CIAIAC
Comisión de Investigación
de Accidentes e Incidentes
de Aviación Civil

TECHNICAL REPORT
A-028/2000

Accident to the aircraft Nimbus 4DT, registration G-929, at Campillo de la Jara (Toledo), on 31st July 2000

MINISTERIO
DE FOMENTO

Technical report

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SECRETARÍA GENERAL DE TRANSPORTES
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident and its causes and consequences.

In accordance with the provisions of Law 21/2003 and Annex 13 to the Convention on International Civil Aviation, the investigation has exclusively a technical nature, without having been targeted at the declaration or assignment of blame or liability. The investigation has been carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report has originally been issued in Spanish language. This English translation is provided for information purposes only.

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Abbreviations

°C	Degrees Celsius or Centigrade
°F	Degrees Fahrenheit
AFM	Aircraft Flight Manual
AMSL	Altitude above Mean Sea Level
BFU	Bundesstelle für Flugunfalluntersuchung (German Federal Aircraft Accident Investigation Office)
BGA	British Gliding Association
CAVOK	Ceiling and Visibility OK
CG	Center of Gravity
CFRP	Carbon Fiber Reinforced Plastic
E	East
FL	Flight Level
FRM	Fiber Reinforced Material
FRP	Fiber Reinforced Plastic
ft	Foot (feet)
ft/min	Feet per minute
g	Acceleration of gravity
GPS	Global Positioning System
GFRP	Glass Fiber Reinforced Plastic
h	Hour(s)
HF	High Frequency
Hz	Hertz (cycles per second)
IAS	Indicated Airspeed
JAR	Joint Aviation Requirements
kg	Kilogram(s)
km	Kilometer(s)
kph	Kilometers per hour
kN	Kilonewton
Lb	Pound(s)
LBA	Luftfahrt Bundesamt (German Civil Aviation Authority)
LT	Local time
m	Metro(s)
m/s	Metros per second
N	North
NE	North-east
NW	North-west
NIAR	National Institute for Aviation Research (Wichita State University, USA)
NM	Nautical Mile(s)
NTSB	National Transportation Safety Board (USA)
QFE	Atmospheric pressure at aerodrome elevation
RCC	Rescue Coordination Center
s	Second(s)
S	South
SE	South-east
SM	Safety Margin
SW	South-west
UTC	Universal Time Coordinated
V_A	Maneuvering speed
V_D	Maximum design spin speed
V_{FE}	Flap extension speed limit
V_{NE}	Never exceed speed
V_S	Stall speed
V_Y	Minimum descent speed
VFR	Visual Flight Rules
W	West

Synopsis

Owner and operator:	Private
Aircraft:	Nimbus 4DT registration G-929
Date and time of the accident:	31st July 2000 at 17:30
Accident site:	Campillo de la Jara, Toledo, Spain
Persons on board:	2
Type of flight:	Pleasure, private

The Nimbus 4DT glider, registration G-929, took off from the aerodrome of Ocaña at 13:30 local time on 31st July 2000 with a crew of two persons on board in a flight towed by a light aircraft. The aim was to fly over the southern meseta of Castille, subsequently returning to the aerodrome of Ocaña at the end of the flight.

At about 17:30, after four hours of flight and when the glider was about 140 km to the south-west of the aerodrome from which it had taken off, the pilot started the homeward stretch of the flight in the direction of Ocaña. At that moment, they were flying at an altitude of some 2,600 m above the Montes de Toledo mountain range, comprising peaks with a height in the region of 1,200 m above sea level and wide valleys with a height of some 625 m.

At a particular moment, whilst flying in a hot-air current, the pilot lost control and the glider took a steep dive, which led to an important increase in speed. Whilst the pilot tried to regain control of the glider and come out of the dive, both wings broke.

The pilot in command gave the order to bale out, which he himself did and was uninjured. The second pilot tried to jump but the parachute's cordage was caught up in the glider, which dragged him with it in its fall and crash into the ground, resulting in his death.

The accident occurred in the municipality of Campillo de la Jara in the province of Toledo (coordinates 39° 30.9′ N; 005° 0.5′ W), on terrain comprising low mountains, covered with scrub, at a height of some 625 m. The wreckage was widely scattered over an area with a diameter of some 1,800 m.

It is estimated that the accident was caused by a loss of control of the glider, initiated by a loss of lift due to thermal turbulence, whilst gliding at a slow speed, possibly close to the minimum descent speed. Failure to immediately correct the loss caused an important increase in the dive speed. The pilot's inadequate reaction to regain control meant that the glider's design loads were exceeded, producing the wing structure's collapse.

1. FACTUAL INFORMATION

1.1. History of the flight

At 13:30 local time[1] on 31st July 2000, after having been towed, the Nimbus 4DT glider, registration G-929, started a free flight from the vicinity of the aerodrome of Ocaña. Two persons, father and son, of British nationality, were on board, having planned a long-distance flight of 500 km. The father, situated in the front seat, was the pilot in command and the son was the accompanying pilot. According to the pilot in command's statement, the meteorological conditions were good.

The accident was notified at 19:00 with a call to the headquarters of the Civil Guard of Campillo de la Jara informing of the presence of a person in the vicinity of an area known as «Casa de la Pizarrita», who declared that he had suffered an aircraft accident and that his son had died.

The surviving pilot himself led the rescue teams to the site of the accident, along a route known as the Ruta Verde de Campillo, next to the Riofrío reservoir, and contacted the aerodrome of Ocaña to communicate what had happened and to obtain assistance in language translation.

The crash occurred at 17:30 LT in a place called «Navalpuercos», 6 km to the south-east of the municipality of Campillo de la Jara in the province of Toledo (coordinates 39° 30.9′ N; 005° 0.5′ W), in an area of low mountains with a height of 625 m, covered with scrub. The site of the accident is a few kilometers from La Nava de Ricomalillo, a point on the western edge of the Sierra de Toledo mountain range, which is sometimes used as the turning point in long-distance triangular flights starting in Ocaña.

1.1.1. *Surviving pilot's statement*

Immediately after the accident the surviving pilot made the following statement.

Towards 17:30 LT, just over 4 hours after taking off from the aerodrome of Ocaña, the pilot in command decided that it was getting late and that it was time to return to their starting point. He took the controls, as up until then the glider had been piloted by his companion, and set course for Ocaña. At that moment the glider was some 140 km to the south-west of Ocaña, at an altitude of 2,600 m, flying over terrain with maximum heights of some 1,200 m.

[1] In this report chronological time is expressed as Local Time (LT). UTC (Coordinated Universal Time) is two hours less than local time.

The pilot in command stated that whilst flying towards Ocaña they entered a strong thermal, upon which the control stick was pulled back in order to reduce speed. The glider immediately took a steep dive towards the ground and started to turn. The pilot realized that they had started to spin and that, in order to come out of the spin, he pulled back hard on the control stick and applied full flaps, without succeeding in regaining control. Meanwhile, the glider quickly gathered speed until it exceeded V_{NE} speed (never exceed airspeed or maximum permissible operating speed) and the flaps got heavier and heavier.

The pilot does not remember the maximum speed achieved.

During the maneuver he did not activate the aerodynamic brakes and the flap position was 2° positive.

Suddenly, and with a tremendous noise, the right outside wing fell off and the canopy broke. The pilot in command shouted to his companion urging him to abandon the aircraft.

The pilot in command jumped out of the glider. He had difficulties getting out of the cockpit because of the inertia force and also had some problems getting his parachute to open. During the fall he did not see his co-pilot's parachute. He landed in an area of thick scrub.

He saw the main wreckage of the glider at some 400 m from the point where he had landed and on approaching it he discovered that his co-pilot had died and that his body together with the unfurled parachute was under part of the glider wreckage.

1.2. Injuries to persons

Injuries	Fatal	Serious	Minor/None
Crew	1		1
Passengers			
Others			

1.3. Damage to the aircraft

The aircraft was completely destroyed and the wreckage, which was very broken up, was spread over a wide area of terrain.

1.4. Other damage

There was no other damage worthy of mention.

1.5. Personnel information

1.5.1. *Pilot in command*

Age:	67 years old
Nationality:	British
License:	Glider pilot
Date of issuance:	1964
Flight hours:	2,100 hours
Hours in Nimbus 3DM:	600 hours
Hours in Nimbus 4DT:	36.5 hours

He had flown the Nimbus for 1:50 hours on the day before.

From a later interview with the surviving pilot, the following data should be highlighted:

Loss of control occurred whilst trying to come out of a spin.

The last time he deliberately went into a spin was 20 years previously (1980) and, according to his statement, he promised to himself never to try it again.

The glider had been delivered by the manufacturer on 5th May (barely three months previously). The pilot had carried out some flights with the test pilot (including diving at V_{NE} and the start of spins) and with another pilot from the manufacturing company in the United Kingdom.

The pilot stated that he did not have the Nimbus 4DT flight manual and did not know the specific procedures defined for this aircraft for regaining control of the glider from losses, spins and dives.

It is not known if he was sufficiently familiar with the aircraft, trying it out in flights at slow speed, exploring loss characteristics and checking stick forces.

The pilot had had a similar experience of loss of control and the aircraft taking a dive, when flying with a pilot with experience in a Nimbus 3D in Namibia. On that occasion, with the wings level at the end of an ascent in a thermal, they suddenly found themselves with the aircraft pointing at the ground.

In conversations between the interviewer and the pilot involved in the incident in Namibia, the latter commented that in that incident there was no spin and that he had been advised not to be brusque with the controls. The pilot involved in the accident tried to pull back on the stick and the Namibia pilot had to prevent this by blocking the stick with his fist. The pilot involved in the accident appeared to suffer from a mental block or a brief loss of orientation. They managed to recover horizontal flight although greatly exceeding the speed limit (V_{NE}). The aircraft did not stall.

1.5.2. *Second pilot*

Age:	31 years old
Nationality:	British
Qualifications and licenses:	— Glider pilot — Civil aviation pilot

1.6. Aircraft information

The Nimbus 4 is a high-performance glider which is made of fiber reinforced plastic (FRP). The Nimbus 4DT is a double-seater with a retractable engine that might not be installed. The fibers used in different parts of the structure are of carbon, Aramid (Kevlar) and glass. This «sandwich» type of construction, with a foam core and outside panels of FRP, is widely used.

The tail assembly, also of the «sandwich» type of construction with foam core and FRP panels, is laid out in the form of a T with a horizontal stabilizer mounted on the upper edge of the vertical tail fin.

1.6.1. *Aircraft identification*

Make:	Schempp-Hirth Flugzeugbau G.M.B.H.
Model:	Nimbus 4DT
Serial No.:	2000/10
Year of manufacture:	2000
Registration:	G-929
MTOW:	750 kg (if no engine is installed)
Owner:	Private
Operator:	Private

1.6.2. *Airworthiness certificate*

Class:	Normal
Issuance date:	01-06-2000
Expiry date:	27-05-2001

The glider is certified in the normal class and aerobatics are not permitted.

1.6.3. *Maintenance log*

Total flight hours:	25.00

Given the low number of flight hours, there were no scheduled maintenance operations outstanding.

1.6.4. *Technical features*

Wing dimensions

Wingspan:	26.5 m (86.94 ft)
Area:	17.96 m^2 (193.32 ft^2)
Wing aspect ratio:	39.1
Mean aerodynamic chord (MAC):	0.728 m (2.39 ft)

Fuselage dimensions

Length:	8.62 m (28.28 ft)
Width:	0.71 m (2.33 ft)
Height:	1.0 m (3.28 ft)

Masses

Empty:	565 kg (1,246 lb)
Maximum:	750 kg (1,653 lb) (if no engine is installed)
Wing load (empty):	35.6 kg/m^2 (7.3 lb/ft^2)
Wing load (maximum):	41.8 kg/m^2 (8,6 lb/ft^2)

Speeds

V_{NE} (flap «–1», «–2»):	285 kph (never exceed airspeed)
V_{RA}:	180 kph (turbulent air speed)
V_{A}:	180 kph (maneuvering speed)
V_{FE} (flap «+0»):	180 kph (flaps extended speed)
V_{FE} (flap «+1», «+2»):	160 kph
V_{FE} (flap «+L»):	160 kph
V_{D}:	324 kph (maximum design spin or structural integrity speed)
V_{S}:	82 kph (stall speed)
V_{Y}:	95 kph (minimum descent speed)

Optimum glide coefficient

60 (V = 105 kph)

1.6.5. *Engine*

This unit does not include the engine, which is mounted on other versions of this model.

1.6.6. *Flight operation procedures contained in the Aircraft's Flight Manual*

1.6.6.1. Recovery from stall

The chapter on Emergencies indicates that recovery of a normal flying attitude after a stall, flying straight or banking, is achieved by easing the stick forwards and, if necessary, applying rudder and ailerons in the opposite direction.

A warning is made to the effect that as the spoiler and flap controls are interconnected in this model, if the aerodynamic brakes are completely pulled out, the flaps acquire their maximum positive position, as a result of which a severe nose down dive angle should be expected.

In another chapter on normal glider operation, the pilot is recommended to explore, at a safe height, the aircraft's low speed and stall flying characteristics. Stall announcements usually occur at a speed of 5 to 10 kph above stall speed and the flap controls become loose. On reaching stall, in the Nimbus-4DT, with its center of gravity in its rear position, the tendency is for a wing to slowly drop. With the center of gravity further forward, neither the nose nor wing tend to drop.

When recovering from a stall up to 50 m of height can be lost.

When stalling occurs during a coordinated 45° turn with the center of gravity in the rear position, the Nimbus-4TD rolls slightly into the turn and, when the stick is eased, the nose drops slightly. The AFM states that the Nimbus-4DT does not have an uncontrollable tendency to fall into a spin.

1.6.6.2. Recovery from a spin

In the chapter on Emergencies the following method is specified for safe recovery from a spin:

a) Hold the flaps in the neutral position
b) Apply rudder in the opposite direction (that is, against the turning direction of the spin)
c) Ease the stick forward until turning ceases and aerodynamic flow is restored
d) Center the rudder and gently pull on the stick whilst coming out of the spin

With the center of gravity in the rear position, a stable spin is possible, from which the aircraft can be recovered by applying the method described, in 1/4 or 1/2 turns and losing up to 150 m in height. Recovery speed is between 130 and 210 kph.

1.6.6.3. Recovery from a spiral dive

The chapter on Emergencies states that, depending on the position of the center of gravity, the flap position and the use of the flight controls, a spin can turn into a dive, which is characterized by a rapid increase in speed and acceleration.

The recovery technique consists of easing the stick forward and applying rudder and aileron in the opposite direction.

A warning is made to the effect that on coming out of a dive, the speed limitations for each flap position must be respected and, if necessary, the flaps should be repositioned by 0° or –1°. Pilots are reminded that permitted deflections of the flight controls at V_{NE} are one third of maximum deflections and maximum deflection of control surfaces is only permitted at speeds below V_A.

1.6.6.4. High-speed flying

In the corresponding section of the AFM on normal aircraft operation, pilots are reminded of maximum speed limitations depending on the position of the flaps and the permitted deflections of flight controls depending on the speed.

The Manual states that when there is strong turbulence a speed of V_{RA} = 180 kph should not be exceeded.

1.6.6.5. Baling out

The first action specified is to throw off the canopy. Then, to help him/herself to get out of the cabin, the front seat's occupant can grab the canopy frame, which is strong and without sharp edges. In addition, the rear seat's occupant can help him/herself to climb out by grasping the handles situated on the sides of the instrument panel.

1.6.7. *Supplementary information on the Nimbus 4DT glider*

The Nimbus-4DT, manufactured by the company Schempp-Hirth, is a model in the Nimbus 4 series which consists of single-seater and double-seater versions, with and without engine. As at 31st July 2000, the different models were as follows:

Model	Type	Certified in	Certification date	No. manufactured
Nimbus 4	Single-seater	Germany	01-01-1994	11
Nimbus 4D	Double-seater	Germany	24-02-1995	9
* Nimbus 4T	Single-seater	Germany	15-06-1993	12
* Nimbus 4M	Single-seater	Germany	01-01-1994	10
* Nimbus 4DT	Double-seater	Germany	05-1995	6
* Nimbus 4DM	Double-seater	Germany	07-11-1995	37

* With retractable engine.

Constructional features

- The wings are built in six pieces: two 3.84 m long *internal wings,* two 8.21 m long *external wings* and two 1.2 m long *wingtips*. The glider has a total span of 26.5 m.
- The internal wing's spar is box-shaped and the external wing's spar is in the form of a double T. The spars' web is made up of «sandwich» panels with a foam core and CFRP panels. The spar caps are made of CFRP and GFRP.

— The different wing sections are covered in panels, of a smaller thickness, based on the same type of «sandwich» construction, in the shape of the glider's aerodynamic profile. Coverings are joined together and to the spar by polymerization.
— The forward fuselage, cabin and canopy frame are of a laminated Aramid (Kevlar), carbon and glass fiber construction. The fuselage aft of the wing is of a semi single-hull structure reinforced by a «sandwich» frame, with external carbon fiber panels and a foam core and glass fiber spars. This provides high energy absorption in the event of possible impacts.
— Flight control transmissions, from the control column, aerodynamic brake and flap stick to the control surfaces, consist of double-action tubes. The rudder bar is activated by cables that transmit the pedals' control movements.
— A single flap occupies the whole central wing, three aileron sections cover the major part of the external wing's trailing edge and a fourth aileron, used to minimize the effects of adverse yaw, is located in the wingtip section.
— The glider involved in the accident was not equipped with an oxygen installation.

Flight characteristics

— Pilots with experience in the Nimbus series 4 recognize that these gliders are very sensitive, due to their large span and the action of the rudder bar during turns, with a tendency to generate adverse yawing and twisting moments.
— Due to the small aerodynamic resistance, acceleration when the glider takes a dive is virtually produced by the gravity acceleration component in the direction of the dive path. Thus, in a dive of 45° with respect to the horizon, in order to accelerate from the stall speed (V_S = 82 kph) to limit speed with flaps extended to +2° ($V_{FE2°}$ = 160 kph), only some three seconds are needed, with a loss of height of some 75 m.
— According to the manufacturer, in order to achieve V_{NE} from stall speed 8.6 seconds are needed, plus a further 1.8 seconds to pass to $V_{D.}$
— Through in-flight tests it has been verified that the Nimbus 4D, with aerodynamic brakes retracted, cannot be stabilized at descent angles in excess of –26° without exceeding V_{NE}.
— The results of in-flight tests, for certification, show that the forces on the stick are relatively low: a forward force of 5.4 kg is needed on the stick to maintain a nose down attitude, in a dive at $V_{NE,}$ when the elevator control is compensated for a speed of 135 kph.

Maximum design and ultimate loads

— The Nimbus 4 DT is a high-performance glider, certified in the «normal» class as per JAR 22. The maximum design load factor is 5.3 g with a positive flap in positions «+1» or «+2» configuration and a speed of 160 kph. The load factor at a V_{NE} of

285 kph with negative flap in positions «–1» or «–2» is 4.0 g. The maximum design load conditions that the aircraft and each one of its structural elements should support without permanent damage are established on the basis of these load factors and the aerodynamic and mass force distributions.
- Certification standards establish a minimum safety margin (SM) of 1.5 applicable to the maximum design loads (corresponding to the different load factors, depending on the different flap and airbrake configurations and V_A, V_{FE} and V_{NE} speeds), in order to establish the ultimate loads.
- The aircraft must be able to support the ultimate loads without breaking in flight.
- The SMs for the wing spar, calculated by the manufacturer, vary between 1.55 and 1.75 in the internal wing station. The safety margin calculated for the spar, at the weakest point, SM = 1.5, occurs in station 6.6 m, in the external wing. This station is very close to that of the primary fracture recorded in the accident.

1.7. Meteorological information

The weather forecast for the region where the flight took place was that of a hot day with maximum temperatures of 32° in Ocaña and 30° in the Montes de Toledo mountain range. The appearance of thermals was predicted after 12:30 pm, first with blue skies which, later in the afternoon and particularly over the mountains, would give rise to isolated patches of small cumulus clouds with a height at the base of the clouds of some 2,700 m.

Visibility was good and there was no risk of storms.

The force of the thermals was predicted to reach 5 or 6 m/s.

Winds would be light from the NW, which at heights of 2,000 m could reach 20 kph.

In general, a good day for unpowered sailplane soaring.

1.8. Aids to navigation

The flight was following visual flight rules, VFR, and consequently no radio aids to navigation from ground were being used. Nevertheless, the glider was equipped with GPS instrumentation and its geographical position was accurately known.

1.9. Communications

The glider was equipped with a VHF transceiver and maintained radio communication with the Ocaña airfield and with the towing plane at the start of the flight. There is no knowledge of any other communications during the flight.

1.10. Aerodrome information

The aerodrome of Ocaña (LEOC), which is used for Pleasure Flying, with coordinates 39° 56′15″ N – 003° 30′12″ W, is located to the south of Ocaña at an altitude of 731 m AMSL. It has two crossed runways: Runway 29-11, measuring 1,260 × 100 m (of which 1,200 m have an asphalt surface), and Runway 35-17, measuring 900 × 100 m, of natural terrain.

The aerodrome's site and installations bore no relationship to and in no way influenced the events that lead to the accident.

1.11. Flight recorders

The aircraft was not equipped with flight recorders nor was it mandatory for it to carry them.

It was fitted with GPS-LOGGER A-20/02 satellite-based positioning and recording equipment, which can be used to demonstrate the passing through controls in competitions. This equipment was recovered from amongst the wreckage.

1.12. Wreckage and impact information

The crash occurred in a place called Navalpuerco, some 6 km to the south-east of Campillo de la Jara in the province of Toledo, in a fairly flat scrub area, covered with rock roses. Appendix A contains maps (general and detailed) of the site of the accident, as well as numerous photographs of the crash area and the aircraft wreckage.

Access to the site of the accident, from Campillo de la Jara, was by road for some two kilometers and then along a dirt track as far as the site. Vegetation in this area was scrub, mainly rock roses, which were not very tall but sufficiently high to make it difficult to see the aircraft wreckage from the ground. Civil Guard helicopters assisted in the search for the wreckage.

The wreckage was spread over an area of some 1,800 m in diameter, accumulated in four Zones D, C, B and A, aligned in a SW-NE direction. A mass of minor remains, pieces of covering, fragments of plastic and small items were found to the SE of the line of Zones A, B, C and D.

The main wreckage, comprising fuselage and part of the left internal wing, were located in Zone A, the northernmost area. The second pilot's dead body and his red unfurled parachute were found under some of the largest pieces of this wreckage.

Pieces of the left external wing were collected in Zone B.

A large piece, more than 8 m long, of the right internal and external wing and pieces of the aileron were found in Zone C.

The end of the right outside wing and wingtip, together with other smaller pieces, were found in Zone D.

The surviving pilot's parachute was picked up at the spot marked as E on the map, to the NW of the A, B, C and D line.

Figure 1.12.1 provides a layout of the area in which the wreckage was distributed, with its corresponding Zones. Table 1.12.2 contains a list with the distribution of the wreckage associated with each different Zone.

Appendix B includes a map of the wreckage with the Zones indicated and superimposed on it the complete list of the wreckage corresponding to each one of the Zones.

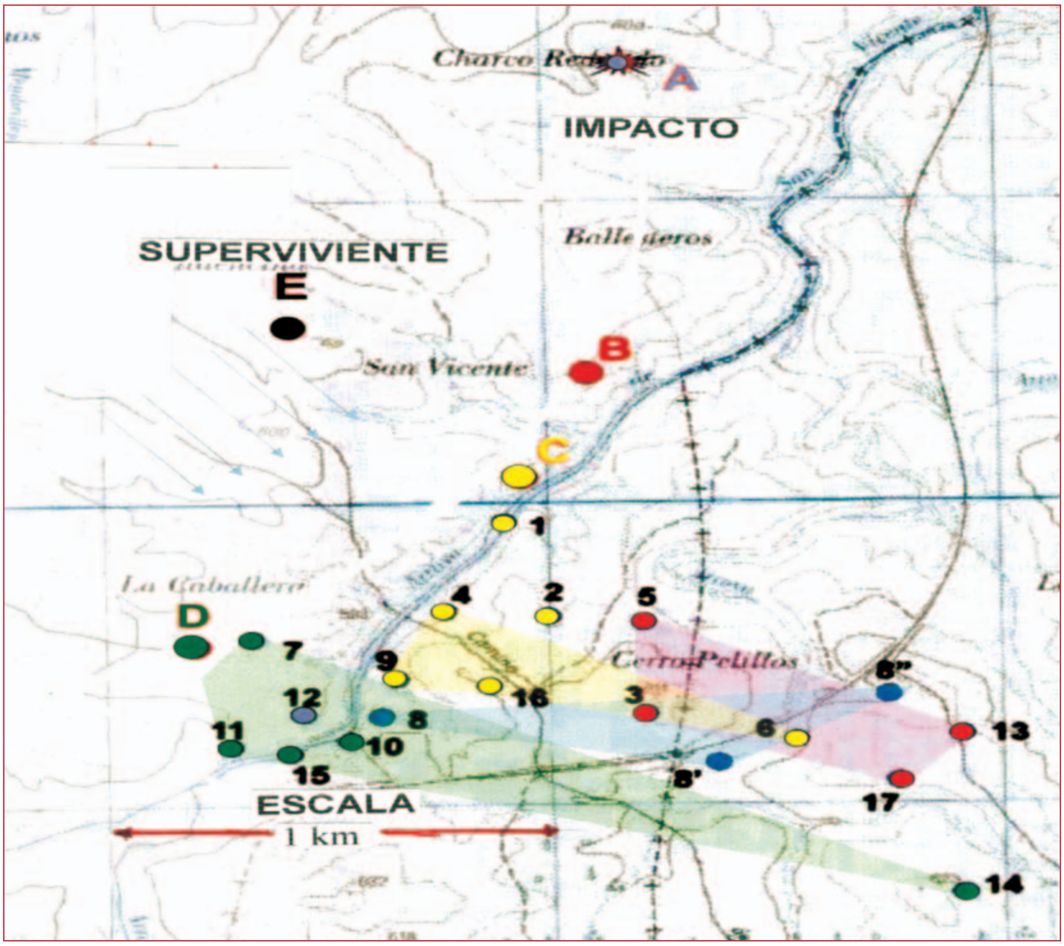


Figure 1.12.1. Layout of distribution of wreckage

Table 1.12.2. Wreckage distribution zones

Zone A	Area with main wreckage: fuselage and left internal wing.
Zone B	Pieces of left wing and aileron.
Zone C	Piece of right wing (> 8 m) and piece of aileron (> 1,5 m).
Zone E	The survivor's parachute.
Zone D	Far right wing (> 6 m), aileron (> 1.5 m) and other minor wreckage.
Numbers	Small pieces.

1.12.1. *Wing breakages*

— The wing structure showed faults due to bending in four stations of its span.

— Figure 1.12.3 and Table 1.12.4 show the stations in which the four breakages occurred. The resulting five broken wing pieces are marked on the Figure with the letter of the Zones A, B, C or D in which they were picked up, and which are also shown on the layout of Figure 1.12.1 and in Table 1.12.2.

— The appearance of the breaks shows no signs of possible manufacturing faults.

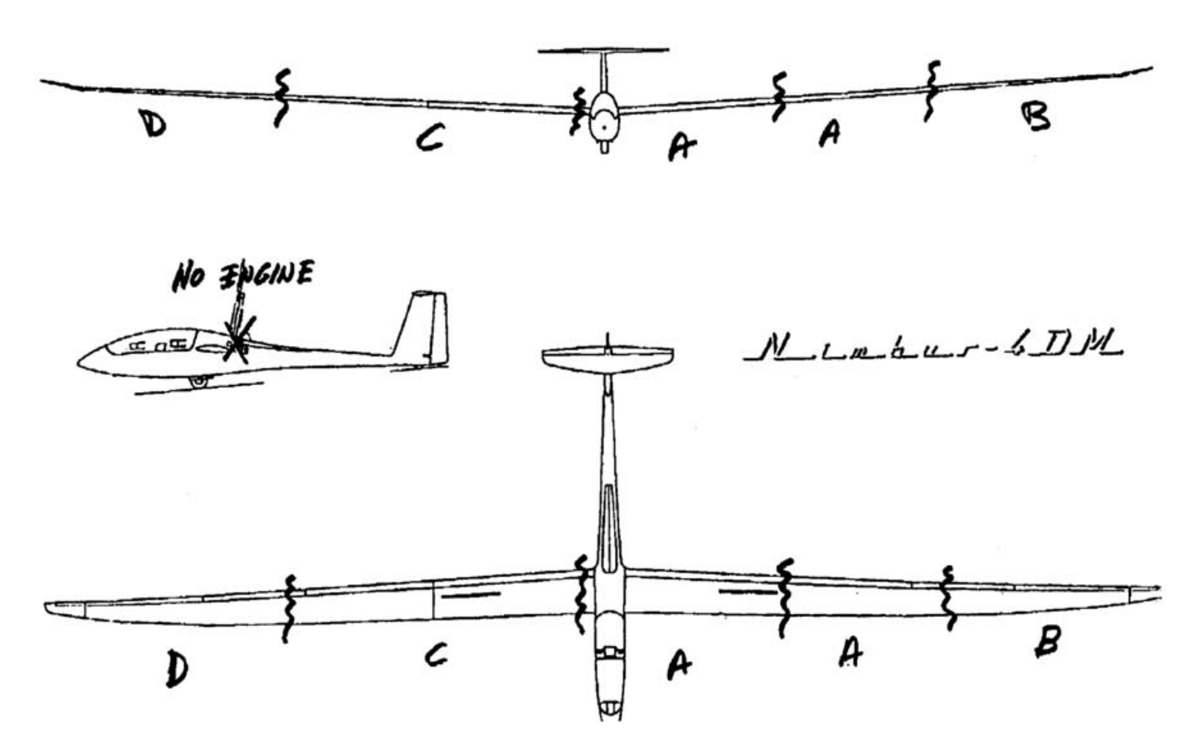


Figure 1.12.3. Position of the broken wing sections

Table 1.12.4

Right wing	
	— Fracture in *external wing,* amongst the pieces found in Zones C and D. — Fracture in *internal wing,* close to the wing-fuselage joint, C-A
Left wing	
	— Fracture in *external wing,* between parts A and B. — Fracture in the *internal wing-external wing* connection. A-A.
The wreckage corresponding to Zones A, B, C and D was found at a distance of several hundred meters. Parts A of the left wing were found right beside parts of the fuselage.	
Small pieces of both wings were spread over an area measuring 1.8 by 1.3 km.	

1.12.2. *Other wreckage information*

- — From the inspection of the wreckage it is known that the aerodynamic brakes were not activated.
- — There was no trace of water in the wings' tanks.
- — The landing gear was not extended.
- — The whole tail assembly was complete.
- — There was no prior damage in the elevator control column.

1.13. Medical and pathological information

According to the results of the autopsy, there were numerous serious internal and external fractures and traumatisms in the accompanying pilot's lifeless body, leading to the assumption that he died at the moment the glider crashed into the ground.

1.14. Fire

There was no fire; the unpowered glider was not carrying fuel. There were no electric sparks or short-circuits.

1.15. Survival aspects

Both pilots were wearing parachutes. The glider's structural collapse occurred when it was soaring at a height above ground of some 1,000 m over the tops of the closest mountains and 1,600 m above flat ground. The pilot in command saved his life by baling out.

As regards his companion, who also jumped out of the glider, the premature opening of the parachute caused the parachute canopy and cordage to get caught up in a part of the glider, which dragged him in its fall. The unfurled parachute, with the cordage caught up in the wreckage and the dead body joined to it, appeared at the point of impact. Given the severity of the injuries, survival was impossible and death must have been instantaneous.

1.16. Additional information

1.16.1. *Applicable background information*

Up to 31st July 2000 a number of Nimbus 4 glider accidents have been recorded in the world. Two of them involve certain similarities in the events leading up to the accidents, as follows:

- An accident occurred during training for the World Gliding Championship in France in 1995. The glider was the property of the French Air Force. It suffered loss of control and destruction in the air at a speed in excess of 400 kph. There were no deaths or injuries; the pilot having baled out.
- A Nimbus 4DM glider broke in flight on 13th July 1999 in Minden, Nevada, USA, after a loss of control and a steep dive. The pilot and the passenger died.

A report was published on the accident in Minden, from which the information given in paragraph 1.16.1.1 below has been taken.

1.16.1.1. Details of the breakage in flight of the Nimbus 4DM, which occurred in Nevada, USA, in 1999 (Report LAX99MA251 of the NTSB)

At 13:10 LT on 13th July 1999, a Nimbus 4DM glider, registration N-807BB, broke whilst thermal soaring at an altitude of some 3,000 m and 1,500 m above the level of the ground where the wreckage was found, in Minden, Nevada. The glider's two occupants died in the crash.

Numerous witnesses during the flight and on the ground stated that the glider fell into a spin and subsequently a steep dive, with the nose at an angle of 45° below the horizon. On coming out of the dive, strong bending moments were exerted on the wing that bent the tips of the wings and deformed the whole wing structure, which suffered a deflection of some 45° before breaking.

Breakages were caused by positive bending, in symmetrical wing locations, at some 5.5 m and 9.8 m measured from the aircraft's symmetrical vertical plane.

During the course of the investigation into this accident, the NTSB set in motion a complete investigation and analysis of the fault modes of structures made of compound materials, in which the National Institute for Aviation Research (NIAR) assisted. Due to the fact that the accident subject of this report occurred in Spain during the course of the investigation into the Minden accident and that both the NTSB and the CIAIAC noticed certain similarities in both accidents, the CIAIAC made available to the NIAR samples of the structural materials of the wings of the Nimbus 4DT that is the subject of this report.

The NIAR's investigation, applicable to the Spanish case because it analyzed structural samples taken from the glider that took off from Ocaña, reached the following conclusions:

- The properties of the composites materials showed a certain degree of variability between some zones and others and between the samples taken from the Minden aircraft and those taken from the Ocaña aircraft. These variations (in the proportions of resin and fiber and the degree of curing or polymerization) are considered to be normal in the type of artisan manufacture used by Schempp-Hirth.
- The wings were built in accordance with the design specifications. Although some deviations were found, such as an additional layer of fabric, which Schempp-Hirth justified on the grounds of surface finish requirements, these did not affect structural integrity.
- The mechanical properties of the materials used in the wing spar cords were checked in different samples and it was established that the results of the compressive strength tests were on average higher than the design values.
- The fault modes of structures in compound materials were investigated, differentiating two main modes: stress failure characterized by the breakage of fibers and occasionally by fibers being pulled out, and compressive failure caused by the local buckling of the «sandwich» structures' surface panels.

Applying this knowledge to the fault modes of the Minden aircraft's wing breakages, it was noted that one of these breakages was caused by the wing's negative bending. A study using the finite elements method showed that negative bending was possible as a reaction and dynamic response of the wing structure after the initial failure, with the broken section being released from the loads transmitted by the separated part.

Otherwise, the NTSB established that the probable cause of the accident was the pilot's excessive use of the elevator control during recovery from an inadvertently entered spin and/or spiral dive during which the glider exceeded the maximum permissible speed, which resulted in the overload failure of the wings at loadings beyond the structure's ultimate design loads.

Report LAX99MA251 states that Schempp-Hirth incorporated into its mass production of the Nimbus-4DM the recommendations issued by the LBA on the layout of the rear cabin of the Duo-Discus, similar to that of the Nimbus. These recommendations called for the equipping of new harnesses and non-slip rubber coverings on the floor of the rear cabin so as to facilitate evacuation.

2. ANALYSIS

2.1. Flight

At 13:10 LT on 31st July 2000, the pilot started the flight from the aerodrome of Ocaña, accompanied by his son, also a pilot who occupied the rear seat of the NIMBUS 4DT double-seater glider, registration G-929. The weather forecast for the glider's flying conditions was good for the region to the south of Ocaña.

The glider had been delivered by the manufacturer only three months before and it had accumulated 25 FH.

It is estimated that the weight at take off was some 750 kg[2], that is, the maximum authorized weight, and that the glider was not carrying water ballast. With the two pilots the center of gravity adopted an intermediate position.

The task they had set for themselves was a long-distance flight over the southern meseta of Castille. It is not known whether it had passed through any pre-established turning points, but at 17:30 it was gliding over the Montes de Toledo mountain range some 140 km to the SW of Ocaña and in the direction of the aerodrome. The flying height, some 1,900 m above the level of Ocaña, and the glider's good performance qualities, would have allowed them to cover the major part of the distance that separated them from their destination but they still needed to gain several hundreds of meters before embarking upon the last glide. With a gliding coefficient of 60 they could cover nearly 115 km given their height.

There being no risk of storms and with minimal cloud, it was expected that thermal activity would continue beyond 20:00 LT. Sunset would not occur in Ocaña until 21:30.

It was in these circumstances that they encountered a thermal and shortly afterwards the in-flight breakage of the glider occurred.

Both pilots jumped overboard and the pilot in command parachute landed without mishap. The second pilot did not jump sufficiently clear of the glider and his parachute was caught up in some point of the glider, which dragged him with it until it crashed into the ground at a spot in the municipality of Campillo de la Jara in the province of Toledo, with coordinates N 39° 30.9' – W 005° 0.5', and he died.

2.2. Glider wreckage analysis

According to the pilot in command's own statement, after entering the thermal he realized that he had entered a situation of loss of control which he was unable to handle,

[2] The empty weight was 565 kg, to which has to be added the weight of the two adult men, estimated at 85 kg each one, plus the weight of the two parachutes, estimated at 15 kg.

whilst the glider's speed grew until it exceeded V_{NE} and the primary breakage of the right wing occurred in a section of the external wing.

In effect, the right wing structure failed in a location at approximately 7 m away from the glider's symmetrical vertical plane, and this failure was caused by positive bending. The left wing also broke in a similar station on the opposite side. In addition, the right wing broke in a location close to the root of the wing, in a station some 3.5 m away from the restraint.

The spreading of the wreckage over an area of 1,800 m in diameter confirms the pilot's statement that wing breakage occurred in flight at some considerable height. The different sections and loose fragments of the glider separated by the breakages followed different trajectories to the ground conditioned by their size, density, the moment of their separation and the action of the wind. Those of greatest density would have followed a ballistic trajectory established by their inertia and the acceleration of gravity. The descent of large pieces of average density would have also been influenced by their aerodynamic resistance. Those of least density and size could have gained height initially dragged along by the thermal current in which the glider was soaring, subsequently being carried by the wind for different time periods of the order of several minutes; these latter remains comprise the mass of small fragments indicated in Appendix B, Figure 1, separated by varying distances in a SE direction.

The SW-NE direction of the large-sized pieces of wreckage and the D, C, B, A alignment (see Appendix B, Figure 1) of the zones in which this wreckage was picked up suggests that this was the direction of the glider's flight when it tried to come out of the dive.

The first large separated fragment, the right wing tip, could have fallen in a place close to where the breakage occurred, Zone D.

The rest of the right wing would have broken immediately afterwards, having been picked up in Zone C.

The end of the left wing may have been initially dragged along by the main wreckage, subsequently falling in Zone B.

The major part of the wreckage, fuselage and the two sections of the left internal wing were found in Zone A, 1,800 m from the first Zone D. Due to the fact that the separated piece of the inboard part of the left wing was next to the other wreckage, it can be assumed that this breakage occurred in the impact with the ground.

It is estimated that the glider descended some 350 m or 400 m from its flying height on entering the thermal until the wing collapsed on exceeding V_D. Thus the flying height above ground at the moment of the structural failure would have been some 1,600 m and the speed would have been very high. From the dispersion of the wreckage it has to be recognized that the speed at which the glider came out of the dive exceeded the aircraft's design speed.

2.3. Similarities with the accident in Minden, Nevada

The accident referred to in this report has similarities with another accident which occurred one year previously in Minden, Nevada, USA.

In the Minden accident, the numerous statements taken coincide in the circumstances of the glider soaring in a thermal in the middle of the day, with strong thermals, and then falling into a spin and a steep dive, from which the pilot tried but was unable to regain control. In the Ocaña accident, the surviving pilot's statement indicates similar circumstances.

The symmetry of the wing breakages, which coincide in both accidents, the only difference being that the stations of the primary breakages are further outside, from 1.5 to 2 m in the present case, lead to the conclusion that the mechanics of the failure and the maneuvers that led to it were also similar.

Consequently, the Minden accident can provide information that is applicable to this new case.

2.4. Flight characteristics of the Nimbus 4DT's and pilot actions

Paragraph 1.6.6 above gives details of the procedures specified in the AFM for regaining flight control in cases of stall, spin and spiral dive. Other paragraphs give the different speed limits in the different configurations.

As regards the use of the aerodynamic brakes, which can be used in the whole speed range up to V_{NE}, the AFM recommends not to extend them at high speed except in an emergency or when maximum speed is accidentally exceeded. At the same time, a warning is given of the different pitch angle with the aerodynamic brakes extended.

It should be noted on the other hand that the glider is certified in the Normal category and that aerobatics are not permitted. Spinning is an aerobatic and therefore is not permitted; if a spin is accidentally entered, control must be regained immediately.

Several sources coincide in that this glider is very demanding as to the careful use of the control due to its tendency to undesired yaw and roll moments. It is recommended that the elevator control be handled gently, that is, in small smooth increments, at high speeds.

Tiredness after four hours of flight, a possible lack of oxygen in the case of the older pilot, flying at a medium height, slow reflexes, difficulties of vision at the base of the clouds, or even the onset of panic may have prevented rapid recovery from the beginning of loss of control induced in a turning flight in the middle of a turbulent thermal.

In a few seconds, a stall could have turned into the start of a spin, or rather a spiral dive.

The pilot stated that he did not extend the brakes, confirmed by the inspection of the wreckage, which would have limited the glider's speed, that he had flaps of +2°, with which its maximum speed was only 160 kph, and that he pulled the stick all the way back although at high speed deflection of only one third of the controls' run is permitted. He said nothing about using the rudder, which is necessary to stop rotation in the spin or spiral movement, but from the symmetry of the breakages it can be assumed that he managed to stop rotation around the longitudinal axis. The small force necessary to move the stick may have had an influence on the abrupt movement of the control that probably happened.

It should be remembered that the aircraft had only 25 flight hours, which was insufficient time for the pilot to familiarize himself with it and that the pilot was not in possession of the flight manual, which describes the emergency procedures.

All the evidence indicates that the aircraft's elevator control operated normally.

2.5. Structural behavior of the aircraft

The aircraft, flying with its maximum weight, tried to come out of a steep dive at high speed, imposing high aerodynamic lift loads on the wings. The wingtips would have bent upwards a great deal, in a similar way to that observed in the Nimbus 4DM in Minden, exceeding the dihedral angle of 45° and bearing load factors in excess of 5.3 g.

At a particular moment, the wing structure collapsed due to the enormous bending to which it was subjected. The wing's upper surface was stressed by compression and the lower surface by traction. This is further supported by the clean breakages of fibers in the lower surface and the loosening of panels and coverings of the upper surface's «sandwich» structures in the areas close to the primary failure sections, in the stations at 7 m in both wings.

Although there are no conclusive data to firmly establish the failure sequence, the breakage of the right wing close to the fuselage could be explained by a mechanism of dynamic response and reaction of the remaining structure to the breaking off of the end of the right wing and the sudden alleviation of the aerodynamic loads transmitted by that part. This mechanism was studied by the NIAR, with the assistance of Finite Element Methods, as it would seem that it appeared in that accident.

The results of the investigation carried out by the NIAR on the materials' properties, compliance of manufacture with the design and the wing spar's integrity, in which samples taken from the glider in that accident were analyzed, are directly applicable to this case. Therefore, it can be said that there is no evidence that manufacturing defects or faults in the materials used affected the structural failure and, consequently, it can be stated that the collapse was brought about by aerodynamic overloads with respect to design loads. These aerodynamic loads were the result of the high speed acquired by the aircraft and the brusque maneuvers carried out with the stick.

2.6. Survival aspects

As the collapse of the wing occurred at a height of some 1,600 m above ground, there was a high probability of being able to bale out with a successful opening of the parachute. In the case of the pilot in the front seat, he was able to bale out without mishap.

The rear pilot's seat is lower down in the fuselage than the front seat. As explained in the AFM, handles are provided on the rear instrument panel to help the pilot to raise him/herself and jump overboard. After the Minden accident report (see paragraph 1.16.1), some modifications were made to the Nimbus's rear cabin to facilitate in-flight evacuation.

Both pieces of information can lead to the suspicion that in conditions of uncontrolled fall with possible adverse inertia, the pilot in the rear seat had difficulties when trying to climb out, having to perform actions for which he would not usually have been trained. The loss of time and height would have prevented the parachute from unfolding normally.

3. CONCLUSIONS

3.1. Findings

- The 67 year old pilot was in possession of a valid flying license.
- The aircraft had a valid airworthiness certificate, in the Normal class, for which aerobatics were not permitted.
- The aircraft had accumulated 25 flight hours.
- The aircraft was operating with its maximum weight.
- The meteorological conditions were appropriate for this type of flight.
- The pilot, experienced in glider flying, had 36.5 FH in the type of aircraft involved in the accident.
- The pilot in command's flying capacity may have been negatively affected by tiredness and fatigue and a slight hypoxia, due to the flight's altitude and duration.
- The aircraft suffered an in-flight breakage whilst at an altitude of around 2,600 m during thermal soaring.
- Before the in-flight wing breakage, there was loss of control and the glider went into a spin or spiral dive.
- The wing structure failed due to severe bending during the pitch up maneuver to recover from the dive.
- No evidence has been found to doubt the glider's structural integrity. No manufacturing defects or abnormal behavior of the materials used in the glider's construction or flight controls were found.
- The pilot in command in the front seat saved his life by baling out.
- The pilot in the rear seat was able to get out of the cabin but the canopy of his parachute got caught up, in the air, with parts of the glider, which dragged him until it crashed into the ground, causing his death.

3.2. Causes

The causes that would explain the accident possibly occurred in the following sequence:

- There was loss of control during the flight in a turbulent thermal, probably caused by the combined effect of in-flight maneuvers:

  a) With a limited margin of speed above the minimum rate of descent speed, and
  b) With excessive roll angle for the flight in a circle within thermals,

  which led to the stall of the glider.
- The crew did not immediately correct the loss situation by using the controls as per the procedure established in the AFM, which resulted in the glider starting a spin or spiral dive in which it exceeded the maximum design speed.

— In the effort to come out of the dive, the aerodynamic forces produced exceeded the design load of the wing, causing its structural collapse.

Probably the pilot in the rear seat was unable to get out of the cabin in time and open his parachute successfully, virtually leaving him with little possibility of survival.

4. SAFETY RECOMMENDATIONS

None.

APPENDICES

APPENDIX A
Site and panoramic maps

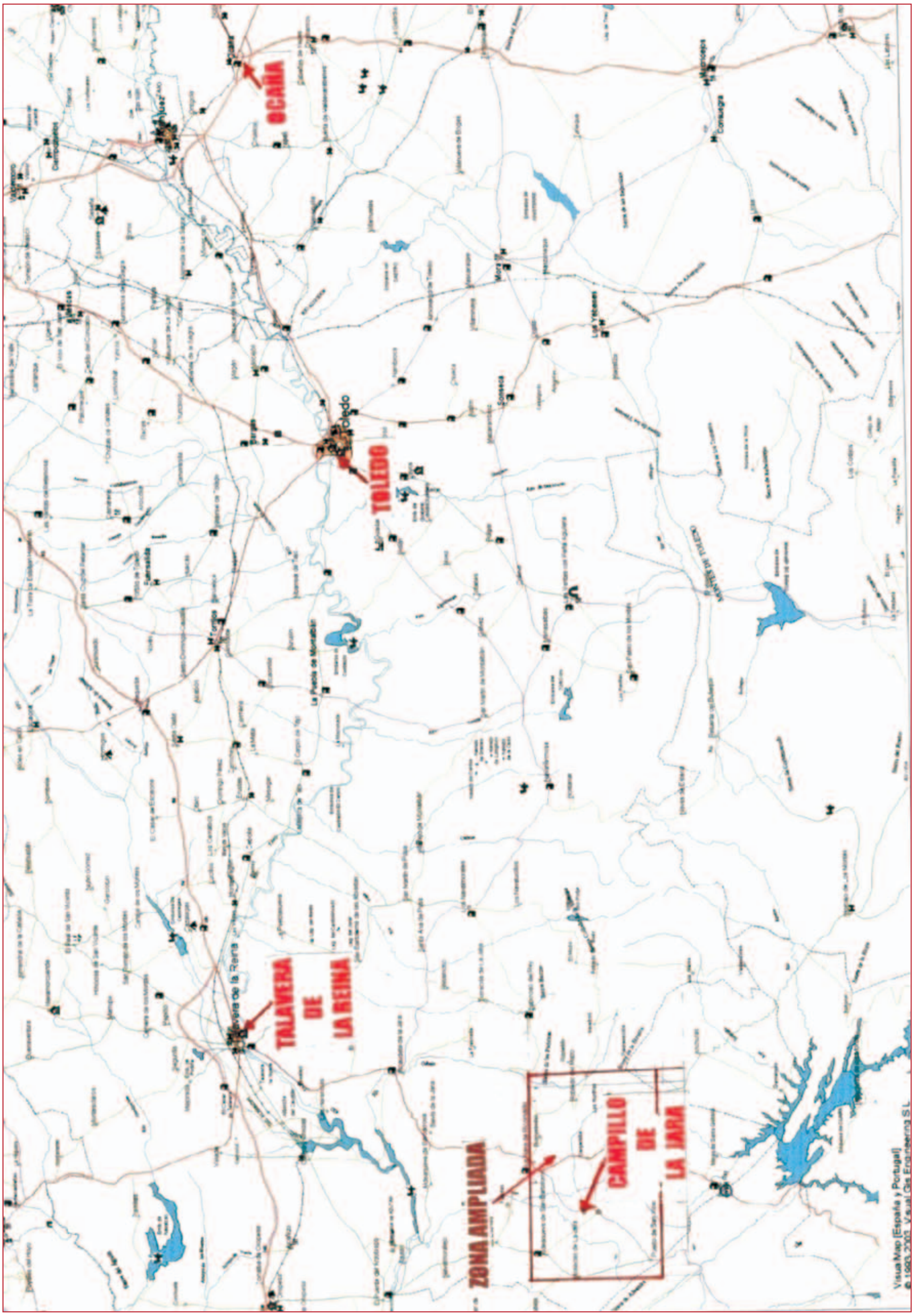


Figure A1. *General map of the area*

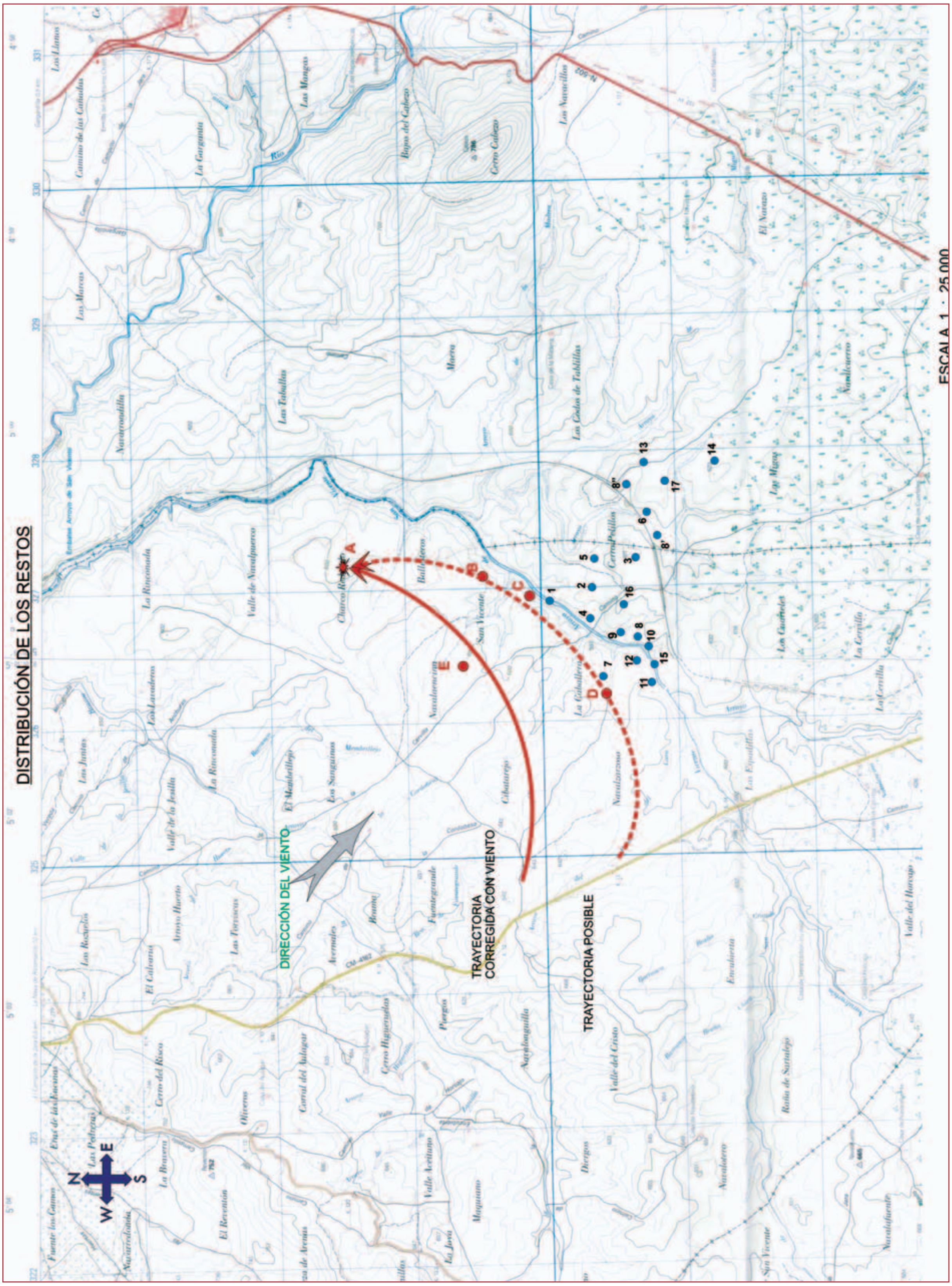


Figure A2. *Impact area*

Figure A3. *Panoramic views*

Figure A4. *Close-up of the fuselage and parachute wreckage*

APPENDIX B
Wreckage layout and impact zones

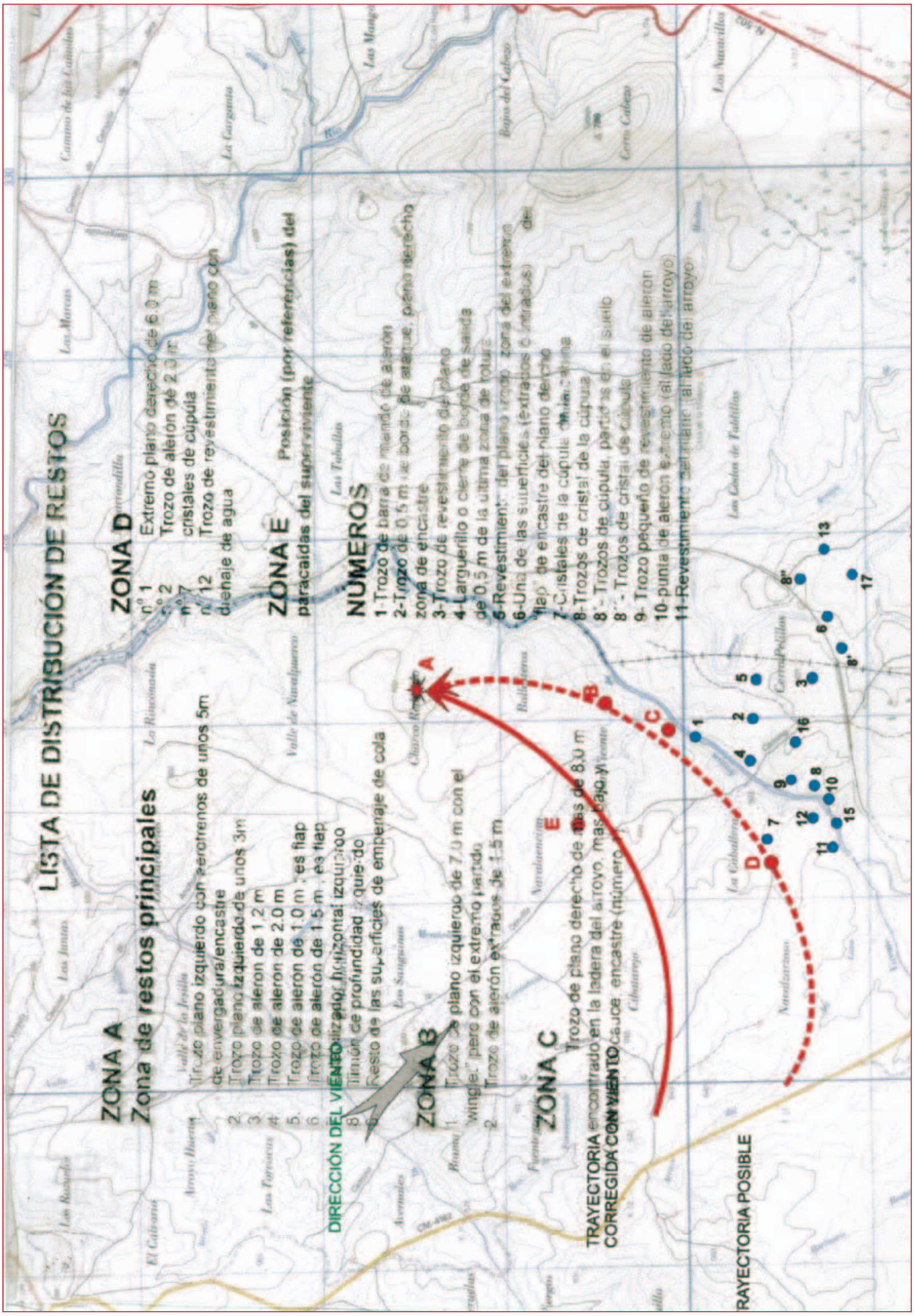
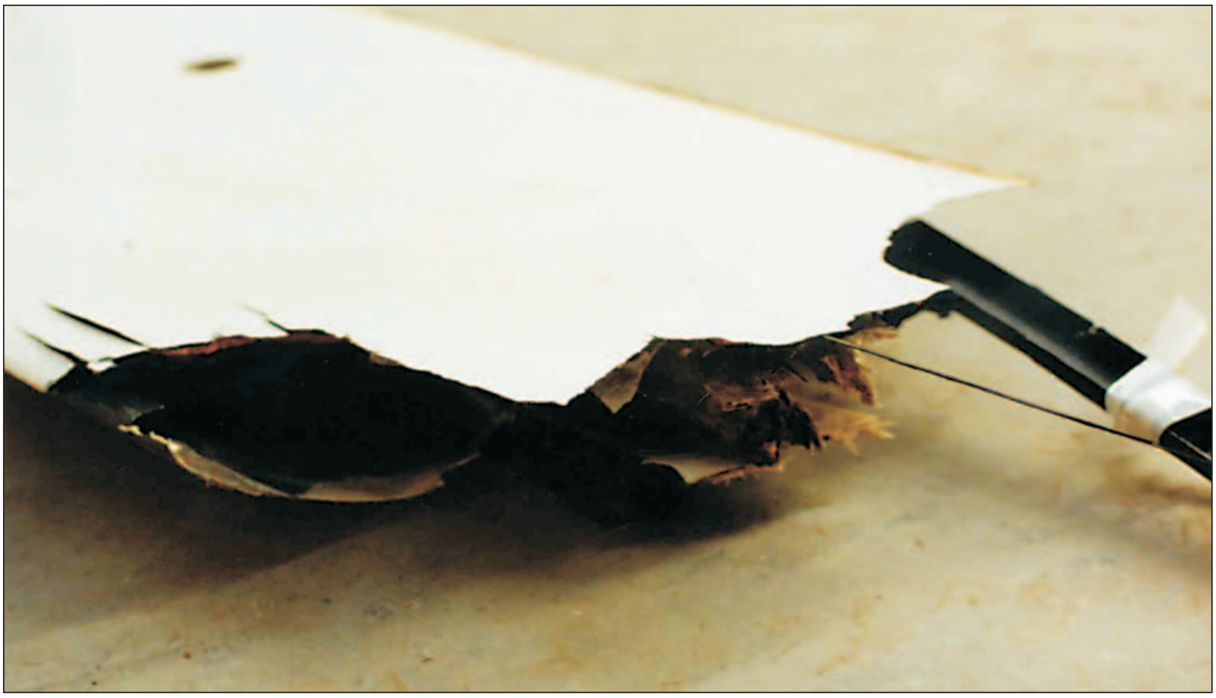


Figure B1. *Drawing showing the wreckage layout. Explanatory list*

APPENDIX C
Details of breakages

Wing breakages – General view of the wing

External breakages of the wing – Upper surface



External breakage to right wing – Bottom surface
(Breakage in the bottom surface is caused by traction, which is why it is cleaner)

External breakage of right wing – Upper surface

Internal breakage of right wing – Upper surface