

SMART|LD Loading



SMART Short Course
The Aircraft Airworthiness & Sustainment
Conference
Grapevine, Texas – March 21, 2016

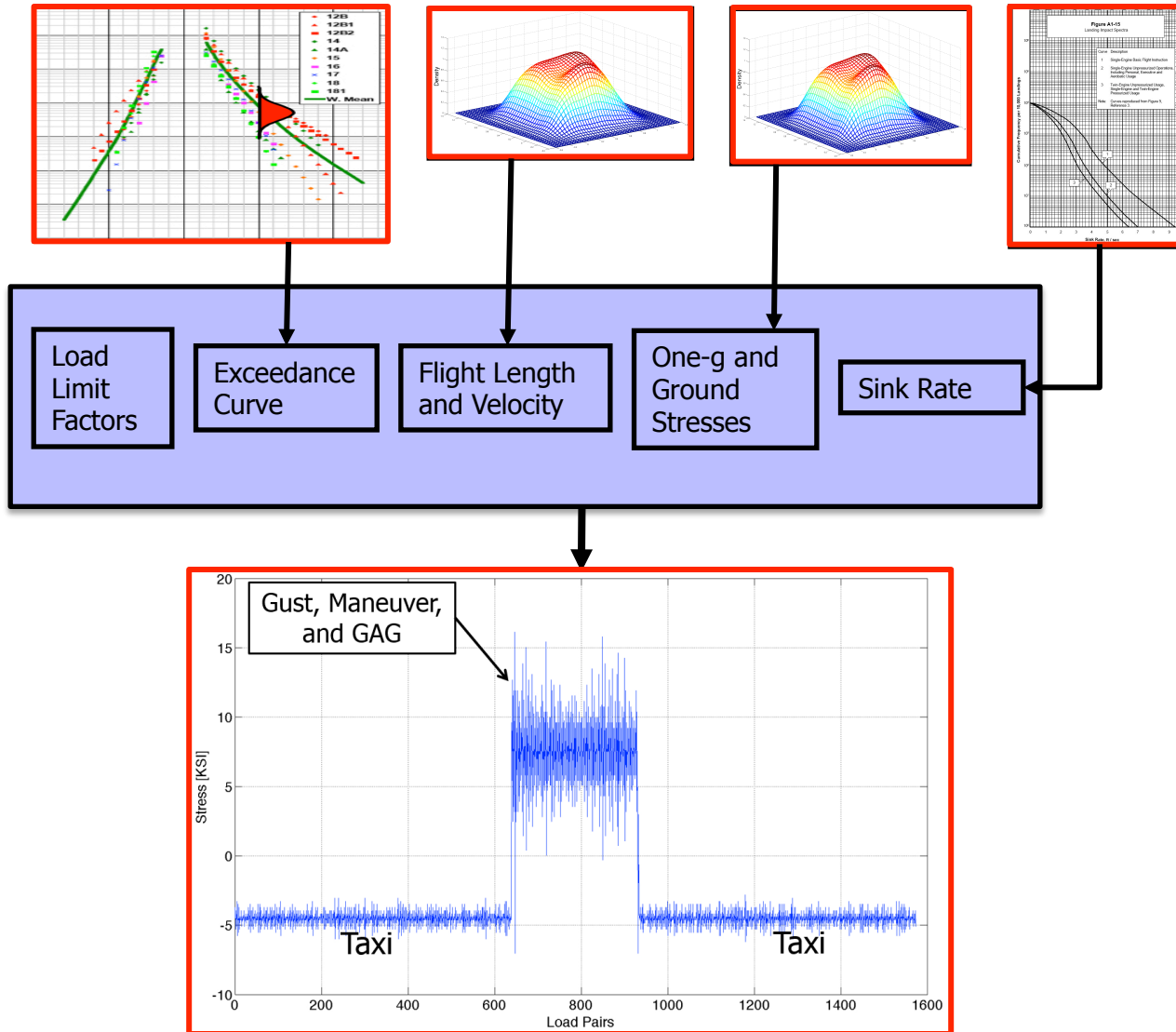
Spectrum Loading



SMART_{DT}

SMall Aircraft Risk Technology - Damage Tolerance Analysis

Spectrum Generation



- ✓ Exceedance curves
 - ✓ internal and user-defined
- ✓ Mixed usages
- ✓ Flight duration and weight matrices random to simulate flight profiles and different operations
- ✓ Randomized flights and stresses
- ✓ Spectrum editing options
- ✓ User-defined spectra
 - ✓ Afgrow format

Loading Exceedance Options

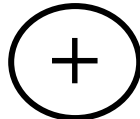
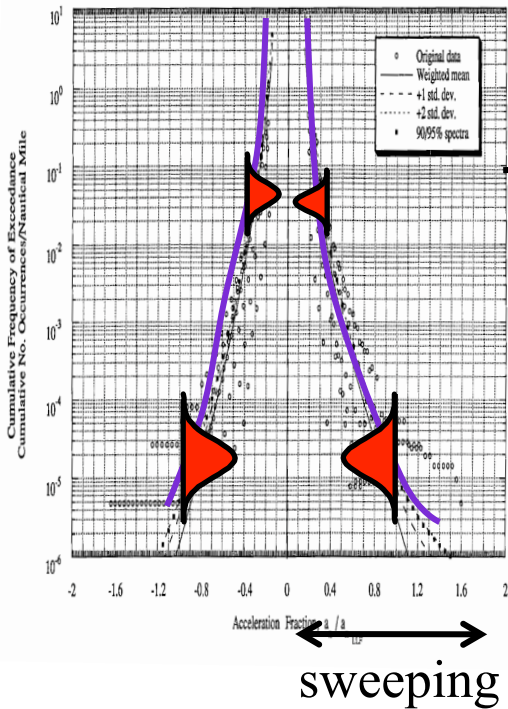


Usages
Single-Engine Unpressurized Usage Basic Flight Instruction
Single-Engine Unpressurized Usage Personal Usage
Single-Engine Unpressurized Usage Executive Usage
Single-Engine Unpressurized Usage Aerobatic Usage
Twin-Engine Unpressurized Usage Basic Flight Instruction
Twin-Engine Unpressurized Usage General Pressurized Usage
Agricultural/Special Usage
User defined

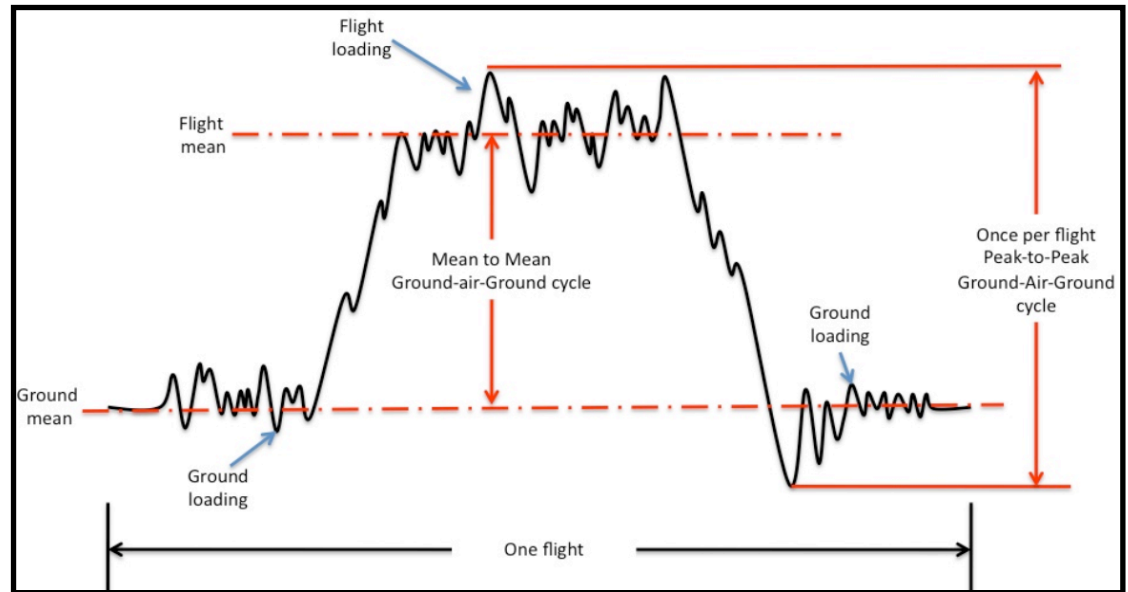
Mix of weighted usages allowed



Loading Generation



Load Limit Factors
 One-g Stress
 Ground Stress
 Sink Rate
 Flight Velocity and Duration





TEXTRON AVIATION

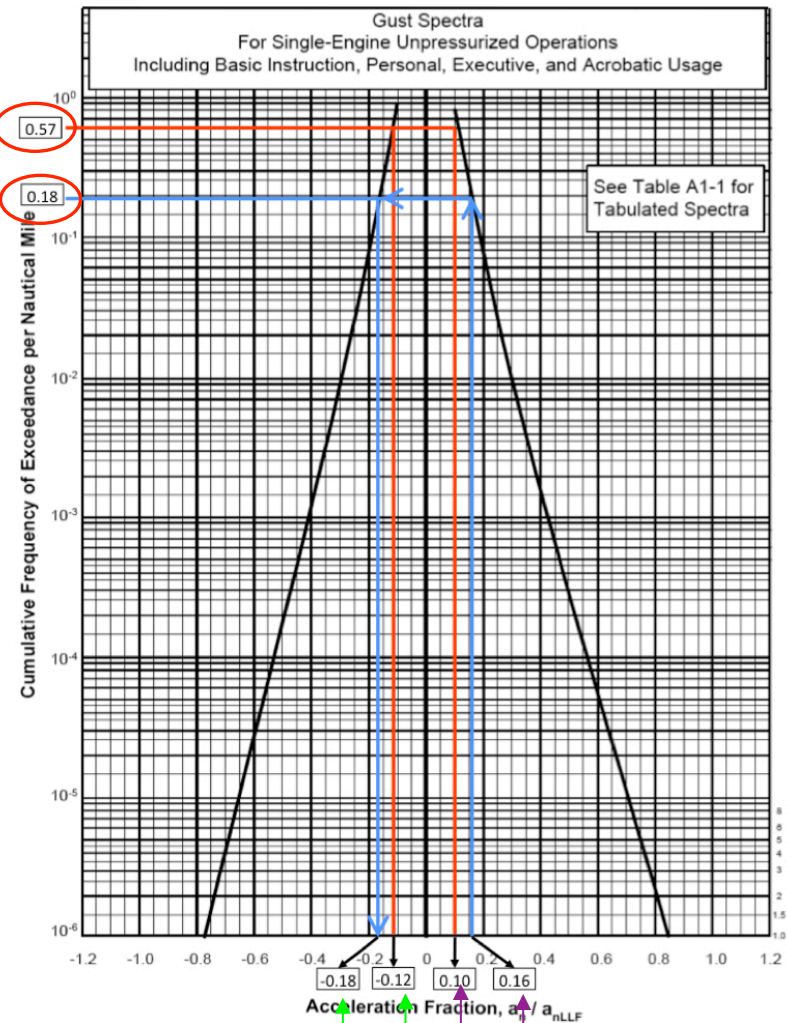
Load Spectrum Generation



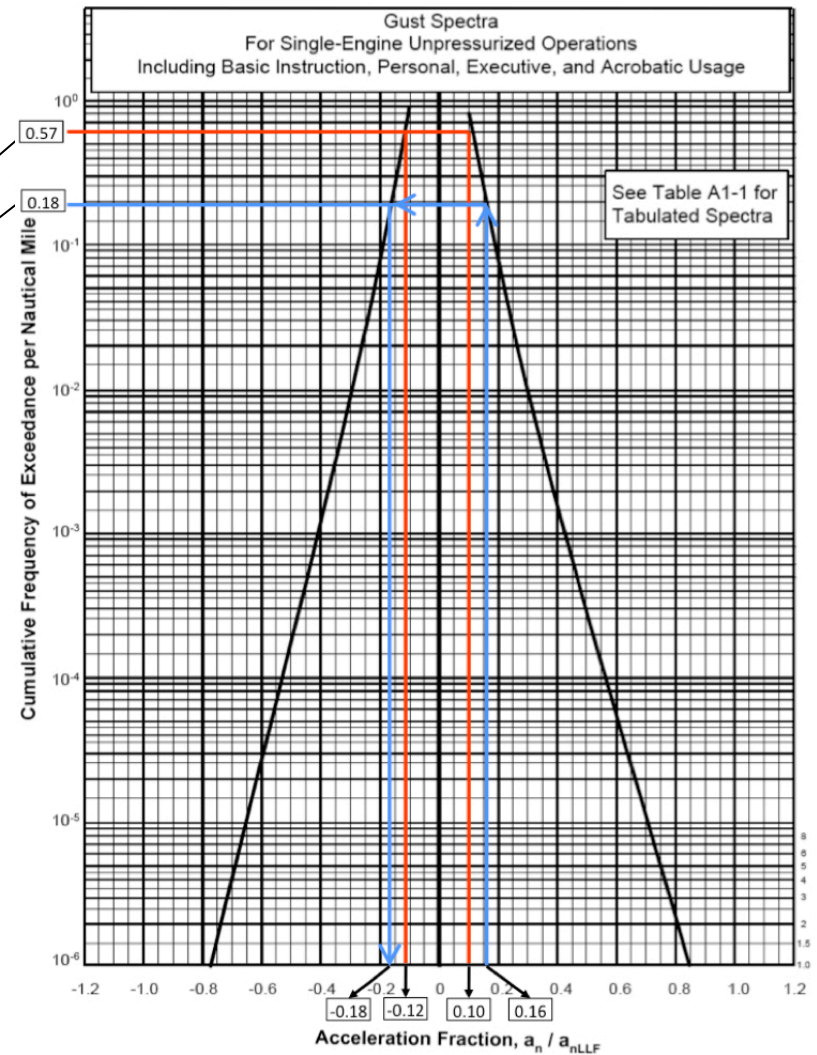
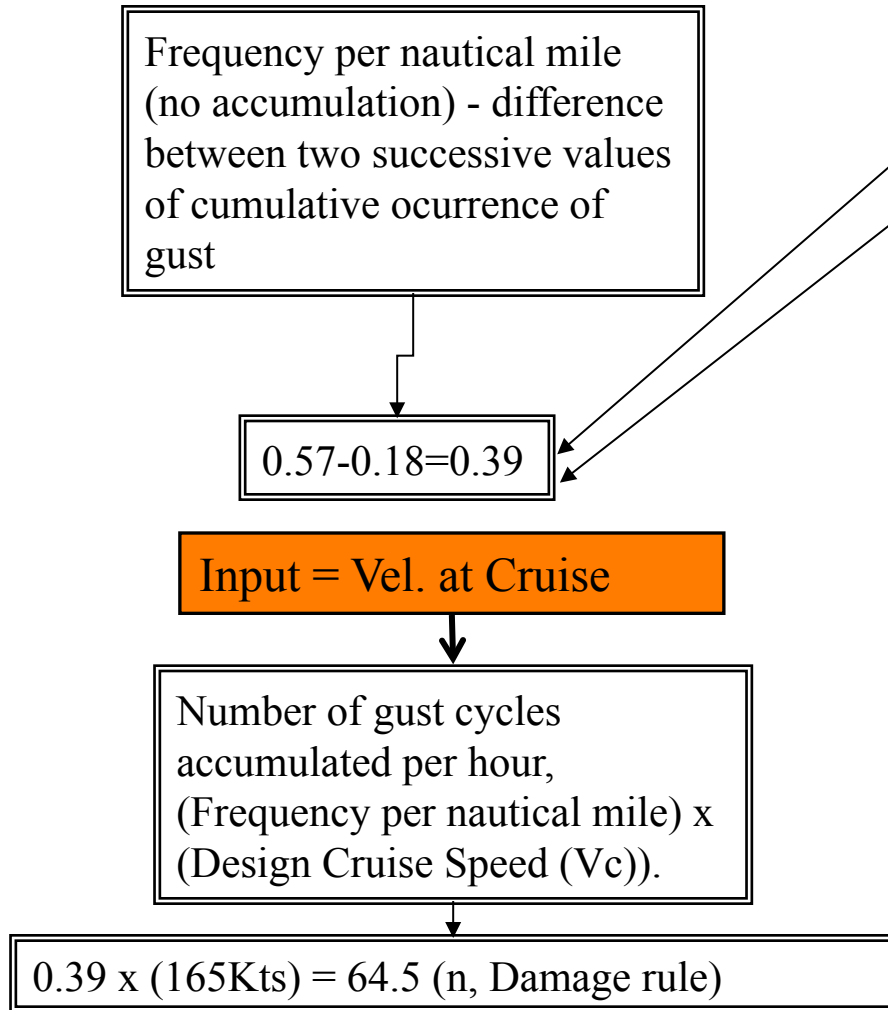
From the Figure, make a sweep reading the a_n/a_{nLLF} (+), Positive values of gust load factor ratio.

From the Figure read the values of cumulative occurrence of gust per nautical mile at a specific gust load factor.

From the Figure read the a_n/a_{nLLF} (-), Negative values of gust load factor ratio at a positive gust load factor.



Load Spectrum Generation





TEXTRON AVIATION

Load Spectrum Generation



$$a_{NLLF} = \pm 2.155$$

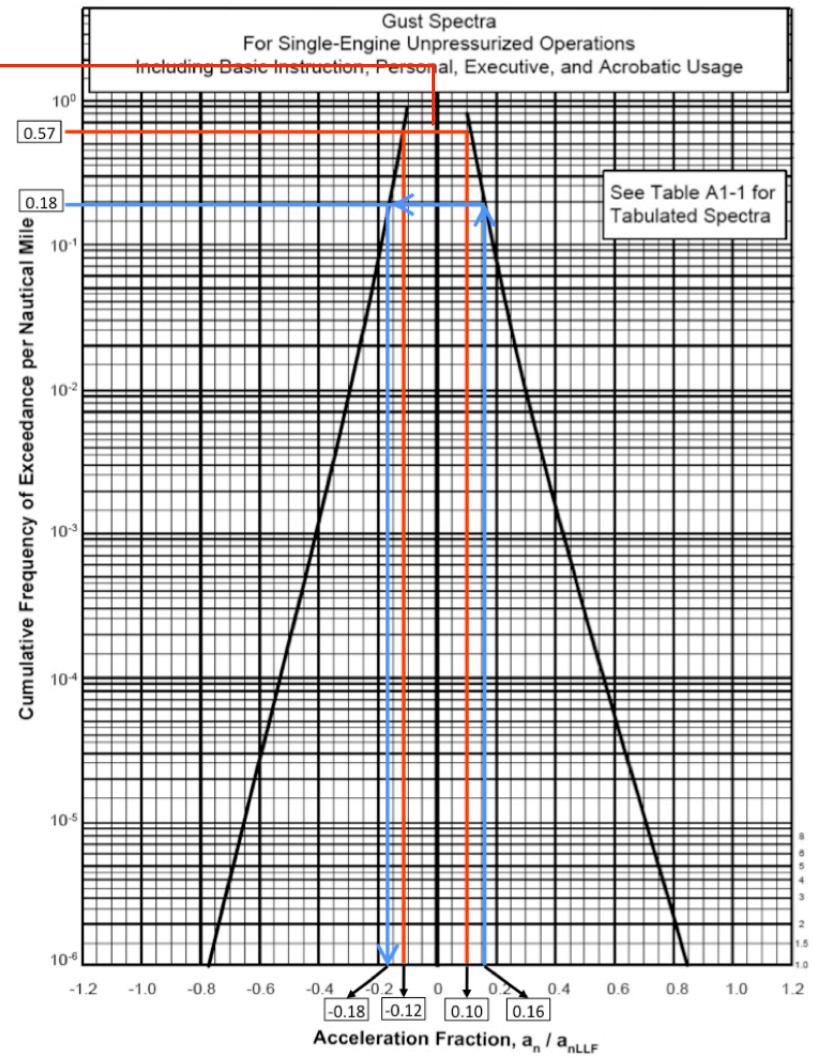
Stress increment due to the gusts (a_n)
 $(a_{NLLF}) \times (a_n/a_{NLLF})$

$$a_n = -0.259$$
$$a_n = 0.28$$

Stress = 7410 PSI @
Critical Component
(1 g)

Maximum and minimum delta stress over and below the maximum stress @ the critical component

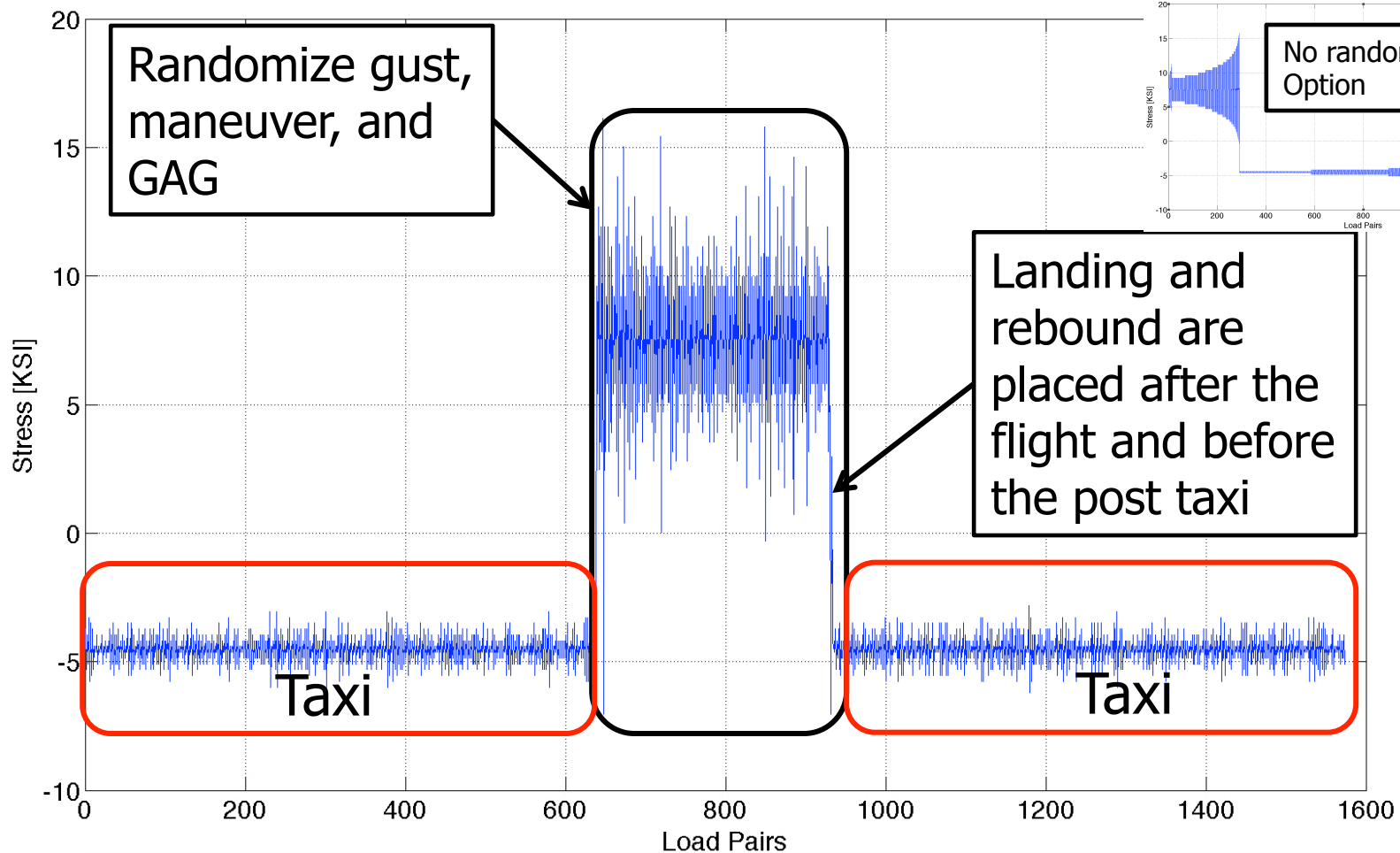
(+) Δ Max. Stress = 2070 psi (-)
 Δ Max Stress = -1920 psi





TEXTRON AVIATION

Loading Example



Randomize taxi loads and split half before the flight and half after the flight, Taxi load can be excluded from the analysis.

Building Spectra



SMART - Small Aircraft Risk Technology

File Documentation

Begin Usage Spectra

Load Spectrum: Browse... Transfer Factor:

Flight Hours per Flight:

Load Usages:

Usage Spectra

Aircraft Usage:

Percent of Total Usage:

Exceedance COV

Design Maneuver Load Factor High:

Design Gust Load Factor High:

Design Maneuver Load Factor Low:

Design Gust Load Factor Low:

Ground Stress (psi):

One G Stress (psi):

Average Velocity (V_{no}/V_{mo}(Knots)):

Number of Flight Times:

Number of Velocities:

Load Matrices

File: Browse...

Flight Variation

07/10/2015-V4.0.7

Select usages

Define spectrum standard deviation

Design limit load factors

Define 1g stress, V_C, & matrix size



TEXTRON AVIATION

Flight Duration & Weight Matrices



- ❑ Velocity matrix scales occurrences
- ❑ Weight matrix scales 1g stresses
 - ❑ Can also use matrix to scale on 1g stress directly
- ❑ Can use matrix to define
 - ❑ Mission mixes
 - ❑ Flight profiles
- ❑ Multiple usages allowed

Adjusts occurrences

Flight Times vs. Velocity		%Vno or %Vmo																	
Ft. Time(hrs)	% of Flts.																		
0.83	0.5	0.00	0.00	0.04	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.08	0.5	0.092	0.015	0.00	0.185	0.708	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Adjusts stresses

Flight Times vs. Weight		%Max. Wt.																		
Ft. Time(hrs)	% of Flts.																			
0.83	0.5	0.38	0.32	0.26	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1.08	0.5	0.00	0.00	0.00	0.00	0.031	0.262	0.015	0.185	0.03	0.154	0.231	0.092							

01/05/2014-V3.1 W

Accept Weight Matrix Same as Velocity Matrix Save Matrices Cancel



TEXTRON AVIATION

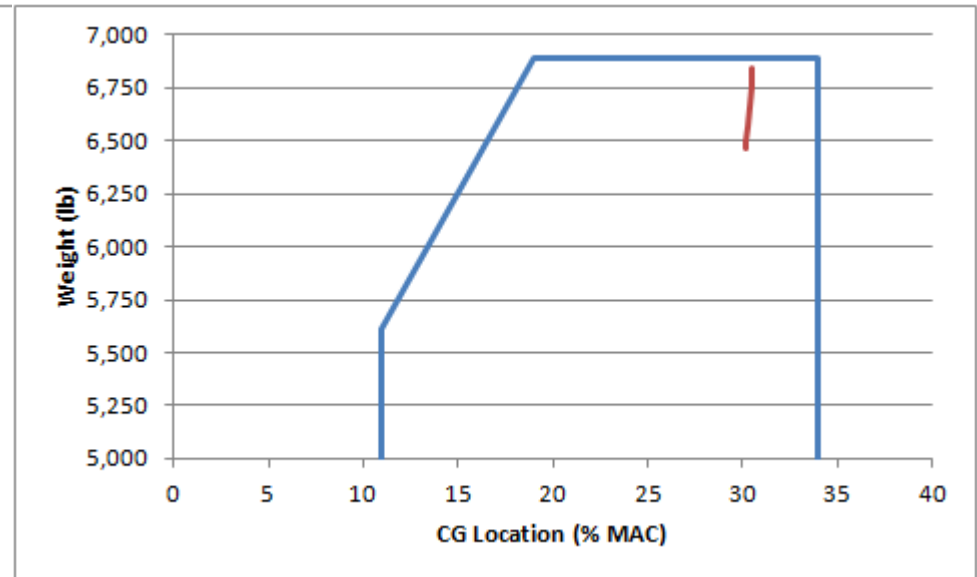
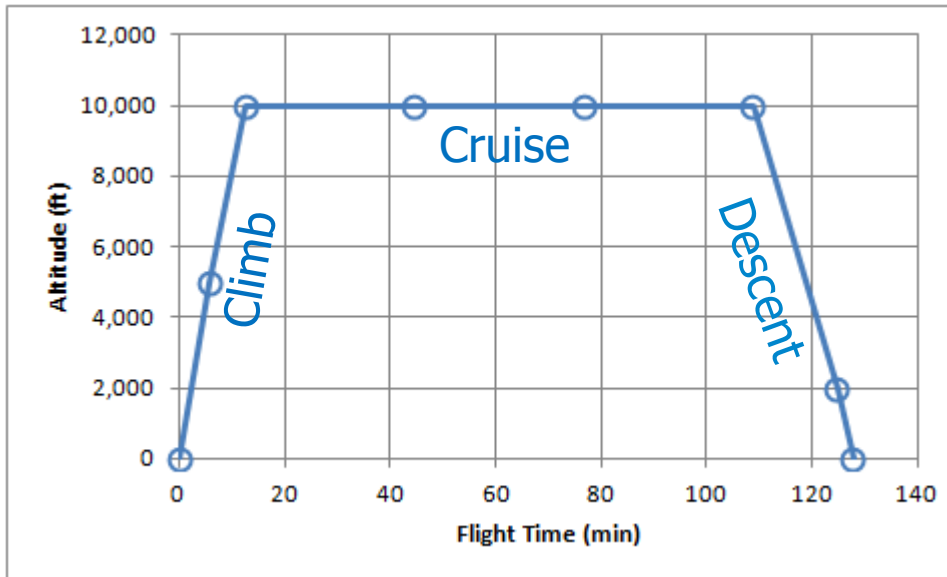
Flight Duration & Weight Matrices



Mission Mix

Mission	Mission Name	% of flights	Flight Duration (hr)	MTOW (lb)	Cruise Speed (Kts)
A	Check ride	10%	0.2	5200	160
B	High speed cruise	20%	0.9	6800	180
C	Max weight	30%	1.1	7000	175
D	Max range	40%	3	6600	170

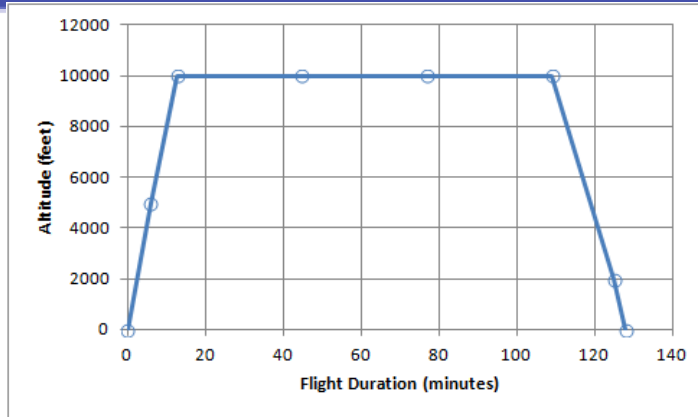
Flight Profile



Or combination of both



Defining Flight Matrices



Segment	Weight	KEAS	% Duration
CLIMB	6838	121	0.046
CLIMB	6814	120	0.053
CRUISE	6755	147	0.251
CRUISE	6664	148	0.251
CRUISE	6572	149	0.251
DESCENT	6502	180	0.125
APPROACH	6466	102	0.023

$V_C = 200$ KEAS, MTOW = 6850 lb

Sort matrix in ascending order for speed & weight

		Average Weight During Flight, % Max Takeoff Weight						
Flight Time (hrs)	% of Flights	0.944	0.949	0.959	0.973	0.986	0.995	0.998
2.133	1.0	0.023	0.125	0.251	0.251	0.251	0.053	0.046

		Average Speed During Flight, % Design Velocity						
Flight Time (hrs)	% of Flights	0.510	0.600	0.605	0.735	0.740	0.745	0.900
2.133	1.0	0.023	0.053	0.046	0.251	0.251	0.251	0.125

Defining Flight Matrices



SMART - Small Aircraft Risk Technology

File Documentation

Begin Usage Spectra

Load Spectrum: Browse...

Flight Hours for this Spectrum: Flight Hours per Flight:

Load Usages:

Usage Spectra

Aircraft Usage: TWIN_ENGINE_UNPRESS_GENERAL_USAGE

Percent of Total Usage:

Design Maneuver Load Factor High:

Design Gust Load Factor High:

Design Maneuver Load Factor Low:

Design Gust Load Factor Low:

Ground Stress (psi):

Exceedance COV:

One G Stress (psi):

Average Velocity (Vno/Vmo(Knots)):

Number of Flight Times:

Number of Velocities:

Load Matrices

File: Browse...

Flight Variation

07/10/2015-V4.0.7

Define 1g stress,
 V_C , & matrix size

Defining Flight Matrices



Matrix [X]

Flight Times vs. Velocity

Fit. Time(hrs)	% of Flts.	%Vno or %Vmo	%Vno or %Vmo	%Vno or %Vmo	%Vno or %Vmo	%Vno or %Vmo	%Vno or %Vmo	%Vno or %Vmo
		0.510	0.600	0.605	0.735	0.740	0.745	0.900
2.133	1.0	0.023	0.053	0.046	0.251	0.251	0.251	0.125

Flight Times vs. Weight

Fit. Time(hrs)	% of Flts.	%Max. Wt.	%Max. Wt.	%Max. Wt.	%Max. Wt.	%Max. Wt.	%Max. Wt.	%Max. Wt.
		0.944	0.949	0.959	0.973	0.986	0.995	0.998
2.133	1.0	0.023	0.125	0.251	0.251	0.251	0.053	0.046

Define velocity matrix

Define weight matrix

Scaling 1g Stresses

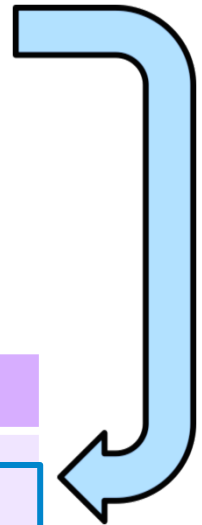


- Weight matrix uses weight as a proxy to scale 1g stresses
- If 1g stresses are known can use weight matrix to scale stresses directly

Segment	1g Stress	KEAS	% Duration
CLIMB	5186	121	0.046
CLIMB	5223	120	0.053
CRUISE	5317	147	0.251
CRUISE	5413	148	0.251
CRUISE	5429	149	0.251
DESCENT	5434	180	0.125
APPROACH	5520	102	0.023

Max 1g Stress = 5600 psi

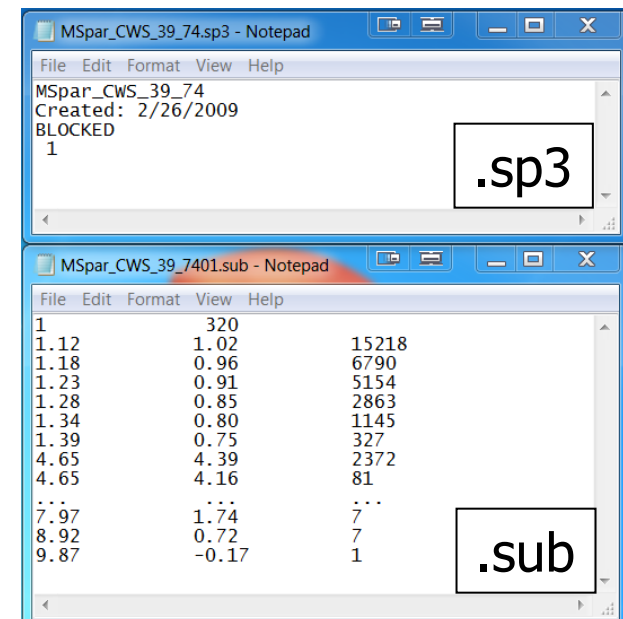
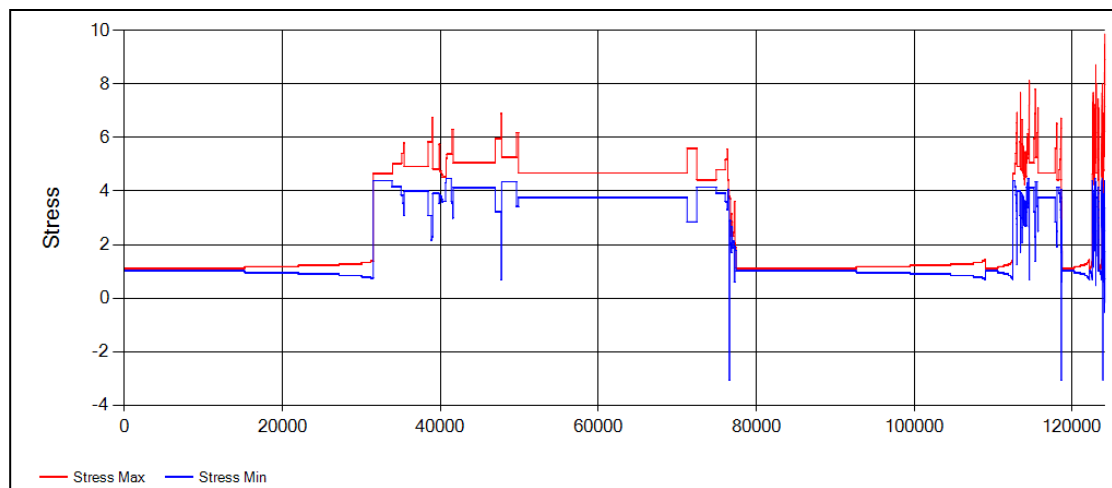
Flight Time (hrs)	% of Flights	Average Weight During Flight, % Max Takeoff Weight						
		0.926	0.933	0.949	0.967	0.969	0.970	0.986
2.133	1.0	0.023	0.125	0.251	0.251	0.251	0.053	0.046



Loading Generation (User Defined)



Smart allows the user to load Afgrow spectra files (.sp3 and .sub). The GUI will read the “.sp3”



User Defined Spectrum



Select spectrum file
-AFGROW file format

Stress multiplication factor
to adjust spectrum stresses

The screenshot shows the 'Usage Spectra' software interface. At the top, there are tabs for 'Begin' and 'Usage Spectra'. The main area contains several input fields and buttons:

- Load Spectrum:** A checked checkbox followed by a text box containing the file path 'C:\Users\c38006\Documents\hurst\UTSA FMP\ICW-3\GC\SG102_Grand_Canyon.sp3' and a 'Browse...' button. This area is highlighted with a red box.
- Transfer Factor:** A text box containing the value '0.95', highlighted with a green box.
- Flight Hours for this Spectrum:** A text box containing the value '1000', highlighted with a blue box.
- Flight Hours per Flight:** A text box containing the value '1.0', highlighted with a purple box.
- # of flight hours spectrum represents:** A callout box pointing to the 'Flight Hours for this Spectrum' field.
- # of flight hours per flight:** A callout box pointing to the 'Flight Hours per Flight' field.
- Design Gust Load Factor High:** A text box.
- Design Maneuver Load Factor Low:** A text box.
- Design Gust Load Factor Low:** A text box.
- Ground Stress (psi):** A text box.
- Average Velocity (Vno/Vmo(Knots)):** A text box.
- Number of Flight Times:** A text box.
- Number of Velocities:** A text box.
- File:** A text box with a 'Browse...' button.
- Load Matrices:** A checkbox and a 'Matrix' button.
- Flight Variation:** A checkbox.
- Buttons:** 'Save Usage', 'Deleted Usages', and 'Next Tab'.

At the bottom left of the window, the version number '07/10/2015-V4.0.7' is displayed.