Space launching base in stratosphere

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Abstract

Developing the MAAT (Multibody Advanced Airship for Transport) project concept, a cruiser-feeder airship is green and renewable energy powered transportation system. In this paper is discussed that is possible to utilize such system, conveniently revised, as a stratobase solar powered airship. The proposal consist of a cruiser type of modular airship, permanently stationed in the stratosphere in a convenient location, the feeder, as a smaller vehicle utilized for two way transportation of cargo and passengers from the surface to flying cruiser. Such airship will be powered, as MAAT, by PV cells during the day, and Hydrogen fuel cells by night, the entire system being completely autonomous in the air. It will be equipped with LOX manufacturing systems and facilities to allow the docking of the incoming feeders that will transfer the rockets and their payloads for fueling, once fueled all empty tanks, will leave the spaceport and launch, at higher altitude, the rocket with its payload. After the launching the feeder can return to its land base safely. Such system may reduce of an order of magnitude space accessibility costs; it allows the transfer at high altitude of larger vehicles for more demanding missions which require heavy payloads. In this paper is described the concept and the preliminary design, systems, vehicles and procedures, in order to make the entire operation successful and achieve the expected goals.

Introduction

In the general frame of the MAAT (Multiple body Advanced Airship for Transport) project, sponsored by the European Union in the WP7 research program, a cruiser-feeder airship combination concept – completely conceived as an autonomous green and renewable energy powered transportation system, we are considering the possibility to utilize such system, conveniently revised, as a stratospheric platform to launch a variety of different space payloads Recent advances in airship design, new materials and technologies have radically changed our attitude and prospects toward airships , severely biased due to past accidents.

New specific technologies allows the safe utilization of airships for several functions that can integrate and cooperate, not compete , with other transportation systems . At the same time , applying new concepts such as solar energy , together with hydrogen supplied in flight for fuel cells charge, that can allow permanent flying capabilities and the cruiser-feeder concept with its in-flight docking technique , we can open entirely new and , at the moment, still unthinkable , opportunities.

We will explore such possibilities , by considering one application, the stratobase concept for an affordable rocket launching system in the stratosphere.

1-Scope of work

The MAAT system

The MAAT project currently under development by an EU funded program, consist in a new air transportation system based on airships , powered by renewable and green sources, that can rendez-vous and dock in flight, to transfer cargo and passengers to and from different destinations.

This concepts can revolutionize air transportations that since its beginnings , was based in a single flying vehicle, delivering goods or passengers from one airport to another. The entire travel experience and the entire system based in single vehicles.
Air transportation is still based on a single vehicle system. An aircraft taking off at an airport and landing in another one delivering passengers and cargo.
This system has many disadvantages, including lack of flexibility while being extremely costly. More updated technology can change such approach, improving air transportation to create an ecosystem with several benefits and reduced overall costs. The cruiser-feeder concept is based in several vehicles, transferring and delivering, where due, passengers and cargo , to their destination. Such system may revolutionize air transportation, saving costs, optimizing resources and minimizing airport areas.

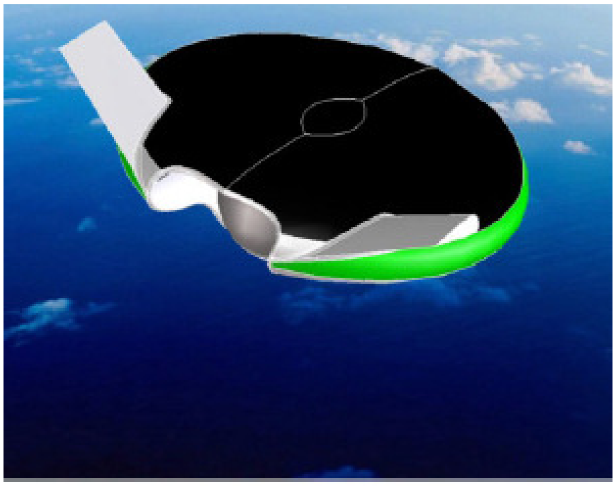

Fig.1 MAAT, temporary configuration

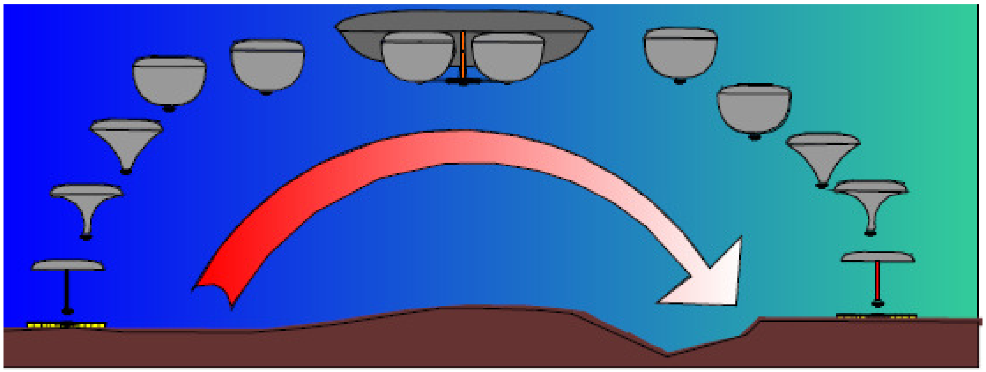

Fig.2 MAAT general procedure

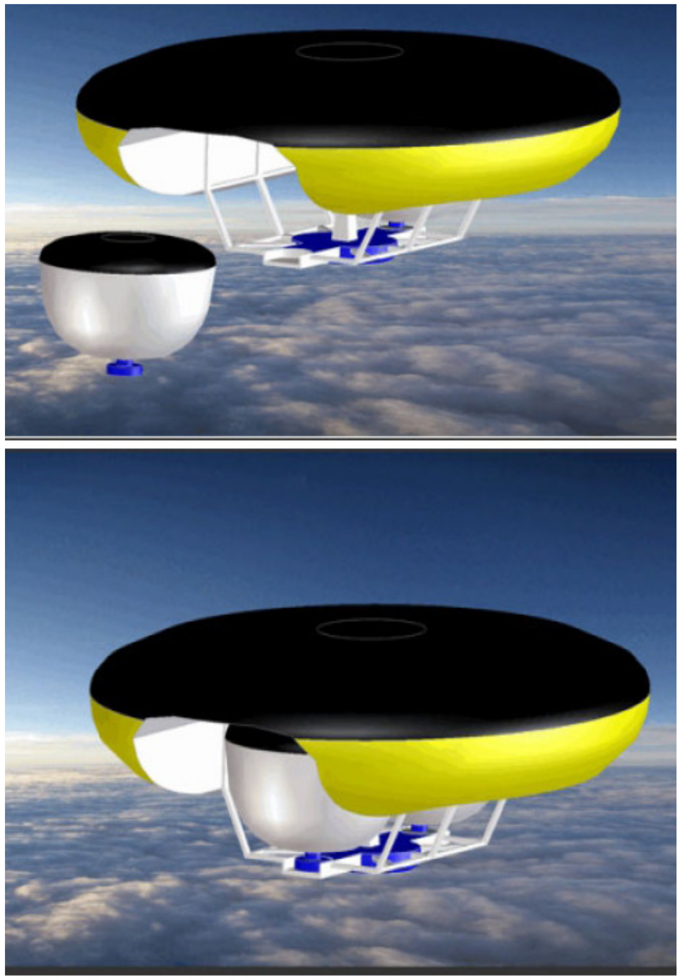

FIG. 3-MAAT docking sequence

System Goals

-Maximize resources utilization
-Reduce costs and optimize aircraft utilization
-Eliminate need of airports as final passenger destination
-Eliminate utilization of fuel from non renewable sources
-Totally green system, generating power from renewable sources
-Transform air terminals in components of an integrated urban ground transportation system .
-Maximize utilization of vehicles
-Minimize maintenance time while reducing delays
-Simplify traveling procedures
-Reduce costs

To achieve economies of scale we must transform the system in a multivehicle one, transferring and transporting cabin/containers from one urban terminal to another, saving time and money while simplifying procedures to passengers, airlines and airport operators.

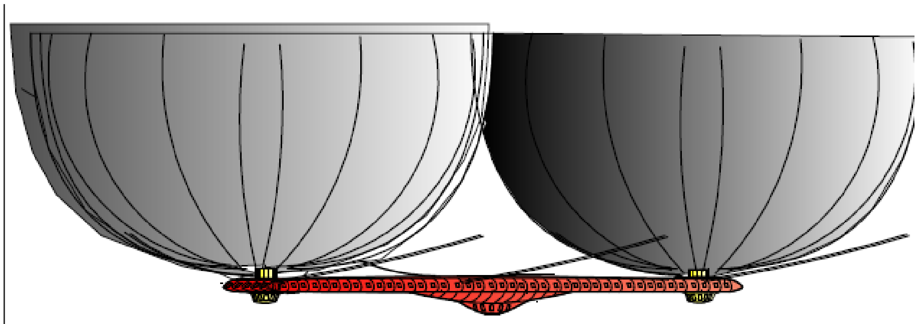

Fig.4-MAAT cabin view

The proposed MAAT system components are , the cruiser , as a 450 meters diameter airship, in permanent flight in VLEO (Very Low Earth Orbit) at stratospheric 15 Km altitude, and the feeder, as a smaller vehicle, airship or balloon-type, utilized for two way transportation of cargo and passengers from the ground to the flying cruiser. (Fig.1, 2,3,4)

Main features of the MAAT project are :

-The power system based in photovoltaic film applied to the upper external surface of the airships that in daylight will generate electric power for the engines and all systems , including production of hydrogen from the atmosphere, that will recharge the hydrogen fuel cells that will guarantee power supply during night time.

-the in-flight docking and undocking of the incoming or outgoing feeder from the cruiser that will allow the two-way transfer of cargo and passengers

-The AHA (airship hub airport) specially designed land based terminals , that due to the VTOL capabilities of the feeder and its noiseless system, will allow convenient city center to city center locations eliminating the need for large and far away major airports.

-the flying hub possibility to transfer feeders in flight between cruisers flying in different directions or even basing them in flying hubs, cruiser-type, waiting for connecting cruisers.

2-The Stratobase

Considering such features and their possibilities we believe that by utilizing and expanding such concepts we can build a cruiser-type stratospheric rocket launching platform , being supported by feeder-like airships that will transfer personnel, equipment and payloads for launch.

The envisaged stratospheric platform will be a cruiser type modular airship, which is permanently stationed in the stratosphere, placed at a convenient location, with facilities to:

1- Manufacture LOX (liquid oxygen), with oxygen provided by the atmosphere to fuel the incoming rocket engines since the vehicles would be transferred without fuel

2- Receive incoming feeders, with attached space rockets, fuel and prepare them for launching,

3- Launch rockets and payloads to LEO (Low Earth Orbit), GEO (Geostationary earth orbit) or more distant space destinations.

Such airship will be powered as MAAT, by PV cells during the day, and Hydrogen fuel cells by night, in order to render the entire system completely autonomous (without ground refueling).

It will be equipped with the LOX manufacturing systems and facilities, to allow the envisaged docking of the incoming feeders that will transfer the rockets and their payloads for fueling.

Once fueled and ready, the rockets will be launched directly to space from a dedicated launch pad in the cruiser vehicle. After the launching, and completing the expected mission at higher altitudes, the feeder will be able to return safely to its land base and resume its transfer activity.

Such system may reduce the space accessibility costs by an order of magnitude, because it allows the transfer at high altitude of larger vehicles for more demanding missions - expected to require heavy payloads.

Let's analyse the main components

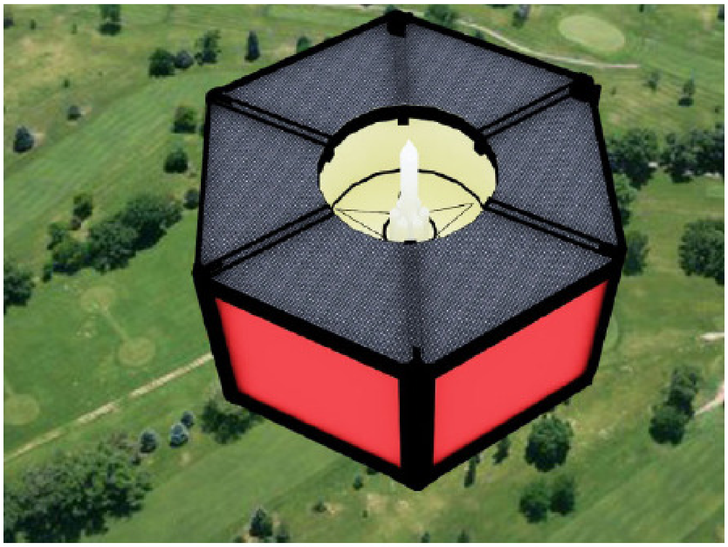

Fig.5-Feeder heading to Stratobase

3-The cruiser platform

Will be based , due to its large dimensions and the potential requirement for future system expansion, not on a single large vehicle but in smaller modular units that will dock and be connected in flight to form a larger continuous single vehicle.

Due to geometrical shape optimization, such modules will be of exagonal shape, about 100 meters high and 100 m diameter. By properly positioning they will maintain a good aerodynamic configuration during flight.

Such platform can initially be formed by five modular components but its shape can be expanded as shown in the image.

Main reasons for expansion could be additional service capabilities such

as Lox manufacturing or heavier vehicle launching.

The cruiser will contain the cabins that will manufacture LOX, store it , with all needed equipment for rocket refueling, support the launch pad and house all needed personnel with their services.

Being in permanent flight the cruiser don't need to be permanently manned but only during its launching utilizations or for maintenance and overhaul activities.

The cabins will be dimensioned in accordance to a modular shape and will be interconnected from each module to allow circulation.

Their weight is estimated in 15 tons for each cruiser module, raising the total payload to 60 tons.

The cabins will be dedicated to different functions, as a preliminary scheme the five initial modules will contain one cabin for the crew and personnel, two for LOX manufacturing and two for fuel storing and refueling equipment.

The entire system will also support the launch pad.

4-The feeder system

Two basic feeder types will be needed:

-the rocket transfer feeder and the platform service feeder

The first one will deliver the empty rocket and its payload from the ground station to the docking position in the cruiser system

The second one will previously deliver personnel and equipment for the launching operations and take them back after launch. It will also be utilized for maintenance and overhaul activities in the cruiser. It will be dimensioned as the exagonal modules in order to properly fit in the cruiser geometry.

The second one will be equipped with the personnel cabin while the first one with a proper frame to support and transfer the rocket payload.

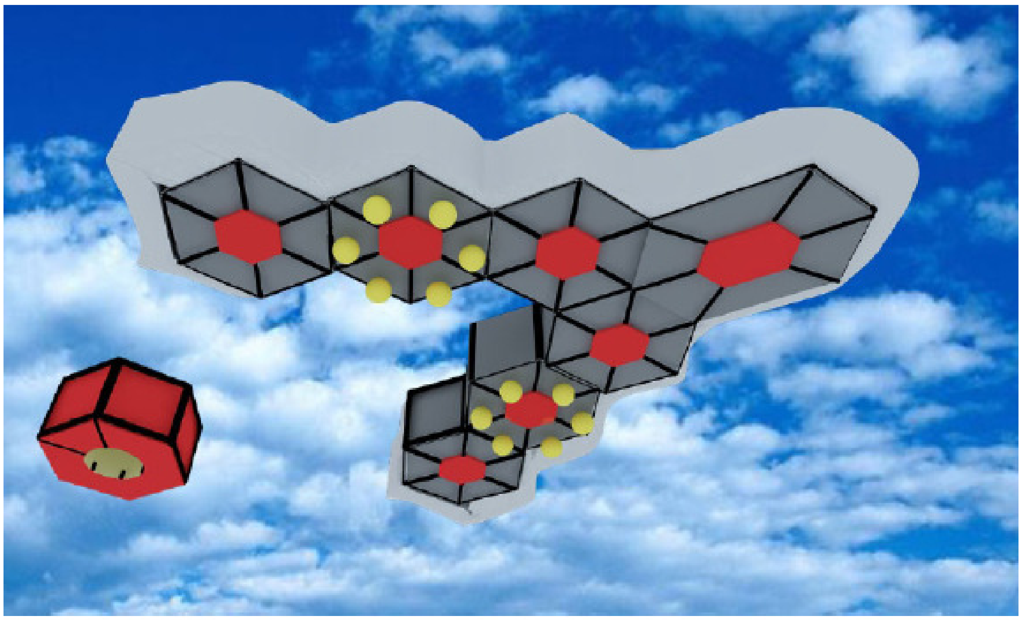

Fig.6 Feeder approaching Stratobase

5-The typical mission architecture

As shown in the drawings (Fig.5, 6, 7,8, 9, 10) the typical operation can be divided in different phases:

Phase 1-launch preparation activities

send the personnel feeder that will control , test and activate all equipments for the fueling and launching operations .

Phase 2-Deliver the rocket payload

The rocket feeder will leave its ground base fully loaded with the prepared rocket and its payload to the cruiser launching pad, where it will dock and secure the payload

Phase 3-docking

This critical activity will be performed with the cruiser and feeder in hovering mode , with a partial vertical and horizontal approach to the docking position above the launching pad .

Securing rocket payload

A ring system will embrace the rocket payload while the feeder will move upwards in order to secure it to the cruiser system while the feeder will slowly depart and undock .

Vertical arms will grab the rocket after the feeder will leave the area to ensure its stability

Phase 4-cruiser fueling activities

The feeder will undock, leaving its payload secured to the cruiser launch pad, where it will be fueled from the lox storage tanks.

Phase 5-launching

With the feeders in distant and safe hovering positions, the cruiser , at moment zero plus of the countdown and immediately after rocket burning will leave its hovering mode to a maximum acceleration speed to reach a safe distance from the high temperatures generated by the rocket during its first seconds of operation.

Phase 6 –return to the base

After launching, the crew will check all equipment leaving the cruiser in stand by mode for future luanchs, board the incoming personnel feeder , undock and procede to land at the ground station.

At the same time also the rocket feeder , unmanned, will procede to land at its ground station

With the above sequence a safe and secure launching operations can be obtained for multiple and continuous utilizations. Rate of launches will mostly be defined by LOX production speed , for more continuous operations additional LOX manufacturing equipment can be added by additional modules to the cruiser system. See the figures (11,12,13) to visualize the components.

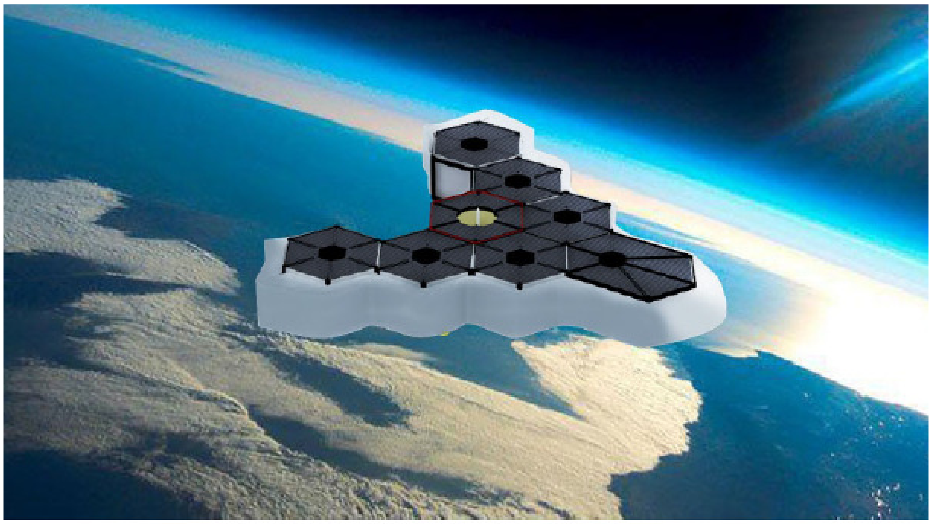

Fig.7-Fueling launcher in Stratobase

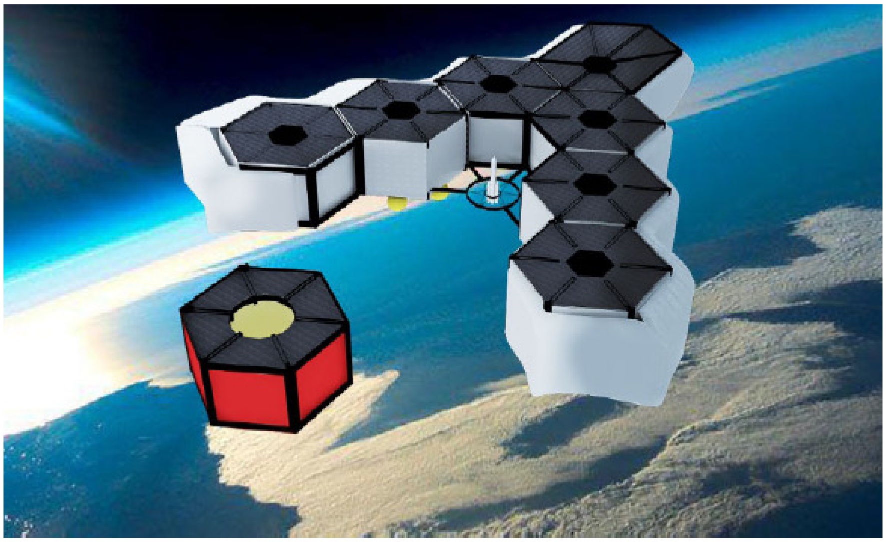

Fig.8 Feeder leaving Stratobase for launching

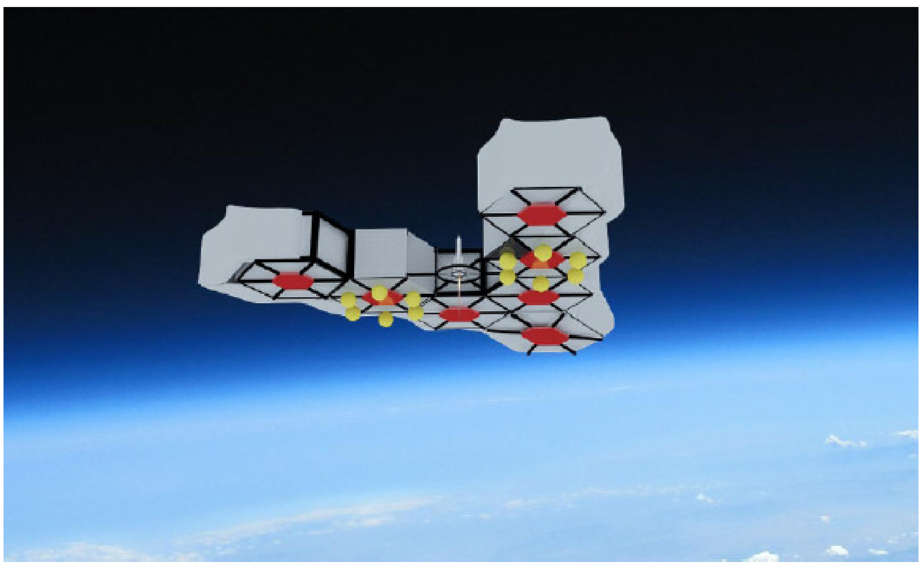

Fig.9-Launching from Stratobase

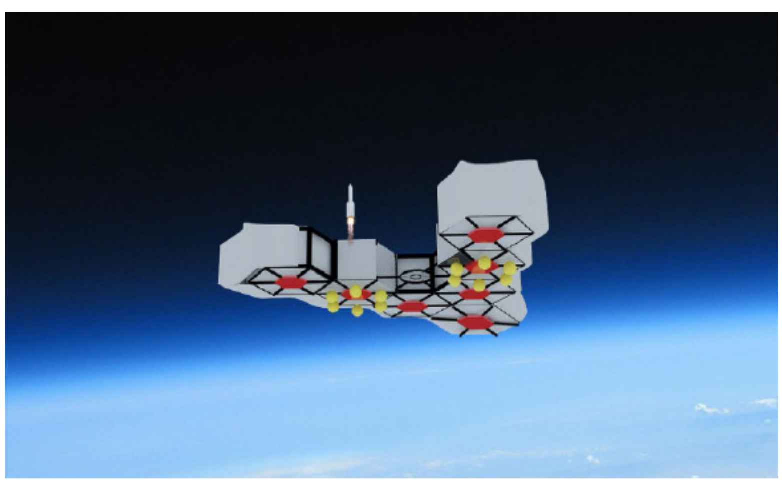

Fig.10 Startobase clearing area

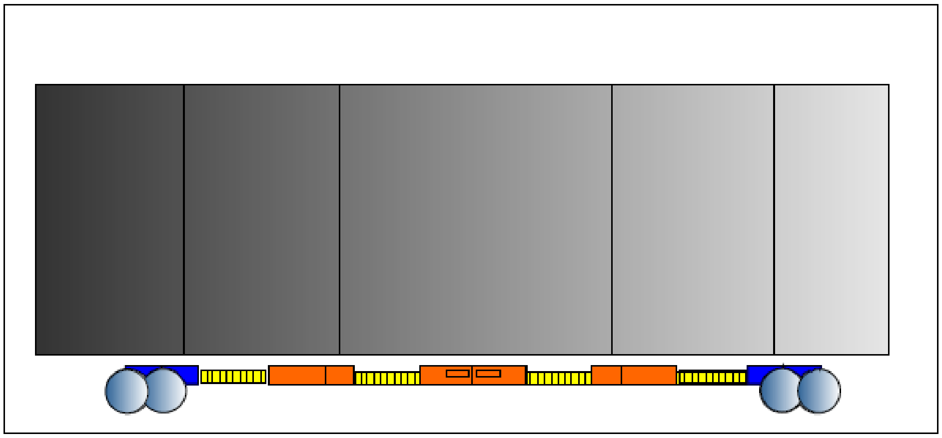

Fig.ii Stratobase view

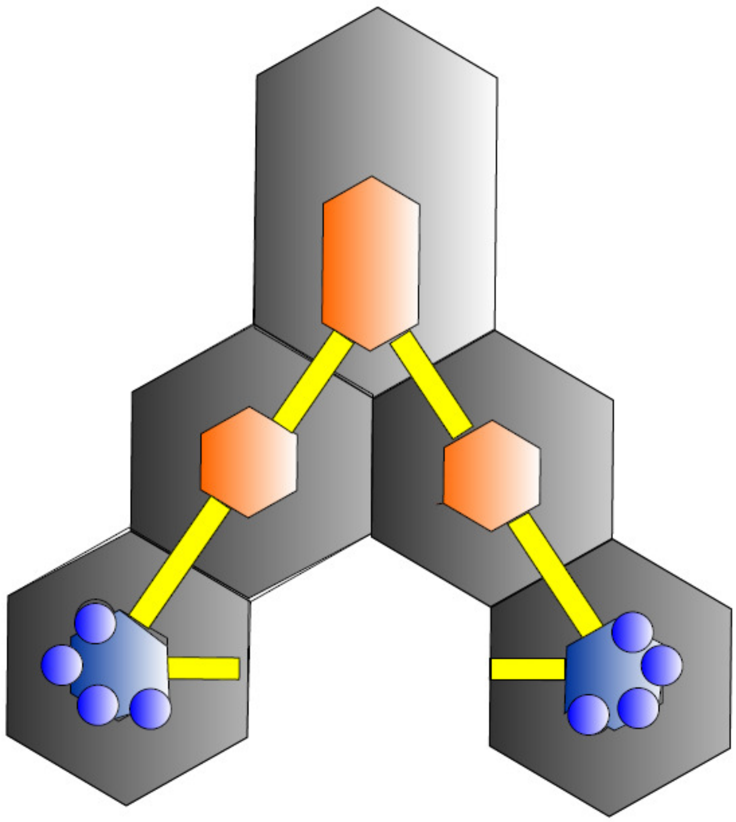

Fig.12- Stratobase from below

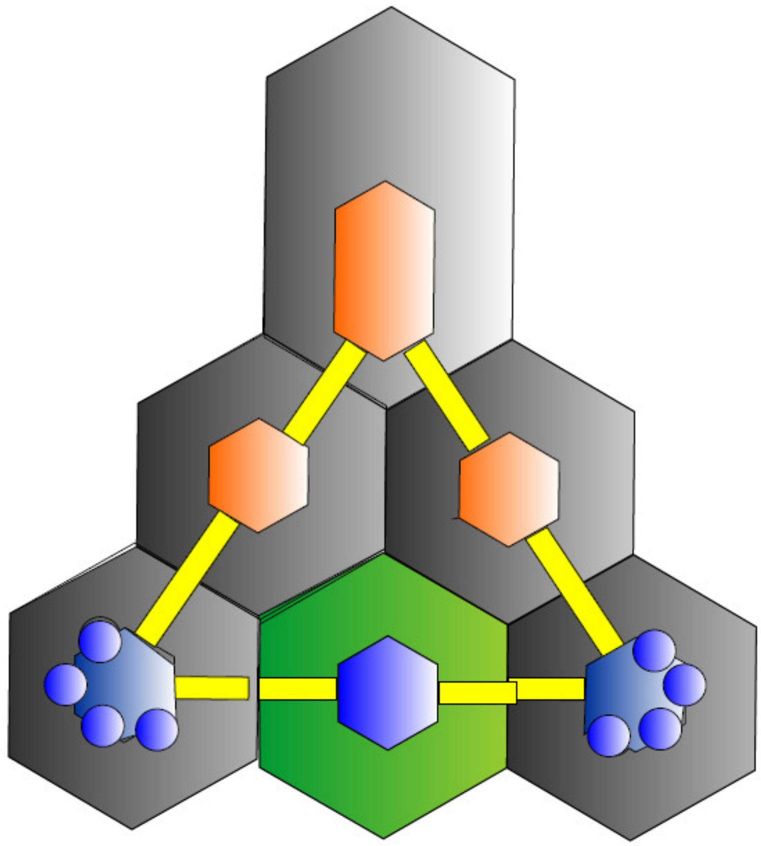

Fig.13-Stratobase with feeder

6-VLEO

VLEO (Very Low Earth Orbit), at 15 to 30 km altitude, remains as the occasionally used, unexploited and readily accessible space resource. The technological readiness for advanced airship placements and activities will transform the VLEO latent potential, allowing a wide range of activities, including for dual phase airship based feeder-cruiser systems, thereby providing transport to VLEO, docking, transfer and fuelling platform and a maintained orbital access point, within standardized and long term VLEO placements.

VLEO launch potentials for Earth to space based missions will support an expedient outlook at many levels for effective and integrated space transportation dynamics, such technologies with some advancement can profitably support and improve the structure and capacity of space launch systems. A comprehensive space launch eco-system may be fully developed through the early provision of a cruiser-feeder system whose goals lie within several forward looking areas of scope. These totally energy self-sufficient vehicles will operate through a connected system of launch, relay, fuel production, transfer and return. The cruiser is a stationary airship platform at VLEO with function to process and produce LOX from the atmosphere. The stationary StratoBase airship and fuel production platform is powered by Solar PV cells during the daylight hours and by Hydrogen fuel cells at night.

The station is maintained by a manned crew and overhaul is provided through the inter-connected feeder system. An alternative method for obtaining VLEO airship power source would be through beamed microwave power within space based solar power plant utilities. In this case the airship would act as a rectenna, such configurations also have the potential to actuate through laser based originations with VLEO acting as additional instrument of transfer from laser to microwave bandwidths with reference to further relay into terrestrial power source supply. The model components will achieve a stable VLEO platform, comprising the StratoBase cruiser which is an airship of approximately 500 meters in diameter, flying 24/7 at 18 km altitude together with the associated feeder craft.

7-Further possibilities

VLEO is an entire new active territory with enormous and untapped potentials to be developed.

Airship vehicles with docking technology and self supporting capabilities can change the rules of the game in air transportation . Much research will be needed entire new technologies, systems, subsystems and procedures must be researched and developed.

The MAAT project is paving the way by producing two docking demonstrated ina few months to prove the concept.

New and traditional players will enter this field and create an entire new industry, technology and opportunities.

Once demostrated this potential possibility , the cruiser-feeder system allows several other possibilities by its utilization such as (Fig.14,15,16) :

-region surveillance platform to control all activites ina permanent way with possibilities to change its positions with manned or unamanned missions

-military attack platform

By placing weapons , such as guided missiles or other type of weapons, laser and MW beams and others permanent flying military bases can be located in convenient VLEO locations

-resort-type of activities

With a hotel type of cabins and equipment for slow and leasure transportation

-cargo transportation

-. Sightseeing

.power platform by receiving solar energy with pv films and transfer such poewer to needed stations by pumperd laser or MW systems

-communication platform

-beam power supplying platform , by beaming its solar generated porwer to flying vehicles properly equipped with receiving panels

-flying cities

-flying hubs

And several others that future experience with the system will certainly indicates.

For sure airtransportation will have an additional player with unique and advantageous capabilities to ocunt on.

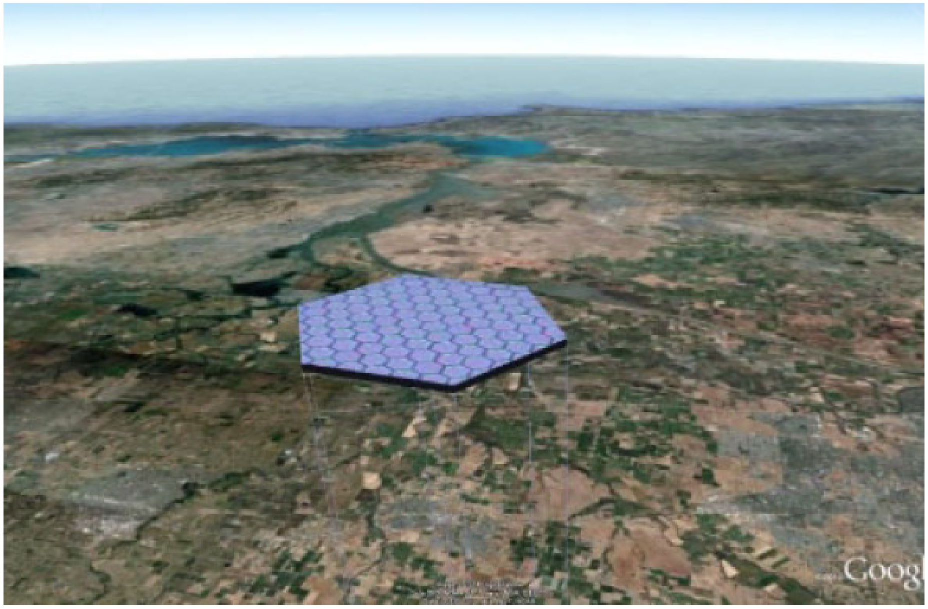

Fig.14 Stratosolar platform

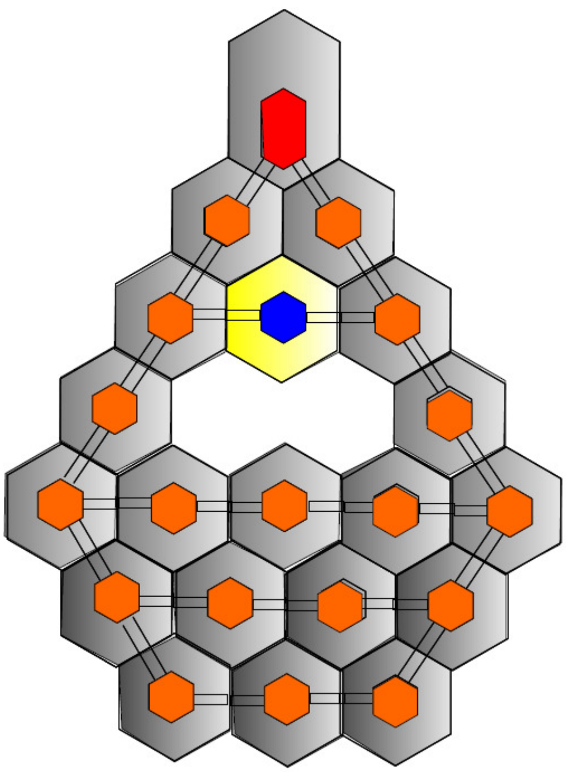

Fig. 15-Flying city

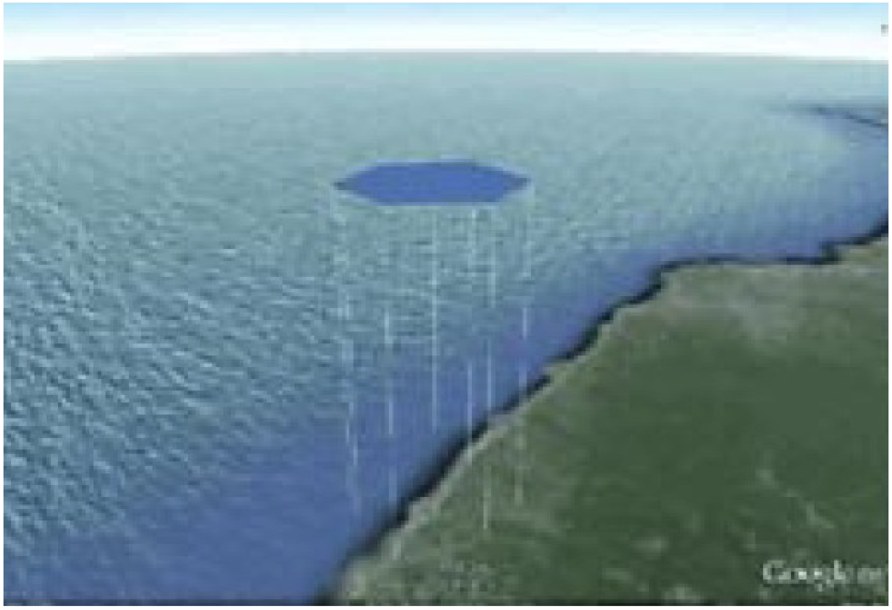

Fig.16-Power generating system

A Conceptual approach to find the solar energy Received from the sun
Available solar Energy

The Direct solar radiation can be calculated as below.
E_D = Direct solar radiation
D = Direct normal solar flux
A_p = projected area

$$E_D = DxA_p \qquad (1)$$

Direct normal solar flux was found by the following equation
D = Direct solar flux

D_0 = Solar constant($1.353 kw/m^2$)

C = 0.357

S = 0.678

csc = 1/sin A = sec lamda

lamda **=** zenith distance

By the following equation solar altitude can be determined and L,H are latitude on Earth and Hour angle at time 't' after solar noon respectively.

$$\boldsymbol{D(A) = D_0 e^{-C[\csc A]^S}} \qquad (2)$$
$$\boldsymbol{Sin\ A = Cos\ NCos\ HCos\ L + Sin\ NSin\ L} \qquad (3)$$

Equation 3 shows that direct solar flux depends on the latitude on earth. At time 't' hour angle can be determined by the following equation

H = Hour angle

$$H = \left(\frac{t}{24}\right) x\ 260 = 15t\ degrees \qquad (4)$$

And 'N' is the declination angle that is defined as seasonal variation in the Sun's apparent position and it varies between +23.5 at the summer solstice and -23.5 at the winter solstice. If the time of year are measured from spring (March 21st) Equinox the declination angle as follows,

$$N = 23.5\sin\left(\frac{2\pi d}{365}\right) degrees \qquad (5)$$

$$D = 1.353*10^{3}*e^{-0.357[2]0.678} = 861.404 W/m^{2}$$

$$D(A,h) = D_o(1 - ah)e^{-c(\csc A)^S} + ahD_o \qquad (6)$$

Where a = 0.14 per km of altitude

Above equation only valid for first few kilometres of altitude and solar flux is increasing when the altitudes becomes smaller. The total direct solar flux increases by about 6%, 17% for 1km and 3km respectively.

The diffuse solar radiation can be calculated as below

$$E_S = (S_d \, x A_w)/2 \qquad (7)$$

S_d = Diffuse radiation

A_w = Wetted area of the airship

Calculation of Scattered Energy from the radiation
Total Solar Energy Gained = Direct Solar Energy + Diffused Solar Energy

$$E_T = E_D + E_S \qquad (8)$$

$$P_{TOTAL} = (A_P \text{ x } D)+(A_D \text{ x } (S_d+S_r))/2 \qquad (9)$$

Efficiency of Solar Power System

$$\gamma t = \gamma a \,.\, \gamma c \,.\, \gamma e \,.\, \gamma g \,.\, \gamma p \qquad (10)$$

Where:

γ_a = Solar cell packing area efficiency

γ_c = Solar cell conversion efficiency

γ_e = Electrical component efficiency

γ_p = Propulsive efficiency

Conclusions

The MAAt project will develop two flying demonstrators to prove the docking in- flight technology and to further advance to its final goal , a new, totally green transportation system based on multiple vehicle system. The possibilities from such technology, once developed and successful , will allow several entirely new activities utilizing airships and the VLEO location. In the future years we may see many developments and concepts , today totally ignored.

Acknowledgement
The authors would like to acknowledge the support of European Commission through the Seventh Framework Program (FP7), for MAAT project, Grant Agreement no: 285602.

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