

Atlantic City, NJ USA | 17-19 October 2017

Undetectable by collision avoidance systems

..... Undetectable by the flight crew

Atlantic City (ACY) Aircraft Geometric Height Measurement Element (AGHME) Findings



Federal Aviation Administration ..... Undetectable by air traffic control

# Aircraft Geometric Height Measurement Element (AGHME)







### **Arbitrary Waveform Generator (ARB)**

- This device allows for a repeatable Mode S message to be presented to the front-end of the AGHME element
  - + Allowed for accurate observations of 1090 MHz receiver response
  - + Time coherent between system clock and trigger from the GPS receiver
  - Allowed analysis code to be developed
  - Presents same consistent stimuli to all the AGHME elements
- Programmable Attenuator allowed dynamic response curves of 1090 MHz receiver to be developed





### New 1090 MHz Receiver Built In-house

- Father of RVSM, Brian C. said and I quote:
  "An AGHME is an AGHME when all things are identical"
- The old receivers were in almost every aspect not identical
  - No longer available (primary problem)
  - Log receiver with 3 amplitude dependent bandpass filters
  - Made determining the propagation delay of the receiver impossible to determine
  - All aspects of pulse shape (rising edge, falling edge, pulse width, etc.) adjustable via tuning coils
  - Receivers designed to decode Mode S and Mode A/C data packets
  - They were not designed for timing message receipt time
  - Lower bandwidth to reduce the noise figure of the receiver





### New 1090 MHz Receiver Built In-house

- New receiver built for message receipt time functionality
  - + Higher Bandwidth
    - Much faster rising edge where measurement is made
  - Most components and sub-systems factory produced
    - Uniformity between units much higher
  - No adjustability of pulse parameters (no tuning coils)
  - Negative aspect of receiver is higher noise figure
    - At low amplitudes, pulses fracture, making decoding more challenging





## Hardware half the challenge, DSP software is equally important

- Salient features of code
  - Analyze ½ Gigabyte of data within 2 to 4 seconds
  - Reliably recognize preamble pulse set of Mode S message
  - Reliably decode Mode S message packet





#### **Mode S Format**



### **Present Technique**

- Low Pass Filter determines energy is up for at least 64 usecs
- The front of the energy envelope is examined to see if the 1st four pulses have the appropriate time signature
- If true, a receipt time is obtained by traveling down 27 digitizer counts on the leading edge of first preamble pulse





## **Present Technique**

- Weaknesses in present algorithm
  - Pulses are orphans from birth
    - Analysis has shown that any pulse can be as much as 40 to 50 system clocks off
    - Determination of Pulse amplitude is weak
    - This receipt time is used to register the chip start times
    - Each chip is examined to determine if the pulse energy is in the 1st or 2nd part of the chip
      - + If the chip start times are skewed, this analysis technique is compromised
      - + Also, at low amplitudes the pulse tops become irregular shapes





## **New Paradigm**

- Data is treated as a stream of pulses
  - Each pulse is analyzed for specific salient features
  - Timing relationships are determined for pulselets
    - If the time relationship of four pulses define a Mode S preamble, the next 56 or 112 bits are handled as a Mode S data packet
- Analysis has shown that the average of the receipt times of the 40 or so pulses that comprise a Mode S signature form a normal distribution around the actual message time
  - Decoding is more reliable because decisions are based on the most stable part of the pulse, the leading edge
  - More pulse slop is tolerated because the closest two rising edges can be is 500 system clocks





## **New Paradigm**

- Rule sets exist that help aide in the decoding process
  - Pulses have to be either 250 or 500 system clocks
  - ½ usec pulse is a one or a zero
    - Multiples of 500 must be a 1 bit
    - Multiples of 250 have to be a 0 bit
  - 1 usec pulse must be a 0 1 combination
- All of these decisions are based on a much coarser ruler, thus allowing for more variance in pulse position





## **New Paradigm**

- Other advantages of new philosophy
  - Present decoding is about 50% rate
    - My prediction is it will go to about 80% with new technique
      - Coarser ruler
      - + Judging is done on most stable part of the pulse
  - Treated as a pulse stream, Mode A & Mode C can be accommodated for decoding
  - + Receipt time accuracy should be much better and more consistent
    - More 5 tuplets will be generated?







le	Edit View	Bookmarks	Settings Help	6				
	Pulse	P Start	Real PW	Pulse Amp	Rx	Norm Rx	Rel IPT	Tot IPT
		2			4		1	
	1	433230	250	200	433238	390236		Θ
	2	433730	250	201	433736	433236	500	500
	З	434980	250	192	434988	433238	1250	1750
	4	435480	250	193	435490	433240	500	2250
	5	437450	500	203	437488	433238	2000	4250
	6	438480	500	199	438491	433241	1000	5250
	7	439220	250	194	439239	433239	750	6000
	8	439970	250	198	439986	433236	750	6750
	9	440460	250	180	440486	433236	500	7250
	10	440950	500	207	440991	433241	500	7750
	11	441970	500	207	441990	433240	1000	8750
	12	442970	250	201	442989	433239	1000	9750
	13	443480	500	210	443488	433238	500	10250
	14	444470	250	193	444489	433239	1000	11250
	15	444970	500	207	444989	433239	500	11750
	16	445970	500	205	445990	433240	1000	12750
	17	446970	500	209	446988	433238	1000	13750
	18	447970	500	207	447990	433240	1000	14750
	19	448980	250	198	448988	433238	1000	15750
	20	449480	500	211	449491	433241	500	16250
	21	450470	250	178	450486	433236	1000	17250
	22	450970	250	199	450986	433236	500	17750
	23	451480	500	204	451489	433239	500	18250
	24	452220	250	198	452237	433237	750	19000
	25	452720	500	188	452738	433238	500	19500
	26	453470	250	197	453488	433238	750	20250
	27	453960	500	206	453989	433239	500	20750
	28	454960	500	201	454987	433237	1000	21750
	29	455720	250	193	455738	433238	750	22500
	30	456230	250	200	456236	433236	500	23000
	31	456680	500	187	456736	433236	500	23500
	32	457230	250	201	457241	433241	500	24000
	33	457960	500	203	457987	433237	750	24750
	34	458720	250	193	458738	433238	750	25500
	35	459470	500	204	459490	433240	750	26250
	36	460230	250	200	460237	433237	750	27000
	37	460940	500	204	460992	433242	750	27750
	38	461670	250	189	461735	433235	750	28500
	39	462230	250	198	462239	433239	500	29000
	40	462970	250	198	462986	433236	750	29750
	41	463470	500	208	463488	433238	500	30250
	42	464470	250	199	464485	433235	1000	31250
	43	464950	250	192	464985	433235	500	31750

Run - Konsole

433235 | 3 433236 | 8 433237

433238

433239 433240 433241 4 433242 1

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							di	) =	3	
Mode	S	Message:	58	a4	aa	47	2f	b6	e4	

Mode S Message: 58 a4 aa 47 2f b6 e4

ModeS: P43: ThisRx = 464985 LastRx = 464485 ThisPW = 250 IPTval = 500

The French Weighted Average for this Mode S message is 433238







San war			40.					Ru
Pulse I	P Start	Settings Hei Real PW I	Pulse Amo	I Ry I	Norm Bx 1	Rel IPT	1 Tot IPT	
indese (	-Theore I	1000-100	r a coc ranp	1 194 1	norm_ros 1	the states	1 100_111	
1	421480	250	159	433236	433236		0	
2	433720	250	156	433737	433237	500	500	
Э	434970	250	157	434997	433247	1250	1750	
4	435470	250	162	435487	433237	500	2250	
5	437460	500	166	437488	433238	2000	4250	
6	438460	500	163	438493	433243	1000	5250	
7	439210	250	163	439235	433235	750	6000	
8	439960	250	163	439983	433233	750	6750	
9	440480	250	163	440483	433233	500	7250	
10	440980	500	169	440988	433238	500	7750	
11	441980	500	173	441983	433233	1000	8750	
12	442970	250	160	442982	433232	1000	9750	
13	443470	500	165	443486	433236	500	10250	
14	444470	250	160	444484	433234	1000	11250	
15	444950	500	170	444989	433239	500	11750	
16	445980	500	171	445987	433237	1000	12750	
17	446980	500	172	446988	433238	1000	13750	
18	447870	500	162	447987	433237	1000	14750	
19	448970	250	162	448982	433232	1000	15750	
20	449480	500	178	449486	433236	500	16250	
21	450480	250	158	450484	433234	1000	17250	
22	450980	250	169	450987	433237	500	17750	
23	451470	500	169	451492	433242	500	18250	
24	452150	500	156	452236	433236	750	19000	
25	452720	250	166	452732	433232	500	19500	
26	453460	250	155	453484	433234	750	20250	
27	453900	500	172	453990	433240	500	20750	
28	454970	500	168	454986	433236	1000	21750	
29	455720	250	161	455736	433236	750	22500	
30	456230	250	172	456238	433238	500	23000	
31	456720	250	169	456733	433233	500	23500	
32	457220	250	159	457232	433232	500	24000	
33	457970	500	171	457988	433238	750	24750	
34	458710	250	158	458737	433237	750	25500	
35	459480	500	171	459494	433244	750	26250	
36	460220	250	155	460237	433237	750	27000	
37	460980	500	172	460984	433234	750	27750	
38	461670	250	155	461732	433232	750	28500	
39	462220	250	164	462239	433239	500	29000	
40	462970	250	155	462982	433232	750	29750	
41	463480	500	174	463487	433237	500	30250	
42	464480	250	155	464488	433238	1000	31250	
43	464980	250	164	464989	433239	500	31750	

Run - Konsole

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Mode S Message:	58 a4 aa 47	db = 6 2f b6 e4
Mode & Message:	58 a4 aa 47	2f b6 e4 📕
433232   6 433233   4 433234   4		

ModeS: P43: ThisRx = 464989 LastRx = 464488 ThisPW = 250 IPTval = 501

The French Weighted Average for this Mode S message is 433235







									Run - Konsole	
File	Edit View	Bookmarks	Settings Hel	0						
1.04470	Pulse	P Start	Real PW	Pulse Amp	Rx	Norm Rx	Rel IPT	Tot IPT		db = 9
	a service a				1. 1. Mar. 1. M	and the second s	10.000	C. and <del>a</del> const	Mode	S Message: 58 a4 aa 47 2f b6 e4
	1	461710	250	126	476229	476229		Θ		
	2	476730	250	123	476745	476245	500	500		
	З	477980	250	126	477979	476229	1250	1750		
	4	478480	250	136	478491	476241	500	2250	Mode	S Message: 58 a4 aa 47 21 b6 e4
	5	480480	500	134	480483	476233	2000	4250		
	6	481480	500	137	481506	476256	1000	5250		
	7	482230	250	131	482235	476235	750	6000		
	8	482980	250	124	482989	476239	750	6750	476141	1
	9	483480	250	137	483495	476245	500	7250	476227	1
	10	483980	500	133	483989	476239	500	7750	476229	2
	11	484980	500	135	484986	476236	1000	8750	476230	1
	12	485980	250	125	485991	476241	1000	9750	476232	1
	13	486480	500	138	486487	476237	500	10250	476233	3
	14	487480	250	139	487489	476239	1000	11250	476234 j	1
	15	487980	500	137	488002	476252	500	11750	476235 j	4
	16	488970	500	135	488995	476245	1000	12750	476236	3
	17	489980	500	135	489995	476245	1000	13750	476237	3
	18	490960	500	132	490991	476241	1000	14750	476238	4
	19	491960	250	130	491986	476236	1000	15750	476239	5
	20	492480	500	132	492489	476239	500	16250	476240	1
	21	493460	250	125	493496	476246	1000	17250	476241	3
	22	493980	250	127	493993	476243	500	17750	476243	1
	23	494480	500	135	494480	476230	500	18250	476245	4
	24	495230	250	126	495237	476237	750	19000	476246	1
	25	495730	250	133	495739	476239	500	19500	476247	1
	26	496470	250	127	496477	476227	750	20250	476252	1
	27	496980	500	138	496985	476235	500	20750	476256	2
	28	497980	500	138	497990	476240	1000	21750		
	29	498730	250	123	498738	476238	750	22500		
	30	499240	250	134	499238	476238	500	23000		
	31	499730	250	131	499733	476233	500	23500		
	32	500230	250	124	500238	476238	500	24000		
	33	500980	500	126	500988	476238	750	24750		
	34	501730	250	140	501735	476235	750	25500		
	35	502390	500	130	502391	476141	750	26250		
	36	503230	250	136	503237	476237	750	27000		
	37	503980	500	134	503997	476247	750	27750		
	38	504730	250	127	504734	476234	750	28500		
	39	505230	250	129	505233	476233	500	29000		
	40	505950	250	133	505985	476235	750	29750		
	41	506480	500	135	506506	476256	500	30250		
	42	507480	250	128	507486	476236	1000	31250		
	43	507980	250	128	507982	476232	500	31750		

ModeS: P43: ThisRx = 507982 LastRx = 507486 ThisPW = 250 IPTval = 496

The French Weighted Average for this Mode S message is 476238





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File	and the second sec	a second s	The second se							
	Pulse I	Bookmarks P Start L	Settings Help Real PW I	Pulse Amo	I By I	Norm Bx 1	Rel IPT	Tot IPT		db =
	indexe 1	attended 1	near_in 1	racial raip	1 100 1	identifi_res 1	ine start in the	i ioc_xi i	Mode	S Message: 18 a4 aa 87 Of be
	1	3230	250	91	3241	Θ		Θ		
	2	3750	250	93	3749	3249	500	500		
	З	4930	250	91	4934	3184	1250	1750		
	4	5450	250	91	5447	3197	500	2250	Mode	S Message: 58 a4 aa 47 21 b6
	5	7480	Θ	95	7487	3237	2000	4250		
	6	8480	500	95	8475	3225	1000	5250		
	7	9240	250	97	9253	3253	750	6000		
	8	9990	250	103	9991	3241	750	6750	3184	2
	9	10480	250	98	10495	3245	500	7250	3194	1
	10	10990	500	101	10995	3245	500	//50	3197	1
	11	12000	500	103	11998	3248	1000	8750	3204	1
	12	12980	250	93	12995	3245	1000	9750	3216	1
	13	13480	500	99	13487	3237	500	10250	3221	1
	14	14490	250	92	14511	3261	1000	11250	3223	1
	15	14990	500	100	15017	3267	500	11/50	3225	1
	10	15990	500	97	15991	3241	1000	12750	3233	2
	17	17000	500	100	17007	3257	1000	13/50	3234	1
	18	17990	500	97	17994	3244	1000	14/50	3237	4
	19	18980	500	87	18983	3233	1000	15750	3238	3
	20	19490	0	95	19492	3242	500	10250	3239	4
	21	20470	250	88	20473	3223	1000	17250	3241	3
	22	20970	250	90	20984	3234	500	17750	3242	1
	23	21490	500	90	21493	3243	500	18250	3243	2
	24	22230	250	60	22233	3233	750	19000	3244	2
	25	22/30	250	90	22/3/	3237	500	19500	3245	3
	20	23440	200	101	23444	3194	750	20250	3240	1
	27	23980	500	98	23989	3239	500	20750	3248	1
	28	24990	500	95	24988	3238	1000	21/50	3249	1
	29	25710	250	91	25704	3204	/50	22500	3253	2
	20	20200	200	90	20244	3244	500	23000	3234	1
	51	20/00	200	82	20/04	3204	200	23000	3207	1
	32	27220	200	100	27210	3210	200	24000	3201	1
	33	2/960	500	101	2/995	3240	750	24/00	3207	1
	24	20750	200	92	20/33	2222	750	20000		
	22	29490	250	101	29407	2227	750	20200		
	30	30240	250	90	30239	3239	720	27000		
	37	30940	250	00	30909	2238	750	27750		
	20	20040	250	97	31/30	2230	500	20000		
	29	22000	250	09	22000	2239	750	29000		
	40	22990	250	97	22471	2230	500	29750		
	41	33470	250	94	334/1	3221	1000	30250		
	42	34430	250	97	34434	2042	500	31250		
	43	33000	250	0.5	34993	5243	500	51750		

ModeS: P43: ThisRx = 34993 LastRx = 34434 ThisPW = 250 IPTval = 559

The French Weighted Average for this Mode S message is 3239





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								Run - Konsole					
Edit View	Bookmarks D Start	Settings Hel	p Dulco Amp	I Dy I	Norm Dy 1	Dol IDT	I Tot IPT					db -	14
Furse 1	C_brain 1	ned i_rw	I ruise hilp	1 00 1	Norm_rox 1	net_tra	1 TOLLIN	Mode	S Message:	5a a4 (	a2 47 1	2f b2	24
1	3240	250	90	3235	Θ		Θ		C Northeast				
2	3740	250	82	3745	3245	500	500						
з	5000	250	89	4999	3249	1250	1750						
4	5500	250	82	5494	3244	500	2250	Mode	S Messade:	58 a4	aa 47 1	2f b6	64
5	7480	500	87	7484	3234	2000	4250		100				
6	8500	500	86	8499	3249	1000	5250						
7	0220	250	83	0222	3000	750	6000						
8	0880	500	70	0881	3131	750	6750	3131	1				
0	10400	250	00	10401	22/1	500	7250	2102	1				
10	10490	200	0.0	10491	2241	500	7250	2204	1				
10	10980	500	04	10980	3230	1000	7750	3204	1				
11	11980	500	03	11962	3232	1000	8750	3217	4				
12	12950	250	86	12954	3204	1000	9750	3222	1				
13	13440	500	87	13442	3192	500	10250	3225	1				
14	14470	250	76	14467	3217	1000	11250	3230	1				
15	14990	500	82	14988	3238	500	11750	3232	2				
16	16010	500	85	16013	3263	1000	12750	3234	2				
17	16990	Θ	81	16984	3234	1000	13750	3235	2				
18	17990	500	92	17993	3243	1000	14750	3236	1				
19	18990	250	84	18988	3238	1000	15750	3237	3				
20	19480	500	87	19480	3230	500	16250	3238	3				
21	20470	250	80	20467	3217	1000	17250	3239	3				
22	20990	250	94	20995	3245	500	17750	3241	2				
23	21500	500	89	21496	3246	500	18250	3242	2				
24	22250	250	85	22254	3254	750	19000	3243	2				
25	22740	250	80	22742	3247	500	10500	3240	1				
20	22/40	250	72	22/92	2220	750	20250	3245	Â				
20	23490	500	02	23405	2027	500	20250	2245	1				
20	23900	500	92	23907	2237	1000	20750	2240	1				
20	24990	500	07	24992	3242	1000	21/00	3240	1				
29	25750	250	94	23743	3245	/50	22500	3249	2				
30	20230	250	/8	20225	3225	500	23000	3254	1				
31	26740	250	/8	26/3/	3237	500	23500	3258	1				
32	27240	250	/9	2/23/	3237	500	24000	3261	1				
33	27990	500	87	27995	3245	750	24750	3263	1				
34	28740	250	76	28738	3238	750	25500						
35	29500	Θ	84	29511	3261	750	26250						
36	30230	250	83	30248	3248	750	27000						
37	30990	500	91	30985	3235	750	27750						
38	31730	250	79	31732	3232	750	28500						
39	32260	250	95	32258	3258	500	29000						
40	32990	250	85	32993	3243	750	29750						
41	33499	500	83	33489	3239	500	30250						
42	34490	250	83	34491	3241	1000	31250						
17	34080	250	00	34080	3730	500	31750						
45	34900	200	90	24909	2239	200	21/20						

ModeS: P43: ThisRx = 34989 LastRx = 34491 ThisPW = 250 IPTval = 498

The French Weighted Average for this Mode S message is 3240





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									Run - Konsole						
File	Edit View	Bookmarks	Settings Hel	р											
100460	Pulse	P Start	Real PW	Pulse Amp	Rx	Norm Rx	Rel IPT	Tot IPT						db	= 15
	NS.0000073	Addition of	Concernance of the	a new course	A second A	and the second second second	100 0 <del>10</del> 0 000	1	Mode	S Message:	58 a	4 ea	47	27 t	06 e0
	1	4678420	250	66	4690237	4690237		0		1.2					
	2	4690730	250	54	4690726	4690226	500	500							
	З	4691980	250	68	4691981	4690231	1250	1750							
	4	4692470	250	67	4692472	4690222	500	2250	Mode	S Message:	58 a	4 aa	47	21 6	6 e4
	5	4694460	500	67	4694461	4690211	2000	4250							
	6	4695510	500	67	4695506	4690256	1000	5250							
	7	4696250	250	76	4696251	4690251	750	6000							
	8	4696990	250	55	4696985	4690235	750	6750	4690147	11					
	9	4697480	250	68	4697479	4690229	500	7250	4690188	11					
	10	4697900	500	70	4697897	4690147	500	7750	4690205	1 1					
	11	4699000	500	67	4698995	4690245	1000	8750	4690211	j 1					
	12	4699970	250	69	4699962	4690212	1000	9750	4690212	11					
	13	4700480	500	68	4700482	4690232	500	10250	4690217	11					
	14	4701480	250	72	4701477	4690227	1000	11250	4690218	j 1					
	15	4701990	500	73	4701984	4690234	500	11750	4690219	j 1					
	16	4702980	500	69	4702975	4690225	1000	12750	4690222	2					
	17	4703990	500	67	4703988	4690238	1000	13750	4690225	11					
	18	4704960	500	69	4704955	4690205	1000	14750	4690226	j 1					
	19	4706020	250	69	4706019	4690269	1000	15750	4690227	j 1					
	20	4706480	500	73	4706483	4690233	500	16250	4690228	11					
	21	4707580	250	72	4707581	4690331	1000	17250	4690229	3					
	22	4707970	250	71	4707969	4690219	500	17750	4690231	11					
	23	4708480	500	66	4708472	4690222	500	18250	4690232	13					
	24	4709240	250	64	4709232	4690232	750	19000	4690233	11					
	25	4709770	250	64	4709765	4690265	500	19500	4690234	11					
	26	4710480	250	67	4710479	4690229	750	20250	4690235	11					
	27	4711000	500	65	4710992	4690242	500	20750	4690237	j 1					
	28	4712010	250	69	4712007	4690257	1000	21750	4690238	j 3					
	29	4712720	250	67	4712718	4690218	750	22500	4690242	j 2					
	30	4713240	250	66	4713238	4690238	500	23000	4690243	11					
	31	4713750	250	63	4713745	4690245	500	23500	4690245	3					
	32	4714240	250	67	4714238	4690238	500	24000	4690248	j 1					
	33	4714970	500	63	4714967	4690217	750	24750	4690249	j 1					
	34	4715730	250	68	4715728	4690228	750	25500	4690251	j 1					
	35	4716480	500	66	4716482	4690232	750	26250	4690256	11					
	36	4717260	250	74	4717262	4690262	750	27000	4690257	11					
	37	4717980	500	65	4717979	4690229	750	27750	4690262	11					
	38	4718740	250	74	4718742	4690242	750	28500	4690265	11					
	39	4719250	250	67	4719243	4690243	500	29000	4690269	11					
	40	4720000	250	59	4719999	4690249	750	29750	4690331	1					
	41	4720440	250	71	4720438	4690188	500	30250		22					
	42	4721500	250	70	4721495	4690245	1000	31250							
	43	4722000	250	63	4721998	4690248	500	31750							

ModeS: P43: ThisRx = 4721998 LastRx = 4721495 ThisPW = 250 IPTval = 503

The French Weighted Average for this Mode S message is 4690236







File	Edit View	Bookmarks	Settings Help					
	Pulse	P Start	Real PW	Pulse Amp	Rx	Norm Rx	Rel IPT	Tot IPT
			1.200		1 2 1			1 1 1
	46	38940	250	245	38920	7170	750	31750
	2	7690	250	245	7672	7172	500	500
	З	8940	250	245	8921	7171	1250	1750
	4	9440	250	245	9424	7174	500	2250
	5	11440	500	245	11419	7169	2000	4250
	6	12440	500	245	12421	7171	1000	5250
	7	13190	500	245	13170	7170	750	6000
	8	13940	250	245	13922	7172	750	6750
	9	14460	500	245	14423	7173	500	7250
	10	15190	250	245	15174	7174	750	8000
	11	15940	500	245	15919	7169	750	8750
	12	16940	250	245	16920	7170	1000	9750
	13	17440	500	245	17423	7173	500	10250
	14	18190	250	245	18172	7172	750	11000
	15	18710	250	245	18674	7174	500	11500
	16	19440	250	245	19420	7170	750	12250
	17	19940	500	245	19922	7172	500	12750
	18	20690	250	245	20671	7171	750	13500
	19	21440	250	245	21424	7174	750	14250
	20	21940	500	245	21922	7172	500	14750
	21	22940	500	245	22922	7172	1000	15750
	22	23690	250	245	23670	7170	750	16500
	23	24440	500	245	24420	7170	750	17250
	24	25190	250	245	25170	7170	750	18000
	25	25940	250	245	25920	7170	750	18750
	26	26440	500	245	26422	7172	500	19250
	27	27440	500	245	27424	7174	1000	20250
	28	28190	250	245	28172	7172	750	21000
	29	28690	250	245	28675	7175	500	21500
	30	29190	250	245	29173	7173	500	22000
	31	29700	250	245	29676	7176	500	22500
	32	30440	250	245	30421	7171	750	23250
	33	30940	250	245	30923	7173	500	23750
	34	31440	250	245	31424	7174	500	24250
	35	31940	500	245	31924	7174	500	24750
	36	32940	250	245	32924	/1/4	1000	25750
	37	33440	250	245	33423	7173	500	26250
	38	33940	250	245	33924	/1/4	500	26/50
	39	34440	500	245	34426	/1/6	500	27250
	40	35440	250	245	35424	/1/4	1000	28250
	41	35940	250	245	35924	/1/4	500	28/50
	42	36440	250	245	36424	/1/4	500	29250
	43	36940	500	245	30925	/1/5	500	29750
	44	37700	250	245	5/6//	/1//	750	30500
	Modes .	P461 Thic	200	1 act Ry = 20	301/4 17/ ThicPh	/1/4 = 250 IPTvo	1 - 746	31000

Run - Konsole	
Mode	db = 0 S Message: 59 a7 32 d9 7c 21 0e
Mode	S Message: 59 a7 32 d9 7c 21 0e 📕
7169 7170 7171 7172 7173 7174 7175 7176 7177	2 8 4 9 5 13 2 2 1

#### Real Data - Full Amplitude

The French Weighted Average for this Mode S message is 7172





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-	and particular		anana an						Run - Konsole	8
	File Edit View	P Start	Settings Hel	Pulse Amo	I Bx I	Norm Bx 1	Rel IPT	I Tot IPT	db = 0	
	forme 1		10000-101	i acor mip	0.1.096.1		100 S - 41 (1)	1 104-111	Mode S Message: a0 00 0d 11 80 00 c0 00 08 00 05 d9 5d 00	
	91	482130	500	128	482155	430905	1000	51250		
	92	482890	250	123	482901	430901	750	52000		
	93	483380	250	125	483390	430890	500	52500		
	94	484130	500	127	484149	430899	750	53250	Mode S Message: a0 00 Dd 11 80 00 c0 00 00 00 05 d9 5d 00	
	95	484890	250	121	484900	430900	750	54000		
	96	485630	250	121	485653	430903	750	54750		
	97	486140	500	130	486150	430900	500	55250		
	98	487140	500	131	487156	430906	1000	56250	430879   1	
	99	488130	500	132	488151	430901	1000	57250	430881   1	
	100	488880	250	120	488896	430896	750	58000	430882   1	
	101	489380	250	120	489395	430895	500	58500	430883   1	
	102	490140	500	128	490156	430905	750	59250	430885 1	
	58	465130	250	124	465149	430899	500	34250	430886   4	
	59	465630	250	124	465641	430891	500	34/50	430887 5	
	60	466130	250	121	466147	430897	500	35250	430888 2	
	01	400030	250	124	400044	430894	500	35/50	430009 0	
	62	407150	250	120	407147	430097	500	26750	430690   5	
	64	467030	250	124	467040	430090	500	37250	430691 0	
	65	468620	250	110	468643	430803	500	37250	430802 1 14	
	66	469130	250	124	469143	430893	500	38250	430894 0	
	67	469630	250	124	469643	430893	500	38750	430895 9	
	68	470130	250	125	470143	430893	500	39250	430896 9	
	69	470630	250	122	470644	430894	500	39750	430897 5	
	70	471130	250	122	471147	430897	500	40250	430898 1	
	71	471630	250	125	471643	430893	500	40750	430899 6	
	72	472130	250	123	472143	430893	500	41250	430900 2	
	73	472620	500	119	472643	430893	500	41750	430901   3	
	74	473130	250	125	473141	430891	500	42250	430902   1	
	75	473620	250	117	473645	430895	500	42750	430903   1	
	76	474120	250	121	474144	430894	500	43250	430904   1	
	77	474630	250	122	474643	430893	500	43750	430905   1	
	78	475130	250	123	475146	430896	500	44250	430906 2	
	79	4/5630	250	121	475649	430899	500	44/50		
	80	4/0130	250	125	4/0145	430895	500	45250		
	01	470030	200	118	470043	430893	500	40700		
	02	477130	250	120	477548	430901	500	40230		
	84	478130	250	120	477040	430890	500	47250		
	85	478630	250	123	478639	430889	500	47750		
	86	479130	250	126	479143	430893	500	48250	Real Data – Long Squitter	
	87	479630	250	125	479645	430895	500	48750	rou Data Long Oquittor	
	88	480130	250	125	480140	430890	500	49250		
	89	480630	250	120	480645	430895	500	49750		
	90	481120	500	128	481149	430899	500	50250		
	ModeS:	P102: Th1	sRx = 4901	56 LastRx	= 489395 Th	1 sPW = 500  IP	Tval = 76	51		

The French Weighted Average for this Mode S message is 430893





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Edit Min	u Bookmader	Cottings Liele					
Pulse I	P Start L	Real PW I	Pulse Amo	I Bx I	Norm Bx 1	Rel IPT	I Tot IPT
1.04496	C_ocure 1	red - i in 1	r actor ramp	1 100 1	norm_res 1	the survey of	1 100_111
46	240860	250	71	240862	209362	750	31500
2	209870	250	83	209867	209367	500	500
З	211130	250	76	211135	209385	1250	1750
4	211630	250	80	211625	209375	500	2250
5	213620	500	78	213642	209392	2000	4250
6	214620	500	79	214623	209373	1000	5250
7	215380	250	75	215375	209375	750	6000
8	215880	250	81	215884	209384	500	6500
9	216630	500	81	216631	209381	750	7250
10	217370	250	81	217372	209372	750	8000
11	218120	500	75	218125	209375	750	8750
12	219130	250	75	219138	209388	1000	9750
13	219630	250	82	219633	209383	500	10250
14	220130	250	78	220133	209383	500	10750
15	220620	500	80	220616	209366	500	11250
16	221620	250	77	221622	209372	1000	12250
17	222130	500	84	222127	209377	500	12750
18	222870	250	78	222874	209374	750	13500
19	223620	500	82	223616	209366	750	14250
20	224370	250	72	224364	209364	750	15000
21	224870	250	78	224868	209368	500	15500
22	225380	250	73	225377	209377	500	16000
23	226120	500	82	226123	209373	750	16750
24	227130	500	81	227130	209380	1000	17750
25	227860	250	75	227855	209355	750	18500
26	228380	250	80	228385	209385	500	19000
27	228870	250	80	228868	209368	500	19500
28	229399	250	76	229388	200388	500	20000
20	220550	250	76	220000	200000	500	20500
30	230620	250	80	230627	200077	750	21250
31	231130	500	84	231132	209382	500	21750
32	232120	500	81	232131	209381	1000	22750
99	232880	250	78	232883	200383	750	23500
34	233380	250	76	233301	200000	500	24000
35	234120	250	81	234133	200383	750	24750
36	234600	500	78	234605	200355	500	25250
37	235640	250	71	235642	2000000	1000	26250
38	236110	250	73	236114	209364	500	26750
30	236620	250	70	236624	200374	500	27250
40	237120	250	79	237126	209376	500	27750
40	237640	500	82	237641	200301	500	28250
42	238370	250	77	238376	200001	750	20200
17	230370	250	70	230373	2000763	750	20000
11	239110	250	81	239113	209303	500	29750
15	200120	500	83	240121	209307	500	30750
45	240120	500	0.1	240121	-04 050 107	300	20120

Mo

Moi

209388 | 2 209391 | 2 209392 | 2

le S	Message:	5d	al	37 af	cb	90 63	
le S	Message:	5d	al	37 af	¢þ	90 63	•

db = 0

#### Real Data - Low Amplitude

Hodes, 140, 111310 - 240002 Lastny - 240121 111310 - 250 111000

The French Weighted Average for this Mode S message is 209379





