6-8	97
11-20	99
21-25	100
26-30	103

Table 2 Speed of high speed ferry and the corresponding sound pressure level

* sound pressure levels in the 4-8 kHz octave band at an average distance of 500 m from the EAR station

Impact of high-speed ferries on CWDs (cont'd)

- Long-term effect of HSF traffic on CWD travelling behaviour and distribution
  - Reduced dolphin occurrence especially in the Brothers Islands area to the east of the existing airport;
  - Increased dolphin density within SCLKCMP.
- Indirect impact of transiting boat traffic (e.g. the boats which travelled through the CWD habitat without approaching the dolphins for the purpose of viewing them) on the acoustic behaviour of CWDs:
  - The boats' passage did not affect the rates at which CWDs produced click trains and burst pulse vocalizations;
  - CWDs significantly increased their whistling rate immediately after a boat had passed through but was still within 1.5 km from the CWD groups;
  - The noise from transiting vessels affected the CWD group cohesion, the dolphins need to re-establish vocal contact with associates after the vessel had passed;
  - CWDs need to expend more energy in adjusting the timing of their signals.



Impact of high-speed ferries on CWDs (cont'd)

- Underwater noise shifts in loudness and pitch attendant with vessel speed changes
  - Gear shifts:
    - Produce broadband (0 -35 kHz) and high-level sound (peak-peak source levels of up to 200 dB re 1μPa) of high amplitude, short-duration and reverberant nature;
    - Much higher than regular engine noise (around 90-130dB re 1μPa).
- The simple change in speeds (change in "closing-in distance") may present an extra physical danger to marine mammals
  - Added unpredictability of where the boat will be relative to marine mammals.
- Dolphins can anticipate the imminent arrival of a vessel from the approaching noise, but would be confused as to anticipation of when the boat would be above or near them by a sudden change in boat speed.

EIA Mitigation Measures

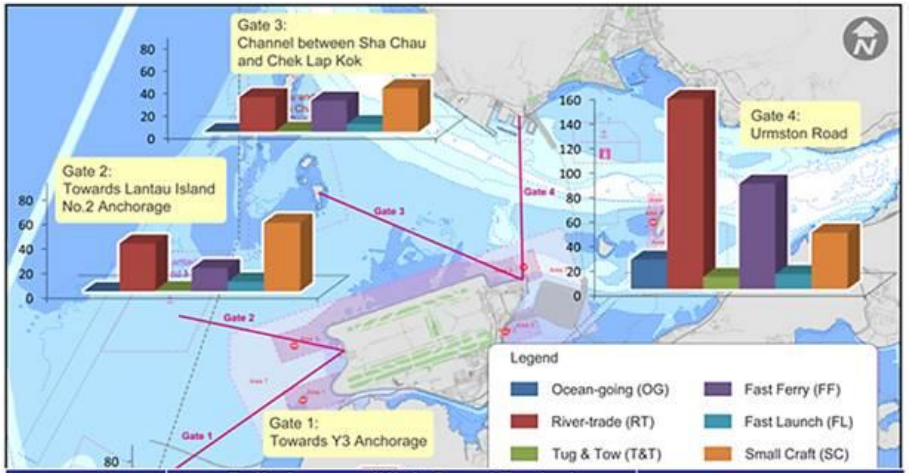
- Route diversions to the north of SCLKCMP for SkyPier HSFs operating to / from Zhuhai and Macau:
  - HSFs using a narrower navigation corridor between SCLKCMP and the new 3RS land formation;
  - Closer spacing of the vessels;
  - Reduced area for CWDs to surface with increased risk of being hit by HSFs & disturbance from increased anthropogenic noise.
- Mitigation measures in relation to marine traffic control need to be specified:
  - Reduce acoustic disturbance;
  - Reduce risk of injury or mortality;
  - Reduce changes to abundance and patterns of habitat use.
- Once the project construction is underway
  - The paths of vessel movements from the east side of the airport platform to the waters west of Hong Kong will be further restricted.

EIA Mitigation Measures (cont'd)

- For the section of diverted route passing through high CWD abundance grid squares
  - A 15-knot speed controlled zone is proposed to reduce potential adverse impacts on CWDs within these areas:
  - ➢ Reduce collision risk;
  - ➢ Less acoustic and behavioural disturbance to CWDs.
- Simulations of the HSF route diversion (e.g. a Full Bridge Simulation Workshop):
  - HSFs can operate much more reliably at 15 knots rather than at 10 knots in the vicinity of the proposed speed controlled zone;
  - HSFs operating at 10 knots for a long distance would be more likely to cause sea sickness (especially under choppy sea conditions).
  - ➢ The 15 knots speed restriction was determined to be optimal with an acceptable reduction in risk to CWDs.

EIA Mitigation Measures (cont'd)

- SkyPier HSFs operating to / from Zhuhai and Macau would divert north of the SCLKCMP with a 15 knot speed limit to apply for the part-journey crossing high CWD abundance grid squares;
- Adopt by all SkyPier HSFs operating to / from Zhuhai and Macau (Up to 60% of the HSFs in this area);
- Avoid the current situation of the SkyPier HSFs travelling to Zhuhai and Macau passing south of the SCLKCMP at high speeds;
  - ➢ Reduce the impacts of these vessels.



Year	Daily Average (High-Speed Ferries)		Daily Average (Total Marine Traffic)
	SkyPier	Non-SkyPier	
Gate 3			
2011	34	24	Approx. 230
2021	Approx. 45	Approx. 30	NA
2030	Approx. 50	Approx. 35	Approx. 330

Figure 2 Marine traffic forecast of HSFs navigating between HKIAAA and south of the SCLKCMP

EIA Mitigation Measures (cont'd)

SCLKC North diverted route:

- The stretch of navigation waters for the diverted route going via SCLKC north is much wider (approx. 2.4km) than that of the existing route along the airport north (approx. 0.6km);

➢ Less impact on CWD travelling areas.

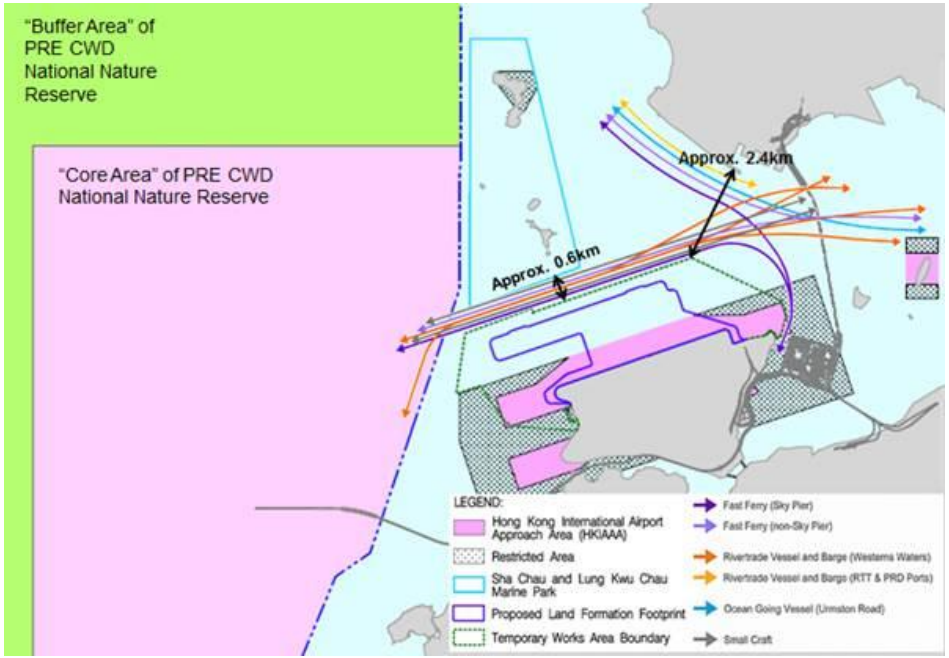


Figure 3 Stretch of navigation waters for the diverted route to SCLKC North and the existing route along Airport North

EIA Mitigation Measures (cont'd)

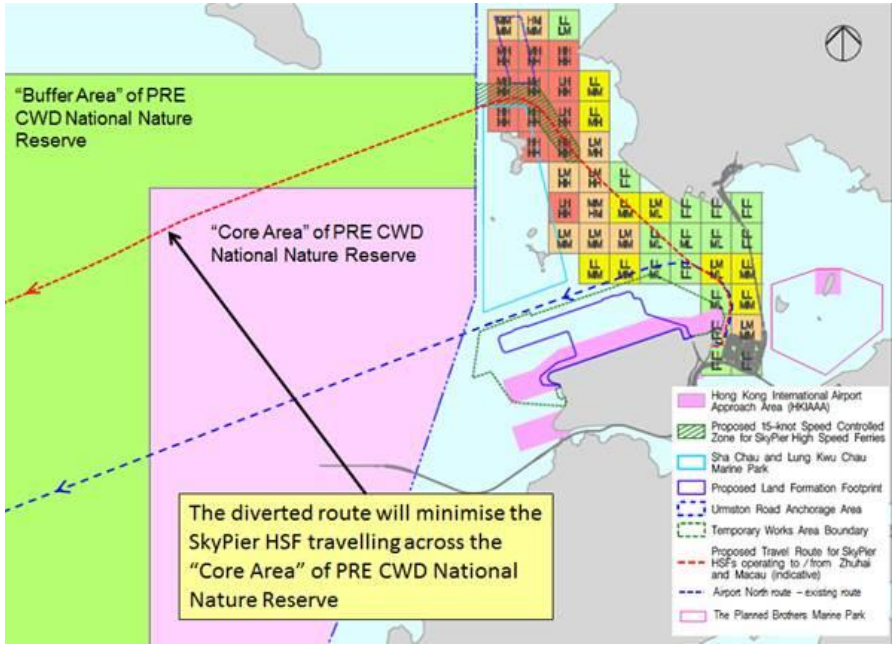


Figure 4
Recommended route diversion and the PRE CWD National Nature Reserve

SkyPier HSFs using the diverted route going via SCLKC north:

- Less conflict with the CWD travelling area;
- Less risk of collision with CWD;
- Reduce the SkyPier HSF travel time across the "Core Area" of the Pearl River Estuary (PRE) CWD National Nature Reserve.

EIA Mitigation Measures (cont'd)

- The additional diverted traffic (typically 1 – 4 movements per hour during SkyPier HSF operating hours):
  - Make Urmston Road marginally busier;
  - The number of additional vessels is not significant compared to the total marine traffic in Urmston Road;
  - ➢ Not result in any congestion problem.
- The marine traffic density in Urmston Road in the future would remain lower than the marine traffic density in certain other Hong Kong shipping channels e.g. The Western Harbour;
- The diverted route of SkyPier HSF will be along the western part of Urmston Road
  - ➢ Avoid overlapping with majority of the existing marine traffic along the eastern part of Urmston Road.

Year	Daily Average (HSFs)		Daily Average (Total Marine Traffic)
	SkyPier	Non-SkyPier	
(i) via South Sha Chau			
2011	34	24	Approx. 230
2021	Approx. 45	Approx. 30	NA
2030	Approx. 50	Approx. 35	Approx. 330
(ii) via Urmston Road			
2011	54	54	Approx. 540
2021	Approx. 70	Approx. 70	NA
2030	Approx. 80	Approx. 80	Approx. 810

Table 3 Daily average of HSFs and total marine traffic in Year 2011 and projection to Year 2030

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Design of marine travel route and speed controlled zone

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Considerations for setting marine travel route

1. **Shallow water zones**
   - Unsafe for HSFs (with a draft of approximately 1 - 2m) to travel in shallow water zones (water depth is less than 2m);
   - The western and north-western waters of Urmston Road Anchorage Area contain several shallow water zones with general water depth of less than 2 m.

2. **Hong Kong International Airport Approach Area**
   - Restricted areas in the vicinity of Hong Kong International Airport e.g. HKIAAA;
   - Vessels are not allowed to pass through without authorization.

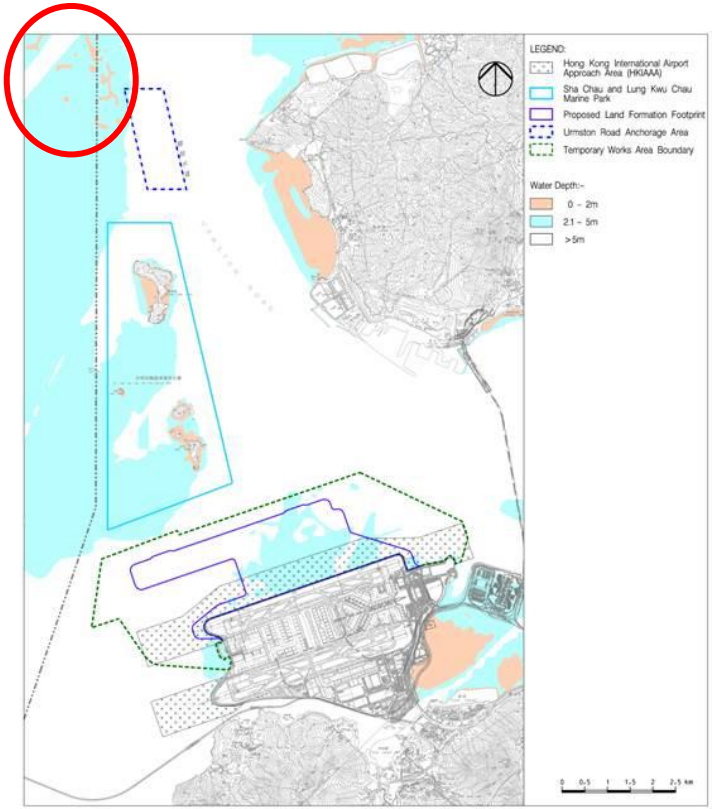


Figure 5 Various marine constraints in the North Lantau waters

Considerations for setting marine travel route (cont'd)

3. **Other marine facilities**
   - Works area of the 3RS project will be demarcated by floating booms;
   - Adjacent projects e.g. the Hong Kong-Zhuhai-Macau-Bridge HKBCF/ Tuen Mun-Chek Lap Kok Link (TM-CLKL);
   - SCLKCMP: Operating vessels are not allowed to travel at speed exceeding 10 knots inside Marine Park;
   - Urmston Road Anchorage: Marine vessels may anchor at this area.

4. **Ecological concerns**
   - Areas with high CWD abundance e.g. in and around SCLKCMP;
   - Feasible if there is suitable mitigation measure (e.g. speed reduction) to minimise the impact of the HSFs on CWDs
     - With the provision of proper training to HSF captains that they can strictly follow the pre-defined travel route.

- The captain shall strictly follow all navigation safety requirements (e.g. local regulations and requirements of the Marine Department) and relevant international practices;
- Other marine vessels may be encountered
  - The marine travel route will be fine-tuned locally for safety reasons.
- The navigation route may also be affected by:
  - Natural conditions e.g. wind, current, wave, poor visibility, extreme weather event etc.;
  - Special events e.g. closure of routes due to fireworks and other events;
  - Avoidance of shallow water areas;
  - Stranded ships.

E.g. Sudden sharp angle turning with high speed is not encouraged at Urmston Road with relatively high traffic density.

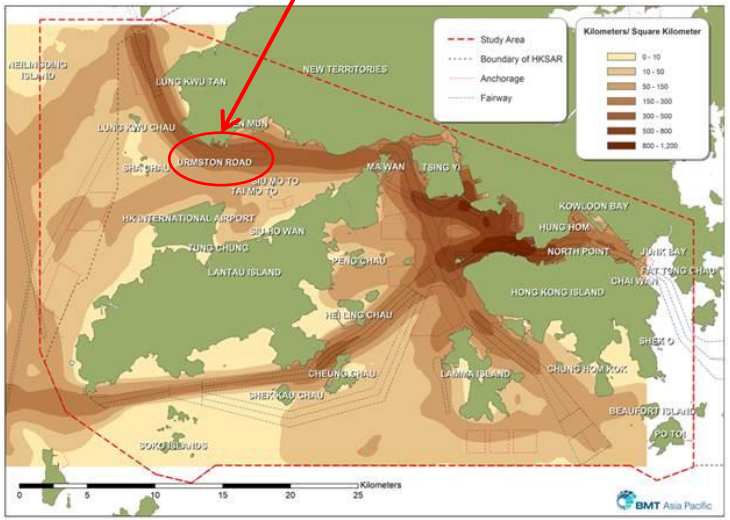


Figure 6 Existing marine traffic plan

Design of Marine Travel Route for SkyPier HSFs Operating to / from Zhuhai and Macau (cont'd)

- Upon leaving or arriving at SkyPier:
  - HSFs have to make a slight detour around the HKIAAA and temporary works area of the 3RS project;
- For the water space between HKIA and Pillar Point/ Castle Peak Power Station:
  - Sharp angle turning in high speed is avoided in Urmston Road due to safety navigation issues;
- In order to avoid going through the Urmston Road Anchorage and SCLKCMP
  - ➢ The proposed route has to pass through the channel between these two areas.

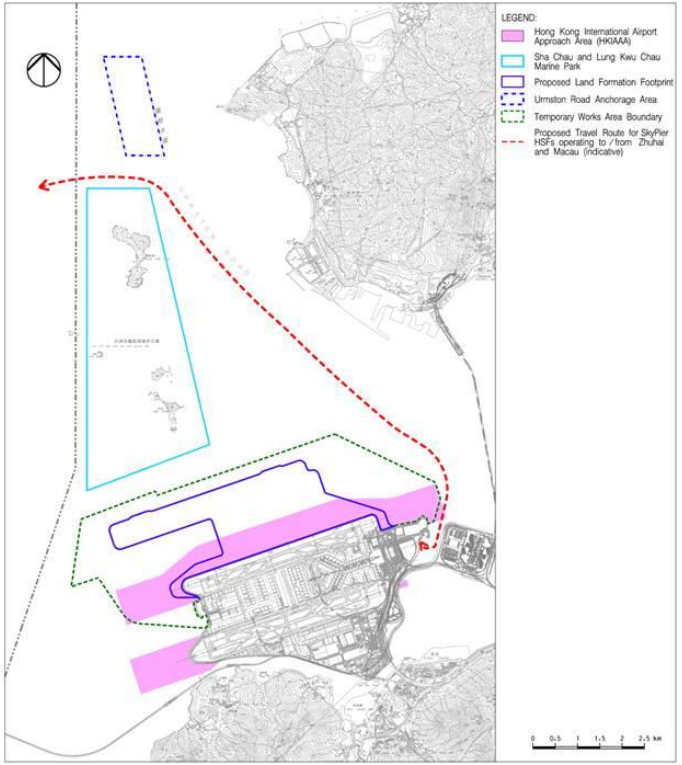


Figure 7 Pre-defined marine travel route for SkyPier HSFs operating to / from Zhuhai and Macau

Chinese White Dolphin “Hotspot” areas

- Dolphin Habitat Index
  - Determine the area to which HSF speed limits should be applied for reducing impacts on CWDs.
- To avoid potential biases from any single measure, a matrix of four measures of dolphin use of each grid would be used. For each 1 x 1 km grid in the potential HSF route area, four factors have been considered:
  1. Current density by DPSE (The number of CWDs per 100 units of survey effort in the 1 x 1 km grid) (Figure 8)
  2. Historical density by DPSE (Figure 9)
  3. Habitat rating (Figure 10)
  4. 50% core area usage by CWDs (Figure 11)

Dolphin habitat index	Criteria
Least critical	3 “Low”; or 4 “Low”
Less critical	2 “Medium” and 2 “Low”; or 1 “High” and 1 “Medium” and 2 “Low”
Moderately critical	2 “High” and 1 “Medium”; or 2 “High” and 2 “Low”; or 1 “High” and 2 “Medium”; or 3 “Medium”
Highly critical	3 “High”; or 4 “High”

Table 4 Criteria for each 1 km^2 grid in defining the dolphin habitat index, based on the ranking of four factors

Chinese White Dolphin “Hotspot” areas (cont’d)

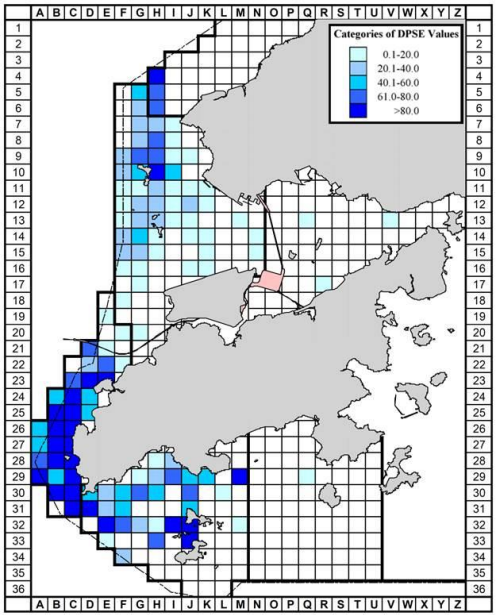


Figure 8 Current density of CWDs with corrected survey effort per km^2 in waters around Lantau Island between January – December 2014 (number within grids represent DPSE). In the dolphin habitat index developed for this plan, DPSE of 0.0 – 20.0 is rated as “Low”, 20.1 – 40.0 as “Medium” and 40.1 or above as “High”.

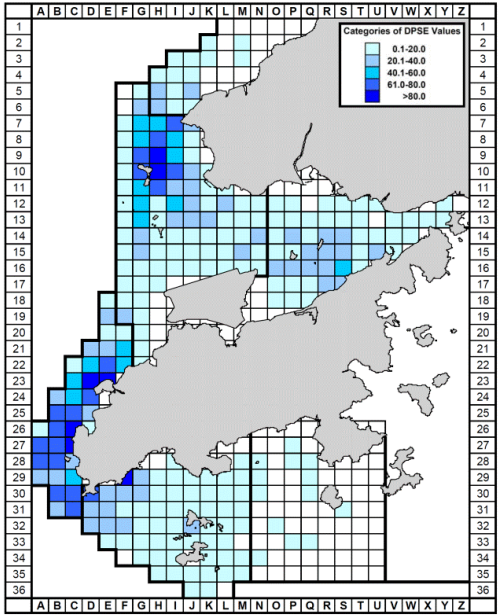


Figure 9 Historical density of CWDs with correct survey effort per km^2 in waters around Lantau Island during 2001 – 2012 (numbers within grids represent DPSE). In the dolphin habitat index developed for this plan, DPSE of 0.0 – 20.0 is rated as “Low”, 20.1 – 40.0 as “Medium” and 40.1 or above as “High”.

Chinese White Dolphin "Hotspot" areas (cont'd)

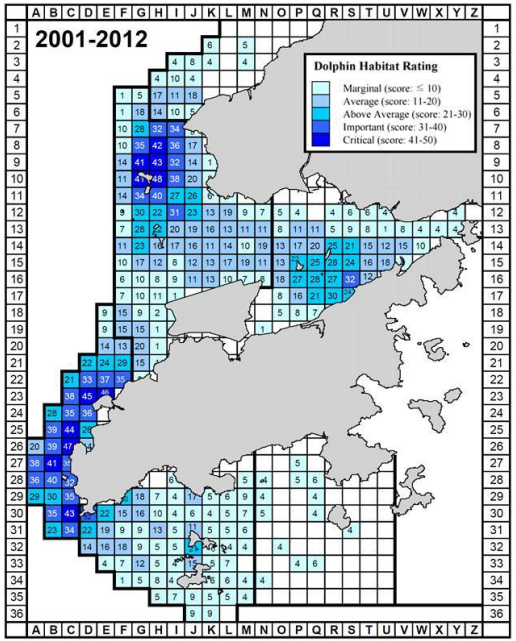


Figure 10 Habitat rating of CWDs in Hong Kong using quantitative habitat use information collected during 2001 – 2012 (number with grids represents the sum of scores totalled from 10 selection criteria). In the dolphin habitat index developed for this plan, habitat rating of 0 – 10 is rated as "Low", 11 – 20 as "Medium", and 21 or above as "High".

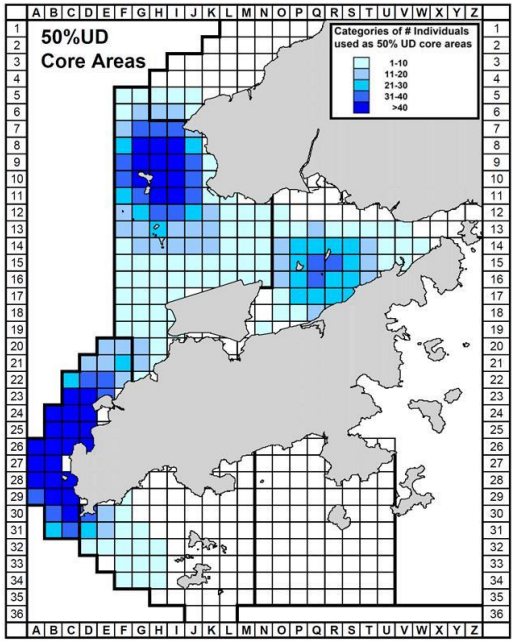


Figure 11 Number of individual CWDs with their 50% utilization distribution (UD) core areas overlapped with each 1 km^2 grid in waters around Lantau Island from 2001 – 2012. In the dolphin habitat index developed for this plan, 50% core area of 0-10 is rated as "Low", 11-30 as "Medium", and 31 or above as "High".

Chinese White Dolphin “Hotspot” areas (cont’d)

- The resulting matrix demonstrates a highly critical CWD habitat to the northeast of SCLKCMP;
- HSFs can adversely impact cetaceans:
  - Behavioural disturbance & ship strikes;
- SkyPier ferries can reduce impacts on dolphins:
  - Slowing to 15 knots in the section of important dolphin habitat extending all the way to the HK/PRC boundary.

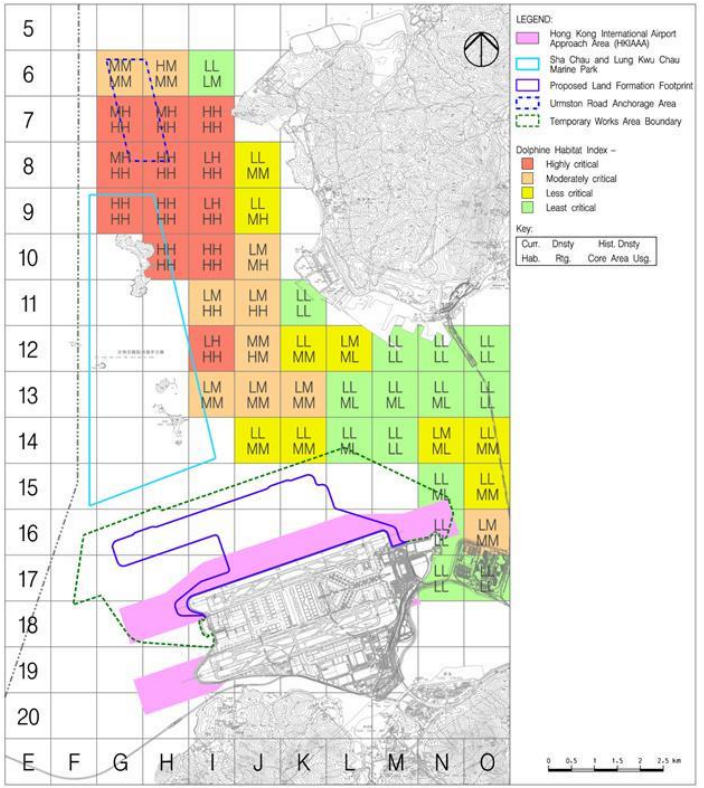


Figure 12 Dolphin Habitat Index

Design of speed controlled zone for SkyPier HSFs

- The indicative diverted marine travel route is overlaid with the Dolphin Habitat Index
  - ➢ Speed controlled zone (SCZ)
- The water space between HKIA and Pillar Point/ Castle Peak Power Station:
  - The route shall mainly transit through the “Least Critical” dolphin habitat grids;
- When leaving and/ or approaching the SkyPier terminal at the HKIA:
  - Ferries should gradually increase and/ or decrease speed.

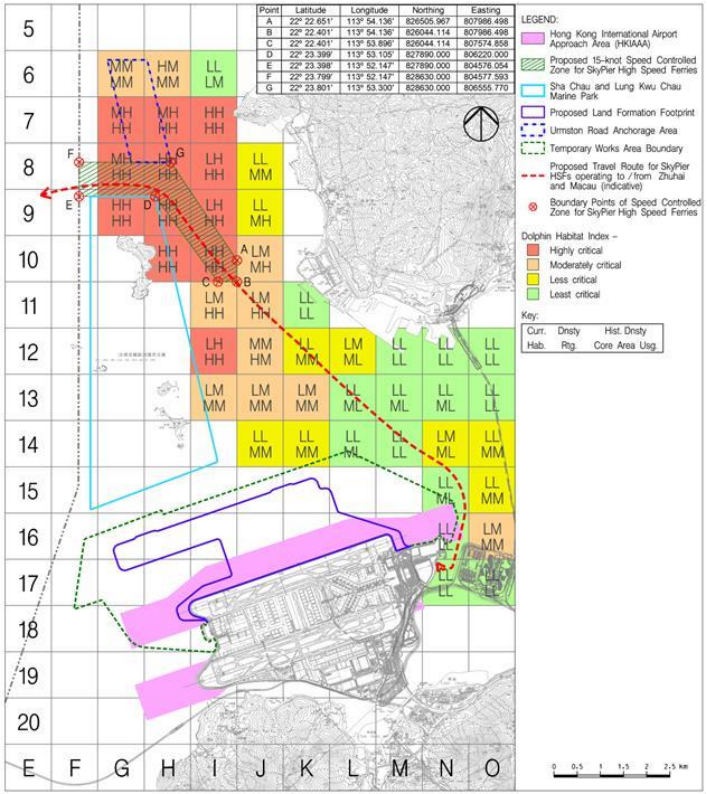


Figure 13 Speed controlled zone for SkyPier HSFs

Design of speed controlled zone for SkyPier HSFs (cont'd)

On approaching the "Highly Critical" dolphin habitat grids around SCLKCMP:

- Require to enter a defined 15-knot SCZ at the north and northeast of SCLKCMP;
- Require to enter and/ or leave the SCZ through Gates A-B-C and E-F;
- Movement through the "Highly Critical" dolphin habitat is restricted
  - ➢ Minimise the chances of encounter with CWDs;
  - ➢ Allow dolphins to habituate to these predictable routes.

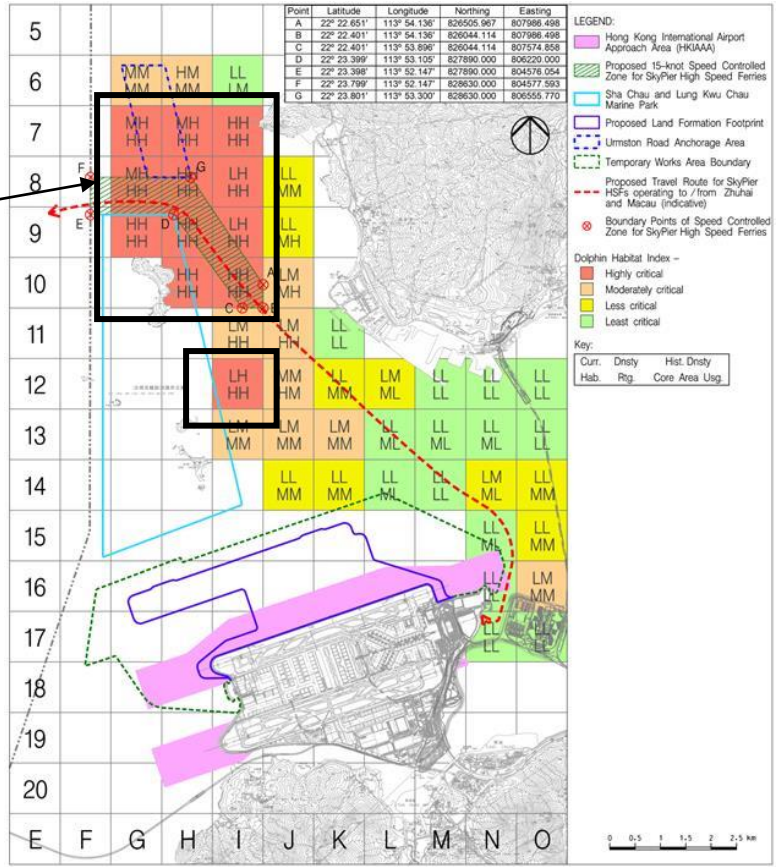


Figure 13 Speed controlled zone for SkyPier HSFs

Design of speed controlled zone for SkyPier HSFs (cont'd)

When travelling through the SCZ:

- Must adhere to the speed limit of 15 knots;
- Need to decelerate gradually before entering the SCZ;
- Can only increase the speed to over 15 knots upon leaving the SCZ gradually.

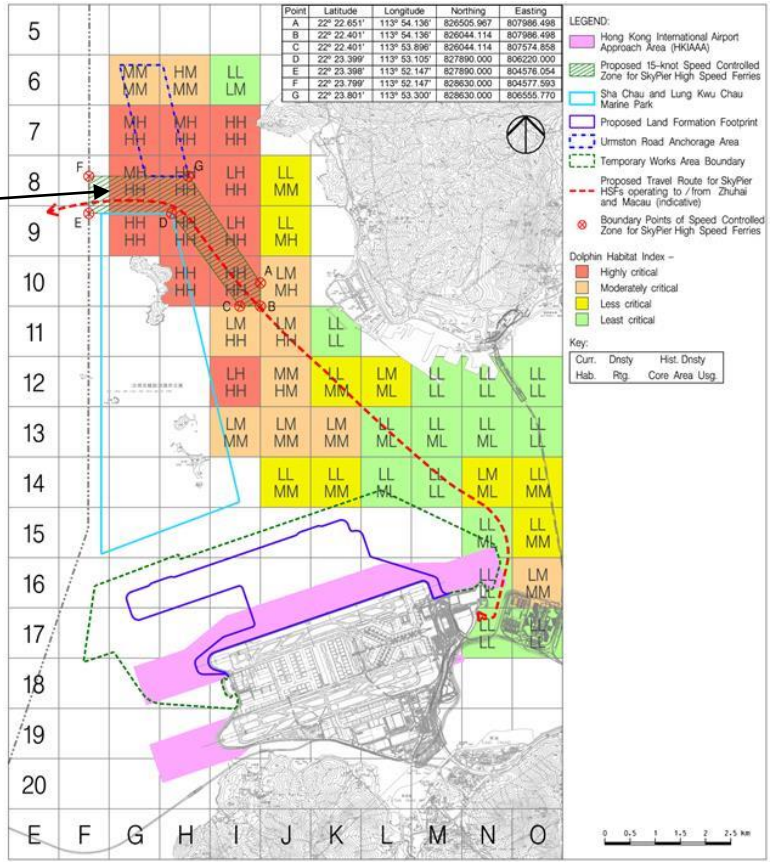


Figure 13 Speed controlled zone for SkyPier HSFs

Design of speed controlled zone for SkyPier HSFs (cont'd)

- Rapid and frequent speed changes should be avoided to reduce disturbance to CWDs & potential vessel / CWD collisions;
- SkyPier HSFs that use the Urmston Road to travel north into the PRE interface with the speed restriction area for the SkyPier HSFs operating to / from Zhuhai and Macau:
  - Require to adhere to the 15 knots speed restriction.

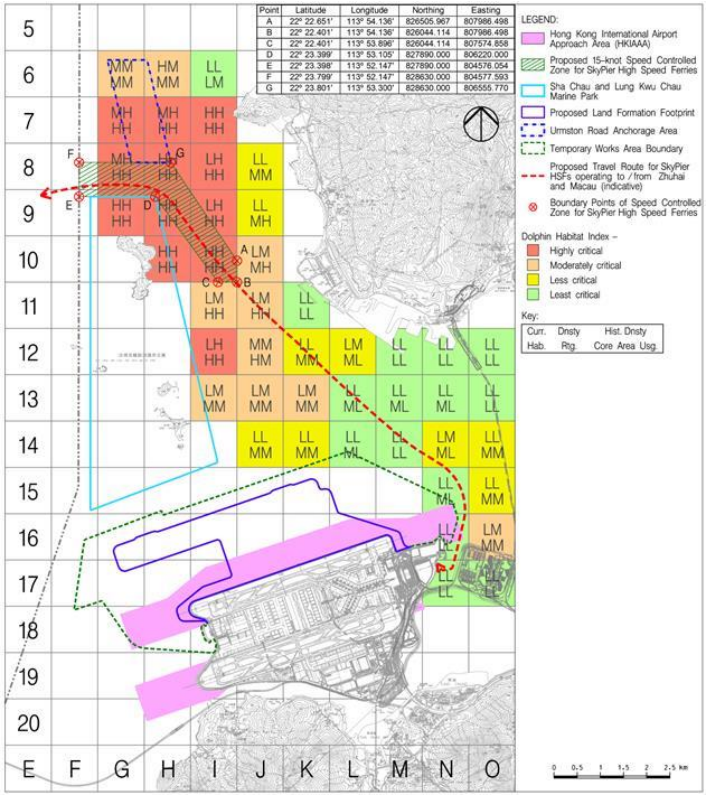
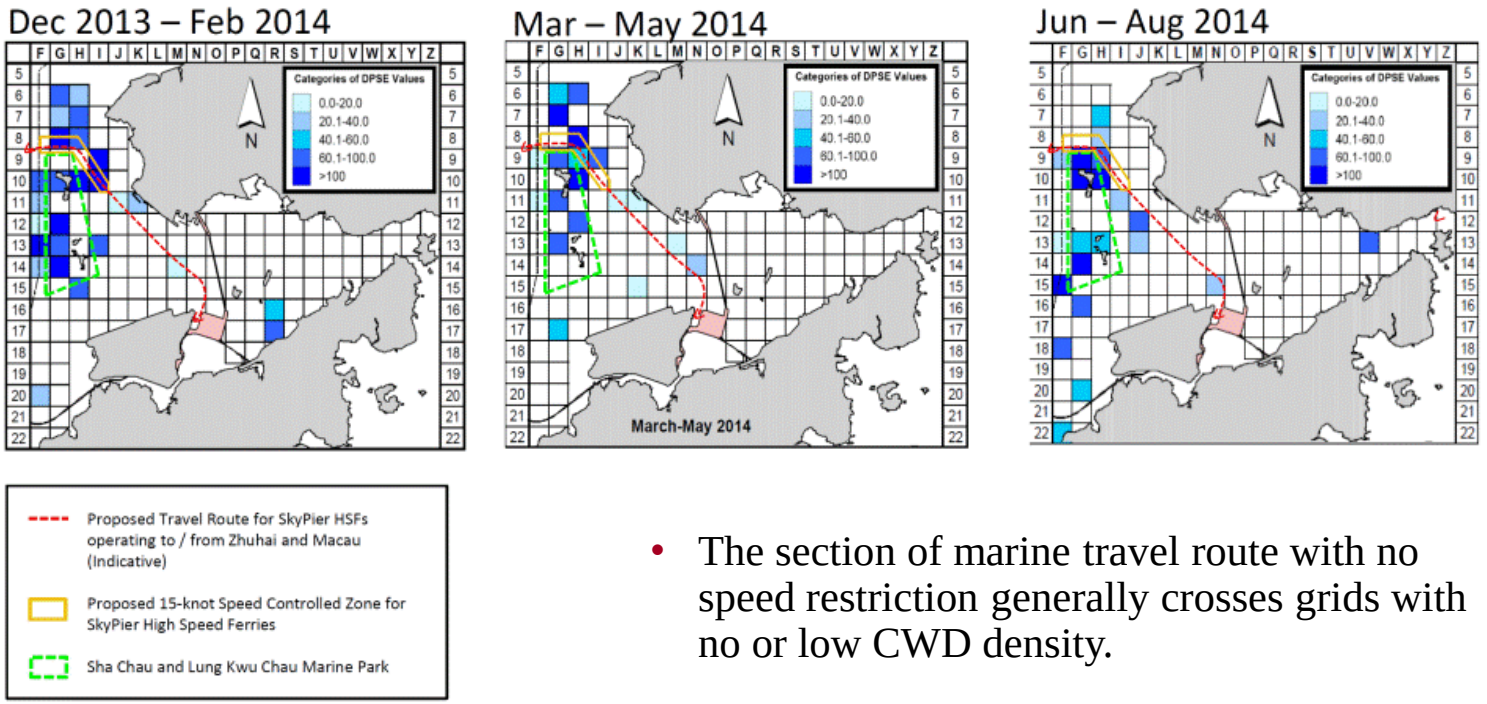


Figure 13 Speed controlled zone for SkyPier HSFs

Design of speed controlled zone for SkyPier HSFs (cont'd)

Figure 14 Density of Chinese white dolphins from HZMB-HKLR Monitoring Reports



- The section of marine travel route with no speed restriction generally crosses grids with no or low CWD density.

Daily cap on HSF numbers

- AAHK will cap the SkyPier HSF movements at an annual daily average of 99 prior to designation of the proposed marine park in addition to the route diversion and speed restrictions in high-density CWD areas;
- Operational considerations:
  - Expected seasonal fluctuations above and below the annual daily average;
  - Allow some capacity for operations recovery after inclement weather events e.g. typhoons;
  - Expected peak demand periods during any year e.g. Lunar New Year or the Golden Week holiday (very high traffic demand is expected).
- An absolute cap on maximum daily movements at SkyPier may present a significant operational challenge:
  - During busy periods each year e.g. the Golden Week holiday;
  - Accommodate HSF service recovery in the aftermath of inclement weather events;
  - ➢ A further maximum daily movement cap has been explored.

Daily cap on HSF numbers (cont'd)

- The history of SkyPier HSF movements since 2010:
  - Actual daily HSF movements only vary up and down slightly (within +/- 5 movements) from the annual average daily movements for most days in any year;
  - The highest number of scheduled movements in any one day was 123, actual movements were a little below;
  - Days with HSF movements above 110 totalled less than 30.
- Propose 125 movements as the maximum daily movement cap in conjunction with the overall commitment to 99 annual daily average HSF movements;
  - ➢ Provide operational flexibility for handling any unexpected and rare operational challenges.
- AAHK works closely with SkyPier HSF Operators:
  - Ensure the annual daily average HSF movements can be kept within the target of 99 per day / 36,135 movements during one whole year (with 365 calendar days)
  - During 'normal' operations, daily movements are slightly below the 99 target;
  - ➢ A buffer of extra movement slots.

Feasibility of imposing further speed restrictions

1. Impose further speed restrictions along the diverted route

- The SkyPier HSFs are prohibited from entering the Marine Prohibited Zone:
  - Develop based on the dolphin protection area proposed during the construction phase – comments from the Advisory Council on the Environment (ACE);
  - Stringent management control on SkyPier HSFs;
  - Cover much of the "Moderately Critical" and "Highly Critical" dolphin habitats;
  - Except areas inside the SCZ but a 15-knot speed restriction shall apply.
- Avoid frequent and rapid HSF speed changes:
  - More gear shifts → higher disturbance to CWDs;
  - ➢ Further speed restrictions on any additional sections along the pre-defined travel route between SkyPier and the entrance gate to the SCZ may be counterproductive.

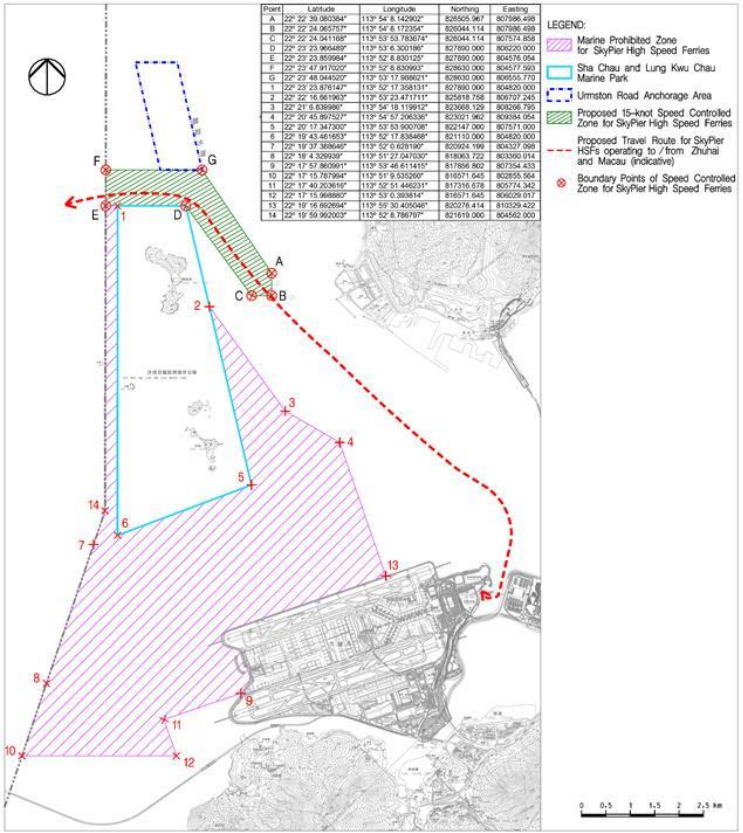


Figure 15 Marine Prohibited Zone for SkyPier HSFs

Feasibility of imposing further speed restrictions (cont'd)

1. Impose further speed restrictions along the diverted route

- 3RS marine construction works are expected to be underway for several years
  - Environmental Team
    - Review the density and habitat index from time to time during the construction period;
  - Make suggestions on appropriate changes / alterations
    - E.g. Adopt in new agreements with Ferry Operators using SkyPier.
- In the operation phase:
  - Any decision on the section of the diverted route subject to the speed limit;
  - Application to SkyPier ferries will be taken after consideration of updated CWD abundance data from both the AFCD database & additional 3RS EM&A data obtained during the pre-construction and construction monitoring periods;
  - After successful designation of the proposed Marine Park, all vessels will be required to travel with a speed limit of 10 knots within the proposed Marine Parks according to the Marine Park Ordinance.

Feasibility of imposing further speed restrictions (cont'd)

2. Impose a speed limit to SkyPier HSFs heading north to the Pearl River Delta (PRD)

- Total number of SkyPier HSFs would increase from the current annual average daily traffic level of less than 100 to about 130 in 2030;
- AAHK has committed daily cap on the SkyPier HSF movements:
  - Cover all SkyPier HSFs;
  - Include the diverted HSFs going to the west & the remaining SkyPier HSFs that are heading north into the PRD.
- AAHK shall include the 15-knot speed requirement (when travelling across CWD hotspots in Hong Kong) as one of the contract terms when tendering for the next SkyPier operation contract.

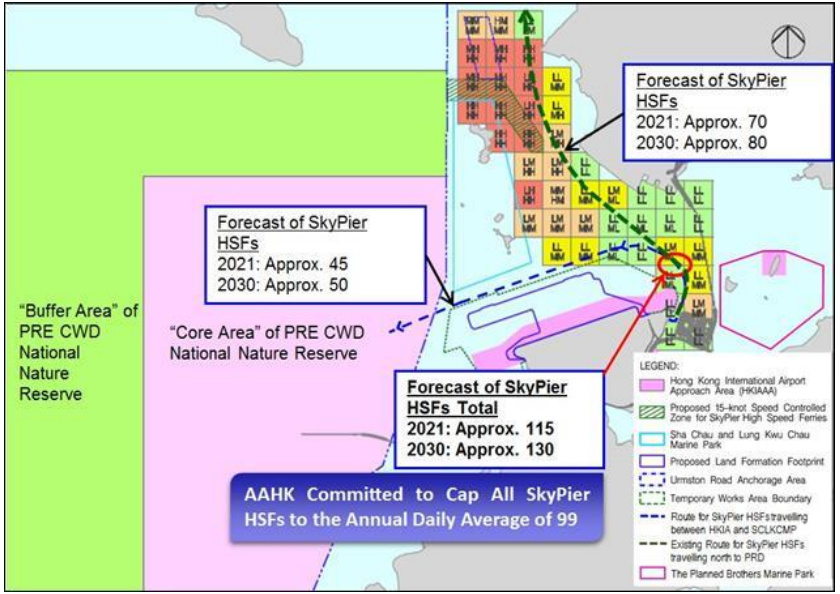


Figure 16 EIA forecast of daily average SkyPier HSFs in 2021 and 2030

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Implementation and monitoring

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Implementation

Implement by AAHK and the SkyPier Ferry Operators (FOs)

- FOs will be required to track compliance regularly
  - Specify in the supplemental agreement to ensure FOs follow all agreed restrictions;
- In the operation phase:
  - Any decision on the section of the diverted route subject to the speed limit;
  - Application to SkyPier ferries will be taken after consideration of updated CWD abundance data from both the AFCD database & from additional 3RS EM&A data obtained during the pre-construction and construction monitoring periods;
- Cap the number of SkyPier HSF at an annual daily average of 99 prior to designation of the proposed marine park.

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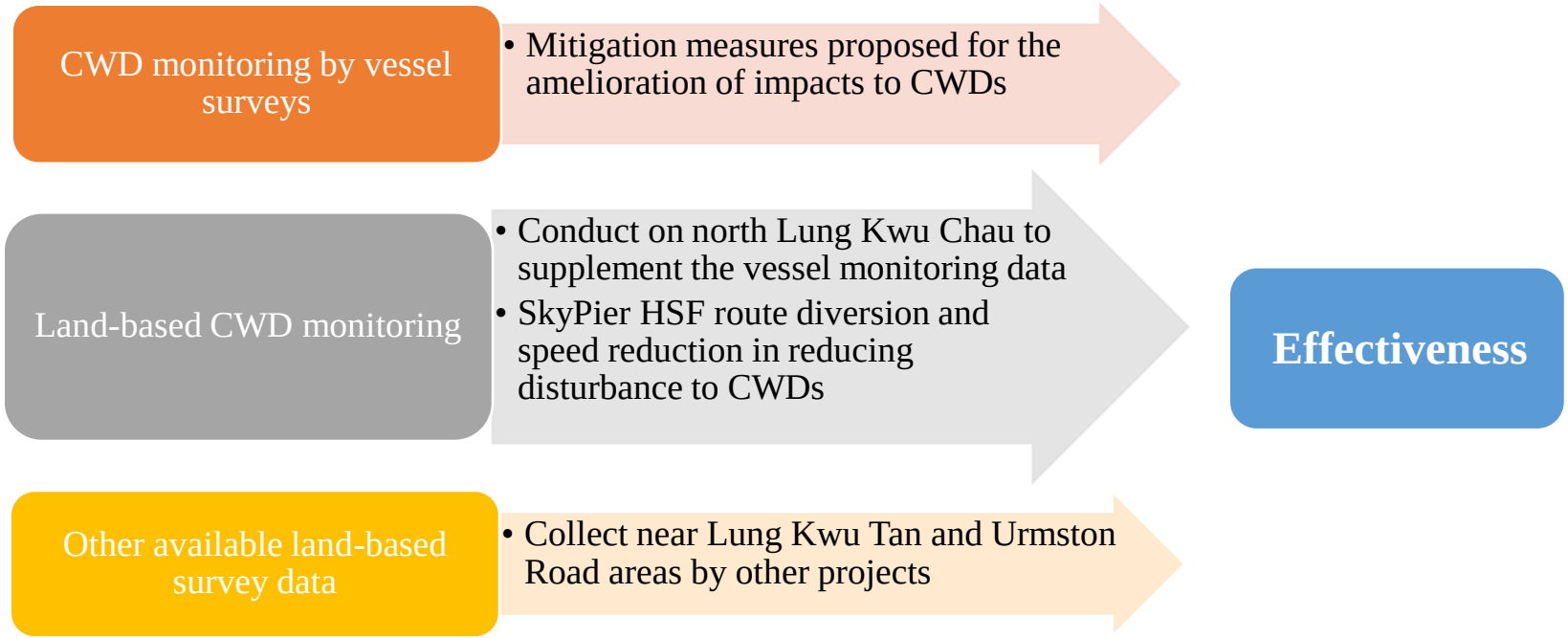
Method of implementation and monitoring

- Supplemental Agreement with the ferry handling agent for all SkyPier FOs, includes:
  - All HSFs using the diverted route shall install and operate GPS receivers / AIS transponders to facilitate accurate route tracking and record keeping;
  - Ferry Operators shall provide information on the number and type of ferry taking the diverted route for AAHK to verify on a monthly basis;
  - Any non-compliance with the requirements and arrangements for diversion and speed control shall initially result in warnings to operators, with any repeated non-compliance leading to suspension of that particular movement until submission of report explaining the reason of non-compliance with preventive measures in place to the satisfaction of the AAHK;
  - Vessel captain may decide to deviate from the proposed route in response to an emergency or in the interest of public safety e.g. in case of adverse sea conditions. The ferry operators have to provide valid reasons to AAHK for such case or otherwise the non-compliance shall lead to warnings or suspension.

Method of implementation and monitoring (cont'd)

- The Environmental Team will audit various parameters:
  - Actual daily numbers of HSFs;
  - Compliance with the 15-knot speed limit in the speed control zone & diversion compliance for SkyPier HSFs operating to / from Zhuhai and Macau;
  - Monthly EM&A reports.
- All ferry operators shall comply with the relevant international conventions, and local regulations and requirements of the Marine Department, including but not limited to the following:
  - Merchant Shipping (Local Vessels) Ordinance, Cap 548 – Regulation and control of local vessels in Hong Kong or in the waters of Hong Kong and for other matters affecting local vessels, including their navigation and safety at the sea;
  - The International Regulations for Preventing Collisions at Sea 1972 – Regulation with rules including safe speed, measures to identify collision risk, actions to avoid collision and the actions to be taken during different situations to prevent collisions;
  - The Shipping and Port Control Ordinance (Cap 313) – Regulation and control of ports and vessels in Hong Kong or in the waters of Hong Kong;
  - The Shipping and Port Control Regulations (Cap 313A) – Rules for the navigation and control of vessels.

Review the effectiveness of the mitigation measures



- AAHK will report to ACE on the effectiveness of the CWD mitigation measures six months after implementation of the SkyPier Plan;
- Review and analyse data from CWD monitoring surveys during the initial six month implementation of SkyPier HSF diversion and speed restriction.

Precautionary measures for High Speed Ferry

- AAHK - Marine Ecology and Fisheries Enhancement Plan:
  - Fund and support initiatives in promoting environmental education and eco-tourism in relation to the marine ecological and fisheries resources in the North Lantau coast and Northwest Lantau waters;
  - Develop and conduct skipper workshops to alert HSF captains / drivers on the risk of collisions with CWDs and Finless Porpoises & ways of reducing such risks:
    - General education on local cetaceans;
    - Guidelines for avoiding adverse water quality impact;
    - Guidelines for operating vessels safely in the presence of CWD.
- Recommended precautionary measures to HSF operators for the route to / from Zhuhai and Macau:
  - Ensure that all captains of HSF are well trained - strictly follow the pre-defined travel route and speed restriction rules;
  - The vessel captains should make sure that there is sufficient distance for slowing down prior to passing CWD hotspots and take action to avoid collision;
  - Vessel captains need to make sure that all reasonable efforts (within safety parameters) are taken to minimise the risk and disturbance to CWDs along the whole route, not just within the speed-controlled zone.

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