

SECTION 6

MASS AND BALANCE

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APPENDED TO SECTION 6

Form MBR MASS AND BALANCE RECORD
 Form EL EQUIPMENT LIST

SECTION 6

MASS AND BALANCE

6.1 GENERAL

This section provides information required for helicopter loading and computing mass and balance.

It shall be the pilot's responsibility to make certain that:

- the helicopter is properly loaded so that the entire flight is conducted within the Center of Gravity Limits.
- all cargo is stowed and tied down properly so that in-flight shifting is impossible
- proper tie-down equipment (i.e. ropes, belts, etc.) of sufficient strength has to be used. As many tie-down fittings as possible have to be used per single cargo item in order to reduce the individual load per fitting and to avoid inadvertent in-flight shifting.

6.1.1 Mass definitions

Basic empty mass

The basic empty mass consists of the basic helicopter with required standard equipment, optional equipment, unusable fuel, and full operating fluids including transmission, gear-box and engine oils, hydraulic fluid, rotor brake oil.

Gross mass

The gross mass is the sum of the basic empty mass and the pilot/crew, the passengers, the baggage/cargo and the fuel.

This value will vary with mission.

6.1.2 Balance definitions

Locations on and within the helicopter can be determined in relation to **fuselage stations**, **buttock lines** and **waterlines**, measured in millimeters (mm) from known reference points (Fig. 6-1). Fuselage stations, buttock lines, and waterlines are planes perpendicular to each other.

Reference plane is the plane at the longitudinal centerline of the helicopter perpendicular to the cabin floor.

Fuselage stations (F.S. or STA.)

Fuselage stations are vertical planes perpendicular to, and measured along, the longitudinal axis of the helicopter.

Station 0 is an imaginary vertical plane forward of the nose of the helicopter, from which all horizontal distances are measured for balance purposes (see also "reference datum").

Buttock lines (B.L.)

Buttock lines are vertical planes perpendicular to, and measured to the left and right along the lateral axis of the helicopter.

Buttock line (0) is the plane at the longitudinal centerline of the helicopter.

Waterline (W.L.)

Waterlines are horizontal planes perpendicular to, and measured along, the vertical axis of the helicopter.

Waterline (0) is a plane below the lowest point on the fuselage of the helicopter.

Reference datum (RD)

The reference datum (RD) is the station 0. It is located 2160 mm (85 in) in front of the Leveling Point (LP) (see Fig. 6-1).

Arm

The arm, for longitudinal balance purposes, is the horizontal distance from the reference datum to the center of gravity of a given item. For other purposes, Fuselage Stations (F.S. or STA) may be used. For the EC 135 helicopter arm and fuselage station are the same.

Moment (Massmoment)

The moment is the mass of an item multiplied by its arm.

$$\text{Moment (kgmm)} = \text{Mass (kg)} \quad \text{Arm (mm)}$$

Center of Gravity (CG)

Center of gravity is the point about which the helicopter would balance if suspended. Distance from the RD is found by dividing the total moment by the gross mass of the helicopter.

$$\text{Arm (mm)} = \frac{\text{Sum of all moments (kgmm)}}{\text{Sum of all masses (kg)}}$$

CG Limits

CG limits are the extremes of movements to which the helicopter CG can travel. The CG of the loaded helicopter must remain within these limits at takeoff, throughout flight, and at landing.

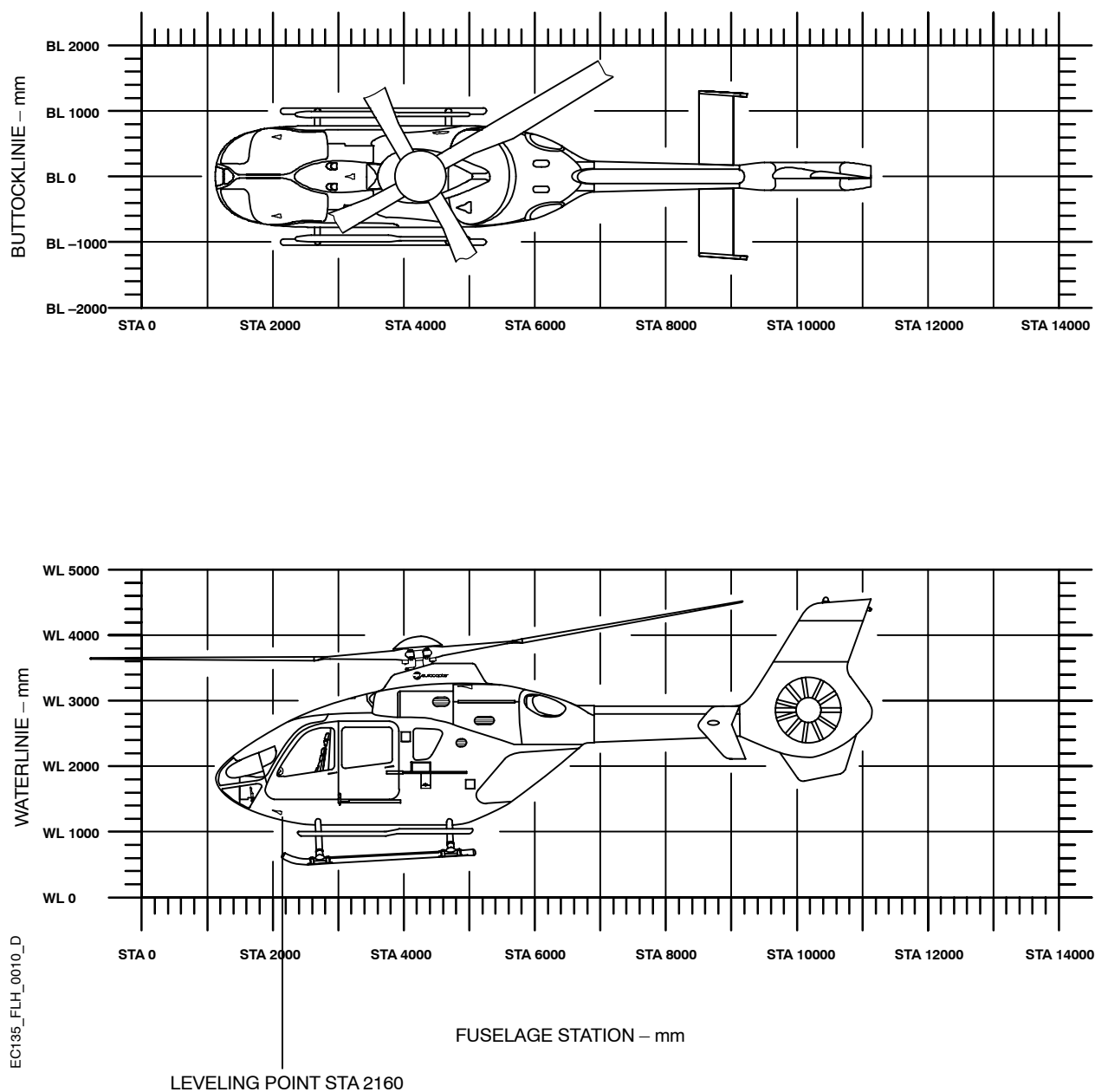


Fig. 6-1 Location diagram

6.2 BASIC EMPTY MASS CENTER OF GRAVITY

The procedure for establishing mass and moment (relative to the reference datum) of the empty helicopter is described in the EC 135 Maintenance Manual (MM). The MASS AND BALANCE RECORD (Form MBR-1) appended to this Section is used to maintain a continuous history of changes to the basic "as delivered" helicopter mass and balance data.

6.2.1 Mass and balance record

The basic empty mass (BEM) and center of gravity (CG) location are determined through actual weighing carried out by the helicopter manufacturer. This data is then entered on the first line of the MASS AND BALANCE RECORD, Form MBR-1 which then becomes a permanent part of the Flight Manual.

The MASS AND BALANCE RECORD must be updated (normally by transcribing the applicable information from the EQUIPMENT LIST) when necessary as follows:

- When additional equipment is installed on the helicopter necessitating a change in the basic empty mass (as per definition), add the new entry or entries to the previous totals of basic empty mass and moment then compute the new basic empty mass, moment and CG location (arm).
- Likewise, when equipment is removed from the helicopter, subtract the new entry or entries from the previous totals of basic empty mass and moment then compute the new basic empty mass, moment and CG location (arm).

At all times, the last mass and moment entries are considered the current basic empty mass and balance status of the helicopter.

6.2.2 Equipment list

An EQUIPMENT LIST, Form EL-1 is appended to this Section and contains optional equipment of the particular helicopter when delivered. Each item on the list is provided with a number and description for identification, together with its mass, arm and moment.

Those items of equipment that were installed when the particular helicopter was initially weighed are so indicated by a check (✓) mark in the „Initial Weighing" column. Therefore the mass, arm and moment of these items are included in the basic empty mass (BEM) data found on the MASS AND BALANCE RECORD, Form MBR.

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6.3 LOADING EXAMPLE

The following example shows the method of calculation of the longitudinal center of gravity.

	Mass (kg)	Arm (mm)	Mass Moment (kgmm)
Mass empty	1544	4560	7040640
+ Pilot	80	2428	194240
+ Copilot	80	2428	194240
+ Fwd passengers (3)	240	3371	809040
+ Aft passengers (2)	160	4250	680000
+ Baggage	76	5000	380000
+ Fuel (Supply tank)	92	5026	462392
+ Fuel (Main tank)	480	4075	1956000
Total	2752		11716552

NOTE The mass empty C.G. and mass moment is to be taken from the “Empty mass and balance report” in this section.

$$\text{C.G.} = \frac{11716552}{2752} \frac{\text{kgmm}}{\text{kg}} = 4257 \text{ mm}$$

The C.G. is 4257 mm aft of the reference datum.

From Fig. 6-2 it can be seen, that the C.G. lies within the allowable C.G. limit.

NOTE For the height adjustable pilot / co-pilot seat the STA 2428 is defined for the full rearward seat position. For non height adjustable pilot / co-pilot seats the STA 2428 is defined for the middle position.

6.4 ALLOWABLE C.G. ENVELOPE (LONGITUDINAL)

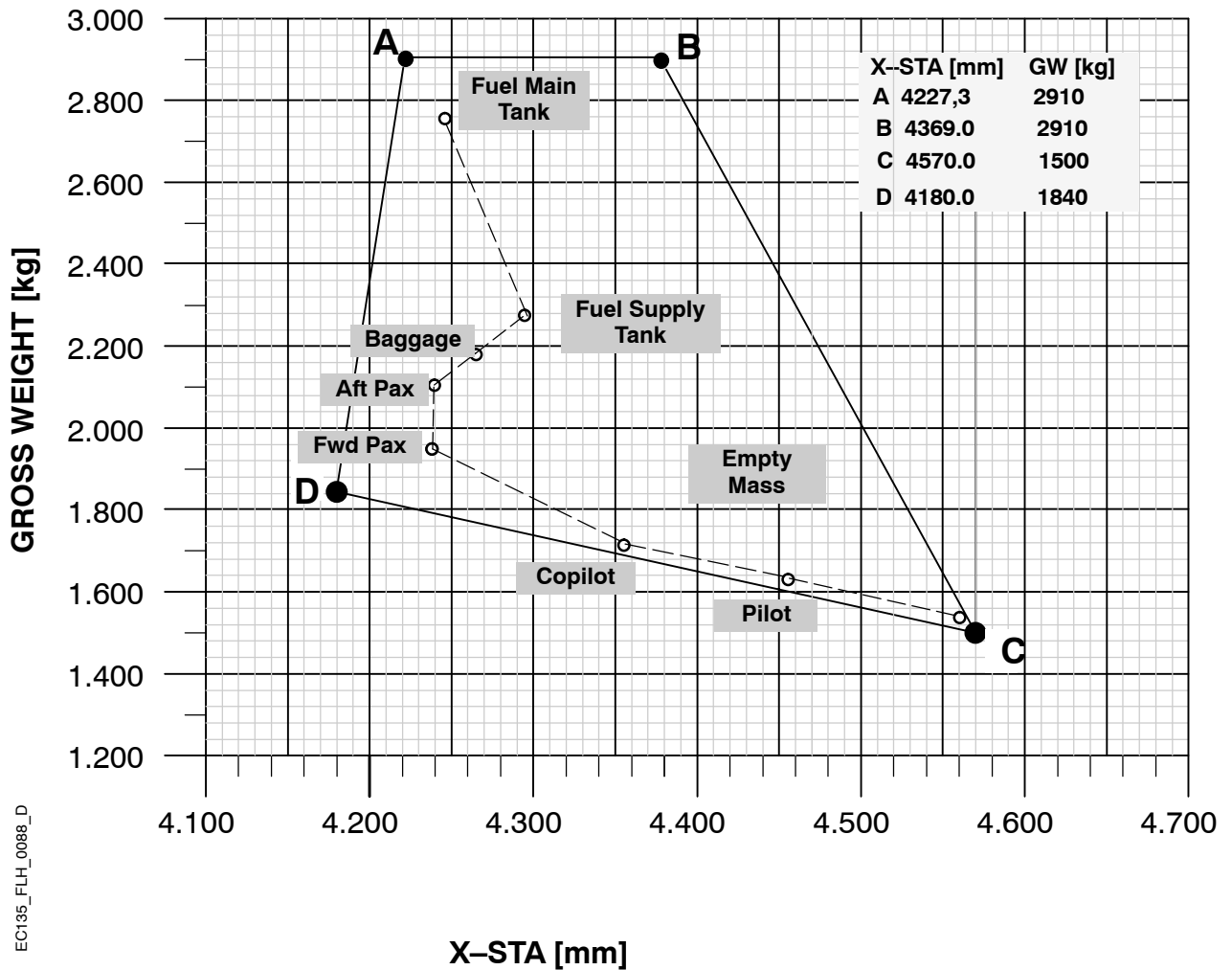


Fig. 6-2 C.G. envelope

6.5 LOADING CHARTS AND TABLES

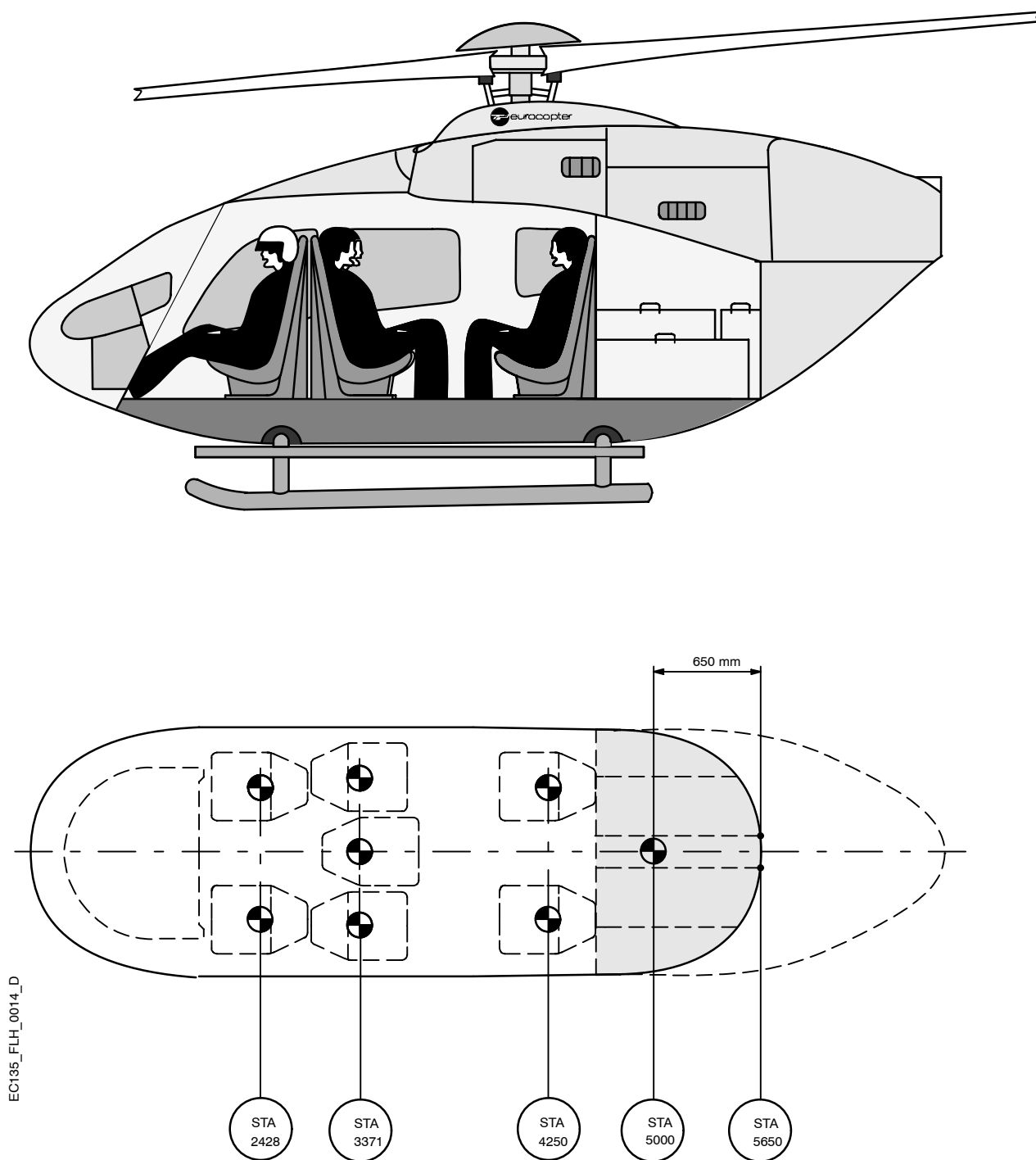


Fig. 6-3 Crew/passenger and baggage centroids (7 seat arrangement)

LOADING TABLE (SEVEN SEAT ARRANGEMENT)				
Mass (kg)	Mass Moment (kgmm)			
	PIL/Pax STA 2428	FWD Pax STA 3371	AFT Pax STA 4250	Baggage STA 5000
50	121400	168550	212500	250000
55	133540	185405	233750	275000
60	145680	202260	255000	300000
65	157820	219115	276250	325000
70	169960	235970	297500	350000
75	182100	252825	318750	375000
80	194240	269680	340000	400000
85	206380	286535	361250	425000
90	218520	303390	382500	450000
95	230660	320245	403750	475000
100	242800	337100	425000	500000
105	254940	353955	446250	525000
110	267080	370810	467500	550000
115	279220	387665	488750	575000
120	291360	404520	510000	600000
125	303500	421375	531250	625000
130	315640	438230	552500	650000
135	327780	455085	573750	675000
140	339920	471940	595000	700000
145	352060	488795	616250	725000
150	364200	505650	637500	750000
155	376340	522505	658750	775000
160	388480	539360	680000	800000
165	400620	556215	701250	825000
170	412760	573070	722500	850000
175	424900	589925	743750	875000
180	437040	606780	765000	900000
185	449180	623635	786250	925000
190	461320	640490	807500	950000
195	473460	657345	828750	975000
200	485600	674200	850000	1000000
205	497740	691055	871250	1025000
210	509880	707910	892500	1050000
215	522020	724765	913750	1075000
220	534160	741620	935000	1100000
225	546300	758475	956250	1125000
230	558440	775330	977500	1150000
235	570580	792185	998750	1175000
240	582720	809040	1020000	1200000
245	594860	825895	1041250	1225000
250	607000	842750	1062500	1250000

Fig. 6-4 Loading Table (seven seat arrangement)

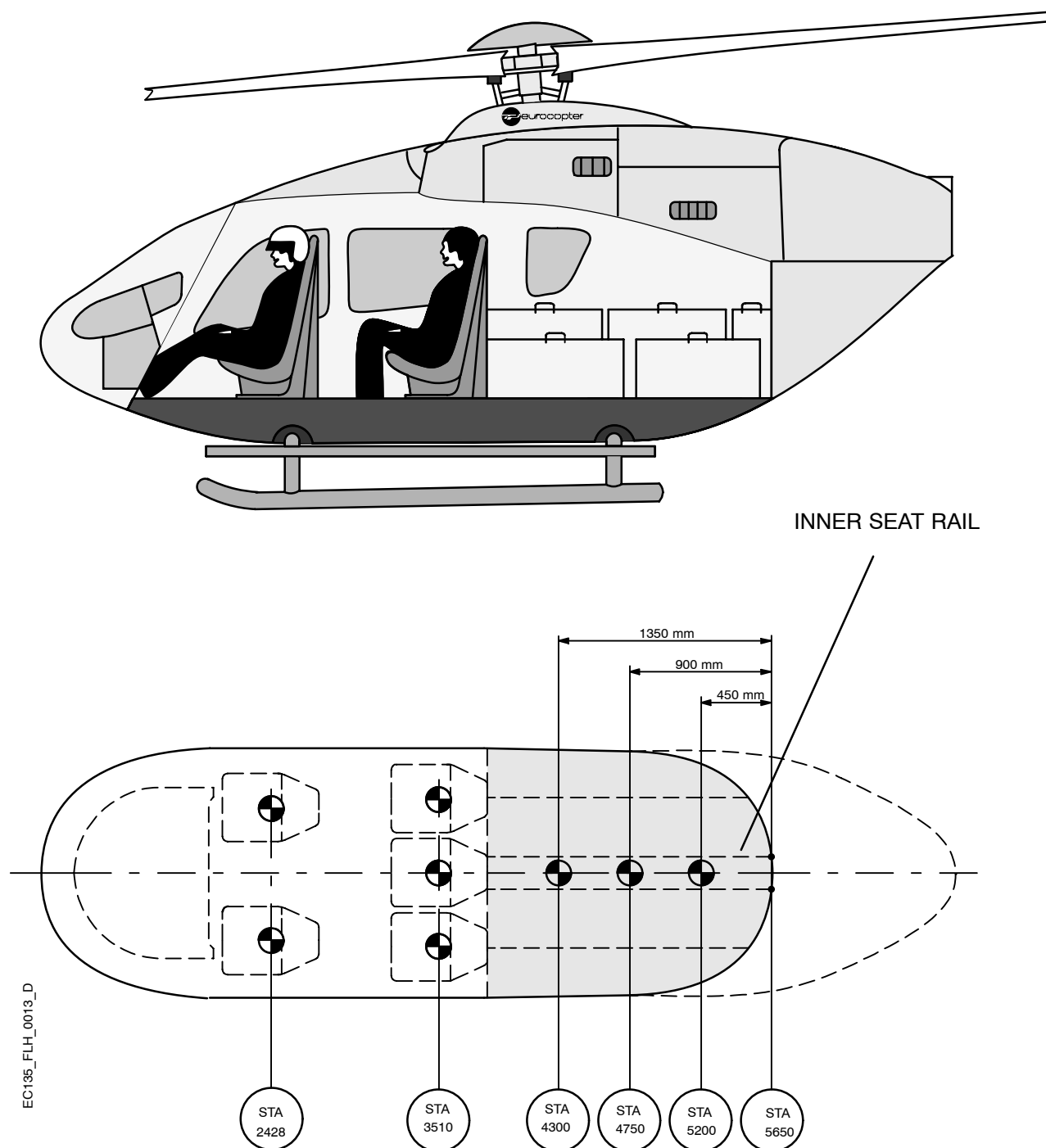


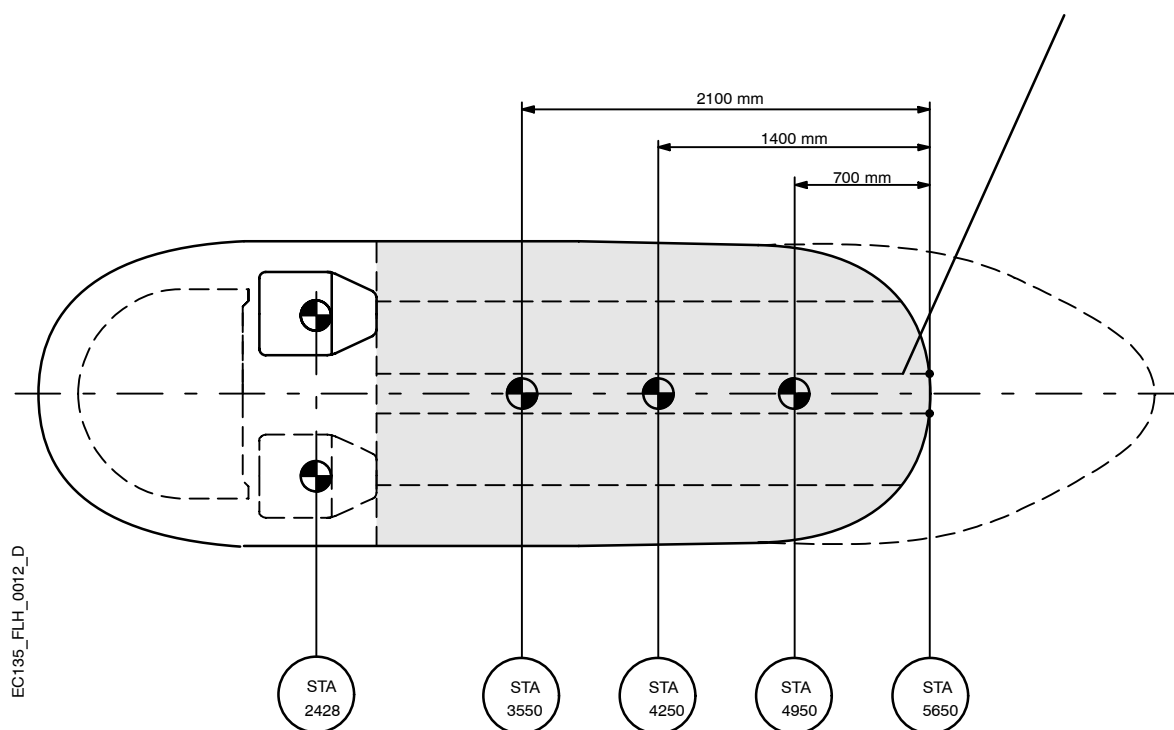
Fig. 6-5 Crew/passenger and baggage centroids (5 seat arrangement)

LOADING TABLE (FIVE SEAT ARRANGEMENT)					
Mass (kg)	Mass Moment (kgmm)				
	PIL/Pax STA 2428	AFT Pax STA 3510	Baggage		
			STA 4300	STA 4750	STA 5200
50	121400	175500	215000	237500	260000
55	133540	193050	236500	261250	286000
60	145680	210600	258000	285000	312000
65	157820	228150	279500	308750	338000
70	169960	245700	301000	332500	364000
75	182100	263250	322500	356250	390000
80	194240	280800	344000	380000	416000
85	206380	298350	365500	403750	442000
90	218520	315900	387000	427500	468000
95	230660	333450	408500	451250	494000
100	242800	351000	430000	475000	520000
105	254940	368550	451500	498750	546000
110	267080	386100	473000	522500	572000
115	279220	403650	494500	546250	598000
120	291360	421200	516000	570000	624000
125	303500	438750	537500	593750	650000
130	315640	456300	559000	617500	676000
135	327780	473850	580500	641250	702000
140	339920	491400	602000	665000	728000
145	352060	508950	623500	688750	754000
150	364200	526500	645000	712500	780000
155	376340	544050	666500	736250	806000
160	388480	561600	688000	760000	832000
165	400620	579150	709500	783750	858000
170	412760	596700	731000	807500	884000
175	424900	614250	752500	831250	910000
180	437040	631800	774000	855000	936000
185	449180	649350	795500	878750	962000
190	461320	666900	817000	902500	988000
195	473460	684450	838500	926250	1014000
200	485600	702000	860000	950000	1040000
205	497740	719550	881500	973750	1066000
210	509880	737100	903000	997500	1092000
215	522020	754650	924500	1021250	1118000
220	534160	772200	946000	1045000	1144000
225	546300	789750	967500	1068750	1170000
230	558440	807300	989000	1092500	1196000
235	570580	824850	1010500	1116250	1222000
240	582720	842400	1032000	1140000	1248000
245	594860	859950	1053500	1163750	1274000
250	607000	877500	1075000	1187500	1300000

Fig. 6-6 Loading Table (five seat arrangement)



INNER SEAT RAIL



NOTE The cargo centroid is to be measured from the rear end of the inner seat rails.

Fig. 6-7 Crew and baggage centroids

CABIN LOADING TABLE				
Mass (kg)	Mass Moment (kgmm)			
	PIL/PAX STA 2428	Load		
		STA 3550	STA 4250	STA 4950
10	24280	35500	42500	49500
20	48560	71000	85000	99000
30	72840	106500	127500	148500
40	97120	142000	170000	198000
50	121400	177500	212500	247500
60	145680	213000	255000	297000
70	169960	248500	297500	346500
80	194240	284000	340000	396000
90	218520	319500	382500	445500
100	242800	355000	425000	495000
110	267080	390500	467500	544500
120	291360	426000	510000	594000
130	315640	461500	552500	643500
140	339920	497000	595000	693000
150	364200	532500	637500	742500
160	388480	568000	680000	792000
170	412760	603500	722500	841500
180	437040	639000	765000	891000
190	461320	674500	807500	940500
200	485600	710000	850000	990000
210	509880	745500	892500	1039500
220	534160	781000	935000	1089000
230	558440	816500	977500	1138500
240	582720	852000	1020000	1188000
250	607000	887500	1062500	1237500
260	631280	923000	1105000	1287000
270	655560	958500	1147500	1336500
280	679840	994000	1190000	1386000
290	704120	1029500	1232500	1435500
300	728400	1065000	1275000	1485000
310	752680	1100500	1317500	1534500
320	776960	1136000	1360000	1584000
330	801240	1171500	1402500	1633500
340	825520	1207000	1445000	1683000
350	849800	1242500	1487500	1732500
360	874080	1278000	1530000	1782000
370	898360	1313500	1572500	1831500
380	922640	1349000	1615000	1881000
390	946920	1384500	1657500	1930500
400	971200	1420000	1700000	1980000

Fig. 6-8 Cabin loading table

FUEL LOADING TABLE - SUPPLY TANK							
Vol. (ltr)	Mass (kg)	Arm (mm)	Mass Moment (kgmm)	Vol. (ltr)	Mass (kg)	Arm (mm)	Mass Moment (kgmm)
10	8	4940	39520	70	56	4996	279776
20	16	4946	79136	80	64	5003	320192
30	24	4957	118968	90	72	5011	360792
40	32	4968	158976	100	80	5018	401440
50	40	4978	199120	110	88	5025	442200
60	48	4987	239376	115	92	5026	462392

FUEL LOADING TABLE - MAIN TANK							
Vol. (ltr)	Mass (kg)	Arm (mm)	Mass Moment (kgmm)	Vol. (ltr)	Mass (kg)	Arm (mm)	Mass Moment (kgmm)
10	8	3881	31048	310	248	3915	970920
20	16	3882	62112	320	256	3916	1002496
30	24	3883	93192	330	264	3916	1033824
40	32	3884	124288	340	272	3916	1065152
50	40	3885	155400	350	280	3916	1096480
60	48	3887	186576	360	288	3917	1128096
70	56	3889	217784	370	296	3917	1159432
80	64	3890	248960	380	304	3917	1190768
90	72	3892	280224	390	312	3926	1224912
100	80	3895	311600	400	320	3935	1259200
110	88	3898	343024	410	328	3943	1293304
120	96	3900	374400	420	336	3954	1328544
130	104	3902	405808	430	344	3962	1362928
140	112	3904	437248	440	352	3971	1397792
150	120	3905	468600	450	360	3978	1432080
160	128	3906	499968	460	368	3988	1467584
170	136	3907	531325	470	376	3995	1502120
180	144	3908	562752	480	384	4003	1537152
190	152	3909	594168	490	392	4010	1571920
200	160	3910	625600	500	400	4017	1606800
210	168	3911	657048	510	408	4024	1641792
220	176	3911	688336	520	416	4030	1676480
230	184	3912	719808	530	424	4034	1710416
240	192	3912	751104	540	432	4040	1745280
250	200	3913	782600	550	440	4046	1780240
260	208	3913	813904	560	448	4052	1815296
270	216	3914	845424	570	456	4057	1849992
280	224	3914	876736	580	464	4063	1885232
290	232	3915	908280	590	472	4068	1920096
300	240	3915	939600	600	480	4075	1956000

Fig. 6-9 Fuel loading tables