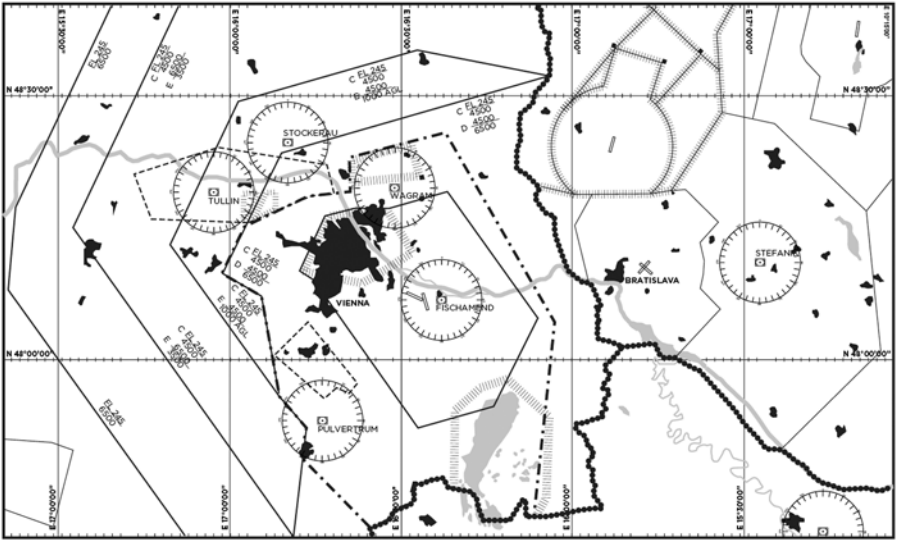
A MANUAL FOR



BECOMING AEROSOLAR

www.iak-institute.org/seminars/becomingaerosolar

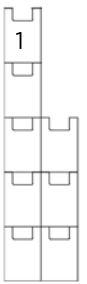
Contents

Introduction

This booklet, made together with seminar participants of Becoming Aerosolar at the IAK, TU Braunschweig, is not only a *Do It Yourself* manual, but also an extensive 'solar database': carbonic textures of ancient peat bogs tapped by coniferous forests, extracted and pressed into cellulose and fiber, trans-mutated into recycled surfaces on which the participants have traced the shapes of their collaboration and ideas.

This is an experimental, architectural art work that could only have arisen from the intra-actions, dis/junctions and re/orientations of day-night workshops, twilight fires, nomadic conversations and pneumatic inflations.

Embedded in these pages are speculations of many aerial species and spaces, lines of flight made explicit in maps, charts, diagrams, and manifestos to (re)occupy air/space and (re)imagine thermodynamics. Through these concepts, pressed and continuous with their materials (hands and minds, folded envelopes, and mechanisms of Lighter Than Air systems), the Aerosolar futures of spaceship Earth come in contact with the present.



Things to Know About Weather Conditions

Wind: Use your skin to sense the condition. Many catastrophes come from strong winds. With best conditions we can travel around the world with winds.

Rain: It is a part of the hydrological cycle. It is full of life! But for flying Aerosolar sculpture it´s the worst.

Sun: Best Conditions! The sun does all the work in the entire solar system! We can only fly Aerosolar with the sun. Becoming Aerosolar is recognizing the amazing power of our star.

Why can´t we fly when rain falls?
We need warmer air inside the sculpture than outside for lift. Rain will cool the sculpture and make flying it impossible.

Visibility:
Visibility can be very difficult to predict, and is probably the most commonly occurring error in waether forecasts.

Mobility Pollution contributes to low visibility and smog.

With Aerosolar we have no pollution and brighter horizons!

Aerosolar Boarding Pass

Premier Class

From	VIENNA
To	STRATOSPHERE
Passenger	Aeroplankton
	GATE: C-120
Flight	H21-BAS2015
Date	21 Jun
Gate closes	**Dusk**
Departs	**Dawn**
Queue type	**SkyAdvantage**
Seq	83iri8

CONFIRMATION: BLNINGSPDR

BAS2015

Announcement!

AEROSOLAR FREE FLIGHT in VIENNA this weekend!

If the weather agrees, we will fly aerosolar sculptures at sunrise on June 20, 21 and 22nd.
Please check <http://iak-institute.org/seminars/becomingaerosolar/> for exact time and location!

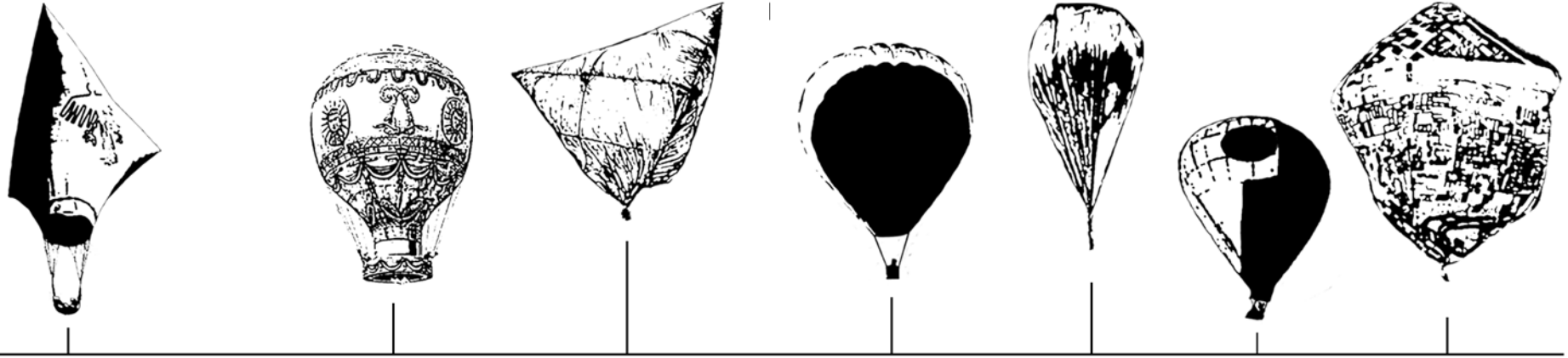
It is weather dependent! We need a calm, sunny day to fly.

Join us! So far with: IAK (TU Braunschweig) “Becoming Aerosolar” seminar participants instructed by Tomás Saraceno, Sasha Engelmann and Jol Thomson; Funk und Computer Zentrum Hohenschönhausen, Sven Steudte and Thomas Krahn; and Adrian Krell, Daniel Schulz, Kotryna Slapšinskaité and Stefano Arrighi.

For real-time updates follow @tomassaraceno, @IAKinstitute and @sashacakes on Twitter. Use #becomingaerosolar to be featured on our social media streams!

HISTORY

Time line of Aerosolar sculptures



1300
Pre-Incan Hot Air Balloon

1783
Montgolfière Hot Air Balloon

1973
Solar Firefly

1974
Double Envelope Solar Balloon

1977
Montgolfière Infrared (MIR) Solar Balloon

1978
Sunstat

2007
Museo Aero Solar

Time line of Aerosolar sculptures

Some scholars believe that the Incas might have flown with hot air balloons made from woven material.

Joseph-Michel and Jacques Etienne Montgolfière invented the first hot air balloon. They piloted several balloon flights including the gigantic "Le Flesselles" balloon which carried six people.

The "Solar Firefly" was the first confirmed truly solar balloon created by Tracy Barnes. It was a black tetrahedron with a volume of 5700 cubic meters.

Dominic Michaelis' solar balloon had a double envelope (outer transparent envelope of 4,000 cubic meters and inner black envelope of 3000 cubit meters) and was piloted across the English Channel in 1981 by balloonist Julian Nott.

The CNES developed the Montgolfière Infrarouge (MIR) balloon to carry out scientific experiments in the lower stratosphere. The MIR is a unique solar balloon since it also captures infrared radiation and therefore can stay aloft at night.

The Sunstat was invented by Iranian Frederick Eshoo and employs a partial transparent design to capture solar radiation with the greenhouse effect.

Museo Aero Solar, initiated by Tomás Saraceno, Alberto Pesavento and the Isola Arts Center, is a solar sculpture assembled from reused plastic bags. Thousands of people from twenty one countries have participated and the project is ongoing.

Anyone Can Fly Aerosolar!

Tethered Solarballonflights under 30 meters and a maximum weight of 500 grammes do not require permisson or any further clearances.

Just make sure, that your balloon can not break away or harm other people or property.

Best you choose a wide field with no trees as your site location.
Now you can instantly start building and flying your own Aerosolars!

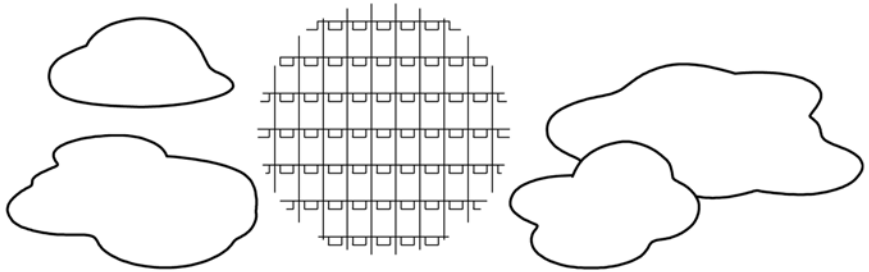
For advanced Aerosolar sculptures and Freeflights please read the further informations in the Section “Aerosolar Sculptures and Air Law”.

On the following page is a petition we can collect to change the rules of air law so that it might become easier to fly Aerosoalr in the future - but we need your help!

DO IT YOURSELF
DO IT TOGETHER

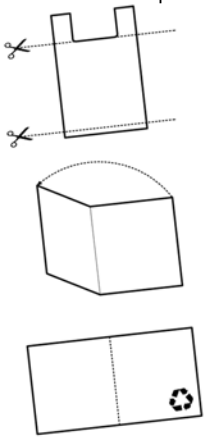
Make your own Aerosolar sculpture!

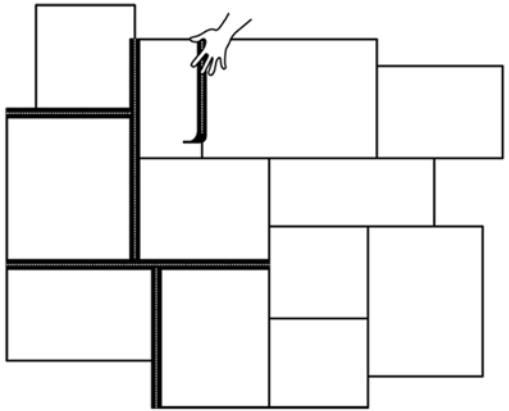
Aerosolar structures can be many meters long and sometimes reach altitudes of several kilometres, they can even lift people up in the sky, so maybe one day we can even use them as a means of transportation.



You can fly your own Aerosolar sculpture: collect old plastic bags, reuse them, tape them all ttogether and become Aerosolar.

Cut plastic begs in rectangular shaped sheets. There should be no holes on them. Make a patchwork sheet and carefully tape them together so no air can escape.





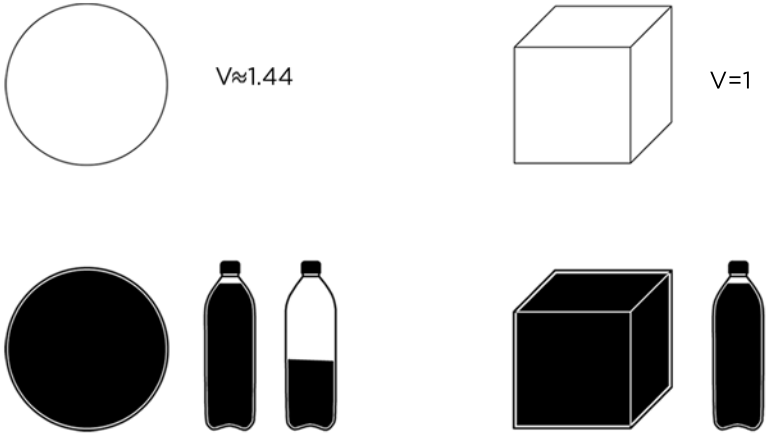
Form finding

Why is a spherical shape the most optimal?

Our Aerosolar sculpture should be as light as possible if it is going to take-off. Smaller surface area means lighter weight - and also less material! The sphere is the one solid that has the greatest volume to surface area efficiency. This is why it appears so often in nature, in water drops, bubbles, stars and planets.

An Aerosolar sculpture gains buoyancy when the air inside is absorbs heat from the sun, usually with the help of black or dark materials. The heated air inside the Aerosolar sculpture has lower density than the surrounding air. The structure floats because of the buoyant force exerted on it by these slight temperature differences. The amount of lift (or buoyancy) provided depends primarily upon the difference between the temperature of the air from inside and outside the envelope.

Surface area is the same, and what about volume?



Sphere

The Sphere is the most efficient shape for the capturing air, but also most difficult. There are several ways how to build a spherical shape. We would refer to world map projections, and evolution of Dymaxion map for motivation.

Cahill, 1909.

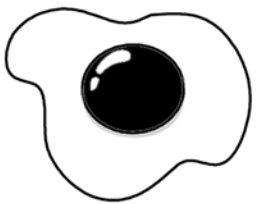
Goode, 1923.

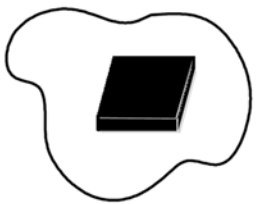
Fuller, 1954.

Cahill-Keyes, 1975.

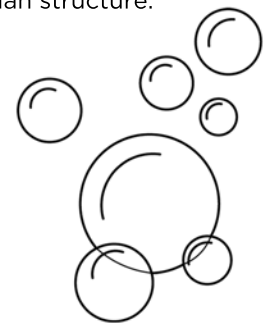
What if world is a cube?

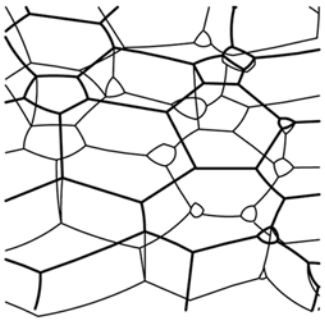
What if egg yolk is rectangular?





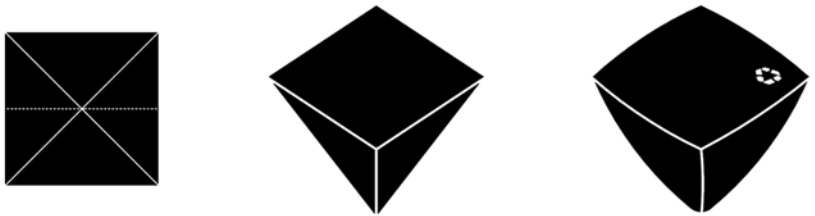
Soap bubbles are physical examples of the complex mathematical problem of minimal surfaces. Since 1884 it has been known that a spherical soap bubble is the optimal-area way of enclosing a given volume of air. In 2000 it was proven that two merged soap bubbles provide the optimum way of enclosing two given volumes of air of different size with the least surface area and is described by the Weaire-Phelan structure.



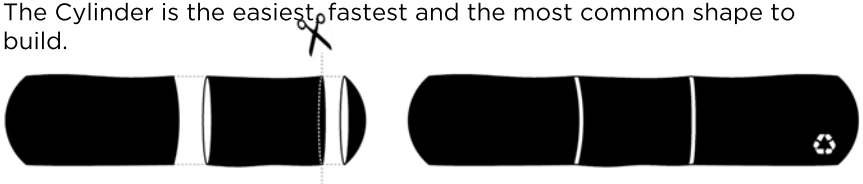


Other shapes

The Tetrahedron is the strongest 3D shape in the entire universe. It is similar to a sphere for volume and weight efficiency and is very easy to build.



The Cylinder is the easiest, fastest and the most common shape to build.



How to build an Aerosolar Tetrahedron

1. Make a long sheet out of mutually taped plastic begs.

2.Join one third of the longer sides with opposite short side corresponding to diagrams, and tape them together.

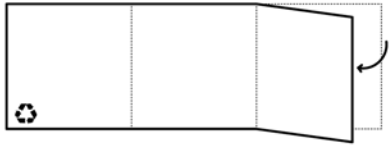
3. Tape the other pair of sides, carefuly fold the tape over the edge pressing firmly to achieve strong, reliable connection.

4. Move sides A-A towards each other, do the same for sides B-B.

5. Tape together sides A-A and afterwards sides B-B.

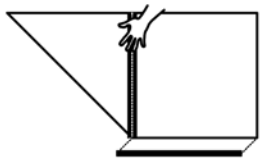
6. Flatten the structure around one of the corners. The choice of corner will influence the final shape. Measure out 20 cm from corner on both of the edges. Mark the points and connect them. Cut a straight line. To reinforce the mouth cut 10 cm along the seams of the sides, place a strip of tape, place a piece of rope fold over the rope and tape along the edge.

1. step

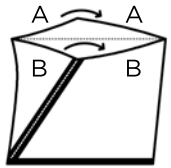


3. step

3. step

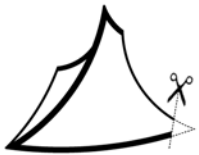


4. step



5. step

6. step



How to Build an Aerosolar Cylinder

1. Take four or more rectangular sheets.

2. Tape them all together on the longer side close to the vertex and than patch the corner.

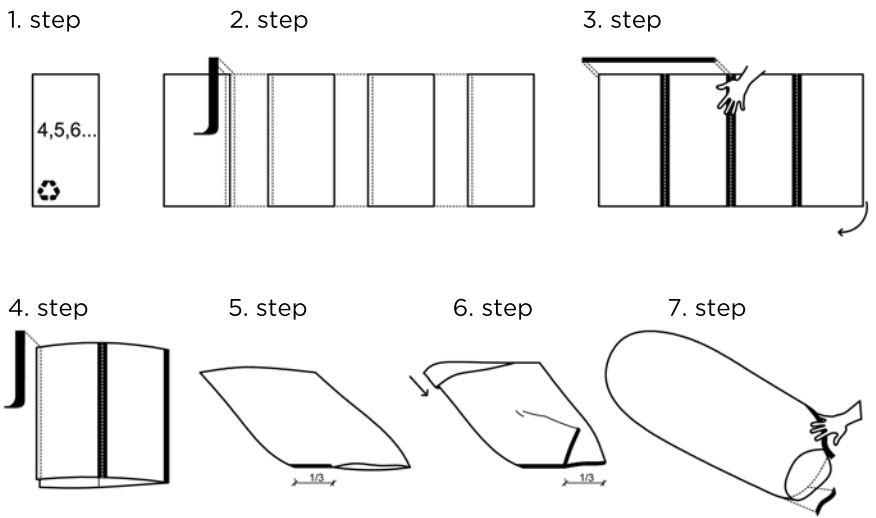
3. Repeat this process, tape them and rotate so you can form a tube.

4. In the end join the two ends with tape, you should now have a flat tube shape.

5. Seal one of the open ends with tape. At the other end of this seam, take the remaining open end and pull it open.

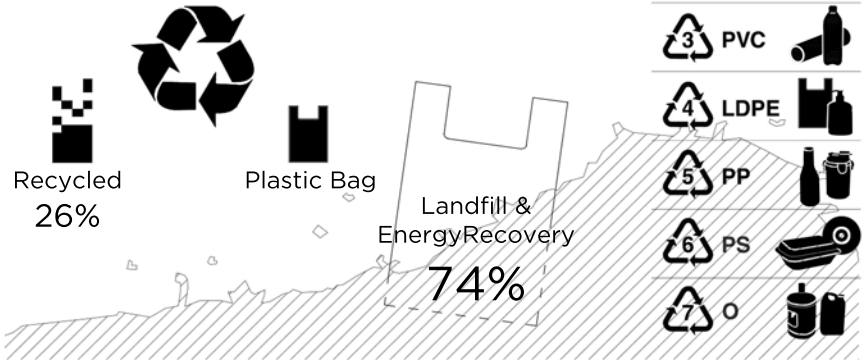
6. Seal this opening so that seam is perpendicular. There should be 3 corners of the balloon. Invert the entire balloon, inside-out like a sock.

7. Fill your Aerosolar sculpture with fresh air outside. When it is full, tape it shut and wait for sun to warm the air. Let it fly in the sky!



Circulation and Classification of Plastic

Raw Materials:
1. Crude Oil
2. Natural Gas
3.Recycled Materials



Learn more about plastic bags

1.Characteristics of Plastic bags:
a. Low cost b. Good chemical resistance
c. Can be modified according to different needs.

2.How does a plastic bag get its properties?
Processing Technique --> Material Composition --> Material Properties

Squeeze Film Blowing	Tensile Property
Flat Extrusion Casting	Shock Resistance
Production Pressure	Tear Resistance
Rate of Extrusion	Friction Factor
Cooling Rate	Transparency
Aftertreatment	Glossiness

3.Why do we need the Resin identification codes?
a.To figure out if there is any poison in the bag.
b.To figure out if it is degradable.

How does plastic damage the environment?

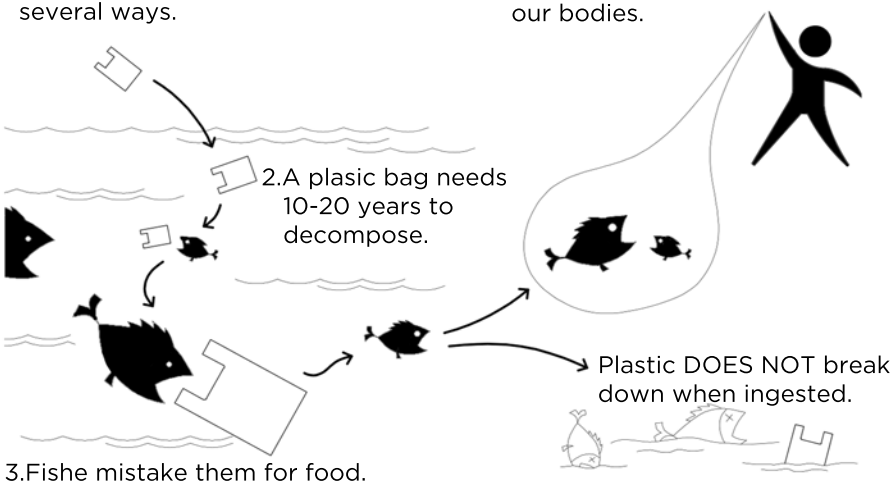
1.Plastic waste gets into the sea in several ways.

2.A plasic bag needs 10-20 years to decompose.

3.Fishe mistake them for food.

4.Finally the plastic goes into our bodies.

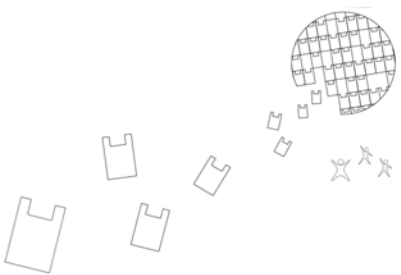
Plastic DOES NOT break down when ingested.



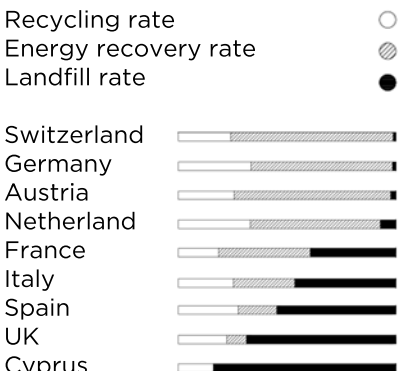
Recycle or Re-use?

Plastic recycling consumes a lot of costs and energy. Landfilling is still the 1st option in many EU countries.

Maybe we can find a way to RE-USE this waste, instead of burying it.



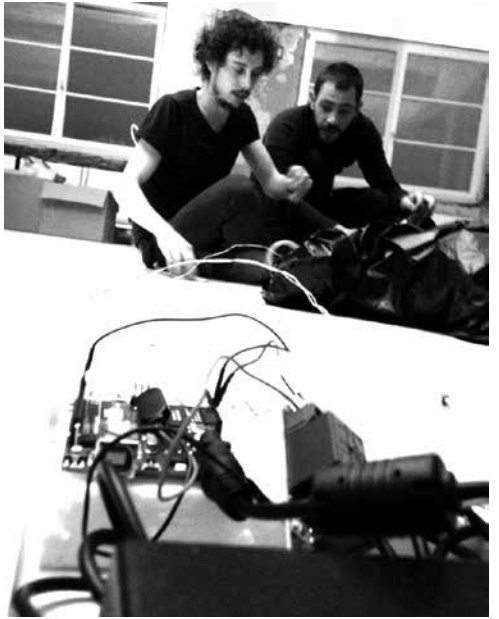
Treatment of post-consumer plastic waste in 2012:



China produces the greatest number of plastic bag waste daily.

China is a country with the biggest potential of becoming Aero Solar.

AEROGRAPHY



Mapping the Sky

Within each layer of our atmosphere lies a certain cultural legacy, a series of human interventions defining skies above us. We use this notion as a departure point for our mapping process. **As we explore we try to assimilate the sky as an added realm of our geography, however this curtain of transparency, paradoxicaly, obscures a complex of political and technological projects at work above us.** *
Untill we are introduced with all the elements that define our sky we will never be able to become it's righfull inhabitants.

a - glıder

b - aerosolar sculpture

c - polar front

d - commercial airplane

e - high altitude drone

f - driftsonde

g - aeroplankton

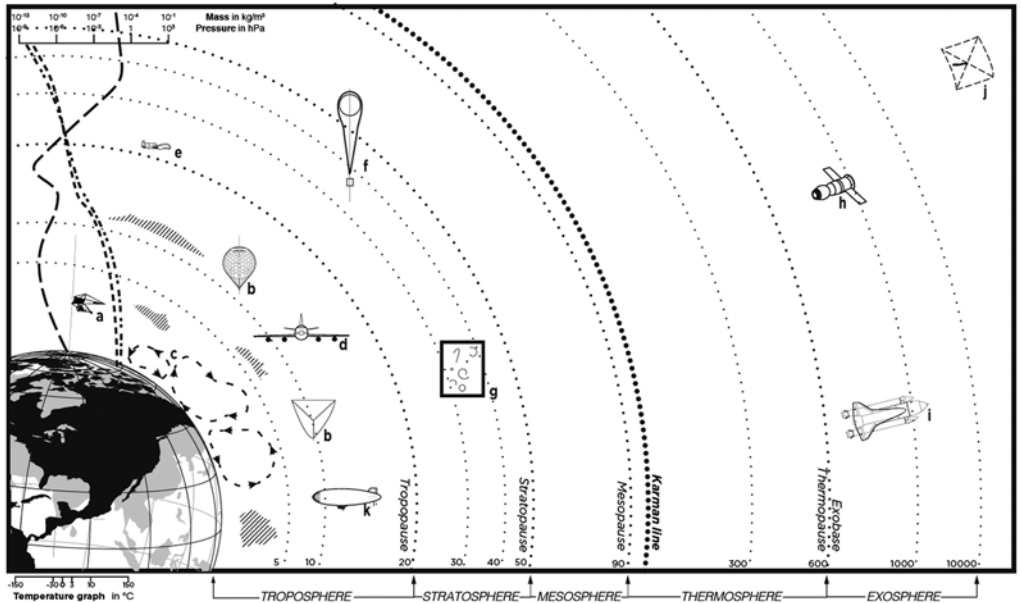
h - satelite

i - space shuttle

j - solar sail

k- zeppelin

Atmosphere Section



Aeronautical Charts

Visual flight rules [VFR] are a set of regulations under which a pilot operates an aircraft in weather conditions of good visibility. A VFR chart therefore contains information on visual ground markers and air traffic restrictions.

Aeronautical symbols:

VOR - VHF omni-directional radio range

Runway with a wind rose, rotated towards magnetic north

Danger zone/ Military area

National airspace border

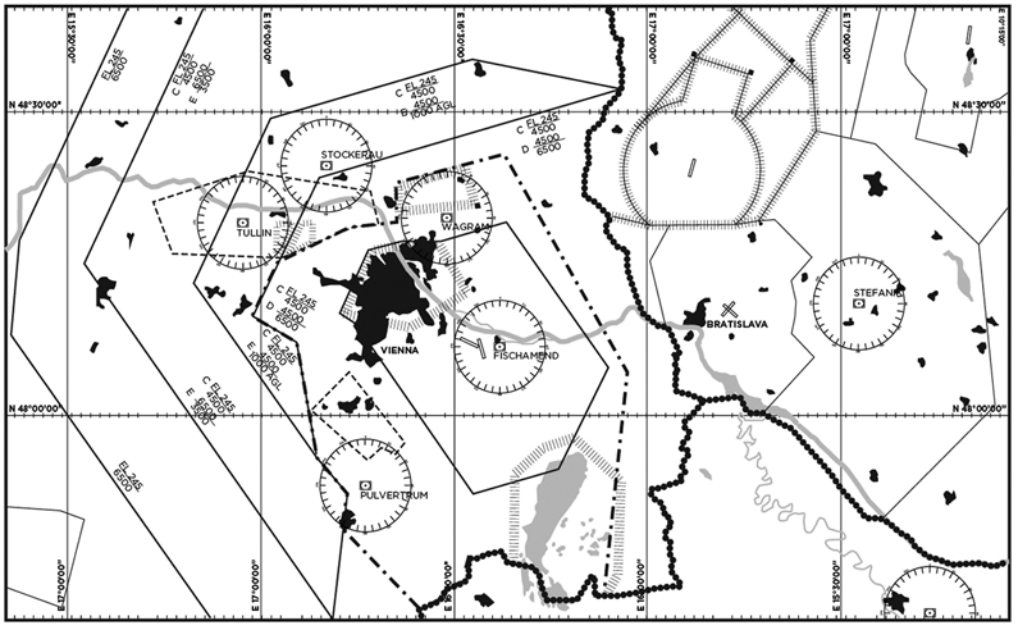
Aerodrome traffic zone

TMZ [transponder mandatory zone]

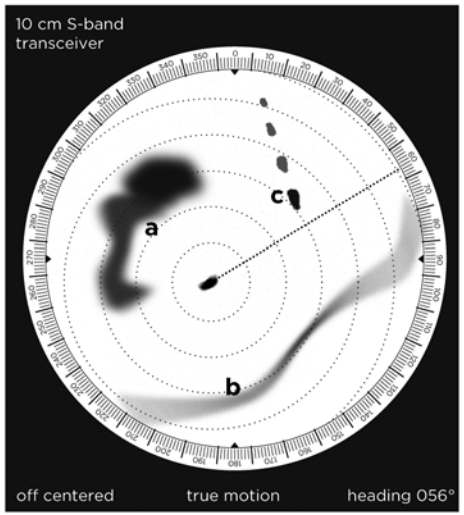
FL 100 / **4500** — Altitude in feet above MSL

1500AGL / GND — Altitude in feet above ground level

VFR [Vienna Airspace]



Viable Charting Alternatives



Modern Air Traffic control depends on the global weather station grid. Each of the weather stations is equiped with basic 10cm S-band transceivers with abilities to detect any solar sculpture containing a silver mylar as a part of outer envelope. By taping into this existing infrastructure, a solar sculpture would in fact become part of the ever changing weather conditions.

a - storm or a typhoon
b - cold front
c- solar sculpture

Aerosolar Sculptures and Air Law

What do I have to consider when flying my Aerosolar?
De jure, flying models and any objects operating more than 30 metres above the ground are Aircrafts. When in the air they are subject to the Air Traffic Act (LuftVG-Deutschland).

Any participant in airtraffic has to behave in such way, that nobody else can be harmed or disturbed.

When can I fly my Arosolar?
You can fly your >Aerosolar< any time of the day!

Where can i fly my Aerosolar?
First you need the permission of the property owner on whose area you are intending to start your Solar sculpture.
In addition, you must keep away from aerodroms or restricted military areas (ED-R) within a radius of 1.5 km.

In the following cases you need permission from the local aviation authority:
- Your Solar sculpture weighs more than 5 kilogrammes.
- Your >Aerosolar< will fly uncontrolled and autonomous.
- You are intending to fly your Solar sculpture at a distance of less than 1.5 kilometres from an aerodrome.
- You are holding the >Aerosolar< on a rope of more than 100metres length.
- For flights within controlzones. (It is very unlikely to get a flight permit in Airspace D and F - please see Airspace Structure on next page).

Who is responsible for obtaining the clearance?
The launcher of the aircraft. This person is also to check airspace conditions at the site location.

How high am I allowed to fly?
In principle not higher than 3km above the mean sea level (FL100, Airspace C).
The Airspace above this mark is intended exclusively for jets and airline traffic.
When claiming controlled airspace (generally from 2500ft (750m) upward E) you have to obtain a clearance form the appropriate air traffic control in the following cases:
-Your unmanned Solarballoon weighs more than 0.5 kg.
-The same applies for clustered balloons or mass ascensions.

Aerosolar and Air Law cont.

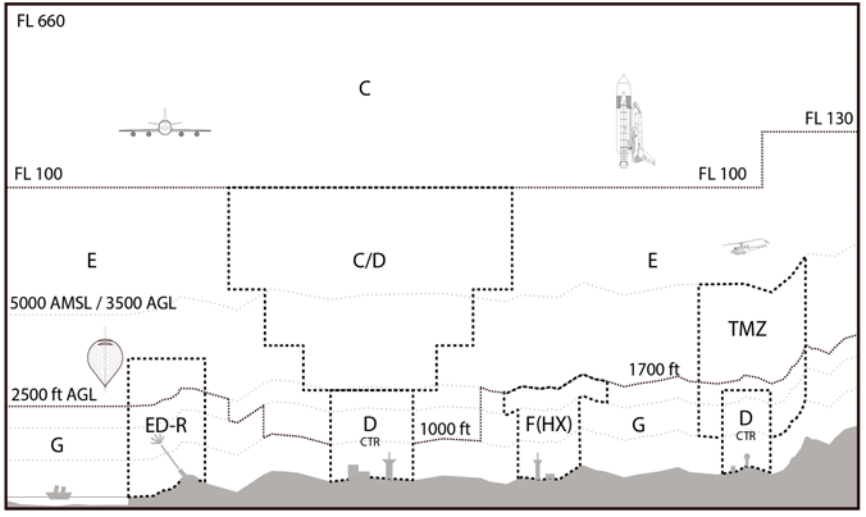
Do I have to mark my Aerosolar
Flying objects weighing 5 kilogrammes and more must be marked visible with the name and address of the owner in durable and fireresistant labeling.

Do I need an insurance?
Yes you do. You have to be insured for any flight you undertake with your Solar balloon. Since 2005 there are no exceptions for flying models under 5 kilogrammes anymore. Uninsured holders are liable for accidents with their private assets.

Can I drop something from the Aerosolar sculpture?
Dropping or abandoning objects or other substances from the aircraft is prohibited.
This does not apply for ballast in form of water or fine sand, for fuels, tow ropes, tow banners and similar objects when they are dropped or discharged at points where danger for persons or property does not exist.

(All rules in this text refer to the German regulations and are subject to change if you **sign the petition to change air law** *(p.41) for aerosolar flights!)*

Airspace Structure in Section View



Just as engine boats give way to sail boats on international water
so should
heavier-than-air vehicles (airplanes, helicopters etc)
give way to

solar lighter-than-air vehicles

in the air !

Solar lighter-than-air vehicles gain buoyancy when air inside an envelope is heated, expands and generates lift. Large aerosolar structures can become buoyant through the temperature differential created by the metabolism of living bodies in their interiors; smaller ones achieve buoyancy by capturing the short waves of sunlight during the day and infrared radiation from the Earth at night. They do not use helium, hydrogen, solar panels or batteries; there is no burner, except for the sun or living being inside.
Let's become more sensitive towards the circulation of energy around us in a solidarity act, towards a thermodynamic imagination, becoming aerosolar!
Toward a clean and sustainable future.

Please sign this petition to change the rules of the air

Name _____ Last Name _____ Signature _____

To sign online or learn about workshops and weather dependent demonstrations of solar lighter-than-air vehicles; please check here:

www.museoaerosolar.wordpress.com - www.tomasaraceno.com - #MuseoAeroSolar or #BecomingAeroSolar

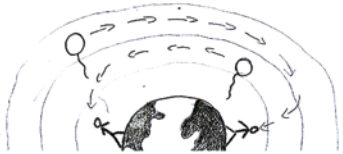
Petition to change the law of the air, Towards solar lighter than air vehicles... work in progress... "becoming aerosolar " Tomás Saraceno 2014 - presented first at Development & Climate Days, 2014, Lima, Peru – during UN Climate Change Conference COP20

Altitude Control and Cut Down Mechanism

However although it doesn't look like it, even the sky has restricted areas. These restrictions vary depending on altitude and proximity to airfields. So, for an Aerosolar flight you need to have an eye on the position of your sculpture, otherwise you will have to confront with even faster and louder opponents!
There is a section in this booklet dedicated to air rules (pp. 36-40).

The second reason for controlling altitude is even more interesting. You have to imagine the sky has different layers and at each layer there is a different air pressure. In these different layers the direction of the wind can change.

If you know the wind velocity at different pressures, you can design a route for your aerosolar sculpture. This gives flying a new purpose. Suddenly you are able to connect points with each other and you can start think about ...



With the different methods of constructing aerosolar sculptures, like those outlined in this booklet, there come different possibilities for work with these kind of flying objects.

Open SLTA

With an open SLTA sculpture you are able to have a one day journey with your solar sculpture. You have a surface, no matter which geometry, with a small hole at the bottom of it.

This hole at the bottom makes sure that the air inside the sculpture is able to escape while rising into layers of lower air pressure.

Because the air is able to escape, the sculpture can rise until the lift force of hot air inside equals the weight of the surface.

If you want to know which altitude your sculpture is able to lift up, you have to do some math.

Start measuring the size of your sculpture, because you need to know the size of volume and surface.

The relation of these values determines the lift capacity and you can know the maximum weight the sculpture is able to lift.

With growing volume of the sculpture the surface is getting smaller in relation to the volume, that means you have a smaller material volume to lift.

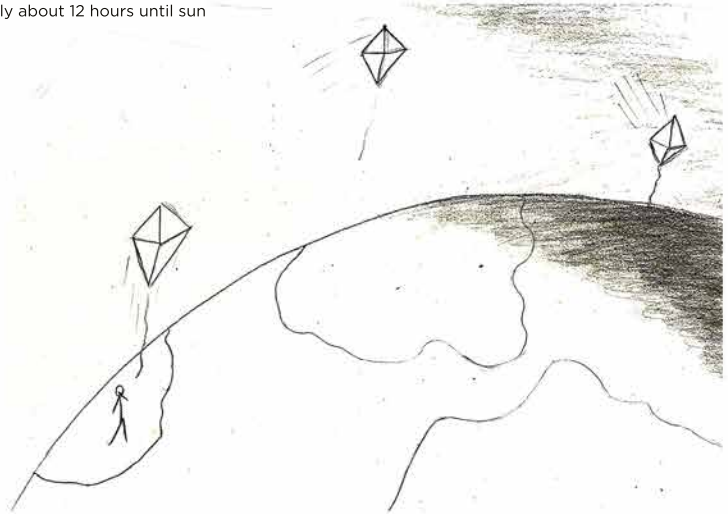
On the other side the lift force of the warm air decrease with lower air pressure as you ascend.

That means even if you have a big volume, there will be a point when the weight of your surface equals the lift force of warm air inside.

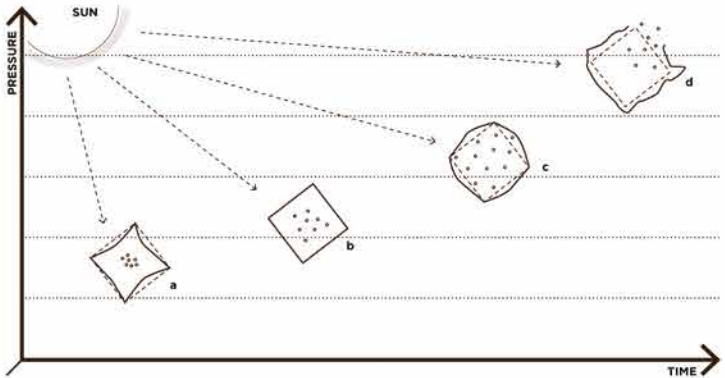
Once you have these three values, you can start to calculate. . .

Duration of Open SLTA Travel

Your SLTA will fly about 12 hours until sun goes down.



Closed SLTA



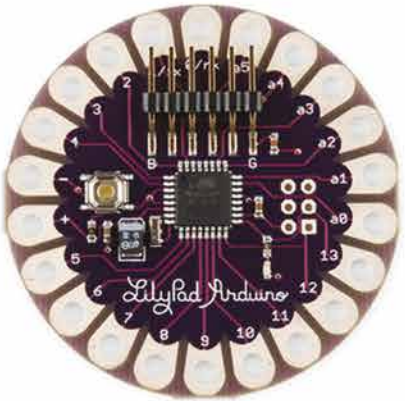
This is for starters who don´t want do lose their sculpture once built. With a closed surface the warm air inside is not able to expand that much. Especially when you take off in the morning you have a bigger different between the air temperature around the sculpture and the heated air in the volume. If you then close the ballon as tight as possible, it will just take a few minutes until the decreasing pressure will burst the surface.

Start Programming!

If you want to get serious you can experiment with micro controllers. These are small devices you have in nearly every electronic device at home.
But you can also get open platforms to program them by yourself.

For example the Arduino board offers you an easy entry to this world. There is a great Community of other Do It Yourself enthusiasts who upload already written programs and explain every step they made them.

Once you get into the arduino device you are able to do amazing things like measuring air pressure, temperature, moving servo motors or #:you can even go online up in the air. These are all useful tools to interact with the environment of your solar sculpture. There are endless possibilities, just start to be creativ

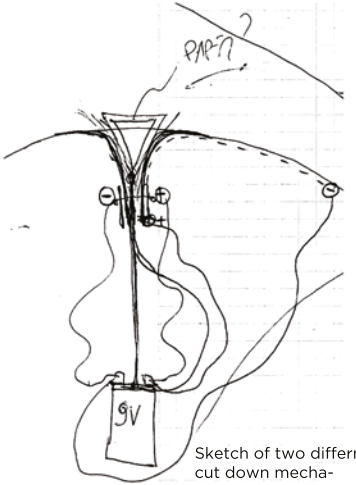


Try it yourself

The first step we made, when we start experimenting, is building count-down cut-off mechanisms for our sculpture.
We wrote an easy program, which just turns on a switch after a defined time. Then the switch turns on a 9V battery with a short heating wire attached to it. This wire starts to glow immediately and cut off the top of the sculpture, so the warm air escapes and deflates.

Most of the stuff we need you have already at home except the Arduino and switch.

Now you are able to tell your sculpture how long it stays up in the air.



Sketch of two differnt cut down mechanisms.

Research

Our next step now is working on a technik, which has already been proved by pioneers of solar flying, to stay in one pressure layer by using a hole on the top of the SLTA. For opening or closing we install a small parachute below the hole, which is pressed up by the warm air. If you now pull down the rope that is attached to the parachute, the warm air at the top can escape and you slowly start sinking until you stop pulling.

With this technik you can float between two pressures as long as the sun is shining.

We want to connect this mechanism to our Arduino device and get our sculpture intelligent.

First step is to let your sculpture know where it is. To make sure of this we install a pressure sensor, then we also add a servo motor for pulling down the rope. Now you just have to define two pressures you want to float between and give the order to open the parachute if it passes the lower pressure and close it again when it passes the higher pressure.

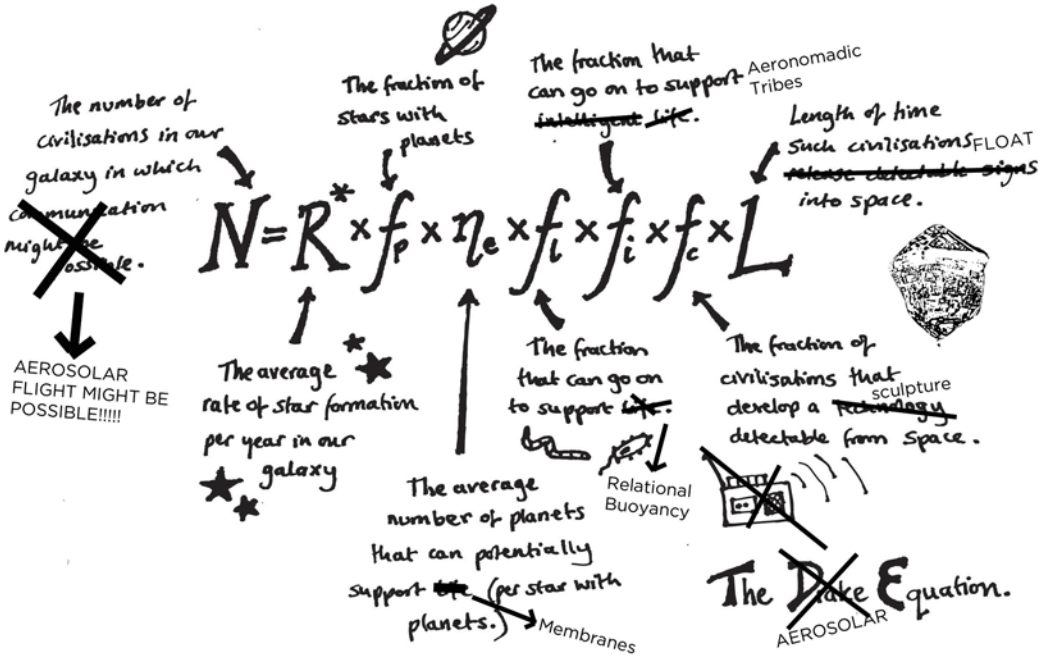
These are just two examples to start with:. . .

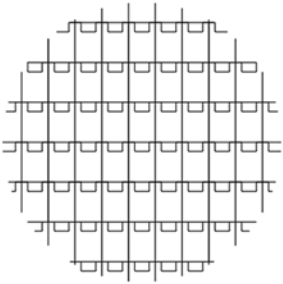
The Aerosolar Equation

Inspired by a recent conversation with Bronislaw Szersynski, we decided to rewrite and approriate the famous Drake Equation which initially was developed in the 60's at a meeting of scientists including Carl Sagan and John C. Lilly, dubbing themselves, 'The Order of The Dolphin'. Their intention was to discover how many extraterrestrial intelligent species in the cosmos might be able to actively communicate beyond their own solar system. Essentially they were interested in communicating with other intelligent lifeforms around different stars.

As inspiring as the Drake Equation is, it is representative of a linear and anthropic view of what constitutes both intelligence and Life. In Stanislaw Lems novel >Fiasco< there are radically other types of lifeforms that have not follwed the same paths and trajectories of biological and material organization that we know here on Earth.

The Aerosolar Equation investigates the probability of active Aerosolar civilizations in the Milkyway galaxy and if it is possible to critically fold the Drake Equation back on itself like a möbius strip or sculpture.





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www.iak-institute.org/seminars/becomingaerosolar

This booklet, published on the occassion of Tomás Saraceno's exhibition "Becoming Aerosolar" at 21er Haus, Vienna, is the outcome of rich and active collaboration that is being carried out at the Institut für Architekturebezogenekunst (IAK, TU-Braunschweig) in the graduate seminar of Tomás Saraceno, Sasha Engelmann and Jol Thomson.

Becoming Aerosolar is an art project - dialogue, initiated by the artist Tomás Saraceno and based on open-source ideas and knowledge sharing principles.

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