# RESUMEN DE DATOS

## LOCALIZACIÓN

| | |
|---|---|
| Fecha y hora | **Jueves, 17 de enero de 2013; 17:26 h local** |
| Lugar | **Pista 28 del aeropuerto de Cuatro Vientos (Madrid)** |

## AERONAVE

| | |
|---|---|
| Matrícula | **EC-ICG** |
| Tipo y modelo | **PA-60-601P (Aerostar 601P)** |
| Explotador | **Privado** |

### Motores

| | |
|---|---|
| Tipo y modelo | **LYCOMING IO-540-S1A5** |
| Número | **2** |

## TRIPULACIÓN

### Piloto al mando

| | |
|---|---|
| Edad | **48 años** |
| Licencia | **PPL(A)** |
| Total horas de vuelo | **1.500 h** |
| Horas de vuelo en el tipo | **500 h** |

## LESIONES

| | Muertos | Graves | Leves/ilesos |
|---|---|---|---|
| Tripulación | | | **1** |
| Pasajeros | | | **1** |
| Otras personas | | | |

## DAÑOS

| | |
|---|---|
| Aeronave | **Menores** |
| Otros daños | **Ninguno** |

## DATOS DEL VUELO

| | |
|---|---|
| Tipo de operación | **Privado** |
| Fase del vuelo | **Carrera de aterrizaje** |

## INFORME

| | |
|---|---|
| Fecha de aprobación | **30 de octubre de 2013** |

# 1. INFORMACIÓN SOBRE LOS HECHOS

## 1.1. Reseña del vuelo

La aeronave, procedente del aeródromo de la Axarquía (Málaga) fue autorizada a aterrizar por la pista 28. La aproximación transcurrió con normalidad pero tras la toma de contacto el tren delantero cedió. La parte inferior del morro se apoyó sobre la superficie de la pista y se deslizó sobre ella hasta que el avión se detuvo en el último tercio de la pista. Los dos ocupantes resultaron ilesos y abandonaron inmediatamente la aeronave que sufrió desperfectos como consecuencia de la fricción del fuselaje con el asfalto.

Durante el tiempo que la pista permaneció ocupada por la aeronave, el resto de los tráficos que llegaban al aeropuerto, o bien aterrizaron en la pista de tierra existente en la zona militar del aeropuerto, o bien se desviaron a otro aeródromo cercano.

## 1.2. Información del personal

El piloto propietario de la aeronave, obtuvo su primera licencia de vuelo en el año 1998. Posteriormente obtuvo la habilitación de avión poli-motor, que se encontraba en vigor el día del incidente.

Desde su adquisición en el año 2003 volaba regularmente esta aeronave a razón de 50-100 h por año. Previamente había sido propietario de otras dos aeronaves, la última de las cuales era también un bimotor.

Su acompañante, aunque no era piloto, volaba asiduamente con él como pasajero.

## 1.3. Información de la aeronave

El Aerostar 601P es un bimotor presurizado de tren triciclo retráctil y con capacidad para piloto y 5 pasajeros[1]. Obtuvo su certificado de tipo en el año 1973.

La unidad del incidente, fabricada en 1979, acumulaba un total de 16.48:50 h de vuelo. Contaba con un certificado de revisión de la aeronavegabilidad (ARC) emitido por AESA el 3/07/2012 con una validez de un año. Era la única unidad de este modelo matriculada en España en la fecha de incidente.

[1] Desde el año 1991 Aerostar Aircraft Corporation es el titular del certificado de tipo que había estado anteriormente en poder de Piper Aircraft Corporation (desde 1978).

### 1.3.1. *Descripción del sistema de tren de morro*

El tren de aterrizaje retráctil es operado hidráulicamente. El tren de morro (Figura 1) se retrae por la acción de un actuador hidráulico (ítem 1) que al extenderse hace bascular el brazo de arrastre superior (ítem 2) que arrastra al brazo inferior (ítem 3) y éste a la pata (ítem 4). No hay elemento alguno de blocaje del tren en posición retraída de manera que una pérdida de presión hidráulica resulta en una extensión por gravedad. Al liberar la presión hidráulica del cilindro el peso de la propia pata comprime el vástago del actuador y la pata se extiende. Una vez extendida la pata, un sobre-centro (ítem 5) mantiene los dos brazos de arrastre alineados impidiendo que se plieguen y que la pata se retraiga. Un muelle (ítem 6) estira del sobre-centro para favorecer el blocaje.

En la articulación del sobre-centro se aloja un micro-interruptor encargado de enviar la señal de tren abajo y blocado (ítem 7).

El eje de giro del brazo de arrastre superior (ítem 8) va atornillado al propio brazo y gira en el interior de casquillos alojados en sendas vigas de sección en «U» que se hacen firmes a ambos lados del mamparo lateral izquierdo del pozo del tren mediante remaches (Figura 2). En el extremo exterior de dicho eje va montada una leva (ítem 9) que cuando el tren se retrae entra en contacto con un micro-interruptor (ítem 10) responsable de enviar la señal de tren de morro arriba.

Este diseño no exige ninguna acción especial en el caso de extensión del tren con fallo hidráulico siendo suficiente accionar la palanca de tren y esperar a que se extienda por gravedad.

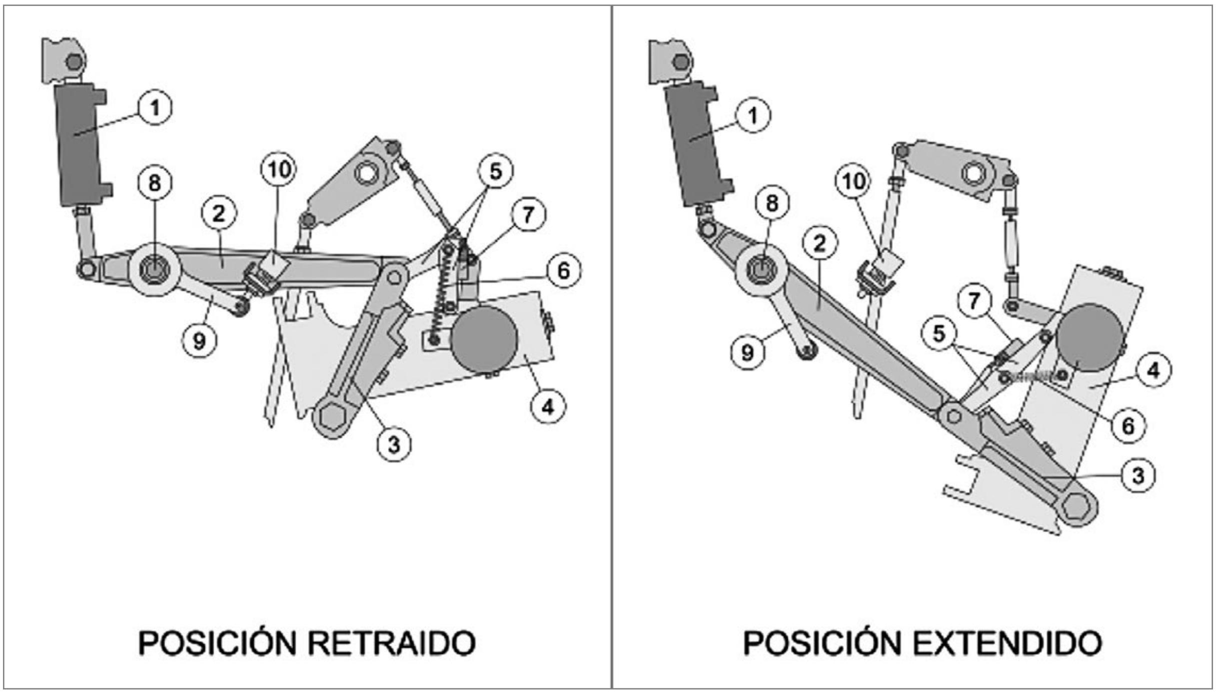


**Figura 1.** Esquema del tren de morro

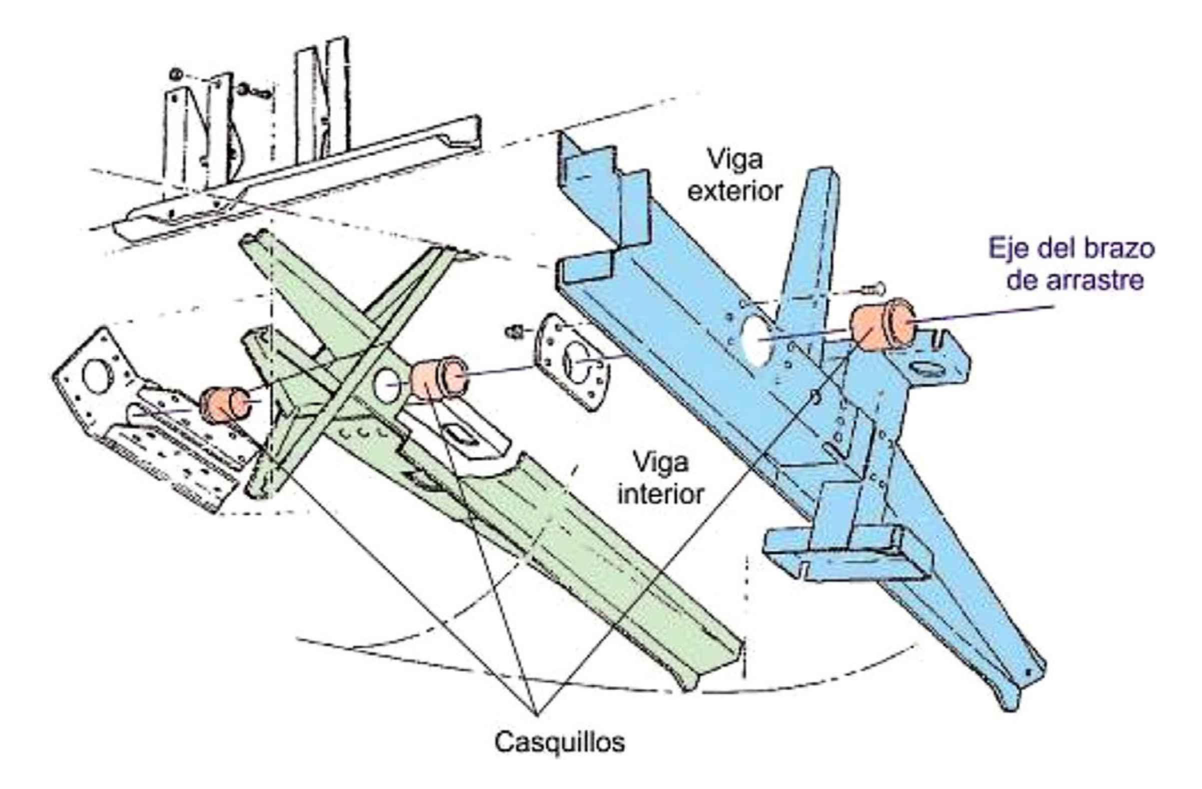


**Figura 2.** Vigas de sujeción del eje del brazo de arrastre principal

El tren de morro cuenta con cuatro compuertas. Las dos delanteras se abren y cierran completamente tanto al extender como al retraer el tren, mientras que las dos traseras permanecen abiertas con el tren extendido. La apertura y cierre de estas compuertas se consigue mediante un sistema de varillas que transmiten mecánicamente el movimiento a la pata del tren.

La rueda del tren de morro es orientable en un arco de 60° y su control se consigue mediante un actuador hidráulico que actúa así mismo como amortiguador de vibraciones («anti-shimmy»). La línea hidráulica de este sistema accede al pozo del tren a través de su mamparo posterior.

La palanca de accionamiento del tren se encuentra en la parte central del panel de instrumentos. La posición de tren abajo se indica en cabina mediante tres luces verdes que se encienden cuando, con la palanca en la posición correspondiente, los micro-interruptores de cada pata mandan la señal de tren abajo y blocado. La indicación de tren arriba la proporciona una sola luz ámbar que se enciende cuando recibe la señal de otros tres micro-interruptores. No hay indicación alguna asociada al tránsito del tren. El correcto funcionamiento de todas estas luces se puede comprobar presionando sobre ellas.

La posición del tren puede ser observada directamente desde la cabina del avión, para el caso del tren principal e indirectamente para el caso del tren de morro, mediante el reflejo de esta en alguno de los conos de las hélices.

En previsión de un inadvertido accionamiento de la palanca del tren a su posición de retraído estando el avión en tierra, el avión dispone de un miro-interruptor («squat-switch») instalado en la pata de morro que envía una señal que bloquea la palanca del tren de aterrizaje cuando el amortiguador se encuentra comprimido.

El avión cuenta también con una bocina y una luz roja de aviso en caso de que la presión de admisión a los motores no supere las 14 in Hg (gases retrasados) y el tren de aterrizaje no se encuentre en posición extendido y blocado.

Los flaps, que pueden deflectarse hasta los 45°, se accionan hidráulicamente al igual que el tren.

### 1.3.2. *Historial de mantenimiento*

Conforme al programa de mantenimiento[2] la aeronave ha de ser sometida a revisiones programadas a intervalos de 50 h, 100 h (o anual), 500 h y 1000 h. Ni en el listado de elementos con vida límite, ni en el programa de inspecciones estructurales aplicable a las versiones presurizadas de este avión hay requisito alguno referente a revisar las vigas en «U» que aloja el eje de giro del brazo principal.

La última tarea de mantenimiento programada a la que fue sometida la aeronave fue una revisión de 100 h, en abril de 2012. En esta revisión se ha de comprobar el estado general del tren de aterrizaje, procediendo al engrasado de sus partes móviles y realizando una prueba funcional del mismo. No hay ningún requerimiento específico para revisar la viga en busca de grietas. En esta ocasión también se sustituyó la cubierta de la rueda del tren de morro por desgaste.

Posteriormente, en el mes de octubre de 2012, el avión tuvo un problema con la compuerta de la pata izquierda del tren principal. El problema se resolvió sustituyendo una electroválvula del sistema hidráulico. Según el personal de mantenimiento responsable de estos trabajos, una vez reparados los desperfectos, se realizaron los reglajes necesarios y las pruebas funcionales del tren en su conjunto que resultaron satisfactorias. Los registros asociados a estas tareas no muestran acciones específicas en el tren de morro.

Durante la revisión anual anterior, en marzo del 2011, se detectó una grieta en la viga interior de sujeción del eje del brazo de blocaje superior del tren de morro. Se reparó remachando una chapa de refuerzo por encima de la zona de la grieta. Para realizar esta reparación no se utilizó documentación específica del fabricante, que no cuenta con un documento para reparaciones estructurales y se remite a un documento de la

[2] Programa de Mantenimiento con referencia de aprobación: PM.ICG rev. 2 19/06/2012.

FAA[3]. También en esta revisión se sustituyó un casquillo de una de las articulaciones de las barras de bloqueo al detectar una holgura excesiva. Aparte de esta reparación no hay datos de modificación o refuerzo alguno de la estructura original.

## 1.4. Información meteorológica

Los informes de observaciones de aeródromo (METAR) indicaban buenas condiciones de visibilidad con pocas nubes a 3.000 ft y viento de 7 kt aproximadamente alineado con la pista (dirección variable entre 230° y 290°).

La información proporcionada por el controlador a la aeronave momentos antes del aterrizaje era de viento medio de 7 kt con rachas máximas de 15 kt y dirección 230°.

En el vuelo previo con origen Cuatro Vientos y destino la Axarquía, a la hora del aterrizaje el viento en la zona del aeródromo era fuerte con rachas de hasta 50 km /h.

## 1.5. Comunicaciones

La torre de Cuatro Vientos comunicó con normalidad tanto con la aeronave protagonista del incidente, como con otros tráficos que se encontraban en el entorno del aeropuerto. Tras el incidente la torre también estableció comunicaciones con los servicios del aeropuerto, con el centro de control de área de Madrid y con la torre del aeropuerto de Getafe.

A las 16:22:50 h el piloto notificó su posición próxima al circuito de aeródromo. El controlador de torre solicitó que notificara una vez establecido en viento en cola izquierda de la pista 28.

A las 16:23:57 h ya en final, el piloto solicitó información de viento que le fue proporcionada por el contralor.

A las 16:24:36 h Torre autorizó el aterrizaje.

A las 16:26:26 h el controlador ordenó frustrar la aproximación a la aeronave que seguía en la secuencia de aterrizajes, desvió a éste y a otro tráfico a puntos de espera en el entorno del aeródromo y solicitó intenciones al piloto de la aeronave que permanecía en la pista.

A las 16:27:22 h informó al servicio contraincendios de la posición y estado de la aeronave autorizando su entrada en el área de movimientos.

[3] AC.43.13.-1B Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair. En su punto 4.4 el documento proporciona directrices para las reparaciones en piezas metálicas.

A continuación se produjeron diversas llamadas para coordinar las actividades de los servicios de emergencia en pista, e intercambiar información con la oficina ARO[4]. El controlador avisó al centro de control de área de Madrid y a la torre de Getafe sobre lo ocurrido en previsión de que fuera necesaria su asistencia para gestionar los tráficos con destino Cuatro Vientos.

A las 16:35:48 h, tras recibir de los bomberos información sobre que las tareas de limpieza de la pista se demorarían algún tiempo, el controlador transmitió a todas las estaciones (en español e inglés) informando del cierre temporal del aeropuerto por accidente en la pista.

## 1.6. Información del aeropuerto

El aeropuerto cuenta con una pista (28/10) asfaltada de 1.500 m de longitud. Dentro de la zona militar del aeródromo, junto a la pista de asfalto y paralela a ella hay una pista de terreno natural de 1.127 m de longitud.

## 1.7. Ensayos e investigaciones

### 1.7.1. *Declaraciones de piloto y acompañante*

El piloto indicó que tras el despegue de la Axarquía, la luz ámbar indicadora de tren arriba no se encendió. Permaneció un tiempo en la vertical del campo para comprobar el estado del tren. Su sensación fue que las velocidades y ruido aerodinámico eran congruentes con la configuración de tren retraído. Además observó la situación del tren de morro por su reflejo en uno de los conos de la hélice (procedimiento que utilizaba habitualmente) comprobando que estaba arriba al igual que el principal que pudo observar de manera directa a través de las ventanas.

La luz se mantuvo apagada durante todo el vuelo. Antes del aterrizaje, en el circuito de Cuatro Vientos, comprobó la posición del tren tanto a través de la indicación de cabina (tres luces verdes indicativas de abajo y blocado) como directamente observando a través de las ventanas.

La aproximación y la toma fueron normales. Manifestó que el viento no era preocupante aunque había algo.

Tras el contacto con el tren principal, el avión posó la pata de morro, momento en el que percibió un ruido extraño, como un golpe súbito. El avión continuó rodando unos instantes hasta que el tren cedió, apoyó el morro en la pista y lo arrastró hasta que se detuvo. Todavía en carrera cortó la mezcla, depósitos, magnetos y máster. Aunque no pudo precisar el tiempo con exactitud, su percepción fue que los bomberos llegaron al lugar rápidamente.

[4] Oficina de Notificación de Tránsito Aéreo. Es la designada para la presentación y aprobación de los planes de vuelo.

Recordaba que en dos inspecciones pre-vuelo de vuelos anteriores al incidente había observado que las compuertas delanteras del tren de morro no estaban cerradas. En la primera ocasión se trató de una apertura parcial que después se hizo más evidente. Consultó telefónicamente con el taller de mantenimiento que no vio mayor problema siempre que comprobara que las compuertas seguían firmes a las varillas y no estaban sueltas. Acordaron que se revisaría ese punto en la siguiente visita al taller.

Preguntado sobre la toma previa en la Axarquía confirmó que efectivamente fue un vuelo con bastante turbulencia aunque no percibió que la toma hubiera sido especialmente dificultosa. No recordaba una toma especialmente dura en los últimos vuelos aunque tampoco lo descartó categóricamente. Si mencionó un antecedente en este sentido pero mucho tiempo atrás (un año y medio o dos antes) en el que en una toma con viento racheado el avión «se desplomó» sobre la pista instantes antes de la toma de contacto. Sin embargo no lo consideró lo suficientemente importante como para informar de ello al taller de mantenimiento.

Su acompañante no observó nada anormal durante la aproximación y corroboró la versión del piloto sobre un golpe súbito en carrera y la sensación de que el tren cedió después de que el avión rodara normalmente durante los instantes posteriores al contacto con la pista.

### 1.7.2. *Declaración del controlador*

El circuito y aproximación de la aeronave transcurrieron con normalidad. Notificó viento existente que era de 7 kt prácticamente alineado con la pista. Era el primero en la secuencia de aterrizaje sin tráfico precedente.

Un par de segundos después de la toma notó como el avión caía sobre el morro y poco después observó chispas y llamaradas bajo el morro. Se mantuvo más o menos en el centro de la pista y se detuvo en el último tercio de la pista.

Inmediatamente activó la alarma e informó al tráfico que venía detrás, que frustró la aproximación. Llamó a la aeronave sin obtener respuesta pero enseguida vio salir a una persona. Comunicó al Servicio de Extinción (SEI) la posición y tipo de aeronave y tras consultar con la oficina ARO, el número de personas a bordo.

La pista estuvo cerrada hasta las 17:19 h (unos 50 min). Otras aeronaves se desviaron a alternativos o aterrizaron en la pista de tierra previa autorización del control militar.

### 1.7.3. *Inspección de los restos*

La posición de los interruptores y mandos del sistema eléctrico (master, alternadores) y suministro de combustible (mezcla y potencia) eran congruentes con lo que el piloto declaró haber hecho durante la carrera de aterrizaje.

La palanca del tren estaba en posición de tren abajo.

Los flaps estaban desplegados a una posición intermedia (20°) y coherente con lo seleccionado en la palanca correspondiente.

La viga en «U» que aloja el eje sobre el que pivota el brazo de arrastre superior del tren de morro, estaba partida a la altura del alojamiento por donde se desplaza la varilla de accionamiento de la compuerta delantera izquierda. La parte de la viga por delante de dicho alojamiento había perdido los remaches que la sujetan al mamparo lateral y estaba suelta (Figura 3 y Figura 4).

Sobre la viga se identificó una marca con tinte rojo junto a una grieta que comenzaba en el orificio de un tornillo de sujeción de la pieza al mamparo (véase Figura 6). El personal del taller no pudo aclarar su origen, indicando que probablemente ya existiera cuando el avión se llevó al taller por primera vez en 2007. Se contactó con otros dos talleres que realizaron tareas de mantenimiento en el avión con anterioridad sin que en ninguno de ellos se conservaran registros que evidenciaran la detección y seguimiento de esta grieta.

La chapa que se había utilizado para reforzar la zona donde se había detectado una grieta dos años antes, presentaba así mismo una grieta.

Esta pieza se envió a un laboratorio para el análisis de la rotura.

**Figura 3.** Pozo del tren delantero. Se observa la zona de fractura y la pérdida de remaches de la viga de sujeción del brazo de arrastre

Figura 4. Viga una vez desmontada

La viga que aloja la prolongación del eje del brazo al otro lado del mamparo también estaba rota de manera que el eje se había desplazado de su posición. Debido a este desplazamiento, con la pata en posición retraída, la leva adosada al eje y que hace contacto con el micro-interruptor responsable de enviar la señal de tren arriba, no alcanzaba su posición nominal y no llegaba a contactar con el micro-interruptor (Figura 5).

Figura 5. Leva y micro-interruptor de tren arriba

No se observaron marcas o señales de impacto en la goma de la rueda del tren delantero que había sido sustituido recientemente. El neumático izquierdo si presentaba un desgaste puntual fuerte compatible con una toma dura.

La tubería de retorno de hidráulico del actuador estaba rota, posiblemente como consecuencia del desplazamiento del propio actuador al ser arrastrado por el brazo de blocaje en el desplazamiento del eje de éste (Figura 6).

Como consecuencia de la pérdida de rigidez del sistema de blocaje ocasionada por la rotura y desplazamiento de la viga, la pata basculaba en exceso hacia atrás de manera que su estructura entraba en contacto con el mamparo trasero del pozo del tren en el mismo punto en el que éste presentaba un impacto. En esta zona del mamparo se aloja un codo de la línea de hidráulico del sistema de control direccional de la rueda de morro que se había partido (Figura 7).

Las compuertas de la pata de morro presentaban daños compatibles con el arrastre sobre la superficie del asfalto.

Se comprobó el funcionamiento del sistema de alerta de posición del tren que fue satisfactorio.

**Figura 6.** Retorno de la línea hidráulica que alimenta el actuador

**Figura 7.** Impacto en el mamparo posterior y zona de la pata responsable del mismo

El sistema de protección de retracción en tierra también funcionaba correctamente, bloqueando la palanca de tren con el amortiguador comprimido.

#### 1.7.3.1. Análisis de la viga en laboratorio

Los análisis indicaron que el material se corresponde con una aleación de aluminio del tipo AW 2024 sin aparentes defectos o heterogeneidades micro-estructurales en las zonas de fallo.

El estudio reveló la existencia de zonas de fallo con características diferentes.

Por un lado los orificios de los remaches en la zona delantera superior de la pieza presentaban una micro-morfología característica de un progreso de fatiga. Su incubación se desarrolló a través de un número alto de ciclos que se prolongaron a lo largo de un periodo relativamente largo como muestran los signos de corrosión encontrados. La zona del extremo de la pieza, que había sido reparada y el orificio del tornillo de sujeción marcado con tinte rojo también presentaban grietas por fatiga de la misma naturaleza.

Por el contrario la fractura de la zona central de la viga, que había partido la pieza en dos mitades, había sido producida por un mecanismo de desgarro dúctil, típico de este material cuando es sometido a un sobre esfuerzo. También los remaches de sujeción de la pieza al fuselaje más próximos a esa zona central rompieron por este mecanismo dúctil. De igual manera en la zona del brazo que permaneció unida al mamparo tanto en la fractura transversal del cuerpo del brazo, como en los remaches, se identificó una fractura por sobre esfuerzo.

El estudio del laboratorio concluyó que la probable secuencia de rotura comenzaría con la incubación y desarrollo del mecanismo de fatiga que se propagaría en forma de grietas en las zonas de la unión remachada. Una vez debilitadas estas uniones, la viga se vería sometida a esfuerzos de flexión, lo que provocaría la rotura de los remaches contiguos y en última instancia la rotura del cuerpo central y el brazo de la viga.

### 1.7.4. *Otra información*

El titular del certificado de tipo ha manifestado no tener conocimiento de antecedentes similares en los que el tren de morro haya cedido por fallo de esta estructura, aunque sí ha sido objeto de reparaciones en otras aeronaves.

Aerostar también informó de que se ha desarrollado un kit de refuerzo de la viga exterior al mamparo para inhibir las grietas en esa zona. El departamento de ingeniería está evaluando la posibilidad de hacer lo propio para la viga interna. No ha sido posible confirmar si el motivo de estos refuerzos y reparaciones es la recurrente aparición de grietas por fatiga, ni ha sido posible recabar información detallada sobre las modificaciones (como su fecha de aprobación, aplicabilidad o los detalles de las instrucciones de implementación).

Durante la investigación no se han encontrado antecedentes de accidentes o incidentes relacionados con la rotura por fatiga de esta pieza en otras unidades de este modelo de avión.[5]

## 2. ANÁLISIS Y CONCLUSIONES

Ni de los testimonios de piloto y controlador, ni del estado del neumático delantero, se desprende que la toma en Cuatro Vientos fuera excepcionalmente dura, como para justificar por sí misma la rotura de la viga de sujeción del sistema de blocaje y el subsiguiente colapso del tren de morro.

La paulatina degradación de la estructura que aloja el eje del brazo de arrastre sería fruto de la progresión de las grietas por fatiga iniciadas en diversos puntos de su viga interior y explicaría la aparición de las sucesivas anomalías detectadas por el piloto.

En un primer estadio de degradación de la viga, con el avión en tierra, se modificaría ligeramente el ángulo de la pata en su posición extendida y blocada. Puesto que el movimiento de las varillas que accionan las compuertas del tren viene determinado por la posición de la pata, una modificación de este ángulo llevaría aparejado un cambio en la posición de las varillas al final del recorrido de extensión lo que afectaría a la posición de las compuertas que fue detectado por el piloto en las inspecciones pre-vuelo.

Los esfuerzos asociados a los subsiguientes rodajes, carreras de despegue, ciclos del tren y aterrizajes (entre ellos la última toma en la Axarquía en condiciones de fuerte viento) deteriorarían aún más la estructura de las vigas de manera que en último vuelo de retorno a Cuatro Vientos, aún con el tren retraído la leva que activa el micro-interruptor de luz ámbar indicativa de tren arriba no alcanzaría su posición por la acción del peso de la pata.

Accionada la palanca para extender el tren antes de la última toma, éste caería por gravedad y, en ausencia de cargas hasta el contacto con la pista, completaría su recorrido nominal enviando la señal para el encendido de la luz verde en cabina con normalidad.

En este punto el debilitamiento de la estructura la incapacitaría para soportar los esfuerzos asociados a la toma. La pérdida de rigidez del sistema de blocaje permitiría

[5] Consulta realizada en la base de datos on-line del NTSB (National Transportation Safety Board) de los EE.UU.

cierto movimiento de la pata que podría golpear el mamparo trasero del pozo del tren probablemente durante los primeros metros de la carrera lo que explicaría el golpe seco sentido por el piloto y la rotura de la línea de hidráulico que lo atraviesa. El retorno del circuito hidráulico de accionamiento del tren se rompería al desplazarse en exceso el extremo del pistón que se articula en el extremo del brazo de blocaje. Ambas pérdidas de hidráulico se habrían producido ya en tierra por lo que no habrían afectado ni a la retracción del tren tras del despegue ni a la extensión de los flaps previa a la toma.

Según los resultados del laboratorio, la pieza que falló presentaba grietas por fatiga, una de las cuales había sido detectada y marcada aparentemente para asegurar su localización y seguimiento, si bien no fue posible determinar quién lo hizo, ni dónde ni cuándo. La reproducción de la grieta en la zona reparada por el taller, denota la naturaleza persistente del problema.

En ausencia de instrucciones de mantenimiento de la aeronavegabilidad específicas para la monitorización o control de posibles grietas en la estructura que falló, tampoco hubo un seguimiento continuado de estos antecedentes que podría haber ayudado a anticipar la progresión generalizada de la fatiga en la pieza y que en última instancia originó su debilitamiento y rotura.

Las consultas realizadas tanto directamente al fabricante como a la bases de datos del NTSB no han proporcionado información sobre antecedentes que permitan determinar si el nivel de incidencia de la fatiga en la pieza que falló pudiera requerir acciones correctoras, ya fuera de mantenimiento o de ingeniería, aplicables a la flota aún en servicio. Aunque el fabricante ha comunicado que ha desarrollado y sigue desarrollando actividades relacionadas con el aumento de la resistencia de esta estructura, no ha proporcionado información suficiente que permita evaluar mínimamente estas actividades y en particular si su aplicación a este caso hubiera resultado útil.

La monitorización de la toma por parte del controlador de torre permitió la inmediata alerta del servicio de extinción de incendios así como la gestión de los otros tráficos que o bien se desviaron a sus alternativos o aterrizaron por la pista de tierra disponible en la zona militar del aeródromo.

## 3. CAUSAS

El incidente se produjo por la rotura de la estructura de sujeción del brazo de arrastre superior del tren de morro, como consecuencia de un proceso generalizado de fatiga del material.

## RESUMEN DE DATOS

### LOCALIZACIÓN

| | |
|---|---|
| Fecha y hora | **Viernes, 11 de octubre de 2013; 12:50 h local[1]** |
| Lugar | **Proximidades del aeródromo de Benabarre (Huesca)** |

### AERONAVE

| | |
|---|---|
| Matrícula | **EC-XFO** |
| Tipo y modelo | **AKRO PIRAT** |
| Explotador | **Privado** |

#### Motor

| | |
|---|---|
| Tipo y modelo | **ROTAX 582** |
| Número | **1** |

### TRIPULACIÓN

#### Piloto al mando

| | |
|---|---|
| Edad | **55 años** |
| Licencia | **Piloto de ultraligero (TULM)** |
| Total horas de vuelo | **9.000 h** |
| Horas de vuelo en el tipo | **145 h** |

### LESIONES

| | Muertos | Graves | Leves/ilesos |
|---|---|---|---|
| Tripulación | | | **1** |
| Pasajeros | | | |
| Otras personas | | | |

### DAÑOS

| | |
|---|---|
| Aeronave | **Importantes** |
| Otros daños | |

### DATOS DEL VUELO

| | |
|---|---|
| Tipo de operación | **Aviación general – Privado** |
| Fase del vuelo | **Maniobrando – Acrobacia** |

### INFORME

| | |
|---|---|
| Fecha de aprobación | **27 de enero de 2014** |

# 1. INFORMACIÓN SOBRE LOS HECHOS

## 1.1. Reseña del vuelo

El viernes 11 de octubre de 2013 el propietario y constructor de la aeronave ultraligera (ULM) de construcción por aficionado, Akro Pirat, con matrícula EC-XFO, se encontraba practicando una tabla de entrenamiento de acrobacia sobre el aeródromo de Benabarre (Huesca), como preparación para su participación en la Copa Pirineos de acrobacia aérea que se iba a celebrar durante los dos días siguientes en el mismo aeródromo.

A la salida de una maniobra el piloto oyó un ruido extraño e inmediatamente después la aeronave entró en barrena. Trató de recuperar el control del avión, y al actuar sobre los mandos apreció que, aunque aparentemente no había perdido capacidad de mando, la aeronave no reaccionaba de la forma esperada.

A la vista de la situación, el piloto decidió activar el paracaídas de emergencia que equipaba la aeronave, produciéndose su despliegue rápidamente. Seguidamente el piloto paró el motor y cortó el interruptor general (master). La aeronave descendió suavemente colgada del paracaídas, y cuando estaba ya a muy poca altura sobre el terreno impactó contra un árbol, quedando detenida junto a éste.

**Figura 1.** Vista general de la aeronave

La aeronave quedó apoyada sobre el morro, con su eje longitudinal formando un ángulo de unos 45° con la horizontal, de manera que la cola quedaba levantada.

El piloto sufrió lesiones de carácter leve en la nariz y pudo abandonar la aeronave por sus propios medios.

## 1.2. Daños sufridos por la aeronave

La aeronave tuvo daños en la estructura del plano izquierdo que afectaron negativamente su resistencia.

Asimismo, el lanzamiento del paracaídas de la aeronave y el impacto final de ésta contra el suelo produjeron daños en la cabina y en la parte delantera del fuselaje.

### 1.3. Información sobre el personal

El piloto disponía de licencia de piloto de ultraligero emitida inicialmente el 11/07/1988, y con validez hasta el 16/04/2014, y de las siguientes habilitaciones:

- Desplazamiento del centro de gravedad (DCG), válida hasta 16/04/2014.
- Instructor vuelo ultraligero FI (ULM), válida hasta 16/04/2014.

Su experiencia total de vuelo alcanzaba 9.000 h, de las que 145 h las había realizado en aeronaves del tipo de la del incidente. Asimismo, acumulaba una experiencia en vuelo acrobático de unas 250 h.

Disponía de un certificado médico válido hasta el 15/03/2014 (clase 2).

### 1.4. Información sobre la aeronave

La aeronave del accidente tenía la denominación Akro Pirat y había sido construida por su propietario (construcción por aficionado) con el número de serie 99047-1321.

Estaba equipada con un motor Rotax 582 de dos cilindros en línea de 580,7 $cm^3$ de cilindrada, adaptado para vuelo invertido, que proporciona una potencia máxima de 65 HP a 6.500 rpm.

Disponía de un certificado de aeronavegabilidad especial restringido, en las categorías: privado – 3 – normal – ULM, cuya validez alcanzaba hasta 13/05/2015.

Su peso en vacío es de 170 kg y el máximo al despegue de 295 kg.

En el momento del accidente la célula tenía 145 h de vuelo, en tanto que el motor alcanzaba 750 h.

### 1.5. Inspección de la aeronave

El piloto y constructor de la aeronave volvió al aeródromo de Benabarre el día siguiente al del accidente y estuvo inspeccionando la aeronave.

Comprobó que todas las superficies de mando estaban en su sitio, que tenían plena libertad de movimiento y que se mantenía la continuidad de mando entre ellas y la palanca de control/pedales.

Observó que había una ligera holgura en la unión del estabilizador horizontal con el fuselaje. No obstante, no parecía que esta circunstancia fuese suficiente para justificar el comportamiento de la aeronave.

Después observó que el plano izquierdo mostraba una deformación importante (borde de ataque hacia arriba) cuya causa no era muy evidente, ya que no se apreciaba ningún impacto en el plano que lo hubiera podido producir, y que además este plano no había llegado a entrar en contacto con el suelo durante el aterrizaje. Debido a que el plano no dispone de ningún registro, no pudo observarse la estructura interior.

Por otra parte, advirtió que el paracaídas había sufrido daños de importancia, encontrándose rotas algunas de sus costuras (véase figura 2).

Posteriormente se desmontaron los planos, lo que permitió comprobar que la deformación que presentaba el plano izquierdo se debía a la rotura de varias costillas.

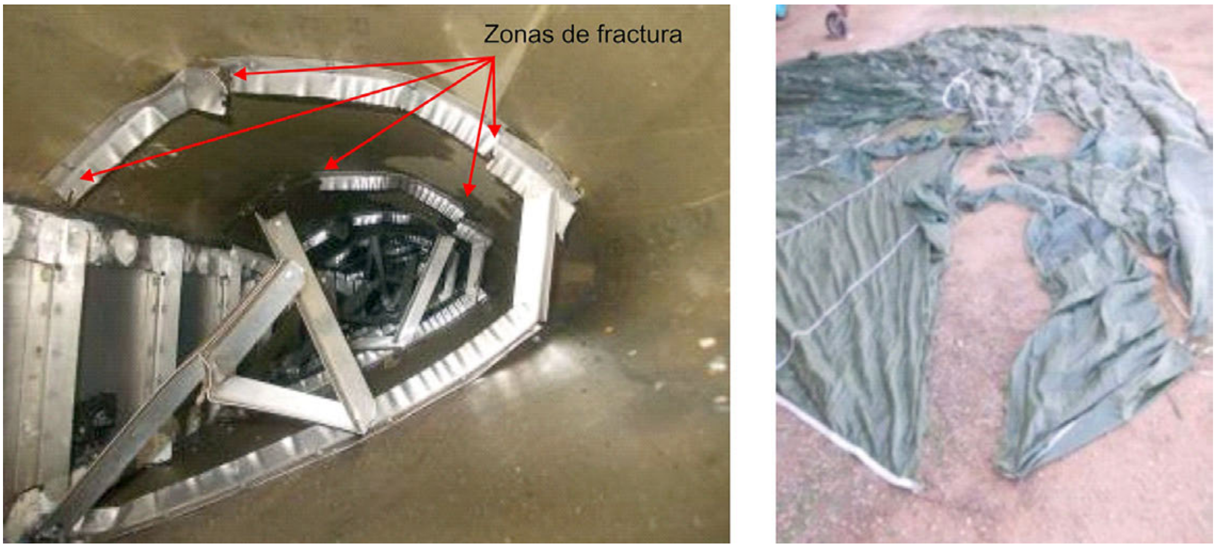


**Figura 2.** Fotografías del interior del plano izquierdo y del paracaídas

## 1.6. Ensayos e investigaciones

### 1.6.1. *Declaración del piloto*

Se había desplazado hasta el aeródromo de Benabarre (Huesca) ya que tenía previsto participar en el campeonato Pirineos de acrobacia que se iba a celebrar durante el fin de semana.

Estuvo practicando alguna de las maniobras que habría de hacer en el campeonato, comprobando posteriormente en el medidor de g que lleva la aeronave, que se habían alcanzado factores de carga de hasta 6,5 g, que está ligeramente por encima del valor de carga límite de diseño de la aeronave, que es de 6,0 g.

Por ese motivo realizó una revisión detallada de la aeronave, no encontrando ningún daño ni anomalía.

El día anterior al de comienzo del campeonato, se encontraba realizando una tabla de entrenamiento de acrobacia. Al salir de una maniobra, que no era especialmente fuerte, oyó un ruido raro y, prácticamente a la par, la aeronave entró en una barrena acelerada. Tras ello notó que el tacto de los mandos no era el habitual, y que la aeronave no reaccionaba de la forma esperada a las acciones que hacía sobre los mismos.

En ese momento la aeronave se encontraba cayendo casi en picado, por lo que decidió activar el paracaídas de emergencia con el que está equipada la aeronave, que se desplegó rápidamente. El paracaídas al desplegarse produce el desprendimiento de la capota de la cabina. Una vez que se cercioró del correcto despliegue del paracaídas, paró el motor y desconectó el interruptor general (master).

La aeronave descendió suavemente colgada del paracaídas. Debido a la posición del anclaje de las sujeciones del paracaídas, durante el descenso la aeronave adopta una posición de fuerte morro abajo (alrededor de 45°).

Recordaba que estando la aeronave muy próxima al suelo chocó contra un árbol y cree que alguna de las ramas pudo golpearle, aunque no estaba seguro si fue en ese o en otro momento cuando se golpeó en la nariz.

Cuando la aeronave quedó detenida, se desabrochó el cinturón y salió de ella, echando a andar en dirección al aeródromo. Poco después se dio cuenta de que estaba sangrando por la nariz.

Respecto a si llevaba puesto casco indicó que solamente llevaba un casquete con los auriculares.

### 1.6.2. *Declaración de testigos*

#### 1.6.2.1. Testigo

Declaró que estaba en el aeródromo observando a la aeronave, que estaba ejecutando una tabla acrobática.

En un momento dado, encontrándose la aeronave a una altura de entre 200 y 250 m sobre el suelo, oyó un sonido similar al de un cohete e inmediatamente observó que se desplegaba un paracaídas de la aeronave. Añadió que antes de este ruido no escuchó ni observó nada anómalo en la aeronave.

El avión descendió suavemente colgado del paracaídas (descenso lento y girando como en una barrera), cayendo en una zona de carrasca próxima al aeródromo. Indicó que percibió que durante el descenso se paró el motor.

Avisó telefónicamente a los servicios de emergencia y junto con otras personas se dirigieron hacia el lugar donde había caído la aeronave, que localizaron unos 8 minutos después.

## 2. ANÁLISIS

### 2.1. Análisis del vuelo

El vuelo en el que ocurrió el accidente tenía como objeto el ensayo de una tabla de maniobras acrobáticas que el piloto tenía previsto realizar durante los dos días siguientes, en el marco de una competición de acrobacia.

Durante la realización de una de las maniobras el piloto escuchó un sonido extraño, e inmediatamente después la aeronave entró en barrena.

En la inspección efectuada posteriormente a la aeronave se comprobó que varias costillas del plano izquierdo se encontraban rotas.

De acuerdo con lo declarado por el piloto, durante el vuelo de entrenamiento que realizó con anterioridad al del suceso se alcanzaron valores del factor de carga de hasta 6,5 g, que está ligeramente por encima del valor de carga límite de diseño de la aeronave, que es de 6,0 g.

Tras este vuelo el piloto inspeccionó exteriormente la aeronave sin observar nada anómalo. No obstante, al no disponer la aeronave de registros en los planos que permitieran visualizar el interior, no pudo comprobar el estado de la estructura interna del plano (largueros, costillas, larguerillos, etc.), siendo verosímil la hipótesis de que en ese momento ya existiera alguna grieta en alguno de estos elementos.

Durante el vuelo del accidente, esa grieta o grietas pudieron progresar siguiendo un mecanismo de rotura progresiva, que iría produciendo una minoración de la resistencia de los elementos afectados. La resistencia de dichos elementos continuó disminuyendo hasta que se hizo menor que las solicitudes a las que se encontraban sometidos, produciéndose entonces la rotura instantánea por sobrecarga.

La falla de varias costillas produjo una modificación de la geometría del plano, que a su vez provocó una alteración importante en sus características aerodinámicas, que se hizo patente en el extraño comportamiento de la aeronave que apreció el piloto.

La decisión que tomó el piloto de activar el paracaídas de emergencia, se considera que fue plenamente acertada, ya que las condiciones aerodinámicas del plano izquierdo habrían dificultado enormemente, o tal vez imposibilitado, el control de la aeronave. Es más, cabe la posibilidad de que de haberse continuado el vuelo, el mecanismo de rotura estructural hubiera continuado progresando, lo que habría agravado la situación.

Con respecto a los daños que mostraba el paracaídas, el piloto y constructor de la aeronave opinaba que se habían producido por dos circunstancias. De una parte, que la capacidad del paracaídas estaba demasiado ajustada al peso de la aeronave, y de otra que la activación la realizó cuando la aeronave se encontraba cayendo en picado a gran velocidad y con el motor a plena potencia. Al estar la aeronave en actitud de picado, la tracción proporcionada por la hélice tendería a aumentar aún más la velocidad de descenso.

A fin de mejorar estas deficiencias, el piloto y constructor de la aeronave considera que debería remplazar el paracaídas por otro de mayor capacidad, así como modificar su sistema de activación, con objeto de que simultáneamente actúe también sobre el motor produciendo su parada.

La rotura del paracaídas debió comenzar durante los primeros instantes tras su activación, y fue progresando durante el descenso, de manera que la disminución de su capacidad de retención fue paulatina, lo que permitió que la aeronave llegara al suelo con poca velocidad.

## 3. CONCLUSIONES

Se considera que este accidente fue causado por la rotura de varias costillas del plano izquierdo de la aeronave durante el vuelo, propiciada probablemente por la existencia de daños estructurales previos, que modificaron sustancialmente sus características aerodinámicas.

## RESUMEN DE DATOS

### LOCALIZACIÓN

| | |
|---|---|
| Fecha y hora | **Sábado, 30 de noviembre de 2013; 11:30 h local[1]** |
| Lugar | **Término municipal de Marines (Valencia)** |

### AERONAVE

| | |
|---|---|
| Matrícula | **EC-YEM** |
| Tipo y modelo | **AVID FLYER STOL** |
| Explotador | **Privado** |

#### Motores

| | |
|---|---|
| Tipo y modelo | **ROTAX 582** |
| Número | **1** |

### TRIPULACIÓN

| | Piloto | Copiloto |
|---|---|---|
| Edad | **64 años** | **34 años** |
| Licencia | **Piloto de ultraligero (TULM)** | **Piloto de ultraligero (TULM)** |
| Total horas de vuelo | **500 h** | **2.000 h** |
| Horas de vuelo en el tipo | **35 h** | **400 h** |

### LESIONES

| | Muertos | Graves | Leves/ilesos |
|---|---|---|---|
| Tripulación | | | **1** |
| Pasajeros | | | **1** |
| Otras personas | | | |

### DAÑOS

| | |
|---|---|
| Aeronave | **Importantes** |
| Otros daños | **Ninguno** |

### DATOS DEL VUELO

| | |
|---|---|
| Tipo de operación | **Aviación general – Privado** |
| Fase del vuelo | **En ruta – Crucero** |

### INFORME

| | |
|---|---|
| Fecha de aprobación | **27 de febrero de 2014** |

[1] Para hallar la hora UTC hay que restarle una unidad a la hora local.

# 1. INFORMACIÓN SOBRE LOS HECHOS

## 1.1. Descripción del suceso

La aeronave Avid Flyer Stol de construcción por aficionados, con matrícula EC-YEM, había despegado a las 10:35 h con dos ocupantes a bordo, del campo de vuelos de El Gramizal que está en Olocau[2] (Valencia), donde tenía su base.

Hicieron un vuelo de 55 min alrededor del campo realizando varias tomas y despegues. El piloto iba sentado a la izquierda, y a su derecha iba el Jefe de vuelos del campo que solamente se encargaba de las comunicaciones.

De acuerdo con el relato de los ocupantes, cuando estaban a 600 ft de altura sobrevolando el término municipal de Marines (Valencia), el motor empezó a fallar y el copiloto tomó los mandos por ser el más experimentado de los dos. Retrasó la palanca de gases y el motor dejó de dar síntomas de fallo, pero al volver a acelerar, el motor empezó a fallar de nuevo. Repitió la misma acción un total de tres veces y finalmente el motor se paró.

A continuación eligió un campo de labor[3] para hacer una toma de emergencia, y realizó un viraje de 90° a la izquierda y otro de 180° a la derecha para alinearse con


**Figura 1.** Fotografía de la aeronave después del accidente

[2] El centro de vuelos de Olocau, está situado 35 km al norte de Valencia, y cuenta con una pista de hierba de 650 m, designada como 15/33, y una elevación de 220 m sobre el nivel del mar.

[3] Era un campo de labor donde había sembradas coliflores, que se caracteriza por estar constituidos por surcos paralelos de hasta 30 cm de profundidad.

los surcos que presentaba el terreno, y luego aterrizaron. Al tocar en el suelo, el tren delantero quedó clavado en el terreno y se rompió, haciendo que la aeronave capotara y volcase quedando en posición invertida.

Los ocupantes resultaron ilesos y pudieron salir por sus propios medios.

La aeronave resultó con daños en el ala, en el tren, en la cola y en la parte delantera, rompiéndose la hélice por su mitad[4].

## 1.2. Información personal

El piloto, de 64 años de edad, tenía licencia de piloto de ultraligero (TULM) desde 1990. Su experiencia era de 500 h, y de ellas en el tipo había volado aproximadamente 35 h.

El copiloto, de 34 años de edad, tenía licencia de piloto de ultraligero (TULM) desde 1998, habilitación de instructor de ultraligero FI (ULM), y habilitación de radiotelefonía nacional. Su experiencia era de 2.000 h, de las cuales 400 h las había hecho en el tipo.

La licencia las habilitaciones y el certificado médico de ambos estaban en vigor.

## 1.3. Información sobre la aeronave

La aeronave AVID FLYER STOL (S/N 31/89) es un biplaza de construcción por aficionados que fue fabricada a partir de un kit en 1991.

Su peso en vacío era 193 kg, y su peso máximo al despegue 379 kg.

Iba equipada con un motor ROTAX R-582 (S/N 4016304), de 65 CV de potencia que es de dos tiempos, con dos cilindros y refrigeración líquida.

En noviembre de 2011, se hizo una reparación importante en el taller que el distribuidor tiene en España, en la que se sustituyeron muchos de los elementos más importantes.

La última revisión de mantenimiento (anual) del motor se había realizado el 11 de mayo de 2013 cuando el motor tenía 1.159:54 h, y desde entonces acumulaba 40 h de funcionamiento.

[4] El suceso fue comunicado a la CIAIAC varios días después de ocurrir el accidente y después de que se retirara la aeronave, lo que impidió realizar una investigación en el lugar donde cayó.

## 1.4. Inspección del motor

Durante la investigación se realizó una primera inspección en el hangar donde tenía su base la aeronave, y se constató que había combustible en los depósitos y que no estaba obstruido el sistema de suministro. Se desmontó el motor y se envió al taller del distribuidor en España, donde se realizó una inspección detallada en la que se encontraron daños compatibles con un fuerte impacto contra el terreno, y se evidenció lo siguiente:

- Los radiadores estaban tapados por unas aletas, lo que supone que se caliente en exceso cuando la temperatura exterior es elevada y se enfríe mucho cuando la temperatura es baja.
- La bomba de combustible estaba bien colocada, pero no iba apoyada en «silentblocks»[5], lo que hace que la membrana esté sometida a mayores vibraciones.
- El escape estaba limpio.
- La tubería que iba al radiador no era la original, sino que se había sustituido por otra usada en fontanería.
- Al desmontar el radiador se vio que estaba llenó de agua, lo que le hacía más vulnerable a corroerse más rápidamente.
- La tubería que salía de la bomba de combustible era muy larga, y al funcionar por depresión pierde mucha efectividad.
- Los dos carburadores que llevaba estaban bien montados, y los filtros no estaban obstruidos.
- Se les probó sometiéndoles a una depresión (succión) y se constató que no tenían pérdidas, y se sacó la cubeta de ambos comprobando que los flotadores hacían su función correctamente.
- La cubeta de uno de los carburadores tenía suciedad acumulada en el fondo, que podría atascar el chiclé que hay a la salida y hacer que el motor se parase.
- En lo que a las válvulas se refiere, no se observaron deformaciones en los respectivos asientos, ni había tolerancias excesivas. El disco giraba bien y la puesta a punto era correcta.
- Los cilindros eran originales de fábrica y no se habían rectificado nunca, no obstante el color del sensor que hay situado entre las válvulas indicaba que el motor había estado sometido a un calentamiento excesivo pero sin llegarse a gripar.

## 1.5. Información adicional

El Real Decreto 389/1998 sobre investigación de accidentes e incidentes de aviación civil, que es la normativa que aplica a las aeronaves de construcción por aficionados, establece en sus artículos 15 y 16 la obligatoriedad para todas las personas de notificar

[5] Acrónimo en inglés de un mecanismo que es un bloque silencioso antivibratorio hecho de material flexible que permite absorber vibraciones y choques entre los componentes mecánicos y la estructura sobre la que está apoyado.

inmediatamente a las autoridades los accidentes o incidentes de los cuales hayan tenido conocimiento. Las Autoridades a su vez tienen la obligación de comunicarlo lo antes posible a la CIAIAC.

La Ley 7/2003 de Seguridad Aérea, que también aplica a las aeronaves de construcción por aficionados, en su artículo 16 también establece la obligatoriedad de comunicar lo antes posible a la CIAIAC a las autoridades aeronáuticas, los responsables de las instalaciones y los servicios de navegación aérea, los propietarios, explotadores y tripulantes de las aeronaves involucradas y las personas y entidades relacionadas con el suceso

## 2. ANÁLISIS

No se pudo realizar una investigación completa en el lugar del accidente porque el suceso no fue comunicado a la CIAIAC hasta varios días después.

En este sentido la normativa que regula el uso de aeronaves por aficionados dice claramente que los ocupantes de la aeronave deberían haber notificado el accidente a la CIAIAC lo antes posible, por lo que conviene recalcar lo importante informar cuanto antes al tener conocimiento de un accidente, para facilitar el inicio de la investigación lo más rápidamente posible y evitar que se pierdan evidencias que impidan por un lado determinar la causa del accidente y por otro sacar conclusiones que permitan avanzar en la mejora de la seguridad aérea.

En lo que a la investigación propiamente dicha se refiere, durante la inspección que se realizó en el hangar donde estaba basada la aeronave se descartó que la parada del motor sobreviniera por falta de combustible, ya que los depósitos albergaban una cantidad suficiente, y las líneas de conducción no estaban obstruidas.

Al estudiar el motor en profundidad se encontraron algunas evidencias de que no se había realizado un buen mantenimiento del mismo, como por ejemplo el hecho de que la tubería que iba al radiador no fuera la original y se hubiera sustituido por otra construida de un material que se suele usar en instalaciones de fontanería.

Aunque no se encontraron pruebas determinantes que fueran suficientemente claras como para explicar una parada de motor, si se hallaron una serie de indicios que en determinadas condiciones podrían conducir a una parada del motor, como por ejemplo la suciedad acumulada en el fondo de la cubeta de uno de los dos carburadores, que podría haber atascado el siclé que hay a la salida produciendo una parada.

Respecto a la operación, es lógico que fuera el jefe del campo de vuelos el que tomase los mandos, dado que tenía mayor experiencia.

De acuerdo con su relato no tomó en el primer campo que tenía delante de él, sino que realizo virajes a ambos lados buscando un campo que no tuviera obstáculos y presentase mejores condiciones. Estando a 600 ft de altura no es fácil apreciar la profundidad de los surcos que había, por lo que la elección del campo parece acertada en principio, al estar nivelado. También fue correcto realizar la toma paralela al sentido de dichos surcos.

## 3. CONCLUSIONES

Durante la investigación no se ha podido determinar la causa exacta de la parada de motor, pero se ha podido constatar que el motor tenía un mantenimiento deficiente que lo hacían proclive a un tener mal funcionamiento.

## 4. RECOMENDACIONES

Ninguna.

# ADDENDA

# Foreword

This Bulletin 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 object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1, 4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

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

This Bulletin was originally issued in Spanish. This English translation is provided for information purposes only.

## Abbreviations

| | |
|---|---|
| 00° | Degree(s) |
| 00 °C | Degree(s) centigrade |
| AC | Airworthiness Certificate |
| ACAS | Airbone Collision Avoidance System |
| ACC | Area Control Center |
| ACSS | Aviation Communication & Surveillance System |
| AD | Airworthiness Directive |
| AENA | Aeropuertos Españoles y Navegación Aérea |
| AESA | Spanish National Aviation Safety Agency |
| AGRO | Agricultural spraying |
| AIP | Aeronautical Information Publication |
| APP | Approach Control Office |
| APU | Auxiliary Power Unit |
| ARC | Airworthiness Review Certificate |
| ARO | Air Traffic Services Reporting Office |
| ATC | Air Traffic Control |
| ATPL(H) | Air Transport Pilot License (Helicopter) |
| ATZ | Aerodrome Traffic Zone |
| BEA | Bureau de Enquetes Aeronautiques |
| CAA | UK Civil Aviation Authority |
| CAMO | Continuing Airworthiness Management Organization |
| CHT | Cylinder Head Temp |
| CIAIAC | Comisión de Investigación de Accidentes e Incidentes de Aviación Civil de España (Spain's Civil Aviation Accident and Incident Investigation Commission) |
| CPL(A) | Commercial Pilot License (Airplane) |
| CPL(H) | Commercial Pilot License (Helicopter) |
| CRM | Crew Resource Management |
| CVR | Cockpit Voice Recorder |
| DGAC | Civil Aviation General Directorate |
| EASA | European Aviation Safety Agency |
| EGT | Exhaust Gas Temp |
| EU | European Union |
| FAA | Federal Aviation Administration |
| FAF | Final Approach Fix |
| FFF | Firefighting |
| FFS | Firefighting Service |
| FH | Flight Hours |
| FL | Flight Level |
| FMS | Flight Management System |
| ft | Feet |
| ft/min | Feet per minute |
| GPS | Global Positioning System |
| h, Hr | Hour(s) |
| HDG | Heading |
| HP | Horse Power |
| IAC | Instrument Approach Chart |
| IAF | Initial Approach Fix |
| IAX | Ibiza Approach Sector |
| IF | Intermediate Fix |
| IFR | Instrument Flight Rules |
| ILS | Instrumental Landing System |
| IRX | Ibiza Route sector |
| JAA | Joint Aviation Authorities |
| JAR-FCL | Joint Aviation Regulations – Flight Crew Licenses |
| kg | Kilogram(s) |
| km | Kilometer(s) |

# Abbreviations

| | |
|---|---|
| km/h | Kilometer(s) per hour |
| kt | Knot(s) |
| LEIB | Ibiza Airport ICAO code (Spain) |
| LECP | Palma Area Control Center (Spain) |
| LFMN | Nice Airport ICAO code (France) |
| LLZ | Localizer |
| LoA | Letter of Agreement |
| LPPR | Porto Airport ICAO code (Portugal) |
| LH | Left Hand |
| LT | Local Time |
| m | Meter(s) |
| MCC | Multi Crew Cooperation/Coordination |
| METAR | Aviation routine weather report |
| MLS | Microwave Landing System |
| MSB | Manufacturer's Service Bulletin |
| MSL-GML | Mean Sea Level |
| MTOW | Maximum Take Off Weight |
| N1 | Engine fan speed |
| N2 | Maximum turbine RPMs |
| NM | Nautical Mile(s) |
| NTSB | National Transportation Safety Board (USA) |
| OM | Operations Manual |
| PPL(A) | Private Pilot Licence (Airplane) |
| QNH | Altimeter sub-scale setting to obtain elevation when on the ground |
| RA | Resolution Advisory |
| RCA | Spain's Air Traffic Regulations |
| RH | Right Hand |
| RPM | Revolutions per minute |
| RWY | Runway |
| S/N | Serial Number |
| STAR | Standard Instrumental Arrival |
| SB | Service Bulletin |
| TA | Traffic Advisory |
| TACC | Terminal Area Control Center |
| TCAS | Traffic Collision Avoidance System |
| TCM | Teledyne Continental Motors |
| TDC | Top Dead Center |
| TMA | Traffic Management Area |
| TOT | Turbine Outlet Temperature |
| TQ | Torque supplied by the engine |
| TWR | Control Tower |
| UTC | Universal Time Coordinated |
| VMC | Visual Meteorological Conditions |
| $V_{NE}$ | Velocity not to be exceded |

# DATA SUMMARY

## LOCATION

| | |
|---|---|
| Date and time | **Saturday, 18 June 2011; 17:15 local time** |
| Site | **Tabuyo del Monte (León, Spain)** |

## AIRCRAFT

| | |
|---|---|
| Registration | **SP-SUI** |
| Type and model | **PZL W-3AS** |
| Operator | **LPU Heliseco sp. z o.o.** |

### Engines

| | |
|---|---|
| Type and model | **PZL-10W** |
| Number | **2** |

## CREW

| | Pilot in command | Copilot |
|---|---|---|
| Age | **52 years old** | **38 years old** |
| Licence | **ATPL(H)** | **CPL(H)** |
| Total flight hours | **7,075 h** | **859 h** |
| Flight hours on the type | **1,700 h** | **622 h** |

## INJURIES

| INJURIES | Fatal | Serious | Minor/None |
|---|---|---|---|
| Crew | | | **2** |
| Passengers | | | **9** |
| Third persons | | | |

## DAMAGE

| | |
|---|---|
| Aircraft | **Destroyed** |
| Third parties | **Trees at the crash site** |

## FLIGHT DATA

| | |
|---|---|
| Operation | **Aerial work – Commercial – Training** |
| Phase of flight | **Takeoff – Initial climb** |

## REPORT

| | |
|---|---|
| Date of approval | **30th October 2013** |

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

Minutes before 15:00[1] on 18 June 2011, the crew of a PZL W-3AS aircraft, registration SP-SUI, commenced with the engine start procedure. Weather conditions were suitable for the flight. After two attempted stand-alone engine starts, first with the #2 engine and then with the #1, they had to resort to the external auxiliary power unit (APU) to start the #1 engine, followed by the #2.

The flight was scheduled to be a training flight for one of the firefighting brigades stationed at the Tabuyo del Monte base in León, located at an elevation of 986 m. They were going to fly to an area located some 10 km away from the base. The flight crew[2] assembled by the operator consisted of a captain, sitting in the no. «2» position in the cockpit, and another pilot seated in the no. «1» position who would be the pilot flying, and who would be supervised by the captain.

The brigade boarded the helicopter when instructed by the crew. After securing the tool they were carrying in the space allocated for that purpose, the brigade members took their seats and fastened their seatbelts.

The helicopter started its takeoff at 15:14:08 on a heading of 305°. The crew confirmed that the cockpit instruments were in the green normal operating region and after yawing slightly left and a short taxi run on the ground, they started climbing 10 seconds later and turned right. The ground below was at a 6% incline.

Twelve seconds later (15:14:30), with the aircraft at a radio-altitude of 45 m (147 ft), a difference in the torque readings for the two engines of 12% was recorded, after which the turbine gas exhaust temperature for the #1 engine (TOT_1), which at that instant was 614° C, and the #1 engine compressor RPMs (N1_1) started to decrease gradually while the #1 engine torque (TQ_1) rose rapidly.

Eleven seconds later (15:14:41) the pilot flying (in the «1» position) is heard on the cockpit voice recorder considering a return to base and reporting on the radio "we're going back", immediately followed by "yours" as he transferred control to the captain. Four seconds later (15:14:45) the difference in the torque readings between the two engines was 80%, N1_1 (RPMs) was at 77% and the temperature (TOT_1) had fallen to 490 °C.

[1] All times in this report are in UTC. To obtain local time, add two hours to UTC.
[2] The minimum crew required for a PZL W-3AS aircraft is one pilot seated in the LH seat in the cockpit (the «1» position). The «2» position is in the RH seat in the cockpit.

The helicopter maintained its altitude above the ground thanks to the downslope of the hill they were flying over. The crew continued to manage the emergency while they tried to clear a power line that cut across their path.

Another 11 seconds later (15:14:56), the captain is heard on the cockpit voice recorder saying “the other one, downward”, to which the pilot in the «1» position asks, ”number two?”, with the captain replying “two, down a little”.

At 15:15:15 the helicopter crashed as it made contact with the tops of some pine trees some 200 m away from the takeoff location.

The aircraft fell on its right side. Its main rotor blades broke and the tail cone separated from the central part of the frame, which had been pierced by a tree trunk (Figure 1).

The aircraft’s occupants were uninjured or had light bruises.

Figure 2 shows the path taken by the aircraft as determined from global positioning system (GPS) data. The timestamps are those recorded by the GPS.

**Figure 1.** Aircraft wreckage

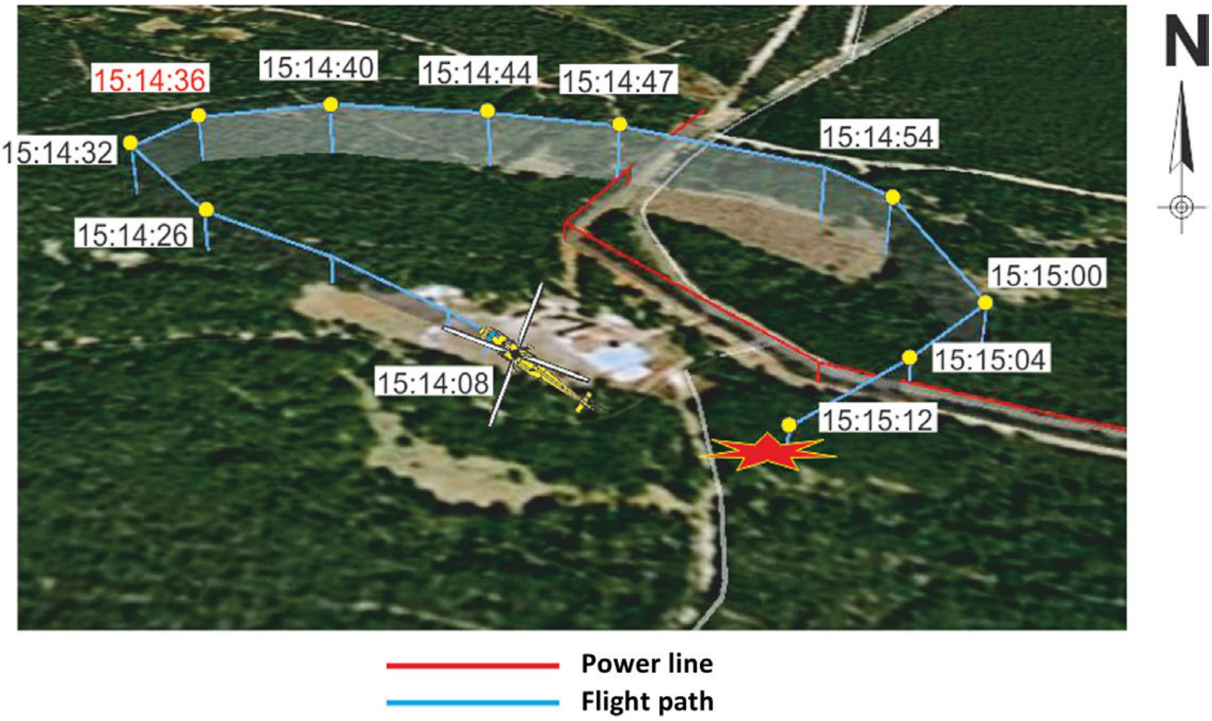


Figure 2. Path taken by the aircraft

## 1.2. Personnel information

Both pilots had valid licenses and medical certificates, which were in compliance with the Joint Aviation Requirements for Flight Crew Licensing (JAR-FCL) approved by the Joint Aviation Authorities (JAA). They had also taken part in the refresher training required for the aircraft type.

The pilot in «1» position used to fly for Spanish operator of aerial works Hispánica de Aviación, S.A., alternating with other flights for Polish operator LPU Heliseco Sp. Z.o.o. He had recently started flying as captain in flights for this operator. This experience lasted for some three hours.

The pilot in the «2» position was of a different nationality than the pilot supervising him and had considerable flying experience. As experienced pilot he had the status of base chief for his operator.

This distribution and function of each of the pilots in the cockpit was due to the fact the pilot in position «1» was at the beginning of his training period as captain for the Polish operator.

Both pilots flew basically the same aircraft type and model and during this flight the communications between them took place in Spanish.

### 1.2.1. *Pilot in the «1» position*

| | |
|---|---|
| Age: | 38 |
| Nationality: | Spanish |
| Flight license: | CPL(H)[3] |
| | • Initial issue date: 14/06/2005<br>• Expiration date: 24/07/2014 |
| Class 1 medical certificate: | • Date renewed: 7/04/2011<br>• Expiration date: 21/04/12 |
| Valid ratings and expiration dates: | • W-3 Sokol: 28/02/2012<br>• Agricultural (firefighting only): 31/05/2012 |

Training: CRM[4] aptitude check by refresher training on 7/02/2011

Training courses received from operator Heliseco Sp. Z.o.o. covering: organization and regulations of the aerial operations; introduction to regulations Part M and Part 145 of airworthiness and maintenance; minimum equipment list and technical logbook onboard helicopters.

### 1.2.2. *Pilot in the «2» position*

| | |
|---|---|
| Age: | 52 |
| Nationality: | Polish |
| Flight license: | ATPL(H)[5] |
| | • Initial issue date: 3/04/2006<br>• Expiration date: 23/03/2016 |
| Class 1 medical certificate: | • Date renewed: 10/01/2011<br>• Expiration date: 10/01/2012 |
| Valid ratings and expiration dates: | • TR W-3 Sokol: 20/11/2011<br>• TR Mi2: 4/02/2012<br>• AGRO (Agricultural spraying), 4/02/2013<br>• FFF (firefighting), 20/11/2011 |

Training: MCC – Multi Crew Cooperation/Coordination, valid until 28/02/2012

Spanish competence certificate and specific vocabulary.

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[3] CPL(H): Commercial Pilot License (Helicopter).
[4] CRM: Crew Resource Management.
[5] ATPL(H): Airline Transport Pilot License (Helicopter).

## 1.3. Aircraft information

The PZL W-3AS aircraft, manufactured by PZL-Świdnik, is equipped with two PZL-Rzeszów PZL-10W engines. The aircraft's weight at the start of the operation was 5,929 kg. Its maximum takeoff weight (MTOW) was 6,400 kg.

The aircraft had a valid airworthiness certificate issued by the Polish authority and had been maintained in accordance with the approved maintenance program.

According to the aircraft logbook, it had a total of 3,076 flight hours. The engines had been installed in April 2011. They, along with the airframe, underwent 300-hr inspections on 6 June 2011. They had been flown a total of three hours between then and the date of the accident.

The aircraft manual specifies that the minimum flight crew is one crewmember seated in the LH seat, and two crewmembers for instrument flight (IFR).

### 1.3.1. *Brief description of the aircraft's controls and devices*

ALAE-2

This unit electronically controls the fuel flow to the engine. It automatically keeps it from functioning above its limits and stabilizes its operation. It relies on information from various parameters, primarily N1, TQ, TOT and maximum turbine RPMs (N2), which it processes before sending the fuel supply signals to the corresponding engine.

ALRT-2B

A hydromechanical limiter that regulates the speed of the power turbine. It is located next to the engine and it takes over the functions of the ALAE-2 if it fails.

The operation of ALAE-2 and ALRT-2B is mutually exclusive, meaning they can provide the same functions but not at the same time. If the pilot selects MANUAL on the engine power control lever, then ALRT-2B takes over and the automatic engine fuel control system (ALAE-2) can only be reengaged once the helicopter is on the ground.

ALRP-5

This unit controls the direct supply of fuel to the engine based on the signals it receives from ALAE-2. Inside this unit is WLP-3-5, an electrical actuator that governs the fuel valve.

Both ALRT-2B and ALRP-5 feature a mechanical device whose position mirrors the type of control, manual or automatic, selected via the engine power control lever in the cockpit and that can only be reset to automatic mode by a technician with the helicopter on the ground.

### Engine power control lever

There are two levers, one for each engine, located in the top control panel in the cockpit, that are used to select or control the thrust required at any given moment. The positions of the levers are as follows (see Figure 3):

- "SHUT-OFF": to stop the engine (fuel cutoff).
- "GROUND IDLE": idle position.
- "START": start position.
- "GOV FLIGHT": automatic control during flight.
- "MANUAL": switch to hydromechanical control.

## 1.3.2. *Aircraft emergency procedures*

Section 3 of the Aircraft Flight Manual includes various emergency procedures, including one for a malfunctioning engine fuel control system. This procedure lists the steps to take when the difference in torque readings between the two engines is above 5% during normal flight. Appendix 1 to this report contains a copy of this procedure.

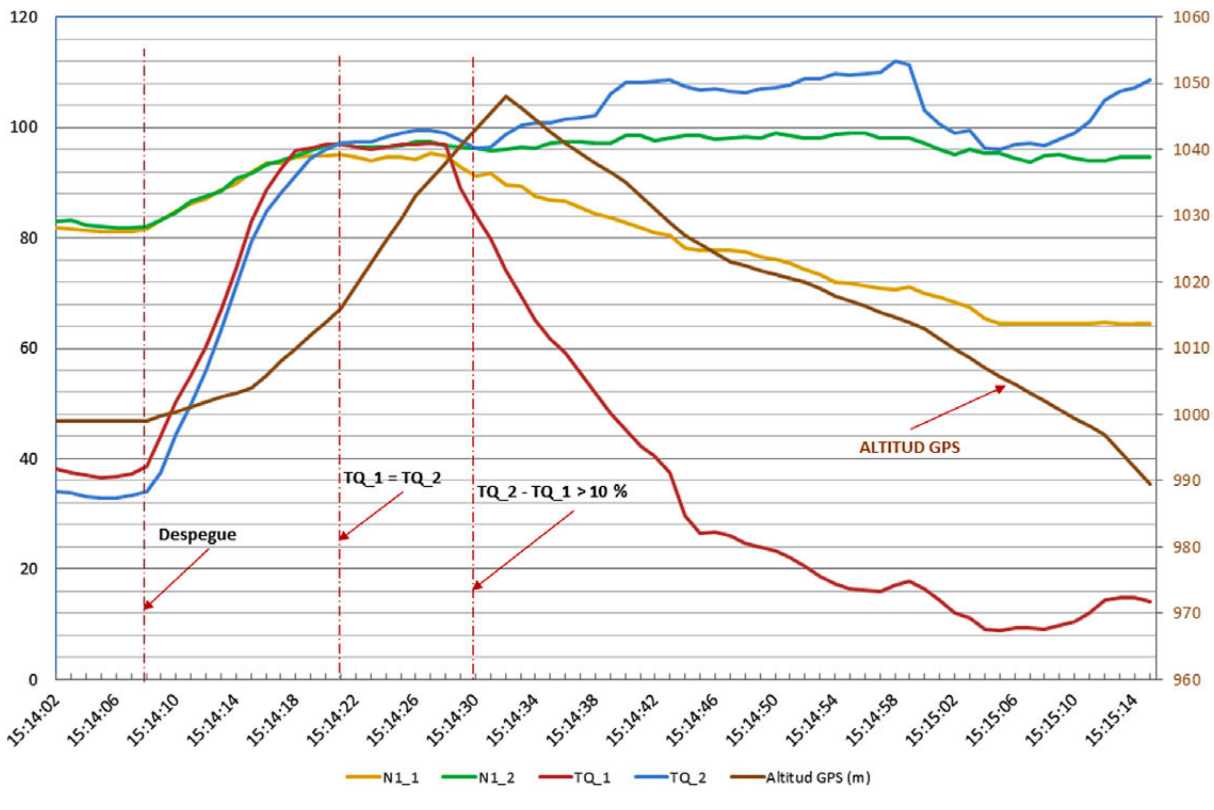


Figure 3. Flight data recorder parameters

### 1.4. Flight recorders

The aircraft was outfitted with flight data and cockpit voice recorders. Figure 3 shows the values for torque (TQ_1 and TQ_2 in percent) and compressor RPMs (N1_1 and N1_2 in percent) for both engines, along with GPS altitude[6]. The values for main rotor RPMs could not be validated.

The cockpit voice recorder taped the conversation referenced in Section 1.1. No exchanges were recorded between the flight crew and the firefighting brigade being transported onboard.

### 1.5. Survival aspects

Both the flight crew and the members of the firefighting brigade had their seat belts fastened throughout the entire flight; however the helmets were only being worn by the latter ones. After the aircraft crashed to the ground, everyone onboard was restrained by the harnesses and only some occupants received minor bruises.

The evacuation was orderly despite the initial confusion. The position of the helicopter, which was resting on its right side, meant that only the left door was accessible, though it had to be opened by one of the pilots from the outside after efforts to open it from the inside were unsuccessful.

The airframe withstood the impact with no deformation of the interior.

### 1.6. Tests and research

#### 1.6.1. *Inspection of the aircraft*

##### 1.6.1.1. Findings of the onsite inspection

The inspection of the wreckage revealed that:

- There were small tree branches in the ventilation system ducts for the engine and accessories, as well as firefighting powder residue, which had been sprayed by the responders who reported to aid the aircraft's occupants.
- The hydromechanical turbine RPM limiter (ALRT-2B) and the fuel control pump (ALRP-5) on the #1 (left) engine showed that the engine power control lever was placed in manual control during the flight. This indication could not be checked in the right engine, which could not be accessed during the onsite inspection.
- The right engine power control lever was jammed at about the 60% position. The lever for the left engine was in the SHUT-OFF (fuel cutoff) position. See Figure 4.

[6] The GPS altitude shown is approximate, since the vertical accuracy of the system is limited.

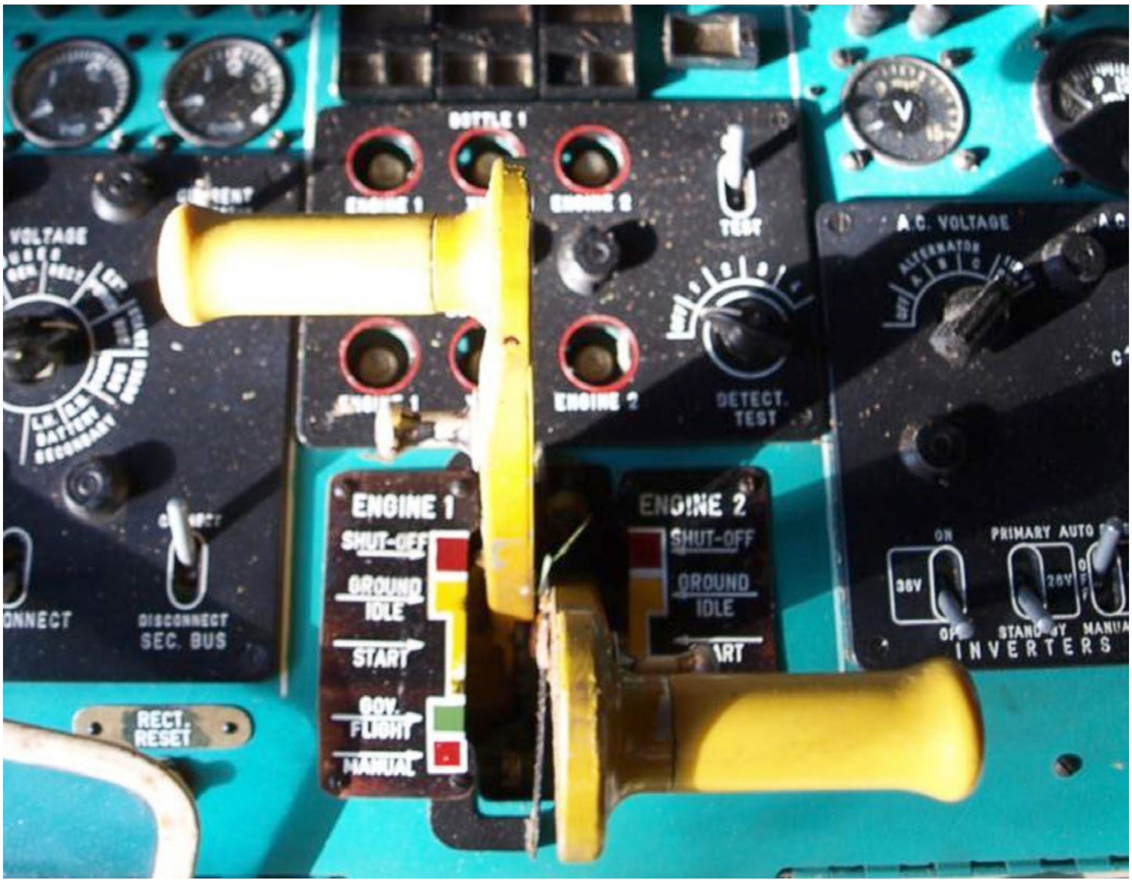


Figure 4. As-found positions of the engine power control levers

### 1.6.1.2. Workshop inspection

The aircraft was inspected on 28 June 2011 by a working group consisting of representatives from the aircraft, engine and fuel system manufacturers, the operator and this Commission.

The most important findings are listed below:

- The tests conducted on each engine's electronic fuel control unit (ALAE-2) showed that they were both within operating tolerances.
- A visual inspection of the filter on the #1 engine fuel supply control pump (ALRP-5) showed some impurities.
- The #2 (right) engine ran in automatic mode throughout the flight.
- There were no metal chips in the engine detectors.
- The right engine could not rotate freely due to the damage it had sustained as the aircraft struck the ground.
- The left engine rotated freely. The borescope inspection performed showed damage on the blades of the axial compressor stages that gradually decreased toward the

internal stages. Traces of firefighting powder was also found on some of the axial compressor stages.

The inspection concluded that the following additional tasks should be carried out:

- Inspection of pump ALRP-5 on the #1 and #2 engines.
- Inspection of the ALAE-2 control units on the #1 and #2 engines.
- Inspection of the ALRT-2B hydromechanical limiter the #1 and #2 engines.
- Borescope inspection of the #1 engine.

#### 1.6.1.3. Borescope inspection of the aircraft's left engine

A second, more detailed borescope inspection was conducted in August 2011. The results helped to determine the extent of the internal damage in the left engine.

Of the axial compressor's six stages, the first exhibited significant damage to at least 60% of its moving blades, thus placing it outside its operating limits. The blades on the second and third stages showed progressively less damage, though they too were beyond operating limits. A thin layer of firefighting powder was found on these three stages.

The last three stages did not show any signs of powder residue. Some of the blades were visibly damaged but not seriously affected.

No damage was found in the centrifugal compressor, the combustion chamber, the compressor turbine or the high-pressure turbine.

No internal engine components were found to have detached and caused internal damage affecting the engine's operation.

### 1.6.2. *Status of the investigation*

So as to locate the source of the mismatch between the left and right engine torques, this Commission repeatedly requested the country of manufacture to inspect the components singled out after the first inspection, but the tests proposed were never arranged since no reply was received.

### 1.6.3. *Inspection of the access doors*

The operation of the passenger compartment's left door was checked once the aircraft was recovered. It was noted that after releasing the locking mechanism, the door was difficult to slide along the upper and lower tracks due to the misalignment caused following the crash. Also, since the aircraft was inclined at a 115° angle from its longitudinal axis, its weight was being transferred to the upper track.

#### 1.6.4. *Crew statements*

The two crewmembers stated that they had flown together two or three times and that they were familiar with the base of operations from previous fire seasons. The crew was seated in the cockpit in accordance with the policy of the operator that employed the pilot seated in the «1» position, where pilots being considered for promotion to captain are supervised by more experiences captains.

As regards the operation, they knew the surrounding landscape, which caused the takeoff to be slightly more vertical than normal. It was the first flight of the day.

During the emergency, the pilot in the "1" position stated having seen yellow lights on the instrument panel. The other pilot did not. They did not hear any aural warnings.

In response to the emergency, the pilot in the "1" position stated that the power control levers were placed in MANUAL, but that this action did not result in the mismatched engine torques equalizing. As for the main rotor RPMs, the captain recalled they were at 105% at the start of the emergency.

Their decision to return to base was hampered by the power lines they had to fly over.

In terms of the members of the firefighting brigade, there were no instructions given during the flight to the brigade leader regarding the emergency landing procedure.

#### 1.6.5. *Fuel*

The helicopter had been refueled to maximum capacity the day before the flight. The fuel tank at the base had been refilled three days earlier. The analysis of the fuel samples taken from the supply tank, as well as from each engine's fuel pump, showed that the fuel complied with the manufacturer's specifications.

### 1.7. Organizational and management information on the operator

LPU Heliseco sp. z o.o. is certified by Poland's civil aviation authority as an aerial work operator and a Part-145 maintenance center. As a maintenance organization, it has several facilities in Spain, including one located in the Tiétar Aerodrome (Toledo).

At the time of the accident, the aircraft was being operated under a wet lease[7] agreement between LPU Heliseco sp. z o.o as the lessor, and the Spanish company

Hispánica de Aviación, S.A., also an aerial operator, as the lessee. The lease contract was entered into with the approval of Spain's Aviation Safety Agency (AESA) under the stipulations that allow for foreign crews and aircraft to be contracted during annual forest firefighting and fire prevention campaigns. The authorization granted imposed a series of requirements on both the lessor and lessee concerning inspections and the conduct of the activity.

The two air operators mentioned are different companies that are based at the same aerodrome and that basically operate the aircraft of the same type and model. At the same time both operators have signed contracts to collaborate in performing aerial works.

As for the flight crew, the operator LPU Heliseco sp. z o.o. assigned to the operation two pilots who were licensed in accordance with the Joint Aviation Requirements Flight Crew Licensing (JAR-FCL) requirements and that enabled them to pilot the PZL W-3AS aircraft. The captain on the flight, seated in the «2» position in the cockpit, was Polish and flew regularly for this operator. The second pilot, seated in the «1» position in the cockpit, was Spanish and flew regularly for Hispánica de Aviación. Both crewmembers had received refresher training and cockpit resource management training from their respective usual operators.

LPU Heliseco sp. z o.o. has an Operations Manual (OM) that is approved by Poland's civil aviation authority. It was originally written in Polish, though a certified translation of some of its contents to English exists. The contents of said OM include the following information, found in Section A, Part 5, regarding the qualifications of the members of the flight crew:

- The "pilot under instruction" is the flight crewmember who is undergoing training or, in agricultural flights, the crewmember who is performing the practical tasks in the training manual. In the first case said member shall be accompanied by an instructor and in the second case by the chief of the agricultural base or by an instructor.
- Procedure for validating the qualifications obtained at another air operator by pilots performing flight duty for the operator. In this case the pilot's experience shall be verified and training shall be conducted as specified by Heliseco under the supervision of an instructor assigned by management.

## 2. ANALYSIS

### 2.1. Analysis of the flight crew's actions

Immediately after takeoff the crew confirmed that the parameters were in the green band and started to climb in a manner suitable to their operational setting. The torque

[7] A wet lease agreement is one in which air operators lease both aircraft and crews to or from other operators.

on both engines rose to 97%, a value that remained stable for about 10 seconds. Then, suddenly, before reaching the highest point on their flight path, as shown in Figure 2, the TQ_1 torque value started to fall gradually, reaching a difference of 10% with respect to the #2 engine torque value (TQ_2).

This situation requires executing an emergency procedure that is included in Section 3 of the Aircraft Flight Manual titled "Engine Fuel Control System Malfunction" (see Appendix 1), which specifies the following actions:

- Set both engine power levers to MANUAL.
- If a torque split above 10% persists during prolonged flight eliminate it by retarding the power lever of the engine with the higher torque.
- Before landing move the previously retarded power lever to the full forward position.
- If engine parameters exceed takeoff limits and cannot be controlled manually, shut down affected engine.

Figure 5 shows the communications that took place in the cockpit and the flight data recorded.

Once the torque TQ_1 dropped to point A, the crew recognized the emergency, though no dialogue took place between the crewmembers. The pilot flying stated seeing yellow warning lights on the instrument panel, possibly involving GOV MAX.

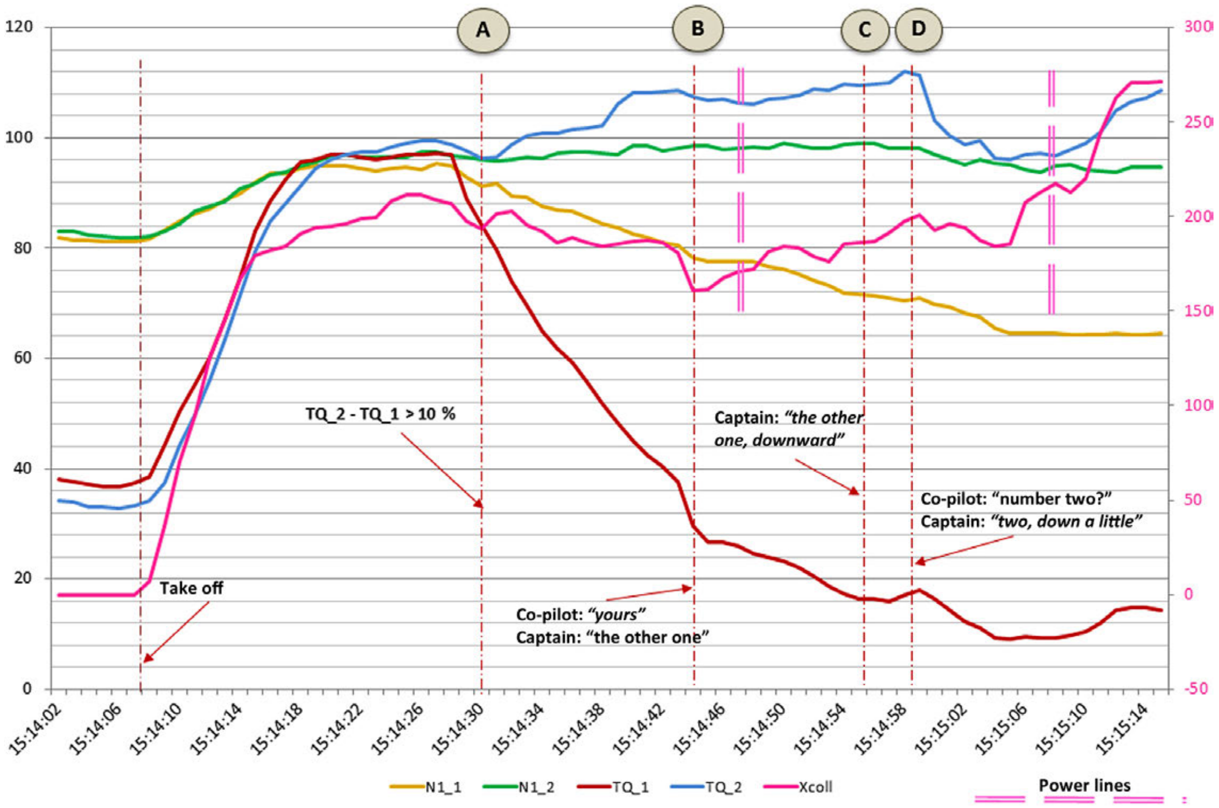


**Figure 5.** Significant flight events

The torque on the #2 engine (TQ_2) increased gradually and automatically to a value of 109%, point B, in keeping with the design characteristics of its control system. The pilot in the «1» position transferred control to the captain. The N1 value continued to fall on the #1 engine.

Eleven seconds elapsed between points B and C, during which the captain made two inaccurate remarks that are not specifically acknowledged by the copilot. The torque value for the #2 engine (TQ_2) was consistent with the GOV FLIGHT mode of operation and with the slightly increased output commanded by the captain through the collective control during that time as he attempted to ensure obstacle clearance above the terrain.

At point D the CVR recording seems to indicate that the captain was instructing the copilot to work the #2 engine controls, which is what he could have been referring to since just before reaching point C. This assumption stems from the fact that the copilot was operating the thrust lever for the #1 engine, which was found in the MANUAL position during the inspection of this engine's ALRT-2B limiter.

Upon identifying and realizing that the captain's instruction was to reduce the thrust on the #2 engine ("two, down a little") and executing it, TQ_2 dropped, though the torque immediately rose in response to the captain's operation of the collective control as he attempted to keep clear of the power lines and the wooded area where they would soon be landing.

The subsequent inspection of the ALRT-2B limiter revealed that the position of the #2 engine power control lever was corrected without having gone through the MANUAL position. The #1 engine is also thought not to have stopped, rather its thrust was reduced, since the lowest recorded N1_1 value was 64%[8].

The crew's reaction to the emergency and its handling of the situation was very likely conditioned by the low margin of clearance above the ground, which could have justified the absence of communications with the fire brigade leader so that the firemen could have assumed the proper protective position.

In general there was a lack of communication between the two crewmembers with imprecise phraseology and no clear method for handling the emergency. In short, there was a lack of proper resource management.

## 2.2. Operational and organizational aspects of the operator

LPU Heliseco sp. z o.o. is certified by Poland's civil aviation authority as an aerial work operator and a Part-145 maintenance center.

This company was engaged in an aerial work operation at the Tabuyo del Monte (León) firefighting base under a "wet lease in" contract with the Spanish operator

[8] The Aircraft Flight Manual indicates that below 58% N1, the engine is in an ENGINE OUT condition.

Hispánica de Aviación, S.A. Said contract was approved by Spain's Aviation Safety Agency.

The two companies mentioned above are both aerial work operators and Part-145 maintenance centers, with their corresponding certificates approved by the civil aviation authorities in their countries, Poland and Spain, meaning that each has its own organizational manuals and procedures.

As regards the flight crew, both members had the individual legal qualifications required by the regulations in their countries of origin. Both also complied with the Joint Aviation Requirements for Flight Crew Licensing (JAR-FCL).

The findings reveal that there was an arrangement between the two aerial work operators that, perhaps due to their contractual situation, to their same location and to having a similar fleet, led the operator (Heliseco) to put together a flight crew in which each member was from a different operator. This resulted in a captain from the company operating the flight flying with a copilot from another operator (Hispánica de Aviación) and, despite of the standardization and training procedures to be used, the emergency management had an improper execution.

### 2.3. Possible mechanical failure

Given the lack of tests on the components proposed during the workshop inspection for the reasons stated in this report, it is impossible to know for certain what caused the difference in torque that existed between the two engines. As a result the circumstances that could have caused a failure in one of the systems in the #1 engine are unknown.

The information and tests conducted, however, indicate that:

- The fuel used to refill the aircraft was in compliance with the engine specifications.
- The hydromechanical RPM limiter (ALRT-2B) on the #1 engine turbine could have experienced a fault or been out of synchronization.
- The condition of the fuel filters in the systems supplying the #1 engine was not sufficient to produce the improper operation of the engine.
- The possibility exists that ALRP-5 improperly controlled the fuel flow.
- The power control lever could have been operated incorrectly during the flight, either in automatic or manual mode.

## 3. CONCLUSION

### 3.1. Findings

- The aircraft had a valid airworthiness certificate issued by the state of registration and was maintained in accordance with the approved maintenance plan.

- Both crewmembers had a valid license and type rating for the type of aircraft they were flying.
- The torque reading for the aircraft's #1 engine dropped.
- When the mismatch in the torque readings for the two engines occurred, the aircraft was at an altitude above the ground of approximately 45 m (147 ft).
- The power control lever for the #1 engine was put in the MANUAL position.
- The emergency procedure was not followed properly.
- Before crashing to the ground, neither engine was in the ENGINE OUT operating regime.
- The investigation's findings indicate that the most likely cause of the drop in torque in the #1 engine could have involved the turbine's hydromechanical governor (ALRT-2B) or the fuel flow supplied by (ALRP-5) on said engine.

### 3.2. Causes

The accident is deemed to have been caused by the improper execution by the crew of the emergency procedure included in the Aircraft Flight Manual for handling a torque split between the two engines.

# APPENDIX 1
## Emergency procedure for an engine fuel control system malfunction

## MALFUNCTION PROCEDURES

## ENGINE FUEL CONTROL SYSTEM MALFUNCTION

Indications:

Engine torque split above 5% in steady flight.

**$N_1$** split.

Engine 1 or engine 2 **GOV. MAX** or **GOV. MIN** caution light comes on.

Procedure:

Verify engine instruments. If oil pressure and temperature are normal and there is no vibration signal, increase the collective while monitoring engine instruments for the following symptoms:

Symptoms - group I:

Engine torque split remains the same.

Torquemeter indications are stable.

**TQ**, **$N_1$**, and **TOT** response follows the collective input.

Procedure for symptoms - group I:

1. Adjust **$N_r$** = 104...100% with **NR TRIM** toggle switch located on the grip of collective control lever.

### NOTE

*When operating at **$N_r$** below 105% select **$V_{NE}$** from the **AIRSPEED LIMITS (INDICATED AIRSPEED) $N_r$ = 104 to 100%** placard.*

2. Continue flight.

### NOTE

*A momentary torque split or decrease may result from interference with strong magnetic fields and does not require any corrective action if engine power output remains unchanged.*

*Continued on next page*

## ENGINE FUEL CONTROL SYSTEM MALFUNCTION *- continued*

Symptoms – group II:

Torque split above 10%.

**TQ**, **$N_1$**, and **TOT** response does not follow the collective input.

Procedure for symptoms - group II:

1. Both engines power levers – Set to **MANUAL** (in case of power decay the demanded power output should be restored in 1...3 s).
2. If a torque split above 10% maintains during prolonged flight eliminate it by retarding the power lever of engine with a higher torque.
3. Before landing move the previously retarded power lever to extreme forward position.
4. If engine parameters exceed takeoff limits and cannot be controlled manually shut down affected engine.

### WARNING

*Engine power decreasing in order to eliminate torque split shall be accomplished with only one engine power lever at a time while the other engine power lever is left in **MANUAL** position. Manipulating with both power levers at the same time may lead to loss of engine power.*

### CAUTION

*Limiters in the engine fuel control switched-over to hydromechanical backup mode enable engine operation beyond takeoff limits. Monitor engine parameters closely to prevent twin engine operation within OEI power range.*

### NOTE

1. *When the engine power lever is set to **MANUAL** the hydromechanical backup of engine fuel control maintains **$N_2/N_r$** within 102...104% at takeoff power.*
2. *When the engine power levers are set to **MANUAL** avoid exceeding **$N_r$** = 108% during helicopter maneuvers (in transients).*

*Continued on next page*

**ENGINE FUEL CONTROL MALFUNCTION** *- continued*

3. *If time and flight conditions permit, instead of simultaneous setting both levers, set only the affected engine power lever to **MANUAL** while the good engine will remain in normal mode of operation. In such a case minimize torque split by $N_r$ change with **NR TRIM** toggle switch on the grip of collective control lever.*

## DATA SUMMARY

### LOCATION

| | |
|---|---|
| Date and time | **Friday, 23 July 2011; 13:05 local time[1]** |
| Site | **Vicinity of the Santa Cilia de Jaca Aerodrome (Huesca, Spain)** |

### AIRCRAFT

| | |
|---|---|
| Registration | **G-CCRC** |
| Type and model | **CESSNA TU-206 (S/N U206-07001)** |
| Operator | **Centro de Paracaidismo Pirineos** |

#### Engines

| | |
|---|---|
| Type and model | **TELEDYNE CONTINENTAL MOTORS TSIO 520-M7B (S/N: 532404)** |
| Number | **1** |

### CREW

| | Pilot in command |
|---|---|
| Age | **39 years old** |
| Licence | **CPL(A)** |
| Total flight hours | **1,720 h** |
| Flight hours on the type | **800 h** |

### INJURIES

| | Fatal | Serious | Minor/None |
|---|---|---|---|
| Crew | | | **1** |
| Passengers | | | **5** |
| Third persons | | | |

### DAMAGE

| | |
|---|---|
| Aircraft | **Minor** |
| Third parties | **None** |

### FLIGHT DATA

| | |
|---|---|
| Operation | **Aerial work – Non-commercial – Parachute drop** |
| Phase of flight | **En route – Parachute drop** |

### REPORT

| | |
|---|---|
| Date of approval | **27 February 2014** |

[1] All times in this report are local (LT) unless otherwise specified. To obtain UTC, substract two hours from local time.

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

On 23 July 2011 at 13:05, a Cessna U-206 aircraft took off from the Santa Cilia de Jaca Aerodrome for the purpose of conducting a parachute drop. It was the aircraft's third such flight that day. The weather conditions were suitable for visual flight and for parachuting. There was a slight wind from the west. Onboard the aircraft were five parachutists and the pilot.

As the pilot was reducing engine RPMs to level out after the climb while flying above the airfield at an altitude of about 3,300 m (approximately 11,000 ft), he smelled smoke and felt vibrations as the engine lost power.

The parachutists made a routine jump from the airplane, descended without difficulties and landed in the planned spot. The pilot started to descend for landing, keeping the selected engine RPMs. Shortly before landing the pilot commanded power from the engine, which did not respond though it remained operational.

The terrain along the approach to runway 27 at the Santa Cilia de Jaca Aerodrome descends sharply and there is usually mountain turbulence in the area before the threshold. The pilot, noticing the turbulence had increased in strength, opted to make an emergency landing on a clear field outside the aerodrome that was parallel to and to the right of runway 27. He reported this intention on the radio and after the landing informed the aerodrome of his situation.

Neither the pilot nor the aircraft was harmed in the landing. All of the material damage was confined to the engine.

## 1.2. Aircraft information

### 1.2.1. *General*

The Cessna TU-206 is a single-engine, high-wing strutted airplane with a maximum takeoff weight of 1,633 kg.

The incident aircraft was equipped with a Teledyne Continental Motors TSIO-520-M engine with a maximum takeoff power of 310 HP. This aircraft was registered by the United Kingdom's CAA under registration G-CCRC in February 2004 to its current owner.

The aircraft's owner, Skycentre Moonjumper International, based in Coleraine – Londonberry – North Ireland – United Kingdom, dry leased the aircraft to the Centro de

Paracaidismo Pirineos, based in Santa Cilia de Jaca – Huesca – Spain. The renewable one-year contract was for a minimum of 250 hours and for conducting parachute drops. The cost of maintenance was deducted from the weekly rental payment.

The aircraft, registration G-CCRC, had an ARC (Airworthiness Review Certificate), reference 058/2010, issued by the CAMO Köhler (Approval ref. DE.MG.1007) on 29/06/2010 with expiration date 24/09/2011.

### 1.2.2. *Engine*

The TCM TSIO-520-M turbocharged, fuel injected engine has six horizontally opposed, air cooled cylinders with a bore of 5.25 inches. This alternating turbocharged engine is the most popular in light aviation and has been utilized on several types of single- and dual-engine airplanes, having been manufactured in large numbers.

### 1.2.3. *Maintenance program and history*

The aircraft had a generic maintenance program approved by the CAA, CAP 766 and CAP 411, for piston-engine aircraft under 2,730 kg used for commercial and non-commercial aviation.

During the airplane's last two years of operation, the Centro de Paracaidismo Pirineos had contracted the maintenance out to Locavions, located in Pau, France. The maintenance was then shifted in June 2011 to Futurhangars, S.L., located in Sabadell, Barcelona.

The Locavions maintenance center relied on assistance from Rectimo for major work on the engine and from Aeromecanics in Marseille to solve one-time failures in other systems from time to time.

Locavions followed a generic maintenance program, with 50FH, 150FH and annual inspections.

On 05/06/2011, Futurhangars sent an email to the Centro de Paracaidismo Pirineos to inquire about the maintenance program to use, as there seemed to be no schedule for weighing the airplane, keeping track of ADs or conducting structural inspections, tasks included in airworthiness continuing management to be carried out by the CAMO.

The line and daily inspections were made by the crew, which reported any abnormal operations to the workshop and tracked the potential life of both airplane and engine hours.

### 1.2.4. *Number of flight hours and inspections*

| Inspection type | Date | Airplane hours | Engine hours | Maint. center |
|---|---|---|---|---|
| Overhaul Motor | 03/08/2008 | 2,807 | 0 | ¿? |
| Issuance and MSB 09-1ªA control | April 2009 | 2,845 | 38 | Locavions |
| 50 h | July 2009 | 2,896 | 89 | Locavions |
| 150 h | August 2009 | 2,942 | 135 | Locavions |
| Change of cylinders (6) MSB 09-1B | October 2009 | 2,990 | 183 | RECTIMO |
| 50 h + 150 + annual | April 2010 | 3,038 | 231 | Locavions |
| CAMO contract signing | June 2010 | | | CAMO Köhler (Locavions) |
| Change of alternator | 02/07/2010 | 3,077 | 270 | Locavions |
| 50 h | 27/07/2010 | 3,086 | 279 | Locavions |
| 50 h + vacuum pump | 22/09/2010 | 3,137 | 330 | Locavions |
| Change of tires | 14/10/2010 | | | Locavions/AD Santa Cilia de Jaca |
| 150 FH + change No. 3 cylinder | 07/03 to 01/04/2011 | 3,184 | 376 | Locavions/RECTIMO |
| 50 FH | 9/6/2011 | 3,234 | 425 | Futurhangars |
| Incident | 23/07/2011 | 3,281 | 472 | Santa Cilia de Jaca |

The next 50-FH inspection was scheduled with 475 total FH on the engine. The incident occurred 47 FH after the last inspection of the airplane, meaning it was almost due for a 50-FH inspection.

The last annual inspection had been overdue since April 2011. On that date the CAMO should have alerted to the operator and maintenance shop about this time calendar inspection.

A review of the maintenance documentation gathered from Locavions through the BEA revealed that the inspection of 22/09/2010 was listed as a 150-FH inspection when in fact it was a 50-FH inspection. There are also repeated errors in the documentation, which lists the engine as a Lycoming engine.

In the last 150-FH inspection on April 2011, additional work was done involving disassembling the exhaust to repair cracks, disassembling the turbocharger to replace gaskets and disassembling/assembling the no. 3 cylinder, followed by a search for the source of significant exhaust gas leaks. The cylinder was disassembled so as to machine the attachment of at least one exhaust gas outlet stud and its collar. Workshop personnel had great difficulty assembling the cylinder after this repair, resulting in a long delay in returning the aircraft to operation.

In the two last 150-h inspections, in April 2010 and April 2011, the cylinder compression test was annotated with an entry of 80 for each one of six cylinders and on both checks (without specifying the calibrated equipment used for the measurement or the units).

In the last 50-h inspection, a measurement carried out by the new maintenance shop contracted by the operator, it was perceived again smudge produced by exhaust gas leaks.

### 1.2.5. *Features of the engine and its operation*

Cylinders

Each of the six cylinders on the Continental TSIO 520-M7B engine consists of two cast halves: the cylinder itself made of cast steel and a cast aluminum cylinder head, both permanently joined during the manufacturing process. The head houses the spark plugs, fuel injectors and spring-loaded inlet and exhaust valves. The valves are operated by the motion of the tappets atop the rocker arms that drive the valve stems in the conventional manner. Being air cooled, the outside of the cylinders feature cooling fins that are integrated into the cast components.

The engine is designed so that the highest risk cylinders (one of the rear ones, no. 1 or 2) are equipped with CHT (cylinder head temperature) sensors. Normal operating temperatures should not exceed 380 °F, with the maximum being 460 °F. There is also an exhaust gas temperature, EGT, sensor on the right-side manifold (hotter side due to the location of the turbocharger). The engine in this incident included a digital indicator and 12 sensors that provided the CHT and EGT for each of the engine's six cylinders.

As stated by mechanics who have worked on this engine, it is expensive to maintain and it is intolerant of fast changes from cruise thrust to idle thrust. The drop from the high temperature associated with an engine at high thrust to the temperature of an engine at idle can lead to cracks and thermal stress on the cylinder heads due to rapid cooling.

When the engine is operated correctly during a parachute drop, it is regarded as reliable, though several expert mechanics reported that its 1,400-hour lifespan between overhauls was very rarely obtained.

The aircraft's lease contract stipulated that the lessor was to be sent copies of the aircraft logs so that it could check the times for each flight cycle and ensure that the descents were not being made too quickly.

TCM Service Bulletin SB 03-3 provides a differential pressure test and complements the leak check with a boroscope inspection. This SB is applicable at each 100-hr interval, annual inspection or when cylinder problems are suspected.

Valves

Combined experience in alternating engines reveals that valves in general can be damaged by thermal fatigue under various constant use conditions, such as:

- Extreme thermal cycles.
- Constant and sudden changes from maximum to minimum power.
- Incorrect valve seating.
- Bent valve stem.
- Incorrect tappet setting.
- Excessive temperature due to pre-ignitions and detonations.
- Lack of sealing in the cylinders.

### 1.2.6. *Aircraft flight operation conditions*

Information compiled from the three pilots that mainly flied the aircraft for skydiver jumping operations and annotations on the aircraft flight logbooks shown that skydiver jumping flights had an average duration of 24 minutes, varying slightly from the 22 minutes during some operation days in season with low temperatures and 25, 26 minutes in hot season.

It has been checked that all of the pilots were updated about the previous engine failure in 2008, they were aware of the need to operate the engine with a smooth regime variation and even they applied Flight Manual procedures in a conservative way.

The fuel charge was always made for two or three rotations as maximum, the maximum people on board was five parachutists, two tandems plus a cameraman, although most of the flights were done with one tandem and one cameraman or with 2 tandems The maximum height with sky divers was 14,000 ft QNH; the most common and used was 12,500 ft QNH.

Specifically, and related to flight procedures, the maximum power for takeoff, 35”, was reduced to 30”, maximum continuous power, as soon as the aircraft was flying over the obstacles and at 500 ft above the ground. The descent was achieved by reducing the mixture to avoid a quick engine cooling, with cowl-flaps closed, at a maximum speed of 140 kt and an engine power setting for the descent quite higher than the idle one.

## 1.3. Information on the condition of the aircraft after the incident

### 1.3.1. *On-site inspection*

After the off-field, power-off emergency landing, the aircraft was verified to have suffered no damage beyond the engine, the damage to which was mainly confined to the no. 3 cylinder.

Figure 1. Right side of the engine; Nos. 1, 3 and 5 cylinders

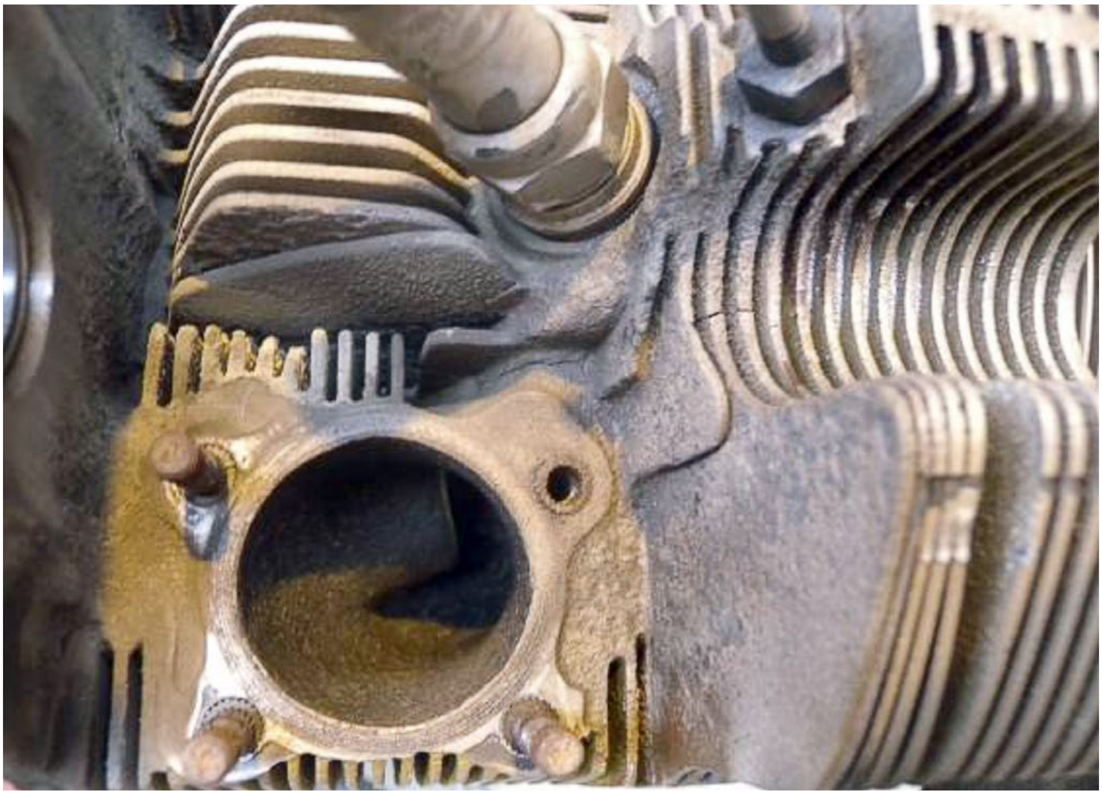

Figure 2. Cracks near the exhaust port and lower spark plug on the no. 3 cylinder

Once the airplane was moved to the hangar, the engine was opened in the presence of representatives of the parties involved (operator, maintenance center and France's accident investigation authority).

It was discovered that the main material failure had been the fracture of the stem in the neck of the no. 3 cylinder exhaust valve. The detached head of the valve had fallen inside the cylinder with the engine in operation, triggering a cascade of damage inside the engine. An analysis of the engine's lubricating and cooling oil showed that it was full of bright bronze particles.

This damage resulted in cooling oil being lost to the outside of the engine through the no. 3 cylinder gasket, in bulging of the crank case in the area where the no. 3 cylinder is attached and in a recent crack at the port of the upper spark plug in the same cylinder.

The remaining damage to the no. 3 cylinder (twisted piston rod, crushed piston, bent tappet or pushrod, etc.) was also considered secondary and caused by the engine being driven by the remaining five cylinders after the failure of the exhaust valve in the no. 3 engine.

Other damage found that was apparently unrelated to that caused by the failure of the exhaust valve on the no. 3 cylinder included cracks and gas exhaust deposits in the fins of the cylinder in the area of the exhaust manifold, loosening of a stud on said manifold and a broken brake collar, deformation and grouping of several cooling fins on the no. 3 cylinder, and a circumferential crack in excess of 180° at the exhaust nozzle of the no. 3 cylinder.

Damage and tarnishing due to overheating were observed in the exhaust gas passages, exhaust valve and rocker arms on the no. 3 cylinder. The adjacent cylinders, nos. 1 and 5, exhibited similar signs though on a smaller scale.

The general condition of the remaining cylinders was acceptable.

The detailed inspection further revealed that:

- The timing on the right magneto was 26° from TDC (top dead center).
- The timing on the left magneto was 24° from TDC (the normal timing is 22° with a ±1° tolerance). Task 67 on magneto timing (as per MSB 94-08D) does not require that the adjusted values be annotated.
- The attachments of the magnetos to the engine crank case and the magneto covers still had the seal from the overhaul center, indicating that the magnetos had not been opened for routine maintenance since the last overhaul (the 150-hr and annual

inspections require opening the magneto covers to inspect the points, lubricate the felt and inspect the eccentric cam).

- There was excessive wear on the electrodes on several spark plugs., though within operating tolerances for the approximately 90 FH of operation since their replacement.
- The points on the magnetos were pitted and exhibited a gap, though they seemed to be within tolerance.
- The sensor to the head of the no. 2 cylinder was improperly connected and the one to the no. 3 cylinder was disconnected.
- The general exhaust temperature sensor was disconnected.

### 1.3.2. *Inspection of the valve*

The head of the no. 3 cylinder exhaust valve struck the inside of the cylinder several times after it separated from the stem. This led to various deformations of the rest of the stem as well as of the entire circumferential perimeter. An analysis of the head showed a large groove on its skirt that seemed to have resulted from the partial fracture of the head before it broke off from the stem, as shown in Figure 3.

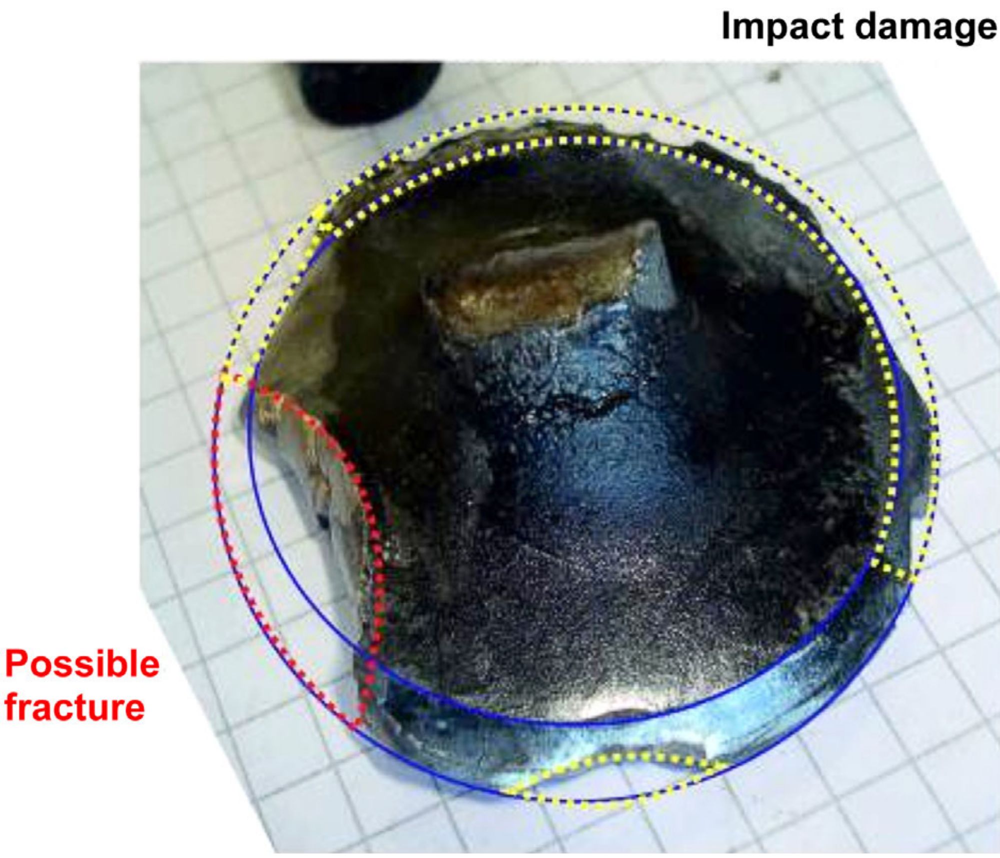


**Figure 3.** . Head of the valve on the no. 3 cylinder

## 1.4. Tests and research

### 1.4.1. *Disassembly and inspection at the manufacturer, TCM*

The entire engine was sent to Continental Motors, Inc. for an in-depth examination by the manufacturer, which yielded the following significant results:

The lubrication system was intact, with no damage to the radiator or oil pump. The oil sump was normal, with only a residual amount of oil contaminated by the mechanical damage to the engine. There were no signs of insufficient lubrication to either the crankshaft bearing or to the cylinder head components (rocker arms, axles, valve guides, etc.), including the no. 3 cylinder.

The distribution and timing of the crankshaft and the camshaft were correct.

Functional magneto tests were satisfactory and showed them to be operating normally. The wear on the spark plugs was also normal. The timing on the magnetos was confirmed to be slightly advanced.

The fuel pump and system were working normally.

All of the cylinders and their pistons and pushrods, except for the no. 3, were in good condition with only normal wear. The intake and exhaust valves were properly seated. The amount of combustion deposits on the cylinders, pistons and valves, except for no. 3, was normal.

**Figure 4.** Cracks and signs of overheating in the no. 3 exhaust port.

The no. 3 cylinder and its internal components, pistons, segments, pushrod, etc., showed heavy generalized damage.

The head on the no. 3 cylinder exhaust valve was recovered from the inside of the cylinder.

The remaining components, such as the gearbox, turbocharger, half-casings, etc., were normal or had minimal external damage.

**Figure 5.** Piston, valve and other components of the no. 3 cylinder

**Figure 6.** Interior of the no. 3 cylinder

In summary, the engine showed no significant abnormalities with the exception of the fracture in the no. 3 cylinder exhaust valve, as well as cracks in that cylinder and overheating damage to the exhaust outlet, port and exhaust tubes. The remaining mechanical damage occurred as a result of the valve failure.

#### 1.4.2. *Metallurgical report*

The valve seats, according to the engine design, are made of steel and are welded to the cylinder head to improve their resistance to wear and to heat cycles. Fragments from the seat of the valve that failed and the two pieces that resulted from the fracture of the valve were analyzed at the TCM laboratories. The hardness values at different points were determined and the material's macro and microstructures were examined, which led to the following conclusions:

- The valve failed due to thermal fatigue.
- The hardness measurements of the materials were within design specifications.
- No abnormalities were found in the material.

### 1.5. Eyewitness statements

#### 1.5.1. *Statement of the aircraft's normal crew*

The aircraft's most frequent pilot, also charged with monitoring its operations, stated that as early as February 2010, in the wake of the replacement of the six cylinders to comply with MSB09-1, during the 25-FH inspection, high temperature readings were noticed for the no. 3 CHT sensor. Two months later large amounts of exhaust gas deposits were found in the area of the no. 3 cylinder, which was reported to the Locavions maintenance center. This was repeated on 22/07/2010 during an inspection visit in Pau.

The maintenance center was repeatedly informed of the high CHT readings on the no. 3 cylinder, as well as of the high exhaust gas temperature readings on some of the cylinders.

Later, on 01/04/2011, when the airplane was picked up after the last 150-FH inspection, it was discovered that the maintenance center had cleared the airplane for service with the CHT reading from the no. 3 and another cylinder inoperative. The pilots insisted on reporting these abnormalities, seeing as they frequently saw widely varying CHT and EGT values that were occasionally out of specification.

The delay in delivering the aircraft in March-April 2011 was due to difficulties in assembling the no. 3 cylinder at the maintenance center, Locavions, which had to resort to an outside specialist to complete this task.

From August to September 2009 the airplane had an electrical problem that caused the fuel pump breaker to open. The workshop tried on four occasions to fix this problem, without fully solving the malfunction. In October another workshop, Rectimo located in Chambery-Aix les Bains, replaced all the engine cylinders but the electrical problem persisted in the return flight. By a suggestion of regular maintenance shop they consulted a third workshop, Aeromecanics in Marseille, which replaced the fuel booster pump and the electrical malfunction was finally solved.

The day before the 50-hour inspection in September 2009, the workshop was notified of the need to replace the nose tire due to wear. After the nine-day long inspection, the aircraft was returned with the old tire, which was not able to be replaced until three weeks later when a new tire was finally found.

The maintenance center suggested the services of a German CAMO to renew the aircraft's airworthiness certificate in June 2010 three months ahead of its expiration date as it lowered the cost, since several aircraft could be flown to Pau and recertified together. So it was decided to fly the aircraft from Santa Cilia to Pau, though unfortunately an alternator malfunction grounded the aircraft. As a result, one of the workshop supervisors along with the airworthiness inspection personnel from the CAMO went to Santa Cilia to renew its ARC with the aircraft in the hangar.

In May 2011, efforts were made to have the workshop contact the CAMO so that it could renew the AC, though these efforts were fruitless since the trust between the operator and the maintenance center had deteriorated.

In early June 2011, as part of the operator's search for a new center to maintain the aircraft, it contacted Futurhangars, based out of the Sabadell Airport, which conducted the last 50-h inspection prior to the incident.

### 1.6. Background

The CIAIAC has records that show at least two similar events occurring, one of them involving the same operator:

- A-001/2008 of 13 January 2008 in Abay-Jaca (Huesca) involving the same operator, Centro de Paracaidismo Pirineos, and the same engine type mounted on the same aircraft type, G-BYIC. It was determined that the engine failed due to inadequate lubrication of the crank head bushings, which caused the head on the no. 4 pushrod to overheat and fracture.
- IN-013/2003 of 8 August 2003 in Pastrana (Guadalajara) involving the private operator of a Socata Rallye-100-ST aircraft, registration EC-ICI, with a TCM O-200-A engine. The engine failure was determined to have been caused by the fracture of an exhaust valve head due to several radial thermal fatigue cracks.

### 1.7. Organizational and management information

The Centro de Paracaidismo Pirineos is covered by the regulation on non-profit sports clubs and has a certificate from AESA (Spain's National Aviation Safety Agency) recognizing it as a parachuting center. It is a Spanish non-profit aviation center that is not necessarily required to contract a CAMO to maintain its airworthiness.

Aircraft G-CCRC had an ARC that expired on 24/09/2011 issued by a CAMO approved by the Federal Republic of Germany (approval reference DE.MG.1007), which managed the continuous airworthiness as from June 29 of year 2010.

The maintenance center Locavions, PART-145 Licence FR 145.297 and approved by aeronautical authority of the Republic of France, was contracted by the operator, with the consent of aircraft owner, since March 01 2009, and it was in charge of maintenance up to May 02 2011; that date the Centro de Paracaidismo Pirineos terminated unilaterally the contract, they paid the invoices of late tasks done and finalized first of April (150 h check and tasks in cylinder no. 3) and they removed whole aircraft documentation from maintenance shop.

Locavions proposed to the Centro de Paracaidismo Pirineos that it use the services of the German CAMO (license no. DE.MG.1007). The professional relationship between Operator and CAMO was not fully established. The interchange of information about flight time and any service anomalies follow the pattern Operator – Maintenance shop - CAMO; instead Operator –CAMO - Maintenace shop should have been more appropriate.

When the incident involving the in-flight engine failure took place, the maintenance center contracted was Futurhangars S.L., with EASA Part 145 license ES 140.

As regards the aircraft with United Kingdom registration G-CCRC, it was owned by an organization located in Northern Ireland – United Kingdom.

## 2. ANALYSIS

### 2.1. General

When the Cessna U206 took off on 23 July 2011, it had a long history of abnormalities involving the operation of its engine, a history that went back to shortly after the six cylinders were replaced in compliance with a mandatory service bulletin from October 2009 (MSB 09-1B) and that included abnormally high temperature readings, especially for the no. 3 cylinder, and more recently signs of exhaust gas leaks.

A parachute drop operation is demanding for an aircraft. It requires all of the power that its turbocharged engine can provide, an engine that warms up during the takeoff and climb phases until the drop altitude, and that then cools rapidly during the descent. In the summer, with high noontime temperatures at airfield level and noticeably lower temperatures aloft, the thermal variance is extreme.

The flight to drop parachutists takes place in a small area in the vicinity of the field that the pilot is very familiar with. In this case when the failure occurred mid-flight, no problems were encountered in completing the parachute drop or in finding a place deemed best by the pilot for carrying out a smooth landing.

The failure took place mid-air, where the pressure difference between the inside of the engine and ambient pressure is at a maximum and when the pilot changed the engine output by reducing RPMs to stabilize the horizontal flight and start the drop. It could, however, have failed in a more difficult situation for the aircraft, such as during the takeoff or when flying at a lower altitude, which would have put the aircraft and its occupants in grave danger.

Since the immediate concern of terminating the flight was successfully resolved, the investigation focused primarily on analyzing the engine failure, on the airplane's routine operations, on its material condition prior to the failure and on the regulated aviation business environment that did not prevent this hazardous situation from developing.

## 2.2. Engine failure

TCM's detailed inspection of the engine revealed that all of the components and systems, except for the no. 3 cylinder, were in good operating condition and were functioning normally. The crankshaft bearings, the cylinder head components, rocker arms, tappets, etc., were all being properly lubricated. The camshaft timing was perfectly synchronized and the spark plugs were firing correctly, though somewhat advanced in their timing. The fuel feed and turbo-compressor were also functioning properly.

The analysis of the engine showed that the no. 3 exhaust valve had failed. It also revealed the presence of cracks in the walls of this cylinder and on the exhaust flanges, as well as wear of the components near the exhaust due to heating.

TCM's metallurgical analysis confirmed that the engine, a Teledyne Continental Motors TSIO 520-M7B, S/N 532404, failed due to thermal fatigue of the fractured valve. Several conditions can contribute to this fatigue if they are repeated over a prolonged period of time:

a) Sudden and constant changes from maximum to minimum power.
b) A bent, off-angle or improperly seated valve.
c) Improper regulation of the engine's distribution components.
d) Excessive temperature due to pre-ignitions and detonations.
e) Improperly sealed cylinders.

Figure 7. Taken from SB03-03 by TCM. Shows a burned exhaust valve with signs of leakage and damage

Even without knowing exactly how the failure initiated, it can be surmised that since it only affected one cylinder, the cause must be related to a unique feature of that cylinder and its assembly or adjustments. In light of the evidence found, it is very likely that an improperly seated exhaust valve causing leakage through that valve (see Figure 7) resulted in the initial degradation and loss of material around the perimeter of that valve's head (see Figure 3).

This leakage caused the partial fracture, which in turn led to a larger leak and greater heating of the cylinder head due to combustion that was not contained within the cylinder and piston. Over a period of time with the engine operating in these conditions, thermal fatigue made the incubating cracks grow until the head finally broke off from the stem.

The cracks on the outside of the no. 3 cylinder and on the exhaust port and tubes, as well as the wear, discoloration and damage to the cable linings and components in the area prove that the combustion was not confined to the combustion chamber and that the flames reached the exhaust pipes. These signs of wear, readily observable externally when opening the fairing, should have pointed to the abnormal operation of that cylinder.

Early detection of the problems with leaks, overheating and thermal fatigue would have prevented the failure.

Conducting the differential pressure and boroscope inspection tests of the cylinder would have detected these problems in time. There is no record in the maintenance files of a boroscope inspection ever having been conducted on the cylinders, and there are serious doubts as to whether valid differential pressure and compression tests of the cylinders were ever conducted since the values recorded for the six cylinders on the last two inspections performed by Locavions were always the same and the pressures for the "Master Orifice" calibration standard were not annotated, as required by procedure. The manufacturer's service bulletin MSB03-3 has instructions on the applicable procedures.

The statements from the crews regarding other repeated and unsuccessful maintenance activities involving other malfunctions not related to the engine could be indicative of incompetent performance by the maintenance center.

### 2.3. Normal operation of the airplane and engine

The constant takeoff-climb-descent-land cycles to which the airplane was subjected as part of its parachute drop operations have a direct bearing on the propagation of the thermal fatigue that led to the failure. Pilots, mechanics and operators know that the reliability of this engine is highly dependent on the careful operation and management of the engine's heating/cooling cycles. In this regard, the lease contract for the aircraft underscores the concern of the lessor, who demanded to be kept informed of the cycles and typical operating times. This information can be used to verify that sufficiently slow cooling cycles are being observed during the normal use of the aircraft. In fact, so as to better monitor the operation of the engine, the aircraft had an additional digital sensor installed with readouts for all the cylinders.

This notwithstanding, various accounts and exchanges between the operator and the maintenance center referred to problems involving a lack of CHT and EGT readings going back two years, which calls into question how an operator can monitor heating/cooling cycles without constantly measuring these temperatures.

### 2.4. Maintenance

The line and daily inspections at the Centro de Paracaidismo Pirineos were the responsibility of the crews, which notified the maintenance center of any operating abnormalities so that they could be corrected.

Judging by the mistakes in the documentation, the repeated maintenance actions that failed to correct faults, it is reasonable to presume that the maintenance center was not properly maintaining the Cessna G-CCRC aircraft.

Despite some items on the annual review and other checks not being completed in April 2011, the airplane continued to fly until the date of the incident. Likewise, the documentation indicates that neither the leak checks nor the boroscope examinations were properly carried out. This was also evidenced by the fact that the seals from the center that performed the overhaul were found intact, meaning that the magneto timings were never checked, which allowed for an improperly adjusted firing sequence during continuous operations.

This maintenance organization, assisted by the CAMO concerning the need for inspections and corrective actions that aircraft G-CCRC required, should have known about the applicable inspections, checks, tests and SB's, as well as the procedures for checking and correcting any anomalies that could have been present or that were reported by the operator.

As a result of the above, a safety recommendation is issued to the aviation authority on the country of the maintenance center to reevaluate the technical suitability of this aircraft's maintenance center, Locavions.

## 2.5. Airworthiness management

In this case an airplane from Northern Ireland, registered in the United Kingdom, operated by a Spanish organization and maintained by a French center with aid from a German CAMO seems to have created an environment in which responsibilities were enormously diluted.

The small operator tasked the duty of renewing the airworthiness certificate to a CAMO that was not involved efficiently in the day-to-day tracking of the airplane's airworthiness, for instance the aircraft operated with the annual inspection not in force. The PART-145 maintenance center should have performed the actions requested directly by the operator or the CAMO. It seems that this maintenance center did so without adhering to the applicable SB's, without coordinating with a CAMO and, ultimately, without providing reliable solutions to the engine's operational problems.

The center that took over the aircraft's maintenance in June 2011, Futurhangars, also did not receive adequate information regarding possible earlier problems still affecting the engine, meaning that the potential for engine failure was still present.

An operator with the structure of the Club de Paracaidismo does not have the technical ability to control its aviation assets, which in this case consisted only of the incident aircraft. As a result it was unable to confirm the deficient maintenance status and correct it, except for tangential aspects involving the reliability and timeliness of the tasks performed. This caused it to change maintenance organizations without adequately conveying the deficiencies and without managing to get the engine in good operating condition, this because the new maintenance center prioritized timeliness over the correct performance of its tasks.

As a result of the above a safety recommendation is issued to the operator so that it improve its oversight of the airworthiness of the aircraft it operates either by contracting qualified personnel or by contracting a CAMO capable of such oversight.

From July 2010 with the CAMO intervention, this should have been in charge of airworthiness continuous management, establishing a direct relationship with the operator to know flight activities and possible flight service anomalies, to communicate and coordinate the maintenance tasks with the shop. As a significant example of this deficient management the aircraft operated with its last annual time inspection not in force.

As a result of the above a safety recommendation is issued to the Civil Aviation Authority of the CAMO country, Federal Republic of Germany, so that it re-evaluate the technical suitability of the airworthiness continuous manager of this aircraft, CAMO Köhler.

## 3. CONCLUSION

### 3.1. Findings

- The airplane had a long history of engine problems involving leaks, high temperatures on the no. 3 cylinder heat and the CHT and EGT temperature indication systems.
- On the day of the incident, 23/07/2011, the airplane was on a flight with the pilot and five parachutists onboard.
- While over the airfield, at the desired altitude and before the parachute drop, the engine suddenly failed, losing practically all power as vibrations increased and smoke and the smell of burnt oil issued from the engine.
- The parachutists jumped out and the pilot made an uneventful, power-off emergency landing on a field north of the Santa Cilia de Jaca airfield, a short distance away from the runway.
- The no. 3 cylinder exhaust valve had broken off from the stem at the neck due to thermal fatigue. The cylinder head and the exhaust pipes had cracks caused by thermal stress and there was a loss of material from the cooling fins.
- The engine’s cylinders had been installed some 450 FH earlier during a replacement required by a mandatory SB. The problems started in the wake of that replacement, first as high temperatures and as temperature indication problems, and then as losses and leaks of exhaust gases.

- The deficient maintenance of the aircraft was not able to correct the problem with the abnormal operation of the engine.

### 3.2. Causes

- The immediate cause of the engine failure was the fracture of the exhaust valve on the no. 3 cylinder.
- The fact that the failure was not detected earlier is attributed to deficient maintenance of the aircraft.
- Possibly contributing to the deficient aircraft maintenance was the sharing of responsibilities among organizations from various countries, even though they were all subject to EU regulations.

## 4. SAFETY RECOMMENDATIONS

**REC 09/14.** It is recommended that the French Civil Aviation Authority, responsible for monitoring and inspecting the maintenance center, reevaluate the technical suitability of this aircraft's maintenance center, Locavions.

**REC 10/14.** It is recommended to this Skydiver Club that it improve its oversight of the airworthiness of the aircraft it operates either by contracting qualified personnel or by contracting a CAMO capable of such oversight.

**REC 11/14.** It is recommended to the Civil Aviation Authority of Federal Republic of Germany, country of CAMO Köhler, that it re-evaluate the technical suitability of the airworthiness continuous manager of this aircraft.

## DATA SUMMARY

### LOCATION

| | |
|---|---|
| Date and time | **Friday, 21 September 2012; 19:16 UTC**[1] |
| Site | **On approach to runway 06 at the Ibiza Airport (LEIB) (Spain)** |

### AIRCRAFT

| | | |
|---|---|---|
| Registration | **EC-JIL** | **CS-DNP** |
| Type and model | **BOMBARDIER Inc. BD-700-1A10** | **DASSAULT FALCON 2000** |
| Operator | **Punto-FA, S.L.** | **Netjets Europe** |

#### Engines

| | | |
|---|---|---|
| Type and model | **ROLLS & ROYCE BR700-710A2-20** | **HONEYWELL CFE 738-1-1B** |
| Number | **2** | **2** |

### CREW

| | Captain | First officer | Captain | First officer |
|---|---|---|---|---|
| Age | **38** | **46** | **48** | **38** |
| Licence | **ATPL** | **CPL** | **ATPL** | **CPL** |
| Total flight hours | **6,600 h** | **3,600 h** | **7,570 h** | **5,000 h** |
| Flight hours on the type | **2,900 h** | **1,900 h** | **1,767 h** | **1,000 h** |

### INJURIES

| INJURIES | Fatal | Serious | Minor/None | Fatal | Serious | Minor/None |
|---|---|---|---|---|---|---|
| Crew | | | **2** | | | **3** |
| Passengers | | | **9** | | | **7** |
| Third persons | | | | | | |

### DAMAGE

| | | |
|---|---|---|
| Aircraft | **None** | **None** |
| Third parties | **None** | **None** |

### FLIGHT DATA

| | | |
|---|---|---|
| Tipo de operación | **General aviation – Business** | **Commercial Air Transport – Charter – International – Passenger** |
| Phase of flight | **Approach** | **Approach** |

### REPORT

| | |
|---|---|
| Date of approval | **27 February 2014** |

[1] All times in this report are in UTC unless otherwise specified. To obtain local time, add 2 hours to UTC.

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

On 21 September 2012, a Bombardier BD-700 aircraft, registration EC-JIL and call sign MGO758, was making a flight from Nice (LFMN) to Ibiza (LEIB).

At the same time, a Dassault Falcon 2000, registration CS-DNP and call sign NJE599U, was flying to Ibiza from Porto (LPPR).

Aircraft EC-JIL was in radio and radar contact with the Palma ACC[2], Ibiza Approach (APP) Sector, and was receiving vectors to intercept the runway 06 localizer (LLZ) at LEIB. It was on a course of 240° to the southeast descending to FL[3] 080.

Aircraft CS-DNP was on a southeasterly course direct to the IAF[4] TILNO on the ILS[5] approach to runway 06 at LEIB. It was under the control of TACC[6] Levante. Later, once in contact with Ibiza APP, it was cleared to continue its descent to FL 090.

At 19:12:24, Ibiza APP cleared aircraft EC-JIL to descend to 2,500 ft, and at 19:13:36, it instructed aircraft CS-DNP to reduce speed to 250 kt and cleared it to descend to 3,000 ft.

At 19:14:58, aircraft CS-DNP reached the IAF TILNO. After passing it the aircraft turned left toward the localizer. Seconds later, at 19:15:35, aircraft CS-DNP requested to intercept the ILS glide slope for runway 06. Ibiza APP instructed it to turn right to 160° and cross the localizer. After several requests made by aircraft CS-DNP to confirm the instruction to cross the localizer, at 19:16:06, Ibiza APP, after instructing a turn to 160° on two occasions, instructed the crew to turn immediately heading 180°. Aircraft CS-DNP started the turn when it was over the localizer, placing it on a course toward EC-JIL, which had previously been cleared to turn right heading 270°.

At 19:16:38, both aircraft notified ATC[7] that they had received a TCAS RA[8]. Aircraft CS-DNP was established at 3,000 ft and had passed the runway 06 localizer, on a heading opposite that being flown by EC-JIL, which was descending to 2,500 ft as authorized. The two aircraft flew within 1.2 NM horizontally and 300 ft vertically of each other.

Both aircraft completed their flights without further incident. There were no injuries and there was no damage to either aircraft.

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[2] ACC – Area Control Center.
[3] FL – Flight Level.
[4] IAF – Initial Approach Fix.
[5] ILS – Instrumental Landing System.
[6] TACC – Terminal Area Control Center.
[7] ATC – Air Traffic Control.
[8] TCAS RA – Traffic Collision Avoidance System Resolution Advisory.

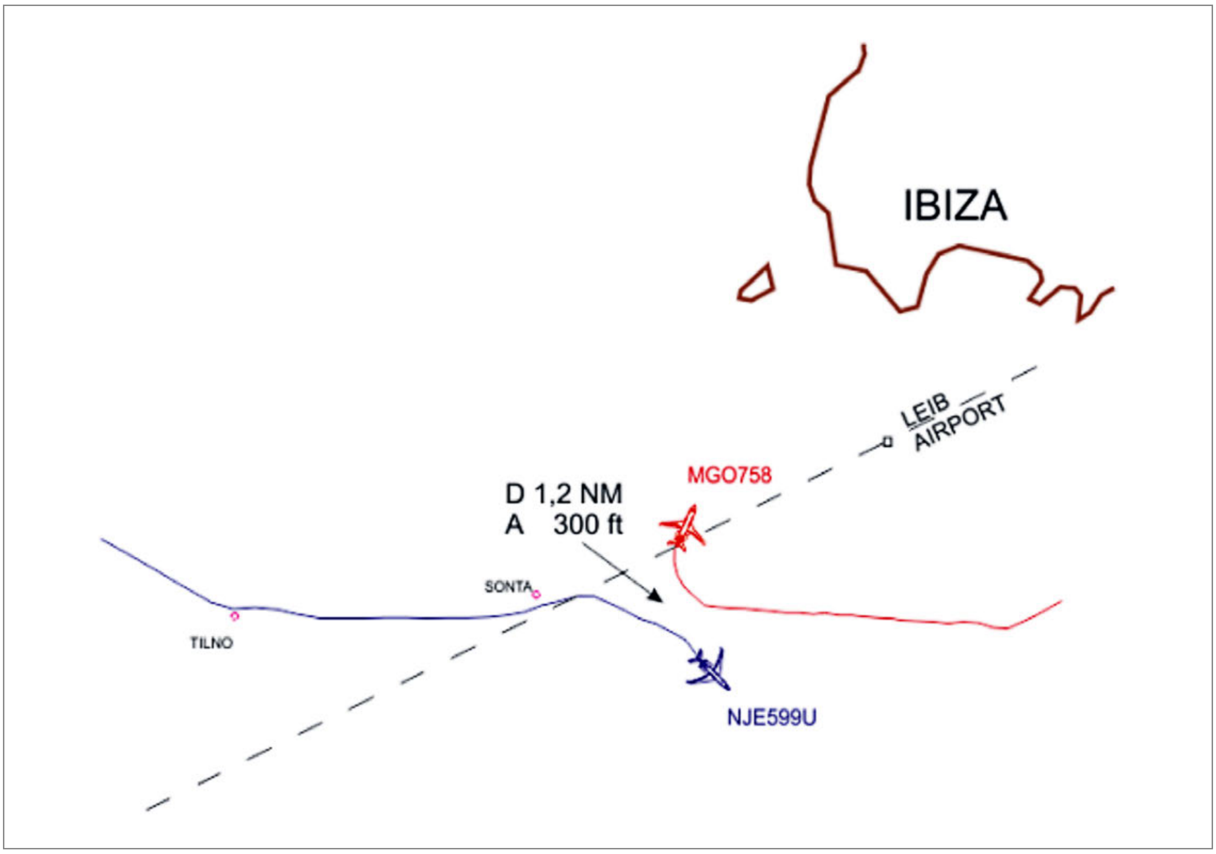


**Figure 1.** Aircraft flight paths

## 1.2. Personnel information

### 1.2.1. *Information on the crew of aircraft EC-JIL*

The captain of the aircraft, a 38-year old Spanish national, had an airline transport pilot license and a class 1 medical certificate, both valid and in force at the time of the incident. He had a total experience of 6,600 flight hours, of which 2,900 had been on the type. He had an English proficiency level of 5.

The aircraft's first officer, a 46-year old Spanish national, had a commercial pilot license and class 1 and 2 medical certificates, all valid and in force at the time of the incident. He had a total experience of 3,600 flight hours, of which 1,900 had been on the type. He had an English proficiency level of 5.

### 1.2.2. *Information on the crew of aircraft CS-DNP*

The captain of the aircraft, a 48-year old Dutch national, had an airline transport pilot license and a class 1 medical certificate, both valid and in force at the time of the incident. He had a total experience of 7,570 flight hours, of which 1,767 had been on the type. He had an English proficiency level of 6.

The first officer of aircraft CS-DNP, a 38-year old Dutch national, had a commercial pilot license and a class 1 medical certificate, both valid and in force at the time of the incident. He had a total experience of 5,000 flight hours, of which 1,000 had been on the type. He had an English proficiency level of 6.

#### 1.2.3. *Information on ATC personnel*

The Ibiza APP Sector controller was a Spanish national. He had the necessary air traffic controller license and control ratings, all valid and issued by the Spanish authority in June 1989. He also had the endorsement of the LECP[9] unit, issued in September 2011. He had a Spanish proficiency level of 6 and an English level of 5.

### 1.3. Aircraft information

Both aircraft are medium-sized twin engine jet business airplanes with maximum takeoff weights in excess of 5,700 kg.

Both had valid and in force Airworthiness Certificates.

Both aircraft were equipped with an ACAS II (Airborne Collision Avoidance System). The Dassault Falcon 2000 had a TCAS-4000 unit made by Rockwell Collins, while the Bombardier had a TCAS 2000 made by ACSS (Aviation Communication & Surveillance Systems).

### 1.4. Meteorological information

According to data supplied by the National Weather Agency, weather conditions at 19:00 at the Ibiza Airport were as follows: wind from the northeast at 7 kt, visibility in excess of 9,999 m, scattered clouds at 4,500 ft, temperature 24 °C, dew point 21 °C, QNH 1,015 and no significant changes.

### 1.5. Communications

Communications during the incident were handled on the Ibiza APP frequency of the Palma ACC control station. Conversations between Ibiza APP and aircraft CS-DNP were

[9] LECP – Palma Area Control Center.

handled all in English, while with EC-JIL they were conducted in Spanish except during the close approach with aircraft CS-DNP, when English was used. The recordings of the communications revealed some noise on the frequency that did not impede understanding the messages. The full conversations are included in Appendix I, so only the most relevant exchanges are considered in this section.

At 19:07:03, aircraft CS-DNP made contact on the Ibiza APP frequency. From then on both aircraft were in radio and radar contact with Ibiza APP. Aircraft CS-DNP was proceeding from the NW direct to the IAF TILNO and descending to FL 090, cleared by the previous ATC station (TACC Levante) after coordinating it with Ibiza APP. Aircraft EC-JIL was flying S to the RWY 06 localizer on a heading of 240° and descending to FL 080.

Between 19:07:51 and 19:10:30, Ibiza APP instructed aircraft CS-DNP to reduce its speed and descend to 4,000 ft. In the meantime, it cleared aircraft EC-JIL to descend to 3000 ft and instructed it to descend to 2,500 ft at 19:12:24. Subsequently, at 19:13:36, it cleared aircraft CS-DNP to descend to 3,000 ft and reduce speed to 250 kt.

At 19:14:12, aircraft EC-JIL reported having the preceding traffic on approach in sight (this aircraft was not involved in the near miss), and requested to adjust visually. Ibiza APP instructed it to turn right heading 270°. A minute later, Ibiza APP asked LEIB TWR if aircraft EC-JIL could adjust visually to the preceding traffic, to which LEIB TWR replied no since there was an aircraft ready for takeoff and if EC-JIL adjusted too much it would be unable to pass through. Later, at 19:15:25, aircraft EC-JIL reported it was ready to turn, to which Ibiza APP replied an aircraft was ready for takeoff and he would have to ensure an 8 NM separation with it.

At 19:15:35, aircraft CS-DNP reported reaching 3000 ft and requested to intercept the glide slope. Ibiza APP instructed it to turn right to heading 160° and cross the localizer. After this exchange, aircraft CS-DNP requested confirmation that the 160° heading was to intercept the localizer, and Ibiza APP instructed it to cross the localizer. The aircraft then asked that the message be repeated, and Ibiza APP instructed it to fly HDG[10] 160° through the localizer, repeating this last instruction. Aircraft CS-DNP then stated that it was crossing the localizer at that time and that it should be on heading 060° to intercept the localizer. Ibiza APP then instructed aircraft CS-DNP to immediately turn right to heading 180°. The aircraft acknowledged and requested that Ibiza APP state its intentions, but the controller did not reply.

Immediately afterward, at 19:16:14, Ibiza APP instructed aircraft EC-JIL (in the first exchange in English with this aircraft) to turn right heading 030° on final vector to intercept the runway 06 localizer at LEIB, and cleared it for an ILS approach to this runway. The aircraft did not acknowledge. Ibiza APP then instructed aircraft CS-DNP to once more turn immediately to HDG 180°, after which the aircraft reported a TCAS RA.

[10] HDG – Heading.

Two seconds, later, the LEIB TWR called Ibiza APP to report that aircraft CS-DNP and EC-JIL were both at almost 3,000 ft.

Finally, at 19:16:39, Ibiza APP called aircraft EC-JIL, which reported it had received a TCAS RA and that it was turning to heading 020° to intercept and complete the ILS approach to runway 06.

## 1.6. Aerodrome information

### 1.6.1. *STAR – Standard Instrument Arrival*

As indicated on the flight plan for aircraft CS-DNP, the standard arrival (STAR) planned for the day of the incident was STAR VARUT1V, published in the AIP Spain in chart AD2-LEIB STAR 1.2. Onboard the aircraft was the Jeppesen 10-02G chart for Ibiza, corresponding to the instrumental standard terminal arrival route for runway 06 at the Ibiza Airport. This chart warns not to proceed beyond the IAF without ATC clearance. It also lists the minimum hold altitude over IAF TILNO as 4,000 ft.

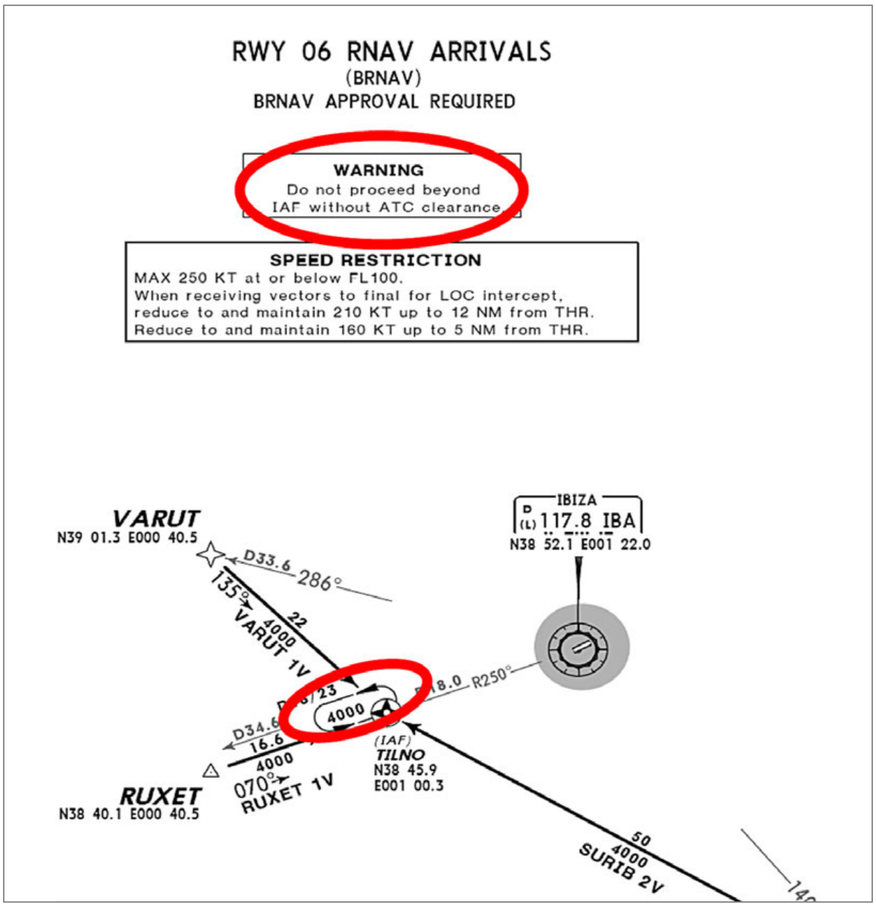


Figure 2. Portion of Jeppesen chart 10-2G

### 1.6.2. *IAC*[11]

The ILS instrument approach procedure for runway 06 at LEIB is published in chart AD 2-LEIB IAC/1 of the AIP Spain. Aircraft CS-DNP had onboard Jeppesen chart 11-1, corresponding to the IAC for runway 06 at Ibiza. Both charts establish the heading to fly after leaving the IAF TILNO as 088° until the intermediate fix (IF) is reached.

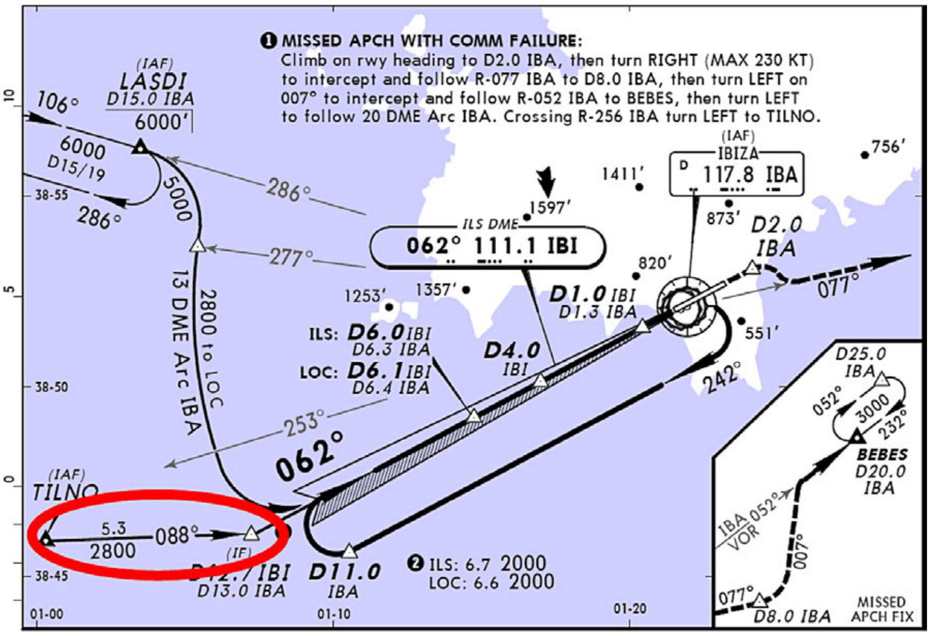


Figure 3. Portion of Jeppesen chart 11-1

## 1.7. Tests and research

### 1.7.1. *Statement from crew of aircraft EC-JIL*

The pilot of aircraft EC-JIL stated that as they were flying on a heading of 240°, they had visual contact with the traffic ahead of them on the approach, so they asked ATC if they could continue visually and adjust to the traffic. ATC denied the request because they had to be 8 NM back from the preceding traffic to give another aircraft room to take off on runway 06.

They were then instructed to turn right heading 270° toward the localizer. This heading placed them on a path opposite that of CS-DNP, which was heading toward the localizer from the west at almost the same altitude. The pilot stated that they saw the situation on the TCAS screen and started to become concerned when the other traffic

[11] IAC – Instrument Approach Chart.

was within 10 NM of their position and closing. He added they could see their lights. In light of their concern, the pilot informed ATC that they were ready to turn toward the localizer, but the controller, instead of clearing them to do so, instructed aircraft CS-DNP to turn HDG 160°. When they were some 5 NM away from the other aircraft, there were several misunderstandings on the frequency between the controller and aircraft CS-DNP, with several incorrect acknowledgments from the other crew, which did not seem to understand the intentions of ATC's instructions.

He finally stated that aircraft CS-DNP reported a TCAS RA, immediately after which they also had a descent RA. They followed the TCAS instructions and descended and turned right. During the TCAS warning the controller instructed them to turn heading 030° as the final intercept vector and cleared them for an ILS approach to runway 06, an instruction they did not acknowledge as they were carrying out the evasive maneuver.

### 1.7.2. *Statement from crew of aircraft CS-DNP*

The crew of aircraft CS-DNP stated that they were proceeding direct to the IAF TILNO, as cleared by ATC. Upon reaching it, they requested instructions, but the controller was speaking at the moment with another aircraft in Spanish. They kept flying on a more or less easterly heading. The autopilot was engaged and following the FMS[12], which had a turn to the runway 06 FAF[13] programmed into it. The controller then gave them an instruction that they could not quite understand due to the controller's heavy Spanish accent. They were unsure whether it was "060° to intercept the ILS" or "160° to intercept ILS". Since they did not understand the clearance, they asked the controller, who instructed them to turn heading 160°. When they started the turn, ATC instructed them to turn to 180°, at which time they received a TCAS RA to climb, disengaged the autopilot and complied with the RA.

The crew also stated that they were in visual contact with the other aircraft throughout the entire incident, from the time they passed the IAF TILNO until they completed the maneuver indicated by the TCAS.

### 1.7.3. *Statement from the Ibiza APP controller*

The Ibiza APP controller stated that the locations of the aircraft before the incident took place were as follows: there was a third aircraft established on the localizer and cleared for an ILS approach to RWY 06, aircraft EC-JIL was on the base leg cleared to 2,500 ft, and aircraft CS-DNP had been cleared by the Levante TACC to proceed direct to the IAF TILNO. He stated that the priority was to turn aircraft EC-JIL and establish it on the localizer

[12] FMS – Flight Management System.
[13] FAF – Final Approach Fix.

to clear it for the approach. His intention was to have aircraft CS-DNP cross the LLZ and then give it radar vectors to intercept the localizer and adjust it to aircraft EC-JIL.
As the situation progressed, aircraft EC-JIL requested to do a visual approach, but this was denied because the LEIB Tower had requested a 10 NM separation between the traffic already established on the localizer. Aircraft CS-DNP called to report it was arriving at the IAF TILNO and requested to follow the localizer, which was denied, being instructed instead to cross the localizer on heading 160°. Since the aircraft did not understand the instruction, he had to repeat it three times, which kept him from clearing aircraft EC-JIL to turn onto final earlier. He pointed to this as the origin of the conflict.

The controller further pointed out that aircraft CS-DNP had not been cleared for an ILS approach, meaning the limit of its clearance was TILNO, which it should not have proceeded past without clearance.

Lastly, the controller noted that on the day of the incident, he was responsible for the Ibiza route and Ibiza approach sectors, which meant his radar display was not ideally suited to work the approach since said display was too broad and distorted the view of the approach.

### 1.7.4. *Radar Information*

The radar data provided by the Air Navigation Office of the Balearic Islands show aircraft CS-DNP on a constant descent from 4,700 ft at a rate in excess of 1,800 ft/min that gradually decreased to 1,000 ft/min as it approached its cleared altitude of 3,000 ft. Thirty-five seconds later the close approach with aircraft EC-JIL occurred.

The radar data also show that once aircraft CS-DNP was past the IAF TILNO, it turned left and proceeded toward the runway 06 localizer at LEIB, apparently in keeping with the standard procedure published in the IAC[13] for the runway 06 ILS approach (AIP Spain AD2-LEIB IAC/1).

In the meantime, aircraft EC-JIL was descending at a constant rate of about 900 ft/min heading west to an altitude of 2,700 ft, where the near miss with aircraft CS-DNP took place.

The closest point of approach was at 19:16:38, with the two aircraft closing to within 1.2 NM horizontally and 300 ft vertically of each other. Aircraft CS-DNP was at an altitude of 3,000 ft on an easterly heading while turning to HDG 160° as instructed, and aircraft EC-JIL was descending through 2,700 ft heading west.

Five seconds later, aircraft EC-JIL was turning right and descending through 2,600 ft, while aircraft CS-DNP was climbing through 3,100 ft.

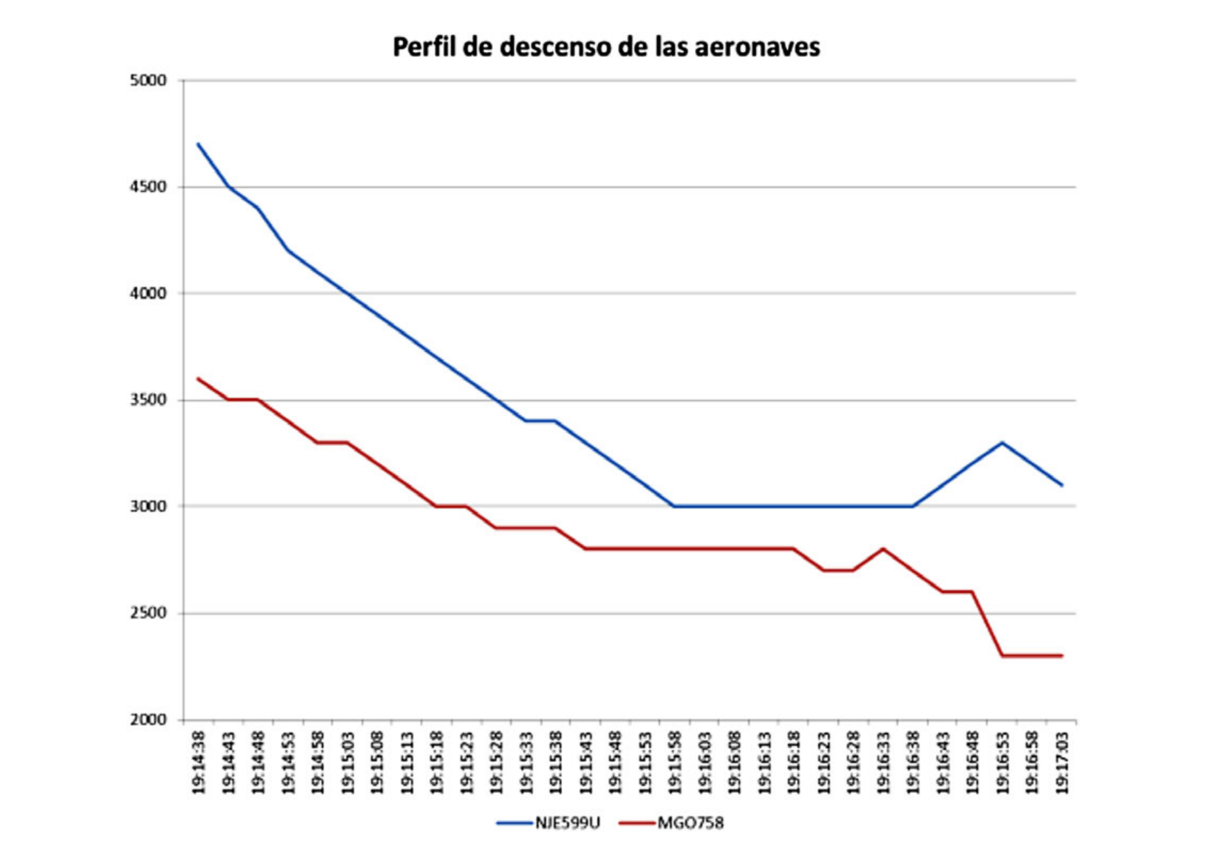


**Figure 4.** Descent profiles of aircraft NJE599U and MGO758

The vertical and horizontal distances between the aircraft, as well as their altitudes, are given below in Table 1.

| UTC time | Altitude (ft) CS-DNP | Altitude (ft) EC-JIL | Vertical dist. (ft) | Horizontal dist. (NM) |
|---|---|---|---|---|
| 19:16:18 | 3,000 | 2,800 | 200 | 3.2 |
| 19:16:23 | 3,000 | 2,700 | 300 | 2.7 |
| 19:16:28 | 3,000 | 2,800 | 200 | 2.2 |
| 19:16:33 | 3,000 | 2,700 | 300 | 1.7 |
| 19:16:38 | 3,000 | 2,700 | 300 | 1.2 |
| 19:16:43 | 3,100 | 2,600 | 500 | 1 |
| 19:16:48 | 3,200 | 2,600 | 600 | 0.9 |
| 19:16:53 | 3,300 | 2,300 | 1,000 | 1.2 |
| 19:16:58 | 3,200 | 2,300 | 900 | 1.6 |

**Table 1.** Horizontal and vertical distances during the incident

## 1.8. Organizational and management information

### 1.8.1. *Operations Manual of the Palma Control Center (LECP)*

Section 9.4, "Operational Organization of the Station" of the LECP's Operations Manual states that the number of open positions or sectors and their groupings depends on the traffic demand and on the number of controllers on duty.

On the day of the incident, the Ibiza Approach Sector was grouped with the Route Sector. This grouping is called IXX. The main responsibilities of each sector are as follows:

The *Ibiza Route Sector (IRX)* controls traffic departing from or arriving at Ibiza and all flights between FL 115 and FL 225. In the winter, when the Ibiza Airport is closed, this sector handles the traffic in the Ibiza Approach Sector. The collateral sectors are Barcelona ACC, Valencia TACC and other sectors of the Palma ACC (Section 9.5.2.3).

The *Ibiza Approach Sector (IAX)* handles sequencing, approach and takeoff operations involving the Ibiza airport, in addition to any aircraft operating between MSL-GML[14] and FL 115 within its airspace. The collateral sectors are Barcelona ACC, Valencia TACC, Ibiza TWR and other sectors of the Palma ACC (Section 9.5.2.4).

### 1.8.2. *Letter of Agreement (LOA) between Ibiza Approach Control (Ibiza APP) and the Ibiza Airport Control Tower (Ibiza TWR)*

Section D.2.1, *Flights from Ibiza APP to Ibiza TWR*, in Annex D of the LOA between the two stations states that the separation between successive aircraft shall be 8 NM in visual meteorological conditions (VMC). This separation is to be established as soon as the first aircraft is at the ATZ[15] limit, 5 NM away from landing.

Section E.3 in Annex E, *Transfer of Control and Transfer of Communications*, indicates that Ibiza APP will transfer aircraft to Ibiza TWR between 15 and 6 NM out on final or coordinate the transfer on a segment of the circuit.

### 1.8.3. *Operations Manual of the company Netjets*

Section 8.3.22.7 of the Part A Operations Manual, *Descent to Cleared Altitudes on Approach*, states that the altitudes specified in instrument approach procedures must be strictly adhered to. It also notes that the descent to the next lower cleared altitude is to be made only after passing the associated fix and only if the aircraft is following the flight path specified in the procedure.

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[14] MSL-GML – Mean Sea Level.
[15] ATZ – Aerodrome Traffic Zone.

It then notes that these instructions do not apply when the aircraft is cleared to descend when receiving radar vectors or when executing a visual approach.

Section 8.3.1.10 of the same manual, *ATC Clearances*, specifies that any concerns from any member of the crew regarding the contents of a clearance must be clarified with ATC, and gives the following example: "Say again clearance for Fraction 123".

## 1.9. Additional information

### 1.9.1. *ACAS Airborne Collision Avoidance System*

The purpose of the Airborne Collision Avoidance System (ACAS) is to warn pilots of possible collisions. According to Regulation (EU) No. 1332/2011 of the Commission of 16 December 2011, laying down common airspace usage requirements and operating procedures for airborne collision avoidance, all turbine-powered airplanes with a maximum certified takeoff weight in excess of 5,700 kg, or that are authorized to transport more than 19 passengers, and that fly in the air space of European Union Member states, are required to be equipped with the ACAS II system. Additionally, this requirement is applicable internationally pursuant to Annex 6, Aircraft Operations, Part I, International Commercial Air Transport – Airplanes, of the International Civil Aviation Organization.

ACAS equipment can provide two types of advisories:

- **TA – Traffic Advisory,** the purpose of which is to alert the flight crew sufficiently far in advance of possible threat aircraft. Its aim is, on the one hand, to encourage crews to visually locate those aircraft that could pose a threat (a TA indicates distance, altitude, speed, change in altitude and bearing), and on the other, to act as a precursor to a RA.
- **RA – Resolution Advisory,** provides vertical maneuvers or restrictions to said maneuvers so as to ensure sufficient vertical separation within the restrictions imposed by the two aircraft's abilities in terms of climb rate and proximity to the ground. If the ACAS system's threat detection logic determines that an encounter with a nearby aircraft could lead to a collision or quasi-collision, the threat resolution logic will determine the appropriate maneuver so as to ensure vertical separation between the two aircraft.

### 1.9.2. *Spain's Air Traffic Regulations (RCA)*

Spain's Air Traffic Regulations specify the following in terms of the contents and phraseology of an instruction given by ATC when providing radar vectors to an aircraft on approach:

*4.3.11. Content of air traffic control clearances.*

*4.3.11.1. Clearances shall contain verified and concise information and, insofar as possible, shall follow a standard format.*

*4.6.9.3.7. When an aircraft is assigned a vector that passes through the final approach bearing, the aircraft shall be duly informed of this along with the reasons for using said vectoring.*

*4.10.4.2.2. Vectoring for ILS and other aids interpreted by the pilot.*

| | |
|---|---|
| h) PREVEA GUIA VECTORIAL PARA CRUZAR (rumbo del localizador o ayuda) (motivo); | h) EXPECT VECTOR ACROSS (localizer cource or aid) (reason); |
| i) ESTE VIRAJE LE HARA PASAR POR (ayuda) [motivo]; | i) THIS TURN WILL TAKE YOU THROUGH (aid) [reason]; |
| i) LE LLEVAMOS A PASAR POR (ayuda) [motivo]; | i) TAKING YOUR THROUGH (aid) [reason]; |

And the reason shall be stated as follows:

NOTE: When a reason for the radar vectoring or for the stated maneuvers must be given, the following phraseology should be used:

| | |
|---|---|
| *NOTA.- Cuando sea necesario especificar un motivo para la guía vectorial radar o para las maniobras mencionadas debería utilizarse la fraseología siguiente:* | |
| a) DEBIDO A TRÁFICO; | a) DUE TO TRAFFIC; |
| b) PARA SEPARACIÓN DE TRÁFICO; | b) FOR TRAFFIC SEPARATION; |
| c) PARA SECUENCIA DE TRÁFICO (POSICIÓN); | c) FOR TRAFFIC SECUENCY; |
| d) PARA PROCEDER A TRAMO VIENTO EN COLA (BASE o FINAL). | d) FOR DOWNWIND (BASE, or FINAL). |

The RCA specifies the following regarding clearance limits:

Clearance limit.
Point to which an aircraft is granted an air traffic control clearance.

*4.3.12.1. Clearance limit.*

*4.3.12.1.1. The clearance limit shall be described by specifying the name of the corresponding reporting point, aerodrome or controlled air space limit.*

*4.3.12.1.3. If an aircraft is cleared to an intermediate point in an adjacent control area, the corresponding area control center shall then be responsible for issuing an amended clearance to the destination aerodrome as soon as possible.*

As regards the general radar procedures for approach and for vectoring to intercept a final approach aid interpreted by the pilot, such as an ILS, the RCA states that:

*4.6.9.3.6. Aircraft being vectored to final approach shall be given a heading or series of headings calculated such that they are directed toward the final approach bearing. The final vector shall allow the aircraft to remain firmly established, in level flight, on the final approach bearing before intercepting the specified or nominal glide slope if the approach is to be made using MLS, ILS or radar. The final vector shall also provide an angle for intercepting the final approach bearing that is 45° or less.*

*4.6.9.4.1. An aircraft being vectored to intercept an aid interpreted by the pilot for final approach shall be given instructions to report when established on the final approach bearing. The approach clearance shall be expedited before the aircraft reports being established on the bearing, unless circumstances impede issuing the clearance at that time. Normally, radar vectoring will terminate when the aircraft departs from the last assigned heading and proceeds to intercept the final approach bearing.*

As for the information to be provided when two controlled aircraft are no longer separated by radar separation minima:

*4.3.14.1. Essential traffic is that controlled traffic to which the provision of separation by ATC is applicable, but which, in relation to a particular controlled flight is not separated from other controlled traffic by the minima established in Sections 4.3.2 to 4.3.9 inclusive, Section 4.4.3 and Section 4.6.6.6.*

*4.3.14.2. Essential traffic information shall be given to controlled flights concerned whenever they constitute essential traffic to each other.*
*This information will inevitably relate to controlled flights cleared subject to maintaining own separation and remaining in visual meteorological conditions (See 4.3.13.1.).*

As regards the actions that a pilot can carry out to avoid a traffic conflict, the RCA states the following:

*2.3.2.2.8.2. Nothing specified in the procedures in 2.3.2.2.8.3 shall impede the pilot in command from using his own judgment and exercising full authority in selecting those actions deemed most appropriate for resolving a traffic conflict or preventing a possible collision.*

*Note: The ability of ACAS to fulfill its function of aiding pilots avoid possible collisions depends on the correct and prompt response by pilots to the ACAS instructions.*

Aircraft CS-DNP was flying in class A air space, meaning it was subject to ATC control, as indicated in RCA 3.2.6.3.

*3.2.6.3. The requirements for flights within each class of air space shall be as indicated in the table below_*

| Class | Type of flight | Separation provided | Service provided | Speed limitation | Radio communications requirements | Subject to ATC clearance |
|---|---|---|---|---|---|---|
| A | IFR only | All aircraft | ATC | Not applicable | Continuous two ways | Yes |

### 1.9.3. *Information from the air traffic service*

The incident took place in class A air space, in which air traffic control service is provided to all IFR flights within the Ibiza APP Sector. Specifically, ATC provides radar-based approach control service, whose functions include:

a) Vector incoming traffic to final approach aids or to a point from which a precision radar approach, a surveillance radar approach or a visual approach can be made.
b) Provide radar assistance for approaches made to facilities not equipped with radar and notify aircraft of deviations from normal approach trajectories.
c) Provide radar separation between:

  i. Successive departing aircraft,
  ii. Successive arriving aircraft and,
  iii. A departing aircraft and the next arriving aircraft.

# 2. ANALYSIS

## 2.1. Flight path of aircraft CS-DNP

Aircraft CS-DNP had been cleared by the Levante TACC to proceed direct to the IAF TILNO, the initial approach fix for runway 06 at LEIB. This meant it was receiving radar vectors and was therefore not following a standard approach procedure. Once in radio and radar contact with Ibiza APP, it was cleared to descend to 3,000 ft without amending its clearance limit, meaning said limit was still the IAF TILNO. After reaching said point, aircraft CS-DNP, as revealed by radar data and confirmed by the pilot's statement, turned toward the localizer, following the RWY 06 approach procedure that was programmed into the FMS.

The communications do not indicate that aircraft CS-DNP was cleared by Ibiza APP to cross point TILNO, nor that the aircraft called to inform ATC that it was reaching its clearance limit. Since the aircraft was flying in class A air space, IFR flights were subject to ATC clearance, meaning aircraft CS-DNP should have received a new instruction to proceed beyond the IAF. The pilot stated that he tried to report on the frequency that they had passed TILNO, but it was not possible because the controller was guiding another aircraft at that moment.

According to the radar data, the aircraft crossed the IAF at 19:14:58. The transcript of the oral communications does not reveal any exchanges between 19:14:24 and 19:15:10. A minute after turning left once past the IAF TILNO, aircraft CS-DNP turned left again to line up with the final approach bearing without being cleared to do so.

The clearance to descend to 3,000 ft given to aircraft CS-DNP before reaching the IAF TILNO, a thousand feet below the minimum altitude specified in the STAR for the IAF, could have made the crew think that they were cleared to continue with the IAC procedure, as shown by the radar trajectory. The aircraft did not descend below 4,000 ft until it was past the IAF, as instructed in the company's Flight Manual (see Section 1.9.4) for descents following an approach procedure. In this case, however, the aircraft was receiving radar vectors, meaning it was not necessary to maintain that altitude.

## 2.2. Flight path of aircraft EC-JIL

At 19:14:12, aircraft EC-JIL requested from Ibiza APP to adjust visually to the preceding traffic on the approach sequence, which was already established at the RWY 06 LLZ. Ibiza APP denied the request citing the need to establish an 8 NM separation between aircraft EC-JIL and an aircraft that was going to take off from LEIB. According to the LOA between the LEIB TWR and Ibiza APP, the minimum separation between successive aircraft is 8 NM. Providing this separation with the departing aircraft meant increasing the separation between aircraft EC-JIL and the one preceding it in the approach sequence. This is why ATC kept aircraft EC-JIL on its heading of 270°.

The decision to maintain aircraft EC-JIL on heading 270°, convergent with the heading being flown by CS-DNP, caused the horizontal separation between the two aircraft to decrease. This, along with the fact that Ibiza APP had cleared EC-JIL to descend to 2,500 ft first (at 19:12:28) and then aircraft CS-DNP to descend to 3,000 ft (at 19:13:13), resulted in the minimum vertical radar separation (1,000 ft) not being maintained at the closest point of approach. The vertical distance was also less than the 500 ft guaranteed by the clearances because aircraft EC-JIL had not yet reached its cleared altitude (2,500 ft) when it crossed the path of aircraft CS-DNP.

## 2.3. Clearances for aircraft CS-DNP to cross the LLZ

At 19:15:42, the Ibiza AP controller instructed aircraft CS-DNP to turn heading 160° for the first time and cross the runway 06 localizer after aircraft CS-DNP requested clearance to follow the ILS glide slope for runway 06. Based on the approach sequence the controller had planned, aircraft CS-DNP was second behind aircraft EC-JIL. At that time, the aircraft was proceeding to the localizer after leaving the IAF TILNO, despite not having been cleared to do so. Aircraft CS-DNP, having failed to understand ATC's instruction, requested confirmation that the heading being given was to intercept the LLZ, since it is possible that the aircraft was expecting a heading to intercept the localizer and make the approach to runway 06. The controller, without replying negatively, instructed it once more to cross the localizer, a communication that did not clarify the aircraft's situation, which again asked that the instruction be repeated. Fifteen seconds after the initial instruction, ATC again instructed aircraft CS-DNP to turn heading 160° and cross the localizer. Aircraft CS-DNP replied they were crossing the localizer at that moment and further stated that the intercept heading should be 060°, which seems to indicate they did not understand the controller's intentions. ATC then ordered aircraft CS-DNP to turn immediately heading 180°. The aircraft acknowledge, requesting the intentions behind said instruction, but the Ibiza APP controller did not reply.

Almost thirty seconds elapsed between the first instruction from the Ibiza APP controller to aircraft CS-DNP to turn HDG 160° and cross the localizer and the aircraft's acknowledgment to turn heading south following the instruction to turn immediately. During this time, ATC sent two messages, providing a radar vector and informing the aircraft to cross the LLZ, but the controller did not inform the aircraft of the reason for doing so. This is in violation of Spain's Air Traffic Regulations (see Section 1.10.1), which states that when an aircraft is given a vector that involves crossing the final approach bearing, a reason shall be given for providing said vectoring.

Aircraft CS-DNP requested that the instruction be clarified on several occasions since the crew came to believe that given the time and their location in the approach, the next instruction they would receive would be to turn to the final approach bearing. ATC, however, continued providing only the vector and the instruction to cross the localizer, which did nothing to clarify the confusion onboard aircraft CS-DNP. Only once did aircraft CS-DNP use the phraseology indicated in its Operations Manual to request clarification of a clearance, "Say again clearance for Fraction 123" (see Section 1.8.3).

## 2.4. Language of the communications between ATC and the aircraft

All the communications between aircraft CS-DP and the Ibiza APP controller before and after the incident were in English. The communications between ATC and aircraft EC-JIL, however, were in Spanish, except for one exchange that was made in English, at 19:16:23, during the close approach between the two aircraft.

The fact that ATC did not use English with aircraft EC-JIL while it was providing vector guidance to both to intercept the localizer on the same runway prevented the crew of aircraft CS-DNP from having a clear picture of the approach sequence, since they were unaware that the preceding aircraft in the approach sequence was aircraft EC-JIL, information that was conveyed in Spanish. This lack of a clear situational awareness by the crew of aircraft CS-DNP could have contributed to its crew's misunderstanding of the instruction to cross the LLZ.

One of the contributing factors has thus been identified as the use of Spanish in a situation involving an aircraft whose crew did not master this language.

This problem has been addressed before by the CIAIAC, which issued safety recommendation REC 25/03 in its report IN-060/2002 regarding the use of English on frequency:

> REC 25/03 (IN-060/2002). It is recommended that the DGAC create a working group with the participation of AENA and representatives from operators, professional pilot associations and professional controller associations to study the possibility of regulating the sole use of English in ATC communications in situations involving a pilot who does not speak Spanish, and the conditions under which said regulation is to be implemented.

In reference to said recommendation, on 10 February 2012 AESA reported the creation of a working group for the Madrid TMA consisting of AESA and AENA representatives, the main purpose of which is to identify, propose and monitor improvement measures related to safety incidents and complaints from the various groups.

The first meeting was held on 11 February 2011, where one of the primary areas of concern was identified as the implementation of English as the sole language to be used in all ATC communications in the Madrid TMA. In this regard, the group deemed it necessary to make a series of inquiries to determine the acceptance of the measure by users and the possible negative effects it could have on operational safety. In response to this concern, in May 2011 AESA requested information from ENAC (Italy) on their experience in the exclusive use of English in aviation communications.

On 31 May, the CIAIAC closed out the recommendation, deeming the response satisfactory.

## 2.5. Conflict management

During all the time that ATC was instructing aircraft CS-DNP to cross the runway 06 LLZ, said aircraft was closing in on aircraft EC-JIL. The Ibiza APP controller, on seeing that aircraft CS-DNP did not understand or obey the instruction to turn heading 160° (twenty-four seconds after the initial clearance), ended up instructing it to turn immediately heading south to resolve the conflict situation that had resulted between the two aircraft. This did not remedy the situation since aircraft CS-DNP was over the runway 06 localizer, a horizontal distance of 2.7 NM and a vertical distance of 300 ft away from EC-JIL, when it acknowledged the turn to heading 180°.

During the turn to heading south of aircraft CS-DNP, the horizontal separation between the aircraft decreased, causing the anti-collision systems on both aircraft to issue resolution advisories. The ACAS on EC-JIL instructed its crew to descend. This was complemented by the pilot's action to turn right to increase the horizontal separation with aircraft CS-DNP, which was executing the climb maneuver indicated by its ACAS. While the two aircraft were carrying out the RA maneuvers, the controller instructed aircraft EC-JIL to turn heading 030°, the final vector to intercept the localizer. This measure did not prevent the conflict, since by then the minimum separation distances between the aircraft had already been breached.

Ibiza APP did not provide essential traffic information to either of the two aircraft in terms of maintaining own separation and remaining in visual meteorological conditions, as specified in Section 4.3.13.1 of the RCA.

The Ibiza APP controller stated that the display on the radar screen was not ideal for working approaches since it was too broad and gave a distorted view of the approaches. According to the station's document, *Sectors, Operating Configurations and Stated Capacities of the Balearic Island Region*, the sizes of the Ibiza Approach and the Ibiza Route sectors are the same, the main difference between the two being the flight levels handled by each.

## 3. CONCLUSIONS

Both aircraft were equipped with airborne anti-collision systems (ACAS II), as required by Regulation (EU) no. 1332/2011.

The aircraft with registration CS-DNP went past the IAF TILNO without being cleared by Ibiza APP to do so.

Ibiza APP only realized that aircraft CS-DNP had gone past the IAF when said aircraft called requesting clearance to follow the localizer.

The subsequent instructions by Ibiza APP to aircraft CS-DNP led to a series of explanatory messages due to the lack of situational awareness on the part of aircraft CS-DNP.

Ibiza APP did not explain to aircraft CS-DNP the reasons for its instruction to cross the localizer.

The communications between Ibiza APP and aircraft EC-JIL were held in Spanish.

Neither aircraft was cleared to altitudes that ensured the minimum vertical radar separation of 1,000 ft, a separation that fell to under 500 ft by the time the aircraft reached their cleared altitudes (3,000 ft and 2,500 ft).

The incident, then, can be deemed to have been caused when the flight paths of EC-JIL and CS-DNP converged as Ibiza APP was vectoring them for the approach to runway 06 at LEIB, resulting in a violation of the prescribed minimum radar separation distances.

This happened because aircraft CS-DNP crossed the IAF TILNO without the relevant clearance due to not having a clear picture of the approach sequence. Contributing to this was the failure of Ibiza APP to indicate the reason for its instructions and the fact that the communications between Ibiza APP and aircraft EC-JIL were in Spanish.

## 4. SAFETY RECOMMENDATIONS

This problem had already been addressed previously by the CIAIAC with the issuance of Safety Recommendation REC 25/03 directed at the DGAC. The actions to be taken were subsequently reported and the recommendation closed out, with the response being considered satisfactory.

Given the time elapsed since and in light of the persistent problem, the CIAIAC considers it necessary to issue a new recommendation along the same lines as 25/03 regarding the exclusive use of English in communications:

**REC 08/14.** It is recommended that AESA promote the implementation of the necessary actions in order to minimize the problems caused by the use of Spanish in situations involving crews that do not master the language.

# APPENDIX I

| HORA | DEP/AERO | MENSAJE |
|---|---|---|
| 190404 | LECP | SI |
| 190406 | LECL | HOLA BUENAS EL NJE PARA IBIZA ME PIDE DIRECTO A TILNO |
| 190409 | LECP | MANDALE |
| 190410 | LECL | ESO....DONDE LO ABRO HACIA LA IZQUIERDA O HACIA LA DERECHA? |
| 190413 | LECP | ESO ME PREGUNTO ESPERATE.......TILNO COMO QUE SE FUESE A FINAL COMO SI FUESE A FINAL |
| 190419 | LECL | O SEA LO ABRO HACIA LA DERECHA |
| 190421 | LECP | HACIA LA DERECHA CORRECTO |
| 190422 | LECL | MUY BIEN HASTA LUEGO |
| | | |
| | | |
| 190929 | LECP | IBIZA COMO TIENES AL DESPEGUE PARA IR BAJANDO AL MGO |
| 190935 | LEIB | AUN NO HA RODADO BAJALO A LO QUE QUIERAS |
| 190938 | LECP | VALE |
| | | |
| | | |
| 191450 | LECP | EL MGO ME PIDE AJUSTAR AL RYR PUEDE? |
| 191455 | LEIB | REPITE POR FAVOR |
| 191456 | LECP | EL MGO ME PIDE AJUSTAR AL RYR QUE SI PUEDE? |
| 191459 | LEIB | NO NEGATIVO TENGO AL ANE PREPARADO PARA SALIR SI SE ECHA MUCHO ENCIMA NO VOY A TENER SITIO PARA EL ANE |
| 191502 | LECP | VALE |
| | | |
| | | |
| 191630 | LEIB | PALMA EL MGO Y EL NJE ESTAN CASI A 3000 LOS DOS |
| | | |
| 191909 | LEIB | EL MGO NO ME LLAMA |

| HORA | DEP/AERO | MENSAJE |
|---|---|---|
| 190157 | MGO758 | PALMA BUENAS NOCHES MGO758 DESCENSO A NIVEL 150 EN CURSO A IBA POS2B |
| 190206 | ACC | MGO758 BUENAS NOCHES EN CONTACTO RADAR DESCENSO A NIVEL 130 |
| 190211 | MGO758 | AUTORIZADOS A NIVEL 130 MGO758 |
| 190216 | RYR2084 | |
| 190221 | ACC | |
| 190228 | RYR2084 | |
| 190312 | MGO758 | PALMA MGO758 REQUERIMOS RUMBO 230 POR LA IZQUIERDA PARA EVITAR |
| 190320 | ACC | RECIBIDO VUELE EN RUMBO 230 MGO758 |
| 190323 | MGO758 | ASI LO HACEMOS |
| 190328 | ACC | MGO758 Y DESCENSO PARA NIVEL DE VUELO 90 |
| 190332 | MGO758 | 90 MGO758 |
| 190412 | MGO758 | PALMA MGO758 PODRIAMOS REASUMIR YA PROPIA NAVEGACION A IBA |
| 190425 | ACC | SORRY STATION CALLING? |
| 190426 | MGO758 | SI EL MGO758 PODRIAMOS REASUMIR PROPIA NAVEGACION A IBA ESTAMOS LIBRES YA DEL TIEMPO |
| 190433 | ACC | RECIBIDO VUELE EN RUMBO 2....3....240 |
| 190441 | MGO758 | CONFIRME RUMBO 240 PARA EL MGO758 |
| 190444 | ACC | CORRECTO RUMBO 240 |
| 190446 | MGO758 | COPIADO RUMBO 240 GRACIAS |
| 190458 | ACC | |
| 190504 | IBS2507 | |
| 190519 | ACC | |
| 190530 | RYR2084 | |
| 190614 | MGO758 | PROXIMOS A 90 MGO758 |
| 190618 | ACC | MGO758 RECIBIDO DESCENSO A NIVEL 80 |
| 190622 | MGO758 | 80 MGO758 |
| 170703 | NJE599U | PALMA GOOD EVENING NJE599U DESCENDING TO FL190 INBOUND TILNO |
| 190708 | ACC | NJE599U MUY BUENAS RADAR CONTACT DESCEND FL090 |
| 190714 | NJE599U | CLEARED FL90 NJE599U |
| 190718 | MGO758 | MGO758 PROXIMOS A 80 |
| 190721 | ACC | RECIBIDO MANTENGA LE LLAMO |
| 190723 | MGO758 | MANTENEMOS MGO758 |

| | | |
|---|---|---|
| 190751 | ACC | NJE599U REDUCE SPEED 270KTS |
| 190755 | NJE599U | REDUCING 270 NJE599U |
| 190939 | ACC | MGO758 DESCENSO A ALTITUD DE 3000FT 1014 |
| 190943 | MGO758 | 3000FT 1014 MGO758 |
| 191025 | ACC | NJE599U DESCEND ALTITUDE 4000FT QNH1014 |
| 191030 | NJE599U | YES 4000FT 1014 NJE599U |
| 101045 | ACC | |
| 191047 | RYR2084 | |
| 191214 | RYR2084 | |
| 191217 | ACC | |
| 191219 | RYR2084 | |
| 191224 | ACC | MGO758 DESCENSO A ALTITUD DE 2500 |
| 191228 | MGO758 | DESCENSO A 2500FT MGO758 |
| 191233 | EZY967Q | |
| 191240 | ACC | |
| 191249 | EZY679Q | |
| 191336 | ACC | NJE599U SPEED 250 DESCEND 3000FT |
| 191341 | NJE599U | DESCEND 3000FT 250 NJE599U |
| 191412 | MGO758 | PALMA MGO758 TENEMOS AL RYR EL PRECEDENTE COMPLETAMENTE A LA VISTA YA PASADO EL ABEAM PODRIAMOS AJUSTAR VISUALMENTE? |
| 191420 | ACC | MGO758 VUELE POR SU DERECHA RUMBO 270 |
| 191424 | MGO758 | 270 MGO758 |
| 191510 | NIM01 | |
| 191516 | ACC | |
| 191522 | NIM01 | |
| 191525 | MGO758 | MGO758 ESTAMOS LISTOS YA PARA VIRAJE |
| 191528 | ACC | SI RECIBIDO PERO HAY UN DESPEGUE LISTO Y TENGO QUE DARLE 8 MILLAS CON EL DESPEGUE |
| 191533 | MGO758 | COPIADO |
| 191535 | NJE599U | NJE599U APPROACHING 3000FT CAN WE INTERCEPT THE GLIDE OF THE LOCALIZER FROM HERE |
| 191542 | ACC | NJE599U TURN RIGHT ON HEADING 160 AND CROSS THE LOCALIZER |
| 191547 | NJE599U | CONFIRM HEADING 160 TO INTERCEPT THE LOACALIZER |
| 191551 | ACC | YES CROSS THE LOCALIZER |
| 191554 | NJE599U | SAY AGAIN PLEASE FOR NJE599U |
| 191557 | ACC | FLY ON HEADING 160 THROUGH THE LOCALIZER THROUGH THE LOCALIZER |
| 191601 | NJE599U | WE ARE GOING THROUGH THE LOCALIZER AND GLIDE NOW AND IT SHOULD BE HEADING 060 TO INTERCEPT THE LOCALIZER |
| 191606 | ACC | TURN INMEDIATELY TURN RIGHT HEADING 180 |
| 191610 | NJE599U | TURNING RIGHT HEADING 180 NJE599U SAY INTENTIONS PLEASE |
| 191614 | ACC | MGO758 TURN RIGHT ON HEADING 030 FINAL VECTOR CLEARED ILS RWY06 |
| 191623 | ACC | NJE599U INMEDIATELY RIGHT HEADING 180 |
| 191628 | NJE599U | TCAS RA NJE599U |
| 191639 | ACC | MGO758 |

| | | |
|---|---|---|
| 191641 | MGO758 | MGO758 HEMOS TENIDO UN TCAS RA ESTAMOS VIRANDO A RUMBO 020 PARA INTERCEPTAR Y COMPLETAR ILS PISTA 06 NJE MGO758 CLEAR OF TRAFFIC NOW |
| 191654 | ACC | SI RECIBIDO HA TENIDO UN TCAS PORQUE NO HA SEGUIDO MIS INSTRUCCIONES |
| 191657 | MGO758 | NEGATIVO SEÑORITA HEMOS SEGUIDO SUS INSTRUCCIONES CUANDO HA ORDENADO RUMBO 020 YA HEMOS TENIDO EL TRAFICO EL NJE NO LE HA RESPONDIDO NO LE HA COLACIONADO A TIEMPO Y ESTABAMOS VIENDO QUE ESTABA POR DEBAJO DE 3 MILLAS Y NOS DABA UN TCAS RA |
| 191710 | ACC | RECIBIDO MGO758 AUTORIZADO ILS PISTA 06 |
| 191714 | MGO758 | PARA SU INSTRUCCIÓN VOY A EJECUTAR EL 3...???...RI ESTO HAY QUE DENUNCIARLO |
| 191719 | ACC | RECIBIDO YO TAMBIEN HARE UN INFORME GRACIAS |
| 191722 | RYR5025 | |
| 191729 | ACC | |
| 191734 | ACC | NJE599U TURN RIGHT HEADING 290 |
| 191743 | ACC | NJE599U TURN RIGHT HEADING 290 |
| 191746 | NJU599U | COPIED YOUR CLEARANCE TURNING NOW AND IN A FUTURE IF YOU ARE TALKING ABOUT US TO ANOTHER AIRCRAFT I WILL APRECIATE EVERYBODY WOULD SPEAK IN ENGLISH PLEASE AFTER TCAS |
| 191757 | ACC | ROGER THANK YOU BUT THE OTHER TRAFFIC WAS NOT RESPONDED ME IN ENGLISH AND THIS IS WHY I RESPONDED IN SPANISH WE WERE TALKING ABOUT THE TCAS ADVISORY AND HE WAS SAYING THAT HE IS GOING TO DO A REPORT |
| 191808 | NJE599U | SORRY I CAN'T HEARD IN...???...PLEASE SPEAK SLOWLY TURNING NOW TO HEADING 290 DESCENDING 3000FT READY FOR VECTORS TO JOIN THE ILS AGAIN |
| 191820 | ACC | |
| 191824 | EZY697Q | |
| 191827 | MGO758 | NJE THE PROBLEM IS NOT TALKING IN SPANISH OR ENGLISH THE PROBLEM IS TO COMPLY WITH THE INSTRUCTIONS OF THE CONTROLLER AND HE TOLD YOU ONE MINUTE AGO HEADING 160 THROUGH THE LOCALIZER AND YOU DIDN'T DO THAT AND THAT'S WHY WE HAD THE RA |
| 191841 | ACC | I SAID THROUGH THE LOCALIZER THROUGH THE LOCALIZER |
| 191844 | NJE599U | FOR CLARIFICATION AS YOU PROBABLY HEARD AS WELL BUT IS NOT MY ...???... SIR |
| 191850 | MGO758 | I HEARD THE INSTRUCTION |
| 191853 | ACC | NJE599U TURN RIGHT ON HEADING 320 |
| 191858 | NJE599U | RIGHT HEADING 320 599U |
| 191903 | ANE8117 | |
| 191906 | ACC | |
| 191912 | ANE8117 | |
| 191915 | ACC | MGO758 IBIZA 118,5 HASTA LUEGO |
| 191918 | MGO758 | 118,5 MGO758 |
| 191925 | ACC | NJE599U TURN RIGHT ON HEADING NORTH |
| 191928 | NJE599U | RIGHT HEADING NORTH NJE399U |
| 191934 | ACC | |
| 191940 | ACC | |

| | | |
|---|---|---|
| 191947 | ACC | NJE599U TURN RIGHT ON HEADING 030 FINAL VECTOR CLEARED FOR ILS APPROACH RWY06 |
| 191953 | NJE559U | RIGHT HEADING 030 CLEARED FOR ILS APPROACH RWY06 NJE599U |
| 192007 | RYR5025 | |
| 192011 | ACC | |
| 192012 | RYR5025 | |
| 192019 | ACC | |
| 192024 | RYR5025 | |
| 192107 | ACC | |
| 192112 | ANE8117 | |
| 192117 | ACC | |
| 192123 | ANE8117 | |
| 192125 | ACC | |
| 192126 | ANE8117 | |
| 192133 | ACC | |
| 192138 | ANE8117 | |
| 192143 | ACC | |
| 192144 | ANE8117 | |
| 192147 | ACC | NJE599U CALL IBIZA 118,5 BYE |
| 192151 | NJE599U | 118,5 BYE |

## DATA SUMMARY

### LOCATION

| | |
|---|---|
| Date and time | **Thursday, 17 January 2013; 17:26 local time** |
| Site | **Runway 28 at the Cuatro Vientos Airport (Madrid, Spain)** |

### AIRCRAFT

| | |
|---|---|
| Registration | **EC-ICG** |
| Type and model | **PA-60-601P (Aerostar 601P)** |
| Operator | **Private** |

#### Engines

| | |
|---|---|
| Type and model | **LYCOMING IO-540-S1A5** |
| Number | **2** |

### CREW

#### Pilot in command

| | |
|---|---|
| Age | **48 years old** |
| Licence | **PPL(A)** |
| Total flight hours | **1,500 h** |
| Flight hours on the type | **500 h** |

| INJURIES | Fatal | Serious | Minor/None |
|---|---|---|---|
| Crew | | | **1** |
| Passengers | | | **1** |
| Third persons | | | |

### DAMAGE

| | |
|---|---|
| Aircraft | **Minor** |
| Third parties | **None** |

### FLIGHT DATA

| | |
|---|---|
| Operation | **Private** |
| Phase of flight | **Landing run** |

### REPORT

| | |
|---|---|
| Date of approval | **30 October 2013** |

# 1. FACTUAL INFORMATION

## 1.1. History of the flight

The aircraft, which had taken off from the Axarquia Aerodrome (Malaga), was cleared to land on runway 28. The approach proceeded normally but after making contact with the ground, the front landing gear collapsed. The underside of the nose came to rest on the surface of the runway, sliding on it until the airplane stopped in the final third of the runway. The two occupants were uninjured and immediately exited the aircraft, which was damaged as a result of the friction between the fuselage and the asphalt.

While the aircraft remained on the runway, other arriving traffic at the airport either landed on the unpaved runway in the military part of the airport or was diverted to another nearby aerodrome.

## 1.2. Personnel information

The aircraft's pilot-owner obtained his first flying license in 1998. He then obtained a multi-engine rating, which was valid on the day of the incident.

He had purchased the aircraft in 2003 and regularly flew it 50-100 h a year. He had previously owned two other aircraft, the last of which had also been a twin-engine airplane.

The other person in the aircraft, though not a pilot, flew regularly with him as a passenger.

## 1.3. Aircraft information

The Aerostar 601P is a pressurized twin-engine airplane with retractable gear. It can hold 5 passengers and the pilot[1]. It was type certified in 1973.

The incident aircraft, manufactured in 1979, had a total of 1648:50 flight hours. It had an airworthiness review certificate (ARC) issued by AESA on 03/07/2012 that was valid for one year. It was the only unit of this model registered in Spain on the date of the incident.

[1] The type certificate, which had originally been held by the Piper Aircraft Corporation (since 1978), was transferred to the Aerostar Aircraft Corporation in 1991.

### 1.3.1. *Description of the nose landing gear*

The landing gear is hydraulically operated. The nose gear (Figure 1) is retracted by the action of a hydraulic actuator (item 1) which, when it extends, swing the upper drag link (item 2), which in turn drags the lower link (item 3), and with it the leg (item 4). There is no way to lock the gear in the retracted position, meaning that a loss of hydraulic pressure will cause it to drop due to gravity. When the hydraulic pressure is released from the cylinder, the weight of the leg compresses the stem on the actuator and the leg extends. Once this happens, an overcenter (item 5) keeps the two drag links aligned, keeping them from folding and the leg from retracting. A spring (item 6) stretches the overcenter to keep it locked.

The hinge in the overcenter houses a micro-switch that is responsible for transmitting the gear down and locked signal (item 7).

The rotating axis of the upper drag link (item 8) is screwed to the link itself and it rotates inside bushings housed in two U-shaped beams that are fixed on either side of the left landing gear bulkhead by means of rivets (Figure 2). Mounted at the outer end of the axis is a cam (item 9) that, when the gear retracts, makes contact with a micro-switch (item 10) that then sends the gear-up signal.

This design does not require any special action to extend the gear in the event of a hydraulic failure other than actuating the gear lever and waiting for it to drop by gravity.

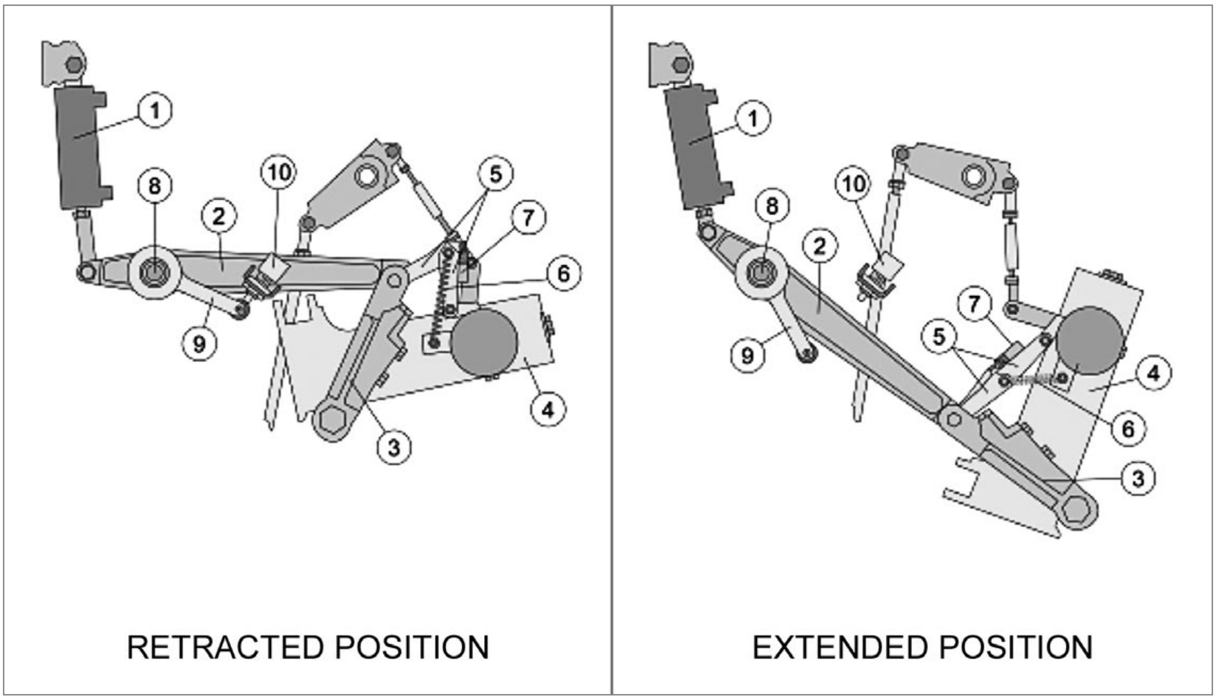


**Figure 1.** Diagram of the nose gear

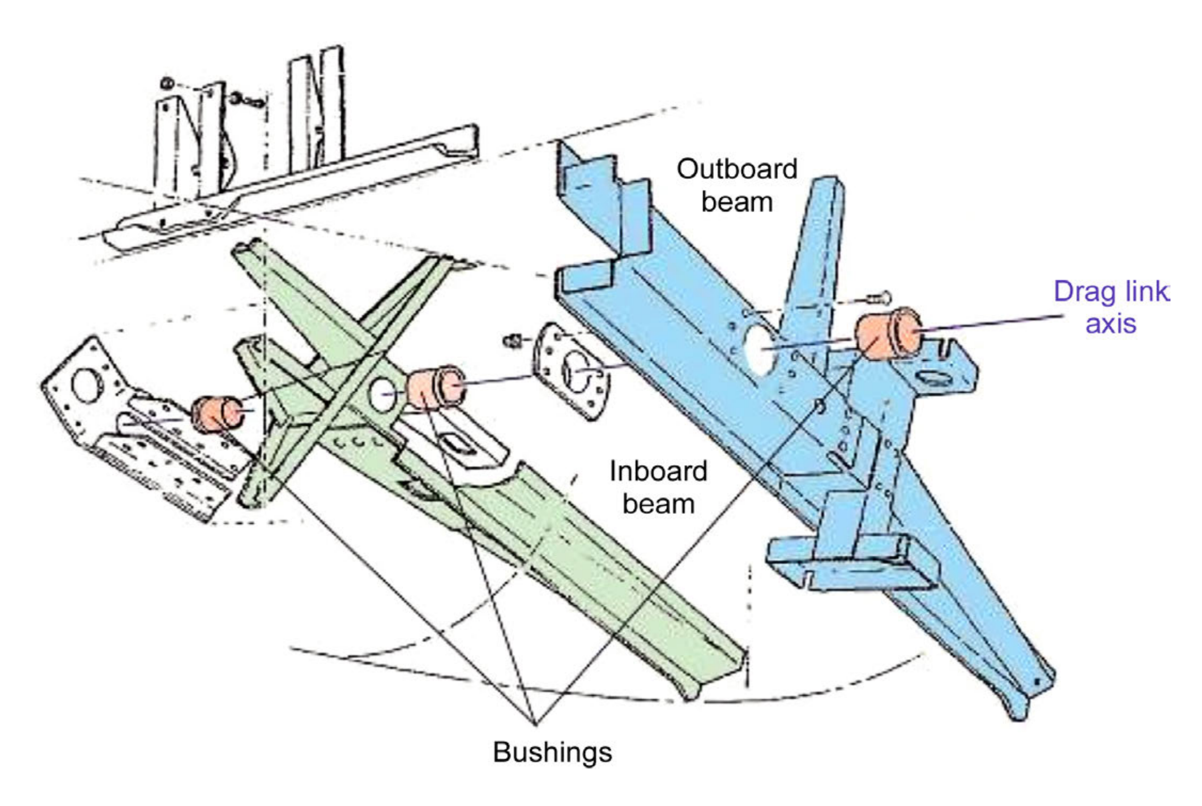


**Figure 2.** Anchoring beams for the axis of the main drag link

The nose gear has four doors. The two front ones open and close fully when the gear is lowered or raised, while the two rear doors remain open with the gear down. These doors are opened and closed by a system of linkages that mechanically transmit the motion of the gear leg.

The nose gear wheel can be steered through a 60° angle by means of a hydraulic actuator that doubles as a vibration (anti-shimmy) damper. The hydraulic line for this system enters the gear well through the well's aft bulkhead.

The gear actuating lever is located on the central part of the instrument panel. The gear down position is indicated in the cockpit by three green lights that turn on when the gear down and locked signal is received from micro-switches on each leg with the gear in the down position. The gear up position is indicated by a single amber light that turns on when it receives a signal from three other micro-switches. There is no light to indicate that the gear is in motion. All of these lights can be checked for proper operation by pressing them.

The main gear's position can be observed directly from the cockpit. The nose gear's position can be observed indirectly through its reflection in either propeller hub.

So as to prevent the gear lever from being inadvertently moved to the up position while the airplane is on the ground, there is a squat micro-switch on the nose gear that sends a signal to lock the landing gear lever in place when the strut is compressed.

The airplane also features a horn and a red warning light to indicate when the engine intake pressure is below 14 in Hg (low throttle) and the landing gear is not down and locked.

The flaps, which can extend to 45°, are also hydraulically actuated, like the gear.

### 1.3.2. *Maintenance history*

The aircraft's maintenance program[2] requires that it be subjected to scheduled inspections at intervals of 50, 100 (or annual), 500 and 1,000 h. Neither the listing of limited lifetime components nor the structural inspection program applicable to the pressurized versions of this airplane require checking the U-beams that house the rotating axis of the main link.

The last scheduled maintenance task performed on the aircraft was a 100-hr check, done in April 2012. This inspection checks the overall condition of the landing gear and involves greasing all of its moving parts and conducting an operational test of the gear. There is no specific requirement to inspect the beam for cracks. During this check the tire on the nose gear wheel was also replaced due to wear.

Subsequently, in October 2012, the airplane experienced a problem with the well door for the left main landing gear leg. The problem was solved by replacing a solenoid valve in the hydraulic system. According to the maintenance personnel that carried out the work, once the problem was repaired, the necessary adjustments and operational tests were carried out for the entire landing gear, all of which were satisfactory. The records for these tasks do not reflect any work specific to the nose gear.

During the previous annual inspection, in March 2011, a crack was detected on the interior attaching beam for the upper locking link axis on the landing gear. The crack was repaired by riveting a reinforcing plate over the area with the crack. This repair was not performed by following any specific documentation from the manufacturer, which does not have documents for structural repairs, instead referring to an FAA document[3]. Also during this inspection a bushing was replaced on a loose locking bar hinge. Apart from this repair, there are no records of any changes or reinforcements being made to the original structure.

[2] Maintenance Program with approval reference PM.ICG rev. 2 19/06/2012.
[3] AC.43.13.-1B Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair. Section 4.4 of this document contains guidelines for repairing metal components.

### 1.4. Meteorological information

The aerodrome observation reports (METAR) indicated good visibility conditions with few clouds at 3.000 ft and wind at 7 kt more or less in line with the runway heading (varying between 230° and 290°).

Moments before landing, the controller informed the aircraft that the average wind speed was from 230° at 7 kt gusting to a maximum of 15 kt.

In the previous flight from Cuatro Vientos to Axarquia, there were strong winds in the destination aerodrome when the airplane landed, with gusts of up to 50 km/h.

### 1.5. Communications

The Cuatro Vientos tower was in communications with both the incident aircraft and with other traffic in and around the airport. After the incident the tower also established communications with airport services, with the Madrid area control center and with the tower at the Getafe Airport.

At 16:22:50, the pilot reported his position near the aerodrome's circuit. The tower controller requested that he report once established on the left downwind leg for runway 28.

At 16:23:57, while on final approach, the pilot asked for the wind information, which the controller provided.

At 16:24:36, the aircraft was cleared to land.

At 16:26:26, the controller ordered the next aircraft in the landing sequence to go around, diverting it and another aircraft to hold points around the aerodrome and asked the pilot of the aircraft that was still on the runway what his intentions were.

At 16:27:22 the controller informed the firefighting service of the aircraft's position and condition, authorizing its entry into the movement area.

Several calls were then made to coordinate the activities of the emergency services on the runway and to exchange information with the ARO office[4]. The controller notified the Madrid area control center and the Getafe tower of the incident in anticipation of requiring their assistance to handle the traffic that was heading to Cuatro Vientos.

[4] Air Traffic Reporting Office, where flight plans are filed and approved.

At 16:35:48, after being notified by the firefighters that the task of cleaning the runway would take some time, the controller informed all stations (in Spanish and English) that the airport was temporarily closed due to an accident on the runway.

## 1.6. Airport information

The airport has one 1,500-m long asphalt runway in a 28/10 orientation. In the military part of the aerodrome, next and parallel to the asphalt runway, there is an unpaved runway measuring 1,127 m in length.

## 1.7. Tests and research

### 1.7.1. *Statement from the pilot and the passenger*

The pilot stated that after taking off from Axarquia, the amber gear-up light did not turn on. He remained above the airfield for a while to check the condition of the gear. He thought that the speed and aerodynamic noise were consistent with a gear up configuration. He also saw the position of the nose gear reflected in one of the propeller hubs (a typical practice) and confirmed that it was retracted, as was the main gear, which he could see directly through the windows.

The light remained off for the duration of the flight. While in the Cuatro Vientos circuit before landing, he checked the position of the gear through the cockpit indication (three green lights indicating the gear was down and locked) and by direct observation through the windows.

The approach and landing were normal. He stated that though there was some wind, it did not concern him.

After the main gear made contact, the nose gear touched down. He then heard a strange noise, like a sudden thud. The airplane continued moving for a few seconds before the gear collapsed, with the nose of the airplane resting on the runway until it came to a stop. While still moving he cut the mixture control, fuel supply, magnetos and master. Although he could not give a specific time, his perception was that the firefighters reported to the scene quickly.

He recalled that during two pre-flight checks on previous flights, he had noticed that the front doors on the nose gear were not closed. The first time they were partially open, and even more so during the second check. He called the maintenance shop, which informed him that it was not a problem as long as the doors were firmly attached to the rods and they were not loose. They agreed to check the doors during the next visit to the shop.

When asked about the previous landing in Axarquia, he confirmed that it had been a fairly turbulent flight, though he did not think that the landing had been unusually difficult. He did not recall making any particularly hard landings in recent flights, though he also did not rule out the possibility. He did mention one previous event in this regard but it had happened a long time ago (a year and a half or two years earlier), when the airplane "pancaked" on the runway while making a landing in gusty conditions. He did not consider it significant enough to warrant informing the maintenance workshop.

The passenger did not notice anything unusual during the approach and corroborated the pilot's report of the sudden thud during the landing run and feeling the gear give way after the airplane had traveled normally for a few seconds after touching down on the runway.

### 1.7.2. *Controller's statement*

The circuit and approach phases were uneventful. He reported the wind at 7 kt practically in line with the runway. It was the first aircraft in the landing sequence. There were no preceding aircraft.

A couple of seconds after the landing he saw how the airplane collapsed on its nose. He then saw sparks and flames bursting from the nose. The airplane remained more or less in the center of the runway, stopping in the final third of the runway.

He immediately sounded the alarm and informed the traffic behind to go around. He called the aircraft and received no reply, but saw someone exiting it right away. He reported the aircraft's location and type to the firefighting service (FFS) and, after checking with the ARO office, the number of people onboard.

The runway was closed until 17:19 (about 50 minutes). Other aircraft were diverted to alternates or were cleared by military controllers to land on the unpaved runway.

### 1.7.3. *Post-incident inspection*

The position of the switches and controls of the electrical (master, alternators) and fuel supply (mixture and throttle) systems were consistent with the pilot's statement regarding the actions he took during the landing run.

The gear lever was in the down position.

The flaps were extended to an intermediate position (20°) that matched that selected on the flaps lever.

The U-beam that houses the axle on which the nose gear's upper drag link pivots was broken near the housing where the actuating rod that moves the front left well door shifts back and forth. The part of the beam forward of this housing had lost the rivets that attach it to the side bulkhead and was loose (Figures 3 and 4).

**Figure 3.** Forward gear wheel well showing the fracture area and the loss of the rivets that hold the drag link in place

**Figure 4.** Beam disassembly

There was a reddish mark on the beam next to a crack that started in the hole for a screw that attached the part to the bulkhead (see figure 6). Workshop personnel could not ascertain its origin, indicating that it was probably present when the airplane was first taken to the workshop in 2007. Two other centers that had carried out maintenance on the airplane before were contacted, but neither one had records indicating that this crack had been detected and was being monitored.

The plate that had been used to reinforce the area where a crack had been detected two years earlier was itself cracked.

This part was sent to a laboratory for an analysis of the fracture.

The beam that houses the extension of the link axis on the other side of the bulkhead was also broken, such that the axle had moved from its position. Due to the motion, with the leg in the retracted position, the cam that is attached to the axle and that makes contact with the micro-switch responsible for transmitting the gear-up signal could not reach its normal position, meaning it was unable to make contact with the micro-switch (Figure 5).

There were no impact marks on the tire on the front gear wheel, which had been replaced recently. The left tire did exhibit a flat spot consistent with a hard landing.

The hydraulic return line from the actuator was broken, possibly as a consequence of the movement of the actuator itself when it was dragged by the locking arm when its axle moved (Figure 6).

**Figure 5.** Cam and gear-up micro-switch

As a result of the loss of rigidity of the locking system caused by the fracture and motion of the beam, the leg swung excessively toward the rear, such that its structure made contact with the wheel well's rear bulkhead at the point indicated by an impact mark. This part of the bulkhead houses an elbow of the hydraulic line for the nose wheel steering system, which had broken (Figure 7).

The doors on the front wheel well exhibited damage that was consistent with being dragged on the asphalt surface.

**Figure 6.** Return of the hydraulic line that supplies the actuator

**Figure 7.** Impact on the rear bulkhead and part of the leg responsible for the impact

The gear position alerting system was verified to be working correctly.

The interlock that prevents retracting the gear on the ground was also working properly, keeping the lever from actuating with the strut compressed.

#### 1.7.3.1. Laboratory analysis of the beam

The analyses indicated that material was made from an AW 2024 aluminum alloy with no apparent micro-structural defects or discontinuities in the failure zones.

The study revealed the presence of failure zones with different characteristics.

The rivet holes in the top front part of the component exhibited a micro-morphology indicative of a fatigue process. The crack developed over the course of many cycles that encompassed a relatively long period of time, as evidenced by the signs of corrosion that were found. The end of the piece, which had been repaired, and the red-tinged hole for the mounting screw, also exhibited fatigue cracks of the same nature.

In contrast, the fracture in the central part of the beam, which had broken the part in two, resulted from a ductile tearing mechanism, typical in this material when subjected to excessive stress. The rivets used to attach the part to the component that were closest to this central area also broke as a result of this same ductile mechanism. Likewise, on the section of the arm that remained attached to the bulkhead, a stress fracture was identified on both the transversal fracture on the body of the arm and on the rivets.

The laboratory analysis concluded that the fracture sequence most likely started with the incubation and development of the fatigue mechanism, which propagated through cracks in the riveted junction. Once this junction was weakened, the beam was subjected to bending stresses that caused the adjacent rivets to break, eventually causing the fracture of the central part and arm of the beam.

### 1.7.4. *Additional information*

The type certificate holder stated that it was unaware of any prior similar events in which the nose gear collapsed due to the failure of this structure, though it is a component that has been the focus of repairs in other aircraft.

Aerostar also reported that a kit is available to reinforce the beam external to the bulkhead and inhibit cracks in that area. Its engineering department is evaluating the possibility of making a similar kit available for the internal beam. Investigators were unable to confirm if the reason for these reinforcements and repairs was the recurring appearance of fatigue cracks, nor were they able to compile detailed information on the modifications (such as their approval date, applicability or details on the implementation instructions).

The investigation did not find a history of accidents or incidents associated with the fatigue failure of this part in other units of this airplane model[5].

## 2. ANALYSIS AND CONCLUSIONS

Neither the pilot's nor controller's statements nor the condition of the front tire point to a particularly hard landing at Cuatro Vientos that could, by itself, account for the

[5] Investigators consulted the NTSB's (National Transportation Safety Board) online database.

fracture of the beam to which the locking system is attached and for the subsequent collapse of the nose gear.

The gradual degradation of the structure that houses the axis of the drag link was caused by the growth of the fatigue cracks that initiated at various points on the beam inside the bulkhead. This would also explain the worsening anomalies detected by the pilot.

The first effect of this degradation of the beam would have been a slight change in the angle of the leg in the down and locked position while on the ground. Since the motion of the rods that actuate the gear doors depends on the position of the leg, a change in this angle would imply a change in the position of the rods at the end of their travel, which would affect the position of the doors, as the pilot detected during the pre-flight checks.

The stresses associated with the subsequent taxiing, takeoff runs, cycling of the gear and landings (including the last landing in Axarquia under very windy conditions) would have deteriorated the structure of the beams even more such that on the return flight to Cuatro Vientos, even with the gear retracted, the cam that activates the micro-switch and switches on the gear-up amber indicating light was unable to reach its position due to the weight of the leg.

When the lever was actuated to lower the gear before the final landing, the gear would have dropped by gravity and, in the absence of loads before contacting the runway, would have extended normally, sending the signal that turned on the green light in the cockpit.

At this point the weakened structured would have been unable to withstand the landing stresses. The loss of rigidity in the locking system allowed a certain degree of motion in the leg, which probably struck the wheel well's aft bulkhead during the first few meters of the landing run. This would explain the dull thud felt by the pilot and the break in the hydraulic line that crosses the bulkhead. The return line on the gear actuating system broke when the end of the piston that pivots at the end of the locking arm moved excessively. Both hydraulic system failures took place on the ground and thus did not affect the gear retraction on takeoff or the extension of the flaps before landing.

Based on the laboratory findings, the part that failed exhibited fatigue cracks, one of which had been detected and stained apparently so as to facilitate its location and tracking, though it was not possible to determine who stained it, nor when or where. The appearance of a crack in the area repaired in the workshop indicates the persistent nature of the problem.

In the absence of specific airworthiness maintenance instructions for monitoring potential cracks in the structure that failed, these tracks were not being actively monitored, something that could have aided in anticipating the overall progression of the crack that eventually led to the weakening and fracture of the structure.

Neither the inquiries sent directly to the manufacturer nor the checks of the NTSB database yielded any information on previous occurrences that could be used to determine whether the fatigue of the part that failed could require fleet-wide corrective maintenance or engineering actions. Even though the manufacturer reported that it has engaged and continues to engage in activities designed to bolster the strength of this structure, it has not provided sufficient information for even a minimal evaluation of these activities, or specifically if their application in this case would have been of any use.

The fact that the tower controller was watching the landing allowed him to immediately alert the firefighting service and to properly handle the other aircraft by either diverting them to their alternates or having them land on the unpaved runway in the military part of the aerodrome.

## 3. CAUSES

The incident occurred when a generalized fatigue process caused the fracture of the support structure for the upper drag link on the nose gear.