Mode S related researches in ENRI

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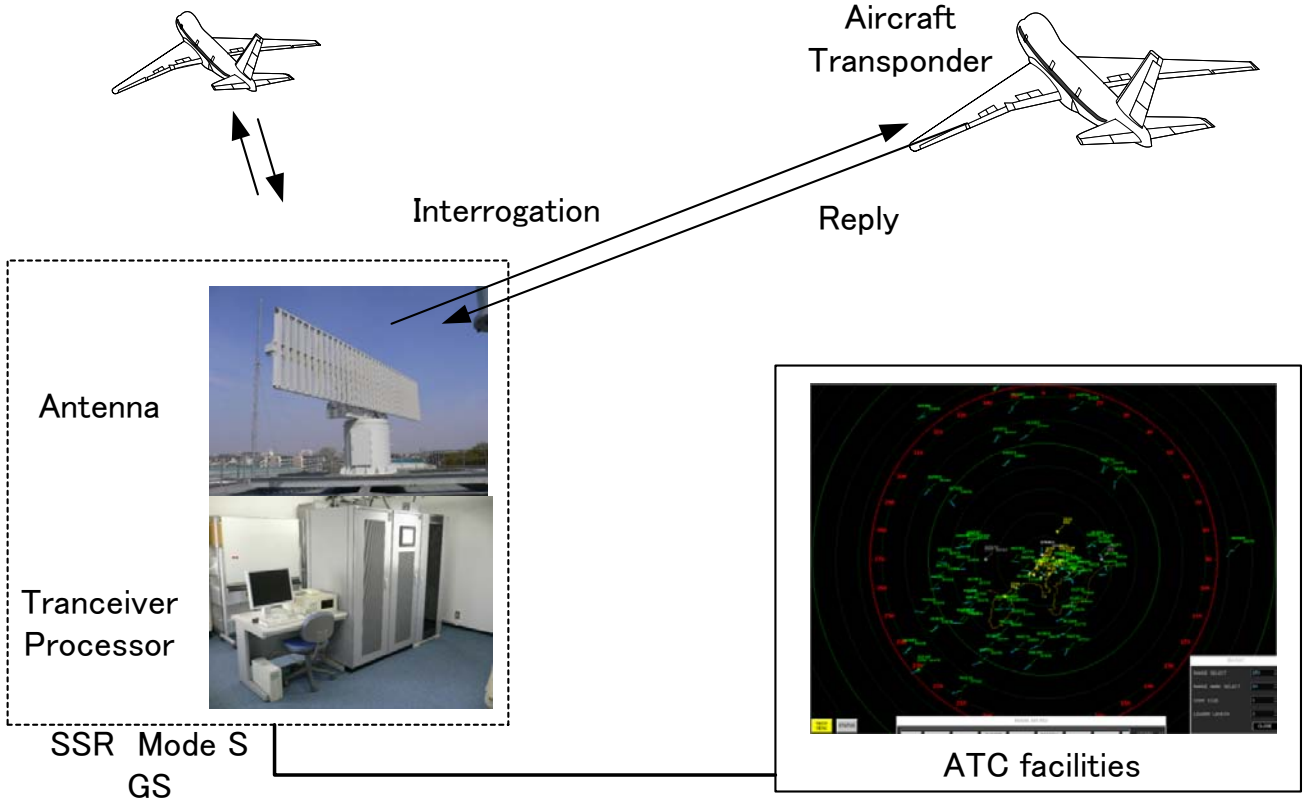
Introduction:

Secondary Surveillance Radar(SSR) Mode S

- Enhanced surveillance capability
- Datalink capability



ENRI has started R&D of SSR Mode S with two new functions since 2006 in order to prepare future deployment of new Mode S in Japan.

Part I

Downlink Aircraft Parameters(DAPs) function

Part II

Interrogator Identifier code coordination function

Part I

Downlink Aircraft Parameters

（DAPs）

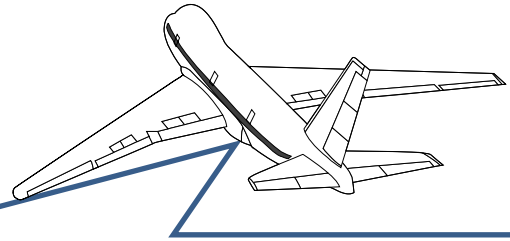
1. Background

- European states launches DAPs project in 1990s.
- DAPs is mandatory in some European states.
- The percentage of aircraft with DAPs is increasing in Japan.

register		ELS	EHS
–	24bit address	*	*
–	Mode 3/A	*	*
–	25 ft altitude	*	*
–	Flight status	*	*
10	Datalink capability report	*	*
17	GICB	*	*
20	Aircraft identification	*	*
30	RA	*	*
40	Selected Vertical intention		*
50	Track and turn report		*
60	Heading and speed report		*

2. GICB protocol

GICB downlinks 56bits data from transponder.



GICB request

GICB reply

Transponder

#	Contents
00	----------
05	Airborne position
20	Aircraft ID
…	
40	Vertical intention
…	
255	----------

FMS

Altimeter

Sensor

GPS

HMI

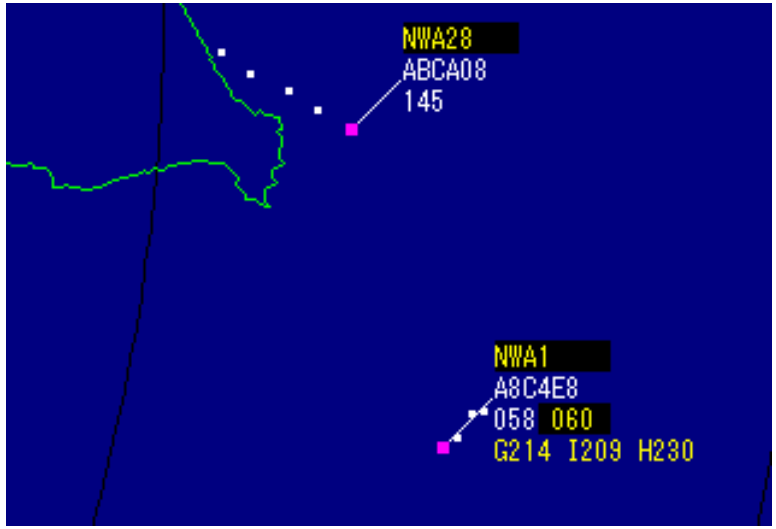
Requests(ID)

Network

ATM Systems

DAPs application

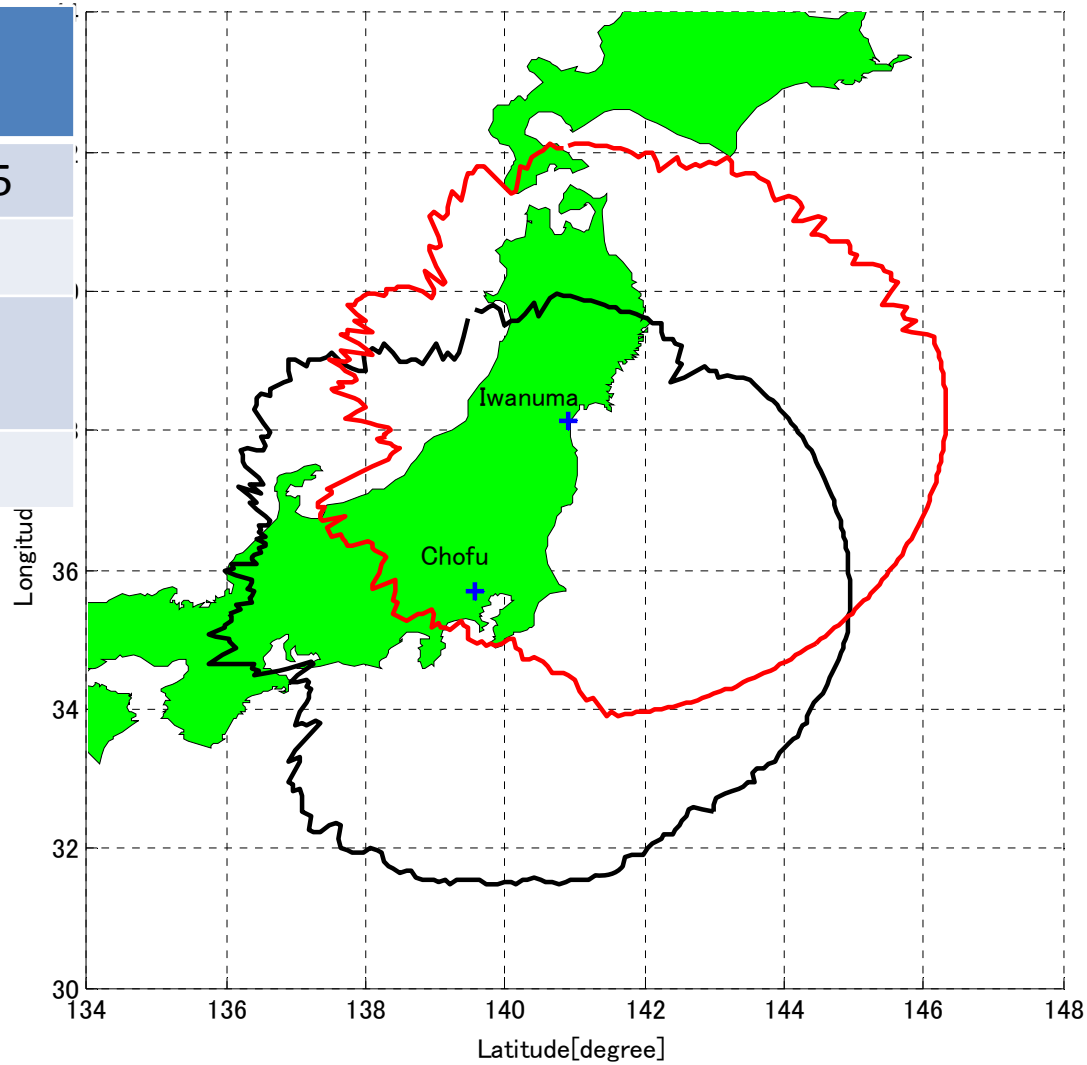
Improve
Air picture
Of controllers



Enhance
conflict
detection
algorithm

3. Experimental System

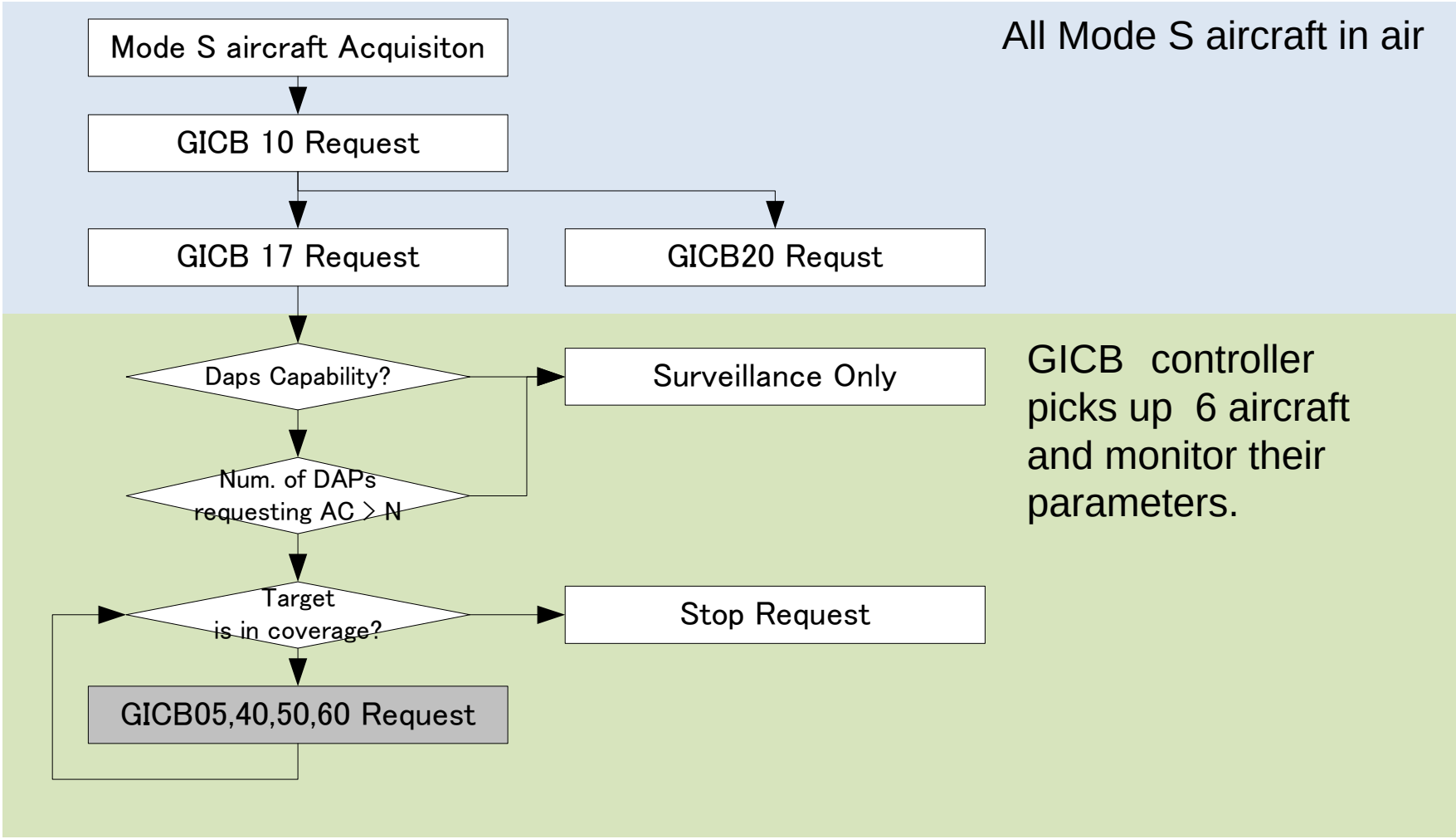
	CHOFU GS	IWANUMA GS
Year	April 2008	March 1995
Power	Max 1.5kw	Max 1.5kw
Coverage	250NM	200NM
Period	10seconds	4seconds



We validate new functions through real aircraft monitoring.

4. DAPs monitoring

Downlink procedure



Results of GICB capability monitoring

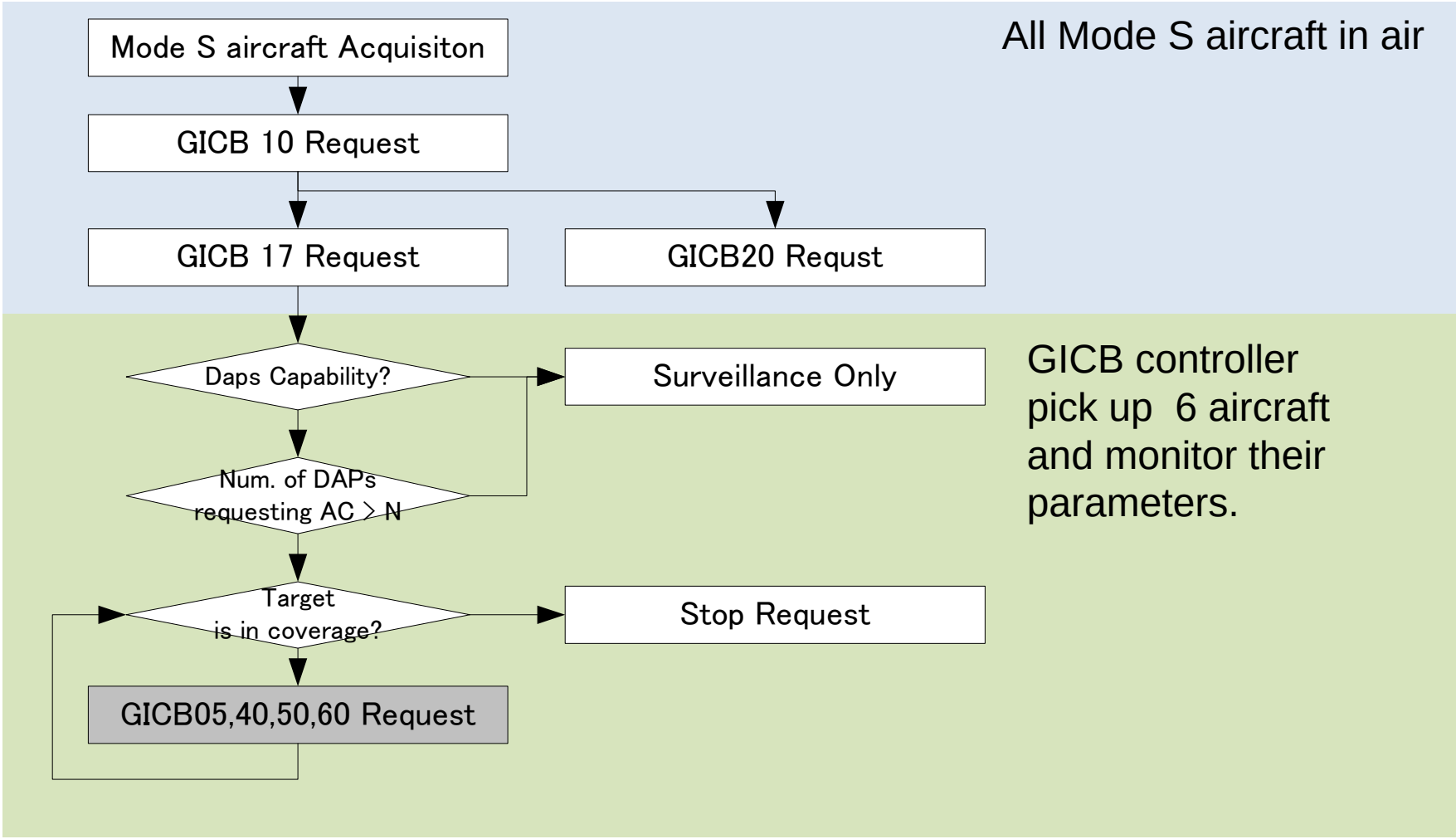
961 aircraft

Register Number	Data Content	Number of aircraft	%
05	Extended squitter airborne position	569	59.2
06	Extended squitter surface position	563	58.6
07	Extended squitter status	602	62.6
08	Extended squitter identification and type	581	60.5
09	Extended squitter airborne velocity	592	61.6
0A	Extended squitter event-driven information	14	1.5
20	Aircraft identification	591	61.5
21	Aircraft registration number	248	25.8
40	Selected vertical intention	584	60.8
50	Track and turn report	611	63.6
60	Heading and speed report	588	61.2

60 % of aircraft have DAPs capability

4. DAPs monitoring

Downlink procedure



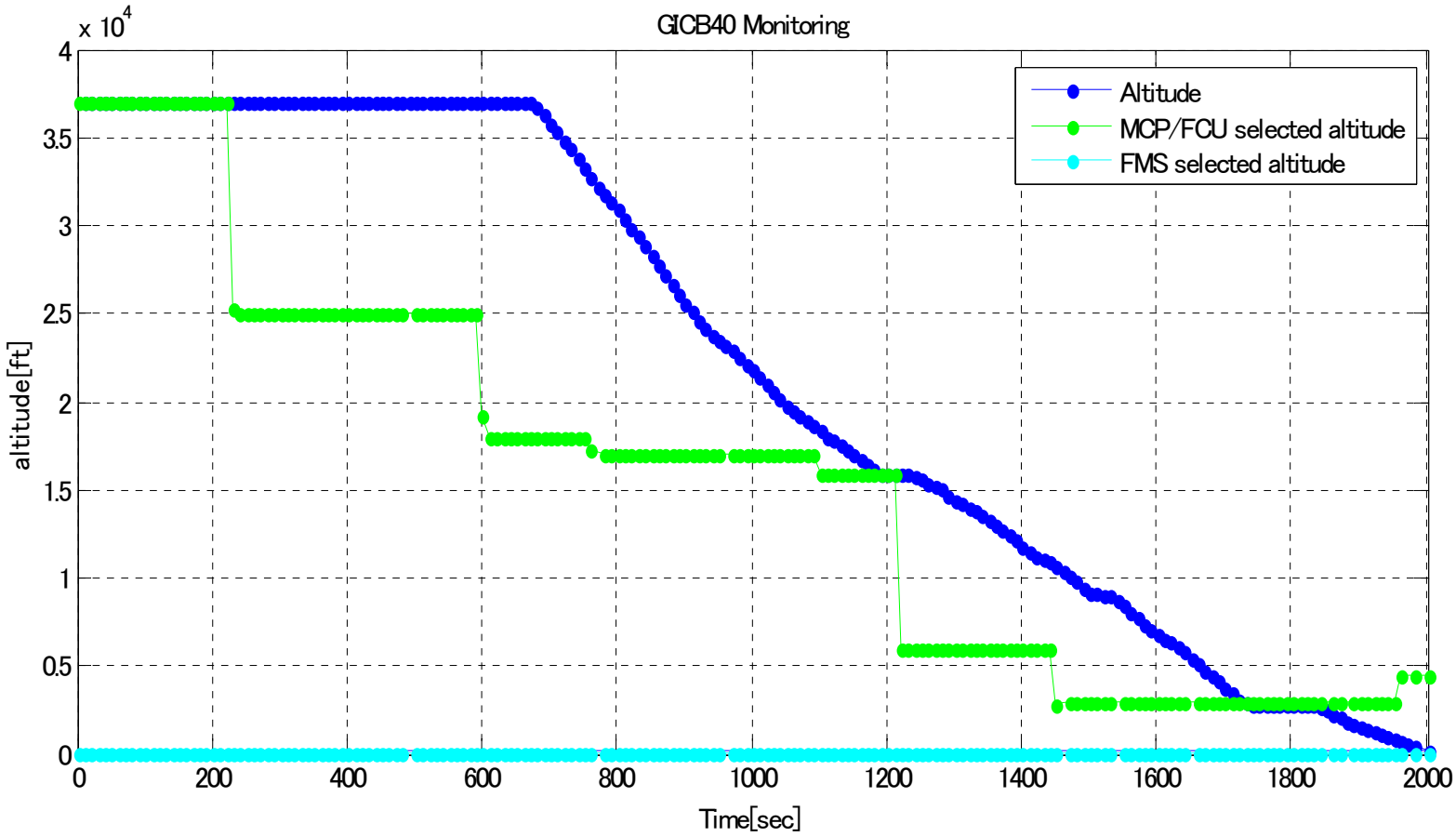
Parameter monitoring

(1) GICB 40 Selected vertical Intention

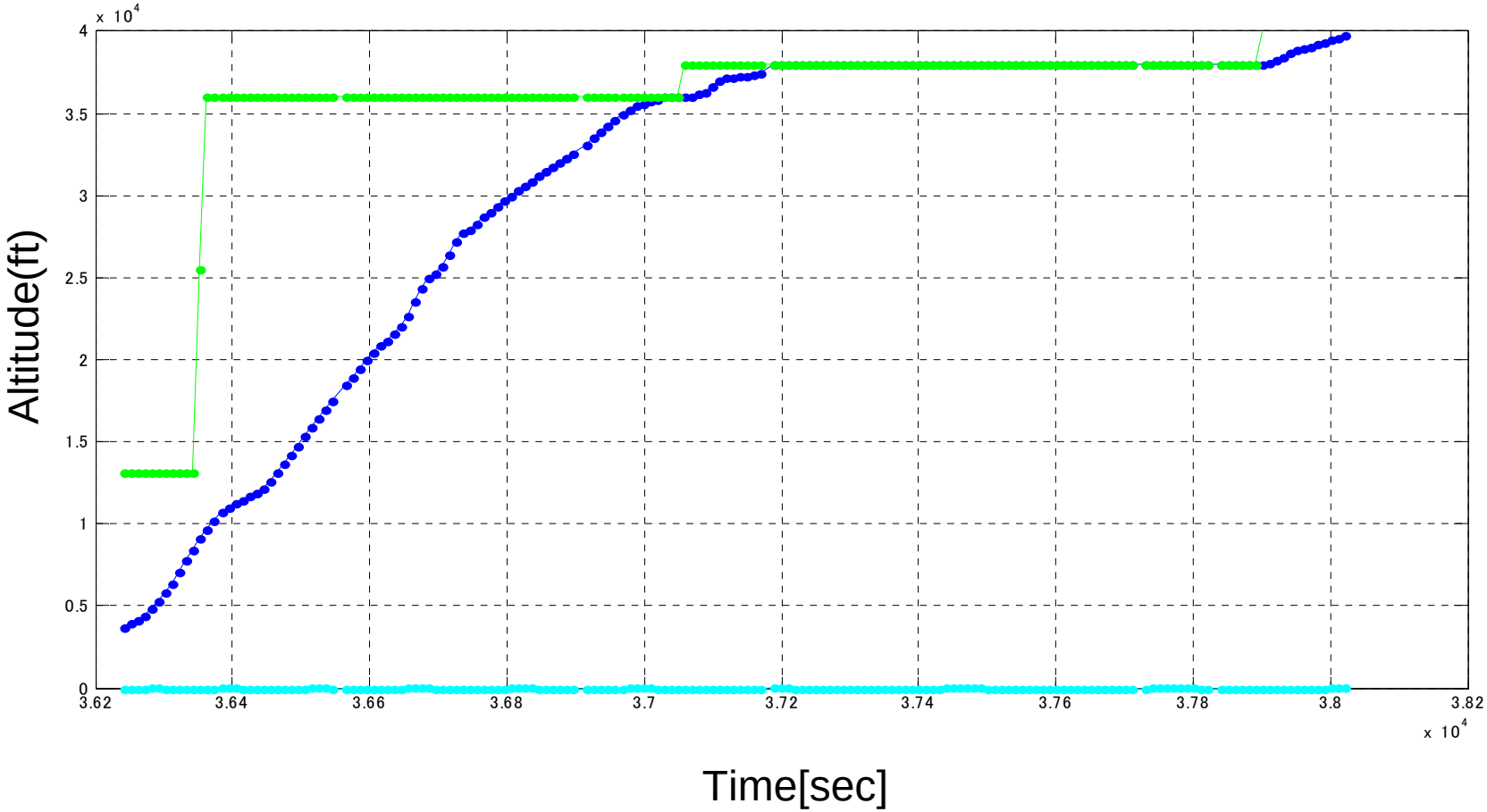
- MCP/FCU selected altitude (Range: 0 to 65520 ft)
- FMS selected altitude (Range: 0 to 65520 ft)
- Barometric pressure setting (Range: 800-1210mb)
- MCP/FCU Mode bits
  - VNAV Mode, ALT Hold Mode or Approach Mode
- Target alt source
- Status bits

Examples of GICB 40 monitoring

Arrival aircraft



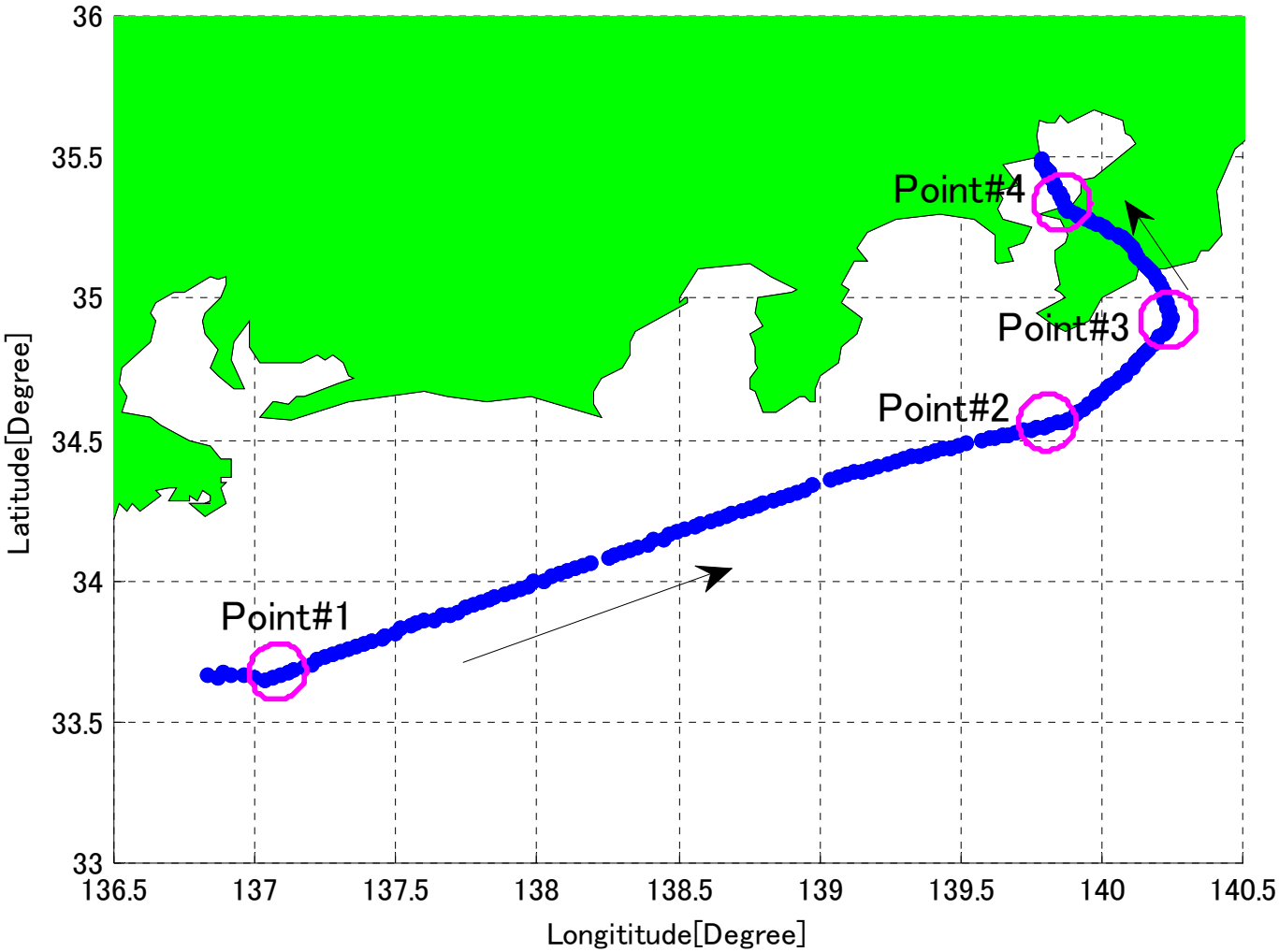
Departure aircraft



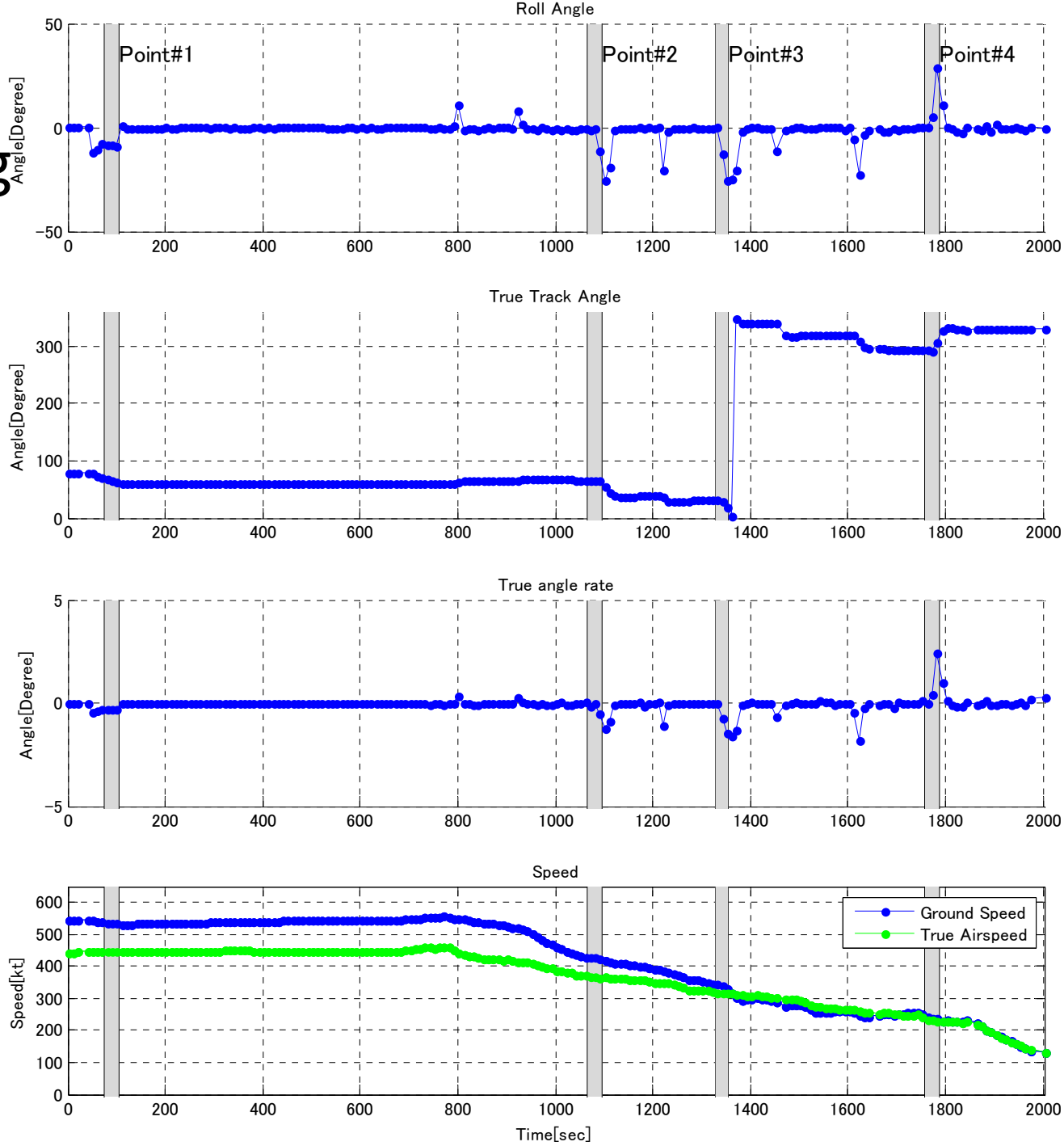
(2) GICB 50 Track and turn report

- Roll Angle (Range: -90 to 90 degrees)
- True track angle (Range: -180 to 180 degrees)
- Track angle rate (Range: -16 to +16 degrees/second)
- Ground speed (Range: 0-2046knots)
- True airspeed (Range: 0-2046knots)
- Status bits

Aircraft Track



GICB50 monitoring

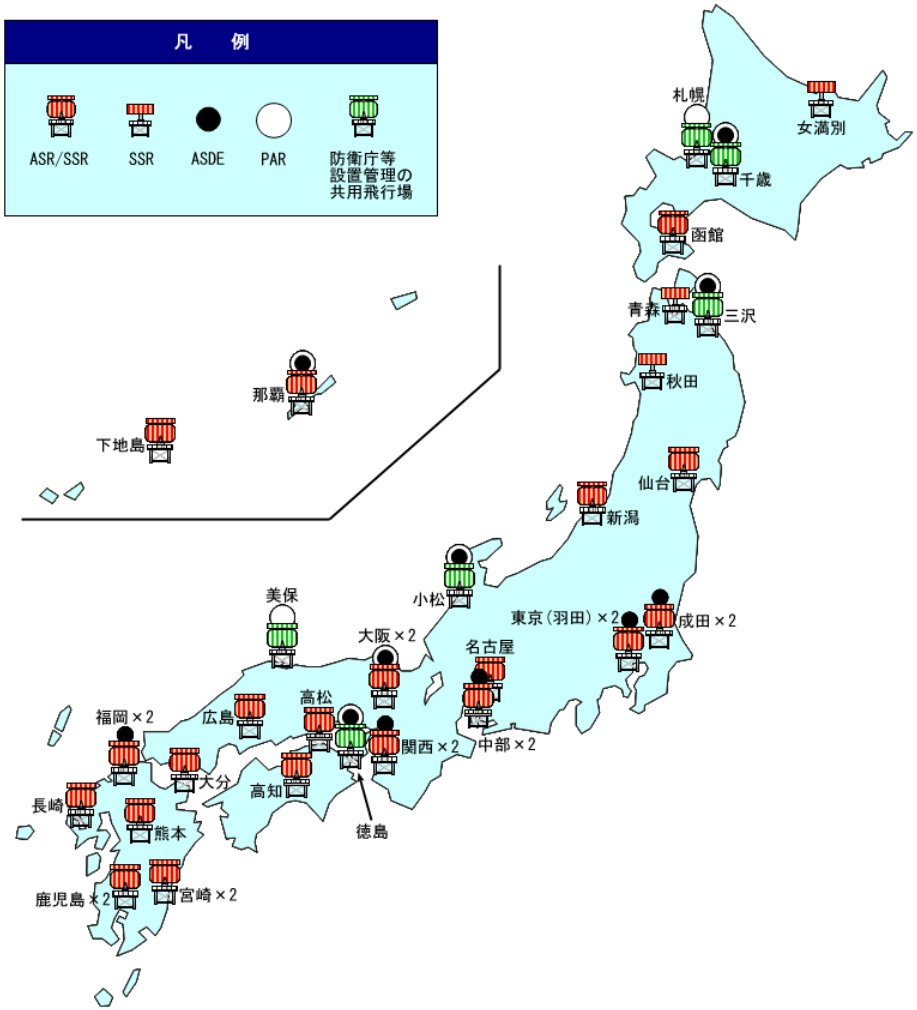


Part II.

Interrogator Identifier Code Coordination

1. Background

Airport Surveillance Radar (ASR)



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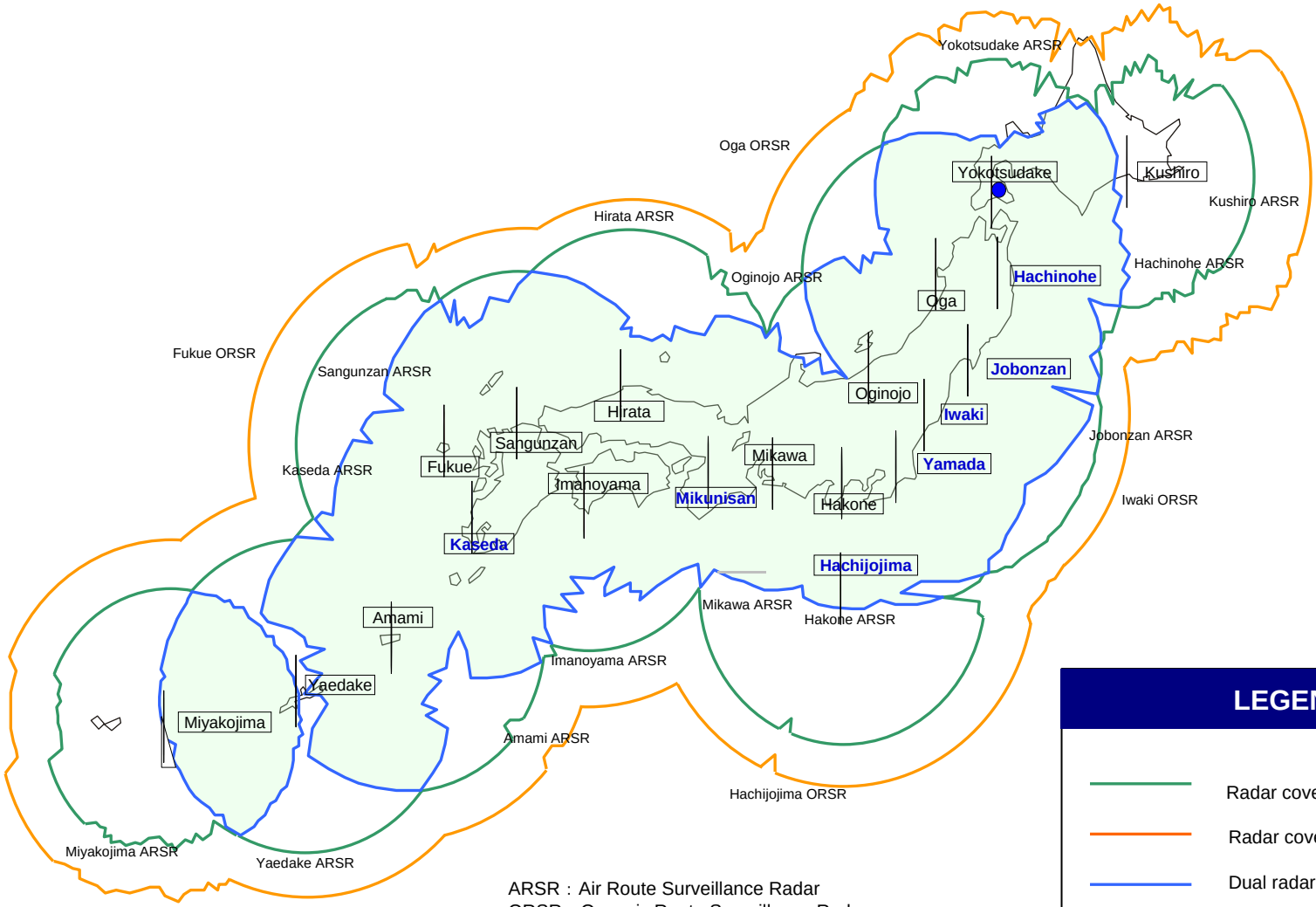
Air Route Surveillance Radar(ARSR)



ARSR : Air Route Surveillance Radar
ORSR : Oceanic Route Surveillance Radar

LEGEND

- Radar covering area(15,000ft)
- Radar covering area(30,000ft)
- Dual radar covering area (15,000ft)

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Interrogator Identifier(II) code allocation problem

- ICAO defined only fifteen II codes.
- II code should be allocated without conflicts between neighbor ground stations(GS) .

Many GS are deployed.

Run short of II codes.

Allocate the same II code between neighbor GS.

GS are not able to achieve continuous aircraft surveillance in overlapping area.

II code coordination function

2. Il code coordination methods

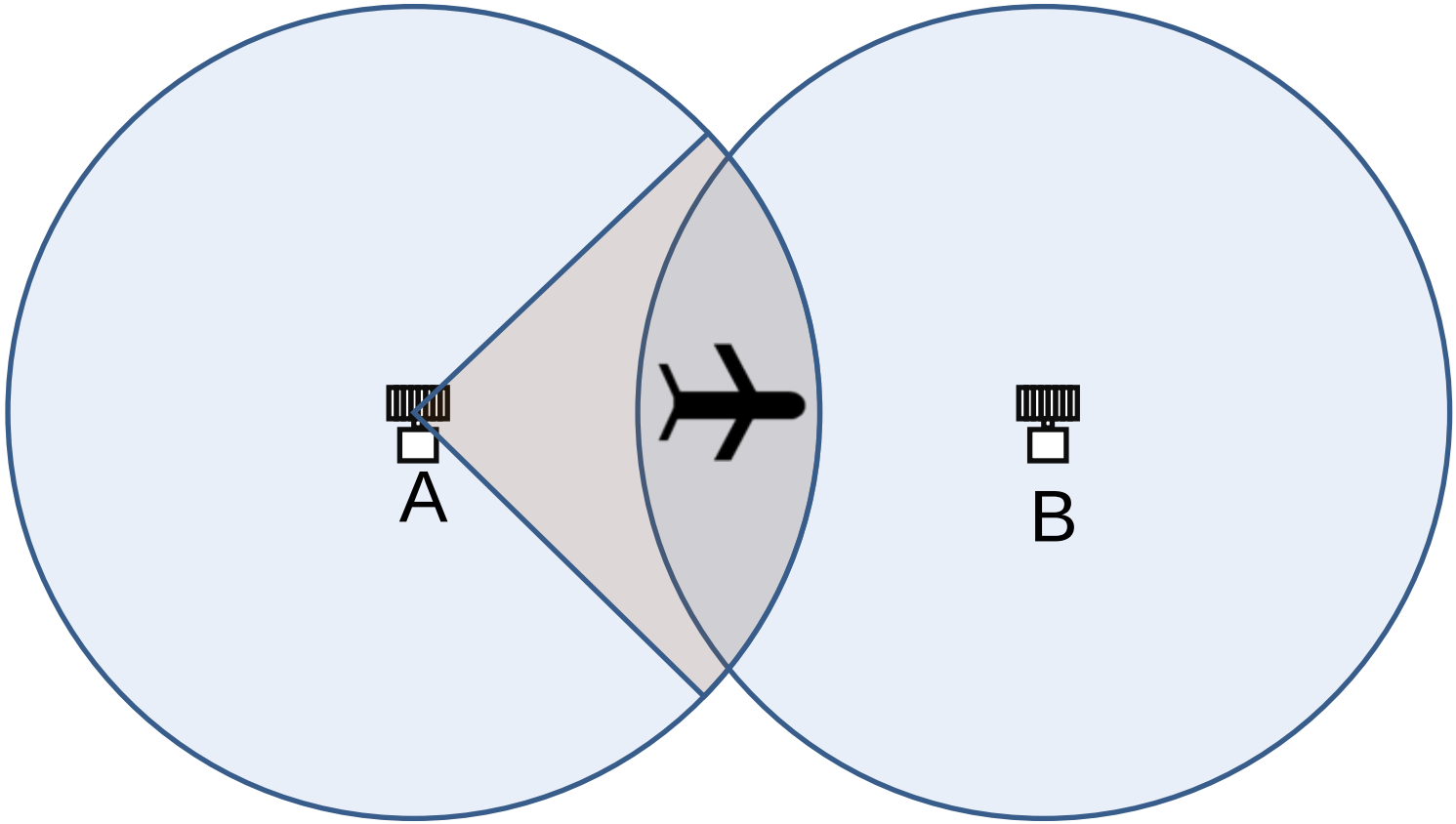
There are several solutions.

We decide to develop two methods.

- The Independent Coordination(2006-2008)
  - Stochastic Lockout Override (SLO)
  - Lockout coverage restriction (LCR)

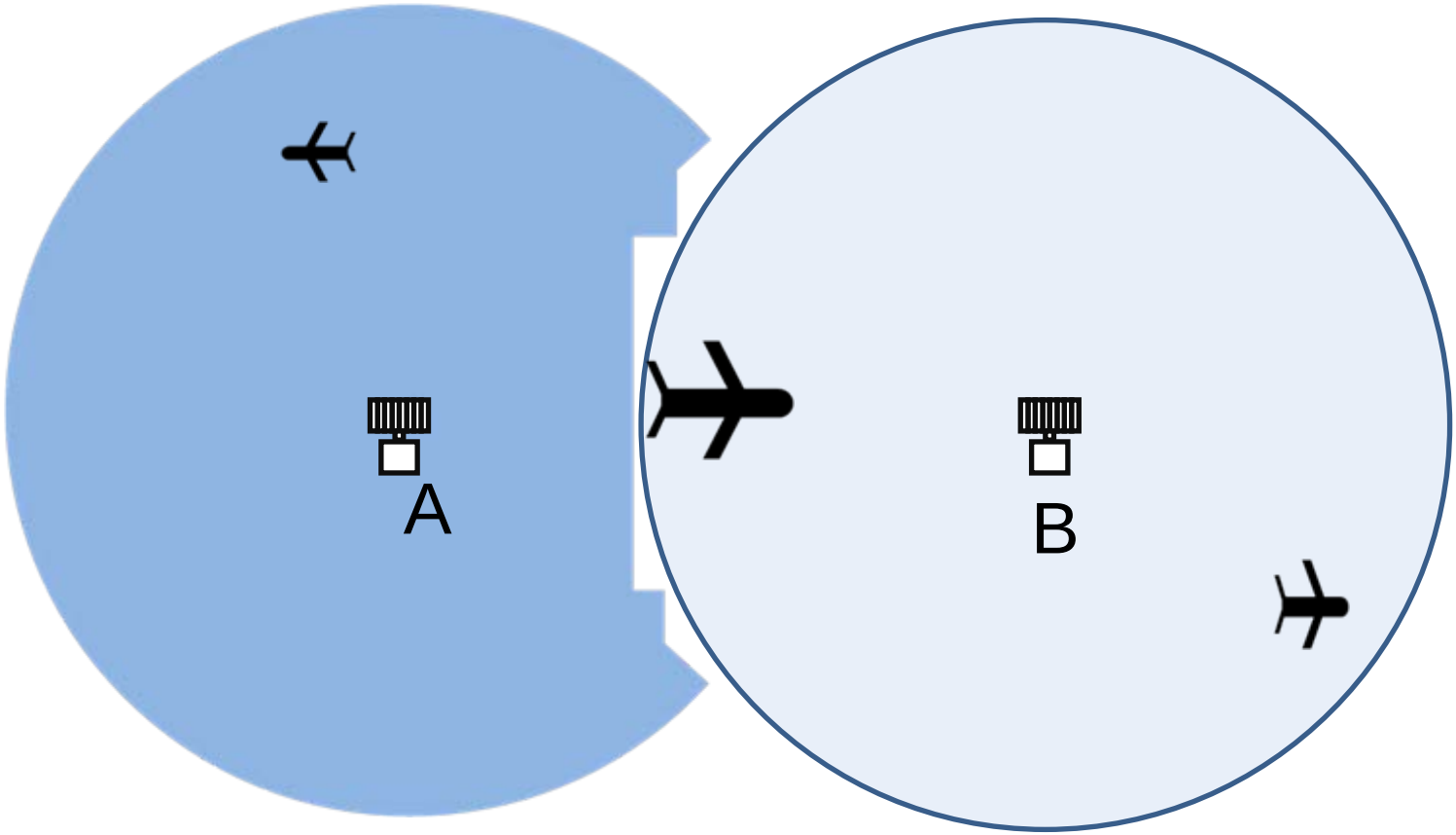
- The network-aided Coordination(2008-2010)

(1)Stochastic Lockout Override(SLO) Technique



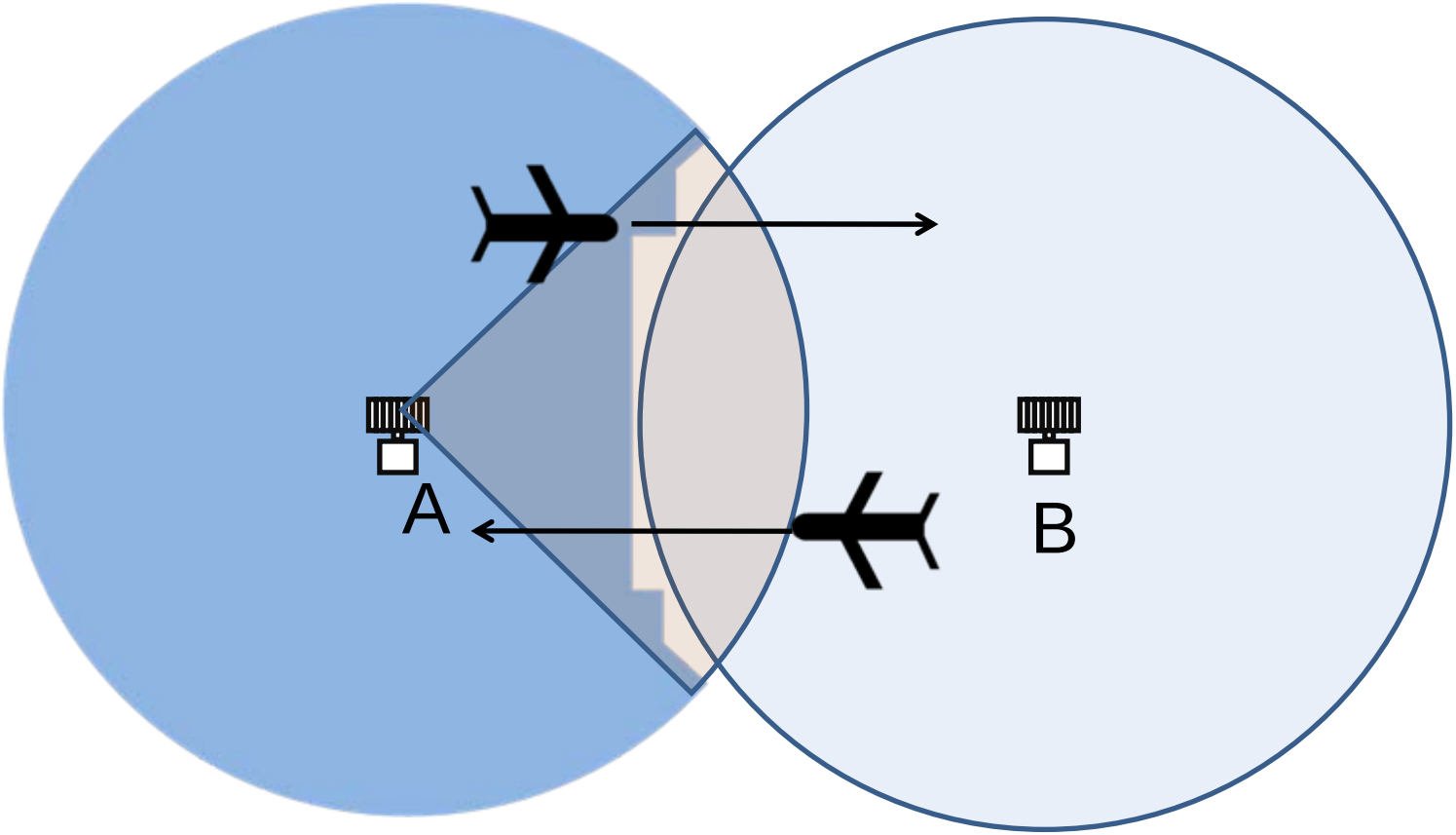
Override Interrogation:
Transponders must reply all-call replies in spite of lockout condition with designated probability (1, ½ , ¼ , 1/8, 1/16).

(2)Lockout Coverage Restriction(LCR)Technique



GS A controls lockout coverage by using coverage map.

SLO + LCR



With combination of SLO and LCR,
the independent coordination achieve continuous surveillance in overlapping area.

5.2 Experiment for function test

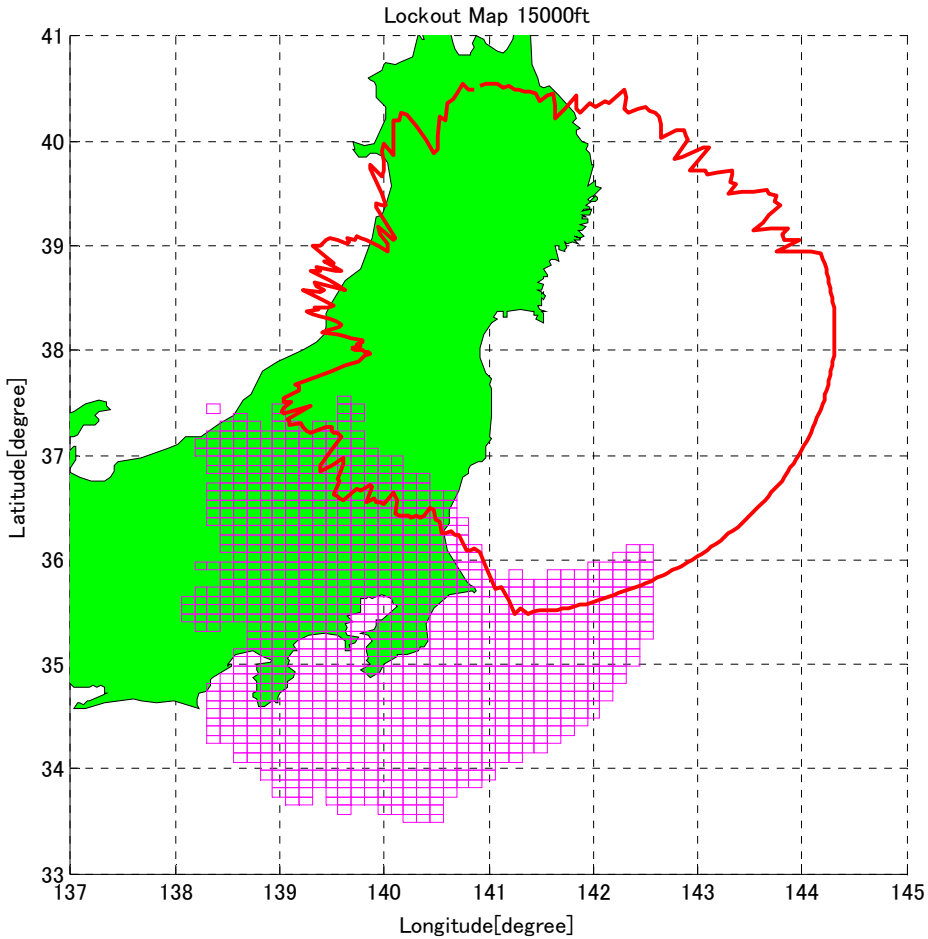
Chofu GS settings

SLO: 120 degrees
(-45 to 75degree)

RR : 1, ½ , ¼

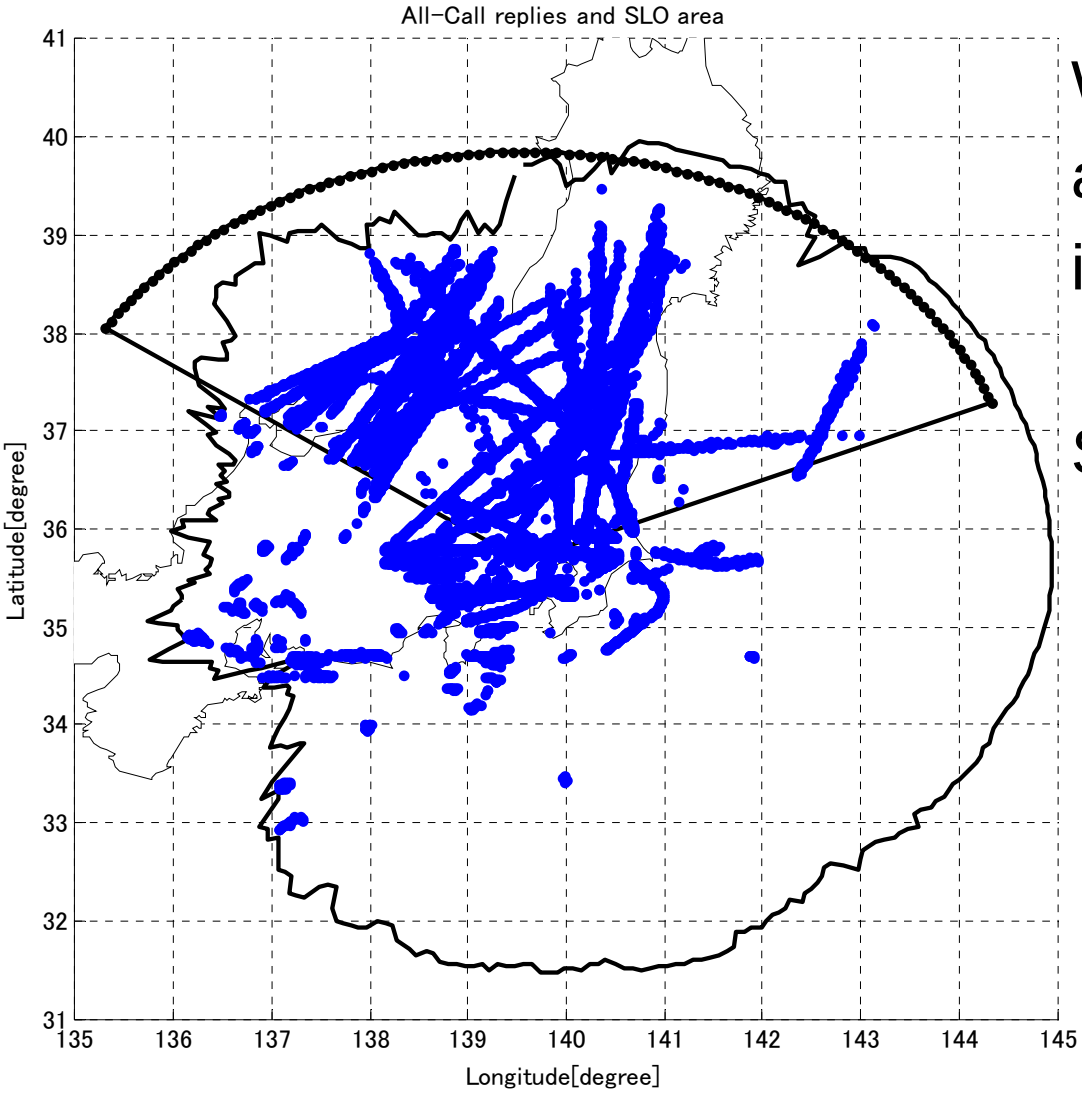
PRF: 113pps

Lockout map:
3D Cell
5NM × 5NM × 200ft
(9km × 9km × 60m)



Lockout Map at 15,000ft

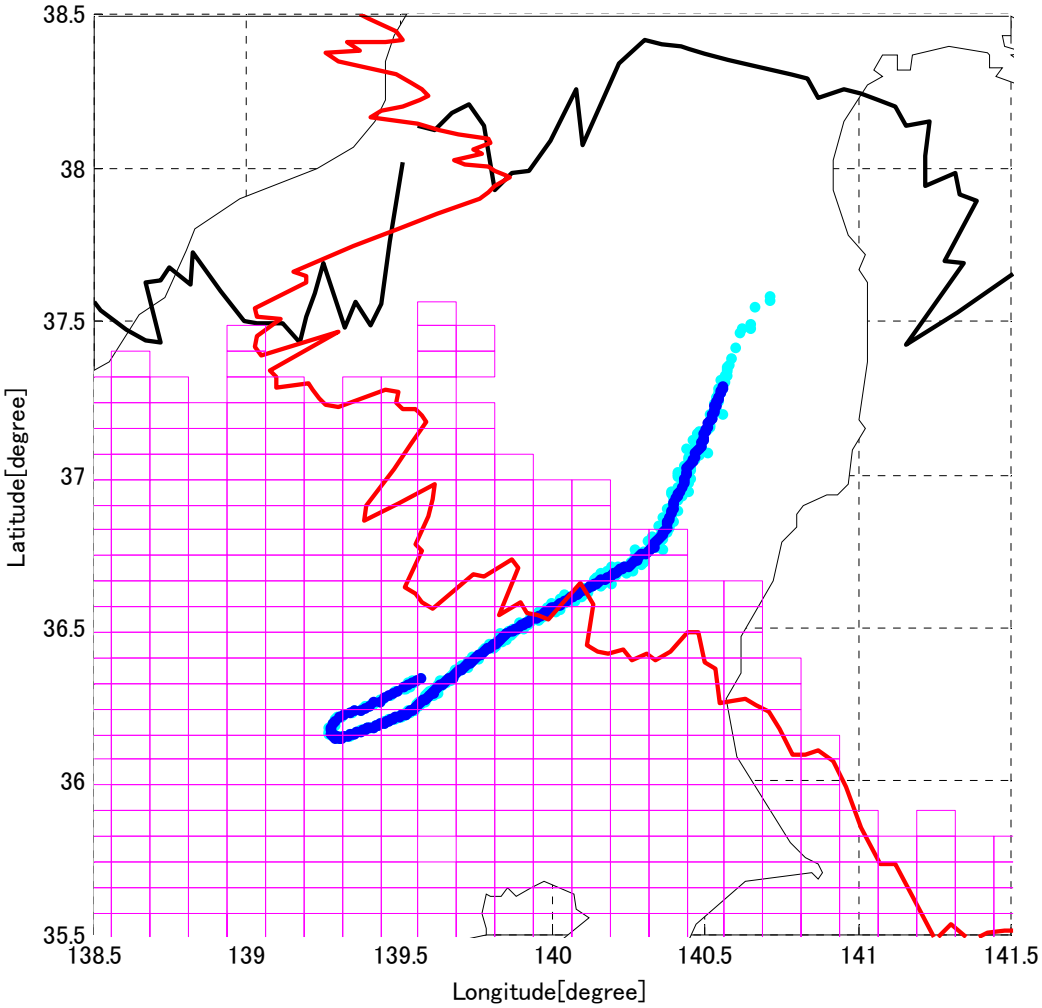
5.3 Results of tests



We observed
a lot of all-call replies
in SLO area

SLO is working correctly
both in transponders
and in GS.

Aircraft track passing overlap coverage



Cyan: all-call replies
Blue: roll-call replies

Chofu GS acquire aircraft in overlap area.

Conclusion

We developed Mode S with two functions.

- DAPs
  - 60% of aircraft have DAPs capability.
  - Aircraft are sending reasonable values.

- II code coordination
  - Independent Coordination achieves continuous aircraft surveillance in overlapping area