Airship Training and Simulation

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Airship Ventures
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• Flying an airship

• LTA Commercial Rating
  • Ab Initio (From the Beginning)
  • Commercial Fixed or Rotary Wing
  • Transition (Commercial LTA to Zeppelin)

• Simulator
  • Training Costs Airship vs. G-IV
  • Benefits
  • Challenges of Simulating an Airship

• Summary
**DIMENSIONS**
- Length: 75.0 m
- Max. width: 19.5 m
- Height: 17.4 m
- Envelope volume: 8,020 m³
- Ballonet volume: 1,400 m³
- Surface area: 2,630 m²

**MASS**
- Max. take-off weight: 8,040 kg
- Useful load: 1,950 kg

**PERFORMANCE**
- 3 x Lycoming IO-360: 200 hp
- Max. level flight speed: 100 km/h
- Range: 900 km
- Ceiling: 2,850 m
- Max. Endurance: apx. 24 hrs

**CABIN**
- No. of seats: 2 + 12
- Cabin volume: 26 m²
- Cabin length: 10.7 m
Zeppelin in Flight Configuration
Zeppelin NT-07

New Technology

Re-defined rigid structure – outstanding safety
aluminum / carbon fiber hybrid structure

Multi-layer composite envelope

Automatic envelope pressure system

Thrust vector flight control

Full fly-by-wire flight controls

Composite empennage and cabin
state-of-the-art light weight construction
Zeppelin NT in Landing Configuration
The Zeppelin NT: Re-Definition of the
Semi-Rigid Airship Concept

Zeppelin NT internal rigid structure:
Comprises 3 longerons
Connected via 12 triangular frames
Engines, passenger gondola and empennage attached to rigid structure.
Envelope attached to the structure
Increased total stability through helium inflated envelope
In case of loss of helium pressure structure ensures flight controllability – no envelope collapse
Our airship flies with the combination of three forces:

**Static Lift** – the buoyancy provided by the lifting gas \( \sim 7200 \text{ m}^3 \) – constant from sea level to pressure ceiling

**Dynamic lift** – the aerodynamic lift provided by the air moving over the envelope – dependant on airspeed

**Vectored Thrust** – the power provided by the static thrust of the propellers angled upwards – dependant on throttle setting
Aerostatics

Super Heat – helium becomes warmer than the outside air temperature – less dense, more lift

- This occurs daily
  - After sunrise and prior to flight the superheat value measured in 1 degree C increments can reach up to 10 degrees C for a light colored ship
  - After takeoff, this value will decrease due to air flow over the envelope and within the ballonet
  - Superheat value will increase at zero airspeed
  - Superheat value will change in flight
    - Day to Night or Night to Day flight
    - IFR to VFR or vice versa
  - 3 degrees of superheat in the NT-07 equals approximately 100 kg of additional static lift

- Temperature Inversion
  - Cooler air trapped near the ground – causes sudden increase in lift during approach
1. Weight and Balance Basics

1.1 Airship Weight and Balance – Weight (Heaviness)

The *lift* of an airship comes from the weight difference between helium and air. For better understanding of weight and balance of an airship, the lift can be merged to one point. This point is called **Center of Buoyancy**.

The **weights** of an airship can be merged to one point too. This point is called **Center of Gravity**.

The heaviness of the airship is defined by:  \[ \text{Heaviness} = \text{Weight} - \text{Lift} \]
Ballonets are inflatable bags located inside the airship that can be filled with air.

The Ballonets perform two functions:

- Maintain a constant pressure on the envelope by compensating for the expansion and contraction of the helium as the temperature or altitude of the airship changes.
- Maintaining the trim of the airship fore and aft.

As the airship rises in the atmosphere, the helium expands due to lowered external air pressure – air is forced from the ballonets through relief valves.

When the ballonets are empty, the airship is at its pressure ceiling – and cannot rise further without risking damage to the envelope or venting (expensive) helium.
Flight Factors

Helium Volume
- “Shoot” helium (add helium to the envelope)
- Or release helium via the valves
- We lose some amount of helium each day from osmosis and leaks

Helium Purity
- Attach aircraft to helium purification plant (about every 6 weeks)
- Air and humidity get into the envelope

Fuel

Ballast
- Ballast is our safety net in case we have an emergency, a strong descent, or have to vent helium

Service Load (passengers and payloads)
What happens when you fly backwards?

Positive angle of attack generates lift on the envelope. Center of lift is well forward on the airship.
### The Zeppelin NT: Thrust Vector Control – Propulsion System

<table>
<thead>
<tr>
<th>Lateral Power Plants</th>
<th>Aft Power Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="0 position" /></td>
<td><img src="image2" alt="Aft Power Plant" /></td>
</tr>
<tr>
<td><img src="image3" alt="90 position" /></td>
<td><img src="image4" alt="Zeppelin NT-07 Thrust Vector Control" /></td>
</tr>
</tbody>
</table>

Two lateral power plants, with a 0 to 120 propeller swivel range and adjustable pitch propeller blades for precise thrust and direction adjustability.

One additional dual propeller (one swivel) aft power plant for simultaneous lateral and vertical thrust.

Maximum maneuverability sustained during take off and landing when aerodynamic control is ineffective.

Continuous complete pilot control at all flight conditions.

Only 3 ground crew necessary for passenger turn-around (12 passengers) in four minutes.
Thrust Controls

- Side Engine THRUST Levers (2)
- Side Engine SWIVEL Levers (2)
- Aft Engine SWIVEL Lever
- MIXTURE Levers (3)
- RPM SEL Levers (3)
- RPM SEL Mode Switches (3)
Thrust levers control the pitch of the propellers – including zero and reverse. Throttles are automatic.
Getting your Airship Rating
LTA Commercial Rating – Ab Initio (no experience)

Standard duration of training: Approximately 20 months
Maximum duration of training: 24 months
Theoretical (ground) training: 300 hours
Practical training: Three months on a ground crew
Minimum of 50 training flight hours
Minimum of 150 supervised flight hours
Pass the Written Test, Practical Test, and Class II Medical

“Supervised” means a current, rated commercial pilot is in the other seat
Standard duration of training: Approximately 15 months
Theoretical training: Minimum of 93 hours
Practical training: Three months on a ground crew
Minimum of 40 training flight hours
Minimum of 130 supervised flight hours
Pass the Written Test, Practical Test, and Class II Medical

There is NO Airship Flight Instructor rating – any commercial Airship Pilot can act as a CFI - and therefore the CFI material (FOI) is on the Commercial Airship test
Zeppelin Transition – LTA Commercial Pilot

Standard duration of training: Approximately four months
Theoretical training: Minimum of 49 hours
Practical training: Minimum of 25 training flight hours
Minimum of 100 supervised flight hours

No additional FAA Written or practical test is required
(a) Zeppelin Airship systems training;
(b) Airship flight manual (AFM) and all appropriate AFM supplements;
(c) Use of emergency equipment;
(d) Use of the PITEX computerized weight and balance program;
(e) Use of the FAA-Approved minimum equipment list (MEL);
(f) Pre-flight inspection procedures;
(g) Normal procedures;
(h) Abnormal and emergency procedures;
(i) Engine runups and systems checks;
(j) Ground crew coordination to include unmasting;
(k) Refueling operations;
(l) Masting and taxiing with the mast truck, and
(m) Post-flight procedures.
1. Flight and Crew Coordination
2. Weight and Balance and Trim
3. Pre-Flight and Checklists
4. Engine Runs and System Checks
5. Ground Maneuvering on the Mast
6. Straight and level Flight (Altitude/Heading)
7. Turns, Climbs and Descents (Alt/Pressure) Control
8. Unmasting Procedures
9. Ground Maneuvering Off the Mast
10. Takeoff with Various Static Heaviness
11. Takeoff with Maximum Static Heaviness
12. Transition into Flight Configuration
13. Flight to and from Pressure Height
15. Manual Pressure Control
16. Trim in Flight
17. Hovering Maneuvers
18. Approaches to Landings
19. Landing with Various Static Heaviness
20. Landing with Maximum Static Heaviness
21. Landing Light and at Equilibrium
22. Landing with Maximum Static Lightness
23. Go-Around Procedures
24. Ground Maneuvering off the Mast
25. Masting Procedures
26-28 Flying by Instruments
29. Engine Failure and Runaways on Takeoff
30. Vector Failure and Runaways on Takeoff
31. Engine Failure and Runaways on Landing
32. Vector Failure and Runaways on Landing or during Hover
33. Engine Failure and Runaways in Flight
34. Vector Failure and Runaways in Flight
35. Engine Failure and Runaways during Hover
36. Free Ballooning
37. Envelope Emergencies
38. Ditching and Emergency Landings
39. Electrical System Failures
40. Aerodynamic System Control Failures
41. Fire Emergencies
... + 28 more emergencies and failures
Zeppelin Flight Experience
8 hours ground school
Walkthrough of Airship Preflight
30 minutes of “stick time”

Airship Currency
Airship Flight Training (LTA)
Airship Flight Training (Non-LTA)
Simulators

A Simulator artificially recreates aircraft flight and the flight environment

Several types:
• Procedural – switches, knobs and dials, checklists
• Physics – flight models, aerodynamics – may be used for research, engineering (CFD, FEA, etc.)
• Desktop – PC / display + joystick
• Handling – responses, power, controls
• Full Flight Simulator – cockpit, handling, and environment
  • FAA approved for logging time
Why do we care?

Practice emergency procedures without risk to the airship
Practice rare events (major envelope leak)
Environmental Conditions outside of normal range
Flight operations out of normal range (CG extremes, exceeding pressure ceiling)
Practice time consuming events (IFR approaches)
Cost of training pilots
G-IV - $36M, seats 14-19, 73,000 lbs, Mach 0.88 (528mph)

21 days – $26,200 – 120 hours

Of which 100% are in the simulator

$218/hour

1 hour in the aircraft = $5500

120 hours = $660,000
Full Flight Simulators

FAA - Levels A-D
ICAO Document 9625-3 Types 1-7

Positive Transfer of Training
- Habits learned in the simulator directly correspond to habits needed to fly the actual aircraft
Agreed list of simulation features elements required to support any individual training task

Source: ICAO “Simulator Int. Working Group”
<table>
<thead>
<tr>
<th>Color legend</th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Type IV</th>
<th>Type V</th>
<th>Type VI</th>
<th>Type VII</th>
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</thead>
<tbody>
<tr>
<td><strong>Specific</strong></td>
<td>PPL,</td>
<td>IR</td>
<td>Class</td>
<td>MPL2</td>
<td>TR, ATPL</td>
<td>MPL3</td>
<td>TR, ATPL</td>
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<tr>
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<td>(T)</td>
<td>Rating</td>
<td>(T+TP)</td>
<td>IO, RO, RL</td>
<td>(T+TP)</td>
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<td>(T)</td>
<td>(T)</td>
<td>(T)</td>
<td>(All T)</td>
<td>(T+TP)</td>
<td>RE, RO, RL</td>
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</table>

<table>
<thead>
<tr>
<th>Cockpit &amp; Structure</th>
<th>Class, enclosed</th>
<th>Generic, Open</th>
<th>Class, enclosed</th>
<th>Class, enclosed</th>
<th>Aircraft replica, enclosed</th>
<th>Class, enclosed</th>
<th>Aircraft replica, enclosed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruments &amp; Panels</td>
<td>Flat Panel &amp; Overlay</td>
<td>Hi Quality Flat Panel &amp; Overlay</td>
<td>High Quality Flat Panel &amp; Overlay</td>
<td>Hi Quality Flat Panel &amp; Overlay</td>
<td>Hi Quality Flat Panel &amp; Overlay</td>
<td>Hi Quality Flat Panel &amp; Overlay</td>
<td>Hi Quality Flat Panel &amp; Overlay + Full 3D replication</td>
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<tr>
<td>Non sim area</td>
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<td>Visual display</td>
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<td>45 x 30 Flat Screen</td>
<td>200 x 40 Direct</td>
<td>45 x 30 Flat Screen</td>
<td>200 x 40 Direct</td>
<td>200 x 40 Collimated</td>
<td>200 x 40 Collimated</td>
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<td>None</td>
<td>None</td>
<td>Reduced 6 DOF</td>
<td>Full 6 DOF</td>
<td>Full 6 DOF</td>
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<tr>
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<td>Class rep.</td>
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<td>Aircraft Specific</td>
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<td>Aircraft Systems</td>
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<td>Aircraft Representative (Required Procedures)</td>
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<td>Background Chatter</td>
<td>Background Chatter</td>
<td>Background Chatter</td>
<td>Background Chatter + Dynamic Automated Environment + Dynamic ATC Environment</td>
</tr>
</tbody>
</table>

Source: ICAO “Simulator Int. Working Group”
VMS is a large scale full motion simulator with 60 feet of vertical movement and 40 feet of horizontal movement.

Has been used for Space Shuttle, F-35, helicopters and airships.