89-1500-CP

SEARCH AND RESCUE AMPHIBIOUS AIRCRAFT IN JAPAN

Yushi Tanaka

Shin Meiwa Industry Co.,Ltd.
Aircraft Division

1-1 Ohgi, 1 chome, Higashinada-ku
Kobe, Japan, 685

ABSTRACT

Since July of the year 1976, Japan Maritime Self Defense Force (JMSDF) has been operating US-1A Amphibious Aircraft as open sea search and rescue aircraft as Japan is surrounded by vast sea.

US-1A is the modified amphibian version of the PS-1 flying boat which made its first flight in the year 1967 and is equipped with open sea search and rescue equipment. Since then, it has for the past 12 years rescued many civilians from ships out in the open sea and from remote islands where airports are not available to evacuate them to large hospitals where they are fully equipped.

This rescue operation is planned to be continued hereafter too but the background to enable operational feasibility is the seaplane technology possessing great seaworthiness, and the existence of sever training and total dedication by operator crew and maintenance personnel.

1. RECORD OF RESCUE OPERATION

Rescue operation records of seriously injured personnel from open sea beyond 1,000 Km

At the end of the month June when the rainy season was still continuing, badly injured patient on ship at sea over 1,000 kilometers away from Tokyo became very serious. A surgical doctor from a town close to where the Rescue Squadron Base is located was requested by Maritime Safety Agency to board search and rescue aircraft flying to the rescue. The doctor together with the accompanying nurse hurried to the air base and boarded US-1A amphibian aircraft which took off at 13:30 hours towards objective route south southeast out towards the open sea.

The Pacific Ocean seen from above was beautiful and serene. Looking out at the vast open sea from the aircraft the doctor thought that nature was mischievous to see a patient confronting death in the quiet open sea. Smoke marker were dropped at 16:00 hours near the drifting ship the size of a leaf awaiting rescue and the aircraft landed in wave height of approximately 2 meters after checking the sea condition at very low altitude. The smooth sea condition seen from above greatly changed from quietness to motion due to rolling soon after water landing shock. The wave lifted the aircraft high,jolted and suddenly you feel sea sick. The crewmen wearing wet suit move actively to throw out the rubber boat inflated airborne, install engine and move out from the aircraft toward the ship bobbing up and down in the waves. The anxiety for the serious patient whom she still have not seen clings on the face of the nervous nurse with only red color of her lips standing out.

At 17:05 hours, the raft returned to the aircraft and completed transferring the patient for evacuation. The patient's face was very pale, his pulse weak and consciousness not clear indicating his shocked condition. Administrating drip injection immediately, and asking Air

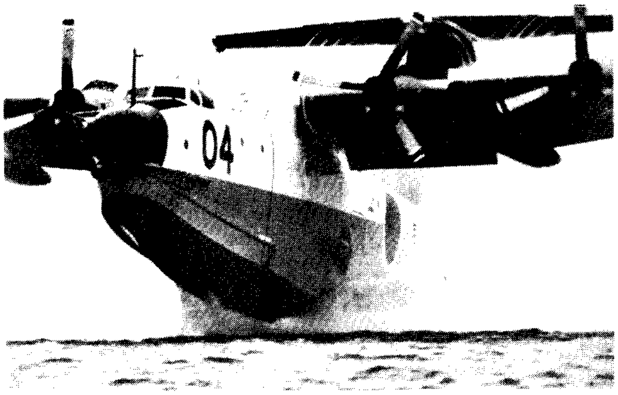

Fig. 1 Water takeoff

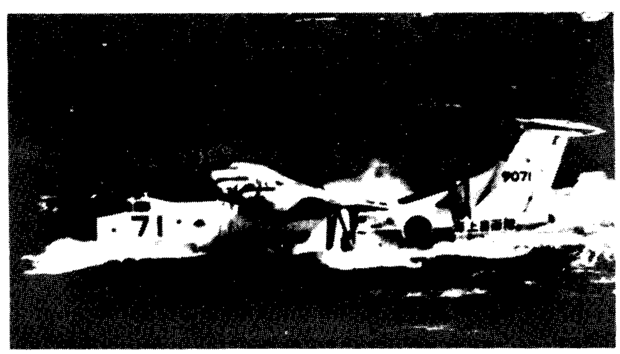

Fig. 2 Rough sea operation

Medic to check the blood pressure, blood transfusion was given and injury bandage applied to stop bleeding severed arteries and injuries were cleaned and treated without any disruption in the pitching and rolling sea. During this time, the aircraft slowly took off from the water. Operating in-flight was completed at 18:30 hours. The patient was able to reply to questions. The cause of the external injury was that a 6 kilogram fish dropped and penetrated the right leg groin during fishing operation.

At 19:15 hours, Tokyo metropolis light became visible and not being able to wait for landing, it seemed like the great land was coming out to meet them. 'Great, we were able to save him ! '

Gentility gradually came back to the faces of crew who were energetically moving about in-flight and shook hands all around as if everyone was an old friend. There were streak of tears on the patient's face as he was transferred to the waiting ambulance. (From Emergency surgical Doctor's Diary)

Rescue records

The US-1 which entered into search and rescue mission back in July of 1976 have accomplished a total of approximately 260 rescue operation up to the end of the year 1988, and played an important role in saving the lives of many people. Its missions were mainly in evacuating seriously injured or ill patients from vessels out in the open seas and remote islands without an airport.

The outline of the present US-1A search and rescue amphibian is ; overall width approximately 109 feet, overall length 110 feet, overall height 33 feet, wing area 1,460 square feet and maximum take off and landing weight is 99,200 pounds on land and 94,800 pounds on water. 4 turboprop engines T64-IHI-10J are installed as power plant and the maximum power of single engine is 3,493 ESHP.
For propellers, 14.5 feet 3 blade HAMILTON/SUMITOMO 63E60-27 is used. the aircraft's empty weight is 56,500 pounds with a crew of 12 personnel and equipped with 2,200 pounds of search and rescue equipment. Regular fuel load is 38,300 pounds and cruising at 230 knots 2,300 nautical miles.[6]

Flight and Maintenance Squadron exists at the main search and rescue amphibian base on a 24 hour standby. Rescue operation close to the Japan sea is performed by helicopters and the rescue range the amphibian is responsible for is out in the open sea far from its base. Its radius is approximately 500 to 1600 nautical miles so that most of the operation take from 3 to 4 to 6to 7 hours from the time it leaves the base to reach its destination. At times it lands and refuel at remote islands, thus, from the time it leaves the base and return, it requires 3 days.

2. TECHNOLOGY FOR ACHIEVING RESCUE

2.1 Low speed water takeoff and landing

One of the most important performance of this search and rescue amphibian is its low speed water takeoff and landing performance. Open sea water landing is performed by measuring wave height and length with the wave height indicator equipped on the aircraft and then comparing this information with the weight of the aircraft, makes a water landing within the range of the restricted load. The regular open sea water takeoff and landing gross weight is 79,400 pounds.

The water landing method is with flap angle 60 degrees against head wind and maintaining 6 degrees attitude it descends at the rate of 250 to 300 fpm. Path angle is 2 to 3 degrees and landing speed 53 knots. Water takeoff flap angle is 50 degrees and when the engine thrust is placed at maximum, it rises a bit and speed is accelerated by gradually increasing the attitude angle. At about 27 knot it becomes 'on step' and once it overcomes maximum water resistance of 35 to 40 knots, it can maintain 6 degrees attitude for water takeoff. Water takeoff speed is 53 knots, water takeoff time is 14 seconds and water taxi distance approximately 800 feet.[6]
In regards to seaworthiness limitation, water landable wave height and wave length are determined in detail by aircraft weight (Weight at landing) and head wind speed. Seaworthiness evaluation depends upon the annual operational feasibility ratio by comparing wave generating annual ratio of Northern Pacific and Japan Sea. Conventional characteristics seaplane can be operated

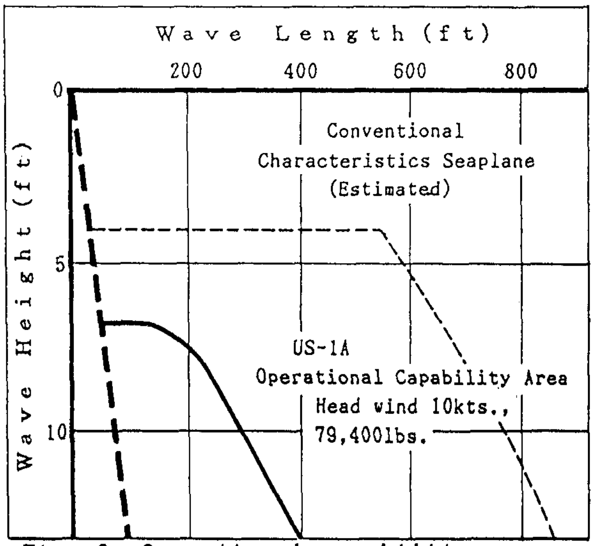

Fig. 3 Operational capability area on the wave hight and length

at wave height of 2 to 4 feet so that this operational feasibility annual ratio is assumed to be about 25%. But US-1A is assumed to be 77%.[6] From the past open sea rescue operation, its rate of success in open sea rescue was 87%.

High lift device

One of the most important technology which make it possible to water takeoff and landing at very low speed is the high lift device. Compressor is driven by 1,500SHP turbine engine (T58-IHI-10) equipped on the back of the fuselage to produce compressed air and blowing this air out of the flap leading edge.[5]

It prevents separation of the boundary layer. The propeller slipstream acquired from large thrust and large propeller greatly deflects the angle to generate super circulation making lift co-efficient 6 to 7 (during water landing operation CL is 5.3).[2] During water takeoff taxi, the amphibian takes an attitude over 10 degrees. Then again, during water landing descent, it can maintain 6 degree attitude angle to make a normal descent. To prevent marked drop in lift during these operation, this BLC system works effectively, and stabilized lift can also be acquired during great angle of incidence. At the initial design stage, flap angle 80 degrees configuration was considered for very low speed operation , but was never put into practical use. Then again, stall characteristic during great angle of incidence and to maintain longitudinal stability, slats were provided on the main wing inner nacelle exterior entire span and to the leading edge of the horizontal stabilizer. However, as a result of detailed study of these characteristics during aircraft operation, design change was made only to use this slat partially at the outer wing of the main wing.

Flight control system

To ensure flight control force during low speed flight is another important factor. Flight control system is an independent system comprising of dual hydraulic mechanical powered system.

Feeling device is incorporated into the elevator,aileron and rudder and also automatic flight control system is provided. Many tests were performed to investigate the tail's effectiveness especially in the strong downwash. BLC system was incorporated into the elevator , and a gear ratio change device was incorporated to enable greater surface angle than that of during cruise, in STOL configuration (flap angle over 40 degrees, less than 130 knots). The lateral flight control device enables the outer flap to operate as an aileron during STOL configuration and the spoiler is linked to the aileron. The power of lateral flight control and BLC system greatly affected the designing of the landing gear. Rudder builds-in gear ratio change device as same as an elevator. To control low speed flight , quick and accurate judgment is necessary. But to control aircraft watching the rough sea is an operation involving big workload, so that Automatic Thrust Control System (ATS) is equipped. However, taking into consideration its confrontation with complicated wave, its usage was restricted, and to enable operation by looking at the sea surface more closely, Head Up Display (HUD) was added.

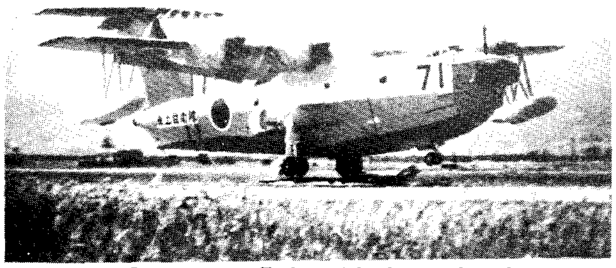

Fig. 4 Takeoff from land

Hull

Narrow high length beam ratio hull shape has been applied to improve hydrodynamic characteristic and aircraft efficiency. The hydrodynamic length of the hull is 89 feet, beam at step 7.5 feet (L/B=11.8), dead rise angle at step is 23.5 degrees. This shape was obtained from many water tank test results. Groove type Spray Suppresser is applied to prevent spray in rough water.[1] During the initial step of operation, reinforcement to hull structure and spray preventive measures were added based on data obtained from its operation. For analysis of Hydrodynamic characteristics, computer simulation technique was developed and applied. To the peculiar combination of infinite wave, wind, aircraft speed and motion, the hydrodynamic load and the motion can be outputted every 1/100 seconds. In this computer simulation model, corrections have been made from the data obtained from many water tank test and flight test results. Then, from this simulation, water landing movement and hull load in compound wave were analyzed and reflected into the operation manual.[3]

Of lately, a research in being made to find method of reducing load by controlling load to active by providing fin at the bottom of the hull.

Propulsion system

Propulsion system plays an important role especially during water takeoff. Originally, the lift during water take-off accounted approximately 60% of the lift through propeller slipstream deflection.[2] In order to simplify water takeoff in the open sea, initial 3,060

ESHP T-64 engine output was upgraded to 3,439 ESHP. Pilot will become comfortable by leaving the water as quickly as possible. However, it is truly a very undesirable problem to pilot when it flames out after being sprayed during water takeoff and landing. Water cleaning device for engine, re-ignition device to restart and complicated spray preventive measeure were set up.

2.2 Direct rescue

Navigation and Communication

Navigation and communication is composed of approximately 40 equipment and are useful in search and communication. For navigation, automatic LORAN device is employed in indicating on the display the aircraft location and flight path to approach assumed objective. At site, radar is visually viewed to search for survivor. The main equipment for communication is HF,UHF and VHF. As a special device, loud speaker is equipped on the aircraft and calling out to the survivor from above, it gives him encouragement.

Rescue equipment

For rescue equipment, floatable container, rubber boat with engine, rescue rope launcher, etc. to be used in rescue work are provided.

Smoke marker, float light, etc. are dropped from the air at site to clarify the objective location and floatable container are dropped to survivor as a first phase indirect rescue. The rubber boat stored beneath the floor is inflated, the door is opened and floating ramp is attached outside the door.

Placing the boat outside the aircraft, outboard engine is attached and the rescue crew jumping aboard move out toward the survivor. This is the direct rescue operation. In the event a rope is required between the aircraft and the survivor, rescue rope is launched with the rope launcher, and when this has reached the survivor the rope is reeled in using drag unit to draw in the boat.

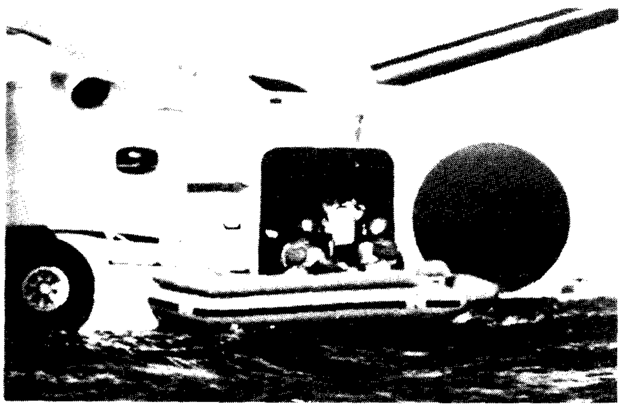

Fig. 5 Rescue training

When the boat cannot be used due to bad weather condition, there are cases where the crew wearing wet suit wind the rope around himself and swim directly to rescue.

Sea surface maneuverability

In order to approach the survivor after water landing, the pilot can operate 4 engine individually and perform fixed point turn, stop and slip backward. Pilot approaches the survivor as if holding him at the starboard part of the hull. When the wind is strong and the sea is rough, the fundamental rule is to keep the bow of the aircraft in the direction of wind blowing. Protecting boat retrieval work and survival recovery work from the wind and protecting the engine and propeller from waves, preparation for emergency water takeoff is made.

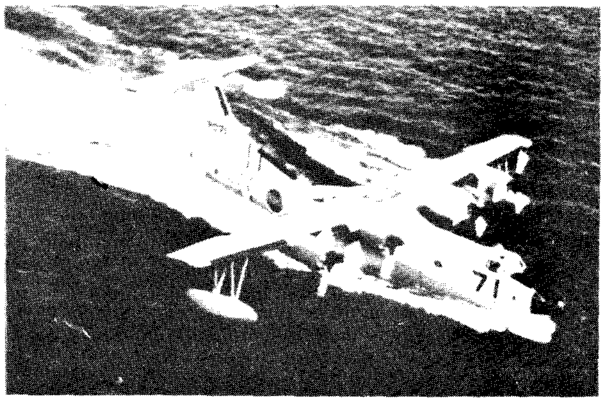

Fig. 6 Taxi operation

Hull structure

At the starboard aft hull is provided a large entrance/exit door. This makes various sea surface work easy. In regards to the anxiety of water seeping in from the door while on sea surface, structural compartment of the door portion and the natural water drainage structure are of great use. On the other hand , for the hull's water tightness, it is of an important structural mode to maintain aircraft safety. And together with watertight bulkhead, a complete watertight structure is taken. As for corrosion control, in addition to surface treatment and painting of each material, composite materialization is applied for structures like the nose landing gear door, etc. where corrosion occurs readily.

In regards to search and rescue equipment, inertia navigation, satellite communication, and infrared ray searching device, etc. new equipment installation is being planned one after another.

2.3 Human factor

Operator's daring challenge and support from people concerned

As an aircraft it is of medium class but once it lands on the wide open sea, it does not come to par even with a small fishing boat. Great uneasiness accompany aircraft landing in the rough sea. Conquering this and being able to fulfill responsibility of their task in saving valuable lives and in contributing to the safety of the public are based on their continuing daring challenging will and rigorous training.

On the other hand, in the background for achieving open sea rescue are aircraft procurement people, engineers who are upkeeping reliability and performing technical improvements, maintenance personnel responding smoothly to the needs, personnel involved in many years in parts supply, and also those people who are positively cooperating and supporting continuance of seaplane technology as well as to continually maintain steady rescue structure.

3. RESEARCH STUDY RELATING TO FUTURE SEARCH AND RESCUE AIRCRAFT

3.1 Rescue aircraft system desired by operators

Based on many years of operation and the peculiarities of the present search and rescue amphibious aircraft, the summarized demand for search and rescue aircraft brought forth by the operators are as follow.

Far better water landing capability

Few, but there are cases where water landing is not possible due to bad weather condition even though they arrive at objective sea area. In rescue operation, one cannot neglect direct rescue. Positive water landing and achieving rescue is always an important task.

Greater speed

When one thinks of the distant patient, it is common for everyone to have the same feeling of arriving on the scene as fast as possible. Instead of thinking about cutting short the time to get to the scene it is desirable to fly faster.

Payload reserve

There are many occasion where detail information is not readily available of distant patients at the time of departure. Desire to load as much rescue equipment, medical supplies and fuel.

Comfortableness

Due to structural characteristic, the aircraft is not pressurized. To overcome long distance cruising and thunderstorm and also for the comfortableness of the patient, pressurization and internal environment condition improvement is desirable.

3.2 Research study of future search and rescue amphibian

Desirable research and development to secure greater seaworthiness and higher altitude high speed cruising large seaplane. For this purpose , future search and rescue seaplane research is being continued to attain greater seaworthiness hull configuration, application of jet engine, application of composite material for light weight structure, including updating of search, communication and rescue equipment.

References

1. Kikuhara,S., " A study of Spray Generated by Seaplane Hulls, " Journal of the Aero/Space Sciences, Vol.27, No.6, pp.415-428 (June 1960)
2. Kikuhara,S., Tokuda,K., " A new STOL Flying Boat Design, " Journal of Aircraft, Vol.3, No.5, pp.426-468 (September-October 1966)
3. Kikuhara,S., " Hydrodynamic Design of Seaplane Hull, " Journal of the Japan Society for Aeronautical and Space Sciences, Vol.20, No.223, pp.426-434 (August 1972)
4. Tanaka,Y., Suganuma,M., " On the Operation of Transport Seaplanes, " Journal of the Japan Society for Aeronautical and Space Sciences, Vol.25, No.282, pp.332-336 (July 1977)
5. Kikuhara,S., " Some Aspect of the Flying-Boat Development in Japan, " Journal of the Japan Society for Aeronautical and Space Sciences, Vol.30, No.341, pp.313-320 (June 1982)
6. Shin Meiwa Industry Co., Ltd., " Shin Meiwa US-1A Stol Amphibious Aircraft, " Catalog