FLEET MONITORING

BDS SWAP problem

EUROCAE WG49
28-30 June 2010

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BDS SWAP Problem

Reported by USAF – MITRE – FAA – BELGOCONTROL and LVNL

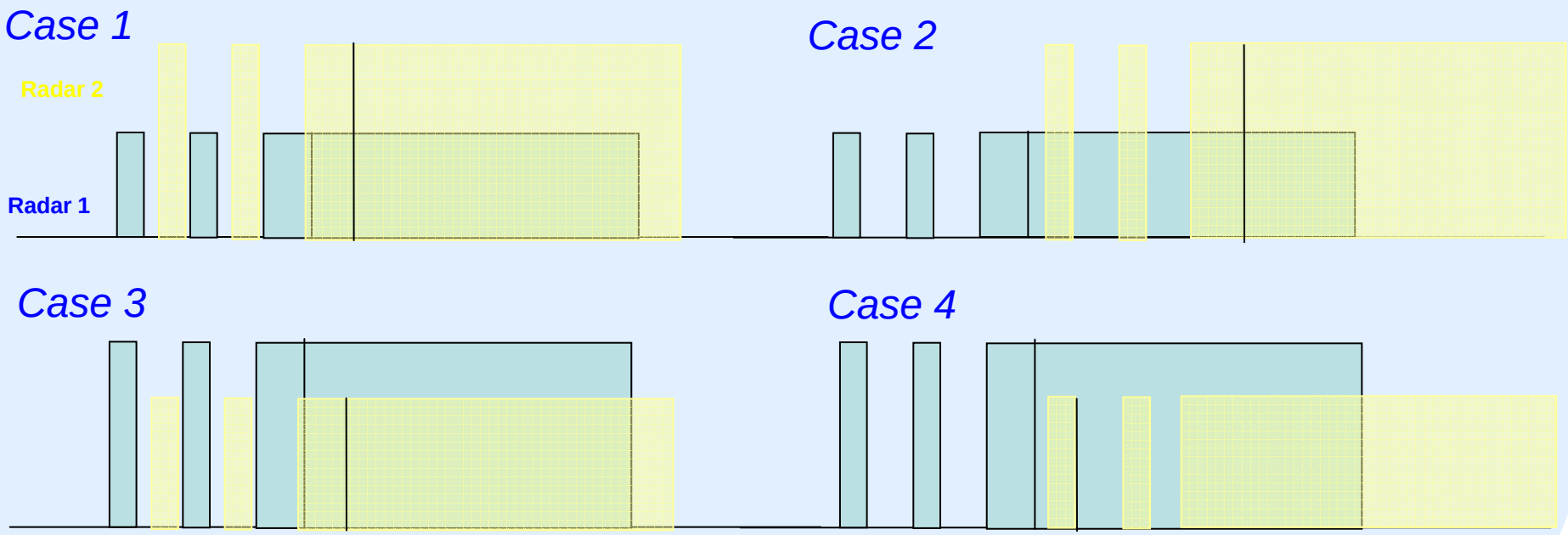
This problem was particularly interesting because three different problems were mixed, and for two generating the same effect : **BDS swap**

-**A design problem**
-**A transponder problem**
-**A Radar problem**

BDS SWAP Problem

Theoretical analysis

Simultaneous Interrogations at the level of the transponder



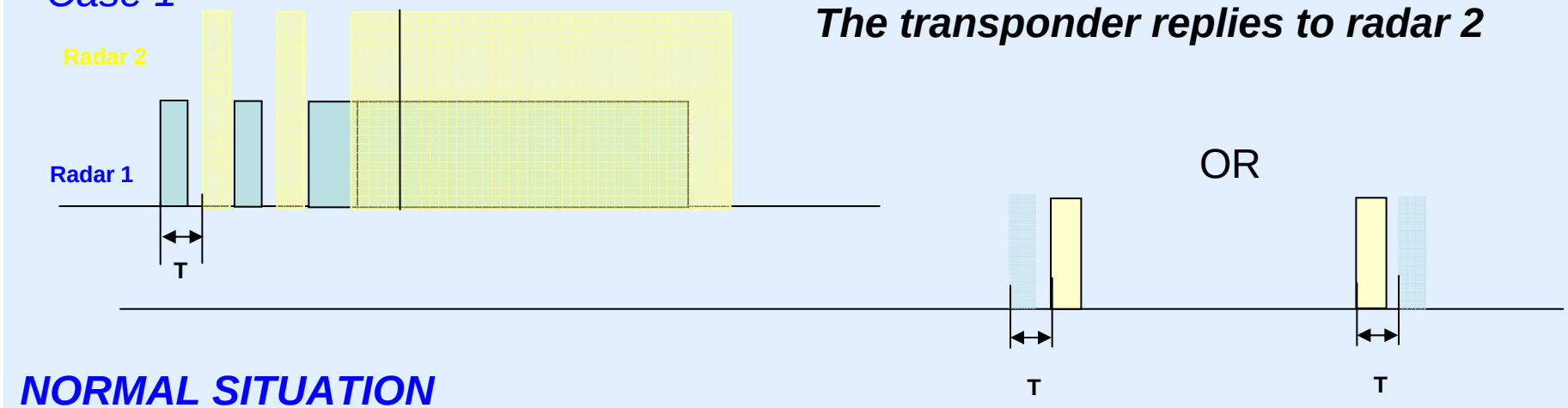
Case 1 power radar 2>Power radar 1 & Int Radar 2 arrives before the SPH >>>> Transponder replies to radar 2
Case 2 power radar 2>Power radar 1 & Int Radar 2 arrives after the SPH >>>> Garbling situation no reply >>>>> Normal
Case 3 power radar 2<Power radar 1 & Int Radar 2 arrives before the SPH >>>> Transponder replies to radar 1 >>>>> Normal
Case 4 power radar 2<Power radar 1 & Int Radar 2 arrives after the SPH >>>> Transponder could reply to radar 1

The swap BDS can arrive with case 1

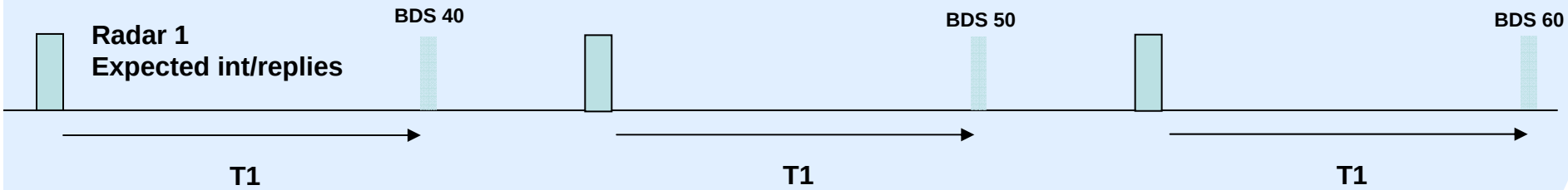
Theoretical analysis

Case 1

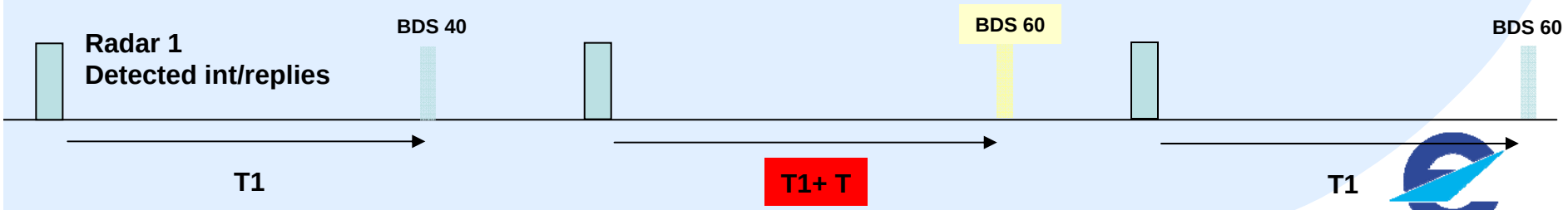
The transponder replies to radar 2



NORMAL SITUATION



BDS SWAP Situation



-10µs< T < + 4.75µs

Theoretical analysis

CONCLUSIONS

- If the radar 1 required a BDS 50 and the radar 2 a BDS 60 the transponder accept the interrogation of radar 2 and reply a BDS 60.
  The radar takes this reply and considers the reply as a BDS 50 but on AXTERIX line we obtain BDS 40 -60 -60 or all other positions.

- This problem could occur with all BDS 10-17- and other.

- If this problem exists really we should measure the time difference on successive replies. This time difference should between **-10µs< T < + 4.75µs**

However three considerations should take into account :

Theoretical analysis

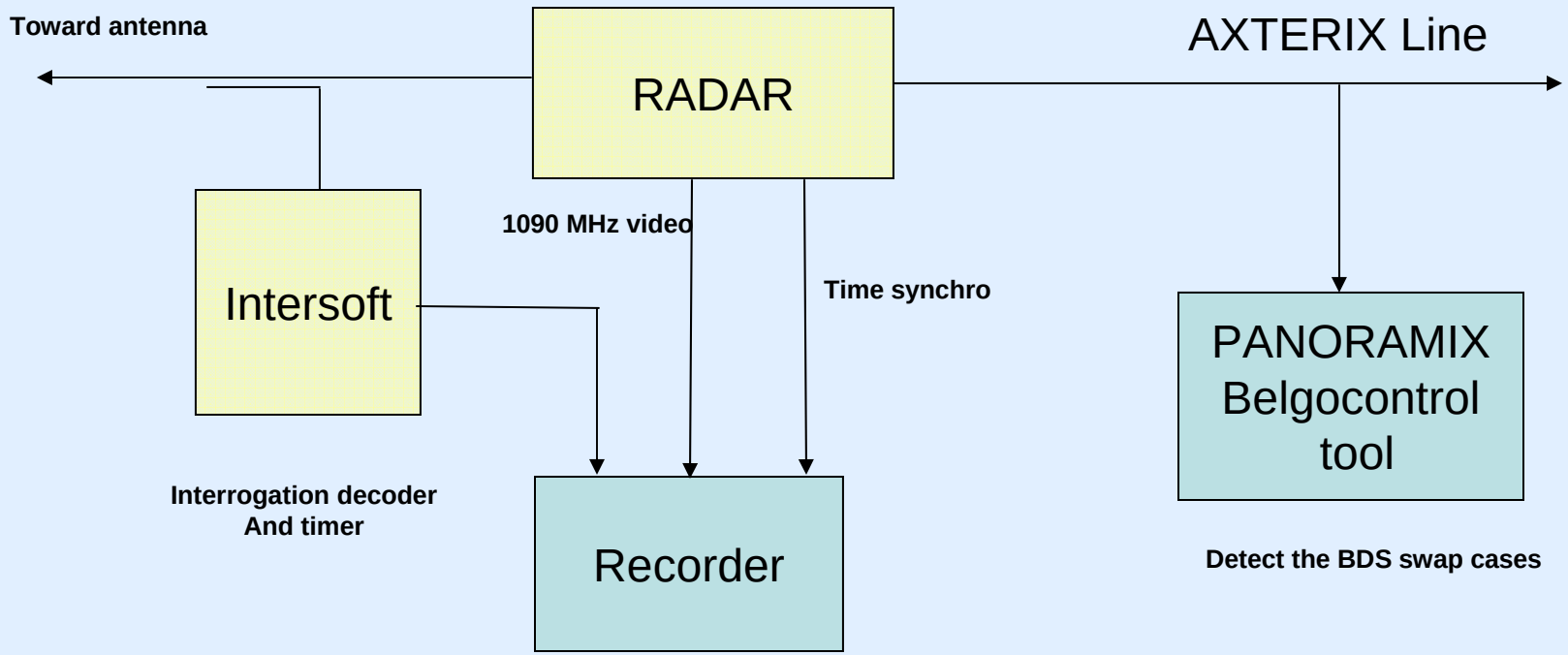
- In Europe this situation was understandable because we have several Mode S radar making the BDS extraction. So a FRUIT situation was possible.
- In US, they have only one radar extracting the BDS and this case was not in line with our theoretical approach.
- In Europe many cases at Schiphol and Bertem reported the problem with KC135 aircraft.

Only a measurement campaign could clarify the situation

It was our objective when we started the measurement with BELGOCONTROL on the Bertem Radar.

BERTEM Measurements

Measurement chain at BERTEM Mode S radar



BERTEM Measurements

In two days 14 different cases were detected and recorded;

EVENTS	ACID	Address	Type	Date	Hour	intersoft
1	DLH	3C4E47		17-Feb	13:13:40	N
2	AEA	3412CA		17-Feb	16:42:13	N
3	RCH	AE04C6	**KC135**	17-Feb	20:41:55	N
4	RCH	AE04C6	**KC135**	17-Feb	20:51:12	N
5	QID	AE064E	**KC135**	18-Feb	13:25:59	Y
6	QID	AE064E	**KC135**	18-Feb	13:32:31	Y
7	QID	AE064E	**KC135**	18-Feb	13:36:52	Y
8	QID	AE064E	**KC135**	18-Feb	13:38:26	Y
9	QID	AE064E	**KC135**	18-Feb	13:40:01	Y
10	QID	AE064E	**KC135**	18-Feb	13:50:06	Y
11	BEE	405C0F		18-Feb	15:37:41	Y
12	BAW	4007F6		18-Feb	15:48:58	Y
13	TYW	440CC2		18-Feb	17:46:01	Y
14	HLX	3C60C9		18-Feb	23:19:02	Y

The objective was to research in all these cases the time difference if exists

BERTEM Measurements

Research of the time difference

(Analyse Panoramix)

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	time	ModeS	ACID	modeA	modeC	BDS40	BDS50	BDS60	
case 1)	15:37:30.02	405C0F	BEE7266	A2517	24000	AEE00000000000	FFBC6D278004AA	E1E9E523FFEFFF	
case 2)	15:37:41.86	405C0F	BEE7266	A2517	24000	**FF9C6F278004AB**	**FF9C6F278004AB**	E1E9E724200C01	BDS40 = BDS50
case 3)	15:37:53.70	405C0F	BEE7266	A2517	24000	AEE00000000000	FFBC6F274004AA	E1E9E323FFC401	

(Analyse RMR)

The swap problem is detected with the case 2

(case 1) sequence ,,

= Intersoft interrogations recording =

a) ti= 15:37:29.856 792 UF=4:PC=0:RR=22(BDSx60)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F

b) ti= 15:37:29.870 215 UF=5:PC=0:RR=21(BDSx50)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F

c) ti= 15:37:29.870 614 UF=5:PC=0:RR=20(BDSx40)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F

d) ti= 15:37:29.883 646 UF=5:PC=0:RR=0:DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F

= RMR replies Recording ==

a) T=39.2233 DTIR= 1230.051 µs DF BDS60

b) T=39.2367 DTIR= 1229.990 µs DF BDS50

c) T=39.2371 DTIR= 1229.975 µs DF BDS40

d) T= DTIR= µs DF BDS

conclusion : OK

In this case the relative delta T is always < 100 ns

BERTEM Measurements

Research of the time difference

(case 2) sequence 60,50,

= Intersoft interrogations recording =

```
 a) ti= 15:37:41.698 898                UF=4:PC=0:RR=22(BDSx60 )::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F
 b) ti= 15:37:41.712 190 DT= 13292      UF=5:PC=0:RR=21(BDSx50 )::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F
 c) ti= 15:37:41.712 590 DT=   400      UF=5:PC=0:RR=20(BDSx40 )::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F
 d) ti= 15:37:41.725 600 DT= 13010      UF=5:PC=0:RR=0:DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=405C0F
```

= RMR replies Recording ==

```
 a) T=51.0457 AEE00000000        DTIR=  N/A              DF20  BDS?                 No interrogation
 b) T=51.0653 E1E9E724200C01     DTIR=  1242.5   µs      DF20  BDS60               OK reply to interrogation a)
 c) T=51.0786 FF9C6F278004AB     DTIR=  1242.550 µs      DF21  BDS50   (-36Dbm)    OK reply to interrogation b)
 d) T=51.0790 FF9C6F278004AB     DTIR=  1244.200 µs      DF20  BDS50 (-52 Dbm)     critical case reply to interrogation c)
```

Delta T = 50 ns

Delta T = 1.7µs

Interrogation C requires reply with DF =21 (UF=5)
And we receive DF=20

BERTEM Measurements

Research of the time difference

The cases analysis shows two behaviours

Civilian aircraft

ACID	Address	Date	Hour	DT i-r
DLH	3C4E47	17-Feb	13:13:40	-4,17 µs
AEA	3412CA	17-Feb	16:42:13	-5 µs
BEE	405C0F	18-Feb	15:37:41	+1,7µs
BAW	4007F6	18-Feb	15:48:58	-2,5µs
TYW	440CC2	18-Feb	17:46:01	-2µs
HLX	3C60C9	18-Feb	23:19:02	-1,8µs

Military aircraft KC135

EVENTS	ACID	Address	Type	Date	Hour	DT i-r	DF20
3	RCH	AE04C6	KC135	17-Feb	20:41:55	0	OK
4	RCH	AE04C6	KC135	17-Feb	20:51:12	0	OK
5	QID	AE064E	KC135	18-Feb	13:25:59	0	OK
6	QID	AE064E	KC135	18-Feb	13:32:31	0	OK
7	QID	AE064E	KC135	18-Feb	13:36:52	0	OK
8	QID	AE064E	KC135	18-Feb	13:38:26	0	OK
9	QID	AE064E	KC135	18-Feb	13:40:01	0	OK
10	QID	AE064E	KC135	18-Feb	13:50:06	0	OK

First conclusions

- We proved the existing of time difference and proven that the BDS swap was due to FRUIT
- The KC135 problem was different and suggested a transponder problem
- The radar accepted DF=20 when a DF21 was expected

BERTEM Measurements

KC135 Interrogation/replies sequence

RAYTHEON TRANSPONDER KC135 aircraft

(Analyse Panoramix)
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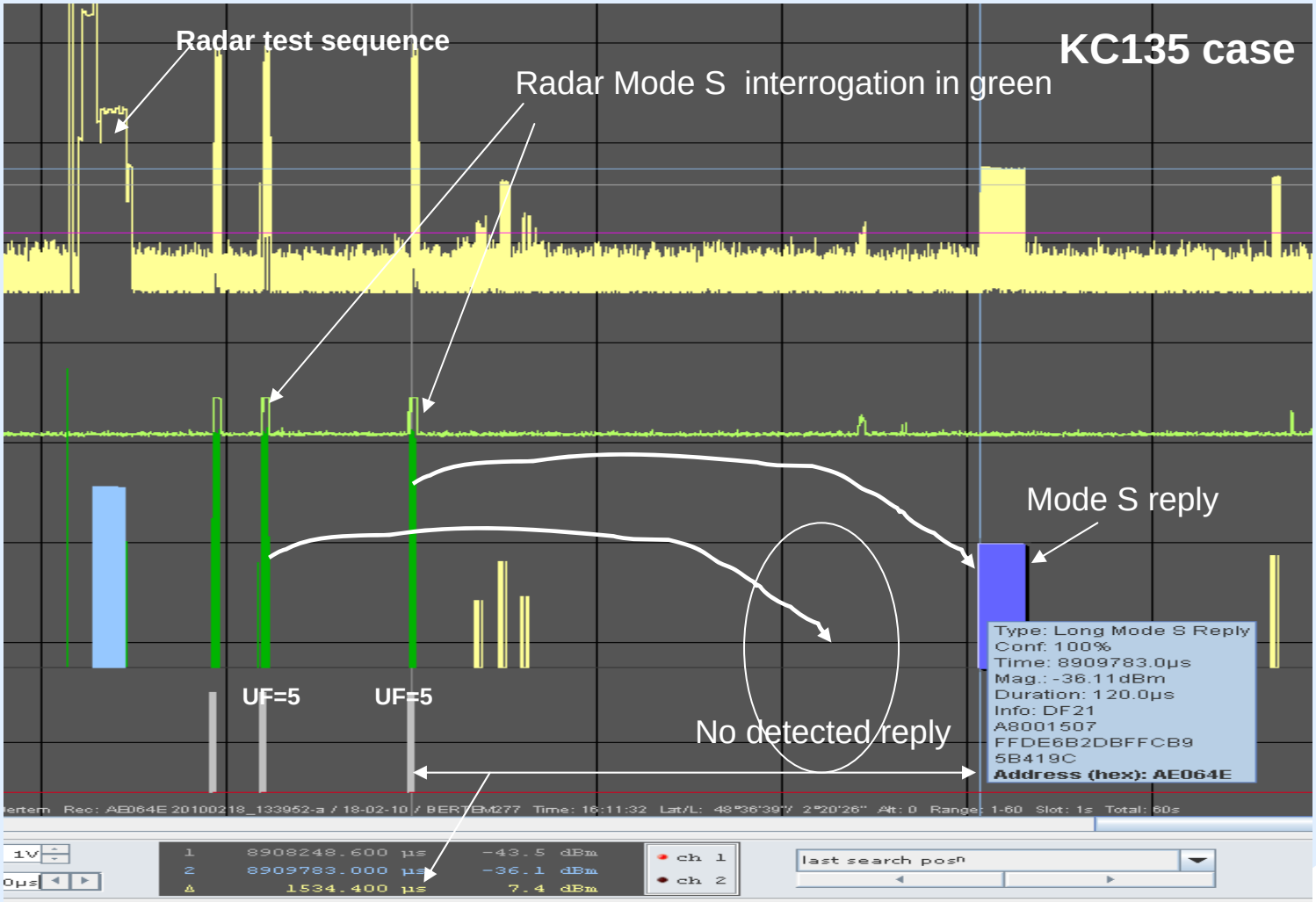
	time	ModeS	ACID	modeA	modeC	BDS40	BDS50	BDS60	
case 1)	13:38:15.12	AE064E	QID96	A0476	27000	B4C5A630AC0107	FF7E6B323FFCCB	F05A292AA007FF	
case 2)	13:38:26.98	AE064E	QID96	A0476	27000	**FF7E6B327FFCCC**	**FF7E6B327FFCCC**	F07A2B2AE02402	BDS40 = BDS50
case 3)	13:38:38.85	AE064E	QID96	A0476	26900	A90D4870AC0107	FF3E6D31FFF4CA	F08A272A7EEFDE	

(case 2) sequence ,,

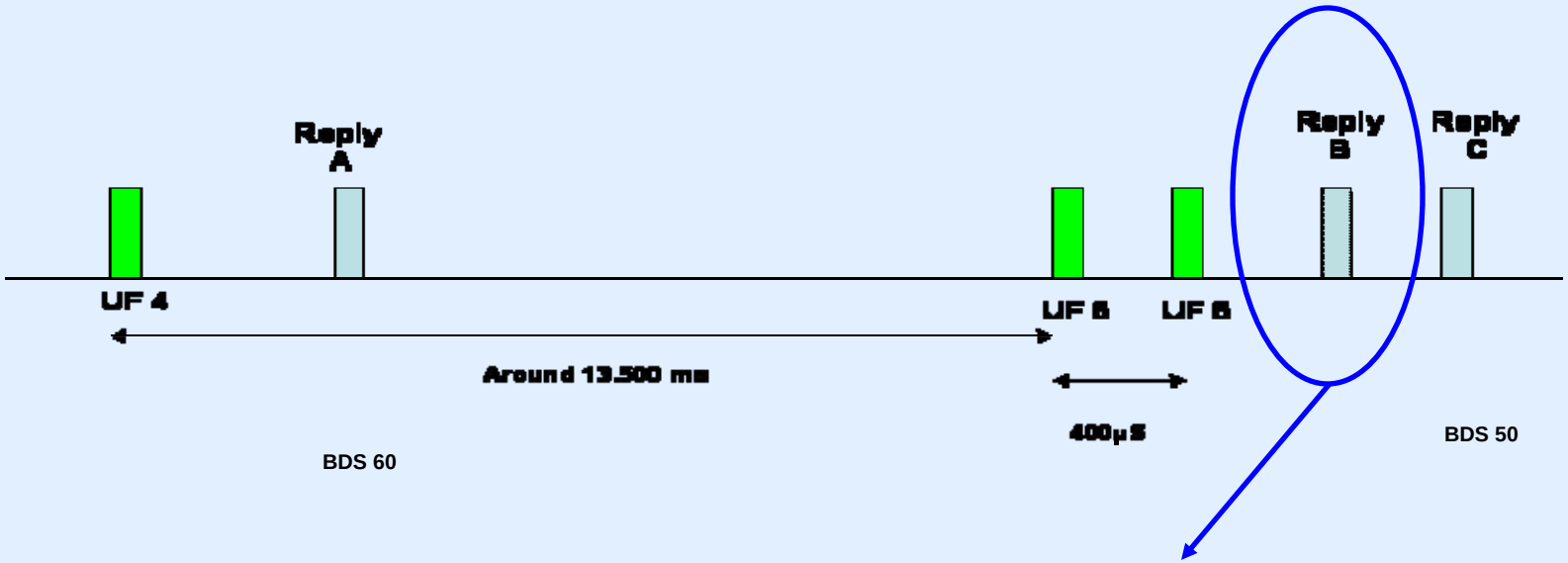
= Intersoft interrogations recording =
a) ti= 13:38:26.799 967 DT= N/A UF=4:PC=0:RR=22(BDSx60)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=AE064E
b) ti= 13:38:26.813 380 DT= 13413 UF=5:PC=0:RR=21(BDSx50)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=AE064E
c) ti= 13:38:26.813 780 DT= 400 UF=5:PC=0:RR=20(BDSx40)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=AE064E
d) ti= 13:38:26.826 781 DT= 13001 UF=5:PC=0:RR=21(BDSx50)::DI=1:IIS=8:MBS=0:MES=0:LOS=1:RSS=0:TMS=0:AA=AE064E
= RMR replies Recording ==
a) T=34.0406 F07A2B2AE02402 DTIR= 1484.1 µs DF20 BDS60 **OK**
b) **No reply with DF=21**
c) T=34.0544 FF7E6B327FFCCC DTIR= 1484.1 µs DF21 BDS50 **The transponder reply with the value of the previous reply (BDS 50 in place of 40)**
d) T=34.0674 FF7E6B327FFCCC DTIR= 1484.1 µs DF21 BDS50 **The radar repeat the request for a BDS 50 don't receive in 2**

No time difference

BERTEM Measurements



BERTEM Measurements



With the KC135 we don't receive time to time the reply B and in this case the reply C has the message of the reply B.

As the reply B is missing the radar will generate at the next sequence a new UF 5 interrogation requesting the BDS 50

The sequence will be always BDS60 – BDS50 – BDS 50 with BERTEM radar

The question is why the reply B is missing ? The analysis proved that the interrogation was correct and only an internal transponder process could explain this behaviour.

BERTEM Measurements

RAYTHEON confirmed the problem immediately and explained that the missing reply was the fact of the software transmission limiter. An index was not correctly reported and explains why the next reply was with the value of the previous. A fix is ready.

Related to the radar problem, which apparently don't check the DF value of the received reply , THALES has been informed.

We have to underline that in all cases having this problem the DF analysis and the rejection of the bad DF will be sufficient to solve the problem.

CONCLUSIONS

- -Transponder problem is solved and an adapted retrofit process have to put in place
- -Radar problem is identified but not yet confirmed by Thales
- -System problem due to the FRUIT seams minor if the DF analysis is done correctly but we propose an other measurement campaign with an other type of radar to confirm.

END of the PRESENTATION