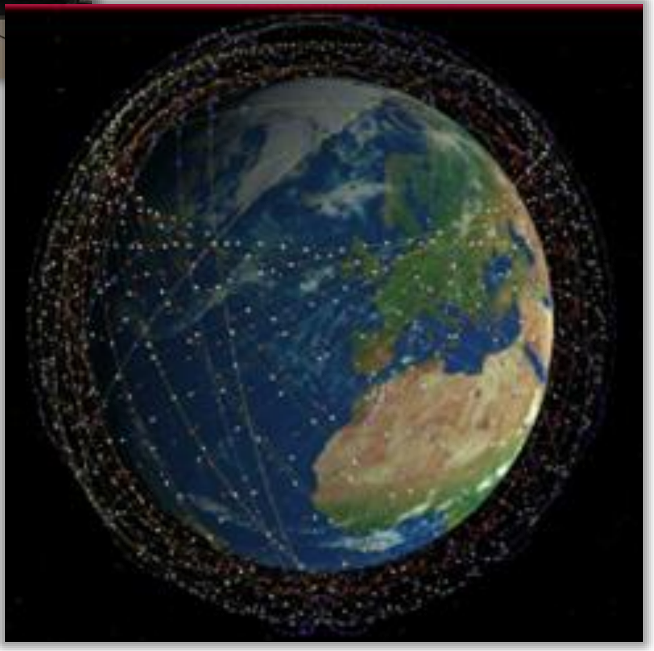
System Engineering course 2023

High Altitude Airship Challenge

as advanced 5/6G networks platform



Background

1. One of the most promising areas for the development of mobile communications are systems in which base stations are located on low-orbit (200+/- km) satellites, for example, the already operating Starlink (https://www.starlink.com/).

2. Perhaps a more cost effective solution might be Unmanned High Altitude Airship (UHAA) operating at 20+/- km altitude as a platform.

- The “constellation” of such service UHAAs shall mostly drift employing natural winds creating moving network of mobile base stations. The idea is to keep energy consumption for propulsion as low as possible.
- To form close-loop routs we could develop and build special towing UHAA to return service UHAA to starting points of the route.
- Another solution could be to develop service UHAA to operate in two modes: energy-saving free drift and energy-intensive propulsion flight.

3. Let's test this hypothesis.

4. To do this, you should study and understand the technologies that are critical to economically viable UHAA and formulate the requirements for those technologies to make UHAA economically feasible.

Possible projects

1. Service UHAA

Three teams:

- Design the structural components and layout of the service UHAA, including sufficient propulsion for steering, altitude controls, communications, remote sensing.
- Specify materials, dimensions, and basic systems.
- Develop a scaled-down model and prototype of the UHAA both virtual and physical to test some important functionalities of the proposed system.
- Implement basic autonomous features for the service prototype.
- Design the connecting mechanism in collaboration with one of the Towing UHAA teams.

2. **Towing UHAA**

Three teams:

- Design the structural components and layout of the towing airships., including propulsion, storage of energy, controls., etc.
- Design the towing mechanisms (tethering and steering systems to alter the flight path or direction(Forward & Reverse) of the towed UHAA).
- Create a scaled-down prototype of the towing UHAA including the mechanism capable of adjusting trajectory while maintaining stability and controllability.
- Plan and execute the simulated towing and trajectory-altering process to demonstrate how the towing mechanism influences the direction of the towed UHAA.
- Identify potential risks during the towing process and propose mitigation strategies. Ensure compliance with aviation regulations when flying tandem, changing trajectory or towing.

3. UHAA horizontal trajectory (in wind field) coordination system

Two team:

- Design and prototype the systems responsible for controlling the UHAA's horizontal trajectory in varying wind conditions.
- Develop a scaled-down model demonstrating the trajectory control functionalities within simulated wind fields.
- Create and integrate systems for wind sensing, trajectory adjustments, and adaptive algorithms.

Project objectives

1. Each team must

- study and analyze contemporary airship architecture, constituents and appropriate set of technologies,
- select a concrete technology,
- develop and prototype technology solution to support feasible UHAA vehicle.

2. All projects must deliver:

a) Stakeholders analysis
b) ConOps of the proposed system
c) Clear set of technical requirements
d) Risk analysis
e) MBSE model of the system based on SysML
f) A physical prototype and its digital twin including PBS and BOM
g) Verification and validation plans
h) Interface management plan and results
i) Configuration management and data management implementation
j) Demonstration of the prototypes: physical and virtual
k) Certification plan meeting air and maritime regulations
l) Project plan including WBS

Team structure

Each team must be structured at a minimum with :

- Team leader selected amongst its members
- MBSE modeler
- Analyst: interfaces, risks, certification, DSM, …
- Configuration and data manager
- Prototyping: physical/virtual team

Note : Each team member must take responsibility for some deliverables; this responsibility must be clearly described in the WBS at the PDR presentation and report. Responsibilities can be shared between team members but must be clearly identified. Peer review within each team will also be carried out and will be part of the final grade of the course.

Important notes

Principle of focus : the number of identifiable issues that will influence a system at any point is beyond one's ability to understand. One must identify the most critical and consequential issues, and focus on them.

Systems Architecture: Strategy and Product Development for Complex Systems **1st Edition**
by Edward Crawley, Bruce Cameron , Daniel Selva, Pearson, 2016, page 36

- The purpose of the physical and virtual prototypes is to support the functional verification of the proposed system for some of the technical parameters.
- The development of the prototypes must also be linked to the mitigation of some identified risks.

A useful sources

3 parts review: https://lynceans.org/all-posts/modern-airships-part-1/

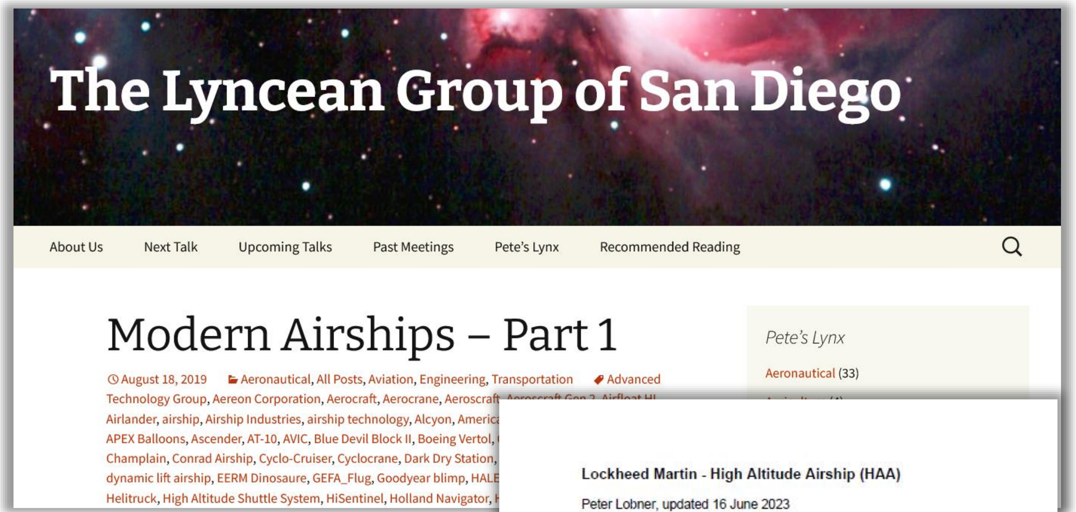
https://lynceans.org/wp-content/uploads/2021/08/Lockheed-Martin_HAA.pdf

https://link.springer.com/article/10.1007/s11831-022-09867-9

https://www.sciencedirect.com/science/article/abs/pii/S1270963821007616

https://www.sciencedirect.com/science/article/abs/pii/S1270963821004326

https://en.wikipedia.org/wiki/Prevailing_winds



Lockheed Martin - High Altitude Airship (HAA)

Peter Lobner, updated 16 June 2023

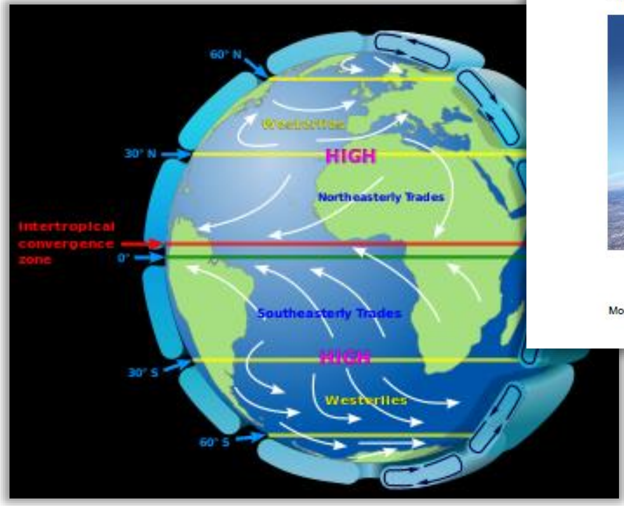
1. Introduction

The Army's High Altitude Airship (HAA) Advanced Concept Technology Demonstration (ACTD) program's original long-term objective was to develop and deploy very large solar-powered airships (HAA Operational Systems) capable of carrying a 2,000 pound (907 kg) payload to an altitude of 65,000 feet (12.3 miles, 19.8 km) while generating 15 kilowatts of power for a payload for conducting persistent (24/7) on-station intelligence, surveillance, and reconnaissance (ISR) missions lasting more than 30 days.

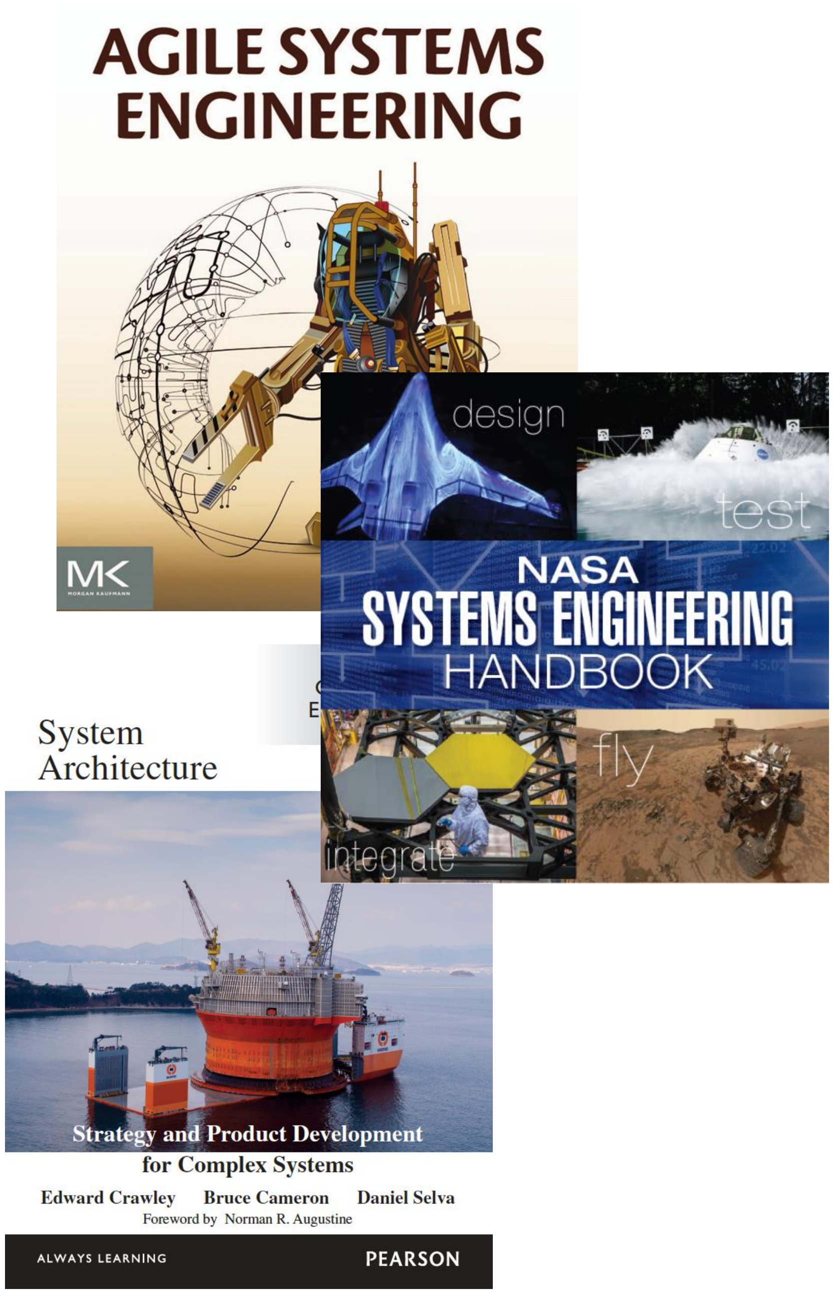
Development of the full-scale HAA stratospheric airship was conducted in parallel with science and technology development efforts being performed under separate programs with the sub-scale High-Altitude Long-Endurance Demonstrator (HALE-D) airship and the HiSentinel family of airships. These stratospheric airships are the subjects of separate articles.

Artist's rendition of an early version of the Lockheed Martin HAA stratospheric airship in flight. Source: Lockheed Martin

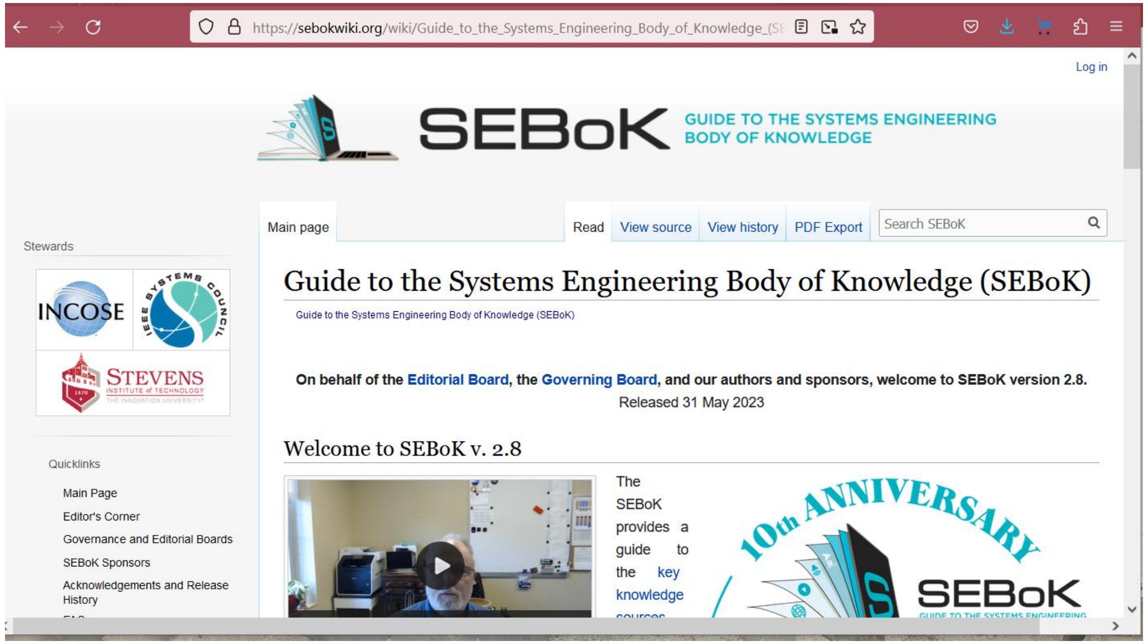
Modern Airships 1

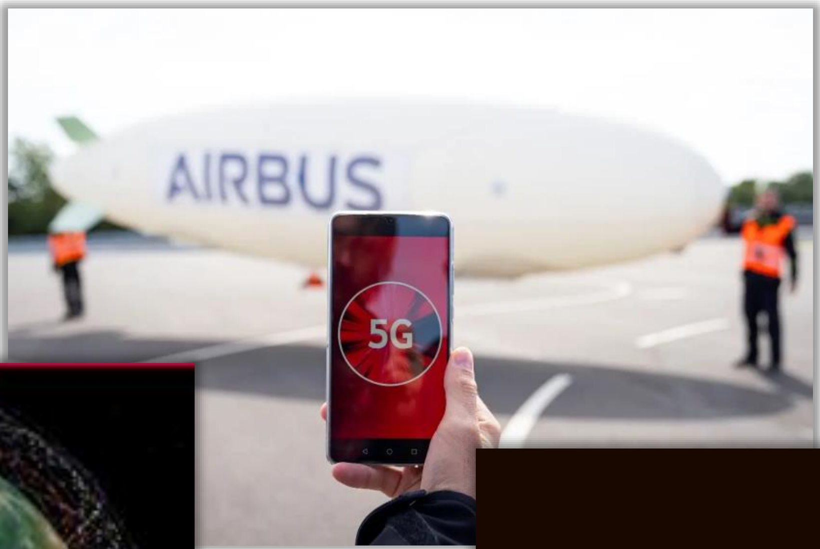


SE literature:



https://sebokwiki.org/wiki/Guide_to_the_Systems_Engineering_Body_of_Knowledge_(SEBoK)





Any questions?