Presented by **Regule Aire Transportation Safety Committee**

Final Report of 8L-CAX Seniorious 300 Accident over Lyell on May 30th, 449

Released in May 450

ABBREVIATIONS

CVR	Cockpit Voice Recorder
ATC	Air Traffic Control
FIR	Flight Information Region
REAA	Regule Aire Aviation Administration
RATSC	Regule Aire Transportation Safety Committee
Δp	Pressure Difference (usually: between the inner and outer of the aircraft) (unit: Pa or psi)
p	Pressure (Unit: Pa or psi)
C	Cold
H	Hot
ATPL	Airline Transportation Pilot License
APU	Alternative Power Unit
ENG	Engine
IRS	Inertia Navigation System
PF	Pilot Flying
PM	Pilot Monitoring
FMC	Flight Management Computer
VOR	Very High Frequency Omnidirectional Beacon
FDR	Flight Data Recorder
VHF	Very High Frequency
S/N	Signal-Noise Ratio
PTT	Push-To-Talk Button
DNA	Deoxyribose Nucleic Acid
AOC	Air Operator Certificate
ΔH	Enthalpy Change
V	Volume (Unit: L)
T	Temperature (Unit: ℃ / Celsius Temperature)
n	Amount of Substances (Unit: mol)
℃	Celsius Temperature
V/S	Vertical Speed
CRM	Cockpit Resource Management
EICAS	Engine Indication and Crew Warning System

FLIGHT NUMBER:	**RE193**
OPERATOR:	**Air RE**
OWNER:	**Air RE**
MANUFACTURER:	**Seniorious Aircraft Manufactory CO**
AIRCRAFT TYPE:	**Seniorious 300**
REGISTRATION:	**8L-CAX**
PLACE OF ACCIDENT:	**Over Lyell Airspace**
DATE AND TIME:	**MAY 30TH, 449 – 13:16:25**

Note:

(1) All timepoints refer to the local time in this report.

(2) The timepoints of FDR and CVR may differ for less than 30 seconds.

SYNOPSIS

3 days before the accident, the aircraft had an oxygen generation system issue and was sent to maintenance. However, the maintenance wasn't correctly conducted, leaving some additional components which caused the oxygen generator's leakage.

Before the takeoff of the aircraft, the air conditioning system was set to "active cooling" mode, which accumulated heat in the equipment area nearby and increased the leakage of the oxygen generation. At approximately 13:01, the aircraft took off while the leakage continued.

At approximately 13:08, flight attendant noticed the probable leakage and reported it to the crew members. However, crew members failed to determine the situation correctly and considered it a fuel leakage. At approximately 13:16, the oxygen generation system as well as its fuselage component eventually exploded, causing rapid depressurization in the cabin.

At approximately 13:18, crew members struggled to maintain the altitude of the aircraft and fainted. Since then, Ryell and Corna di Luce ATC tried to contact the aircraft, only to get no response. Considering this a hijack, they sent fighter jets to perform accompanying flight. The fighter jet noticed the fainting crew members and passengers at approximately 13:35. An emergency committee was also established.

At approximately 13:39, a passenger, as a soldier in Leprechauns' Battery, entered the cockpit through an erosion (see following text) from Chtholly, the designer of the aircraft. Then, she contacted Corna di Luce ATC and landed the aircraft.

The emergency committee was partially turned into an investigation team. On August 15th, 449, a primary report was released. Then, this final report was released. Investigators agree that the direct causes of the accident were:

- The inappropriate maintenance work to the oxygen generator system;
- The unawareness of the inappropriate maintenance work, reflecting the lack of effective revision and cross-check system, which eventually led to the failure and explosion of the oxygen generator; and
- The inappropriate response to the pressurization warning, making crew members miss the chance to solve the problem.

Following text will discuss the accident in greater detail.

The composition of the investigation team is:

Manufacturer Representative: Pannibal Noke Katena;
Operator Representative: Ithea Myse Valgulious;
RATSC: Seabird Starch and Claire Asplay; and
The Guardian Wing Corps: Naught Sun and Widegrace Evergarden

BE ADVISED

The investigation was conducted under the requirements of:

- *The Chicago Convention (Annex 13)* (except 5.12.3);
- *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)*;
- *Lyell Aviation Act*; and
- *Corna di Luce Aviation Act*.

Notice that an investigation report aims to prevent accidents and incidents in the future. It is not used to pursue accountability.

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CONTENTS

1 Factual Information

1.1 History of Flight

3 days before the accident, it was reported by crew members that "***the passenger oxygen indication is illuminated from time to time***" (The maintenance record, see following sections) and "***the passenger oxygen supply unexpectedly deployed***" (The flight attendant logbook). Therefore, maintainers in Lyell Airport checked the passenger oxygen devices. According to the maintainers, they "***found the isolation locker*** (See following sections) ***of the oxygen system moved, leading to the production of the oxygen, which pushed the passenger oxygen masks.***"

Therefore, they moved the isolation locker to the original position but eventually damaged it accidentally. By default, a designated plastic isolation should be installed. However, the ground engineer reported that "***there's no plastic isolation for Seniorious 300 in the storeroom of Lyell airport so far… They say that the last one was used by Lyell Airlines. Luckily, I got Aluminum blocks.***" Thus, he replaced the isolation locker by using an Aluminum block, and he was also required to "***ask the manager of the storeroom to have the necessary components***". The maintenance record also said that "***a pipe is connected from the bottom of the container to the top of the container for debug purposes.***"

After the maintenance, the aircraft was assigned for a flight from Lyell to Brisun. Before pushback, CVR recorded captain and first officer discussing "***Today is a bit hot, isn't it?***" "***Yes. We have to use air conditioning. (Sound of turning knob) that's it, almost full cold. As long as we have electricity, these passengers will feel really well.***"

According to the Leprechauns' Battery (Leprechauns' Brigade)[1], a leprechaun in the team, Ryehl, was on this aircraft to go on a vacation.

Before the aircraft pushed back, the aircraft was delayed for approximately 30 minutes due to other traffic activities in the air, during which the air conditioning system kept running. The aircraft took off at approximately 13:01.

At 13:08:34, when the aircraft was passing 18 600 ft, a flight attendant called the cockpit and reported "***there was something flowing above the ceiling. I have been a flight attendant for a long time and I know that there shouldn't be anything flowing.***" The captain replied "***OK, we'll keep tracking this.***"

Then, the CVR recorded crew members discussing this problem. "***There's no problem in hydraulics,***" said the captain, "***what about fuel leak? Fuel leak checklist?***" Then the first officer read the checklist (see following sections) and said "***we have to wait for 20 minutes. The current fuel weight is …***"

At 13:16:25, when the aircraft reached approximately 27 500 ft, a low voice of explosion appeared in the CVR, followed by captain saying "***what's that?***". Then, part of the ceiling of the cabin collapsed and liquid came out, injuring passengers on seat 6D, 7C and 7D, according to a flight attendant. Then, at 13:16:37, the "MASTER CAUTION" amber light in the front panel and "OFF SCHED DESCENT" amber light in the pressurization panel of top panel were illuminated, during which Δp started growing. CVR recorded crew members discussing the malfunction and

[1] *Battery* is a military unit.

carrying out checklist items (See following sections). Meanwhile, the oxygen masks in the cabin deployed. However, passengers told the flight attendants that they couldn't get any oxygen from the mask. A flight attendant tried to establish contact with the crew members through the internal telephone system (according to an interview with the survived flight attendant), only to get no answer.

At 13:16:55, the crew members saw cabin pressure indication kept growing. The captain asked "***why is the cabin pressure growing?***" the first officer recommended asking company maintainers for assistance. Meanwhile, at approximately 13:17:09, the safety depressurization valve opened due to the increasing Δp reaching 8.65 psi (See following sections).

At 13:17:35, the Δp reached its maximum value 9.55 psi and remained this value.

At approximately 13:17:43, the first officer said "***I felt sick. Maybe there's hypoxia.***" and they tried to wear the oxygen mask. However, the captain found that "***there's no oxygen coming out from the mask!***" Then they set the transponder code to 7700[2]. The last thing they did before fainting was pressing "ALT HOLD" (i.e., instruct the autopilot to maintaining current altitude) button of autopilot panel, and the aircraft leveled off at 28 800 ft at approximately 13:18:02. Then they remained silent, and CVR recorded their breaths weakened and disappeared.

Seeing transponder code set to emergency code, the Lyell ATC tried to contact the aircraft since 13:18:11, but there was no reply from the aircraft. The ATC official immediately reported this emergency to the aviation departments in Lyell. From 13:18:11 to 13:21:55, the Lyell ATC tried to establish communication with the aircraft for 4 times, only to get no answer.

During the whole period, flight attendant never established communication. Some flight attendants used alternative oxygen bottles to provide oxygen for both passengers and themselves. Seeing some passengers who failed to get oxygen fainting, one of the flight attendants rushed towards the cockpit and knocked at the door, but there was no response inside. She tried to input the password but they were all wrong.

At 13:20:05, Lyell ATC and aviation authorities informed the Guardian Wing Corps about the emergency situation and asked if any assistance could be provided. the Guardian Wing Corps asked if fighter jets were needed. Lyell aviation authorities said "***currently not needed.***"

At 13:22:02, the aircraft was about to exit the radar service area of Lyell. Lyell ATC tried to contact the aircraft through the controller frequency saying "***Regule Aire 193, radar service terminated. If you hear me, contact Corna di Luce control at 122.50,***" delivering the aircraft to the Corna di Luce FIR. Meanwhile, Lyell authorities informed Corna di Luce about the situation of the aircraft.

According to the flight attendant, she fainted at approximately 13:24:43, when she was running out of oxygen supply.

At 13:32:12, an emergency committee had been set up, consisting of aviation officials in Lyell and Corna di Luce, as well as officials from REAA, RATSC and the Guardian Wing Corps. They had a meeting and agreed that "***fighter jets' accompanying flights are suitable for this circumstance.***" They also agreed that "***here's a probable hijack.***"

At approximately 13:33:09, the first fighter jet took off from Scarborough Military Airport to have the accompanying flight. Then, at 13:35:12, the fighter jet pilot reported that "***visual contact with Regule Aire 193 has been established***". He described the scene inside as: "***There is a part of fuselage at the top of the aircraft missing. I can see pipes exposed to the air … and I can see***

[2] 7500 means hijack, 7600 means communication failure, and 7700 means technical problem.

everyone sitting in their chairs or … probably lying on the corridors of the cabin … The windows are blurred, and there are … probably ice pieces inside." When it came to the cockpit, he reported that "***I can see two pilots lying on their seats … They're not responding to me.***"

The fighter jets were instructed to follow the aircraft to track it.

At 13:38:12, aviation officials from the Leprechauns' Battery arrived at the workplace of the committee.

At 13:39:55, when the aircraft was 149 miles away from the Lyell FIR border, the fighter jet pilot reported that "***a young woman with blue hair is moving from the back of the aircraft.***" Then, at 13:40:33, he said "***She was standing in front of the cockpit door.***" Meanwhile, CVR recorded a low voice of a woman saying "***Though I am the former designer of this aircraft … I have no idea about whether this works.***"

At 13:40:59, the CVR recorded the voice of the cockpit door opening. The fighter jet pilot reported the same: "***She has opened the cockpit door and is entering the cockpit. I don't know what she is going to do.***" He then tried to establish contact at her by making gestures. Then he got her gestures.

At 13:41:53, both the CVR and the frequency of Lyell heard a young woman's voice "***MAYDAY, MAYDAY, MAYDAY, Regule Aire 193, cabin depressurization,***" which was the first response from the aircraft since 13:18. The ATC replied, "***Regule Aire 193, roger MAYDAY. Say your intention.***"

"***We have cabin depressurization here and all of the passengers and crew members except me have fainted… We request vector to the nearest airport to divert,***" she replied, "***and can you confirm fighter jets accompanying us?***"

"***Affirmative,***" replied Lyell ATC, "***we have assigned fighter jets here.***" Then she requested, "***can you leave us alone?***"

"***Negative, but we're vectoring you to Lyell. Vector for visual runway 11R. Turn right heading 270, descend and maintain 9,000.***" replied ATC.

Then, the woman generally acknowledged and followed the guidance and instructions of the ATC. Before landing, she requested "***Regule Aire 193, request firefighters and ambulances.***"

However, when asked about on-board passenger information, she replied "***I'm not sure about the number of passengers …***" Then, a leprechaun, Ithea, grabbed the microphone and asked "***I'm Ithea from RATSC. Who are you?***"

"***Ithea? Oh, I'm Chtholly,***" replied the woman in the radio communication. "***Are you serious?***" asked Ithea, as Chtholly has been dead in an aviation accident before.

"***Or probably I'm Ryehl,***" she replied, "***I just knew this.***" Hearing that, Ithea told the emergency committee that "***this might be the former-soul erosion*** (See further sections for its explanation)***, which has made the dead Chtholly take control of another leprechaun***", while other members in the committee doubted this explanation and still suspected if it was a hijack. But, with this assumption, a team was dispatched to the base of the Leprechauns' Battery in Sky Island 68 to examine and safeguard the body of Chtholly stored there, and firefighters and ambulances were prepared for the aircraft's landing. Then, the aircraft was instructed to complete several turns, climbs and descents to prove that they were not hijacked, and the fighter jet kept the aircraft company. Knowing that the aircraft followed the instructions, the emergency committee concluded that "***this is probably not a hijack,***" but the fighter jet still followed the aircraft.

At 13:59:36, when the aircraft was 2 500 ft above the ground and was about to land, in the

tower frequency of Lyell, she said "***this is the last time Chtholly is with you. Hope to see you again somewhere, and … don't forget to tell Willem that I love him,***" with significant sadness. "***Willem?***" doubted Ithea.

At 14:02:11, the aircraft touched the ground of Lyell airport with -21 ft/min sink rate, and at approximately 14:02:55, the aircraft stopped on the runway. Soon after that, engines were turned off. Meanwhile, at approximately 14:03:11, the team in the Sky Island 68 reported that "***Chtholly's body started to shine and disappear in the air,***" and at 14:09:25, they reported that "***Her body has completely disappeared into the air in this way.***"

When the aircraft stopped, the rescue activities immediately started. See following sections.

1.2 Injuries to Persons

Injury type/Category	Crews	Passengers	Others
Fatal	4	96	0
Major	1	34	0
Minor/None	0	32	-

1.3 Damage to Aircraft

The aircraft structure generally remained complete, except a part of fuselage at the top of the aircraft (**Diagram – General Damage of Aircraft**):

Diagram – General Damage of Aircraft
(The rectangle area is the approximate damaged area)

1.4 Other Damage

There's no additional damage caused by the aircraft.

1.5 Personnel Information

1.5.1 Pilots

1.5.1.1 Captain

The captain was male Bogre, 20 years old.

He was issued an ATPL and instrument flying license (category III) on February 22nd, 442 after studying aviation in Lyell University for 4 years, which valid until August 8th, 453 after his last examination.

Flying Experience:

1 722 hours	Boeing 737-700
2 432 hours	Seniorious 300
257 hours	In last 90 days
29 hours	In last 7 days
34 hours	Rest hours before accident

Employment History:

443 – 450	Air Regule Aire

Medical Certificate: Class A on December 12th, 448.

CRM Training: on June 448.

The training records say that his "***depressurization and emergency procedure test is passed.***" The record of company highlights that his "***performance is usually outstanding, including the ability of dealing with unexpected circumstances***".

1.5.1.2 First Officer

The first officer was male Imp, 22 years old.

He was issued an ATPL and instrument flying license (category III) on March 25th, 445 after studying aviation in Corna di Luce University for 4 years, which valid until November 11st, 455 after his last examination.

Flying Experience:

833 hours	Seniorious 300
211 hours	In last 90 days
22 hours	In last 7 days
40 hours	Rest hours before accident

Employment History:

445 – 447	Corna di Luce Airlines
447 – 450	Air Regule Aire

Medical Certificate: Class A on October 6th, 448.

CRM Training: on June 448.

The training records say that his "***depressurization and emergency procedure test is passed.***"

1.5.2 Flight Attendants

1.5.2.1 Flight Attendant in Section 1.1

The flight attendant was female Troll, aged 25.
She got her certification in April 446.
Duty Hours:

309 hours	In last 90 days
45 hours	In last 7 days
29 hours	Rest hours before accident

Employment History:

446 – 450	Air Regule Aire

Medical Certificate: Class A on October 6th, 448.
CRM Training: on June 448.

The training records say that she "***has outstanding co-operation skills and is always caring.***"

1.5.2.2 Flight Attendant 2

The flight attendant was female Troll, aged 27.
She got her certification in April 443.
Duty Hours:

298 hours	In last 90 days
47 hours	In last 7 days
32 hours	Rest hours before accident

Employment History:

443 – 444	The Guardian Wing Corps
444 – 450	Air Regule Aire

Medical Certificate: Class A on October 5th, 448.
CRM Training: on July 448.

1.5.2.3 Flight Attendant 3

The flight attendant was Golem.

1.5.3 Passenger

1.5.3.1 Ryehl

She was a soldier in Leprechauns' Battery.

She was issued a military pilot license on August 11th, 446 and an ATPL and instrument flying license (category III) on June 8th, 447 after studying in the Guardian Wing Corp's Military Aviation School for Leprechauns.

Flying Experience:

566 hours	Seniorious Military 40
12 hours	In last 90 days
None	In last 7 days

Medical Certificate: Class A on December 19th, 448.

CRM Training: on January 448.

The ratings say: "***She is good at flying … Her performance and hair remind us of Chtholly.***"

According to the accounts of her fellow officers, "***she has blue hair and her hairstyle is usually similar to the former Chtholly.***" (**Photo – Ryehl** (She permitted RATSC to publish the picture)):

Photo - Ryehl

She was believed to be similar to Chtholly (**Photo – Chtholly** (the Guardian Wing Corps

permitted RATSC to publish the photos)):

Photo – Chtholly (Younger)

Photo – Chtholly

1.5.3.2 Other Passengers

According to the name list provided by the airline, no passenger named “Chtholly” or having been using this name before.

1.5.4 ATC

1.5.4.1 Lyell ATC

The Lyell ATC in Lyell FIR had 2 officials, both of whom held required licenses and had worked since 441 and 1 manager holding required licenses and having been working since 439 on duty at that time.

1.5.4.2 Corna di Luce ATC

The Lyell ATC in Lyell FIR had 3 officials, both of whom held required licenses and had worked since 440, and the other of whom had worked since 442, and 1 manager holding required licenses and having been working since 441 on duty at that time.

1.5.5 Leprechauns' Battery (Leprechauns' Brigade) (Chtholly)

Chtholly Nota Seniorious was a soldier in Leprechauns' Battery (at that time, it was called Leprechauns' Armory as well). She took part in the design and manufactory of the Seniorious aircrafts. She died in an aviation accident in November 438.

According to the former investigation report, "***She was well trained and passed all tests on May 3, 432. Before Mr. Kmetsch took control of the 'special battery', she was one of the actual managers of it. She had taken part in many battles, almost all of which succeeded. However, her records showed that she would likely use up her strength too much, making herself in danger. More detailed, According to WG-A-17044.3, at 120h after the beginning, she was 'eroded' but didn't quit. At 724h, she completely 'cut down' the Timere as well as the whole island. It's believed that this overused her ability. See the investigation to learn more.***

> ***She was diagnosed unsuitable for taking part in battles several days before the event, after she lost her ability to fly and use the sword as usual. Therefore, she got such a job and wanted to live a happy life with Willem, according to her friends.[3]***"

The investigation report concluded that "***It can be inferred that Chtholly is probably the virtual descendant of the goddess Elk, which not only gave her ability, courage and determination but also eroded her, and all of them were boosted by the encounter. Whether it's true, as a soldier, she did a lot more than she was required and fought until the last moment. She killed all Timeres, making hundreds of cities are no longer threaten. It was the overuse of her energy during this fight that finally caused her heartbreaking death. Her courage and determination were inspiring.[4]***"

[3] See *The Third Edition of Final Report of 3W-CHT Pltanago Asiatica's Accident* (Raimuskin, et al.), Page 12-13.
[4] Ibid, Page 60.

1.5.6 Ground Engineer

According to the maintenance record, one ground engineer conducted all these emergency maintenance work. He held all essential licenses and started working since March 431 in Air RE.

However, there were also following records in his ratings:

"***He tends to use his own ways to conduct maintenance works.***" (October 435)

"***He sometimes forgets to remove debug devices after maintenance work, which made an aircraft diverted.***" (November 436)

1.6 Aircraft Information

1.6.1 General

The aircraft was Seniorious 300 designed by Seniorious Aircraft Manufactory Co.

It has 2 CFM56 engines, and loaded 35 125 pounds of jet A1 type fuel before taking off.

The aircraft is equipped with 155 passenger seats.

The aircraft had accumulated 13 322 flying hours in its lifespan.

According to the manufacturer, the aircraft's fuselage can suffer 16 psi (110 316 Pa) pressure. When the cabin pressure inside can be considered 12.16 psi, i.e., 83 840 Pa, the outer pressure is usually approximately 4.46 psi, i.e., 30 750 Pa, under AUTO mode of pressurization (See following sections). Thus, in this condition, the maximum internal pressure the fuselage can suffer is 20.46 psi, i.e., 141 066 Pa, beyond which the fuselage's shape will change, and when the pressure goes beyond 33.5 psi, i.e., 225 388 Pa, the fuselage may break apart.

1.6.2 Maintenance History

1.6.2.1 General

The maintenance record of the aircraft is:

Maintenance Type	**Actual Interval (Flight Hours)**	**Required Interval (Flight Hours)**
Special Maintenance (About Pressurization and Oxygen System)	-	-
A Maintenance	231	250
B Maintenance	978	1 000
C Maintenance	3 779	4 000
D Maintenance	-	24 000

1.6.2.2 Special Maintenance

Due to the in-flight malfunction mentioned in History of Flight (the unexpected deployment of oxygen masks), a special maintenance was conducted by a maintainer mentioned in Personnel Information. According to the maintenance record and his accounts, he conducted the maintenance in following ways:

1. Checking the system: He "***found the isolation locker*** (See further sections) ***moved a bit***". Therefore,
2. He "***tried to reset the block but failed***", and then hen "***replaced the block by an Aluminum block weighing approximately 72g and adjusted the position of the motor***".
3. To examine the whole system, he "***connected the two parts*** (See further sections) ***of the oxygen generators by using a pipe***". When asked about whether he had removed the pipe, he said he did.

When asked about the consequence of using an Aluminum block, which might be easily eroded, he said that "***I think water won't easily go in… Therefore, there's little chance for it to be eroded. The vapor under that temperature won't be so much.***"

1.6.2.3 Required Procedure of the Emergency Maintenance

According to the Seniorious 300 Maintenance Manual, the maintenance steps of the oxygen generation system is: "**…**

> ***To examine the installed/maintained system, connect both 'test holes' with a <u>temporary</u> pipe and add a little more oxygen concentrator. If there are bubbles which contain gas re-igniting extinguishing matches, the system is operative.*** " The word "***<u>temporary</u>***" is in bold and underlined.

Investigators examined other 121 Seniorious 300 aircrafts of Lyell and Corna di Luce airlines. It turned out that all of them didn't have the unexpected pipe connected.

1.6.3 System Information

1.6.3.1 Bleed (Pressurization) System

In the bleed system, the air conditioning devices provide gas for the cabin to maintain the cabin pressure by making off the leaking gas.

The bleed system has 3 modes: AUTO, ALTN and MANUAL. The three systems work like (notice that this system differs from Boeing 737):

- AUTO mode: With the given FLT ALT (cruise altitude) and LAND ALT (landing altitude), the pressurization system automatically uses following phases:
  - Climbing phase: The automatic system calculates the most comfortable climb rate of the cabin altitude[5] towards the related cabin altitude in the cruise altitude,

[5] Cabin altitude means an altitude value whose related air pressure equals to the actual air pressure in the cabin.

i.e., select the most comfortable pressurization speed.

- Cruise phase: The automatic system keeps a constant cabin altitude, whose pressure value is comfortable and safe.
- Descending phase: The automatic system calculates the most comfortable descending rate of the cabin altitude towards the related cabin altitude in the landing altitude.

The system fails when one of the following situations occurs:

- Low DC power volts.
- The climbing/descending rate of cabin altitude exceeding 2 000 ft/min.
- The cabin altitude exceeding 14 000 ft.

- ALTN mode: With the given target cabin altitude and climbing/descending rate, the system adjusts the valves. This works like the V/S mode of the autopilot, i.e., the system tries to keep the given rate until the cabin pressure reaches the value.
- MAN mode: The opening and closing of valves are completely manual, adjusted by a switch.

The bleed system is controlled by this panel (**Diagram – P5 Bleed Panel**):

Diagram – P5 Bleed Panel

In which:

- "AUTO FAIL" red or amber light (depends on the manufacturer): The AUTO (automatic) mode failed.
- "OFF SCHED DESCENT" amber light: This will be illuminated in one of the following situations:

- The aircraft starts descending before reaching designated cruise altitude, making the aircraft entering descending phase (may quit after another climb), or
- The cabin pressure unexpectedly drops (when the descending rate is 400 ft/min more than expected) but didn't go beyond the limit of AUTO mode.

- "ALTN" and "MANUAL": Indicating the ALTN or MANUAL mode of bleeding.
- "FLT ALT" input: The cruise altitude in AUTO mode or target altitude in ALTN mode.
- "LAND ALT" input: The landing altitude in AUTO mode or expected climbing/descending rate in ALTN mode.
- "MANUAL" part:
  - "VALVE": indicate the current valve (See following introduction) position.
  - "CLOSE/OPEN": switch used to adjust the valve.
- "AUTO/ALTN/MEN": The mode selector of bleed system.

There is also a cabin pressure indication device (**Diagram – Cabin Altitude Indication Panel**):

Diagram – Cabin Altitude Indication Panel

This indicates the cabin altitude and its climbing/descending rate.

More detailed, this system is connected to a pressure detector providing Δp information (will be mentioned in further sections). The climbing/descending rate will be calculated by related independent components in the cockpit, which control the 2 indications in the diagram above.

The bleed system uses the gas from the engine or APU and following valves to control the pressure in the cabin:

- Front and rear air flow valves,
- 2 safety depressurization valves, and
- negative-pressure depressurization valves.

1.6.3.2 Passenger Emergency Oxygen Supply System

Both the passenger oxygen and crew oxygen come from a single device (**Diagram – Model of Oxygen Supporter** (Some supporting structures are not drawn in the diagrams)):

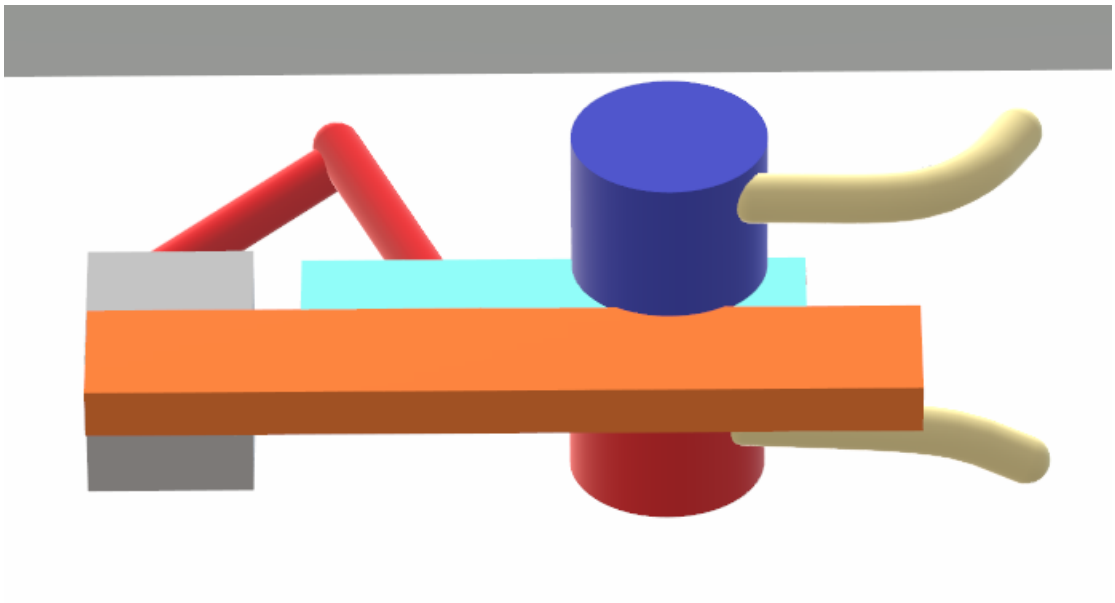

Diagram – Model of Oxygen Supporter (a: Front view)

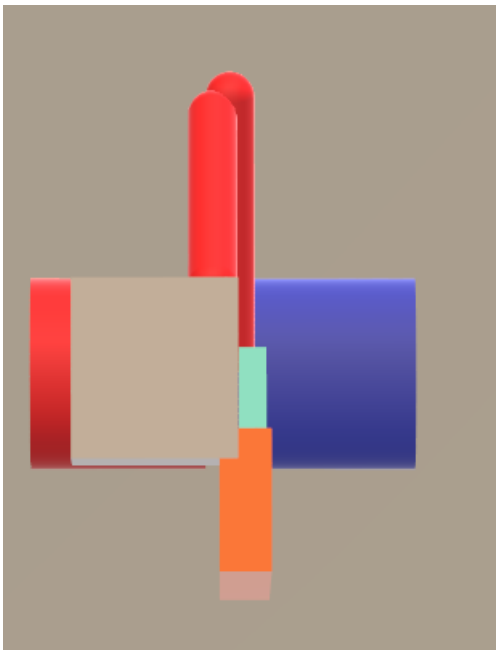

Diagram – Model of Oxygen Supporter (b: Left view)

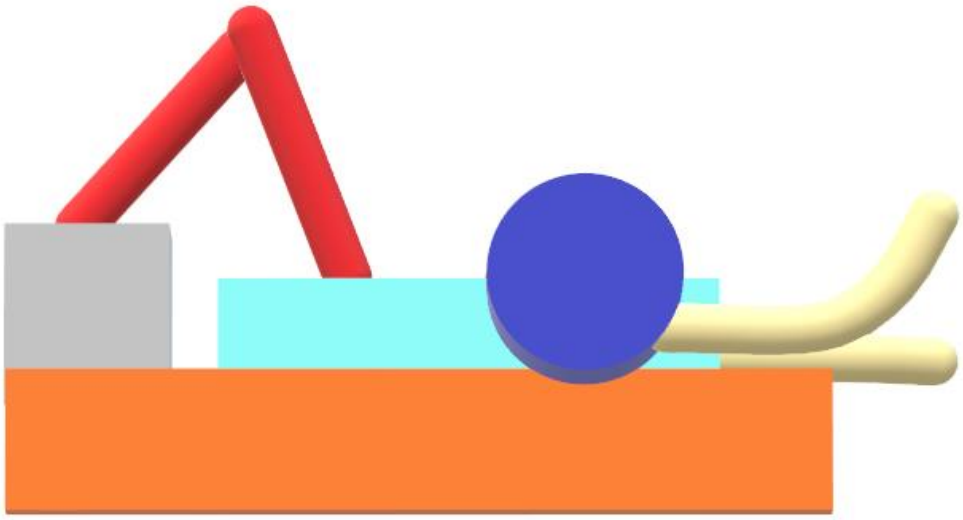

Diagram – Model of Oxygen Supporter (c: Top View)

In which:

- Gray: Motor receiving instruction from cabin or pressure detector to start the oxygen generator;
- Cyan: The locker isolating the blue (storage of oxygen-generation substances, whose main substance is Na_2O_2) and the red (H_2O storage);
- Red: Sticks to support the movement of the locker;
- Orange: Panels limiting the movement of the locker;
- White: O_2 supply for passengers and crew members or CO_2 input from them.

In each of the 3/4 position of the bottles, there is a “test hole” for maintainers to connect a pipe for debug purpose.

The major related chemical equations are:

$$2Na_2O_2 + 2H_2O = 4NaOH + O_2 \uparrow$$

According to the requirement of REAA, it should provide 19 000 L (Approximately 810 mol[6]) oxygen in total. This means approximately 126 kg (Approximately 1 620 mol) Na_2O_2. In view of other substances and probable unexpected reaction with H_2O gas in the air inside, usually, 135 kg of Na_2O_2 is loaded.

Besides, the equipment cooling area doesn't include oxygen generator, as it is usually turned off and not working.

1.6.3.3 Air Conditioning System

The air conditioning control panels are (**Diagram – Air Conditioning Panels**):

Diagram – Air Conditioning Panels (1)

In which:

- "AIR TEMP" switch and indication: Providing the air temperature of the given area;
- "TRIM AIR" switch: Turn on or off additional air trimmer (allocator);
- "CONT CAB", "FWB CAB" and "AFT CAB" knob: Adjust the temperature of the cockpit, forward or backward cabin;
- "ZONE TEMP": Failed to get the temperature data or maintain the temperature in

[6] The value depends on the temperature. As it often changes, a larger value is used.

the area.

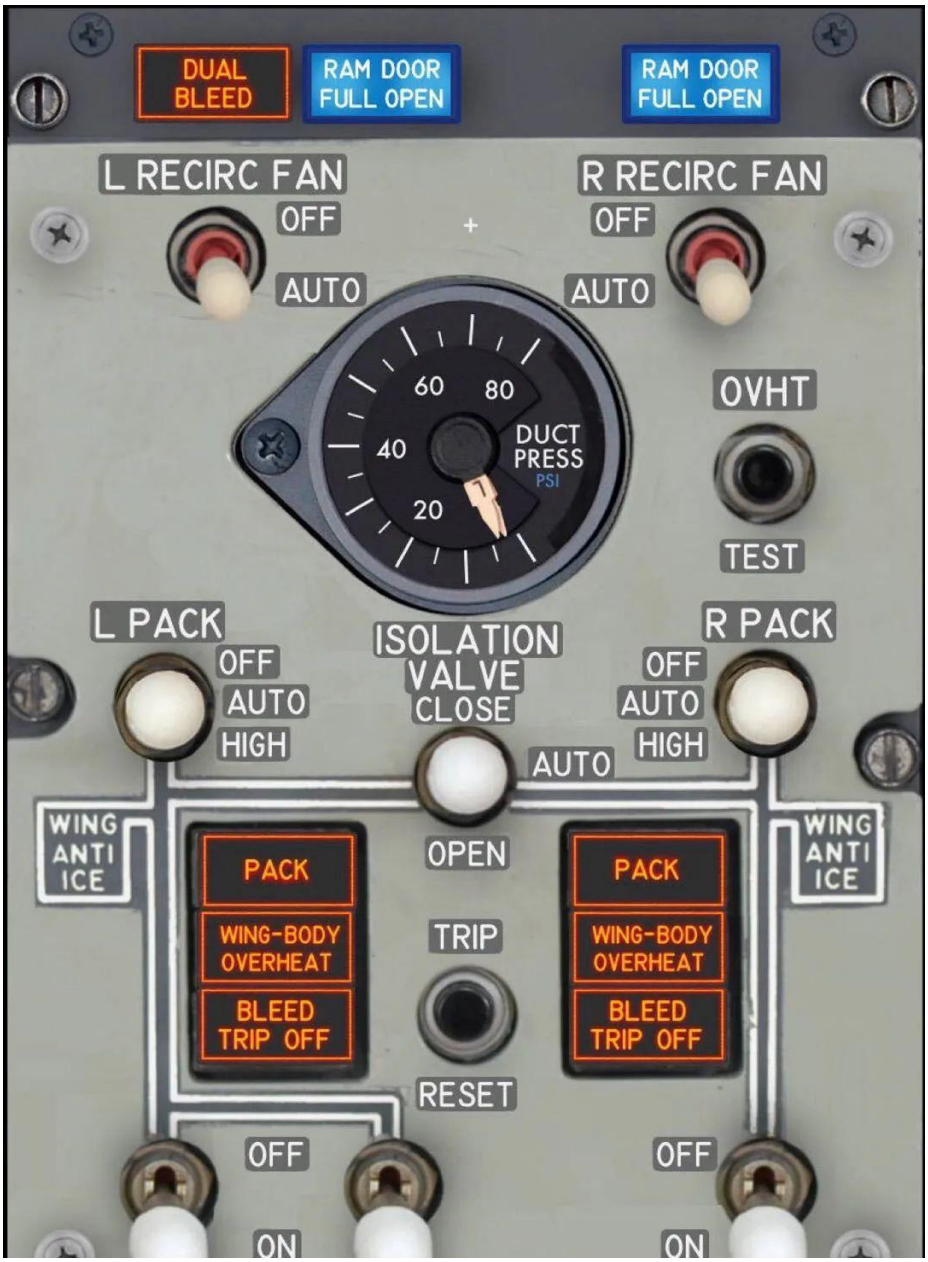

Diagram – Air Conditioning Panels (2)

In which:

- "DUAL BLEED" amber light: Indicate that the aircraft has 2 independent bleed sources, which makes the air goes in from the one and goes out from the other;
- "RAM DOOR FULL OPEN" blue light: Whether ram air door, used for providing cooled air, is full open;
- "L/R RECIRC FAN" switch: Control whether the air flows as a circle in the cabin;
- "DUCT PRESS" indication: The remaining pressure in the air pipes, which can be provided for other systems;
- "L/R PACK" switch: The L/R air conditioning pack ON/OFF switch;
- "PACK" amber light: Indicating that the air conditioning pack has been malfunctioning;
- "WING-BODY OVERHEAT" amber light: Indicating the overheating status of the air

conditioning parts;

- "BLEED TRIP OFF": The bleed system is automatically disconnected from the aircraft due to high temperature;
- "RESET" button: Resetting the air conditioning electric circuit to fix malfunctions;
- The 3 switches at the bottom: ENG 1, APU and ENG 2 bleed input switches.

In these systems, the aircraft has not only normal hot-cold air combination but also an "active cooler/heater". Turning the know to the left 1/3 part of "C" or right 1/3 part of "H" on the ground means turning it on.

The air conditioning system consists of two surfaces. In the "active" mode, the one towards the cabin can cool the cabin down and transfer the heat to the other side in the equipment area, so that it can go into the air outside later. Without the ground air conditioning support, this increases hot or cool air.

1.6.3.4 General Layout of Systems

The systems mentioned above are put at the top of the ceiling of the cabin (**Diagram – Layout of Systems**):

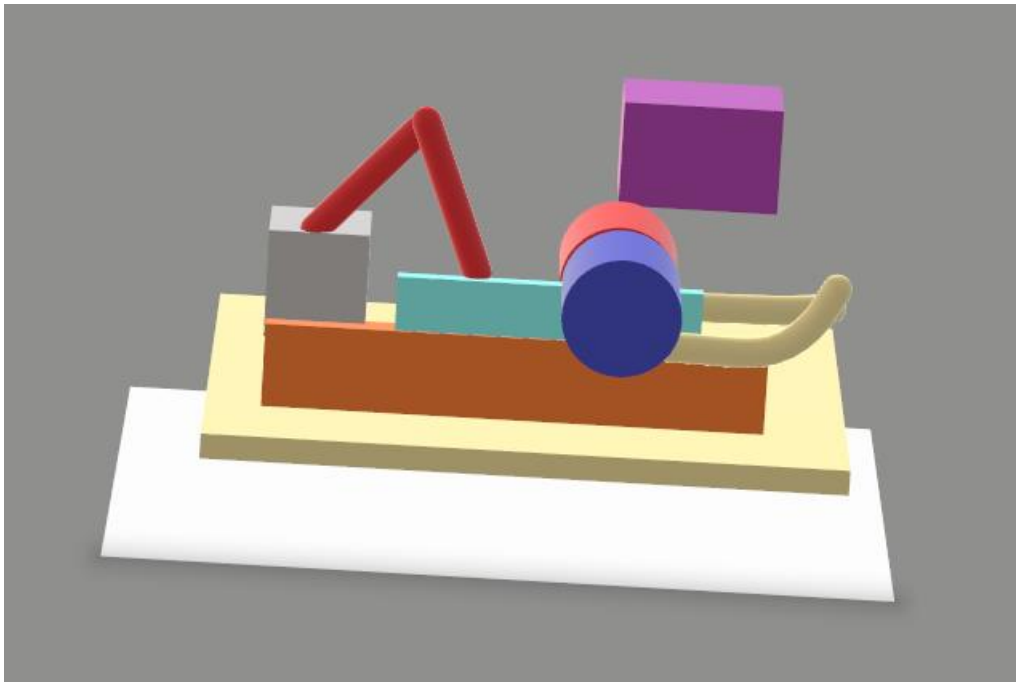

Diagram – Layout of Systems

In which:

- Purple: Cabin pressure detector;
- Yellow: Air conditioning surfaces;
- White: Cabin;
- Gray: Fuselage.

Moreover, there is a plastic isolation panel between the oxygen device and other components to prevent the negative influence of probable leakage of chemical substances of the oxygen

generator. The isolated space is 12 000 L in size.

The systems are located above the seat 7C of the aircraft.

1.6.3.5 Cockpit Door System

According to the manufacturer, the cockpit door will open if:

- One of the correct passwords (including manufacturer password and operator password) is input, or
- The Δp between the cockpit and the cabin becomes > 1.4 psi.

and unless:

- The cockpit door switcher is turned to "DENY" position.

1.6.3.6 In-Flight Operative and Inoperative Systems

According to the FDR data:

- Before 13:16:55, the bleed system was set to AUTO and the system worked normally.
- At 12:29:16, the air conditioning systems were set to 1/3 "C" position, which turned on the "active cooling" system.
- At 13:02:11, the "active cooling" system was automatically powered off.
- At 13:05:15, the autopilot was engaged.
- At 13:17:09, the AUTO system opened safety depressurization values to deal with the increasing Δp detected.
- At 13:42:32, the bleed system was set to MANUAL and the valves were set to full CLOSE position.
- At 13:47:53, the autopilot was disengaged.
- At 14:02:13, the speed-brake (spoilers) and autobrakes were applied.

1.7 Meteorological Information

The weather provided by the Lyell FIR is:

"***METAR RHEL 301030Z AUTO 23002KT CAVOK 30/M25 Q1012***"

i.e., At 10:30 UTC, the auto weather station reported that the wind direction was 230 kts and the visibility was high enough. The temperature was 30 degrees Celsius and the dew point was 25 degrees Celsius.

The ground temperature reached 35 to 40 degrees Celsius according to the airport workers.

According to the Lyell weather departments, there was a "***sudden change***" of weather these days. "***Yesterday, the highest temperature was just 21 degrees Celsius,***" said an official on the day when the accident took place.

1.8 Aids to Navigation

The aircraft was equipped with IRS, FMC and VOR devices. According to the maintenance record, they never got malfunctioning since last A-type maintenance.

1.9 Communications

1.9.1 Communication Devices

The communication devices include:

- VHF communication ranging from 105 MHz to 155 MHz and including 243 MHz;
- Transponder;
- FMC message service.

All of them are manufactured by Seniorious Aircraft Manufactory Co.

According to both the CVR and ATC's tape record, the communication devices worked normally.

1.9.2 Communication Quality

It has been measured by the ATC's device that the S/N was approximately -84dbm during the accident. Therefore, the quality of the communication is guaranteed.

1.10 Airport Information

The aircraft took off from Lyell airport and diverted at Lyell airport.

1.10.1 General

The airport has runway 11L/25R and 11R/25L, and its runway lengths are 5 250 ft and 6 630 ft.

The airport supports CAT III landing on 11L/25R and CAT II landing on 11R/25L. PAPI and other devices are also installed.

The airport is equipped with corridor bridges, which provide passengers more comfortable boarding experience and prevent them from deliberately entering the ground engineer area[7].

[7] This is under the requirement of *Final Report of Seniorious SEN-001 Severe Incident in Scarborough* (Doc WG-R-3493) (January 437).

1.10.2 Firefighters and Ambulances

The airport is equipped with 9 firefighters. Also, there is a co-operation between the airport and nearby hospitals, ensuring that ambulances can directly enter the runway or apron to start rescue missions.

1.10.3 Maintenance Devices

The airport provides all airlines with qualified maintenance devices, which contribute to efficient and safe maintenance work. The pipes the maintainers used, to better suit the aircraft, are usually the same as the ones on the aircraft.

According to the maintainers of Air RE, they always used them as their utilities.

1.10.4 Ground Power and Air Conditioning Services

The airport provides free ground power vehicle, which can be used by any operators allowed to takeoff from or land at this airport with entrance fee.

However, the ground air-conditioning vehicle can't be used for free.

1.11 Flight Recorders

The flight recorders are located at the tail wing of the aircraft (**Photo – Flight Recorder**). Soon after the accident, they were collected in time and sent for analyses.

Photo – Flight Recorder

1.12 Wreckage Information

According to the description of the damages to the aircraft, the aircraft remained generally complete, with only a piece of fuselage separating from it.

1.12.1 The Fallen Component

The piece of fallen fuselage has been found (**Photo – The Fallen Component**):

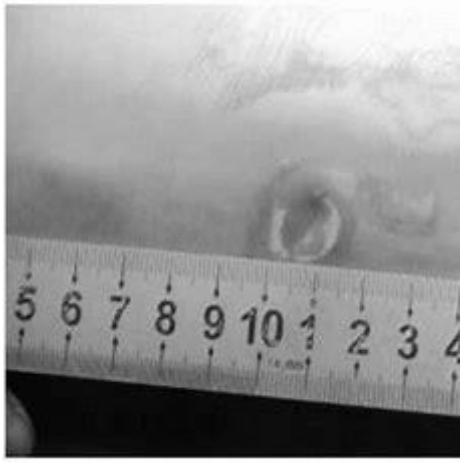

Photo – The Fallen Component

The point in the center, whose length is approximately 15 mm, suggests internal explosion.

Besides, from where the fallen fuselage should have connected to the aircraft, investigators found rivets exposed to the air.

1.12.2 The Oxygen Generator Component

The oxygen generator components are also well collected.

1.12.2.1 Containers

Investigators found cracks on the both of the containers, suggesting explosion inside. Both the containers have a hole approximately 5×6 cm in size.

1.12.2.2 Isolation Locker

The isolation locker has broken apart. Investigators used microscopes to examine the locker (**Photo – Broken Isolation Locker Component Under Microscope**):

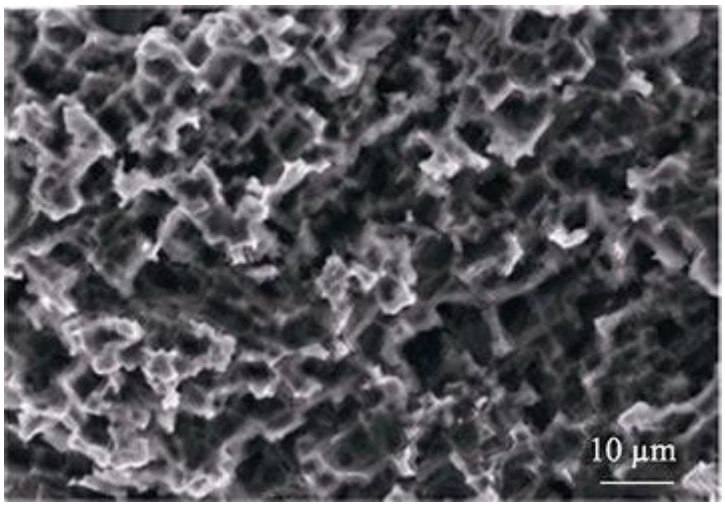

Photo – Broken Isolation Locker Component Under Microscope

This structure suggests erosion of the Aluminum material.

1.12.2.3 External Information

Different from the maintainer's account, investigators found broken components of pipes connected to the container, and the broken surfaces successfully match each other. Therefore, the pipe is probably connected during the accident, allowing the gas to go through it.

1.12.3 The Configuration of the Aircraft

The air conditioning panel and the bleed panel was configured as follows when the plane touched the ground and the rescuers examined the aircraft:

- "AUTO/ALTN/MEN" mode selector: MAN, with "VALVE" at full "CLOSED";
- "AIR TEMP" switch and indication: FWD;
- "TRIM AIR" switch: ON;
- "CONT CAB", "FWB CAB" and "AFT CAB" knob: At 1/3 "C" position;
- "L/R RECIRC FAN" switch: ON;
- "L/R PACK" switch: ON;
- ENG 1 Bleed: ON;
- APU Bleed: OFF;
- ENG 2 Bleed: ON;

1.13 Medical and Pathological Information

1.13.1 Medical Information

1.13.1.1 Medical Detect Before Flight

According to the company record, before the pilots got on board, they all passed drug and alcohol test.

1.13.1.2 Cabin Depressurization Results

Cabin depressurization may cause following responses:

- Altitude sickness, including dizziness, followed by
- Hypoxia, leading to fainting. The effects of hypoxia are described in the additional information section.

When the oxygen pressure continues to drop, passengers will be dying. The following pathological will discuss this.

1.13.2 Pathological Results

In the dead bodies of passengers, pathological analyses saw cyanosis of fingertips, or, in other words, the fingertips became purple because the hemoglobin began to separate from oxygen. Similar process also happened to their lips, indicating hypoxia death.

Pathological analyses also saw the injury caused by blunt instrument on the passengers on seats in row 6, 7 and 8. Some surfaces of the dead bodies were sticky.

1.13.3 Leprechauns' (Ryehl's) Facts

1.13.3.1 General

According to the former investigation report[8]: "***Leprechaun is a race. It should be clear that leprechauns are virtual beings which are caused by the world's 'pointer error'. More detailed, they are created from early died creatures, and as they 'inherit' genetic material, they seem to inherit the former souls from ancestors.***

Besides, it has been frequently reported that the erosion take place, which is usually caused by the overuse of their energy and represented by the changes of colors of hair and eyes, usually becoming red, which is similar to Chtholly's experience. Most of the eroded ones failed to recover

[8] Ibid (see footnote 3), Page 43.

and soon died, but some of them successfully recovered. One of the success examples is Ms. Valgulious in our investigation team, but she couldn't remember anything else special besides keeping and reading her own diary. This showed few contributions to others' recovery."

The report also concluded that a low pH suggests erosion, and found out that $pH \leq 5$ suggests complete erosion of Chtholly. However, the erosion cases of leprechauns are not always the same. The most different case was Ithea, who had no feeling about erosion before complete replacement, according to herself.

The report analyzed: "***As for her recovery, both the factors above and the hypoxia the low air pressure might have caused this.***"[9] This suggests that under hypoxia conditions, leprechauns have better performance than normal creatures.

The report mentioned: "***It is measured that this connections between leprechauns and their former souls , or ancestors, are implemented by*** H^+ ***(but not spent), while the force it brings comes from spending*** NO_2^-***, which are the only differences of substances between humans' and leprechauns'.***

From this, we can say that the key difference between other creatures and leprechauns is H^+***, because it indicates how leprechauns suppress their connection to their ancestors to stop being eroded, while others needn' t. As for*** NO_2^-***, it might be introduced to increase the pH of leprechauns and increasing their ability to fight is probably an unexpected effect.***"[10]

The report concluded and suggested: "***Chemical analysis suggests that the leprechauns can be boosted by*** NO_2^-***, as this is the true reason why they can fight, but its negative effects are unknown. The detection using*** Ag^+ ***to evaluate their ability is outdated and should be stopped, therefore, but the function of examining their health is approved. Instead, use reducer or oxidant to detect is a better idea.***"[11]

1.13.3.2 Zoological Facts

It was measured that Ryehl's blood pH changes as follows (**Figure – Measured Blood pH**):

[9] Ibid, Page 50.
[10] Ibid, Page 47.
[11] Ibid, Page 70-71.

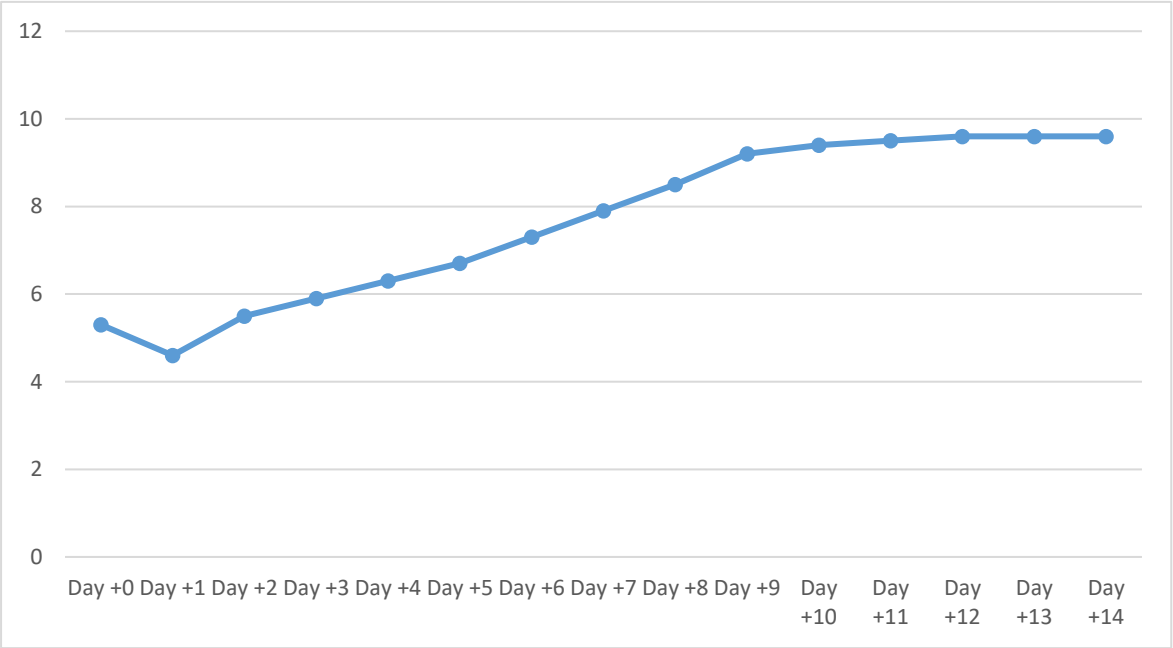

Figure – Measured Blood pH

According to the former investigation, it suggests that erosion had taken place. However, it seems that she recovered from it. In 155 days, she wasn't eroded again.

Besides, DNA analyses before accident have proved that in 40 DNA sequences examined by investigators, compared with stored Chtholly's DNA sequences, Ryehl had 33 identical ones, and this value remained the same after the accident.

1.13.3.3 Mental Facts

According to the Guardian Wing Corps, Ryehl once mentioned that "***she feels like someone else existing in her mind. … I saw a gray plain and a girl with blue hair faraway. … I tried to pull her but her tried to stay. I have no idea about who she was and why I did that actually.***"

During the interview with Ryehl after the accident, she accounted:

"***At that time, I saw oxygen masks deployed. Everyone was scared, and some passengers started to scream as they were hurt by the collapsed ceiling or found there was no oxygen coming out from the mask. Flight attendants tried for many times but it didn't work. Soon some passengers fainted.***

Then the flight attendants brought several large oxygen bottles for everyone. These bottles struggled to provide oxygen for about 10 minutes (Actually 8 minutes) ***– and then everyone fainted, including me.***

Then I probably had a dream. On the dark gray plain, I saw a girl with blue hair standing in front of me. She asked, 'are you taking flight 193 to Brisun?' 'Yes,' then I replied.

She then said, 'well, that's not good. The bleed system has failed and everyone has fainted, haven't they?', 'yes,' I answered, 'but what can I do?'

'Don't worry, I'll help you,' she said.

After that, it seemed that I woke up – I don't know if I really woke up – and I heard she saying: 'go towards the cockpit'. I did that.

'I'll do all of the works,' then she said, 'oh, besides, what's your name?'

'Ryehl,' I told her, 'so what's yours?'

'I'm Chtholly,' she said, during which I saw my hands pushing the keys of the password keyboard – yet I can't control them and the only thing I could do is to watch this.

Then I felt a force pushing my legs to move into the cockpit. Before I could response, I had been in the captain seat. I had never seen the cockpit of Seniorious 300 – I have only flown military planes. Then she told me, 'I'm one of the designers of the aircraft, so it's my turn to save all of you.' I tried to nod – probably she got my meaning. From that on I saw her hands quickly moving through the front panel, adjusting the settings. She, or I, turned the pressurization switch – I guess that is, because our military planes have the same design – to 'MANUAL'. Then she pushed PTT button and declared MAYDAY. I couldn't remember more.

When the radio altimeter called out '2 500', I heard myself, or her, saying 'this is the last time Chtholly is with you' to the radio. I just can't understand this – and I still have nothing to do but to watch.

Then, when the aircraft touched the ground, I suddenly found that I could regain control of myself. Within a second, I knew that I had to stop the plane. I extended speed-brakes and thrust reversers at once. Then the aircraft stopped and I shut down the engines – but I felt as if I had been in a dream."

1.14 Fire

There was no sign of fire on board.

1.15 Survival Aspects

1.15.1 Rescue Activities in Lyell

Before the touchdown of the aircraft, as the pilot required, firefighters and ambulances had been ready. After the aircraft touched the ground, firefighters and ambulances immediately started their rescue missions. But they "***see no doors opened and can't enter the cabin***", according to the radio communication at that time.

At 14:04:15, the firefighters and other rescues tried to open the door as they saw no one was deploying emergency slides from the cabin doors.

At 14:04:53, the emergency committee entered "***rescue phase***".

At 14:06:22, the first cabin door was successfully opened. Firefighters entered the cabin and reported that "***everyone has fainted except a young woman***" through radio. She was asked to join the rescue work and they worked together then.

At 14:25:36, all passengers went out of the aircraft. As they got off, they were immediately sent to Lyell's hospital. By 15:30, the hospital declared 85 deaths, including 81 passengers and 4 crew members. In 30 days, 15 extra passengers died. It was also reported by hospital that they found some passengers had alkali burn.

34 passengers and 1 crew member survived but need to stay in the hospital for 2 to 60 days. It

was reported that their ability of memorizing things reduced.

There were also 32 passengers survived and only minorly hurt. They recovered quickly, but the loss of memory was also reported among them.

1.15.2 Search and Rescue Activities in Sky Island 68

The search and rescue team arrived at the Leprechauns' Battery in Sky Island 68 at 13:57. They safeguarded Chtholly's body, but were surprised to found Chtholly shining and disappearing. They tried to stop this, but nothing worked.

1.16 Experiments and Researches

1.16.1 Oxygen Generator System

The probable chemical reactions are the original reaction of oxygen generation and

$$2NaOH + 2Al + 6H_2O = 2Na[Al(OH)_4] + 3H_2 \uparrow$$

In this case, there's less Al than $NaOH$ in the end.

1.16.1.1 Single Leakage Experiment

Investigators tested if the leakage of Na_2O_2 or its combination with water directly causes the accident. To test this, investigators put these two materials in two containers and removed the isolation locker between them. The pipes to output oxygen and input other gas were blocked (so were following experiments).

Investigators initially placed a simulated sealed cabin environment in 20 degrees Celsius, and then heated it without adding or reducing its gas inside.

Investigators tested this under different temperature:

(Value means the internal pressure, unit: psi)

Starting Temperature / Time	2 min	4 min	6 min	8 min
20	18.11	23.04	27.72	32.44
30	18.29	23.36	28.15	32.57
40	18.42	23.85	28.89	32.63
50	18.60	24.28	29.44	32.69

However, none of the groups broke down the fuselage, as all values are smaller than 33.5 psi.

Besides, investigators tested if the leakage can happen on its own. The result is that if a pipe is connected from the bottom to the top and the whole device is heated, the leakage is more likely to happen (32% probability, compared with 1% probability among devices directly exposed to the air).

1.16.1.2 Single Explosion Experiment

Investigators tested if the combination of H_2 and O_2 directly causes the separation of the fuselage.

It has been known that:

$$2H_2 + O_2 = 2H_2O \ \Delta H = -571.6\,\text{kJ/mol}$$

It has also known that the explosion concentration of H_2 is 4% ~ 75.6%, and it requires 400 ~ 600℃ temperature.

In the real-life experiment, explosion happened, damaging the pressure detector system and making the fuselage separated from the aircraft.

1.16.1.3 Air Conditioning Heat Accumulation

Investigators tested if the air conditioning produces significant heat on the ground. The result is given below (values are the temperature values of the ceiling devices, regular text for no "active cooling/heating", **bold text** for turning on "active cooling/heating"):

Outer Temperature/ Set Temperature	15	20	25	30
15	16 **16**	24 **29**	33 **37**	39 **43**
20	21 **22**	21 **21**	29 **36**	35 **40**
25	25 **26**	26 **26**	26 **26**	34 **37**
30	30 **30**	30 **30**	31 **31**	31 **31**

From this table, it can be seen that when "active cooling" (Outer > Setting) works, the additional heat is significant.

1.16.2 Flight Simulation

1.16.2.1 Bleed System

Investigators tested the behavior of bleed control panel (P5 panel mentioned in the former sections) under the similar circumstances. It turned out that the "OFF SCHED DESCENT" amber light was illuminated.

Investigators were surprised to find when the pressure detector system stopped outputting to the bleed control panel, the indication of the cabin pressure remained the same.

1.16.2.2 Aerodynamic Performances

Investigators also tested the aerodynamic performance when a part of fuselage is separated from the aircraft.

1.16.2.3 Other Pilots' Participation

Investigators invited other pilots to participate in the flight simulation with a similar circumstance and process. The result was that most pilots only conducted the "OFF SCHED DESCENT" checklist and failed to consider other affairs, including the probably-separated wreckage in the blackout time (approximately 40 seconds according to the CVR).

1.17 Organizational and Management Information

1.17.1 Air RE

1.17.1.1 General

The operator has an AOC, numbered No. 1 [365], since 365, and has been updated every 4 to 5 years. The next update is scheduled in 452. The record says that in the past 5 years, the airline had no accident or severe incident.

The passengers tend to have positive comments on this airline, saying "***The planes are usually on time… I have never heard an Air RE flight cancelled because of technical reasons these years. I guess their maintenance work is excellent and efficient.***"

1.17.1.2 Maintenance Workflow

The maintenance and dispatching workflow of Air RE requires following steps:

1. Pilots or ground engineers report the maintenance requirement to the Air RE system. From this step, the aircraft will be "not dispatchable";
2. Air RE system dispatches engineers and other maintainers to conduct maintenance mission and dispatch additional materials if needed;
3. Air RE system dispatches engineers to check the maintenance work;
4. Pilots or other engineers confirm the completion of the maintenance, or re-execute the maintenance procedure;
5. The aircraft is re-added into the "dispatchable" list.

However, investigators noticed that the 4th step (confirmation) doesn't require detailed check. Or, in other words, by simply clicking "Completed", without any revision item given, the step is completed.

1.17.1.3 Emergency Flying Procedures

The "OFF SCHED DESCENT – Seniorious 300" checklist of the airline is:

OFF SCHED DESCENT (Off-Scheduled Descent)

Status: "OFF SCHED DESCENT" light is illuminated.
1 Consider one of them: ◆ **Landing** at the takeoff airport: Continue normal flight. ◆ **Not landing** at the takeoff airport: Reset "FLT ALT" to the actual altitude. Continue normal flight. ■■■■

As for other kinds of procedures related to this accident, the "FUEL LEAK" checklist instructs the pilots as follows[12]: "

…

When suspecting fuel leakage, …

[Step 3] ***Record the current fuel weight. Then wait for 20 minutes.***

[Step 4] ***If the fuel use of one side is significantly faster (e.g., 10 lbs/min difference), or the total difference reaches more than 120 lbs, consider a fuel leak: …***"

The cabin depressurization as well as emergency descent procedure requires "***Immediately descend to 9,000 or MDA. Select the higher.***" (Step 6 in cabin depressurization and step 4 in emergency descent). However, as for cabin depressurization procedure, before this step, it requires "***Level off the aircraft and check …***" (Step 4).

1.17.1.4 Standard Ground Procedures

According to Air RE clerks, there was an internal announcement in their company:

"***The use of the ground air-conditioning vehicle in some airports, including Ryell, must be reduced to cut down the cost of a flight. … For Seniorious 300, 400 and 500 equipped with 'active cooler', it should be used. … The bonus of the pilots who used ground air-conditioning vehicle if not necessary will be reduced.***"

Some pilots from the Air RE says that "***we tend to use the 'active cooler' if possible… It only uses electricity and meets the company's standard.***"

Besides, on the ground, the CRM is required to be like as follows without special conditions: "***Captain: PF; First Officer: PM (unless a training project is being conducted);***
Finish following tasks:

1. ***Before pushback checklist (PF+PM); - 2 min[13]***
2. ***Performances' calculation (PF) and on-board passenger announcement (PM); … Cross-check - 4 min***
3. ***Pushback request (PM); - >2 min***
4. ***Before takeoff checklist (PF+PM) when taxiing; - 5 min***
5. ***Takeoff. - >13 min***"

[12] The checklist is too long and the other parts have nothing to do with this investigation.
[13] The values are provided by the airline to help with predicting the actual takeoff time.

Some pilots say that "***our muscles are going to memorize these items… We just want to do it faster, not only for bonus but also for the reputation for the airline. You know, the aviation these days are not developing well.***"

1.17.1.5 Training of Flight Attendants

Through the interview with the manager of the Air RE, investigators learned that "***the airline's training never involves entering the cockpit with the correct password… in order to prevent a probable hijack, which frequently happened at the time when Air RE was established.***"

1.17.2 Aviation Authorities

The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2) states: "

Article 4 All nations, autonomous cities and regions shall[14] have its own aviation authorities, taking on following responsibilities:

…

(c) Ensure the safety and freedom of the aircrafts and the winged species aimed to safeguard the whole Regule Aire, including the Guardian Wing Corps, unless they violate Article 15 (a);

…

(g) Securing its airspace, preventing hijacking and other activities threatening the safety of residents in Regule Aire and normal flights;

(h) Have an independent organization to conduct aviation accident and incident investigation of aircrafts, and

The flying of the winged species should be managed by other particular organizations;

…

(k) An emergency committee or the creation workflow of an emergency committee in case of emergency situations."

The structure of Lyell aviation authorities is given as follows (**Diagram – Lyell Aviation Authorities**), under the requirement of *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)*:

[14] *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)* also states: "***The 'shall' means requirements, while 'should' means recommendations.***"

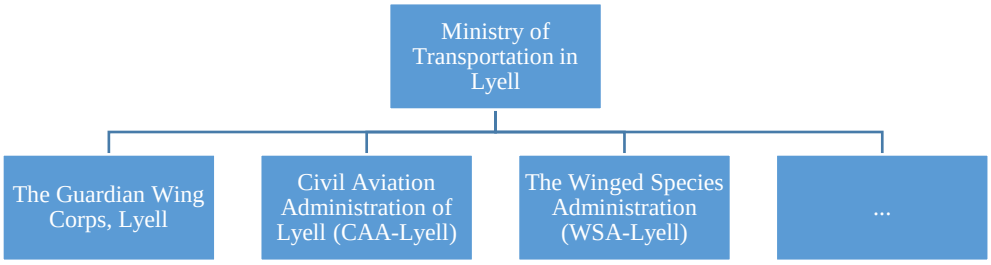

Diagram – Lyell Aviation Authorities

The structure of Corna di Luce aviation authorities is similar.

1.17.3 The Guardian Wing Corps

The Guardian Wing Corps is led by the central command, with air force and ground force.

1.17.4 Emergency Committee During the Accident

The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2) states: "

Article 24 ***Emergency situation is a situation where at least one aircraft's safety is threatened. It can be caused by following factors:***

(a) ***Hijack or other crimes included in The Constitution of Regule Aire or local laws[15] committed on board;***

…

(f) ***The failure of pressurization and/or bleed system, causing hypoxia;***

…

Article 29 ***In case of emergency situation defined in Article 24, the persons and organizations included in aviation accident and incident investigation team shall be organized and an emergency committee or similar organizations shall be established in order to respond to and try to solve the emergency situation.***

The members in the emergency committee shall get the same rights and permissions as the members in investigation team have.

The emergency committee is responsible for the following affairs:

(a) ***Take effective measures to prevent emergency from becoming an***

[15] The laws of the aircraft's departure and arrival nations are valid here.

accident or incident;

…

(c) Announce the status of the aircraft(s) in danger;

(d) Inform the operator of the aircraft, the owner of the aircraft, and passengers' and crew members' relatives of the emergency;

…

(g) Participate in the further investigation of the emergency (if needed)."

Therefore, the emergency committee included the Ryell and Corna di Luce aviation administration officials, REAA, RATSC and the Guardian Wing Corps.

1.17.5 ATC Service Workflows

The ATC service rules in Lyell are given in an internal document: "***When losing contact with an aircraft, immediately report this to the on-duty manager.***" *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)* also states: "

Article 26 When an aircraft is in MAYDAY emergency or an aircraft has lost contact with all ATC stations, local aviation departments shall:

(a) Inform the FIR the aircraft has been in or might be in;

(b) Try to establish reliable communication with the aircraft;

…

Article 27 The assistance shall be given by aviation authorities on duty when an emergency aircraft needs or is believed to need one or more of them:

…

(g) The further information of the airborne aircraft, if it has left a radar range which the aircraft has via;

…

Article 28 If the aircraft reports hijack or is believed to be probably hijacked, the aviation authorities have the right to:

…

(c) Ask the current pilot flying certain questions to figure out his/her identity;

(d) Ask the air force to dispatch fighter jets to accompany the aircraft, but the air force shall not shoot down the aircraft unless it satisfies the condition in Article 157;

(e) Ask the current pilot flying to fly certain flight paths, but this can't be done if the aircraft is in a low-fuel emergency;

…"

Therefore, after the aircraft established communication with ATC at approximately 13:42, both fighter jet pilot and the ATC suspected if the aircraft was hijacked.

1.17.6 Manufacturer

The manufacturer of the aircraft is Seniorious Aircraft Manufactory Co., whose chief designer was the former Chtholly Nota Seniorious at the time when the Seniorious 300 was designed.

The Seniorious aircraft consists of two series: military and commercial. The initial products of

the company are all for military. Since 430, the manufacturer started producing commercial flights. Passenger says that "***it's usually comfortable – especially the air conditioning system, which makes me feel at home,***" and pilots also says that "***both air force pilots and normal commercial pilots are suitable for this aircraft.***"

1.18 Additional Information

1.18.1 Relevant Accident

1.18.1.1 HCY522 Accident in Corna di Luce

On August 14th, 431, an aircraft operated by Helios Airways, HCY522, Boeing 737-31S, taking off from Bethanes for Corna di Luce, encountered on-board cabin depressurization because of wrong configuration of bleed system. However, due to the bad design of the warning system, pilots failed to understand the depressurization situation and fainted. With no one to control the aircraft, it crashed into the hills near the Corna di Luce airport and no one survived.

Corna di Luce Aviation Administration collected information about hypoxia and summarized its effects, including symptomatology, as follows: "***Exposure to high altitude with consequent hypobaric hypoxia and reduced oxygen supply to the central nervous system causes a variety of neuropsychological symptoms (Koller et al., 1991; Lieberman et al., 1994). The most commonly experienced symptoms recognized as hypoxia are cognitive impairments (Blanchet et al., 1997; Bonnon et al., 1995; Cable, 2003; Cahoon, 1972; Macintosh et al., 1988; Shepard, 1956; Shukitt-Hale et al., 1998). In addition to deterioration of cognitive performance, emotional changes including euphoria, irritability, hostility, and overconfidence have been reported (Shukitt-Hale & Banderet, 1988). Exposure to altitudes above 19 700 ft is accompanied by increased susceptibility to hallucinatory experiences and deficits in visual perception (Pavlicek et al., 2005).***"[16]

The altitude the aircraft was in (27 500 ft) is considered a "critical stage": "***In this stage of acute hypoxia, there is almost complete mental and physical incapacitation, leading to rapid loss of consciousness, convulsions, and finally in failure of respiration, and death.***"[17]

Also, according to the table provided by the report, the time of useful consciousness in the altitude is approximately 75 ~ 80 seconds[18].

1.18.1.2 The Percentage of Pressurization and Oxygen Accidents and Incidents

From the database of REAA and RATSC, while 92% of the pressurization system accidents and incidents in the past 30 years are about "OFF SCHED DESCENT", 96% of which is caused by the actual aircraft's descent instead of the internal pressure increment. The other 4%, however, is mainly about the unexpected "MAN" or "ALTN" configuration of the pressurization system.

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[16] *Helios Airways Flight HCY522 Boeing 737-31S Aircraft Accident Report*, Page 62.
[17] Ibid, Page 63.
[18] Ibid, Page 64.

The number of fuel leakage events (1 255) is also far more than the number of the pressurization failure (113).

Besides, in the database of REAA and RATSC, there were 33 cases where the oxygen generator moved from its original position, 15 of which caused unexpected deployment of oxygen masks.

1.18.2 The Service Bulletin

1.18.2.1 The Service Bulletin of "Active Cooler/Heater"

On July 14th, 439, Lyell Local Airlines reported that their aircraft had "PACK" amber light was illuminated on the ground and the ground engineer found the air conditioning components overheated with the "active cooler" turned on. Therefore, a service bulletin and detailed explanation was delivered by Seniorious Aircraft Manufactory Co.: "***… Using 'active cooler' may lead to additional heat accumulation on the ceiling. Ensure that this works for less than 10 minutes. After 10 minutes' use, the temperature knob must be in 1/3 'C'~ 2/3 'H' … Before the next use, the system must be cooled down for at least 15 minutes.***"

2 Analyses

2.1 To the Process of the Accident

2.1.1 Findings of Experiments

The chemical equations in the container are given as:

$$2Na_2O_2 + 2H_2O = 4NaOH + O_2\uparrow \ \Delta H = -210\ \mathrm{kJ/mol}$$
$$2NaOH + 2Al + 6H_2O = 2Na[Al(OH)_4] + 3H_2\uparrow$$

2.1.1.1 Oxygen Generation Speed

Let $R = 8.5\ \mathrm{J/(mol \cdot K)}$, and the default setting of cabin is $T = 293.15\ \mathrm{K}, V = 12\,000\ \mathrm{L}$.

Before the leakage or explosion event inside, here is

$$n = \frac{pV}{RT} \approx 403.76\ \mathrm{mol}$$

, i.e.,

$$m = n\bar{N} \approx 11\,709\ \mathrm{g}$$

The temperature rise can be described as follows:

$$T = T_0 + \frac{kQ}{c(m + \Delta n \times N)} = T_0 + \frac{k\Delta n \Delta H}{c(m + \Delta n \times N)}$$

in which $k \approx 0.8, c \approx 1.007\ \mathrm{kJ/(kg \cdot K)}$.

So that in each circumstance,

$$p = \frac{nRT}{V} = \frac{R(n + \Delta n)(T_0 + \frac{k\Delta n\Delta H}{c(m + \Delta n \times N)})}{V}$$

It can be inferred that the amount of substance Δn of the table mentioned in the experiments are:

Starting Temperature / Time	2 min	4 min	6 min	8 min
20	9.6	17.6	25.2	32.9
30	9.9	18.1	25.9	33.1
40	10.1	18.9	27.1	33.2
50	10.4	19.6	28.0	33.3

This helps with the evaluation of the reaction speed.

Also, the final temperature will be:

Starting Temperature / Time	2 min	4 min	6 min	8 min
20	153.3	259.3	355.9	450.1
30	157.3	265.7	364.6	452.5
40	160.0	276.1	379.5	453.7
50	164.1	285.1	390.6	454.9

2.1.1.2 Explosion

According to the chemical equation and the given amount of substance Al 3 mol, the final H_2 produced will be 4.5 mol. Thus, the volume percentage of H_2 will be:

Starting Temperature / Time	2 min	4 min	6 min	8 min
20	31.9%	20.3%	15.1%	12.0%
30	31.3%	19.9%	14.8%	12.0%
40	30.8%	19.2%	14.2%	11.9%
50	30.2%	18.7%	13.8%	11.9%

It has been known that in the explosion condition, the explosion occurs.

2.1.1.3 Heated Air Conditioning

The air conditioning system produces heat, according to the experiment mentioned in the factual information. In the formula $p = \frac{nRT}{V}$, it can be seen that the air pressure increases for at most 10%, taking the difference of the temperature in each component into account. Therefore, the

difference between the setting pressure and the actual pressure will also be approximately 10%. For default cabin altitude setting 5 150 ft, it will be approximately 6 000 ft, which is not significant enough for crew members or passengers to notice.

2.1.2 The Recovered Process of Accident

On the ground, the pilots put the temperature selection knob at 1/3 “C” position for more than 15 minutes, accumulating sufficient heat.

At approximately 13:08:34, when the flight attendant reported “something flowing”, the leakage had probably started, which matches the experiment and analyses above (the explosion happens approximately 8 minutes after the beginning of the leakage).

As the reaction continued, the H_2 and O_2 accumulated, and more heat was produced. When the temperature and gas were sufficient, at 13:16:25, when the low voice was recorded by CVR, the explosion happened. As the pressure detector is just nearby, it detected lots of high-speed gas coming out from the oxygen generator and outputted a higher value, making the “OFF SCHED DESCENT” amber light illuminated and pressurization system opening valves to decompress the cabin.

Meanwhile, with some gas coming to the cabin through the pipes, the oxygen masks deployed. However, the gas mainly ran towards the broken fuselage, and only little O_2 came out from the passenger oxygen masks.

Then, soon after that, due to further explosion, the sensor was disconnected, making the indication stay the same.

2.2 To the Design of Aircraft

2.2.1 Pressurization System

From the introduction of the pressurization system and the flight simulation, the “OFF SCHED DESCENT” can’t indicate a clear status, so that pilots have to determine the actual situation through:

(1) V/S indication to determine whether the aircraft is descending, or

(2) Cabin altitude V/S indication to determine whether the cabin altitude is descending unexpectedly.

The deciding time of the pressurization system matters, as a rapid depressurization can make crew members faint within 30 seconds at cruise altitude. This workflow actually increases the work of crew members and make the decision insufficient, which will probably lead to accidents and incidents like this.

Moreover, if a situation in (2) above occurs but (1) doesn’t occur, with “AUTO FAIL” light not illuminating and the system working at “AUTO” mode, the pilots will probably have trouble determining what systems are malfunctioning. Pilots have to decide one or more from the following probable reasons:

(1) The out-flow valves are jammed at “CLOSE” position,

(2) The engine or APU input valves are jammed at “OPEN” position, or

(3) Gas is being produced inside the aircraft unexpectedly.

For the (1) and (2), pilots need to open the valves; However, for (3), pilots must conduct emergency depressurization in time to prevent further damage.

The difference between (1), (2) and (3) is the status of the valves. Therefore, adding indications of valves' controls may be effective.

Besides, the pressurization system's indication value may be false when the pressure detector is unexpectedly damaged by the explosion. Although it might be impossible for a sensor to suffer explosion, the indication value is not fail-safe, because an explosion is a rapid increment of pressure inside, which needs depressurization as a safety measure to prevent further damages.

2.2.2 Oxygen Supply System

2.2.2.1 In The First Maintenance

Investigators agree that the supporting components of the motor is not strong enough, making it to unexpectedly move with certain flight path, just like the analyses of the ground engineer mentioned in factual information.

2.2.2.2 During The Accident

According to the factual information and analyses above, the oxygen supply system unexpectedly produced O_2 and H_2 due to:

- The steam entering the Na_2O_2 storage, creating O_2;
- The chemical reaction between the produced $NaOH$ and Al, creating H_2.

In this system, H_2 is harmful, because it doesn't support breathing and causes explosion. Therefore, isolation lockers made of Aluminum and other similar metals should never be used in the device.

The pipe the maintainer installed greatly contributed to the steam's entrance to the Na_2O_2 storage. When being heated, the steam will go through the pipe and start the reaction. While this doesn't eventually destroy the fuselage, it may lower the strength of the whole fuselage, which probably makes other accidental factors work.

When the air pressure inside the container was enough to damage the container, the base liquid came out. While this decelerated the reaction, this caused more negative effects, ranging from the initial damage to the fuselage to the injury of passengers after the ceiling of the cabin collapsed. To make matters worse, the initial damage to fuselage made it easier for the fuselage to separate from the aircraft.

2.2.3 Air Conditioning System

The "active cooling" system produces a lot of heat, which advanced the unexpected reaction speed of the oxygen generator.

The air conditioning system don't have clear indication about whether the "active cooling" system is running. There is no sign about this mode on or near the knob, either. Therefore, it's easy for crew members to forget turning the knob.

2.2.4 Other Systems

2.2.4.1 Navigation

Radar data and FDR data proved that the aircraft went on its designated route even if the crew members fainted. During the whole flight, the navigation system worked normally.

2.2.4.2 Flight Attendant Telephone

The flight attendant telephone worked normally before the explosion happened. Therefore, the reason why no one answered the telephone was that the crew members were all fainted.

2.2.4.3 Cockpit Doors

The cockpit door is not fail-safe. When both the cockpit and the cabin depressurization took place, both crew members and passengers may faint. In this case, when crew members faint or are unable to fly the aircraft, it's possible for passengers to take control of the aircraft and deal with the emergency. In this case, the cockpit depressurization and cabin depressurization happened at the same time, making no pressure difference. That's the reason why the cockpit door didn't open automatically.

Besides, turning the cockpit door switch to "DENY" with Δp might make the cockpit door directly break down.

2.2.4.4 Cabin Ceiling

The cabin ceiling collapsed during the accident. According to the analyses above, it can be inferred that the heated air not only damaged fuselage of the aircraft but also damaged the supporting structures of the cabin ceiling.

Investigators considered the reason why the cabin ceiling was less seriously damaged than the fuselage, and agree that it's mainly because the gas was mostly accumulated near the reaction container, which is lifted from the cabin ceiling by the supporting structures.

2.3 To Communication and Cooperation

2.3.1 Between Aircraft and ATC

The ATC could not confirm Ryehl's identity in time, because Ryehl wasn't on duty at that time. The behavior of ATC matches as follows:

Rules	**Responses**
(Internal rule) ***When losing contact with an aircraft, immediately report this to the on-duty manager.***	The ATC official immediately reported this emergency to the aviation departments in Lyell.
Article 26 When an aircraft is in MAYDAY emergency or an aircraft has lost contact with all ATC stations, local aviation departments shall: ***(a) Inform the FIR the aircraft has been in or might be in;*** ***(b) Try to establish reliable communication with the aircraft;*** **…**	(a) Lyell ATC tried to contact the aircraft through the controller frequency saying "***Regule Aire 193, radar service terminated. If you hear me, contact Corna di Luce control at 122.50,***" delivering the aircraft to the Corna di Luce FIR. Meanwhile, Lyell authorities informed Corna di Luce about the situation of the aircraft. (b) From 13:18:11 to 13:21:55, the Lyell ATC tried to establish communication with the aircraft for 4 times, only to get no answer.
Article 27 The assistance shall be given by aviation authorities on duty when an emergency aircraft needs or is believed to need one or more of them: **…** ***(g) The further information of the airborne aircraft, if it has left a radar range which the aircraft has via;*** **…** ***Article 28 If the aircraft reports hijack or is believed to be probably hijacked, the aviation authorities have the right to:*** **…** ***(c) Ask the current pilot flying certain questions to figure out his/her identity;*** ***(d) Ask the air force to dispatch fighter jets to accompany the aircraft, but the air force shall not shoot down the aircraft unless it satisfies the condition in***	27 (g) See (a) above. 28 (c) is not well followed. 28 (d) 1. At 13:20:05, Lyell ATC and aviation authorities informed the Guardian Wing Corps about the emergency situation and asked if any assistance could be provided. the Guardian Wing Corps asked if fighter jets were needed. Lyell aviation authorities said "***currently not needed.***"; 28 (d) 2. The emergency committee had a meeting and agreed that "***fighter jets' accompanying flights are suitable for this circumstance.***" They also agreed that "***here's a probable hijack.***" 28 (e) is not deliberately conducted, but the guidance to the airport has the similar effects.

Article 157; ***(e) Ask the current pilot flying to fly certain flight paths, but this can't be done if the aircraft is in a low-fuel emergency;*** ***…***"	

Besides, the ATC suspected if Ryehl was a hijacker according to the existing workflow (See following sections to know Ryehl's intention). This is partially reasonable as Ryehl, or Chtholly taking control of her, failed to answer the total number of passengers on board. While this might prevent problems during a real hijack, in this accident, it caused:

- The worse cooperation between the ATC and Ryehl,
- The difficult for Ryehl to get technical support from the ground engineers, and
- The feeling of being threatened, which might influence the performance in case of emergency.

From the following aspects, the ATC could have determined the kind intention of Ryehl:

- The active attempt of declaring MAYDAY,
- The 7700 transponder code, rather than 7500,
- The request to divert, and
- Accepting the guidance to the airport to divert.

Investigators agree that one single behavior of items above can't confirm the intention of the pilot, but there's no motivation for a hijacker to do all of them, as hijackers usually intend to fly the aircraft to the destination they wanted or destroy the aircraft.

However, the ATC didn't do this. Investigators found that this was probably because of an unfamiliar voice appearing in the frequency. Moreover, the pilots assigned to fly a route tend to be constant, so that they can accumulate the experience unique to the route to better fly the aircraft. This also makes it strange for ATC to hear from an unfamiliar voice.

When Ithea arrived at the ATC station and established communication with the Ryehl on board, Ithea was probably hearing "Chtholly" speaking to her. This will be discussed in following sections.

2.3.2 Among Aviation Authorities

As the laws and conventions required:

Rules	**Responses**
Article 4 All nations, autonomous cities and regions shall[19] have its own aviation authorities, taking on following responsibilities: ***…*** ***(k) An emergency***	(k) 1. At 13:32:12, an emergency committee had been set up, consisting of aviation officials in Lyell and Corna di Luce, as well as officials from REAA, RATSC and the Guardian Wing Corps. 2. At 13:38:12, aviation officials from the

[19] *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)* also states: "***The 'shall' means requirements, while 'should' means recommendations.***"

committee or the creation workflow of an emergency committee in case of emergency situations.	Leprechauns' Battery arrived at the workplace of the committee.
Article 29 In case of emergency situation defined in Article 24, the persons and organizations included in aviation accident and incident investigation team shall be organized and an emergency committee or similar organizations shall be established in order to respond to and try to solve the emergency situation. ***The members in the emergency committee shall get the same rights and permissions as the members in investigation team have.*** ***The emergency committee is responsible for the following affairs:*** ***(a) Take effective measures to prevent emergency from becoming an accident or incident;*** ***…*** ***(c) Announce the status of the aircraft(s) in danger;*** ***(d) Inform the operator of the aircraft, the owner of the aircraft, and passengers' and crew members' relatives of the emergency;*** ***…*** ***(g) Participate in the further investigation of the emergency (if needed).***	(g) The investigation team was set up to investigate this accident. See synopsis page.

The organization was in time, and the cooperation, especially between the ATC and Leprechauns' Battery, helped a lot in numerous aspects including the recognition of Ryehl.

2.4 To Passenger

2.4.1 Probability of Hijacking

Investigators considered the probability of on-board hijack. However, current evidence shows

no motivation of any passenger to hijack the aircraft. According to the CVR, no person entered the cabin after the takeoff before 13:40, when the crew members had fainted, and there was no one attempting to enter the cockpit during that time as well.

Investigators also considered the probability of deliberate damage in maintenance. However, as the analyses above have mentioned, these single factors can't ensure the final result of the accident. Therefore, investigators agree that no hijack or hijack attempt exists in the accident.

2.4.2 Ryehl

2.4.2.1 General

According to Ithea during the accident, Ryehl was probably eroded. Also, she had never seen or heard of Willem, let alone expressing love. Thus, the memory of Willem must be inherited from other leprechauns, which suits the definition of erosion (presenting the former leprechauns' memory).

From the expressed love to Willem, taking the "***girl with blue hair***" Ryehl accounted into account, investigators agree that the source of erosion is probably Chtholly.

2.4.2.2 Stage of Erosion

Investigators collected opinions about Ryehl in this accident in the whole RATSC and other aviation authorities taking part in the investigation. From the Ryehl's account, the CVR data and the ATC tape record, it can be seen that Ryehl is partially or completely equipped with Chtholly's mind.

Investigators considered the reason why erosion started. The former investigation[20] pointed out that when the leprechaun approaches scenes related to their ancestors, the erosion is more likely to take place. Investigators agree that the aircraft Chtholly designed and the in-flight accident related to hypoxia, which was similar to the one Chtholly experienced, stimulated the erosion.

Investigators debated about the probability of Ryehl completely replaced by Chtholly during the accident. It has been reported that Ryehl had part of Chtholly's mind, which can be considered as a type of erosion, according to the record of the Guardian Wing Corps mentioned before, therefore, it's possible to let the erosion develop. The biochemistry examination on Ryehl after the accident also shows that she was probably partially or completely eroded.

In the former investigation of 3W-CHT[21], investigators agreed that $\mathrm{pH} \leq 5$ represents complete erosion for Chtholly, represented by her hair consisting of litmus. However, difference among leprechauns' erosions has made it less persuasive to directly use this value. Investigators agree that this value must be determined through detailed experiment. Therefore, there's no clear and sufficient evidence to prove the complete erosion of Ryehl.

[20] Ibid (see footnote 3).
[21] Ibid (see footnote 3).

2.4.2.3 Feature of Erosion

Through the account of Ryehl before the accident recorded by the Guardian Wing Corps, investigators found the process of erosion partially active[22], as Ryehl actively pulled "***a girl with blue hair***", who was probably Chtholly, and according to accounts of erosion, during the erosion, the distance to the representative of the "former soul" will gradually decrease until the moment a face-to-face communication is established, which suggests the coming erosion blackout and complete replacement.

This symptomatology of erosion also serves as cons to the complete before-accident erosion of Ryehl. As Ryehl "***tried to pull her***", the representative of Chtholly "***tried to stay***", suggesting the existence of distance between them. This also suggests that the representative of Chtholly never means to replace Chtholly, which can explain the behavior of her during the accident and suit the account of Ryehl.

In the interview with Ryehl, she mentioned her face-to-face communication, most of which were dialogues. However, despite the fact that this usually suggests complete replacement, no further replacement happened. Therefore, investigators inferred an "active resistance" of Chtholly and a "limited erosion" caused by Chtholly.

The DNA of Ryehl is believed to be similar to the DNA of Chtholly, according to the DNA examination mentioned in factual information. Therefore, investigators believe that erosion is caused by the activation of certain gene parts related to Chtholly. However, since the detailed relationship between biochemistry features and leprechauns' connections and erosions is unclear, investigators couldn't conclude this.

Investigators had several assumptions based on former researches[23]:

- Ryehl has its independent existence, with Chtholly's "souls" represented by "genes" exists, and Chtholly's substances gradually but temporarily and partially replaced Ryehl's, or
- Ryehl and Chtholly shared the same DNA information, but was modified later by NO_2^-, which is an ion that leprechauns usually have in their blood.

However, neither of the assumptions has strong evidence to support.

Investigators noticed that besides the recalling memory brought by erosion, Ryehl is similar to Chtholly from several aspects. This is a phenomenon unique to her, and investigators agree that this:

- Represents and proves her connection with Chtholly, and
- Show that the erosion could have been developed but stopped for some reasons, probably including Chtholly's active resistance mentioned above.

2.4.2.4 Existence of Chtholly

Investigators agree that the existence of Chtholly is a requirement of Chtholly's physical existence, as Chtholly disappeared into the air after the erosion of Ryehl stopped. Since Chtholly has disappeared, investigators couldn't determine the detailed biochemistry reason of Chtholly's existence and disappearance.

Investigators collected opinions had several assumptions:

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[22] Based on *Research on Leprechauns' Erosion Cases* (F. Jesuman et al, July 441).
[23] Ibid.

- The Chtholly's memory remains in Ryehl's DNA substances and might be recalled through gene transcription and translation; or
- The Chtholly's memory will disappear from Ryehl through the disappearance or suppression of related genes.

Investigators agreed that the former assumption is likely to be correct, but the decreasing frequency of erosion on Ryehl, rather than the usually expected increment, partially supports the latter. Investigators agree that further erosion should be monitored and express respect to Chtholly.

2.4.3 Injury Factors

Investigators agree that the main factor of injury is the hypoxia caused by the cabin depressurization. Besides, some injuries might be caused by the collapsed ceiling of the cabin.

Investigators also considered the source of alkali burn and agree that it's probably caused by the leakage of $NaOH$ from the collapsed parts of the ceiling, as the analyses above mentioned the production of this substance.

2.5 To Pilots

2.5.1 With Service Bulletin and Air Conditioning

According to the factual information, the pilots kept the temperature control knob at 1/3 "C" position on the ground, which continuously engaged the "active cooler" for 15 minutes. Thus, it can say that the pilots failed to follow the service bulletin.

This might be caused by the high working pressure before taking off mentioned in the ground procedure section. When they're using their "***muscle memory***" to speed themselves up (said a pilot from Air RE in an interview), which is partially against the safety principles, they tend to forget temporary or newly-added items. In this case, the cooling requirement is just "newly-added" because of the significant hot weather differing from the previous days.

2.5.2 With Pressurization System

The signs of the failure had been there since 13:08:34, when the flight attendant first reported the sound of flowing. The crew members might recognize this as:

(1) **The oxygen generator leakage** – The correct answer in this accident;
(2) **The fuel leakage (The most frequent)** – The crew members have to track the use of fuel within 20 minutes;
(3) **The hydraulic leakage** – The crew members have to see the hydraulic panel in approximately 3 seconds.

In fact, during the accident, the crew members considered (3) and (2) (in order) and ignored (1), as its probability seemed small.

As for the explosion at 13:16:25, this might be recognized as:

(1) **The oxygen and hydrogen (or other mixed gas) explosion** – The correct answer in this

accident;

(2) **The fuel explosion** – The sound should be louder.

However, during the explosion, the depressurization had started, bringing hypoxia to crew members, which prevented them from making the correct choice. They also had no sufficient time to reconsider their plans and choices (See additional factual information). Therefore, there should be a quicklier way for pilots to notice the importance of considering cabin depressurization.

The action of leveling off the aircraft is considered a part of cabin depressurization procedure. In fact, the procedure of cabin depressurization starts with wearing the oxygen mask and leveling off the aircraft. Investigators believe that the reason why the crew members had only conducted a few steps of this checklist is probably that:

- They had been confused by the situation, facing the rare warning signs, as few pilots experience pressurization problem, and
- The effect of hypoxia, influencing discretion.

It is the correct procedure to wear the oxygen mask, which was actually conducted by crew members later (from approximately 13:17 to approximately 13:18). However, since the oxygen generator has exploded, no oxygen supply can be provided.

2.5.3 With Flight Attendants

2.5.3.1 Pilots to the Flight Attendants

Investigators considered the reason why the pilots never tried to establish communication with flight attendants. There's no deliberate motivation for them to do so, thus, investigators agree that this is because pilots were trying to find out the reason behind unknown situations and they mainly concentrated on the malfunctioning systems. Due to hypoxia, it became difficult for pilots to consider something else. This also explained why pilots didn't answer flight attendants' internal telephone calls.

Investigators agree that after the pilots set the "ALT HOLD" mode, they fainted and lost consciousness. That's why they didn't respond to further calls.

2.5.3.2 Flight Attendants to Pilots

Investigators considered the reason why flight attendants failed to enter the cockpit. While the loss of consciousness of pilots is one of the contributing factors, flight attendants should have input the correct password. Investigators agree that the deliberate lack of training on entering the cockpit through the emergency password made this.

Investigators agree that if one or more flight attendants had succeeded entering the cabin, they might help pilots recover consciousness by providing them oxygen.

2.6 To Maintenance Work

2.6.1 Emergency Maintenance

The emergency maintenance wasn't well conducted, because the material of the isolation locker wasn't well selected and the pipe connecting two containers contributed to the accident.

As the ground engineer had studied well, passed essential examinations and got license, investigators believe that he didn't do it deliberately. There was no motivation for him to do so, either. Investigators believe that he failed to consider further possibilities, but it was also a bit difficult to have such a prospect, as it required taking weather, the use of air conditioning, the probable maintenance fault and other factors into general account.

Also, Due to the efficiency pressure of the maintenance, the ground engineer failed to notice the unremoved pipe, which was "hidden behind" normal pipes if the ground engineer doesn't carefully recognize it. When the ground engineer believed that he had removed the pipe, it became almost impossible to notice it.

The increasing work, which included a notification to the manager to the airport that should be delivered by the engineer, also contributed to the mistake. As the requirement of removing the temporary pipe is only mentioned by the item where the maintainers are instructed to install it, maintainers tend to forget it if they have other affairs to memorize.

The revision procedure also failed. The contributing factor is similar to the reason why the ground engineer failed to notice it: On the assumption that "there are pipes", adding a pipe is not considered unusual without careful observation.

Investigators also considered the possibility of the ground engineer having removed the pipe and others having added the pipe. However, as

- Passengers are kept away from the maintenance area by corridor bridges, and
- No maintenance record or airport camera indicates another maintenance,

the assumption can be considered false.

Investigators considered how significant it is to add a pipe to it. According to the information of provided maintenance materials mentioned in factual information, it's probably impossible. However, having a significant difference between normal pipes and temporary equipment might prevent this from happening.

2.6.2 Other Maintenance Affairs

It can be seen from both the maintenance workflows and the account of the pilots and passengers (indirectly) that the maintenance work might focus on efficiency too much, which leads to the decrement of the maintenance quality when the system to maintenance is complex.

3 Conclusions

3.1 Findings

The investigators found that:

- The pilots were qualified, but they failed to:
  - Notice the overuse of the "active cooling" system, and
  - Figure out the situation after the depressurization.
- The aircraft was unsuitable for flying, because of the inappropriate maintenance, caused by
  - The efficiency requirement of the work, and
  - The increasing pressure of work;
- The ATC finished all required tasks and took on all required responsibilities, but the ATC failed to establish more efficient and friendly communication with a passenger offering to help;
- The passenger, Ryehl, with the limited erosion from Chtholly, helped saving the aircraft and some of the crew member and passengers, but later led to the disappearance of Chtholly;
- The sudden change of weather (the air temperature) led to the overuse of the air conditioning system;
- The design of aircraft consists of following problems:
  - The unstable structure of the oxygen generator,
  - The overuse of "active cooling", when being neglected, causes the overheat of equipment area, and
  - The overheat of equipment area, with an inappropriate maintenance, causes the explosion and leakage of oxygen generator system;
- The cooperation of aviation authorities helped with dealing with the emergency; and
- The temporary and limited former-soul erosion connection between Chtholly and Ryehl existed during the accident and stopped after the accident, which helped with diverting and helped save people on board.

3.2 Causes

3.2.1 Direct Causes

Investigators agree that direct causes are:

- The inappropriate maintenance work to the oxygen generator system;
- The unawareness of the inappropriate maintenance work, reflecting the lack of effective revision and cross-check system, which eventually led to the failure and explosion of the oxygen generator; and
- The inappropriate response to the pressurization warning, making crew members miss the

chance to solve the problem.

3.2.2 Indirect Causes

Investigators agree that indirect causes are:

- The preference of performing quick maintenances and turning on “active cooling”, stressed by the income, bonus and reputation of the airline;
- The unawareness of the malfunctioning oxygen generation system, caused by the lack of training and hypoxia;
- The lack of difference between the aircraft’s own equipment and additional equipment, causing the unawareness of the left pipe; and
- The lack of notification in the maintenance manual of the aircraft, caused by the pressure of efficiency and other additional affairs.

3.2.3 Contributing Factors

Investigators agree that following factors contributed to the accident:

- The lack of internal rules and workflows to establish contact with other persons, except assigned pilots and hijackers, controlling the aircraft, which caused the inefficiency in dealing with the emergency; and
- The lack of training of flight attendants to enter the cockpit in the emergency circumstances.

4 Safety Recommendations

4.1 To the Design and Manufactory of Aircraft

4.1.1 To The Oxygen Generator

RATSC Recommendation 450 – 15 The oxygen generator is recommended to use other materials which does not erode metal isolation lockers.

Response: The oxygen generator material has been changed to Na_2FeO_4, which produces $Fe(OH)_3$ in the reaction so that the metal isolation locker won’t be eroded so seriously by then end of March 450.

RATSC Recommendation 450 – 16 The oxygen generator is recommended to have an independent failure indication so that it will be easier for crew members to determine the source of failure.

Response: A “PASS OXY FAIL” indication has been independently added to EICAS display (Seniorious 400, 500) and/or passenger oxygen panel (Seniorious 300, 400, 500) by the end of

February 450.

RATSC Recommendation 450 – 17 The oxygen generator is recommended to be added into the equipment cooling area to prevent overheat.

Response: The range of the cooling area has been expanded to the required space by the end of January 450.

RATSC Recommendation 450 – 18 The motor of the oxygen generator is recommended to be tied to the ceiling of the cabin more tightly, and a service bulletin is recommended to be announced to mention the accident's factors.

Response: A service bulletin has been delivered by Seniorious Aircraft Manufactory Co. on February 11th, 450: "***… It's recommended to recheck the strength of the motor tied to the ceiling. Unexpected movement may cause unexpected deployment of passenger oxygen masks. Also be sure that:***

(1) Aluminum or other materials that might be eroded by bases are not recommended as repair materials;

(2) Na_2FeO_4 ***is recommended to be the oxygen generator's material; and***

(3) Be sure that no unexpected pipe is connecting two containers before startup.

…

In-flight leakage may be presented by the unexpected flowing sound. Be sure to be aware of this kind of signs to prevent a possible explosion."

RATSC Recommendation 450 – 19 The ceiling of the cabin connected to the oxygen generator is recommended to be strengthened in order to prevent probable damage caused by the explosion of the oxygen generator.

Response: By the end of January 450, two additional supporting structures have been added for the part of ceiling.

4.1.2 To The Pressurization System and Its Control Panel

RATSC Recommendation 450 – 21 The working method of the pressure detector is recommended to be improved. The pressure detector is recommended to send out "malfunctioning" signal when being damaged, which should later trigger the failure of AUTO pressurization mode.

Response: According to the manufacturer, by the end of January 450, the design of the system had been improved. By the end of March 450, all Seniorious 300, 400 and 500 aircraft had been equipped with the new system.

RATSC Recommendation 450 – 22 It's recommended to add a "OFF SCHED CABIN PRESS" / "OFF SCHED DESCENT" indication to EICAS to tell two reasons of "OFF SCHED DESCENT" amber light to reduce the decision time of pilots in case of unexpected rapid pressurization.

Response: According to the manufacturer, by the end of November 449, the design of the system had been improved. By the end of February 450, all Seniorious 300, 400 and 500 aircraft had been equipped with the new system.

4.1.3 To The Air Conditioning System

RATSC Recommendation 450 – 25 It's recommended for the "active cooling/heating" system, especially the "active cooling" part, to automatically cut off power after 10 minutes' use and illuminate "ACT COOLING" green light while being used.

Response: According to the manufacturer, by the end of November 449, the design of the system had been improved. By the end of March 450, all Seniorious 300, 400 and 500 aircraft had been equipped with the new system. The checklist also involved following pages:

ACT COOLING (Active cooling)	
Status: "ACT COOLING" light is illuminated.	
1	The "ACT COOLING" light, as well as its active cooling system, only works on the ground.
2	Active cooling system is running and will be turned off automatically within 10 minutes.
3	Wait for **at most** 10 minutes.
4	Turn the zone temperature selection knob of the related air conditioning system to 1/3 "C" ~ 2/3 "H" (both not included). When the "ACT COOLING" light extinguishes, the active cooling system is turned off.
	■■■■

4.2 To the Maintenance of Aircraft

RATSC Recommendation 450 – 42 When debugging, pipes and other equipment with colors and/or shapes different from the ones originally in the aircraft, instead of those similar ones, are recommended to use.

Response: 155 maintenance utility kits in airports in Regule Aire have been updated as required by the end of March 450.

RATSC Recommendation 450 – 43 It's recommended for Air RE and other airlines to establish effective revision procedure after each maintenance, which at least contains detailed examination to key components.

Response: The revision procedure of the Air RE now requires engineers or pilots to take photos of the key components and sign their names. There are also random examinations conducted by the managers to prevent maintenance mistakes.

Other airlines have also established similar procedures by the end of February 450.

RATSC Recommendation 450 – 44 The maintenance training and maintenance manual is recommended to mention the significance of reviewing "***temporary***" and other important descriptions.

Response: In maintenance manual, for all maintenance items with temporary equipment, there have been an item which reads "***Remove the temporary equipment (…) from the device.***"

4.3 To ATC

RATSC Recommendation 450 – 51 It's recommended for ATC to add "hijack or kindness recognition" procedure to quickly tell hijack from passengers' help in case of pilots losing their consciousness.

Response: *The Aviation Convention of Regule Aire (The Constitution of Regule Aire, Annex 2)* has been edited and became: "

Article 28 ***If the aircraft reports hijack or is believed to be probably hijacked, the aviation authorities have the right to:***

…

The aviation authorities are also responsible for assisting the aircraft if the pilot followed all the instructions. The assistance consists of:

…

(b) ***When passengers offer to help, guide them to fly the aircraft properly until the aircraft lands safely;***

…"

A training project has also been started by REAA to help ATC assist these kinds of passengers when needed through radio communication.

4.4 To Training

4.4.1 To Pilots' Training

RATSC Recommendation 450 – 59 It's recommended to add pilots' training for the active cooling system, with the checklist mentioned in the recommendations to the air conditioning system.

Response: By the end of November 449, the additional training project has been completed, according to REAA.

RATSC Recommendation 450 – 60 It's recommended to add pilots' training for the oxygen generation system, including recognizing the leakage of the oxygen generation and preventing further explosion by actively engaging its oxygen output.

Response: By the end of December 449, the additional training project has been completed, according to REAA.

4.4.2 To Flight Attendants' Training

RATSC Recommendation 450 – 63 It's recommended to give at least one flight attendant on board permission to enter the cockpit by telling him/her emergency password of the cabin and tell him/her the responsibility of entering the cockpit in case of emergency.

Response: By the end of November 449, the additional training project has been completed, according to REAA. The flight attendant responsible for this will be told to follow ATC's instruction.

4.5 To Further Research

RATSC Recommendation 450 – 71 It's recommended for the Guardian Wing Corps organizations and other related organizations to continue studying the feature of erosion and replacement to help REAA and RATSC better consider its significances in aviation.

Response: The Guardian Wing Corps has started a long-term project to study leprechauns' erosion.

Corna di Luce May 6th, 450