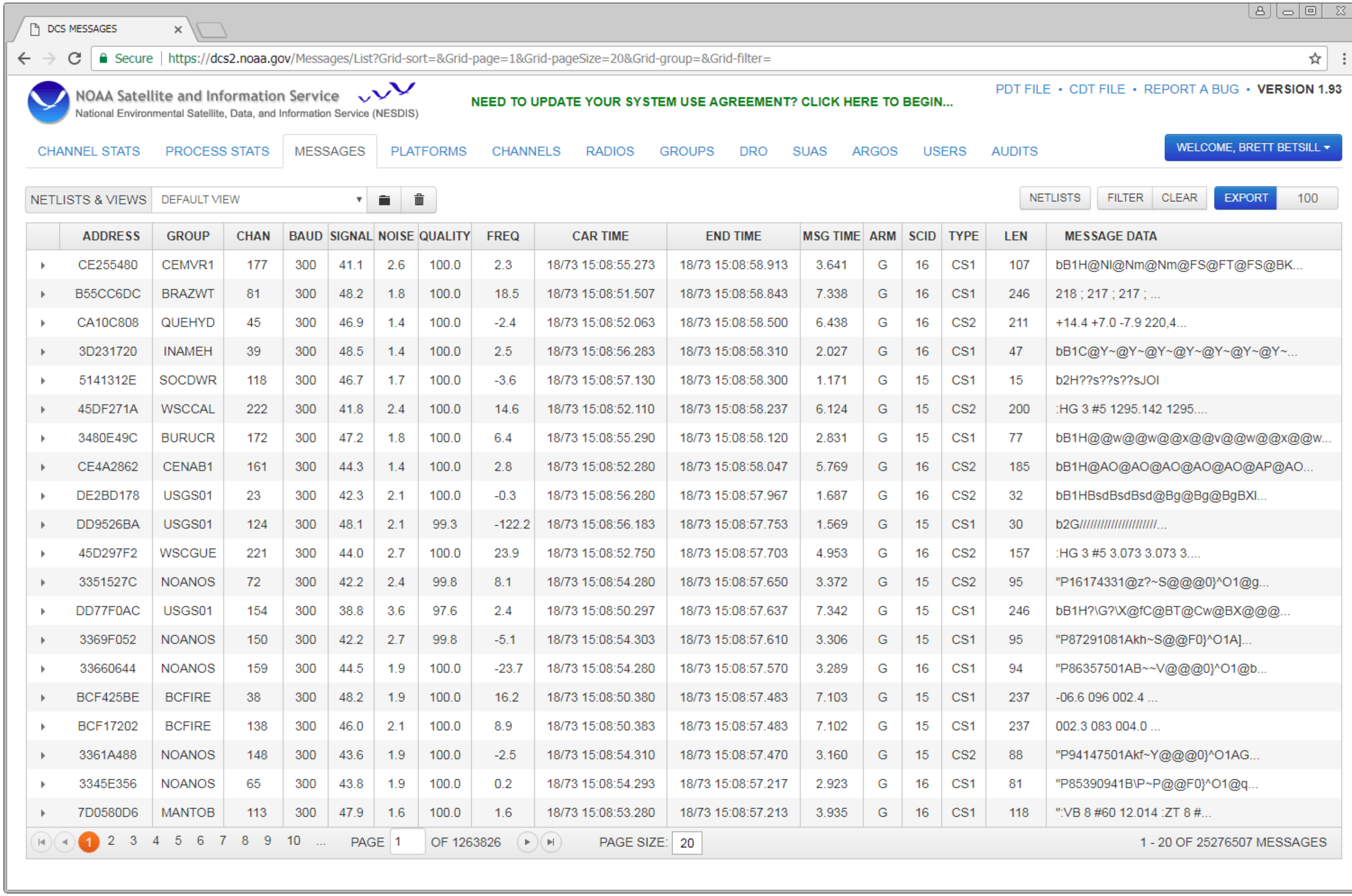
DCS Message Statistics

Presented by

Microcom Design, Inc.

September 2019

DADDS Message Data Tab



ADDRESS	GROUP	CHAN	BAUD	SIGNAL	NOISE	QUALITY	FREQ	CAR TIME	END TIME	MSG TIME	ARM	SCID	TYPE	LEN	MESSAGE DATA
CE255480	CEMVR1	177	300	41.1	2.6	100.0	2.3	18/73 15:08:55.273	18/73 15:08:58.913	3.641	G	16	CS1	107	bB1H@NI@Nm@Nm@FS@FT@FS@BK...
B55CC6DC	BRAZWT	81	300	48.2	1.8	100.0	18.5	18/73 15:08:51.507	18/73 15:08:58.843	7.338	G	16	CS1	246	218 ; 217 ; 217 ; ...
CA10C808	QUEHYD	45	300	46.9	1.4	100.0	-2.4	18/73 15:08:52.063	18/73 15:08:58.500	6.438	G	16	CS2	211	+14.4 +7.0 -7.9 220,4...
3D231720	INAMEH	39	300	48.5	1.4	100.0	2.5	18/73 15:08:56.283	18/73 15:08:58.310	2.027	G	16	CS1	47	bB1C@Y~@Y~@Y~@Y~@Y~@Y~@Y~...
5141312E	SOCDWR	118	300	46.7	1.7	100.0	-3.6	18/73 15:08:57.130	18/73 15:08:58.300	1.171	G	15	CS1	15	b2H??s??s??sJOI
45DF271A	WSCCAL	222	300	41.8	2.4	100.0	14.6	18/73 15:08:52.110	18/73 15:08:58.237	6.124	G	15	CS2	200	:HG 3 #5 1295.142 1295....
3480E49C	BURUCR	172	300	47.2	1.8	100.0	6.4	18/73 15:08:55.290	18/73 15:08:58.120	2.831	G	15	CS1	77	bB1H@@w@@w@@x@@v@@w@@x@@w...
CE4A2862	CENAB1	161	300	44.3	1.4	100.0	2.8	18/73 15:08:52.280	18/73 15:08:58.047	5.769	G	16	CS2	185	bB1H@AO@AO@AO@AO@AO@AP@AO...
DE2BD178	USGS01	23	300	42.3	2.1	100.0	-0.3	18/73 15:08:56.280	18/73 15:08:57.967	1.687	G	16	CS2	32	bB1HBsdBsdBsd@Bg@Bg@BgBXI...
DD9526BA	USGS01	124	300	48.1	2.1	99.3	-122.2	18/73 15:08:56.183	18/73 15:08:57.753	1.569	G	15	CS1	30	b2G//////////////////////...
45D297F2	WSCGUE	221	300	44.0	2.7	100.0	23.9	18/73 15:08:52.750	18/73 15:08:57.703	4.953	G	16	CS2	157	:HG 3 #5 3.073 3.073 3....
3351527C	NOANOS	72	300	42.2	2.4	99.8	8.1	18/73 15:08:54.280	18/73 15:08:57.650	3.372	G	15	CS2	95	"P16174331@z?~S@@@0}^O1@g...
DD77F0AC	USGS01	154	300	38.8	3.6	97.6	2.4	18/73 15:08:50.297	18/73 15:08:57.637	7.342	G	15	CS1	246	bB1H?\G?\X@fC@BT@Cw@BX@@@...
3369F052	NOANOS	150	300	42.2	2.7	99.8	-5.1	18/73 15:08:54.303	18/73 15:08:57.610	3.306	G	15	CS1	95	"P87291081Akh~S@@F0}^O1A]...
33660644	NOANOS	159	300	44.5	1.9	100.0	-23.7	18/73 15:08:54.280	18/73 15:08:57.570	3.289	G	16	CS1	94	"P86357501AB~~V@@@0}^O1@b...
BCF425BE	BCFIRE	38	300	48.2	1.9	100.0	16.2	18/73 15:08:50.380	18/73 15:08:57.483	7.103	G	15	CS1	237	-06.6 096 002.4 ...
BCF17202	BCFIRE	138	300	46.0	2.1	100.0	8.9	18/73 15:08:50.383	18/73 15:08:57.483	7.102	G	15	CS1	237	002.3 083 004.0 ...
3361A488	NOANOS	148	300	43.6	1.9	100.0	-2.5	18/73 15:08:54.310	18/73 15:08:57.470	3.160	G	15	CS2	88	"P94147501Akf~Y@@@0}^O1AG...
3345E356	NOANOS	65	300	43.8	1.9	100.0	0.2	18/73 15:08:54.293	18/73 15:08:57.217	2.923	G	16	CS1	81	"P85390941B\P~P@@F0}^O1@q...
7D0580D6	MANTOB	113	300	47.9	1.6	100.0	1.6	18/73 15:08:53.280	18/73 15:08:57.213	3.935	G	16	CS1	118	":VB 8 #60 12.014 :ZT 8 #...

Message Stats – Who, What, Where & Why

- Why Are They Important
  - Message Data versus Message Quality
  - Proactive Monitoring versus Reactive Troubleshooting
- Where Do They Come From
  - NOAA/NESDIS
  - Via the DADDS Website
  - Beginning with the DAMS-NT System
- What Are They
  - Time, Frequency, Amplitude, Phase
  - What do they mean?
  - What do they tell us?
- Who Needs to Know About Them and Can Access Them
  - DCS Users, Managers, etc.
  - Field Techs, Service Depot Techs, etc.

Message Statistics
Why Are They Important?

Message Data versus Message Quality

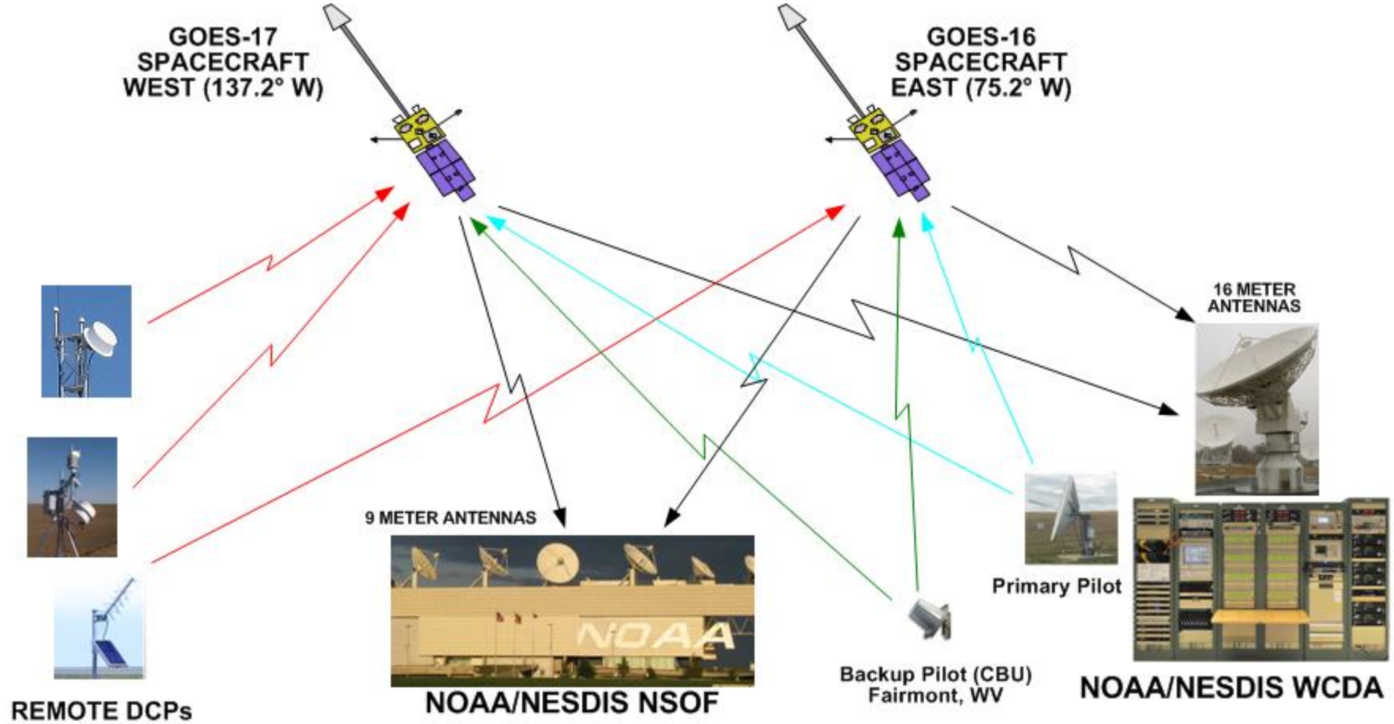
- Isn't getting the Message Data is what is most important?
  - Certainly!
  - The environmental data being collected is often critical and in some cases life-saving (e.g. flood, tsunami, etc.).
- However, these Data Collection Platforms (DCPs) are satellite based because …
  - They are in remote locations.
  - Often difficult to get to (some require a helicopter trip).
  - Have no other communication option.
- For reliable message data reception it is important to know the quality of the "received" message.

Proactive versus Reactive

- Users should proactively monitor message quality.
  - Not doing so could result in loss of data when it is needed most.
  - Data lost from a garbled or missed message typically cannot be recovered in real time.
- Reactive troubleshooting is possible on a garbled message.
  - Message statistics are available and can usually explain why a message was received with errors.
- A "missed" message is not received at all.
  - No Data $\Rightarrow$ No site troubleshooting information is received, e.g. battery voltage or transmitter power readings.
  - No Message Quality or Statistics are available.
  - Cannot troubleshoot a missed message.
- Proactive Monitoring of the Message Statistics is key to ensuring reliable message reception.

Message Statistics
Where Do They Come From?

GOES DCS Overview



- Geostationary Satellites: GOES East @ 75.2° W and GOES West @ 137.2° W
- WCDA – Primary Receive Site NSOF – Alternate Receive Site
- DCPs Uplink in UHF Band (~402 MHz) & DCS Downlink in L Band (~1680 MHz)
- Primary Pilot: Uplink = 401.850 MHz Downlink = 1679.850 MHz
- Backup Pilot: Uplink = 401.700 MHz Downlink = 1679.700 MHz

GOES DCS – A Shared Resource

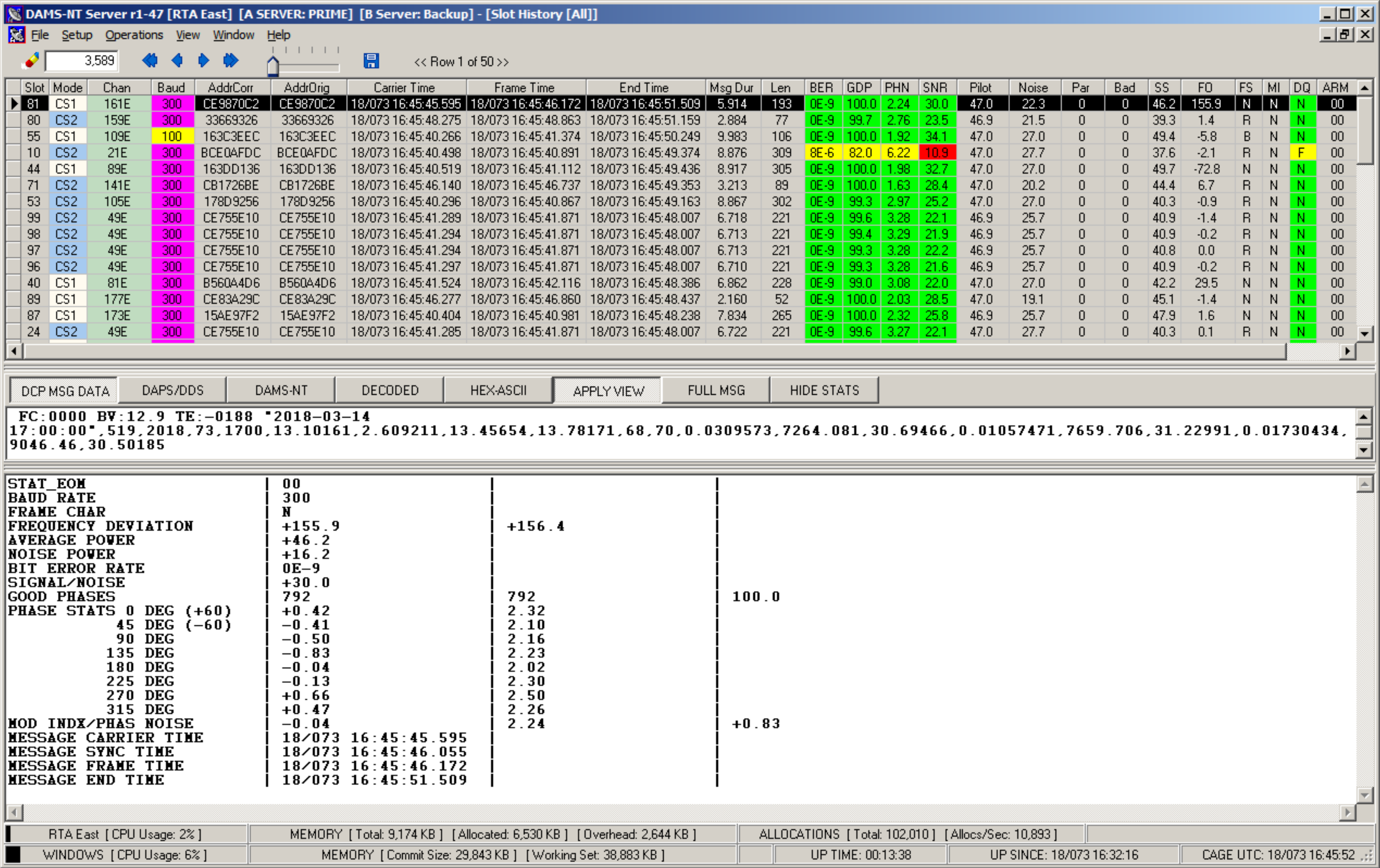
- FDMA: Frequency Division Multiple Access
  - Each DCP is assigned a specific number channel.
  - Channels are shared by multiple DCPs and/or Users.
- TDMA: Time Division Multiple Access
  - On a given channel, each DCP is assigned a specific time window.
  - Time windows are typically 5-15 seconds.
- Power Sharing
  - All active DCP signals are received at the satellite, translated in frequency, and retransmitted as a composite signal to the Direct Readout Ground Stations (DRGS).
  - The composite signal's downlink power is held constant, i.e. each active DCP shares a portion of the total power.
- GOES DCS Pilots
  - Provide an Amplitude and Frequency reference for all DCPs.
  - Critical to system operation. No Pilot $\Rightarrow$ No DCS.
  - Pilots have special frequency (channel) and share downlink power.

GOES DCS Rails at WCDA and NSOF

DAMS-NT System – *DigiTrak* Demodulator

- Every GOES DCS Message is received by a DAMS-NT *DigiTrak* DSP based demodulator at WDCA and NSOF (and the USGS EDDN at EROS).
- As messages are received, the message data and message statistics are collected in real-time by the DAMS-NT Server application.

DAMS-NT *DigiTrak* Message Statistics



DAMS-NT Server r1-47 [RTA East] [A SERVER: PRIME] [B Server: Backup] - [Slot History [All]]

File Setup Operations View Window Help

3,589 << Row 1 of 50 >>

Slot	Mode	Chan	Baud	AddrCorr	AddrOrig	Carrier Time	Frame Time	End Time	Msg Dur	Len	BER	GDP	PHN	SNR	Pilot	Noise	Par	Bad	SS	FO	FS	MI	DQ	ARM
81	CS1	161E	300	CE9870C2	CE9870C2	18/073 16:45:45.595	18/073 16:45:46.172	18/073 16:45:51.509	5.914	193	0E-9	100.0	2.24	30.0	47.0	22.3	0	0	46.2	155.9	N	N	N	00
80	CS2	159E	300	33669326	33669326	18/073 16:45:48.275	18/073 16:45:48.863	18/073 16:45:51.159	2.884	77	0E-9	99.7	2.76	23.5	46.9	21.5	0	0	39.3	1.4	R	N	N	00
55	CS1	109E	100	163C3EEC	163C3EEC	18/073 16:45:40.266	18/073 16:45:41.374	18/073 16:45:50.249	9.983	106	0E-9	100.0	1.92	34.1	47.0	27.0	0	0	49.4	-5.8	B	N	N	00
10	CS2	21E	300	BCE0AFDC	BCE0AFDC	18/073 16:45:40.498	18/073 16:45:40.891	18/073 16:45:49.374	8.876	309	8E-6	82.0	6.22	10.9	47.0	27.7	0	0	37.6	-2.1	R	N	F	00
44	CS1	89E	300	163DD136	163DD136	18/073 16:45:40.519	18/073 16:45:41.112	18/073 16:45:49.436	8.917	305	0E-9	100.0	1.98	32.7	47.0	27.0	0	0	49.7	-72.8	N	N	N	00
71	CS2	141E	300	CB1726BE	CB1726BE	18/073 16:45:46.140	18/073 16:45:46.737	18/073 16:45:49.353	3.213	89	0E-9	100.0	1.63	28.4	47.0	20.2	0	0	44.4	6.7	R	N	N	00
53	CS2	105E	300	178D9256	178D9256	18/073 16:45:40.296	18/073 16:45:40.867	18/073 16:45:49.163	8.867	302	0E-9	99.3	2.97	25.2	47.0	27.0	0	0	40.3	-0.9	R	N	N	00
99	CS2	49E	300	CE755E10	CE755E10	18/073 16:45:41.289	18/073 16:45:41.871	18/073 16:45:48.007	6.718	221	0E-9	99.6	3.28	22.1	46.9	25.7	0	0	40.9	-1.4	R	N	N	00
98	CS2	49E	300	CE755E10	CE755E10	18/073 16:45:41.294	18/073 16:45:41.871	18/073 16:45:48.007	6.713	221	0E-9	99.4	3.29	21.9	46.9	25.7	0	0	40.9	-0.2	R	N	N	00
97	CS2	49E	300	CE755E10	CE755E10	18/073 16:45:41.294	18/073 16:45:41.871	18/073 16:45:48.007	6.713	221	0E-9	99.3	3.28	22.2	46.9	25.7	0	0	40.8	0.0	R	N	N	00
96	CS2	49E	300	CE755E10	CE755E10	18/073 16:45:41.297	18/073 16:45:41.871	18/073 16:45:48.007	6.710	221	0E-9	99.3	3.28	21.6	46.9	25.7	0	0	40.9	-0.2	R	N	N	00
40	CS1	81E	300	B560A4D6	B560A4D6	18/073 16:45:41.524	18/073 16:45:42.116	18/073 16:45:48.386	6.862	228	0E-9	99.0	3.08	22.0	47.0	27.0	0	0	42.2	29.5	N	N	N	00
89	CS1	177E	300	CE83A29C	CE83A29C	18/073 16:45:46.277	18/073 16:45:46.860	18/073 16:45:48.437	2.160	52	0E-9	100.0	2.03	28.5	47.0	19.1	0	0	45.1	-1.4	N	N	N	00
87	CS1	173E	300	15AE97F2	15AE97F2	18/073 16:45:40.404	18/073 16:45:40.981	18/073 16:45:48.238	7.834	265	0E-9	100.0	2.32	25.8	46.9	25.7	0	0	47.9	1.6	N	N	N	00
24	CS2	49E	300	CE755E10	CE755E10	18/073 16:45:41.285	18/073 16:45:41.871	18/073 16:45:48.007	6.722	221	0E-9	99.6	3.27	22.1	47.0	27.7	0	0	40.3	0.1	R	N	N	00

DCP MSG DATA | DAPS/DDS | DAMS-NT | DECODED | HEX-ASCII | APPLY VIEW | FULL MSG | HIDE STATS

```
FC:0000 BV:12.9 TE:-0188 "2018-03-14
17:00:00",519,2018,73,1700,13.10161,2.609211,13.45654,13.78171,68,70,0.0309573,7264.081,30.69466,0.01057471,7659.706,31.22991,0.01730434,
9046.46,30.50185
```

STAT_EOM	00		
BAUD RATE	300		
FRAME CHAR	N		
FREQUENCY DEVIATION	+155.9	+156.4	
AVERAGE POWER	+46.2		
NOISE POWER	+16.2		
BIT ERROR RATE	0E-9		
SIGNAL/NOISE	+30.0		
GOOD PHASES	792	792	100.0
PHASE STATS 0 DEG (+60)	+0.42	2.32	
45 DEG (-60)	-0.41	2.10	
90 DEG	-0.50	2.16	
135 DEG	-0.83	2.23	
180 DEG	-0.04	2.02	
225 DEG	-0.13	2.30	
270 DEG	+0.66	2.50	
315 DEG	+0.47	2.26	
MOD INDX/PHAS NOISE	-0.04	2.24	+0.83
MESSAGE CARRIER TIME	18/073 16:45:45.595		
MESSAGE SYNC TIME	18/073 16:45:46.055		
MESSAGE FRAME TIME	18/073 16:45:46.172		
MESSAGE END TIME	18/073 16:45:51.509		

RTA East [CPU Usage: 2%] | MEMORY [Total: 9,174 KB] [Allocated: 6,530 KB] [Overhead: 2,644 KB] | ALLOCATIONS [Total: 102,010] [Allocs/Sec: 10,893]

WINDOWS [CPU Usage: 6%] | MEMORY [Commit Size: 29,843 KB] [Working Set: 38,883 KB] | UP TIME: 00:13:38 | UP SINCE: 18/073 16:32:16 | CAGE UTC: 18/073 16:45:52

Message Statistics
What Are They?

DADDS/DAMS-NT Message Statistics

DCS MESSAGES

Secure | https://dcs2.noaa.gov/Messages/List?Grid-sort=&Grid-page=1&Grid-pageSize=20&Grid-group=&Grid-filter=

NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service (NESDIS)

NEED TO UPDATE YOUR SYSTEM USE AGREEMENT? CLICK HERE TO BEGIN...

PDT FILE • CDT FILE • REPORT A BUG • **VERSION 1.93**

CHANNEL STATS | PROCESS STATS | MESSAGES | PLATFORMS | CHANNELS | RADIOS | GROUPS | DRO | SUAS | ARGOS | USERS | AUDITS

WELCOME, BRETT BETSILL ▾

NETLISTS & VIEWS | DEFAULT VIEW ▾

NETLISTS | FILTER | CLEAR | EXPORT | 100

	ADDRESS	GROUP	CHAN	BAUD	SIGNAL	NOISE	QUALITY	FREQ	CAR TIME	END TIME	MSG TIME	ARM	SCID	TYPE	LEN	MESSAGE DATA
▸	CE255480	CEMVR1	177	300	41.1	2.6	100.0	2.3	18/73 15:08:55.273	18/73 15:08:58.913	3.641	G	16	CS1	107	bB1H@NI@Nm@Nm@FS@FT@FS@BK...
▸	B55CC6DC	BRAZWT	81	300	48.2	1.8	100.0	18.5	18/73 15:08:51.507	18/73 15:08:58.843	7.338	G	16	CS1	246	218 ; 217 ; 217 ; ...
▸	CA10C808	QUEHYD	45	300	46.9	1.4	100.0	-2.4	18/73 15:08:52.063	18/73 15:08:58.500	6.438	G	16	CS2	211	+14.4 +7.0 -7.9 220,4...
▸	3D231720	INAMEH	39	300	48.5	1.4	100.0	2.5	18/73 15:08:56.283	18/73 15:08:58.310	2.027	G	16	CS1	47	bB1C@Y~@Y~@Y~@Y~@Y~@Y~@Y~...
▸	5141312E	SOCDWR	118	300	46.7	1.7	100.0	-3.6	18/73 15:08:57.130	18/73 15:08:58.300	1.171	G	15	CS1	15	b2H??s??s??sJOI
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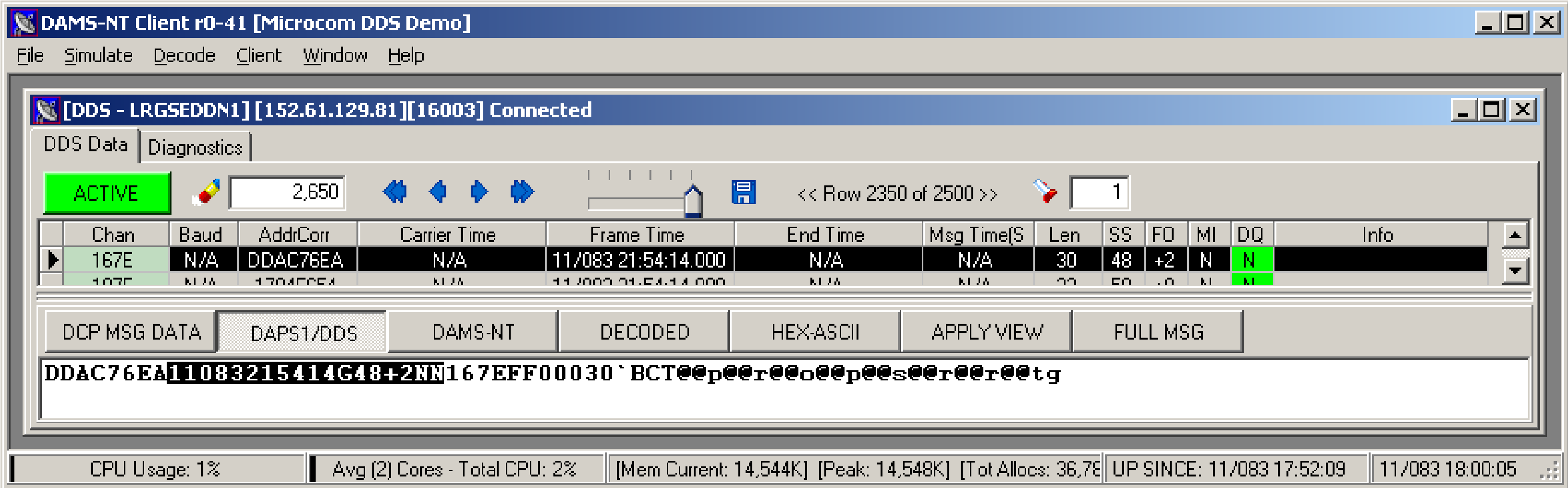
Message Statistics – The Final Four

- Four Most Critical/Useful Message Statistics:
  - Time
    - DCP transmissions must stay within NESDIS window or time slot.
    - Straying outside the window can cause interference with another DCP/User.
    - Transmission start and end times should be monitored.
  - Frequency
    - CS1 transmissions must be within ±500 Hz of center of 1500 Hz channel.
    - CS2 transmissions must be within ±150 Hz of center of 750 Hz channel.
    - Straying outside of channel can affect other transmissions.
  - Signal Strength
    - Ensures that the message can be received in a noisy radio environment.
    - Upper and lower limits must be observed.
  - Phase Measurements
    - DCP Transmitters use Phase Modulation (PM) to convey information.
    - Phase statistics can single handedly identify the reliability of signal reception and message data processing.
- Maintaining these four in acceptable ranges will virtually guarantee valid message data reception.

Message Statistics – DADDS versus DAPS

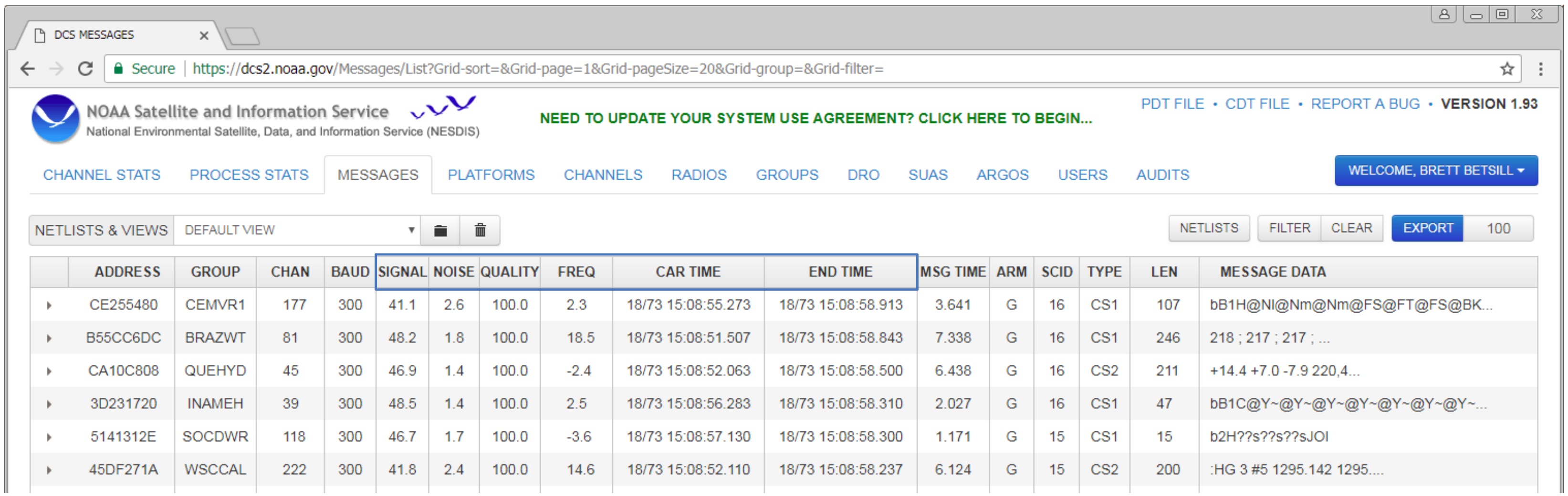


- DAPS Legacy Stats Still Used by DDS (aka LRGS or OpenDCS)

11083215414G48+2NN	
YYDDDHHMMSS	Time: YYDDDHHMMSS (Frame Sync)
T	Type: G = Good ? = Parity Errors (ARM)
SS	Signal Strength: dBm EIRP
±X	Frequency: Sign & Digit (±F times 50 Hz)
M	Modulation Index (Phase): Normal, High, Low
D	Data Quality (Phase): Normal, Fair, Poor

- HRIT converted to DAMS-NT stats in 2019

Message Statistics – DADDS versus DAPS



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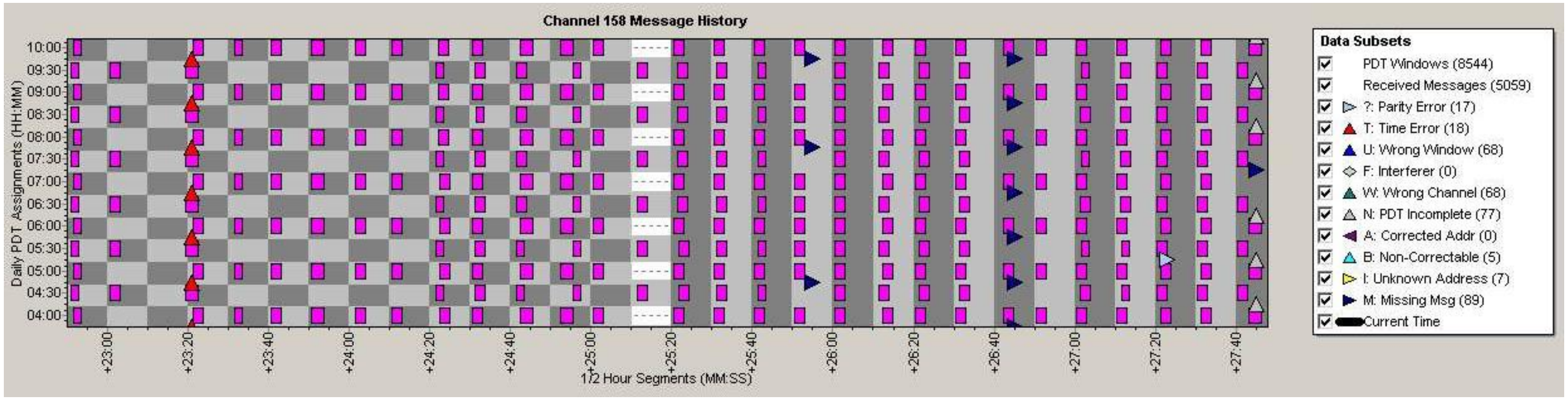
5141312E	SOCDWR	118	300	46.7	1.7	100.0	-3.6	18/73 15:08:57.130	18/73 15:08:58.300	1.171	G	15	CS1	15	b2H??s??s??sJOI
45DF271A	WSCCAL	222	300	41.8	2.4	100.0	14.6	18/73 15:08:52.110	18/73 15:08:58.237	6.124	G	15	CS2	200	:HG 3 #5 1295.142 1295....

- Time: "Carrier Time" (Start) & "End Time" to 0.001 seconds
  "Msg Time" in seconds to 0.001 seconds
- Frequency: "Freq. Dev" from channel center to 0.1 Hz
- Strength: "Signal" dBm EIRP to 0.1 dB
- Phase: "Phase Noise" in degrees RMS to 0.1°
  "Msg Quality" in percent to 0.1% (aka "Batting Average")
- Type: "ARM" is same as in DAPS legacy stats

Message Stats – Time – Relative or Absolute?

- Absolute
  - Each DCP has a defined Time Window.
  - Time windows and time stamps are in UTC (Coordinated Universal Time), which is same as GMT (Greenwich Mean Time).
  - Time stamps down to the millisecond.
- Relative
  - ~0.24 second travel time (72,000 km / 300,000 km per sec)
  - How close are we to our neighbor?
  - Message length versus window size.



Message Stats – Time – Keeping Synced

- Monitor for Time Syncs in Data Stream
  - Flag Byte or Character is a required part of certification.
  - GOES transmitters must send this byte after GOES ID and before data.
  - Identifies:
    - Message format - ASCII or Pseudo-Binary (Binary in future)
    - Whether or not there has been a GPS time sync since the last transmission.

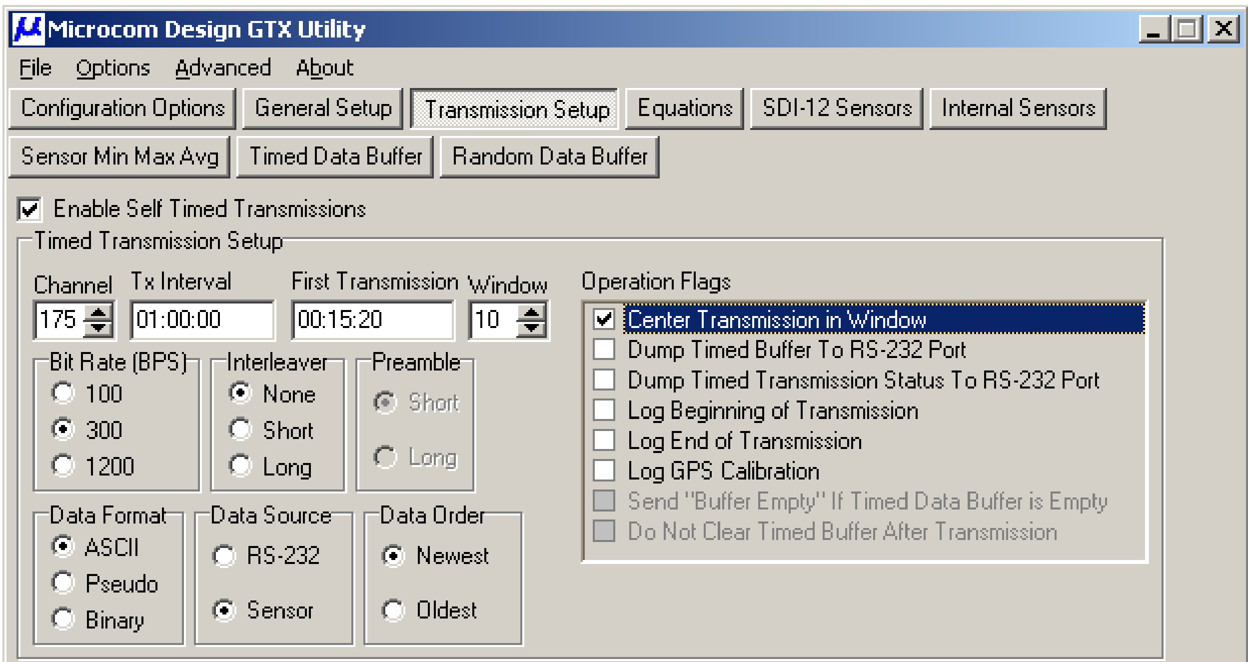
- Deciphering the Flag Byte/Character:
  - ASCII Message:
    - No Time Sync: Space (0x20)
    - GPS Time Sync: " Double Quote (0x22)
  - Pseudo-Binary:
    - No Time Sync: ` Tic Mark (0x60)
    - GPS Time Sync: b (0x62)

MESSAGE DATA
`BST@?f@@@A@v@?f@@@AAM@?f...
`BCT@B?@B|@Bw@Bt@Bq@Bo@Bm...
":stage 13 #15 4.00 4.00 ...
bBST@Ft@Ft@Fv@Fv@Fx@Fx@Fy...
2 14:50:00 30,15,6.2,...
bB1M@AF@AH@AD@A@@AD@A@@@~...
":HG 13 #15 5.03 5.03 5.0...

ADDRESS	GROUP	CHAN	BAUD	SIGNAL	NOISE	QUALITY	FREQ	CAR TIME	END TIME	MSG TIME	ARM	SCID	TYPE	LEN	MESSAGE DATA
DDD596E8	USGS01	156	300	49.9	1.7	100.0	-65.2	18/73 15:43:50.560	18/73 15:43:55.310	4.750	G	15	CS1	149	`BST@?f@@@A@v@?f@@@AAM@?f...
163A4660	USGS01	89	300	48.6	1.7	100.0	-120.8	18/73 15:43:50.513	18/73 15:43:55.273	4.759	G	16	CS1	149	`BCT@B?@B|@Bw@Bt@Bq@Bo@Bm...
DE14E400	USGS01	35	300	35.8	3.4	98.9	-2.0	18/73 15:43:50.287	18/73 15:43:55.143	4.858	G	16	CS1	153	":stage 13 #15 4.00 4.00 ...

Message Stats – Time – Making Sure

- "To Center or Not to Center"
  - Until DADDS, message centering was not advisable due to latency in DAPS time stamping.
  - Centering ensures maximum time guard bands at start and end of transmission



Message Stats–Frequency CS1 versus CS2

- Certification Standard 1 (CS1) versus Certification Standard 2 (CS2)

	CS1	CS2
Channel Capacity (300bps)	220	440
Total Frequency Bandwidth	330 kHz	330 kHz
Basic Channel Bandwidth	1500 Hz	750 Hz
300 bps Bandwidth	1500 Hz	750 Hz
1200 bps Bandwidth	3000 Hz	2250 Hz
Tx Allowed Uncertainty	±425 Hz	±125 Hz
Tx Frequency Stability	±1 ppm	±0.3 ppm

- CS1 versus CS2 Channel Mapping

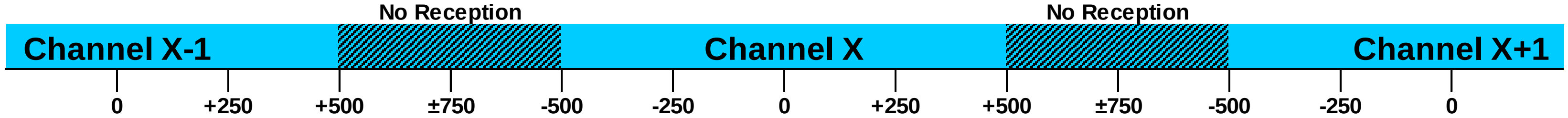
1 2 3 4 5 6 … OLD … 215 216 217 218 219 220

1 301 2 302 3 303 4 304 5 305 6 306 … NEW … 514 215 515 216 516 217 517 218 518 219 519 220 520

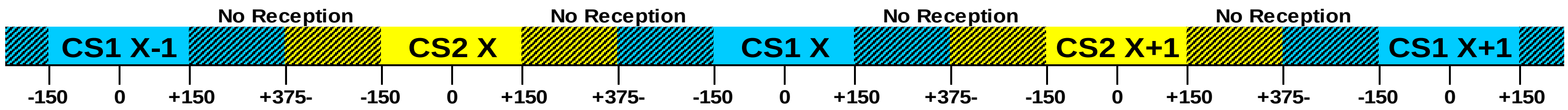
- Transition to CS2 forced reducing demodulator acquisition range to ±150 Hz making frequency monitoring more critical.
- DAPS stat has not been updated and is not useful for CS2.

Message Stats – Frequency – Where Are You?

- *DigiTrak* DSP Demods allow ±500/±150 Hz error from CS1/CS2 channel center.
  - 300 bps CS1 channel spacing is 1500 Hz.



  - 300 bps CS2 channel spacing is 750 Hz.
    (new CS2 channels interspersed with legacy CS1 channel centers)



- Outside this designed limit, messages will not be received.
- Most transmitters today have little trouble meeting limit.
  - Loss of data due to frequency is usually the result of a faulty transmitter.
- Good idea to monitor "FREQ" for excessive deviation from channel center.

Message Stats – Signal Strength – Bad?

- Too Low
  - Missed messages - *DigiTrak* DSP Demods have programmable reception threshold of 25 dBm EIRP.
  - Poor Signal-Noise-Ratio (SNR)
    - Signal Strength relative to RF Noise.
    - Lower Signal Strength ⇒ Higher SNR ⇒ Increased Phase Noise ⇒ Worse Performance
- Too High
  - Demod overload - *DigiTrak* DSP Demods have maximum reception threshold of 56 dBm EIRP (should not be an issue with CS2).
  - Violation of certification and use agreements.
  - Not being a good neighbor – excessive transmit powers increases noise which lowers SNR for others.
  - Unnecessary battery discharge.

Message Stats – Signal Strength – Good?

- Measured in dBm EIRP (Equivalent Isotropic Radiated Power)
  - Three Components:
    - Transmitter Power – Usually specified in Watts
    - Antenna Gain – Specified in dB (typical 3-11 dB)
    - Cable Loss – Between Transmitter & Antenna (0.5 – 1.0 dB)
  - dBm = Decibel (logarithmic) scale relative to one milliwatt.

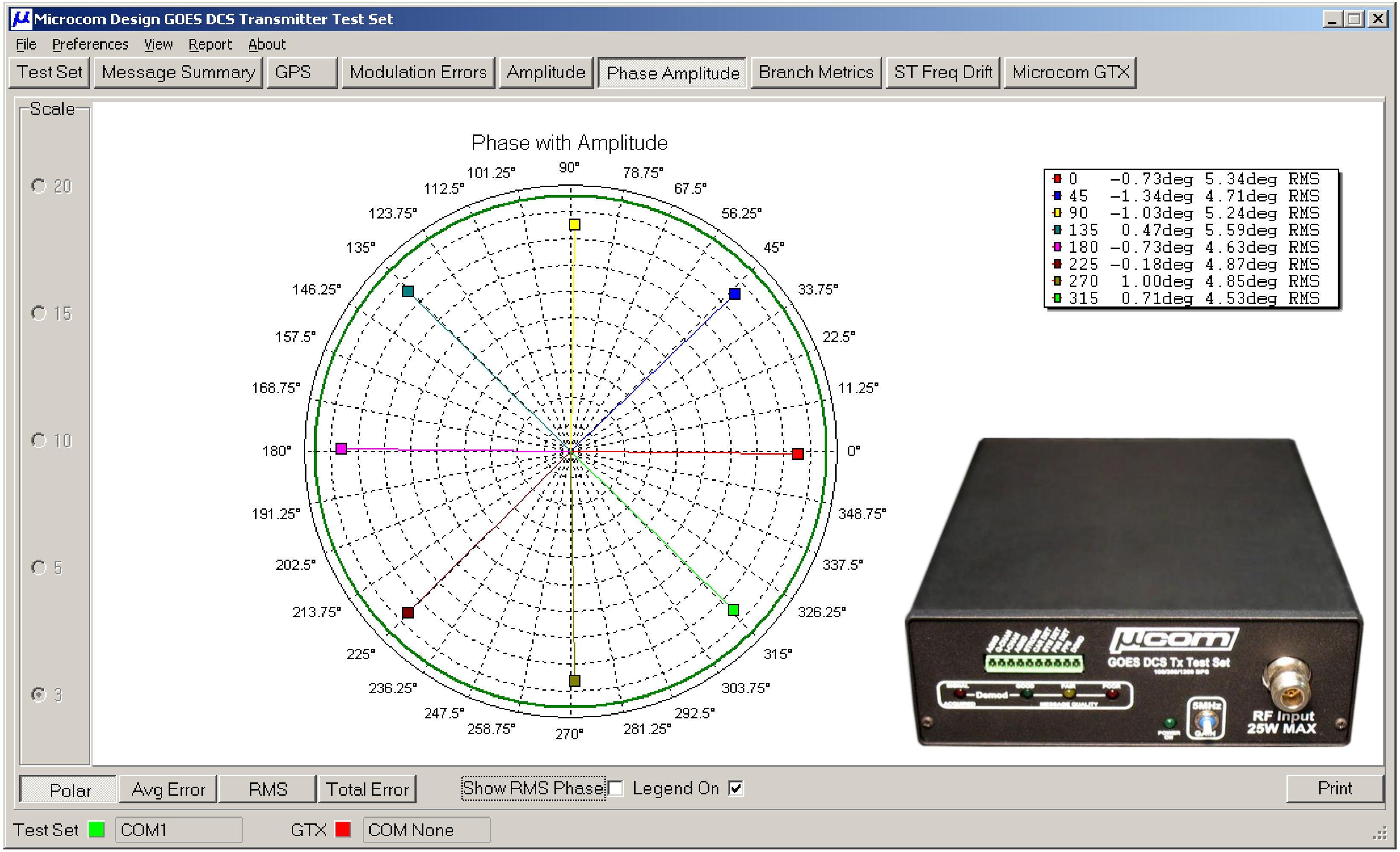
Watts	1	1.2	1.5	1.7	2	2.5	3	4	5	6	7	8	9	10	11	12	13	15	17	20
dBm	30.0	30.8	31.8	32.3	33.0	34.0	34.8	36.0	37.0	37.8	38.5	39.0	39.5	40.0	40.4	40.8	41.1	41.8	42.3	43.0

- CS1 Example: Microcom GTX-1.0 (12 Watts) with Microcom UB8.
  - 40.8 dBm + 8 dB – 0.8 dB = 48.0 dBm EIRP
- CS2 Example: Microcom GTX-2.0 (1.5 Watts) with Microcom UB8.
  - 31.8 dBm + 8 dB – 0.8 dB = 39.0 dBm EIRP
- Certification Levels:
  - CS1:
    - 300 bps: Max 48 dBm EIRP
    - 1200 bps: Max 51 dBm EIRP
  - CS2:
    - 300 bps: 39 ± 2 dBm EIRP
    - 1200 bps: 45 ± 2 dBm EIRP

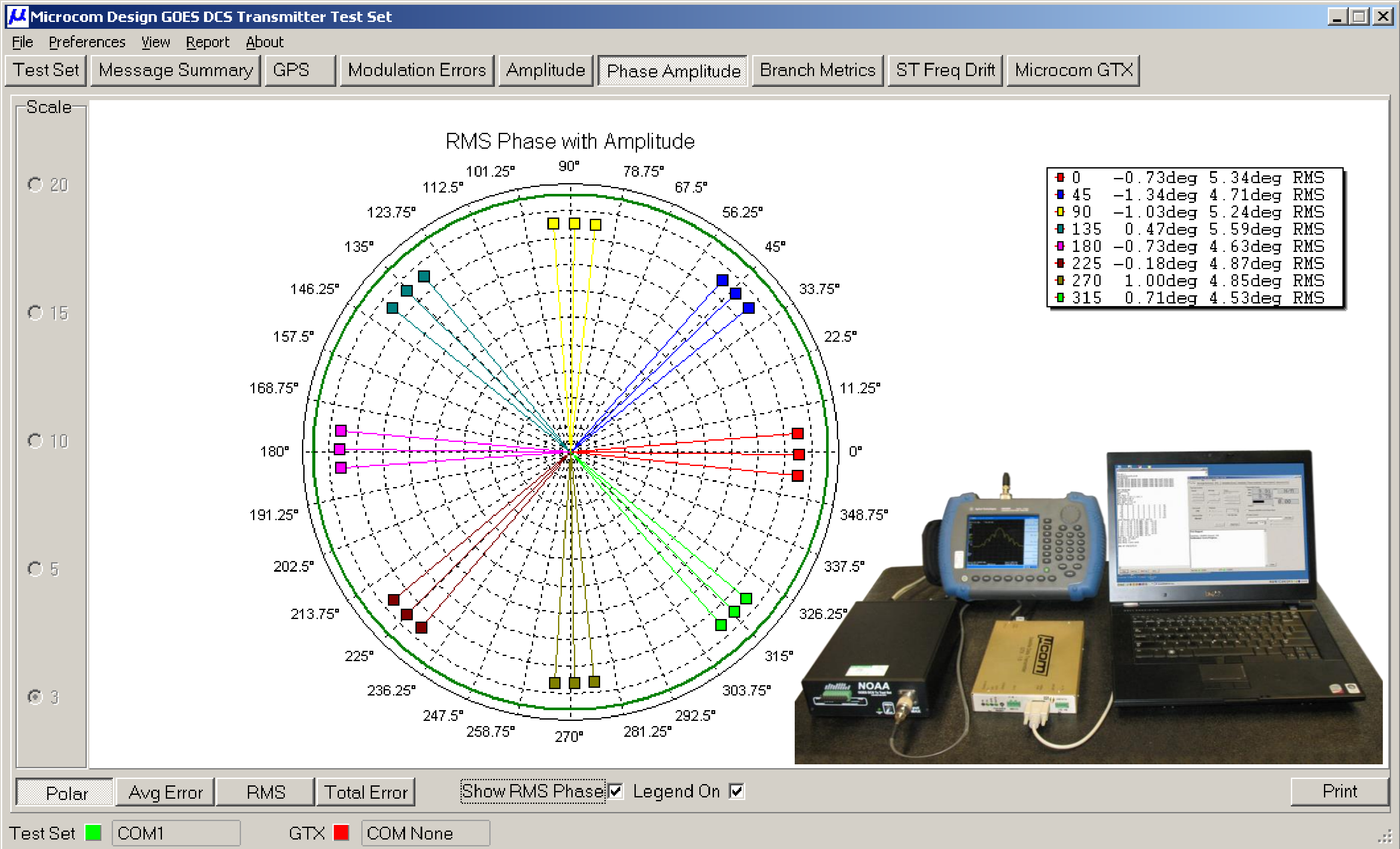
Message Stats – Phase – The Ultimate Telltale

- What Is Phase?
  - GOES DCS Transmitters use Phase Modulation, as opposed to Amplitude Modulation (AM) or Frequency Modulation (FM).
  - Modulation ⇒ Change in a Deterministic Pattern.
  - Phase is Measure in Degrees ⇒ Think of Position Around a Circle
  - Transmitters send one of Eight Phase Symbols to convey message information (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°).
- Two Components Determine Quality of Phase Modulation
  - Absolute Phase – Average – How close is average to nominal?
  - RMS Phase Noise – Standard Deviation – How much do the phase symbols vary around the average?
- Under Normal Circumstances …
  - Average Phase is strictly a function of the transmitter.
  - Phase Noise is a function of the Signal-to-Noise Ratio (SNR).

Message Stats – Phase – Average



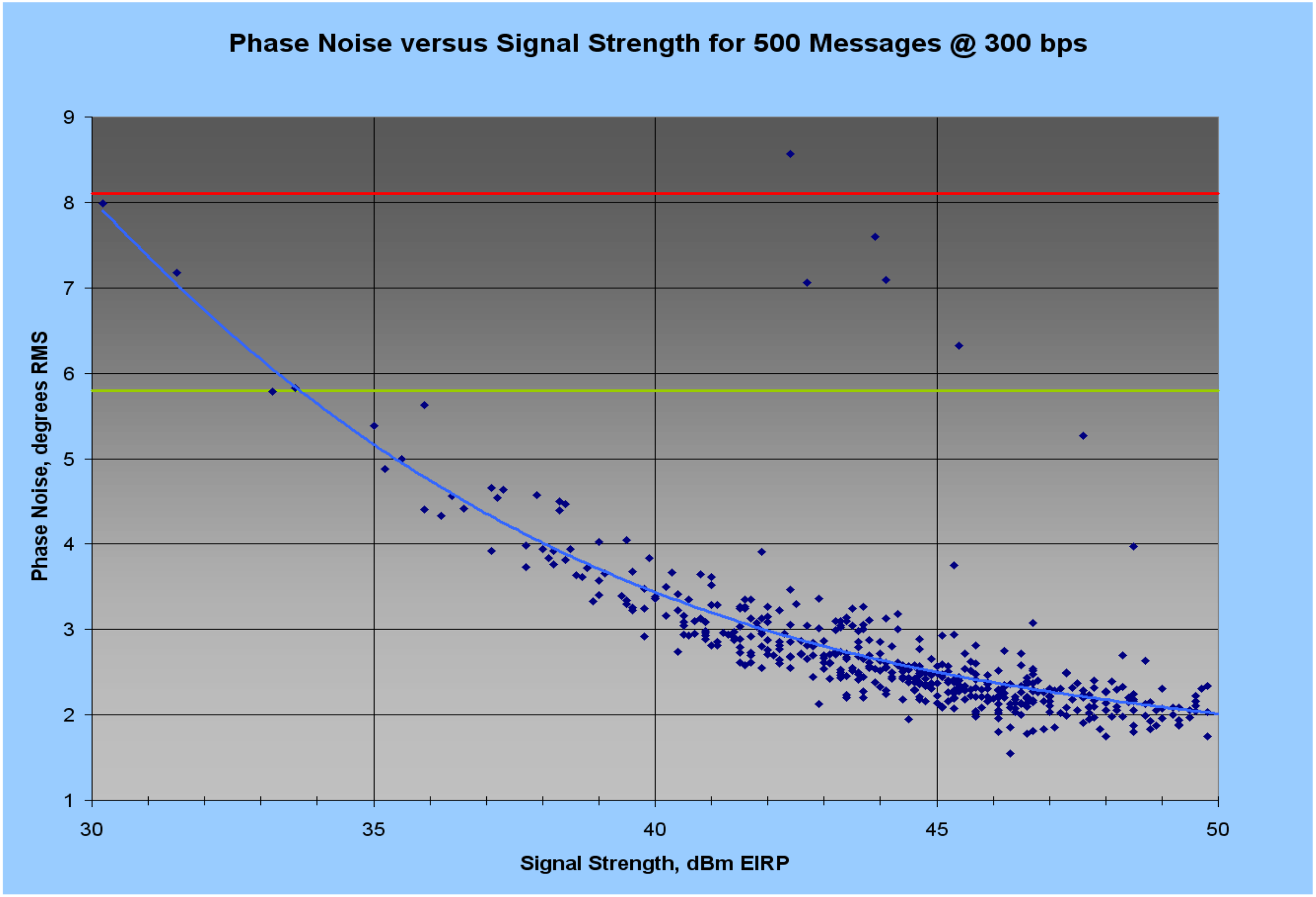
Message Stats – Phase – RMS Variation



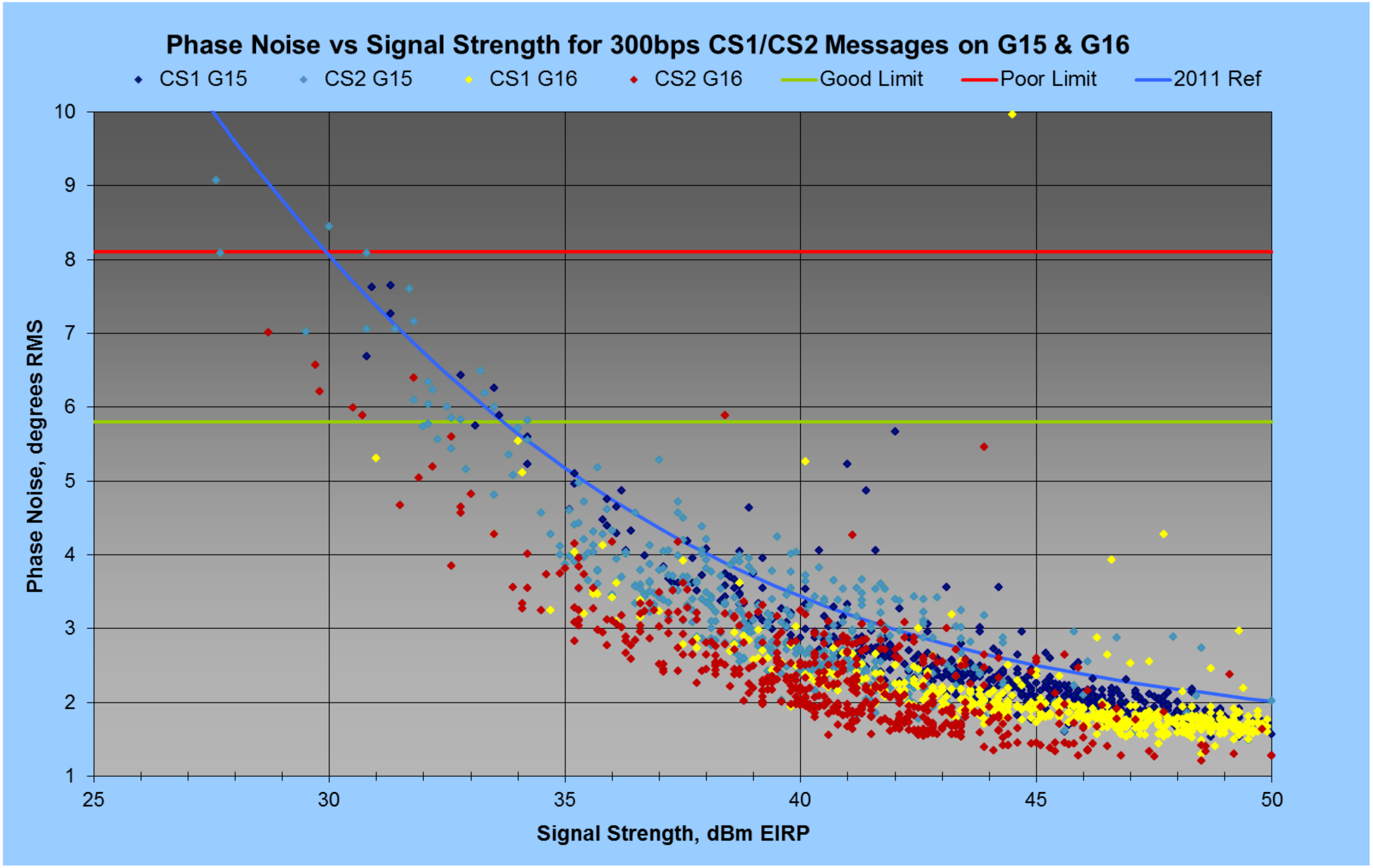
Message Stats – RMS Phase Noise

- Standard Deviation of Phase Symbols Relative to Average
  - Designated by Greek Symbol σ (sigma).
  - 68.3% of received symbols should be within ±1σ
  - 95.4% of received symbols should be within ±2σ
  - 99.7% of received symbols should be within ±3σ
- Good, Fair, and Poor …
  - 300 bps: Good < 6.0° < Fair < 8.0° < Poor
  - 1200 bps: Good < 5.5° < Fair < 7.5° < Poor
- Lower Limit
  - Can never be less than 0
  - Typically, never less than 1.5° - 2.0° (due to Satellite Link Budget)
- Upper Limit
  - Reception barely possible around 11° - 12° (short messages)
  - Beyond 13° highly unlikely.
- Seeing Phase Noise Improvement due to CS2 and GOES-R

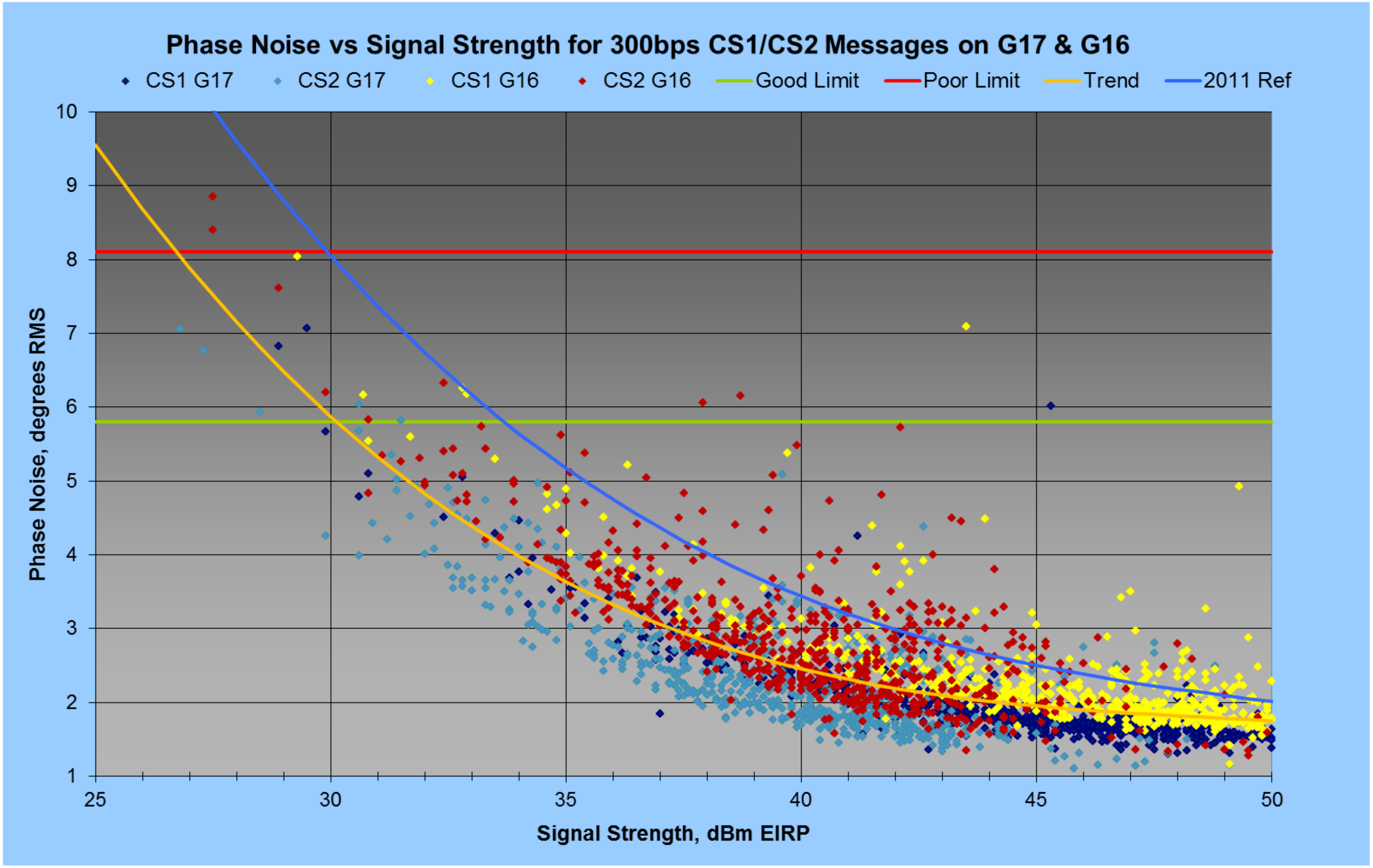
Phase Noise vs. Signal Strength - 2011



Phase Noise vs. Signal Strength - 2018

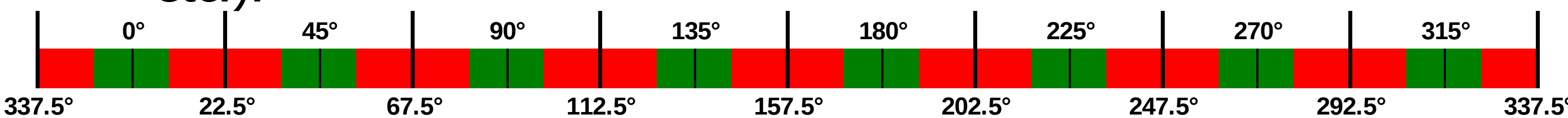


Phase Noise vs. Signal Strength - 2019



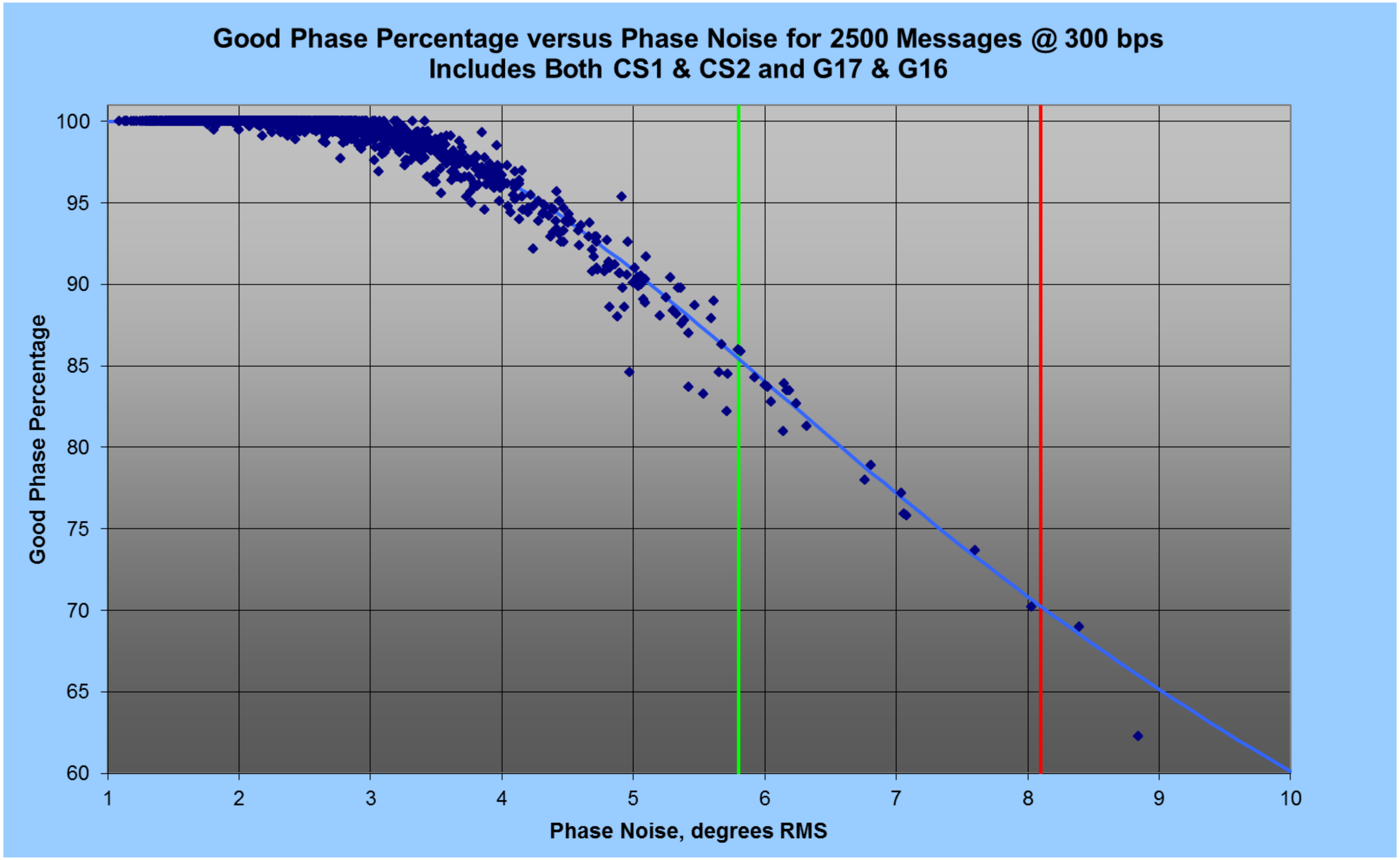
Message Stats – Phase – Batting Average

- Also Known As – "Good Phases"
  - Percentage of "Good" phase symbols relative to total.
  - Combines phase average and standard deviation into one metric.
  - Used to determine DAPS Data Quality:
    - Good: 100%-85% Fair: 85%-70% Poor: Below 70%
- What is a "Good" Phase Symbol
  - Any symbol received within ~ ±8.4° of nominal phase (0°, 45°, etc.).

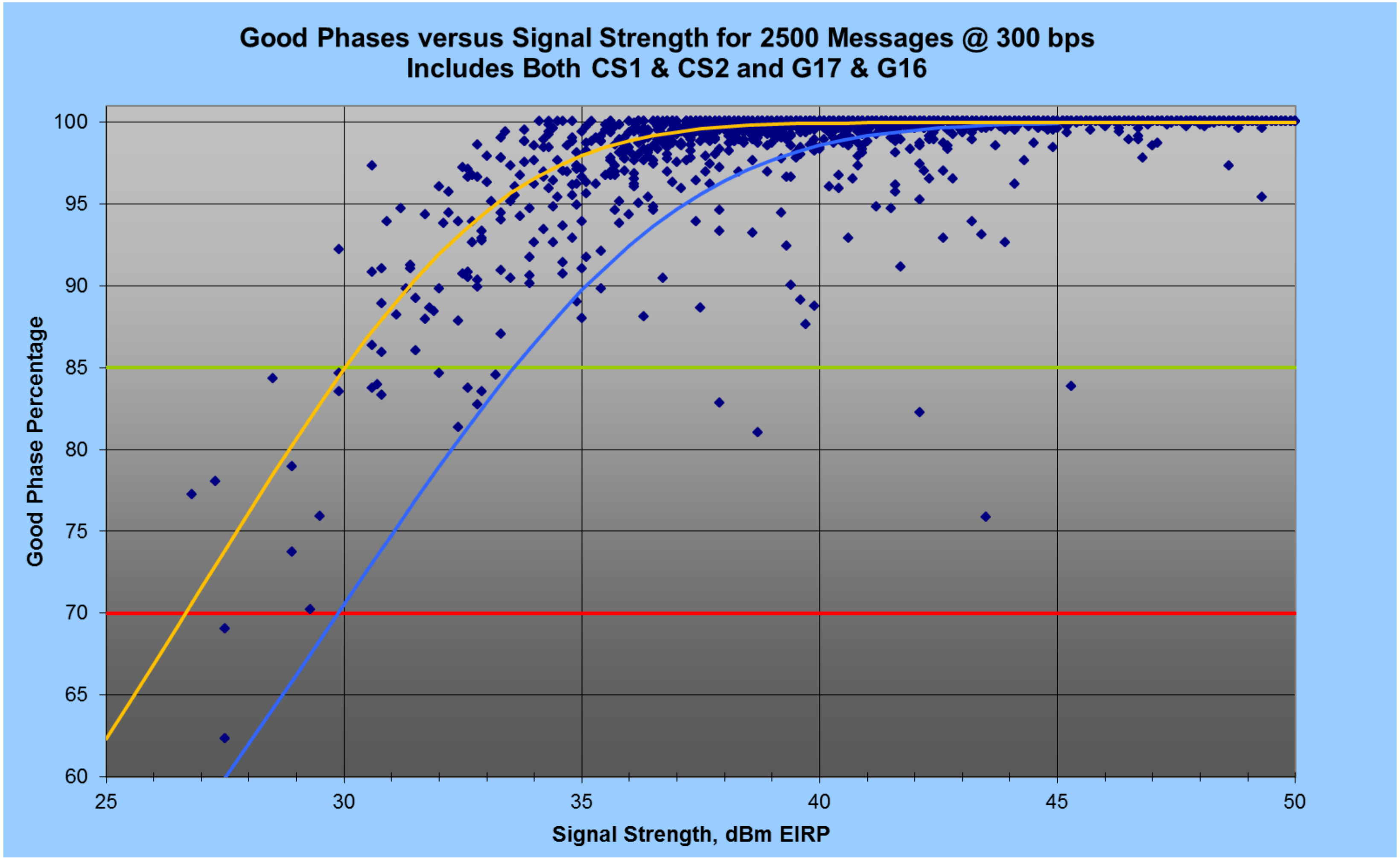


- "Good Phases" versus RMS Phase Noise with Perfect Average
  - 85% $\Rightarrow$ ~1.44σ = 8.4° $\Rightarrow$ $\sigma \approx$ 5.8°
  - 70% $\Rightarrow$ ~1.04σ = 8.4° $\Rightarrow$ $\sigma \approx$ 8.1°

Good Phases versus Phase Noise



Good Phases versus Signal Strength



Message Stats – Signal Strength – Optimum?

- 300 bps
  - 37-42 dBmi yields consistent good phase percentage in upper 90’s to 100%.
  - Optimum range is independent of CS1 or CS2.
  - Point of diminishing returns is ~43 dBmi
    - Good Phases consistently at 100%.
    - Phase Noise below 3 ° RMS.
    - Signal performance at peak ⇒ increasing signal strength provides little benefit while negatively affecting battery drain.
- 1200 bps
  - ~44 – 48 dBmi should produce equivalent results to graphs shown for 300 bps.

Message Stats – Summary – Thumb Rules

- Time:
  - Verify Message (Start-to-End) is in Window
  - Use Window Centering if Available
  - Verify Transmitter Clock is Being Synced to GPS (UTC)
- Frequency:
  - Verify Frequency Deviation is within ±400 Hz for CS1
  - Verify Frequency Deviation is within ±100 Hz for CS2
- Signal Strength:
  - Not Too High and Not too Low
  - Best If Within Optimum Range
    - 37-42 dBm EIRP @ 300 bps; 43-48 dBm EIRP @1200 bps
- Phase:
  - RMS Phase Noise Should Be Less Than 5.5°
  - Message Quality Should be Greater Than 85%

END OF PRESENTATION

"THANK YOU" FOR YOUR ATTENTION