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Kleinbekman, Imke; Mitici, Mihaela; Wei, Peng

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eVTOL Arrival Sequencing and Scheduling for On-Demand Urban Air Mobility

Imke C. Kleinbekman
MSc. Student Aerospace Engineering
Delft University of Technology
Delft, the Netherlands
i.c.kleinbekman@student.tudelft.nl

Mihaela A. Mitici
Assistant Prof. Aerospace Engineering
Delft University of Technology
Delft, the Netherlands
m.a.mitici@tudelft.nl

Peng Wei
Assistant Prof. Aerospace Engineering
Iowa State University
Ames, IA, United States of America
pwei@iastate.edu

***Abstract*—Urban Air Mobility (UAM) has the ability to reduce ground traffic congestion by enabling rapid on-demand flight through three-dimensional airspace with zero operational emissions by using electric Vertical Take-Off and Landing (eVTOL) vehicles. In the long term with more UAM flights, air traffic control is expected to limit further growth of such operations. Therefore, a first research has been performed on energy-efficient trajectory optimisation for a given required time of arrival, as the arrival phase is the most safety-critical flight phase with much higher air traffic density and limited battery energy. However, research on the computation of the optimal required time of arrival (RTA) for eVTOL aircraft has not yet been performed. Unlike fixed-wing aircraft or helicopters in commercial aviation, eVTOL aircraft have different flight dynamics, limited battery energy supply and a limited number of landing spots at a vertiport such as the top of high-rise buildings. This work is the first to utilise a mixed-integer linear program that computes the optimal RTAs for eVTOLs to safely separate them for minimum delay based on remaining battery state of charge and vertiport capacity. A concept of operations for vertiport terminal area airspace design is also proposed while making use of the existing energy-efficient trajectory optimisation tool. The research serves as a basis for further development of safe and efficient UAM operations. The mathematical model can also be applied to Unmanned Aircraft System Traffic Management (UTM) by inserting new separation requirements and flight dynamics for smaller drones when optimising a high density arrival terminal airspace.**

***Index Terms*—Urban Air Mobility, on-demand, eVTOL, arrival, sequencing, scheduling**

I. Introduction

Urban Air Mobility (UAM) is an envisioned air transportation concept, where innovative aircraft could safely and efficiently transport passengers and cargo within urban areas by rising above traffic congestion on the ground. "The convergence of technologies, and new business models enabled by the digital revolution, is making it possible to explore this new way for people and cargo to move within our cities," said Jaiwon Shin, NASA Associate Administrator for Aeronautics Research Mission Directorate. Companies such as Airbus, Bell, Embraer, Joby, Zee Aero, Pipistrel, Volocopter, and Aurora Flight Sciences are working with their battery vendors to build and test electric vertical takeoff and landing (eVTOL) aircraft to ensure that vehicle safety and energy efficiency become an integral part of people's daily commute. However, there is a lack of concept of operations (ConOps) and air traffic control tools to support safe and efficient UAM operations with these new eVTOL aircraft. In this paper, we focus on designing the optimal UAM arrivals by integrating airspace design/configuration, trajectory optimisation, eVTOL battery modelling and arrival scheduling to enable safe and efficient flight operations in on-demand urban air transportation.

Unlike the small drones that can take off and land almost anywhere in the UAS Traffic Management (UTM) framework, eVTOL vehicles of UAM operations need to take off from and land at vertiports. When UAM operations are expected to increase, one of the major emerging bottlenecks will be the limited number of vertiports and landing pads, which will create a denser arrival UAM traffic in the corresponding terminal airspace. Therefore, we believe UAM arrival is the most safety-critical flight phase due to high-density terminal traffic, low remaining battery energy on eVTOLs, and limited resource of vertiport landing pads.

In this paper, we address the challenge of UAM arrival by developing an arrival sequencing and scheduling algorithm for multiple arriving eVTOL aircraft competing for limited terminal airspace and vertiport resources. Our approach is to formulate this problem as a mixed-integer linear program. We propose a ConOps for UAM terminal airspace design with multiple arrival fixes/routes. The objective is to minimise the total eVTOL arrival delay at the vertiport. Each eVTOL aircraft is constrained by its remaining battery energy and flight performance parameters. We provide an optimal required time of arrival (RTAs) to all the arriving eVTOLs, whose onboard avionics can then compute their energy-efficient optimal arrival trajectories using tools presented in [1], [2].

The remainder of this paper is as follows. In Section II we outline the current research on aircraft and eVTOL arrival sequencing and scheduling. In Section III we present our model for eVTOL arrival scheduling. A case study on the EHANG 184 eVTOL is discussed in Section IV. In Section V we provide conclusions and recommendations.

II. Related Literature

In recent years, several studies have been conducted for on-demand Urban Air Mobility (UAM), i.e., point-to-point air traffic operations that do not follow a pre-defined service schedule, as is the case of traditional commercial aviation. Most research efforts are focused on the current UAM concept definition, demand forecasting and vehicle design. In [3] the UAM concept is described in terms of certification needs, infrastructure, traffic management, operational challenges. [4] researches the nature of these challenges and quantifies their impact by performing a case study on Los Angeles, USA. The development of tools and analysis to support this investigation of near- to far-term evolution of UAM has been described in [5] by a study on the San Fransisco Bay Area, USA. Both [4], [5] simulate the passenger flight demand to perform their feasibility studies. A system-level model on the number of vehicles needed in the system to meet demand, the number of vehicles airborne at any given time, and the length of time vehicles may have to loiter before a landing pad has been developed in [6].

One of the operational challenges for eVTOLs is the scheduling of arrivals at vertiports since eVTOLs are battery constraint and, thus, flight time in the final approach is restricted. Moreover, pre-scheduling is not possible since flights are performed on-demand. This also requires scheduling arrivals in real-time and absorbing delays while airborne. For commercial aviation, a significant amount of research has addressed the problem of aircraft arrival sequencing and scheduling [7]–[9], with the objective, for instance, of minimising delay [10]–[13], cost or environmental impact [14], [15]. Such problems are constrained by, for instance, feasible landing time, time-based separation requirements, runway capacity [10] and airline preferences [16], [17]. Some of the frequently used methods to solve the aircraft arrival scheduling problem are position shifting [18], dynamic programming [17], [19], branch-and-bound [10], branch-and-price [12] and data-splitting [20], [21]. These methods are also combined with heuristics [22]. None of the models, however, are constrained to airport (e.g. gate) capacity or remaining fuel, while this should be considered when modelling eVTOL arrivals. Current research on scheduling of eVTOL arrivals at a vertiport is, however, limited. In [1], [2] the arrival trajectory of eVTOLs is optimised for minimal energy consumption based on a given RTA for a multi-rotor and tandem-tilted wing eVTOL, the EHANG 184 and Airbus A^3 Vahana respectively. In [6] a study on airspace system demand is performed for a range of values that future separation requirements would need to take to support high-demand, high-tempo UAM operations. In [23] continuous eVTOL vehicle routing, departure and arrival scheduling for UAM is developed such that minimum separation is ensured and eVTOL traffic is integrated with existing air traffic.

An important constraint for eVTOLs is the current electric battery technology. No battery models for eVTOL vehicles are available, but research on battery predictions for electric winged aircraft [24], [25] and drones [26] has been performed. These models create a voltage and state of charge profile based on a flight plan using an Equivalent Circuit Model (ECM) to check if the plan can be fulfilled. Also, the ECM parameters are determined by flight testing a 33% scale model of the Zivko Edge 540T aircraft and one battery cell of the DJI Phantom 3 Standard drone, respectively. Complementary to existing research on eVTOLs traffic management, this research develops an arrival sequencing and scheduling model for UAM that minimises total delay while considering the battery status of each eVTOL and flying energy-optimal trajectories where possible.

III. Modelling approach

In this section, we describe our model for eVTOL arrivals at one vertiport. The model consists of 4 parts: i) the concept of eVTOLs arrivals at a vertiport; ii) the flight dynamics model for an eVTOL equipped with one electric battery; iii) the electric battery model and iv) an optimisation model for eVTOL arrival sequencing and scheduling at a vertiport.

A. *eVTOL Arrivals at A Vertiport - Concept of Operations*

We consider eVTOLs arriving at one landing platform, i.e., a vertiport. Moreover, the eVTOLs operate in a segregated airspace volume and at a frequency of maximum 40 arrivals/hr [23]. We assume a total cruise phase of 25 minutes and altitude $500m$ [27] with the final approach at a vertiport defined as follows. We also assume 2 arrival and 2 departure metering fixes at the vertiport [18] (see Fig. 1). These metering fixes have the purpose of separating climbing and descending traffic.

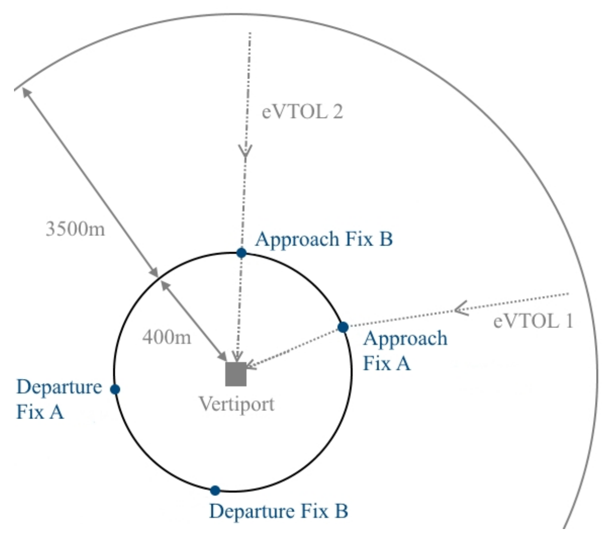

Fig. 1. eVTOL arrivals at a vertiport - concept of operations.

The arrival approach fixes are located at a radius of $400m$ away from the vertiport. A minimum time separation of $90s$ [13] is assumed for the eVTOLs arriving at the 2 approach fixes. Furthermore, their required altitude at the approach fix is set to $200m$. This requirement is needed to ensure clearance from high rise buildings, as well as to provide sufficient space to absorb delay through shallow descent paths [1]. Between the approach fix and the vertiport, each eVTOL flies at a predefined speed and altitude profile (see Fig. 2), while maintaining a separation of $90s$ between consecutive arrivals. This last phase of the trajectory is a step-down approach,

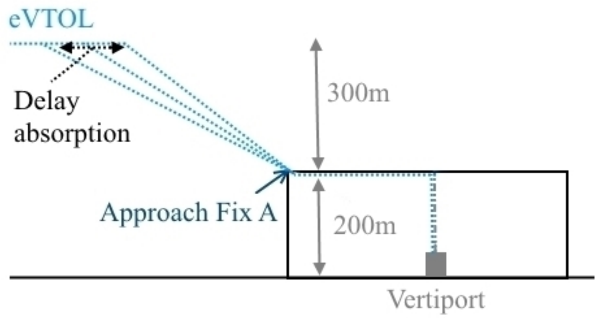

Fig. 2. eVTOL arrivals at a vertiport through approach fix A - side view.

which is considered to be efficient in minimising delay [28] and beneficial for clearance from high rise buildings.

We assume that the arrival sequencing and scheduling of incoming eVTOLs is initiated at $3900m$ radius around the vertiport (see Fig. 1). This radius has been determined based on a trade-off between maximising shallow descent flights and minimising the duration of approach procedures. This proposed ConOps allows for the absorption of delay up to 3 minutes without applying holding or vectoring.

B. eVTOL Flight Dynamics Model

We use the following flight dynamics model for an eVTOL equipped with one electric battery [1].

$$P_r = P_i + P_a + P_c + P_f \quad (1)$$
$$= 4 \cdot T \cdot v_i + T \cdot V \cdot sin(\alpha) + 0.2 \cdot P_r \quad (2)$$
$$V = \sqrt{V_x^2 + V_h^2} \quad (3)$$
$$\alpha = \theta + \gamma = \theta + arctan\left(\frac{V_x}{V_h}\right) \quad (4)$$
$$v_h = \sqrt{\frac{T_r}{2\rho\pi R^2}} \quad (5)$$
$$v_i = \frac{v_h^2}{\sqrt{(V \cdot cos(\alpha))^2 + (V \cdot sin(\alpha) + v_i)^2}}, \quad (6)$$

where P_r, P_i, P_a, P_c, P_f are the required, induced, parasite, climb and profile power, respectively, with $P_f = 0.2P_r$ [29]. V is the true airspeed with the vertical component V_x and the horizontal component V_h. T, P, α, θ, γ are the thrust, the battery power, the angle of attack, the pitch angle and flight path angle, respectively. v_i, v_h, R, T_r, ρ are the induced velocity, the induced velocity in hover, rotor radius, thrust per rotor and the air density, respectively. ρ is assumed to be equal to the international standard atmosphere density at sea level.

We further assume that all rotors produce equal thrust. Thus, we assume an upper and lower rotor to produce equal thrust [30], such that $T_r = \frac{1}{8}T$. The induced velocity v_i is computed using Momentum Theory and v_h, leading to (6). A fourth-degree polynomial arises when computing v_i, which is solved using the MATLAB Roots package [31].

C. Battery Discharge Model

We consider the following model for the total electric power demand, P_d, [26], [32]:

$$P_d = SF \cdot \frac{1}{\eta_P}\frac{1}{\eta_e}P_r \quad (7)$$

where SF is the safety factor to account for weather conditions and emergency diversion, $SF = 1.5$, η_P is the rotor efficiency, $\eta_P = 0.7652$, η_e, is the mechanical efficiency, $\eta_e = 0.85$.

We further consider the following model for the battery State of Charge (SOC) during a mission [32]:

$$I(t_k) = \frac{P_d(t_k)}{V_n} \quad (8)$$
$$SOC(t_k) = SOC(t_{k-1}) - \frac{I(t_k) \cdot (t_k - t_{k-1})}{3600 \cdot Q}, \quad (9)$$

where $I(t_k)$ is the total current of all battery cells at time step t_k, V_n is the nominal battery voltage, Q is the battery capacity. The battery is assumed to be empty if the voltage is below $12V$ or if it reaches a 0% SOC.

D. eVTOL Arrival Sequencing and Scheduling Model

Using the ConOps for eVTOLs arrivals at a vertiport in Section III-A, the flight dynamics model for an eVTOL in Section III-B and the eVTOL battery model in Section III-C, we propose an optimal sequencing and scheduling algorithm for eVTOL arrivals at a vertiport (see Fig. 3).

Firstly, using the ConOps for eVTOLs arrivals (Section III-A) and the eVTOL flight dynamics (Section III-B), we determine the optimal flight trajectory with respect to energy consumption for a given RTA at the vertiport [1], [2]. The optimal trajectories are computed using the GPOPS-II software [33]. The rotorcraft equations of motion are continuous-time nonlinear differential equations, such that the trajectory optimisation problem is solved numerically using a pseudospectral method. This method transcribes a multi-phase optimal control problem to a large sparse nonlinear programming problem. The output of the GPOPS-II optimisation is the total energy required to fulfil the trajectory, the state variables (V_x, V_h, altitude and distance) and the control variables (T and θ).

Secondly, we use the GPOPS-II optimisation output to determine P_r at each instance of the flight trajectory (see Section III-B). Further, P_r is used to determine the battery power demand P_d and the SOC demand (see Section III-C). The latest possible RTA is now found for each arriving eVTOL based on its battery status.

Thirdly, we determine an eVTOL arrival sequence and schedule at a vertiport for minimal total arrival delay. Equation (10) shows the objective function for minimum total delay for all eVTOLs p in set G, where G is the set of all eVTOLs considered, c_e^p and c_l^p are the cost of eVTOL p being earlier and later than $ETA^p(i)$ at approach fix $i \in \{A, B\}$, respectively. Here, $ETA^p(i)$, $i \in \{A, B\}$, is obtained from the most energy-optimal trajectory.

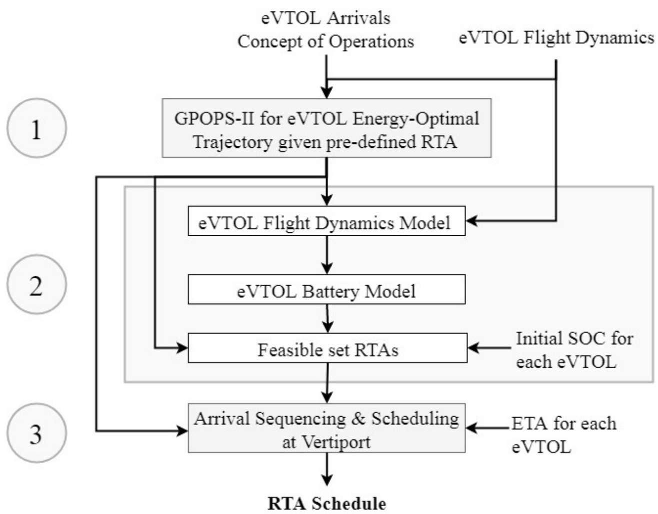

Fig. 3. eVTOL arrival sequencing and scheduling model overview.

We consider the decision binary variables $a^p, b^p \in \{0,1\}$, where $a^p = 1$ means that eVTOL p uses approach fix A and $a^p = 0$ otherwise; $b^p = 1$ means that eVTOL p uses approach fix B and $b^p = 0$ otherwise; $a^p + b^p = 1$. Also, the decision variables Δt_e^p and Δt_l^p describe the time that eVTOL p arrives before and after $ETA^p(i)$, respectively, at the approach fix i, $i \in \{A, B\}$. The delay resulting from choice of arrival route $\Delta t_{l,i}^p$, $i \in \{A, B\}$, is calculated by (11) and (12) in which T_t^p is the transfer time of flight between the approach fix and vertiport.

Objective function

$$min \sum_{p \in G} c_e^p \cdot \Delta t_e^p + c_l^p \cdot \left(\Delta t_l^p + a^p \cdot \Delta t_{l,A}^p + b^p \cdot \Delta t_{l,B}^p \right) \tag{10}$$

$$\Delta t_{l,A}^p = max\left(0, (ETA^p(A) + T_t^p(A) - ETA^p(B) - T_t^p(B))\right) \tag{11}$$

$$\Delta t_{l,B}^p = max\left(0, (ETA^p(B) + T_t^p(B) - ETA^p(A) - T_t^p(A))\right) \tag{12}$$

Equation (13) and (14) define $s^{pq} = 1$ if eVTOL p arrives prior to eVTOL q and $s^{pq} = 0$ otherwise; $z^{pq} = 1$ if eVTOL p and q fly through the same approach fix and $z^{pq} = 0$ otherwise. Constraint (15) ensures that either eVTOL p follows eVTOL q or eVTOL q follows eVTOL p. Constraint (19) ensures that one eVTOL uses only one approach fix. The time window available for landing at the vertiport is described in (16). The earliest possible time of arrival RTA_e^p is derived from the flight performance model (see Section III-B), while the latest RTA_l^p results from the battery model (see Section III-C). Similarly, the earliest and latest possible time of arrival at approach fix A and B are given in equations (17) and (18), respectively. Equation (20) ensures that if eVTOL p and q go through the same approach fix, the reverse is also true. Equations (21) and (22) further define $z^{pq} = 1$ to if both eVTOL p and q use approach fix A and B, respectively. Equations (23) and (24) define $z^{pq} = 0$ if eVTOLs p and q fly through different approach fixes. Equations (25-27) ensure a time-based separation of at least Δt_{sep}^{qp} if p follows q at the vertiport and the approach fixes. Lastly, equations (28-31) show the calculation for the Big-M method and define the RTA for eVTOL p using approach fix A and B, respectively.

Constraints

$$s^{pq}, z^{pq}, a^p, b^p = \{0,1\} \qquad \forall p, q \in G \tag{13}$$

$$\Delta t_e^p, \Delta t_l^p \geq 0 \qquad \forall p, q \in G \tag{14}$$

$$s^{pq} + s^{qp} = 1 \qquad \forall p, q \in G \tag{15}$$

$$RTA_e^p \leq RTA^p \leq RTA_l^p \qquad \forall p \in G \tag{16}$$

$$RTA_e^p(A) \leq RTA^p(A) \leq RTA_l^p(A) \qquad \forall p \in G \tag{17}$$

$$RTA_e^p(B) \leq RTA^p(B) \leq RTA_l^p(B) \qquad \forall p \in G \tag{18}$$

$$a^p + b^p = 1 \qquad \forall p \in G \tag{19}$$

$$z^{pq} = z^{qp} \qquad \forall p, q \in G \tag{20}$$

$$z^{pq} \geq a^p + a^q - 1 \qquad \forall p, q \in G, p \neq q \tag{21}$$

$$z^{pq} \geq b^p + b^q - 1 \qquad \forall p, q \in G, p \neq q \tag{22}$$

$$z^{pq} \leq \frac{1}{2}a^p - \frac{1}{2}a^q + 1 \qquad \forall p, q \in G, p \neq q \tag{23}$$

$$z^{pq} \leq \frac{1}{2}b^p - \frac{1}{2}b^q + 1 \qquad \forall p, q \in G, p \neq q \tag{24}$$

$$RTA^p \geq RTA^q + \Delta t_{sep}^{qp} - M^{pq} \cdot s^{pq} \tag{25}$$

$$RTA^p(A) \geq RTA^q(A) + \Delta t_{sep}^{qp} \cdot z^{qp} - M^{pq} \cdot s^{pq} \tag{26}$$

$$RTA^p(B) \geq RTA^q(B) + \Delta t_{sep}^{qp} \cdot z^{qp} - M^{pq} \cdot s^{pq} \tag{27}$$

$$\forall p, q \in G, p \neq q$$

$$M^{pq} = RTA_l^q + \Delta t_{sep}^{qp} - RTA_e^p \tag{28}$$

$$RTA^p = a^p \cdot (ETA^p(A) + T_t^p(A)) + b^p \cdot (ETA^p(B) + T_t^p(B)) + \Delta t_l^p - \Delta t_e^p \tag{29}$$

$$RTA^p(A) = ETA^p(A) + \Delta t_l^p - \Delta t_e^p \tag{30}$$

$$RTA^p(B) = ETA^p(B) + \Delta t_l^p - \Delta t_e^p \tag{31}$$

IV. Case Study EHANG 184

We consider a case study for EHANG 184, a multi-rotor eVTOL designed to transport a single passenger [27]. Fig. 4 shows the results from the first step in the algorithm, the GPOPS-II energy-efficient trajectory optimisation for a trivial selection of RTAs. An RTA= $165s$ at the approach fix (AF) is the lowest input to ensure convergence to a solution. The cruise flight phase is performed at $500m$ altitude and $27.8m/s$ cruise speed. The eVTOL arrival scheduling and sequencing is initiated at $3900m$ distance from the vertiport (see Section III-A). Based on the results of this optimisation, the eVTOL control system initiates a shallow descent between $3400m$ and $1000m$ from the vertiport at a constant $V_x = 5.9m/s$ and variable V_h. After passing the AF, a horizontal flight phase is executed at cruise speed and a vertical flight at $2.9m/s$. Fig. 4 also shows the feasible time window of the scheduling tool. For an RTA at the AF between $165s$ and $525s$, the eVTOL is required to arrive at the vertiport between $307s$ and $667s$ as the flight between the AF and vertiport takes $142s$. A trajectory with RTA= $165s$, which also corresponds to the minimum energy required, is used as a baseline trajectory, while its corresponding ETA is an input for the scheduling tool.

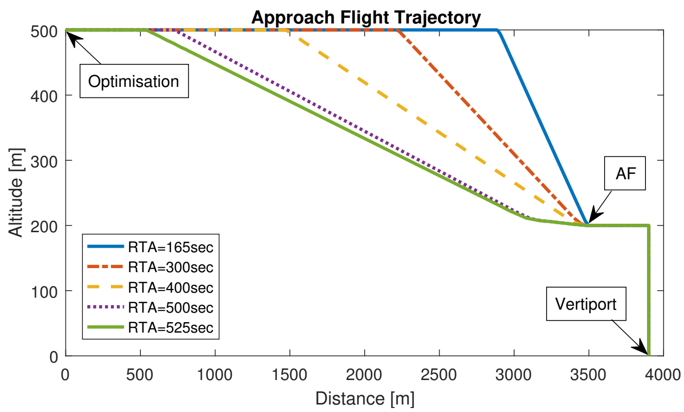

Fig. 4. EHANG 184 energy-optimal trajectory for different RTA to approach fix.

The SOC required to perform each of the trajectories shown in Fig. 5 is computed during the second step of the model (see Fig. 3). The battery characteristics specific to EHANG 184 are not made public so it is assumed that Q is $5000Ahr$ and V_n is $12V$. When the remaining SOC of an incoming eVTOL is equal to e.g. 25%, Fig. 5 indicates RTA= $434s$ at the AF, thus an RTA at the vertiport of $576s$ can be scheduled at the latest.

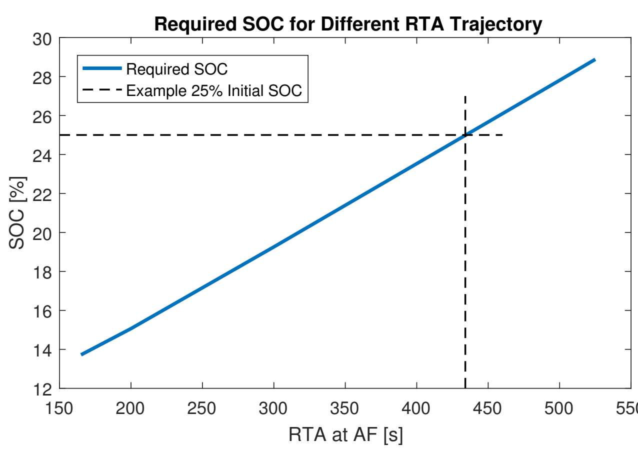

Fig. 5. SOC required to perform different delay absorption trajectories with example 25% SOC and resulting latest RTA of $434s$.

The eVTOL sequence and schedule are now obtained using the model in step 3 (see Fig. 3). An example of input for our model is shown in Table I. We also assume $c_e = 10$ and $c_l = 30$ [11]. The values for Δt_l^p represent the delay to be absorbed by flying shallow descent, while $\Delta t_{l,AF}^p$ is the delay due to flying through the furthest approach fix (AF). Table II shows that the eVTOLs are rescheduled and sequenced when this minimises delay or when an eVTOL has a low SOC (see eVTOL 8 and 9). Furthermore, eVTOLs are delayed if the separation requirements are not satisfied (see eVTOL 8 and 10). It also selects the AF, which is a means to separate eVTOLs and absorb delay (see eVTOLs 3 and 4).

TABLE I
TEST DATASET OF 10 EHANG 184 EVTOLS

Flight Nr [-]	**ETA (A) [s]**	**ETA (B) [s]**	**Initial SOC [%]**
1	165	180	13
2	250	250	18
3	335	325	25
4	420	410	30
5	505	505	18
6	590	590	13
7	665	675	25
8	750	760	25
9	855	845	14
10	930	930	28

TABLE II
ARRIVAL SEQUENCE AND SCHEDULE FOR TEST DATASET

Flight Nr [-]	**RTA [s]**	Δt_l^p [s]	**AF [-]**	$\Delta t_{l,AF}^p$ [s]
1	307	0	A	0
2	397	5	B	0
3	487	20	A	10
4	577	25	A	10
5	667	20	A	0
6	757	25	A	0
7	847	40	A	0
9	987	0	B	0
8	1077	185	A	0
10	1167	95	B	0

The computational time required to obtain the described results is 2 seconds, using CPLEX LP Solver [34] extension of MATLAB [31] on a computer with Intel CORE i7 processor. To analyse the computational performance of our model, we further vary the number of arriving eVTOLs. We generate ETAs for the eVTOLs using a Poisson process with rate 40 arrivals/hr, while a normal distribution with mean 30% and variance of 5% is used to for the initial SOC. The computational performance is given in Table III. Our model can optimally schedule up to 40 incoming eVTOLs within $79s$, which provides enough time for eVTOLs to absorb the scheduled delay flying energy-efficient shallow descent trajectories through the selected approach fix. However, for a larger number of eVTOL arrivals, further developments of more computational efficient scheduling algorithm are needed.

TABLE III
COMPUTATIONAL TIME FOR DIFFERENT NUMBERS OF ARRIVING EVTOLS

Number of eVTOLs [-]	10	20	30	40	60	80
Computational time [s]	1.6	9.7	31	79	470	5333

V. Conclusion and Recommendations

A sequencing and scheduling algorithm with a route selection function for on-demand UAM arrivals is proposed in this paper. The problem is formulated as a mixed integer linear program whose objective is to minimise the total arrival delay. The problem formulation includes constraints such as minimum time separation, eVTOL battery energy and vehicle dynamics. We compute the optimal required times of arrival (RTAs) for eVTOLs arriving at a vertiport within a given planning horizon. Numerical experiments show that our proposed algorithm has near real-time computational performance when scheduling the arrival of up to 40 eVTOLs. Our proposed algorithm and ConOps for terminal airspace design provide a potential solution framework to support safe and efficient on-demand arrivals in Urban Air Mobility (UAM).

The contribution of this paper is two-fold. Firstly, we propose a ConOps for vertiport airspace design and configuration. We introduce multiple arrival routes with multiple arrival metering fixes. Secondly, this is the first research work on eVTOL arrival sequencing and scheduling for on-demand Urban Air Mobility. The algorithm has arrival route selection capability. It includes a battery discharge prediction model that makes this arrival scheduling algorithm specially designed for eVTOL operations. It outputs landing time slots (or RTAs) for all arriving eVTOLs for minimum total delay. This algorithm can be used as a baseline for future research on optimal UAM arrival scheduling.

Future work includes a more in-depth research on the airspace design, both for arrival and departure procedures, as well as safe separation from other aviation traffic in the integrated airspace. Detailed battery testing and modelling are recommended to provide a more accurate model for battery discharge prediction. More efficient optimisation algorithms should be investigated to improve the computational performance of the sequencing and scheduling model. Finally, this arrival sequencing and scheduling algorithm should be incorporated with departure scheduling and conflict detection and resolution models to reach the highest efficiency in Urban Air Mobility and ensure safe flight operations.

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