



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 30, 2015

Group Chairman's Factual Report

STRUCTURES

DCA13MA081

Attachment 11

Telair Study
M-ATV Vehicle Restraint Analysis (with tie down straps)
June 3, 2014

M-ATV Vehicle Restraint Analysis (with tiedown straps)

B747-428 (BCF)

Registration: N949CA

MSN 25630

29-Apr-2013, Bagram (Afghanistan)

Tall Rigid Cargo Requirement

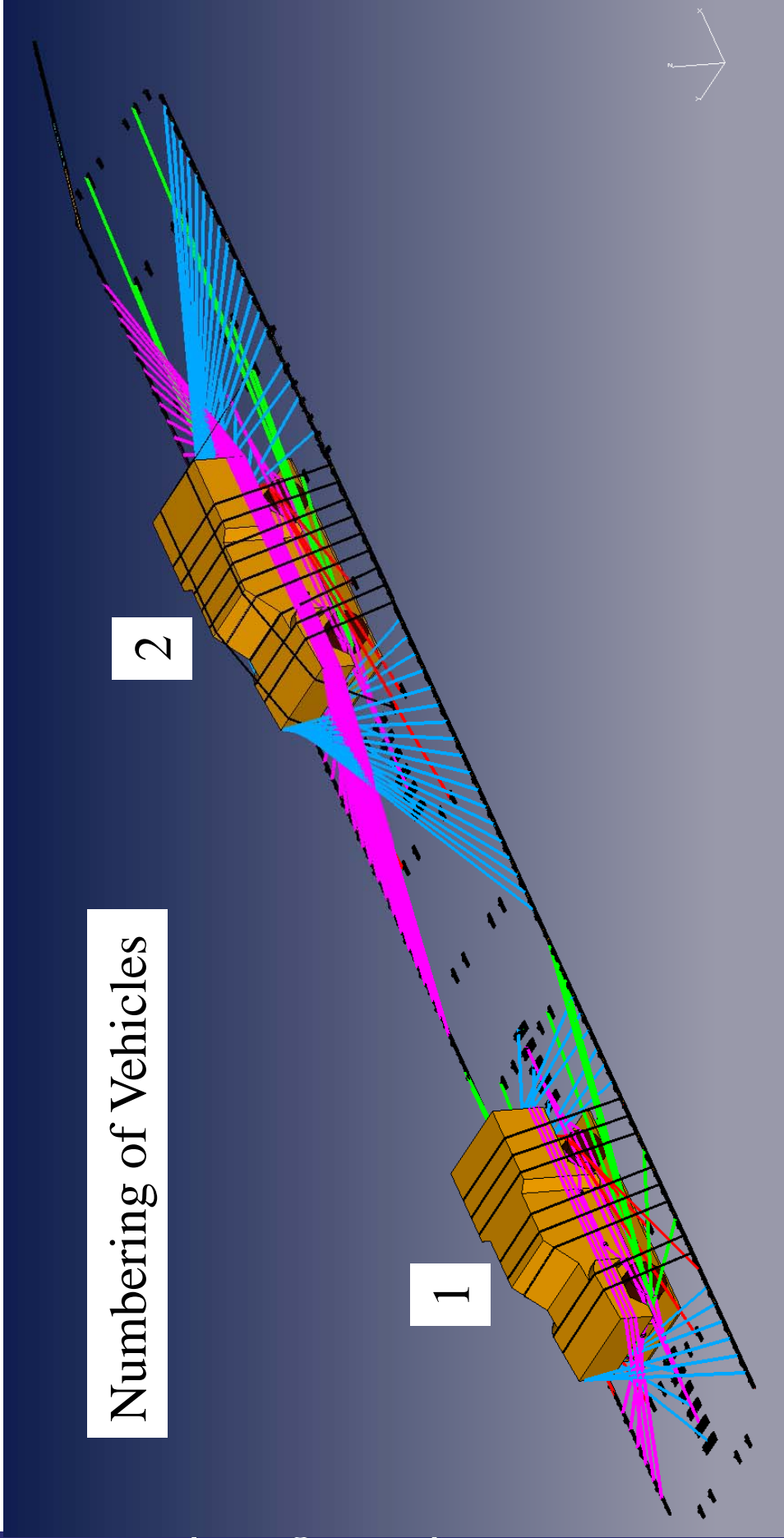


- Centerline loaded cargo must be aft of B.A. 1220.
- There must be a minimum of the equivalent of seven 125 inch long loaded unit load devices positioned directly forward of the rigid cargo greater than 96 inches.
- It is not possible to safely and properly secure a M-ATV vehicle in any location.
- FWD of tall rigid cargo there is no access to sufficient tiedown points, because this area must be occupied with other frangible cargo.
- The following tiedown schemes violate the tall rigid cargo requirements, and have been performed only for NTSB investigation support at the NTSB's request.

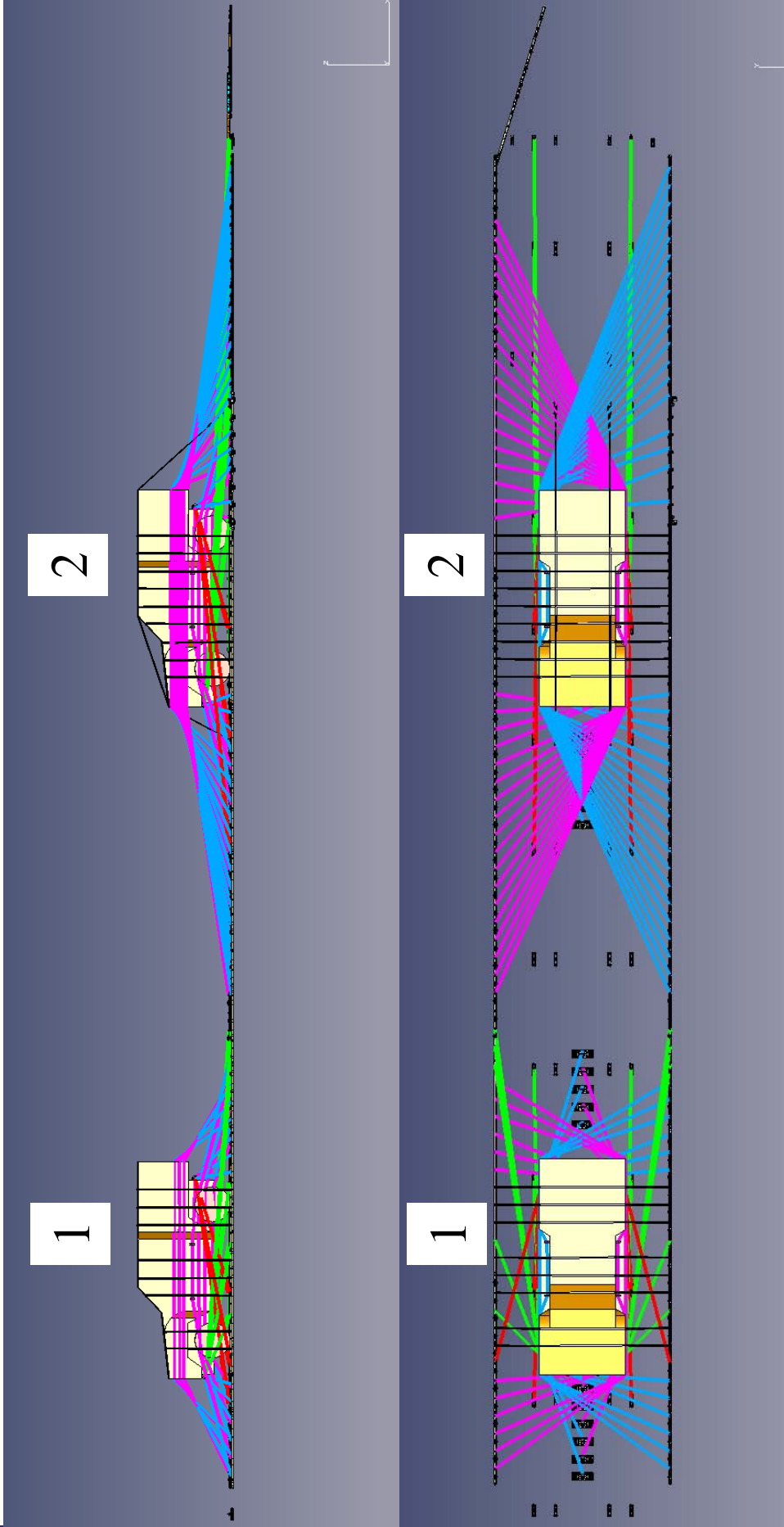
Loading Setup



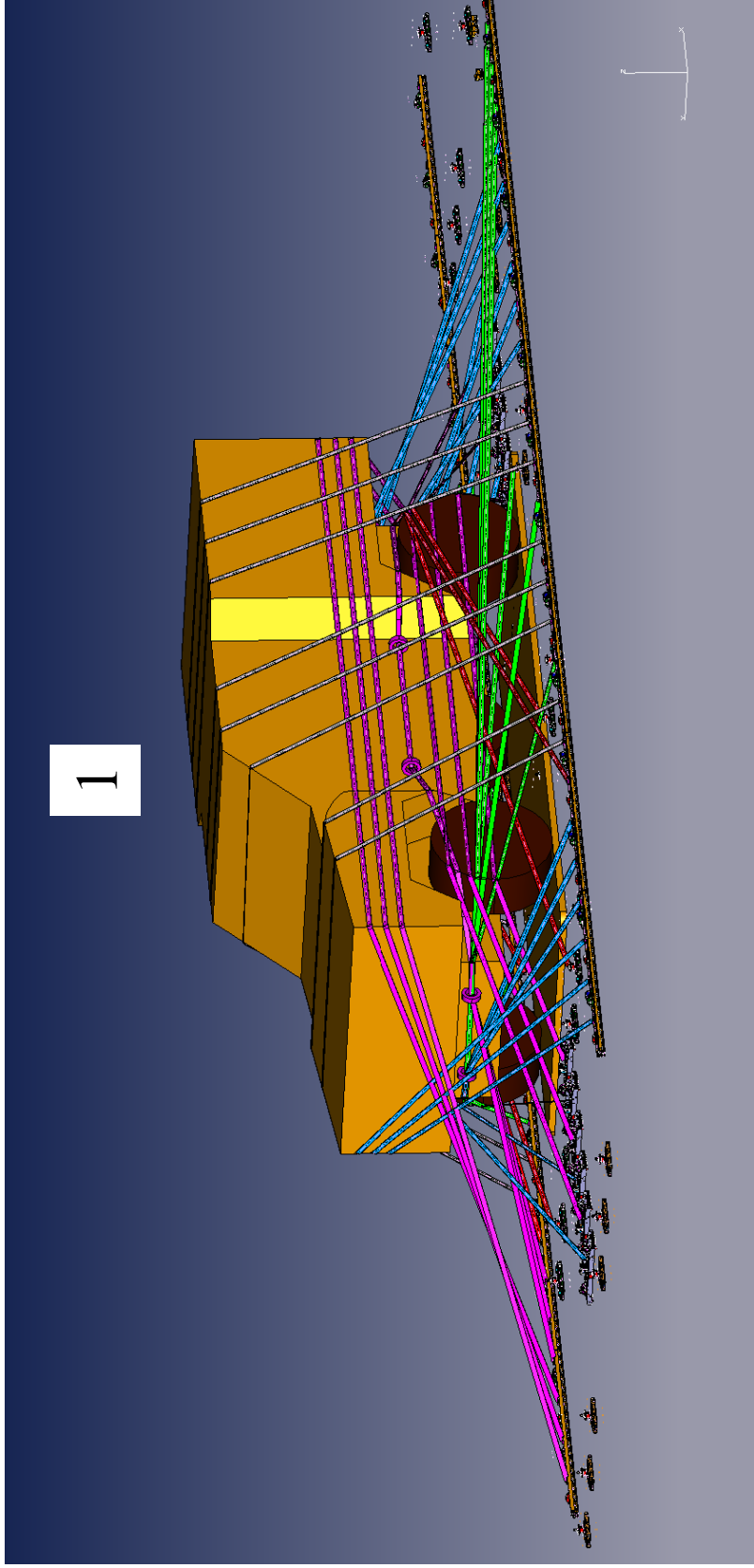
Numbering of Vehicles



Loading Setup



Tiedown Straps for first M-ATV (B.A. 809.3 – 1056.1, 12614 kg, CG at B.A. 952.7)



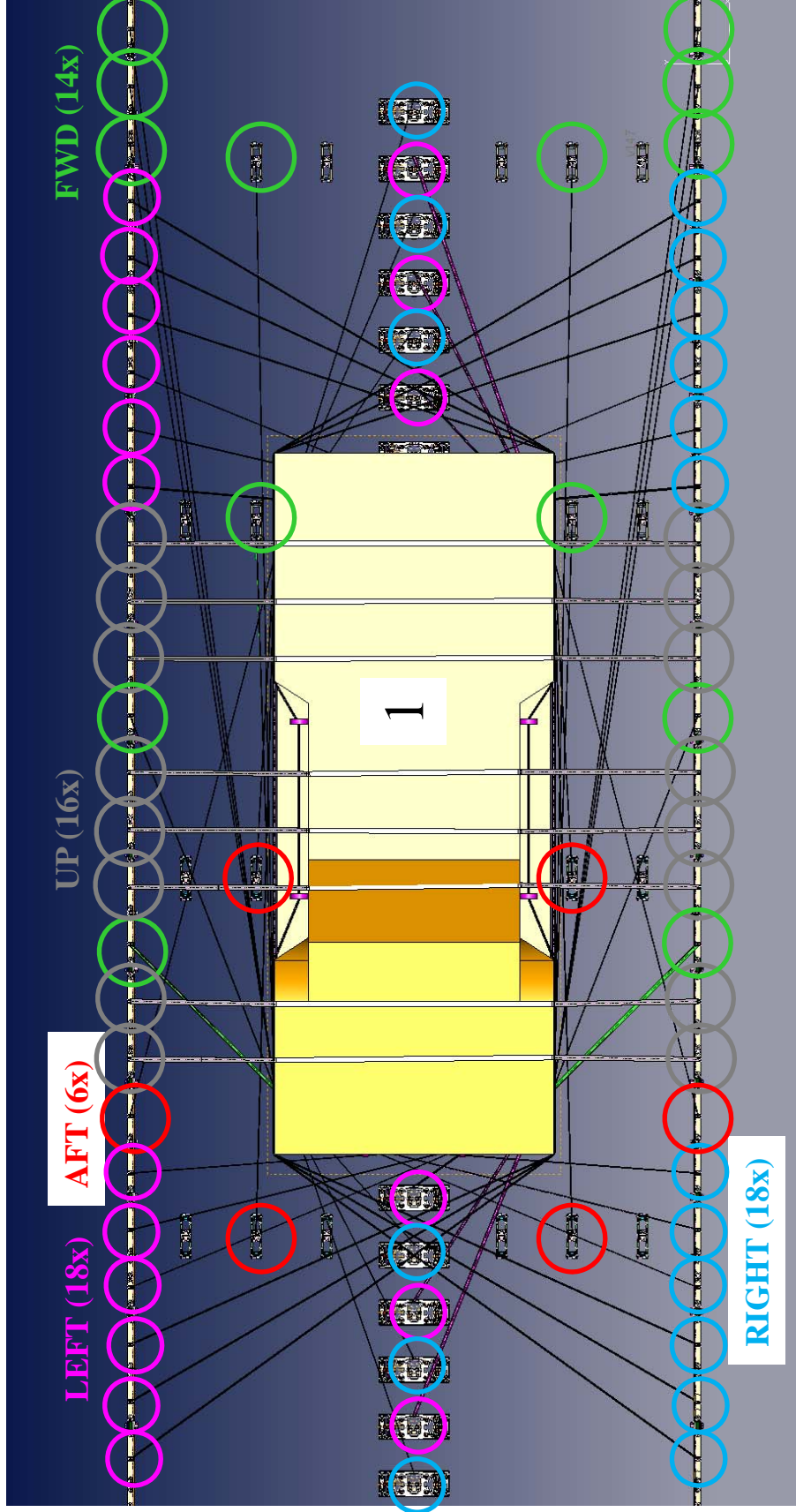
13.2.2. Load Factors

The most critical load factors are given in the following table.

TIEDOWN LOCATION	BODY STATION		ULTIMATE LOAD FACTOR			
	FROM	TO	FORWARD	AFT	SIDE	UP
Center Guide, and Side Guide Main Deck End Lock, End Stop	228	500			1.45	1.5
	500	1000	1.5	0.75	0.78	1.5
	1000	1480			1.76	1.3
	1480	2365				2.34

Reference:
25-55-66 Rev.L p.106

Tiedown Points for first M-ATV (B.A. 809.3 – 1056.1, XY-Plane)



Tiedown Points for first M-ATV (FWD Direction)



M-ATV, TIEDOWN CALCULATION FWD		AVAILABLE CAPABILITY				REQUIRED CAPABILITY			
DIRECTION	TIEDOWN LOCATION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT TOTAL (KG)	MARGIN OF SAFETY
FWD	PALLET LOCK TIE DOWN RING	8	2	2	2268	19794	1,5	12614	0,04
FWD	PALLET LOCK TIE DOWN RING	5	1	2	2268				
FWD	SIDE GUIDE, DOUBLE STUD FITTING	4	8	2	1247				
FWD	SIDE GUIDE, DOUBLE STUD FITTING	4	8	2	1247				
FWD	SIDE GUIDE, DOUBLE STUD FITTING	5	8	2	1247				
FWD	SIDE GUIDE, DOUBLE STUD FITTING	10	21	2	1080				
FWD	SIDE GUIDE, DOUBLE STUD FITTING	16	50	2	540				

13.2.5. Pallet Lock - Tie Down Ring (STA 500-Z2365)
The following table summarizes tiedown fitting allowable loads for the pallet locks with ring tie-downs.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)					
		0°	30°	60°	90°	ALLOWABLE LOAD	
		LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	N/A	N/A	N/A	N/A
Side	0° (Horizontal)	0	0	250	113	433	196
	30°	0	0	217	98	375	170
	60°	0	0	125	57	217	98
	90° (Vertical)	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0
	30°	2500	1134	N/A	N/A	N/A	N/A
	60°	4330	1964	N/A	N/A	N/A	N/A
	90° (Vertical)	5000	2268	N/A	N/A	N/A	N/A
Aft	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	0	0	0	0

Values marked with N/A are not applicable, because this would cause other values to exceed the allowables.
Max. allowed center line angle +/- 3.2 for FWD/AFT and UP load.
See also chapter 13.5 for tiedown restrictions.

Reference:
25-55-66 Rev.L p.108 & p.111

13.2.8. Side Guide - Double Stud Fitting

The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)					
		0°	30°	60°	90°	ALLOWABLE LOAD	
		LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624
	30°	2382	1080	2063	936	1191	540
	60°	1375	624	1191	540	688	312
	90° (Vertical)	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786
	30°	0	0	866	393	1500	680
	60°	0	0	500	227	866	393
	90° (Vertical)	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0
	30°	1675	760	1675	760	1675	760
	60°	2901	1316	2901	1316	2901	1316
	90° (Vertical)	3350	1520	3350	1520	3350	1520
Aft	0° (Horizontal)	2750	1247	2382	1080	1375	624
	30°	2382	1080	2063	936	1191	540
	60°	1375	624	1191	540	688	312
	90° (Vertical)	0	0	0	0	0	0

Tiedown Points for first M-ATV (AFT Direction)



M-ATV, TIEDOWN CALCULATION AFT		AVAILABLE CAPABILITY				REQUIRED CAPABILITY			
DIRECTION	TIEDOWN LOCATION	FLOOR ANGLE	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)	TOTAL MARGIN OF SAFETY
AFT	PALLET LOCK TIE DOWN RING	17	3	2	1964	10958	0,75	12614	0,15
AFT	PALLET LOCK TIE DOWN RING	11	1	2	2268				
AFT	SIDE GUIDE, DOUBLE STUD FITTING	10	14	2	1247				

13.2.5. Pallet Lock – Tie Down Ring (STA 500-2365)
The following table summarizes tiedown fitting allowable loads for the pallet locks with ring tiedowns.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)																	
		0°			30°			60°			90°								
		LB	KG	N/A	LB	KG	N/A	LB	KG	N/A	LB	KG	N/A						
Forward	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Side	0° (Horizontal)	0	0	250	113	433	196	500	227										
	30°	0	0	217	98	375	170	443	196										
	60°	0	0	125	57	217	98	250	113										
	90° (Vertical)	0	0	0	0	0	0	0	0										
Up	0° (Horizontal)	0	0	0	0	0	0	0	0										
	30°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aft	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	0	0	0	0	0	0										

Values marked with N/A are not applicable, because this would cause other values to exceed the allowables.
Max. allowed center line angle +/- 3.2° for FWD/AFT and UP load.

See also chapter 13.5 for tiedown restrictions.

13.2.8. Side Guide - Double Stud Fitting

The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)											
		0°			30°			60°			90°		
		LB	KG	N/A	LB	KG	N/A	LB	KG	N/A	LB	KG	N/A
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0				
	30°	2382	1080	2063	936	1191	540	0	0				
	60°	1375	624	1191	540	688	312	0	0				
	90° (Vertical)	0	0	0	0	0	0	0	0				
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907				
	30°	0	0	866	393	1500	680	1732	786				
	60°	0	0	500	227	866	393	1000	454				
	90° (Vertical)	0	0	0	0	0	0	0	0				
Up	0° (Horizontal)	0	0	0	0	0	0	0	0				
	30°	1675	760	1675	760	1675	760	1675	760				
	60°	2901	1316	2901	1316	2901	1316	2901	1316				
	90° (Vertical)	3350	1520	3350	1520	3350	1520	3350	1520				
Aft	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0				
	30°	2382	1080	2063	936	1191	540	0	0				
	60°	1375	624	1191	540	688	312	0	0				
	90° (Vertical)	0	0	0	0	0	0	0	0				

Reference: 25-55-66
Rev.L p.108 & p.111

Tiedown Points for first M-ATV (LEFT/RIGHT Direction)



DIRECTION	M-ATV, TIEDOWN CALCULATION LEFT		AVAILABLE CAPABILITY			REQUIRED CAPABILITY			
	TIEDOWN LOCATION	FLOOR ANGLE	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT TOTAL (KG)	MARGIN OF SAFETY
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	26	85	2	786	10942	0,78	12614	0,11
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	18	77	2	786				
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	18	67	2	680				
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	22	71	2	680				
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	20	64	2	680				
LEFT	SIDE GUIDE, DOUBLE STUD FITTING	17	58	2	680				
LEFT	CENTER GUIDE, DOUBLE STUD FITTING	16	42	2	393				
LEFT	CENTER GUIDE, DOUBLE STUD FITTING	16	26	2	393				
LEFT	CENTER GUIDE, DOUBLE STUD FITTING	16	18	2	393				

13.2.8. Side Guide - Double Stud Fitting
The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)							
		0°		30°		60°		90°	
		LB	KG	LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0
	30°	2382	1080	2083	936	1191	540	0	0
	60°	1375	624	1191	540	688	312	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907
	30°	0	0	866	393	1500	680	1732	786
	60°	0	0	500	227	866	393	1000	454
	90° (Vertical)	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0
	30°	1675	760	1675	760	1675	760	1675	760
	60°	2901	1316	2901	1316	2901	1316	2901	1316
	90° (Vertical)	3350	1520	3350	1520	3350	1520	3350	1520
Aft	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0
	30°	2382	1080	2083	936	1191	540	0	0
	60°	1375	624	1191	540	688	312	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0

13.2.9. Center Guides - Double Stud Fitting
The following table summarizes tiedown fitting allowable loads for Center Guides - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)							
		0°		30°		60°		90°	
		LB	KG	LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	3000	1361	2598	1178	1500	680	0	0
	30°	2493	1178	2250	1021	1299	589	0	0
	60°	1500	680	1299	589	750	340	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907
	30°	0	0	866	393	1500	680	1732	786
	60°	0	0	500	227	866	393	1000	454
	90° (Vertical)	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0
	30°	1500	680	1500	680	1500	680	1500	680
	60°	2598	1178	2598	1178	2598	1178	2598	1178
	90° (Vertical)	3000	1361	3000	1361	3000	1361	3000	1361
Aft	0° (Horizontal)	3000	1361	2598	1178	1500	680	0	0
	30°	2598	1178	2250	1021	1299	589	0	0
	60°	1500	680	1299	589	750	340	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0

Tiedown direction
LEFT shown.

Direction
RIGHT is similar.

Reference: 25-55-66 Rev.L p.111 & p.114

Tiedown Points for first M-ATV (UP Direction)



DIRECTION	TIEDOWN LOCATION	M-ATV, TIEDOWN CALCULATION UP			AVAILABLE CAPABILITY			REQUIRED CAPABILITY		
		FLOOR ANGLE	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)	TOTAL (KG)	MARGIN OF SAFETY
UP	SIDE GUIDE, DOUBLE STUD FITTING	64	90	2	1316	21056	1,5	12614	18921	0,11
UP	SIDE GUIDE, DOUBLE STUD FITTING	64	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	64	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	59	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	59	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	57	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	56	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	55	90	2	1316					

13.2.8. Side Guide - Double Stud Fitting
The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

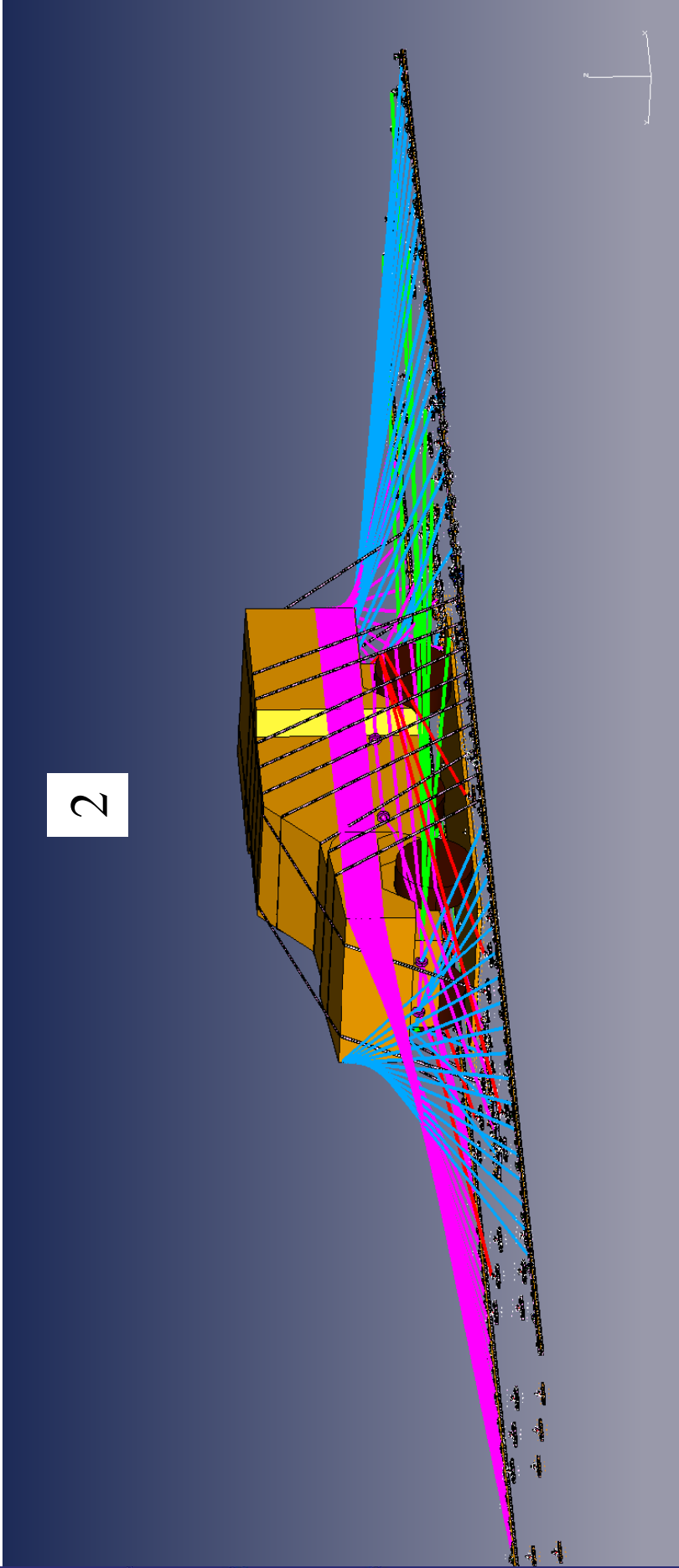
RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)															
		0°				30°				60°				90°			
		LB	KG	LB	KG	LB	KG	LB	KG	LB	KG	LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0	0	0	0	0	0	0	0	0
	30°	2382	1080	2063	936	1191	540	0	0	0	0	0	0	0	0	0	0
	60°	1375	624	1191	540	688	312	0	0	0	0	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907	0	0	0	0	0	0	0	0
	30°	0	0	866	393	1500	680	1732	786	0	0	0	0	0	0	0	0
	60°	0	0	500	227	866	393	1000	454	0	0	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30°	1675	760	1675	760	1675	760	1675	760	1675	760	1675	760	1675	760	1675	760
	60°	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316
	90° (Vertical)	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520
AIT	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0	0	0	0	0	0	0	0	0
	30°	2382	1080	2063	936	1191	540	0	0	0	0	0	0	0	0	0	0
	60°	1375	624	1191	540	688	312	0	0	0	0	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Reference: 25-55-66 Rev.L p.111

Tiedown Straps for second M-ATV (B.A. 1573.9 – 1820.7, 12614 kg, CG at B.A. 1717.3)



2



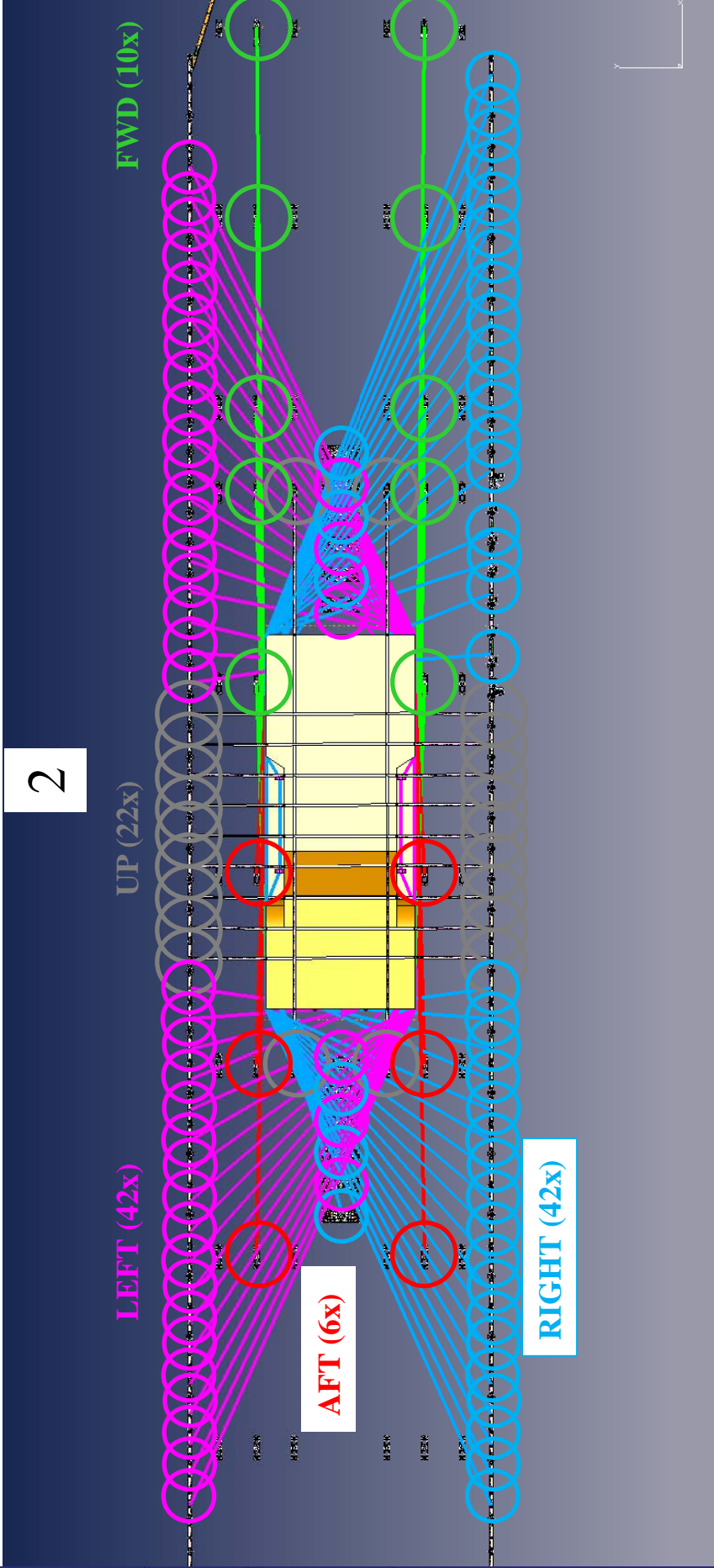
13.2.2. Load Factors

The most critical load factors are given in the following table.

TIEDOWN LOCATION	BODY STATION		ULTIMATE LOAD FACTOR			
	FROM	TO	FORWARD	AFT	SIDE	UP
Center Guide, and Side Guide Main Deck	228	500	1.5	0.75	1.45	1.5
	500	1000	1.5	0.75	0.78	1.5
End Lock, End Stop	1000	1480	1.5	1.76	1.5	1.5
	1480	2365	1.5	1.76	1.76	2.34

Reference:
25-55-66 Rev.L p.106

Tiedown Points for second M-ATV (B.A. 1573.9 – 1820.7, XY-Plane)



Tiedown Points for second M-ATV (FWD Direction)

DIRECTION	TIEDOWN LOCATION	AVAILABLE CAPABILITY				REQUIRED CAPABILITY			
		FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	MARGIN OF SAFETY
FWD	PALLET LOCK TIE DOWN RING	7	2	2	2268	1,5	12614	18921	0,09
FWD	PALLET LOCK TIE DOWN RING	5	1	2	2268				
FWD	PALLET LOCK TIE DOWN RING	4	1	2	2268				
FWD	PALLET LOCK TIE DOWN RING	3	1	2	2268				
FWD	END STOP, DOUBLE STUD FITTING	2	1	2	1247				

13.2.5. Pallet Lock - Tie Down Ring (STA 500-2385)
The following table summarizes tiedown fitting allowable loads for the pallet locks with ring tiedowns.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)					
		0°		30°		90°	
		ALLOWABLE LOAD					
		LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A
Side	0° (Vertical)	0	0	N/A	N/A	N/A	N/A
	30° (Horizontal)	0	0	250	113	433	196
	60°	0	0	217	98	375	170
Up	0° (Vertical)	0	0	0	0	0	0
	30°	0	0	125	57	217	98
	60°	0	0	0	0	0	0
Aft	0° (Horizontal)	0	0	0	0	0	0
	30°	0	0	0	0	0	0
	60°	0	0	0	0	0	0

Reference:
25-55-66 Rev.L p.108 & p.112

Values marked with N/A are not applicable, because this would cause other values to exceed the allowables.
Max. allowed center line angle +/- 3.2° for FWD/AFT and UP load.

See also chapter 13.5 for tiedown restrictions.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)					
		0°		30°		90°	
		ALLOWABLE LOAD					
		LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624
	30°	2382	1080	2063	936	1191	540
	60°	1375	624	1191	540	688	312
Side	0° (Vertical)	0	0	0	0	0	0
	30° (Horizontal)	0	0	1000	454	1732	786
	60°	0	0	866	393	1500	680
Up	0° (Vertical)	0	0	0	0	0	0
	30°	1675	760	1675	760	1675	760
	60°	2901	1316	2901	1316	2901	1316
Aft	0° (Horizontal)	2750	1247	2382	1080	1375	624
	30°	2382	1080	2063	936	1191	540
	60°	1375	624	1191	540	688	312

Tiedown Points for second M-ATV (AFT Direction)



DIRECTION	M-ATV, TIEDOWN CALCULATION AFT	AVAILABLE CAPABILITY				REQUIRED CAPABILITY			
		TIEDOWN LOCATION	FLOOR ANGLE	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)
AFT	PALLET LOCK TIE DOWN RING	16	3	2	1964	13000	0,75	12614	0,37
AFT	PALLET LOCK TIE DOWN RING	8	2	2	2268				
AFT	PALLET LOCK TIE DOWN RING	6	1	2	2268				

13.2.5. Pallet Lock – Tie Down Ring (STA 500-2365)
The following table summarizes tiedown fitting allowable loads for the pallet locks with ring tiedowns.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)												
		0°			30°			60°			90°			
		LB	KG	LB	KG	LB	KG	LB	KG	LB	KG			
Forward	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Side	0° (Horizontal)	0	0	250	113	433	196	500	227	500	227	500	227	500
	30°	0	0	217	98	375	170	433	196	433	196	433	196	433
	60°	0	0	125	57	217	98	250	113	250	113	250	113	250
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0	0	0	0	0	0
	30°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aft	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0	

Values marked with N/A are not applicable, because this would cause other values to exceed the allowables.
Max. allowed center line angle +/- 3.2° for FWD/AFT and UP load.

See also chapter 13.5 for tiedown restrictions.

Reference: 25-55-66 Rev.L p.108

Tiedown Points for second M-ATV (LEFT/RIGHT Direction)



M-ATV, TIEDOWN CALCULATION RIGHT		AVAILABLE CAPABILITY				REQUIRED CAPABILITY			MARGIN OF SAFETY
DIRECTION	TIEDOWN LOCATION	FLOOR ANGLE	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)	
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	26	87	2	786	22322	1,76	12614	0,00
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	18	68	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	24	72	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	23	66	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	20	54	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	18	49	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	17	45	2	680				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	16	41	2	393				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	14	38	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	13	35	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	12	33	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	11	31	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	10	29	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	10	27	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	9	25	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	8	24	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	8	23	2	454				
RIGHT	SIDE GUIDE, DOUBLE STUD FITTING	7	22	2	454				
RIGHT	CENTER GUIDE, DOUBLE STUD FITTING	13	33	2	454				
RIGHT	CENTER GUIDE, DOUBLE STUD FITTING	14	22	2	454				
RIGHT	CENTER GUIDE, DOUBLE STUD FITTING	15	16	2	454				

Reference: 25-55-66 Rev.L p.111 & p.114
See next Slide

Tiedown direction RIGHT shown. Direction LEFT is similar.

Tiedown Points for second M-ATV (LEFT/RIGHT Direction)



13.2.8. Side Guide - Double Stud Fitting

The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)											
		0°			30°			60°			90°		
		LB	KG	LB	KG	LB	KG	LB	KG	LB	KG		
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0	0	0	0	0
	30°	2382	1080	2063	936	1191	540	0	0	0	0	0	0
	60°	1375	624	1191	540	688	312	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907	0	0	0	0
	30°	0	0	866	393	1500	680	1732	786	0	0	0	0
	60°	0	0	500	227	866	393	1000	454	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0	0	0	0	0
	30°	1675	760	1675	760	1675	760	1675	760	1675	760	1675	760
	60°	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316	2901	1316
	90° (Vertical)	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520	3350	1520
Aft	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0	0	0	0	0
	30°	2382	1080	2063	936	1191	540	0	0	0	0	0	0
	60°	1375	624	1191	540	688	312	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0

13.2.11. Center Guides - Double Stud Fitting

The following table summarizes tiedown fitting allowable loads for Center Guides - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)											
		0°			30°			60°			90°		
		LB	KG	LB	KG	LB	KG	LB	KG	LB	KG		
Forward	0° (Horizontal)	3000	1361	2598	1178	1500	680	0	0	0	0	0	0
	30°	2598	1178	2250	1021	1299	589	0	0	0	0	0	0
	60°	1500	680	1299	589	750	340	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0
Side	0° (Horizontal)	0	0	1000	454	1732	786	2000	907	0	0	0	0
	30°	0	0	866	393	1500	680	1732	786	0	0	0	0
	60°	0	0	500	227	866	393	1000	454	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0
Up	0° (Horizontal)	0	0	0	0	0	0	0	0	0	0	0	0
	30°	1500	680	1500	680	1500	680	1500	680	1500	680	1500	680
	60°	2598	1178	2598	1178	2598	1178	2598	1178	2598	1178	2598	1178
	90° (Vertical)	3000	1361	3000	1361	3000	1361	3000	1361	3000	1361	3000	1361
Aft	0° (Horizontal)	3000	1361	2598	1178	1500	680	0	0	0	0	0	0
	30°	2598	1178	2250	1021	1299	589	0	0	0	0	0	0
	60°	1500	680	1299	589	750	340	0	0	0	0	0	0
	90° (Vertical)	0	0	0	0	0	0	0	0	0	0	0	0

Reference: 25-55-66 Rev.L p.111 & p.114

Tiedown direction RIGHT shown. Direction LEFT is similar.

Tiedown Points for second M-ATV (UP Direction)



M-ATV, TIEDOWN CALCULATION UP			AVAILABLE CAPABILITY				REQUIRED CAPABILITY			
DIRECTION	TIEDOWN LOCATION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE	NUMBER OF TIEDOWN FITTINGS	TIEDOWN ALLOWABLE (KG)	TOTAL TIEDOWN ALLOWABLE (KG)	LOAD FACTOR	WEIGHT (KG)	TOTAL (KG)	MARGIN OF SAFETY
UP	SIDE GUIDE, DOUBLE STUD FITTING	64	90	2	1316	31544	2,34	12614	29517	0,06
UP	SIDE GUIDE, DOUBLE STUD FITTING	64	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	59	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	59	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	59	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	57	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	51	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	56	90	2	1316					
UP	SIDE GUIDE, DOUBLE STUD FITTING	55	90	2	1316					
UP	PALLET LOCK TIE DOWN RING	48	0	2	1964					
UP	PALLET LOCK TIE DOWN RING	48	0	2	1964					

13.2.8. Side Guide - Double Stud Fittings
The following table summarizes tiedown fitting allowable loads for side guide - double stud fittings.

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)							
		0°		30°		60°		90°	
		LB	KG	LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0
	30°	2382	1080	2063	936	1191	540	0	0
	60°	1375	624	1191	540	688	312	0	0
Side	0° (Vertical)	0	0	0	0	0	0	0	0
	30°	0	0	1000	454	1732	786	2000	907
	60°	0	0	866	393	1500	680	1732	786
Up	0° (Horizontal)	0	0	0	0	0	0	0	0
	30°	0	0	500	227	866	393	1000	454
	60°	0	0	0	0	0	0	0	0
Att	0° (Horizontal)	1875	780	1675	760	1675	760	1675	760
	30°	2001	1316	2001	1316	2001	1316	2001	1316
	60°	3350	1520	3350	1520	3350	1520	3350	1520
AT	0° (Horizontal)	2750	1247	2382	1080	1375	624	0	0
	30°	2382	1080	2063	936	1191	540	0	0
	60°	1375	624	1191	540	688	312	0	0
(Vertical)	0°	0	0	0	0	0	0	0	0
	30°	0	0	0	0	0	0	0	0
	60°	0	0	0	0	0	0	0	0

Reference: 25-55-66
Rev.L p.108 & p.111

RESTRAINT DIRECTION	FLOOR ANGLE (DEGREES)	CENTERLINE ANGLE (DEGREES)							
		0°		30°		60°		90°	
		LB	KG	LB	KG	LB	KG	LB	KG
Forward	0° (Horizontal)	5000	2268	N/A	N/A	N/A	N/A	N/A	N/A
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A
Side	0° (Vertical)	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	30°	0	0	256	113	433	196	500	227
	60°	0	0	217	98	375	170	433	196
Up	0° (Horizontal)	0	0	125	57	217	98	250	113
	30°	0	0	0	0	0	0	0	0
	60°	0	0	0	0	0	0	0	0
Att	0° (Horizontal)	0	0	0	0	0	0	0	0
	30°	4330	1964	N/A	N/A	N/A	N/A	N/A	N/A
	60°	2500	1134	N/A	N/A	N/A	N/A	N/A	N/A
(Vertical)	0°	0	0	0	0	0	0	0	0
	30°	0	0	0	0	0	0	0	0
	60°	0	0	0	0	0	0	0	0

Values marked with N/A are not applicable, because this would cause other values to exceed the allowable. Max. allowed center line angle is 3.3° for FWD/ATT and UP load. See also chapter 13.5 for beddown restrictions.

Summary - Tall Rigid Cargo Requirement ignored

- Only Telair hardware was considered (no Boeing seat track).
- Two (2) M-ATV can be restrained on the main deck when the tall rigid cargo restriction is ignored as per the NTSB’s request for analytical purposes only (not permitted under Telair manual).
- The second M-ATV was located at the aftmost position, which allows sufficient tiedown attachment points at the FWD and AFT side of the vehicle.
- The occupied space is 508 and 976 inches.

