

Airship Industry Study

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Abstract

In April, 2015 NASA Ames Research Center conducted a study of the airship industry. The project called for a report that would describe airship concepts proposed or projects initiated, airship performance or capability targets, and the missions these activities were addressing. It would detail the principal technical features of these airships; the proposed value/advantages of the features, notional concepts of operation, and challenges associated with the vehicles. Also investigated would be the current status and near-term prospects of these airship development activities, whether they are active or, if curtailed the circumstances and possible reasons for that conclusion including technical, business, or other mitigating factors. For the most active programs an assessment would be conducted to identify the resources or activities required for airships to advance to series construction and operational deployment. The study would also identify impediments to these developments and deployments, with recommendations provided to address existing issues in the airship industry today.

The study was begun with an initial survey of recent and current airship efforts (over the past ten years) including organizations, customer markets; missions; concepts proposed or projects initiated; technical features, performance or capability targets; concepts of operation (CONOPS) and program status (whether active or inactive). A two month information search of publicly available information was conducted of the principal airship and aerostat companies and design organizations. Data was gathered on almost forty organizations, and organized into a common set of categories. These included:

- Customer Markets & Missions
- Airship Concepts & Vehicles - Technical Features, Performance or Capability Targets
- Key Technology Elements
- Concept of Operations (CONOPS)
- Company/Program Status

To provide a technical and operational context to readers of this report a section on Airship Basics was compiled to describe how airships are designed, constructed, and their operational aspects. Subject areas included:

- Buoyancy
- Lifting gases
- Payload to Frame Weight Ratio
- Gas Management
- Temperature Effects
- Airspeed
- Fuel consumption vs speed and range
- The Green Airship
- Buoyancy Management
- Ground Handling, Mooring, and Landing Systems
- Airship Hangars
- Maintenance Philosophies

- Airship Certification and Operations Regulations

An engineering level assessment was undertaken of the airship vehicle classes, designs, and technologies identified in the survey. Their capabilities and challenges to meet a set of notional cargo transport scenarios were highlighted. Also identified were new or enabling technology advances necessary for successful development of the transport airship industry; and principal lessons learned from the industry. This section organized information drawn from the Industry Survey and combined it into several airship related technology categories. These include:

- Hull Configurations
- Solid Structures
- Fabrics
- Propulsion and vectored thrust
- Buoyancy Compensation
- Flight Controls
- Takeoff & Landing Gear and Mooring Systems
- Cargo Handling Systems
- Alternative Lifting Gases to Helium
- Development of New or Enabling Technology Advances

Five cargo airship scenarios were proposed. They were not comprehensive and several additional scenarios could be envisioned, but the ones chosen cover the majority of typical cargo airship applications and CONOPS. In the absence of specific performance and operational requirements a set of general capabilities for cargo airships was offered as a guide for subsequent evaluation of current and near term cargo airship technologies. The list includes:

Performance

- Normal operating altitude maximum of at least 6,000 ft. MSL, (with reduced loads up to 10,000 ft. MSL)
- Minimum cruise speed in the 45-55 mph range
- Maximum speed range in the 65-85 mph range
- Ferry range of at least 3,500 miles
- Self-deployable (airship can deliver all of its ground support equipment to remote operation sites)
- High flight endurance (remain in the air for extended periods; days or weeks)
- Controllable takeoff and landing in strong steady winds (minimum wind speed of 25 kt.)
- Controllable takeoff and landings in light and variable winds (wind speeds of 5-15 kt.)
- Conduct short take-off and landing maneuvers
- Conduct vertical take-off and landing maneuvers
- Rapid loading or unloading of cargo (usually no greater than 30 min. total procedure time)
- As much as possible, all equipment for cargo loading and unloading is incorporated into the airship
- Needs a ground operations area with a diameter no greater than 2.5 times the airship length

- Operate in and out of an area surrounded by obstacles (buildings or trees) 50 ft or less in height
- Conduct cargo loading or unloading from flat ground, inclined ground, soft ground, beach, ice, ship, or barge

Design

- Can operate without the need to conduct a load exchange or take on ballast when offloading cargo
- Can conduct extended operations in all climates (Min. temp -30 deg. C to Max. temp +40 deg. C)
- High resistance to UV radiation degradation of airship materials
- Incorporate designs and technologies to minimize ice and snow accretion on the hull and fins
- Low helium loss rate and low rate of air contamination to the helium gas
- Computer augmented flight control to enable precise hover or landing maneuvers
- Vectoring thrust for greater controllability in hover, and broader airship performance and operations
- Accommodate the widest range of freight types (CONEX containers, vehicles, bulk liquids (fuel or water), bulk dry loads (grain or coal), pallets, cargo net loads, and oversized project freight.
- Enable in-flight refueling, re-crewing, resupply, and minimal maintenance on a continuing basis
- Make multiple small (size/weight) cargo drop-offs at numerous sites during one mission
- Provide airship deliverable fuel storage tanks, automated weather station, ground based cargo handling equipment, maintenance equipment, critical spares, and cabins for ground and flight crews
- Safe and reliable means for maintaining the airship's weight balance during all flight phases and operations (cargo loading, unloading, refueling, re-crewing, resupply, and maintenance).
- Safe refueling (on the ground or in hover) by hose or hoisted fuel bladders
- Airship systems to support carriage of temperature sensitive payloads (food, medicine, perishables)
- Onboard accommodation for required periods of rest for onboard crews
- Onboard accommodation for two flight crews during long duration flight operations

Operations

- Can deliver cargo into austere or unprepared locations
- Can conduct airship cargo operations from austere locations with minimal ground infrastructure
- Can be securely moored when on the ground for extended periods (weather and maintenance)
- Can be temporarily secured when on the ground for short durations (loading/unloading, refueling, re-crewing, resupply, and maintenance)
- All maintenance (except annual inspection and significant repairs) conducted at austere operating site
- Operate out of existing airfields without impairing other aircraft operations
- Able to conduct light landings or substantially heavy landings
- Ability to vector thrust to hold the airship down against the ground to temporarily increase the airship's dynamic heaviness during ground operations durations (loading/unloading, refueling, re-crewing, resupply, and maintenance)
- Modest survivability to small arms and RPG attacks (a more specific description of this metric is needed)

A survey was conducted of modeling and analysis tools applicable to lighter-than-air vehicle design and operations. The sources and users of those tools were identified along with the capabilities, strengths and weaknesses of each tool as they apply to lighter-than-air vehicles. A gap analysis was conducted to delineate further tool development that is required to meet the needs of current and future airship design efforts and the technologies involved in those efforts.

Observations

The study identified a nascent but challenged airship industry and identified several factors that have been and continue to be obstacles to the emergence of an industry capable of constructing viable transport airships:

- Profound underestimation of program funding required
- Overoptimistic assessments of available development or investment funds
- Severe and chronic underfunding of airship programs from initiation to ultimate financial collapse
- Overestimation and overselling of the airship's performance, capabilities, and operational costs
- Poor technical and financial management practices by start-up airship developers
- Shortage of designers and engineers with unique airship skills
- Insufficient customer understanding or influence on airship requirements, design, or CONOPS
- Excessively short or unachievable development schedules set by customers or investors
- Customers and investors unwillingness to risk corporate funding or reputation on airship development
- Unbridgeable gap between customer expectations and airship capabilities
- Investor or customer impatience with:
 - Airship development time and cost outlays
 - Staged development of sub-scale or interim sized airships to establish technical knowledge base
 - Roadmap for specific airship technology R&D efforts to reduce principal program risks
- Schedule delay or increased costs due to unanticipated technical obstacles
- Cutting corners with technical development processes or airship design to save money or shorten schedule
- Unfamiliarity by aviation certification authorities with factors governing airship design, and operation
- Inadequate or non-existent regulations governing airship design, development, certification, and operation
- Underestimation of certification impacts on development schedule and costs

Number 1 Reason: Lack of certitude that the airship company could build the airship that was proposed.

Recommendations

A comprehensive set of airship operational modeling tools is needed that is flexible enough to capture the various inputs of any proposed airship operational market, application, or mission. The set of modeling tools would need to be user friendly enough to allow airship developers (and their end customers) to easily work with the tool developers to quickly identify the airship performance requirements for the preferred operational scenario. This robust set of modeling tools must also enable investigation of the basic airship design, principal sub-systems and how they inter-relate into a platform that can achieve the full airship performance features. These tools need to model the airship's aerodynamics, structures, propulsion systems, landing systems, flight controls, gas management, ground handling, maintenance, and cargo handling systems with opportunities for introduction of new technologies or design approaches within each. This tool set would be of more immediate value to the airship designers who could utilize it in refining their current designs, or in responding with a new design that could meet the airship requirements that the operational model could generate.

There is a small but steadily growing airship development industry which is in need of world class airship modeling and simulation investigations for airship designs, manufacture, and operations. The community of interested potential airship users is also expanding but their commitment of funds toward airship utilization is being withheld due to the lack of comprehensive data on the viability of airship technologies and airship operational cost/effectiveness. NASA Ames is in a prime position to provide the critical modeling and simulation investigations needed to unlock the great potential of the airship industry, especially for its end-users.