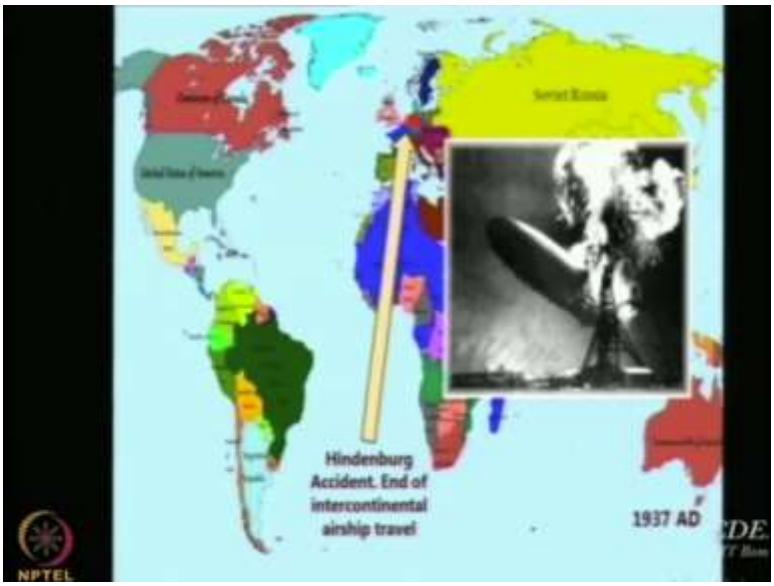
Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

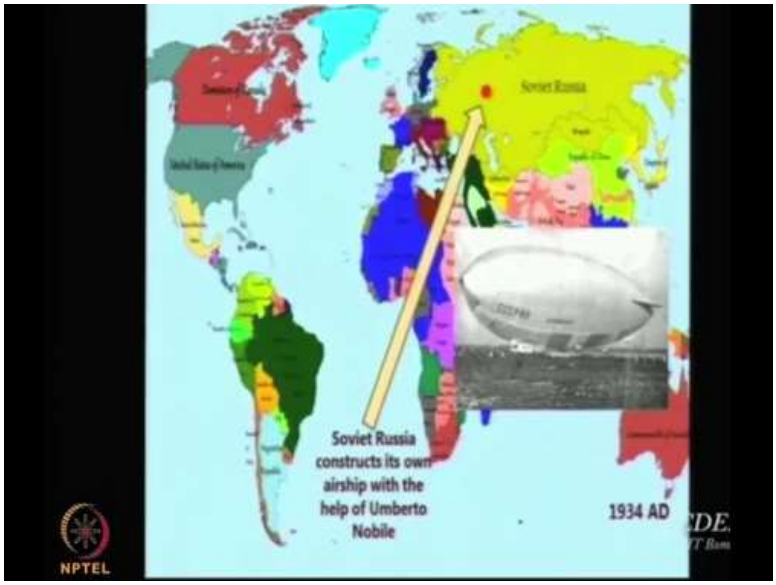
Lecture -14
Historical developments of LTA systems, Part-V

(Refer Slide Time: 00:16)



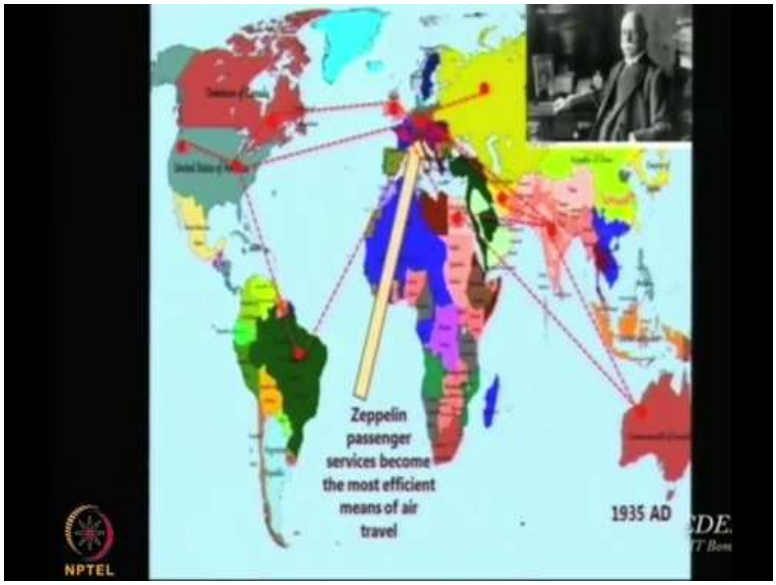
And then we had this disaster which is a very famous disaster called as the Hindenburg disaster. So with the Hindenburg disaster the intercontinental airship travel became completely unacceptable.

(Refer Slide Time: 00:29)



Then the Russians are also catching up very soon but what they are doing is they have now taken help from Umberto Nobile from Italy the same gentleman who went to the North Pole. His technology is being used by the Russians to make their own airships.

(Refer Slide Time: 15:03)



And in 1935, we see that Count Zeppelin is again planning to connect the whole world using airships. So he was planning an airline using airships for connecting various places all over the world.

And interestingly the US had very ambitious plans about use of airships. So when they built at that time the world's tallest building, the empire state building the top of the building was supposed to be an airship mast. Even now when you go to empire state building if you visit the empire state building they say that on the 101st floor if you go to the empire state building beyond that there is a conducted tour for the airship mast.

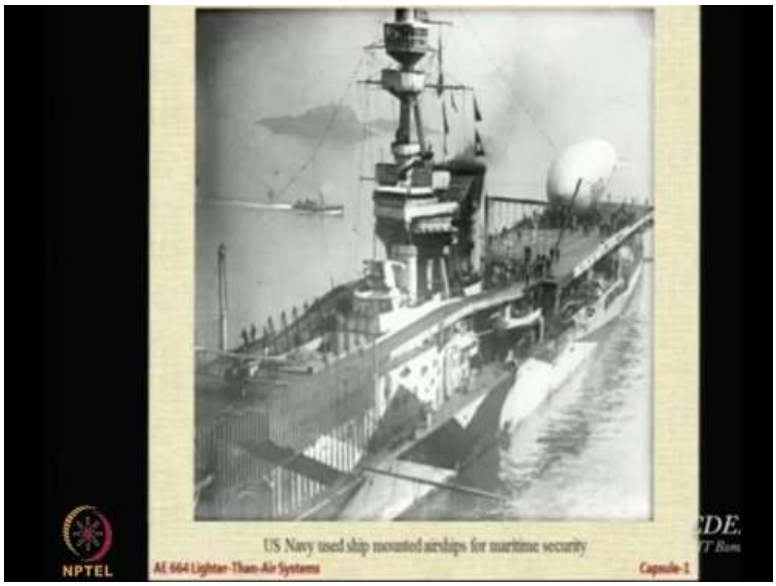
So their idea was that people would travel in airships they would dock at the top of these buildings and then get down and then use the elevator and come down. So this way they said we do not have to really have very large grounds. But imagine how windy it will be and how bumpy it will be for people to walk out at that altitude from an aircraft and then come to a building. So it was planned to be used but it was not used I think except in some attempts like this.

(Refer Slide Time: 14:39)

So what we saw is that they designed this airship for the travel to India and then from there to Australia, but this disaster took place. Now we are going a little bit out of time now but what I wanted to do is look carefully at the picture you will see large number of people here and also on that side these are the people who are required to hold the airship. So if you look at an airship like R101 it may require a ground crew of 200 people may be 300 people, the more the merrier.

Because it is generating so much of lift and it is a buoyant vehicle that to restrain it on the ground you need to have large number of people to help out. So we have gone a bit out of time now because we have seen the Hindenburg disaster and then R101 disaster. I will come back to that, but let us go back now in history little bit.

(Refer Slide Time: 13:09)



We see that now the US has started using airships for as the aircraft to be used on aircraft carriers. So they began patrolling the ship the sea for maritime security using airships mounted on the ships.

(Refer Slide Time: 13:30)

off from Cardington it circled over London giving onlookers a chance to gaze at Britain's newest technological model it then headed for the English Channel on its way to France, it will be the last time Britain would see the R101.

Took off on a rainy misty day and the winds were along the path of travel in the 30-35 mile an hour range, not the most favorable conditions for the reachable travel but certainly not the sort of things you would expect to wipe out this particular craft. But just after 2 am is the R101 was passing through a rainstorm the ship began losing altitude. The captain assumed that the fabric had become waterlogged into heavy what he did not know is that the top fabric from the nose back had whipped off.

And the gas bags were exposed to the storm to the rain to the wind and while it was only a moderate wind 25 miles an hour the airship was going at about 50 miles per hour, so this was hurricane force winds blowing on these gas bags. The high winds violently shook the gas backs closest to the ship's bow causing them to chase against the airship's frame the added stress is turned the numerous pinhole leaks into a fatal fissure accelerating the loss of hydrogen and causing the derivable to nose over realizing that a crash was inevitable.

The homes men cut the ships engines to soften the landing its estimated they hit the ground that less than 13 miles an hour not even a bad bicycle fall with the truth be no however a spark from the twisted metal ignited the gas back closest to the bow of the ship. Sitting off a chain reaction of fast-moving fires that spread from the bow to the stern engulfing the airship in flames of the 54 people on board all but 6 died including Lord Thompson.

Several of the survivors testified that the front end of the airship's outer covering had ripped off a crucial piece of evidence that may have explained the loss of altitude covered by the dark cloud of the R-101s failure the sister ship R-100 was dismantled and sold for scrap. Skeletal frame of the R-101 which represented the best technology in British lighter than air travel was eventually sold for scrap as well, putting an end to the British airship program.

(Video End Time: 11:59)

In fact, it has been reported that they were losing about 22,000 cubic feet of hydrogen per day from pinhole leaks. And even more alarming problem arose in June of 1930, while they R101 was more to its tower.

The outer covering along the starboard side suffered a tear that extended 140 feet. A Fisher that would have been fatal had the ship been in flight. Engineers believe that the gas bag leakage could be controlled with ballast but to give the R101 the required lift needed to drive into India. They opted for a radical solution. They cut the ship in half adding an extra bay and an additional gas bag making the world's longest airship even longer.

It was nearly 800 feet long. When you have something that is that long the pressures on one end of the ship can be very different from the other end of the ship. You can have wind shears that act on the nose that do not act on the tail, so there is going to be some flexing in twisting either nose to up. And down or from side to side and the metal structure was designed to actually flex but that creates a problems later on in the fabric outer covering did not fetch in the same metal structure did.

By 1930 the R 101 was massively over budget and far past its original completion date. Political pressure over the ship's made in flight to India began to mount. The decision to take the R-101 to India was singly driven by one man and that was the first air Lord, Lord Thompson. and he was the principal advocate and the guy whose prestige was on the line for the success of this program.

And he fell back into his mode of management, which had served him well all of his career insists action occur. Damn the doubters were going to go. This was a government project government funded government controlled when the Air Minister said let us go, they went with great anticipation 54 people including Britain's Air Lord. Board of the R101 on October 4th 1930 when the R 101 takes off the hanger and Cardington it symbolizes the embarking upon the longest airship voyage in history.

The first air Lord is going to go all the way to India and back and do it in two weeks which at the time would have been on the order of Lindbergh's flight across the Atlantic. After the R101 took

would be built by private enterprise and would connect Britain to North America. The R101 would be built under government control and would bring Britain closer to India and the far east.

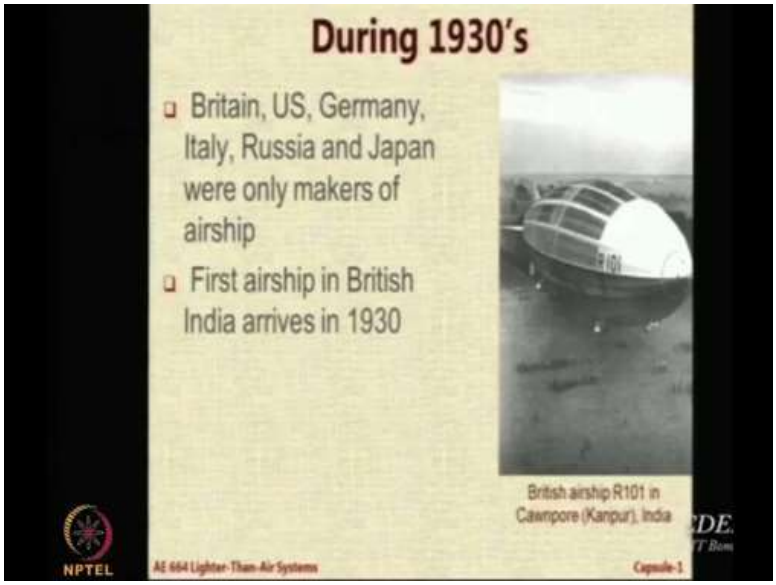
The R101 was designed to be the largest airship that had ever been built it was designed to have range sufficient that was just a couple of intermediate stops it could go from England to India in less than a week carrying 60 passengers and remarkable luxury. Although Germany had a successful airship design with a Graf Zeppelin, so to improve on it with the R101. The structural design and layout of the R101 was very innovative.

The twistable surface was built in circular frames that had individual structural rigidity well to build these rigid frames and still have this thing fly the frames had to be built out of a very new material for the day called aluminum. In a typical derivable passengers and crew were carried in gondolas that were suspended below the gas bag. In the R101 they decided to streamline the vessel and the passengers were actually inside there were two levels like on a ship two decks with all manners of stake rooms, dining rooms and recreation rooms smoking lounges it was very luxurious.

Non-flammable helium, which was used on the US Airship Shenandoah was not readily available in Britain. As hydrogen, which is highly flammable but provides more lift than helium was chosen for the R101. 16 gas bags were held in a mesh screen containment above the passenger accommodations. Each bag weighed approximately 1,000 pounds. Together they were designed to give the R101 a gross lift of around 150 tons more than any other airship ever built.

In October of 1929, 732 foot R101 was taken out of its shed in Cardington undergo preliminary testing in preparation for its maiden flight to India immediately it became apparent that the lighter than air ship was not all that light. When the R101 was first tested, they discovered the hard way that, they had over built it and it was much heavier than they plant it did not have near the spare lift that they wanted or needed for the mission.

They discovered that the gas bags themselves h believe it or not are made out of cow intestines which are stitched together and then coded with varnish. These gas bags are leaking prodigiously.



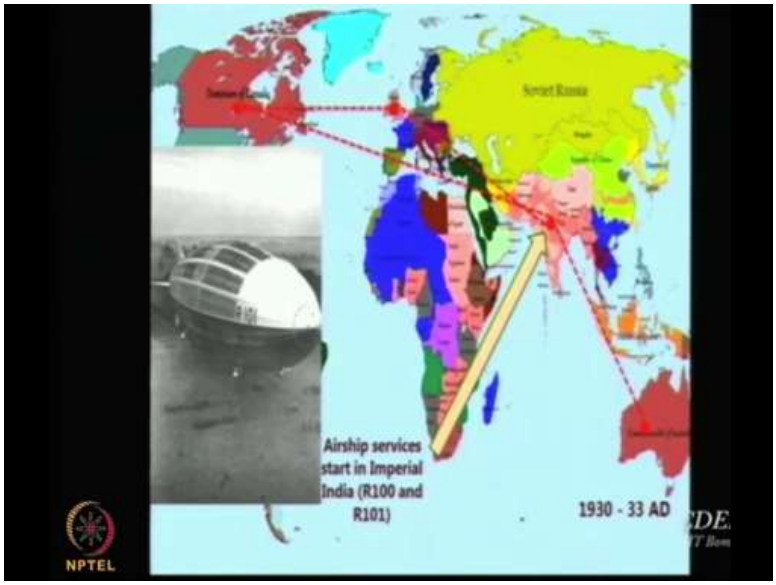
So in 1930's now we have Britain, US Germany, Italy, Russia and japan they were the people who make airship. Japan has now come into the picture why? Because japan was also a big military power so they also realized the importance of airships. So they came in for that reason and the first British airship to arrive in India was in Kanpur 1930. So I have an interesting video about this particular airship and what happened to it.

(Video Start Time: 02:30)

Perhaps the most famous disaster ever recorded when the Hindenburg felt worth in a ball of fire in 1937 the world at a front row seat. But in 1930 no cameras were present to capture the disaster that befell the R 101 airship which burst into flames in an equally spectacular fashion killing 48 passengers and ending the British Airship program. During the early 1900s the majestic lighter than air dirigibles ruled the skies over Europe.

While the airplane of the 1920s remained to work in progress, the airship was viewed as a sophisticated and efficient mode of air travel. Airplanes were wick and unreliable and noisy and uncomfortable and drafty and did not carry many people. The Zeppelin had established excellent reputation for reliability and safety and they were so much more comfortable and would carry so many more people.

After World War 1 the British Empire controlled roughly one quarter of the Earth's surface looking for a way to connect its far empire written developed a program to build two airships the R-100



Now aircraft are still struggling to get to you know be designed safely and properly etcetera. Airships people are thinking of running them as airlines. So interestingly this is where India comes into picture. So the British were planning to operate airships to all the colonies which they were ruling. So you can see there was a dominion of Canada which was under the British territory then we had India of course England and then the commonwealth of Australia.

So, since they were very far away and they had to be administered their one month journey on ship etcetera. They said we will reduce it by going by airship. So there was a plan that they will travel in a week and reach, so that was a big achievement that time. So the airship that was planned to be used for this particular application was the R101. R101 is also a very interesting airship.

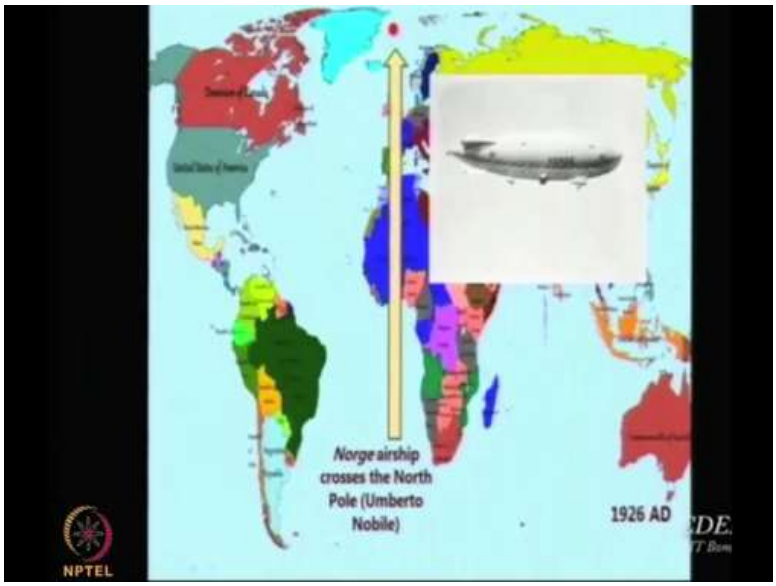
(Refer Slide Time: 02:04)

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -13
Historical developments of LTA systems, Part-IV

So then the next person whom we have to know about is Umberto Nobile who was an adventurer who took airships over North Pole. So that is a very adventurous journey

(Refer Slide Time: 00:30)



And there is a very interesting book about his journey and his experiences, so find out about that book if you can give the link on Moodle page. Nowadays many books are available free online, so if somebody is able to download a free version of the book it will be very handy for us to just have it. So the Moodle page is meant for these things adding information to what we see and learn in the classroom.

(Refer Slide Time: 00:57)

to approach for perhaps to approach for landing at an airport. We have many more videos to see, so probably I will just save some time.

(Video End Time: 15:22)

This is Graf Zeppelin, the airship about which we spoke. So; notice that such a large airship that people sit only in this portion, this is the gondola. So let us see if we can get some idea about this particular airship.

(Video Start Time: 13:13)

So there are some, this is some historical video showing you the aerial view shot from an aircraft or another airship I do not know of the Graf Zeppelin flying. Now this airship is flying in Schiphol in Amsterdam or it is coming in at Amsterdam the Schiphol airport for landing. You can see a small plane on the left side. Maybe that was one of the sources of the aerial video. But this is a very old historical video.

You can see at 11:20 people are waiting excitedly for this airship to come and land. They fly very gracefully So they brought some parcel this is mail postage which has been dropped by the airship and then this is being carried into the postal van on the ground. The fashion of that time the kind of beautiful dresses, ladies are wearing. All of them were wearing gown type dressing. There is no audio in this clip.

It just have an aerial video shot of, there you see a parachute have been launched and that parachute was carrying the mail, did you observe that. That was a parachute which was dropped with a mail. So when you want to drop mail at a particular city, you drop it with a small parachute. So it is when the flag is flattering it is very windy, but still the vehicle is majestically making its maneuver

lift 60000 kilograms. Now this 60000 kilogram is not payload it is the net lifting force available or the gross lifting force available. And if you subtract from this the weight of the self only then you get the payload which was 20 passengers and maybe whatever their cargo that they carry.

(Refer Slide Time: 11:32)

So here is a great beautiful picture of this airship flying in Rio de Janeiro. For those of you know about Rio this is a very beautiful place called as sugar Low Mountain, this is the Copacabana beach. So it is a very beautiful place, I have been there recently so when I saw this picture I could not resist putting it here just for my own memories and then when I went to Rio I actually met an airship expert who said, even recently also we have had airship flying over Rio.

Not 1930s, I was not even born at that time. He did a PhD he was the first I mean, he is the first PhD in the recent times to work on airships. And his name is Sergio Gomez and right now he is an investment banker he works for a bank in Brazil, but his work is mostly to do with looking at the merits tech economical evaluation of various projects. So he did is PhD from Cranfield University in 1960.

In which he did wind tunnel testing and the first flight dynamics model of airships in modern times. Many people say that Sergio was in that time when the airship technology was being revived.

(Refer Slide Time: 12:57)

That was designed in 1925. And it was operated from 1928 to 1937. So close to 9 years it flew till it met a disastrous end. But notice that in these 9 years, it has done safely no incident, no accident. Around 600 flights and it has covered 1.6 million kilometers or more. Interestingly it needed a crew of 40 people 36 officers and 4 supporters for a crew of only for a passenger, only 20, so very large on manpower requirements.

And what do you think was the main job of these 40 people? Why do we need 40 people? Why should an airship need 40 people to operate, what are they doing? They are not serving food on board or drinks on board controlling the, pilot, co-pilot may be one more person for navigation. So, most of these people are on the ground. They are not in the air these are the ground handling people.

So when this airship comes into land it is a buoyant vehicle. The tendency of it will be to bubble as the wind hits it so they were going to hold it on the ground. And that is even today one of the serious limitations of airships that the ground handling staff needed in the conventional airship is very large compared to an aircraft. So now you see that the maximum speed has increased from 17 miles per hour to 18 miles per hour.

We have five IC engines generating around 5450 horsepower each. And we have the length as 236 meters now. So from 420 feet it has become, 776 feet much larger almost double in size. But it can

World war is over there is a treaty signed in Versailles. So after that airships are being used only for civilian purposes because the war is over. So the US now realized the importance of airships because they saw the damage caused by the Germans to the British and the Allied forces. So they said let us start building this technology in our country. So they start if added by extensive airship construction program and what they simply did was.

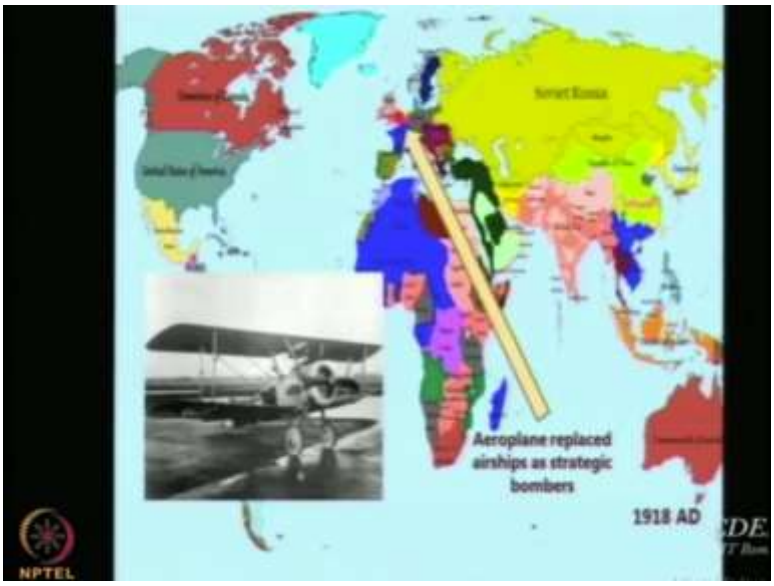
What will normally be when you start something is you look at an existing design and you simply copy it. There is nothing wrong in that. You may not be able to improve it but at least you will be able to do it and if someone denies you the technology the only option you have is to first make something similar or same and then you can go for improvements and you can go for announcements.

This is a beautiful picture of an airship called USS Akron in upper Manhattan. And then the big names in the Airship technology are the Zeppelins. They had LZ1 and LZ 2 earlier and the few more of them.

(Refer Slide Time: 08:30)

Graf zeppelin is an airship which was named in honor of its inventor and that airship was actually LZ1, so 127th airship LZ 127.

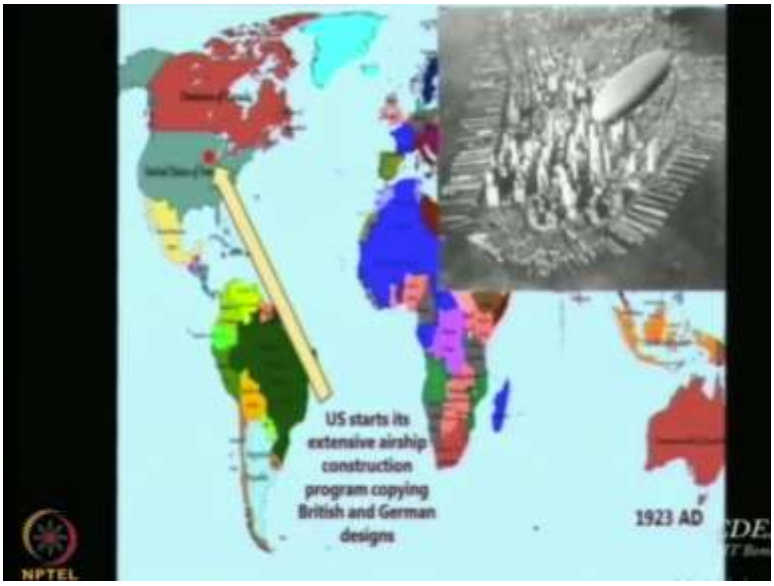
(Refer Slide Time: 08:42)



All right then do not forget that the aircraft technology is also picking up in the meantime. From 1903 is now 15 years since the aircraft has come into being. So, first strategic bombing airships were found to be absolutely useless. Therefore, the plane has replaced it and from this point onwards, you will not find in history much use of airships as strategic bombers or even bombers. So the offensive rule of airships was taken away by aircraft.

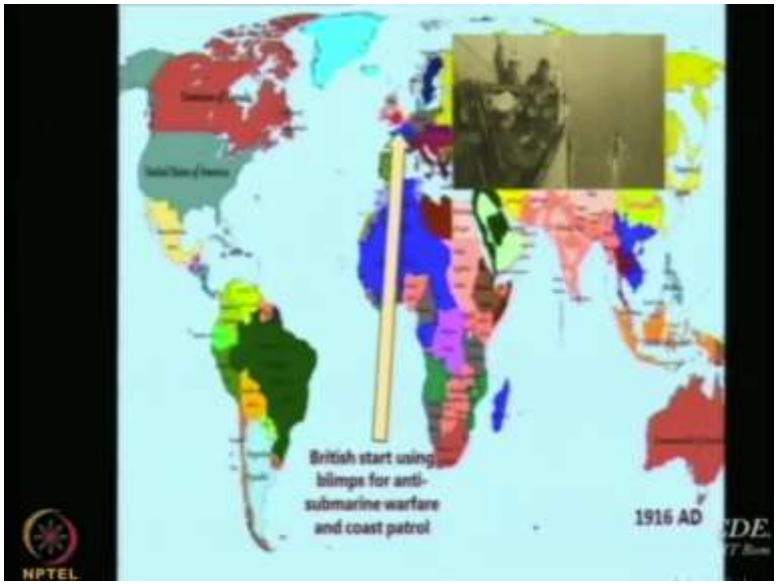
Because of much higher maneuverability as well as much higher safety that you have in operating aircraft in an offensive environment.

(Refer Slide Time: 07:11)



What was the technology available for docking of aircraft onto airships and what kind of technical challenges were faced in docking and you know reattachment of, was it possible for example for an aircraft to come and attack itself back to the airship were there any instances of that type. I am not very familiar myself about this. What I know is and I have seen pictures of aircraft which have been attached to the airship and then it goes for offensive mission. So British started using blimps for anti-submarine warfare and coast patrol.

(Refer Slide Time: 06:12)



Even today we are recommending airships for anti submarine warfare because of the extreme high endurance which is needed when you want to locate submarines.

(Refer Slide Time: 06:12)

So therefore many people said that you know is not worthwhile to use airships, but so much was the terror in London because of the bombing of the city by the Germans.

(Refer Slide Time: 03:42)

That they were ads like this which said, you know, you can see some burning airships during combat. So it is far better to face bullets than to be killed at home buy a bomb. And this bomb is from the Zeppelin. There were many air raids and airships do not began its applicability was mostly limited to escorting ships. So you can see there is the ship below which is being escorted by an airship and it will be used to give early warning to the ship about any impeding attack.

You can use them as offensive weapon also for damaging ships. Because a ship is actually completely defenseless when it is floating in the water against an airship it has no chance of being protected. So you can use it for protection as well as you can use it for offense and interestingly some people came up with brilliant idea of having aircraft mounted on air ships. So you attach small aircraft on airships and you fly in the ocean and to protect the ship.

And if you see some enemy aircraft coming you can launch the aircraft from the airship it will go and bomb the aircraft and then maybe land somewhere because docking onto the airship was very difficult. People attempted it, but they said it is very difficult to dock back to the airship but one can take off with the aircraft attached to the airship and then release it and launch it. So this is the other thing which I want you to search and put on the Moodle page.

itself. So many airships were lost by the Germans and the British to fire from the enemy aircraft. So therefore it was decided that we should not use airships for offensive purposes like this. Before this technology could be developed, so what has done is airships were flown;

(Refer Slide Time: 02:52)

And they were supported in their flight by the aircraft. So there will be one big airship with armament with many small military aircraft supporting it. They will not allow the enemy aircraft to come near the airship. So you have a big group going, then you could do airships. But if by chance you have supporting aircraft and not able to handle any one fellow sneaks through and does some damage boom then it is gone.

(Refer Slide Time: 03:25)

So this is the map again, now we will use the same map because not many changes took place. The; changes to place actually after Second World War. So we will continue to use the same map till that time just for the ease, but the difference is that now the Russian empire has become Soviet Russia, so that will be the only change that we will see. So the first people to use ships for war again in the World War 1, were the Italians, they used against Turkey.

Then we heard about bombings in London by the Germans. In fact, there was a unanimous feeling that the best bombers of a city would be airships. Because they could fly very slowly they could carry large payloads flying slowly is for precision bombing. Getting there is difficult but once you get there, the ability to fly slowly is very good because it includes the precision during bombing.

(Refer Slide Time: 01:28)

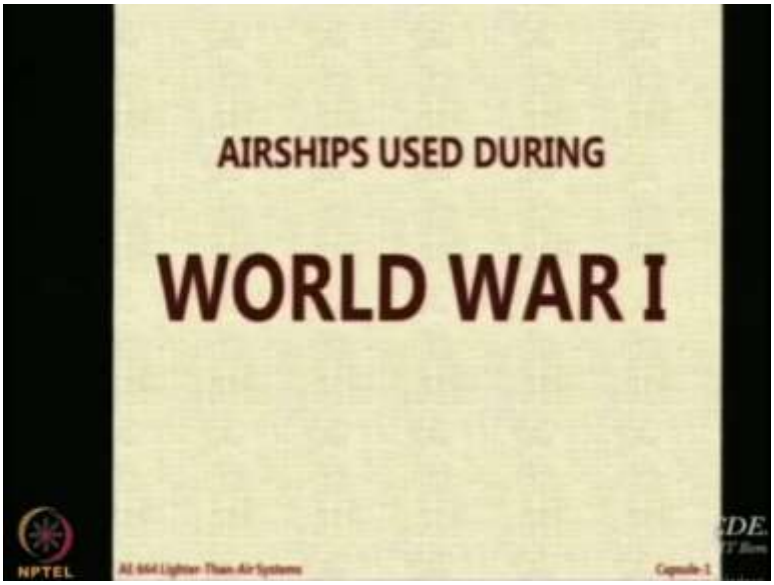
So they also used for scouting looking around where the enemy has built all its important things. Let us say fuel reserves or strategic factory, etc. So and also for practical boundaries go there and drop bomb whenever and wherever you see the need necessity without any great planning or great target in mind. However, there is a serious problem. Many airships were shot down because by this time some military aircraft also came into being.

And most airships were using hydrogen. So all you need to do is there is a huge target in front of you, you have to aim and hit some igniting system onto the envelope and that is it, it will burn

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -12
Historical Developments of LTA Systems, Part-III

(Refer Slide Time: 00:16)

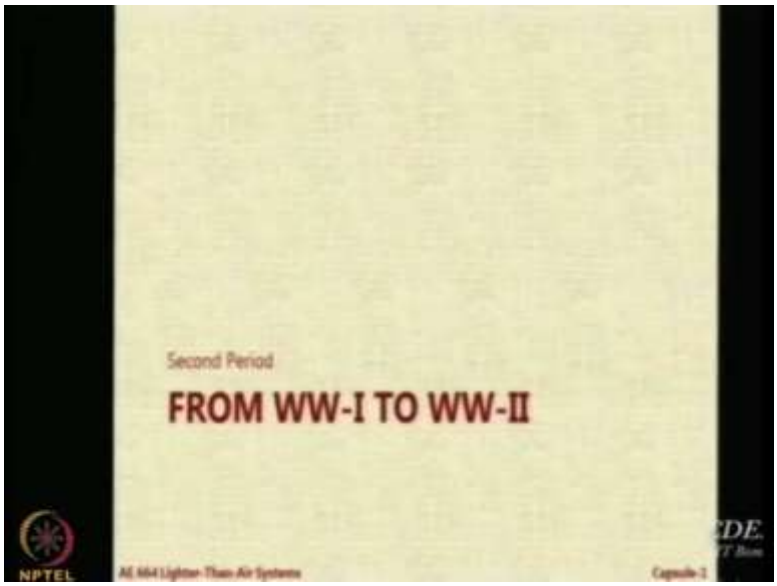


So let us see what was done in the First World War using airships.

(Refer Slide Time: 00:20)

they were so many places in the world where, so you can see that the concentration is in Europe. There are these five stars in Europe, there is one in Russia, one in US and one in Australia. This is where the top one is, the most of them in Germany, France, UK and Italy, Spain.

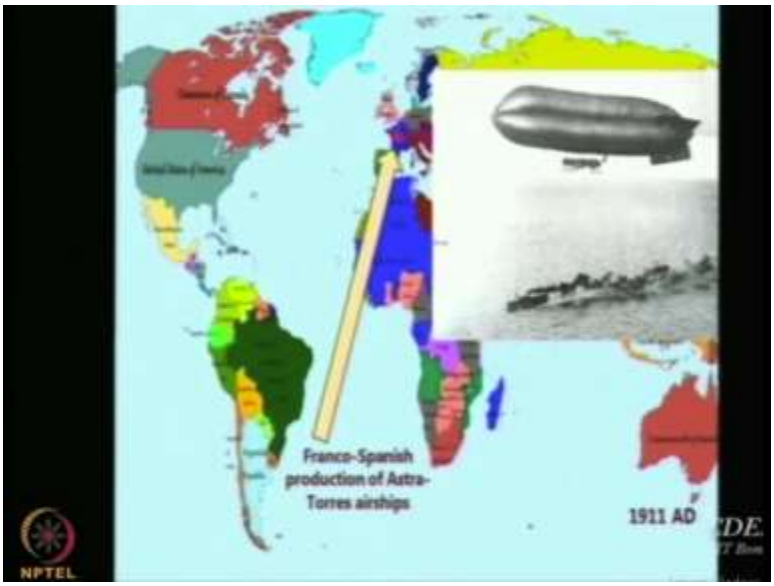
(Refer Slide Time: 12:08)



These are the places where, now that the first period, then we had the first world war.

Russia is not lagging behind again and they also acquired airships from Europe for military purposes.

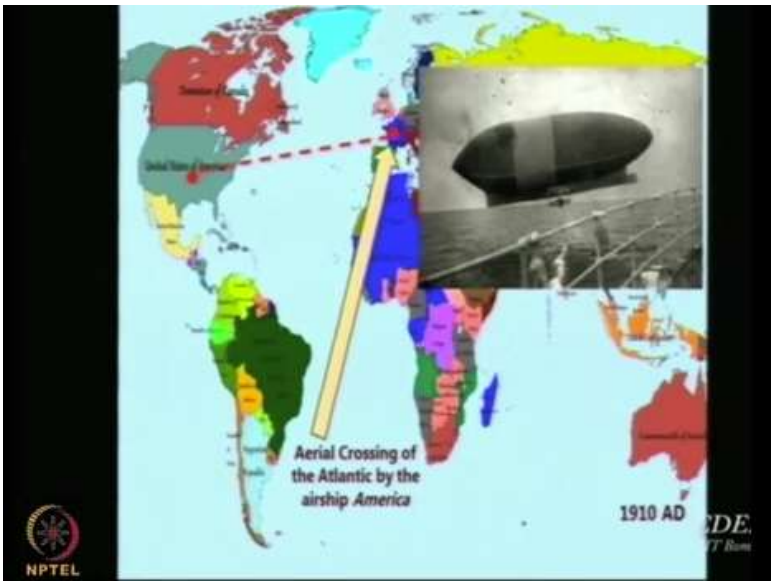
(Refer Slide Time: 10:55)



And then France and Spain they got together and there was a Franco-Spanish production of extra tourist airships. As you can see now some amount of aerodynamic shaping is coming into the design. But there is a complete delinking between the gondola or the passenger carrying dolly and the envelope. So we see that people are being suspended on through ropes below the envelope.

(Refer Slide Time: 11:28)

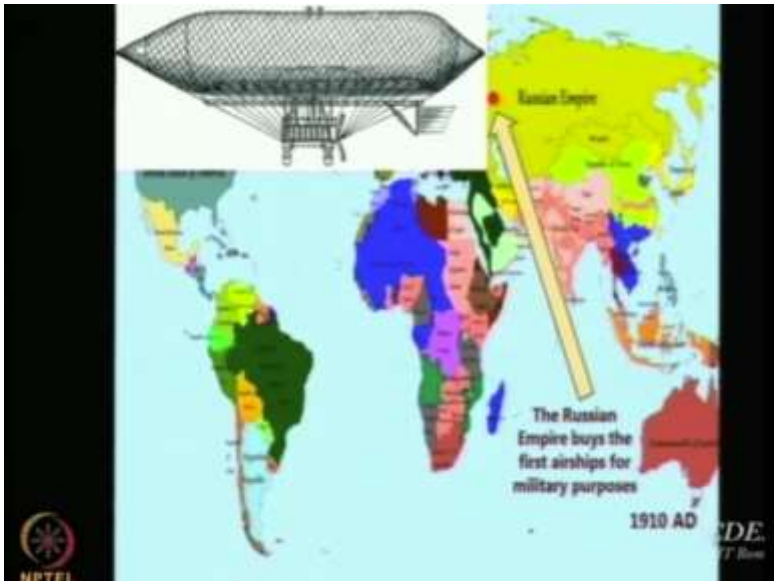
You would see slowly as things to evolve. Let us see how many people, so however the world these are the people places where airship operators and manufacturers were available. In 1911,



So then now we have the first situation in which you can have the crossing of the Atlantic that was the next challenge of people. That happened in 1910 when an airship flew across that atlantic. Now you can imagine how much time it took. The speeds would not be very high and you will be fighting the winds also at most when the winds in the ocean are quite high or can be quite high.

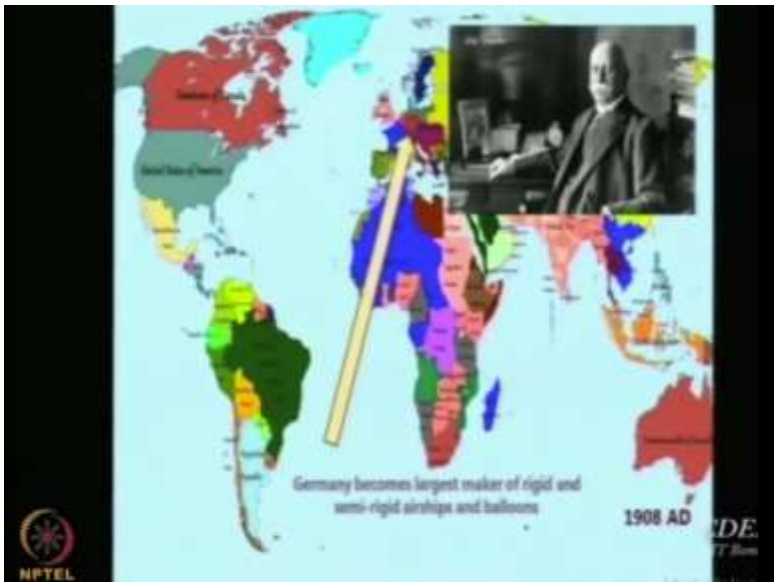
So I would request someone to find out about this particular flight. The first Atlantic crossing by an airship called America. We want to know more details what was the propulsive system what was the maximum speed. So, on the Moodle page you can give us some information about the particular airship.

(Refer Slide Time: 10:44)



control system that you see here and the front as well as in the back. So, the second one lifts off in 1906.

(Refer Slide Time: 08:52)



In between we have the Wright Brothers and the Germany became the largest maker of rigid and semi-rigid airships and balloons. So they realized that there is also some merit in making semi rigid. There is no need to make the whole thing completely rigid you could have a semi-rigid structure, which as you know, contains a framework inside with a flexible covering or flexible envelope.

In the rigid airship everything is rigid the gas bags are inside. But the structure the framework is rigid that covering is also rigid. All right, so then Italy is not lagging behind. Italy is also not succeeded in having their own airship and you can notice there a very interesting system to give you directional. So they have used new system, mounted behind the airship assuming that as airship goes forward the vertical looms will deflect and give you the direct side force.

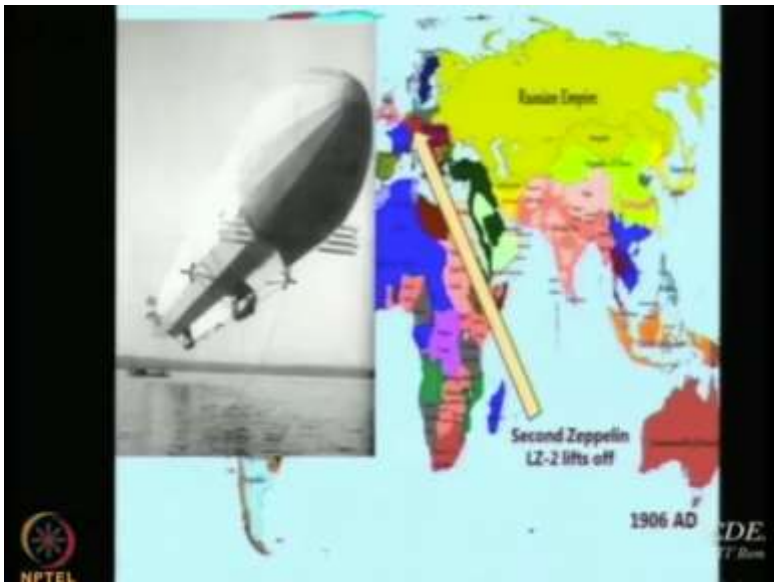
(Refer Slide Time: 09:56)

Now with this airships became more and more popular more and more capable and some person is a Brazilian and many Brazilians feel that he should be credited with the first airship because the claim that he was actually able to make an airship and fly before Henri Giffard. But probably there is no record or no documentation and that is why the claim is not that much acceptable in historical literature.

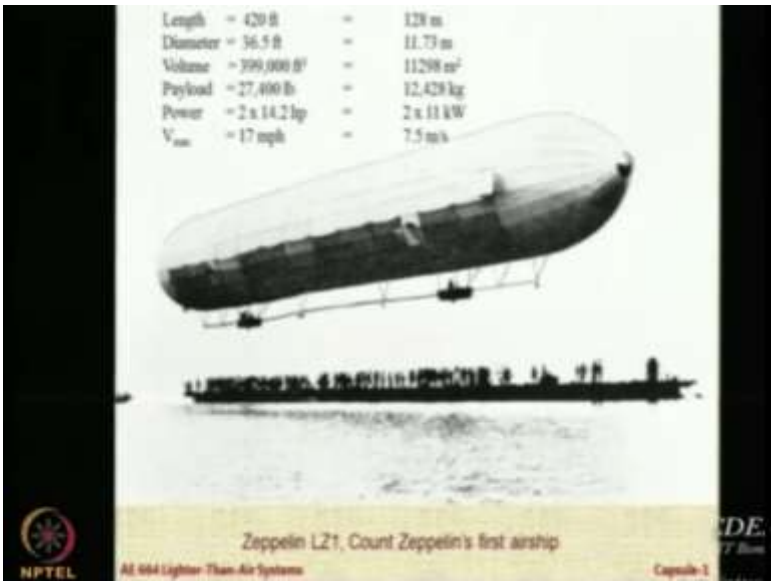
But that is a matter of historical debate interestingly, he was the person who showed that they are very capable and they are able to do things. Now at that point of time in 1901 when you say capable you have to look at the competition, which is only the automobile and the ships. So 7.5 meter per second is not a huge performance at least speed wise. But look at the time it is 1901. So here is a man who is able to fly around the Eiffel tower in 30 minutes using an airship.

And with this demonstration a lot of popularity of airship spread all over Europe. The internet is full of videos of people running and you know looking around where airships are and pointing towards them in the sky and showing excitement about that. So they became very common across Europe and USA and they were being used many many places in large numbers because this was the best thing available at that time.

(Refer Slide Time: 08:25)



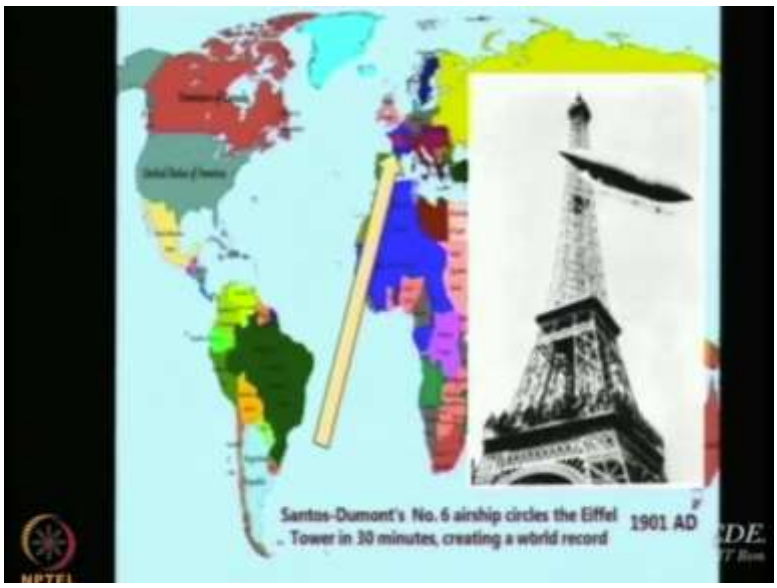
Russians will come later, now the Graf Zeppelin LZ1 was the upgrade or improved to make the another one. Now what is the upgradation? Upgradation is coming in terms of this, this particular



And I just want to share with you some information and some dimensions about this airship. So it is a, 420 feet or 128 meters long and 11.73 meters dia. So the length, diameter ratio is just slightly more than 11, more than 11 that is the L by D. The volume is, if you go in square feet is almost 1,000 square feet. We normally work in the SI units so it is 11,298 meter square, meter cube this is the mistake I just want to correct the mistake. The maximum speed is just 7.5 meters per second. So it is going to fight the winds but only to the extent of 7.5 meters per second.

If the oncoming wind is more than this it is just going to remain where it is slow moving vehicle but ability to travel large distances.

(Refer Slide Time: 06:54)



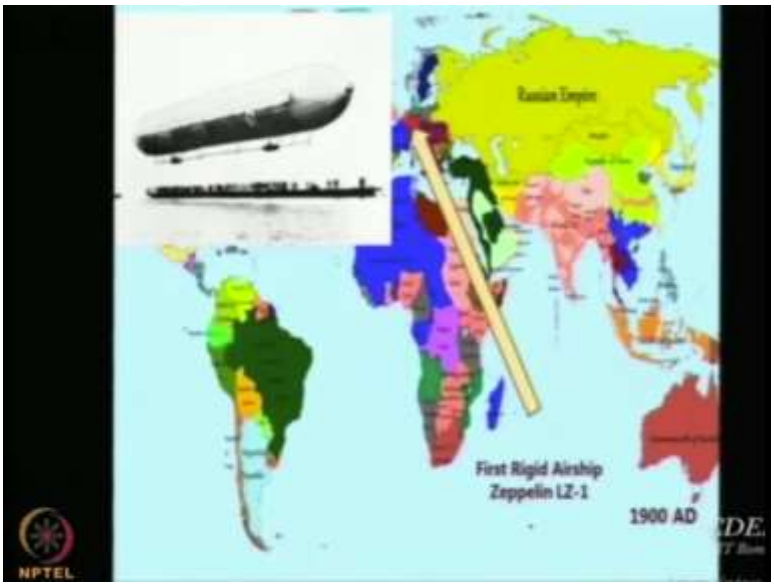
the name of the count. So much is the contribution of these gentlemen that all rigid airships are generally called as zeppelins.

It is like xerox, which has become a name for photocopying machines. So his name is Synonymously in rigid airships and airships at that time are mostly rigid because the technological developments in fabrics were not so advanced that they could think of having a load carrying number as well as a gas barrier, as well as something that can withstand the atmospheric conditions.

Of course they have these gas bags for balloon etcetera or aerostats, but for sustained flight over long distances they were not able to do it only using the air bag or only using the textiles fabric which can be done now. So therefore all airships at that time were generally rigid airships and the Europeans, you know there are many countries in Europe doing that time who were able to use this technology and who were able to give us airships.

And also the technology has also moved to USA. So USA were not the leader in this technology. They got it actually from the people who went Jean-Pierre Blanchard who went to the US he took the technology with him to the US.

(Refer Slide Time: 05:37)

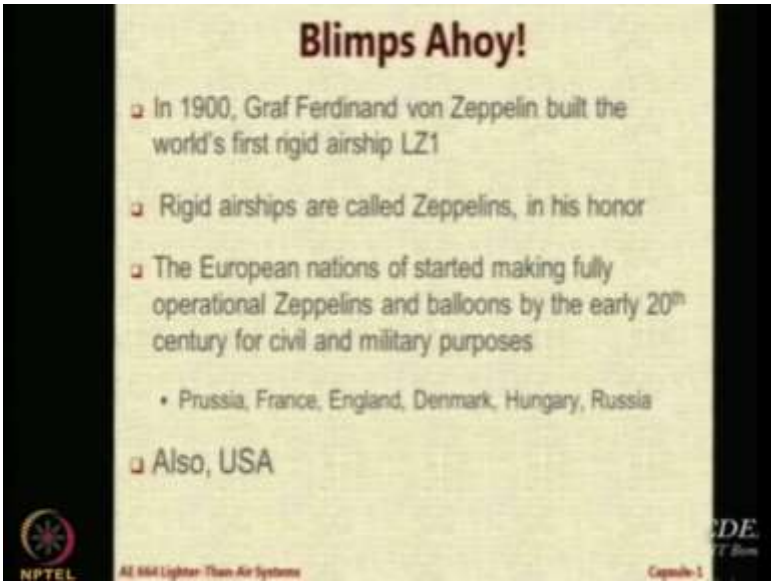


This is Graf zeppelins, first airship LZ1.

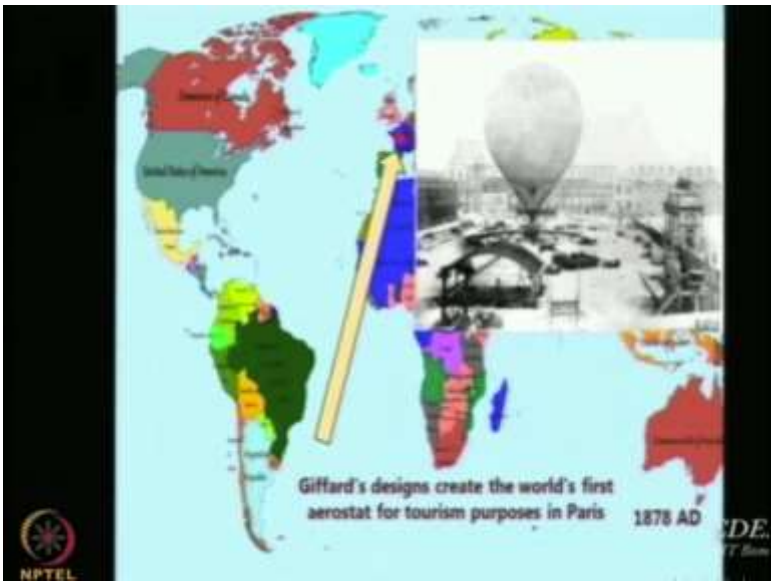
(Refer Slide Time: 05:44)

And, this is the man Count Ferdinand August Graf von Zeppelin, the Von Graf is the German for Count. He is the person who should be credited for the massive increased in the technological levels of airships and it is one thing to invent something is the other to take to the commercial and professional level. So he is the person who has done this. He was a Count in Germany and his contribution to airship technology is very phenomenal.

(Refer Slide Time: 03:38)



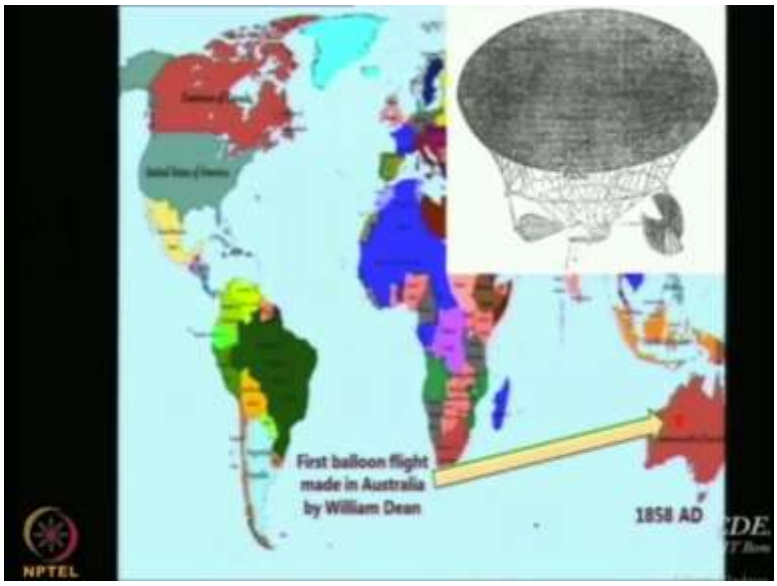
So as a mark of respect what we do is, so he built the first rigid airship in 1900, before Wright Brothers. The world's first rigid airship was built by Count Ferdinand August Graf von Zeppelin, it was called as the Luftschiff Zeppelin 1 or LZ 1. Luftschiff is the airship in German and Zeppelin



Moving on Henri Giffard who made the first airship kept on working further in this technology and he realised that this technology can be used for tourism because at that time people were struggling to get airborne. This is much before 1903 when Wright Brothers flew this is 1878. So the aerospace technology at that time was driven by developments in LTA systems. Aircraft were never to be seen, they were only being conceived and planned.

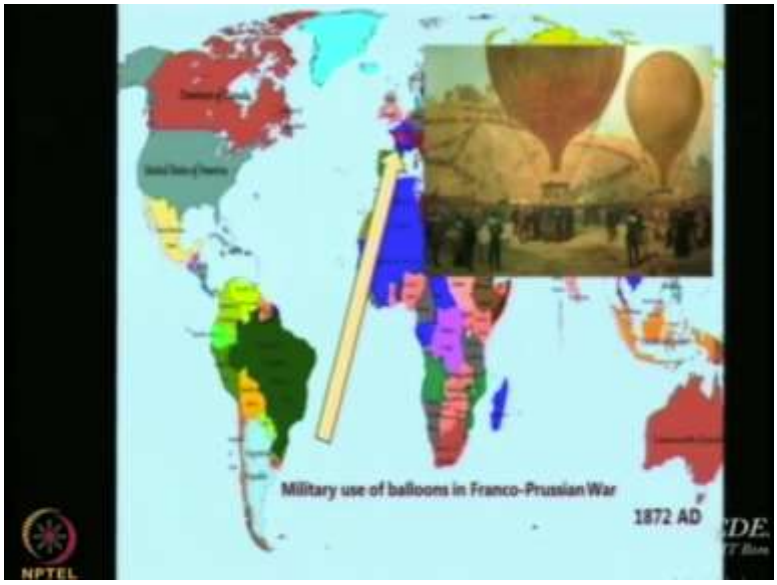
Maybe, there was guidelines set by this time, but no aircraft. But airships aerostat as you can see people are already planning to use aerostats for tourism purposes. That means they are sufficiently confident that they can carry tourists not adventurers, but tourists people like you and me common man they can be taken into an aerostat and flow around.

(Refer Slide Time: 02:59)



Then this technology travelled to Australia and there were other people who made balloon flights in Australia, but not the airship this is still balloon.

(Refer Slide Time: 01:27)



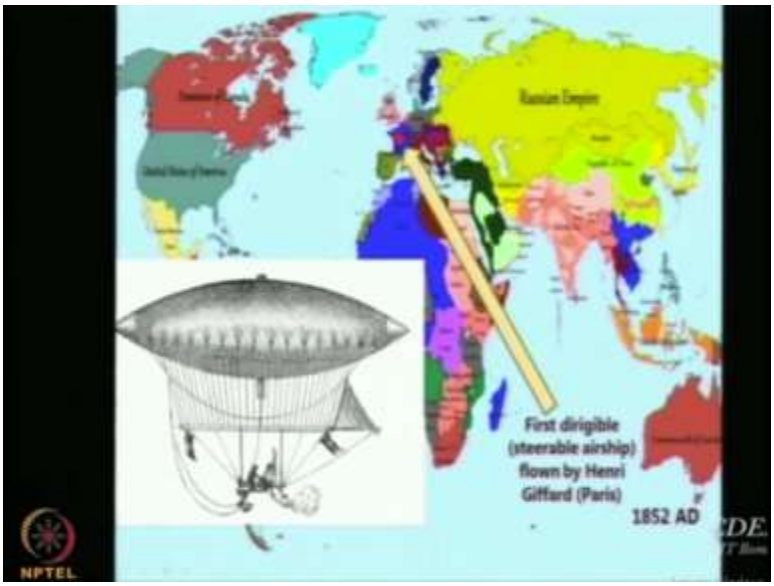
And then we saw the military use of balloons in the Franco-Prussian War, there was a between Persia and France and in that war for the first time in ancient times the Chinese did not use it for an offensive purpose. They used it for only indicating and marking where their troops are etcetera. But this is the first offensive use of the LTA systems in any war or military environment.

(Refer Slide Time: 01:56)

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -11
Historical Developments of LTA Systems, Part-II

(Refer Slide Time: 00:18)

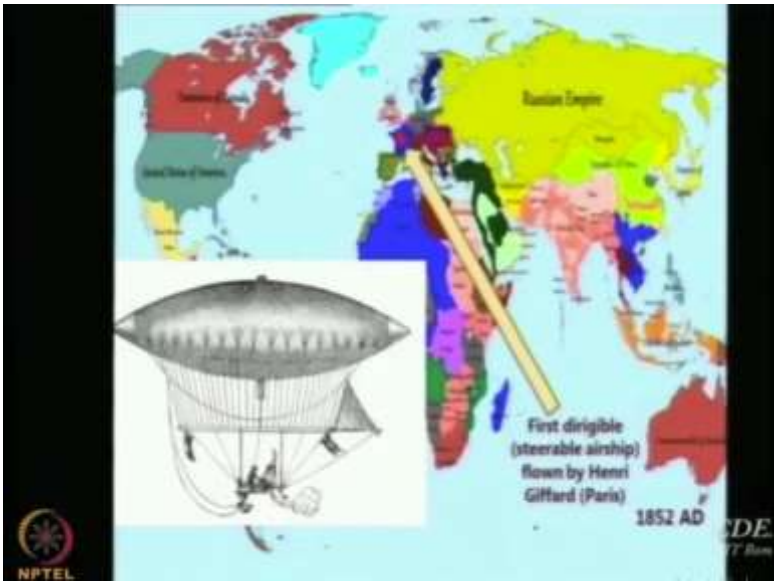


Coming back to history now in 1852 we have the first airship, flown by Henri Giffard and any kind of guesses what kind of engine he has used because we can see steam coming out. So, although IC engine was available but Giffard's first airship was basically a steam engine airship and it was in France. So Henry Giffard is considered to be the pioneer in airship technology. So it had a control system, which you can see there is a sail on the right hand side.

It had an envelope which contained the lighter than air than gas and a propulsion system. So the few things that you require are buoyant lift, which is through the balloon control system to fight the winds and go in the desired direction and the propulsive device to enable you to fight the wind. So, all three were present for the first time in Henri Giffards airship.

(Refer Slide Time: 01:14)

Including a capsule to keep the people protective from the atmospheric conditions at their altitudes, they actually want to hit the jet streams and then be drained by the jet streams. So other things are also technically very important in fact, Breitling the company which makes these very famous chronographs, they were the people who sponsored this called Breitling orbiter. So I would urge you to look up on this particular thing and maybe somebody can give a link on the moodle page, about the documentary around the world flight in a hot air balloon.



Then we will look at the first airship. People have gone around the world there was a competition and our friend Richard Branson also took part in one competition. But this record was broken very recently there is a very interesting documentary on discovery which talks about around the world flight on a hot air balloon. So now it is possible to fly. But it is possible to fly because of technological developments, not that much in the area LTA systems.

Can you guess which technology enables people to fly across around the world with hot air balloons today? GPS is one thing yes, GPS will give you where you are. But GPS will not enable you to do something. Not that much, no it is a hot air balloon it is not going to be propelled. Yes, that technological development in weather forecasting. It is said that they had developed a mathematical model which can predict the wind at any place in the world with thirty six hours in advance.

Very accurately, they could predict for a long time, but very accurate predictions for thirty six hours forecast and that information is not publicly available and it is a very valued secret. So what they did is they were able to go around the world purely by controlling the flight of the balloon, so that they would put it in the right wind pattern because it is all driven by wind. So other things are also very important.

So he is our friend was crossed the Atlantic Ocean to America and then flew within America. He also was an instrumental in using an IC engine for the first time. Before that people were trying to use small steam engines to produce the required thrust force. He was the first to use IC engines. But many years later, no not in the balloon, he just crossed the ship. But very good question, it shows that you are attentive and listening.

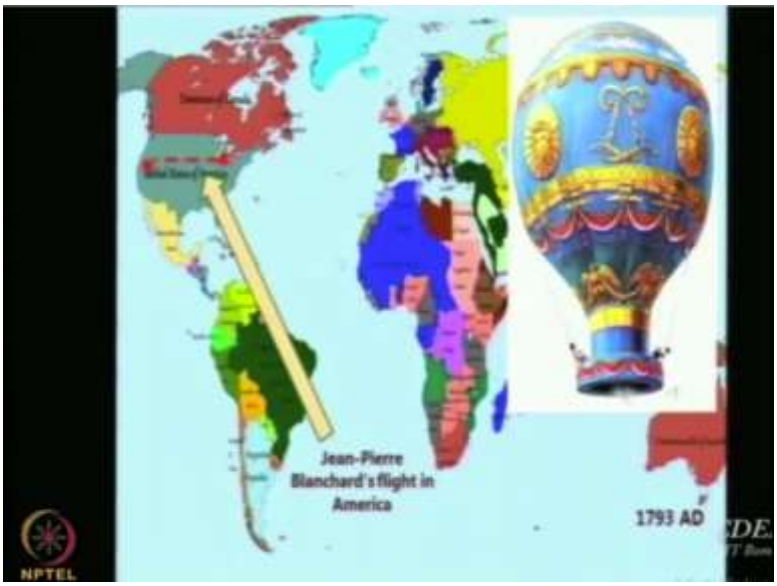
Because history can be little bit boring, but I just want to make it interesting looking at the timeline and seeing history how the technology is progressing. So he did not travel across the Atlantic Ocean using a balloon. But within America he is able to travel across.

(Refer Slide Time: 11:44)

was so fears that one hundred and thirty houses were burnt down and this whole town was damaged.

So this town which is a part of Ireland. Ireland as you know, just next to the UK or actually part of the northern island is part of the UK and this was the town in the middle of Ireland which had the first aviation disaster.

(Refer Slide Time: 10:25)



Then the same gentleman Jean Pierre was also instrumental in bringing LTA systems to USA. So he did a kind of trans American flight in a hot air balloon, and with that the technology started travelling to other countries.

(Refer Slide Time: 10:47)

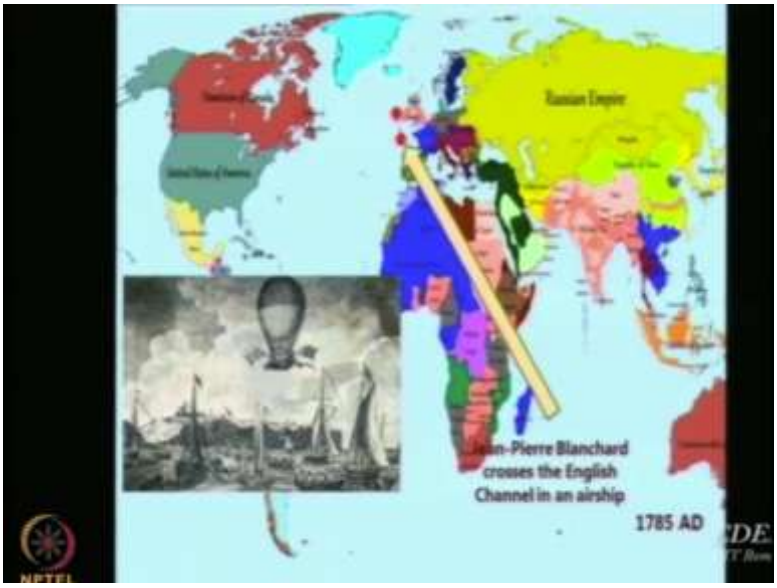
And then we also have the first Aviation disaster very soon. Aviation has a very bad name for disaster. But if we start looking at numbers you actually find statistically aviation is quite safe, nevertheless it makes news. So in this case, now can you guess where this took place by looking at the flag? It is not Scotland, it is Ireland. It is not range also, but the arrow is pointed slightly below the location but I thought the flag will give it away. It is Ireland.

(Refer Slide Time: 09:38)

So this took place in 1785, just you know, two years after the discovery and the first manned flight, we had the first disaster in which a hot air balloon caught fire. Interestingly it is not hydrogen to be blamed here, it is hot air. And this happened in Ireland in a town called Tullamore and this fire

Now, let us move on to England now. This happened in France and as you know, there is a very strong rivalry between England and France which is driven by technical development since many, many years. So, therefore these rivalries took place also in the area of LTA systems. So soon after the next year a Britisher created a balloon to fly in England.

(Refer Slide Time: 07:59)



Then we had another Frenchman Jean Pierre Blanchard. He is going to be appearing in a few more slides in the future. He is an interesting character very adventurous person did a few things. So doing that time, one of the biggest challenges for human beings was to cross the English Channel. Just 24 miles distance between England and France. So now we have built challenge available below the ocean to continue to connect these two countries.

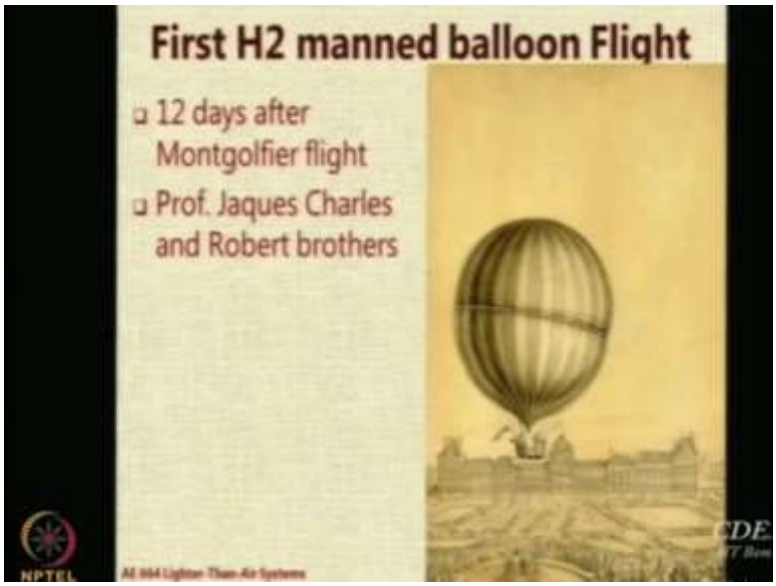
But at that time many aviations were first scored across the channel flight. So there was a challenge and Jean Pierre was able to meet the challenge by doing across the channel flight using a balloon. And as you can see this is a hot air balloon because there is a throat on the bottom, which is open.

(Refer Slide Time: 09:01)

interesting information that something like one point five times of Sulfuric acid was poured over above 4 times of Aluminium or Aluminium oxides or some such compound or maybe metallic compound.

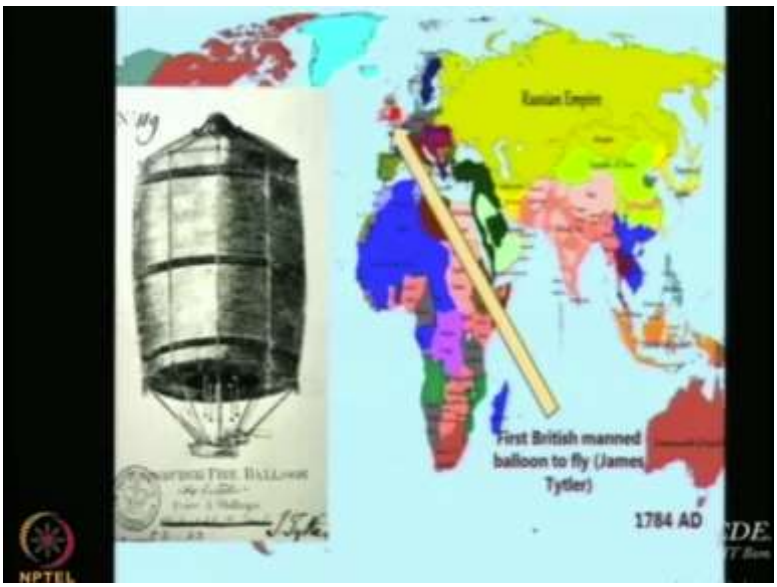
And the gas so produced was used to fill the balloon. But unfortunately the gas was hot when it was produced it became cold very soon. So there were issues in getting the lift.

(Refer Slide Time: 07:18)



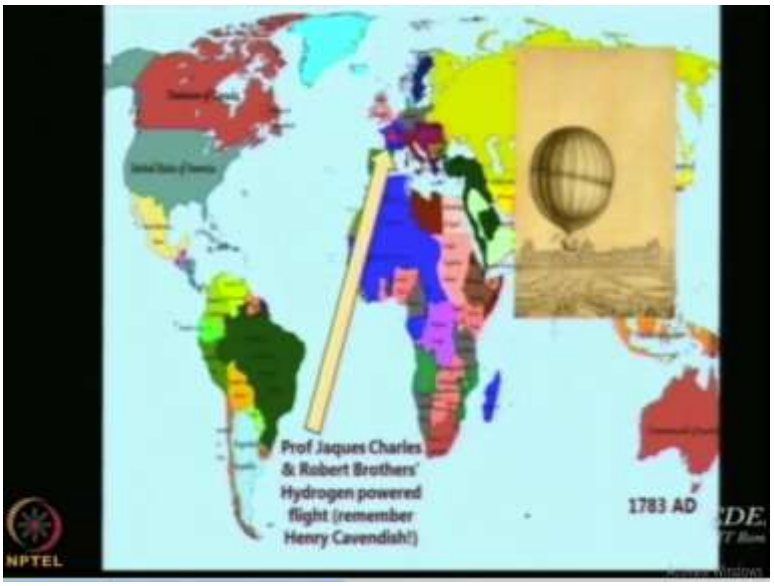
Finally it did succeed and we have this bag filled with hydrogen carrying human beings.

(Refer Slide Time: 07:27)



So when we had the manned flight, which was in 1783. This was done by two brothers, the Montgolfier that is what we call them. And interestingly the balloon was made in paper and the gas used was hot air. So this was the first hot air balloon in history which carried human beings. This is 1783, many years after hydrogen has been discovered. But the causes of combustion of hydrogen people were worried whether we can use it. And even now people worry whether hydrogen can be used as a lifting gas for manned carrying applications.

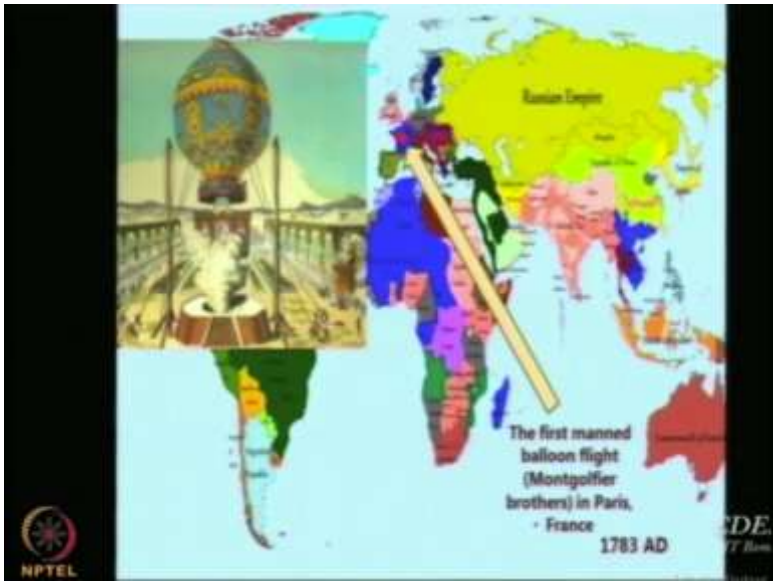
(Refer Slide Time: 06:30)



So, just 12 days after the first manned flight with a balloon, that was a Jaques Charles and Robert Brothers, what they did they use the gas discovered by Henry Cavendish. So history has an

And then our friend Henry Cavendish discovered this gas called hydrogen in 1766. And people realize that apart from being highly combustible, this all this gas also is much lighter than air. And therefore it can be used for some meaningful purposes.

(Refer Slide Time: 05:12)

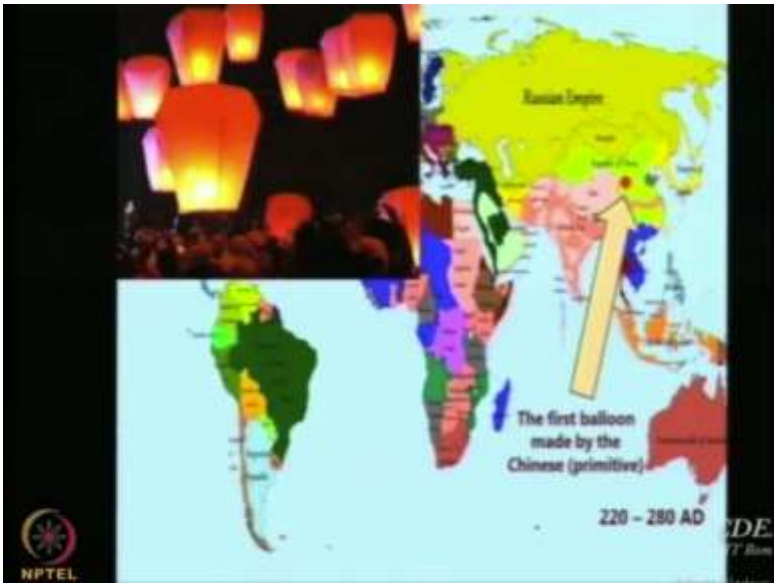


So in 1783 we had the first flight, as we all know from our school textbooks of the manned balloon flight. But interestingly the first flight ever was not a manned flight. Perhaps they were too scared and unsure whether it is safe. So it is said that they took a duck, a rooster and a pig and put it on this balloon they have no wife, they have no I know they had no choice and it raised up when it went up successfully, this seems to be safe.

(Refer Slide Time: 05:50)

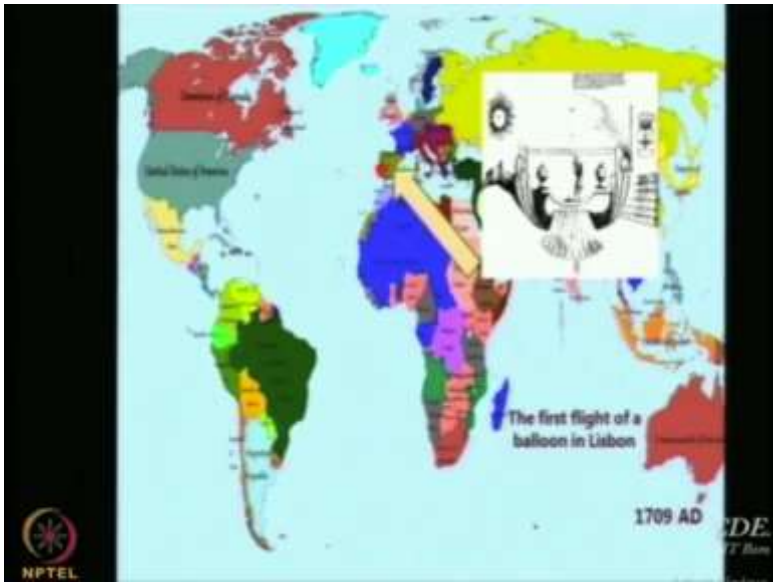
So what happened is that there is Brazilians Portuguese priest and he did this flight in front of the king. The maximum height achieved was only 4 meters. And this was nothing but a paper balloon. But please understand, even today to make a simple paper balloon filled with hot air and to make it rise 4 meters, it is not a simple task. I am going to challenge you in assignment very soon and you realize then what seems really simple is not actually that simple. Anyway, this is, we have this first flight of a balloon in Europe.

(Refer Slide Time: 04:49)



So this is what was primitive to 220AD to 280AD.

(Refer Slide Time: 03:50)



After that the first recorded flight of a balloon was made in Lisbon, Portugal.

(Refer Slide Time: 03:59)

The first known LTA system if we forget about historical and you know unproved or undocumented information is the Chinese Lantern. And the main application that they found for this was to use it for signaling during a military operation. And then the Mongolians have used it in some kind of a battle in 1291. So that is how it started.

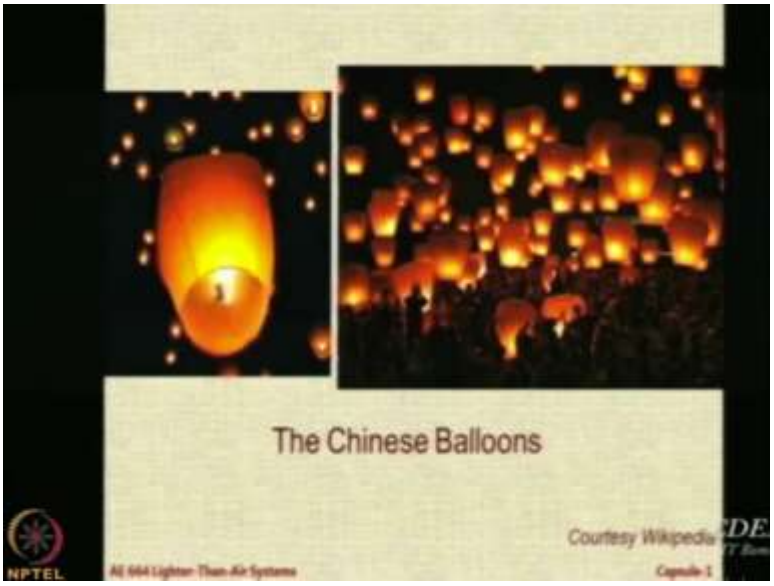
(Refer Slide Time: 03:12)

Now we will try to trace the historical developments of LTA systems using this map of the world and also the map will change slightly as the history progresses. But barely speaking this is the kind of map from 1912 approximately we use it for our explanation. So you see that there is British Raj in India. So Pakistan, Bangladesh, Sri Lanka and India are all under the British raj there.

(Refer Slide Time: 03:44)

During World War 2 there was some applications which were very unique, after that technology went into a kind of hibernation. So from 1940 to mid 80's there was not much happening. But then it bounced back in the mid 80's due to a very interesting project. And then from now on it is again up on the rise, and that is why we are actually having this course. So let us look at the first period.

(Refer Slide Time: 02:14)



The first period started with the Chinese balloons. And all of us were aware of these lanterns, we see them in all festivals, including indigo type fest. There have been many instances when these lanterns have been lit up in the sky. This is the most primitive LTA system. So it all started.

(Refer Slide Time: 02:14)

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -10
Historical developments of LTA systems, Part-I

So let us start today's talk, good morning and welcome to all. Today's lecture is basically rooted in history. We have lots of lessons to learn from history and we will look at the historical perspective of our LTA systems. The aim of this particular talk is to give you an exposure on how this technology started off, how it reached a peak and then there was a period in which there were lots of negative views about LTA systems and then bounced back recently. So, looking at the historical data available. One can classify as five main periods.

(Refer Slide Time: 01:05)

Now, there is no reasons for classifying in this manner and I am not historian as you know. I have done this only on the basis of certain interesting events that took place. So from ancient ages to the First World War, where is the first period which is a very long period as you can imagine. And then between the two wars there were certain things that took place certain motivations were there to evolve this technology.

minus that gravitational or download force. So when the engine stops, comes down. Anything else? Prathik, you have something. So it means you are going to introduce helium from balloon into the air stream of the engine.

No, instead of that, I would say why do you need to get small systems, which only do this? Because if you mix air and helium how will you recover only helium from that? No, what someone said is simply to release the helium. Liquefaction this; what has been attempted is a small liquefaction system inside the envelope, which when commanded, liquefies the gas and pushing the cylinder.

But you see that the same engine is having an airstream. In that you will introduce helium stream. And that then the fan will compress it and then you have to push it back inside the envelope, then where will it go? See whether you have an integrated system or a dedicated system, we decide based on our assessment of the cost complexity and weight. It can be done. I mean things can be done to attempt it, right?

So now last time I mentioned something on the moodle page for the moodle page and one person has responded to that. Also we have got some information about helium now on the moodle page towards to also now proceed further. So the question for you to attempt at the end of this lecture is find out photographs, videos, description of very innovative uses of airships and aerostats which will add value to our understanding.

So if you look at something about an application which are not shown or which you think will really add value or even excitement to our study, please give links of that on the moodle page and the second question is think of other innovative ways people have used for bringing an airship down or buoyancy control. Ok, on that note, we will stop for the day.

Or more lift than drag, you know, that is what we do. We want to have higher L by D, lift over drag. So if I can carefully shape the envelope in such a way that when it starts moving it starts lifting. Let us say 10%, 15% of the total lift comes from dynamic lift. So you are heavy on the ground, the total buoyancy is, let us say 1000 and the vehicle weight is 1,200. So 200 kg force you create by maybe tilting the engine.

Or 200, 220, 230kg force. So you start moving up, you acquire some speed. Now the dynamic lift starts coming. Then you can release the engine and when you fly at some particular speed you might be able to manage comfortably with the dynamic lift plus the started lift equal to weight. Supplementing with the thrust vectoring and when we want to come down it will stop flying.

Now this is what we do when we fly our airships. Our airships are normally heavier than air. But the only reason we want to come down if things go wrong what do I want? I want the airship to come down. So already I called them LTA vehicles. In reality, I cheat and fly HTA vehicles. So you can tell it has a buoyant, heavier than air vehicle to be very precise. So this is one solution. True, very true.

But you see one has to do a trade-off between what is the total consumption of fuel? Either you have to always fly lighter than air. You fly lighter than air and then have some system which will bring it down forcefully. So which of them will consume more power or more fuel? We do not know, right now. So from a safety point of view, normally airships are flown statically heavy.

The static heaviness of a typical airship with 50 passengers is around 500 kg which means there is a 500 kg force acting down always. So if you are offsetting gravity with a 500 kg lag, so that if something goes wrong, you can slowly come down. Anything else? Yes, so this is called a static heaviness, so you can make it around 6 to 10% statically heavy. So the extent of buoyant force is only 90 or 95 percent. 5 percent, you would like to create by aerdynamic forces.

You can what we do is, in our flight, we mount the engine on a slight angle. So, as she takes off it is not following flight, it is always giving, so one component of the engine always giving me that

Because then you are losing it is like consuming fuel or consuming their gas. So it is done but only in an emergency is when other things fail and you desperately want to come down. Then, venting of helium gas is perhaps the last resource available to you to reduce the lift any other way of bringing an airship down? Yeah, reverse thrust vectoring. Yes, so you create a downward force and you bring it down. Anything else you can do?

Reduce the volume of the balloon, how do you do that? So what are you saying is that you will do something, so that the envelope volume is reduced. Yes, it can be done, it can be done. This is a really nice innovative way of doing it. This is this is something which we have to think about. When we do any aerostatics at that point we will realize it, whether we can have a multi compartment gas bag and then you can push gas from say three bags into one bag and then collapse 3 bags.

So that the volume of the envelope reduces but the mass of the gas remains the same. We have to revisit this when we come to aerostatics. There was something that you were saying. Liquefy the gas inside. A very complicated mechanism because the system that you have to carry on board to liquefy the gas will be difficult. I will tell you simpler methods of doing it. Yes, this is what I was going to say.

Collect water vapour from the atmosphere, condense it, you get water, which is very heavy and that can. But you have to wait for a situation when there is water vapor. Above Sahara desert there is no water in the atmosphere and you cannot come down. You have to wait for rain. You cannot do that. So it is done. Collection of water is done. In fact, what also we do is the exhaust of the engine. Even there, there is some water vapor sometimes.

So we will see that all this will be a part of the course any other way of bringing it down. So why not do the following. Why not make it heavier than air in the first place? So that when you want to bring it down, do nothing. It will come down. So what you do is, remember that when you are flying at some speed because of the shape it will generate some dynamic lift. If you are a clever aerospace designer, you will be able to give a shape that gives you a very good lift.

How do airships come down? This is a very good question because I have learned that whatever goes up must come down. But in this case of airships, how do they come down? So first question is how do they go up? The mechanism which is used to make them go up, I would say a kind of reverse of that is used to bring them down. For example, you saw in the airship video that the power plant was tilted to give vector thrust.

So vector thrust was overcoming gravity to go up. Of course, gravity is overcome by buoyancy but you want to physically go up to create an unbalanced force, you can do it by tilting the engine. So you can do the reverse to bring it down. That is one way of doing it. That is a very technologically expensive way of doing the thing. Of course airships do have thrust vectoring mechanisms.

So can someone help in this? It is a very interesting question and it needs a little bit of thought on how do we bring it down? So like what would you do to bring an airship down? Name? Vineeth, from which department are you? Bring it down or pull you down. When a boat reaches near the shore, they throw a rope. There is a big poll and tie around it and then some people pull it. Similarly, we can bring some airships down by physically pulling it down.

This is one way of doing it. But then you have to either you have to fly very near the ground, so there is a rope always hanging below. Suppose you are above that. Let us say you are at thousand feet. Now you can throw a thousand feet rope and ask people to pull you down. It is difficult. Yes, tell me. This is one way of doing it. You have a small air bag inside the gas bag. So when you have the right amount of air along with the lifting gas inside such that lift is more than or equal to the weight, it will go up.

But when you want to make it heavy, you can collect air from atmosphere in that air bag. So you can have a system which just takes in ambient air. Now this air is heavier than the gas inside. So the net weight increases, so she will slowly start sinking down. This is one way of doing it. Yes, please say. Controlled venting of helium is a way to bring it down, to bring the airship down but very expensive way of doing it.

a manned airships with the tether. So now whether you will call it as a tethered airship or a man carrying an aerostat that is up to you. But yes, but what kind of application did you have in mind for a manned aerostat?

We say the endurance is 48 hours, let me correct you. The 48 Hours endurance is for a manned airship. For a aerostat the endurance could be even 6 months. Just a function of how much gas type the envelope can be made. And over how much period of time the gas will leak out sufficiently to run the buoyancy is completely lost and she starts coming down. And if you use so much height it becomes ineffective.

So, you are talking of an application where you have a tether and then you have an airship. So it will move around or whether it is stationary. So if it is stationary why do you want to put a man on board? What will be the benefit? No, the differences are only this, that the usage of LTA gas there are some constraints as well as because of human being on board in the safety issues, there are higher factors safety's in the design. Anybody else has any questions?

Yes, name. Let everybody know you also, I know her but others should also know, yes Ramya. Oh yes, we will have a special lecture on materials used for LTA systems. Anyway we will discuss what is done to ensure that the gas leakage is minimized. So I will just tell you basically what we do is there are two approaches. One approach is to use a double chamber envelope.

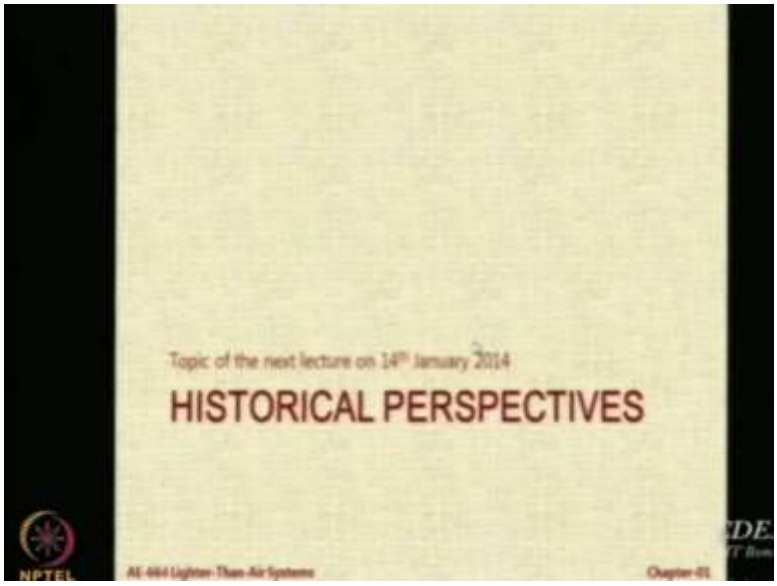
So you can have like a football, internal bladder will be only for controlling the gas leakage or to hold a gas and the external envelope will be to take care of all the loads, scrubbings and other issues. Or with modern technology, you can have a single fabric with either laminates or coatings. So you can think about multiple laminates. There are two envelopes. One example is Tedlar and mylar. These are two kinds of preventing materials.

So many people use Tedlar, mylar laminate. Similarly what most people do is they go for coatings. So if they take a base fabric for strength, they coat inside for gas retention, they coat outside for atmospheric UV protection or ability to withstand the scrubbing of other loads. So, this is what is normally done. Any other questions anybody has? Yes, But you have not mentioned your name.

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -09
Some Queries on Aerostats

(Refer Slide Time: 00:16)



So now the next time when we meet which will be on I think 14th of January we will go back in history and we will try to look at how this technology first came into being and then subsequently, how it went ahead further. I also want to inform you about the first assignment that we will be looking at in this course. Allows it next time because it is to do what we cover in the next lecture.

At this point, I think we can take some questions or doubts that you may have regarding the modern aerostat or airships based on what you saw or if anything else we have in mind. We can take these questions. Yes, please mention your name as you before you speak. There is no difference, except a manned airship. Normally it is designed with a higher factor of safety for every structural component and in manned airships use of hydrogen as a lifting gas is not permitted by law.

So the best of my information that is the only difference between a manned airship and an unmanned system. Yes, there are these examples of hydrogen systems in which people have used

All right now let us look at what I would call as a dream aerostat system, something that is what one day I wish to develop with the help of researchers and that is the rapid elevated aerostat platform.

ground. For protection of dams or other areas where you expect trouble, this is the winch that they have designed, you can see, it is a triangular tripod kind of a winch. This is a close view of how the winch automatically aligns when the wind direction changes.

Some demonstration about the tracking capability of the cameras now these cameras have been purchased from companies in Israel. But when you integrate them they have a correction mechanism. So that the vibrations of the airstrike can be automatically corrected. Now there is a question people ask about what happens if somebody shoots bullets on this balloon, it will bear, it will create a catastrophe.

I will show you a small testing result of a firing bullet where you go. These are being fired through the balloon. There will be a slow motion video which will show you that the bullet enters and leaves. Of course there are two holes created but this is a low pressure balloon, so it does not explode. The gas inside is helium that does not catch fire and it takes time for this gas to slowly leak out by the time you can take emergency measures and bring the system down.

So during the world cup football there was in brazil nearby these highways if there are any mis happening, where you can see people are Standing at the top, now in case of fishing so in the IR camera but this picture without all cameras a transponder mounted below the aerostat for mobile communications.

(Video End Time: 17:41)

(Refer Slide Time: 17:43)

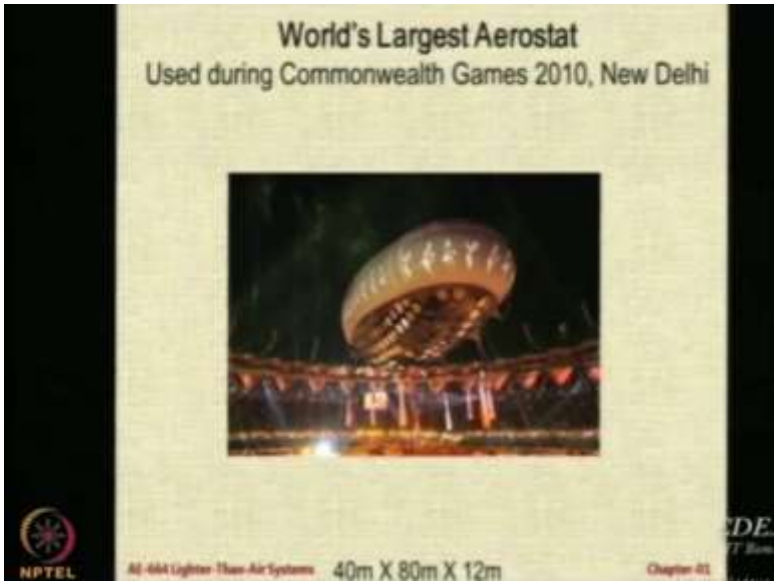
And then a similar application is also being used by a company, with which I very closely work. Now, this is a startup company by two M Tech Aero students from a university in Brazil called as ITA Institute Technological Aeronautical. So these guys have started a small company which uses this simple oblate steroid aerostat with sail. So let us just have a look at what they do, this is also a promotional video.

(Video Start Time: 13:15)

There is no audio in this, just music. I will tell you how, what things are happening here. So this is an example of how it can be deployed from a field, so there is a small customized winch which has been patented by this company for a small aerostat. At the moment they are buying this aerostat envelope and tether from a company in US, but eventually they have a plan to make it indigenously.

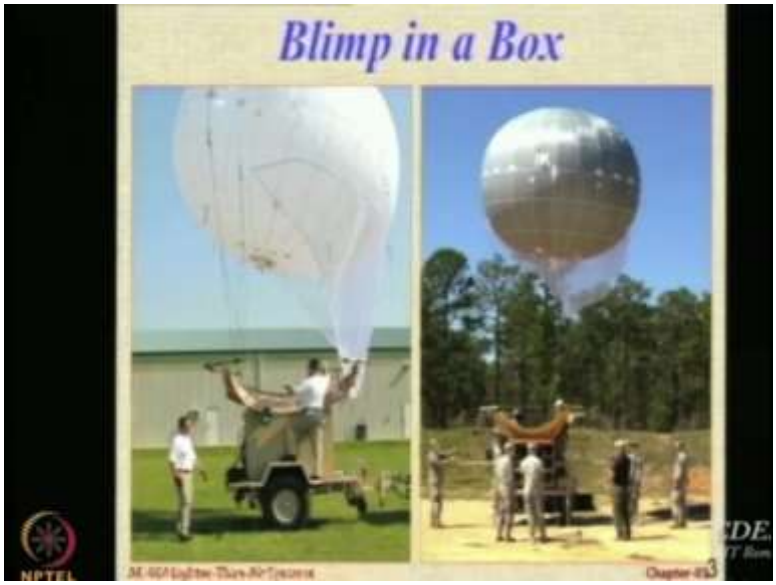
This is aerial view of the campus of that institute where this company is located, so this is their wind tunnel hangar, they have a big wind tunnel here, these are the departments. And next door is the airport you can see a small aircraft coming into land and at the end of this is the hangar and production facilities of a company called Embraer Aerospace, which is the Brazilian aerospace manufacturer.

So this institute is co-located with Embraer and also with the military base, you can notice how infrared cameras can be mounted on this balloon to identify people, this is a shot from the aerostat



This is the common wealth aerostat which was nothing but an aerial screen on which information was projected for entertainment purposes. So this is also although you can call it non-technical application, but it is an application and it is also in the same family of inflatable systems.

(Refer Slide Time: 12:04)



Now to increase the portability of aerostats simplicity in their design and to ensure that they can be used more for remote applications. People have come up with designs which are making them highly portable. So this is one called as Blimp in a box, it is a trade name of a company which uses either for defense applications as you see on your right or applications for civilian on your left.

(Refer Slide Time: 12:41)

Another example is for collecting the meteorological data, so for that small aerostats like this can be sent up or can be stationed at a particular place for a long time you can collect data regarding the weather, atmospheric properties and many other parameters which are difficult to calculate. For example, if someone wants to do a study about pollution happening because of a chimney in one particular area.

You can actually use the tethered aerostat at various heights, sample the air and calculate the presence of harmful compounds. So aerostats allow aerospace engineers to collaborate with other disciplines and enhance the capability of their sensors or their systems. And they allow it to be done in a very cost effective manner. You do not have to be a pilot because it does not fly, it does not need any piloting skills and it is safe, because it is tethered to the ground.

If there is a serious problem if the winds are very high or there is a disturbance you can just bring it down and it is possible to install on an aerostat and airship. Many safety systems which will take care of emergency situations we will showcase to you some systems that our students and researchers have developed as part of their work. And also I will showcase one example in which we successfully use that system during our own testing when things went bad. One can also find some other applications of aerostats.

(Refer Slide Time: 11:42)

A revolutionary long-range surveillance capability providing continuous detection and fire control data on army, navy, air force joint and coalition networks. JLENS extends the battle space allowing war fighters to simultaneously detect and engage threats in three hundred and sixty degrees including ground targets, sea skimming anti-ship cruise missiles, unmanned aircraft and surface moving targets like swarming boats from up to five hundred and 50 kilometers away.

JLENS provides more time. Conventional radar can detect an anti-ship cruise missile only seconds away. JLENS can detect that same threat when it's launched and because JLENS has fire controlled radar commanders can protect themselves from that threat at the maximum kinematic range of their defensive weapons. JLENS is always on, it provides three hundred and sixty degrees of continuous surveillance twenty four seven, thirty days at a time.

Allowing commanders to develop and analyze patterns of life over time and make better evaluations. JLENS is proven capable, cost effective and ready an existing system for a growing threat, a smart approach to safeguarding commercial and military interest in strategic waterways. JLENS more time and distance to detect to decide to engage.

(Video End Time: 08:56)

So Raytheon is a company which has developed this system as you observed, there were two aerostats one of them has got a fire control radar and a ranging system the other is used only for observation. So as soon as the observation aerostat observes something that is fishy. It will communicate the information to the other aerostat which will then immediately communicate with the fire control system.

There is a fire control radar so it will communicate with the fire or launching system which can very quickly engage with the adversary. Otherwise by the time the adversary is detected it is too late. So this kind of a couple so that is why it is the netted system, it has got two sensors which are netted together. So this is one example of how aerostats have been used recently.

(Refer Slide Time: 09:55)

For that one can use what is called as a balloon barrage system. This system was developed by the allied forces in the Second World War in which they mounted these or sorry in the First World War they mounted these aerostats on the border of an aerodrome.

And the steel wires of the tether would entangle with any enemy aircraft coming in to bomb these fields. So by putting a family of aerostats around you can protect it from the enemy aircraft

(Refer Slide Time: 05:41)

Let us look at some very modern applications of aerostat once again. I would like to reiterate the aspect which I mentioned and I will keep repeating it that your own imagination, your own creativity can play a very big role in finding new applications for aerostat. This is also one very interesting and creative application which is now developed into a product called as the JLEN system. So let us have a look at the JLENS. It is a promotional video by a company but approved for public release.

(Video Start Time: 06:23)

As you can notice there is a growing threat to our vital sea lanes and strategic waterways multiple fast-moving asymmetrical threats such as anti-ship cruise missiles, unmanned aircraft and swarming boats which can be armed with missiles suicide bombers or small arms. Today's warfighter needs more time and more distance to detect, decide and engage the threat. The threat is immediate, the solution already exists.

Let us see the applications of aerostats again. These applications are ones which have already been done, so surveillance and communication you can use it for surveillance at the border, surveillance to give huge coverage. the Indian air force. For example, has installed aerostats for aerial surveillance, they are typically installed around 50 to 100 kilometers inside our territory and they can give a visual coverage of around 350 kilometers.

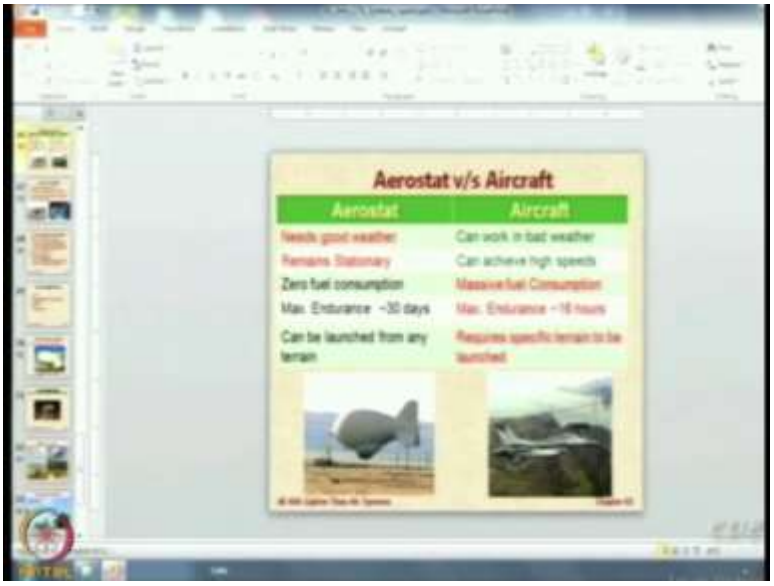
So they are safely located inside our territory, they can be protected by our own aircraft but they can still give you very good visual information about activities across. Similarly aerostats have been extensively used for surveillance over the sea and for military applications and by mounting the communication equipment on the aerostat you can use it as a transponder for wireless communication for high speed last mile data links in areas where there is no connectivity.

Or if there is a disaster at a place and there is no coverage there you want to give temporarily. Some coverage to help in the rescue operations you can set up a small communication station and then relocate it very quickly to some other place by using tethered aerostats. We have done some work in this area I will showcase the work done by our students and researchers in a separate lecture towards the end of the course.

Then you can use it for local area surveillance. One very interesting application which we will elaborate more when we look at historical perspectives is to go for protection of the aerodromes.

And then because aerostats are lower to the ground they are going to give you much clearer and sharper detail as compared to pictures or videos taken from an aircraft. Because they are closer if you are the height of the obstacle, the height of the object to be surveyed if it is more you get larger coverage area but you will then you the flip side is you lose on detail. So what we have seen is aerostats versus satellite, I think I should show you before that.

(Refer Slide Time: 02:01)



These are some of the applications of the aerostats, maybe we can just look at this. If we look at aerostat versus aircraft. Now Aerostats there are two red marks which are its drawbacks first of all they only work in good weather, they need the weather to be good and they remain stationary not as exciting and as dynamic as an F16 or an aircraft but the Fuel consumption is zero and they can give you endurance for a month and they can be launched from any terrain.

On the other hand aircraft can be used in even bad weather conditions to an extent and also you can achieve very high speeds supersonic, hypersonic. But the other three things are not in favor. So because of this, there is a role for aircraft there is a role for aerostats there is a role for satellites. The best thing to do is to use all of them together in conjunction with each other.

(Refer Slide Time: 03:08)

Lighter-than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Lecture -08
Why use Aerostats?

Question is why should we have aerostat? Why should we study this technology? Why should we make aerostats?

(Refer Slide Time: 00:23)

So there are certain comparisons which people make. Now please notice I am not saying that the aerostat on the left is equivalent to the aircraft on the right. I am not going to make that claim the aircraft on the right is far more capable than the aircraft on the left but you know it is just F16 versus one small aerostat just to show you that. There are aircraft, there are aerostats. So let us see.

Aerostats are considered to be very highly cost effective because for surveillance requirements over a month, let us say the amount of money you will spend in operating an aircraft to do that work will be much more than what you do with an aerostat. They are portable and can be relocated so can aircraft they can also be relocated they can fly wherever you want, but they need airports, they need facility on the ground, they need runways which aerostats do not.

just the balloon ok. So now we have NDTV confirmation that aerostat are available and made in India.

have highly maneuverable kite what should I do? I was taught by my senior that there should be 1 inch or 1 figure width more on the top that give you more maneuverable kite.

If the wind conditions are very poor and you are going to basically fly by giving it a constant jerk then the bottom should be longer than the top. So these are the few things you learn. Similarly there are confluence lines which are used to attach the envelope to the tether to which and the length of these lines and their orientation helps in deciding the stability characteristics. You will study this when we come to stability of aerostat.

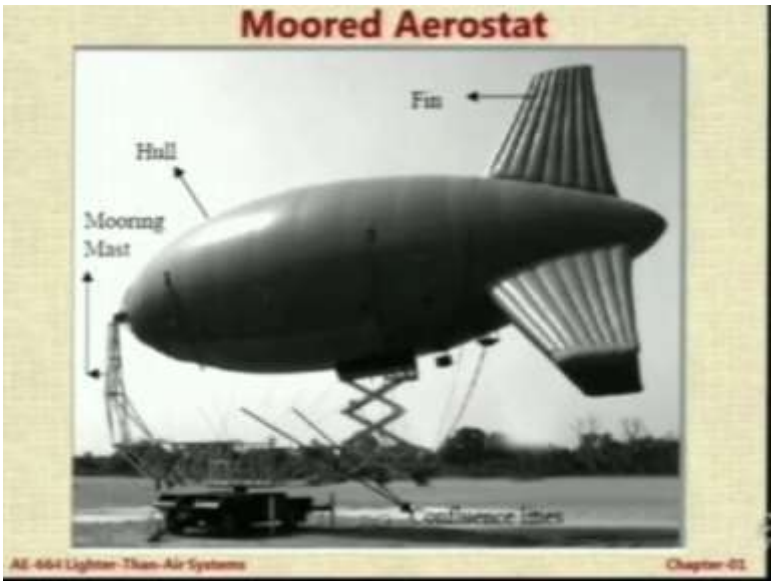
(Refer Slide Time: 17:59)

This is one of the recent aerostats developed by the same laboratory. And this photograph was taken at the aero India show. So you can see that there is very neat winching and mooring system developed instantly by LnT in Powai. And then you have this envelope and here you can see the payload is mounted in this case directly onto the envelope ok. So let see there is very interesting news..

(Video Starts: 18:30)

(Video Ends: 19:46)

Ok now these particular aerostat 17 crore rupees that they mention. Please note the bulk of the money has gone in the radar development or cost of the radar is much more than the aerostat ok. My guess would be that the aerostat system everything together will be not more than 4 to 5 crores and the remaining money will be for the radar ok. But the whole system is what is important not



Ok this is the Moored aerostat developed in India by ADRDE laboratory called as Aerial Delivery Research and Development Establishment in Agra. So pioneering institute or lab in the country which; has done work in the area of LTA systems. Mostly they have worked in aerostat by now I believe they are also starting to work on airships. So this is one of the first aerostats. So you can see that there is this hull or envelope.

Now hull and envelope are interchangeable word. They come from the aerospace lineage and which comes from the ship lineage or naval lineage. Hull basically the body. So hull is as same as anonymous with the envelope. You have fins on the back and notice the fins are quite large in size in aerostats. And then you have this Mooring mast and here you have the system called winching it up and down.

And then we also see something called as confluence line which are basically line which are then attached together. I am sure when you fly kites you will remember when you flew kites that we attach a single tether to the kite with 2 ropes towards the end which are properly sized ok. The angle between the 2 ropes is actually done. How is the angle between the 2 ropes? As children when you flew kites did some one teach you how to do Kanni.

So we hold the knot it should be it should hit the top portion at the top attachment point and the bottom attachment point. So that 2 of them should be the same length which means 45 degree angle that gives the best characteristics. But there were few who are quite enthusiast if I want to

It may not lead to stability so what may happen is if I disturb the system if I take it let us say away it should tend to come back it may exceed and gone the other side. It is still statically stable ok. But then as Hrithik mention over the period of time normally we except the oscillation to slowly reduce and it should actually come back to the position that is dynamic stability. So dynamic stability is what happens in the end does it actually come back.

Static stability is does it tend to come back or not. Say we should have both in aerostat. We should have static stability that means we should have a tendency of it to automatically reacts to someway that it tends to comeback and not only that over the period of time or a recently periods of time we want it to actually also comeback. Not keep on oscillating for whole life. So the tail fins help in both and their size is from both the consideration.

The tether is basically a cable which attaches the envelope to the ground and the payload is what you as a user mount on to the system either on the envelope or at a point below it. At the ground station it is something that helps in 2 things in winching and mooring. So what is the meaning of winching and what is the meaning of mooring? And how are they different. Can someone try to explain? What comes to your mind winching and mooring? Yes your name? Kiran.

The winching is the process of holding in the place and what is mooring? Ok so it is not correct. Actually mooring is the holding in a particular place and the winching is basically a raising or layering to the desired location. So a winch is system which pulls or pushes to intentionally changes the location and a mooring system is the one where you attach it when you do not want it to move.

So you have to have a winching system for the up lowering and raising and lowering and a mooring system to hold it when you do not want. For example when you want to leave the aerostat on the ground for some reason for couple of hour you do not want it to keep moving around you want it to be moored around the ground.

(Refer Slide Time: 15:33)

I will tell you the problem is with the angle that the aerostat envelope is shown. Actually if there is wind it will trend to some angle of attack. It will not remain horizontal the balloon will actually acquire some equilibrium angle ok. So I will correct this figure I have the correct figure I do not know how it is wrong figure has come here. It is made by one of our M Tech student and I had told him that it has to be corrected.

But it is my mistake I put the wrong figure in the presentation. Ok yes it could be but in that case the tethered will not be so much catenary when there is a catenary position we normally expected to trim at some angle. But you are right I could alter the center of gravity and create a situation where the trimmed angle is kind of 0. But normally that is not the case ok. So let us go ahead the tail fins that are mounted behind in are essentially for static and dynamic stability.

Ok now there are 2 words here static stability and dynamic stability. So the aerospace engineers among you I am sure you will appreciate the difference between the meaning of static and dynamic stability. But for the benefit of others who may not know or for those who have forgotten let us have brief idea about what is meant by static stability? What is meant by dynamic stability? And what is the difference between them.

So; any volunteers to explain the difference between these two terms. Do not worry about aerostat talk about aircraft in general. We have the same things apply here. What is meant by static stability of an aircraft or a system. Suneera you want to try? So what you said is if a force is applied on the system it will return back to the original position no this is not static stability. This is of course if this happens the system is statically stable but something less also is acceptable.

Ok so this is not the requirement this is more than the requirement. What do you think is the minimum requirement for a system to be statically stable ok. So you do not have to use many new terms to explain it. Basically you should say if a system is equilibrium and if some unbalanced for acts on it or an external force acts on it. What is the tendency of the system? Under the option of this external force if the response of the system natural response without any intervention is to tend towards the original position rather than going away then it is statically stable ok.

or the equipment that you want to carry could be directly on the balloon if the local loads can be handled by the envelope materials or else you can delete that by mounting it on a point called as a confluence point.

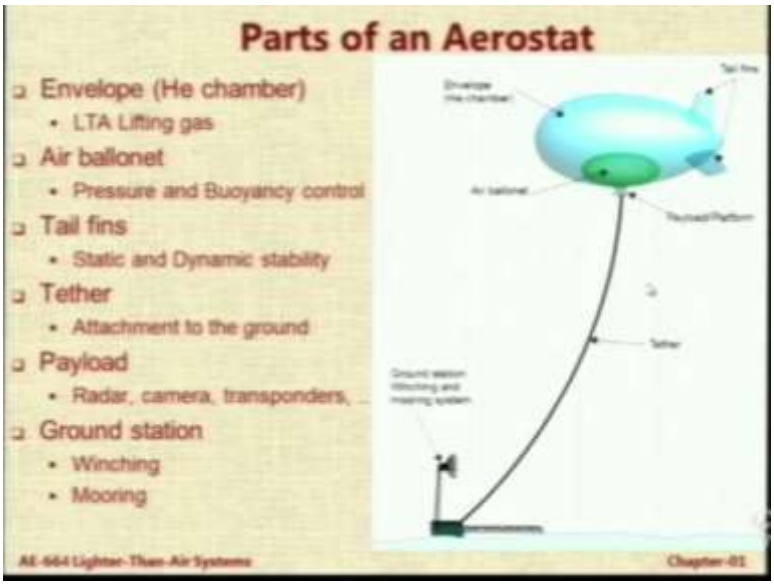
And then the connection between the envelope and the ground is this tether. In this case we have shown some type of a catenary profile because we are expecting it to be under high wind conditions. But there is one serious mistake in this figure. I do not know whether you can make out. What do you think is not correct at least conceptually in this particular figure? At the ground yes the tether will be connected to something on the ground.

In this case they have shown of winching and mooring system. Not necessary I mean you can have various kinds of system. The sketch shows a system which has a small you know cup like thing to hold the nose etc. But one can mount it anywhere as it is conceptual sketch. What is it? Just a minute Amir you were saying something. That can happen if the wind is very high.

When you fly a kite for example in a high wind condition this is the kind of profile you see for even the kite. So the tether can remain in high winds in this particular shape. Yes you had a point yes your name Ashish yes why should face opposite. So it is actually facing opposite the wind that is right. The wind if the wind is from left to right then that is the right direction in which it is facing.

Why should if face opposite to the wind? It should not it is remaining stationery. So the best way to remain stationary is to face the wind and use the fins at the back because as the wind direction changes the fin will bring you back. This is called a weather cocking. So the direction is right. Yes Jagadeesh. That is a conceptual sketches as I said the tether is connected to the envelope it may not be there it may be some other.

I know this is the conceptual sketch I agree there is something more fundamental which is wrong. Yes Suneera yes can be the payload can be on the balloon as I said. It can be on the balloon or it can be below anything else? Ok fine. So basically what we wanted to show was a 3 tail configuration with the third one hidden because it is behind. This one is actually a top fin it may seems to you as something it is incline towards to you as actually it meant to be vertical.



Alright let us look at what are the key parts of the aerostat. So the first and most important part obviously is the envelope. Here we say the helium chamber because we are assuming that helium will be used but it could also contain hydrogen or any other lifting gas. So it is basically the one that contains the liquid gas so it is nothing but the container, it is nothing but the envelope to carry a given volume of gas.

To control the pressure inside the envelope and to ensure that the envelope does not reach breaking point due to stretching because of the change in temperature in or because of any other reason which causes stretch in the envelope? We have a relieving system called as the air ballonet. Please note the t in this word is silence. So it is called as air ballonet. So it is actually a small air bag inside the gas bag.

And by controlling intentionally the volume of this air bag that means by taking out the air or taking in the air in this gas bag you can control the volume available for the helium or hydrogen or a LTA gas inside to expand or contract. So we use it essentially for buoyancy control and stress relieving the envelope. Then we have a payload platform now in this sketch we have shown pay load directly attached to the envelope and we have shown it below the ballonet, but it could be actually anywhere on the body of the aerostat.

And in many cases such as the picture which I showed you ahead the payload is mounted not on the envelope but at a particular place called as a confluence point below the aerostat. So the payload

disturbances occur it should on it own align itself and not demonstrate a continuous motion which will basically distracted from its application.

Now all of these are effected by the envelope shape. And hence the sizing of the envelope the shaping of the envelope and very accurate calculation of the size location and type and shape of the fins that you see on the back is an important exercise. We have to learn all these things as part of this course ok. So this particular aerostat as an example can carry around 10 to 15 pounds of payload at a height of 700 to 2000 feet.

And it is not very long it is probably easily fit into these room. But it can remain upto 48 hours. Now my question to you is should it not remain endlessly why there should be 48 hour limit or so for this particular system. So what do you think is the reason due to which 48 yes I would also encourage people to speak their names because we are still new to each other. Sowmya, you from which department are you? Nanotechnology ok.

So might because of the leakage of the gas contain inside over a period of time the precisely the reason. If we are able to make an envelopes which have got little or no leakage ok then actually there is no limit to endurance. But typically fabrics have a particular leak rate and that introduces a limit to how many hours you can keep it without popping up. In this case it is around 48 hours which is good enough if you want to do if you want to have a system for around 2 days to do surveillance just one deployment and it is there.

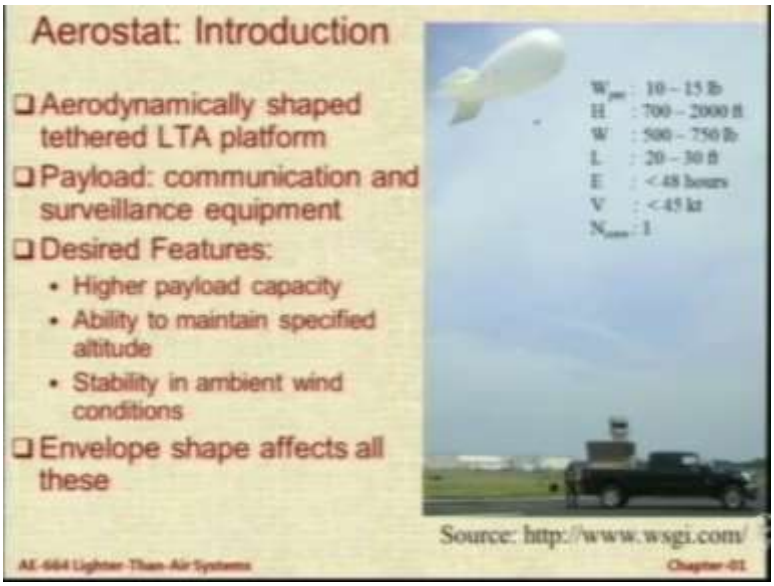
Interestingly it can withstand winds of around 45 knots which become almost 90 kilometer per hour approximately. And it just need one crew member who is standing below you can say. So it is a single man operation or a single woman operation and it can be easily deployed. And the same person can even drive the vehicle and take it around.

(Refer Slide Time: 04:32)

Lighter than Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology – Bombay

Module No # 02
Lecture No # 07
Tethered Aerostat systems

(Refer Slide Time: 00:19)



Let us move on to the next system. This system is not exciting or as dramatic as airship because it is just a balloon which is tethered to the ground. But even though it is tethered to the ground it can be made use for very interesting and far reaching applications. So this is the photograph of a small portable airship which is launched from back of the pickup truck ok. So what is this basically an aero dynamically shaped tethered LTA platform.

So it is not a vehicle, it is not an aircraft it is a platform because it is expected and desired to remain stationery. So one huge degree of freedom we have removed. The payload that can be mounted on this is again limited by your imagination more of people use it for either communication equipment or for surveillance equipment. Now what are the desired feature of a good aerostat for a given size we should be able to carry the largest amount of payload.

It is like just like any other aeronautical system we should have high payload fraction. It should be able to maintain a specified altitude on its own without any great intervention. And once it maintains its position it should remain stable that means as the wind direction changes or

Okay so what i say is that the applications are limited purely by your imagination and creativity I want to share with you one very interesting application which was reported in the Bond movie okay. This is a clip from the film called a view to a kill in which there is a.

(Video Starts: 09:59)

perhaps a demonstration would convenience you I want no part of it thank you for this man Zorin's plan. The rest of our discussion must cross be confidential would you wait outside if you would like me to yes excuse me thank you my day I provide you with a drink.

(Video Ends: 10:54)

Classis James Bond stuff okay so if you disagree with what I say and I you do not agree with what I say which is the same thing by the way you know what will happen.

interesting video which I would urge you to find and locate which shows an airship locating or identifying a person who carries a weapon into the car park of the Olympic Games in Athens. And by the time he parks the car and moves out the airship camera has identified that there is a weapon inform the police and he is immediately apprehended even before he leaves the car park.

Similarly in the Olympic Games in Atlanta before that they were used and recently I got a new article from one of my ex-students that airships are also being planned for the upcoming Tokyo Olympics. Let me show you a time lapse video that shows.

(Video starts: 08:30)

You will see a small thing floating in the sky this is a video which has been accelerated. So what you see is that there is an eye in the sky continuously moving around. And observing what is what is happening below and the beauty of this particular video is that it will cover the whole night. And the airship will be able to do the monitoring without any break because it can go up for many hours. So slowly you will see that the ambient light will start receding and also you will see a slight change in the route which their airship takes while doing the surveillance.

Some lights have come on now this is completely in the dark and it continuous and continuous till early morning.

(Video Ends: 09:36)

(Refer Slide Time: 09:37)

(Refer Slide Time: 06:51)

The picture on your right shows how instrumentation can be mounted on the airship for scanning for mines and the picture on the bottom left with the red peak shows you the result of scanning that was done using airship for locating the mines. The red peak indicates a return where the mine is expected to be located. So then people know where the mine is now you can send equipment to remove the mine without the need to scan the whole landscape. This is one very interesting application.

(Refer Slide Time: 07:24)

The other application which is very common is police surveillance or security surveillance. Many Olympic Games have seen airships being used for security and surveillance and there is a very

But then looking at some other very interesting applications there is one which stands out and that is called as the mine seeker or use of airships for removing mines. So I have a very small film which shows what is happening here.

(Video Starts: 04:33)

As patrons of the mine seeker foundation my wife and I take this opportunity to call upon the world business leaders and statesman to support a new technology our request to read the world of land minds. 15 years we are very privileged to get Brad Pit on board as a patron and he is just accepted. We asked Brad as a big Hollywood movie star and a caring man to join as well absolutely. It is an extraordinary technology right now there is something of 70 million landmines out there people are being heard daily.

We are not really sure exactly where they are and instead of the, what has now become an antiquated technique of searching then out with metal detectors or dogs. This is an extraordinary technology that is able to monitor hundreds of square meters a second and define exactly where and what kind of landmines are there and which will lead to a much quicker removal. So it is an extraordinary technology right now it is just sitting on a shelf and it needs to be put into action and that is why we are here.

We as a group have decided we are going to get the funding we have people standing by that will fund mine seekers and our equipment and our technology and getting the first vehicle actually in the air floating in the air. Our goal is I believe to make 6 to 7 of these and various parts of the world and if for any reason everything else fails. Every aircrafts every friend probably have to fly people on Virgin airlines and everybody we now will make a contribution but we are dedicated to getting this done.

And we are very certain we have the financial means to be able to do that without relying on politics to get it done. But we need political help obviously once we are in the country with groups that help remove them.

(Video Ends: 06:34)

Okay so just a small clip that explained how with imagination and planning and creativity you can use airships for interesting applications in this case for removal of mines.

One can use airships with the advanced imagery systems for sports events or for recording action as it takes place without too much disturbance to the people below.

(Refer Slide Time: 03:40)

And a new application that seems to have come become very popular nowadays is called as the corporate hospitality in which company or an organization hires and airship for a particular period of time. And gives a joyride to its executives or its employees or whomever they want to promote. So you just go up and have a nice meeting in the air for about 90 minutes so let us assume that sometime we will have a lecture on LTA systems above in the airship.

(Refer Slide Time: 04:14)

many cities I know for example San Francisco where airships are used to take tourists up and give them an aerial view of the city and the important sites.

(Refer Slide Time: 02:44)

Tourism or transporting people in or from areas of tourism importance the most famous example of this is in Germany where there is a huge lake called us the Bodensee which is the lake mass that borders Switzerland and Germany. Airships are used for a 90 minute aerial sightseeing tour and it is said that this tour is already booked for the next one year. So if you want to take a tour you have to wait for a year or year and a half there is a so much of demand for this aerial sightseeing tour.

(Refer Slide Time: 03:23)

So, the most fundamental and relevant usage of airships is for advertisements or product promotion. So you simply use the large size of the envelope to communicate a message or a brand and when it flies slowly unobtrusively you cannot but observe it. Airships flying over cities with messages or with logos have been found to be one of the most effective ways of producing or promoting a brand.

For example the 2 famous airships that we all know about are the Good Year airship or the Good Year blimp as it is called and the Fuji film blimp. You will find small models of this hanging below you know outside the shops of many photographic studios because they have promoted the brand to a large extent. So all they do is simply fly all over the world at various places with the logo of the company.

It is said that the Good Year contract or the Fuji contract I do not remember which one has been record braking promotion which is continuing uninterrupted since early seventies using airships. One of the records are longest advertisement contract which has been renewed every year because of its global reach. Similarly when you want to announce a new product or any other thing you can use airships to promote it.

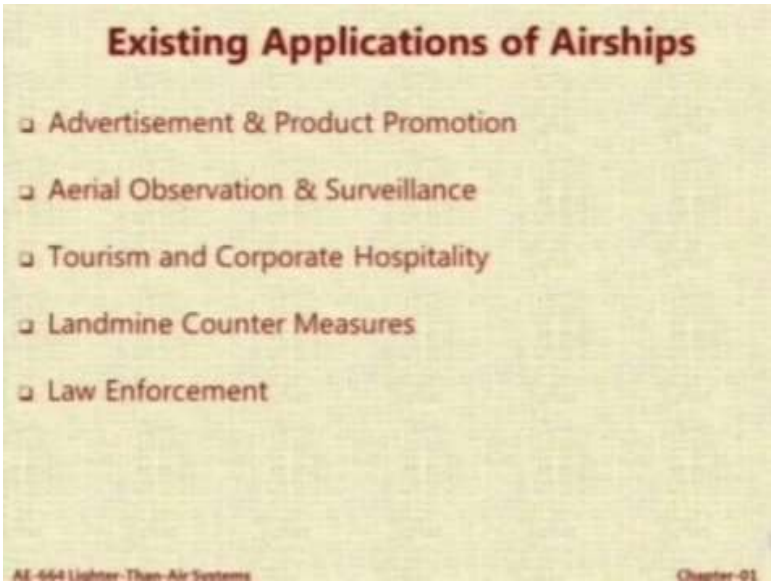
(Refer Slide Time: 02:10)

The other application which has found favor at many places is aerial observation. These pictures shows a company which uses airships for aerial sightseeing over Las Vegas. Similarly there are

Lighter than Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Module No # 02
Lecture No # 06
Application of Airships

(Refer Slide Time: 00:19)



So let us have a look at some of the applications which have already been attempted these are not what can be done. But what which has already been done and kind of order of extent of usage?

(Refer Slide Time: 00:39)

want to do observation of marine, fishery or other let us say you want to observe animals in their natural habitat presence of a helicopter is going to create lot of vibrations and they will not be there in the natural environment. So in short the bottom line is that an airship can be used for various applications as an aerial platform.

That means once you fill fuel without refueling how long can you fly a manned aircraft 16, 17 hours okay. Is the typical endurance of a manned aircraft as against that an airship can easily operate in 48 hours for 48 hours and in 1 trial we also went up to 52 hours of non-stop flight. The third aspect of airships is something that may people makes use of for scientific technical or commercial work.

Applications in which you need either a low speed flight or the ability for the aircraft to remain stationary for sometimes or for long periods of time. And you want an environment which has got lower levels of vibration lower levels of mechanical clutter. For example if there is a helicopter which can do the same things 2 main problems are excessive fuel consumption high levels of vibration which have to be isolated in order to get any meaningful data or pictures from the helicopter.

It is possible and there are correctional algorithms available which will automatically cancel out the vibrations. But still it is a not a straight forward thing plus the helicopter is very sensitive to presence of obstacles in the vicinity. And a small mistake can lead to a fatal crash as we have seen so many accident videos of helicopter if the tail rotors hits in any object or obstacle or the main rotor normally we have a catastrophe.

The airship will allow a large cabins to space with low vibration level and hence the crew can fly. If you have to fly for 48 hours of 40 hours nonstop you need have comfortable environment it is very difficult to fly more than 2 hours in a helicopter. And it gives you a low noise vehicle because the propulsion system as to do less work as I mentioned the gravity is taken care by the buoyancy.

So there is less work to do so smaller engines hence in general lower noise levels. Lesser fuel consumptions means lower pollution and when I say unobtrusive vehicle I mean a vehicle that does not disturb the things below. Below a helicopter you have a massive wash or you have this vortex below the rotor and this kind of rotor wash which is also there below quad-copters can actually sometimes disturb or interfere with the activities happening below.

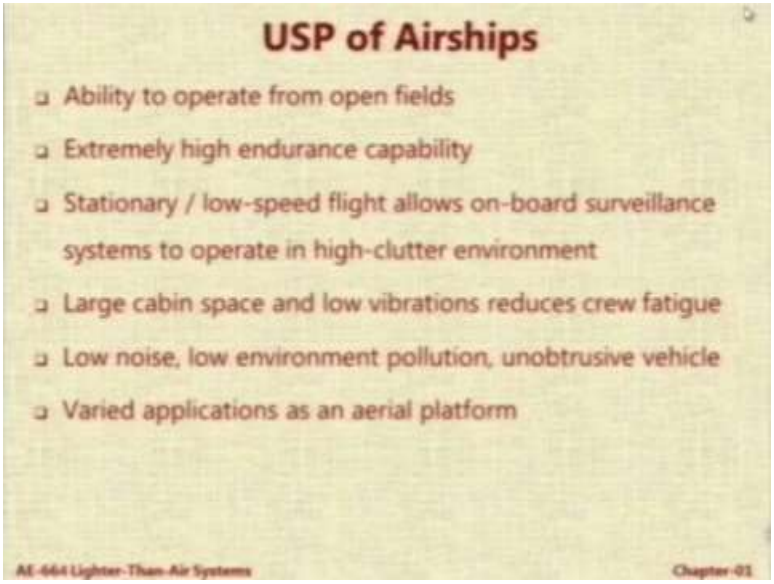
Imagine if there is a football or a cricket match going on and you bring a helicopter to take aerial video obviously it will create lot of disturbances to the activities happening below. Let us say you

That the engines on both sides and there is one of the engines back side which will come fixed on the mass will remove the engines have been picked up to give direct vertical thrust and once the aircraft was left the ground now the engines will be forward to give forward motion.

(Video ends: 08:10)

This third engine on the back which I am right now pointing here gives a direct side force to control the airship.

(Refer Slide Time: 08:22)



So these are the modern airships and what you see now are the USP's of airships. Can anybody in the audience explain the meaning of the work USP unique selling point or unique selling proposition? What do airships have to offer which is unique and which can make themselves or stand out against other alternatives which are available. So these are some of the important USP's of airships as we have seen in both the films.

And airship does not require a runway it does not require an elaborate airport infrastructure virtually any field is sufficient to operate airships. Typically we say that the length and the width of the ground should be approximately 1.3 times the length of the airship and that is sufficient for it to operate safely. Similarly you must have heard that the endurance of sky ship 600 is 48 hours as against this can someone share with me what is your understanding of the maximum endurance of any other manned aircraft.

unparalleled endurance and large payload volume eminently qualifies sky ship for coastal and maritime patrol including fishery convection, navigation, monitoring and pollution control as well as airborne early warning anti-submarine warfare and mine sweeping.

Already defense and coast guard agencies from Britain, America and France are conducting technical evaluations on sky ship 600. After many of hours flying pilot Nick Bennett makes a steep approach to the airfield and brings the ship to a stable hover prior to landing. The vectored thrust engines allow total control in positioning the craft and the rate of descent can be accurately adjusted to suit any payload.

This capability to take off and land vertically make the craft unique among airships gone are the days when fast tracts of runway were needed for their operation the sky ships of airship industries can easily take off and land unprepared ground the size of a football pitch. Once on the ground the ship docks quickly and easily secured to the mast she needs no further tethering no restraint.

The maiden flight had been an unqualified success the concept has been to take a very good old idea of buoyant flight. And then to use new materials or to the best advantage in order to get the structure weight down as low as possible and this is not achievable. So the use of the new materials is enabling us to save weight and weight in an airship is absolutely fundamental because the gas has got to lift the structure as the whole line you can get a structural weight badge next nothing you can see the lift.

That is exactly what airship industries have done already the sky ship 500 is in service in the united states and Japan. And after this tremendously successful maiden flight the 600 is heading for even wider markets.

(Video Ends: 06:14)

Okay so this was a promotional video by the company called as global sky ship industries or air ship industries at that time. They are they have described in this video the modification of a previous airship called as sky ship 500. So this particular airship that you saw is the one that kind of revived the LTA technology in the mid-eighties. But let us take one step further and look at the most modern airship available today for passenger transport and that is called as the Zeppelin.

(Video Starts: 06:50)

Lighter than Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology, Bombay

Module No # 01
Lecture No # 05
Introduction of Sky ship 600 and USP of Airships

Today we start with the short video of one of the modern airships which was developed in mid-eighties the sky ships 600.

(Video Starts: 00:25)

This is a clip recorded during the maiden flights at airship and this will give an idea about what modern airships are as against what you might have in your mind, regarding the first time sky ship 600 has emerged from the royal aircraft establishment of Carrington the traditional shrine of British airship aviation. Now this famous landmark has the latest generation of lighter than aircraft designed and built by airship industries and packed with state of the art aviation technology.

The world's media were out reinforce to witness 600 maiden flight reflecting the global interest in this multipurpose craft. The 600 is a stretched version of the earlier sky ship 500 with passenger capacity doubled from 10 to 20 seats increasing speed increased to 55 knots airborne endurance to in remarkable 48 hours and virtually every other aspect of aircraft refined and upgraded satisfied with the running of the twin turbo charged podded engines.

Chief test pilot commander Nick Bennett was now ready for takeoff using only alone power setting the 600 executed a perfect 0 roll takeoff and climbed steeply and quietly into the sky she had entered her element and was performing to the highest expectations of the airship industries team. Starship 600 ability to stay airborne or 48 hours gives her unique operational flexibility and the non-combustible helium lift gas has eliminated the fire hazards normally associated with hydrogen in her civil role the ship can be transformed into an eye catching aerial advertisement.

She can be used for promotional and pleasure flights and she provides a perfect platform for aerial photography without any of the vibration and operational problems usually associated with conventional craft. As an eye in the sky the 600 can fulfill many defense roles slow flight

observed that it is bit flabby. Why it is so buggy? He said. So we got it down and then we discovered that there is whole on the bottom and then we found that tip and then we did a rewind of the video and we could see the antenna hitting and there was a sound and the tip broke of it.

So whole from the bottom no problem or not much problem from the top yes and one more thing I want to tell you the recent study from the module of dynamics of aerostat. There was a question asked that as the gas comes out there going to be a thrust created so will that affect the dynamics of airship. So there was confusion was the thrust which is creating only 2% of magnitude of the total lift.

And the plots of the trajectory with and without this considered are all identical. So to answer your question, operationally there are measures available to recover a airship even when the envelope is. And finally I will show you a video of our own testing in Gymkhana ground in which we put fire a hydrogen filled balloon to see how it explodes. And that video has become viral all over the world now. Because I will show you, you can draw a conclusion when you see the video ok. I think in that note we can close.

the shape. And of course we have some calculations where to determine this number. There are kind of loads coming on aerostat envelope we calculate these particular number. But it is not very high so therefore the tendency of the gas inside to gush out is not so high. But if there is a hole on the top then being lighter than air gas it will tend to go out and it will go out.

However studies have shown that because the pressure is not so much more than atmospheric the rate at which gas is pushes out are not very large. Interestingly if the hole is on the bottom side then what will happen simply is the outside air will come inside. Because the gas wants to push the envelope up inside if the hole is created some gas will come out very soon you will find that ambient air will start going inside and it will be making airship is slightly heavy.

But to answer your questions specifically there have been instances of envelope tear during flight the time taken for the balloon to come down has been 3 hour 2 and half hours. Enough for you to do recently there was a German airship accident in which the pilot was able to steer the airship with a puncture envelope away from the human territory and unfortunately he died because in the crash landing there was some fire not because of hydrogen.

The fire was because of the engine and the gasoline in the engine spilled out and got fire not the envelope, the envelope was helium. Because legally speaking or regulatory bodies; do not permit use of hydrogen for any human carrying airship. So today you cannot make an airship and fly with human being on both either pilot or passenger where both with hydrogen. It is legally not permitted today.

So in this case helium there was an envelope tear but people where saved the airship got fire and the pilot lost his live but it took quite amount of time. There is a you tube video where it show it is slowly coming down and getting little bit neutrally buoyant and drifting by wind and again coming down. So it is not catastrophic not catastrophic. We had one experience interestingly in IIT Bombay where we were flying a small RC airship and you know a remote controller has got an aerial a telescopic aerial which comes out.

So while starting the engine the pilot who is holding this by mistake his aerial hit the propeller tip and the tip of the aerial broke and it went through the envelope inside. But we did not notice it, airship was flown it began flying then my son was on field with me. He was in class 7 that time he

And generally airships are made to be seen because their body is used to advertise something. So normally airships fly at around a 1500 to 2000 feet above the ground level. They have no benefit in making them like an helicopter they lose payload capacity as they go higher and higher that is the another reason. So the loss in payload capacity with altitude is very dramatic in airships; that is why they do not fly very high.

Yes but the ability to carry payload will sharply fall at high altitude. So you may be flying very smoothly but not payload. And nobody can see you. And something goes wrong and then you will have great time coming down. So that is why the whole purpose is not to fly very high. So above the ground level they are generally 2000 to 3000 feet not more. Unless there are regulatory requirement unless they are made to fly little bit higher by the air traffic control they rather fly as low as possible.

But clear from the ground turbulence, the turbulence from the ground is up to around 500 meters. That is around 1700 feet. So that is why they fly just above the ground level of the earth just above that where the weather is clearly steady anything else? It is good question if there is a break away aerostat that is what it is called. An aerostat which has got a tethered break so what will happen is that it will start rising up.

Why it rise up because in general the total lift produce by the envelope of an aerostat is kept slightly more 15% so more than weight to ensure that the rope remains tight. So that it remains more or less vertical. So when that tether is cut it will become a free flying balloon it will rise up. As it rises up the ambient air density will fall whereas the density inside will remain almost the same or the same. So the delta row will increase.

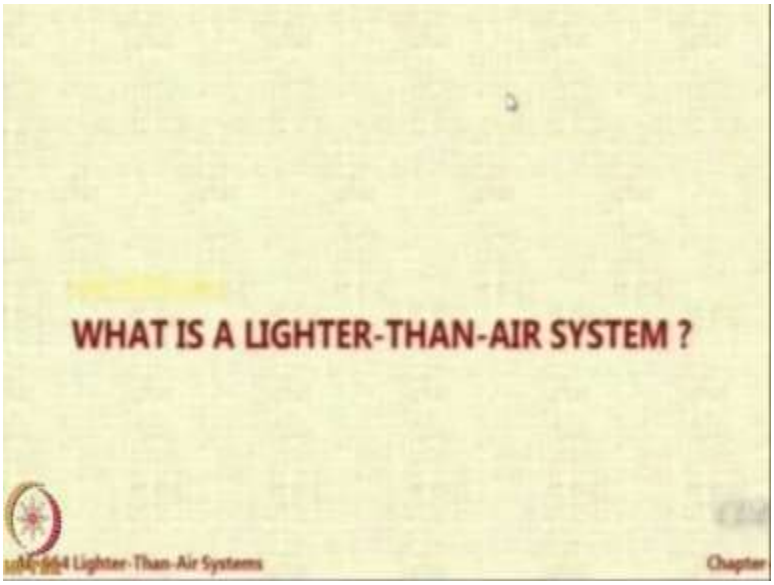
So envelope will getting stretch ok and a time will come when the envelope cannot take it. So it will tear ok. So we have done some studies on mathematical modeling of breakaway aerostats. We will cover that part of the course towards to the in the modern trends. We will show you some results of our studies on breakaway aerostats ok. So where do thing we have? Ok so let me first explain to you that an airship or aerostat envelope is not a high pressure balloon.

The pressure inside is only slightly more than outside. Typical values are around 500 Newton's per square meter higher. So sea level pressure 101325 and the delta P is only 500 just to maintain

kg payload capacity but It can pack into my suitcase because it is non rigid. And then we have a semi rigid which is a combination of both on a cross between rigid and non-rigid some part of it.

So there is internal frame work structure but the envelope is flexible. In the rigid you have an external frame work and you have inside gas bags here there are no gas bags. This envelope is the gas bag but there is structure inside. So as I said we will discuss about this more when we come to the next configuration. Ok I think this is historical facts and we will come to that later.

(Refer Slide Time: 09:41)



So we have come to the end of today's class it is already twelve thirty. May be I can take few questions that you have based on the discussion we had so far or based on what you have heard so for? So either any point that you would like to get clarify. We have few minutes before we wind up. Yes there is a question here yes the question that we have asked is what is the maximum of altitude? Which these airships can go?

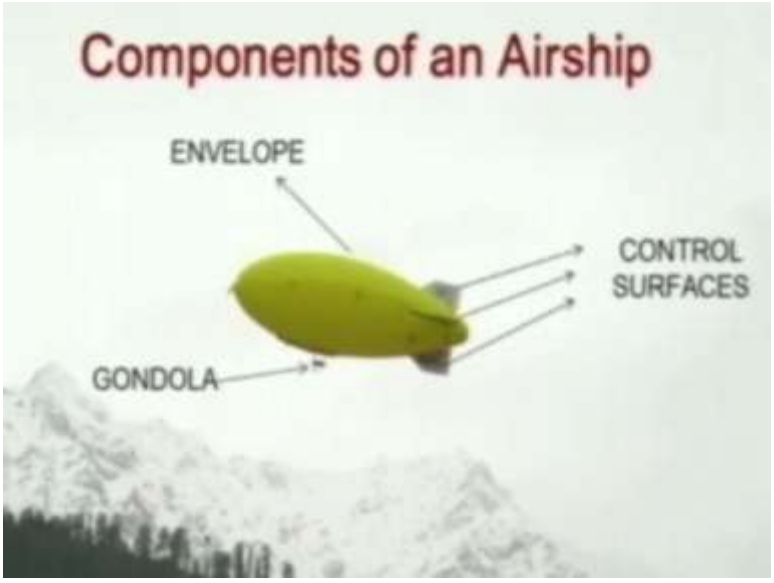
The maximum altitude to which the airships generally fly is around maybe 11 to 12000 feet that is typical maximum altitude at which they can fly. Please understand that in an airship there is no benefit is flying higher. In an aircraft the efficiency of the propel systems becomes more efficient when we go to higher altitudes. In case of airships there is no advantage because most airships are using either an IC engine or some of them use gas turbine but there is no advantage in really going much higher.

Alright there are four types of airship from the structural configuration and I will not spend more time here because we will have a special section on special configuration of airships. But just to tell you very briefly that this rigid airship where the things that we saw mostly in the past they had a rigid frame work totally rigid framework. On the other extreme is the hot air airship this is the hybrid balloon.

So this is the hot air balloon but its envelope will be shaped like a airship envelope. So below the balloon you will have the same heating elements. And this balloon will get inflated with hot air and you will also have integral on that the vertical and horizontal surfaces which are also filled with hot air and you can fly and you can sell kit-Kat make money by. I know a Russian pilot who says i like to fly hot air airships and kit-Kat will pays for it ok or beer company pays for it.

Because they just put the Ads in the balloon and the revenue they get is used for their own flying. So this are like a very intelligent modification to a hot air balloon. Then on the bottom left we have non rigid airship. This is airship which has got no moving parts sorry I am sorry it has got no structure member inside. This is an airship which has got no structure member inside. So the entire thing can collapse and be filled into a bag.

So last summer I went to brazil to spend 2 months in a company and I took an airship envelope with me in the suitcase which was non rigid type just fold it, pack it in the back and take it. It was 12 and half kilograms the ship is 8 meters in length when it is inflated and it can give around 15



Now here I have here is your slide which tells you about the components of an airship. So like an aircraft we have control surfaces. But in the aircraft, we normally see only 1 vertically tail normal we see 1 vertical tail on the top and we see a conventional horizontal tail. Here also we see horizontal tail but here we also see a tail on the bottom. So this is another interesting question that I want you to think about.

Why is it so that in aircraft you can manage with 1 vertical tail and 2 horizontal tail and nothing below or why you do not put anything below. In airships on the other hand almost always you will see 4 tails. And interestingly in case if you want only one vertical tail in airships we put it below not above. So that too I want you to figure out on a single fin airship single vertical fin airship why do we see vertical tail below not above and first of all why do we see if possible people put two of them.

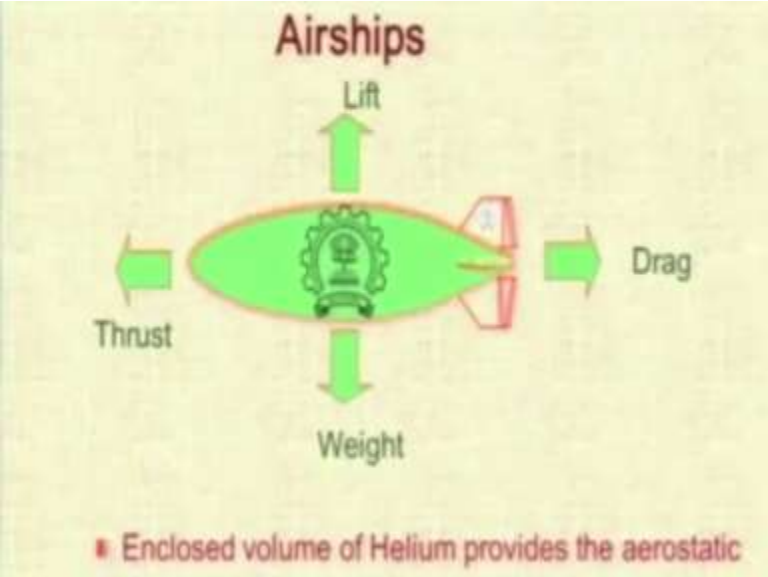
So that is a second question of Moodle. Now the envelope of the airship is equivalent to the wing of the aircraft the main lift producing system. And the gondola of the body which is below the envelope is equivalent to the fuselage of the aircraft where you put the passenger, payload etc., But interestingly the gondola is much smaller size compare to the wing and we see the opposite in aircraft. Generally the fuselage is bigger than the wing is relatively smaller or of the same size. Here the gondola is much smaller than the actually envelope.

(Refer Slide Time: 06:41)

gas. We are forgetting now what about hydrogen? Is there is any shortage of hydrogen. Can it be easily produced? Is it easily available? It is easily available right. Everybody who does welding normally has hydrogen cylinder. Party balloons ok you can create hydrogen from water also.

So if you can do something to hydrogen to make it non-combustible and also not loose its density that is another great discovery ok. But it is not easy. So maybe somebody can search and tell me if there is are efforts going in this direction to create less combustible or un-combustible hydrogen. ADRDE ok so find out and tell me. What ADRDE is doing what is that?

(Refer Slide Time: 04:24)



Alright so this is the first thing I want to do.

(Refer Slide Time: 04:26)

Lighter than Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology – Bombay

Module No # 01
Lecture No # 04
LTA gases, Types of Airships and their components

Can we create or discover? I do not know a gas which has got density lower than hydrogen. If we can we will bring a revolution to LTA system. So this is the earlier research which I would urge people to look into. Can we think of creating either naturally discovering probably it is not there that is why we are not discovered it so far. But we do not know but can we not think of doing something so that the density of the gas reduces.

So practical limitation today is hydrogen But hydrogen somebody has said it is highly combustible. So let say we do not want to put a combustible gas. So now what do we do? The next best gas is helium. What is wrong with helium? It is very scare where in how helium is produced or how it is created? Fractional distillation of air ok yes I have with me in the lab a small helium leak detector which essentially does an analysis of ambient air and tell you how much helium is available.

If I bring that instrument here and move around it will show the amount of helium but 10 to the power minus 5 very small amount. So if I take the entire air in this room and passed it through a special filter I may get a small amount of helium. The whole process is very expensive. It is not commercially viable to recover helium from atmosphere. The presence is in traces. So how is helium produced? So what happens?

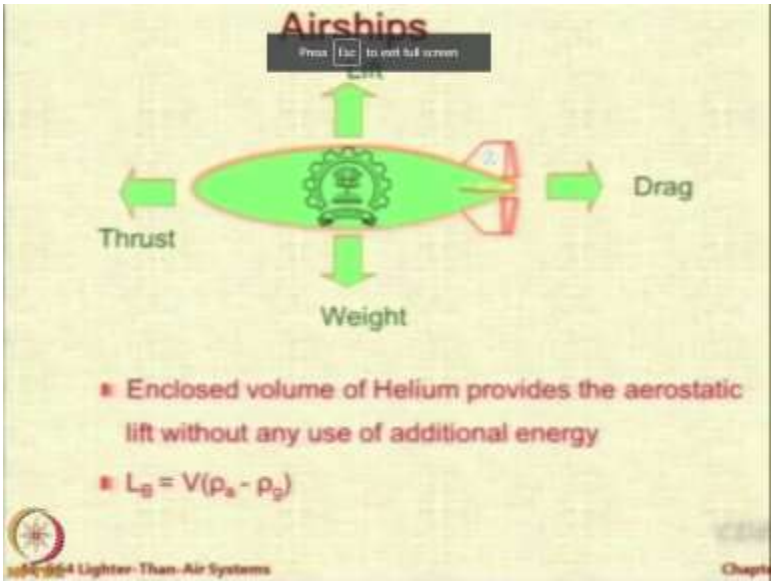
Ok so this is the first question on model for everybody. I want you to tell me where is helium available? What is the cost of helium? Which country had maximum amount of helium reserves and the toughest question is in India where is helium being produced? Not purchase and sold that way I can give you so many phone numbers. Naturally occurring helium where is it being mined in India. Let say if you want to get me a commercial price for helium.

And tell me for example how many resources are available? What is the expected quantity of helium. So let us do some study about availability of helium because helium is our principle LTA

are 4 forces 2 of them are cancelling each other in the vertical direction and 2 in the horizontal direction. Now out of this 4 forces 2 of them are natural and 2 of them are manmade.

So hot air balloon is a very exciting system and the amount of LTA technology that you need to know to make a good hot air balloon and to make it fly well is phenomenal. So all the LTA experts actually are hot air balloon enthusiast normally because they can implement their knowledge and the expertise live on a system.

(Refer Slide Time 12:20)



Ok in an airship like any flying aircraft whereas same four forces. Now first think I want to ask all the aerospace engineering here is there something fundamentally wrong in this picture. We are showing an airship ok IIT Bombay it is not a wrong thing good. shapes also seems to be alright and yes there are 4 surfaces 2 vertical and 2 horizontal. But there is something wrong fundamentally wrong in the way this figure has been drawn.

What is wrong with the drag right that is one point that the direction of the drag will be always along the ambient wind. So this may not be at 0 angle of attack that is acceptable. What else? So if we assume that there is an airship in equilibrium with 0 angle of attack suppose I assume that. Then lift will be equal to weight and thrust will be equal to drag. So the 4 forces will be in balanced as we have shown but still there is something fundamentally wrong.

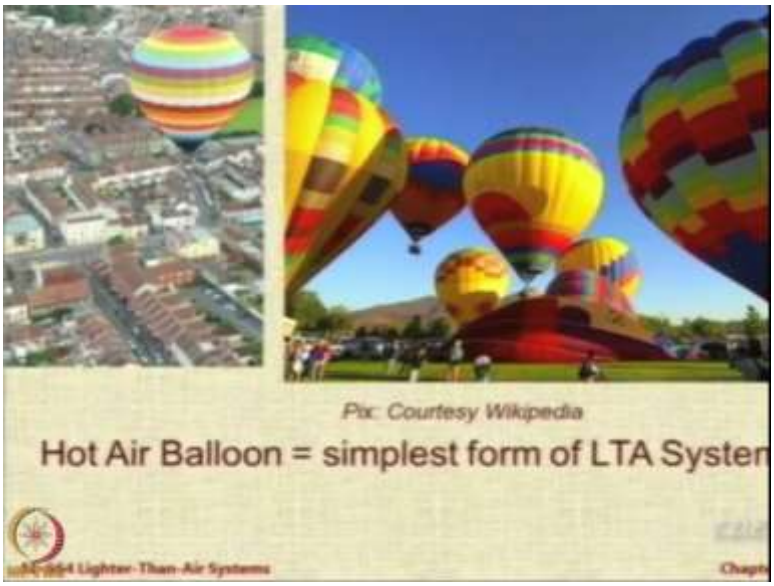
What is it? Ok what is the real scenario they may not be aligned. What about thrust and drag? Correct so may not be. So there is no need for lift to be exactly opposite to weight and drag to be exactly opposite to thrust. That is what is wrong it this picture that the point of action of these forces needs not to be exactly at the same. It is representative picture which just show that there

So you do not want the balloon to be near the ground. You want the balloon to be up in the air at the height you want. So there is something called blowby which is that lateral motion of the balloon because of drag it has to be the least and for that we need low drag shape ok. And the on the extreme left we have a system called airship which is not which is untethered it have got a dynamic shape to give you low drag but it has got these control surfaces on the back.

It also has some portion of the control surfaces are fixed. For example these figure if you can see the hashed member are fixed. The light thing is moving radar. So you need stability also and control. We will discuss this when we come to stability and the control. But additional feature is there is also power plant or an engine in this which gives forward motion. So this is like a proper three axis control with the propulsion system as against the aerostat which has a tether on the ground.

As against a balloon which has no propulsion no tether and no directional control at all. So mostly we will discuss aerostats and airship because they are the one which can be used for some serious or useful scientific or commercial work. However hot air balloons make a lot of money. So for commercial purposes hot air balloons are also very good right. We are not dispensing them we are saying that their capable is limited because they are at the mercy of the wind ok.

(Refer Slide Time 11:49)



are unhappy with it. We do not want it to move. We want it to remain stationary. We want it to automatically aligned with the wind and maybe drift slightly but remains stationary. So what we do is we arrest one of the degree of freedom of the balloon.

So you can assume it to be an aerospace system which is divert to the ground. So all of us who are played with the balloon as children we have played with the most basic aerostat. A string attached to a balloon which contains gas is an aerostat. The difference is that the envelope of the aerostat is designed in such a way that it has best possible aerodynamic behavior. So please tell me what kind of aerodynamic behavior you would like to have in a good aerostat envelope.

What aerodynamic feature you would like to have? Do you want to have it or no? So what is dynamics? You are have an pitching dynamics ok and I am coming over aerostatics. Yes that is dynamics. Alignment requires motion talk about only statics. Will you be happy with positive lift. Will you happy with some amount of lift. No I want to maximum lift. I would like to have maximum lift possible from a given shape ok.

So now which shape will give you a maximum lift. Which shape will give you maximum lift or aerostatic lift. Elliptical is one answer ok. But I do not thing optically you are right. It will be spherical because a sphere is a geometrical body which has got the least surface area for a given volume. So if weight of the system is proportional to the square limit area of the envelope which is true then the best envelope shape will spherical from the weight point of view.

But the spherical envelope need not have a best aerodynamic characteristics. It may not be the best to align it may not be the best shape to prevent yaw and role or pitch ok. So therefore you have to give it an aerodynamic shape so that the drag is minimized. So an aerostat envelope is shaped so that the drag is minimized on the back side you can see there are with fins which I have given so that it align with the ambient wind.

Because it is not aligned with the wind it will have more drag, if it aligned with the wind it will be facing with the least possible frontal area and hence it will have less drag ok. Your question is that if it is a stationery system you should have more drag, so that it does not move. So your argument is true for your flying vehicle which is untethered. If in a balloon you have more drag what will happen is it will actually go like this.

3 types of systems that are normally consider there are hybrids also so you will have combinations of these. And we will cover that in the last capsule of this course. But for the moment let us assume that there are 3 basic vehicle 3 basic system. Extreme right is hot air balloon which is simply hot air. So you generate buoyancy by using the fact that when air is hot its density becomes less compare to the ambient air. So either you can cool the air around you that is very expensive and very difficult.

What is easy is you create a bag which is gas proof or air proof. And the air inside can be contained heated and hence you get buoyancy. So you go up that is what you can do. You go up and then the wind will take over. So with the hot air balloon you can have fun you call it adventure. You cannot plan your journey. Your journey will depend on wind condition your destination and speed is a function of wind conditions.

Some people have tried to make control of balloon by using the sector but they become very complicated. So this is the most basic LTA system and we will experiment with this system also but as you can understand it has got limitations in its capability. Go to the middle of the slide you come with you come across a system which is actually a kind of you know it is a very confusing thing. It is an aerospace system which remains stationary. Hence the name is aerostat ok.

This is very much contrary to common perception how can an aircraft remains stationary. But this aircraft is considered to be good and well-designed if it remains stationary. If an aircraft moves we