State of Israel
Ministry of Transport and Road Safety
Aviation Incidents and Accidents Investigation

Safety Investigation Report

(Final Report)

Serious Incident Case No. 52-14

Go-around as a result of a failure to deploy landing gears

Date	**28.3.2014**
Type of Aircraft	**Boeing 737**
Registration mark	**4X-EKL**
Location	**Luton Airport, London**

For safety purposes only

The Investigations conducted by the Israeli Investigation Office (IAIAI) are in accordance with Annex 13 to the ICAO Convention on International Civil Aviation, and the Israeli Aviation Law 2011, chapter 7, and its respective Aviation regulations.

The sole objective of the investigation of an accident or incident under these Regulations is the prevention of future accidents and incidents. It is not the purpose of such an investigation to apportion blame or liability.

Accordingly, it is not appropriate that AIAI reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

This report has been translated to the English language for other parties' convenience, and should adhere to the Original report in the Hebrew language - In any case of abstruseness or miss-understanding, the original report in the Hebrew language is taking over.

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Summary

On 28th March 2014 at 04:15 in the morning (Israel local time), EL AL flight number 311 - a B-737-800 aircraft, registration mark 4X-EKL, took off from Tel Aviv to Luton Airport in London with 180 persons on board: 2 pilots, 5 cabin attendants and 173 passengers.

At Luton Airport, prior to the arrival of the above investigated flight, the weather was foggy with a horizontal visibility of 200-250 meters. The aircraft approached at 06:40 Luton local time (UTC).

At the beginning of the final approach to runway 08 at Luton, the Air Traffic Controller (ATC) reported to the flight crew of worsening visibility values measured at the three sections of the runway (RVR), : 175,175 and 200 meters.

The crew, which had been in the process of preparing the aircraft for landing, prior to the deployment of the landing gears and flaps, began to doubt the legitimacy of continuing the approach and landing at the airport and in fact stopped the preparation of the aircraft for landing, while continuing its approach. During the approach, while at 800 feet AGL, the crew was surprised to receive a warning from the aircraft's systems that the landing gears had not been deployed. The crew initiated a go-around to a second procedure. After a short holding, during which visibility improved, the crew began its second approach, and landed uneventfully at Luton.

The incident was reported in writing as an incident with low severity. After the return of the crew to Israel, it was debriefed by the fleet representatives and a summary of the debriefing was distributed within the company. A month later, and after details of the incident had been made public, the Chief Investigator initiated an investigation with the participation of representatives of EL AL.

The aircraft involved in the incident

1.1 Factual information

History of the Flight

Background

Flight LY311 from Ben Gurion Airport to Luton Airport in London was due on the 28.3.2014, pick up time of flight crew to the airport was 01:10 LT, and door-locking time was 04:10.

Comment: On the night before the flight the daylight saving time was adjusted and so pick up took place two hours before the flight.

The Captain was assigned to the flight, approximately five hours before collection, at 20:30 LT. During the previous day he had attended a training- session day at the company's facilities. The Captain tried unsuccessfully to sleep before the flight.

For the First Officer this had been a scheduled flight. He had spent the previous day at home after landing at 00:30 LT and he managed to sleep approximately two hours before the pick up.

At the flight briefing it was indicated that weather conditions were expected to be foggy at the time of landing at Luton. The crew discussed the implications of the limited visibility and added 600 kilograms of extra fuel.

The course of the flight

In the absence of the CVR recording of the flight, despite the fact that it was requested, the following description of the flight is based on the testimonies of the crew.

The First Officer (**"F/O"**) was the flying pilot (**"PF"**) during departure, however, later on during the flight, he switched positions with the Captain who from then on was the PF, as required in a CAT III approach.

Weather conditions at the destination were monitored throughout the flight. Visibility reports showed: RVR- 250, 250, 250, with slight variations.

Approximately an hour and a half before landing, the crew briefed in detail the approach and landing, and went over the CAT III approach checklist as set out in the EL AL information booklet. The first paragraph of this checklist states as follows:

Refer to chapter Operating Minima and verify:

- ✓ *Fitness/qualification of the crew and the aircraft.*
- ✓ *Airport qualification (lighting and navigation aids) and CAT II/III in progress is declared.*
- ✓ *Limitations: visibility (RVR), wind (tail, crosswind), precipitation, braking coefficient and runway length.*

  Review the Low Visibility operating procedures in the aerodrome's Jeppesen chapter.

<u>Note</u>: There are no details regarding the subjects which must be reviewed according to this chapter.

The crew did not referred to the chapter which defines the conditions for an approach when visibility is poor:

COMMENCEMENT AND CONTINUATION OF AN APPROACH - APPROACH BAN.

During the landing briefing, the Captain briefed to intercept the G/S at 2,000 feet, based on the procedure chart, and defined 2 checkpoints in the Approach Profile: The first at 4 miles/1,840 feet and the second at 3 miles/1,520 feet. No checkpoint was assigned to replace the Outer Marker (OM).

As the aircraft was nearing Luton Airport, the crew received radar vectoring instructions to intercept the final approach while maintaining an altitude of 3,000 feet. The crew then received clearance to begin the final approach. At this point the aircraft was with flap configuration 5 and indicated airspeed of approximately 175 knots.

Immediately after the G/S was captured, the crew switched to the control tower frequency. The control tower updated the crew on the current visibility values (RVR): 175, 175, 200.

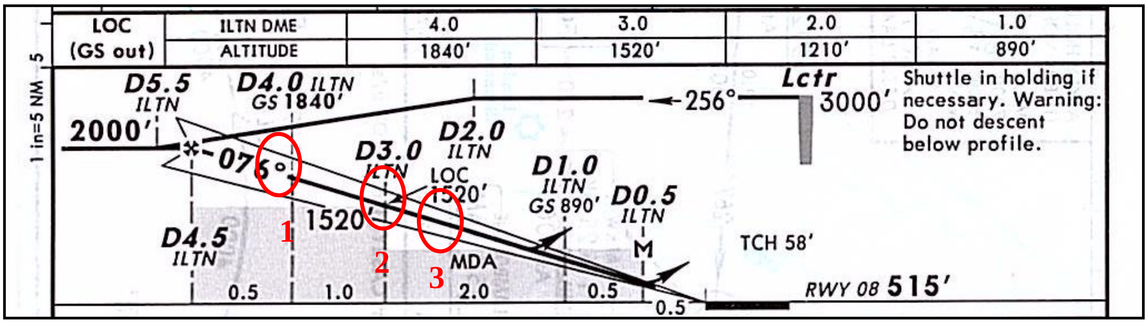
Upon intercepting the G/S, the crew was about to deploy the landing gears and flaps. The information provided by the control tower regarding the revised visibility ranges, led the crew to understand that this visibility was beneath the allowed minima. The crew discussed the point to which they were allowed to descend during the approach.

During the crew's discussion, while the aircraft was still flying with flap configuration 5 at a speed of approximately 175 knots (a relatively high speed for this stage of the approach), an automatic call was heard in the cockpit: "ONE THOUSAND", this surprised the crew since it had expected to hear the call in a later stage of the approach.

The Captain intuitively answered: "STABILIZED" - the F/O looked at the gear lights and saw 3 red lights. Immediately thereafter the red warning was issued - STEADY WARNING HORN. The crew executed a go-around and informed the control tower accordingly.

While holding and checking the weather conditions at alternate airports, the visibility at Luton improved and the crew executed an additional approach to Luton, and landed safely. After landing, the Captain called the fleet's Chief Pilot and reported the incident, although neither of them reported the incident by phone to the Chief Investigator.

Approach Profile View



1. Checkpoint - OM replacement.
2. Additional checkpoint chosen by the flight crew (1,000 feet AGL).
3. 2.3 mile (800 feet AGL) - at this point the crew received a warning that the landing gears were up at low altitude.

1.2 The crew

The Captain

- ☒ 57 years old.
- ☒ Employed by the EL AL in the past 15 years.
- ☒ Captain since 2006.
- ☒ 16,800 hours of flying experience, of which approximately 6,600 hours on B-737.

The First Officer

- ☒ 39 years old.
- ☒ Employed by the EL AL in the past 3 years, flying B-737.
- ☒ Before hence flew four years with C.A.L. as F/O and piloted business jets.

1.3 Aircraft Information

- Boeing 737-800 aircraft, Registration 4X-EKL.
- Registered in the name of "El Al Israel Airlines Ltd".
- C.O.A. in valid until 12.6.2014.
- Maximum takeoff weight - 79,015 kg.

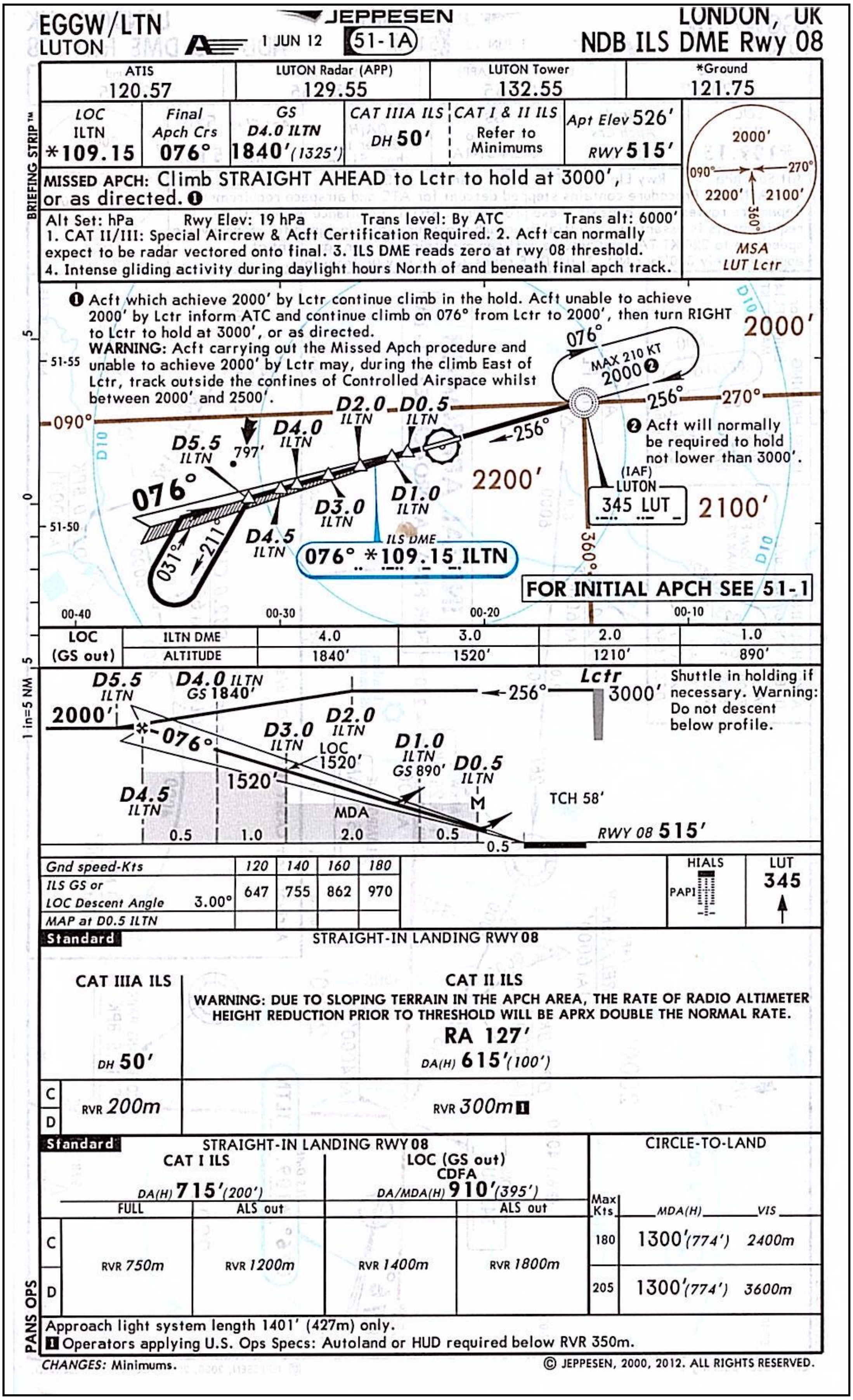
1.4 Weather conditions at Luton Airport

- Low clouds and a forecast of fog between midnight and 9AM local time (which on the day in question was the same as (UTC).
- Visibility according to the forecast - 200 meters.
- Wind - Northeasterly, 8 knots.
- Temperature: 2°C.

1.5 Luton Airport and the approach procedure

- London's Luton Airport is located on a hilly terrain. The aerodrome elevation is 526 feet above sea level.
- The Airport has a single, relatively short runway - 7,093 feet.
- The runway is equipped and approved for CAT II/III approaches.
- The approach is standard with a 3 degree angle and a DME range for the beginning of the runway.
- The approach does not have an OUTER MARKER (**"OM"**), and a point at 4NM/1840' appears at the top of the approach chart as a checkpoint in the process.
- In the approach chart to runway 08, there is a, remark indicating that due to the sloping terrain in the approach area of the ILS to runway 08, the rate of radio altimeter height reduction prior to the threshold will be approximately double the normal rate.

The approach chart used in the incident



2. Analysis

A flight is comprised of a sequence of processes. The time-frames in which these processes are being executed called "Phases of Flight". These "phases of flight" are triggered by one of the following parameters:

- ☒ Time
- ☒ The distance to the destination or to a calculated point of descent
- ☒ Altitude (in relation to the destination)
- ☒ The indication on the aircraft instruments (for example: The G/S indicator on the pilot's instrumentation panel).

The manufacturer designs, manufactures and produces the aircraft and its systems to the highest standard of reliability. The systems are designed to assist the crew to understand the aircraft's spatial situation and its technical status at any given moment. The manufacturer specifies the procedures for operating the aircraft and updates them in the light of the accumulated experience gained from operating it by the world's airline companies and lessons learned in the event of serious accidents.

2.1 The failure obstruction theory

Often, an accident is caused by one or more linear sequences of errors which align at a particular point in time and either cause an accident or fail to prevent it. Generally, preventing one of these errors may be enough to halt the process which leads to the occurrence of an accident.

Before an aircraft even takes off, the regulator, manufacturer and operator take measures designed to reduce the probability of negligent incidents.

For example:

- ☒ The regulator introduces laws and restrictions for operating aircraft based on accumulated, global aviation experience and in accordance with the level of safety defined for the commercial aviation industry. The purpose of these laws is to guarantee the existence of proper safety standards and to prevent accidents.
- ☒ The manufacturer endeavors to identify potential shortcomings from the early stages of the aircraft design and during its test flights, in order to solve and predefine solutions to possible failures. The manufacturer develops solutions to possible faults which manifest themselves in the concept regarding the aircraft's operation, in the standard operating procedures and work practices which the operator must abide.

- The operator implements the operating concept, the standard procedures which must be executed by flight crews, and the operating practices designed to identify mistakes and failures and thus prevent the occurrence of dangerous situations and accidents.

The flight crew, controllers and others involved in the aircraft's operation are also charged in real time with creating and maintaining mechanisms designed to prevent mistakes and failures from occurring, mechanisms which are cumulatively referred to as "failure obstructions", since their purpose is to identify shortcomings and block the continuance chain of events which may culminate in an accident.

The principal areas of prevention (in hierarchical order)

The first area - Regulation

The regulator introduces laws and limitations designed to ensure proper safety standards and prevent the occurrence of dangerous situations. The laws and limitations apply to all the aspects related to flight: the technical proficiency of the aircraft with all that this entails and implies - maintenance procedures, inspections, competency of technicians, and so forth; Pilot competency with all that this entails and implies - training, instruction, occupation and rest and so forth, the competency of cabin crews and the competency of the company to plan, dispatch and operate flights, etc.

The second area - Technology

Modern aircraft design and manufacturing incorporate the accumulated knowledge, lessons and experience gained from tackling previous failures and accidents. These lessons lead to the development of means, software and systems which are installed in modern aircrafts. These means help pilots understand the overall situation of the aircraft and to recognize any deviation from desirable and permitted situations. In this manner the aircraft and its systems constitute an initial failure obstruction during the flight.

The third area - SOP

The primary obstacle to failure in operating aircraft is the standard operating procedure (**SOP**). The philosophy of aircraft operation postulates that precise adherence to the SOP is a basic condition for a safe operation of the aircraft. This philosophy is based on:

☒ A clear division of tasks between the crewmembers.

☒ Clear Area of Responsibility within the cockpit.

☒ Cross-control – Execution of every essential action with the approval of the other crew member.

The fourth area – Operational Practices

As a derivative of the operating philosophy, the manufacturer publishes recommended practices for aircraft operations. The operating practices are designed to ensure standardization in the aircraft's operation, a comprehensive and common approach amongst pilots regarding the overall situation of the aircraft, and awareness of every action in the cockpit. For example:

☒ Reading aloud every message displayed in the cockpit.

☒ The declaration of each action being taken in the cockpit.

The fifth area - Work Methods

A work method which derives from the operational practices, applies the operating philosophy and combines techniques which ensure the safe implementation of the pilots' activities, for instance: by linking one action to another or an action to a declaration.
For example: An identification of GLIDE SLOPE ALIVE will ultimately lead to deployment of the landing gear and flaps for landing.

The sixth area – Human Factors

The sixth area, the human factor, is the "soft" area. This area addresses human nature and the weaknesses and biases derived from it which affect the pilot's performance during a flight: lack of concentration, forgetfulness, dividing of attention, fatigue, etc., as well as his physical, mental and physiological condition. The preventative obstructions in this area are techniques which bypass the weaknesses, such as: preliminary decisions, physical reminders, linking one action to another, linking an action to a particular display or to an automatic reading of a system in the aircraft.
<u>Comment</u>: In each area there may be a number of sub-obstructions.

2.2 Analysis of the crew's actions

Approximately an hour and a half before landing, the crew held a detailed descent and approach briefing and went over the CAT III approach checklist appearing in the EL AL INFO booklet.

During the briefing, the crew missed an important paragraph which defined the point at which a decision is needed to be taken: whether it was permitted to carry out the approach or not from that point.

The importance of this matter lies in the fact that not defining the point, caused the crew to be distracted and to deviate from the routine actions and practices.

In addition, the crew defined two checkpoints within the approach profile: at 4 miles/1,840 feet and at 3 miles/1,520 feet. An OM replacement point was not defined - a point which according to the regulations is the point of decision in the approach.

During the landing briefing, the Captain indicated a G/S interception altitude of 2,000 feet based on the approach chart. The crew was radar vectored by ATC to the final approach and received clearance to begin the final approach at 3,000 feet (the approval to engage the G/S). Immediately after locking on the G/S, the crew switched to the control tower channel. The control tower transmitted to the crew a visibility update, which was: –RVR – 200,175,175. Upon locking on the G/S, the crew was about to deploy the landing gears and flaps, as required when preparing the aircraft for landing.

The Tower update regarding the current visibility, lead the crew to realize that it was lower than their approved visibility limitation, and caused them to discuss how far they could continue the descent before canceling the approach.

It appears that this discussion was prolonged due to the crew's fatigue and the difficulty of remembering what was stated in the relevant documentation on the matter. The discussion would have been superfluous had a clear decision point been defined during the landing briefing. This discussion in fact paused the process of preparing the aircraft for landing –deploying the landing gears and flaps, and reducing speed accordingly.

During the crew's deliberations, an automatic announcement was heard in the cockpit: "ONE THOUSAND". The crew was surprised by the automatic announcement since it had expected it to come later on. The fact that the crew continued the decent with flaps 5 degrees (F5) caused the aircraft to travel at high speed relative to the speed expected at this stage of the descent and therefore from time and space aspect this announcement was perceived by the crew to be early than usual.

The Captain answered intuitively: "STABILIZED", even though it was the duty of the PM to check the aircraft's situation and read aloud "STABILIZED" or to point out the data which needed to be altered and only as a result thereof would the PF be required to confirm that the aircraft had indeed been "STABILIZED".

he F/O checked the data and saw 3 red lights. Immediately thereafter the red warning light came on - STEADY WARNING HORN, indicating that the aircraft was flying at a low altitude and without being in a landing configuration. The Captain had reacted intuitively without checking the situation and out of habit and had given a standard answer to an expected/recognized announcement. It may be surmised, as aforesaid, that fatigue made a contribution to this response.

The crew regained its composure, canceled the approach and executed a go-around, and by doing so - effectively stopped the dangerous chain of events.

2.3 Analysis of the incident according to the "failure obstructions" theory

In the light of the tens of millions of successful takeoffs and landings by the new generation of B-737s, it is likely to assume that the standard practices, operating procedures and protective measures developed by the manufacturer addressed the safety requirements.

The part played by the "failure obstructions" in this incident shall be analyzed in reverse order, relative to the timeline - from the incident backwards.

2.3.1 The sixth obstruction - the human factor

Another major failure obstruction is crew resource management (CRM). The manufacturer specifies operating practices for the crew, exclusive areas of responsibility, clear division of roles and cross supervision procedures in order to harness a synergetic operation of the two crewmen in the cockpit so as to improve the flight safety. Areas of responsibility, division of tasks and cross supervision are the obstruction to failure.

The impact of fatigue on crew performance is hard to quantify precisely, even in cases it serves as a component in an incident. Flight crews are obliged to estimate their degree of fatigue before agreeing to fly, when called upon to do so, and in any case before undertaking the flight. In the present case, neither pilot disqualified himself from flying the aircraft.

One of the components in the sixth obstruction is situational awareness (**S.A.**). i.e. the crew is understanding its overall situation and that of the aircraft's spatial orientation in 4 axes: navigation (right/left), altitude (up/down), speed (forward/backwards) and time. The manufacturer integrated numerous technological and procedural aids in order to maintain the crew's situational awareness where it is essential to the aircraft's safe operation. For example: the purpose of the synthetic announcement - "Radar Altimeter Alive" - is to drawn the crewmen's attention to the proximity to the ground during the descent for landing (and in general). SOP combines elements with the sole objective of creating situational awareness in order for the aircraft to be flown in a controlled and defined way. For example, the announcement: "Glide Slope Alive", serves the purpose of alerting the crew that the aircraft is approaching the line of descent and to initiate the required preparation for its capture. This announcement is accompanied by the actions which need to be taken to prepare the aircraft for landing - deploying the landing gears and deploying the flaps to an intermediate state.

In the incident in question, the human factor was the weakest link in the chain (the distraction of the crew from the required order of actions coupled with fatigue) which caused the crew to lose its situational awareness of the aircraft. The crew thought that there was enough distance and time for landing and was surprised that the aircraft had reached an altitude of 1,000 feet.

In this case, the functioning of the crew was generally good, but since the two crewmen failed to define the conditions for continuing the approach, both of them had doubts and deviated from the standard order of actions.

This failure obstruction did not work!

2.3.2 The fifth obstruction – Work Methods

At an altitude of 1,000 feet during the final approach, the crew has to verify that "the aircraft is in the correct landing configuration" (FCTM). After checking, the PM must declare "Stabilized" and the PF must check and confirm that the approach is indeed stable by making an identical declaration.

In the incident in question, the crew, which was engaged in the aforementioned deliberations, was taken aback by the "1,000" notice and the Captain automatically responded by declaring "Stabilized", even though he had not checked to see whether the aircraft was in the correct landing configuration. The

F/O checked and identified that the landing gear was not deployed and his response was accompanied by the warning of the aircraft's system that the wheels were folded up at a height of 800 feet above the ground. The prolonged indecision and the slow and automatic responses may be attributed to the crew's fatigue.

This obstruction did not work!

2.3.3 The fourth obstruction - Operational Practices

The manufacturer provides (in the FCTM book) a clear and simple instruction regarding the point at which the landing gear and flaps are to be deployed:

"Deploying landing gear: When the glide slope pointer begins to move (glide slope alive)"

Following to landing gear deployment, the manufacturer also states that the flaps should be deployed to position 15 and speed reduced accordingly.

The timing of flaps deployment to the "landing" position and the reduction of speed to landing speed is defined by the manufacturer as: "At glide slope capture"; that is, when deploying the flaps for landing, the landing checklist must be executed.

During the incident, the crew was about to carry out the correct actions but the ATC revised visibility report has distracted the crew's attention away from the actions required to prepare the aircraft for landing. The crew was discussing the question of how long is it permissible to continue the approach and thus failed to deploy the landing gears and the flaps as required. The "trigger" which was supposed to cause the crew to return to the SOP and deploy the landing gears and flaps - did not work. This obstruction did not work!

The landing checklist is supposed to be read by the PM and the PF verifies that each step in the process of preparing the aircraft for landing has been carried out is the complementary measure which the manufacturer provided to the crew as an SOP to be followed before landing. Since the crew was engaged in the aforementioned deliberations, the routine sequence of actions was interrupted, and the fact that the landing gears and the flaps were not deployed, prevented the checklist procedure from being followed.

This obstruction did not work!

2.3.4 The third obstruction - SOP

The manufacturer's and operator's SOP require that a detailed briefing take place before a low visibility instrument approach is carried out. All subjects that arose and were discussed by the pilots during the final phase of the approach were supposed to be defined and agreed upon at the pre-descent briefing: the descent sequence, the go-around point, the conditions for continuing the approach, etc. The crew failed to clearly define the OM replacement point and the conditions for continuing the descent. The crew tackled these issues during the final phase of the descent without preparation.

This obstruction did not work!

2.3.5 The second obstruction - Technology

The technological failure obstructions are designed to help the crew to understand the position of the aircraft and its spatial situation, and where necessary - to warn the crew of the discrepancy between the existing situation and the desirable one:

1. The RADIO ALTIMETER ALIVE announcement is designed to alert the crew when the aircraft is approaching the ground (when below 2,500 feet AGL).
2. The "Too Low Flaps" warning which is activated at an electronic altitude of less than 800 feet AGL.
3. The EGPWS "Terrain" system which alerts the crew of the aircraft's proximity to the ground (while the landing gear is in the "up" position) with different levels of severity (Caution or Warning).
4. The aircraft's systems "warning horn" and three red landing gear indicator lights, which are activated at electronic altitude of less than 800 feet AGL when the engines are on low power and the landing gear has not yet been deployed.

   <u>Remark</u>: The EGPWS system is designed to give an additional, more intense warning which it did not do in this case since it is only activated in certain conditions, such as the aircraft flying at under 500 feet AGL without the landing gear having yet been deployed.

This obstruction did work; it carried out its function and interrupted the chain of errors for which the crew was responsible during the previous stages.

2.3.6 The first obstruction - Regulation

The regulator has established laws and limitations which are designed to guarantee a proper level of safety and to prevent dangerous situations in advance.

During the incident, with the exception of the crew's hours of work and rest, which was a background factor in explaining how it behaved in the incident, the regulatory bodies made no contribution in any matter concerning the airworthiness of the aircraft, its maintenance, inspection, the competency of its technicians, operator, flight attendants, the adequacy of their training or the composition and competency of the flight crew.

It should be emphasized, that while it is most uncommon for fatigue, which is, inter alia, the result of compliance with the hours of work and rest restrictions together with lifestyles and operating and air crew staffing norms, to be defined as the substantive and decisive cause of an accident, it is a background factor which could in certain circumstances be the element which transforms an incident into an accident, and therefore it is an area which must be studied and its implications must be dealt with.

With this reservation, which shall be addressed in greater detail hereinafter, it may be concluded that: **in the incident in question there were no regulatory obstructions which failed.**

2.4 Occupation and rest restrictions

Analysis of the Aviation Regulations

Section 4 of the Aviation Regulations (Restrictions on Flying Time in Aviation Services), 1971, "minimal rest times", defines the hours of rest which are binding on the operator and the flight crew (the following translation is unofficial and does not qualify as legal translation):

"4. (a) An operator shall not employ a crewman and a crewman shall not serve, on a commercial flight, shortly after the completion of a period of duty within the framework of the flying hours specified in section 3, unless he managed to rest in a place of rest, before performing his duties, for a period of not less than the one specified hereinafter…"

Under this Regulation, the operator cannot employ a crewman prior to a flight during the period of time specified therein. Moreover, the crewman is obligated to be competent to undertake the flight.

Operator's literature

The EL AL INFO booklet is used by the crewmen during the flight and before a poor visibility CAT III landing. The booklet contains various information, including a checklist indicating the actions required before undertaking a CATIII approach.

The checklist refers the reader to the chapter in the annex entitled "Operating Minima", which contains a detailed description of the approach and landing limitations. The checklist does not indicate which specific information in the chapter the crew needs to go over.

Paragraph 10.6 of the chapter "Operating Minima", which is entitled "Commencement and Continuation of an Approach" presents the conditions for commencing and continuing an instrument approach in accordance with the level of visibility. This chapter in the Annex of the EL AL booklet which was in use on the date of the incident is divided into three paragraphs: Israel; USA; All other countries. The paragraph relating to "all other countries" instructs flight crews to refer to additional books in order to verify which laws apply in the relevant state. A flight crew which has to perform an instrument approach on short notice will not be able to peruse all the requisite literature in order to understand the rules that apply in the country of destination.

2.5 The fatigue factor

2.5.1 General

Fatigue is defined as a subjective feeling of tiredness, "lack of energy" and lack of concentration that decreases cognitive performance, and has a negative effect on the ability to undertake tasks.

Symptoms of fatigue

- ☒ Decrease in cognitive capacity.
- ☒ Increase in reaction time.
- ☒ Diminished ability of judgment.
- ☒ Diminished decision-making capacity.
- ☒ Forgetfulness.
- ☒ Muscle weakness and drooping eyelids (closing eyes).

2.5.2 The reasons for fatigue

- ☒ Depleted sleep "reserve" resulting from insufficient sleep. This shortfall may be temporary (continuous work, especially at night) or a chronic, caused by worry, illness or other problems (The average amount of sleep which is adequate and beneficial for an adult person is supposed to be around 7-8 hours a day!), although it seems that 6 hours of sleep is enough.
- ☒ Changes in the biological clock (Circadian Rhythm) – Working in shifts and flight jet lag induced by rapidly crossing from one time zone to another.
- ☒ "Sleep Inertia" - Getting up quickly after sleeping and immediately starting energetic work. Each person requires a certain amount of adaptation ("waking up"), the length of which varies from one individual to another.

2.5.3 The findings of studies on the subject of fatigue

Numerous studies have shown that fatigue causes Tunnel Vision (restricted ability to multi-task) and a significant impairment of the ability to process information arriving simultaneously from a number of sources. Fatigue induces slow thinking, a substantially impaired ability to process information, concentrate on a particular task and/or to try and extract information (in literature, stored on a computer, etc.), "multi-task" and think about several things simultaneously (fuel, the aircraft's configuration, its overall position).

Studies carried out in U.S.A.F. labs show that 4-5 nights of good sleep (approximately 8 hours) are required to compensate for one sleepless night and to return to the base line of optimal performance!

A sleep deficit of 24 hours is equivalent to having a blood alcohol level of 0.8% (8 milligrams per gram), which is a dangerous level at which driving is prohibited! After 17 hours of being awake a decline in performance occurs which is akin to drinking what is considered to be an unsafe quantity of alcohol.

Modern aircrafts fly long distances (journeys of up to 18 hours at a time) and the commercial desire to operate the aircrafts round the clock is leading to more and more night flights and the corresponding fatigue of flight crews. The management and control of fatigue in the cockpit is a significant factor in maintaining the safety of the flight.

Pilots have reported acute fatigue as a result of sleep deprivation on both long and short flights. The phenomenon is attributable to various aspects of this type of work - night flights, the crossing of time zones, waking up in the early hours of the morning and landing late at night after spending long hours in an oxygen-depleted environment.

Evidence exist today which show that in the aviation industry, fatigue is involved in 4-8 percent of the accidents and in a far larger percentage of incidents.

POWER NAPPING: Numerous studies have shown that levels of performance and alertness are enhanced after a nap of approximately

25-40 minutes in the pilot's seat (in coordination of course with the other crewman). Many airline companies permit the practice: BA, Air France, Emirates, Lufthansa, Air New Zealand and Qantas.

The European aviation authorities have been implementing a new law since 2008 which regulates flying hours and night work.

Some authorities prohibit two consecutive night flights (Australia, France and Scandinavia).

2.5.4 Fatigue in Israeli Legislation

The Israeli Aviation Regulations, which are generally derived from the FAA Regulations, make no distinction between day and night flights. According to the Aviation Regulations in force, a single flight crew may fly up to 8 consecutive hours during the day or night. The first method of reducing risks is to reduce the hours of night work, night flight and give consideration to time zones. The restrictions on work hours for flight crews are set out in the Aviation Regulations of the State of Israel (Flight Time Limitations in Air Transport Services), 1971. These restrictions are quoted verbatim (from the relevant sections) in the EL AL professional guidebook, as well as the company's own stringent comments and supplements.

In addition to the provisions of the Aviation Regulations, the work hours of EL AL flight crews are regulated by the provisions of Chapter 25 - "Work Arrangements for Flight Crews" - of the Collective Agreement, which are broader, more stringent and allocate longer rest periods to crewmen; in practice they may be reduced, with the crewman's consent, but not below the statutory requirements.

2.5.5 Causes of fatigue in the 737 fleet

- **Fatigue due to overwork (local and cumulative)**

  Over the years, and more noticeably during the last two years, each crewman flying on EL AL's 737 fleet has been excessively overworked and has piloted a higher number of flights; many of them starting or ending at night. Many flights, like the one in question, depart at an early hour, with crewmembers being picked-up from home at 04:00 in the morning local time, or alternatively in the afternoon, when a roundtrip flight is leaving during the afternoon-evening and touching back down again at Ben Gurion Airport in the early hours of the morning. These flights arrangements are most challenging for flight crews, since the opportunity to rest after the flight lands in the early hours of the morning, or before the early morning flight departs, is limited. The minimum crew required to operate a 737 consists of two pilots, or to quote the Regulation: "a single pilot and an additional crewman". Some 737 flights are "revolving", when flight duration is above the permitted for minimum crew, and are flown by an "enlarged" or "double" crew.

- **Rest during the flight**

  When an aircraft is flown with an enlarged or double crew on board, the redundant crew members will be allocated a place to rest in the passenger cabin. The definition as it appears in paragraph 1 of the aforementioned Regulation states as follows:

  "Rest during flight: with regard to a crewman - A period of not less than two hours, in which he may rest in the aircraft, on a comfortable seat, which is not a folding seat, outside of the cockpit".

  Comment: The term "comfortable seat" is not defined in the Aviation Regulations of the State of Israel. In 737 aircraft (which are not equipped with recliner seats as is customary in wide bodied aircrafts) a business class seat is set aside for "rest during flight". As a result of configuration changes made in the company's aircrafts in 2013, the layout of business class seating was rearranged in a way which didn't provide sufficient resting conditions during flight. These conditions were improved again recently.

Approximately 3 years ago, the EL AL Corporation received a delivery of B-737 aircrafts which were fitted with economy class seating only (as opposed to the two-class design which had been customary until then). According to the Israeli Aviation Regulation, and a decision of the EL AL Corporation's VP of Operations, an economy class seat cannot under any circumstances be considered to be a "comfortable seat" for the purposes of "rest during flight".

- **Flight scheduling**

  EL AL's method of scheduling flights derives from its crew members service contracts. At the stage of drawing up the monthly schedule, the company only allocates personnel to some of its flights and waits to decide upon the composition of the crews for the rest of them during the month, shortly before the aircrafts are due to fly. The flights are manned by on-call crewmen (if they are available), crewmen who were not allocated to flight, crewmen who agree to undertake an unplanned flight or crewmen who are "compelled" to man such a flight, in accordance with the terms of their service contract. Since crewmen may be posted to unplanned flights at short notice, it may be supposed that even if a crewman appears to have had the statutory rest period, he may not necessarily be physically prepared for undertaking the flight, since he did not manage to take an adequate rest prior to the flight.

- **Fatigue induced by "cabin altitude" (passenger cabin air pressure)**

  An additional element which may contribute to the fatigue of flight crews, whether during the flight or as a result of repeated exposure, is passenger **cabin altitude**. Passenger cabins on aircrafts which cruise at high altitudes are equipped with air pressure regulators, so that air pressure within the passenger cabin is maintained at a level which is comfortable. Cabin altitude is limited in the aviation industry to 8,000 feet. In B-737 aircrafts, cabin altitude at cruising altitude is between 7,000 feet and 8,000 feet, compared to wide-bodied aircrafts where in most cases cabin altitude is maintained at less than 6,000 feet.

2.5.6 The crew of the investigated flight

The Captain - Was assigned to the flight with his consent approximately four and a half hours before the crew was picked-up. On the day before the flight he had taken part in a training session at the company's facilities (marginal from the point of view of the rest hours which he had at his disposal). He had spent 3 days before then in a simulator abroad. The Captain tried unsuccessfully to sleep before the flight and testified that he was tired throughout the flight and during the pre-landing descent.

The First Officer - The flight in question was a scheduled flight. He had landed at 00:30 on the day before this flight and had gone to sleep at around 02:00. He spent the day during the two flights at home. He managed to sleep for approximately two hours before departing for the flight.

2.5.7 The effect of fatigue on pilot performance in this incident

Fatigue causes phenomena, such as: impaired cognitive capacity, slow processing of information, slow reaction to visual information - switching on of warning lights, voice alerts, change of modes on the display screens, etc.

In this flight the crew did not clearly define in advance a "red line" for continuing/discontinuing the approach. When the ATC's report was received containing updated visibility values, the crew's fatigue contributed to the difficulty which it encountered in processing the significance of this information to the decision to go-around on time, and the attention shifted to attempting to remember the written restrictions.

The attempt to recall the restrictions caused a distraction from the essential actions required to prepare the aircraft for landing - i.e. deploying the landing gears and the flaps and undertaking the necessary pre-landing checklists.

Although flight crews do brief on the subject of fatigue, this is not translated into actions or specific limitations on actions. In some fleets the practice is for aircrafts to be landed in an "Auto Landing" mode, after a long night flight or when the crew feels tired, however, no binding policy or direction has been issued on the subject.

2.5.8 **Measures of improvement (fatigue subject)**

☒ **At the regulatory level**: To adopt the new U.S. or European rest laws which relate to hours of occupation during the day and night, time zones, etc. Note: It ought to be pointed out, that as far as it is known, the subject is currently being debated under the initiative of the CAA.

At the company level:

✓ Apply scheduling method which takes into account the time of waking up, the duration of the flight, the crossing of time zones and the fatigue of the crew ngendered by these factors. Similarly, scheduling and taking into consideration the rest requirements of the operating crew/crews - before, during and after the flight.

✓ To establish an on-call crew which is competent to fly at short notice (being implemented)

✓ To limit the number of consecutive night flights.

✓ Where a crew is alerted to fly during "extreme hours", to add an extra crewman.

It is further recommended that the company consider, in addition to strict observance of the Regulations, a broad approach regarding the fatigue potential of a crewman who is called to an unscheduled flight. Thus for example:

✓ To expressly clarify with the crewman who is called upon to fly whether or not he is tired, with the emphasis on the fact that he was called out in circumstances in which it may reasonably be assumed that he had not himself managed to rest, such as in a request to fly on short notice, a call out during the evening hours, etc.

✓ To refrain from repeatedly contacting a crewman who has given notice that he is tired in order to ask him whether he is able to fly, both because this violates the company's policy and because it applies seemingly implied pressure on a crewman to agree to undertake the flight.

- ☒ **At the individual level:**
  - ✓ To rest well before and after flights.
  - ✓ To properly hydrate during the flight.
  - ✓ To drink beverages containing anti-oxidants substances.
  - ✓ To eat fruit and vegetables.
  - ✓ During a flight, in the event of tiredness, during straight and horizontal flight, to take "micro naps" - short and measured periods of sleep while the other crewman is in control.

    Comment: This practice has not yet received approval in the Israeli regulations or the company's professional guidebook.
  - ✓ To take a number of inhales of 100% oxygen before and during the descent phase in order to maintain a high level of alertness and concentration during the critical landing stage.
  - ✓ It is recommended to walk or do stretching exercises once every hour or two in order to prevent DVT (deep vein thrombosis).

2.6 The functioning of the crew

2.6.1 Teamwork

The crewmembers testified that they performed well and in a professional manner. Each of them was receptive to the ideas of and listened to the other, there was no fear of expressing thoughts or to issue a warning. At the operational level, the team work did not constitute a cause of the incident although in the final analysis neither did it constitute an obstruction which arrested the development of the failure mechanism that led to the incident.

2.6.2 The crew's actions

- ☒ Unfamiliarity with the policy regarding when it was permissible/ forbidden to make the approach, which led to a failure to define a clear cancel-approach procedure/go-around point.
- ☒ At the "moment of truth" - on the G/S in the final descent, the crew began to have doubts and to discuss where the decisive point was and, broadly speaking, actually stopped flying the aircraft. The fatigue to which the crew was subject, helped mire it in indecision and lose its bearings regarding the aircraft's exact airspace position.
  - ☒ The automatic "ONE THOUSAND" announcement took the crew by surprise but also "woke" it out of its indecision and led it to understand that they had to go-around.

2.6.3 The decision making process

In every flight, the Captain with the help of his crew must take various decisions, starting at the briefing stage and then throughout the flight until the aircraft has landed.

In any situation in which the information is unclear or could change over time, decision points must be fixed and the conditions for the requisite decision defined. For example: The quantity of fuel which shall be required in the event of a change in passenger and/or cargo weight, the quantity of fuel which shall be required in the event of worsening weather conditions which force the aircraft to land at an alternate airport.

On this flight, in which visibility was the significant factor, it was necessary to decide the minimum visibility level beneath which making an approach would be prohibited, the stage at which such information should be checked and the point at which it would be necessary to decide to abort or stop the approach.

2.6.4 The conduct of the crew following the incident

It should be noted in favor of the crew that the incident was reported immediately to its managers. The crew fully cooperated with the subsequent inquiry, which helped to ascertain the causes of the incident and learn from it. It should also be pointed out, however, that the crew "minimized" the severity of the incident in the report that was filled, did not report it to the Chief Investigator immediately after landing as required and did not pulled out the CVR breaker - actions which would have greatly assisted in understanding the incident in the safety inquiry.

3. Conclusions

3.1 **This serious incident was caused by pilot error on the part of both crewmen** and manifested itself in a failure to configure the aircraft for landing, descending to a low altitude without deploying the landing gear and consequently a forced go-around at an altitude of 800 feet AGL.

3.2 **The severity of the incident lies in the fact** that even though **the flight crew was aware of the poor visibility conditions** and the fatigue to which it was subject, **it failed to take the appropriate measures** needed in order to avoid the potential safety threat that was created, so much that it was only the aircraft's system which alerted the crew of the dangerous situation.

3.3 **The situation which the flight crew encountered** at an advanced stage of the final approach for landing, despite the preceding briefing that was given, **was attributable to a combination of errors, as the major ones being:**

- ☒ The crew's failure to define in the pre-landing briefing the conditions in and the point at which it would execute a go-around.
- ☒ The crew "drifted" and continued the descent for landing even after crossing the point which had seemingly defined.
- ☒ The crew failed to configure the aircraft for landing (landing gear, flaps, speed).

3.4 **The flight crew's response upon receiving the warning at an altitude of 800 feet AGL**, to go-around, **was decisive** and halted the progression of the safety incident.

3.5 **The fatigue component affected each of the crewmen and significantly contributed to the errors which they made during the approach.**

3.6 **Assigning a single crew to a flight, on short notice, during the night** carries with it a serious risk of fatigue and impaired function at the critical stages of the flight.

3.7 **While the causative effect of fatigue on dysfunction is generally familiar to crews and operators**, but has not yet led to specific guidelines and measures for contending with the issue in an effective way.

3.8 **Given the operating framework of the company's aircrafts and the onerous burden placed on its crews, especially in relation to the B-737 fleet, the issue of fatigue is a significant factor which may impair the performance and alertness of flight crews.** However, it is a problem shared by numerous airline companies throughout the world and is being treated by international legislation, and recently, also in Israeli.

3.9 **Power Napping is a method which has been accepted by many companies throughout the world**, is helps to contend with fatigue during flight and it should also be incorporated into the Israeli Aviation Regulations or in any other format.

3.10 **The checklist which the crew used during the landing briefing is too general and contributed to the fact that the crew missed the appropriate chapter:**

COMMENCEMENT AND CONTINUATION OF AN APPROACH.
The referral in the Annex to Jeppessen literature with the aim of covering the rules for descent to the target airport is problematic and could cause the crew to miss this information, for example upon receiving a short notice of poor visibility.

3.11 **The non-reporting of a severe safety incident as required by the Aviation Law immediately after it occurred** and the non-retention of information following such an incident **significantly undermines the ability to investigate the incident and learn from it** in order to prevent its repetition.

4. Recommendations

4.1 To update the Aviation Regulations relating to the issues of occupation and rest hours or the subject of fatigue, in a way which takes into account the operational character of the aircrafts today and in the near future, while adopting regulations which have been enacted by the FAA, the Europeans authorities and others in reliance upon research studies and experience.

Comment: In so far as is known, this subject is being addressed by the CAAI. **Responsibility**: The CAAI administration

Recommended implementation date: As soon as possible

4.2 Instrument descent checklist - To include and specify the paragraphs in which the crew must go over. **Responsibility**: The CEO of EL AL

Recommended implementation date: As soon as possible

4.3 To consider to issue a request to CAAI to approve POWER NAPPING on flights, a practice which has been accepted by airline companies throughout the world.

Responsibility: The CEO of EL AL

Recommended implementation date: In his discretion

4.4 To consider manning night flights which are defined as "difficult" with an augmented crew.

Responsibility: The CEO of EL AL

Recommended implementation date: As soon as possible

4.5 To set out in the aviation literature the law applying in each state vis-à-vis the conditions for continuing an instrument approach rather than leaving this to the flight crew to determine during the flight.

Responsibility: The CEO of EL AL

Recommended implementation date: 1.11.2014

4.6 To specify a checklist which ought to be considered during situations such as pre-landing fatigue, in order to make it easier for the crew to determine, in accordance with the specific circumstances, the measures which they should take.

Responsibility: The CEO of EL AL

Recommended implementation date: 1.11.2014

4.7 To act in conjunction with the flight crews and to emphasize their responsibility and obligation to retain the information and data pertaining to a serious safety incident after it occurred.

Responsibility: The CEO of EL AL

Recommended implementation date: As soon as possible

4.8 To set guidelines for the person charged with assigning crews who asks the pilot to undertake an unscheduled flight, which will clarify for example the explicit question: "are you fit to undertake this flight?"

Responsibility: The CEO of EL AL

Recommended implementation date: In his discretion

Kind regards,

Raz Itzhak (Razchik), Adv.
Chief Investigator

Date: 5.8.2014 Ref: 27674614

Return of objects which were seized during a safety investigation

Under section 114(b)(5)-(7) of the Aviation Law, 5771-2011, the Chief Investigator shall return objects which were seized , apart from aircraft fragments, within 45 days from the date of publication of his Final Investigation Report. The objects shall be returned to the person from whom they were taken or to their owner. Aircraft fragments shall not be returned other than at the request of the aircraft owner and at his expense. A request for their return must be submitted to the Chief Investigator by no later than 45 days from the date on which the report was published. **A person who does not wish seized objects to be returned to their owner, may file an appropriate request with the Magistrates Court which has jurisdiction in the geographical area in which the object was seized.**