FF-ICE Release 2 Services Towards Trajectory-Based Operations (TBO)

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FF-ICE: Flight and Flow – Information for a Collaborative Environment

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Overview

- **Trajectory-Based Operations (TBO)**
- **FF-ICE a necessary mechanism for TBO**
- **Phased Implementation of FF-ICE**
- **Focus on Release 2 features and expected services**
- **Possible evolution from Release 1 services**
- **Release 2 is a work in progress**
  - Example areas that are being developed

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ATM – Distributed Participants & Decisions

Aircraft Operator

Manage single flight within global network

Ground Resources

Connectivity – Airframes, Crew, Passengers, Cargo

Flight Time & Rest Requirements

Equipment Qualifications

And Others

    Winds

    Weather

    Fuel

    Alternates

    Performance

    Obstacles

    Weight & Balance

    De-icing

    Volcanic Ash

    ETOPS Requirements

    Minimum Equipment Lists

GUIDE TO PART 117 FLIGHT TIME LIMITATIONS AND

Edition 1 May 2013

Image: GE Aviation

ATM: Air Traffic Management
ETOPS: Extended Twin Engine Operations
ATFM: Air Traffic Flow Management

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ATM – Distributed Participants & Decisions

Aircraft Operator

ATFM Strategic

ATFM Tactical

Air Traffic Control

Manage single flight within global network

Ground Resources

Connectivity – Airframes, Crew, Passengers, Cargo

Flight Time & Rest Requirements

Equipment Qualifications

And Others

    Winds

    Weather

    Fuel

    Alternates

    Performance

    Obstacles

    Weight & Balance

    De-icing

    Volcanic Ash

    ETOPS Requirements

    Minimum Equipment Lists

Plan workforce

Manage airspace

Manage flows
Congestion, Weather, Outages

Synchronize Flights

Separation

- **Every participant makes decisions pertaining to a flight**
- **Decisions are hierarchical, some are coordinated**
- **TBO seeks to develop solutions across decisions using the trajectory as the common currency**
  - **Strategic decisions accommodate tactical actions**
  - **Tactical decisions respect the strategic plans**

ATM: Air Traffic Management
ETOPS: Extended Twin Engine Operations
ATFM: Air Traffic Flow Management

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Trajectory-Based Operations

- **Every participant / system is operating to a plan**
- **Everyone operates to the same plan**
- **That plan is expressed & shared through the trajectory**

- **Sharing** trajectory information
- **Managing** that information
- **Using it as reference for the flight**

Flight Crew

Flight Deck Automation

FOC Automation

Shared plans, consistent trajectories

ATC Automation

FOC

ATC

TFM Automation

Voice

Data

HMI

TM ATCSCC

TMU
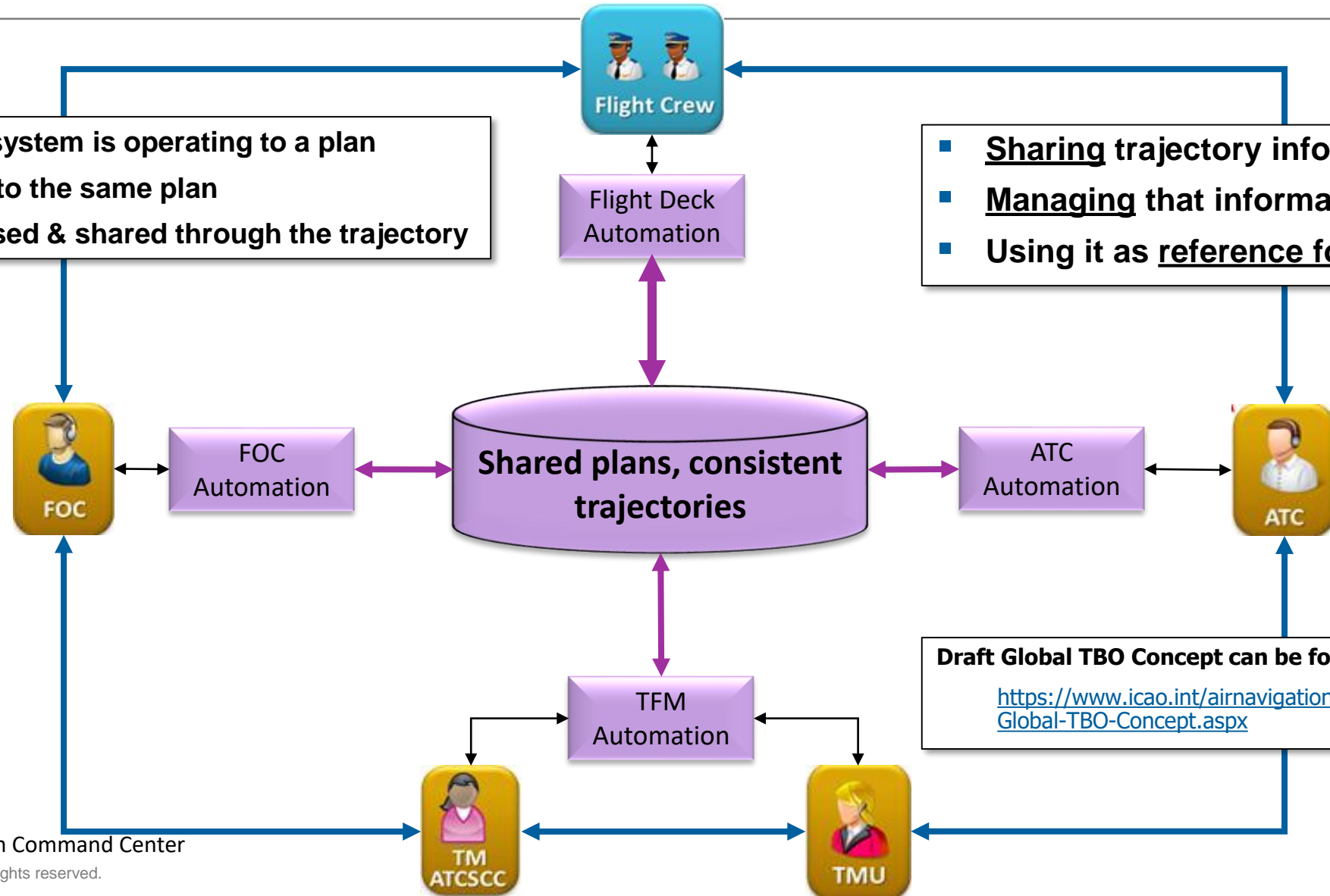
Draft Global TBO Concept can be found at:

https://www.icao.int/airnavigation/tbo/Pages/Why-Global-TBO-Concept.aspx

FOC: Flight Operations Center
ATC: Air Traffic Control
TMU: Traffic Management Unit
TM: Traffic Manager
ATCSCC: Air Traffic Control System Command Center

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Trajectories as the reference for the flight

Each participant *influences* the trajectory:
- ATM imposes constraints (e.g., routing, altitudes, speeds)
- ATC may provide tactical clearances
- AOC plans the route and profile (w/ Flight Crew)
- Flight Crew selects appropriate modes, controls and targets

Flight Crew

FOC   ATC

TM
ATCSCC   TMU

Ensure resulting trajectory meets their needs

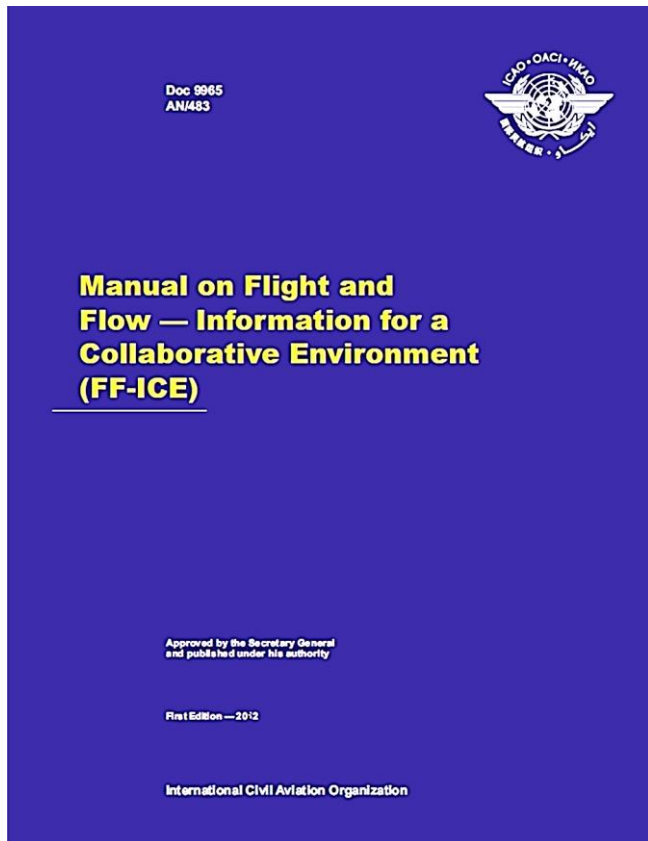**Trajectory Prediction**

Image: ICAO

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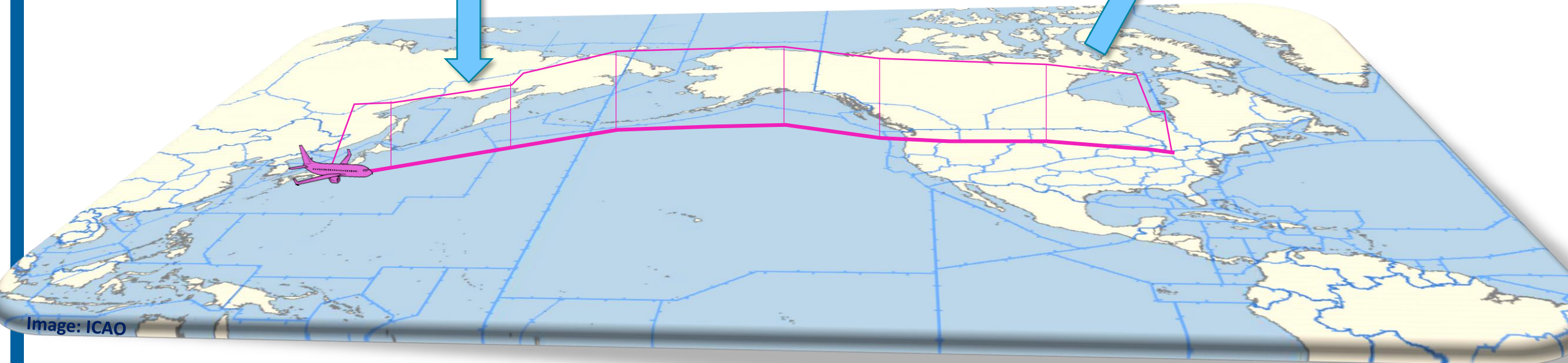
An Information Problem

Etkin, *Dynamics of Flight,* **2nd Ed.**

- **Trajectory Prediction**
  - We know the physics
  - Models make assumptions
- **We don't all know:**
  - Aircraft performance
  - Met data
  - Future ATC commands
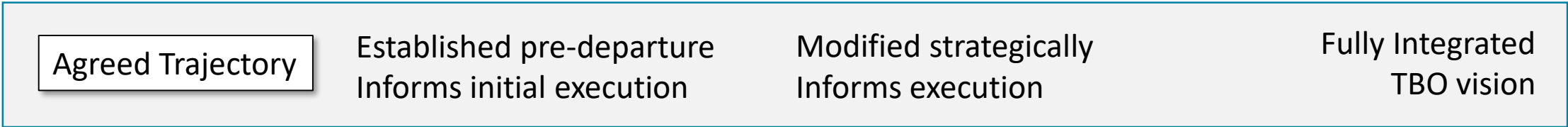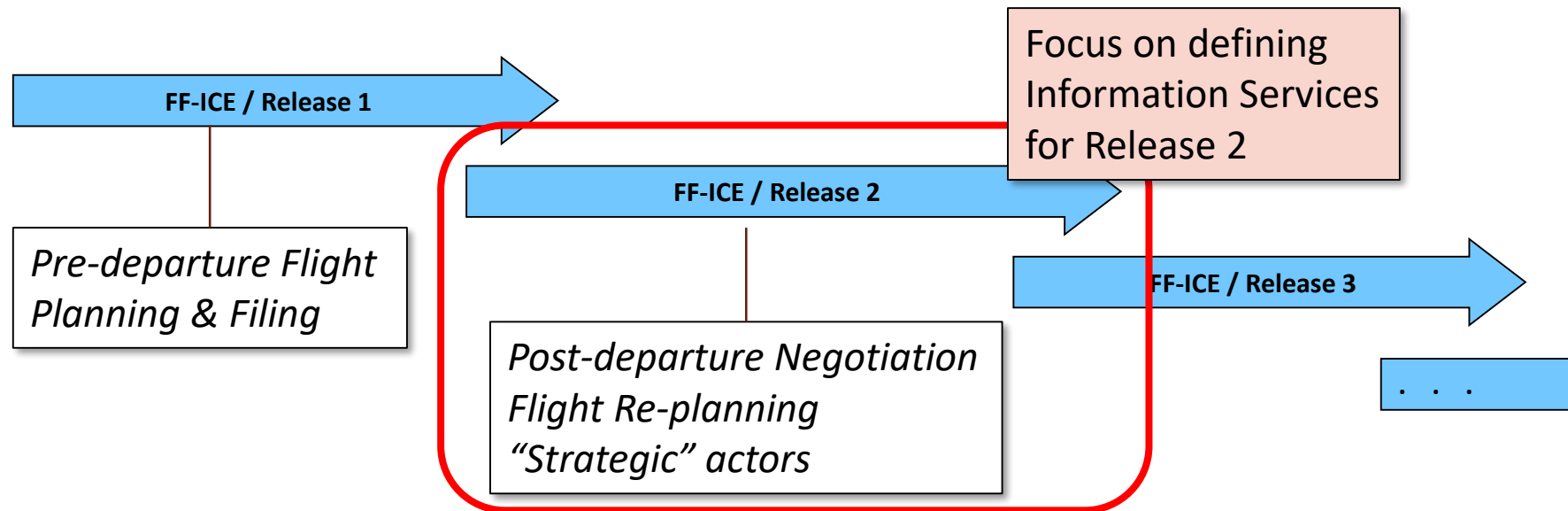 - How the aircraft will operate (Aircraft intent)

To achieve TBO, we must address the information problem

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FF-ICE Releases

Manual on Flight and Flow — Information for a Collaborative Environment (FF-ICE)

Doc 9965
AN/483

Approved by the Secretary General and published under his authority

First Edition — 2012

International Civil Aviation Organization

- **A phased approach to delivering the FF-ICE Concept**
- **No "big-bang" = mixed environment**

Focus on defining Information Services for Release 2

FF-ICE / Release 1

FF-ICE / Release 2

FF-ICE / Release 3

Pre-departure Flight Planning & Filing

Post-departure Negotiation Flight Re-planning "Strategic" actors

. . .

Agreed Trajectory

Established pre-departure
Informs initial execution

Modified strategically
Informs execution

Fully Integrated
TBO vision

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Post-departure Negotiation - Framework

Changing Circumstances

New constraints
Changing MET
Fleet considerations

Re-optimize →

Keep up with uncertainty & clearances

Maintain →

Tactical Interventions →

Negotiation

FF-ICE/1
Re-negotiation in FF-ICE/2

Manage Agreed Trajectory

Share and ensure agreement reflects what has happened

Deliver Clearance

ATC delivers the Agreed Trajectory using clearances

Legend

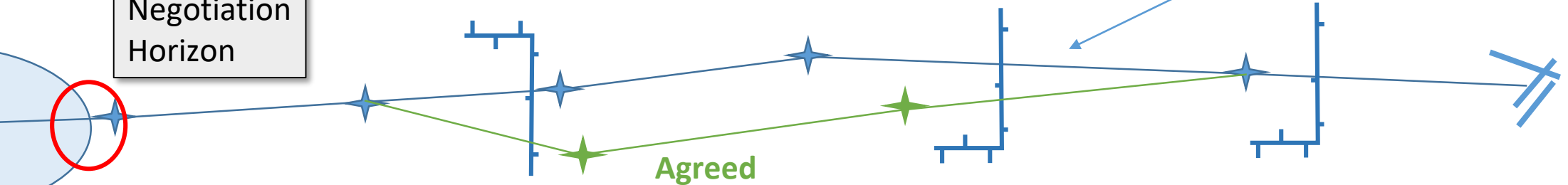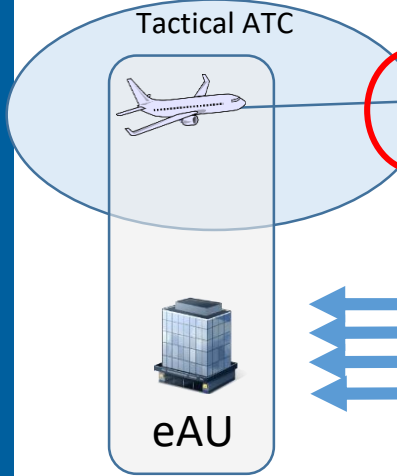→ Flight Information Sharing

MET: Meteorology

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Features of FF-ICE / Release 2 (1 of 2)

ATC not involved in negotiation

Smooth transition: Release 1→2
- No service interruption
- Continuous services

Agreed Trajectory obtained via FF-ICE/R1

Negotiation Horizon

Tactical ATC

Agreed

eAU/r2 & eASP/r2 may negotiate on Agreed Trajectory

eAU

eAU includes Flight Deck via EFB & Dispatch as applicable

eASP-1   eASP-2   eASP-3   eASP-n

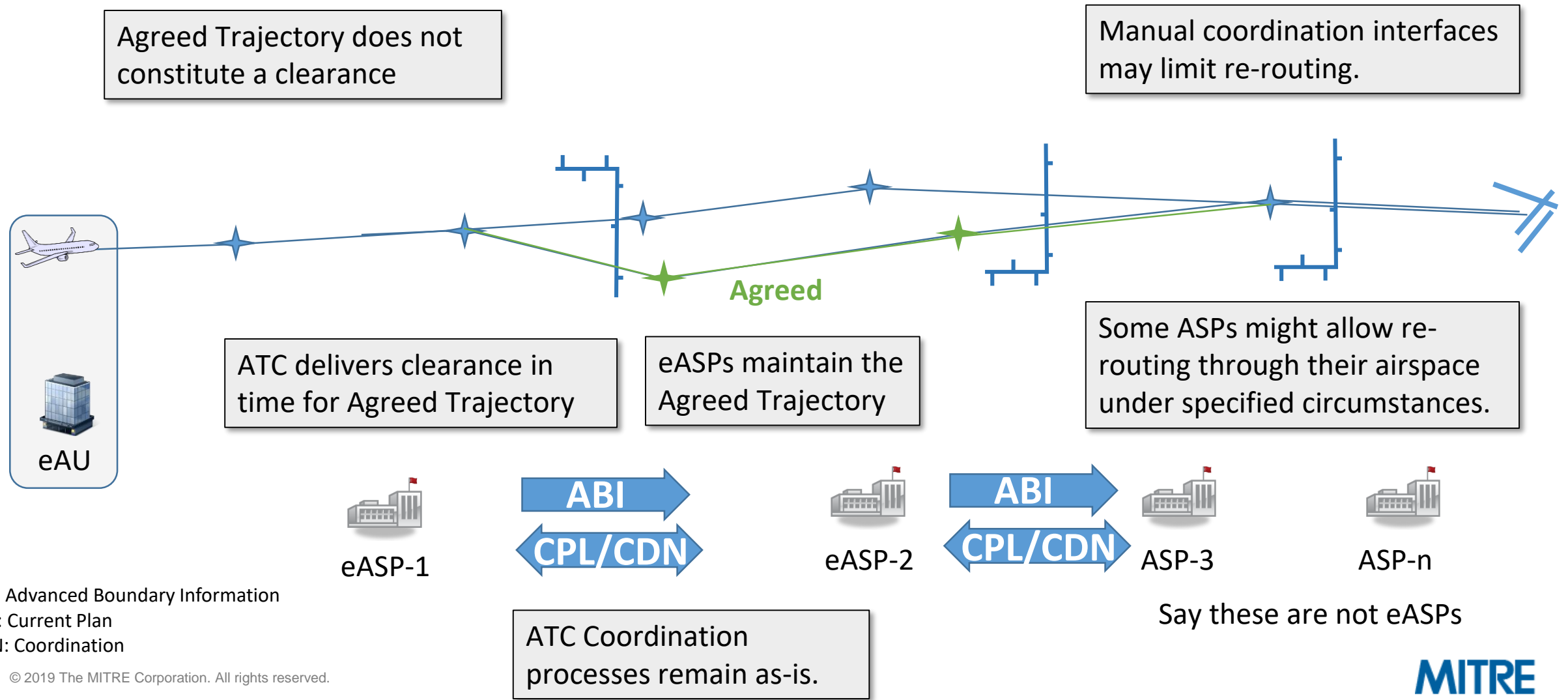AU: Airspace User
ASP: ATM Service Provider
eAU/eASP: FF-ICE-enabled AU/ASP

All eAU & eASP/r2 are R1 capable

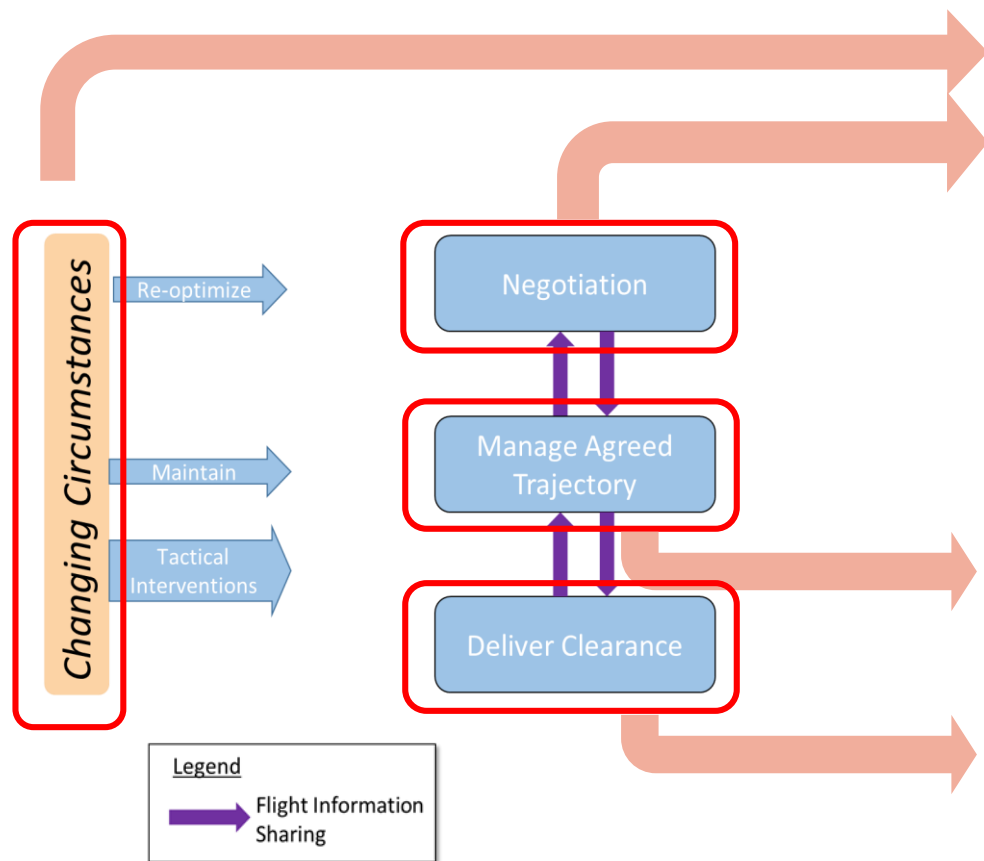ATFM not required for FF-ICE. If present, an ATFM system might implement FF-ICE capabilities.

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Features of FF-ICE / Release 2 (2 of 2)

Agreed Trajectory does not constitute a clearance

Manual coordination interfaces may limit re-routing.

Agreed

eAU

ATC delivers clearance in time for Agreed Trajectory

eASPs maintain the Agreed Trajectory

Some ASPs might allow re-routing through their airspace under specified circumstances.

eASP-1

ABI

CPL/CDN

eASP-2

ABI

CPL/CDN

ASP-3

ASP-n

Say these are not eASPs

ABI: Advanced Boundary Information
CPL: Current Plan
CDN: Coordination

ATC Coordination processes remain as-is.
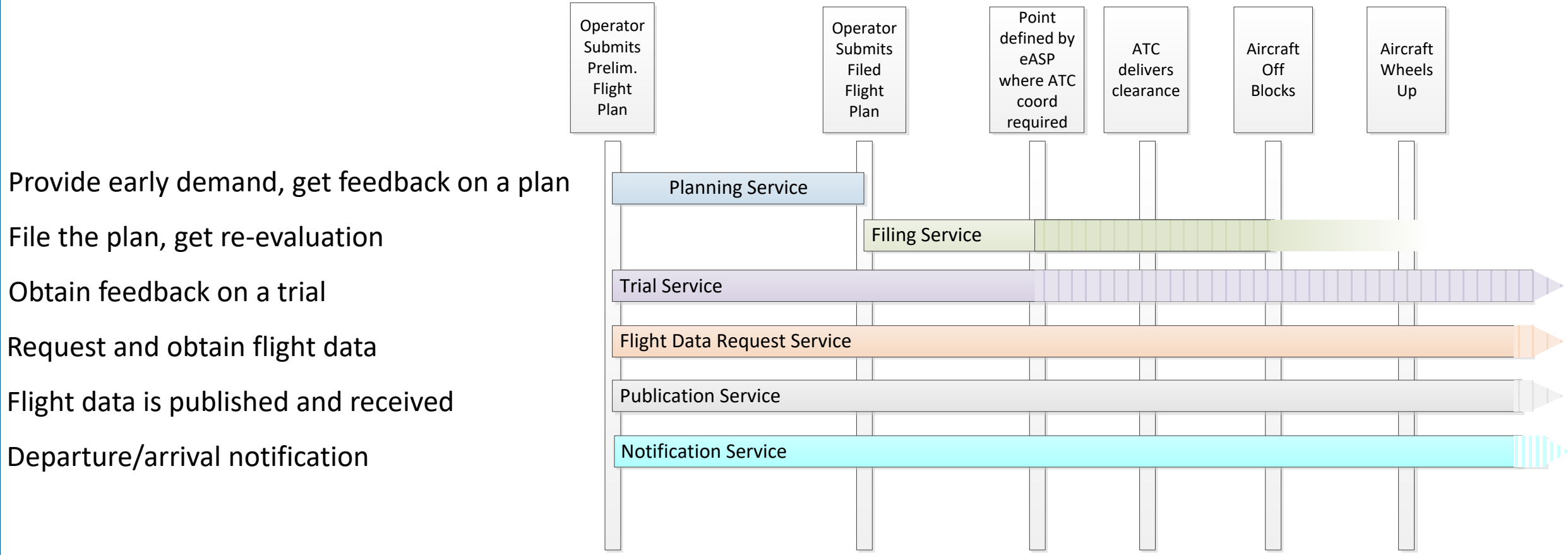
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FF-ICE/Release 2 Services

- **Publish known constraints**
- **Negotiation[†] involves two processes:**
  – Evaluation of a Desired Trajectory across multiple ASP
  – Commitment to revise the Agreed Trajectory
- **Update and publication of the Agreed Trajectory as it changes**
- **Clearance delivery → via existing methods (Voice, CPDLC)**

[†]Must communicate negotiation horizon

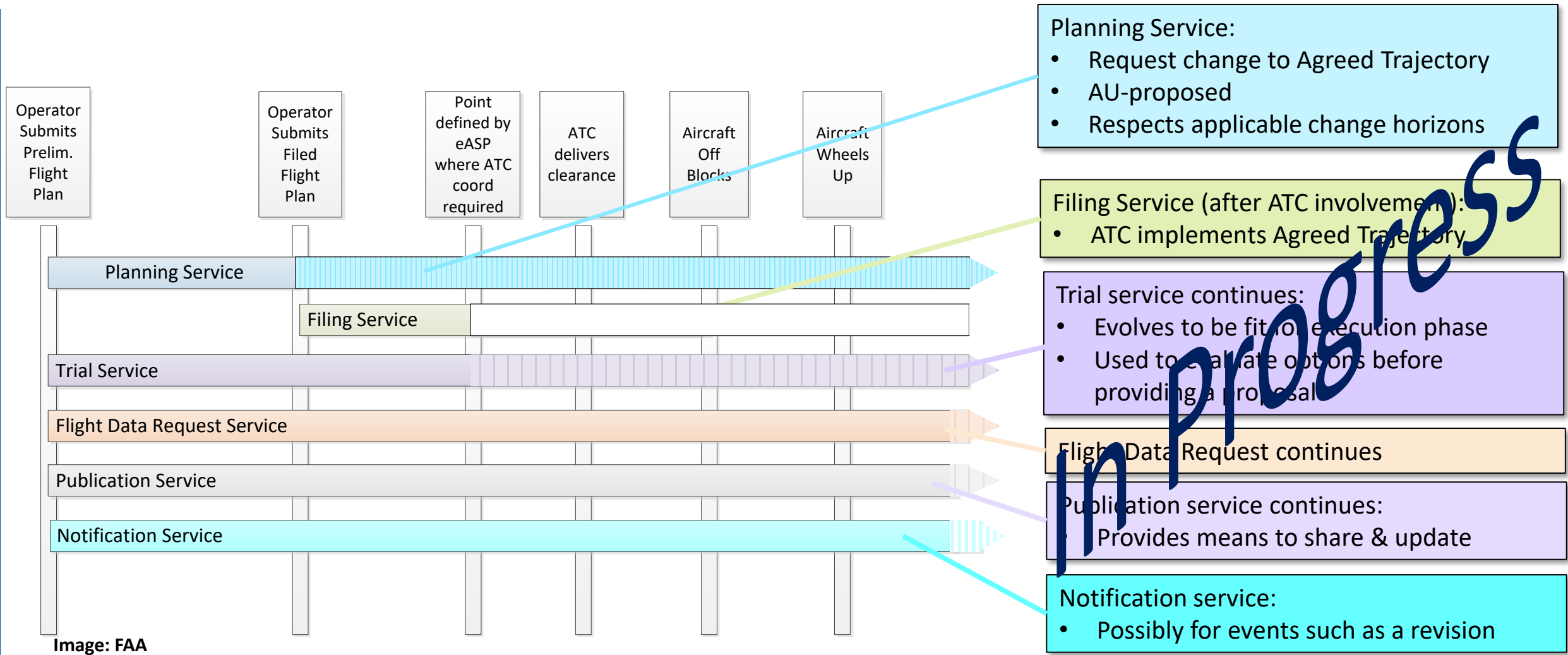CPDLC: Controller/Pilot Data Link Communications

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FF-ICE/Release 1 Services

ICAO draft documents defined Release 1 services

| Operator Submits Prelim. Flight Plan | Operator Submits Filed Flight Plan | Point defined by eASP where ATC coord required | ATC delivers clearance | Aircraft Off Blocks | Aircraft Wheels Up |

Provide early demand, get feedback on a plan — Planning Service

File the plan, get re-evaluation — Filing Service

Obtain feedback on a trial — Trial Service

Request and obtain flight data — Flight Data Request Service

Flight data is published and received — Publication Service

Departure/arrival notification — Notification Service

Image: FAA

Seek to leverage & evolve these to FF-ICE/ Release 2

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Evolution of Services

Operator Submits Prelim. Flight Plan	Operator Submits Filed Flight Plan	Point defined by eASP where ATC coord required	ATC delivers clearance	Aircraft Off Blocks	Aircraft Wheels Up

Planning Service

Filing Service

Trial Service

Flight Data Request Service

Publication Service

Notification Service

Planning Service:
- Request change to Agreed Trajectory
- AU-proposed
- Respects applicable change horizons

Filing Service (after ATC involvement):
- ATC implements Agreed Trajectory

Trial service continues:
- Evolves to be fit for execution phase
- Used to evaluate options before providing a proposal

Flight Data Request continues

Publication service continues:
- Provides means to share & update

Notification service:
- Possibly for events such as a revision

In Progress

Image: FAA

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FF-ICE/Release 2 is a work in progress

Example areas of further development

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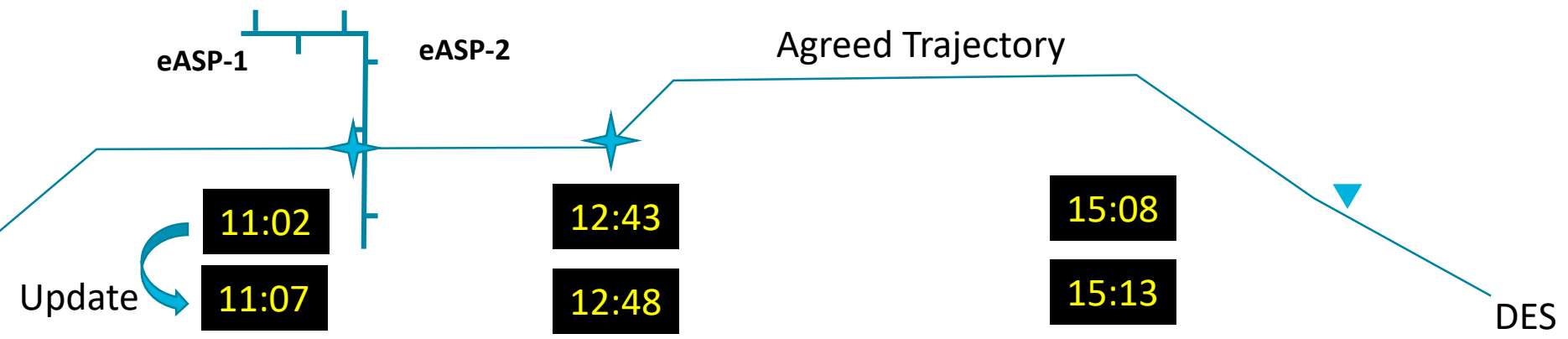# Transition from Release 1 to Release 2

Image: Google Earth

Negotiation Horizon takes on a different context:
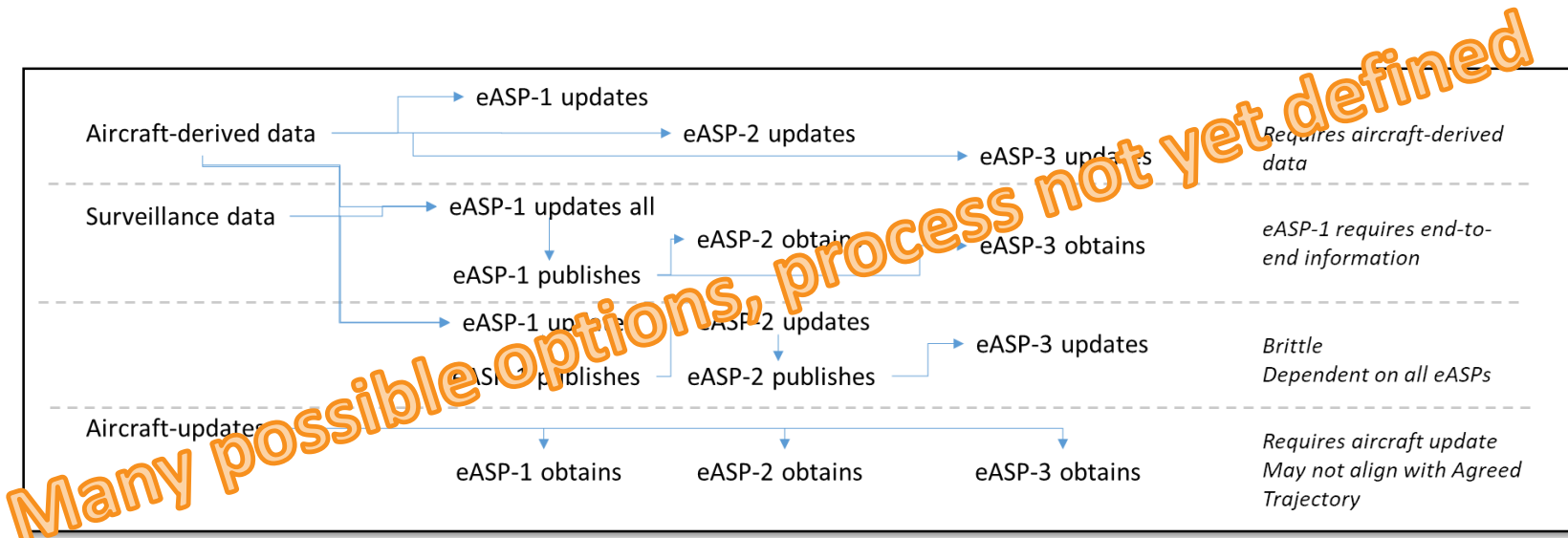
- **Flight may be in a tactical phase**
  - Maneuvering on surface towards departure runway
  - Imminent takeoff

  → eAU may negotiate <u>downstream changes</u> to be implemented later. However, flight deck involvement would be limited.

- **Clearance may have been delivered but flight is delayed**
  - Prior to or subsequent to surface movement

  → eAU may negotiate <u>entire flight plan</u>, process is required to synchronize plan with ATC & clearance prior to committing to agreement

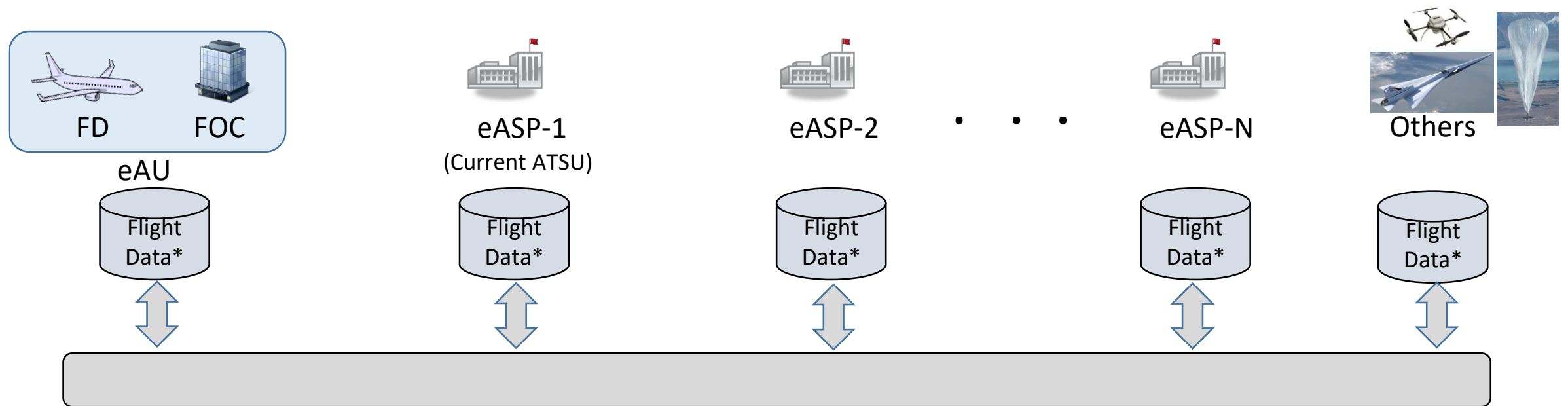- **Existing surface CDM processes expected to interact with Agreed Trajectory**

CDM: Collaborative Decision Making

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Update of Agreed Trajectory

Uncertainty, wind, departure, climbs, speeds…

eASP-1

eASP-2

Agreed Trajectory

11:02

Update → 11:07

12:43

12:48

15:08

15:13

DES

Who updates, how and when?

Aircraft-derived data	→ eASP-1 updates	→ eASP-2 updates	→ eASP-3 updates	*Requires aircraft-derived data*
Surveillance data	→ eASP-1 updates all	→ eASP-2 obtain	eASP-3 obtains	*eASP-1 requires end-to-end information*
	eASP-1 publishes			
	eASP-1 updates	eASP-2 updates	→ eASP-3 updates	*Brittle*
	eASP-1 publishes	eASP-2 publishes		*Dependent on all eASPs*
Aircraft-updates	eASP-1 obtains	eASP-2 obtains	eASP-3 obtains	*Requires aircraft update*
				May not align with Agreed Trajectory

Many possible options, process not yet defined

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Flight Data Sharing

*Participants may have different models for internal data storage and management (e.g., internal databases, cloud services, private vendors)

- Participants maintain local flight data as required
- Flight data is shared between participants using standardized Information exchange models
- Flight data is consistent, update as necessary (e.g., thresholds, events or periodic)
- Used to maintain the Agreed Trajectory across participants
- Notification that flight data is modified might be variable (e.g., by look-ahead)
- Other participants (e.g. Upper airspace) exchange flight data for their operations and transition

FD: Flight Deck

Images: NASA, Google

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Example – Describing exchanges

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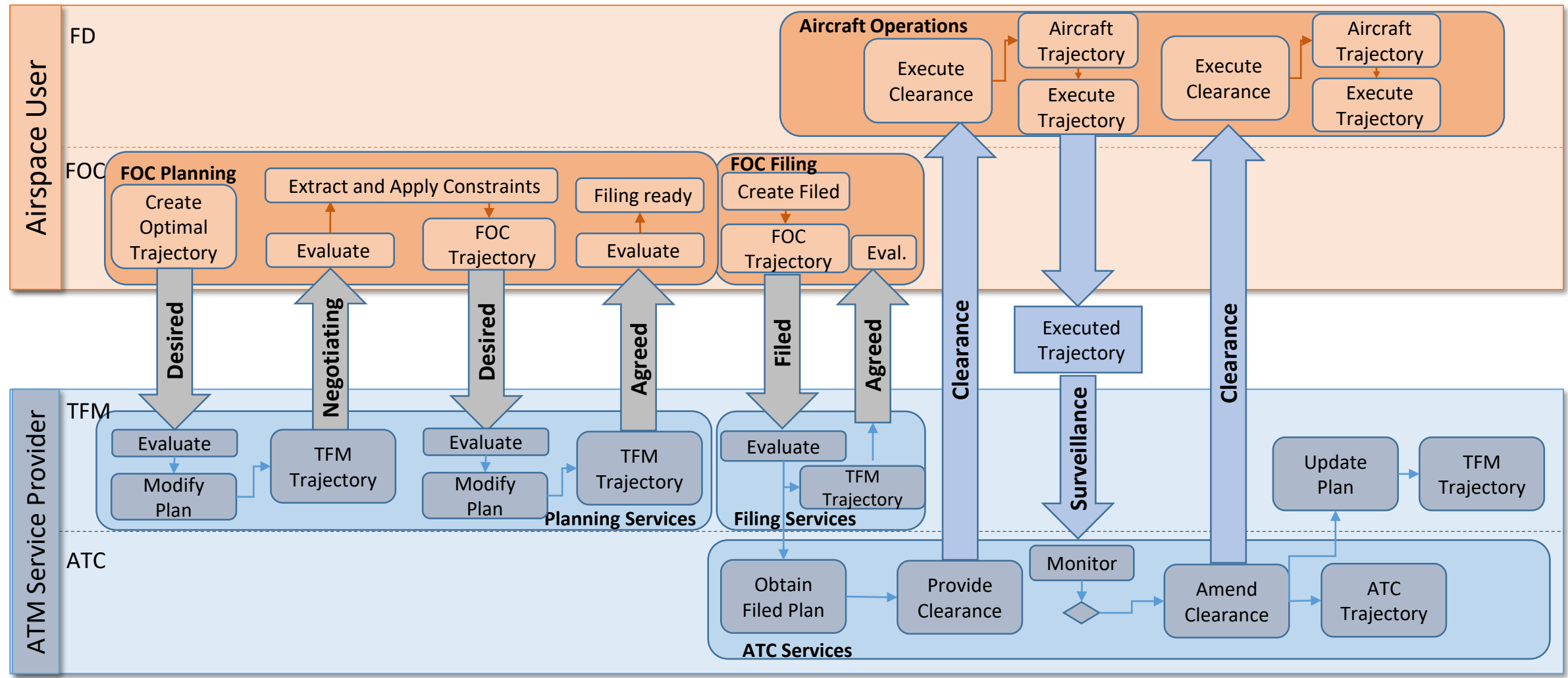
Many Additional Areas under Investigation

- **Negotiation processes**
  - Initiation of negotiation
  - Identifying the negotiation horizon
  - Multi-ASP negotiation and agreement processes
  - ATFM Interactions
  - Obtaining an end-to-end trajectory
  - Mixed-mode
- **Clearance delivery**
  - Across multiple eASP, across an ASP
  - Communicating what has been & remains to be cleared

- **Managing the Agreed**
  - Tactical interventions
  - Use of tolerances
  - Flight through legacy ASPs
- **ATC Interactions**
  - ATC Coordination processes
  - Arrival and Extended arrival management tools

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