DATA SUMMARY

LOCATION

Date and time	**Thursday, 23 April 2009; 11:20 local time**
Site	**Moncofa (Castellón)**

AIRCRAFT

Registration	**OE-KPC**
Type and model	**CESSNA TU 206 F**
Operator	**Private**

Engines

Type and model	**THIELERT, Centurion 4.0**
Number	**1**

CREW

Pilot in command

Age	**32 years old**
Licence	**Commercial pilot license**
Total flight hours	**1,000 h**
Flight hours on the type	**15 h**

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

DAMAGE

Aircraft	**Significant**
Third parties	**N/A**

FLIGHT DATA

Operation	**General aviation – Private**
Phase of flight	**En route – Cruise level**

REPORT

Date of approval	**3 May 2012**

1. FACTUAL INFORMATION

1.1. History of the flight

On 23 April 2009, a Cessna TU206F aircraft, registration OE-KPC, made a water landing at 11:20 near the beach in the town of Moncofa (Castellon) following an engine failure while flying at 7,000 ft over the coast. Both occupants onboard, the pilot and a passenger, were rescued by eyewitnesses to the event. The aircraft turned over during the maneuver and ended up floating upside down.

On the day of the accident, the pilot made the pre-flight inspection and refueled. After requesting the VFR flight plan by phone, he took off at about 10:30 from the Ontur (LEOT) aerodrome in Albacete, en route to the airport in Reus (LERS), where scheduled maintenance work was going to be performed at a maintenance center located in said airport.

Over the course of the flight, the aircraft crossed the Valencia Airport control zone (CTR) at an altitude of 7,000 ft, leaving the zone at 11:10 via the North Corridor at point N on SGO (Sagunto), located at 17 NM on the VLC 044 RDL.

Upon exiting the TMA, ATC informed the pilot of traffic below it, to which the pilot replied that he was performing a “sweep turn” to confirm the presence of the traffic.

Figure 1. Aircraft

[1] All times in this report are local. To obtain UTC, subtract two hours from local time.

A short time later, the pilot noticed an oil sheen starting to form on the windshield and that the oil and temperature readings had dropped. At 11:11, with the aircraft on the VLC 046 RDL at 20.5 NM and 7,000 feet, the pilot contacted Valencia approach control to declare an emergency due to an engine problem, and to inform of his intention to find a place to land.

Seconds later he contacted ATC again to declare an emergency due to an engine stoppage. At 11:14, the radar trace disappeared at 4,800 feet and 22.8 NM from the Valencia Airport VOR. The controller lost contact with the pilot.

The pilot stated that during the flight, the engine started making strange noises and he could see oil on the windshield. The oil pressure and temperature indications had dropped while he was reporting the emergency to ATC, the engine stopped and he lost all radio communications.

Then, during the descent maneuver, he tried starting the engine but was unsuccessful. At 800 feet AGL, after deciding on a landing location on the beach he had in sight, he noticed that the flaps were not working, which kept him from reaching the beach. He eventually landed on the water and flipped over near the coast.

Aircraft in the area and rescue personnel had been alerted by ATC, and the aircraft was sighted on the edge of the beach.

Eyewitnesses to the water landing reacted quickly when they saw the aircraft fall and aided in rescuing the two occupants, who were only four meters away from the shore. They were then assisted by medical services at the scene and taken to a hospital for a check-up before being released.

Once the aircraft was pulled from the ocean, the damage to the lower engine cowl and the propeller blades from the impact with the water became apparent. All of the aircraft's components were affected by salt water corrosion and the perforation of the engine block resulted in an oil stain that coated the lower surface of the fuselage.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total on aircraft	Third persons
Fatal				
Serious				
Minor				N/A
None	1	1	2	N/A
TOTAL	**1**	**1**	**2**	

1.3. Damage to aircraft

The aircraft was heavily damaged as a result of the impact with the water surface, which affected the propeller, engine cowl and wing tips. The rest of the airframe was subsequently damaged by the salt water.

1.4. Other damage

There were small slicks from leaking fluids on the water near the beach.

1.5. Personnel information

1.5.1. *Pilot*

Age:	32
Nationality:	Spanish
Flying license:	Commercial Pilot CPL(A)
• Initial issue date:	21/08/2003
• Expiration date:	09/01/2014
Medical certificate renewed on:	17/11/2008
Medical certificate valid until:	23/11/2009
Ratings in effect and validity:	
• Agricultural (firefighting only) until:	24/08/2009
• Multi-engine piston (land) until:	02/01/2010
• Single-engine piston (land) until:	21/08/2009
• Instrument flight IR(A) until:	02/01/2010
• Flight instructor FI(A).	
Flying hours:	
• Total:	1,000 h
• Hours in last 3 months:	20 h
• Hours on OE-KPC:	15 h

1.6. Aircraft information

The aircraft arrived in Spain on 16/11/2008 with 4,374 h TSN (Time Since New).

The aircraft logbook listed a total of 4,390:55 flight hours prior to the accident. The logbook also noted that most of the flights performed, at least since the installation of the Centurion 4.0 engine, had been to drop parachutists.

1.6.1. *Airframe*

Manufacturer:	Cessna
Model:	TU206F
Production number:	U206-02898
Registration:	OE-KPC
Year of manufacture:	1977
MTOW:	1,633 kg

1.6.2. *Airworthiness certificate*

Number:	3006
Issue date:	25/07/2001
Expiration date:	28/04/2009

1.6.3. *Maintenance record*

Last inspection:	Date	Hours
50 hours:	24/10/2008	4,368 h
100 hours:	13/09/2008	4,358 h
500 hours:	14/09/2007	4,248 h

1.6.4. *Engine*

Manufacturer:	Thielert Aircraft Engine GmbH
Model:	Centurion 4.0 (TAE 310)
Power:	310 HP
Serial number:	03-01-0505-SL01-001-P0124
Installed on aircraft:	27 April 2007 TSN: 0 h

Inspections:	Date	Aircraft hours
• 48 hours:	06/06/2007	4,168 h
• 127 hours:	13/09/2007	4,248 h
• 180 hours:	05/03/2008	4,299 h

1.6.5. *Propeller*

Manufacturer:	MT-Propeller	
Model:	MTV-9-D	
Serial number:	070481	
Installed:	Hours on aircraft	Date
	4,120 h	27/04/2007

1.6.6. *FADEC (Full Authority Digital Engine Control)*

Manufacturer	Thielert Aircraft Engine GmbH	
Serial number	4280	
Part number	05-7611-K000102	
Installed:	Hours	Date
	0	December 2008
Initialization date[2]:	8 January 2009	

The aircraft featured a FADEC (Full Authority Digital Engine Control) with two channels, A and B, to control the engine. The second channel was a back-up.

1.6.7. *Documentation on aircraft certification*

The aircraft was originally certified under CAR (Civil Air Regulation) 3, Amendment 8 of the FAA (Federal Aviation Administration), which issued Type Certificate No. A4CE and its corresponding Type Certificate Data Sheet (TCDS).

Subsequently, on 13 April 2007, the European Aviation Safety Agency (EASA) approved a change to the type design by way of a Supplemental Type Certificate (STC) (EASA.A.S.02565), at the request of Thieler Aircraft Engines GmbH, as a result of replacing the original powerplant with a Centurion 4.0 engine and an MTV-9-D propeller. The process for obtaining this STC was based on the 14 November 2003 edition of EASA CS-23 (Certification Specification).

Associated with the aforementioned STC was a supplement to the original Flight Manual, document number 72-0310-72021, from which the following «Notes»[3] are taken, highlighting differences from the original:

[2] Date of first entry.

[3] Section 1, page 1-1 of the Flight Manual, see Appendix 1, has three warning levels, «Note», «CAUTION» and «WARNING», depending on the impact on safety or the damage to the aircraft that can result from non-compliance as defined by the following criteria:
«NOTE»: Information added for a better understanding of an instruction.
«CAUTION»: Non-compliance with these special notes and safety measures could cause damage to the engine or to the other components.
«WARNING»: Non-compliance with these safety rules could lead to injury or even death.

- In reference to the maneuvering limits, page 2-4 in Section 2 includes the following «Note»:

  "Intentionally initiating spins or negative-G flight is prohibited"

- As for the emergency procedures, page 3-4 in Section 3 has the following '¿Note' on re-starting the engine in the event that it fails:

  "The propeller will normally continue to turn as long as the airspeed is above 65 KIAS. Should the propeller stop at an airspeed of more than 65 KIAS, the reason for this should be found out before attempting a restart. If it is obvious that the engine or propeller is blocked, do not use the Starter."
  "If the Engine Master is in OFF position, the Load Display shows 0% even if the propeller is turning"

On 26 September 2007, the EASA published a TCDS, no. E-014, Issue 4, which lists the information concerning the installation of Centurion 4.0 engines on "normal and utility" airplanes.

1.6.8. *Electrical system*

The electrical system installed on the accident aircraft included the following components (see Appendix 2):

- A main bus (MAIN DIST BUS) supplied by the main battery (Bat 1), by the main alternator (Alt 1) and by an external power source.
- A Gill G247 24-volt battery, 'Batt 1', with a 150A fuse between it and the main bus.
- Between Alt 1 and the main bus there is an 80A fuse. There is no fuse between the external source and the main bus.
- The main bus supplies current to:

  — The starter motor, which has no fuse in its starting line.
  — The essential bus (ESS BUS) via a diode bridge 'D1'.
  — The 'GLOW PLUG CONTROL',
  — The 'FADEC B',
  — The 'AIRCRAFT MAIN BUS', which feeds, among others, the communications system, ADF, flaps, pitot heater, stall warning, fuel pump, aircraft lights, etc.

- The essential bus is fed from the main bus, Alt 2 and the battery 'Batt 2'.
- Battery 'Batt 2' consists of two 12V/12A-h batteries connected in series.
- The essential bus supplies:

  — 'FADEC A',

- The vacuum pump (VAC PUMP)
- The Auxiliary engine display / Compact engine display (AED / CED)

- The diode group 'D1' ensures that the connection between the main and essential busses is unidirectional. This means that 'Batt 1' cannot be charged from 'Alt 2', and also that 'Batt 2' cannot supply the main bus or the systems that are fed from it.

Installing this system on the aircraft required placing the main battery, 'Batt 1', in the tail compartment, connected using a 5-m long wire. This was to avoid problems with battery overheating and to maintain the aircraft's balance. A 150A fuse was also installed near this battery. It should be noted that during the inspection of the aircraft following the accident, a fuse identical to the 150A fuse was found inside a bag next to the main battery.

The technical documentation on the electrical system in the STC, shown in Appendix 2 of this report, shows that the installation of the system on the accident aircraft was in accordance with the STC.

As mentioned in Section 1.6.7, associated with the approval of the STC was a supplement to the original Flight Manual. In Section 7 of this supplement there is a diagram of the electrical system (see Appendix 1) for the pilot's reference.

A comparison of the electrical diagram in the STC technical documentation with that of the supplement shows significant differences. In particular, the diagram in the Supplement to the Flight Manual shows that when the 'Alt 1' and 'Alt 2' alternators are not working, the communications and navigations systems, pitot heating, flaps, fuel pump and stall warning, all of which are supplied by the ESS BUS as part of the essential equipment, are supplied by both batteries, 'Batt 1' and 'Batt 2', which was not the case on the accident aircraft.

1.7. Tests and research

1.7.1. *Inspection of wreckage*

After it was recovered, the aircraft was taken to a workshop for inspection. With the cooperation of the engine manufacturer, the FADEC device and the engine were removed and both elements taken to the manufacturer's facilities in Germany for analysis.

The inspection of the electrical system revealed that a 150A fuse near the 'Batt 1' battery had blown, see Figure 2.

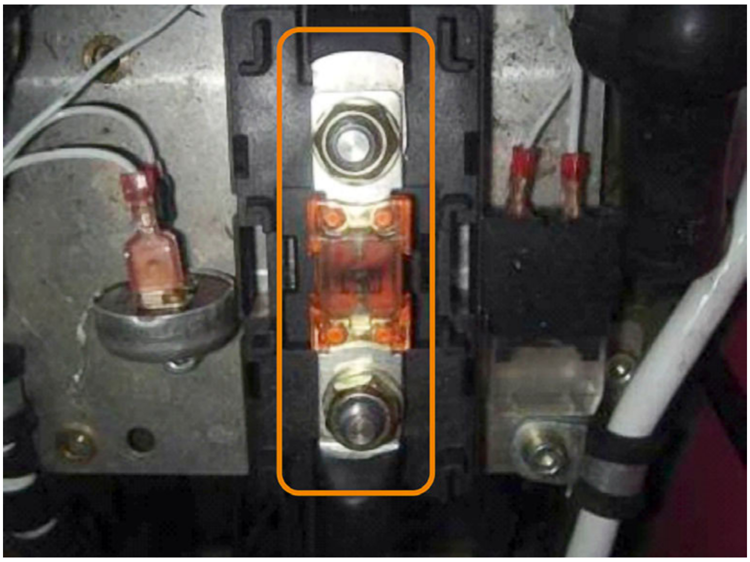

Figure 2. Battery fuse

1.7.1.1. Engine inspection

The engine block was perforated due to impacts from internal engine components.

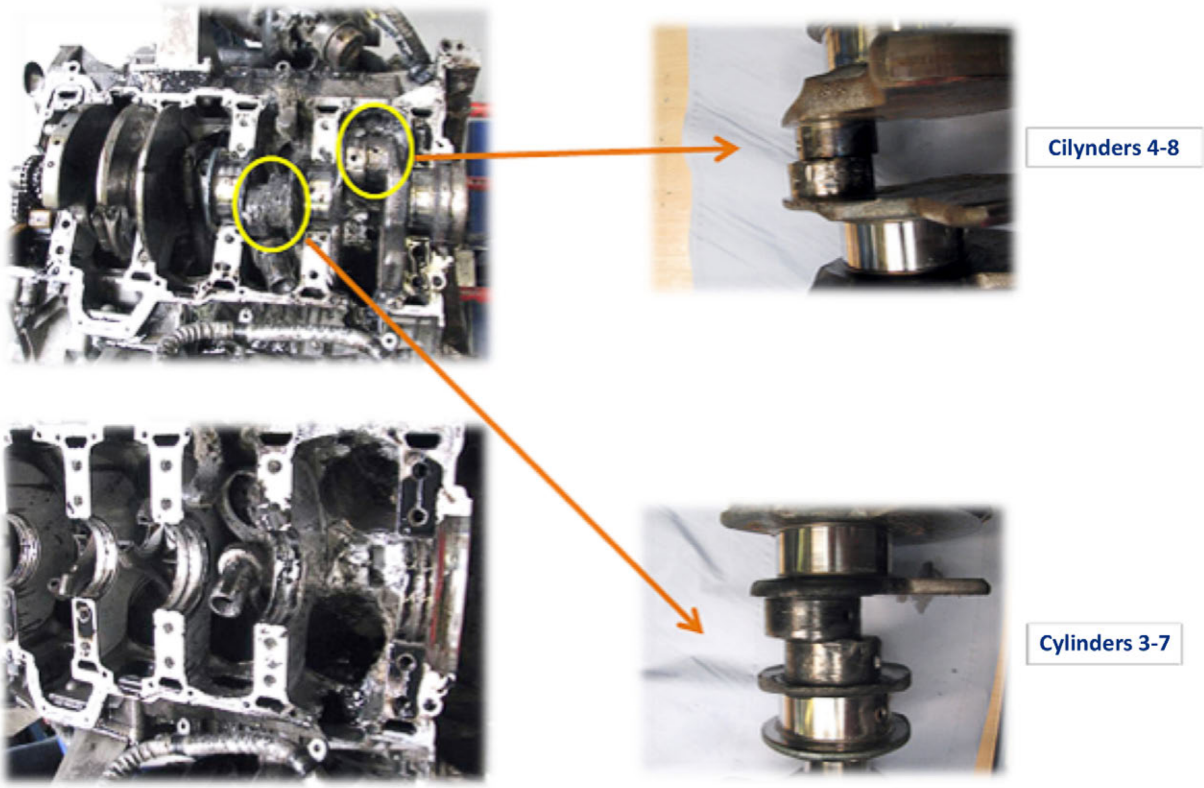

Figure 3. Damage to the engine

The cylinders are arranged from back to front, paired in the sequence 1-5, 2-6, 3-7 and 4-8. The connecting rods and pistons on cylinders 4 and 8 were destroyed, and the connecting rods on 3-7 were severely damaged. Cylinder 6 was also affected. The rest were not.

The crankshaft pins on the most affected cylinders had bluish stains, a sign of overheating. The pieces and fractures were also subjected to metallographic testing, which revealed the fast nature of the fracture process. See Figure 3.

Based on the information obtained, the most likely cause of the damage was a lack of lubrication to the engine, though the source of this lack of lubrication could not be identified.

1.7.1.2. Inspection of the electrical system

The electrical system installation on the accident aircraft was inspected. The results of this inspection showed that it corresponded accurately to that shown in the diagram contained in the STC technical documentation shown in Appendix 2 of this report, but not to that contained in Section 7 of the Supplement to the Flight Manual (see Appendix 1).

As noted earlier in Section 1.7, the 150A fuse located next to the battery 'Batt 1' was blown (see Figure 2).

1.7.1.3. Data recorded on the FADEC

The FADEC readings showed the following sequence of events:

- On engine start, the oil pressure *(Poil)* reached a maximum value of 6,516 mbar, and the oil temperature *(Toil)* 14 °C, with *Poil* decreasing and *Toil* increasing as the engine warmed up.
- During the flight, the average values for these parameters were 3,614 mbar for *Poil* and 116 °C for *Toil*. According to the flight manual, these figures are within the green operating arc.
- At one point during the flight, the following data, sequenced in seconds, were recorded for intake pressure (MAP)[4] and atmospheric pressure at flight altitude *(Pbaro).*

  Note how, after the intake pressure increased by about 150 mbar since the start of the interval, the atmospheric pressure (*Pbaro*) rose for seven seconds, followed by a sharp 6-second drop in *Poil* (colored region). *Poil* then recovered immediately in 1 second and *Pbaro* dropped again to the same value it had at the start of the interval.

[4] MAP: Manifold Absolute Pressure.

MAP (mbar)	Poil (mbar)	Pbaro (mbar)
2,548	3,729	795
2,535	3,900	795
2,510	3,655	795
2,456	3,545	791
2,416	1,919	787
2,441	1,222	786
2,493	1,479	784
2,505	758	786
2,491	330	786
2,498	171	786
2,491	3,374	786
2,503	3,606	786
2,513	3,252	790
2,530	3,337	788
2,535	3,240	788
2,493	3,741	788
2,443	4,034	788
2,426	3,667	788
2,406	3,606	792
2,404	3,399	790
2,339	3,643	790

- Then, 29 seconds after *Poil* reached a value of 171 mbar, the oil pressure dropped to 0 mbar, engine and propeller RPMs started to decrease gradually and the fuel supply pressure disappeared. The time stamp on the FADEC indicated that *Poil* fell to 0 mbar at 11:13:14.
- The power supply to the FADEC was transferred to 'Batt 2' 93 seconds after *Poil* fell to 0 mbar.
- From this moment on, the aircraft commenced a gradual descent until the water landing.

Figure 4 shows the variation in the readings[5] recorded in the last segment. The units[6] on the horizontal axis are in seconds.

[5] VBatt: Battery voltage. PBaro: Barometric pressure. PRail: Rail pressure. POil: Oil pressure. TH2O: Cooling water pressure. MAP: Manifold Absolute Pressure. Revs: Revolutions per minute
[6] The FADEC records data in 300-s segments. Figure 4 shows part of one of those segments.

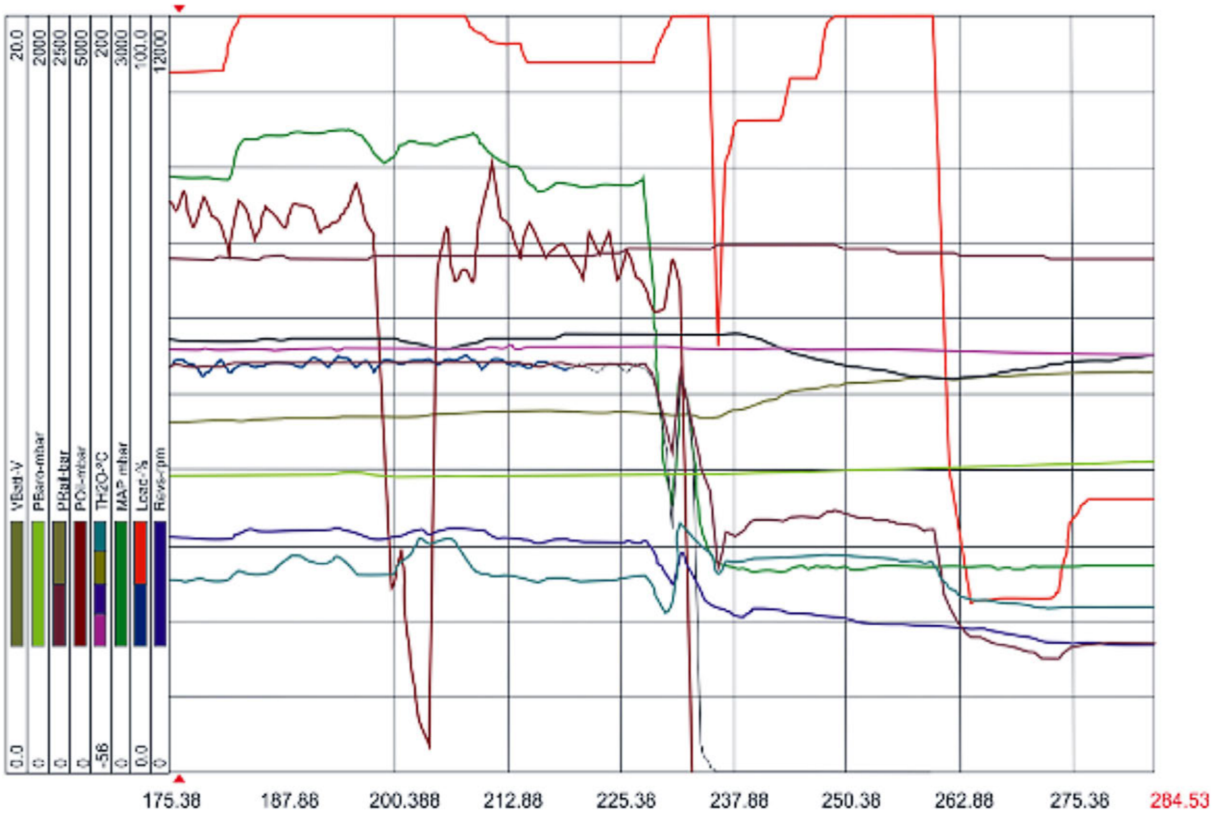

Figure 4. Graphs the values recorded in the last segment of the flight

1.7.2. *Pilot's statement*

The pilot and passenger on the aircraft were contacted several times during the investigation for the purpose of compiling detailed information on the events of the flight.

The information provided revealed that the aircraft had been operated by the same pilot since its arrival in Spain. A total of 1 liter of lubricating oil (Shell Helix Ultra 5w-30) was replaced during the flights made in Spain.

The pilot stated that on the day of the accident, the pre-flight inspection revealed that the oil level was slightly below the top mark. After taking on a little over 100 l of Jet A1 fuel, he filed the flight plan over the phone and, at 10:30, took off for Reus Airport with a passenger onboard.

Approach control at Valencia assigned a transponder code and cleared him to cross the TMA at 7,000 feet and to depart using the North visual corridor. Upon exiting the TMA, ATC reported traffic below, to which the pilot reacted by doing a "sweep turn" to confirm the presence of the traffic.

Shortly thereafter, he saw how an oil stain had begun to form and expand on the windshield. On checking the oil pressure and temperature indicators, he noted that they had fallen. He contacted Valencia to report the problem with the engine.

A few seconds later, while talking to the controller, the engine and propeller stopped. This affected the electrical system somehow, since the transponder and radio stopped working at that very moment.

During the descent, he tried unsuccessfully to restart the engine and, while making a final turn at about 800 ft AGL, noticed that the flaps were not working.

2. ANALYSIS

2.1. General

Based on an analysis of the available information, the sequence of events was as follows:

The accident occurred during a VFR flight from the Ontur aerodrome in Albacete to the Reus Airport. The purpose of the flight was to take the aircraft to a maintenance center in Reus for a periodic inspection.

The pilot did not note any abnormalities on the pre-flight inspection. He refueled and after filing the VFR flight plan over the phone, took off at approximately 10:30.

During the flight, the aircraft crossed the Valencia Airport CTR (Control Zone) at an altitude of 7,000 ft, leaving the CTR at 11:10 via the North Corridor at point N on SGO (Sagunto). Upon exiting the TMA, ATC informed the pilot of traffic below him, to which the pilot replied he was doing a "sweep turn" to confirm the presence of the traffic.

Shortly thereafter, with the aircraft on the VLC 046 RDL, at 20.5 NM and an altitude of 7,000 ft, the pilot noticed that an oil sheen was starting to form on the windshield. He checked the oil temperature and pressure indicators and saw both readings were dropping. At 11:11, the pilot contacted Valencia Approach Control to report the engine problems and his intention to find a place to land. Seconds later he declared an emergency due to an engine stoppage.

During the descent maneuver he unsuccessfully attempted to restart the engine.

At 11:14 the controller lost communications with the pilot and the aircraft's radar trace disappeared at an altitude of 4,800 ft at a distance of 22.8 NM away from the Valencia Airport VOR.

Also, after the engine stopped, the aircraft was left without electrical power, which caused the pilot to lose contact with ATC and resulted in the inoperability of several more systems. During the inspection of the wreckage, a blown fuse was found between the battery and the main bus. This blown fuse isolated the main battery from the rest of the electrical distribution system.

At 800 feet AGL, and after deciding on the landing spot on the beach in sight, the pilot noticed that the flaps were not working. He was unable to reach the landing spot. During the water landing the aircraft flipped over and ended up floating upside down near the beach in the town of Moncofa (Castellón).

The investigation considered the possibility that the pilot may have performed a sudden maneuver during the descent causing a load factor $n < 0$, which may have affected the engine lubrication and caused it to break, stop and then seize.

Another aspect considered in this analysis is the contents of the Flight Manual and of the Supplement associated with the STC, particularly as regards the instructions and Notes contained in them.

2.2. Aspects involving the engine failure and the data recorded on the FADEC

In Section 1.7.1.1, the damage found during the internal inspection of the engine is described. The fracture of the internal components, connecting rods and pistons produced a hole in the crankshaft through which lubricating oil leaked out. Several dark blue areas were also noted on the crankshaft pins on several cylinders, meaning that they were subjected to high temperatures resulting from insufficient engine lubrication. The investigation was unable to determine the origin of this lack of lubrication.

The parameters recorded on the FADEC reveal a high value for *Poil* on engine start caused by a low initial oil temperature *(Toil)*. After engine start and during the flight, the parameter readings remained constant and did not provide any indication of an impending engine failure.

However, when the FADEC readings for the *Pbaro* and *Poil* parameters in the minute prior to the failure were analyzed, the following was noted (see Figure 5):

- Before point **A**, the aircraft was flying horizontally at a pressure altitude (*Hp*) corresponding to *Pbaro* = 790 mbar (*Hp* = 6,673 ft)[7]. At that point, a descent was commended to *Pbaro* = 795 mbar (*Hp* = 6,560 ft) over a period of 4-5 seconds. This implies a push-over maneuver with a rate of descent (R/D) of between 2,100 and 2,600 ft/min and load factors estimated at between $-0.7 < n < -0.8$. The pilot then pulled up to recover, a maneuver that lasted 4 seconds with an estimated load factor

[7] Note: The difference between the indication on theaircraft´s altimeter –7,000 ft– and the pressure altitude recorder by the FADEC is due to the QNH setting for the flight.

of n = 2.3 and a rate of climb (R/C) of about 5,850 ft/min, to an *Hp* = 6,890 ft (*Pbaro* = 784 mbar).

- The aircraft would have then exceeded the initial flight altitude by about 220 ft. The pilot then begun a second push-over maneuver to regain the initial altitude. The load factor during this second maneuver, which lasted about 4 seconds, is estimated at n = 0.25
- In order to regain the initial altitude, the pilot performs a stabilized descent with a descent rate of 1,120 ft/min for about 10 seconds to point **B.**
- Figure 5 shows that the drop in oil pressure, *Poil*, took place 3-4 seconds after the completion of the previous push-over maneuver, and that the drop lasted about 2 seconds. *Poil* then increased slightly for 1 second before falling to 173 mbar over the next 3 seconds. Note also that the continuing drop in *Poil* to its minimum value coincided with the time of the second push-over maneuver.
- Figure 5 shows that the engine was subjected to a low oil pressure (*Poil* below the normal pressure during the rest of the flight) for about 7.5 seconds.
- During the time between points **A** and **B,** the values for engine and propeller rpm's were normal.

These events very likely occurred during the maneuver described by the pilot as a "sweep turn", performed to confirm the presence of the traffic below him that had been reported by ATC.

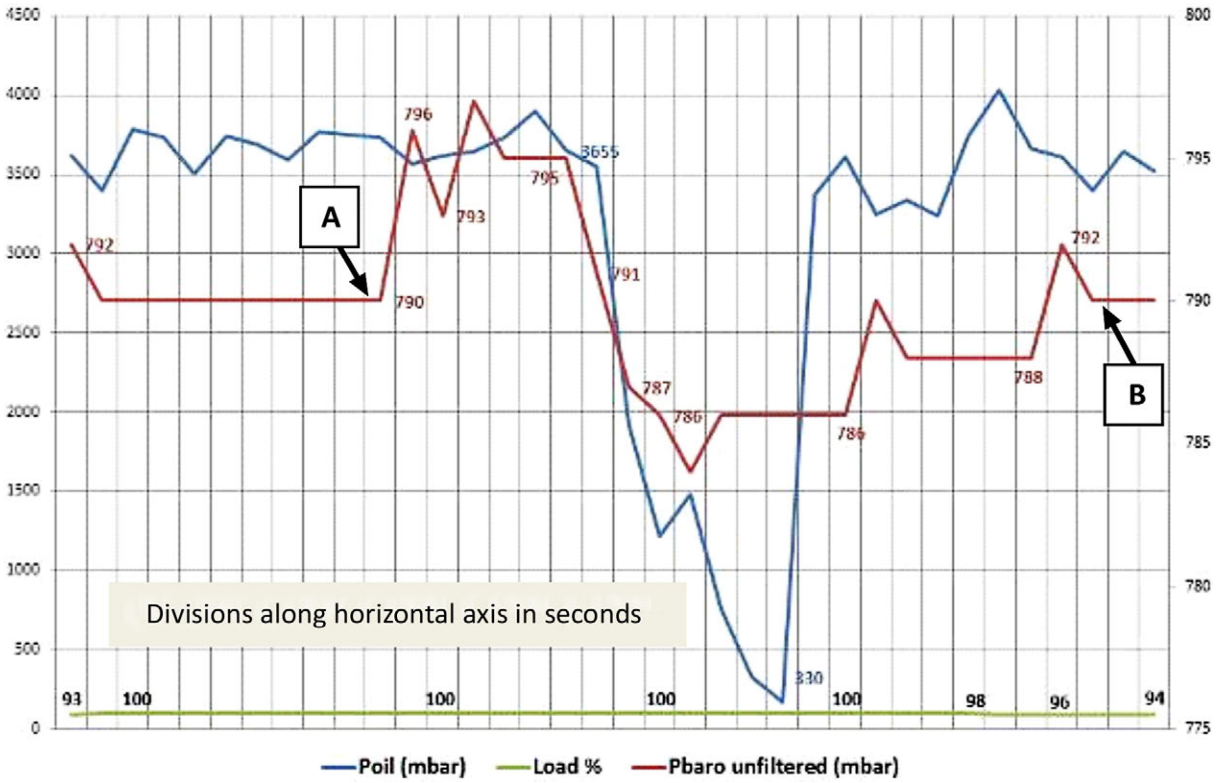

Figure 5. Variation in oil pressure, engine load and barometric pressure

An assessment of the time interval (about 6 seconds) during which the engine was subjected to an oil pressure that was 50% below normal in-flight pressure indicates that since the engine parameters remained within the allowed values (green arc) during the flight, the lack of lubrication during this time must have been offset by the presence of a residual film of lubricant in the engine.

The formation of the blue hues present on some of the crankshaft pins, evidence of oxidation, requires exposing the steel to a combination of time and temperature that is significantly higher than that to which the crankshaft was exposed during the maneuver in question. This implies that prior to the accident flight, the engine must have been exposed to one or several periods of low lubrication.

In summary, the engine failure cannot be attributed solely to the momentary lack of lubrication recorded on the FADEC as a consequence of the sudden maneuver that led to the drop in oil pressure.

However, since *Poil* started to drop 7.5 seconds after the first push-over was initiated, recovered slightly at the end of the climb following the drop (t = 9.5-10.5 s), dropped again during the second push-over (t = 10.5-13.5 s) to a minimum value for *Poil* of 171 mbar, and then started to recover when the aircraft was in a stable descent rate to recover the initial altitude (t = 13-23 s), with *Poil* reaching a normal value of 3,600 mbar within 1.5 seconds, it seems evident that the pressure oscillations were due to the sudden changes in the aircraft's flight path.

The foregoing, thus, indicates that the roller coaster maneuver recorded on the FADEC triggered the drop in pressure seen between t=7.5-15 s, which, in conjunction with the effects from the previous shortages of lubrication, led to the fracture of several components and to the subsequent stoppage/seizure of the engine 43 seconds after the start of said maneuver.

Although, as stated earlier, the cause of the lack of lubrication could not be determined, it most likely occurred due to a lack of lubricant at the intake of the oil pump during aggressive maneuvers that, under certain combinations of attitude and acceleration (linear and angular), could result in such a shortage of lubricant. This hypothesis could not be analyzed in detail since readings from the relevant parameters were not available.

The oil pump itself functioned normally during the flight. During the 7.5-second interval in which the pressure dropped, the pressure recovered 1.5 seconds after *Poil* reached its minimum value. It was only after the engine failure and the loss of oil that the pressure dropped to 0.

2.3. Analysis of the electrical system

The implementation of the STC for the Centurion 4.0 engine on the Cessna TU206F aircraft required a major modification of the electrical system.

The electrical system installed on the accident aircraft was verified to correspond to the modified design approved by the STC.

This design includes two bus bars, a main and an essential bus. Each bus supplies the systems listed in Section 1.6.8. Specifically, the battery 'Batt 1', the starter motor, the communications and navigations systems, the pitot heater, the flaps, fuel pump and stall warning are all powered directly from the main bus. There is a 150A fuse located near 'Batt 1'.

The essential bus supplies FADEC A, the vacuum pump and the multifunctional engine data display.

The connection between the busses is unidirectional from the main to the essential bus.

Indications are that the aircraft was left without electrical power at an altitude of 4,800 ft, after the pilot reported that the engine had stopped and declared an emergency.

In light of the sequence of events that took place during the flight and of the design of the electrical system, this situation could only have occurred if, between 11:11 and 11:14, while descending from 7,000 to 4,800 ft, the pilot attempted to start the blocked engine. Since the internal damage prevented the engine from rotating, the current drawn was in excess of what the fuse could withstand, causing it to blow. This left 'Batt 1' isolated from the main bus and caused the communications system and the flaps, as well as other systems of no consequence to this investigation, to become inoperative. The design of the system is such that no other alternative is possible.

The Supplement to the Flight Manual associated with the STC shows a simplified diagram of the electrical system. Section 7 of this supplement (see Appendix 1) includes a diagram that differs in some key areas from the actual system installed in the aircraft and described in the documentation associated with the STC and in the above sections.

These differences focus on the power supply to the so-called "Essential Equipment", which should be fed from two power sources, as required by the safety conditions applicable to essential components. This was not the case, however, in the system approved in the STC and installed on the aircraft, since the aforementioned equipment was left without an alternative power source to 'Batt 1'.

In summary, in the system installed, while the location of a fuse next to 'Batt 1' does protect the electrical system from a potential short-circuit, it also eliminates the possibility that 'Batt 1' will be able to supply other essential systems. Moreover, since the connection between the main and essential busses is made unidirectional by the group of diodes 'D1', this means that 'Batt 2' cannot supply the main bus and the systems that rely on it should 'Batt 1' be isolated.

As a result of the foregoing analysis and considerations, the design of the electrical system approved by the STC and installed on the aircraft is believed to pose functional and safety deficiencies in terms of the systems that rely on it. A Safety Recommendation is thus issued to have the design modified so as to avoid a repeat of the circumstances that occurred on this flight whenever the pilot attempts to restart the engine in-flight.

2.4. Aspects involving the flight manual

The aircraft's Flight Manual classifies the instructions into three levels, depending on the effect they have on the safety of the aircraft. These are, from greatest to least, «WARNING», «CAUTION» and «Note».

A «Note» is described as: "information added for a better understanding of an instruction".

As regards starting the engine in-flight, the Supplement to the Flight Manual includes a «Note» on page 3-4 of Section 3, Emergency Procedures, that states:

> *"The propeller will normally continue to turn as long as the airspeed is above 65 KIAS. Should the propeller stop at an airspeed of more than 65 KIAS, the reason for this should be found out before attempting a restart. If it is obvious that the engine or propeller is blocked, do not use the Starter."*

An analysis of this specific «Note» on page 3-4 in Section 3 yields the following conclusions:

I. The importance of the repercussions on the electrical system currently installed in the aircraft when the starter is used with the engine blocked is such that this «Note» should be elevated to at least to «CAUTION».
II. The wording of this instruction should also be changed to clarify and highlight the importance of not using the starter in these conditions.
III. The flight Manual does not adequately reflect the negative effects that attempting to start the engine with the engine or the propeller blocked has on the operability of several systems.

Therefore, the effect of attempting to start the engine with the engine or propeller blocked, leaving several systems inoperative, was not properly highlighted and evaluated by way of a «Note». It is considered that the flight manual should expressly inform pilots of the effect of starting the engine in flight and the resulting cockpit indications (plaque, sign). This consideration might not be needed if the electrical system were to be modified.

3. CONCLUSION

3.1. Findings

- The aircraft had a valid "Normal" and "Utility" airworthiness certificate and the periodic inspections indicated in the aircraft logbook had been performed.
- The pilot had a valid license and was qualified for the flight.
- The aircraft's original engine and propeller were replaced by a Thielert Centurion 4.0 engine and a MTV-9-D propeller pursuant to EASA STC A.S.02565.
- The STC expanded the original flight manual with a supplement.
- The diagram of the electrical system installed on the accident aircraft agrees with the design included in the STC.
- The diagram for the electrical system contained in the Supplement to the Flight Manual differs from that included in the STC.
- The data recorded on the FADEC from the start of the flight until just before the engine stoppage did not exhibit any abnormalities indicative of a problem with the operation of the engine.
- Over the course of the flight, the aircraft crossed the Valencia Airport CTR (control zone) at an altitude of 7,000 ft, exiting said CTR via the North Corridor at point N of the SGO (Sagunto) at 11:10.
- After exiting the TMA, ATC reported traffic below the aircraft, to which the pilot reacted by performing a maneuver to confirm the presence of said traffic.
- The analysis of the information recorded on the FADEC revealed that this maneuver consisted of a push-over lasting 4-5 seconds, during which a load factor on the order of n = –0.7 was reached, followed by a pull up of 4 seconds, and its associated load factor of n = 2.3, then another push-over lasting 4 seconds, followed by a descent in a straight line lasting some 10 seconds. The total duration from start to finish was about 23 seconds. The change in altitude was limited to 400 ft. The maneuver resulted in strong and sudden changes to the aircraft's flight path.
- These findings reveal that the Maneuvering Limits contained in the «Note» in Section 2, page 2-4 of the Supplement to the Flight Manual, and which states "*Intentionally initiating spins or negative-G flight is prohibited*", were exceeded.
- Approximately 7.5 seconds after the start of this roller coaster maneuver, the FADEC readings show that the oil pressure dropped significantly over a 6-second to a minimum value before recovering even more suddenly over the next 1.5 seconds to its normal value. The oil pressure was below its normal value for a total of 7.5 seconds. The pressure was back to its normal value 15 seconds after the start of the maneuver.
- This drop in pressure for 7.5 seconds was not enough to cause the appearance of the bluish oxidation marks indicative of overheating that were present on some of the crankshaft pins, and which point to previous events involving a lack of lubrication.
- Forty-three seconds after the start of this roller coaster maneuver, the oil pressure dropped to 0 and the engine failed and stopped as a result of catastrophic internal damage that kept the engine from turning.

- The roller coaster maneuver recorded by the FADEC triggered the drop in pressure recorded between t = 7.5-15 seconds which, in conjunction with the effects from the previous shortages of lubrication, led to the fracture of several components and to the subsequent stoppage/seizure of the engine 43 seconds after the start of said maneuver.
- The internal damage found was consistent with the effects resulting from a lack of lubrication. The source of the lack of lubrication could not be accurately determined.
- The pilot did not observe the instructions of the '¿Note' on page 3-4 of Section 3 (Emergency Procedures) in the Supplement to the Flight Manual regarding restarting the engine in the event of an engine failure, which states, "*If it is obvious that the engine or propeller is blocked, do not use the Starter.*"
- The attempt to restart the blocked engine in-flight caused the fuse located between 'Batt 1' and the main bus to blow. This rendered the flaps and communications systems inoperative, as well as other systems that, though irrelevant to the investigation of this accident, are important to flight safety.
- The instructions in the Supplement to the Flight Manual regarding starting the engine in-flight with the engine blocked do not adequately reflect the severity of the repercussions of such a restart on the electrical system currently installed on the aircraft.

3.2. Causes

The accident was caused by the breakdown and subsequent stoppage of the engine in-flight as a result of improper lubrication of the engine.

As a result of the engine stoppage and blockage, and of the pilot's subsequent effort to restart it, an electrical fault occurred that left other aircraft systems inoperative, such as the flaps, which prevented them from extending during the forced landing.

4. RECOMMENDATIONS

REC 04/12. It is recommended to the European Aviation Safety Agency (EASA) that the suitability of the design of the electrical system contained in the STC (EASA.A.S.02565) be evaluated in terms of the location, identification and possible replacement of the 150-amp fuse situated next to 'Batt 1'.

REC 05/12. It is recommended that the European Aviation Safety Agency (EASA) reconsider the approval of the Supplement to the Flight Manual of the Cessna TU206F aircraft with a Centurion 4.0 engine installed so that it:

- Properly reflects the information regarding the electrical system.
- Provides the pilot with adequate instructions on what to do (or not do) in the event of an in-flight engine failure.

APPENDIX 1
Extracts from Flight Manual

SECTION 1
GENERAL

CONVENTIONS IN THIS HANDBOOK

This manual contains following conventions and warnings. They should be strictly followed to rule out personal injury, property damage, impairment to the aircraft's operating safety or damage to it as a result of improper functioning.

▲ **WARNING:**	Non-compliance with these safety rules could lead to injury or even death.
■ CAUTION:	Non-compliance with these special notes and safety measures could cause damage to the engine or to the other components.
◆ Note:	Information added for a better understanding of an instruction.

UPDATE AND REVISION OF THE MANUAL

▲ **WARNING:**	A safe operation is only assured with an up to date POH supplement. Information about actual POH supplement issues and revisions are published in the TAE Service Bulletin TM TAE 000-0004.
◆ Note:	The TAE-No of this POH supplement is published on the cover sheet of this supplement.

Engine Instrument Markings

The engine data of the Centurion 4.0 installation to be monitored is integrated in the combined engine instrument CED. The ranges of the individual engine monitoring parameters are shown in the following table, see also Figure 2-1.

Instrument		Red range	Yellow range	Green range	Yellow range	Red range
Tachometer	[RPM]	---	---	0 - 2300	---	> 2300
Oil pressure	[mbar]	0-1000	1000-2300	2300-6500	6500-7000	> 7000
	[psi]	0 - 17.4	17.4 - 33.4	33.4 - 94.3	94.3-101.5	>101.5
Coolant temperature	[°C]	< -25	-25....+ 60	60 - 101	101 - 105	> 105
	[°F]	< -13	-13..+140	140 - 214	214 - 221	> 221
Oil temperature	[°C]	< -25	-25....+ 50	50 - 125	125 - 140	> 140
	[°F]	< -13	-13....+122	122 - 257	257 - 284	> 284
Gearbox temperature	[°C]	---	---	< 115	115 - 120	> 120
	[°F]	---	---	< 239	239 - 248	> 248
Load	[%]	---	---	0 - 100	---	---

Table 2-1 Markings of the engine instruments

◆ Note: If an engine reading is in the yellow or red range, the "Caution" lamp is activated. It only extinguishes when the "CED-Test/ Confirm" button is pressed. If this button is pressed longer than a second, a selftest of the instrument is initiated.

■ CAUTION: Operation in yellow range should not last more than 5 min. After 5 min. refer to Emergency procedures for operation in red range, Section 3

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Figure 2-1a CED

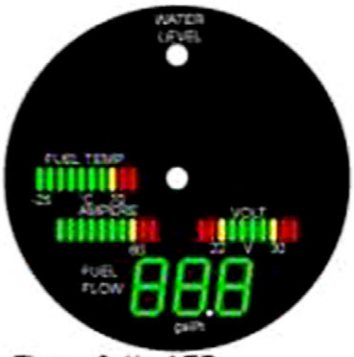

Figure 2-1b: AED

Weight Limits

No change, refer to original POH.

Center of Gravity Limits

No change, refer to original POH.

Maneuver Limits

Refer to original POH. .

■ CAUTION Intentionally initiating spins or negative-G flights is prohibited

Flight Loads Factor Limits

No change, refer to original POH.

Kinds of Operation

No change, refer to original POH.

Fuel Limitations

■ CAUTION: Using non-approved fuels and additives can lead to dangerous engine malfunctions.

Approved fuel grades:............... JET A, JET A-1 (ASTM D1655)
.... JP-8, JP-8+100 (MIL-DTL-83133E)

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ENGINE FAILURE IMMEDIATELY AFTER TAKE-OFF

(1) Airspeed..80-85 KIAS (flaps up)
....70-75 KIAS (flaps down)
(2) Load Control .... IDLE (pull full out)
(3) Fuel Selector Valve...OFF
(4) Engine Master...OFF
(5) Wing Flaps............AS REQUIRED (FULL recommended)
(6) Battery Switches ....OFF
(7) Auxiliary Fuel Pump..OFF
(8) Cabin Door...UNLATCH
(9) Land .... Straight Ahead

ENGINE FAILURE DURING FLIGHT (RESTART PROCEDURE)

(1) Airspeed.................................BEST GLIDE (75-80 KIAS)
(2) Fuel Selector Valve...BOTH
(3) Auxiliary Fuel Pump..ON
(4) Load Control ....IDLE
(5) Engine Master .... Cycle OFF to ON
(if the propeller does not turn, then additionally Starter ON)

◆ Note: The propeller will normally continue to turn as long as the airspeed is above 65 KIAS. Should the propeller stop at an airspeed of more than 65 KIAS, the reason for this should be found out before attempting a restart. If it is obvious that the engine or propeller is blocked, do not use the Starter.

◆ Note: If the Engine Master is in OFF position, the Load Display shows 0% even if the propeller is turning.

(6) Check the engine power: .... Load Control 100%, engine parameters, check altitude and airspeed

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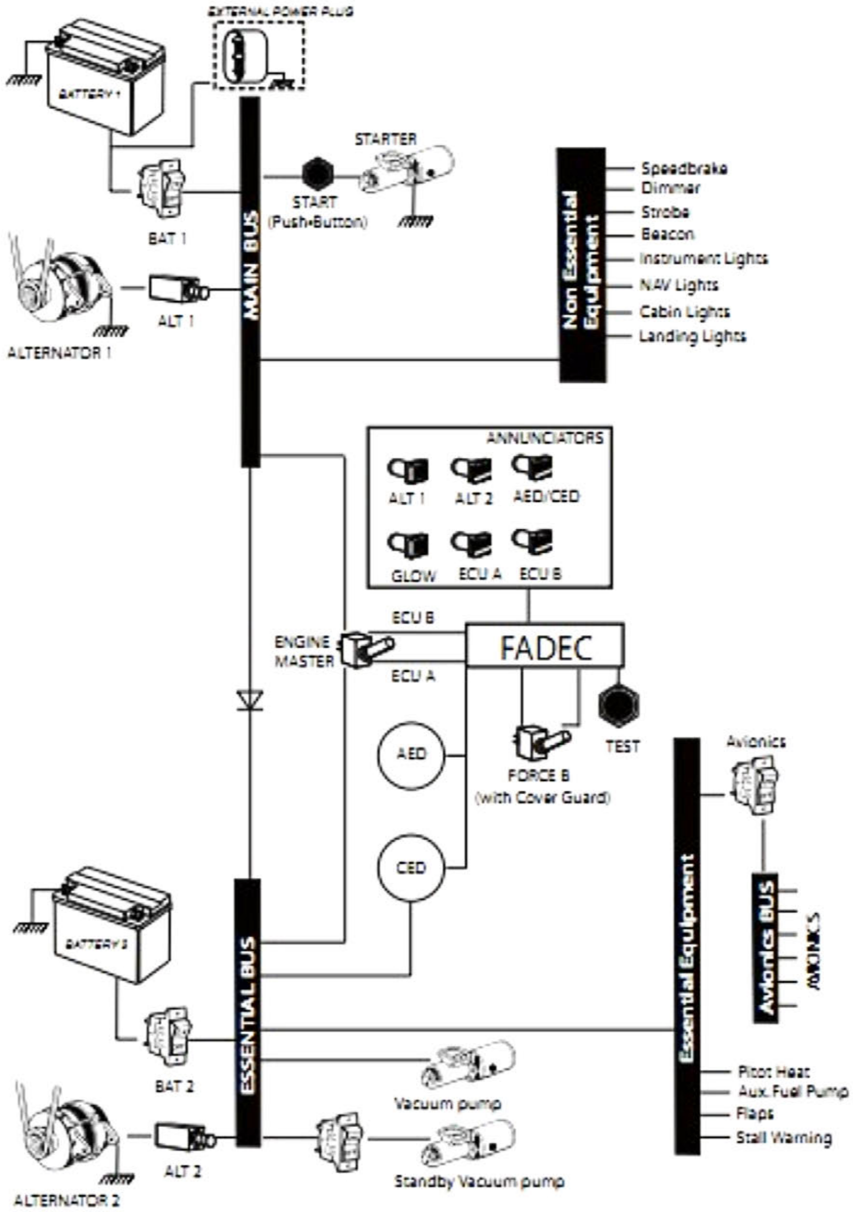

Figure 7-8: Basic Schematic of the Electrical System of the Cessna (T)U206F & G (28V) with Centurion 4.0 installation

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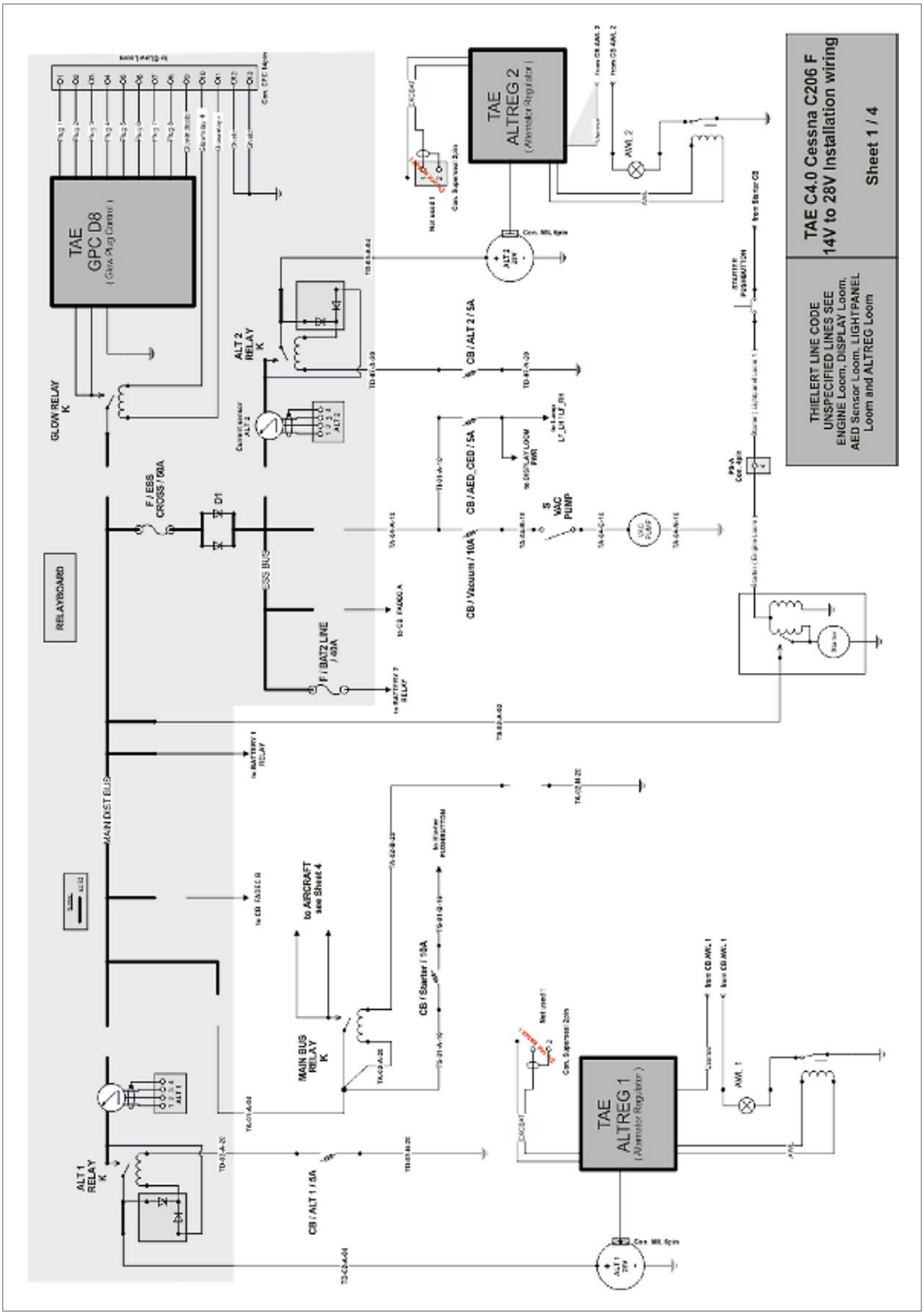
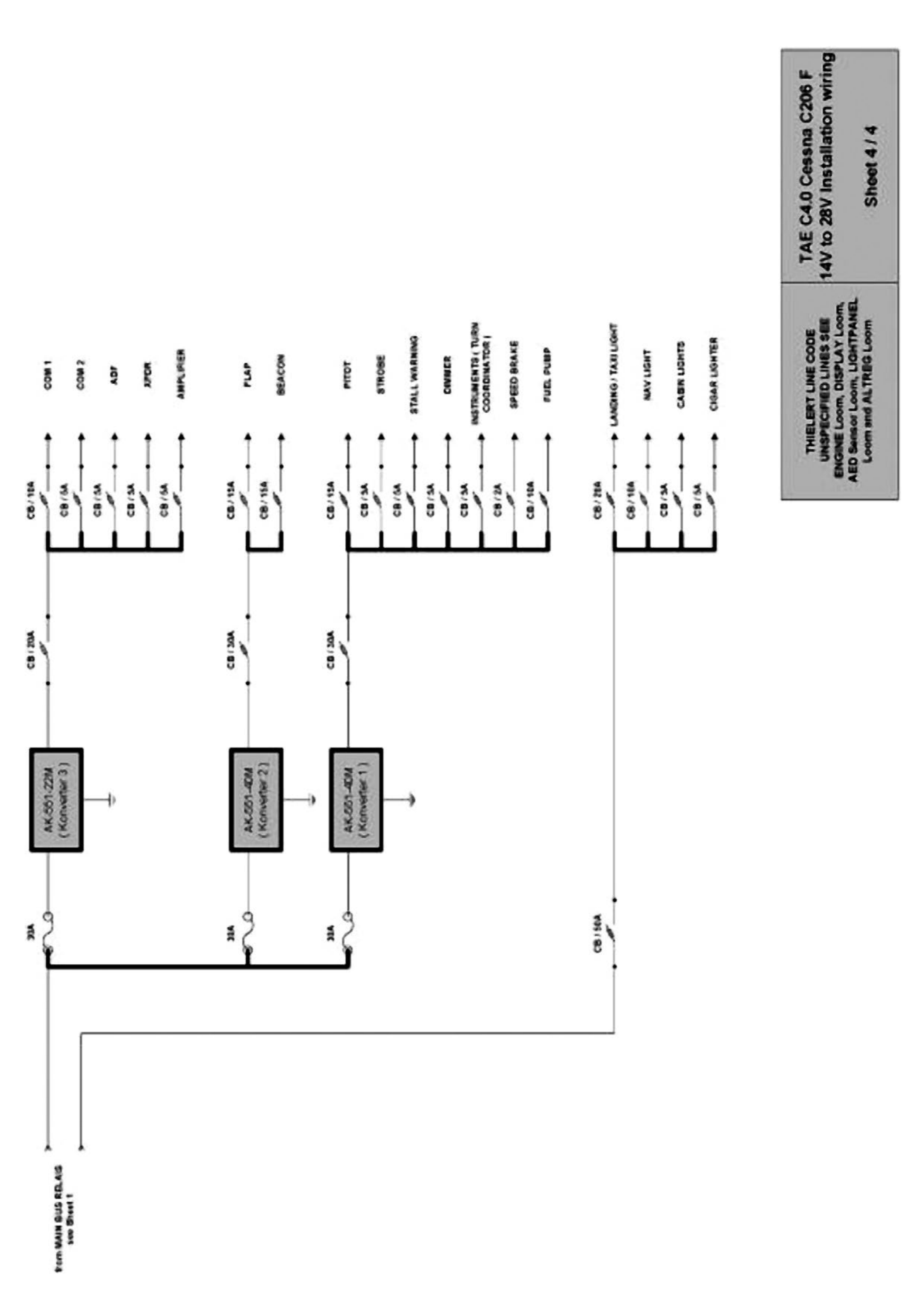
APPENDIX 2
Electrical system diagram


TAE C4.0 Cessna C206 F
14V to 28V installation wiring
Sheet 1 / 4
THIELERT LINE CODE
UNSPECIFIED LINES SEE
ENGINE Loom, DISPLAY Loom,
AED Sensor Loom, LIGHTPANEL
Loom and ALTREG Loom
TAE GPC D8 (Glow Plug Control)
TAE ALTREG 2 (Alternator Regulator)
TAE ALTREG 1 (Alternator Regulator)
GLOW RELAY K
ALT 2 RELAY K
ALT 1 RELAY K
MAIN BUS RELAY K
RELAYBOARD
F / ESS CROSS / 60A
D1
ESS BUS
MAIN DIST BUS
F / BAT2 LINE / 40A
CB / ALT 2 / 5A
CB / AED_CED / 5A
CB / Vacuum / 10A
S VAC PUMP
CB / Starter / 10A
CB / ALT 1 / 5A
to AIRCRAFT see Sheet 4


TAE C4.0 Cessna C206 F
14V to 28V Installation wiring
Sheet 4 / 4
THIELERT LINE CODE
UNSPECIFIED LINES SEE
ENGINE Loom, DISPLAY Loom,
AED Sensor Loom, LIGHTPANEL
Loom and ALTREG Loom
from MAIN BUS RELAIS
see Sheet 1
CB / 50A
CB / 20A
CB / 20A
CB / 20A
AK-551-22M (Konverter 3)
AK-551-40M (Konverter 2)
AK-551-40M (Konverter 1)
COM 1
COM 2
ADF
XPDR
AMPLIFIER
FLAP
BEACON
PITOT
STROBE
STALL WARNING
DIMMER
INSTRUMENTS (TURN COORDINATOR)
SPEED BRAKE
FUEL PUMP
LANDING / TAXI LIGHT
NAV LIGHT
CABIN LIGHTS
CIGAR LIGHTER