

Regule Aire

Transportation Safety Committee

Final Report of

The Winged Guard Seniorious SEN-001

Severe Incident in Scarborough

On March 22nd, 436

Released in January 437

Abbreviations

ATPL	Airline Transportation Pilot License
ATC	Air Traffic Control
FDR	Flight Data Recorder
CVR	Cockpit Voice Recorder

Introduction

The severe incident took place on March 22nd, 436. Before the aircraft landed, the RATSC had been informed the incident and taken part in the assistance. During the investigation, RATSC was responsible for it. RATSC and The Winged Guard sent SINCID notification to the whole Regule Aire as required.

On August 8th, 436, a primary report was released. Then, with some improvements, this final report came out. Investigators agree that the severe incident was mainly caused by:

- The illegal operation to the landing gear system done by criminals, and
- The failure of preventing such a damage through security measures, and
- The incorrect design of the landing gear system, providing opportunity for the criminals to damage the system without being noticed and making it difficult for crew member(s) to extend the gears manually through emergency devices.

Investigation Team

The Group Leader of RATSC	Seabird Starch
The Delegate of The Winged Guard	Naught Sun

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Note: The airport is more frequently called “aire-port”. In this report, the word “airport” is still used.

1 Investigated Facts

1.1 Flight Experience

The aircraft, SEN-001, took off from Scarborough at 08:00¹ for training. It was scheduled to land again in Scarborough at approximately 09:50. However, at 09:36, when the aircraft was in the crosswind², the crew³ declared Pan-Pan emergency for the failure of landing gear.

When the emergency was declared, officials from the Winged Guard, which is the manufacturer of the aircraft, and the Regule Aire Transportation Safety Committee, soon arrived to offer help. In view of the 40-minute available fuel and several failed attempts to unlock the gear manually, the crew decided to land with gear up. Also, according to the crew's requirement, firefighters were prepared.

At 09:51, SEN-001 touched the ground with nose gear retracted and stopped successfully, using 11,482 feet of the runway. Soon after that, the crew got off without being hurt. However, the temperature of the fuselage near the landing gear area soon reached higher than 950°C. Because of the sudden cooling measure taken by the firefighters, this part of fuselage soon broke apart.

Besides, the occupied runway also stopped other aircrafts from landing normally. Luckily, they either diverted or waited, and their fuels were sufficient.

1.2 Injuries

Injuries / Category	Crew	Passenger	Other
Fatal	0	0	0
Major	0	0	0
Minor/None	1	0	

1.3 Damages to Aircraft

The bottom fuselage of the aircraft was seriously damaged. Other parts of the fuselage remained generally complete and undamaged.

1.4 Other Damages

The aircraft left broken fuselages on the runway, which caused an external maintenance work taking approximately 3 hours.

¹ All refer to local time.

² The 2nd part of an aircraft's approach route.

³ Equipped with intelligent systems, the aircraft can have only 1 pilot for a flight.

1.5 Individuals

1.5.1 Crew

The crew was 13. She joined the Winged Guard in 430 and got her ATPL in 431. She had flown A320 and A400 for 1,222 hours. In November 435, she started her training project to fly Seniorious, and she got her license in January 436. This flight was her external practice, and she had flown Seniorious for 335 hours before.

1.5.2 ATC

The ATC was 12. She joined the Winged Guard in 431 and got her ATPL in 433. After that, she mainly worked in the Scarborough tower as an ATC.

1.6 Maintenance of the Aircraft

The last maintenance of the aircraft was done on February 11th, 436. During the maintenance, it was reported that the landing gear module worked normally, and it was confirmed by the maintainers that no external maintenance was conducted after that.

After the last maintenance, the aircraft departed for several times, during all of which the landing gear successfully extended.

1.7 Weather

The METAR information of the weather was: *METAR SCBR 220930Z 26901MPS CAVOK 18/M08 Q1028 NOSIG=*

(Wind direction 269, wind speed 1m/s, no cloud and visibility > 10km, temperature 18 degrees, dew point negative 8 degrees, QNH 1028, no significant weather change in 1h)

1.8 Navigation Devices

The navigation devices, including VOR/DME receiver and ILS receiver, worked normally, according to the crew.

1.9 Communication

The communication between the crew and the ATC was loud and clear, according to the both CVR and the ATC's tapes.

The conversation from one of these two sources well matches each other.

1.10 Airport

The Scarborough airport is both for military and commercial use.

1.10.1 Hardware Equipment

The Scarborough airport is equipped with 3 runways:

- 09L/27R 22,966 feet long (CAT III)
- 09R/27L 15,122 feet long (CAT II)
- 18/36 16,100 feet long (CAT II)

The Seniorious and another kind of aircraft, Historia, can only land on 09L/27R, which is the only runway whose length is sufficient.

1.10.2 Security Procedure

According to the airport manager, when having passed security check, passengers are allowed to freely get on or off board. If the airplane isn't connected to a corridor bridge, passengers may enter aprons and get on other aircraft.

1.11 FDR and CVR

1.11.1 Overview

The FDR and CVR are located in the tail wing of the aircraft. They were undamaged.



Figure 1. The FDR

After these two devices were gotten, they were well protected and immediately sent to the Winged Guard to download data. All of the data were successfully downloaded.

1.11.2 FDR and CVR Data

Following text provides related FDR and CVR data.

Time	CVR	FDR
09:32:55	Crew	Gear down.
09:33:12	Crew	Landing gear: NOSE, LEFT and RIGHT red. GEAR DISAGREE checklist.
09:33:34	Crew	Gear lever position: DOWN. Go to step 9: Check landing gear indication.
09:33:55	Crew	NOSE, LEFT and RIGHT gear not extended. Go to MANUAL GEAR EXTENSION checklist.
09:33:51	Crew	MANUAL GEAR EXTENSION: Landing Gear Lever: OFF.
09:34:02	Crew	Maximum speed 270K/.82M, checked. Manual Landing Gear Extension Lever: DOWN.

		Wait for 15 seconds.	
09:34:33	Crew	Landing Gear Lever: DOWN.	<i>LEFT and RIGHT gear were successfully extended.</i>
09:34:55	Crew	Landing gear: NOSE red, LEFT and RIGHT green. Go to PARTIAL GEAR UP LANDING.	
09:35:11	Crew	Confirm manual landing gear extension attempt. ATC notification; Except runway 40 landing.	<i>Transponder was set to 7700.</i>
09:35:44	Crew	Landing Gear Warning Circuit Breaker: TRIP. Cabin indication unavailable.	
09:35:55	Crew	Auto Speed-brake Circuit Breaker: TRIP.	
09:36:04	Crew	No arm Autobrake and Speed-brake. Checklist completed except delayed items.	
09:36:33	Crew	Pan Pan Pan, SEN 1, my nose gear failed to extend.	
	(To ATC)		
09:36:55	ATC	SEN 1, Roger Pan-Pan. Do you want to continue landing?	
09:37:11	Other aircraft	Landing gear not down? Do you want to try again?	
09:37:34	Crew	Eh... Affirmative. <i>(The pilot said that she executed the manual procedure again at that time)</i> Still not down.	
09:37:55	Other aircraft	Don't be worried – Seniorious' strength is reliable.	
09:38:04	Crew	I have 40 minutes' fuel only. And ... Request firefighters.	
09:38:34	ATC	SEN 1, cleared to land ⁴ .	
09:38:55	Crew	Cleared to land, SEN 1.	
09:39:11	ATC	HIS 1, climb and maintain FL210, expect to wait until 1200 ⁵ .	
09:39:44	Other aircraft	Climb and maintain FL210, expect 1200, HIS 1.	
	(HIS1)		
09:41:22	Crew	Delayed items: Descend checklist. Compression: LAND ALT 100. Recall checked. Autobrake OFF. Landing data: VREF 40, 144kts. Approach briefing completed.	

⁴ The runway had been assigned before the conversation.

⁵ Means 12:00 local time.

		Descend checklist completed.	
09:44:35			<i>API disengaged.</i>
09:46:11			<i>ILS and LOC captured.</i>
09:47:35	Crew	Approach checklist: Altimeter 1028 set. Landing procedure recalling: No speed-brake or reverser and set pumps to OFF before level.	
09:48:11	Crew	APU OFF check. GPWS LDG GEAR INHIBIT check. Bleed ... OFF.	
09:49:12 ⁶	Crew	Landing Checklist: Engine starter CONT. Speed-brake: DOWN. Gear: NOSE retracted, LEFT and RIGHT extended... Checked. Flaps: 40, Green, Checked. Landing Checklist completed.	
09:51:33			<i>The aircraft touched the ground.</i> <i>V/S: -22ft/min</i>
09:52:03	ATC ⁷	We're pouring water to the fuselage. Stairs will be soon ready.	
09:52:33	Crew	Fuel pump OFF. Hydraulic panel set. Flaps ... UP. Park brake skipped. Engine lever ... CUTOFF. WX Radar ... OFF.	

Besides, at 10:09:33, the CVR recorded the voice of the broken fuselage.

1.12 Wreckages

1.12.1 General Overview

According to the crew and firefighters, the aircraft remained complete even after the bottom of the fuselage was damaged because of the heat and sudden cool.

The bottom part of the fuselage was seriously damaged.

⁶ Some GPWS signals are not given in this text.

⁷ This is from the firefighters.

1.12.2 Landing Gear Component

The nose gear component was inoperative during the incident. Investigators successfully got the component and found an incorrect wire. More detailed, the door opener motor of the gear extension module was reversely connected. Therefore, the door can never open (because it's going towards exactly opposite direction). See the circuit diagram below.

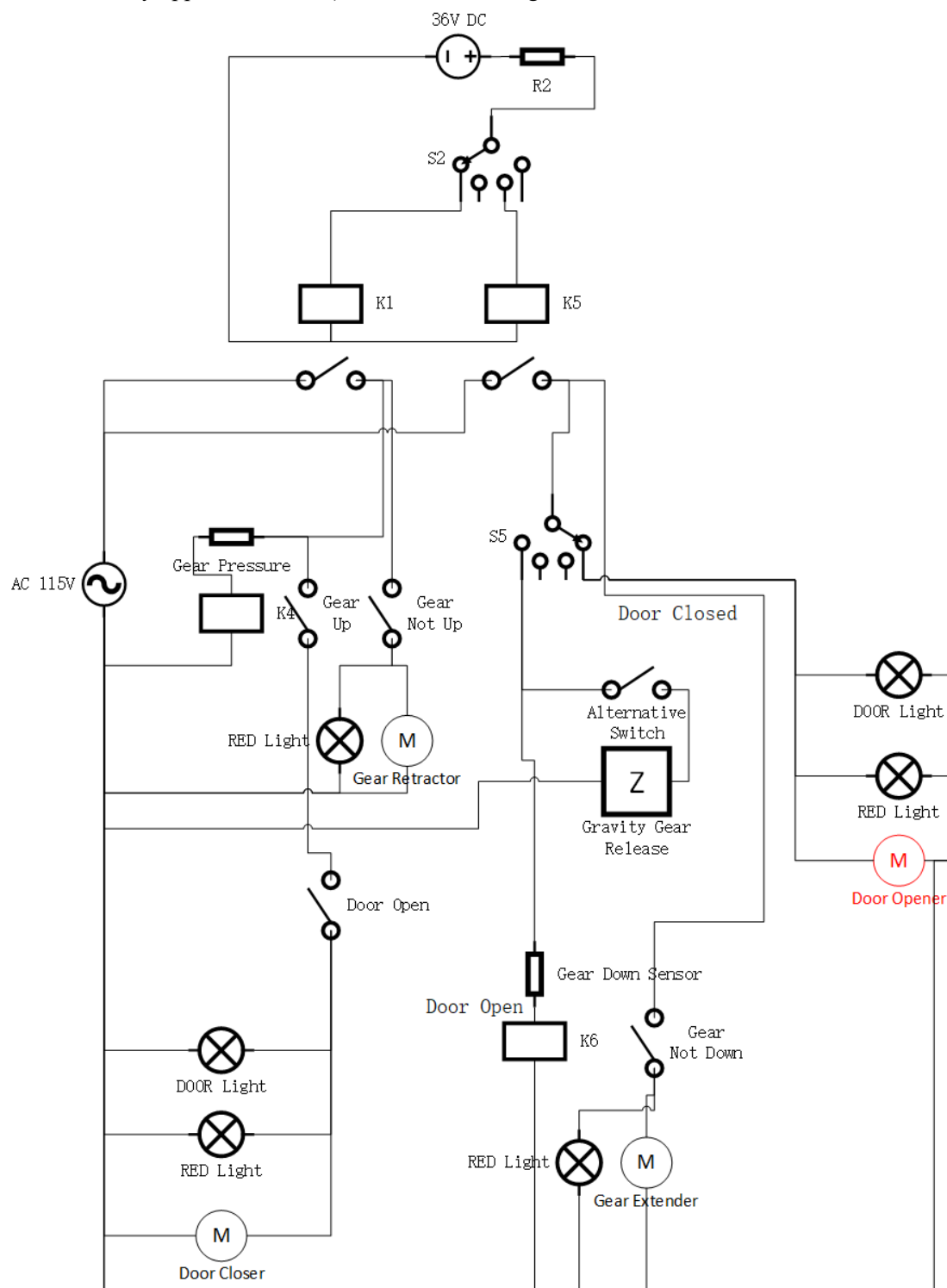


Figure 2. Circuit diagram of the landing gear system (The incorrectly wired motor is in red)

Investigators also noticed that the wire near the left gear's and right gear's door-opening motors were partially cut down.

1.13 Medical Analysis

Before getting on board, the crew passed the alcohol test. Her medical records show that she was healthy and suitable for the flight.

1.14 Fire

Although smoke came out from the fuselage after landing, there's no fire or sign of fire on board.

1.15 Search and Rescue (SAR) Activities

As the crew required, firefighters had been ready before landing. After firefighters' arrival, they began to pour water on the bottom of the fuselage to cool it down. However, this sudden temperature change damaged its structure.

After the crew got off, she got on the bus and returned to the airport buildings without being hurt.

1.16 Experiment and Researches

1.16.1 Landing Gear System

Investigators tested what will happen if the motor is reversely wired into the circuit. During all experiments, the door failed to open, and the following procedure couldn't continue.

Investigators also tested what if the gear directly extends with the door closed. The result is that the gear door is damaged, but the gear can usually extend to normal position.

1.16.2 Strength of the Fuselage (When Being Heated)

Investigators heated the material whose size is the same as the aircraft to certain temperature, and then let it suddenly cool down (which takes at most 5 minutes) and recorded the maximum cooling temperature in which they broke done. The result is given below:

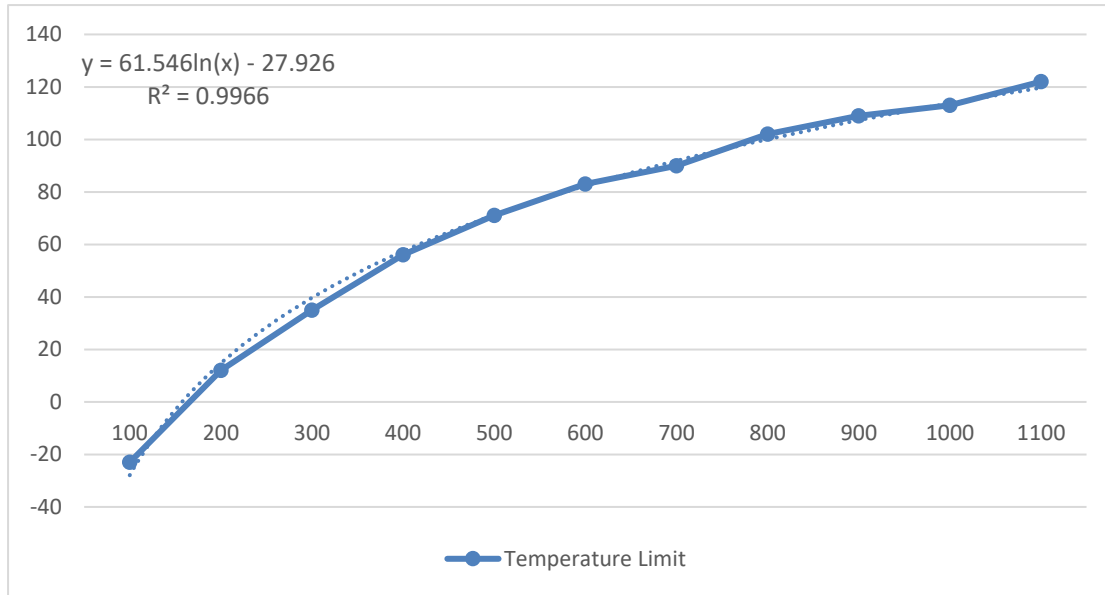


Figure 3. The measured temperature limit (beyond which the material would break down)

Investigators also measured the k value (which influences the conduction of heat in Section 2.4) by pouring water weighing 1kg in a specific temperature to the material.

The calculation is:

$$k = \frac{Q_{panel}}{Q_{water}} = \frac{c_p m_p \Delta T_{panel}}{c m_w \Delta T_{water}}$$

The result is given below.

Test #	ΔT_{water}	ΔT_{panel}	k
1	42	18	0.50
2	43	18	0.51
3	43	19	0.48
4	42	18	0.50
5	44	18	0.52

In which $c \approx 9 \times 10^2 \text{ J}/(\text{kg} \times ^\circ\text{C})$ and $m_p = 1\text{kg}$. Therefore, we have $k \approx 0.5$.

1.16.3 Flight Simulation

Investigators used flight simulation to see whether the crew's action was reasonable. To test this, investigators invited several pilots from the same organization to try this, and their performance was evaluated by:

- Whether the land was successful,
- The touch-ground velocity, G-force and vertical speed,
- The length of the runway used, and
- The temperature of the bottom surface.

The result is given below.

Test #	v	a	V/S	l	$T_{surface}$
(Actual flight)	144	1.2g	-22	11482	950

1	146	1.3g	-53	12233	1022
2	142	1.1g	-15	11023	945
3	143	1.2g	-29	12102	966
4	151	1.4g	-73	13932	1094
5	144	1.3g	-49	11654	966

(There were 2 unsuccessful attempts, in which the acceleration was too high and the fuselage broke apart before stopping)

1.17 Organization

The Winged Guard Air Force was short of pilots, so they started a training project. This flight was included in this project.

1.18 External Information

In December 436, two men from Elpis Mercantile Federation were arrested by the Scarbrough police station and admitted their crime towards the landing gear system. They admitted that they used the problem of the security procedure (which has been mentioned in Section 1.10.2) to damage the landing gear system.

More detailed, their damages to the system include partially damaging the wire of the left and right gear and completely rewiring the nose gear motor. They believed that two different phenomena will confuse the pilot.

2 Analysis

2.1 To The Landing Gear Extension System

2.1.1 The Reason of Incorrect Wire

The incorrect wire couldn't be because of natural reasons, and it can't also because of the maintenance work. Therefore, there must be illegal operations.⁸

2.1.2 The Design of the System

According to the circuit diagram, the gear won't be extended if the door couldn't open, even if the alternative system is used. This stops pilots from manually extending the gear during an

⁸ Before the two criminals mentioned in the Section 1.18 were arrested, investigators had suspected that there was crime. According to the 5.11 of *The Chicago Convention*, investigators reported this to the Winged Guard and Scarbrough Police Station.

emergency in which the door is stuck.

Also, the plugs might be reversely connected, since they have the same shape and only use color to tell the difference. These are against the safety principle of the designing.

Another threat is that if the motor is stuck, it might produce too much heat and cause smoke and/or fire.

2.2 To The ATC Procedure

According to both the CVR and the ATC tape, the ATC mainly paid attention to the emergency aircraft, sometimes leaving other aircraft behind. The longest wait was HIS 1's, which lasted for approximately 4 hours.

Other parts of the ATC work were in time and correct, which can be seen from the cooperation between the ATC, the pilot and the firefighter and the success of landing.

Besides, when the ATC was dealing with the emergency, monsters'⁹ defense systems were not completely working. The military defense at that time was also incomplete.

2.3 To The Firefighters' Procedure

The firefighter's mission was done in time, but the sudden cool-down of the fuselage caused its damage. The detailed curve is given in Section 1.16.2.

2.4 To The Performance of the Fuselage

It can be believed that the kinetic energy of the aircraft when it touches the ground mainly becomes the heat. Therefore:

$$\frac{k}{2}m_A v^2 = cm_B \Delta t$$

In which m_A represents the gross weight and m_B represent the weight of the bottom surface. So that

$$\Delta t = \frac{kv^2 m_A}{2cm_B}$$

In which $c \approx 9 \times 10^2 \text{ J}/(\text{kg} \times ^\circ\text{C})$, $k \approx 0.5$, $m_A \approx 12000 \text{ kg}$ and $m_B \approx 20 \text{ kg}$, and according to 1.16, $v \approx 145 \text{ kt} \approx 74.6 \text{ m/s}$, which means $\Delta t \approx 927.389 ^\circ\text{C}$, which suits the final result well.

From the relationship between Δt and m_B , you can see that adding the weight of m_B can help. If $m_B \approx 120 \text{ kg}$, the temperature will be approximately $154.565 ^\circ\text{C}$; as for $m_B \approx 30 \text{ kg}$, that will be $618.259 ^\circ\text{C}$, which is apparently much safer (the temperature limit mentioned in Section 1.16.2 is lower than the vapor's existence temperature).

⁹ Including Timeres, Aurora, etc. In some documents, they're called beasts.

2.5 To The Security Procedure

It can be confirmed that the security procedure has bugs for criminals to use. More detailed, criminals may go on board and directly go off to enter the apron area. Then, the aircraft without a guard will be threaten.

3 Conclusions

Investigators agree that:

- The design of the landing gear system should be improved. More detailed, there should be measures to prevent plugs from being reversely wired.
- The security procedure of the airport should be improved. More detailed, airport should prevent passengers from getting off unexpectedly and enter apron area.
- The design of the fuselage should be improved to reduce the temperature rise.
- The ATC and dispatching procedure can be improved. More detailed, the defense work and the emergency procedure can be better balanced.
- The landing gear extension procedure can be improved to prevent the motor from being overheated.

4 Safety Recommendations

4.1 To The Landing Gear System

The manual system of the landing gear extension can be like:

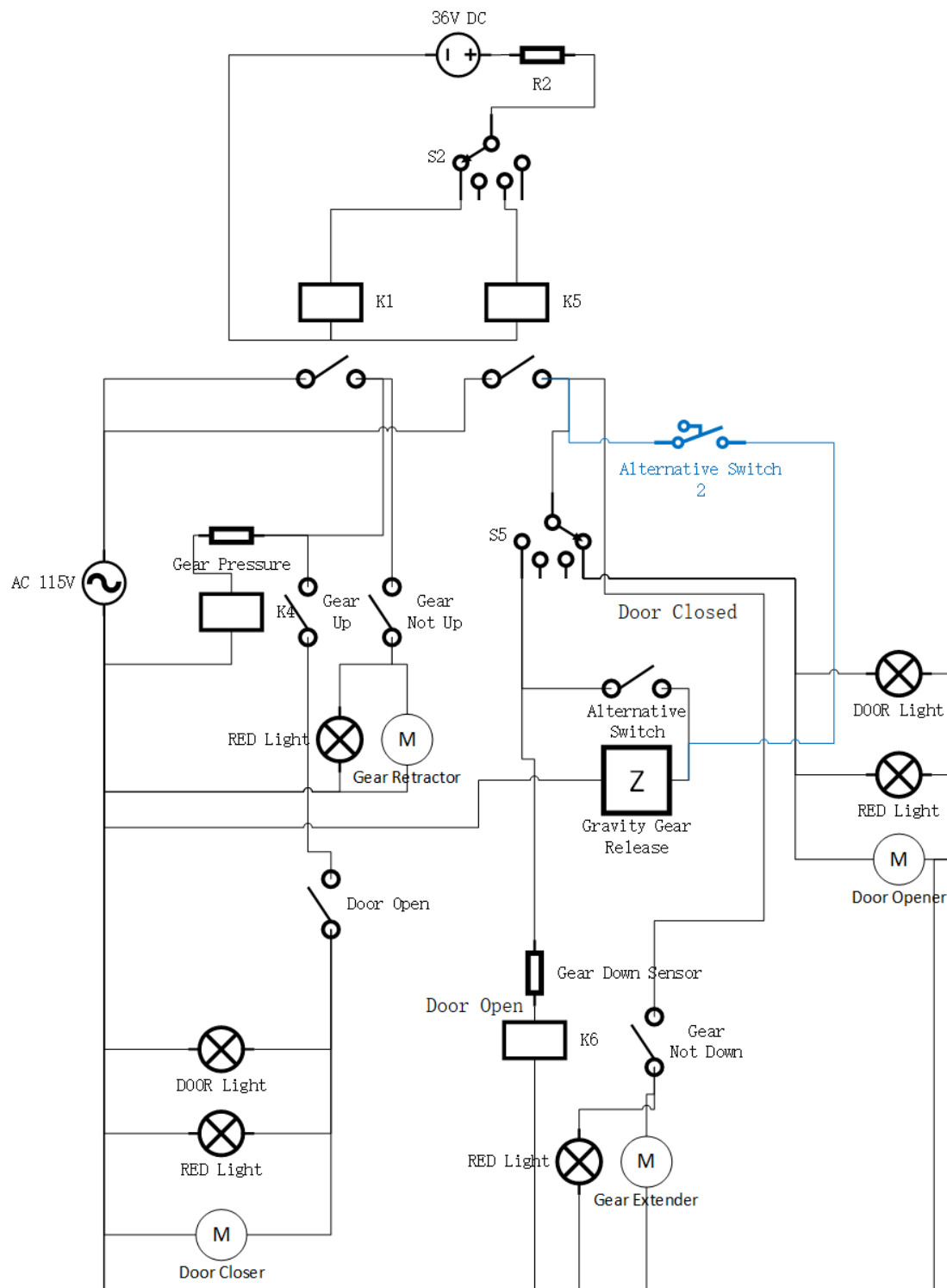


Figure 4. Recommended electronic system

(Blue switch is a delayed switch which automatically engages after being turned on for a few seconds. The timeout should be determined through calculation or experiment.)

In this way, even if the door is stuck, the gear will extend. However, whether the broken door will cause damage, remains to be seen. Anyway, the damage caused by the broken door won't be more serious than the damage caused by unextendible landing gear.

Besides, to prevent unexpected wire, plugs are recommended to use both different colors and different shapes, which should be different enough so that a plug can't be connected to the wrong position.

Response: All Seniorious and Historia aircraft, which have similar design, have all been equipped with new alternative system by the end of January 437.

4.2 To The Security Procedure

Airports should use as many corridor bridges as they can to prevent unexpected getting-off. Guards and barriers are also recommended to add to protect important aircraft.

Response: 30 Corridor bridges have been built by then end of January 437. Besides, barriers have been set up to separate the military area and the commercial area in the Scarbrough airport.

4.3 To The Design of The Fuselage

According to the analysis, an external panel can be added to the bottom of the fuselage to prevent such an overheat. This can also work for other functions, including protecting the aircraft when monsters or other combats attack that area.

Response: Some aircrafts whose route goes through monster-threatened airspaces have been equipped with new panel. By the end of January 437, 35 planes have installed such an external device.

4.4 To The ATC Procedure

The number of ATC staff(s) is recommended to increase, because having only one ATC may lead to trouble when there's an emergency, which has bad effects on defending monsters or dealing with other aircraft's requirements.

Response: All airports have at least 2 ATC staffs on duty when the airport is open by the end of January 437.

4.5 To The Firefighters' Procedure


Firefighters should not pour too much water to heated fuselages to cool it down in order to prevent sudden breakdown. However, when the fuselage is likely to be on fire, an immediate cooling-down procedure should still be carried out as usual.

Response: All airports' firefighters have had online lessons or offline lectures about this by

the end of January 437.

4.6 To The Landing Gear Procedure

With the adjustment of the landing gear system, the related procedure, represented as checklists, are recommended to adjust. More detailed, the checklist is recommended to be like:

Manual Gear Extension		
Status: One of the following situations: <ul style="list-style-type: none">● When the landing gear lever is in DOWN position, any of the gears is not down and locked.● The landing gear lever is stuck in OFF position.		
Note: If at least one related gear indication of main panel and overhead panel is green, the gear is down and locked.		
1	Landing gear lever	... OFF (If possible)
2	Manual gear-down lever (The not-extended gear) The related red light will indicate that the module is working.	... DOWN
3	After all gears are dealt with, wait for 15 seconds and check landing gear indications.	
Note: The landing gear indication may illuminate regardless of the gear lever position.		
4	Consider one of them: <ul style="list-style-type: none">◆ All landing gear indication shows down and locked: ▶▶ Go to step 5.◆ At least one landing gear indication doesn't show down and locked: ▶▶ Go to Partial or All Gear Up Landing Procedure (Page 14.24).	
Note: It's not recommended to move the landing gear lever, or the motor may continue running.		
5	GPWS	... Gear inhibit
Note: Wheel steering is not working.		
6	Land normally. 	

(More detailed, a notice is added)

Response: A service bulletin was published and all checklists of the similar aircrafts have been updated by then end of December 436.