GOES DCS
System Overview and Message Statistics

Presented by

Microcom Design, Inc.

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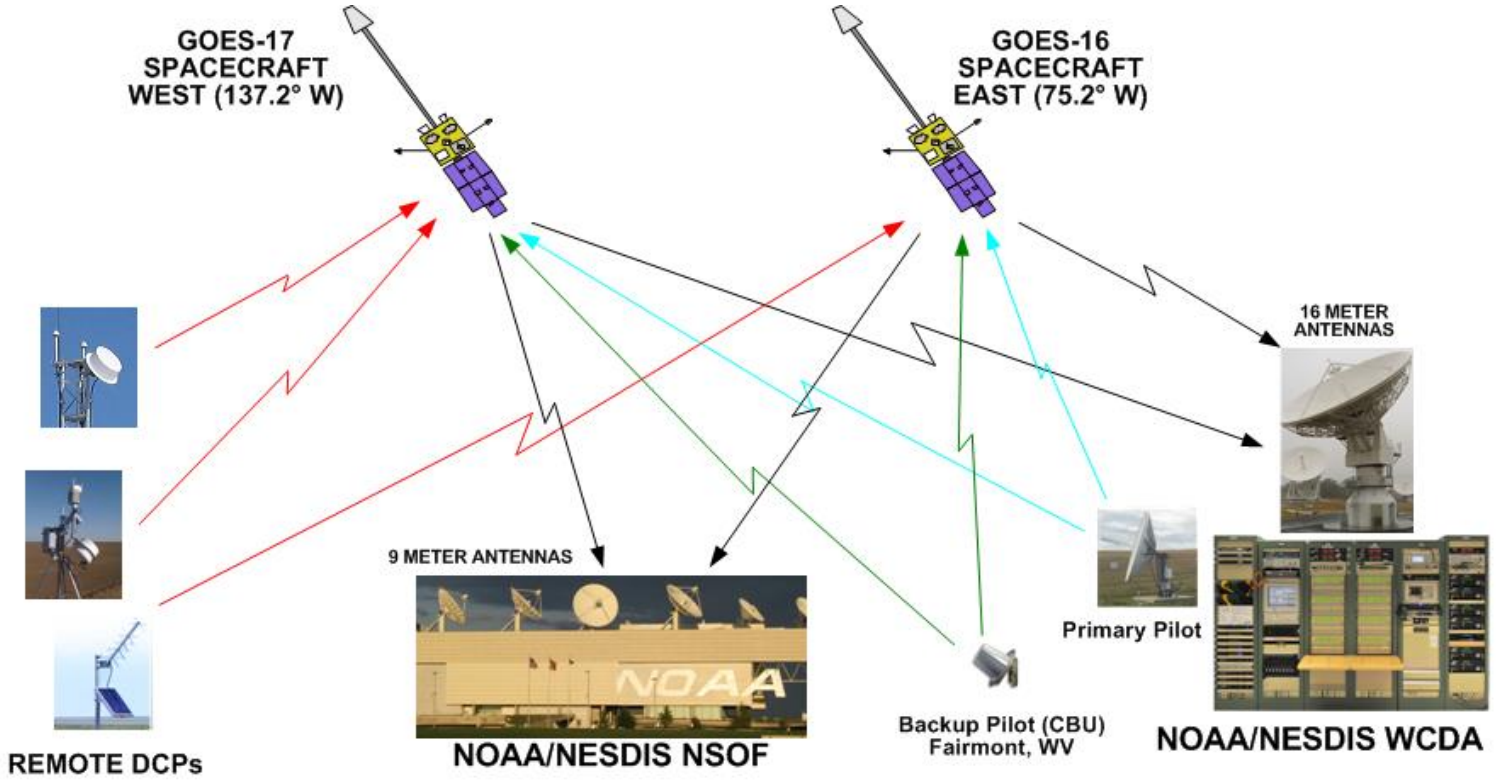
MICROCOM ENVIRONMENTAL

GOES DCS Overview: What is the Data Collection System?

- Data Relay System used for Collecting Environmental Data from Ground Based Sensors/Transmitters via Satellites to Receiving Stations.
  - NOAA = National Oceanic and Atmospheric Administration
  - NESDIS = National Environmental Satellite, Data, and Information Service
  - GOES = Geostationary Operational Environmental Satellite
- Carried on board all NOAA GOES Satellites since the 1970's.
  - GOES-1 (aka GOES-A) was launched in October 1975.
  - GOES-16 (aka GOES-R) was launched in November 2016, and became operational in December 2017.
  - GOES-17 (aka GOES-S) was launched in March 2018, and became operation in November 2018.
- Critical System used by a variety of US Government Agencies, State Agencies, Foreign Governments, and even Private Industry for Environmental and Meteorological Monitoring, Prediction and Warnings.

GOES DCS Overview: Communication Path

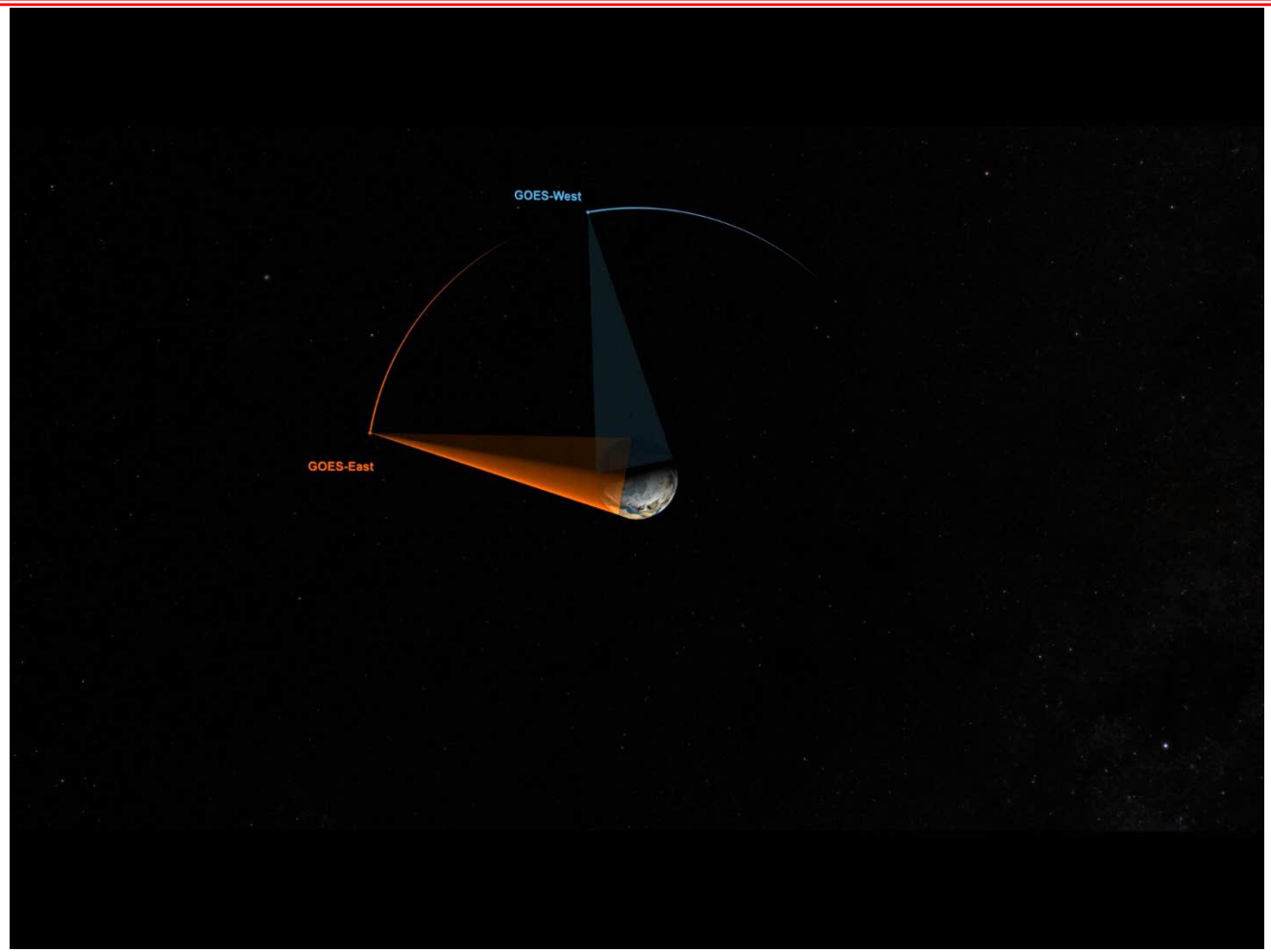


- Geostationary Satellites: GOES East @ 75.2° W and GOES West @ 137.2° W
- WCDA – Primary Receive Site NSOF – Alternate Receive Site
- DCPs Uplink in UHF Band (~402 MHz) & DCS Downlink in L Band (~1680 MHz)

GOES DCS Overview: GOES East and West Satellite Orbit

Satellites are in geosynchronous orbit: 35,786 km (22,236 mi) away from the Earth's surface.

Radio signal is attenuated by 175 dB – a factor of 3 followed by 17 zeroes or 300,000 trillion or 0.3 quintillion



(Video credit: NASA/Goddard Space Flight Center Scientific Visualization Studio)

Radio signals take 0.12 seconds to travel between satellites and Earth.

GOES East and West provide overlapping hemispherical coverage from Australia to Africa; Arctic to Antarctic.

GOES DCS Overview: 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.

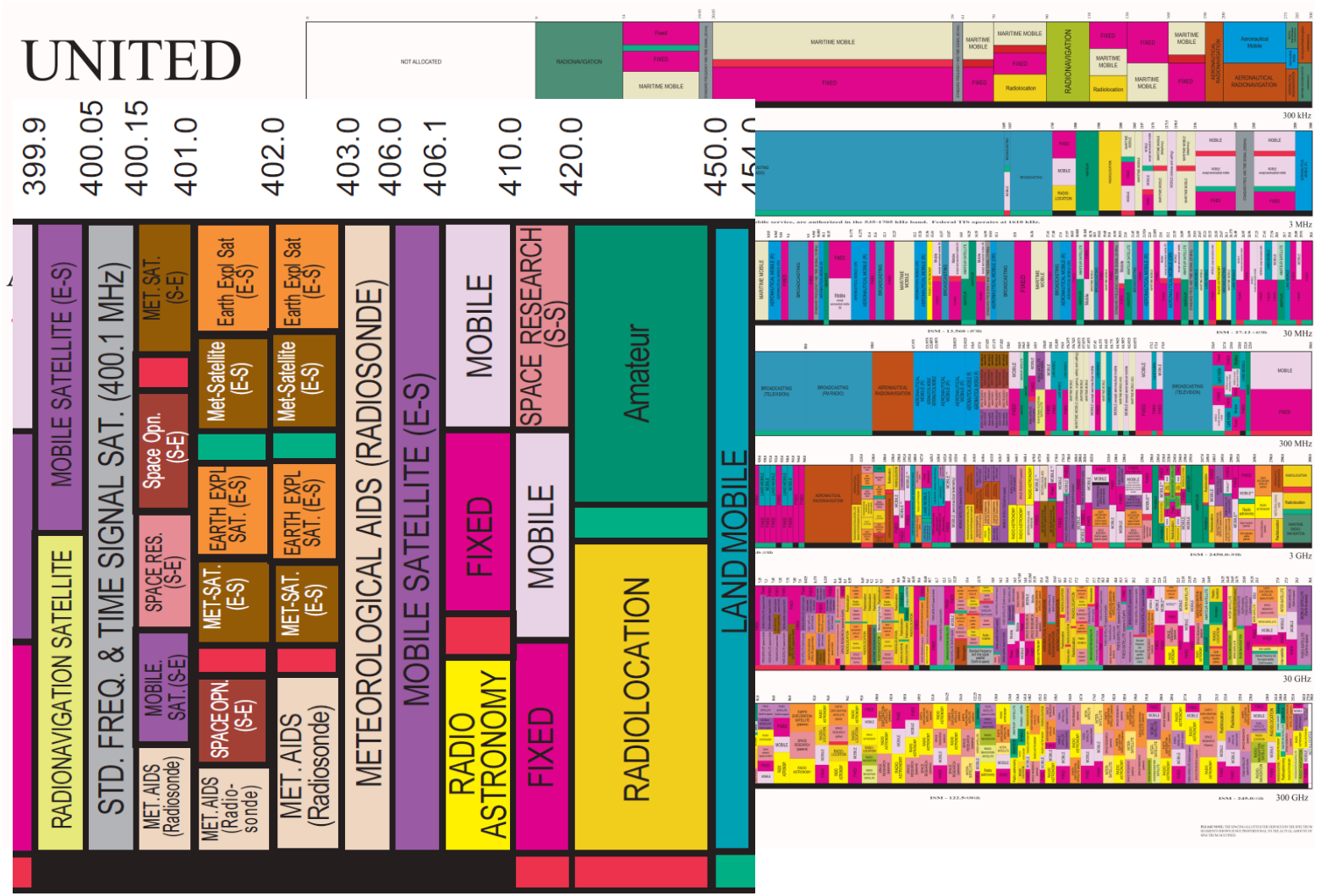
GOES DCS Overview: CS1 versus CS2

- Certification Standard 1 (CS1) was first High Data Rate (HDR) standard:
  - Adopted in March 2000
  - Replace 100 bit per second (bps) transmissions with 300 or 1200 bps (300 most common).
- Certification Standard 2 (CS2) was second generation (HDR) standard:
  - Adopted in June 2009
  - CS2 DCPs are also known as Version 2 or narrowband transmitters.
  - Narrowing of transmit Bandwidth, improvement in Frequency Stability, and reduction in Uplink Power allowed for a doubling of the channels without increasing the overall DCS bandwidth.

Specification	CS1	CS2
Total 300 bps Channel Capacity	266	532
Domestic 300 bps Channel Capacity	220	440
Total 1200 bps Channel Capacity	133	177
Domestic 1200 bps Channel Capacity	110	145
Total Frequency Bandwidth	400 kHz	400 kHz
Domestic 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
Demodulator Acquisition	±500 Hz	±150 Hz
300 bps Uplink Power (EIRP)	48 dBm	39 dBm
1200 bps Uplink Power (EIRP)	51 dBm	45 dBm

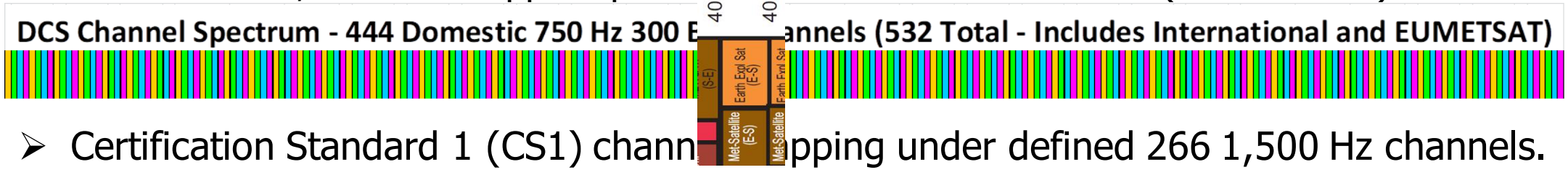
GOES DCS Overview: Frequency Utilization

- Graphic shows the spectrum allocation for the US in 2016 from 0 Hz (hertz) to 300 GHz (gigahertz, 300,000,000 hertz).
- Available online at nist.gov; produced by the National Telecommunication and Information Administration (NTIA).
- GOES DCS is a very small portion of a large frequency spectrum.

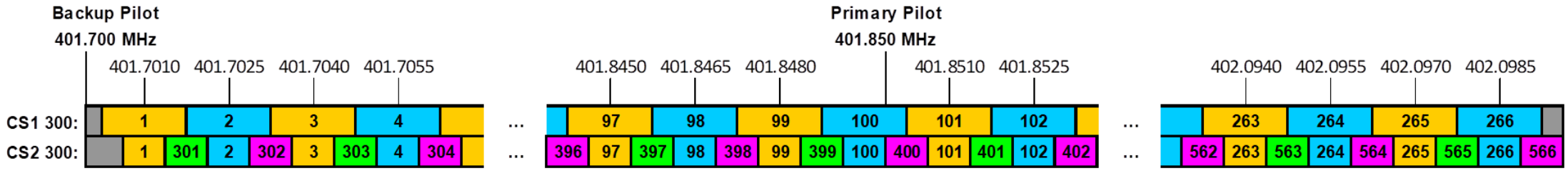


GOES DCS Overview: DCS Frequency Utilization

- DCS resides in the subsection of the 401-403 MHz spectrum and is subdivided significantly further.
  - Total GOES DCS satellite transponder covers only 400 kHz (0.4 MHz), from 401.7 MHz to 402.1 MHz, which is chopped up into total channels of 750 Hz (0.00075 MHz).



- Certification Standard 1 (CS1) chann pping under defined 266 1,500 Hz channels.
- Certification Standard 2 (CS2) changed channel mapping in 2009 to double channel capacity by cutting channels bandwidth in half.
  - New channels were designated as 301 to 566 and located in between legacy channels.
- Two Pilot frequency tones (Primary and Backup) are uplinked by NOAA to allow receive systems to precisely handle extremely narrow channels utilized on the DCS.



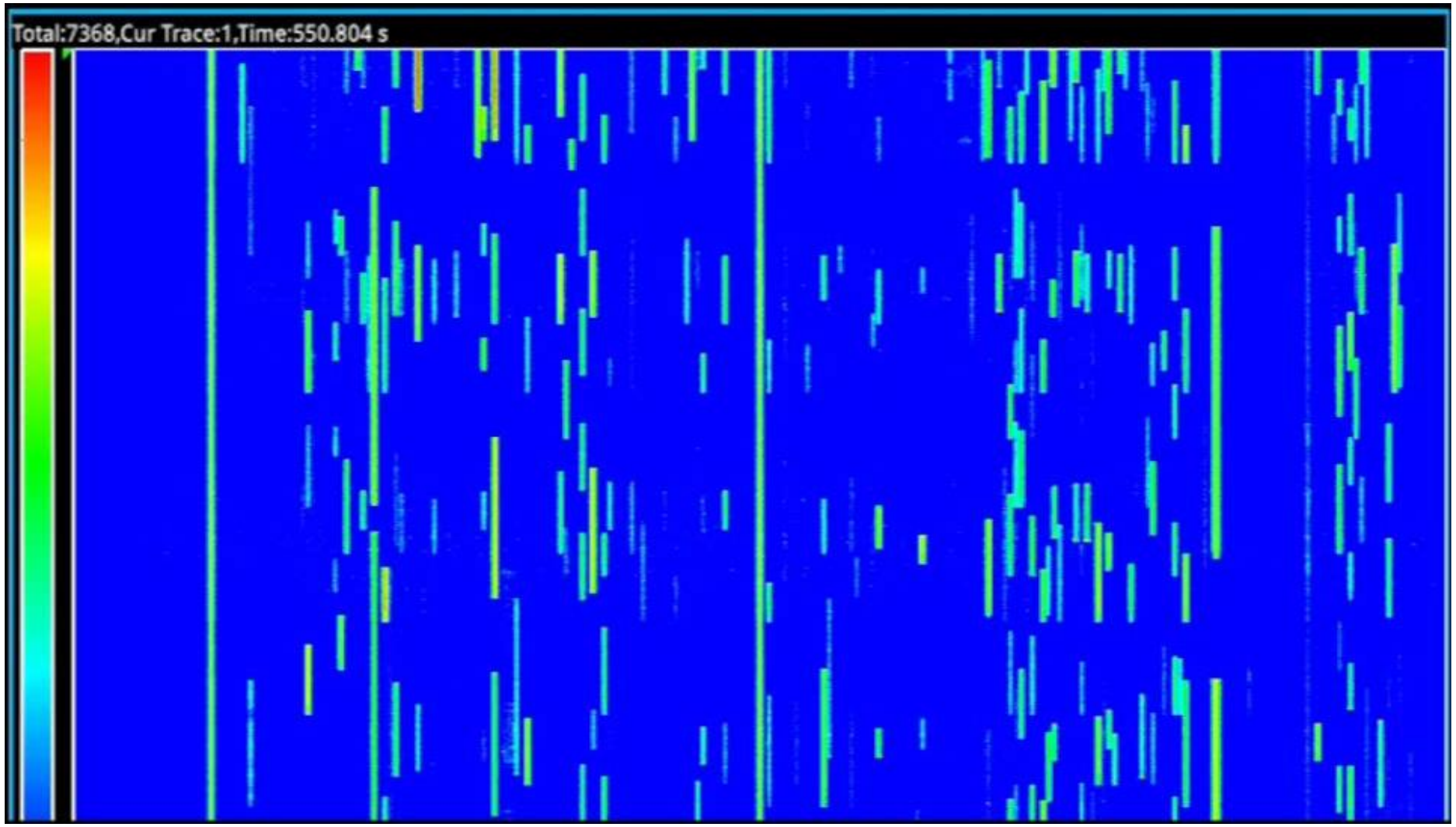
GOES DCS Overview: Self-Timed Transmissions

- Time Windows and Interval Assigned by NESDIS
  - Typically hourly transmissions with 5, 10, or 15 second windows.
  - Some special cases allowed more frequent intervals.
  - Hope to move to more frequent self-timed transmissions (i.e. 15 minute intervals) for all in future supported by additional CS2 channels, but will also require smaller windows.
    - A Binary Protocol would help support shorter windows.
  - Window and interval determine total number of platforms per channel.
    - Hourly 10-second interval allows for 360 DCPs
    - Hour = 3,600 seconds / 10 seconds = 360.
    - 15 Minute Interval with 5 second windows would allow for 180 DCPs per channel.
- Channels also assigned by NESDIS
  - Some dedicated channels for specific agencies (larger users such as USGS and USACE).
  - More typically channels are shared usage.
- Platform Owners Must Ensure DCP is Properly Configured
  - Lat/Long Tx ID system enhancement would aid in identifying misconfigured DCPs.

GOES DCS Overview: Random Transmissions

- Often utilized in conjunction with Self-Timed Transmissions.
- Allows for more frequent transmissions (5-15 minutes) as a result of some environmental event (e.g. heavy rain, high water, excessive wind, etc.).
  - Not to be used for regular non-event driven transmissions.
  - Can perform daily "I'm Alive" transmission if DCP is used in Random only operation, but shouldn't be needed if DCP is also configured for self-timed operation.
- Only requires channel assignment by NESDIS.
  - Random channels are most typically shared use.
  - Currently only 300 bps Random channels are assigned.
  - Allows for repeated 3 second maximum transmissions.
- In July 2021, NOAA published updated Random Reporting User's Guide
  - Link can be found in the "General Information" section of the "System Information" page on any of the four DCS websites (dcs1.noaa.gov dcs2.noaa.gov dcs3.noaa.gov dcs4.noaa.gov).
  - General recommendation is for 3-5 repeated transmissions on random 5-minute interval after triggering event.

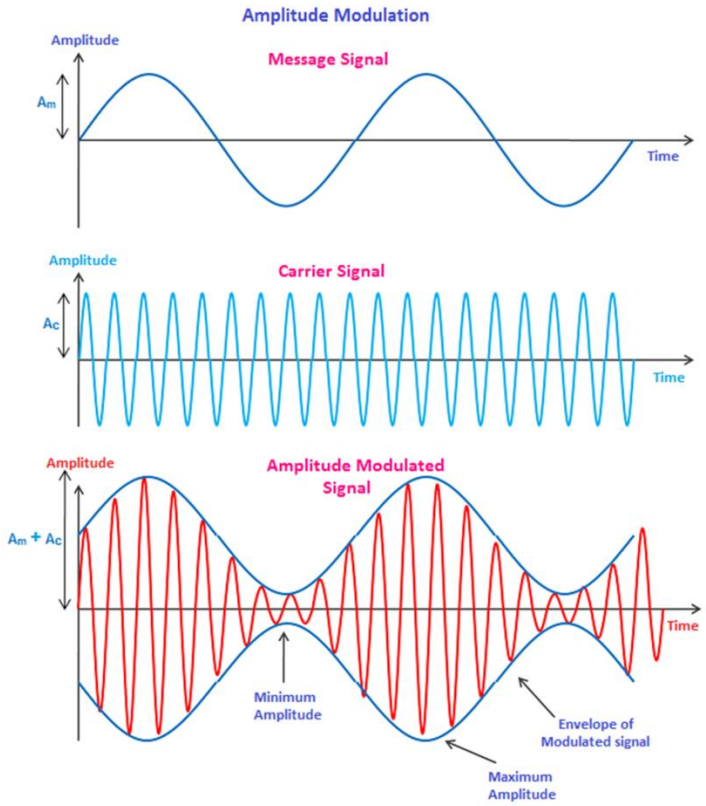
GOES DCS Overview: Frequency and Time Demonstration

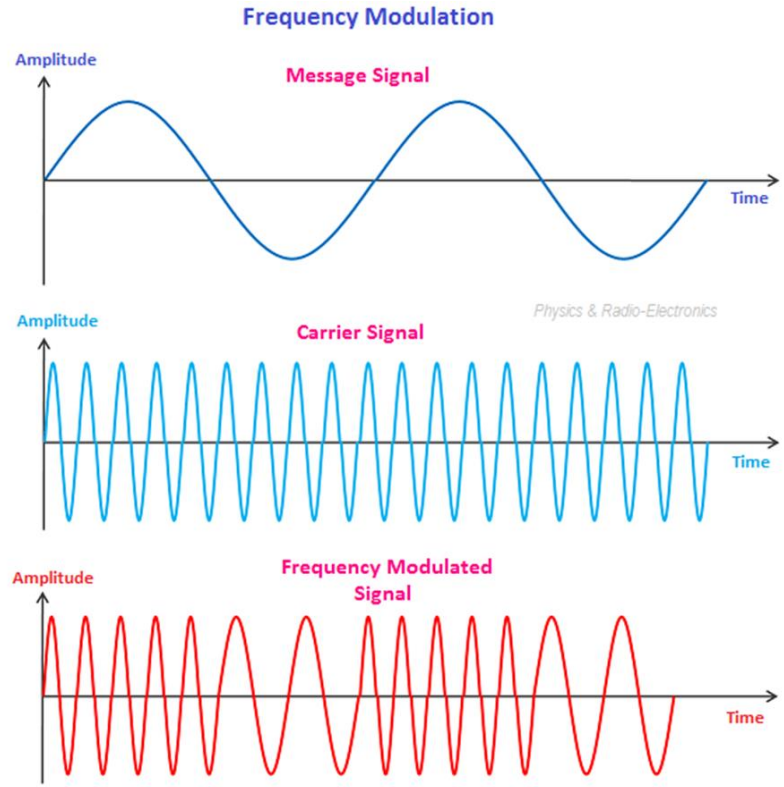


GOES DCS Overview: How is Information Transmitted?

- Modulation – Varying one or more characteristics of the carrier (aka center) frequency.
- Analog signals (audio/video) were originally transmitted using

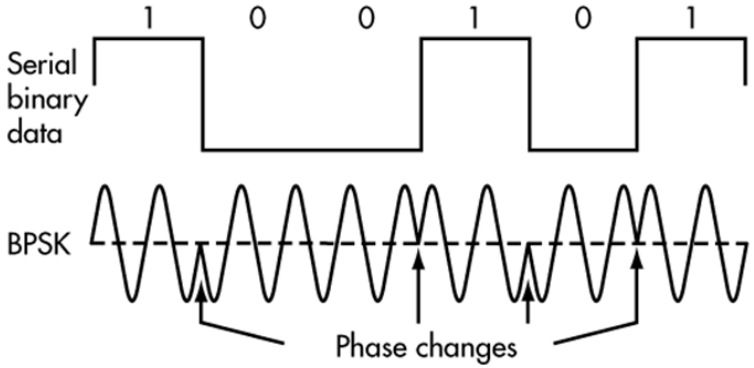
  Amplitude Modulation (AM) or Frequency Modulation (FM)

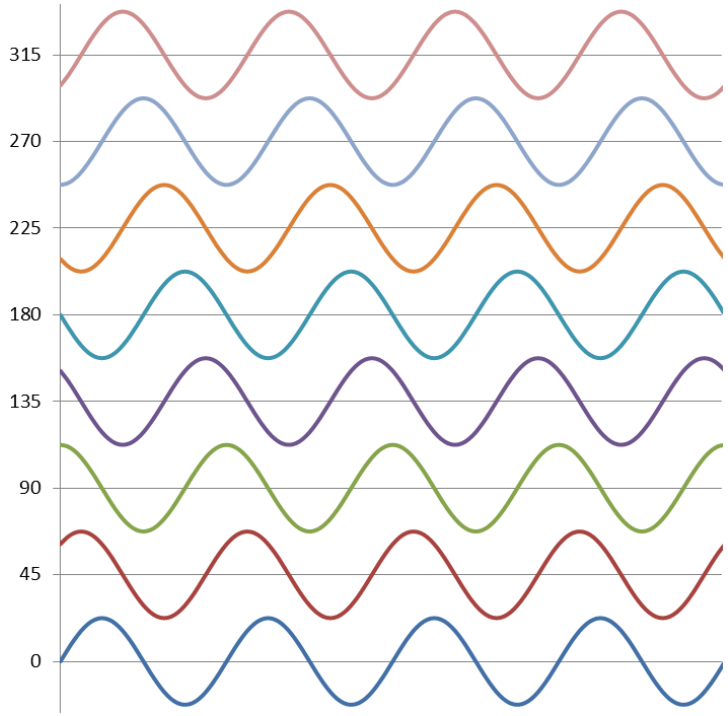




GOES DCS Overview: DCS Info - Phase Modulation

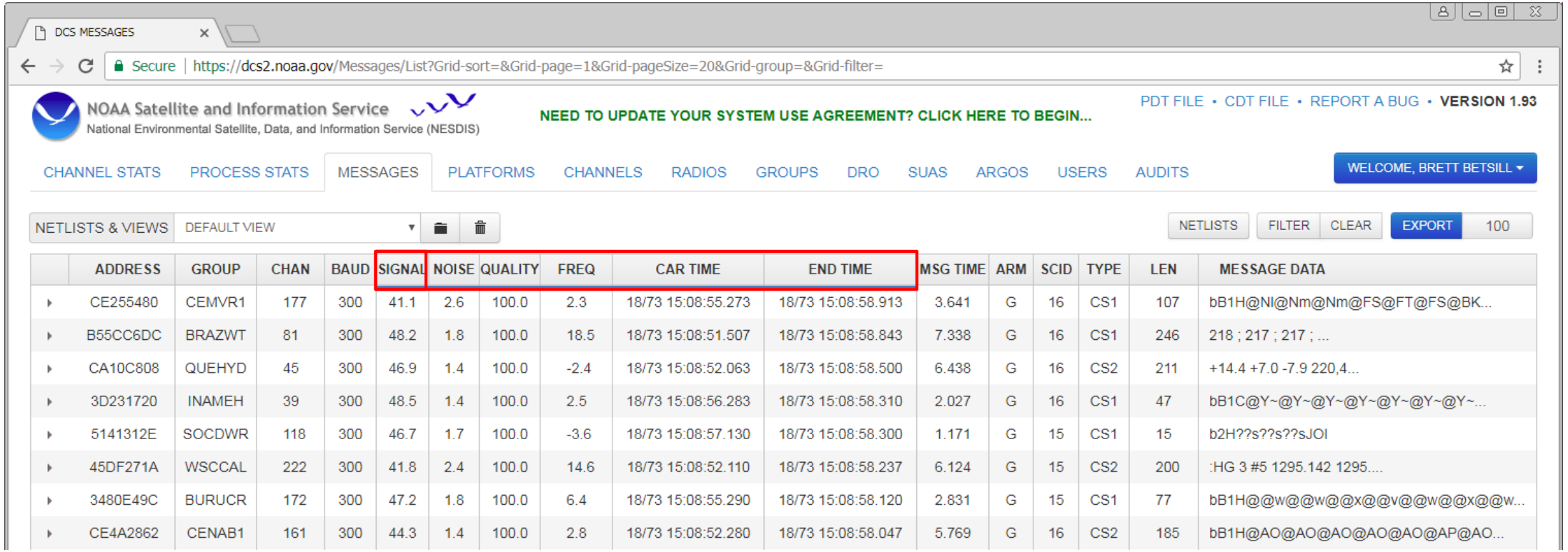
- Digital data sent using Phase Modulation (PM); also called Phase Shift Keying (PSK).
  - Phase is the relative position of a sine wave to a reference signal.
- Original 100 bps DCS transmission were done using Binary PSK (BPSK).
  - One of two phases used to transmit a “0” or a “1”.





- High Date Rate (HDR) DCS (300 or 1200 bps) transmissions use Octal PSK (8PSK).
  - One of ***eight*** phases used to transmit information.
  - Each phase or symbol conveys three *bits* (binary digits – 0 or 1) of information, but the distinction between phases is more difficult to determine.
  - This means that the phase modulation performance of a transmitter is more critical for HDR DCS.

GOES DCS Overview: DADDS Message Statistics



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...

SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME

SIGNAL: Power Level or Signal Strength of transmitted message as measured by receiver.

Message Statistics: Signal Strength – Bad?

- *Distance to satellite and nature of demods requires proper power …*
- Too Low
  - Missed messages – DCS 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
  - Demodulator overload – DCS demods have maximum reception threshold of 56 dBm EIRP, which should never be an issue with a CS2 platform.
  - Violation of certification and use agreements.
  - Not being a good neighbor – excessive transmit powers increases noise which lowers SNR for others.
  - Unnecessary battery discharge.

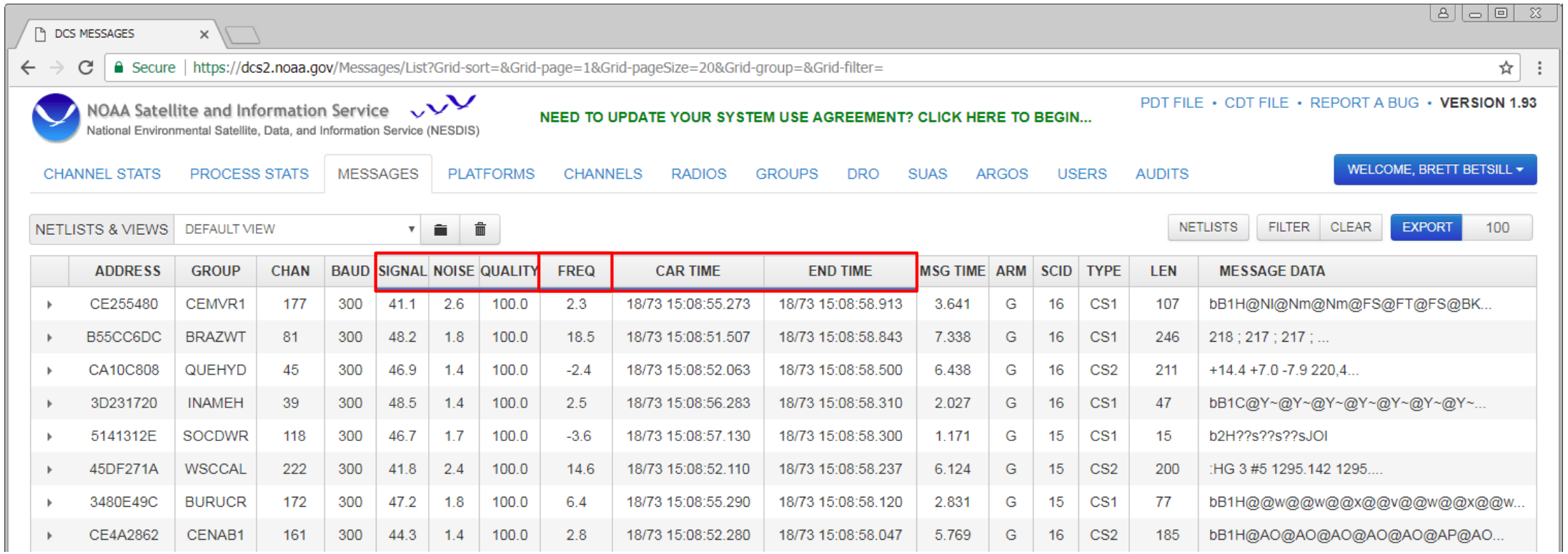
Message Statistics: Signal Strength – Good?

- 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**

GOES DCS Overview: DADDS Message Statistics



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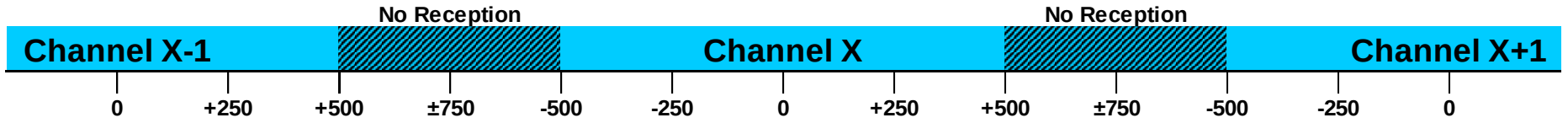
CE4A2862	CENAB1	161	300	44.3	1.4	100.0	2.8	18/73 15:08:52.280	18/73 15:08:58.047	5.769	G	16	CS2	185	bB1H@AO@AO@AO@AO@AO@AP@AO...

SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME

FREQ: Frequency offset from channel center in Hertz (Hz).

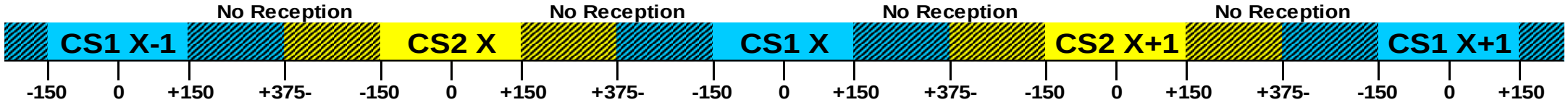
Message Statistics: Frequency – Where Are You?

- *Small Channels used on DCS require precision control at transmitter …*
- DCS 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.

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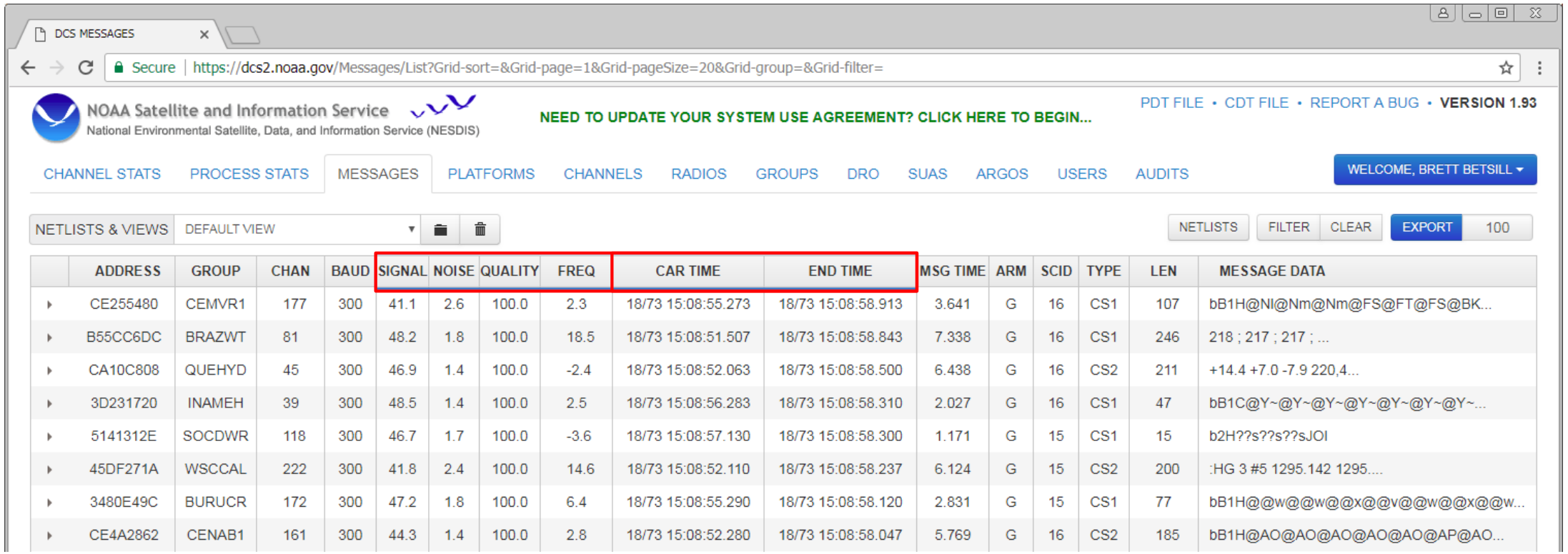

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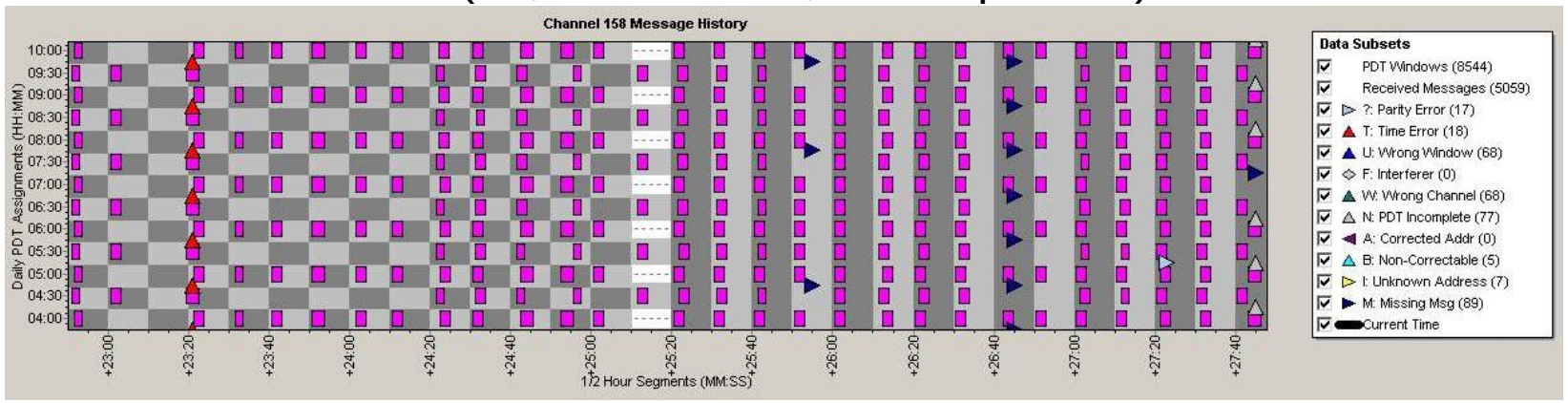
SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME

CAR TIME: UTC start time of transmission as determined by the receiver.
END TIME: UTC end time of transmission as determined by the receiver.

Message Statistics: Time – Why is it Important

- Each Self-Timed DCP has a defined Time Window.
  - 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.
  - Time windows and time stamps are in UTC (Coordinated Universal Time), which is same as GMT (Greenwich Mean Time).
  - Time stamps are captured down to the millisecond.
- Need to account for travel time to/from GOES spacecraft.
  - ~0.24 second travel time (72,000 km / 300,000 km per sec)



Message Statistics: 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.

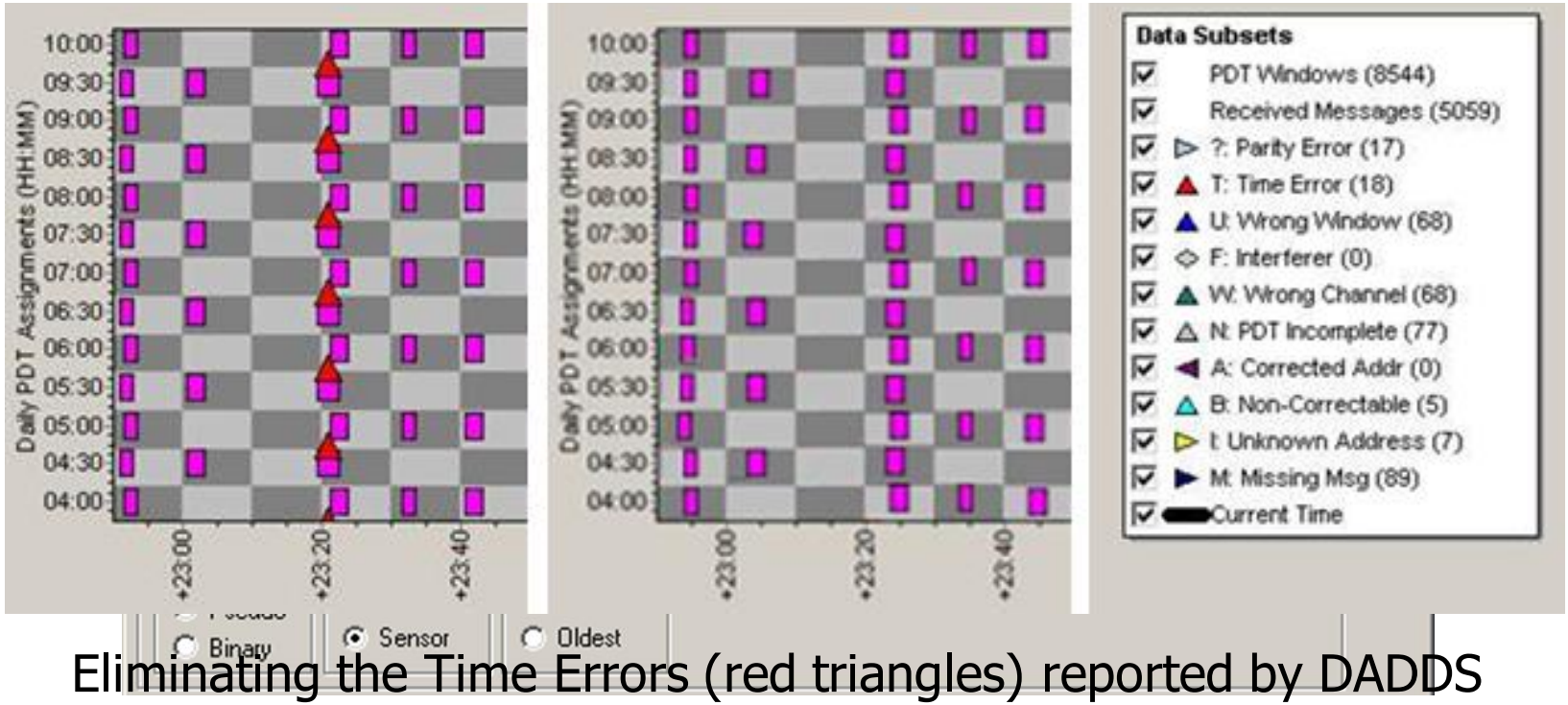
- Deciphering the Flag Byte/Character:
  - ASCII Message:
    - No Time Sync: Space (0x20)
    - GPS Time Sync: " Double Quote (0x22)
  - Pseudo-Binary:
    - No Time Sync: ` Tic Mark (0x60)
    - GPS Time Sync: b (0x62)

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 ...

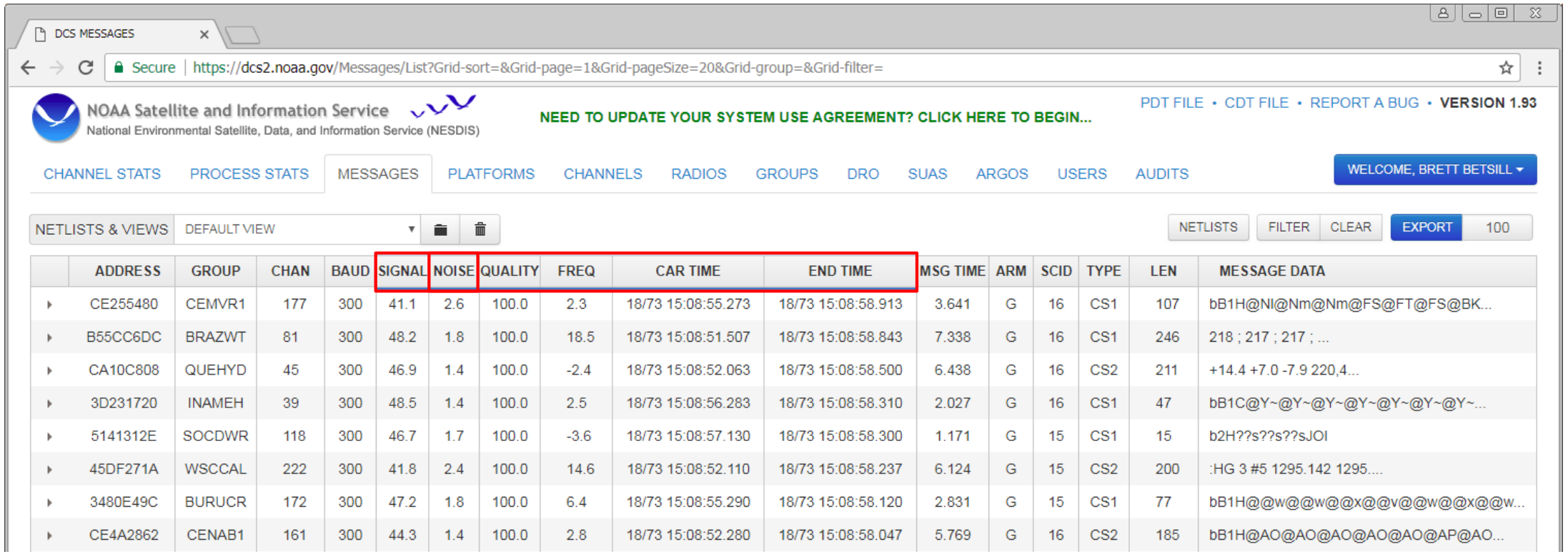
Message Statistics: Time – Making Sure

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



Eliminating the Time Errors (red triangles) reported by DADDS

GOES DCS Overview: DADDS Message Statistics



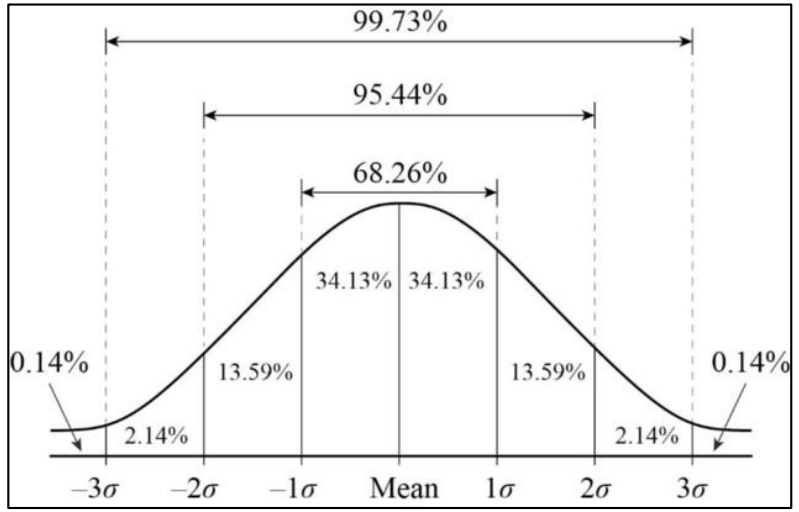
ADDRESS	GROUP	CHAN	BAUD	SIGNAL	NOISE	QUALITY	FREQ	CAR TIME	END TIME	MSG TIME	ARM	SCID	TYPE	LEN	MESSAGE DATA
CE255480	CEMVR1	177	300	41.1	2.6	100.0	2.3	18/73 15:08:55.273	18/73 15:08:58.913	3.641	G	16	CS1	107	bB1H@NI@Nm@Nm@FS@FT@FS@BK...
B55CC6DC	BRAZWT	81	300	48.2	1.8	100.0	18.5	18/73 15:08:51.507	18/73 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...

SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME

NOISE: Variation or Noise of phase modulation; also known as Phase Noise.

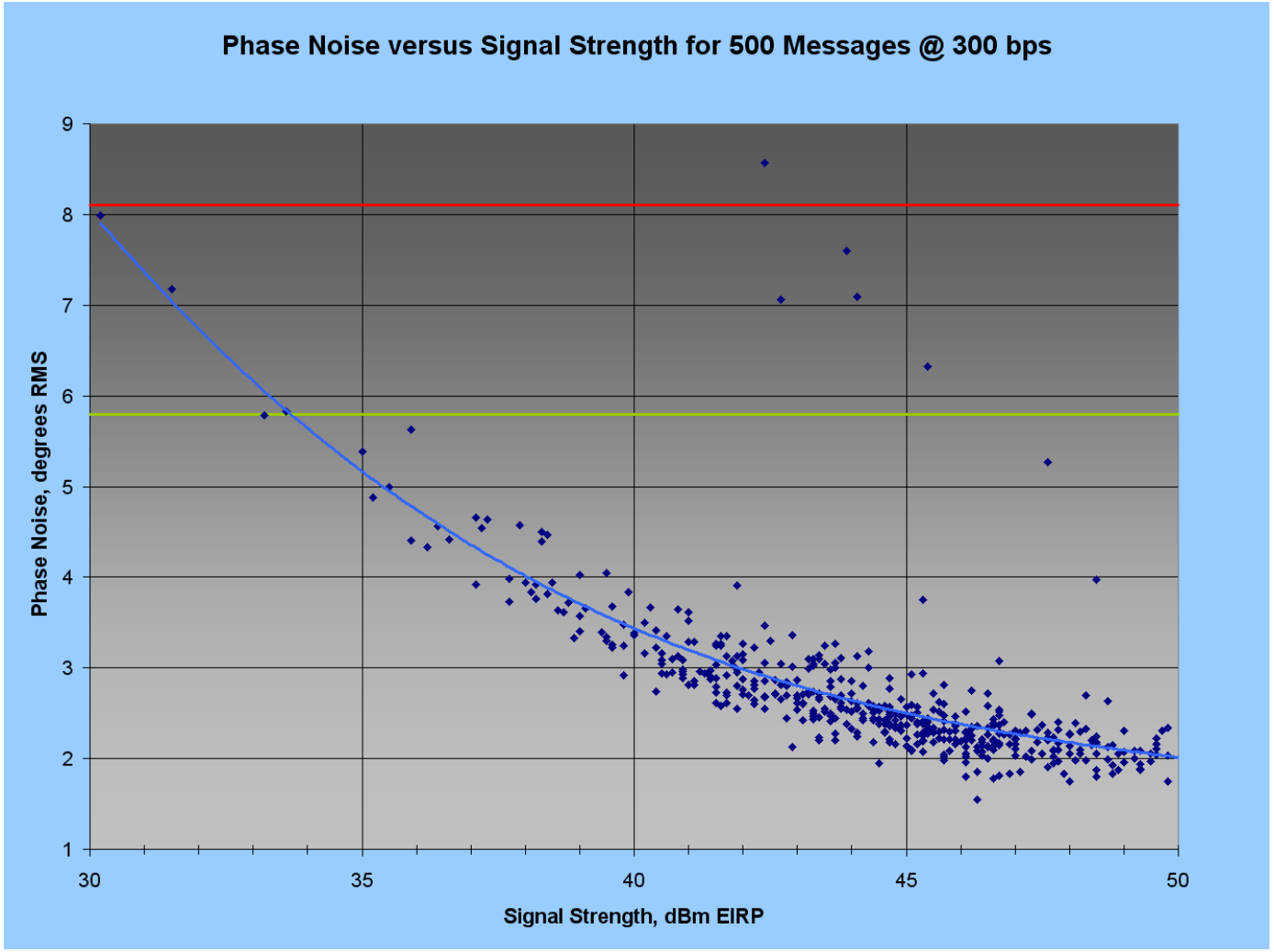
Message Statistics: RMS Phase Noise

- *Use of Phase Modulation by DCS means "Phase Noise" is a critical parameter …*
- Standard Deviation (designated by σ - sigma) of Phase Symbols Relative to Average
  - 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



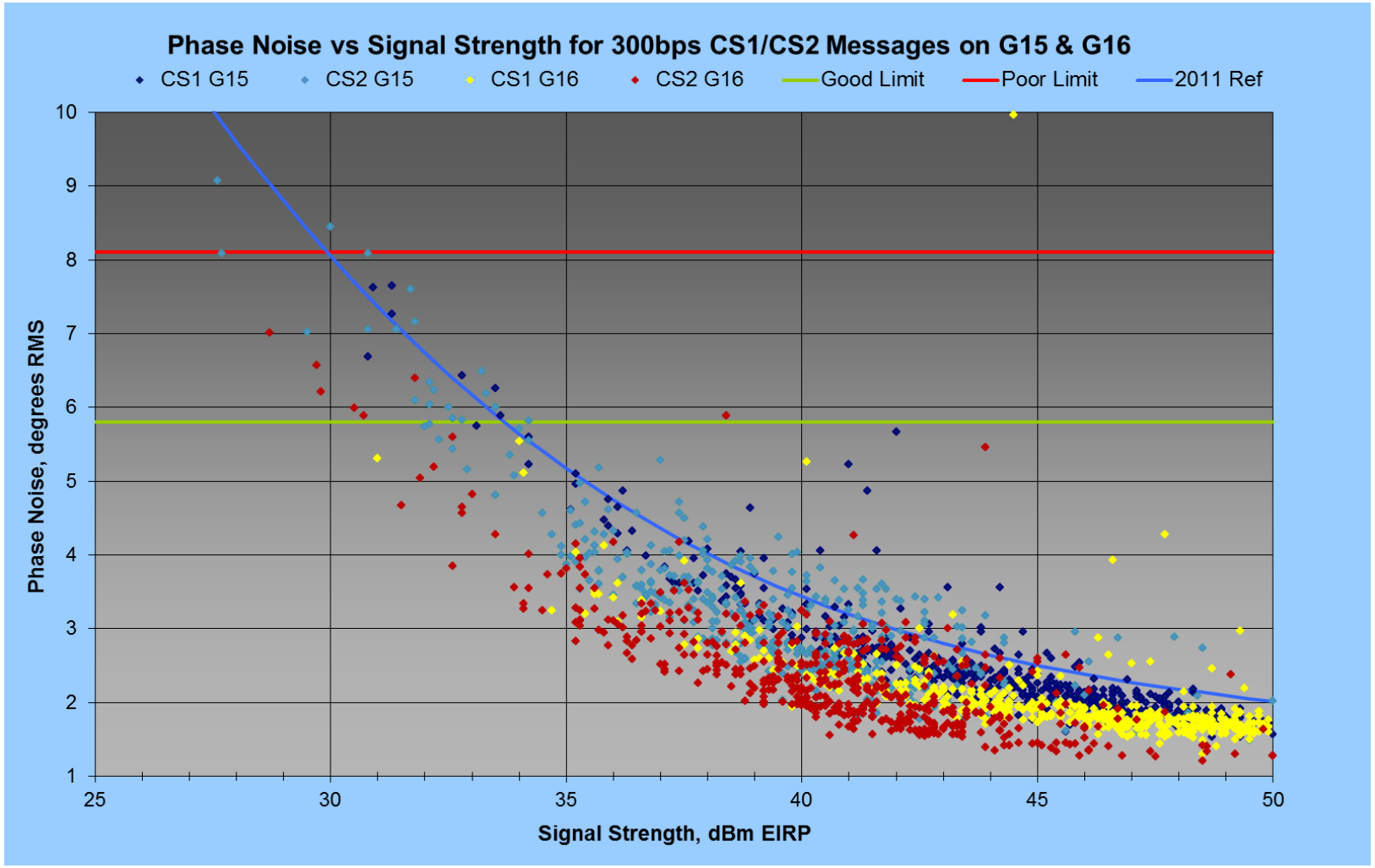
- Good, Fair, and Poor …
  - 300 bps: Good < 6.0° < Fair < 8.0° < Poor
  - 1200 bps: Good < 5.5° < Fair < 7.5° < Poor
- Lower Limit
  - Can never be less than 0
  - Typically, never less than 1.5° - 2.0° (due to Satellite Link Budget)
- Upper Limit
  - Reception barely possible around 11° - 12° (short messages)
  - Beyond 13° highly unlikely.
- Seeing Phase Noise Improvement due to CS2 and GOES-R

Message Statistics: Phase Noise vs. Signal Strength - 2011



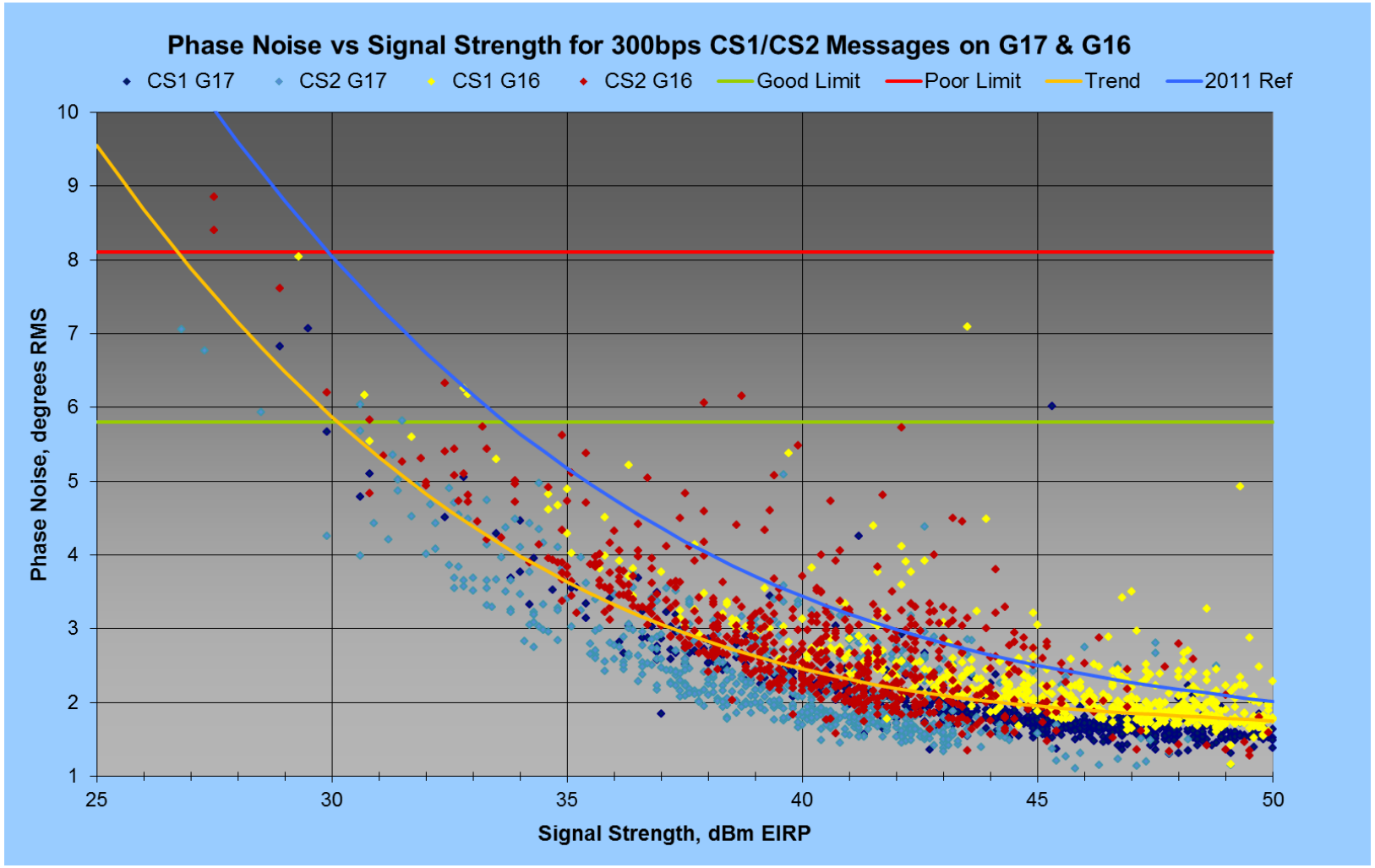
- In 2011, CS1 and the GOES-NOP series satellites were in use.
- Phase noise was and is a strong function of transmit signal strength.
- Phase noise did not begin to "flatten" out until signal strength exceeded ~ 45 dBm EIRP.

Message Statistics: Phase Noise vs. Signal Strength - 2018



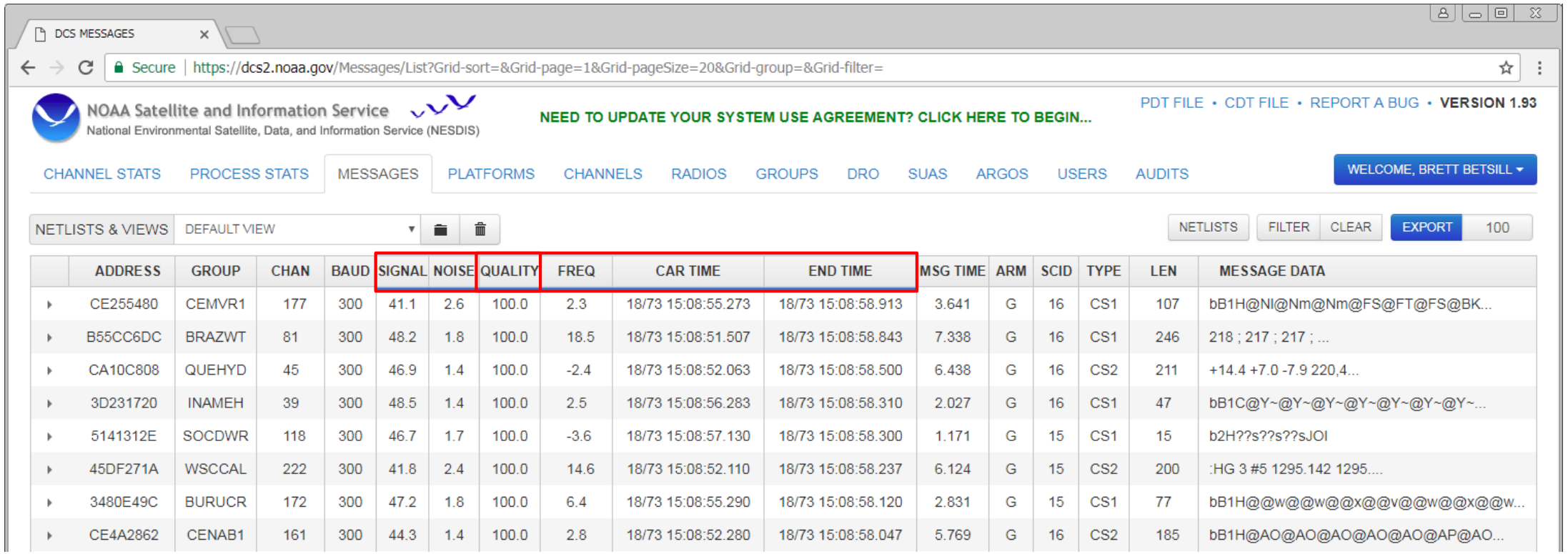
- GOES-East had become GOES-16 (aka GOES-R) and CS2 transmitters were gaining substantial use.
- GOES-West was still GOES-15 (aka GOES-P) and there were still a lot of DCPs using CS1 transmitters.
- Resulted in four distinct groupings:
  CS1/G15, CS2/G15
  CS1/G16, CS2/G16

Message Statistics: Phase Noise vs. Signal Strength - 2019



- GOES-West became GOES-17 (aka GOES-S).
- Four Groupings noted in 2018, merged into two determined by CS1 versus CS2.
- All groupings generally below 2011 trend line.
- New trend line begins flattening out around 40 dBm EIRP.
- Confirming new CS2 levels.

GOES DCS Overview: DADDS Message Statistics



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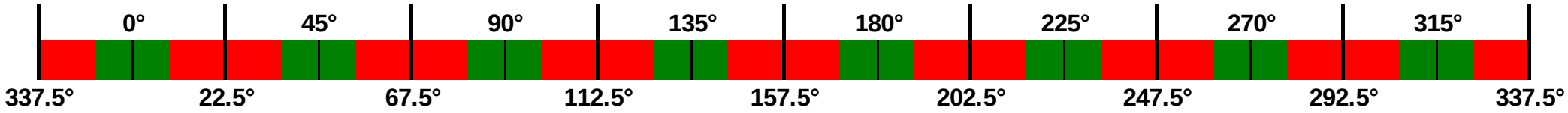
B55CC6DC	BRAZWT	81	300	48.2	1.8	100.0	18.5	18/73 15:08:51.507	18/73 15:08:58.843	7.338	G	16	CS1	246	218 ; 217 ; 217 ; ...
CA10C808	QUEHYD	45	300	46.9	1.4	100.0	-2.4	18/73 15:08:52.063	18/73 15:08:58.500	6.438	G	16	CS2	211	+14.4 +7.0 -7.9 220,4...
3D231720	INAMEH	39	300	48.5	1.4	100.0	2.5	18/73 15:08:56.283	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...

SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME

QUALITY: Good Phase Percentage of message.

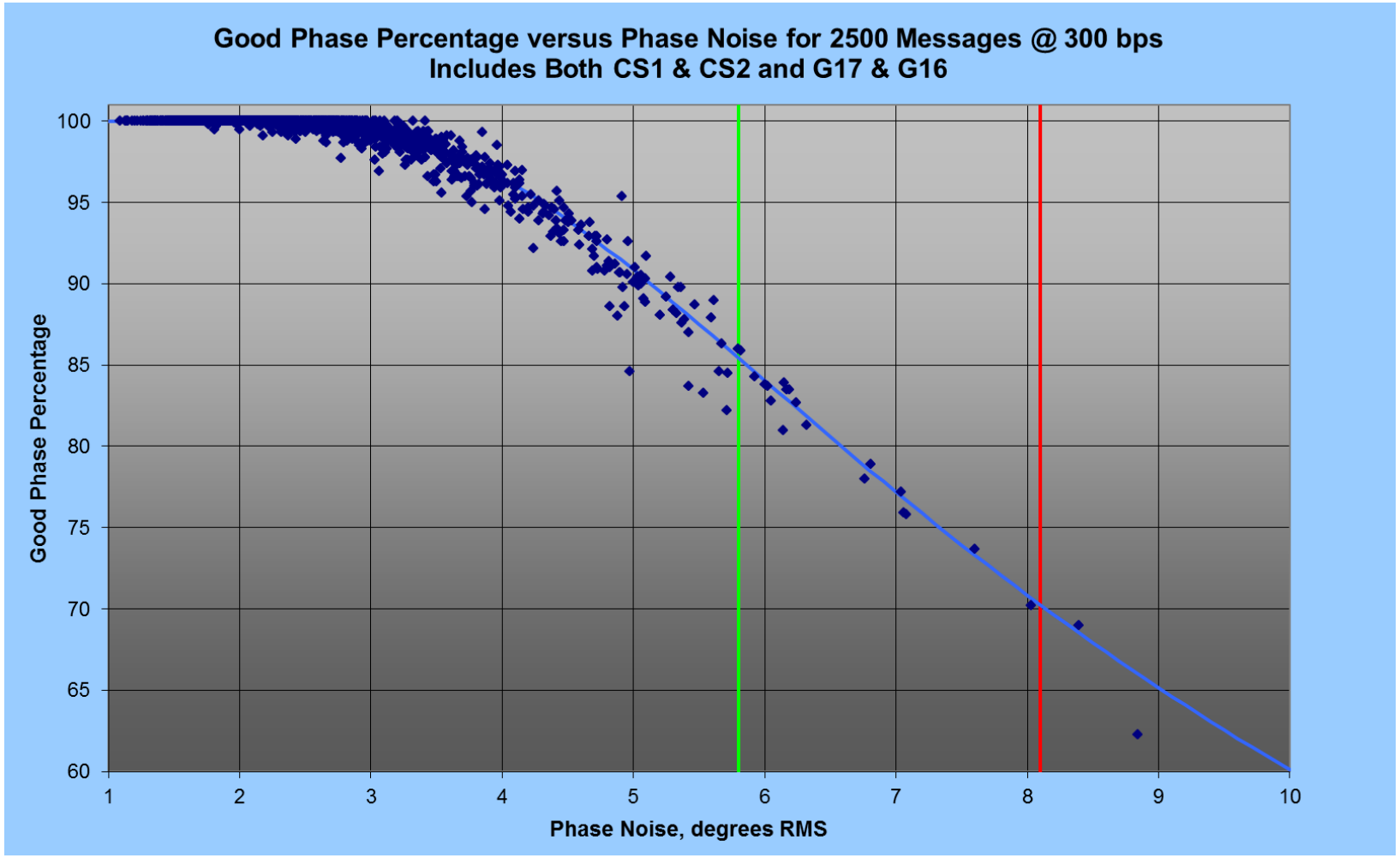
Message Statistics: "Quality" Percentage

- Also Known As – "Good Phases" and "Batting Average"
  - Percentage of "Good" phase symbols relative to total.
  - Combines phase average and standard deviation (aka Phase Noise) into one metric.
  - Also used to determine overall Good/Fair/Poor 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.).



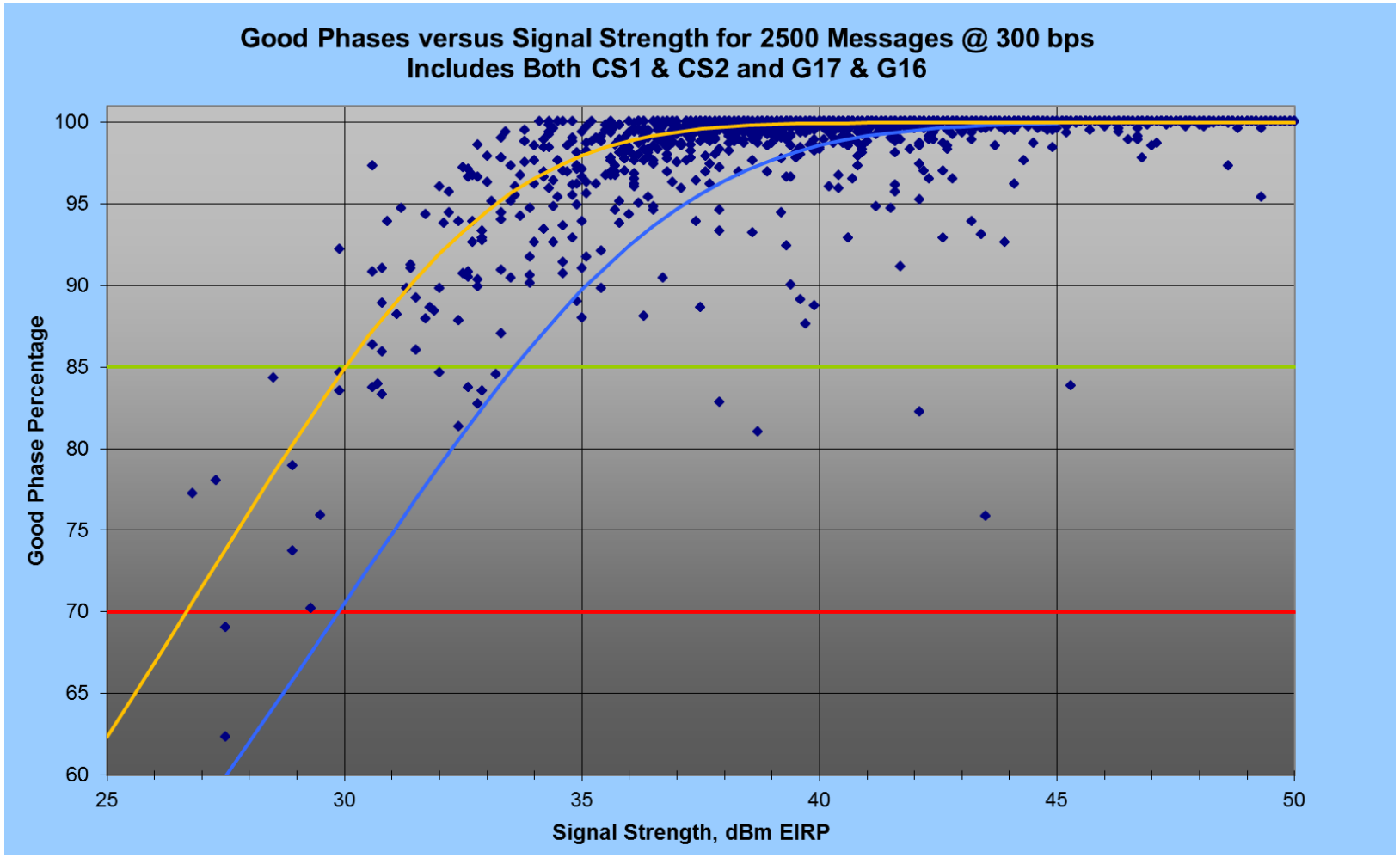
- "Good Phases" versus RMS Phase Noise with Perfect Average
  - 85% $\Rightarrow$ $\sim 1.44\sigma = 8.4° \Rightarrow \sigma \approx 5.8°$
  - 70% $\Rightarrow$ $\sim 1.04\sigma = 8.4° \Rightarrow \sigma \approx 8.1°$
  - These limits are in agreement with RMS Phase Noise limits noted on slide 24.

Message Statistics: Good Phases versus Phase Noise



- Since Good Phase statistic is a strong function of RMS Phase Noise, graphing Good Phase versus Phase Noise shows a strong correlation.
- Good Phase score flattens out at 100% below 3°.

Message Statistics: Good Phases versus Signal Strength

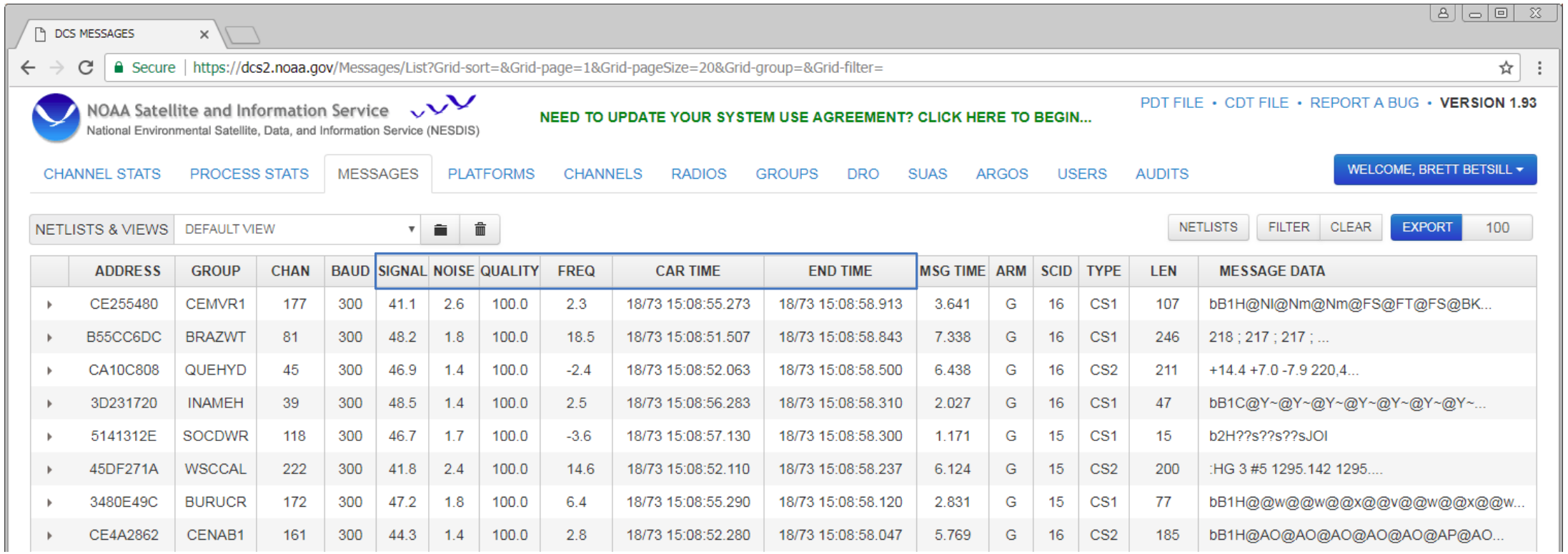


- Plotting Good Phase scores against Signal Strength clearly shows why a target signal strength of 39 dBm is specified.
- Ignoring outliers, at signal strengths above 37 dBm EIRP Good Phase flattens out at 100%.
- Blue line is 2011 trend; yellow is current trend (same as in slide 27).

Message Statistics: Signal Strength – Optimum?

- 300 bps
  - 37-41 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 life.
- 1200 bps
  - ~43 – 47 dBmi should produce equivalent results to graphs shown for 300 bps.

GOES DCS Overview: DADDS Message Statistics



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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...

SIGNAL, NOISE, QUALITY, FREQ, CAR TIME, END TIME … also known as
Signal Strength, Phase Noise, Good Phase Percentage, Time Window Alignment

Message Statistics: Summary – Thumb Rules

- Signal Strength:
  - Not Too High and Not too Low
  - Best If Within Optimum Range regardless of CS1 or CS2
    - 37-41 dBm EIRP @ 300 bps; 43-47 dBm EIRP @1200 bps
- Phase:
  - RMS Phase Noise Should Be Less Than 5.5°
  - Message Quality Should be Greater Than 85%
- Frequency:
  - Verify Frequency Deviation is within ±400 Hz for CS1
  - Verify Frequency Deviation is within ±100 Hz for CS2
- Time:
  - Verify Message (Start-to-End) is in Window
  - Use Window Centering if Available
  - Verify Transmitter Clock is Being Synced to GPS (UTC)

Thank you for your attention!

Questions?

Presented by

Microcom Design, Inc.

August 2022

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