NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594

December 3, 2003

ADDENDUM NUMBER 11 TO THE STRUCTURES GROUP CHAIRMAN'S FACTUAL REPORT

DCA02MA001

A. ACCIDENT

Location:	Belle Harbor, NY
Date:	November 12, 2001
Time:	09:16:14 EST
Aircraft:	American Airlines Flight 587, Airbus Model A300-605R, N14053 Manufactures Serial Number (MSN) 420

B. STRUCTURES GROUP

Chairman:	Brian K Murphy National Transportation Safety Board Washington, DC

C. AIRBUS REPORT

1. "Engine loads calculation for the A300-600R (flight number 587)"

AIRBUS

DEPARTEMENT	: ---------	REFERENCE	: C72RP0303930	TOME	:
SECTION	: -----	EDITION	: 01		
GO	:	PROJET	:		
		REF. PROJET	:	REV	:
PROGRAMME	: A300-600	O.F.	:		
OU AFFAIRE	:	ATA	: - -		
DATE	: 03/06/03	CLIENT	:		

TITRE : **Engine loads calculations for the A300-600R (flight number 587)**

AUTEUR(S) : [redacted]

RESUME :

At the request of the NTSB, structures department, the present note supplies for the plane A300-600R MSN 420 flight number 587 (New York accident) the structural analysis relative to the Pylon/Engine mounts and the Pylon/Wing attachments. The calculations are made for 3 points for which the sideslip angle is maximum.

The general parameters of the aircraft result from 2 different origins. The first one is the handling qualities program of simulation noted "OsmaC". The second one is the reconstruction of the behaviour of the plane by the integration of the Euler's angles measured in flight. This formulation is noted "INT18".

The calculations show that for the two modellings the values of loads for the Engine/Pylon mounts and the Pylon/Wing attachments remain in the design loads envelope of the A300-600 fitted with GE CF6-80C2A5F engine.

MOTS CLES : ENGINE – PYLON – LOADS – FLIGHT

LIENS :

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EMETTEUR : ----------	Nom : ----------	Nom : ----------
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1 – AIRCRAFT GENERAL PARAMETERS

1.1 – Sideslip angle

The following graph present the time history of the sideslip angle of the aircraft and indicate the various points taken into account in the calculations.

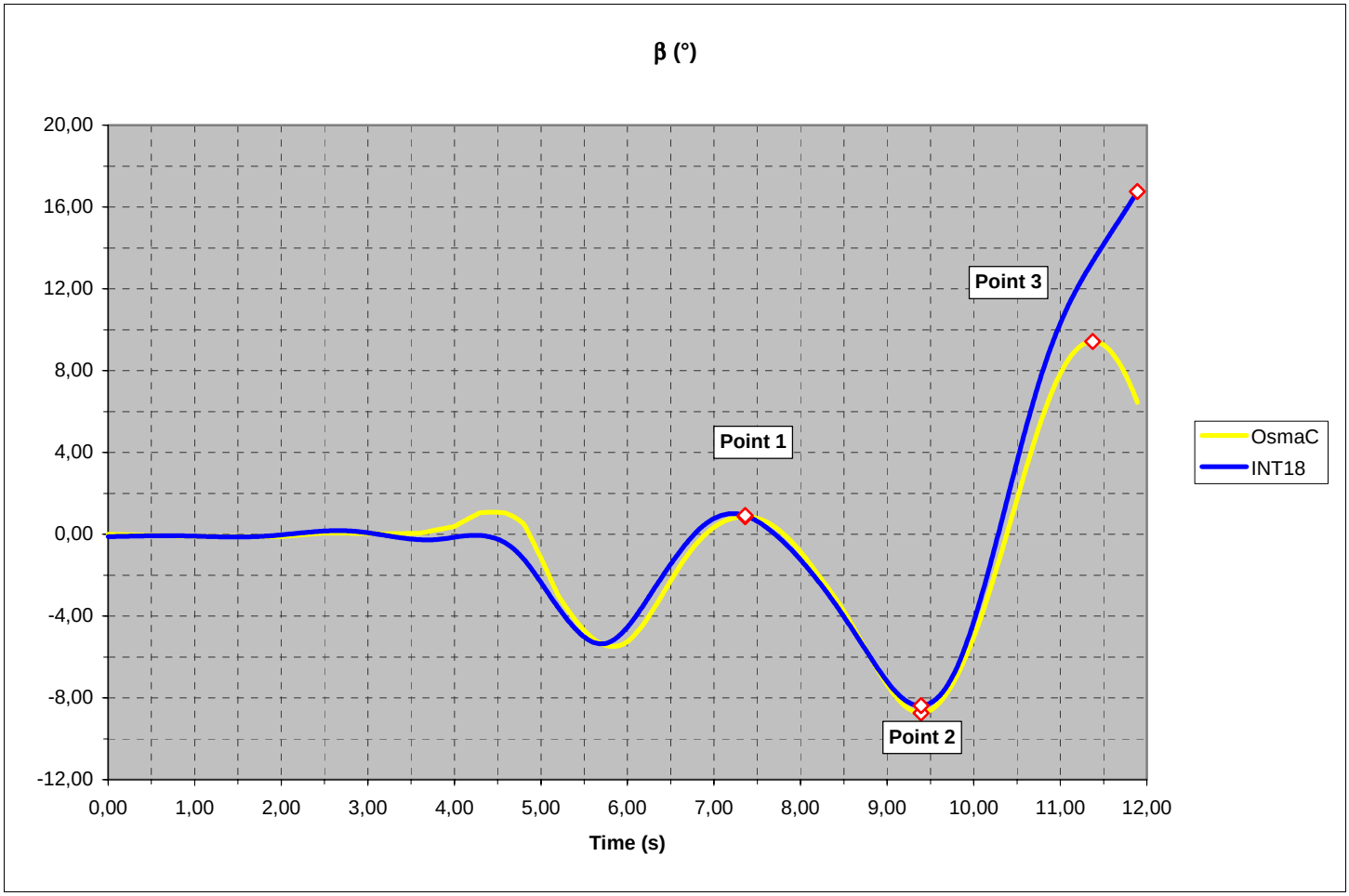

fig. 1.1 – Sideslip angle

1.2 – Time of calculations

For the 2 models, the following table supplies the main characteristic parameters of the three points of calculation.

Point	**1**		**2**		**3**		
Model	**OsmaC**	**INT18**	**OsmaC**	**INT18**	**OsmaC**	**INT18**	
Time	7,3594	7,3594	9,3906	9,3906	11,3750	11,8906	s
Mach	0,3778	0,3792	0,3854	0,3881	0,3945	0,4035	
V_C	241	241	245	247	251	256	kt
Z_P	2170	2197	2206	2275	2182	2324	ft
Dynamic Pressure	936	942	972	983	1020	1061	daN/m^2
α	2,5569	3,1358	0,8516	0,2412	-0,8674	5,0504	°
θ	6,1609	6,2204	-1,1928	0,1335	-3,2823	-3,4279	°
β	0,8645	0,9120	-8,7368	-8,3802	9,4281	16,7633	°
Φ_1	-2,6937	-4,2561	1,3479	1,7816	7,5097	-0,6037	°
p_1	-3,9596	-9,5556	14,4249	12,1113	-12,6657	-16,3654	°/s
q_1	0,2626	0,4241	-0,3937	-0,4584	-0,0847	-2,9466	°/s
r_1	-0,6712	0,1970	2,0785	1,7965	-1,3824	-8,7540	°/s
p_1 dot	-25,5643	-7,7630	-6,3917	-4,8508	6,8578	-11,5068	°/s^2
q_1 dot	-9,1359	-6,1070	5,4865	-2,4396	-20,3280	-7,0554	°/s^2
r_1 dot	-31,2331	7,4163	7,9504	-16,9144	21,2256	-7,9631	°/s^2
$n_{x\ cg}$	-0,1729	-0,1787	-0,1502	-0,1752	-0,1481	-0,1910	
$n_{y\ cg}$	0,0810	0,0872	-0,4102	-0,3565	0,4728	0,1736	
$n_{z\ cg}$	0,8491	0,9752	0,5406	0,5744	0,3672	0,9013	
N1	98	98	98	98	98	98	%
Net Thrust	24178	24178	24277	24277	24349	24504	daN
Ram Drag	9567	9567	9773	9773	9893	10130	daN
Gross Thrust	33745	33745	34051	34051	34242	34635	daN
$n_{x\ left\ engine\ cg}$	-0,2448	-0,2602	0,1128	0,0715	-0,4809	-0,0359	
$n_{y\ left\ engine\ cg}$	-0,0813	-0,0269	-0,3304	-0,2724	0,1329	0,0997	
$n_{z\ left\ engine\ cg}$	0,4352	0,8215	0,4666	0,4925	-0,0006	0,6851	
$n_{x\ right\ engine\ cg}$	-0,0502	-0,0483	-0,4598	-0,4046	0,1194	-0,2852	
$n_{y\ right\ engine\ cg}$	-0,0733	0,0183	-0,2255	-0,1983	0,2131	0,2699	
$n_{z\ right\ engine\ cg}$	1,1590	1,0413	0,7256	0,6303	0,8835	0,9981	

2 – ENGINE LOADS CALCULATIONS

The equations are established from the fundamental principle of the dynamic.

The forces are:

- Inertia forces,
- Aerodynamics forces,
- Thrust forces.

The equations are established in an axis linked to the engine. The origin is the centre of gravity of the system with the following conventions:

- $\vec{x}_M$ axis positive forward,
- $\vec{y}_M$ axis positive port,
- $\vec{z}_M$ axis positive upward.

2.1 – Transformation matrices

The transformation matrices provide the existing relation between the efforts applied at the reference point and the efforts at the Pylon/Engine mounts and the Pylon/wing attachments. These data are in the technical note " A300-600R - Transformation matrices for loads one powerplant attachments " reference 438.061/86.

Reference point coordinates are:

P_R	Left	Right
X (m)	-19,1780	-19,1780
Y (m)	7,9560	-7,9560
Z (m)	-2,4890	-2,4890

2.1.1 – Engine/Pylon mounts

Port side

X_{AV}		-0,9983	0,0047	-0,0021	0,0012	-0,0034	-0,0650		F_X
Y_{AV}		0,0041	-0,7671	0,0000	0,0033	0,0000	-0,3708		F_Y
Z_{AV}	=	-0,1799	0,0031	-0,7687	0,0064	0,3708	0,0000	*	F_Z
V_2		0,1036	0,7803	-0,1156	1,5250	-0,2121	-0,0646		M_X
V_3		0,0805	-0,8264	-0,1220	-1,6154	-0,1674	0,0681		M_Y
S_4		0,0215	-0,4957	-0,0388	-0,5172	-0,0532	0,3925		M_Z

Starboard side

X_{AV}		-0,9983	0,0047	-0,0021	0,0012	-0,0034	-0,0650		F_X
Y_{AV}		0,0041	-0,7671	0,0000	0,0033	0,0000	-0,3708		F_Y
Z_{AV}	=	-0,1799	0,0031	-0,7687	0,0064	0,3708	0,0000	*	F_Z
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S_4		0,0215	-0,4957	-0,0388	-0,5172	-0,0532	0,3925		M_Z

The forces are expressed in daN and moments m daN. The calculated efforts represent the **action of the pylon on the engine**.

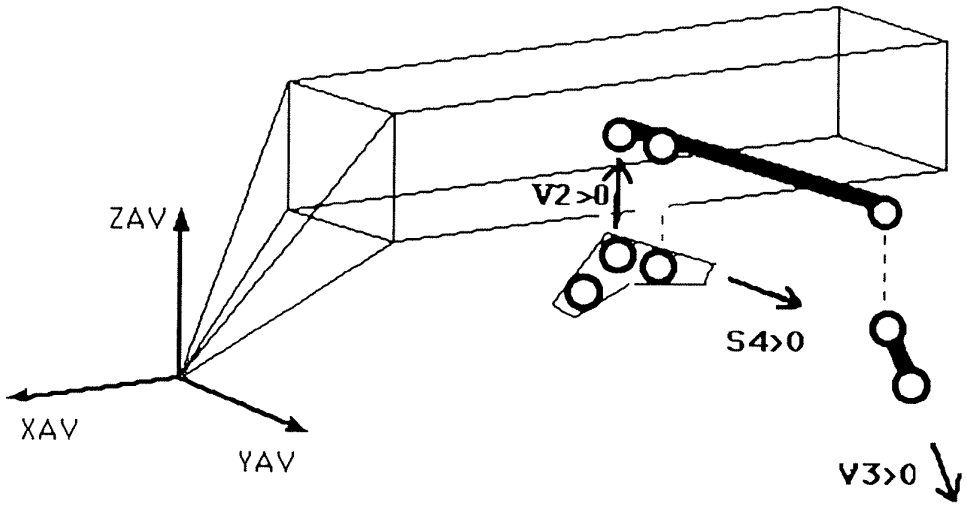

fig. 2.1 – Engine/Pylon mounts design

2.1.2 – Pylon/Wing attachments

Port side

$Z_{N8\ EXT}$		0,2958	6,8168	1,1011	3,2873	-0,2160	0,3380		F_X
$Z_{N8\ INT}$		0,7241	-6,7603	1,7628	-3,2873	-0,4539	-0,3188		F_Y
X_{SP}	=	1,0173	-0,7403	0,0000	0,0000	0,0000	-0,2516	*	F_Z
Y_{SP}		0,0000	3,1783	0,0000	0,0000	0,0000	0,7404		M_X
Y_{14}		0,0000	-2,2966	0,0000	0,0000	0,0000	-0,7806		M_Y
Z_{14}		-1,2066	0,0794	-1,8639	0,0000	0,6699	0,0270		M_Z

Starboard side

$Z_{N8\ EXT}$		0,2958	6,8168	1,1011	3,2873	-0,2160	0,3380		F_X
$Z_{N8\ INT}$		0,7241	-6,7603	1,7628	-3,2873	-0,4539	-0,3188		F_Y
X_{SP}	=	1,0173	-0,7403	0,0000	0,0000	0,0000	-0,2516	*	F_Z
Y_{SP}		0,0000	3,1783	0,0000	0,0000	0,0000	0,7404		M_X
Y_{14}		0,0000	-2,2966	0,0000	0,0000	0,0000	-0,7806		M_Y
Z_{14}		-1,2066	0,0794	-1,8639	0,0000	0,6699	0,0270		M_Z

The forces are expressed in daN and moments m daN. The calculated efforts represent the **action of the engine on the wing**.

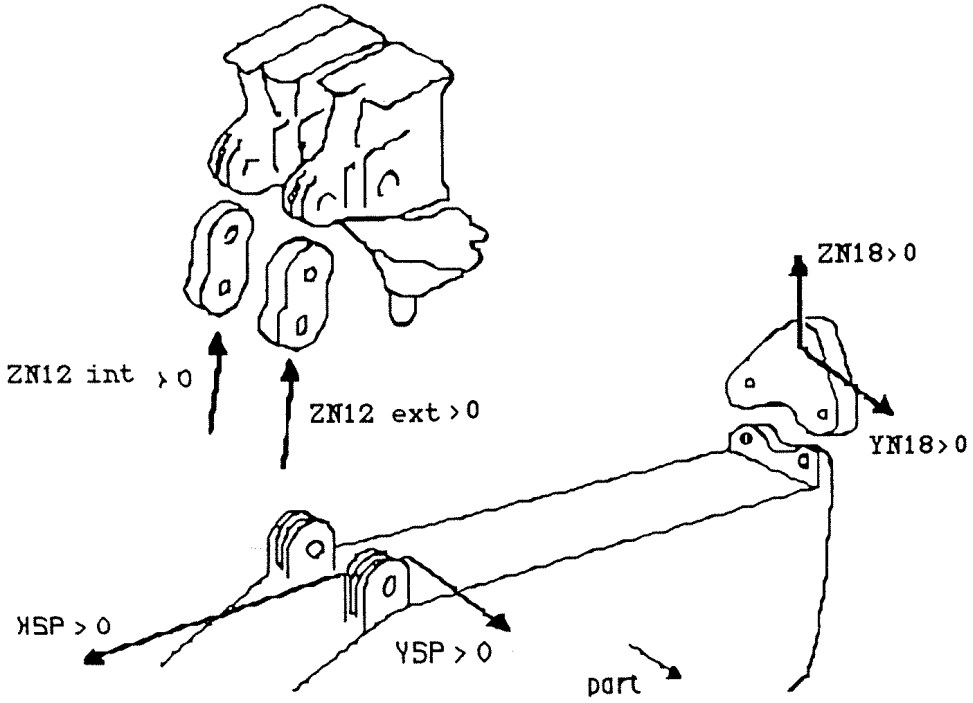

fig. 2.2 – Pylon/Wing attachments design

2.2 – Mass and geometrical characteristics

Pitch angle and pinch angle of the engines are:

α_c	4,00	°
β_c	1,00	°

Wing reference surface and the mean aerodynamic chord are:

S	260	m^2
$\mathbf{l_a}$	6,6081	m

The masses, the centre of gravity and the inertia matrices of the engine and the pylon are provided by the following tables:

Engine CG	**Left**	**Right**
X (m)	-19,1780	-19,1780
Y (m)	7,9560	-7,9560
Z(m)	-2,4890	-2,4890

Weight	6123	kg

The engine inertias are the following:

- I_{XX} = 3 307 kg m^2
- I_{YY} = 12 270 kg m^2
- I_{ZZ} = 12 023 kg m^2

2.2 – Loads at Engine/Pylon Mounts

The tables below present the Left/Right envelope of loads for the 3 points of analysis at Engine/Pylon mounts. The first six lines correspond to maximum (compression) observed on the 3 selected points of calculation and the six last ones in minimum (tension). The values in bold type are the values envelopes of every criterion. The comparisons of the same signs are only calculated.

The loads comparison is made with regard to the limit loads and ultimate loads of this aircraft.

Note 1: Ultimate loads include the limit loads with a safety factor (generally 1.5) and loads for which condition is considered as ultimate.

Note 2: The formulation of the comparison is the following: $100 * \left(\frac{\text{Load} - \text{Design Load}}{\text{Design Load}} \right)$.

For example, if we consider the Y_{AV} positive criteria, the load is 62 % below the limit load of the aircraft.

OsmaC Results

Case	Side	X_{AV} (daN)	Y_{AV} (daN)	Z_{AV} (daN)	V_2 (daN)	V_3 (daN)	S_4 (daN)	LIMIT	ULTIMATE
Point 1	Port	**-20080**	-2281	189	4263	1390	287		
Point 2	Port	-23573	**6340**	-600	-14	3757	-595	-62%	-75%
Point 3	Stbd	-20941	2189	**2209**	-1338	3590	1496	-92%	-95%
Point 1	Port	-20080	-2281	189	**4263**	1390	287	-75%	-90%
Point 2	Port	-23573	6340	-600	-14	**3757**	-595	-79%	-87%
Point 3	Port	-25464	-7254	-2551	4153	458	**3347**	-49%	-79%
Point 3	Port	**-25464**	-7254	-2551	4153	458	3347	-15%	-53%
Point 3	Port	-25464	**-7254**	-2551	4153	458	3347	-57%	-71%
Point 1	Stbd	-25276	-1427	**-3842**	4198	1223	-414	-66%	-90%
Point 3	Stbd	-20941	2189	2209	**-1338**	3590	1496	-92%	-94%
Point 3	Port	-25464	-7254	-2551	4153	**458**	3347		
Point 2	Port	-23573	6340	-600	-14	3757	**-595**	-92%	-97%

INT18 Results

Case	Side	X_{AV} (daN)	Y_{AV} (daN)	Z_{AV} (daN)	V_2 (daN)	V_3 (daN)	S_4 (daN)	LIMIT	ULTIMATE
Point 3	Port	**-20911**	-11319	-6877	9485	-946	5573		
Point 3	Stbd	-25694	**6332**	-2853	2379	3266	618	-63%	-75%
Point 2	Port	-21083	5163	**755**	1332	1753	-1657	-97%	-98%
Point 3	Port	-20911	-11319	-6877	**9485**	-946	5573	-44%	-77%
Point 3	Stbd	-25694	6332	-2853	2379	**3266**	618	-82%	-89%
Point 3	Port	-20911	-11319	-6877	9485	-946	**5573**	-15%	-64%
Point 3	Stbd	**-25694**	6332	-2853	2379	3266	618	-15%	-53%
Point 3	Port	-20911	**-11319**	-6877	9485	-946	5573	-33%	-55%
Point 3	Port	-20911	-11319	**-6877**	9485	-946	5573	-39%	-83%
Point 2	Port	-21083	5163	755	**1332**	1753	-1657		
Point 3	Port	-20911	-11319	-6877	9485	**-946**	5573	-94%	-98%
Point 2	Port	-21083	5163	755	1332	1753	**-1657**	-77%	-92%

Engine/Pylon mounts remain in the design envelope of the limit loads and the ultimate loads.

2.3 – Loads at Pylon/Wing attachments

The following tables present the values of the limit and ultimate loads calculated for the Pylon/Wing attachments.

OsmaC Results

Case	Side	Z_{N12EXT} (daN)	Z_{N12INT} (daN)	X_{SP} (daN)	Y_{SP} (daN)	Y_{N18} (daN)	Z_{N18} (daN)	LIMIT	ULTIMATE
Point 3	Port	**35149**	-16331	19262	22034	-18641	-24834	-73%	-82%
Point 2	Port	-29672	**41707**	29770	-20880	16592	-21046	-61%	-77%
Point 2	Port	-29672	41707	**29770**	-20880	16592	-21046	-6%	-47%
Point 3	Port	35149	-16331	19262	**22034**	-18641	-24834	-66%	-78%
Point 2	Port	-29672	41707	29770	-20880	**16592**	-21046	-61%	-74%
Point 3	Stbd	-17849	21048	22570	-7564	5707	**-12266**		
Point 2	Port	**-29672**	41707	29770	-20880	16592	-21046	-76%	-84%
Point 3	Port	35149	**-16331**	19262	22034	-18641	-24834	-88%	-92%
Point 1	Port	14783	-11671	**17496**	8978	-6639	-13447		
Point 2	Port	-29672	41707	29770	**-20880**	16592	-21046	-63%	-76%
Point 3	Port	35149	-16331	19262	22034	**-18641**	-24834	-62%	-75%
Point 1	Stbd	19698	1985	24464	6992	-4747	**-28272**	-10%	-71%

INT18 Results

Case	Side	Z_{N12EXT} (daN)	Z_{N12INT} (daN)	X_{SP} (daN)	Y_{SP} (daN)	Y_{N18} (daN)	Z_{N18} (daN)	LIMIT	ULTIMATE
Point 3	Port	**53137**	-30606	10700	31896	-27780	-27379	-58%	-72%
Point 3	Stbd	-29052	**46742**	31745	-21674	16925	-26977	-57%	-75%
Point 3	Stbd	-29052	46742	**31745**	-21674	16925	-26977	0%	-43%
Point 3	Port	53137	-30606	10700	**31896**	-27780	-27379	-51%	-68%
Point 3	Stbd	-29052	46742	31745	-21674	**16925**	-26977	-60%	-74%
Point 2	Port	-19617	26272	25660	-15608	13037	**-15797**		
Point 3	Stbd	**-29052**	46742	31745	-21674	16925	-26977	-77%	-84%
Point 3	Port	53137	**-30606**	10700	31896	-27780	-27379	-78%	-86%
Point 3	Port	53137	-30606	**10700**	31896	-27780	-27379		
Point 3	Stbd	-29052	46742	31745	**-21674**	16925	-26977	-62%	-75%
Point 3	Port	53137	-30606	10700	31896	**-27780**	-27379	-44%	-63%
Point 3	Port	53137	-30606	10700	31896	-27780	**-27379**	-12%	-72%

Pylon/Wing attachments remain in the design envelope of the limit loads and the ultimate loads.