STOLPort land space requirements using current FAA airport design guidance versus performance-based design

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Abstract

Urban Air Mobility is quickly approaching reality, with many manufacturers of electric vertical takeoff and landing (eVTOL) aircraft nearing Federal Aviation Administration (FAA) certification. Although eVTOL aircraft are the most popular category of Urban Air Mobility due to their ability for vertical takeoff and landing, requiring little land space and infrastructure, the often-overlooked electric short takeoff and landing (eSTOL) aircraft provides many interesting advantages when compared to eVTOL. A few of these advantages include, but are not limited to: higher payload capacity, increased range, and lower cost of operation per nautical mile of travel.

eSTOL vehicles, however, will require private companies or local/state governments to dedicate more land space for STOLPort infrastructure. How much land space is required depends upon the allowable design standards to which this infrastructure is to be constructed. Current regulations for fixed-wing aircraft operating for commercial purposes, primarily passenger transport and accepting federal funding for infrastructure development, would require the infrastructure to be constructed to FAA Airport Design Standards. This requirement would limit the number of possible locations for a STOLPort near Urban or Suburban areas, and would prove cost-prohibitive due to the land area required for this infrastructure. However, if STOLPorts are designed to safely accommodate eSTOL, short takeoff and landing (STOL), or super-short takeoff and landing (SSTOL) aircraft and their unique performance capabilities, they would likely require less land.

This study will compare the land space requirements for a STOLPort designed on current FAA design guidance versus a STOLPort designed based on eSTOL' s unique expected performance capabilities.

Table of Contents

List of Figures vi
List of Tables vii
List of Abbreviations viii
Chapter 1 - Introduction 1
Chapter 2 - Literature Review 3
Published Runway and Airport Design Standards 4
Takeoff Field Length Determination 5
eSTOL Performance and Capabilities 7
Previous STOLPort Siting Studies 8
Gaps Identified in the Literature Review 11
Chapter 3 - Methodology 14
Part A – STOLPort Design Using Current FAA Design Procedures 14
Establishing the design aircraft and determining this aircraft's approach speed 14
Determining the Minimum Runway Length 15
Determining the Aircraft Design Group (ADG) and Aircraft Approach Category (AAC) of the Design Aircraft. This will provide the Runway Design Code (RDC) 15
Using the ADG to find the applicable Runway Design Standards Table in Appendix G of AC 150/5300-13B. 16
Determining the critical aircraft's Taxiway Design Group (TDG) 19
Using the TDG to determine all geometric design standards for all taxiways. 20
Determining the TSA, TOFA, TLOFA, Taxiway, and Taxilane Separation requirements. . 21
Determining Apron Location and Minimum Depth 22
Part B 23
Determining the Minimum Runway Length 23
Determining the Minimum Runway Width 24
Determining the Minimum Runway Safety Areas and Object Free Areas 25
RSA Dimension Determination 25
ROFA Dimension Determination 28

RPZ Dimension Determination 28
Determining the Minimum Runway to Taxiway Separation 29
Minimum Taxiway Widths and Safety Area Dimension Determination 29
Minimum Taxiway Centerline to Parallel Taxilane Centerline Separation and Apron Location 30
Chapter 4 - Results 30
Part A 30
Part B 34
Chapter 5 - Discussion 36
References 39
Appendix A - Interview with Electra Aero 41

List of Figures

Figure 1: Concept 1 Air Park by Robinson et al. 10
Figure 2: Concept 2 Air Park by Robinson et al. 14
Figure 3: Barge Air Park Concept by Robinson et al. 15
Figure 4: Electra Aero EL9 Dimensions 15
Figure 5: Table 1-1 from AC 150/5300-13B-Change 1 16
Figure 6: Table 1-2 from AC 150/5300-13B-Change 1 16
Figure 7: Table G-3 From AC 150/5300-13B 19
Figure 8: Table 1-4 from AC 150/5300-13B 20
Figure 9: Table J-1 from AC 150/5300-13B 21
Figure 10: Table 4-1 from AC 150/5300-13B 22
Figure 11: Table B-1 from AC150/5300-13B 25
Figure 12: STOLPort Layout - Part A 33
Figure 13: STOLPort Layout – Part B 35
Figure 14: Performance-Based Design vs. FAA Criteria Design STOLPort 36

List of Tables

Table 1: Applicable FAA Advisory Circular Sections 5
Table 2: Part A - FAA Design Guidance Geometric Layout 32
Table 3: Part B - Performance-Based Design Geometric Layout 34

List of Abbreviations

AAC – Aircraft Approach Category
AAM – Advanced Air Mobility
AC – Advisory Circular
ADG – Aircraft Design Group
CTOL – Conventional Takeoff and Landing
eSTOL – Electric Short Takeoff and Landing
eVTOL – Electric Vertical Takeoff and Landing
AAC – Aircraft Approach Category
ADG – Airplane Design Group
TDG – Taxiway Design Group
FAA – Federal Aviation Administration
FATO – Final Approach and Takeoff
IT-OFZ – Inner-Transitional Object Free Zone
MTOW – Maximum Takeoff Weight
OFZ – Obstacle Free Zone
POFZ – Precision Obstacle Free Zone
STOL – Short Takeoff and Landing
SSTOL – Super Short Takeoff and Landing
RDC – Runway Design Code
RSA – Runway Safety Area
ROFA – Runway Object Free Area
ROFZ – Runway Obstacle Free Zone
RPZ – Runway Protection Zone
TSA – Taxiway Safety Area
TOFA – Taxiway Object Free Area
TOLF – Touchdown and Lift Off
UAM – Urban Air Mobility

Chapter 1 - Introduction

It is expected that eVTOL vehicles will be the first to serve the UAM market, as there are 10 manufacturers of eVTOL aircraft (eVTOL.travel, 2026), with some manufacturers currently under review for certification, and one, the BETA ALIA, receiving the first-ever special airworthiness certificate for an eVTOL that will allow it to conduct flights with prospective customers (General Aviation News, 2026). For powered-lift vehicles, eVTOLs in particular, TOLA requirements have been researched and developed in the FAA-published *EB 105A Vertiport Design, Supplemental Guidance to Advisory Circular 150/5390-2D, Heliport Design*. Additionally, the FAA selected eight partner states or metropolitan entities to serve as partners for the eVTOL Integration Pilot Program. This program will allow the federal government to develop a new framework and policy around safe and effective AAM, utilizing powered-lift vehicles, primarily eVTOLs.

However, current FAA airport design guidance for a new STOLPort could prove to be restrictive to urban and suburban areas, where eSTOL operations would prove most effective and efficient. For instance, current FAA runway design guidance in FAA AC 150/5300-13B provides runway width and safety areas based on a minimum approach speed of just under 121 knots (Federal Aviation Administration [FAA], 2024), whereas the Electra Aero EL9 has an expected approach speed of just 35 knots and a landing and takeoff ground roll of just 150 feet (Electra Aero, 2026).

The FAA, in the Draft AC 150/5390-4, released in October 2026, states that STOL vehicles, which include eSTOL, may be able to use heliports as a potential takeoff and landing area, given that the heliport (or vertiport) contains an elongated TLOF and an elongated FATO (FAA, 2026). In this draft AC, the FAA additionally states that the infrastructure of STOL aircraft is still under development, and "will release more guidance for these novel distributed propulsion blow lift systems as data becomes available". (FAA, 2026)

eSTOL will take off and land much like a traditional fixed-wing aircraft, albeit with a significantly shorter ground roll. As such, it is expected that STOLPorts will be designed much like standard airports. With the much shorter ground roll than traditional fixed-wing aircraft, how much area is required for the safe operation of eSTOL vehicles, and how long should an eSTOL runway be? Very little research has been performed on this topic, as it is likely that, in the early stages of

eSTOL operations, most flights will be conducted to and from existing airport infrastructure, much like early eVTOL operations.

For eSTOL operations to be viable in urban and suburban areas, the infrastructure needed to support them must be as small a footprint as safely possible. According to current FAA guidance, an airport (or STOLPort) sponsor must own, at a minimum, the land containing all safety areas, including the Runway Safety Area (RSA), Runway Object Free Area (ROFA), Taxiway Safety Area (TSA), and Taxiway Object Free Area (TOFA). Additionally, for new aviation facilities, the sponsor must also own the property containing the Runway Protection Zone (RPZ), or, at a minimum, own avigation easement rights to this property with action taken to own the property in the future (FAA, 2024).

Electra Aero, a developer and manufacturer of eSTOL aircraft, is expected to produce the first eSTOL aircraft capable of commercial passenger service in the UAM Market. They have produced the EL2, which is a two-seat demonstration and test vehicle to showcase the capabilities of blown-wing aircraft. Their ultimate vehicle, the EL9, will be a 9-passenger aircraft utilizing blown-wing technology to allow the aircraft to have a 35-knot approach speed and a landing and takeoff ground roll of just 150 ft (Electra Aero, 2026). As the EL9 is likely to be the first eSTOL to enter the market, it shall serve as the design aircraft of this study.

This thesis will set the theoretical minimum land space required for an STOLPort at mean sea level (MSL) based on two sets of design criteria: 1. Current FAA design standards and guidance, and 2. Aircraft performance capabilities, with safety margins and expected required safety areas. The second option will blend both the current FAA guidance for distances with aircraft-specific performance capabilities, both real-world and conceptual, to determine runway length, runway-to-taxiway centerline separation, taxiway-to-taxilane centerline separation, and runway protection zone (RPZ) size.

In chapters 3 and 4 that follow, the information will be divided into Part A and Part B. Part A will provide the design and sizing of a STOLPort using only current FAA design criteria. Part B will represent the vehicle performance design criteria mixed with FAA design criteria.

Delimitations

All dimensions discussed in this piece are assumed to be at or near mean sea level. It is expected that, similar to traditional aircraft runways, runway length will require additional length with elevation. This, in turn, would require additional land ownership for the STOLPort. Additionally, this thesis does not take into consideration runway orientation based upon the prevailing wind coverage, as it will be assumed that for early eSTOL operations, STOLPorts will be single-runway facilities in urban or suburban areas. Additionally, this paper does not consider the additional runway length and obstruction clearance requirements that may be required for autonomous flight; rather, this paper analyzes the design based on the likelihood of on-board piloted flights for the foreseeable future. This paper will not take into consideration the longitudinal or transverse grading of the STOLPort facilities, as each proposed site will require unique grading and drainage requirements. Grading of each specific site may require additional land space and should be taken into consideration when choosing a proposed STOLPort location. Thirdly, the EL9 will contain the technology capable of Instrument Flight Rules (IFR) flight. It is unknown how this technology in eSTOL will impact landing ground roll or required runway distance, and, therefore, IFR technology is not considered due to the potential for significant variability of this unknown.

Furthermore, some assumptions based on experience in airport/heliport design and construction have been made where gaps in available data existed. An example of gaps in the data is an expected approach and/or departure angle for the Electra Aero EL9 eSTOL**,** as well as skid performance of the EL9 on either a grooved or ungrooved, wet or dry pavement. This data was requested during the author's interview with Electra Aero, but the data could not be provided due to either the data being proprietary or an exact value being currently under development by the manufacturer. The questions asked and answers provided during this interview are provided in Appendix A.

Chapter 2 - Literature Review

Existing airport design is shaped by regulatory guidance through design ACs, Engineering Briefs (EBs), and the Code of Federal Regulations (CFR), while AAM/UAM is shaped by a combination of regulatory guidance, technological innovation, and emerging concepts in

advanced air mobility. In reviewing existing literature, there are several topics to consider. These topics include;

1. Published runway and airport design standards,
2. Takeoff field length calculations,
3. eSTOL Performance and Capabilities,
4. Previous STOLPort siting studies

Each of these topics will provide critical information in developing the land space possibilities for both proposed scenarios: Part A – Design using current FAA design standards, and Part B – Design using a mixture of FAA design standards and design aircraft performance characteristics. Topic one, listed above, will be the only topic researched for the design requirements in Part A land space determination, as it contains not only the FAA Design Advisory Circulars, but also all applicable Code of Federal Regulations.

Published Runway and Airport Design Standards

To determine the land space required for a STOLPort using current FAA design standards, one must refer to the published FAA design Advisory Circulars (AC), as well as 14 CFR Part 77. The ACs set standards for each area of an airfield, such as runway width and length, taxiway width, and runway-to-taxiway separation, among others. Table 1 below summarizes each AC and applicable federal regulations that will be utilized in this paper, along with each applicable section and what that section covers.

Advisory Circular Number	Section	Design Element
150/5300-13B-Change 1	2.6.4	Visibility Categories
	2.8	Modification of Standards
	3.4.2	Runway Threshold
	3.6	Approach and Departure Surfaces
	3.7.2	Runway Width
	3.7.3	Runway Shoulders
	3.4.11	Runway Safety Area (RSA)
	3.11	Obstacle Free Zone (OFZ)
	3.12	Runway Object Free Area (ROFA)
	3.13	Runway Protection Zone
	3.15	Stopway

	3.17	Runway to taxiway separation standards
	4.2	Taxiway Design Group
	4.5	Taxiway/Taxilane Clearance
	4.7	Taxiway Fillet Design
	4.8	Runway/Taxiway Intersections
	4.10	Taxiway Turnarounds
	Appendix G	Runway Design Standards
	Appendix J	Taxiway Additional Information
150/5325-4B	Chapter 2	Runway Lengths for Small Airplanes with Maximum Certificated Takeoff Weight of 12,500 Pounds or Less
150/5000-17	Chapter 3	Application of Critical Aircraft Determination
14 CFR Part 77	Subpart C	Standards for Determining Obstructions to Air Navigation or Navigational Aids or Facilities

Table 1: Applicable FAA Advisory Circular Sections

Takeoff Field Length Determination

Takeoff distance calculation requirements are found in 14 CFR Part 25 §25.113, Takeoff distance and takeoff run. This section of the CFR provides the takeoff distances for three takeoff scenarios:

1. Takeoff distance on a dry runway
2. Takeoff distance on a wet runway
3. Takeoff distance on a wet or dry runway that does not include a clearway, which is a rectangular area beyond the end of a runway cleared or suitable for use in lieu of a runway to satisfy takeoff distance requirements (FAA, 2024).

Each of these three scenarios includes two or more ways to calculate takeoff distance, with the official distance being the greater of all the distances (14 CFR Part 25, 1998).

For takeoff distance on a dry runway, the CFR provides two calculations, with the critical takeoff distance being the greater of:

1. The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 35 feet above the takeoff surface, determined under §25.111 for a dry runway; or (CFR Part 25, 1998)
2. 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to the point at which the airplane is 35 feet above the takeoff surface, as determined by a procedure consistent with §25.111. (CFR Part 25, 1998)

Takeoff distance on a wet runway is calculated as the greater of:

1. The takeoff distance on a dry runway determined in accordance with paragraph (a) of this section; or
2. The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 15 feet above the takeoff surface, achieved in a manner consistent with the achievement of V_2 before reaching 35 feet above the takeoff surface, determined under § 25.111 for a wet runway.

If the takeoff distance does not include a clearway (defined in AC 150/5300-13B), the takeoff run is equal to the takeoff distance. If the takeoff distance includes a clearway:

1. The takeoff run on a dry runway is calculated as the greater of:
    a. The horizontal distance along the takeoff path from the start of the takeoff to a point equidistant between the point at which VLOF is reached and the point at which the airplane is 35 feet above the takeoff surface, as determined under § 25.111 for a dry runway; or
    b. 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to a point equidistant between the point at which VLOF is reached and the point at which the airplane is 35 feet above the takeoff surface, determined by a procedure consistent with § 25.111.
2. The takeoff run on a wet runway is calculated as the greater of:
    a. The horizontal distance along the takeoff path from the start of the takeoff to the point at which the airplane is 15 feet above the takeoff surface, achieved in a manner consistent with the achievement of V_2 before reaching 35 feet above the takeoff surface, as determined under § 25.111 for a wet runway; or

b. 115 percent of the horizontal distance along the takeoff path, with all engines operating, from the start of the takeoff to a point equidistant between the point at which V_{LOF} is reached and the point at which the airplane is 35 feet above the takeoff surface, determined by a procedure consistent with § 25.111.

Note: All points above are quoted directly from CFR Part 25 §25.113.

For the purposes of this paper, it will be assumed that due to the expected shorter required runway lengths, clearways will not be considered as part of the land space siting calculations.

eSTOL Performance and Capabilities

To begin the discussion on potentially reducing the size of a STOLPort, one must first be able to determine the performance characteristics of eSTOL aircraft. Courtin, in his paper titled "An assessment of Electric STOL Aircraft" (Courtin, 2019), theorizes a Landing Ground Roll for eSTOL at 87 feet and a Takeoff Ground Roll of 59 feet for an eSTOL with blown wing technology. He goes so far as to also calculate predicted landing and takeoff distances over a 50-ft obstacle of 300 feet and 264 feet, respectively. According to the pilot guide to takeoff safety, section 2.3.1.1 (FAA, 2000), three scenarios are to be considered to determine runway length. The first being, the runway shall be 1.15 times the length required to reach a point 35 feet above the ground. The second requirement is the engine-out accelerate-go distance, which is the distance required to accelerate with all engines operating, have one engine fail at V_{EF} at least one second before V_1, continue the takeoff, and reach a point 35 feet above the runway surface at V_2 speed. The third scenario is the Accelerate-Stop distance, which is the distance required to accelerate with all engines operating, have an engine failure or other event at V_{EVENT} at least one second before V_1, recognize the event, reconfigure for stopping, and bring the airplane to a stop using maximum wheel braking with the speed brakes extended. Dependent upon blown wing performance with one or more engines out, Courtin and colleagues theorize a runway length of 300 ft would satisfy these requirements (Courtin et al., 2018).

For payload capacity, it is estimated that eSTOL aircraft will be able to carry 1.8 to 206 times the payload at the same speed and range compared to eVTOL (Courtin et al., 2021), or provide a greater range at the same payload and speed. Electra, a leading eSTOL developer, is seeking full

FAA certification of a 9-passenger aircraft by 2028. The EL9 is projected to have a ferry range of 1,100 nautical miles, have a cargo payload of 3,000 pounds, and have a cruising speed of 175 knots, all while maintaining a 150-ft ground roll distance (Electra.Aero, 2026).

To be able to perform to these standards, Electra has developed their two aircraft (the EL2 and EL9) utilizing blown-wing technology. Blown wing technology is a part of Blown Airfoil Theory, which states, "A blown airfoil has a jet of high-velocity air (relative to the freestream) directed over its surfaces." (Agrawal et al., 2019). The paper authored by Agrawal, Berk, Long, Lubin, Courtin, Thomas, Hansman, and Drela focuses on blowing air mostly under the airfoil, as is the case with the Electra aircraft. By blowing air under the airfoil, this wind-tunnel test was able to determine that lifting performance was increased by nearly a factor of 4 over an unblown airfoil, while requiring lower power input (Agrawal et al.,2019).

It is also expected that for all-electric VTOL and all-electric STOL, the STOL vehicle would not only be able to carry additional batteries over the eVTOL architecture, but if carrying the same battery pack, would have a longer range when compared to eVTOL aircraft. This is due in part to the energy required to perform the vertical takeoff and landing of the eVTOL. Much of the battery energy is used during these two operations. Whereas, in the blown wing model in the previous paragraph, there is no significant increase in power requirement for eSTOL takeoff, and very little is required for landing, except for slight course and speed corrections.

Previous STOLPort Siting Studies

An exhaustive search of previous research on eSTOL runway length determination and STOL port siting returned very few results. Four peer-reviewed and published papers were found and reviewed, with three of the papers being authored and published through the Aerospace Systems Design Laboratory at Georgia Institute of Technology.

In his paper "Feasibility Study of Short Takeoff and Landing Urban Air Mobility Vehicles using Geometric Programming" (Courtin et al., 2018), Coutin concludes that for the 4-seat aircraft, a field length of 100 ft is possible, whereas 'Runway lengths of 300ft are readily available for

eSTOL aircraft with current technologies, which is also achievable from the perspective of building infrastructure within urban centers."

A series of papers published by Georgia Institute of Technology's Aerospace Systems Design Laboratory go beyond possible runway lengths to not only explore possible STOLPort land space requirements, but also to explore how many of these STOLPorts could be constructed in any given city based on a metropolitan area's available land (geodensity), the runway orientation for either of these locations, which would determine runway orientation, and possible obstructions to approach surfaces at these locations. While these latter steps will be critical in determining an exact location for a STOLPort in any given metropolitan area, this study focuses solely on the land space required for the STOLPort. Therefore, the review of this series of papers will focus on the authors' STOLPort configuration determination, which is determined in the first paper of the series.

In the first paper of the series, Robinson, Sokollek, Justin, and Mavris develop 3 "realistic, parametric, resizable airpark concepts to fit within the metropolitan region itself." (Robinson et al., n.d.). The authors, in this paper, do not utilize a standard, constant runway length, as one of their objectives is to compare the geodensity changes of airparks as runway length increases. In their formulation for airpark sizing, the authors reject the FAA's standard of a 600-foot RSA beyond the runway ends, as it would prove restrictive to STOL on-demand mobility feasibility (Robinson et al., n.d.). They formulate an equation to represent a "bounding box" represented by a length and a width for each of the three concepts.

Concept one is what they refer to as the "standard airpark concept", with the length calculated using the formula L+2R, where L is the runway length and R is the width of the RSA, and the width formulated by 109+S, where S is the parking lot side length, and the constant 109 being a constant taxiway width and safety margin of 49 feet plus the constant runway width of 60 feet. The taxiway width is set at 49 feet for aircraft with a wingspan of 49 feet and an apron space adjoining the taxiway.

For the variable R, the authors provide an equation of $R = (h_{OF} - 35)/\tan(\gamma)$, where h_{OF} is the prescribed overfly height, and γ is the departure flight path angle, assumed to be 15° in the paper (Robinson et al., 2018).



Figure 1: Concept 1 Air Park by Robinson et al

Concept two, referred to as the narrow concept, places a full-length apron in lieu of a parallel taxiway, and contains a taxilane on the edge. For the "bounding box" calculations, the length remains constant from concept one, but the formula for the width is revised to be 60+S. This represents the reduction in the constant by 49 feet (taxiway width plus safety margin). In this concept, there would not be an ability for an aircraft to taxi behind a parked aircraft, requiring some aircraft to utilize the runway to taxi or back-taxi to the proper parking position.



Figure 2: Concept 2 Air Park by Robinson, et al

Concept three in this paper is a barge concept that will not be considered as part of this literature review, due to the unlikelihood that this will be an allowable solution in scheduled and unscheduled passenger service commercial flights (expanded upon in the following section).



Figure 3: Barge Air Park Concept by Robinson, et al

Gaps Identified in the Literature Review

Current FAA Advisory Circulars do not account for the unique performance capabilities of eSTOL or SSTOL vehicles. For instance, the lowest AAC, which is a determining factor in many of the Runway and Taxiway design criteria, has a maximum approach speed of "less than 91 knots" (FAA, 2024). It is expected that many eSTOL aircraft will have approach speeds of approximately 35 knots (Electra Aero, 2026). Other classifications based on aircraft dimensions such as ADG and TDG will likely remain applicable for design of STOLPorts. The slower approach speed should allow for a reduction of key land space determining factors such as runway length and width, runway safety area width and length, and RPZ dimensions.

In the paper titled "Development of a Methodology for Parametric Analysis of STOL Airpark Geo-Density" by Robinson, Sokollek, Justin, and Mavris, the authors explore the hypothesis that there is a certain airpark geo-density that would allow STOL aircraft to be as capable as VTOL aircraft in a given region. This density would be a function of runway length, with density increasing with shorter runway lengths, and vice versa. The authors additionally contend that this

would not apply to all major urban areas, as some, such as New York City, are too dense, with little to no suitable space within a reasonable distance of the downtown area. The authors weighed nine metropolitan areas against eight criteria, grading each criterion as "advantage, disadvantage, or neutral" and assigning a numerical value to those grades. The Miami metro area was ultimately selected for this research, scoring a 6 out of 8 possible points.

To better determine air-park density, an approximate overall footprint must first be established. The authors developed three air-park concepts, developing densities for each. The first, which they call the "standard" airpark concept, uses an airpark length of $L+2R$, with L being the runway length, and R being an author-determined Runway Safety Area Length. This length, if following the current FAA guidance, would require 600 feet on each end of the runway based on an expected STOL aircraft size, which would most likely fit the FAA's standards for Aircraft Approach Category (AAC)-A, Airplane Design Group (ADG)-1 (combined category for airport design = A-1), and TDG-1. If the FAA keeps this requirement for commercial STOL ports, it would exclude many areas, and most cities could not commit this much land space in multiple locations. The authors calculated this value by assuming the vehicle will have reached 35 feet in altitude at the point it passes the runway threshold, as this is a common assumption in calculating takeoff field length requirements, where the safety area will increase or decrease, depending upon prescribed overfly height.

For the standard width concept equation, 109 feet was calculated from a combination of "runway width including safety area margin" (60 ft) and "taxiway width including safety margin" (49 ft). There are, however, a few items excluded or assumed in the development of this equation. Per the current regulations, the minimum overall runway width for a Runway for A/B-1 aircraft would be 60 feet, with a Runway Object Free Area width of 250 feet, centered along the runway centerline. Additionally, there is a required runway centerline-to-parallel taxiway centerline separation of 150 feet (for Visibility Minimum not lower than ¾ mile), a taxiway width of 25 feet, and a Taxilane Object Free Area (TLOFA) of 79 feet, centered along the taxiway centerline. If this parallel taxiway leads directly to the STOL parking positions, then the minimum field width under current FAA regulations would be 339.5+S feet, or $340+S$ feet when rounded, instead of $109+S$, where S is the parking lot side length. This would be the minimum width

required from security fence to security fence around an STOLPort under current FAA regulations. I do believe that for STOL and SSTOL ports and STOLPorts, the runway/taxiway separation could be reduced due to the low landing and takeoff speeds of the vehicles, but I do not believe it would be to the magnitude to which the authors have stated for this first concept.

Bearing in mind that Robinson et al. recognized the need to reduce the width of the RSA, there exists a misunderstanding of what the RSA is developed for. The RSA is developed to provide an area outside of the paved runway area to prevent damage to an aircraft in the event of an undershoot, overshoot, or excursion from the Runway (FAA, 2024). This statement implies a scenario in which an aircraft has made contact with the ground outside of the paved surface, either prior to the landing threshold, beyond the runway end threshold, or beyond the runway width. Robinson, Sokollek, Justin, and Mavris' formula for "R" implies they have only considered scenarios in which an aircraft is airborne, leading to improper RSA width calculations.

Concept two maintains the formula for STOLPort length, but removes the taxiway component of the concept, leaving just the parking apron, resulting in the authors' formulating a STOLPort width of *60+S.* As with the first concept, the authors have neglected to include a few key FAA safety areas and pavement-area separations. Additionally, for this concept, a taxilane (a taxiway located on an apron) is still required and has the same required Taxiway Object Free Area (TOFA) width, or at a minimum, requires the minimum wingtip-to-fixed or movable object clearance from the wingtip of the widest expected aircraft to utilize the facility to the tail of the longest expected aircraft to utilize the facility. The authors have attempted to circumvent this by stating that aircraft would utilize the runway to taxi to the proper parking position. This thought poses many operational challenges, the most adverse being the time for an aircraft to taxi from one taxiway connector to the next. Additional operational challenges would be the event that an aircraft located in the center of the apron needs to depart, but is surrounded by other aircraft in their parking positions, requiring this aircraft to sit and wait until the other aircraft depart first. This alone negates the possibility of this concept becoming a reality. Additionally, for ADG I aircraft, the taxilane centerline to a fixed or movable object is 39.5 feet. With a required taxilane width of 25 feet, assuming the 9-passenger Electra EL9 aircraft could have a length of 40 feet,

with a minimum standoff from aircraft to building of 25 feet (which is likely to be expanded due to the intense heat produced from all-electric vehicle fires), the parking apron alone would require a width of 104.5 feet, and still require the same runway centerline to taxiway centerline separation. This concept, in my opinion, is not possible, as a taxilane is still required on an apron to allow safe taxiing of aircraft behind parking stands.

The third concept that Robinson et al. develop, which is unlikely to be a viable option due to its oversimplified design, is an STOLPort located on a barge in a downtown body of water. This concept provides some interesting advantages. The runway in this scenario could be reoriented in such a manner as to leave no obstructions in the approach or departure paths, depending on the direction of the body of water and the direction of the prevailing wind. It is very possible that a runway could be located on a barge, or, as demonstrated by the Electra EL2, on a pier, with parking stands being located on shore. However, the concept presented in the illustration of the paper shows a barge that is simply a runway, and a few parking stands to the side of this runway. A major concern with this is that the FAA does not, and is not likely to, allow parking stands directly adjacent to a runway, even for eSTOL and SSTOL operations, as it creates a risk of damage to persons and property in the case of a runway incursion/excursion. eSTOL and SSTOL aircraft are often light, making them more subject to sudden changes in altitude, pitch, roll, and yaw due to sudden wind direction changes, making a runway excursion possible.

Chapter 3 - Methodology

Part A – STOLPort Design Using Current FAA Design Procedures

All current FAA design guidelines and standards are found in the FAA-published Advisory Circulars as well as in Title 14 of the CFRs. In designing a new airport, or in this case, a STOLPort, there is a specific, sequential process by which the design must proceed for the horizontal infrastructure of the STOLPort.

Establishing the design aircraft and determining this aircraft's approach speed

For STOLPorts that are designed to facilitate the arrival and departure of eSTOL aircraft, the Electra Aero EL9 will serve as the critical aircraft, as it is the largest eSTOL aircraft currently in

development at the time of the writing of this paper, and shall serve as the design critical aircraft. According to Electra Aero, the EL9 is expected to have an MTOW of 12,250 lbs. (Electra Aero, 2026), qualifying it as a "small aircraft" (FAA,2005), as well as an approach speed of approximately 35 knots. (Electra Aero, 2026)

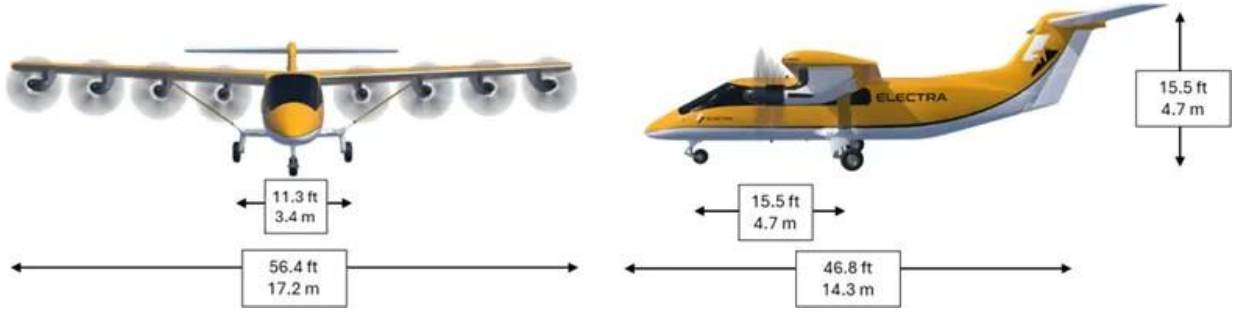


Figure 4: Electra Aero EL9 Dimensions

Determining the Minimum Runway Length

The EL9, as established above, has an MTOW of 12,250 lbs. and an approach speed of 35 knots. Runway Length can then be determined from AC 150/5325-4B, Runway Length Requirements. Table 1-1 from this AC provides the location of the design guidelines for our design aircraft. This table directs to Chapter 2, Paragraph 204. Per this design guidance, the required runway length for the Electra EL9 is 800 feet at mean sea level.

Determining the Aircraft Design Group (ADG) and Aircraft Approach Category (AAC) of the Design Aircraft. This will provide the Runway Design Code (RDC)

The Aircraft Design Group is determined from Table 1-2 in AC 150/5300-13B, and the AAC is determined from Table 1-1 from the same AC. Electra Aero has confirmed that the design wingspan for the EL9 is 56.4 feet and has a tail height of 15.5 feet, which is shown in Figure 1 (Electra Aero, 2026).

While the tail height of the aircraft falls within ADG I, the wingspan dictates an ADG of Group II. Additionally, with an approach speed of much less than 91 knots, the AAC of the EL9 is expected to fall within approach category A. These two categories, coupled with the MTOW, give the RDC of A/B-II – Small Aircraft.

AAC	V_{REF}/Approach Speed
A	Approach speed less than 91 knots
B	Approach speed 91 knots or more but less than 121 knots
C	Approach speed 121 knots or more but less than 141 knots
D	Approach speed 141 knots or more but less than 166 knots
E	Approach speed 166 knots or more

Figure 5: Table 1-1 from AC 150/5300-13B-Change 1

Group #	Tail Height	Wingspan
I	< 20 ft (< 6.1 m)	< 49 ft (< 14.9 m)
II	20 ft to < 30 ft (6.1 m to < 9.1 m)	49 ft to < 79 ft (14.9 m to < 24.1 m)
III	30 ft to < 45 ft (9.1 m to < 13.7 m)	79 ft to < 118 ft (24.1 m to < 36.0 m)
IV	45 ft to < 60 ft (13.7 m to < 18.3 m)	118 ft to < 171 ft (36.0 m to < 52.1 m)
V	60 ft to < 66 ft (18.3 m to < 20.1 m)	171 ft to < 214 ft (52.1 m to < 65.2 m)
VI	66 ft to < 80 ft (20.1 m to < 24.4 m)	214 ft to < 262 ft (65.2 m to < 79.9 m)

Figure 6: Table 1-2 from AC 150/5300-13B-Change 1

Using the ADG to find the applicable Runway Design Standards Table in Appendix G of AC 150/5300-13B.

In the previous section, the RDC was established as A/B-II Small Aircraft. Appendix G of AC 150/5300-13B provides the Runway Design Standards Matrix table. For A-I1, in particular, an A-I1 weighing less than 12,500 lbs. leads to the use of Table G-3 for RDC A/B-I1 Small Aircraft due to the Maximum Takeoff Weight (MTOW) of the EL9 expected to be 12,250 lbs. This table will provide the runway width, dimensions of the RSA, ROFA, RPZ, and runway-to-taxiway centerline separation.

Using the table in Figure 4 below, the runway, along with the RSA, ROFA, and RPZ, are able to be designed. 75 feet in width. The RSA has a total width of 150 feet, centered along the runway

centerline, and a length that extends 300 feet beyond each threshold end. The RPZ begins 200 feet beyond the runway threshold and extends 1,000 feet. The inner width is 250 feet, and the outer width is 450 feet.

Although the land within an RPZ is not required to be owned by the STOLPort owner/sponsor, there are land-use restrictions of the RPZ that must be controlled through either land ownership, land zoning restrictions, or establishment of an avigation easement (FAA, 2022). When planning for a new STOLPort using existing airport design guidance from AC 150/5190-4B (FAA,2022), the land-use activities that are generally prohibited from being located within the RPZ are:

1. Residential uses, which include single-family homes, multi-family dwellings, and short-term living facilities (such as hotels and condominiums). Residential structures can be placed on the outer edge of the RPZ, as long as they do not encroach on the Part 77 approach surface.
2. Commercial Uses, which involve the sale of products or services for profit. Commercial uses are "specifically discouraged" within the RPZ.
3. Industrial Uses, which involve material processing, assembly, manufacturing, and storage of finished products. Industrial uses are "specifically discouraged" within the RPZ.
4. Institutional Uses, which include educational facilities (preschool through college), health care facilities (hospitals, clinics, nursing homes, assisted living facilities, etc.), and religious assemblies (churches, tabernacles, mosques).

The main reasons for excluding these land uses are the higher density of people who tend to congregate in these areas, as well as the tendency for these activities to attract wildlife.
There are land uses that can generally be allowed within RPZ areas. According to AC 150/5190-4B, these uses include"

1. Infrastructure/Utilities/Energy Production Uses. One item of concern about this land use is the construction of towers of any kind (water towers, cellular communication towers, power transmission towers, etc.) that could penetrate the Part 77 Approach Surface or attract wildlife. Additionally, if roadways or walking paths (sidewalks, park trails, etc.) are located within the RPZ, signage should be installed to not allow stopping and/or

standing within the RPZ area. Roadway usage should ideally be limited to low-volume traffic.

2. Agriculture and open spaces, most commonly used for farming, are generally allowed, as long as property wildlife management practices are used.

The last land use mentioned in the AC is Parks and Recreation/Entertainment Uses, including Sports Arenas, which includes both allowable and discouraged land use compatibility. Generally, open parks can be allowable if certain measures are taken, such as ensuring lighting does not interfere with approach lighting or create visual challenges for pilots, and no areas of stopping are within the RPZ (picnic areas, playgrounds, etc.). Land uses specifically mentioned as not being compatible within the RPZ are golf courses, sports arenas, aquatics centers, skating rinks, and health clubs.

Table G-3. Runway Design Standards Matrix, A/B–II Small Aircraft

Aircraft Approach Category (AAC) and Airplane Design Group (ADG):		A/B – II Small Aircraft			
ITEM	DIM [1]	VISIBILITY MINIMUMS			
		Visual	Not Lower than 1 mile	Not Lower than 3/4 mile	Lower than 3/4 mile
RUNWAY DESIGN					
Runway Length	A	*Refer to paragraphs 3.3 and 3.7.1*			
Runway Width	B	75 ft	75 ft	75 ft	100 ft
Shoulder Width		10 ft	10 ft	10 ft	10 ft
Blast Pad Width		95 ft	95 ft	95 ft	120 ft
Blast Pad Length		150 ft	150 ft	150 ft	150 ft
Crosswind Component		13 knots	13 knots	13 knots	13 knots
RUNWAY PROTECTION					
Runway Safety Area (RSA)					
Length beyond departure end [9, 10]	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	C	150 ft	150 ft	150 ft	300 ft
Runway Object Free Area (ROFA)					
Length beyond runway end	R	300 ft	300 ft	300 ft	600 ft
Length prior to threshold	P	300 ft	300 ft	300 ft	600 ft
Width	Q	500 ft	500 ft	500 ft	800 ft
Obstacle Free Zone (OFZ)					
Runway, Inner-approach, Inner-Transitional		*Refer to paragraph 3.11*			
Precision Obstacle Free Zone (POFZ)					
Length		N/A	N/A	N/A	200 ft
Width		N/A	N/A	N/A	800 ft
Approach Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,700 ft	2,500 ft
Inner Width	U	250 ft	250 ft	1,000 ft	1,000 ft
Outer Width	V	450 ft	450 ft	1,510 ft	1,750 ft
Departure Runway Protection Zone (RPZ)					
Length	L	1,000 ft	1,000 ft	1,000 ft	1,000 ft
Inner Width	U	250 ft	250 ft	500 ft	500 ft
Outer Width	V	450 ft	450 ft	700 ft	700 ft
RUNWAY SEPARATION					
Runway centerline to:					
Parallel runway centerline	H	*Refer to paragraph 3.9*			
Holding Position		125 ft	125 ft	125 ft	175 ft
Parallel taxiway/taxilane centerline [2, 4]	D	240 ft	240 ft	240 ft	300 ft
Aircraft parking area	G	*Refer to paragraph 3*			
Helicopter touchdown pad		*Refer to AC 150/5390-2*			

Figure 7: Table G-3 From AC 150/5300-13B

Determining the critical aircraft's Taxiway Design Group (TDG)

Table 1-4 in AC 150/5300-13B uses the critical aircraft's Cockpit to Main Gear distance (CMG), as well as the Main Gear Width (MGW), to determine the TDG. For small aircraft, where the

aircraft cockpit sits aft of the nose gear, use the aircraft's wheelbase (measured as the distance from the center of the nose gear to the center of the main gear) instead of the CMG (FAA, 2005). For the Electra Aero EL9, the CMG distance (or wheelbase) is 15.5 feet, and the MGW is 11.3 feet (See Figure 7 above). These dimensions place the EL9 in TDG 1A.

Table 1-4. TDG Table

	TDG (feet)							
	1A	**1B**	**2A**	**2B**	**3**	**4**	**5**	**6**
CMG	0 to ≤ 20	> 20 to ≤ 40	0 to ≤ 40	> 40 to ≤ 65	0 to ≤ 65	> 65 to ≤ 100	0 to ≤ 100	> 100 to ≤ 125
MGW	0 to ≤ 15	0 to ≤ 15	> 15 to ≤ 20	0 to ≤ 20	> 20 to ≤ 30	0 to ≤ 30	> 30 to ≤ 47	0 to ≤ 47

Figure 8: Table 1-4 from AC 150/5300-13B

Using the TDG to determine all geometric design standards for all taxiways.

Once the TDG is determined as 1A, Table J-1 (Shown in Figure 9 below) in Appendix J of AC 150/5300-13B provides the geometric information for fillet design of a taxiway turn and/or intersection. Additionally, Table 4-2 from the same AC provides the Taxiway width, Taxiway Way Edge Safety Margin (TESM), and Taxiway Shoulder Width (both paved and unpaved),

Table J-1. Taxiway Intersection Dimensions for TDG 1A

Dimension (see note)	Δ (degrees)						
	30	45	60	90	120	135	150
W-0 (ft)	12.5	12.5	12.5	12.5	12.5	12.5	12.5
W-1 (ft) *	17	19	21	21	22	23	24
W-2 (ft) *	17	19	21	21	22	23	24
L-1 (ft) *	40	47	53	52	55	56	57
L-2 (ft) *	0	0	0	0	0	0	0
L-3 (ft) *	5	8	12	21	38	55	87
R-Fillet (ft)	0	0	0	0	0	0	0
R-CL (ft)	50	50	50	19	23	24	24
R-Outer (ft)	62.5	62.5	62.5	31.5	35.5	36.5	36.5

Figure 9: Table J-1 from AC 150/5300-13B

Determining the TSA, TOFA, TLOFA, Taxiway, and Taxilane Separation requirements.

Using the previously established ADG, Table 4-1 (shown in Figure 10 below) from AC 150/5300-3B provides the minimum dimensions for the TSA, TOFA, TLOFA, separation distances, and wingtip clearances.

Table 4-1. Design Standards Based on Airplane Design Group (ADG)

Item	ADG					
	I	II	III	IV	V	VI
Taxiway and Taxilane Protection						
TSA (maximum ADG wingspan)	49 ft (14.9 m)	79 ft (24.1 m)	118 ft (36.0 m)	171 ft (52.1 m)	214 ft (65.2 m)	262 ft (79.9 m)
TOFA [2]	89 ft (27.1 m)	124 ft (37.8 m)	171 ft (52.1 m)	243 ft (74.1 m)	285 ft (86.9 m)	335 ft (102.1 m)
TLOFA [2]	79 ft (24.1 m)	110 ft (33.5 m)	158 ft (48.2 m)	224 ft (68.3 m)	270 ft (82.3 m)	322 ft (98.1 m)
Taxiway and Taxilane Separation						
Taxiway centerline to parallel taxiway centerline [1]	70 ft (21.3 m)	101.5 ft (30.9 m)	144.5 ft (44.0 m)	207 ft (63.1 m)	249.5 ft (76.1 m)	298.5 ft (91.0 m)
Taxiway centerline to fixed or movable object [2]	44.5 ft (13.6 m)	62 ft (18.9 m)	85.5 ft (26.1 m)	121.5 ft (37.0 m)	142.5 ft (43.4 m)	167.5 ft (51.1 m)
Taxilane centerline to parallel taxilane centerline [1]	64 ft (19.5 m)	94.5 ft (28.8 m)	138 ft (42.1 m)	197.5 ft (60.2 m)	242 ft (73.8 m)	292 ft (89.0 m)
Taxilane centerline to fixed or movable object [2]	39.5 ft (12.0 m)	55 ft (16.8 m)	79 ft (24.1 m)	112 ft (34.1 m)	135 ft (41.1 m)	161 ft (49.1 m)
Wingtip Clearance						
Taxiway wingtip clearance	20 ft (6.1 m)	22.5 ft (6.9 m)	26.5 ft (8.1 m)	36 ft (11.0 m)	35.5 ft (10.8 m)	36.5 ft (11.1 m)
Taxilane wingtip clearance	15 ft (4.6 m)	15.5 ft (4.7 m)	20 ft (6.1 m)	26.5 ft (8.1 m)	28 ft (8.5 m)	30 ft (9.1 m)

Figure 10: Table 4-1 from AC 150/5300-13B

Determining Apron Location and Minimum Depth

The location of the apron can vary on any STOLPort, but most will likely place it along the center of the airfield, so that both runway ends are an equal distance from the apron. Most aprons will have a designated and marked taxilane along the edge, running parallel to the taxiway (if one exists). The location of this taxilane marking is determined from the step above with the taxiway-to-taxilane centerline separation requirements. With this centerline location determined, the taxilane width shall equal the taxiway width per the critical aircraft TDG.

The next step in determining the apron depth is to place the critical aircraft at a proposed parking location. This parking location shall keep all parts of the parked aircraft outside of the TLOFA of the apron taxilane. As an additional safety measure, it will be verified that an EL9 taxiing behind a parked EL9 does not encroach on the minimum wingtip clearances. In most cases, it is best

practice to maintain 15 to 30 feet between the aircraft nose and the building to maintain adequate area for ground support vehicle maneuvering (FAA,1988). For the purposes of this paper, it is assumed that the minimum of 20 feet will be sufficient.

Part B

To determine the minimum horizontal infrastructure required for the safe operation of an eSTOL aircraft, such as the EL9, the design process shall follow a more performance-based criterion. AC 150/5325-4B, Runway Length Requirements, groups small airplanes (those that have an MTOW of 12,500 lbs. or less) together by approach speed (FAA, 2005). With an approach speed of 35 knots, the EL9 is expected to require a much shorter runway than what is required for a small airplane with an approach speed of at least 30 knots, but less than 50 knots (FAA, 2005). To determine this runway length, one can calculate the minimum takeoff field length and the minimum landing distance based on the expected and theoretical performance data of the EL9. Additionally, with the slower approach speeds expected of eSTOL (slower than the "less than 50 knot" maximum for the category), it is reasonable to expect smaller RSA, ROFA, RPZ, runway centerline to taxiway centerline, TSA, TOFA, and taxiway to taxilane separation, as well.

The steps mentioned in this Part B will often differ from those mentioned in Part A of this chapter. Some airfield infrastructure components are likely to remain unchanged based solely on aircraft performance, such as required apron depth. Others, however, will likely change.
The aircraft approach category V_{ref}/Approach speed for AAC A is 91 knots. With an expected approach speed of 35 knots, many of the safety areas meant for the safety of the flying public in the event of a runway excursion, either a veer off of the runway centerline or a runway overrun, the minimum runway safety areas and object-free areas are disproportionately large.

Determining the Minimum Runway Length

There are several methods for determining the minimum runway length. One of these methods is to calculate the minimum takeoff distance based on the performance of either your individual aircraft or the critical design aircraft. 14 CFR Part 25, §25.113, provides several scenarios for calculating takeoff distance and takeoff run, with more detail on these scenarios having been

mentioned in Chapter 2. Another method is to reference Airport Planning Manuals from the aircraft manufacturers, where available. Many aircraft manufacturers of large commercial jetliners will publish an airport planning manual for each type, or group of similarly performing aircraft. In this manual, the manufacturer will provide a runway length requirement chart that provides the runway length requirements for varying expected gross weight (which may be restricted due to pavement strengths), airport elevation, and sometimes maximum air temperature.

During an interview with Electra Aero, they were unable to share takeoff and landing roll calculations, as it contains proprietary information that remains confidential, but claims on Electra Aero's website state that the EL9 will have a takeoff and landing roll distance of 150 feet (Electra Aero, 2026). With this distance known, an important piece of information remains unknown at the time of writing this paper. Without knowing the exact approach and departure angles of the EL9, calculating a runway distance with any level of confidence would prove difficult, as a wide range of estimated approach and departure angles would greatly affect this distance, leading to a large degree of variation in runway length determinations. The questions asked and answers provided during the interview with Electra Aero are provided in Appendix A.

In their paper, Feasibility Study of Short Takeoff and Landing Urban Air Mobility Vehicles using Geometric Programming, Courtin, Burton, Butler, Yu, Vascik, and Hansman conclude that a runway length of 300 feet is a "conservative" length, with runway lengths of 100-300 feet being possible (Courtin et al., 2018). For the purposes of this paper, a runway length of 300 feet shall prove sufficient not only for the EL9, but other eSTOL, STOL, and SSTOL vehicles as well. With a total takeoff ground roll of 150 ft and a remaining runway length of 150 ft, this allows a departure angle of 15° to clear a 35 ft obstacle as outlined in 14 CFR Part 25, §25.113.

Determining the Minimum Runway Width

Per AC 150/5300-13B, the runway width accommodates "performance needs during landing and takeoff operations, taking into account various weather and surface conditions." Small aircraft are generally more affected by crosswind than large aircraft, as indicated by Table B-1 in AC 150/5300-13B, shown below.

RDC	Allowable Crosswind Component
A-I and B-I *	10.5 knots
A-II and B-II	13 knots
A-III, B-III, C-I through D-III D-I through D-III	16 knots
A-IV and B-IV, C-IV through C-VI, D-IV through D-VI	20 knots
E-I through E-VI	20 knots

Note: * Includes A-I and B-I small aircraft.

Figure 11: Table B-1 from AC150/5300-13B

The runway should provide adequate width to protect for an off-centerline landing as well as crosswind to affect the pilot's ability to hold the centerline during the takeoff roll. The EL9 will have a MGW of 11.3 feet. A runway width of 50 feet will provide a factor of safety of 4.4X for an off-centerline landing, which, when also taking into consideration the slow approach speeds of the EL9, provides sufficient space for the aircraft to recover back to centerline while providing ample safety buffer to prevent damage to the aircraft and injury to its occupants.

Determining the Minimum Runway Safety Areas and Object Free Areas

The three runway safety areas that will be under consideration for space reduction compared to the FAA Design requirements are the RSA, ROFA, and the RPZ.

RSA Dimension Determination

According to AC 150/5300-13B, the RSA is to provide a prepared surface for reducing the risk of damage to an aircraft in the case of an undershoot, overshoot, or runway excursion (FAA, 2022). Current FAA standards state that for RDC A/B-1, the width of the runway safety area is 120 feet, with the RSA extending 240 feet beyond each runway end, or threshold. As stated previously in this paper, the RDC is developed by grouping similarly sized aircraft of similar performance criteria. For A/B-II aircraft, ADG II is an aircraft with a wingspan of 49 feet to less than 79 feet, and a tail height of 20 feet to less than 30 feet, and the AAC is an aircraft with an

approach speed of less than 121 knots. Although the EL9 would fall under strictly an AAC A, the runway design standards in Appendix G of AC 150/5300-13B group AAC A and B together.

An inquiry was sent to the FAA Office of Airports Safety and Standards, Airports Design and Construction Branch regarding the formulation of current RSA dimensions. According to the FAA, the exact formulation of these dimensions is no longer known. It is likely that the ultimate determinations were a result of analysis of aircraft accidents and runway excursions, and that no mathematical formula exists.

In lieu of the lack of a mathematical formula, initial RSA width for STOLPorts will likely be determined based on possible aircraft incident scenarios. To first establish this, a real-world aircraft incident would have to be predicted. For the purposes of this paper, the incident that will be analyzed is an eSTOL on approach with flap and slat failure, resulting in a higher-than-nominal approach speed of 40 knots. Secondly, upon touchdown, a main gear tire will experience a failure, resulting in a 15° departure from the runway heading (in either direction). Lastly, due to the main gear tire failure, brake failure has also occurred, and reverse thrust is not available, resulting in the brakes locking, causing the vehicle to slide on a wet surface.

The departure angle from the runway centerline is determined by analyzing crash data from a 2025 report published by the International Air Transport Association (IATA) that lists Runway excursions from 2019 through 2024 (IATA, 2025). All accidents listed as having an excursion type of “veer off” were analyzed, and the accident sketches were used to calculate the aircraft angle of deviation from the “point of veer” or “point of deviation”. In the 10 accidents listed, none of them exceeded 11.3° of deviation. Allowing for a factor of safety and error, and rounding to the nearest 5°, a deviation angle of 15° will be used.

For the purposes of this paper, equations from the Fifteenth Edition of the Civil Engineering Reference Manual (CERM) will be utilized (Lindeburg, 2015). This equation is used to calculate the braking and skidding distance of a vehicle on an incline/decline.

This distance of on-pavement skid can be determined through basic trigonometry: the vehicle that begins a 15° departure from runway heading on a 50-foot-wide runway on the centerline will travel approximately 96.6 feet longitudinally before it reaches the edge of the pavement. Equation 75.25 from the CERM (Lindeburg, 2015) can provide the final velocity of the EL9 at the point it reaches the edge of the pavement. This equation is;

$$s_b = \frac{v_1^2 - v_2^2}{30(f + G)}$$

Where:

s_b= braking distance = 60 feet

v_1 = Initial Speed = 46 mph (40 knots)1217.16

v_2 = Final Speed

f = coefficient of friction = 0.42* for wet pavements at 40 mph on a grooved runway surface (AC 150/5320-12C, 1997)

G = grade = negligible on a level runway with a 1-1.5% cross slope = 0%

*AC 150/5320-12C states *"Since wet pavement always yields the lowest friction measurements, CFME should routinely be used on wet pavement which gives the "worst case" condition."* 0.42 represents the lowest, worst-case scenario for the minimum acceptable coefficient of friction for a wet, grooved runway.

At the end of 96.6 feet, the vehicle will be traveling at approximately 30 mph upon reaching the edge of the pavement. Once off the pavement, the coefficient of friction will become significantly less. Through exhaustive online and published research, there are no reliable sources for the coefficient of friction between a rubber tire and grass in a skid. For the purposes of this paper, the coefficient of friction for grass surfaces will be considered half of the lowest friction value for 'Maintenance Planning' in Table 3-2 of AC 150/5320-12C.

Knowing the final speed of the vehicle shall be 0.00 mph, a gradient of approximately 1% downward (average of 3% cross slope traversed at a 15° angle, rounded to the nearest whole percent) leads to an additional traveled length of 142.6 feet. The total braking/skidding distance for the EL9 in this theoretical emergency situation is approximately 239.5 feet, traveled at 15° of runway heading. This translates to a distance of 62 feet perpendicular to the runway centerline and 231.4 feet parallel to the runway centerline. For this theoretical STOLPort based on aircraft

performance, a 20% factor of safety will be added to account for an off-centerline landing, and rounding up to the nearest 5-foot increment. The RSA width from the centerline shall be 75 feet.

For RSA distance beyond the threshold, the crash scenario shall be that of an aircraft touching down on the runway pavement at midfield (150 feet beyond threshold) on a wet, grooved runway pavement. Additionally, anti-lock brake failure has caused all tires to skid. Using the above formula, this aircraft would be traveling at a speed of 15 mph at the end of the runway, at which time it would skid an additional 35 feet.

ROFA Dimension Determination

The ROFA is defined as a clear area limited to equipment necessary for air and ground navigation and provides wingtip protection in the event of an aircraft excursion from the runway (FAA, 2024). IF calculating the ROFA for the EL9, the distance will be the RSA width plus ½ of the wingspan of the EL9. This distance from the runway centerline is 113.2 feet. Rounding to the nearest 5-foot increment results in a ROFA distance from centerline of 115 feet.

RPZ Dimension Determination

Per AC 150/5300-13B, the RPZ is a “protection zone that serves to enhance the protection of people and property on the ground.” There are two RPZs: the approach RPZ and the departure RPZ. The ultimate dimensions of the approach RPZ are determined by the design aircraft approach category. For both A/B-I Small Aircraft and A/B-II Small Aircraft, the RPZ dimensions are the same (FAA, 2024). With maximum approach speeds for AAC B of up to, but not including, 121 knots, it is expected that the overall length of the RPZ can be reduced as a function of the EL9 having an approach speed of approximately 30% of the maximum allowable in the category. With the RPZ length being determined by the aircraft approach category, which is a function of approach speed, it can be safely assumed that the RPZ can be reduced from 1,000 feet to 500 feet. Additionally, with the reduced RSA and ROFA distance beyond the runway end, the RPZ shall begin at the limits of these safety areas.

Determining the Minimum Runway to Taxiway Separation

To find the minimum safe runway centerline to taxiway centerline separation distance, there will be two calculations performed. The first is to determine the distance from the runway centerline to the runway holding position located on the connector taxiway, and the second will be to simply add the distance required for the aircraft to position itself completely perpendicular to the runway centerline so that the pilot in command can safely see both approach and departure paths. In determining if current FAA guidance on runway centerline-to-holding-position separation requirements could be reduced, the dimensions of the inner-transitional object-free area (IT-OFZ) should be determined for eSTOL aircraft. The IT-OFZ slopes 3 (horizontal) to 1 (vertical) out from the edges of the ROFZ and IA-OFZ to a height of 150 feet (46 m) above the established airport elevation. (FAA, 2024).

For runways serving small aircraft with approach speeds less than 50 knots, the ROFZ is 120 feet in width, centered on the runway centerline, with an elevation at the highest point of that runway. Additionally, this ROFZ extends 200 feet beyond each runway end (FAA, 2024). Extending from this width (60 feet from the centerline), the distance required for the IT-OFZ to clear a 15.5-foot aircraft tail height at a rate of 3H:1V would be approximately 46.5 additional feet, bringing the total distance from the runway centerline to approximately 106.5 feet. Providing 10% factor of safety and rounding this number up to the next 10-foot increment provides a separation distance of 120 feet.

Minimum Taxiway Widths and Safety Area Dimension Determination

eSTOL aircraft will taxi much like traditionally powered fixed-wing aircraft. The landing gear configuration of most eSTOL, including the EL9, is expected to be a traditional tricycle configuration, leading to turning movements similar to those of other tricycle gear aircraft in this ADG/TDG category. It is recommended to adopt the current FAA design guidance for taxiway widths and turn geometry. The TSA is equal to the maximum wingspan of the design aircraft ADG. With the EL9 expected to be the first eSTOL in production, as well as the largest eSTOL currently in design, the wingspan of the EL9 will serve as the TSA dimension.

AC 150/5300-13B allows for a reduction of the stated TOFA in Table 4-1. This calculation can be found in Appendix J, section J.4.3 (FAA, 2024). Using the example in this calculation and information in Table J-9, the TOFA can be calculated to be:

$$\frac{1}{2}\,TOFA = \frac{1}{2}\,wingspan + allowable\ lateral\ deviation + safety\ buffer$$
$$= 28.2ft + 7.5ft + 15ft = 50.7ft.$$

Likewise, the TLOFA can be determined to be, using information from Table J-10:

$$\frac{1}{2}\,TLOFA = \frac{1}{2}\,wingspan + allowable\ lateral\ deviation + safety\ buffer$$
$$= 28.2ft + 5ft + 10.5ft = 43.7ft.$$

Minimum Taxiway Centerline to Parallel Taxilane Centerline Separation and Apron Location

The minimum offset of the taxiway centerline to a parallel taxilane centerline is determined by the maximum wingspan of the design aircraft and a wingtip clearance. Using the EL9, this separation distance will be 2 times half of the wingspan, plus the FAA-recommended taxiway wingtip clearance. This results in a taxiway centerline to parallel taxilane centerline separation of 76.4 feet.

It is possible that the apron would be co-located along the parallel taxiway. However, the FAA does not allow direct Runway-to-Apron access via a straight taxiway connector. With a runway length of just 300 feet, it is likely that an apron area would be 300 feet wide. IF serving only the Electra Aero EL9, a 300 foot wide apron would be able to park 5 aircraft with a 15-foot wingtip clearance between aircraft. To allow for more parking stand locations, a central taxilane connector from the parallel taxiway to the apron will be included.

Chapter 4 - Results

Part A

The first step in determining the size of the STOLPort is to determine the design, or critical, aircraft. The process for determining the critical aircraft for purposes of runway length

determination can be found in section 3.2 of AC 150/5000-17 (FAA, 2017). Subparagraph 3.2.1 states, “Choose the single aircraft, or grouping of aircraft with similar operational requirements, that have the longest runway length requirement that makes regular use of the runway (FAA, 2017). Using this selection criterion, the largest known eSTOL currently in development that is known to this author is the Electra Aero EL9, and it is likely to require the longest runway length.

A review of AC 150/5325-4B (or the latest version) shows that the two pieces of information needed for runway length determination are the aircraft’s approach speed as well as the Maximum Takeoff Weight (MTOW). Electra Aero was able to provide this information during the interview (Electra Aero Interview, 2026) and stated that the expected approach speed of the EL9 is 35 knots, with an MTOW of 12,250 lbs. With this data, AC 150/5325-4B, Chapter 2, Section 204 becomes the applicable design criteria. This section states that for aircraft weighing less than 12,500 lbs. and an approach speed of more than 30 knots but less than 50 knots, there is a required minimum runway length of 800 feet at mean sea level, increasing in length by 0.08 feet for every foot above sea level, so a runway in an area that has an elevation of 1,000 feet above sea level would have a required runway length of 880 feet.

The second step in the design process is determining the minimum runway width, which can be found in AC 150/5370-13B-Change 1 (or the most recent version), Chapter 3, and Appendix G. The runway design criteria are based upon a Runway Design Code (RDC). The first element is the Aircraft Approach Category. 14 CFR Part 97, Section 97.3, as well as Table 1-1, is AC 150/5300-13B, which provides the criteria for the determination of aircraft approach category based on approach speed. The second part of the RDC, the Aircraft Design Group (ADG), is shown in Table 1-2 of AC 150/5300-13B. Tables 1-1 and 1-2 from AC 150/5300-13B are shown below.

As mentioned in Chapter 3, the expected approach speed of the EL9 is 35 knots, indicating an AAC Category A. It is also expected that the EL9 will have a tail height of 15.5 feet and a wingspan of 56.4 feet, which indicates an ADG of Group II. A third, and special element of the RDC for A/B-I or A/B-II is the additional criteria for “small aircraft”. To be able to have “small

aircraft" as part of the RDC, the critical aircraft must have an MTOW of 12,500 lbs. or less (FAA, 2024). With an expected MTOW of 12,250 lbs., the EL9 qualifies as a "small aircraft". Additionally, with a MGW of 11.3 feet and a CMG of 15.5 feet, the EL9 falls within TDG 1A.

Based on these determinations, the STOLPort dimensions can be summarized in Table 2, below.

Table 2: Part A - FAA Design Guidance Geometric Layout

Dimension	Item	Measurement
A	Runway Length (at MSL)	800 ft
B	Runway Width	75 ft
C	RSA Width	150 ft
D	RSA Length Beyond Threshold	300 ft
E	ROFA Width	500 ft
F	ROFA Length Beyond Threshold	300 ft
G	RPZ Length	1,000 ft
H	RPZ Inner Width	250 ft
I	RPZ Outer Width	450 ft
J	Runway Centerline to Parallel Taxiway Separation	240 ft
K	Taxiway Width	25 ft
L	TSA Width	79 ft
M	TOFA Width	124 ft
N	1/2 TLOFA Width	110 ft
O	Taxiway Centerline to Parallel Taxilane Centerline	94.5 ft

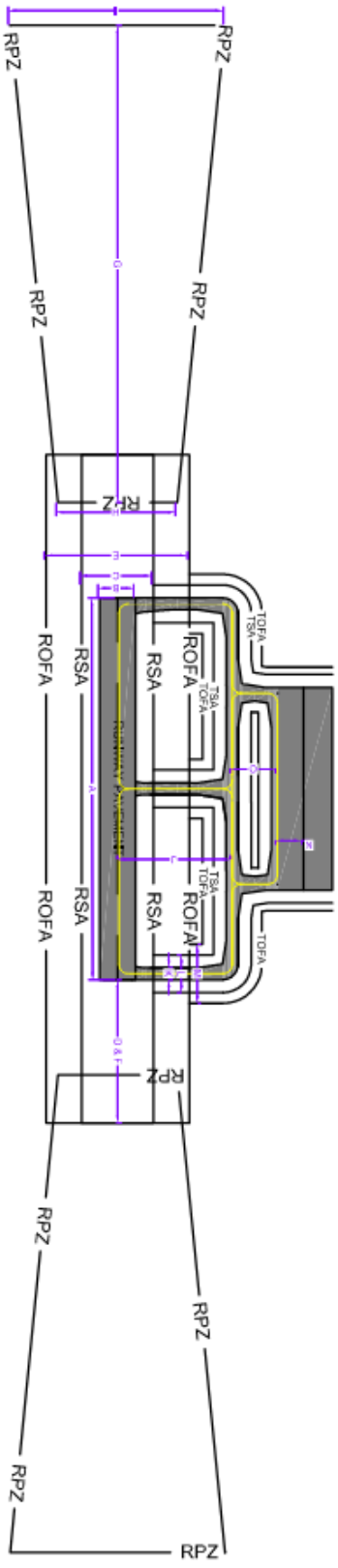


Figure 12: STOLPort Layout - Part A

Based upon this layout, a total of 29.32 acres would need to be dedicated to accommodate a STOLPort in urban and suburban areas. This requirement would prove highly restrictive in finding a suitable site within a reasonable distance to urban areas, but also highly cost-restrictive in not only land cost, but overall infrastructure cost.

Part B

The performance-based designed STOLPort resulted in significantly reduced geometry compared to the current FAA design guidance geometry. With a runway reduced in size from 800 feet in length and 75 feet in width to 300 feet in length and 50 feet in width, this provides a land area reduction of just over 1 acre, alone. Table 3 below summarizes the findings and design parameters established in Chapter 3, Part B above.

Table 3: Part B - Performance-Based Design Geometric Layout

Dimension	Item	Measurement
A	Runway Length (at MSL)	300 ft
B	Runway Width	50 ft
C	RSA Width	150 ft
D	RSA Length Beyond Threshold	35 ft
E	ROFA Width	210 ft
F	ROFA Length Beyond Threshold	35 ft
G	RPZ Length	500 ft
H	RPZ Inner Width	250 ft
I	RPZ Outer Width	450 ft
J	Runway Centerline to Parallel Taxiway Separation	120 ft
K	Taxiway Width	25 ft
L	TSA Width	56.4 ft
M	TOFA Width	101.4 ft
N	1/2 TLOFA Width	87.4 ft
O	Taxiway Centerline to Parallel Taxilane Centerline	76.4 ft

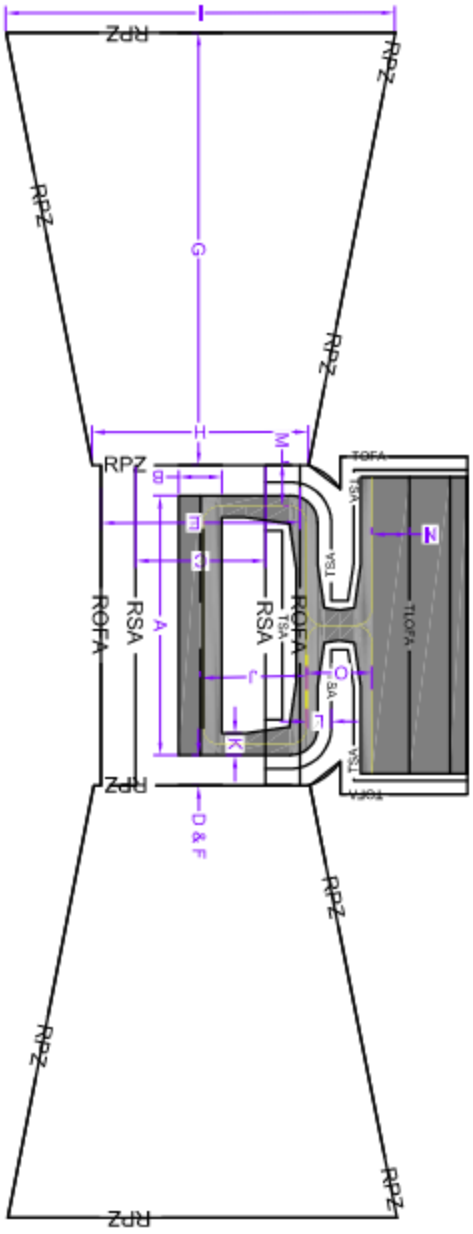


Figure 13: STOLPort Layout – Part B

Based on this layout, a total of 11.68 acres would need to be dedicated to accommodate a STOLPort in urban and suburban areas. While still not an insignificant land space, when compared to the layout shown in Part A of this chapter, it would prove conceivable for urban and, more likely, suburban areas.

Chapter 5 - Discussion

If it is to remain that the FAA will require, at a minimum, for STOLPorts to own all property within the RPZs and safety areas, mandating STOLPorts be designed to current FAA airport design criteria leads to a land space of 2.5 times greater than what is actually required for the safe, effective use of the Electra Aero EL9. Figure 14 below shows the performance-based STOLPort design (darker image) against the FAA-design criteria STOLPort (transparent image).

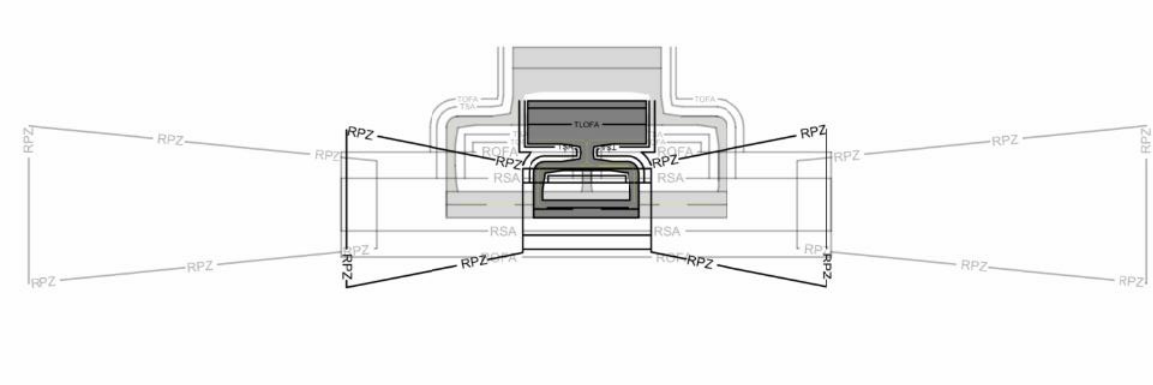


Figure 14: Performance-Based Design vs. FAA Criteria Design STOLPort

The FAA-design criteria STOLPort shows a minimum land area of approximately 29.32 acres. As mentioned in Chapter 4, this area would prove highly prohibitive to locating these facilities in urban areas, as well as in most suburban areas. In addition to the land space required, there is the additional cost of infrastructure. This design (FAA-criteria based) requires 17,350 square yards of paved surface, whereas the performance-based STOLPort would require only 7,995 square yards of paved surface.

In this author's nearly 12 years as an airport civil engineering designer and project manager, it has been determined that approximate land acquisition costs in the Southeast United States are

nearly $150,000 per acre in suburban areas, or areas closer to downtown centers, bearing in mind that this land cost varies greatly depending upon region and proximity to urban areas.. Additionally, to construct horizontal infrastructure, that is, land grading, paving, airfield lighting, and pavement striping, costs approximately $215.00 per square yard of paved area. This cost is heavily dependent upon pavement section thickness, pavement type, and cubic yards of grading required, and may vary widely. When associating these costs with the areas of land space and the area of pavement required for both Parts A and B, the breakdown is:

Part A				**Part B**			
Unit	Quantity	Cost per Unit	Total	Unit	Quantity	Cost per Unit	Total
Acre of Land	29.32	$150,000	$4,398,000	Acre of Land	11.68	$150,000	$1,752,000
Area of Pavement	17,350	$215	$3,730,250	Area of Pavement	7,995	$215	$1,718,925
TOTAL			$8,128,250	**TOTAL**			$3,470,925

As eSTOL evolves and new technology is developed, STOLPort design will likely change, much like airport design throughout the century. Further study will be needed once proprietary data becomes publicly available. This data could be used to determine a more refined required runway length, provide insight into the impact of runway length with elevation for eSTOL aircraft with blown-wing technology, and affect overall STOLPort design.

STOLPorts will also likely seek to go beyond land-based infrastructure as well, as Electra has demonstrated that their EL2 is capable of landing and taking off from a heliport located on a pier in downtown Manhattan, New York. For this to become a possibility, the FAA would need to either develop new guidance for runway/landing area safety areas for eSTOL aircraft, or some land-based infrastructure would be required for a parking area outside of the runway safety areas, either of which is possible and very advantageous for those metropolitan areas near bodies of water.

What is yet to be seen from eSTOL is how autonomous flight may impact the infrastructure. It could lead to additional infrastructure being required, as in autonomous flight, the FAA may require room for computational or AI error in takeoff and landing maneuvers, which would expand not only the required paved surfaces, but also their associated safety areas. It could also just as likely lead to a decrease in the safety areas, as autonomous flight technology may be able to more quickly and accurately react to atmospheric and weather changes during approach and departure, allowing safety areas to become smaller than what is calculated in this study.

STOLPort design guidance will eventually be published by the FAA. The recently distributed Draft AC 150/5390-4 has a placeholder for STOLPort Design in Appendix I of the AC. In this placeholder, the FAA states that they will release more guidance as data becomes more available (FAA, 2026). As STOLPorts are included in this draft AC, the FAA is accepting questions and comments until January 11, 2027. It is not known at the time whether the FAA will publish a separate advisory circular for STOLPort design, or if it will be published as an addendum to the draft AC 150/5390-4 in Appendix I. Much of the content of Part B of this paper will be submitted as comments to the draft AC for consideration.

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Appendix A - Interview with Electra Aero

1. **Question:** What is the design/ultimate MTOW of EL9? If an exact number cannot be shared, could you confirm if the EL9 will qualify as a "small aircraft" under current FAA guidance as an aircraft with a certified MTOW of less than 12,500 lbs.?

   Answer: 12,250lbs

2. **Question:** What are the dimensions of EL9? (wingtip to wingtip, length, tail height, wheelbase, etc.). If exact dimensions cannot be shared at this time, has an equivalent Aircraft Design Group been determined? Could you confirm that it would fall under ADG I for aircraft having a tail height of less than 20 feet and a wingspan of less than 49 feet?

   Answer: ADG II based on wingspan

3. **Question:** How is performance affected by ambient air temperature, and how does that differ from the effect of ambient air temperature on "normal" small airplanes?

   Answer: No answer was provided at the time of the interview.

4. **Question:** What is the departure angle? If not able to share exact data, can you confirm a departure angle of 10°-15°?

   Answer: No answer was provided at the time of the interview.

5. **Question:** Has Electra developed a Landing Runway Length table and/or chart for the EL9?

   Answer: This data is Work in Progress

6. **Question:** Will the EL9 have capabilities for a non-precision instrument approach, precision instrument approach, or visual approach only?

   Answer: The EL9 will be IFR-capable

7. **Question:** What is the approach angle?

   Answer: No answer was provided at the time of the interview.

8. **Question:** How many engines can fail at once, and a safe departure still be accomplished? How does this affect ground roll distance/departure angle?

   Answer: The aircraft can land with multiple engines out. Naturally, the ground roll and angle will be affected.

9. **Question:** What is the braking distance from a speed of 1 second before V1, and then max braking applied to a full stop?

   Answer: No answer was provided at the time of the interview.

10. **Question:** What is the approach speed of EL9?

    Answer: Approximately 35kts

11. **Question:** How is performance affected by altitude?

    Answer: No answer was provided at the time of the interview.

12. **Question:** Has there been ground roll testing on wet and ungrooved paved surfaces versus dry and grooved surfaces?

    Answer: This is currently being tested.

13. **Question:** Has Electra Aero had any conversations with the FAA about eSTOL/SSTOL infrastructure, and if so, what have been the results of those conversations, and with whom have you spoken?

    Answer: No answer was provided at the time of the interview.