Regional Focus



Advancing ATM Research & Development in the Asia Pacific- Spotlight on MAPS

Thursday 05 November 2020 06:00 – 08:00 CET

Moderator



Mr. Hai Eng Chiang Director Asia Pacific Affairs

CANSO



Dr Juliana Goh Assistant Director and Site Leader, MAPS



Colin Teo, Senior Human Factors Engineer MAPS



Mike Robinson Principal Engineer, MITRE



Ho Man Lui Lead Systems Engineer MAPS

Speaker



Dr. Juliana Goh Assistant Director and Site Leader,

MAPS

MITRE Asia Pacific Singapore

Juliana Goh

Asst. Dir. & Site Leader

5 November, 2020





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National Security Engineering Center





Center for Enterprise Modernization

Judiciary

Engineering and

Modernization

Center

National

Cybersecurity

FFRDC



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MITRE's Aviation Mission



To serve the public interest by advancing the **safety**, **security, effectiveness, and efficiency** of aviation in the **United States and around the world** by conducting a continuing program of research, development, and engineering **in collaboration with the aviation community**

MAPS Timeline



MITRE and CAAS MOA Signed



Facility Commissioned



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MAPS Includes an Advanced Air Traffic Management (ATM) Research Laboratory







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MAPS Facilitates the Consensus Building Process



Thank you

Name

jgoh@mitre-ap.sg

in linkedin.com/in/julianagoh





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Regional Focus



Advancing ATM Research & Development in the Asia Pacific- Spotlight on MAPS

Speaker



Mike Robinson Principal Engineer



COVID-19 Planning for Air Traffic Recovery

Mike Robinson The MITRE Corporation

CANSO Meeting: Advancing ATM Research & Development in Asia Pacific – Spotlight on MITRE Asia Pacific Singapore (MAPS)

November 5, 2020



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Outline

- Challenge and Motivation
- COVID-19 Planning for Aviation Recovery
- Planning Capability Use Cases
- Global Extensibility of Planning Capability
- Summary

Challenge



Google / New York Times

Evolving, Uneven Pandemic Impacts / Response



of NY Times



Star Tribune via Getty Images

r Tribune via Getty Images

Courtesy of IATA

Global Aviation System Response to Pandemic is Complex Difficult to quickly assess, gain actionable insights for aviation interests

Anderson et al. (2020) Lancet



<image>

Complex Cause and

Response Relationship

(pandemic evolution,

air travel demand)

USA Today

Business Insider



General Aviation News

MITRE

Infections in Aviation Ecosystem Follow Overall COVID-19 Trends

COVID-19 Infections: U.S. and U.S. Aviation Ecosystem





Total Level 3 cleaning events for COVID-19, U.S. ATC Facilities, last 6 months: > 250 *(FAA)*

Getty Images



COVID-19 incidents, U.S. Transportation Security Agency (TSA) Personnel: 2,255 total infections, 8 deaths (end of Oct) (*TSA.gov*)

Demand is Returning to Air Traffic System(s)



Source: ASPM number of quarter-hours per week where actual arrivals greater than 90% of AAR is the measure of peak periods used; Traffic Management actions are often needed during peak periods







BUT....Recovery is Uncertain



MITRE

What Can We Do?

Collect and Synthesize Pertinent Data

Derive Insight of COVID-19 Risks and Evolving Aviation Operation

Anticipated COVID Risks and Resource Needs



Condition Findings and Inform Aviation Stakeholders, Applicable Use Cases





cnn.com



Delta

Aviation Today

MITRE

Outline

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- Sample Use Cases
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COVID-19 Planning for Aviation Recovery

Initial Prototype

Demand / COVID-Risk Predictions through Data Synthesis and Machine Learning

| Facility | 2020-10-18 | w1 | w2 | w3 | w4 | 2020-10-25 | 2020-11-01 | 2020-11-08 | 2020-11-15 |
|----------|------------|----|----|----|----|------------|------------|------------|------------|
| ATL | 1486 | | | | | 1290 | 1260 | 1530 | 1600 |
| BOS | 366 | | | | | 340 | 350 | 380 | 410 |
| BWI | 373 | | | | | 360 | 360 | 370 | 390 |
| CLT | 1013 | | | | | 960 | 930 | 1010 | 1010 |
| DCA | 197 | | | | | 190 | 200 | 220 | 230 |
| DEN | 1202 | | | | | 1170 | 1180 | 1210 | 1230 |
| DFW | 1404 | | | | | 1330 | 1330 | 1390 | 1400 |
| DTW | 620 | | | | | 560 | 550 | 640 | 660 |
| EWR | 450 | | | | | 430 | 430 | 450 | 470 |
| FLL | 346 | | | | | 320 | 340 | 380 | 410 |
| HNL | | | | | | 60 | 60 | 70 | 70 |
| IAD | 327 | | | | | 310 | 310 | 310 | 320 |
| IAH | 602 | | | | | 570 | 620 | 640 | 640 |
| JFK | 382 | | | | | 340 | 350 | 380 | 400 |
| LAS | 599 | | | | | 570 | 590 | 610 | 620 |
| LAX | 789 | | | | | 720 | 730 | 760 | 790 |
| LGA | 219 | | | | | 210 | 210 | 250 | 260 |
| мсо | 466 | | | | | 450 | 480 | 520 | 560 |
| MDW | 297 | | | | | 280 | 290 | 300 | 300 |
| MEM | 101 | | | | | 90 | 90 | 100 | 100 |
| MIA | 359 | | | | | 310 | 380 | 440 | 470 |
| MSP | 597 | | | | | 560 | 540 | 620 | 640 |
| ORD | 1181 | | | | | 1120 | 1130 | 1150 | 1170 |
| PHL | 387 | | | | | 370 | 370 | 450 | 460 |
| РНХ | 659 | | | | | 640 | 650 | 680 | 690 |
| | | _ | | | | | | | |

| Facility | 2020-10-18 | 2020-10-25 | 2020-11-01 | 2020-11-08 | 2020-11-15 |
|----------|------------|------------|------------|------------|------------|
| ZAB | 1799 | 1700 | 1750 | 1900 | 1900 |
| ZAU | 2378 | 2400 | 2400 | 2550 | 2600 |
| ZBW | 967 | 1000 | 1000 | 1100 | 1200 |
| ZDC | 2179 | 2100 | 2200 | 2450 | 2600 |
| ZDV | 2269 | 2300 | 2250 | 2400 | 2450 |
| ZFW | 2479 | 2400 | 2450 | 2600 | 2650 |
| ZHU | 1746 | 1750 | 1950 | 2050 | 2100 |
| ZID | 1946 | 1750 | 1800 | 1950 | 2000 |
| ZJX | 2142 | 2100 | 2300 | 2600 | 2800 |
| ZKC | 1805 | 1700 | 1750 | 1850 | 1900 |
| ZLA | 2280 | 2250 | 2300 | 2400 | 2450 |
| ZLC | 1664 | 1650 | 1650 | 1750 | 1800 |
| ZMA | 1328 | 1450 | 1650 | 1850 | 2000 |
| ZME | 2177 | 2000 | 2050 | 2250 | 2300 |
| ZMP | 1720 | 1800 | 1800 | 1950 | 2000 |
| ZNY | 1515 | 1450 | 1500 | 1650 | 1750 |
| ZOA | 1417 | 1450 | 1450 | 1500 | 1500 |
| ZOB | 1814 | 1800 | 1800 | 2000 | 2050 |
| ZSE | 1311 | 1300 | 1300 | 1400 | 1400 |
| ZTL | 3398 | 3100 | 3150 | 3600 | 3750 |

COVID Disruption Risk Prediction: High Low

Demand Compared to 2019: ■> -20% ■-20% to -40% ■-40% to -60% ■-60% to -80% ■-80% to -100%

Predicting Airport COVID-19 Risk How We Are Doing This...





Data Aggregation and Synthesis for COVID-19 Support

Air Traffic / Travel Restrictions





Infections, Fatalities, Testing





Pandemic Interventions



MITRE

STAY at HOME

Population Mobility



COVID-19 Planning **Observations & Forecasts**

| Facility | 2020-08-23 | w1 | w2 | w3 | 114 | 2020-08-30 | 2020-09-06 | 2020-09-13 | 2020-09-20 |
|----------|------------|----|----|----|-----|------------|------------|------------|------------|
| ATL | 1444 | | | | | 1434 | 1390 | 1396 | 1401 |
| BOS | 406 | | | | | 397 | 359 | 354 | 356 |
| BWI | 439 | | | | | 441 | 368 | 361 | 362 |
| ατ | 982 | | | | | 968 | 922 | 991 | 991 |
| DCA | 285 | | | | | 278 | 201 | 196 | 195 |
| DEN | 1211 | | | | | 1199 | 1082 | 1073 | 1076 |
| DFW | 1354 | | | | | 1315 | 1244 | 1271 | 1274 |
| DTW | 608 | | | | | 598 | 572 | 570 | 572 |
| EWR | 416 | | | | | 375 | 344 | 347 | 349 |
| FLL | 275 | | | | | 255 | 239 | 238 | 241 |
| HNL | | | | | | 44 | 42 | 42 | 42 |
| IAD | 322 | | | | | 300 | 300 | 318 | 321 |
| IAH | 472 | | | | | 538 | 513 | 538 | 540 |
| JEK | 347 | | | | | 318 | 313 | 319 | 324 |
| LAS | 622 | | | | | 628 | 548 | 524 | 528 |
| LAX | 749 | | | | | 727 | 671 | 679 | 682 |



Use Case Applications

City-Pair "Flyability"

| Airport City-Pair | Recovery Flyability Index | Flyability Trend |
|---|------------------------------|---------------------|
| KBOS – KDCA | <u></u> | |
| KDEN – KSFO | * * * 🛧 | \sim |
| KJFK – KTPA | *** | 1 |
| KDEN – KIAD | * * 💮 * | |
| KJFK - KMCO | | 1 |
| Airport COVID Risk & Resource Planning | Airline Planı | Crew ning |
| DFW (Week of MM/DD 12 4 Day 1(MM/DD) Day 2 Day 3 Day 4 Day 4 Day 5 Day 6 Day 7 Morring Afternoon Even | International B | usiness Times |
| ATC | ATF | -M |

Outline

- Challenge and Motivation
- COVID-19 Planning for Aviation Recovery
- Sample Use Cases
- Global Extensibility of Planning Capability
- Summary

The Perception Socialized COVID-19 Impacts Suggest Whole States, Countries under Duress





bloomberg.com

COVID-19 impacts, portrayed in this manner, contributes to wholesale perceptions among public that its largely unsafe, undesirable to fly

Long Beach

The Challenge Even Finer-Resolution COVID-19 Data Does Not Highlight Air Travel Opportunities

Similar Infection Rates Dissimilar Testing Rates

Feb. 29



during the pandemic

Sep. 30

Feb. 29

Sep. 30

The Opportunity and Concept

Synthesized Data on COVID-19 Impact to Provide City-Pair Flyability Dashboard

Data Synthesis

Air Traffic / Travel Restrictions



Infections, Fatalities, Testing



657

Pandemic Interventions





Population Mobility



Airport
City-PairRecovery
Flyability IndexFlyability
TrendKBOS – KDCA☆ ☆ ☆ ☆ ☆ ☆KDEN – KSFO☆ ☆ ☆ ☆ ☆KJFK – KTPA☆ ☆ ☆ ☆ ☆KDEN – KIAD☆ ☆ ☆ ☆ ☆KJFK - KMCO☆ ☆ ☆ ☆ ☆

Air Travel Recovery Insights

"Flyable" means relatively safe and unencumbered travel, with proper pandemic precautions, given aggregate assessment of airport-vicinityspecific COVID-19 infection severity, active interventions (e.g., maskwearing protocols) and ease / ability for localized travel

Table lists city-pairs considered viable travel options based on data assessment, given range of positive flyability index score (includes trend)

The Opportunity and Concept

Synthesized Data on COVID-19 Impact to Provide City-Pair Flyability Dashboard

| Airport City-Pair | Recovery Flyability Index | Flyability Trend |
|--|---|---------------------|
| KBOS – KDCA | | |
| KDEN – KSFO | | |
| KJFK – KTPA | | 1 |
| KDEN – KIAD | | |
| KJFK - KMCO | | |
| | | |
| Airport City-Pair | Recovery Flyability Index | Flyability Trend |
| Airport City-Pair EGPF – EGBB | Recovery Flyability Index | Flyability Trend |
| Airport City-Pair EGPF – EGBB LFLL – OMDB | Recovery Flyability Index Image: A market of the second s | Flyability Trend |
| Airport City-Pair EGPF – EGBB LFLL – OMDB EDDH – LIRQ | Recovery Flyability Index Image: A marked m | Flyability Trend |
| Airport City-Pair EGPF – EGBB LFLL – OMDB EDDH – LIRQ EKCH – LICJ | Recovery Flyability Index Image: A marked m | Flyability Trend |

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Airport – Flight Operator COVID-19 Risk / Resource Planning (1 of 2)

- 1. Predict Notably High / Low COVID Potential Disruption (CPD)
- 2. Identify predicted arrival flights from High / Low CPD locations (airports) over next 4 weeks

- By week, by day and "period" for EWR, LGA, and JFK

| Period: | 06-09 AM LT | Early Morning |
|---------|-------------|-----------------|
| | 09-Noon | Late Morning |
| | Noon-3 PM | Early Afternoon |
| | 3-6 PM | Later Afternoon |
| | 6-9 PM | Evening |
| | > 9 PM | After 9 PM |
| | | |

|--|

High Risk

Low Risk

| Facility | 2020-10-18 | w1 | w2 | w3 | w4 | 2020-10-25 | 2020-11-01 | 2020-11-08 | 2020-11-15 |
|----------|------------|----|----|----|----|------------|------------|------------|------------|
| MIA | 359 | | | | | 310 | 380 | 440 | 470 |
| MSP | 597 | | | | | 560 | 540 | 620 | 640 |
| ORD | 1181 | | | | | 1120 | 1130 | 1150 | 1170 |
| PHL | 387 | | | | | 370 | 370 | 450 | 460 |





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Airport – Flight Operator COVID-19 Risk / Resource Planning (2 of 2)



Outline

- Challenge and Motivation
- COVID-19 Planning for Aviation Recovery
- Sample Use Cases
- Global Extensibility of Planning Capability
- Summary

Model / Dashboards Extensible for Global Use

Global Pandemic Data Accessible (Infections, Testing, Restrictions, Travel Orders)



MITRE

Air Traffic / Schedule Demand MITRE Global Flight Informatics (MGFI)









Use-Case-Targeted COVID-19 Planning Observations and Forecasts





Google Maps

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Summary

- COVID-19 pandemic is an unprecedented, prolonged global impact
- Aviation system recovering, but opportunities to better inform and assist these efforts
- MITRE synthesizing disparate infection, societal, and air traffic data to produce short-term forecasts to extend planning capabilities for range of stakeholder needs
- Approach under test in U.S. extensible to improved global aviation recovery planning insights
- Through all this, have learned much of how to explicitly consider public health as part of optimized and resilient aviation ecosystem
 - Methods and approach to pandemic scenario can be applied to other potential scenarios (e.g., wildfires / climate crises, significant flu seasons, public unrest)

Mike Robinson michaelr@mitre.org



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Questions

and

Answers
Speaker



Colin Teo Senior Human Factors Engineer

MAPS

Remote/Smart Towers

From Concept to Reality

5 November 2020

Colin Teo



Approved for public release. Distribution unlimited 19-03437-2.

Content

What is Remote/Smart Tower and Why?

Bringing a Concept into Reality

The future of Remote/Smart Tower



What are the components of a Remote/Smart Tower?



Camera positions, Remote/Smart Tower facility locations indicated are notional and for illustration purpose only



MITRE





Reduce costs

- Remote airports with low traffic
- Multiple Remote Tower Operations (MRTO)
- Reduce need for conventional tower



Modernize air traffic services

 Introduction of technology to improve efficiency and safety



Images Source: MITRE, Google Earth

Security

 Remote facility can be located in a more secure location

Bringing a Concept into Reality

MITRE's System Engineering Process



Image source: MITRE



MITRE's System Engineering Process



Image source: MITRE



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Feasibility Study & Requirements Development

Concept Exploration

Risk Mitigation

Concept Exploration

Risk Mitigation Concept Development Remote Tower Deployment Assessment

Smart Tower

 Technology Assessment and Evaluation

Systems
 Engineering

Feasibility Study & Requirements Development

MITRE

Smart Tower
 Prototype

Cost Analysis

Transition Plan

Stakeholder Engagement



Map showing airports looking at implementing remote tower

Over the past several years, a number of ANSPs around the world collaborated with research organizations to conduct research to develop concepts on providing air traffic services to airports remotely. At present, Europe is leading in the developmental efforts on remote tower and these efforts are focused on:

- Contingency airport control from a remote facility;
- Control of a single airport from a single facility;
- Control of multiple airports from a single facility;
- Providing Aerodrome Flight Information Services (AFIS).



Risk Mitigation

Assessment and Evaluation

Technology

- Systems Engineering
- Feasibility Study & Requirements Development

MITRE

Developm
 Remote To
 Deployme



Display 2: 2K Rear Projector

Display 1:

4K Front Projector

Display 3: 4K LED Panel

Video Display Assessment





MITRE conducted the Video Display Assessment (VDA) in 2016 to evaluate the readiness of the existing display and camera technology in the market in providing critical operational information and the ATCOs' acceptance of the display technology.



Image source: MITRE

l



- Risk Mitigation
 - EvaluationSystemsEngineering

and

Technology

Assessment



MITRE

- Smart Tower Prototype
- Cost Analys
 - Transition Plar
- Stakeholde
 Engageme



Display 2: 2K Rear Projector

Display 1:

4K Front Projector

Display 3: 4K LED Panel





Image source: MITRE

Video Display Assessment



In general, results indicated that recorded ultra high definition (UHD) images, as presented on all three displays, could be used to deliver air traffic services from a remote location during daylight periods at Changi Airport, but there may be visibility issues during night periods.

Recommendation

Image source: MITRE

- Reproducing natural-looking night time images
- Making image stabilization an integral aspect of the Smart Tower system design and specifications.



 Technology Risk Mitigation Assessment and

Evaluation

Engineering

Feasibility Study & Requirements Development

MITRE

Holdline Surveillance Assessment



Image source: MITRE



Concept Developmer

Remote Tower Deployment Assessment

Risk Mitigation

- Assessment and Evaluation
- Systems
 Engineering

Feasibility Study & Requirements Development

MITRE

- Smart Tower Prototype
- Cost Analy
- Transition Plan
- Stakeholder
 Engagement

Capacity Human-In-The-Loop Simulation

In 2016, MITRE carried out a Capacity human-in-the-loop (HITL) simulation in the MAPS' laboratory with ATCOs to see if the Smart Tower concept can achieve the envisioned operational capabilities for Changi Airport.

The suite of surveillance technologies, together with the current systems used by the ATCOs, were categorized together under different service levels and evaluated to determine operational feasibility and ATCOs' acceptability.

Image source: MITRE

HITL conducted at MAPS laboratory



Assessment

Risk Mitigation

Evaluation Systems Engineering

and

- Feasibility Study & Requirements velopment
 - Study Develo MITRE

Capacity Human-In-The-Loop Simulation

Two key findings:

Smart Tower concept appears feasible for providing air traffic services at the expected capacity level when all the air traffic management systems in the Smart Tower are fully functional.

Service levels with fewer operational Smart Tower systems (e.g. absent of a panoramic view, Pan-Tilt-Zoom cameras etc.) are less operationally acceptable even though operations are still possible for short durations during contingency.

mage source: MITRE

HITL conducted at MAPS laboratory



MITRE

Certification Process

Remote

Tower

Facility

Complete

Report

Phase 4



MITRE conducted a certification workshop with CAAS and its regulator to assist CAAS to develop a plan for the Smart Tower Systems Engineering and Certification Process.

The plan outlined the different activities and processes required for Smart Tower certification and deployment in Changi Airport.



MITRE

Risk Mitigation Activities

Develop Preliminary System Design Develop Operational Requirements Human Factors Assessment Procedures Assessment

- Concept Exploration
- Concept
- Remote Tower Deployment Assessment
- Technology Assessment and Evaluation
- Systems
 Engineeri

Risk Mitigation

- Smart Tower
 Prototype
- Cost Analysis
- Transition Plan

Stakeholder Engagement





Development of System Requirements

MITRE assisted in the development of the functional and non-functional requirements for the Smart Tower Prototype, preparation of tender documents and supported the technical evaluation of the tender proposals.



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2091

2116

2141 Year

Cost Analysis

MITRE conducted a lifecycle cost estimate to evaluate the rough order of magnitude difference in cost of architecture alternatives for providing air traffic services at Changi Airport.

The cost analysis looked at the cost differentials associated with two separate cases of remote tower use: contingency operations and main control.





Cost Analysis

• All Smart Tower alternatives considered in this study are less costly than a traditional tower.

• There is very little lifecycle difference in costs between Smart Tower alternatives despite wide variances in equipment requirements





Transition Plan

MITRE developed an initial launch plan for the Smart Tower which identified essential components and activities required for a successful transition to Smart Tower operations for each phase of the transition.

The plan details a high-level process to carry out the initial launch, including outlining the initial training requirements, operational validation activities such as passive and shadow mode operations, and monitoring operations after the initial launch.



Concept Developmer

- Remote Tower Deployment Assessment
- Risk Mitigation

Assessment and Evaluation

Systems
 Engineering

Feasibility Study & Requirements Development

MITRE

- Smart Tower Prototype
 - Cost Analysis
 - **Transition Plan**

Stakeholder
 Engagement



Workshop conducted with stakeholders



Demonstration of remote tower concept at MAPS laboratory

Stakeholder Engagement

MITRE's experience working with CAAs around the world is that early acceptance of a new operational concept by the aviation community such as the ATCOs, regulators and the aviation safety units, is vital for successful operational transition.

Since 2015, MITRE has provided ongoing support to help CAAS engage the different stakeholders in the aviation community to engender acceptance of the Smart Tower concept. MITRE

What's Next?

Future of Air Control Tower

- Application of Remote/Smart tower
 - Dependent on individual airport size, infrastructure and cost-benefits analysis
 - Future for small airports
- Technology improvements
 - Camera resolution, object detection and recognition, Artificial Intelligence, data bandwidth
- Digitalization of information
 - More operational information available



Image source: International Airport Review

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Regional Focus



Advancing ATM Research & Development in the Asia Pacific- Spotlight on MAPS

Speaker



Ho Man Lui Lead Systems Engineer

MAPS

Departure Spacing Tool (DST) as Decision Support for Wake Recategorization (RECAT)

5 November 2020





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Agenda

- Background
- Wake Turbulence Recategorization (RECAT)
- Ideal Start Take-off Roll Time
- Departure Spacing Tool (DST)
- Human-in-the-loop (HITL) Simulation



Background

The proposed Wake Turbulence Recategorization (RECAT) of aircraft is expected to provide an opportunity for increased runway efficiency by reducing wake turbulence separations, but it would increase the number of wake categories from four to seven.

Civil Aviation Authority of Singapore (CAAS) would like to adopt International Civil Aviation Organization (ICAO) RECAT for departures to potentially increase runway throughput, but is aware of challenges to controllers in managing the increased number of wake categories and their associated separations.

CAAS is seeking a decision support tool to help controllers apply the ICAO RECAT departure separations efficiently to maximize departure runway throughput.

MITRE is developing a prototype Departure Spacing Tool (DST) as decision support for controllers to efficiently apply the required ICAO RECAT separation standards .





Wake Turbulence Recategorization (RECAT)¹

| Current Wake Turbulence Categories | RECAT Wake Turbulence Groups | Example Aircraft Types |
|---------------------------------------|---------------------------------|------------------------|
| Superheavy (J) | А | A388 |
| Heavy (H) | В | A359, B773 |
| | С | B763 |
| Medium (M) | D | A320, B738 |
| | E | GLF5 |
| | F | CL60 |
| | 0 | G150 |
| Light (L) | G | C172 |

¹ RECAT from Air Navigation Commission Working Paper AN-WP/9289 dated 19/2/2019 entitled "Preliminary Review of Proposed Amendments to the PANS-ATM relating to Wake Turbulence arising from the Tenth Meeting of the Wake Turbulence Specific Working Group (WTSWG/10)





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Time-based Separation

| Trailing→ ↓Leading | Н | Μ | L |
|-----------------------|-----|-----|-----|
| J | 120 | 180 | 180 |
| н | | 120 | 120 |
| М | | | 120 |

| Trailing→ ↓Leading | В | С | D | E | F | G |
|-----------------------|-----|-----|-----|-----|-----|-----|
| Α | 100 | 120 | 140 | 160 | 160 | 180 |
| В | | | 100 | 120 | 120 | 140 |
| С | | | 80 | 100 | 100 | 120 |
| D | | | | | | 120 |
| E | | | | | | 100 |



D2 lift-off time is X seconds after D1 lift-off time

Image Source: MITRE





Distance-based Separation

| Trailing→ ↓Leading | н | Μ | L |
|-----------------------|---|---|---|
| J | 5 | 7 | 8 |
| н | 4 | 5 | 6 |
| Μ | | | 5 |

| Trailing→ ↓Leading | В | С | D | E | F | G |
|-----------------------|---|---|---|-----|-----|---|
| А | 4 | 5 | 5 | 6 | 6 | 8 |
| В | 3 | 4 | 4 | 5 | 5 | 7 |
| С | | | 3 | 3.5 | 3.5 | 6 |
| D | | | | | | 4 |
| E | | | | | | 4 |



D2 lift-off when D1 is Y NM from D2 lift-off location

Image Source: MITRE



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Ideal Start Take-off Roll Time

If trailing departure aircraft D2 start take-off roll at the ideal time, the separation requirement will be satisfied exactly when D2 lift-off



Image Source: MITRE



Departure Spacing Tool (DST)

DST prototype computes the ideal start take-off roll time of a trailing departure of a departure pair, and indicates a countdown timer towards the ideal start take-off roll time as decision support to the controller

DST interface design has gone through iterations, considering inputs from operational controllers and systems subject matter experts

- Where to display the DST?
 - Standalone vs existing displays; Which existing display;
- What to display on the DST?
 - Comprehensive information for decision making vs minimal information necessary for departure



Handling Departures for RECAT With and without DST

Without DST

- Controllers recall from memory, or read from table(s), the correct departure separation requirement out of 7 x 7 combinations of departure separations
- Controllers mentally estimate the rolling distance, rolling time, etc to work out the ideal time for trailing departure to start take-off roll to satisfy the departure separation

With DST

• DST shows the departure separation required for the departure pair

 Controllers follow the countdown timer on DST for the ideal time for trailing departure to start take-off roll

The effectiveness of DST prototype as decision support for controllers to efficiently apply the required ICAO RECAT separation standards is to be tested in human-in-the-loop (HITL) simulations participated by operational controllers


Human-In-The-Loop (HITL) Simulation



Tower Simulation

Experiment will be conducted on the Tower simulator in the MITRE lab. The Tower has a 220-degree field of view showing a simulated view of Changi Airport, the aerodrome and immediate airspace.





Controller Workstation

The controller workstation is equipped with the same equipment controllers use in the tower cabin which include the Electronic Flight Strip (EFS), Airfield Ground Lighting Control and Monitoring System (AGLCMS), radar display and voice communication panel.



Sim-pilot Workstation

Controllers will communicate with simpilots through their pushto-talk headsets. The simpilots are situated in another part of the lab and will execute instructions issued by the controllers.

HITL Scenarios

| Scenario | Current or RECAT | Time-based or Distance-based | With or Without DST |
|----------|------------------|------------------------------|---------------------|
| S1 | Current | Time | Without DST |
| S2 | Current | Time | With DST |
| S3 | RECAT | Time | Without DST |
| S4 | RECAT | Time | With DST |
| S5 | RECAT | Distance | Without DST |
| S6 | RECAT | Distance | With DST |

Both objective and subjective measures are recorded in the HITL

- Objective measures actual separation time, actual separation distance, etc
- Subjective measures controller workload, situation awareness, etc derived from controller responses in questionnaires done post-simulation

HITL is for finding relative performance by comparing the results of the measures between the scenarios





HITL Results as Advice for Investment Decisions

The effectiveness of DST assessed from the HITL simulation results provide evidence to advise CAAS in future investment decisions for DST

- Is DST necessary for RECAT time-based separation rules?
- Is DST necessary for RECAT distance-based separation rules?
- Does DST also help even for current separation rules?
- Whether to further develop DST for operations?

While not assessed here, DST could also be useful for future implementation of pair-wise separation for RECAT Phase II





Thank You

Lui Ho Man

hmlui@mitre-ap.ag



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Regional Focus



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You are welcome to contact the speakers with any questions you have.

Dr. Juliana Goh: jgoh@mitre-ap.sg

Mike Robinson: michaelr@mitre.org

Colin Teo: chee@mitre-ap.sg

Lui Ho Man: <u>hmlui@mitre-ap.sg</u>



Thank you

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