



# Practices of ATFM Technology Implementation in China Aviation

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- As the manager of ATFM in SKLATM, organize and conduct researches on cross-region collaborative ATFM operational concept, top-level architecture, and application of advanced technology.
- Successively take charge of key technology researches of North China Regional ATFM system and China National ATFM system, participated in the compilation of ATFM collaborative operation rule and procedure of China aviation.
- It is committed to conduct application research of big data, AI and other Internet frontier technology in the field of ATFM, and explore novel technology, pattern and applications.

# C ontents

## 1 Introduction

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## 2 Practices

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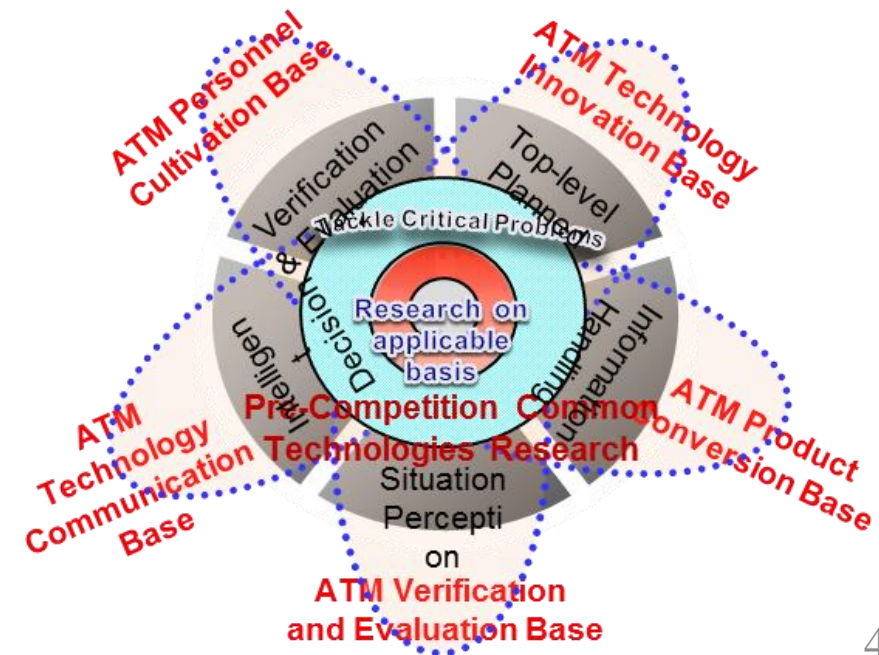
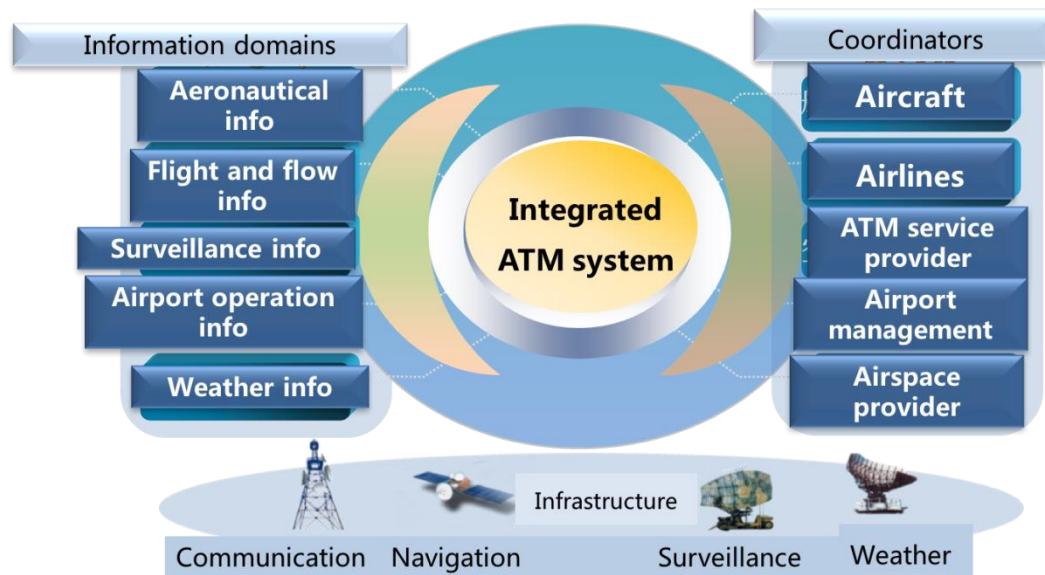
## 3 Conclusion

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# 1. Introduction

## 1) Laboratory Positioning

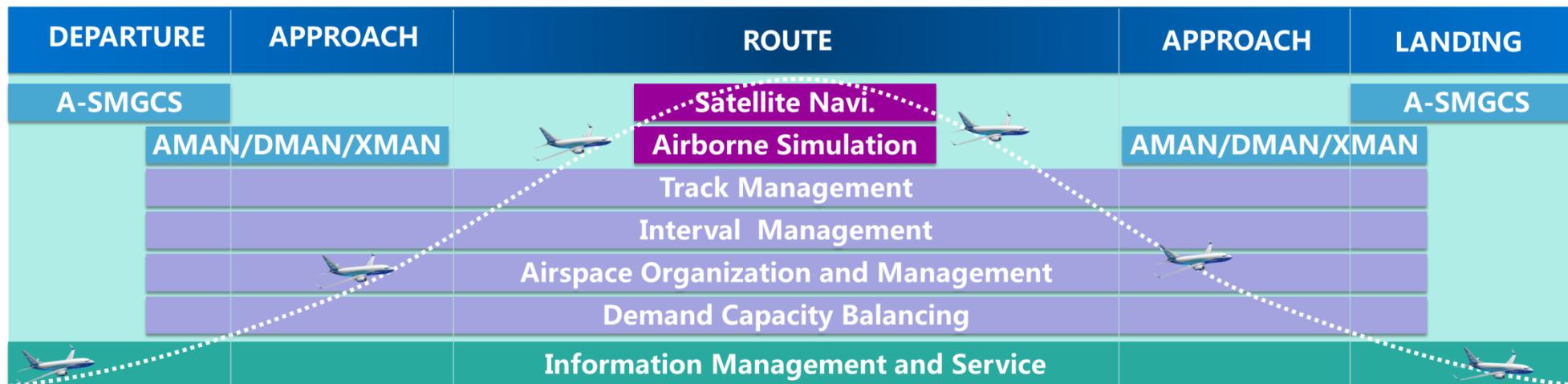
- ◆ To carry out application fundamentals research and pre-competitive technical research on integrated ATM system
- ◆ To become a major standard developer in the industry
- ◆ To promote the research production in the industry



# 1. Introduction

## 2) Research Directions

- ◆ **Direction 1:** Theories and methods for Air Traffic Management system top-level planning and architecture
- ◆ **Direction 2:** Air traffic situation generation and service technology
- ◆ **Direction 3:** Intelligent assistance of decision making process for ATM
- ◆ **Direction 4:** ATM system simulation and evaluation



# 1. Introduction

## 3) Capability Framework

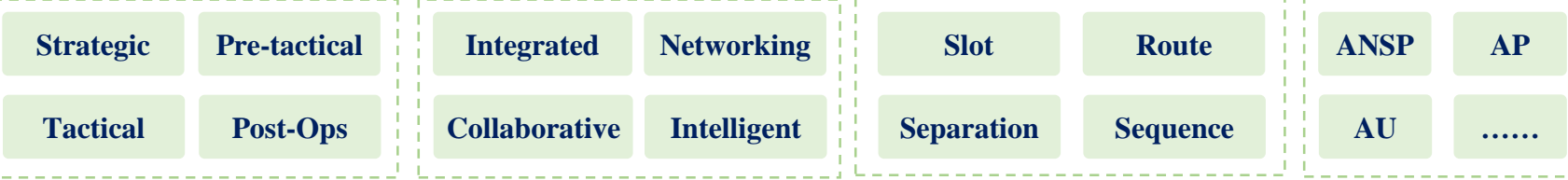
**3-Level ATFM Organizational Structure**



**Enhanced Capability**

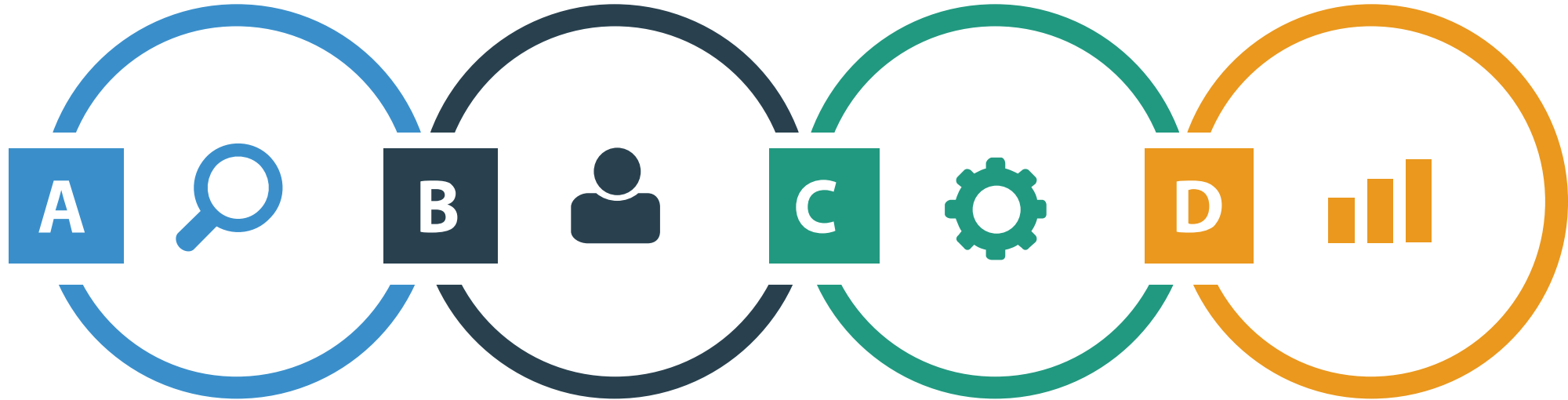


**Multi-dimensional Characteristic**



# 1. Introduction

## 4) Major Problem



### Accurate Prediction of Demand and Capacity

Predict demand and capacity with different time-interval, to capture the accurate operational trend.

### Scientific Model of ATFM Measure

Based on operational scenarios, model different Measures, to avoid redundancy and excess.

### Coordinated Scheduling of Flight Operation

Assign CTOT, CTO coordinately, to satisfy the efficiency and stability performance.

### Collaborative Implementation of Program/Plan

All related participants can express their demands, and intervene the plans flexibility.

**Key Issues of ATFM Development from Regional to Wide Area**

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1 Introduction

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2 Practices

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3 Conclusion

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### 1) Key Technology

01

#### Meteorological Impact Quantification Technology

Analysis the impact of operation based on quantitative index, focus on the objects, range, time horizon, and impact degree.

02

#### Airspace Capacity Assessment Technology

Under the complex operational scenario, realize the capacity assessment by using simulation and numerical analysis.

03

#### Flight Collaborative Scheduling Technology

With the constraints of multiple ATFM measures, calculate CTOTs to realize the objectives of safety, efficiency, stability and fairness.



## Meteorological Impact Quantification Technology

## Airspace Capacity Assessment Technology

## Flight Collaborative Scheduling Technology

### ◆ Multi-source Data Fusion

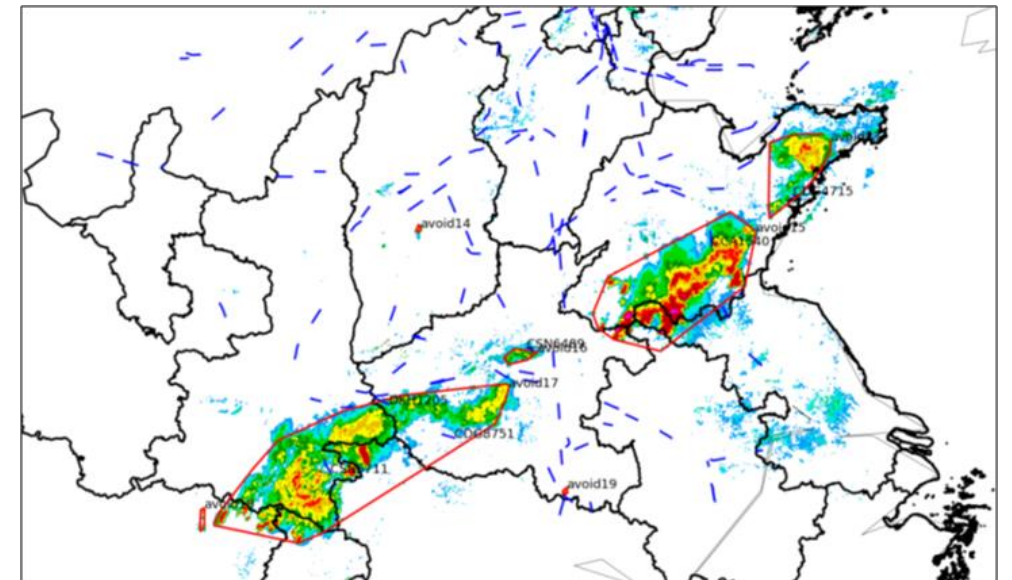
For multi-source heterogeneous meteorological data, analysis, contrast, and fusion the key elements, realizing accurate situation awareness.

### ◆ Meteorological Blockage Analysis

Build airspace operational network based on digital meteorological condition, quantify blockage degree for airspace operation.

### ◆ Assistant Decision Making

Build historical meteorological and trajectory database, exploring flight rules under the condition of convective weather, and establishing weather avoidance field.



## 2. Solutions

### Meteorological Impact Quantification Technology

### Airspace Capacity Assessment Technology

### Flight Collaborative Scheduling Technology



#### Implementation

- 1 Spatial resolution of meteorological information processing is 1km×1km.
- 2 Support airport weather warning, numerical weather prediction, TAF, etc.
- 3 Build airport traffic light tool, route blockage analysis tool.



#### Direction

- 1 Enhance the ability of quantitative analysis for 4-D aeronautical meteorological impact.
- 2 Research on reliability evaluation method of aeronautical meteorological impact.



## 2. Solutions

### Meteorological Impact Quantification Technology



#### ◆ Complex Scenario Modeling

Based on assessment scenario, complete digital mapping of objective rule, environment and traffic flow.

### Airspace Capacity Assessment Technology



#### ◆ Fast Operational Simulation

Simulate flights generation and flight process, calculate KPIs of evaluation results.

### Flight Collaborative Scheduling Technology



#### ◆ Similar Feature Extraction

Design capacity metric system including flow, airspace, and incident, to realize the evolution from data statistical to business characteristics.

# 2. Solutions

## Meteorological Impact Quantification Technology

## Airspace Capacity Assessment Technology

## Flight Collaborative Scheduling Technology

### Implementation

- 1 Support capacity assessment for sector, airway, terminal, airports, etc.
- 2 Support capacity assessment with multi time granularity.
- 3 Design management procedure of airspace capacity assessment, report, and approval.

### Direction

- 1 Improve the comprehensive evaluation elements of airspace capacity.
- 2 Explore joint airspace capacity assessment model.



## 2. Solutions

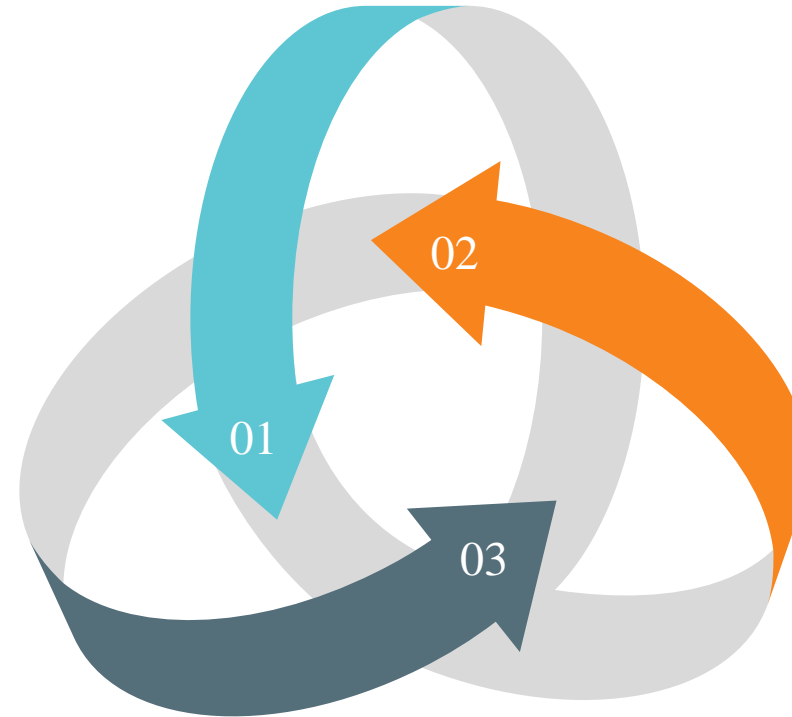
Meteorological Impact  
Quantification Technology

Airspace Capacity  
Assessment Technology

Flight Collaborative  
Scheduling Technology

### Multiple Measures

In complex operational scenario, multiple ATFM measures, with various of models and parameters, make the problems complicated and instable.



### Collaborative Implementation

ATFM managers adjust plan flexibility, to handle dynamic operational environment with disruptions and improve the coordination capability.

### Slot Allocation

Assign feasible time slot for each flight, based on rules with interpretability, aiming to produce the solution with safety and efficiency.

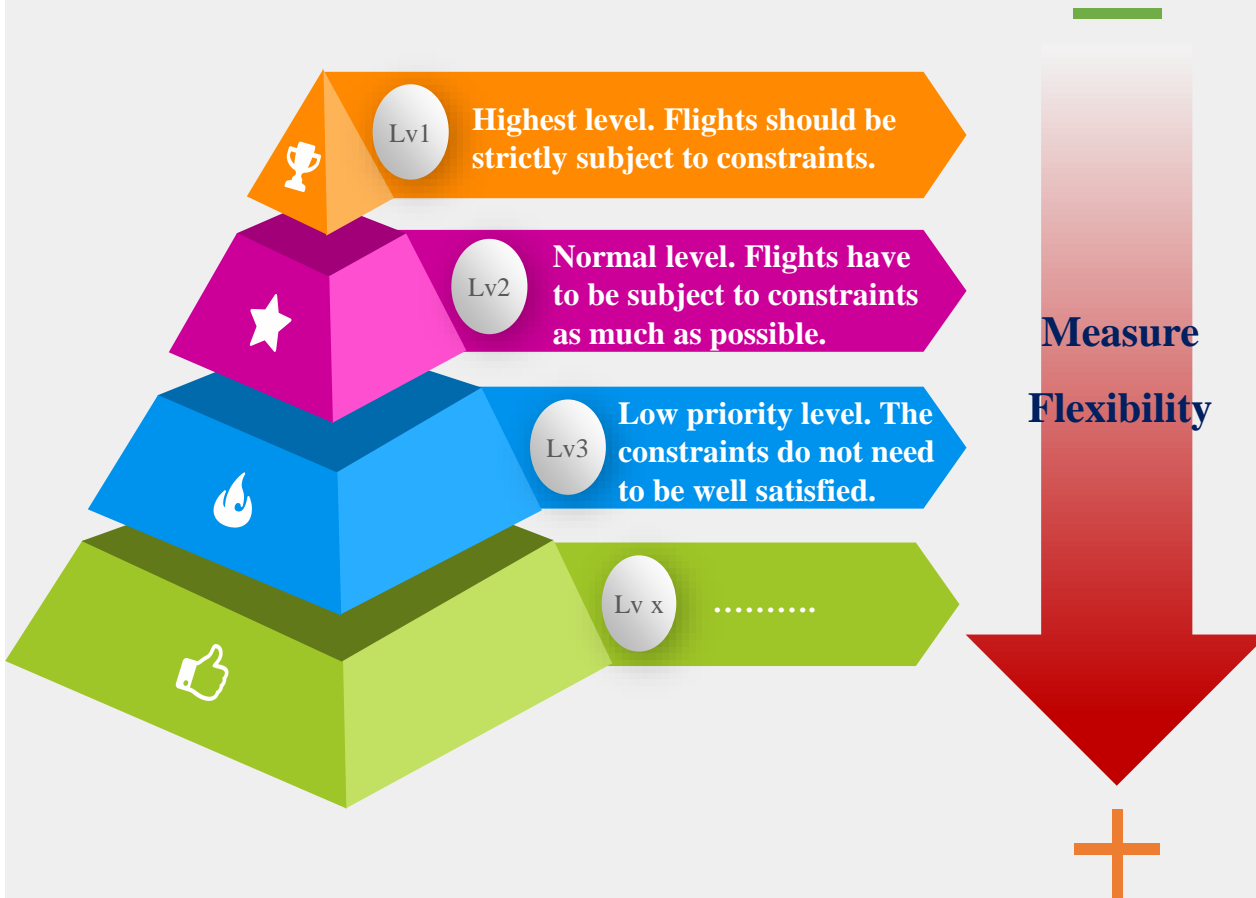
# 2. Solutions

Meteorological Impact  
Quantification Technology

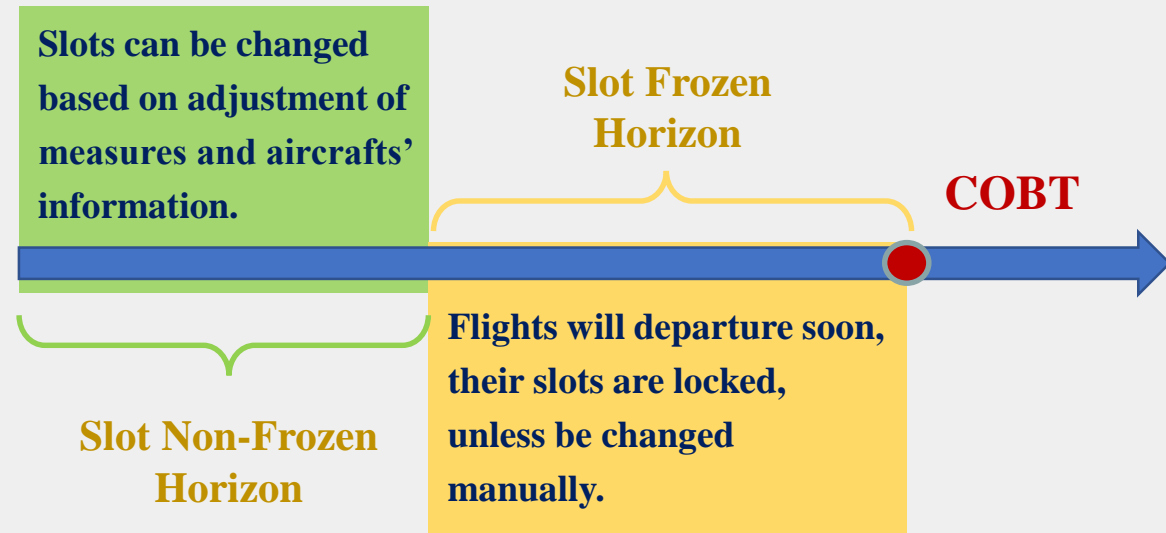
Airspace Capacity  
Assessment Technology

Flight Collaborative  
Scheduling Technology

## ATFM Measure Levels



## Design of Slot Locked



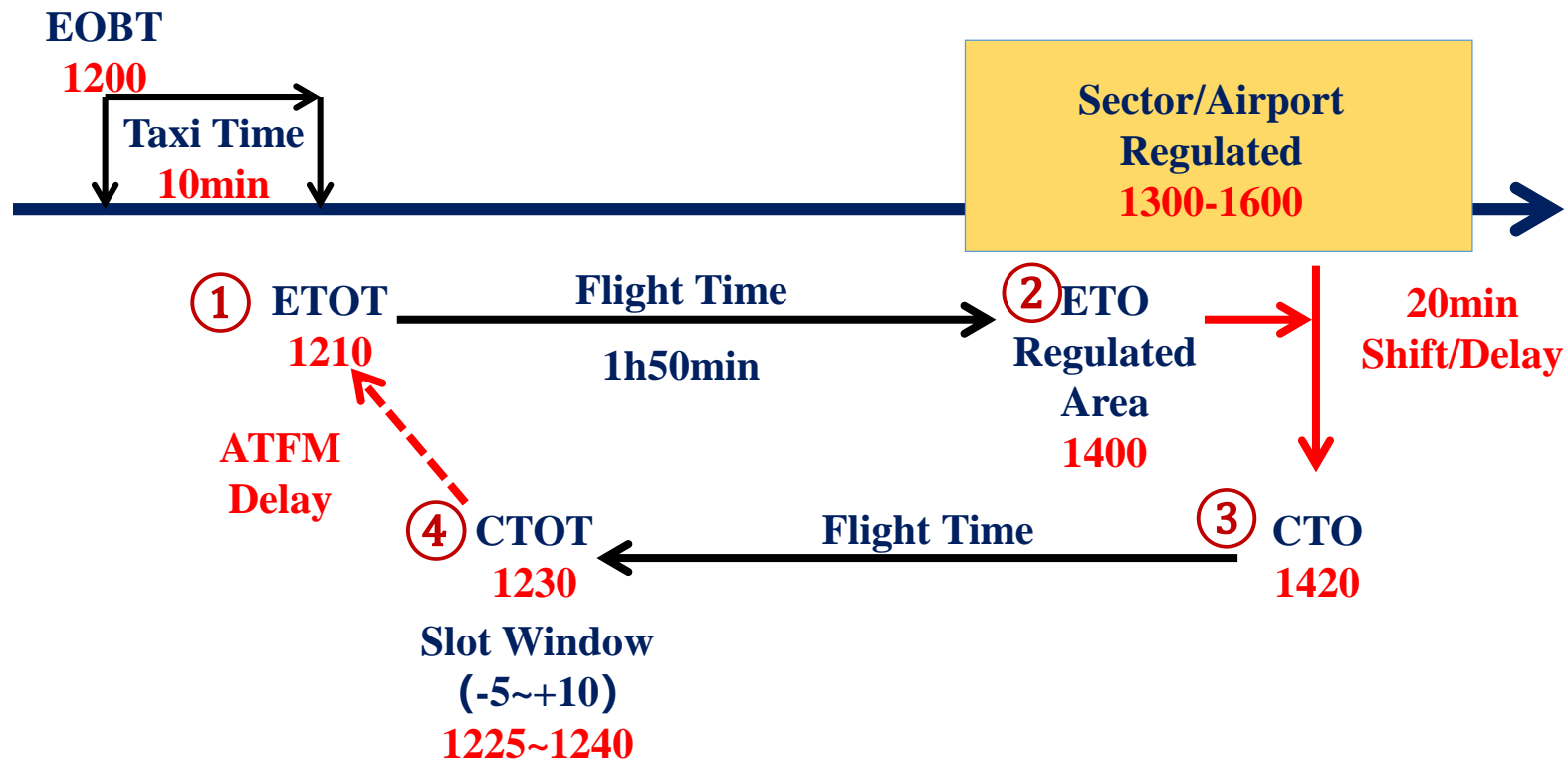
## 2. Solutions

Meteorological Impact  
Quantification Technology

Airspace Capacity  
Assessment Technology

Flight Collaborative  
Scheduling Technology

### CTOT-CTO Calculation



Key Issue : How to calculate CTO?

# 2. Solutions

## Meteorological Impact Quantification Technology

## Airspace Capacity Assessment Technology

## Flight Collaborative Scheduling Technology

### Flight Sequencing



Impact Flight



- Lv1: condition1-1、 ...
- Lv2: condition2-1、 ...
- Lv3: condition3-1、 ...
- LvN: conditionN-1、 ...



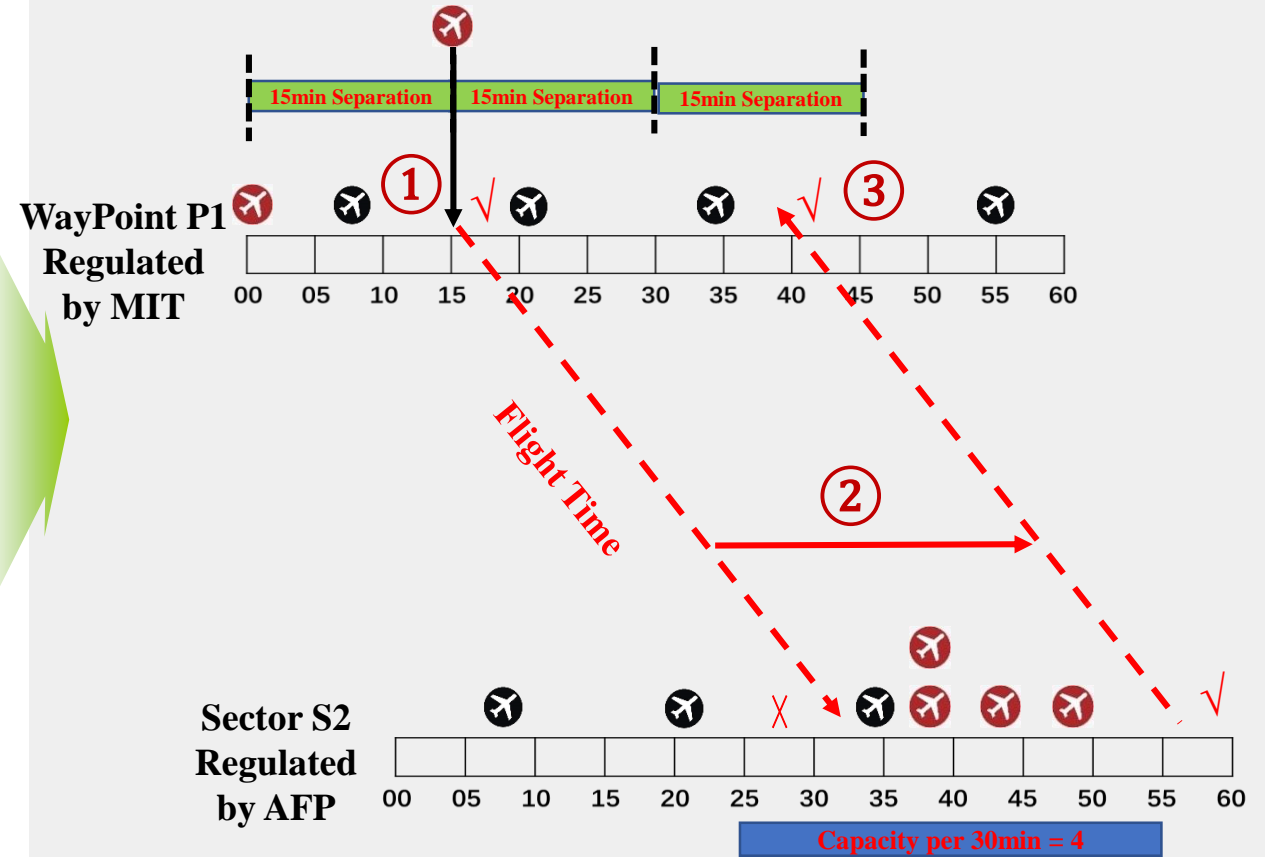
Priority Rule



Flight Sequence



### Feasible Slot Assignment



## 2. Solutions

### Meteorological Impact Quantification Technology

### Airspace Capacity Assessment Technology

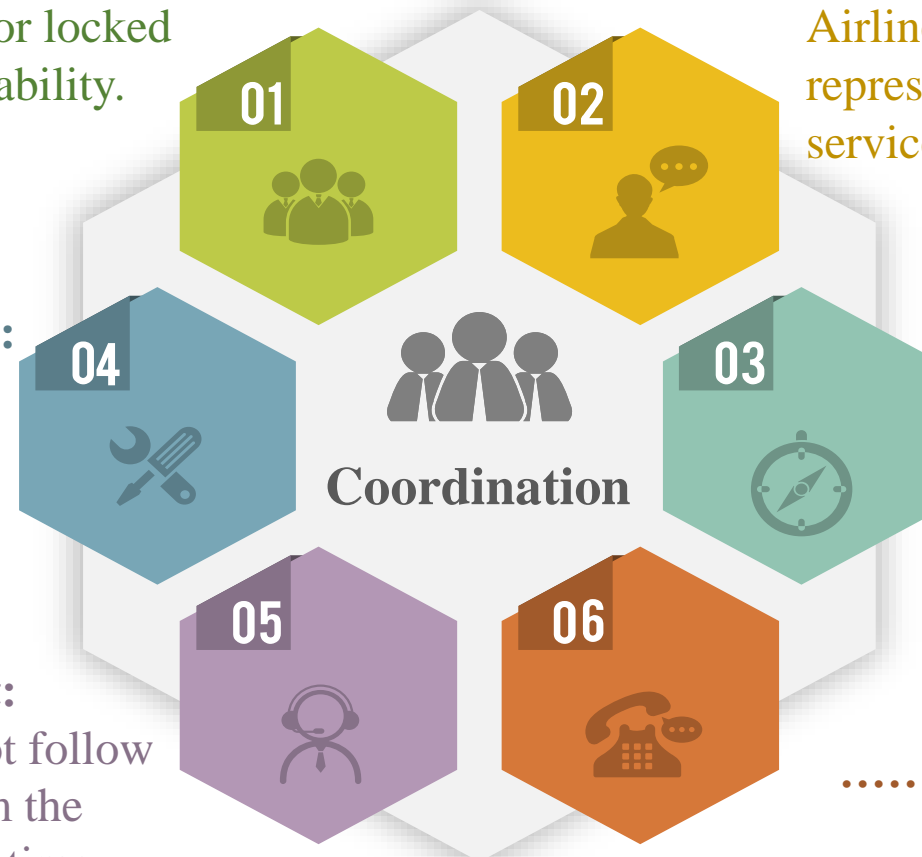
### Flight Collaborative Scheduling Technology

#### Slot Management:

Adjust slot manually, or locked status, to ensure the stability.

#### Baseline Time Management:

Airlines submit TTOT and TOBT, representing the approved time to provide service, to promote re-allocating of time slot.



#### Exempt Status Management:

According to the flow distribution and operational requirements, adjust exempt status of flights in ATFM measures.

#### Separation/Capacity Management:

According to the coordination of ATC, some priority flights do not follow constraints of measures.

#### “Waiting Pool” Management:

In order to handle flights do not follow rules, putting or removing from the waiting pool, and re-allocating time slots simultaneously.

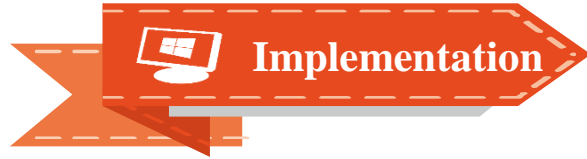
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# 2. Solutions

Meteorological Impact  
Quantification Technology

Airspace Capacity  
Assessment Technology

Flight Collaborative  
Scheduling Technology



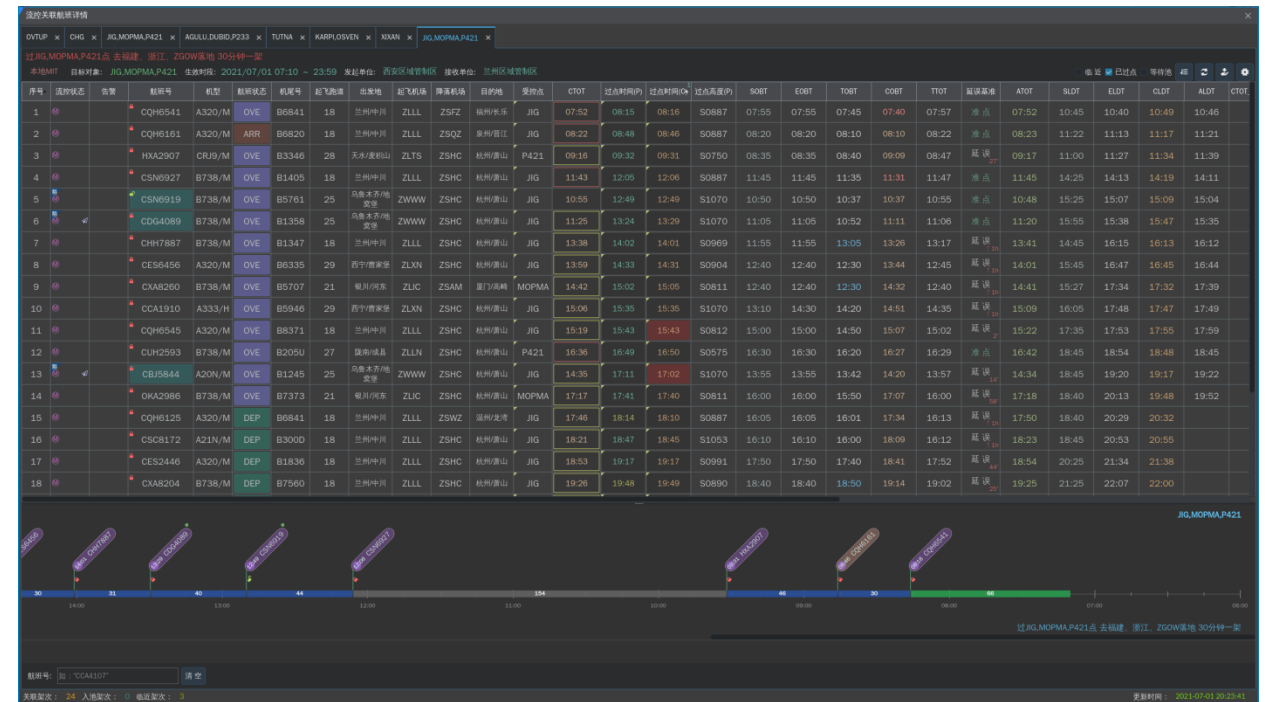
## Implementation

- 1 Support periodic slot allocation for 20000+ flights with 500+ ATFM measures.
- 2 Support ATFM measures of MINIT, GDP, AFP, GS and their combinations.
- 3 Support the total solution with CTOT/CTO calculation and flight level assignment.



## Direction

- 1 Enhance route selection capability.
- 2 Enhance coordination capability with ATC.



序号	运行状态	航班号	机型	航班状态	机尾号	起飞跑道	进离场	起飞机场	降落机场	目的地	受扰点	CTOT	过点时间O	过点时间C	过点高度O	S0BT	E0BT	T0BT	C0BT	T1OT	延误等级	ATOT	SLDT	ELDT	CLDT	ALDT	CTOT
1	📌	CQH6541	A320/M	OVE	B6841	18	兰州中川	ZLLL	ZSFZ	福州长乐	JIG	07:52	08:15	08:16	S0887	07:55	07:55	07:45	07:40	07:57	延误 <sub>27</sub>	07:52	10:45	10:40	10:49	10:46	
2	📌	CQH6161	A320/M	ARR	B6920	18	兰州中川	ZLLL	ZSQZ	泉州晋江	JIG	08:22	08:48	08:46	S0887	08:20	08:20	08:10	08:10	08:22	延误 <sub>28</sub>	08:23	11:22	11:13	11:17	11:21	
3	📌	HXA2907	CRJ9/M	OVE	B3346	28	天府成都	ZLTS	ZSHC	杭州萧山	P421	09:16	09:32	09:31	S0750	08:35	08:35	08:40	09:09	08:47	延误 <sub>27</sub>	09:17	11:00	11:27	11:34	11:39	
4	📌	C5N6927	B738/M	OVE	B1405	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	11:43	12:05	12:06	S0887	11:45	11:45	11:35	11:31	11:47	延误 <sub>28</sub>	11:45	14:25	14:13	14:19	14:11	
5	📌	C5N6919	B738/M	OVE	B5761	25	乌鲁木齐地窝堡	ZWWW	ZSHC	杭州萧山	JIG	10:55	12:49	12:49	S1070	10:50	10:50	10:37	10:37	10:55	延误 <sub>28</sub>	10:48	15:25	15:07	15:09	15:04	
6	📌	CDG4089	B738/M	OVE	B1358	25	乌鲁木齐地窝堡	ZWWW	ZSHC	杭州萧山	JIG	11:25	13:24	13:29	S1070	11:05	11:05	10:52	11:11	11:06	延误 <sub>28</sub>	11:20	15:55	15:38	15:47	15:35	
7	📌	CHH7887	B738/M	OVE	B1347	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	13:38	14:02	14:01	S0969	11:55	11:55	13:05	13:26	13:17	延误 <sub>28</sub>	13:41	14:45	16:15	16:13	16:12	
8	📌	CES6456	A320/M	OVE	B6335	29	西宁曹家堡	ZLXN	ZSHC	杭州萧山	JIG	13:59	14:33	14:31	S0904	12:40	12:40	12:30	13:44	12:45	延误 <sub>28</sub>	14:01	15:45	16:47	16:45	16:44	
9	📌	CXA8260	B738/M	OVE	B5707	21	银川河东	ZLIC	ZSAM	厦门高崎	MOPMA	14:42	15:02	15:05	S0811	12:40	12:40	12:30	14:32	12:40	延误 <sub>28</sub>	14:41	15:27	17:34	17:32	17:39	
10	📌	CCA1910	A333/H	OVE	B9946	29	西宁曹家堡	ZLXN	ZSHC	杭州萧山	JIG	15:06	15:35	15:35	S1070	13:10	14:30	14:20	14:51	14:35	延误 <sub>28</sub>	15:09	16:05	17:48	17:47	17:49	
11	📌	CQH6545	A320/M	OVE	B8371	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	15:19	15:43	15:43	S0812	15:00	15:00	14:50	15:07	15:02	延误 <sub>27</sub>	15:22	17:35	17:53	17:55	17:59	
12	📌	CUH2593	B738/M	OVE	B205U	27	昆明长水	ZLLN	ZSHC	杭州萧山	P421	16:38	16:49	16:50	S0575	16:30	16:30	16:20	16:27	16:29	延误 <sub>28</sub>	16:42	18:45	18:54	18:48	18:45	
13	📌	CBJ5844	A20N/M	OVE	B1245	25	乌鲁木齐地窝堡	ZWWW	ZSHC	杭州萧山	JIG	14:35	17:11	17:02	S1070	13:55	13:55	13:42	14:20	13:57	延误 <sub>28</sub>	14:34	18:45	19:20	19:17	19:22	
14	📌	DKA2986	B738/M	OVE	B7373	21	银川河东	ZLIC	ZSHC	杭州萧山	MOPMA	17:17	17:41	17:40	S0811	16:00	16:00	15:50	17:07	16:00	延误 <sub>28</sub>	17:18	18:40	20:13	19:48	19:52	
15	📌	CQH6125	A320/M	DEP	B6841	18	兰州中川	ZLLL	ZSWZ	温州龙湾	JIG	17:48	18:14	18:10	S0887	16:05	16:05	16:01	17:34	16:13	延误 <sub>28</sub>	17:50	18:40	20:29	20:32		
16	📌	C5C8172	A21N/M	DEP	B300D	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	18:21	18:47	18:45	S1053	16:10	16:10	16:00	18:09	16:12	延误 <sub>28</sub>	18:23	18:45	20:53	20:55		
17	📌	CES2446	A320/M	DEP	B1836	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	18:53	19:17	19:17	S0991	17:50	17:50	17:40	18:41	17:52	延误 <sub>28</sub>	18:54	20:25	21:34	21:38		
18	📌	CXA8204	B738/M	DEP	B7560	18	兰州中川	ZLLL	ZSHC	杭州萧山	JIG	19:28	19:48	19:49	S0890	18:40	18:40	18:50	19:14	19:02	延误 <sub>28</sub>	19:25	21:25	22:07	22:00		

# C contents

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## 2 Practices

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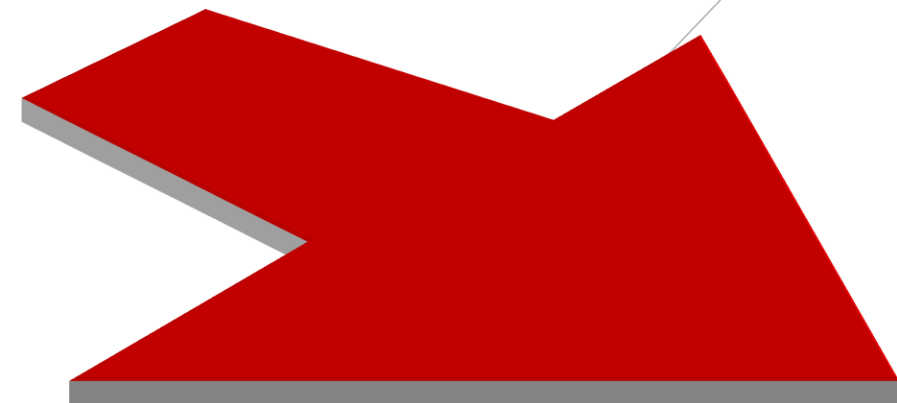
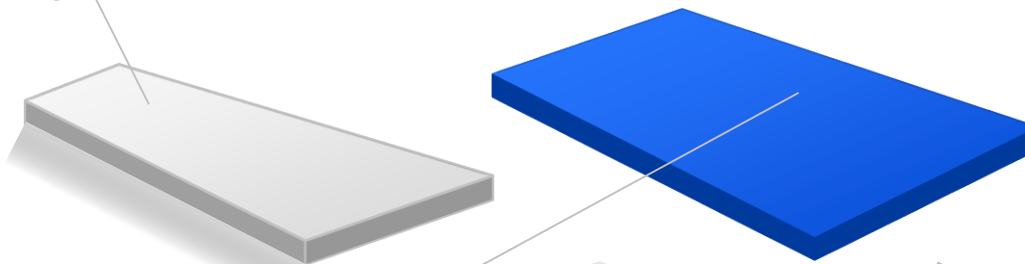
## 3 Conclusion

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### 3. Conclusion

It is a critical job to construct platform of information exchange and CDM, which to provide unified and accurate situation awareness, and to generate solutions with high coordination.

Dealing with complex scenarios in Asia, especially in demand and capacity prediction, ATFM measures model, flights collaborative scheduling, it is required to have accurate, scientific and efficient processing ability, meeting real-time operation needs.



There are obvious differences in operation conditions and requirements among countries. It is necessary to form a flexible way to provide good inclusiveness for all countries to participate.



### 3. Conclusion

The development of Cross-Border Multi-Nodal ATFM will promote all participants to form a uniform and accurate understanding of Asia regional aviation situation. Meanwhile, it can provide a convenient and effective collaborative decision making platform and significantly improve aviation operation efficiency, acting as an important demonstration of global integrated ATM development.

We have actively and deeply participate in National ATFM system, and some remarkable achievements have been made in integrating regional ATFM ability into centralized capability. The best practice can provide experience for Asia collaborative ATFM. As a state key laboratory, we will be devoted to provide technical support for air traffic flow management in Asia.



**Thank you!**