Electric Training Sailplane RFP

Background

Sailplanes (also commonly referred to as gliders) represent the ultimate in environmentally friendly recreational flying. Sailplanes come in many different forms and have evolved greatly over the last 100+ years to high efficiency designs with glide ratios (L/D) exceeding 70-1.

Wright Glider 1911 L/D Unknown | Göppingen Gö 3 Minimoa 1935 L/D: 28-1 @ 39 kts | Schleicher Ka 6 1955 L/D: 32-1 @ 43 kts | Schempp-Hirth Standard Cirrus 1969 L/D: 38-1 @ 49 kts | Jonkers JS3 & Schempp-Hirth Ventus 3 2016 L/D: 55-1 @ 65 kts

Figure 1. Progression of sailplane design and performance

Once aloft, sailplanes are "powered" by the energy in the atmosphere utilizing thermals, ridge, wave, and convergence to climb. They are capable flights over 76,000 feet, 1,870 miles, and several days of continuous flight (so long that the international record keeping body stopped accepting duration records!). Because they are a low-cost form of recreational flying, the sport is growing with over 20,000 glider pilots in the US and 500+ new glider pilots joining every year. Information on soaring, soaring locations, and scholarships (available to all 26 years old and under) to learn to fly are available at https://www.ssa.org/.

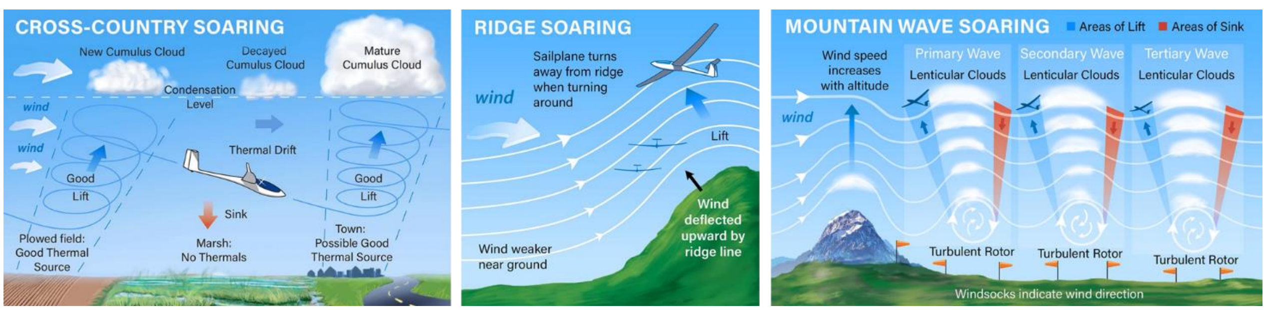


Figure 2. Typical soaring lift mechanisms: Thermal, Ridge, and Wave.

In order to takeoff, gliders may use one of three common methods:

Aerotow | Winch/Ground Launch | Self Launch

Figure 3. Typical launch methods.

In order to takeoff, most gliders use one of three methods: aerotow, winch, and self-launch. Aerotow uses a second airplane which pulls the glider into the air. This airplane, known as a "towplane" has a specially designed mechanism (TOST tow release) on the aft fuselage/tailwheel assembly connected to a similar mechanism in the nose or main landing gear assembly of the glider. the glider have using on the tail of the towing aircraft, the nose of the glider, and a rope connecting them. The pilots climb in formation (both actively flying their respective aircraft) with the rope attached until the desired altitude is reached.

Winch launches use a powerful engine or electric motor fixed to the ground which reels in a long towline attached to the glider, pulling it into the air.

Self-launching employs a propulsions system integral to the sailplane which can be started and stopped in flight (and is often retracted). It climbs into the air conventionally and then shuts the propulsion system down.

Most newly manufactured competition sailplanes are equipped with either self-launching or auxiliary propulsion systems. This is driven in part by the operational flexibility offered by a motor, but in part by reduced availability of tows in some areas as the fleet of towplanes ages. Despite this, relatively few training sailplanes are motor equipped due to cost and complexity.

Because the typical sailplane flight is only “under power” from an external source for the first few minutes of the flight, current battery technology is adequate to make self-launching sailplanes viable, and a number are in limited production. Electric power has the potential to simplify operation of the propulsion systems of these aircraft, improve reliability, and reduce maintenance costs.

The confluence of aging towplanes and training sailplanes with improvements in battery technology suggests a market for an electrically powered self-launching training sailplane. Market analysis suggests a total international market of 500 aircraft over the next 15 years.

Schleicher ASK-21, a modern composite training glider. (https://www.alexander-schleicher.de/wp-content/uploads/2018/07/21B-001-Luftbild-010.jpg)

Glasflugel elibelle, a self-launching glider equipped with a retractable electric propulsion system. (https://streiflyshop.de/wp-content/uploads/2023/03/CPF24214-1920x1280.jpg)

Alisport Silent Electro, a single seat self-launching glider with a folding nose mounted propeller (https://static.homepagetool.ch/var/m_7/75/75e/253592/11444417-DIA_home3-c9f0f.jpg)

Schempp-Hirth Arcus M, a two seat self-launching racing sailplane, equipped with a retractable two cycle engine. (https://www.schempp-hirth.com/fileadmin/_processed_/a/4/csm_b1948-RS6577_DSC_2264_f9d50bc81e.jpg)

Scope & Requirements

This RFP seeks proposals for a modern electric self-launching sailplane suitable for training and recreational flying.

The Figures of Merit are:

FoM		**Threshold**	**Objective**
Operating cost per design reference instructional flight. Assume $0.1287/kWh US residential electricity average.	Minimize	<$50/flight	<$20/flight
Aircraft unit acquisition cost.	Minimize	<$300,000	<$100,000
Number of instructional flights which can be performed in 6 hours	Maximize	6	18
Minimum sink rate in a turn with radius of 250 feet (3000 feet MSL ISA+10C)	Minimize	250 ft / min	175 ft / min
Indicated airspeed at which a lift-to-drag ratio of 25 is achieved	Maximize	45 kt	70 kt
Total cost of ownership per year (600 flights).	Minimize	-	-
Climb altitude on one charge	Maximize	2500 feet	10,000 feet
Self-retrieve range	Maximize	50 km	200 km

The requirements for the design are summarized below with two types of requirements:
(M) = Mandatory Requirement, the design must comply with these requirements.
(T) = Tradable requirement, the design should comply with these requirements but if the respondent believes that the compliance (or degree of compliance) may be traded favorably against the Figures of Merit, they have the flexibility to do so.

General Requirements

1. Mission/Performance:
   a. (M) The aircraft shall be capable of completing the following design reference missions ("Design reference Instructional Flight" and the "Design reference Self-retrieve"). In each case where there is no specified parameter, an "X" is used to represent the value which the respondent can specify (i.e. the vertical speed is a free-design variable).
      - Total Pilot weight: 400 lbs.
      - Assume airport elevation of 1,000 ft above sea level, ISA +10C.
      - Assume the runway surface is cut grass.

      i. Design reference instructional flight:

Segment	Motor On?	Segment Time (min)	Speed (kts)	Altitude (ft)	Vertical Speed (ft/min)
Taxi to end of runway	Yes	2 min	<10 kts	Airport elevation	N/A
Takeoff	Yes	X	X	Airport elevation	X
Climb	Yes	X	1.3 Vso < X < 80 kts	Constant climb to motor shutdown	X >600 ft/min
Shutdown	No	X	N/A	2,500 ft above airport elevation	N/A
Descent	No	10 min	X	Constant descent from shutdown	X
Landing	No	3 min	X	Airport elevation	X

      ii. Design reference self-retrieve flight:
      - The self-retrieve begins with a self-launch and includes 30 minutes of soaring flight before the glider is unsuccessful in finding atmospheric lift to continue soaring flight and must use motor power to "self-retrieve". This includes a climb, cruise-climb, then descent during which the aircraft must cover a distance of at least 50 km, ending at an altitude at least 1000 feet above the airport.

Segment	Motor On?	Segment Time (min)	Speed (kts)	Altitude (ft)	Vertical Speed (ft/min)
Taxi to end of runway	Yes	2 min	<10 kts	Airport elevation	N/A
Takeoff	Yes	X	X	Airport elevation	X
Climb	Yes	X	1.3 Vso < X < 80 kts	Constant climb to motor shutdown	X >600 ft/min
Shutdown	No	0 min	N/A	2,500 ft above airport elevation	N/A
Soaring Flight	No	30 min	X	Various	X
Climb	Yes	X	X	Begins 1000 feet above airport elevation and ends at 2000 ft above airport elevation	X
Cruise-Climb	Yes	X (cruise + descent cover 50 km)	X	X > 2000 feet above airport elevation	X
Shutdown	No	0 min	N/A	X > 2000 feet above airport elevation	N/A
Descent	No	X (cruise + descent cover 50 km)	X	X > 1000 feet above airport elevation and end of segment	X

   b. (T) In gliding flight, the aircraft should achieve a lift to drag ratio of at least 30:1 at an indicated airspeed speed not slower than 50 kt.
   c. (T) The aircraft should be capable of three design reference instructional flights without charging or changing batteries.

   d. (M) All cost, life, performance, etc. analysis shall be done using a mission utilization spectrum at the conditions described above for each mission including 600 instructional flights and 10 self-retrieves per year.
2. Environmental
   a. (M) The aircraft shall be operable in conditions colder than -15 deg C and warmer than 50 deg C surface temperature in full sun.
   b. (M) The aircraft shall have a service ceiling at or above 14,000 ft MSL.
3. Operations
   a. (M) The aircraft shall have a wingspan ≤ 20 m.
   b. (T) The aircraft should store in a hangar bay 9 m long and 18 m in span, configuration changes required to store the aircraft (i.e. removal of wing tips) should be accomplished by one person in less than 5 minutes.
   c. (M) The aircraft shall be able to be assembled or disassembled by three people with simple mechanical aids in 30 minutes.
   d. (T) The aircraft should be able to be assembled or disassembled by two people with simple mechanical aids in 15 minutes.
   e. (M) All control connections shall connect automatically during assembly and disconnect automatically during disassembly.
   f. (M) The disassembled aircraft shall fit into a box with dimensions of 35 feet x 6 feet x 6 feet.
   g. (M) If batteries are to be removed for charging, removal and reinstallation shall require less than 15 minutes.
   h. (T) If batteries are to be removed for charging, removal and reinstallation should require less than 5 minutes.
   i. (M) In any attitude supported by the landing gear, the flight controls shall not contact the ground at any deflection angle permitted by the control stops.
   j. (M) in a wings-level attitude the lowest point on the wingtips shall not be less than 3 feet above the ground.
   k. (M) Configuration changes required to transition between gliding to powered flight or powered flight to gliding shall be accomplished via a single control action (i.e. a switch).
   l. (M) During the transition between gliding and powered flight the aircraft shall not descend more than 250 feet.
   m. (T) During the transition between gliding and powered flight the aircraft should not descend more than 100 feet.
   n. (M) With the propulsion system in the launch configuration but without the motor operating (representing a failure to retract) the aircraft shall have a glide ratio greater than 15:1.
   o. (T) The aircraft should be capable of launching via winch or aerotow.
4. Entry Into Service (EIS)
   a. (M) The aircraft entry into service shall be 2030 or sooner.
   b. (M) Use systems/technologies shall reflect a technology level which could be certified by 2029, at least a year prior to the airplane EIS.
      i. Assumptions on at least specific fuel consumption/efficiency, thrust/power and weight must be documented.
      ii. Engine/propulsion system assumptions documented.
         1. Use of electric motor(s), controller(s) and batteries which could be in service by 2029 and document battery energy and power density assumptions based on reasonable technology trends.
         2. Document system efficiency including at least the efficiency of the batteries, wires, controllers, thermal management system, connectors, motors and propellers to calculate a total propulsive efficiency. (Example)
5. Crew/Passengers

a. (M) The aircraft shall be capable of being operated by a single pilot at the solo stage of flight training.
b. (M) The aircraft shall be equipped with two crew stations with a complete set of controls (including propulsion) available at each.
c. (M) The aircraft shall be capable of being operated with both crew stations occupied.
d. (M) The crew stations shall be designed
    i. for a minimum pilot weight of 90 lbs or less;
    ii. for a maximum pilot weight of 270 lbs or more;
    iii. to accommodate 5th percentile or smaller and 95th percentile or larger dimensions (Recommend USA AEDR Pilots data set provided in AD-A208 609 "Anthropometric Measurements of Aviators Within the Aviation Epidemiology Data Register" or other suitable reference).
e. (T) The aircraft should be capable of being operated by:
    i. Single pilot in one of the two crew stations meeting the weights described above.
    ii. Both crew stations simultaneously occupied
        1. Crew who both weigh 90 lb or less
        2. Crew who both weigh 270 lb or more
f. (M) A proportional throttle control shall be installed.
g. (M) Removable ballast required to achieve a safe CG with the range of pilot weights specified shall be rigidly affixed to the aircraft structure and be inspected, installed, and removed without tools by a single person in less than 5 minutes.

6. Certifications
    a. (M) The aircraft shall be equipped for VFR Day flight.
    b. (M) The aircraft shall meet applicable certification rules in FAA 14 CFR Part 21, AC 21.17-2A (with JAR-22 replaced by CS-22), and CS-22 with Special Condition SC-22.2014-01.

Other Considerations

- Identify all systems functionality and components that are required for the aircraft to operate in both controlled and uncontrolled airspace.
- List the equipment required.
- Consider what features will be basic and which will be optional to a customer.
- Minimize production cost by choosing materials and manufacturing methods appropriate for the annual production rate that is supported by the team's assessment of the potential market size.
- Make the aircraft visually appealing so it will be marketable and identify what features are important to the operators for different missions.
- Make the aircraft reliability equal or better than that of comparable aircraft.
- Make the aircraft maintenance equal or better than that of comparable aircraft.

Report and Design Data Requirements

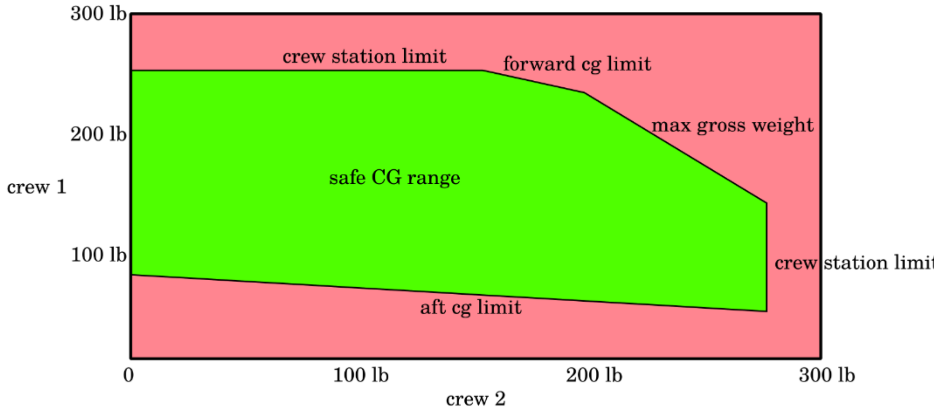
The technical report shall present the design of this aircraft clearly and concisely; it shall cover all relevant aspects, features, and disciplines. Pertinent analyses and studies supporting design choices shall be documented.

Full descriptions of the aircraft are expected along with performance capabilities and operational limits. These include, at a minimum:

1. A complete Design and Performance Summary Table/Mission Tables as provided in Appendix A.
2. A description of the design missions defined for the proposed concepts for use in calculations of mission performance as per design objectives. This includes the selection of the parameters not

otherwise specified in the reference mission profiles supported by pertinent trade analyses and discussion.

3. Aircraft performance summaries shall be documented for each reference mission and the aircraft flight envelope shall be shown graphically.
4. A V-n diagram for the aircraft with identification of necessary aircraft velocities and design load factors.
5. A diagram of indicated airspeed vs descent rate ("speed polar") in the gliding configuration.
6. Materials selection for main structural groups and general structural design, including layout of primary airframe structure as well as the strength capability of the structure and how that compares to what is required at the ultimate load limits of the aircraft. The maximum dive speed of the aircraft shall be specified.
7. Complete geometric description, including dimensioned drawings, control surfaces sizes and hinge locations, and internal arrangement of the aircraft illustrating sufficient volume for all necessary components and systems.
    a. Scaled three-views (dimensioned) and 3-D model imagery of appropriate quality are expected. The three-view must include at least:
        i. Fully dimensioned front, left, and top views
        ii. Location of aircraft aerodynamic center (from nose)
        iii. Location of average CG location (relative to nose)
        iv. Tail moment arms
    b. Diagrams and/or estimates showing that internal volume requirements are met for the crew/baggage.
        i. Cross-section showing seats
        ii. Layout of cockpit and size/location of doors or canopies
        iii. Fuselage centerline diagram
    c. Diagrams showing the location and functions for all aircraft systems
8. Important aerodynamic characteristics and aerodynamic performance for key mission segments and requirements
9. Aircraft weight statement, aircraft center-of-gravity. Establish a forward and aft center of gravity (CG) limit for safe flight.
    a. Weight assessment summary shall be shown at least at the following level of detail:
        i. Propulsion (motor, batteries, controller, wiring, heat sink, cowl, strut, propeller, spinner etc. as applicable)
        ii. Airframe Structure
            1. Wing
            2. Empennage
            3. Landing Gear (including wheels tires and brakes)
            4. Fuselage
        iii. Control system (flight controls linkages, hydraulics, wires, actuators bellcranks, engine controls etc.)
        iv. Payloads
        v. Systems
            1. Instruments and Avionics
            2. Hydraulic/pneumatic/electrical systems (if applicable)
            3. Others as relevant
    b. A diagram depicting the safe center of gravity envelope with weight of each crew member, including a diagram for any removable ballast and the constraint which limits the safe CG range. For example:



10. Propulsion system description and characterization including performance, dimensions, and weights. The selection of the propulsion system(s), sizing, and airframe integration must be supported by analysis, trade studies, and discussion.
    a. Breakdown of the battery system to include metrics (at least specific energy and power densities) at the cell level and pack/system level, and also include a technical overview of pack integration strategies.
11. Summary of basic stability and control characteristics; this should include, but is not limited to static margin, pitch, roll and yaw derivatives.
12. Summary of cost estimate and a business case analysis. This assessment should identify the cost groups and drivers, assumptions, and design choices aimed at the minimization of production costs.
    a. Estimate the non-recurring development costs of the airplane including engineering, FAA/EASA certification, production tooling, facilities and labor.
    b. Estimate the fly away cost.
    c. Estimate the price that would have to be sold for to generate at least a 15% profit
        i. Show how the airplane could be produced profitably at production rates ranging from 3-6 airplanes per month or a rate that is supported by a brief market analysis.
    d. Estimate of direct operating cost per airplane flight hour
        i. Tires, brakes, battery, and other consumable quantities
        ii. Estimate of maintenance cost per flight hour

The design report will include trade documentation on the two major aspects of the design development, a) the concept selection trades, and b), the concept development trade studies.

The student(s) is (are) to develop and present the alternative concepts considered leading to the down-select of their preferred concept. The methods and rationale used for the down-select shall be presented. At a minimum a qualitative assessment of strengths and weaknesses of the alternatives shall be given, discussing merits, leading to a justification as to why the preferred concept was the best design. Quantitative justification of why the selected concept is the best at meeting the measures of merit(s) will strengthen the report.

In addition, the submittal shall include the major trade studies conducted justifying the optimization, sizing, architectural arrangement and integration of the specifically selected concept. Quantitative data shall be presented showing why their concept 'works' and is the preferred design compromise that best achieves the design requirements.

Specific analysis and trade studies of interest include:
Mission performance and sizing for the definition of a mission profiles.
Overall aircraft concept selection (airframe and propulsion system) vs. design requirements objectives

All concept and technology assumptions must be reasonable and justified for the EIS year.

Questions & Reference Material

Questions may be submitted to AIAASailplaneRFP@gmail.com which will be periodically answered as they are received. Additional Q&A materials may be added to this document during the year.

References:

- 14 CFR Part 23
- Soaring Society of America (Flying Sites, Scholarships, General information)
  - Consider contacting a soaring site near you for an introductory visit to learn first-hand from experienced pilots and clubs.
  - Additional information on soaring available by emailing Juniors@SSA.org
- OSTIV – Technical Organization for Soaring
- Glider Flying Handbook (FAA)
- Anthropometric Measurements of Aviators Within the Aviation Epidemiology Data Register
- Example Glider Assembly
- Example Self-Launching Trainer (non-electric)
- Example Self-Launching High-Performance Glider (rear electric motor)
- Example Self-Launching High-Performance Glider (front electric sustainer)
- Example Battery Installation
- Perlan High-Altitude Mission

Appendix A: Design and Performance Summary Table

Parameter	**SI Units**	**Imperial Units**	**Notes**
Aircraft Design			
Wingspan (assembled)	m	ft	
Storage Wingspan (wingtips removed if applicable)	m	ft	
Length	m	ft	
Height	m	ft	
Reference Wing Area	m^2	ft^2	
Wing Aspect Ratio			
Maximum Takeoff Weight	kg	lbm	
Operating Empty Weight	kg	lbm	
Minimum Individual Crew Weight	kg	lbm	
Maximum Individual Crew Weight	kg	lbm	
Propulsion			
Propulsor Type/Number/Location			
Motor Peak Power Duration / Power / Specific Power / Efficiency	sec / kW / kW/kg / %	sec / hp / hp/lbm / %	
Motor Max Continuous Power Power / Specific Power / Efficiency	kW / kW/kg / %	hp / hp/lbm / %	
Total Max Thrust	N	lbf	
Battery Chemistry			
Installed Energy at 1C Discharge	kW.h	hp.h	
Battery Energy Density at 1C Discharge	kW.h	hp.h	
Battery Peak Power	kW	hp	
Number of Instructional Flights Between Re-Charge			
General Performance/Operations			
Minimum/Maximum Ambient Operating Temperature	deg F	deg C	
Service Ceiling	m	ft	
Altitude Lost During Transition Between Gliding and Powered Flight	m	ft	
Stall Speed and Flap Setting, MTOW, ISA, SL (CAS)	m/s	kts	
Maximum L/D (clean – propulsor off/retracted) @ speed	X:1 @ m/s	X:1 @ kts	
Maximum L/D (dirty – propulsor off/extended if applicable) @ speed	X:1 @ m/s	X:1 @ kts	

Takeoff Ground Roll, 400 lb crew, 1000 ft MSL, ISA+10C, Cut Grass	ft	m	
Takeoff Distance Over 50' Obstacle, 400 lb crew, 1000 ft MSL, ISA+10C, Cut Grass	ft	m	
Landing Ground Roll, 400 lb crew, 1000 ft MSL, ISA+10C, Cut Grass	ft	m	
Landing Distance Over 50' Obstacle, 400 lb crew, 1000 ft MSL, ISA+10C, Cut Grass	ft	m	
KPPs			
Operating cost per design reference instructional flight	USD		
Aircraft unit acquisition cost	USD		
Number of instructional flights which can be performed in 6 hours			
Minimum sink rate in a turn with radius of 250 feet (3000 feet MSL ISA+10C)	m/s	kts	
Indicated airspeed at which a lift-to-drag ratio of 25 is achieved	m/s	Kts	
Total cost of ownership per year (600 flights).	USD		
Climb altitude on one charge	m	ft	
Self-retrieve range	km	nm (nautical miles)	

Design reference instructional flight:

Segment	**Motor On?**	**Segment Time (min)**	**Speed (kts)**	**Altitude (ft)**	**Vertical Speed (ft/min)**
Taxi to end of runway	Yes	2 min	<10 kts	Airport elevation	N/A
Takeoff	Yes	X	X	Airport elevation	X
Climb	Yes	X	1.3 Vso < X < 80 kts	Constant climb to motor shutdown	X >600 ft/min
Shutdown	No	X	N/A	2,500 ft above airport elevation	N/A
Descent	No	10 min	X	Constant descent from shutdown	X
Landing	No	3 min	X	Airport elevation	X

Design reference self-retrieve flight:

Segment	**Motor On?**	**Segment Time (min)**	**Speed (kts)**	**Altitude (ft)**	**Vertical Speed (ft/min)**
Taxi to end of runway	Yes	2 min	<10 kts	Airport elevation	N/A
Takeoff	Yes	X	X	Airport elevation	X
Climb	Yes	X	1.3 Vso < X < 80 kts	Constant climb to motor shutdown	X >600 ft/min
Shutdown	No	0 min	N/A	2,500 ft above airport elevation	N/A
Soaring Flight	No	30 min	X	Various	X
Climb	Yes	X	X	Begins 1000 feet above airport elevation and ends at 2000 ft above airport elevation	X
Cruise-Climb	Yes	X (cruise + descent cover 50 km)	X	X > 2000 feet above airport elevation	X
Shutdown	No	0 min	N/A	X > 2000 feet above airport elevation	N/A
Descent	No	X (cruise + descent cover 50 km)	X	X > 1000 feet above airport elevation and end of segment	X