Address to the engineers, scientists, technologists of VSSC and also Students, faculties and professors of IIST

THIRUVANATHAPURAM, Jun 2 2013

Dr. A.P.J. Abdul Kalam

SPACE FUTURE IN THE 21ST CENTURY

"Humanity needs a great vision to forget all the conflicts and move towards a common goal of peace and prosperity for all the global citizens. We visualize the birth of world vision leading to "livable planet Earth". This vision will be greater than any other vision so far envisioned by humanity".

Dear friends, VSSC indeed was a cradle for me in acquisition of knowledge on space science and technology. I thank this great institution. I am delighted to share some thoughts on space solar power with VSSC engineers, scientists, technologists and also IIST Students, faculties and professors. The topic I am going to talk to you is **Space future in the 21st Century** derived from my address 32nd International Space Development Conference (ISDC 2013) at San Diego, California on the topic **"Space Solar Power: Key to a Livable Planet Earth"**. Before I deliver my address at ISDC 2013 at San Diego on 24 May 2013, I had sent my paper to ISRO Chairman in advance and got his inputs and also the approval. Also I had suggested IIST should become the partner in the World Space Knowledge Platform along with the similar Space institution from USA and other space faring nations. Hence I feel it is appropriate to share my thoughts to all of you from VSSC on the topic **"Space Solar Power: Key to a Livable Planet Earth"** which I delivered at ISDC 2013.

Dear friends, On 20 July 1969 the Saturn-V booster injected the lunar module of Apollo 11 with two astronauts Armstrong and Buzz Aldrin; and history was made when Armstrong walked on the Moon. For the whole world, Von Braun became a hero of building its biggest booster and fulfilling mankind's age-old vision of Man going to the Moon. At that time, I was a young fellow, just entered into aeronautical profession, building hovercraft and meteorological rockets. It was a great surprise and fulfillment in my mind to meet my hero at the place of my own work, Vikram Sarabhai Space Centre (VSSC) where Von Braun was visiting at the invitation of Prof Vikram Sarabhai. I became his host. From the time he had landed at VSSC and till he took off, I was with him for the full day. Von Braun gave a very important lecture at VSSC auditorium which was full and over flowing. Von Braun spoke on the subject "outer space provides the greatest challenges to humanity".

Subsequently, I met Von Braun in the conference hall for discussion on the launch vehicle, particularly on the SLV3 project, for which I was the Project Director. It was a very important discussion for me, because we got into serious discussion on some of the technical aspects on my project, particularly L/D (that is slenderness) ratio of SLV3 with reference of aero-elasticity and sufficient control force requirement. We always cherish the memory of the tall rocket engineers' visit to India. I am happy to receive NSS Von Braun Award which is filled with my memories of Von Braun and his achievements and I had the same wonderful feeling while receiving the award from NSS.

Wernher Von Braun

MAN ON THE MOON

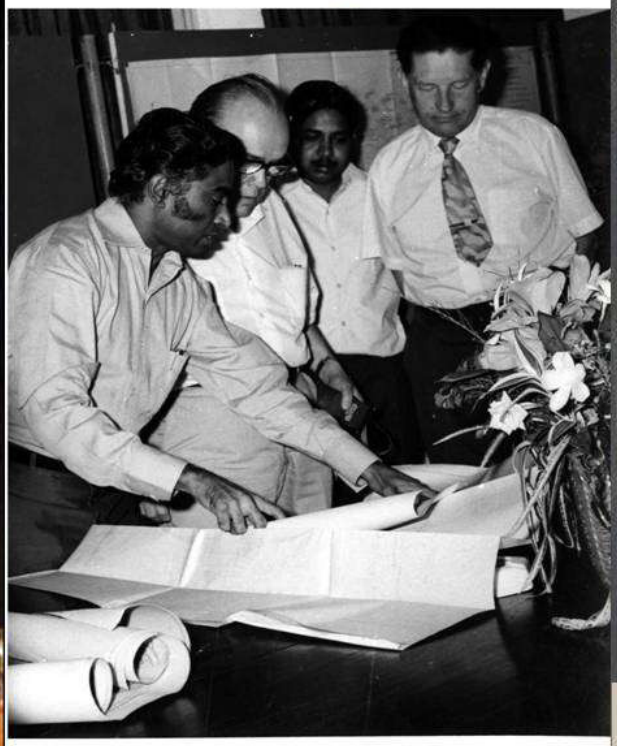
APOLLO 11 LAUNCH

VON BRAUN & HIS F1 ENGINE FPR APOLLO 11

Wernher Von Braun

Saturn - V

Von Braun @ VSSC/ISRO on MAY 1973 – during SLV3 times



My discussion with Von Braun @ VSSC

GOVERNMENT OF INDIA COMMERATES SLV-3 LAUNCH WITH ISSUE OF POSTAL STAMPS

World Space Vision 2050

I was elated about the 32nd International Space Development Conference (ISDC) in San Diego since they have chosen the theme for the conference as "Global Collaboration in 21st Century Space." This is a topic I cherish, one that I have actively promoted for now nearly one quarter of a century, in India and abroad, to a wide variety of audiences. I have been advocating a World Space Vision 2050 for more than a decade in many national and international aerospace forums, structured to enable mankind formulate and implement:

1. Large Scale Societal missions (including Space Solar Power mission] enabled by low cost access to space

2. Evolution of a comprehensive space security doctrine, policy and programme

3. Expansion of Space exploration and current application missions

Such a World Space Vision 2050 would enhance the quality of human life, inspire the spirit of international collaborative space exploration, expand the horizons of knowledge, and ensure space security for all nations of the world.

There are many initiatives, potential research studies in India, US and other space faring nations which have now brought together India and US to work on the mission of harvesting energy from space with the pioneering effort taken by NSS. I cherish sharing my perspectives with Mark Hopkins, Chairman NSS and his team from ISDC 2010 where I delivered an Address on the topic **"Harvesting Solar Energy from Space"** . I was glad that by mid-2010 we could sign off an understanding to start up an international SSP Feasibility Study with the initiative of **"Kalam-NSS Space based Solar Power initiative"** . We need to set a new direction and pace to accelerate our progress further on this mission, setting significant milestones amidst the many global challenges, socio-economic as well political challenges. However the world today is not the same as it was a few years ago.

Focus on Space based solar power amidst of challenges

Every nation and also the space faring nations are going through certain socio economic challenges, there is limited time and resources available for these nations to give priority for the big mission like space based solar powered satellite. However the nations have taken certain essential initial step towards realizing this bigger mission.

In India The need for space based solar power stations was identified as far back as 1993 in anticipation of the emerging global energy crisis of the 21st century. Since then, indeed earlier from 1987, work has been carried out in India on advanced space transportation system design concepts for affordable space solar power. India's vision is to bring down the cost of access to space to less than $2000 per orbital kilogram initially.

Considering the magnitude of the looming energy and environmental problems, a strong view has emerged that the situation faced by India warrants consideration of all energy options, including the concept of SSP. ISRO has recently carried out some preliminary concept studies on SSP and examined three SSP configurations. ISRO has also welcomed an International Preliminary Feasibility Study and are aware that this would call for strong and long-term cooperation between institutions in every nation blended into an International R&D programme for SSP.

Dear friends, let me give a story about a unique personality who spent his lifetime in the design and development of Hypersonic Reusable Launch Vehicle.

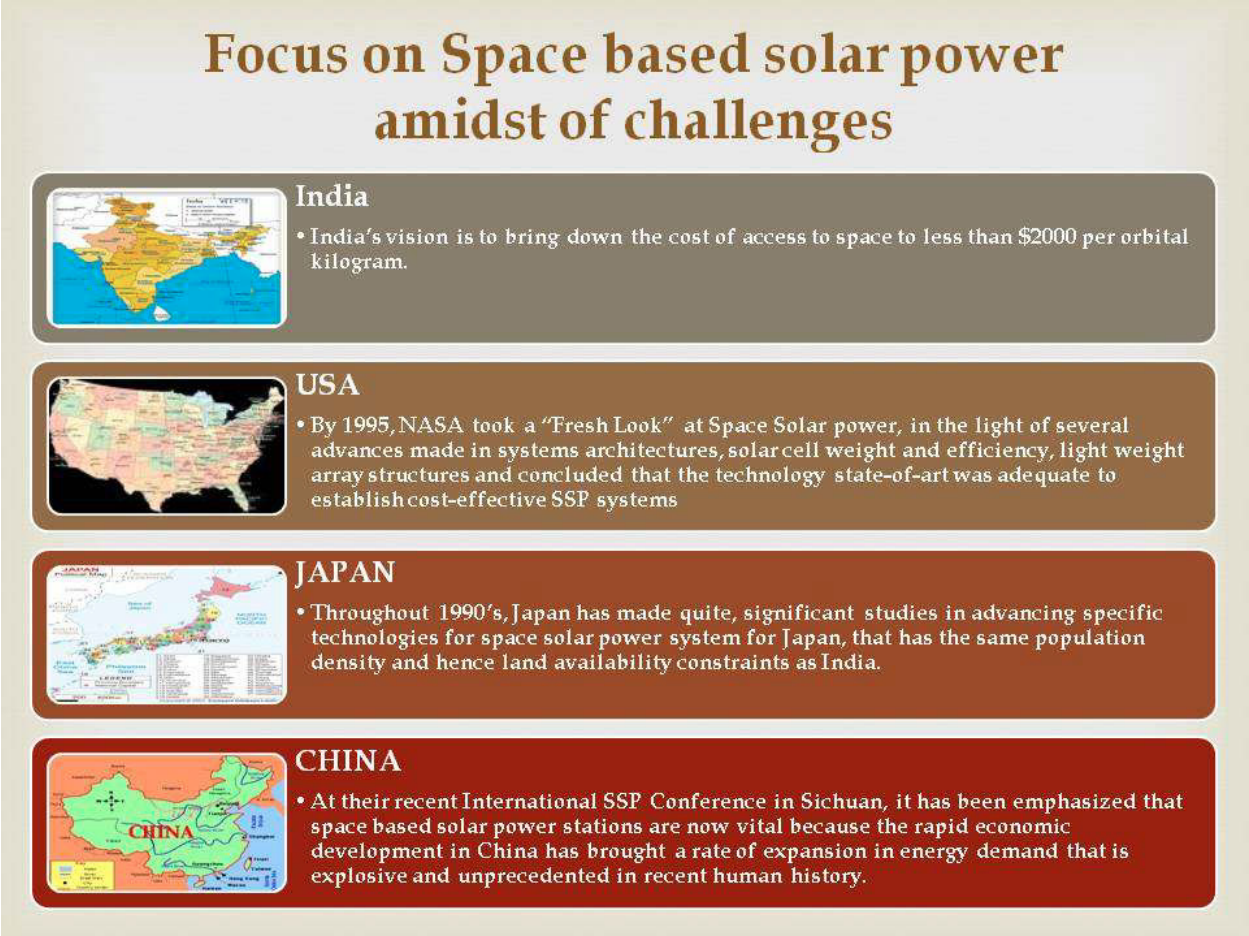
HTV Gopalsamy: Dear friends, when I left ISRO in 1982, after working for over 2 decades, I joined DRDO carrying the decades of my ISRO experience. In DRDO, I came across a unique person called Air Cmdr. Gopalsamy, who is a well-known expert for System design, System integration and System management. He was a demanding technologist with innovative ideas backed with professional expertise.

I gave him job of designing a Reusable Launch Vehicle to put 15 tonnes of payload at low earth orbit with at least 100 times takeoff and landing evolving the technologies for 50% payload capacity using air breathing concept. Using the SSTO concept, the team of Scientists, technologists from DRDO has put over 100,000 man-hours of work towards this approach over many years in DRDL in collaboration with many Universities and IITs in India. The DRDO has extensively published this work in India and the USA. The mathematical concept of "virtual staging" is explored and it is established that the highest mass ratios are obtained by a SSTO that takes-off with lox tank empty and then gathers, cools and liquefies incoming air to separate out lox at high mass flow rates and store them on board the hypersonic vehicle between Mach 3 to Mach 8. Still he is active and pursuing the international research efforts on Space Transportation systems.

Based on this approach and preliminary design, DRDO has designed a Hypersonic Flight Test Vehicle. Certainly the vast experience and the professional expertise of Air Cmdr Gopalasamy in the Space Transportation systems will be a greatest advantage to further the mission of harvesting energy from Space using Solar power satellites in India by ISRO and DRDO and also with collaborative missions. Since DRDO and ISRO has collaborated on launching satellites using the on-demand launch vehicle platform by DRDO, I definitely see the emergence of technological coherence soon in Space Solar Power mission, which will benefit the nation and the world in a big way.

In the USA By 1995, NASA took a "Fresh Look" at Space Solar power, in the light of several advances made in systems architectures, solar cell weight and efficiency, light weight array structures and concluded that the technology state-of-art was adequate to establish cost-effective SSP systems. I commend National Space Society for an impressive list of library of documentation on solar power from space.

In Japan Throughout 1990's, Japan has made quite, significant studies in advancing specific technologies for space solar power system for Japan, that has the same population density and hence land availability constraints as India. On 28 June 2009, Japan announced its goals for an operational $ 21 billion SSP programme.



In China, at their recent International SSP Conference in Sichuan, it has been emphasized that space based solar power stations are now vital because, the rapid economic development in China has brought a rate of expansion in energy demand that is explosive and unprecedented in recent human history.

Similarly, ***Europe and Russia*** have great potential and core competence in space technology for participation in the world space solar mission.

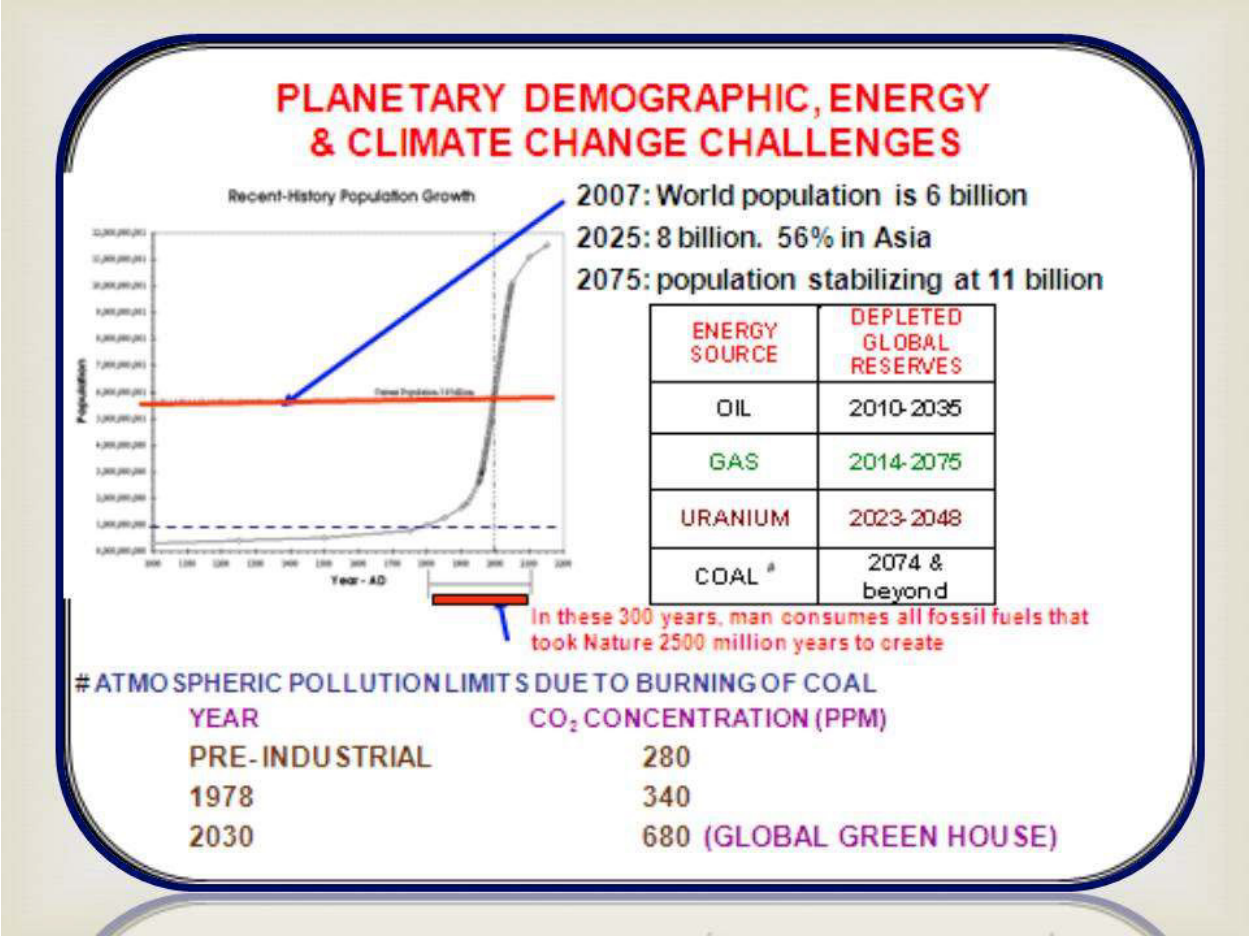
The energy situation and its influence on development, economy and quality of life have touched every nation as evidenced by the statements of the leaders of various nations at different levels. Each nation recognising the need is trying to draw plans, enhance research and invest for improving the energy security and independence. While it is important to concentrate on every aspect of renewable energy sources including terrestrial solar energy, space community has a great potential to lead to nearly a continuous unlimited energy source. Hence every nation needs a great vision, bigger than its own people, bigger than the nation, to move the world away from a potential energy crisis in the 21st century. So can we the space community now together share our perspectives and evolve such a vision that should be greater than any other vision so far envisioned by humanity? That is clean energy from space solar power for 24x7.

Great Vision & Mission

So far, in all known history, international visions, missions and programmes *have been earth based:* like in areas of food and agriculture, commerce and trade, education and culture, humanitarian aid to mitigate natural and man-made disasters etc. Can we conceive and implement, as a historically first, epoch making happening, a new vision for international collaboration in space? The benefits from such a great vision shall be tangible to each one of the world?s population and bring together all human feelings and thoughts, from the most material to the most spiritual, leading on to a Liveable Planet Earth through Space Industrialization. This means a sustainable world where we have taken less from nature than what we have given to it.

Such a mission in space industrialization could start up with an intensely human international mission in *societal-critical areas of energy, water, environment and security* which would expand over the decades and centuries to all other human needs and activities on planet earth through space exploration and a new order in space through space security. I think there cannot be a greater vision for all nations other than transforming our terrestrial habitat into a liveable planet earth through international collaboration in space. From my perspective, I believe that the driving force towards a liveable planet is the common threats and opportunities that all nations face. These threats to a liveable planet earth are:

1. Massive shortages, escalating costs of energy and rapidly depleting fossil fuel reserves world over.
This is among the most serious challenges faced by the world of nations. The global solution to this is achieving Energy Independence globally which such a space industrial mission can deliver. It may be recalled that the US National Security Space Office (NSSO) study concluded in October of 2007 that *"The magnitude of the looming energy and environmental problems is significant enough to warrant consideration of all options, to include ... space-based solar power."* This NSSO report also concluded that SSP has *"enormous potential for energy security, economic development, improved environmental stewardship, advancement of general space faring, and overall national security for those nations who construct and possess a (SSP) capability."*



2. Global environment degradation and climate change.
Among the greatest risks to the environment is presented by massive coal mining, deforestation, over fishing, unsustainable agriculture, mega dams on rivers. Burning coal and oil/natural gas is said to be the cause of climate change, but mining for the valuable resource endangers local ecosystems as well. Even though the era of wood has ended, massive deforestation continues to create more agricultural land to cultivate grain for humans as well as livestock for rapidly expanding populations.

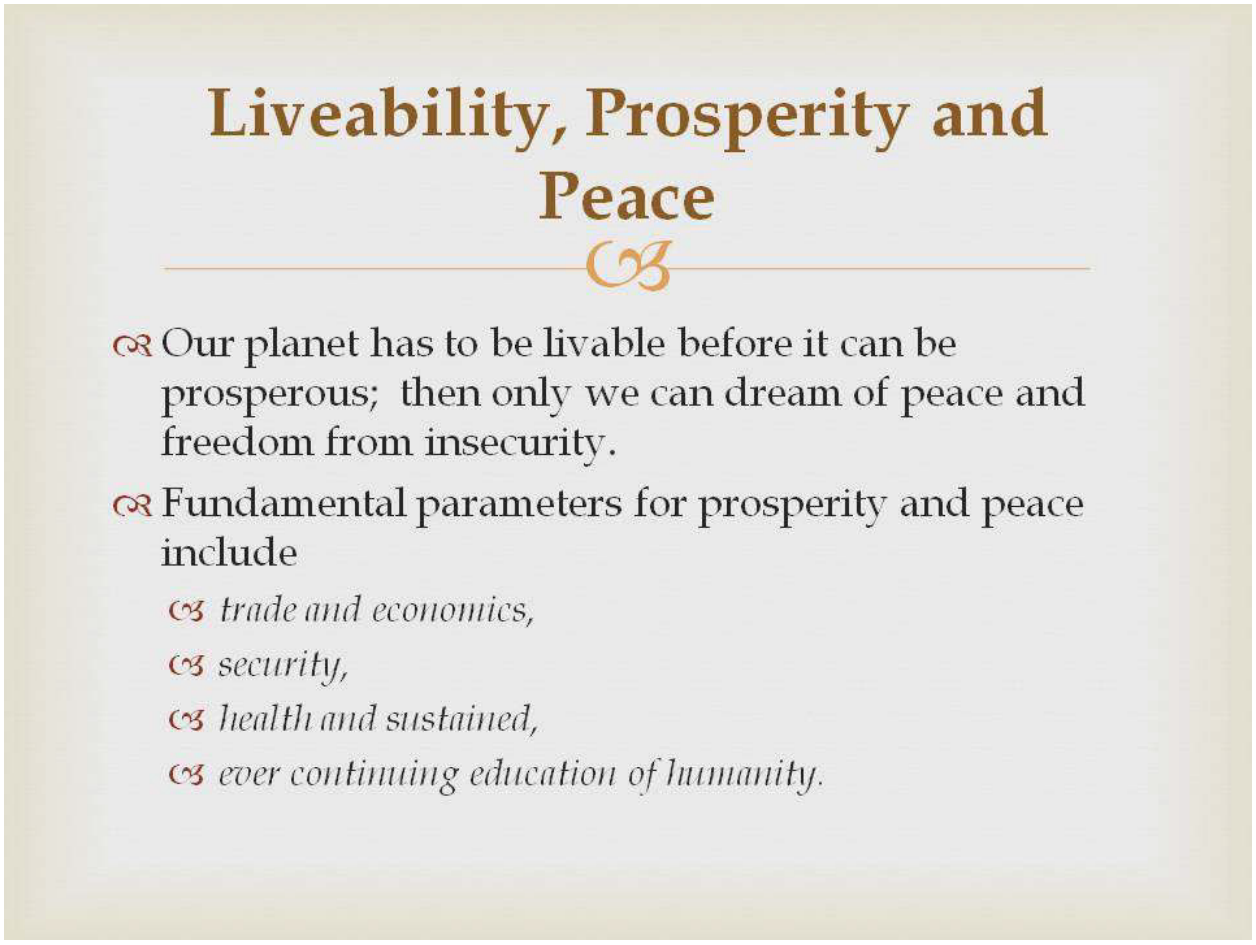
3. Depletion of Mineral Resources. Fossil fuels are not the only material that are depleting world over. Rapid technological growth, over-consumption and industrial development over the last 200 years has resulted in meta-depletion of the world?s non-renewable mineral resources. Habitats have been degraded leading to the loss of biodiversity (i.e. species and ecosystems). In the longer term the search for extra-terrestrial sources of minerals would become inevitable not just due to scarcity of minerals, but the environmental degradation that has taken place. This leads to space colonization and mining on asteroids and planetary bodies.

Liveability, Prosperity and Peace

I am glad that ISDC 2013 has had talks on asteroids, living in Space, Space Solar Power, Space Settlements Trans-humanism and Space Exploration. It is clear to us now that our planet has to be liveable before it can be prosperous; and it has it be both liveable and prosperous before we can dream of peace and freedom from insecurity.

The basic and most compelling need now is obviously livability. However, the process of making our now devastated planet livable again even when supporting a population growing from 7 to 11 billion by the

turn of the 21st Century is a necessary but not a sufficient condition to obtain prosperity and peace for mankind.



Fundamental parameters for prosperity and peace include *trade and economics, security, health and sustained, ever continuing education of humanity.* These four parameters connect the world with a compounding positive effect, meaning that well-being of one nation on these parameters imply the well-being of every other nation as well. I feel appropriate to make a reference here about the message which I gave during my Special Address at the Beijing Forum 2012 on 02 November 2012. *"All nations of the world have in one way or the other, for centuries, survived based on conflicts, be it national, regional and global. There is an element of frustration, among nations themselves, and the people would like to live in peace. I have come to the conclusion; every nation needs a mission bigger than its people, bigger than the nation. Can the Beijing Forum evolve and present a greater vision where the nation will be busy and committed, work globally, regionally and nationally resulting in conflict free, peaceful, prosperous societies of the world."*

I had presented in Beijing, my experience of evolving one such vision which will unify many nations to come together and work for the sustainability of the earth and the humanity. This was the concept of a **World Knowledge Platform for Global Action** that I shall speak about shortly here as well. How then will space industrialization and space solar power help us to address these larger issues as well?

Why Space Solar Power?

SSP has significant long-term advantages, and is unusual among renewable energy options as it satisfies all of the following criteria:

1. **Immensely Scalable SSP** can scale to provide the energy needs of the entire human civilization at well enhanced standard of living. Most other near-term renewable options are strictly limited in scalability.

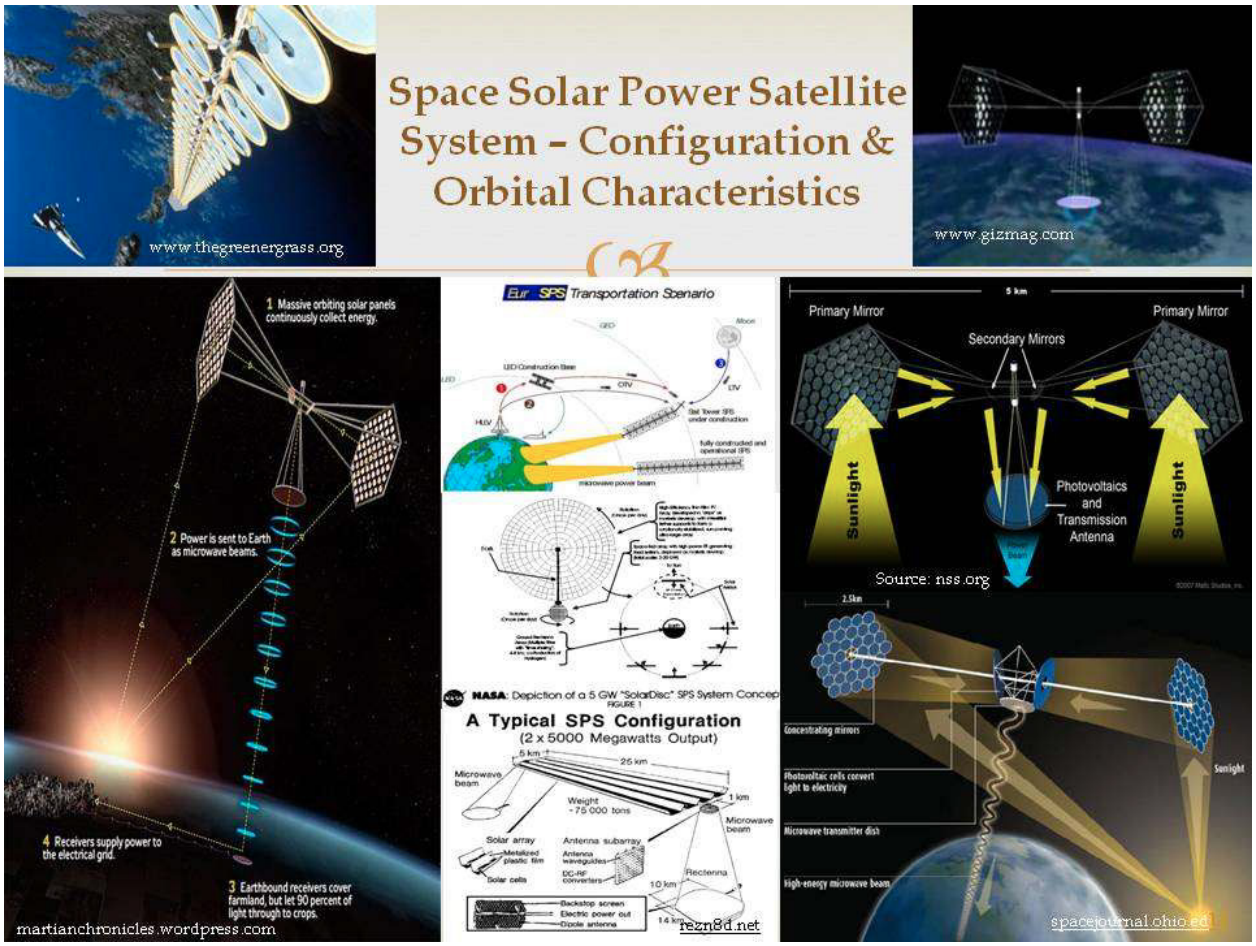
2. A single kilometre-wide band of geosynchronous Earth orbit experiences enough **solar flux** in one year to nearly equal the amount of energy contained within all known recoverable conventional oil reserves on Earth today.

3. It is **safe and globally available**, and can be safely shared with all countries on this planet without proliferation concerns.

4. It is **steady & assured**, for SSP is a continuous, rather than intermittent, power source. It is not subject to the weather, the seasons, or the day-night cycle.

5. It needs **no fundamental breakthroughs** in either physics or engineering.

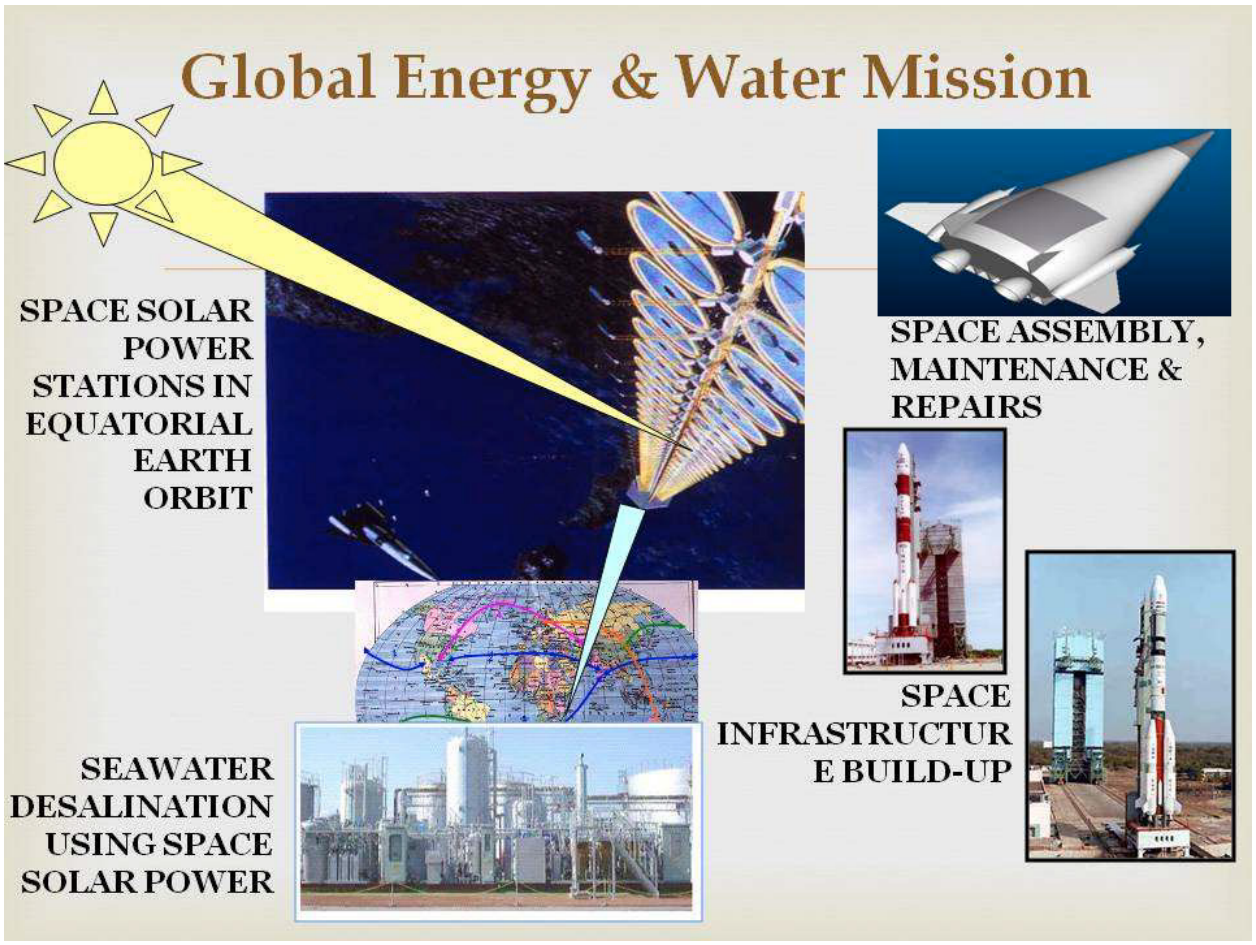
To take advantages of these attributes of space solar power we need to be clear of what we mean by international collaboration for a space solar power mission.



Successful Collaboration In organizational research on what makes collaboration work , the following factors influencing successful collaboration and ranked as the most important:

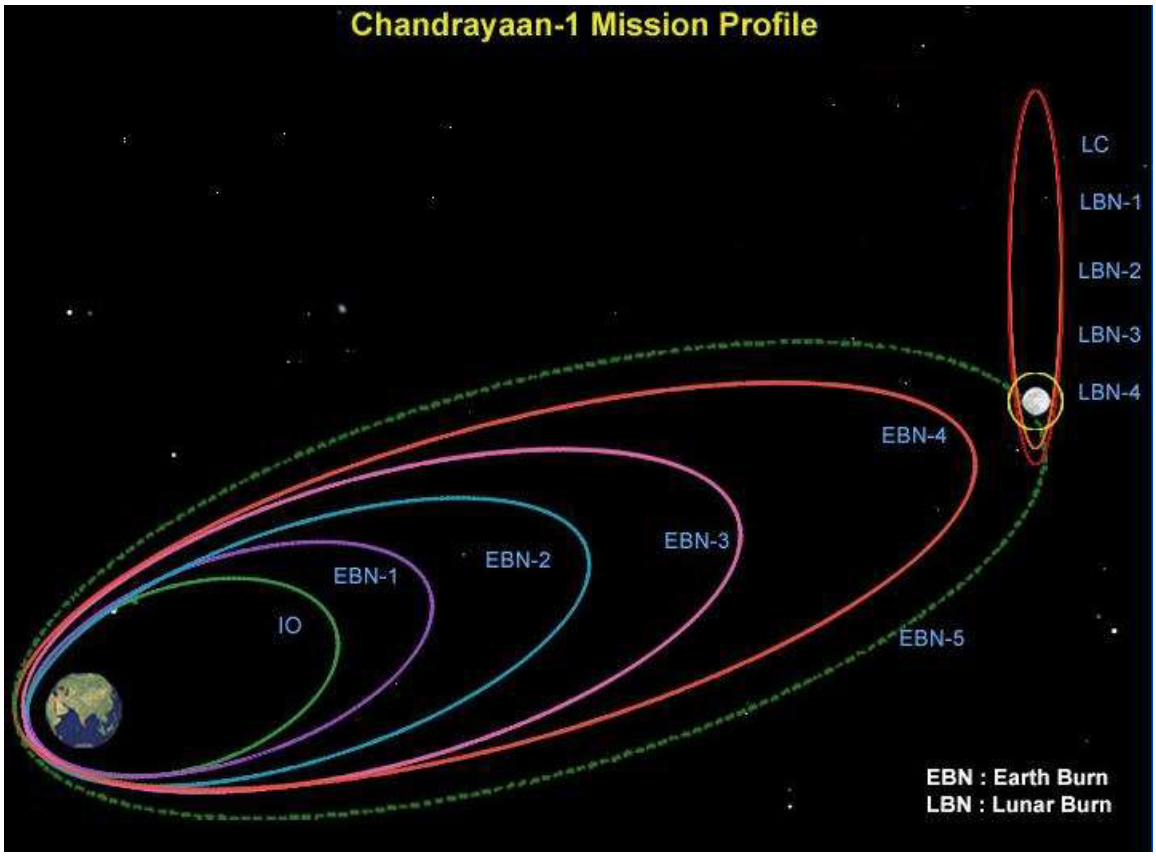
1. Mutual respect, understanding and trust
2. Appropriate cross-section of members
3. Open and frequent communication
4. "Sufficient funds"

I am most happy to note that we have had open and frequent communication these last few years with appropriate cross-sections of members and we have established mutual respect, understanding and trust. So what is left? I shall now ask you an open question. Is it only that we have to find sufficient funds? For every one of us knows in his or her own heart of hearts that this is certainly not the case when two nations like the US and India decide to work together along with other nations for a liveable planet earth, lack of optimum funds would never be a problem!



For example, India and USA collaborated and launched a Joint efforts through M3 (Moon-Mineralogy-Mapper) payload of Chandrayaan-1. This joint effort of ISRO and NASA succeeded in finding water molecule traces of HO/H2O in the first attempt itself. That is symbol of success of International collaboration between India and US.

So what remains for us to move ahead? *This is a tough question and it cannot be any delay in finding an answer*, given the new level of turbulence in the world?s political economy. We need to address this clearly and *make a new beginning* to our proposal for an international SSP mission study that is to be the live end of growth into space industrialization and a liveable, peaceful and prosperous world.



Core Competencies & Competitive Advantages of Nations

Very clearly, an international collaboration toward such an epochal mission like space solar power as a movement towards a livable planet earth requires careful study and analysis of the competitive advantages of nations to take part in such a global collaborative venture. I define these as the strengths of the nation/organization *that are transferable to another nation/organization through a collaborative mission.* It is to be noted that nations/organizations may have many strengths **that are not transferable** because of the existing regulations/restrictions imposed by them for whatever reason. In such a case, these strengths are NOT to be considered as competitive advantages of that nation/organization for the purpose of meeting the goals of the collaborative mission.

Michael Porter had developed a model for competitive advantage of nations. I have used this model to examine six of the principal space faring nations (USA, India, Japan, China, Russia and the European Union) from the perspective of this well-known model.

1. ***Demand Conditions:*** The nature of home demand for the product/service. In this case, energy and water

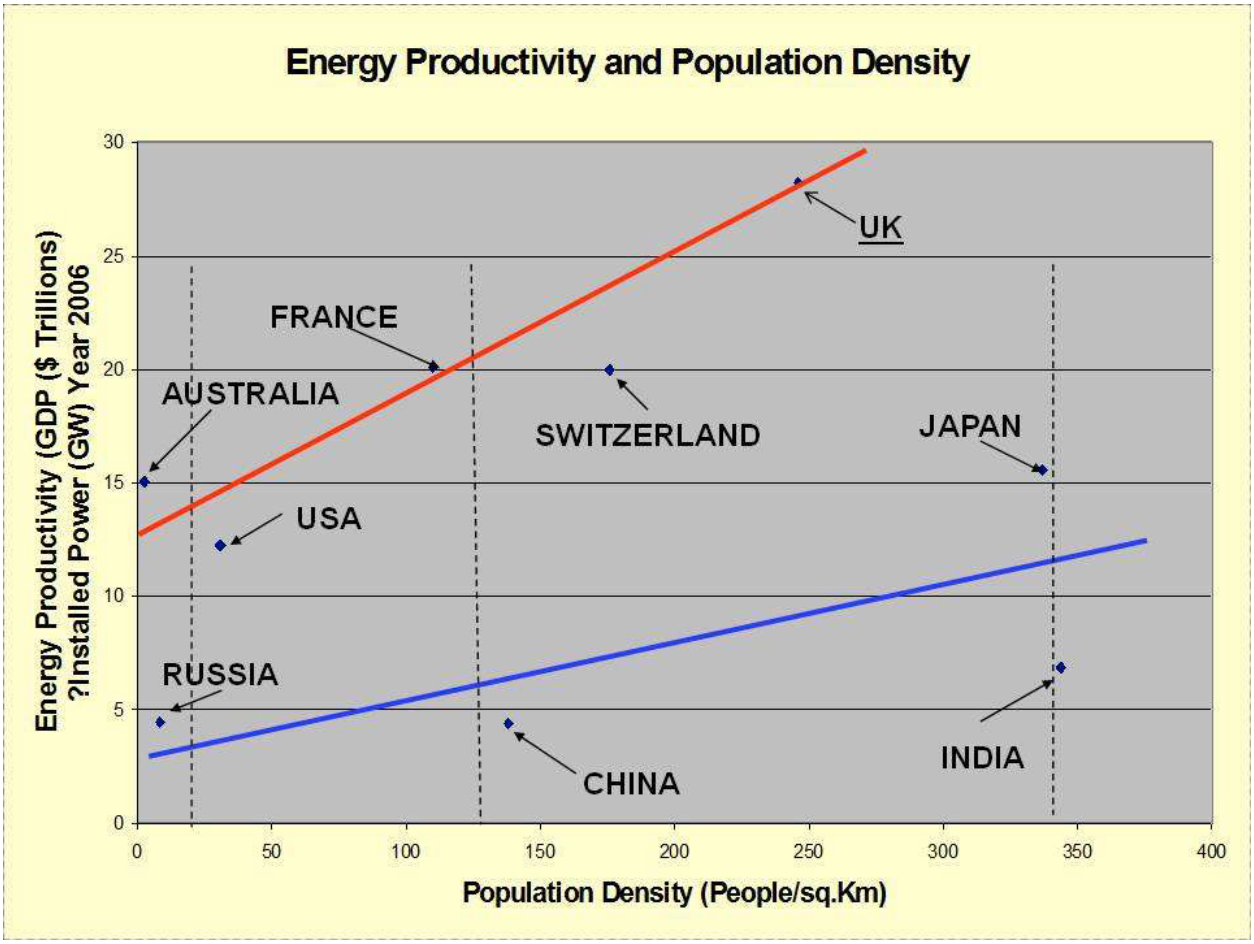
2. ***Factor Conditions:*** The nation?s position in technology development, production, skilled labour, and infrastructure needed to compete in the industry

3. ***Related and Supporting Industries:*** the presence or absence of a nation's supplier and related industries that are internationally competitive

4. ***Internal rivalry, strategy and structure:*** the nature of domestic rivalry and how the company was created, and is governed and managed

5. **Two other conditions** affect competitive advantage: chance and government policies

I examined *at a very preliminary level* the core competencies and competitive advantages of a six nation group of space faring nations (USA, India, Japan, China, Russia, European Union) comparing multiple variables e.g. the energy productivity of a nation in relation to its population density.



This chart conveys a sense that a sub-continental nation like India having almost the same population density as a small island nation like Japan has at the same time less than half its energy productivity. Other nations like France and UK have even lower population densities and higher energy productivities. Which nation then has the conditions for greatest demand for energy, which is a competitive advantage for the international collaboration?

Other technological, industrial, infrastructure, skills, etc, the "factor conditions" that constitute the strengths in terms of competitive advantage of the nation /organization related to a collaborative

mission for space solar power were also examined and the outcome: *I was astonished to find that all these six space faring nations have almost equal competitive advantages for such an international SSP mission with the US having an overall slight advantage!!*

It does seem reasonable to structure the international collaboration on the basis of the real competitive advantages of participating space faring nations for the maximum benefit of the ultimate customers, humanity; and certainly not by arbitrary factors that inhibit real competitive advantage for such a mission.

Making International Collaborations Work

How then can we make this collaboration work? We already share a sense of mission, develop and deploy a shared mission and goals, we already have open dialogue about why people are involved, what they hope to accomplish. Perhaps this is what has been happening these last few years. We, the NSS and our small team in India, have also built strong, trusting relationships through a participatory process. We need to introspect, the NSS and Indian organisations, perhaps we have to look at another important factor that successful collaborations work best when they develop an effective governance process, for which we have to evolve an appropriate international and internal dialogue structure.

For example, the NSS/USA and Indian Aero Space Organisations may like to identify say 25 to 30 experts from space faring nations.

World Space Knowledge Platform: International SSP Mission

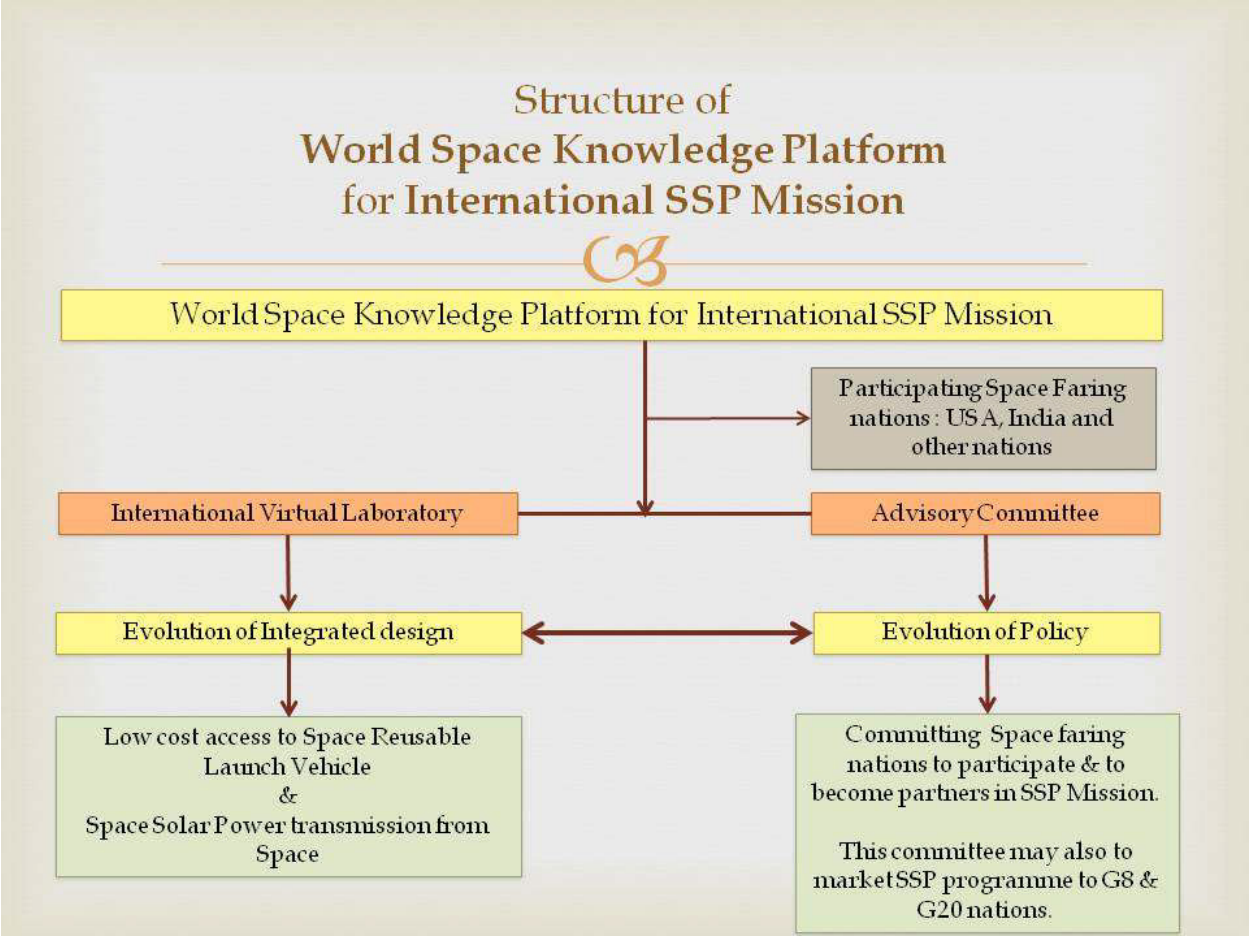
With this background, can we initiate a mission to create a **World Space Knowledge Platform**, with these selected 25 experts from the collaborators, as an *International Virtual Laboratory* for conceptual, perspective and strategic planning of technical and management systems and bring reality our cherished dream for a liveable planet earth through a space industrialization mission, starting with space solar power and reusable space transportation systems? This world knowledge platform will become an advisory body for Space Industrialization. *This then is direction and hard core content of what we must accomplish today and in the next few months,* in the spirit and name of our visionaries like von Braun and Peter Glaser whose ideas and hard work have brought humanity to this new level of thinking.

This ***World Space Knowledge Platform*** which is to be an International Virtual Laboratory will take the form of a **coalition of leading academic institutions in space and energy science & technology, one or two in each of the partner nations.** Guided and coordinated by the World Space knowledge Platform?s International Advisory Committee, they would be directed towards bringing out an International Feasibility Study for SSP. It needs to be funded initially as an international cooperative venture with about **$ US 4 billion over the next five years** with dedicated spending to developing customizable and scalable solutions. *Needless to say, each national stakeholder in this collaboration would be required to*

provide, up front, small seed money to be used for starting-up such an International SSP Feasibility Study Report: so let us see who the first to sign up are!!

These academic institutions, one or two in each nation would thus be *sufficiently funded by world governments and industries.* The representatives of government and industries being on the World Space Knowledge Platform?s International Advisory Committee and all other operational coordination mechanisms would know exactly what is happening (as the mission moves forward. I trust that answers your question of what would be the source and use of funds. In their turn the academic institutions would fund and coordinate sub-scale technology demonstrations of space solar power and reusable launch vehicle systems on ground, air and in space. Let me now brief on the immediate steps to be taken for the coherent planning and implementation of the International SSP Mission.

Dear friends, at this stage, I would like to introduce my young friend V. Ponraj, he is doing Ph.D under my guidance, on the topic "Cost effective healthcare" using space systems and ICT. He has worked with me closely in the formulation of World knowledge platforms based on few of our experiences. I ask my friend to give his analysis on the structure of the World Space Knowledge Platform and the immediate steps needed for coherent planning and implementation of World Space Knowledge platform briefly.

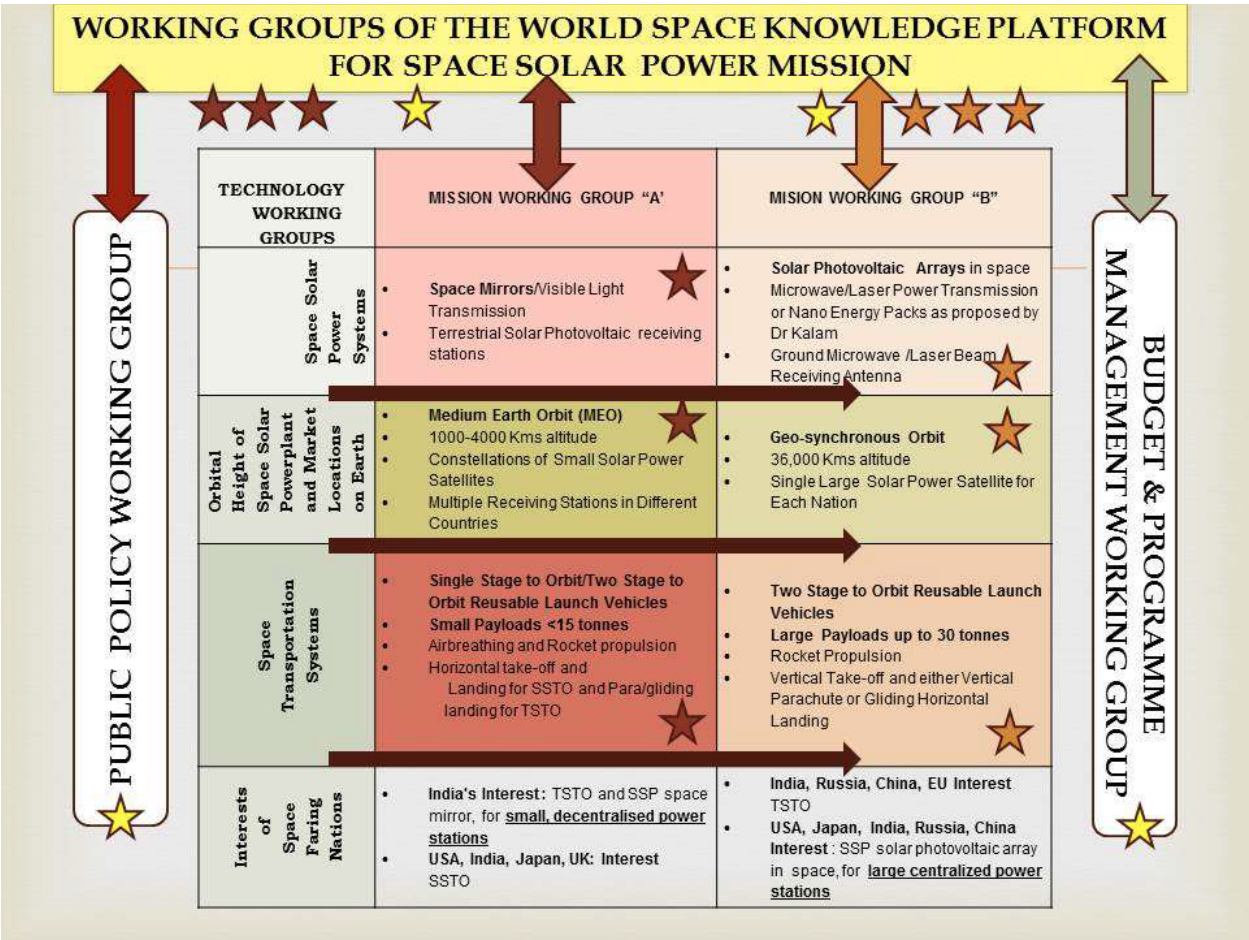


Coherence:

It might appear to everyone that this World Space Knowledge Platform is a very complex approach, and the issues to be dealt with by the World Space Knowledge Platform would be unimaginably difficult. *But then I do not see them as impediments or challenges, because these are the actual opportunities and strengths of the world community.* We have to harmoniously blend and "stream" these competing options in space and energy systems and technologies, and opposing ideologies in the realms of vision, geopolitical alignments, and mission management structures and styles. These chronic dualities are legacies of the 20th century and by "streaming" the competitive options and opposing ideologies into TWO coherent, cooperative, mutually beneficial collaborative streams of activity within the apex structure of the international SSP mission. I shall briefly illustrate what I mean.

The World Space Knowledge Platform could have two types of membership that would harmonize current reality: core members; participating and observer members. They would discuss among themselves and with their governments and industries these competing options and opposing ideologies and "stream" them into the two coherent "streams" of activity, taking into account the core competencies (i.e. the transferable talents, skills and resources) of the nations they represent. This process would itself bring in coherence, so long as we do not look at the available options as impediments and threats, but as opportunities and strengths of the international SSP mission as a whole.

Dear friends, Among the co-chairmen of the International Advisory Committee, as a Chancellor of IIST, I had proposed that the *Indian Institute of Space Science and Technology (IIST) and other similar space based institutions from USA would* jointly outreach to space faring nations interested in Space Based Solar Power.



Current Status of International initiatives towards SSP

Before I conclude, you would be happy to learn that the world is not standing still in regard to solar power and reusable space transportation systems. Energized by the NSS vision for space solar power, ISRO has a small group of scientists studying space mirror approach that has been highlighted here at ISDC 2013. Japan has announced its long term SSP development programme.

In the reusable space transportation domain, recall that Dr Von Braun had a far reaching vision for reusable launch vehicles even in the 1960's!!

Now, about 50 years later, the US has just completed its last of a series of four flight tests on an air launched solid rocket boosted scramjet engine test vehicle.

India is moving rapidly ahead and has planned a launch of its ground launched liquid booster assisted RLV Technology Demonstrator.

Reusability: Mission Critical Concept

Each nation has, thus far, its own unique approach to RLV technology demonstration.
India has two concepts and the ISRO version is to be launched soon. India's Mars Orbiter mission is planned when Mars would be closest to the Earth. It would be launched either in the last week of October or the first week of November 2013.

Even though Japan had abandoned its Hope-X TSTO RLV Technology Development programme HYFLEX in 2004, it has redirected its funding and efforts into SSTO RLV Technology Development and Demonstration programmes.

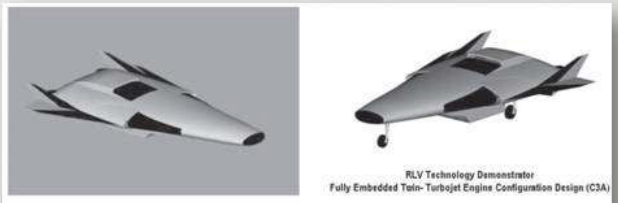
But it is strange and indeed baffling to see that even after 60 years of efforts, not one of these nations has demonstrated and established by actual flight tests the *very basic concept of reusability.*

RLV-TD TECHNOLOGY DEMONSTRATOR CONCEPTS FROM INDIA

EX0- ATMOSPHERIC RLV TECHNOLOGY DEMONSTRATOR (ISRO-RLV-TD)

Source: https://www.google.co.in/search?hl=en&q=isro+rlv+td

ENDO-ATMOSPHERIC RLV TECHNOLOGY DEMOMNSTRATOR (HTV)



Configuration Tentative

- Take-off Mass: 3.5 to 5.0 tonnes
- Horizontal Take-off & Landing
- Fully Reusable
- Demonstrates Reusability & Maintainability
- Flying Test Bed for Airbreathing Engine (Turbojet /LACE/Scramjet)
- Demonstrates aerocryogenic technologies in Flight (Heat Exchangers & LOX Separators)
- Atmospheric Flight Regime Identical to Hyperplane/Avatar Spaceplane.
- Non-orbital
- Dual Fuel (Hydrogen/Aviation Kerosene)

Source: Journal of the British Interplanetary Society, Vol. 63, Pp.395-405, 2010

International Standard RLV Technology Demonstrator: Can the proposed World Space Knowledge Platform and its International Advisory Committee call for competing proposals and then synthesize to bring out a design of a single multi-role RLV technology demonstrator? A world standard RLV Technology Demonstrator, a small one, not heavier than 3.5 to 5.0 tonnes weight, that would effectively be hypersonic flight test vehicle for sub-scale flight testing of a variety of critical engine and airframe technologies needed for both SSTO and TSTO RLVs and *above all fully validate the concept of reusability in actual practice?*

Space Solar Power Systems Demonstration: Secondly, can the proposed International Advisory Committee through the World Space Knowledge Platform call for proposals and demonstrate at least on the ground competing concepts of space solar power systems and technologies on a very small scale (say 500-1000 Kw) and at least one single value added niche application like seawater desalination with space solar power?

Integrated Electricity and Drinking Water Mission for India

Dear friends, In India, when we think of the Space Solar Power mission, I am reminded of two pilot projects which you can think of leading to Integrated Electricity and Drinking Water Mission for India.

1. **Space Mirrors to Synergize Existing Terrestrial Solar Power Plants:** One I visualize any state that is having 500 MW solar power plant installed can be taken for synergizing existing terrestrial solar power plant through Space Mirror concept. For example using the Space mirrors that are simpler, lighter and hence can be launched earlier than the more complex and heavier space photovoltaic array systems. They can be deployed to synergize existing terrestrial SPV plants, like the 500 MW system in Charanka, Gujarat State. The Charanka Solar Park covers 2000 hectares, or 5000 acres of land. This area is equivalent to a circle of 5 Km diameter. To illuminate any spot on earth from space depends on the size of the sun?s disc as viewed from earth. Hence for a 5 Km diameter sunbeam light spot, equivalent in area to the area of the Charanka Solar Park, the maximum allowable orbital height would be 500 Kms. So there is another economic factor for then the *multiple solar power satellite constellation has to serve at least as many customer ground stations as there are orbiting satellites.*

2. **Space Solar PV Array Systems for Seawater Desalination Plants:** For example, the State of Tamil Nadu on coastal locations like Auroville, the ground water up to nearly 20 Kms inland is fully contaminated by seawater ingress. Tamil Nadu State is already operating a number of reverse osmosis based seawater desalination plants. The sizes range from small sized plants (less than 5 Million liters/day, MLD) to 100MLD. These desalination plants are placing heavy demand on electricity generated by coal based plants in a State that is already plagues by power shortages.

1 MW of power is needed to generate 4 MLD of water. Terrestrial solar plants can operate RO pumps for only 6 hours a day, space based solar power systems would run the RO system pumps continuously for 24 hours a day throughout the year. Hence the entire power for seawater desalination for the State of Tamil Nadu can be easily provided by space based solar PV arrays beaming power by microwave / millimeter wave to offshore platforms. Considerable research on seawater desalination using solar power has been carried out in IIT (Madras) and a 500 liter/day proof-of-concept Technology Demonstrator has been running and gathering data over several years.

Within this range of techno-economic choices we in India would have to choose one set of technically optimized orbits (mission) and systems concepts that would meet India's interests. Charanka would be the first to go on stream. This is the first challenge of the Indian space community as it expands its societal mission to rebuild our planet for stable peace and sustainable prosperity.

Conclusion

In conclusion, we shall embark on a path-breaking international mission for space solar power within the ambit of a global vision for space industrialization leading on to a new era of peace, prosperity and abundance for all humanity.

We shall build upon the trusting relationships we have established and consolidated these last 4 years between the NSS and India. We shall now strive to expand this relationship in an organized and well-structured manner creating a World Space Knowledge Platform with a virtual laboratory of 25 specialists and generalists drawn from Government and Industry in the US, India along with other space faring nations.

Finally I would like to suggest the following points of action plan needed for realizing the great mission **"Space Solar Power: Key to a Liveable Planet Earth"**

1. Creation of the World Space Knowledge Platform with Virtual Laboratory for Space Industrialization by USA and India with other space faring nations.

2. Identify the Space Virtual Laboratory partners ? minimum 10 nations with clearly defined missions, to draw up a Detailed Feasibility Study Report on the International Space Solar Power Mission supported by definitive sub-scale technology demonstrations of critical SSP and RLV technologies on ground, air and space; and fully validate the critical concept of reusability of space transportation systems on which the whole mission concept rests along with the defined period of study with the necessary institutional and financial support.

3. There are choices for Space Solar power wireless transmission including microwave, millimeter wave (W band), Laser Wave or "Nano Energy packs" and Visible sunlight deflection through space mirror approach. In 3 years? time, Virtual Laboratory for Space Solar power can bring an optimum, workable and possible solution particularly for transportation of Space Solar power to its terrestrial stations.

4. Within the next 6 months? time, we need to bring out a workable 20 page research document for marketing SSP to Space faring nations.

5. The challenge is marketing the Space Solar Power to the nations of importance for taking up the mission by joining this World Space Knowledge Platform as a partner. That means Space Solar power proposal has to be marketed to G8 or G20 nations. From Indian side, I can assure you that, I can initiate necessary action in consultation with my Government. Similarly NSS can simultaneously work on it and initiate necessary action with US Government, so that the International Space Solar power mission can be realized through the World Space Knowledge Platform.

I visualize IIST in partnership with other ISRO centers will spearheads in harnessing solar power with five point focus which I have given.

Dear friends, based on my discussions with many aerospace platforms and with NSS for the last 6 years and with the experts assembled from various space faring nations including USA at ISDC 2013, I am

happy to inform you that I am releasing today at VSSC, the agreed Joint Statement by me and Mr. Mark Hopkins, Chairman, NSS on the "Space Solar Power: Key to a Livable Planet Earth" for creating the World Space Knowledge platform and further our efforts in bringing space faring nations, G8 or G20 nations to come together to realize the mission of Space based Solar power by joint collaboration. We will soon jointly work together to identify the core members and observer members for the World Space Knowledge Platform.

I am confident that with this context, certainly the role of ISRO and IIST has acquired new dimension in working for realizing the Space Solar power. My greeting to all of you.