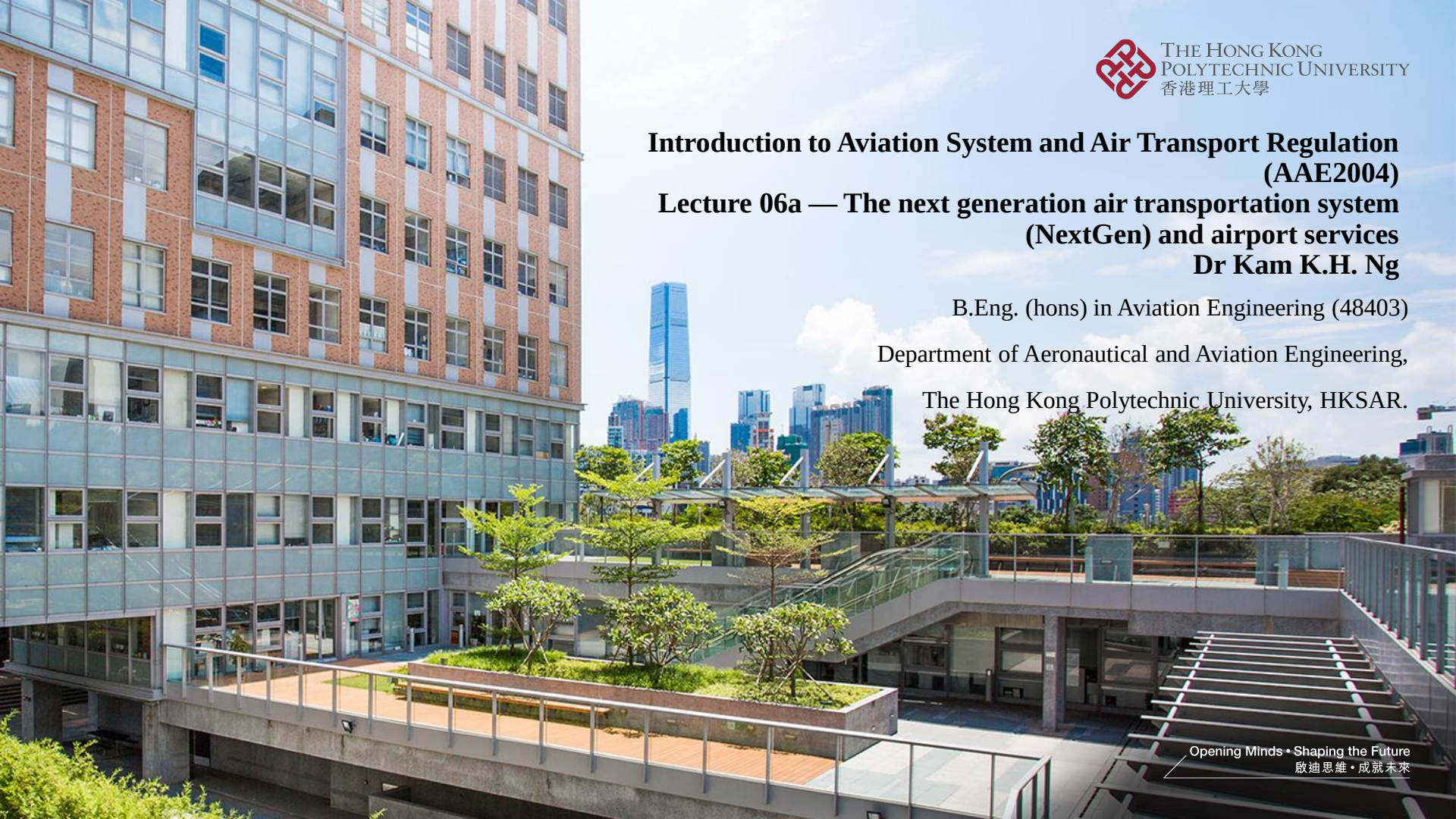


THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Introduction to Aviation System and Air Transport Regulation (AAE2004)

Lecture 06a — The next generation air transportation system (NextGen) and airport services

Dr Kam K.H. Ng

B.Eng. (hons) in Aviation Engineering (48403)

Department of Aeronautical and Aviation Engineering,

The Hong Kong Polytechnic University, HKSAR.

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Agenda

- Background Information of Nextgen
- Critical elements of Nextgen
- Performance and Concerns of Nextgen
- ATD
- Similar examples

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Background Information

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Next generation air transportation system (NextGen)

An ongoing modernisation project of the United States National Airspace System (NAS), FAA-led

Justification of *NextGen*

Air travel was impeded by severe congestion and costly delays since summer of 2000.

"Beyond Traffic: Trends and Choices 2045", a 30-year outlook report published in 2016,

- Estimated flight delays and congestion cost the U.S. economy more than $20 billion each year.
- Number of people flying on U.S. airlines will increase by 50 percent over the next two decades

Goals of *NextGen*

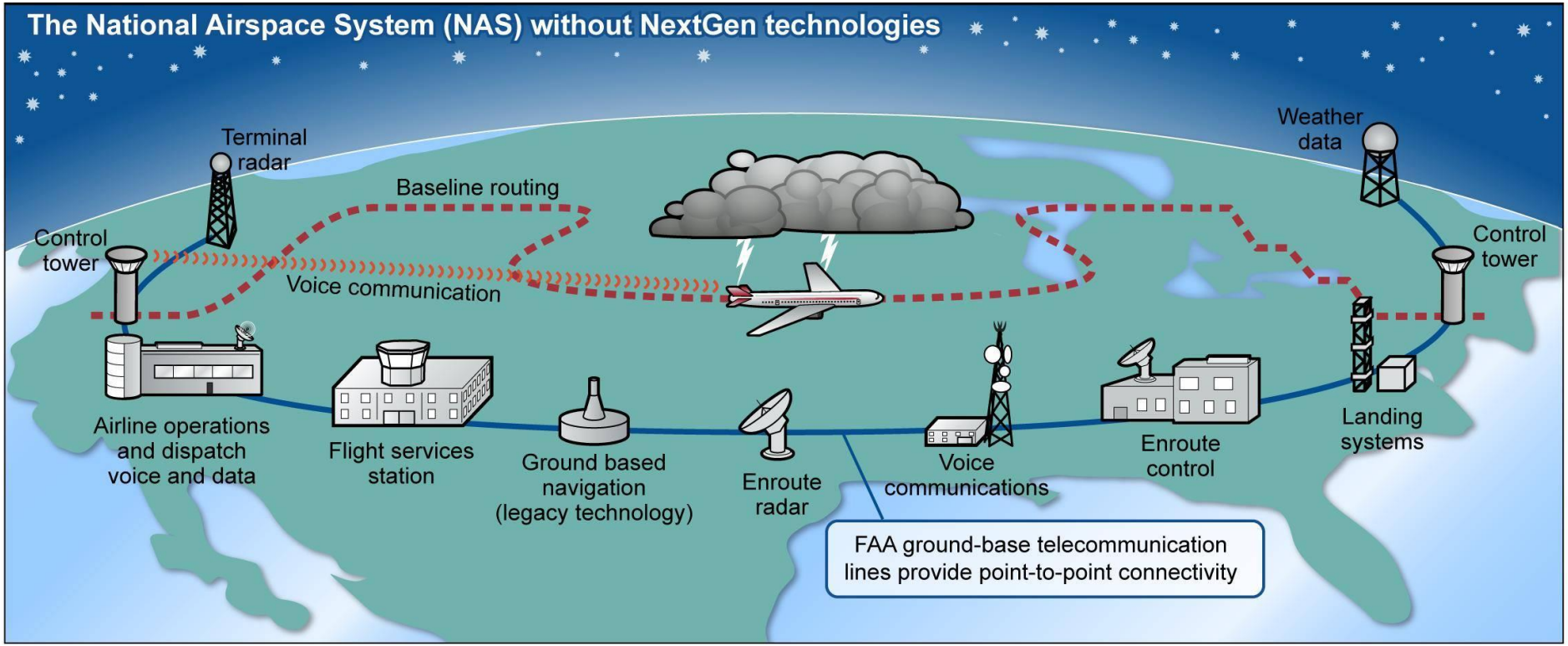
Using new technologies and procedures to:

a. increase safety, efficiency, capacity, access, flexibility, predictability;
b. resilience of the NAS while reducing the environmental impact of aviation.

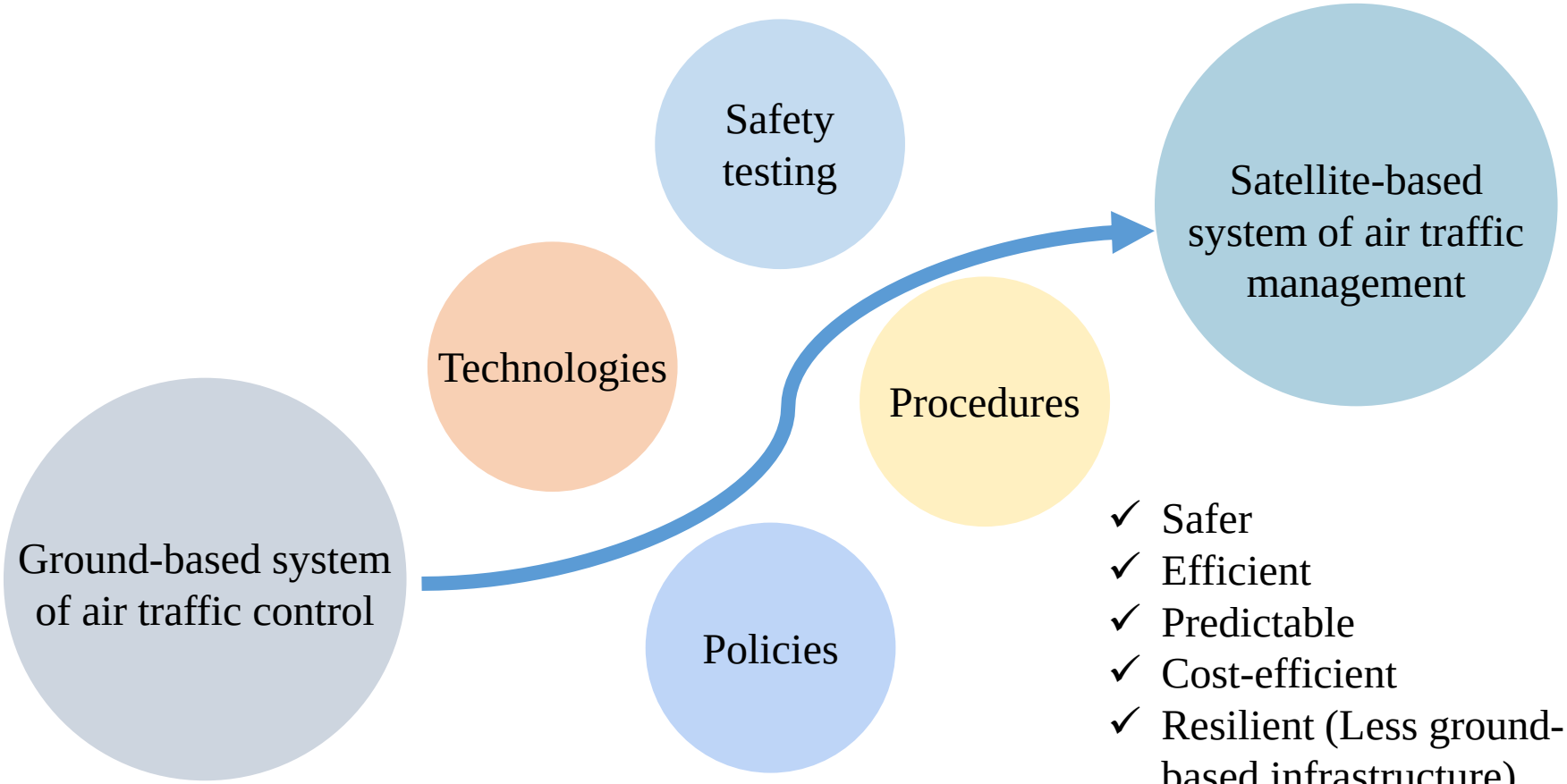
Benefits of *NextGen*

a. Air traffic controllers have better information to track and separate aircraft safely and efficiently;
b. Pilots have more aeronautical, traffic, and weather information inside the cockpit;
c. Airlines fly shorter, more direct routes to get passengers to their destinations more quickly;
d. Air travels burn less fuel and produce fewer emissions.

Ground-based system of air traffic control

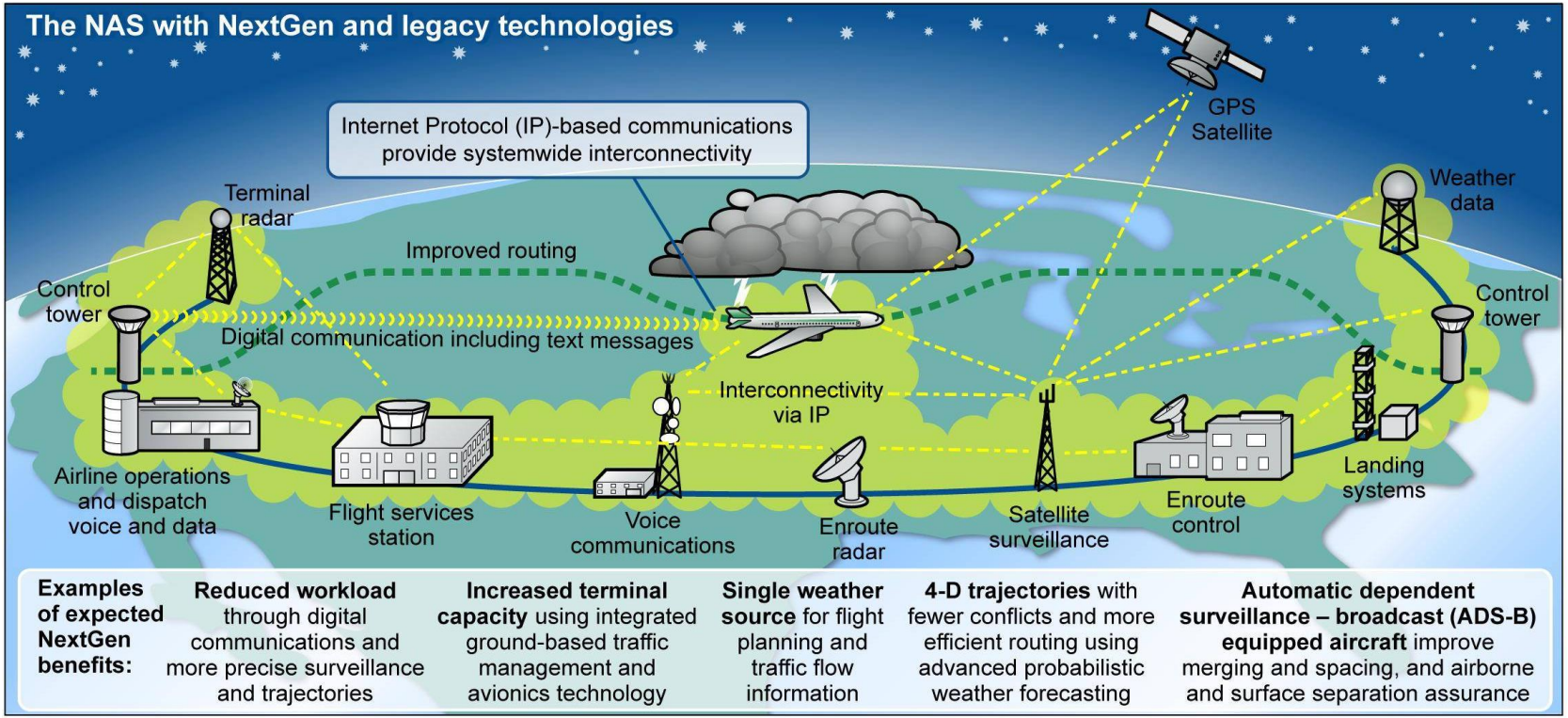


NextGen



- ✓ Safer
- ✓ Efficient
- ✓ Predictable
- ✓ Cost-efficient
- ✓ Resilient (Less ground-based infrastructure)

Satellite-based system of air traffic management



Operation view

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
1. Communication

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Controller pilot data link communications

- Use typed digital messages to supplement voice communications between air traffic controllers and pilots.
- Help the equipped aircraft to take off sooner through messages
  - Quickly exchanged & Clearly understood
  - Efficient time-saving departure

Tower air traffic controllers send pilots of equipped aircraft departure clearance instructions to read, accept, and load into their flight management system.

Pilot read the text display and press "Wilco" to declare the messages have been noted.

- Clearance instructions include climbs, descents, reroutes, and hand-offs between Air Traffic Control(ATC) sectors in the Air Route Traffic Control Centres (ARTCC) environment.

Controller pilot data link communications (cont'd)

Only two voice only planes have taken off; five data com planes are already on their way.

Highly accurate information allows:

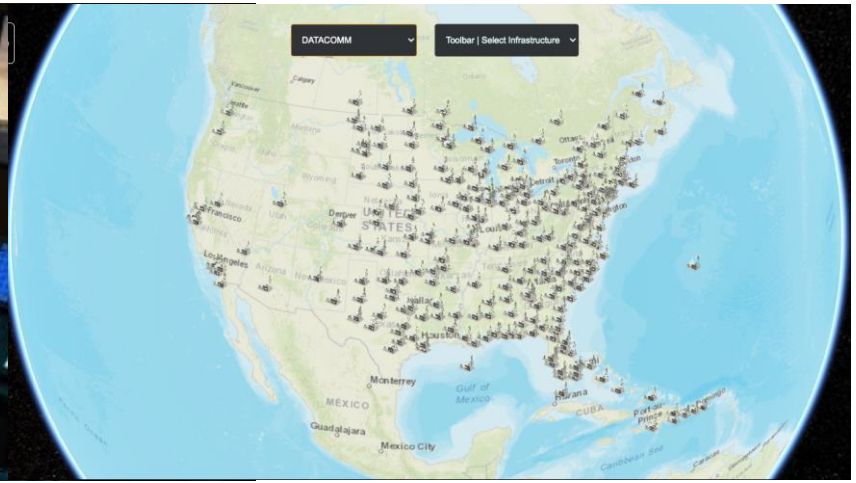
- Time saving
- Increase departure volume
- Avoid misunderstood messages
- Ensure safety while flying

https://youtu.be/rTCLHZ0fGsU?t=61 (1:00 – 2:30)

Avoids communication barriers

- Data Comm messages sent by controllers are delivered only to the intended aircraft;
  - Eliminate the chance of another pilot acting on instructions for another aircraft with a similar call sign;
  - Avoid misunderstood messages because of busy radio chatter or variations in the way people speak.
- Can be a backup if a microphone malfunctions;
- Preserve radio bandwidth when voice communication is necessary or preferred.

Controller pilot data link communications (cont'd)



- Messages also are sent to flight dispatchers, all relevant parties have a shared awareness for faster reactions to changing circumstances, such as approaching thunderstorms.
- Improve flight safety as reroutes are provided in a form
  - Flight Management System – an automatic loading that could eliminate typing errors and name confusion.
- Data Comm saves aircraft time waiting to take off, particularly when routes change
  - Reduce fuel use and engine exhaust emissions;
  - Lower the chances of delays or cancellations when weather affects the flight route;
  - Expected to save more than $10 billion operators cost over the 30-year life cycle of the program.

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
2. Navigation

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Navigation

Performance Based Navigation (PBN) is an instrument flight rules way of moving through airspace that varies depending equipage, navigational aids, and pilot training.

- Performance standards for certain airspace are conveyed to pilots through navigation specifications;
- Identify the aircraft avionics;
- Choice of ground- or satellite-based navigation aids.

1. With Area navigation (RNAV)
   - Equipped aircraft fly any desired path within the coverage of ground- or space-based navigation aids, within the capability of aircraft equipage, or both.
2. With Required navigation performance (RNP)
   - Equipped aircraft monitor on-board navigation performance and alert pilots trained to use it if a requirement is unmet during an operation;
   - Aircraft can operate safely near mountainous terrain or in congested airspace by using RNP procedures.

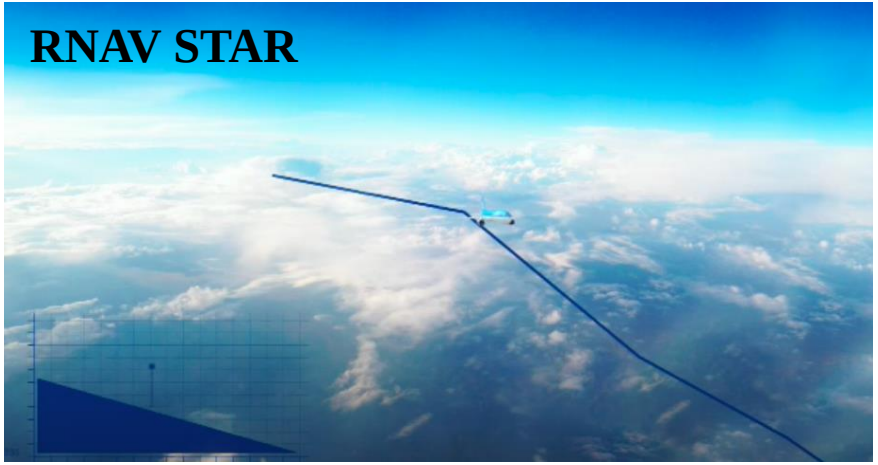
Navigation (cont'd)

Wide Area Augmentation System

- Instrument-rated pilots now can land at airports where that was previously impossible using just GPS;
- At an airport where a ground-based Instrument Landing System (ILS) may be out of service;

  →PBN approach serves as a backup to save money.
- The FAA is working to cut costs by reducing the amount of ground-based navigation infrastructure, which will remain as alternative in case of satellite service disruptions.

Navigation (cont'd)



https://youtu.be/Oyi9l3cGE8M?t=275 (4:34 - 5:18)

RNAV Standard Terminal Arrivals (STAR)

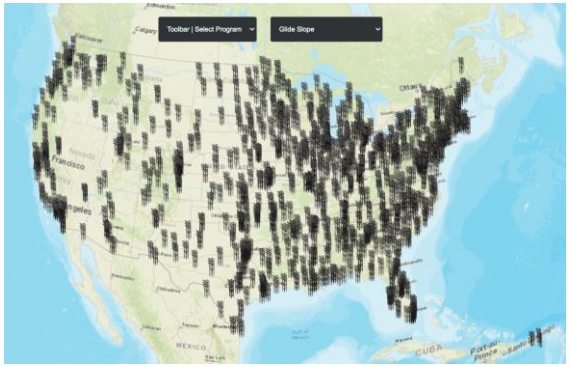
- A continuous descent approach /an optimised profile descent (OPD);
- Descent from cruising altitude to save fuel and reduce emissions and noise;
- FAA published many procedures with this capability that enable aircraft to fly closer to the airport at a more fuel-efficient altitude before descending, which also saves fuel by eliminating level-offs.

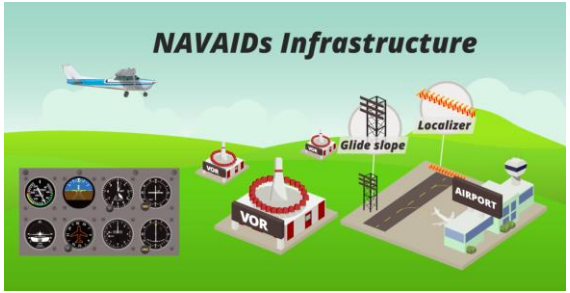
Navigation (cont'd)

- PBN primarily uses satellite-enabled technology and creates precise, repeatable, and predictable 3-D flight paths free from the constraints previously imposed by the physical locations of ground-based navigation infrastructure.
- A new route structure makes straighter paths possible for greater efficiency & more routes can fit into the same airspace → increase capacity;
- From 2009 – 2016, PBN procedures available nearly tripled at airports across the nation. As of December 2019, the FAA has published more than 9,600 PBN procedures and routes.
  - RNAV standard instrument departures, RNAV STAR;
  - T-Routes (1,200 feet above the surface to 18,000 feet of altitude);
  - Q-Routes (18,000–45,000 feet of altitude);
  - RNAV (GPS) approaches, and RNP approaches.
- Integrate with the real-time GPS radar;
- Dynamic route can be provided
  - Avoid the adverse weather;
  - Find the most fuel-efficient and time-saving routes.

Navigational aids (NAVAIDs)

- Physical devices on the ground that aircraft can detect and fly to:
  - Very High Frequency (VHF)
  - Omnidirectional Range / Distance Measuring Equipment (VOR/DME)
    - VOR facilities allow the pilot to follow a designated flight path by using the aircraft's cockpit gauges to indicate their positions.
  - Instrument Landing System (ILS)
    - Made up of the Glideslope (GS) and the Localizer (LOC);
    - Transmit guidance beams to allow the pilot to land safely and efficiently.
- The navigation instruments indicate the position of the aircraft in relation to a selected navigation facility or fix;
- Provide Pilotage information such as a predetermined path along a route;
- Provide vertical slope guidance towards runway landing;
- Provide horizontal slope guidance for aligning an aircraft to the centre of the runway.





Benefits

- ✓ Provide pilotage information so the aircraft can be manoeuvred to keep it on a predetermined path;
- ✓ Allow aircraft to descend to the runway at the most optimal angle;
- ✓ Allow aircraft to align with the centre of the airport's runway during landing.

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
3. Surveillance

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Automatic dependent surveillance–broadcast (ADS-B)

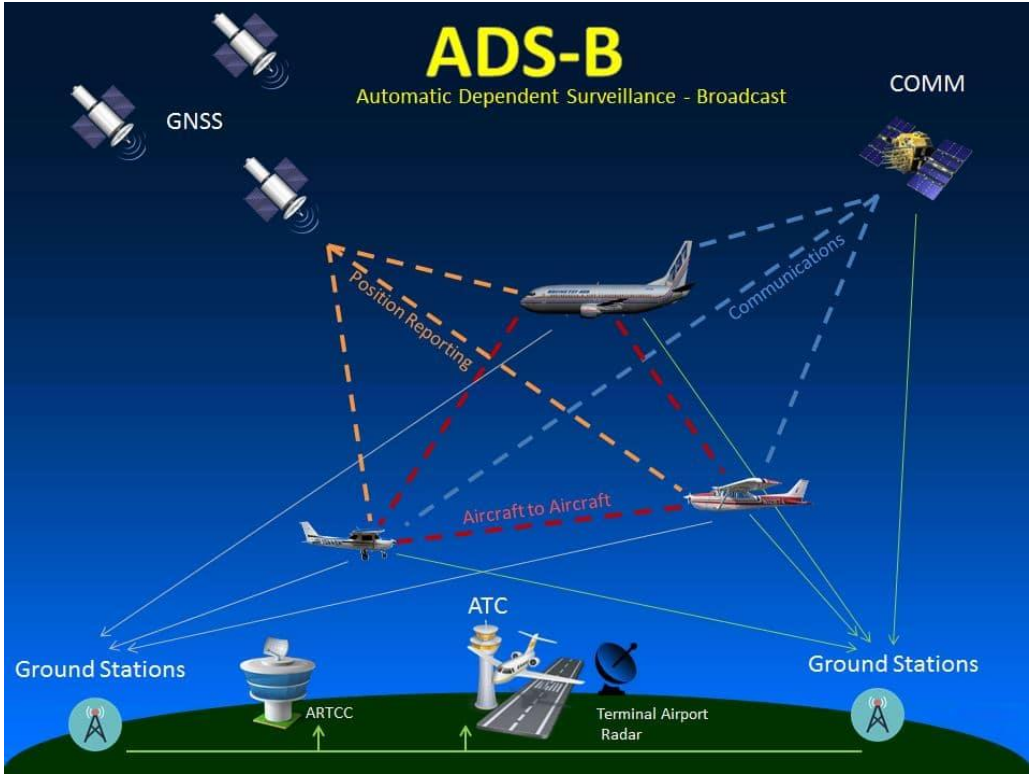
- A more precise, satellite-based successor:
  - Depend on an accurate satellite signal for position data, enhances surveillance services, and continuously broadcasts aircraft position and other data to ground stations and aircraft equipped to receive ADS-B.
- Former flight tracking system
  - Use ground-based radar to receive aircraft position, speed, and direction every 5 to 12 seconds.

With ADS-B

- Aircraft equipped with newer GPS transponders determine above information and then automatically send it out every second to air traffic control;
- Always on and require no operator intervention;
- Pilots and air traffic controllers can for the first time see the same real-time display of air traffic;

  →Improve situational awareness for improved safety.
- Moving from the current system of ADS-B ground stations to radios hosted on satellites offers the potential for reduced separation standards;
- Surveillance radar is still relevant and will be used as a supplement and ultimately as backup to ADS-B in the event of service disruption;
- Less investment on infrastructure.

Automatic dependent surveillance–broadcast (ADS-B) (cont'd)

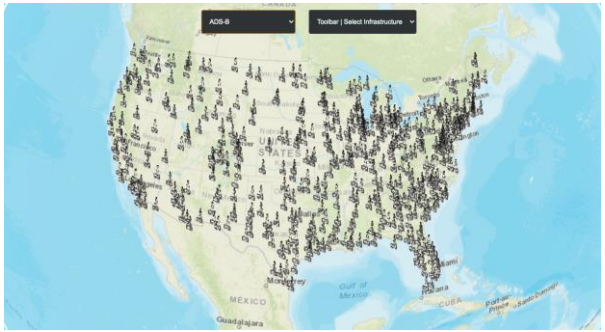


Automatic: It's always ON and requires no operator intervention

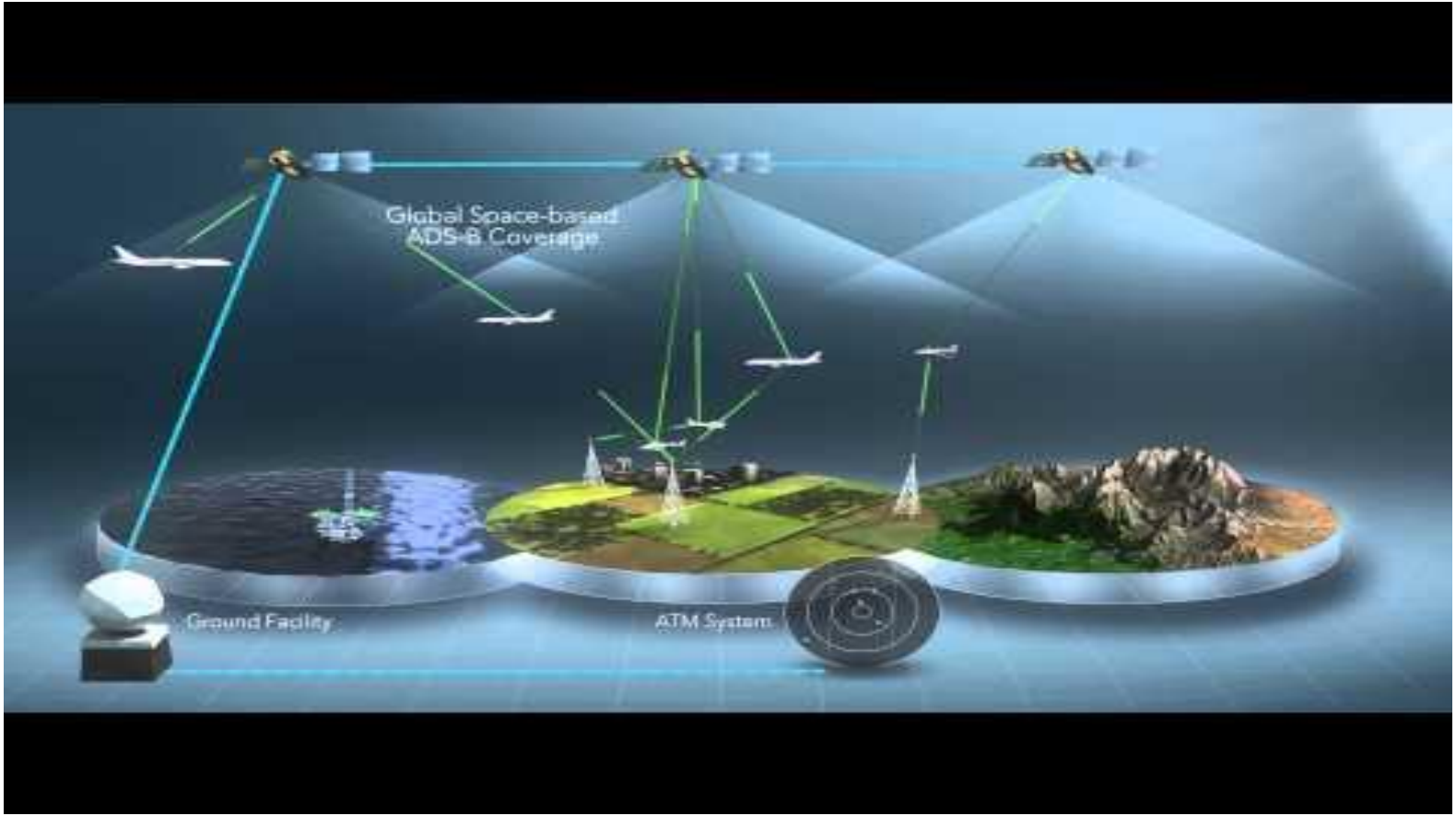
Dependent: It depends on an accurate GNSS signal for position data

Surveillance: It provides "Radar-like" surveillance services, much like RADAR

Broadcast: It continuously broadcasts aircraft position and other data to any aircraft, or ground station equipped to receive ADS-B



Automatic dependent surveillance–broadcast (ADS-B) (cont'd)



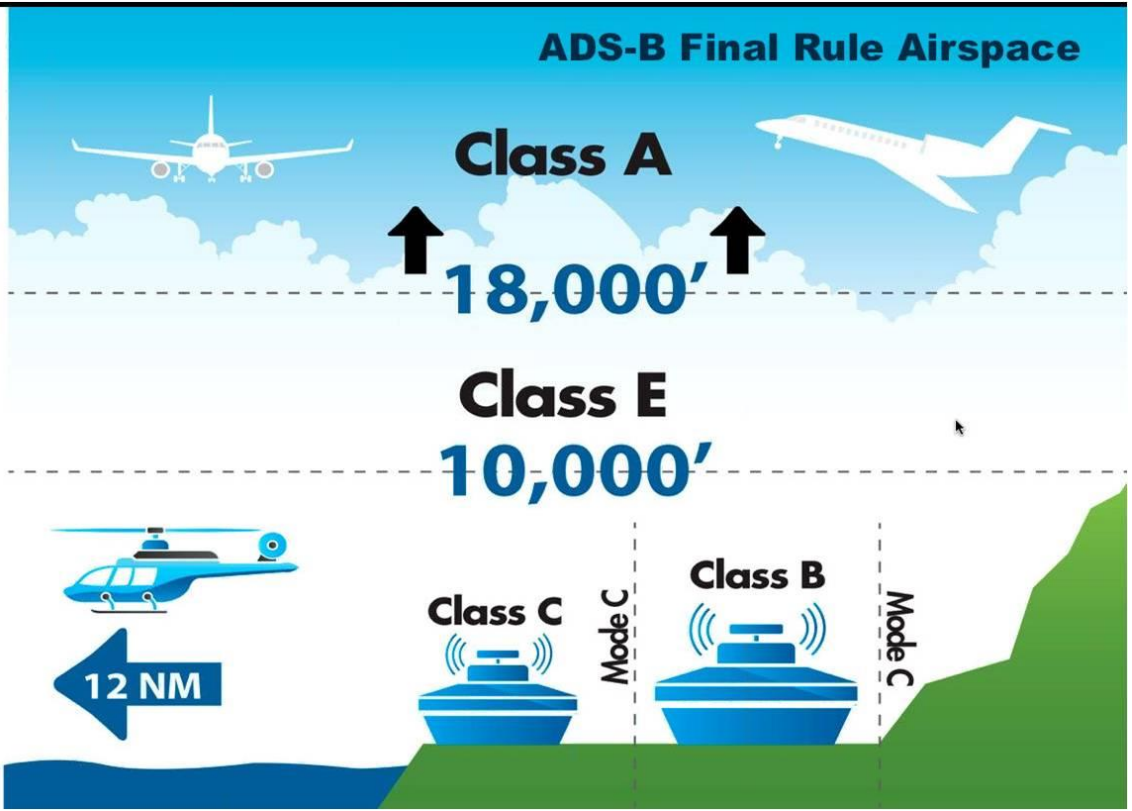
https://www.youtube.com/watch?v=WTRc7qW9EE4&feature=emb_logo

Automatic dependent surveillance–broadcast (ADS-B) (cont'd)

Class A
All airspace at and above 18,000 feet MSL (mean sea level) over the 48 contiguous United States and the District of Columbia.

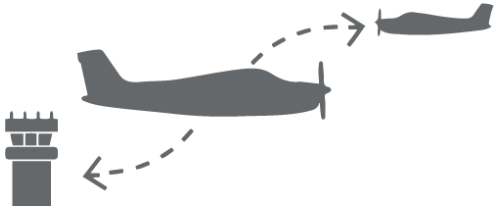
Class B and Class C and
within 30 nautical miles of airports listed above, from the surface up to 10,000 feet MSL.

Class E 10,000 feet and above, and in the Gulf of Mexico from the coastline of the United States out to 12NM, at 3,000 feet MSL and above.



ADS-B Out

- An aircraft determines the information about itself by GPS technology, and broadcasts that information to a network of ground stations;
  - Location, airspeed, altitude and velocity.

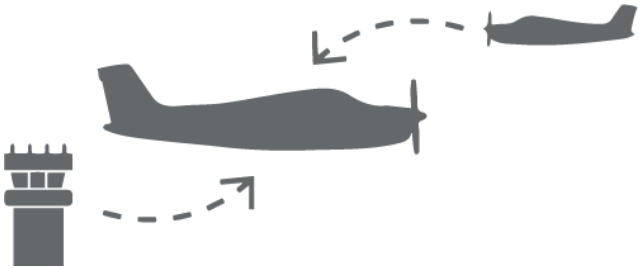


- Provide air traffic controllers with real-time position information of the aircraft. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing;
- Controllers can track the surface movement of aircraft and airport ground vehicles

  →Reduce the risk of taxiway conflicts and runway incursions;
- Surveillance coverage increases because ground stations can be provided in locations where obstructions or physical limitations don't allow radar;
  - More accurate intended time and position of aircraft
  - Achieve optimal flight and traffic flow.
  - Be diverted less often due to weather
- Another ground-based surveillance system that uses ADS-B is Wide Area Multilateration (WAM), which can be installed in locations where radar is limited or can't be used.

ADS-B In

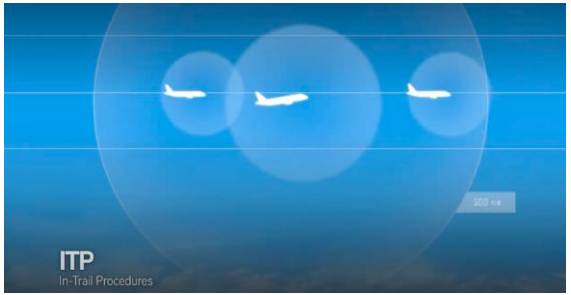
- ATC relay the data to equipped nearby aircraft to receive the data via ADS-B In;
- With ADS-B, an aircraft can receive direct communication from another nearby aircraft;
- ADS-B In provides operators and pilots in the cockpit with:
  - Weather and traffic position information;
  - Nearby aircraft.

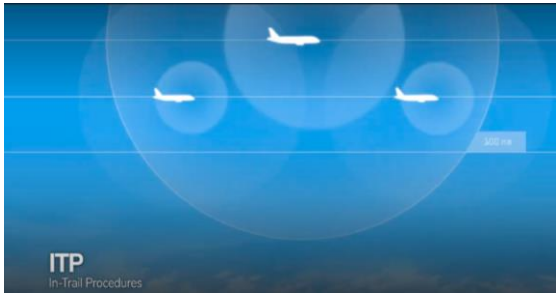


- For general aviation aircraft, ADS-B Traffic Awareness System offers a low-cost alerting capability to prevent aircraft collisions;
- Airborne Collision Avoidance System X (ACAS X) supports access to closely spaced runways in almost all the weather conditions, and flight deck interval management;
- Assist enhanced air traffic control capabilities for closely spaced parallel runway approach operations to integrate with terminal automation systems;
- Research continues by using ADS-B for paired approaches to parallel runways, in which aircraft stay separated enough to avoid wake turbulence while also maintaining a precise relative position to ensure safe separation.

In-trail procedures (ITP)

- Reduce separation between aircraft during oceanic flights;
- Can fly more often at more fuel-efficient or less-turbulent flight levels;
- The FAA is developing interval management applications that use ADS-B Into sequence and space aircraft pairs.
    - More-efficient flight paths in congested airspace and maximizes airspace and airport use.





https://www.youtube.com/watch?v=lJ-deOyB1uM&feature=emb_logo

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

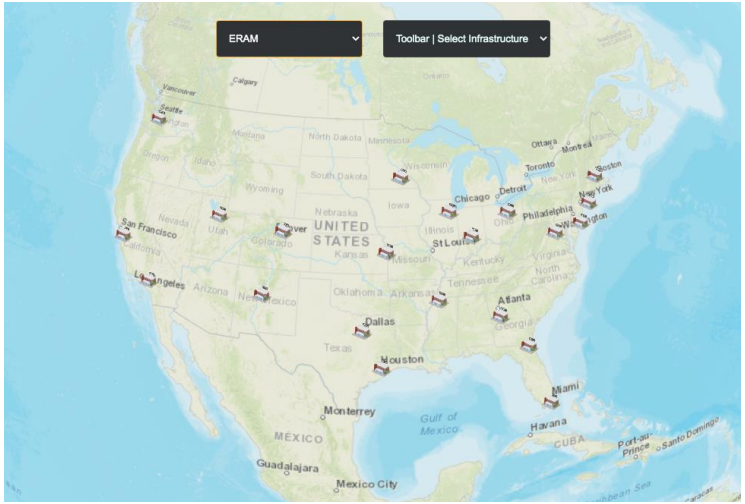
Elements
4. Automation

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Air traffic control computer stations

- NextGen's En Route Automation Modernisation (ERAM)
- Replaced the legacy Host system for en route air traffic control in 2015

	ERAM	Legacy host system
Number of aircraft can be tracked at a time	1900	1100
Number of radars can be processed at a time	64	24



Air traffic control computer stations (cont'd)

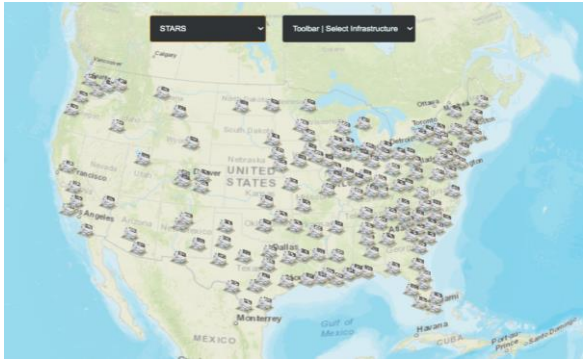
ERAM

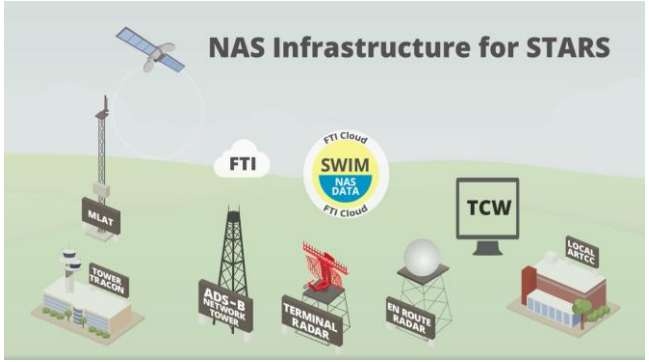
- Pilots
  - Extend the radar coverage beyond facility boundaries
  - Increase flexible routing while:
    - Congestion
    - Weather
  - Real-time ATMS
    - Reframe the flight routes with minimal changes
    - Smoother, faster, and more cost-efficient flights
- Controllers
  - User-friendly interface with customisable displays
  - Trajectory modelling
    - Accurate
    - Maximum airspace use
    - Better conflict detection
    - Better decision making
  - Revolutionize controller training with realistic, high-fidelity system
    - Challenges developmental practices with complex approaches, manoeuvres, and simulated pilot scenarios.

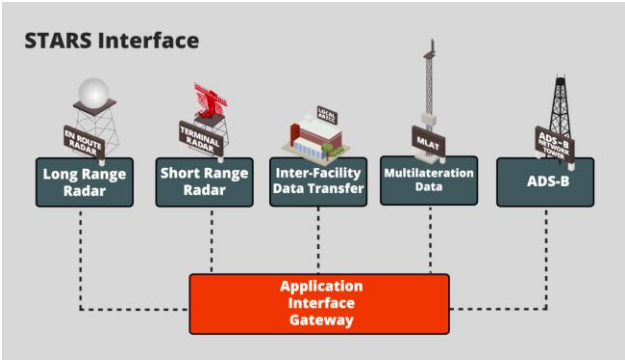
Air traffic control computer stations (cont'd)

STARS is a fully digital system & capable to track all the aircraft within the terminal airspace.

- Separating and sequencing of aircraft;
- Conflict and terrain avoidance alerts;
- Weather advisories;
- Radar vectoring for departing and arriving traffic;
- Maintain safety while increasing cost effectiveness at terminal facilities across NAS;
- Offer an easier-to-maintain infrastructure for technicians.

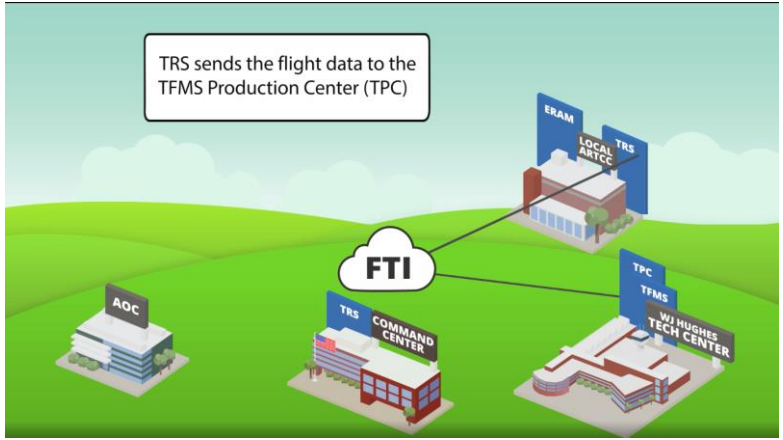


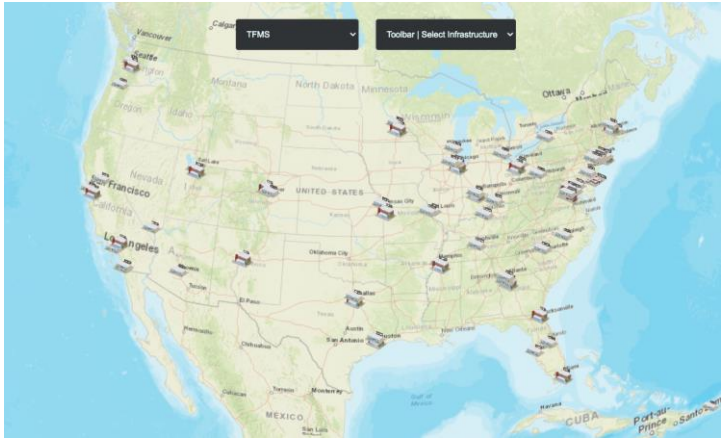




Traffic flow management system (TFMS)

- DSS is to optimize the traffic flow
  1. **Traffic flow management system (TFMS)**
     - Can view all aircraft traffic data e.g. demand and capacity, flight time, routes, and delay;
     - Regulate air traffic flow, manage throughput, and plan for future air traffic demand;
     - Exchange information and support other DSS through system wide information management (SWIM);
     - Provide arrival management/situational awareness;
     - Provide airborne metering and balance demand with capacity;
     - Provide departure scheduling to traffic managers and predict demand/capacity imbalances;
     - Reduce delays, travel time, and fuel expenses.

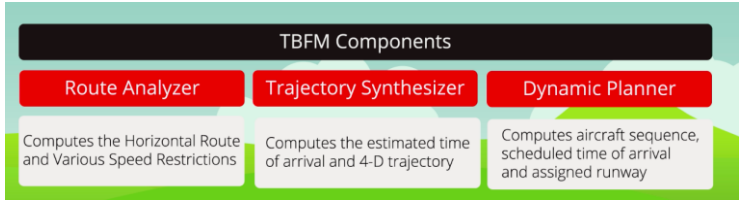




Time based flow management (TBFM)

2. Time based flow management (TBFM)

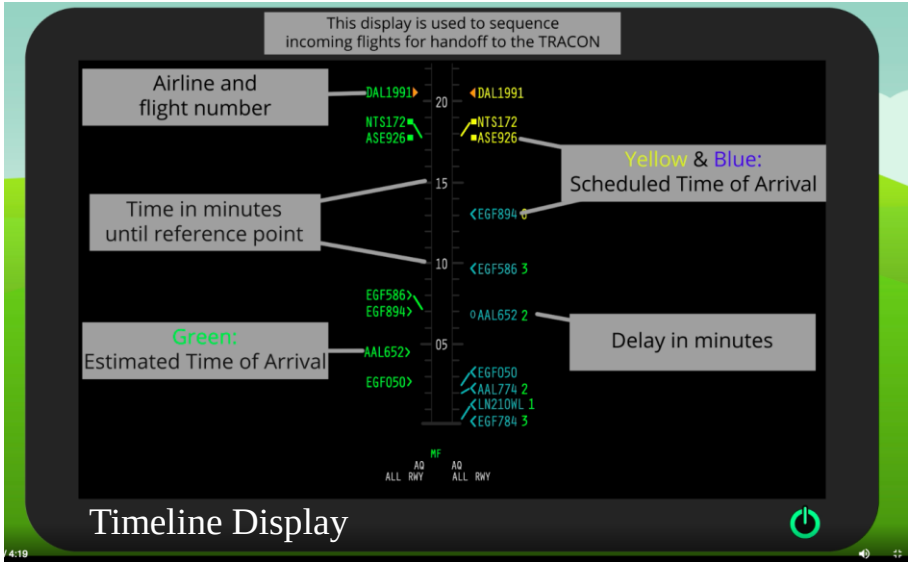
- Allow traffic management units to schedule and optimise the arrival load for major airports;
- Extended metering and integrated departure arrival capability are the tools to help controllers sequence traffic with time instead of distance;
- Implement TMA's adjacent metering capability at additional locations;
- Implement TMA at additional airports;
- Implement TSAS at five key airports;
- Integrated departure and arrival capability (IDAC).

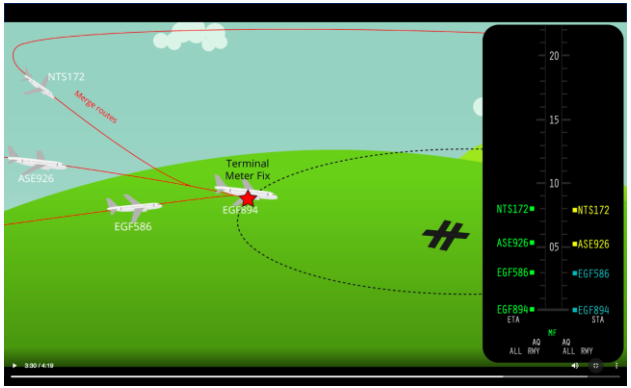


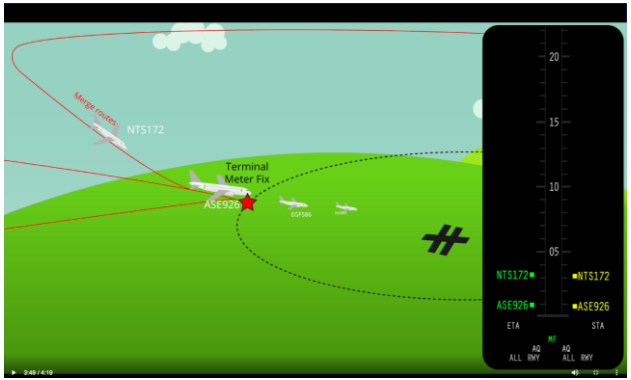
Time based flow management (TBFM) (cont'd)

Benefits:

- Enable controllers to more accurately deliver aircraft to the TRACON facilities;
- Provide opportunity for aircraft to fly optimised descents;
- Expand Time Based Metering to additional geographical areas;
- Increase departure time compliance.

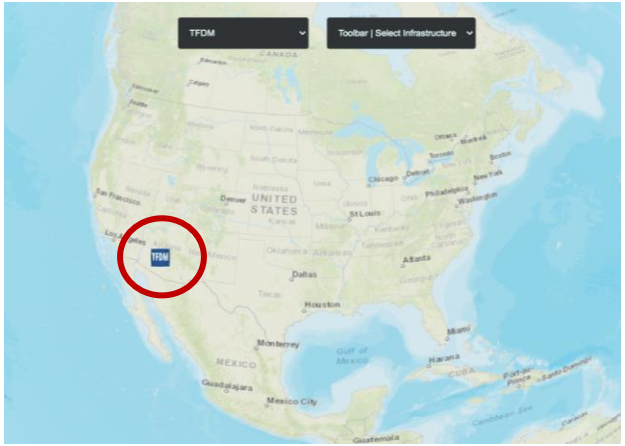






Terminal flight data manager (TFDM)

3. **Terminal Flight Data Manager (TFDM)**
   - NextGen's surface management solution, delivers decision support capabilities on the airport ground;
   - Integrate flight, surface surveillance, and traffic management information using SWIM (consolidate some previously independent systems);
   - Consist of electronic flight strips, departure queue management, surface management, and surface situational awareness;
   - Provide Electronic Flight Data exchange and Electronic Flight Strips in the tower;
   - Provide Departure Scheduler metering with live data;
   - Enhances real-time data exchange with stakeholders (TRACON, ATC Tower, ARTCC, Flight Operators);
   - Traffic Flow Management feed of data into TBFM(Time Based Flow Management)/TFMS(Traffic Flow Management System) to more efficiently perform overhead slot management.

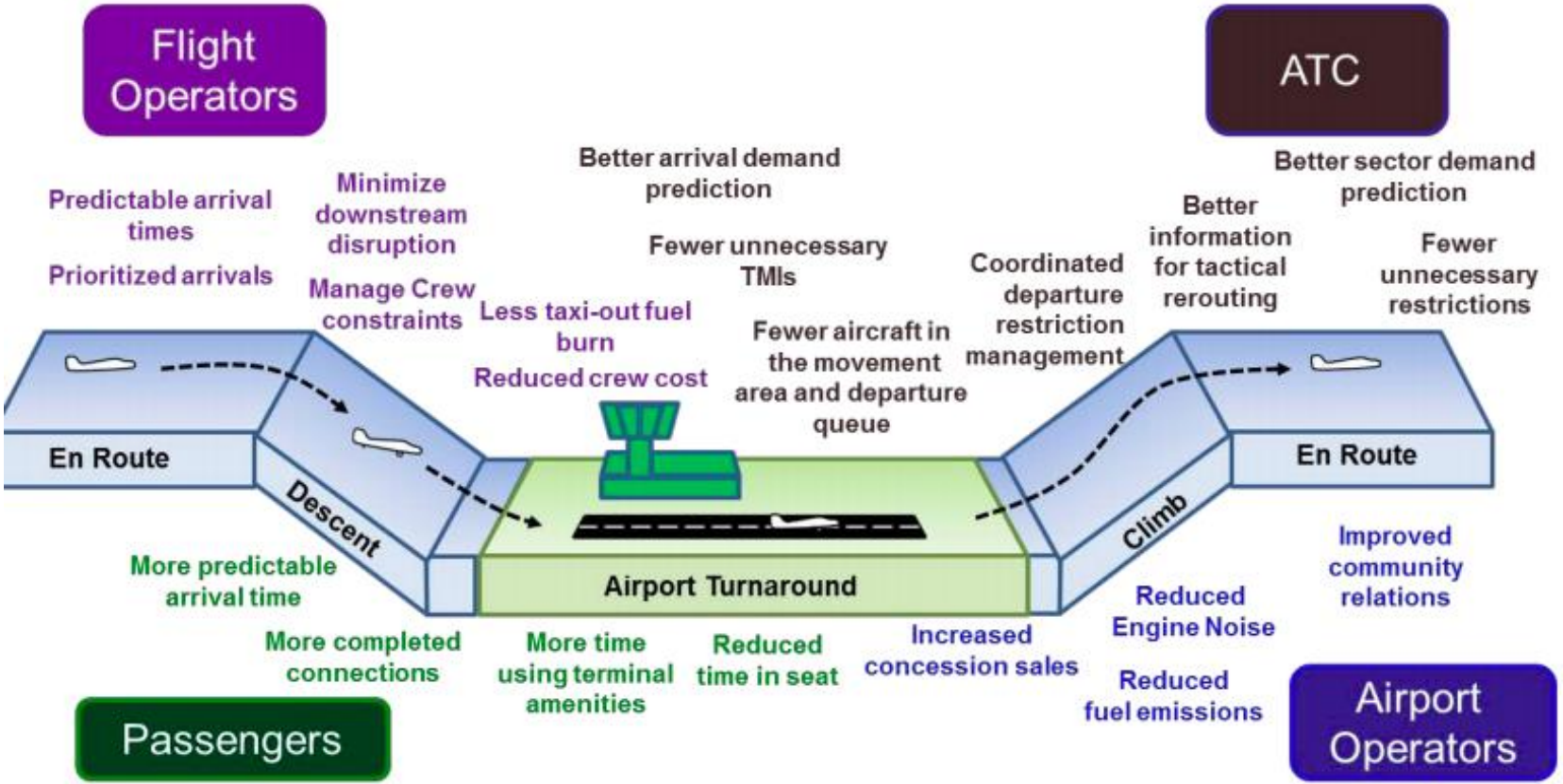


Terminal flight data manager (TFDM) (cont'd)

Benefits

- Maximise airport efficiency and reduce delays by providing ATC with optimised options for streamlining aircraft departure sequence, while accounting for aircraft arrivals and delays;
- Increase surface situational awareness, resulting in fewer delays and restrictions, fewer aircraft in the movement area and improved departure queue management;
- Improve schedule predictability, decreases taxi time/out fuel burn and improves crew utilization.

Estimated benefits of TFDM



Advanced technologies and oceanic procedures (ATOP)

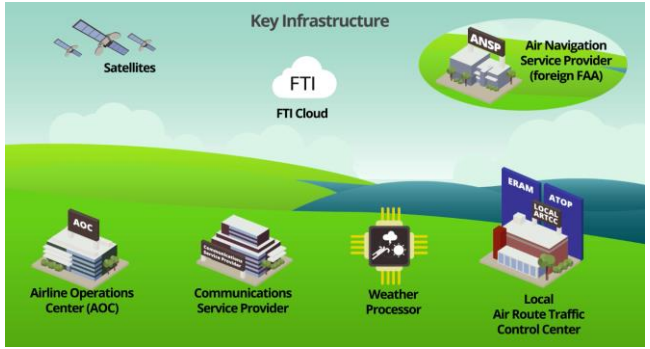
The most advanced mixed mode air traffic control (ATC) system in the world, to replace existing oceanic air traffic control systems and procedures.

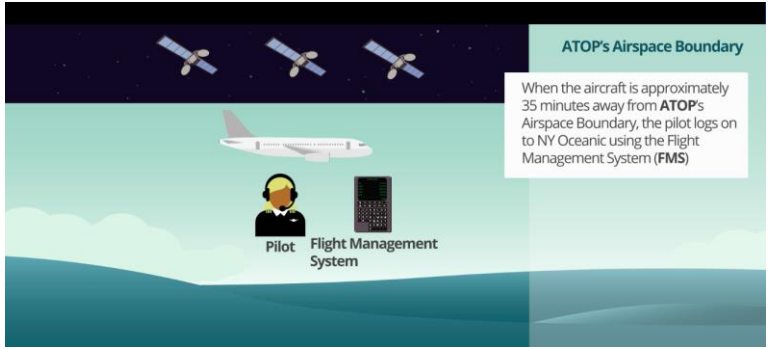
- Integrate flight and radar data processing;
- Detect conflicts between aircraft;
- Provide satellite data link communication and surveillance;
- Eliminate paper flight strips;
- Provide real-time aeronautical information;
- Increase flexibility in routing aircraft around congestion, weather and other airspace restrictions;
- Enable seamless information sharing and coordination between controllers and en route centres.

Benefits:

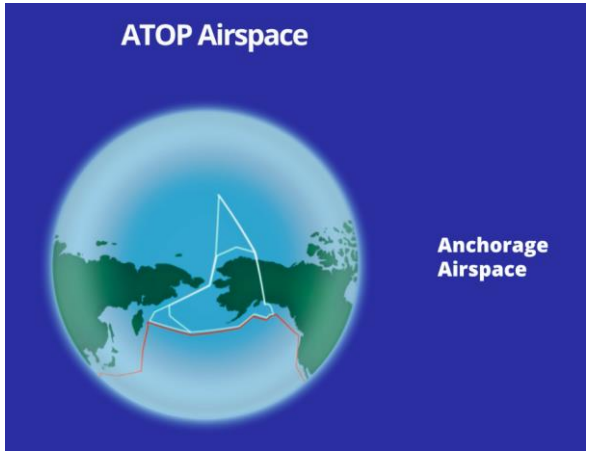
- Increase capacity and improve efficiency in skies;
- Improve automated navigation and conflict detection services;
- Automate manual processes, therefore controller can safely handle airline requests for more efficient tracks or altitudes over long oceanic routes, and focus on only the “out of the ordinary” activities;
- Reduce controllers’ workloads and stress, increase collaboration, and seamless data sharing between centres;
- Increase flexible routing, and radar coverage which leads to smoother, faster, and more cost-efficient flights for pilots;
- Provide a very advanced platform to experiment and implement concepts for the future Next Generation Air Transportation System

Advanced technologies and oceanic procedures (ATOP) (cont'd)





ATOP is used at all three oceanic en route traffic control centres, which are in Anchorage, New York, and Oakland.



THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
5. Information System

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

System wide information management (SWIM)

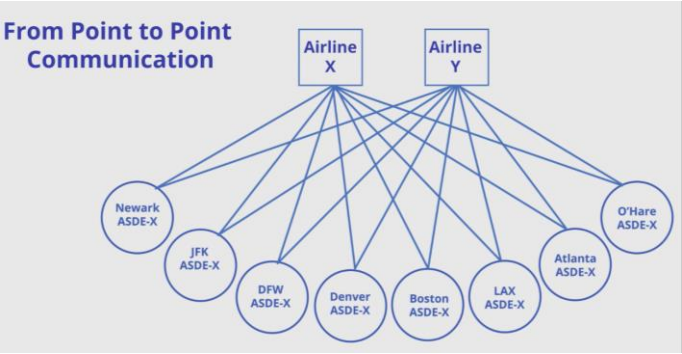
SWIM is the national airspace data sharing infrastructure, which enables Air Traffic Management-related information sharing among diverse qualified systems.

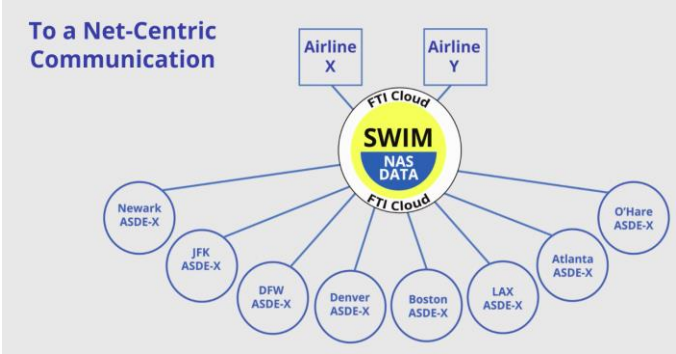
- SWIM Terminal Data distribution Systems (STDDS) convert raw surface data at Towers and send it to Terminal Radar Approach Control (TRACON) facility;
- STDDS will provide surface data to the Traffic Flow Management System which controllers use to balance traffic demands with capacity across the NAS;
- SWIM Flight Data Publication Service (SFDPS) will improve flight data sharing and ensure consistency of this data cross the NAS.

- Real-time flight Data
- Weather information
- Surveillance
- Special use airspace status
- Airport Operational status

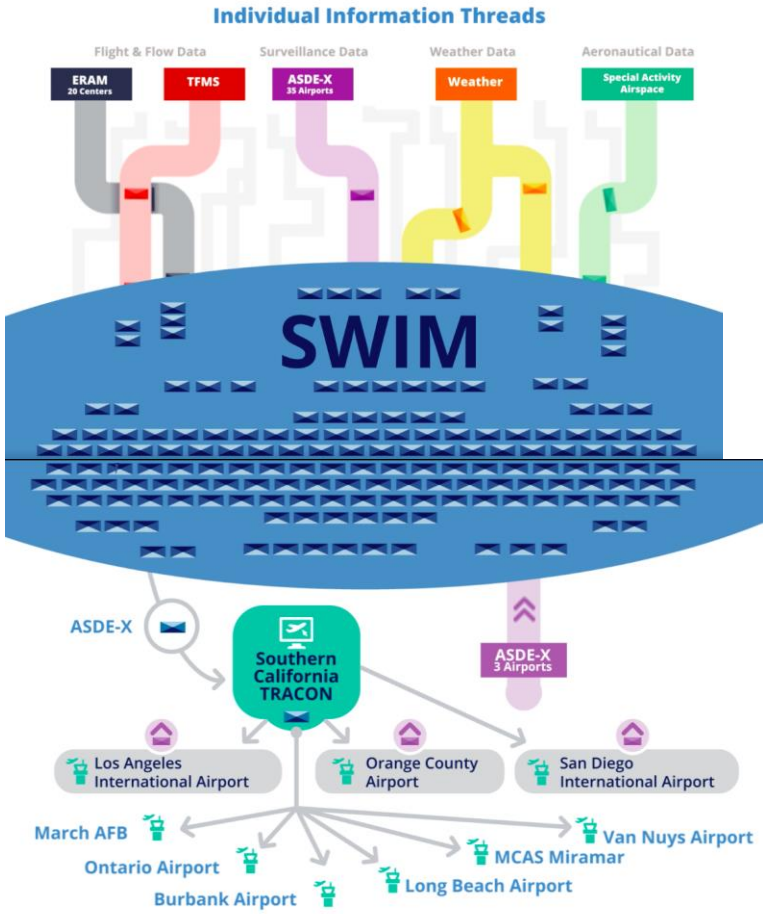
Benefits

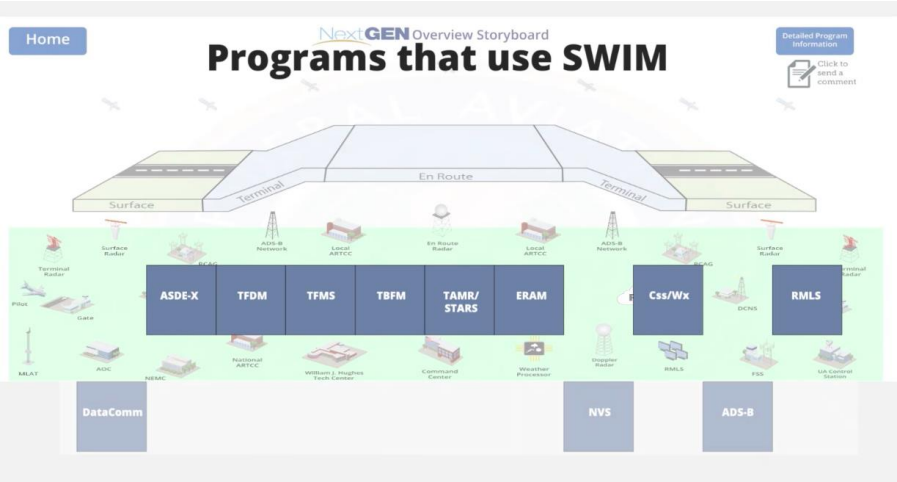
- Increase and improve products from SFDPS;
- Increase security of NAS data flows with Identify and Access Management;
- Add new data query functionality to the NAS;
- Enable efficient transition to global harmonization of information standards.

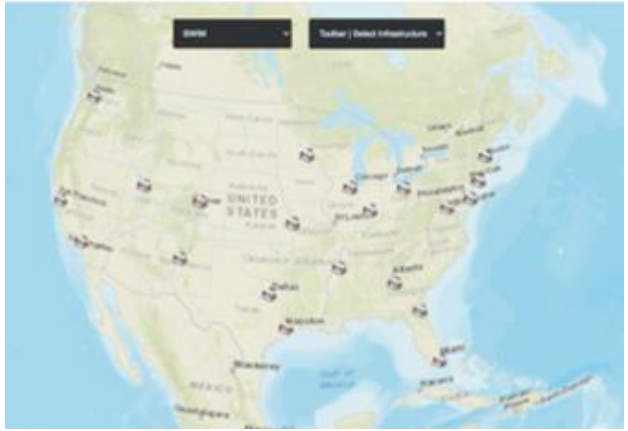




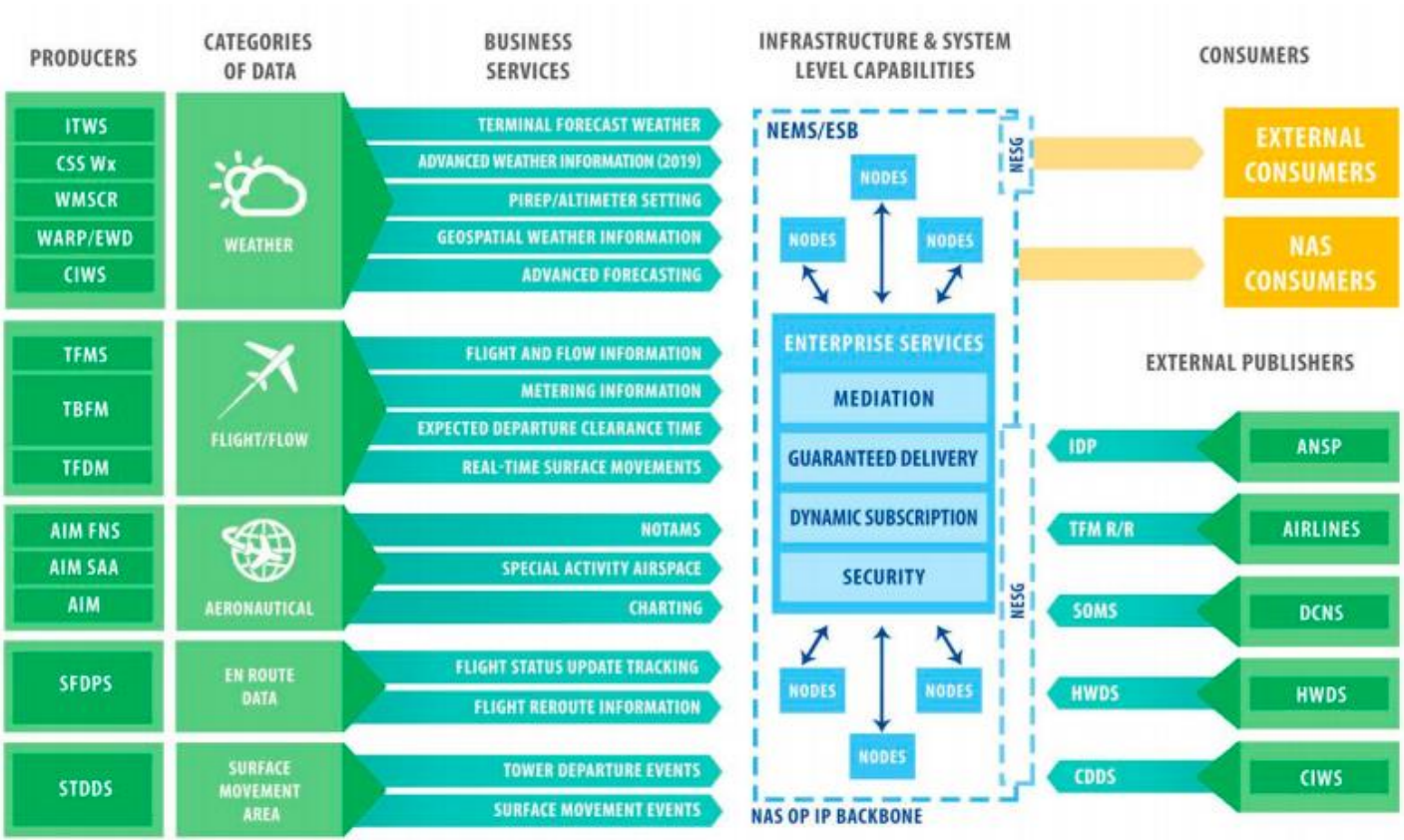
SWIM (cont'd)


Individual Information Threads
Flight & Flow Data
Surveillance Data
Weather Data
Aeronautical Data
ERAM
20 Centers
TFMS
ASDE-X
35 Airports
Weather
Special Activity Airspace
SWIM
ASDE-X
Southern California TRACON
ASDE-X
3 Airports
Los Angeles International Airport
Orange County Airport
San Diego International Airport
March AFB
Ontario Airport
Burbank Airport
Long Beach Airport
MCAS Miramar
Van Nuys Airport

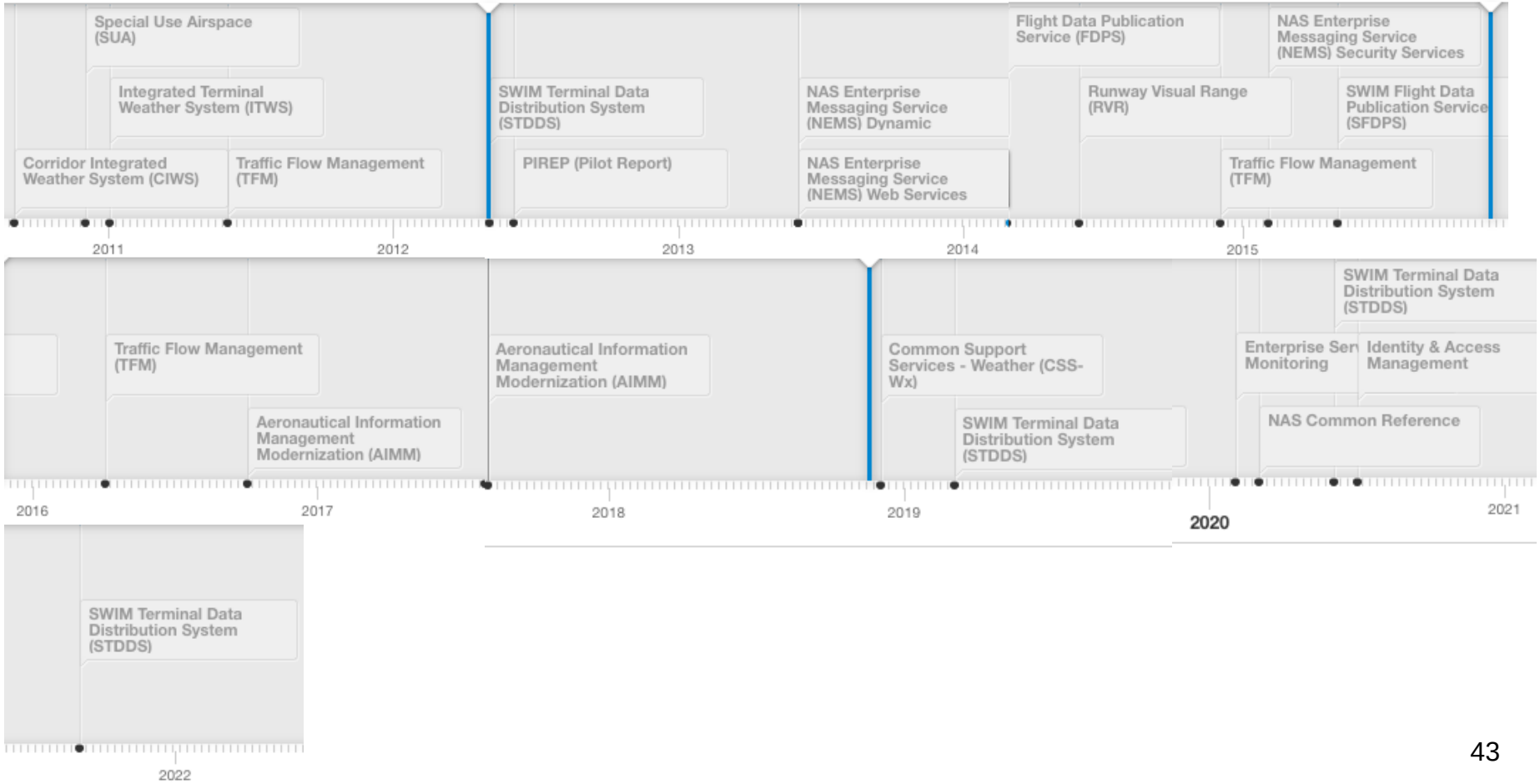

Home
NextGEN Overview Storyboard
Programs that use SWIM
Detailed Program Information
Click to send a comment
Surface
Terminal
En Route
Terminal
Surface
ASDE-X
TFDM
TFMS
TBFM
TAMR/ STARS
ERAM
Css/Wx
RMLS
DataComm
NVS
ADS-B



SWIM (cont'd)


PRODUCERS
CATEGORIES OF DATA
BUSINESS SERVICES
INFRASTRUCTURE & SYSTEM LEVEL CAPABILITIES
CONSUMERS
ITWS
CSS Wx
WMSCR
WARP/EWD
CIWS
WEATHER
TERMINAL FORECAST WEATHER
ADVANCED WEATHER INFORMATION (2019)
PIREP/ALTIMETER SETTING
GEOSPATIAL WEATHER INFORMATION
ADVANCED FORECASTING
TFMS
TBFM
TFDM
FLIGHT/FLOW
FLIGHT AND FLOW INFORMATION
METERING INFORMATION
EXPECTED DEPARTURE CLEARANCE TIME
REAL-TIME SURFACE MOVEMENTS
AIM FNS
AIM SAA
AIM
AERONAUTICAL
NOTAMS
SPECIAL ACTIVITY AIRSPACE
CHARTING
SFDPS
EN ROUTE DATA
FLIGHT STATUS UPDATE TRACKING
FLIGHT REROUTE INFORMATION
STDDS
SURFACE MOVEMENT AREA
TOWER DEPARTURE EVENTS
SURFACE MOVEMENT EVENTS
NEMS/ESB
NODES
NODES
NODES
ENTERPRISE SERVICES
MEDIATION
GUARANTEED DELIVERY
DYNAMIC SUBSCRIPTION
SECURITY
NODES
NODES
NODES
NESG
NESG
NAS OP IP BACKBONE
EXTERNAL CONSUMERS
NAS CONSUMERS
EXTERNAL PUBLISHERS
IDP
ANSP
TFM R/R
AIRLINES
SOMS
DCNS
HWDS
HWDS
CDDS
CIWS

SWIM (cont'd)


Special Use Airspace (SUA)
Integrated Terminal Weather System (ITWS)
Corridor Integrated Weather System (CIWS)
Traffic Flow Management (TFM)
SWIM Terminal Data Distribution System (STDDS)
PIREP (Pilot Report)
NAS Enterprise Messaging Service (NEMS) Dynamic
NAS Enterprise Messaging Service (NEMS) Web Services
Flight Data Publication Service (FDPS)
Runway Visual Range (RVR)
NAS Enterprise Messaging Service (NEMS) Security Services
SWIM Flight Data Publication Service (SFDPS)
Traffic Flow Management (TFM)
2011
2012
2013
2014
2015
Traffic Flow Management (TFM)
Aeronautical Information Management Modernization (AIMM)
Aeronautical Information Management Modernization (AIMM)
Common Support Services - Weather (CSS-Wx)
SWIM Terminal Data Distribution System (STDDS)
SWIM Terminal Data Distribution System (STDDS)
Enterprise Ser Monitoring
Identity & Access Management
NAS Common Reference
2016
2017
2018
2019
2020
2021
SWIM Terminal Data Distribution System (STDDS)
2022

NextGen weather program

- Help to reduce the impact of weather on aviation

  → Safer, more efficient and predictable day-to-day National Airspace System (NAS) operations.

- Prevent as many as 66% of weather-related delays and cancellations
  - 69% of system-impacting delays are resulted by the weather.

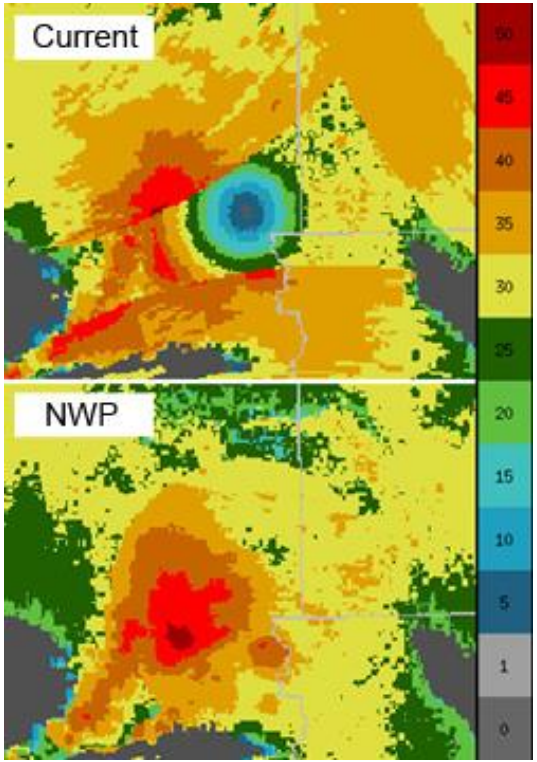
NextGen weather processor (NWP)

1. NextGen Weather Processor (NWP)

Combine information from weather radars, satellites, lighting, and other sources to identify terminal and en route safety hazards to reduce weather-related air traffic delay up to eight hours.

- Establish a common weather processing platform to replace the legacy FAA weather processor systems and supply new capabilities;
- Fully automated NWP will identify safety hazards around airports and in cruising altitude airspace;
- Support strategic traffic flow management, including the translated weather information;
    - Predict route blockage and airspace capacity constraints up to eight hours in advance.
- Use advanced algorithms to create current and predicted aviation-specific weather information with data from the FAA and National Oceanic and Atmospheric Administration (NOAA) radar and sensors, and NOAA forecast models;
- Aviation Weather Display (Part of the NWP) consolidates the current Weather and Radar Processor, Integrated Terminal Weather System, and the Corridor Integrated Weather System displays.
    - Provide consistent weather information immediately for en route and terminal controllers and include NWP and NOAA weather products.

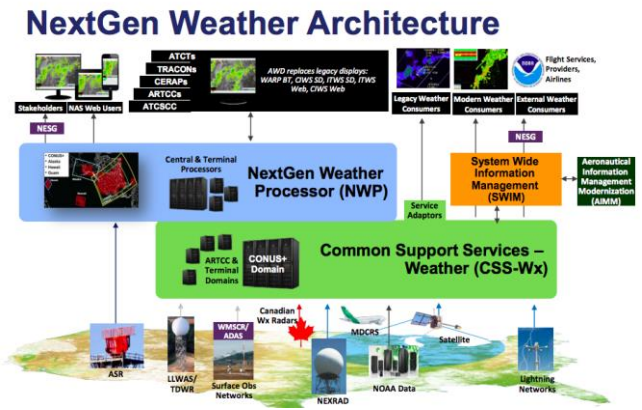
NextGen weather processor (NWP) (cont'd)



The Current mosaic is range limited, leading to poor high-altitude coverage directly over the centre radar and curved artifacts from the other radars.

The NWP Echo Tops mosaic provides a realistic, artifact-free image that does not exaggerate echo tops values at long range.

NWP improvement in Echo Tops mosaics, an important product for determining En Route airspace availability.

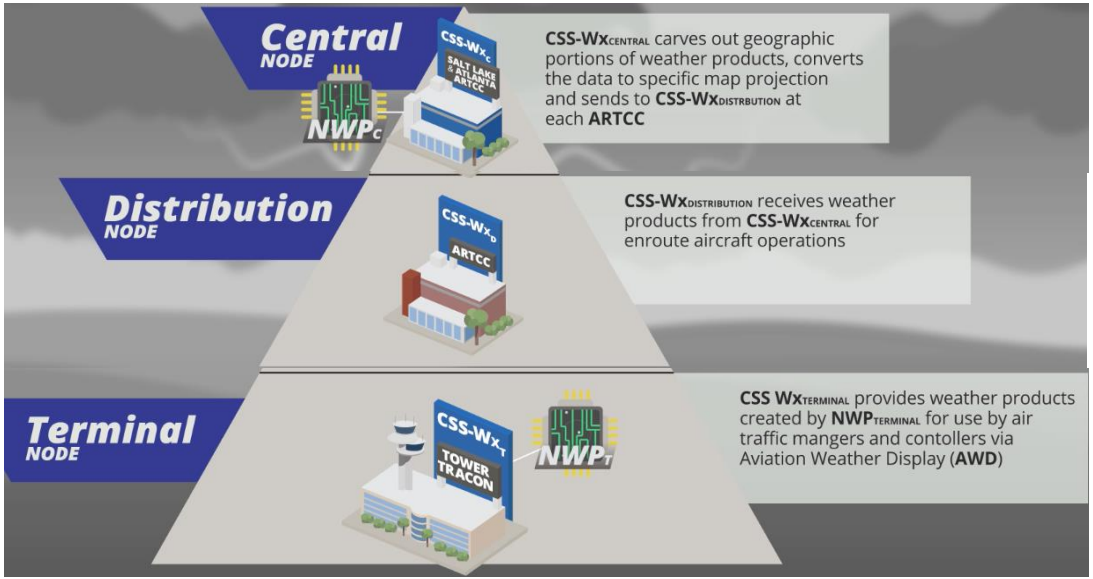


- ✓ Provide a consistent weather picture, with timely analyses and short-term predictive elements tailored to specific aviation requirements;
- ✓ Translate weather picture into reliable airspace constraints for integration into air traffic decision-making;
- ✓ Enable safe, timely, and efficient operation of the National Airspace System (NAS) in all kinds of weather and seasons;
- ✓ Consolidate multiple FAA weather programs with overlapping capabilities into a single NextGen Weather System.

2. Common support services – weather (CSS-Wx)

The single provider of weather data, products, and imagery within the NAS, and using standards-based weather dissemination via SWIM.

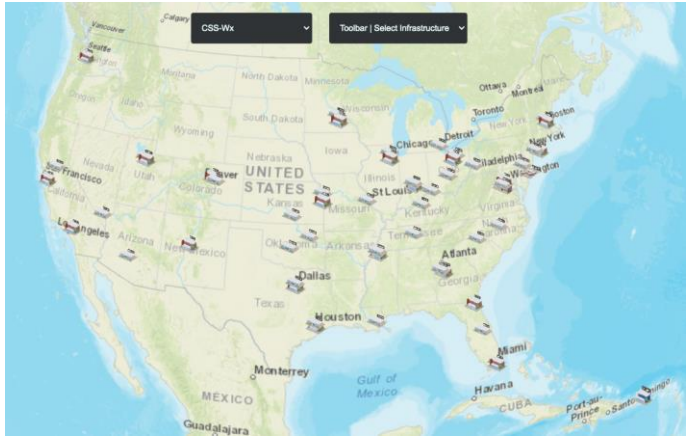
- Provide a single source for FAA weather information and establishes enterprise level common support services with SWIM;
- Provide weather data sets in broadly adopted geographic standardized formats;
- Provide image map rendering for consumer displays;
- Filter weather information to provide user-specific subsets;
- Enable the decommissioning of legacy weather dissemination systems.



CSS-Wx (cont'd)

Benefits

- Facilitate consistent weather information
  - Publish weather datasets in broadly-adopted geographic standardized formats;
  - Simplify global, national and inter-agency data exchange.
- Increase NAS weather access
  - Increase availability of common weather information;
  - Provide image map rendering for consumer display.
- Reduce interface development costs
  - Eliminate custom point-to-point interfaces;
  - Transform products into NAS legacy formats;
  - Store and archive aviation weather data set.
- Reduce infrastructure / bandwidth costs
  - Filter weather information to provide user-specific subsets;
  - Partners with SWIM to achieve enterprise-wide bandwidth efficiency;
  - Provide hosted algorithm capability to support tailored product generation and display.
- Reduce FAA Operations Costs ($2 billion USD cost avoidance over 25 years lifecycle)
- Integrate NWP and NOAA weather products in into air traffic decision support systems,
  - Improve the quality of traffic management decisions and enhance controller productivity during severe weather.



THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

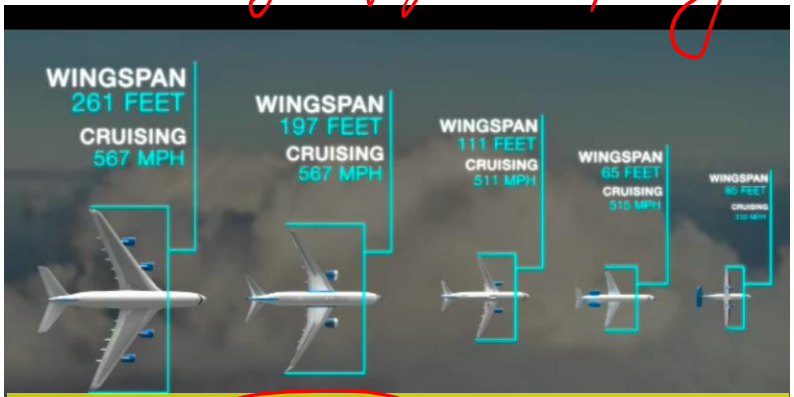
Elements

6. Multiple Runway Operations and Separation Management

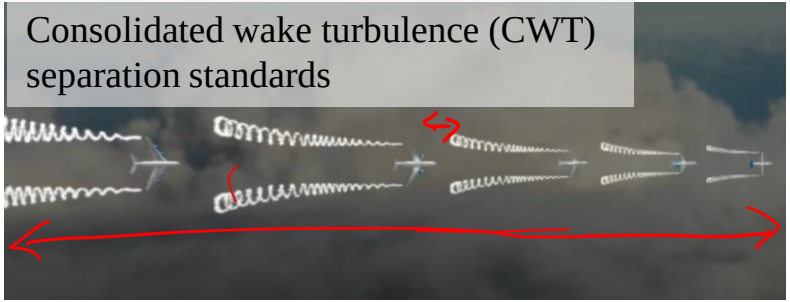
Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Multiple runway operations (MRO)

- MRO limited by the safety risk, including collision avoidance and the interplay of wake vortices (also known as wake turbulence) with nearby aircraft;
- Speed weight and wingspan impact the strength of the wake or turbulence and aircraft creates and its reaction to the wake of an aircraft in front of it;
- The longer the required distance, the fewer aircraft can take off and land;
- MRO advancements improve access to closely spaced parallel runways to enable more departure and arrival operations during instrument meteorological conditions;
- FAA has recategorize the separation standards to increase efficiency and capacity while reducing flight delays.



✓ Boost the capacity 20%
✓ Allow 22 more arrivals per hours.



MRO (cont'd)

- Consolidated wake turbulence (CWT) aims to use the best set of separation standards derived from these phases;

	Past	2013
Separation Standard (feet)	4300	3600
Staggered diagonal separation		Do not have to maintain

- New procedures in 2015
  - 3900 ft (triple independent approaches)
  - 3000 ft (offset dual independent approaches without requiring high-update-rate radar or Automatic Dependent Surveillance–Broadcast)
  - 2500 ft (dual dependent approaches); the diagonal spacing is reduced from 1.5 nautical mile (nm) to 1 nm.
- Enable the use of simultaneous approaches in low-visibility conditions;
- Decrease separation for approaches to runways with stricter spacing requirements;
- Reduce the effects of wake turbulence that leads to increased separation.

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
7. Low-Visibility Operations

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Enhanced flight vision system (EFVS)

- An installed aircraft system that uses a HUD or equivalent display to present:
  - Aircraft Information
  - Flight Symbology
  - Electronic real-time sensor image of the forward external scene
  - ✓ Enhanced flight visibility
  - ✓ Average forward horizontal distance
  - ✓ Prominent topographical objects may be clearly distinguished and identified by day or night
- Replace natural vision by EFVS to conduct an instrument landing procedure in low-visibility conditions;
- A clear, real-time virtual image of the view outside the aircraft is provided to the pilot, regardless of the cloud cover and visibility conditions;
- A synthetic vision guidance system combines flight guidance display technology with high-precision position assurance monitors to provide a continuous and correct depiction of the external scene and runway;

  → Assist a pilot's transition to natural vision references
- Enable taxiing at airports in low-visibility conditions.

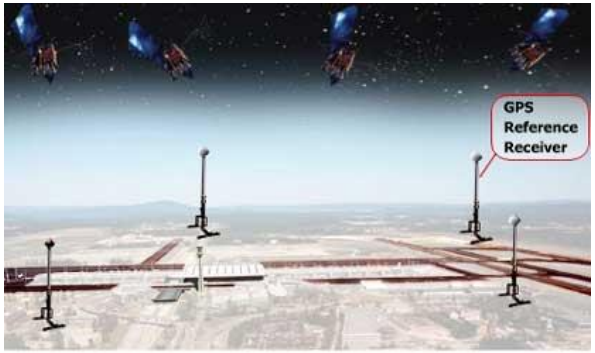
Ground based augmentation system (GBAS)

- Provide differential corrections and integrity monitoring of Global Navigation Satellite Systems (GNSS);
- Provide navigation and precision approach service in the vicinity of the host airport;
- Broadcast its differential correction message via a very high frequency (VHF) radio data link from a ground-based transmitter.

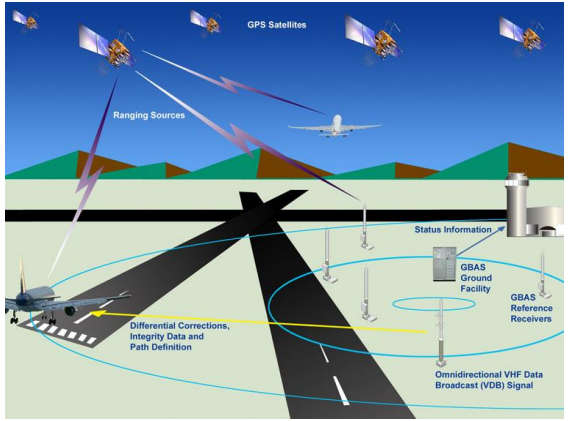
✓ High accuracy

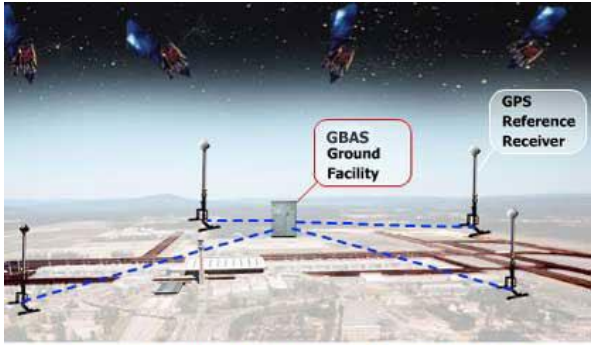
✓ Availability

✓ Integrity necessary



GPS Reference Receivers Calculate Position





GBAS Ground Facility (LGF) Calculates Errors in GPS Position and Formulates the GBAS Correction Message

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Elements
8. Safety

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

NextGen safety management system (SMS)

- An integrated safety risk management (ISRM) for research and development, prototyping, testing and evaluation, and flight trials and demonstrations;
- Enable aircraft to fly more precise approaches within coverage of ground-based or satellite-based navigation aids;
- All new capabilities are implemented only after thorough safety testing and must maintain safe operations in NAS;
- Incorporate risk-based decision-making to support agency-wide safety initiatives;
- Program teams can access centralised data to provide a holistic perspective on system risks with the following resources:
    - Hazard identification
    - Risk management
    - Tracking tool
    - Aviation system information analysis and sharing
    - System safety management transformation
    - Airport surface anomaly investigation capability tool
- Identify safety issues by assessing risk across organizational, system, and program boundaries, and rely on FAA-wide collaboration to capture the most relevant safety information to assist in decision-making;
- Improved risk analysis processes and new safety intelligence tools help safety analysts go beyond examining past accident data to detecting risk, evaluate potential safety risk mitigations and implement mitigation strategies for accident prevention;
- Latest goal: lower the U.S. commercial fatality risk another 50 percent by 2025 from the 2010 rate.

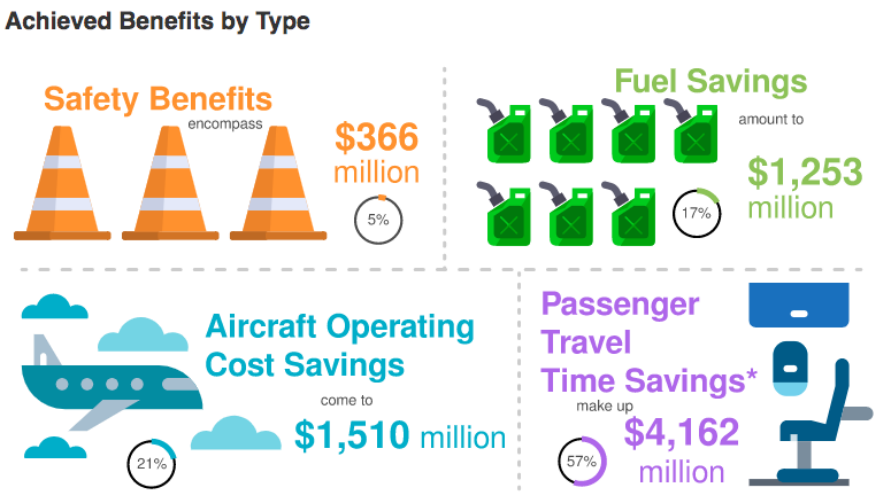
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Performance

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

$ 7 billion in benefits

Generated by the implemented capabilities between 2010 - 2019



Terminal Sequencing and Spacing (TSAS) and Flight Deck Interval Management (FIM)

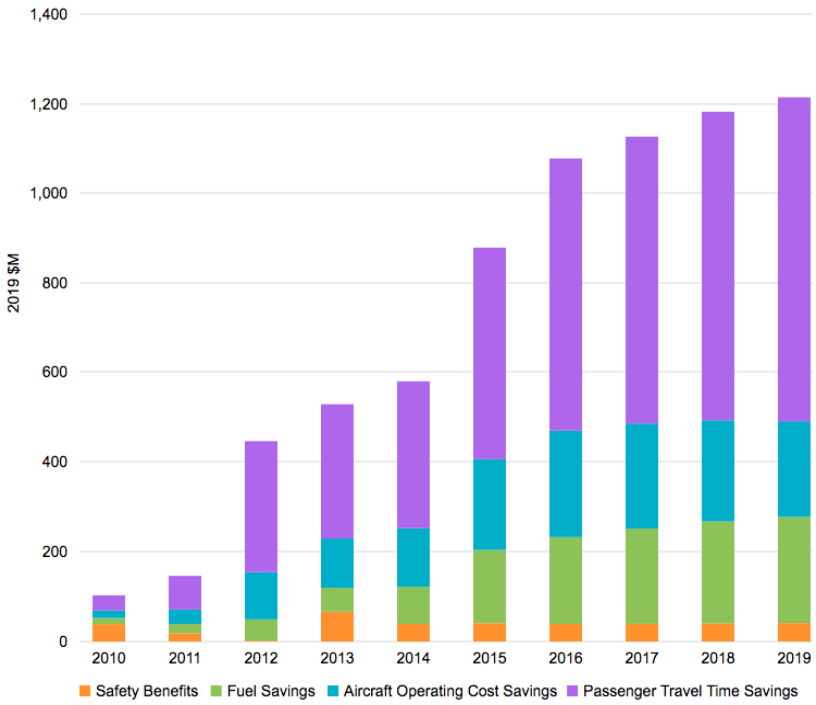
- Forecast $500 million national fuel savings

Integrated Arrival, Departure, Surface Operations

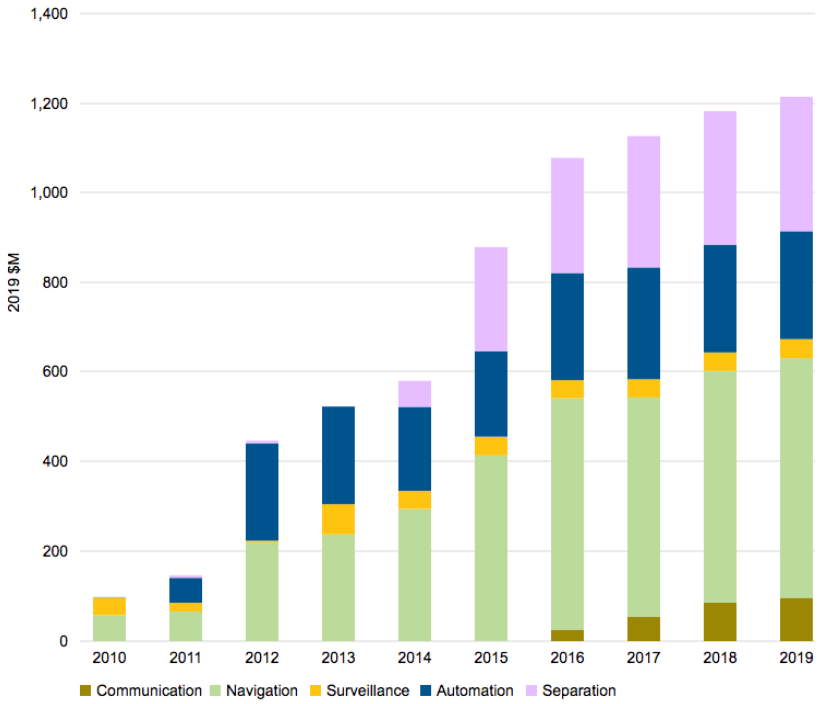
- 2.8 million pounds of fuel saved and CO2 emissions reduction equivalent to 63,101 urban trees, 2,122 hours reduced engine runtime (as of July 31, 2019 CLT trials)

Efficient re-routes around weather which are more direct, fuel-efficient, wind optimal, conflict free, and avoid congested airspace.

Achieved benefits



By Year by Type



By Year by Domain

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Concerns

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

High-confidence control algorithms

- Fundamental design decision;
- Level of decentralisation that balances system safety and efficiency;
- New surveillance technologies that use satellite navigation, such as ADS-B, can potentially be used to shift air traffic control to a more distributed architecture;
- Channel variations and interference with existing secondary radar replies can affect ADS-B systems;
- The use of data transmitted from aircraft for surveillance also raises concerns about vulnerability to GPS jamming and spoofing.

Over budget and behind schedule

In 2003, NextGen was slated to be fully deployed by 2025 to replace the use of ground-based radar with satellite-based GPS technology.

- Several key NextGen features have been delayed from 2025 to 2030, and others have been delayed indefinitely;
- Starting with the initial 2007 investments and continuing through to 2030, NextGen will cost about $20.6 billion, or $2.6 billion more than its 2012 projection;
- Breakdown of direct government costs:
    - $16 billion for facilities and equipment
    - $3.1 billion for operations
    - $1.5 billion for research and development
- Aviation industry partners will pay about $15 billion for new equipment and training;
- For 2020, the FAA is asking for $1.37 billion for the NextGen program;

According to a 2016 MITRE Avionics Coster Report, the total equipage cost estimate for commercial aircraft from 2015 – 2030 is $4.9 billion.

Possible causes and solution of NextGen delays

Causes

1. A government agency is ill-suited to manage airspace
   - Fundamental mismatch between the FAA's role as a regulatory agency and its ATC function;
   - FAA's identity as "an organisation that prioritises day-to-day operations over more strategic and policy-driven change over time.";
   - Inability to make key decisions "that will determine NextGen capabilities, timing, and costs";
   - Frequent management turnover.
2. Aircraft operator reluctance to equip their aircraft
   - Expense and uncertainty;
   - FAA inability to accurately define requirements for the system's more advanced capabilities.
3. Uncertainty over the length and amount of funding
4. Reluctant to embrace technologies not developed in-house

Possible causes and solution of NextGen delays (cont'd)

Solution

- A self-sufficient entity funded by user fees rather than congressional appropriations. A non-governmental corporation could also seek financing from the private sector.
  - More stable and predictable funding stream;
  - More responsive to its users, rather than to politicians.
- Legislation to spin off the ATC system from the FAA was introduced in 1976. The Heritage Foundation released a similar proposal in 1982;
- Approximately 60 other countries, including the U.K., Germany, and Canada, have separated their ATC functions from their government civil-aviation authorities.

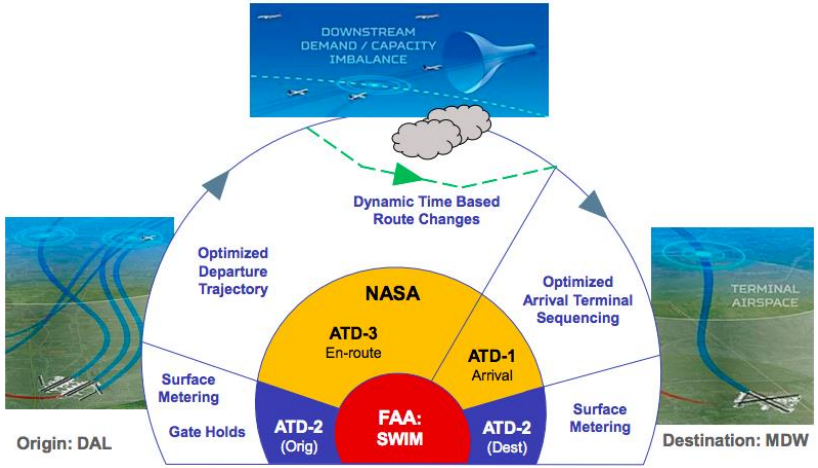
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

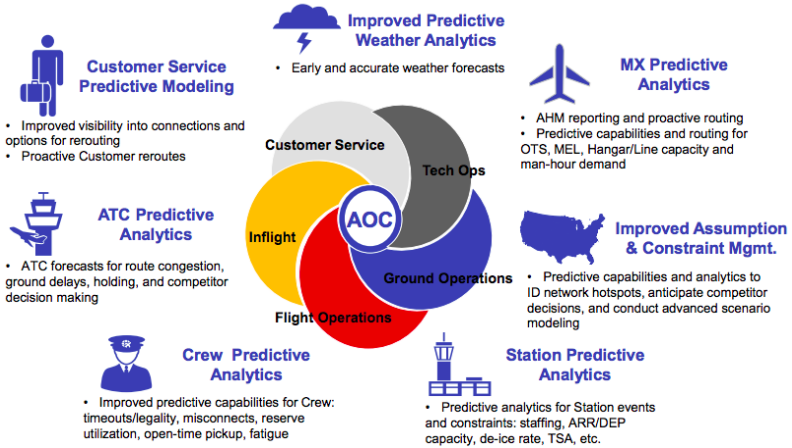
ATD

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Airspace technology demonstration (ATD)

- ATD project team has developed an Integrated Arrival/Departure/Surface (IADS) technology which has been demonstrated in an operational environment and high-fidelity simulations.
- Aim to drive optimal network level solutions with:
  - Much richer datasets
  - More robust processing capabilities
  - Advanced analytics





ATD-1 integrates TBFM, Controller Managed Spacing, and Flight Deck Interval Management developed by NASA to efficiently manage arrival aircraft from just before top-of-descent to the runway.

ATD-2

- Current-day metroplex traffic management practices lead to multiple operational shortfalls:
  - Identical ticketed departure times, a pushback-when-ready operational paradigm, and reactive first-come-first-served (FCFS) management of clearances at ramp transition spots, lead to inefficient departure sequences causing taxi inefficiency (stop and-go) and throughput loss;
  - Lack of information sharing amongst the operators responsible for managing air traffic in busy terminal environments;
  - Lack of predictability in the departure process:
    - Force tower controllers to impose buffers (e.g. runway separation buffers) to ensure safety;
    - Force the receiving Terminal Radar Approach Control (TRACON) facility and Centres to impose inefficient departure restrictions (e.g., excess miles-in-trail (MIT);
    - Cause airlines to set excess block times, which limits fleet utilization and increases personnel and fuel costs.
- NASA plans to address these shortfalls by IADS
  → Increase the predictability, efficiency, and throughput of metroplex operations while meeting future air traffic demand and reducing fuel usage and emissions.
- Accomplish by sharing data among pilots, controllers, flight operators, and airport operators to produce a fully coordinated schedule;
- NASA needs reliable information regarding the operational shortfalls that ATD-2 can address to help with effective transition of ATD-2 tools to the field.

Potential information to predict

Weather
- Hurricane
- Snowstorm
- Thunderstorm
  - Frontal
  - Popcorn
- Icing
- Fog
- Winds
- Windshear
- Hail
- Visibility

ATC
- Congestion
- Airspace constraints
- Ground delay programs
- Ground stops
- Holding patterns
- Anticipated competitor decisions

MX
- OTS
- MEL
- Hangar capacity
- Line capacity
- Manhour demand

Crew
- Timeouts / Legality
- Misconnects
- Sick
- Reserve utilization
- Straight open time pick-up
- Premium open time pick-up
- Fatigue

Station
- Ground staffing levels
- Arrival capacity
- Departure capacity
- De-icing rate
- Temporary runway closures
- Temporary taxiway closures
- Airport congestion
- TSA congestion

Customer
- Load factor
- Connections
- Misconnects
- Disrupted – will not reach destination
- No shows/ last minute changes

Network
- OTP
- Delays
  - A14
  - D0
- Cancellations
- ETA
- Block time
  - In air
  - On ground
- Turn time
- Cost of IROPS
- Fuel
  - Total cost
  - Usage

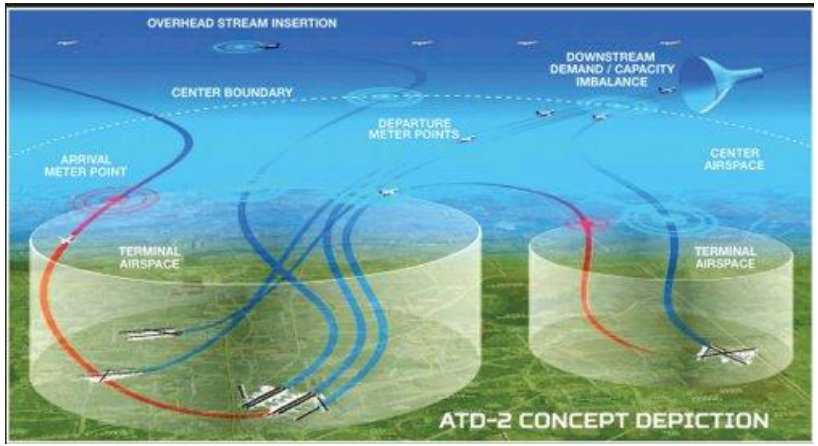
- Improving accuracy, consistency, and predictability of key decisions

ATD-2 (cont'd)

ATD-2 will include:

- Three major operational DSS: TFMS, TBFM, and TFDM
- NASA's Spot and Runway Departure Advisor
- Precision Departure Release Capability

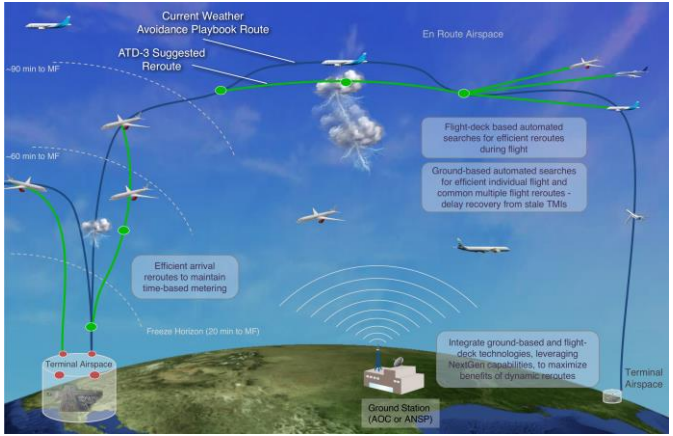
✓ Reduce overall departure delays by 40% and enable aircraft to wait out delays at the gate instead of on the tarmac with engines running.



- The ATD-2 Field Demonstration will preview several aspects of the under-development TFDM system:
  - Surface Collaborative Decision Making (Surface CDM) departure metering;
  - Electronic Flight Data user interface in the airport tower;
  - Data sharing with industry via the TFDM Terminal Publication (TTP) service.
- ATD-2 improves the efficiency of surface operations at the nation's busiest airports through time-based metering of departures and improved sharing of flight operations information amongst the various airport surface stakeholders.

ATD-3

- Challenge to manage traffic flow safely and efficiently during convective weather (major cause of delay).
- Predetermined reroutes
  - Avoid areas of adverse weather or other airspace constraints;
  - Can be overly conservative due to uncertainties in forecast accuracy.
- The flights often remain on inefficient routes even after convective weather has dissipated
  - Reduce throughput and incur costly and unnecessary delays, fuel consumption, and emissions.
- Integrate ground and flight deck technologies that continuously seek and identify more efficient routes around adverse weather and other airspace constraints.
- The automation technologies enable air traffic service providers and airspace users to identify, evaluate, and implement workable opportunities for dynamic flight plan route amendments that can improve flight time efficiency and fuel saving.



ATD-3 solutions

Air/Ground Integration (AGI) includes ground- and flight-deck-based components and streamlines the coordination between dispatcher and pilot

- Reduce delays by proposing more efficient reroutes through the airspace;
- Account for dynamic weather, traffic, and other airspace constraints.

Multi-Flight Common Route (MFCR) - ground-based component of AGI

- Generate dynamically tailored time- and fuel-saving reroutes and searches for flights that could benefit from MFCR advisories.

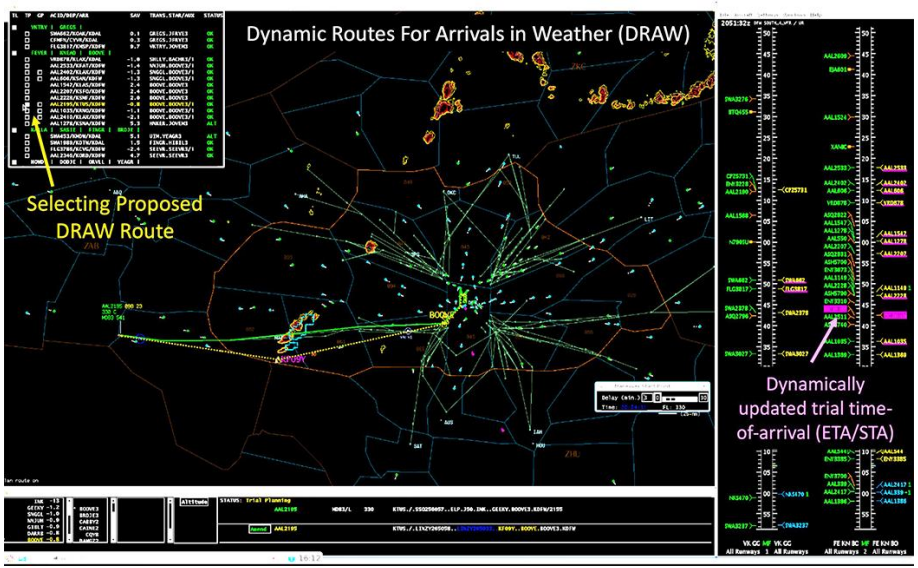
Traffic Aware Strategic Aircrew Requests (TASAR) - cockpit-based component of AGI

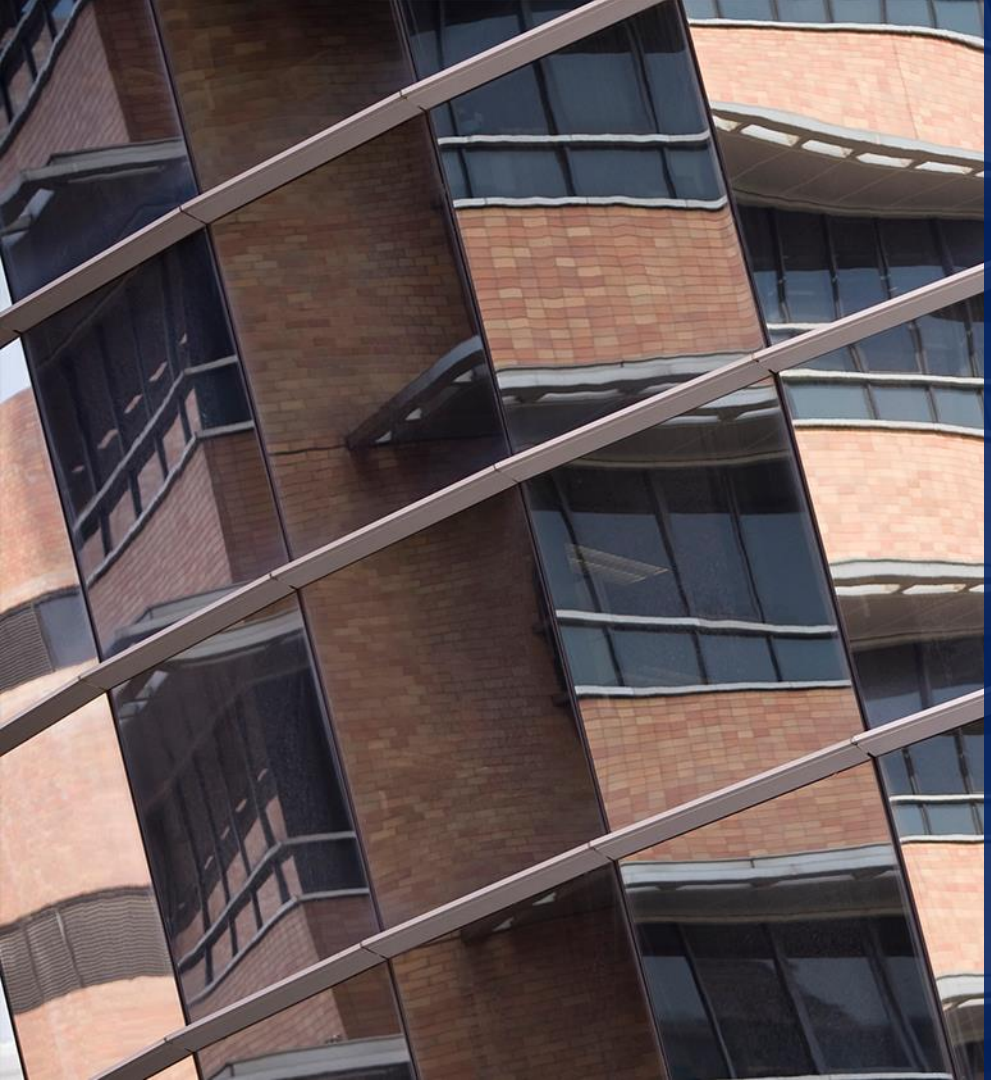
- Search for more efficient routes using data available onboard the aircraft;
- Leverage flight management system and onboard weather radar, wind, and traffic data to identify wind-optimized routes and altitudes that save time and fuel;
- Improve flight schedule compliance, passenger comfort, and reduce pilot and controller workload.

ATD-3 solutions (cont'd)

Dynamic Routes for Arrivals in Weather (DRAW) - arrival solution of AGI

- Dynamically reroutes impact flights and balances arrival demand across meter fixes;
- The system can identify minor route changes that enable aircraft to deviate around weather and return to the currently active arrival route or DRAW redirects them to the next most efficient arrival fix that is free of weather.





THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

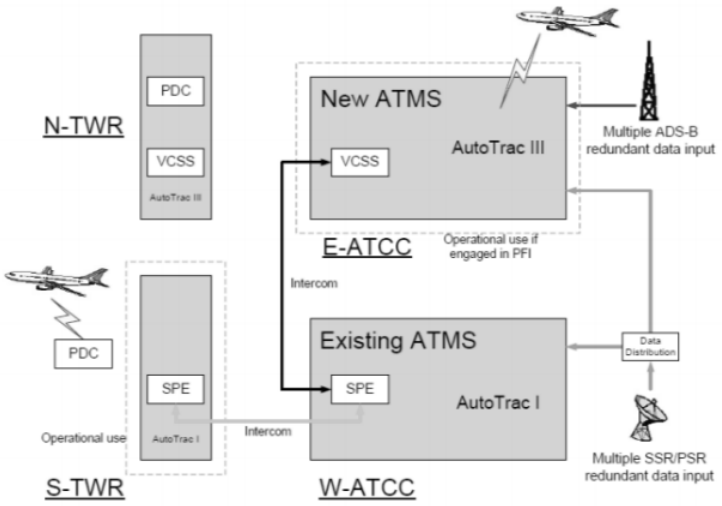
Similar examples

Opening Minds • Shaping the Future
啟迪思維 • 成就未來

Hong Kong aviation

Replacement of ATC Systems (fully commissioned in November 2016)

- Eight major systems in E-ATCC and N-ATCC;
- Replace the pervious system operating at the W-ATCC commissioned since 1998;
- Stage 1: Allow ATC executive control to be provided by the new N-TWR, whilst the Area executive control was provided by the existing W-ATCC. The S-TWR and new E-ATCC were maintained in shadowing mode with full manning.
- Stage 2: Allow Aerodrome Tower control to be provided by the S-TWR, with the Area executive control to be provided by combinations of the existing ATC systems in W-ATCC and the new ATC systems in E-ATCC.



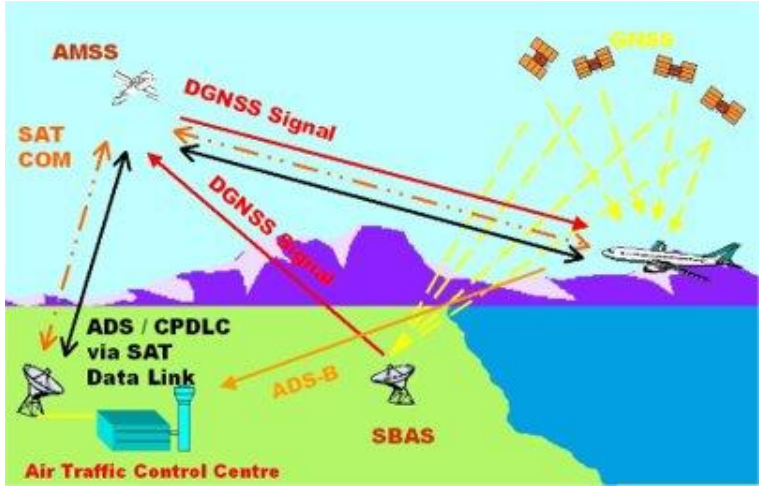
TWR : Aerodrome Control Tower
South-TWR: S-TWR
North-TWR: N-TWR
East ATC Centre (E-ATCC)
North ATC Centre (N-ATCC)
West ATC Centre (W-ATCC)

Hong Kong aviation (cont'd)

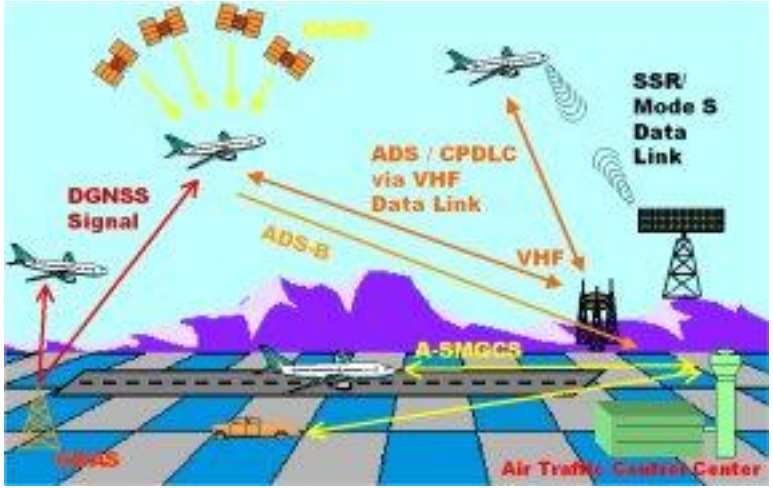
Trials on the following CNS/ATM systems have been completed satisfactorily and put into operational use :

- Digital Automatic Terminal Information Service (D-ATIS) and Digital VOLMET (D-VOLMET);
- 2-way Pre-Departure Clearance (PDC) delivery via data link;
- Aeronautical Telecommunications Network (ATN) link between Hong Kong and Bangkok - the first of such link put into operational use in the Asia and Pacific Regions;
- Air Traffic Services Inter - facility Data Communication (AIDC) between Hong Kong and Sanya;
- Advanced Surface Movement Guidance and Control System (A-SMGCS) for airfield surveillance at the Hong Kong International Airport;
- ATS Message Handling System (AMHS) for exchange of aeronautical and meteorological information between Hong Kong, China and Macao, China, the first city-pair in the Asia and Pacific Regions operating AMHS.

Hong Kong aviation (cont'd)



En route operation



Approach/landing operations

Hong Kong aviation (cont'd)

- With much enhanced data transmission, processing and display power, the new system can provide up to twice the handling capacity of the old system and will be able to support 490 000 aircraft movements in 2025 as forecast by AA;
- In 2018, the total number of aircraft movements handled by the ATMS increased by 7.1% as compared with 2017;
- In September 2018, the ATMS handled 2 130 aircraft movements in a 24-hour period following Super Typhoon Mangkhut;
  - The ATMS performed satisfactorily and no irregularity was observed during the period.
  - Capability of the ATMS in both coping with the challenges and clearing the traffic backlogs brought by adverse weather.
- Ensure the continued provision of safe, reliable, efficient and effective ATC service in line with air traffic growth;
- Indirect positive impact on the trading, logistics and tourism sectors which rely heavily on the capacity and traffic of our world-class airport.

Singapore aviation

- Terminal 4 opened in Singapore during the second half of 2017;
- To cater for longer-term growth, a new Terminal 5 is also being developed by 2030;
- Terminal 5 will have an eventual capacity that is larger than Terminals 1, 2 and 3 combined – bringing Changi Airport's total passenger handling capacity to 135 million passengers per annum;
- Challenge of air traffic management (ATM) increase with high intensity multiple-runway operations.

Singapore aviation (cont'd)

1. Civil Aviation Authority of Singapore(CAAS) adopted LORADS III in 2014:
   - A paperless, highly automated and integrated environment;
   - Technologies and innovative features with enhanced aircraft navigational accuracy and functionality;
   - A significant increase in traffic handling capacity;
   - A comprehensive air situation picture with the fusion of data from multiple surveillance sources;
   - Unprecedented layers of safety nets and redundancies.
2. Airport Collaborative Decision Making (A-CDM) is to establish procedures and systems to co-ordinate sharing and usage of operational data amongst airport partners, including airport operators, airlines, ground handlers and ATC.
   - Aim to enhance situational awareness;
   - Aid in decision-making processes by airport workers;
   - Lead to improved operational efficiency and optimised use of resources;
   - Accurate prediction of the aircraft's readiness for departure (through information provided by ground handlers and airlines), ATC can plan an optimal pre-departure sequence at which aircraft are dispatched from the parking stand;

   → Reduce time spent by the aircraft idling before take-off.

Singapore aviation (cont'd)

3. Air Traffic Flow Management (ATFM)
   - Regulate air traffic in the most efficient manner by considering airport or air traffic control capacity;
   - Better manage cross-border flow of air traffic in the Asia Pacific region;

   A regional Multi-Nodal ATFM concept, which involved looking at interconnected information sharing platforms between participating regional partners
   - ATFM nodes (comprising of ANSPs and associated stakeholders) are set up, with sharing of information (e.g. take-off and landing times) between nodes;
   - Air traffic flow comes more efficient balancing of demand and capacity at airports.
4. ATS Inter-Facility Data Communication (AIDC)
   - Automation of certain routine coordination between Air Traffic Services units;
   - Provide a reliable and timely means of conducting coordination, mitigating errors that occasionally occur when voice coordination is used;
   - With routine coordination woven into the AIDC workflow, controllers' workload has also been reduced.
5. Remote tower operations/ smart ATC have been planned to take off the physical ATC.

Philippine aviation

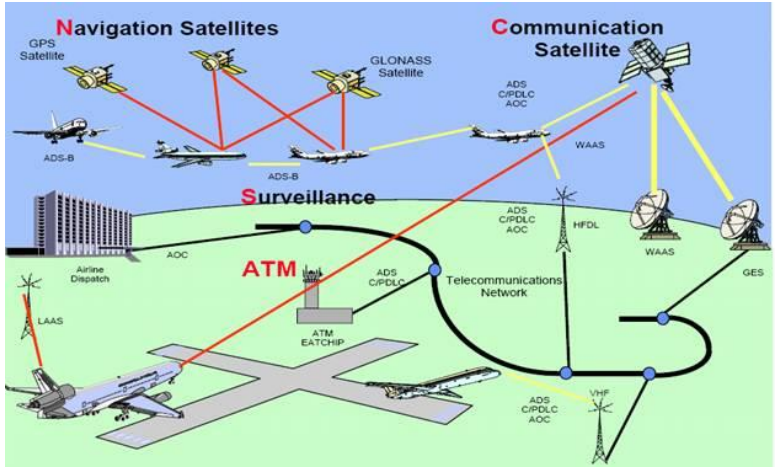
COA Clears CNS/ATM Project

- Slated for Completion in 2015, with two packages

1. Design and construction of the ATM Centre and ATM Automation System, as well as the final integration of the whole CNS/ATM system;

2. Design and construction of a surveillance and communication system.

✓ Bring the country closer to the highest of international aviation safety standards;
✓ Result in more revenues for the government;
✓ Bolster the country's tourism goals;
✓ Lower pollution emission levels through efficient air traffic management.



Philippine aviation (cont'd)

The state-of-the-art CNS/ATM System

- Provide safety alerts and warnings;
- Manage the use of the airspace and air traffic flow;
- Enhance the communications and monitoring capabilities of the CAAP.

→ Modernise aviation safety and security capabilities;

→ Increase airport capacity;

→ Minimise flight delays and aircraft collision.

- https://www.transportation.gov/testimony/review-and-update-management-faa%E2%80%99s-nextgen-program
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/nextgen-overview.html#storyboards/
- https://web.archive.org/web/20150313110025/http://www.faa.gov/nextgen/update/progress_and_plans/data_comm/
- https://www.youtube.com/watch?v=rTCLHZ0fGsU
- https://www.faa.gov/nextgen/how_nextgen_works/
- https://web.archive.org/web/20150313110025/http://www.faa.gov/nextgen/update/progress_and_plans/data_comm/
- https://www.youtube.com/watch?v=Oyi9l3cGE8M
- https://www.youtube.com/watch?v=rTCLHZ0fGsU
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/navaid.html
- https://web.archive.org/web/20150313061251/http://www.faa.gov/nextgen/update/progress_and_plans/adsb/
- https://www.youtube.com/watch?v=d6bo2mKpy9Q
- https://txtav.com/en/journey/articles/articles/adsb-out-explained
- https://www.faa.gov/nextgen/programs/adsb/pilot/
- https://www.faa.gov/nextgen/equipadsb/research/airspace/#interactiveMap
- https://www.youtube.com/watch?v=lJ-deOyB1uM&feature=emb_logo
- https://www.faa.gov/air_traffic/technology/eram/
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/stars.html
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/tfms.html
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/tbfm.html
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/tbfm.html
- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/tfdm.html
- https://www.faa.gov/air_traffic/technology/tfdm/benefits/
- https://www.faa.gov/air_traffic/technology/tfdm/implementation/ (timeline)

- https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/storyboard/detailedwebpages/atop.html
- https://www.faa.gov/air_traffic/technology/swim/
- https://www.icao.int/airnavigation/IMP/Documents/SWIM%20Concept%20V2%20Draft%20with%20DISCLAIMER.pdfhttps://www.faa.gov/nextgen/programs/weather/nwp/
- https://ral.ucar.edu/sites/default/files/public/events/2018/friends-and-partners-in-aviation-weather/docs/alfred-nextgen-weather-fpaw-july-2018.pdf
- https://www.faa.gov/documentLibrary/media/Order/JO_7110.126A_Consolidated_Wake_Turbulence_Separation_Standard_FINAL_SIGNED_508.pdf
- https://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afx/afs/afs400/afs410/efvs/media/EFVS_Overview.pdf
- https://www.transportation.gov/testimony/causes-delays-faas-nextgen-program
- https://www.washingtonpost.com/local/trafficandcommuting/inspector-generals-report-says-the-faa-has-bungled-a-36-billion-project/2018/03/08/5436c6ba-22f6-11e8-badd-7c9f29a55815_story.html
- https://www.faa.gov/nextgen/faqs/
- https://thehill.com/opinion/technology/475451-modernize-our-skies-to-improve-passenger-safety-and-national-security
- https://www.researchgate.net/publication/294457234_Potential_Vulnerabilities_of_the_NextGen_Air_Traffic_Control_System
- https://aviationsystems.arc.nasa.gov/atd2-industry-workshop/presentations.html
- https://aviationsystems.arc.nasa.gov/publications/atd2/tech-transfers/3_Technical_Publications/3.1-09%20DASC2017_Saraf.pdf
- https://www.aviationsystemsdivision.arc.nasa.gov/research/strategic/atd3.shtml
- https://www.internationalairportreview.com/article/72782/singapore-atc-operations/
- http://philippineairspace.blogspot.com/2013/06/coa-clears-cnsatm-project.html

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Thank You!

Opening Minds • Shaping the Future
啟迪思維 • 成就未來