AFGROW European Workshop

Spectrum Manager Version 1.2 Overview

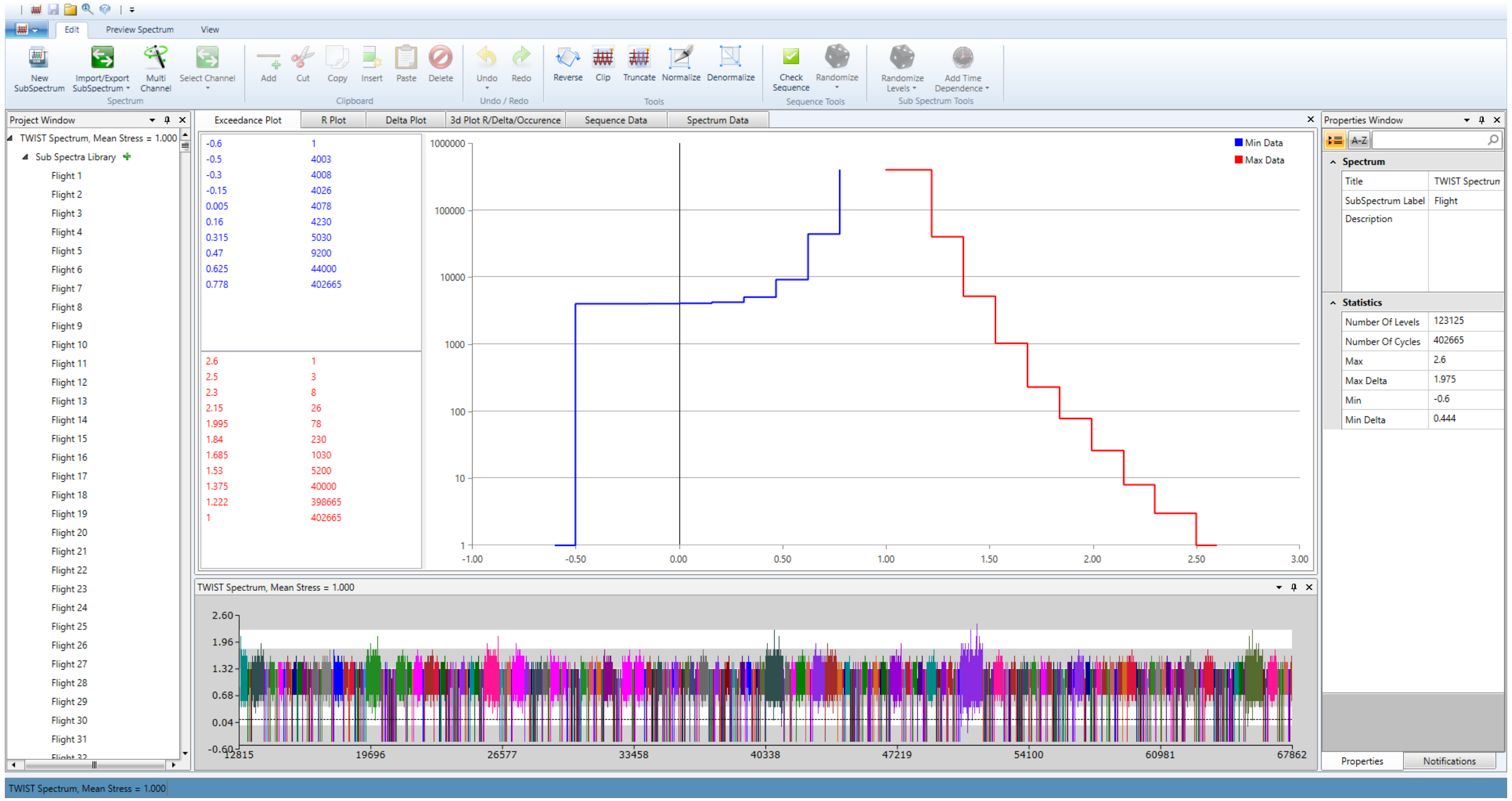
Jun 23, 2022

ZHAW School of Engineering

Centre for Aviation

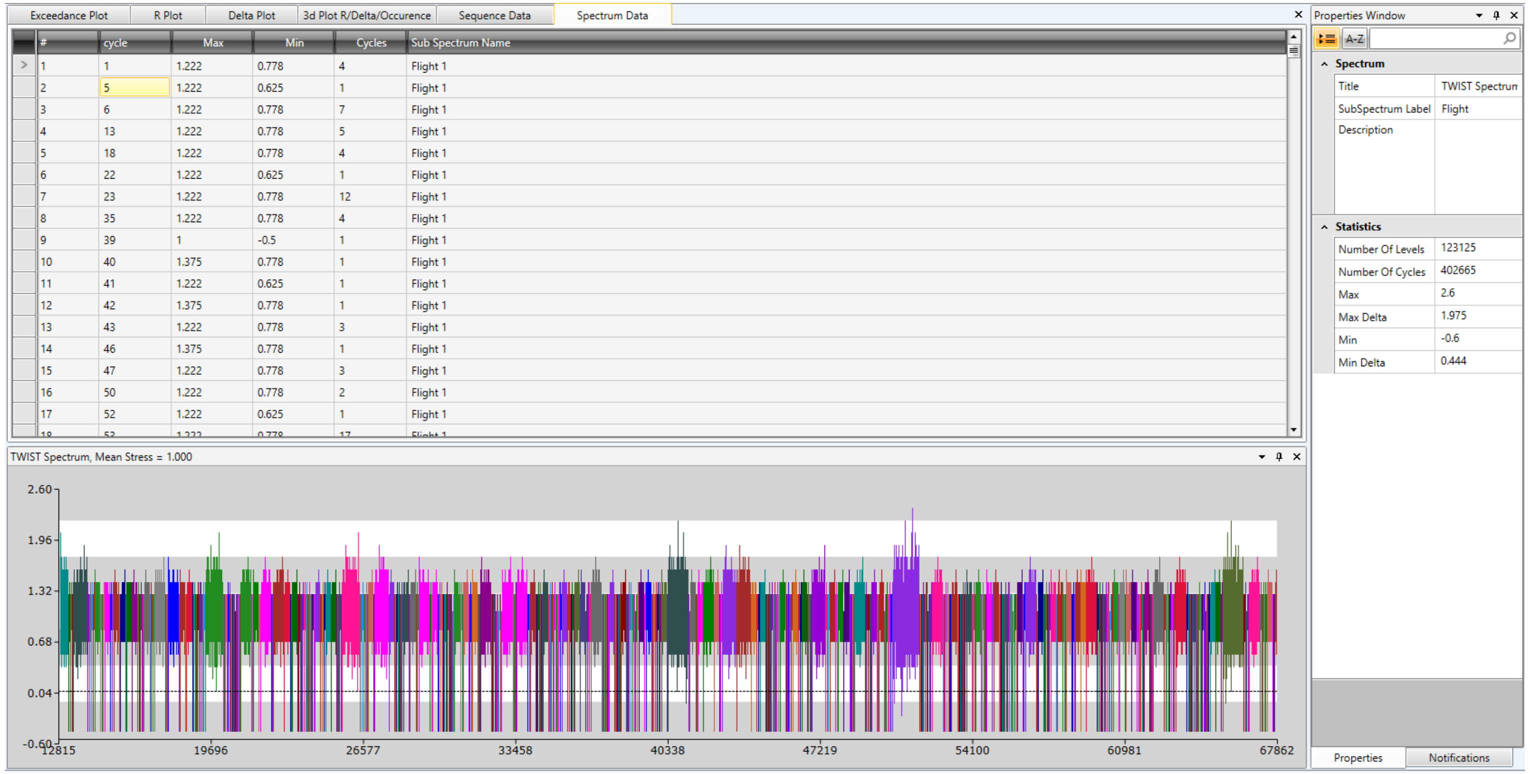
What is Spectrum Manager

- Next evolution in AFGROW Spectrum generation using XML capabilities.
- Used to Generate Spectrum files for use in AFGROW.
- Create, Edit, and View Spectra Data through multiple detailed windows.
- Resulting Spectrum files are cycle-counted



Basic Capabilities

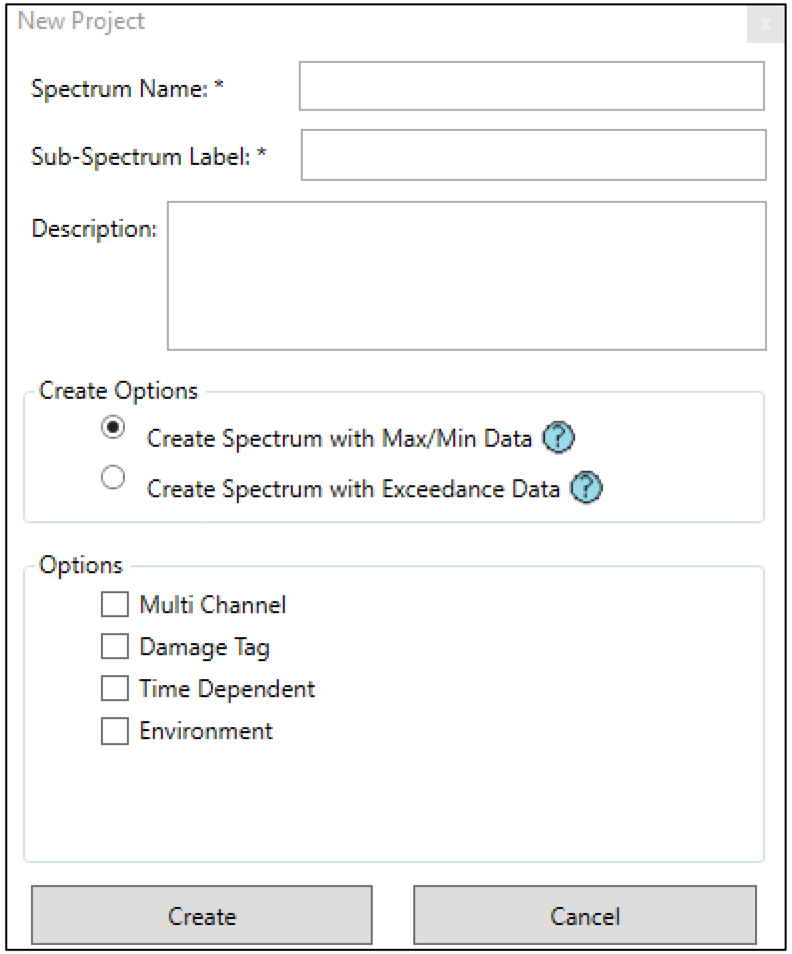
- Visual spectrum design
- Sub-spectra organized in any user-defined sequence
- Spectrum statistics
- Exceedance curve plot, R-plot, Delta plot
- Sub-spectra tagging for future analysis
- Synchronized data views
- Spectrum level damage tagging
- Spectra normalization/de-normalization
- Clipping/Truncation capability



Creating a new Spectrum Project with Spectrum Manager

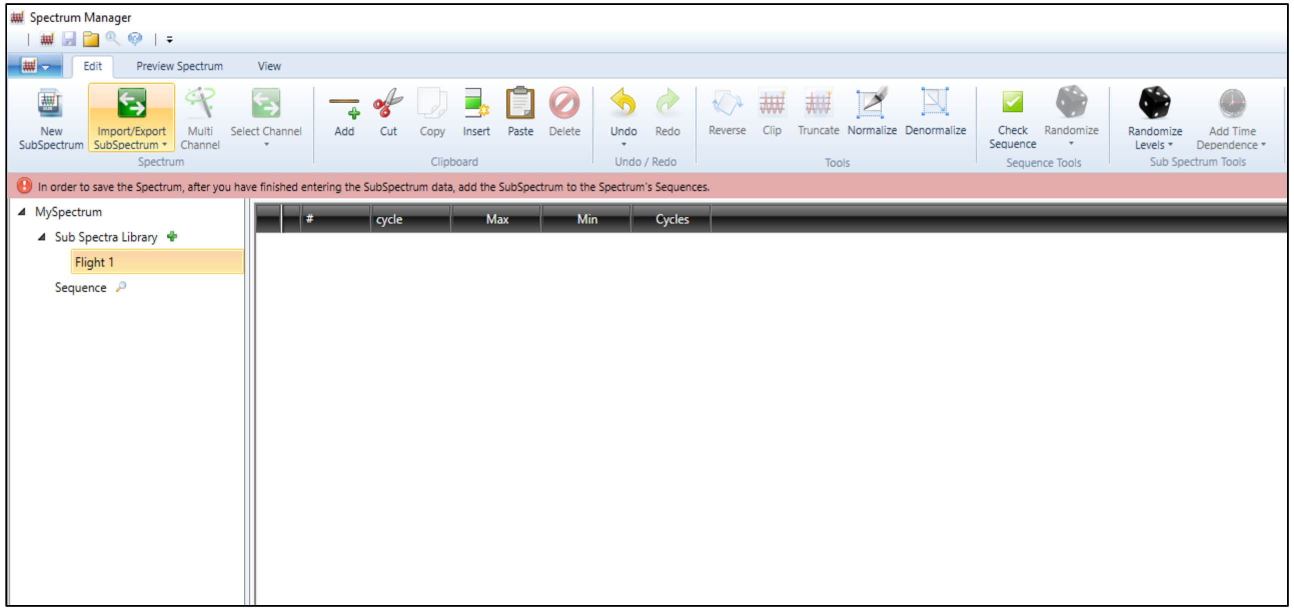
Spectrum Generation from Max/Min Data

- Select the “Create Spectrum with Max/Min Data” option in the New project dialogue
- Start with an empty project
- Create new sub spectra with cycle counted Max/Min/Cycles data
- Use the GUI to edit level data
- Create a sequence from sub spectra library



Spectrum Generation from Max/Min Data

- Start with an empty project
- Create new sub spectra with imported/entered cycle counted Max/Min/Cycles data
- Use the GUI to edit level data
- Create a sequence from sub spectra library



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Spectrum Generation from Exceedance Curve

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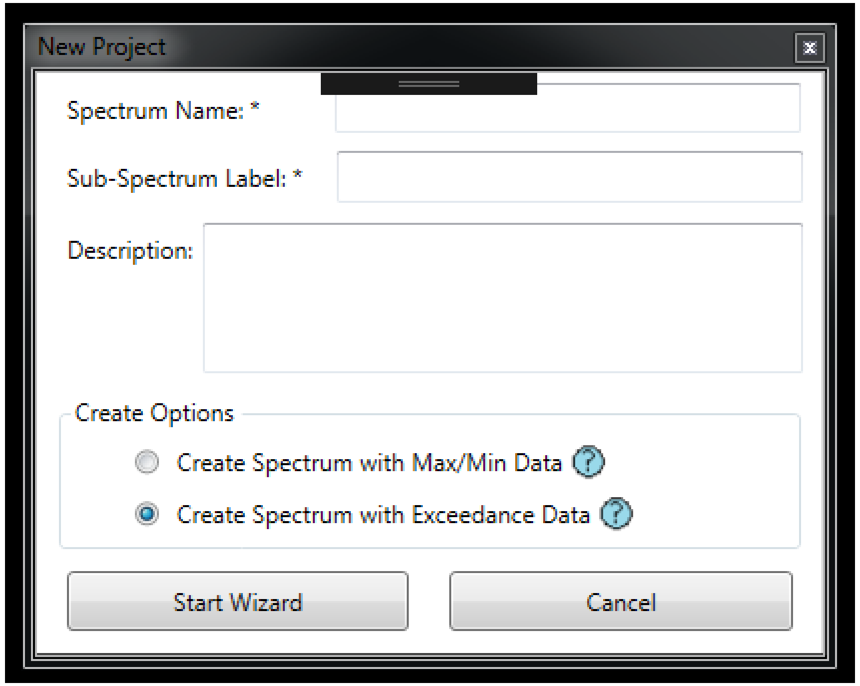
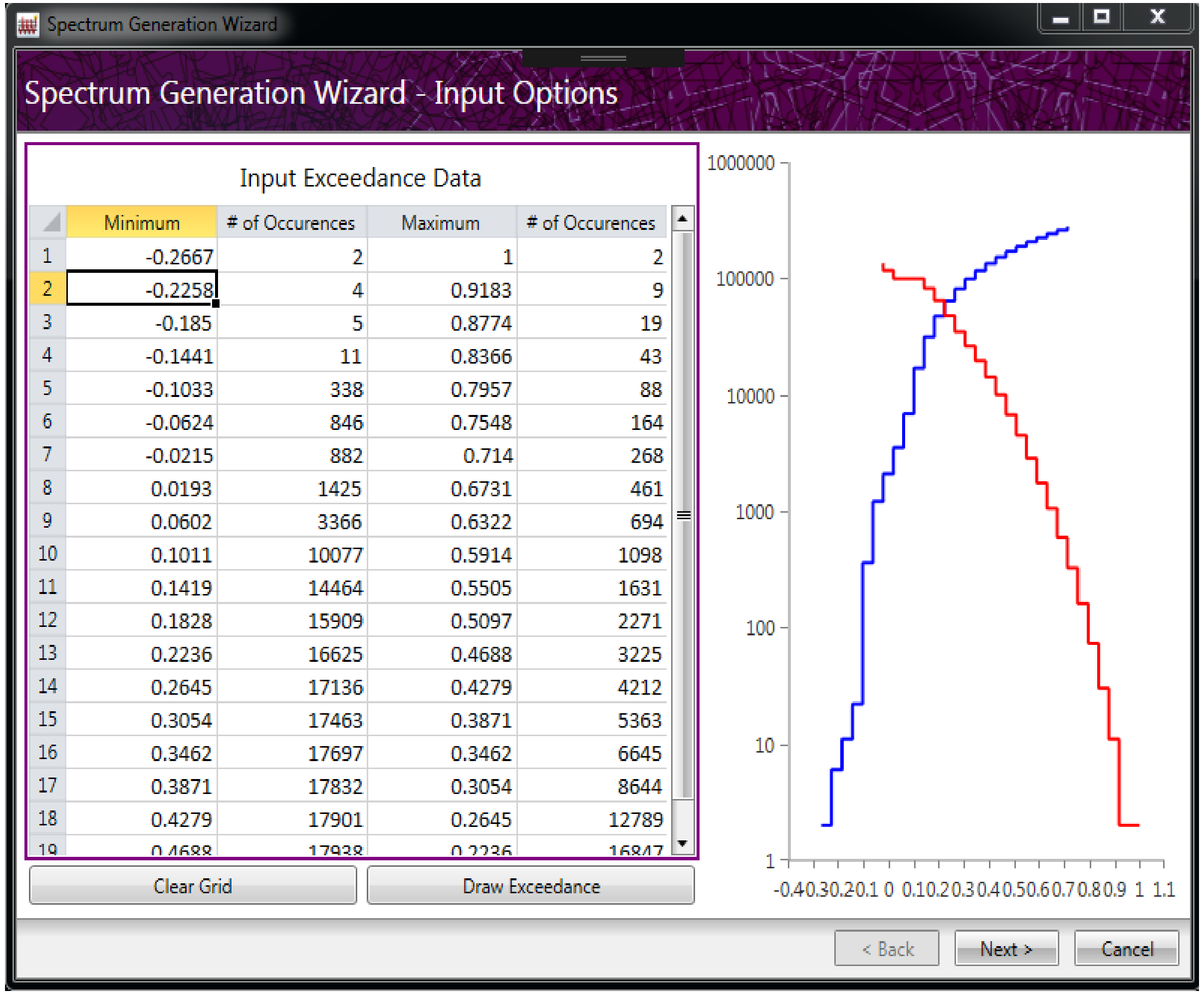
- Create a spectrum from exceedance curve data.
- Select the “Create Spectrum with Exceedance Data” option in the New project dialogue.



Spectrum Generation from Exceedance Curve

- Enter/Paste exceedance data into the grid (table).
- Clicking “Draw Exceedance” will create a chart visualizing the data.

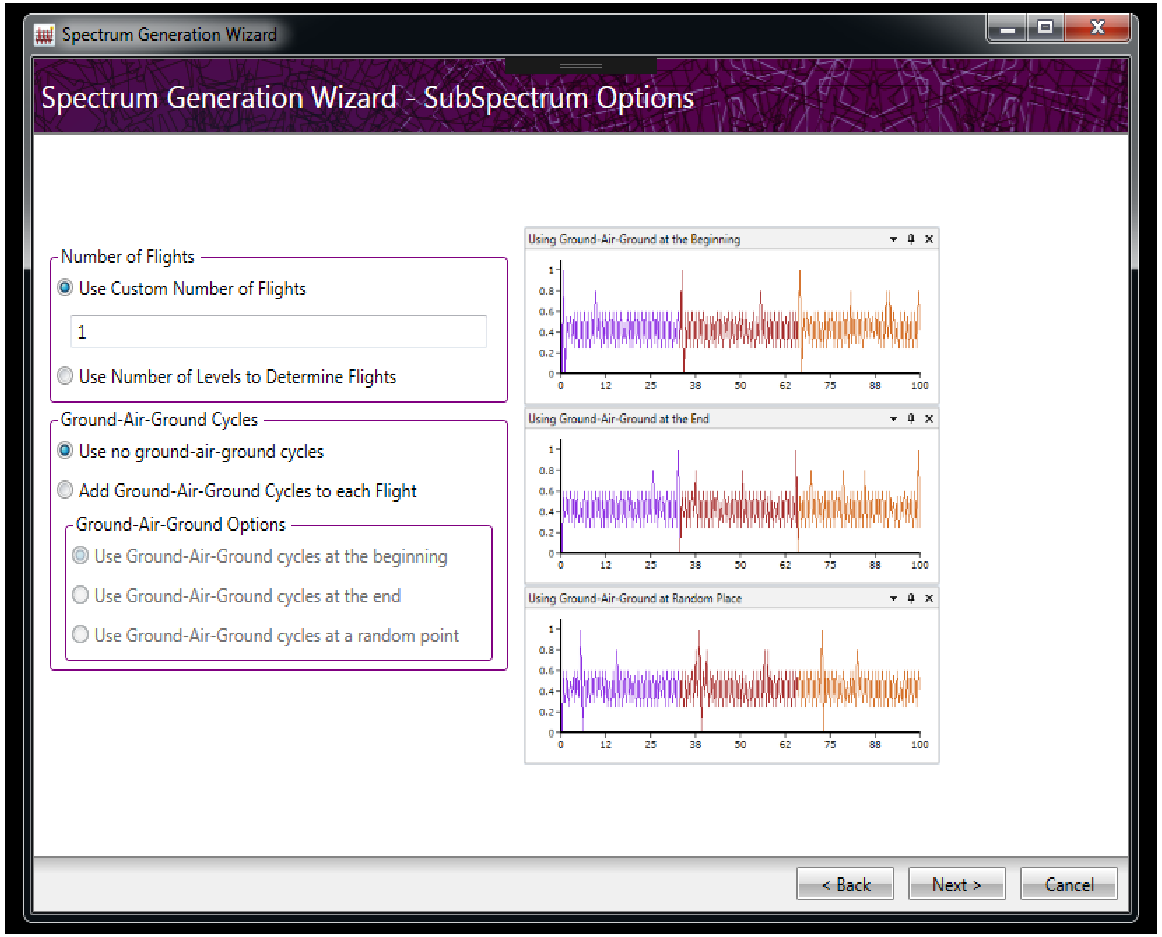


	Minimum	# of Occurences	Maximum	# of Occurences
1	-0.2667	2	1	2
2	-0.2258	4	0.9183	9
3	-0.185	5	0.8774	19
4	-0.1441	11	0.8366	43
5	-0.1033	338	0.7957	88
6	-0.0624	846	0.7548	164
7	-0.0215	882	0.714	268
8	0.0193	1425	0.6731	461
9	0.0602	3366	0.6322	694
10	0.1011	10077	0.5914	1098
11	0.1419	14464	0.5505	1631
12	0.1828	15909	0.5097	2271
13	0.2236	16625	0.4688	3225
14	0.2645	17136	0.4279	4212
15	0.3054	17463	0.3871	5363
16	0.3462	17697	0.3462	6645
17	0.3871	17832	0.3054	8644
18	0.4279	17901	0.2645	12789
19	0.4688	17938	0.2236	16847

Spectrum Generation from Exceedance Curve

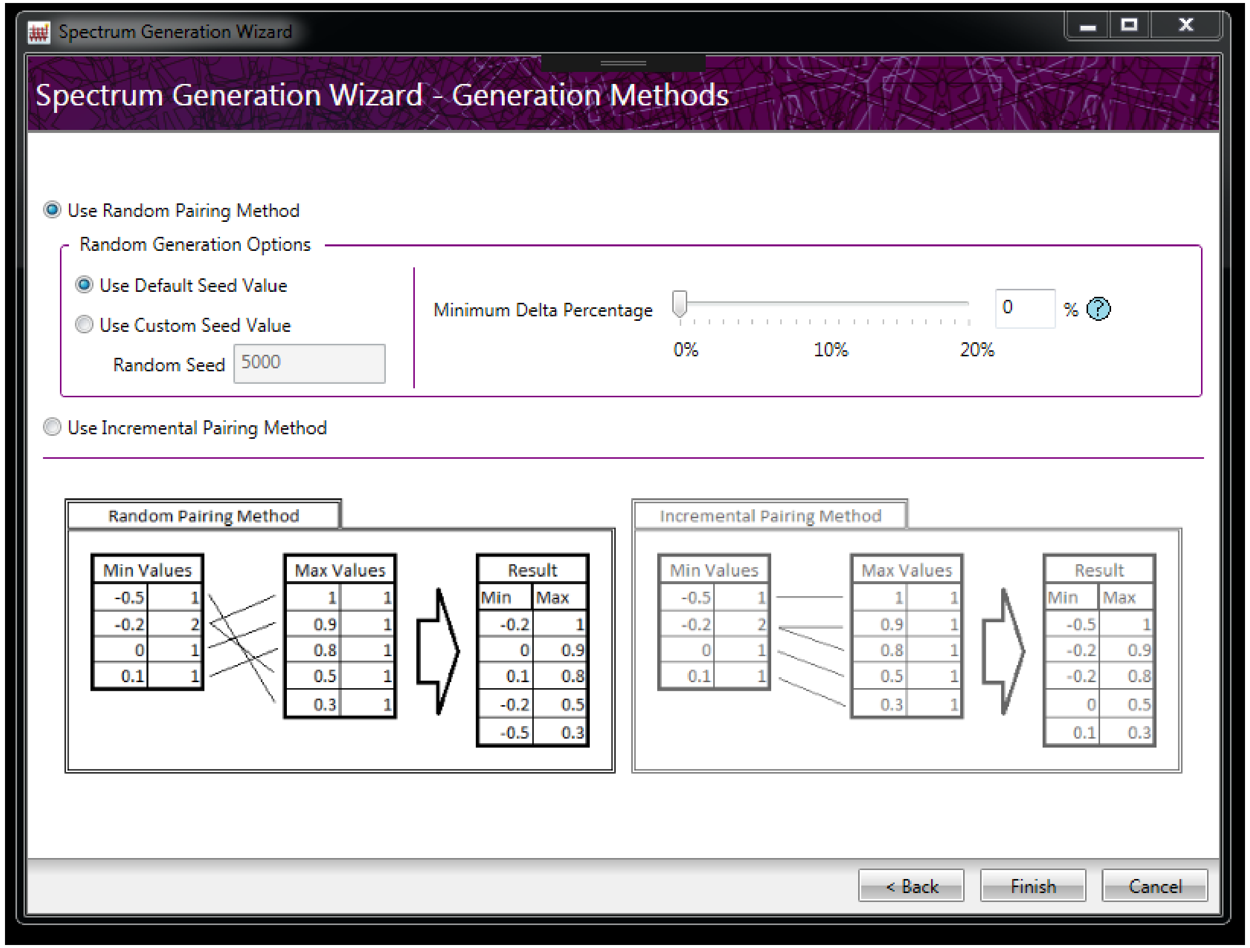
- Specify the number of flights (sub spectra) for the spectrum, or the number of levels per flight (sub spectra).

- Ground-Air-Ground cycles can be included and placed at the beginning, end, or a random point inside each sub spectrum.



Spectrum Generation from Exceedance Curve

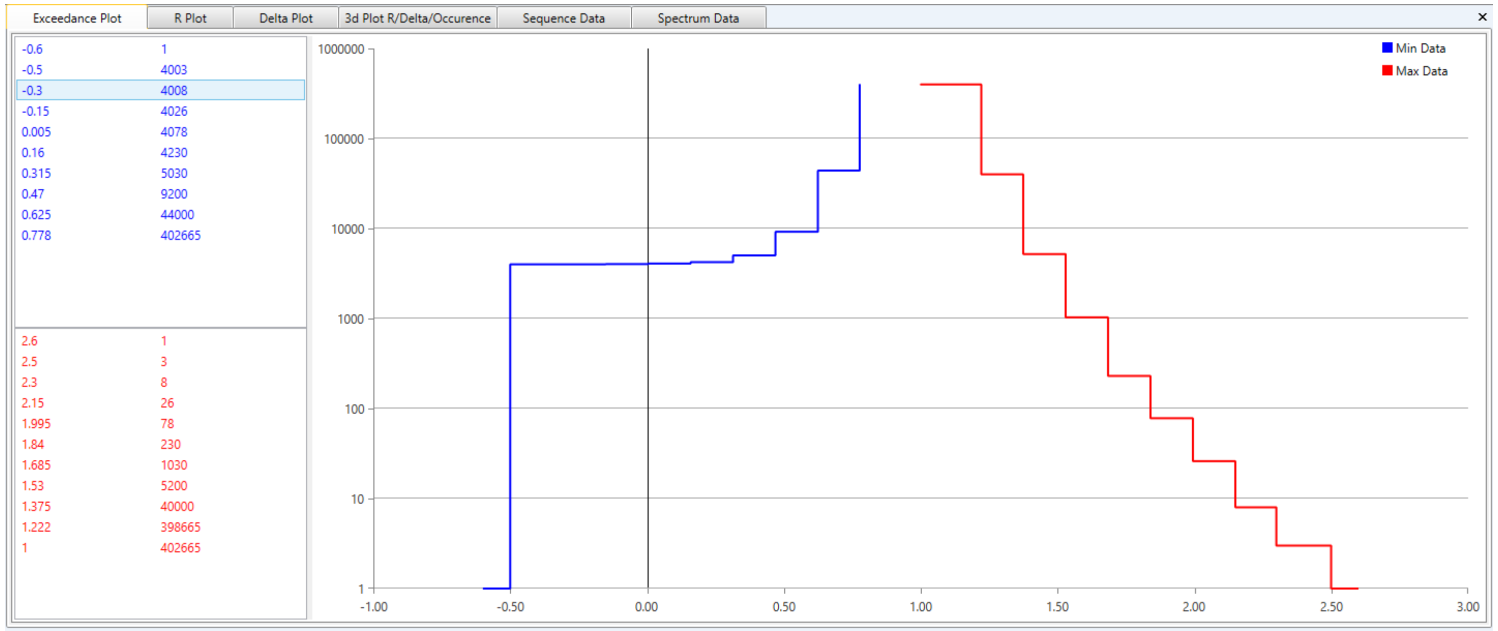
- Random pairing will match the Max and Min values randomly.
- Incremental pairing sorts the max and min values, then sequentially pairs the greatest max value with the least min value.



Spectrum Manager GUI

Exceedance Plot

- The exceedance plot graphs the cumulative number of stress (or load) values in the spectrum.
- The legend on the left of the exceedance plot list the max values (in red) and the min values (in blue), along with the corresponding cumulative cycles.



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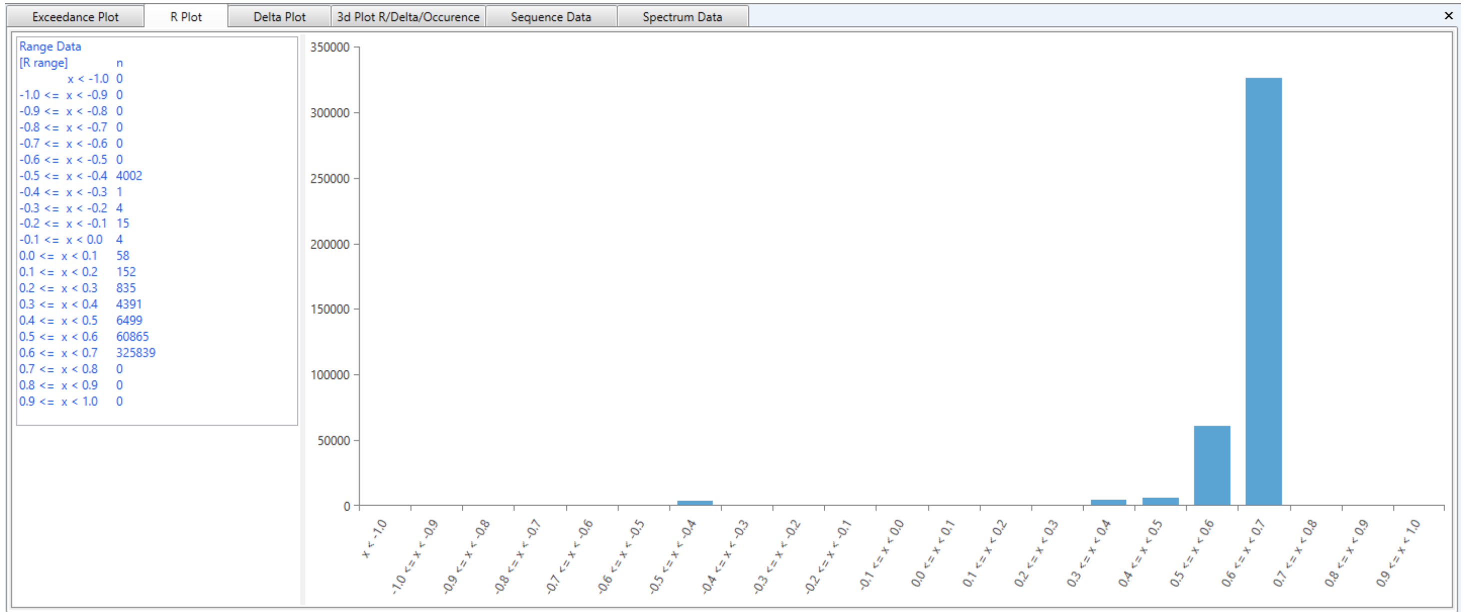
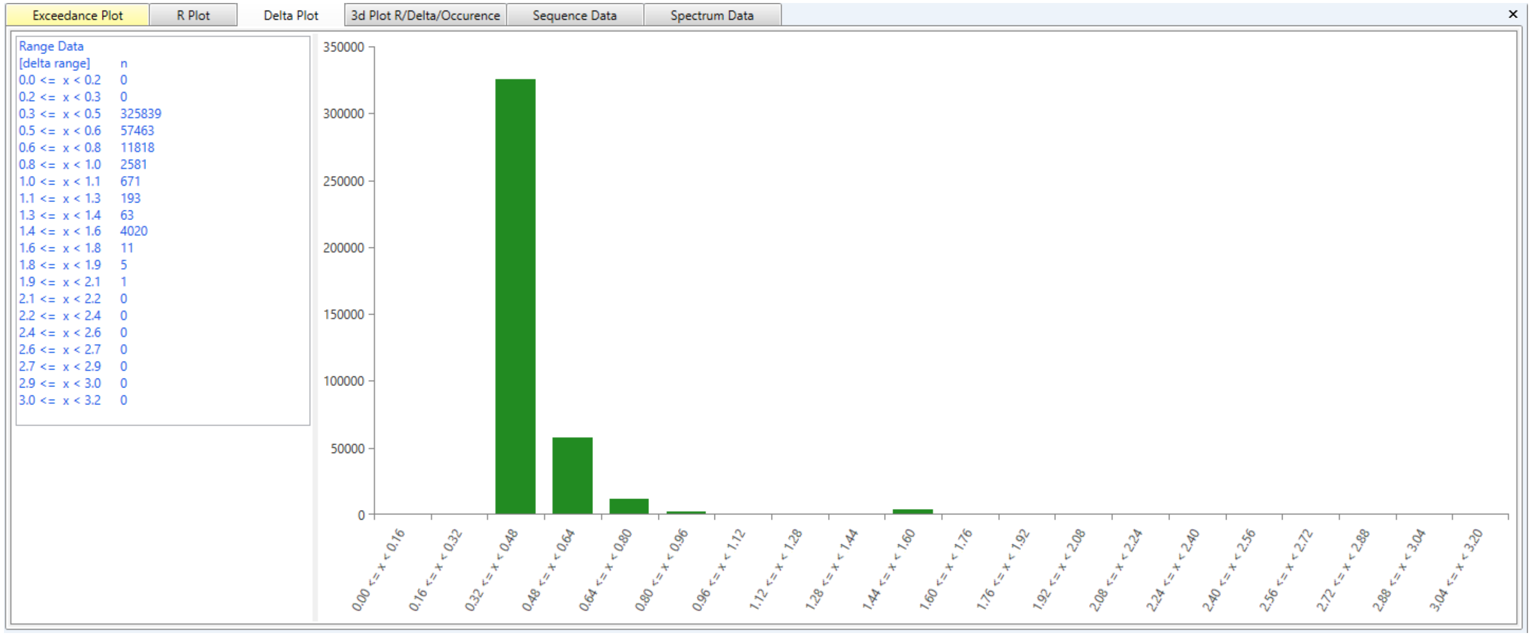
R-Plot

- The R Plot displays the ranges of min over max stress ratios versus the number of cycles for the entire spectrum. Users can plot R values from -100 to 1.
- The legend for the R plot is show to the left of the graph. The legend lists the ranges of stresses (or loads) ratios in the spectrum with their total number of cycles.



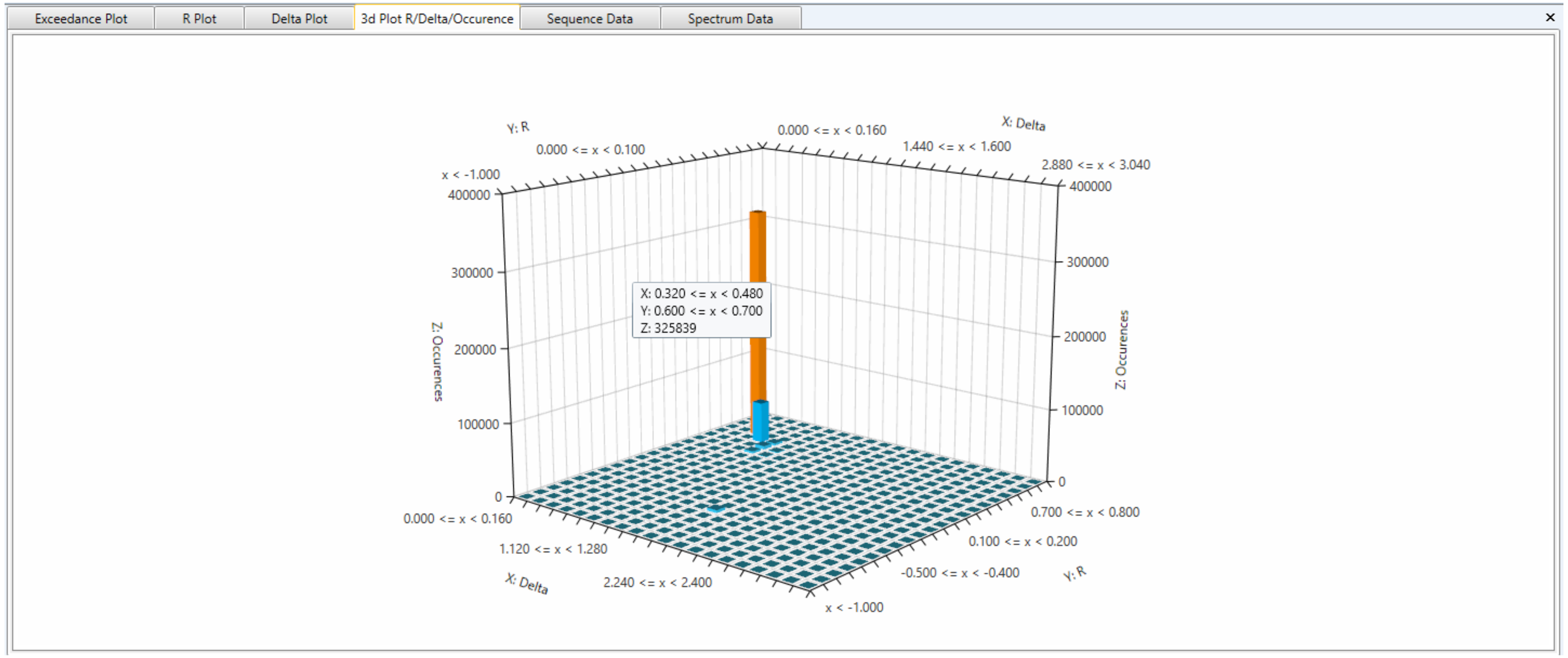
Delta Plot

- Visual representation of the spectrum stress range values
- Legend displays the occurrences of each level's delta value. (Max – Min)



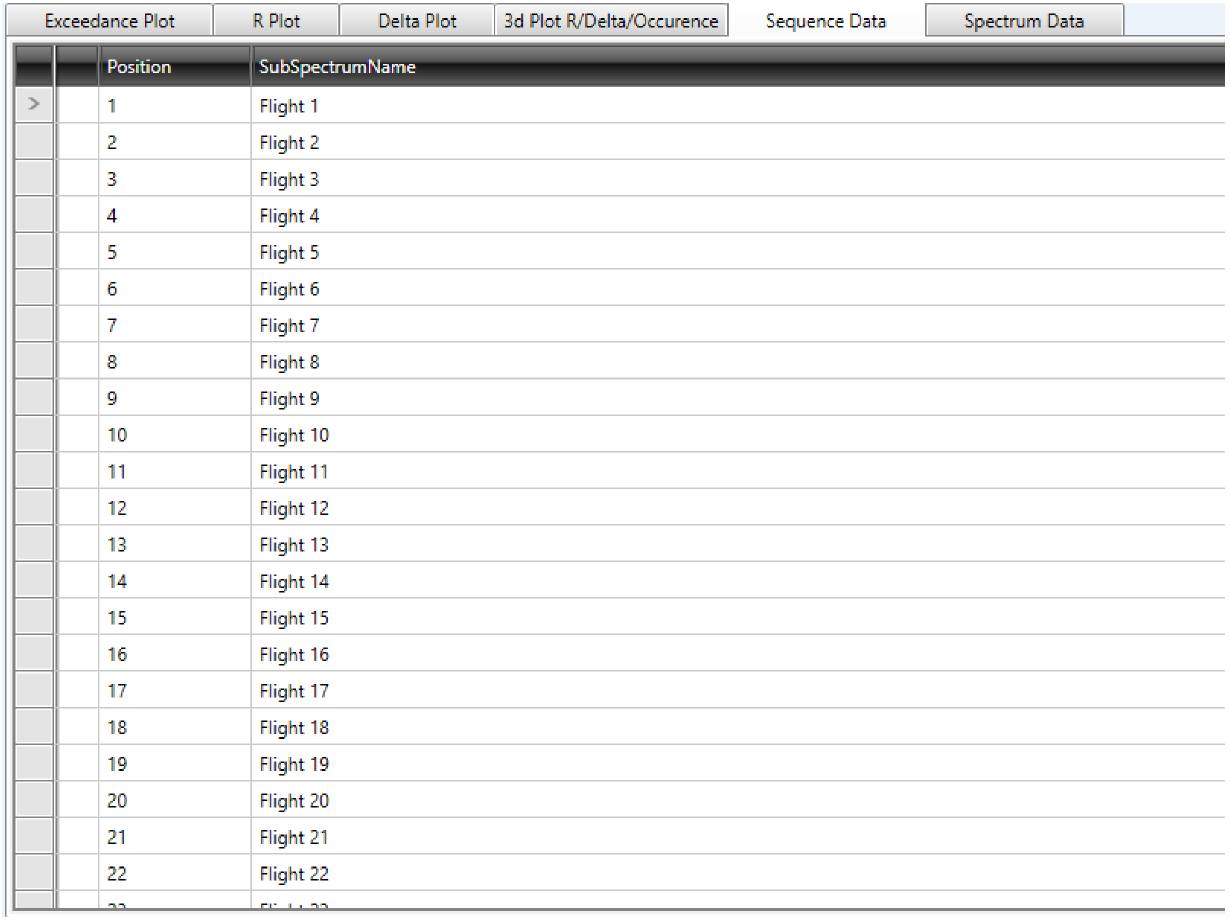
R/Delta/Occurrence 3D Plot

- Plots Delta vs R values vs Occurrences
- Hover over desired bar to see values
- Plot can be zoomed and rotated for alternate views of data



Sequence Data

- The sequence data window is where the user can place each sub spectrum from the library in the desired order.
- Cut, Copy, Insert, Paste, and Delete options are all available here.



Position	SubSpectrumName
1	Flight 1
2	Flight 2
3	Flight 3
4	Flight 4
5	Flight 5
6	Flight 6
7	Flight 7
8	Flight 8
9	Flight 9
10	Flight 10
11	Flight 11
12	Flight 12
13	Flight 13
14	Flight 14
15	Flight 15
16	Flight 16
17	Flight 17
18	Flight 18
19	Flight 19
20	Flight 20
21	Flight 21
22	Flight 22

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Spectrum Data

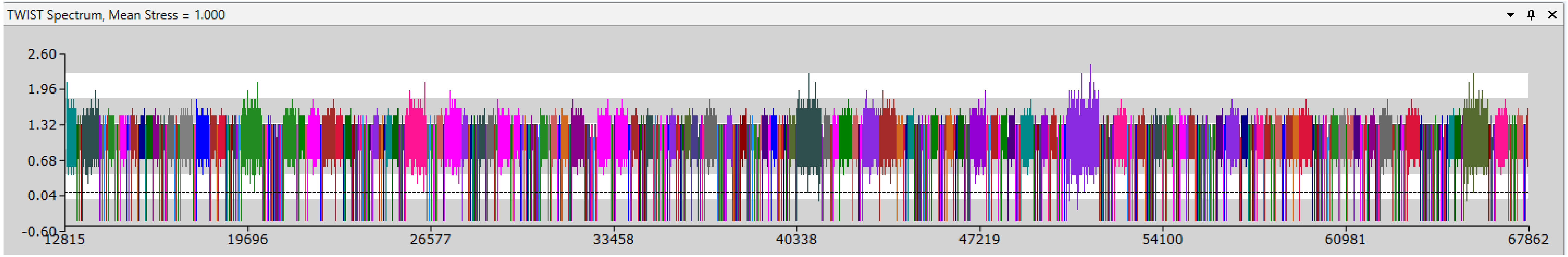
- If the spectrum is selected, this window lists the values of each level of the spectrum.
- If a sub spectrum is selected in the Project Window, the window allows edits to the values of each level in the sub spectrum.
- Cut, Copy, Insert, Paste, and Delete options are all available if a sub spectrum is selected.

Exceedance Plot | R Plot | Delta Plot | 3d Plot R/Delta/Occurence | Sequence Data | Spectrum Data

#	cycle	Max	Min	Cycles	Sub Spectrum Name
1	1	1.222	0.778	4	Flight 1
2	5	1.222	0.625	1	Flight 1
3	6	1.222	0.778	7	Flight 1
4	13	1.222	0.778	5	Flight 1
5	18	1.222	0.778	4	Flight 1
6	22	1.222	0.625	1	Flight 1
7	23	1.222	0.778	12	Flight 1
8	35	1.222	0.778	4	Flight 1
9	39	1	-0.5	1	Flight 1
10	40	1.375	0.778	1	Flight 1
11	41	1.222	0.625	1	Flight 1
12	42	1.375	0.778	1	Flight 1
13	43	1.222	0.778	3	Flight 1
14	46	1.375	0.778	1	Flight 1
15	47	1.222	0.778	3	Flight 1
16	50	1.222	0.778	2	Flight 1
17	52	1.222	0.625	1	Flight 1
18	53	1.222	0.778	17	Flight 1
19	70	1.222	0.625	1	Flight 1
20	71	1.222	0.778	3	Flight 1
21	74	1.375	0.778	1	Flight 1
22	75	1.375	0.778	1	Flight 1
23	76	1.375	0.778	1	Flight 1

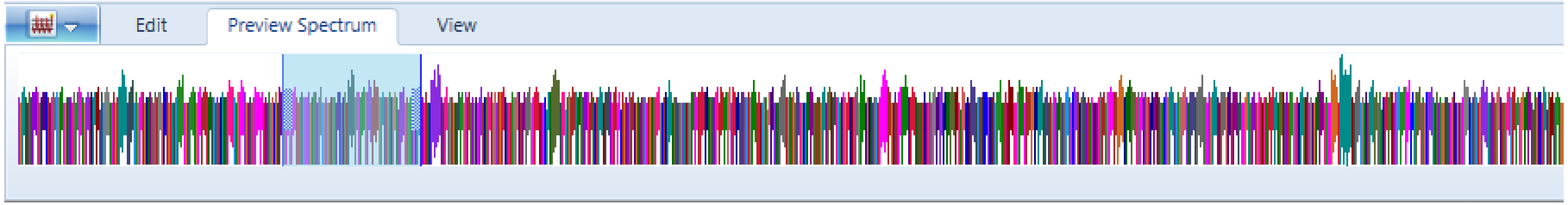
Spectrum Plot

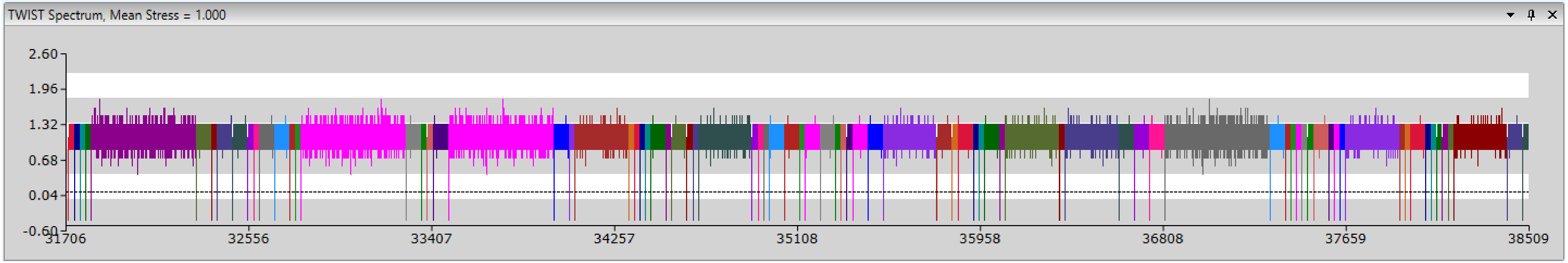
- Visual representation of the spectrum
- Shows the spectrum's/sub spectrum's stress vs cycles plot
- Cycles are plotted as vertical lines indicating Max/Min



Preview Spectrum

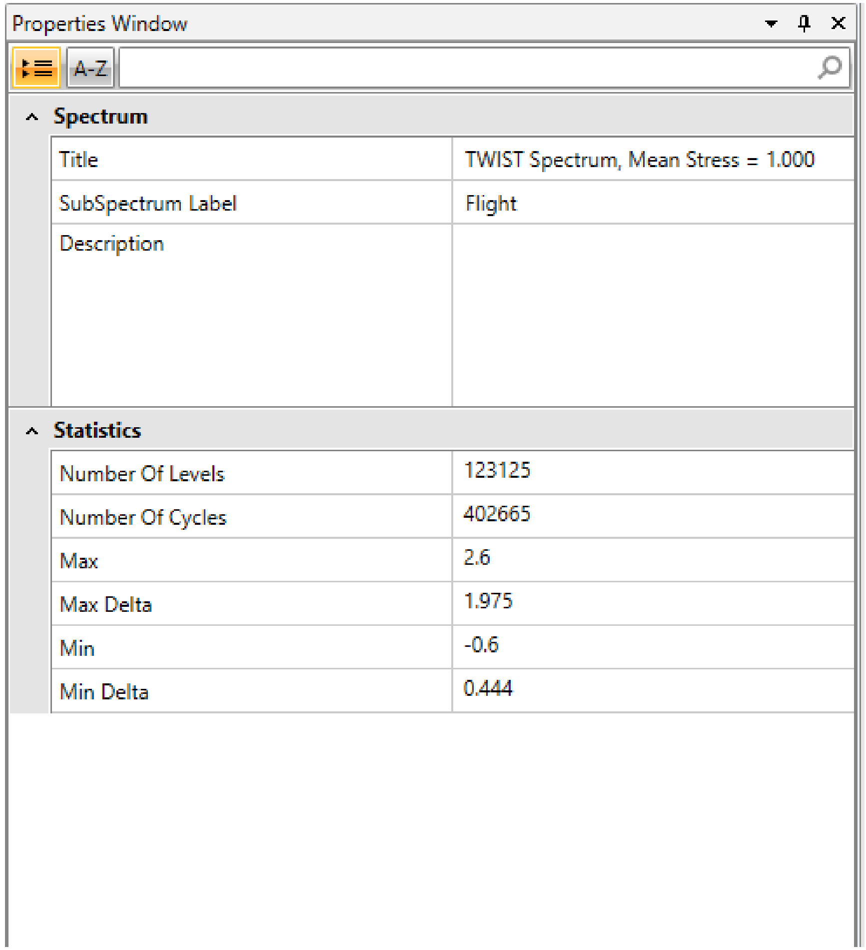
- Zoom control
- Allows user to focus spectrum plot on selected section of spectrum/sub spectrum





Properties

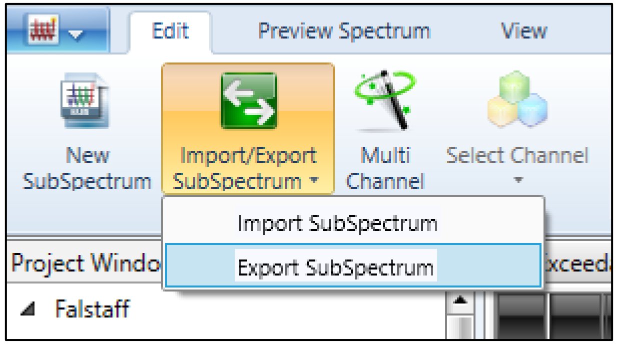
- If the spectrum is selected, the Properties Window lists the properties and statistics of the spectrum.
- If a sub spectrum is selected, the Properties Window lists the properties and statistics of the sub spectrum.
- The sub spectrum name and description are shown and can be edited in this window.



Spectrum Manager Commands

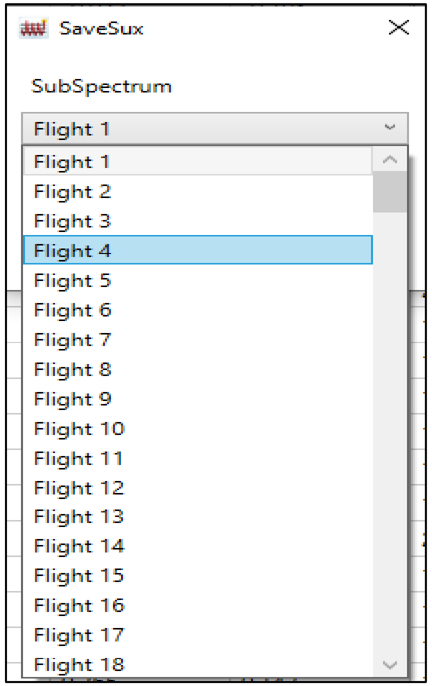
Export Sub-Spectrum

- Save a single sub spectrum to a file.



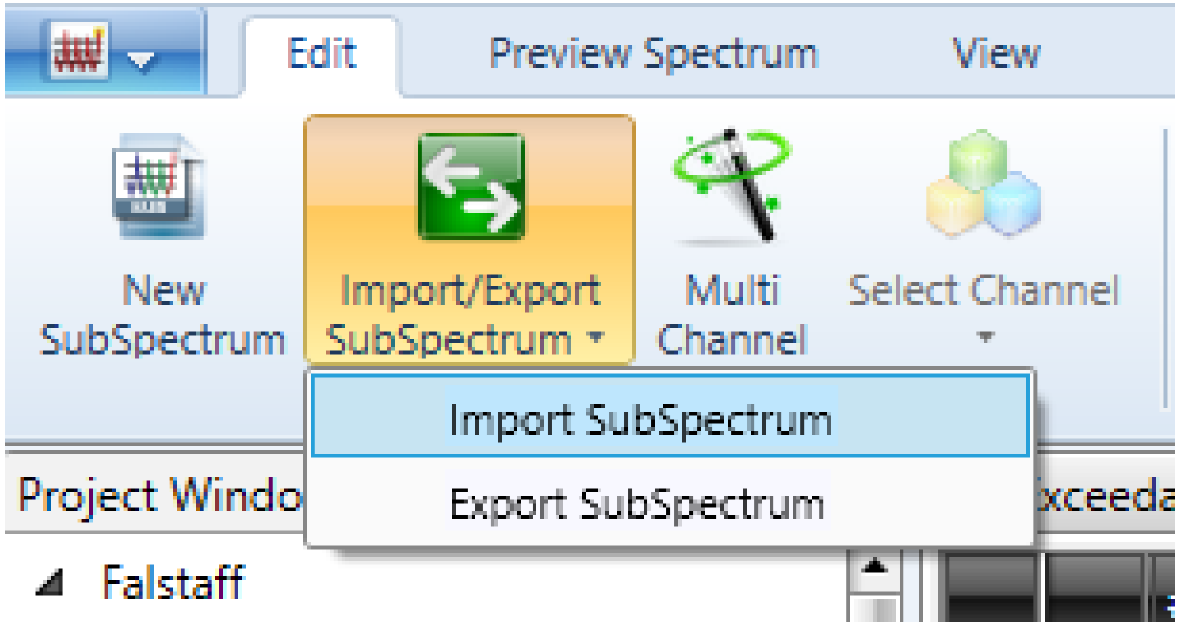
- Click on the Import/Export Sub spectrum button and select Export.

- Select which sub spectrum to save from the dropdown and click OK. Navigate to a path to save the file to, and click Save.



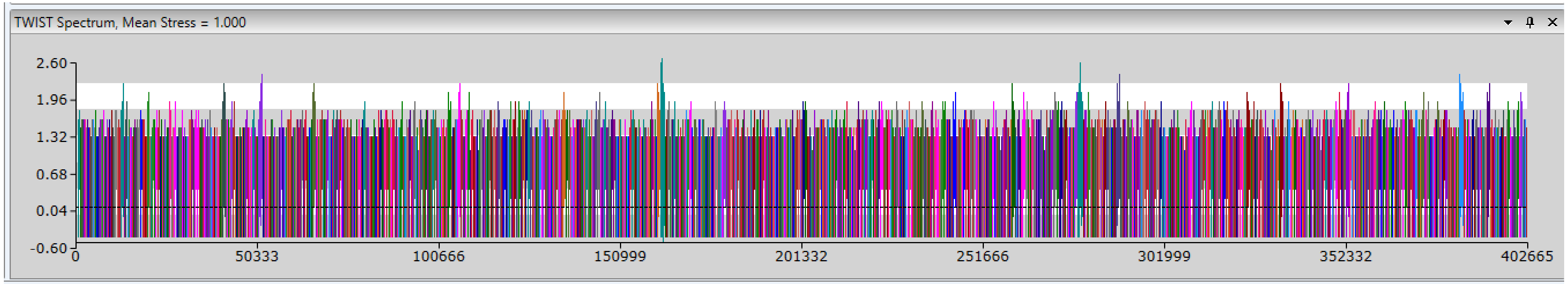
Import Sub-Spectrum

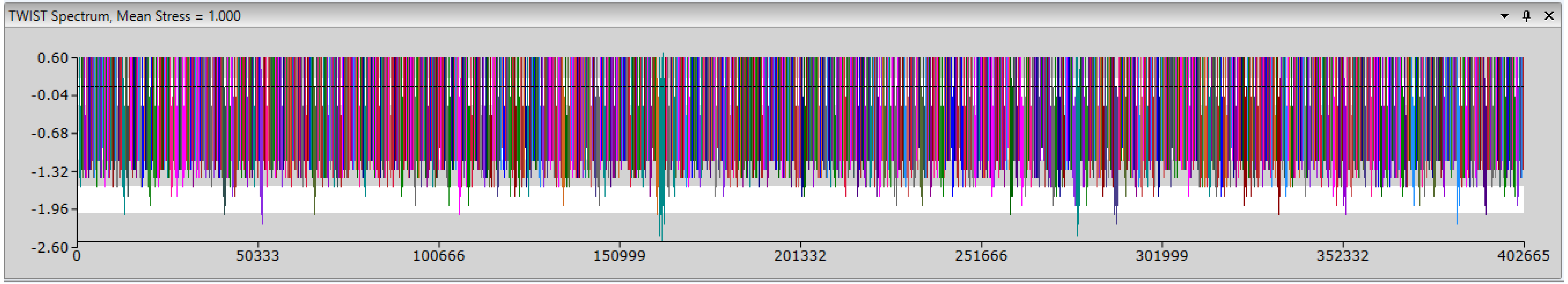
- Can import previously exported sub spectrum files files
- When importing a sub spectrum file, an option will be presented to either use the sub spectrum name included with the file properties, or to autogenerate a name for the sub spectrum based off the current project's sub spectrum label.
- An imported sub spectrum will not be automatically added to the sequence and must be added through the sequence data window



Reverse

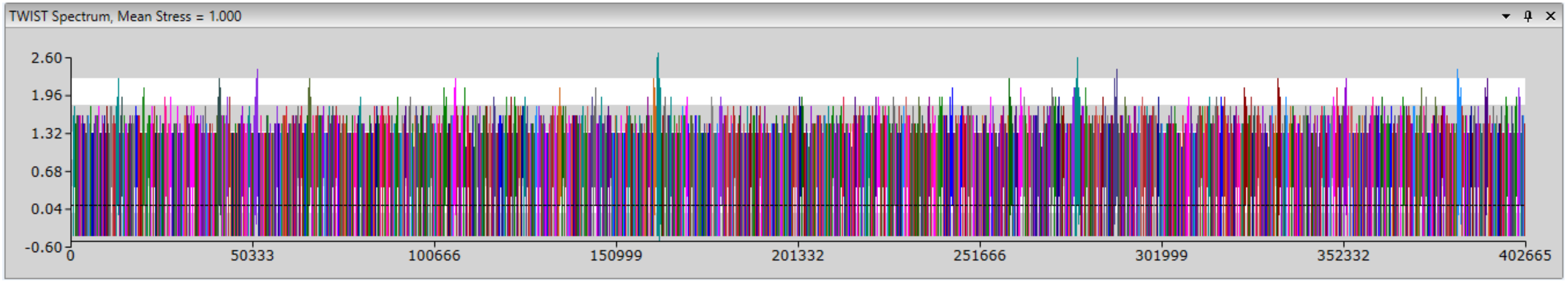
- Multiplies the maximum and minimum stress values by negative one, which will invert the spectrum
- Example use: upper vs lower wing skin.

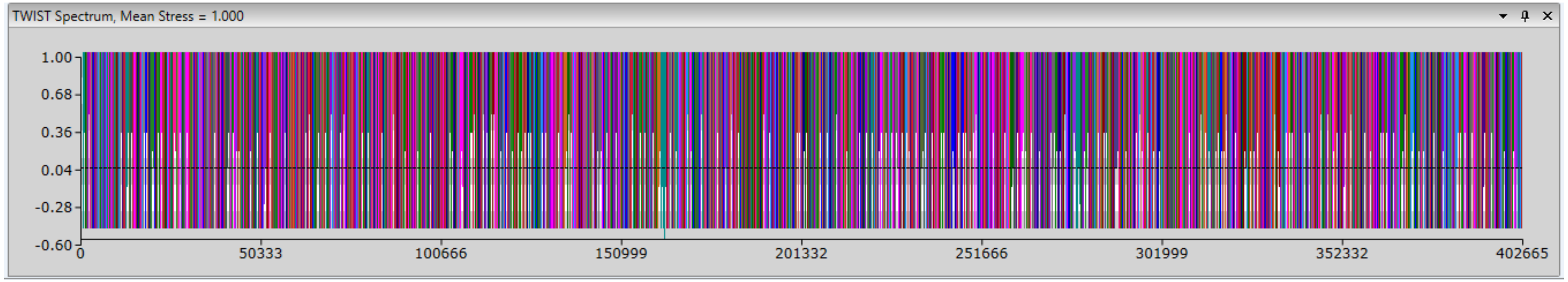




Clip

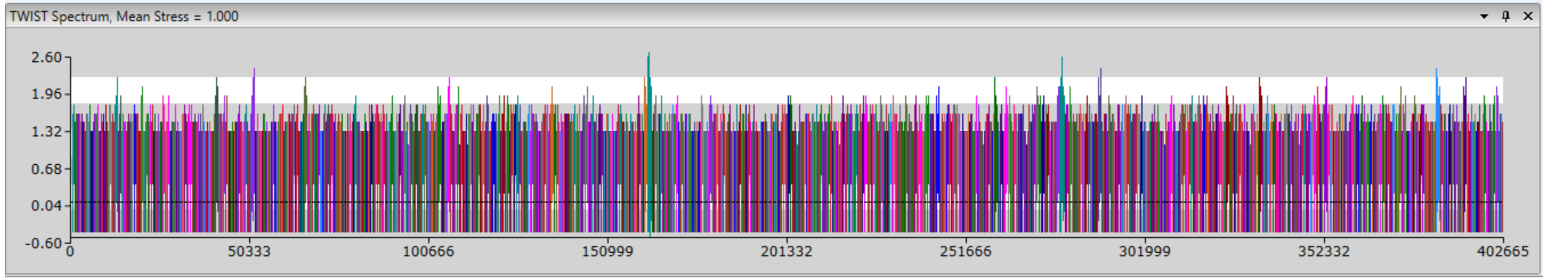
- Limits the maximum stress or load value for the entire spectrum or a selected sub spectrum.
- If the max and min values of any level exceed the upper bound, that level will be removed.

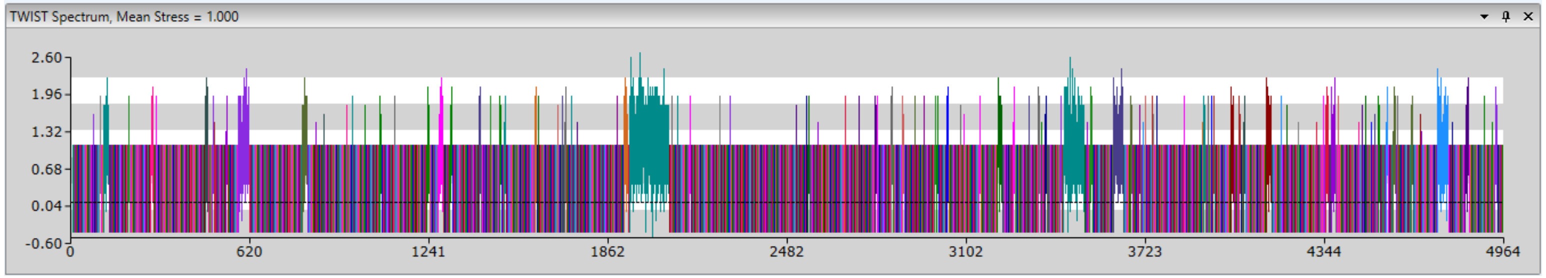




Truncate

- Limits the difference between the maximum and minimum stress (or load) values, or "delta values“, for all the levels in the spectrum or selected sub spectrum.
- Removes any level that has a delta value less than the input value.
- If a sub spectrum would have all levels deleted, the user is prompted to delete the sub spectrum.



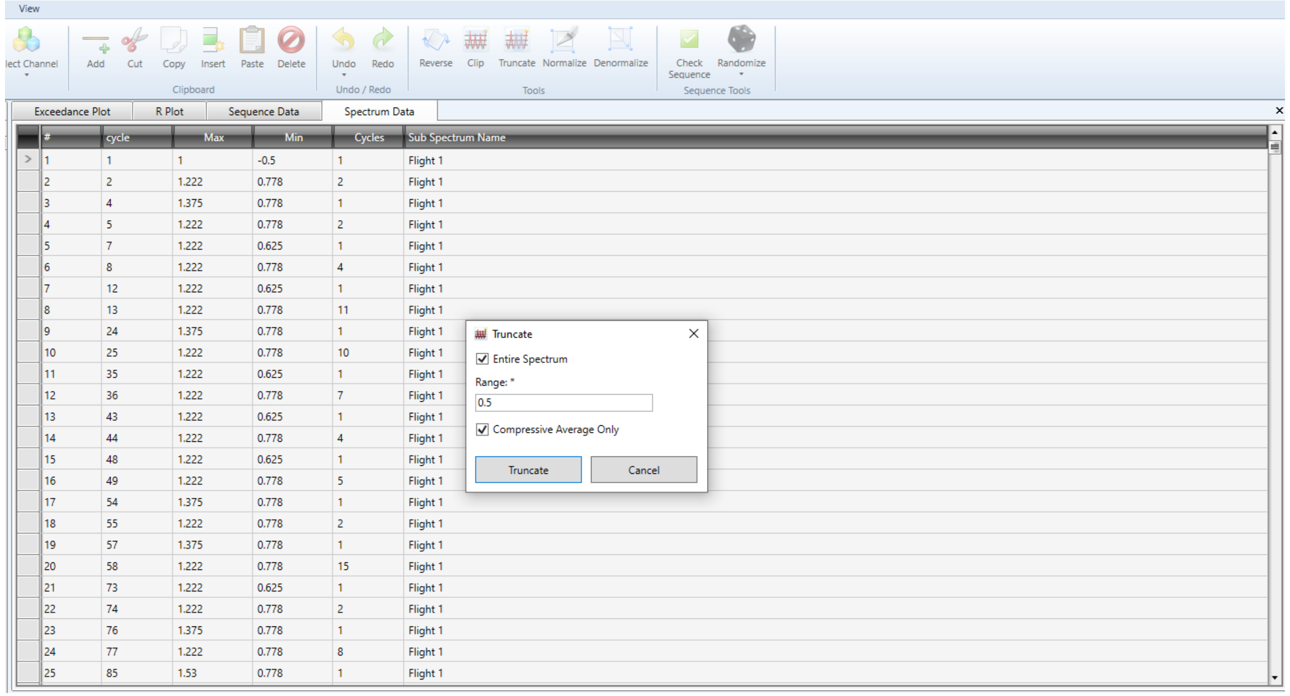


Compressive Truncation

- Truncate by Compressive Average Only.

- Checking the Compressive Average box tells the truncation operation to only remove levels meeting the truncation criteria whose average value is negative.

- A prompt will appear to remove any resulting empty sub spectra.

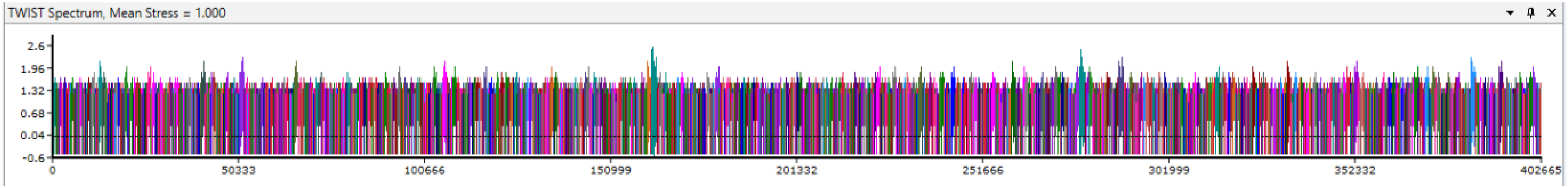


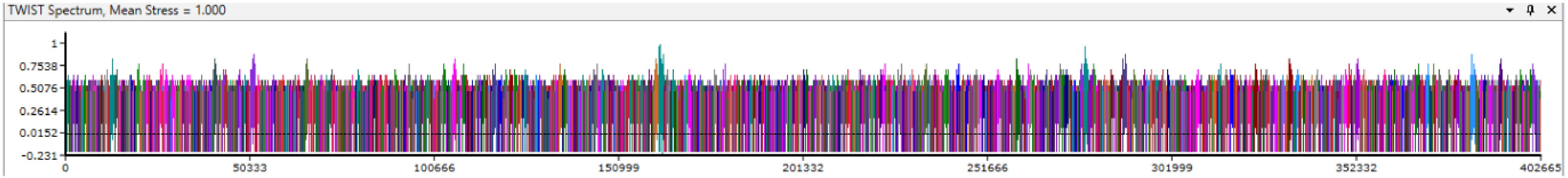
#	cycle	Max	Min	Cycles	Sub Spectrum Name
1	1	1	-0.5	1	Flight 1
2	2	1.222	0.778	2	Flight 1
3	4	1.375	0.778	1	Flight 1
4	5	1.222	0.778	2	Flight 1
5	7	1.222	0.625	1	Flight 1
6	8	1.222	0.778	4	Flight 1
7	12	1.222	0.625	1	Flight 1
8	13	1.222	0.778	11	Flight 1
9	24	1.375	0.778	1	Flight 1
10	25	1.222	0.778	10	Flight 1
11	35	1.222	0.625	1	Flight 1
12	36	1.222	0.778	7	Flight 1
13	43	1.222	0.625	1	Flight 1
14	44	1.222	0.778	4	Flight 1
15	48	1.222	0.625	1	Flight 1
16	49	1.222	0.778	5	Flight 1
17	54	1.375	0.778	1	Flight 1
18	55	1.222	0.778	2	Flight 1
19	57	1.375	0.778	1	Flight 1
20	58	1.222	0.778	15	Flight 1
21	73	1.222	0.625	1	Flight 1
22	74	1.222	0.778	2	Flight 1
23	76	1.375	0.778	1	Flight 1
24	77	1.222	0.778	8	Flight 1
25	85	1.53	0.778	1	Flight 1

Normalize/Denormalize

- Divides each max and min value by the factor entered in the normalization dialog.
- By default, the normalization factor is the maximum value in the spectrum setting the max value in the spectrum to 1.

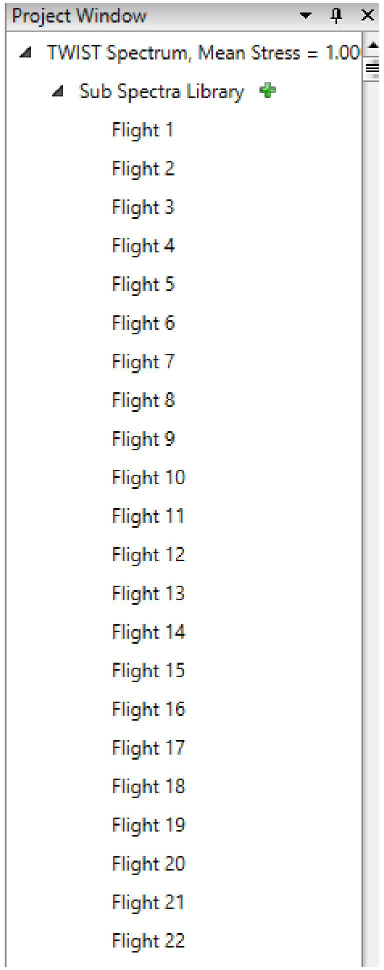
An example of a spectrum normalized by 2.6

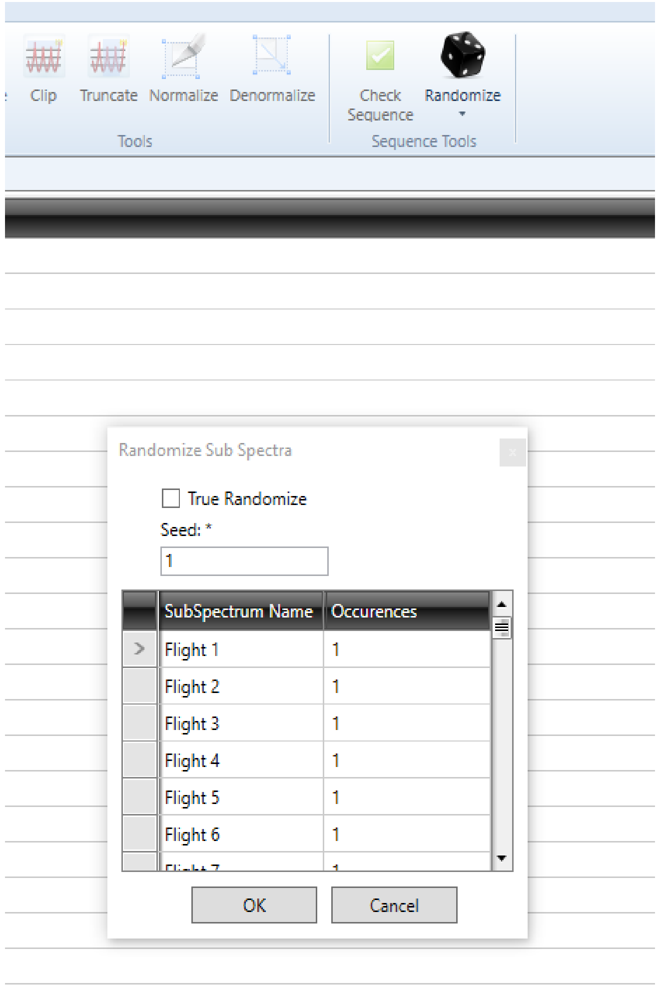




Randomize Sub Spectra

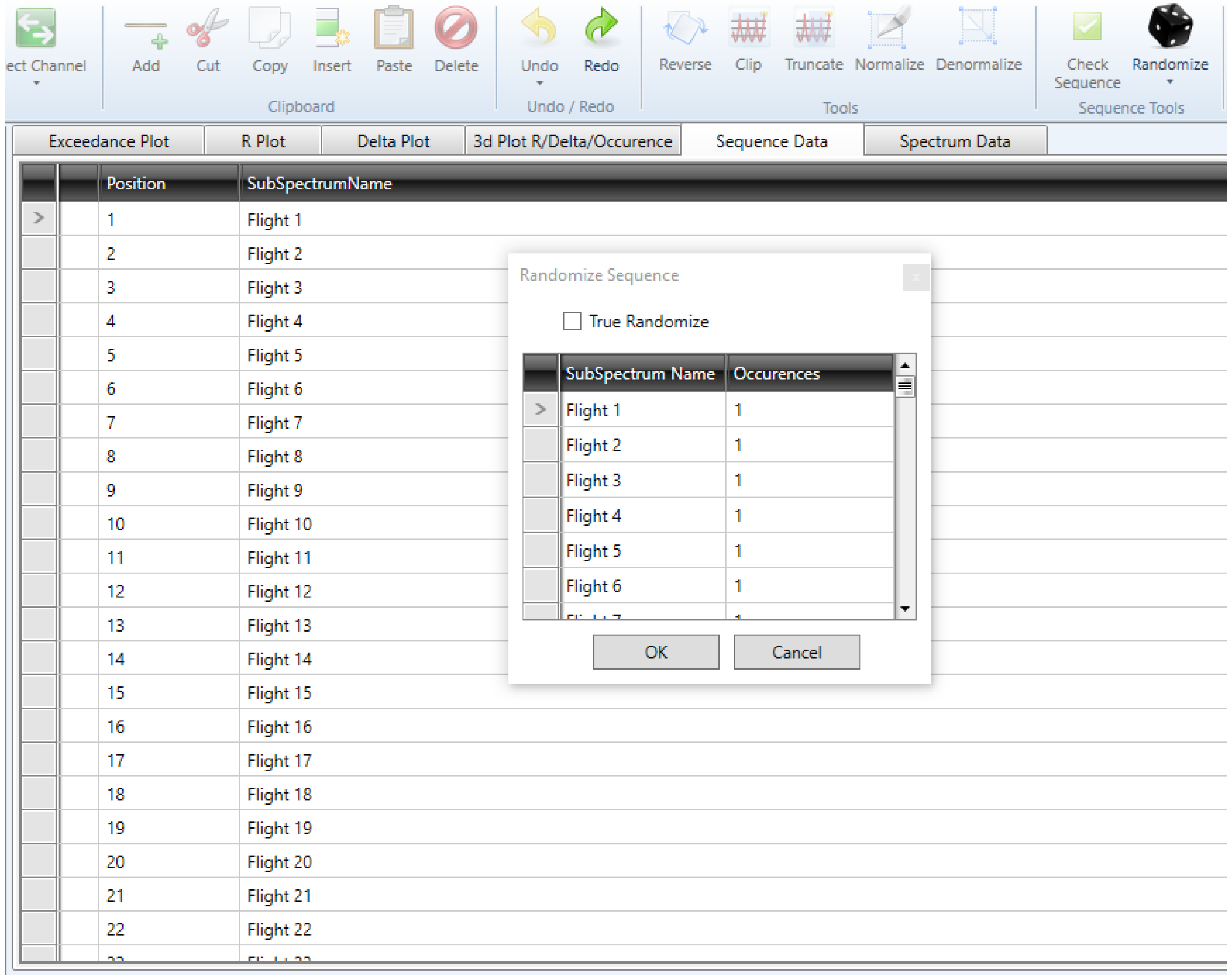
- Arranges all sub spectra in the project's Sub Spectra Library into a sequence in random order.
- Each sub spectrum will appear in the sequence a number of times equal to the Occurrences value next to the sub spectrum name.
- Uses the seed value set in project options.
- Will overwrite the existing sequence, if one exists.





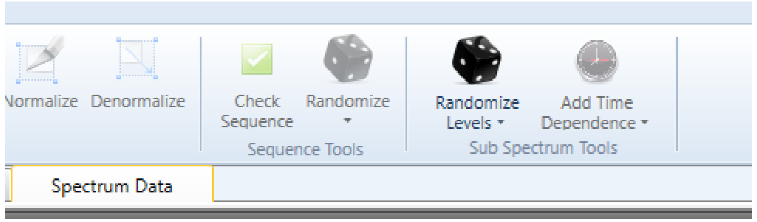
Randomize Sequence

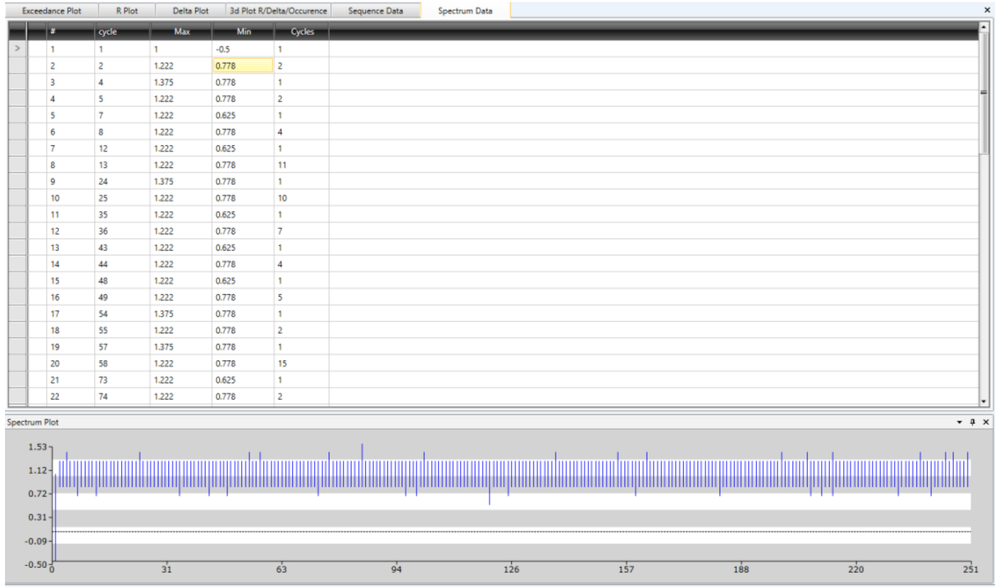
- Will arrange all sub spectra in the current sequence into a new sequence in random order.
- There must be an existing sequence.
- Each sub spectrum will be appear in the sequence a number of times equal to the Occurrences value next to the sub spectrum name.
- Uses the seed value set in project options.



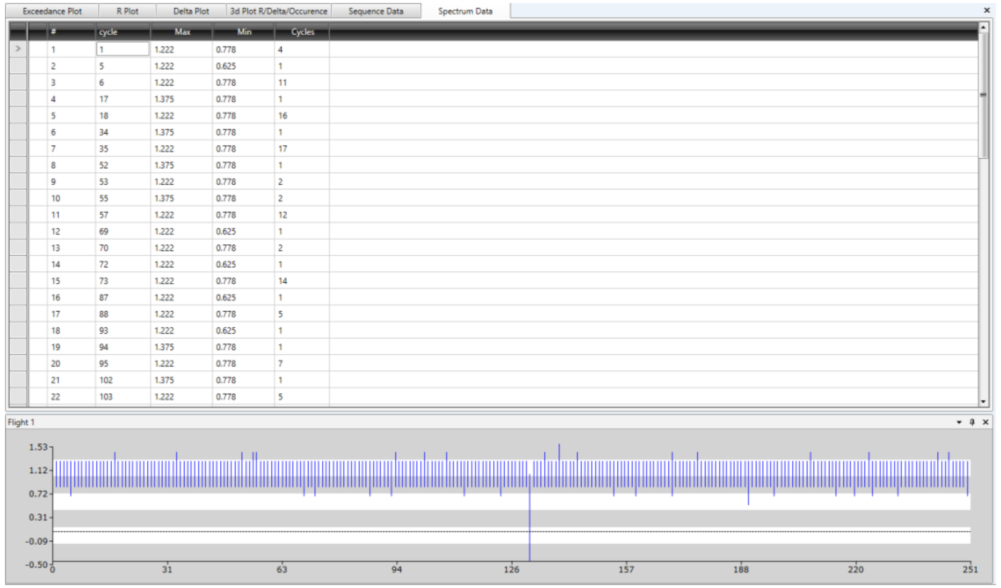
Randomize Levels

- Will shuffle the order of levels in a sub spectrum by levels or by cycles
- Randomize by cycles splits each level into a number of equivalent levels with one cycle each, shuffles them, then combines adjacent equivalent levels





#	cycle	Max	Min	Cycles
1	1	1	-0.5	1
2	2	1.222	0.778	2
3	4	1.375	0.778	1
4	5	1.222	0.778	2
5	7	1.222	0.625	1
6	8	1.222	0.778	4
7	12	1.222	0.625	1
8	13	1.222	0.778	11
9	24	1.375	0.778	1
10	25	1.222	0.778	10
11	35	1.222	0.625	1
12	36	1.222	0.778	7
13	43	1.222	0.625	1
14	44	1.222	0.778	4
15	48	1.222	0.625	1
16	49	1.222	0.778	5
17	54	1.375	0.778	1
18	55	1.222	0.778	2
19	57	1.375	0.778	1
20	58	1.222	0.778	15
21	73	1.222	0.625	1
22	74	1.222	0.778	2

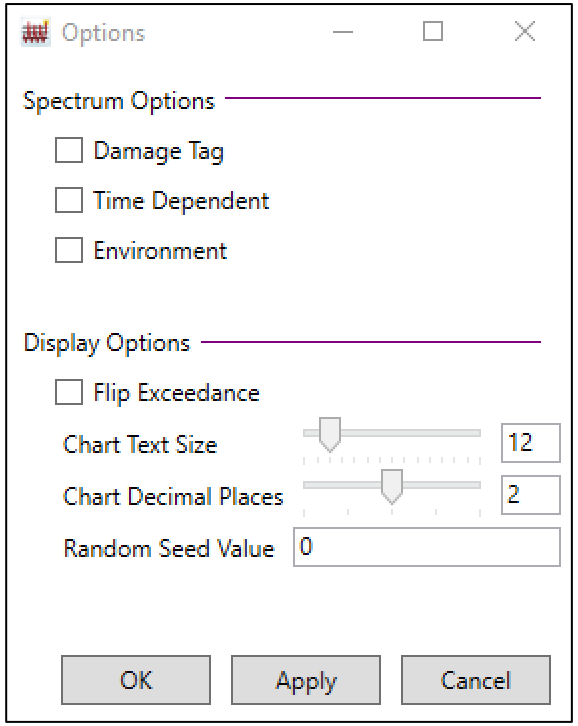


#	cycle	Max	Min	Cycles
1	1	1.222	0.778	4
2	5	1.222	0.625	1
3	6	1.222	0.778	11
4	17	1.375	0.778	1
5	18	1.222	0.778	16
6	34	1.375	0.778	1
7	35	1.222	0.778	17
8	52	1.375	0.778	1
9	53	1.222	0.778	2
10	55	1.375	0.778	2
11	57	1.222	0.778	12
12	69	1.222	0.625	1
13	70	1.222	0.778	2
14	72	1.222	0.625	1
15	73	1.222	0.778	14
16	87	1.222	0.625	1
17	88	1.222	0.778	5
18	93	1.222	0.625	1
19	94	1.375	0.778	1
20	95	1.222	0.778	7
21	102	1.375	0.778	1
22	103	1.222	0.778	5

Additional Features

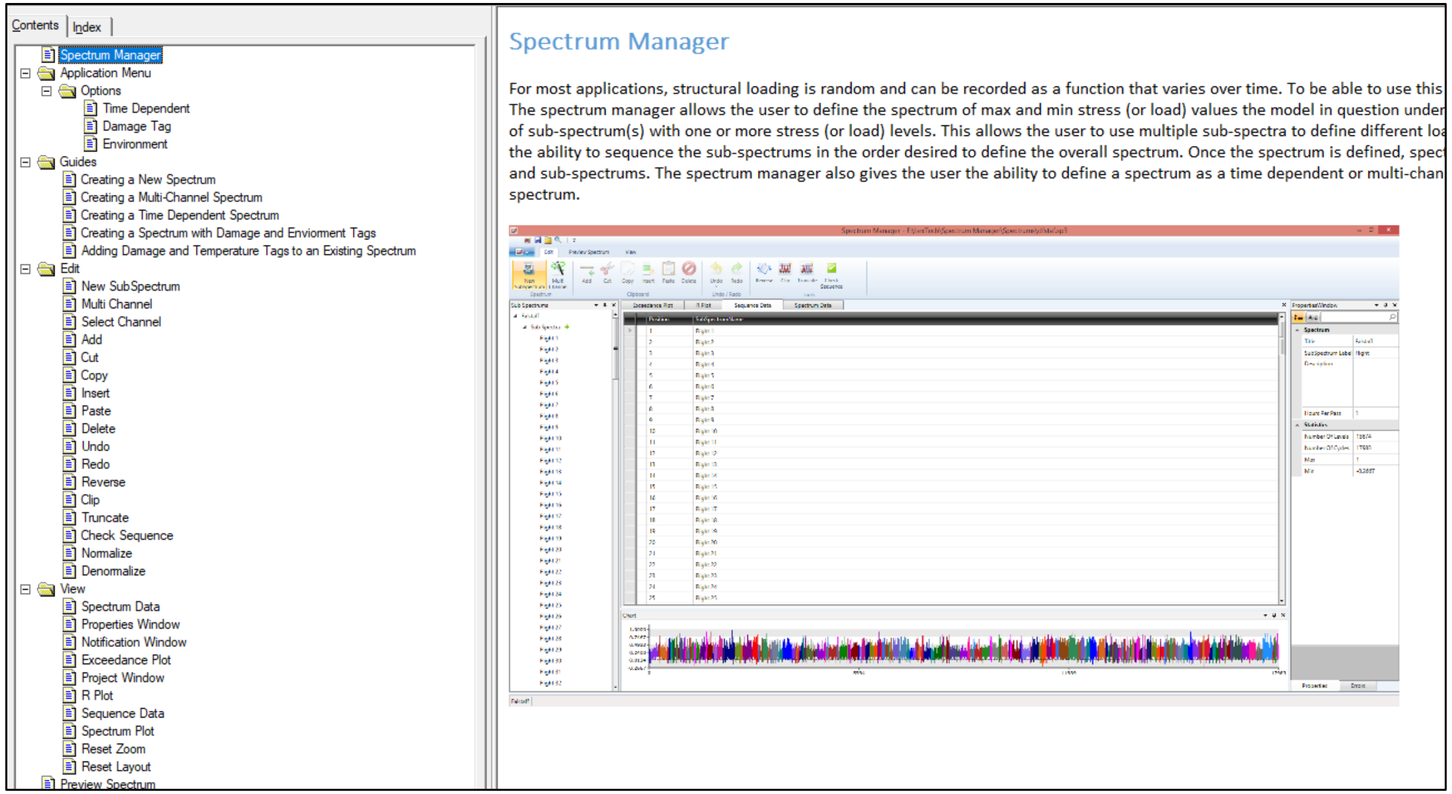
Preference Options

- Enable damage tags, environmental tags, and time dependent parameters.
- You can interchange the x and y axes of the Exceedance chart
- Set the text size, number of decimal places, and the seed value for randomization functions



Context Sensitive Help

- Contains additional information on every current feature of Spectrum Manager.
- Also contains guides explaining how to do basic operations in Spectrum Manager.
- By clicking on a section of the GUI and pressing “F1,” the relevant page in the Help guide will be opened.



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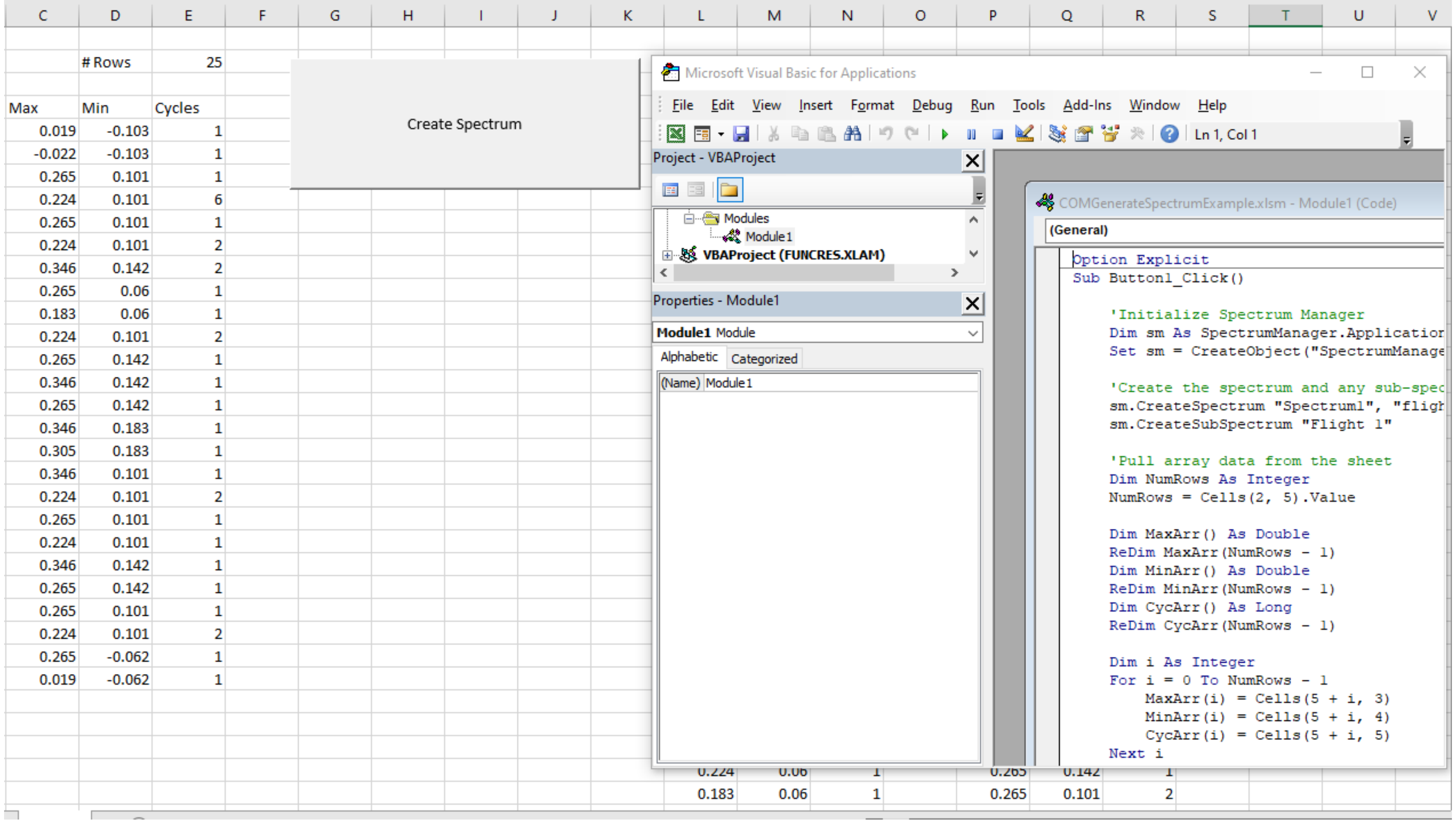
History Log

- Log of major events
- Examples include Clip, Truncate, Randomization, Reversal, and Normalization
- Includes the time, date, and description of the event

Description	Timestamp
Spectrum Reversed	6/28/2021 12:57
Spectrum Normalized	6/29/2021 10:18
Spectrum Reversed	6/29/2021 13:30
Spectrum Normalized	6/29/2021 13:31
Spectrum Sequence Randomized	6/29/2021 13:31

COM Interface

Spectrum Manager allows to perform most often used actions through COM Interface



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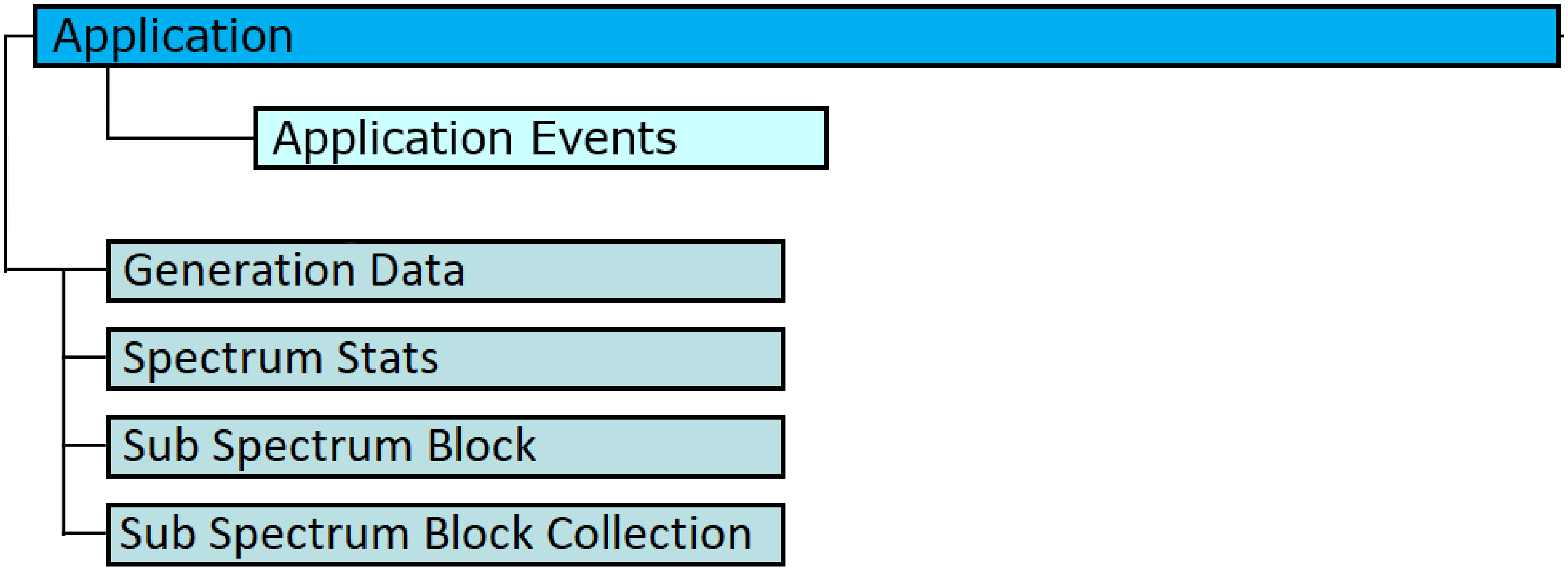
AFGROW .NET

COM Interface



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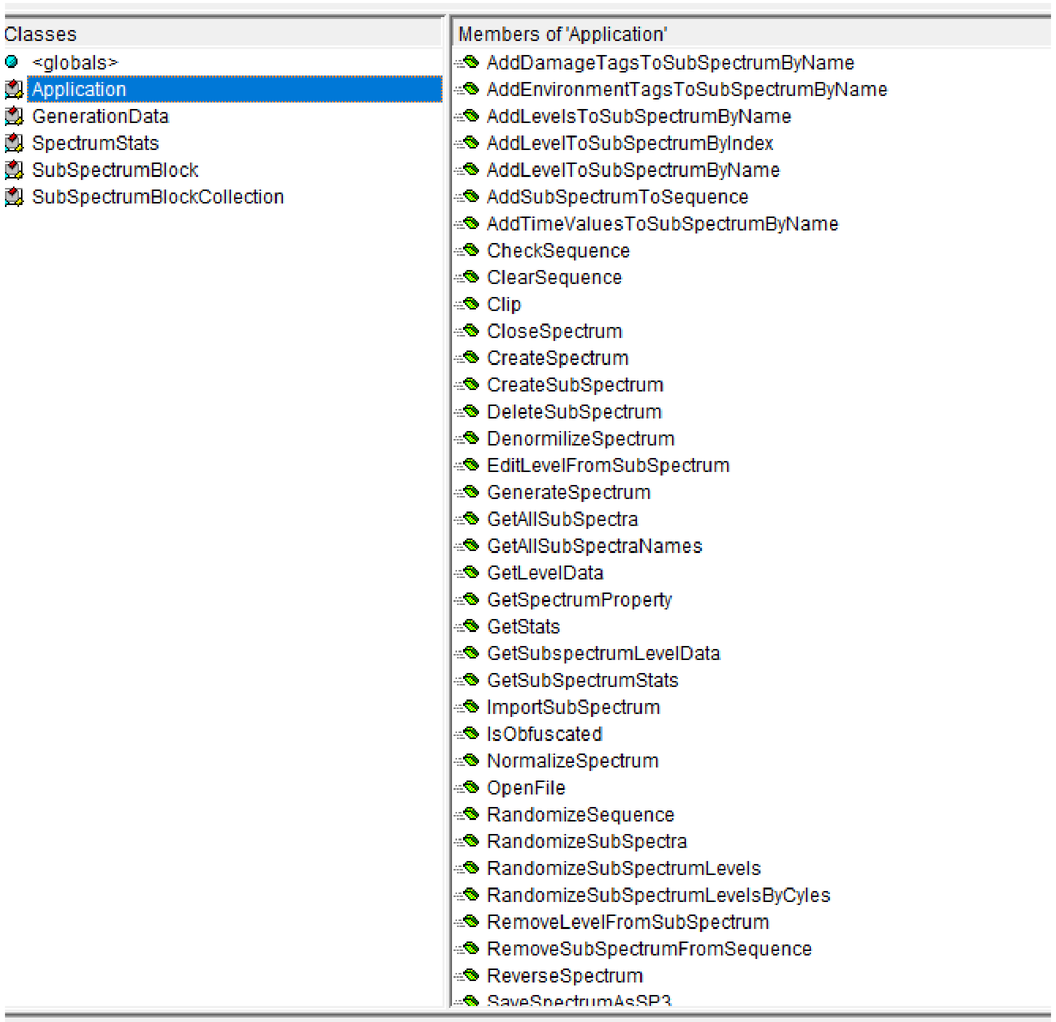
What can be done with Spectrum Manager

- Create spectrum, create sub spectra, add/remove levels to sub spectrum, add/remove sub spectra to/from sequence
- Open/save spectrum, inport spectrum data from different file types
- Clip, truncate, normalize, de-normalize, reverse, randomize spectrum
- Get statistics from spectrum or sub spectrum
- Add tags to single level or all levels in a sub spectrum



COM Interface - Example

- Click on the Developer tab and click “Visual Basic.”
- Go to Tools -> References, and make sure that “SpectrumManager” is selected in the references
- Add the following to the top of the Module1 code file

```
Option Explicit
Sub Button1_Click()
```

- Initialize spectrum manager with the following code

```
Dim sm As SpectrumManager.Application
Set sm = CreateObject("SpectrumManager.Application")
```

- Create the spectrum, specifying the sub-spectrum label and adding a simple description and the first sub-spectra

```
sm.CreateSpectrum "Spectrum1", "Flight", "Spectrum creation example"
sm.CreateSubSpectrum "Flight 1"
```

COM Interface - Example

- Create 2 arrays of doubles and 1 array of integers. These arrays will be used for *max* values, *min* values, and *cycle* values for each level in our sub-spectrum.

```
Dim NumRows As Integer
NumRows = 25
Dim MaxArr() As Double
ReDim MaxArr(NumRows - 1)
Dim MinArr() As Double
ReDim MinArr(NumRows - 1)
Dim CycArr() As Long
ReDim CycArr(NumRows - 1)
```

COM Support - Example

- Read the data from the spreadsheet into the 3 arrays using a for loop

```
Dim i As Integer
For i = 0 To NumRows - 1
        MaxArr(i) = Cells(5 + i, 3)
        MinArr(i) = Cells(5 + i, 4)
        CycArr(i) = Cells(5 + i, 5)
Next i
```

- Add the data to the sub-spectrum

```
sm.AddLevelsToSubSpectrumByName "Flight 1", CycArr, MaxArr, MinArr
```

- Add the sub-spectrum to the sequence.

```
sm.AddSubSpectrumToSequence "Flight 1"
```

COM Interface - Example

- Create the second sub-spectrum

```
sm.CreateSubSpectrum "Flight 2"
```

- Change arrays dimensions to accommodate the second data set, load the data from the spreadsheet into the 3 arrays

```
NumRows = 160
ReDim MaxArr(NumRows - 1)
ReDim MinArr(NumRows - 1)
ReDim CycArr(NumRows - 1)
For i = 0 To NumRows - 1
        MaxArr(i) = Cells(5 + i, 12)
        MinArr(i) = Cells(5 + i, 13)
        CycArr(i) = Cells(5 + i, 14)
Next I
```

- Add the data to the second sub-spectrum

```
sm.AddLevelsToSubSpectrumByName "Flight 2",      CycArr, MaxArr, MinArr
```

COM Interface - Example

- Add second sub-spectrum to the sequence.

```
sm.AddSubSpectrumToSequence "Flight 2"
```

- Create the third sub spectrum

```
sm.CreateSubSpectrum "Flight 3“
```

- Change arrays dimensions to accommodate the third data set, load the data from the spreadsheet into the arrays

```
NumRows = 49
ReDim MaxArr(NumRows - 1)
ReDim MinArr(NumRows - 1)
ReDim CycArr(NumRows - 1)

For i = 0 To NumRows - 1
        MaxArr(i) = Cells(5 + i, 16)
        MinArr(i) = Cells(5 + i, 17)
        CycArr(i) = Cells(5 + i, 18)
Next i
```

COM Interface - Example

- Add the data to the third sub-spectrum, by the sub-spectrum's name

```
sm.AddLevelsToSubSpectrumByName "Flight 3", CycArr, MaxArr, MinArr
```

- Add that sub spectrum to the sequence.

```
sm.AddSubSpectrumToSequence "Flight 3"
```

- It is possible to add any of sub-spectra to the sequence any number of times. To demonstrate, add a second instance of the first sub spectra to the end of the sequence

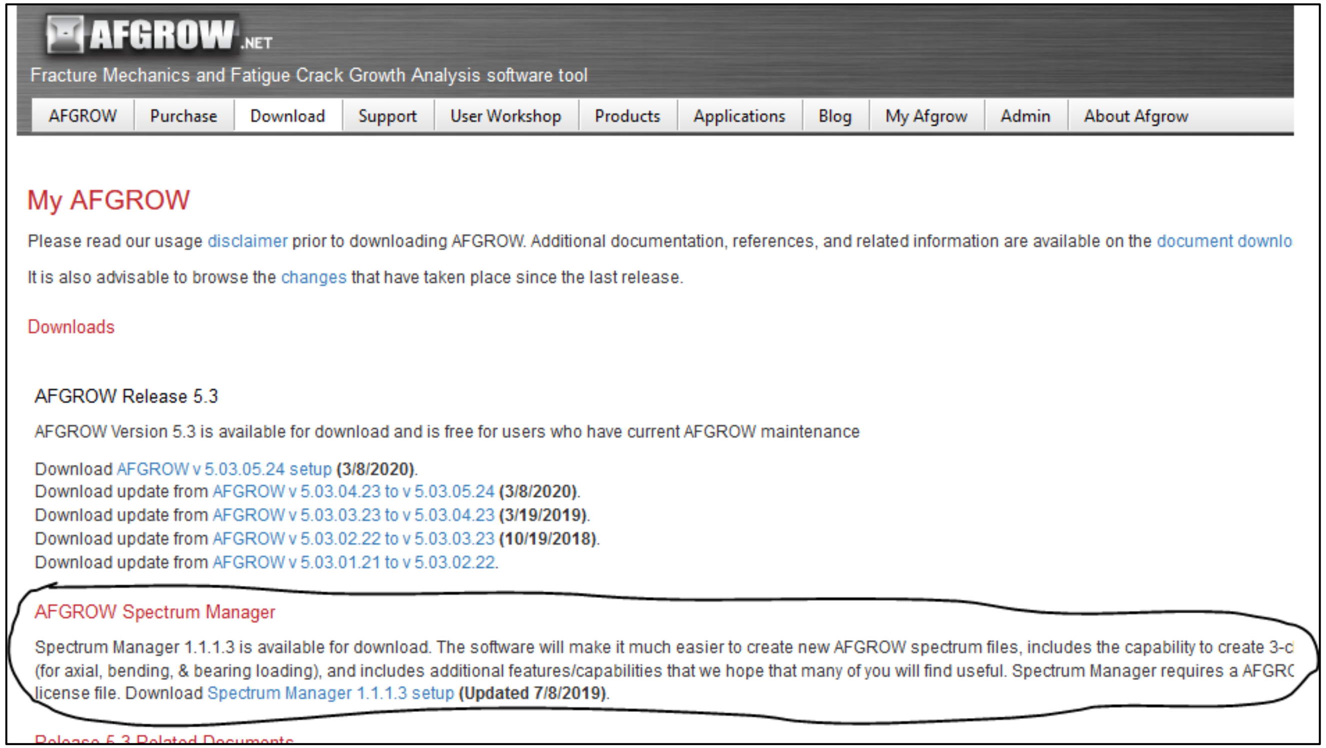
```
sm.AddSubSpectrumToSequence "Flight 1“
```

- Save the spectrum.

```
sm.SaveSpectrumAsSPX "(path to your file)"
```

Download Spectrum Manager

- Download can be found on AFGROW.net
- Currently separate installation from AFGROW
- Available to anyone with a current AFGROW license
- Version 1.2 to be released with upcoming AFGROW release 5.4 and included in AFGROW installation



Conclusion

- Spectrum Manager v 1.2 brings several new features including Spectrum Generation from Exceedance Curve data, improved application speed, randomization options, a new preview selector and spectrum chart, and COM Interface.

- Version 1.2 will be available to licensed users with the next release of AFGROW 5.4

Questions/Comments?