DAMAGE ANALYSIS WITH GLYPHWORKS FOR AWD GEAR COMPONENTS

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5/1/13

My Objectives

- #1 Goal = calculate gear damage for PTU hypoid, RDU hypoid & RDU differential gears.
- #2 Verify RLD
  - What channels are available?
  - What are the sampling frequencies?
  - What are the units?
  - Are these parameters common between data sets?
- #3 Configure channels into working channels
- #4 Inspect data; spikes, data zoids, within limits?
- #5 Create individual histograms and check histograms
- #6 Calculate individual histogram damage and check damage
- #7 Create duty cycle histogram and double check
- #8 Create Rainflows, etc

Verify Data

- My primary goal is to “show my work”!
- I like to leave a work trail that can be revisited.
- I use Excel; Excel and Glyphworks compliment eachother.

CHANNEL TITLES	CHANNELS	SAMPLING FREQ	UNITS
DS_TORQ	CHAN31	500Hz	FTLBS
WHSPD_LF	CHAN70	50Hz	KPH
WHSPD_RF	CHAN71	50Hz	KPH
WHSPD_LR	CHAN72	50Hz	KPH
WHSPD_RR	CHAN73	50Hz	KPH
LF_TORQ	CHAN52	500Hz	FTLBS
RF_TORQ	CHAN53	500Hz	FTLBS
LR_TORQ	CHAN54	500Hz	FTLBS
RR_TORQ	CHAN55	500Hz	FTLBS
TRN_GEAR	CHAN74	50Hz	GEAR
ENG_SPD	CHAN65	50Hz	RPM
VEH_SPD	CHAN66	50Hz	KPH
GPS_SPD	CHAN93	50Hz	MPH

Configure Working Channels

- Tips:
  - Use a common sampling frequency (500Hz is fine)
  - Use common units; I like SI (Nm & RPS)
  - Use Excel to write out your equations, then copy paste into Glyphworks Timeseries calculators.

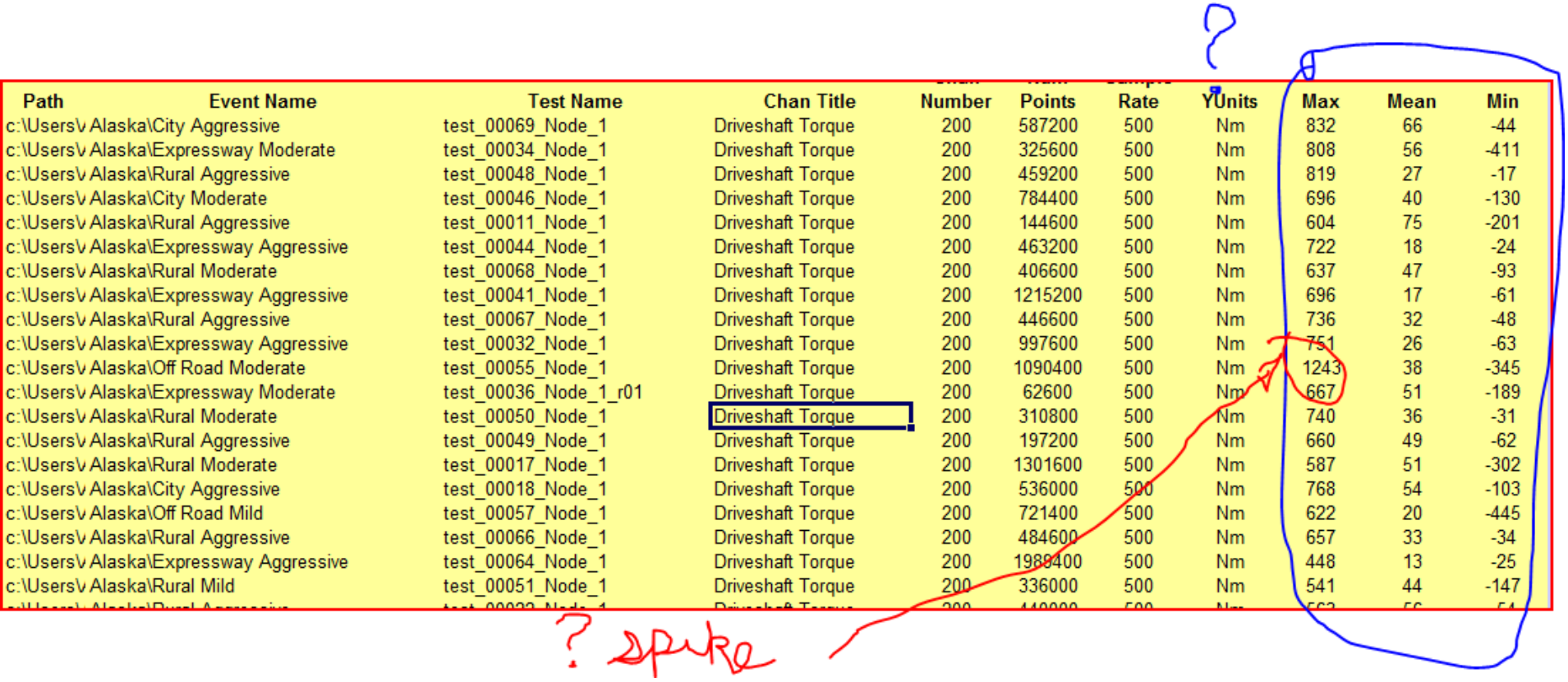
CHANNEL TITLES	EQUATIONS	SAMPLING FREQ	UNITS
ACTUAL DRIVESHAFT TORQ	CHAN31*1.35582	500Hz	NM
DRIVESHAFT TQ CALCULATED FROM HALFSHAFT TRANSDUCERS	(CHAN54+CHAN55)*(41/14)*1.35582	500Hz	NM
CALCULATED TRANS DIFF TORQ	((CHAN52+CHAN53)+((CHAN54+CHAN55)/0.95^2))*1.35582	500Hz	NM
RDU RING GEAR TORQ	(CHAN54+CHAN55)*1.35582	500Hz	NM
PTU OUTPUT SPEED	((CHAN70+CHAN71)/2)*(1/3600)*468	500Hz	RPS
RDU INPUT SPEED	((CHAN72+CHAN73)/2)*(1/3600)*468	500Hz	RPS
RDU DIFFERENTIAL SPEED	ABS(CHAN72-CHAN73)*(1/3600)*468	500Hz	RPS

Inspect Data

- Now that your data has been converted into “working channels” – does it make sense???
- Use Meta data display glyphs to compare max, min and mean values.
- Use Timeseries display glyphs to visualize each file.

Meta Data Display

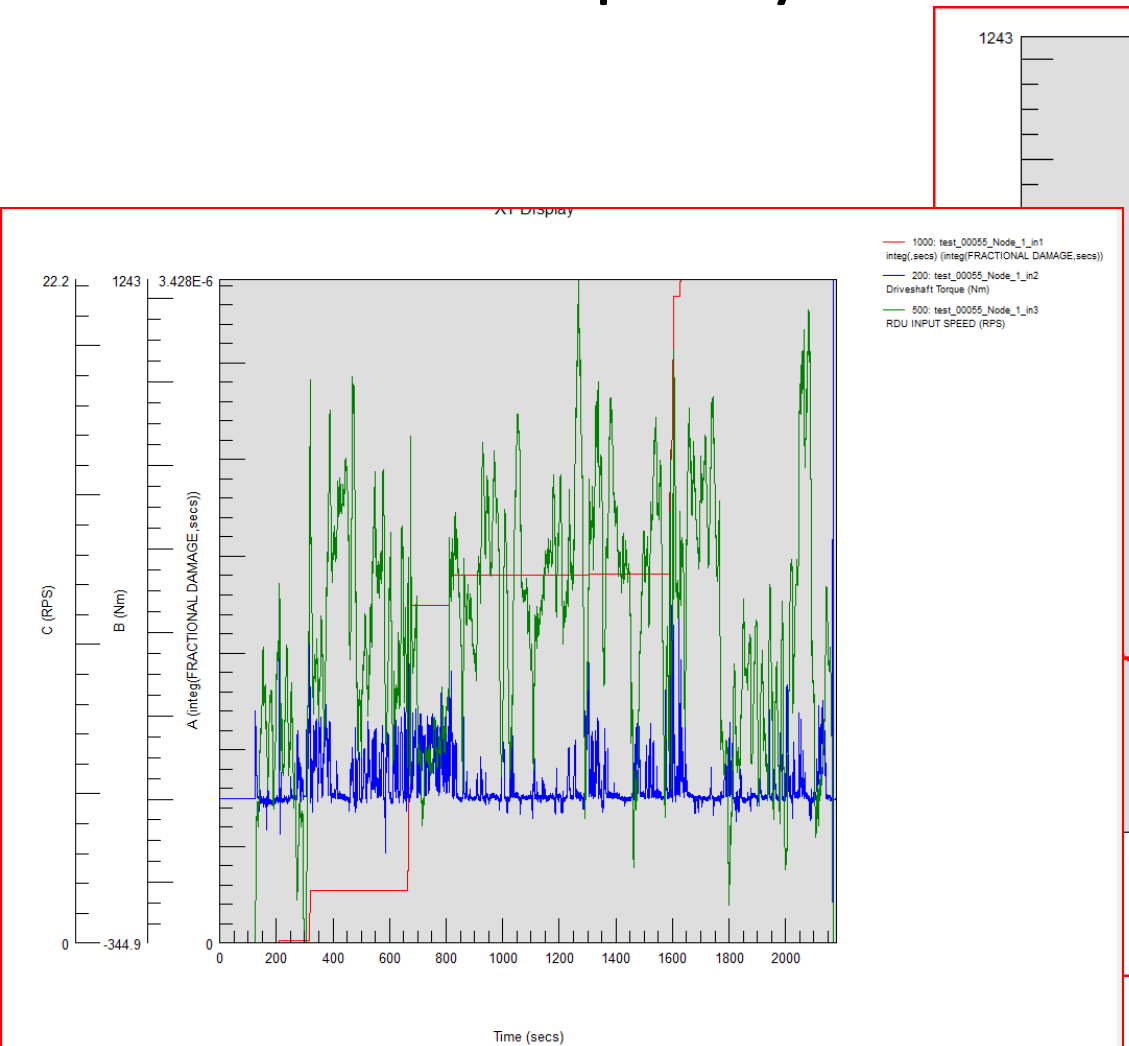
- Copy and paste data into Excel; does it make sense??? Check torque and speed!

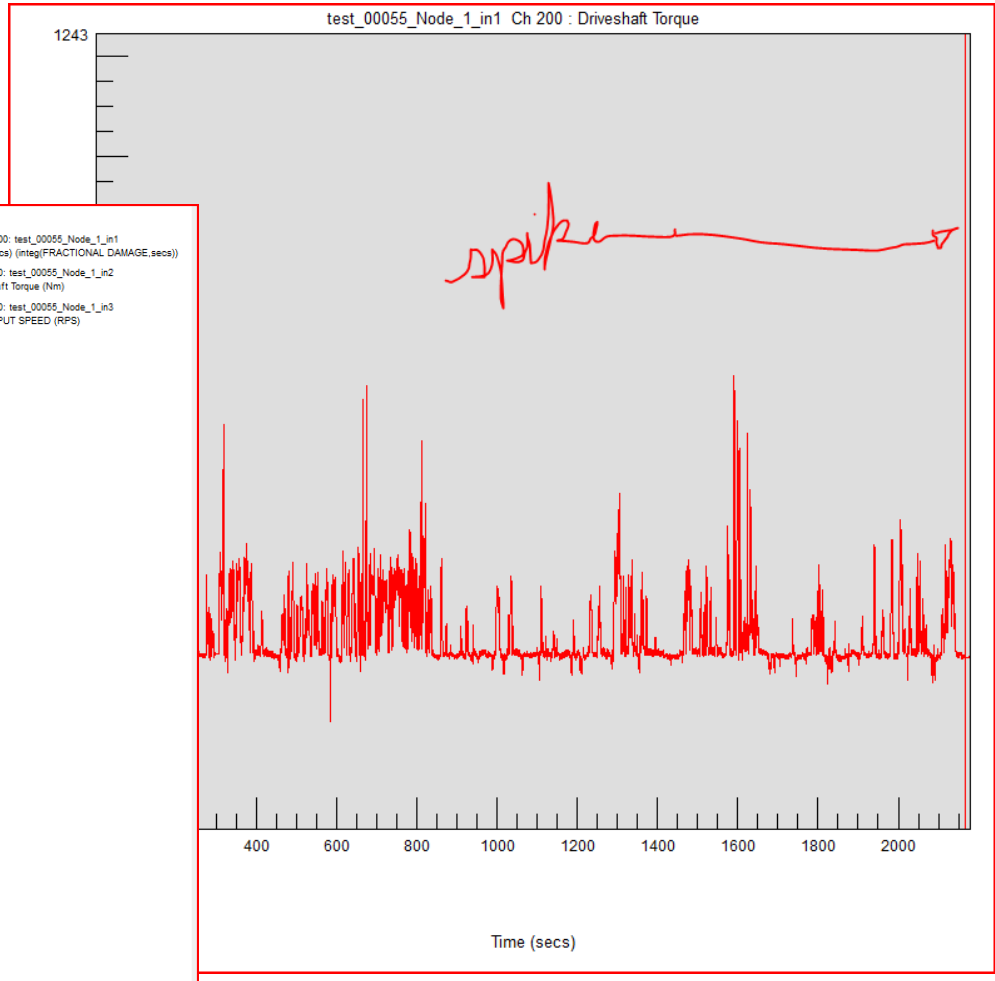


Path	Event Name	Test Name	Chan Title	Number	Points	Rate	YUnits	Max	Mean	Min
c:\Users\	Alaska\City Aggressive	test_00069_Node_1	Driveshaft Torque	200	587200	500	Nm	832	66	-44
c:\Users\	Alaska\Expressway Moderate	test_00034_Node_1	Driveshaft Torque	200	325600	500	Nm	808	56	-411
c:\Users\	Alaska\Rural Aggressive	test_00048_Node_1	Driveshaft Torque	200	459200	500	Nm	819	27	-17
c:\Users\	Alaska\City Moderate	test_00046_Node_1	Driveshaft Torque	200	784400	500	Nm	696	40	-130
c:\Users\	Alaska\Rural Aggressive	test_00011_Node_1	Driveshaft Torque	200	144600	500	Nm	604	75	-201
c:\Users\	Alaska\Expressway Aggressive	test_00044_Node_1	Driveshaft Torque	200	463200	500	Nm	722	18	-24
c:\Users\	Alaska\Rural Moderate	test_00068_Node_1	Driveshaft Torque	200	406600	500	Nm	637	47	-93
c:\Users\	Alaska\Expressway Aggressive	test_00041_Node_1	Driveshaft Torque	200	1215200	500	Nm	696	17	-61
c:\Users\	Alaska\Rural Aggressive	test_00067_Node_1	Driveshaft Torque	200	446600	500	Nm	736	32	-48
c:\Users\	Alaska\Expressway Aggressive	test_00032_Node_1	Driveshaft Torque	200	997600	500	Nm	751	26	-63
c:\Users\	Alaska\Off Road Moderate	test_00055_Node_1	Driveshaft Torque	200	1090400	500	Nm	1243	38	-345
c:\Users\	Alaska\Expressway Moderate	test_00036_Node_1_r01	Driveshaft Torque	200	62600	500	Nm	667	51	-189
c:\Users\	Alaska\Rural Moderate	test_00050_Node_1	Driveshaft Torque	200	310800	500	Nm	740	36	-31
c:\Users\	Alaska\Rural Aggressive	test_00049_Node_1	Driveshaft Torque	200	197200	500	Nm	660	49	-62
c:\Users\	Alaska\Rural Moderate	test_00017_Node_1	Driveshaft Torque	200	1301600	500	Nm	587	51	-302
c:\Users\	Alaska\City Aggressive	test_00018_Node_1	Driveshaft Torque	200	536000	500	Nm	768	54	-103
c:\Users\	Alaska\Off Road Mild	test_00057_Node_1	Driveshaft Torque	200	721400	500	Nm	622	20	-445
c:\Users\	Alaska\Rural Aggressive	test_00066_Node_1	Driveshaft Torque	200	484600	500	Nm	657	33	-34
c:\Users\	Alaska\Expressway Aggressive	test_00064_Node_1	Driveshaft Torque	200	1980400	500	Nm	448	13	-25
c:\Users\	Alaska\Rural Mild	test_00051_Node_1	Driveshaft Torque	200	336000	500	Nm	541	44	-147

Timeseries Display

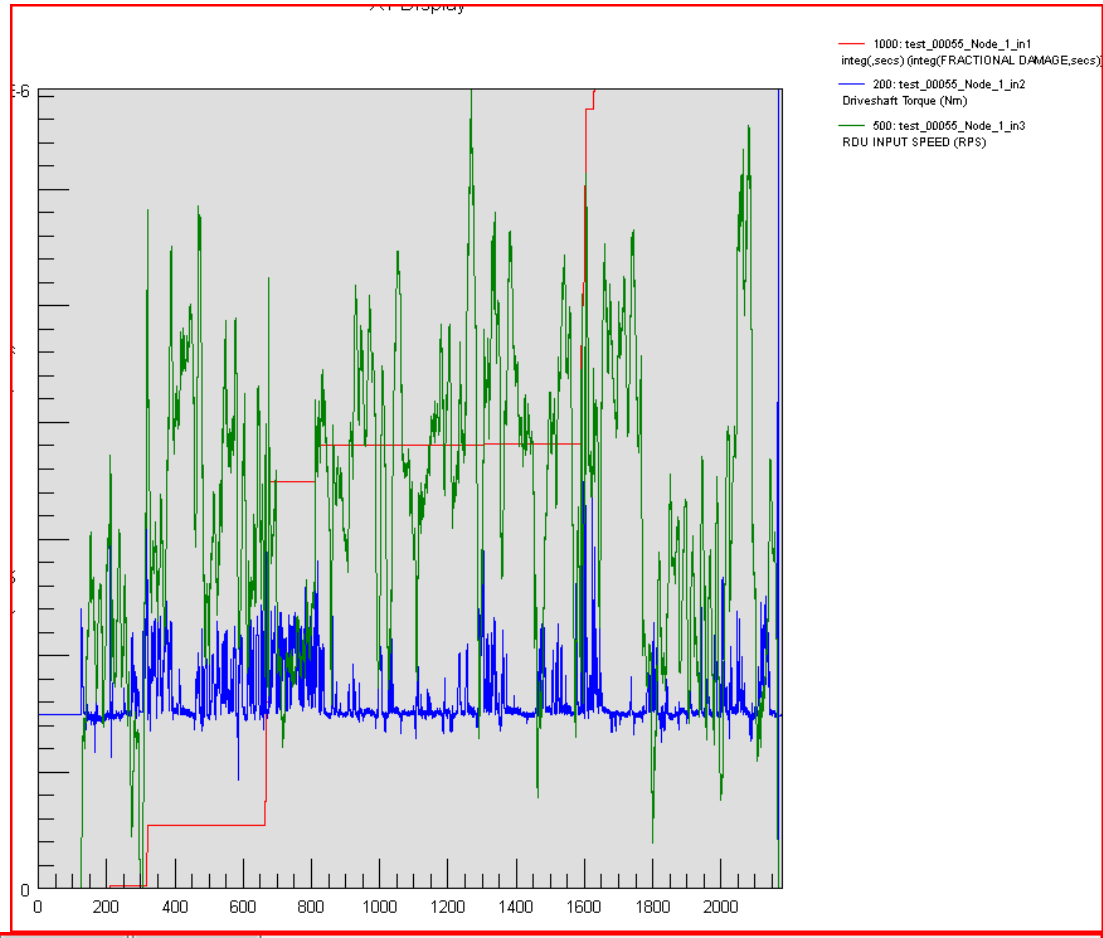
- Visually inspect “working channels” to determine quality of data.





Integration Glyph

- With your TN curve, torque & speed; utilize the Integration Glyph to predict gear damage for each individual Timeseries file.
- Use Metadata & Timeseries displays to inspect data.



	Path	TestName	ChanTitle	ChanNumber	NumPoints	SampleRate	YUnits	Max	Mean	Min
1	c:\Use	test_00055_Node_1	Driveshaft Torque	200	1090400	500	Nm	1243.03	38.1938	-344.906

	Path	TestName	ChanTitle	ChanNumber	NumPoints	SampleRate	YUnits	Max	Mean	Min
1	c:\Users	test_00055_Node_1	PTU OUTPUT SPEED	400	1090191	500	RPS	22.0765	10.0527	0

PTU HYPOID DAMAGE

Clear | Export... | Copy | Displ

	Max
1	1.37595e-005

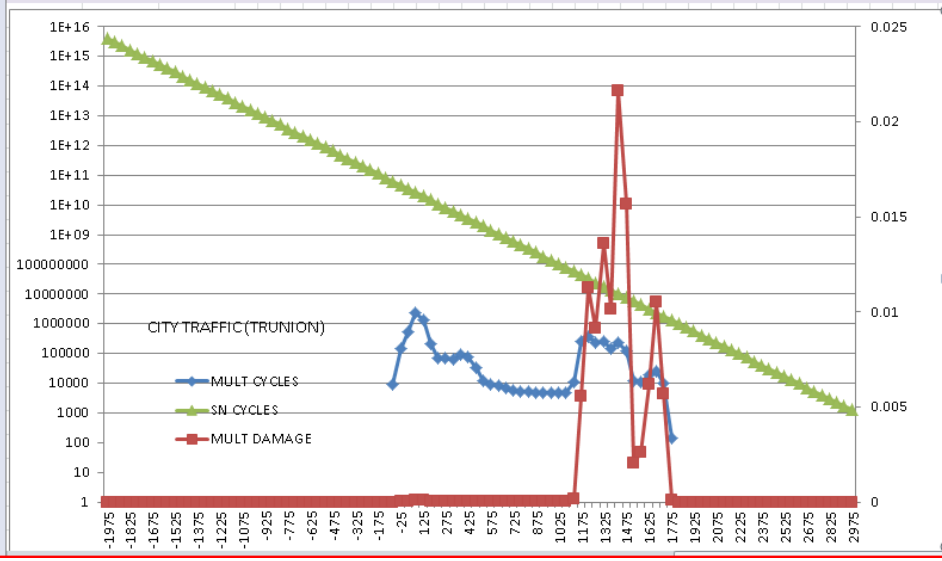
Create Histograms & Double Check

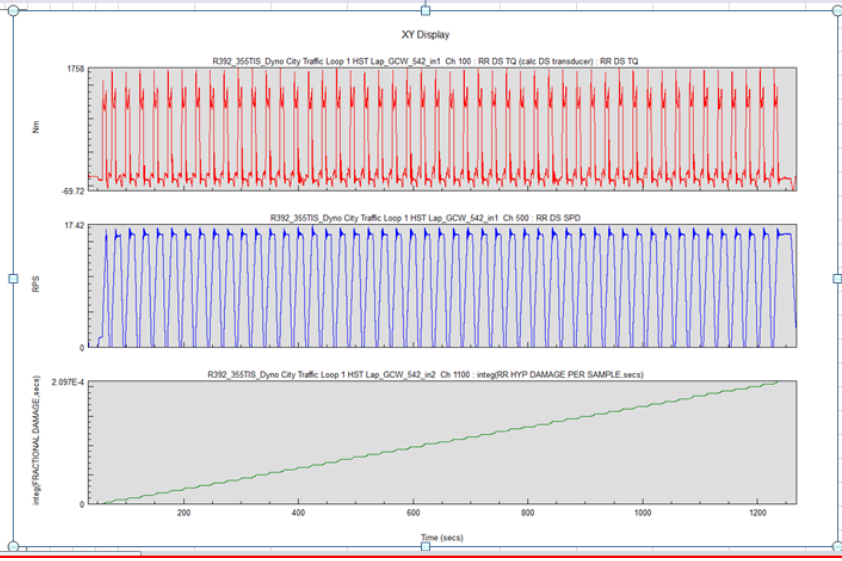
- Now that you have your working channels in the proper units and sampling frequencies; create your histograms!
- Double check your histograms with your Metadata display – Example:
  - If your mean driveshaft speed is 10RPS and your file length is 10sec then your histogram should have 100 driveshaft revolutions!
  - If your max driveshaft torque is 800Nm and your min driveshaft torque is -500Nm then your histogram should agree!
  - Same with maximum drivshaft speed.

Visualize Your Histograms with Excel

A	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG
FTLBS	-129	-92	-55	##	18	55	92	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	1309	1346	1383	1420	1457	1494	1530	1567	1604	16
NM	-175	-125	-75	##	25	75	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	1775	1825	1875	1925	1975	2025	2075	2125	2175	22
SN CYCLES	#########	#########	#########	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	1347064	1007086	752913	562889	420824	314615	235211	175847	131466	98
RPS																																																
75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	11.88	18	##	##	##	##	##	##	##	##	##	64	21	17	16	12	10	9	9	8	8	8	8	8	15	##	##	##	##	##	##	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	5.044	##	##	79	58	##	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	5	##	##	##	42	36	32	21	22	21	37	47	19	0.2714	0	0	0	0	0	0	0	0	0
EVENT CYCLES	**0**	**0**	**16.924**	##	##	##	##	##	##	##	##	##	##	**64**	**21**	**17**	**16**	**12**	**10**	**10**	**9**	**9**	**9**	**9**	**9**	**9**	**21**	##	##	##	##	##	##	**22**	**21**	**37**	**47**	**19**	**0.2714**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
MULT CYCLES	**0**	**0**	**9172.808**	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	##	**147.0988**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
EVENT DAMAGE	0	0	2.66E-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.01E-07	0	0	0	0	0	0	0	0	0
MULT DAMAGE	**0**	**0**	**1.44E-07**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.000109**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

MULT
EVENT DAMGE
EVENT CYCLES
EVENT KM





- Double check your histograms; max tq, min tq, number of revolutions, max speed, etc.

Put it all together

- You have:
  - Error proofed the raw data
  - Created & inspected working channel data
  - Calculated damage per individual events
  - Created and inspected histograms
- With multipliers, use Excel to calculate damage for each multiplied event and entire duty cycle:
  - What are the big hitters?
  - What torque buckets contain the most damage?
  - Upgrade new TN into Glyphworks; are you green?
- Schedule full duty cycle into a histogram:
  - Does Damage from multiplied individual events equal scheduled histogram (Yes, it should)!!!

Next Step

- You should be very confident with the raw data and your flow:
  - Grow your flow to incorporate post-processing:
    - Front/ rear driveshaft & halfshaft Rainflow cyclic torque histograms
    - Truncation scenarios
    - Etc, etc, etc . . .