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POPULAR SCIENCE ARTICLE

Fuel Depletion, Restriction and Management

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Abstract

To address fuel-related occurrences, the first part of the analysis of a historical series that identified and categorised such occurrences in Argentina during the period 2013-2022, through the Aviation Data Reporting Program/ European Co-ordination Centre for Accident and Incident Reporting Systems (ADREP/ECCAIRS) system of the institutional repository of the Transportation Safety Board (JST) is provided.

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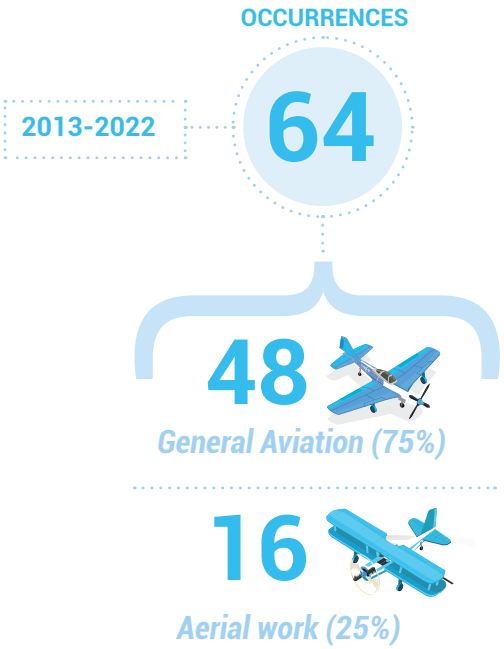
Introduction

ECCAIRS is a system developed by the European Union that allows, in a standardized manner, the collection, analysis, and sharing of accidents and incidents information in a format compatible with the Aviation Accident/Incident Data Reporting System (ADREP).

A fuel-related occurrence, FUEL in ICAO taxonomy[1], is one in which one or more powerplants experience a partial or total loss of power due to:

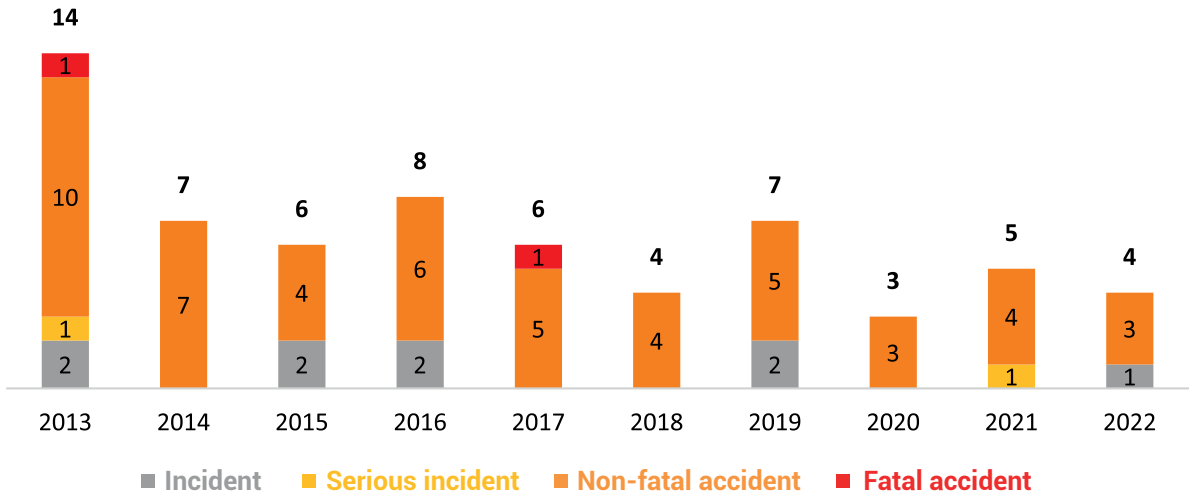
- Depletion or inability to use the fuel available on board.
- Use of incorrect or contaminated fuel.
- Ice formation in the engine induction system.

In Argentina, there were 64 occurrences of this type between 2013 and 2022, with the particularity that they took place in general aviation or aerial work operations (non-commercial aviation). The analysis will be presented in three parts, each addressing FUEL occurrences independently.



"A fuel-related event, FUEL, is one in which one or more power plants experienced a partial or total power drop.

Chart 1. Annual series of fuel-related occurrences in Argentina for the period 2013-2022.



Source: ADREP/ECCAIRS system, JST database

1. It is one of the occurrence categories established by the Commercial Aviation Safety Team (CAST) and the ICAO Common Taxonomy Team (CICTT): http://www.intlaviationstandards.org/Documents/OccurrenceCategoryDefinitions.pdf

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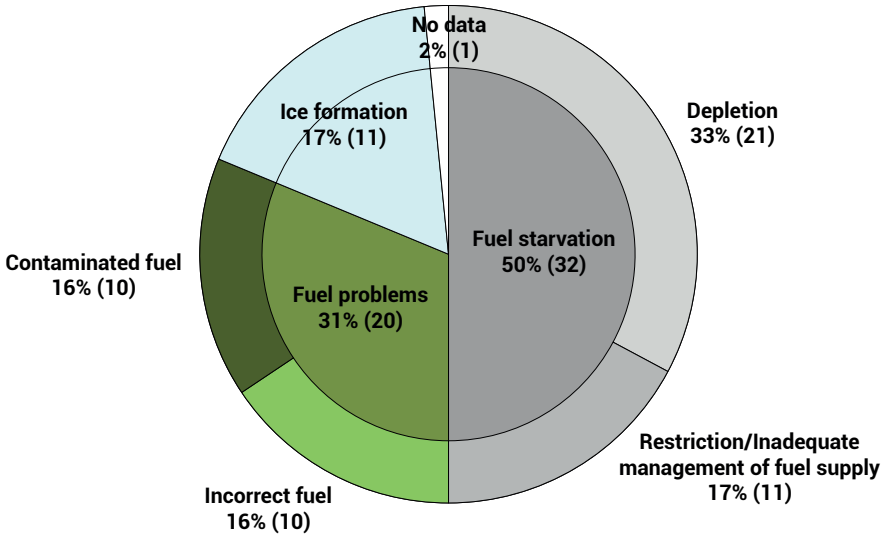
Of the 64 occurrences mentioned, 32 (50%, or 1 in 2) originated from a fuel starvation issue.

This article will focus on occurrences caused by fuel depletion and those related to a restriction or inadequate management of fuel supply, that is, those that resulted in fuel starvation to the powerplant.

Chart 2. Fuel-related occurrences for the period 2013-2022.



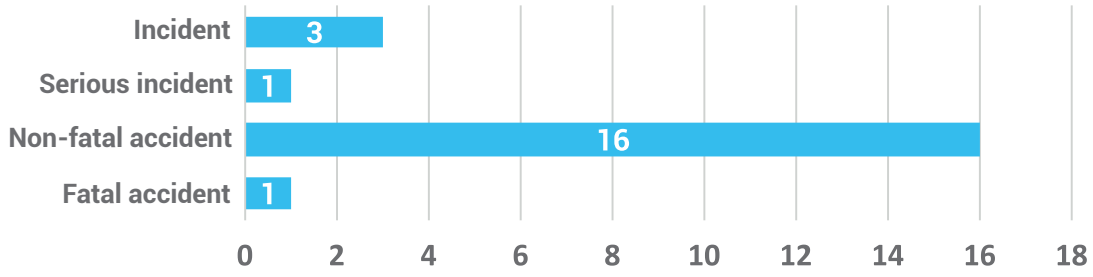
Source: ADREP/ECCAIRS system. Institutional Transportation Safety Board (RI-JST)[2] database

Fuel Depletion

This is the most recurrent scenario, accounting for 21 of these cases (33%, nearly 1 in 3). The lack of fuel available on board the aircraft is mainly due to deficiencies in flight planning.

Before starting an operation, it is essential to know precisely the amount of fuel available and the amount needed to complete the flight safely.

Chart 3. Fuel depletion occurrences for the period 2013-2022



Source: ADREP/ECCAIRS system. Transportation Safety Board (RI-JST) institutional database

2. The percentages in this document are rounded to the nearest value.

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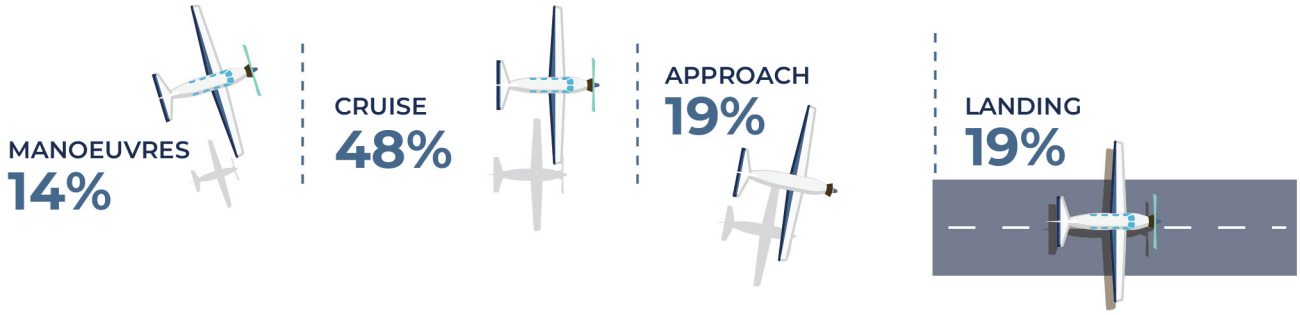
Illustration 1. Phases of flight of fuel depletion occurrences



Source: ADREP/ECCAIRS system. Transportation Safety Board (RI-JST) institutional database

Available fuel should not be considered as a quantity, but as flight time. For a consistent combination of altitude, power settings, and mixture settings, fuel consumption will be controlled; however, deviations due to weather conditions could alter flight time.

Knowing the amount of available fuel involves considering many factors and types of operations that can limit it. To reduce possible adverse situations, it is important for the pilot to make it a habit, in addition to the checks recommended by the aircraft manufacturer, to adopt some good practices that will help ensure reliable information about the amount of fuel available. To accurately calculate fuel and flight endurance, it is recommended to follow these guidelines:

- Use the fuel consumption rates provided in the flight manual.
- Calculate the amount of fuel required to reach the destination aerodrome and alternate aerodromes, plus the reserve (pre-calculated).
- Calculate flight endurance without counting the reserve.
- Check the weather along the route where the activity will take place.
- Visually inspect the contents of the tanks and the condition of the seals on their caps.
- Verify the consistency of the values on the visual quantity indicators, if available.
- Examine the instrument readings in the cockpit.
- Verify the logical sequence and values of the last fuel loads.
- Check for visible leaks on the ground where the aircraft was parked.
- Detect any excessive smell of fuel inside the engine cowling, or even in the cockpit.
- Pay special attention to mixture adjustment as altitude increases.
- Verify throughout the flight that the values of the pre-calculated navigation align with the expected ones.
- Regularly check that the fuel available according to the instrument corresponds to the consumption as per the table, given the flight conditions.

In summary, before starting a flight, the pilot should be able to answer the following questions:

- How much (usable) fuel does the aircraft have?
- What is the fuel consumption of the engine according to the manufacturer?
- How much fuel will the engine consume to reach each reporting point in my navigation?
- How much fuel will the engine consume to perform the operation under the expected conditions?
- How much residual fuel will be available upon arrival at the destination?
- If applicable: which tank or tanks will be selected for landing?

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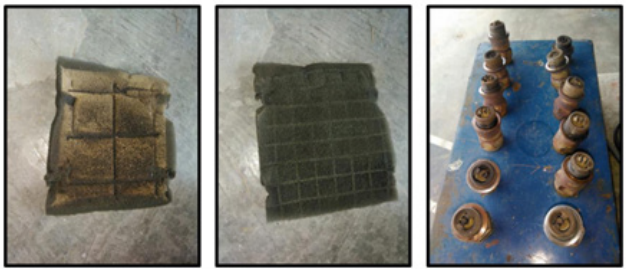
Figure 1. Oil quantity check using the dipstick

Source: JST investigators.

Figure 2. Engine air filter and spark plugs



Source: JST investigators.

Example Case: LV-GTV[3] Occurrence

To illustrate the importance of flight planning, the accident involving the aircraft registration LV-GTV, Cessna 172A, which occurred on February 18, 2019, is presented below. Upon beginning the approach, after 2 hours and 20 minutes of flight, the engine experienced a failure and subsequently stopped. In this situation, the pilot declared an emergency and landed on a dirt road, with no consequences for the occupants or the aircraft.

The investigation determined that the engine stoppage occurred due to fuel depletion, as both wing tanks were empty. It was found that:

- The oil quantity in the engine was 6 liters less than the minimum required for operation, which caused fluctuations and a decrease in oil pressure during the power reduction.
- The spark plugs were in a state of advanced deterioration.
- The air filter used was not suitable for aviation use, and its condition may have resulted in higher than expected fuel consumption.

The combination of these conditions likely resulted in increased fuel consumption, which reduced flight endurance.

Link to LV-GTV research report: https://so.jst.gob.ar/informe/?id=1508

Fuel Management

Of the analyzed cases, 11 (17%, or nearly 1 in 5) resulted from an interruption in fuel supply due to inadequate management. Unlike fuel exhaustion, where no usable fuel remains in the aircraft's tanks, inefficient management implies that, while fuel is available, it is not being used by the engines. In some cases, it is possible to restore fuel flow and recover engine power. This often occurs due to incorrect selection of a fuel tank that is either empty or has low fuel levels, allowing air to enter the system, which interrupts the supply to the engine.

11 OCCURRENCES — **17%** — *Interruption in fuel supply due to inadequate management*

3. Link to the LV-GTV investigation report: https://so.jst.gob.ar/informe/?id=1508.

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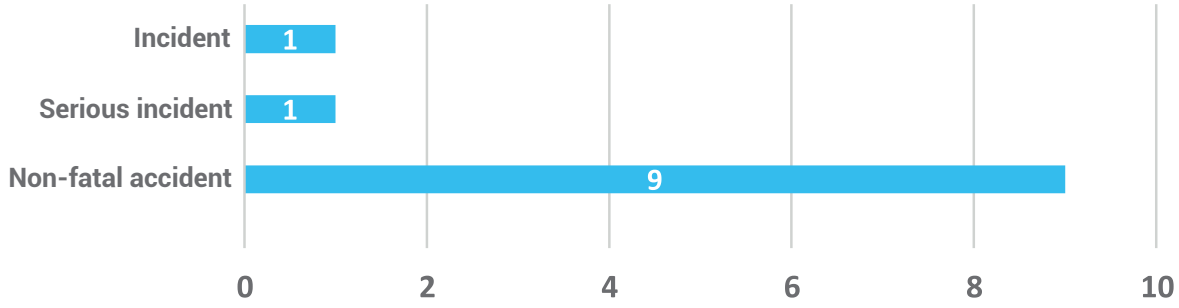
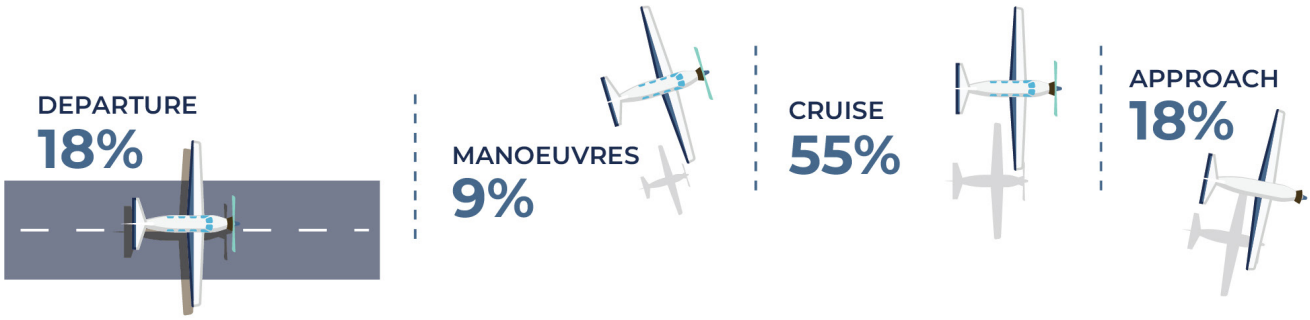
Chart 4. Occurrences by management for the period 2013-2022



Source: ADREP/ECCAIRS system. Transportation Safety Board (RI-JST) institutional database.

Illustration 2. Phases of flight of fuel management occurrences for the period 2013-2022



Source: ADREP/ECCAIRS system, JST database.

To avoid the situations mentioned, the following good practices are recommended:

- Do not change the tank selection just before takeoff. In several cases, the selector was incorrectly positioned, resulting in the stoppage of the engine or engines.

- If auxiliary tanks are available, do not use them for takeoff or landing, as their capacity is limited, and forgetting to switch back to the main tank(s) afterwards can lead to engine failure or stoppage.

- Consider changing the tank selection at a regular and comfortable interval for the operation (this timing also depends on the aircraft).

- Have an effective method to remember to change the tank selection, such as a flight planning checklist, pre-calculated navigation, or a timed alarm (this could be a watch or cell phone).

- Avoid imbalances between tanks, keep them as balanced as possible, and ensure there is sufficient fuel for descent, approach, and a potential go-around.

- Periodically check the condition of the tank selector switches.

Fuel management in flight is a learned skill that requires knowledge of the situation and the aircraft.

For it to be effective, pre-flight fuel planning must be followed by management that monitors fuel consumption as planned for each phase of the flight.

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Example Case: LV-S058[4] Occurrence

To illustrate poor fuel management, the accident involving the aircraft registration LV-S058, a Tecnam P92 Eaglet, which occurred on September 14, 2019, is presented below. The aircraft experienced engine stoppage during the cruise phase, prompting the pilot to make an emergency landing. During this landing, the aircraft impacted the ground.

The investigation found that the left fuel tank had approximately half a liter, while the right tank contained about 30 liters of fuel. The opposing logic of the fuel tank opening valves may have induced undesirable behavior, which likely set the stage for the engine stoppage. These findings suggest that the fuel selector valve for the right tank was closed at the time of the engine stoppage.

Link to LV-GTV research report:
https://so.jst.gob.ar/informe/?id=73

Figure 3. Fuel selector valves of an aircraft similar to the one involved in the accident

Source: JST investigation.

4. Link to the LV-S058 investigation report: https://so.jst.gob. ar/informe/?id=73.