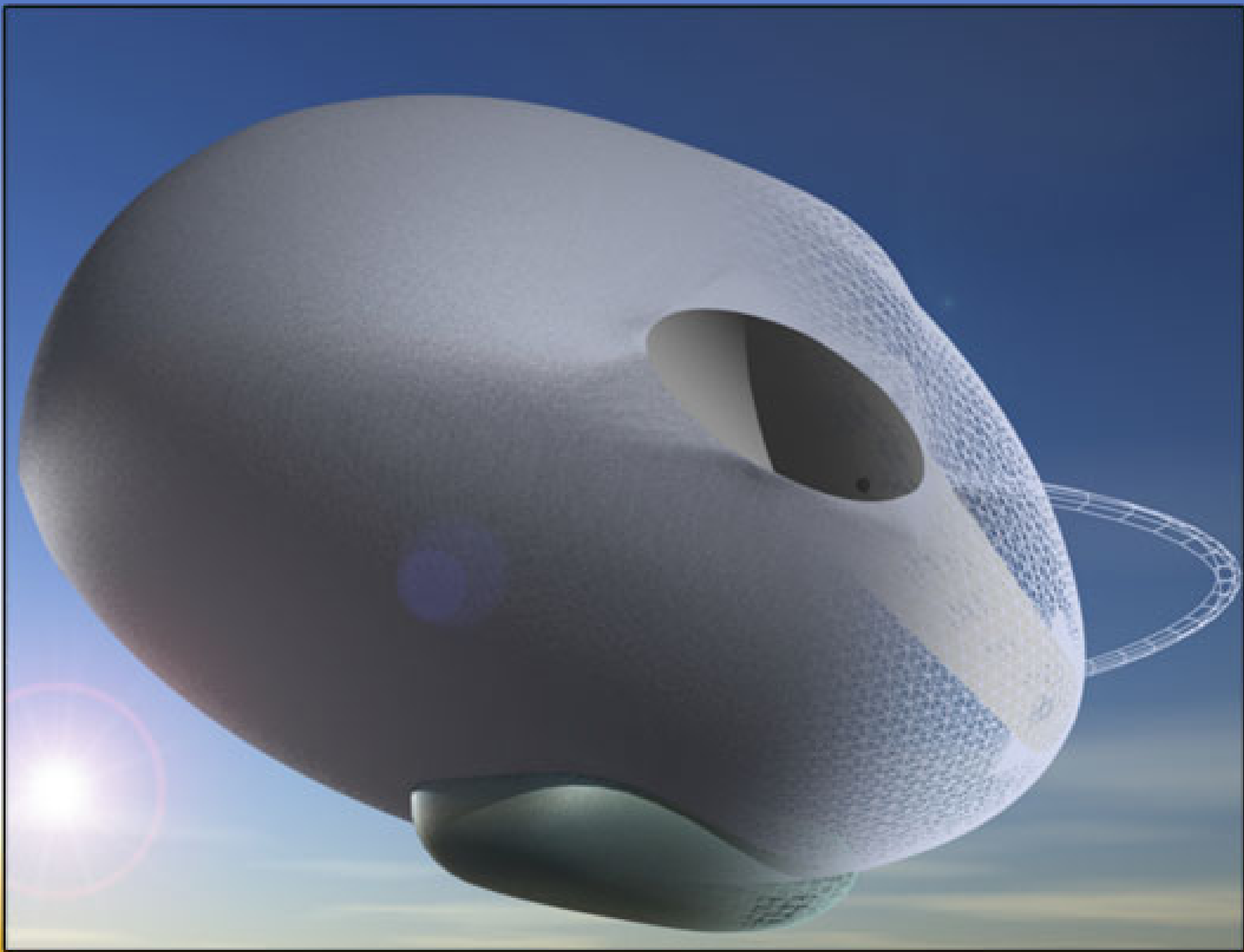
AEROSPACE CHALLENGE

2005



Team Horizon:

Alan Baban	12/3/88
Maxim Daniline	17/10/87
Chris Oulton	19/1/88
Ravi Raja Rayan	11/12/87
Johnny Rees	11/8/89

School info:

St Paul's School
Lonsdale Road
SW13 9JT
020 8748 9162

Adult Sponsor:

Dr A Gardam
(Physics teacher)
ag@stpaulsschool.org.uk

Email Adresses:

raviki@gmail.com
dag00se@msn.com
chawalabear@hotmail.com
evilcretin@hotmail.com

Specific Questions

1. What are the most challenging targets that would need to be detected, tracked and identified?
The key aim of the airship is in air policing and airspace surveillance and thus, must be able to detect the presence of, track and be able to identify any flying object within the airships field of view, the hardest of which being small, but fast moving objects such as fighter jets and perhaps even missiles

2. What sensor technologies might be used to address these targets?
Radar would be a vital piece of equipment required to determine how many bodies are present in the air but to identify these bodies, infrared elements as well as optical detection with image recognition would be required including means of communication (radio) with any aircrafts in the area for identification.

3. What are the main advantages of airships over other platforms?
Airships have the ability of carrying large-aperture radars more effectively, since the radar is mounted in an envelope, free from any governing constraints on shape, its stationary and low-speed flight allowing better surveillance in turbulent surroundings. Highly fuel efficient, they are better in the long term economically, costing less to support and maintain.

4. What are the main disadvantages of airships over other platforms?
The great size of the airship poses manoeuvrability difficulties, with the craft being tied to surveying a limited area, whilst movement is slow, causing problems in emergency situations, so that several airships may be needed, each with its own designated area, which is in itself problematic, due to the high capital input for the initial manufacture of them.

5. What other roles might airships perform?
Airships can be used to track criminal activities such as drug smuggling, its large inner space and mid-air stability, free from vibrations, facilitating the crew to accomplish actions efficiently, whilst its large lift potential means that it can surmount any radiation, chemical poisoning or viruses so a long-standing, airborne command centre can form.

The History and Development of Airspace Surveillance

The 20th century gave birth to some of the most lauded and important scientific development, useful for both civil and military purposes.

A decisive breakthrough was the first aircraft flight by brothers Orville and Wilbur Wright in 1903, using the 'Wright Brothers' Flyer'. Such successes and the publication of books such as Octave Chanute's *Progress in Flying Machines*, meant that the theories behind flying were harnessed and improved to such an extent as to allowing them to be used more widely.

Such technology became invaluable in allowing the war effort made by several countries between the two great wars of the 20th century, the production output of certain companies like Panam focused mainly on the fighter jets that became as synonymous with war as the images of soldiers in trenches or doing battle.

The Cold War, however, ushered in a new era of paranoia, the possibilities of moles in countries and the fact that the Second World War showed the moral depths to which modern man had stooped, for example the development of nuclear capability, meant that some sort of surveillance system was needed for national security purposes.

For any surveillance to work effectively, the emergence of aircraft radar was needed, and this was worked on in America, in places such as the Massachusetts Institute of Technology's Lincoln Laboratory and the MITRE corporation which pioneered SAGE, the Semi-Automatic Ground Environment.

This was first put to use in air traffic control systems, which is surveillance essential in the running of an efficient and profitable airport system, before being transferred to more militaristic uses.

The Electronic Systems Center, activated on the 1st April 1961, as the Electronic Systems Division (ESD), and placed under the newly-established Air Force Systems Command, marked the establishment of the first major airspace surveillance system, in response to possible threats to North American from long range, nuclear-armed bombers. So-called 'C3' systems for command, control and communications developed during this period.

As weapon technology progressed further and the tantalizing sense of world paranoia heightened, more surveillance efforts were made, notably the construction of the Ballistic Missile Early Warning System (BMEWS) and new command centers for Air Defense, sheltered from interference radar signals from enemy vessels and from attack in general, for example under the Cheyenne Mountains in Colorado.

One problem, though, was that such surveillance systems were ground based and so could not offer a fully accurate data view of any designated area. Eventually organizations such as the ESD expanded into airborne radar systems, made possible by the 1970s Airborne Warning and Control System (AWACS), which overcame previous 'ground clutter' difficulties.

This was joined in the 1980s by the Joint Surveillance and Target Attack Radar System (Joint STARS), which monitored movement on the battlefield for the Gulf War. Other than wars and air traffic controls, the increasing reliability of such systems meant that they could be securely applied to intelligence data transmission and computer-based training systems.

The new climate of global terrorism has meant that the ESC has developed new airspace surveillance programs that work towards the integration and interoperability of communications systems, so that the ESC can engage in ongoing information exchange and acquire such information in new and better ways.

Existing Projects

Due to the growing importance of airships in today's modern society and altered political climate, several airship projects are currently underway around the world.

The first ever 'Airship Airport' is being developed in the College Point Corporate Park in New York by 'Airships Unlimited Inc.', which contains a large enough grass area for the mooring of three airships at anytime, with a separate operations building, complete with weather and communications facilities nearby for the efficient coordination of airship take offs and landings. A planned public airship museum will also be housed in the area, in order to bring added revenue to improve built facilities, and to spread knowledge about the history of airships.

In the Netherlands, an extensive scheme of implementing airships into monitoring the skies is currently underway, most notably in the 'Dutch Airship Cooperation', whose goal is to set up a public-private partnership in relation to the exploitation of airship technology for observation tasks. There is also a project, financed by CONNEKT (the Dutch knowledge centre for transport and logistics) and to be potentially executed by the 'Platform of Airships' in association with Delft Technical University, to use airships for transportation in the Netherlands, with various travel agencies interested in the project's tourism aspect.

Nasa is soliciting offers for a protected airspace surveillance system for a national airspace system. The study and assessment focuses on a surveillance system of the airspace of high value institutions and restricted airspaces.

While these projects are underway, LTA (lighter-than-air) technology is continually being improved on around the world, an example being the studies of the German aerospace organisation '*Deutsche Gesellschaft für Luft- und Raumfahrttechnik (DGLR)*', which holds regular conferences on LTA. Several companies coordinate to ensure fast progress in aerospace technology, with 'Charles Ross Associates Limited' also currently developing surveillance concepts for expeditionary forces and Homeland Defence.

Design Objectives

The requirements for the airship are stated to be that:

UK forces require a 24/7 airspace surveillance capability for Homeland Defence should it become necessary to establish an Exclusion Zone or for force protection/air policing in a deployed operation.

From these requirements we have identified a number of design objectives that must be reached for the airship to suitably meet the requirements

The fact that the airspace surveillance capability has to be able to maintain altitude and operation '24/7' makes an airship an obvious choice on account of its **low running costs** and is able to remain in the air for extended periods of time. However in order to keep the airship afloat for the maximum amount of time a number of design objective s can be determines:

1. The airship will have to be **unmanned** so that the airship need not have to descend to exchange crews
2. The airship will need to have a large **energy source**, one which can fuel the engines and the surveillance equipment for months

Ideally, the airship will have to be able to continue operations and remain in the sky, and our goal is to design it so that it can remain in the sky for as long as a *year* before needing to be brought down for maintenance.

In the event that an Exclusion Zone need to be created, the airship would have to be the only aircraft allowed in such a no-flight zone and would have to be able to provide as much information to ground stations on the airspace status such as alerting control centres of any aircraft entering the exclusion zone.

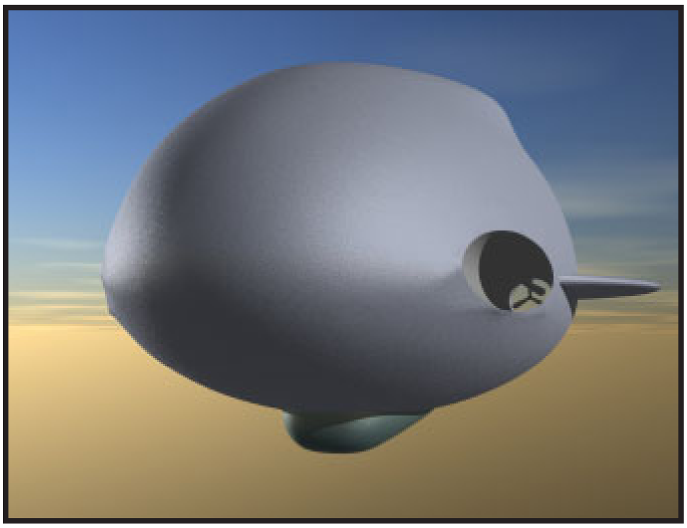
As air policing is one of the requirements, the airship ought to be able to *identify* all aircrafts within its radar's field of view, *communicate* with airport servers to find if the acknowledged aircrafts are permitted to be in the area and be able to establish a connection to any unidentifiable aircrafts so that a ground station can communicate with such vessels.

During a deployed operation, the airship can divert its resources to aid such an operation by acting as an **information hub**, providing information to ground troops as to the airspace situation above where they are and act as an information relay, so that ground based forces can transmit data to each other so long as both are within the airships large range.

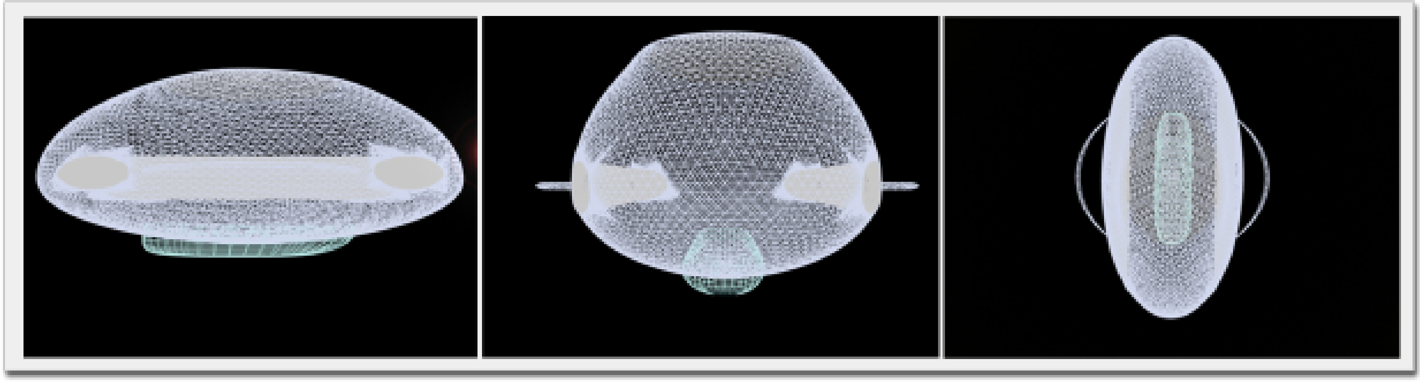
Airship Design

Structure

On account of the many disadvantages associated with the more classical rigid design where a metal frameworks would maintain the shape, a quasi rigid structure is being undertaken, whereby the strong sheet acting as the envelope withstands the forces of nature and maintaining its shape without requiring an internal, heavy metal framework. The material to be used will be made using the newly developed technology of nanotubing: nanometer-sized tubes composed of various substances, in this case, carbon. Using **carbon nanotubes** is ideal for the envelope sheet to surround the airship as it is both incredibly light at only 1.4g / cm^3 (similar to that of polyester) and one of the strongest materials known with a tensile strength of 150GPA (compared to Kevlar's tensile strength of of 3.4GPa). The weight of the load from the equipment will be held from the underside of the non-rigid part of the airship via a rigid lower keel construction hence evenly distributing the force to the envelope and reinforcing the entire system



In a worst case scenario, the airship may find itself in situations where it might be targeted by hostile aircraft and while carbon nanotubes are a very strong material and most helium airships can withstand small punctures to its structure an remain afloat for long periods of time after, on impact from a small missile or bullet, the



entire airship may be damaged to such an extent that it loses enough helium, quickly enough to fall to the ground and on anything underneath. To combat this possibility and while keeping the weight of the airship structure to a minimum, a **second envelope** would surround the existing helium filled envelope and itself be filled with air maintained at a constant pressure (so its pressure remains equal to that of the helium). Therefore, surrounding the main helium envelope there is essentially a buffer layer of air and further carbon nanotube surface acting as a sacrificial layer. Should there be impact from a missile, while the outer envelope may be damaged; the inner envelope will remain intact.

The propellers will be situated within the airships structure as shown on the diagram on the right. This is to ensure that they remain protected, hence have a longer lifespan and also, when the airship moves forward, as the airship ploughs through the air, the front of the airship can force the air either side, essentially funneling air into the propellers, hence providing a greater air intake.

Position

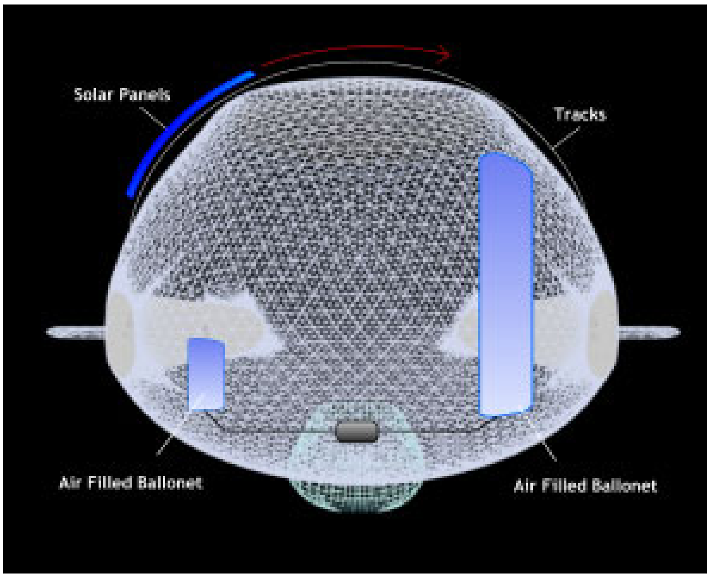
The airship will be positioned roughly 21km ±1km in the air (the stratosphere) so that they would be held between the powerful jet streams below and the strong stratospheric winds above so that the airship can maintain its position with minimum power consumption. At such a height, it's coverage is significantly increased too.

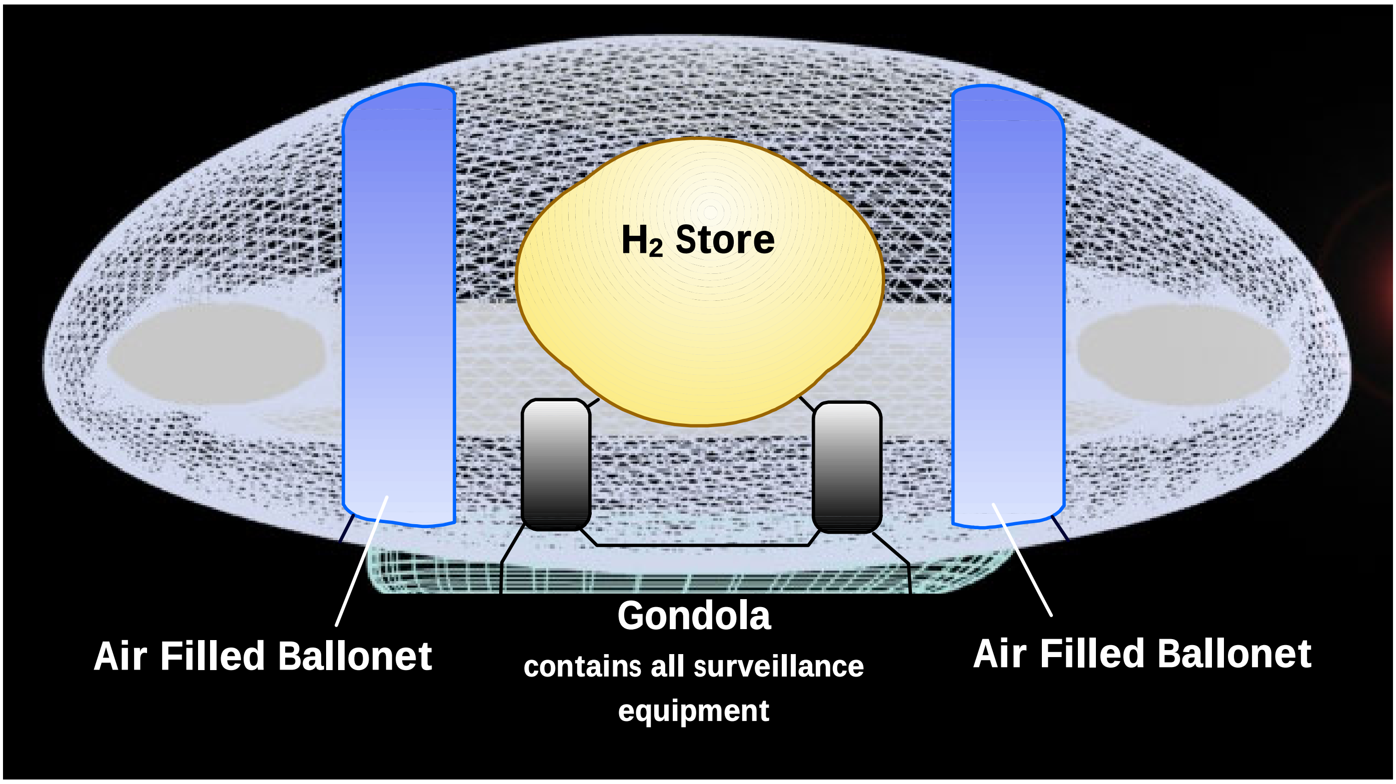
Energy Source

A design objective previously identified is that the airship will need to be able to stay afloat for as long as a year without refueling or maintenance. As helium is not used up and the amount lost to the air is negligible so long as there are no fractures in the inner envelope (and even so, any escaping helium would be contained within the outer envelope), the airship needs not have to descend to be refilled with helium.

However power is needed to run the engines (so as to keep the airship at a specific position), the surveillance equipment as well as the power needed to inflate or deflate the ballonets (the air filled bags which can be filled with air to adjust the altitude). While conventional airships use diesel powered engines, if the airship is to stay aloft for long periods of time, large amounts of fuel (and hence additional weight) would need to be stored and would eventually run out, thus another source of energy need be provided.

As the airship is to be located in the stratosphere, 13 miles above the Earth's surface, it will be predominantly above cloud cover. Hence, during the day time the craft would have a constant supply of fuel: the sun. Using **lightweight, thin-film photovoltaic arrays** (solar cells) to cover the top surface of the airship, the craft would be able to harness the energy from the sun and the electric power can be then diverted to power the electric motors to drive the lightweight but strong carbon fibre propellers and to power the electrically powered equipment. Even the lightest photovoltaic arrays creates additional weight to the airship and can be very expensive, and with only a portion of the top surface ever immersed in light, there will always be unused photocells, hence unnecessary weight. To overcome this problem, only **a third** of the airship's top and side surfaces will ever be covered and the solar cells will be arranged on tracks, so that as the day passes, the solar cells can slowly **move along the tracks,** around the top of the airship, hence always facing the sun. As the solar panels slowly move around the top of the airship, however, the weight distribution would change. This is why two of the four air filled ballonets will be dedicated to keeping the airship horizontally stable. Looking at the diagram (modelled in Lightwave), as the solar panels move fro left to right, air is transferred from the right ballonet to the left so as to keep the centre of gravity of the airship at the centre. The





other two air filled ballonets (shown in the diagram overleaf) are designed to alter the height of the airship, so pumps in air from the outside if it needs to descend back to ground level and pumps out air in order to reach the 21km altitude.

During the night, however, the main energy source (the sun) is removed, and while the obvious solution may be to use batteries to store the energy to be used overnight; batteries can be exceedingly heavy and even the specially designed low density ones have too low a power capacity to be worth the extra weight.

Instead of using batteries to store the energy, using the principle of the newly emerging fuel cell technology, the energy can be harnessed in the form of **hydrogen**. As water vapour (which is abundant in the atmosphere) consists of hydrogen and oxygen atoms, through electrolysis, it can be split into H_2 and O_2 molecules. The hydrogen can then be stored within a tank at the core of the airship. In order to generate electricity from this the hydrogen through fuel cell technology. This is where two electrodes are sandwiched around a an electrolyte and by passing over the stored H_2 gas over one electrode and O_2 gas (from the previous splitting process or from the surrounding air) over the other electrode, an electric current is produced as well as water vapour as waste which can then be diverted back to the splitting process where it is again split into hydrogen and oxygen.

Through this, while some hydrogen will be used to power the airship, there will be surplus made during the day as the power from the solar panels exceeds the power usage so a store of hydrogen is attained by the end of the day. Once the sun has set, the stored hydrogen can be used to keep a constant supply of electricity until day time. As hydrogen is also a lighter-than-air gas, storing it does not weigh down the ship but actually provides additional lift so is ideal for the design requirements of the ship. While hydrogen is often frowned upon for its highly reactive nature with oxygen (and many have preconceived prejudice against it as a result of the Hindenburg disaster last century) there is virtually no risk involved in storing the hydrogen as it will be at the core of the airship, surrounded by the envelope of inert helium and thus the risk of it combusting is minuscule.

Onboard equipment

Will consist of:

- A radar system using antennas as large as the airship's cross sectional area creating huge power aperture.
- High resolution digital cameras also equipped with infra red to identify objects at night
- Powerful computing equipment capable of processing the information from radar and optical inputs (for image recognition) will be onboard with lower power consumption and low weight using components specifically designed for portable use (such as the mobile AMD chip range)
- Radio transmitter and receiver for communications with unidentifiable aircrafts
- High bandwidth digital signals are to be produced and received on the 5.8GHz channel band will be able to transfer up to 34Mbps of data over the 21km down to ground stations, all of which encrypted with 128bit encrryption.. This will be used for transfering all data it recieves down to ground stations to be interpretted and can also be used as a large wireless access point for ground troops to communicate with each other via.