Operational Statistics for Rotary Wing Aero Medical Transportation in the U.S. (2020)

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Abstract

Aero Medical Transportation (AMT) services provide transportation of patients, medical teams, and organs for the U.S. healthcare system. Categories of AMT operations include scene response (33%), inter-facility transfers (54%), delivering specialty care and organs (13%), and repatriation from outside the U.S. (statistics not recorded). Scene response is conducted primarily using Rotary Wing aircraft that can land and takeoff from accident scenes and hospital helipads. Data from 12 publicly available databases were combined to identify aeromedical transportation

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vehicles and to generate operational statistics including the number of vehicles, ownership, flight distances, flight frequency, geographic distribution, and the types of airports, air traffic control, and navigation systems used. This information can be used for aircraft design, airport and air traffic control infrastructure assessment and funding, industry sector analysis, and strategic planning.

Introduction

Aero Medical Transportation (AMT) services provide transportation of patients, medical teams, and organs for the U.S. healthcare system. Aeromedical services are also known as Helicopter Emergency Medical Services (HEMS), Helicopter Air Ambulance (HAA), and Medical Evacuation (Medivac). Aero Medical Transportation Service Providers (AMTSPs) are the entities that provide the transportation service.

The majority of medical transportation (97%) is conducted using Ground Emergency Medical Services (GEMS) (Loyd & Swanson, 2020; Taylor, 2018). When appropriate, due to time, distance, or remote location considerations, the remaining 3% are transported by AMT. Scene response, conducted using Rotary Wing aircraft, accounts for an estimated 33% of AMT (Loyd et.al. 2020). Inter-facility transfers (54%), delivering specialty care and organs (13%), and repatriation from outside the U.S. (statistics not recorded) are predominantly conducted using Fixed Wing (Steenhoff, et.al. 2021).

The number of Rotary Wing aircraft in the AMT fleet has grown 6.6% per year over the last decade along with a 6.6% per year expansion in the number of AMT Rotary Wing Bases. These vehicles operate from AMTSP bases at airports and heliports to the accident scene, and then to hospital helipads. These operations use government-provided navigation equipment but operate largely in un-controlled airspace that is not under the jurisdiction of air traffic control and is not generally supported by other services such as aviation weather forecasts.

This paper provides a statistical analysis of flight operations of the U.S. AMT rotary-wing operations in 2020 including the type and age of the fleet, the duration and stage-length of flights, the number of operations per day and time of day of operations, and the types of airports and navigation equipment used. These results inform aircraft design (e.g. electric vehicles), airport infrastructure and IFR navigation needs, and vehicle equipment (e.g. avionics) needs of this vital segment of the aviation industry.

The paper is organized as follows: the next section provides a short overview of the AMT industrial sector. The following section describes the data and process used to characterize AMT operations. The next section describes the results. The final section provides a conclusion with a discussion and future trends.

Overview of the Aero Medical Transport Industry

AMT Services are provided by Aero Medical Service Providers (AMTSPs). The characteristics of the AMT services available are shaped by regulatory, economic, and technological forces.

Aero Medical Transportation Service Providers (AMTSPs)

According to the most recent Atlas & Database of Air Medical Services (AAMS/CUBRIC, 2019), in the U.S, 303 AMSTPs operate out of 1,114 bases (i.e., helipads and airports).

AMT services are provided by rotary-wing and fixed-wing aircraft. Rotary wing aircraft operate from helipads located at hospitals, helipads located at airports, or stand-alone helipads. Fixed-wing aircraft operate between airports. One hundred and eighty-one (181) AMSTPs (i.e. 60%) operate rotary-wing vehicles only, 37 (12%) fixed-wing only, and 85 (28%) fixed-wing and rotary-wing.

There are 1,115 rotary-wing and 283 fixed-wing aircraft registered to AMSTPs. Nine hundred and fifty-nine (959) bases support rotary-wing operations, 212 bases support fixed-wing operations. Fifty-seven (57) bases support both rotary-wing and fixed-wing aircraft. The fixed-wing bases are all located at Federal government-supported airports that are part of the National Plan of Integrated Airport Systems (NPIAS).

AMTSP Business Models

There are four basic AMTSP business models: (1) Hospital-affiliated, (2) Independent operations, (3) Hybrid, and (4) Government.

Hospital-affiliated AMTSPs provide medical services, medical staff, and medical equipment. They either own and operate the aviation services or contract for the aviation services from independents. Independent AMTSPs employ medical and flight crews to provide air ambulance services. Hospital-affiliated operators are generally not-for-profit, while Independent operators are for-profit.

Hybrid operators are a joint venture between a hospital and an independent provider where the hospital typically provides the medical crew but (unlike the hospital-affiliated model) does not make business decisions (e.g., process, setting prices).

Government AMTSPs, typically in regions where dedicated aero medical services are not economically viable, provide both medical services and aviation services.

Before 2002, AMTSPs were predominantly owned and operated by hospitals. In 2002, Medicare, a Federal Health Insurance program, created a national fee schedule for air ambulances based on a “reasonable cost” for emergency medical services (EMS). This schedule increased the Medicare reimbursement rate for AMT, in particular for rural transports. This directly resulted in a 27% increase in the number of fixed-wing aircraft registered by AMTSPs since 2007, and an increase of 69% in the number of rotary-wing aircraft registered by AMTSPs since 2007.

AMT Service Regulations

In the U.S., AMT services are regulated by a patchwork of State and Federal regulations. States regulate the medical services related to patient safety. The Federal government - Department of Transportation/Federal Aviation Administration (FAA) - regulates the aeromedical flight operations conducted under 14 CFR Part 135 regulations. The FAA also provides air traffic control and navigation services (e.g., RNAV(GPS), ILS, etc.), and supports the development of airport infrastructure through an Airport Improvement Program (AIP).

The rates (i.e., prices) for AMT services are primarily set by State health insurance regulations. The Federal government establishes rates for Medicare patients (i.e., U.S. citizens over 65 years).

In the U.S. AMTSPs can achieve voluntary accreditation from the Commission on Accreditation for Medical Transport Systems (CAMTS - camts.org). One hundred fifty-three (153) U.S. AMTSPs currently hold CAMTS accreditation.

Airport Roles in Supporting AMT Services

AMTSPs are typically based at airports. To support AMT services, airports provide hangar, ramp, helipads (for rotary wing), office space/sleeping quarters, fuel sales, weather reporting services, de-icing services and snow removal (if necessitated by prevailing weather conditions), secure (i.e., gated) access to the airport, and signage for ground ambulances.

To ensure the availability of transportation services, AMTSPs prefer to operate out of airports with IFR services including instrument approaches and departure procedures. Most airports with AMT services are included in the FAA's NPIAS and have the widespread availability of RNAV (GPS) approaches. These airports include a mix of towered and non-towered facilities.

Airports are inclined to welcome AMTSPs as tenants. AMTSPs generate revenues from long-term (5-10 year) leases and fuel sales. AMTSPs also provide the airport the opportunity to show to showcase the benefits of the airport to the region by providing a "community service."

AMTSPs, operating as for-profit enterprises, choose the airport location of their operational bases based on the potential for a financially viable operation. The catchment area is generated by the population, income, and insurance coverage demographics, types of industry (e.g., manufacturing), transportation networks (e.g., highways), and the location and type of hospitals. AMTSPs also consider the presence of competing AMTSPs and market saturation.

AMT Aircraft

AMT aircraft are operated under Federal Regulations for Commuter and on Demand Operations known as a Part 135 certificate. These aircraft must have equipment that specifically meets the standards defined in an Advisory Circular AC 135-14B: Helicopter Air Ambulance Operations. These regulations identify minimum performance standards such as those for sealed, flame-retardant, moisture-resistant panels, stretchers, restraining devices, medical oxygen systems, and Medical Portable Electronic Devices (MPEDs). There are also standards for supplemental lighting, and requirements for multiple electrically powered auxiliary systems. Aircraft used for AMT services must be equipped with advanced life support equipment.

Pressurization and noise are two other aircraft considerations. Not all aircraft authorized for use for AMT purposes in all jurisdictions have pressurized cabins and those that do typically tend to be pressurized to only 10,000 feet above sea level. These pressure changes require advanced knowledge by flight staff concerning the specifics of aviation medicine, including changes in physiology and the behavior of gases.

Part 135-14B stipulates that all AMT aircraft be equipped with: (1) Radio Altimeter, (2) Terrain Awareness Warning Systems (TAWS), (3) FDM Recorder, and (4) Life-preservers and Emergency Location Transmitter (ELT) for over-water operations. Equipment, such as Night Vision Imaging System (NVIS), satellite communication (SATCOM), position tracking and reporting systems, and possibly equipment supporting instrument flight rules (IFR) are encouraged. Most states require aircraft to be equipped with an ILS receiver or IFR-approach-capable GPS receiver that is maintained to IFR standards (including a current IFR database).

Method of Analysis and Data

This section describes the sources of data used and the process for analysis.

Data Sources

Twelve sources of data were required to perform the analysis (Table 1). Eleven data sources are publicly available. Traffic Flow Management Systems (TFMS) data was provided by the Federal Aviation Administration (FAA) on request. The TFMS flight track data was de-identified. All flight track data is reported in aggregate statistics.

Table 1. List of Data Sources used to perform the AMT rotary-wing analysis

Database	Description	Source
Atlas & Database of Air Medical Services (ADAMS)	descriptive & geographic information on air medical service providers, their communication centers, base helipads, RW aircraft, and receiving hospitals.	**https://aams.org/page/research**
FAA Aircraft Registration Releasable Aircraft Database	Aircraft N-Numbers, Owners, Aircraft Type, Engine Type/Count	https://www.faa.gov/licenses_certificates/aircraft_certification/aircraft_registry/releasable_aircraft_download/
FAA Aircraft Reference	Manufacturer name & code, Model #	FAA
Traffic Flow Management Systems (TFMS) data, CY 2019 20220 - TailNumber_RW_FW_030921	Flight track data (all flights, aggregate results, Tail Numbers de-identified	FAA
ADS-B Data	Flight track data (only transponding flights)	FlightAware
Airport Distances	Airport Lat/Long, Elevation	FAA
BTS Airport Latitude/Longitude	Airport Lat/Long	Bureau of Transportation Statistics
Airport Data	(Coordinates, Time zones)	https://raw.githubusercontent.com/jpatokal/openflights/master/data/airports.dat
SIAP-Minima-data	Approach information	FAA
FAA Airport Approach Data	Number of RNAV approaches, ILS, and LPV/LP availability.	FAA
FAA Aircraft Characteristics Database	RDC categories for aircraft types (AAC, ADG)	FAA
Airport Codes	Airport ICAO and local codes, facility type, geographic location (country, city)	DataHub https://datahub.io/core/airport-codes#data

Analysis Process

The data was processed according to the flow in Figure 1.

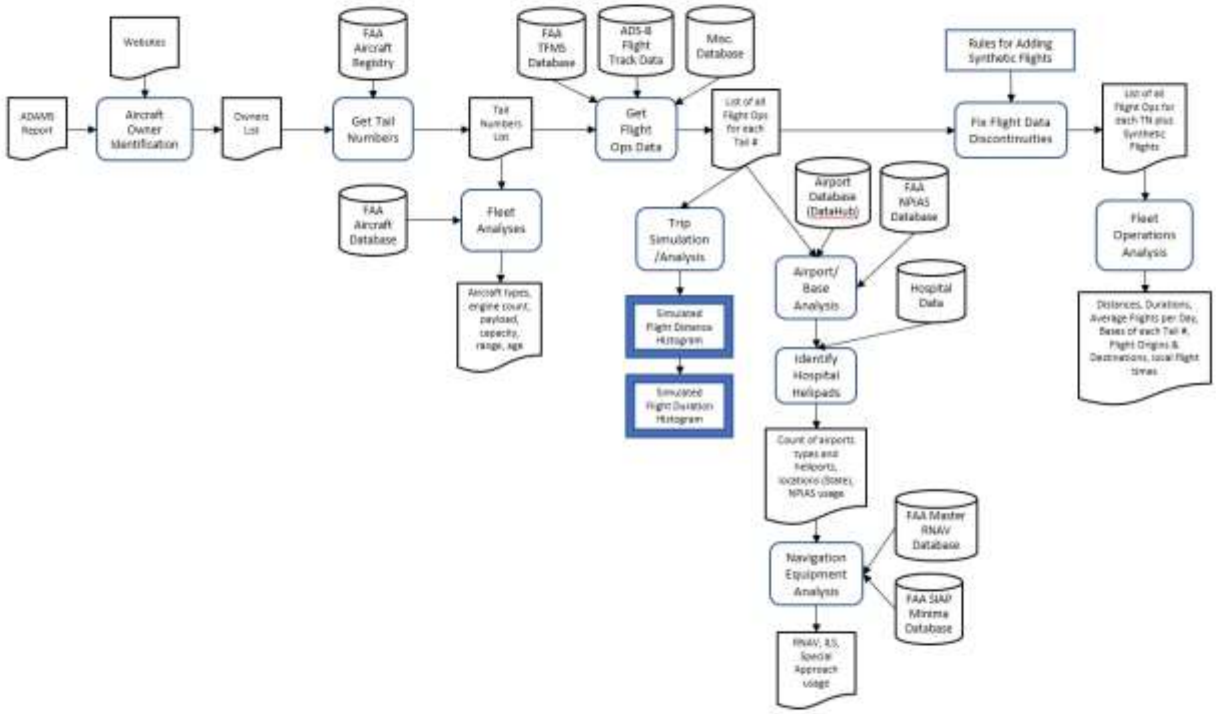

Fig. 1. Process for analysis of Rotary Wing AMT operations

Aircraft Ownership

Aircraft Owners (i.e., AMSPs) were identified from publicly available ADAMS Database 2019 (AAMS, 2019; AAMS 2020, Flanigan et.al. 2005). This list was verified using publicly available secondary and tertiary sources including company websites. The data was exclusively derived from publicly available data (e.g. AAMS database). No proprietary data was used.

Tail Numbers

Tail numbers in the AMT fleet were identified from the publicly available FAA Aircraft Registry based on Aircraft Owners. Tail numbers were verified using publicly available secondary and tertiary sources including company websites.

Aircraft Characteristics

Aircraft characteristics (type, engine count) were identified by matching Tail Numbers to the public aircraft database provided by the FAA.

Operartional Flight Statistics

Tail Numbers were submitted in a query to the operational flight track- databases (e.g. FAA TFMS data, third-party flight tracking data). The database returned flights with a unique identifier replacing the Tail number to keep the anonymity of the flights. Flight-track data was processed to generate origin, destination, UTC departure time and UTC arrival time, physical class, and aircraft type. Some data sources included flight data: origin, destination, UTC departure time and UTC arrival time, physical class, and aircraft type. This data was reported in statistical aggregates only. No specific information on individual tail numbers (or individual owners) was analyzed or reported.

For the purpose of this analysis, the flight data had to be manipulated as follows:

- Local Times: The flight operations data was processed to convert UTC to local times and account for daylight savings by extracting the US State each airport is located and using the State to determine UTC offset.
- Flight Duration: The flight duration was calculated using UTC. Special processing was required to account for flights from one day to the next (i.e. crossing midnight).
- Flight Stage-length: The flight distance was calculated in nautical miles using the Haversine formula which calculates the distance between two sets of latitude/longitude coordinates. Special attention should be paid to airports outside of

the continental US (Alaska and Hawaii) as the codes may vary and require a modified search value criterion.

- Discontinuities in Flight Legs: Operational flight data exhibited gaps between the arrival and departure airports between two flight entries. In the case of rotary-wing operations, this was done by comparing the distance between two locations. If an aircraft appears for a departure at a location defined by an airport or heliport or by latitude/longitude greater than 1 mile from its previous flight arrival location (without a connecting flight), it is considered a discontinuity. Flights with a discontinuity were filled with synthetic flight entries to interpolate the gaps. This created an artificial flight between point A and point B on the same day. The purpose of filling these discontinuities is primarily to obtain a more accurate flight count and operation count for airports. Forty-three percent of total flights analyzed were synthetic flights added to close flight leg discontinuities. As a consequence of the addition of synthetic flights, the flight count is a conservative (i.e. low) estimate.

AMT Base

An AMT Base is defined as the airport/heliport that a given de-identified tail number had the largest number of takeoffs and landings. In the event a de-identified tail number has a similar number of takeoff and landings at more than one airport/heliport, all the airports/heliports are considered to be a Base.

Fleet Statistics

Flight operations per type were compared against fleet sizes (i.e. how many flights does a specific aircraft type perform compared to how many of them there are in the fleet).

Operations Time of Day:

Daylight was considered to be 6 a.m. to 6 p.m. local time. Over the course of seasons, the differences between actual diurnal cycles average out.

Airport Statistics and Airport Characteristics

Airports were analyzed for the count of AMT operations, the number of hub and satellite airports, facilities available at airports (ILS, RNAV, special approaches). The data in the Airport database used for the analysis of the type of approaches available (e.g. RNAV), did not have data for 600 airports listed in the TFMS data. The results of the analysis are reported as percentages of the airports in the database.

Operational Statistics for AMT Rotary Wing Operations

This section provides the results of the analysis of AMT rotary-wing operations. The results are organized as follows:

1. Fleet Characteristics
2. Aircraft Ownership
3. Flight Operations (flights per day, flight duration, flight stage-length)
4. Fleet vs Flight Operations
5. Flight-Cycles
6. Flight Time of Day
7. Air Traffic Control, Airports, Navigation Equipment, Airport Design

Fleet Characteristics

During the period December 2020 through March 2021, the AMT rotary-wing service was supported by a fleet of 953 helicopters (Table 2). The fleet was entirely composed of turboshaft-powered helicopters. The fleet was evenly divided between the single-engine and twin-engine helicopters.

Table 2. AMT rotary-wing fleet statistics

Aircraft	Number of Engines	Example Aircraft
953 Aircraft - Turboshaft powered helicopters (100%)	Twin-engine (50%)	Eurocopter 135
		Augusta 109
		Sikorsky 76
	Single-engine (50%)	Bell 407
		Eurocopter 130
		Bell 206

Five aircraft models make up 75% of the AMT fleet: Eurocopter 135 (22%), Bell 407 (19%) , Bell 206 (13%), Eurocopter AS350 (11%), and Eurocopter 145 (10%). See Figure 2.

Fig. 2. Rotary Wing AMT Fleet composition by aircraft model. Five models make up 75% of the U.S. AMT fleet.

The average age of the fleet is 16 years with a median age of 13 years (Figure 3). The newest aircraft in the fleet is 2 years old. The oldest aircraft in the fleet is 52 years old (a Bell 205).

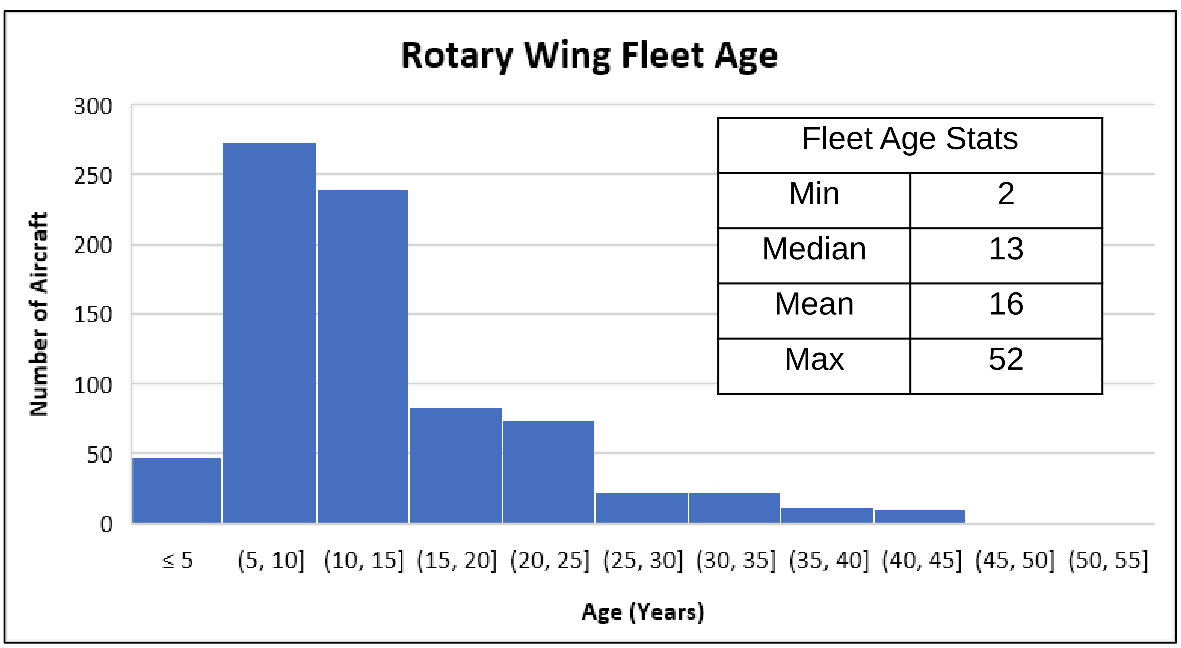

Fig. 3. Histogram of the age of AMT rotary-wing fleet. The AMT fleet has a median age of 13 years and a mean age of 16 years.

Payload, range, and capacity for the top 10 vehicles in the AMT fleet are summarized in Table 3. The median published range is 372 n.m. and the average range is 386 n.m. Five of the top ten are single-engine aircraft, the other 5 are two-engined. Published payload ranges from 2315 lbs to 4693 lbs. Service ceilings are between 13,800 ft and 23,000 ft.

Table 3. Payload, range, and capacity for the top 10 vehicles in the AMT rotary-wing fleet

Fleet Specs	Fleet Types	Engine Count	Payload (lbs)	Capacity	Crew	Main Rotor Area (sq ft)	Cruise Speed (kts)	Service Ceiling (ft)	Max Rate of Climb (ft/min)	Range (nm)
EC135	EC35	2	3208	6 pax	1 or 2	879	137	20000	1500	343
B407	B407	1	2347	5 pax	1 or 2	962	133	18690	1350	324
B206	B06	1	1019	4 pax	1 or 2	872	110	13500	1350	374
AS350	AS50	1	2372	4-6 pax	1 or 2	966	132	15100	1670	357
EC145	EC45	2	3953	9 pax	1 or 2	1020	133	17190	1590	370
EC130	EC30	1	2315	6-7 pax	1 or 2	966	130	23000	1800	330
B429	B429	2	2755	7 pax	1 or 2	1018	150	20000	2000	390
AW119	A119	1	3014	6-7 pax	1 or 2	991	132	15000	1790	515
S76	S76	2	4693	13 pax	2	1520	155	13800	1350	411
AW109	A109	2	2778	6-7 pax	1 or 2	990	154	15000	1930	450

Aircraft Ownership

The analysis identified 201 owners (i.e., vehicle "registrants") for the 953 vehicles in the FAA Vehicle Registration Database (Table 2). The top 5 owners operate 31% of the rotary-wing fleet (300 out of 953 vehicles). One hundred and fifty-six (156) owners (i.e. 77%) have 3 or fewer aircraft. It should be noted that several owners may be subsidiaries. For example, Privately-held Global Medical Response (GMR) operates under the Air Evac Lifeteam, Guardian Flight, Med-Trans Corp., and REACH Air Medical Services brands. Subsidiaries were not aggregated in this analysis.

Flight Operations

There was an estimated average of 1891 AMT Rotary Wing flight operations per day with a median of 1964, a minimum of 895, and a maximum of 2750 flights operations per day. The average vehicle in the fleet flew 1.97 flights per day (Figure 4). Eighteen percent of the fleet averaged more than 3 flights per day.

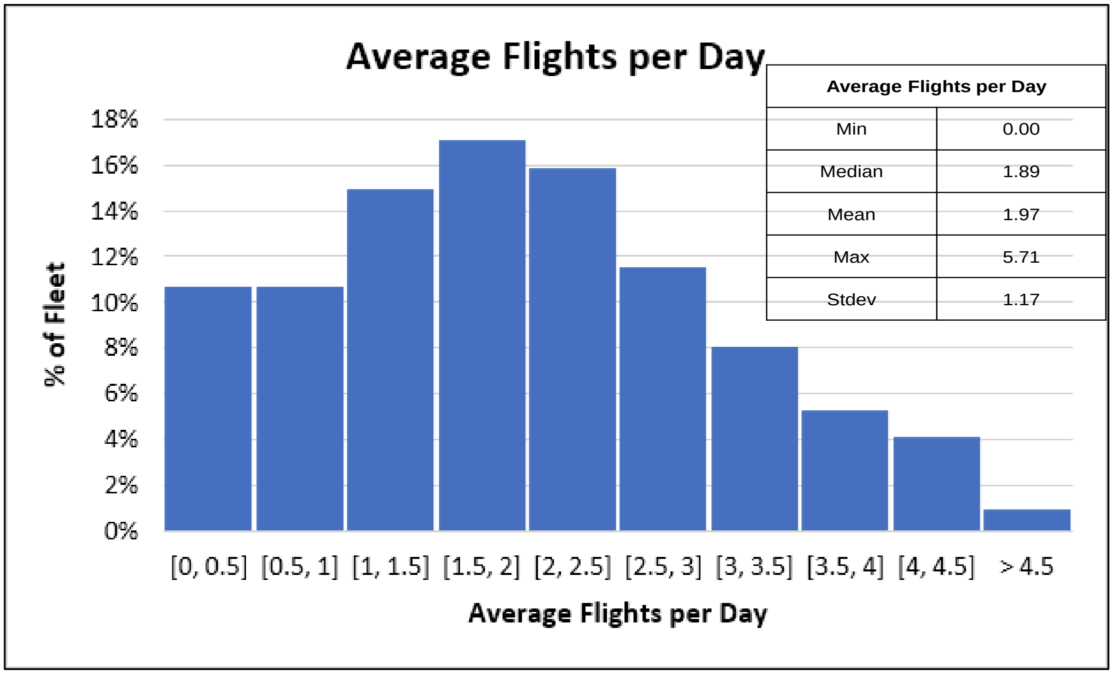

Fig. 4. Histogram AMT rotary-wing average flights per day per vehicle. Individual vehicles operate on average 2 flights per day.

The duration of AMT flights averages 48 minutes with a median of 32 minutes (Figure 5). The distribution of the flight duration exhibits a long right tail with 31% of the flights between 1 to 2 hours. Sixty-nine percent (69%) of the flights were less than 60 minutes.

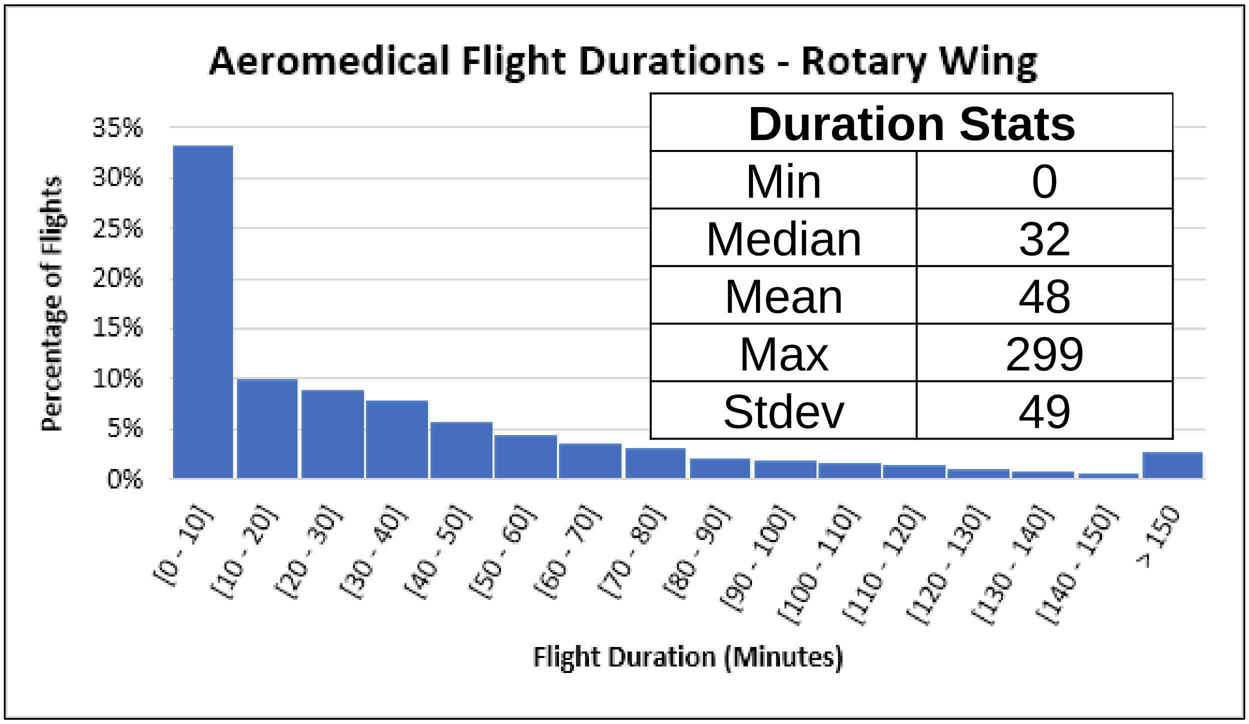

Fig. 5. Distribution of flight duration. The average duration of AMT rotary-wing flights is 48 minutes with a median of 32 minutes. Sixty-nine (69%) of flights were less than 60 minutes. The distribution of the flight duration exhibits a long right tail with 31% between 1 to 2 hours.

The stage length for the AMT fleet averaged 34 nm with a median of 22 nm (Figure 6). The histogram shows a concentration (83%) of flights between 0 to 100 nm and 17% of flights being greater than 100 nm.

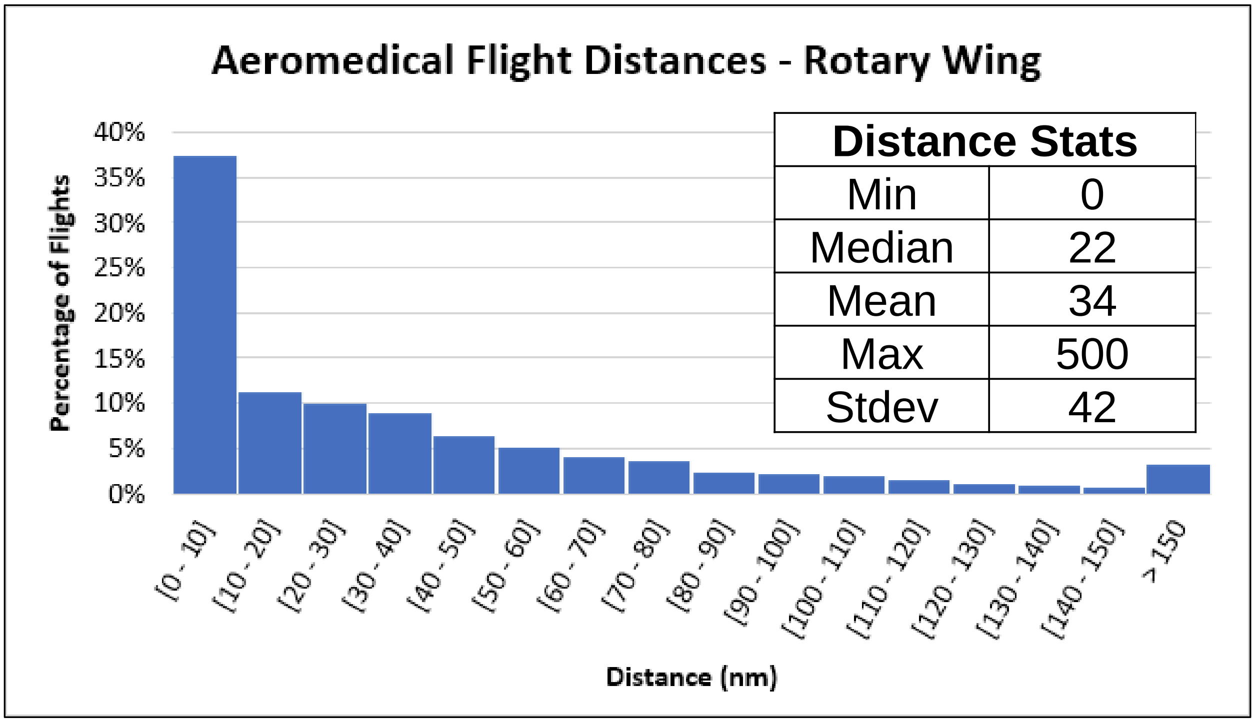

Fig. 6. Distribution of flight distances. The average stage length of AMT rotary-wing flights was 34 n.m. with a median of 22 n.m. Eighty-three percent (83%) of flights were less than 100 n.m.

Thirty-six percent (36%) of the total Rotary Wing operations were to/from the site of patient extraction. The remaining flights are between airports/heliports, and from airports/heliports to hospitals.

The number of operations by each vehicle type is proportional to the number of vehicles in the fleet For example, the Eurocopter 135 and Bell 407 constitute 41% of the fleet, performing 46% of the operations.

Flight Cycles

Flight cycle analysis indicates that 24% of flights conducted were “shuttle” flights flying from an Origin airport/heliport to a destination, then immediately back to the Origin (Table 4). The remaining 76% of the flights were multi-leg trips that did not immediately return to the Base airport/heliport. These flights may be for repositioning the aircraft or other logistics (e.g. maintenance, refueling, etc.)

Table 4. AMT rotary wing flight cycle types

Type of Flight Cycle	Count (%)
Origin – XXX – Origin	24%
Origin – XXX – ,,,, – Origin	76%

Time of Day

Flight departure and arrival times (local) were calculated based on the provided UTC adjusted for local Time Zones (Figure 7). There were approximately 8 percent more daytime operations (54%) than nighttime operations (46%).

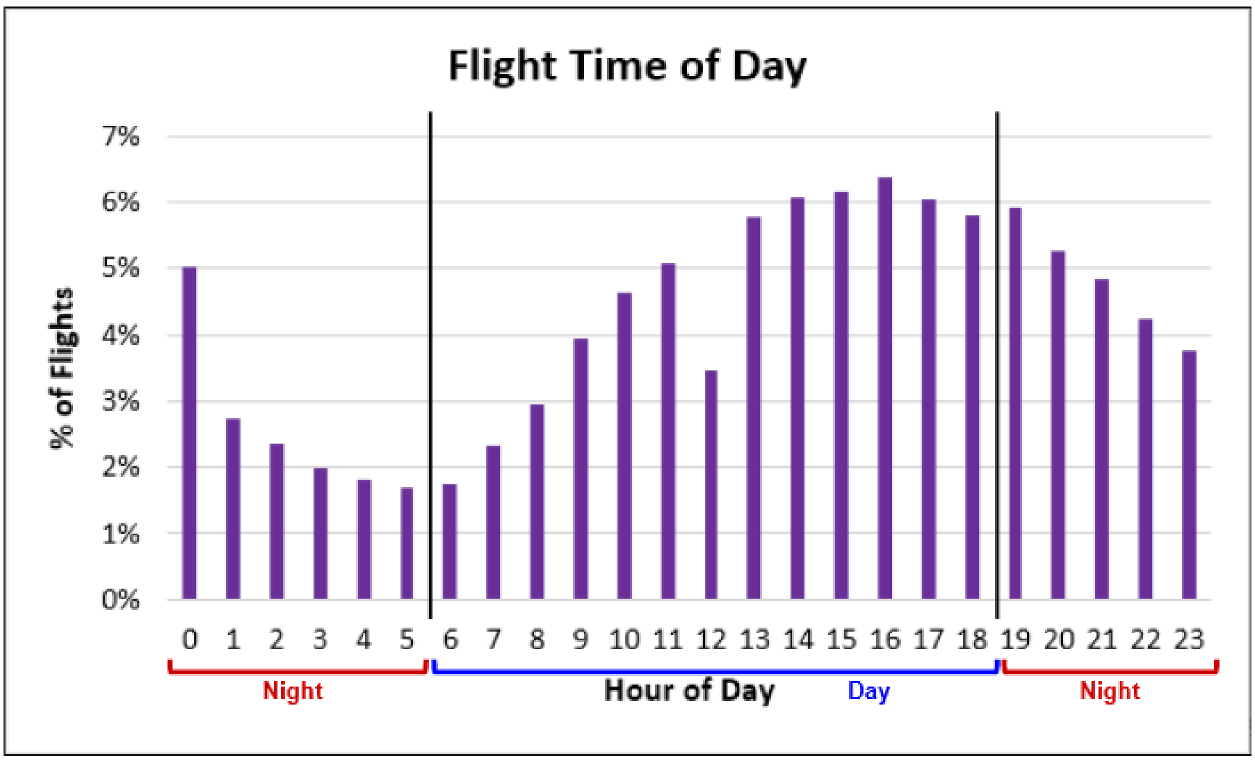

Fig. 7. Time of day of operations of AMT rotary-wing flights. There were approximately 8 percent more daytime operations (54%) than nighttime operations (46%).

Airports

U.S. AMT flights operated at 5,492 private and public airports/heliports including some flights to/from Canada and Mexico.

The National Plan of Integrated Airport Systems (NPIAS) coordinated by the Federal Aviation Administration (FAA) includes 3,310 public U.S. airports that are eligible for support by the Airport Improvement Program (AIP). AMT Rotary Wing operations used 44% (2,416 airports) of the NPIAS airports.

Sixty-seven percent (67%) of the airports/heliports used by rotary wing vehicles are classified as small airports (Figure 8). Thirty-one percent (31%) of these small airports are not NPIAS airports, 36% of the airport/heliports are NPIAS airports. Fourteen percent (14%) of the airports are classified as medium airports (1.2% non-NPIAS airports), 4% large airports (0.4% non-NPIAS airports), and 10% heliports (9.1% non-NPIAS airports). Note the non-NPIAS airports are predominantly military airports including Davis Monthan Air Force Base (DMA), Davison Army Air Field (DAA), and Tinker Air Force base (TIK).

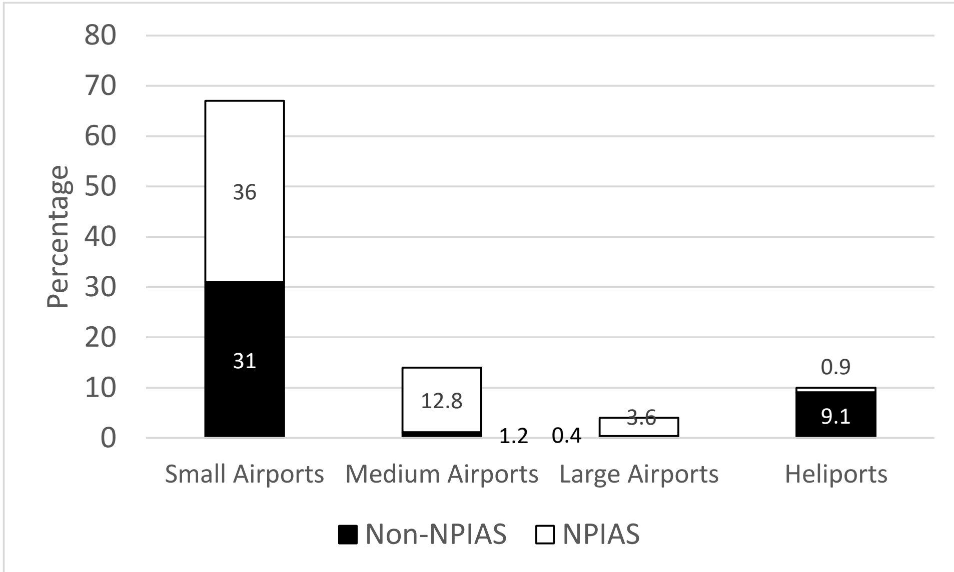

Fig. 8. Types of airports/heliports used by Rotary Wing Vehicles

AMT rotary-wing operations were geographically dispersed. Sixty percent (3271) of the airports/heliports visited had 5 or fewer operations in the data used for the analysis. The top 100 airports/heliports used accounted for 17% of the total operations in this period.

The average AMT vehicle visited 15 different airports/heliports at least once (Table 5). The distribution of unique airports visited (not shown) has a long right tail. Fifty-nine percent (59%) of the vehicles visited less than the mean unique airports (15 airports). Example flight routes from airports/heliports used by AMT operations for the 81II (Methodist Hospital of Indiana Inc Heliport) heliport downtown Indianapolis, and H71 (Mid-America Industrial Airport) small airport in Fayetteville, Arkansas are shown in Figure 9.

Five hundred and sixty-five (565) airports/heliports met the criteria for serving as AMT Bases used in this analysis.

Table 5. AMT rotary-wing unique airports visited statistics

Unique Airport Stats	
Min	1
Median	13
Mean	15
Max	63
Stdev	11

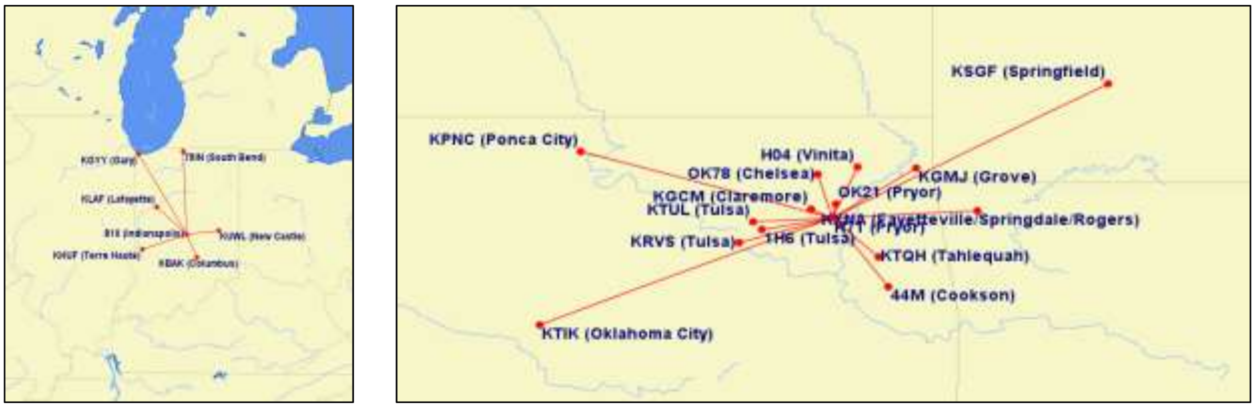

Fig. 9. Visualization of Flight operations from 81II Heliport (Indianapolis) went to six other airports/heliports. Flight operations from H71 small airport Fayetteville, Arkansas went to 15 other airports/heliports. These destinations do not include patient extraction landing zones.

Air Traffic Control and Navigation Equipment

Of the 5,492 NPIAS airports/heliports that supported at least one AMT operation, 54% of the airports/heliports are not present in the FAA Approached database. Of the 46% of the airports that appeared in the database, 22% are equipped with an ILS, 24% are not equipped with ILS. Assuming that the missing airports do not have ILS procedures, a breakdown of the airports/heliports is shown in Table 6.

Table 6. AMT rotary wing percentage of airports/heliports categories with ILS equipment in FAA Approach data-base

Airport/Heliport Type	Percentage with ILS in FAA Approach Data-base
Heliport	0%
Small	7.3%
Medium	10.3%
Large	4%

Forty-five percent (45%) of airports/heliports have at least 1 RNAV approach. A breakdown of RNAV procedures by the type of airports/heliports is shown in Table (left table). Seven percent (7%) of airports/heliports have at least 1 special approach. Forty-five percent (45%) of the airports have no ILS, RNAV, or special approaches. Breakdown of Special Approaches by airports types are shown in Table 9 (right table).

Table 7. AMT rotary-wing percentage of airports/heliports categories with RNAV and special approaches in FAA Approach data-base

RNAV Airport Composition	
Heliport	0.3%
Small Airport	28.8%
Medium Airport	11.7%
Large Airport	4.0%

Special Approaches	
Heliport	5.3%
Small Airport	1.0%
Medium Airport	0.2%
Large Airport	0.2%

Conclusions and Future Trends

Aero Medical Transportation (AMT) services provide transportation of patients, medical teams, and organs for the U.S. healthcare system. An estimated 33% of the total AMT services are scene response flights. These flights are conducted exclusively using rotary-wing vehicles (i.e. helicopters) to enable landing and takeoff at remote locations (e.g. side of the highway). Some interfacility transfers and medical team/organ transport are also conducted using a rotary wing. The analysis described in this paper identified the following main findings:

- There is an average of 1891 Rotary Wing AMT flight operations per day (maximum 2750 flights).
- Each Rotary Wing aircraft averaged approximately two flights per day (maximum 5).
- The average stage length was 34 nautical miles (maximum 500 n.m.) with an average duration of 48 minutes (maximum 299 minutes). Thirty-six percent (36%) of the total Rotary Wing operations were to/from the site of patient extraction. The remaining flights were between airports/heliports.
- The AMT fleet is completely composed of turboshaft-powered helicopters, evenly split between single-engine and twin-engine aircraft. Five helicopter types make up 75% of the fleet: EC135, Bell 407, Bell 206, AS350, and EC145. The average age for the fleet is 16 years old.
- There are 201 owners identified in the Aeromedical data. Five registered owners operate 300 aircraft (31% of the fleet). One hundred and fifty-six (156) owners (i.e. 77%) have 3 or fewer aircraft.
- Out of the total 5,492 airports/heliports used for AMT rotary-wing operations, 44% of the facilities used are part of the NPIAS. The breakdown of the airports/heliports used for AMT rotary-wing operations: 10% are heliports, 67% are small airports, 14% are medium airports, and 4% are large airports.
- The flight operations are geographically dispersed with 85% of the airports/heliports having flights to fewer than 5 unique airports/heliports. Forty-six percent of the airports/heliports used as Bases are NPIAS facilities.
- Analyzing the navigation equipment found that 28% of airports/heliports are equipped with ILS, 55% of airports/heliports have at least one RNAV approach, 18%

of airports/heliports have at least one special approach, and 26% of airports/heliports had no ILS, RNAV, or special approaches.

Implications for Air Transportation Infrastructure

Rotary wing AMT operations are mostly well supported by the Federal and State air transportation value-chain. Federal and State regulators certify and inspect aircraft, airports, medical equipment, medical operational processes, and AMTSP operational processes. Due to the nature of the rotary-wing AMT operations (i.e. low altitude, non-airport landing zones,) these operations are partially supported by NPIAS airport infrastructure, and air traffic and navigation services due to the nature of these operations.

The biggest operational issue faced by the rotary-wing AMT operations is the absence of accurate weather information (e.g. visibility, and winds) for the Landing Zones (LZs) and route of flight from base to LZ. Although airports have excellent weather reporting capabilities, the non-traditional routes and non-airport LZs have little to no coverage and prevent operations when the information is not available. Operators estimate that as high as 20% of the requests for flights in some regions, during some seasons, are turned away due to risks due to unknown weather conditions.

In addition to weather, the Notice to Airmen (NOTAM) system, which provides information about navigation equipment status (e.g. outages), and airport and airspace availability is tailored for fixed-wing operations and is difficult to use by AMTSPs.

As the low-altitude traffic in the vicinity of metropolitan areas increases, there is a need for more structured airspace for deconflicting trajectories. This is particularly an issue with the introduction of drones and electric vehicles into the airspace.

Future Trends

As is the case for all industry sectors the AMT businesses are shaped by changing economic, infrastructure, regulatory, social, and technological forces.

Economic Factors

The coverage and type of AMT services provided are based on the economic viability of each market. Changes in Medicare coverage (circa 2002) resulted in the growth of AMSP services over the last decade averaging 6.6% per year for rotary-wing and 2% per year for fixed-wing. However, the market may have reached saturation, and increased regulation of billing practices (i.e., overbilling) may result in the leveling-off in growth in traditional patient transport and consolidation of the industry (GAO, 2017).

One of the future growth opportunities for AMTSPs is providing medical services at the point of care (Lyng, et.al., 2021). These services include pediatric care, neonatal care, and other niche health care services. These services could result in small increases in the number of operations using the existing fleet and facilities.

Changes in Air Transportation Infrastructure and Services

Air transportation infrastructure and services provide both an opportunity to increase service availability (i.e., all-weather) and to maintain safety levels in an increasingly dense air traffic environment in metropolitan areas (i.e., drones, UAM, and other helicopter traffic). Increased services and improved safety would be facilitated by improved weather services for low altitude transit and non-airport landing zones. Also, better coordination of NOTAMS for rotary-wing operations and low altitude airspace coordination and navigation procedures. See Section 5.3 above.

Technological Advances

Technological changes are also creating opportunities. In the future, rotary-wing AMT missions could be conducted by electric-powered aircraft (Mahvelatishamsabadi and A. Emadi, 2020; ADAC Luftrettung, 2020). These aircraft have the potential to significantly reduce operating costs and emissions. Also, remotely piloted and pilot-less aircraft (i.e. Autonomous) could significantly reduce costs of providing the AMT service.

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