APPENDIX A

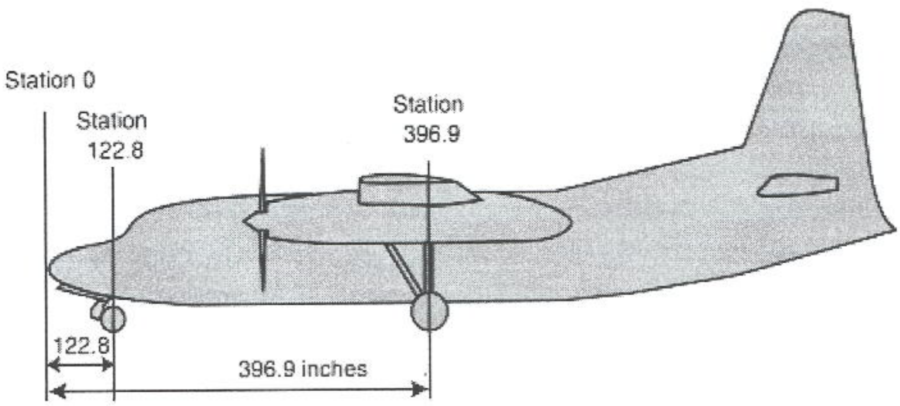
CENTRE OF GRAVITY CALCULATIONS

1. **Definition of centre of gravity**

An aircraft's weight is distributed throughout its structure with regions where the weight is concentrated (eg the engines) and regions where there is little weight (eg an empty cargo area). Consequently, the point at which an aircraft would, in theory, balance on a fulcrum is unlikely to be its geometric centre. For aerodynamic purposes, it is necessary to determine the point along the length of the fuselage at which the aircraft would, in theory, balance. This point is called the 'centre of gravity' which is often abbreviated to 'CG'. It's relevance is that for aerodynamic purposes the entire weight of the aircraft may be considered to be centred at this point.

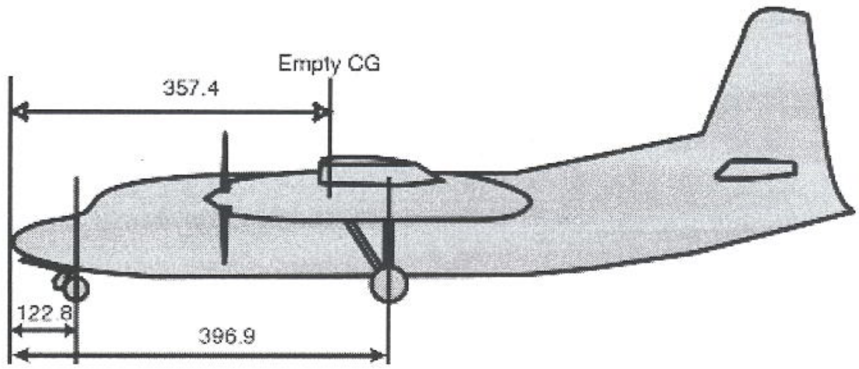
2. **Station numbers**

The aircraft manufacturer uses a system of station numbers to identify the location of fuselage components. 'Station 0' is essentially the tip of the aircraft's nose and the station number of any fuselage component is simply the horizontal distance between station zero and the fuselage location expressed in inches. For instance, the horizontal distances between the tip of the nose and the aircraft's nosewheel and main landing gear axles are 122·8 and 396·9 inches respectively. For CG calculation purposes, the nosewheel may be considered to be at 'Station 122·8' and the mainwheels at 'Station 396·9'.



3. **Empty aircraft centre of gravity**

The aircraft manufacturer used Station 0 as the datum for calculating the longitudinal position of the centre of gravity, expressed as a distance in inches aft of Station 0. The position of the empty aircraft's CG was determined by weighing the aircraft and determining the weight borne by each landing gear leg. These weights are then multiplied by the 'moment arm' which is the station number of each wheel. The sum of these moments is then divided by the total weight to determine the horizontal distance of the CG from the datum. This process was completed for G-CHNL by a specialist company and their figures are reproduced in the diagram and table below.



	Weight lbf	Moment arm inches	Moment lbf inches
Nosewheel	3,385	122·8	415,780
Left mainwheels	10,306	396·9	4,090,761
Right mainwheels	9,763	396·9	3,875,228
Totals	**23,454**	-	**8,381,768**
Centre of Gravity		**357·4**	

4. Loaded aircraft centre of gravity calculations

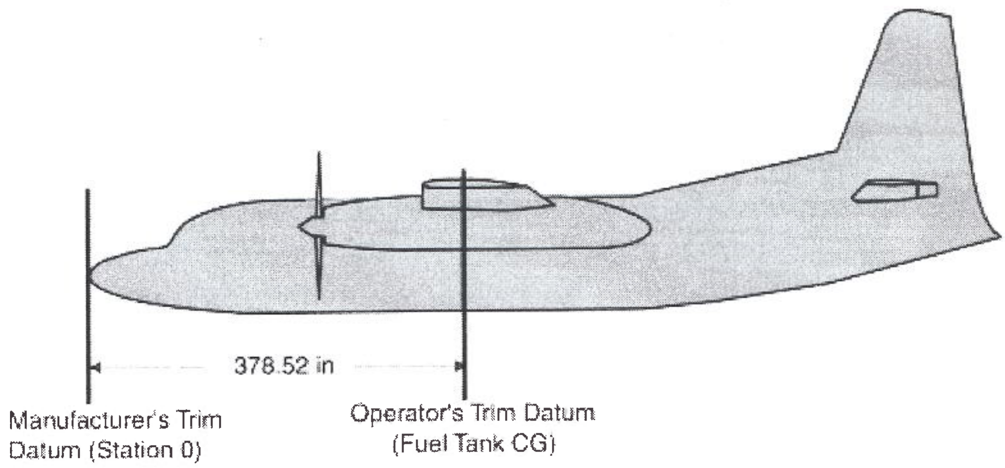
As role equipment, crew, fuel and payload are added to an aircraft, the longitudinal movement of the centre of gravity can be determined by calculation provided that the weight of each object is known together with its station number. For large objects and fuel in the tanks, the moment arm is measured horizontally from the object's own geometric centre to the datum point. For bulk cargo, the mid-point of the cargo bay is used as the moment arm.

Each component gives rise to a moment and a weight. The same process of dividing the sum of all the moments (including that of the aircraft itself) by the sum of the weights can be used to calculate the position of the centre of gravity. However, in practice this method of determining the CG requires numerous calculations and the manipulation of large numbers. The method is suitable for computer generated loadsheets but it is not user friendly on the flight deck.

5. **The index system**

When calculating mass and balance the weight units used are unimportant provided they are consistent. The operator chose to use kilograms instead of pounds. The position of the datum point for determining moment arms is also unimportant because the choice of datum position will not affect the location of the aircraft's centre of gravity.

Because the Fokker F27 has straight wings and all the fuel tanks are inside the wings, a good datum point is the centre of gravity of the fuel tanks. This datum has two distinct advantages: firstly, it is inside the wing chord (and close to the allowable range for the centre of gravity); and secondly, although the centre of gravity may move in flight as fuel is consumed, because the centre of gravity of the fuel in the tanks does not change, the laden index does not change.



6. **Index units**

Despite the choice of datum position and the use of kilograms for weight, numerically large moments still occur. In the index system, to reduce the numbers to manageable size, all the moments are divided by 10,000. By convention, moments produced by weights aft of this index datum will be positive and those forward of it will be negative. If, as in this case, the sum of the moments is negative because the empty aircraft CG is forward of the datum, the index number can be made positive by adding an arbitrary number to the end result. This is explained more fully in the next paragraph.

7. **Aircraft Prepared for Service**

The operator's F27 aircraft normally flew in the same freight configuration with two pilots and appropriate role equipment such as route documentation, cargo nets and wooden floor boards. To save the crews routinely calculating the weight and CG changes induced by these items, the operator determined an equipped empty weight termed 'Aircraft Prepared for Service' which is usually abbreviated to APS. The index in this configuration was -28·25. To avoid mixing positive and negative numbers on a loaded index scale, the operator chose to add 30 to the aircraft's APS index number thus changing it from -28·25 to + 1·75. There was no special significance to the number 30. The addition of 30 simply converted the aircraft's APS index to a positive number thus ensuring that all the index positions between the forward and aft CG limits were positive.

8. **Loaded aircraft index computation**

To calculate the index for a loaded aircraft, it is necessary to calculate the change in index position for each item of payload. However, it is important to appreciate that 30 must not be added to the indices of load components because these indices represent CG movement relative to the APS index. Because the distance of the operator's trim datum from Station 0 remains fixed at 378·52 inches, the moment arm of an object relative to the operator's trim datum is determined by subtracting 378·52 from the object's station number. Consequently, the index of any object carried on board G-CHNL may be calculated from the station using the formula:

$$\text{Index} = \frac{[\text{Mass(kgs)} \times (\text{Station number} - 378{\cdot}52)]}{10{,}000}$$

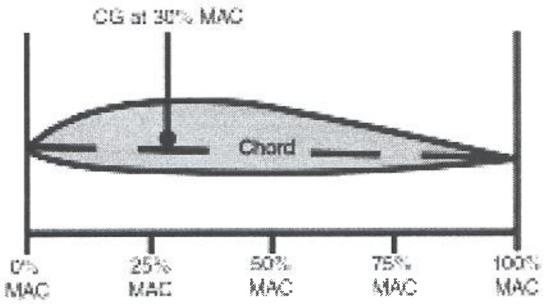
9. **Graphical determination of CG position**

The aim of the index system is to allow calculation of the CG position by graphical means. Vertical and horizontal lines can be drawn from the aircraft's 'unladen index' to represent movement of the CG caused by loading a given weight in a specific compartment. The index number for a component of the payload can be represented by divisions on a graph. The number of divisions can be minimised by using practical weight units of 100, 500 or 1000 kg for each division. Some index numbers will be positive and some will be negative; these can be graphically represented by movement left or right. If all the load component indices are algebraically added to the index number for the empty aircraft, the total will be the index for the loaded aircraft or 'laden index'. The process is illustrated at paragraph 11 of this appendix

10. **Mean aerodynamic chord**

The option of using a different trim datum position to that used by the aircraft manufacturer could give rise to a requirement for the operator to translate the manufacturer's CG limits to new figures relative to its chosen trim datum. In practice this is avoided by expressing the CG position in non-dimensional terms. The system adopted is to express CG position in terms of a percentage of mean aerodynamic chord (MAC). (The expression standard mean chord or SMC has the same meaning as MAC).

The mean aerodynamic chord is the average distance between the leading edge and trailing edge of the wings across the full span. It may be calculated by dividing the wing area by the wing span but it is normal practice to use the MAC defined by the aircraft manufacturer. For aerodynamic reasons, in flight the CG is between these two positions and thus it is convenient to relate the CG position to a percentage aft of the leading edge as shown in the diagram below.

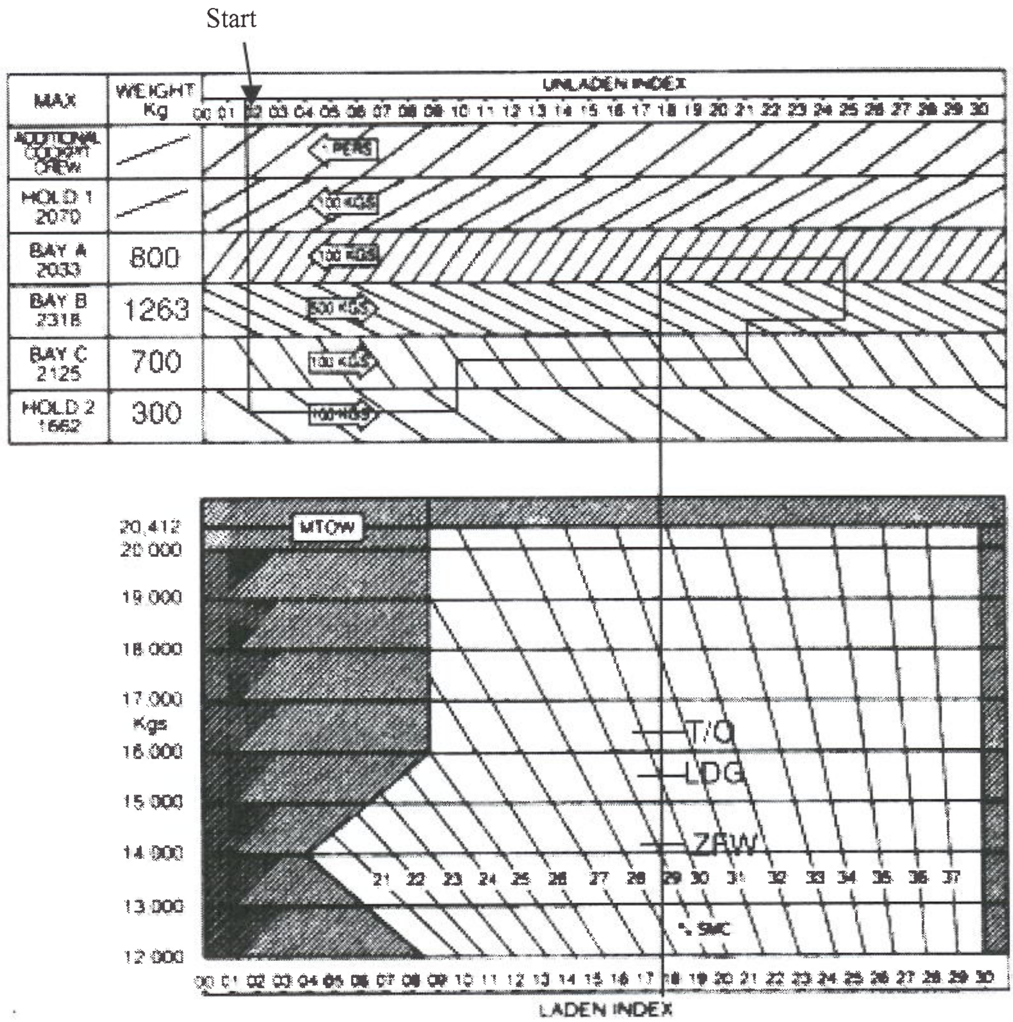


The station of the leading edge is also provided by the aircraft manufacturer. For the F27-600 the station for 0% MAC is Station 340 and the length of the mean aerodynamic chord is 101·38 inches. Using this system the index can then be related to the CG position on a trim graph. This technique was used on the operator's loadsheets.

11. **The trim graph**

The trim graph example shown at the end of this paragraph is extracted from the load and balance sheet prepared by the co-pilot for the accident flight. It illustrates the process of determining the CG. To begin, a line is drawn vertically downwards from the aircraft's unladen index of 1·74 (marked 'Start') to the horizontal row of any hold containing cargo; in this example Hold 2 is chosen. From the point where the vertical line crosses the sloping line within the row, a horizontal line is drawn in the direction of the arrow for 3 divisions since the arrow indicates one division for every 100 kg and there is 300 kg in Hold 2. From that end point a vertical line is drawn upwards to the region of the next bay containing payload.

The process is repeated for each area containing cargo, noting that the arrows point in different directions and the weight represented by each division may differ (eg Bay B is 500 kg per division whereas Bays A and C are 100 kg per division). From the end of the last line, a vertical line is drawn downwards to the laden index line (the x axis), which in this case is intersected close to 18. Finally, horizontal lines are drawn from the weight scale (the y axis) to intersect the laden index line at three important weights: take-off, expected landing and zero fuel.



Interpretation of the graph is simple. The shaded area represents an unacceptable total weight or CG position; in this example the CG is approximately in the centre of the range. Fuel consumption during flight does not change the laden index but movement of the CG is represented in SMC (MAC) units by the intersection of the laden index line with the array of lines which slope steeply downwards from left to right. In this example, the CG moves from 30·5% at take-off to 30% at planned landing weight.

It is also apparent from the graph that the aircraft cannot be flown empty (ie with a laden index of 1.75) because the CG would be forward of the forward limit. For this reason, empty positioning flights required ballast to be carried at the rear of the aircraft to move the CG aft into the acceptable range. It was normal practice to load ballast into Hold 2 for empty positioning flights. The ballast was subsequently off-loaded before a cargo flight.

The loadsheet for the flight from Exeter to Liverpool on page 1 of Appendix C shows the effect on centre of gravity of loading 300 kg ballast into Hold 2.

APPENDIX B

AERODYNAMICS

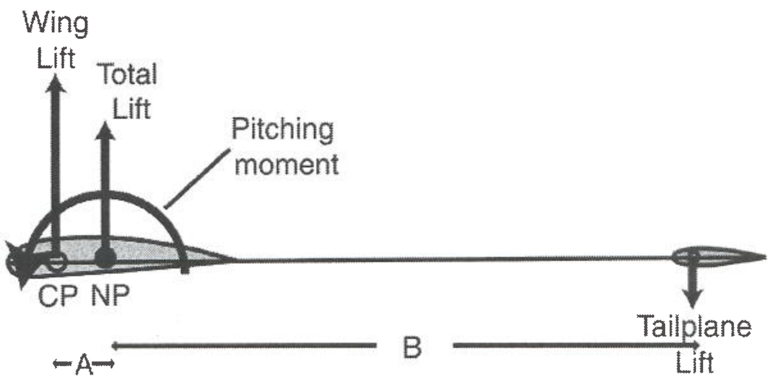
1. **Aim**

The aim of this appendix is to explain the rudiments of pitch control to persons unfamiliar with aerodynamics. It is neither a detailed nor a comprehensive explanation of all the aerodynamic factors contributing to this accident.

2. **Lift forces**

For an aircraft in level flight, total lift must be equal and opposite to weight. There are two main components of lift: lift from the wing and lift from the tail surfaces. In very simple terms for aircraft such as the Fokker F27, lift produced by the wing is a function of the speed of the air over the wing and the angle between the airflow and the wing ('the angle of attack'). The same factors apply to the tailplane.

However, in producing lift the wing and fuselage create a rotational force, which normally acts in the nose-down sense. This nose-down force or 'pitching moment' has to be counterbalanced by forces on the tailplane.



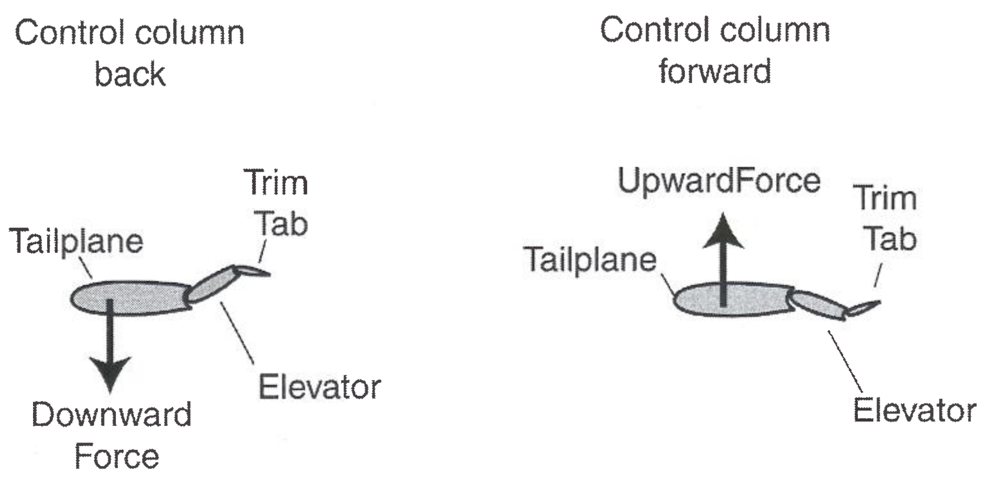
Balancing the moments mathematically gives rise to the concept of the 'neutral point'. The neutral point is an imaginary point about which the variation of the nose-up and nose-down pitching moments with angle of attack is zero. Consequently there is only a variation of the resulting lift force, acting at the neutral point.

In the diagram above the neutral point is represented by the letters NP and the aerodynamic centre of pressure of the wing is annotated CP. The nose-down pitching moment is opposed by the wing lift moment acting over the moment arm 'A'. If the wing lift moment is insufficient to counterbalance the nose-down pitching moment, the tail surfaces have to augment it by producing a downward force which, although relatively small, acts over the much longer moment arm 'B'. Because the tail surfaces are producing a downward force, the total lift acting through the imaginary neutral point is less than the wing lift, which must be sufficient to oppose the sum of the aircraft's weight and the tailplane force. This balance of forces is typical for a conventional aircraft at normal cruising speed. Therefore the tailplane design is optimised for a certain amount of download.

3. **Variation of tailplane force**

Because most aerodynamic forces vary in flight, the tailplane force must be variable, both in magnitude and in direction, to enable the pilot to control the aircraft. On the Fokker F27 this capability is achieved by moving the elevator attached to the trailing edge of the tailplane. The control linkages are arranged such that pulling the control column backwards raises the trailing edge of the elevator increasing its downward force; pushing the control column forwards has the opposite effect.

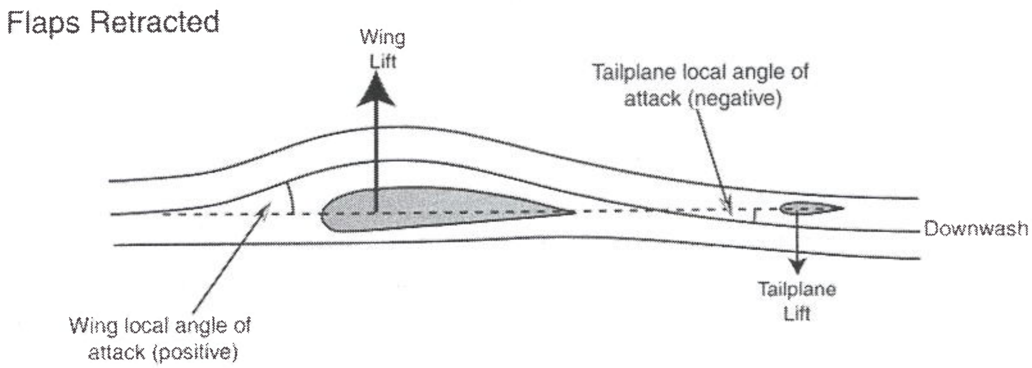
It would be very tiring for the pilot to have to hold the elevator in the required position for long periods so a section of the elevator called the trim tab can be moved relative to the trailing edge of the elevator. The trim tab is actuated by a wheel on the centre console of the flight deck moving a linkage which keeps the trim tab in the same position relative to the elevator without any requirement for the pilot to hold the wheel. By rotating this wheel, the pilot can reduce to zero the control force required to keep the elevator in the required position. This state is known as being 'in trim'. Two different situations are illustrated below.

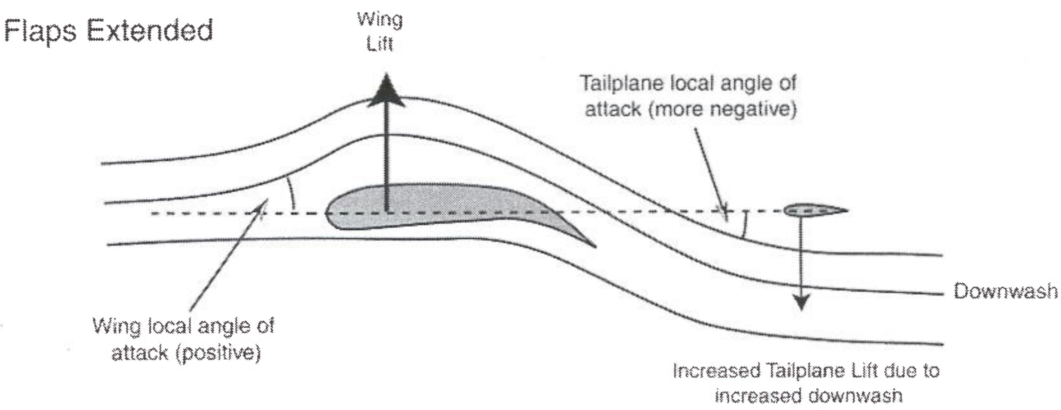


This is a simplistic explanation. In reality, moving the elevator just varies the force created by the tail surfaces. Other factors such as airspeed, manoeuvres, propeller slipstream and flap position also affect the tailplane force. In some circumstances moving the control column forward may just decrease the downward force created by the tail surfaces instead of creating an upward force.

4. The effect of flap extension on pitch trim

At landing speeds, trailing edge flaps on the wings are lowered to restore the wing's ability to produce sufficient lift. This produces a stronger nose-down pitching moment, requiring a greater downward force on the tailplane. However the local angle of attack at the tailplane will become more negative because of the wing downwash effect (see below).





This may produce more download on the tailplane than required to counterbalance the pitching moment, so that a downward elevator deflection (aircraft nose-down sense) may be needed to adjust the tailplane download and restore equilibrium. Some of the effects of extending the trailing edge flaps may be mathematically represented by a forward shift of the neutral point.

Within the approved centre of gravity range, the F27 will need an upward tailplane load only at low airspeeds with flaps retracted and an aft CG position. With movement of the CG rearwards, the wing lift and the aircraft weight forces produce an increasing nose-up pitching moment, needing an upward change of the tailplane load to counterbalance. At extreme aft CG positions (beyond the permitted envelope), the upward tailplane load change needed to obtain static equilibrium may exceed the elevator capacity, particularly in conditions in which the tailplane itself would generate a substantial amount of download due to negative local angle of attack.

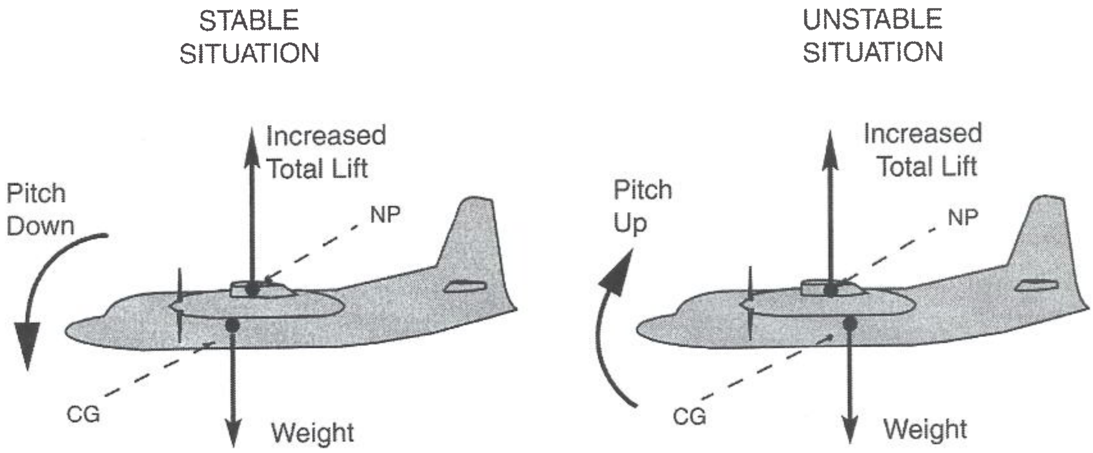
5. Pitch stability concepts

There are two types of pitch stability: static and dynamic. Static stability is the aircraft's tendency either to diverge from or to return to a steady pitch state when affected by a disturbance of the airflow, usually conceived in terms of a small change in the angle of attack. If there is an increase in angle of attack there will be an increase in wing lift. If at the same time the aircraft tends to pitch nose-up, thereby further increasing the angle of attack, it is said to be statically unstable. If, on the other hand, the aircraft pitches nose-down and tends to return towards its original angle of attack, it is said to be statically stable. Dynamic stability is concerned with what happens after that. If the aircraft returns to the original angle of attack or oscillates through a series of pitch changes, which get progressively smaller until it returns to the original trimmed angle of attack, it is dynamically stable. Problems with dynamic pitch stability were not a factor in this accident but the transition from a statically stable approach configuration to a statically unstable configuration was responsible for the initial loss of control.

6. Pitch stability and centre of gravity

The relationship between the longitudinal positions of the neutral point (NP) and the centre of gravity (CG) affects static stability. Mathematically the relationship assumes that the variation of total lift with angle of attack acts through the neutral point and the aircraft's weight acts through its centre of gravity. Any change in the lift force will tend to pitch the aircraft about its centre of gravity.

A small increase in angle of attack caused by an airflow disturbance will create an increase in total lift. If the centre of gravity is ahead of the neutral point the increase in lift acting on the aircraft's inertia creates a nose-down pitch moment, which tends to reduce the angle of attack. This is a stable situation. If, however, the centre of gravity is astern of the neutral point, a momentary increase in lift causes a pitch-up moment which further increases the angle of attack. This is an unstable situation. The two states are illustrated on the next page.



Consequently, to be statically stable, the aircraft's centre of gravity must be ahead of the neutral point.

7. **Variations in stability**

The aircraft's stability is also a function of the distance between the neutral point and the centre of gravity. If the CG is too far ahead of the neutral point the aircraft will be so stable that its response to pitch control inputs will be sluggish and the control forces will be high. If the CG is aligned with the neutral point, the control forces will be low but the aircraft will be difficult if not impossible to trim. As the CG moves progressively aft of the neutral point, the aircraft will become more difficult to fly, particularly in turbulent air. It will be impossible to trim and the pilot will frequently have to make considerable control inputs to constrain the flight path. Eventually, if the CG moves too far aft of the neutral point, the elevator will reach full travel as the pilot attempts to stop the aircraft's nose rising. If full travel is insufficient to overcome the pitch–up, control will be lost.

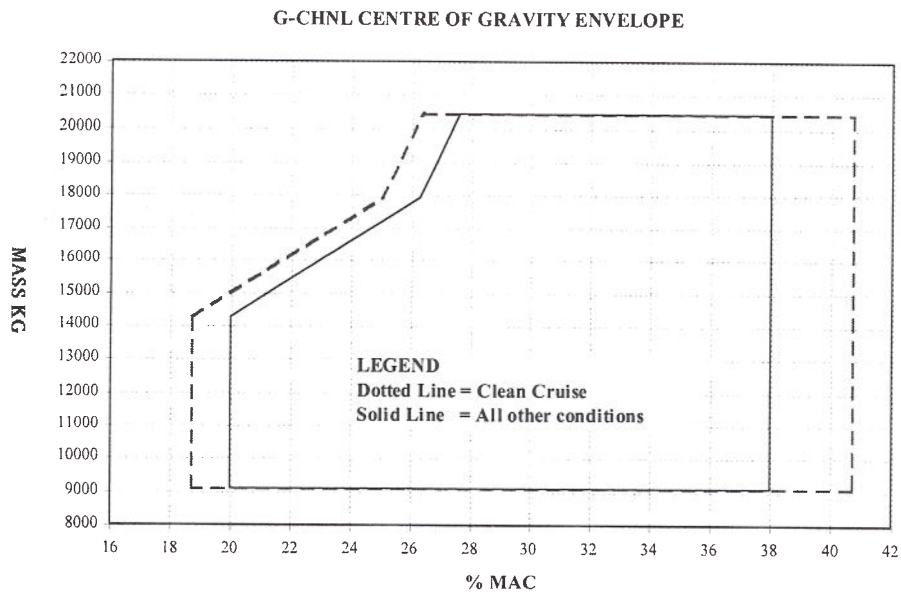
8. **Movement of the neutral point**

Normally in-flight centres of gravity movements are small. Fuel consumption may slowly move the centre of gravity and other effects such as passenger movement or landing gear operation may alter the CG position relatively rapidly. The neutral point may, however, move much more significantly and more quickly than the centre of gravity. One feature of propeller driven aircraft is that when the engines accelerate from idle power to full power, the neutral point moves forward. On the Fokker F27 it moves approximately 10% MAC further forward (for an explanation of MAC see Appendix A). Lowering flap also moves the neutral point forward. The pilots feel this movement as a tendency for the aircraft to pitch up and they need to push forward on the control column to hold a steady flight path (thus lowering the elevator). Usually the pilot will re-trim by winding the trim wheel forward which moves the trim tab to keep the elevator in the new position without the pilot having to maintain a push force on the control column.

9. Stability control

The manufacturer of a transport aircraft such as the Fokker F27 must ensure that the aircraft is statically stable at all times. Movement of the neutral point in flight can be minimised by careful design but unlike the centre of gravity, its position cannot be directly controlled. Consequently, the primary method of ensuring that the aircraft is always statically stable is to limit the position (and movement) of the centre of gravity. Flight-testing and calculation determine limitations on the position of the CG. Limitations on CG movement in a cargo aircraft are achieved by securing the cargo to the cabin floor.

Once the absolute limits are determined, safety margins are applied to the absolute limits to produce the operating limits, which are published in the manufacturer's aircraft manuals. An aircraft will also have structural weight limits and these may be combined with CG limits and illustrated on a graph. The limits for G-CHNL are shown on the diagram below.

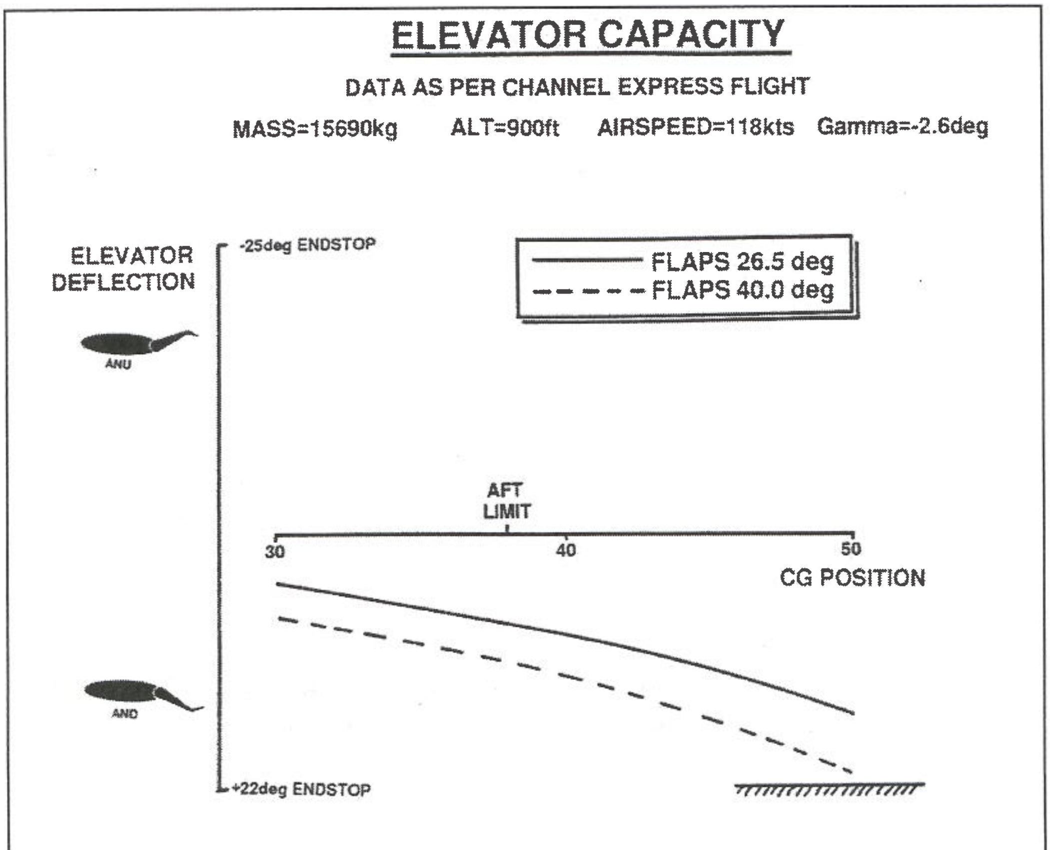


The allowable range for the CG is given as a percentage of MAC. In real terms the distance between 20% and 38% MAC equates to 18·25 inches. These are the limits for the aircraft both on the ground and in the air under any conditions apart from cruising flight with gear and flaps retracted.

The F27's landing gear is heavy and its movement between retracted and extended causes an average 0·7% MAC rearward shift in the centre of gravity. In the cruise a margin of 2% is permitted to allow for the movement of passengers. These two factors result in an allowable range **in the cruise** between 18·7% (20-2+0·7) and 40·7% (38+2+0·7). Beyond these limits, control of the aircraft throughout a flight is no longer assured. Under any other conditions, particularly take-off and landing, the allowable range reverts to between 20% and 38%.

10. Elevator capacity

The capability of the elevator to provide sufficient control authority is known as its 'capacity'. As the aircraft's CG position approaches the aft limit, progressively more down elevator is required to trim the aircraft. Eventually, when the CG is well aft of the aft limit, there is insufficient elevator capacity to control the aircraft at any stage of flight. It is not practicable to determine this point by flight testing because of the inherent dangers but the aircraft manufacturer can draw conclusions as to the probable limit by extrapolating flight test data. However, there is a range of CG positions in which the aircraft is controllable depending on flap position and engine power. Using data relevant to the accident flight, the Type Certificate holder prepared the diagram below.



Notes: ANU = aircraft nose up, AND = aircraft nose down, Gamma = flight path angle

The diagram shows that lowering full flap (40°) requires more nose down elevator than approach flap (26·5°). It also shows that as the CG moves further aft towards 50% MAC, the elevator position approaches the end stop of 22°. Moreover, although the diagram indicates that the endstop is not reached until the CG position reaches about 50%, the lines indicate an equilibrium position. In practice, more elevator travel is necessary for adequate control margins and to allow for aerodynamic disturbances such as turbulence.

Finally, the diagram does not show the likely effect of increasing engine power from low power to high power. The increase in power moves the neutral point forward which requires still more nose-down elevator to counteract the aircraft's tendency to pitch up. Consequently, there is a range of CG positions in which the aircraft flies reasonably normally until full flap is lowered and/or power is significantly increased.

LOADSHEETS (Shown 70% actual size)

Exeter to Liverpool

(1)

FOKKER F27 600 SERIES channel express Cargo Loadsheet & Balance Chart — **ALL WEIGHTS IN KILOS**

Address	From: Ext	Originator	Version: F1
A/C Regn: NL / Flight No.: 014P / Date: 11/1/99	To: LPL	Captain: Commander	Crew: 2/0

	Weight	Index
APS WEIGHT	11110	+1.75
Supernumerary Crew +		
Additional Equipment	11110	+1.75
DRY OPERATING WEIGHT		
Water Methanol +	150	
Take-off Fuel +	1500	
WET OPERATING WEIGHT	12760	

	ZERO-FUEL	TAKE-OFF	LANDING
MAXIMUM WEIGHT FOR	17917		18597
Take-off Fuel and Water Methanol +	1650	TRIP FUEL +	686
ALLOWED WEIGHT Lowest of 1, 2 or 3	1) 19567	2) 20648	3) 19283
Wet Operating Weight −			12760
ALLOWED TRAFFIC LOAD			6523

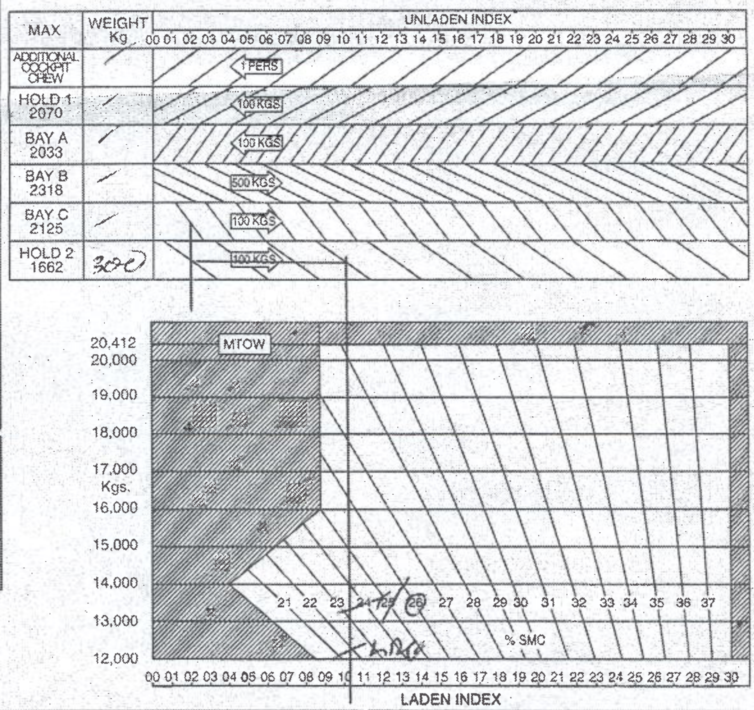
SPLIT LOADS DEST		HOLD 1	BAY A	BAY B	BAY C	HOLD 2	TOTAL
LPL	CARGO	Bm	—	—		300	300
	MAIL						
	CARGO						
	MAIL						
TOTALS							

NOTES / DANGEROUS GOODS

12374
6223
18597

Total traffic load	=	300
Dry operating weight	+	11110
Zero fuel weight LMC / Max 17917		11410
Take-off fuel and water methanol	+	1650
Take-off weight LMC / Max 19283		13060
Trip fuel	−	686
Landing weight LMC / Max 18597		12374
Allowed traffic load		6523
Total traffic load	−	300
Underload before LMC	=	6223

MAX	WEIGHT Kg
ADDITIONAL COCKPIT CREW	/
HOLD 1 2070	/
BAY A 2033	/
BAY B 2318	/
BAY C 2125	/
HOLD 2 1662	300



LAST MINUTE CHANGES (LMC)				
DEST	Specification	Cpt	+/-	Weight
			Total LMC	

LADEN INDEX +10.2

TRAFFIC OFFICER'S CERTIFICATE
I hereby certify that this aircraft is loaded in accordance with the current Loading Instructions of CHANNEL EXPRESS (AIR SERVICES) LTD.
Signed: Co-pilot's signature
Date: 11/1/99

CAPTAIN'S CERTIFICATE
I hereby certify that I am satisfied that all the relevant requirements of the A.N.O's and A.N.R's have been complied with.
Captain: Commander's signature
Date: 11/1/99

Liverpool to Gatwick (diverted to East Midlands)

(2)

FOKKER F27 600 SERIES channel express Cargo Loadsheet & Balance Chart **ALL WEIGHTS IN KILOS**

Address		From LPL	Originator	Version 1-1	
A/C Regn NL	Flight No. 472	Date 11/1/99	To LGW	Captain Commander	Crew 2/0

APS WEIGHT		Index	MAXIMUM WEIGHT FOR	ZERO-FUEL	TAKE-OFF	LANDING
Supernumerary Crew +	11110	+ 1.75		17917		18597
Additional Equipment		+	Take-off Fuel and Water Methanol +	1930	TRIP FUEL → +	689
DRY OPERATING WEIGHT	11110	1.75	ALLOWED WEIGHT Lowest of 1, 2 or 3	1) 19847	2) 20410	3) 19286
Water Methanol +	150					
Take-off Fuel +	1780		Wet Operating Weight			13040
WET OPERATING WEIGHT	13040		ALLOWED TRAFFIC LOAD			6246

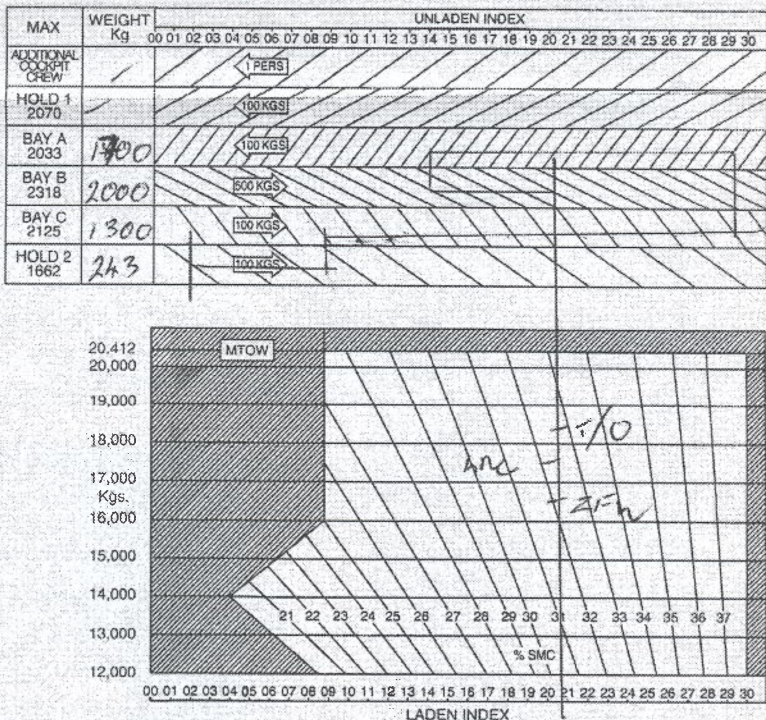
SPLIT LOADS DEST		HOLD 1	BAY A	BAY B	BAY C	HOLD 2	TOTAL
LGW	CARGO	—	1700	2000	1300	243	5243
	MAIL						
	CARGO						
	MAIL						
TOTALS							

NOTES / DANGEROUS GOODS

17594
1003
18597 ✓

Total traffic load	=	5243
Dry operating weight	+	11110
Zero fuel weight LMC		16353
Max 17917 ±	=	
Take-off fuel and water methanol	+	1930
Take-off weight LMC		18283
Max 19286 ±	=	
Trip fuel	−	689
Landing weight LMC		17594
Max 18597 ±	=	
Allowed traffic load		6246
Total traffic load	−	5243
Underload before LMC	=	1003

MAX	WEIGHT Kg
ADDITIONAL COCKPIT CREW	/
HOLD 1 2070	/
BAY A 2033	1700
BAY B 2318	2000
BAY C 2125	1300
HOLD 2 1662	243



LAST MINUTE CHANGES (LMC)				
DEST	Specification	Cpt	+/-	Weight
	Total LMC			

LADEN INDEX +20.5

TRAFFIC OFFICER'S CERTIFICATE
I hereby certify that this aircraft is loaded in accordance with the current Loading Instructions of CHANNEL EXPRESS (AIR SERVICES) LTD.
Signed Co-pilot's signature
Date 11/1/99

CAPTAIN'S CERTIFICATE
I hereby certify that I am satisfied that all the relevant requirements of the A.N.O's and A.N.R's have been complied with.
Captain Commander's signature
Date 11/1/99

East Midlands to Luton

FOKKER F27 600 SERIES — channel express — Cargo Loadsheet & Balance Chart — ALL WEIGHTS IN KILOS

Address	From: LCW	Originator	Version: F1
A/C Regn: NL / Flight No. 820 / Date: 12/1/99	To: GCI	Captain: Commander	Crew: 2/0

		Index
APS WEIGHT	11110	+1.75
Supernumerary Crew +		
Additional Equipment		
DRY OPERATING WEIGHT	11110	+1.75
Water Methanol +	150	
Take-off Fuel +	2416	
WET OPERATING WEIGHT	13676	

MAXIMUM WEIGHT FOR	ZERO-FUEL	TAKE-OFF	LANDING
	17917		18597
Take-off Fuel and Water Methanol +	2566	TRIP FUEL +	~~542~~ 323
ALLOWED WEIGHT Lowest of 1, 2 or 3	20483	20410	~~19134~~
			18920
Wet Operating Weight −			13676
ALLOWED TRAFFIC LOAD			5244

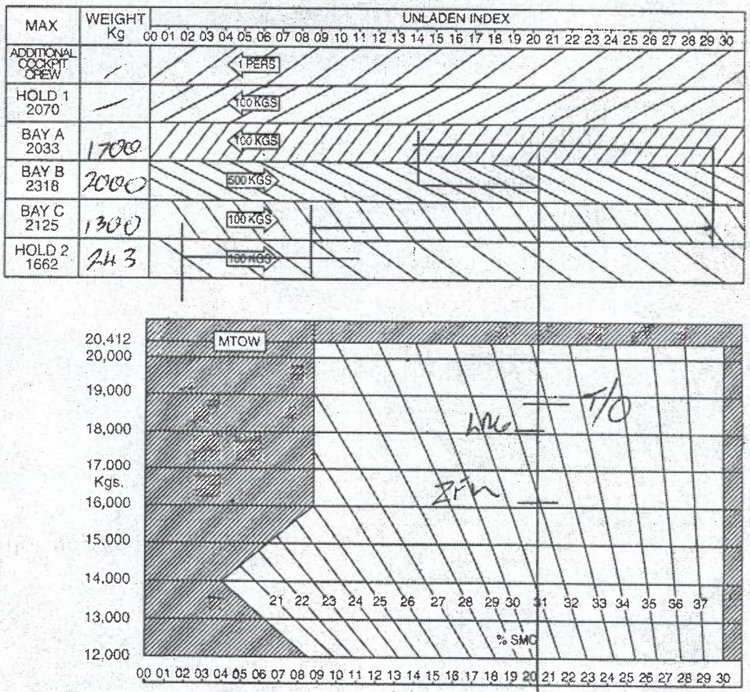
SPLIT LOADS DEST		HOLD 1	BAY A	BAY B	BAY C	HOLD 2	TOTAL
GCI	CARGO	—	1700	2000	1300	243	5243
	MAIL						
	CARGO						
	MAIL						
TOTALS							

NOTES / DANGEROUS GOODS

18546+1 = 18547

Total traffic load =	5243
Dry operating weight +	11110
Zero fuel weight LMC Max 17917	16353
Take-off fuel and water methanol +	2566
Take-off weight LMC Max 18920	18919
Trip fuel −	~~542~~ 323
Landing weight LMC Max 18597	18596
Allowed traffic load	5244
Total traffic load −	5243
Underload before LMC =	1

MAX	WEIGHT Kg
ADDITIONAL COCKPIT CREW	—
HOLD 1 2070	—
BAY A 2033	1700
BAY B 2318	2000
BAY C 2125	1300
HOLD 2 1662	243



LAST MINUTE CHANGES (LMC)				
DEST	Specification	Cpt	+/-	Weight
	Total LMC			

LADEN INDEX +20.5

TRAFFIC OFFICER'S CERTIFICATE

I hereby certify that this aircraft is loaded in accordance with the current Loading Instructions of CHANNEL EXPRESS (AIR SERVICES) LTD.

Signed: Co-pilot's signature

Date: 12/1/99

CAPTAIN'S CERTIFICATE

I hereby certify that I am satisfied that all the relevant requirements of the A.N.O's and A.N.R's have been complied with.

Captain: Commander's signature

Date: 12/1/99

Guernsey to Gatwick (pre-prepared but not flown)

(K)

FOKKER F27 600 SERIES channel express Cargo Loadsheet & Balance Chart **ALL WEIGHTS IN KILOS**

Address	From	Originator	Version
	CCI		F1
A/C Regn NL / **Flight No.** / **Date** 12/1/98	**To** LGW	**Captain** Commander	**Crew** 2/0

	Weight	Index	MAXIMUM WEIGHT FOR	ZERO-FUEL	TAKE-OFF	LANDING
APS WEIGHT	11110	+ 1.75		17917		18597
Supernumerary Crew +			Take-off Fuel and Water Methanol +		TRIP FUEL → +	
Additional Equipment		+	ALLOWED WEIGHT Lowest of 1, 2 or 3	1	2	3
DRY OPERATING WEIGHT	11110	1.75 −	Wet Operating Weight			
Water Methanol +	150		ALLOWED TRAFFIC LOAD			
Take-off Fuel +						
WET OPERATING WEIGHT						

SPLIT LOADS DEST		HOLD 1	BAY A	BAY B	BAY C	HOLD 2	TOTAL
LGW	CARGO						
	MAIL						
	CARGO						
	MAIL						
TOTALS							

NOTES / DANGEROUS GOODS

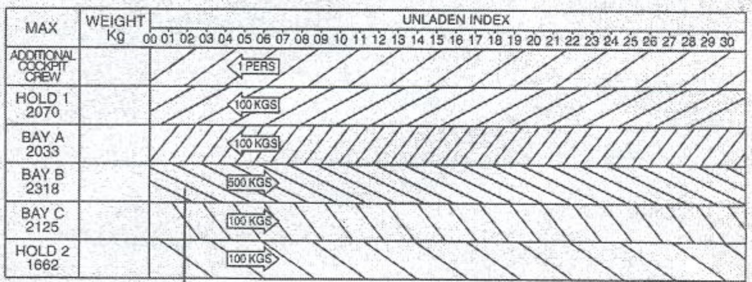
Total traffic load	=	
Dry operating weight	+	11110
Zero fuel weight LMC Max ±	=	
17917 ±	=	
Take-off fuel and water methanol	+	
Take-off weight LMC Max ±	=	
±	=	
Trip fuel	−	
Landing weight LMC Max ±	=	
18597 ±	=	

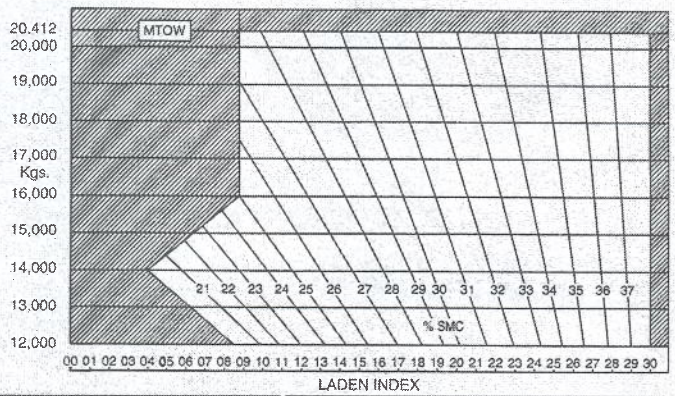
Allowed traffic load		
Total traffic load	−	
Underload before LMC	=	

LAST MINUTE CHANGES (LMC)

DEST	Specification	Cpt	+/-	Weight
	Total LMC			

LADEN INDEX





TRAFFIC OFFICER'S CERTIFICATE

I hereby certify that this aircraft is loaded in accordance with the current Loading Instructions of CHANNEL EXPRESS (AIR SERVICES) LTD.

Signed Co-pilot's signature

Date 12/1/99

CAPTAIN'S CERTIFICATE

I hereby certify that I am satisfied that all the relevant requirements of the A.N.O's and A.N.R's have been complied with.

Captain

Date 12/1/99

Luton to Guernsey (the accident flight)

①

FOKKER F27 600 SERIES channel express Cargo Loadsheet & Balance Chart **ALL WEIGHTS IN KILOS**

ess	From LUT	Originator	Version F1
A/c Regn ..L	Flight No. 017W	Date 12/1/99	To GCI
Captain Commander	Crew 2/0		

	Weight	Index		Maximum weight for	Zero-fuel	Take-off	Landing
APS WEIGHT	11110				17917		18597
Supernumerary Crew +		+ 1.75		Take-off Fuel and Water Methanol +	2144	TRIP FUEL →	627
Additional Equipment				Allowed Weight Lowest of 1, 2 or 3	20061	20400	19224
DRY OPERATING WEIGHT	11110	+ 1.75		Wet Operating Weight			13254
Water Methanol +	150			Allowed Traffic Load			5970
Take-off Fuel +	1994						
WET OPERATING WEIGHT	13254						

SPLIT LOADS DEST		HOLD 1	BAY A	BAY B	BAY C	HOLD 2	TOTAL
GCI	CARGO	/	800	1263	700	300	3063
	MAIL						
	CARGO						
	MAIL						
TOTALS							

NOTES / DANGEROUS GOODS

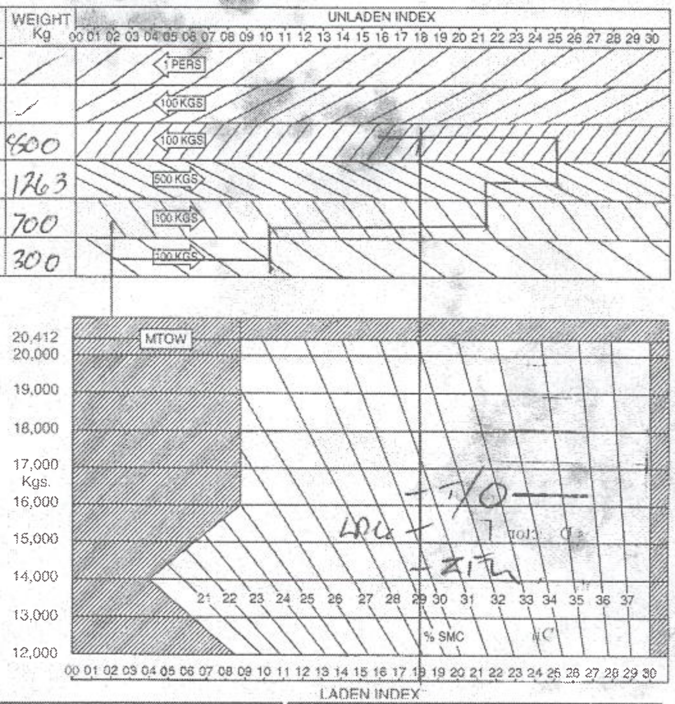
15640
2407
18547 ✓

Total traffic load	=	3063
Dry operating weight	+	11110
Zero fuel weight LMC Max 17917	=	14173
Take-off fuel and water methanol	+	2144
Take-off weight LMC Max 19224	=	16317
Trip fuel	−	627
Landing weight LMC Max 18597	=	15640
Allowed traffic load		5970
Total traffic load	−	3063
Underload before LMC	=	2907

LAST MINUTE CHANGES (LMC) DEST	Specification	Cpt	+/-	Weight
	Total LMC			

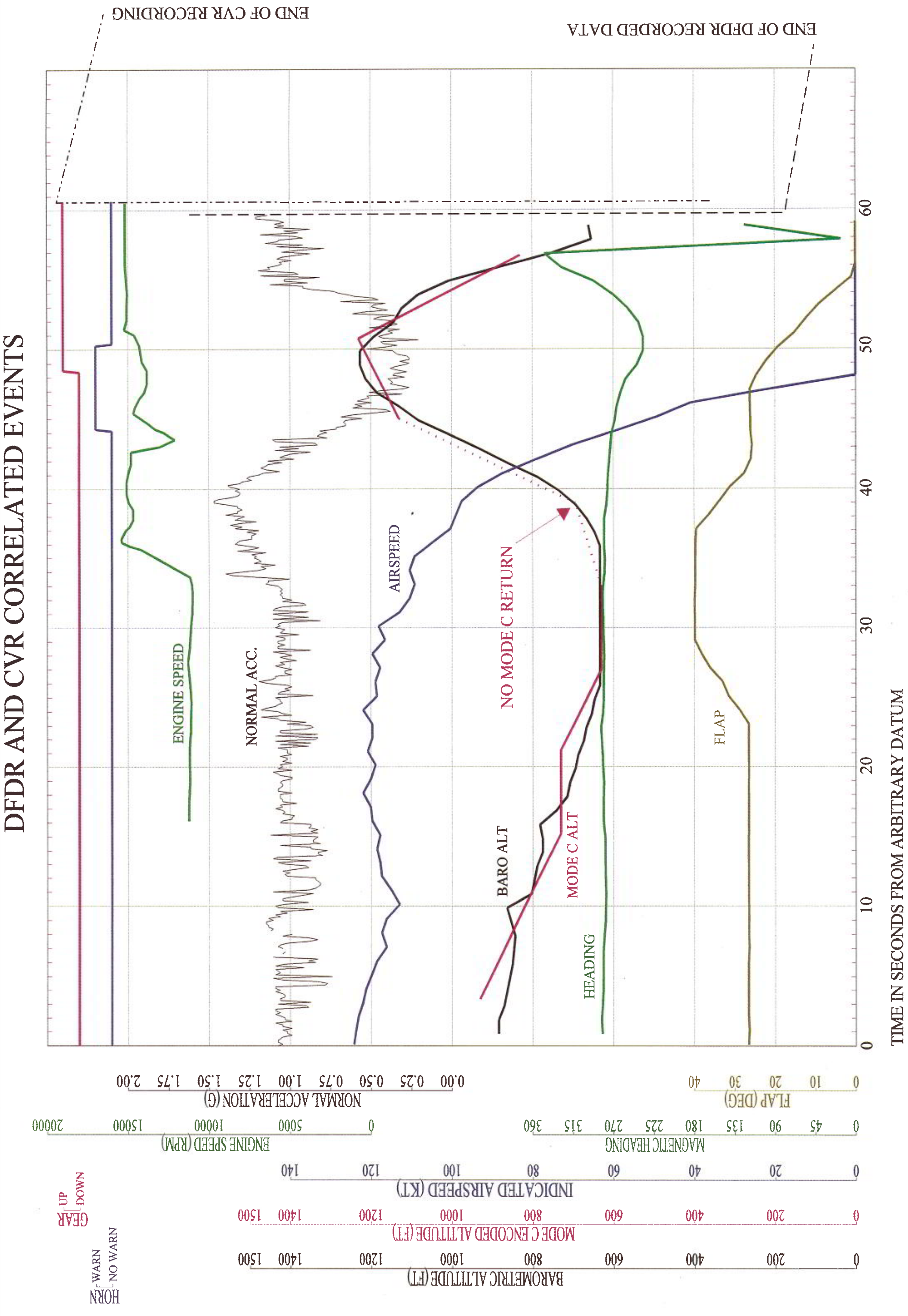
LADEN INDEX +18.0

MAX	WEIGHT Kg	UNLADEN INDEX
ADDITIONAL COCKPIT CREW	/	1 PERS
HOLD 1 2070	/	100 KGS
BAY A 2033	800	100 KGS
BAY B 2318	1263	500 KGS
BAY C 2125	700	100 KGS
HOLD 2 1662	300	100 KGS



TRAFFIC OFFICER'S CERTIFICATE	CAPTAIN'S CERTIFICATE
I hereby certify that this aircraft is loaded in accordance with the current Loading Instructions of CHANNEL EXPRESS (AIR SERVICES) LTD.	I hereby certify that I am satisfied that all the relevant requirements of the A.N.O's and A.N.R's have been complied with.
Signed Co-pilot's signature	Captain Commander's signature
Date 12/1/99	Date 12/1/99

APPENDIX D



DFDR AND CVR CORRELATED EVENTS
END OF CVR RECORDING
END OF DFDR RECORDED DATA
ENGINE SPEED
NORMAL ACC.
AIRSPEED
NO MODE C RETURN
BARO ALT
MODE C ALT
HEADING
FLAP
TIME IN SECONDS FROM ARBITRARY DATUM
0
10
20
30
40
50
60
NORMAL ACCELERATION (G)
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
ENGINE SPEED (RPM)
0 5000 10000 15000 20000
INDICATED AIRSPEED (KT)
0 20 40 60 80 100 120 140
MODE C ENCODED ALTITUDE (FT)
0 200 400 600 800 1000 1200 1400 1500
BAROMETRIC ALTITUDE (FT)
0 200 400 600 800 1000 1200 1400 1500
FLAP (DEG)
0 10 20 30 40
MAGNETIC HEADING
0 45 90 135 180 225 270 315 360
GEAR
UP
DOWN
HORN
WARN
NO WARN

APPENDIX E

EXTRACTS FROM RELEVANT REGULATIONS

Source material

The following texts which relate to loading and loading procedures have been extracted from CAP 393 and CAP 360. The words have been copied verbatim but the formatting varies slightly from the original documents.

Extract from The Air Navigation(No 2) Order 1995

ANO Art. 31

Loading - public transport aircraft and suspended loads

31 (1) The operator of an aircraft registered in the United Kingdom shall not cause or permit it to be loaded for a flight for the purpose of public transport, or any load to be suspended therefrom, except under the supervision of a person whom he has caused to be furnished with written instructions as to the distribution and securing of the load so as to ensure that:

(a) the load may safely be carried on the flight; and

(b) any conditions subject to which the certificate of airworthiness in force in respect of the aircraft was issued or rendered valid, being conditions relating to the loading of the aircraft, are complied with.

(2) (a) Subject to sub-paragraph (b), the instructions shall indicate the weight of the aircraft prepared for service, that is to say the aggregate of the weight of the aircraft (shown in the weight schedule referred to in article 18 of this Order) and the weight of such additional items in or on the aircraft as the operator thinks fit to include; and the instructions shall indicate the additional items included in the weight of the aircraft prepared for service, and show the position of the centre of gravity of the aircraft at that weight.

(b) Sub-paragraph (a) shall not apply in relation to a flight if:

(i) the aircraft's maximum total weight authorised does not exceed 1150 kg;

(ii) the aircraft's maximum total weight authorised does not exceed 2730 kg and the flight is intended not to exceed 60 minutes in duration and is either:

(aa) a flight solely for training persons to perform duties in an aircraft; or

(bb) a flight intended to begin and end at the same aerodrome; or

(iii) the aircraft is a helicopter the maximum total weight authorised of which does not exceed 3000 kg, and the total seating capacity of which does not exceed 5 persons.

(3) The operator of an aircraft shall not cause or permit it to be loaded in contravention of the instructions referred to in paragraph (1).

(4) (a) Subject to sub-paragraph (b), the person supervising the loading of the aircraft shall, before the commencement of any such flight, prepare and sign a load sheet in duplicate conforming to the prescribed requirements, and shall (unless he is himself the commander of the aircraft) submit the load sheet for examination by the commander of the aircraft who shall sign his name thereon.

(b) The requirements of sub-paragraph (a) shall not apply if:

(i) the load and the distributing and securing thereof upon the next intended flight are to be unchanged from the previous flight and the commander of the aircraft makes and signs an endorsement to that effect upon the load sheet for the previous flight, indicating the date of the endorsement, the place of departure upon the next intended flight and the next intended place of destination; or

(ii) paragraph (2)(a) does not apply in relation to the flight.

(5) (a) Subject to sub-paragraph (b), one copy of the load sheet shall be carried in the aircraft when article 66 of this Order so requires until the flights to which it relates have been completed and one copy of that load sheet and of the instructions referred to in this article shall be preserved by the operator until the expiration of a period of six months thereafter and shall not be carried in the aircraft.

(b) In the case of an aeroplane of which the maximum total weight authorised does not exceed 2730 kg, or a helicopter, if it is not reasonably practicable for the copy of the load sheet to be kept on the ground it may be carried in the aeroplane or helicopter, as the case may be, in a container approved by the Authority for that purpose.

(6) The operator of an aircraft registered in the United Kingdom and flying for the purpose of the public transport of passengers shall not cause or permit baggage to be carried in the passenger compartment of the aircraft unless such baggage can be properly secured and, in the case of an aircraft capable of seating more than 30 passengers, such baggage (other than baggage carried in accordance with a permission issued pursuant to article 40(2)(d) of this Order)shall not exceed the capacity of the spaces in the passenger compartment approved by the Authority for the purpose of stowing baggage.

ANO Sect 1/38

August 1995

Extract from AIR OPERATORS' CERTIFICATES

19 LOADING

19.1 Loading Instructions

In order to carry cargo in what would normally be the passenger cabin an Approved modification is usually necessary, taking into account the airworthiness requirements for the particular type of aircraft and the Flight Manual limitations.

NOTE The airworthiness requirements to be satisfied in order to gain CAA Approval for the carriage of cargo in passenger compartments are given in CAP 360 Part 2 Chapter 4.

19.1.1 The Approval reference number of the appropriate Approved modification must be shown in the Operations Manual or, if the Authority has deemed that a modification is not necessary, the basis for the Authority's acceptance.

19.1.2 Where no Approval/acceptance has been granted and shown in the manual, cargo must not be carried other than in designated cargo compartments.

19.1.3 Instructions must provide guidance for traffic staff, handling agents and aircraft crew, as appropriate, on the loading, weight and balance of an aircraft and include instructions on:

(a) Controlling and promulgating the basic or Aircraft Prepared for Service (APS) weights and indices. Where used, all items of equipment that convert basic to APS weight must be listed;

(b) regulating the carriage and stowage of baggage and cargo in passenger compartments, including instructions on the amount of hand baggage allowed and how it is stowed. Emergency exits, gangways and dinghy launching stations must be kept clear during taxying, take-off and landing;

(c) carriage of Dangerous Goods;

(d) limitations on floor loading, the strength and distribution of attachment points, use of weight spreading devices and positioning and securing of ballast;

(e) checking that items of cargo or baggage allocated to particular compartments or holds are distributed and restrained correctly. The person responsible for the trim of the aircraft must give written instructions to the person responsible for loading the aircraft;

(f) advising the aircraft commander and cabin crew of seating restrictions;

(g) the effect of the maximum zero fuel weight, landing weight restrictions at planned destination, take off and climb performance requirements at the departure aerodrome and en route performance requirements on Regulated Take-Off Weight (RTOW);

(h) the care and maintenance of Unit Load Devices (ULD), responsibilities for ensuring their fitness for use prior to loading and the procedure for directing damaged units to an Approved organisation for repair;

(j) fuel loading limitations;

(k) where appropriate, limitations on loading for ferrying aircraft with one engine inoperative, Certificate of Airworthiness (C of A) tests or any other non-standard flight;

(l) where applicable, the use of the standard weights or any notional weights given in exemptions granted by the Authority.

19.2 **Cargo Loading Instructions**

These instructions must include the following additional details:

(a) diagrams and dimensions of cabin bays and cargo holds and compartments to facilitate the pre-planning of cargo distribution;

(b) the strength and usable directions of all lashing points and/ or rings and details of the spacing between lashing points;

(c) the types and working strengths of lashing provided, and stowage, when not in use;

(d) instructions concerning the loading of stretchers, carriage of livestock or other unusual loads;

(e) where appropriate, the handling, loading and securing of pallets or containers;

(f) a care and maintenance programme for Unit Load Devices (ULDs); these include cargo containers, nets and pallets. Guidance must be given to both loading and maintenance personnel on the division of duties in respect of ULD serviceability;

(g) instructions on the use of passenger aircraft for the carriage of cargo;

(h) guidance on the duties and responsibilities of individuals when making cabin configuration changes. These changes require a Certificate of Release to Service (CRS). Further information on these procedures can be obtained from the Assigned Inspector;

(j) where appropriate, instructions on the loading and securing of mail bags or similar cargo, including checking for leakage or spillage and consequential aircraft contamination;

(k) a statement that a load/trim sheet cannot serve as a loading instruction and a trim slide rule does not dispense with the requirement to complete a load sheet.

19.3 The position of the laden centre of gravity must be given on the load sheet. For this purpose, a trim sheet may be regarded as part of the load sheet, even though it can be a separate document. The complete document must include particulars of how the load is distributed and special attention paid to the wording of the loading certificate. This may be met by establishing that the Centre of Gravity (C of G) lies within the permitted limits and it is not necessary to determine the precise position, unless it affects aircraft handling or other factors. The load sheet must bear the reference of the APS form used and, if standard weights have been used, an endorsement to that effect.

19.4 Where a 'loading plan' method is used, the basic assumptions upon which the plan is formulated must be given and must specify C of G limits more stringent than those permissible under the C of A. It must also be stated that loading in accordance with the 'plan' ensures that the laden C of G always falls within the restricted limits. If this is done, a simple statement on the load sheet that the laden C of G is between the operator's more stringent limits is acceptable.

19.5 Operators must provide traffic staff and handling agents, including agents at overseas aerodromes, with:

(a) loading instructions, including the principles of effective cargo restraint;

(b) current APS forms for all types, marks and variants of aircraft used;

(c) details of the RTOW and fuel load for each flight.

19.6 Where traffic staff and handling agents are responsible for calculating the RTOW, operators must ensure that they are provided with all relevant information and are competent.

APPENDIX F

EXTRACTS FROM COMPANY OPERATING PROCEDURES

Source material

> The following texts which relate to loading and loading procedures have been extracted from the Operator's 'Flight Operations Manual' Part A General/Basic, from Operating Staff Instructions, and from Volume Five A Loading Instructions. The words have been copied verbatim but the formatting varies slightly from the original documents.

Extract from Section 8.1 entitled "Flight Preparation Instructions'.

Paragraph 8.1.8.6

(Part of section 8.1.8 entitled 'Mass and centre of Gravity')

A company mass and balance document is to be raised in duplicate for each flight carried out for the purpose of commercial air transport. One copy is to be carried on the aeroplane whilst another, as accepted by the Commander, must remain available on the ground for at least 3 days. Part B contains detailed loading instructions and a sample mass and balance document for the particular aeroplane type. Irrespective of whether a 'drop-line' mass and balance document, an index system, a trim wheel, or a computer programme is used in establishing the aeroplane's mass and C of G position, the final mass and balance document must contain details of the disposition of all loaded items, including fuel, cargo, mail and any supernumerary crew/couriers. The person supervising the loading must confirm by signature that the load and its distribution are as stated on the mass and balance document which must also contain the name of the person who prepared it. The mass and balance document must be acceptable to, and countersigned by, the aeroplane Commander. Details of any late alterations in the load must be passed to the Commander and entered in the 'last minute changes' spaces on the mass and balance documents.

Extract from Section 8.2 entitled "Ground Handling Instructions'.

Paragraph 8.2.2.3 Loading and Securing of Cargo

Cargo is not to be carried on an aircraft unless the aircraft has been specifically cleared and equipped to do so. The equipment required will be detailed in Part B Sections 6 and 7 of this

Manual. Procedures for loading cargo will be detailed in Part B section 7 and/or the cargo loading Manual.

During loading a qualified person must check that the cargo is correctly positioned and secured and accessible if required. The Commander must be informed of the mass and arrangement of the load carried.

Hold baggage is to be stowed and secured only in those areas and compartments which are designated for its carriage and subject to the floor loading limitations of the particular area. It may be necessary to restrict the weight carried for balance purposes rather than structural considerations. The Commander is to ensure that all personnel who may be responsible for loading the aeroplane are made aware of any additional restrictions.

For the transport of live animals refer to the IATA "Live Animal Regulations" manual, held in Bournemouth operations.

For the carriage of Dangerous Goods refer to Part A Section 9 of this Manual.

Extract from Volume 5A Part II Section 3 Page 3 paragraph 3

3. LOADSHEET

The company is required by law to, for every flight, calculate the weight and the centre of gravity of an aircraft. These details are to be recorded on a loadsheet, the person completing the loadsheet shall unless he/she is the commander of the aircraft submit the Loadsheet to the commander for approval.

The loadsheet must be completed accurately and the aircraft must be loaded in accordance with the issued written instructions. A certificate to this effect must be signed by the person responsible for the loadsheet. The aircraft commander will also sign a certificate to the effect that he/she is satisfied that all the relevant requirements of the air navigation order and the air navigation regulations have been complied with. All entries on the loadsheet are to be clear and legible with blue or black ink.

Extract from Operating Staff Instruction G11 dated 1 Sep 1991.

LOADING OF AIRCRAFT FOR ON TIME DEPARTURES

Unsatisfactory load distribution and/or load security should never be the cause for a delayed departure in our operations. This applies equally to ....*(five named clients)*... and any other operation.

Aircraft commanders are required to monitor and where necessary supervise aircraft loading, load distribution and load security during loading operations, so that as and when loading is completed last minute delays in this area will be eliminated.

When it is not possible for the aircraft Commander to be in attendance at the aircraft for all or part of the loading procedures the task is to be delegated to the F/O or to the loadmaster; however, an aircraft Commander must satisfy himself that these staff fully understand what is required regarding the load distribution and security when delegating this task.

The monitoring of aircraft loading can usually be combined with other essential pre-flight checks and it is the Commander's responsibility to organise the pre-flight time available to the crew so as to ensure all essential tasks are carried out in an efficient and expeditious manner. This will also ensure that any delay to departure time which may then occur, will not reflect on the performance of the crew, their operating procedures, or the reputation of Channel Express.

Extract from Volume 5A Part II Section 9 Page 7

LOAD INSTRUCTION/REPORT

(PTO)

CHANNEL EXPRESS AIR SERVICES

LOAD INSTRUCTION / REPORT

FOKKER F27 - 600 FLT NO____________ DATE: ____________________ STATION:________________

I CERTIFY THAT THIS AEROPLANE HAS BEEN LOADED IN ACCORDANCE WITH THESE INSTRUCTIONS AND THE LOAD DETAILED ACCURATELY REFLECTS THE LOAD ON BOARD THE AEROPLANE

NAME______________________________ SIGNATURE________________________________

LOAD DISTRIBUTION

REQUESTED	ACTUAL	
		→ HOLD 1 MAX LOAD 2070 KGS
		→ BAY A 2033 KGS
		→ BAY B 2318 KGS
		→ BAY C 2125 KGS
		→ HOLD 2 1662 KGS
TOTAL		

Printed in the United Kingdom for The Stationery Office
on material containing 75% post–consumer waste and 25% ECF pulp
TJ000829, C5, 3/00, 5673.