X-57 Mod III Wing Ground Vibration Test

IMAC XLIII – Orlando, FL

Session #13: Dynamics of Aircraft/Aerospace Structures I

Submission #18239

2/10/2025

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X-57 Background

LEAPTech

Conceptual distributed electric propulsion system

Mod I

Flight testing of baseline Tecnam P2006T

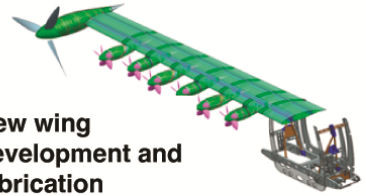
Goals:
- Establish baseline Tecnam performance
- Pilot familiarity

Mod II

Ground and flight test validation of electric motors, battery, and instrumentation.

Goals:
- Establish electric power system flight safety
- Establish electric Tecnam retrofit basline

Mod III



New wing development and fabrication

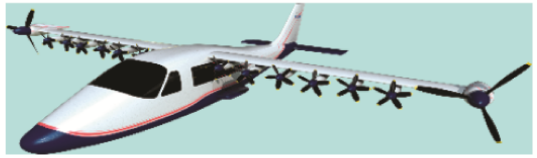
Flight test electric motors relocated to wingtips on new wing including nacelles (but no high-lift (HL) motors, controllers, or folding props).

Achieves primary objective of high-speed cruise efficiency

Spiral development process
- Build – Fly – Learn

Mods III and IV are now combined

Mod IV



Flight test with integrated HL motors and folding propellers (cruise motors remain in wingtips).

Achieves secondary objectives:
- HL acoustics testing
- Low-speed control robustness
- Certification basis of HL technologies

Mod I

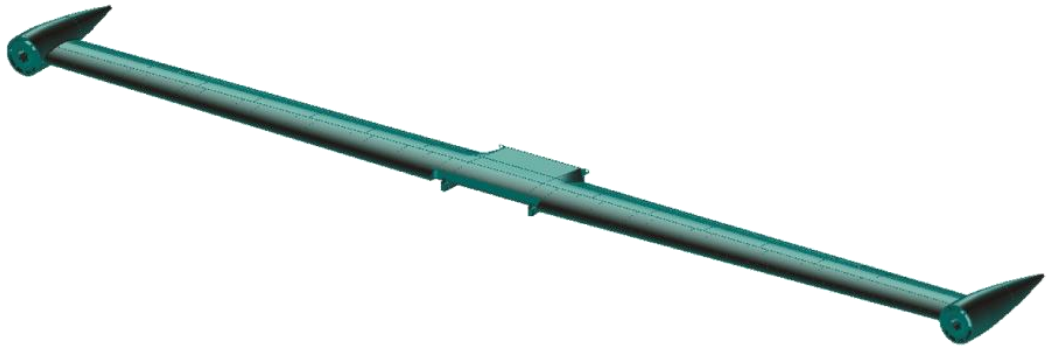
Mod II

Mod III

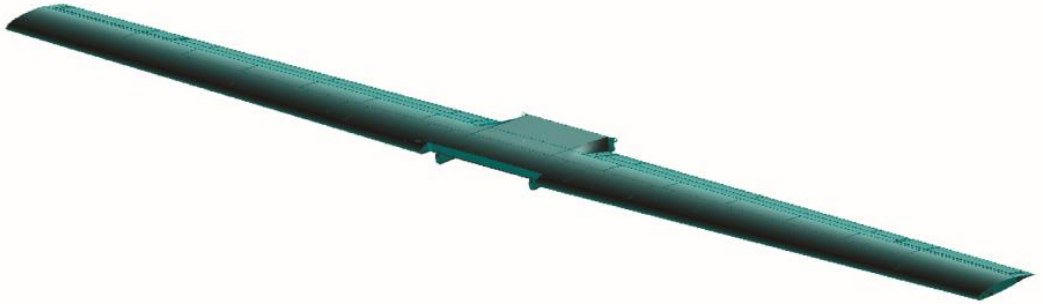
Mod IV

X-57 Mod III Wing GVT – Background

- NASA Armstrong's Flight Loads Laboratory (FLL) conducted a ground vibration test (GVT) of the X-57 Mod III wing (June 2019) to gather wing modal data that would help in correlating the fundamental wing modes in the finite element model (FEM).
- Having a tuned FEM would help with early updates to the classical and whirl flutter analyses of the aircraft.
- Performing GVT early in the design process would help identify any problems with the wing structure prior to it being mounted to the aircraft fuselage.
- Proof loads test performed concurrently following GVT.
- Two main configurations were tested:
  - Config A – Mod III wing with cruise motor nacelle mass simulators at wingtips
  - Config B – Mod III clean wing
- 192 total test runs performed for this GVT.



Config A - Mod III wing FEM with cruise motor nacelles



Config B - Mod III clean wing FEM

X-57 Mod III Wing GVT - Test Article

- The 31.6 ft Mod III wing, manufactured by Empirical Systems Aerospace, Inc. (ESAero), was designed to have a smaller chord and a higher-aspect-ratio wing when compared to the original wing to aid with increase cruise flight efficiency.
- Clean wing weighs approximately 313 lbs, which includes the mounting plate underneath.

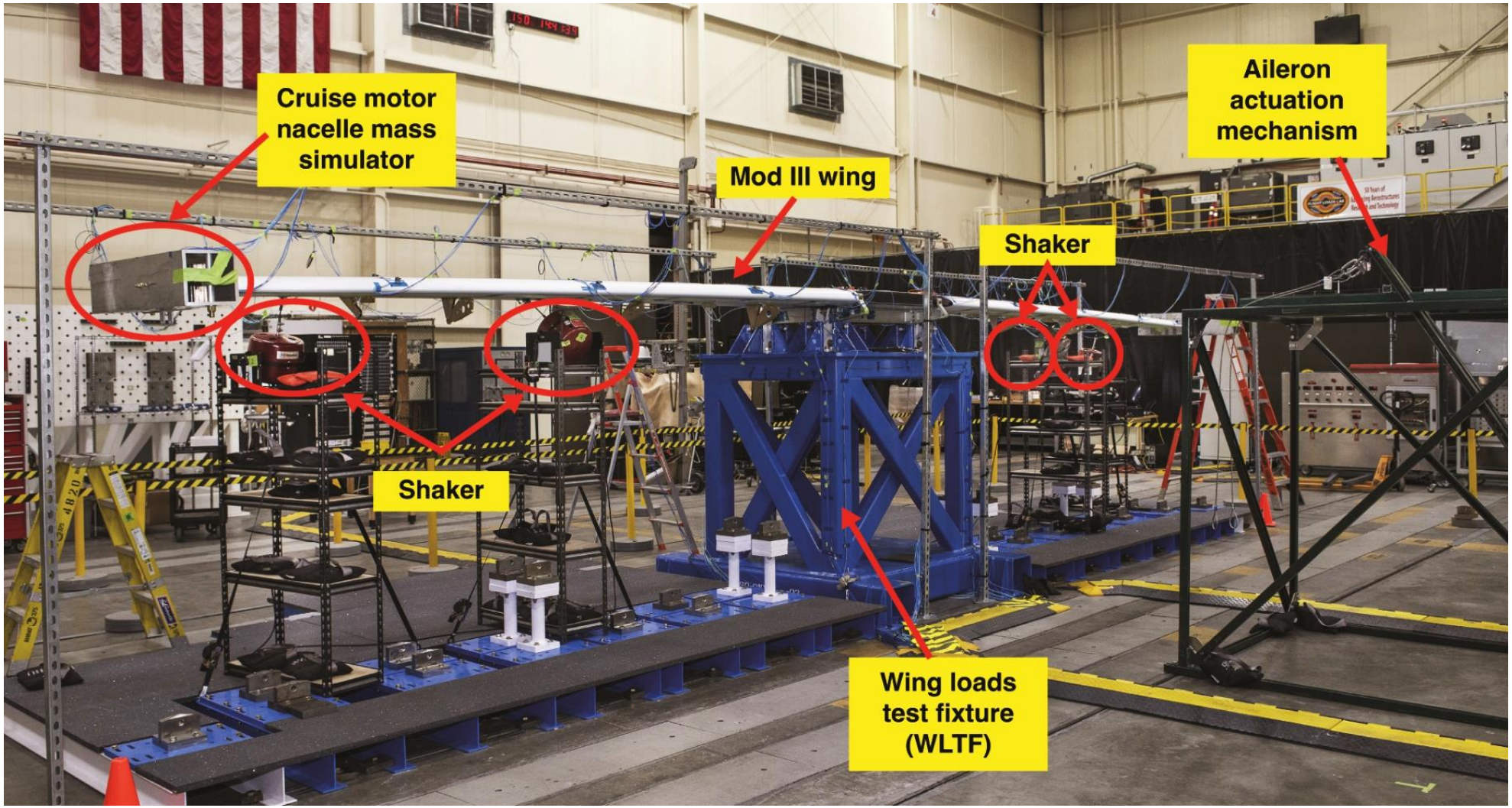
X-57 Mod III Wing GVT – FEM

- FEM modal analysis performed using MSC Nastran. Only stowed flap FEM available at time of GVT.
- FLL performed GVT on the wing loads test fixture (WLTF), fabricated by Pyramid Space, Inc., and model updating was done prior to X-57 Mod III wing GVT. GVT showed 1st frequency of the WLTF around 58 Hz.
- Integrated pre-test FEM showed predicted coupling between test fixture and test article around 52 Hz for both configurations.
- FEM showed most of the modal frequencies below this coupling frequency, so only the top portion of the WLTF was instrumented during the GVT.

Config A - Mod III wing with cruise motor nacelles, mounted on WLTF

Config B - Mod III clean wing, mounted on WLTF

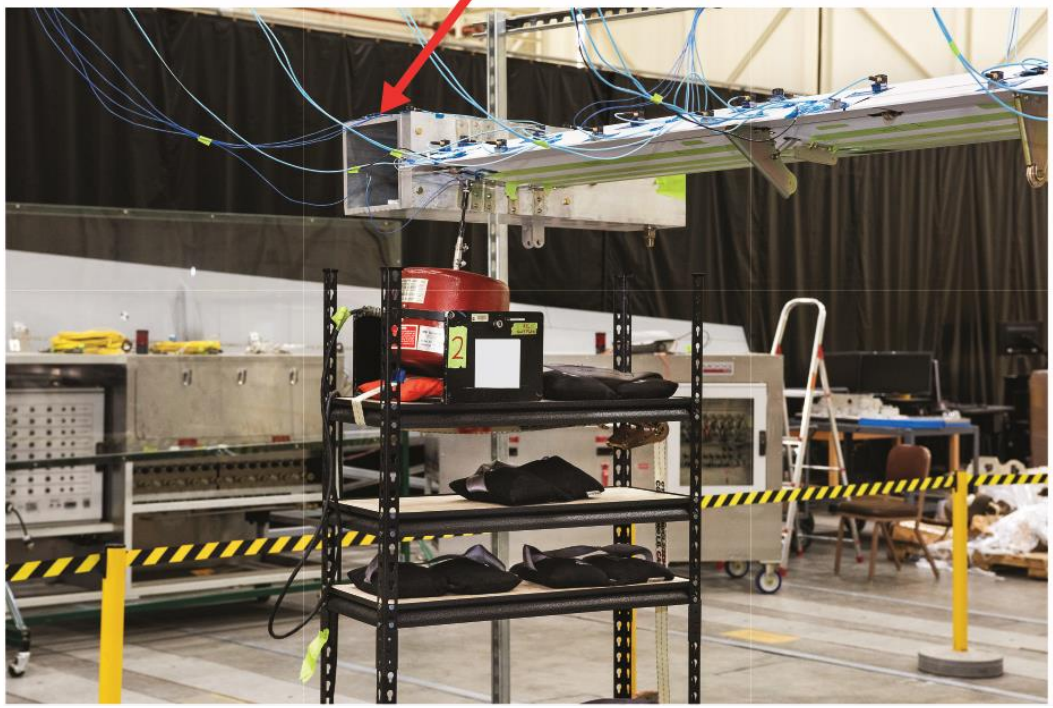
X-57 Mod III Wing GVT Setup



X-57 Mod III Wing GVT Setup (cont.)

Configuration A

Cruise nacelle mass simulator



Configuration B

Cruise nacelle mass simulator and wingtip plate removed

- Various flap deflection settings (stowed, slightly deployed & fully deployed) were tested, all with flaps and ailerons were locked.

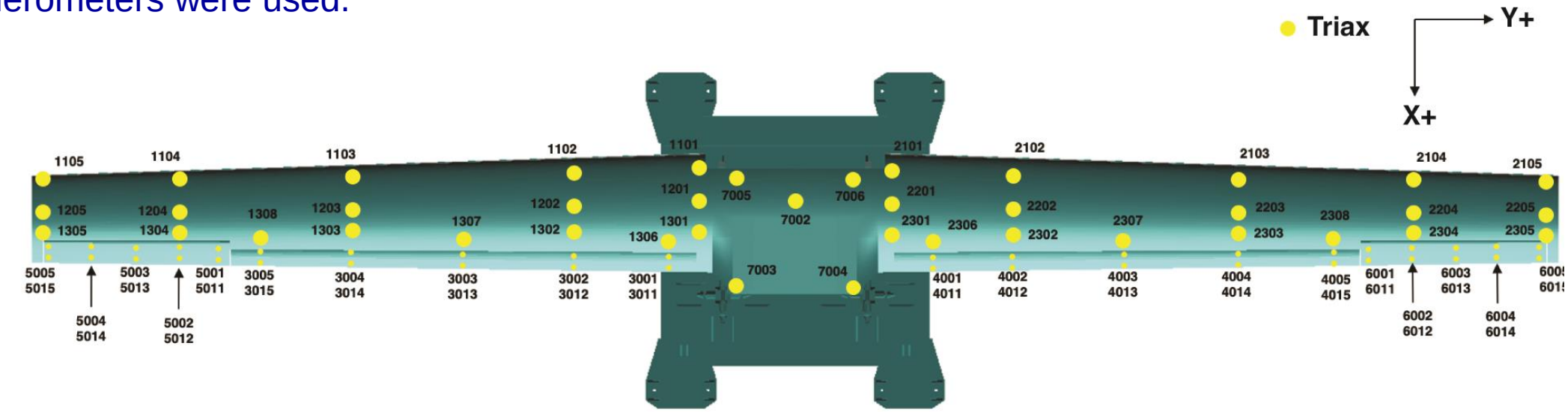
X-57 Mod III Wing GVT - Test Objectives

- Objective of the GVT was to capture modes that were predicted to be participants in the wing flutter mechanism.

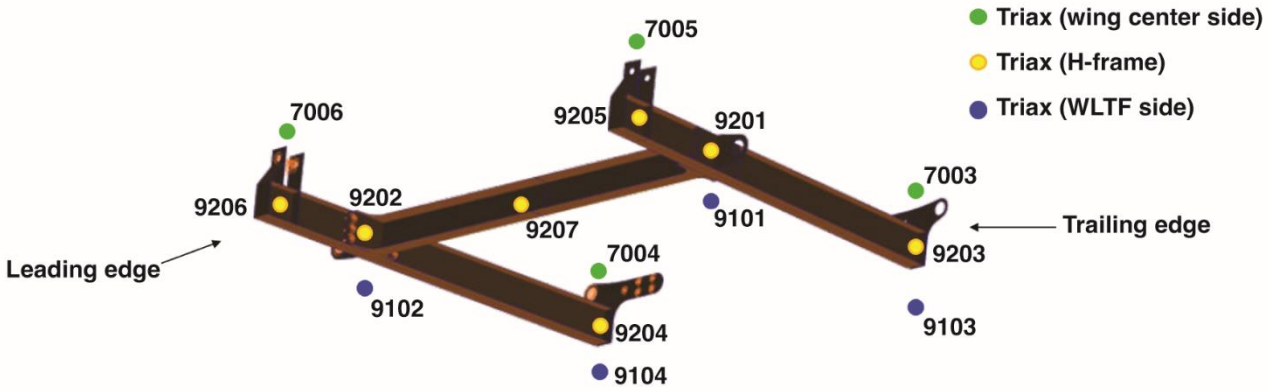
	Objective Modes	Reasoning
Primary	▪ Wing 1st bending (W1B) ▪ Wing 2nd bending (W2B) ▪ Wing 1st torsion (W1T) ▪ Wing fore/aft ▪ Bending & rotational modes of the flaps and ailerons	▪ Primary modes predicted in pre-test FEM and for updates to the flutter model.
Secondary	▪ Flap and aileron modes for the clean wing configuration	▪ Understand the effect of the wing deflection due to the added mass of the mounted motors at the wingtips.

X-57 Mod III Wing GVT - Instrumentation

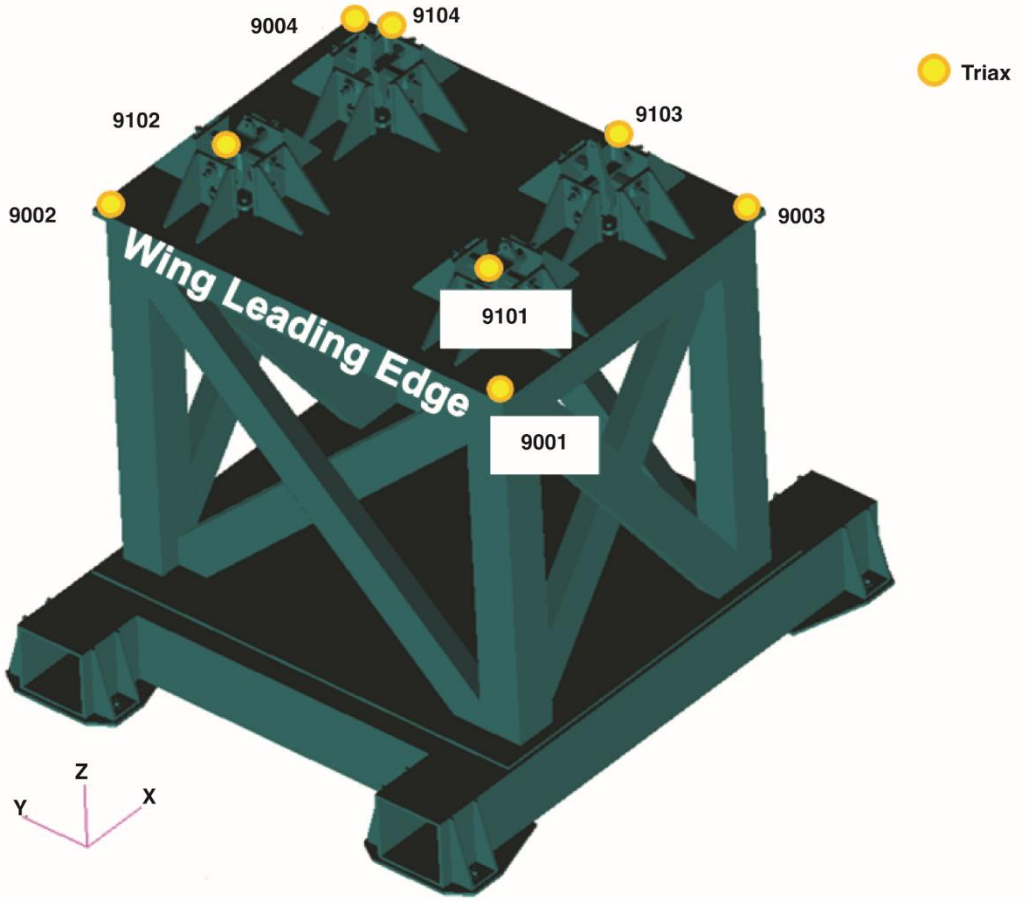
- Brüel & Kjær LAN-XI data acquisition hardware used, first large-scale GVT by NASA AFRC using this system.
- BK Connect software used for data collection.
- Configuration A - Total of 104 accelerometer locations measuring 312 DOFs.
- Configuration B – Total of 96 accelerometer locations measuring 288 DOFs.
- Each accelerometer location measured 3 DOFs and a combination of both uniaxial and triaxial PCB accelerometers were used.



X-57 Mod III Wing GVT – Instrumentation (cont.)



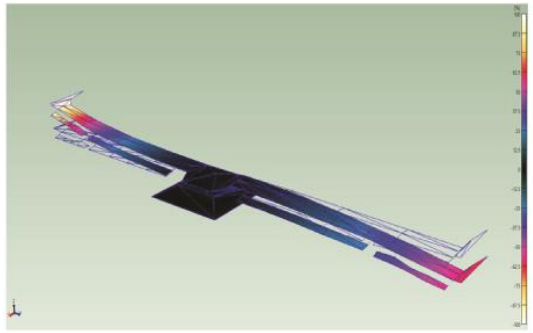
H-Frame Accel Locations



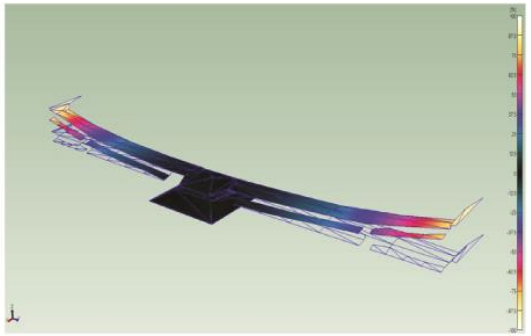
Wing Loads Test Fixture (WLTF) Accel Locations

X-57 Mod III Wing GVT – Config A Results

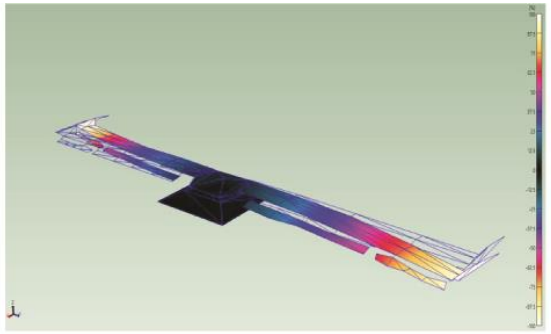
- Configuration A – Mod III wing with cruise nacelle mass simulators (flaps stowed & ailerons locked):



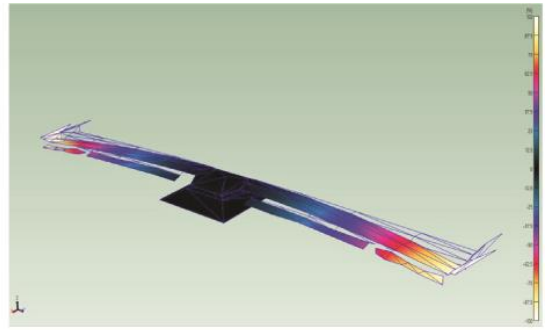
2.14 Hz
AW1B



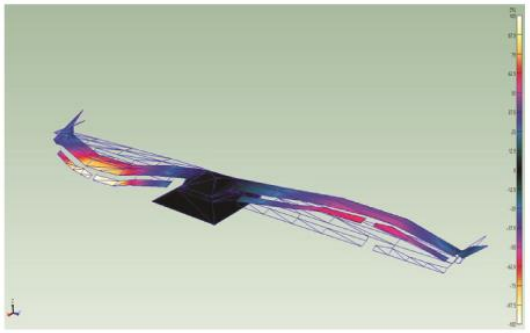
2.26 Hz
SW1B



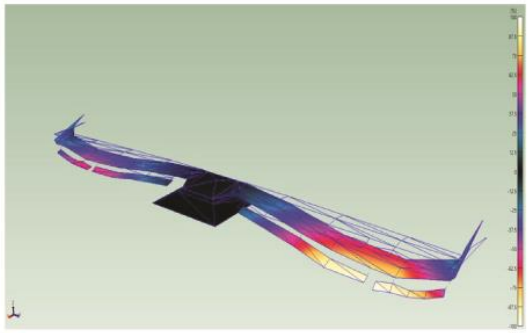
6.22 Hz
AWFA



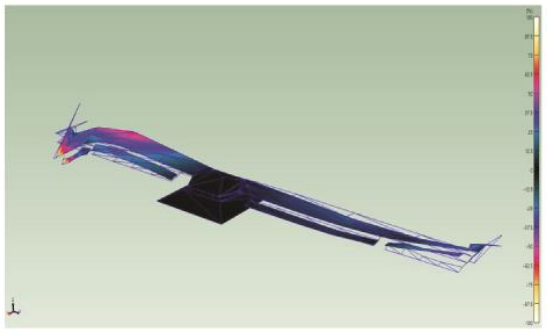
7.91 Hz
SWFA



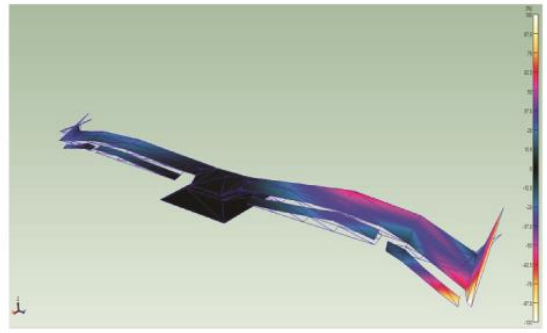
14.82 Hz
AW2B



15.76 Hz
SW2B



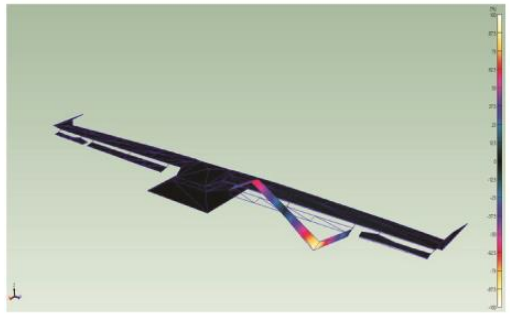
22.81 Hz
AW1T



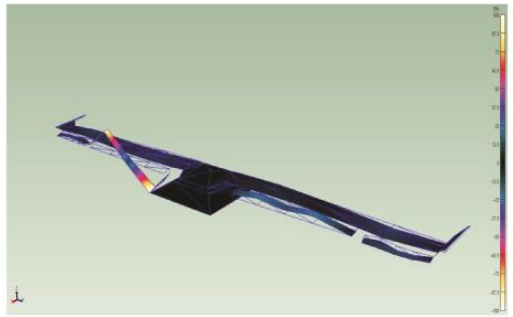
23.35
SW1T

X-57 Mod III Wing GVT – Config A Results

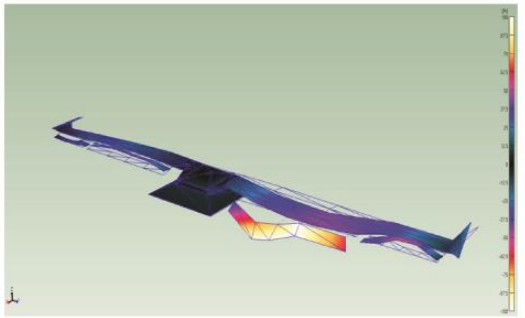
- Configuration A – Mod III wing with cruise nacelle mass simulators (flaps stowed & ailerons locked):



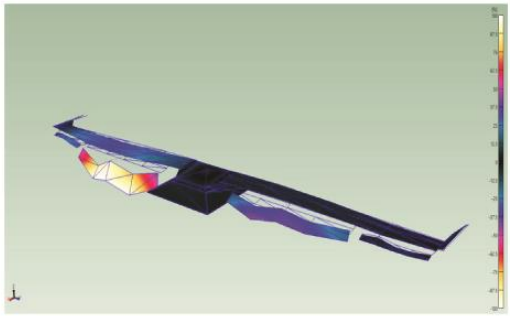
36.10 Hz
Anti-sym flap sine wave bending



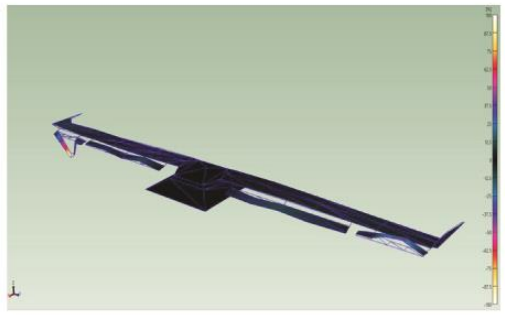
40.89 Hz
Sym flap sine wave bending



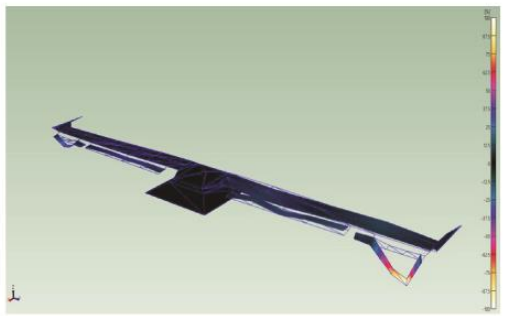
49.99 Hz
Anti-sym flap rotation



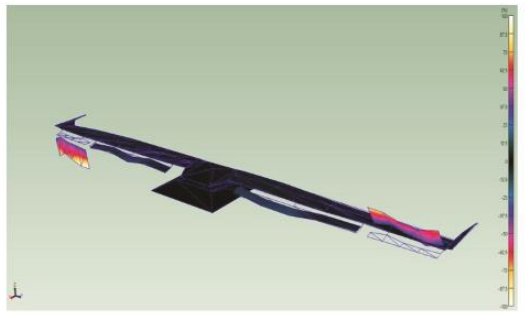
52.20 Hz
Sym flap rotation



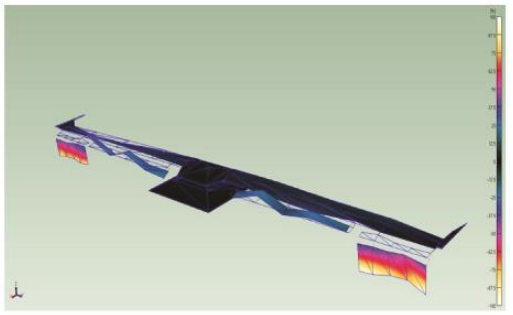
66.81 Hz
Anti-sym aileron bending



68.43 Hz
Sym aileron bending



100.11 Hz
Anti-sym aileron rotation



122.79 Hz
Sym aileron rotation

X-57 Mod III Wing GVT – Config A Results

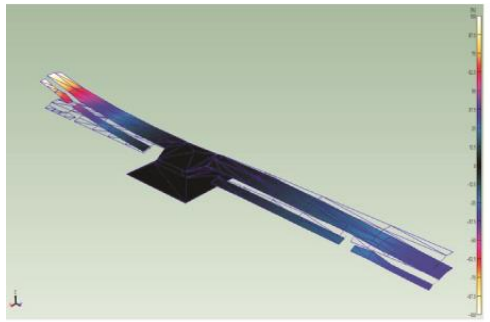
≥ 5% Diff

Mode Name	FEM Predictions Frequency (Hz)	GVT Frequency (Hz)	% Difference from FEM	Notes on GVT Mode Shape
Anti-Sym Wing 1st Bending (AW1B)	2.11	2.14	1.68%	Left wing dominant
Sym Wing 1st Bending (SW1B)	2.26	2.26	-0.05%	Left wing dominant
Anti-Sym Wing Fore/Aft (AWFA)	5.12	6.22	21.53%	Both wings dominant
Sym Wing Fore/Aft (SWFA)	7.14	7.91	10.85%	Both wings dominant
Anti-Sym Wing 2nd Bending (AW2B)	14.62	14.82	1.42%	Left wing dominant
Sym Wing 2nd Bending (SW2B)	15.62	15.76	0.89%	Right wing dominant
Anti-Sym Wing 1st Torsion (AW1T)	21.89	22.81	4.21%	Left wing dominant
Sym Wing 1st Torsion (SW1T)	22.42	23.35	4.15%	Right wing dominant
Anti-Sym Flap Sine Wave Bending	31.06	36.10	16.22%	Right-flap sine wave. GVT has not anti-sym shape. Only right flap responding.
Sym Flap Sine Wave Bending	31.12	40.89	31.42%	Left-flap sine wave. GVT has no sym shape. Only left flap responding.
Sym Flap Rotation	34.47	52.20	51.46%	Left-flap dominant
Anti-Sym Flap Rotation	36.96	49.99	35.23%	Right-flap dominant with AWFA & right aileron bending
Anti-Sym Aileron Rotation	46.21	100.11	116.66%	Left aileron dominant
Sym Aileron Rotation	46.93	122.79	161.67%	Both ailerons dominant
Anti-Sym Aileron Bending	59.83	66.81	11.67%	Left aileron dominant
Sym Aileron Bending	61.41	68.43	11.43%	Right aileron dominant

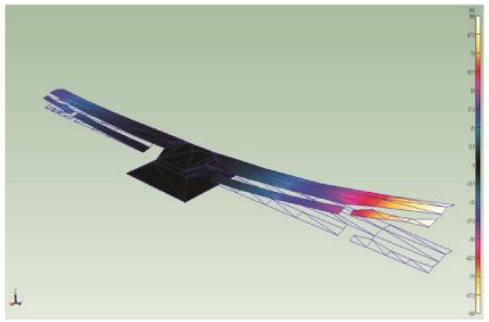
Note: Mode name is abbreviated to only focus on the dominant motion. There may be other differences between the GVT mode shape and the FEM.

X-57 Mod III Wing GVT – Config B Results

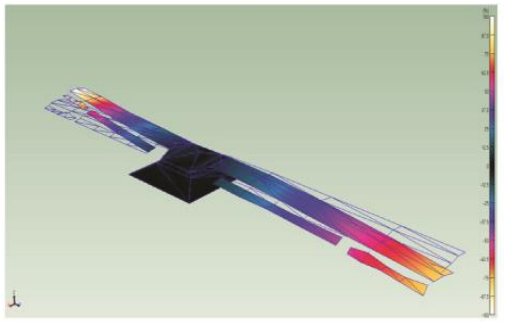
- Configuration B – Mod III clean wing (flaps stowed & ailerons locked):



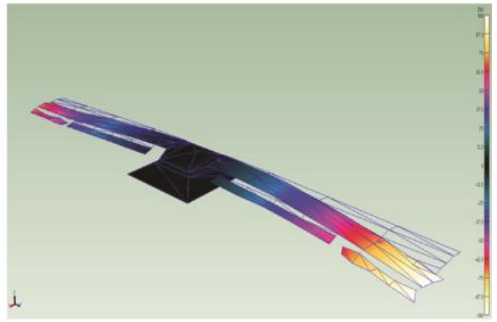
5.76 Hz
AW1B



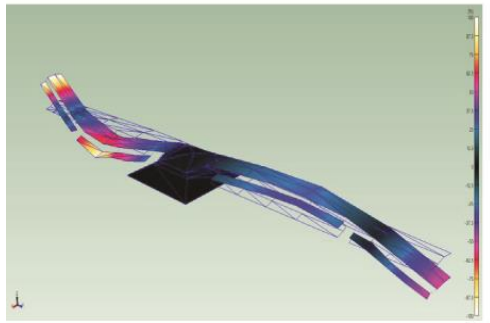
6.55 Hz
SW1B



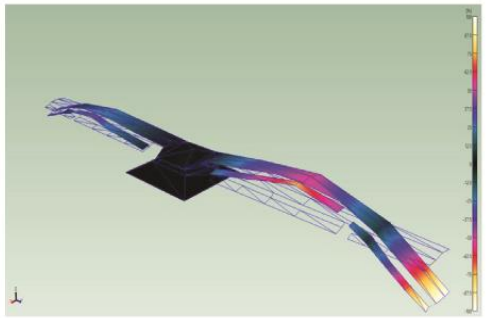
15.14 Hz
AWFA



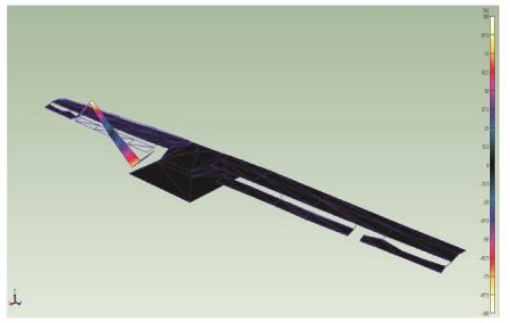
20.64 Hz
SWFA



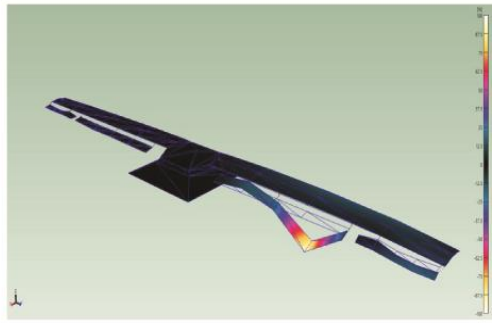
23.90 Hz
AW2B



26.36 Hz
SW2B



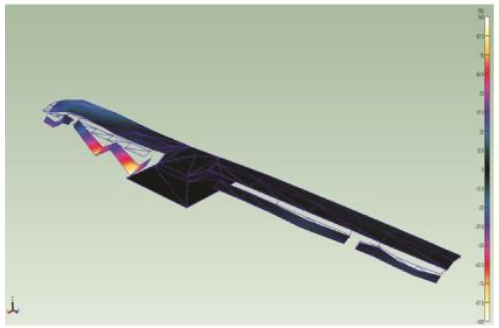
41.61 Hz
Anti-sym flap sine wave bending



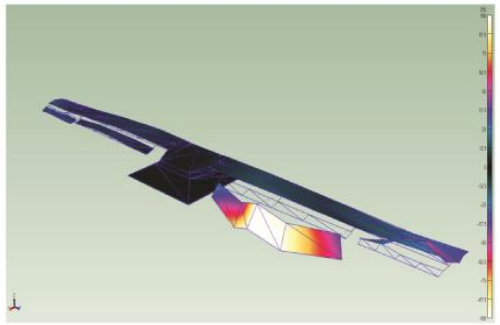
46.36 Hz
Sym flap sine wave bending

X-57 Mod III Wing GVT – Config B Results

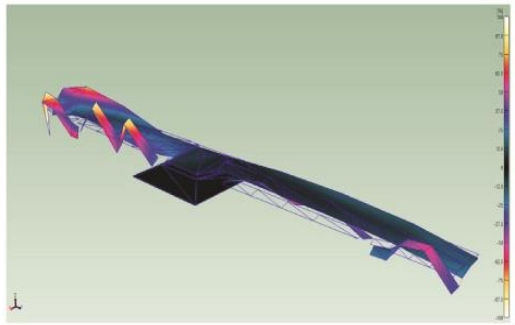
- Configuration B – Mod III clean wing (flaps stowed & ailerons locked):



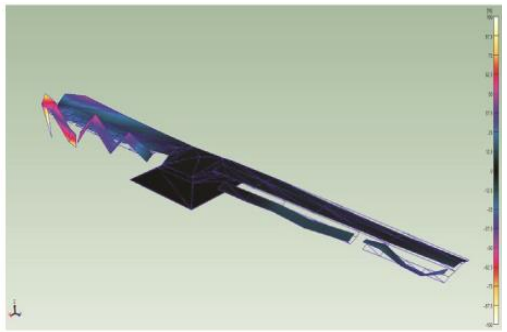
51.15 Hz
SW1T



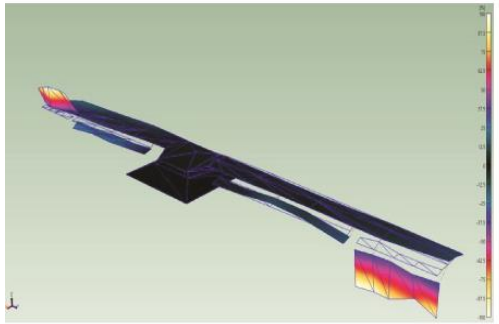
70.60 Hz
Anti-sym flap rotation



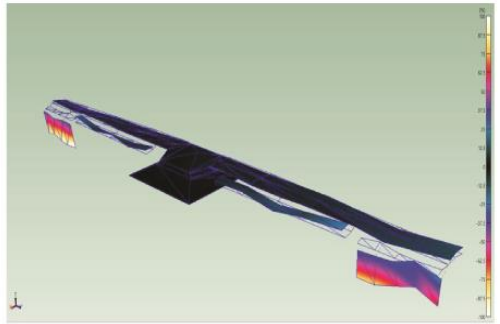
78.71 Hz
Sym aileron bending



84.43 Hz
Anti-sym aileron bending
and AW1T



89.28 Hz
Anti-sym aileron rotation



116.22 Hz
Sym aileron rotation

X-57 Mod III Wing GVT – Config B Results

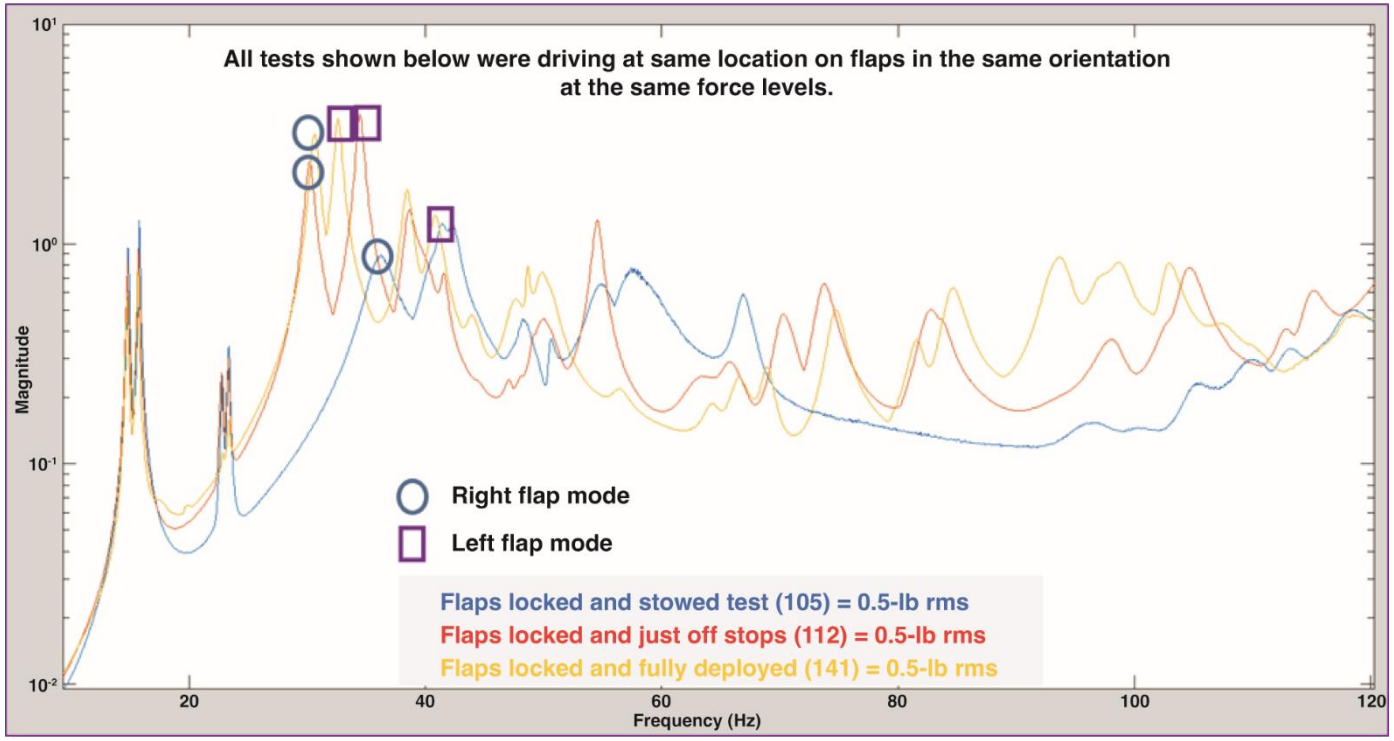
≥ 5% Diff

Mode Name	FEM Predictions Frequency (Hz)	GVT Frequency (Hz)	% Difference from FEM	Notes on GVT Mode Shape
Anti-Sym Wing 1st Bending (AW1B)	6.32	5.76	-8.88%	Left wing dominant
Sym Wing 1st Bending (SW1B)	7.13	6.55	-8.21%	Right wing dominant
Anti-Sym Wing Fore/Aft (AWFA)	12.95	15.14	16.87%	Left wing dominant
Sym Wing Fore/Aft (SWFA)	19.99	20.64	3.26%	Right wing dominant
Anti-Sym Wing 2nd Bending (AW2B)	24.84	23.90	-3.78%	Left wing dominant
Sym Wing 2nd Bending (SW2B)	26.95	26.36	-2.20%	Right wing dominant
Anti-Sym Wing 1st Torsion (AW1T)	N/A	84.43	N/A	NOT IN FEM; see anti-sym aileron bending below.
Sym Wing 1st Torsion (SW1T)	N/A	51.15	N/A	NOT IN FEM; Lt wing dominant with strong left-flap bending and left aileron bending
Anti-Sym Flap Sine Wave Bending	31.09	41.61	33.86%	Left-flap sine wave. GVT has no anti-sym shape.
Sym Flap Sine Wave Bending	31.19	46.36	48.64%	Right-flap sine wave. GVT has no sym shape. Right-flap outboard half dominant.
Sym Flap Rotation	35.65	N/A	N/A	DID NOT SHOW UP IN GVT
Anti-Sym Flap Rotation	39.24	70.60	79.91%	Right-flap dominant with right aileron bending.
Anti-Sym Aileron Rotation	46.42	89.28	92.32%	Both dominant with slight left wing torsion.
Sym Aileron Rotation	48.34	116.22	140.41%	Both dominant with slight left wing torsion.
Anti-Sym Aileron Bending	58.66	84.43	43.93%	Left aileron dominant with anti-sym wing torsion (left dominant) & left-flap bending.
Sym Aileron Bending	58.82	78.71	33.81%	Left aileron dominant with sym wing torsion (left dominant) & left-flap bending.

Note: Mode name is abbreviated to only focus on the dominant motion. There may be other differences between the GVT mode shape and the FEM.

X-57 Mod III Wing GVT – Flap Nonlinearity

- Different flap deployment settings affected the flap modal response for both frequency and damping, despite having the same excitation location and force level input.
- Flap frequencies higher for stowed flap configuration. Had to model flap contact with PBUSH elements.
- Damping values for the flap modes were four to eight times larger than that of wing modes, possibly due to nonlinear joints & bearings associated with the control surface actuation system.



X-57 Mod III Wing GVT – Model Correlation

- A reduced-order analysis model (Guyan reduction) was used to compare the analytical results to the GVT data.
- Model updating focused mainly on updating the joint properties to ensure the FEM matched the as-built test article hardware.
- Wing modes and primary flap modes were well correlated up to around 40 Hz.
- Several flap modes that showed up in the deployed flap case did not show up in the flap stowed case. This is likely due to the flaps being restrained by contact with the wing-flap cove surface in the stowed position, causing it to be heavily damped.

Config A – Cross-Ortho Before/After

- Config A – Flaps stowed, ailerons locked

FEM/Test Cross Orthogonality Table

FEM Shapes

Otg	Test Shapes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			2.17	2.35	4.62	7.37	15.11	16.32	19.07	19.27	22.74	23.54	31.87	33.10	33.17	38.02	41.60	42.24	45.99	47.87	48.86
100	1	2.13	100																	5	
95	2	2.25		100																	8
90	3	6.21			100																
85	4	7.88				100															
80	5	14.82	7				99				5									16	13
75	6	15.77		9				99				11									31
70	7	22.78					5	6			98	18								16	24
65	8	23.34				6		9			18	97								7	29
60	9	36.16												91	28			6		7	9
55	10	40.89	7							5			11	20	65		63	12	8	28	
50	11	41.35	9												18		75	52	9	42	6
45	12	42.30	7	9							5			10	19	9	55	65		6	47
40	13	44.26							23	7			10		18	89		21	7		11
35	14	48.30							7	6			60	5	7	5	9	6	67	42	19
30	15	52.32								8			40			26	6	5	68	42	12
25	16	54.77	5	7			6	6					8	6			7	10	5	40	17
20	17	57.21	5	6									5				22	16	10	22	
15	18	59.38	6	6			8	5					18				23	12	7	24	

Before Correlation

FEM/Test Cross Orthogonality Table

FEM Shapes

Otg	Test Shapes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			2.22	2.41	6.00	8.12	15.61	17.04	18.81	20.22	24.45	25.12	37.50	42.86	44.91	45.57	46.50	50.10	52.97	56.91	60.87
100	1	2.13	100	5																	
95	2	2.25		100																	
90	3	6.21			100																
85	4	7.88				100															
80	5	14.82	5				99	7													
75	6	15.77		7			6	99													
70	7	22.78									99	5									
65	8	23.34				6						99									
60	9	36.16											95			5	5			6	
55	10	40.89	6								5			36	87	20	13				
50	11	41.35	9										7	37	19	87	6				
45	12	42.30	6	8							5			25			91	11			6
40	13	44.26							17	13				80	10	27	40	23			
35	14	48.30								5				12		5	8	95	9		
30	15	52.32												7		8			94		27
25	16	54.77	5	6			6	5				6	7			7				91	
20	17	57.21		6															5	6	85
15	18	59.38	6	6			7				7										84

After Correlation

X-57 Mod III Wing GVT – Summary

- Two main configurations were tested to understand the aeroelastic behavior of the X-57 Mod III wing structure.
- GVT results helped with updates to the finite element model as well as the classical & whirl flutter analyses.
- Frequencies of the wing modes aligned with the finite element model.
- However, the frequencies of the flaps and ailerons were much higher than predicted. Nonlinear behavior contributed to asymmetries in the modes between the left and right sides.
- Using the fixed base correction method would have eliminated the coupling problem seen between the wing test article and the wing loads test fixture.

Questions?

BACKUP SLIDES

X-57 Mod III Wing GVT – Config A Frequency Comparison

Mode Name	Flaps Stowed/Ailerons Locked GVT Frequency (Hz)	Flaps Deployed/Ailerons Locked GVT Frequency (Hz)	Flaps Slightly Deployed/Ailerons Locked GVT Frequency (Hz)	% Difference from Stowed	% Difference from Deployed
Anti-Sym Wing 1st Bending (AW1B)	2.14	2.14	2.12	-1.26%	-1.11%
Sym Wing 1st Bending (SW1B)	2.26	2.26	2.23	-1.12%	-1.15%
Anti-Sym Wing Fore/Aft (AWFA)	6.22	6.04	6.11	-1.81%	1.17%
Sym Wing Fore/Aft (SWFA)	7.91	7.54	7.54	-4.71%	-0.07%
Anti-Sym Wing 2nd Bending (AW2B)	14.82	14.69	14.76	-0.45%	0.44%
Sym Wing 2nd Bending (SW2B)	15.76	15.60	15.76	0.04%	1.00%
Anti-Sym Wing 1st Torsion (AW1T)	22.81	22.84	22.78	-0.12%	-0.25%
Sym Wing 1st Torsion (SW1T)	23.35	23.38	23.32	-0.11%	-0.23%
Anti-Sym Flap Sine Wave Bending	36.10	30.59	30.56	-15.34%	-0.10%
Sym Flap Sine Wave Bending	40.89	32.58	34.43	-15.80%	5.66%
Anti-Sym Flap Rotation*	49.99	47.50	N/A	N/A	N/A
Sym Flap Rotation	52.20	35.40	39.92	-23.53%	12.75%
Anti-Sym Aileron Bending	66.81	64.11	66.33	-0.72%	3.47%
Sym Aileron Bending	68.43	68.90	67.23	-1.76%	-2.43%
Anti-Sym Aileron Rotation	100.11	96.96	111.99	11.87%	15.51%
Sym Aileron Rotation	122.79	115.27	117.76	-4.10%	2.16%

*Mode did not appear in the GVT.

≥ 5% Diff

X-57 Mod III Wing GVT – Config B Frequency Comparison

Mode Name	Flaps Stowed/Ailerons Locked GVT Frequency (Hz)	Flaps Deployed/Ailerons Locked GVT Frequency (Hz)	% Difference from Stowed
Anti-Sym Wing 1st Bending (AW1B)	5.76	5.83	1.21%
Sym Wing 1st Bending (SW1B)	6.55	6.69	2.15%
Anti-Sym Wing Fore/Aft (AWFA)	15.14	14.77	-2.42%
Sym Wing Fore/Aft (SWFA)	20.64	18.57	-10.01%
Anti-Sym Wing 2nd Bending (AW2B)	23.90	23.91	0.02%
Sym Wing 2nd Bending (SW2B)	26.36	25.80	-2.13%
Anti-Sym Flap Sine Wave Vertical Bending	46.36	30.87	-33.42%
Sym Flap Sine Wave Vertical Bending	41.61	32.57	-21.73%
Anti-Sym Flap Rotation*	N/A	42.87	N/A
Sym Flap Rotation*	N/A	35.93	N/A
Anti-Sym Wing 1st Torsion (AW1T)*	N/A	56.54	N/A
Sym Wing 1st Torsion (SW1T)	51.15	57.68	12.77%
Anti-Sym Aileron Vertical Bending	84.43	64.34	-23.79%
Sym Aileron Vertical Bending	61.22	71.07	16.08%
Anti-Sym Aileron Rotation	89.28	92.10	3.16%
Sym Aileron Rotation	116.22	124.10	6.78%

*Mode did not appear in the GVT.

≥ 5% Diff

Config A – Cross-Ortho Before/After

- Config A – Flaps deployed, ailerons locked

FEM/Test Cross Orthogonality Table

FEM Shapes

Otg	Test Shapes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			2.20	2.42	4.68	8.06	15.34	15.74	15.79	16.72	24.31	24.98	28.60	34.33	34.37	38.73	42.50	44.01	46.08	47.56	53.09
100	1	2.15	100																		
95	2	2.26	5	100																	
90	3	6.00			100																
85	4	7.52				100															
80	5	14.74					99	9	6												
75	6	15.63		7					9	99											
70	7	17.45						78	61	7			11								
65	8	19.63					9	63	76	10											
60	9	22.81									99						5				
55	10	23.37				5						99	12								
50	11	30.57											24	27	90						
45	12	32.58						5	5					92	27						
40	13	34.11						6				10	87		17			38		5	
35	14	38.43	6								5		15		5		92	20	13	13	5
30	15	40.79							5				32		5	20	40	78		9	
25	16	43.99	5		5								5			94	7	15		22	10
20	17	46.73	5					6					13				10	15	5	29	60
15	18	47.59									5		9			18			9	91	17
10	19	48.59	6		5						5					6	17	13		10	85
5	20	49.70	7							5	6					15	20			25	87
0	21	50.40		9			5					5	5					27			15
	22	56.34								6		5				13	15	13		16	17

Before Correlation

FEM/Test Cross Orthogonality Table

FEM Shapes

Otg	Test Shapes		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			2.23	2.43	6.01	8.14	15.44	16.84	17.29	18.33	24.44	25.16	34.36	34.49	39.35	42.37	43.56	45.52	49.55	53.72	54.77
100	1	2.15	100																		
95	2	2.26	6	100																	
90	3	6.00			100																
85	4	7.52				100															
80	5	14.74	5				100														
75	6	15.63		7				99	6												
70	7	17.45							99						9						
65	8	19.63								100											
60	9	22.81								5	99					6					
55	10	23.37				5						99									
50	11	30.57							6				96	12	5						
45	12	32.58								9			11	96							
40	13	34.11													96		10	13			7
35	14	38.43	6								5				12	65	68	18	6	5	
30	15	40.79							5						8	41	10	86			
25	16	43.99	5													70	61	14	32		
20	17	46.73	5						5						15	11		12	25	73	56
15	18	47.59									5					13	23	5	91	9	11
10	19	48.59	6		6						5					13	9	12	21	84	14
5	20	49.70	7				5				6					8	16	6	16	91	22
0	21	50.40		9			5					5			5			23			93
	22	56.34						7				6				5	13	9	15	14	12

After Correlation

Config A – Cross-Ortho Before/After

- Config A – Flaps slightly deployed, ailerons locked

FEM/Test Cross Orthogonality Table

			FEM Shapes																		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Otg	Test Shapes		2.17	2.35	4.62	7.37	15.11	16.32	19.07	19.27	22.74	23.54	31.87	33.10	33.17	38.02	41.60	42.24	45.99	47.87	48.86
100	1	2.08	100	6																5	
95	2	2.24		100																	6
90	3	6.01			100																
85	4	7.51				100															
80	5	14.76	7				99				5									14	13
75	6	15.70		9				99				11									31
70	7	22.71					5	6			98	18								15	23
65	8	23.29				6		9			19	97								6	29
60	9	30.17							7				5	93	27						
55	10	34.43								9			13	26	85		25	14		12	14
50	11	38.54	5	5					5				36	6	5	5	45	74	20	52	27
45	12	39.93							9				82		7	29	31	25	15	7	10
40	13	41.54	9	6							6		11	8	26	8	76	41	10	23	37
35	14	44.51								7			24		10	94		10	7		
30	15	47.10		7					5	6		5	7			16	5	15	29	45	
25	16	48.30								15	7		5		12	15	5	17	91	63	27
20	17	49.14							5	15			26			21	25	8	78	57	12
15	18	49.89		7					5	10			14		5	7	7	17	46	6	14
10	19	50.32		5				5		12		5	8			24	17	17	70	58	10
5	20	54.50	7	7									5	7	24		15	8		17	15
0	21	63.11					5			13			14		11	8	6	7		5	
	22	65.65					13	7			15				6	6	7		10	9	17
	23	66.64		5			5	5			8	8	7								31
	24	70.14	7		6		18				5		6	6	5		10			23	23
	25	70.87		5				16		5				14							35

Before Correlation

FEM/Test Cross Orthogonality Table

			FEM Shapes																		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Otg	Test Shapes		2.22	2.42	6.02	8.16	15.59	17.02	18.02	19.13	24.43	25.10	34.24	34.29	41.20	42.62	44.40	44.96	49.80	54.52	55.53
100	1	2.08	100	7																	
95	2	2.24		100																	
90	3	6.01			100																
85	4	7.51				100															
80	5	14.76	5				99	6													
75	6	15.70		7			6	99	6												
70	7	22.71									99	5						5			
65	8	23.29				5					5	99									
60	9	30.17							6				88	40	6						
55	10	34.43								9			37	82		8	22	14		9	5
50	11	38.54	5										5		36	38	38	70	11	6	6
45	12	39.93							6	5			7		86	12	33	31	14		
40	13	41.54	8	6							7		11	25	17	45	63	43		21	12
35	14	44.51								7				5	28	79	49		12		
30	15	47.10		6					6	5								10	23	30	56	68
25	16	48.30								16	7			11		7	14	20	89	12	
20	17	49.14								15					17	7	19	12	82	32	29
15	18	49.89		6						11					9			22	51	44	65
10	19	50.32						5		12		6					16	24	73	44	30
5	20	54.50	6	6									10	23			7			64	53

After Correlation