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AIRCRAFT SERIOUS INCIDENT
INVESTIGATION REPORT

TAKUMI ENTERPRISE
HELICOPTER & AIRPLANE CO., LTD.
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November 29, 2018

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.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

AIRCRAFT SERIOUS INCIDENT INVESTIGATION REPORT

SHORTAGE OF FUEL REQUIRING URGENT MEASURES AT AN ALTITUDE OF ABOUT 5,300 FT OVER THE AREA 28 KM NORTHEAST OF OTSU CITY SHIGA PREFECTURE, JAPAN AT AROUND 17:05 JST, AUGUST 27, 2017

TAKUMI ENTERPRISE HELICOPTER & AIRPLANE CO., LTD. ROBINSON R44(ROTORCRAFT), JA7981

October 26, 2018

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Toru Miyashita
Member	Toshiyuki Ishikawa
Member	Yuichi Marui
Member	Keiji Tanaka
Member	Miwa Nakanishi

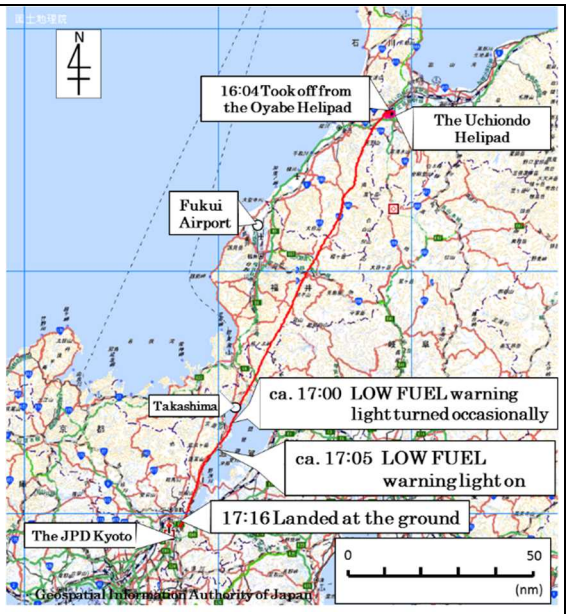
1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Serious Incident	On Sunday, August 27, 2017, at around 17:05 Japan Standard Time (JST: UTC + 9hrs, unless otherwise stated all times are indicated in JST on a 24-hour clock), a Robinson R44, registered JA7981, operated by Takumi Enterprise Helicopter & Airplane Co., Ltd. made an emergency landing at the ground of a school in Fushimi Ward, Kyoto City, as the "LOW FUEL" warning light came on while flying at about 5,300 ft over the area 28 km northeast of Otsu City, Shiga Prefecture. Only a pilot was on board. There were no casualties.
1.2 Outline of the Serious Incident Investigation	The occurrence covered by this report falls under the category of "Shortage of fuel requiring urgent measures" as stipulated in Clause 12, Article 166-4 of the Ordinance for Enforcement of the Civil Aeronautics Act, and is classified as a serious incident. On August 28, 2017, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and an investigator to investigate this serious incident. Although this serious incident was notified to the United States of America, as the State of Design and Manufacture of the Rotorcraft involved in this serious incident, the United State did not designate its accredited representative.

	Comments on the draft report were invited from parties relevant to the cause of the serious incident and the Relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight	According to the statements of the pilot and persons concerned with the serious incident as well as portable GPS receiver records, the history of the flight is summarized as below. A Robinson R44, registered JA7981 (hereinafter referred to as "the helicopter"), operated by Takumi Enterprise Helicopter & Airplane Co., Ltd. (hereinafter referred to as "the Company"), took off from JPD Kyoto temporary helipad (hereinafter referred to as "the JPD Kyoto") in Fushimi Ward, Kyoto City at around 08:12, August 26, 2017 in order to participate in an event held in Oyabe city, Toyama Prefecture, with a pilot on board and about 135 liters of fuel onboard. After landing at Oyabe temporary helipad (hereinafter referred to as "the Oyabe Helipad"), the event site, at around 09:36, the helicopter performed a flight to support parachute descent and a demonstration flight for 12 minutes, respectively. Afterwards, while the helicopter moved to Uchiondo temporary helipad (hereinafter referred to as "the Uchiondo Helipad") in Oyabe City, Toyama Prefecture for refueling service, the "LOW FUEL" warning light came on in a moment before its landing. After landing, a refueler supplied 100 liters of fuel into its main tank. The pilot confirmed the fuel gage needle was moved toward fuel increasing but did not read the remaining fuel quantity accurately on the gage. Besides, he did not open the fuel caps to check visually after refueling. The helicopter took off from the Uchiondo Helipad, returned to the Oyabe Helipad and parked there. In the morning on August 27, the next day, the helicopter performed a flight to support parachute descent and a sightseeing flight for 12 minutes, respectively, but it was not refueled after that. After the event was over, the pilot made a flight plan to the JPD Kyoto calculating minimum required quantity of onboard fuel as 110 liters by estimating the total flight distance as 120 nm and one hour and 50 minutes of airborne time (= one hour and 20 minutes of elapsed time + 10 minutes of delay correction + 20 minutes of reserve fuel). During preflight checks, the pilot checked the fuel gage and thought that the quantity of fuel onboard was enough to reach the destination. Afterwards, he informed the Civil Aviation Bureau via the headquarters that in his flight plan, the helicopter would take off from the Oyabe Helipad at 16:00 and land at the JPD Kyoto at 17:30 with 110 liters of fuel onboard. The helicopter took off from the Oyabe Helipad at 16:04 and flew straight to Kyoto via over Takashima, Lake Biwa. The pilot set at 24.00 inHg output power at the time of take-off to have the helicopter climb gradually maintaining constantly the maximum continuous power that would not exceed the range between 22.0 and 22.5 inHg. He did not estimate accurately the effect of wind for his calculation but he assumed there would be tailwind when the helicopter climbed, and he went up to 8,500 ft so that the ground

	speed on GPS receiver was able to exceed the indicated airspeed. When he made a position report at 16:48, he looked at the fuel gage but did not read the indication accurately. The pilot noticed the consumed fuel amount was larger than usual while flying around over the north end of Lake Biwa and thought about changing the destination to Fukui Airport, but eventually decided to fly toward the JPD Kyoto as planned because its distance was closer by 10 nm.  Figure 1: Estimated flight route of JA7981 The LOW FUEL warning light started to come on occasionally from at around 17:00 and it completely came on at around 17:05 over the area around southwest of Lake Biwa. The indicator on the GPS receiver showed that the estimated time of arrival at the JPD Kyoto was around 17:18; and according to the flight manual, if the helicopter continues flying at a cruise power, its fuel would run out in about 10 minutes after the LOW FUEL warning light comes on, which meant being short of 3 minutes to land safely; therefore, the pilot judged it would be difficult for the helicopter to continue flying to the destination without any changes. The pilot decided to land at the empty ground after informing the JPD Kyoto that the pilot would make a precautionary landing and looking for an appropriate landing site. The pilot confirmed the ground safety over the target site, made a landing at the ground at around 17:16, and stopped the engine after cooling. After that, a mechanic of the Company refueled about 58 liters of fuel with a hand pump at the ground; the helicopter took off from the ground at 06:11 on the next morning, and landed at 06:17 at the JPD Kyoto located in around 7 km southwest of the ground. This serious incident occurred at around 17:05 on August 27, 2017, at an altitude of about 5,300 ft over the area 28 km northeast of Otsu City, Shiga Prefecture (35° 15' 01" N, 135° 57' 59" E).
2.2 Injuries to Persons	None
2.3 Damage to Aircraft	None
2.4 Personnel Information	(1) Captain Male, Age 33 Commercial pilot certificate (Rotorcraft) August 29, 2011 Pilot competence assessment Expiry of practicable period for flight May 24, 2019 Type of rating for single-piston engine (land) August 29, 2011 Class 1 aviation medical certificate Validity date: October 17, 2017

	Total flight time 682 hours and 34 minutes Flight time on the same type of aircraft 355 hours and 46 minutes Flight time in the last 30 days 2 hours and48 minutes
2.5 Aircraft Information	(1) Type Robinson R44 Serial number 1011 Date of manufacture March 1, 2001 Certificate of Airworthiness No.To-28-388 Validity date November 27, 2017 Total flight time 1,402 hours and 24 minutes (2) When the serious incident occurred, the weight and the balance of the helicopter were both within the allowable range.
2.6 Meteorological Information	Aeronautical weather observations around the time of the serious incident at Fukui Airport, which is close to the flight route, were as follows: 16:00 Wind direction 350°; Wind velocity 9 kt; Visibility 10 km or more Present weather phenomena: Cloudy Cloud Amount: 2/8 to 3/8, Type: unknown, Cloud base: 5,000 ft Amount: 4/8 to 6/8, Type: unknown, Cloud base: unknown Temperature 28°C; Dew point 22°C Altimeter setting (QNH) 29.94 inHg The wind direction, wind velocity and outside air temperature along the flight route were as follows:

Time	Location	Observation altitude (ft)	Wind direction (degree)	Wind velocity (kt)	Outside air temperature	Sources
16:30	Fukui	6,000 5,000 3,500	190 160 160	10 15 10	-	Wind profiler
16:30	Katsuyama	643	315	5	28	Local meteorological observatories
17:00	Imazu	289	070	3	29	
17:20	Kyoto	135	090	8	32	

Table 1: Wind direction, wind velocity and outside air temperature along the flight route of JA7981

2.7 Additional Information	(1) GPS receiver records A portable GPS receiver brought in the helicopter had recorded the flight data from the time when the helicopter took off from the JPD Kyoto on one day before to the serious incident occurrence till when it landed at the ground. Figure 1 shows the helicopter's estimated flight route from taking off from the Oyabe Helipad to landing at the ground.

Photo 1: Instrument panel of JA7981

(2) Fuel system of Robinson R44

a. Fuel tank capacity

Main fuel tank capacity	29.5 gal (US) (112.0 liters)
Auxiliary fuel tank capacity	17.0 gal (US) (64.0 liters)
Unusable fuel quantity	1.5 gal (US) (5.6 liters)

The auxiliary fuel tank, which is interconnected with the main fuel tank, is located higher than the main fuel tank, therefore it will become empty first.

b. Fuel gages

The fuel gages that show the quantity by fractions are mounted below the instrument panel and electrically operated by float-type transmitters in the fuel tanks.

c. LOW FUEL warning light

The "LOW FUEL warning light" on the instrument panel is operated by a separate electric sender located on the bottom of the main tank. According to the flight manual, an illuminated low fuel warning light indicates that the usable remaining fuel quantity is about 3 gallons (US) (11.3 liters) and the fuel will run out within about 10 minutes if the helicopter continues flying at a cruise power; and it is also noted as follows:

"Caution"

Do not rely on the "LOW FUEL warning light" to judge the quantity of remaining fuel.

d. Safety Notices [1]

In addition, as the appendices of the flight manual for Robinson 44, attached are safety notices that describe the measures to prevent accidents resulting from fuel exhaustion as follows:

Safety Notice SN-15 (excerpts)

FUEL EXHAUSTION CAN BE FATAL

[1] The "Safety Notice" refers to safety information issued by Robinson on the bases of various accidents and incidents in the past so that pilots can study mistakes made by other pilots to avoid making the same errors.

1) *Never rely solely on the fuel gage or the low fuel warning light* (LOW FUEL warning light). *These electromechanical devices have questionable reliability in any airplane or helicopter. Always record the hourmeter[2] reading each time the fuel tanks are filled.*

2) *During your preflight:*
   a) *Check the fuel level in the tanks visually.*
   b) *Be sure the fuel caps are tight.*
   c) *Drain a small quantity of fuel from each tank and the gascolator to check for water or other contamination.*

3) *Before takeoff:*
   a) *Insure that the fuel valve is full on.*
   b) *Be sure guard is placed on mixture control.*
   c) *Plan your next fuel stop so you will have at least 20 minutes of fuel remaining.*

4) *In flight:*
   a) *Continually check both hourmeter and fuel gages. If either indicates low fuel, LAND.*
   b) *Always land to refuel before the main tank fuel gage reads less than 1/4 full.*
   c) *NEVER allow the fuel quantity to become so low in flight that the low fuel warning light comes on.*

(3) The required quantity of fuel onboard applied to the Company's aerial work services

a. Onboard fuel shall be calculated taking into consideration the following matters, and the amount of fuel shown in b. shall be loaded.
   (i) Weather forecast
   (ii) Expected delay in air traffic control
   (iii) Other situations that lead to a delay in landing of aircraft or an increase of fuel consumption

b. Onboard fuel

	Aerial work services
Rotorcraft (Helicopter)	*1. The amount of fuel required for flight from departure to destination* *2. Reserve fuel of 10 minutes (Cruise)*

(4) Calculation of elapsed time and minimum amount of fuel stipulated in the Company's Robinson R 44 Series Aircraft Operation Manual (Excerpt)

As this flight was not air transport services but a company flight, though it was part of aerial work services, this report describes the followings as reference for the calculation of onboard fuel.(*added as reference values.)

(I) Fuel consumption rate shall be 16 gallons per one hour (about 60.6 liters).*

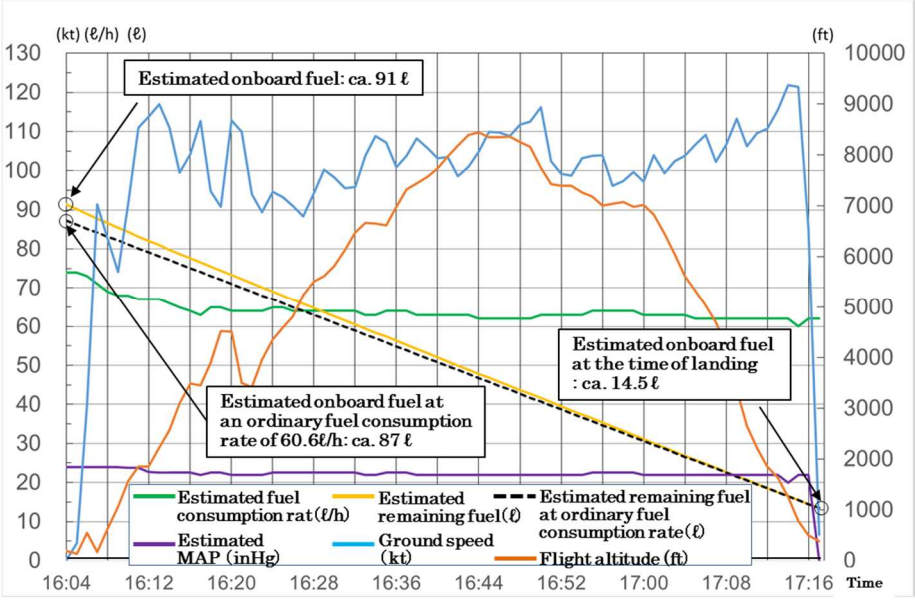
[2] The "hourmeter" refers to an integrated indicator which detects the engine power change (the collective pitch lever position) and keeps track of the flight time.

	(II) Starting engine and run-up *It shall be the consumed fuel amount (*about 5 liters) for starting engine and run-up (for 5 minutes).* *(III) Tour distance* *According to the limitations stated in the Section 2 of the manual as well as wind condition on the flight date, the elapsed time required for flying tour distance in a cruising status shall be calculated.* *a. Climb compensation* *The correction for speed decrease due to the climb to the cruising altitude shall be 2 minutes per 1,000 ft climb.* *b. Cruise* *It shall be flight time from departure point to destination* *(IV) Delay compensation* *The time delay in the course of flight shall be calculated to be 10 % of elapsed time.* *(V) Reserve fuel* *It shall be the amount of fuel that can be flown for 20 minutes at the speed capable of flying the longest distance, plus amount of fuel[3] that is stipulated and notified by the Minister of Land, Infrastructure taking into consideration unforeseen situations.* (5) Measuring results of the quantity of remaining fuel collected from the helicopter and the quantity of remaining fuel at the time of the LOW FUEL warning light ON After the flight from the ground to the JPD Kyoto, the remaining fuel in the helicopter's fuel system was collected from drain holes located on the bottom of the tanks, the quantity of the collected remaining fuel and that of remaining fuel at the time of the LOW FUEL warning light ON were measured respectively as follows: Remaining fuel collected from the helicopter : 61.5 liters Remaining fuel at the time of the LOW FUEL warning light ON : 18.6 liters (measured in a grounding attitude)

3. ANALYSIS

3.1 Involvement of Weather	Yes
3.2 Involvement of Pilot	Yes
3.3 Involvement of Aircraft	None
3.4 Analysis of	(1) Estimated remaining fuel quantity at the time of the LOW FUEL warning

[3] Regarding the VFR flight by aircraft not providing the aerial work services, the amount of fuel is not stipulated in this notification as with this flight by the helicopter.

Findings	light ON Judging from the remaining fuel quantity measured in the investigation, the remaining fuel quantity at the time of landing at the ground is estimated as follows: The quantity of remaining fuel collected from the helicopter, which was confirmed in the investigation : +61.5 liters Fuel consumption required for the flight from the ground to the JPD Kyoto (5 litters for starting engine/run-up + 6 minutes of flight time = 6 litters) : +11.0 liters The amount of refueling at the ground :-58.0 liters Estimated remaining fuel quantity at the time of landing at the ground : 14.5 liters It is probable that the remaining fuel quantity at the time of landing at the ground was estimated to be about 14.5 liters. (2) Estimated quantity of fuel onboard at the time of departure from the Oyabe Helipad  Figure 2: The Change of Ground Speed, Flight Altitude and Consumed Fuel of JA7981 The change of consumed fuel corresponding to the output calculated by the manufacturer of the helicopter was created into a graph, based on the estimated remaining fuel quantity, the helicopter weight, the wind direction and velocity, the outside air temperature, the flight altitude, the air speed and utilized power output at the time of landing at the ground. It is probable that the fuel consumption rate had come to become particularly higher until around 16:20 because the helicopter, as shown in Figure 2, took off from the Oyabe Helipad and then climbed at a high power (about 22.5 inHg) and flew at a ground speed of 100 kt or more; and furthermore, after 16:44, the fuel consumption was larger than usual because the helicopter kept flying at a high power and increased the speed even when

starting descending. In addition, it is somewhat likely that its flight against headwind increased the fuel consumption. The remaining fuel quantity of the helicopter at the time of landing at the ground was about 14.5 liters. It is probable that with the consumed fuel that was accumulated during the flight added to this 14.5 liters, the estimated quantity of fuel onboard at the time of take-off was about 91 liters; additionally, the estimated quantity of onboard fuel, if calculated at an ordinary fuel consumption rate, was about 87 liters.

(3) Minimum required quantity of onboard fuel in the flight plan for the helicopter

Referring to the Company's Robinson R 44 Series Aircraft Operation Manual, it is probable that minimum required quantity of onboard fuel in the flight plan for the helicopter was 108 liters and the details are as follows;

a. Starting engine / Run-up : 5 liters
b. Cruise (Tour distance 121 nm; Maximum knot indicate airspeed 100 KIAS [109 KTAS]; Cruising altitude 6,500 ft [in consideration of the geographical features] ; Outside air temperature 16℃; Wind direction 190° Wind velocity 10 kt); Elapsed time one hour 17 minutes : 73 liters
c. Climb compensation (2 liters / 1,000 ft) : 13 liters
d. Delay compensation (10 % of elapsed time) : 7 liters
e. Reserve fuel (10 minutes of flight time) : 10 liters

(4) Judgments taken by the pilot

a. Recognition on the quantity of fuel onboard

The pilot informed that in his flight plan, the required flight time would be one hour and 50 minutes and the fuel onboard, 110 liters, but it is probable that the actual onboard fuel quantity, which was estimated from the accumulated fuel quantity that had been consumed in previous flights, was about 87 to 91 liters and not the same as that in the flight plan. It is highly probable that the pilot did not fully grasp the quantity of fuel onboard before departure because he did not fully confirm the quantity of fuel onboard at that time either visually or with the fuel gages before departure in this flight, even though he had consumed some onboard fuel during other flights up to this flight after refueling the helicopter.

b. Recognition on the consumed fuel amount

It is probable that the pilot did not continuously monitor the quantity of remaining fuel even though the helicopter consumed higher amount of power after climbing and its consumed fuel amount increased because he assumed that the consumed fuel amount during the flight was uniformly 60 liters per hour, not taking into sufficient consideration the changes in flight conditions. In addition, it was not until LOW FUEL warning light came on that the pilot judged the flight to the JPD Kyoto to be impossible; but it is probable that the pilot could have chosen the appropriate landing site much earlier stage prior to the LOW FUEL warning light ON if he had continuously checked the fuel gages during the flight in accordance with the safety notice stating that "*Always land to refuel before the main tank fuel*

	gage reads less than 1/4 full." (5) Flight plan confirmation made by operation controller The pilot submitted his flight plan to the Civil Aviation Bureau via the headquarters, but the operation controller at the headquarters did not acknowledge that the pilot had refueled the helicopter on the previous day, but had not refueled before departure on the day of the serious incident occurrence. (6) Measures to prevent recurrence of the similar serious incidents a. Preparation and submission of elaborate and accurate flight plan It is necessary to make a flight plan that states the required quantity of fuel onboard after calculating elapsed time corresponding to the cruising altitude and cruising speed by taking into account weather conditions on the flight day. Furthermore, it is also required that the quantity of fuel onboard in a flight plan should indicate the required flight time and be stated accurately because it is concerned with judgments on search and rescue operations. b. Confirmation of the quantity of fuel onboard before departure The pilot must read the values on fuel gages as accurately as possible and confirm visually the fuel level in the tanks.

4. PROBABLE CAUSES

It is highly probable that this serious incident occurred because the helicopter took off without carrying the sufficient onboard fuel, as reported in its flight plan, to reach the destination and the pilot did not continuously monitor the fuel gages during the flight, which resulted in an emergency landing due to insufficient quantity of remaining fuel.

It is also highly probable that the helicopter did not carry the onboard fuel as reported in the flight plan because the pilot did not fully confirm the quantity of fuel onboard at that time before its departure, even though he had consumed some onboard fuel during other flights up to this flight after refueling the helicopter.

5. SAFETY ACTIONS

The Company has taken the following measures to prevent recurrence.

(1) The Company provided the pilot with re-education on the basic rules including the pre-flight checks.

(2) The Company thoroughly made the following matters known to all flight crew.

a. Understand the characteristics of fuel gages so that they can grasp the quantity of remaining fuel without fail by taking into consideration the accumulated fuel consumption that had been consumed in previous flights. Especially be sure to confirm the quantity of fuel onboard in accordance with the safety notice.

b. Be sure to create a flight plan that includes accurate fuel calculations.

c. Carry out the pre-flight checks with sufficient margin to ensure confirmation before departure.