AI2023-3

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

Privately owned
B – 3 2 0 3

March 30, 2023

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board (and with Annex 13 to the Convention on International Civil Aviation) is to prevent future accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

TAKEDA Nobuo
Chairperson
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

《Reference》

The terms used to describe the results of the analysis in "3. ANALYSIS" of this report are as follows.

i) In case of being able to determine, the term "certain" or "certainly" is used.
ii) In case of being unable to determine but being almost certain, the term "highly probable" or "most likely" is used.
iii) In case of higher possibility, the term "probable" or "more likely" is used.
iv) In a case that there is a possibility, the term "likely" or "possible" is used.

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

MULTIPLE MALFUNCTIONS IMPEDING

THE SAFE FLIGHT OF AIRCRAFT

PRIVATELY OWNED

(ENTRUSTED FLIGHT OPERATION TO SINO JET)

EMBRAER ERJ190-100ECJ, B-3203

AT AN ALTITUDE OF APPROX. 240 FT

OVER 2.3 KM SOUTH OF NEW CHITOSE AIRPORT

AT 12:26:17, DECEMBER 23, 2019

March 10, 2023
Adopted by the Japan Transport Safety Board
Chairperson TAKEDA Nobuo
Member SHIMAMURA Atsushi
Member MARUI Yuichi
Member SODA Hisako
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE AIRCRAFT SERIOUS INCIDENT INVESTIGATION

1.1 Summary of the serious incident	On December 23 (Monday), 2019, a privately owned Embraer ERJ190-100ECJ, registered B-3203, was on the final approach to New Chitose Airport, the destination aerodrome, with 24 persons on board, consisting of the captain, four other crewmembers and 19 passengers, but at a pressure altitude of approximately 240 ft (AGL: about 165ft), the indication on all the display units powered by multiple systems temporarily disappeared in the cockpit. The aircraft landed without any change.
1.2 Outline of the serious incident investigation	The occurrence covered by this report falls under the category of "Multiple malfunctions in one or more systems equipped on aircraft impeding the safe flight of aircraft" as stipulated in Article 166-4, item (ix) of the Ordinance for Enforcement of Civil Aeronautics Act (Ordinance of Ministry of Transport No. 56 of 1952) prior to revision by the Ministerial

	Ordinance on Partial Revision of the Ordinance for Enforcement of Civil Aeronautics Act (Ordinance of Ministry of Land, Infrastructure, Transport and Tourism No. 88 of 2020) , and is classified as a serious incident. On December 23, 2019, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge to investigate this serious incident. In addition, another investigator was assigned on December 26, 2019. An accredited representative and an advisor of the Federative Republic of Brazil, as the State of Design and Manufacture of the aircraft involved in this serious incident, an accredited representative and an advisor of the People's Republic of China, as the State of Registry and Operator of the aircraft involved in this serious incident, an accredited representative of the United States of America and an accredited representative of the Republic of France, as the States of Design and Manufacture of the components of the aircraft involved in the serious incident, participated in the investigation. Comments on the draft Final Report were invited from parties relevant to the cause of the serious incident and the relevant States.

2. FACTUAL INFORMATION

2.1 History of the Flight	At 08:17 (JST: UTC+9 hours; unless otherwise noted, all times are indicated in JST in this report on a 24-hour clock), a privately owned Embraer ERJ190-100ECJ, registered B-3203, took off from Hong Kong International Airport to New Chitose Airport (hereinafter referred to as "the Airport"), with 24 persons on board, consisting of the Captain, four other crewmembers and 19 passengers. According to the statements of the crewmembers of the Aircraft, the air traffic controller of the Chitose ATC Squadron (hereinafter referred to as "Chitose Tower") and flight data records of the flight recorder, the history of the serious incident is summarized as follows (Figure 1). In the Aircraft, the Captain sat in the left seat as PF*1 and the First Officer (FO) sat in the right seat as PM*1. At this time, among the Aircraft's five display units (hereinafter referred to as "DU"), the rightmost DU5 was in failure, but the Aircraft was in flight by applying the MEL*2. The Aircraft was flying without any problems until the start of the final approach to Runway 01R at the Airport. The weather around the Airport was fine and the runway was dry. At 12:24:43 when the Aircraft was

*1 "PF" and "PM" is a term for identifying a pilot from role sharing in an Aircraft controlled by two people, PF (Pilot Flying) mainly manipulates the Aircraft and PM (Pilot Monitoring) Mainly performs monitoring of flight condition of the Aircraft, and makes cross check of operation of PF and operations other than maneuvering.
*2 "MEL", which stands for Minimum Equipment List, is a list prepared by an operator and approved by the CAB. It allows an aircraft operator to fly even with a certain item(s) inoperative at the commencement of a flight, and includes the conditions such as operation conditions, operational restriction, operation procedures and others.

	on the final approach to Runway 01R, the failure of IDG*3 2 in the EICAS*4 message saying "IDG2 OFF BUS*5" (CAUTION: Orange) was indicated at a pressure altitude of about 1,260 ft and an airspeed of about 130 kt. However, the Captain and the FO decided to continue the approach without responding to this message because the altitude was low as the Aircraft was on the final approach, the power was supplied to all equipment as the other system, IDG1 normally operated, and this EICAS message did not require emergency operations. After that, they turned off the autopilot according to the normal landing procedures. At 12:26:17, the indication on all the DUs disappeared at a pressure altitude of about 240 ft (AGL: about 165ft) and an airspeed of about 130 kt, the flight recorder stopped recording. According to the statement of the FO, the message "ELEC EMERGENCY" (WARNING: Red) meaning the AC main buses are de-energized was momentarily indicated. At this time, as for the standby instrument, the indication was present, and the RAT*6 was automatically deployed. The indication on DU2 and DU3 appeared again afterward. According to the FO, it was for one to two seconds during which the indication on all the DUs disappeared (Figure 2). The FO as PM reported the situation to the Captain as PF. The Captain judged that it would be safe to land as is since landing preparation had been already made. At about 12:26:30, the Aircraft landed on Runway 01R. During the landing roll, the reverse thrust, autobrakes, steering and spoilers of the Aircraft did not operate, but the Captain reduced the speed with the brake operations and vacated the runway via the Highspeed Taxiway B4 in the same way as he did in the past simulation training. The Aircraft stopped short of Runway 01L as being instructed by Chitose Tower to hold short of Runway 01L. There were no anomalies about the transmission and reception on radio communication equipment.

*3 "IDG", which stands for Integrated Drive Generator, is an electrical generator installed in each of the left and right engine gear boxes, which provides stable 3-phase AC power at 400Hz, 115/200VAC, and 30/40KVA.
*4 EICAS stands for Engine Indication and Crew Alerting System, which refers to a system designed to display the operational conditions of the engines and part of other systems and notify the pilot of the occurrence of abnormalities by visual and auditory means.
*5 "BUS" in this report refers to the power bus-bar.
*6 "RAT" stands for Ram Air Turbine, which refers to a wind turbine generator used to provide emergency electrical power to the aircraft (See 2.7(1)).

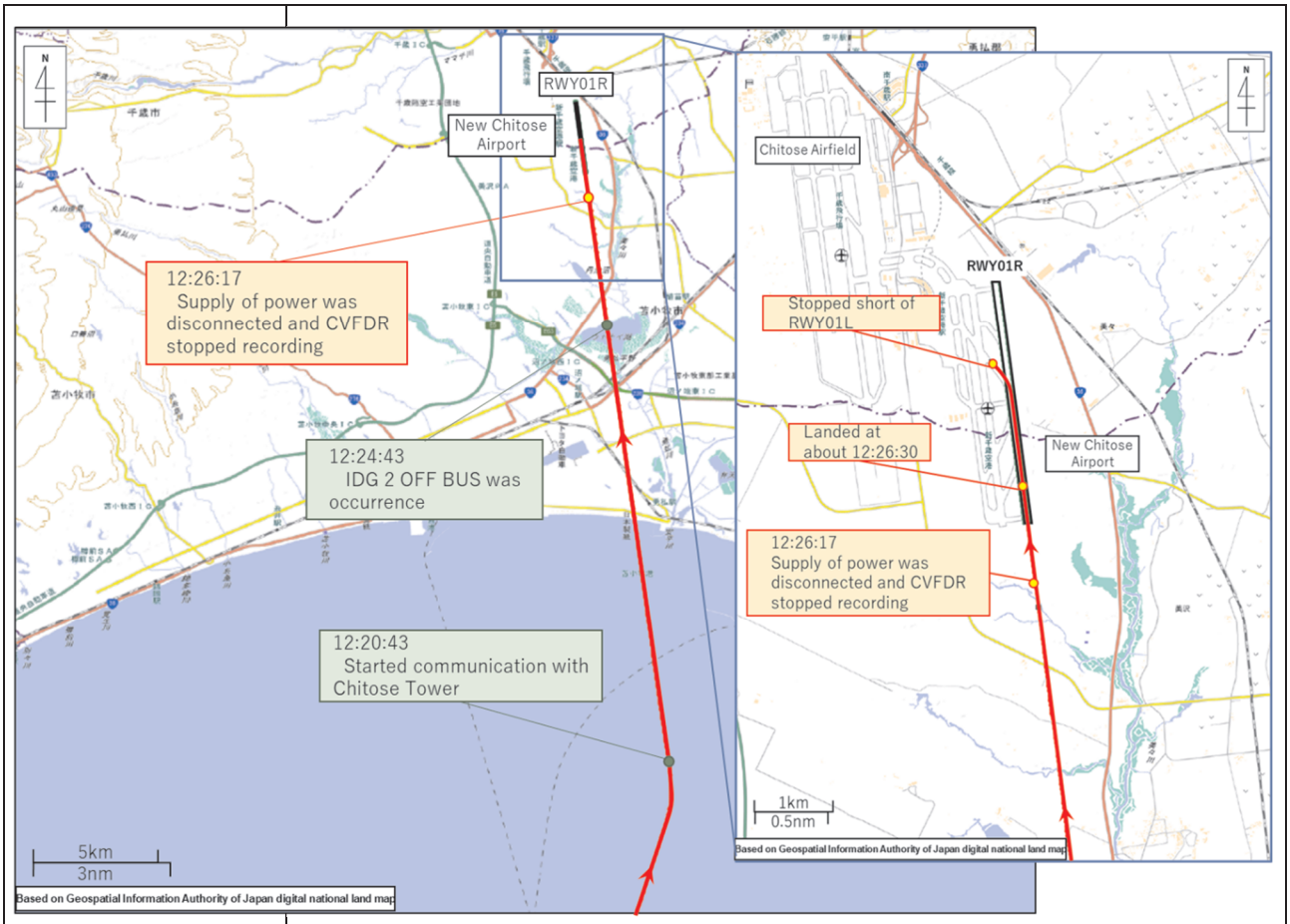


Figure 1: Estimated flight route

After that, when the Captain started up the APU*7 to ensure the power supply, and confirmed that all the indication from DU1 to DU4 except DU5 was displayed, and on EICAS, there were many messages, among which were "IDG2 OFF BUS", "ELEC EMERGENCY" as well as "IDG1 OFF BUS". The Captain and the FO performed the check lists for "ELEC EMERGENCY" and "IDG1 (2) OFF BUS" in accordance with the handbook describing the Aircraft's operation procedures.

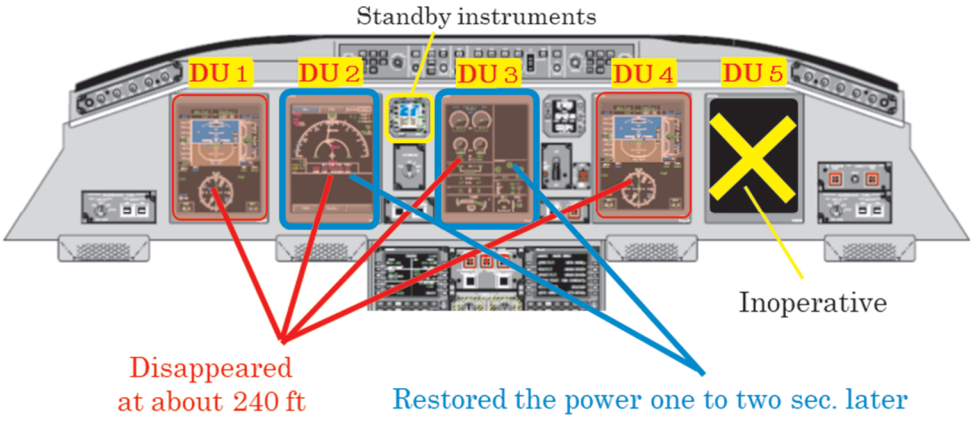
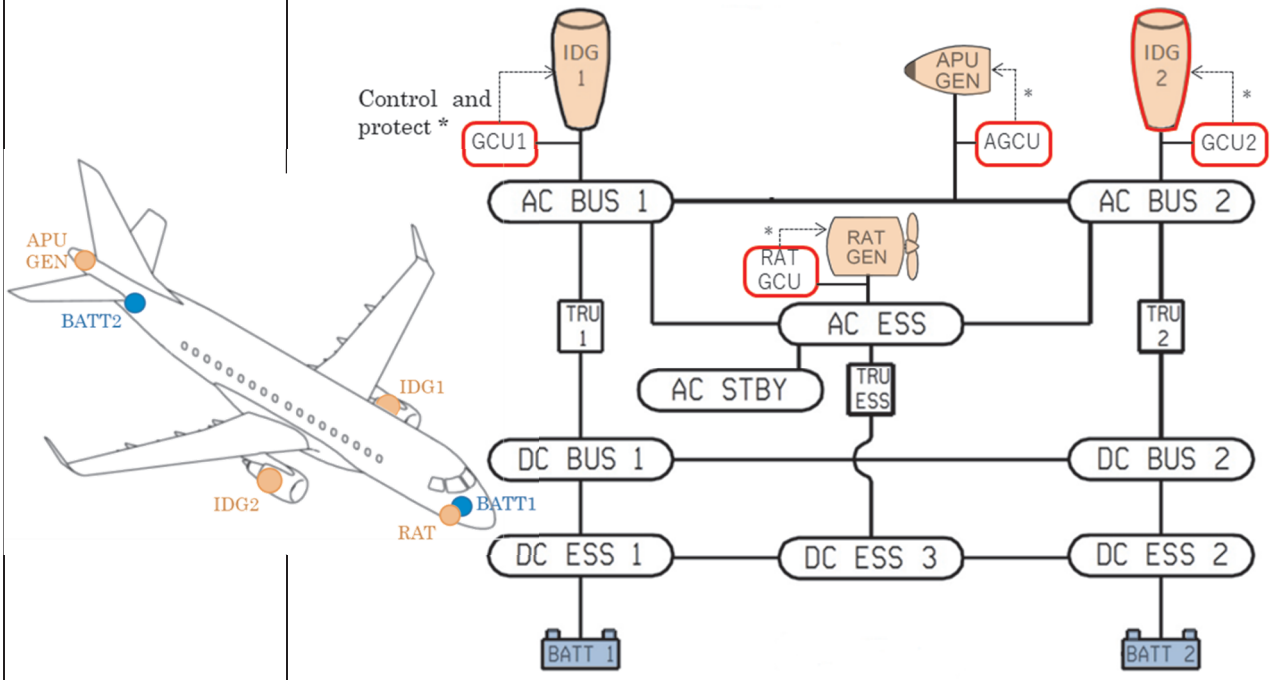


Figure 2: DU (Display Unit) location (As for the indications, see 2.7.(2))

*7 APU stands for the Auxiliary Power Unit installed separately from the propulsion engine to supply the aircraft with pneumatic pressure, oil pressure and electricity.

	As Chitose Tower was about to instruct the Aircraft to cross Runway 01L, at 12:27:57, the Aircraft requested a towing car due to the aircraft trouble, and for the first time, Chitose Tower recognized the abnormality of the Aircraft. The Aircraft shut down both engines and was moved by towing car to the apron, and disembarked the passengers. The serious incident occurred at an altitude of approximately 240 ft over 2.3 km south of New Chitose Airport (42'45"16 N, 141'41"52 E) at 12:26:17 on December 23, 2019.
2.2 Injuries to Persons	None
2.3 Damage to the Aircraft	None
2.4 Personnel Information	(1) Captain Age 42 Airline transport pilot certificate (Airplane) May 13, 2010 Type rating for Embraer ERJ-190 June 26, 2018 Class 1 aviation medical certificate Validity May 11, 2020 Total flight time 7,935 hours 34 minutes Flight time in the last 30 days 26 hours 20 minutes Total flight time on the type of aircraft 93 hours 36 minutes Flight time in the last 30 days 22 hours 36 minutes (2) FO Age 32 Commercial pilot certificate (Airplane) May 25, 2015 Type rating for Embraer ERJ-190 June 26, 2018 Instrument flight certification March 6, 2015 Class 1 aviation medical certificate Validity November 6, 2020 Total flight time 604 hours 32 minutes Flight time in the last 30 days 15 hours 24 minutes Total flight time on the type of aircraft 73 hours 43 minutes Flight time in the last 30 days 15 hours 24 minutes
2.5 Aircraft Information	(1) Aircraft Type: Embraer ERJ 190-100 ECJ Serial number: 19000453 Date of manufacture: August 1, 2012 Certificate of airworthiness: AC4297 Category of airworthiness: Airplane, Transport T Total flight time 1,029 hours 09 minutes (2) When the serious incident occurred, the weight and the position of the center of gravity of the Aircraft were each within the allowable range.
2.6 Meteorological Information	The aerodrome routine meteorological reports (METAR) for the Airport around the time of the serious incident were as follows:

	12:00 Wind direction: 340°, Wind velocity: 8 kt, Prevailing visibility: 10 km or more Cloud: Amount 1/8; Type Cumulus; Cloud base 3,000 ft; Cloud: Amount 5/8; Type Unknown; Cloud base Unknown; Temperature -5℃; Dew point -8℃; Altimeter setting (QNH) 29.97 inHg 12:30 Wind direction: 340°, Wind velocity: 7 kt, Prevailing visibility: 10 km or more Cloud: Amount 1/8; Type Cumulus; Cloud base 3,000 ft; Cloud: Amount 7/8; Type Unknown; Cloud base Unknown; Temperature -4℃; Dew point -7℃; Altimeter setting (QNH) 29.96 inHg
2.7 Additional Information	(1) Power supply systems (Figure 3) The power supply systems of the Aircraft consist of AC (alternating current) and DC (direct current) power supplies. As AC power generators, one IDG is installed in each of the left and right engine gear boxes, one APU GEN (Generator) is installed in the APU, and one RAT is stowed on the right side of the nose. During normal operation, two IDGs supply power to the AC BUS as the main power supply. The DC power supply converts the AC power from the IDG and the APU GEN into the DC power, and provide it to the DC BUS and the DC ESS BUS. One battery is installed in each of the front and aft fuselage as a backup for the DC power supply, and they supply power to the DC ESS BUS in the event of power loss, before the RAT is fully deployed, or if the power supply from the RAT is cut off to ensure operation of the Essential equipment (standby instruments, radio communication equipment and others). When the power supply from the both IDGs stops during flight, the RAT is automatically deployed outside of the aircraft, and supplies the power generated by rotating the propeller with the air current to the DC ESS BUS via the AC ESS BUS. The IDG, APU GEN and RAT are controlled and protected in voltage and frequency by the GCU (Generator Control Unit), AGCU (Auxiliary GCU) and RAT GCU, respectively.



*Equipment in red box was investigated in detail (See 2.7(5))

Figure 3: Power supply systems

(2) DU (Display Unit)

The DU of the type of the aircraft operates on DC power.

The DU displays the status of the aircraft and avionics systems. Each DU indication during normal operation is as follows.

- DU1・・・PFD (Primary Flight Display: displays major flight instruments and others)
- DU2・・・MFD (Multi-Function Display: displays the information related to navigation)
- DU3・・・EICAS (displays engine instruments, system parameters, and warning messages)
- DU4・・・MFD
- DU5・・・PFD

Even in the event of power loss, the DU2 and DU3 will be supplied with power from the batteries via the DC ESS BUS. When the "MFD Mode Switch" on the overhead panel, which is used to switch the display at the time of the DU failure, is set to "AUTO" mode, the DU2 will function as PFD, and DU3 as EICAS.

As the DU1, DU4 and DU5 are supplied with power from the DC BUS, the power supply will be stopped in case of power loss.

During a normal inspection for the Aircraft on December 12, 2019, a failure in DU5 was found, but it was confirmed to be a failure of a DU5 itself, therefore the Aircraft was allowed to make three days flight until the repair was completed by applying the MEL. When the DU5 fails and the "MFD MODE Switch" is set to "AUTO", the DU4 will function as PFD (Figure 2).

When the serious incident occurred, the switch of the Aircraft was set to "AUTO".

(3) Inoperative items in an emergency and abnormal event

The Aircraft Operations Manual (AOM) of the type of the Aircraft includes the descriptions on the items that will be inoperative in each emergency and abnormal event.

(Excerpt)

① *DC BUS 2 OFF*

- *Autobrakes*

② *ELEC EMERGENCY*

- *Multi-Function Spoilers, L3, R3, L4, R4, L5 and R5*
- *Auto throttle*
- *Nose wheel steering*
- *Display units, 1, 4 and 5*
- *Engine 1 and Engine 2 reversers*
- *Speed brake*
- *Ground spoilers, L1, R1, L2 and R2*

(4) Flight recorder

The Aircraft is equipped with a Combined Voice and Flight Data Recorder (CVFDR) developed by Universal Avionics Systems Corporation of the United States of America, which functions as both a Flight Data Recorder (hereinafter referred to as "FDR") and a Cockpit Voice Recorder (CVR), one each on the forward and aft fuselage.

The CVFDR of the type of the Aircraft operates on DC power, and even in the event of power loss, it will be supplied with power from the batteries via the DC ESS BUS. In addition, the FDR is designed to record when Engine 1 or 2 is in operation, or in flight.

Regarding the flight records of the Aircraft, the records up to the occurrence of the serious incident were kept, but it stopped recording after the serious incident, and the records were not kept during the period between the Aircraft's landing and the APU start-up by the Captain.

The mechanic on board was troubleshooting the failure in the cockpit of the Aircraft after the passengers disembarked, during which the cockpit voice recording was continuing, as a result, the records at the time of the serious incident had been overwritten.

(5) Detailed investigation of components removed from the Aircraft

After the occurrence of the serious incident, the following components were removed and a detailed investigation of them was conducted by the designers and the manufacturers of the Aircraft and each component.

Component name	Part number
IDG2	1701317A
GCU1	1701321D
GCU2	1701321D
AGCU	1701321D
RAT GCU	1700894A
GLC*[8]2	900CA01
SPDA*[9]2 (Microcomm board)	1713878A

As a result of the detailed investigation, it was confirmed that each component was normally functioning, but the analysis of the operation records in the GCU and SPDA (Microcomm board) revealed the following.

① Due to the detection of an Overfrequency condition, the GCU2 had tripped the IDG2 off from the No.2 power supply system, but it was a false detection, which was not caused by an IDG2 fault but by an internal fault with the GCU2.

② Due to the detection of an Undervoltage, the GCU1 had tripped off the IDG1 from the No.1 power supply system, but it was a false detection, which was not caused by an IDG1 fault but by an internal fault with the GCU1.

(6) Similar failure cases

① GCU

The similar cases, in which IDG was tripped off from the power supply systems as an Overfrequency or Undervoltage condition was detected due to the internal fault with the GCU, had already been confirmed, and each occurred independently. To respond to these issues, the designer and the manufacturer of the components issued the Service Bulletins (hereinafter referred to as the "SB", described later in 3.4 (4)). The outline of the SBs is as follows.

a SB 40EPS04G-24-5 (June 30, 2015 First edition)

As there exists, in the circuit used to monitor frequency, an issue that can cause the reference point of the circuits to float, momentarily, to a different value, the circuit shall be isolated from the other circuits.

The incorporation of this SB shall be accomplished at first shop visit for all relevant GCU is removed from the aircraft.

After the incorporation of this SB, the GCU Part Number shall be 1701321E.

b SB 40EPS04G-24-6 (September 17, 2018 First edition)

As an electromagnetic interference can cause a drop in its

*8 "GLC" stands for Generator Line Contactor, which is installed between IDG and AC BUS to open and close the power circuit.

*9 "SPDA" stands for Secondary Power Distribution Assembly, which is a distribution system to deliver and monitor DC power to utility systems.

	output level of the power supply used in the GCU in some conditions, a shield shall be installed under the power supply circuit to prevent the electromagnetic interference. The incorporation of this SB shall be accomplished at first shop visit for all relevant GCU is removed from the aircraft. After the incorporation of this SB, the GCU Part Number shall be 1701321F. Since the GCUs installed on the Aircraft had not been removed until this serious incident, these modifications in the SBs had not been incorporated. In addition, in order to inform operators from the designers and manufacturers of the type of the Aircraft, service newsletters related to these SBs were issued, however, they were intended for passenger (E-Jets) aircraft of the Embraer ERJ190 and ERJ195 series types, and not for the ERJ190-100ECJ type aircraft, therefore, the Operator was not aware of the above SBs until the serious incident occurred. When the above failures occur, by performing the "IDG1 (2) BUS" check list, the GCU will reset and the power supply from the IDG will be resumed. ② Flight recorder The SB issued by the designer and the manufacturer of the Aircraft includes the description about the CVFDR harnesses. This SB was intended for the commercial fleet (E-Jets) among Embraer ERJ190 and Embraer ERJ195 aircraft and was not intended for the ERJ190-100 ECJ aircraft. This SB related to the data communication of FDR 512wps*[10] configuration for the CVFDR developed by Universal Avionics System Corporation. And as it was confirmed that the channel for this data communication was not connected to the DC ESS BUS powered by the batteries, this SB gives the instruction to modify the connection. The first edition was issued in December 1, 2017, and its incorporation was left to the discretion of the operator. In the wake of this serious incident, in the investigation by the designer and the manufacturer of the Aircraft, it was also confirmed that regarding the ERJ190-100 ECJ aircraft including the Aircraft, this channel was not connected to the DC ESS BUS.

3. ANALYSIS

3.1 Involvement of Weather	None
3.2 Involvement of Pilot	None

*10 "wps" stands for words per second, which is a unit to indicate the amount of data transferred to the FDR. One word consists of 12 bits.

3.3 Involvement of Aircraft	Yes
3.4 Analysis of Findings	(1) Loss of main power supply The JTSB concludes that the Aircraft was on the final approach to the Airport when the IDG2 was tripped off from the No.2 Power Supply System, however, the Aircraft continued to approach, and 1 minute and 34 seconds later, the IDG1 was also tripped off from the No.1 Power Supply System, thus both two main power supply systems of the Aircraft were certainly lost. As a result of this, it is highly probable that the indication on all the DUs temporarily disappeared, and the reverse thrust, autobrakes, steering and spoilers did not operate during the landing roll. As the Aircraft's landing preparation had been already made before the main power loss, the runway at the Airport was dry, and the Highspeed Taxiway was available, the Aircraft was probably able to sufficiently reduce the speed on the runway by the brake operations and stop after vacating the runway via the taxiway. Also contributing to this is probably the fact that the Captain had conducted a simulation training for landing in the power loss situation in the past. The reason why the IDG1 and IDG2 were tripped off from each power supply system is probably because the conditions of Overfrequency and Undervoltage were erroneously detected due to the internal fault with the GCU that controls the IDG. These false detections more likely resulted from the unmodified GCU that the Aircraft was using. The SB states that a false detection of the Undervoltage by the GCU1 may occur during engine start and certain loading conditions. However, as a result of detailed investigation of components, regarding the relationship between the load increase, which was found when one IDG tripped off during the landing approach and the entire load was taken by only one system (not two), and the certain load conditions, which may lead to a false detection as above stated in the SB, it could not be confirmed. Therefore, regarding the two false detections occurred successively in a short time, it could not be specified whether there are any relations between the two erroneously detected faults. (2) Emergency power supply The JTSB concludes that it is certain that when the main power supply of the Aircraft was lost, the RAT, which is an emergency AC generator, was automatically deployed. The batteries, which are emergency DC power supply, most likely were supplying power normally, because the indication was present on the standby instrument during the period between the main power loss and the APU start-up, the DU2 and DU3 immediately restored the power, and there was no fault in the radio communication equipment. (3) Flight record during main power loss The JTSB concludes that it is certain that when this serious incident occurred, the flight data was under the conditions possible to be recorded,

	but the Aircraft's CVFDR stopped recording after the occurrence of the serious incident. The reason why the CVFDR stopped recording is certainly because the power to the channel for the data communication of the Aircraft's CVFDR was disconnected, and the data communication became impossible, as with the similar failure cases for which the SBs have been already issued. It is certain that the power supply to the channel was disconnected because the channel was not connected to the BUS powered by the batteries. (4) Service Bulletin (SB) A SB is a notice to aircraft in operation, which is issued by the designers and the manufacturers of the aircraft, engine, or component in order to recommend or instruct on improvement, inspection, repairs, and modifications. The incorporation of the improvements provided in the SB is left to the operators' discretion. When the designers and the manufacturers issue the SBs, it is important to consider carefully the scope of application. In addition, it is important for operators to always obtain the SBs related to aircraft in their fleet, and decide whether to incorporate the SB or not by evaluating carefully the risks in the case of not incorporating it.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of this serious incident was that when the Aircraft was on the final approach, the IDG2 was tripped off from the power supply system due to the false detection of an Overfrequency condition by the GCU2, and then the IDG1 was also tripped off from the power supply system due to the false detection of an Undervoltage condition by the GCU1, which most likely resulted in the power loss of the both two main power supply systems of the Aircraft.

Regarding the fact that the both two IDGs were tripped off due to the false detections of the Overfrequency and Undervoltage, the two GCUs involved in the event did not have the Service Bulletins (to correct the faults) incorporated, which probably contributed to it.

5. SAFETY ACTIONS

The designer and the manufacturer of the Aircraft took the following safety actions.

(1) Issued a service newsletter regarding the SBs recommending the GCU modification in order to make the SBs known to operators.

(2) Issued the SBs instructing operators, including the Aircraft, to modify the wiring for the CVFDR data communication circuits on July 23, 2020, regarding the problem where the CVFDR stopped recording the flight data.

(3) Introduced this serious incident at the Embraer Operators Safety Meeting in September 2020.