ORIGINAL ARTICLE

An Assessment of the Use of Rotary Wing Aircraft for Primary and Medical Emergency Care Service – Sabah State Experience

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ABSTRACT

Introduction: Rotary wing aircraft (RWA) or the helicopter has been used in Primary Health Care and Medical Emergency Services in the state of Sabah since the seventies. The use of RWA has distinct advantages in terms of speed, ability to access remote areas and in the transportation of patients to tertiary care. Single engine RWA was used for the last forty years which has now been replaced with twin engine RWA. The objective of this study is to compare the different type of RWA which was used and the suitability of these machines for health services in Sabah. **Methods:** A detailed analysis and comparison of manufacturers' specifications which include the performance, size, the number of power plant, passenger capacity, safety track record, aircraft manufacturer' s support, maintenance and operational costs of different types of RWA available in Sabah taking into account current and future demands as well as functional requirements and the capability of the aircraft service providers were considered. **Results:** The choice of aircrafts depends on the type of service and its suitability. From the assessment, a single engine RWA would be adequate to support the current and future need in Sabah. **Conclusion:** Adequate technical knowledge in choosing the type of aircraft to provide an effective health service is vital. These also contribute to the cost effectiveness of the program and significantly determine efficiency of the service and the interest of the rural people with poor accessibility to health care.

Keywords: Helicopter, Primary health care, Rural, Emergency health service.

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INTRODUCTION

Sabah, being the second largest state in Malaysia after the state of Sarawak, is mostly mountainous over the western side which is still largely covered by tropical rainforests(1). The eastern part of it where the Kinabatangan River stretches, is surrounded by forest which forms the largest forest covered floodplain in Malaysia(2). Most of the urban towns in Sabah are located along the coastal areas while small villages and towns form the interiors. The lack of connectivity is still one of the key issues in Sabah(3). Insufficient and unreliable connections between rural areas and major towns are particularly challenging especially in providing access to basic healthcare for the people(4).

Rotary wing aircraft (RWA) has been used in Primary Health Care and Medical Emergency Services in the state of Sabah since the 1970's. The Sabah State Health Department started its Flying Doctor Service (FDS) in 1978(5), gradually taking over the service initiated by the Sabah Foundation. The FDS comprised of two teams, in which one was based in Kota Kinabalu International Airport, covering the remote areas of the west coast of Sabah and the other team was stationed at Sandakan Airport, which covered the eastern areas(6). The Sabah Crocker Range served as the operational demarcation for the two areas (Fig 1). Both FDS teams provided mobile primary health care as well as maternal and child health care services to villages which were difficult to be accessed by other means of transportation (Table I). The primary health care services were generally handled by a team of paramedics consisting of a Medical Assistant (MA) along with a Community Health Nurse (JM) and a Health Assistant (HA). From time to time, one Medical Officer (MO) would join the team if available or a need arise. The service of RWA was procured by the, Sabah State Health Department through contract tenders, which were renewed in several specified durations.

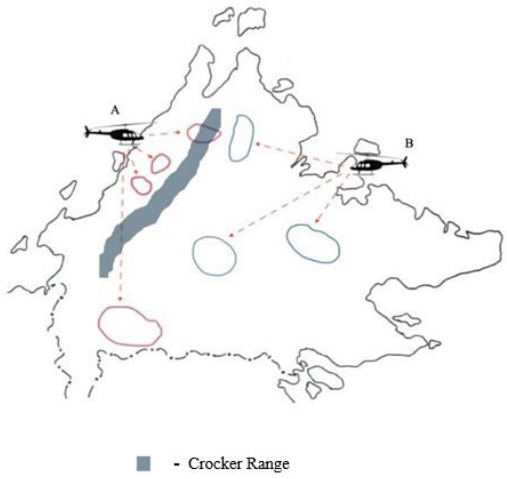

Fig. 1 : Areas covered by FDS Kota Kinabalu (A) dan FDS Sandakan (B)

Table I : Services Provided by the Flying Doctor Service

No.	Types Of Services
	A. **ROUTINE SCHEDULED SERVICES**
1.	Outpatient Treatment
2.	Follow-up treatment of chronic diseases such as hypertension, diabetes and asthma
3.	Maternal and Child Health Services
	• Antenatal Examination
	• Postnatal Check-up
	• Child and Baby Inspection
	• Immunization
4.	Examination for Under nutrition & Food Basket provision
5.	Family Planning Program
6.	School Health Check-up
7.	Pap Smear
8.	Provision of iodized salts
9.	Health Promotion
10.	Infectious disease control activities - blood tests for malaria, sputum examination for tuberculosis.
	B. **NON-SCHEDULED EMERGENCY SERVICES**
1.	Emergency Medical Evacuation (MedEvac) Service

Source: Sabah State Health Department

The type of the RWA used for the FDS was determined by the requirements set by the Sabah State Health Department. Initially, these activities were carried out using single engine RWA for the last forty years but had since been replaced with twin engine aircraft in 2012 (7). The change was deemed necessary and followed suit from neighboring Sarawak State Health Department which changed the specification of their RWA from single engine helicopters to twin engine helicopters after subsequent several mishaps involving RWA in the early 2000 (8,9). Nevertheless, the types of RWAs which could be used by the FDS, also depended on the types of RWAs owned by the companies providing the helicopter services. Sabah was indeed fortunate to have two locally based companies which provided the helicopter services while the other company is based in the state of Sarawak (5).

The objective of this study is to compare the different type of RWA which was in use and the suitability of these machines for health services in Sabah. A detailed assessment of the type of RWA for the Primary and Medical Emergency Care Service is vital to ensure both the safety and efficiency of the services at a justifiable minimal cost.

MATERIALS AND METHODS

This study was conducted based on the analysis and comparison of manufacturers' specifications which include the performance, size, the number of power plant, passenger capacity, safety track record, aircraft manufacturer's support, maintenance and operational costs of different types of RWA available in Sabah. Operational details of the individual types of RWA for suitability assessment in this study were obtained from the two RWA service providers for the FDS in Sabah, as well as the aircraft regional suppliers based in Singapore.

The types of RWA owned by these companies from the 1970's, which were available at different times were listed in Table II. The use and preference of type of RWA in Sabah FDS were also determined by other factors, either documented and undocumented, as well as known and less known factors. Major specific factors emphasizing on the aspect of safety, functionality and practicality were also taken into consideration.

TABLE II : Types of RWA Available in Sabah from the 1970's

No.	Models	Types
1.	Bell 206 B3 Jetranger	Single Engine
2.	Bolkov BO 105	Twin Engine
3.	Agusta 109s Grand	Twin Engine
4.	Eurocopter EC 350	Single Engine
5.	Eurocopter EC 355 NP	Twin Engine
6.	Eurocopter EC 145	Twin Engine

Source: Department of Health, Sabah – as offered by RWA service providers.

RESULTS

Analysis and Comparison of Manufacturers' Specifications

Aircraft specifications from the helicopter brochures and respective published manufacturers' aircraft manuals and specifications for five RWA models available

Table III : Comparison of Different RWA Models and The Respective Manufacturers' Specifications

RWA Manufacturer and Model	Bell 206 B3	Eurocopter EC350	Eurocopter EC355	Bolkov BO105	Eurocopter EC145
					
Country of Origin	United States	France	France	West Germany	France
No. of engine/s	Single	Single	Twin	Twin	Twin
		EC 350 & EC 355 both has similar external dimensions but differ in the no. of engines			
			CAPACITY		
Passenger transportation	1 pilot + 4 passengers	1 pilot + up to 5 passengers	1 pilot + up to 5 passengers	1 pilot + 4 passengers	1 or 2 pilots + up to 8 passengers
EMS / Casualty evacuation config.	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 or 2 pilots + up to 2 stretchers + up to 3 passengers / HEMS crew
			AIRCRAFT SPECIFICATIONS		
Fuel Capacity (weight)	344 liters (265 kg)	541 litres (416 kg)	736 litres (577 kg)	570 liters (438 kg)	902 liters (694 kg)
Maxm Take-Off Weight	1451.5 kg	2,370 kg	2,600 kg	2,500 kg	3,650 kg
Typical Cruising Speed	167 km/h	245 km/hr	218 km/hr	205 km/hr	246 km/hr
Maxm Cruising Speed	234km/h	259 km/hr	278 km/h	240 km/hr	268 km/hr
Maxm Range (without reserve)	585 km	622 km	700 km	670 km	680 km
Maxm Endurance (without reserve)	3 hours	4 hours	4 hours	3 hours 30 min	3 hours 30 min
Useful Load	677 kg	995 kg	1,097 kg	1,199 kg	1,793 kg
Cargo Compartment	0.45 m^3 located at the aft of the aircraft	1.0 m^3 (35.5 cu.ft) Divided into three compartments two on both sides of the aircraft, and one near to the tail boom (limited cargo space)	1.0 m^3 (35.5 cu.ft) Divided into three compartments two on both sides of the aircraft, and one near to the tail boom (limited cargo space)	The cabin & cargo floor extends through cockpit, cabin, and cargo compartment. The rear compartment is limited in height due to the engine & gearbox compartment above	The cabin & cargo floor extends through cockpit, cabin, and cargo compartment
Rotor diameter	10.16 meters	10.69 meters	10.69 meters	9.84 meters	11 meters
Length	9.5 meters	10.93 meters	10.93 meters	8.81 meters	10.2 meters
Width	1.32 meter	1.65 meter	1.65 meter	1.58 meter	1.73 meter
Overall length with blade in front	11.82 meters	12.94 meters	12.94 meters	11.85 meters	13.03 meters
Landing skid / wheel	Skid	Skid	Skid	Skid	Skid
Performance Class	Class 3	Class 3	Class 2	Class 2	Class 1

Sources: (10-17)

among the RWA service provider companies from the commencement of FDS in Sabah were obtained and compared (Table III). Agusta 109s Grand is not included in the comparison table as it is equipped with landing wheel, and it is not suitable for the purpose of FDS in Sabah.

RWA Performance Class

Helicopters are categorised into three performance classes, based on a mandatory requirement for the helicopter to return to a predetermined safe launch/ recovery helipad (Table IV)(10).

Table IV: Different Class Performance of Different types of RWA

No.	Models	Types
1.	Performance Class 1	Includes twin/multi-engine helicopters that are capable of continuing flight with one engine inoperative regardless of when the engine fails.
2.	Performance Class 2	Refers to twin/multi-engine helicopters that are capable of continuing flight after one engine fails except that a forced landing would be required following an engine failure between take-off and transition to safe forward speed and in reverse to landing.
3.	Performance Class 3	Refers to all single-engine helicopter operations; which require an emergency landing after engine failure.

Source: *Air Marshal (Retd) V.K. Bhatia. Twin vs Single. SP Guide Publications Pvt Ltd, Issue 6* (11)

RWA Manufacturer

Great considerations had to be given to the choice of RWA manufacturers. This is because certain manufacturers such as Eurocopter, only allow the purchase of RWA spare parts directly from its original manufacturer whereas other manufacturers allow spare parts to be ordered and supplied by their nearby regional branch. Therefore, the supply and availability of spare parts at the RWA service provider company base for maintenance and repair purposes often required longer time which then forced a longer RWA downtime. This directly affect the efficiency of FDS delivery in Sabah.

Safety of Single Engine vs. Twin Engine RWA

Generally, it seems that there is a popular belief that Twin Engine RWA is safer compared to Single Engine RWA (11). According to the Association of Air Medical Services which was founded in 1980, there is an estimation of around 400,000 rotor wing medical emergency transportations performed annually in the United States alone. With the vast experiences in hand, they asserted that single engine RWA is actually a safe and economical choice. This is because of the advent of truly reliable turbine engines, which attributes to the probability of an engine failure being greatly reduced (12). An example which can be used to support the argument are the Bell 206 B3 helicopters and its range being a single engine, are well known, time tested and proven to be best in safety records as well as other features like lowest operating costs and auto rotational characteristics among other RWA especially in its class.

An article in The Rotor Journal No.44 May/June 2002, titled "Single vs. Twin Engine", published by Eurocopter, it stated that "twin and single-engine helicopters offer practically the same degree of safety. Evidence has proven that 95% of the causes of helicopter accidents (ground impacts, power line collisions, etc) have nothing to do with whether the aircraft was a twin or single-engine model. It is only amongst the remaining 5%, which includes accidents caused by equipment failure not due to maintenance faults that the single-engine helicopter proves to be more accident-prone. Based on statistics, generally, there is only a difference of 2% between single and twin-engine flight in terms of safety. Nevertheless, a distinct contrast to this figure is the 30 to 50% increase in the acquisition and operating costs of a twin-engine helicopter (13).

A twin engine RWA is basically a necessary requirement mainly in missions involving extensive over water flights and rooftop landings. On that note, the class performance of different types of RWA as reflected in Table IV provides a good additional outlook on the actual capabilities of different RWA models.

Operational Cost of Single Engine vs. Twin Engine RWA

The use of RWA is often very expensive. RWA are not only expensive to purchase but inherently requires very high fixed maintenance costs. Combined with high fuel consumption and higher fuel prices makes the cost per transport extremely high(14). Different types of RWA have obvious advantage and disadvantages in comparison to one another. Generally single engine RWA has the advantage of simplicity as one engine translates to fewer controls, in addition to many of other simpler systems such as fuel, electrical and others. Operational cost is also particularly minimized, especially in term of fuel consumption as in a single RWA only one engine would burn fuel per flight hour as compared to the two engines in a twin engine RWA.

The increase in cost is also naturally attributed to the costs involved in repairs and maintenance of more engines, and the more complicated aircraft systems. To give an idea, the comparison of cost between a single and a twin engine RWA is indicated in the estimate of hourly charter rate of the different types of RWA in Sabah based on a minimum 40 hours guaranteed flight hours / month in the late 2000's (Table II).

Fuel Capacity (weight), Maximum Take of Weight, Useful Load and Endurance

Fuel capacity is translated into the fuel weight that is to be carried by an RWA. This is a particularly important in a smaller single engine BELL 206 B3 whereby when a longer flight distance is to be covered, the flight would require more fuel on board, hence the unavoidable

requirement that a passenger is to be reduced from the maximum capacity of five to four to compensate for the fuel weight that the aircraft has to carry for the mission. RWA endurance therefore is very much affected by the maximum payload in both types and categories of aircrafts. In addition to that 30 minutes allowance of reserve fuel to provide a safe margin for landing approaches is a normal necessary requirement for all RWA, hence the actual airborne time of an RWA is limited to about 30 minutes less of the actual without reserve maximum endurance duration (Table III).

Typical Cruising Speed

In general, a faster cruising speed is an obvious advantage to an RWA. Considering the geography of Sabah, the maximum distance of the villages covered by the FDS is within a maximum 160 - 170 km radius. A difference of about 20-30 minutes per flight on a twin engine RWA and a single engine Bell 206 B3 RWA which totals to about 40 - 60 minutes for a return flight is rather significant. In an actual operational setting, this would actually mean a 20-30 minutes maximum difference for a medical personal to reach and provide a support for a critically ill patient. A single engine EC350 however could perform a comparatively similar typical cruising speed with its other twin engine RWA counterpart, at a lower operational cost.

External Dimension – Rotor Diameter, Length, Width and Overall Length with Blade in Front

These dimensions indicate the cabin room and space. A twin engine RWA in the models discussed herewith generally provides a slightly bigger room for the onboard crew and passenger. This however serves more as an option and not a real mandatory necessity especially when the operational cost involved in the service is of a significant concern. Furthermore, a larger sized RWA is actually not a practical option for FDS purpose in Sabah. This is because it requires a relatively bigger space to land which is a safety concern in certain conditions (e.g. hilly terrain), in addition to more pronounced rotor downwash that could affect fixed structures in the villages.

Other General Advantage of a Twin Engine over Single Engine RWA

Single engine RWA generally tend to have less spacious cabins than twin engine RWA. A twin engine RWA tends to be faster and provides a margin of getting to a safe landing site in the event of one engine failure. Twin engine RWA tend to have more sophisticated avionics such as auto-pilot feature, terrain awareness, and weather radar (on bigger types of twin engine RWA) which to some extent add to safety. Certain types of twin engine RWA provides rear loading feature allowing relative ease in loading stretcher cases into the aircraft (Table VI).

DISCUSSION

The analysis of the different type of RWA depicts the RWA advantages and disadvantages in consideration to the purpose of Sabah FDS. The choice of aircrafts mainly depends on the type of services needed and their suitability (10). According to the Association of Air Medical Services (AAMS), there is no one standard aircraft or model utilized in MedEvac operations (12). Similarly, the choice of RWA is based on mission suitability, parts and support availability, as well as budget(15). In Sabah, payload capability, range, economy of operation and local geographical profiles are additional important aspects that need to be considered. The commonly used RWA are the Bell 206/407, and Airbus AS-350 (formally EC350)/EC 130 for single-engine aircraft. On the other hand, for multi-engine medium sized RWA, Bell 222/230/412/429,BO-105/BK-117/EC-135/EC-145/AS-365, Agusta A-109/139 and the Sikorsky S-76 are the preferred choices (16).

From the comparison, a single engine RWA would be adequate to support the current and future need in Sabah over the twin-engine counterpart (Table VI). Although Bell 206 B3 has a good reliability and safety track record (10) as well as provided an excellent service for over 40 odd years in Sabah, there are certain limitations to this model. A further exploration of the single engine alternative with the same features and range of model which is readily available in the Malaysian Borneo is Bell 206 L4. It has a longer cabin size, a stronger engine, better capacity and capability. In this study the overall features and product specifications of this model is highly competitive with the other available options in this region of different single engine RWA model namely Eurocopter EC350 and Eurocopter EC130. These models have at least the minimal functional requirements specific to the health and medical services, including the geographical need of the state of Sabah and the capability of the aircraft service providers in Sabah.

Table V : Hourly Charter Rate of the Different Types of RWA In Sabah Based on Minimum 40 Hours Guaranteed Flight Hours / Month in the Late 2000's

No.	Models	Type of RWA	Ringgit Malaysia / Hour
1.	Bell 206 B3 Jetranger	Single Engine	2,500.00
2.	Eurocopter EC 350	Single Engine	3,800.00
3.	Bolkov 105	Twin Engine	6,000.00
4.	Eurocopter EC 355 NP	Twin Engine	5,500.00
5.	Eurocopter EC 135	Twin Engine	9,000.00
6.	Eurocopter EC 145	Twin Engine	15,000.00

Source: Sabah State Health Department

Table VI: Comparison of Different Types of Single Engine RWA Suitable for FDS in Sabah

	Bell 206 L4	Eurocopter EC350	Eurocopter EC130
			
Country of Origin	**United States**	**France**	**France**
No. of engine/s	**Single**	**Single**	**Single**
	CAPACITY		
Passenger transportation	1 pilot + 6 passengers	1 pilot + up to 5 passengers	1 or 2 pilots + up to 8 passengers
EMS / Casualty evacuation config.	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 pilot + 1 stretcher + 2 passengers / HEMS crew	1 or 2 pilots + up to 2 stretchers + up to 3 passengers / HEMS crew
	AIRCRAFT SPECIFICATIONS		
Fuel Capacity (weight)	416 liters (320 kg)	541 liters (416 kg)	540 liters (415 kg)
Maxm Take-Off Weight	2,018 kg	2,370 kg	2,427 kg
Maxm Speed	241 km/hr	259 km/hr	287 km/hr
Typical Cruising Speed	185 km/hr	254 km/hr	240 km/hr
Maxm Range	693 km	622 km	610 km
Useful Load	961 kg	995 kg	1,046 kg
Performance Class	Class 3	Class 3	Class 3
Overall length with blade in front	12.92 meters	12.94 meters	12.64 meters *With fenestron instead of conventional tail rotor which adds to ground personnel safety

Source: (15-17)

CONCLUSION

Based on the analysis of this study, the use of a single engine RWA proved to be more cost-effective for the healthcare delivery service in Sabah as it is 55% lower per hour compared to twin engine RWA (Table V). The preference for single RWA in providing a more effective health and medical service are based on its ability to land on limited landing spaces in many interior villages, its capability to perform the minimal essential required functions to fulfil the interest of the rural people with poor accessibility to health care as well as the long-term continuity of service for the Sabah State Health Department.

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