Data-driven Airspace Efficiency & Case Study

Bin (Kevin) Hu

ICAO Webinar on Free Route Airspace Implementation

15 September 2025

Content

1. Data-driven Airspace Efficiency Study

2. FRA and Flight Planning Systems in Action

Where are we for today

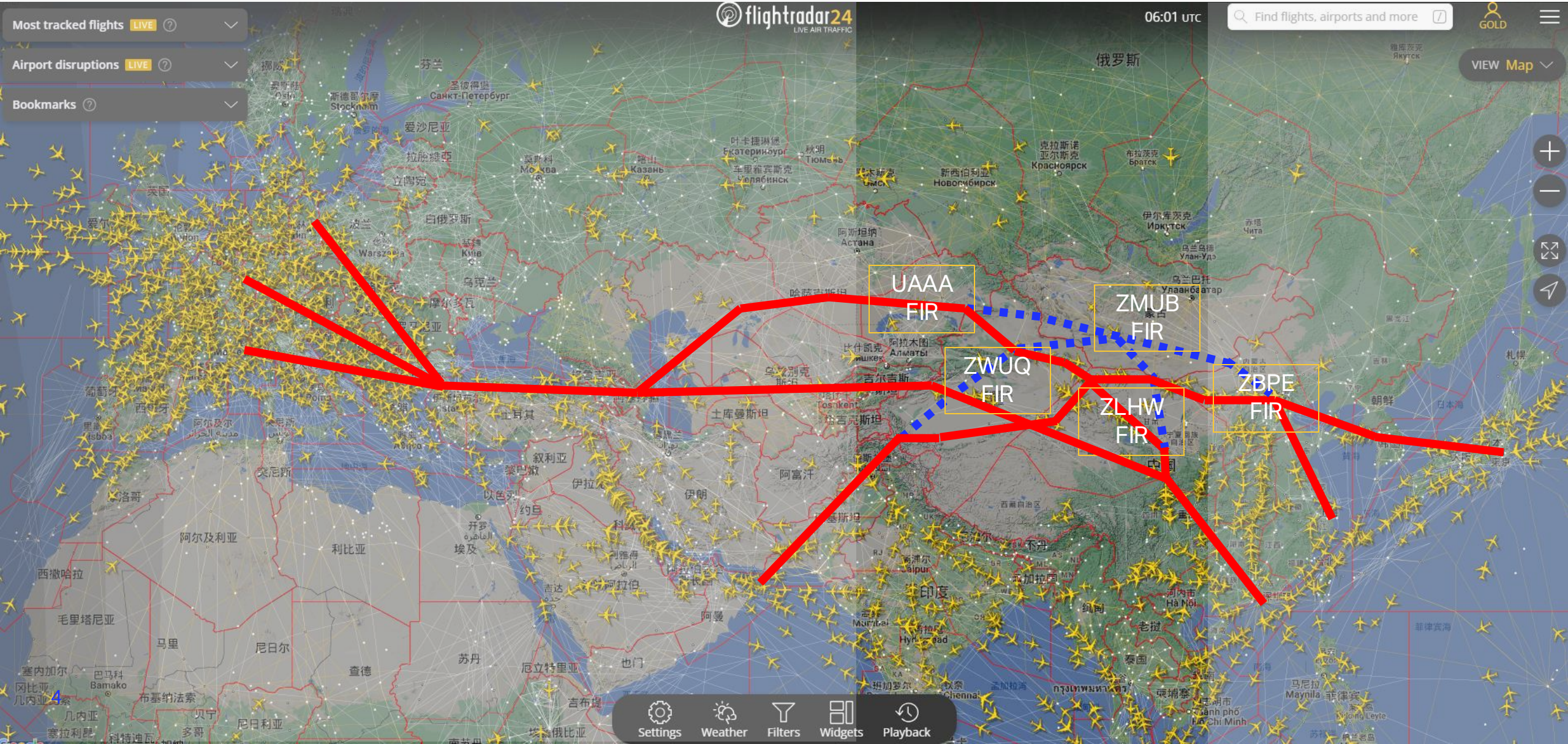
Challenges for operators

- Airspace structure and capacity issues – ATFM delay, vertical/lateral efficiency…
- Geopolitical and operational disruptions (e.g., airspace and route closure with short notice by NOTAMs) – ATFM delay, increased flight time and distance, additional fuel burn and emissions…
- Inflexible routes and limited alternatives – operational flexibility, efficiency and costs…
- Limited and inflexible entry/exit points – operational flexibility and efficiency…
- Limited options for diversion or emergency forced landing – operational costs and flight safety…
- Operational limitations (e.g., crew duty time for long-haul flights) – ATFM delay, operational costs…
- ANS charges – operational costs and sustainability…

Challenges for the industry

- Multi-party coordination among the stakeholders in complex airspace – cross-region/State/FIR and civil-military coordination, consultation with airspace users
- Fragmented airspace plannings – uncoordinated airspace/route design and development
- Collection of real data – airspace simulation/evaluation, data-driven decision making
- Performance-based approach – KPI monitoring to identify and proactively address the airspace issues (safety, capacity, efficiency and environmental impact, etc.)
- Slow adoption of the new technologies/concepts – e.g., models and tools to support the evaluation of the “What-if” scenarios, FRA planning and implementation
- Environmental protection – industry targets to minimize the environment impact

EU – Asia Interface



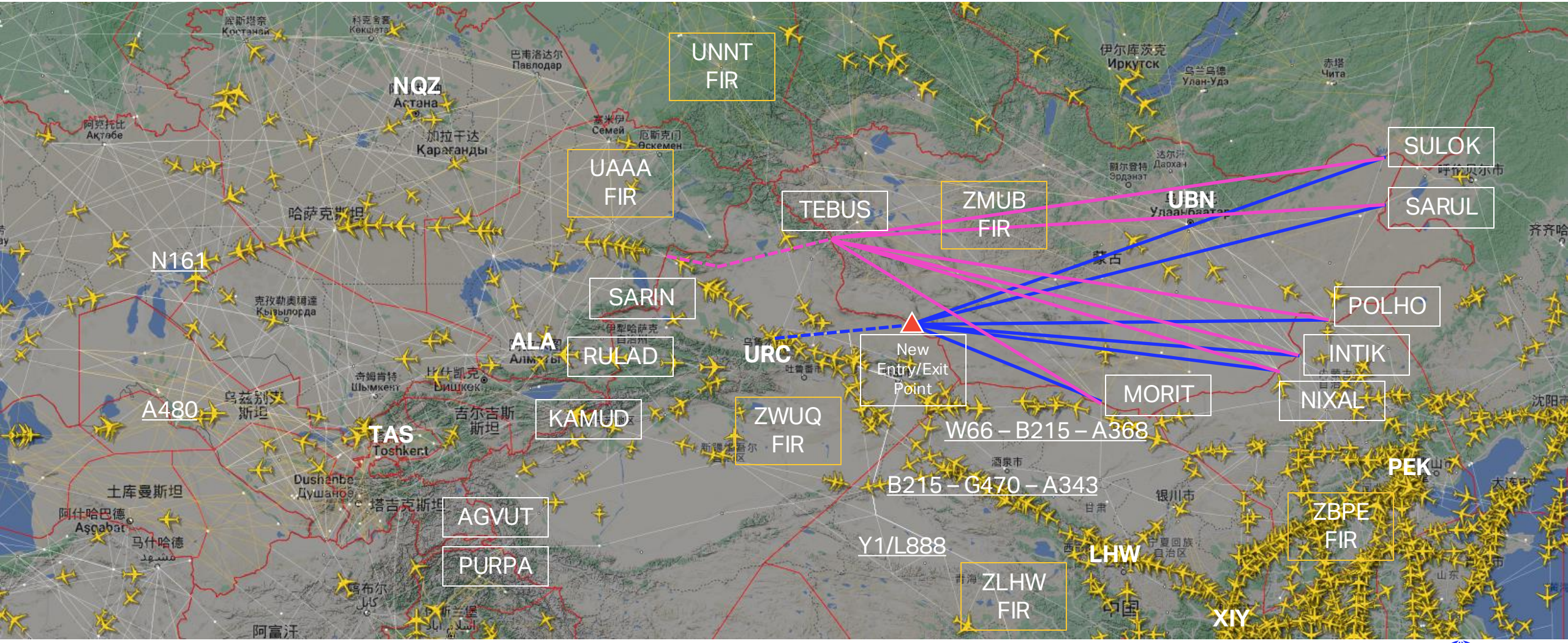
Background

- With the traffic recovery between EU and East Asia, as well as the rapid growth in Central Asia, currently the EU – Asia Interface is one of the busiest air corridors in Eurasia.
- The infrastructure of this area is developing rapidly, including the 2nd and 3rd runways opened at URC airport in April 2025 and planned Free Route Airspace (FRA) implementation in neighboring FIRs (e.g., Mongolia and Central Asia countries).
- Meanwhile, due to geopolitical conflicts and military activities, the airlines are suffering from many operational challenges in this air corridor, in terms of air route closure, ATFM delays, inefficient or inflexible airspace, enroute alternate options in high terrain area, and increased fuel burn and emissions, etc.
- IATA and the airlines are proposing new ATS routes and FRA implementation to address these issues. However, the advocacy activities are difficult to carry out effectively due to the lack of comprehensive data or technical evaluation, and the airspace optimization initiatives in the area are fragmented and not well-coordinated by the stakeholders.

Annual flights by FIRs

FIR	2022	2023 (YoY)	2024 (YoY)
ZWUQ	26,008	157,178 (+504.34%)	429,905 (+173.51%)
ZLHW	431,380	912,827 (+111.61%)	1,313,810 (+43.93)
ZMUB	35,339	48,554 (+37.39%)	73,755 (+51.90%)
UAAA	112,721	160,231 (+42.15%)	191,599 (+19.58%)
UACN	104,802	139,104 (+32.73%)	152,113 (9.35%)
UAII	141,243	188,397 (+33.39%)	223,576 (+18.67)

Proposed new ATS routes



Proposed new ATS routes (Option 1)

Current route: ADPET W188 GOVSA W66 DKO W69 HUR B339 LADIX W34 VAPGU W100 ORAVA W201 UNSEK A326 DONVO G597 AGAVO

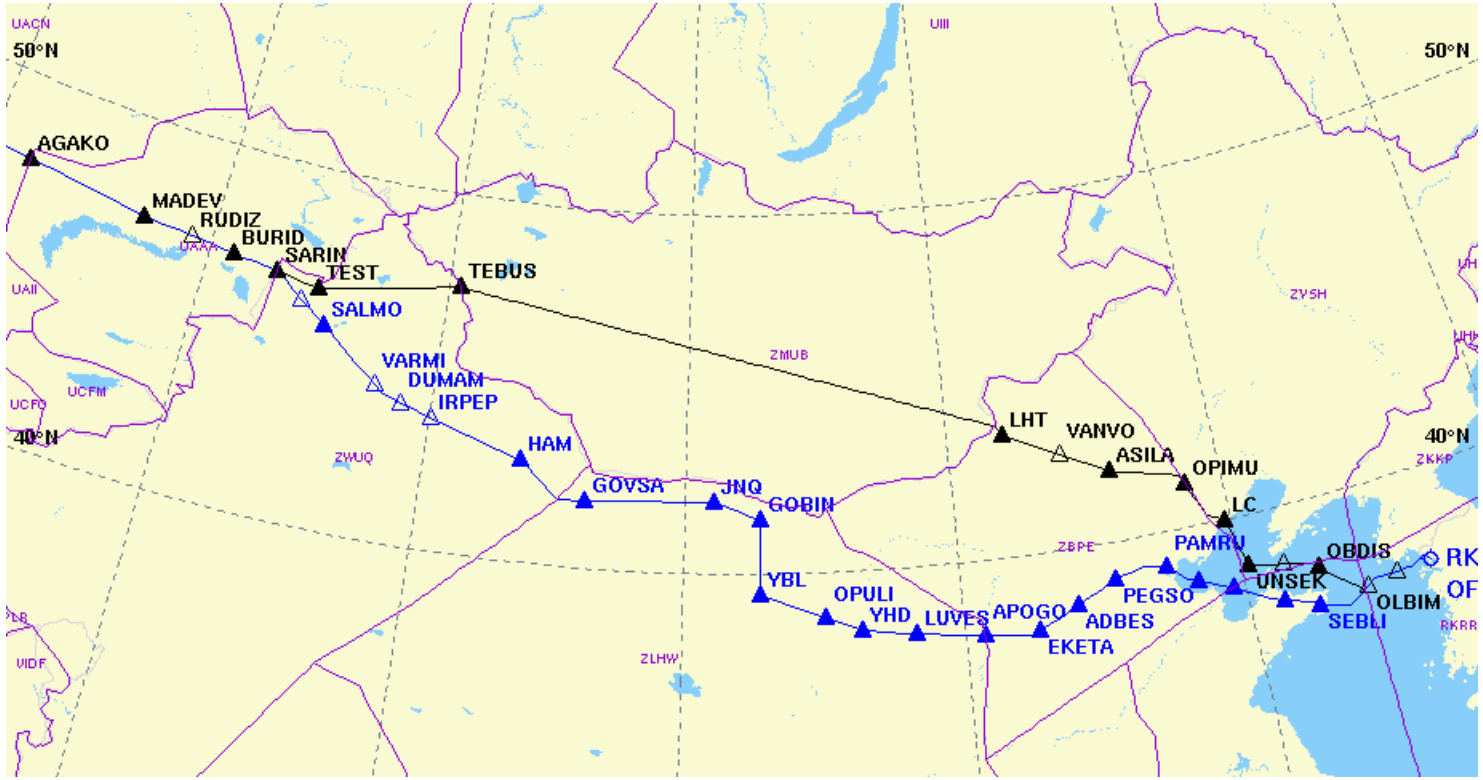
Proposed route: ADPET DCT 4433N09419E DCT NIXAL G343 TMR B458 BIKUT W69 HUR B339 LADIX W34 VAPGU W100 MUDOT DCT UNSEK A326 DONVO G597 AGAVO

- Required changes: a new entry/exit point between ZWUQ and ZMUB FIRs with a new ATS route connecting ADPET, and a new ATS route in ZMUB FIR based on FRA
- Distance/-26nm
- Time/-8min
- Fuel/-700kg
- Co2/-2205kg

Proposed new ATS routes (Option 2)

Current route: AGAVO A591 IKEKA W4 HCH W200 DOVIV W55 PAMRU W34 VYK B215 YHD W199 YBL B330 GOBIN W66 NUKTI B215 FKG A368 SARIN

Proposed route: AGAVO G597 DONVO A326 UNSEK W201 UKDUM A575 INTIK DCT TEBUS DCT 4640N08444E DCT SARIN



- Required changes: a new ATS route between TEBUS and SARIN in ZWUQ FIR and a new ATS route in ZMUB FIR based on FRA
- Distance/-194nm
- Time/-30min
- Fuel/-3000kg
- Co2/-9450kg

Summary of the potential benefits

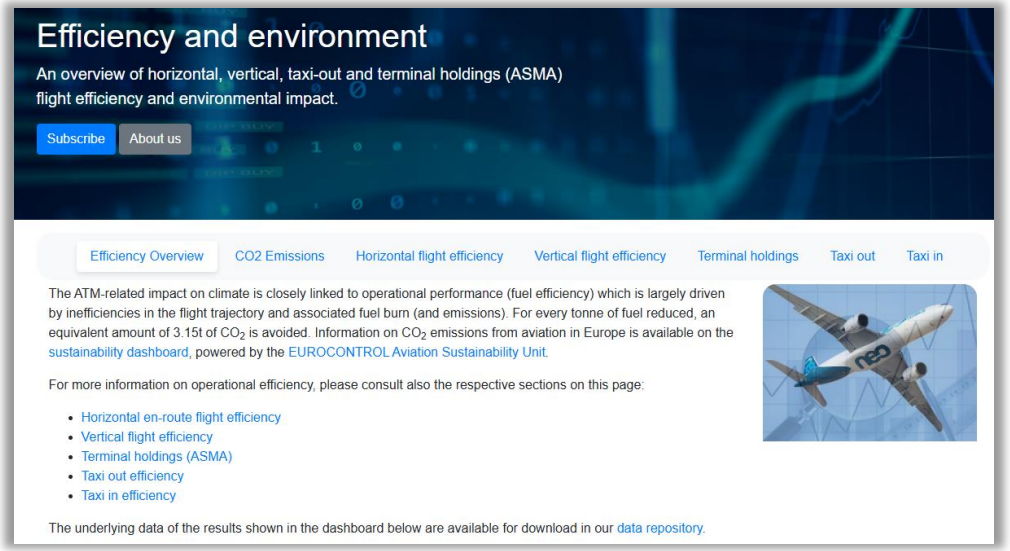
- Saving of the track miles, flight time, fuel burn and CO2 emissions
- Increase the operational flexibility and efficiency – provide the operators with an alternate option during airspace closure to reduce the ATFM delay and enhance the passenger satisfaction (especially for flight connections)
- Reduce the traffic congestion in the FIRs and ATC workload
- Facilitate the FRA implementation in this area
- …

Data-driven Airspace Efficiency Study

- Work with the airlines and industry stakeholders to develop and validate a data-driven methodology on airspace efficiency optimization initiatives.
- Complete the analysis and statistical modelling, also deliver a white paper as well as a workshop with the industry stakeholders.
- Use the EU – Asia Interface as the case study and validate the approach to support our advocacy activities.
- The developed prototype to be further applied to other airspaces.

Scope & KPIs

- Scope – enroute flight efficiency within focused FIRs:
  - China: ZWUQ, ZLHW, ZBPE FIRs
  - Mongolia: ZMUB FIR
  - Kazakhstan: UAAA FIR
- KPI reference:
  - ICAO: GANP KPIs on ATM efficiency
  - Eurocontrol: Efficiency and environment
  - IATA: ATM WG prioritized ATM metrics & KPIs from the ICAO GANP (Flight efficiency & environmental impact)

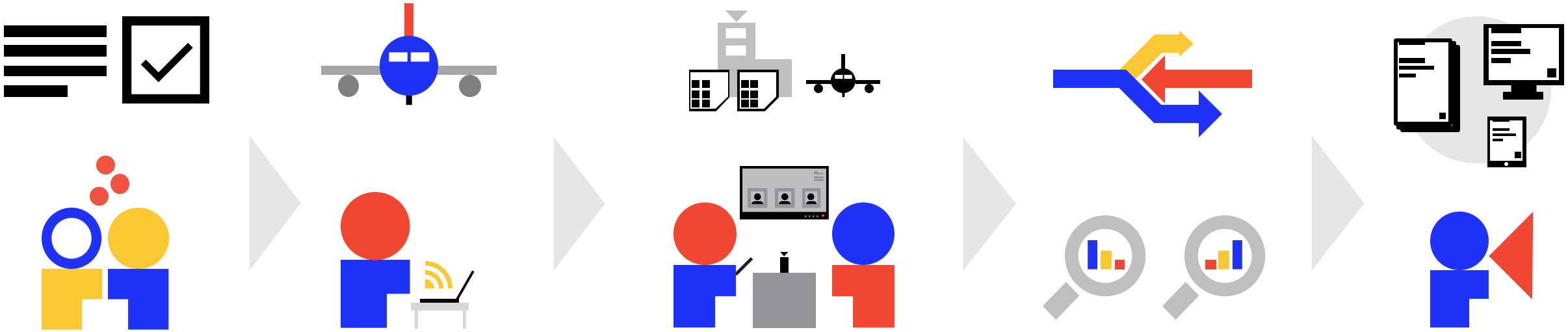


Implementation methods

The approach proposed by project team:

- Real data collection and analysis
- Statistical modelling
- Interviews with key stakeholders
- Technical visits to key facilities
- Desk research and draft white paper
- Industry review and validation with all stakeholders

Project timeline



Q2 – Q3 2025 | Q4 2025 | Jan 2026

Stakeholder survey & interviews

Data analysis & measure potential costs/benefits

Industry workshop with stakeholders
Nov 25-27 in China (tentatively)

Collect feedback & summarize findings

White paper & advocacy

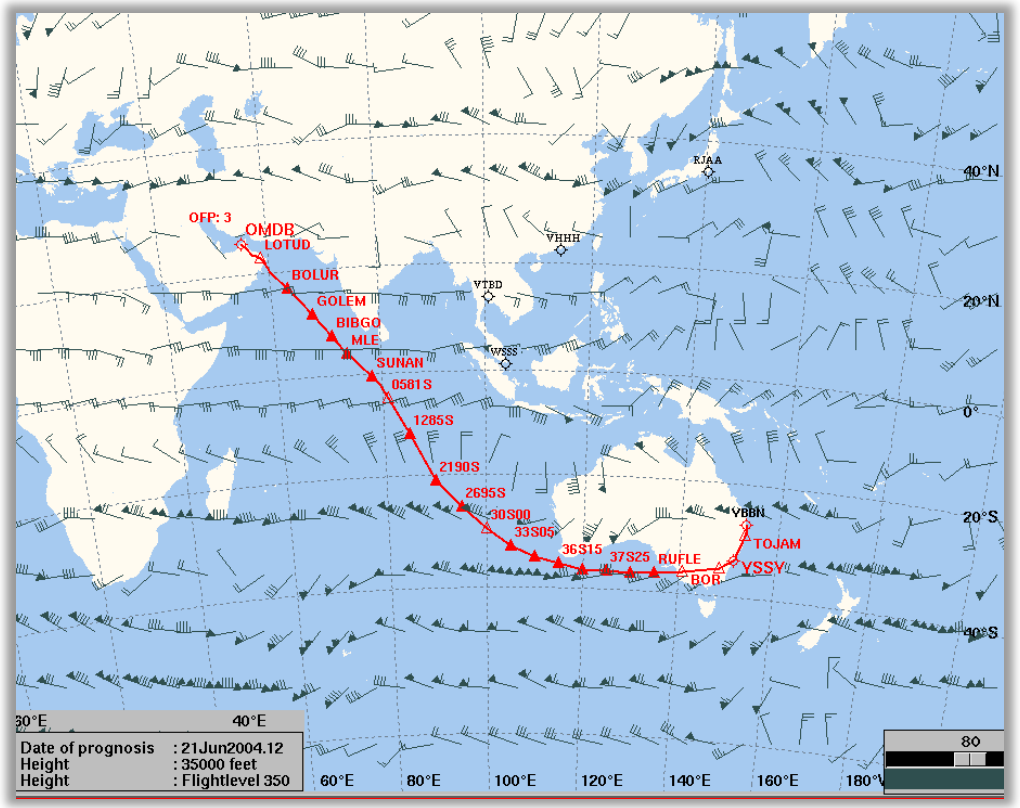
Content

1. Data-driven Airspace Efficiency Study

2. FRA and Flight Planning Systems in Action

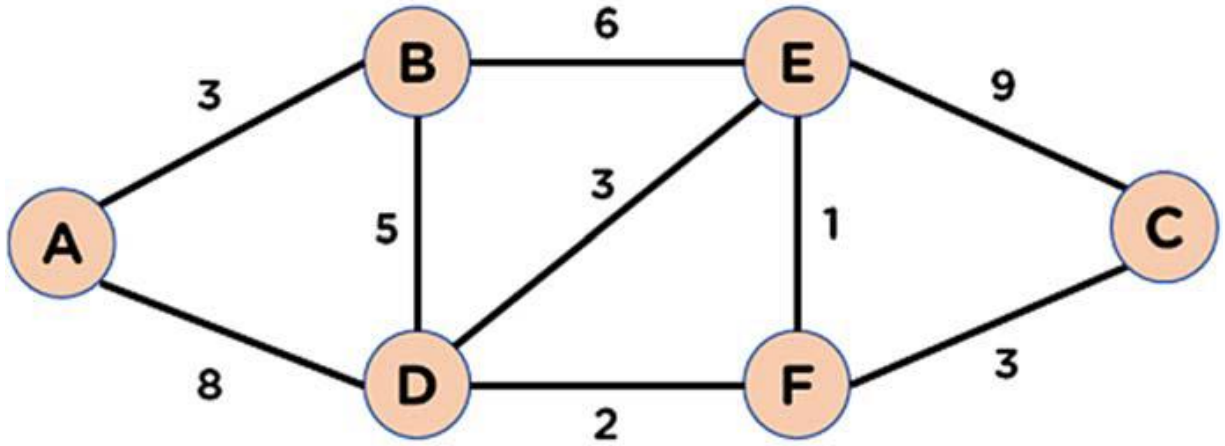
FRA is not DCT

- Free Route Airspace is not direct (sometimes this is common understanding from Pilot and Controller perspective).
- The modern flight planning tools are proposing optimum routings for Dispatchers, considering numerous factors:
  - Aircraft performance and payload
  - Weather conditions
  - ANS charges
  - …
- Example (OMDB – YSSY):
  - Distance increase – 1200 NM
  - Time saving – 43 mins
  - Fuel saving – 8400 kg



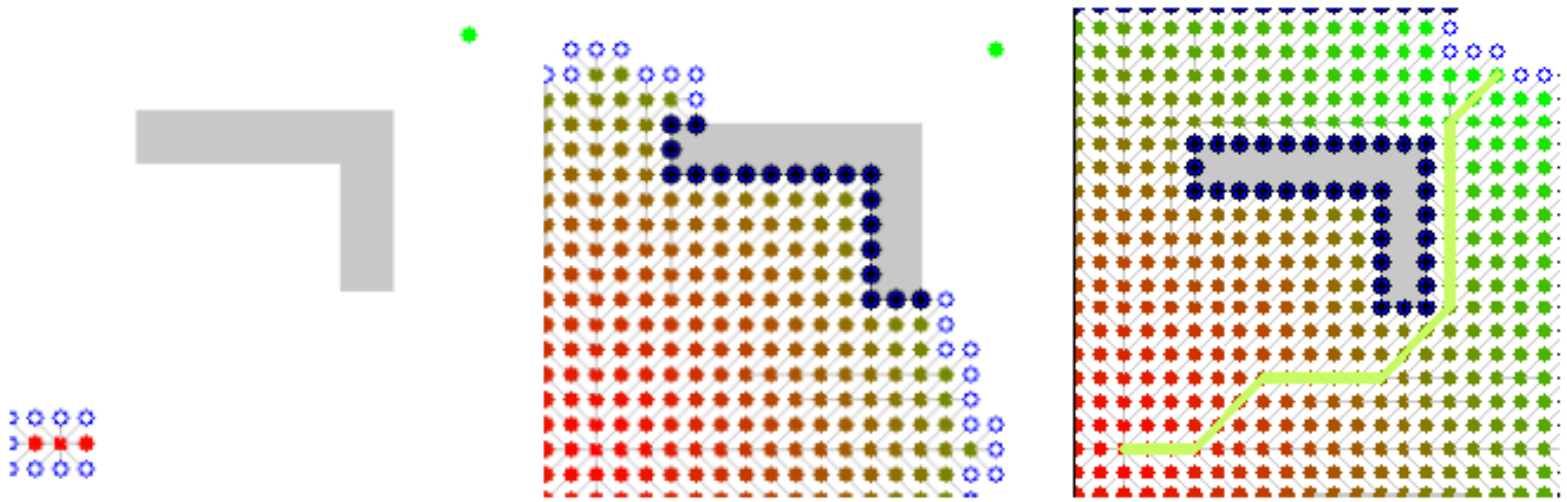
Why FRA?

- Route generation by modern flight planning systems – find the most optimal trajectory with advanced flight planning programs
- Dijkstra's Algorithm – select the leg with the shortest route
- For example, from point A to point C: A – B – D – F – C



Dijkstra's Algorithm in action

- The algorithm is attempting to find the shortest distance between the Red and Green dots, and against a restriction (gray bar).
- Flight planning systems can take rules created by ANSPs and put them into action.



Modern flight planning systems

- The modern flight planning systems make the calculation under their algorithms and generate route options based on the ANSPs rules (e.g., the restrictions in place).
- Flight planning systems also take optimization methods (fuel burns, emissions, cost or time), weather, winds, and operator preferred rules into account while performing the route generation process.
- Future use idea: utilizing the SWIM network, flight planning systems could import ATC airspace/flow control restrictions in real time and take them immediately into account during flight planning, this would allow ANSPs greater levels of collaboration between all stakeholders.

Using rules to find the route

- One of the best examples on how to present flight planning rules is the Route Availability Document (RAD) in Eurocontrol airspace:
  - Reduce rule complexity
  - Present in a machine-readable format
  - Remove the need to publish permanent NOTAMs

Airway	From	To	Point or Airspace	Utilization	Time Applicability	Categorisation	Operational Goal
P55	SONEB	GOTIG		ONLY AVBL FOR TFC ARR (EHAM, EHGG, EHLE)	H24	S	To force traffic onto arrival transitions
P62	TEBRO	PISAP		ONLY AVBL FOR TFC ARR (EDDL,EDLN, EDLV, ETAD, ETNG, ETNN, ETOU)	H24	S	To force traffic onto arrival transitions
Z729	BADLI	ZWN		NOT AVBL FOR TFC ARR (EDDR, EDRZ, ELLX, ETAR) THIS TRAFFIC SHALL FILE LBU Z11 TAGIK Z818 RINEX MANEM	H24	S	to force traffic to inbound routes
Z12	UMDAS	KETEG		NOT AVBL FOR TFC 1. WITH RFL ABV FL245 EXC DEP ETAR 2. DEP EDDS	H24	S	1. To integrate departures from ETAR into upper airspace routings 2. To force departing traffic onto correct routing
L608	KPT	TEDGO		NOT AVBL FOR TFC 1. DEP (EDMMFIR, LSZR) 2. VIA N851 LBU 3. DEP LI** WITH ARR BASEL_GROUP 4. ARR EDGGFIR EXC ARR (EDDG, EDDK, EDDL, EDDR, EDFH, EDKZ, EDLA, EDLD, EDLE, EDLI, EDLM, EDLN, EDLP, EDLS, EDLV, EDLW, EDRZ, EDVK, EDWO)	H24	C	1.,2.: No direct connection from lower airspace.To force traffic to another transition route 3. to reduce complexity avoiding creative FPLs 4. to force not listed ARR via other routes.

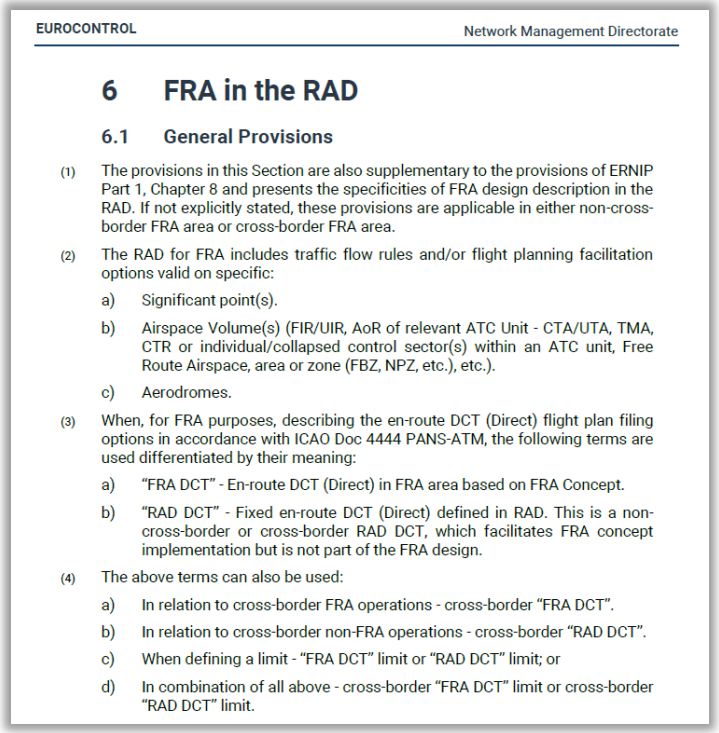
Authorized direct routes

- Eurocontrol also publishes authorized direct routes, which allow flight planning systems to take advantage of numerous options from a single waypoint, instead of fixed airways.
- The direct route may not be the most efficient; however, with the options provided by ANSPs, the most efficient direct can be found by the flight planning systems prior to departure with weather forecast, etc.

ID	From	To	Lower Vert. Limit (FL)	Upper Vert. Limit (FL)	Available or Not (Y/N)	Utilization	DCT Time Availability	Operational Goal
LT5026	YAPZU	ADKAR	275	660	Yes	TBD - General conditions apply	H24	To avoid Air Defence Zone
LF5491	GONEK	TABOV	305	500	Yes	ONLY AVBL FOR TFC VIA LFRRGA	H24	Fuel saving Direct trajectories

Recommendations

- Simplify the rules as much as possible (e.g., clearly state which airway or points affected and what the operators can/can't do within the airspace, and the applicable time, etc.) and enable the operators storing them in the system to allow for route generation.
- Add a process to modify the rules mid-cycle as needed or create a "dynamic" rule system that would allow ATC to make changes to flows as required.
- Include flight planning system providers in discussions to find the best way to present the information (machine-readable).
- Phased approach and multi-tier roll out to the system, e.g., trial and transitions to new preferred trajectory system, expansion to domestic/cross-border airspace, expansion to FRA concept system.



EUROCONTROL — Network Management Directorate

6 FRA in the RAD

6.1 General Provisions

(1) The provisions in this Section are also supplementary to the provisions of ERNIP Part 1, Chapter 8 and presents the specificities of FRA design description in the RAD. If not explicitly stated, these provisions are applicable in either non-cross-border FRA area or cross-border FRA area.

(2) The RAD for FRA includes traffic flow rules and/or flight planning facilitation options valid on specific:

a) Significant point(s).

b) Airspace Volume(s) (FIR/UIR, AoR of relevant ATC Unit - CTA/UTA, TMA, CTR or individual/collapsed control sector(s) within an ATC unit, Free Route Airspace, area or zone (FBZ, NPZ, etc.), etc.).

c) Aerodromes.

(3) When, for FRA purposes, describing the en-route DCT (Direct) flight plan filing options in accordance with ICAO Doc 4444 PANS-ATM, the following terms are used differentiated by their meaning:

a) "FRA DCT" - En-route DCT (Direct) in FRA area based on FRA Concept.

b) "RAD DCT" - Fixed en-route DCT (Direct) defined in RAD. This is a non-cross-border or cross-border RAD DCT, which facilitates FRA concept implementation but is not part of the FRA design.

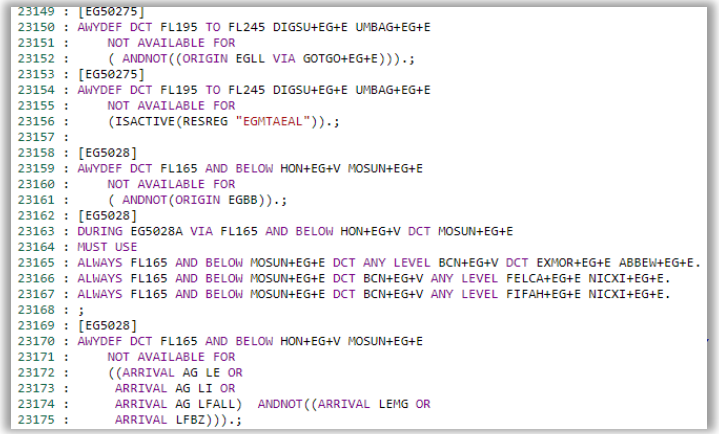
(4) The above terms can also be used:

a) In relation to cross-border FRA operations - cross-border "FRA DCT".

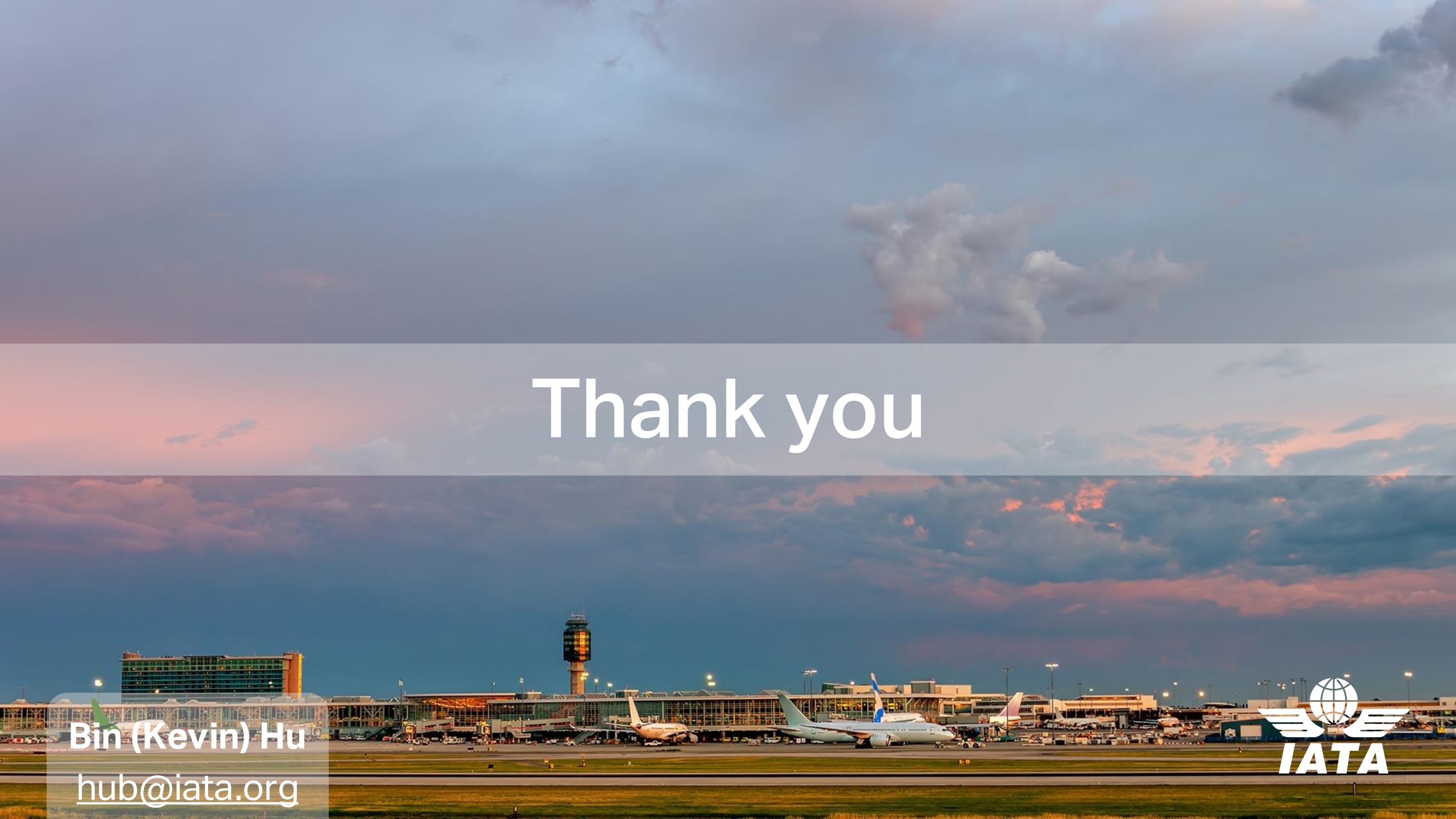
b) In relation to cross-border non-FRA operations - cross-border "RAD DCT".

c) When defining a limit - "FRA DCT" limit or "RAD DCT" limit; or

d) In combination of all above - cross-border "FRA DCT" limit or cross-border "RAD DCT" limit.



```
23149 : [EG50275]
23150 : AWYDEF DCT FL195 TO FL245 DIGSU+EG+E UMBAG+EG+E
23151 :     NOT AVAILABLE FOR
23152 :     ( ANDNOT((ORIGIN EGLL VIA GOTGO+EG+E))).;
23153 : [EG50275]
23154 : AWYDEF DCT FL195 TO FL245 DIGSU+EG+E UMBAG+EG+E
23155 :     NOT AVAILABLE FOR
23156 :     (ISACTIVE(RESREG "EGMTAEAL")).;
23157 :
23158 : [EG5028]
23159 : AWYDEF DCT FL165 AND BELOW HON+EG+V MOSUN+EG+E
23160 :     NOT AVAILABLE FOR
23161 :     ( ANDNOT(ORIGIN EGBB)).;
23162 : [EG5028]
23163 : DURING EG5028A VIA FL165 AND BELOW HON+EG+V DCT MOSUN+EG+E
23164 : MUST USE
23165 : ALWAYS FL165 AND BELOW MOSUN+EG+E DCT ANY LEVEL BCN+EG+V DCT EXMOR+EG+E ABBEW+EG+E.
23166 : ALWAYS FL165 AND BELOW MOSUN+EG+E DCT BCN+EG+V ANY LEVEL FELCA+EG+E NICXI+EG+E.
23167 : ALWAYS FL165 AND BELOW MOSUN+EG+E DCT BCN+EG+V ANY LEVEL FIFAH+EG+E NICXI+EG+E.
23168 : ;
23169 : [EG5028]
23170 : AWYDEF DCT FL165 AND BELOW HON+EG+V MOSUN+EG+E
23171 :     NOT AVAILABLE FOR
23172 :     ((ARRIVAL AG LE OR
23173 :      ARRIVAL AG LI OR
23174 :      ARRIVAL AG LFALL)  ANDNOT((ARRIVAL LEMG OR
23175 :      ARRIVAL LFBZ))).;
```



Thank you

Bin (Kevin) Hu
hub@iata.org