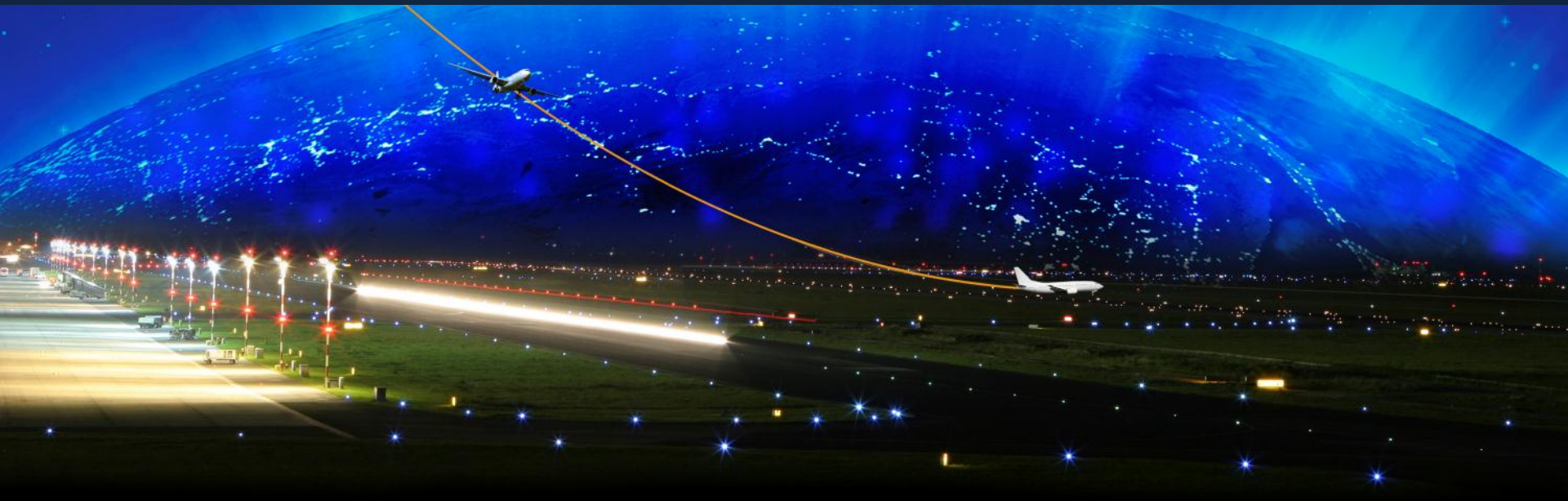
Method to Enhance Scheduled Arrival Robustness (MESAR)



Jaewoo Jung

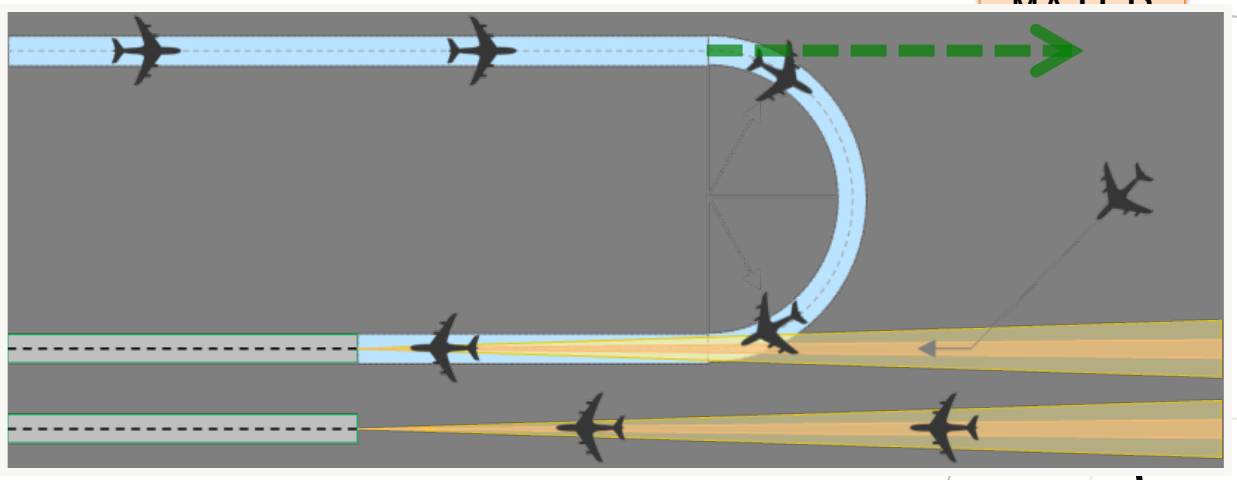
Outline

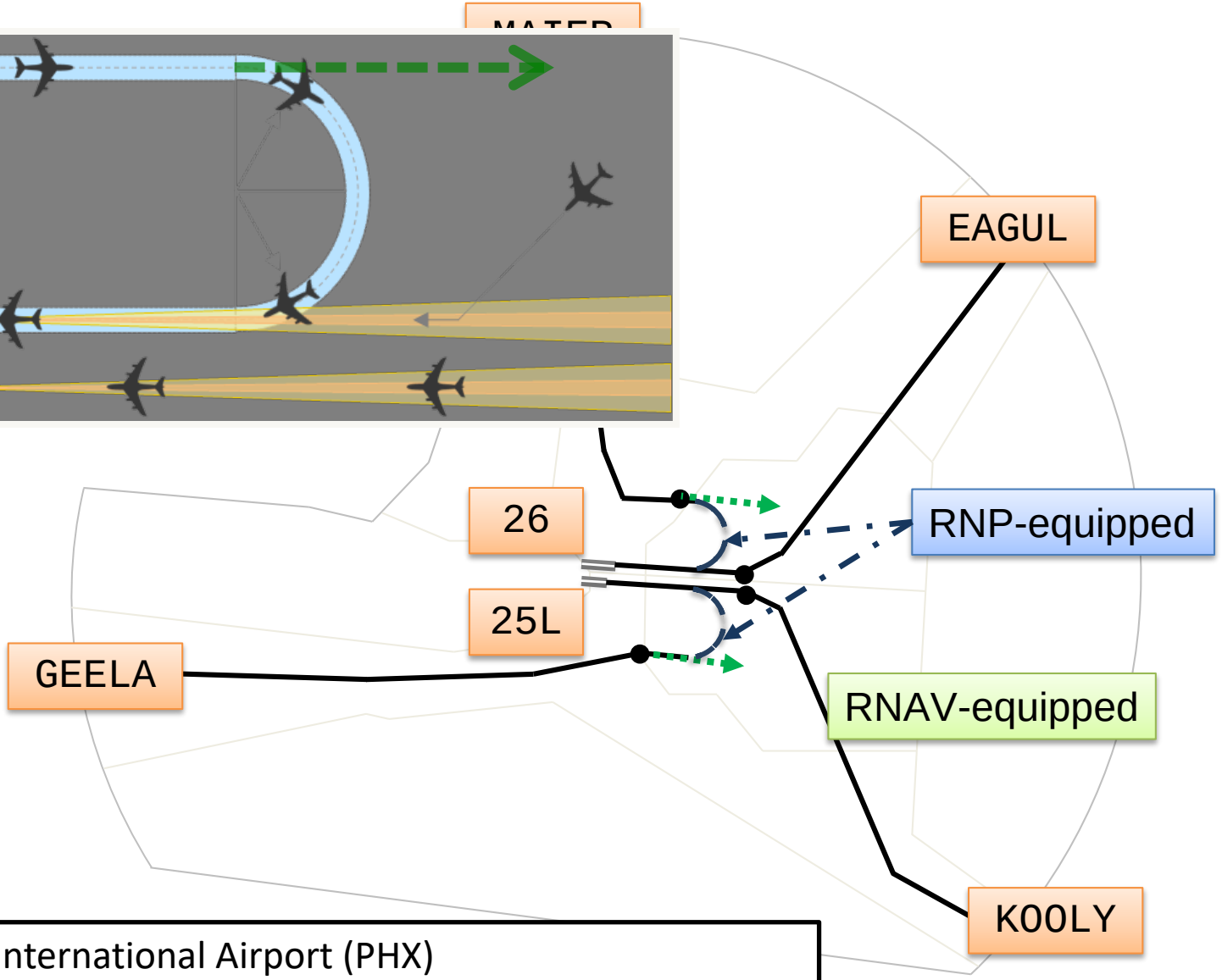
- Background
- Motivations
- Objectives
- Methods
- Lessons learned (so far)

Background


NASA and FAA
Research Transition Team
Terminal Sequencing and Spacing (TSS)
Technology Transfer Ceremony
July 14, 2014
NASA

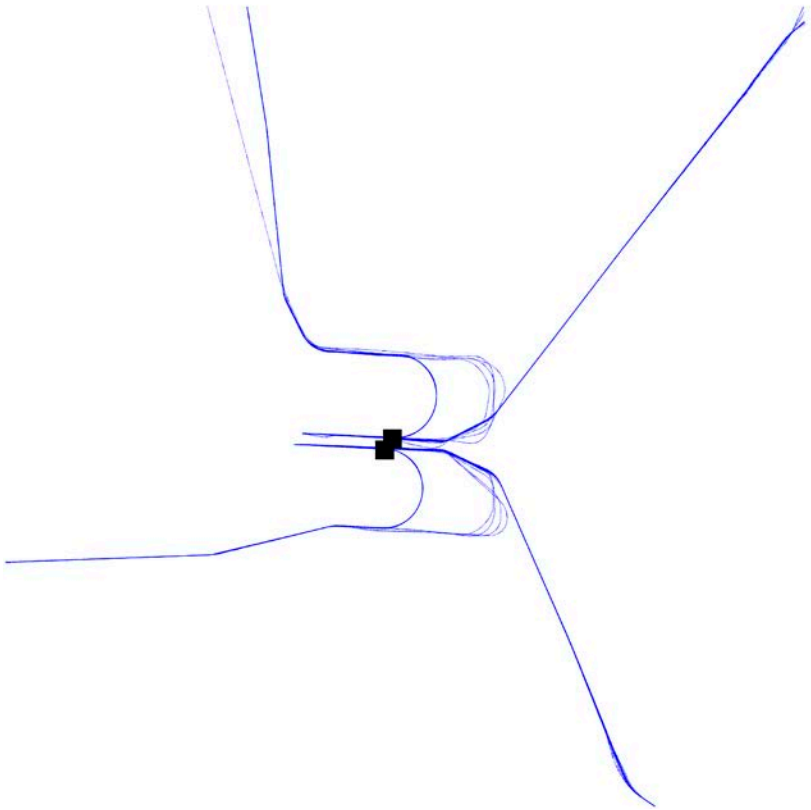
2013 NASA, the FAA, MITRE CAASD joint human-in-the-loop (HITL) simulation





Phoenix Sky Harbor International Airport (PHX)

Among the 2013 TSS HITL simulation runs, differences observed



Operation entered "Stressed" state

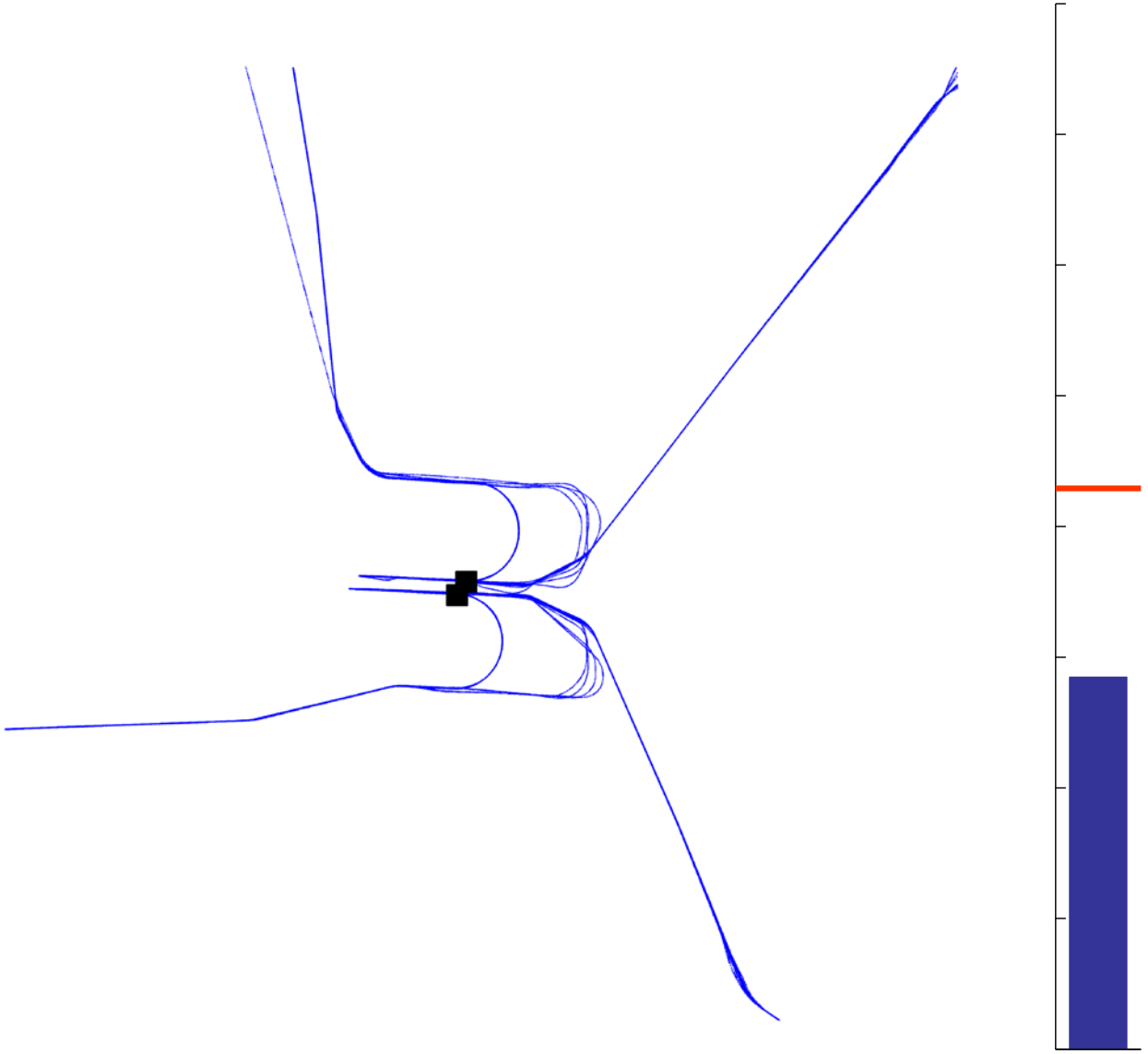
- Higher schedule nonconformance (2.7x)
- Higher lateral route inefficiency (+22%)
- Higher time inefficiency (+12%)
- More controller instruction (+1.8)

Motivation

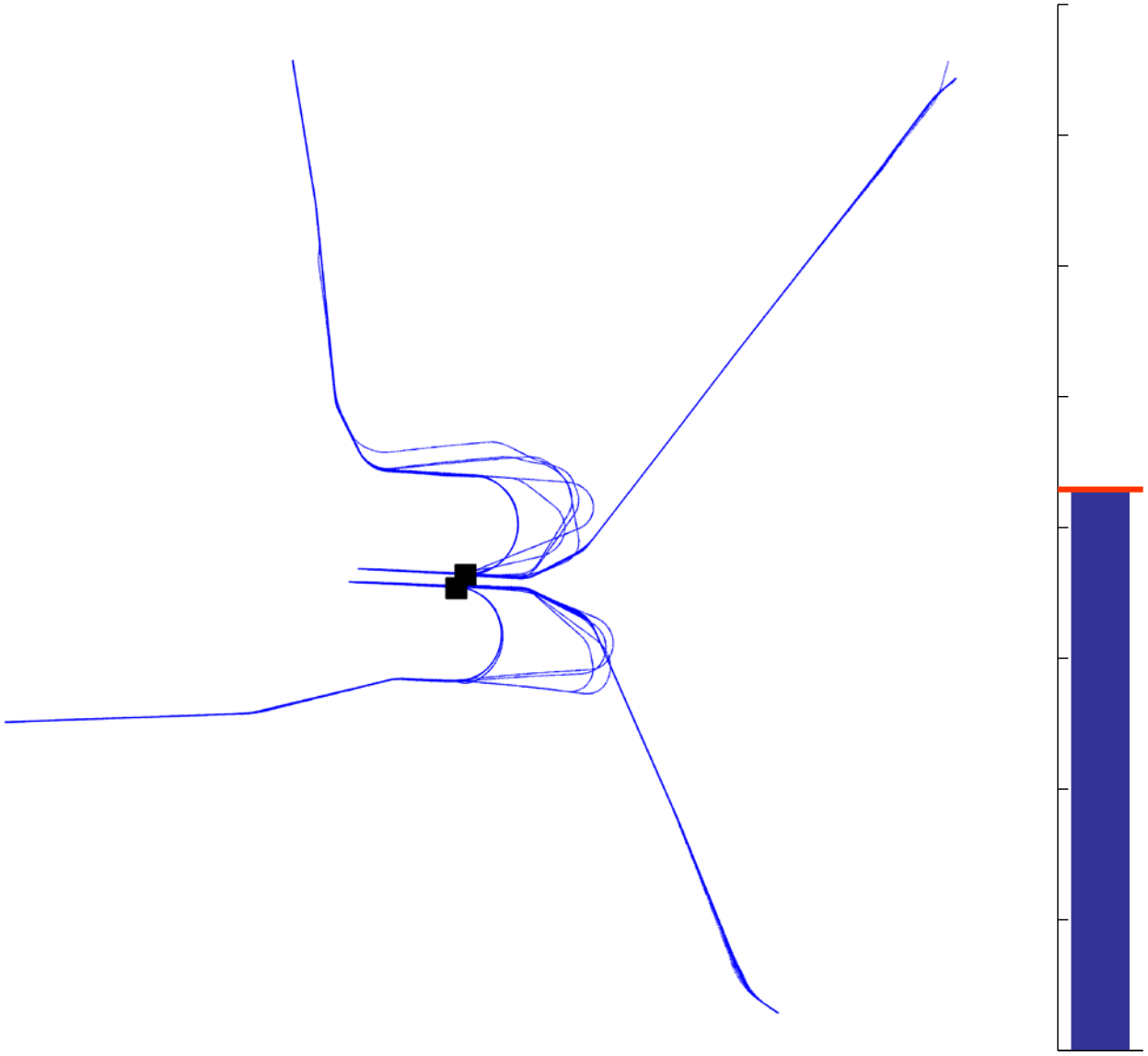
Enhance robustness and resilience of scheduled arrival operation, in presence of disturbances

- Resist entering stressed state
- Expedite return from stressed state

Objectives

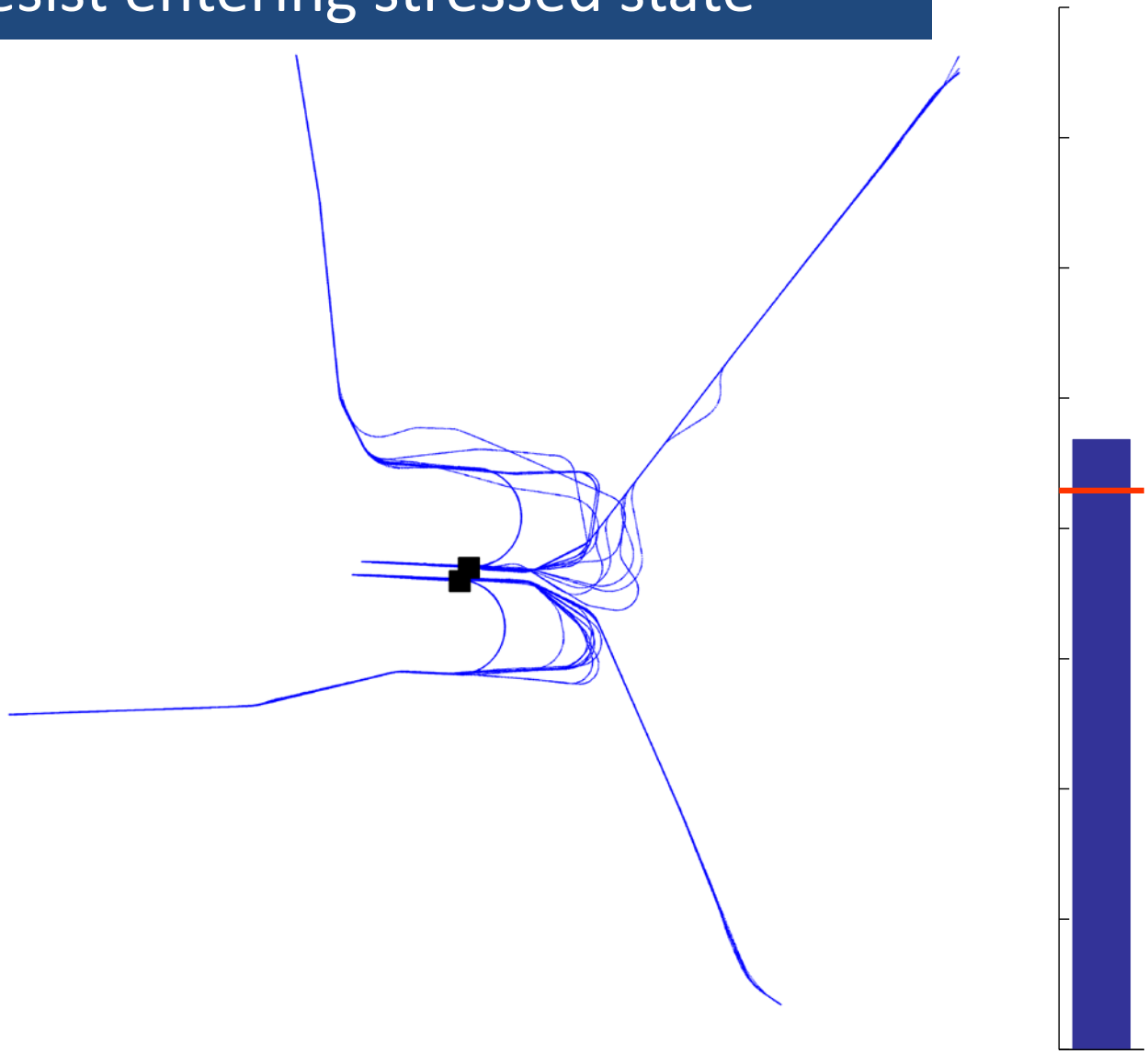


“Operational Sequencing Quality”



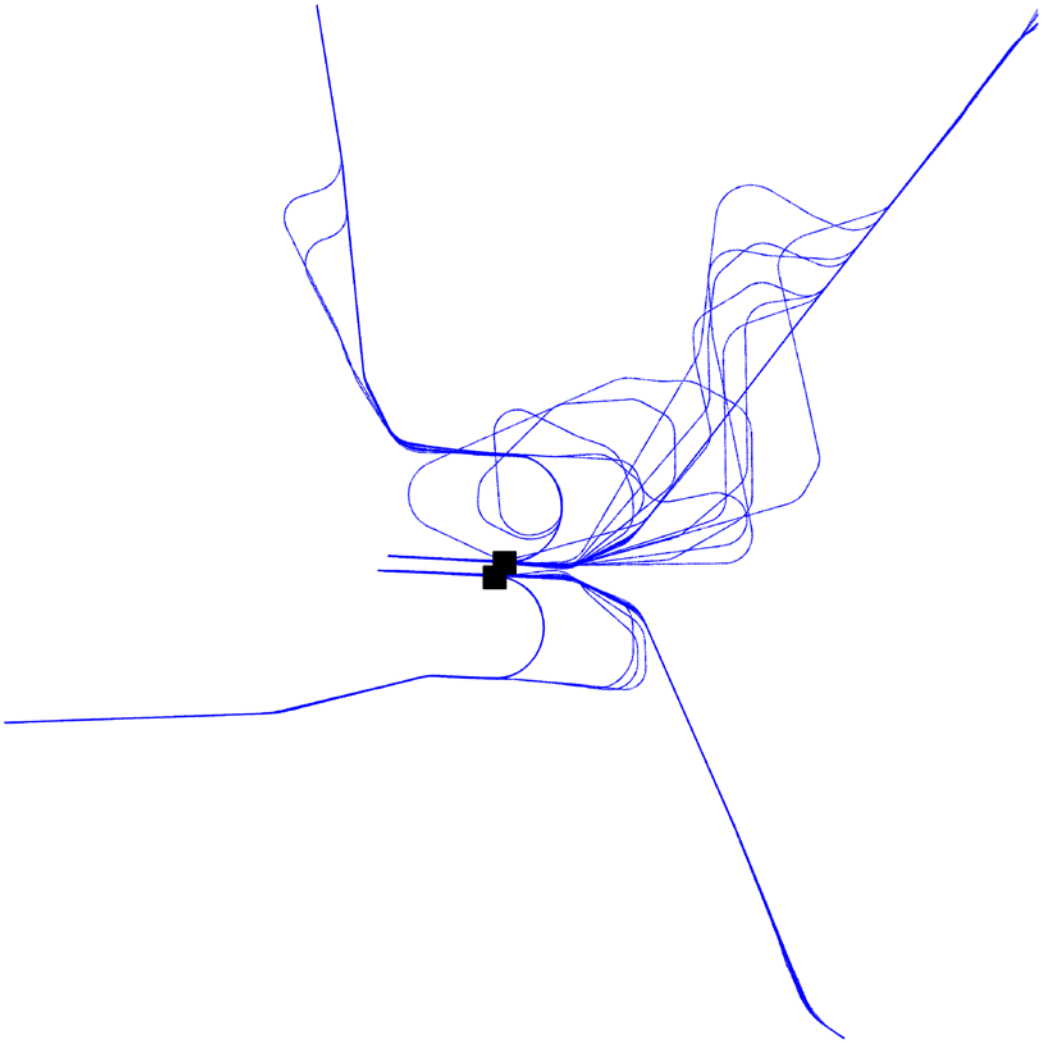
“Operational Sequencing Quality”

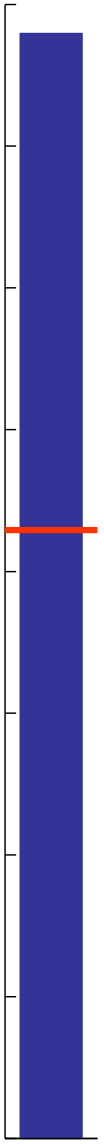
Apply tactical schedule update to resist entering stressed state



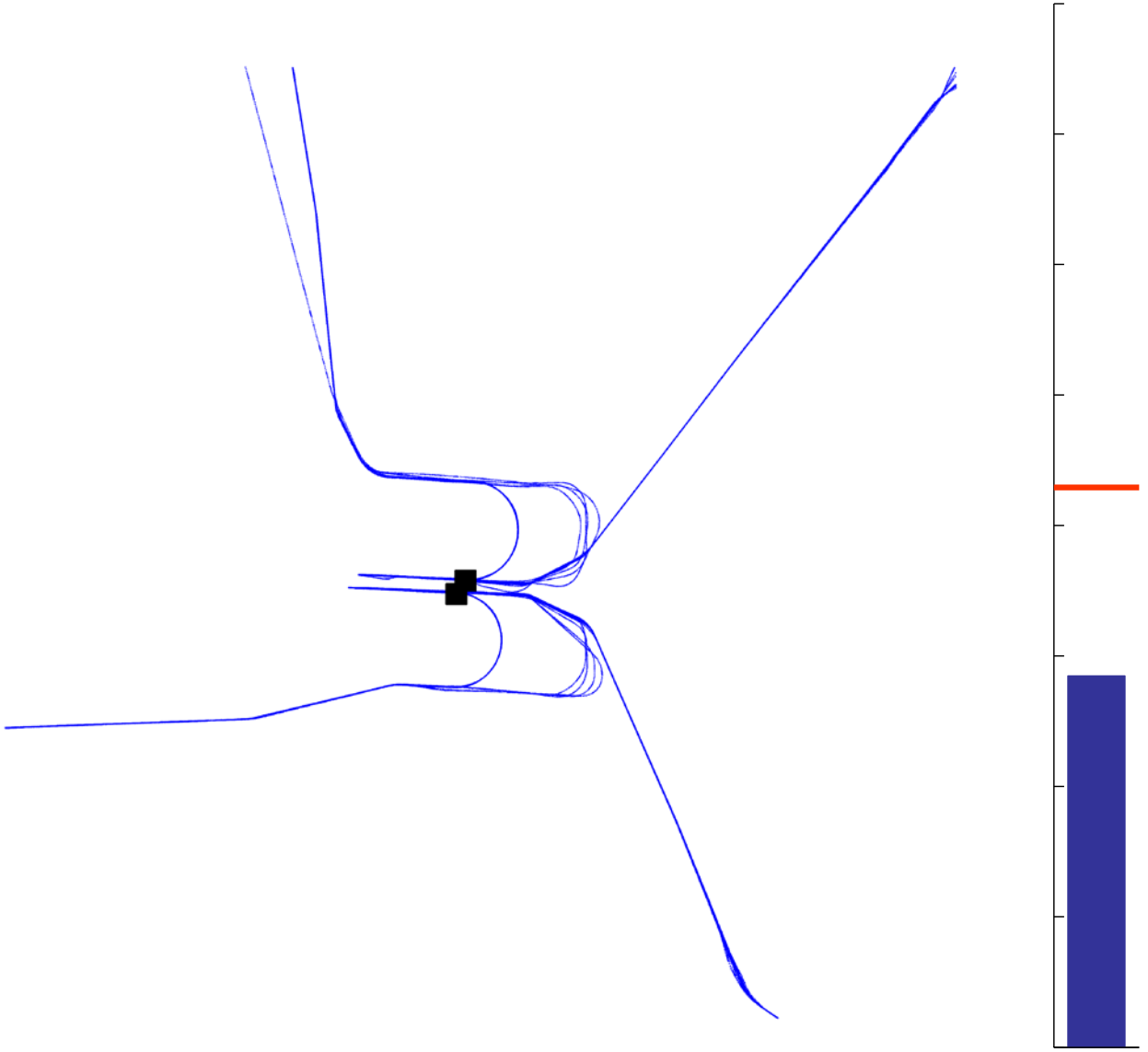
“Operational Sequencing Quality”

Apply tactical schedule update to expedite return from stressed state





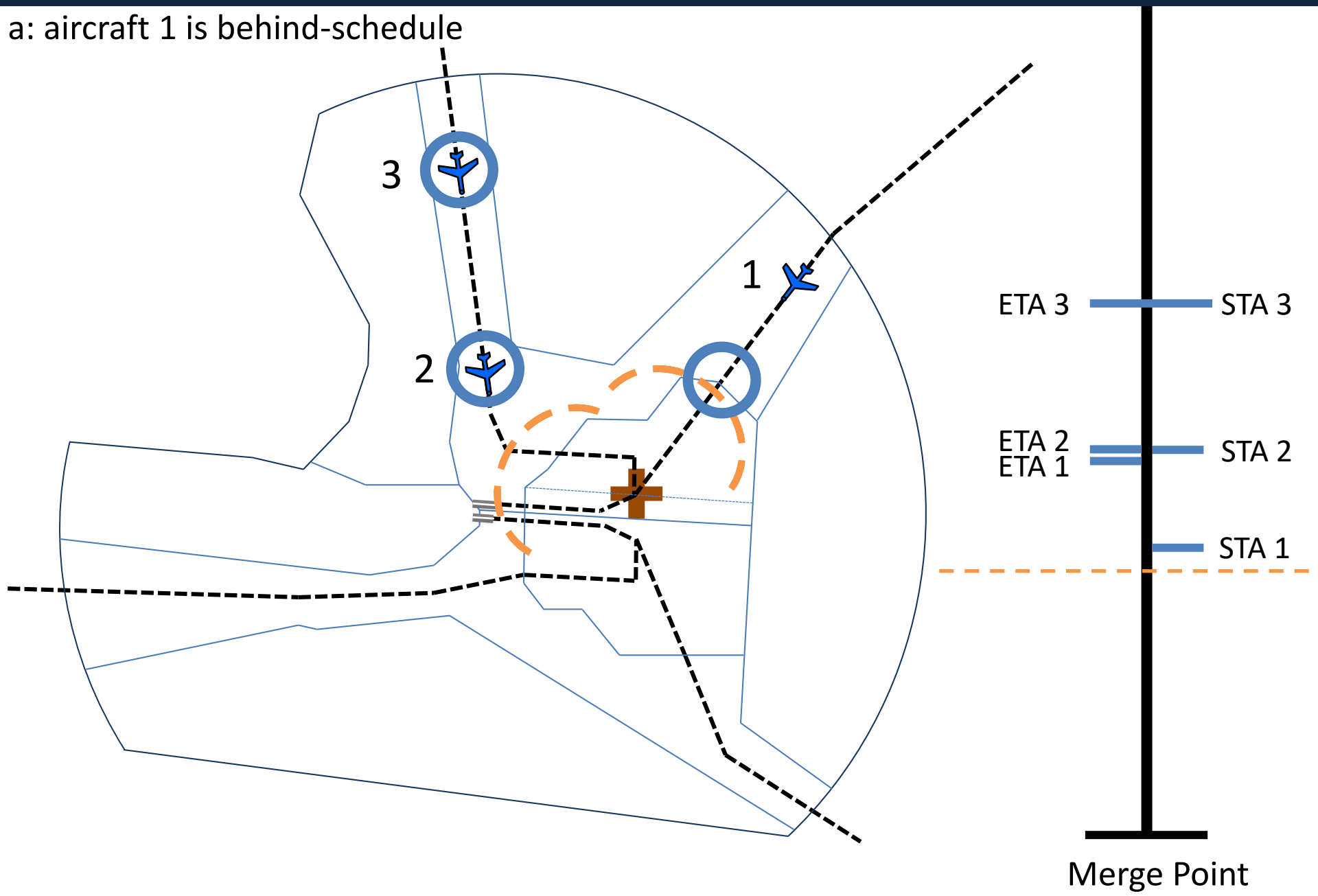
“Operational Sequencing Quality”



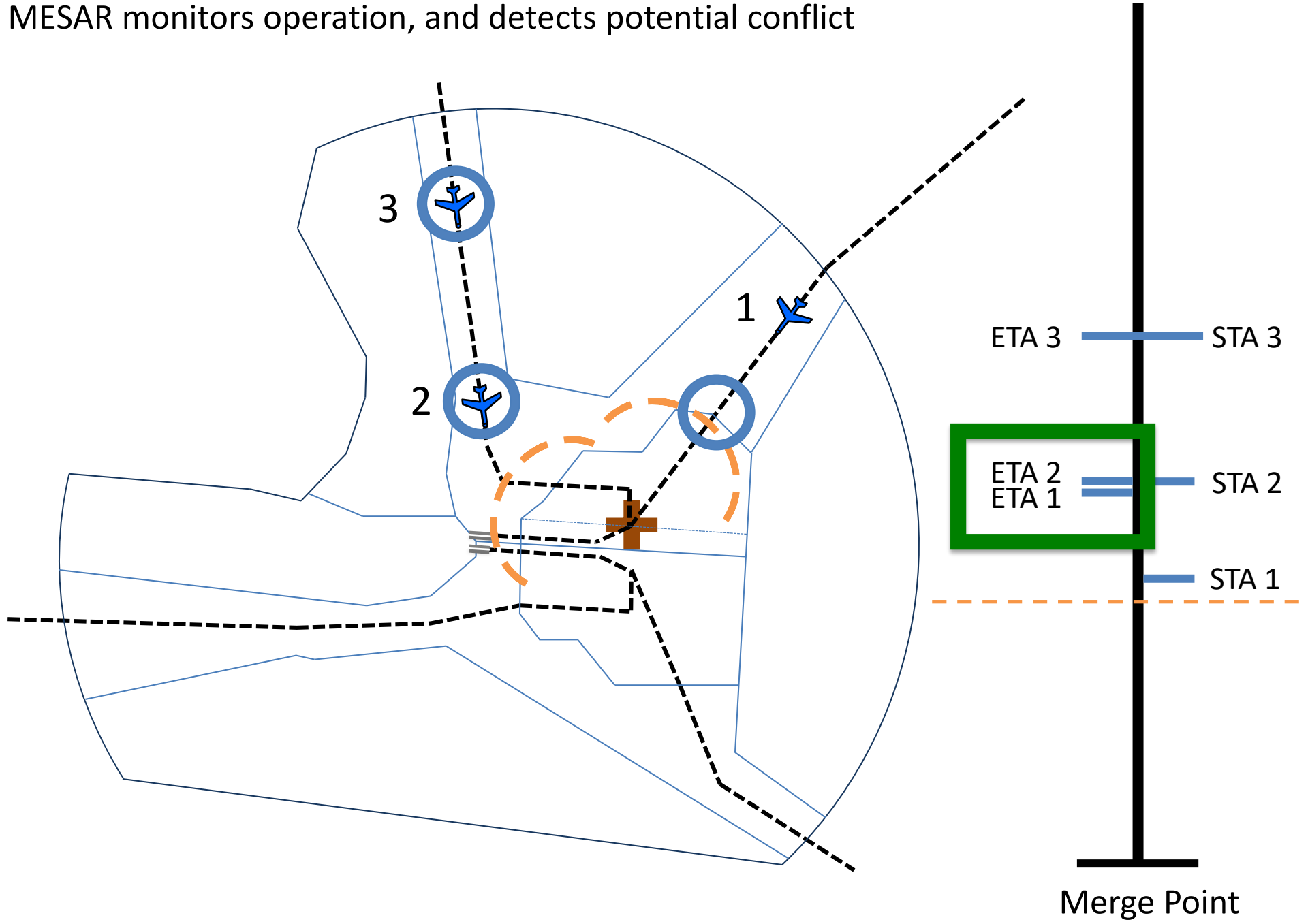
“Operational Sequencing Quality”

Method

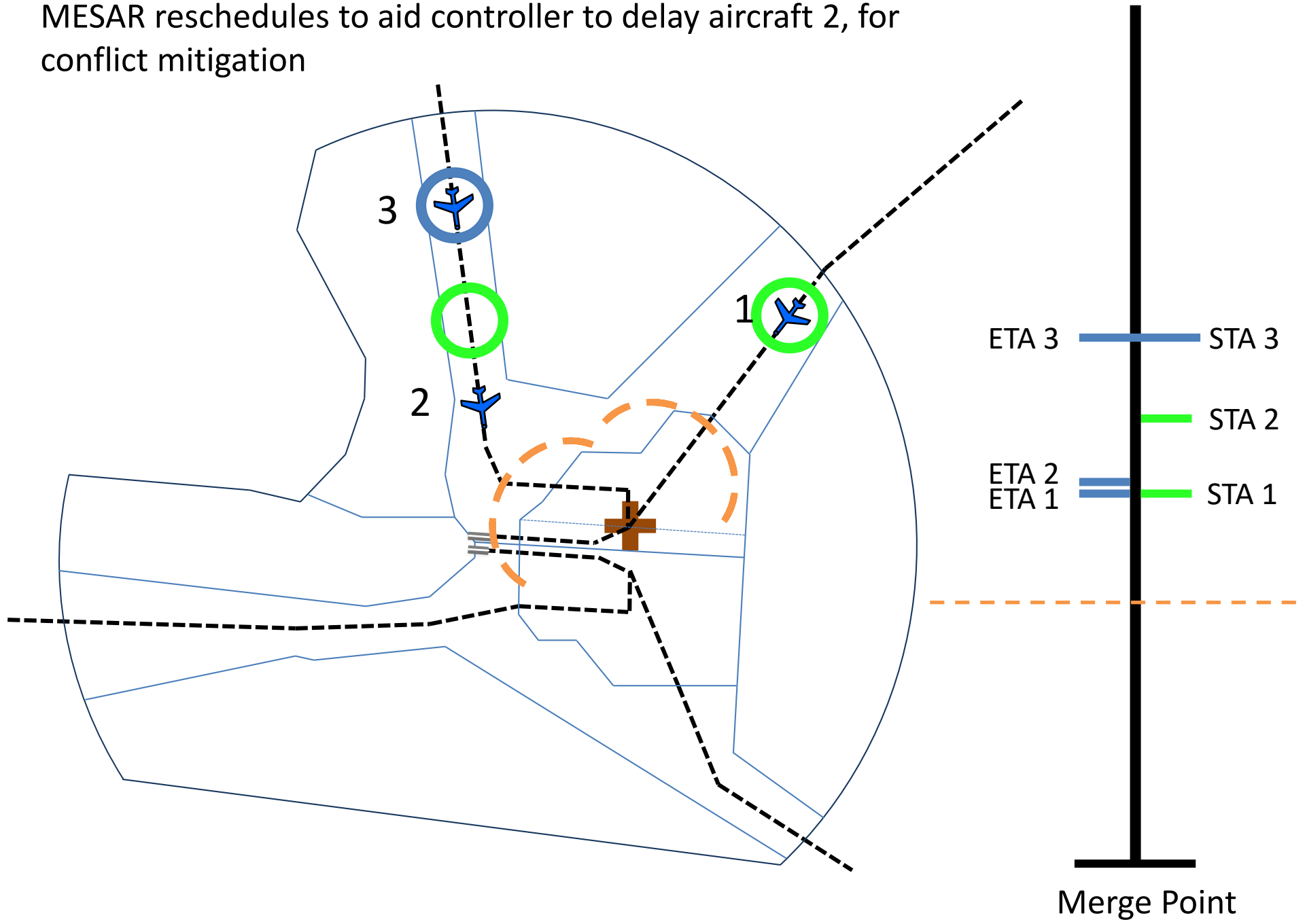
a: aircraft 1 is behind-schedule



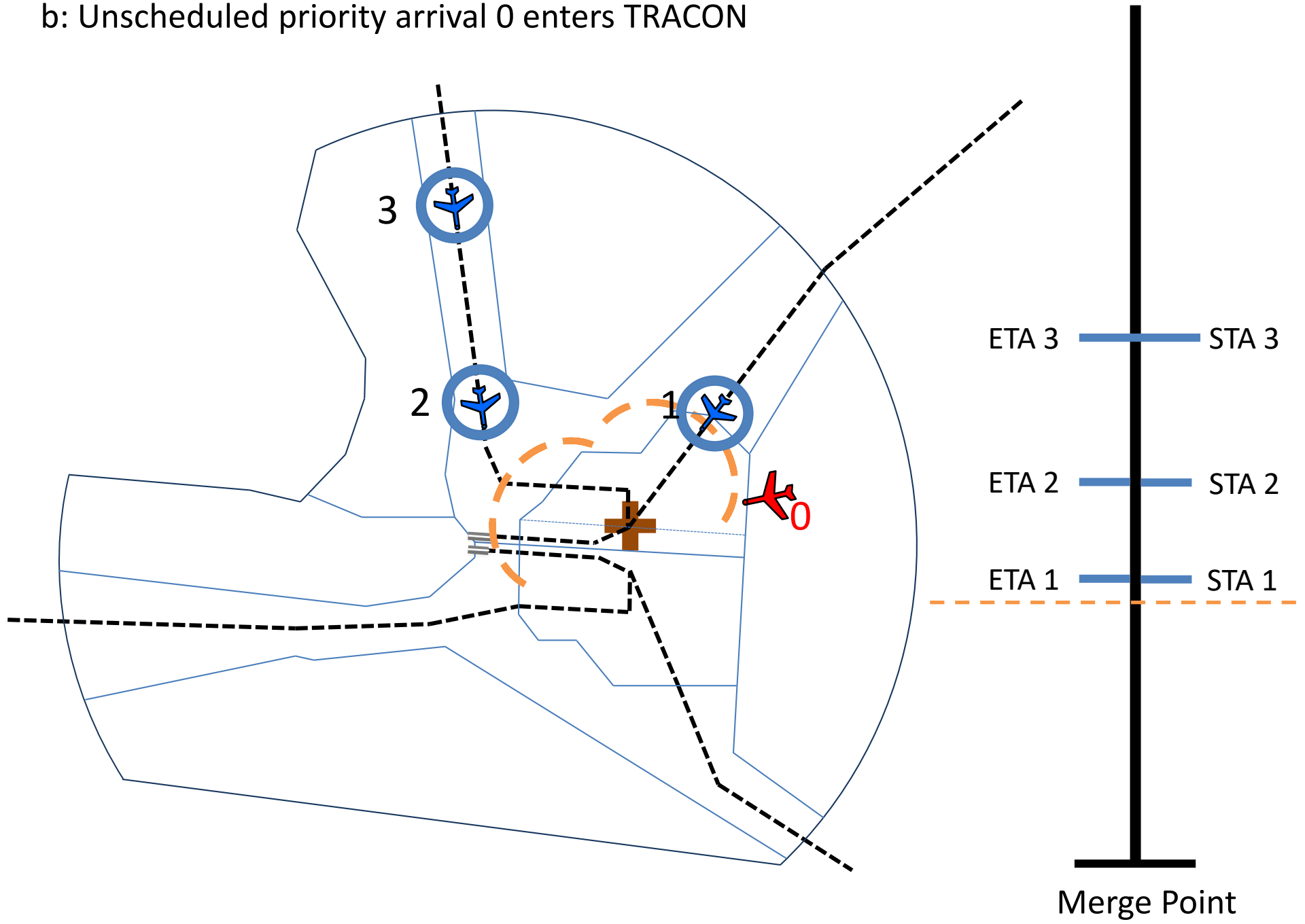
MESAR monitors operation, and detects potential conflict



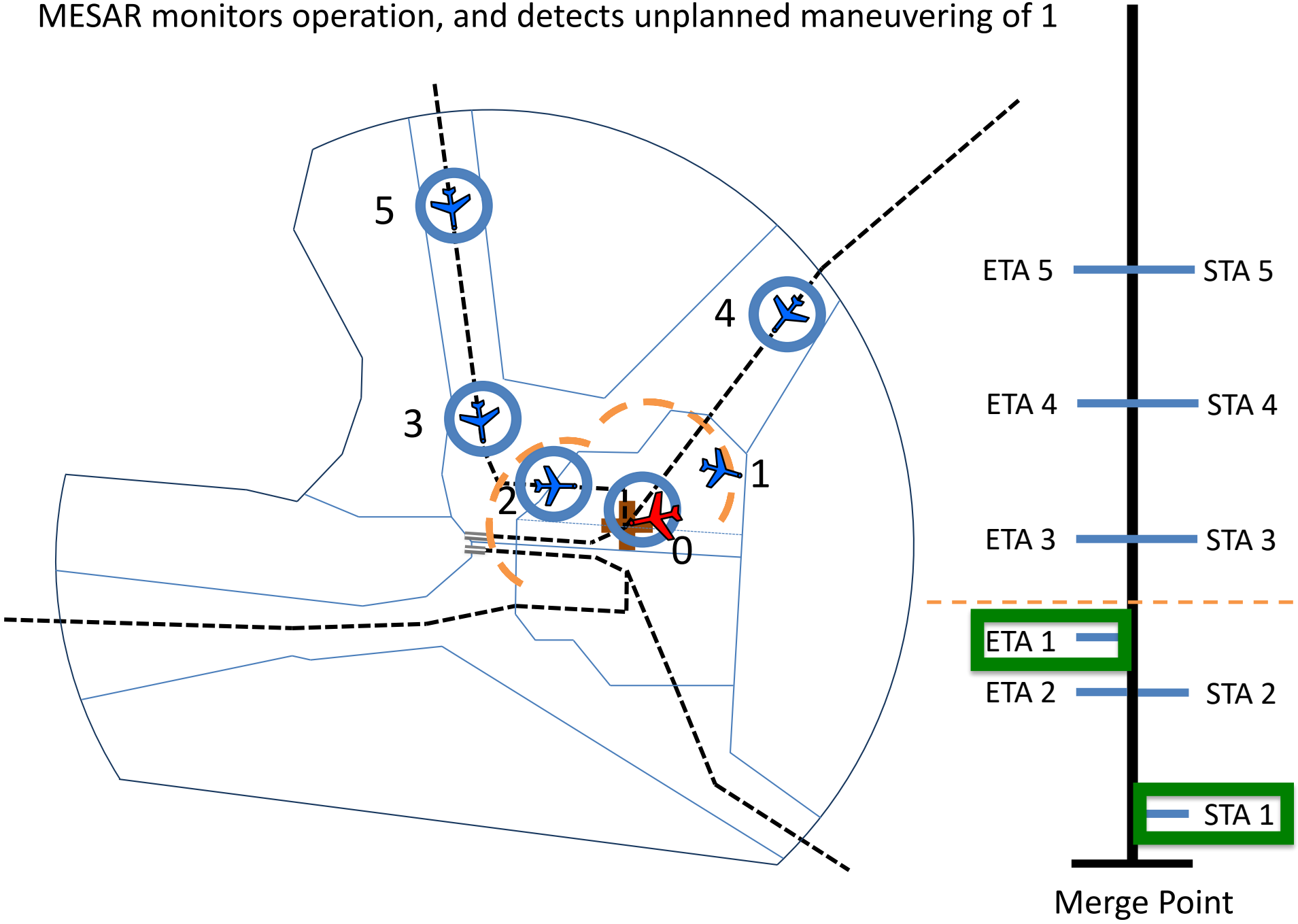
MESAR reschedules to aid controller to delay aircraft 2, for conflict mitigation



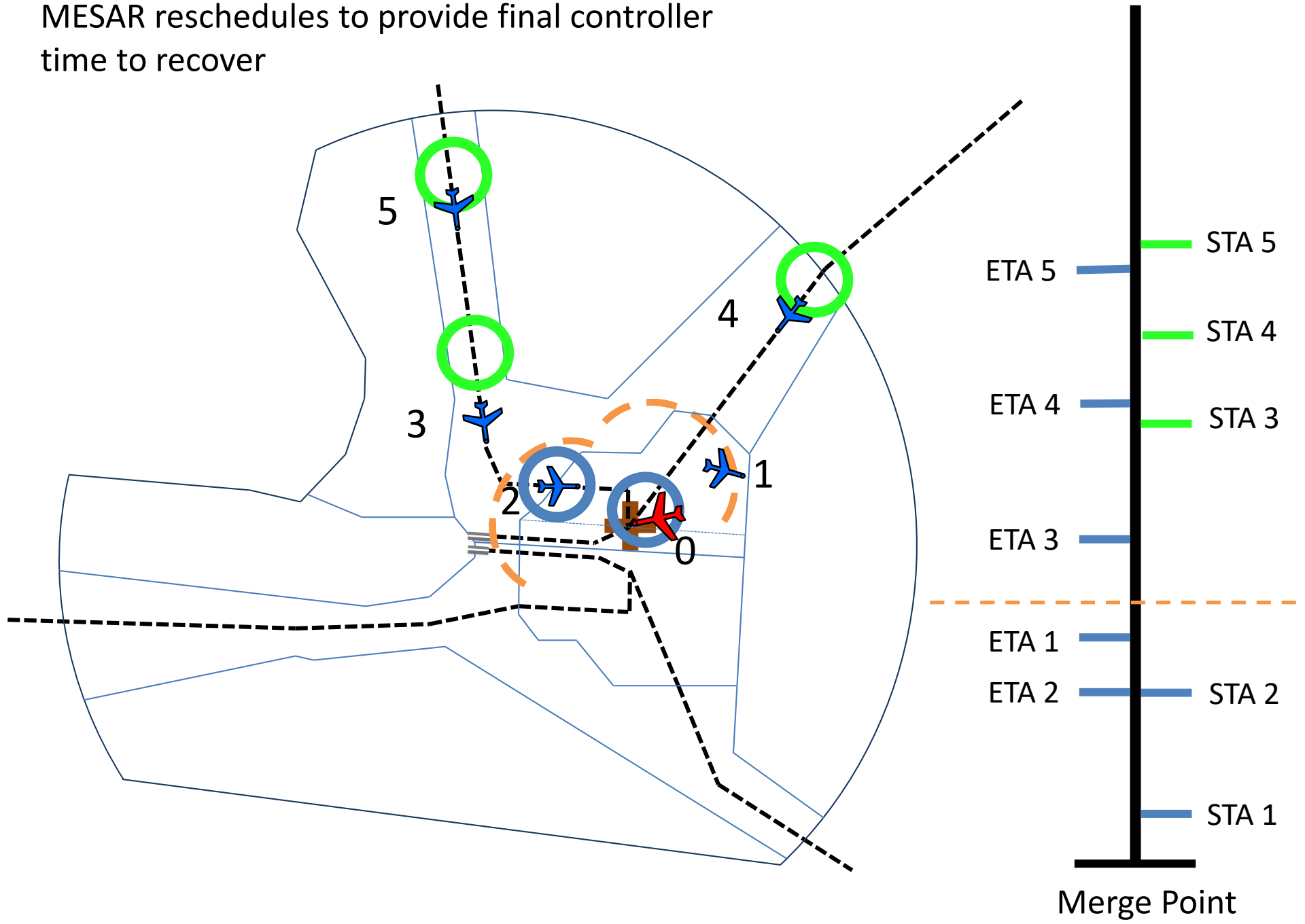
b: Unscheduled priority arrival 0 enters TRACON



MESAR monitors operation, and detects unplanned maneuvering of 1



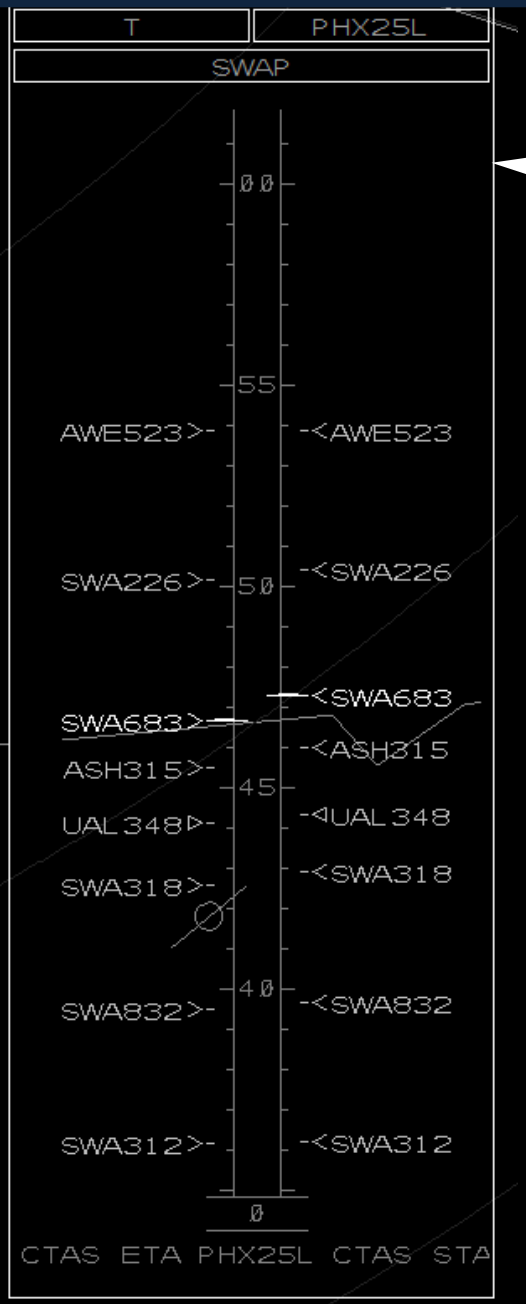
MESAR reschedules to provide final controller time to recover



MESAR Experiment Setup

- 4 Shakedowns, Data collection August 2014
- PHX West Flow configuration (2 Feeders and 2 Finals)
- Mostly Area Navigation equipped jets
- Instrument Meteorological Condition
- Independent two runway arrival operation, with altitude separation
- Terminal area Traffic Management Coordinator (TMC) provides support in handling disturbances
- TSS system, with Automate Terminal Proximity Alert (ATPA)

Feeder Tools



Timeline

Slot marker IAS

279

Aircraft IAS

27

Q

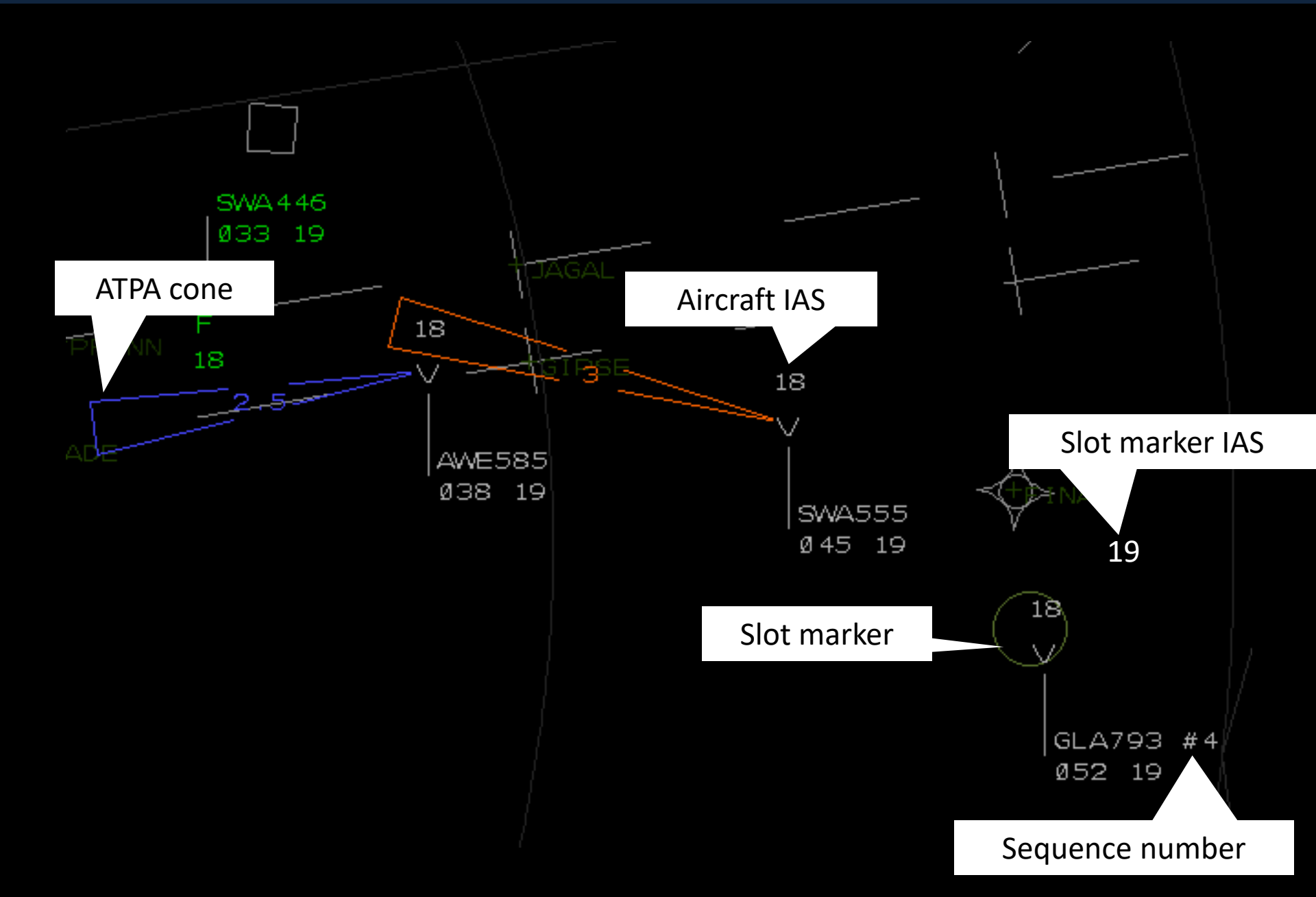
Slot marker

SWA683 #23
128 B737
210 LINEA

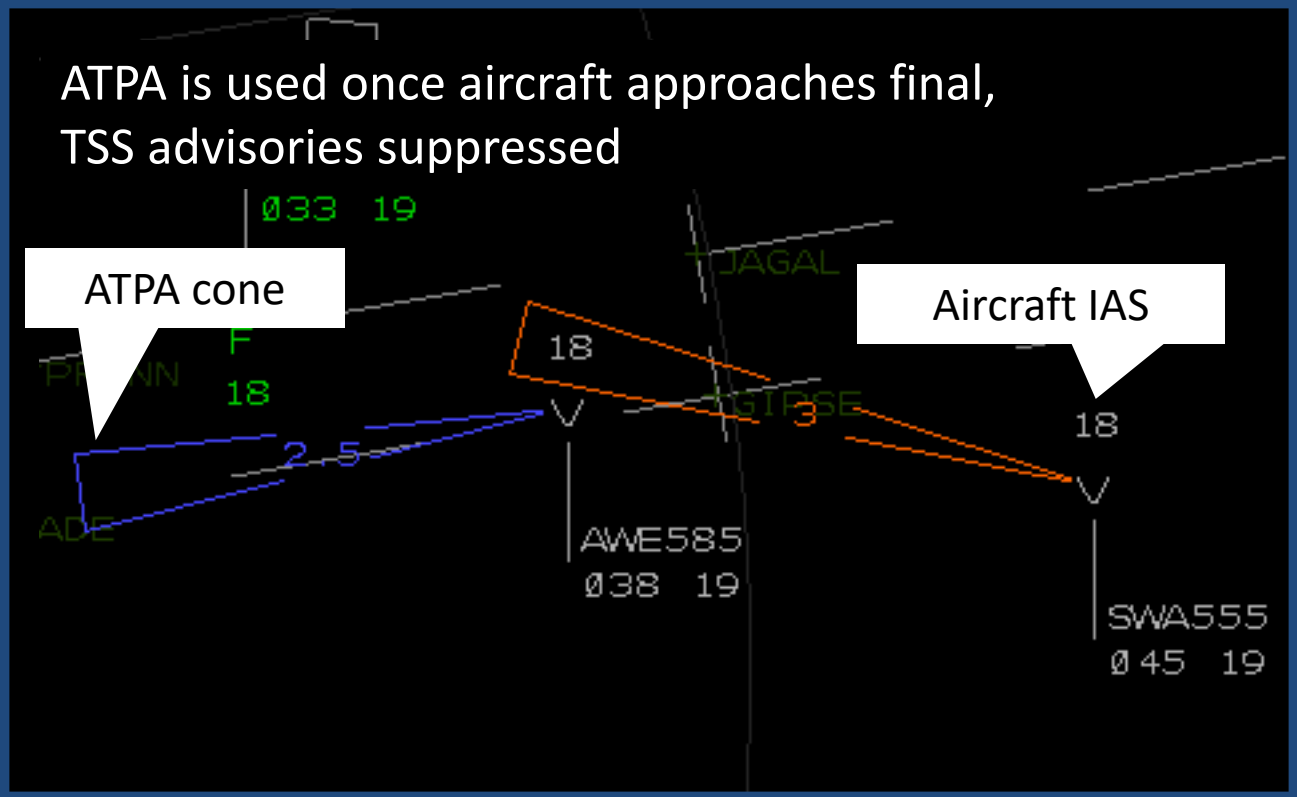
Sequence number

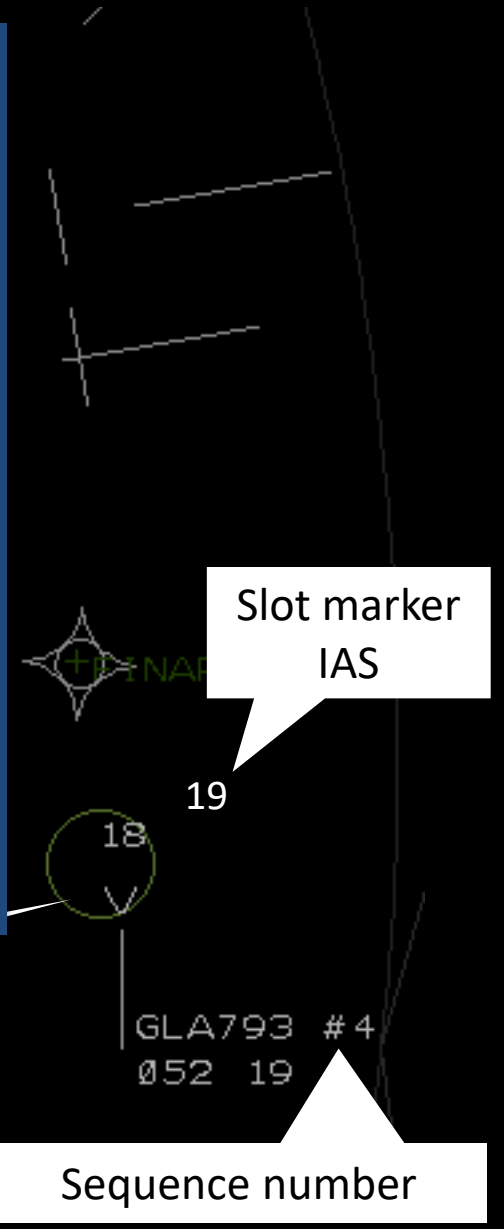
Speed advisory

Final Tools


SWA446
033 19
ATPA cone
F
18
2.5
ADE
18
3
AWE585
038 19
JAGAL
Aircraft IAS
18
SWA555
045 19
Slot marker IAS
19
18
Slot marker
GLA793 #4
052 19
Sequence number

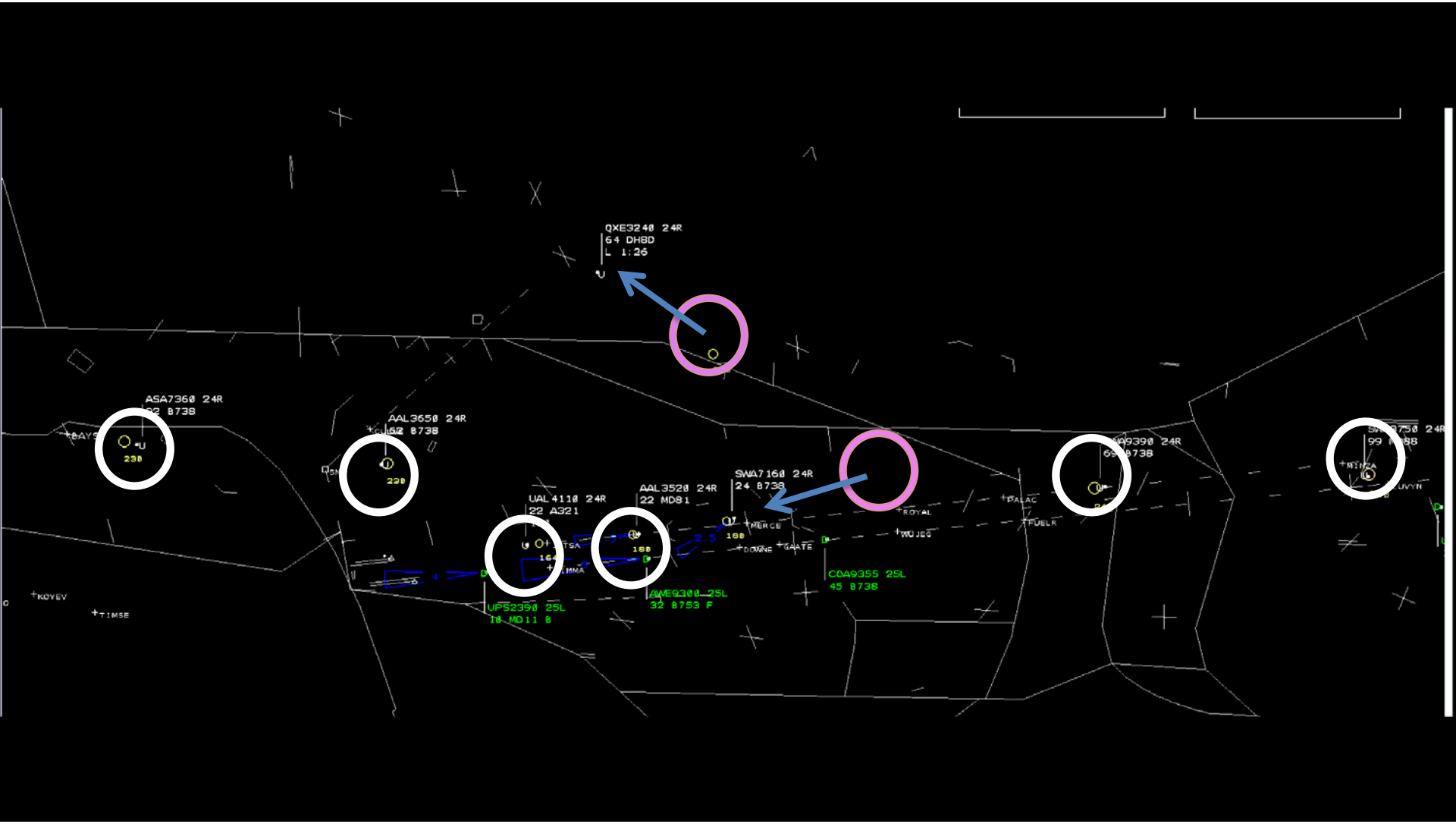
Final Tools


ATPA is used once aircraft approaches final,
TSS advisories suppressed
033 19
ATPA cone
JAGAL
F
18
2.5
ADE
18
3
Aircraft IAS
18
AWE585
038 19
SWA555
045 19


Slot marker
IAS
19
18
Slot marker
GLA793 #4
052 19
Sequence number

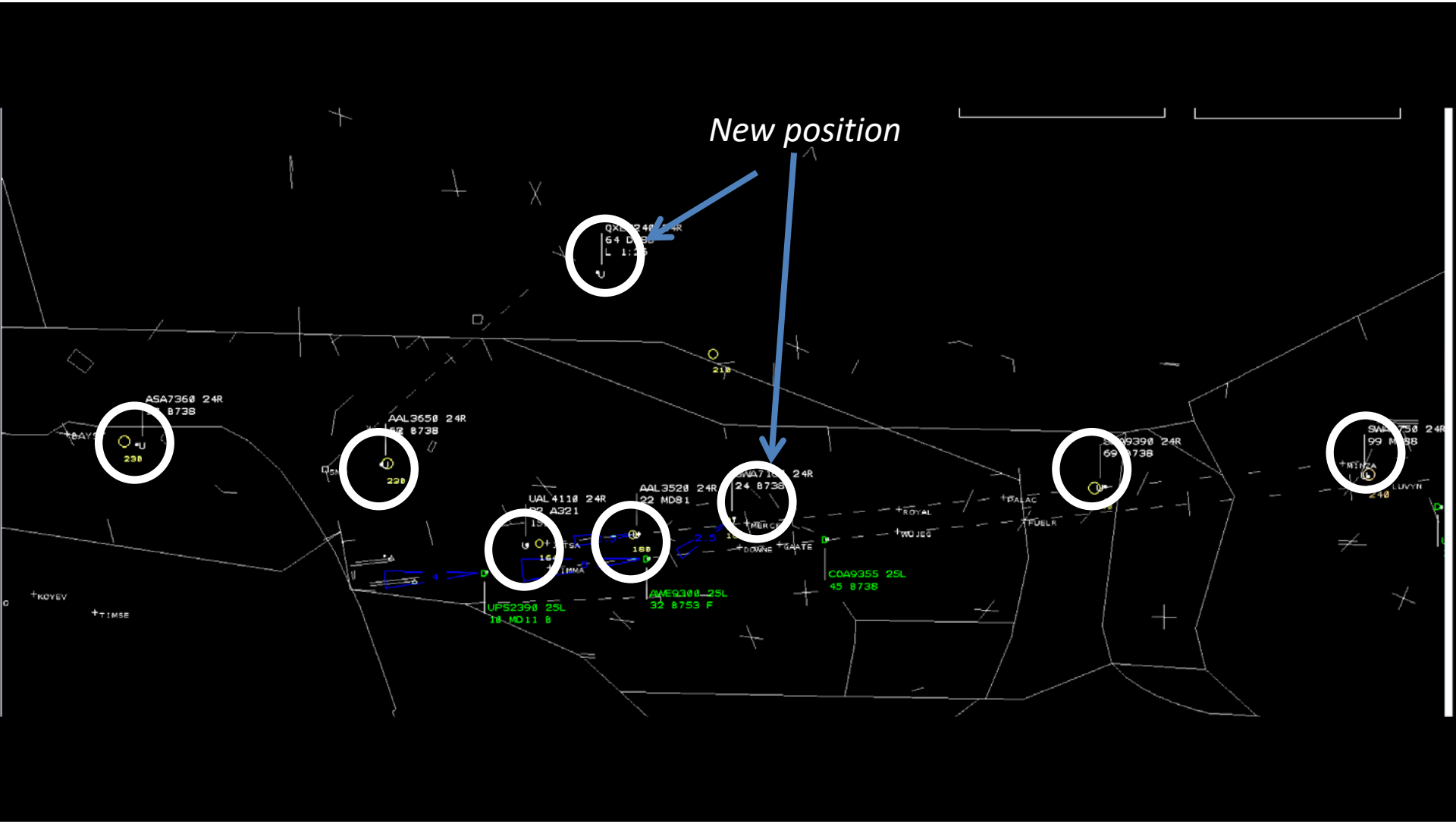
Tools- Creeping Slot Markers

The slot markers change color and gradually move to their new position calculated by the MESAR reschedule



Tools- Creeping Slot Markers

After moving, slot markers go back to regular white



MESAR Experiment Matrix

Type of Disturbance	Tactical Schedule Adjustment	By MESAR	By Terminal Traffic Management Coordinator
	Excessive Delay		
	Pop up Priority VFR		
	Missed Approach		

MESAR Research Questions

1. Does tactical reschedule enhance the existing robustness and resiliency of schedule based arrival operation?

2. What are advantages and disadvantages of tactical schedule adjustment performed by MESAR and TMC?

Lessons Learned (so far)

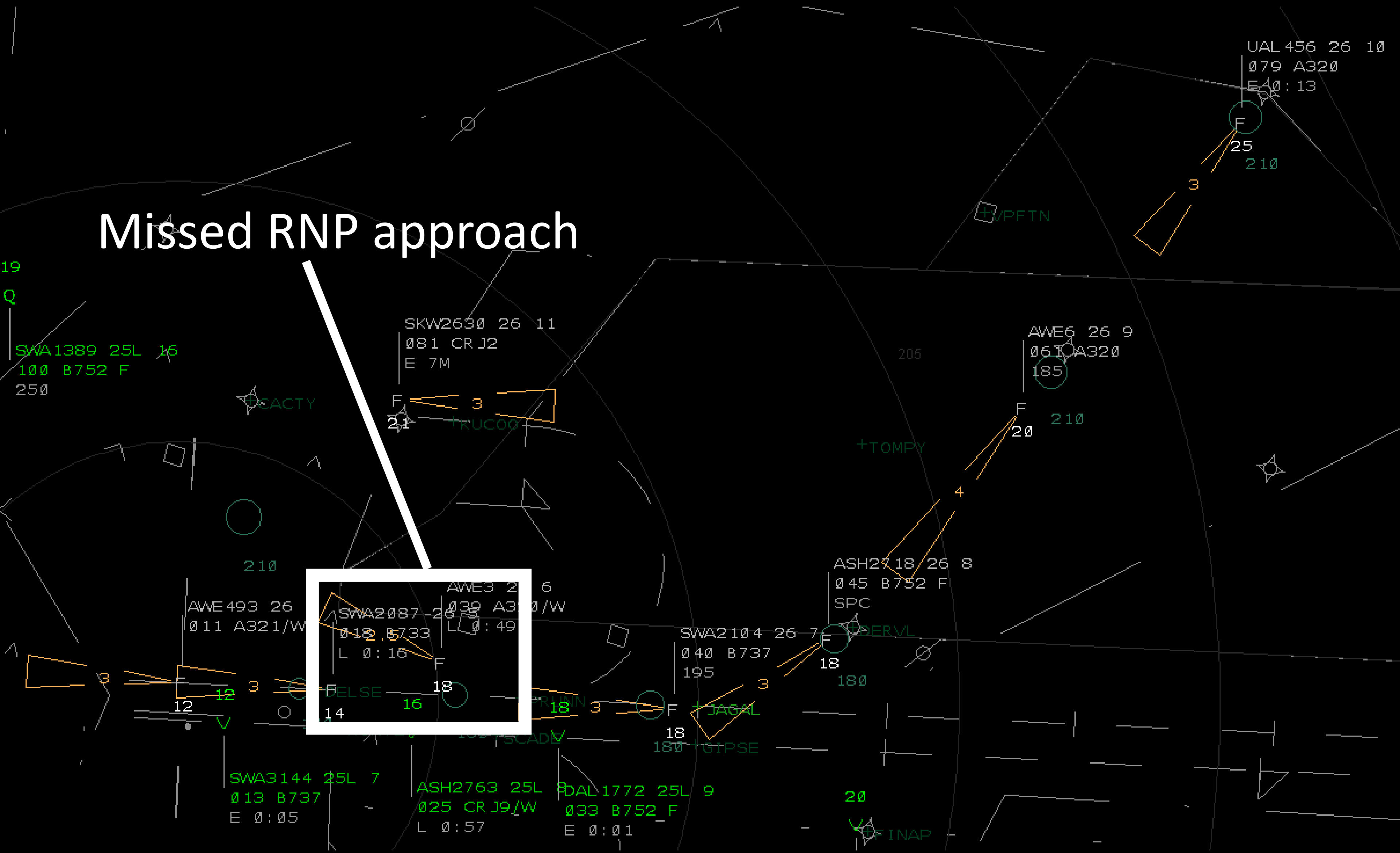
- Coordination and communication is essential in handling disturbances (TMC roles and responsibilities)
- MESAR schedule adjustment is consistent and predictable, but is reactive
- TMC schedule adjustment is proactive, but requires accurate situational awareness
- Potential future work is to develop synergistic interaction between human and algorithm

Questions?

Backup slides

Metrics

- Measure of Operational Performance
  - Ratio between actual and planned arrival makespan
  - Proportion of arrivals with extra track distance
  - Average extra track distance
  - Estimated Fuel efficiency: average time below 10,000 ft
  - Estimated objective workload: average clearance
  - Estimated subjective workload: WAK, TLX
  - Inter arrival spacing
  - Landing sequence mismatch, number and magnitude
- Measure of Schedule Nonconformance
- Measure of Robustness
- Measure of Resilience



Missed RNP approach
UAL456 26 10
079 A320
E 0:13
SKW2630 26 11
081 CRJ2
E 7M
SWA1389 25L 16
100 B752 F
250
AWE6 26 9
185
ASH2718 26 8
045 B752 F
SPC
SWA2104 26 7
040 B737
195
AWE493 26
011 A321/W
SWA2087 26
L 0:16
AWE3 2 6
L 0:49
SWA3144 25L 7
013 B737
E 0:05
ASH2763 25L 8
025 CRJ9/W
L 0:57
DAL1772 25L 9
033 B752 F
E 0:01
CACTY
TOMPY
JAGAL
GIPSE