Suitability of South East Asia and the Caribbean as Antipodal Spaceports for Global Point-to-Point Commercial Suborbital Flight

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Abstract

As Earth is a sphere, there are antipodes on the Earth surface. The distances between these antipodes in the opposite directions is the same, which is about 20,000km since the Earth circumference is about 40,000km. However since more than 70% of Earth surface is covered by oceans and seas, 70% of the antipodes are in the water, while most of the balanced 30% landed antipodes are located in South East Asia and northern South America, China and southern South America, Iberian Peninsula and New Zealand and Arctic and Antarctic. Of these, those that near the Equator, are located in South East Asia and northern South America. In space economy, being located near the equator is an advantage because space launch vehicles launched from spaceports near the equator is more economic due to their rockets thrust being subsidized by Earth rotational momentum which is maximum at the Equator. Therefore the antipodes in South East Asia and northern South America have the potential to be developed into antipodal spaceports for global point-to-point commercial suborbital spaceflight, the economic driven suborbital flight between 2 fixed destinations on Earth. However, as the Caribbean being a global tourist destination and is more economically developed than the nearby northern South America, the more suitable antipodal spaceports with economic correction is South East Asia and the Caribbean.

Keywords: Point-to-point suborbital flight, South East Asia and the Caribbean antipodal region, new regional aviation hub, antipodal spaceplane, antipodal spaceports.

Introduction

Suborbital flight is spaceflight of minimum altitude with a momentum not high enough to escape gravity. The minimum altitude is Karman line, an imaginary line 100km from sea level. Human who flies at or beyond Karman line is recognized as flying in space and can be awarded with astronaut wing to recognize him or her as an astronaut. The Earth escape gravity is 11.2km/s at Earth surface. To escape gravity and be in orbit, a rocket must produce high enough momentum to have a velocity at least equivalent to the Earth escape velocity. If the rocket fails to escape gravity, it will not reach orbit, but falls back to Earth due to gravity. When this happens, the rocket is said to have performed suborbital flight.

Most suborbital flights are suborbital jumps from a location to an altitude around 100km and back to the same location or a nearby location. A sounding rocket for atmospheric study may perform a suborbital flight by launching from a site, reaching 100km from sea level and falling back due to gravity at a nearby site. A commercial suborbital aircraft carrying space tourists may launch from a spaceport, carrying its passengers reaching the Karman line so that its passengers can be awarded with astronaut wings and land back at the same spaceport. The suborbital aircraft is performing suborbital spaceflight which is also the most economic space tourism flight at the time being.

Suborbital aircraft fly at very high altitudes compared to conventional fixed wing aircraft. At these altitudes, the atmosphere is very thin and air friction is very minimum. This is the region where hypersonic flight can be very practical, the reason the flight faster than 5 times the speed of sound or above Mach 5 can be performed efficiently using rocket or ramjet. Such flight when performed between 2 points of significant distance can also be described as point-to-point suborbital flight. Global point-to-point suborbital flight between 2 airports on different continents is the future of long distance commercial aviation, because hypersonic flight will cut short the flight time very significantly.

Normally, long haul flights of around 15,000km are performed within 20 hours by large passenger jets carrying around 300 passengers. Although such flights have been hardly impacted by the COVID19 pandemic, they are recovering and seeing the returning to normal within a couple of years. Hypersonic point-to-point suborbital flight capability will allow such flight to be performed within 4 hours, meaning one can make return intercontinental flight within a day by hypersonic technology. However, this paper is not to discuss hypersonic technology, but to justify 2 regions as the most suitable sites for a pair of antipodal spaceports.

Antipodes are points on the Earth surface that have antipodal points on the opposite side of the Earth, where an imaginary straight line tangential to the Earth surface passes the center of the Earth and the paired points. This is due to the Earth being a sphere. 70% of the antipodes are in the water because more than 70% of the Earth surface is water as in oceans and seas. The other 30% antipodes are on the land, mostly in the 4 landed antipodal pairs, which are South East Asia and northern South America, China and southern South America, Iberian Peninsula and New Zealand and Arctic and Antarctic. Among these landed antipodes, those that are located in South East Asia and northern South America are nearest to the Equator.

1	South East Asia & northern South America
2	China & southern South America
3	Iberian Peninsula & New Zealand
4	Arctic & Antarctic

The 4 landed antipodal pairs.

Being a sphere and spinning on its axes, Earth produces rotational momentum which is maximum at its equatorial plane. This momentum contributed to rocket thrust when a rocket powered launch vehicle is launched from a spaceport. The closer the spaceport to the Equator, the more the contribution received from the Earth rotational momentum. The momentum subsidizes the rocket thrust therefore it is more cost effective to launch rocket powered launch vehicles from spaceports nearer the Equator.

This equatorial factor of cost effectiveness is very significant in space economy because launch services are the most fundamental element of space economy. Russian Space Agency have moved their launch vehicle, Soyuz from Baikonur Spaceport in Kazakhstan to Guiana Space Center in the Equator and started to launch from the equatorial spaceport since 2011. By doing so, Soyuz has managed to double its payload if not reducing half of its rocket fuel.

There are destinations in space where launches can only be cost effective if launch vehicles meant to deliver satellites there are launched exclusively from spaceports along the Equator. An example is geosynchronous orbit where geostationary satellites or satellites that are fixed over a location on Earth are sent to. Up to date, there are more than 500 geostationary satellites, which is more than 10% of total satellites in orbit. There are more than 1000 slots available for geostationary satellites in the orbit.

Like most of the planets in the Solar System, Earth rotational plane or equatorial plane is closer to its orbital plane or the plane where Earth orbits around the Sun. This is why planets including our neighboring planets Mars and Venus are high in sky when seen from the Equator most of the time in a year. Therefore interplanetary space missions, or flight to planets including Mars and Venus are more cost effective if launched from spaceports near the Equator, because all the planets lie in the Solar System orbital plane.

Spaceports at the time being are for launching vehicles to space, but in the future they will also serve hypersonic aviation. By this time, some of the airports may have been upgraded into spaceports too, where they serve both aviation and space transportation. This is when 2 or more spaceports will support each other just like current airports do.

Hypersonic technology will allow long distance but short duration suborbital flight between 2 spaceports on the opposite side of Earth. This is where antipodal spaceports come into play, and the law of Physics remains valid though, where due to Earth rotational momentum, launches between 2 equatorial antipodal spaceports is the most cost effective. Of the 4 pairs of landed antipodal regions, the regions that enjoy the most that particular law of Physics is South East Asia and northern South America, because both regions are equatorial.

For maximum efficiency of hypersonic flights between equatorial antipodal spaceports, there should be antipodal spaceplane. This is a concept of spaceplane specially designed to fly between the antipodal spaceports with maximum cost effectiveness and safety.

Point-to-Point Suborbital Spaceplane

At one time the most famous suborbital spaceplane was SpaceShipOne which later became the embryo for the development of SpaceShipTwo that became the first suborbital spaceplane carrying passengers to space. SpaceShipOne first flew to space exceeding the Karman Line of 100km from sea level on June 2004. About exactly 17 years later, SpaceShipTwo flew to almost reach the Karman Line carrying 6 passengers.

These suborbital vehicles are called "spaceplane" because they look and operate like airplane. They have fixed wing and take-off and land like airplane. They are fully reusable too, but different from fully reusable vertically launched and landed space vehicles.

The most important is suborbital spaceplanes can take-off from and land on runways at airports, allowing them to potentially share airports with airplanes. Both SpaceShipOne and SpaceShipTwo took-off from and landed at the same airport. SpaceShipTwo took-off from and landed at Spaceport America in New Mexico.

These were actually the earlier steps for point-to-point suborbital flight; suborbital flight between two different airports. Since suborbital spaceplanes are powered by rockets, they are able not only to reach space, but also fly very fast up to 5 times the speed of sound or 5 times faster than modern jet-powered airplanes. This is why suborbital spaceplane has great potential in future aviation.

Point-to-point suborbital flights however were successfully performed many decades before. In the 60s, X-15 of NASA and USAF was piloted for point-to-point suborbital flight reaching the speed of Mach 6.7 and altitudes above the Karman Line. In 2015, IXV (Intermediate Experiment Vehicle) of ESA (European Space Agency) became the suborbital spaceplane that have flown the longest distance and the highest altitude. IXV was launched vertically on top of the Italian light launch vehicle Vega from ESA spaceport in French Guiana, flew eastward and landed more than 30km away in the Pacific Ocean near Panama. It reached more than 400km from sea level, an altitude way beyond the Karman Line.

IXV was developed by Thales Alenia Space Italy (TASI) and tracked and retrieved by ALTEC (Aerospace Logistics Technology Engineering Company), a subsidiary of TASI and ASI (Italian Space Agency). The main author had an opportunity to worked few assignments by the subsidiary and viewed the final assembly of IXV at TASI.

IXV did not have wing, but it employed flaps and lifting body design, new option for suborbital spaceplane. Meaning, future suborbital spaceplane flying point-to-point intercontinentally can be developed with smaller wings with flaps and lifting body technology.

South East Asia and the Caribbean Antipodal Regions

To be exact, the antipode of South East Asia is northern South America where the ESA spaceport is. However, it is better to consider the Caribbean as the economic antipode of South East Asia, as the Caribbean is a major tourist destination in the world, which is significant as a catalyst for the establishment and successful operation of an antipodal spaceport in that region.

There is an interesting symbiotic relationship between the Caribbean and Mediterranean in tourism industry, specifically in the ocean liner and superyacht operation. Ocean liners and superyachts tend to sail between these sea tourism destinations. During summer in Europe, those luxury ships carrying rich tourists sail to the Mediterranean, while when it is winter in Europe, the ships sail to the Caribbean. So the Caribbean understands the sharing of global industry between 2 well separated regions very well.

The Caribbean and the Mediterranean share the luxurious ocean liner and superyacht tourism industry because both have an exclusive similarity. They are both sea tourism destinations. Both have beautiful beaches and excellent ports plus beautiful weather. They can share not only the ocean liners and superyachts, but also hotels and resorts.

Now the Caribbean can look into another very similar sharing with South East Asia, being the antipode of South East Asia. But the only practical transportation system connecting 2 antipodal points on Earth must be hypersonic as the distance between them is approximately 20,000km, as the average perimeter of earth is slightly above 40,000km. As an example, the distance between Kuala Lumpur in Malaysia and San Juan in Puerto Rico is 17,255km, which is also the shortest distance between 2 major cities in central South East Asia and eastern Caribbean. The main author went to San Juan in 2014 under invitation by an organization in San Juan to establish a spaceport in that capital city of Puerto Rico.

This hypersonic transportation system must also be supported by other regional transportation system which provides passengers and payloads to the antipodal transportation system.

The most practical hypersonic transportation system that will be able to travel such distance across many countries and several continents and also across oceans and seas is hypersonic aircraft. For cost effective, the hypersonic aircraft should be able to be operational at airports so that it will share the facilities with commercial aviation. Therefore airports where antipodal hypersonic aircrafts operate should be regional aviation hubs, where regional flights take-off from and land there.

Not only that, our world consists of 2 megacontinents separated by 2 largest oceans on both sides. One of the megacontinents is North America and South America and the other one is Europe, Africa and Asia. These megacontinents are separated by Atlantic Ocean at one side and Pacific Ocean on the other side. Due to this macro geographical factor, the hypersonic flight should fly between these megacontinents, either across the Atlantic Ocean or across the Pacific Ocean, because one aviation hub should be at one megacontinent and the another aviation hub should be on the other megacontinent.

These are the natural facts that will justify the exclusive economic relationship between South East Asia and the Caribbean pertaining to them being antipodal to each other.

New Regional Aviation Hub

Today, Dubai and Amsterdam are successful regional aviation hubs. One of the reasons is the large passenger aircrafts serving these hubs are near-supersonic or supersonic, meaning they fly near the speed of sound or almost Mach 1.0.

With such speed the aircrafts need only between 6 to 10 hours to reach Dubai and Amsterdam from almost all major cities anywhere in the world. Aircrafts from South East Asia, Far East, Europe and southern Africa fly between 6 to 10 hours to reach Dubai, while aircrafts from North America and South Asia also fly 6 to 10 hours to reach Amsterdam. The time between 6 to 10 hours is psychologically, physiologically and culturally accepted flight travel time for human passengers, beyond which above that, it is considered too long and not accepted psychologically, physiologically and culturally. If the flight travel period is beyond 10 hours, the travelers will suffer boredom, tiresome, loss of comfort and ineffective. They will need long period resting after the 10 hours flight.

This fact is also being supported by Dubai and Amsterdam operating their own aircrafts at relatively large number compared to other operators. Their aircrafts land exclusively in Dubai and Amsterdam only respectively.

If there is development in jet engines and aircraft design in the near future which enable large passenger aircrafts to fly between Mach 1.2 and Mach 1.5, Dubai and Amsterdam will still be able to remain as the most successful regional aviation hubs. However with the foreseeable advancement of hypersonic technology that will enable passenger carrying aircrafts to fly between Mach 3.0 and Mach 6.0, other destinations will emerge as the regional aviation hubs.

The emergence of these hypersonic aircrafts will enable flight a distance of 20,000km in 4 hours only. With such new aviation, one can travel on direct flight in less than 4 hours between megacontinents, and less than half a day or 12 hours including regional flights to reach his or her final destination.

For example, with hypersonic flight, a family from Kuala Lumpur, Malaysia can reach San Juan, Puerto Rico, United States in 4 hours. After an hour and 30 minutes of airport transfer in San Juan, the family will arrive in Miami in another 2 and half hour with conventional flight. Therefore the Malaysian family only takes 8 hours to reach Miami from Kuala Lumpur. Compare to contemporary flight service, the family will need more than 24 hours to fly from Kuala Lumpur to Miami with transit in Tokyo and Los Angeles.

In this case, San Juan will be the regional aviation hub, because the hypersonic aircraft will land in San Juan and the passengers will continue their travel to other cities in North America and South America on conventional flights taking off from San Juan airport. So does Kuala Lumpur.

These new aviation hubs will emerge with the emergence of hypersonic flight services. They will still serve conventional flights using large passenger aircrafts. These conventional flight services will not only take the passengers to their final destinations, but also become the feeder to the intermegacontinental hypersonic flights. With good management of these feeder flights, such new aviation hubs will be able to manage steady operation of hypersonic flights up to 3 or 4 per day.

Central South East Asia generally and Kuala Lumpur specifically will be able to function effectively as the new aviation hub because it can serve connecting flight from and to Middle East, Far East and Oceania (Australia and New

Zealand). So does eastern Caribbean generally and San Juan specifically which can serve connecting flights from and to southern and eastern United States and northern and eastern South America. These connecting flights only need less than 8 hours to reach the new aviation hubs or to reach the final destinations from the new aviation hubs.

This new aviation calls for new aircraft which is specially designed and develop to effectively serve the antipodal aviation hubs in central South East Asia and eastern Caribbean, namely Kuala Lumpur and San Juan. This new aircraft is called, "antipodal spaceplane" because it flies between antipodes and above the Karman Line.

Antipodal Spaceplane

Up to date, the most practical engine for hypersonic flight is rocket. It is a matured commercial technology as rockets have been successfully launched and flown for more than half a century delivering satellites to orbit, human passengers to space stations and recently carrying passengers on suborbital flight and also being improved and developed for better efficiency, safety and reusability. It uses rocket propellant, be it liquid or solid, or combination of both, but mostly liquid as liquid propellant is found to be more responsive to control and fine adjustment, which very much affect safety and comfort for human passengers.

Unlike fuel tanks that that can be refilled, those of rockets cannot be refilled. Therefore the size and shape of the propellant storage on rockets are specially designed for the distance of the rockets flight. Furthermore, the propellant occupied most of the space onboard rockets, meaning the propellant determine the size and design of the rockets.

Similarly, the size and design of antipodal spaceplane will be determined by its propellant too, which in return will be determined by the distance it will fly, specifically 20,000km. This is why antipodal spaceplane is needed to fly between the antipodes, because it has to be specially designed and developed for cost effectiveness.

As the objective of this paper is not to focus on designing of antipodal spaceplane, it describes only the imaginary concept of the design and operation of the spaceplane.

To enable the spaceplane to take-off from conventional airport, the spaceplane will need to use jet engines or turbofans as in conventional large passenger aircrafts. Not only this will fulfill the conventional regulatory regime of airport and civil aviation, it will also simplify and reduce the cost of operation and maintenance of the spaceplane because it will be using the same turbofans and airport facilities as being used by conventional large passenger aircrafts.

In 15 minutes after take-off and after the spaceplane have reached above 10km from sea level, it will switch off its turbofans and ignite its rocket engines to fly into space reaching 100km from sea level or the Karman Line. This is when the universal law of Physics pertaining to the maximum Earth rotational momentum near the equator becomes vital. The momentum has both the magnitude and direction. The reason the spaceplane flying at Karman Line altitude is to fly safely above all conventional air traffics and in an environment free of air friction to economically reach above Mach 5.0. So, most of the distances will be covered by spaceflight free of air friction. Such flight will be safer and more comfortable.

After 2 hours of spaceflight the rocket propellant will be depleted, but the spaceplane will proceed steadily due to its momentum. Much smaller auxiliary rockets will be used to maintain its altitude and continuously correct its trajectory. Early depletion of rocket propellant will make the spaceplane much lighter and safer for landing.

After another hour of unpowered suborbital momentum driven glide supported and corrected by auxiliary rockets, the spaceplane will perform reentry or smooth reentering into the lower atmosphere. Upon reaching the altitude of 10km, it will reignite its turbofans and land safely and smoothly at the destination airport. There will be zero risk of rocket explosion during landing because the rocket propellant has been depleted by then.

Of course there can be much more innovative solution to be added to the design and operation of the spaceplane for better safety, comfort and operational cost. Among others, it can use universal carriers, which are conventional large passenger aircrafts to carry it to 10km from sea level and air-launch it from that altitude. By this, the spaceplane can be designed simpler and less expensive as it will not require large turbofans for take-off.

Instead of using turbofans for landing, the spaceplane can also use electric propulsion assisted by its wing and lifting body design. The spaceplane will be smaller, lighter, quieter (no noise from turbofans), cleaner (no fume from turbofans) and safer (no accident caused by malfunction of turbofans and free of jet fuel). This solution will be very suitable if the spaceplane uses universal carriers.

As for the passengers, they will all qualify as astronauts because they are to fly above the Karman Line and each of them deserved to be awarded with an astronaut wing. This itself will be a desirable reward and encourage people to fly on the antipodal spaceplane. For those who fly as tourists, they will entitle themselves as space tourists too. They pay a fee to become tourists at their destination and space tourists on suborbital flight to their destination.

They will also use conventional airport facilities as passengers of conventional flights do. So, both the spaceplanes and the passengers will be using conventional airport facilities, which will be very cost effective.

Antipodal Spaceports

Antipodal spaceplane may be built by the same aircraft manufacturers which manufacture contemporary large passenger aircrafts or new aerospace company which built contemporary new generation of space vehicles. However, antipodal spaceports are to be developed by the country hosting the spaceport.

As the paper is justifying the establishment of antipodal spaceports in South East Asia and the Caribbean, the spaceports are to be developed by countries in those 2 regions.

It happened to be that countries in the regions are not the most developed countries in the world. They are developing countries that will benefit so much from the operation of antipodal spaceports.

If antipodal spaceports can be realized in South East Asia and the Caribbean, new industries and new jobs can be realized too. The spaceports will not only provide facilities for passengers, but also for commodities and manufactured products to be exported and imported. These commodities and products may not be exported and imported before due to the travelling time restriction, but with hypersonic flight operating at the spaceport drastically reducing the travelling time, they can be exported and imported.

It will also be very cost effective if the rocket propellant can be produced locally by the spaceport hosting countries of South East Asia and the Caribbean. The propellant can be of petroleum based or agricultural based (bio rocket fuel). There are tremendous economic possibilities for those countries.

Antipodal spaceports are so much different from orbital spaceports. Antipodal spaceports are to provide services only to point-to-point suborbital flights, while orbital spaceports operated by developed countries are to provide services to orbital flight with final destinations in orbit. As for antipodal spaceports, the final destinations are still on the ground on Earth.

Antipodal spaceports however will have so much similarity with conventional airports. In fact, an airport can just be upgraded into antipodal spaceport or added with antipodal spaceflight terminal. Therefore there will not be very complicated or very expensive for developing countries in South East Asia and the Caribbean to develop antipodal spaceports.

A Case for Malaysia and Puerto Rico, USA

This paper not only justifies that South East Asia and the Caribbean are the suitable antipodes to host antipodal spaceports for global point-to-point commercial suborbital flight, but also is justifying the antipodal spaceports should be in Kuala Lumpur, Malaysia and San Juan, Puerto Rico. This justification is well supported by universal law of Physics pertaining to the maximum momentum of Earth rotation near the equator, the antipodal location between the 2 cities and basic rocket science and aviation technology. There is no reason antipodal spaceports cannot be realized within this universal law of Physics.

However, universal law of Physics is not enough to determine the outcome alone. Technologies were often used by developed countries employing universal law of Physics to their advantage although according to the law, developing countries were the one to benefit the most. A classic example is the development of space launch vehicles and orbital spaceports.

According to the law of Physics, the best location on Earth for the operation of space launch vehicles, and hence the location of orbital spaceports is along or near the equatorial line that lies within or near developing countries in South East Asia, Africa and northern South America. But, developed counties built the launch vehicles and they chose where to build the spaceport. So, they controlled both the space launch vehicles and the orbital spaceports.

Developing countries are not able to build space launch vehicles and spaceports because they lack both the technology and financial means. This is so because those infrastructures are so much complicated and expensive.

Suborbital flights however is a totally different technology from orbital spaceflight infrastructures which were based on intercontinental ballistic missiles technology developed during the cold war. Suborbital flight technology is more toward aviation rather than space. It is viable to be developed by developing countries as aviation industry is. As explained in this paper, suborbital spaceplane may use conventional airport facilities as in aviation industry.

Point-to-point suborbital flight however is the key to the success of suborbital flight industry because the number of users will multiply exponentially when single point suborbital flight evolves into point-to-point suborbital flight. Point-to-point suborbital flight is the future of aviation.

Both Malaysia and Puerto Rico are tropical countries sharing much economic potentials which can be multiplied by being collaborative with each other. Operating antipodal spaceports is the large realm. There are many overlapping ecosystems within the realm. An example is the development of agricultural based rocket propellants as both countries may collaboratively develop from a tropical agricultural source.

Tropical and marine tourism is another very obvious industry that both countries can share cost effectively because similar facilities can be built at both destinations. They can offer suborbital antipodal flights that are packaged together with tropical and marine tourism activities.

As for Malaysia, if it has any intention of operating a regional spaceport along with neighboring Indonesia which may be hosting a Space-X launch facility since Space-X have showed interest in operating in Indonesia, realizing an antipodal spaceport is a realistic option. Space-X reusable rockets are vertically launched. They may land back at the same destination or other destination away from the launch facility, and they have their own market, which is different from that of suborbital antipodal spaceplane. Vertically launch rockets such as those of developed by Space-X are more suitable to serve orbital flight to orbital destinations, which is not the market for antipodal spaceplane. Furthermore Space-X may be more keened to further develop its vertically reusable rockets rather than developing spaceplanes that take-off and land like airplanes. Therefore an antipodal spaceport is viable to be developed in Malaysia even if Space-X really is going to launch its rockets from Indonesia. However the latest development shows that Space-X has cancelled its plan to launch its reusable rockets from Indonesia.

As for Puerto Rico, being a territory under the administration the United States of America will be an advantage because USA is the leading country in aviation and space transportation industry.

Malaysia and Puerto Rico however must be at the forefront if not initiate the development of this antipodal new aviation, although the antipodal spaceplane manufacturing most probably will be led by companies that currently are building large passengers aircrafts and new generation space vehicles. Both governments should support and provide all kind of assistances including incentives to initiate any activities leading to the development of antipodal spaceplane and antipodal spaceport. Establishing a common committee to further study antipodal spaceplane and antipodal spaceport before calling for early concepts will be a good start. Later, the committee will foresee the design and development of the antipodal spaceplane and raise the investment globally as the development of the spaceplane and operation of the antipodal spaceport will definitely have a very significant development on global aviation industry.

The collaboration between the 2 antipodal spaceports will be extended into many new possibilities. For example, both spaceports will need to foresee the establishment of tracking and emergency landing facilities between them. Since the shorter route which is 17,255km between Kuala Lumpur and San Juan is to fly over northern Indian Ocean, North Africa and Atlantic Ocean near the Equator, the facilities will have to be established in those regions. This will call for international investment opportunity to pay for the facilities.

As explained that momentum has both magnitude and direction. The direction of Earth rotation is eastward. The spaceplane that take-off from Puerto Rico will fly eastward at the distance of 17,255km to Malaysia and gain advantage from this momentum. But, the spaceplane which take-off from Malaysia if it wishes to fly the same distance will fly westward and against the momentum. Science, engineering and economy will have to take care of this and decide the best route either to fly westward with the same distance or fly eastward with the longer distance of 22,820km, but gaining the advantage of the eastward Earth rotation.

Global point-to-point commercial suborbital flight will be among the greatest economic opportunity ever for South East Asia and the Caribbean if antipodal spaceports, one on each region can be realized.

Conclusions and Recommendations

South East Asia and the Caribbean are antipodal to each other, and there are no other 2 landed regions in the Equator which are antipodal. Therefore, twin antipodal spaceports are very suitable to be developed one in South East Asia and another one in the Caribbean. The 2 countries where there have been significant efforts for decades to develop spaceports in South East Asia and the Caribbean are Malaysia and Puerto Rico (United States of America) respectively. There was even a memorandum of understanding for collaboration between the 2 spaceports projects. These antipodal spaceports will be perfect to provide the landing and take-off facilities for global point-to-point commercial suborbital flight. Both the governments of Malaysia and Puerto Rico should support the effort to develop the spaceports in their countries, for there are very large economic opportunities for the operation of antipodal spaceports between the 2 countries.

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