A Visualization Tool for Analyzing Task Demands in En-route Air Traffic Control

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Background

- In response to rapid increase in air traffic demands, Air Traffic Management (ATM) is being introduced

Air Traffic Flow Management (ATFM)

- ✓ For enhancing air traffic efficiency and reducing the workload of controllers in each ATC sector
- ✓ Performed by time-based control to air traffic at departure airports and specific geometrical points (FIXes)

Background

- Regardless of the introduction of ATFM, features of ATC tasks in each sector is almost the same
  - ✓ dealing with multiple aircraft at the same time in variable situations
  - ✓ regulating workload by adopting an appropriate control strategy of air traffic
- Harmonization between flow control by ATFM and controllers' working methods is a key issue
  - *Mismatches might lead to additional task demands and put burden on the controller*

Effects of ATFM on ATC task demands with consideration of controllers' working methods

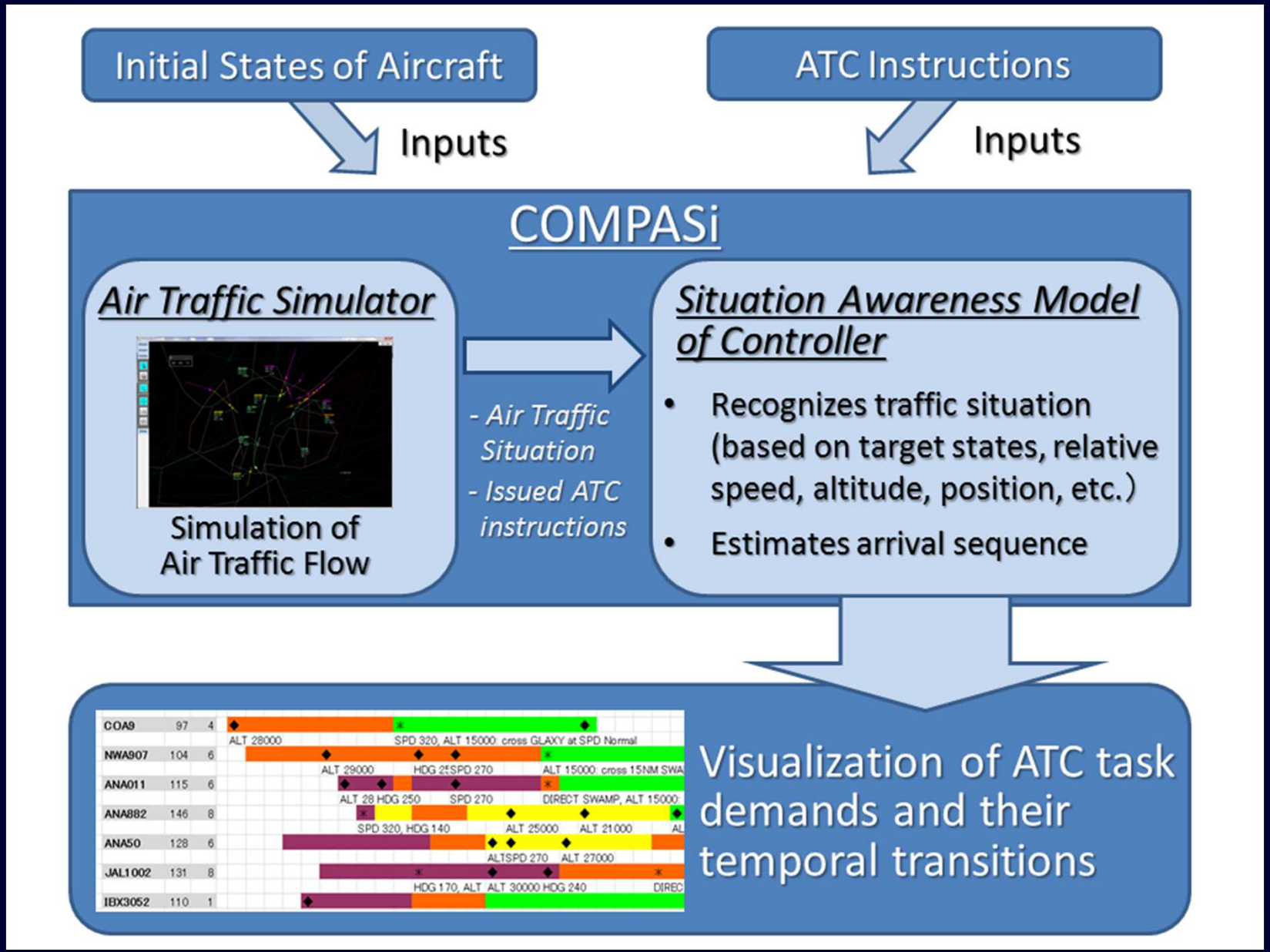
Purpose

- Dealing with controllers' working methods / ATC task demands is difficult
  - Cognitive aspects of an ATCO
  - No common support tools
- A process visualization tool of ATC tasks called COMPASi
  - *Can visualize ATCO's control activities and their effects on ATC task demands*
- *The purpose of the present research:*

COMPASi
(COMPAS in interactive mode / COMPAS: COgnitive system Model for simulating Projection-based behaviors of Air traffic controller in dynamic Situations)

To examine applicability of our COMPASi as a support tool for analyzing effects of ATFM on ATC task demands with consideration of controllers' working methods

COMPASi


Initial States of Aircraft
ATC Instructions
Inputs
Inputs
COMPASi
Air Traffic Simulator
Simulation of Air Traffic Flow
- Air Traffic Situation
- Issued ATC instructions
Situation Awareness Model of Controller
• Recognizes traffic situation (based on target states, relative speed, altitude, position, etc.)
• Estimates arrival sequence
COA9 97 4
NWA907 104 6
ANA011 115 6
ANA882 146 8
ANA50 128 6
JAL1002 131 8
IBX3052 110 1
ALT 28000
SPD 320, ALT 15000: cross GLAXY at SPD Normal
ALT 29000
HDG 25SPD 270
ALT 15000: cross 15NM SWA
ALT 28 HDG 250
SPD 270
DIRECT SWAMP, ALT 15000
SPD 320, HDG 140
ALT 25000
ALT 21000
ALTSPD 270
ALT 27000
HDG 170, ALT
ALT 30000 HDG 240
Visualization of ATC task demands and their temporal transitions

ATC Task Index

Task Demand Levels: TDLs (Aoyama et al., 2010*)

Indicate required ATC tasks for each aircraft

Lv.	Situation / Task Demand	Display Colors on COMPASi
4	time-critical situation in terms of conflict resolution(s)	Red
3+	multiple separation assurances (conflict resolution(s) / in-trail spacing) between the target aircraft and two or more related aircraft	Magenta
3	separation assurance (conflict resolution / in-trail spacing) between the target aircraft and one related aircraft	Orange
2	altitude change	Yellow
1	(ATC tasks are completed)	Green

*Aoyama H., Iida H., Karikawa D. (2010b) Study on air traffic control system based on Cognitive Systems Engineering IV (1). In: Proceedings human interface symposium 2010. Kusatsu, pp 209-212

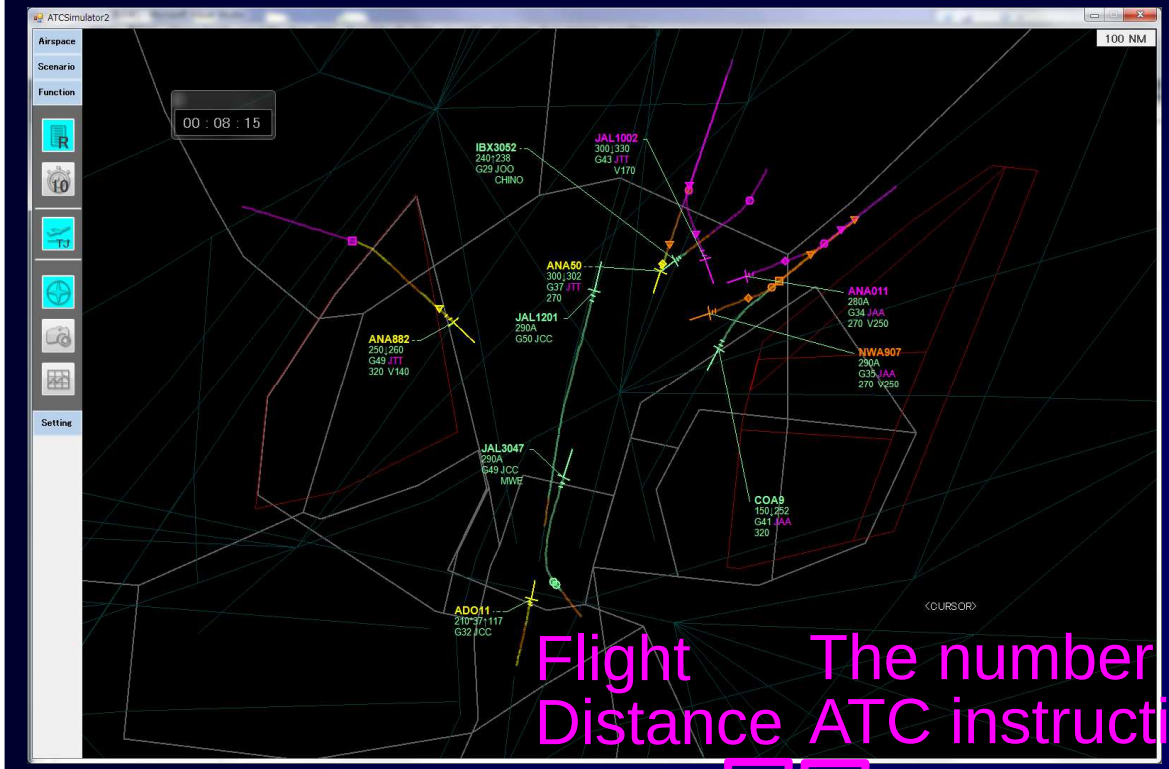
Potential Findings from TDLs

- Higher level of TDL can indicate more complex tasks
  - ➡ • *Higher task demands*
    • *Possible greater workload of the controller*

- Decreasing of TDLs by flow control of ATFM
  - ➡ • *The flow control is well-matched*

  Increasing of TDLs by flow control of ATFM
  - ➡ • *Potential mismatch with controllers' working method*

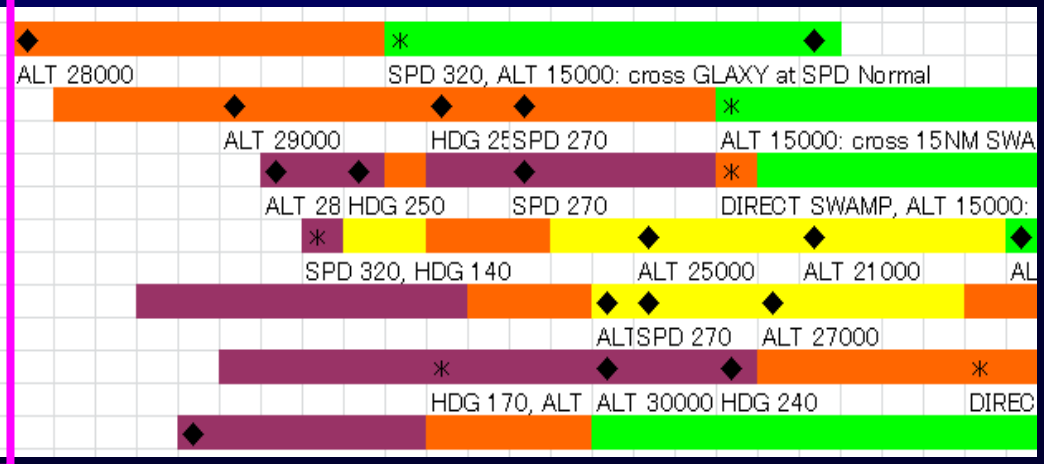
Output of COMPASi



Flight Distance

The number of ATC instructions

COA9	97	4
NWA907	104	6
ANA011	115	6
ANA882	146	8
ANA50	128	6
JAL1002	131	8
IBX3052	110	1



Simulation-based Experiment

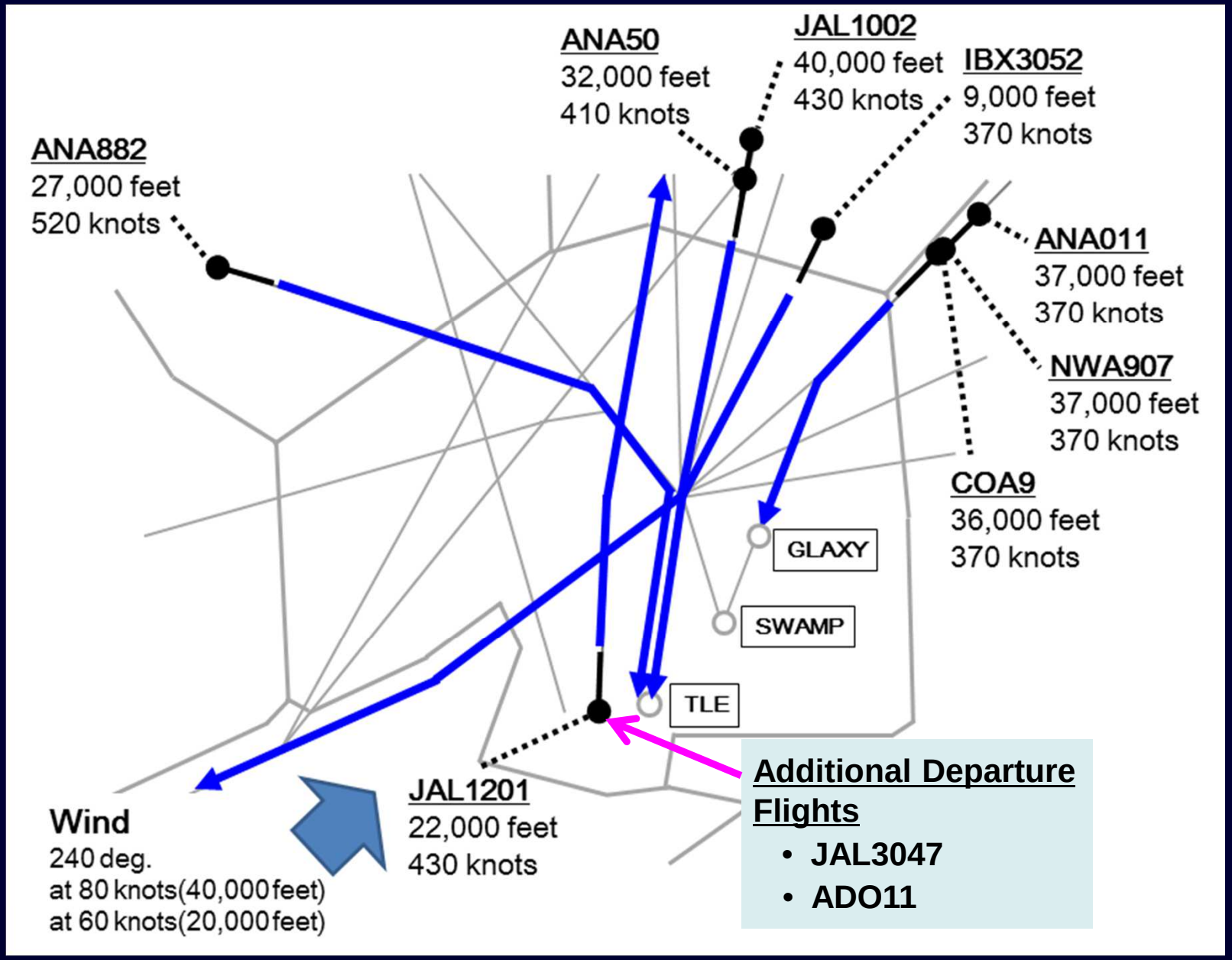
To examine applicability of COMPASi through tentative analysis of the effects of ATFM on ATC task demands

Experimental framework

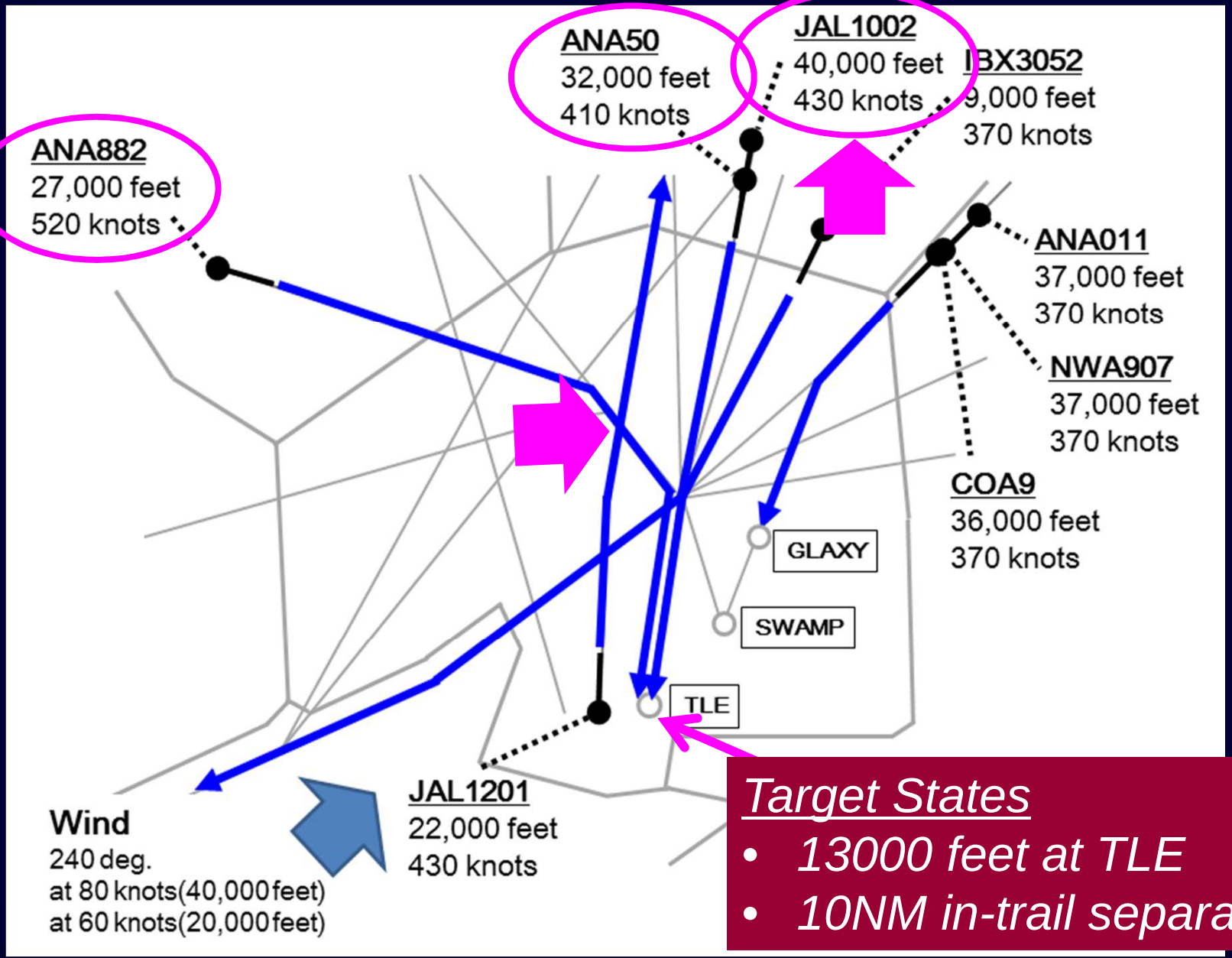
- ✓ (1) A sample traffic scenario of Kanto-North sector
  (2) Two control options of ATFM
  (3) Two control strategies of ATCOs
  were prepared
- ✓ The effects of ATFM were visualized using COMPASi under several simulation conditions (combinations of (2) and (3))

- Can COMPASi visualize the possible beneficial and adverse effects of ATFM under different simulation conditions?
- Are the results consistent to the assessment of the effects of ATFM made by an experienced controller?

(1) Traffic Scenario



(1) Traffic Scenario

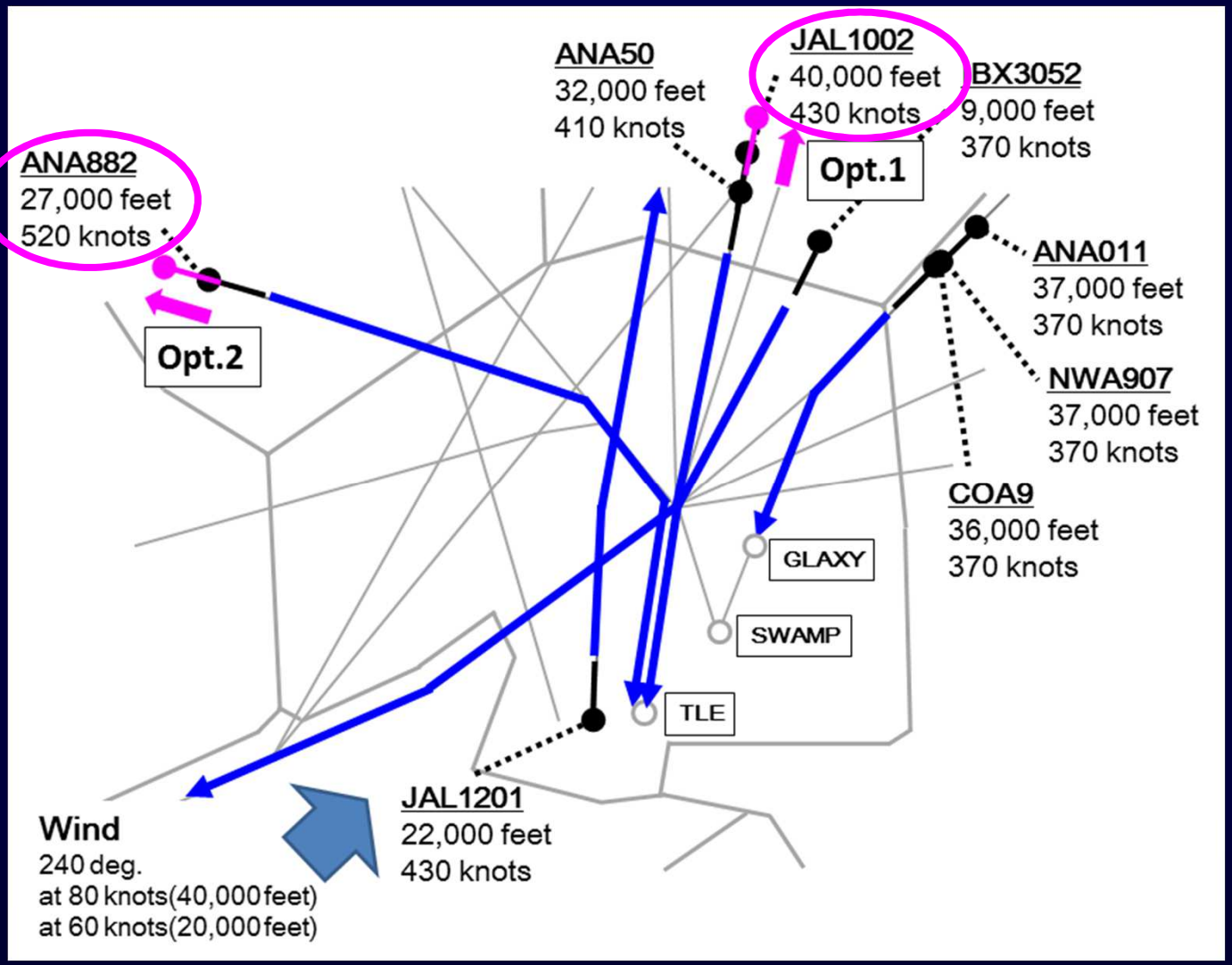


Target States

- *13000 feet at TLE*
- *10NM in-trail separation*

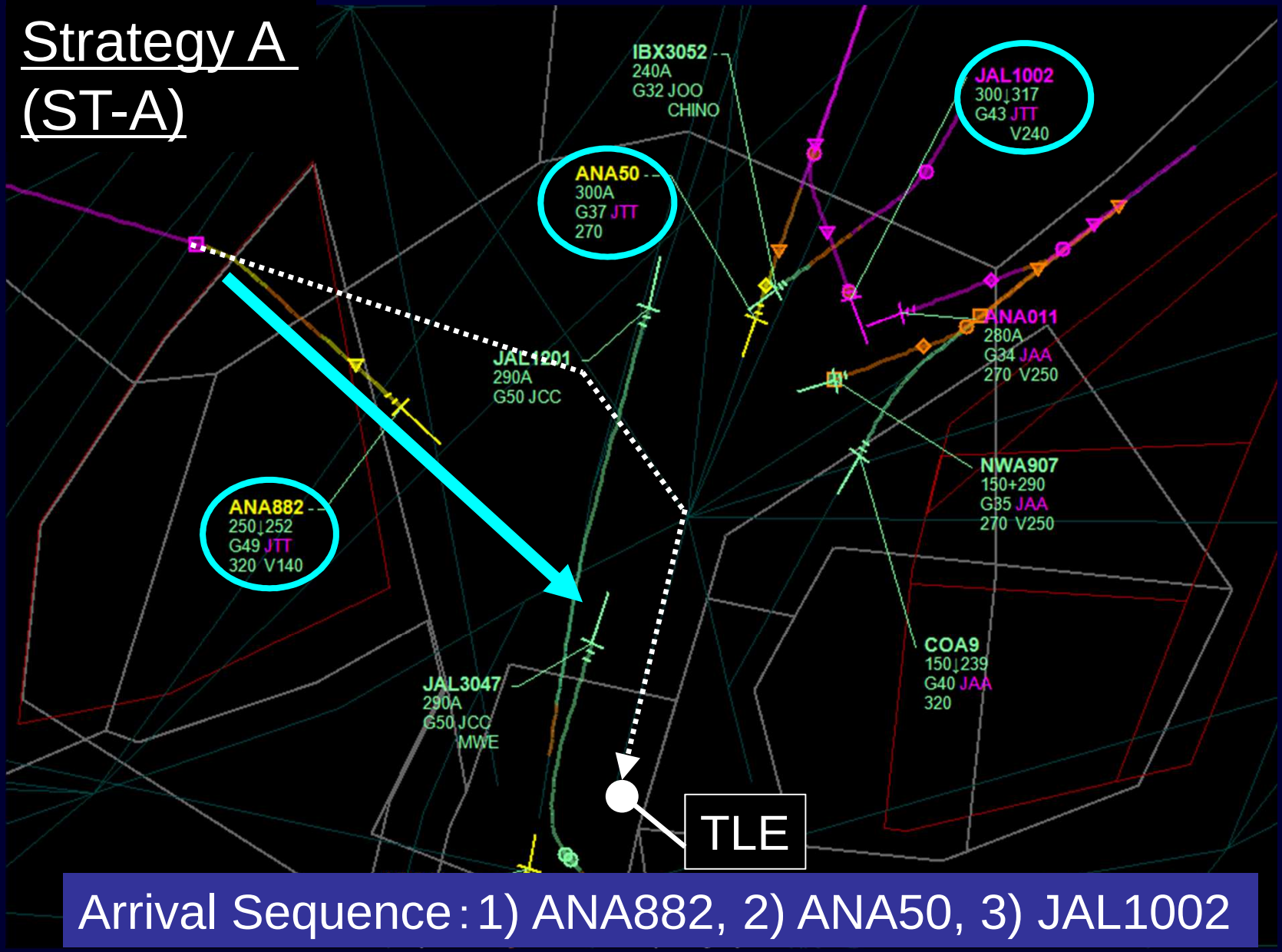
(2) Simulating ATFM

Moving the initial position of the aircraft back by 5NM
(approximately 1 minute delay)



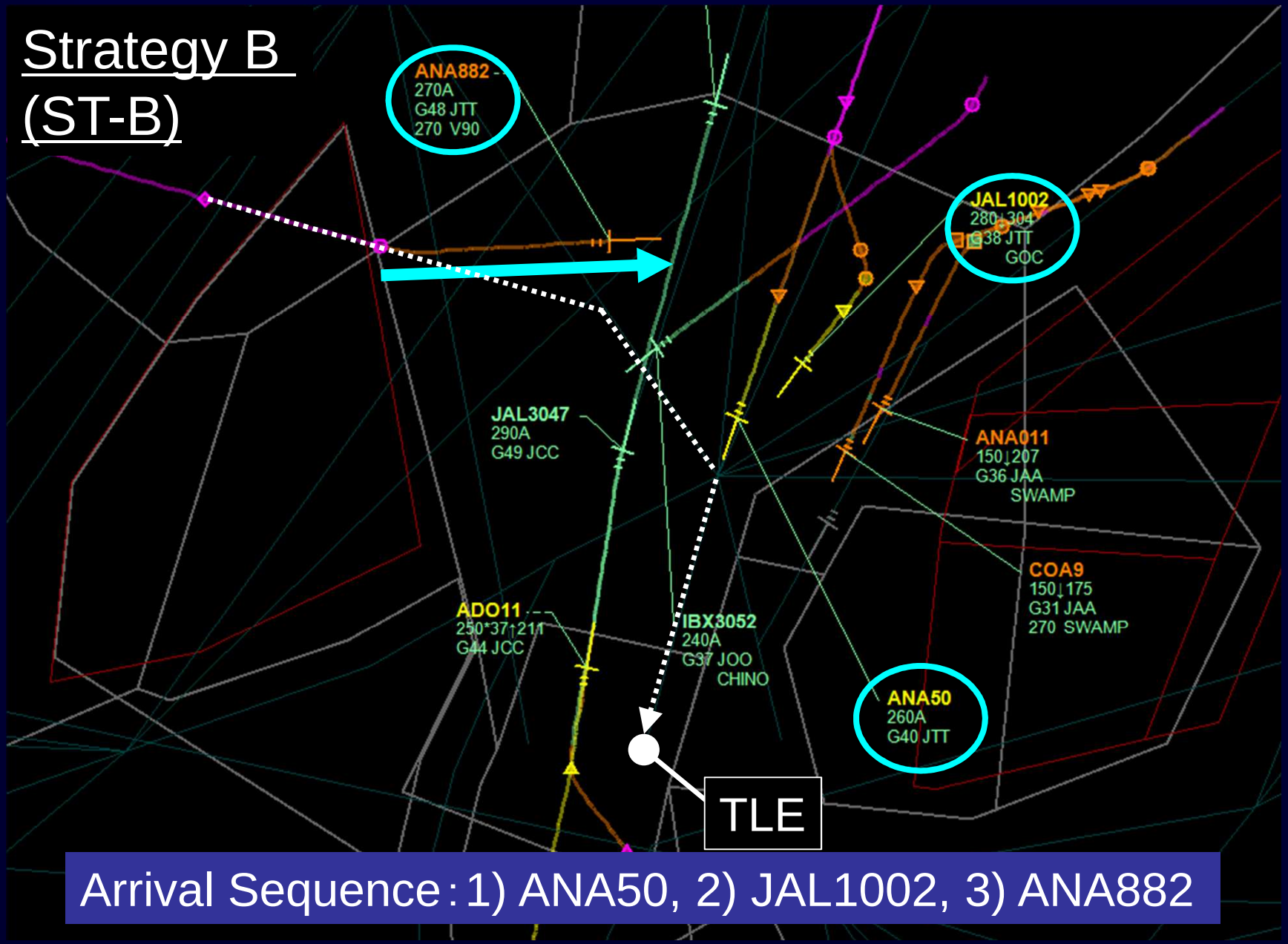
(3) Control Strategies

Strategy A (ST-A)



Arrival Sequence : 1) ANA882, 2) ANA50, 3) JAL1002

(3) Control Strategies



Simulation Cases

Experiment A*

	Control Strategy	ATFM
Baseline Case A	ST-A	No
Case A1	ST-A	Opt.1
Case A2	ST-A	Opt.2

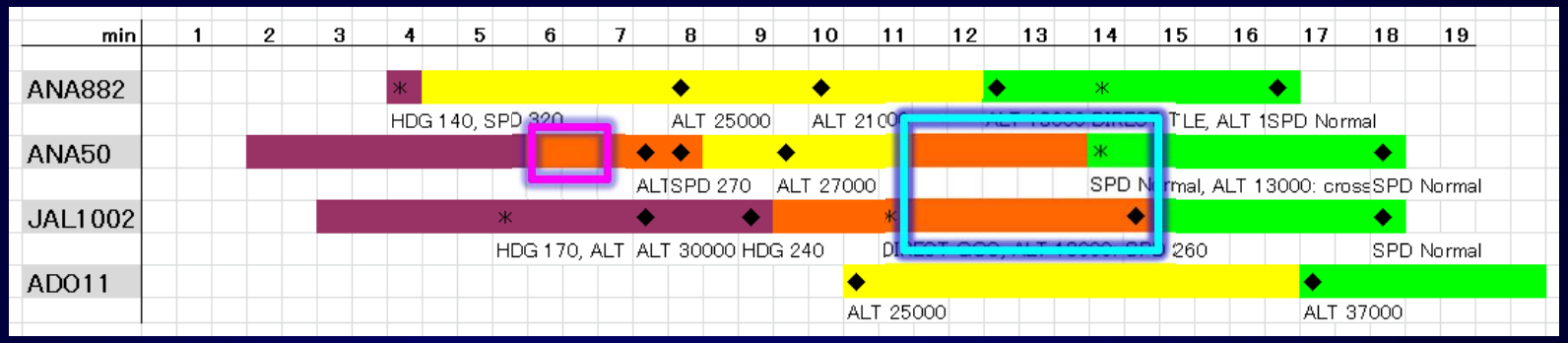
Experiment B

	Control Strategy	ATFM
Baseline Case B	ST-B	No
Case B1	ST-B	Opt.1
Case B2	ST-B	Opt.2

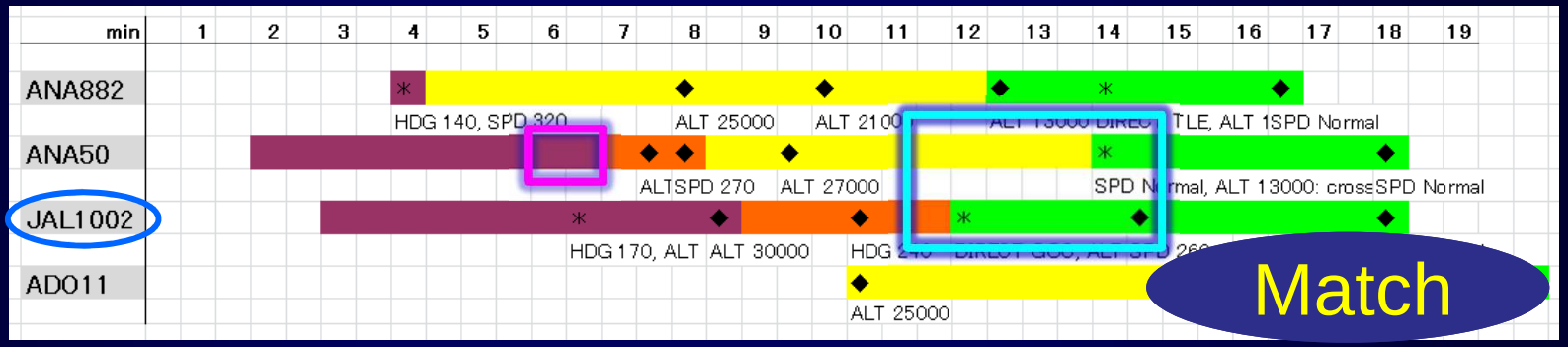
*Aoyama H., Karikawa D., Iida H. (2012) Development of Resilience-oriented Safety Support Methods (4) - A Consideration for Evaluation and Improvement of Air Traffic Flow Management-. In: Proceedings human interface symposium 2012. Fukuoka, pp 53-58

Results (Experiment A)

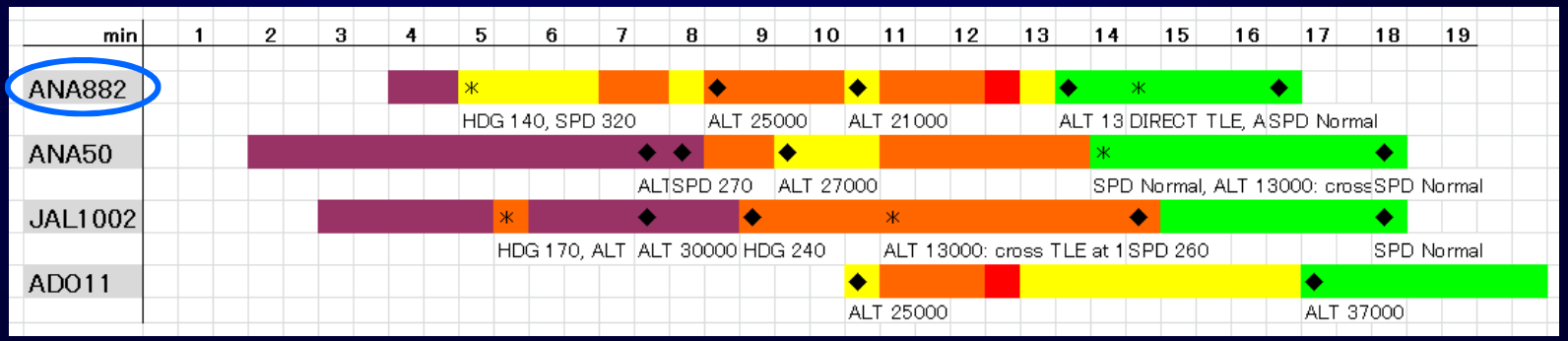
Baseline Case A



Case A1

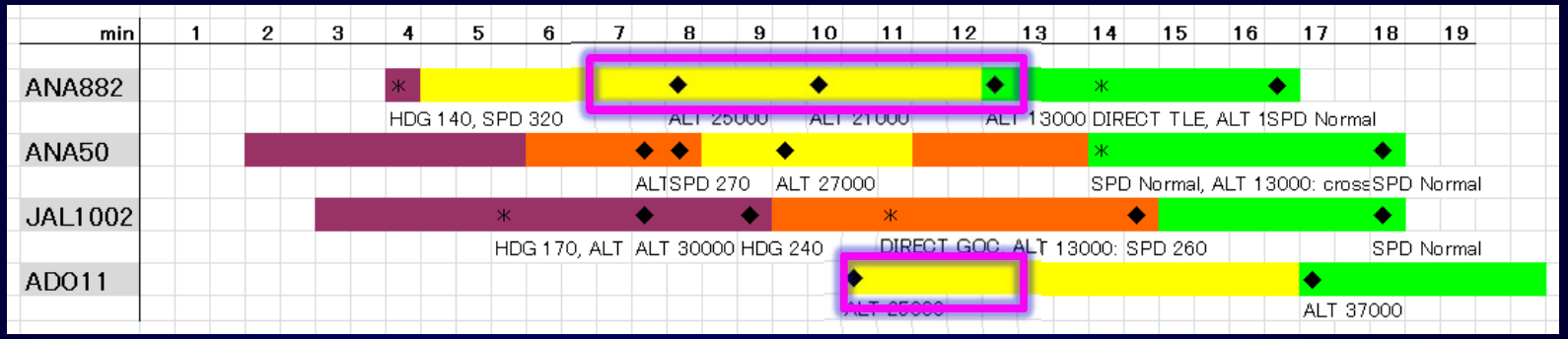


Case A2

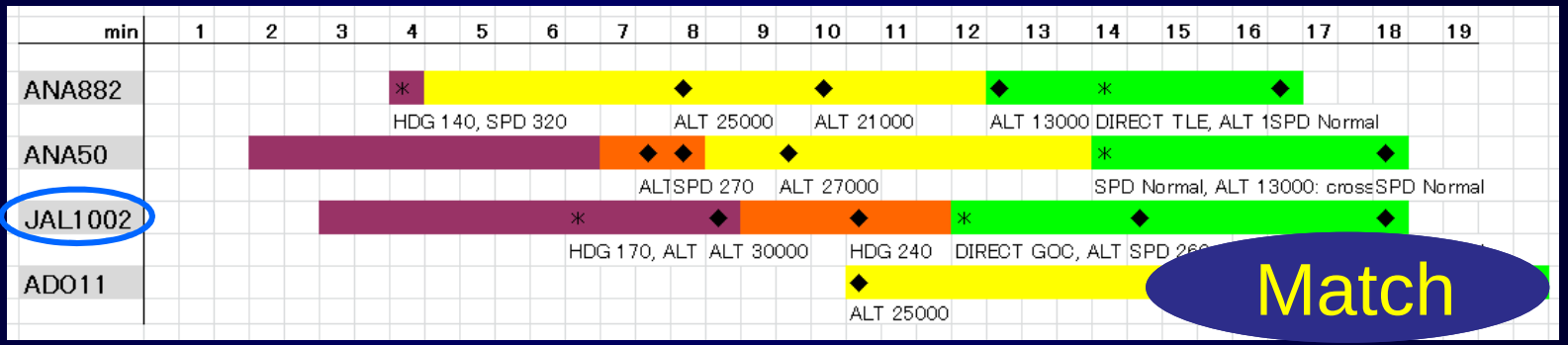


Results (Experiment A)

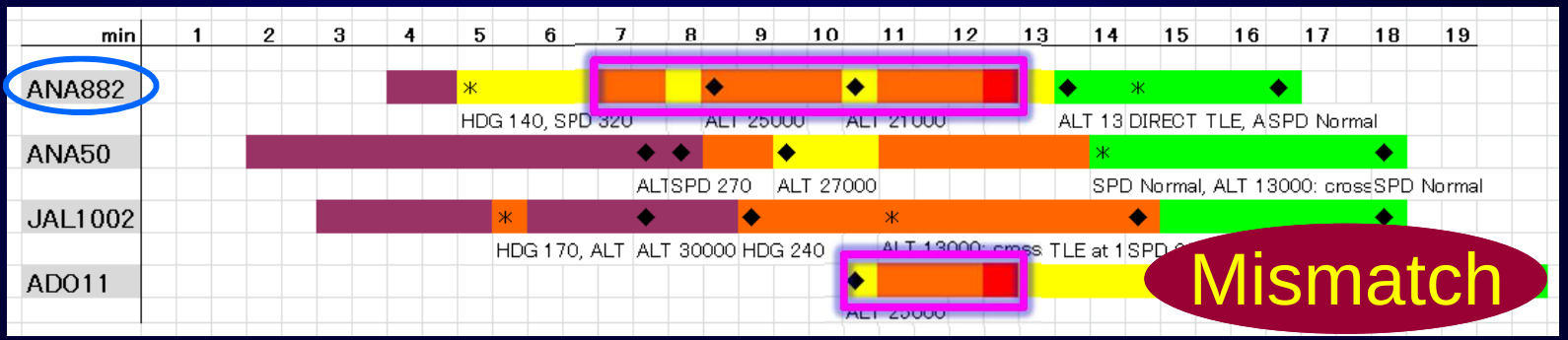
Baseline Case A



Case A1

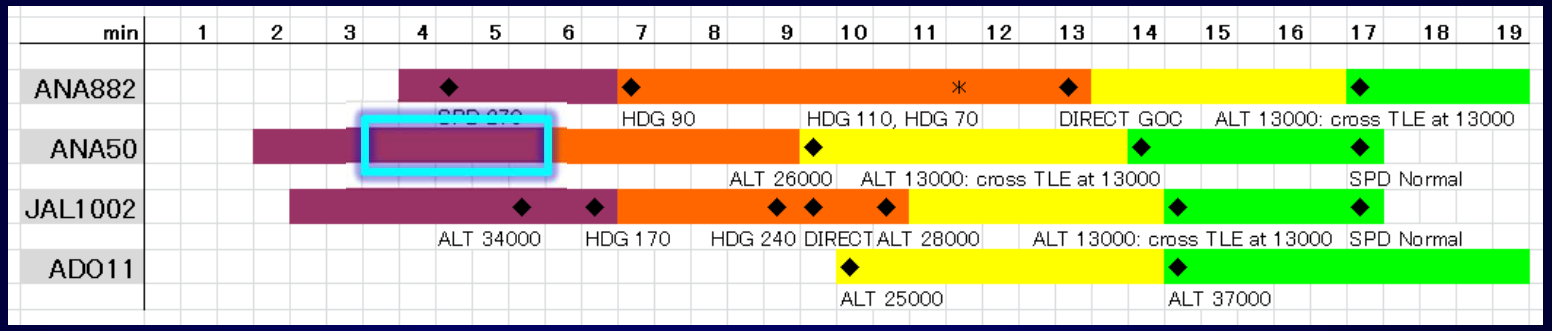


Case A2

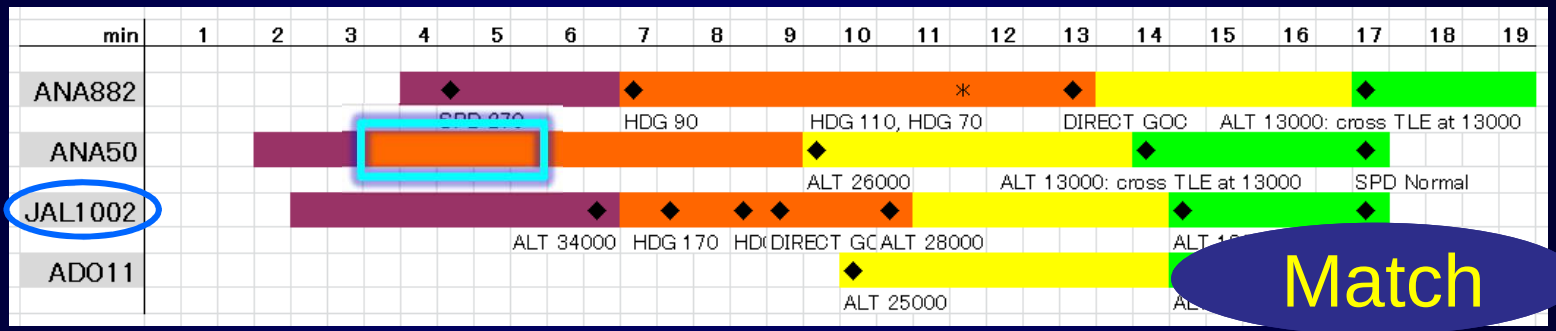


Results (Experiment B)

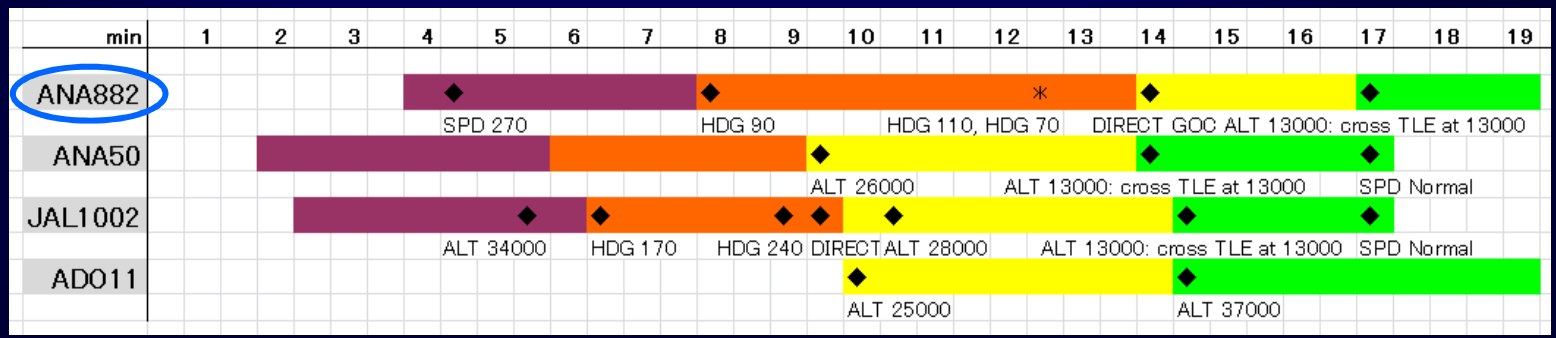
Baseline Case B



Case B1

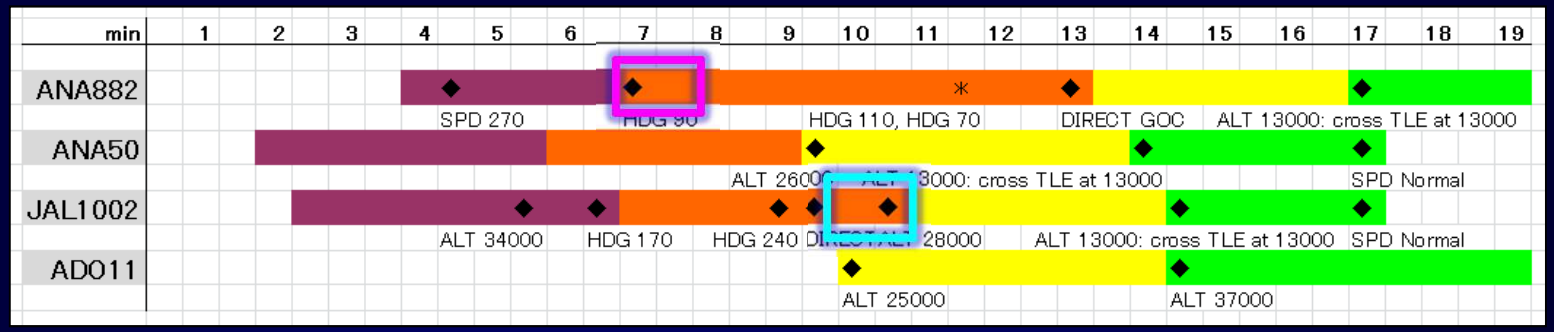


Case B2

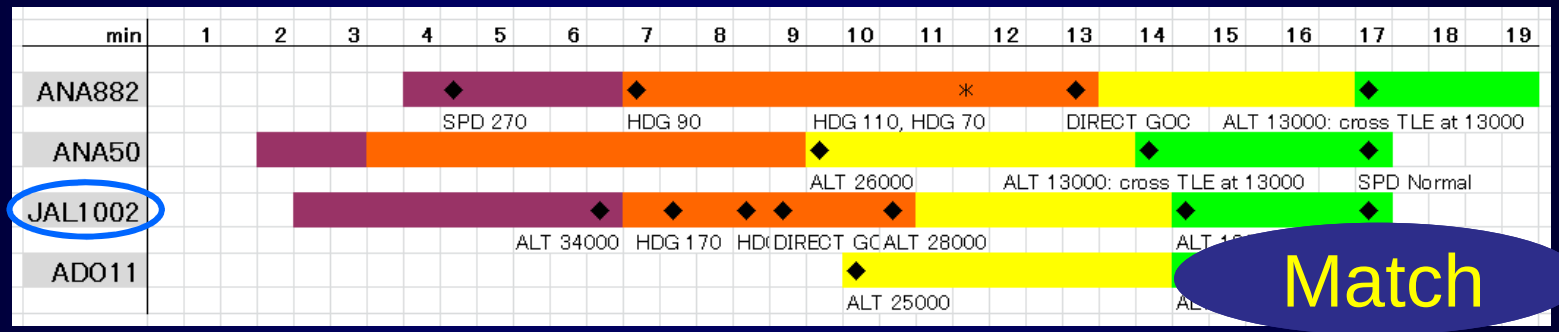


Results (Experiment B)

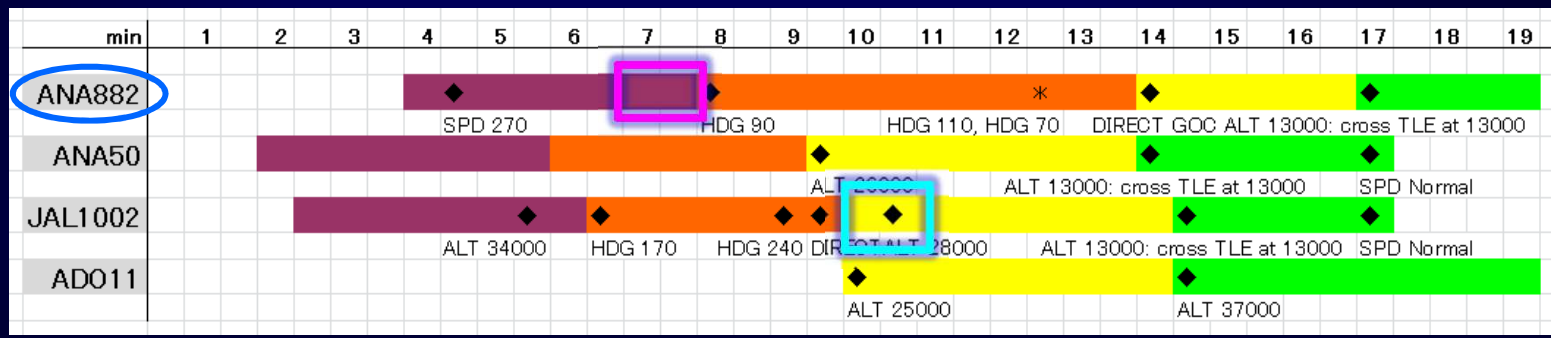
Baseline Case B



Case B1



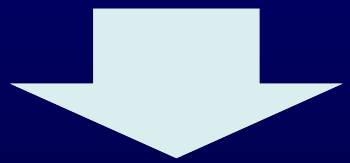
Case B2



Results

- Through the Exp. A and Exp. B, COMPASi has successfully visualized beneficial and adverse effects of control options of ATFM on ATC task demands
- The validity of the results has been confirmed by an experienced controller

Differences of effects of ATFM depending on ATCO's control strategies were visualized



Applicability of COMPASi for analyzing effects of ATFM on ATC task demands with consideration of controllers' working methods

Conclusion

- The present research attempted to visualize the effects of simulated flow control by ATFM on ATC task demands using COMPASi
- A simulation-based experiment has demonstrated the applicability of COMPASi as a support tool for analyzing effects of ATFM on ATC task demands with consideration of controllers' working methods

Which types of traffic situations should be made (or avoided) by ATFM?

Our future work

- Evaluates the effectiveness of COMPASi using different sector configurations and further realistic traffic scenarios
- Explores effective flow control methods of ATFM

ACKNOWLEDGMENTS

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