

Simplified explanation of II/SI code operations

Prepared for ICAO Sur ICG/8

6-9 April 2023

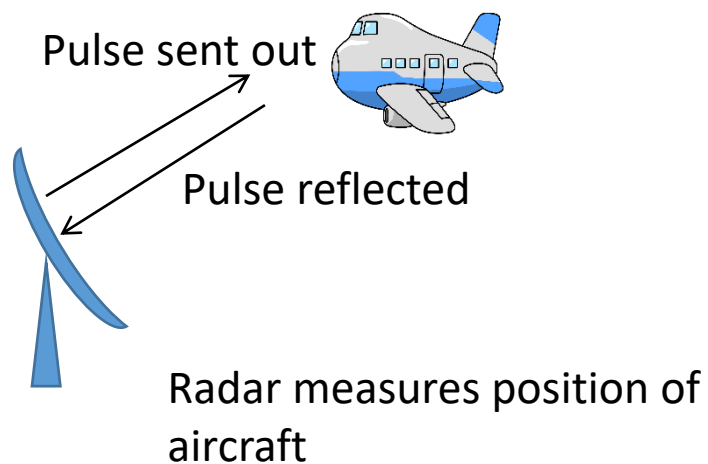
By HO Wee Sin

Civil Aviation Authority of Singapore

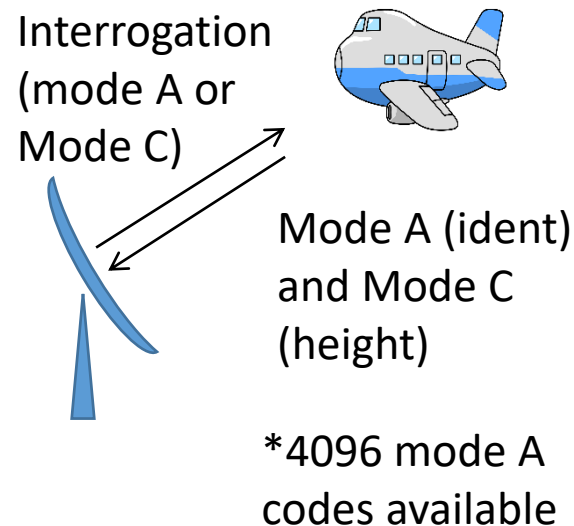
Working principles of radar

- Primary radar only provides position of aircraft
 - Secondary (mode A/C) radar provides the Mode A (i.e. ident code) and Mode C (barometric height), plus position
 - Secondary (mode S) radar provides other information (e.g. unique 24-bit Aircraft address, call-sign, vertical intent etc), plus what mode A/C radar can provide.
- Note that mode A/C is mandatory but not mode S

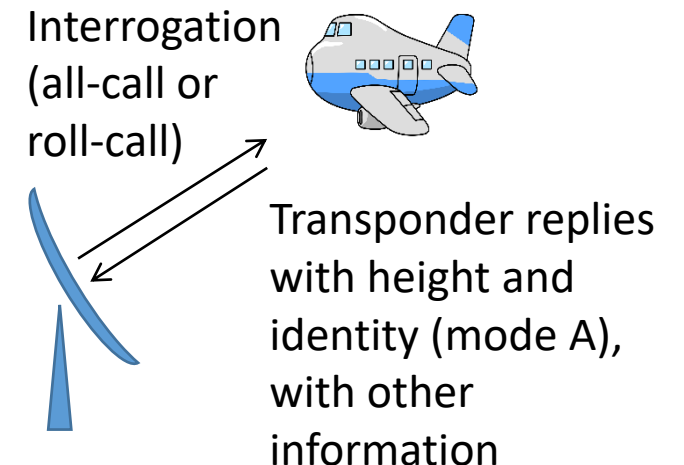
Primary radar



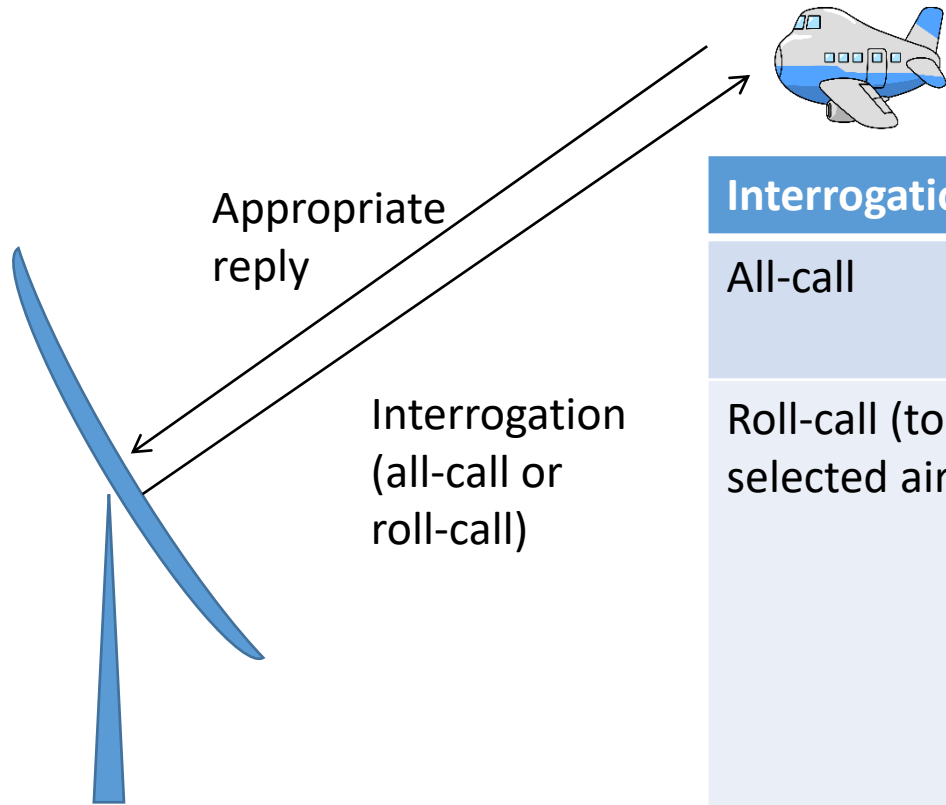
Secondary radar (Mode A/C)



Secondary radar (Mode S)



Broad principle for mode S

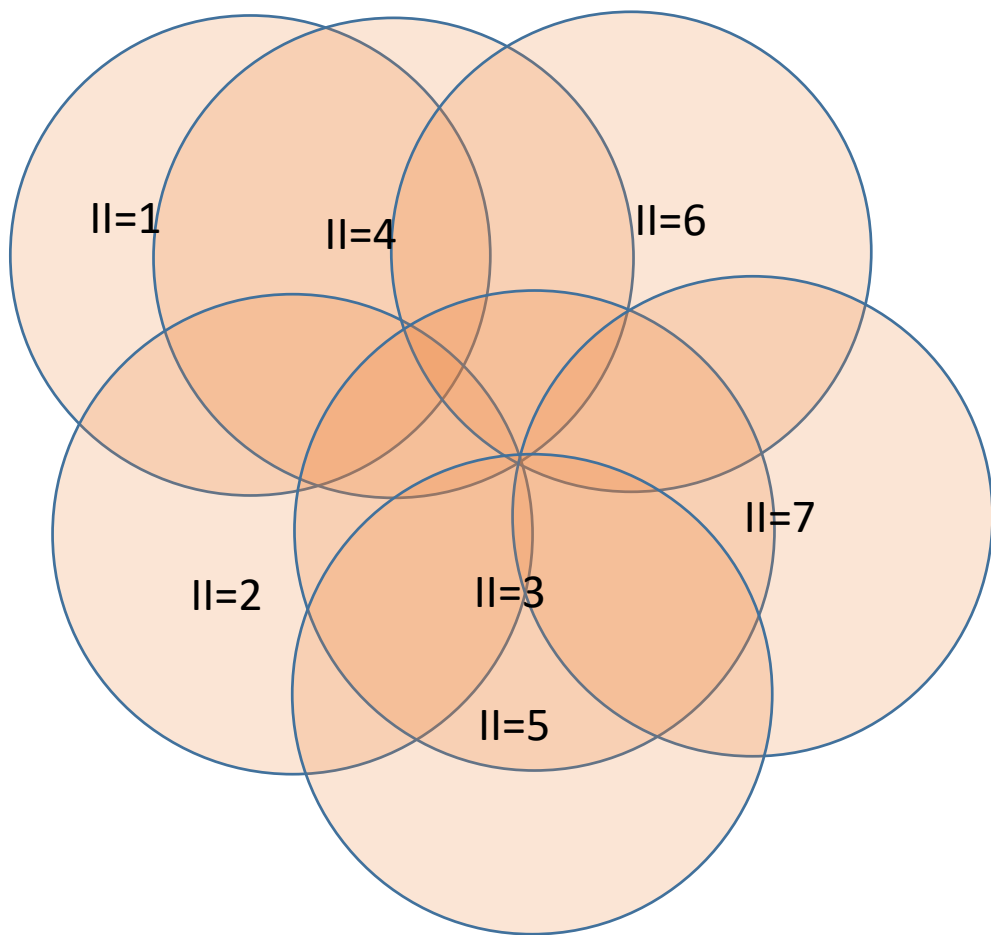


Interrogation	Reply	Remark
All-call	24-bit Aircraft address	Only non-locked out aircraft will reply
Roll-call (to only selected aircraft)	Aircraft address + height / Mode A with: <u>Elementary Mode S</u> a) Datalink capability report; b) Flight ID (aka call-sign); c) TCAS resolution advisory report; <u>Enhanced Mode S</u> a) Selected vertical intention; b) Track and turn; c) Heading and speed;	Only target aircraft will reply.

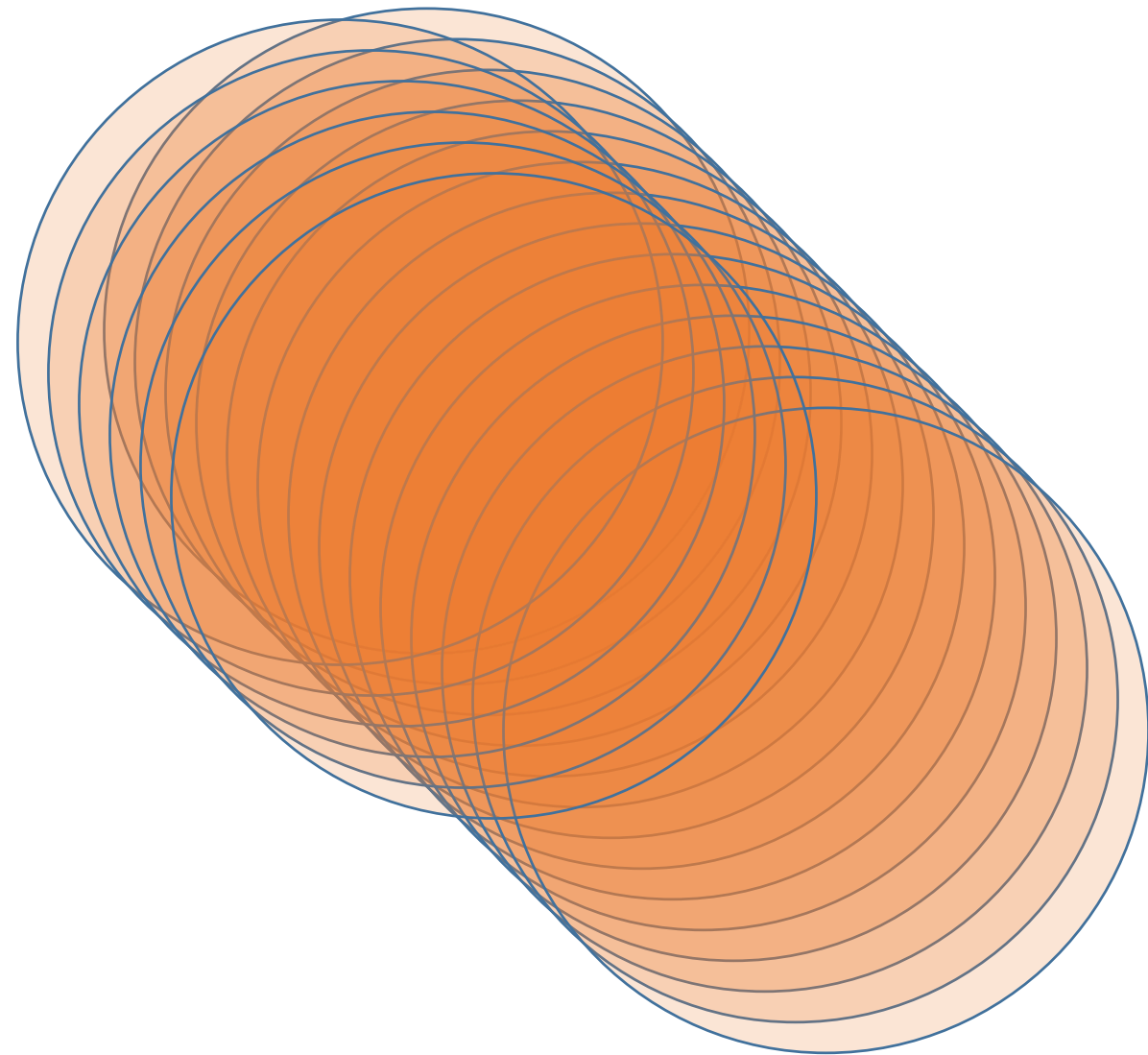
For purpose of locking out to all-call, each radar has its own identifier code (IC). Old scheme is the interrogator identifier (II) (15 combination). New scheme is the surveillance identifier (SI) (63 combination). Not all aircraft can recognize the SI code.

Radar identifiers

II codes can be used if not too many overlapping radars



SI codes has to be used if too many overlapping radars



All-call

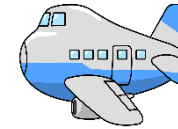
24 bit aircraft address = 76ABCD
Locked out to II = 4, 7
Locked out to SI = 21, 22



All call interrogation

No reply to all call interrogation from radar with II=7

24 bit aircraft address = 34ABCE
Locked out to II = 4
Locked out to SI = 21, 22

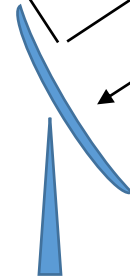


All call interrogation

Reply with 24 bit address = 34ABCE and II=7

Currently acquired aircraft
24 bit aircraft address = 76ABCD

Newly acquired aircraft
24 bit aircraft address = 34ABCE



Radar with II=7

Roll-call

24 bit aircraft address = 76ABCD
Locked out to II = 4, 7
Locked out to SI = 21, 22



roll call
interrogation to
76ABCD, with
lock out
command

Reply with 24 bit
address = 76ABCD
with requested data

Currently acquired aircraft
24 bit aircraft address =
76ABCD, 34ABCE

Radar with II= 7

roll call
interrogation to
34ABCE, with
lock out
command



Reply with 24
bit address =
34ABCE and
requested
data

24 bit aircraft address = 34ABCE
Locked out to II = 4
Locked out to SI = 21, 22

Addition radar to lock out II = 7

Coding of the II and SI number

Within the all-call interrogator message (UF=11), it contains 4 bit IC field and 3 bit CL field

4 bit IC field	3 bit CL field
representing range of 0 to 15 decimal	3 bit field to represent 0 to 5 decimal

SI code and II codes with same IC fields are 'matching'

E.g. II = 7 is a 'matching' II code for SI = 23

CL field	how it affects interpretation of IC field
000 (or 0 dec)	IC field contains II code 0 to 15
001 (or 1 dec)	IC field contains SI codes 1 to 15
010 (or 2 dec)	IC field contains SI codes 16 to 31
011 (or 3 dec)	IC field contains SI codes 32 to 47
100 (or 4 dec)	IC field contains SI codes 48 to 63

Aircraft transponder need to be SI capable to interpret CL field, else it assume CL field is 0

All-call (effects of aircraft with non-SI capable transponders)

24 bit aircraft address = 76ABCD
SI capable transponder



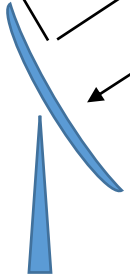
CL = 010, IC=0111,
Its SI = 23

All call
interrogation
SI = 23

Reply with 24 bit address
= 76ABCD and SI=23

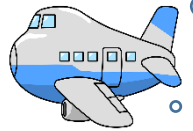
Newly acquired aircraft
24 bit aircraft address = 76ABCD

Failed to acquire 24 bit aircraft
address = 34ABCE



Radar with SI=23 (does not
support II/SI code operations)

24 bit aircraft address = 34ABCE
Non-SI capable transponder



CL = 000, IC=0111,
Its II = 7

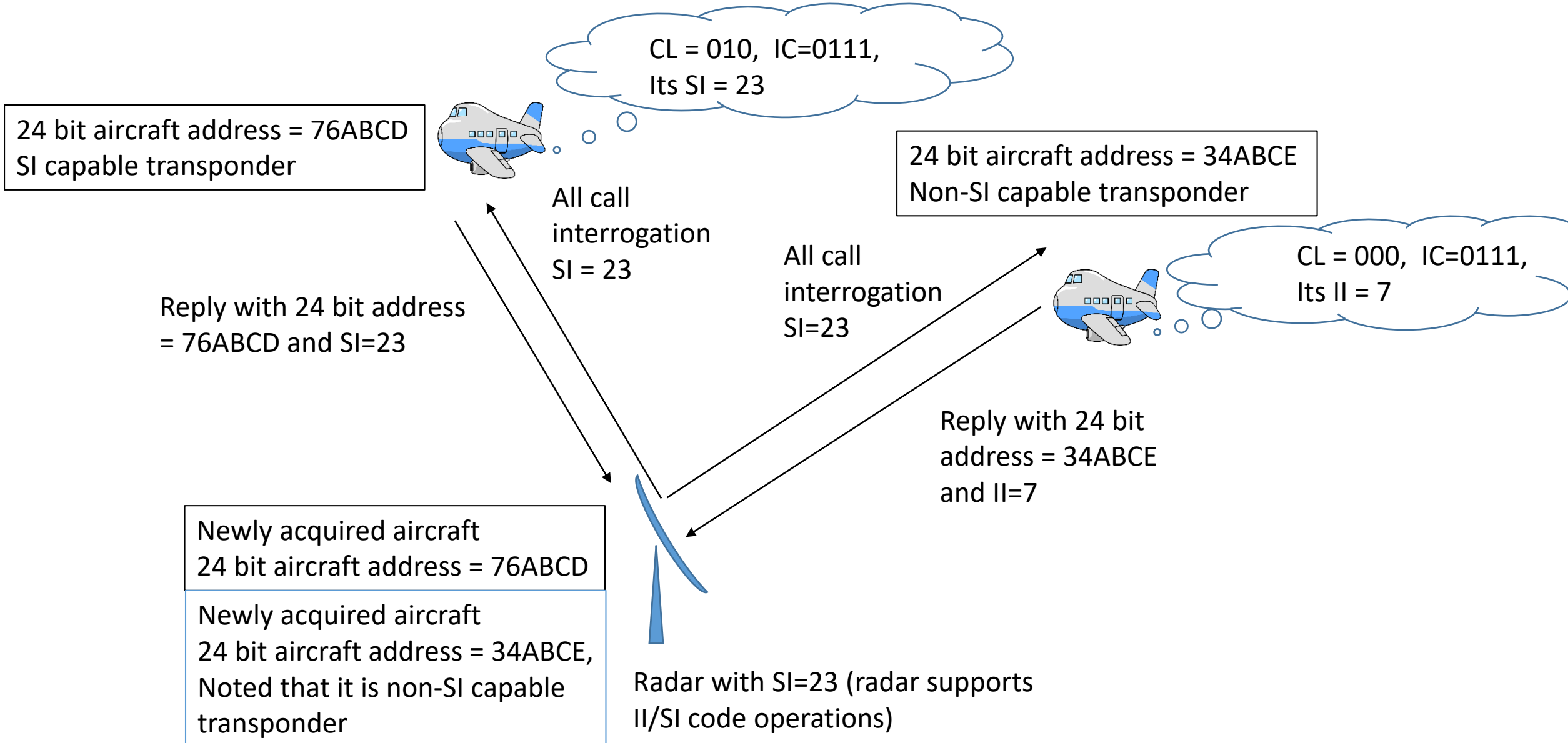
All call
interrogation
SI=23

Reply with 24 bit
address = 34ABCE
and II=7

Work-around available (II/SI code operations) using SI codes

- All-call interrogations with SI codes
- If transponder replies with SI code, to subsequently roll-call with SI code and issue lockout command
- If any transponder replies with 'matching' II code, to subsequently roll-call with 'matching' II code and not issue lockout command

All-call (SI radars with II/SI code operations)



Roll-call (SI radar with II/SI code operations)

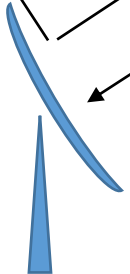
24 bit aircraft address = 76ABCD
SI code capable
Locked out to SI=23 for future all-calls



roll call interrogation to 76ABCD, SI=23 with lock out command

Reply with 24 bit address with requested data

Currently acquired SI transponder
24 bit aircraft address = 76ABCD
Currently acquired non-SI capable transponder
24 bit aircraft address = 34ABCE



Radar with SI=23 (radar supports II/SI code operations)

roll call interrogation to 34ABCE, II=7, without lock out command

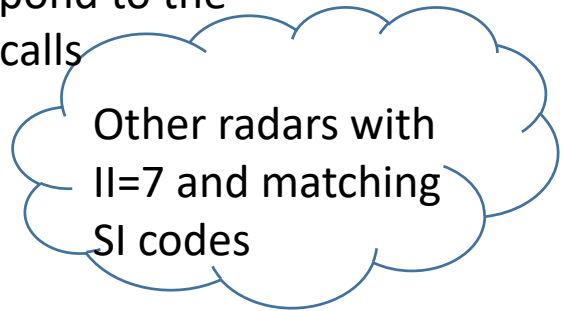
Reply with 24bit address and requested data

24 bit aircraft address = 34ABCE
Non-SI capable



Not locked out to II = 7

All call by other radars
Aircraft can respond to the all-calls

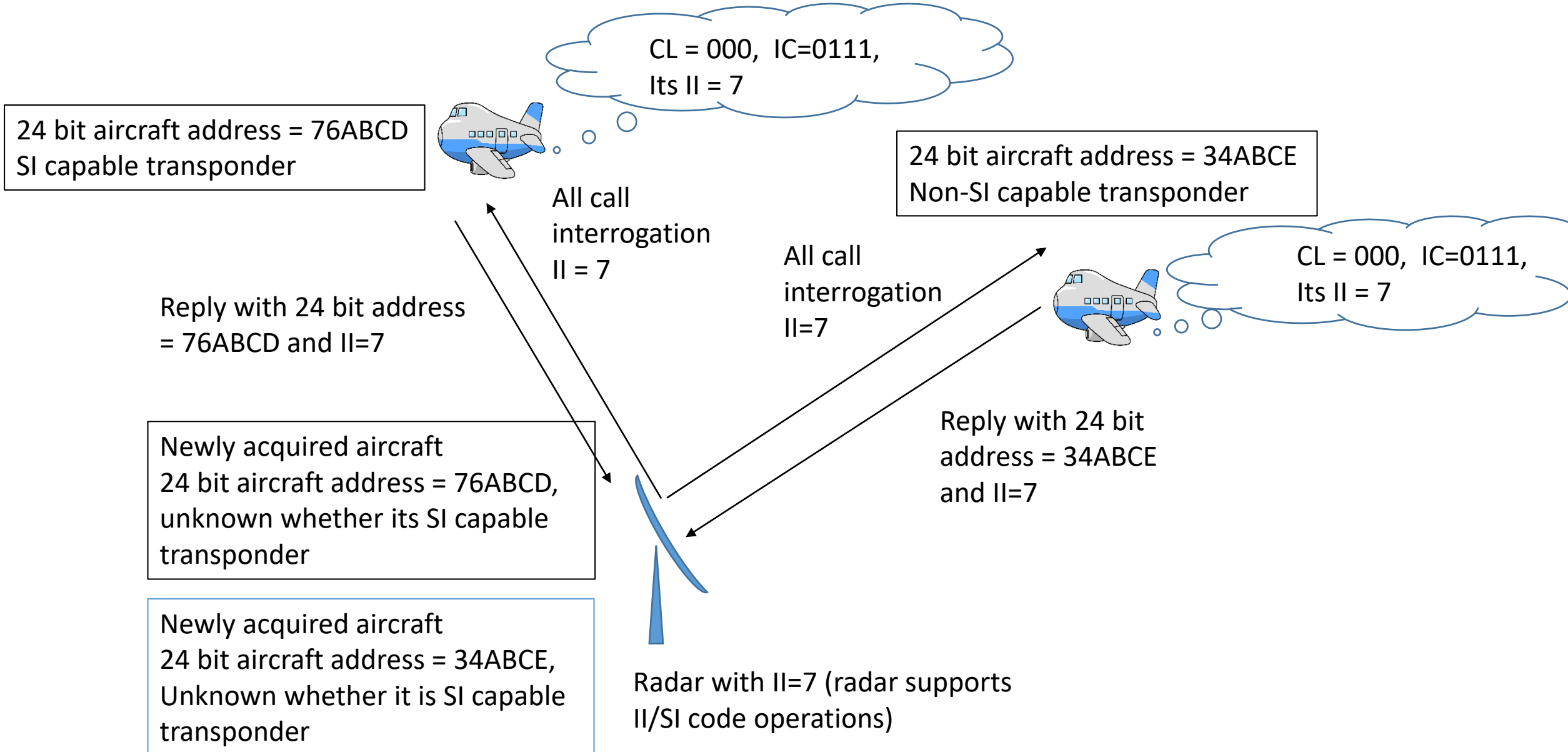


Other radars with II=7 and matching SI codes

Work-around available (II/SI code operations) using II codes

- All-call interrogations with II codes
- Roll-call to ascertain whether transponder is SI capable by requesting for BDS 1,0
- If BDS 1,0 indicates that transponder is SI capable, to subsequently roll-call with II code and issue lockout command
- If BDS 1,0 indicates that transponder is not SI capable, to subsequently roll-call with II code and not issue lockout command
- Currently practised in Europe

All-call (II radars with II/SI code operations)



Initial Roll-call (II radar with II/SI code operations)

24 bit aircraft address = 76ABCD
SI code capable



Reply with 24 bit address
and BDS 1,0 indicating its
SI capable

roll call
interrogation to
76ABCD, II=7
without lock out
command, request
for BDS 1,0

Currently acquired transponder
24 bit aircraft address = 76ABCD

Known whether 76ABCD is SI capable

Currently acquired transponder
24 bit aircraft address = 34ABCE

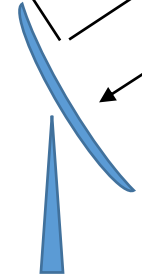
Known whether 34ABCE is SI capable

roll call
interrogation to
34ABCE, II=7,
without lock out
command, request
for BDS 1,0

24 bit aircraft address = 34ABCE
Non-SI capable



Reply with 24bit
address and BDS 1,0
indicating its not SI
capable



Radar with II=7 (radar supports
II/SI code operations)

Subsequent Roll-call (II radar with II/SI code operations)

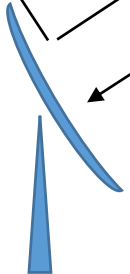
24 bit aircraft address = 76ABCD
SI code capable
Locked out to II=7 for future all-calls



roll call interrogation to 76ABCD, II=7 with lock out command

Reply with 24 bit address with requested data

Currently acquired SI transponder
24 bit aircraft address = 76ABCD
Currently acquired non-SI capable transponder
24 bit aircraft address = 34ABCE



Radar with II=7 (radar supports II/SI code operations)

roll call interrogation to 34ABCE, II=7, without lock out command

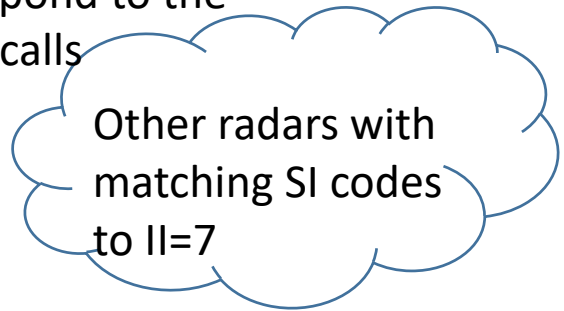
Reply with 24bit address and requested data

24 bit aircraft address = 34ABCE
Non-SI capable



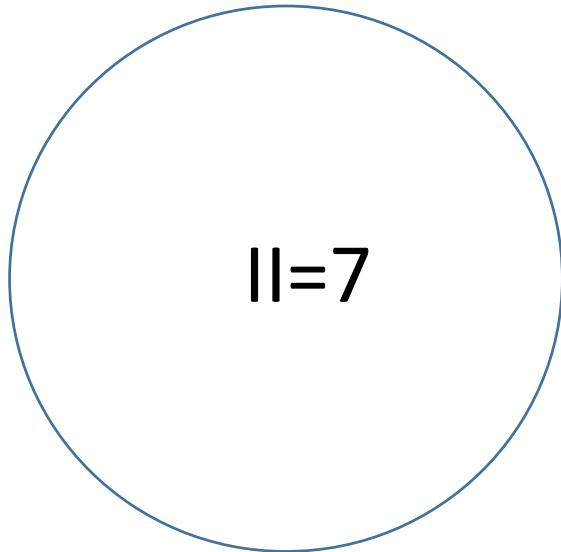
Not locked out to II = 7

All call by other radars
Aircraft can respond to the all-calls

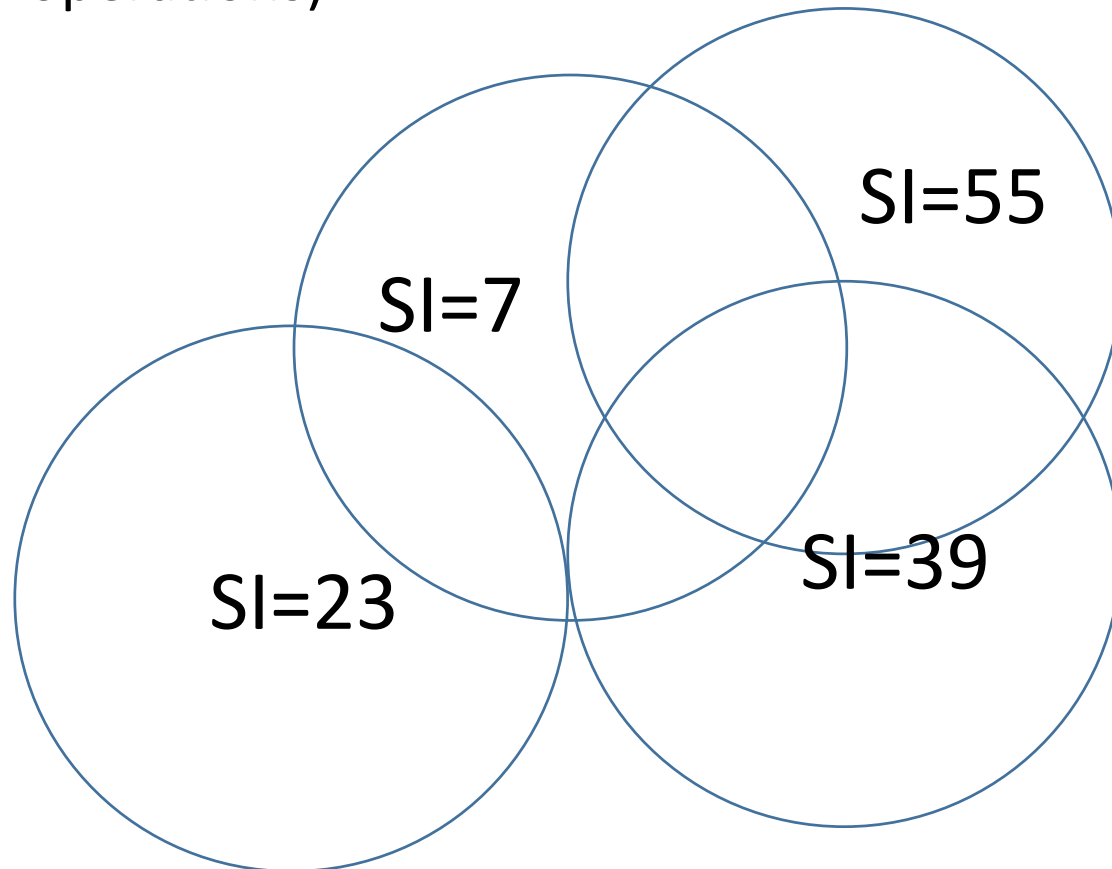


General strategy in migration from II to SI

Existing

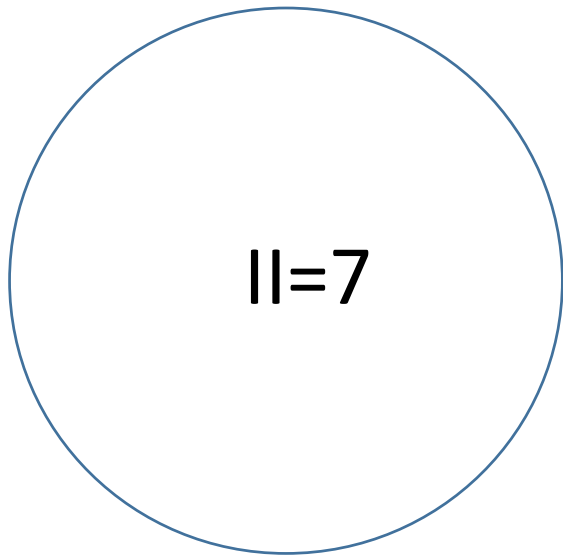


New (remove one II code, replace with 4 SI codes, ensuring that all radars supports II/SI code operations)



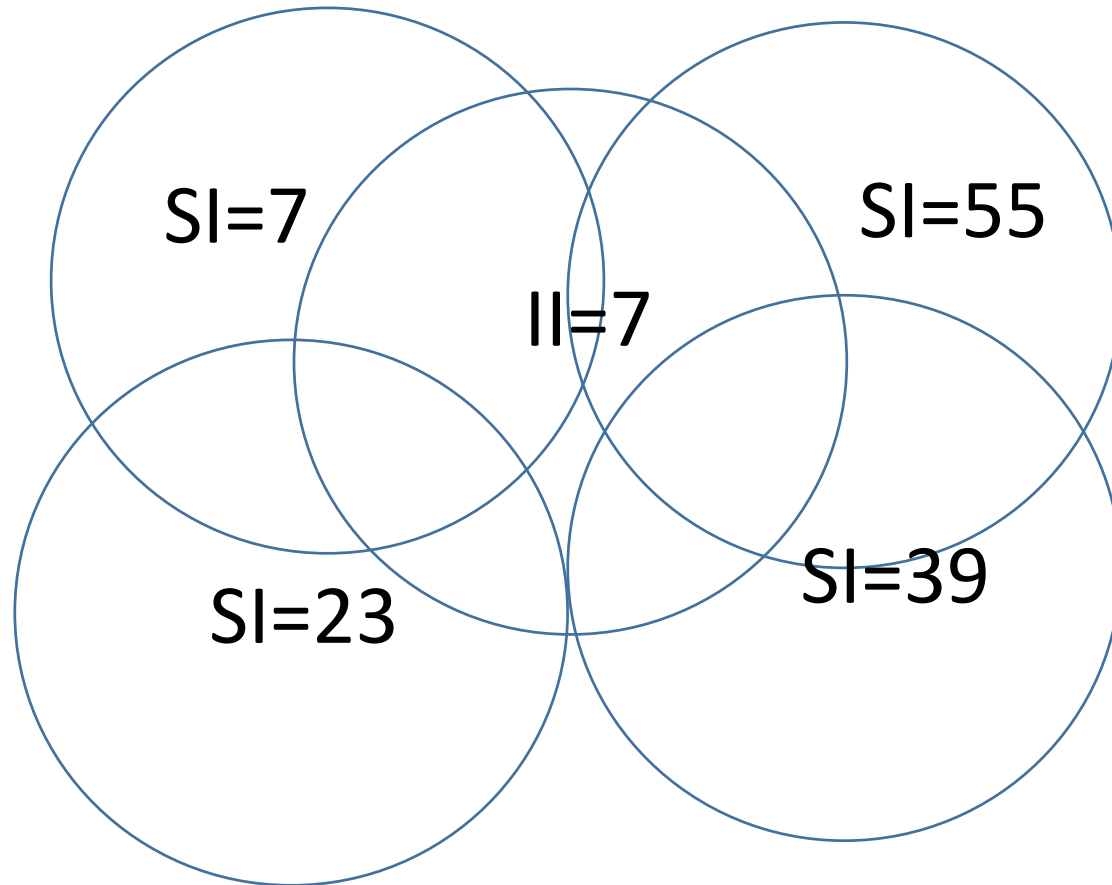
General strategy in migration from II to SI

Existing



Unknown whether the radar supports II/SI code operations

New (there will be risk to add radars with matching SI codes without first removing the out matching II code) –see next slide



All-call (effects when radar with II/SI code operations overlaps with radar having match II code)

24 bit aircraft address = 76ABCD
SI capable transponder



CL = 010, IC=0111,
Its SI = 23

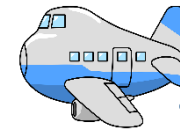
All call
interrogation
SI = 23

Reply with 24 bit address
= 76ABCD and SI=23

Newly acquired aircraft
24 bit aircraft address = 76ABCD

Could not acquired aircraft
24 bit aircraft address = 34ABCE,

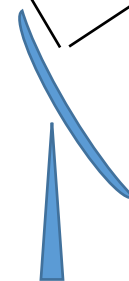
24 bit aircraft address = 34ABCE
Non-SI capable transponder,
locked out to II=7 by another
radar



CL = 000, IC=0111,
Its II = 7

All call
interrogation
SI=23

No reply



Radar with SI=23 (radar supports
II/SI code operations)

Conclusion

- These slides are meant for simple explanation of II/SI code operations.
- For mode details, please refer to Doc 9924 Appendix H and J.