Federal Democratic Republic of Ethiopia
Ministry of Transport
Aircraft Accident Investigation Bureau

Aircraft Accident Investigation Final Report

Delta 2 Turbo Thrush (F-HLDD)

Arsi Zone Shirka Woreda

February 11, 2021

Report No. AI-01/21

August 23, 2021

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Acronyms

AGL.......................... Above ground level
BEA ....Aviation Accident Investigation Bureau of France
BKN .... Broken
FAO .... Food and Agricultural Organization
GPS...........................Global Positioning System
GS............................Ground Speed
HAAB........................Addis Ababa Bole International Airport
HAGB.......................Goba/Robe Airport
ICAO.........................International Civil Aviation Organization
METAR.....................Metrological Aerodrome Reports
NM .... Nautical Miles
N/A .... Not Applicable
OVC.........................Overcast
S/N ....Serial Number
TAF.........................Terminal Aerodrome Forecast
UTC..........................Universal time co-ordinates
VMC ....Visual Meteorological Conditions

General information

Aircraft Type---------------------- Turbo Thrush

Model------------------------------ S2R-T-34 (510P)

Serial No-------------------------- T34-477

Aircraft Registration ------------- F-HLDD

Operator and owner--------------- Delta 2

People on board--------------------1 pilot

Flight purpose-------------------- Locust spraying - Aerial Work

Flight destination --------------- Robe Airport

Place of accident------------------ Arsi Zone shirka Woreda

Date and time of occurrence----- February 11, 2021 at 06:20 UTC [1]

Synopsis

On February 11, 2021 Delta 2 Aerial work Thrush aircraft registered F-HLDD was scheduled to perform a Locust spraying mission in the Arsi zone under the support of the FAO[2]. The plane and the pilot had been put in place at Robe airport one day before the accident. They were previously based at Dire Dawa (HADR) and had arrived in Robe the day before the accident day. On February 11, 2021 two spraying missions were planned in the morning for this pilot. The pilot took off from Robe Airport at 03:38 UTC for the first objective which was 40NM from the airport on heading 330^0. He accomplished his first mission and returned to the airport where he landed at 05:15 UTC. The second mission was planned to be performed at 45NM from Robe on heading 300°. After refuelling and loading the necessary chemical products, the pilot took off from Robe airport at 05:57. The signal[3] from the aircraft was lost at 06: 20 UTC at coordinates: N 7°32’ 28.14” E 39° 25' 7.51”.

[1]The times in this report are in Coordinated Universal Time (UTC). Two hours should be added to obtain the legal time applicable in Ethiopia on the day of the event.

[2] Food and Agricultural Organization

[3] The plane system Spidertrack sends a signal every 15 seconds to the FAO application which allows the FAO to follow the operations in progress.

1. Factual Information

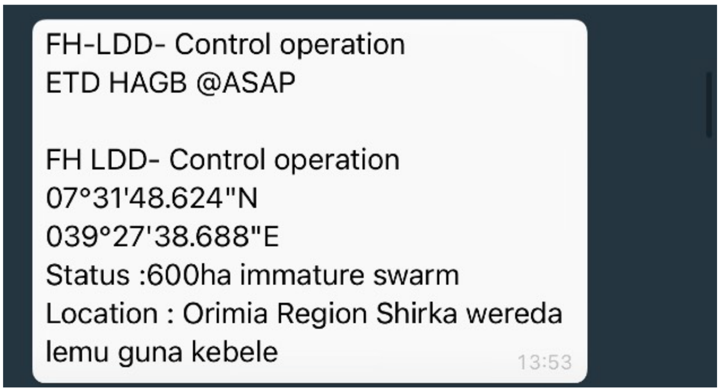
1.1. History of the flight

In the morning of February 11, 2021 Delta 2 Aerial work Thrush aircraft registered F-HLDD was scheduled to perform two Locust spraying missions in the Arsi zone.

The weather report available for the pilot was the METAR from Addis Ababa Airport (HAAB). This METAR issued at 03:00 UTC on 11 February 2021 reported good conditions in the capital : visibility more than 10km and scattered clouds at 2400ft. Conditions at Robe airport (HAGB) were good, cloudless and with good horizontal visibility according to local testimonies. Having this report and satellite information collected on a dedicated website[4], the pilot decided that the conditions were met to carry out the first mission.

The pilot took off from Robe Airport at 03:38 UTC for the first target which was 40NM from the airport on route 330. He accomplished his first mission and returned to the Airport where he landed at 05: 15 UTC.

The second mission (Target 2) was planned to be performed on a target 45NM from Robe on route 300°. The coordinates were 07°31'48.624"N and 039° 27'38.688"E as per the mission order received by message by the pilot the day before (see figure 1).


FH-LDD- Control operation
ETD HAGB @ASAP

FH LDD- Control operation
07°31'48.624"N
039°27'38.688"E
Status :600ha immature swarm
Location : Orimia Region Shirka wereda
lemu guna kebele
13:53

Figure 1 : Mission order received by message from the FAO

The terrain in this area is relatively rugged and the target is on a high plateau.

After refuelling (800 liters of Jet A1 fuel) and loading the necessary chemical products (600 liters), the pilot took off from the airport.

After taking-off at 05 h57min (point 1) the pilot climbed to 9725 ft (2964m) above sea level to cross a mountain ridge that he overflew at 06h07 min (point 2).

After crossing the mountain ridge, the pilot began a slow descent, following the downward slope of the mountain until 06:16:01 UTC when he faced a second mountain slope. He was at that time at around 7700 ft (point 3).

[4] www.windy.com

Until that point, the pilot had been flying at an average height of 1000 ft, maintaining a heading of approximately 305° heading directly to the target.

From 06h 16 min 46 sec (point 4), the pilot began to climb. From that moment, he flew at around 200 ft above the ground. The ground speed started to decrease.

At 06h 17 min 31 sec, the rate of climb was around 430 ft/min. The ground speed decreased below 110 kt.

At 06 h 18 min 31 sec (point 5), after passing over GADO town (see figure 3), the pilot performed a heading change to the left. He was at that time passing 8 390ft , climbing at a rate of about 430 ft/min. During this turn, he passed around 200 meters north of the target.

At 06:19:31 (point 6) the ground speed went below 95 kt. The aircraft was at that time passing 8 750 ft. The rate of climb was around 440 ft/min. The gap since the start of climb between the plane and the ground had remained until then between 200 and 300 ft.

The pilot turned to the right and stopped his turn on heading 310°.

At 06h 20min 31sec UTC (point 7), contact was lost at 9 190 ft.

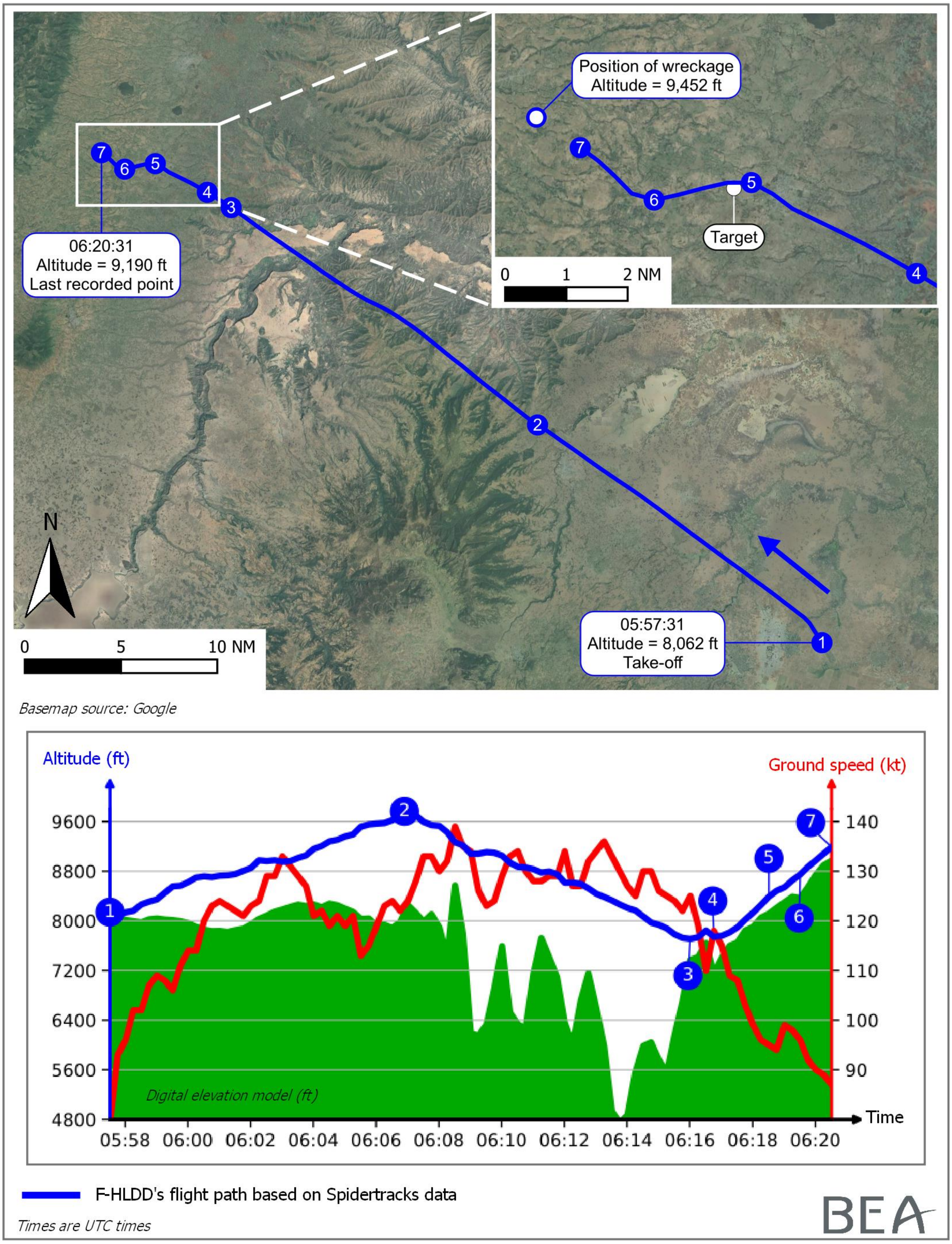


Figure 2 : flight path reconstructed by the BEA (France) on the basis of the airborne Spidertracks data system

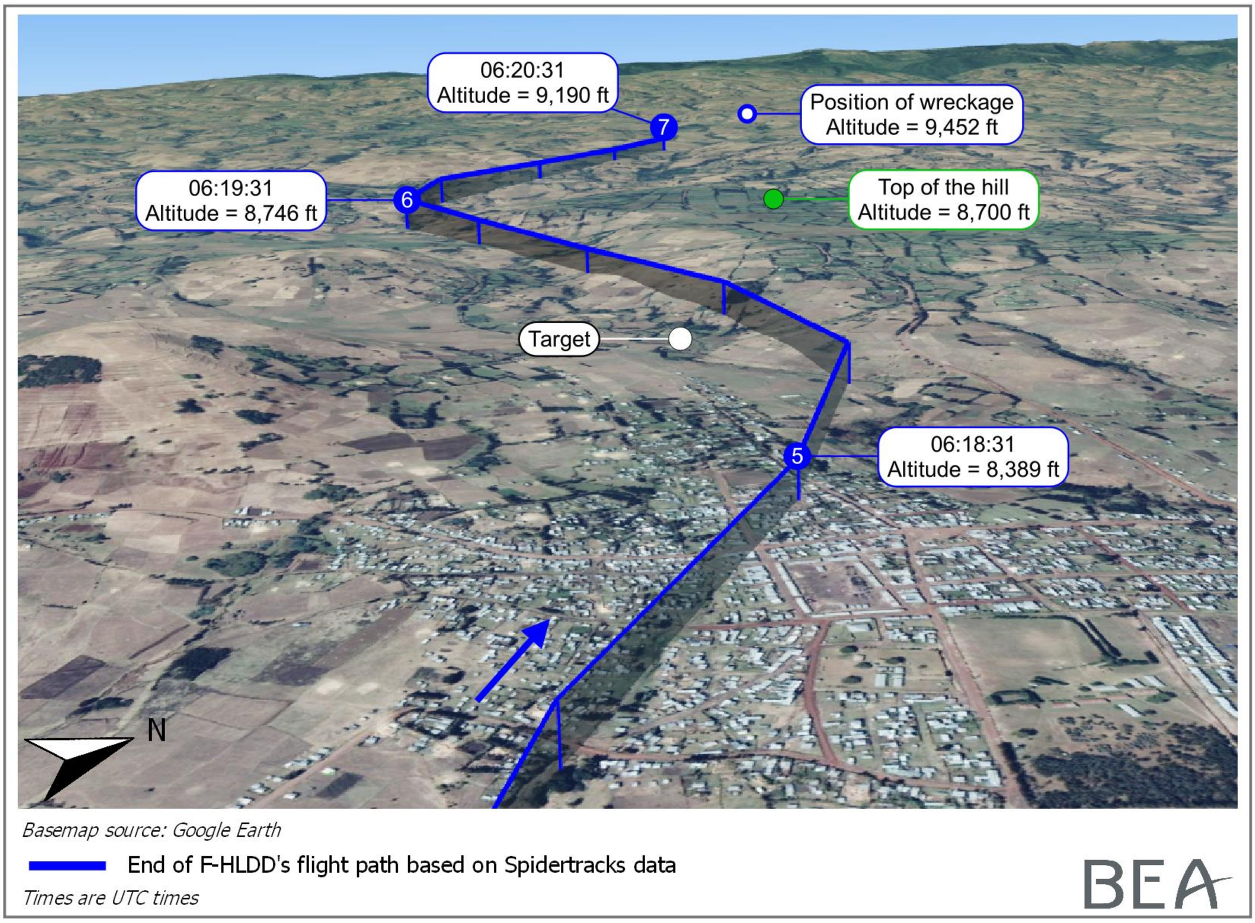


Figure 3 : Last portion of the flight path

Approximately 30 seconds later, the plane made a forced landing at the altitude of 9452ft on a plateau strewn with fields, woods and scattered housing. In that area, fields are separated by ditches and little mounds. At touchdown, the landing gear hit a first mound. The plane continued its run on about 10 meters until it hit a second mound head-on. At impact the plane turned approximately 150 ° on itself to the right and caught fire.

The crash site was spotted by the local people who evacuated the pilot from the burning aircraft and notified the representative of the ministry of Agriculture in the region. The pilot was seriously injured by the fire which broke out after the impact. He was evacuated by a helicopter to Addis Ababa Hospital where he died two days later.

1.2. Injuries to Personnel

Injuries	Crew	Passenger	Others
Fatal	1	-	-
Serious	-	-	-
Minor	-	-	-

1.3. Damage to the aircraft

The aircraft was totally destroyed by impact forces and post impact fire as seen below

1.4. Other Damage

No other damage

1.5. Personnel Information

1.5.1. **Pilot In command**

The pilot was born on February 13, 1958 and died February 13, 2021. He was 63 years old.

He was an experienced pilot in flying the Thrush S2R-T34 and in aerial work; he showed no signs of poor physical or mental health. On the day of the accident, he seemed in full possession of his means.

He held a class 1 medical aptitude issued on 01/14/2021 by the CEMPN[5] of Toulon (France) and valid until 07/23/2021.
Qualifications

- SEP Terrestre (Land) ....Valid until 10/31/2021
- Pilatus PC6 SET.......Issued on 03/10/2019 and valid until 31/10/2021

[5]Centre d'Expertise Médicale du Personnel Navigant (Flight Crew Medical Expertise Center)

- Snow Ayres SET.......Issued on 03/10/2019 and valid until 31/10/2021
- Qualification mountain wheels.....Valid until 10/31/2021
- Qualification mountain skis..........Valid until 10/31/2021

Total flight hours

7050 flight hours (6350 hrs on airplanes, 700 hrs on gliders)

The 6350 hrs on airplanes include:

- 4500 hrs agricultural spraying (on Thrush S2RT34, Grumman G164, Thrush S2R)
- 270 hrs fire fighting (on Grumman G164, Thrush S2R)
- 700 hrs Pilatus PC 6 (aerial work, parachute dropping) –including 300 hrs as instructor

Total on Thrush S2RT34: 2050 hrs

1.6. Aircraft Information

1.6.1 General

Manufacturer	Thrush Aircraft
Model	S2R-T34
S / N	T34-477
Airframe time since new	764 hours (As of 05/01/2021)
Date and country of manufacture	24/07/2018, USA
Registration at the time of the accident	F-HLDD
Engine type and power	Pratt & Whitney PT6-A34-AG (750hp)
Engine S/N	PC-PH-1249
Engine time since new	764 hours (As of 05/01/2021)

The aircraft registered F-HLDD was purchased by the French company DELTA 2 in November 2020 from the company MIDCONTINENT based in the United States and specialized in the resale of aircraft.

The aircraft was transported by a specialized company and delivered on 05-11-2020 to Montpellier airport (LFMT) and was then registered in the French register.

When the mission to Ethiopia was set up, the aircraft was flown by a Delta 2 pilot from Montpellier (LFMT) to Addis Ababa.
The aircraft arrived at Addis Ababa Bole airport on 24/11/2020 and the last 100 hours periodic inspection was accomplished on 05/01/2021 in accordance with the existing procedures and check lists.

Figure 4 : picture of the plane while still under US registration

1.6.2 Weight and Balance

The load and mass balance sheet shows that the plane was within the operating limits.

1.7 Meteorological Information

1.7.1 Estimated conditions at the time of the accident

According to the ramp agent's testimonies, conditions at Robe airport (HAGB) were good, cloudless and with good horizontal visibility.
The only weather reports available in the country are those from Addis Ababa Airport (METAR, TAF and wind charts). Addis Ababa airport is located at 133 NM from Robe airport. The conditions at Addis Ababa airport (HAAB) can be drastically different from the ones at Robe airport (HAGB). The pilots know it and are instructed to look at the satellite images available on the windy.com site in

order to update the weather information before departure to the target. The Addis Ababa (HAAB) METAR issued at 0300UTC on 11 February 2021 reported good conditions in the capital with visibility greater than 10km and scattered clouds at 2400ft.

MVFR HAAB 110300Z 28004KT 9999 BKN024 11/10 Q1025 - 11h 6m

METAR from Addis Ababa Airport (HAAB) on 11 February 2021 broadcast at 0300UTC

1.7.2 Weather conditions at the time of the accident estimated by Meteo France

Following the EAIB's request, the BEA requested Meteo France to perform an estimation of the weather conditions at Robe and on the accident area at the time of the accident.

1.7.2. 1 Weather estimation at Robe airport

The estimation of the weather conditions at Robe airport at 6: 00 UTC were estimated as follows:

Ceiling: 4 octas Stratocumulus at 800 m

Visibility : 30 km

Wind calm.

1.7.2 2 Satellite images

The satellite weather images have been extracted from the report of the French Meteorology Agency (Meteo France), who conducted the analysis of the weather conditions covering the accident area on 02/11/2021 6h UTC (figure 5).
On this figure, the pink zone and the number 90 reflect the humidity field at 650hPa, thresholded at 90% humidity.

This humidity, which is also visible on a radio sounding, is associated with a fairly large cloud layer (BKN/OVC) lying approximately between 3000m and 4500m.

The conclusions from the METEO France analysis are the following:
- Low winds at all levels;

- No instability;
- No icing;
- A fairly large cloud layer (BKN / OVC) approximately between 3000m (9840 ft) and 4500m (14 760ft).
- Locally lower cloud ceiling Possible (near the ground).

1.7.2.3 Aircraft flight track superposed on the satellite weather images

The BEA superposed the F-HLDD flight track on the satellite images. This tends to show that the sky was partly covered by clouds in the Robe area. In the middle portion of the flight the sky seemed to be clear. In the last portion of the flight the cloud layer seemed to be compact.

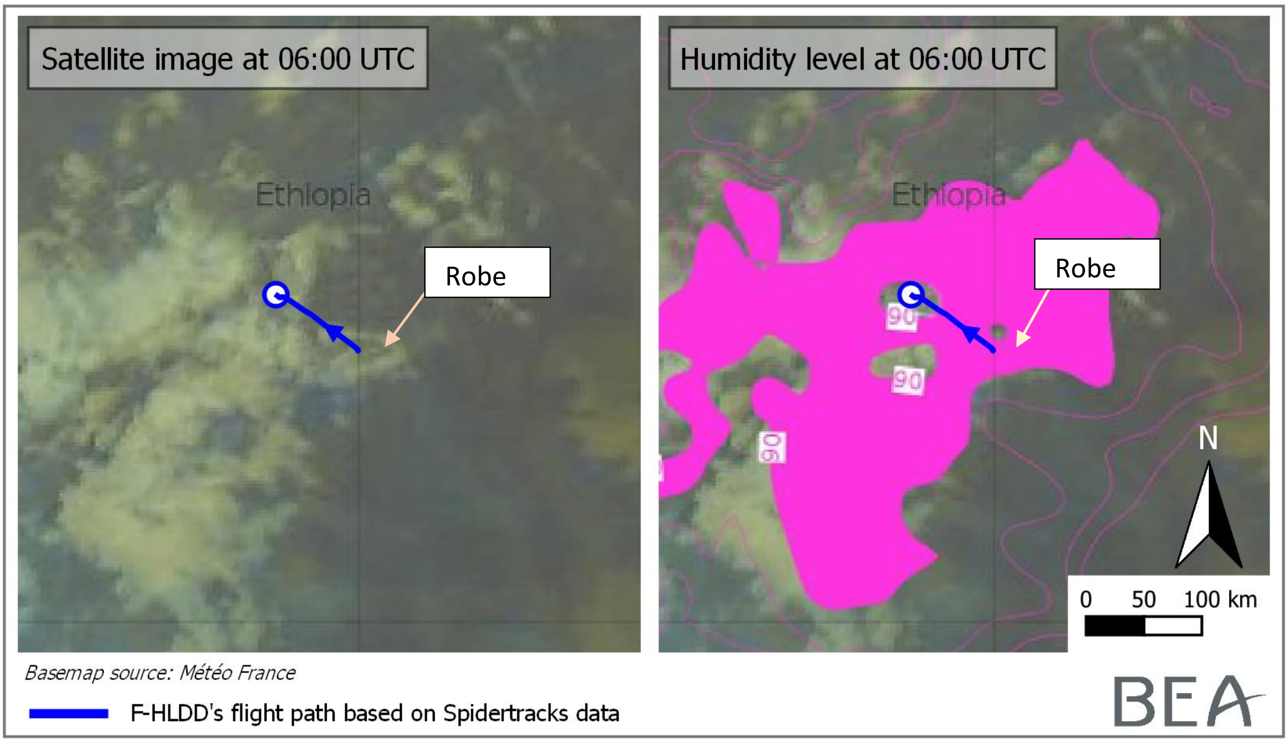


Figure 5: full horizontal flight path superposed on the satellite images

1.8. Aids to navigation

There are no navigational aids in the area. Pilots get position and navigation information from the Spider track system, Ipad and Garmin Aera 760 [6].

1.9. Communication

After leaving the tower frequency, the pilots are not in contact with any ground or air stations.

[6] The Ipad and Garmin Aera 760 were burnt in the post-crash fire and could not be used for the investigation.

1.10. Aerodrome Information

ICAO call name..... HAGB
Location ....Bale Robe Oromia Regional State
Elevation ....7892 ft /2405 m
Location 07 7 5.02N 40 2 44.99E
Run way length 2370m
RWY orientation 15/33

1.11. Flight recorder

The aircraft was not equipped with Flight data Recorder.
The Spider Track system was taken from the wreckage for trajectory reconstitution and analysis. The following flight parameters were recorded by this computer:

- GPS altitude (relative to sea level)
- GPS speed (ground speed)
- GPS ground track
- GPS coordinates

These parameters are updated every 15 seconds.

1.12. Wreckage and Impact Information

The aircraft crashed on the upward slope of a hill made up of fields, separated by ditches and mounds (see figure 6).

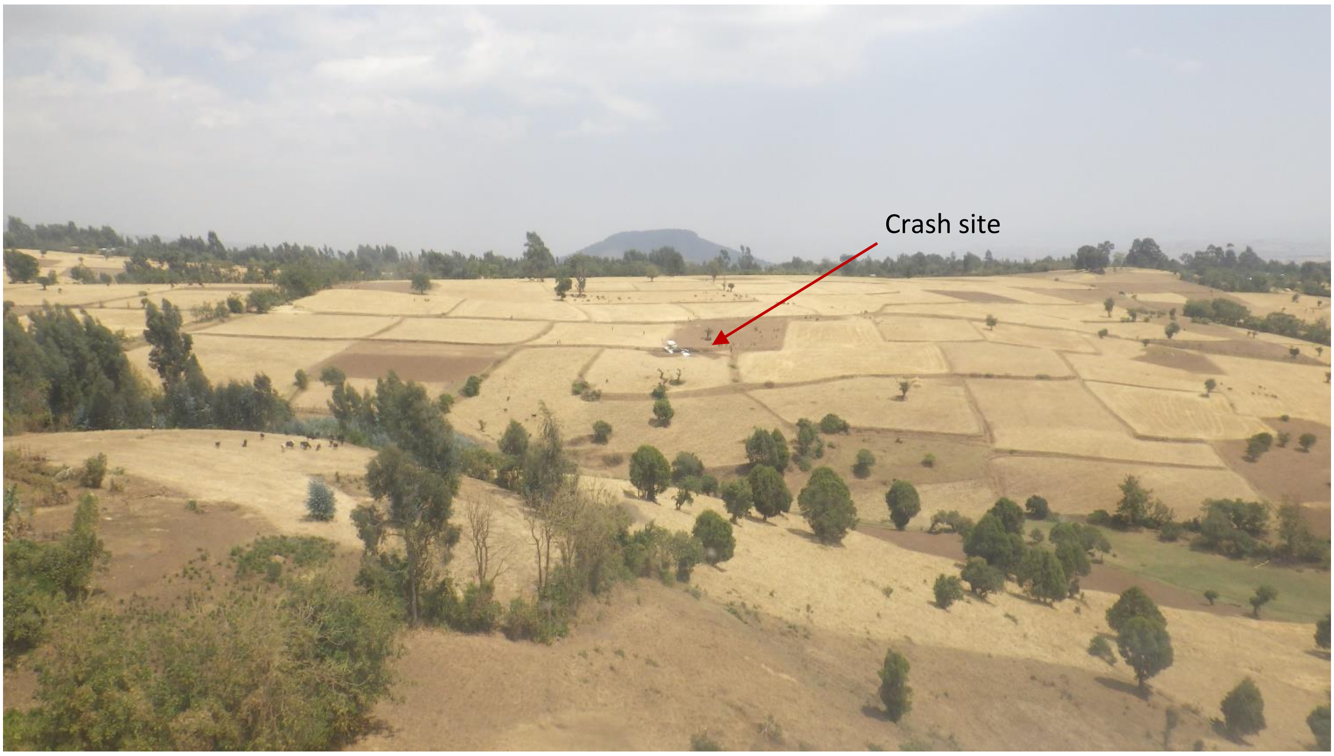


Figure 6: general view of the crash site

The main landing gear impacted a first mound. The aircraft then continued its course on about 10 meters until it hit another mound. At this second impact the aircraft turned about 150° degrees to the right on itself and caught fire (see figure 7).

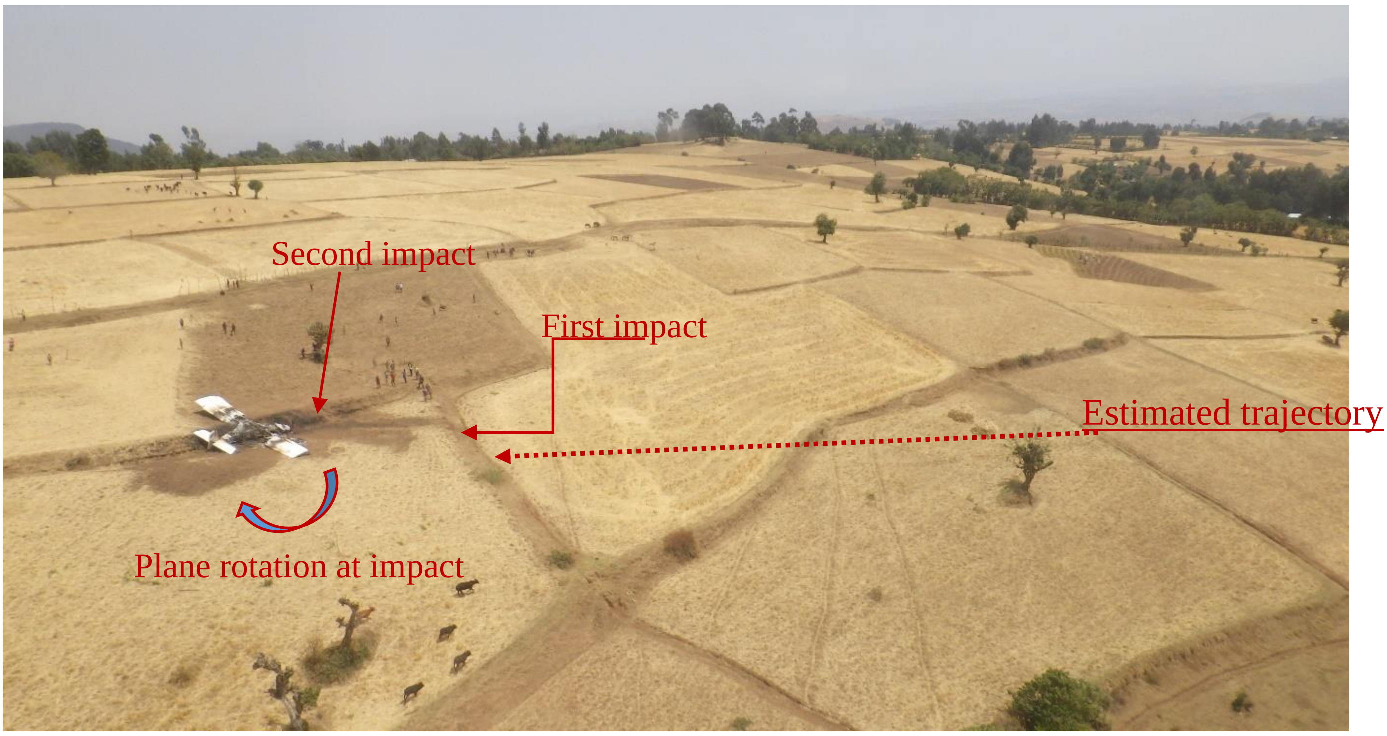


Figure 7: Impact zone

The examination of the wreckage, especially of the propeller aspect tends to show that the engine was delivering power (see figure 8). The amount of power could however not be determined.

Figure 8: propeller

1.13. Medical and pathological Information

The pilot had no known pathology prior to the accident.
His medical certificate was valid (see paragraph 1.5.1)

1.14. Fire

The fire probably broke out in the middle part of the aircraft soon after the impact and destroyed major parts specially the engine, propeller and the fuselage structures. (see figure 9).

Figure 9: F-HLDD wreckage

1.15. Survival aspect

Following the impact of the emergency landing, fire broke out immediately and the pilot assisted by local farmers vacated the aircraft. He was evacuated by helicopter to Addis Ababa and was placed in artificial coma. His condition was steady for the first two days but the pilot died on the third day of February 13, 2021 due to cardiac arrest.

1.16. Test and Research

Not applicable

1.17. Organizational and management Information

1.17.1Global description of the mission

The French company DELTA 2 has been in contract with FAO in Ethiopia since March 2020 for locust control missions with the ultimate goal of protecting populations against the invasion of locusts in the East Horn of Africa. This mission is carried out with aircraft initially designed for agricultural treatments. The company DELTA 2 implemented two aircraft of the same type over the country with the following distribution:

- S2R-T34 F-HLAA since March 2020
- S2R-T34 F-HLDD since November 2020

DELTA 2 maintains an operational posture known as "QRA[7]" over the entire country with regular base changes (see map on figure 10). These base changes require significant implementations, particularly in terms of logistics.

[7] Quick Reaction Alert

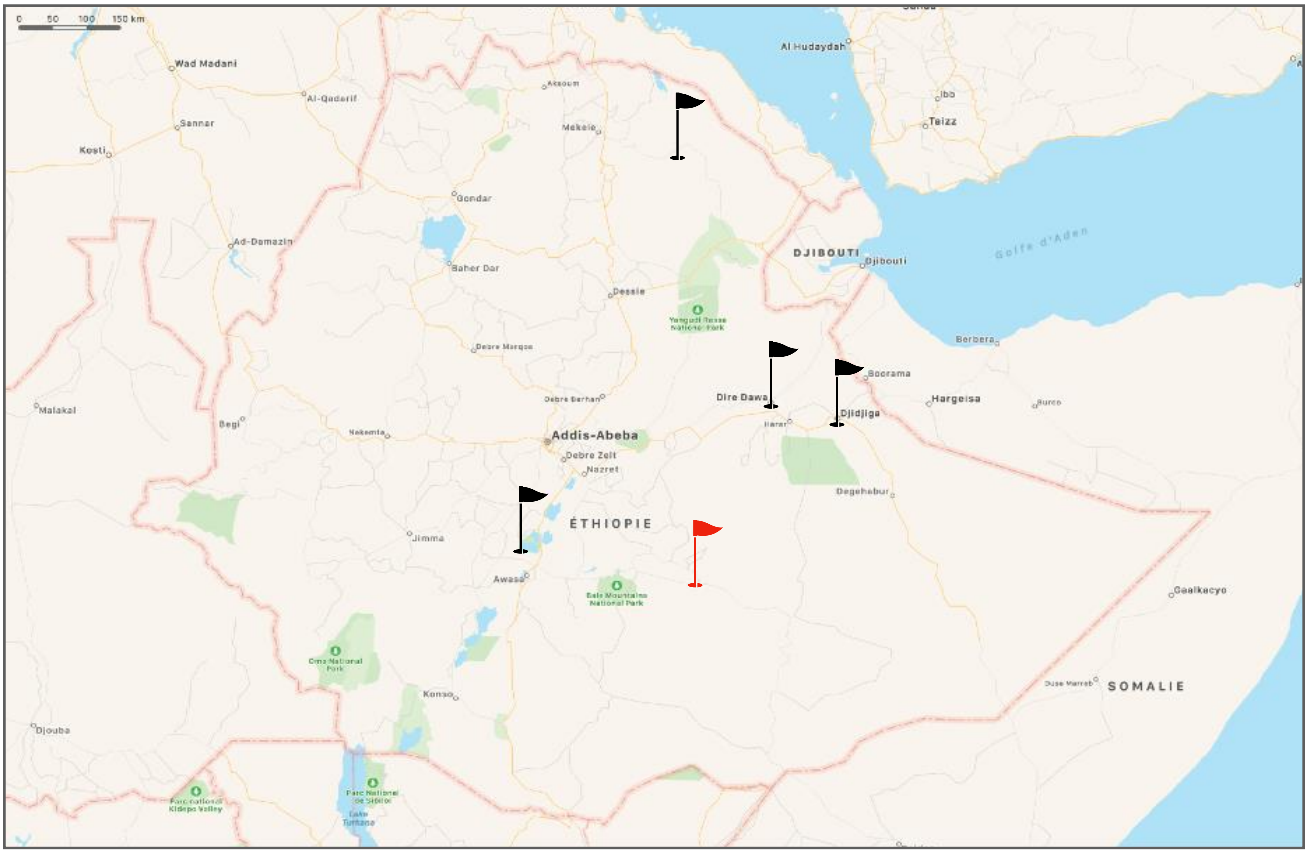


Figure 10: FAO operational bases. Robe airport (HAGB) is identified in red

The missions consist in detecting and suppressing swarms of desert locusts by spraying an organophosphate of the Malathion type. Spraying is generally carried out about 30 meters above the ground (around 100ft) at a ratio of 1 litre per hectare (1liter/ha).

1.17.2 The Delta 2 pilots' missions

The pilots tasked on the mission are all highly qualified pilots on spraying and / or fire fighting missions as well as accustomed to flying the Thrush S2R-T34. During the first deployment, the pilots perform a training period with a DELTA 2 expert pilot on the mission. This training period consists in acquiring adequate knowledge of the FAO procedures (See § 1.17.3).

The locust control mission has little in common with conventional spraying missions in many ways:

- Significant distance between the base and the targets
- Need to carry out surveillance and target search missions. The swarm of locusts are spotted by ground staff (in cars or motorbikes) or helicopters who report to the FAO the characteristics of observed swarms under an appropriate format (see figure 1). The FAO then selects the appropriate planes to accomplish the spray missions. It is up to the pilot to search for

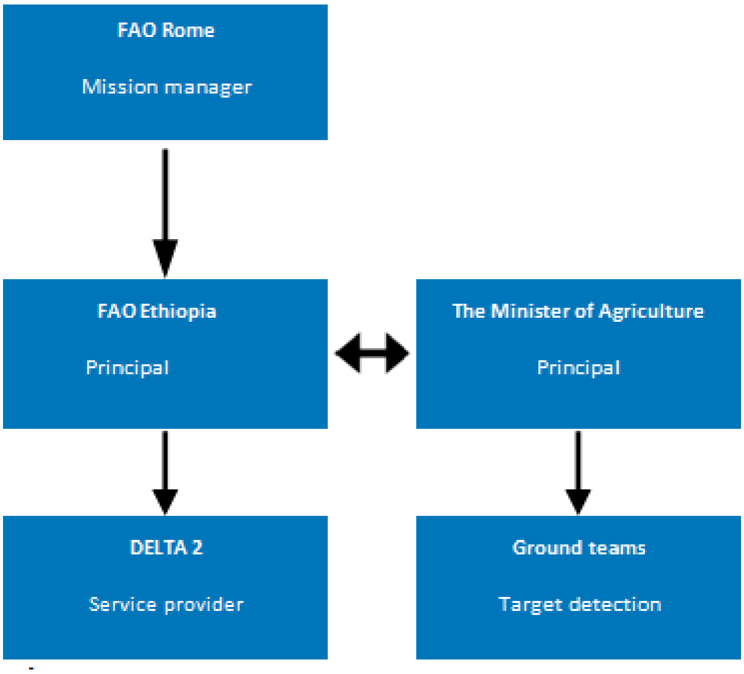
the targets, taking into account that due to the elapsed time between the ground spotting and the plane take-off, the swarms of locusts may have moved.

- Need to acquire previous knowledge of the topography where the target is located.
- Significant weather changes possible due to the remoteness of the targets and the mountainous environment in some cases.

The pilots have the support of a logistics and mechanical team distributed as follows:

- 1 mechanic per aircraft
- 1 field logistician per aircraft
- 1 driver per aircraft
- 1 global logistician (based in Addis Ababa)

The organization of the mission is divided between the principal (FAO) and the ground detection teams set up by the Ethiopian Ministry of Agriculture, the hierarchical organization chart is as follows:



1.17.3 The FAO Standard Operating Procedures (SOP)

The FAO has developed Standard Operating Procedures (SOP) for Aviation Crews in Aerial Desert Locust Operations (See Annex 1).
The SOPs provide guidance for survey flights and control flights, coordination and communication between operators and the FAO, and information on the readiness status (called “Notice-to-Move) for the aircraft and aircrews.

1.18. Additional Information

1.18.1 Ramp engineer Testimony

According to the ramp engineer’s testimonies who accompanied the pilot during his evacuation to the hospital in Addis Ababa the pilot reported that he believed in a decrease of power although engine parameters and indications were normal and that there were at that moment no other options than performing an emergency landing.

On the other hand the farmers at the crash site confirmed that they saw a white smoke from behind before he crashed and were wondering why he is spraying here where there is no locust. This indicates that the pilot didn't spray the chemical on the assigned target but was dumping it before the emergency landing.

1.18.2 Local farmer’s testimony

Local farmers reported that they had seen like a “white like” smoke just before impact[8].

1.18.3 Estimated trajectory after the loss of contact

The point of loss of contact with the plane and the location of the crash site could precisely be spotted on Google earth. It appears that between both points the plane route was around 305° (see figure 11).

The distance between the two points is 1.6 km which represents around thirty seconds of flight[9].

[8]Note : this is similar to what is observed during an emergency dump
[9]If the Spider Track system loses power it doesn't have time to send out the last few tracking points, which explains why the last recorded point was 30 seconds before the crash time.

Figure 11: estimated flight path after the loss of contact.

1.18.4 Calculation of the slope in the last portion of the flight

Between the points 3 and 6 (Fig 2), the plane climbed from 7700 ft to 8700 ft (1000 ft or 300 meters). While following the mountain slope on an 11500 meter-distance gives an average slope of 100 x 300/11500 = 2.6%.

2. Analysis

The investigation committee visited the accident site, took statements from witnesses and examined the aircraft document, the weather charts and the reconstructed trajectories to help determine the scenario of the accident.

2.1 General

The pilot was properly licensed, medically fit to operate the spray mission. His flying record indicates that he was an experienced pilot in agricultural spraying and aerial work.

The locality on the way and around the accident site is semi mountainous with many hills, ridges, slopes and valleys. The accident site is at an altitude of 9452 feet.

Maintenance documents show that the aircraft and engine were periodically checked and well maintained in accordance with existing procedures and checklists.

2.2 Scenario of the accident

The first 18 minutes of the flight were uneventful. The pilot flew with an average height of 1000 ft above the terrain. He set a direct heading to the target. It is highly probable that at that moment the weather conditions were good and favourable for a VFR flight.

After flying at 9 700 ft over a first mountain ridge (point 2) the pilot followed the downward mountain slope during nine minutes at 1000 ft/ground on average.

He then arrived in a valley and quickly faced another climbing terrain. The weather analysis which was performed for the investigation shows that a cloud layer was probably covering this area at that time with a cloud base at 9 000 ft, locally lower in some areas. He stopped his descent at 7 700ft. (point 3), flew up and down over a small hill at low level (between point 3 and 4) and then started to climb (point 4).

From that moment, he followed the terrain at 200 ft on average above the ground, very probably because the weather conditions could not allow him to fly with a higher margin.

Indeed, very low altitude flights are only performed when spraying. From that moment, the speed started to decrease and soon went below 110 kt. The pilot maintained a rate of climb around 400 ft/min. The mountain slope has the characteristics of a “false flat” (unnoticeable upward slope). The slope value is there around 2.6%. It is highly probable that the pilot, in the absence of adequate external references, didn’t perceive that he was climbing. Consequently the thrust was probably not adjusted accordingly.

The speed continued to decrease. The weather conditions during this climb probably led him to focus on the external environment in order to maintain a safety margin with the ground. This was likely done to the detriment of the cockpit indications surveillance.

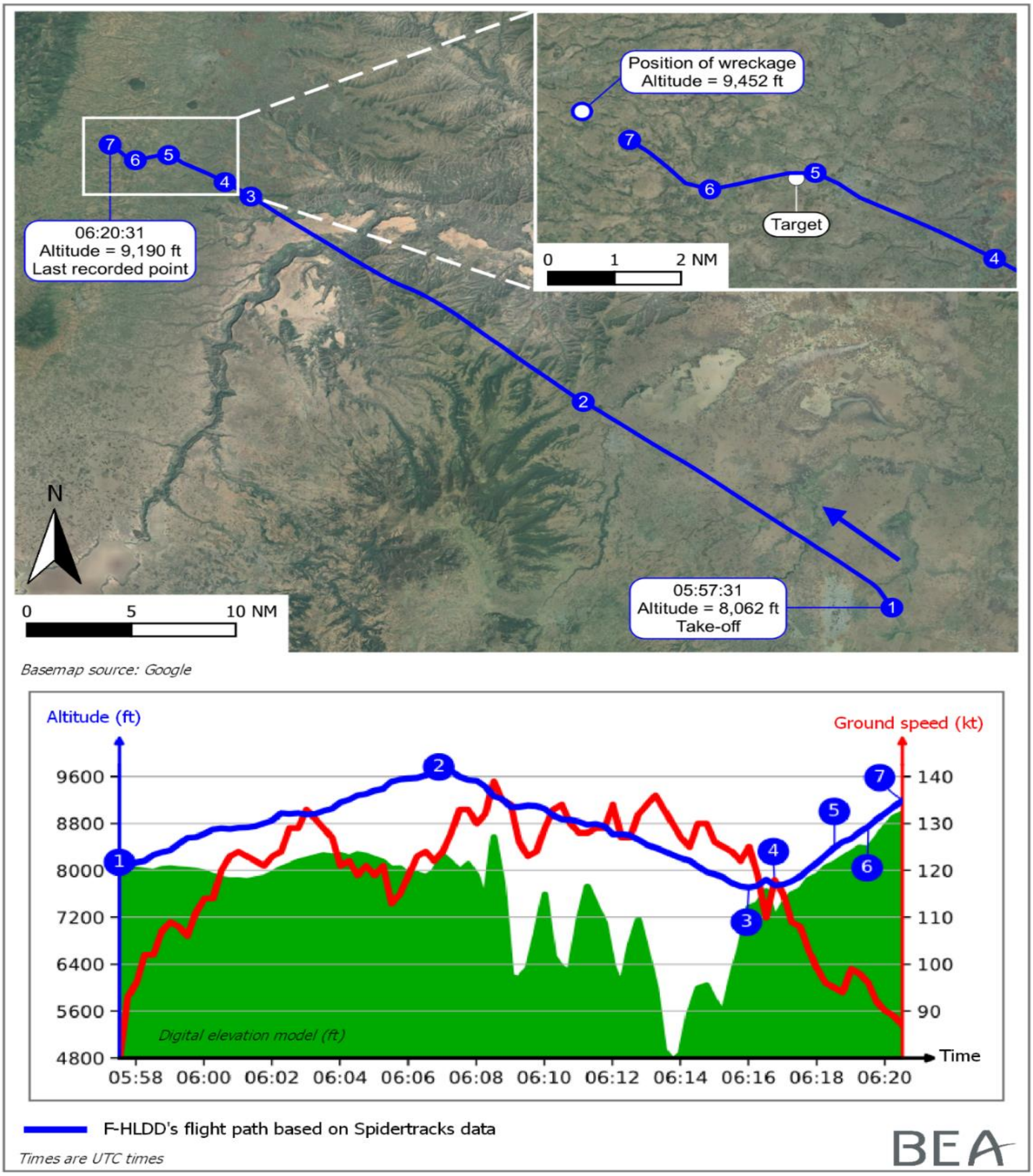
Shortly before reaching the target, the pilot performed a heading change to the left. At that time he was passing 8 390ft (point 5), climbing at a rate of about 430 ft/min. The investigation could not determine if this heading change was due to the presence of the hill ahead of him, which culminates at 8 700 ft, or if this turn was intended to reach the target, or if it was a combination of both. In any case, he flew about 200 meters north of the target during this turn and continued on course. It is highly probable that, at that time, his intention was no longer to find the target but rather to find a way to get out of the poor weather situation and the funnel in which he was.

Shortly after flying abeam north of the target, the pilot performed a right turn, probably to by-pass the hill that he probably had kept in sight on his right. At mid-turn, the ground speed went below 95 kt. At that time the aircraft was passing 8 750ft with the hill top located at about 800 meters on his right (point 6). The rate of climb was still around 430 ft/min. He stopped his right turn on heading 305° and continued to fly on that heading.

The weather conditions and the probable poor visibility were probably reducing his possibilities of evolutions. He maintained a low level flight at around 200ft above ground.

The pilot likely noticed at this stage that his speed had dangerously gone low. He thought of a power decrease as he later stated during his evacuation to the hospital. He probably didn’t realize at the end of this flight that he had been climbing and that this climb, that he had commenced four minutes before, had generated a gradual speed decrease.

There was no other solution for him at that time than performing a forced landing. Any turn could cause a stall. The pilot maintained his current heading and very likely looked for a suitable land. The area ahead of him was composed of fields, little woods and scattered housing. He chose a set of fields which, from his position, probably seemed to be flat with no obstacle. However the fields are surrounded by ditches and mounds which could not be easily spotted from the sky. Farmers working in the fields witnessed that the aircraft was dumping the chemical before it crash landed. The landing gear hit a first mound of earth, continued its run on about 10 meters and hit a second mound head-on. At impact the plane turned approximately 150 ° on itself to the right and caught fire causing the total damage of the aircraft.



3. Conclusions

3.1. Findings

1. The pilot was properly licensed and medically fit. His flying record indicates that he was an experienced pilot, including in agricultural spraying and aerial work;
2. Maintenance documents show that the aircraft and engine are periodically checked and well maintained in accordance with existing procedures and checklists;
3. The locust spraying missions have little in common with conventional spreading missions. Pilots need to carry out target search missions which require a high level of knowledge of the local topography;
4. Significant weather changes are possible due to the remoteness of the targets and the mountainous environment in some cases;
5. The pilot had arrived in Robe the evening before the accident day. He was previously based in Dire Dawa, another base in Ethiopia;
6. At the time of the accident, the area of the accident was covered by a fairly large cloud layer;
7. Even though the weather conditions at the departure airport was fairly good, the condition at the accident area which is on high plateau and 45NM from Robe could not be known to the pilot before departure due to limited weather forecast capabilities;
8. The landscape on the way and around the accident site is semi mountainous with many hills, ridges, slopes and valleys;
9. After crossing a valley, the terrain changed into a continuously rising slope; this terrain was probably covered by a cloud layer;
10. The aircraft began to climb at low altitude (around 200 ft/ ground on average) probably because the weather conditions, especially the cloud layer, could not allow him to fly higher;
11. It is very likely that the pilot didn't not identify that the terrain was a "false flat rising", probably because of a restricted visibility;
12. As the aircraft climbed, the ground speed continuously decreased;

13. When the pilot realized that the speed had dropped too low, he had no other option than to perform a forced landing as any turn could cause a stall;
14. The landing site was strewn with ditches and mounds that delimit the fields;
15. These landing site characteristics are not easily identifiable in flight;
16. Upon landing, the main landing gear hit a first mound. The plane continued its run on about 10 meters and hit a second mound;
17. At the second impact, the plane caught fire. The pilot was evacuated from the plane. He died two days later at the hospital determination.

3.2 Probable causes of the accident

- Pilot's focus in his willingness to reach the target and to achieve the mission despite the adverse weather conditions;
- Late perception of the speed decrease probably due to the pilot's focus on the external environment in order to maintain a safety margin with the terrain effort;
- Reduced possibilities of any manoeuvre/Turn except emergency landing, because of the risk of stalling due to too low speed.

3.3 Probable contributing factors

- Difficulty to identify, in flight, the rugged characteristics on the terrain which was chosen for the forced landing.
- Probable insufficient knowledge of the region on the part of the pilot due to his arrival in Robe on the evening before the accident day.

4. Safety Recommendation

4.1 After crossing the valley, the terrain changed in to a continuously rising terrain. The pilot began to climb under unfavourable weather conditions in low level to maintain visual contact with the ground. During this climb, the ground speed continuously decreased. It probably went unnoticed by the pilot.

As the weather conditions deteriorated, it was necessary to make a decision to abort the mission and return to the airport. The pilot elected to continue the flight in his willingness to complete his mission.

It should also be noted that the targets can be, like in this case, located in mountainous areas, which requires optimal weather conditions, a good knowledge of the local topography and a good flight preparation.

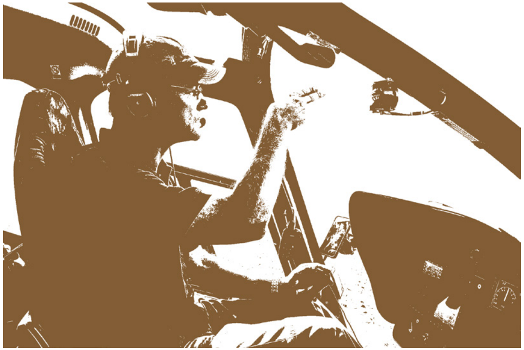
Therefore the EAIB recommends that the operators performing spray missions raise awareness among their pilots on the need to perform a rigorous flight preparation with regard to the meteorological and topographical conditions and do not hesitate to abort the mission rather than taking unnecessary risks.

4.2 The investigation showed that the pilot had arrived on Robe airport on the evening before the day of the accident and that the accident occurred on the following morning. He had not acquired knowledge of the environment prior to this flight.

Therefore the EAIB recommends that the FAO requests the contracted operators to perform reconnaissance flights allowing an adequate appropriation of the environment before performing the spraying missions.

Appendix-1

Standard Operating Procedures (SOP) for Aviation Crews in Aerial Desert Locust Operations in Ethiopia



Food and Agriculture Organization of the United Nations

Ethiopia

Standard Operating Procedures (SOP)
for Aviation Crews
in Aerial Desert Locust Operations

Objective

The objective of this Standard Operating Procedures (SOP) for Aviation Crews in Aerial Desert Locust Operations is to provide contracted aviation operators and aircrews with the best practical guidance for conducting survey and control operations under the United Nations (UN) Food and Agricultural Organizations (FAO) and the Ministry of Agriculture (MoA) and its Desert Locust Control Unit.

Regular survey and targeted control operations based on best evidence from the field are critical in the effort to limit the number of dangerous Desert Locust infestations that may pose a risk to people's livelihoods. FAO along with the national partner organisation, the Ministry of Agriculture, have gained significant experience on how to conduct both survey and control flights, manage the logistics of these operations and to ensure ground and air teams are adequately guided. FAO has utilized this experience in the development of these recommendations and SOPs.

1. Definitions

Desert Locust operations require diffrent aspects and considerations in support of more accurate and sensible decision making at the National Desert Locust Control Unit that operates under the MoA.

This SOP provides guidance to aviation crews on aspects such as handover/takeover procedures, communication, rules of control, survey, logistical procedures, notice to move or standby and other information. It is intended to cover flights in both fixed-wing and rotary aircraft.

This SOP belongs to the aircrews and will be regularly updated with any relevant information as required.

DEFINITIONS

- **Control Flight** – A qualified pilot carrying out aerial Desert Locust (DL) pesticide spraying activity in a recommended and coordinated manner as directed by the joint FAO/MoA Operations Office.
- **Survey Flight** – A qualified pilot carrying out aerial DL survey operations in coordination with an experienced DL Survey Officer as directed by the joint FAO/MoA Operations Office.
- **Ferry Flight** – A qualified pilot carrying personnel from one point to another as directed by the joint FAO/MoA Aviation Coordinator.

2. Brevity words

PLAY TIME	The maximum flight time available according to the fuel capacity and load of the aircraft
RTB	Returning to Base
BINGO	Out of fuel or chemical and RTB
FENCE IN	To be used when coordinating with other aircraft and entering a control area
FENCE OUT	To be used when coordinating with other aircraft and exiting the control area
NO JOY	No locust seen at the target location
TALLY	Locust seen at target location, or as described by another pilot in flight
COMPLETE	I have now completed my operation and ready to SWITCH or RTB
CANCEL	The current target is cancelled, awaiting or await further instructions
VISUAL	Sighting of another DL operations aircraft; I am now in charge of coordinating collision avoidance
BLIND	I have no visual of the other DL operations aircraft
POSIT	To be used to give your location or to ask for another aviation assets location, e.g. LAA POSIT ROBE 350/25nm
SWITCH	To be used when the original target is either COMPLETE or NO JOY and you are now moving to a secondary target
STATUS	Send the status of your aircraft in terms of PLAYTIME and chemical
NTM	Notice to move (30NTM = 30 minutes, 1NTM = 1hr and 2NTM = 2hrs)

3. Handover / takeover procedures

NEW ARRIVAL

Any new pilot or crew arriving in country or base should make contact with the below operational entities, providing their name, phone number and email address and length of stay. The new arrival should also update the information on the DL Aviation Asset Contact List.

1. The FAO Aviation Coordinator
2. The joint FAO/MoA Operations Office
3. Local DL Base Manager
4. Local Airport Manager
5. Local Security Manager

HANDOVER NOTES

A brief Handover Note should be prepared for the FAO Aviation Coordinator and the incoming pilot or crew on:

- Aircraft parking area
- Maintenance, equipment and storage area
- Water and electricity facilities at the airport
- Security and clearance requirements
- Fuel logistics process
- Any issues with the aviation asset
- Chemical pesticide handling, storage, safety procedures
- Aviation authority contact list
- DL operations contact list
- Coordination such as daily briefings at the Ops Base with MoA Base Manager and local FAO Asset Coordinator
- Other observations and information as required

The local FAO Asset Coordinator should make sure that the handing over procedures are followed correctly.

4. Coordination & communication

It is crucial that the local FAO Asset Coordinator and the MoA Base Manager organise with the aviation crew at the referring bases daily briefing meetings in the evening to discuss the day's observations, make proposals for operations on the following day, and advise the Joint FAO/MoA Operations Office for decision-making.

FLIGHT REPORTS

Control and survey flight reports should be communicated before 2000 hours each day as per the format in Annex A or as stipulated in each vendor's contact. All flight reports should be countersigned by either the local FAO Asset Coordinator or the local Base Manager. Once the report is countersigned, the correctness of flights is approved and validated. The FAO Asset Coordinator has the overall responsibility of ensuring that the report has been completed correctly and the operations justified according to the contract.

COMMUNICATION USING WHATSAPP APPLICATION

All communications from the joint FAO/MoA Operations Office provided on WhatsApp should be at the pilot's discretion and in accordance with international safety guidelines. All pilots should be aware of the following:

An approval of each flight is required by the joint FAO/MoA Operations Office before each flight. The approval can be communicated either by voice or WhatsApp.

4. Coordination & communication (cont.)

TASKING

Tasking will be communicated each day by the Desert Locust Operations Centre in the following format:

Base Name – Base Aviation Code
Tail No:
ETD:
Grid:
Location:
Elevation:
Prevailing wind direction:
Type of Operation:
Target Area (Coordinates):
Survey Officer:
Other:

ACKNOWLEDGMENT

Each pilot should affirm their tasking's on the WhatsApp ET DL Aviation Coordination Group, if no acknowledgment is received, the FAO/MoA Operations Officer in charge will call the pilot an hour before their flight to ensure that the operational tasking has been received and is understood.

REPORTING DESERT LOCUST INFESTATIONS (SWARMS OR HOPPER BAND) FOR CONTROL

When reporting Desert Locust infestations (hopper band or swam) that have been seen during a survey flight, the following reporting format should be used:

Date and time:

GPS coordinates of target:

Location (if known):

Type of Locust:

Size of infestation (swarm or hopper band):

Behaviour:

Comments:

Type of Locust

- Immature (pink) swarm
- Mature (yellow) swarm
- hopper bands

Behaviour

- Settled (on ground)
- Roosting (on treetops)
- Flying

LEAVING AND RETURNING TO BASE

Each pilot should communicate on the *ET DL Aviation Coordination* WhatsApp Group when they are leaving and returning to base in the following format:

1. *Airborne, Playtime X Hrs/minutes*
2. *Safe at 'Airport Code'*

Example:

1. LAA Airborne, Playtime 2Hrs
2. LAA Safe at HAGB

RADIO COMMUNICATION

The Area of Responsibility (AOR) frequency should be used to de-conflict when working in tandem with other aircraft on control operations or whilst transiting to the target area. For more information on the communication plan and airport frequency guidance, see Annex B.

USING eLOCUST3g AND eLOCUST3m

The procedure in Annex C should be followed when reporting an infestation on eLocust3g. It is not mandatory for pilots to send reports on eLocust3g or eLocust3m. However, pilots should ensure that the seconded Survey Officers are reporting regularly during survey flights. It is important that a message of locust presence or absence is sent every 10 to 20 km during a survey flight.

5. Loading & unload aircraft

The pilot has the final say on the quantity of fuel and pesticide loaded into the aircraft. The pilots take overall responsibility for the vessels. Their authority on the loading of the aircraft should not be challenged by any associated agencies.

1. Loading of fuel is based on the Airport Authorities Rules at your local base.
2. Loading of pesticides is to be conducted by the local MoA representative using a motorised closed circuit or electric loading pump.
3. Unloading of chemical is to be conducted by the local MoA representative using a motorised closed circuit or electric pump.
4. While adhering to aircraft chemical loading procedures, water and soap must be available at the point of loading to clean off any accidental skin contamination of pesticide operators.
5. The local MoA representative should also ensure that chemical loaders are wearing adequate Personal Protective Equipment (PPE) such as closed shoes, masks, gloves or face shield, hat and protective apron.

6. Guidance for survey flights

The following are the basic principles for conducting aerial survey operations by a rotary aircraft:

- **Detecting roosting swarms:** survey flights should be conducted early in the morning (start shortly after sunrise) or in the evenings shortly before sunset.
- **Detecting flying swarms:** survey flights should be conducted from mid to late morning (once adults have warmed up and taken off) until shortly before sunset (when they land). Fly either about 50 m above the ground so that the maximum number of locusts are above the horizon or fly higher and look downwards into the sun. A swarm will look similar to smoke.
- **Detecting hopper bands:** survey flights should be conducted early in the morning (starting about one hour after sunrise) from the East to the West with the sunlight in the back to detect basking hopper bands on open ground (up to about 2 hours after sunrise) and marching bands (up to about midday), and again in late afternoon. Look ahead and to the side of the aircraft. It will be difficult to see hopper bands in dense vegetation; otherwise, bands should be visible up to about 500 m or more from the aircraft when there is little vegetation or in areas of scattered trees and shrubs.
- **Green vegetation:** surveys should be undertaken at the beginning of the rainy season to identify those areas where annual grasses and low-lying bushes are first becoming green.

6. Guidance for survey flights (cont.)

- When green vegetation or suitable breeding grounds are detected, fly towards it and level off 5 to 10 m above the ground, reduce speed to 40-50 km/h, and swing the tail from side to side, looking to the rear to see if any locusts were flushed out.
- Make sure that a qualified locust survey officer equipped with an eLocust reporting device is on board during the aerial survey.
- Fly not higher than 300 m above the ground when searching for locusts or green vegetation.
- Track Spacing = 50 m (for swarms and vegetation) or 10 m (for hopper bands).
- Land regularly and ask the local population for desert locust infestations observed.
- When you spot an infestation, use measure map (or any other application able to send KML and KMZ file) to measure the outer perimeter of the swarm and send to the ET DL Aviation Coordination Group.
- Ensure that all information is recorded on the Daily Flight Report as per Annex A.
- Unauthorized passengers are under no circumstances permitted on board of a survey helicopter.

7. Guidance for control flights

The following are the basic principles for conducting aerial control operations:

- **Minimum area** which can be accurately and efficiently sprayed by a fixed wing spray aircraft is 50 to 100 ha.
- **Spraying settled swarms** must be done early in the morning before they warm up and take off or late in the afternoon after they have landed.
- **Swarms settled on crops** may be sprayed at any time during the day when the weather is cool and there is no convection.

Standard control parameters

Volume median diameter (VMD): 75-100 µm

Blade angle: set to give the correct VMD

Emission height: 5-10 m, depending on wind

Aircraft speed: according to aircraft flight manual

Application rate: one litre per hectare

Swath width: 100 m

7. Guidance for control flights (cont.)

LIMITS FOR A QUALITY CONTROL OPERATION

- Do not spray during the hottest part of the day, usually 1100–1600 hours
- Do not spray at low wind speed less than 2 m/s
- Do not spray at high wind speed more than 10 m/s
- Do not spray when locusts are in flight
- Do not spray when it is raining

AVOIDING COLLATERAL DAMAGE

- Do not spray over inhabited areas
- Do not spray over water bodies, wells, rivers, lakes, streams, etc.
- Do not spray near ruminates
- Do not spray over parks
- Alert the local population before spraying

8. Notice-To-Move times

The Notice-to-Move times below are guidance notes on how ready each pilot and crew should be for flight for the purposes of survey or control operations. These times will be used when putting an aircraft on standby for imminent future operations.

30NTM Crew are at the airport with dust covers removed, engineer on standby to fill the required fuel and MoA representative on standby to fill the aircraft with chemical pesticide.

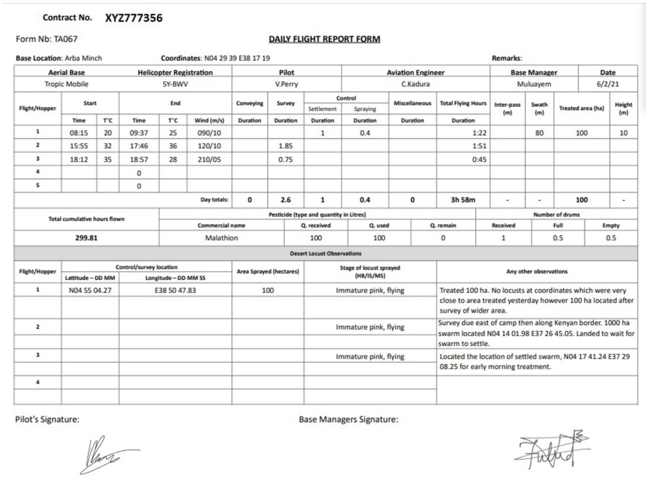
1NTM Crew and MoA staff at the airport awaiting further instruction.

2NTM Crew and MoA staff are situated at their relevant hotels awaiting further instruction, drivers within 10 minutes of the crew's location.

Requesting a day off

Any maintainance days or crew rest days should be requested at least two days in advance to the joint FAO/MoA Operations Office. This is to provide ample time for the Asset Coordinator to ensure that there will be no gaps in operational capacity whilst the asset in question is grounded.

Annex A. Flight report example



Contract No. **XYZ777356**

Form Nb: TA067

DAILY FLIGHT REPORT FORM

Base Location: Arba Minch **Coordinates:** N04 29 39 E38 17 19 **Remarks:**

Aerial Base	Helicopter Registration	Pilot	Aviation Engineer	Base Manager	Date
Tropic Mobile	5Y-BWV	V.Perry	C.Kadura	Muluayem	6/2/21

Flight/Hopper	Start		End			Conveying	Survey	Control		Miscellaneous	Total Flying Hours	Inter-pass (m)	Swath (m)	Treated area (ha)	Height (m)
								Settlement	Spraying						
	Time	T°C	Time	T°C	Wind (m/s)	Duration	Duration	Duration	Duration	Duration	Duration				
1	08:15	20	09:37	25	090/10			1	0.4		1:22		80	100	10
2	15:55	32	17:46	36	120/10		1.85				1:51				
3	18:12	35	18:57	28	210/05		0.75				0:45				
4			0												
5			0												
					Day totals:	0	2.6	1	0.4	0	3h 58m	-	-	100	-

Total cumulative hours flown	Pesticide (type and quantity in Litres)				Number of drums		
	Commercial name	Q. received	Q. used	Q. remain	Received	Full	Empty
299.81	Malathion	100	100	0	1	0.5	0.5

Desert Locust Observations

Flight/Hopper	Control/survey location		Area Sprayed (hectares)	Stage of locust sprayed (HB/IS/MS)	Any other observations
	Lattitude – DD MM	Longitude – DD MM SS			
1	N04 55 04.27	E38 50 47.83	100	Immature pink, flying	Treated 100 ha. No locusts at coordinates which were very close to area treated yesterday however 100 ha located after survey of wider area.
2				Immature pink, flying	Survey due east of camp then along Kenyan border. 1000 ha swarm located N04 14 01.98 E37 26 45.05. Landed to wait for swarm to settle.
3				Immature pink, flying	Located the location of settled swarm, N04 17 41.24 E37 29 08.25 for early morning treatment.
4					

Pilot's Signature: Base Managers Signature:

Annex B. Ethiopian DL airfields

ICAO	Name	APP	TWR	GND	ATIS	Elevation	QFU	Runway	Latitude	Longitdue	Update
HAAB	Bole Int.	119.7	118.1	121.9	128.5	7625′	07/25 R/L	3700x45m	8°58′36.64″N	38°47′55.94″E	20/03/21
HAGB	Goba Robe		118.4			8093′	15/33	2500x45m	7°07′05.85″N	40°02′45.01″E	20/03/21
HAJJ	Jijiga		118.5			5935′	03/21	2500x45m	9°19′55.36″N	42°54′42.33″E	20/03/21
HADR	Dire Dawa	102.3/118.3	118.3	121.9		3792′	15/33	2700x46m	9°37′26.42″N	41°51′16.89″E	20/03/21
HAAM	Arba Minch		118.6			3895′	03/21	2800x45m	6°02′22.08″N	37°35′26.78″E	20/03/21
HAGO	Gode		118.6			834′	04/22	2400x35m	5°56′04.33″N	43°34′41.14″E	20/03/21
HADC	Combolcha		118.9			6134′	17/35	2000x35m	11°47′20.92″N	39°43′33.43″E	20/03/21
HAKD	Kabri Dar		*125.9*			1770′	08/26	2500x45m	6°43′58.07″N	44°14′31.30″E	20/03/21
HASM	Semera		*125.9*	121.9		1365′	13/31	2500x45m	11°47′20.92″N	40°59′23.88″E	20/03/21
HALA	Hawassa		118.7			5702′	01/19	2500x45m	7°05′59.59″N	38°23′46.78″E	20/03/21
HAMK	Mekele		118.8			7401′	11/29	3000x45m	13°28′01.85″N	39°32′02.42″E	20/03/21

uncontrolled airfield frequency

For any changes, contract FAO at locustet@51degreesltd.com

AOR Frequency: 133.55

Annex C. eLocust3g procedure