AAM Ecosystem Community Integration Working Group: Vertiport Location Considerations

Background & Brainstorming Ground Rules Used

Background

- The list was compiled over 2, hour-long meetings October 12th and 13th, 2021.
- The contributors started with an initial set of groupings and considerations
- During the meetings additional considerations were captured both verbally and via the chat function
- Additional considerations were submitted via e-mail

Brainstorming Ground Rules

- There are no bad ideas
- Just looking to identify considerations
- Will be grouping considerations to manage the number of them
- Considerations can be submitted verbally, via chat, whiteboard function, e-mail,
- Meeting – 60 min
  - 5 min logistics, intro
  - 10 min looking at a grouping slide to generate ideas
  - 40 min focused look each of 18 categories
  - 5 min wrap up

Early Engagement with the FAA

- In addition to utilizing this list of vertiport location considerations, specific planning or implementation should include early engagement with the Federal Aviation Administration.
- The FAA must assess the safety of any proposed vertiport location, as well as assess any impacts to the existing National Airspace System.
- The FAA's current regulations require a vertiport proponent to provide Notice to the FAA.
- In advance of filing that Notice, early coordination with the FAA could help the proponent become aware of possible challenges at a particular location before expending resources on detailed planning and analysis.
- For early coordination with the FAA on possible vertiport locations, the proponent should reach out to the Airports Regional Office or Airports District Office covering the geographic area where the vertiport would be located. A list of these FAA offices and contact information can be found at https://www.faa.gov/airports/regions/ by clicking on the corresponding region on that page.
- For more general questions or assistance from the FAA on vertiports, AAM, or UAM, you can email their UAS Help Desk at UAShelp@faa.gov.
- The FAA is currently developing safety guidance on the design and operation of vertiport facilities. The agency expects a draft will be published in early 2022 for public comment, and final interim guidance is expected in mid 2022.

Thank yous, & Assumptions

Thank you

- Sincerest thanks to the approximately 150 people who gave so freely of their expertise and dialed in to one or both of the hour-long sessions where this list was pulled together. Thank you also to the folks who've e-mailed in comments.
- I think it's a true testimony to the depth of knowledge, passion and dedication of the participants that we were able to capture 445 considerations.
- You all are AWESOME!

Assumptions

- U.S. Regulatory Framework
- Vertiports sized for passenger/large cargo operations. Can be multi use with sUAS, but not capturing considerations relative to solely sUAS operations
- This is a living document and can be updated, modified and or matured.
- The groupings are simply a way to organize the data in PowerPoint and the information can be re-grouped or organized depending upon the desired usage(s) for the information
- The list is intended to be location agnostic, but also to capture considerations that may be relevant to just a subset of potential sites

Notes & Potential Next Steps

Notes

- This list is an initial compilation, and not definitive or binding. It is intended to provide a starting point for planners and decision makers.
- Considerations were listed with short titles and could be interpreted multiple ways or may not be as descriptive as possible.
- Many of the considerations listed across the groups are based upon ensuring and improving safety and are typically captured in a group other than safety. While they could have also been listed in the safety group it was felt that attempting to limiting duplication was necessary for efficient management of the list.

Potential Next steps

- Convert list to a document that is more accessible and searchable than a PPT deck.
- Perform a risk and or impact assessment of considerations listed
- Refine groups e.g.. divide group by physical vs operational considerations or applicability to public vs private vertiport(s)
- Match governing documents or references with greater detail to considerations
- Identify where considerations or groups of considerations are being more deeply considered
- Additional items for the list(s) can be sent to nancy.mendonca@nasa.gov

Considerations

Groups

- Federal Regulatory
- Local Regulatory
- Physical – fixed
- Physical – mobile & temporary
- Vertiport configuration
- Surrounding uses
- Economic considerations
- Equity considerations
- Demand considerations
- Environmental considerations
- Airspace integration considerations
- Contingency considerations
- Utility considerations
- Communications/Data
- Physical and Cyber Security
- Safety
- Automation
- Others

Federal Regulatory Considerations

- Federal funding used
- Public vs Private
- Airspace impact evaluation
- Design Circular(s)
- Maturing Design Circular(s)
- Grant restrictions
- OSHA and ADA requirements
- Future climate requirements
- LEED Goals/requirements
- Physical security (pax + cargo) regulations
- Applicable existing regulations
- Regs developed for AAM
- Environmental requirements e.g.. NEPA, FAA 1050.1
- Cross-boarder operations
- Governing regs e.g.. Part 135
- FAA Regulatory Roles & Responsibilities (CAA)
- FAA Operational Roles & Responsibilities (ANSP)
- Federal vs Local Roles and Responsibilities
- Species protection regulations
- Registration in National Registry of Airports
- Airport Master Record e.g.. 5010-1 forms
- Mitigation Programs e.g.. noise abatement
- Interstate commerce regs
- Part 157 Forms 7480 & 7460 Notice of Construction
- 49 USC 5501 National Intermodal Transportation
- Data collection, retention and disposal policies and procedures (for audit and safety trend analysis)
- Federally provided vs commercially provided service
- Engage early with the FAA

State and Local Regulatory Considerations

- Zoning of site
- Zoning of surrounding area
- Local/state funding
- Noise ordinances
- Operating hours
- Economic Development Plan
- Building, plumbing code(s)
- Lack of building codes
- Local data requirements
- Adopted fire codes
- Incorporate & adhere to local master and transportation plans
- Support local planning goals
- Current or future land use plans
- Environmental requirements. e.g.. Special purpose state/local laws, e.g.. California Environmental. Quality Act Coastal Commission
- Long term local goals and plans
- Long term transportation integration planning
- Stakeholder groups assembled
- Processes in place to obtain stakeholder input
- Understanding public opinion
- Federal vs Local Roles and Responsibilities
- Digital Policy (flexible & rapid policy implementation tools)
- IT system requirements for publicly funded infrastructure
- Local mandate of publicly funded vertiport requirements on private vertiports
- Differences in state vs local regulations
- Local airport land use plans
- State Aviation System and other aviation Plans

Physical – Fixed Considerations

- Near-by buildings (e.g.., high rises)
- Antennas
- Towers (cell & water)
- Trees
- Power and other lines
- Power poles
- Billboards
- Current local land use
- Compatible with existing airports & their future plans
- Compatible with other transportation infrastructure and plans
- Property owner(s) rights
- Time/ease for multi-modal transportation changes

Physical – mobile & temporary Considerations

- Temporary vertiport (1 year, disaster recovery, special event)
- Building cranes
- Blowing debris
- Construction staging
- Noise
- Non-acoustic annoyance factors e.g.. visual
- Static discharge
- Lightening
- Urban wind shadows
- Future local land use

Surrounding Use Considerations

- School in vicinity
- Critical infrastructure nearby
- Property under approach and departure paths
- Local Fire station
- Metro/bus/train stop
- Noise sensitive area
- Building security
- Local land use
- Visual distractions e.g.. solar panel reflectivity, ambient or artificial lighting, both on ground in and air
- Maturing vegetation
- Compatibility - Business/industrial vs residential
- Nearby animals (zoo, domestic)
- Protected wildlife habitats
- Future property values
- Connectivity to existing transportation networks
- Impact on local community, environment or surrounding land use considerations impacts from increased traffic accessing vertiport
- Follow-on development compatibility
- Distance to Maintenance or Repair Facility (MRO)
- Hazards from specific land uses e.g.. birds at landfills, ash from burning, weather radar around wind farms
- Privacy of vertiport neighbors
- Operations distracting other activities e.g.. drivers on a freeway
- Down wind of wind farm

Vertiport Configuration Considerations

- Single pad
- Multi-pad
- Pad separation
- Public vs Private use
- Public vs Private funded
- #s of vehicle configurations, sizes e.g.. capable for multiple
- Types of vehicles eVTOL, sUAS, STOL, etc..
- Vehicle ownership – public, commercial, private, personal, etc.
- Vehicles with different propulsion energy sources
- Emergency use only
- In route charging e.g.. “rest stop” use
- At ground level
- Height above ground
- Mean Seal Level (MSL)
- Downwash at vertiport
- Adjacent pad downwash
- Water run off
- Contain chemicals (deicing)
- Passenger safety boarding and deplaning
- Passenger comfort
- Planned life-cycle
- Configuration flexibility
- Incorporate new technology and or fuels
- Incorporate new regulations
- Incorporate new safety features
- Expandability
- Arrival & departure routes
- Vertiport equivalent of landside/airside coordination
- Throughput
- Annual, seasonal, daily # ops
- Ground handling of aircraft e.g.. air taxi, towed
- Surface Flow Traffic Management
- Electronic Aids for coordinating surface flow movement, accident& incident mitigation
- Vehicle separation
- Overall footprint
- On & offsite amenities
- Passenger, cargo or hybrid missions (business cases)
- Ground handing safety (existing plus new procedures/guidelines)
- Passenger onsite reservations, ticketing, information, screening including international pax (customs)
- Pax post screening area security
- Appropriate standards incorporated
- Impact of ground procedures on throughput
- Architecture integration with local architecture (visual ascetics)
- Climate appropriate design
- Consistency across vertiports within a “system”
- Vehicle performance impacts e.g.. landing/takeoff profile
- Shared or single provider operations
- Shared or single user
- On vertiport Electromagnetic interference (EMI)/Radio Frequency Interference (RFI) e.g.. rebar in structure or charging equipment
- Amount of overnight aircraft parking
- Distance to/from aircraft overnight parking locations
- Repurposed or purpose-built infrastructure
- Repurposed from aviation or non-aviation use infrastructure
- Physical access e.g.. time to switch modes
- Accessibility (walking/biking distance)
- Surface and airspace scheduling & reservations
- Charging scheduling
- Time to fully charge
- Pre-flight procedures
- Flight line personnel safety e.g.. charging cord or battery swap safety procedures
- Specific operating models e.g.. battery swaps vs charging
- Usage e.g.. passenger, cargo, emergency
- Turn around maintenance needs including reservations
- Pads to charge or conduct minor maintenance
- Prepositioning e.g.. overnight parking
- “Down aircraft” parking
- Spares storage
- Minor maintenance facilities
- Movement of aircraft requiring relocation to MRO
- Supply deliveries
- Vertiport personnel certification/qualification requirements
- Impacts from new materials e.g.. aircraft construction, building materials
- Mobile Vertiport e.g. on a barge
- Issues for vertiport at an airport

Economic Considerations

- Existing infrastructure
- Fits business case
- Land purchase cost
- Building cost
- Operational costs
- Maintenance costs
- Improvement costs
- End of life-cycle costs
- Opportunity costs
- Equipment costs (e.g. GSE)
- Supporting infrastructure cost e.g.. weather or surveillance equip
- Re-use or purpose built
- Start up costs
- Private or publicly operated
- For profit or non-profit
- Public good contribution
- Funding sources
- Operating infrastructure life cycle costs
- Compatible with long term local/regional economic goals
- Co-located uses (e.g.. entertainment)
- Affordability e.g.. ride cost, taxpayer burden
- Funding e.g.. bonds, usage fees, grants
- Funding sources - publicly funded “public good” mission % vs commercial % non-profit %

Environmental Considerations

Significant Effort to Mitigate

- Heat islands
- Prevailing winds
- Winds near vertiport, e.g., up and down drafts
- Local prevailing winds
- Lightening Protection
- Weather sensors @ Port
- Wildlife water, food sources or nesting locations nearby
- Impact on migratory paths and/or navigation
- For vertiports near water – impacts on fresh and saltwater ecosystems, animals and plants
- Seasonal weather
- Hazardous weather
- Typical ceiling & visibility
- Typical climate
- Local environment e.g.. humidity, salt water, dust
- Land suitability, e.g.. flood plain, over a fault

Necessary or Manageable Mitigations

- Micro weather sensing capability
- Micro/hyperlocal weather
- Downwash beyond pad
- Operational impacts on wildlife e.g., lights on sea turtle nesting
- Water runoff
- Snow removal
- Equipment for low visibility operations
- Aircraft emissions
- Impacts of heat and cold e.g. Batteries, other equipment
- Rules associated with weather predictability (vertiports in mountains likely have different rules than ones in Los Angeles)
- Hazmat storage & cleanup facilities
- EMI/RFI emanating from non-vertiport sources e.g.. 5G impacts on GPS, altimeters or impacts on navigation equip

Airspace Considerations

- Class of airspace, E, B?
- Distance to airport
- Helicopter corridor usage, procedures, approval process
- Traffic volume nearby
- Migratory patterns
- Special Use Airspace (SUA)
- Military Use Airspace (MUA)
- No fly zones (e.g. prisons)
- Flights over sensitive infrastructure, events, etc..
- Multiple approach & departure routes available
- Future airspace uses
- Expandability
- sUAS, passenger sized eVTOL & STOL vehicles operating in vicinity of a vertiport (mixed operations)
- Cross boarder flights
- Nearby airport airspace uses
- Metropolitan airspace strategy
- Airspace system and individual route density
- Distribution vs consolidation of traffic impacts
- Vertiport traffic density
- #s of types of aircraft
- Aircraft performance impacts
- Passenger arrival/departure experience
- Tailorable approaches (both VFR and instrument, vehicle performance and operator energy management goal driven)
- Ability to support dynamic system balancing
- TERPS evaluation
- Managing airspace design changes
- Community inputs on routing of aircraft between vertiports
- Vertiport operator role & responsibility for airspace in vicinity of vertiport
- Vertiport at airport considerations
- Closely located vertiports
- Separation violation reports (Electronic Occurrence Reports (if applicable to AAM Operations)
- Route planning to minimize hazard to population etc. below flight path
- Entry and exit into ATC controlled airspace
- Access to a vertiport at an airport
- Distance between ground and MSL e.g.. a vertiport at 9,000ft could impact the number and shape of routes with class E airspace at 10,000’ MSL

Demand Considerations

- High traffic area
- Seasonal demand
- Multi-modal integration
- Impacts of demand or congestion across multiple modes
- Existing or generating demand
- Capacity – Demand feedback loop
- Dynamic sizing of vertiport
- Dynamic sizing of system of vertiports
- Scheduling capability
- Interoperability with other modes of transportation
- Special event demand
- Prioritization of access e.g.. emergencies, first come first served, greatest benefit
- Need for dynamic rebalancing (early outbound needs exceed late inbound needs)
- Demand prediction capability
- Analysis models for understanding and optimizing transition amongst modes.
- PSU(s) role and responsibility WRT individual vertiports and the AAM system
- Impact of individual vertiport throughput on the AAM system

Contingency Considerations

- Nearby Emergency landing site(s)
- Availability of nearby landing site(s) – hours open
- Rescue considerations
- Backup power
- Grid resiliency
- Firefighting needs (e.g.., foam system?)
- AAM system resiliency
- Fire codes IFC/NFPA (adopted/developed)
- Locally driven building/fire codes (e.g.. earthquake)
- Local emergency response time(s)
- Distance to medical care
- Distance to local law enforcement
- Accident & incident investigation procedures
- Drill planning
- Resiliency to AAM disruptions
- Resiliency contribution to entire transportation system
- Role in local disaster plans e.g.. shelter or search and rescue
- “Down” aircraft procedures
- Search and Rescue Procedures
- Hazmat procedures
- Event containment e.g.. isolation of event on one pad
- Propulsion unique contingency procedures
- Fire suppression technologies e.g. water, chemical, or new technologies e.g. automated mobile systems
- Fire thermal, gas, particulate and suppression system venting during the fire and containment for clean up afterwards
- Procedures for passenger flight changes e.g.. wx delays
- Aircraft lost comm procedures common and specific to one vertiport
- Other signal losses e.g.. navigation, surveillance
- Surface incident reporting (Mandatory Occurrence Reports (if applicable to AAM operations)
- Contingency policies, standard operating procedures (SOPs) for graceful degradation of vertiport operations
- Understanding Emergency Procedures that are common across multiple vertiports vs procedures unique to each vertiport
- Vertiports accounted for in Flight Termination System requirements
- Understand contingency flight plan data available to and needed by the vertiport operator, vs PSUs vs vehicles operating out of that vertiport
- Operation during loss of utilities e.g.. blackout
- Widespread disasters vs localized
- Natural vs man-made disasters
- Conditions when private vertiports open for public use or contingency operations

Equity Considerations

- Local median income
- Visual "pollution" (from low-flying aircraft on approach/departure paths)
- Impact to property value
- Impact to land value
- Public vs private vertiport impacts
- **Social Equity**
- **Access Equity (may divide this section into 2)**
- Equity failure lessons
- Environmental justice e.g.. flying over low-income neighborhoods
- Equal access to “public” resources in normal conditions e.g.. airspace when safety related requirements are met
- Ability to prioritize flights e.g.. emergency services
- Operators (vehicle and vertiport) have the ability to determine and operate at their “optimal” performance e.g.. turn around times
- Ability to equitably allocate limited or scarce resources
- Fair allocation of negative impacts
- Cost as a percentage of income
- Business models incentivized to be more equitable
- Locations of supporting infrastructure e.g.. comms, nav

Communications/Data Considerations

- Approved spectrum
- Bandwidth
- Available spectrum
- Infrastructure (towers, transmitters, etc.)
- Interference, e.g.. EMI or LOS
- Interoperability with 1st responder equipment
- Comms Plan(s)
- Need for intra PSU comms data exchange for strategic deconfliction
- Data integration w/ other transportation modes
- Lost comm procedures
- Data security
- Data sharing policies and procedures (external data requests)
- Data for performance metrics
- Passenger data connectivity
- Vertiport data connectivity
- AAM system data/comms connectivity
- Comms/data availability
- Comms needs for vertiport operator
- Data “chain of control” policies and tools to trace data “chain of events” and actions taken e.g. communications between PSU and FAA, or pilot and vertiport operator
- Minimum Operational Data Exchange requirements between stakeholders
- Vertiport operations and performance awareness and reliability of data systems e.g.. flight plans, individual aircraft performance weather, surveillance sensors
- Understand flight plan data available to and needed by the vertiport operator, vs PSUs vs vehicles operating out of that vertiport
- Datalink for advisory and clearance data, etc.
- Exchange of flight plan and surveillance data between ATC & PSUs
- Flight Information System (FIMS) data exchanges.
- Data exchange between PSU, USSs, xTM and NAS system
- Data needed for or automated systems

Physical & Cyber Security Considerations

- Passenger physical security
- Cargo control
- Pax and cargo screening & security
- Building (Vertiport) security
- Cross-boarder operations
- Network & data security
- Network and data reliability/continuity
- Access to hazardous areas
- Detection
- Security requirements
- Security procedures
- Security drills
- Security personnel
- Security of automated systems
- Comms/data integrity
- Federal regulations
- Data at rest and data in transit policies
- Internal & external access system control policies and procedures
- Assessment of vulnerabilities, risks, criticality, priorities and attach mechanisms
- Assessment, mitigation and impact of attack types e.g.. denial of service, jamming, spoofing
- Cybersecurity risk quantification metrics e.g.. probability of occurrence, consequence, cost
- Ability to differentiate between cyber attacks and other faults e.g.. system, human-machine interaction
- System cyber robustness e.g.. real-time analytics, fault containment, use of redundant sensors
- Layered cyber security procedures e.g.. people, technology, processes

Utility Considerations

- Electrical service
- Electrical demand
- Projection of future demand
- Source of energy e.g.. on/offsite, renewable
- Integration with grid
- Data networks e.g.. fiber
- Water demand (fire, pax)
- Energy storage
- Impacts on peak electrical demand
- Impacts of large voltages e.g.. human health, equipment, incidents
- Fast or slow charging amps
- Impact of variable utility costing, incentive policies or availability e.g.. electricity more expensive during peak demand
- Ability to pass along variable utility costs to user/consumer(s)
- Fuel deliveries & storage (e.g.. gas/avgas for hybrid aircraft, APUs or GSE
- Future fuel compatibility (hydrogen, new batteries)
- Septic
- Graceful degradation of critical utilities
- Planning and providing service timelines and approvals
- Competition and/or demand pricing for limited utilities
- Resiliency
- Climate or carbon neutral policy, goals or requirements

Safety Considerations

- Safety Management System
- In-Time System-wide Safety Assurance tools & techniques
- Bird strike query
- Passenger visual queues
- Accident reconstruction capability
- Rapid identification of improvements
- Understanding failure modes and relationship with vertiport operations
- Simulation and modeling tools to discover failure modes

Automation Considerations

- Passenger/cargo reservations, ticketing, and check-in systems
- Security screening
- Surface operations management (Ground handling)
- Surface movement and traffic control
- Passenger/cargo routing
- Charging
- Performance based routing
- Reliability
- Graceful degradation
- Availability
- Accuracy/performance
- Automated workflow processes for error and status reporting and approval
- Understanding of human vs automation functions for fault analysis
- Automated signage & lighting e.g.. hazards, nighttime
- Aids to assist surface movement separation
- Automation to prevent unauthorized entry to movement areas, TLOF etc.
- Monitoring of sensor performance
- Virtual vertiport (surface traffic, etc.. controlled remotely)
- Digital vertiport (similar to non-towered vertiport
- Operations with remote pilot
- Integrated arrival, departure, surface planning & management allowing for ops with multiple vehicle types and configurations

Other Considerations

- Multi-modal integration
- Visual aesthetics e.g.. does the vertiport structure visually integrate with community & surroundings
- Integration into a long-term AAM system plan(s)
- Occasional uses e.g.. Olympics
- Incorporation of long-term infrastructure lessons learned e.g.. Olympics
- Sustainable city planning
- Synergies with ground electric vehicles and or automated ground vehicles
- Prediction of near and long-term desires e.g.. urban vs exurbs vs rural living
- Taxonomy – verti- stop, place, hub port
- Applicable and evolution of case law
- Navigational aid infrastructure, cost, interference, reliability, accuracy
- Surveillance aid infrastructure, cost, interference, reliability, accuracy
- Balancing demand across multiple transportation modes
- Ability to rapidly incorporate system improvements, lessons learned
- Incorporation of personal pads or UML-6 operations
- Modeling and simulation tools for characterizing vertiport and system performance
- Leveraging Subject Matter Experts and Lessons Learned